FLEXINET

FP7-2013-NMP-ICT-FOF (RTD) Project 608627

Deliverable D3.5

Product-service-production ontologies report

Workpackage: WP3 – Product-Service-Production Ontologies Report

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Document History

Version	Date	Author (Partner)	Remarks
0.1	28/01/16	Esmond Urwin (LU)	Initial draft version.
0.15	12/02/16	Esmond Urwin (LU)	Changes to structure and layout.
0.18	19/02/16	Esmond Urwin (LU)	Updated Level 2, 4 and End User content.
0.20	24/02/16	Esmond Urwin (LU), Ester Palacios (ITI)	Updated Level 2, 4 and End User content. Moved Level 5 End User code to separate 'End User Annex'.
0.24	05/03/16	Esmond Urwin (LU), Ester Palacios (ITI), Avelino Font (AINIA)	Updated Level 4, End User content and queries.
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0.35	21/03/16	Bob Young & Esmond Urwin (LU)	Updates to summary, conclusions, addition of BuzzBikes knowledge base and final checks.
1.0	31/03/16	Bob Young	Final version for submission

Executive Summary

This D3.5 deliverable reports the output from Task 3.4 to refine the compliance evaluator methods and reference ontologies. These refinements follow from the understanding of the results produced during the development and initial testing of the WP5 software services as well as new understanding from WP2 and WP4. D3.5 delivers the final Product-Service Production Reference Ontology for the FLEXINET project

As in the earlier WP3 ontology deliverables, this D3.5 follows the five levels of concept specialisation initially defined in D3.1. These levels are based on applying a systems context at level 1, followed by broad ranging concept specialisations at level 2. Level 3 provides a manufacturing business systems context and Level 4 provides ontology specialisations against categories to suit the range of FLEXINET software support applications across business model development, Product-Service configuration and global production network configuration. The key categories of concepts that have been developed within the reference ontology are "Business", "Product", "Network Scenario", "Location", "Market", "Risk", "Project", "Indicator" and "Metrics".

The D3.5 deliverable also extends the compliance evaluator outputs provided in D3.4. In particular it details the final sets of queries defined in FLEXINET and used by the FLEXINET software services. It also details the specialisations of the reference ontology required to meet our three manufacturing end user requirements and offers an additional set of facts based on a fictitious "BuzzBikes" company that has been used as a generic test case in the project.

The formalisation of the ontologies has been undertaken using the Knowledge Frame Language (KFL) of HIGHFLEET inc. This language is based on the Common Logic standard (ISO/IEC 24707) and therefore provides a good basis for a standard reference ontology as well as providing an expressive logic based representation of the concepts, relations, constraints and rules that are important to the project. The key global production network elements of the reference ontology are in the process of being standardised as ISO 20534 within ISO TC184 SC4 JWG8.

Table of Contents

List of Figures

1 Introduction

1.1 Purpose and Scope

This technical document details the formal representation of the reference and specialised ontologies produced in Task T3.4, it represents the final version of the FLEXINET product-service production ontologies. These have been produced in the Knowledge Frame Language (KFL) and Extended Common Logic Interchange Format (ECLIF), both based upon Common Logic (ISO/IEC 24707) and used in the HIGHFLEET[1] inc. software.

The main objective of Task T3.4 has been to 'refine the compliance evaluator methods and reference ontologies'. As planned, the development, testing and evaluation activities in WP6 and WP7 have been feeding back valuable results and thereby formed an iterative loop enabling the ontologies to be further developed and refined to facilitate and support the FLEXINET software. This deliverable D3.5 therefore has the following objectives:

- This deliverable documents the final product-service-production ontologies and the Compliance Evaluator methods following their refinement in T3.4.
- This deliverable includes any necessary refinements that have been identified during the implementation and evaluation work in T7.2 and T7.3.

Deliverable D3.5 is in the form of ontologies, queries and facts that have been implemented in HIGHFLEET's ontology and knowledge base development environment. These are now being used to support the FLEXINET applications that are currently being evaluated in WP7 D7.2 due in M35.

1.2 Approach for Work Package and Relationship to other Work Packages and Deliverables

The final ontologies that are presented herein have built upon the work accomplished in deliverables D3.3 and D3.4, this has included input from WP2 and WP4. Additionally, feedback has been received from WP6 and WP7 from the testing and evaluation activities that, has enabled the ontologies to be further developed to support the FLEXINET software and the information interactions between the services and applications.

1.2.1 Key updates

The final version of the FLEXINET ontologies reflects a number of changes and updates that have been made since the previous WP3 deliverables. A number of areas of the ontologies have been updated; the changes made are listed here so as to easily highlight the differences within this report as compared with the previous WP3 deliverables D3.3 and D3.4. They are follows:

- Level 1 Reference Ontology
    - Control has been remodelled and is now a type of Input. Added a new concept called Entity.
- Level 2 Reference Ontology

[1] http://www.highfleet.com/

- Network has been renamed Network Scenario and remodelled in relation to Flow.
- Business has had a minor update to the models:
  - Business Model: the addition of the BMC_System concept.
  - Balanced Score Card: added relationships to Facility, Fuzzy Error, Fuzzy Measure and Metric.
  - Business Rules: the concept of Facility has been added and the relationships to Indicator, Location and Organisation have been changed.
- Indicator has had the model slightly remodelled, renaming the concept of Organisation to Facility. Additionally, extra concepts have been implemented within the ontology for Economic Factor, Environmental Factor, Social Factor and Purchasing and Sales Factor.
- Risk has had the concept of Organisation renamed to Facility and the concept of Regional Specific Risk Factor removed. Risk Factors are related to Location, which in turn is related to Region.
- Metrics has had the model updated adding the concept of Fuzzy Error.
- Project has had the concept of Idea removed as a direct relationship, as Idea can be derived from the relationship to Concept in a Project. The relationships to Scenario and Product have been remodelled.

- Level 4 Reference Ontology
  - The new concept Project World has been introduced to act as a "container" for Projects. This reflects the idea that new projects are developed beyond a business' existing ecosystem and must be able to explore network possibilities that do not exist within their normal operational business.
  - Scenario has been further developed with the addition of the concepts of Business Model Scenario, Product Scenario, Product Design Scenario, Production Network Scenario and Network Scenario.
  - Risk has had the concepts of Intended Revenue, Node Inter Dependency and Inter Dependency Rating added.
  - Product has had some of the axioms removed to reflect changes in the model that have led to their becoming redundant.
- Level 5 End User Ontologies, Facts and BuzzBikes Knowledge Base
  - CustomDrinks changes include extra additions to the facts in the End User knowledge base within the separate End User Annex.
  - INDESIT changes include an update to the End User knowledge base, which has been expanded to include GPN scenarios and had further additions to the facts such as products, suppliers, facilities, services and locations.
  - KSB changes include updated axioms with the addition of one further axiom. The knowledge base has been updated with new facts related to different flows between processes, different external factors and different components.
  - BuzzBikes fictitious example test case has been added, with the knowledge base listed in Annex D.
- Competency Questions and Application Queries
  - Queries for Services section has been added to show the queries that are used to support more than one application.
  - Queries for Applications have been updated.

1.3 Structure of the Document

Deliverable D3.5 sets out the final version of the ontologies, this comprises the:

- Four levels of the reference ontology (Levels 1, 2, 3 and 4).
- Three end user specific ontologies and facts (CustomDrinks, INDESIT and KSB), together with the BuzzBikes fictitious example test case knowledge base.
- Competency questions together with service and application queries.

Each of these areas of the document sets out an overview for the respective ontology levels, together with an overview of the end user competency questions and application queries which map the ontological queries to the services and applications that utilise them. As per D3.3, the repetitive nature of explaining the KFL and ECLIF code used to create the ontologies has been minimised, to which, only the axioms and rules (where applicable) have been set out. Only the first axiom and rule from each section is expressed in ECLIF code in order to provide greater clarity of the content. Moreover, UML class models have been included to help the reader visualise the ontologies. The complete KFL and ECLIF code for the reference levels of the ontology (Levels 1, 2, 3 and 4) is contained within the annexes of this document. To avoid any confidentiality and sensitivity issues, the Level 5 end user ontologies are contained within a separate 'End User Annex' which has been classed as 'Restricted'.

Chapter 2 presents the approach to the formal definition of the ontologies within WP3. Chapters 3, 4, 5 and 6 describe each of the reference ontology Levels 1, 2, 3 and 4 respectively, describing the axioms and rules created in ECLIF code that represent the ontology. Chapter 7 sets out the end user specific (Level 5) ontologies and how these map to the reference ontology, showing the final changes and versions, together with the BuzzBikes fictitious example test case knowledge base. Chapter 8 presents the end user competency questions and query sets, the queries are mapped to the FLEXINET software services and applications showing how they are utilised. The main body of the deliverable is drawn to a close with the conclusions presented in Chapter 9. The full KFL and ECLIF code is presented in annexes A, B and C related to the reference ontology. Annex D Lists in full the knowledge base code for the fictitious BuzzBikes generic test case and Annex E provides a basic description of and introduction to the use of the key KFL terminology.

Note: Axioms in KFL can provide 'Hard' or 'Soft' constraints where Hard constraints must be followed and Soft constraints are recommendations that may or should be followed. In the natural language description of axioms we include a KFL term (IC Hard) or (IC Soft) to indicate which of these apply.

Note: We recognise that there is potential confusion between the use of the words "class", "concept" and "property". We use these synonymously in this document. We use the word "concept" to be a generalisation of things or objects, which aligns with the meaning of the word "class" in UML terminology. In KFL the word "property" is used with this same meaning and so where KFL code is being explained in the text "property" can be assumed to have the same meaning as "concept" and "class".

2 The FLEXINET Formal Ontology

2.1 FLEXINET Ontology Levels

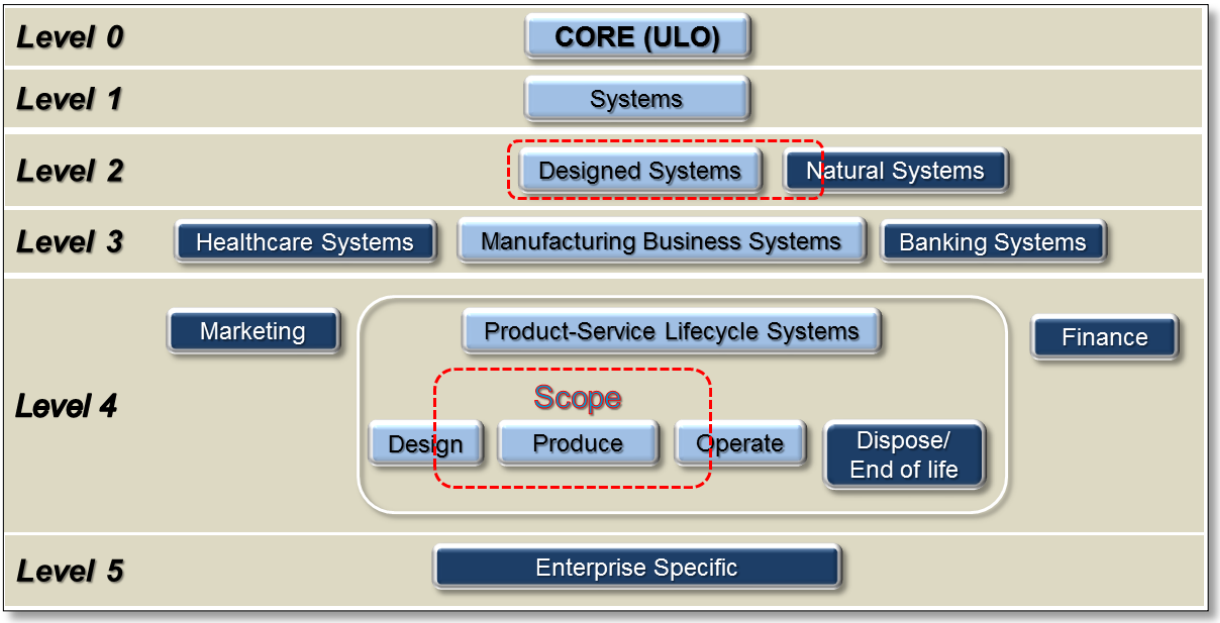


Figure 2-1: FLEXINET reference ontology levels

The approach being taken here was introduced in D3.1 and further developed in D3.2, D3.3, and D3.4. D3.5 presents the final version of the FLEXINET ontology and the levels within it. The underlying concept behind the levels has not changed and is re-stated here for completeness.

The premise behind the proposed formal semantic models for the configuration of global production networks is that for ease of construction, effective interoperability and flexible re-use, enterprise ontologies must be built from a common base that utilises a common reference ontology wherever possible. A simple statement may describe the basis of generalisation: "A design of an ontology representing the core elements of a particular enterprise, will end up with a good number of elements that are not exclusive to this particular enterprise, but common to some other enterprises that operate in the same sector".

Following this reasoning, it can be inferred that a subset of the elements that are common to a particular sector might be applicable or extrapolated to different sectors. In other words, some of the elements that are applicable to the Pumps Industry sector might be also applicable to the White Goods sector. Both sectors are part of the manufacturing industry, so we state that the concepts that are widely applicable to different sectors belong to the broader area of Manufacturing Industry, and not to a particular sector. In this area reside the elements that are specific to the manufacturing industry and not necessarily to other types of industries like Finance, Assurance, Construction, Mining, Agriculture, etc.

However, some of the concepts identified for manufacturing industry are applicable, in a general sense, to other different man-made systems. In this case, they belong to the broader area of Designed Systems. This leads to a comprehensive set of general concepts and relations that are universally accepted and understood across the full range of business sectors.

To enable the management of complexity within the ontology and to facilitate re-use across domains the proposed formal semantic models for the configuration of global production networks approach is organised into five levels, as illustrated in Figure 2-1. These levels are needed to specialise the concepts from the foundation to the enterprise specific product-service production domain. Each level inherits concepts from the level above and provides a constraining influence on the subsequent level, the ontology becoming more domain specific (specialised) with each level.

The Level 0 Core (which is fully generic) consists of foundation concepts applicable to all domains, having nothing to do directly with Product-Service Lifecycle Systems. The foundation concepts include time, events, aggregation and lists which, are derived from the Highfleet Upper Level Ontology (ULO) (Highfleet, 2014). The Highfleet ULO is in itself, based upon OntoClean (Guarino and Welty, 2002).

Level 1 contains the few key concepts necessary to model any system. A system transforms inputs into outputs and is defined as "a combination of interacting elements organised to achieve one or more stated purposes" (Athena, 2006). Much of level 1 is an extension and formalisation of the IDEF0 concepts (PUBs, 1993).

Level 2 uses Banathy's classification (1992) to specialise systems into "Natural Systems" and "Designed Systems". Natural systems are living systems of all kinds, including the solar system and the Universe as examples. Designed systems, are man-made creations, including fabricated physical systems, conceptual knowledge and purposeful creations.

Level 3 differentiates designed systems by specifying the business system context for subsequent applicable areas. A few example areas are illustrated in Figure 2-1 but include manufacturing, healthcare, construction, tourism, grocery, farming, finance, etc. Manufacturing Business Systems concepts are then further specialised within Level 4. Level 3 areas such as Healthcare Systems and Banking Systems would also possess areas providing relevant specialisations at Level 4 and some of these areas might be similar to those within the Manufacturing Business Systems domain (e.g. finance would also apply to Healthcare Systems) however the concepts contained would be specialised within the context of the parent area (i.e. the Healthcare Systems Finance area would contain concepts related to healthcare).

Level 4 contains concepts specifically relating to the Manufacturing Business Systems domain. The area considered at level 4 is Product-Service Lifecycle Systems, implemented as Global Production Networks. The lifecycle phases are denoted as design, produce, operate and end of life (including disposal, recycling and remanufacturing). The focus is how to design a GPN to produce and operate a product-service. The main area considered within the Product-Service Lifecycle is therefore "Produce" (producing the product-service) but the scope also overlaps into "Design" (of the network) and "Operate" as the operation of the product and the service needs to be considered in design.

Level 5 provides enterprise specific concepts for the product-service production domain for each of the three enterprises. These are mapped to the reference ontology concepts in order to take advantage of underlying structure that it provides. In our case there are three level 5 ontologies; one each for KSB, INDESIT and CustomDrinks.

3 Reference Ontology Level 1

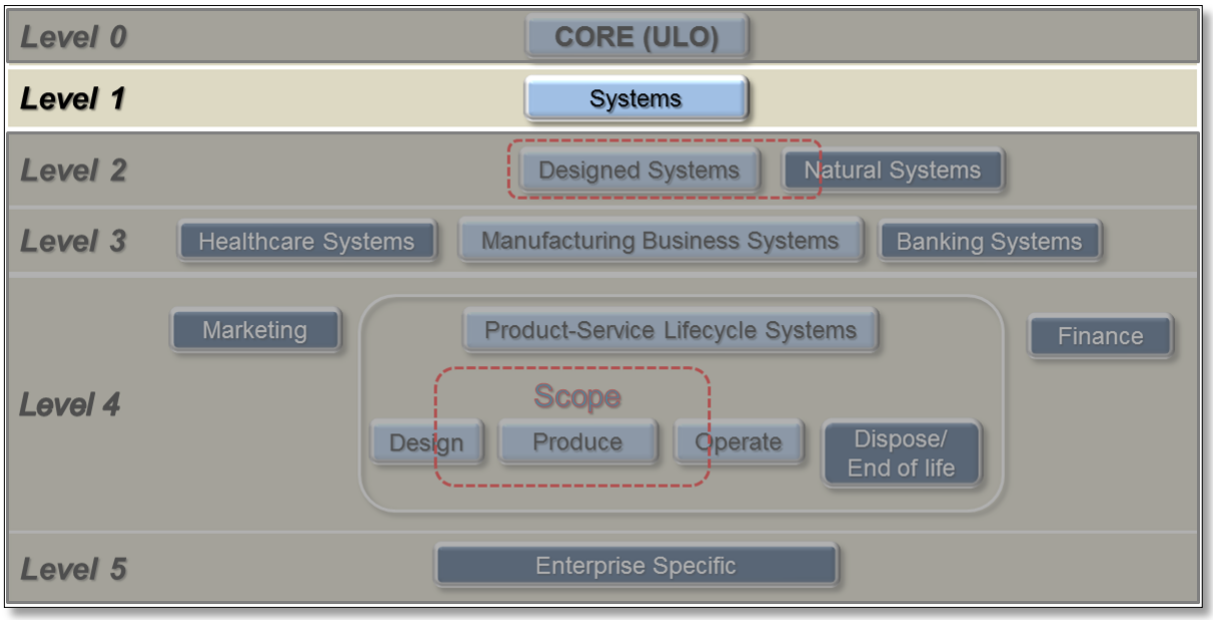


Figure 3-1: FLEXINET Reference ontology level 1

This chapter describes the final version of the Level 1 FLEXINET Reference Ontology as depicted in Figure 3-1.

3.1 Level 1 Properties and Relationships

Figure 3-1 sets out the focus of the level 1 reference ontology, this is illustrated in Figure 3-2 using the Unified Modeling Language[2] (UML) method, detailing the concepts and relations necessary to specify a system. The focus of this approach is the representation of a system and the extension and formalisation of the IDEF0 concepts (PUBs, 1993). There are two main parent classes at level 1, those of basic and role.

A Basic concept is independent of the system or context, its definition does not depend on another concept and an instance of a Basic always retains its identity as such. Basics occurring at level 1 can be classified as an Entity or a System.

A Basic can be comprised of Basics, e.g. "bottled water" is comprised of the materials "bottle", "cap" and "mineral water". An Entity is a subtype of Basic and is defined as a Basic which is not a System. Information, Material and Energy are subtypes of Entity. A System is a subtype of Basic and provides a context for the Roles it contains (shown via the "depends on" relation and the composition filled diamond in the Figure 3-2). The definition of a Role depends on a context and an instance of a Role cannot exist without a context, for example a person Joe has a Role as a lecturer (context "university"); "bottled water" has a role as a product (context "beverage company"). It can be seen that (for example) a lecturer Role cannot exist without the university context. If the university closes the lecturer role ceases to exist whereas the person Joe (an instance of a Basic) will still be present.

[2] http://www.uml.org/

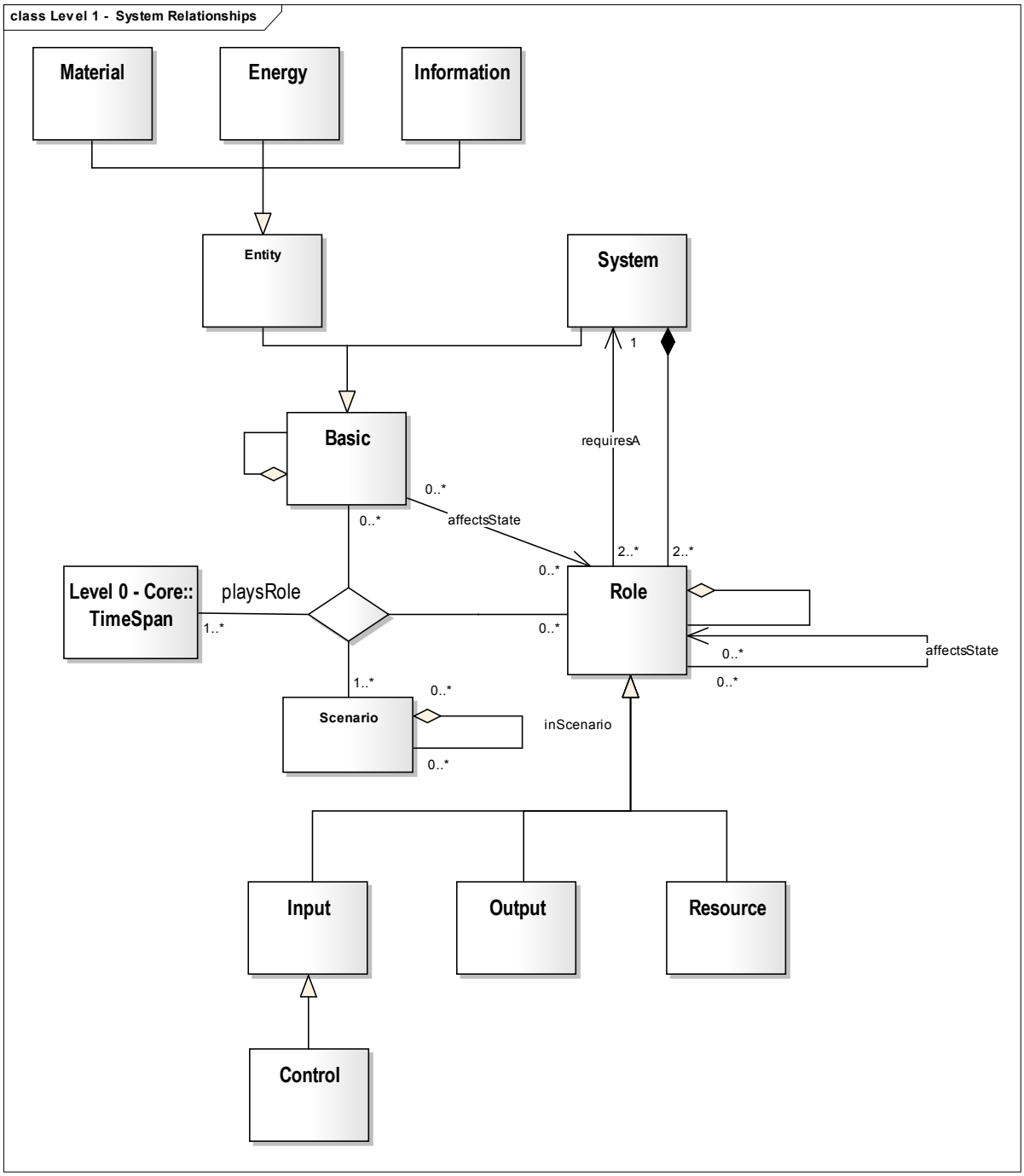


Figure 3-2: Level 1 UML model

Roles may be comprised of Roles (e.g. a lecturer Role may be comprised of administration, teaching and staff Roles). The "playsRole" relation is transient, i.e. it exists for a certain time. A Basic plays a Role for certain TimeSpans, modelled in the ternary relation "playsRole". For example in the context of a manufacturing organisation system, the Basic "bottled water" can play the Role of a Product during the TimeSpan of the system. Within a University a person could, for example, play the Role of a lecturer for a TimeSpan of five years, become unemployed and then play the Role of a lecturer again for a further TimeSpan. Roles are played within a scenario, as such Scenario concepts are defined within the ontology in order to provide a method to describe multiple alternative instantiations of global production networks. Additionally scenarios can be composed of scenarios.

Within the widely known ontology analysis methodology OntoClean Roles are modelled as concepts which are not essential to their instances (anti-rigid), a typical example provided being a student (Guarino, 1998) (This vision of Roles is implemented within the Highfleet development environment as the metaproperty "MaterialRole"). However, this research takes the view that many Roles are essential to the System that incorporates them, for example it would be difficult for a university to exist without students. In addition, to model the concept of an empty role (i.e. a vacant or required role) it is essential that a Role concept cannot cease to be (is rigid). This research captures the changeability of Roles through the playsRole relations which explicitly models the times in which individuals participate in a Role.

This ontology level utilises the concept TimeSpan (inherited from Level 0) and contains two parent concepts: Basic and Role. A TimeSpan includes the first and last instants of a date and all the instances in between (ISO 10303-233:2012).

The modelling of Role as a specific concept is necessary to be able to evaluate whether a system is capable of meeting specified requirements. The division of Basic and Role concepts enables the number of Role instances counted to differ from the number of Basic instances playing the Roles (see the Wieringa et al. (1995) counting problem). For example, one person (instance of a Basic) can play two lecturer roles, the first time from June 1997 - July 2002 and the second time from May 2005 to the present date. A Basic can play more than one Role at the same time (e.g. a person could be a lecturer (context "university") and a parent (context "family"). A Role can be played by more than one Basic, e.g. the role of a laundry would require a washer and a drier. There is no requirement for a Basic to play a Role (shown by the 0..* multiplicity next to the Role concept in the Figure 3-2). Role and Basic concepts exist separately and have separate identities. There is also no requirement for a Role to be played by a Basic, enabling empty Roles to be modelled (e.g. if a person Joe left his Role as a lecturer the Role would still exist as a lecturer vacancy; also the equipment features required to fulfil the Role of a cutting resource within a manufacturing cell would be present even though no equipment was available to cut).

In the literature there is discussion of the idea "Roles can play roles" (Steimann, 2000; Loebe, 2003; West, 2008). The rationale behind this premise is the need to capture conditions such as only an employee can play the Role of a manager. However, an "employee" cannot be a "manager" - it is the person (a Basic) who plays the Role of the employee who also plays the Role of the manager. A "RolePlaysRole" relation would imply that all employees would play the Role of a manager, which is unlikely to be the case. In this approach "Role can play roles" conditions will be modelled through the use of constraint axioms. The use of constraints will also enable the following to be modelled: negative conditions such as "Roles cannot play Roles" (e.g. a person playing the role of an evaluator cannot also play the role of a manager at the same time) and cardinality conditions (e.g. only one person can play the Role of U.K. Prime Minister at a time).

The ideas on Roles share views with those of Kozaki et al. (2006), Kozaki et al. (2008) and Mizoguchi et al. (2012). In common with those views, the concepts of Basic, Role and Role aggregation are captured. However in this approach Time and Role context are explicitly modelled. Time is not considered by Mizoguchi et al. (2012); Roles are recognised as being context-dependent but the context is not specified being left to the choice of the modeller, whereas in this approach the context is defined as the System.

A Basic may affect the state of a role, e.g. the size of a Basic "bottled water" playing the Role of a product could influence the dimensions required for a packing resource Role. Additionally a Role may affect the state of a Role, e.g. within the lecturer Role more duties allotted to the administration Role would cause duties to be removed from the teaching Role).

The three key Roles that describe a system are input, output and resource. An input represents what is brought into and is transformed or consumed by the system to produce outputs. An output represents what is brought out from or is produced by the system. A resource is used by or supports the execution of the system. A control is a specialised type of input required to produce the correct system output (PUBs, 1993; Athena, 2006).

A simple example of the key Roles applied to a Designed system is an IT System in which input Roles are played by the Basics information (for example in the form of keyboard signals and numbers), output Roles are played by information (e.g. in the form of monitor signals and numbers), the resource Role is played by a basic "person" (a Natural System) who acts as the operator and control Roles are played by the material "control unit" and the information "analysis algorithm".

A Natural Systems example is a tree. Input Roles are played by the Basics materials "carbon dioxide" and "water" and energy (solar) which also play Resource Roles for this system. Output Roles are played by the materials "glucose", "oxygen" (both produced by photosynthesis) and "water" (produced by transpiration). Control roles are played by the information "concentration of carbon dioxide", "light intensity" , "temperature" (controlling photosynthesis), "humidity" and "wind strength" (controlling transpiration).

The final concept introduced at level 1 is that of Scenario. Scenario concepts are defined in order to provide a method to describe multiple alternative instantiations of system configurations that can be used to answer "what-if" questions. It is defined at level 1 in order to catch its relationship with Basics and Roles.

The entire listing of the KFL and ECLIF code for level 1 can be found in Annex A.

3.2 Level 1 Axioms

1. Axiom - a role must have a system to provide a context (IC Hard).

```
:Name  "1SYS - Axioms"

:Description "Axioms pertaining to relations occurring at the Systems level."

:Use 1SYSCtx

(=> (Role ?r)

   (exists (?s)

                  (and (System ?s)

                              (requiresA ?r ?s))))

:IC hard "The Role ?r requiresA System to provide a context."
```

2. Axiom - a System may require a resource (IC Soft).

3. Axiom - a control must also be an input (IC Hard).
4. Axiom - the same System cannot contain a Role and play the Role (IC Hard).

Note: as described in section 1.3, only the first axiom and rule in each list is provided as a full ECLIF representation, with the others listed as natural language statements. The full ECLIF representations are provided in the annexes.

3.3 Level 1 Rules

Rule - system containing a role

```
(=> (systemContainsRole ?x ?y)
    (requiresA ?y ?x))
;;;A System containing a Role implies that the Role requires the System as a context
```

Ontology rules are used to derive new information from the existing knowledge within the knowledgebase. The ECLIF rule code above shows an example of a rule, it states that if an instance of a role 'requires A' specific system, then that system also contains that role.

4 Reference Ontology Level 2

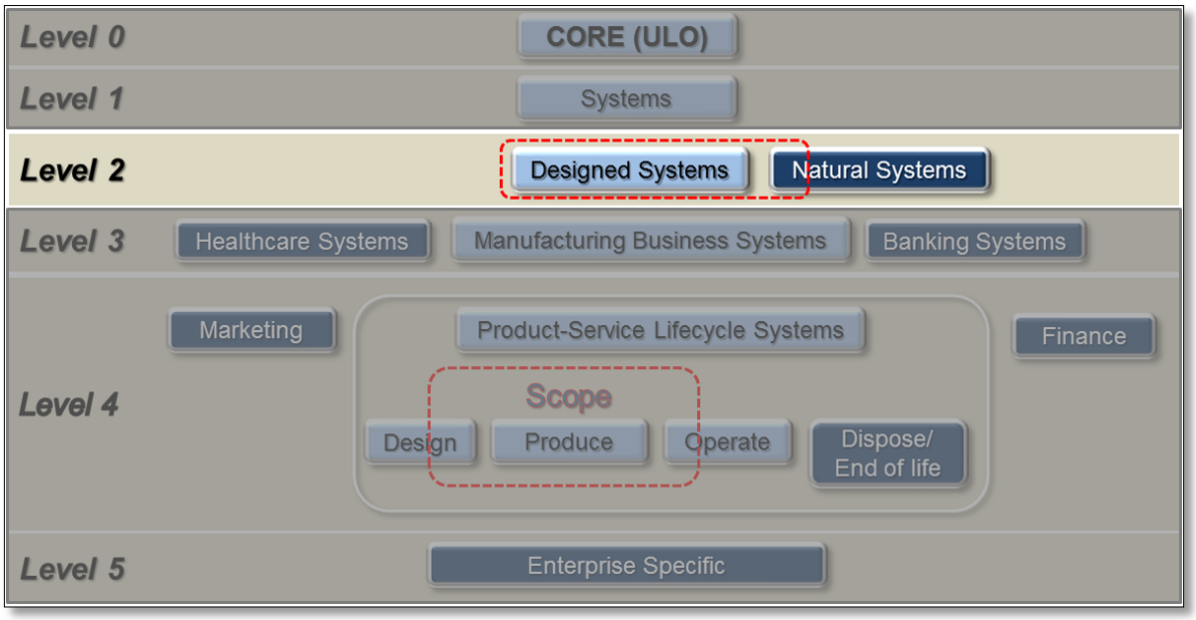


Figure 4-1: FLEXINET Reference ontology level 2

This chapter describes the final version of the Level 2 FLEXINET Reference Ontology as highlighted in Figure 4-1. It explains Level 2 of the ontology along with the axioms and rules that have been generated in Knowledge Framework Language (KFL) and Extended Common Logic Interchange Format (ECLIF) code.

To enable a fuller perspective for the reader of the level 2 FLEXINET reference ontology, Figure 4-2 provides a high level overview of the layout and structure of the concepts (properties in KFL) that have been developed within Level 2 to provide support to Level 4 concepts. These Level 2 concepts have been categorised into sets of concepts that relate to Location, Flow, Business, Indicator, Risk, Metrics, Idea, Product and Project. Where applicable, the axioms and rules that have been developed as part of the ontology, are listed with individual examples of ECLIF code showing the logic used to describe them.

A full listing of the Level 2 KFL and ECLIF Code can be found within Annex B.

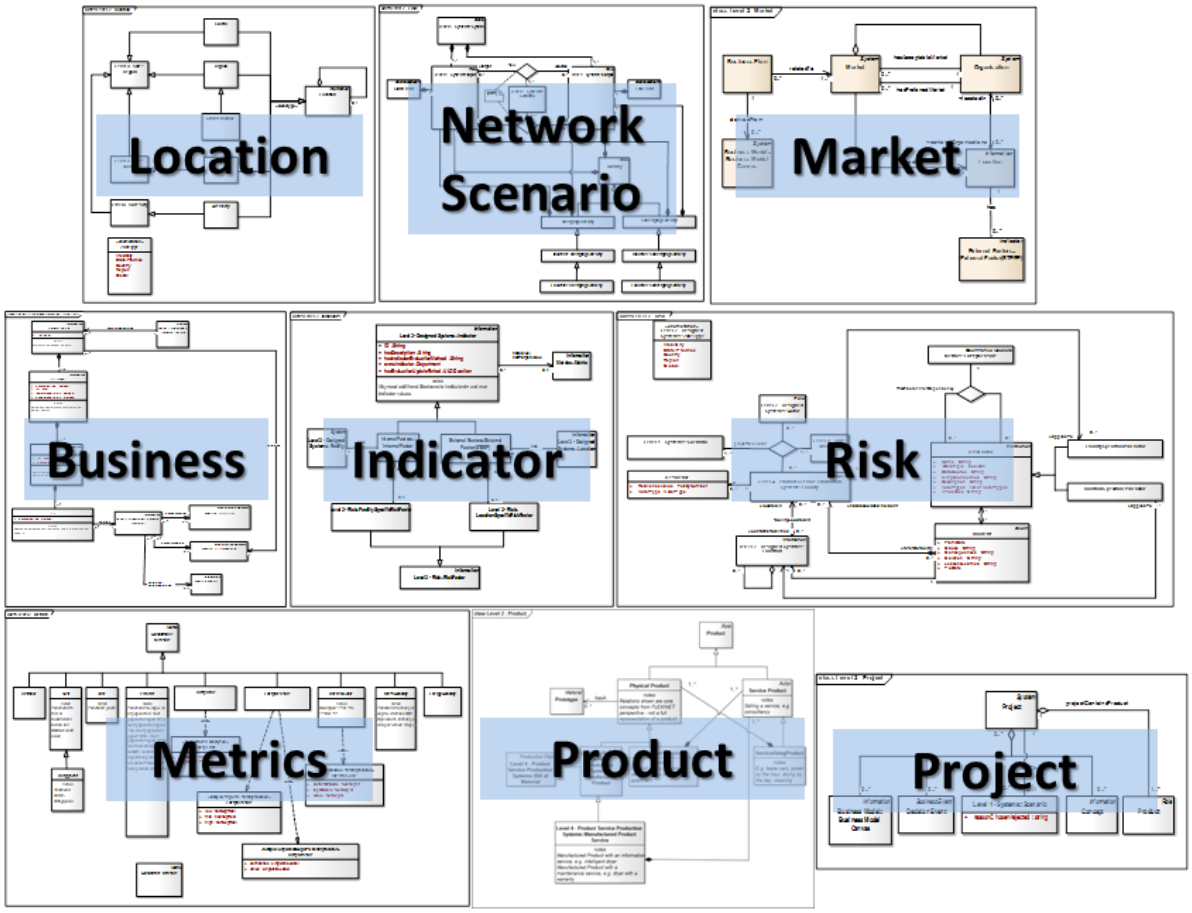


Figure 4-2: Overview of the Level 2 reference ontology Properties

4.1 Location

4.1.1 Location Properties and Relationships

For globally based decision making in FLEXINET, "Location" is an important concept, with various categories of location having been specified in D2.3. From the general literature, definitions for "Location" can also be found. For example, Location is defined as a region which is an object that can poses a fiat boundary (Smith & Varzi, 2000), i.e. a boundary that can be determined by human demarcation. Here, we combine D2.3 requirements with a general Location ontology provided by the Highfleet ULO. Figure 4-3 shows that the "Location" section of the ontology uses inheritance to extend the Core ULO properties defined for Geographic Bodies. The inclusion of the ULO Geographic Bodies Ontology allows the use of existing rules which employ Region Connection Calculus (Randal et al., 1992) and the Nine-Intersection Model (Clementini et al., 1993) to infer spatial relations between regions. An extension is required in order to model all the "Location" concepts required by the Strategic and Initial Risk Assessment applications. Zonetype (see Figure 4-3) is a metaproperty which is defined as there is a need for the risk section of the ontology to relate to "Location" properties (e.g. "Country") rather than instances of the properties (e.g. "France").

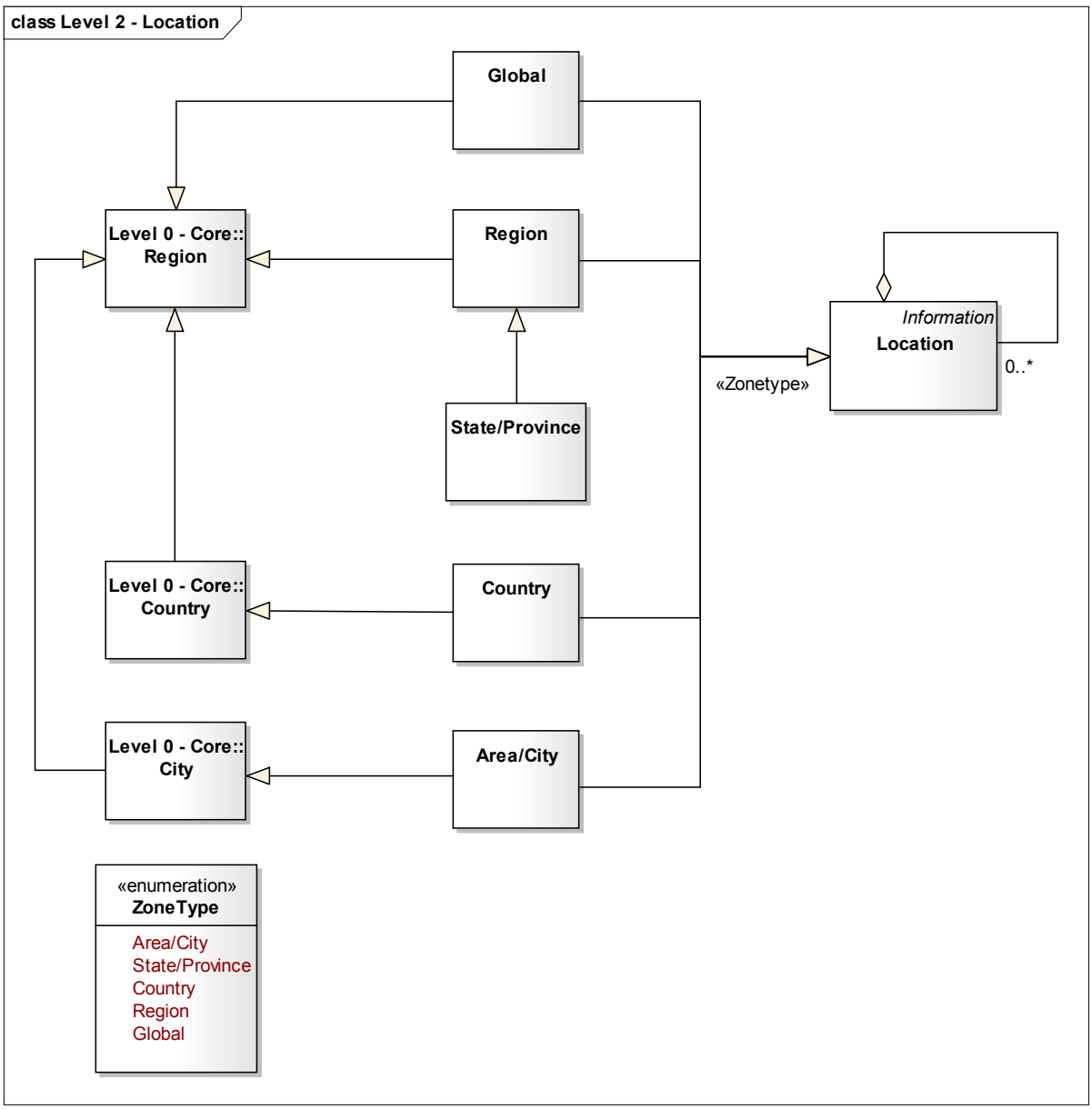


Figure 4-3: Level 2 Location Properties

4.2 Network Scenario

4.2.1 Network Scenario Properties and Relationships

The concepts present within Level 2 Designed Systems relevant to describing network scenario are "Network Scenario", "Flow", "Start Event", "End Event" and "Gateway", these are illustrated in Figure 4-4. "Network Scenario" is a 'specialisation of a scenario which provides views of flows within a network'. "Flow" 'occurs from an Input to an Output or from an Output to an Input within a given Network Scenario'. A "Start Event" represents the start of a process, whilst an "End Event" is used to indicate the end of a process.

Modelling flows at Level 2 requires the ability to capture processes and decisions. Processes are modelled using the Basic "System". A "Gateway" is an abstract concept whose sub-types (shown in Figure 4-4) are able to capture process decisions.

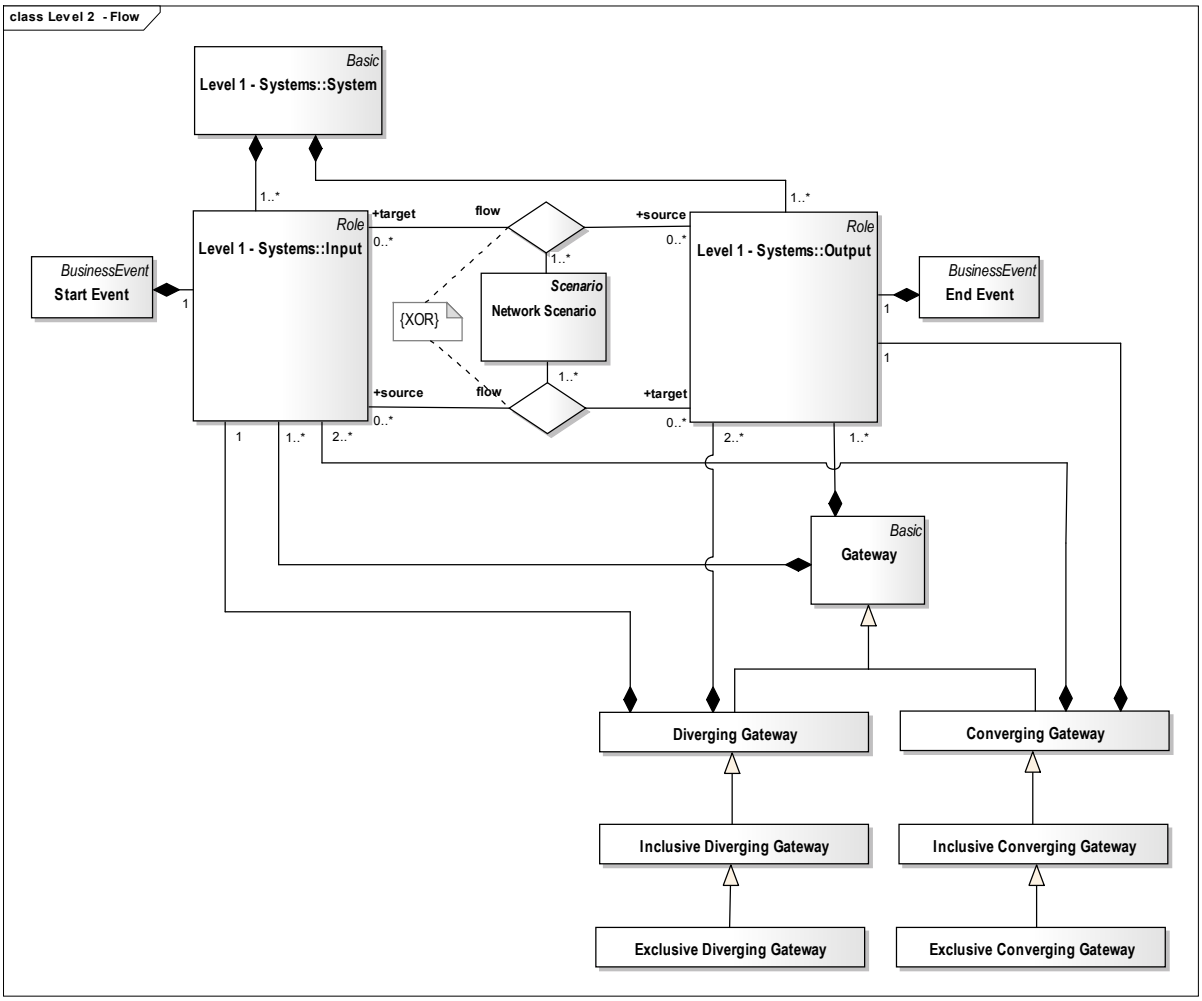


Figure 4-4: Level 2 Network Scenario Properties

"Flow" requires process decisions, "Gateways" are concerned with processes and decisions and thus are placed at Level 2. If process decisions need to be modelled within a "Flow" it will contain "Gateways", hence, it is necessary to represent decision points with multiple paths thereafter. A "Gateway" is a specialised type of Basic with at least one input and one output, it being based on the BPMN Gateway Process Element (Object Management Group, 2011) and the equivalent requirements following from D4.1. Figure 4-4 shows this constraint and the "Gateway" subtypes. "Gateway" has six sub-types: Diverging (an "opening AND" or a fork), Converging (a "closing AND" or a join), Inclusive Diverging (an "opening OR"), Inclusive Converging ("closing OR"), Exclusive Diverging ("opening XOR" or a branch) and Exclusive Converging ("closing XOR" or a merge). Figure 4-4 shows that a "Start Event", "End Event" and "Gateway" are sub-types of a Basic.

4.2.2 Network Scenario Related Axioms

In FLEXINET, a "Flow" is defined as 'a Flow occurs from an Input to an Output or from an Output to an Input within a given Network Scenario'. Axioms applied to "Flow" concepts are aimed at assuring and guaranteeing that all instantiations of a system/process flow in the knowledge base must meet certain requirements on connectivity and flow of inputs and outputs. The following are the axioms that concern "Network Scenario" and "Flow" at Level 2:

1. Axiom – A flow can only exist between an Input and an Output or an Output and an Input (IC Hard).

```
(=>  (flow ?source ?target ?scenario)
        (or (and (Input ?source)
                 (Output ?target))
                 (and (Output ?source)
                 (Input ?target))
         )
)
```

2. Axiom – A flow can only exist from a target to a source or a source to a target but not in both directions (XOR). (IC Hard).
3. Axiom – In a flow relation the source basic must flow to target (IC Hard).
4. Axiom – A network scenario should contain more than one system (IC Soft).
5. Axiom – A basic playing the role of an output should play the role of an input to another entity (a basic) within the network scenario (IC Soft).
6. Axiom – A gateway must have one input and one output (IC Hard).
7. Axiom – A diverging gateway has only one input and 2 or more outputs (describes an opening AND or a fork (IC Hard).
8. Axiom – A converging gateway has 2 or more inputs and only one output (describes a closing AND or a join (IC Hard) (IC Hard).
9. Axiom – An inclusive diverging gateway (opening OR) has one input and 2 or more outputs An output must have a condition (a Boolean) (IC Hard).
10. Axiom – An inclusive converging gateway ("closing OR") has one default output and two or more inputs. An input must have a condition (a Boolean) (IC Hard).
11. Axiom – An exclusive diverging gateway ("opening XOR", branch) inherits from an inclusive diverging gateway (IC Hard).
    - Note: The value of the condition of an output must not be identical to the value of the condition of any of the other outputs of the XOR gateway (i.e. only one condition within the XOR gateway can activated, so only one branch can be taken).
12. Axiom – An exclusive converging gateway ("closing XOR", merge) inherits from an inclusive diverging gateway (IC Hard).
    - Note: The value of the condition of an input must not be identical to the value of the condition of any of the other inputs of the XOR gateway (i.e. only one condition within the XOR gateway can activated, so only one incoming flow is needed)

13. Axiom – A Start Event is a specialised type of Basic which has an output role only (which is played by the trigger for the network) (IC Hard).
14. Axiom – An End Event is a specialised type of Basic which has an input role only (IC Hard).

4.3 Scenario

4.3.1 Scenario related Rules

The following are the rules that concern Scenario at level 2:

1. Rule – If a component scenario is contained within a compound scenario, a plays Role Actor relation which applies in the component scenario also applies in the compound scenario.

```
(=>
        (and
                (inScenario ?component ?compound)
                (playsRoleActor ?role ?basic ?component)
        )
        (playsRoleActor ?role ?basic ?compound))
```

- Note: If a component scenario is contained within (inScenario) a compound scenario, a playsRoleActor relation which applies in the component scenario also applies in the compound scenario.

2. Rule – If a component scenario is contained within a compound scenario, a plays Role Qualifier relation which applies in the component scenario also applies in the compound scenario.

4.4 Market

4.4.1 Market Properties and Relationships

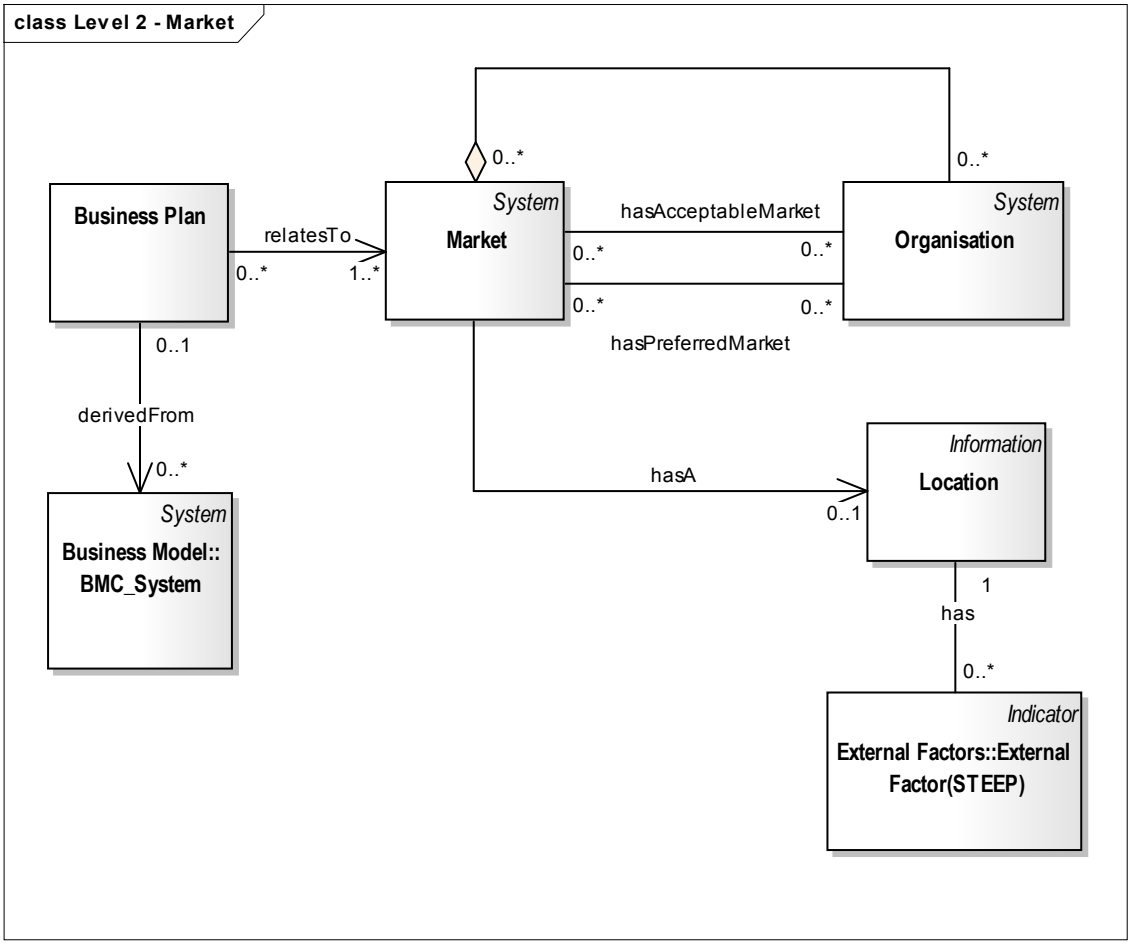


Figure 4-5: Level 2 Market Properties

At Level 2 (see Figure 4-5) "Market" is represented by "Organisation", "Location" and "External Factor" (as expressed in D2.3). "Market" is defined as 'an actual or nominal place where forces of demand and supply operate, and where buyers and sellers interact (directly or through intermediaries) to trade goods, services, or contracts or instruments, for money or barter'. A "Business Plan" (defined as 'a set of documents prepared by a firm's management to summarize its operational and financial objectives for the near future (usually one to three years) and to show how they will be achieved') is also related to a "Market" and is derived from "BMC_System". "BMC_System" is described as 'the system defined by the Business Model Canvas' (see section 4.5 for an explanation). An "Organisation" is a social unit of people that is structured and managed to meet a need or to pursue collective goals. "Location" is defined as in section 4.1." "External Factor" is a general social, technological, environmental, economic or political issue which can affect a GPN, but is outside of its direct control.

4.5 Business

4.5.1 Business Properties and Relationships

As shown in Figure 4-6, Business Model is represented showing the concepts and relationships involved. The concepts involved are "BMC_System", "Business Model Canvas", "Driver", "Objective", "Key Resources", "Key Partner", "Key Activities", "Distribution Channel", "Customer Relationship", "Value Proposition", "Revenue Streams", "Customer Segment" and "Cost Structure".

"BMC System" is a Business Model Canvas system. "Business Model Canvas" is defined as a framework, providing categories (building blocks) to let the user autonomously describe their business models. A "Driver" is an element of a system that has a major or critical effect on the associated elements or the entire system. An "Objective" is a specific result that a person or system aims to achieve within a time frame and with available resources. "Key Resources" are important economic or productive resources required to accomplish an activity, or as means to undertake an enterprise and achieve desired outcome. "Key Partner" is a key individual who joins with other individuals (partners) in an arrangement (partnership) where gains and losses, risks and rewards, are shared among the partners. "Key Activities" are key measurable amounts of work performed to convert inputs into outputs. "Distribution Channel" is a path through which goods and services travel from the vendor to the consumer or payments for those products travel from the consumer to the vendor. "Customer Relationship" is the development of an ongoing connection between a company and its customers. "Value Proposition" is the analysis or statement of the combination of goods and services offered by a company to its customers in exchange for payment. "Revenue Streams" are the different forms of income generated from sale of goods or services, or any other use of capital or assets, associated with the main operations of an organization before any costs or expenses are deducted. "Customer Segment" is one of several parts or sections into which customer is divided (derived from Collins), this is usually based upon demographics. "Cost Structure" is the method to determine how much it will cost a company to manufacture a product and how much profit will be recognized from manufacturing the product.

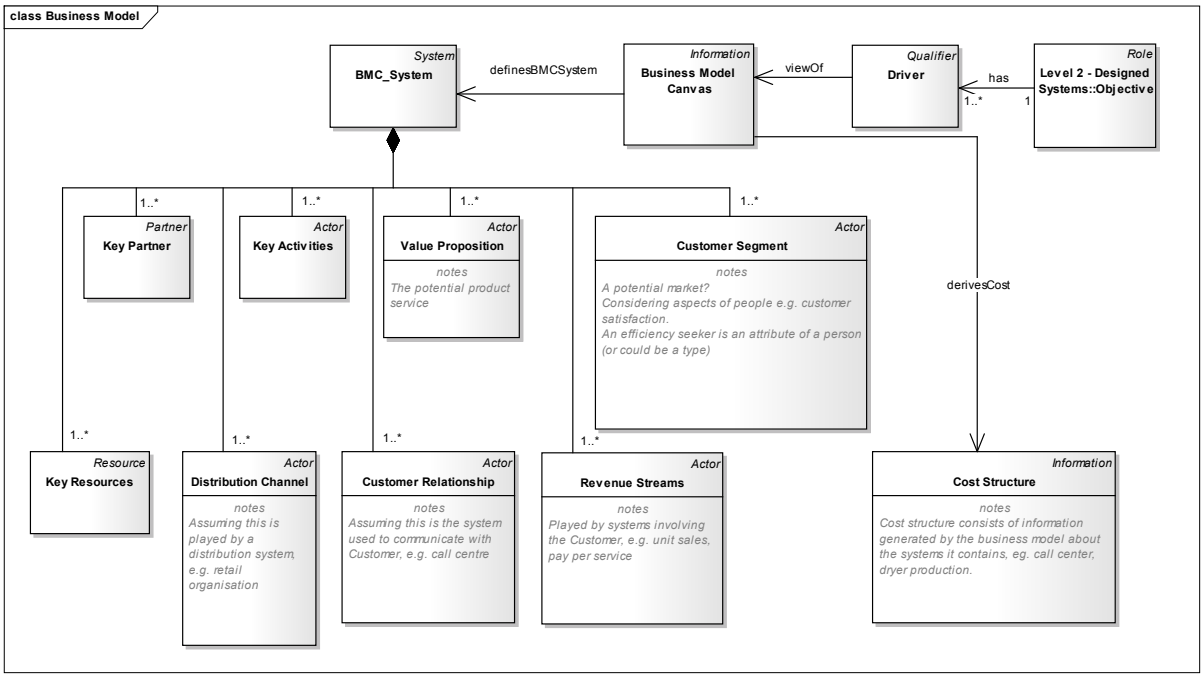


Figure 4-6: Level 2 Business Model Properties

Figure 4-7 shows the Balanced Score Card properties at level 2, they are "Strategic Value", "Facility", "Business Scorecard (BSC) View", "Key Performance Indicators" (KPI), "Performance Indicator" (PI), "Indicator", "Fuzzy Error", "Fuzzy Measure" and "Metric". These concepts and relationships follow from the requirements of D2.3.

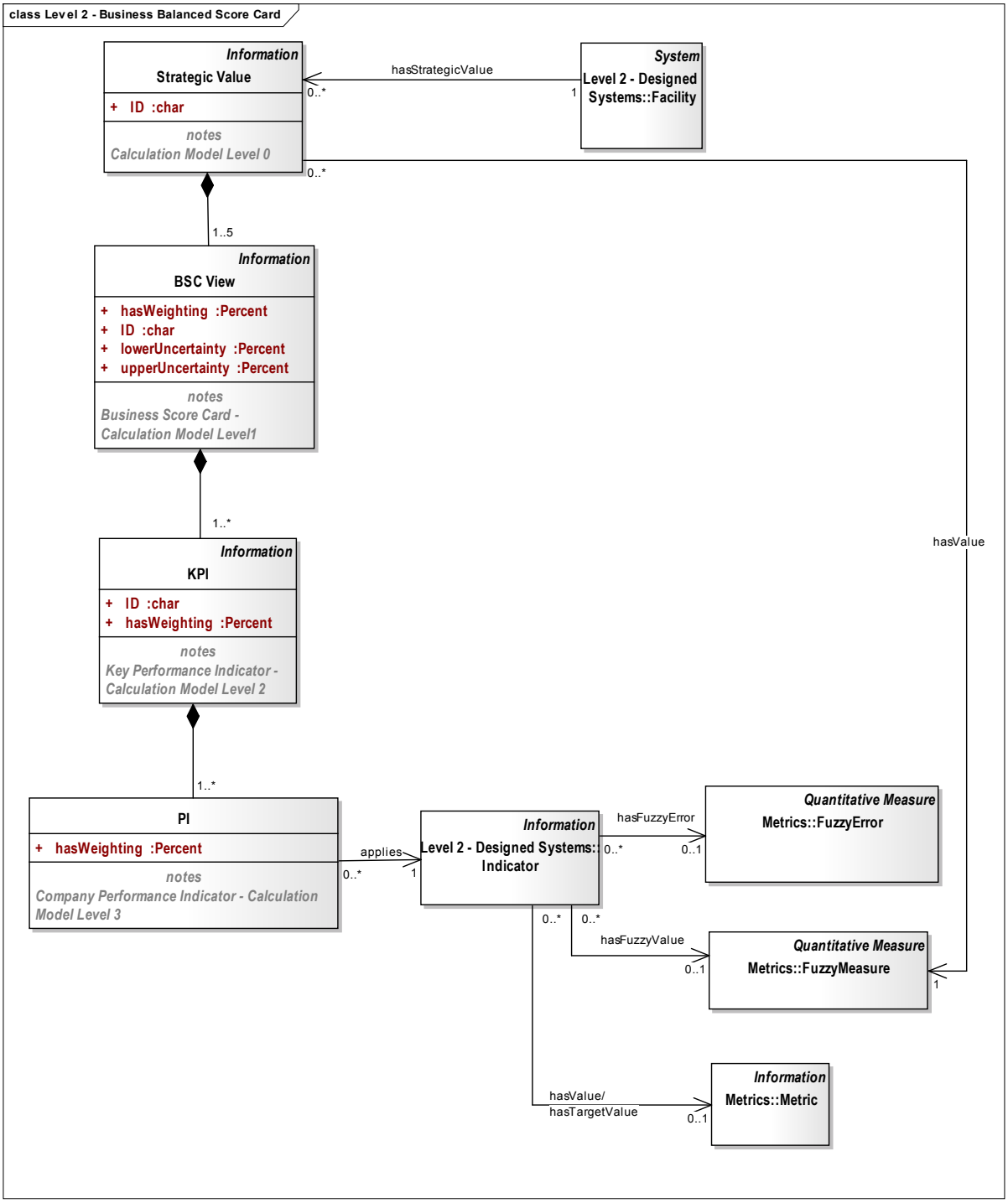


Figure 4-7: Level 2 Balanced Score Card properties

Figure 4-8 illustrates an example of a set of instances for the Balanced Score Card at Level 2 related to Strategic Value. Five BSC views are presented relating to Economic Feasibility, those being "Financial", "Internal", "Innovation", "Customer" and "Risk" as described in D2.3.

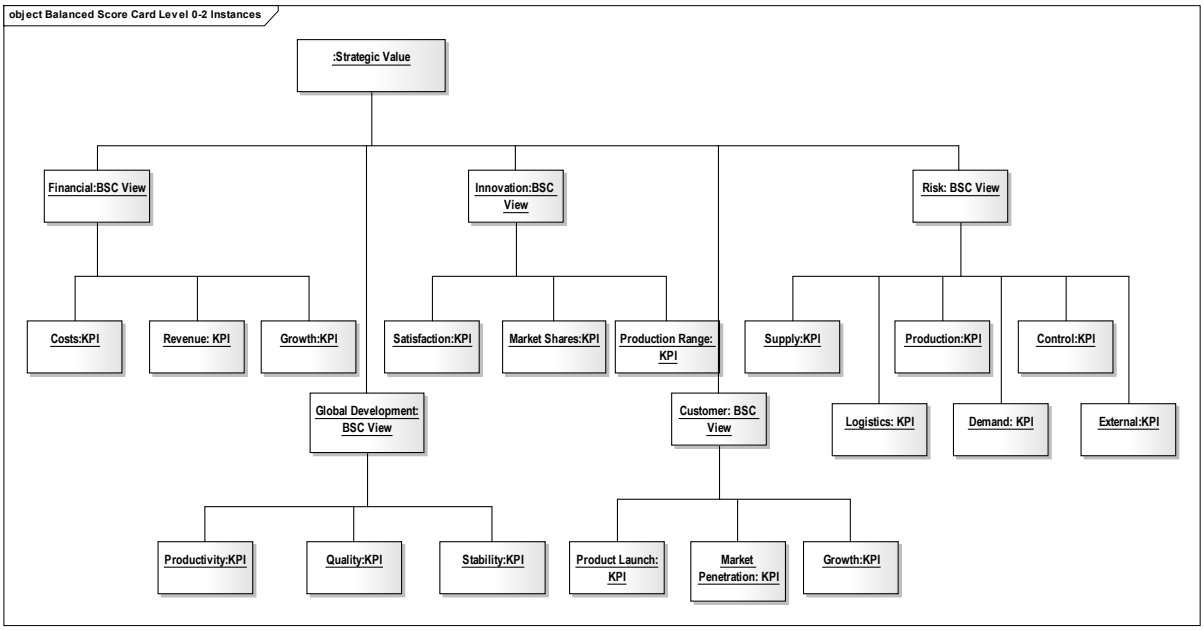


Figure 4-8: Level 2 Balanced Score Card instances

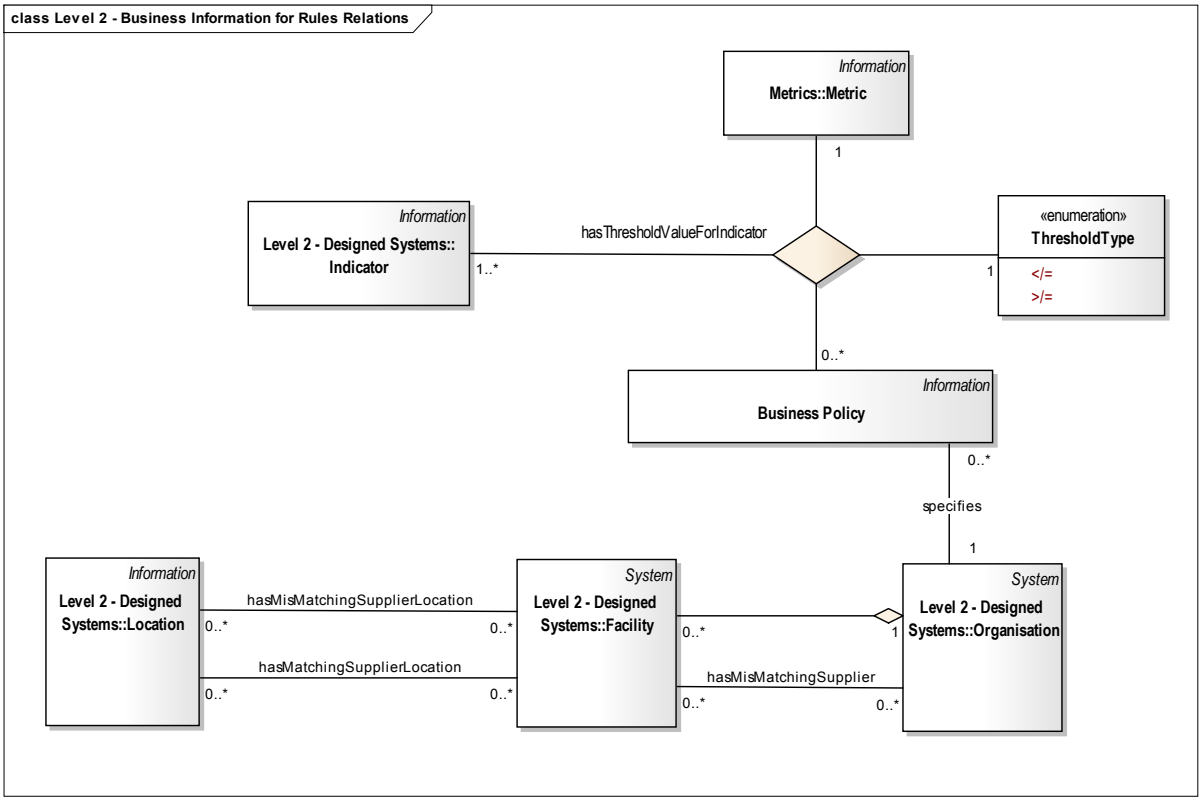


Figure 4-9: Business Rules Properties

Figure 4-9 represents the properties and relationships for Business Rules that follow from the Business Rule work presented in D2.3. "Business Policy" is defined as set of broad guidelines, formulated after an analysis of all internal and external factors that can affect a firm's objectives, operations, and plans, whilst, "Facility" is specified as a 'permanent, semi-permanent, or temporary

commercial or industrial property such as a building, plant, or structure, built, established, or installed for the performance of one or more specific activities or functions'.

Additionally, the model for Business Information for Rules is shown in Figure 4-9 and drawn from the evaluation of the work in D2.3. It sets out the properties that are types of Business Policy and therefore have an influence. These are "Location Factor", "Policy about Supplier" and "Policy about Market". Additionally, types of "Location Factor" relate to "Supplier", "Market" and "Producer".

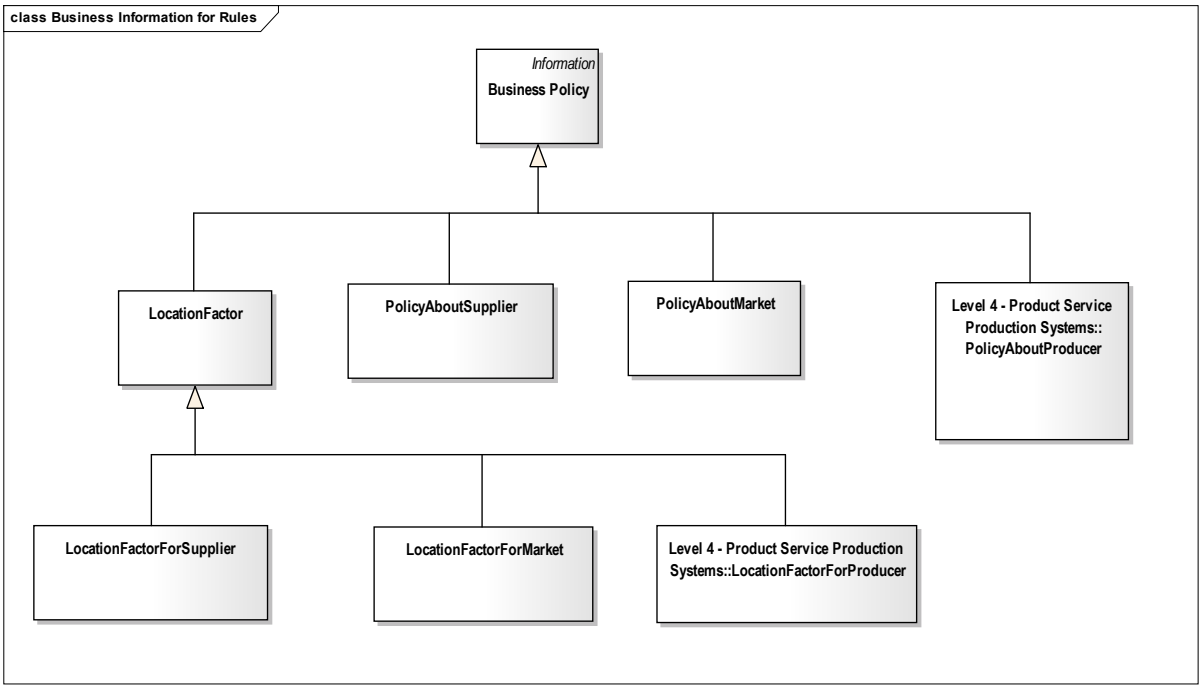


Figure 4-10: Level 2 Business Information for Rules

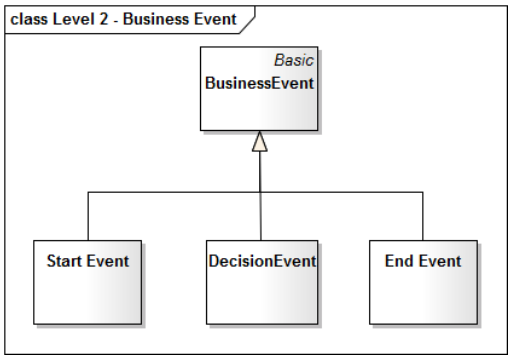


Figure 4-11: Level 2 Business Event Properties

The properties for Business Event are portrayed in Figure 4-11. They are "Business Event" together with "Start Event", "Decision Event" and "End Event" that are types of "Business Event". "Business Event" pertains to events that take place in the course of normal operation for a business that reoccur as business processes are executed. A "Start Event" is an event that initiates a process, a "Decision Event" is an event where decisions are made, and an "End Event" is an event that ends a process.

4.5.2 Business Model Related Axioms

The following are the axioms that concern Business Models at level 2:

1. Axiom - The Strategic Value is a score within the values of 0 and 1000 (IC Hard).

```
(=>  (strategicValuehasValue ?var1 (fuzzyValTripleFN ?l ?m ?h))
        (and(lteNum ?m 1000)
           (gteNum ?m 0))
```

2. Axiom - For a Strategic Value it is prohibited that the sum of the contained Balanced Scorecard View weightings exceed 100% (IC Hard).
3. Axiom - For a Balanced Score Card view it is prohibited that the sum of the contained KPIs weightings exceed 100% (IC Hard).
4. Axiom - For a Key Performance Indicator it is prohibited that the sum of the contained PIs weightings exceed 100% (IC Hard).
5. Axiom - A Business Policy has one Threshold Value for an Indicator (IC Hard).
6. Axiom - A Business Policy has at most one Preferred Threshold Value for an Indicator (IC Hard).
7. Axiom - For a given Type of Internal factor a facility has at most one internal factor instance (IC Hard).
8. Axiom - For a given Type of External factor a location has at most one external factor instance (IC Hard).

4.5.3 Business Model Rules

The following are the rules that concern Business Models at level 2:

1. Rule - If a facility is located in a country which is a mismatching supplier Location for company Specifying then the facility is a mismatching supplier for company Specifying.

```
(=>
        (and (systemLocatedAt ?potentialSupplier ?co-ord ?area ?locationofCountry)
            (hasMisMatchingSupplierLocation ?companySpecifying ?locationofCountry)
        )
        (hasMisMatchingSupplier ?companySpecifying ?potentialSupplier)
)
```

2. Rule - If a company Specifying has a business policy which has an indicator of type with a value which has a UNARY function unitType and an location has an instance of this type of external factor with a value which has a UNARY unitType NOT the same as unitType (i.e. the unitTypes don't match) then the location is a MisMatching Supplier Location for company Specifying.
3. Rule - If company Specifying has a business policy which has an indicator of type indicator type with a value which has a TERNARY function unitType and an location has an instance of this type of external factor with a value which has a TERNARY unitType NOT the same as unitType (i.e.

the unitTypes don't match) then the location is an MisMatching Supplier Location for company Specifying.

4. Rule - If company Specifying has a business policy which has an indicator of type indicator type with a value which has a TERNARY function unitType and a location has an instance of this type of external factor with a value which has a UNARY function unitType (i.e. the unitTypes don't match) then the location is an MisMatching Supplier Location for company Specifying.
5. Rule - "If company Specifying has a business policy which has an indicator of type indicator type with a value which has a UNARY function unitType and a location has an instance of this type of external factor with a value which has a TERNARY function unitType (i.e. the unitTypes don't match) then the location is an MisMatching Supplier Location for company Specifying.
6. Rule - "If a location has an instance of external factor IntervalScale and company Specifying has a business policy which has an indicator of this type, the units of the external factor value and the business policy indicator value are equal and the LOWER Scale value of the external factor interval scale is not equal to the LOWER Scale value of the business policy interval scale then the location is an MisMatching Supplier Location for company Specifying (i.e. both values must use the same scale range).
7. Rule - "If a location has an instance of external factor Interval Scale and company Specifying has a business policy which has an indicator of this type, the units of the external factor value and the business policy indicator value are equal and the UPPER Scale value of the external factor interval scale is not equal to the
8. the UPPER Scale value of the business policy interval scale then the location is a MisMatching Supplier Location for company Specifying (i.e. both values must use the same scale range).
9. Rule - If a location has an external factor which is less than the minimum threshold value specified by the company Specifying for this type of external factor then the location is a misMatching Supplier location for company Specifying. Units of metrics are of same UNARY type
10. Rule - If a location has an external factor which is NOT less than/equal to the maximum threshold value specified by the company Specifying for this type of external factor then the location is an MisMatching Supplier location for company Specifying. Units of metrics are of same UNARY type"
11. Rule - If a location has an external factor which is less than the minimum to the maximum threshold value specified by the company Specifying for this type of external factor then the location is an MisMatching Supplier location for company Specifying. Units of metrics are assumed to be of same TERNARY type
12. Rule - If a location has an external factor which is NOT less than/equal minimum to the maximum threshold value specified by the company Specifying for this type of external factor then the location is an MisMatching Supplier location for company Specifying. Units of metrics are of same TERNARY type.
13. Rule - If there is a Location Supplier factor which has a location factor and a country doesn't have a value for this external factor then the country is a MisMatching Supplier Location. I.e. if company specifying specifies a location factor for a Supplier location which is not a member of the list of external factors for a country then this country is a mismatching supplier Location for company Specifying.
14. Rule - If a country for a potential supplier is not mismatching for company Specifying (a member of the list of mismatching Supplier Locations) then it is matching supplier Location.

15. Rule - If an organisation is located in a country which is an undesired supplier Location for company Specifying then the organisation is an undesired supplier for company Specifying.
16. Rule - If a location has an external factor which is less than the minimum threshold value specified by the company Specifying for this type of external factor then the location is an UnDesired Supplier location for company Specifying. Units of metrics are assumed to be of same type.
17. Rule - If a location has an external factor which is NOT less than/equal to the maximum threshold value specified by the company Specifying for this type of external factor then the location is an UnDesired Supplier location for company Specifying. Units of metrics are assumed to be of same type.
18. Rule - If there is a Location Supplier factor which has a location factor and a country doesn't have a value for this external factor then the country is an UnDesired Supplier Location. I.e. if company specifying specifies a location factor for a Preferred Supplier location which is not a member of the list of external factors for a country then this country is an UnDesired supplier Location for company Specifying.
19. Rule - If a country for a potential supplier is not unDesired for company Specifying (a member of the list of UnDesired Supplier Locations) and is matching then it is Desired.

4.6 Indicators

4.6.1 Indicator Properties and Relationships

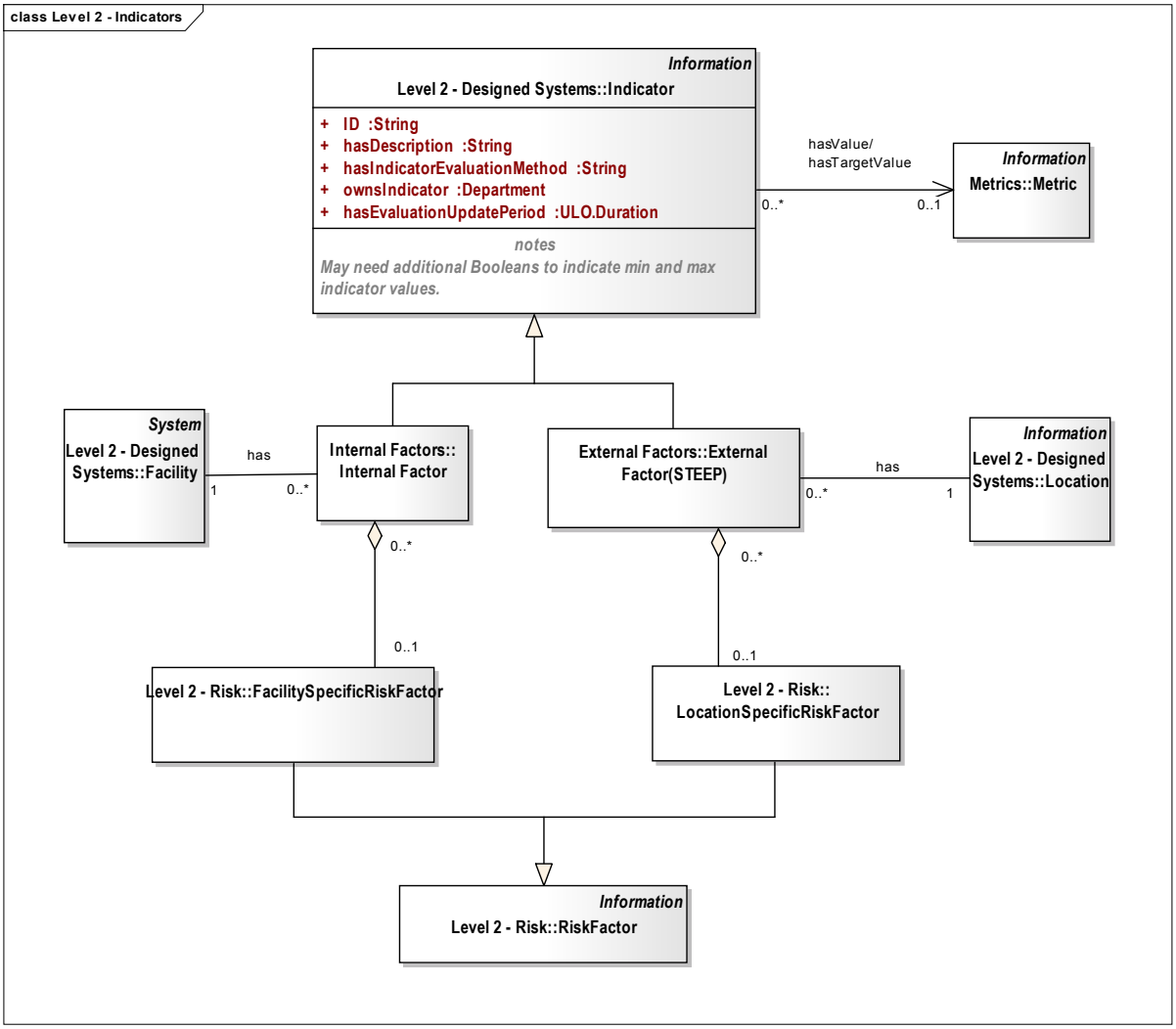


Figure 4-12: Level 2 Indicator Properties

The Indicator properties at Level 2 follow the input from WP1, WP2 and WP4 and are illustrated within Figure 4-12. These are composed of "Indicator", "Metric", "Risk Factor", "External Factor", "Location", "Location Specific Risk Factor", "Internal Factor", "Facility" and "Facility Specific Risk Factor". An "Indicator" is defined as something that influences actors in global production networks. "Metric" is a system or standard of measurement, a criterion or set of criteria stated in quantifiable or qualitative terms. "Risk Factor" is encompassed by an internal or external factor that may influence a Global Production Network adversely. "External Factor" is a STEEP factor. "Location" is as described in section 4.1. "Location Specific Risk Factor" is a risk factor that is specific to a location. An "Internal Factor" is an inner strength or weakness that an organization exhibits. "Facility" is defined as 'a permanent, semi-permanent, or temporary commercial or industrial property such as a building, plant, or structure, built, established, or installed for the performance of one or more specific activities or functions'. "Facility Specific Risk Factor" is a risk factor that is specific to a "Facility".

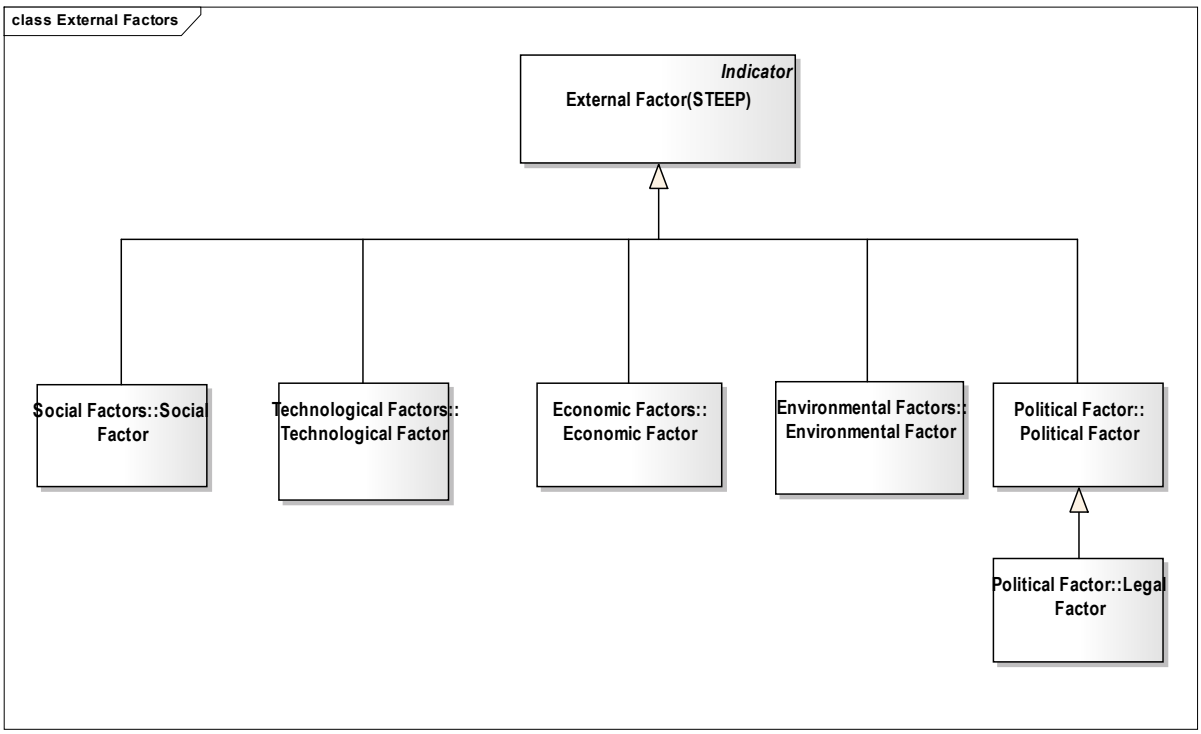


Figure 4-13: Level 2 External Factors properties

The External Factors as shown in Figure 4-13, are broken down into the following properties, "Social Factor", "Technological Factor", "Economic Factor", "Environmental Factor", "Political Factor" and "Legal Factor". "Social Factor" can determine the cultural dimension which includes aspects like health consciousness, population growth rate, age distribution (demographics), career attitudes and safety. They influence a company's products and services and particularly how a company operates. A "Technological Factor" is related to R&D activities, automation and technology incentives. An "Economic Factor" can have a major impact on a company's business operations and decision-making. An "Environmental Factor" is concerned with the general environment like weather, climate and climate change. A "Political Factor" identifies to what degree a government intervenes in the economy. Also, political factors determine health, education and infrastructure of a nation to a certain extent. A "Legal Factor" is concerned with the legal environment of an actor in a market.

The types of "Economic Factors" are shown in Figure 4-14 are drawn from D2.3. These relate to "Industrial Gas Prices", "Industrial Electricity Prices", "Deposit Interest Rate", "Lending Interest Rate", "GDP Growth", "Real Interest Rate", "Foreign Direct Investment", "GDP", "Household final consumption expenditure per capita growth", "Cost to Export", "Cost to Import", "Pump Price for Diesel Fuel", "Pump Price for Gasoline", "Consumer Price Index", "Export of Goods & Services", "Import of Goods", "Economic Sanctions", "Industry Value Added", "Services Value Added", "Listed Domestic Companies", "Inflation Rate", "Currency Risk" and "Recession".

Figure 4-15 provides the types of "Environmental Factors" that are identified in D2.3, those being "CO2 Emissions", "Other Greenhouse Gases", "Nitrous Oxide Emissions", "Alternative and Nuclear Energy", "Railway Goods Transported" and "Airtransport Freight".

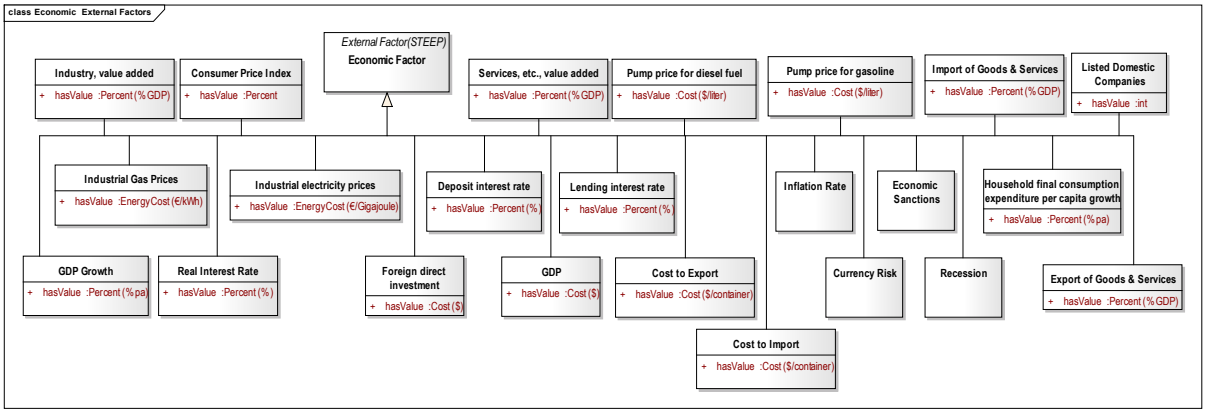


Figure 4-14: Level 2 Economic Factor Properties

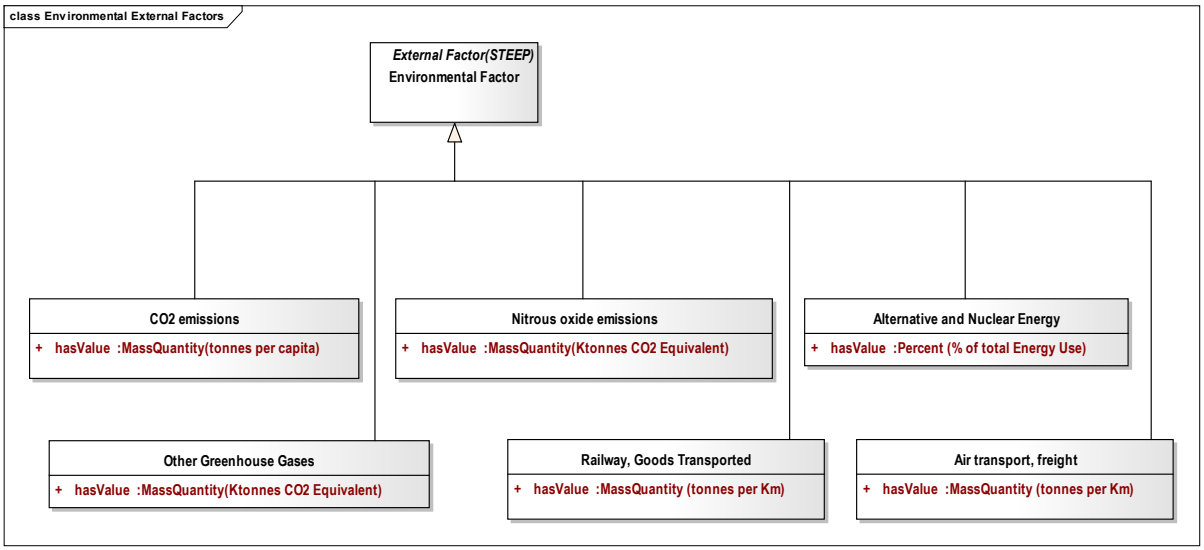


Figure 4-15: Level 2 Environmental Factor Properties

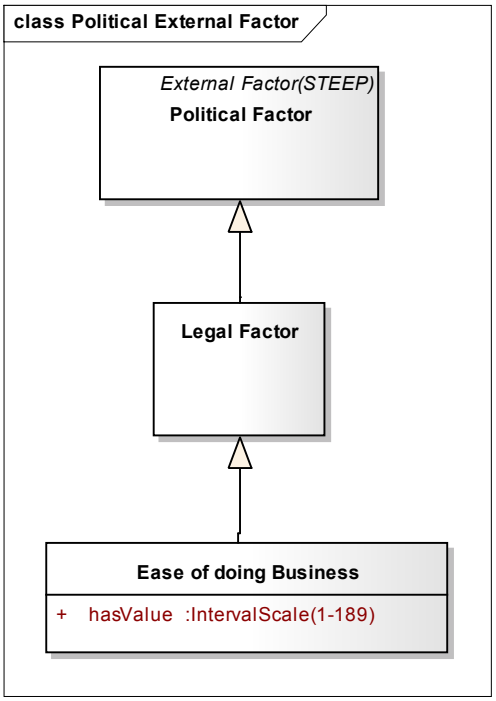


Figure 4-16: Level 2 Political Factor Properties

Figure 4-16 shows the "Political Factor" properties, illustrating that "Ease of Doing Business" is a type of "Legal Factor", which is a type of "Political Factor". It is defined as 'business ranks economies from 1 to 189, with first place being the best. A high ranking (a low numerical rank) means that the regulatory environment is conducive to business operation. The index averages the country's percentile rankings on 10 topics covered in the World Bank's Doing Business. The ranking on each topic is the simple average of the percentile rankings on its component indicators'.

Figure 4-17 presents the "Social Factor" properties. These comprise of the following, "Literacy Rate Adult Total", "CPIA transparency accountability and corruption in the public sector rating", "Labour Force with Primary Education", "Population Aged 0-14", "Female Children In Employment", "Literacy Rate Youth Total", "Access to Electricity", Labour Force with Secondary Education", "Population Aged 15-64", "Male Children In Employment", "Access to Non-Solid Fuel", "Labour Force with Tertiary Education", "Strike", "Industrial Dispute" and "Technicians in R&D".

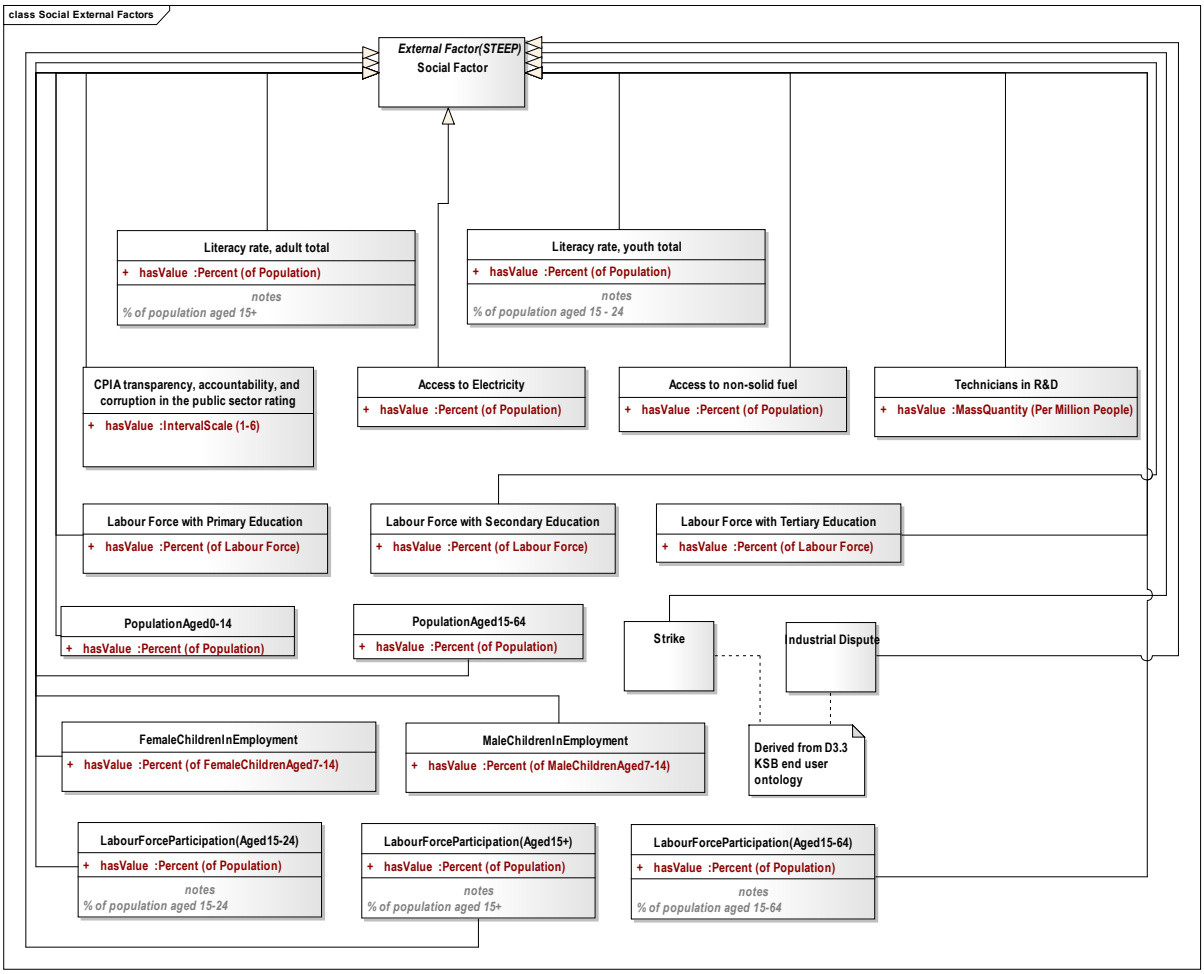


Figure 4-17: Level 2 Social Factor Properties

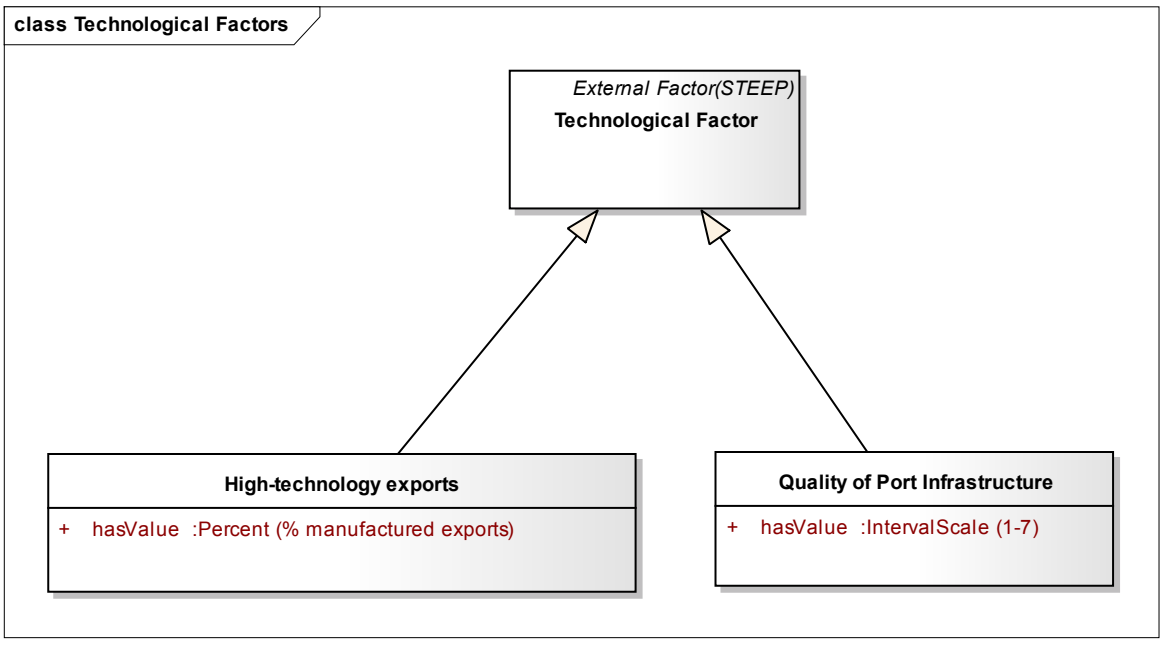


Figure 4-18: Level 2 Technological Factor Properties

The "Technological Factors" diagram in shown in Figure 4-18, it shows that "High Technology Exports" and "Quality of Port Infrastructure" are types of "Technological Factor".

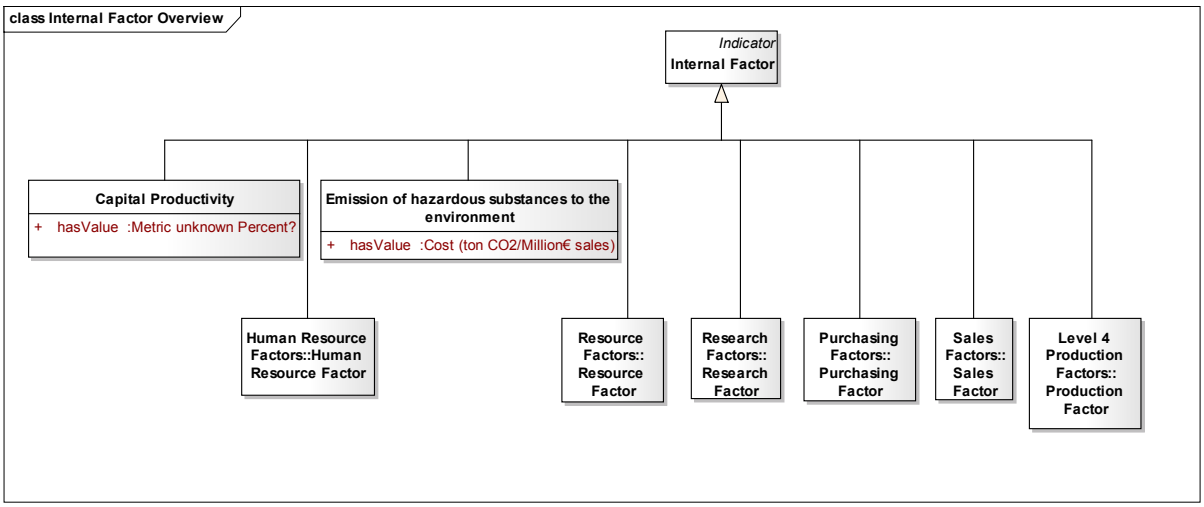


Figure 4-19: Level 2 Internal Factor Properties

An overview of "Internal Factors" is set out in Figure 4-19 drawn from WP2. It shows the properties that are types of "Internal Factors", these are "Capital Productivity", "Human Resource Factor", "Emission of Hazardous Substances to the Environment", "Resource Factor", "Research Factor", "Purchasing Factor", "Sales Factor" and "Production Factor". "Capital Productivity" is the productivity of factors of production that are used to create goods or services and are not themselves in the process. "Human Resource Factor" represents the factors relating the resource that resides in the knowledge, skills, and motivation of people (see Figure 4-20). "Emission of Hazardous Substances to the Environment" represents aspects such as carbon dioxide and other associated substances that can harm the environment. "Resource Factor" (see Figure 4-20) relates to resources that apply to systems and processes for example, Efficiency of Information Systems (see Figure 4-20). "Research Factor" (see Figure 4-20) characterises aspects that influence research, such as Number of Registered Patents and Expenses for Research and Innovation. "Purchasing Factor" (see Figure 4-23) has one type of property, that of Supplier On-Time Delivery Performance. "Sales Factor" has numerous types of properties for example Market Share, Ratio of Sales and Trademark Index (see Figure 4-23). "Production Factor" represents those factors that relate to production.

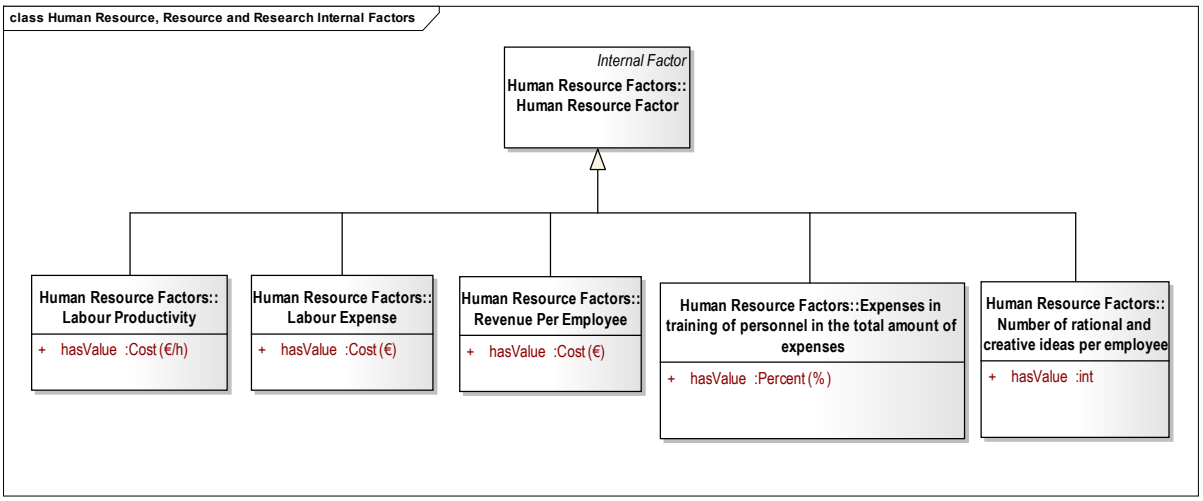


Figure 4-20: Level 2 Human Resource Factor Properties

Figure 4-20 sets out the "Human Resource Factor" properties. These are "Productivity", "Labour Expense", "Revenue Per Employee", "Expenses in training of personnel in the total amount of expenses" and "Number of rational and creative ideas per employee".

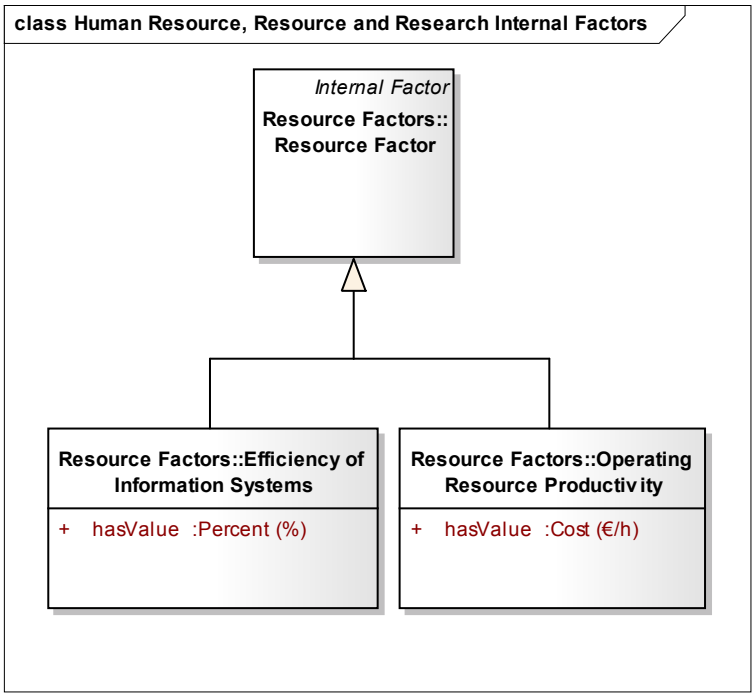


Figure 4-21: Level 2 Resource Factor Properties

Figure 4-21 sets out the "Resource Factor" properties. These are "Efficiency of Information Systems", "Labour Expense" and "Operating Resource Productivity".

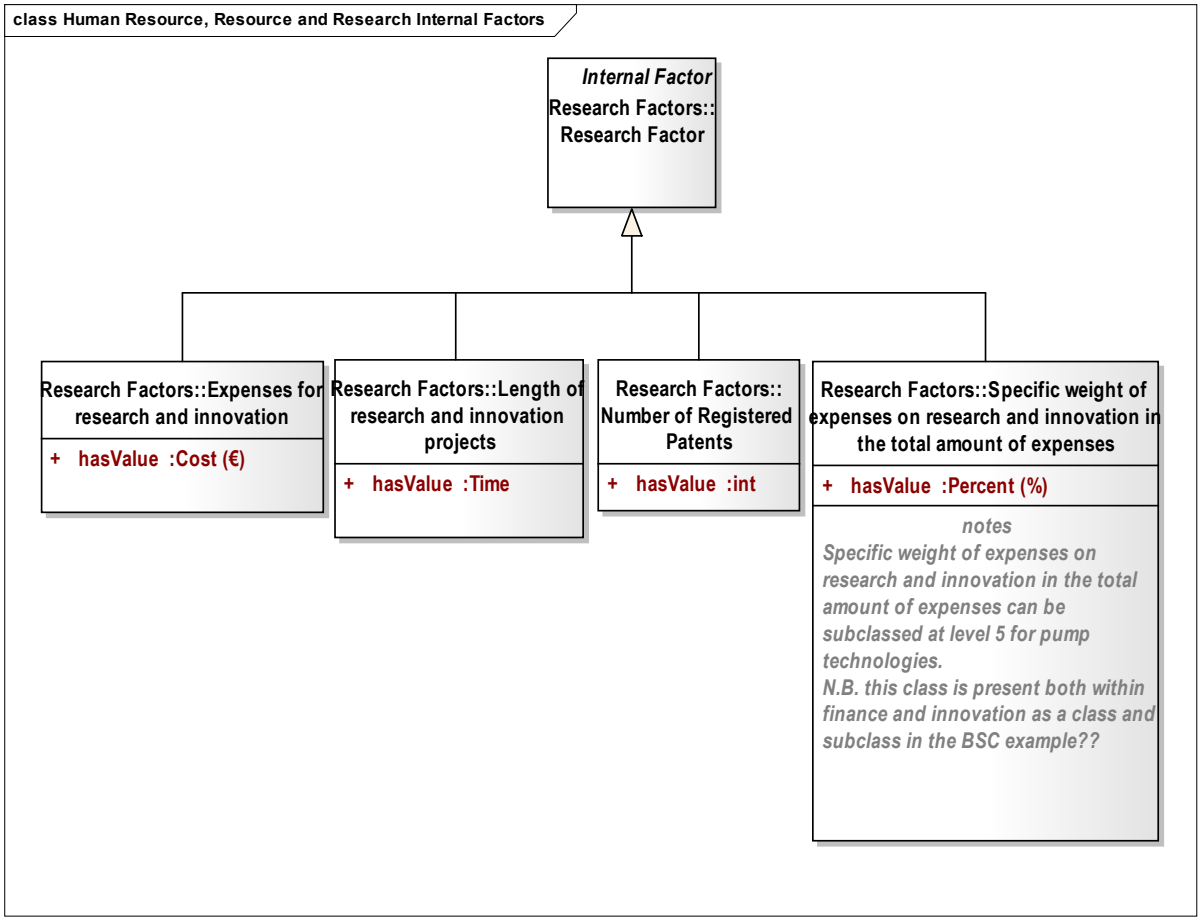


Figure 4-22: Research Factor Properties

Figure 4-22 sets out the "Research Factor" properties. These are "Expenses for research and innovation", "Length of research and innovation projects", "Number of Registered Patents" and "Specific weight of expenses on research and innovation in the total amount of expenses".

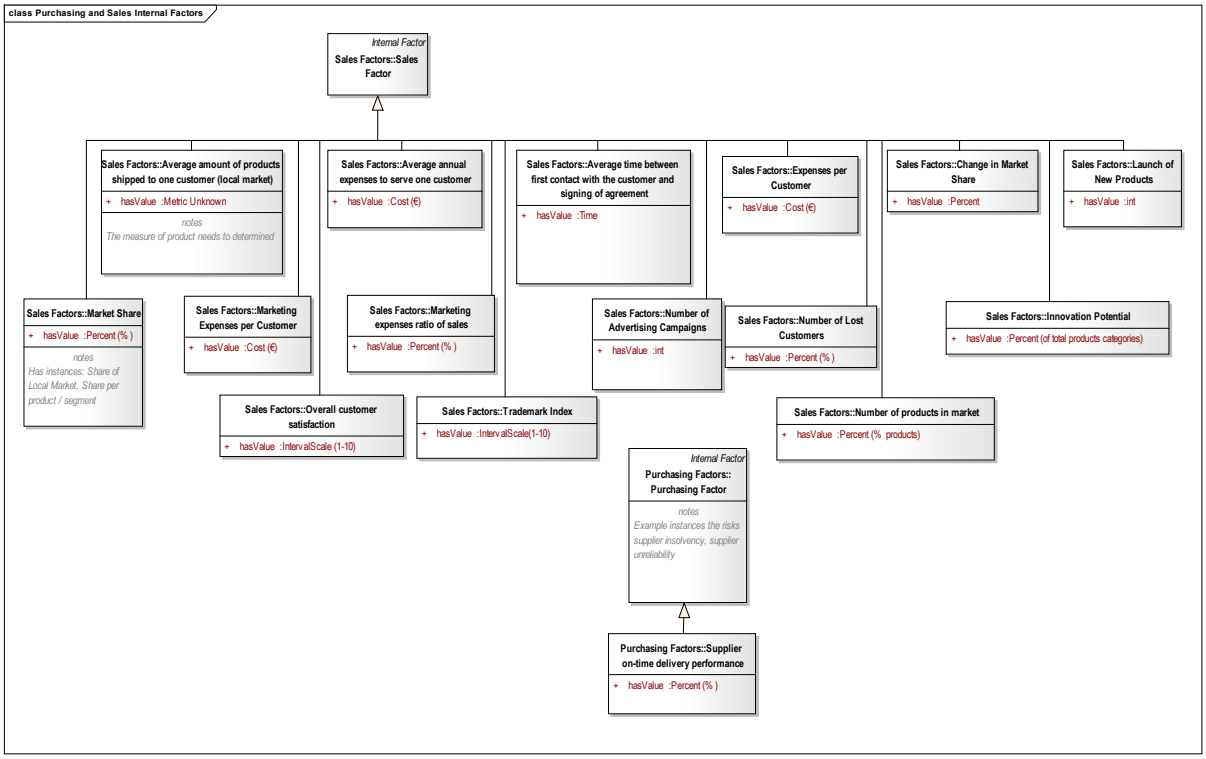


Figure 4-23: Level 2 Purchasing and Sales Factor Properties

Figure 4-23 presents the Level 2 "Purchasing and Sales Factor" properties. The "Sales Factors" are "Average amount of products shipped to one customer local market", "Average annual expenses to serve one customer", "Average time between first contact with the customer and signing of agreement", "Expenses per Customer", "Change in Market Share", "Launch of New Products", "Market Share", "Marketing Expenses per Customer", "Overall customer satisfaction", "Marketing expenses ratio of sales", "Trademark Index", "Number of Advertising Campaigns", "Number of Lost Customers", "Number of products in market" and "Innovation Potential". The "Purchasing Factor" is "Supplier on-time delivery performance".

4.7 Risk

4.7.1 Risk Properties and Relationships

Figure 4-24 exhibits the properties that relate to risk utilising the work within WP2. These are "Fuzzy Measure", "Risk Factor", "Incident", "Facility Specific Risk Factor", "Location Specific Risk Factor" and "Resilience". "Fuzzy Measure" is defined as a special type of fuzzy set that represents a vague number. "Risk Factor" is encompassed by an internal or external factor that may influence a Global Production Network adversely, accordingly, "Facility Specific Risk Factor" and "Location Specific Risk Factor" are all specialisations of "Risk Factor" as per their namesakes. "Incident" is a specialisation of Event from the Highfleet Middle Level Ontology (MLO), whilst "Resilience" is defined as the ability of a Global Production network node to react to the disruptive event and its agility to compensate for inoperability that has arisen.

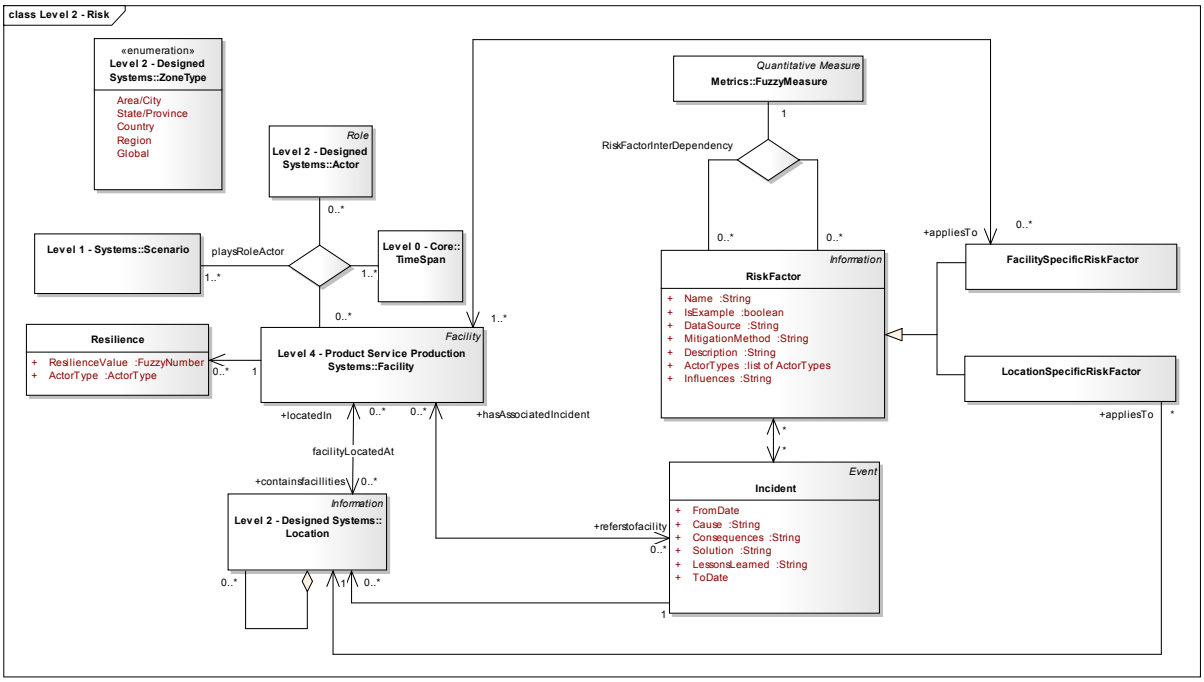


Figure 4-24: Level 2 Risk Properties

4.7.2 Risk Related Axioms

The following is the axiom that concerns Risk at Level 2:

1. Axiom - An actor must not depend on itself (IC Hard).

```
(=> (actorInterDependencyOnActor ?actor1  ?interdependency ?actor2)
        (/= ?actor1 ?actor2)
```

4.8 Metrics

4.8.1 Metrics Properties and Relationships

Metrics represents measure within the ontology. Figure 4-25 lays out the properties that are types of "Quantitative Measure" and "Qualitative Measure" which follow the work developed in D2.2, D2.3 and WP4. The types of property that relate to "Quantitative Measure" are "Distance", "Cost", "Energy Cost", "Time", "Percent", "Fuzzy Error", "Fuzzy Measure", "Interval Scale", "Mass Quantity" and "Energy Quantity". "Distance" is the amount of space between two things. "Cost" is usually a monetary valuation of effort, material, resources, time and utilities consumed, risks incurred, and opportunity forgone in production and delivery of a product or service. "Energy Cost" is the cost of energy. "Time" is a quantity measuring duration (Collins Dictionaries). "Percent" is one part in every hundred. "Fuzzy Error" consists of a fuzzy set plus the fuzzy weightings applied. "Fuzzy Measure" is a special type of fuzzy set that represents a vague number. "Interval Scale" relates to numerical scales, i.e. one to ten, one to one hundred, etc. "Mass Quantity" is the amount of matter in any solid object or in any volume of liquid or gas and "Energy Quantity" is a measure of Energy. "Qualitative Measure" relates to measures that are not quantitative.

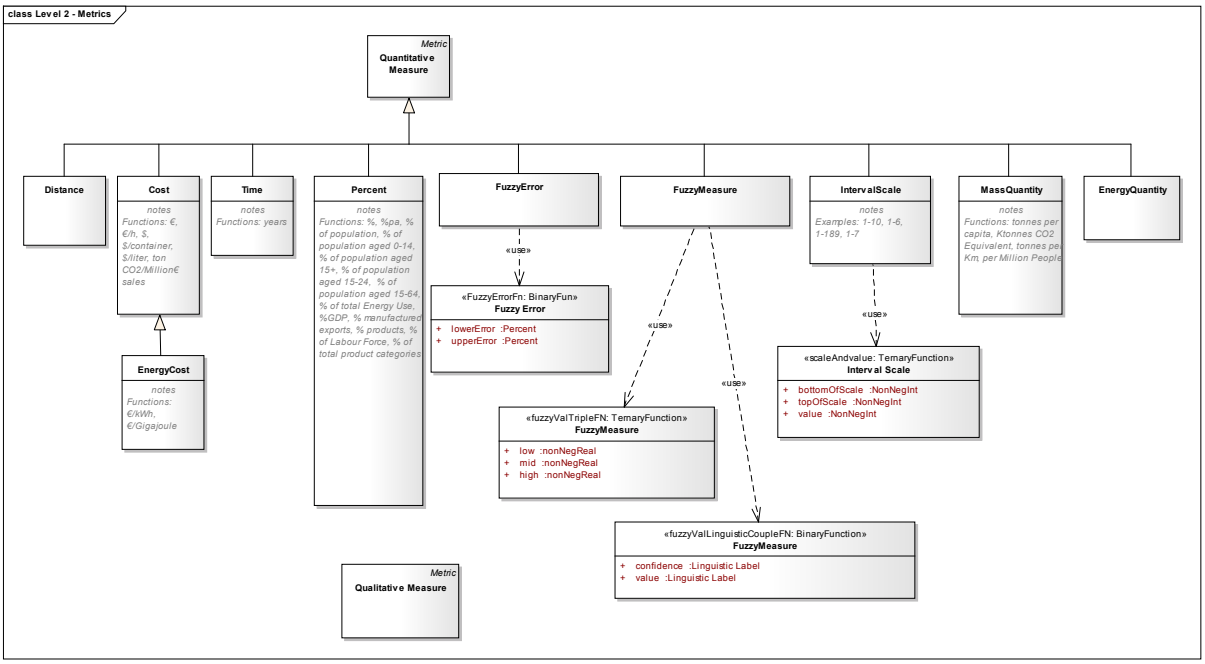


Figure 4-25: Level 2 Metrics Properties

4.8.2 Metric Related Axioms

The following are the axioms that concern Metrics at level 2:

1. Axiom - In relation ?relation ?var1 has a Fuzzy value. In a Fuzzy value triple ?l must be <= ?m must be <= ?h (IC Hard).

```
(=>
        (?relation ?var1 (fuzzyValTripleFN ?l ?m ?h))
        (and (lteNum ?l ?m)
                (lteNum ?m ?h)))
```

2. Axiom – In relation a Fuzzy value exists between ?var1 and ?var2. In a Fuzzy value triple ?l must be <= ?m must be <= ?h (IC Hard).
3. Axiom - Relation ?relation ?var1 has an IntervalScale value. Value ?value must be within the interval [?bottom , ?top] (IC Hard).

4.9 Product

4.9.1 Product Properties and Relationships

Figure 4-26 sets out the UML model view upon a product and its definition. FLEXINET seeks to model just the key concepts and relationships that are significant to advancing the FLEXINET Knowledge Base. It is not intended to fully model the concept of product per se. With regards to the concept

"Product", for FLEXINET's purposes there are two types, (i) a physical product and (ii) a service product.

The model is composed of "Product", "Physical Product", "Service Product", "Service Using Product", "Product Service", "Manufactured Product" (represented at Level 4), "Bill of Material" (represented at Level 4), "Prototype" and "Manufactured Product Service" (again represented at Level 4). A "Product" is defined as 'a process output'. A "Physical Product" is 'a material artefact', e.g. car, boat, plane (Baines et al., 2009). A "Service Product" refers to 'an offering', e.g. maintenance, repair, insurance (Baines et al., 2009). A "Service Using a Product" is 'an offering that employs a product'. A "Product Service" is 'an integrated product and service offering that delivers value in use' (Annamalai et al., 2011). A "Manufactured Product" is a product that exploits/consumes a raw material. A Bill of Material is a list of all raw materials, parts, intermediates, subassemblies, etc. required to complete an order, and a Prototype is a pre-production model of a product, engineered for full service test. A Manufactured Product Service is a specialisation of Product Service within the Level 4 Product Service Production domain.

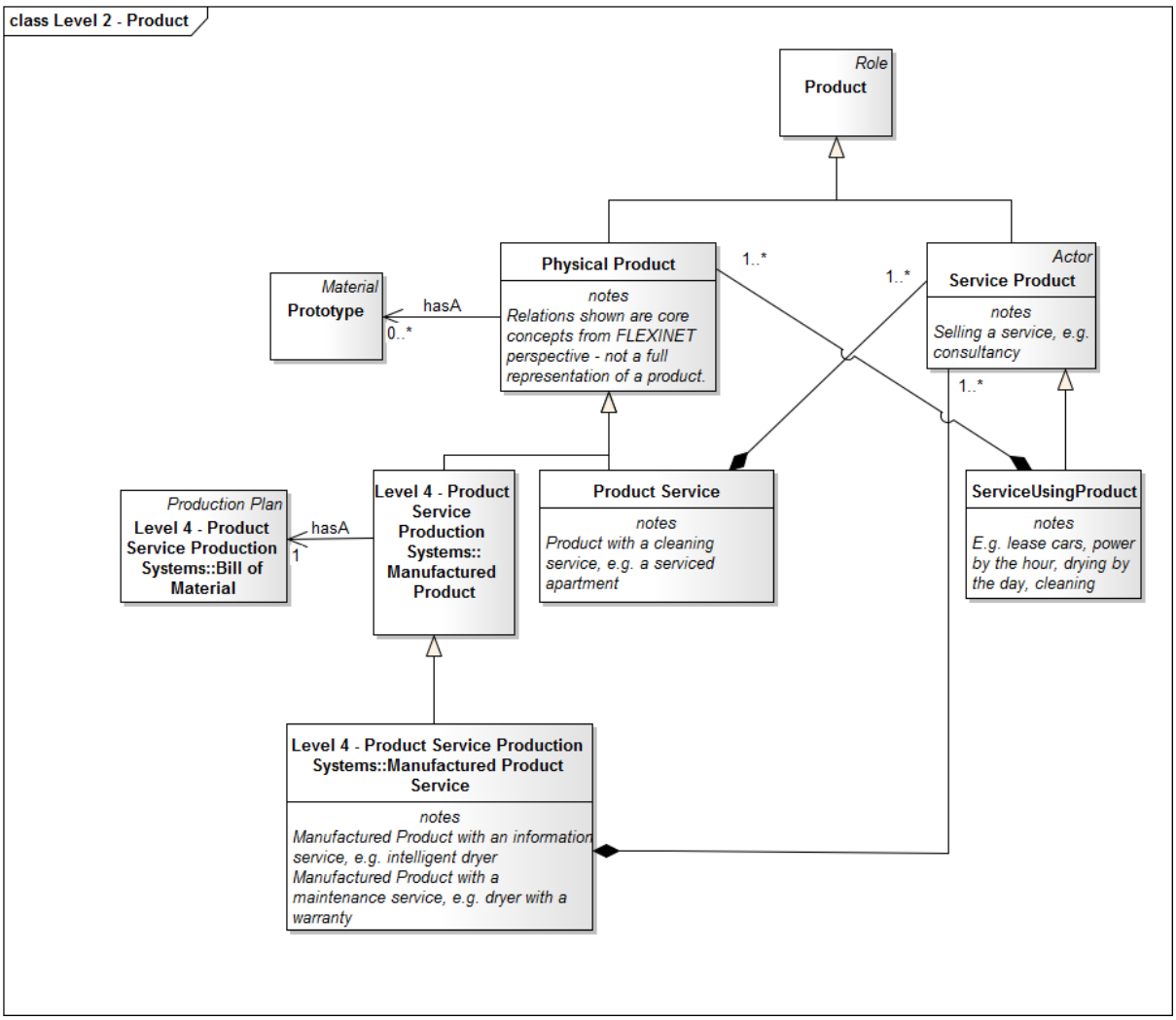


Figure 4-26: Level 2 and Level 4 Product Properties

The properties for Idea that exist at Level 2 for "Idea" (see Figure 4-27) are the following, "Owner", "Contributor", "Stakeholder", "Benefit", "Idea", "Identifier", "Concept", "Product", "Requirements", "Evaluation Scheme", "Demand Identification", "Feasibility Study", "Concept Development", "Ideation", "Product Configuration", "Testing", "Realisation", "Product Life-Cycle" and "Maintenance". "Idea" is defined as 'a thought or collection of thoughts that generate in the mind'.

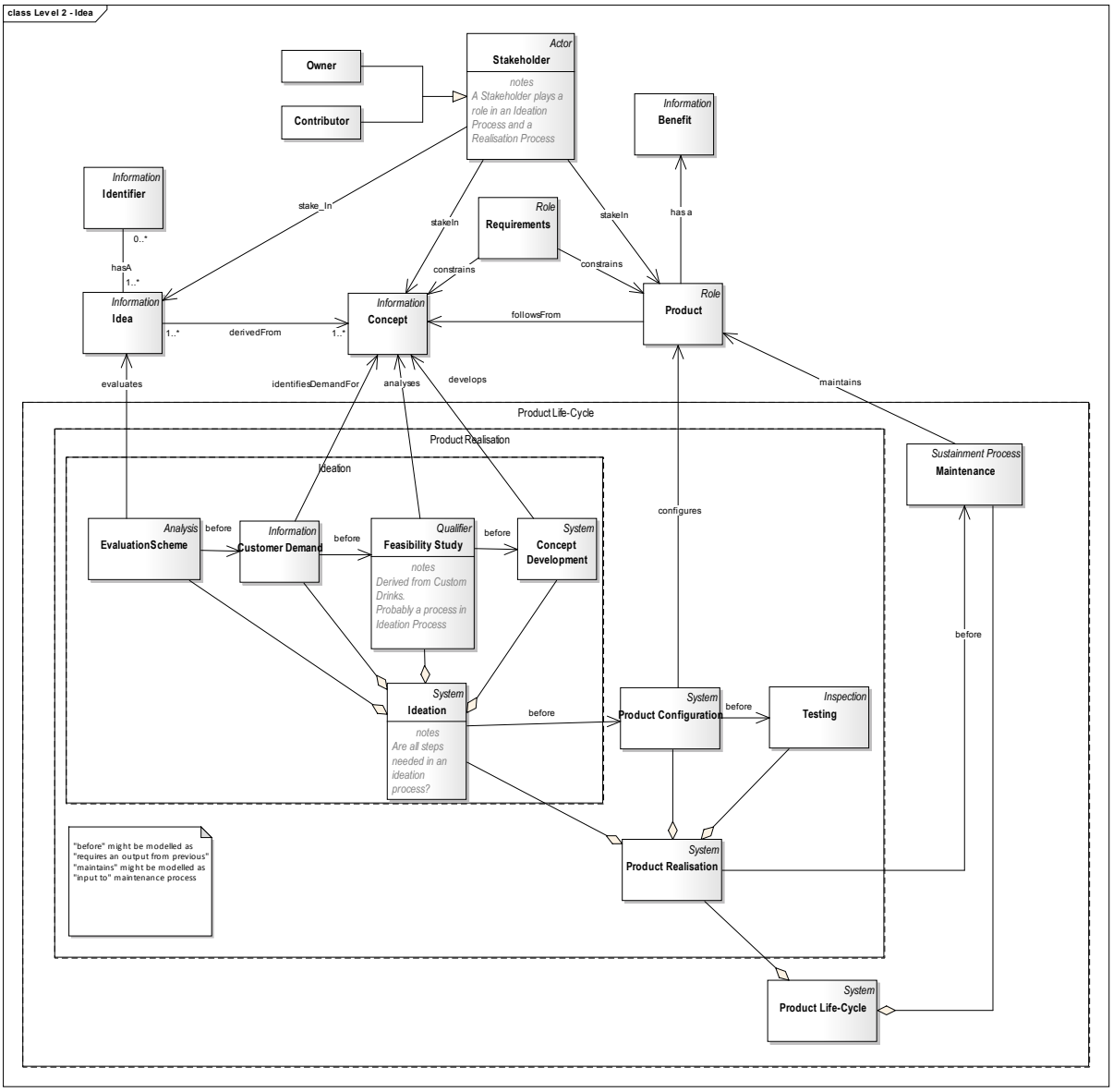


Figure 4-27: Level 2 Idea Properties

A "Stakeholder" is a person, group or organisation that has interest or concern in an organisation. An "Owner" and "Contributor" are types of "Stakeholder". An "Owner" is an employee or executive who has the principle responsibility for a process, program, or project. A "Contributor" is a person who contributes to the ideation process (Collins). "Benefit" is the desirable attribute(s) of a good or service, which a customer perceives he or she will get from purchasing. "Idea" pertains to a thought or collection of thoughts that generate in the mind. An "Idea" is usually generated with intent, but

can also be created unintentionally. "Identifier" is information that establishes the identity of something. "Concept" is a clear, detailed description of the attributes and benefits of a new product that addresses the needs of the targeted customers, and "Product" (as per section 4.10) is defined as a process output. "Requirements" are constraints, demands, necessities, needs, or parameters that must be met or satisfied, usually within a certain timeframe. An "Evaluation Scheme" is defined as a broad picture of how to an objective could be evaluated and achieved but not a detailed and formalised plan. "Demand Identification" is the identification of the desire for certain good or service supported by the capacity to purchase it. "Feasibility Study" is an analysis and evaluation of a proposed project to determine if it is (i) technically feasible, (ii) feasible within the estimated cost, and (iii) will be profitable. "Concept Development" is the process for development of a concept. "Ideation" is the process of forming, imagining or conceiving of an idea (derived from Collins). A "Product Configuration" is the physical layout, interconnections, and functional characteristics of a product, set forth in its technical documentation as required for its assembly, testing, installation, operation, and maintenance (derived from BusinessDictionary.com). "Testing" is the means by which the capability of a manufactured item to meet its specified requirements is determined and documented by subjecting the item to a set of operating conditions. "Realisation" is the process of bringing to fruition; making actual or concrete an idea or concept (derived from Collins)." Product Life-Cycle" describes the four distinct but not wholly-predictable stages every product goes through from its introduction to withdrawal from the market: (i) introduction, (ii) growth in sales revenue, (iii) maturity, during which sales revenue stabilizes, and (iv) decline, when sales revenue starts to fall and eventually vanishes or becomes too little to be viable. Finally, "Maintenance" relates to the actions necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable condition to achieve its maximum useful life.

4.10 Project

4.10.1 Project Properties and Relationships

As illustrated in Figure 4-28, the concept "Project" is composed of a number of different related types of concepts, those being "Business Model", "Decision Event", "Scenario", "Concept" and "Product". "Project" is defined as a planned set of interrelated tasks to be executed over a fixed period and within certain cost and other limitations. "Business Model" is a description of means and methods a firm employs to earn the revenue projected in its plans. "Scenario" is as per the definition set out in Level 1. "Concept" is a clear, detailed description of the attributes and benefits of a new product that addresses the needs of the targeted customers, and "Product" (as per section 4.10) is defined as system output that is to be sold. The role of a product will comprise a combination of material parts and/or services.

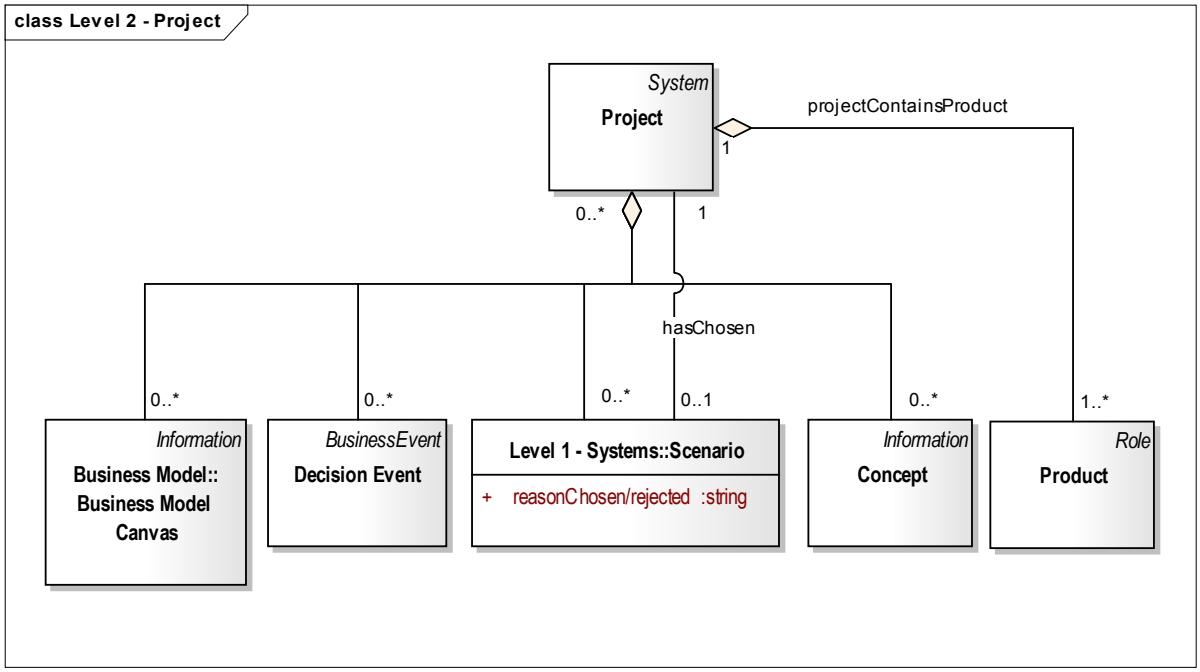


Figure 4-28: Level 2 Project Properties

5 Reference Ontology Level 3

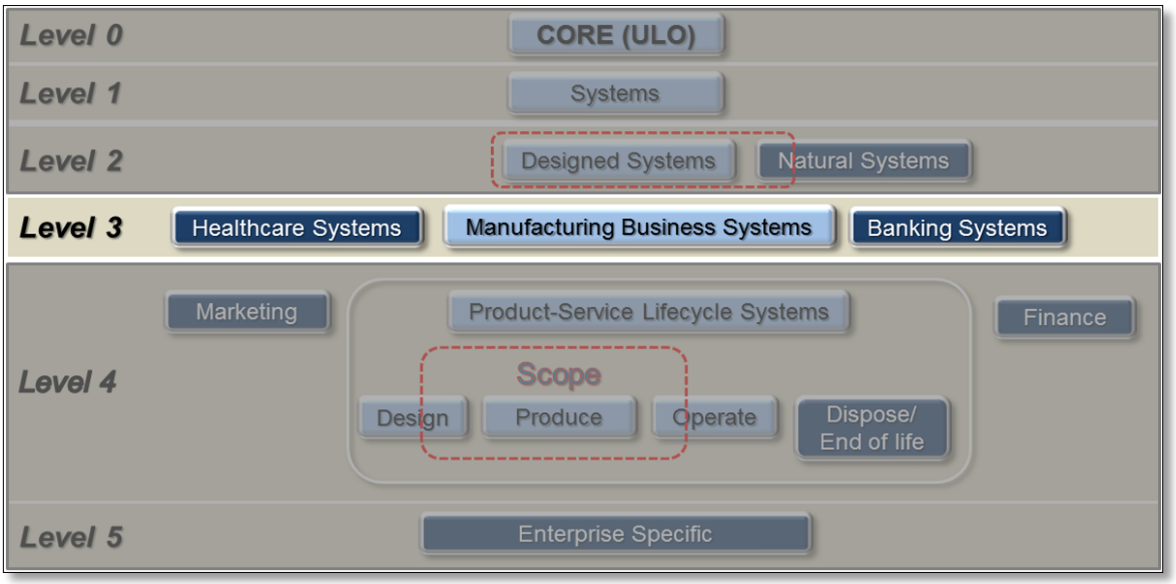


Figure 5-1: FLEXINET Reference ontology level 3

The Level 3 section of the reference ontology is different to levels 1, 2, and 4. It is the level used to define the context for the particular business specific concept specialisations that follow at level 4. For example the context specified here makes it possible to distinguish between the set of concepts related to manufacturing businesses as opposed to those used in healthcare or banking systems as illustrated in Figure 5-1. Many other business areas could also have a context included at this level such as shipping, oil and gas, retail, farming, etc., etc., etc. The sort of concepts that best illustrate the context distinction for manufacturing businesses are possibly the operational process related concepts such as machining, casting, moulding, welding, assembly and their related resources, which would not be important concepts for other areas of business.

The KFL context code that exists for Level 3 can be found in Annex C.

6 Reference Ontology Level 4

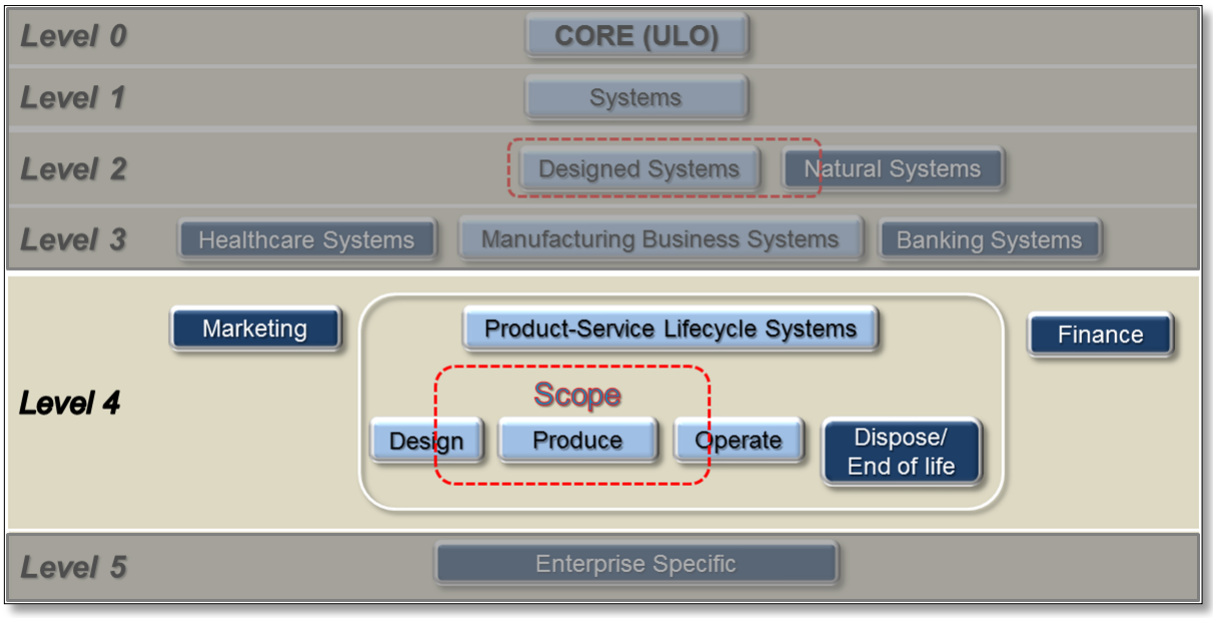


Figure 6-1: FLEXINET Reference ontology level 4

This chapter describes the final version of the Level 4 FLEXINET Reference Ontology as seen in Figure 6-1. It further specialises the ontology used to represent a manufacturing business, by progressing the definition to global production network concepts. FLEXINET considers Product-Service Lifecycle Systems, and the Global Production Networks that may be configured to produce them. The lifecycle phases are denoted as design, produce, operate and end of life (including disposal, recycling and remanufacturing). The focus of FLEXINET is how to design a GPN to produce and operate a product-service. The main area FLEXINET considers within the Product-Service Lifecycle is "Produce" (producing the product) but the scope also overlaps into "Design" (of the network) and "Operate" as the operation of the product and the service needs to be considered.

Figure 6-2 exhibits an overview of the Level 4 FLEXINET reference ontology. This shows the structure of the five groups of concepts, those being Project World, Scenario, Business, Risk, and Product. Where applicable, the axioms and rules that have been developed as part of the ontology are listed with individual examples of ECLIF code showing the logic used to describe them.

The full KFL and ECLIF code listing for Level 4 is provided within Annex C.

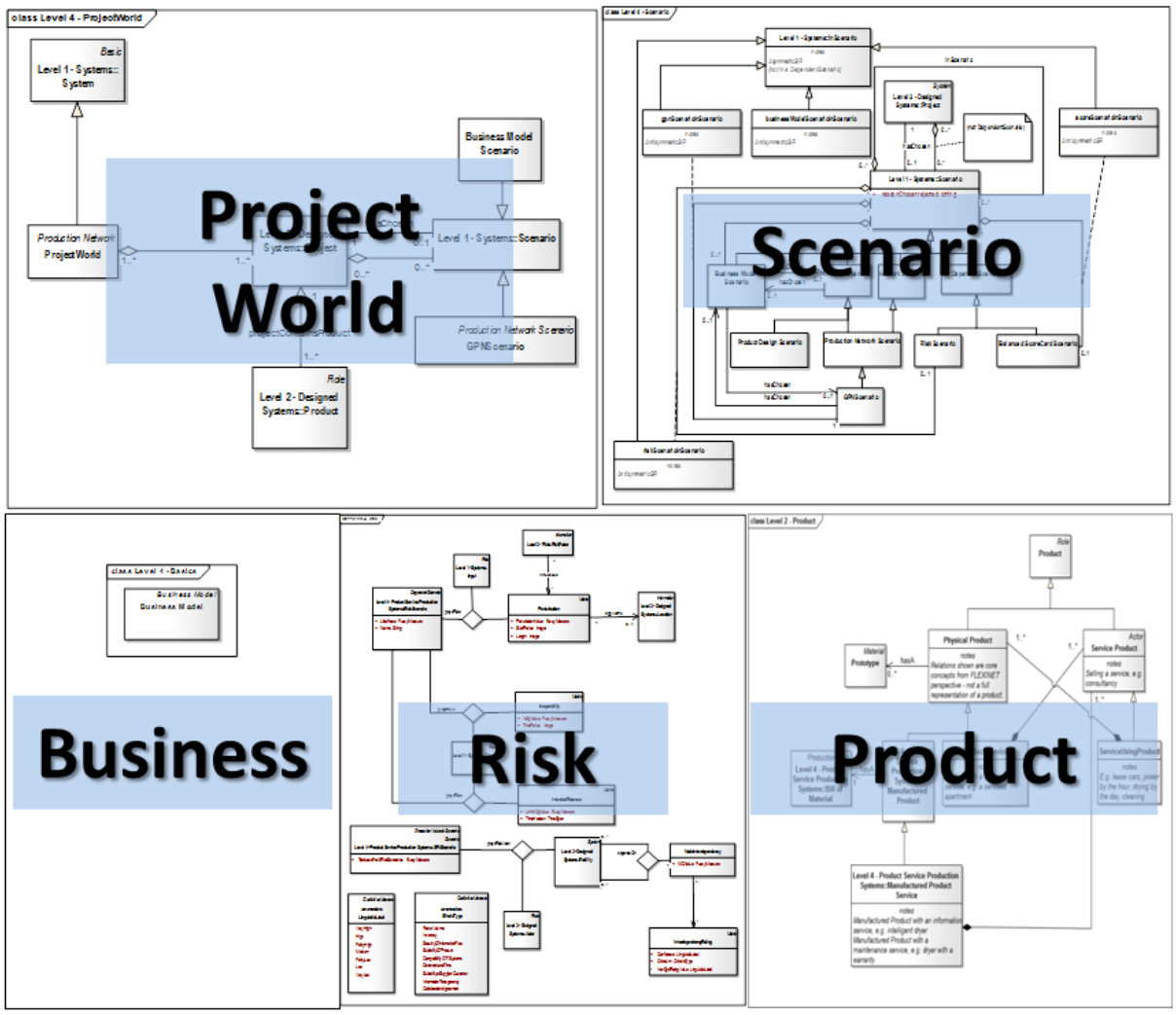


Figure 6-2: Property grouping overview of Level 4

6.1 Project World

6.1.1 Project World Properties and Relationships

The Level 4 "Project World" (see Figure 6-3) is a container for projects. It contains all of the background knowledge for ideas, facilities, parts and products so that projects can be created, built, configured and reconfigured. The properties at Level 4 are "Project World", "GPN Scenario" and "Business Model Scenario". "Project World" contains Roles played by globally dispersed Systems and identifies all the potential contributors for a particular project. "GPN Scenario" is defined as a global specialisation of a Production Network Scenario, additionally "Business Model Scenario" provides a view on a Business Model at Level 2.

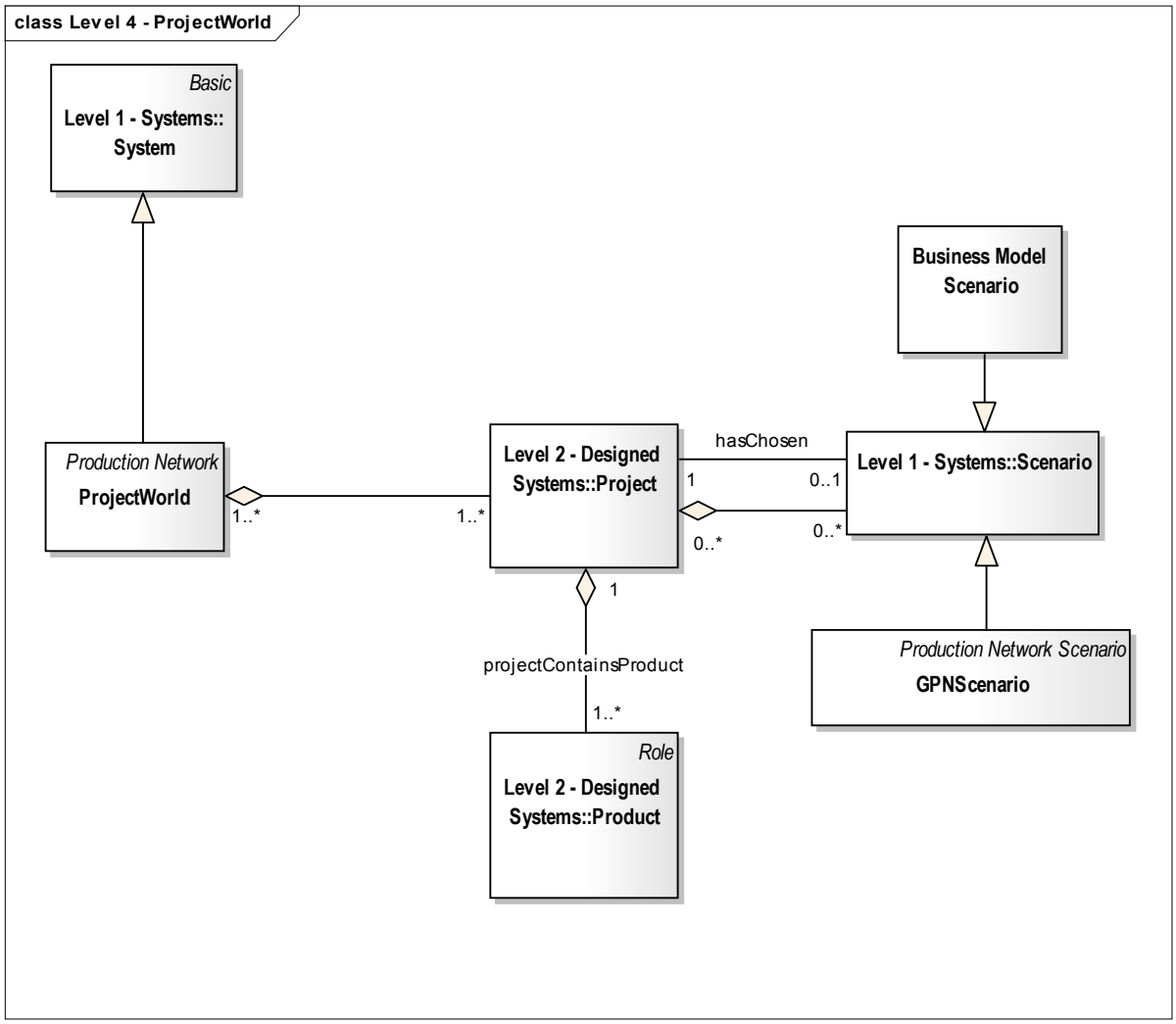


Figure 6-3: Level 4 Project World Properties

6.2 Scenario

6.2.1 Scenario Properties and Relationships

At Level 4, Scenario is specialised, those concepts that enable this are "Business Model Scenario", "Product Scenario", "Product Design Scenario", Production Network Scenario", "GPN Scenario", Network Scenario", "Dependant Scenario", "Risk Scenario" and "Balanced Scorecard Scenario". "Business Model Scenario" is described provides a view on a Business Model at level 2. A "Product Scenario" provides a view of the systems concerned with a Product. A "Product Design Scenario" is defined as a specialisation of a Product Scenario which provides a view of design aspects. A "Production Network Scenario" provides a view of production networks, inheriting from both Product and Network scenarios. A "GPN Scenario" is a global specialisation of a Production Network Scenario. A "Network Scenario" is a specialisation of a Scenario which provides a view of flows with a network. A "Dependant Scenario" is contained within another Scenario and is dependent on the structure of a GPN Scenario. A "Risk Scenario" provides a view of risk factors upon a Project World system. Finally,

a "Balanced Scorecard Scenario" provides a view of qualitative and quantitative cost factors upon a Project World system or a Business Model.

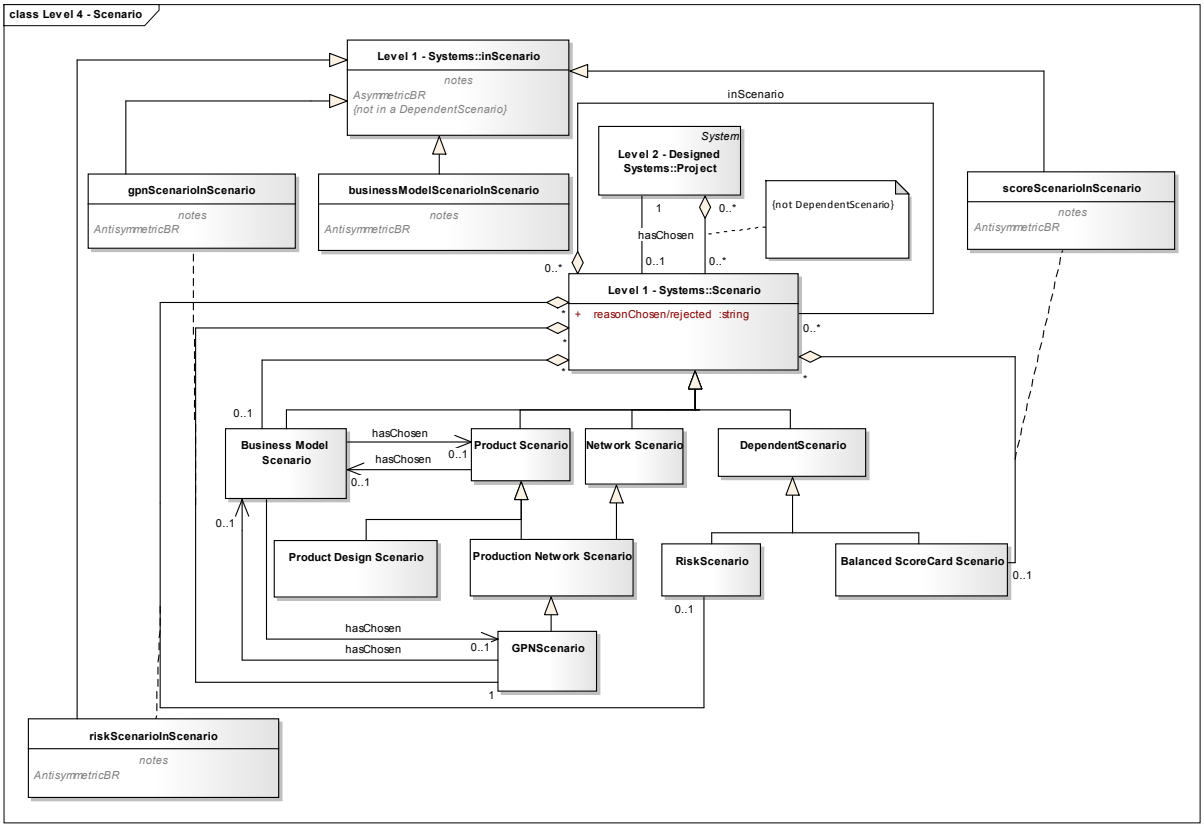


Figure 6-4: Level 4 Scenario properties

6.2.2 Scenario related Axioms

The following are the axioms that concern Scenario at level 4:

1. Axiom - A project cannot contain DependentScenarios (IC Hard).
    - **Note**: The relation projectContainsScenario does not hold between the Project ?x and the DependentScenario ?y

```
(=> (projectContainsScenario ?x ?y)
(not (DependentScenario ?y))
)
```

2. Axiom – A Scenario cannot be contained within (inScenario) a Dependent Scenario (IC Hard).
3. Axiom – A Dependent Scenario requires a GPNScenario to exist within the same compound scenario as the Dependent Scenario (IC Hard).
4. Axiom – A Balanced Score Card Scenario could depend on a Business Model (IC Soft).
5. Axiom – A Business Model Scenario could have a chosen Product Scenario (IC Soft).
6. Axiom – A Business Model Scenario could have a chosen Product Scenario (IC Soft).
7. Axiom – A Product Scenario could have a chosen Business Model Scenario (IC Soft).
8. Axiom - In a Risk Scenario only Input, Output, Control or Resource roles can be played (IC Hard).

9. Axiom - Given that a Dependent Scenario is in the same compound Scenario as the GPN Scenario then a node in the Dependent Scenario must also be present in the GPN Scenario (IC Hard).
10. Axiom - Given that a Risk Scenario and a Balance Score Card Scenario are present in the same compound Scenario then a node in the Risk Scenario must also be present in the Balanced Score Card Scenario (IC Hard).
11. Axiom - Given that a Balanced Score Card Scenario and a Risk Scenario are present in the same compound Scenario then a node in the Balanced Score Card Scenario must also be present in the Risk Scenario (IC Hard).
12. Axiom - A System playing a role within a GPN must have External Factors (IC Soft).
13. Axiom - A System playing a role within a GPN must have Location Specific Risk Factors (IC Soft).
14. Axiom - A Production Network Scenario must contain the role Manufactured Product (IC Hard)
15. Axiom - A Production Network Scenario must contain the role Producer (IC Hard).
16. Axiom - A Production Network Scenario should contain the role Supplier (IC Soft).
17. Axiom - A Production Network Scenario should contain the role Customer (IC Soft).
18. Axiom - A Production Network Scenario should contain the role Consumer (IC Soft).
19. Axiom - A network scenario contains at least two systems connected by flow (IC Hard).
20. Axiom - A basic playing the role of an output must play the role of an input to another System within the network Scenario (IC Hard).
21. Axiom - The facility playing the role of a customer should have an input (IC Soft).
22. Axiom - The facility playing the role of a producer should have an output (IC Soft).
23. Axiom - The facility playing the role of a supplier should have an output (IC Soft).
24. Axiom - The role Product should be played in a GPN Scenario (IC Soft).
25. Axiom - The role Producer should be played in a Production Network Scenario (IC Soft).
26. Axiom - A facility should have a location (IC Soft).
27. Axiom - A System playing a role within a GPN scenario must have Location Specific Risk Factors (IC Hard).
28. Axiom - A System playing a role within a GPN scenario must have Location Specific Risk Factors (IC Soft).

6.3 Business

6.3.1 Business Properties

At Level 4 one property has been defined (see Figure 6-5), that of Business Model (as set out in D2.1). It is included as we anticipate a number of manufacturing business related concepts, axioms or rules that have yet to be identified as we go through the end user customisation process. However, we may find that business model concepts are generic to all business systems and therefore none of the level 2 concepts need to be further specialised.

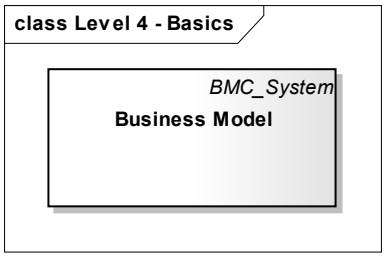


Figure 6-5: Level 4 Business property

6.4 Risk

6.4.1 Risk Properties and Relationships

Level 4 specialises risk, by adding a number of concepts (see Figure 6-6), those being "Perturbation", "Inoperability", "Intended Revenue", "Node Inter Dependency", "Inter Dependency Rating", "Criteria Type" and "Linguistic Label" (developed from the work within WP2). "Perturbation" is the direct effect of disruption on a Global Production Network node. "Inoperability" is the reduced percentage of operability of a Global Production Network node as a result of the original disruption and propagation of that original disruption, compared with the expected level of operability. "Intended Revenue" is an average of inoperability over a time horizon, modelled as a MaterialRole so, a TimeHorizon can be applied to this property. "Node Inter Dependency" is the interdependency coefficient that presents a probability of a disruption propagation from node j to node I (see Deliverable D2.2). "Inter Dependency Rating" is a specialised metric. "Criteria Type" is the relationships between the network nodes. "Linguistic Label" is a metric that relates to levels of confidence, those being high, medium and low.

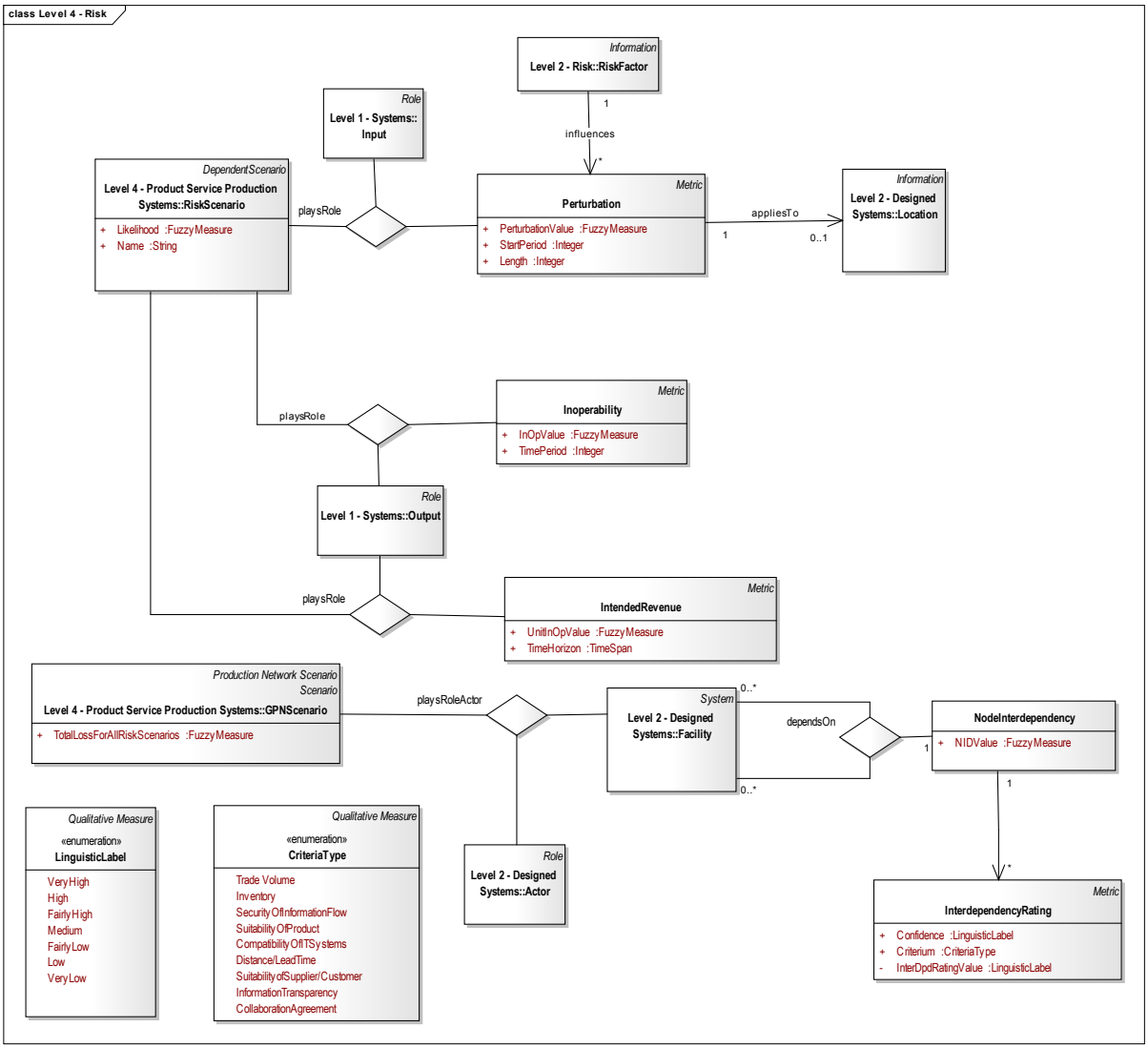


Figure 6-6: Level 4 Risk Properties

6.4.2 Risk Related Axioms

The following are the axioms that concern Risk at level 4:

1. Axiom - A node (facility playing a role in a GPNScenario) cannot depend on itself, but ?node1 has interdependency ?interdependency upon itself (IC Hard).

```
(=> (nodeInterDependencyOnNode ?node1  ?interdependency ?node2)
        (/= ?node1 ?node2)
)
```

2. Axiom – nodeInterDependencyOnNode only exists between nodes (facilities playing actor roles in a GPNScenario). ?node1 does not play an actor role in a GPNScenario (IC Hard).
3. Axiom – nodeInterDependencyOnNode only exists between nodes (facilities playing actor roles in a GPNScenario). ?node2 does not play an actor role in a GPNScenario (IC Hard).

4. Axiom - nodeInterDependencyOnNodes only exists between nodes (facilities playing actor roles) in the same GPN scenario. ?node1 has ?interdependency upon ?node2 but not in the same GPN Scenario (IC Hard).
5. Axiom - In a RiskScenario an IntendedRevenue can only play an Output role (IC Hard).
6. Axiom - In a RiskScenario, Inoperability must only play an Output role (IC Hard).
7. Axiom - In a RiskScenario a Perturbation must only play an Input role (IC Hard).
8. Axiom - In a RiskScenario the Metric sub-properties Perturbation, Inoperability or IntendedRevenue can play roles (IC Hard).

6.5 Product

6.5.1 Product Properties and Relationships

This has been described within the Level 2 Product section in Chapter 4, please refer to this section for more detail.

6.5.2 Product Related Axioms

The following are the axioms that concern Product at level 4:

1. Axiom - A ManufacturedProductService is always associated to a Benefit (IC Soft).

```
(=>
(ManufacturedProductService ?ps)
    (exists (?benefit)
     (and (Benefit ?benefit)
          (productHasAssociatedBenefit ?ps ?benefit))))
```

2. Axiom - If there is an Idea and its status is accepted, there will be at least one keyword associated to it (IC Soft).
3. Axiom - A keyword should always be associated to at least one Idea (IC Soft).
4. Axiom - A Concept should always be associated to at least one Idea (IC Soft).
5. Axiom - A Requirement should always be associated to at least one Concept (IC Soft).
6. Axiom – If there is a ManufacturedProductService, then it has an associated Life Cycle (IC Soft).
7. Axiom - If there is a Concept, then there is an associated Product (IC Soft).
8. Axiom - If there is a Requirement, then there is an associated ManufacturedProductService (IC Soft).
9. Axiom - If there a Support System, then there is a ManufacturedProductService that uses it (IC Soft).
10. Axiom - An idea can only have one status at the same time but Idea ?idea has Status ?status1 and ?status2 at time ?span (IC Hard).
11. Axiom - A concept can only have one status at the same time but Concept ?concept has Status ?status1 and ?status2 at time ?span (IC Hard).

12. Axiom - A concept can only have one PilotProductionStatus at the same time but Concept ?concept has PilotProductionStatus ?status1 and ?status2 at time ?span (IC Hard).
13. Axiom - A concept can only have one conceptHasGPNConfigurationStatus at the same time but Concept ?concept has conceptHasGPNConfigurationStatus ?status1 and ?status2 at time ?span (IC Hard).
14. Axiom - A concept can only have one conceptHasBusinessModelScenarioStatus at the same time but Concept ?concept has conceptHasBusinessModelScenarioStatus ?status1 and ?status2 at time ?span (IC Hard).
15. Axiom – If there is an Idea and a Demand Identification, then the Product-Service Life-Cycle Status of the associated Product-Service is the Demand Identification (IC Hard).
16. Axiom – If there is a Concept and a Feasibility Study, then the Product-Service Life-Cycle Status of the associated Product-Service is the Feasibility Study (IC Hard).
17. Axiom – If there is a Requirement and a Concept Development, then the Product-Service Life-Cycle Status of the associated Product-Service is the Concept Development (IC Hard).
18. Axiom – If there is a Support System and a Configuration, then the Product-Service Life-Cycle Status of the Product-Service that uses the Support System is the Configuration (IC Hard).

6.5.3 Product Related Rules

The following are the rules that concern Product at level 4:

1. Rule – Derives the most recently known to be true status of the idea. Uses the first date in a span to derive the date.

```
(=>
   (and
                  (holdsIn ?date (ideaHasStatus ?idea ?status))
      (maxTermf ?date (?date ?status) (holdsIn ?date (ideaHasStatus ?idea ?status))  ?latestDate)
      (= ?date ?latestDate)
   )
   (ideaHasCurrentStatus ?idea ?status)
)
```

2. Rule – Derives the most recently known to be true status of the concept.
3. Rule – Derives the most recently known to be true Pilot Production status of the concept.
4. Rule – Derives the most recently known to be true GPNConfiguration status of the concept.
5. Rule – Derives the most recently known to be true BusinessModelScenario status of the concept.
6. Rule – Derives the most recently known to be true name of the concept.
7. Rule – Derives the most recently known to be true description of the concept.

7 End User Ontology Level 5, Facts and BuzzBikes Knowledge Base

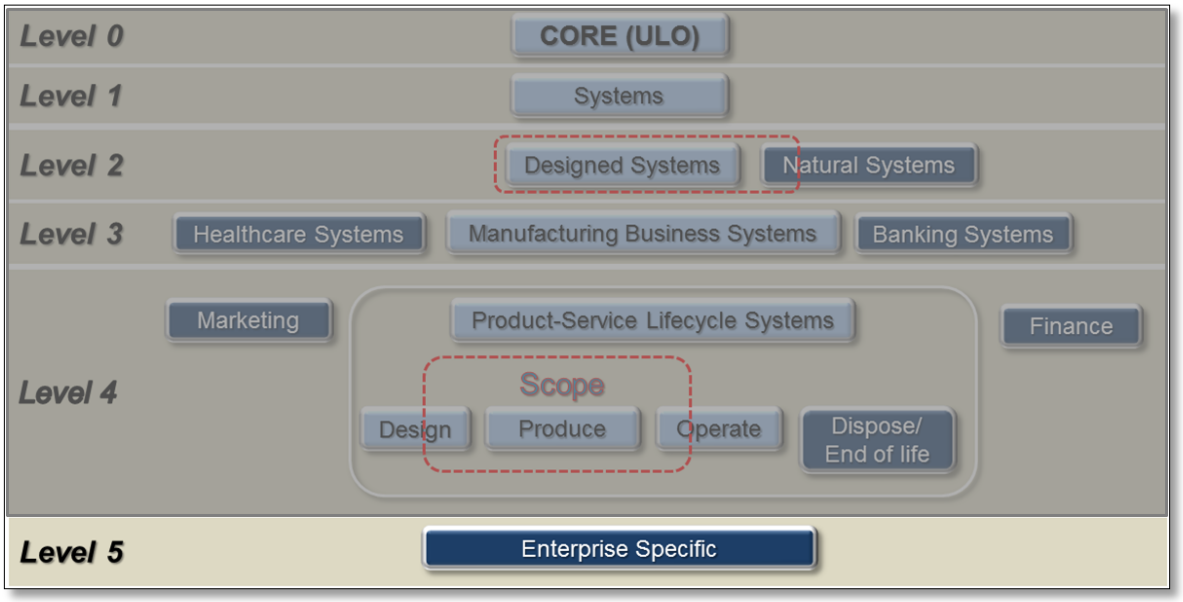


Figure 7-1: FLEXINET Reference ontology level 5

The area of focus in Chapter 7 is the Level 5 FLEXINET enterprise specific or end user ontologies as highlighted in Figure 7-1, these cover the KSB, INDESIT and CustomDrinks ontologies. The end user ontologies have utilised and employed the structure and concepts of the reference ontology by specialising them for each specific context. The concepts within the end user ontologies are mapped to concepts within the reference ontology. With this in mind, they therefore inherit the associated relationships. The mappings from the end user concepts to the reference ontology concepts are indicated by the italicised names at the top of the relevant class "boxes" in the Level 5 UML class diagrams below. Additionally, a fictitious "BuzzBikes" company example knowledge base has been developed, which, has been used as a generic test case in the project.

The following sections explain the three End User Ontologies and the BuzzBikes example knowledge base. The ECLIF code for the fictitious BuzzBikes example can be found in Annex D, whereas the KFL and ECLIF code for Level 5 resides within Part 2 of the D3.5 deliverable (End User Annex) due to confidentiality issues.

7.1 CustomDrinks

7.1.1 CustomDrinks Properties and Relationships

Within FLEXINET, CustomDrinks is focusing upon three main Use Cases as set out in D1.3. These are:

1. Feasibility Study: The initial stage carried out by CustomDrinks when a request from a potential client arrives and they have to analyse its feasibility in order to accept the project or not and to evaluate the reasons of feasibility.

2. GPN Configuration and Reconfiguration: The second stage looks at estimating the budget and time-to-market to develop and deliver a product.
3. Innovation Management: The third stage for CustomDrinks is dedicated to the establishment of an objective and reliable link between product and information flow during the whole innovation process, from the request from the client until one step before the manufacturing.

Each of the concepts starts with the prefix of "5CD_" denoting that it is a Level 5 CustomDrinks concept. The CustomDrinks UML model (see Figure 7-2) represents concepts needed to supports the three Use Cases. "Development Project" is the main concept underpinning the approach. This represents any potential project that might be requested by a customer by way of "Product Request". This relates to "Idea" so "New Content", "Containers", "New Packs" and "New Designs" can be considered and assessed and "Catalogue" is used to provide access to currently available products for assessment. "Customers" and "Clients" can be assessed against market information and regulations by way of the "Player" concept. "External Factors" are related to "Risk Factors" and can be assessed accordingly. Additionally "Supplier" and "Manufacturer" (which are types of Player) can be assessed for the configuration of a GPN. Aligned with this are "Production Process", "Production Asset" and "Material" for the development of the Innovation Management by way of "Manufacturer".

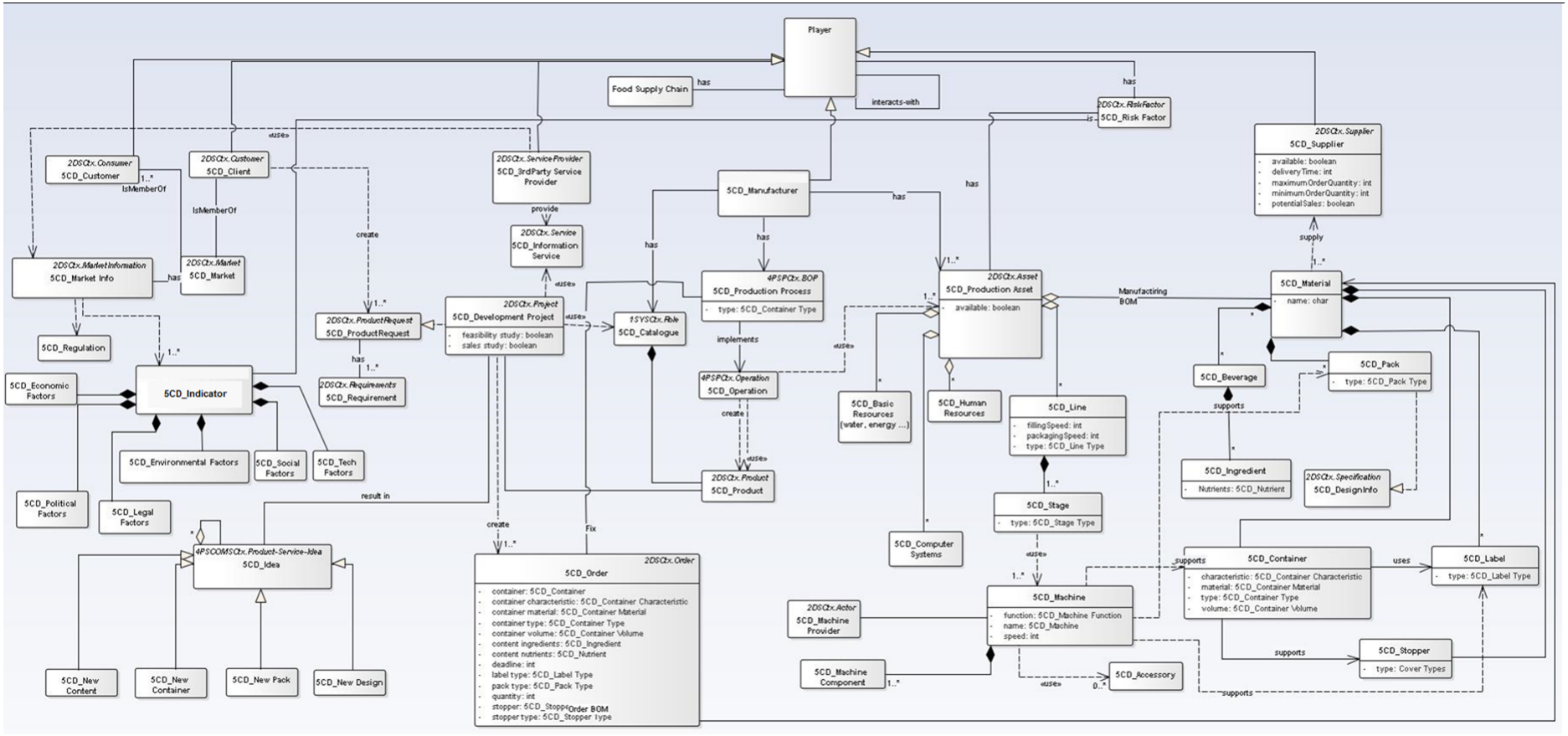


Figure 7-2: CustomDrinks End User UML Ontology Model

7.1.2 CustomDrinks Axioms

The following are the axioms for CustomDrinks at level 5:

Axiom CD_1 - There should be at least one Product in a Catalogue (IC Soft).

```
(=> (5CD_Catalogue ?cat)
  (and (5CD_Product ?prod)
  (count (5CD_CatalogueIsCompossedBy ?cat ?prod) ?nProds)
  (RootCtx.lteNum 1 ?nProds)))
IC:Soft
```

Axiom CD_2 - There should be at least one Client in a Market (IC Soft).

Axiom CD_3 - A beverage should have at least one ingredient (IC Soft).

Axiom CD_4 - There should be at least one Stage in a Line (IC Soft).

Axiom CD_5 - There should be at least one Machine in a Stage (IC Soft).

Axiom CD_6 - A Manufacturer should have at least one Production Process (IC Soft).

Axiom CD_7 - A Request should have at least one Requirement (IC Soft).

7.1.3 CustomDrinks Rules

The following are the rules for CustomDrinks at level 5:

Rule CD_1 - If a Player creates a Product Request, then the Player is a Client.

Rule CD_2 - If a Player supplies Material, then the Player is a Supplier.

Rule CD_3 - If a Material has Ingredients, then the Material is a Beverage.

Rule CD_4 - If a Machine supports a Container, then the Machine supports the Label of that Container.

- Note: The term 'support' means in this context 'is compatible with'.

Rule CD_5 - If a Machine supports a Container, then the Machine supports the Stopper of that Container.

```
(=>
      (and (5CD_Machine ?m)
      (5CD_Container ?con)
      (5CD_Stopper ?stp)
      (5CD_MachineSupportContainer ?m ?con))
(5CD_MachineSupportStopperType ?l))
```

Rule CD_6 - If one of the Production Assets involved in a Project is not supported by a Machine, then the Project is not feasible, else the project is feasible.

7.1.4 CustomDrinks Knowledge Base

The CustomDrinks Knowledge Base (Fact Base) contains a set of instances that enable the CustomDrinks queries to be answered. The knowledge base, provided in Annex A of the separate 'D3.5 End User Annex' report contains the following:

- Instances for different types of ingredients.
- Instances for different suppliers and clients.
- Instances for new client requests.
- Instances for different types of production processes, production stages, machines and production lines.
- Instances for different types of resources.
- Instances for products, materials and components.

7.2 INDESIT

7.2.1 INDESIT Properties and Relationships

Within FLEXINET, INDESIT is focusing upon four main Use Cases as set out in D1.3. These are:

1. Idea Generation and Management: the focus is upon the process collecting potentially innovative ideas concerning the design of new products, the re-design of other existing ones and also the offering of new services that support some of the existing products.
2. Business Model definition: is concerned with the process that drives the Business Model definition, startinhg with the definition of a new idea that represents a new business opportunity and assessing it from an economical point of view in order to developed it.
3. Product-Service architecture design/check: concerns the formal method/tool to describe the product or product-service functionalities and their connections with the product. Additionally, it is necessary to define the relations among product components and service functionalities.
4. Production Network configuration: focuses on the definition of a network of suppliers that fulfil certain criteria related to the proposed manufacture of a product, for example cost of supply, time to satisfy the order, distance from the INDESIT production plant/site, etc.

The INDESIT end user ontology model is depicted in Figure 7-3. Each of the concepts starts with the prefix of "5IND_" denoting that it is a Level 5 INDESIT concept. The inheritance from / mapping to reference ontology concepts is represented in the top left hand section of the UML class boxes in *italics*.

The concepts of "Idea", "Concept" and "Prototype" represent the necessary concepts needed to support idea generation and management. These relate to "Product", "Service", "Component" as well as "Department", "Requirement" and thus "Customer" together with the "Business Model". The definition of business models is supported by the concept of business model which is defined from the

INDESIT concept of "Business Plan". This then relates to the market and external factors. Importantly Business Model relates to "Partner", "Supply Chain" and "Risk Factor". For the checking of Product-Service architectures, "Product" relates to the definition and structure of product at Level 2 in section 4.8. Additionally, Product is related to "Component List" and "Component" by way of "Bill of Material". For the configuration of production networks, the concept "GPN" is composed of "Supply Chain" (which relates to Supplier), "Risk Factor", "Ecosystem" and is defined by the "Business Model".

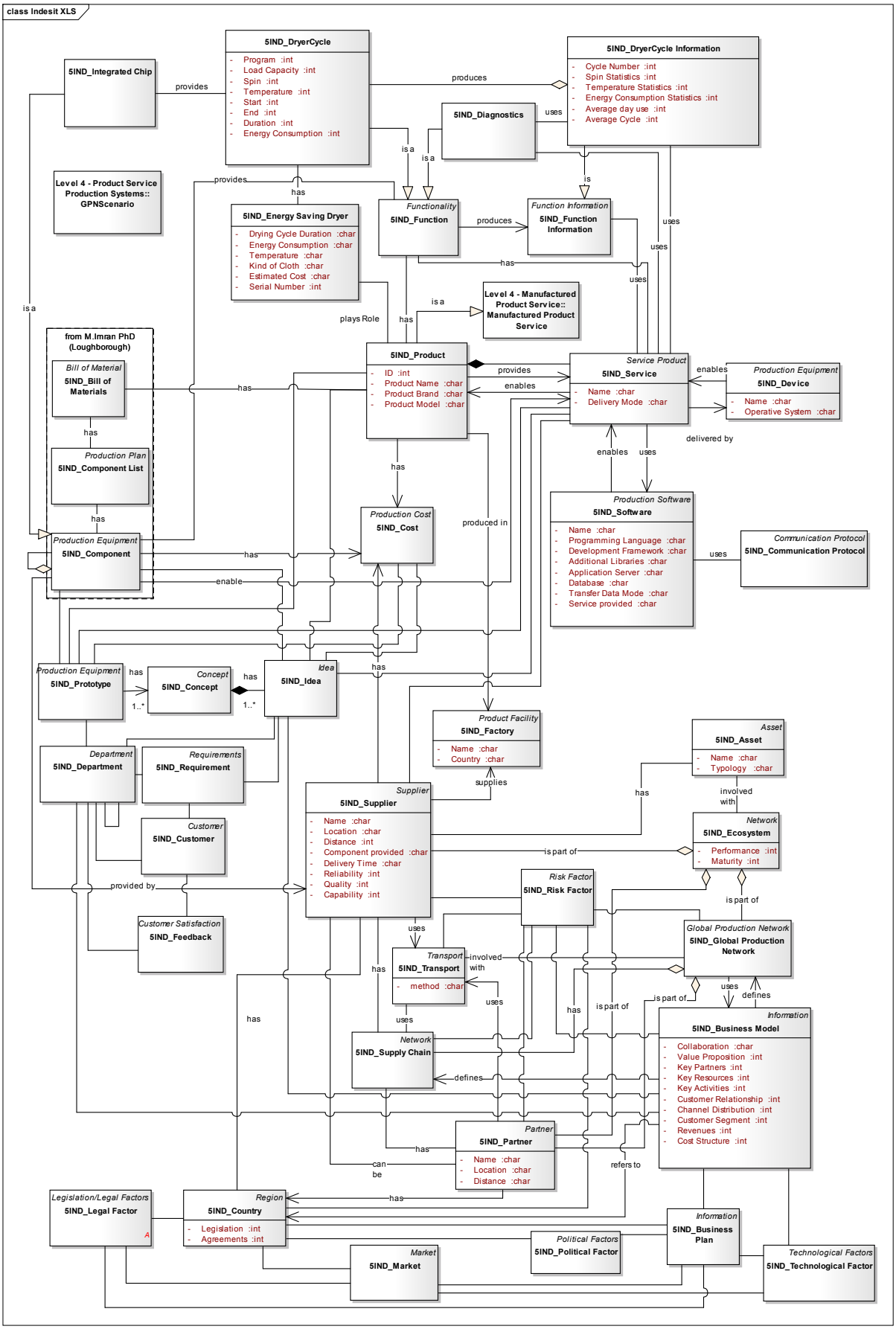


Figure 7-3: INDESIT End User UML ontology model

7.2.2 INDESIT Axioms

The following are the axioms for INDESIT at level 5:

Axiom IND_1 - A business model must have a business plan (IC Hard).

Axiom IND_2 - A concept must have one or more ideas (IC Hard).

Axiom IND_3 - A prototype must have a concept (IC Hard).

7.2.3 INDESIT Knowledge Base

The INDESIT Knowledge Base (Fact Base) contains a set of instances that enable the INDESIT queries to be answered. The knowledge base, provided in Annex B of the separate 'D3.5 End User Annex' report contains the following:

- Instances for different facilities.
- Instances for different types of components, equipment and material.
- Instances for different assembly processes.
- Instances for different types of suppliers.
- Instances for different Global Product Networks.

7.3 KSB

7.3.1 KSB Properties and Relationships

Within FLEXINET, KSB is focusing upon three main Use Cases as set out in D1.3. These are:

1. New application areas for a smart drive: This use case includes the strategic aspects and target definitions as well as the selecting and implementation of new business models.
2. GPN design: KSB is targeting lower process complexity within the GPN design. The GPN design includes the data gathering and the application of the data into different GPN scenarios.
3. GPN scenarios evaluation and management proposition: The GPN scenarios need to be analysed in order to gather sufficient information of good quality. This will be used to create a management proposition to decide on the go or no-go for the implementation of a GPN.

The UML model for KSB is depicted is Figure 7-4. The prefix "5KSB_" is used in all terms referring to KSB concepts at level 5. The key points of the model are focused on the development of ideas (Business Ideas) based on existing products or services. KSB centres its business area on Pumps and Valves, therefore any new Business idea is based on a new kind of Product, understood as a Manufactured Product, or a new type of Service.

In KSB, when a new Idea is developed a Functional Specification Book is associated with the services or the product with which the Business Idea is associated. The functional Specification book contains the functional specification for the product or service.

Business Ideas are developed within the context of a Business Model and an associated strategy. When defining a strategy for the applicability of the business Idea, KSB focuses on the following targets; Market, Technology Leadership, Environment Protection and Sustainability. The model also addresses a clear list of Opportunities and Competencies when designing the strategy. To this end, the strategy is evaluated via Risk Analyses that are carried out taking into account a range of external and internal factors. There are many important factors for KSB although those related with Technology Trends and Legal Requirements play an important role when analysing the strategy of the new Business Idea.

Additionally, the analysis of the strategy incorporates also the experience from older projects (they are referred in the model as Excel, SAP Systems and Datasources terms).

An important point is the location where a business idea is devised or created. Local Independent Ideas are the ideas arisen from local partners or facilities around the world. These ideas are also important when taken into consideration in the model.

Finally, after the positive result of the analysis of the strategy, a prototype is implemented. The prototype is then evaluated via the measurement of KPIs.

Although all the terms of the model have been customised to KSB (prefix 5KSB_) KSB ontology inherits most of its concepts from the level two of the reference ontology. The terms showed in Figure 7-4 provide in *italics* the property from which the concept inherits. Thus, we can group the concepts of the ontology in terms of the subgroups or applicable areas such as Business, ideas, risks, product and market. But, in most cases, the use of these terms implies a merge of them, for example, a business idea is the union of an idea related with a business area that KSB is interested in.

Figure 7-4 shows the relationship of the concepts of the KSB level 5 ontology with upper levels of the reference ontology. Thus, the terms framed in light pink boxes refer to specific concepts only applicable to KSB (level 5). The terms inside yellow boxes are directly inherited from level 4 concepts. They are more related with process production or product management. Finally, the rest of the terms are level 2 terms as previously discussed.

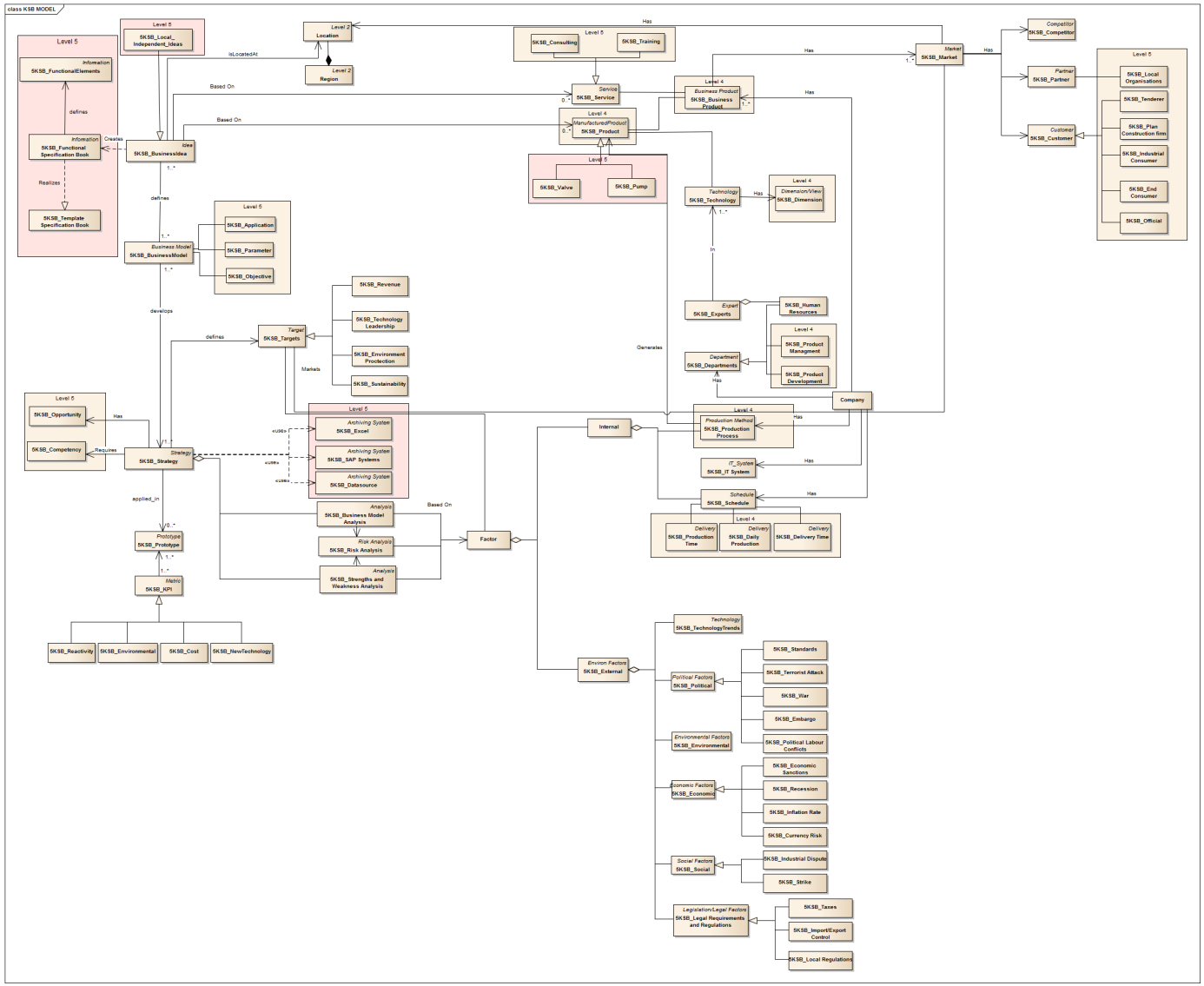


Figure 7-4: KSB End User UML Ontology Model

7.3.1 KSB Axioms

The following are the axioms for KSB at level 5:

Axiom KSB_1: A business Idea defined within the context of a business model should have a Functional Specification Book

```
(=> (and
        (5KSB_BusinessIdea ?bi)
        (5KSB_BusinessModel ?bm)
        (5KSB_BusinessModelOnIdea ?bm ?bi))
        (and
                (5KSB_BusinessIdeaHasFSB ?bi ?FSB)
                (5KSB_FunctionalSpecificationBook ?FSB)))
```

Axiom KSB_2: A strategy developed within the context of a business model must have targets.

Axiom KSB_3: A Business Model must have an application area, parameters and objectives.

Axiom KSB_4: A strategy developed within the context of a business model must take into account the following targets; Revenue, Technology Leadership, Environment protection, sustainability and markets.

Axiom KSB_5: A prototype should be evaluated based on the followings PKIs: Reactivity, Cost, Environmental Indicator and New Technology Indicator.

Axiom KSB_6: A strategy may have competencies.

Axiom KSB_7: A strategy may have opportunities.

Axiom KSB_8: A strategy analysis must take into account new technology trends.

Axiom KSB_9: A strategy analysis must take into account new technology regulations new Legal Factors.

7.3.2 KSB Rules

The following are the rules for KSB at level 5:

Rule KSB_1 - when defining a new business idea, the product, application area and region of application are inserted in the kb.

```
(=> (5KSB_BussinesIdeaProductDefinition ?bi ?p ?app )
        (and
                (5KSB_BusinessIdea ?bi)
                (5KSB_Product  ?p)
                (5KSB_Application ?app)))
```

Rule KSB_2 – Rule for the definition of a new Idea on a Service

Rule KSB_3 - When defining a FunctionalSpecificationBook(fbs) for an idea, a fbs is created.

Rule KSB_4 - When defining a new Business Model for KSB based on a business idea, and a strategy is associated with it, then we define a complete Business model.

7.3.3 KSB Knowledge Base

The KSB Knowledge Base (Fact Base) (situated in the separate End User Annex) contains a set of instances that enable the KSB queries to be answered. The knowledge base, provided in Annex C of the separate 'D3.5 End User Annex' report contains the following:

- Instances for different facilities.
- Instances for different assembly processes.
- Instances for different types of processes.
- Instances for different types of components.
- Instances for different flows between processes
- Instances for different types of suppliers.
    - Instances for different supplied components.
- Instances for different external factors
    - Technology Regulations
    - Markets Influence Area

7.4 Reference Ontology Applicability at Level 5

The end user ontologies have been developed utilising both bottom up and top down approaches within FLEXINET. The bottom up approach has created ontologies that represent the contextual perspective of each end user by developing the properties, relationships and axioms that exist within their industrial domain that characterise the day-to-day activities and operations. Additionally, the top down approach has provided a concise and consistent reference ontological hierarchy, which, has been used to categorise and organise the Level 5 end user concepts. The aim of this has been to fulfil the premise of a reference ontology and show that it can be used in practise to do just that and categorise and organise information systems, moreover, to promote interoperability between systems that reside in and are used by different domains.

The three Level 5 end user ontologies have been studied to assess whether or not they fulfil the aim of a reference ontology for the development of information systems, i.e. have they utilised and applied those developed reference ontology information structures? What has been found is that overall at least 87% of the properties that exist at Level 5 (for all three of the ontologies) are generic and have not been over specialised. Were the end user ontologies heavily specialised, it would imply that the reference ontology could not be used to represent the aspects of their day to day business operations. This would then make the ability to share data, information and knowledge between different systems, contexts and domains very difficult, due to the fact that there would be no basis for interoperability. Therefore, what can be deduced is that the reference ontology does in fact almost fully represent their industrial domains, thereby enabling a solid foundation to facilitate interoperability. Yet, each end user has felt the need to specialise a small number of properties. This has been necessary due to the fact that businesses often have their own individual approaches to the

design and manufacture of products and services together with the development of business ideas and models, hence, the end users have created properties to represent these individual differences. As such, this has a very minimal effect upon the FLEXINET applications, in that almost all of the ontological aspects that need to be represented and utilised are derived from the reference ontology and therefore represent each of the three end users domains and are thus compatible.

In summary, the number of concepts at Level 5 deemed to be specialised enough to deviate from the reference ontology were thus:

- CustomDrinks ontology has 4 out of 50 properties (8% specialised).
- INDESIT ontology has 5 out of 41 properties (12.2% specialised).
- KSB ontology has 11 out of 85 properties (12.9% specialised).

We believe that this high level of commonality is due to the relatively generic nature of supplier relationships and business related concepts. We further believe that as reference ontologies are developed further into the operational aspects of a manufacturing sector, that the concepts needed will become more specific to that sector and therefore need further specialisation.

7.5 BuzzBikes Test Case and Knowledge Base

For the purposes of creating a generic test case for the FLEXINET project, a fictitious company called "BuzzBikes" has been created that produces a product called the "eBike" (see Figure 7-5). This showcases all of the End User use case requirements in one storyline. To accompany this test case a set of example facts have been created to form a BuzzBikes knowledge base. The following sets out an overview of the generic test case:

1. The "BuzzBikes" story background:
   - BuzzBikes (fictional) is a small-medium volume manufacturer of bicycles for the mid-upper price range marketplace.
   - They supply internationally and source parts, materials and services internationally.
   - Their product development department want to investigate the viability of a new model of bike currently code named eBike that features SMART technology that would support further service opportunities.
   - They have chosen to use the FLEXINET platform to evaluate the development and manufacture of this new product.
2. BuzzBikes company objectives:
   - Manage the conceptual development of the new bike
   - Develop a coherent business model for the new bike & additional services
   - Identify potential global production networks (GPN) to produce the new bike
   - Evaluate the risks associated with each facility and GPN
   - Evaluate the strengths of each facility against defined factors
   - Manage the Product / Service Configuration & associated Knowledge
3. BuzzBikes company concerns:
   - Worries about **Risk** associated in bringing a new product to market
   - Concerns about the coherence and viability of the **Business Model**
   - Un-certainty of their **Production Networks** capability to produce the bike

- Lack of tools to support the diverse range of stakeholders to **Collaborate**

Figure 7-5: Fictitious BuzzBikes eBike example

The set of example set of facts (in ELCIF) that form the knowledge base for BuzzBikes has been placed within Annex D for reference. The evaluation of BuzzBikes from a software perspective will be provided by WP5 in deliverable D5.10.

8 Competency Questions and Application Queries

Section 8 sets out the competency questions and queries developed to support the FLEXINET software services. The end user competency questions as listed are a combination of questions related to the ontology and to FLEXINET software services as a whole, rather than just questions that are specific to the ontology.

The aim in FLEXINET is for the knowledge base to support the FLEXINET software services. Therefore the queries specified and described in this section have principally been defined to support the inputs from the knowledge bases required by the FLEXINET software services, rather than simply to explore whether the ontology is competent. The evaluation of these FLEXINET software services as a whole will be provided in WP7 deliverable D7.2 due in M35.

8.1 End User Competency Questions

8.1.1 CustomDrinks Competency Questions

The CustomDrinks competency questions are presented below:

1. List Requests by Client.
2. List Machines by Manufacturer.
3. List Container_Types by Manufacturer.
4. List Cover_Types supported by a given Container.
5. List Ingredients for a given Beverage.
6. List Nutrients for a given Beverage.
7. List Label_Types used by a given Container.
8. List Materials provided by a given Supplier.
9. List Containers supported by a given Machine.
10. List available Components and Accessories for a Machine.
11. List existing Machines for a given Stage.
12. List available Production_Assets for the current time.
13. List Machines compliant with a certain speed.
14. Do we have Suppliers providing a given Material (a type of Stopper)?
15. Which is the minimum order amount, the delivery time and the price per unit for such a Material from the Supplier?
16. Which are the External Factors impacting a specific Market?
17. Which are the Clients members for a given Market?
18. Which are the Operations performed by a given Production_Process
19. Which are the Operations involved in the creation of a given Product
20. List Orders related to a given Production_Asset
21. Is the new Product requested affected by External Factors such as standards or regulations?
22. Affinity of the Request regarding available Technologies (i.e. for instance is the resealable cap available in the CD GPN?
23. List Development_Projects classified as not feasible

24. Which Constraints of the Client's Request are related to the Production_Assets referring to the concept Product of CustomDrinks: Beverage/Container/Label?
25. Which past Requests are related to the current request?
26. For a given established constraint (value of the minimum order amount, delivery time or price per unit), list the GPN Suppliers who meet it.
27. List the GPN Suppliers that have similar (a predefined value for the threshold) network performance in terms of price, quantity, time for a given Material.
28. Which Products from my Catalogue are compatible with the Request?

8.1.2 INDESIT Competency Questions

The INDESIT competency questions are presented below:

1. List the concepts related to a product-service idea.
2. List customer requirements related to an idea.
3. List the company departments involved both in idea generation and product-service design for a specific product-service.
4. List the Bill of Material for a specific product-service.
5. List the services a specific product-service can provide.
6. List the product components needed to guarantee the services for a specific product-service.
7. List the devices needed to deliver the services for a specific product-service.
8. List the functions provided by a specific product-service.
9. List the detail of the functions used to generate energy saving information for a specific product-service.
10. List the products and services for a specific product-service.
11. List the software system components for a specific service.
12. List the compatible databases for a specific service.
13. List the average cost and delivery times for dryer components suppliers.
14. List the countries for dryer components suppliers and related legislation and political factors.
15. Show the Supply Chain for dryer components suppliers involved in a specific supply chain.
16. List the transportation methods of the dryer components suppliers involved in a specific supply chain.
17. List the distance between Indesit and each of the dryer components suppliers involved in a specific supply chain.
18. Show how a partner's risk factor value can be affected by legal and political factors.
19. List the product components the suppliers are able to provide.

8.1.3 KSB Competency Questions

The KSB competency questions are presented below:

1. Which are the necessary technologies for a new Product, new Service or New Business Idea?
2. Do we have experts in these technologies? If so, where are they located?
3. If not, do we have Partners with the expertise in these technologies? If so, where are they located?

4. Which technologies affect new products or services for a specific market?
5. List of new ideas by Location. Affinity of the idea to a specific market (taking into account technology).
6. Are the new potential new Product affected by Standards or Regulations?
7. Given a definition a business model and a strategy, how are they affected by external factors?
8. What are the outputs of defined indicators for a defined strategy?

8.2 FLEXINET Query Sets

8.2.1 Overview

The following section sets out the queries that are utilised by FLEXINET software, they are listed against respective services and applications that they support, those being Services, Global Production Network, Product, Business and Risk as per Figure 8-1. The queries that are listed can be used to interrogate the developed knowledge bases in order to support FLEXINET applications in their provision of feedback to end users.

Figure 8-1: Query Scope

For each query, they are described in natural language, then, the ECLIF code is shown (formal implementation), together with an example of the results obtained from executing the query against a knowledge base.

8.2.2 Queries for Services

This section presents a list of queries that are available for the FLEXINET services to call and apply to the applications. They are presented in the following order:

Service Query 1. List the organisations in the Knowledge base.
Service Query 2. What are the indicators and threshold values for a given organisation?

Service Query 3. Which facilities match the specified threshold values?

Service Query 4. Who are the facilities that match the supplier requirements for a given organisation?

Service Query 5. Does the given organisation threshold values match the given set of end user facility threshold values?

8.2.2.1 Service Query 1

Query
Query Description
List the organisations in the Knowledge base
KFL Code
(setof ?z (Organisation ?z)?l)
Query Result
?l (listof Agrovin Amelia_Ledo_Vence Ba_Vidro Casado Castrillo Conlesa CustomDrinks Fagreco LibraryExampleOrganisation Lopez_Pampin Rivera_Japan Sunset Ullama Verallia Vidrala Wild)

Figure 8-2: Query - List of organisations in the Knowledge base

8.2.2.2 Service Query 2

Query
Query Description
What are the indicators and threshold values for a given organisation?
KFL Code

```
(and
      (specifiesBusinessPolicy DrinksCo ?policy)
      (LocationFactorforSupplier ?policy)
     (hasThresholdValueForIndicator ?policy ?indicatorType ?threshold ?thresholdValue)
)
```

Query Result

?policy	?indicatorType	?threshold	?thresholdValue
locationSupplier	CostToExport	</=	(dollar/container 35)
locationSupplier	GDP	>/=	($ 2000)
locationSupplier	IndustrialGasPrices	</=	(euro/kWh 2)

Figure 8-3: Query – What are the indicators and threshold values for a given organisation

8.2.2.3 Service Query 3

Query
Query Description
Which facilities match the specified threshold values?
KFL Code

```
(exists (?companySpecifying ?coordinates ?area ?locationOfMismatchedSupplier ?externalfactor)
(and   (hasMisMatchingSupplier ?companySpecifying ?misMatchedSupplier)
       (systemLocatedAt ?misMatchedSupplier ?coordinates ?area  ?locationOfMismatchedSupplier)
       (locationHasExternalFactor  ?locationOfMismatchedSupplier ?externalfactor)
       (instAsserted ?externalfactor ?factortype)
       (hasIndicatorValue  ?externalfactor ?indValue)
   )
```

Query Result

?misMatchedSupplier	?factortype	?indValue
Lopez_Pampin	CostToExport	(dollar/container 35)
Lopez_Pampin	GDP	($ 1000)
Lopez_Pampin	IndustrialGasPrices	(euro/kWh 1)
Ullama	GDP	($ 3000)
Ullama	CostToExport	(dollar/container 35)

Figure 8-4: Query – Which facilities match the specified threshold values

8.2.2.4 Service Query 4

Query
Query Description
Who are the facilities that match the supplier requirements for a given organisation?
KFL Code

```
(2DSCtx.hasMisMatchingSupplier DrinksCo Ullama)
```

Query Result

The query is a **true** statement. It contained no variables, so there are no values to display.

Figure 8-5: Query – Who are the facilities that match the supplier requirements for a given organisation

8.2.2.5 Service Query 5

Query
Query Description
Does the given organisation threshold values match the given set of end user facility threshold values?
KFL Code

```
(exists ( ?coordinates ?area  ?locationOfMismatchedSupplier ?externalfactor ?policy)
    (and
      (2DSCtx.facilityLocatedAt GoldenBrewery ?coordinates ?area  ?locationOfMismatchedSupplier)
      (2DSCtx.locationHasExternalFactor  ?locationOfMismatchedSupplier ?externalfactor)
      (RootCtx.instAsserted ?externalfactor ?indicatorType)
      (2DSCtx.hasIndicatorValue ?externalfactor ?supplierValue)
      (2DSCtx.specifiesBusinessPolicy DrinksCo ?policy)
      (2DSCtx.LocationFactorforSupplier ?policy)
      (2DSCtx.hasThresholdValueForIndicator ?policy ?indicatorType ?threshold ?thresholdValue)
))
```

Query Result

?indicatorType	?supplierValue	?threshold	?thresholdValue
CostToExport	(dollar/container 35)	</=	(dollar/container 35)
GDP	($ 3000)	>/=	($ 2000)
IndustrialGasPrices	(euro/kWh 1)	</=	(euro/kWh 2)

Figure 8-6: Query – Does the given organisation threshold values match the given set of end user facility threshold values

8.2.3 Queries for Global Production Network

The FLEXINET ontology provides a vast list of terms and relations in order to model Global Production Networks (GPN). Based on these definitions, a list of potential queries is presented to be used in the Global Production Network applications. Most of them are used by other applications as providers of information for later queries. The following is a list of the queries that apply to the FLEXINET 'Global Production Network' scope, they are:

GPN Query 1. List the Facilities for a given organisation.
GPN Query 2. Where are the facilities of an organisation located?
GPN Query 3. List the systems related to the same country.
GPN Query 4. List the suppliers by Region or Country.
GPN Query 5. List the countries where there are systems dedicated to Design processes.
GPN Query 6. List the connectivity between pairs of systems within a network.
GPN Query 7. Given a new product with a list of requirements associated with them, which is the GPN configuration able to produce the new product?
GPN Query 8. Given a new product with a required technology, which are the suppliers that can provide this technology?

GPN Query 9. Given a new product with a specific need for a technology, which are the systems of the current configuration of the GPN able to produce the product?

GPN Query 10. List the GPN suppliers that can provide motor components.

GPN Query 11. List the GPN suppliers that can provide electronic equipment.

GPN Query 12. List the kinds of assets that the GPN suppliers can provide.

GPN Query 13. A new regulation on Pump Production will be applied in Europe on January 1st 2017. Are our plants in China affected by this regulation?

GPN Query 14. List of technologies by Product.

GPN Query 15. List of Experts by technology and where they are located.

GPN Query 16. Do we have experts in a technology? If so, where are they located?

GPN Query 17. List the GPN suppliers that can provide motors.

GPN Query 18. List the GPN suppliers that can provide electronic equipment.

GPN Query 19. List the kinds of assets that the GPN suppliers can provide.

GPN Query 20. Who are the suppliers in Scenario GPNetwork1?

GPN Query 21. In which scenarios does the organisation CustomDrinks participate?

GPN Query 22. In which scenarios does CustomDrinks act as a supplier?

GPN Query 23. Which scenarios apply to the network CustomDrinks Cider Production Network?

8.2.3.1 GPN Query 1

Query
Query Description
List the Facilities for a given organisation
KFL Code
(and (organisationComposedOfFacility ?org ?facilityName)(= ?org CustomDrinks))
Query Result

?org	?facilityName
CustomDrinks	CD_Italy
CustomDrinks	CD_Lugo

Figure 8-7: Query - List the Facilities for a given organisation

8.2.3.2 GPN Query 2

Query
Query Description
Where are the facilities of an organisation located

KFL Code

```
(and (organisationComposedOfFacility ?org ?facilityName)
(= ?org CustomDrinks)(facilityLocatedAt ?facilityName ?GPS_Position ?city ?Country)
(=?GPS_Position (WGS84.latlong ?long ?lat)))
```

Query Result

?org	?facilityName	?GPS_Position	?city	?Country	?long	?lat
CustomDrinks	CD_Italy	(WGS84.latlong 45.4627338 9.1777323)	Milano	ITA	45.4627338	9.1777323
CustomDrinks	CD_Lugo	(WGS84.latlong 42.5883405 -7.7773165)	Lugo	ESP	42.5883405	-7.7773165

Figure 8-8: Query - Where are the facilities of an organisation located

8.2.3.3 GPN Query 3

Query

Query Description

List the systems related to the same country (Country = ESP (Spain)).

KFL Code

```
(and (System ?sys)(basicContainsBasic ?facilityName ?sys)
(organisationComposedOfFacility ?org ?facilityName)
(= ?org CustomDrinks)(facilityLocatedAt ?facilityName ?GPS_Position ?city ESP))
```

Query Result

?sys	?facilityName	?org	?GPS_Position	?city
Filling	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 -7.7773165)	Lugo
Packing	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 -7.7773165)	Lugo
Rinsing	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 -7.7773165)	Lugo
Labelling	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 -7.7773165)	Lugo
Capping	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 -7.7773165)	Lugo

Figure 8-9: Query - List the systems related to the same country

8.2.3.4 GPN Query 4

Query

Query Description

List the suppliers by Region or Country

KFL Code

```
(and (5CDCtx.5CD_Supplier ?sup)(requiresA ?sup CD_GPN)
(playsRoleActorInGPNS ?supplierFacility  ?sup  CD_GPN_Configurator)
(organisationComposedOfFacility ?org ?facilityName)
(= ?org CustomDrinks)(facilityLocatedAt ?facilityName ?GPS_Position ?city ?country))
```

Query Result

?sup	?supplierFacility	?org	?facilityName	?GPS_Position	?city	?country
BottleSupplier	HijosDeRiveraCenter	CustomDrinks	CD_Italy	(WGS84.latlong 45.4627338 9.1777...	Milano	ITA
BottleSupplier	Owens-IllinoisCenter	CustomDrinks	CD_Italy	(WGS84.latlong 45.4627338 9.1777...	Milano	ITA
BottleSupplier	Owens-IllinoisCenter	CustomDrinks	CD_Lugo	(WGS84.latlong 42.5883405 -7.777...	Lugo	ESP
BottleSupplier	HijosDeRiveraCenter	CustomDrinks	CD_Lugo	(WGS84.latlong 42.5883405 -7.777...	Lugo	ESP

Figure 8-10: Query - List the suppliers by Region or Country

8.2.3.5 GPN Query 5

Query

Query Description

List the countries where there are systems dedicated to "Design processes" (see Note below).

KFL Code

```
(and (Design ?sys)(basicContainsBasic ?factilityName ?sys)
(organisationComposedOfFacility ?org ?factilityName)
(= ?org CustomDrinks)(facilityLocatedAt ?factilityName ?GPS_Position ?city ?country))
```

Query Result

?sys	?factilityName	?org	?GPS_Position	?city	?country
NewBottle_HKY_Design	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 ...	Lugo	ESP
NewBottle_JAPAN_Design	CD_Lugo	CustomDrinks	(WGS84.latlong 42.5883405 ...	Lugo	ESP

Figure 8-11: Query - List the countries where there are systems dedicated to Design processes

This query results in a list the countries in which systems/processes of type "Design" are executed. To this end, we use to term "Design", defined at level 2 of the ontology, identifying the type of system the query is searching for. Thus, the term "Design" can be replaced by other terms, such as "Manage" so that the query results will show processes of type "Manage" currently stored in the KB.

8.2.3.6 GPN Query 6

Query
Query Description
List the connectivity between pairs of systems within a network
KFL Code

```
(and (System ?s1)(System ?s2)
(/= ?s1 ?s2)(requiresA ?role1 ?s1)
(requiresA ?role2 ?s2)(Basic ?basic)
(playsRole ?basic ?role1 ?sce)
(playsRole ?basic ?role2 ?sce))
```

Query Result

?s1	?s2	?role1	?role2	?basic	?sce
Filling	Rinsing	InputFilling	OutputRinsing	RinsedBottles	CD_GPN_Configurator
Filling	Capping	OutputFilling	InputCapping	FilledBottles	CD_GPN_Configurator
Capping	Filling	InputCapping	OutputFilling	FilledBottles	CD_GPN_Configurator
Rinsing	Filling	OutputRinsing	InputFilling	RinsedBottles	CD_GPN_Configurator
Packing	Labelling	InputPacking	OutputLabelling	LabelledBottles	CD_GPN_Configurator
Labelling	Packing	OutputLabelling	InputPacking	LabelledBottles	CD_GPN_Configurator
Labelling	Capping	InputLabelling	OutputCapping	ClosedBottles	CD_GPN_Configurator
Capping	Labelling	OutputCapping	InputLabelling	ClosedBottles	CD_GPN_Configurator

Figure 8-12: Query - List the connectivity between pairs of systems within a network

8.2.3.7 GPN Query 7

Query
Query Description
Given a new product with a list of requirements (Basics) associated with them, which is the GPN configuration (in terms of inputs, outputs and resources) able to produce the new product?
KFL Code

```
(and
;; final product searched
(= ?requiredOutput MountedPump)
(playsRole ?requiredOutput ?finalProduct ?)
(Output ?finalProduct)
(requiresA ?finalProduct ?systemF)

; specific quality searched
(Technology ?requiredTechnology)
(= ?requiredTechnology LowEnergyTechnology)
(requiresA ?requiredTechnology ?systemSupplier)
(playsRole ?component LowEnergyTechnology ?)
(Input ?in)
(requiresA ?in ?systemI)
(playsRole ?component ?in ?)

(Input ?inF)
(requiresA ?inF ?systemF)
(Output ?out)
(flow ?out ?inF  ?))
```

Query Result

?requiredOutput	?finalProduct	?systemF	?requiredTechnology	?systemSupplier	?component	?in	?systemI	?inF	?out
MountedPump	Out_LSPGermany	LocalServicePartnerGermany	LowEnergyTechnology	EMCS_ElectricMotorComp...	ElectricMotorComponent	In_REEL	REEL	In_LSPGermany	Out_KSBInt
MountedPump	Out_LSPGermany	LocalServicePartnerGermany	LowEnergyTechnology	EMCS_ElectricMotorComp...	ElectricMotorComponent	In_REEL	REEL	In_LSPGermany	Out_KSBCent
MountedPump	Out_LSPGermany	LocalServicePartnerGermany	LowEnergyTechnology	EMCS_ElectricMotorComp...	ElectricMotorComponent	In_REEL	REEL	In_LSPGermany	Out_KSBCent_HQ

Figure 8-13: Query - Given a new product with a list of requirements associated with them, which is the GPN configuration able to produce the new product

8.2.3.8 GPN Query 8

Query
Query Description
Given a new product with a required technology (ex: LowEnergyTechnology), which are the suppliers that can provide this technology?
KFL Code

```
(and (Technology LowEnergyTechnology)
(requiresA LowEnergyTechnology ?system)
(5KSB_Product ?product)
(5KSB_AddTechnologyToProduct ?product LowEnergyTechnology))
```

Query Result

?system	?product
EMCS_ElectricMotorComponentsSupplier	Pump_H4100

Figure 8-14: Query - Given a new product with a required technology, which are the suppliers that can provide this technology

8.2.3.9 GPN Query 9

Query

Query Description

Given a new product with a specific need for a technology, which are the systems of the current configuration of the GPN able to produce the product?

KFL Code

```
(and (Role ?role1) (Technology ?tech)
(playsRole ?basic ?tech ?sce)
(playsRole ?basic ?role1 ?sce)
(requiresA ?tech ?sys))
```

Query Result

?role1	?tech	?basic	?sce	?sys
MyTechnology	MyTechnology	GlassBottle	CD_GPN_Configurator	Rinsing
InputRinsing	MyTechnology	GlassBottle	CD_GPN_Configurator	Rinsing

Figure 8-15: Query - Given a new product with a specific need for a technology, which are the systems of the current configuration of the GPN able to produce the product.

8.2.3.10 GPN Query 10 (KSB)

Query

Query Description

List the GPN suppliers that can provide motor components

KFL Code

```
(and  (2DSCtx.Supplier ?supplier)
(playsRole ?company ?supplier ?))
```

Query Result

?supplier	?company
KSBecosystem_Supplier	TEC
KSBecosystem_Supplier	Siemens
KSBecosystem_Supplier	RIL
KSBecosystem_Supplier	REEL
KSBecosystem_Supplier	LocalServicePartnerIndia
KSBecosystem_Supplier	LocalServicePartnerGermany
KSBecosystem_Supplier	KSB_Nashik
KSBecosystem_Supplier	KSB_International
KSBecosystem_Supplier	KSB_Halle
KSBecosystem_Supplier	KSB_Central_HQ
KSBecosystem_Supplier	KSB_Central
KSBecosystem_Supplier	KSB_Bund
KSBecosystem_Supplier	HSCS_HydraulicSingleComponentsSupplier
KSBecosystem_Supplier	EMCS_ElectricMotorComponentsSupplier
KSBecosystem_Supplier	CUSCS_ControlUnitSingleComponentsSupplier
KSBecosystem_Supplier	BMS_BaseMaterialSupplier
KSBecosystem_Supplier	BCPS_BaseConstituentsPumpsSupplier
KSBecosystem_Supplier	AnotherControlUnitMaker

Figure 8-16: Query - List the GPN suppliers that can provide motor components

8.2.3.11 GPN Query 11 (KSB)

Query
Query Description
List the GPN suppliers that can provide electronic equipment
KFL Code

```
(and
(2DSCtx.Supplier ?supplier)
(playsRole ?company ?supplier ?)
(playsRoleActor ?company ?supplier ?)
(ProductionEquipment ?equipment)
(Output ?out)
(playsRole ?equipment ?out ?)
(requiresA ?out ?company))
```

Query Result

?supplier	?company	?out	?equipment
KSBecosystem_Supplier	CUSCS_ControlUnitSingleComponentsSupplier	Out_ControlUnitSingleComponents	ControlUnitSingle_Equipment
KSBecosystem_Supplier	HSCS_HydraulicSingleComponentsSupplier	Out_HydraulicComponents	Hydraulic_Equipment
KSBecosystem_Supplier	BCPS_BaseConstituentsPumpsSupplier	Out_BaseConstituentsPumps	BaseConstituents_Equipment
KSBecosystem_Supplier	EMCS_ElectricMotorComponentsSupplier	Out_ElectricMotorComponents	ElectricMotorComponent

Figure 8-17: Query – List the GPN suppliers that can provide electronic equipment

8.2.3.12 GPN Query 12 (KSB)

Query

Query Description

List the kinds of assets that the GPN suppliers can provide

KFL Code

```
(and
(2DSCtx.Supplier ?supplier)
(playsRole ?company ?supplier ?)
(playsRoleActor ?company ?supplier ?)
(Output ?out)
(playsRole ?assets ?out ?)
(requiresA ?out ?company))
```

Query Result

?supplier	?company	?out	?assets
PumpProductionWorld_Supplier	KSB_Central	Out_KSBCent	LowEnergyPump
PumpProductionWorld_Supplier	Siemens	Out_Siem	ControlUnit
KSBecosystem_Supplier	KSB_Central	Out_KSBCent	LowEnergyPump
KSBecosystem_Supplier	KSB_Central	Out_KSBCent	LowEnergyDrive
KSBecosystem_Supplier	KSB_Halle	Out_KSBHalle	LowEnergyPump
KSBecosystem_Supplier	KSB_Halle	Out_KSBHalle	ElectricMotor
KSBecosystem_Supplier	TEC	Out_TEC	ElectricMotor
KSBecosystem_Supplier	KSB_Central_HQ	Out_KSBCent_HQ	SupplierOrder
KSBecosystem_Supplier	CUSCS_ControlUnitSingleComponentsSupplier	Out_ControlUnitSingleComponents	ControlUnitSingle_Equipment
KSBecosystem_Supplier	LocalServicePartnerIndia	Out_LSPIndia	MountedPump
KSBecosystem_Supplier	HSCS_HydraulicSingleComponentsSupplier	Out_HydraulicComponents	Hydraulic_Equipment
KSBecosystem_Supplier	REEL	Out_REEL	ElectricMotor
KSBecosystem_Supplier	BCPS_BaseConstituentsPumpsSupplier	Out_BaseConstituentsPumps	BaseConstituents_Equipment
KSBecosystem_Supplier	EMCS_ElectricMotorComponentsSupplier	Out_ElectricMotorComponents	ElectricMotorComponent
KSBecosystem_Supplier	LocalServicePartnerGermany	Out_LSPGermany	MountedPump
KSBecosystem_Supplier	Siemens	Out_Siem	ControlUnit
KSBecosystem_Supplier	RIL	Out_RIL	ElectricMotor
KSBecosystem_Supplier	AnotherControlUnitMaker	Out_Anoth	ControlUnit
KSBecosystem_Supplier	KSB_Nashik	Out_KSBNashik	LowEnergyPump
KSBecosystem_Supplier	KSB_Nashik	Out_KSBNashik	ElectricMotor
KSBecosystem_Supplier	KSB_International	Out_KSBInt	PumpHydraulics
KSBecosystem_Supplier	KSB_Bund	Out_KSBBund	LowEnergyPump
KSBecosystem_Supplier	KSB_Bund	Out_KSBBund	ElectricMotor

Figure 8-18: Query - List the kinds of assets that the GPN suppliers can provide

8.2.3.13 GPN Query 13 (KSB)

Query

Query Description

A new regulation on Pump Production (NewRegulationEuropePumpH4100) will be applied in Europe on January 1st 2017. Are our plants in China (NewRegulationChinaPumpH4100) affected by this regulation?

KFL Code

```
(and
(5KSB_LocalRegulations ?factorChina)
(5KSB_LocalRegulations ?factorEurope)
(/= ?factorChine ?factorEurope)
(= ?factorChina NewRegulationChinaPumpH4100)
(= ?factorEurope NewRegulationEuropePumpH4100)
(hasIndicatorValue ?factorChine ?valueChina)
(hasIndicatorValue ?factorEurope ?valueEurope)
(lteNum ?valueChina ?valueEurope))
```

Query Result

?factorChina	?factorEurope	?factorChine	?valueChina	?valueEurope
NewRegulationChinaPumpH4100	NewRegulationEuropePumpH4100	NewRegulationChinaPumpH4100	100	150

Figure 8-19: Query – A new regulation on Pump Production will be applied in Europe on January 1st 2017.

8.2.3.14 GPN Query 14 (KSB)

Query
Query Description
List of technologies by Product.
KFL Code

```
(and (5KSB_Product ?product)
(5KSB_AddTechnologyToProduct ?product ?technology))
```

Query Result

?product	?technology
PumpH_7100	RegenerativePump
Valve_27500	PositiveDisplacementPump
Pump_H4100	LowEnergyTechnology
Valve_12500	EntrapmentPump

Figure 8-20: Query - List of technologies by Product

8.2.3.15 GPN Query 15 (KSB)

Query
Query Description
List of Experts by technology and where they are located.
KFL Code

```
(and (5KSB_ExpertInFacility ?expertName ?technology ?facility)
(facilityLocatedAt ?facility ? ?city ?Country))
```

Query Result

?expertName	?technology	?facility	?city	?Country
MichaelJohansTech2	PositiveDisplacementPump	EMCS_ElectricMotorComponentsSupplier	Fabriano	ITA
BridgetAngelaTech3	RegenerativePump	EMCS_ElectricMotorComponentsSupplier	Fabriano	ITA
BridgetAngelaTech3	EntrapmentPump	EMCS_ElectricMotorComponentsSupplier	Fabriano	ITA
JunoSmithTech3	LowEnergyTechnology	EMCS_ElectricMotorComponentsSupplier	Fabriano	ITA

Figure 8-21: Query - List of Experts by technology and where they are located.

8.2.3.16 GPN Query 16 (KSB)

Query
Query Description
Do we have experts in a technology? If so, where are they located?
KFL Code

```
(and (5KSB_HRHasExpert ?hrdepart ?expert ?technology)
(5KSB_FacilityHasHR ?facility ?hrdepart)
((facilityLocatedAt ?facility ?GPS_Position ?city ?Country)
(=?GPS_Position (WGS84.latlong ?long ?lat))))
```

Query Result

?hrdepart	?expert	?technology	?facility	?GPS_Position	?city	?Country	?long	?lat
HR_DEPARTMENT	EMP_0089	LaserHK34	KSB_HALLE	(WGS84.latlong 49....	Frankenthal	DEU	49.536246	8.350000000000023

Figure 8-22: KSB Query- Do we have experts in a technology? If so, where are they located?

8.2.3.17 GPN Query 17 (INDESIT)

Query
Query Description
List the GPN suppliers that can provide motors
KFL Code

```
(exists (?supplier ?product ?motor)
(and (2DSCtx.Supplier ?supplier)
(playsRoleActorInGPNS  ?org ?supplier  INDESIT_GPN_Configurator)
(2DSCtx.Product ?product)
(requiresA  ?product ?org)
(Motor ?motor)
(playsRole ?motor ?product INDESIT_GPN_Configurator) ))
```

Query Result
?org
ASKOLL_TRE_SPA

Figure 8-23: Query - List the GPN suppliers that can provide motors

8.2.3.18 GPN Query 18 (INDESIT)

Query
Query Description
List the GPN suppliers that can provide electronic equipment
KFL Code

```
(exists (?supplier ?product ?electronics)
(and (2DSCtx.Supplier ?supplier)
(playsRoleActorInGPNS  ?org ?supplier  INDESIT_GPN_Configurator)
(2DSCtx.Product ?product)
(requiresA  ?product ?org)
(ElectronicEquipment ?electronics)
(playsRole ?electronics ?product INDESIT_GPN_Configurator) ))
```

Query Result
?org
COMPUTIME_LIMITED_ORG
FLEXTRONICS_INTERNATIONAL_KFT_ORG

Figure 8-24: Query - List the GPN suppliers that can provide electronic equipment

8.2.3.19 GPN Query 19 (INDESIT)

Query
Query Description
List the kinds of assets that the GPN suppliers can provide
KFL Code

```
(exists (?supplier ?product ?asset)
(and (2DSCtx.Supplier ?supplier)
(playsRoleActorInGPNS  ?org ?supplier  INDESIT_GPN_Configurator)
(2DSCtx.Product ?product)
(requiresA  ?product ?org)
(playsRole ?asset ?product INDESIT_GPN_Configurator)
(instAsserted ?asset ?assetKind) ))
```

Query Result

?org	?assetKind
VETRERIE_RIUNITE_SPA	Glass
INDUSTRIE_PASOTTI_SPA	Aluminium
COMPUTIME_LIMITED_ORG	ElectronicEquipment
TATA_STEEL_COLORSTEELS	Steel
ROSA_EUROPE	Plastic
FLEXTRONICS_INTERNATIONAL_KFT_ORG	ElectronicEquipment
ASKOLL_TRE_SPA	Motor
RGE_YATE_LTD	Plastic

Figure 8-25: Query - List the kinds of assets that the GPN suppliers can provide

8.2.3.20 GPN Query 20

Query
Query Description
Who are the suppliers in Scenario GPNetwork1?
KFL Code

```
(exists (?supplier)
(and(2DSCtx.Supplier ?supplier)
(2DSCtx.Facility ?facility)
(playsRoleActor ?facility ?supplier GPNetwork1)))
```

Query Result

?facility
Verallia
Ullama
Lopez_Pampin
Conlesa
Castrillo
Casado
Agrovin

Figure 8-26: Query - Who are the suppliers in Scenario GPNetwork1.

8.2.3.21 GPN Query 21 (CustomDrinks)

Query
Query Description
In which scenarios does the organisation CustomDrinks participate?
KFL Code

```
(and  (Scenario ?scenario)
(playsRoleActorInGPNS CustomDrinks ?supplier ?scenario))
```

Query Result	
?scenario	?supplier
GPNetwork2	BottledCiderMaker
GPNetwork1	BottledCiderMaker
CiderNetwork	CiderSupplier

Figure 8-27: Query - In which scenarios does the organisation CustomDrinks participate?

8.2.3.22 GPN Query 22 (CustomDrinks)

Query
Query Description
In which scenarios does CustomDrinks act as a supplier?
KFL Code

```
(exists(?supplier) (and  (Scenario ?scenario) (Supplier ?supplier)
(playsRoleActorInGPNS CustomDrinks ?supplier ?scenario)))
```

Query Result
?scenario CiderNetwork

Figure 8-28: Query - In which scenarios does CustomDrinks act as a supplier?

8.2.3.23 GPN Query 23 (CustomDrinks)

Query
Query Description
Which scenarios apply to the network CustomDrinksCiderProductionNetwork?
KFL Code
(exists (?role ?facility) (and (requiresA ?role CustomDrinksCiderProductionNetwork) (playsRoleActor ?facility ?role ?scenario)))
Query Result
?scenario GPNetwork2 GPNetwork1 CiderNetwork

Figure 8-29: Query - Which scenarios apply to the network CustomDrinks Cider Production Network?

8.2.4 Queries for Product

This section sets out the queries that apply to the FLEXINET 'Product' scope. These queries have been implemented in KFL and have been used to interface with the knowledge bases to retrieve information about product-services, ideas, requirements, support system, etc. The following is a list of the 'Product' queries, they are:

Product Query 1. List all the Product-Services.
Product Query 2. What are the Product-Services associated to an Idea?
Product Query 3. What are the keywords associated to an Idea?
Product Query 4. What are the Product-Services related to a given keywords?
Product Query 5. What are the Support-Systems that a Product-Service uses?
Product Query 6. What are the Product-Services associated to a Concept?
Product Query 7. What Benefit is associated to a Product-Service?
Product Query 8. What are the Product-Services associated to a Requirement?
Product Query 9. What Requirements and Stakeholders are related to a Product-Service?

Product Query 10. List the Software and Hardware components of the Infrastructure that are used by the Support-system of a Product-service.

Product Query 11. What is the Support-Network of a Support-System that a Product-Service uses?

Product Query 12. What is the Idea and the Evaluation Scheme related to a Product-Service?

Product Query 13. What is the Life-Cycle associated to the Product-Service?

Product Query 14. List the statuses of the Life-Cycle for a Product-Service.

Product Query 15. List of products in the Manufacturer Catalogue.

Product Query 16. List the requests of a client.

Product Query 17. List the Machines in an assembly line.

Product Query 18. What is the interdependency value between Conlesa and CustomDrinks in GPNetwork1?

Product Query 19. Which suppliers in Global Production Network Scenario PSP_GPN supply the component Uboard as an output?

Product Query 20. Which components do the Product i_Dryer001 and the Service SmartMaintenance both utilise in Global Production Network Scenario PSP_GPN?

Product Query 21. Does the product i_Dryer001 contain the component Uboard which is required by Service SmartMaintenance?

Product Query 22. Which components does the Service SmartMaintenance require which are not contained by the Product i_Dryer001?

8.2.4.1 Product Query 1

Query
Query Description
List all the Product-Services
KFL Code
`(4PSPCtx.ManufacturedProductService ?ps)`
Query Result

?ps
VegetarianBeerProduct

Figure 8-30: Query - List all the Product-Services

8.2.4.2 Product Query 2

Query

Query Description
What are the Product-Services associated to an Idea?
KFL Code

```
(4PSPCtx.productHasAssociatedIdea ?ps ?idea)
```

Query Result

Sweetener	Sacarina
NonAlcoholicBeverage	Mirinda

Figure 8-31: Query - What are the Product-Services associated to an Idea

8.2.4.3 Product Query 3

Query
Query Description
What are the keywords associated to an Idea?
KFL Code

```
(4PSPCtx.ideaHasAssociatedKeyword ?idea ?keyword)
```

Query Result

?idea	?tag
NonAlcoholicBeverage	Sweet
Sweetener	Sweet
Sweetener	Light
NonAlcoholicBeverage	Drink

Figure 8-32: Query - What are the keywords associated to an Idea

8.2.4.4 Product Query 4

Query
Query Description
What are the Product-Services related to a given keyword?
KFL Code

```
(and
  (4PSPCtx.ideaHasAssociatedKeyword ?idea ?keyword)
  (4PSPCtx.productHasAssociatedIdea ?ps ?idea) )
```

Query Result

?idea	?keyword	?ps
DrinksForVeggies	(keywordTypeAndValue "Vegan" "Vegetarian Beer")	VegetarianBeerProduct
DrinksForVeggies	(keywordTypeAndValue "Alcoholic drink" "Vegetari...	VegetarianBeerProduct
DrinksForVeggies	(keywordTypeAndValue "Vegetarian" "Vegetarian ...	VegetarianBeerProduct

Figure 8-33: Query - What are the Product-Services related to a given keyword

8.2.4.5 Product Query 5

Query

Query Description

What are the Support-Systems that a Product-Service uses?

KFL Code

```
(4PSPCtx.productUsesSupportSystem ?ps ?ss)
```

Query Result

?ps	?ss
VegetarianBeerProduct	VegetarianBeerSupportSystem

Figure 8-34: Query - What are the Support-Systems that a Product-Service uses

8.2.4.6 Product Query 6

Query

Query Description

What are the Product-Services associated to a Concept?

KFL Code

```
(4PSPCtx.productHasAssociatedConcept ?ps ?con)
```

Query Result

?ps	?con
VegetarianBeerProduct	VegetarianBeer

Figure 8-35: Query - What are the Product-Services associated to a Concept

8.2.4.7 Product Query 7

Query
Query Description
What Benefit is associated to a Product-Service?
KFL Code

```
(4PSPCtx.productHasAssociatedBenefit ?ps ?ben)
```

Query Result

?ps	?ben
VegetarianBeer	VegetarianBeerProductBenefit

Figure 8-36: Query - What Benefit is associated to a Product-Service

8.2.4.8 Product Query 8

Query
Query Description
What are the Product-Services associated to a Requirement?
KFL Code

```
(and
  (4PSPCtx.conceptHasAssociatedRequirement ?con ?req)
  (4PSPCtx.productHasAssociatedConcept ?ps ?con))
```

Query Result

?con	?req	?ps
VegetarianBeer	VegetarianBeerRequirement	VegetarianBeerProduct

Figure 8-37: Query - What are the Product-Services associated to a Requirement

8.2.4.9 Product Query 9

Query
Query Description
What Requirements and Stakeholders are related to a Product-Service?

KFL Code

```
(and
  (4PSPCtx.stakeholderSetsRequirement ?stk ?req)
  (4PSPCtx.conceptHasAssociatedRequirement ?con ?req)
  (4PSPCtx.productHasAssociatedConcept ?ps ?con))
```

Query Result

?stk	?req	?con	?ps
VegetarianBeerStakeHolder	VegetarianBeerRequirement	VegetarianBeer	VegetarianBeerProduct

Figure 8-38: Query – What Requirements and Stakeholders are related to a Product-Service

8.2.4.10 Product Query 10

Query

Query Description

List the Software and Hardware components of the Infrastructure that are used by the Support-system of a Product-service.

KFL Code

```
(and
  (4PSPCtx.infrastructureContainsHardware ?inf ?hard)
  (4PSPCtx.infrastructureContainsSoftware ?inf ?soft)
  (4PSPCtx.supportSystemContainsInfrastructure ?ss ?inf))
```

Query Result

?inf	?hard	?soft	?ss
infrastructure1	hardware1	software1	VegetarianBeerSupportSystem

Figure 8-39: Query - List the Software and Hardware components of the Infrastructure that are used by the Support-system of a Product-service

8.2.4.11 Product Query 11

Query

Query Description

What is the Support-Network of a Support-System that a Product-Service uses?

KFL Code

```
(and
   (4PSPCtx.productUsesSupportSystem ?ps ?ss)
   (4PSPCtx.supportSystemContainsSupportNetwork ?ss ?sn ))
```

Query Result

?ps	?ss	?sn
VegetarianBeerProduct	VegetarianBeerSupportSystem	VegetarianBeerSupportNetwork

Figure 8-40: Query - What is the Support-Network of a Support-System that a Product-Service uses

8.2.4.12 Product Query 12

Query

Query Description

What is the Idea and the Evaluation Scheme related to a Product-Service?

KFL Code

```
(and
   (4PSPCtx.productHasAssociatedIdea ?ps ?idea)
    (4PSPCtx.ideaHasAssociatedEvaluationScheme ?idea ?es))
```

Query Result

?ps	?idea	?es
VegetarianBeerProduct	DrinksForVeggies	VegetarianBeerES

Figure 8-41: Query – What is the Idea and the Evaluation Scheme related to a Product-Service

8.2.4.13 Product Query 13

Query

Query Description

What is the Life-Cycle associated to the Product-Service?

KFL Code

```
(4PSPCtx.productHasAssociatedLifeCycle ?ps ?lc)
```

Query Result

?ps	?lc
VegetarianBeer	VegetarianBeerLifeCycle

Figure 8-42: Query - What is the Life-Cycle associated to the Product-Service

8.2.4.14 Product Query 14

Query
Query Description
List the statuses of the Life-Cycle for a Product-Service.
KFL Code

```
(and
   (4PSPCtx.productHasAssociatedLifeCycle ?ps ?lc)
   (or
     (4PSPCtx.lifeCycleStatusSetAsDemandIdentification ?lc ?demId)
     (4PSPCtx.lifeCycleStatusSetAsFeasibilityStudy ?lc ?feaS)
     (4PSPCtx.lifeCycleStatusSetAsConceptDevelopment ?lc ?conDev)
     (4PSPCtx.lifeCycleStatusSetAsConfiguration ?lc ?conf)
     (4PSPCtx.lifeCycleStatusSetAsRealisation ?lc ?real)
     (4PSPCtx.lifeCycleStatusSetAsMaintenance ?lc ?main)
     (4PSPCtx.lifeCycleStatusSetAsTesting ?lc ?test)
     (4PSPCtx.lifeCycleStatusSetAsInService ?lc ?inS)
     (4PSPCtx.lifeCycleStatusSetAsUserExperience ?lc ?ux) ) )
```

Query Result

?ps	?lc	?demId	?feaS	?conDev	?conf	?real	?main	?test	?inS	?ux
Vegetarian...	Vegetarian...			Vegetarian...						

Figure 8-43: Query - List the statuses of the Life-Cycle for a Product-Service

8.2.4.15 Product Query 15 (CustomDrinks)

Query
Query Description
List of products in the Manufacturer Catalogue.
KFL Code

```
(and
(5CD_ManufacturerHasCatalogue ?man ?cat)
(5CD_CatalogueIsComposedBy ?cat ?prod ) )
```

Query Result

Custom-Drinks	Custom-Drinks-Catalogue	Tonica-Ledgers
Custom-Drinks	Custom-Drinks-Catalogue	Tonica-Canela-Ledgers
Custom-Drinks	Custom-Drinks-Catalogue	Tonica-Mandarina-Ledgers
Custom-Drinks	Custom-Drinks-Catalogue	Tonica-Regaliz-Ledgers
Custom-Drinks	Custom-Drinks-Catalogue	Bebida-Naranja-MEOrange
Custom-Drinks	Custom-Drinks-Catalogue	Bebida-Limon-MECitrus
Custom-Drinks	Custom-Drinks-Catalogue	Bebida-Naranja-LaGloria
Custom-Drinks	Custom-Drinks-Catalogue	Bebida-Limon-LaGloria
Custom-Drinks	Custom-Drinks-Catalogue	Bebida-Cola-LaGloria
Custom-Drinks	Custom-Drinks-Catalogue	Refresco-Pink-Cow
Custom-Drinks	Custom-Drinks-Catalogue	Energetica-Clasica-Eneryeti
Custom-Drinks	Custom-Drinks-Catalogue	Energetica-Tropical-Eneryeti
Custom-Drinks	Custom-Drinks-Catalogue	Mojito-sinAlc-Personalizada
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Manzana-Applezuvit
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Manzana-CAV
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Manzana-Personalizada
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Manzana-WAHR
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Aloe-WAHR
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Aloe-CAV
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Aloe-Personalizada
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Asai-WAHR
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Asai-CAV
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Asai-Personalizada
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Coco-WAHR
Custom-Drinks	Custom-Drinks-Catalogue	Zumo-Fraxipur
Custom-Drinks	Custom-Drinks-Catalogue	Rebujito-LaTita
Custom-Drinks	Custom-Drinks-Catalogue	Rebujito-Personalizada
Custom-Drinks	Custom-Drinks-Catalogue	Tonica-Pimienta-Prueba-Inovacion
Custom-Drinks	Custom-Drinks-Catalogue	Tonica-Pimienta-METonic
Custom-Drinks	Custom-Drinks-Catalogue	VinoTinto-Emina-Zero
Custom-Drinks	Custom-Drinks-Catalogue	VinoBlanco-SenorioDoCouto
Custom-Drinks	Custom-Drinks-Catalogue	VinoRosado-SenorioDoCouto

Figure 8-44: Query - List of products in the Manufacturer Catalogue

8.2.4.16 Product Query 16 (CustomDrinks)

Query
Query Description
List the requests of a client.
KFL Code

```
5CD_ProductRequest,
5CD_Requirements,5CD_Client

(and    (5CD_ClientCreatesProductRequest
?client ?req)
```

Query Result		
OneClient	OneClientRequest	OneClientRequest-Requirements

Figure 8-45: Query - List the requests of a client

8.2.4.17 Product Query 17 (CustomDrinks)

Query

Query Description

List the Machines in an assembly line.

KFL Code

```
5CD_Line, 5CD_Stage, 5CD_Machine

(and
    (5CD_LineIsComposedBy ?l ?st)
    (5CD_StageUsesMachine ?st ?m) )
```

Query Result

LineaDeEnlatado	Llenado	Enjuagadora-OMC-FM97-30P
LineaDeEnlatado	Llenado	Llenadora-BERTOLASO-Suprema-24-botella
LineaDeEnlatado	Llenado	Despaletizador-TGM-PAL-PAQ-Vega-120B+Enjuag...
LineaDeEnlatado	Llenado	Bloque-latas-COMAC-MCD/ZILLI-BELLINI
LineaDeEnlatado	Agrupado	Empacadora-GRAPHIC-PACKAGING-M-500
LineaDeEnlatado	Agrupado	Colocadora-Tapas-Plasticas-MYPAC
LineaDeEnlatado	Agrupado	Robot-Agrupador-KUKA-pack-cuello
LineaDeEnlatado	Agrupado	Encajonadora-SAMOVI-RICART-Wrap-Around-8500
LineaDeEnlatado	Agrupado	Horno-retractil-DIMAC-Star-One-F30
LineaDeEmbotellado	Taponado	Taponadora-AROL-ESSE-PK-RP-corona/maxicrown
LineaDeEmbotellado	Taponado	Taponadora-AROL-EURO/VA-screwcap-BVS-30H60
LineaDeEmbotellado	Taponado	Encorchadora-CLOSYS-Gemini-FT
LineaDeEmbotellado	Taponado	Alambradora-NORTAN-Mirage
LineaDeEmbotellado	Taponado	Taponadora-BERTOLASO-Alfa-110-screwcap
LineaDeEmbotellado	Taponado	Capsuladora-NORTAN-Bnicap-35W3
LineaDeEmbotellado	Taponado	Cerradora-EMERITO-Emerito-2_8-Twist-Off-f38+f43
LineaDeEmbotellado	Etiquetado	Etiquetadora-KRONES-Vinetta-Cola-fria
LineaDeEmbotellado	Etiquetado	Etiquetadora-SACMI-LABELLING-Opera-210
LineaDeEmbotellado	Etiquetado	Sleever-CLEVER-GS-301+Horno-CLEVER-STJ-2
LineaDeEmbotellado	Agrupado	Empacadora-GRAPHIC-PACKAGING-M-500
LineaDeEmbotellado	Agrupado	Colocadora-Tapas-Plasticas-MYPAC
LineaDeEmbotellado	Agrupado	Robot-Agrupador-KUKA-pack-cuello
LineaDeEmbotellado	Agrupado	Encajonadora-SAMOVI-RICART-Wrap-Around-8500
LineaDeEmbotellado	Agrupado	Horno-retractil-DIMAC-Star-One-F30
LineaDeEnlatado	Llenado	Despaletizador
LineaDeEmbotellado	Llenado	Enjuagadora-OMC-FM97-30P
LineaDeEmbotellado	Llenado	Llenadora-BERTOLASO-Suprema-24-botella
LineaDeEmbotellado	Llenado	Despaletizador-TGM-PAL-PAQ-Vega-120B+Enjuag...
LineaDeEmbotellado	Llenado	Bloque-latas-COMAC-MCD/ZILLI-BELLINI
LineaDeEmbotellado	Llenado	Despaletizador

Figure 8-46: Query - List the Machines in an assembly line

8.2.4.18 Product Query 18 (CustomDrinks)

Query
Query Description
What is the interdependency value between Conlesa and CustomDrinks in GPNetwork1?
KFL Code

```
(and (FuzzyNumber ?interdependValue)
(exists (?actor1 ?actor2 ?interdependency)
(and(playsRoleActorInGPNS Conlesa?actor1 GPNetwork1)
(playsRoleActorInGPNS CustomDrinks?actor2 GPNetwork1)
(actorInterDependencyOnActor ?actor1 ?interdependency ?actor2)
(actorInterDependencyHasValue ?interdependency ?interdependValue))))
```

Query Result

?interdependValue
(fuzzyValTripleFN 0.22 0.52 0.82)

Figure 8-47: Query - What is the interdependency value between Conlesa and CustomDrinks in GPNetwork1?

8.2.4.19 Product Query 19 (INDESIT)

Query
Query Description
Which suppliers in Global Production Network Scenario PSP_GPN supply the component Uboard as an output?
KFL Code

```
(exists (?supplier ?output)
        (and (2DSCtx.Supplier ?supplier)
  (playsRole ?facility ?supplier PSP_GPN)
  (Output ?output)
  (playsRole Uboard ?output PSP_GPN)
  (systemContainsRole ?facility ?output)
  )
```

)

Query Result

```
(exists (?supplier ?output)
   (and (2DSCtx.Supplier ?supplier)
   (playsRole ?facility ?supplier PSP_GPN)
   (Output ?output)
   (playsRole Uboard ?output PSP_GPN)
   (systemContainsRole ?facility ?output)
   )
)
```

?facility
Singapore1_2
Singapore1_1
Singapore1

Figure 8-48: Query - Which suppliers in Global Production Network Scenario PSP_GPN supply the component Uboard as an output?

8.2.4.20 Product Query 20 (INDESIT)

Query
Query Description
Which components do the Product i_Dryer001 and the Service SmartMaintenance both utilise in Global Production Network Scenario PSP_GPN?
KFL Code
(exists (?part ?partTop ?partContained) (and (EnergySavingDryer i_Dryer001) (basicContainsBasic i_Dryer001 ?part) (basicContainsBasic ?partTop ?partContained) (partContains ?partContained ?component) (playsRole ?component SmartMaintenance INDESIT_PSP_GPN)))
Query Result

```
(exists (?part ?partTop ?partContained)
(and
(EnergySavingDryer i_Dryer001)
(basicContainsBasic i_Dryer001 ?part)
(basicContainsBasic ?partTop ?partContained)
(partContains ?partContained ?component)
(playsRole  ?component SmartMaintenance PSP_GPN)
))
```

?component
Harness
Iboard
Ihousing
RFIfilter
Uboard
Ubracket

Figure 8-49: Query - Which components do the Product i_Dryer001 and the Service Smart Maintenance both utilise in Global Production Network Scenario PSP_GPN?

8.2.4.21 Product Query 21 (INDESIT)

Query
Query Description
Does the product i_Dryer001 contain the component Uboard which is required by Service SmartMaintenance?
KFL Code
(exists (?part ?partTop ?partContained) (and (EnergySavingDryer i_Dryer001) (basicContainsBasic i_Dryer001 ?part) (basicContainsBasic ?partTop ?partContained) (partContains ?partContained Uboard) (playsRole Uboard SmartMaintenance PSP_GPN)))
Query Result

```
(exists (?part ?partTop ?partContained)
(and
(EnergySavingDryer i_Dryer001)
(basicContainsBasic i_Dryer001 ?part)
(basicContainsBasic ?partTop ?partContained)
(partContains ?partContained Uboard)
(playsRole Uboard SmartMaintenance PSP_GPN)
))
```

The query is a **true** statement. It contained no variables, so there are no values to display.

Figure 8-50: Query - Does the product i_Dryer001 contain the component Uboard which is required by Service Smart Maintenance?

8.2.4.22 Product Query 21 (INDESIT)

Query
Query Description
Which components does the Service SmartMaintenance require which are not contained by the Product i_Dryer001?
KFL Code
(exists (?listProductComponents) (and (2DSCtx.Component ?serviceComponent) (playsRole ?serviceComponent SmartMaintenance PSP_GPN) (setof ?productComponent (and (EnergySavingDryer i_Dryer001) (basicContainsBasic i_Dryer001 ?part) (basicContainsBasic ?partTop ?partContained) (partContains ?partContained ?productComponent)) ?listProductComponents) (not (item ?listProductComponents ?serviceComponent))))
Query Result

```
(exists (?listProductComponents)
   (and (2DSCtx.Component ?serviceComponent)
        (playsRole  ?serviceComponent SmartMaintenance PSP_GPN)
        (setof ?productComponent
            (and  (EnergySavingDryer i_Dryer001)
                  (basicContainsBasic i_Dryer001 ?part)
                  (basicContainsBasic ?partTop ?partContained)
                  (partContains ?partContained ?productComponent))
         ?listProductComponents)
   (not (item ?listProductComponents ?serviceComponent))
   )
)
```

?serviceComponent

Harnesschannel

Figure 8-51: Query - Which components does the Service Smart Maintenance require which are not contained by the Product i_Dryer001?

8.2.5 Queries for Business

The following is a list of the queries that apply to the FLEXINET 'Business' scope, they are:

Business Query 1. List of Business Ideas in the Knowledge Base.
Business Query 2. List of Targets influencing every business Model.
Business Query 3. List of factors influencing a Business Model developed within a project.
Business Query 4. List of customer types related with a business model.
Business Query 5. What is the list of Objectives for a New Business Model?
Business Query 6. What is the list of Targets associated with a strategy (and Business Idea) and which is the product related to.
Business Query 7. What is the list of Applications Areas in KSB?
Business Query 8. What are the indicators and threshold values for a given organisation? (see Section 8.2.2)
Business Query 9. Which facilities match the specified threshold values? (see Section 8.2.2)
Business Query 10. Who are the facilities that match the supplier requirements for a given organisation? (see Section 8.2.2)
Business Query 11. Does the given organisation threshold values match the given set of end user facility threshold values? (see Section 8.2.2)

Additionally, it must be noted that the 'Business Queries 4 to 7' are listed within the 'Queries for Services' also apply to the 'Business' scope (hence, are listed here too). Please see Section 8.2.2 on Queries for Services to see the KFL code and example results.

8.2.5.1 Business Query 1

Query
Query Description
List of Business Ideas in the Knowledge Base.
KFL Code

```
(and
(DefProject ?project ?BusinessIdea ?BM)
(2DSCtx.Idea ?BusinessIdea))
```

Query Result

?BusinessIdea	?project	?BM
ProductBeberage	BusinessProjectManufacturing_2015_0102	BM_Beberage_Asia
ProductIdeaPump	BusinessProjectManufacturing_2015_0100	BM_Pump_China
ProductIdeaWashmachine	BusinessProjectManufacturing_2015_0101	BM_WashMachine_Europe

Figure 8-52: Query - List of Business Ideas in the Knowledge Base

8.2.5.2 Business Query 2

Query
Query Description
List of Targets influencing every business Model.
KFL Code

```
(and
(BusinessModel ?BM)
(BusinessModelHasTargets ?BM ?targets)
(= ?targets (RootCtx.listof ?target1 ?target2)))
```

Query Result

?BM	?targets	?target1	?target2
BM_WashMachine_Europe	(RootCtx.listof Market_Europe Over25)	Market_Europe	Over25
BM_Beberage_Asia	(RootCtx.listof Market_Asia Customer_Teen)	Market_Asia	Customer_Teen
BM_Pump_China	(RootCtx.listof Market_China SMEs)	Market_China	SMEs

Figure 8-53: Query – List of Targets influencing every business Model

8.2.5.3 Business Query 3

Query
Query Description
List of factors influencing a Business Model developed within a project.
KFL Code

```
(and
(DefProject ?ProjectName ? ?BM)
(BusinessModel ?BM)
(ListOfIndicatorsOnBM ?BM ?indicatorlist)
(= ?indicatorlist (RootCtx.listof ?indicator1 ?indicator2)))
```

Query Result

?ProjectName	?BM	?indicatorlist	?indicator1	?indicator2
BusinessProjectManufacturing_2015_0101	BM_WashMachine_Europe	(RootCtx.listof GDP WaterWaste)	GDP	WaterWaste
BusinessProjectManufacturing_2015_0102	BM_Beberage_Asia	(RootCtx.listof GDP Age)	GDP	Age
BusinessProjectManufacturing_2015_0100	BM_Pump_China	(RootCtx.listof GDP AvgSMEsSize)	GDP	AvgSMEsSize

Figure 8-54: Query – List of factors influencing a Business Model developed within a project

8.2.5.4 Business Query 4

Query
Query Description
List of customer types related with a business model.
KFL Code

```
(and
(BusinessModel ?BM)
(BusinessModelHasTargets ?BM ?targets)
(= ?targets (RootCtx.listof ?target1 ?target2))
(Customer ?customer)
(or (= ?customer ?target1) (= ?customer ?target2)))
```

Query Result

?BM	?targets	?target1	?target2	?customer
BM_WashMachine_Europe	(RootCtx.listof Market_Europe Over25)	Market_Europe	Over25	Over25
BM_Pump_China	(RootCtx.listof Market_China SMEs)	Market_China	SMEs	SMEs

Figure 8-55: Query – List of customers types related with a business Models

8.2.5.5 Business Query 5 (KSB)

Query
Query Description
What is the list of Objectives for a New Business Model?
KFL Code

```
(and (5KSB_BusinessModelDefinition ?businessModel ? ?objectives ?)
(5KSB_BusinessModel ?businessModel)
(5KSB_Objective ?objectives))
```

Query Result

?businessModel	?objectives
PumpEfficent558Asia	MarketAsia
PumpEfficent558Asia	CustomerSMES
PumpEfficent558Asia	Standard460

Figure 8-56: Query - What is the list of Objectives for a New Business Model

8.2.5.6 Business Query 6 (KSB)

Query
Query Description
What is the list of Targets associated with a strategy (and Business Idea) and which is the product related to?
KFL Code

```
(and (5KSBCtx.5KSB_Pump ?product)
(5KSB_BussinesIdeaProductDefinition ?idea ?product ?applicationArea)
(5KSB_DefinitionBM ?idea ? ?strategy ?)
(5KSB_StrategyHasTarget ?strategy ?target))
```

Query Result

?product	?idea	?applicationArea	?strategy	?target
Pump_H4100	NewLowerEnergyPumpIdea	Water	NewLowerEnergyPumpStrategy	PumpEnvProtection
Pump_H4100	NewLowerEnergyPumpIdea	Water	NewLowerEnergyPumpStrategy	PumpHighSustainability

Figure 8-57: Query - What is the list of Targets associated with a strategy (and Business Idea) and which is the product related to

8.2.5.7 Business Query 7 (KSB)

Query

Query Description

What is the list of Applications Areas in KSB?

KFL Code

```
(5KSB_Application ?areas)
```

Query Result

?areas
Water
Waste_Water
Energy
Industry
Building_Services

Figure 8-58: Query - What is the list of Applications Areas in KSB

8.2.6 Queries for Risk

The following is a list of the queries that apply to the FLEXINET 'Risk' scope, they are:

Risk Query 1. Find the risk factors for LibraryExampleFacilities and their attributes.
Risk Query 2. Find the Risk Factors and their attributes.
Risk Query 3. Find Risk Factors.
Risk Query 4. Find the Facility Specific Risk Factors.
Risk Query 5. Find the Location Specific Risk Factors and the Locations to which they apply.
Risk Query 6. Find the Location Specific risk Factors which apply to Library Example Country.

Risk Query 7. Find the Risk Factors (and their names) which have associated Incidents.

Risk Query 8. For risk factor Major Techno Challenge LibraryEx find the name, description, list the actors affected by it, what it influences, its data source and its mitigation method.

Risk Query 9. Find the risk factors which depend on Major Techno Challenge LibraryEx and their dependencies values.

Risk Query 10. Find the Facilities and their perturbation values in scenario GPNetwork1 + Risk1.

Risk Query 11. Find the Interdependencies and their values between the Facilities which play roles in Scenario.

Risk Query 12. Find the Interdependencies and their values between the Facilities which play roles in Scenario GPNetwork1 + Risk1.

Risk Query 13. Perturbation value for the Facility CustomDrinks in scenario GPNetwork1 + Risk1.

8.2.6.1 Risk Query 1

Query

Query Description

Find the risk factors for LibraryExampleFacilities and their attributes.

KFL Code

```
(and   (2DSCtx.Facility LibraryExampleFacility)
       (riskFactorAppliesToFacility ?factor LibraryExampleFacility)
       (name ?factor ?name)
       (riskFactorHasDataSource ?factor ?datasource)
       (riskFactorHasDescription ?factor ?description)
       (setof ?actortype (riskFactorHasActorType ?factor ?actortype) ?l)
)
```

Query Result

?factor	?name	?datasource	?description	?l
MachineModIssueLibraryEx	"Significant Changes to Business M...	"Historical data, experts' judgement."	"Problems that can arise as a result of m...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
MachineModIssueLibraryEx	"Machine Modification Issues"	"Historical data, experts' judgement."	"Problems that can arise as a result of m...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
InsolvencyClientsLibraryEx	"Insolvency of Clients"	"Credit ratings or other types of financial ...	"Insolvency of the client can lead to it bei...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
InadequatePSQualLibraryEx	"Inadequate Product/Service Quality"	"Historical statistics (or experts' judgeme...	"This risk refers to the situation where th...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
DelayedDeliveriesLibraryEx	"Delayed Deliveries"	"Historical statistics (or experts' judgeme...	"When the supplier or the intermediary is ...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
InadequatePQuanLibraryEx	"Inadequate Product Quantity"	"Historical statistics (or experts' judgeme...	"When the supplier is incapable of deliveri...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
SupplierDependencyLibraryEx	"Dependency on Supplier(s)"	"Number of suppliers available for a type ...	"If the end-user depends on particular su...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
FinancialInstabilitySuppliersLibraryEx	"Financial Instability of Suppliers"	"Credit ratings or other types of financial ...	"The financial problems that the supplier i...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
TechnoChallengeLibraryEx	"Technological Challenge"	"Experts' judgement, business model (pr...	"The challenges that can arises as a resul...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...
FoodSafetyLibraryEx	"Food Safety Issues"	"Food Hygiene Ranking/Rating (of the act...	"The problems that can arise in processin...	(RootCtx.listof 2DSCtx.Consumer 2DSCtx.Consumer 2DSCtx.Co...

Figure 8-59: Query – Find the risk factors for LibraryExampleFacilities and their attributes

8.2.6.2 *Risk Query 2*

Query
Query Description
Find the Risk Factors and their attributes.
KFL Code

```
(and (RiskFactor ?factor) (name ?factor ?name)
(riskFactorHasDescription ?factor ?description)
(riskFactorHasActorType ?factor ?actortype)
(riskFactorInfluences ?factor ?influence)
(riskFactorHasDataSource ?factor ?datasource)
(riskFactorHasMitigationMethod ?factor ?method))
 (and (LocationSpecificRiskFactor ?locFactor)
(riskFactorAppliesToLocation ?locFactor ?location))
```

Query Result

?factor	?name	?description	?actortype	?influence	?datasource	?method	?locFactor	?location
UnanticipatedLevelDemandLi...	"Unanticipated Level of Dem...	"When the level of productio...	Customer	"Demand"	"Historical data about variations...	"Improve demand forecasting, ...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
UnanticipatedLevelDemandLi...	"Unanticipated Level of Dem...	"When the level of productio...	Customer	"Demand"	"Historical data about variations...	"Avoid at risk clients, Insurance...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
UnanticipatedLevelDemandLi...	"Unanticipated Level of Dem...	"When the level of productio...	Consumer	"Demand"	"Historical data about variations...	"Improve demand forecasting, ...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
UnanticipatedLevelDemandLi...	"Unanticipated Level of Dem...	"When the level of productio...	Consumer	"Demand"	"Historical data about variations...	"Avoid at risk clients, Insurance...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
ChangesMarketTrendsLibrar...	"Changes in Market Trends"	"New technologies or trends ...	Customer	"Demand"	"Consumer surveys."	"Observe the market trends an...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
ChangesMarketTrendsLibrar...	"Changes in Market Trends"	"New technologies or trends ...	Consumer	"Demand"	"Consumer surveys."	"Observe the market trends an...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
Import/ExportControlsLibraryEx	"Import or Export Controls"	"Countries may impose impo...	Intermediary	"Product Time of Delivery and ...	"Tariffs, transparency in the loc...	"Sourcing/production/market in...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
LegalReqtsInfLibraryEx	"Legal Requirements' Infring...	"none"	Supplier	"Legal Restrictions"	"Probably available through 'Bu...	"Comply with legal requirement...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
PoliticalInstabilityLibraryEx	"Political Instability"	"Issues that related to the po...	ServiceProvider	"Personnel"	"Political risk rankings (such as ...	"Avoid at risk regions, prepare ...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
PriceCurrencyRisk/InflationLi...	"Price and Currency Risks/Inf...	"Economic regions within a r...	Supplier	"Finance"	"Economic risk rankings"	"Use reliable currencies, avoid ...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
PriceCurrencyRisk/InflationLi...	"Price and Currency Risks/Inf...	"Economic regions within a r...	Producer	"Finance"	"Economic risk rankings"	"Use reliable currencies, avoid ...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
PriceCurrencyRisk/InflationLi...	"Price and Currency Risks/Inf...	"Economic regions within a r...	Intermediary	"Finance"	"Economic risk rankings"	"Use reliable currencies, avoid ...	HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
FoodSafetyLibraryEx	"Food Safety Issues"	"The problems that can arise...	Customer	"Product Quality"	"Food Hygiene Ranking/Rating (...	"Comply with limitations for ing...	UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal
FoodSafetyLibraryEx	"Food Safety Issues"	"The problems that can arise...	Supplier	"Product Quality"	"Food Hygiene Ranking/Rating (...	"Comply with limitations for ing...	UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal
FoodSafetyLibraryEx	"Food Safety Issues"	"The problems that can arise...	Producer	"Product Quality"	"Food Hygiene Ranking/Rating (...	"Comply with limitations for ing...	UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal
GlobalSourcingLibraryEx	"Risk of Global Sourcing"	"The general risks that can a...	Intermediary	"Product Time of Delivery, Quali...	"Regional distance of source an...	"Local sourcing, Limit variety of...	UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal
SupplierDependencyLibraryEx	"Dependency on Supplier(s)"	"If the end-user depends on ...	Supplier	"Time of Delivery, Quality and ...	"Number of suppliers available f...	"Increase the number of suppli...	UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal
SupplierDependencyLibraryEx	"Dependency on Supplier(s)"	"If the end-user depends on ...	Producer	"Time of Delivery, Quality and ...	"Number of suppliers available f...	"Increase the number of suppli...	UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal

Figure 8-60: Query – Find the Risk Factors and their attributes

8.2.6.3 *Risk Query 3*

Query
Query Description
Find Risk Factors.
KFL Code

```
(RiskFactor ?factor)
```

Query Result

?factor
HighCostOwnerShipLibraryEx
EnvtPollutionLibraryEx
Import/ExportControlsLibraryEx
FoodSafetyLibraryEx
FutureRegulationLibraryEx
DelayedDeliveriesLibraryEx
MajorTechnoChallengeLibraryEx
GlobalSourcingLibraryEx
TechnoChallengeLibraryEx
SignificantChangesBMLibraryEx
SupplierDependencyLibraryEx
InadequatePSQualLibraryEx
ChangesMarketTrendsLibraryEx
MachineModIssueLibraryEx
ReadinessAdaptTechLibraryEx
InsolvencyClientsLibraryEx
UnavailabilityIngr/MatLibraryEx
UnanticipatedLevelDemandLibraryEx
InadequatePQuanLibraryEx
PriceCurrencyRisk/InflationLibraryEx
LegalReqtsInfLibraryEx
LegalUncertainyLibraryEx
FinancialInstabilitySuppliersLibraryEx
UncertaintyNewMarketLibraryEx
PoliticalInstabilityLibraryEx

Figure 8-61: Query – Find Risk Factors

8.2.6.4 Risk Query 4

Query
Query Description
Find the Facility Specific Risk Factors.
KFL Code
(FacilitySpecificRiskFactor ?facilityFactor)
Query Result

?facilityFactor
DelayedDeliveriesLibraryEx
FinancialInstabilitySuppliersLibraryEx
FoodSafetyLibraryEx
InadequatePQuanLibraryEx
InadequatePSQualLibraryEx
InsolvencyClientsLibraryEx
MachineModIssueLibraryEx
SignificantChangesBMLibraryEx
SupplierDependencyLibraryEx
TechnoChallengeLibraryEx

Figure 8-62: Query – Find the Facility Specific Risk Factors

8.2.6.5 Risk Query 5

Query
Query Description
Find the Location Specific Risk Factors and the Locations to which they apply.
KFL Code
(and (LocationSpecificRiskFactor ?locFactor) (riskFactorAppliesToLocation ?locFactor ?location))
Query Result

?locFactor	?location
UncertaintyNewMarketLibraryEx	LibraryExampleCountry
UncertaintyNewMarketLibraryEx	LibraryExampleState/Province
UnanticipatedLevelDemandLibraryEx	LibraryExampleGlobal
ChangesMarketTrendsLibraryEx	LibraryExampleGlobal
Import/ExportControlsLibraryEx	LibraryExampleCountry
LegalReqtsInfLibraryEx	LibraryExampleState/Province
LegalReqtsInfLibraryEx	LibraryExampleCountry
FutureRegulationLibraryEx	LibraryExampleState/Province
MajorTechnoChallengeLibraryEx	LibraryExampleGlobal
PoliticalInstabilityLibraryEx	LibraryExampleState/Province
PriceCurrencyRisk/InflationLibraryEx	LibraryExampleCountry
EnvtPollutionLibraryEx	LibraryExampleCountry
LegalUncertainyLibraryEx	LibraryExampleState/Province
LegalUncertainyLibraryEx	LibraryExampleCountry
UnavailabilityIngr/MatLibraryEx	LibraryExampleGlobal
HighCostOwnerShipLibraryEx	LibraryExampleEconomicGroup
ReadinessAdaptTechLibraryEx	LibraryExampleEconomicGroup
UncertaintyNewMarketLibraryEx	LibraryExampleEconomicGroup
GlobalSourcingLibraryEx	LibraryExampleGlobal

Figure 8-63: Query – Find the Location Specific Risk Factors and the Locations to which they apply

8.2.6.6 Risk Query 6

Query
Query Description
Find the Location Specific risk Factors which apply to LibraryExampleCountry.
KFL Code

```
(and (LocationSpecificRiskFactor ?locFactor)
(riskFactorAppliesToLocation ?locFactor LibraryExampleCountry))
```

Query Result

?locFactor
LegalUncertainyLibraryEx
Import/ExportControlsLibraryEx
LegalReqtsInfLibraryEx
PriceCurrencyRisk/InflationLibraryEx
EnvtPollutionLibraryEx
UncertaintyNewMarketLibraryEx

Figure 8-64: Query – Find the Location Specific risk Factors which apply to LibraryExampleCountry

8.2.6.7 Risk Query 7

Query
Query Description
Find the Risk Factors (and their names) which have associated Incidents.
KFL Code

```
(and (RiskFactor ?factor) (name ?factor ?name)
 (riskFactorHasIncident ?factor ?incident))
```

Query Result

?factor	?name	?incident
FoodSafetyLibraryEx	"Food Safety Issues"	IncidentLibraryEx

Figure 8-65: Query – Find the Risk Factors (and their names) which have associated Incidents

8.2.6.8 Risk Query 8

Query
Query Description
For Risk Factor MajorTechnoChallengeLibraryEx find the name, description, list the actors affected by it, what it influences, its data source and its mitigation method.
KFL Code

```
(and (name MajorTechnoChallengeLibraryEx ?name)
(riskFactorHasDescription MajorTechnoChallengeLibraryEx ?description)
(setof ?actortype (riskFactorHasActorType MajorTechnoChallengeLibraryEx ?actortype)?L)
(riskFactorInfluences MajorTechnoChallengeLibraryEx ?influence)
(riskFactorHasDataSource MajorTechnoChallengeLibraryEx ?datasource)
(riskFactorHasMitigationMethod MajorTechnoChallengeLibraryEx ?method))
```

Query Result

?name	?description	?L	?influence	?datasource	?method
"Major Technological Change"	"New technological developments can affect the dem...	(listof Consumer Customer)	"Demand"	"Experts' judgement, consumer surveys."	"Research new technologies and prepare."

Figure 8-66: Query – Find the Major Technological Challenges Risk Factors

8.2.6.9 Risk Query 9

Query
Query Description
Find the riskfactors which depend on MajorTechnoChallengeLibraryEx and their dependencies values.
KFL Code
(riskFactorDeptValueOnRF MajorTechnoChallengeLibraryEx ?fuzzyNumber ?factor)
Query Result

?fuzzyNumber	?factor
(fuzzyValTripleFN 0.1 0.2 0.3)	MachineModIssueLibraryEx
(fuzzyValTripleFN 0.1 0.2 0.3)	SignificantChangesBMLibraryEx

Figure 8-67: Query – Find dependency values for Major Technological Challenges Risk Factors

8.2.6.10 Risk Query 10

Query
Query Description
Find the facilities and their perturbation values in scenario GPNetwork1+Risk1.
KFL Code
(and (2DSCtx.Facility ?facility) (FuzzyMeasure ?perturbValue) (exists (?perturb ?actor) (and (requiresA ?actor ?facility) (perturbationHasValue ?perturb ?perturbValue) (playsRole ?perturb ?actor GPNetwork1+Risk1))))
Query Result

?facility	?perturbValue
Verallia	(riskFuzzyValTripleFN 0.36 0.56 0.66)
Ullama	(riskFuzzyValTripleFN 0.1 0.2 0.3)
Sunset	(riskFuzzyValTripleFN 0.39 0.59 0.69)
Rivera_Japan	(riskFuzzyValTripleFN 0.39 0.59 0.69)
Lopez_Pampin	(riskFuzzyValTripleFN 0.3 0.5 0.7)
CustomDrinks	(riskFuzzyValTripleFN 0.38 0.58 0.68)
Conlesa	(riskFuzzyValTripleFN 0.32 0.52 0.62)
Castrillo	(riskFuzzyValTripleFN 0.37 0.57 0.67)
Casado	(riskFuzzyValTripleFN 0.4 0.5 0.7)
Agrovin	(riskFuzzyValTripleFN 0.3 0.5 0.6)

Figure 8-68: Query – Find the facilities and their perturbation values in scenario GPNetwork1+Risk1

8.2.6.11 Risk Query 11

Query
Query Description
Find the Interdependencies and their values between the facilities which play roles in Scenario.
KFL Code
(exists (?actor1 ?actor2 ?interdependency) (and (playsRoleActor ?facility1 ?actor1 GPNetwork1+Risk1) (playsRoleActor ?facility2 ?actor2 GPNetwork1+Risk1) (nodeInterDependencyOnNode ?facility1 ?interdependency ?facility2) (nodeInterDependencyHasValue ?interdependency ?interdependValue)))
Query Result

?facility1	?facility2	?interdependValue
Verallia	CustomDrinks	(riskFuzzyValTripleFN 0.23 0.53 0.83)
Sunset	CustomDrinks	(riskFuzzyValTripleFN 0.35 0.56 0.86)
Rivera_Japan	CustomDrinks	(riskFuzzyValTripleFN 0.34 0.55 0.85)
Castrillo	CustomDrinks	(riskFuzzyValTripleFN 0.24 0.54 0.84)
Lopez_Pampin	Ullama	(riskFuzzyValTripleFN 0.1 0.2 0.3)
Ullama	Lopez_Pampin	(riskFuzzyValTripleFN 0.5 0.6 0.7)
Ullama	CustomDrinks	(riskFuzzyValTripleFN 0.6 0.7 0.9)
Agrovin	CustomDrinks	(riskFuzzyValTripleFN 0.21 0.51 0.81)
CustomDrinks	Casado	(riskFuzzyValTripleFN 0.1 0.6 0.9)
CustomDrinks	Agrovin	(riskFuzzyValTripleFN 0.11 0.61 0.91)
CustomDrinks	Conlesa	(riskFuzzyValTripleFN 0.12 0.62 0.92)
CustomDrinks	Verallia	(riskFuzzyValTripleFN 0.13 0.63 0.93)
CustomDrinks	Castrillo	(riskFuzzyValTripleFN 0.14 0.64 0.94)
CustomDrinks	Rivera_Japan	(riskFuzzyValTripleFN 0.15 0.65 0.95)
CustomDrinks	Sunset	(riskFuzzyValTripleFN 0.17 0.67 0.97)
Casado	CustomDrinks	(riskFuzzyValTripleFN 0.2 0.5 0.8)
CustomDrinks	Ullama	(riskFuzzyValTripleFN 0.3 0.4 0.5)
Conlesa	CustomDrinks	(riskFuzzyValTripleFN 0.22 0.52 0.82)

Figure 8-69: Query – Find the Interdependencies and their values between the facilities which play roles in Scenario

8.2.6.12 Risk Query 12

Query
Query Description
Find the Interdependencies and their values between the facilities which play roles in Scenario GPNetwork1+Risk1.
KFL Code
(exists (?actor1 ?actor2 ?interdependency) (and (playsRoleActor ?facility1 ?actor1 GPNetwork1+Risk1) (playsRoleActor ?facility2 ?actor2 GPNetwork1+Risk1) (nodeInterDependencyOnNode ?facility1 ?interdependency ?facility2) (nodeInterDependencyHasValue ?interdependency ?interdependValue)))
Query Result

?facility1	?facility2	?interdependValue
Verallia	CustomDrinks	(riskFuzzyValTripleFN 0.23 0.53 0.83)
Sunset	CustomDrinks	(riskFuzzyValTripleFN 0.35 0.56 0.86)
Rivera_Japan	CustomDrinks	(riskFuzzyValTripleFN 0.34 0.55 0.85)
Castrillo	CustomDrinks	(riskFuzzyValTripleFN 0.24 0.54 0.84)
Lopez_Pampin	Ullama	(riskFuzzyValTripleFN 0.1 0.2 0.3)
Ullama	Lopez_Pampin	(riskFuzzyValTripleFN 0.5 0.6 0.7)
Ullama	CustomDrinks	(riskFuzzyValTripleFN 0.6 0.7 0.9)
Agrovin	CustomDrinks	(riskFuzzyValTripleFN 0.21 0.51 0.81)
CustomDrinks	Casado	(riskFuzzyValTripleFN 0.1 0.6 0.9)
CustomDrinks	Agrovin	(riskFuzzyValTripleFN 0.11 0.61 0.91)
CustomDrinks	Conlesa	(riskFuzzyValTripleFN 0.12 0.62 0.92)
CustomDrinks	Verallia	(riskFuzzyValTripleFN 0.13 0.63 0.93)
CustomDrinks	Castrillo	(riskFuzzyValTripleFN 0.14 0.64 0.94)
CustomDrinks	Rivera_Japan	(riskFuzzyValTripleFN 0.15 0.65 0.95)
CustomDrinks	Sunset	(riskFuzzyValTripleFN 0.17 0.67 0.97)
Casado	CustomDrinks	(riskFuzzyValTripleFN 0.2 0.5 0.8)
CustomDrinks	Ullama	(riskFuzzyValTripleFN 0.3 0.4 0.5)
Conlesa	CustomDrinks	(riskFuzzyValTripleFN 0.22 0.52 0.82)

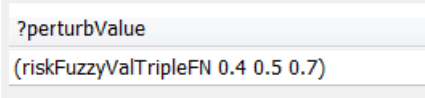
Figure 8-70: Query – Find the Interdependencies and their values between the facilities which play roles in Scenario GPNetwork1+Risk1

8.2.6.13 Risk Query 13

Query
Query Description
Find Perturbation value for the Facility CustomDrinks in scenario GPNetwork1+Risk1.
KFL Code
(and

```
(FuzzyMeasure ?perturbValue)
(exists (?perturb ?actor)
(and (requiresA ?actor CustomDrinks)
(perturbationHasValue ?perturb ?perturbValue)
(playsRole  ?perturb ?actor GPNetwork1+Risk1))))
```

Query Result



?perturbValue
(riskFuzzyValTripleFN 0.4 0.5 0.7)

Figure 8-71: Query – Find Perturbation value for the Facility CustomDrinks in scenario GPNetwork1+Risk1

9 Conclusions

FLEXINET has developed and tested a comprehensive Product-Service production reference ontology. It has shown that this reference ontology provides a basis for information interoperability between the FLEXINET applications and also provides a reference for the development of specific end user knowledge bases. Its capability is targeted at FLEXINET's strategic and tactical decision support software tools that cover: collaboration support for ideas management and Product-Service configuration; business model development; global production network configuration and risk management. These topic areas are used as business recognisable headings, mapped from the three software service areas of the project described in WP5 i.e. economic and risk assessment, Product-Service lifecycle management and production networks evaluation.

The final full version of the FLEXINET reference ontology, end user ontologies, knowledge bases and query sets are presented in D3.5, highlighting the key improvements since the delivery of D3.3 and D3.4. The list of key changes is set out in Section 1.2.1 of the document for easy identification. More substantial end user knowledge bases have been developed as a result of the WP6 and WP7 end user customisation activities. These provide the core integration route for FLEXINET applications via a combination of REST interfaces within the applications and calls to the queries presented in this deliverable. The end user knowledge bases are provided in the separate End User Annex document while a generic set of facts, based on the fictitious Buzz Bikes business exemplar is provided here. The software services perspective on integration will be provided in D5.10.

The key global production network elements of the reference ontology are in the process of being standardised as ISO 20534 within ISO TC184 SC4 JWG8. ISO 20534 is entitled "Formal Semantic Models for the Configuration of Global Production Networks". It has been accepted as a New Work Item and is at the stage of being developed as a Committee Draft. The other categories of the ontology would also benefit from standardisation in the longer term, but would require further effort beyond that available within FLEXINET, to take to a level suitable for standardisation. These categories of the ontology will none-the-less be made freely available for use to any interested parties.

The focus of FLEXINET has been towards support for strategic and tactical decision-making. Operational level decisions are not in scope for FLEXINET and have not been addressed to any depth in the ontology presented here. This is an important and substantial extension that is required towards the development of a full manufacturing reference ontology. Partners in the FLEXINET consortium have submitted a new project proposal where part of that funding, if successful, will support a contribution in this area.

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11 Annex A: Level 1 Ontology Code

Contained herein is the KFL and ECLIF code for the FLEXINET Level 1 reference ontology:

11.1 Level 1 Context

```
:Use MLO

:Ctx 1SYSCtx
:Inst UserContext
:supCtx MLO
```

11.2 Level 1 Properties

```
:Name "1SYS - Properties"
:Description "This file contains the definition of the properties for the Systems level of the FLEXINET Project reference ontology"

:Use 1SYSCtx

:Prop Basic
:Inst Type
:Inst NonLogicalFunctor
:sup Particular
:rem "A Basic concept is independent of the <sym>1SYSCtx.System</sym> or context, its definition does not depend on another concept.
At the Systems level a Basic can be classified as <sym>1SYSCtx.System</sym> or <sym>1SYSCtx.Entity</sym>."

:Prop System
:Inst Type
:sup Basic
:sup MLO.Object
:rem "A group of inter-related objects played by <sym>1SYSCtx.Role</sym>s."
:referenceRem "2014 FLEXINET D3.1"
(disjointSubProps System)

:Prop Entity
:Inst Type
:Inst NonLogicalFunctor
:sup Basic
:partitionedBy (listof Energy Material Information)
:rem "A <sym>1SYSCtx.Basic</sym> which is not a <sym>1SYSCtx.System</sym>."

:Prop Energy
:Inst Type
:Inst NonLogicalFunctor
:sup Entity
```

:rem "The capacity of a body or <sym>1SYSCtx.System</sym> to do work. Could be an integer so modelled as a <sym>MLO.NonLogicalFunctor</sym>.
Properties subsumed by Energy should also be subsumed by <sym>MLO.ConcreteEntity</sym> or <sym>MLO.AbstractEntity</sym>"
:referenceRem "Collins English Dictionary.
http://www.collinsdictionary.com/dictionary/english/energy."
(disjointSubProps Energy)

:Prop Material
:Inst Type
:sup Entity
:sup MLO.Object
:rem "A physical substance that things can be made from. An <sym>MLO.Object</sym> is anything that has a location in time and space."
:referenceRem "Cambridge Dictionaries Online.
http://dictionary.cambridge.org/dictionary/british/material."
(disjointSubProps Material)

:Prop Information
:Inst Type
:Inst NonLogicalFunctor
:sup Entity
:rem "Information is data put in context; it is related to other pieces of data. Could be a number so modelled as a <sym>MLO.NonLogicalFunctor</sym>. Properties subsumed by Information should also
be subsumed by <sym>MLO.ConcreteEntity</sym> or <sym>MLO.AbstractEntity</sym>."
:referenceRem "Liew,A. 2007. Understanding Data, Information, Knowledge And Their Inter-Relationships. Journal of Knowledge Management Practice, Vol. 8, No. 2"
(disjointSubProps Information)

:Prop Role
:Inst Type
:sup MLO.AbstractEntity
:disjointWith Basic
:rem "The Role type includes all of the types of <sym>MLO.AbstractEntity</sym> terms that participate in systems.
A Role cannot exist without a context. A <sym>1SYSCtx.System</sym> provides a context for the Roles it contains.
To aid efficiency all Roles are declared as pairwise disjoint. A Basic can play more than one role."
:referenceRem "2014 FLEXINET D3.1"
(disjointSubProps Role)

:Prop Input
:Inst Type
:sup Role
:rem "An input represents what is brought into and is transformed or consumed by the system to produce outputs."
:referenceRem "2014 FLEXINET D3.1"

:Prop Output
:Inst Type
:sup Role
:rem "An output represents what is brought out from or is produced by the <sym>1SYSCtx.System</sym>."
:referenceRem "2014 FLEXINET D3.1"

:Prop Resource
:Inst Type
:sup Role
:rem "A resource is used by or supports the execution of the <sym>1SYSCtx.System</sym>. "
:referenceRem "2014 FLEXINET D3.1"

:Prop Control
:Inst Type
:sup Input
:rem "A control is a condition required to produce correct system <sym>1SYSCtx.Output</sym>. A control is also an input."
:referenceRem "2014 FLEXINET D3.1"

11.3 Level 1 Relationships

:Use 1SYSCtx

:Rel affectsState
:Inst BinaryRel
:Inst RigidRel
:Inst AsymmetricBR
:Sig Particular Role
:Args "Affector" "Role"
:lex "?1 affects Role ?2"
:rem "affectsState is unidirectional so is an AsymmetricBR"

:Rel basicAffectsState
:Inst BinaryRel
:Inst RigidRel
:supRel affectsState
:Sig Basic Role
:Args "Basic" "Role"
:lex "Basic entity ?1 affects Role ?2"
:rem "basicAffectsState holds between Basic individuals and Role individuals."

:Rel roleAffectsState
:Inst BinaryRel
:Inst RigidRel
:supRel affectsState

:Sig Role Role
:Args "Role" "Role"
:lex "Role ?1 affects Role ?2"
:rem "roleAffectsState holds between Role individuals and Role individuals."

:Rel playsRole
:Inst TernaryRel
:Inst NonRigidRel
:Sig Basic Role Scenario
:Args "Basic" "Role" "Scenario"
:lex "Basic entity ?1 plays Role ?2 in Scenario ?3"
:rem "To provide a <sym>RootCtx.TimeSpan</sym> use the ECLIF operator <sym>holdsIn</sym>."

:Rel requiresA
:Inst BinaryRel
:Inst RigidRel
:Sig Role System
:Args "Role" "System"
:lex "Role ?1 depends on System ?2"
:rem "A role requires a context provided by one system."
;;;(functionalArg requiresA 2)
;;;commented out due to problems with PNES interface
;;;renamed 'dependsOn relation' as clashes with a existing RootCtx relation.

:Rel basicContainsBasic
:Inst BinaryRel
:Inst RigidRel
:Inst AntisymmetricBR
:Sig Basic Basic
:Args "sup" "sub"
:lex "?1 is contains ?2"
:rem "sup contains sub. Given that sup and sub are not identical, then it is not the case that sub is contains sup."

:Rel roleContainsRole
:Inst BinaryRel
:Inst RigidRel
:Inst AntisymmetricBR
:Sig Role Role
:Args "sup" "sub"
:lex "?1 is contains ?2"
:rem "sup is contains sub. Given that sup and sub are not identical, then it is not the case that sub is contains sup."

:Rel systemContainsRole
:Inst BinaryRel
:Inst RigidRel

```
:Sig System Role
:Args "System" "Role"
:lex "System ?1 contains Role ?1"
```

11.4 Level 1 Axioms

```
:Use 1SYSCtx

(=> (Role ?r)
   (exists (?s)
                (and (System ?s)
                        (requiresA ?r ?s))))
:IC hard "The Role ?r requiresA System to provide a context."

(=> (System ?system)
         (exists (?resource)
                  (and(Resource ?resource)
                           (systemContainsRole ?system ?resource))))
:IC soft "A System may contain a resource. System ?system does not contain a resource."

(=>  (and (System ?system)
    (playsRole ?system ?role ?scenario)
          )
          (not(systemContainsRole ?system ?role))
)
:IC hard "The same System cannot contain a Role and play the Role. ?system playsRole ?role in
Scenario ?scenario.
The relation systemContainsRole does not hold between ?system and ?role."
```

11.5 Level 1 Rules

```
:Use 1SYSCtx

(=> (requiresA ?x ?y)
    (systemContainsRole ?y ?x))
;;;A Role requiring a System as a context implies that the System contains the Role
;;;Could use inverserel instead of this rule

(=> (systemContainsRole ?x ?y)
    (requiresA ?y ?x))
;;;A System containing a Role implies that the Role requires the System as a context
```

12 Annex B: Level 2 Ontology Code

Contained herein is the KFL and ECLIF code for the FLEXINET Level 2 reference ontology:

12.1 Context

```
:Use ../1SYSCtx

:Ctx 2DSCtx
:Inst UserContext
:supCtx ../1SYSCtx

:Ctx 2DSExternalFactorsCtx
:Inst UserContext
:supCtx ../1SYSCtx
```

12.2 Level 2 Properties

```
:Use 2DSCtx

:Prop Collaboration
:Inst Type
:sup System
:rem "Cooperative arrangement in which two or more parties (which may or may not have any
previous relationship) work jointly towards a common goal."
:referenceRem "http://www.businessdictionary.com/"

:Prop Insurance
:Inst Type
:sup System
:rem "The act, system, or business of providing financial protection for property, life, health, etc,
against specified contingencies, such as death, loss, or damage, and involving payment of regular
premiums in return for a policy guaranteeing such protection."
:referenceRem "http://www.collinsdictionary.com/"

:Prop Produce
:Inst Type
:sup System
:rem "To bring (a thing) into existence from its raw materials or elements, or as the result of a
process"
:referenceRem "Oxford English Dictionary
http://www.oed.com/view/Entry/151978?rskey=wjgvrK&result=2&isAdvanced=false#eid"

:Prop Operate
:Inst Type
:sup System
:rem "To run something, such as a piece of machinery, or a business."
:referenceRem "http://www.businessdictionary.com/"
```

:Prop Design
:Inst Type
:sup System
:rem "Realization of a concept or idea into a configuration, drawing, model, mould, pattern, plan or specification (on which the actual or commercial production of an item is based) and which helps achieve the item's designated objectives."
:referenceRem "http://www.businessdictionary.com/"

:Prop DataCollection
:Inst Type
:sup System
:rem "The collection of data from surveys, or from independent or networked locations via data capture, data entry, or data logging."
:referenceRem "http://www.businessdictionary.com/"

:Prop Finance
:Inst Type
:sup System
:rem "the management of a supply of money"
:referenceRem "Cambridge Online dictionary, http://dictionary.cambridge.org/dictionary/british/finance"

:Prop Logistics
:Inst Type
:sup System
:rem "The management of materials flow through an organization, from raw materials through to finished goods."
:referenceRem "http://www.collinsdictionary.com/"

:Prop Software
:Inst Type
:sup System
:rem "Organized information in the form of operating systems, utilities, programs, and applications that enable computers to work."
:referenceRem "http://www.businessdictionary.com/"

:Prop Dispose
:Inst Type
:sup System
:rem "to arrange or settle (matters) by placing into correct or final condition ."
:referenceRem "http://www.collinsdictionary.com/"

:Prop Supply
:Inst Type
:sup System
:rem "the act or process of providing something that is needed"

:referenceRem "Macmillan dictionary, http://www.macmillandictionary.com/dictionary/american/supply"

:Prop Manage
:Inst Type
:sup System
:rem "To control something, such as a project, team of people, or idea."
:referenceRem "http://www.businessdictionary.com/"

:Prop NaturalSystems
:Inst Type
:sup System
:rem "Natural Systems are living systems of all kinds, including the solar system and the Universe as examples."
:referenceRem "Flexinet D3.1"

:Prop Person
:Inst Type
:sup NaturalSystems
:rem "an individual human being."
:referenceRem "http://www.collinsdictionary.com/"

:Prop Organisation
:Inst Type
:sup System
:disjointWith Facility
:rem "A social unit of people that is structured and managed to meet a need or to pursue collective goals."
:referenceRem "http://www.businessdictionary.com/"

:Prop Facility
:Inst Type
:sup System
:rem "Permanent, semi-permanent, or temporary commercial or industrial property such as a building, plant, or structure, built, established, or installed for the performance of one or more specific activities or functions."
:referenceRem "http://www.businessdictionary.com/"
(disjointSubProps Facility)

:Prop ProductFacility
:Inst Type
:sup Facility
:name "Product Facility"
:rem "The means or equipment facilitating the performance of a product"
:referenceRem "http://www.wordreference.com/definition/Facility (Adapted)"

:Prop ServiceFacility
:Inst Type

:sup Facility
:name "Service Facility"
:rem "The means or equipment facilitating the performance of a service"
:referenceRem "http://www.wordreference.com/definition/Facility (Adapted)"

:Prop ReportingSystem
:Inst Type
:sup System
:rem "Mechanism for organizing and/or monitoring the information of a particular interest in a organisation."
:referenceRem "FLEXINET ¿? Definition TBR"

:Prop Automation
:Inst Type
:sup System
:rem "The use of methods for controlling industrial processes automatically, esp by electronically controlled systems, often reducing manpower."
:referenceRem "http://www.collinsdictionary.com/"

:Prop ControlSystems
:Inst Type
:sup System
:rem "Procedures designed and established to check, record, regulate, supervise, authenticate, and (if necessary) restrict, the access to an asset, resource, or system."
:referenceRem "http://www.businessdictionary.com/"

:Prop Virtualisation
:Inst Type
:sup System
:rem "Virtualisation, in computing, refers to the act of creating a virtual (rather than actual) version of something, including but not limited to a virtual computer hardware platform, operating system (OS), storage device, or computer network resources."
:referenceRem "http://en.wikipedia.org/wiki/Virtualization"

:Prop Interface
:Inst Type
:sup System
:rem "The point of interaction or communication between a computer and any other entity, such as a printer or human operator."
:referenceRem "http://www.thefreedictionary.com/interface"

:Prop Inspection
:Inst Type
:sup System
:rem "Critical appraisal involving examination, measurement, testing, gauging, and comparison of materials or items."
:referenceRem "http://www.businessdictionary.com"

:Prop ArchivingSystem
:Inst Type
:sup System
:partitionedBy (listof DocumentManagementSystem DatabaseSystem DataStorageSystem)
:rem "system to store (documents, data, etc) in an archive or other repository."
:referenceRem "http://www.collinsdictionary.com/"

:Prop DocumentManagementSystem
:Inst Type
:sup ArchivingSystem
:rem "A document management system (DMS) is a system (based on computer programs in the case of the management of digital documents) used to track and store documents."
:referenceRem "http://en.wikipedia.org/wiki/Document_management_system"

:Prop DatabaseSystem
:Inst Type
:sup ArchivingSystem
:rem "A database is an organized collection of data. The data are typically organized to model aspects of reality in a way that supports processes requiring information. For example, modelling the availability of rooms in hotels in a way that supports finding a hotel with vacancies."
:referenceRem "http://en.wikipedia.org"

:Prop DataStorageSystem
:Inst Type
:sup ArchivingSystem
:rem "Technology consisting of computer components and recording media used to retain digital data."
:referenceRem "http://en.wikipedia.org"

:Prop Diagnosis
:Inst Type
:sup System
:partitionedBy (listof FMEA RiskAnalysis Simulation RootCauseAnalysis)
:rem "Thorough analysis of facts or problems in order to gain understanding and aid future planning."
:referenceRem "http://www.collinsdictionary.com/"

:Prop FMEA
:Inst Type
:sup Diagnosis
:rem "Failure Mode and Effects Analysis, FMEA, was one of the first systematic techniques for failure analysis."
:referenceRem "http://en.wikipedia.org/wiki/Failure_mode_and_effects_analysis"

:Prop RiskAnalysis
:Inst Type
:sup Diagnosis
:rem "Risk analysis is the science of risks and their probability and evaluation."
:referenceRem "http://en.wikipedia.org"

:Prop Simulation
:Inst Type
:sup Diagnosis
:rem "Simulation is the imitation of the operation of a real-world process or system over time."
:referenceRem "http://en.wikipedia.org/wiki/Simulation"

:Prop RootCauseAnalysis
:Inst Type
:sup Diagnosis
:rem "Root cause analysis (RCA) is a method of problem solving that tries to identify the root causes of faults or problems."
:referenceRem "http://en.wikipedia.org/wiki/Root_cause_analysis"

:Prop Analysis
:Inst Type
:sup System
:partitionedBy (listof BooleanAnalysis StatisticalAnalysis)
:rem "A systematic examination and evaluation of data or information, by breaking it into its component parts to uncover their interrelationships."
:referenceRem "http://www.businessdictionary.com"

:Prop BooleanAnalysis
:Inst Type
:sup Analysis
:rem "Analysis to detect deterministic dependencies between the items of a questionnaire or similar data-structures in observed response patterns"
:referenceRem "http://en.wikipedia.org/wiki/Boolean_analysis"

:Prop StatisticalAnalysis
:Inst Type
:sup Analysis
:rem "Study of the collection, interpretation, presentation and organization of data."
:referenceRem "http://en.wikipedia.org/wiki/Statistics"

:Prop EvaluationScheme
:Inst Type
:sup Analysis
:name "EvaluationScheme"
:rem "A plan, design, or program for allowing a structured interpretation and giving of meaning to predicted or actual impacts of an Idea"

:Prop Department
:Inst Type
:sup System
:rem "Specialized functional area within an organization or a division, such as accounting, marketing, planning."

:referenceRem "http://www.businessdictionary.com"

:Prop Inventory
:Inst Type
:sup System
:rem "An itemized catalog or list of tangible goods or property, or the intangible attributes or qualities."
:referenceRem "http://www.businessdictionary.com"

:Prop Transport
:Inst Type
:sup System
:rem "the moving of goods or people from one place to another."
:referenceRem "http://www.businessdictionary.com"

:Prop SustainmentProcess
:Inst Type
:sup System
:partitionedBy (listof Training Monitor Maintenance)
:rem "The process of maintenance"

:Prop Training
:Inst Type
:sup SustainmentProcess
:rem "Organized activity aimed at imparting information and/or instructions to improve the recipient's performance or to help him or her attain a required level of knowledge or skill."
:referenceRem "http://www.businessdictionary.com"

:Prop Monitor
:Inst Type
:sup SustainmentProcess
:rem "To check, supervise, watch, or keep track of. "
:referenceRem "http://www.businessdictionary.com"

:Prop Maintenance
:Inst Type
:sup SustainmentProcess
:partitionedBy (listof EquipmentMaintenance SoftwareMaintenance InfrastructureMaintenance)
:rem "The actions taken to preserve the operation of devices, particularly of electromechanical equipment, to ensure that the devices can perform their intended functions when needed."
:referenceRem "http://www.thefreedictionary.com/"
;;;:rem "the process of keeping equipment in a useable condition or returning it to that condition when it fails. Maintenance involves either preventive maintenance, corrective maintenance, or modifications."

:Prop EquipmentMaintenance
:Inst Type
:sup Maintenance

:rem "Equipment maintenance is a broad term used to describe the various processes that are employed to keep equipment in proper working order."
:referenceRem "http://www.wisegeek.com/what-is-equipment-maintenance.htm"

:Prop SoftwareMaintenance
:Inst Type
:sup Maintenance
:rem "Software maintenance in software engineering is the modification of a software product after delivery to correct faults, to improve performance or other attributes."
:referenceRem "http://en.wikipedia.org"

:Prop InfrastructureMaintenance
:Inst Type
:sup Maintenance
:rem "Maintenance of the infrastructure of a facility"
:referenceRem ""

:Prop KnowledgeMaintenance
:Inst Type
:sup SoftwareMaintenance
:rem ""
:referenceRem ""

:Prop Market
:Inst Type
:sup System
:name "Market"
:rem "An actual or nominal place where forces of demand and supply operate, and where buyers and sellers interact (directly or through intermediaries) to trade goods, services, or contracts or instruments, for money or barter."
:referenceRem "http://www.businessdictionary.com/definition/market.html"

:Prop Project
:Inst Type
:sup System
:name "Project"
:rem "Planned set of interrelated tasks to be executed over a fixed period and within certain cost and other limitations."
:referenceRem "http://www.businessdictionary.com/definition/project.html"

:Prop Lifecycle
:Inst Type
:sup System
:name "Project"
:rem "A course or evolution from a beginning, through development and productivity, to decay or ending."
:referenceRem "Oxford English Dictionary.
http://www.oed.com/view/Entry/108098?redirectedFrom=life+cycle#eid."

:Prop Infrastructure
:Inst Type
:sup System
:name "Infrastructure"
:rem "The basic systems and services, such as transport and power supplies, that a country or organization uses in order to work effectively"
:referenceRem "http://dictionary.cambridge.org"

:Prop ConceptDevelopment
:Inst Type
:sup 1SYSCtx.System
:name "ConceptDevelopment"
:rem "Concept development is a set of activities that are carried out early in the systems engineering life cycle to collect and prioritize operational needs and challenges, develop alternative concepts to meet the needs, and select a preferred one as the basis for subsequent system or capability development and implementation."
:referenceRem "http://www.mitre.org/publications/systems-engineering-guide/se-lifecycle-building-blocks/concept-development"

:Prop ProductConfiguration
:Inst Type
:sup 1SYSCtx.System
:name "ProductConfiguration"
:rem "An activity of customising a product to meet the needs of a particular customer."
:referenceRem "https://en.wikipedia.org/wiki/Knowledge-based_configuration"

:Prop ProductRealisation
:Inst Type
:sup 1SYSCtx.System
:name "Product Realisation"
:rem "Product realization is the term used to describe the work that the organization goes through to develop, manufacture, and deliver the finished goods or services."
:referenceRem "http://www.simplyquality.org/2000%20Summary/req_7-0.html"

:Prop Ideation
:Inst Type
:sup 1SYSCtx.System
:name "Ideation"
:rem "The creation of new ideas."
:referenceRem "Oxford English Dictionary.
http://www.oed.com/view/Entry/90972?redirectedFrom=ideation#eid"

;;Derived from Hastilow/IMKS. note: Ideally a level 0 concept. Is feature a sub-category of material. Don't think so it applies to material
:Prop Feature
:Inst Type
:sup MLO.Object

```
:name "Feature"
:rem  "A distinctive attribute or aspect of something"
:referenceRem "Oxford Dictionaries. http://www.oxforddictionaries.com/definition/english/feature"
:disjointWith Role
:disjointWith Scenario
:disjointWith Project

:Prop InformationStructure
:Inst Type
:sup  Information
:sup MLO.AbstractEntity
:name "Information Structure"
:rem  "The arrangement of and relations between the parts or elements of something complex
(related to information)"
:referenceRem "Oxford Dictionaries. http://www.oxforddictionaries.com/"

;;Derived from Esmond data type. We don't need to model data itself (we just assert it).
:Prop InformationType
:Inst Type
:sup  Information
:sup MLO.AbstractEntity
:name "Information Type"
:rem  "A category of information having common characteristics."
:referenceRem "Oxford Dic. (interpreted)"

:Prop Status
:Inst Type
:sup  Information
:sup MLO.AbstractEntity
:name "Status"
:rem  "Current state of affairs. - Business Dic."
:referenceRem "http://www.businessdictionary.com/definition/status.html"

:Prop TimeStamp
:Inst Type
:sup  Information
:sup MLO.AbstractEntity
:name "Time Stamp"
:rem  "A timestamp is a sequence of characters or encoded information identifying when a certain
event occurred, usually giving date and time of day, sometimes accurate to a small fraction of a
second."
:referenceRem "Wikipedia"

:Prop TraceabilityItem
:Inst Type
:sup  Information
:sup MLO.Object
:name "Traceability Item"
```

:rem "An item or an object whose application, location, and/or history of an activity has been traced by means of recorded data."
:referenceRem "http://www.businessdictionary.com/"

:Prop Prediction
:Inst Type
:sup Information
:sup MLO.Object
:name "Prediction"
:rem "Estimate or forecast of conditions and events in the project's future based on information and knowledge available at the time of the prediction."
:referenceRem "PMP 7: Project Cost Management and WSDOT Glossary for Cost Risk Estimating Management"
(disjointSubProps Prediction)

:Prop Estimate
:Inst Type
:sup Prediction
:name "Estimate"
:rem "An approximate judgment or calculation, as of the value, amount, time, size, or weight of something"
:referenceRem "PMP 7: Project Cost Management and WSDOT Glossary for Cost Risk Estimating Management"

:Prop Quote
:Inst Type
:sup Prediction
:name "Quote"
:rem "An estimation of what a cost or price is likely to be"
:referenceRem "http://www.businessdictionary.com/"

:Prop Decision
:Inst Type
:sup Information
:sup MLO.Object
:name "Decision"
:rem "A judgment, conclusion, or resolution reached or given; verdict"
:referenceRem "Collins Dictionary. http://collinsdictionary.com"
(disjointSubProps Decision)

:Prop Agreement
:Inst Type
:sup Decision
:name "Agreement"
:rem "An arrangement (typically one which is legally binding) made between two or more parties and agreed by mutual consent. Also: a document or instrument embodying this"
:referenceRem "Oxford English Dictionary. http://www.oed.com"

:Prop SupplyAgreement
:Inst Type
:sup Agreement
:name "Supply Agreement"
:rem "A supply agreement states the terms and conditions under which one company (manufacturer) will manufacture and supply goods to another (buyer). A supply contract may be exclusive or non-exclusive, include standards on product quality, and should state how product orders will be handled"
:referenceRem "http://contracts.onecle.com/type/183.shtml"

:Prop Visualisation
:Inst Type
:sup Information
:sup MLO.Object
:name "Visualisation"
:rem "Is the set of (interactive) visual representations of abstract data to reinforce human cognition."
:referenceRem "http://en.wikipedia.org/wiki/Information_visualization"

:Prop Report
:Inst Type
:sup Visualisation
:name "Report"
:rem "A document containing information organized in a narrative, graphic, or tabular form, prepared on ad hoc, periodic, recurring, regular, or as required basis. Reports may refer to specific periods, events, occurrences, or subjects, and may be communicated or presented in oral or written form."
:referenceRem "http://www.businessdictionary.com/"

:Prop Standard
:Inst Type
:sup Information
:sup MLO.Object
:name "Standard"
:rem "set of mandatory requirements established by consensus and maintained by a recognized body to prescribe a disciplined uniform approach or specify a product, that is, mandatory conventions and practices."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Equipment
:Inst Type
:sup Material
:name "Equipment"
:rem "A set of tools, materials, devices, kit, etc, assembled for a specific purpose"
:referenceRem "Wordreference Dic."

:Prop Plan
:Inst Type
:sup Information
:sup MLO.Object
:name "Plan"

:rem "Written account of intended future course of action (scheme) aimed at achieving specific goal(s) or objective(s) within a specific timeframe. It explains in detail what needs to be done, when, how, and by whom, and often includes best case, expected case, and worst case scenarios."
:referenceRem "http://www.businessdictionary.com/"

:Prop BusinessPlan
:Inst Type
:sup Plan
:name "Business Plan"
:rem "Set of documents prepared by a firm's management to summarize its operational and financial objectives for the near future (usually one to three years) and to show how they will be achieved."
:referenceRem "http://www.businessdictionary.com/"

:Prop Response
:Inst Type
:sup Information
:name "Response"
:rem "Reaction to an event, occurrence, or situation, aimed at its containment or control."
:referenceRem "http://www.businessdictionary.com/"

:Prop MarketInformation
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Market Information"
:rem "Information compiled from internal and external sources about a target group of consumers. The type of market intelligence most useful to a marketing department might include data on existing clients, targeted consumer habits, product and market trends, and what the competition is doing (market intelligence)"
:referenceRem "http://www.businessdictionary.com/definition/market-intelligence.html"

:Prop CustomerDemand
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Customer Demand"
:rem "Desire for certain good or service supported by the capacity to purchase it."
:referenceRem "http://www.businessdictionary.com/"

:Prop CustomerSatisfaction
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Customer Satisfaction"
:rem "a measure of how happy customers feel when they do business with a company."
:referenceRem "http://dictionary.cambridge.org/dictionary/business-english/customer-satisfaction"

:Prop HumanFactors

:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Human Factors"
:rem "The characteristics of human beings that are applicable to the design of systems and devices of all kinds."
:referenceRem "http://www.mistakeproofing.com/glossary.html#H"

:Prop Skills
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Skills"
:rem "Something, especially a trade or technique, requiring special training or proficiency."
:referenceRem "Collins Dic."

:Prop DeliveryModel
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Delivery Model"
:rem "Model to represent the act of delivering or distributing goods, services, etc."
:referenceRem "Collins Dic. (interpreted)"

:Prop Catalogue
:Inst Type
:sup Information
:sup MLO.Object
:name "Catalogue"
:rem "List of goods or services on sale with their description and prices published as a printed document, or as an electronic document (e-catalog) on internet or on a diskette, CD, DVD, etc."
:referenceRem "http://www.businessdictionary.com/definition/catalog.html"

:Prop Idea
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Idea"
:rem "A thought or collection of thoughts that generate in the mind. An idea is usually generated with intent, but can also be created unintentionally. Ideas often form during brainstorming sessions or through discussions."
:referenceRem "http://www.businessdictionary.com/definition/idea.html"

:Prop Concept
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Concept"

:rem "Concept is a clear, detailed description of the attributes and benefits of a new product that addresses the needs of the targeted customers."
:referenceRem "FLEXINET 3.3"

:Prop Dimension
:Inst Type
:sup Information
:rem "Dimension definiton from D4.1 ??"

:Prop TechnologyComposition
:Inst Type
:sup Dimension
:rem ""

:Prop TechnologyReadinessLevel
:Inst Type
:sup Dimension
:rem "Technology Readiness Levels (TRL) are a method of estimating technology maturity of Critical Technology Elements (CTE) of a program during the acquisition process. "
:referenceRem "Wikipedia"

:Prop CommunicationProtocol
:Inst Type
:sup Standard
:rem "Communication protocols are formal descriptions of digital message formats and rules. They are required to exchange messages in or between computing systems and are required in telecommunications.
Communications standards - derived from Indesit requirement."
:referenceRem "http://www.techopedia.com/definition/25705/communication-protocol"

:Prop ServiceInfrastructure
:Inst Type
:sup Information
:sup MLO.Object
:name "Service Infrastructure"
:rem "The resources required for a ... <sym>2DSCtx.Service</sym>"
:referenceRem "http://www.merriam-webster.com/dictionary/infrastructure"

:Prop CommunicationInfrastructure
:Inst Type
:sup Information
:sup MLO.Object
:name "Communication Infrastructure"
:rem "The resources required for ... the means of sending or receiving information."
:referenceRem "http://www.merriam-webster.com/dictionary/infrastructure;http://www.oxforddictionaries.com/us/definition/american_english/communication"

:Prop FunctionInformation
:Inst Type
:sup Information
:name "Function Information"
:rem "Information on an action performed by a device, department, or person that produces a result."
:referenceRem "http://www.businessdictionary.com/definition/function.html - modified"

:Prop Prototype
:Inst Type
:sup Material
:name "Prototype"
:rem "Pre-production model of a product."
:referenceRem "http://www.businessdictionary.com/"

:Prop Benefit
:Inst Type
:sup Information
:name "Benefit"
:rem "1.General: Advantage, privilege, right, or financial reimbursement.
2.Finance: Desirable and measurable outcome or result from an action, investment, project, resource, or technology.
3.Marketing: Desirable attribute of a good or service, which a customer perceives he or she will get from purchasing."
:referenceRem "http://www.businessdictionary.com/"

:Prop Identifier
:Inst Type
:Inst NonLogicalFunctor
:sup Information
:sup MLO.AbstractEntity
:name "Identifier"
:rem "Linguistics: A linguistic element that has an identifying function.Computing: A sequence of characters arbitrarily devised to identify or refer to a set of data, a location in a store, or a point in a program."
:referenceRem "http://www.oxforddictionaries.com"

:Prop KeywordType
:Inst Type
:sup Information
:rem "Type of a Keyword"

:Prop Comment
:Inst Type
:sup Information
:rem "A written or spoken remark giving an opinion"
:referenceRem "http://www.macmillandictionary.com/dictionary/british/comment_1"

:Prop Part
:Inst Type
:sup Material
:rem "one of the smaller individual pieces that a machine or vehicle is made of"
:referenceRem "http://www.macmillandictionary.com/dictionary/american/part_1#part_14"

:Prop Component
:Inst Type
:sup Material
:rem "A raw material, ingredient or subassembly that goes into a higher level assembly, compound, or part."
:referenceRem "http://www.engineering-dictionary.org/component (modified)."

:Prop Location
:Inst Type
:sup Information
:sup MLO.Object
:name "Location"
:rem "A site or position; situation"
:referenceRem "Collins Dic."

;;;==========
;;;metaproperty - needed to refer to types of location in risk section of ontology
:Prop ZoneType
:Inst MetaProperty
:sup Type
:name "Measure of Position in Geographical Hierarchy"
:metaPropFor Location

;;;properties below needed to extend the Highfleet definitions of geographic bodies to fit with the risk section of the ontology.
:Prop {Area/City}
:Inst ZoneType
:sup Location
:sup MLO.City
:rem "urban areas"
:referenceRem "Oxford English Dictionary. www.oed.com"

:Prop {State/Province}
:Inst ZoneType
:sup Region
:rem "one of many areas into which some countries are divided"
:referenceRem "http://www.macmillandictionary.com/"

:Prop Country
:Inst ZoneType
:sup Location
:sup MLO.Country

:rem "The territory of a nation; a region constituting an independent state, or a region, province, etc., which was once independent and is still distinct in institutions, language, etc."
:referenceRem "Oxford English Dictionary. www.oed.com"

:Prop Region
:Inst ZoneType
:sup Location
:sup MLO.Region
:rem "A subdivision of the earth. Differs to definition of <sym>MLO.Region</sym>"
:referenceRem "Oxford English Dictionary. www.oed.com"

:Prop Global
:Inst ZoneType
:sup Location
:sup MLO.Region
:rem "Of, relating to, or involving the whole world, worldwide."
:referenceRem "Oxford English Dictionary. www.oed.com"

(partitionedBy Basic (listof System Entity Gateway BusinessEvent))
;;;Basic restriction placed at level 2 not level 1 as Gateway and BusinessEvent are level 2

:Prop Network
:Inst Type
:sup System
:rem "An interconnected or interrelated chain or group of <sym>1SYS.System</sym>s"
:referenceRem "http://www.collinsdictionary.com/"

;;;Gateways - needed to refer to process decisions

:Prop Gateway
:Inst Type
:sup Basic
:rem "Gateways are used to control how Sequence Flows interact as they converge and diverge within a Process "
:referenceRem "OMG, 2011, Business Process Model and Notation (BPMN) Version 2.0"

:Prop DivergingGateway
:Inst Type
:sup Gateway
:rem " A diverging gateway has only one input and 2 or more outputs (describes an opening AND or a fork)"

:Prop ConvergingGateway
:Inst Type
:sup Gateway
:rem "A converging gateway has 2 or more inputs and only one output (describes an closing AND or a join)"

:Prop InclusiveDivergingGateway
:Inst Type
:sup DivergingGateway
:rem "A inclusive diverging gateway (opening OR) has one input and two or more outputs An output must have a condition (a boolean)".

:Prop InclusiveConvergingGateway
:Inst Type
:sup ConvergingGateway
:rem " An inclusive converging gateway ("closing OR") has one default output and two or more inputs. An input must have a condition (a boolean). "

:Prop ExclusiveDivergingGateway
:Inst Type
:sup InclusiveDivergingGateway
:rem "An exclusive diverging gateway ("opening XOR", branch) inherits from an inclusive diverging gateway. The value of the condition of an output must not be identical to the value of the condition of any of the other outputs of the XOR gateway (i.e. only one condition within the XOR gateway can activated, so only one branch can be taken)."

:Prop ExclusiveConvergingGateway
:Inst Type
:sup ExclusiveDivergingGateway
:rem "An exclusive converging gateway ("closing XOR", merge) inherits from an inclusive diverging gateway. The value of the condition of an input must not be identical to the value of the condition of any of the other inputs of the XOR gateway (i.e. only one condition within the XOR gateway can activated, so only one incoming flow is needed)."

:Prop Condition
:Inst Type
:sup MLO.Object
:rem "Boolean value as a result of a condition?. "

;;;==========
;;;Network Events

:Prop BusinessEvent
:Inst Type
:sup Basic
:rem "Events that take place in the course of normal operation for a business that reoccur as business processes are executed."
:referenceRem "FLEXINET D3.3"

:Prop StartEvent
:Inst Type
:sup BusinessEvent
:rem "To indicate the start of a process."
:referenceRem "An event that initiates a process"

:referenceRem "FLEXINET D3.3"

:Prop EndEvent
:Inst Type
:sup BusinessEvent
:rem "To indicate the end of a process."
:referenceRem "FLEXINET D3.3"

:Prop DecisionEvent
:Inst Type
:sup BusinessEvent
:rem "An event where decisions are made or taken."
:referenceRem "FLEXINET D3.3"
;;;can have the outcome of an end, a process for the product or a rework, therefore is more than a system.

:Prop Actor
:Inst Type
:sup Role
:rem "An Actor is a <sym>1SYSCtx.Role</sym> which is able to fulfil a non-functional requirement. Actors are processes that perform functions.
A Actor is played by a <sym>1SYSCtx.System</sym> which is a subtype of <sym>1SYSCtx.Basic</sym>."
(disjointSubProps Actor)

;;;metaproperty - needed to refer to types of actor in risk section of ontology
:Prop ActorType
:Inst MetaProperty
:sup Type
:name "Type of the Actor"
:metaPropFor Actor

:Prop Order
:Inst ActorType
:sup Actor
:rem "A confirmed request by one party to another to buy, sell, deliver, or receive goods or services under specified terms and conditions."
:referenceRem http://www.businessdictionary.com/

:Prop Offer
:Inst ActorType
:sup Order
:rem "Voluntary but conditional promise submitted by a buyer or seller (offeror) to another (offeree) for acceptance, and which becomes legally enforceable if accepted by the offer."
:referenceRem http://www.businessdictionary.com/

:Prop Technology
:Inst ActorType

:sup Actor
:rem "The purposeful application of information in the design, production, and utilization of goods and services, and in the organization of human activities."
:referenceRem http://www.businessdictionary.com/

:Prop Employee
:Inst ActorType
:sup Actor
:rem "An individual who works part-time or full-time under a contract of employment, whether oral or written, express or implied, and has recognized rights and duties. Also called worker."
:referenceRem http://www.businessdictionary.com/

:Prop Supervisor
:Inst ActorType
:sup Actor
:rem "Person in the first-line management who monitors and regulates employees in their performance of assigned or delegated tasks."
:referenceRem http://www.businessdictionary.com/

:Prop Competitor
:Inst ActorType
:sup Actor
:rem "Any person or entity which is a rival against another. In business, a company in the same industry or a similar industry which offers a similar product or service. "
:referenceRem http://www.businessdictionary.com/

:Prop Customer
:Inst ActorType
:sup Actor
:rem "party that receives or consumes products (goods or services) and has the ability to choose between different products and suppliers. "
:referenceRem http://www.businessdictionary.com/

:Prop Partner
:Inst ActorType
:sup Actor
:rem "Individual who joins with other individuals (partners) in an arrangement (partnership) where gains and losses, risks and rewards, are shared among the partners."
:referenceRem http://www.businessdictionary.com/

:Prop Supplier
:Inst ActorType
:sup Actor
:rem "A party that supplies goods or services. A supplier may be distinguished from a contractor or subcontractor, who commonly adds specialized input to deliverables. Also called vendor."

:referenceRem http://www.businessdictionary.com/

:Prop FinancePerson
:Inst ActorType
:sup Actor
:rem "a person in charge? of the financial affairs of an organization"

:Prop ServiceProduct
:Inst ActorType
:sup Actor
:rem "A Service Product refers to an offering, e.g. maintenance, repair, insurance"
:referenceRem "FLEXINET D3.3"

:Prop ServiceUsingProduct
:Inst ActorType
:sup Actor
:rem "An offering that employs a product."
:referenceRem "FLEXINET D3.3"

:Prop MaintenanceEngineer
:Inst ActorType
:sup Actor
:rem "Engineer who maintains a system."

:Prop Designer
:Inst ActorType
:sup Actor
:rem "a person who devises and executes designs, as for works of art, clothes, machines, etc"
:referenceRem http://www.collinsdictionary.com/

:Prop Operator
:Inst ActorType
:sup Actor
:rem "Individual or organization that operates the system; entity that performs the operation of a system."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop LogisticsPerson
:Inst ActorType
:sup Actor
:rem ""
:rem "Person involved in Logistics activities"
:referenceRem "¿¿"

:Prop MaterialControlPerson
:Inst ActorType
:sup Actor
:rem ""

:referenceRem ""

:Prop Delivery
:Inst ActorType
:sup Actor
:rem "Formal and voluntary transfer of possession by actual (physical) delivery, constructive delivery (by an agreement or understanding), or symbolic delivery (by documents) Also called presentation or presentment."
:referenceRem http://www.businessdictionary.com/

:Prop Solution
:Inst ActorType
:sup Actor
:rem "Answer(s) suggested or implemented to try and solve a question or problem. "
:referenceRem http://www.businessdictionary.com/

:Prop Intermediary
:Inst ActorType
:sup Actor
:rem "Firm or person (such as a broker or consultant) who acts as a mediator on a link between parties to a business deal, investment decision, negotiation, etc."
:referenceRem http://www.businessdictionary.com/

:Prop Consumer
:Inst ActorType
:sup Actor
:rem "An end user, and not necessarily a purchaser, in the distribution chain of a good or service."
:referenceRem http://www.businessdictionary.com/

:Prop ServiceProvider
:Inst ActorType
:sup Actor
:rem "Organization, business or individual which offers service to others in exchange for payment."
:referenceRem http://www.businessdictionary.com/

:Prop Stakeholder
:Inst Type
:sup Actor
:name "Stakeholder"
:rem "A person, company, etc., with a concern or (esp. financial) interest in ensuring the success of an organization, business, system, etc."
:referenceRem "Oxford English Dictionary
http://www.oed.com/view/Entry/246856?redirectedFrom=stakeholder#eid"

:Prop Owner
:Inst Type
:sup Stakeholder
:name "Owner"

:rem "A person or organization that owns something: "
:referenceRem "http://dictionary.cambridge.org/dictionary/business-english/owner"

:Prop Contributor
:Inst Type
:sup Stakeholder
:name "Contributor"
:rem "Someone or something that is one of the causes of a situation, event, "
:referenceRem http://www.macmillandictionary.com/dictionary/american/contributor#contributor_6

:Prop Target
:Inst Type
:sup Role
:rem "result, level, or situation that an organization or group wants or plans to achieve"
:referenceRem "http://dictionary.cambridge.org/dictionary/business-english/target_1"

:Prop Requirements
:Inst Type
:sup 1SYSCtx.Role
:rem "a condition or capability that must be met or possessed by a system, system component, product, or service to satisfy an agreement, standard, specification, or other formally imposed documents."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Product
:Inst Type
:sup 1SYSCtx.Role
:rem "A product is a process output."

:Prop PhysicalProduct
:Inst Type
:sup 2DSCtx.Product
:rem "A Physical Product is a material artefact, e.g. car, boat, plane."
:referenceRem "FlEXINET D3.3"

:Prop ProductService
:Inst Type
:sup 2DSCtx.PhysicalProduct
:rem "An integrated product and service offering that delivers value in use."
:referenceRem "FlEXINET D3.3"

:Prop ProductRequest
:Inst Type
:sup Role
:rem "The act of asking for some product to be given or done"
:referenceRem "WordReference Dic.(interpreted)"

:Prop ProductHistory
:Inst Type
:sup Role
:rem "A continuous, systematic telling of past events to get a product"
:referenceRem "WordReference Dic. (interpreted)"

:Prop Asset
:Inst Type
:sup Role
:rem "Something valuable that an entity owns, benefits from, or has use of, in generating income."
:referenceRem "http://www.businessdictionary.com/"

:Prop Storage
:Inst Type
:sup Role
:rem "Space or area reserved for storing"
:referenceRem "Collins Dic."

:Prop Specification
:Inst Type
:sup Role
:rem "A detailed description of the criteria for the constituents, construction, appearance, performance, etc, of a material, apparatus, etc, or of the standard of workmanship required in its manufacture"
:referenceRem "Collins Dic."

:Prop Objective
:Inst Type
:sup Role
:rem "A future state which is desired to be accomplished and/or maintained by a corporation."
:referenceRem "FLEXINET 2.2."

:Prop Qualifier
:Inst Type
:sup Role
:rem "A Qualifier is a <sym>1SYSCtx.Role</sym> which is able to fulfil a non-functional requirement. Qualifiers define how a <sym>1SYSCtx.System</sym> will operate by controlling the system processes. A Qualifier is played by <sym>1SYSCtx.Information</sym> which is a subtype of <sym>1SYSCtx.Basic</sym>."
:referenceRem "2014 FLEXINET D3.1"
(disjointSubProps Qualifier)

:Prop Robustness
:Inst Type
:sup Qualifier
:rem "the degree to which a system or component can function correctly in the presence stressful environmental conditions."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Mitigation
:Inst Type
:sup Qualifier
:rem "An effort to reduce the impact and likelihood of risk"
:referenceRem "2014 FLEXINET D2.1"

:Prop Capacity
:Inst Type
:sup Qualifier
:rem ""
:referenceRem "2013 Hastilow, N. Manufacturing Systems Interoperability in Dynamic Change Environments. PhD Thesis Loughborough University."

:Prop Capability
:Inst Type
:sup Qualifier
:rem "process capability is a characterization of the ability of a process to meet current or projected business goals."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Functionality
:Inst Type
:sup Capability
:rem "The capabilities of the various computational, user interface, input, output, data management and other features provided by a product."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Availability
:Inst Type
:sup Qualifier
:rem "Derived from Hastilow Thesis - performance metric.
1. The degree to which a system or component is operational and accessible when required for use.
2. ability of a component or service to perform its required function at a stated instant or over a stated period of time."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Reliability
:Inst Type
:sup Qualifier
:rem "The ability of a system or component to perform its required functions under stated conditions for a specified
period of time."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Solvency
:Inst Type
:sup Reliability

:rem ""

:Prop Consistency
:Inst Type
:sup Qualifier
:rem "Derived from Hastilow Thesis - quality metric.
The degree of uniformity, standardization, and freedom from contradiction among the documents or parts of
a system or component."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Compliance
:Inst Type
:sup Qualifier
:rem "The state or fact of according with or meeting rules or standards."
:referenceRem "Oxford Dictionaries Online.
http://www.oxforddictionaries.com/us/definition/american_english/compliance."

:Prop Sustainability
:Inst Type
:sup Qualifier
:rem "Able to be maintained at a certain rate or level."
:referenceRem "Oxford Dictionaries Online.
http://www.oxforddictionaries.com/us/definition/american_english/sustainable#sustainable."

:Prop ProductEnergyConsumption
:Inst Type
:sup EnergyConsumption
:rem "the amount of energy used by a Product."
:referenceRem "http://www.collinsdictionary.com"

:Prop ServiceEnergyConsumption
:Inst Type
:sup EnergyConsumption
:rem "the amount of energy used by a Service."
:referenceRem "http://www.collinsdictionary.com"

:Prop EnergyConsumption
:Inst Type
:sup Qualifier
:rem "the amount of energy used."
:referenceRem "Collins English Dictionary.
http://www.collinsdictionary.com/dictionary/english/energy-consumption."

:Prop ProductSustainability
:Inst Type
:sup Sustainability

:rem "Ability to maintain or support a product over the long term."
:referenceRem "http://www.businessdictionary.com"

:Prop ServiceSustainability
:Inst Type
:sup Sustainability
:rem "Ability to maintain or support a service over the long term."
:referenceRem "http://www.businessdictionary.com"

:Prop FeasibilityStudy
:Inst Type
:sup Qualifier
:rem "Derived from Custom Drinks.
A study to identify and analyze a problem and its potential solutions in order to determine their viability,
costs, and benefits."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Performance
:Inst Type
:sup Qualifier
:rem " the degree to which a system or component accomplishes its designated functions within given constraints,
such as speed, accuracy, or memory usage."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Quality
:Inst Type
:sup Qualifier
:rem "1. the degree to which a system, component, or process meets specified requirements.
2. ability of a product, service, system, component, or process to meet customer or user needs, expectations, or requirements.
3. the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.
4. conformity to user expectations, conformity to user requirements, customer satisfaction, reliability, and level of defects present.
5. the degree to which a set of inherent characteristics fulfils requirements.
6. the degree to which a system, component, or process meets customer or user needs or expectations."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Uncertainty
:Inst Type
:sup Qualifier
:rem "the result of not having accurate or sufficient knowledge of a situation."
:referenceRem "BS ISO/IEC IEEE 24765:2010"

:Prop Compatibility
:Inst Type

:sup Qualifier
:rem "Ability of two or more systems or their components to work together without user intervention or modification."
:referenceRem "http://www.businessdictionary.com/definition/compatibility.html"

:Prop BusinessModel
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Business Model"
:rem "Description of means and methods a firm employs to earn the revenue projected in its plans."
:referenceRem "http://www.businessdictionary.com/"

;;;Business Properties for Rules
:Prop BusinessPolicy
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Threshold Values for Business Policies"
:rem "Threshold values for Business Control factors specified by an organisation."

:Prop ThresholdType
:Inst MetaProperty
:sup Type
:name "type of threshold value"

:Prop {</=}
:Inst ThresholdType
:sup MLO.AbstractEntity
:name "greater than or equal to"
:rem "specifies a maximum threshold type"

:Prop {>/=}
:Inst ThresholdType
:sup MLO.AbstractEntity
:name "less than or equal to"
:rem "specifies a minimum threshold type"

:Prop PolicyAboutSupplier
:Inst Type
:sup BusinessPolicy
:name "Threshold Values for Business Policies for a Supplier"
:rem "Threshold values for factors specified by an organisation describing a <sym>2DSCtx.Supplier</sym> with which it is willing to do business, i.e. factors which control the choice of supplier."

:Prop PolicyAboutMarket
:Inst Type

:sup BusinessPolicy
:name "Threshold Values for Business Policies for a Market"
:rem "Threshold values for factors specified by an organisation describing a <sym>2DSCtx.Market</sym> with which it is willing to do business, i.e. factors which control the choice of a market."

;;;PolicyAboutProducer at level 4

:Prop LocationFactor
:Inst Type
:sup BusinessPolicy
:name "Threshold Values for Location Factors"
:rem "Minimum and preferred values for factors specified by an organisation describing a <sym>2DSCtx.Location</sym> with which it is willing to do business."

:Prop LocationFactorforSupplier
:Inst Type
:sup LocationFactor
:name "Threshold Values for Supplier Location Factors"
:rem "Minimum and preferred values for factors specified by an organisation describing a <sym>2DSCtx.Location</sym> whose <sym>2DSCtx.Supplier</sym>s it is willing to do business with."

:Prop LocationFactorforMarket
:Inst Type
:sup LocationFactor
:name "Threshold Values for Market Location Factors"
:rem "Minimum and preferred values for factors specified by an organisation describing a <sym>2DSCtx.Location</sym> whose <sym>2DSCtx.Market</sym>s it is willing to do business with."

;;;Location Factor for Producer at level 4

;;;
;;;Balanced ScoreCard Properties
;;;
:Prop StrategicValue
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Strategic Value"
:rem "Evaluation on a qualitative basis, resulting in an overall score of the Balanced ScoreCard."
:referenceRem "FLEXINET 2.3"

:Prop BSCView
:Inst Type
:sup Information
:sup MLO.AbstractEntity

```
:name "Balanced Score Card View"
:rem  "KPI group (financial, global development, customer, innovation and risk."
:referenceRem "FLEXINET 2.3"

:Prop KPI
:Inst Type
:sup  Information
:sup MLO.AbstractEntity
:name "Key Performance Indicator"
:rem  "Key Performance Indicators within the Balanced Score Card."
:referenceRem "FLEXINET 2.3"

:Prop PI
:Inst Type
:sup Information
:sup MLO.AbstractEntity
:name "Performance Indicator"
:rem  "Performance Indicators within the Balanced Score Card."
:referenceRem "FLEXINET 2.3"

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;Business Model Canvas Properties
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
:Prop BusinessModelCanvas
:Inst Type
:sup  Information
:sup MLO.AbstractEntity
:name "Business Model Canvas"
:rem  "A framework, providing categories (building blocks) to let the user autonomously describe their
business models"
:referenceRem "FLEXINET 2.3"

:Prop BMC_System
:Inst Type
:sup  System
:name "Business Model Canvas System"
:rem  "The system defined by the Business Model Canvas"

:Prop Driver
:Inst Type
:sup  Qualifier
:name "Driver"
:rem  "Driver of the Business"
:referenceRem "FLEXINET 4.1"

:Prop CostStructure
:Inst Type
:sup  Information
```

:sup MLO.AbstractEntity
:name "Cost Structure"
:rem "Generated by the application of the Business model defined."
:referenceRem "FLEXINET 6.2"

;;;roles contained in BMC_System
:Prop KeyResource
:Inst Type
:sup Resource
:name "Key Resource"
:rem "Tangible and intangible assets required to design and develop the value proposed"
:referenceRem "FLEXINET 6.2"

:Prop KeyPartner
:Inst Type
:sup Partner
:name "Key Partner"
:rem "Network of partners, suppliers and others stakeholders needed to support the PSS development"
:referenceRem "FLEXINET 6.2"

:Prop KeyActivity
:Inst Type
:sup Actor
:name "Key Activity"
:rem "Key Actitivities to realize and develop the PSS"
:referenceRem "FLEXINET 6.2"

:Prop DistributionChannel
:Inst Type
:sup Actor
:name "Distribution Channel"
:rem "To deliver the Product-Service System."
:referenceRem "FLEXINET 6.2"

:Prop CustomerRelationship
:Inst Type
:sup Actor
:name "Customer Relationship"
:rem "Types of relationships the firm establishes and maintains with specific <sym>2DSCtx.CustomerSegment</sym>s."
:referenceRem "FLEXINET 6.2"

:Prop ValueProposition
:Inst Type
:sup Actor
:name "Value Proposition"

```
:rem  "Product-Service System to offer to customers in order to satisfy their needs and to create
added value."
:referenceRem "FLEXINET 6.2"

:Prop RevenueStream
:Inst Type
:sup  Actor
:name "Revenue Stream"
:rem  "Generated by each <sym>2DSCtx.CustomerSegment</sym>"
:referenceRem "FLEXINET 6.2"

:Prop CustomerSegment
:Inst Type
:sup  Actor
:name "CustomerSegment"
:rem  "Target customers to reach by value proposed."
:referenceRem "FLEXINET 6.2"

:Prop Metric
:Inst Type
:Inst NonLogicalFunctor
:sup Information
:sup MLO.AbstractEntity
:name "Metric"
:rem  "A system or standard of measurement; a criterion or set of criteria stated in quantifiable
terms"
:referenceRem "Oxford English Dictionary. http://www.oed.com"
(disjointSubProps Metric)

:Prop QuantitativeMeasure
:Inst Type
:Inst NonLogicalFunctor
:sup Metric
:sup Quantity
:rem "a measure of ...amount or size."
:referenceRem "Collins English Dictionary.
http://www.collinsdictionary.com/dictionary/english/quantitative."

:Prop QualitativeMeasure
:Inst Type
:sup Metric
:rem "a measure relating to ...quality of something rather than its quantity."
:referenceRem "Oxford Dictionaries Online.
http://www.oxforddictionaries.com/us/definition/american_english/qualitative."

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;Quantitative measures
```

:Prop Distance
:Inst Type
:sup QuantitativeMeasure
:Inst NonLogicalFunctor
:name "Distance"
:rem "The amount of space between two things"
:referenceRem "Oxford Dictionary.
http://www.oxforddictionaries.com/us/definition/american_english/distance"

:Prop Cost
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:name "Cost"
:rem "It is usually a monetary valuation of effort, material, resources, time and utilities consumed, risks incurred, and opportunity forgone in production and delivery of a product or service."
:referenceRem "http://www.businessdictionary.com/"

:Prop DurationMetric
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:sup MLO.Duration
:name "Duration"
:rem " the continuance or length of time."
:referenceRem "http://www.oed.com/view/Entry/58626?redirectedFrom=duration#eid"

:Prop Percent
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:rem "One part in every hundred."
:referenceRem "Oxford Dictionaries Online.
http://www.oxforddictionaries.com/us/definition/american_english/percent."

:Prop MassQuantity
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:rem "The amount of matter in any solid object or in any volume of liquid or gas."
:referenceRem "http://dictionary.cambridge.org/dictionary/british/mass"

:Prop EnergyQuantity
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:rem "A measure of <sym> 1SYSCtx.Energy</sym>."
:referenceRem "http://dictionary.cambridge.org/dictionary/british/mass"

:Prop FuzzyMeasure
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:rem "A fuzzy measure consists of a fuzzy set plus the fuzzy weightings applied."
:referenceRem "FLEXINET D2.1"

:Prop FuzzyError
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:rem "A Fuzzy Error is applied to the value of the <sym>2DSCtx.Indicator</sym> to produce a <sym> 2DSCtx.FuzzyMeasure</sym>."

:Prop IntervalScale
:Inst Type
:Inst NonLogicalFunctor
:sup QuantitativeMeasure
:rem "A scale of measurement of data according to which the differences between values can be quantified in absolute but not relative terms and for which any zero is merely arbitrary."
:referenceRem "http://www.collinsdictionary.com/dictionary/english/interval-scale"

;;;Time will be implemented using Highfleet builtin functions.

;;;
;;;Qualitative measures

;;;N.B. The values of qualitatitive measures are modelled as classes not instances. Facts about instances
;;;form part of a knowledge base and should not appear in the ontology.
;;;The use of HMLType in a signature restricts the arg values to a list of seven values Very High, Fairly High, High, Medium and Fairly Low, Low Very Low.
;;;There appears to be no way to create a restricted list.
;;;"coveredBy" relates to properties not insts as in insts of facts, consts or metaproperties (as below).

:Prop HMLType
:Inst MetaProperty
:sup Type
:name "Measure of Very Low to Very High"

:Prop VeryHigh
:Inst HMLType
:sup QualitativeMeasure

:Prop High
:Inst HMLType
:sup QualitativeMeasure

:Prop FairlyHigh
:Inst HMLType
:sup QualitativeMeasure

:Prop Medium
:Inst HMLType
:sup QualitativeMeasure

:Prop FairlyLow
:Inst HMLType
:sup QualitativeMeasure

:Prop Low
:Inst HMLType
:sup QualitativeMeasure

:Prop VeryLow
:Inst HMLType
:sup QualitativeMeasure

:Prop RiskFactor
:Inst Type
:sup Information
:sup MLO.Object
:rem "An internal or external factor that may influence a Global Production Network adversely."
:referenceRem "2014 FLEXINET D2.1"

:Prop FacilitySpecificRiskFactor
:Inst Type
:sup RiskFactor

:Prop RegionalSpecificRiskFactor
:Inst Type
:sup RiskFactor

:Prop LocationSpecificRiskFactor
:Inst Type
:sup RiskFactor

:Prop Incident
:Inst MLO.EventType
:sup MLO.Event

:Prop Resilience
:Inst Type
:sup Metric

:rem "Resilience is the ability of a Global Production network node to react to the disruptive event and its agility to compensate for inoperability that has arisen"
:referenceRem "2014 FLEXINET D2.1"

;;;metaproperty - needed to refer to types of Indicator in Business Policy threshold value relations
:Prop IndicatorType
:Inst MetaProperty
:sup MaterialRole
:name "Indicator Type"
:metaPropFor Indicator

:Prop Indicator
:Inst MaterialRole
:Inst IndicatorType
:sup Information
:sup MLO.Object
:rem "Something that influences actors in global production networks."
:referenceRem "FLEXINET D3.3"

;;; declaring Indicator as a ULO MaterialRole in order to use the ULO builtin HoldsIn Relation

;;;
:Prop InternalFactor
:Inst MaterialRole
:Inst IndicatorType
:sup Indicator
:rem "Inner strengths and weaknesses that an organization exhibits. Internal factors can strongly affect how well a company meets its objectives, and they might be seen as strengths if they have a favorable impact on a business, but as weaknesses if they have a deleterious effect on the business."
:referenceRem "http://www.businessdictionary.com"

:Prop HumanResourceFactor
:Inst MaterialRole
:Inst IndicatorType
:sup InternalFactor
:rem "An influence resulting from the resource that resides in the knowledge, skills, and motivation of people."
:referenceRem "www.businessdictionary.com/definition/human-resource.html (modified)"
(disjointSubProps HumanResourceFactor)

:Prop ResearchFactor
:Inst MaterialRole
:Inst IndicatorType
:sup InternalFactor
:rem "An influence resulting from the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions"
:referenceRem "http://www.oxforddictionaries.com/us/definition/american_english/research (modified)"

(disjointSubProps ResearchFactor)

:Prop PurchasingFactor
:Inst MaterialRole
:Inst IndicatorType
:sup InternalFactor
:rem "An influence resulting from the activity of acquiring goods or services to accomplish the goals of an organization."
:referenceRem "http://www.businessdictionary.com/definition/purchasing.html (modified)"
(disjointSubProps PurchasingFactor)

:Prop SalesFactor
:Inst MaterialRole
:sup InternalFactor
:rem "An influence resulting from the activity or business of selling products or services."
:referenceRem "http://www.businessdictionary.com/definition/sales.html (modified)"
(disjointSubProps SalesFactor)

:Prop ResourceFactor
:Inst MaterialRole
:sup InternalFactor
:rem "An economic or productive factor required to accomplish an activity"
:referenceRem "http://www.businessdictionary.com/definition/resource.html"
(disjointSubProps ResourceFactor)

:Prop CapitalProductivity
:Inst MaterialRole
:sup InternalFactor
:referenceRem "Balanced ScoreCard example St. Gallen"

:Prop EmissionOfHazardousSubstancesTotheEnvironment
:Inst MaterialRole
:sup InternalFactor
:referenceRem "Balanced ScoreCard example St. Gallen"

;;
:Prop ExternalFactor
:Inst MaterialRole
:Inst IndicatorType
:sup Indicator
:rem "External Factor is a general geopolitical, environmental or economic issue which can affect a GPN, but is outside its control."
:referenceRem "FLEXINET D3.3"

:Prop PoliticalFactor
:Inst MaterialRole
:Inst IndicatorType
:sup ExternalFactor

:rem "Political factors identify to what degree a government intervenes in the economy. Also, political factors determine health, education and infrastructure of a nation to a certain extent."
:referenceRem "2014 FLEXINET D2.1"
(disjointSubProps PoliticalFactor)

:Prop SocialFactor
:Inst MaterialRole
:Inst IndicatorType
:sup ExternalFactor
:rem "Social factors determine the cultural dimension which includes aspects like health consciousness, population growth rate, age distribution (demographics), career attitudes and safety. They are influencing a company's products and services and particularly how a company operates."
:referenceRem "2014 FLEXINET D2.1"
(disjointSubProps SocialFactor)

:Prop EnvironmentalFactor
:Inst MaterialRole
:Inst IndicatorType
:sup ExternalFactor
:rem "Environmental factors are concerned with the general environment like weather, climate and climate change."
:referenceRem "2014 FLEXINET D2.1"
(disjointSubProps EnvironmentalFactor)

:Prop EconomicFactor
:Inst MaterialRole
:Inst IndicatorType
:sup ExternalFactor
:rem "Economic factors have a major impact on a company's business operations and decision-making."
:referenceRem "2014 FLEXINET D2.1"
(disjointSubProps EconomicFactor)

:Prop TechnologicalFactor
:Inst MaterialRole
:Inst IndicatorType
:sup ExternalFactor
:rem "Technological factors are related to R&D activities, automation, technology incentives."
:referenceRem "2014 FLEXINET D2.1"
(disjointSubProps TechnologicalFactor)

:Prop IndustrialElectricityPrices
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop IndustrialGasPrices

:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop DepositInterestRate
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Deposit interest rate is the rate paid by commercial or similar banks for demand, time, or savings deposits. The terms and conditions attached to these rates differ by country, however, limiting their comparability."
:referenceRem "http://data.worldbank.org/indicator/FR.INR.DPST"

:Prop LendingInterestRate
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector. This rate is normally differentiated according to creditworthiness of borrowers and objectives of financing. The terms and conditions attached to these rates differ by country, however, limiting their comparability."
:referenceRem "http://data.worldbank.org/indicator/FR.INR.LEND"

:Prop GDPGrowth
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2005 U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources."
:referenceRem "http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG"

:Prop RealInterestRate
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator."
:referenceRem "http://data.worldbank.org/indicator/FR.INR.RINR"

:Prop ForeignDirectInvestment
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor

:rem "Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors. Data are in current U.S. dollars."
:referenceRem "http://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD"

:Prop GDP
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used."
:referenceRem "http://data.worldbank.org/indicator/NY.GDP.MKTP.CD"

:Prop HouseholdFinalConsumptionExpenditurePerCapitaGrowth
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Annual percentage growth of household final consumption expenditure per capita, which is calculated using household final consumption expenditure in constant 2005 prices and World Bank population estimates. Household final consumption expenditure (private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country."
:referenceRem "http://data.worldbank.org/indicator/NE.CON.PRVT.PC.KD.ZG"

:Prop CostToExport
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Cost measures the fees levied on a 20-foot container in U.S. dollars. All the fees associated with completing the procedures to export or import the goods are included. These include costs for documents, administrative fees for customs clearance and technical control, customs broker fees, terminal handling charges and inland transport. The cost measure does not include tariffs or trade taxes. Only official costs are recorded. Several assumptions are made for the business surveyed: Has 60 or more employees; Is located in the country's most populous city; Is a private, limited liability company. It does not operate within an export processing zone or an industrial estate with special export or import privileges; Is domestically owned with no foreign ownership; Exports more than 10% of its sales. Assumptions about the traded goods: The traded product travels in a dry-cargo, 20-foot,

full container load. The product: Is not hazardous nor does it include military items; Does not require refrigeration or any other special environment; Does not require any special phytosanitary or environmental safety standards other than accepted international standards."
:referenceRem "http://data.worldbank.org/indicator/IC.EXP.COST.CD"

:Prop CostToImport
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Cost measures the fees levied on a 20-foot container in U.S. dollars. All the fees associated with completing the procedures to export or import the goods are included. These include costs for documents, administrative fees for customs clearance and technical control, customs broker fees, terminal handling charges and inland transport. The cost measure does not include tariffs or trade taxes. Only official costs are recorded."
:referenceRem "http://data.worldbank.org/indicator/IC.IMP.COST.CD"

:Prop PumpPriceForDieselFuel
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Fuel prices refer to the pump prices of the most widely sold grade of diesel fuel. Prices have been converted from the local currency to U.S. dollars."
:referenceRem "http://data.worldbank.org/indicator/EP.PMP.DESL.CD"

:Prop PumpPriceForGasoline
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Fuel prices refer to the pump prices of the most widely sold grade of gasoline. Prices have been converted from the local currency to U.S. dollars."
:referenceRem "http://data.worldbank.org/indicator/EP.PMP.SGAS.CD"

:Prop ConsumerPriceIndex
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Consumer price index reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used."
:referenceRem "http://data.worldbank.org/indicator/FP.CPI.TOTL"

:Prop ExportOfGoodsAndServices
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction,

financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments."
:referenceRem "http://data.worldbank.org/indicator/NE.EXP.GNFS.ZS"

:Prop ImportOfGoodsAndServices
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments."
:referenceRem "http://data.worldbank.org/indicator/NE.IMP.GNFS.ZS"

:Prop EconomicSanctions
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop IndustryValueAdded
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Industry corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: For VAB countries, gross value added at factor cost is used as the denominator."
:referenceRem "http://data.worldbank.org/indicator/NV.IND.TOTL.ZS"

:Prop ServicesValueAdded
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: For VAB countries, gross value added at factor cost is used as the denominator."
:referenceRem "http://data.worldbank.org/indicator/NV.SRV.TETC.ZS"

:Prop ListedDomesticCompanies
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Listed domestic companies are the domestically incorporated companies listed on the country's stock exchanges at the end of the year. This indicator does not include investment companies, mutual funds, or other collective investment vehicles."
:referenceRem "http://data.worldbank.org/indicator/CM.MKT.LDOM.NO"

:Prop InflationRate
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop CurrencyRisk
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop Recession
:Inst MaterialRole
:Inst IndicatorType
:sup EconomicFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop CO2Emissions
:Inst MaterialRole
:Inst IndicatorType
:sup EnvironmentalFactor
:rem "Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring."
:referenceRem "http://data.worldbank.org/indicator/EN.ATM.CO2E.PC"

:Prop NitrousOxideEmissions
:Inst MaterialRole
:Inst IndicatorType
:sup EnvironmentalFactor
:rem "Nitrous oxide emissions are emissions from agricultural biomass burning, industrial activities, and livestock management."
:referenceRem "http://data.worldbank.org/indicator/EN.ATM.NOXE.KT.CE"

:Prop AlternativeAndNuclearEnergy
:Inst MaterialRole
:Inst IndicatorType

:sup EnvironmentalFactor
:rem "Clean energy is noncarbohydrate energy that does not produce carbon dioxide when generated. It includes hydropower and nuclear, geothermal, and solar power, among others."
:referenceRem "http://data.worldbank.org/indicator/EG.USE.COMM.CL.ZS"

:Prop OtherGreenhouseGases
:Inst MaterialRole
:Inst IndicatorType
:sup EnvironmentalFactor
:rem "Other greenhouse gas emissions are by-product emissions of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride."
:referenceRem "http://data.worldbank.org/indicator/EN.ATM.GHGO.KT.CE"

:Prop RailwayGoodsTransported
:Inst MaterialRole
:Inst IndicatorType
:sup EnvironmentalFactor
:rem "Goods transported by railway are the volume of goods transported by railway, measured in metric tons times kilometers traveled."
:referenceRem "http://data.worldbank.org/indicator/IS.RRS.GOOD.MT.K6"

:Prop AirTransportFreight
:Inst MaterialRole
:Inst IndicatorType
:sup EnvironmentalFactor
:rem "Air freight is the volume of freight, express, and diplomatic bags carried on each flight stage (operation of an aircraft from takeoff to its next landing), measured in metric tons times kilometers traveled."
:referenceRem "http://data.worldbank.org/indicator/IS.AIR.GOOD.MT.K1"

:Prop LabourProductivity
:Inst MaterialRole
:Inst IndicatorType
:sup HumanResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop LabourExpense
:Inst MaterialRole
:Inst IndicatorType
:sup HumanResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop RevenuePerEmployee
:Inst MaterialRole
:Inst IndicatorType
:sup HumanResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop ExpensesInTrainingOfPersonnelInTheTotalAmountOfExpenses
:Inst MaterialRole
:Inst IndicatorType
:sup HumanResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop NumberOfRationalAndCreativeIdeasPerEmployee
:Inst MaterialRole
:Inst IndicatorType
:sup HumanResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop War
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop Embargo
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop TerroristAttack
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop PoliticalLabourConflicts
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop Standards
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop Tax
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop ImportExportControl
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop LocalRegulations

:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor

:Prop LegalFactor
:Inst MaterialRole
:Inst IndicatorType
:sup PoliticalFactor
:rem "Legal factors are concerned with the legal environment of an actor in a market."
:referenceRem "2014 FLEXINET D2.1"
(disjointSubProps LegalFactor)

:Prop EaseOfDoingBusiness
:Inst MaterialRole
:Inst IndicatorType
:sup LegalFactor
:rem "Ease of doing business ranks economies from 1 to 189, with first place being the best. A high ranking (a low numerical rank) means that the regulatory environment is conducive to business operation. The index averages the country's percentile rankings on 10 topics covered in the World Bank's Doing Business. The ranking on each topic is the simple average of the percentile rankings on its component indicators."
:referenceRem "http://data.worldbank.org/indicator/IC.BUS.EASE.XQ"

:Prop SupplierOnTimeDeliveryPerformance
:Inst MaterialRole
:Inst IndicatorType
:sup PurchasingFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop ExpensesForResearchAndInnovation
:Inst MaterialRole
:Inst IndicatorType
:sup ResearchFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop LengthOfResearchAndInnovationProjects
:Inst MaterialRole
:Inst IndicatorType
:sup ResearchFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop NumberOfRegisteredPatents
:Inst MaterialRole
:Inst IndicatorType
:sup ResearchFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop SpecificWeightOfExpensesOnResearchAndInnovationInTheTotalAmountOfExpenses

:Inst MaterialRole
:Inst IndicatorType
:sup ResearchFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop InformationSystems
:Inst MaterialRole
:Inst IndicatorType
:sup ResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop Productivity
:Inst MaterialRole
:Inst IndicatorType
:sup ResourceFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop InnovationPotential
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "St. Gallen spreadsheet of Indicators"

:Prop NumberOfProductsInMarket
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "St. Gallen spreadsheet of Indicators"

:Prop MarketShare
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop AverageAmountOfProductsShippedToOneCustomerLocalMarket
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop AverageAnnualExpensesToServeOneCustomer
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop AverageTimeBetweenFirstContactWithTheCustomerAndSigningOfAgreement

:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop ExpensesPerCustomer
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop ChangeInMarketShare
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "St. Gallen spreadsheet of Indicators"

:Prop LaunchOfNewProducts
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "St. Gallen spreadsheet of Indicators"

:Prop MarketingExpensesPerCustomer
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop MarketingExpensesRatioOfSales
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop NumberOfAdvertisingCampaigns
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop NumberOfLostCustomers
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop OverallCustomerSatisfcation

:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop TrademarkIndex
:Inst MaterialRole
:Inst IndicatorType
:sup SalesFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop LifeExpectancyAtBirthTotal
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life."
:referenceRem "http://data.worldbank.org/indicator/SP.DYN.LE00.IN"

:Prop LiteracyRateAdultTotal
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Adult (15+) literacy rate (%). Total is the percentage of the population age 15 and above who can, with understanding, read and write a short, simple statement on their everyday life. Generally, 'literacy' also encompasses 'numeracy', the ability to make simple arithmetic calculations. This indicator is calculated by dividing the number of literates aged 15 years and over by the corresponding age group population and multiplying the result by 100."
:referenceRem "http://data.worldbank.org/indicator/SE.ADT.LITR.ZS"

:Prop LiteracyRateYouthTotal
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Youth (15-24) literacy rate (%). Total is the number of people age 15 to 24 years who can both read and write with understanding a short simple statement on their everyday life, divided by the population in that age group. Generally, 'literacy' also encompasses 'numeracy', the ability to make simple arithmetic calculations."
:referenceRem "http://data.worldbank.org/indicator/SE.ADT.1524.LT.ZS"

:Prop CPIATransparencyAccountabilityAndCorruptionInThePublicSectorRating
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Transparency, accountability, and corruption in the public sector assess the extent to which the executive can be held accountable for its use of funds and for the results of its actions by the electorate and by the legislature and judiciary, and the extent to which public employees within the executive are required to account for administrative decisions, use of resources, and results obtained.

The three main dimensions assessed here are the accountability of the executive to oversight institutions and of public employees for their performance, access of civil society to information on public affairs, and state capture by narrow vested interests."
:referenceRem "http://data.worldbank.org/indicator/IQ.CPA.TRAN.XQ"

:Prop AccessToElectricity
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Access to electricity is the percentage of population with access to electricity."
:referenceRem "http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS"

:Prop AccessToNonSolidFuel
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Access to non-solid fuel is the percentage of population with access to non-solid fuel."
:referenceRem "http://data.worldbank.org/indicator/EG.NSF.ACCS.ZS"

:Prop TechniciansInResearchAndDesign
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Technicians in R&D and equivalent staff are people whose main tasks require technical knowledge and experience in engineering, physical and life sciences (technicians), or social sciences and humanities (equivalent staff). They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers."
:referenceRem "http://data.worldbank.org/indicator/SP.POP.TECH.RD.P6"

:Prop PopulationAged0-14
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Population, age 0-14 (% of total) is the population between the ages of 0 and 14 as a percentage of the total population."
:referenceRem "http://data.worldbank.org/indicator/SP.POP.0014.TO.ZS"

:Prop PopulationAged15-64
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Total population between the ages 15 to 64 is the number of people who could potentially be economically active. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of the country of origin.."
:referenceRem "http://data.worldbank.org/indicator/SP.POP.1564.TO.ZS"

:Prop LabourForceWithPrimaryEducation
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Labor force with primary education is the share of the total labor force that attained or completed primary education as the highest level of education."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.PRIM.ZS"

:Prop LabourForceWithSecondaryEducation
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Labor force with secondary education is the share of the total labor force that attained or completed secondary education as the highest level of education."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.SECO.ZS"

:Prop FemaleChildrenInEmployment
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Children in employment refer to children involved in economic activity for at least one hour in the reference week of the survey."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.0714.FE.ZS"

:Prop MaleChildrenInEmployment
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Children in employment refer to children involved in economic activity for at least one hour in the reference week of the survey."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.0714.MA.ZS"

:Prop LabourForceParticipation_Aged15-24
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Labor force participation rate is the proportion of the population ages 15-24 that is economically active: all people who supply labor for the production of goods and services during a specified period. The participation rates are harmonized to account for differences in national data collection and tabulation methodologies as well as for other country-specific factors such as military service requirements. The series includes both nationally reported and imputed data and only estimates that are national, meaning there are no geographic limitations in coverage."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.ACTI.1524.ZS"

:Prop LabourForceParticipation_Aged15Plus
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor

:rem "Labor force participation rate is the proportion of the population ages 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.CACT.ZS"

:Prop LabourForceParticipation_Aged15-64
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor
:rem "Labor force participation rate is the proportion of the population ages 15-64 that is economically active: all people who supply labor for the production of goods and services during a specified period."
:referenceRem "http://data.worldbank.org/indicator/SL.TLF.ACTI.ZS"

:Prop Strike
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor

:Prop InternalDispute
:Inst MaterialRole
:Inst IndicatorType
:sup SocialFactor

:Prop HighTechnologyExports
:Inst MaterialRole
:Inst IndicatorType
:sup TechnologicalFactor
:rem "High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery."
:referenceRem "http://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS"

:Prop QualityOfPortInfrastructure
:Inst MaterialRole
:Inst IndicatorType
:sup TechnologicalFactor
:rem "The Quality of Port Infrastructure measures business executives' perception of their country's port facilities. Data are from the World Economic Forum's Executive Opinion Survey, conducted for 30 years in collaboration with 150 partner institutes. The 2009 round included more than 13,000 respondents from 133 countries. Sampling follows a dual stratification based on company size and the sector of activity. Data are collected online or through in-person interviews. Responses are aggregated using sector-weighted averaging. The data for the latest year are combined with the data for the previous year to create a two-year moving average. Scores range from 1 (port infrastructure considered extremely underdeveloped) to 7 (port infrastructure considered efficient by international standards). Respondents in landlocked countries were asked how accessible are port facilities (1 = extremely inaccessible; 7 = extremely accessible)."
:referenceRem "http://data.worldbank.org/indicator/IQ.WEF.PORT.XQ"

12.3 Level 2 Relationships

```
:Use 2DSCtx

:Rel partContains
:Inst BinaryRel
:Inst NonRigidRel
:supRel basicContainsBasic
:Sig  Part Component
:Args "Part" "Component"
:lex "A part ?1 contains ?2. "
:rem "A <sym>2DSCtx.Part</sym> contains a <sym>2DSCtx.Component</sym>."

;;;commented out role has characteristic, basic has characteristic, basicHasType for time-being LU 20/06/2015

:Rel systemHasType
:Inst BinaryRel
:Inst NonRigidRel
:Sig  System System
:Args "System" "SystemType"
:lex "A system ?1 is of Type ?2. "
:rem "A system has a type (System) not defined  within the reference ontology."

;:Rel basicHasCharacteristic
;:Inst BinaryRel
;:Inst RigidRel
;:Sig  Basic Characteristic
;:Args "Basic" "Characteristic"
;:lex "?1 basic Has Characteristic ?2"
;:rem "A basic is defined by a one or more characteristics or restrictions, e.g. Size, volume."

;:Rel roleHasCharacteristic
;:Inst BinaryRel
;:Inst RigidRel
;:Sig  Role Characteristic
;:Args "Role" "Characteristic"
;:lex "?1 role Has Characteristic ?2"
;:rem "A role is defined by a one or more characteristics or restrictions, e.g. Size, volume."

:Rel systemHasState
:Inst BinaryRel
:Inst NonRigidRel
:Sig  System Information
:Args "System" "Information"
:lex "A system ?1 has State  ?2. "
:rem "A system has a state."
```

```
:Rel  technologyHasDimension
:Inst BinaryRel
:Inst RigidRel
;:supRel  roleHasCharacteristic
:Sig  Technology Dimension
:Args  "Technology" "Dimension"
:lex "?1 Has ?2"
:rem ""

:Rel  technologyHasTRLevel
:Inst BinaryRel
:Inst RigidRel
:supRel technologyHasDimension
:Sig  Technology TechnologyReadinessLevel
:Args  "Technology" "TechnologyReadinessLevel"
:lex "?1 Has ?2"
:rem ""

;;?necessary?  A product needs an input and resources, these can be technologies.
:Rel  basicDependsOnBasic
:Inst BinaryRel
:Inst RigidRel
:Sig  Basic List
:Args  "Basic" "List"
:lex "?1 depends on a list of basic (usually technologies) ?2"
:rem ""

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;Market relations
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

:Rel marketHasALocation
:Inst BinaryRel
:Inst RigidRel
:Sig Market Location
:Args "Market" "Location"
:lex "?1 has location ?2"
:rem "A <sym>2DSCtx.Market</sym> may only have one <sym>2DSCtx.Location</sym>."
(functionalArg marketHasALocation 2)

:Rel marketcontainsOrganisation
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig Market Organisation
:Args "Market" "Organisation"
:lex "?1 contains ?2"
```

:rem "A <sym>2DSCtx.Market</sym> contains <sym>2DSCtx.Organisation</sym>s, e.g. suppliers, customers etc."

:Rel businessPlanRelatesMarket
:Inst BinaryRel
:Inst RigidRel
:Sig BusinessPlan Market
:Args "BusinessPlan" "Market"
:lex "?1 relates to ?2"
:rem "A <sym>2DSCtx.BusinessPlan</sym> must relate to at least one <sym>2DSCtx.Market</sym>."
(totalArg businessPlanRelatesMarket 1)

:Rel businessPlanDerivedFromCanvas
:Inst BinaryRel
:Inst RigidRel
:Sig BusinessPlan BusinessModelCanvas
:Args "BusinessPlan" "BusinessModelCanvas"
:lex "?1 is derived from ?2"
:rem "A <sym>2DSCtx.BusinessPlan</sym> is derived from <sym>2DSCtx.BusinessModelCanvas</sym>. At most one Business Plan is derived from a Business Canvas Model"
(functionalArg businessPlanDerivedFromCanvas 1)

:Rel organisationComposedOfFacility
:supRel basicContainsBasic
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation Facility
:Args "organisation" "facility"
:lex "?1 is composedOf ?2"
:rem "An organisation is composed of facilities."

;;;===
:Rel facilityHasDepartment
:supRel basicContainsBasic
:Inst BinaryRel
:Inst RigidRel
:Sig Facility Department
:Args "facility" "department"
:lex "?1 has ?2"
:rem "Relation to describe that a facility has a department."
;;;===

:Rel facilityContainsProcess
:supRel basicContainsBasic
:Inst BinaryRel
:Inst RigidRel

```
:Sig  Facility System
:Args "Facility" "System"
:lex "?1 contains ?2"
:rem "Relation to express that the processes of a facility."

;;;=================================================
;;;not a system but leaving here as only one relation of this type - LU
:Rel regionList
:Inst BinaryRel
:Inst RigidRel
:Sig  Region List
:Args "Region" "List"
:lex "Region ?1 is composed by ?2 Countries"
:rem ""
(listOfKind regionList 2 Country)

;;;=================================================
:Rel systemLocatedAt
:Inst RootCtx.QuaternaryRel
:Inst NonRigidRel
:Sig System Coordinates {Area/City} 2DSCtx.Country
:Args "System" "Location" "City" "Country"
:lex "?1 LocatedAt ?2"
:rem "Relation to describe that a System is Located at a Location."

;;;=================================================
:Rel facilityLocatedAt
:Inst RootCtx.QuaternaryRel
:Inst NonRigidRel
:supRel systemLocatedAt
:Sig Facility Coordinates {Area/City} 2DSCtx.Country
:Args "Facility" "Location" "City" "Country"
:lex "?1 LocatedAt ?2"
:rem "Relation to describe that a facility is Located at a Location."

:Rel playsRoleQualifier
:Inst TernaryRel
:Inst NonRigidRel
:supRel playsRole
:Sig Information Qualifier Scenario
:Args "Information" "Qualifier" "Scenario"
:lex "Information entity ?1 plays Qualifier Role ?2 in Scenario ?3"
:rem "A Qualifier is played by a <sym>1SYSCtx.Entity</sym> which is a subtype of
<sym>1SYSCtx.Information</sym>."

:Rel playsRoleActor
:Inst TernaryRel
:Inst NonRigidRel
```

:supRel playsRole
:Sig System Actor Scenario
:Args "System" "Actor" "Scenario"
:lex "System entity ?1 plays Actor Role ?2 in Scenario ?3"
:rem "An Actor is played by a <sym>1SYSCtx.Basic</sym> which is a subtype of <sym>1SYSCtx.System</sym>."

:Rel defProject
:Inst BinaryRel
:Inst RigidRel
:Sig String Project
:Args "String" "Project"
:lex "?1 provides a definition for Project ?2"

:Rel requiresInputOfType
:Inst BinaryRel
:Inst NonRigidRel
:Sig ServiceProduct Type
:Args "Service Product" "Type"
:lex "Service ?1 requires input of type ?2"
;;;could instantiate this as an intensional relation?

:Rel flow
:Inst TernaryRel
:Inst RigidRel
:Sig Role Role Scenario
:Args "Source" "Target" "Scenario"
:lex "Flow from Source ?1 to Target ?2 in Scenario ?3"
:rem "A Flow occurs from an <sym>1SYSCtx.Input</sym> to an <sym>1SYSCtx.Output</sym> or from an <sym>1SYSCtx.Output</sym> to an <sym>1SYSCtx.Input</sym> within a given <sym>1SYSCtx.Scenario</sym>."

;;;==
;;;Relations for gateways

:Rel gatewayContainsRole
:Inst BinaryRel
:Inst RigidRel
:Sig Gateway Role
:Args "Gateway" "Role"
:lex "Gateway ?1 contains Role ?1"

:Rel InputHasCondition
:Inst BinaryRel
:Inst RigidRel
:Sig Input Condition
:Args "Input" "Condition"
:lex " Input ?1 Has a Value-Condition (Boolean) ?2"

```
:Rel OutputHasCondition
:Inst BinaryRel
:Inst RigidRel
:Sig Output Condition
:Args "Output" "Condition"
:lex " Output ?1 Has a Value-Condition (Boolean) ?2"

;;;=================================================
;; Relations for Events. ITI Additions, March 2015
;:Rel eventContainsRole
;:Inst BinaryRel
;:Inst RigidRel
;:Sig StartEvent Role
;:Args "StartEvent" "Role"
;:lex "Start Event ?1 contains Role ?1"

:Rel startEventRel
:Inst BinaryRel
:Inst RigidRel
:Sig StartEvent Output
:Args "StartEvent" "Output"
:lex "Start Event ?1 has an output role ?2"

:Rel endEventRel
:Inst BinaryRel
:Inst RigidRel
:Sig EndEvent Input
:Args "EndEvent" "Input"
:lex "End Event ?1 has an input role ?2"

;;;=================================================
;;; Relations for Product.
;;; ManufacturedProduct relations at level 4
:Rel pContainsService
:Inst BinaryRel
:Inst RigidRel
:supRel roleContainsRole
:Sig ProductService ServiceProduct
:Args "Product Service" "Service"
:lex "Product Service ?1 contains a Service ?2"
:rem "A <sym>2DSCtx.ProductService</sym> contains at least one
<sym>2DSCtx.ServiceProduct</sym>."
(totalArg pContainsService 1)

:Rel spContainsProduct
:Inst BinaryRel
:Inst RigidRel
```

:supRel roleContainsRole
:Sig ServiceUsingProduct PhysicalProduct
:Args "ServiceUsingProduct" "PhysicalProduct"
:lex "Service ?1 contains a Product ?2"
:rem "A <sym>2DSCtx.ServiceUsingProduct</sym> contains at least one <sym>2DSCtx.PhysicalProduct</sym>."
(totalArg spContainsProduct 1)

:Rel hasAPrototype
:Inst BinaryRel
:Inst RigidRel
:Sig PhysicalProduct Prototype
:Args "PhysicalProduct" "Prototype"
:lex "PhysicalProduct ?1 has a Prototype ?2"
:rem "A <sym>2DSCtx.PhysicalProduct</sym> has a <sym>2DSCtx.Prototype</sym>."

:Rel projectContainsProduct
:Inst BinaryRel
:Inst RigidRel
:Sig Project Product
:Args "Project" "Product"
:lex " ?1 projectContainsProduct ?2"
:rem "A <sym>2DSCtx.Project</sym> contains a <sym>2DSCtx.Product</sym>"

:Rel projectContainsConcept
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig Project Concept
:Args "Project" "Concept"
:lex " ?1 projectContainsConcept ?2"
:rem "A <sym>2DSCtx.Project</sym>contains a <sym>2DSCtx.Concept</sym>."
:referenceRem "A project can be comprised of several strictly correlated concepts developed consistently together (a product series, for example, where the same base product is pre-packaged with a different set of otherwise optional accessories) - Holonix"

:Rel projectWorldContainsProject
:supRel basicContainsBasic
:Inst BinaryRel
:Inst RigidRel
:Sig ProjectWorld 2DSCtx.Project
:Args "Project World" "Project"
:lex "Project World ?1 contains Project ?2"
:rem "A <sym>4PSPCtx.ProjectWorld</sym> contains a <sym>2DSCtx.Project</sym>."

;;;other relations involving product categories can be modelled using the level 1 basicContainsbasic relation

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;Balanced ScoreCard relations
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
:Rel hasStrategicValue
:Inst BinaryRel
:Inst RigidRel
:Sig  Facility StrategicValue
:Args "Facility" "StrategicValue"
:lex " ?1 has Strategic Value ?2"
:rem "An <sym>2DSCtx.Facility</sym> has a Strategic value or values which apply only to it.  A Strategic value must be possessed by an organisation."
(functionalArg hasStrategicValue 1)
(totalArg hasStrategicValue 2)

:Rel strategicValueHasID
:Inst BinaryRel
:Inst RigidRel
:Sig  StrategicValue String
:Args "StrategicValue" "Identifier"
:lex " ?1 has identifier ?2"
:rem "A <sym>2DSCtx.StrategicValue</sym> may only have one identifier"
(functionalArg strategicValueHasID 2)

:Rel strategicValuehasValue
:Inst BinaryRel
:Inst RigidRel
:Sig  StrategicValue FuzzyMeasure
:Args "StrategicValue" "FuzzyMeasure"
:lex " ?1 has value ?2"
:rem "A <sym>2DSCtx.StrategicValue</sym> must have one value."
(functionalArg strategicValuehasValue 2)
(totalArg strategicValuehasValue 1)

:Rel strategicValuecontainsBSCView
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig  StrategicValue BSCView
:Args "StrategicValue" "Balanced Score Card View"
:lex " ?1 contains BSC View ?2"
:rem "A <sym>2DSCtx.StrategicValue</sym> contains between 1 and 5 <sym>2DSCtx.BSCView</sym>s. A BSCView must be contained by one Strategic Value."
(cardinalityConstraint strategicValuecontainsBSCView 2 inInterval(interval in 1 5 in))
(totalArg strategicValuecontainsBSCView 2)

:Rel bSCviewHasID
:Inst BinaryRel
:Inst RigidRel
```

:Sig BSCView String
:Args "BSCView" "Identifier"
:lex " ?1 has identifier ?2"
:rem "A <sym>2DSCtx.BSCView</sym> may only have one identifier."
(functionalArg bSCviewHasID 2)

:Rel bSCViewhasWeighting
:Inst BinaryRel
:Inst RigidRel
:Sig BSCView Percent
:Args "BSCView" "Percent"
:lex " ?1 has weighting ?2"
:rem "A <sym>2DSCtx.BSCView</sym> may only have one weighting."
(functionalArg bSCViewhasWeighting 2)

:Rel bSCViewhasUncertainty
:Inst BinaryRel
:Inst RigidRel
:Sig BSCView FuzzyError
:Args "BSCView" "Uncertainty"
:lex " ?1 has Uncertainty ?2"
:rem "A <sym>2DSCtx.BSCView</sym> may only have one uncertainty. The Uncertainty consists of a lower percentage uncertainty and an upper percentage uncertainty"
(functionalArg bSCViewhasUncertainty 2)

:Rel bSCViewcontainsKPI
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig BSCView KPI
:Args "BSC View" "Key Performance Indicator"
:lex " ?1 contains BSC View ?2"
:rem "A <sym>2DSCtx.BSCView</sym> contains more than one <sym>2DSCtx.KPI</sym>. A Key Performance Indicator must be contained by one BSCView."
(cardinalityConstraint bSCViewcontainsKPI 2 gtNum 1)
(totalArg bSCViewcontainsKPI 2)

:Rel kPIHasID
:Inst BinaryRel
:Inst RigidRel
:Sig KPI String
:Args "Key Performance Indicator" "Identifier"
:lex " ?1 has identifier ?2"
:rem "A <sym>2DSCtx.KPI</sym> may only have one identifier."
(functionalArg kPIHasID 2)

:Rel kPIhasWeighting
:Inst BinaryRel

```
:Inst RigidRel
:Sig  KPI Percent
:Args "Key Performance Indicator" "Percent"
:lex " ?1 has weighting ?2"
:rem "A <sym>2DSCtx.KPI</sym> may only have one weighting."
(functionalArg kPIhasWeighting 2)

:Rel kPIcontainsPI
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig  KPI PI
:Args "BSC View" "Key Performance Indicator"
:lex " ?1 contains BSC View ?2"
:rem "A <sym>2DSCtx.KPI</sym> contains more than one <sym>2DSCtx.PI</sym>. A Performance
Indicator must be contained by one Key Performance Indicator."
(cardinalityConstraint kPIcontainsPI 2 gtNum 1)
(totalArg kPIcontainsPI 2)

:Rel pIhasWeighting
:Inst BinaryRel
:Inst RigidRel
:Sig  PI Percent
:Args "Performance Indicator" "Percent"
:lex " ?1 has weighting ?2"
:rem "A <sym>2DSCtx.PI</sym> may only have one weighting."
(functionalArg pIhasWeighting 2)

:Rel pIappliesIndicator
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig  PI Indicator
:Args "Performance Indicator" "Indicator"
:lex " ?1 applies Indicator ?2"
:rem "A <sym>2DSCtx.PI</sym> applies to one <sym>2DSCtx.Indicator</sym>. A Performance
Indicator must apply an Indicator."
(cardinalityConstraint pIappliesIndicator 2 eqNum 1)
(totalArg pIappliesIndicator 1)

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;Business Information for Rules relations
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
:Rel specifiesBusinessPolicy
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation BusinessPolicy
:Args "Organisation" "Business Policy"
```

:lex "Organisation ?1 specifies Business Policy ?2"
:rem "An <sym>2DSCtx.Organisation</sym> specifies a <sym>2DSCtx.BusinessPolicy</sym>. A Business Policy may be specified by only one organisation."
(functionalArg specifiesBusinessPolicy 1)

:Rel hasThresholdValueForIndicator
:Inst QuaternaryRel
:Inst RigidRel
:Sig BusinessPolicy IndicatorType ThresholdType Metric
:Args "Business Policy" "IndicatorType" "Min or Max threshold" "Metric"
:lex "?1 specifies a value of ?2 ?3 ?4"
:rem "A <sym>2DSCtx.BusinessPolicy</sym> specifies a minimum or maximum threshold value for an <sym>2DSCtx.Indicator</sym>. Indicatortype and Threshold type are metaproperties. A Business Policy must specify a threshold value."
(totalArg hasThresholdValueForIndicator 1)

:Rel hasPreferredThresholdValueForIndicator
:Inst QuaternaryRel
:Inst RigidRel
:Sig BusinessPolicy IndicatorType ThresholdType Metric
:Args "Business Policy" "IndicatorType" "Min or Max threshold" "Metric"
:lex "?1 specifies a value of ?2 ?3 ?4"
:rem "A <sym>2DSCtx.BusinessPolicy</sym> specifies a minimum or maximum threshold Preferred value for an <sym>2DSCtx.Indicator</sym>. Indicatortype and Threshold type are metaproperties. "

;;;;Supplier relations
:Rel hasAcceptableSupplier
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation 2DSCtx.Facility
:Args "Organisation" "Facility"
:lex "?2 is an acceptable Supplier for ?l"
:rem "An <sym>2DSCtx.Organisation</sym> has an acceptable Supplier. The supplier is viewed as acceptable even if it does not match all the acceptability criteria."

:Rel hasMisMatchingSupplier
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation 2DSCtx.Facility
:Args "Organisation" "Facility"
:lex "?2 is an mismatching Supplier for ?l"
:rem "An <sym>2DSCtx.Organisation</sym> has a mismatching Supplier with reference to its acceptability criteria."

:Rel hasMatchingSupplierLocation
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation Location

:Args "Organisation" "Location"
:lex "Organisation ?1 has a matching Supplier Location ?2"
:rem "An <sym>2DSCtx.Organisation</sym> has a matching Supplier <sym>2DSCtx.Location</sym>(a supplier location that meets its acceptability criteria)."

:Rel hasMisMatchingSupplierLocation
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation Location
:Args "Organisation" "Location"
:lex "Organisation ?1 has a mismatched Supplier Location ?2"
:rem "An <sym>2DSCtx.Organisation</sym> has a mismatched Supplier <sym>2DSCtx.Location</sym> (a supplier location that does NOT meet its acceptability criteria)."

:Rel hasPreferredSupplier
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation 2DSCtx.Facility
:Args "Organisation" "Facility"
:lex "?2 is a preferred Supplier for ?l"
:rem "An <sym>2DSCtx.Organisation</sym> has a preferred Supplier.The supplier is viewed as preferred even if it does not match all the preferred criteria."

:Rel hasDesiredSupplier
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation 2DSCtx.Facility
:Args "Organisation" "Facility"
:lex "?2 is a preferred Supplier for ?l"
:rem "An <sym>2DSCtx.Organisation</sym> has a desired Supplier (one that meets its preferred criteria)."

:Rel hasUnDesiredSupplier
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation 2DSCtx.Facility
:Args "Organisation" "Facility"
:lex "?2 is an undesired Supplier for ?l"
:rem "An <sym>2DSCtx.Organisation</sym> has an undesired Supplier (one that does NOT meet its preferred criteria)."

:Rel hasDesiredSupplierLocation
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation Location
:Args "Organisation" "Location"
:lex "Organisation ?1 has a desired Supplier Location ?2"

```
:rem "An <sym>2DSCtx.Organisation</sym> has a desired Supplier
<sym>2DSCtx.Location</sym>(a supplier location that meets its preferred criteria)."

:Rel hasUnDesiredSupplierLocation
:Inst BinaryRel
:Inst RigidRel
:Sig Organisation Location
:Args "Organisation" "Location"
:lex "Organisation ?1 has an undesired Supplier Location ?2"
:rem "An <sym>2DSCtx.Organisation</sym> has an  undesired Supplier
<sym>2DSCtx.Location</sym> (a supplier location that does NOT meet its preferred criteria)."

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;Business Model Canvas relations
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

:Rel canvasDerivesCost
:Inst BinaryRel
:Inst RigidRel
:Sig BusinessModelCanvas CostStructure
:Args "BusinessModelCanvas" "CostStructure"
:lex "?1 derives Cost Structure ?2"
:rem "A <sym>2DSCtx.BusinessModelCanvas</sym> derives a
<sym>2DSCtx.CostStructure</sym>."

:Rel canvas_systemContainsKeyResource
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System KeyResource
:Args "Business Model Canvas System" "Key Resource"
:lex "?1 contains Key Resource ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.KeyResource</sym>."
(cardinalityConstraint canvas_systemContainsKeyResource 2 gteNum 1)

:Rel canvas_systemContainsKeyPartner
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System KeyPartner
:Args "Business Model Canvas System" "Key Partner"
:lex "?1 contains Key Partner ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.KeyPartner</sym>."
(cardinalityConstraint canvas_systemContainsKeyPartner 2 gteNum 1)

:Rel canvas_systemContainsKeyActivity
```

:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System KeyActivity
:Args "Business Model Canvas System" "Key Activity"
:lex "?1 contains Key Activity ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.KeyActivity</sym>."
(cardinalityConstraint canvas_systemContainsKeyActivity 2 gteNum 1)

:Rel canvas_systemContainsCustomerRelationship
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System CustomerRelationship
:Args "Business Model Canvas System" "Customer Relationship"
:lex "?1 contains Customer Relationship ?2"
:rem "A <sym>BMC_System</sym> contains at least one
<sym>2DSCtx.CustomerRelationship</sym>."
(cardinalityConstraint canvas_systemContainsCustomerRelationship 2 gteNum 1)

:Rel canvas_SystemContainsValueProposition
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System ValueProposition
:Args "Business Model Canvas System" "ValueProposition"
:lex "?1 contains Value Proposition ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.ValueProposition</sym>."
(cardinalityConstraint canvas_SystemContainsValueProposition 2 gteNum 1)

:Rel canvas_SystemContainsRevenueStream
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System RevenueStream
:Args "Business Model Canvas System" "RevenueStream"
:lex "?1 contains Revenue Stream ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.RevenueStream</sym>."
(cardinalityConstraint canvas_SystemContainsRevenueStream 2 gteNum 1)

:Rel canvas_SystemContainsCustomerSegment
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System CustomerSegment

```
:Args "Business Model Canvas System" "CustomerSegment"
:lex "?1 contains Customer Segment ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.CustomerSegment</sym>."
(cardinalityConstraint canvas_SystemContainsCustomerSegment 2 gteNum 1)

:Rel canvas_SystemContainsDistributionChannel
:Inst BinaryRel
:Inst RigidRel
:supRel systemContainsRole
:Sig BMC_System DistributionChannel
:Args "Business Model Canvas System" "DistributionChannel"
:lex "?1 contains Distribution Channel ?2"
:rem "A <sym>2DSCtx.BMC_System</sym> contains at least one
<sym>2DSCtx.DistributionChannel</sym>."
(cardinalityConstraint canvas_SystemContainsDistributionChannel 2 gteNum 1)

:Rel driverHasViewOfCanvas
:Inst BinaryRel
:Inst RigidRel
:Sig Driver BusinessModelCanvas
:Args "Driver" "BusinessModelCanvas"
:lex "?1 has view of ?2"
:rem "A <sym>2DSCtx.Driver</sym> has a view of a <sym>2DSCtx.BusinessModelCanvas</sym>."

:Rel objectiveHasDriver
:Inst BinaryRel
:Inst RigidRel
:Sig Objective Driver
:Args "Objective" "Driver"
:lex "?1 has a ?2"
:rem "An <sym>2DSCtx.Objective</sym> has a <sym>2DSCtx.Driver</sym>."
(cardinalityConstraint objectiveHasDriver 2 gteNum 1)

:Rel definesBMC_System
:Inst BinaryRel
:Inst RigidRel
:Sig BusinessModelCanvas BMC_System
:Args "BusinessModelCanvas" "Business Model Canvas System"
:lex "?1 defines a ?2"
:rem "An <sym>2DSCtx.BusinessModelCanvas</sym> defines one
<sym>2DSCtx.BMC_System</sym>."
:functionalArg 2

:Rel resilienceHasValue
:Inst BinaryRel
:Inst RigidRel
:Sig Resilience FuzzyMeasure
```

```
:Args "Resilience" "FuzzyMeasure"
:lex "?1 has Value ?2"
:rem "Resilience has one value."
:exampleRem "(resilienceHasValue res1 (fuzzyValTripleFN 0.1 0.2 0.3))"
(functionalArg resilienceHasValue 2)

:Rel resilienceHasActorType
:Inst BinaryRel
:Inst RigidRel
:Sig Resilience ActorType
:Args "Resilience" "ActorType"
:lex "?1 has ActorType ?2"
:rem "Resilience has ActorType(s)."
:exampleRem "(resilienceHasActorType res1 2DSCtx.Supplier)"

:Rel facilityHasResilience
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Facility Resilience
:Args "Facility" "Resilience"
:lex "?1 has resilience ?2"
:rem "One Facility has Resilience(s)."
(functionalArg facilityHasResilience 1)

;;;=================================================
;;;Relations of Incident Property
:Rel facililtyHasIncident
:Inst BinaryRel
:Inst RigidRel
:Sig Facility Incident
:Args "Facility" "Incident"
:lex "?1 has associated Incident ?2"
:rem "Facility(s) have Incident(s)."

:Rel incidentHasCause
:Inst BinaryRel
:Inst RigidRel
:Sig  Incident String
:Args "Incident" "Description of Cause"
:lex "?1 has cause ?2"
:rem "Incident has cause(s)."

:Rel incidentHasConsequence
:Inst BinaryRel
:Inst RigidRel
:Sig  Incident String
:Args "Incident" "Description of Consequence"
:lex "?1 has consequence ?2"
```

:rem "Incident has consequence(s)."

:Rel incidentHasSolution
:Inst BinaryRel
:Inst RigidRel
:Sig Incident String
:Args "Incident" "Description of Solution"
:lex "?1 has preventitive solution ?2"
:rem "Incident has solution(s) to prevent it."

:Rel incidentHasLessonsLearned
:Inst BinaryRel
:Inst RigidRel
:Sig Incident String
:Args "Incident" "Description of LessonsLearned"
:lex "?1 has lessons learned ?2"
:rem "Incident has LessonsLearned(s) from it."

:Rel incidentHasLocation
:Inst BinaryRel
:Inst RigidRel
:Sig Incident Location
:Args "Incident" "Location"
:lex "?1 has location ?2"
:rem "Incident has location(s)."
;;;Not sure we need this relation as incidentHasOrganisation and OrganisationHasLocation but it's in the Coventry model.

;;;using the Highfleet builtin occursAt Relation to model FromDate and ToDate of Incident
;;;e.g. (occursAt Incident1 (Span (Date "2002") (Date "2003")))
;;;The query (hasStartTime Incident1 ?time) returns the FromDate
;;;The query (hasEndTime Incident1 ?time) returns the ToDate
;;;The query (hasDuration Incident1 (minutes ?x)) returns the duration.

:Rel riskFactorHasIncident
:Inst BinaryRel
:Inst RigidRel
:Sig RiskFactor Incident
:Args "RiskFactor" "Incident"
:lex "?1 has occurrence Incident ?2"
:rem "RiskFactor(s) have Incident(s) of occurrence."

;;;==
;;;Relations of RiskFactor Property

;;using builtIn Highfleet name relation

:Rel isExampleRF

```
:Inst UnaryRel
:Sig RiskFactor
:lex "?1 is true"
:rem "The RiskFactor is a member of the FLEXINET RiskFactor example library."

:Rel riskFactorHasDataSource
:Inst BinaryRel
:Inst RigidRel
:Sig  RiskFactor String
:Args "RiskFactor" "DataSource"
:lex "?1 has data source ?2"
:rem "Risk has DataSource(s)."

:Rel riskFactorHasMitigationMethod
:Inst BinaryRel
:Inst RigidRel
:Sig  RiskFactor String
:Args "RiskFactor" "MitigationMethod"
:lex "?1 has MitigationMethod ?2"
:rem "RiskFactor(s) have mitigation method(s)."
;;;might change modelling of mitigation method to a system property later?

:Rel riskFactorHasDescription
:Inst BinaryRel
:Inst RigidRel
:Sig  RiskFactor String
:Args "RiskFactor" "Description"
:lex "?1 has description ?2"
:rem "Risk has One Description."
(functionalArg riskFactorHasDescription 2)

:Rel riskFactorHasActorType
:Inst BinaryRel
:Inst RigidRel
:Sig RiskFactor ActorType
:Args "RiskFactor" "ActorType"
:lex "?1 has ActorType ?2"
:rem "RiskFactor(s) have ActorType(s)."
:exampleRem "(riskFactorHasActorType FoodSafety 4PSPCtx.Producer)"

:Rel riskFactorInfluences
:Inst BinaryRel
:Inst RigidRel
:Sig  RiskFactor String
:Args "RiskFactor" "production metric influenced"
:lex "?1 influences ?2"
:rem "Risk has influence on production processes/metrics."
(functionalArg riskFactorInfluences 2)
```

:Rel riskFactorDeptValueOnRF
:Inst TernaryRel
:Inst RigidRel
:Sig RiskFactor FuzzyMeasure RiskFactor
:Args "RiskFactor" "FuzzyMeasure" "RiskFactor"
:lex "?1 has an interdependency of ?2 upon ?3"
:rem "A RiskFactor has a dependency value upon a RiskFactor. There is only one dependency value for a given pair of RiskFactors."
:exampleRem "(riskFactorDeptValueOnRF rf1 (fuzzyValTripleFN 0.1 0.2 0.3) rf2)"
(functionalArg riskFactorDeptValueOnRF 2)

:Rel riskFactorAppliesToFacility
:Inst BinaryRel
:Inst RigidRel
:Sig FacilitySpecificRiskFactor Facility
:Args "FacilitySpecificRiskFactor" "Facility"
:lex "?1 applies to Organisation ?2"
:rem "RiskFactor(s) apply to Facilities(s). A FacilitySpecificRiskFactor must apply to an facility."
(totalArg riskFactorAppliesToFacility 1)

:Rel riskFactorAppliesToRegion
:Inst BinaryRel
:Inst RigidRel
:Sig RegionalSpecificRiskFactor ZoneType
:Args "RegionalSpecificRiskFactor" "Region"
:lex "?1 applies to Region ?2"
:rem "RiskFactor(s) apply to Region(s). An RegionalSpecificRiskFactor must apply to a Region."
(totalArg riskFactorAppliesToRegion 1)

:Rel riskFactorAppliesToLocation
:Inst BinaryRel
:Inst RigidRel
:Sig LocationSpecificRiskFactor Location
:Args "LocationSpecificRiskFactor" "Location"
:lex "?1 applies to Location ?2"
:rem "RiskFactor(s) apply to Location(s). An LocationSpecificRiskFactor must apply to a Location."
(totalArg riskFactorAppliesToLocation 1)

:Rel hasIndicatorID
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator String
:Args "Indicator" "ID"
:lex "?1 has identifier ?2"
:rem "An <sym>2DSCtx.Indicator</sym> may only have one identifier."
(functionalArg hasIndicatorID 2)

:Rel hasIndicatorDescription
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator String
:Args "Indicator" "Description"
:lex "?1 is described by ?2"
:rem "An <sym>2DSCtx.Indicator</sym> may only have one description."
(functionalArg hasIndicatorDescription 2)

;;; modelling the hasDataPeriod attribute by declaring Indicator as a ULO MaterialRole
;;; and using the ULO builtin HoldsIn Relation.
;;;e.g.(holdsIn (Date "2002 Jan" "2007 Jan") (Indicator CustomerIndex))

:Rel hasIndicatorValue
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator Metric
:Args "Indicator" "Metric"
:lex "?1 has value ?2"
:rem "A certain value is provided by <sym>2DSCtx.Indicator</sym> that can be used for risk assessment or economic valuation purposes. An Indicator may only have one value. An Indicator must specify a threshold value."
(functionalArg hasIndicatorValue 2)
(totalArg hasIndicatorValue 1)
;;subrelationships will be created for the sub properties of Indicator constraining the metric types if necessary.
;;E.g IndustrialElectricityPrices hasValue EnergyCost(€/kWh).

:Rel hasIndicatorTargetValue
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator Metric
:Args "Indicator" "Metric"
:lex "?1 has Target value ?2"
:rem "Required evolution (Target) represents the value to be achieved. An Indicator may only have one Target value."
:referenceRem "FLEXINET 4.1"
(functionalArg hasIndicatorTargetValue 2)

:Rel hasIndicatorFuzzyValue
:Inst BinaryRel
:Inst RigidRel
:supRel hasIndicatorValue
:Sig Indicator FuzzyMeasure
:Args "Indicator" "FuzzyMeasure"
:lex "?1 has fuzzy value ?2"
:rem "<sym>2DSCtx.Indicator</sym> has a <sym>2DSCtx.FuzzyMeasure</sym>. An Indicator may only have one Fuzzy value."

(functionalArg hasIndicatorFuzzyValue 2)

:Rel hasIndicatorFuzzyError
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator FuzzyError
:Args "Indicator" "FuzzyError"
:lex "?1 has fuzzy error ?2"
:rem "An <sym>2DSCtx.Indicator</sym> has a <sym>FuzzyError</sym>. An Indicator may only have one Fuzzy error."
(functionalArg hasIndicatorFuzzyError 2)

:Rel hasIndicatorEvaluationMethod
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator String
:Args "Indicator" "Evaluation Method"
:lex "?1 has Evaluation Method ?2"
:rem "Calculation Processing represents the evaluation method for the indicator."
:referenceRem "FLEXINET 4.1"

:Rel ownsIndicator
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Department Indicator
:Args "Organisation Unit" "Indicator"
:lex "?1 owns the indicator ?2"
:rem "The owner (Who measures) points to the responsible organisation unit. An indicator may only have one owner."
:referenceRem "FLEXINET 4.1"
(functionalArg ownsIndicator 1)

:Rel hasEvaluationUpdatePeriod
:Inst BinaryRel
:Inst RigidRel
:Sig Indicator DurationMetric
:Args "Indicator" "Evaluation Period"
:lex "?1 has evaluation period ?2"
:rem "Period is the time span required to evaluate the indicator. An Indicator may only have one evaluation period. (E.g. Repeat evaluation every month, quarter etc.)"
:referenceRem "FLEXINET 4.1"
(functionalArg hasEvaluationUpdatePeriod 2)

:Rel facilityHasInternalFactor
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Facility InternalFactor
:Args "facility" "InternalFactor"

:lex "?1 has Internal Factor ?2"
:rem "An <sym>2DSCtx.Facility</sym> has <sym>2DSCtx.InternalFactor</sym>s which affect it. The internal factors only apply to one specific facility. An internal factor must have an facility."
(functionalArg facilityHasInternalFactor 1)
(totalArg facilityHasInternalFactor 2)

:Rel locationHasExternalFactor
:Inst BinaryRel
:Inst RigidRel
:Sig Location ExternalFactor
:Args "Location" "ExternalFactor"
:lex "?1 has External Factor ?2"
:rem "A <sym>2DSCtx.Location</sym> has <sym>2DSCtx.ExternalFactor</sym>s which apply to it. The external factors only apply to one specific location (which can be global, city, etc. An external factor must have a location."
(functionalArg locationHasExternalFactor 1)
(totalArg locationHasExternalFactor 2)

:Rel internalFactorContainsFacilityRiskFactor
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig InternalFactor FacilitySpecificRiskFactor
:Args "InternalFactor" "FacilitySpecificRiskFactor"
:lex "?1 has risk factor ?2"
:rem "An <sym>2DSCtx.InternalFactor</sym> may encompass one <sym>2DSCtx.FacililtySpecificRiskFactor.</sym>"
(functionalArg internalFactorContainsFacilityRiskFactor 2)

:Rel externalFactorContainsLocationRiskFactor
:Inst BinaryRel
:Inst RigidRel
:supRel basicContainsBasic
:Sig ExternalFactor LocationSpecificRiskFactor
:Args "ExternalFactor" "LocationSpecificRiskFactor"
:lex "?1 has risk factor ?2"
:rem "An <sym>2DSCtx.ExternalFactor</sym> may encompass one <sym>2DSCtx.LocationSpecificRiskFactor</sym>"
(functionalArg externalFactorContainsLocationRiskFactor 2)

:Rel projectContainsScenario
:Inst BinaryRel
:Inst RigidRel
:Sig Project Scenario
:Args "project" "scenario"
:lex "Project ?1 contains scenario ?2"

:Rel projecthasChosenScenario

:Inst BinaryRel
:Inst RigidRel
:Sig Project Scenario
:Args "project" "scenario"
:lex "Project ?1 hasChosen scenario ?2"
:rem "A <sym>2DSCtx.Project</sym> has one chosen <sym>1SYSCtx.Scenario</sym>"
(functionalArg projecthasChosenScenario 2)

12.4 Level 2 Functions

:Use ../2DSCtx

:Fun numberOf
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegInt -> QuantitativeMeasure
:name "Whole Number of "

:Fun scaleAndvalue
:Inst TernaryFun
:Sig NonNegInt NonNegInt NonNegInt -> IntervalScale
:Args "bottom of scale" "top of scale" "value" -> "IntervalScale"
:rem "The value specified must fall within the range between bottom of scale and top of scale."

:Fun days
:supRel MLO.days
:Inst UnaryFun
:Inst MeasureFun
:measureMultiple 24 hours
:Sig RealNumber -> DurationMetric
:name "days function for a metric"
:lex "?1 days"
:rem "A <sym>RootCtx.Function</sym> used to return a <sym>DurationMetric</sym> measured in days (24 <sym>MLO.hours</sym>)."

:Fun years
:Inst UnaryFun
:Inst MeasureFun
:measureMultiple 365 days
:Sig RealNumber -> DurationMetric
:name "years function for a metric"
:lex "?1 years"
:rem "A <sym>RootCtx.Function</sym> used to return a <sym>DurationMetric</sym> measured in years (assuming 365 <sym>MLO.days</sym>)."

;;
;;; cost functions

```
:Fun euro
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "euro"

:Fun {euro/h}
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "euros per Hour"

:Fun $
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "dollar"

:Fun {dollar/container}
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "dollars per container"

:Fun {dollar/liter}
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "dollars per liter"

:Fun {tonCO2/MillionEuroSales}
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "ton of CO2 per million euro sales"

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;energy cost functions

:Fun {euro/kWh}
:Inst UnaryFun
:Inst MeasureFun
:Sig  NonNegReal -> Cost
:name "euros per kiloWattHour"

:Fun {euro/GJ}
:Inst UnaryFun
:Inst MeasureFun
```

:Sig NonNegReal -> Cost
:name "euros per gigajoule"

:Fun kCal
:Inst MeasureFun
:Sig RealNumber -> EnergyQuantity
:rem "1000 times the energy needed to raise the temperature of 1 <sym>2DSCtx.gram</sym> of water through 1 degree C "
:referenceRem "http://www.oxforddictionaries.com/us/definition/american_english/calorie"

;;;
;;;percent functions

:Fun %
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage"

:Fun percentPa
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage per annum"

:Fun percentOfPopulation
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of population"

:Fun percentOfFemaleChildrenAged7-14
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "% of female children ages 7-14"

:Fun percentOfMaleChildrenAged7-14
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "% of male children ages 7-14"

:Fun percentOfTotalEnergyUse
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of total energy use"

```
:Fun percentGDP
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of gross domestic product"

:Fun percentManufacturedExports
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of manufactured exports"

:Fun percentProducts
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of products"

:Fun percentOfLabourForce
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of labour force"

:Fun percentOfTotalProductCategories
:Inst UnaryFun
:Inst MeasureFun
:Sig NonNegReal -> Percent
:name "percentage of total product categories"

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;mass quantity functions

:Fun gram
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:rem     "A metric unit of mass equal to one thousandth of a kilogram."
:referenceRem "http://www.oxforddictionaries.com/us/definition/american_english/gram#gram-2"

:Fun mgram
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:rem     "A metric unit of mass that is equal to 0.001 <sym>2DSCtx.gram</sym>s."
:referenceRem "http://dictionary.cambridge.org/dictionary/british/milligram"
```

```
:Fun kilogram
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:rem     "A metric unit of mass that is equal to 1000 <sym>2DSCtx.gram</sym>s."
:referenceRem "http://dictionary.cambridge.org/dictionary/english/kilogram"

:Fun tonne
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:rem     "A metric unit of mass that is equal to 1000000 <sym>2DSCtx.gram</sym>s."
:referenceRem "http://dictionary.cambridge.org/dictionary/english/ton"

:Fun ktonne
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:rem     "A metric unit of mass that is equal to 1000000000 <sym>2DSCtx.gram</sym>s."
:referenceRem "http://www.thefreedictionary.com/kiloton"

:Fun tonnesPerCaptia
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:name "tonnes per capita"

:Fun ktonnesCO2Equivalent
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:name "kilotons CO2 equivalent"

:Fun tonnesPerKm
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:name "tonnes per kilometre"

:Fun tonnesPerMillionPeople
:Inst UnaryFun
:Inst MeasureFun
:Sig RealNumber -> MassQuantity
:name "tonnes per million people"

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;fuzzy number functions
:Fun fuzzyValTripleFN
```

:Inst TernaryFun
:Sig NonNegReal NonNegReal NonNegReal -> FuzzyMeasure
:Args "low" "mid" "high" -> "FuzzyMeasure"
:rem "TFNs are identified by three numbers, first representing the lowest possible value, second the value with the highest possibility and third that represents the highest possible value"
:referenceRem "FLEXINET D2.1"

:Fun fuzzyValLinguisticCoupleFN
:Inst BinaryFun
:Sig HMLType HMLType -> FuzzyMeasure
:Args "Confidence" "Value" -> "FuzzyMeasure"
:rem ""
:referenceRem "FLEXINET D2.3"

:Fun riskFuzzyValTripleFN
:Inst TernaryFun
:supRel fuzzyValTripleFN
:Sig UnitRange UnitRange UnitRange -> FuzzyMeasure
:Args "low" "mid" "high" -> "FuzzyMeasure"
:rem "Risk fuzzyValue Triple Functions contain values between 0 and 1"
:referenceRem "FLEXINET D2.1"
;;;UnitRange is nonreal between 0 and 1 inclusive

:Fun fuzzyErrorFN
:Inst BinaryFun
:Sig Percent Percent -> FuzzyError
:Args "Lower Error" "Upper Error" -> "FuzzyError"
:rem "A Fuzzy Error consists of an Lower Error which is used to produce the first (or lowest) value of a <sym>2DSCtx.FuzzyMeasure</sym> and an Upper Error which is used to produce the third (or highest) value of a <sym>2DSCtx.FuzzyMeasure</sym>."

12.5 Level 2 Axioms

:Use 2DSCtx

(=> (and (ServiceProduct ?service1)
(playsRole ?system1 ?service1 ?scenario1)
(Input ?input1)
(systemContainsRole ?system1 ?input1)
(playsRole ?basic1 ?input1 ?scenario1)
(instAsserted ?basic1 ?basictype)
)
(requiresInputOfType ?service1 ?basictype))
:rem "There is a Service. A System plays the Role of the Service. An Input exists to the Service.
;This implies that the Service requires input of this type."

(=> (and (System ?system)
(playsRole ?system ?role ?scenario)

```
        )
        (not(systemContainsRole ?system ?role))
)
```

:IC hard "The same System cannot contain a Role and play the Role. ?system playsRole ?role in Scenario ?scenario.
The relation systemContainsRole does not hold between ?system and ?role."

;;;;Network axioms

```
; ============================================================
(=>    (NetworkScenario ?netS)
      (exists (?source ?target ?system1 ?system2)
                        (and
                              (System ?system1)
                                    (System ?system2)
                                    (systemContainsRole ?system1 ?source)
                                    (systemContainsRole ?system2 ?target)
                                    (/= ?system1 ?system2)
                              (flow ?source ?target ?netS))
                )
)
```

:IC soft "A network scenario must contain a flow between two systems but ?netS does not."
;;;Should be IC hard but this fires as I have no flows defined in my simple Risk examples - I need to update the samples with flow.

```
; ============================================================
(=> (and    (Basic ?basic)
                        (Output ?outputRole)
                        (System ?sOutput)
                        (NetworkScenario ?netS)
                        (playsRole ?basic ?outputRole ?netS)
                        (systemContainsRole ?sOutput ?outputRole)

        )
                (exists (?inputRole ?sInput)
                        (and     (Input ?inputRole)
                              (System ?sInput)
                                    (/= ?sInput ?sOutput)
                                    (playsRole ?basic ?inputRole ?netS)
                                    (systemContainsRole ?sInput ?inputRole)

                         )))
```

:IC soft "A Basic playing the role of an Output to a System must play the role of an Input to a different system within the Network scenario but in ?netS ?basic plays output role ?outputRole in System ?sOutput but does not play an input role to a different System."
;:IC hard "A Basic playing the role of an Output to a System must play the role of an Input to a different system within the Network scenario but in ?netS ;?basic plays output role ?outputRole in System ?sOutput but does not play an input role to a different System."

```
;;;Use IC hard for standards

;;;Gateway axioms
; ============================================================
(=> (Gateway ?g)
        (exists (?inputRole ?outputRole)
                (and
                        (Input ?inputRole)
                        (Output ?outputRole)
                        (gatewayContainsRole ?g ?inputRole)
                        (gatewayContainsRole ?g ?outputRole))))
:IC hard " A gateway must have one input and one output"
;============================================================
(=> (DivergingGateway ?dg)
        ;(exists (?inputRole ?outputRole)
                (and
                        (Input ?inputRole)
                        (Output ?outputRole)
                        (count (gatewayContainsRole ?dg ?inputRole) ?nin)
                        (count (gatewayContainsRole ?dg ?outputRole) ?nout)
                        (= ?nin 1)
                        (RootCtx.lteNum 2 ?nout)))
:IC hard " A diverging gateway has only one input and 2 or more outputs (describes an opening AND or a fork)"

;============================================================
(=>(ConvergingGateway ?dg)
        ;(exists (?inputRole ?outputRole)
                (and
                        (Input ?in)
                        (Output ?out)
                        (count (gatewayContainsRole ?dg ?inputRole) ?nin)
                        (count (gatewayContainsRole ?dg ?outputRole) ?nout)
                        (= ?nout 1)
                        (RootCtx.lteNum 2 ?nin)))
:IC hard " A converging gateway has 2 or more inputs and only one output (describes an closing AND or a join)"

;============================================================
(=>(InclusiveDivergingGateway ?idg)
                (and
                        (Condition ?outCondition)
                        (OutputHasCondition ?outputRole ?outCondition)))
:IC hard " A inclusive diverging gateway (opening OR) has one input and 2 or more outputs An output must have a condition (a boolean)".

;============================================================
(=>(InclusiveConvergingGateway ?icg)
```

```
                (and
                        (Condition ?inCondition)
                        (InputHasCondition ?inputRole ?inCondition)))
```
:IC hard "An inclusive converging gateway ("closing OR") has one default output and two or more inputs. An input must have a condition (a boolean). "

```
;=============================================================
(=> (and  (ExclusiveDivergingGateway ?edg)
                (Output ?outputRole)
                (Output ?outputRole1)
                (/= ?outputRole ?outputRole1)
                (gatewayContainsRole ?edg ?outputRole)

                (gatewayContainsRole ?edg ?outputRole1))
        (not (exists (?outCondition)
                        (and (Condition ?outCondition)
                                (OutputHasCondition ?outputRole ?outCondition)
                                (OutputHasCondition ?outputRole1 ?outCondition)))))
```
:IC hard "An exclusive diverging gateway ("opening XOR", branch) inherits from an inclusive diverging gateway. The value of the condition of an output must not be identical to the value of the condition of any of the other outputs of the XOR gateway (i.e. only one condition within the XOR gateway can activated, so only one branch can be taken). "

```
;=============================================================
(=> (and  (ExclusiveConvergingGateway ?ecg)
                (Input ?inputRole)
                (Input ?inputRole1)
                (/= ?inputRole ?inputRole1)
                (gatewayContainsRole ?ecg ?inputRole)

                (gatewayContainsRole ?ecg ?inputRole1))
        (not (exists (?inputRole1)
                        (and
                                (Condition ?inCondition)
                                (InputHasCondition ?inputRole ?inCondition)
                                (InputHasCondition ?inputRole1 ?inCondition)))))
```
:IC hard "An exclusive converging gateway ("closing XOR", merge) inherits from an inclusive diverging gateway. The value of the condition of an input must not be identical to the value of the condition of any of the other inputs of the XOR gateway (i.e. only one condition within the XOR gateway can activated, so only one incoming flow is needed)."

```
; =============================================================
(=> (StartEvent ?startEvent)
        (and
                (Output ?outputRole)
                (count (startEventRel ?startEventRel ?outputRole)  ?nRels)
                (= ?nRels 1)))
```

:IC hard "A Start Event is a specialised type of Basic which has an output role only (which is played by the trigger for the network). Examples of Start Point outputs are New Technology (KSB), Product-Service Request (Indesit) and Customer Request (CD). "

```
; ============================================================
(=> (EndEvent ?endEvent)
        (and
                (Input ?inputRole)
                (count (endEventRel ?endEvent ?inputRole)  ?nRels)
                (= ?nRels 1)))
```

:IC hard "An End Event is a specialised type of Basic which has an input role only."

```
(=>  (flow ?source ?target ?scenario)
        (or (and (Input ?source)
                 (Output ?target))
                 (and (Output ?source)
                 (Input ?target))
         )
)
```

:IC hard "A flow can only exist between an Input and an Output or an Output and an Input. This does not occur in the relation (flow ?source ?target ?scenario)."

```
(=>  (flow ?source1 ?target1 ?scenario1)
        (exists (?source2 ?target2 ?scenario2)
        (and (= ?source1 ?source2)
            (= ?target1 ?target2)
                (= ?scenario1 ?scenario2)
            (not (flow ?target2 ?source2 ?scenario2) ) ) )
)
```

:IC hard "A flow can only exist from a target to a source or a source to a target but not in both directions (XOR). There is flow from ?source1 to ?target1 in Scenario ?scenario1 for which a reverse flow exists."

```
;(=>  (holdsIn ?span1 (flow ?source1 ?target1 ?scenario1))
;        (exists (?source2 ?target2 ?scenario2 ?span2)
;        (and (= ?source1 ?source2)
;            (= ?target1 ?target2)
;                (= ?scenario1 ?scenario2)
;                (= ?span1 ?span2)
;            (not (holdsIn ?span2 (flow ?target2 ?source2 ?scenario2) ) ) ))
;)
```

;:IC hard "A flow can only exist from a target to a source or a source to a target but not in both directions (XOR) at the same time. There is flow from ;?source1 to ?target1 in Scenario ?scenario1 for which a reverse flow exists."

;;; Experimented with this axiom but it doesn't apply as Flow is a rigid relation.

```
(=> (and (flow ?source ?target ?scenario)
```

```
        (playsRole ?basic ?source ?scenario))
    (playsRole ?basic ?target ?scenario)
)
:IC hard "In a flow relation the source basic must flow to a target. ?basic plays the role of source ?source but does not play the role of target ?target in Scenario ?scenario."

;; ============================================================
;; List of axioms applicable to the Technology Effect Analyser
;; ====  AXIOMS TEA ===

;;      A Technology Has at least one dimension.
(=> (Technology ?t)
        (exists (?d)
        (and (Dimension ?d)
                (technologyHasDimension ?t ?d))))
:IC soft "Axiom PNES_2_2_1: A Technology Has at least one dimension."

(=> (Technology ?t)
        (exists (?trl)
        (and (TechnologyReadinessLevel ?trl)
                (technologyHasDimension ?t ?trl))))
:IC soft "Axiom PNES_2_2_2: A technology Has the dimension TRL. "

;;A role input, output and resource is described in terms of their characteristics. "
;(=> (Input ?in)
;       (exists (?c)
;       (and (Characteristic ?c)
;               (roleHasCharacteristic ?in ?c))))
;:IC soft "Axiom PNES_2_2_3: An Input should have at least one Characteristic"

;(=> (Output ?out)
;       (exists (?c)
;       (and (Characteristic ?c)
;               (roleHasCharacteristic ?out ?c))))
;:IC soft "Axiom PNES_2_2_4: An Output should have least one Characteristic"

;(=> (Resource ?re)
;       (exists (?c)
;       (and (Characteristic ?c)
;               (roleHasCharacteristic ?re ?c))))
;:IC soft "Axiom PNES_2_2_5: A Resource should have at least one Characteristic"


(=> (and (Technology ?t)
                (playsRole ?basic ?t ?))
                        (exists(?r)
                         (and (playsRole ?basic ?r ?)
```

(or (Input ?r)(Output ?r)(Resource ?r)(Control ?r)))))

:IC soft "Axiom PNES_2_2_6: A basic playing role of technology in a System, playsRole also as Input, or Output or Resource or Control in the same system. "

```
(=>  (strategicValuehasValue ?var1 (fuzzyValTripleFN ?l ?m ?h))
          (and(lteNum ?m 1000)
             (gteNum ?m 0))
)
```

:IC hard "?var1 has a value ?m. The Strategic Value is a score within the values of 0 and 1000."

```
(=> (and
       (strategicValuecontainsBSCView ?sv ?)
         (sumf ?weight (?weight ?bsc)
                 (and
                    (strategicValuecontainsBSCView ?sv ?bsc)
                    (bSCViewhasWeighting ?bsc (% ?weight)))
                    ?sumScoreView
          )
                   )
          (lteNum ?sumScoreView 100)
)
```

:IC hard "For a Strategic Value it is prohibited that the sum of the contained Balanced Scorecard View weightings exceed 100%. Strategic value ?sv contains weightings which sum to ?sumScoreView %."

```
(=> (and
       (bSCViewcontainsKPI ?bsc ?)
         (sumf ?weight (?weight ?kpi)
                 (and
                    (bSCViewcontainsKPI ?bsc ?kpi)
                    (kPIhasWeighting ?kpi (% ?weight)))
                    ?sumKPI
          )
                   )
          (lteNum ?sumKPI 100)
)
```

:IC hard "For a Balanced Score Card view it is prohibited that the sum of the contained KPIs weightings exceed 100%. Balanced Score Card view ?bsc contains weightings which sum to ?sumKPI %."

```
(=> (and
       (kPIcontainsPI  ?kpi ?)
         (sumf ?weight (?weight ?pi)
                 (and
                    (kPIcontainsPI  ?kpi ?pi)
                    (pIhasWeighting ?pi (% ?weight)))
                    ?sumPI
```

```
        )
                )
        (lteNum ?sumPI 100)
)
```

:IC hard "For a Key Performance Indicator it is prohibited that the sum of the contained PIs weightings exceed 100%. KPI ?kpi contains weightings which sum to ?sumPI %."

;;;defining allowed cardinalities for quaternary relation hasThresholdValueForIndicator - Highfleet Functional args only work with binary

```
(=>(hasThresholdValueForIndicator ?businessPolicy1 ?indicatorType1 ?thresholdType1 ?metric1)
(not(exists(?thresholdType2 ?metric2)
(and(hasThresholdValueForIndicator ?businessPolicy2 ?indicatorType2 ?thresholdType2 ?metric2)
(= (listof ?businessPolicy1 ?indicatorType1) (listof ?businessPolicy2 ?indicatorType2))
(/=(listof ?thresholdType1 ?metric1)(listof ?thresholdType2 ?metric2))))
))
```

:IC hard "A Business Policy has one Theshold Value for an Indicator. BusinessPolicy ?businessPolicy2 has more than one for indicator ?indicatorType1."

;;;defining allowed cardinalities for quaternary relation hasPreferredThresholdValueForIndicator

```
(=>( hasPreferredThresholdValueForIndicator ?businessPolicy1 ?indicatorType1 ?thresholdType1
?metric1)
(not(exists(?thresholdType2 ?metric2)
(and(hasPreferredThresholdValueForIndicator ?businessPolicy2 ?indicatorType2 ?thresholdType2
?metric2)
(= (listof ?businessPolicy1 ?indicatorType1) (listof ?businessPolicy2 ?indicatorType2))
(/=(listof ?thresholdType1 ?metric1)(listof ?thresholdType2 ?metric2))))
))
```

:IC hard "A Business Policy has at most one Preferred Theshold Value for an Indicator. BusinessPolicy ?businessPolicy2 has more than one for indicator ?indicatorType1."

```
(=>(and (Facility ?potentialSupplier)
                (IndicatorType ?internalfactorType)
                (countf(?internalfactor)
          (and (facilityHasInternalFactor  ?potentialSupplier ?internalfactor)
        (instAsserted ?internalfactor ?internalfactorType))
          ?totalInternalfactor)
        )
   (lteNum ?totalInternalfactor 1)
)
```

:IC hard "For a given Type of Internal factor a facility has at most one internal factor instance. Facility ?potentialSupplier has more than one internal factor instance specified for type ?internalfactorType."

```
(=>(and (Location ?location)
                (IndicatorType ?externalfactorType)
                (countf(?externalfactor)
          (and (locationHasExternalFactor  ?location ?externalfactor)
        (instAsserted ?externalfactor ?externalfactorType))
```

```
            ?totalExternalfactor)
        )
    (lteNum ?totalExternalfactor 1)
)
```
:IC hard "For a given Type of External factor a location has at most one external factor instance. Location ?location has more than one external factor instance specified for type ?externalfactorType."

```
;;;axioms applying to a fuzzy number in arg2 of any binary relation
(=>
        (?relation ?var1 (fuzzyValTripleFN ?l ?m ?h))
        (and (lteNum ?l ?m)
                (lteNum ?m ?h)))
```
:IC hard "In relation ?relation ?var1 has a Fuzzy value. In a Fuzzy value triple ?l must be <= ?m must be <= ?h."
```
;;copied from an example supplied by Lindsey Spratt

;;;=================================================
;;;axioms applying to a fuzzy number in arg2 of any ternary relation
(=>
        (?relation ?var1 (fuzzyValTripleFN ?l ?m ?h) ?var2)
        (and (lteNum ?l ?m)
                (lteNum ?m ?h)))
```
:IC hard "In relation ?relation a Fuzzy value exists between ?var1 and ?var2. In a Fuzzy value triple ?l must be <= ?m must be <= ?h."

```
;;;=================================================
(=>
        (?relation ?var1 (scaleAndvalue ?bottom ?top ?value))
        (inInterval ?value (interval in ?bottom ?top in))
)
```
:IC hard "Relation ?relation ?var1 has an IntervalScale value. Value ?value must be within the interval [?bottom , ?top]."

```
(=> (riskFactorDeptValueOnRF ?factor1 ?fuzzyMeasure ?factor2)
        (/= ?factor1 ?factor2)
)
```
:IC hard "A risk factor cannot depend on itself, but ?factor1 does."

```
(=> (projecthasChosenScenario ?proj ?scen)
        (projectContainsScenario ?proj ?scen)
)
```
:IC hard "The chosen scenario for the project must be contained by the project. Project ?proj has chosen scenario ?scen but does not contain ?scen."

12.6 Level 2 Rules

:Use 2DSCtx

```
(=> (and (ServiceProduct ?service1)
(playsRole ?system1 ?service1 ?scenario1)
(Input ?input1)
(systemContainsRole ?system1 ?input1)
(playsRole ?basic1 ?input1 ?scenario1)
(instAsserted ?basic1 ?basictype)
)
(requiresInputOfType ?service1 ?basictype))
:rem "There is a Service. A System plays the Role of the Service. An Input exists to the Service.
This implies that the Service requires input of this type."

;; ====  RULES GPN ===
;; Rule  - If a system/process contains another system/process, then the child process belongs to the
same Network that the parent process.
(=> (and (System ?x)
       (System ?z)
                  (basicContainsBasic ?z ?x)
                  (Network ?net)
                  (basicContainsBasic ?net ?z))
                  (basicContainsBasic ?net ?x))

;; ====  RULES  TEA ===

;;Rule  - A technology must have always a TRL level (default value). LEVEL_0 Default Value ?????
(=> (Technology ?t)
         (and (TechnologyReadinessLevel 0)
                   (technologyHasDimension ?t 0)))

;; ====  RULES  BUSINESS ===

(=>
         (and (systemLocatedAt ?potentialSupplier ?co-ord ?area ?locationofCountry)
              (hasMisMatchingSupplierLocation ?companySpecifying ?locationofCountry)
         )
         (hasMisMatchingSupplier ?companySpecifying ?potentialSupplier)
)
:rem "If an organisation is located in a country which is an mismatching supplier Location for
?companySpecifying then the organisation is an mismatching supplier for ?companySpecifying."
;;;NB Currently modelling Location based on Country as this is used in the systemLocatedAt relation.
I'm using this as we have no developed geographic knowledge base, i.e. we can't infer Paris is in
France etc.

;;;defining rules for mis/matching Supplier location
(=>
  (and
         (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
         (instDirect ?externalfactor ?indicatorType)
```

```
        (specifiesBusinessPolicy ?companySpecifying ?policy)
        (inst ?policy LocationFactorforSupplier)
        (ifExistsThenElse  (?indUnitX ?threshUnitX ?indValueX ?thresholdX ?threshValueX)
                (and
                        (hasIndicatorValue ?externalfactor (?indUnitX ?indValueX))
                        (hasThresholdValueForIndicator ?policy ?indicatorType ?thresholdX
(?threshUnitX ?threshValueX)))
                (and
                        (/= ?indUnitX ?threshUnitX)
                        (= ?indUnit ?indUnitX)
                        (= ?threshUnit ?threshUnitX)
                        (= ?indValue ?indValueX)
                        (= ?threshold ?thresholdX)
                        (= ?threshValue ?threshValueX))
                (= 0 1)))
        (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
:rem "If  ?companySpecifying has a business policy which has an indicator of type ?indicatortype with a value which has a UNARY function unitType ?unitType and an location has an instance of this type of external factor with a value which has a UNARY unitType NOT the same as ?unitType (i.e. the unitTypes don't match) then the location is an MisMatching Supplier Location for ?companySpecifying."
;;;N.B. this rule is using ifExistsThen to force the evaluation of (/= ?indUnitX ?threshUnitX) to occur after the rest of the literals of interest. There is a bug in Highfleet.

(=>
(and
        (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
        (instDirect ?externalfactor ?indicatorType)
        (specifiesBusinessPolicy ?companySpecifying ?policy)
        (inst ?policy LocationFactorforSupplier)
        (ifExistsThenElse (?indUnitX ?threshUnitX ?indScaleLX ?indScaleUX ?indValueX ?thresholdX
?threshScaleLX ?threshScaleUX ?threshValueX)
                (and
                        (hasIndicatorValue ?externalfactor (?indUnitX ?indScaleLX ?indScaleUX
?indValueX))
                        (hasThresholdValueForIndicator ?policy ?indicatorType ?thresholdX
(?threshUnitX ?threshScaleLX ?threshScaleUX ?threshValueX)))
                (and
                        (/= ?indUnitX ?threshUnitX)
                        (= ?indUnit ?indUnitX)
                        (= ?threshUnit ?threshUnitX)
                        (= ?indValue ?indValueX)
                        (= ?threshold ?thresholdX)
                        (= ?indScaleL ?indScaleLX)
                        (= ?indScaleU ?indScaleUX)
                        (= ?threshValue ?threshValueX)
                        (= ?threshScaleL ?threshScaleLX)
```

```
        (= ?threshScaleU ?threshScaleUX))
                (= 0 1))
)
        (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
```

:rem "If ?companySpecifying has a business policy which has an indicator of type ?indicatortype with a value which has a TERNARY function unitType ?unitType and an location has an instance of this type of external factor with a value which has a TERNARY unitType NOT the same as ?unitType (i.e. the unitTypes don't match) then the location is an MisMatching Supplier Location for ?companySpecifying."

```
(=>
(and
        (specifiesBusinessPolicy ?companySpecifying ?policy)
                (hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit ?threshScaleL ?threshScaleU ?threshValue))
                (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
                (hasIndicatorValue ?externalfactor (?indUnit ?indValue))
        (instDirect ?externalfactor ?indicatorType)
)
        (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
```

:rem "If ?companySpecifying has a business policy which has an indicator of type ?indicatortype with a value which has a TERNARY function unitType and a location has an instance of this type of external factor with a value which has a UNARY function unitType (i.e. the unitTypes don't match) then the location is an MisMatching Supplier Location for ?companySpecifying."

```
(=>
(and
        (specifiesBusinessPolicy ?companySpecifying ?policy)
                (hasThresholdValueForIndicator ?policy ?indicatorType ?thresholdX (?threshUnit ?threshValue))
                (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
                (hasIndicatorValue ?externalfactor (?indUnit ?indScaleL ?indScaleU ?indValue))
        (instDirect ?externalfactor ?indicatorType)
)
        (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
```

:rem "If ?companySpecifying has a business policy which has an indicator of type ?indicatortype with a value which has a UNARY function unitType and a location has an instance of this type of external factor with a value which has a TERNARY function unitType (i.e. the unitTypes don't match) then the location is an MisMatching Supplier Location for ?companySpecifying."

```
(=>
        (and
                (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
                (hasIndicatorValue ?externalfactor (?indUnit ?indScaleL ?indScaleU ?indValue))
```

(hasIndicatorValue ?externalfactor ?indicatorValue)
(specifiesBusinessPolicy ?companySpecifying ?policy)
(inst ?policy LocationFactorforSupplier)
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit ?threshScaleL ?threshScaleU ?threshValue))
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold ?thresholdValue)
(instDirect ?externalfactor ?indicatorType)
(= ?indUnit ?threshUnit)
(instDirect ?indicatorValue IntervalScale)
(/= ?indScaleL ?threshScaleL)
)
(hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier)
)
:rem "If a location has an instance of external factor IntervalScale and ?companySpecifying has a business policy which has an indicator of this type, the units of the externalfactor value and the business policy indicator value are equal and the LOWER Scale value of the external factor interval scale is not equal to the LOWER Scale value of the business policy interval scale then the location is an MisMatching Supplier Location for ?companySpecifying (i.e. both values must use the same scale range)."

(=>
(and
(locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
(hasIndicatorValue ?externalfactor (?indUnit ?indScaleL ?indScaleU ?indValue))
(hasIndicatorValue ?externalfactor ?indicatorValue)
(specifiesBusinessPolicy ?companySpecifying ?policy)
(inst ?policy LocationFactorforSupplier)
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit ?threshScaleL ?threshScaleU ?threshValue))
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold ?thresholdValue)
(instDirect ?externalfactor ?indicatorType)
(= ?indUnit ?threshUnit)
(instDirect ?indicatorValue IntervalScale)
(/= ?indScaleU ?threshScaleU)
)
(hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier)
)
:rem "If a location has an instance of external factor IntervalScale and ?companySpecifying has a business policy which has an indicator of this type, the units of the externalfactor value and the business policy indicator value are equal and the UPPER Scale value of the external factor interval scale is not equal to the
the UPPER Scale value of the business policy interval scale then the location is an MisMatching Supplier Location for ?companySpecifying (i.e. both values must use the same scale range)."

(=>
(and
(locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
(hasIndicatorValue ?externalfactor (?indUnit ?indValue))

(specifiesBusinessPolicy ?companySpecifying ?policy)
(inst ?policy LocationFactorforSupplier)
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit ?threshValue))
(instDirect ?externalfactor ?indicatorType)
(= ?indUnit ?threshUnit)
(= ?threshold 2DSCtx.>/=)
(ltNum ?indValue ?threshValue)
)
(hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier)
)
:rem "If a location has an external factor which is less than the minimum threshold value specified by the company ?companySpecifying for this type of external factor then the location is a misMatching Supplier location for ?companySpecifying. Units of metrics are of same UNARY type"

(=>
(and
(locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
(hasIndicatorValue ?externalfactor (?indUnit ?indValue))
(specifiesBusinessPolicy ?companySpecifying ?policy)
(inst ?policy LocationFactorforSupplier)
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit ?threshValue))
(instDirect ?externalfactor ?indicatorType)
(= ?indUnit ?threshUnit)
(= ?threshold 2DSCtx.</=)
(not(lteNum ?indValue ?threshValue))
)
(hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier)
)
:rem "If a location has has an external factor which is NOT less than/equal to the maximum threshold value specified by the company ?companySpecifying for this type of external factor then the location is an MisMatching Supplier location for ?companySpecifying. Units of metrics are of same UNARY type"

(=>
(and
(locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
(hasIndicatorValue ?externalfactor (?indUnit ?indScaleL ?indScaleU ?indValue))
(specifiesBusinessPolicy ?companySpecifying ?policy)
(inst ?policy LocationFactorforSupplier)
(hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit ?threshScaleL ?threshScaleU ?threshValue))
(instDirect ?externalfactor ?indicatorType)
(= ?indUnit ?threshUnit)
(= ?threshold 2DSCtx.>/=)
(ltNum ?indValue ?threshValue)
)

```
   (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
```

:rem "If a location has has an external factor which is less than the minimum to the maximum threshold value specified by the company ?companySpecifying for this type of external factor then the location is an MisMatching Supplier location for ?companySpecifying. Units of metrics are assumed to be of same TERNARY type"

```
(=>(and
                (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
                (hasIndicatorValue ?externalfactor (?indUnit ?indScaleL ?indScaleU ?indValue))
                (specifiesBusinessPolicy ?companySpecifying ?policy)
                (inst ?policy LocationFactorforSupplier)
                (hasThresholdValueForIndicator ?policy ?indicatorType ?threshold (?threshUnit
?threshScaleL ?threshScaleU ?threshValue))
                (instDirect ?externalfactor ?indicatorType)
                (= ?indUnit ?threshUnit)
                (= ?threshold 2DSCtx.</=)
                (not(lteNum ?indValue ?threshValue))
        )
   (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
```

:rem "If a location has has an external factor which is NOT less than/equal minimum to the maximum threshold value specified by the company ?companySpecifying for this type of external factor then the location is an MisMatching Supplier location for ?companySpecifying. Units of metrics are of same TERNARY type"

```
(=>
        (and (and (LocationFactorforSupplier ?locationFactor)
          (specifiesBusinessPolicy ?companySpecifying ?locationFactor)
        (hasThresholdValueForIndicator ?locationFactor ?indicatortype ?threshold ?value)
                )
                (and (2DSCtx.Country ?locationOfpotentialSupplier)
            (setofx ?externalfactorType (?externalfactorType ?externalfactor)
            (and (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
          (instAsserted ?externalfactor ?externalfactorType))
            ?listExternalfactors)
                )
                (not(item ?listExternalfactors ?indicatortype))
        )
   (hasMisMatchingSupplierLocation ?companySpecifying ?locationOfpotentialSupplier)
)
```

:rem "If there is an Location Supplier factor which has a location factor and a country doesn't have a value for this external factor then the country is an MisMatching Supplier Location. I.e. if ?companyspecifying specifies a location factor for a Supplier location which is not a member of the list of external factors for a country then this country is an mismatching supplier Location for ?companySpecifying."

;;;in this rule need to compare have a metaproperty in the hasThresholdValueForIndicator relation so need to find the property (using instAsserted) of the locationHasExternalFactor relation. Currently modelling Location based on Country.

```
(=>
        (and
                (and
                (specifiesBusinessPolicy ?companySpecifying ?locationFactor)
                (inst ?locationFactor LocationFactorforSupplier)
                (hasThresholdValueForIndicator ?locationFactor ?indicatorType ?threshold
?threshValue)
                (setofx ?misMatchingSupplierLocation (?misMatchingSupplierLocation)
                (hasMisMatchingSupplierLocation ?companySpecifying ?misMatchingSupplierLocation)
?listMisMatchingSupplierLocations)
                )
                (2DSCtx.Country ?potentialSupplierLocation)
                (not (item ?listMisMatchingSupplierLocations ?potentialSupplierLocation))
        )
        (hasMatchingSupplierLocation ?companySpecifying ?potentialSupplierLocation)
)
```

:rem "If a country for a potential supplier is not mismatching for ?companySpecifying (a member of the list of misMatchingSupplierLocations) then it is matching supplier Location."
;;;NB Currently modelling Location based on Country

;;
;;;defining Preferred Rule set
;;;defining rules for preferred Supplier

```
(=>
        (and (systemLocatedAt ?potentialpreferredSupplier ?co-ord ?area ?locationofCountry)
            (hasUnDesiredSupplierLocation ?companySpecifying ?locationofCountry)
        )
        (hasUnDesiredSupplier ?companySpecifying ?potentialpreferredSupplier)
)
```

:rem "If an organisation is located in a country which is an undesired supplier Location for ?companySpecifying then the organisation is an undesired supplier for ?companySpecifying."
;;;NB Currently modelling Location based on Country as this is used in the systemLocatedAt relation. I'm using this as we have no developed geographic knowledge base, i.e. we can't infer Paris is in France etc.

;;;defining rules for un/desired Supplier Location

```
(=>
        (and
                (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
                (hasIndicatorValue ?externalfactor (?indUnit ?indValue))
                (specifiesBusinessPolicy ?companySpecifying ?policy)
                (inst ?policy LocationFactorforSupplier)
```

```
                (hasPreferredThresholdValueForIndicator ?policy ?indicatorType ?threshold
(?threshUnit ?threshValue))
                (instDirect ?externalfactor ?indicatorType)
                (= ?indUnit ?threshUnit)
                (= ?threshold 2DSCtx.>/=)
                (ltNum ?indValue ?threshValue)
        )
   (hasUnDesiredSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
:rem "If a location has an external factor which is less than the minimum threshold value specified by
the company ?companySpecifying for this type of external factor then the location is an UnDesired
Supplier location for ?companySpecifying. Units of metrics are assumed to be of same type"

(=>
        (and
                (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
                (hasIndicatorValue ?externalfactor (?indUnit ?indValue))
                (specifiesBusinessPolicy ?companySpecifying ?locationFactor)
                (inst ?locationFactor LocationFactorforSupplier)
                (hasPreferredThresholdValueForIndicator ?locationFactor ?indicatorType ?threshold
(?threshUnit ?threshValue))
                (instDirect ?externalfactor ?indicatorType)
                (= ?indUnit ?threshUnit)
                (= ?threshold 2DSCtx.</=)
                (not(lteNum ?indValue ?threshValue))
        )
   (hasUnDesiredSupplierLocation ?companySpecifying ?locationOfpotentialSupplier )
)
:rem "If a location has has an external factor which is NOT less than/equal to the maximum threshold
value specified by the company ?companySpecifying for this type of external factor then the location
is an UnDesired Supplier location for ?companySpecifying. Units of metrics are assumed to be of
same type"

(=>
        (and (and (LocationFactorforSupplier ?locationFactor)
          (specifiesBusinessPolicy ?companySpecifying ?locationFactor)
        (hasPreferredThresholdValueForIndicator ?locationFactor ?indicatortype ?threshold ?value)
                )
                (and (2DSCtx.Country ?locationOfpotentialSupplier)
            (setofx ?externalfactorType (?externalfactorType ?externalfactor)
            (and (locationHasExternalFactor ?locationOfpotentialSupplier ?externalfactor)
          (instAsserted ?externalfactor ?externalfactorType))
            ?listExternalfactors)
                )
                (not(item ?listExternalfactors ?indicatortype))
        )
   (hasUnDesiredSupplierLocation ?companySpecifying ?locationOfpotentialSupplier)
)
```

:rem "If there is an Location Supplier factor which has a location factor and a country doesn't have a value for this external factor then the country is an UnDesired Supplier Location. I.e. if ?companyspecifying specifies a location factor for a Preferred Supplier location which is not a member of the list of external factors for a country then this country is an UnDesired supplier Location for ?companySpecifying."

```
(=>
        (and
                (and
                (specifiesBusinessPolicy ?companySpecifying ?locationFactor)
                (inst ?locationFactor LocationFactorforSupplier)
                (hasPreferredThresholdValueForIndicator ?locationFactor ?indicatorType ?threshold
?threshValue)
                (setofx ?unDesiredSupplierLocation (?unDesiredSupplierLocation)
                (hasUnDesiredSupplierLocation ?companySpecifying ?unDesiredSupplierLocation)
?listUnDesiredSupplierLocations)
                )
                (2DSCtx.Country ?potentialSupplierLocation)
                (not (item ?listUnDesiredSupplierLocations ?potentialSupplierLocation))
                (hasMatchingSupplierLocation ?companySpecifying ?potentialSupplierLocation)
                ;(hasAcceptableSupplierLocation ?companySpecifying ?potentialSupplierLocation)
        )
        (hasDesiredSupplierLocation ?companySpecifying ?potentialSupplierLocation)
)
```

:rem "If a country for a potential supplier is not unDesired for ?companySpecifying (a member of the list of UnDesiredSupplierLocations) and is matching then it is Desired."

```
(=>
        (and
                (inScenario ?component ?compound)
                (playsRoleActor ?role ?basic ?component)
        )
        (playsRoleActor ?role ?basic ?compound))
```

;:rem "if a component scenario is contained within (inScenario) a compound scenario, a playsRoleActor relation which applies in the component scenario also applies in the compound scenario."

```
(=>
        (and
                (inScenario ?component ?compound)
                (playsRoleQualifier ?role ?basic ?component)
        )
        (playsRoleQualifier ?role ?basic ?compound))
```

;:rem "if a component scenario is contained within (inScenario) a compound scenario, a playsRoleQualifier relation which applies in the component scenario also applies in the compound scenario."

13 Annex C: Level 3 and Level 4 Ontology Code

Level 3 KFL CODE

Contained herein is the KFL and ECLIF code for the FLEXINET Level 3 reference ontology:

13.1 Level 3 Context

```
:Use ../2DSCtx

:Ctx 3MBSCtx
:Inst UserContext
:supCtx ../2DSCtx
```

Level 4 KFL CODE

Contained herein is the KFL and ECLIF code for the FLEXINET Level 4 reference ontology:

13.2 Level 4 Context: Product Service Lifecycle Systems

```
:Use ../3MBSCtx

:Ctx 4PSLSCtx
:Inst UserContext
:supCtx ../3MBSCtx
```

13.3 Level 4 Context: Product Service Systems

```
:Use ../4PSLSCtx

:Ctx 4PSPCtx
:Inst UserContext
:supCtx ../4PSLSCtx
```

13.4 Level 4 Properties

```
:Use 4PSPCtx

:Prop CommunicationProtocol
:Inst Type
:sup 2DSCtx.CommunicationProtocol
:rem  "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.CommunicationProtocol</sym>."

:Prop ProductionFeature
:Inst Type
:sup Information
:sup Feature
:name "Production Feature"
```

:rem "A <sym>2DSCtx.Feature</sym> relating specifically to the Production domain."

:Prop ProductionMaterial
:Inst Type
:sup Material
:name "Production Material"
:rem "A <sym>1SYSCtx.Material</sym> used within the Production domain."

:Prop FunctionInformation
:Inst Type
:sup 2DSCtx.FunctionInformation
:name "Function Information"
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.FunctionInformation</sym>."

:Prop ProductionEquipment
:Inst Type
:sup 2DSCtx.Equipment
:name "Production Equipment"
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Equipment</sym>."

:Prop ProductionCost
:Inst Type
:sup Cost
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Cost</sym>."

:Prop ProductionPlan
:Inst Type
:sup Plan
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Plan</sym>."

:Prop BOM
:Inst Type
:sup ProductionPlan
:name "Bill of Materials"
:rem "BOM lists the components required to build a <sym>2DSCtx.Product</sym> as well as information related to these components."
:referenceRem "Imran, M. 2013, Towards an Assembly Reference Ontology for Assembly Knowledge Sharing, PhD Thesis, Loughborough University, U.K."

:Prop BOR
:Inst Type
:sup ProductionPlan
:name "Bill of Resources"
:rem "BOR represents the required assembly resources to carry out the assembly processes for a particular <sym>2DSCtx.Product</sym>."
:referenceRem "Imran, M. 2013, Towards an Assembly Reference Ontology for Assembly Knowledge Sharing, PhD Thesis, Loughborough University, U.K."

:Prop BOP
:Inst Type
:sup ProductionPlan
:name "Bill of Process"
:rem "BOP lists the sequence of assembly processes for the production of a particular <sym>2DSCtx.Product</sym>."
:referenceRem "Imran, M. 2013, Towards an Assembly Reference Ontology for Assembly Knowledge Sharing, PhD Thesis, Loughborough University, U.K."

:Prop Idea
:Inst Type
:sup 2DSCtx.Idea
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Idea</sym>."

:Prop Concept
:Inst Type
:sup 2DSCtx.Concept
:name "Concept"
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Concept</sym>."

:Prop CustomerSatisfaction
:Inst Type
:sup 2DSCtx.CustomerSatisfaction
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.CustomerSatisfaction</sym>."

:Prop BusinessModel
:Inst Type
:sup 2DSCtx.BusinessModel
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.BusinessModel</sym>."

:Prop ManufacturingAuthorityLevel
:Inst Type
:sup Metric
:name "Manufacturing Authority Level"
:rem "Level for the right, power or ability to control, command or decide into a manufacturing domain"
:referenceRem "http://www.wordreference.com/definition/authority (Adapted)"

:Prop ManufacturingStandard
:Inst Type
:sup Standard
:name "Manufacturing Standard"
:rem "Something considered to be a basis of comparison into a manufacturing domain"
:referenceRem "http://www.wordreference.com/definition/standard (Adapted)"

:Prop Facility
:Inst Type
:sup 2DSCtx.Facility

:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Facility</sym>."

:Prop ProductFacility
:Inst Type
:sup 2DSCtx.ProductFacility
:name "Product Facility"
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.ProductFacility</sym>."

:Prop ServiceFacility
:Inst Type
:sup 2DSCtx.ServiceFacility
:name "Service Facility"
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.ServiceFacility</sym>."

:Prop ProductionNetwork
:Inst Type
:sup 2DSCtx.Network
:name "Production Network"
:rem "A specialism of a <sym>2DSCtx.Network</sym> which is concerned with producing a <sym>4PSPCtx.ManufacturedProduct</sym>."
;;need to remove in BrightNet

:Prop ProjectWorld
:Inst Type
:sup ProductionNetwork
:name "Project Production Network Domain"
:rem "A specialism of a <sym>4PSPCtx.ProductionNetwork</sym> which contains <sym>1SYSCtx.Role</sym>s played by globally dispersed <sym>1SYSCtx.System</sym>s. Identifies all the potential contributors within the Ecosystem to a global production network for a particular project."
;;need to alter this in BrightNet

:Prop ProductionMethod
:Inst Type
:sup System
:name "Production Method"
:rem "Processes and techniques that are used to manufacture a <sym>2DSCtx.Product</sym>."
:referenceRem "http://encyclopedia2.thefreedictionary.com/Production+methods"

:Prop Stage
:Inst Type
:sup System
:name "Stage"
:rem "A step or degree in a process, development, or series."
:referenceRem "http://www.wordreference.com/definition/stage?s=line%20stage"

:Prop Operation
:Inst Type

:sup System
:name "Operation"
:rem "Series of functions and tasks that are involved in a single process. For example, a manufacturing operation."
:referenceRem "http://www.businessdictionary.com/definition/operation.html"

:Prop Operate
:Inst Type
:sup 2DSCtx.Operate
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Operate</sym>."

:Prop ProductionDepartment
:Inst Type
:sup 2DSCtx.Department
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Department</sym>."

:Prop Transport
:Inst Type
:sup 2DSCtx.Transport
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Transport</sym>."

:Prop ProductionSoftware
:Inst Type
:sup 2DSCtx.Software
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.ManufacturingSoftware</sym>."

:Prop ManufacturingOrganisation
:Inst Type
:sup Organisation
:name "Manufacturing Organisation"
:rem "Organisation for the production of goods, esp by industrial processes"
:referenceRem "http://www.wordreference.com/definition/manufacturing"

:Prop ProductionAutomation
:Inst Type
:sup Automation
:name "Manufacturing Automation"
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Automation</sym>."

:Prop ProductionControl
:Inst Type
:sup ControlSystems
:name "Production Control"
:rem "Activities involved in handling materials, parts, assemblies, and subassemblies, from their raw or initial stage to the finished product stage in an organized and efficient manner. It may also include activities such as planning, scheduling, routing, dispatching, storage, etc."
:referenceRem "http://www.businessdictionary.com/definition/production-control.html"

:Prop ManufacturingVirtualisation
:Inst Type
:sup Virtualisation
:name "Manufacturing Virtualisation"
:rem "Constructing and manipulating abstract (mathematical and/or graphical) representations of manufacturing situations, simulated with the help of a computer system. Also called computer simulation."
:referenceRem "http://www.businessdictionary.com/definition/computer-modeling.html"

:Prop DesignEngineer
:Inst ActorType
:sup Actor
:rem "The term it refers engineers who develop new products or processes with a primary emphasis on functional utility."
:referenceRem "http://en.wikipedia.org/wiki/Design_engineer"

:Prop ProductionEngineer
:Inst ActorType
:sup Actor
:rem "Person dedicate to the design and application of manufacturing techniques to produce a specific product."
:referenceRem "http://www.businessdictionary.com/"

:Prop Producer
:Inst ActorType
:sup Actor
:rem "a person or business enterprise that generates goods or services for sale "
:referenceRem "http://www.collinsdictionary.com/"

:Prop ServiceEngineer
:Inst ActorType
:sup Actor
:rem "someone who maintains and repairs equipment"
:referenceRem "http://www.collinsdictionary.com/dictionary/english/service-engineer"

:Prop Ingredient
:Inst Type
:sup Component
:name "Ingredient"
:rem "A material or substance which you use to make something."
:referenceRem "http://www.dictionarycentral.com/definition/ingredient.html"

:Prop DiscreteComponent
:Inst Type
:sup Component
:name "Discrete component"
:rem "A <sym>2DSCtx.Component</sym> which is individually recognizable and countable, distinct and separate from the similar items."

:referenceRem "http://www.businessdictionary.com/definition/discrete.html"

:Prop Manufacturer
:Inst ActorType
:sup Actor
:rem "Entity that makes a good through a process involving raw materials, components, or assemblies, usually on a large scale with different operations divided among different workers."
:referenceRem "http://www.businessdictionary.com/"

:Prop ManufacturedProduct
:Inst Type
:sup PhysicalProduct
:rem "A <sym>2DSCtx.Product</sym> that exploits/consumes a raw material."

:Prop ManufacturedProductService
:Inst Type
:sup ManufacturedProduct
:rem "A specialisation of <sym>ProductService</sym> within the Level 4 Product Service Production domain."

:Prop Functionality
:Inst Type
:sup 2DSCtx.Functionality
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Functionality</sym>."

:Prop ProductionAsset
:Inst Type
:sup 2DSCtx.Asset
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Asset</sym>."

:Prop ProductionRequirements
:Inst Type
:sup 2DSCtx.Requirements
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Requirements</sym>."

:Prop Customer
:Inst Type
:sup 2DSCtx.Customer
:rem "Level 4PSP specialisation of Level 2DS <sym>2DSCtx.Customer</sym>."

:Prop SoftwareTechnology
:Inst Type
:sup ProductionEquipment
:rem "Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Numerical Control (CNC),
Direct Numerical Control (DNC), Programmable Logic Control (PLC), Numerical Control (NC), program optimization software, and systems integration software"
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop MaterialRemoval
:Inst Type
:sup ProductionEquipment
:rem "Turning, milling, drilling, grinding, tapping, electrical discharge machines (EDM), broaching, sawing, water jet cutting equipment, and laser process equipment."
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop MaterialForming
:Inst Type
:sup ProductionEquipment
:rem "Stamping, bending, joining, hydro-forming, presses, shearing, cold and hot forming equipment."
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop WorkHolding
:Inst Type
:sup ProductionEquipment
:rem "Computer Chucks, fixtures, clamps, blocks, angle plates, and tooling columns."
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop Tooling
:Inst Type
:sup ProductionEquipment
:rem "Drills, taps, reamers, boring bars, dies, punches, and grinding wheels."
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop MaterialHandling
:Inst Type
:sup ProductionEquipment
:rem "Conveyors, automated wire guided vehicles, die handling equipment, robots, pallet changers, and bar feed equipment."
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop AutomatedSystems
:Inst Type
:sup ProductionEquipment
:rem "Transfer machines, assembly systems, automated systems and cells, and Flexible Manufacturing Systems (FMS)."
:referenceRem "http://www.amtonline.org/aboutamt/WhatisManufacturingTechnology/"

:Prop LocationFactorforProducer
:Inst Type
:sup 2DSCtx.LocationFactor
:name "Threshold Values for Producer Location Factors"
:rem "Minimum and preferredvalues for factors specified by an organisation describing a <sym>2DSCtx.Location</sym> whose <sym>4PSPCtx.Producer</sym>s it is willing to do business with."

:Prop PolicyAboutProducer
:Inst Type
:sup 2DSCtx.BusinessPolicy
:name "Threshold Values for Business Policies for a Producer"
:rem "Threshold values for factors specified by an organisation describing a <sym>4PSPCtx.Producer</sym> with which it is willing to do business, i.e. factors which control the choice of a producer."

:Prop ProductionFactor
:Inst MaterialRole
:sup InternalFactor
:rem "An influence resulting from the action or process of making goods from components or raw materials."
:referenceRem "Oxford English Dictonary http://www.oed.com/view/Entry/151994?redirectedFrom=production#eid (modified)"
(disjointSubProps ProductionFactor)

:Prop CycleTimeOfProduction
:Inst MaterialRole
:Inst IndicatorType
:sup ProductionFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop RatioOfTimelyCompletedOrders
:Inst MaterialRole
:Inst IndicatorType
:sup ProductionFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop ExpensesRelatedNewProducts
:Inst MaterialRole
:Inst IndicatorType
:sup ProductionFactor
:rem "Expenses related to preparations and study of new products in the total amount of expenses."
:referenceRem "Balanced ScoreCard example St. Gallen"

:Prop OrderFulfilmentLeadTime
:Inst MaterialRole
:Inst IndicatorType
:sup ProductionFactor
:rem "Balanced ScoreCard example St. Gallen"

:Prop ProductServiceLifeCycle
:Inst Type
:sup 2DSCtx.Lifecycle
:name "Product Service LifeCycle"

:rem "An integration and connection of the life cycles of products and services to a common life cycle."

:Prop SupportSystem
:Inst Type
:sup 1SYSCtx.System
:name "Support System"
:rem "Elements which are used to assist in delivering the PSP systems offerings: infrastructure (hard and soft) and support network (provider, property, QoPS)"

:Prop SupportNetwork
:Inst Type
:sup 2DSCtx.Network
:name "Support Network"
:rem "A network is a series of points or nodes interconnected by communication paths supporting the data transmission among nodes http://searchnetworking.techtarget.com/definition/network"
:rem ""

:Prop Infrastructure
:Inst Type
:sup 2DSCtx.Infrastructure
:name "Infrastructure"
:rem "The basic systems and services, such as transport and power supplies, that a country or organization uses in order to work effectively http://dictionary.cambridge.org"

:Prop Hardware
:Inst Type
:sup 2DSCtx.Equipment
:name "Hardware"
:rem "The physical and electronic parts of a system http://dictionary.cambridge.org"

:Prop Software
:Inst Type
:sup 2DSCtx.Software
:name "Software"
:rem " the instructions that control what a computer does; computer programs. http://dictionary.cambridge.org"

:Prop Benefit
:Inst Type
:sup 2DSCtx.Benefit
:name "Benefit"
:rem "results and expectations of the ProductService over the economic, social and environment."

:Prop DemandIdentification
:Inst Type
:sup 2DSCtx.CustomerDemand
:name "DemandIdentification"

:rem "The desire of consumers, clients, employers, etc. for a particular commodity, service, or other item. http://www.oxforddictionaries.com"

:Prop FeasibilityStudy
:Inst Type
:sup 2DSCtx.FeasibilityStudy
:name "FeasibilityStudy"
:rem "An analysis and evaluation of a proposed project to determine if it (1) is technically feasible, (2) is feasible within the estimated cost, and (3) will be profitable. Feasibility studies are almost always conducted where large sums are at stake. Also called feasibility analysis. See also cost benefit analysis. Read more: http://www.businessdictionary.com/definition/feasibility-study.html#ixzz3bo2jh7nz"

:Prop ConceptDevelopment
:Inst Type
:sup 2DSCtx.ConceptDevelopment
:name "ConceptDevelopment"
:rem "Concept development is a set of activities that are carried out early in the systems engineering life cycle to collect and prioritize operational needs and challenges, develop alternative concepts to meet the needs, and select a preferred one as the basis for subsequent system or capability development and implementation. http://www.mitre.org/publications/systems-engineering-guide/se-lifecycle-building-blocks/concept-development"

:Prop Configuration
:Inst Type
:sup 2DSCtx.ProductConfiguration
:name "ProductServiceConfiguration"
:rem "Product/Service Configuration can cover a wide variety of situations. To some it means Guided Selling. To others Parametric Configuration. Yet others might think of it as Make-to-order or Engineer-to-order. Whatever your spin on it, product and service configuration means taking the legwork out of quoting, specifying, making and/or delivering your products and/or services. http://dominicsystems.com/services/Product-Service-Configuration"

:Prop Realisation
:Inst Type
:sup 2DSCtx.ProductRealisation
:name "Product Service Realisation"
:rem "Product realization is the term used to describe the work that the organization goes through to develop, manufacture, and deliver the finished goods or services. http://www.simplyquality.org/2000%20Summary/req_7-0.html"

:Prop Maintenance
:Inst Type
:sup 2DSCtx.Maintenance
:name "ProductServiceMaintenance"
:rem "Activities required or undertaken to conserve as nearly, and as long, as possible the original condition of an asset or resource while compensating for normal wear and tear.
Read more: http://www.businessdictionary.com/definition/maintenance.html#ixzz3bo6biln9"

:Prop Testing
:Inst Type
:sup 2DSCtx.Inspection
:name "Product Service Testing"
:rem "Quality control means by which the capability of a manufactured item to meet its specified requirements is determined and documented by subjecting the item to a set of operating conditions. Read more: http://www.businessdictionary.com/definition/testing.html#ixzz3bo6uOp46"

:Prop InService
:Inst Type
:sup ProductServiceLifeCycle
:name "Product Service-In Service"
:rem "Product-Service has been deployed and it is in action"

:Prop UserExperience
:Inst Type
:sup ProductServiceLifeCycle
:name "Product Service UserExperience"
:rem "The overall experience of a person using a product service, especially in terms of how easy or pleasing it is to use. http://www.oxforddictionaries.com"

:Prop ProductServiceRequirement
:Inst Type
:sup 2DSCtx.Requirements
:name "Product Service Requirement"
:rem "Constraints, demands, necessities, needs, or parameters that must be met or satisfied, usually within a certain timeframe.
Read more: http://www.businessdictionary.com/definition/requirements.html#ixzz3bo8z01tb"

:Prop ProductServiceIdea
:Inst Type
:sup 4PSPCtx.Idea
:name "Product Service Idea"
:rem "An <sym>4PSP.Ctx.Idea</sym> relating to a <sym>2DSCtx.ProductService</sym> "

:Prop BusinessIdea
:Inst Type
:sup 4PSPCtx.Idea
:name "Business Idea"
:rem "A <sym>4PSPCtx.ProductServiceIdea</sym> about a business"

:Prop ProductIdea
:Inst Type
:sup 4PSPCtx.Idea
:name "Business Idea"
:rem "A <sym>4PSPCtx.ProductServiceIdea</sym> about a Product"

:Prop ProductServiceConcept
:Inst Type
:sup 4PSPCtx.Concept
:name "Product Service Concept"
:rem "A clear, detailed description of the attributes and benefits of a new potential product-service that addresses the needs of the targeted customers. Concept is derived from one or several Ideas. Read more: http://www.businessdictionary.com/definition/concept.html#ixzz3boBLqm4z"

:Prop Keyword
:Inst Type
:Inst NonLogicalFunctor
:sup 2DSCtx.Identifier
:sup MLO.AbstractEntity
:name "Keyword"
:rem "A word that represents the main feature or idea of something"
:referenceRem "http://www.macmillandictionary.com/dictionary/american/keyword"

:Prop Stakeholder
:Inst Type
:sup 2DSCtx.Stakeholder
:name "Stakeholder"
:rem "Person, group or organisation that has direct or indirect stake in designing and delivering the Product-Service because it can affect along all the PS life cycle"

:Prop Owner
:Inst Type
:sup 2DSCtx.Owner
:name "Owner"
:rem "A person or organization that owns something: "
:referenceRem "http://dictionary.cambridge.org/dictionary/business-english/owner"

:Prop Contributor
:Inst Type
:sup 2DSCtx.Contributor
:name "Contributor"
:rem "Someone or something that is one of the causes of a situation, event, "
:referenceRem "http://www.macmillandictionary.com/dictionary/american/contributor#contributor_6"

:Prop EvaluationScheme
:Inst Type
:sup 2DSCtx.EvaluationScheme
:name "EvaluationScheme"
:rem "A plan, design, or program for allowing a structured interpretation and giving of meaning to predicted or actual impacts of an Idea"

:Prop Status
:Inst Type
:sup 2DSCtx.Status

:name "Status"
:rem "The situation at a particular time during a process"
:referenceRem "http://www.oxforddictionaries.com/es/definicion/ingles/status"

:Prop Comment
:Inst Type
:sup 2DSCtx.Comment
:rem "A written or spoken remark giving an opinion"
:referenceRem "http://www.macmillandictionary.com/dictionary/british/comment_1"

:Prop Perturbation
:Inst Type
:sup Metric
:rem "The direct effect of disruption on a Global Production Network node."
:referenceRem "2014 FLEXINET D2.1"

:Prop Inoperability
:Inst Type
:sup Metric
:rem "The reduced percentage of operability of a Global Production Network node as a result of the original disruption and propagation of that original disruption, compared with the expected level of operability. A value of 0% represents the normal operation of a node while a value of 100% express the total and complete suspension of activities in a node."
:referenceRem "2014 FLEXINET D2.1"

:Prop IntendedRevenue
:Inst MaterialRole
:sup Metric
:rem "An average of inoperability over a time horizon. Modelled as a MaterialRole so a TimeHorizon can be applied to this property."
:referenceRem "??"

:Prop NodeInterDependency
:Inst Type
:sup Metric
:rem "The interdependency coefficient that presents a probability of a disruption propagation from node j (facility j playing role in GPNScenario) to node i."
:referenceRem "2014 FLEXINET D2.1"

:Prop InterDependencyRating
:Inst Type
:sup Metric

;;;==========
;;;Criteria Type enumeration

:Prop CriteriaType
:Inst MetaProperty

:sup Type
:rem "The relationships between the network nodes."
:referenceRem "2014 FLEXINET D2.1"

:Prop TradeVolume
:Inst CriteriaType
:sup QualitativeMeasure

:Prop Inventory
:Inst CriteriaType
:sup QualitativeMeasure

:Prop SecurityOfInformationFlow
:Inst CriteriaType
:sup QualitativeMeasure

:Prop SuitabilityOfProduct
:Inst CriteriaType
:sup QualitativeMeasure

:Prop CompatibilityOfITSystems
:Inst CriteriaType
:sup QualitativeMeasure

:Prop {Distance/LeadTime}
:Inst CriteriaType
:sup QualitativeMeasure

:Prop {SuitabilityOfSupplier/Customer}
:Inst CriteriaType
:sup QualitativeMeasure

:Prop InformationTransparency
:Inst CriteriaType
:sup QualitativeMeasure

:Prop CollaborationAgreement
:Inst CriteriaType
:sup QualitativeMeasure

:Prop BusinessModelScenario
:Inst Type
:sup Scenario
:rem "A Business Model Scenario provides a view on a <sym>2DSCtx.BusinessModel</sym>."

:Prop ProductScenario
:Inst Type
:sup Scenario

:rem "A Product Scenario provides a view of the systems concerned with a Product <sym>2DSCtx.Product</sym>."

:Prop NetworkScenario
:Inst Type
:sup Scenario
:rem "A specialisation of a Scenario which provides a view of flows with a network."

:Prop ProductDesignScenario
:Inst Type
:sup ProductScenario
:rem "A specialisation of a Product Scenario which provides a view of design aspects."

:Prop ProductionNetworkScenario
:Inst Type
:sup ProductScenario
;:sup NetworkScenario
:rem "Provides a view of production networks, inheriting from both Product and Network scenarios."

:Prop GPNScenario
:Inst Type
:sup ProductionNetworkScenario
:rem "A GPNscenario is a global specialisation of a </sym>ProductionNetworkScenario</sym>."

:Prop DependentScenario
:Inst Type
:sup Scenario
:rem "A DependentScenario is contained within another <sym>1SYSCtx.Scenario</sym> and is dependent on the structure of a <sym>4PSPCtx.GPNScenario</sym>."

:Prop RiskScenario
:Inst Type
:sup DependentScenario
:rem "A RiskScenario provides a view of risk factors upon a <sym>4PSPCtx.ProjectWorld</sym> system."

:Prop BalancedScoreCardScenario
:Inst Type
:sup DependentScenario
:rem "A BalancedScordCardScenario provides a view of qualitative and quantitative cost factors upon a <sym>4PSPCtx.ProjectWorld</sym> system or a <sym>2DSCtx.BusinessModel</sym>."

13.5 Level 4 Relationships

:Use 4PSPCtx

:Rel ManufacturerProduceManufacturedProduct
:Inst TernaryRel

:Inst NonRigidRel
:Sig Manufacturer ManufacturedProduct Scenario
:Args "Manufacturer" "ManufacturedProduct" "Scenario"
:lex "Manufacturer ?1 produce ManufacturedProduct?2 in Scenario ?3"
:rem "A Manufacturer produces a ManufacturedProduct."

;;;relations concerning Manufactured Product and Manufactured Product Service
:Rel hasABOM
:Inst BinaryRel
:Inst RigidRel
:Sig ManufacturedProduct BOM
:Args "ManufacturedProduct" "Bill of Material"
:lex "ManufacturedProduct ?1 has a BOM ?2"
:rem "A <sym>4PSPCtx.ManufacturedProduct</sym> has at most one
<sym>4PSPCtx.BOM</sym>."
(functionalArg hasABOM 2)

:Rel mpContainsService
:Inst BinaryRel
:Inst RigidRel
:supRel 2DSCtx.pContainsService
:Sig ManufacturedProductService ServiceProduct
:Args "ManufacturedProductService" "Service"
:lex "A Manufactured Product Service ?1 contains a Service ?2"
:rem "A <sym>4PSPCtx.ManufacturedProductService</sym> contains at least one
<sym>2DSCtx.ServiceProduct</sym>."
;;;inherits cardinality contraints from level 2 relation

:Rel productHasAssociatedBenefit
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Product Benefit
:rem "A product has an associated benefit"

:Rel productUsesSupportSystem
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Product SupportSystem
:rem "Product uses Support System"

:Rel productHasAssociatedIdea
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Product 4PSPCtx.Idea
:rem "A product has an associated idea"

:Rel productHasAssociatedConcept
:Inst BinaryRel

:Inst RigidRel
:Sig 2DSCtx.Product 4PSPCtx.Concept
:rem "A product has an associated Concept"

:Rel productHasAssociatedRequirement
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Product ProductServiceRequirement
:rem "A product has an associated Requirement"

;;An stakeholder is a person or group that has an investment, share, or interest in something, as a business or industry.

:Rel stakeholderSetsRequirement
:Inst BinaryRel
:Inst RigidRel
:Sig Stakeholder ProductServiceRequirement
:rem "An Stakeholder sets a requirement"

:Rel stakeholderContributesToConcept
:Inst BinaryRel
:Inst RigidRel
:Sig Stakeholder ProductServiceConcept
:rem "A stakeholder creates or contributes in some way to a concept"

:Rel stakeholderContributesToIdea
:Inst BinaryRel
:Inst RigidRel
:Sig Stakeholder ProductServiceIdea
:rem "A stakeholder creates or contributes in some way to an idea"

:Rel conceptHasAssociatedRequirement
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Concept ProductServiceRequirement
:rem "A concept has an associated requirement"

:Rel conceptHasAssociatedIdea
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Concept 4PSPCtx.Idea
:rem "A concept has an associated idea"

:Rel ideaHasAssociatedKeyword
:Inst BinaryRel
:Sig 4PSPCtx.Idea Keyword
:rem "An idea has associated keywords"

:Rel ideaHasAssociatedEvaluationScheme
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea EvaluationScheme
:rem "An idea has an associated EvaluationScheme"

:Rel supportSystemContainsSupportNetwork
:Inst BinaryRel
:Inst RigidRel
:Sig SupportSystem SupportNetwork
:rem "A support system contains a support network"

:Rel supportSystemContainsInfrastructure
:Inst BinaryRel
:Inst RigidRel
:Sig SupportSystem Infrastructure
:rem "A support system contains an infrastructure"

:Rel infrastructureContainsSoftware
:Inst BinaryRel
:Inst RigidRel
:Sig Infrastructure Software
:rem "an infrastructure contains Software"

:Rel infrastructureContainsHardware
:Inst BinaryRel
:Inst RigidRel
:Sig Infrastructure Hardware
:rem "an infrastructure contains hardware"

:Rel ideaHasId
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea IntegerNumber
:functionalArg 2
:rem "An Idea has an identifier"

:Rel ideaHasStatus
:Inst BinaryRel
:Inst NonRigidRel
:Sig 4PSPCtx.Idea Status
:rem "A ProductServiceIdea idea has an status"
;;;This is a nonRigid relation as there is a need to associate a Timespan for when the relation is valid".

:Rel ideaHasCurrentStatus
:Inst BinaryRel
:Inst RigidRel
:Inst IntensionalRel
:Sig 4PSPCtx.Idea Status
:rem "An idea has a current <sym>2DSCtx.Status<sym>. This relation is derived from a rule which selects most recently known to be true status of the idea."

:Rel ideaHasComment
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea Comment
:rem "An Idea has a comment"

:Rel commentHasValue
:Inst BinaryRel
:Inst RigidRel
:functionalArg 2
:Sig Comment String
:rem "Value of the comment"

:Rel ideaHasOwner
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea Owner
:functionalArg 2
:rem "An Idea has an Owner"

:Rel ideaHasContributor
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea Contributor
:rem "An idea has contributors"

:Rel ideaHasDescription
:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea String
:Args "4PSPCtx.Idea" "Description of Idea"
:lex "?1 has a description ?2"

;:Rel keywordHasType
;:Inst BinaryRel
;:Inst RigidRel
;:Sig Keyword KeywordType
;:rem "A Keyword has a type"

:Rel ideaHasKeywordType

:Inst BinaryRel
:Inst RigidRel
:Sig 4PSPCtx.Idea KeywordType
:rem "sets the possible KeywordTypes for the Keywords associated to an Idea"

:Rel keywordHasValue
:Inst BinaryRel
:Inst RigidRel
:Sig Keyword String
:functionalArg 2
:rem "String value of the Keyword"

:Rel keywordTypeHasValue
:Inst BinaryRel
:Inst RigidRel
:Sig KeywordType String
:functionalArg 2
:rem "String value of the Keyword Type"

:Rel conceptHasStatus
:Inst BinaryRel
:Inst NonRigidRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has a <sym>4PSPCtx.Status</sym>"
;;;This is a nonRigid relation as there is a need to associate a Timespan for when the relation is valid."

:Rel conceptHasCurrentStatus
:Inst BinaryRel
:Inst RigidRel
:Inst IntensionalRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has a current <sym>2DSCtx.Status<sym>. This relation is derived from a rule which selects most recently known to be true status of the concept."

:Rel conceptHasPilotProductionStatus
:Inst BinaryRel
:Inst NonRigidRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has Pilot Production <sym>4PSPCtx.Status</sym>"
;;;This is a nonRigid relation as there is a need to associate a Timespan for when the relation is valid".

:Rel conceptHasCurrentPilotProductionStatus
:Inst BinaryRel
:Inst RigidRel
:Inst IntensionalRel
:Sig 4PSPCtx.Concept Status

:rem "A Concept has a current Pilot Production <sym>2DSCtx.Status<sym>. This relation is derived from a rule which selects most recently known to be true Pilot Production status of the concept."

:Rel conceptHasGPNConfigurationStatus
:Inst BinaryRel
:Inst NonRigidRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has a GPN Configuration <sym>4PSPCtx.Status</sym>"
;;;This is a nonRigid relation as there is a need to associate a Timespan for when the relation is valid".

:Rel conceptHasCurrentGPNConfigurationStatus
:Inst BinaryRel
:Inst RigidRel
:Inst IntensionalRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has a current GPNConfiguration <sym>2DSCtx.Status<sym>. This relation is derived from a rule which selects most recently known to be true GPNConfiguration status of the concept."

:Rel conceptHasBusinessModelScenarioStatus
:Inst BinaryRel
:Inst NonRigidRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has a Business Model Scenario <sym>4PSPCtx.Status</sym>"
;;;This is a nonRigid relation as there is a need to associate a Timespan for when the relation is valid".

:Rel conceptHasCurrentBusinessModelScenarioStatus
:Inst BinaryRel
:Inst RigidRel
:Inst IntensionalRel
:Sig 4PSPCtx.Concept Status
:rem "A Concept has a current BusinessModelScenario <sym>2DSCtx.Status<sym>. This relation is derived from a rule which selects most recently known to be true BusinessModelScenario status of the concept."

;;
;;; Lifecycle information

:Rel productHasAssociatedLifeCycle
:Inst BinaryRel
:Inst RigidRel
:Sig 2DSCtx.Product ProductServiceLifeCycle
:rem "A product has an associated life cycle"

:Rel lifeCycleStatusSetAsDemandIdentification
:Inst BinaryRel

```
:Inst RigidRel
:Sig ProductServiceLifeCycle DemandIdentification
:rem "It sets the status of a life cycle as DemandIdentification"

:Rel  lifeCycleStatusSetAsFeasibilityStudy
:Inst BinaryRel
:Inst RigidRel
:Sig ProductServiceLifeCycle FeasibilityStudy
:rem "It sets the status of a life cycle as FeasibilityStudy"

:Rel lifeCycleStatusSetAsConceptDevelopment
:Inst BinaryRel
:Inst RigidRel
:Sig ProductServiceLifeCycle ConceptDevelopment
:rem "It sets the status of a life cycle as ConceptDevelopment"

:Rel  lifeCycleStatusSetAsConfiguration
:Inst BinaryRel
:Inst RigidRel
:Sig  ProductServiceLifeCycle Configuration
:rem  "It sets the status of a life cycle as Configuration"

:Rel  lifeCycleStatusSetAsRealisation
:Inst BinaryRel
:Inst RigidRel
:Sig ProductServiceLifeCycle Realisation
:rem "It sets the status of a life cycle as Realisation"

:Rel  lifeCycleStatusSetAsMaintenance
:Inst BinaryRel
:Inst RigidRel
:Sig  ProductServiceLifeCycle Maintenance
:rem "It sets the status of a life cycle as Maintenance"

:Rel  lifeCycleStatusSetAsTesting
:Inst BinaryRel
:Inst RigidRel
:Sig ProductServiceLifeCycle Testing
:rem "It sets the status of a life cycle asTesting"

:Rel  lifeCycleStatusSetAsInService
:Inst BinaryRel
:Inst RigidRel
:Sig ProductServiceLifeCycle InService
:rem "It sets the status of a life cycle as InService"

:Rel  lifeCycleStatusSetAsUserExperience
:Inst BinaryRel
```

```
:Inst RigidRel
:Sig ProductServiceLifeCycle UserExperience
:rem "It sets the status of a life cycle as UserExperience"

:Rel riskScenarioHasLikelihood
:Inst BinaryRel
:Inst RigidRel
:Sig RiskScenario FuzzyMeasure
:Args "Resilience" "Likelihood Value"
:lex "?1 has LikeliHood Value ?2"
:rem "RiskScenario has one Likelihood value."
:exampleRem "(riskScenarioHasLikelihood riskS1 (fuzzyValTripleFN 0.1 0.2 0.3)) or
(riskScenarioHasLikelihood riskS1(fuzzyValLinguisticCoupleFN 2DSCtx.VeryHigh 2DSCtx.Low))"
(functionalArg riskScenarioHasLikelihood 2)

;;;the Description of the RiskScenario can be modelled using the defScenario relation inherited from
Scenario.
;;;The name relation is a MLO default relation.

;;;=================================================
;;;Relations of GPNScenario Property

:Rel gpnScenariohasTotalLossforAllRiskScenarios
:Inst BinaryRel
:Inst RigidRel
:Sig GPNScenario FuzzyMeasure
:Args "Resilience" "Value of TotalLossforAllRiskScenarios"
:lex "?1 has TotalLossforAllRiskScenarios Value ?2"
:rem "GPNScenario has one Total Loss Value."
:exampleRem "(gpnScenariohasTotalLossforAllRiskScenarios GPNS1 (fuzzyValTripleFN 0.1 0.2 0.3))"
(functionalArg gpnScenariohasTotalLossforAllRiskScenarios 2)

;;;=================================================
;;;Relations of RiskFactor Property

:Rel riskFactorInfluencesPerturbation
:Inst BinaryRel
:Inst RigidRel
:Sig  RiskFactor Perturbation
:Args "RiskFactor" "Perturbation"
:lex "?1 influences Perturbation ?2"
:rem "One RiskFactor influences Perturbation(s)."
(functionalArg riskFactorInfluencesPerturbation 1)

;;;=================================================
;;;Relations of Perturbation Property

:Rel perturbationHasValue
```

```
:Inst BinaryRel
:Inst RigidRel
:Sig Perturbation FuzzyMeasure
:Args "Perturbation" "Perturbation Value"
:lex "?1 has Perturbation Value ?2"
:rem "Perturbation has one Perturbation value."
:exampleRem "(perturbationHasValue perturb1 (fuzzyValTripleFN 0.1 0.2 0.3)) or
(4PSPCtx.perturbationHasValue Perturb1 (fuzzyValLinguisticCoupleFN 2DSCtx.VeryLow
2DSCtx.Medium)"
(functionalArg perturbationHasValue 2)

:Rel perturbationHasStartPeriod
:Inst BinaryRel
:Inst RigidRel
:Sig Perturbation IntegerNumber
:Args "Perturbation" "Start Period"
:lex "?1 has Start Period ?2"
:rem "Perturbation has one Start Period."
(functionalArg perturbationHasStartPeriod 2)

:Rel perturbationHasLength
:Inst BinaryRel
:Inst RigidRel
:Sig Perturbation IntegerNumber
:Args "Perturbation" "Length"
:lex "?1 has Length ?2"
:rem "Perturbation has one Length."
(functionalArg perturbationHasLength 2)

:Rel perturbationAppliesToLocation
:Inst BinaryRel
:Inst RigidRel
:Sig Perturbation 2DSCtx.Location
:Args "Perturbation" "Location"
:lex "Perturbation ?1 Perturbation applies to ?2"
:rem "One Perturbation applies to a Location."
(functionalArg perturbationAppliesToLocation 1)

;;;=================================================
;;;Relations of Inoperability Property

:Rel inoperabilityHasValue
:Inst BinaryRel
:Inst RigidRel
:Sig Inoperability FuzzyMeasure
:Args "Inoperability" "Inoperability Value"
:lex "?1 has Inoperability Value ?2"
:rem "Inoperability has one Inoperability value."
```

:exampleRem "(inoperabilityHasValue inop1 (fuzzyValTripleFN 0.1 0.2 0.3)) or (4PSPCtx.inoperabilityHasValue Inop1 (fuzzyValLinguisticCoupleFN 2DSCtx.Medium 2DSCtx.Medium)"
(functionalArg inoperabilityHasValue 2)

:Rel inoperabilityHasTimePeriod
:Inst BinaryRel
:Inst RigidRel
:Sig Inoperability IntegerNumber
:Args "Inoperability" "TimePeriod"
:lex "?1 has TimePeriod ?2"
:rem "Inoperability has one TimePeriod."
(functionalArg inoperabilityHasTimePeriod 2)

;;;==========
;;;Relations of IntendedRevenue Property

:Rel intendedRevenueHasValue
:Inst BinaryRel
:Inst RigidRel
:Sig IntendedRevenue FuzzyMeasure
:Args "Intended Revenue" "IntendedRevenue Value"
:lex "?1 has IntenededRevenue Value ?2"
:rem "IntendedRevenue has one IntendedRevenue value."
:exampleRem "(intendedRevenueHasValue UnitInop1 (fuzzyValTripleFN 0.1 0.2 0.3)) or (4PSPCtx.intendedRevenueHasValue intendRev1(fuzzyValLinguisticCoupleFN 2DSCtx.VeryHigh 2DSCtx.Low)"
(functionalArg intendedRevenueHasValue 2)

;;;The TimeHorizon attribute is modelled for IntendedRevenue by declaring this property as a MaterialRole
;;;and using the HoldsIn Relation. e.g. (holdsIn (Date "2003") (IntendedRevenue UnitLossEg))

;;;==========
;;;Relations of NodeInterDependency Property

:Rel nodeInterDependencyHasValue
:Inst BinaryRel
:Inst RigidRel
:Sig NodeInterDependency FuzzyMeasure
:Args "NodeInterDependency" "NodeInterDependency Value"
:lex "?1 has ActorInterDependency Value ?2"
:rem "NodeInterDependency has one NodeInterDependency value."
:exampleRem "(nodeInterDependencyHasValue nodeInd1 (fuzzyValTripleFN 0.1 0.2 0.3)) or 4PSPCtx.nodeInterDependencyHasValue nodeInd1 (fuzzyValLinguisticCoupleFN 2DSCtx.VeryLow 2DSCtx.VeryHigh)"
(functionalArg nodeInterDependencyHasValue 2)

```
:Rel nodeInterDependencyHasRating
:Inst BinaryRel
:Inst RigidRel
:Sig NodeInterDependency InterDependencyRating
:Args "nodeInterDependency" "InterDependencyRating"
:lex "?1 has InterDependencyRating ?2"
:rem "NodeInterDependency has InterDependencyRating(s)."


;;;================================================
;;;Relations of InterDependencyRating Property

:Rel ratingHasConfidence
:Inst BinaryRel
:Inst RigidRel
:Sig  InterDependencyRating HMLType
:Args "InterDependencyRating" "Linguistic label very low to very high"
:lex "?1 has a ?2 confidence value"
:rem "InterDependencyRating has One Confidence value."
:exampleRem "(ratingHasConfidence ratingEx 2DSCtx.Low)"
(functionalArg ratingHasConfidence 2)

:Rel ratingHasCriterium
:Inst BinaryRel
:Inst RigidRel
:Sig InterDependencyRating  CriteriaType
:Args "InterDependencyRating" "Criterium used"
:lex "?1 uses ?2 as a criterium"
:rem "InterDependencyRating has One Criterium."
:exampleRem "(ratingHasCriterium ratingEx 4PSPCtx.TradeVolume)"
(functionalArg ratingHasCriterium 2)

:Rel ratingHasOrdinal
:Inst BinaryRel
:Inst RigidRel
:Sig InterDependencyRating  HMLType
:Args "InterDependencyRating" "Measure of High Medium Low"
:lex "?1 has a ordinal value of ?2"
:rem "InterDependencyRating has One Ordinal value. An ordinal is an ordered category."
:exampleRem "(ratingHasConfidence ratingEx 2DSCtx.Low)"
(functionalArg ratingHasConfidence 2)

;;;================================================

;;;Relations of node in risk network (facilities pertaining to Risk Ontology)
:Rel nodeInterDependencyOnNode
:Inst TernaryRel
:Inst RigidRel
```

:Sig Facility NodeInterDependency Facility
:Args "Facility" "NodeInterDependency" "Facility"
:lex "?1 has NodelInterDependency ?2 upon ?3"
:rem "A Facility has a NodeInterDependency upon an Facility. There is only one NodeInterDependency property for a given pair of Facilities."
(functionalArg nodeInterDependencyOnNode 2)

:Rel businessModelScenarioInScenario
:Inst BinaryRel
:Inst RigidRel
:supRel inScenario
:Inst AntisymmetricBR
:Sig BusinessModelScenario Scenario
:Args "component BusinessModelScenario" "compound Scenario"
:lex "Business Model Scenario ?1 is contained within Scenario ?2"
:rem "Only one Business Scenario can be contained within a Scenario. Business Model Scenario is IN compound Scenario. Given that Business Model Scenario and compound Scenario are not identical, then it is not the case that compound is IN Business Model Scenario."
(functionalArg businessModelScenarioInScenario 1)

:Rel gpnScenarioInScenario
:Inst BinaryRel
:Inst RigidRel
:supRel inScenario
:Inst AntisymmetricBR
:Sig GPNScenario Scenario
:Args "component GPNScenario" "compound Scenario"
:lex "GPNScenario ?1 is contained within Scenario ?2"
:rem "Only one GPNScenario can be contained within a Scenario. GPNScenario is IN compound Scenario. Given that GPNScenario and compound Scenario are not identical, then it is not the case that compound is IN GPN."
(functionalArg gpnScenarioInScenario 1)

:Rel riskScenarioInScenario
:Inst BinaryRel
:Inst RigidRel
:Inst AntisymmetricBR
:supRel inScenario
:Sig RiskScenario Scenario
:Args "component RiskScenario" "compound Scenario"
:lex "RiskScenario ?1 is contained within Scenario ?2"
:rem "Only one RiskScenario can be contained within a Scenario. RiskScenario is IN compound Scenario. Given that Risk Scenario and compound Scenario are not identical, then it is not the case that compound is IN Risk."
(functionalArg riskScenarioInScenario 1)

:Rel balancedScoreCardScenarioInScenario
:Inst BinaryRel

:Inst RigidRel
:Inst AntisymmetricBR
:supRel inScenario
:Sig BalancedScoreCardScenario Scenario
:Args "component Balanced ScoreCard Scenario" "compound Scenario"
:lex "Balanced ScoreCard Scenario ?1 is contained within Scenario ?2"
:rem "Only one Balanced Score Card Scenario can be contained within a Scenario. Balanced Score Card Scenario is IN compound Scenario. Given that Balanced ScoreCard Scenario and compound Scenario are not identical, then it is not the case that compound is IN Business."
(functionalArg balancedScoreCardScenarioInScenario 1)

:Rel businessModelScenarioHasChosenProductScenario
:Inst BinaryRel
:Inst RigidRel
:Sig BusinessModelScenario ProductScenario
:Args "Business Model Scenario" "Product Scenario"
:lex "BusinessModelScenario ?1 hasChosen Product Scenario ?2"
:rem "A <sym>4PSPCtx.BusinessModelScenario</sym> has one chosen <sym>4PSPCtx.ProductScenario</sym>."
(functionalArg businessModelScenarioHasChosenProductScenario 2)

:Rel businessModelScenarioHasChosenGPNScenario
:Inst BinaryRel
:Inst RigidRel
:supRel businessModelScenarioHasChosenProductScenario
:Sig BusinessModelScenario GPNScenario
:Args "Business Model Scenario" "GPN Scenario"
:lex "BusinessModelScenario ?1 hasChosen GPN Scenario ?2"
:rem "A <sym>4PSPCtx.BusinessModelScenario</sym> has one chosen <sym>4PSPCtx.Scenario</sym>."
(functionalArg businessModelScenarioHasChosenGPNScenario 2)

:Rel productScenarioHasChosenBusinessModelScenario
:Inst BinaryRel
:Inst RigidRel
:inverseRel businessModelScenarioHasChosenProductScenario
:Sig ProductScenario BusinessModelScenario
:Args "Product Scenario" "Business Model Scenario"
:lex "Product Scenario ?1 hasChosen BusinessModelScenario ?2"
:rem "A <sym>4PSPCtx.ProductScenario</sym> has one chosen <sym>2DSCtx.BusinessModelScenario</sym>."
(functionalArg productScenarioHasChosenBusinessModelScenario 2)

:Rel gpnScenarioHasChosenBusinessModelScenario
:Inst BinaryRel
:Inst RigidRel
:supRel productScenarioHasChosenBusinessModelScenario
:inverseRel businessModelScenarioHasChosenGPNScenario

:Sig GPNScenario BusinessModelScenario
:Args "GPN Scenario" "Business Model Scenario"
:lex "GPN Scenario ?1 hasChosen BusinessModelScenario ?2"
:rem "A <sym>4PSPCtx.GPNScenario</sym> has one chosen <sym>2DSCtx.BusinessModelScenario</sym>. Subclassed to provide a more intuitive name to end users"
(functionalArg gpnScenarioHasChosenBusinessModelScenario 2)

:Rel projectWorldContainsGPNScenario
:Inst BinaryRel
:Inst RigidRel
:Sig ProjectWorld GPNScenario
:Args "Project World" "Global Production Network Scenario"
:lex "Project World ?1 contains GPN Scenario ?2"
:rem "A <sym>4PSPCtx.ProjectWorld/sym> contains a <sym>4PSPCtx.GPNScenario</sym>. Relation added to enable PNES interface requirements."

13.6 Level 4 Functions

:Use ../4PSPCtx

:Fun keywordTypeAndValue
:Inst BinaryFun
:Sig String String -> Keyword
:Args "Keyword Type" "Keyword value" -> "Keyword"
:rem "Function to classify and provide a value for the keyword."

13.7 Level 4 Axioms

:Use 4PSPCtx

;;;These axioms concerning Start and End Events have been retained as they may be used for simulation in the future. ProductionNetwork should be altered to Production Network Scenario.
;
==========
;(=> (ProductionNetwork ?pNetwork)
; (exists (?startEvent ?ee)
; (and
; (StartEvent ?startEvent)
; (EndEvent ?ee)
; (basicContainsBasic ?pNetwork ?startEvent)
; (basicContainsBasic ?pNetwork ?ee))))
;:IC hard "Axiom4.1: A Production Network must have a Start Event and an End Event(the required presence of an end Event prevents infinite loops forming in the network, by providing a breakpoint)."

;
==========
;(=> (and (Basic ?basic)

```
;                (playsRole ?basic ?roleProductRequest ?Scene1)
;                (ProductRequest ?roleProductRequest))
;        (exists (?startEventRole)
;                (and     (Output ?startEventRole)
;                                 (StartEvent ?startEvent)
;                                 (startEventRel ?startEvent ?startEventRole)
;                                 (ProductionNetwork ?pNetwork)
;                                 (basicContainsBasic ?pNetwork ?startEvent)
;                                 (playsRole ?basic ?startEventRole ?Scene1))))

;:IC hard "Axiom4.4.1: The Basic playing the role of a Product Request WILL also play the role of the
Start Event Output (Trigger) in a Production Network. ;(I.C. Soft)"

;
============================================================
;(=> (and (Basic ?basic)
;        (playsRole ?basic ?roleOrder ?Scene1)
;        (Order ?roleOrder))
;        (exists (?startEventRole)
;                (and     (Output ?startEventRole)
;                                 (StartEvent ?startEvent)
;                                 (startEventRel ?startEvent ?startEventRole)
;                                 (ProductionNetwork ?pNetwork)
;                                 (basicContainsBasic ?pNetwork ?startEvent)
;                                 (playsRole ?basic ?startEventRole ?Scene1))))
;:IC hard "Axiom4.4.2:  The Basic playing the role of a Customer Order WILL also play the role of the
Start Event Output (Trigger) in a Production Network. ;(I.C. Soft)"
;
============================================================

;(=> (and (Basic ?basic)
;        (playsRole ?basic ?roleProduct ?Scene1)
;        (Product ?roleProduct))
;        (exists (?endEventRole)
;                (and     (Input ?endEventRole)
;                                 (EndEvent ?endEvent)
;                                 (endEventRel ?endEvent ?endEventRole)
;                                 (ProductionNetwork ?pNetwork)
;                                 (basicContainsBasic ?pNetwork ?endEvent)
;                                 (playsRole ?basic ?endEventRole ?Scene1))))
;:IC hard "Axiom 4.5.1: The basic playing the role of a Product(-Service) must also play the role of an
End Event Input in a Production Network.  (This is saying that one of the outputs in a Production
network must be a product, as this is what a production network is concerned with producing)."
;;; A Product concept encompasses ProductService.
;
============================================================

;;;ProductionNetworkScenario Scenario axioms
```

```
(=> (ProductionNetworkScenario ?pNetworkS)
        (exists (?producerRole ?player)
                (and (4PSPCtx.Producer ?producerRole)
                        (playsRole ?player ?producerRole ?pNetworkS)
                 )
        )
)
:IC soft "The Role Producer should be played in a Production Network Scenario but in ?pNetworkS this is not the case."
;IC hard "The Role Producer must be played in a Production Network Scenario but in ?pNetworkS this is not the case."
;Use IC hard for standards.

(=> (GPNScenario ?gpnS)
        (exists (?productRole ?player)
           (and (2DSCtx.Product ?productRole)
                        (playsRole ?player ?productRole ?gpnS)
                )
        )
)
:IC soft "The Role Product should be played in GPN Scenario but in ?gpnS this is not the case."
;IC hard "The Role Product must be played in GPN Scenario but in ?gpnS this is not the case."
;Use IC hard for standards.

(=> (ProductionNetworkScenario ?pNetworkS)
        (exists (?supplierRole ?player)
                (and    (2DSCtx.Supplier ?supplierRole)
                                (playsRole ?player ?supplierRole ?pNetworkS)
                )
        )
)
:IC soft "The role Supplier should be played in a Production Network Scenario but in ?pNetworkS this is not the case."


(=> (and (2DSCtx.Facility ?facility)
       (2DSCtx.Supplier ?supplierRole)
       (playsRole ?facility ?supplierRole ?pNetworkS)
         )
         (exists (?output ?basic)
                        (and (Output ?output)
                                (systemContainsRole ?facility ?output)
                                (playsRole ?basic ?output ?pNetworkS)
                         )
         )
)
```

:IC soft "A Supplier must have an output. Facility ?facility plays the role of a Supplier ?supplierRole but does not have an output Role which is played in ProductionNetwork Scenario ?pNetworkS."
;:IC hard "A Supplier must have an output. Facility ?facility plays the role of a Supplier ?supplierRole but does not have an output Role which is played in ProductionNetwork Scenario ?pNetworkS."
;;; IC hard for standards. Needs to be soft for FLEXINET as we have defined an Ecosystem scenario for the PNES interface and within the Ecosystem we do not know the supplier output.

```
(=> (and (2DSCtx.Facility ?facility)
        (4PSPCtx.Producer ?producerRole)
        (playsRole ?facility ?producerRole ?pNetworkS)
          )
          (exists (?output ?basic)
                        (and (Output ?output)
                                (systemContainsRole ?facility ?output)
                                (playsRole ?basic ?output ?pNetworkS)
                         )
          )
)
```

:IC soft "A Producer must have an output. Facility ?facility plays the role of a Producer ?producerRole but does not have an output Role which is played in ProductionNetwork Scenario ?pNetworkS."
;:IC hard "A Producer must have an output. Facility ?facility plays the role of a Producer ?producerRole but does not have an output Role which is played in ProductionNetwork Scenario ?pNetworkS."
;;; IC hard for standards. Needs to be soft for FLEXINET as we have defined an Ecosystem scenario for the PNES interface and within the Ecosystem we do not know the producer output.

```
(=> (and (2DSCtx.Facility ?facility)
        (2DSCtx.Customer ?customerRole)
        (playsRole ?facility ?customerRole ?pNetworkS)
          )
          (exists (?input ?basic)
                        (and (Input ?input)
                                (systemContainsRole ?facility ?input)
                                (playsRole ?basic ?input ?pNetworkS)
                         )
          )
)
```

:IC soft "A Customer must have an input. Facility ?facility plays the role of a Customer ?customerRole but does not have an input Role which is played in ProductionNetwork Scenario ?pNetworkS."
;:IC hard "A Customer must have an input. Facility ?facility plays the role of a Customer ?customerRole but does not have an input Role which is played in ProductionNetwork Scenario ?pNetworkS."
;;; IC hard for standards. Needs to be soft for FLEXINET as we have defined an Ecosystem scenario for the PNES interface and within the Ecosystem we do not know the customer output.

```
;A ManufacturedProductService is always associated to a Benefit
(=>
```

```
    (ManufacturedProductService ?ps)
     (exists (?benefit)
      (and (Benefit ?benefit)
           (productHasAssociatedBenefit ?ps ?benefit))))
:IC soft "ManufacturedProductService ?ps does not have an associated Benefit."

;A keyword is always associated to at least one Idea
(=>
      (Keyword ?t)
      (and (ProductServiceIdea ?idea)
          (count (ideaHasAssociatedKeyword ?idea ?t) ?ni)
          (RootCtx.lteNum 1 ?ni) ) )
:IC soft "Keyword ?t does not have an associated idea."

;A Concept is always associated to at least one Idea
(=>
    (ProductServiceConcept ?con)
    (and (ProductServiceIdea ?idea)
          (count (conceptHasAssociatedIdea ?con ?idea) ?ni)
          (RootCtx.lteNum 1 ?ni) ) )
:IC soft "ProductServiceConcept ?con does not have an associated idea."

;A Requirement is always associated to at least one Concept
(=>
      (ProductServiceRequirement ?req)
      (and (ProductServiceConcept ?con)
           (count(Concept ?req ?con) ?ncon)
           (RootCtx.lteNum  1 ?ncon) ) )
:IC soft "ProductServiceRequirement ?req does not have an associated concept."


;If there is a ManufacturedProductService, then it has an associated Life Cycle
(=>
      (ManufacturedProductService ?ps)
                        (exists (?lc)
                                (and
                                        (ProductServiceLifeCycle ?lc)
                                        (productHasAssociatedLifeCycle ?ps ?lc) ) ))
:IC soft "ManufacturedProductService ?ps does not have an associated lifecycle."

;If there is a Concept, then there is an associated Product
  (=>
       (ProductServiceConcept ?con)
         (exists (?ps)
                                (and
                                        (2DSCtx.Product ?ps)
                                        (productHasAssociatedConcept  ?ps ?con)) ))
:IC soft "ProductServiceConcept ?con does not have an associated <sym>Product</sym>."
```

```
;If there is a Requirement, then there is an associated ManufacturedProductService
 (=>
      (ProductServiceRequirement ?req)
        (exists (?ps)
                                    (and
            (ManufacturedProductService ?ps)
            (productHasAssociatedRequirement ?ps ?req))))
:IC soft "ProductServiceRequirement ?req does not have an associated ManufacturedProductService."

;If there a Support System, then there is a ManufacturedProductService that uses it
(=>
      (SupportSystem ?ss)
                        (exists (?ps)
                                (and
                                        (ManufacturedProductService ?ps)
            (productUsesSupportSystem ?ps ?ss)) ))

:IC soft "SupportSystem ?ss does not have a a ManufacturedProductServices that uses it."


;If an idea is accepted, there is a KeywordType associated which can have two possible values:
Business or Product

;(=>    (ProductServiceIdea ?idea)
;                (or (ProductIdea ?idea)
;                        (BusinessIdea ?idea))
;)
;:IC soft "A ProductServiceIdea must be a ProductIdea or a Business Idea but ?idea is not."
;;;removed as Indesit require ProductServiceIdea LU 23/02/2016

(=> (and (4PSPCtx.Status ?status1)
                (4PSPCtx.Status ?status2)
                (/=  ?status1 ?status2)
   (holdsIn ?span (4PSPCtx.ideaHasStatus ?idea ?status1)))
   (not (holdsIn ?span (4PSPCtx.ideaHasStatus ?idea ?status2)))
)
:IC hard "An idea can only have one status at the same time but Idea ?idea has Status ?status1 and
?status2 at time ?span."

(=> (and (4PSPCtx.Status ?status1)
                (4PSPCtx.Status ?status2)
                (/=  ?status1 ?status2)
   (holdsIn ?span (4PSPCtx.conceptHasStatus ?concept ?status1)))
   (not (holdsIn ?span (4PSPCtx.conceptHasStatus ?concept ?status2)))
)
```

```
:IC hard "A concept can only have one status at the same time but Concept ?concept has Status
?status1 and ?status2 at time ?span."

(=> (and (4PSPCtx.Status ?status1)
                    (4PSPCtx.Status ?status2)
                    (/=  ?status1 ?status2)
   (holdsIn ?span (4PSPCtx.conceptHasPilotProductionStatus ?concept ?status1)))
   (not (holdsIn ?span (4PSPCtx.conceptHasPilotProductionStatus ?concept ?status2)))
)
:IC hard "A concept can only have one PilotProductionStatus at the same time but Concept ?concept
has PilotProductionStatus ?status1 and ?status2 at time ?span."

(=> (and (4PSPCtx.Status ?status1)
                    (4PSPCtx.Status ?status2)
                    (/=  ?status1 ?status2)
   (holdsIn ?span (4PSPCtx.conceptHasGPNConfigurationStatus ?concept ?status1)))
   (not (holdsIn ?span (4PSPCtx.conceptHasGPNConfigurationStatus ?concept ?status2)))
)
:IC hard "A concept can only have one conceptHasGPNConfigurationStatus at the same time but
Concept ?concept has conceptHasGPNConfigurationStatus ?status1 and ?status2 at time ?span."

(=> (and (4PSPCtx.Status ?status1)
                    (4PSPCtx.Status ?status2)
                    (/=  ?status1 ?status2)
   (holdsIn ?span (4PSPCtx.conceptHasBusinessModelScenarioStatus ?concept ?status1)))
   (not (holdsIn ?span (4PSPCtx.conceptHasBusinessModelScenarioStatus ?concept ?status2)))
)
:IC hard "A concept can only have one conceptHasBusinessModelScenarioStatus at the same time but
Concept ?concept has conceptHasBusinessModelScenarioStatus ?status1 and ?status2 at time ?span."

(=> (nodeInterDependencyOnNode ?node1  ?interdependency ?node2)
        (/= ?node1 ?node2)
)
:IC hard "A node (facility playing a role in a GPNScenario) cannot depend on itself, but ?node1 has
interdependency ?interdependency upon itself."

(=>  (nodeInterDependencyOnNode ?node1 ?interdependency ?node2)
    (exists (?scenario ?actor)
    (and
                    (GPNScenario ?scenario)
                    (playsRoleActor ?node1 ?actor ?scenario)))
)
:IC hard "nodeInterDependencyOnNode only exists between nodes (facilities playing actor roles in a
GPNScenario). ?node1 does not play an actor role in a GPNScenario."

(=>  (nodeInterDependencyOnNode ?node1 ?interdependency ?node2)
    (exists (?scenario ?actor)
    (and
```

(GPNScenario ?scenario)
(playsRoleActor ?node2 ?actor ?scenario)))
)
:IC hard "nodeInterDependencyOnNode only exists between nodes (facilities playing actor roles in a GPNScenario). ?node2 does not play an actor role in a GPNScenario."

(=> (nodeInterDependencyOnNode ?node1 ?interdependency ?node2)
(exists (?scenario ?actor1 ?actor2)
(and
(GPNScenario ?scenario)
(playsRoleActor ?node1 ?actor1 ?scenario)
(playsRoleActor ?node2 ?actor2 ?scenario)))
)
:IC hard "nodeInterDependencyOnNodes only exists between nodes (facilities playing actor roles) in the same GPN scenario. ?node1 has ?interdependency upon ?node2 but not in the same GPN Scenario."

(=> (and (playsRole ?intendRev ?role ?riskS)
(RiskScenario ?riskS)
(IntendedRevenue ?intendRev)
)
(Output ?role)
)
:IC hard "In a RiskScenario an IntendedRevenue can only play an Output role. In RiskScenario ?riskS the IntendedRevenue ?intendRev playsRole ?role which is not an Output."

(=> (and (playsRole ?inop ?role ?riskS)
(RiskScenario ?riskS)
(Inoperability ?inop)
)
(Output ?role)
)
:IC hard "In a RiskScenario an Inoperability can only play an Output role. In RiskScenario ?riskS the Inoperability ?inop playsRole ?role which is not an Output."

(=> (and (playsRole ?perturb ?role ?riskS)
(RiskScenario ?riskS)
(Perturbation ?perturb)
)
(Input ?role)
)
:IC hard "In a RiskScenario a Perturbation can only play an Input role. In RiskScenario ?riskS the Perturbation ?perturb playsRole ?role which is not an Input."

```
(=>  (and (playsRole ?basic ?role ?riskS)
          (RiskScenario ?riskS)
          (Role ?role)
          )
          (or (Perturbation ?basic)(Inoperability ?basic)(IntendedRevenue ?basic))
)
```
:IC hard "In a RiskScenario only the Basic sub-properties Perturbation, Inoperability or IntendedRevenue can play roles. In RiskScenario ?riskS the Basic ?basic which playsRole ?role is not one of these."

```
(=> (projectContainsScenario ?x ?y)
(not (DependentScenario ?y))
)
```
:IC hard "A project cannot contain DependentScenarios. The relation projectContainsScenario does not hold between the Project ?x and the DependentScenario ?y."

```
(=> (inScenario ?x ?y)
(not (DependentScenario ?y))
)
```
:IC hard "A Scenario cannot be contained within (inScenario) a DependentScenario. The relation inScenario does not hold between the Scenario ?x and the DependentScenario ?y."

;;;Should we enable a businessScenario to be composed of business Scenarios?

```
(=> (and(DependentScenario ?dependS)
         (inScenario ?dependS ?compound))
         (exists (?gpnS)
                        (and (GPNScenario ?gpnS)
            (inScenario ?gpnS ?compound)
   )))
```
:IC hard "A Dependent Scenario requires a GPNScenario to exist within the same compound scenario as the Dependent Scenario.
A GPNScenario should be in the same compound Scenario ?compound as ?dependS."

```
(=> (and(BalancedScoreCardScenario ?balanceS)
         (inScenario ?balanceS ?compound))
         (exists (?bmS)
                        (and (BusinessModelScenario ?bmS)
            (inScenario ?bmS ?compound)
   )))
```
:IC soft "A Balanced ScoreCard Scenario could depend on a Business Model. Therefore a Balanced ScoreCard Scenario may be required to exist within the same compound scenario as the Business Model Scenario.
A Business Model Scenario should be in the same compound Scenario ?compound as ?balanceS."

```
(=> (businessModelScenarioHasChosenProductScenario ?bmS ?prodS)
                (exists (?compound)
```

```
                        (and
                                (businessModelScenarioInScenario ?bmS  ?compound)
            (inScenario ?prodS ?compound)
                        )
                )
)
```

:IC soft "A Business Model Scenario could have a chosen Product Scenario. Therefore a Business Model Scenario may be in the same compound scenario as the Product Scenario. The chosen Product Scenario ?prodS should be InScenario the same compound scenario as?bmS."
;;a soft axiom as I'm unsure

```
(=> (productScenarioHasChosenBusinessModelScenario ?prodS ?bmS)
                (exists (?compound)
                        (and
                                (inScenario ?prodS ?compound)
            (businessModelScenarioInScenario ?bmS ?compound)
                        )
                )
)
```

:IC soft "A Product Scenario could have a chosen Business Model Scenario. Therefore a Product Scenario may be in the same compound scenario as the Business Model Scenario. The chosen Business Model Scenario ?bmS should businessModelScenarioInScenario the same compound scenario as ?prodS."
;;a soft axiom as I'm unsure

```
(=>  (and (playsRole ?basic ?role ?riskS)
          (RiskScenario ?riskS)
          (Basic ?basic)
          (Role ?role))
          (or(Input ?role) (Output ?role) (Control ?role) (Resource ?role))
)
```

:IC hard "In a RiskScenario only Input, Output, Control or Resource roles can be played.
In RiskScenario ?riskS ?basic playsRole ?role which is not one of these."

```
(=> (and(System ?system)
                (Scenario ?compound)
                (DependentScenario ?dpndS)
                (GPNScenario ?gpnS)
                (inScenario ?dpndS ?compound)
                (inScenario ?gpnS ?compound)
                (systemContainsRole ?system ?dpndRole)
                (playsRole ?rolePlayer ?dpndRole ?dpndS)
        )
        (exists (?gpnRole)
                (playsRole ?system ?gpnRole ?gpnS))
)
```

:IC hard "Given that a DependentScenario is in the same compound Scenario as the GPNScenario then a node in the DependentScenario must also be present in the GPNScenario.
DependentScenario ?dpndS and GPNScenario ?gpnS are InScenario ?compound.
The Role ?dpndRole playsRole ?rolePlayer in DependentScenario ?dpndS and requiresA System ?system to play a Role in ?gpnS but ?system does not."
;;;rem: "Only one GPNScenario and one RiskScenario and one BusinessScenario are present in a compound scenario as defined by functionalargs
;;;on the gpnScenarioInScenario, riskScenarioInScenario and businessScenarioInScenario relations,
;;;therefore this axiom assumes the GPNScenario and the Dependentscenario (risk or business scenario) refer to each other (as there is a one-to-one relationship)."
;;;N.B. This axiom allows nodes to be present in a GPNScenario which are not in the DependentScenario. The DependentScenario is able to form a subset of the GPNScenario."

;;;Might need to change this to In Balanced ScoreCard Scenario ?balanceS the System ?system should play a role

```
(=> (and(System ?system)
                (Scenario ?compound)
                (RiskScenario ?riskS)
                (inScenario ?riskS ?compound)
                (BalancedScoreCardScenario ?balanceS)
                (inScenario ?balanceS ?compound)
                (requiresA ?riskRole ?system)
                (playsRole ?rolePlayerRisk ?riskRole ?riskS)
        )
        (exists (?balanceRole ?rolePlayerBalance)
        (and
                (requiresA ?balanceRole ?system)
                (playsRole ?rolePlayerBalance ?balanceRole ?balanceS))
        )
)
```

:IC hard "Given that a RiskScenario and a Balance ScoreCard Scenario are present in the same compound Scenario then a node in the RiskScenario must also be present in the Balanced ScoreCard Scenario. Cost and risk must be considered for the same node.
RiskScenario ?riskS and Balanced ScoreCard Scenario ?balanceS are InScenario compound Scenario ?compound.
In RiskScenario ?riskS Role ?riskRole playsRole ?rolePlayerRisk and requiresA System ?system. In Balanced ScoreCard Scenario ?balanceS a role should be played which requires the System ?system as a context but this does not occur."
;;;rem: "Only one RiskScenario and one BusinessScenario are present in a compound scenario as defined by functionalargs
;;;on the riskScenarioInScenario and businessScenarioInScenario relations,
;;;therefore this axiom assumes the Risk and Business Scenario refer to each other (as there is a one-to-one relationship)."

;;;Might need to change this to In BalancedScoreCardScenario ?balanceS System ?system playsRole ?rolePlayerBalance.

```
(=> (and(System ?system)
```

```
                (Scenario ?compound)
                (BalancedScoreCardScenario ?balanceS)
                (inScenario ?balanceS ?compound)
                (RiskScenario ?riskS)
                (inScenario ?riskS ?compound)
                (requiresA ?balanceRole ?system)
                (playsRole ?rolePlayerBalance ?balanceRole ?balanceS)
        )
        (exists (?riskRole ?rolePlayerRisk)
        (and(requiresA ?riskRole ?system)
                (playsRole ?rolePlayerRisk ?riskRole ?riskS))
        )
)
```

:IC hard "Given that a BalancedScoreCardScenario and a Risk Scenario are present in the same compound Scenario then a node in the BalancedScoreCardScenario must also be present in the RiskScenario. Cost and risk must be considered for the same node.
BalancedScoreCardScenario ?balanceS and RiskScenario ?riskS are InScenario compound Scenario ?compound.
In BalancedScoreCardScenario ?balanceS Role ?balanceRole playsRole ?rolePlayerBalance and requiresA System ?system. In RiskScenario ?riskS a role should be played which requires the System ?system as a context but this does not occur."
;;;rem: "Only one BalancedScoreCardScenario ?balanceS and one Risk Scenario are present in a compound scenario as defined by functionalargs
;;;on the balancedScoreCardScenarioInScenario and the riskScenarioInScenario relations,
;;;therefore this axiom assumes the Business and Risk Scenario refer to each other (as there is a one-to-one relationship)."

13.8 Level 4 Rules

:Use 4PSPCtx

```
(=>
   (and
                (holdsIn ?date (ideaHasStatus ?idea ?status))
      (maxTermf ?date (?date ?status) (holdsIn ?date (ideaHasStatus ?idea ?status))  ?latestDate)
      (= ?date ?latestDate)
   )
   (ideaHasCurrentStatus ?idea ?status)
)
```

:rem "Derives the most recently known to be true status of the idea. Uses the first date in a span to derive the date. The assumption is that if the second date in a span is specified it is superceded by a more recent ideaHasStatus relation. E.g. (holdsIn (2003 2015) (ideaHasStatus GoodIdea accepted)) (i.e. review in 2015) is superceded by (holdsIn (2014) (ideaHasStatus GoodIdea approved)) (i.e. reviewed in 2014)"

```
(=>
   (and
                (holdsIn ?date (ideaHasDescription ?idea ?description))
```

```
      (maxTermf ?date (?date ?description) (holdsIn ?date (ideaHasDescription ?idea ?description))
?latestDate)
      (= ?date ?latestDate)
   )
   (ideaHasCurrentDescription ?idea ?description)
)
:rem "Derives the most recently known to be true description of the idea."

(=>
   (and
            (holdsIn ?date1 (conceptHasStatus ?concept ?status))
      (maxTermf ?date1 (?date1 ?status) (holdsIn ?date1 (conceptHasStatus ?concept ?status))
?latestDate)
      (= ?date1 ?latestDate)
   )
   (conceptHasCurrentStatus ?concept ?status)
)
:rem "Derives the most recently known to be true status of the concept."


(=>
   (and
            (holdsIn ?date2 (conceptHasPilotProductionStatus ?concept ?status))
      (maxTermf ?date2 (?date2 ?status) (holdsIn ?date2 (conceptHasPilotProductionStatus ?concept
?status)) ?latestDate)
      (= ?date2 ?latestDate)
   )
   (conceptHasCurrentPilotProductionStatus ?concept ?status)
)
:rem "Derives the most recently known to be true Pilot Production status of the concept."

(=>
   (and
            (holdsIn ?date3 (conceptHasGPNConfigurationStatus ?concept ?status))
      (maxTermf ?date3 (?date3 ?status) (holdsIn ?date3 (conceptHasGPNConfigurationStatus
?concept ?status)) ?latestDate)
      (= ?date3 ?latestDate)
   )
   (conceptHasCurrentGPNConfigurationStatus ?concept ?status)
)
:rem "Derives the most recently known to be true GPNConfiguration status of the concept."

(=>
   (and
            (holdsIn ?date4 (conceptHasBusinessModelScenarioStatus ?concept ?status))
      (maxTermf ?date4 (?date4 ?status) (holdsIn ?date4 (conceptHasBusinessModelScenarioStatus
?concept ?status)) ?latestDate)
      (= ?date4 ?latestDate)
```

```
    )
    (conceptHasCurrentBusinessModelScenarioStatus ?concept ?status)
)
:rem "Derives the most recently known to be true BusinessModelScenario status of the concept."

(=>
          (and
            (holdsIn ?date (RootCtx.name ?id ?name))
      (4PSPCtx.Concept ?id)
      (maxTermf ?date (?date ?name ?id) (holdsIn ?date (RootCtx.name ?id ?name)) ?latestDate)
      (= ?date ?latestDate)
    )
    (conceptHasCurrentName ?id ?name)
)
:rem "Derives the most recently known to be true name of the concept."

(=>
    (and
                    (holdsIn ?date (conceptHasDescription ?concept ?description))
        (maxTermf ?date (?date ?description) (holdsIn ?date (conceptHasDescription ?concept
?description)) ?latestDate)
        (= ?date ?latestDate)
    )
    (conceptHasCurrentDescription ?concept ?description)
)
:rem "Derives the most recently known to be true description of the concept."

 (=>
 (and
   (ProductServiceIdea ?idea)
   (DemandIdentification ?di)
   (productHasAssociatedIdea ?ps ?idea)
   (productHasAssociatedLifeCycle ?ps ?lc))
   (lifeCycleStatusSetAsDemandIdentification ?lc ?di))
:rem "If there is an Idea and a Demand Identification, then the Product-Service Life-Cycle  Status  of
the associated Product-Service is the Demand Identification."

;If there is a Concept and a Feasibility Study, then the Product-Service Life-Cycle Status of the
associated Product-Service is the Feasibility Study
 (=>
(and
   (ProductServiceConcept ?con)
   (FeasibilityStudy ?fs)
   (productHasAssociatedConcept?ps ?con)
   (productHasAssociatedLifeCycle ?ps ?lc))
   (lifeCycleStatusSetAsFeasibilityStudy ?lc ?fs))
:rem "If there is an Idea and a Demand Identification, then the Product-Service Life-Cycle  Status  of
the associated Product-Service is the Demand Identification."
```

```
 ;If there is a Requirement and a Concept Development, then the Product-Service Life-Cycle Status
of the associated Product-Service is the Concept Development
(=>
 (and
   (ProductServiceRequirement ?req)
   (ConceptDevelopment ?cd)
   (ManufacturedProductService ?ps)
   (ProductServiceLifeCycle ?lc)
   (productHasAssociatedLifeCycle ?ps ?lc))
   (lifeCycleStatusSetAsConceptDevelopment ?lc ?cd))

 :rem "If there is an Idea and a Demand Identification, then the Product-Service Life-Cycle  Status  of
the associated Product-Service is the Demand Identification."


 ;If there is a Support System and a Configuration, then the Product-Service Life-Cycle Status of the
Product-Service that uses the Support System is the Configuration
 (=>
  (and
   (SupportSystem ?ss)
   (Configuration ?conf)
   (productUsesSupportSystem ?ps ?ss)
          (ProductServiceLifeCycle ?lc)
    (productHasAssociatedLifeCycle ?ps ?lc))
    (lifeCycleStatusSetAsConfiguration ?lc ?conf))
:rem "If there is a Support System and a Configuration, then the Product-Service Life-Cycle Status of
the Product-Service that uses the Support System is the Configuration"
```

14 Annex D: BuzzBikes example Knowledge base

The following knowledge base is provided as an additional set of facts based on a fictitious "BuzzBikes" company that has been used as a generic test case in the project.

```
;;; BuzzBikes Knowledge Base
;;;=============================================================
;;; Defining Ecosystem, Project World, Project & Scenarios
;;;=============================================================

(Ecosystem "GPN")
(4PSPCtx.ProjectWorld "Project World")
(4PSPCtx.ProjectWorld "KSB worldwide")
(2DSCtx.Project "DefaultProject")
(Scenario "BBEcosystem")
(4PSPCtx.GPNScenario "BBWorld default scenario")
(4PSPCtx.GPNScenario "Project World default scenario")
(4PSPCtx.GPNScenario "Project World 1st scenario")
(4PSPCtx.GPNScenario "KSB worldwide default scenario")
(4PSPCtx.RiskScenario "Demo Risk Scenario")
(4PSPCtx.RiskScenario "Risk Scenario 2 (Ali)")
(2DSCtx.projectContainsScenario "DefaultProject" "Project World default scenario")
(2DSCtx.projectContainsScenario "DefaultProject" "Project World 1st scenario")

;;;=============================================================
;;; Defining Systems
;;;=============================================================

(System "BBWorld")
(System "Braking System Assembly Line")
(System "Frame Assembly Assembly Line")
(System "Gear System Assembly Line")
(System "Drivetrain Assembly Line")
(System "Suspension System Assembly Line")
(System "Wheel Assembly Assembly Line")
(System "Steering Assembly Assembly Line")
(System "Bike Assembly Line")
(System "iBike Assembly Line")
(System "Drivetrain Components Supply")

;;;=============================================================
;;; Defining Materials, Parts, Components & Manufactured Products
;;;=============================================================

(2DSCtx.Part "Gear System42")
(2DSCtx.Part "Smart Components43")
(2DSCtx.Part "Steering Assembly44")
```

(2DSCtx.Part "Suspension System45")
(2DSCtx.Part "Wheel Assembly46")
(2DSCtx.Part "Braking System39")
(2DSCtx.Part "Drivetrain40")
(2DSCtx.Part "Frame Assembly41")

(2DSCtx.Component "Headset30")
(2DSCtx.Component "Stem31")
(2DSCtx.Component "Suspension Fork32")
(2DSCtx.Component "Suspension Rear Shock33")
(2DSCtx.Component "Tire (Front)34")
(2DSCtx.Component "Tire (Rear)35")
(2DSCtx.Component "Tubes36")
(2DSCtx.Component "Wheel (Front)37")
(2DSCtx.Component "Wheel (Rear)38")
(2DSCtx.Component "Energy Consumption Meter49")
(2DSCtx.Component "Seatpost collar14")
(2DSCtx.Component "Cable15")
(2DSCtx.Component "Derailleur (Front)16")
(2DSCtx.Component "Derailleur (Rear)17")
(2DSCtx.Component "Cable Housing18")
(2DSCtx.Component "Shifter (Front)19")
(2DSCtx.Component "Shifter (Rear)20")
(2DSCtx.Component "Onboard computer21")
(2DSCtx.Component "Crank sensor22")
(2DSCtx.Component "GPS23")
(2DSCtx.Component "Bluetooth reciever24")
(2DSCtx.Component "HUD module25")
(2DSCtx.Component "SMART band26")
(2DSCtx.Component "Camera27")
(2DSCtx.Component "Handlebar28")
(2DSCtx.Component "Grips29")
(2DSCtx.Component "Brake (Front)1")
(2DSCtx.Component "Brake (Rear)2")
(2DSCtx.Component "Brake Rotor (Front)3")
(2DSCtx.Component "Brake Rotor (Rear)4")
(2DSCtx.Component "Bottom Bracket5")
(2DSCtx.Component "Cassette6")
(2DSCtx.Component "Chain7")
(2DSCtx.Component "Chainguide8")
(2DSCtx.Component "Crankset9")
(2DSCtx.Component "Pedals10")
(2DSCtx.Component "Frame11")
(2DSCtx.Component "Saddle12")
(2DSCtx.Component "Seatpost13")

(Material "Bike47")
(Material "iBike48")

```
(4PSPCtx.ManufacturedProduct "roleManufacturedProduct")
(4PSPCtx.ManufacturedProduct "4PSPCtx.ManufacturedProduct BBWorld")
(4PSPCtx.ManufacturedProduct "4PSPCtx.ManufacturedProduct BBWorld")
(4PSPCtx.ManufacturedProduct "4PSPCtx.ManufacturedProduct Project World")
(4PSPCtx.ManufacturedProduct "4PSPCtx.ManufacturedProduct KSB worldwide")

;;;=============================================================
;;; Defining Customers, Producers & Suppliers
;;;=============================================================

(4PSPCtx.Customer "4PSPCtx.Customer BBWorld")
(4PSPCtx.Customer "4PSPCtx.Customer BBWorld")
(4PSPCtx.Customer "4PSPCtx.Customer Project World")
(4PSPCtx.Customer "4PSPCtx.Customer KSB worldwide")

(4PSPCtx.Producer "4PSPCtx.Producer BBWorld")
(4PSPCtx.Producer "4PSPCtx.Producer BBWorld")
(4PSPCtx.Producer "4PSPCtx.Producer Project World")
(4PSPCtx.Producer "4PSPCtx.Producer KSB worldwide")

(2DSCtx.Supplier "2DSCtx.Supplier Project World")
(2DSCtx.Supplier "2DSCtx.Supplier KSB worldwide")

;;;=============================================================
;;; Defining Status
;;;=============================================================

(4PSPCtx.Status accepted)
(4PSPCtx.Status approved)
(4PSPCtx.Status notApproved)

;;;=============================================================
;;; Defining Events
;;;=============================================================

(2DSCtx.StartEvent "GPN_StartEvent")
(2DSCtx.EndEvent "GPN_EndEvent")

;;;=============================================================
;;; Populating Roles in Scenarios (Plays Role)
;;;=============================================================

(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor
(Rear)4_5" "Project World 1st scenario")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor
(Rear)4_5" "Project World default scenario")
```

(playsRole "Shifter (Front)19" "Output_Shimano supply in Project World_Shifter (Front)19_2" "Project World 1st scenario")
(playsRole "Derailleur (Rear)17" "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Project World 1st scenario")
(playsRole "Derailleur (Rear)17" "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Project World default scenario")
(playsRole "Bottom Bracket5" "Output_Drivetrain Supply in Project World_Bottom Bracket5_2" "Project World 1st scenario")
(playsRole "Bottom Bracket5" "Output_Drivetrain Supply in Project World_Bottom Bracket5_2" "Project World default scenario")
(playsRole "Cassette6" "Output_Drivetrain Supply in Project World_Cassette6_3" "Project World 1st scenario")
(playsRole "Cassette6" "Output_Drivetrain Supply in Project World_Cassette6_3" "Project World default scenario")
(playsRole "Chain7" "Output_Drivetrain Supply in Project World_Chain7_4" "Project World 1st scenario")
(playsRole "Chain7" "Output_Drivetrain Supply in Project World_Chain7_4" "Project World default scenario")
(playsRole "Crankset9" "Output_Drivetrain Supply in Project World_Crankset9_5" "Project World 1st scenario")
(playsRole "Crankset9" "Output_Drivetrain Supply in Project World_Crankset9_5" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_2" "Project World 1st scenario")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_2" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_3" "Project World 1st scenario")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_3" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_4" "Project World 1st scenario")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_4" "Project World default scenario")
(playsRole "Chain7" "Input_Drivetrain Supply Taipei in Project World_Chain7_15" "Project World default scenario")
(playsRole "Chainguide8" "Input_Drivetrain Supply Taipei in Project World_Chainguide8_15" "Project World default scenario")
(playsRole "Crankset9" "Input_Drivetrain Supply Taipei in Project World_Crankset9_15" "Project World default scenario")
(playsRole "Pedals10" "Input_Drivetrain Supply Taipei in Project World_Pedals10_15" "Project World default scenario")
(playsRole "Drivetrain40" "Output_Drivetrain Supply Taipei in Project World_Drivetrain40_15" "Project World default scenario")
(playsRole "Derailleur (Front)16" "Output_Drivetrain Supply Taipei in Project World_Derailleur (Front)16_15" "Project World default scenario")
(playsRole "Shifter (Front)19" "Output_Drivetrain Supply Taipei in Project World_Shifter (Front)19_15" "Project World default scenario")

(playsRole "Shifter (Rear)20" "Output_Drivetrain Supply Taipei in Project World_Shifter (Rear)20_15" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply Taipei in Project World_Brake (Front)1_15" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply Taipei in Project World_Brake (Rear)2_15" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply Taipei in Project World_Brake Rotor (Front)3_15" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply Taipei in Project World_Brake Rotor (Rear)4_15" "Project World default scenario")
(playsRole "Shifter (Front)19" "Output_Shimano supply in Project World_Shifter (Front)19_2" "Project World 1st scenario")
(playsRole "Shifter (Front)19" "Output_Shimano supply in Project World_Shifter (Front)19_2" "Project World default scenario")
(playsRole "Shifter (Rear)20" "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Project World 1st scenario")
(playsRole "Shifter (Rear)20" "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Project World default scenario")
(playsRole "Bottom Bracket5" "Input_Drivetrain Supply Tokyo in Project World_Bottom Bracket5_15" "Project World default scenario")
(playsRole "Cassette6" "Input_Drivetrain Supply Tokyo in Project World_Cassette6_15" "Project World default scenario")
(playsRole "Chain7" "Input_Drivetrain Supply Tokyo in Project World_Chain7_15" "Project World default scenario")
(playsRole "Chainguide8" "Input_Drivetrain Supply Tokyo in Project World_Chainguide8_15" "Project World default scenario")
(playsRole "Crankset9" "Input_Drivetrain Supply Tokyo in Project World_Crankset9_15" "Project World default scenario")
(playsRole "Pedals10" "Input_Drivetrain Supply Tokyo in Project World_Pedals10_15" "Project World default scenario")
(playsRole "Drivetrain40" "Output_Drivetrain Supply Tokyo in Project World_Drivetrain40_15" "Project World default scenario")
(playsRole "Derailleur (Front)16" "Output_Drivetrain Supply Tokyo in Project World_Derailleur (Front)16_15" "Project World default scenario")
(playsRole "Shifter (Front)19" "Output_Drivetrain Supply Tokyo in Project World_Shifter (Front)19_15" "Project World default scenario")
(playsRole "Shifter (Rear)20" "Output_Drivetrain Supply Tokyo in Project World_Shifter (Rear)20_15" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_15" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_15" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_15" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Rear)4_15" "Project World default scenario")
(playsRole "Bottom Bracket5" "Input_Drivetrain Supply Taipei in Project World_Bottom Bracket5_15" "Project World default scenario")

(playsRole "Cassette6" "Input_Drivetrain Supply Taipei in Project World_Cassette6_15" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_Shimano supply in Project World_Brake (Rear)2_14" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_Shimano supply in Project World_Brake Rotor (Front)3_14" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_Shimano supply in Project World_Brake Rotor (Rear)4_14" "Project World default scenario")
(playsRole "Bottom Bracket5" "Output_Drivetrain Supply in Project World_Bottom Bracket5_14" "Project World default scenario")
(playsRole "Cassette6" "Output_Drivetrain Supply in Project World_Cassette6_14" "Project World default scenario")
(playsRole "Chain7" "Output_Drivetrain Supply in Project World_Chain7_14" "Project World default scenario")
(playsRole "Chainguide8" "Output_Drivetrain Supply in Project World_Chainguide8_14" "Project World default scenario")
(playsRole "Crankset9" "Output_Drivetrain Supply in Project World_Crankset9_14" "Project World default scenario")
(playsRole "Pedals10" "Output_Drivetrain Supply in Project World_Pedals10_14" "Project World default scenario")
(playsRole "Derailleur (Front)16" "Output_Drivetrain Supply in Project World_Derailleur (Front)16_14" "Project World default scenario")
(playsRole "Shifter (Front)19" "Output_Drivetrain Supply in Project World_Shifter (Front)19_14" "Project World default scenario")
(playsRole "Shifter (Rear)20" "Output_Drivetrain Supply in Project World_Shifter (Rear)20_14" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply in Project World_Brake (Front)1_14" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply in Project World_Brake (Rear)2_14" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply in Project World_Brake Rotor (Front)3_14" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply in Project World_Brake Rotor (Rear)4_14" "Project World default scenario")
(playsRole "Shifter (Front)19" "Output_Drivetrain Supply Taipei in BBWorld_Shifter (Front)19_10" "BBEcosystem")
(playsRole "Shifter (Rear)20" "Output_Drivetrain Supply Taipei in BBWorld_Shifter (Rear)20_11" "BBEcosystem")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply Taipei in BBWorld_Brake (Front)1_12" "BBEcosystem")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply Taipei in BBWorld_Brake (Rear)2_13" "BBEcosystem")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply Taipei in BBWorld_Brake Rotor (Front)3_14" "BBEcosystem")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply Taipei in BBWorld_Brake Rotor (Rear)4_15" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Shimano supply in Project World_Bottom Bracket5_14" "Project World default scenario")

(playsRole "Cassette6" "Output_Shimano supply in Project World_Cassette6_14" "Project World default scenario")
(playsRole "Chain7" "Output_Shimano supply in Project World_Chain7_14" "Project World default scenario")
(playsRole "Chainguide8" "Output_Shimano supply in Project World_Chainguide8_14" "Project World default scenario")
(playsRole "Crankset9" "Output_Shimano supply in Project World_Crankset9_14" "Project World default scenario")
(playsRole "Pedals10" "Output_Shimano supply in Project World_Pedals10_14" "Project World default scenario")
(playsRole "Derailleur (Front)16" "Output_Shimano supply in Project World_Derailleur (Front)16_14" "Project World default scenario")
(playsRole "Shifter (Front)19" "Output_Shimano supply in Project World_Shifter (Front)19_14" "Project World default scenario")
(playsRole "Shifter (Rear)20" "Output_Shimano supply in Project World_Shifter (Rear)20_14" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_Shimano supply in Project World_Brake (Front)1_14" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply Tokyo in BBWorld_Brake Rotor (Rear)4_15" "BBEcosystem")
(playsRole "Bottom Bracket5" "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Drivetrain40" "Output_Drivetrain Supply Taipei in BBWorld_Drivetrain40_8" "BBEcosystem")
(playsRole "Bottom Bracket5" "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Drivetrain40" "Output_Drivetrain Supply Taipei in BBWorld_Drivetrain40_8" "BBEcosystem")
(playsRole "Derailleur (Front)16" "Output_Drivetrain Supply Taipei in BBWorld_Derailleur (Front)16_9" "BBEcosystem")
(playsRole "Crankset9" "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Drivetrain40" "Output_Drivetrain Supply Tokyo in BBWorld_Drivetrain40_8" "BBEcosystem")
(playsRole "Bottom Bracket5" "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2" "BBEcosystem")

(playsRole "Cassette6" "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Input_Drivetrain Supply Tokyo in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Drivetrain40" "Output_Drivetrain Supply Tokyo in BBWorld_Drivetrain40_8" "BBEcosystem")
(playsRole "Derailleur (Front)16" "Output_Drivetrain Supply Tokyo in BBWorld_Derailleur (Front)16_9" "BBEcosystem")
(playsRole "Shifter (Front)19" "Output_Drivetrain Supply Tokyo in BBWorld_Shifter (Front)19_10" "BBEcosystem")
(playsRole "Shifter (Rear)20" "Output_Drivetrain Supply Tokyo in BBWorld_Shifter (Rear)20_11" "BBEcosystem")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply Tokyo in BBWorld_Brake (Front)1_12" "BBEcosystem")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply Tokyo in BBWorld_Brake (Rear)2_13" "BBEcosystem")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply Tokyo in BBWorld_Brake Rotor (Front)3_14" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Supply in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Supply in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Supply in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Supply in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Supply in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Derailleur (Front)16" "Output_Drivetrain Supply in BBWorld_Derailleur (Front)16_8" "BBEcosystem")
(playsRole "Shifter (Front)19" "Output_Drivetrain Supply in BBWorld_Shifter (Front)19_9" "BBEcosystem")
(playsRole "Shifter (Rear)20" "Output_Drivetrain Supply in BBWorld_Shifter (Rear)20_10" "BBEcosystem")
(playsRole "Brake (Front)1" "Output_Drivetrain Supply in BBWorld_Brake (Front)1_11" "BBEcosystem")
(playsRole "Brake (Rear)2" "Output_Drivetrain Supply in BBWorld_Brake (Rear)2_12" "BBEcosystem")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Supply in BBWorld_Brake Rotor (Front)3_13" "BBEcosystem")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Supply in BBWorld_Brake Rotor (Rear)4_14" "BBEcosystem")
(playsRole "Bottom Bracket5" "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Input_Drivetrain Supply Tokyo in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "BBEcosystem")

(playsRole "Derailleur (Front)16" "Output_Drivetrain Components Supply in Shimano in BBWorld_Derailleur (Front)16_8" "BBEcosystem")
(playsRole "Shifter (Front)19" "Output_Drivetrain Components Supply in Shimano in BBWorld_Shifter (Front)19_9" "BBEcosystem")
(playsRole "Shifter (Rear)20" "Output_Drivetrain Components Supply in Shimano in BBWorld_Shifter (Rear)20_10" "BBEcosystem")
(playsRole "Brake (Front)1" "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake (Front)1_11" "BBEcosystem")
(playsRole "Brake (Rear)2" "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake (Rear)2_12" "BBEcosystem")
(playsRole "Brake Rotor (Front)3" "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake Rotor (Front)3_13" "BBEcosystem")
(playsRole "Brake Rotor (Rear)4" "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake Rotor (Rear)4_14" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Drivetrain Supply in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Supply in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Supply in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Supply in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Supply in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Supply in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Drivetrain Supply in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "BBEcosystem")

(playsRole "Bottom Bracket5" "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "HUD module25" "Input_iBike Assembly Line_HUD module25_7" "BBEcosystem")
(playsRole "SMART band26" "Input_iBike Assembly Line_SMART band26_8" "BBEcosystem")
(playsRole "Camera27" "Input_iBike Assembly Line_Camera27_9" "BBEcosystem")
(playsRole "iBike48" "Output_iBike Assembly Line_iBike48_10" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Drivetrain Components Supply_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Components Supply_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Components Supply_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Components Supply_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Components Supply_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Components Supply_Pedals10_7" "BBEcosystem")
(playsRole "Bottom Bracket5" "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "BBEcosystem")
(playsRole "Chainguide8" "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "BBEcosystem")
(playsRole "Stem31" "Input_Steering Assembly Assembly Line_Stem31_5" "BBEcosystem")
(playsRole "Steering Assembly44" "Output_Steering Assembly Assembly Line_Steering Assembly44_6" "BBEcosystem")
(playsRole "Braking System39" "Input_Bike Assembly Line_Braking System39_2" "BBEcosystem")
(playsRole "Drivetrain40" "Input_Bike Assembly Line_Drivetrain40_3" "BBEcosystem")
(playsRole "Frame Assembly41" "Input_Bike Assembly Line_Frame Assembly41_4" "BBEcosystem")
(playsRole "Gear System42" "Input_Bike Assembly Line_Gear System42_5" "BBEcosystem")
(playsRole "Smart Components43" "Input_Bike Assembly Line_Smart Components43_6" "BBEcosystem")
(playsRole "Steering Assembly44" "Input_Bike Assembly Line_Steering Assembly44_7" "BBEcosystem")
(playsRole "Suspension System45" "Input_Bike Assembly Line_Suspension System45_8" "BBEcosystem")
(playsRole "Wheel Assembly46" "Input_Bike Assembly Line_Wheel Assembly46_9" "BBEcosystem")
(playsRole "Bike47" "Output_Bike Assembly Line_Bike47_10" "BBEcosystem")
(playsRole "Bike47" "Input_iBike Assembly Line_Bike47_2" "BBEcosystem")

(playsRole "Onboard computer21" "Input_iBike Assembly Line_Onboard computer21_3" "BBEcosystem")
(playsRole "Crank sensor22" "Input_iBike Assembly Line_Crank sensor22_4" "BBEcosystem")
(playsRole "GPS23" "Input_iBike Assembly Line_GPS23_5" "BBEcosystem")
(playsRole "Bluetooth reciever24" "Input_iBike Assembly Line_Bluetooth reciever24_6" "BBEcosystem")
(playsRole "Chainguide8" "Input_Drivetrain Assembly Line_Chainguide8_5" "BBEcosystem")
(playsRole "Crankset9" "Input_Drivetrain Assembly Line_Crankset9_6" "BBEcosystem")
(playsRole "Pedals10" "Input_Drivetrain Assembly Line_Pedals10_7" "BBEcosystem")
(playsRole "Drivetrain40" "Output_Drivetrain Assembly Line_Drivetrain40_8" "BBEcosystem")
(playsRole "Suspension Fork32" "Input_Suspension System Assembly Line_Suspension Fork32_2" "BBEcosystem")
(playsRole "Suspension Rear Shock33" "Input_Suspension System Assembly Line_Suspension Rear Shock33_3" "BBEcosystem")
(playsRole "Suspension System45" "Output_Suspension System Assembly Line_Suspension System45_4" "BBEcosystem")
(playsRole "Tire (Front)34" "Input_Wheel Assembly Assembly Line_Tire (Front)34_2" "BBEcosystem")
(playsRole "Tire (Rear)35" "Input_Wheel Assembly Assembly Line_Tire (Rear)35_3" "BBEcosystem")
(playsRole "Tubes36" "Input_Wheel Assembly Assembly Line_Tubes36_4" "BBEcosystem")
(playsRole "Wheel (Front)37" "Input_Wheel Assembly Assembly Line_Wheel (Front)37_5" "BBEcosystem")
(playsRole "Wheel (Rear)38" "Input_Wheel Assembly Assembly Line_Wheel (Rear)38_6" "BBEcosystem")
(playsRole "Wheel Assembly46" "Output_Wheel Assembly Assembly Line_Wheel Assembly46_7" "BBEcosystem")
(playsRole "Handlebar28" "Input_Steering Assembly Assembly Line_Handlebar28_2" "BBEcosystem")
(playsRole "Grips29" "Input_Steering Assembly Assembly Line_Grips29_3" "BBEcosystem")
(playsRole "Headset30" "Input_Steering Assembly Assembly Line_Headset30_4" "BBEcosystem")
(playsRole "Braking System39" "Output_Braking System Assembly Line_Braking System39_6" "BBEcosystem")
(playsRole "Frame11" "Input_Frame Assembly Assembly Line_Frame11_2" "BBEcosystem")
(playsRole "Saddle12" "Input_Frame Assembly Assembly Line_Saddle12_3" "BBEcosystem")
(playsRole "Seatpost13" "Input_Frame Assembly Assembly Line_Seatpost13_4" "BBEcosystem")
(playsRole "Seatpost collar14" "Input_Frame Assembly Assembly Line_Seatpost collar14_5" "BBEcosystem")
(playsRole "Frame Assembly41" "Output_Frame Assembly Assembly Line_Frame Assembly41_6" "BBEcosystem")
(playsRole "Cable15" "Input_Gear System Assembly Line_Cable15_2" "BBEcosystem")
(playsRole "Derailleur (Front)16" "Input_Gear System Assembly Line_Derailleur (Front)16_3" "BBEcosystem")
(playsRole "Derailleur (Rear)17" "Input_Gear System Assembly Line_Derailleur (Rear)17_4" "BBEcosystem")
(playsRole "Cable Housing18" "Input_Gear System Assembly Line_Cable Housing18_5" "BBEcosystem")
(playsRole "Shifter (Front)19" "Input_Gear System Assembly Line_Shifter (Front)19_6" "BBEcosystem")
(playsRole "Shifter (Rear)20" "Input_Gear System Assembly Line_Shifter (Rear)20_7" "BBEcosystem")
(playsRole "Gear System42" "Output_Gear System Assembly Line_Gear System42_8" "BBEcosystem")

(playsRole "Bottom Bracket5" "Input_Drivetrain Assembly Line_Bottom Bracket5_2" "BBEcosystem")
(playsRole "Cassette6" "Input_Drivetrain Assembly Line_Cassette6_3" "BBEcosystem")
(playsRole "Chain7" "Input_Drivetrain Assembly Line_Chain7_4" "BBEcosystem")
(playsRole "Brake (Front)1" "Input_Braking System Assembly Line_Brake (Front)1_2" "BBEcosystem")
(playsRole "Brake (Rear)2" "Input_Braking System Assembly Line_Brake (Rear)2_3" "BBEcosystem")
(playsRole "Brake Rotor (Front)3" "Input_Braking System Assembly Line_Brake Rotor (Front)3_4" "BBEcosystem")
(playsRole "Brake Rotor (Rear)4" "Input_Braking System Assembly Line_Brake Rotor (Rear)4_5" "BBEcosystem")
(playsRole "PerturbirtLnFqVsA" "PerturbirtLnFqVsASupplierIn" "Risk Scenario 2 (Ali)")
(playsRole "PerturbdGyLzCQejr" "PerturbdGyLzCQejrSupplierIn" "Risk Scenario 2 (Ali)")
(playsRole "Onboard computer21" "Input_Smart iBike Assembly Central Factory in Project World_Onboard computer21_3" "Project World default scenario")
(playsRole "Crank sensor22" "Input_Smart iBike Assembly Central Factory in Project World_Crank sensor22_4" "Project World 1st scenario")
(playsRole "Crank sensor22" "Input_Smart iBike Assembly Central Factory in Project World_Crank sensor22_4" "Project World default scenario")
(playsRole "GPS23" "Input_Smart iBike Assembly Central Factory in Project World_GPS23_5" "Project World 1st scenario")
(playsRole "GPS23" "Input_Smart iBike Assembly Central Factory in Project World_GPS23_5" "Project World default scenario")
(playsRole "Bluetooth reciever24" "Input_Smart iBike Assembly Central Factory in Project World_Bluetooth reciever24_6" "Project World 1st scenario")
(playsRole "Bluetooth reciever24" "Input_Smart iBike Assembly Central Factory in Project World_Bluetooth reciever24_6" "Project World default scenario")
(playsRole "HUD module25" "Input_Smart iBike Assembly Central Factory in Project World_HUD module25_7" "Project World 1st scenario")
(playsRole "HUD module25" "Input_Smart iBike Assembly Central Factory in Project World_HUD module25_7" "Project World default scenario")
(playsRole "SMART band26" "Input_Smart iBike Assembly Central Factory in Project World_SMART band26_8" "Project World 1st scenario")
(playsRole "SMART band26" "Input_Smart iBike Assembly Central Factory in Project World_SMART band26_8" "Project World default scenario")
(playsRole "Camera27" "Input_Smart iBike Assembly Central Factory in Project World_Camera27_9" "Project World 1st scenario")
(playsRole "Camera27" "Input_Smart iBike Assembly Central Factory in Project World_Camera27_9" "Project World default scenario")
(playsRole "iBike48" "Output_Smart iBike Assembly Central Factory in Project World_iBike48_10" "Project World 1st scenario")
(playsRole "iBike48" "Output_Smart iBike Assembly Central Factory in Project World_iBike48_10" "Project World default scenario")
(playsRole PerturbyKWCGNAFPn PerturbyKWCGNAFPnSupplierIn "Demo Risk Scenario")
(playsRole "Handlebar28" "Output_Newware Supply in Project World_Handlebar28_4" "Project World default scenario")
(playsRole "GPS23" "Output_Planetcan Supply in Project World_GPS23_2" "Project World 1st scenario")
(playsRole "GPS23" "Output_Planetcan Supply in Project World_GPS23_2" "Project World default scenario")

(playsRole "HUD module25" "Output_Subplus Supply in Project World_HUD module25_2" "Project World 1st scenario")
(playsRole "HUD module25" "Output_Subplus Supply in Project World_HUD module25_2" "Project World default scenario")
(playsRole "Wheel (Front)37" "Output_Koncon Supply in Project World_Wheel (Front)37_2" "Project World 1st scenario")
(playsRole "Wheel (Front)37" "Output_Koncon Supply in Project World_Wheel (Front)37_2" "Project World default scenario")
(playsRole "Wheel (Rear)38" "Output_Koncon Supply in Project World_Wheel (Rear)38_3" "Project World 1st scenario")
(playsRole "Wheel (Rear)38" "Output_Koncon Supply in Project World_Wheel (Rear)38_3" "Project World default scenario")
(playsRole "Grips29" "Output_Indigotech Supply in Project World_Grips29_2" "Project World 1st scenario")
(playsRole "Grips29" "Output_Indigotech Supply in Project World_Grips29_2" "Project World default scenario")
(playsRole "Pedals10" "Output_Indigotech Supply in Project World_Pedals10_3" "Project World 1st scenario")
(playsRole "Pedals10" "Output_Indigotech Supply in Project World_Pedals10_3" "Project World default scenario")
(playsRole "Bike47" "Input_Smart iBike Assembly Central Factory in Project World_Bike47_2" "Project World 1st scenario")
(playsRole "Bike47" "Input_Smart iBike Assembly Central Factory in Project World_Bike47_2" "Project World default scenario")
(playsRole "Onboard computer21" "Input_Smart iBike Assembly Central Factory in Project World_Onboard computer21_3" "Project World 1st scenario")
(playsRole "Cable Housing18" "Output_Silware Supply in Project World_Cable Housing18_3" "Project World default scenario")
(playsRole "Frame11" "Output_Retechi Supply in Project World_Frame11_2" "Project World 1st scenario")
(playsRole "Frame11" "Output_Retechi Supply in Project World_Frame11_2" "Project World default scenario")
(playsRole "Seatpost13" "Output_Retechi Supply in Project World_Seatpost13_3" "Project World 1st scenario")
(playsRole "Seatpost13" "Output_Retechi Supply in Project World_Seatpost13_3" "Project World default scenario")
(playsRole "Handlebar28" "Output_Retechi Supply in Project World_Handlebar28_4" "Project World 1st scenario")
(playsRole "Handlebar28" "Output_Retechi Supply in Project World_Handlebar28_4" "Project World default scenario")
(playsRole "Bluetooth reciever24" "Output_Doublemedia Supply in Project World_Bluetooth reciever24_2" "Project World 1st scenario")
(playsRole "Bluetooth reciever24" "Output_Doublemedia Supply in Project World_Bluetooth reciever24_2" "Project World default scenario")
(playsRole "Tubes36" "Output_Rankjalex Supply in Project World_Tubes36_2" "Project World 1st scenario")
(playsRole "Tubes36" "Output_Rankjalex Supply in Project World_Tubes36_2" "Project World default scenario")

(playsRole "Seatpost collar14" "Output_Newware Supply in Project World_Seatpost collar14_2" "Project World 1st scenario")
(playsRole "Seatpost collar14" "Output_Newware Supply in Project World_Seatpost collar14_2" "Project World default scenario")
(playsRole "Stem31" "Output_Newware Supply in Project World_Stem31_3" "Project World 1st scenario")
(playsRole "Stem31" "Output_Newware Supply in Project World_Stem31_3" "Project World default scenario")
(playsRole "Handlebar28" "Output_Newware Supply in Project World_Handlebar28_4" "Project World 1st scenario")
(playsRole "HUD module25" "Output_Trionix Supply in Project World_HUD module25_2" "Project World default scenario")
(playsRole "Bottom Bracket5" "Output_Zaptrans Supply in Project World_Bottom Bracket5_2" "Project World 1st scenario")
(playsRole "Bottom Bracket5" "Output_Zaptrans Supply in Project World_Bottom Bracket5_2" "Project World default scenario")
(playsRole "Cassette6" "Output_Zaptrans Supply in Project World_Cassette6_3" "Project World 1st scenario")
(playsRole "Cassette6" "Output_Zaptrans Supply in Project World_Cassette6_3" "Project World default scenario")
(playsRole "Chain7" "Output_Zaptrans Supply in Project World_Chain7_4" "Project World 1st scenario")
(playsRole "Chain7" "Output_Zaptrans Supply in Project World_Chain7_4" "Project World default scenario")
(playsRole "Crankset9" "Output_Zaptrans Supply in Project World_Crankset9_5" "Project World 1st scenario")
(playsRole "Crankset9" "Output_Zaptrans Supply in Project World_Crankset9_5" "Project World default scenario")
(playsRole "Cable15" "Output_Silware Supply in Project World_Cable15_2" "Project World 1st scenario")
(playsRole "Cable15" "Output_Silware Supply in Project World_Cable15_2" "Project World default scenario")
(playsRole "Grips29" "Output_Streetcore Supply in Project World_Grips29_2" "Project World 1st scenario")
(playsRole "Grips29" "Output_Streetcore Supply in Project World_Grips29_2" "Project World default scenario")
(playsRole "Cable15" "Output_Silware Supply in Project World_Cable15_2" "Project World 1st scenario")
(playsRole "Cable15" "Output_Silware Supply in Project World_Cable15_2" "Project World default scenario")
(playsRole "Cable Housing18" "Output_Silware Supply in Project World_Cable Housing18_3" "Project World 1st scenario")
(playsRole "Seatpost13" "Output_Rankware Supply in Project World_Seatpost13_7" "Project World default scenario")
(playsRole "Frame11" "Output_Unotechno Supply in Project World_Frame11_2" "Project World 1st scenario")
(playsRole "Frame11" "Output_Unotechno Supply in Project World_Frame11_2" "Project World default scenario")

(playsRole "Saddle12" "Output_Cantinice Supply in Project World_Saddle12_2" "Project World 1st scenario")
(playsRole "Saddle12" "Output_Cantinice Supply in Project World_Saddle12_2" "Project World default scenario")
(playsRole "Frame11" "Output_Itlam Supply in Project World_Frame11_2" "Project World 1st scenario")
(playsRole "Frame11" "Output_Itlam Supply in Project World_Frame11_2" "Project World default scenario")
(playsRole "Onboard computer21" "Output_Mathfase Supply in Project World_Onboard computer21_2" "Project World 1st scenario")
(playsRole "Onboard computer21" "Output_Mathfase Supply in Project World_Onboard computer21_2" "Project World default scenario")
(playsRole "SMART band26" "Output_Mathfase Supply in Project World_SMART band26_3" "Project World 1st scenario")
(playsRole "SMART band26" "Output_Mathfase Supply in Project World_SMART band26_3" "Project World default scenario")
(playsRole "Tire (Front)34" "Output_Runhouse Supply in Project World_Tire (Front)34_2" "Project World 1st scenario")
(playsRole "Tire (Front)34" "Output_Runhouse Supply in Project World_Tire (Front)34_2" "Project World default scenario")
(playsRole "Tire (Rear)35" "Output_Runhouse Supply in Project World_Tire (Rear)35_3" "Project World 1st scenario")
(playsRole "Tire (Rear)35" "Output_Runhouse Supply in Project World_Tire (Rear)35_3" "Project World default scenario")
(playsRole "HUD module25" "Output_Trionix Supply in Project World_HUD module25_2" "Project World 1st scenario")
(playsRole "Handlebar28" "Output_Kandomex Supply in Project World_Handlebar28_4" "Project World default scenario")
(playsRole "Suspension Fork32" "Output_Kandomex Supply in Project World_Suspension Fork32_5" "Project World 1st scenario")
(playsRole "Suspension Fork32" "Output_Kandomex Supply in Project World_Suspension Fork32_5" "Project World default scenario")
(playsRole "Suspension Rear Shock33" "Output_Kandomex Supply in Project World_Suspension Rear Shock33_6" "Project World 1st scenario")
(playsRole "Suspension Rear Shock33" "Output_Kandomex Supply in Project World_Suspension Rear Shock33_6" "Project World default scenario")
(playsRole "Crankset9" "Output_Rankware Supply in Project World_Crankset9_2" "Project World 1st scenario")
(playsRole "Crankset9" "Output_Rankware Supply in Project World_Crankset9_2" "Project World default scenario")
(playsRole "Handlebar28" "Output_Rankware Supply in Project World_Handlebar28_3" "Project World 1st scenario")
(playsRole "Handlebar28" "Output_Rankware Supply in Project World_Handlebar28_3" "Project World default scenario")
(playsRole "Stem31" "Output_Rankware Supply in Project World_Stem31_4" "Project World 1st scenario")
(playsRole "Stem31" "Output_Rankware Supply in Project World_Stem31_4" "Project World default scenario")

(playsRole "Suspension Fork32" "Output_Rankware Supply in Project World_Suspension Fork32_5" "Project World 1st scenario")
(playsRole "Suspension Fork32" "Output_Rankware Supply in Project World_Suspension Fork32_5" "Project World default scenario")
(playsRole "Suspension Rear Shock33" "Output_Rankware Supply in Project World_Suspension Rear Shock33_6" "Project World 1st scenario")
(playsRole "Suspension Rear Shock33" "Output_Rankware Supply in Project World_Suspension Rear Shock33_6" "Project World default scenario")
(playsRole "Seatpost13" "Output_Rankware Supply in Project World_Seatpost13_7" "Project World 1st scenario")
(playsRole "Bike47" "Output_Bike Assembly Factory in Project World_Bike47_10" "Project World default scenario")
(playsRole "HUD module25" "Output_Laelectrics Sypply in Project World_HUD module25_2" "Project World 1st scenario")
(playsRole "HUD module25" "Output_Laelectrics Sypply in Project World_HUD module25_2" "Project World default scenario")
(playsRole "Bluetooth reciever24" "Output_Laelectrics Sypply in Project World_Bluetooth reciever24_3" "Project World 1st scenario")
(playsRole "Bluetooth reciever24" "Output_Laelectrics Sypply in Project World_Bluetooth reciever24_3" "Project World default scenario")
(playsRole "Wheel (Front)37" "Output_Planetex Supply in Project World_Wheel (Front)37_2" "Project World 1st scenario")
(playsRole "Wheel (Front)37" "Output_Planetex Supply in Project World_Wheel (Front)37_2" "Project World default scenario")
(playsRole "Wheel (Rear)38" "Output_Planetex Supply in Project World_Wheel (Rear)38_3" "Project World 1st scenario")
(playsRole "Wheel (Rear)38" "Output_Planetex Supply in Project World_Wheel (Rear)38_3" "Project World default scenario")
(playsRole "Pedals10" "Output_Ventoins Supply in Project World_Pedals10_2" "Project World 1st scenario")
(playsRole "Pedals10" "Output_Ventoins Supply in Project World_Pedals10_2" "Project World default scenario")
(playsRole "Seatpost collar14" "Output_Kandomex Supply in Project World_Seatpost collar14_2" "Project World 1st scenario")
(playsRole "Seatpost collar14" "Output_Kandomex Supply in Project World_Seatpost collar14_2" "Project World default scenario")
(playsRole "Seatpost13" "Output_Kandomex Supply in Project World_Seatpost13_3" "Project World 1st scenario")
(playsRole "Seatpost13" "Output_Kandomex Supply in Project World_Seatpost13_3" "Project World default scenario")
(playsRole "Handlebar28" "Output_Kandomex Supply in Project World_Handlebar28_4" "Project World 1st scenario")
(playsRole "Braking System39" "Input_Bike Assembly Factory in Project World_Braking System39_2" "Project World default scenario")
(playsRole "Drivetrain40" "Input_Bike Assembly Factory in Project World_Drivetrain40_3" "Project World 1st scenario")
(playsRole "Drivetrain40" "Input_Bike Assembly Factory in Project World_Drivetrain40_3" "Project World default scenario")

(playsRole "Frame Assembly41" "Input_Bike Assembly Factory in Project World_Frame Assembly41_4" "Project World 1st scenario")
(playsRole "Frame Assembly41" "Input_Bike Assembly Factory in Project World_Frame Assembly41_4" "Project World default scenario")
(playsRole "Gear System42" "Input_Bike Assembly Factory in Project World_Gear System42_5" "Project World 1st scenario")
(playsRole "Gear System42" "Input_Bike Assembly Factory in Project World_Gear System42_5" "Project World default scenario")
(playsRole "Smart Components43" "Input_Bike Assembly Factory in Project World_Smart Components43_6" "Project World 1st scenario")
(playsRole "Smart Components43" "Input_Bike Assembly Factory in Project World_Smart Components43_6" "Project World default scenario")
(playsRole "Steering Assembly44" "Input_Bike Assembly Factory in Project World_Steering Assembly44_7" "Project World 1st scenario")
(playsRole "Steering Assembly44" "Input_Bike Assembly Factory in Project World_Steering Assembly44_7" "Project World default scenario")
(playsRole "Suspension System45" "Input_Bike Assembly Factory in Project World_Suspension System45_8" "Project World 1st scenario")
(playsRole "Suspension System45" "Input_Bike Assembly Factory in Project World_Suspension System45_8" "Project World default scenario")
(playsRole "Wheel Assembly46" "Input_Bike Assembly Factory in Project World_Wheel Assembly46_9" "Project World 1st scenario")
(playsRole "Wheel Assembly46" "Input_Bike Assembly Factory in Project World_Wheel Assembly46_9" "Project World default scenario")
(playsRole "Bike47" "Output_Bike Assembly Factory in Project World_Bike47_10" "Project World 1st scenario")
(playsRole "Wheel (Front)37" "Input_Wheel Assembly Factory in Project World_Wheel (Front)37_5" "Project World default scenario")
(playsRole "Wheel (Rear)38" "Input_Wheel Assembly Factory in Project World_Wheel (Rear)38_6" "Project World 1st scenario")
(playsRole "Wheel (Rear)38" "Input_Wheel Assembly Factory in Project World_Wheel (Rear)38_6" "Project World default scenario")
(playsRole "Wheel Assembly46" "Output_Wheel Assembly Factory in Project World_Wheel Assembly46_7" "Project World 1st scenario")
(playsRole "Wheel Assembly46" "Output_Wheel Assembly Factory in Project World_Wheel Assembly46_7" "Project World default scenario")
(playsRole "Handlebar28" "Input_Steering Assembly Factory in Project World_Handlebar28_2" "Project World 1st scenario")
(playsRole "Handlebar28" "Input_Steering Assembly Factory in Project World_Handlebar28_2" "Project World default scenario")
(playsRole "Grips29" "Input_Steering Assembly Factory in Project World_Grips29_3" "Project World 1st scenario")
(playsRole "Grips29" "Input_Steering Assembly Factory in Project World_Grips29_3" "Project World default scenario")
(playsRole "Headset30" "Input_Steering Assembly Factory in Project World_Headset30_4" "Project World 1st scenario")
(playsRole "Headset30" "Input_Steering Assembly Factory in Project World_Headset30_4" "Project World default scenario")

(playsRole "Stem31" "Input_Steering Assembly Factory in Project World_Stem31_5" "Project World 1st scenario")
(playsRole "Stem31" "Input_Steering Assembly Factory in Project World_Stem31_5" "Project World default scenario")
(playsRole "Steering Assembly44" "Output_Steering Assembly Factory in Project World_Steering Assembly44_6" "Project World 1st scenario")
(playsRole "Steering Assembly44" "Output_Steering Assembly Factory in Project World_Steering Assembly44_6" "Project World default scenario")
(playsRole "Braking System39" "Input_Bike Assembly Factory in Project World_Braking System39_2" "Project World 1st scenario")
(playsRole "Pedals10" "Input_Drivetrain Central Factory in Project World_Pedals10_7" "Project World default scenario")
(playsRole "Drivetrain40" "Output_Drivetrain Central Factory in Project World_Drivetrain40_8" "Project World 1st scenario")
(playsRole "Drivetrain40" "Output_Drivetrain Central Factory in Project World_Drivetrain40_8" "Project World default scenario")
(playsRole "Suspension Fork32" "Input_Suspension Central Factory in Project World_Suspension Fork32_2" "Project World 1st scenario")
(playsRole "Suspension Fork32" "Input_Suspension Central Factory in Project World_Suspension Fork32_2" "Project World default scenario")
(playsRole "Suspension Rear Shock33" "Input_Suspension Central Factory in Project World_Suspension Rear Shock33_3" "Project World 1st scenario")
(playsRole "Suspension Rear Shock33" "Input_Suspension Central Factory in Project World_Suspension Rear Shock33_3" "Project World default scenario")
(playsRole "Suspension System45" "Output_Suspension Central Factory in Project World_Suspension System45_4" "Project World 1st scenario")
(playsRole "Suspension System45" "Output_Suspension Central Factory in Project World_Suspension System45_4" "Project World default scenario")
(playsRole "Tire (Front)34" "Input_Wheel Assembly Factory in Project World_Tire (Front)34_2" "Project World 1st scenario")
(playsRole "Tire (Front)34" "Input_Wheel Assembly Factory in Project World_Tire (Front)34_2" "Project World default scenario")
(playsRole "Tire (Rear)35" "Input_Wheel Assembly Factory in Project World_Tire (Rear)35_3" "Project World 1st scenario")
(playsRole "Tire (Rear)35" "Input_Wheel Assembly Factory in Project World_Tire (Rear)35_3" "Project World default scenario")
(playsRole "Tubes36" "Input_Wheel Assembly Factory in Project World_Tubes36_4" "Project World 1st scenario")
(playsRole "Tubes36" "Input_Wheel Assembly Factory in Project World_Tubes36_4" "Project World default scenario")
(playsRole "Wheel (Front)37" "Input_Wheel Assembly Factory in Project World_Wheel (Front)37_5" "Project World 1st scenario")
(playsRole "Shifter (Front)19" "Input_Gear Central Factory in Project World_Shifter (Front)19_6" "Project World default scenario")
(playsRole "Shifter (Rear)20" "Input_Gear Central Factory in Project World_Shifter (Rear)20_7" "Project World 1st scenario")
(playsRole "Shifter (Rear)20" "Input_Gear Central Factory in Project World_Shifter (Rear)20_7" "Project World default scenario")

(playsRole "Gear System42" "Output_Gear Central Factory in Project World_Gear System42_8" "Project World 1st scenario")
(playsRole "Gear System42" "Output_Gear Central Factory in Project World_Gear System42_8" "Project World default scenario")
(playsRole "Bottom Bracket5" "Input_Drivetrain Central Factory in Project World_Bottom Bracket5_2" "Project World 1st scenario")
(playsRole "Bottom Bracket5" "Input_Drivetrain Central Factory in Project World_Bottom Bracket5_2" "Project World default scenario")
(playsRole "Cassette6" "Input_Drivetrain Central Factory in Project World_Cassette6_3" "Project World 1st scenario")
(playsRole "Cassette6" "Input_Drivetrain Central Factory in Project World_Cassette6_3" "Project World default scenario")
(playsRole "Chain7" "Input_Drivetrain Central Factory in Project World_Chain7_4" "Project World 1st scenario")
(playsRole "Chain7" "Input_Drivetrain Central Factory in Project World_Chain7_4" "Project World default scenario")
(playsRole "Chainguide8" "Input_Drivetrain Central Factory in Project World_Chainguide8_5" "Project World 1st scenario")
(playsRole "Chainguide8" "Input_Drivetrain Central Factory in Project World_Chainguide8_5" "Project World default scenario")
(playsRole "Crankset9" "Input_Drivetrain Central Factory in Project World_Crankset9_6" "Project World 1st scenario")
(playsRole "Crankset9" "Input_Drivetrain Central Factory in Project World_Crankset9_6" "Project World default scenario")
(playsRole "Pedals10" "Input_Drivetrain Central Factory in Project World_Pedals10_7" "Project World 1st scenario")
(playsRole "Saddle12" "Input_Frame Central Factory in Project World_Saddle12_3" "Project World default scenario")
(playsRole "Seatpost13" "Input_Frame Central Factory in Project World_Seatpost13_4" "Project World 1st scenario")
(playsRole "Seatpost13" "Input_Frame Central Factory in Project World_Seatpost13_4" "Project World default scenario")
(playsRole "Seatpost collar14" "Input_Frame Central Factory in Project World_Seatpost collar14_5" "Project World 1st scenario")
(playsRole "Seatpost collar14" "Input_Frame Central Factory in Project World_Seatpost collar14_5" "Project World default scenario")
(playsRole "Frame Assembly41" "Output_Frame Central Factory in Project World_Frame Assembly41_6" "Project World 1st scenario")
(playsRole "Frame Assembly41" "Output_Frame Central Factory in Project World_Frame Assembly41_6" "Project World default scenario")
(playsRole "Cable15" "Input_Gear Central Factory in Project World_Cable15_2" "Project World 1st scenario")
(playsRole "Cable15" "Input_Gear Central Factory in Project World_Cable15_2" "Project World default scenario")
(playsRole "Derailleur (Front)16" "Input_Gear Central Factory in Project World_Derailleur (Front)16_3" "Project World 1st scenario")
(playsRole "Derailleur (Front)16" "Input_Gear Central Factory in Project World_Derailleur (Front)16_3" "Project World default scenario")

(playsRole "Derailleur (Rear)17" "Input_Gear Central Factory in Project World_Derailleur (Rear)17_4" "Project World 1st scenario")
(playsRole "Derailleur (Rear)17" "Input_Gear Central Factory in Project World_Derailleur (Rear)17_4" "Project World default scenario")
(playsRole "Cable Housing18" "Input_Gear Central Factory in Project World_Cable Housing18_5" "Project World 1st scenario")
(playsRole "Cable Housing18" "Input_Gear Central Factory in Project World_Cable Housing18_5" "Project World default scenario")
(playsRole "Shifter (Front)19" "Input_Gear Central Factory in Project World_Shifter (Front)19_6" "Project World 1st scenario")
(playsRole "Cable15" "Output_Salin Supply in Project World_Cable15_2" "Project World default scenario")
(playsRole "Cable Housing18" "Output_Salin Supply in Project World_Cable Housing18_3" "Project World 1st scenario")
(playsRole "Cable Housing18" "Output_Salin Supply in Project World_Cable Housing18_3" "Project World default scenario")
(playsRole "Brake (Front)1" "Input_Braking Central Factory in Project World_Brake (Front)1_2" "Project World 1st scenario")
(playsRole "Brake (Front)1" "Input_Braking Central Factory in Project World_Brake (Front)1_2" "Project World default scenario")
(playsRole "Brake (Rear)2" "Input_Braking Central Factory in Project World_Brake (Rear)2_3" "Project World 1st scenario")
(playsRole "Brake (Rear)2" "Input_Braking Central Factory in Project World_Brake (Rear)2_3" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Input_Braking Central Factory in Project World_Brake Rotor (Front)3_4" "Project World 1st scenario")
(playsRole "Brake Rotor (Front)3" "Input_Braking Central Factory in Project World_Brake Rotor (Front)3_4" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Input_Braking Central Factory in Project World_Brake Rotor (Rear)4_5" "Project World 1st scenario")
(playsRole "Brake Rotor (Rear)4" "Input_Braking Central Factory in Project World_Brake Rotor (Rear)4_5" "Project World default scenario")
(playsRole "Braking System39" "Output_Braking Central Factory in Project World_Braking System39_6" "Project World 1st scenario")
(playsRole "Braking System39" "Output_Braking Central Factory in Project World_Braking System39_6" "Project World default scenario")
(playsRole "Frame11" "Input_Frame Central Factory in Project World_Frame11_2" "Project World 1st scenario")
(playsRole "Frame11" "Input_Frame Central Factory in Project World_Frame11_2" "Project World default scenario")
(playsRole "Saddle12" "Input_Frame Central Factory in Project World_Saddle12_3" "Project World 1st scenario")
(playsRole "Crank sensor22" "Output_Villaelectronicas Supply in Project World_Crank sensor22_2" "Project World default scenario")
(playsRole "HUD module25" "Output_Bluefinron Supply in Project World_HUD module25_2" "Project World 1st scenario")
(playsRole "HUD module25" "Output_Bluefinron Supply in Project World_HUD module25_2" "Project World default scenario")

(playsRole "Handlebar28" "Output_X-cone Supply in Project World_Handlebar28_2" "Project World 1st scenario")
(playsRole "Handlebar28" "Output_X-cone Supply in Project World_Handlebar28_2" "Project World default scenario")
(playsRole "Grips29" "Output_X-cone Supply in Project World_Grips29_3" "Project World 1st scenario")
(playsRole "Grips29" "Output_X-cone Supply in Project World_Grips29_3" "Project World default scenario")
(playsRole "Headset30" "Output_X-cone Supply in Project World_Headset30_4" "Project World 1st scenario")
(playsRole "Headset30" "Output_X-cone Supply in Project World_Headset30_4" "Project World default scenario")
(playsRole "Stem31" "Output_X-cone Supply in Project World_Stem31_5" "Project World 1st scenario")
(playsRole "Stem31" "Output_X-cone Supply in Project World_Stem31_5" "Project World default scenario")
(playsRole "Chainguide8" "Output_Cangreen Supply in Project World_Chainguide8_2" "Project World 1st scenario")
(playsRole "Chainguide8" "Output_Cangreen Supply in Project World_Chainguide8_2" "Project World default scenario")
(playsRole "Crank sensor22" "Output_Techbam Supply in Project World_Crank sensor22_2" "Project World 1st scenario")
(playsRole "Crank sensor22" "Output_Techbam Supply in Project World_Crank sensor22_2" "Project World default scenario")
(playsRole "Cable15" "Output_Salin Supply in Project World_Cable15_2" "Project World 1st scenario")
(playsRole "Cassette6" "Output_SRAM Supply in Project World_Cassette6_6" "Project World default scenario")
(playsRole "Chain7" "Output_SRAM Supply in Project World_Chain7_7" "Project World 1st scenario")
(playsRole "Chain7" "Output_SRAM Supply in Project World_Chain7_7" "Project World default scenario")
(playsRole "Crankset9" "Output_SRAM Supply in Project World_Crankset9_8" "Project World 1st scenario")
(playsRole "Crankset9" "Output_SRAM Supply in Project World_Crankset9_8" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_SRAM Supply in Project World_Brake (Front)1_9" "Project World 1st scenario")
(playsRole "Brake (Front)1" "Output_SRAM Supply in Project World_Brake (Front)1_9" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_SRAM Supply in Project World_Brake (Rear)2_10" "Project World 1st scenario")
(playsRole "Brake (Rear)2" "Output_SRAM Supply in Project World_Brake (Rear)2_10" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_SRAM Supply in Project World_Brake Rotor (Front)3_11" "Project World 1st scenario")
(playsRole "Brake Rotor (Front)3" "Output_SRAM Supply in Project World_Brake Rotor (Front)3_11" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_12" "Project World 1st scenario")

(playsRole "Brake Rotor (Rear)4" "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_12" "Project World default scenario")
(playsRole "Onboard computer21" "Output_Bamtech Supply in Project World_Onboard computer21_2" "Project World 1st scenario")
(playsRole "Onboard computer21" "Output_Bamtech Supply in Project World_Onboard computer21_2" "Project World default scenario")
(playsRole "Crank sensor22" "Output_Villaelectronicas Supply in Project World_Crank sensor22_2" "Project World 1st scenario")
(playsRole "Shifter (Front)19" "Output_Shimano supply in Project World_Shifter (Front)19_2" "Project World default scenario")
(playsRole "Shifter (Rear)20" "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Project World 1st scenario")
(playsRole "Shifter (Rear)20" "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Project World default scenario")
(playsRole "Derailleur (Rear)17" "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Project World 1st scenario")
(playsRole "Derailleur (Rear)17" "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Project World default scenario")
(playsRole "Derailleur (Front)16" "Output_Shimano supply in Project World_Derailleur (Front)16_5" "Project World 1st scenario")
(playsRole "Derailleur (Front)16" "Output_Shimano supply in Project World_Derailleur (Front)16_5" "Project World default scenario")
(playsRole "Brake (Front)1" "Output_SRAM Supply in Project World_Brake (Front)1_2" "Project World 1st scenario")
(playsRole "Brake (Front)1" "Output_SRAM Supply in Project World_Brake (Front)1_2" "Project World default scenario")
(playsRole "Brake (Rear)2" "Output_SRAM Supply in Project World_Brake (Rear)2_3" "Project World 1st scenario")
(playsRole "Brake (Rear)2" "Output_SRAM Supply in Project World_Brake (Rear)2_3" "Project World default scenario")
(playsRole "Brake Rotor (Front)3" "Output_SRAM Supply in Project World_Brake Rotor (Front)3_4" "Project World 1st scenario")
(playsRole "Brake Rotor (Front)3" "Output_SRAM Supply in Project World_Brake Rotor (Front)3_4" "Project World default scenario")
(playsRole "Brake Rotor (Rear)4" "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_5" "Project World 1st scenario")
(playsRole "Brake Rotor (Rear)4" "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_5" "Project World default scenario")
(playsRole "Cassette6" "Output_SRAM Supply in Project World_Cassette6_6" "Project World 1st scenario")

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;;; Defining Operations
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(4PSPCtx.Operation "Retechi Supply in Project World")
(4PSPCtx.Operation "Doublemedia Supply in Project World")
(4PSPCtx.Operation "Rankjalex Supply in Project World")

(4PSPCtx.Operation "Newware Supply in Project World")
(4PSPCtx.Operation "Planetcan Supply in Project World")
(4PSPCtx.Operation "Subplus Supply in Project World")
(4PSPCtx.Operation "Koncon Supply in Project World")
(4PSPCtx.Operation "Indigotech Supply in Project World")
(4PSPCtx.Operation "Smart iBike Assembly Central Factory in Project World")
(4PSPCtx.Operation "Steering Assembly Factory in Project World")
(4PSPCtx.Operation "Bike Assembly Factory in Project World")
(4PSPCtx.Operation "Laelectrics Sypply in Project World")
(4PSPCtx.Operation "Planetex Supply in Project World")
(4PSPCtx.Operation "Ventoins Supply in Project World")
(4PSPCtx.Operation "Kandomex Supply in Project World")
(4PSPCtx.Operation "Rankware Supply in Project World")
(4PSPCtx.Operation "Unotechno Supply in Project World")
(4PSPCtx.Operation "Cantinice Supply in Project World")
(4PSPCtx.Operation "Itlam Supply in Project World")
(4PSPCtx.Operation "Mathfase Supply in Project World")
(4PSPCtx.Operation "Runhouse Supply in Project World")
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(4PSPCtx.Operation "Zaptrans Supply in Project World")
(4PSPCtx.Operation "Streetcore Supply in Project World")
(4PSPCtx.Operation "Silware Supply in Project World")
(4PSPCtx.Operation "Drivetrain Supply Tokyo in Project World")
(4PSPCtx.Operation "Shimano supply in Project World")
(4PSPCtx.Operation "SRAM Supply in Project World")
(4PSPCtx.Operation "Bamtech Supply in Project World")
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(4PSPCtx.Operation "Bluefinron Supply in Project World")
(4PSPCtx.Operation "X-cone Supply in Project World")
(4PSPCtx.Operation "Cangreen Supply in Project World")
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(4PSPCtx.Operation "Salin Supply in Project World")
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(4PSPCtx.Operation "Frame Central Factory in Project World")
(4PSPCtx.Operation "Gear Central Factory in Project World")
(4PSPCtx.Operation "Drivetrain Central Factory in Project World")
(4PSPCtx.Operation "Suspension Central Factory in Project World")
(4PSPCtx.Operation "Wheel Assembly Factory in Project World")
(4PSPCtx.Operation "Drivetrain Components Supply in Shimano in BBWorld")
(4PSPCtx.Operation "Drivetrain Supply in BBWorld")
(4PSPCtx.Operation "Drivetrain Supply Tokyo in BBWorld")
(4PSPCtx.Operation "Drivetrain Supply Taipei in BBWorld")
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;;; Defining Interest Rates
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(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_ALB)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_DZA)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_ASM)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_AND)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_AGO)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_ATG)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_ARG)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_ARM)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_ABW)
(2DSCtx.LendingInterestRate 2DSCtx.LendingInterestRate_AUS)

;;;==
;;; Defining Perturbations
;;;==

(4PSPCtx.perturbationHasValue PerturbyKWCGNAFPn (2DSCtx.fuzzyValTripleFN 0.105 0.35 0.595))
(4PSPCtx.perturbationHasValue "PerturbirtLnFqVsA" (2DSCtx.fuzzyValTripleFN 0.03 0.1 0.17))
(4PSPCtx.perturbationHasValue "PerturbdGyLzCQejr" (2DSCtx.fuzzyValTripleFN 0.11 0.35 0.6))
(4PSPCtx.perturbationHasLength PerturbyKWCGNAFPn 6)
(4PSPCtx.perturbationHasLength PerturbirtLnFqVsA 6)
(4PSPCtx.perturbationHasLength PerturbdGyLzCQejr 6)
(4PSPCtx.Perturbation "PerturbirtLnFqVsA")
(4PSPCtx.Perturbation "PerturbdGyLzCQejr")
(4PSPCtx.perturbationHasStartPeriod PerturbyKWCGNAFPn 0)
(4PSPCtx.perturbationHasStartPeriod PerturbirtLnFqVsA 0)
(4PSPCtx.perturbationHasStartPeriod PerturbdGyLzCQejr 0)
(4PSPCtx.Perturbation PerturbyKWCGNAFPn)

;;;==
;;; Defining Fuzzy Error Indicators
;;;==

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TUV (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_UGA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_UKR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ARE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GBR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_USA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_URY (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_UZB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_VUT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_VEN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_VNM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_VIR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PSE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_YEM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ZMB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ZWE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SUR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SWZ (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SWE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CHE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SYR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TJK (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TZA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_THA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TLS (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TGO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TON (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TTO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TUN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TUR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TKM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TCA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SLE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SGP (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SXM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SVK (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SVN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SLB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SOM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ZAF (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SSD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ESP (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LKA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KNA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LCA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MAF (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_VCT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SDN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PER (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PHL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_POL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PRT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PRI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_QAT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ROU (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_RUS (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_RWA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_WSM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SMR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_STP (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SAU (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SEN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SRB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SYC (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NAM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NPL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NLD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NCL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NZL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NIC (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NER (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NGA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MNP (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_NOR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_OMN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PAK (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PLW (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PAN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PNG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PRY (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MYS (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MDV (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MLI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MLT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MHL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MRT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MUS (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MEX (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_FSM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MDA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MCO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MNG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MNE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MAR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MOZ (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MMR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_XKX (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KWT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KGZ (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LAO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LVA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LBN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LSO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LBR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LBY (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LIE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LTU (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_LUX (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MAC (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MKD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MDG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_MWI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_IND (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_IDN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_IRN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_IRQ (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_IRL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_IMN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ISR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ITA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_JAM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_JPN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_JOR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KAZ (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KEN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KIR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PRK (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KOR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GEO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_DEU (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GHA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GRC (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GRL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GRD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GUM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GTM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GIN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GNB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GUY (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_HTI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_HND (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_HKG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_HUN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ISL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_DMA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_DOM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ECU (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_EGY (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_SLV (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GNQ (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ERI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_EST (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ETH (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_FRO (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_FJI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_FIN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_FRA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_PYF (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GAB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_GMB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_TCD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CHL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CHN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_COL (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_COM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_COD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_COG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CRI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CIV (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
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(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CZE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_DNK (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_DJI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BMU (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BTN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
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(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BWA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BRA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BRN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BGR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
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(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BDI (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
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(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_KHM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CMR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CAN (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_CYM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
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(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ATG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ARG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ARM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ABW (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_AUS (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_AUT (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_AZE (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BHS (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BHR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BGD (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BRB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_BLR (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
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(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_AFG (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ALB (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_DZA (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_ASM (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))
(2DSCtx.hasIndicatorFuzzyError 2DSCtx.LendingInterestRate_AND (2DSCtx.fuzzyErrorFN (2DSCtx.% 80) (2DSCtx.% 80))

;;;===
;;; Defining Location has External Factors Relationships
;;;===

(2DSCtx.locationHasExternalFactor TUV 2DSCtx.LendingInterestRate_TUV)
(2DSCtx.locationHasExternalFactor UGA 2DSCtx.LendingInterestRate_UGA)
(2DSCtx.locationHasExternalFactor UKR 2DSCtx.LendingInterestRate_UKR)
(2DSCtx.locationHasExternalFactor ARE 2DSCtx.LendingInterestRate_ARE)
(2DSCtx.locationHasExternalFactor GBR 2DSCtx.LendingInterestRate_GBR)

(2DSCtx.locationHasExternalFactor USA 2DSCtx.LendingInterestRate_USA)
(2DSCtx.locationHasExternalFactor URY 2DSCtx.LendingInterestRate_URY)
(2DSCtx.locationHasExternalFactor UZB 2DSCtx.LendingInterestRate_UZB)
(2DSCtx.locationHasExternalFactor VUT 2DSCtx.LendingInterestRate_VUT)
(2DSCtx.locationHasExternalFactor VEN 2DSCtx.LendingInterestRate_VEN)
(2DSCtx.locationHasExternalFactor VNM 2DSCtx.LendingInterestRate_VNM)
(2DSCtx.locationHasExternalFactor VIR 2DSCtx.LendingInterestRate_VIR)
(2DSCtx.locationHasExternalFactor PSE 2DSCtx.LendingInterestRate_PSE)
(2DSCtx.locationHasExternalFactor YEM 2DSCtx.LendingInterestRate_YEM)
(2DSCtx.locationHasExternalFactor ZMB 2DSCtx.LendingInterestRate_ZMB)
(2DSCtx.locationHasExternalFactor ZWE 2DSCtx.LendingInterestRate_ZWE)
(2DSCtx.locationHasExternalFactor SUR 2DSCtx.LendingInterestRate_SUR)
(2DSCtx.locationHasExternalFactor SWZ 2DSCtx.LendingInterestRate_SWZ)
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(2DSCtx.locationHasExternalFactor CHE 2DSCtx.LendingInterestRate_CHE)
(2DSCtx.locationHasExternalFactor SYR 2DSCtx.LendingInterestRate_SYR)
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(2DSCtx.locationHasExternalFactor MAF 2DSCtx.LendingInterestRate_MAF)
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(2DSCtx.locationHasExternalFactor SDN 2DSCtx.LendingInterestRate_SDN)
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(2DSCtx.locationHasExternalFactor PHL 2DSCtx.LendingInterestRate_PHL)
(2DSCtx.locationHasExternalFactor POL 2DSCtx.LendingInterestRate_POL)
(2DSCtx.locationHasExternalFactor PRT 2DSCtx.LendingInterestRate_PRT)
(2DSCtx.locationHasExternalFactor PRI 2DSCtx.LendingInterestRate_PRI)

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(2DSCtx.locationHasExternalFactor ROU 2DSCtx.LendingInterestRate_ROU)
(2DSCtx.locationHasExternalFactor RUS 2DSCtx.LendingInterestRate_RUS)
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(2DSCtx.locationHasExternalFactor SAU 2DSCtx.LendingInterestRate_SAU)
(2DSCtx.locationHasExternalFactor SEN 2DSCtx.LendingInterestRate_SEN)
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(2DSCtx.locationHasExternalFactor SYC 2DSCtx.LendingInterestRate_SYC)
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(2DSCtx.locationHasExternalFactor MEX 2DSCtx.LendingInterestRate_MEX)
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(2DSCtx.locationHasExternalFactor MMR 2DSCtx.LendingInterestRate_MMR)
(2DSCtx.locationHasExternalFactor XKX 2DSCtx.LendingInterestRate_XKX)
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(2DSCtx.locationHasExternalFactor KGZ 2DSCtx.LendingInterestRate_KGZ)
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(2DSCtx.locationHasExternalFactor LVA 2DSCtx.LendingInterestRate_LVA)

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(2DSCtx.locationHasExternalFactor GUY 2DSCtx.LendingInterestRate_GUY)
(2DSCtx.locationHasExternalFactor HTI 2DSCtx.LendingInterestRate_HTI)
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(2DSCtx.locationHasExternalFactor FRA 2DSCtx.LendingInterestRate_FRA)
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(2DSCtx.locationHasExternalFactor GAB 2DSCtx.LendingInterestRate_GAB)
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(2DSCtx.Country BHS)
(2DSCtx.Country BTN)
(2DSCtx.Country BVT)
(2DSCtx.Country BWA)
(2DSCtx.Country BLR)
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(2DSCtx.Country COG)
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(2DSCtx.Country CIV)
(2DSCtx.Country COK)
(2DSCtx.Country ABW)
(2DSCtx.Country ALA)
(2DSCtx.Country AZE)
(2DSCtx.Country BIH)
(2DSCtx.Country BRB)
(2DSCtx.Country BGD)
(2DSCtx.Country BEL)
(2DSCtx.Country BFA)
(2DSCtx.Country BGR)
(2DSCtx.Country BHR)
(2DSCtx.Country BDI)
(2DSCtx.Country BEN)
(2DSCtx.Country BLM)
(2DSCtx.Country BMU)
(2DSCtx.Country BRN)
(2DSCtx.Country BOL)
(2DSCtx.Country AND)
(2DSCtx.Country ARE)

(2DSCtx.Country AFG)
(2DSCtx.Country ATG)
(2DSCtx.Country AIA)
(2DSCtx.Country ALB)
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(2DSCtx.Country AGO)
(2DSCtx.Country ATA)
(2DSCtx.Country ARG)
(2DSCtx.Country ASM)
(2DSCtx.Country AUT)
(2DSCtx.Country AUS)

;;;===
;;; Defining Inputs
;;;===

(Input "Input_Bike Assembly Factory in Project World_Steering Assembly44_7")
(Input "Input_Bike Assembly Factory in Project World_Suspension System45_8")
(Input "Input_Bike Assembly Factory in Project World_Wheel Assembly46_9")
(Input "Input_Smart iBike Assembly Central Factory in Project World_Bike47_2")
(Input "Input_Smart iBike Assembly Central Factory in Project World_Onboard computer21_3")
(Input "Input_Smart iBike Assembly Central Factory in Project World_Crank sensor22_4")
(Input "Input_Smart iBike Assembly Central Factory in Project World_GPS23_5")
(Input "Input_Smart iBike Assembly Central Factory in Project World_Bluetooth reciever24_6")
(Input "Input_Smart iBike Assembly Central Factory in Project World_HUD module25_7")
(Input "Input_Smart iBike Assembly Central Factory in Project World_SMART band26_8")
(Input "Input_Smart iBike Assembly Central Factory in Project World_Camera27_9")
(Input PerturbyKWCGNAFPnSupplierIn)
(Input "PerturbirtLnFqVsASupplierIn")
(Input "PerturbdGyLzCQejrSupplierIn")
(Input "Input_Suspension Central Factory in Project World_Suspension Fork32_2")
(Input "Input_Suspension Central Factory in Project World_Suspension Rear Shock33_3")
(Input "Input_Wheel Assembly Factory in Project World_Tire (Front)34_2")
(Input "Input_Wheel Assembly Factory in Project World_Tire (Rear)35_3")
(Input "Input_Wheel Assembly Factory in Project World_Tubes36_4")
(Input "Input_Wheel Assembly Factory in Project World_Wheel (Front)37_5")
(Input "Input_Wheel Assembly Factory in Project World_Wheel (Rear)38_6")
(Input "Input_Steering Assembly Factory in Project World_Handlebar28_2")
(Input "Input_Steering Assembly Factory in Project World_Grips29_3")
(Input "Input_Steering Assembly Factory in Project World_Headset30_4")
(Input "Input_Steering Assembly Factory in Project World_Stem31_5")
(Input "Input_Bike Assembly Factory in Project World_Braking System39_2")
(Input "Input_Bike Assembly Factory in Project World_Drivetrain40_3")
(Input "Input_Bike Assembly Factory in Project World_Frame Assembly41_4")
(Input "Input_Bike Assembly Factory in Project World_Gear System42_5")
(Input "Input_Bike Assembly Factory in Project World_Smart Components43_6")
(Input "Input_Frame Central Factory in Project World_Frame11_2")
(Input "Input_Frame Central Factory in Project World_Saddle12_3")

(Input "Input_Frame Central Factory in Project World_Seatpost13_4")
(Input "Input_Frame Central Factory in Project World_Seatpost collar14_5")
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(Input "Input_Gear Central Factory in Project World_Derailleur (Rear)17_4")
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(Input "Input_Drivetrain Central Factory in Project World_Cassette6_3")
(Input "Input_Drivetrain Central Factory in Project World_Chain7_4")
(Input "Input_Drivetrain Central Factory in Project World_Chainguide8_5")
(Input "Input_Drivetrain Central Factory in Project World_Crankset9_6")
(Input "Input_Drivetrain Central Factory in Project World_Pedals10_7")
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(Input "Input_Braking Central Factory in Project World_Brake Rotor (Front)3_4")
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(Input "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5")
(Input "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6")
(Input "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4")
(Input "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5")
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(Input "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7")
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(Input "Input_iBike Assembly Line_Onboard computer21_3")

(Input "Input_iBike Assembly Line_Crank sensor22_4")
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(Input "Input_iBike Assembly Line_HUD module25_7")
(Input "Input_iBike Assembly Line_SMART band26_8")
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(Input "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6")
(Input "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7")
(Input "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2")
(Input "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3")
(Input "Input_Wheel Assembly Assembly Line_Tire (Rear)35_3")
(Input "Input_Wheel Assembly Assembly Line_Tubes36_4")
(Input "Input_Wheel Assembly Assembly Line_Wheel (Front)37_5")
(Input "Input_Wheel Assembly Assembly Line_Wheel (Rear)38_6")
(Input "Input_Steering Assembly Assembly Line_Handlebar28_2")
(Input "Input_Steering Assembly Assembly Line_Grips29_3")
(Input "Input_Steering Assembly Assembly Line_Headset30_4")
(Input "Input_Steering Assembly Assembly Line_Stem31_5")
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(Input "Input_Bike Assembly Line_Drivetrain40_3")
(Input "Input_Bike Assembly Line_Frame Assembly41_4")
(Input "Input_Bike Assembly Line_Gear System42_5")
(Input "Input_Bike Assembly Line_Smart Components43_6")
(Input "Input_Bike Assembly Line_Steering Assembly44_7")
(Input "Input_Bike Assembly Line_Suspension System45_8")
(Input "Input_Bike Assembly Line_Wheel Assembly46_9")
(Input "Input_Frame Assembly Assembly Line_Seatpost collar14_5")
(Input "Input_Gear System Assembly Line_Cable15_2")
(Input "Input_Gear System Assembly Line_Derailleur (Front)16_3")
(Input "Input_Gear System Assembly Line_Derailleur (Rear)17_4")
(Input "Input_Gear System Assembly Line_Cable Housing18_5")
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(Input "Input_Braking System Assembly Line_Brake (Rear)2_3")

(Input "Input_Braking System Assembly Line_Brake Rotor (Front)3_4")
(Input "Input_Braking System Assembly Line_Brake Rotor (Rear)4_5")
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(Input "Input_Frame Assembly Assembly Line_Saddle12_3")
(Input "Input_Frame Assembly Assembly Line_Seatpost13_4")

;;;==========
;;; Defining Outputs
;;;==========

(Output "Output_Silware Supply in Project World_Cable Housing18_3")
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(Output "Output_Newware Supply in Project World_Seatpost collar14_2")
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(Output "Output_Subplus Supply in Project World_HUD module25_2")
(Output "Output_Koncon Supply in Project World_Wheel (Front)37_2")
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(Output "Output_Cantinice Supply in Project World_Saddle12_2")
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(Output "Output_Shimano supply in Project World_Derailleur (Rear)17_4")
(Output "Output_Shimano supply in Project World_Derailleur (Front)16_5")
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(Output "Output_SRAM Supply in Project World_Brake (Rear)2_3")
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(Output "Output_Drivetrain Supply in Project World_Brake (Rear)2_14")
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(Output "Output_Drivetrain Supply in BBWorld_Cassette6_3")
(Output "Output_Drivetrain Supply in BBWorld_Chain7_4")
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(Output "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7")
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(Output "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7")
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(Output "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4")
(Output "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5")
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(Output "Output_Drivetrain Components Supply_Cassette6_3")
(Output "Output_Drivetrain Components Supply_Chain7_4")
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(Output "Output_Drivetrain Assembly Line_Drivetrain40_8")
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(Output "Output_Wheel Assembly Assembly Line_Wheel Assembly46_7")
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;;;===
;;; Defining Organisation & Facilities
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(2DSCtx.facilityLocatedAt "Indigotech, MÃ¼nster in Project World" (WGS84.latlong 51.97597813720238 7.569096672814339) "Toppheideweg 56, 48161 MÃ¼nster, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Rankware, Rome in Project World" (WGS84.latlong 41.93393006735843 12.362397301476449) "Via Giulio Cesare Graziani, 00166 Roma RM, Italia" ITA)
(2DSCtx.facilityLocatedAt "Unotechno, Strasbourg in Project World" (WGS84.latlong 48.589190227289926 7.656815636437386) "4 Impasse des Merles, 67203 Oberschaeffolsheim, Francia" FRA)
(2DSCtx.facilityLocatedAt "Cantinice, Nagasaki in Project World" (WGS84.latlong 32.79590485792718 129.78616057662293) "482 Yotsuemachi, Nagasaki-shi, Nagasaki-ken 851-1123, JapÃ³n" JPN)
(2DSCtx.facilityLocatedAt "Runhouse, Copenhagen in Project World" (WGS84.latlong 55.68821117270641 12.524617302697152) "GodthÃ¥bsvej 83, 2000 Frederiksberg, Dinamarca" DNK)
(2DSCtx.facilityLocatedAt "Zaptrans, Zaragoza in Project World" (WGS84.latlong 41.66596247716976 -0.9392994758673012) "Calle / LogroÃ±o / Pamplona / Soria / Huesca / Barcelona, 1, 50011 Zaragoza, Zaragoza, EspaÃ±a" ESP)
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(2DSCtx.facilityLocatedAt "Planetcan, Memphis in Project World" (WGS84.latlong 35.13055176645172 -90.0655430671759) "597 Madewood Dr, Memphis, TN 38103, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Subplus, Tours in Project World" (WGS84.latlong 47.41261691961677 0.601876366417855) "57 Rue de la Grosse Pierre, 37230 Fondettes, Francia" FRA)
(2DSCtx.facilityLocatedAt "Koncon, Rotterdam in Project World" (WGS84.latlong 51.93715401394255 4.449494469445199) "Paadje van duizend TreÃª 33, 3039 ME Rotterdam, PaÃ-ses Bajos" NLD)
(2DSCtx.facilityLocatedAt "BuzzBikes Central Factory in Project World" (WGS84.latlong 52.36698466739427 -1.74073577625677) "19 Darley Green Rd, Knowle, Solihull, West Midlands B93 8PP, Reino Unido" GBR)
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(2DSCtx.facilityLocatedAt "Bamtech, Berlin in Project World" (WGS84.latlong 52.51327551146041 13.11393080977723) "Dallgower Chaussee 7, 14624 Dallgow-DÃberitz, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Villaelectronics, Madrid in Project World" (WGS84.latlong 40.431243565384825 -3.851878058630973) "Av. Prado Largo, 21, 28223 Pozuelo de AlarcÃ³n, Madrid, EspaÃ±a" ESP)
(2DSCtx.facilityLocatedAt "Bluefinron, Stockholm in Project World" (WGS84.latlong 59.32590455893761 17.81556426314637) "StrÃmdalsvÃ¤gen 28, 178 93 Drottningholm, Suecia" SWE)
(2DSCtx.facilityLocatedAt "X-cone, Detroit in Project World" (WGS84.latlong 42.339616056124875 -83.26346100540832) "Coonville Dr, Dearborn Heights, MI 48127, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Cangreen, Paris in Project World" (WGS84.latlong 48.85791680935648 2.249997246544808) "Avenue de l'Hippodrome, 75016 Paris, Francia" FRA)
(2DSCtx.facilityLocatedAt "Techbam, Bordeaux in Project World" (WGS84.latlong 44.86813431780431 -0.6812924263067544) "8 Rue Camille Desmoulins, 33185 Le Haillan, Francia" FRA)

(2DSCtx.facilityLocatedAt "Salin, Lisbon in Project World" (WGS84.latlong 38.7445519563278 -9.256293189246207) "Estr. de Acesso ao CemitÃ©rio, 2745 Queluz, Portugal" PRT)
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(2DSCtx.facilityLocatedAt "Mathfase, Liverpool in Project World" (WGS84.latlong 53.4074653907935 -3.012453925330192) "Scotts Quays, Wallasey, Birkenhead, Merseyside CH41 1FB, Reino Unido" GBR)
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(2DSCtx.facilityLocatedAt "Doublemedia, Manchester in Project World" (WGS84.latlong 53.50048455367702 -2.32186020584777) "251 Lancaster Rd, Salford, Salford M6 8WA, Reino Unido" GBR)
(2DSCtx.facilityLocatedAt "Ventoin, Brussels in Project World" (WGS84.latlong 50.84213233703704 4.268391716759652) "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica" BEL)
(2DSCtx.facilityLocatedAt "Kandomex, Stuttgart in Project World" (WGS84.latlong 48.77427074718945 9.012253868859261) "Unnamed Road, 71229 Leonberg, Alemania" DEU)
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(2DSCtx.facilityLocatedAt "Rankjaylex, Helsinki in BBWorld" (WGS84.latlong 60.20424369971764 24.89848433760926) "Mannerheimintie, 00300 Helsinki, Finlandia" FIN)
(2DSCtx.facilityLocatedAt "Newware, Nashville in BBWorld" (WGS84.latlong 36.2784348447083 -86.97683991165832) "2076 Valley View Rd, Joelton, TN 37080, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Planetcan, Memphis in BBWorld" (WGS84.latlong 35.13055176645172 -90.0655430671759) "597 Madewood Dr, Memphis, TN 38103, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Subplus, Tours in BBWorld" (WGS84.latlong 47.41261691961677 0.601876366417855) "57 Rue de la Grosse Pierre, 37230 Fondettes, Francia" USA)
(2DSCtx.facilityLocatedAt "Koncon, Rotterdam in BBWorld" (WGS84.latlong 51.93715401394255 4.449494469445199) "Paadje van duizend TreÃª 33, 3039 ME Rotterdam, PaÃ-ses Bajos" NLD)
(2DSCtx.facilityLocatedAt "Subplus, Tours in BBWorld" (WGS84.latlong 47.41261691961677 0.601876366417855) "57 Rue de la Grosse Pierre, 37230 Fondettes, Francia" FRA)
(2DSCtx.facilityLocatedAt "Shimano in Project World" (WGS84.latlong 39.9184133626103 116.12241416587494) "9 Ti Bei Lu, Mentougou Qu, Beijing Shi, China, 102308" CHN)

(2DSCtx.facilityLocatedAt "Shimano, Kuala Lumpur in Project World" (WGS84.latlong 3.135854871565123 101.59077941207215) "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia" MYS)
(2DSCtx.facilityLocatedAt "Shimano, Tokyo in Project World" (WGS84.latlong 35.68585700974822 139.52845870284364) "3 Chome-10-3 ?sawa, Mitaka-shi, T?ky?-to 181-0015, JapÃ³n" JPN)
(2DSCtx.facilityLocatedAt "Shimano, Taipei in Project World" (WGS84.latlong 25.01916519120958 121.3414507987909) "Lane 151, Zhongkeng St, Guishan District, Taoyuan City, TaiwÃin 333" TWN)
(2DSCtx.facilityLocatedAt "SRAM, Chicago in Project World" (WGS84.latlong 41.83347761405188 -87.89591492386535) "11101-11121 31st St, Westchester, IL 60154, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Laelectrics, Bristol in BBWorld" (WGS84.latlong 51.46061774418323 -2.6880139228887856) "Sandy Ln, Bristol, North Somerset BS8, Reino Unido" GBR)
(2DSCtx.facilityLocatedAt "Planetex, Reading in BBWorld" (WGS84.latlong 51.446604614815655 -1.09139145584777) "28 A340, Englefield, Reading, West Berkshire RG7, Reino Unido" GBR)
(2DSCtx.facilityLocatedAt "Mathfase, Liverpool in BBWorld" (WGS84.latlong 53.4074653907935 -3.012453925330192) "Scotts Quays, Wallasey, Birkenhead, Merseyside CH41 1FB, Reino Unido" GBR)
(2DSCtx.facilityLocatedAt "Streetcore, London in BBWorld" (WGS84.latlong 51.508401160995774 -0.032240760046988726) "Limehouse Link, London E14, Reino Unido" GBR)
(2DSCtx.facilityLocatedAt "Doublemedia, Manchester in BBWorld" (WGS84.latlong 53.50048455367702 -2.32186020584777) "251 Lancaster Rd, Salford, Salford M6 8WA, Reino Unido" GBR)
(2DSCtx.facilityLocatedAt "Ventoin, Brussels in BBWorld" (WGS84.latlong 50.84213233703704 4.268391716759652) "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica" BEL)
(2DSCtx.facilityLocatedAt "Ventoin, Brussels in BBWorld" (WGS84.latlong 50.84213233703704 4.268391716759652) "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica" BEL)
(2DSCtx.facilityLocatedAt "Kandomex, Stuttgart in BBWorld" (WGS84.latlong 48.77427074718945 9.012253868859261) "Unnamed Road, 71229 Leonberg, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Kandomex, Stuttgart in BBWorld" (WGS84.latlong 48.77427074718945 9.012253868859261) "Unnamed Road, 71229 Leonberg, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Itlam, Dortmund in BBWorld" (WGS84.latlong 51.521327211362724 7.427304375451058) "Huckarder Str. 122, 44147 Dortmund, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Ventoin, Brussels in BBWorld" (WGS84.latlong 50.84213233703704 4.268391716759652) "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica" BEL)
(2DSCtx.facilityLocatedAt "Trionix, Frankfurt in BBWorld" (WGS84.latlong 50.114722904695526 8.620694268029183) "Wiesbadener Str., 60486 Frankfurt am Main, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Indigotech, MÃ¼nster in BBWorld" (WGS84.latlong 51.97597813720238 7.569096672814339) "Toppheideweg 56, 48161 MÃ¼nster, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Rankware, Rome in BBWorld" (WGS84.latlong 41.93393006735843 12.362397301476449) "Via Giulio Cesare Graziani, 00166 Roma RM, Italia" ITA)
(2DSCtx.facilityLocatedAt "Unotechno, Strasbourg in BBWorld" (WGS84.latlong 48.589190227289926 7.656815636437386) "4 Impasse des Merles, 67203 Oberschaeffolsheim, Francia" FRA)
(2DSCtx.facilityLocatedAt "Cantinice, Nagasaki in BBWorld" (WGS84.latlong 32.79590485792718 129.78616057662293) "482 Yotsuemachi, Nagasaki-shi, Nagasaki-ken 851-1123, JapÃ³n" JPN)
(2DSCtx.facilityLocatedAt "Shimano, Taipei in BBWorld" (WGS84.latlong 25.01916519120958 121.3414507987909) "Lane 151, Zhongkeng St, Guishan District, Taoyuan City, TaiwÃin 333" TWN)
(2DSCtx.facilityLocatedAt "SRAM, Chicago in BBWorld" (WGS84.latlong 41.83347761405188 -87.89591492386535) "11101-11121 31st St, Westchester, IL 60154, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Bamtech, Berlin in BBWorld" (WGS84.latlong 52.51327551146041 13.11393080977723) "Dallgower Chaussee 7, 14624 Dallgow-DÃberitz, Alemania" DEU)

(2DSCtx.facilityLocatedAt "Villaelectronics, Madrid in BBWorld" (WGS84.latlong 40.431243565384825 -3.851878058630973) "Av. Prado Largo, 21, 28223 Pozuelo de AlarcÃ³n, Madrid, EspaÃ±a" ESP)
(2DSCtx.facilityLocatedAt "Bluefinron, Stockholm in BBWorld" (WGS84.latlong 59.32590455893761 17.81556426314637) "StrÃmdalsvÃ¤gen 28, 178 93 Drottningholm, Suecia" SWE)
(2DSCtx.facilityLocatedAt "Shimano in BBWorld" (WGS84.latlong 39.9184133626103 116.12241416587494) "9 Ti Bei Lu, Mentougou Qu, Beijing Shi, China, 102308" CHN)
(2DSCtx.facilityLocatedAt "Shimano, Kuala Lumpur in BBWorld" (WGS84.latlong 3.135854871565123 101.59077941207215) "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia" MYS)
(2DSCtx.facilityLocatedAt "Shimano, Tokyo in BBWorld" (WGS84.latlong 35.68585700974822 139.52845870284364) "3 Chome-10-3 Å?sawa, Mitaka-shi, TÅ?kyÅ?-to 181-0015, JapÃ³n" JPN)
(2DSCtx.facilityLocatedAt "Shimano, Taipei in BBWorld" (WGS84.latlong 25.01916519120958 121.3414507987909) "Lane 151, Zhongkeng St, Guishan District, Taoyuan City, TaiwÃin 333" TWN)
(2DSCtx.facilityLocatedAt "SRAM, Chicago in BBWorld" (WGS84.latlong 41.83347761405188 -87.89591492386535) "11101-11121 31st St, Westchester, IL 60154, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Bamtech, Berlin in BBWorld" (WGS84.latlong 52.51327551146041 13.11393080977723) "Dallgower Chaussee 7, 14624 Dallgow-DÃberitz, Alemania" DEU)
(2DSCtx.facilityLocatedAt "Villaelectronics, Madrid in BBWorld" (WGS84.latlong 40.431243565384825 -3.851878058630973) "Av. Prado Largo, 21, 28223 Pozuelo de AlarcÃ³n, Madrid, EspaÃ±a" ESP)
(2DSCtx.facilityLocatedAt "X-cone, Detroit in BBWorld" (WGS84.latlong 42.339616056124875 -83.26346100540832) "Coonville Dr, Dearborn Heights, MI 48127, EE. UU." USA)
(2DSCtx.facilityLocatedAt "Cangreen, Paris in BBWorld" (WGS84.latlong 48.85791680935648 2.249997246544808) "Avenue de l'Hippodrome, 75016 Paris, Francia" FRA)
(2DSCtx.facilityLocatedAt "Techbam, Bordeaux in BBWorld" (WGS84.latlong 44.86813431780431 -0.6812924263067544) "8 Rue Camille Desmoulins, 33185 Le Haillan, Francia" FRA)
(2DSCtx.facilityLocatedAt "Salin, Lisbon in BBWorld" (WGS84.latlong 38.7445519563278 -9.256293189246207) "Estr. de Acesso ao CemitÃ©rio, 2745 Queluz, Portugal" PRT)
(2DSCtx.facilityLocatedAt "Shimano in BBWorld" (WGS84.latlong 39.9184133626103 116.12241416587494) "9 Ti Bei Lu, Mentougou Qu, Beijing Shi, China, 102308" CHN)
(2DSCtx.facilityLocatedAt "Shimano, Kuala Lumpur in BBWorld" (WGS84.latlong 3.135854871565123 101.59077941207215) "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia" CHN)
(2DSCtx.facilityLocatedAt "Shimano, Tokyo in BBWorld" (WGS84.latlong 35.68585700974822 139.52845870284364) "3 Chome-10-3 Å?sawa, Mitaka-shi, TÅ?kyÅ?-to 181-0015, JapÃ³n" JPN)
(2DSCtx.facilityLocatedAt "Shimano, Kuala Lumpur in BBWorld" (WGS84.latlong 3.135854871565123 101.59077941207215) "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia" MYS)
(2DSCtx.facilityLocatedAt "Shimano, Kuala Lumpur in BBWorld" (WGS84.latlong 3.135854871565123 101.59077941207215) "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia" MYS)

;;;==
;;; Defining Interdependencies
;;;==

(4PSPCtx.NodeInterDependency
"DeptRetechi,ValenciainProjectWorldOnVentoin,BrusselsinProjectWorld")
(4PSPCtx.NodeInterDependency
"DeptUnotechno,StrasbourginProjectWorldOnRetechi,ValenciainProjectWorld")
(4PSPCtx.nodeInterDependencyOnNode "Retechi, Valencia in Project World"
"DeptRetechi,ValenciainProjectWorldOnVentoin,BrusselsinProjectWorld" "Ventoin, Brussels in Project World")

(4PSPCtx.nodeInterDependencyOnNode "Unotechno, Strasbourg in Project World" "DeptUnotechno,StrasbourginProjectWorldOnRetechi,ValenciainProjectWorld" "Retechi, Valencia in Project World")
(4PSPCtx.nodeInterDependencyHasValue "DeptRetechi,ValenciainProjectWorldOnVentoin,BrusselsinProjectWorld" (2DSCtx.fuzzyValTripleFN 0.21 0.7 1))
(4PSPCtx.nodeInterDependencyHasValue "DeptUnotechno,StrasbourginProjectWorldOnRetechi,ValenciainProjectWorld" (2DSCtx.fuzzyValTripleFN 0.03 0.1 0.17))

;;;===
;;; Defining Areas
;;;===

(2DSCtx.Area/City "8 Rue Camille Desmoulins, 33185 Le Haillan, Francia")
(2DSCtx.Area/City "Estr. de Acesso ao CemitÃ©rio, 2745 Queluz, Portugal")
(2DSCtx.Area/City "Sandy Ln, Bristol, North Somerset BS8, Reino Unido")
(2DSCtx.Area/City "28 A340, Englefield, Reading, West Berkshire RG7, Reino Unido")
(2DSCtx.Area/City "Scotts Quays, Wallasey, Birkenhead, Merseyside CH41 1FB, Reino Unido")
(2DSCtx.Area/City "Limehouse Link, London E14, Reino Unido")
(2DSCtx.Area/City "251 Lancaster Rd, Salford, Salford M6 8WA, Reino Unido")
(2DSCtx.Area/City "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica")
(2DSCtx.Area/City "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia")
(2DSCtx.Area/City "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia")
(2DSCtx.Area/City "Lane 151, Zhongkeng St, Guishan District, Taoyuan City, TaiwÃin 333")
(2DSCtx.Area/City "11101-11121 31st St, Westchester, IL 60154, EE. UU.")
(2DSCtx.Area/City "Dallgower Chaussee 7, 14624 Dallgow-DÃ¶beritz, Alemania")
(2DSCtx.Area/City "Av. Prado Largo, 21, 28223 Pozuelo de AlarcÃ³n, Madrid, EspaÃ±a")
(2DSCtx.Area/City "StrÃ¶mdalsvÃ¤gen 28, 178 93 Drottningholm, Suecia")
(2DSCtx.Area/City "9 Ti Bei Lu, Mentougou Qu, Beijing Shi, China, 102308")
(2DSCtx.Area/City "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia")
(2DSCtx.Area/City "3 Chome-10-3 Å?sawa, Mitaka-shi, TÅ?kyÅ?-to 181-0015, JapÃ³n")
(2DSCtx.Area/City "Lane 151, Zhongkeng St, Guishan District, Taoyuan City, TaiwÃin 333")
(2DSCtx.Area/City "11101-11121 31st St, Westchester, IL 60154, EE. UU.")
(2DSCtx.Area/City "Dallgower Chaussee 7, 14624 Dallgow-DÃ¶beritz, Alemania")
(2DSCtx.Area/City "Av. Prado Largo, 21, 28223 Pozuelo de AlarcÃ³n, Madrid, EspaÃ±a")
(2DSCtx.Area/City "Coonville Dr, Dearborn Heights, MI 48127, EE. UU.")
(2DSCtx.Area/City "Avenue de l'Hippodrome, 75016 Paris, Francia")
(2DSCtx.Area/City "9 Ti Bei Lu, Mentougou Qu, Beijing Shi, China, 102308")
(2DSCtx.Area/City "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia")
(2DSCtx.Area/City "3 Chome-10-3 Å?sawa, Mitaka-shi, TÅ?kyÅ?-to 181-0015, JapÃ³n")
(2DSCtx.Area/City "25 Avenue Gilbert Bauduz, 44300 Nantes, Francia")
(2DSCtx.Area/City "Autovia V-30, 46920 Mislata, Valencia, EspaÃ±a")
(2DSCtx.Area/City "Mannerheimintie, 00300 Helsinki, Finlandia")
(2DSCtx.Area/City "2076 Valley View Rd, Joelton, TN 37080, EE. UU.")
(2DSCtx.Area/City "597 Madewood Dr, Memphis, TN 38103, EE. UU.")
(2DSCtx.Area/City "57 Rue de la Grosse Pierre, 37230 Fondettes, Francia")
(2DSCtx.Area/City "Paadje van duizend TreÃª 33, 3039 ME Rotterdam, PaÃ-ses Bajos")

(2DSCtx.Area/City "19 Darley Green Rd, Knowle, Solihull, West Midlands B93 8PP, Reino Unido")
(2DSCtx.Area/City "Unnamed Road, 60044 Fabriano AN, Italia")
(2DSCtx.Area/City "Brussels")
(2DSCtx.Area/City "Andorra la Vella")
(2DSCtx.Area/City "Namur")
(2DSCtx.Area/City "Unnamed Road, Luanda, Angola")
(2DSCtx.Area/City "D 67227 Frankenthal")
(2DSCtx.Supplier "2DSCtx.Supplier BBWorld")
(2DSCtx.Supplier "2DSCtx.Supplier BBWorld")
(2DSCtx.Area/City "Estr. de Acesso ao CemitÃ©rio, 2745 Queluz, Portugal")
(2DSCtx.Area/City "Sandy Ln, Bristol, North Somerset BS8, Reino Unido")
(2DSCtx.Area/City "28 A340, Englefield, Reading, West Berkshire RG7, Reino Unido")
(2DSCtx.Area/City "Scotts Quays, Wallasey, Birkenhead, Merseyside CH41 1FB, Reino Unido")
(2DSCtx.Area/City "Limehouse Link, London E14, Reino Unido")
(2DSCtx.Area/City "251 Lancaster Rd, Salford, Salford M6 8WA, Reino Unido")
(2DSCtx.Area/City "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica")
(2DSCtx.Area/City "Unnamed Road, 71229 Leonberg, Alemania")
(2DSCtx.Area/City "Huckarder Str. 122, 44147 Dortmund, Alemania")
(2DSCtx.Area/City "Wiesbadener Str., 60486 Frankfurt am Main, Alemania")
(2DSCtx.Area/City "Toppheideweg 56, 48161 MÃ¼nster, Alemania")
(2DSCtx.Area/City "Via Giulio Cesare Graziani, 00166 Roma RM, Italia")
(2DSCtx.Area/City "4 Impasse des Merles, 67203 Oberschaeffolsheim, Francia")
(2DSCtx.Area/City "482 Yotsuemachi, Nagasaki-shi, Nagasaki-ken 851-1123, JapÃ³n")
(2DSCtx.Area/City "GodthÃ¥bsvej 83, 2000 Frederiksberg, Dinamarca")
(2DSCtx.Area/City "Calle / LogroÃ±o / Pamplona / Soria / Huesca / Barcelona, 1, 50011 Zaragoza, Zaragoza, EspaÃ±a")
(2DSCtx.Area/City "2076 Valley View Rd, Joelton, TN 37080, EE. UU.")
(2DSCtx.Area/City "597 Madewood Dr, Memphis, TN 38103, EE. UU.")
(2DSCtx.Area/City "57 Rue de la Grosse Pierre, 37230 Fondettes, Francia")
(2DSCtx.Area/City "Paadje van duizend TreÃª 33, 3039 ME Rotterdam, PaÃ-ses Bajos")
(2DSCtx.Area/City "57 Rue de la Grosse Pierre, 37230 Fondettes, Francia")
(2DSCtx.Area/City "9 Ti Bei Lu, Mentougou Qu, Beijing Shi, China, 102308")
(2DSCtx.Area/City "1-4, Jalan TR 2/5, Tropicana, 47410 Petaling Jaya, Selangor, Malasia")
(2DSCtx.Area/City "3 Chome-10-3 ?sawa, Mitaka-shi, T?ky?-to 181-0015, JapÃ³n")
(2DSCtx.Area/City "Lane 151, Zhongkeng St, Guishan District, Taoyuan City, TaiwÃin 333")
(2DSCtx.Area/City "11101-11121 31st St, Westchester, IL 60154, EE. UU.")
(2DSCtx.Area/City "Dallgower Chaussee 7, 14624 Dallgow-DÃ¶beritz, Alemania")
(2DSCtx.Area/City "Av. Prado Largo, 21, 28223 Pozuelo de AlarcÃ³n, Madrid, EspaÃ±a")
(2DSCtx.Area/City "StrÃ¶mdalsvÃ¤gen 28, 178 93 Drottningholm, Suecia")
(2DSCtx.Area/City "Coonville Dr, Dearborn Heights, MI 48127, EE. UU.")
(2DSCtx.Area/City "Avenue de l'Hippodrome, 75016 Paris, Francia")
(2DSCtx.Area/City "8 Rue Camille Desmoulins, 33185 Le Haillan, Francia")
(2DSCtx.Area/City "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica")
(2DSCtx.Area/City "Unnamed Road, 71229 Leonberg, Alemania")
(2DSCtx.Area/City "Unnamed Road, 71229 Leonberg, Alemania")
(2DSCtx.Area/City "Huckarder Str. 122, 44147 Dortmund, Alemania")
(2DSCtx.Area/City "Kapelstraat 1-11, 1700 Dilbeek, BÃ©lgica")
(2DSCtx.Area/City "Wiesbadener Str., 60486 Frankfurt am Main, Alemania")

(2DSCtx.Area/City "Toppheideweg 56, 48161 MÃ¼nster, Alemania")
(2DSCtx.Area/City "Via Giulio Cesare Graziani, 00166 Roma RM, Italia")
(2DSCtx.Area/City "4 Impasse des Merles, 67203 Oberschaeffolsheim, Francia")
(2DSCtx.Area/City "482 Yotsuemachi, Nagasaki-shi, Nagasaki-ken 851-1123, JapÃ³n")
(2DSCtx.Area/City "GodthÃ¥bsvej 83, 2000 Frederiksberg, Dinamarca")
(2DSCtx.Area/City "Calle / LogroÃ±o / Pamplona / Soria / Huesca / Barcelona, 1, 50011 Zaragoza, Zaragoza, EspaÃ±a")
(2DSCtx.Area/City "Calle / LogroÃ±o / Pamplona / Soria / Huesca / Barcelona, 1, 50011 Zaragoza, Zaragoza, EspaÃ±a")
(2DSCtx.Area/City "25 Avenue Gilbert Bauduz, 44300 Nantes, Francia")
(2DSCtx.Area/City "Autovia V-30, 46920 Mislata, Valencia, EspaÃ±a")
(2DSCtx.Area/City "Mannerheimintie, 00300 Helsinki, Finlandia")

;;;==
;;; Defining Contexts for Roles
;;;==

(requiresA "PerturbirtLnFqVsASupplierIn" "BuzzBikes Central Factory in Project World")
(requiresA "PerturbdGyLzCQejrSupplierIn" "X-cone, Detroit in BBWorld")
(requiresA "4PSPCtx.Producer KSB worldwide" "KSB worldwide")
(requiresA "4PSPCtx.ManufacturedProduct KSB worldwide" "KSB worldwide")
(requiresA "4PSPCtx.Customer KSB worldwide" "KSB worldwide")
(requiresA "2DSCtx.Supplier KSB worldwide" "KSB worldwide")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_SMART band26_8" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Camera27_9" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Camera27_9" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Output_Smart iBike Assembly Central Factory in Project World_iBike48_10" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Smart iBike Assembly Central Factory in Project World_iBike48_10" "Smart iBike Assembly Central Factory in Project World ")
(requiresA PerturbyKWCGNAFPnSupplierIn "X-cone, Detroit in Project World")
(requiresA "Output_Indigotech Supply in Project World_Grips29_2" "Indigotech Supply in Project World ")
(requiresA "Output_Indigotech Supply in Project World_Pedals10_3" "Indigotech, MÃ¼nster in Project World ")
(requiresA "Output_Indigotech Supply in Project World_Pedals10_3" "Indigotech Supply in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Bike47_2" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Bike47_2" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Onboard computer21_3" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Onboard computer21_3" "Smart iBike Assembly Central Factory in Project World ")

(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Crank sensor22_4" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Crank sensor22_4" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_GPS23_5" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_GPS23_5" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Bluetooth reciever24_6" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_Bluetooth reciever24_6" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_HUD module25_7" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_HUD module25_7" "Smart iBike Assembly Central Factory in Project World ")
(requiresA "Input_Smart iBike Assembly Central Factory in Project World_SMART band26_8" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Rankjalex Supply in Project World_Tubes36_2" "Rankjalex Supply in Project World ")
(requiresA "Output_Newware Supply in Project World_Seatpost collar14_2" "Newware, Nashville in Project World ")
(requiresA "Output_Newware Supply in Project World_Seatpost collar14_2" "Newware Supply in Project World ")
(requiresA "Output_Newware Supply in Project World_Stem31_3" "Newware, Nashville in Project World ")
(requiresA "Output_Newware Supply in Project World_Stem31_3" "Newware Supply in Project World ")
(requiresA "Output_Newware Supply in Project World_Handlebar28_4" "Newware, Nashville in Project World ")
(requiresA "Output_Newware Supply in Project World_Handlebar28_4" "Newware Supply in Project World ")
(requiresA "Output_Planetcan Supply in Project World_GPS23_2" "Planetcan, Memphis in Project World ")
(requiresA "Output_Planetcan Supply in Project World_GPS23_2" "Planetcan Supply in Project World ")
(requiresA "Output_Subplus Supply in Project World_HUD module25_2" "Subplus, Tours in Project World ")
(requiresA "Output_Subplus Supply in Project World_HUD module25_2" "Subplus Supply in Project World ")
(requiresA "Output_Koncon Supply in Project World_Wheel (Front)37_2" "Koncon, Rotterdam in Project World ")
(requiresA "Output_Koncon Supply in Project World_Wheel (Front)37_2" "Koncon Supply in Project World ")
(requiresA "Output_Koncon Supply in Project World_Wheel (Rear)38_3" "Koncon, Rotterdam in Project World ")
(requiresA "Output_Koncon Supply in Project World_Wheel (Rear)38_3" "Koncon Supply in Project World ")

(requiresA "Output_Indigotech Supply in Project World_Grips29_2" "Indigotech, MÃ¼nster in Project World ")
(requiresA "Output_Silware Supply in Project World_Cable15_2" "Silware Supply in Project World ")
(requiresA "Output_Streetcore Supply in Project World_Grips29_2" "Streetcore, London in Project World ")
(requiresA "Output_Streetcore Supply in Project World_Grips29_2" "Streetcore Supply in Project World ")
(requiresA "Output_Silware Supply in Project World_Cable15_2" "Silware, Nantes in Project World ")
(requiresA "Output_Silware Supply in Project World_Cable15_2" "Silware Supply in Project World ")
(requiresA "Output_Silware Supply in Project World_Cable Housing18_3" "Silware, Nantes in Project World ")
(requiresA "Output_Silware Supply in Project World_Cable Housing18_3" "Silware Supply in Project World ")
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(requiresA "Output_Retechi Supply in Project World_Frame11_2" "Retechi Supply in Project World ")
(requiresA "Output_Retechi Supply in Project World_Seatpost13_3" "Retechi, Valencia in Project World ")
(requiresA "Output_Retechi Supply in Project World_Seatpost13_3" "Retechi Supply in Project World ")
(requiresA "Output_Retechi Supply in Project World_Handlebar28_4" "Retechi, Valencia in Project World ")
(requiresA "Output_Retechi Supply in Project World_Handlebar28_4" "Retechi Supply in Project World ")
(requiresA "Output_Doublemedia Supply in Project World_Bluetooth reciever24_2" "Doublemedia, Manchester in Project World ")
(requiresA "Output_Doublemedia Supply in Project World_Bluetooth reciever24_2" "Doublemedia Supply in Project World ")
(requiresA "Output_Rankjalex Supply in Project World_Tubes36_2" "Rankjaylex, Helsinki in Project World ")
(requiresA "Output_Mathfase Supply in Project World_SMART band26_3" "Mathfase Supply in Project World ")
(requiresA "Output_Runhouse Supply in Project World_Tire (Front)34_2" "Runhouse, Copenhagen in Project World ")
(requiresA "Output_Runhouse Supply in Project World_Tire (Front)34_2" "Runhouse Supply in Project World ")
(requiresA "Output_Runhouse Supply in Project World_Tire (Rear)35_3" "Runhouse, Copenhagen in Project World ")
(requiresA "Output_Runhouse Supply in Project World_Tire (Rear)35_3" "Runhouse Supply in Project World ")
(requiresA "Output_Trionix Supply in Project World_HUD module25_2" "Trionix, Frankfurt in Project World ")
(requiresA "Output_Trionix Supply in Project World_HUD module25_2" "Trionix Supply in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Bottom Bracket5_2" "Zaptrans, Zaragoza in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Bottom Bracket5_2" "Zaptrans Supply in Project World ")

(requiresA "Output_Zaptrans Supply in Project World_Cassette6_3" "Zaptrans, Zaragoza in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Cassette6_3" "Zaptrans Supply in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Chain7_4" "Zaptrans, Zaragoza in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Chain7_4" "Zaptrans Supply in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Crankset9_5" "Zaptrans, Zaragoza in Project World ")
(requiresA "Output_Zaptrans Supply in Project World_Crankset9_5" "Zaptrans Supply in Project World ")
(requiresA "Output_Silware Supply in Project World_Cable15_2" "Silware, Nantes in Project World ")
(requiresA "Output_Rankware Supply in Project World_Stem31_4" "Rankware Supply in Project World ")
(requiresA "Output_Rankware Supply in Project World_Suspension Fork32_5" "Rankware, Rome in Project World ")
(requiresA "Output_Rankware Supply in Project World_Suspension Fork32_5" "Rankware Supply in Project World ")
(requiresA "Output_Rankware Supply in Project World_Suspension Rear Shock33_6" "Rankware, Rome in Project World ")
(requiresA "Output_Rankware Supply in Project World_Suspension Rear Shock33_6" "Rankware Supply in Project World ")
(requiresA "Output_Rankware Supply in Project World_Seatpost13_7" "Rankware, Rome in Project World ")
(requiresA "Output_Rankware Supply in Project World_Seatpost13_7" "Rankware Supply in Project World ")
(requiresA "Output_Unotechno Supply in Project World_Frame11_2" "Unotechno, Strasbourg in Project World ")
(requiresA "Output_Unotechno Supply in Project World_Frame11_2" "Unotechno Supply in Project World ")
(requiresA "Output_Cantinice Supply in Project World_Saddle12_2" "Cantinice, Nagasaki in Project World ")
(requiresA "Output_Cantinice Supply in Project World_Saddle12_2" "Cantinice Supply in Project World ")
(requiresA "Output_Itlam Supply in Project World_Frame11_2" "Itlam, Dortmund in Project World ")
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(requiresA "Output_Mathfase Supply in Project World_Onboard computer21_2" "Mathfase, Liverpool in Project World ")
(requiresA "Output_Mathfase Supply in Project World_Onboard computer21_2" "Mathfase Supply in Project World ")
(requiresA "Output_Mathfase Supply in Project World_SMART band26_3" "Mathfase, Liverpool in Project World ")
(requiresA "Output_Ventoins Supply in Project World_Pedals10_2" "Ventoins Supply in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Seatpost collar14_2" "Kandomex, Stuttgart in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Seatpost collar14_2" "Kandomex Supply in Project World ")

(requiresA "Output_Kandomex Supply in Project World_Seatpost13_3" "Kandomex, Stuttgart in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Seatpost13_3" "Kandomex Supply in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Handlebar28_4" "Kandomex, Stuttgart in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Handlebar28_4" "Kandomex Supply in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Suspension Fork32_5" "Kandomex, Stuttgart in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Suspension Fork32_5" "Kandomex Supply in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Suspension Rear Shock33_6" "Kandomex, Stuttgart in Project World ")
(requiresA "Output_Kandomex Supply in Project World_Suspension Rear Shock33_6" "Kandomex Supply in Project World ")
(requiresA "Output_Rankware Supply in Project World_Crankset9_2" "Rankware, Rome in Project World ")
(requiresA "Output_Rankware Supply in Project World_Crankset9_2" "Rankware Supply in Project World ")
(requiresA "Output_Rankware Supply in Project World_Handlebar28_3" "Rankware, Rome in Project World ")
(requiresA "Output_Rankware Supply in Project World_Handlebar28_3" "Rankware Supply in Project World ")
(requiresA "Output_Rankware Supply in Project World_Stem31_4" "Rankware, Rome in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Steering Assembly44_7" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Suspension System45_8" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Suspension System45_8" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Wheel Assembly46_9" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Wheel Assembly46_9" "Bike Assembly Factory in Project World ")
(requiresA "Output_Bike Assembly Factory in Project World_Bike47_10" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Output_Bike Assembly Factory in Project World_Bike47_10" "Bike Assembly Factory in Project World ")
(requiresA "Output_Laelectrics Sypply in Project World_HUD module25_2" "Laelectrics, Bristol in Project World ")
(requiresA "Output_Laelectrics Sypply in Project World_HUD module25_2" "Laelectrics Sypply in Project World ")
(requiresA "Output_Laelectrics Sypply in Project World_Bluetooth reciever24_3" "Laelectrics, Bristol in Project World ")
(requiresA "Output_Laelectrics Sypply in Project World_Bluetooth reciever24_3" "Laelectrics Sypply in Project World ")

(requiresA "Output_Planetex Supply in Project World_Wheel (Front)37_2" "Planetex, Reading in Project World ")
(requiresA "Output_Planetex Supply in Project World_Wheel (Front)37_2" "Planetex Supply in Project World ")
(requiresA "Output_Planetex Supply in Project World_Wheel (Rear)38_3" "Planetex, Reading in Project World ")
(requiresA "Output_Planetex Supply in Project World_Wheel (Rear)38_3" "Planetex Supply in Project World ")
(requiresA "Output_Ventoins Supply in Project World_Pedals10_2" "Ventoin, Brussels in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Headset30_4" "Steering Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Stem31_5" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Stem31_5" "Steering Assembly Factory in Project World ")
(requiresA "Output_Steering Assembly Factory in Project World_Steering Assembly44_6" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Output_Steering Assembly Factory in Project World_Steering Assembly44_6" "Steering Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Braking System39_2" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Braking System39_2" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Drivetrain40_3" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Drivetrain40_3" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Frame Assembly41_4" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Frame Assembly41_4" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Gear System42_5" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Gear System42_5" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Smart Components43_6" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Smart Components43_6" "Bike Assembly Factory in Project World ")
(requiresA "Input_Bike Assembly Factory in Project World_Steering Assembly44_7" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Tire (Front)34_2" "Wheel Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Tire (Rear)35_3" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Tire (Rear)35_3" "Wheel Assembly Factory in Project World ")

(requiresA "Input_Wheel Assembly Factory in Project World_Tubes36_4" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Tubes36_4" "Wheel Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Wheel (Front)37_5" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Wheel (Front)37_5" "Wheel Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Wheel (Rear)38_6" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Wheel (Rear)38_6" "Wheel Assembly Factory in Project World ")
(requiresA "Output_Wheel Assembly Factory in Project World_Wheel Assembly46_7" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Output_Wheel Assembly Factory in Project World_Wheel Assembly46_7" "Wheel Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Handlebar28_2" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Handlebar28_2" "Steering Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Grips29_3" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Grips29_3" "Steering Assembly Factory in Project World ")
(requiresA "Input_Steering Assembly Factory in Project World_Headset30_4" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Chain7_4" "Drivetrain Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Chainguide8_5" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Chainguide8_5" "Drivetrain Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Crankset9_6" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Crankset9_6" "Drivetrain Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Pedals10_7" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Pedals10_7" "Drivetrain Central Factory in Project World ")
(requiresA "Output_Drivetrain Central Factory in Project World_Drivetrain40_8" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Drivetrain Central Factory in Project World_Drivetrain40_8" "Drivetrain Central Factory in Project World ")
(requiresA "Input_Suspension Central Factory in Project World_Suspension Fork32_2" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Suspension Central Factory in Project World_Suspension Fork32_2" "Suspension Central Factory in Project World ")

(requiresA "Input_Suspension Central Factory in Project World_Suspension Rear Shock33_3" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Suspension Central Factory in Project World_Suspension Rear Shock33_3" "Suspension Central Factory in Project World ")
(requiresA "Output_Suspension Central Factory in Project World_Suspension System45_4" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Suspension Central Factory in Project World_Suspension System45_4" "Suspension Central Factory in Project World ")
(requiresA "Input_Wheel Assembly Factory in Project World_Tire (Front)34_2" "BuzzBikes Assembly Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Derailleur (Front)16_3" "Gear Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Derailleur (Rear)17_4" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Derailleur (Rear)17_4" "Gear Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Cable Housing18_5" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Cable Housing18_5" "Gear Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Shifter (Front)19_6" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Shifter (Front)19_6" "Gear Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Shifter (Rear)20_7" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Shifter (Rear)20_7" "Gear Central Factory in Project World ")
(requiresA "Output_Gear Central Factory in Project World_Gear System42_8" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Gear Central Factory in Project World_Gear System42_8" "Gear Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Bottom Bracket5_2" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Bottom Bracket5_2" "Drivetrain Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Cassette6_3" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Cassette6_3" "Drivetrain Central Factory in Project World ")
(requiresA "Input_Drivetrain Central Factory in Project World_Chain7_4" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake Rotor (Rear)4_5" "Braking Central Factory in Project World ")
(requiresA "Output_Braking Central Factory in Project World_Braking System39_6" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Braking Central Factory in Project World_Braking System39_6" "Braking Central Factory in Project World ")

(requiresA "Input_Frame Central Factory in Project World_Frame11_2" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Frame11_2" "Frame Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Saddle12_3" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Saddle12_3" "Frame Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Seatpost13_4" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Seatpost13_4" "Frame Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Seatpost collar14_5" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Frame Central Factory in Project World_Seatpost collar14_5" "Frame Central Factory in Project World ")
(requiresA "Output_Frame Central Factory in Project World_Frame Assembly41_6" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_Frame Central Factory in Project World_Frame Assembly41_6" "Frame Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Cable15_2" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Cable15_2" "Gear Central Factory in Project World ")
(requiresA "Input_Gear Central Factory in Project World_Derailleur (Front)16_3" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_X-cone Supply in Project World_Stem31_5" "X-cone Supply in Project World ")
(requiresA "Output_Cangreen Supply in Project World_Chainguide8_2" "Cangreen, Paris in Project World ")
(requiresA "Output_Cangreen Supply in Project World_Chainguide8_2" "Cangreen Supply in Project World ")
(requiresA "Output_Techbam Supply in Project World_Crank sensor22_2" "Techbam, Bordeaux in Project World ")
(requiresA "Output_Techbam Supply in Project World_Crank sensor22_2" "Techbam Supply in Project World ")
(requiresA "Output_Salin Supply in Project World_Cable15_2" "Salin, Lisbon in Project World ")
(requiresA "Output_Salin Supply in Project World_Cable15_2" "Salin Supply in Project World ")
(requiresA "Output_Salin Supply in Project World_Cable Housing18_3" "Salin, Lisbon in Project World ")
(requiresA "Output_Salin Supply in Project World_Cable Housing18_3" "Salin Supply in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake (Front)1_2" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake (Front)1_2" "Braking Central Factory in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake (Rear)2_3" "BuzzBikes Central Factory in Project World ")

(requiresA "Input_Braking Central Factory in Project World_Brake (Rear)2_3" "Braking Central Factory in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake Rotor (Front)3_4" "BuzzBikes Central Factory in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake Rotor (Front)3_4" "Braking Central Factory in Project World ")
(requiresA "Input_Braking Central Factory in Project World_Brake Rotor (Rear)4_5" "BuzzBikes Central Factory in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Front)3_11" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_12" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_12" "SRAM Supply in Project World ")
(requiresA "Output_Bamtech Supply in Project World_Onboard computer21_2" "Bamtech, Berlin in Project World ")
(requiresA "Output_Bamtech Supply in Project World_Onboard computer21_2" "Bamtech Supply in Project World ")
(requiresA "Output_Villaelectronicas Supply in Project World_Crank sensor22_2" "Villaelectronics, Madrid in Project World ")
(requiresA "Output_Villaelectronicas Supply in Project World_Crank sensor22_2" "Villaelectronicas Supply in Project World ")
(requiresA "Output_Bluefinron Supply in Project World_HUD module25_2" "Bluefinron, Stockholm in Project World ")
(requiresA "Output_Bluefinron Supply in Project World_HUD module25_2" "Bluefinron Supply in Project World ")
(requiresA "Output_X-cone Supply in Project World_Handlebar28_2" "X-cone, Detroit in Project World ")
(requiresA "Output_X-cone Supply in Project World_Handlebar28_2" "X-cone Supply in Project World ")
(requiresA "Output_X-cone Supply in Project World_Grips29_3" "X-cone, Detroit in Project World ")
(requiresA "Output_X-cone Supply in Project World_Grips29_3" "X-cone Supply in Project World ")
(requiresA "Output_X-cone Supply in Project World_Headset30_4" "X-cone, Detroit in Project World ")
(requiresA "Output_X-cone Supply in Project World_Headset30_4" "X-cone Supply in Project World ")
(requiresA "Output_X-cone Supply in Project World_Stem31_5" "X-cone, Detroit in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Rear)2_3" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Front)3_4" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Front)3_4" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_5" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Rear)4_5" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Cassette6_6" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Cassette6_6" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Chain7_7" "SRAM, Chicago in Project World ")

(requiresA "Output_SRAM Supply in Project World_Chain7_7" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Crankset9_8" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Crankset9_8" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Front)1_9" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Front)1_9" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Rear)2_10" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Rear)2_10" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake Rotor (Front)3_11" "SRAM, Chicago in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_3" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_4" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_4" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Rear)4_5" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Rear)4_5" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Front)19_2" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Front)19_2" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Front)16_5" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Front)16_5" "Shimano supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Front)1_2" "SRAM, Chicago in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Front)1_2" "SRAM Supply in Project World ")
(requiresA "Output_SRAM Supply in Project World_Brake (Rear)2_3" "SRAM, Chicago in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Front)19_2" "Shimano supply in Project World ")

(requiresA "Output_Shimano supply in Project World_Shifter (Rear)20_3" "Shimano in Project World ")
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(requiresA "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Rear)17_4" "Shimano supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Bottom Bracket5_2" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Bottom Bracket5_2" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Cassette6_3" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Cassette6_3" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Chain7_4" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Chain7_4" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Crankset9_5" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Crankset9_5" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_2" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_2" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_3" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Drivetrain40_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Derailleur (Front)16_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Derailleur (Front)16_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Shifter (Front)19_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Shifter (Front)19_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Shifter (Rear)20_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Shifter (Rear)20_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake (Front)1_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake (Front)1_15" "Drivetrain Supply Taipei in Project World ")

(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake (Rear)2_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake (Rear)2_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake Rotor (Front)3_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake Rotor (Front)3_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake Rotor (Rear)4_15" "Shimano, Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Brake Rotor (Rear)4_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Front)19_2" "Shimano in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Rear)4_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Rear)4_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Bottom Bracket5_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Bottom Bracket5_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Cassette6_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Cassette6_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Chain7_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Chain7_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Chainguide8_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Chainguide8_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Crankset9_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Crankset9_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Pedals10_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Taipei in Project World_Pedals10_15" "Drivetrain Supply Taipei in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in Project World_Drivetrain40_15" "Shimano, Taipei in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Crankset9_15" "Drivetrain Supply Tokyo in Project World ")

(requiresA "Input_Drivetrain Supply Tokyo in Project World_Pedals10_15" "Shimano, Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Pedals10_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Drivetrain40_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Drivetrain40_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Derailleur (Front)16_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Derailleur (Front)16_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Shifter (Front)19_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Shifter (Front)19_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Shifter (Rear)20_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Shifter (Rear)20_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Front)1_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake (Rear)2_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply Tokyo in Project World_Brake Rotor (Front)3_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake (Front)1_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake (Rear)2_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake (Rear)2_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake Rotor (Front)3_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake Rotor (Front)3_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake Rotor (Rear)4_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake Rotor (Rear)4_14" "Drivetrain Supply in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Bottom Bracket5_15" "Shimano, Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Bottom Bracket5_15" "Drivetrain Supply Tokyo in Project World ")

(requiresA "Input_Drivetrain Supply Tokyo in Project World_Cassette6_15" "Shimano, Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Cassette6_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Chain7_15" "Shimano, Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Chain7_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Chainguide8_15" "Shimano, Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Chainguide8_15" "Drivetrain Supply Tokyo in Project World ")
(requiresA "Input_Drivetrain Supply Tokyo in Project World_Crankset9_15" "Shimano, Tokyo in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Cassette6_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Chain7_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Chain7_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Chainguide8_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Chainguide8_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Crankset9_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Crankset9_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Pedals10_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Pedals10_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Derailleur (Front)16_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Derailleur (Front)16_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Shifter (Front)19_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Shifter (Front)19_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Shifter (Rear)20_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Shifter (Rear)20_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Brake (Front)1_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Front)16_14" "Shimano supply in Project World ")

(requiresA "Output_Shimano supply in Project World_Shifter (Front)19_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Front)19_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Rear)20_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Shifter (Rear)20_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake (Front)1_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake (Front)1_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake (Rear)2_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake (Rear)2_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake Rotor (Front)3_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake Rotor (Front)3_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake Rotor (Rear)4_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Brake Rotor (Rear)4_14" "Shimano supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Bottom Bracket5_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Bottom Bracket5_14" "Drivetrain Supply in Project World ")
(requiresA "Output_Drivetrain Supply in Project World_Cassette6_14" "Shimano, Kuala Lumpur in Project World ")
(requiresA "4PSPCtx.ManufacturedProduct Project World" "Project World")
(requiresA "4PSPCtx.Customer Project World" "Project World")
(requiresA "2DSCtx.Supplier Project World" "Project World")
(requiresA "Output_Shimano supply in Project World_Bottom Bracket5_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Bottom Bracket5_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Cassette6_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Cassette6_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Chain7_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Chain7_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Chainguide8_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Chainguide8_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Crankset9_14" "Shimano in Project World ")
(requiresA "Output_Shimano supply in Project World_Crankset9_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Pedals10_14" "Shimano in Project World ")

(requiresA "Output_Shimano supply in Project World_Pedals10_14" "Shimano supply in Project World ")
(requiresA "Output_Shimano supply in Project World_Derailleur (Front)16_14" "Shimano in Project World ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Shifter (Front)19_10" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Shifter (Rear)20_11" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Shifter (Rear)20_11" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake (Front)1_12" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake (Front)1_12" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake (Rear)2_13" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake (Rear)2_13" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake Rotor (Front)3_14" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake Rotor (Front)3_14" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake Rotor (Rear)4_15" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Brake Rotor (Rear)4_15" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "4PSPCtx.Producer Project World" "Project World")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Drivetrain40_8" "Shimano, Taipei in BBWorld ")

(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Drivetrain40_8" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Derailleur (Front)16_9" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Derailleur (Front)16_9" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Shifter (Front)19_10" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake Rotor (Rear)4_15" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Cassette6_3" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chain7_4" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Chainguide8_5" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Crankset9_6" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Pedals10_7" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Drivetrain40_8" "Shimano, Taipei in BBWorld ")
(requiresA "Output_Drivetrain Supply Taipei in BBWorld_Drivetrain40_8" "Drivetrain Supply Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Taipei in BBWorld_Bottom Bracket5_2" "Shimano, Taipei in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Drivetrain40_8" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Drivetrain40_8" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Derailleur (Front)16_9" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Derailleur (Front)16_9" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Shifter (Front)19_10" "Shimano, Tokyo in BBWorld ")

(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Shifter (Front)19_10" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Shifter (Rear)20_11" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Shifter (Rear)20_11" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake (Front)1_12" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake (Front)1_12" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake (Rear)2_13" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake (Rear)2_13" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake Rotor (Front)3_14" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake Rotor (Front)3_14" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Brake Rotor (Rear)4_15" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Drivetrain40_8" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply Tokyo in BBWorld_Drivetrain40_8" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chain7_4" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chain7_4" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Pedals10_7" "Shimano, Tokyo in BBWorld ")

(requiresA "Output_Drivetrain Supply in BBWorld_Brake (Front)1_11" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake (Rear)2_12" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake (Rear)2_12" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake Rotor (Front)3_13" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake Rotor (Front)3_13" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake Rotor (Rear)4_14" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake Rotor (Rear)4_14" "Drivetrain Supply in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Bottom Bracket5_2" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Cassette6_3" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chain7_4" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chain7_4" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5" "Shimano, Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Chainguide8_5" "Drivetrain Supply Tokyo in BBWorld ")
(requiresA "Input_Drivetrain Supply Tokyo in BBWorld_Crankset9_6" "Shimano, Tokyo in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Cassette6_3" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chain7_4" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chain7_4" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chainguide8_5" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chainguide8_5" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Crankset9_6" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Crankset9_6" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Pedals10_7" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Pedals10_7" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Derailleur (Front)16_8" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Derailleur (Front)16_8" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Shifter (Front)19_9" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Shifter (Front)19_9" "Drivetrain Supply in BBWorld ")

(requiresA "Output_Drivetrain Supply in BBWorld_Shifter (Rear)20_10" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Shifter (Rear)20_10" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Brake (Front)1_11" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake Rotor (Rear)4_14" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Bottom Bracket5_2" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Bottom Bracket5_2" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Cassette6_3" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Cassette6_3" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chain7_4" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chain7_4" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chainguide8_5" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Chainguide8_5" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Crankset9_6" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Crankset9_6" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Pedals10_7" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Pedals10_7" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Bottom Bracket5_2" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Bottom Bracket5_2" "Drivetrain Supply in BBWorld ")
(requiresA "Output_Drivetrain Supply in BBWorld_Cassette6_3" "Shimano, Kuala Lumpur in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Derailleur (Front)16_8" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Derailleur (Front)16_8" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Shifter (Front)19_9" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Shifter (Front)19_9" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Shifter (Rear)20_10" "Shimano in BBWorld ")

(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Shifter (Rear)20_10" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake (Front)1_11" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake (Front)1_11" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake (Rear)2_12" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake (Rear)2_12" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake Rotor (Front)3_13" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake Rotor (Front)3_13" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Brake Rotor (Rear)4_14" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Shimano in BBWorld ")

(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply_Chainguide8_5" "Drivetrain Components Supply")
(requiresA "Output_Drivetrain Components Supply_Crankset9_6" "Drivetrain Components Supply")
(requiresA "Output_Drivetrain Components Supply_Pedals10_7" "Drivetrain Components Supply")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Cassette6_3" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chain7_4" "Drivetrain Components Supply in Shimano in BBWorld ")

(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Chainguide8_5" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Crankset9_6" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Pedals10_7" "Drivetrain Components Supply in Shimano in BBWorld ")
(requiresA "Output_Drivetrain Components Supply in Shimano in BBWorld_Bottom Bracket5_2" "Shimano in BBWorld ")
(requiresA "Input_Bike Assembly Line_Steering Assembly44_7" "Bike Assembly Line")
(requiresA "Input_Bike Assembly Line_Suspension System45_8" "Bike Assembly Line")
(requiresA "Input_Bike Assembly Line_Wheel Assembly46_9" "Bike Assembly Line")
(requiresA "Output_Bike Assembly Line_Bike47_10" "Bike Assembly Line")
(requiresA "Input_iBike Assembly Line_Bike47_2" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_Onboard computer21_3" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_Crank sensor22_4" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_GPS23_5" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_Bluetooth reciever24_6" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_HUD module25_7" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_SMART band26_8" "iBike Assembly Line")
(requiresA "Input_iBike Assembly Line_Camera27_9" "iBike Assembly Line")
(requiresA "Output_iBike Assembly Line_iBike48_10" "iBike Assembly Line")
(requiresA "Output_Drivetrain Components Supply_Bottom Bracket5_2" "Drivetrain Components Supply")
(requiresA "Output_Drivetrain Components Supply_Cassette6_3" "Drivetrain Components Supply")
(requiresA "Output_Drivetrain Components Supply_Chain7_4" "Drivetrain Components Supply")
(requiresA "Input_Wheel Assembly Assembly Line_Tire (Front)34_2" "Wheel Assembly Assembly Line")
(requiresA "Input_Wheel Assembly Assembly Line_Tire (Rear)35_3" "Wheel Assembly Assembly Line")
(requiresA "Input_Wheel Assembly Assembly Line_Tubes36_4" "Wheel Assembly Assembly Line")
(requiresA "Input_Wheel Assembly Assembly Line_Wheel (Front)37_5" "Wheel Assembly Assembly Line")
(requiresA "Input_Wheel Assembly Assembly Line_Wheel (Rear)38_6" "Wheel Assembly Assembly Line")
(requiresA "Output_Wheel Assembly Assembly Line_Wheel Assembly46_7" "Wheel Assembly Assembly Line")
(requiresA "Input_Steering Assembly Assembly Line_Handlebar28_2" "Steering Assembly Assembly Line")
(requiresA "Input_Steering Assembly Assembly Line_Grips29_3" "Steering Assembly Assembly Line")
(requiresA "Input_Steering Assembly Assembly Line_Headset30_4" "Steering Assembly Assembly Line")
(requiresA "Input_Steering Assembly Assembly Line_Stem31_5" "Steering Assembly Assembly Line")

(requiresA "Output_Steering Assembly Assembly Line_Steering Assembly44_6" "Steering Assembly Assembly Line")
(requiresA "Input_Bike Assembly Line_Braking System39_2" "Bike Assembly Line")
(requiresA "Input_Bike Assembly Line_Drivetrain40_3" "Bike Assembly Line")
(requiresA "Input_Bike Assembly Line_Frame Assembly41_4" "Bike Assembly Line")
(requiresA "Input_Bike Assembly Line_Gear System42_5" "Bike Assembly Line")
(requiresA "Input_Bike Assembly Line_Smart Components43_6" "Bike Assembly Line")
(requiresA "Input_Gear System Assembly Line_Derailleur (Front)16_3" "Gear System Assembly Line")
(requiresA "Input_Gear System Assembly Line_Derailleur (Rear)17_4" "Gear System Assembly Line")
(requiresA "Input_Gear System Assembly Line_Cable Housing18_5" "Gear System Assembly Line")
(requiresA "Input_Gear System Assembly Line_Shifter (Front)19_6" "Gear System Assembly Line")
(requiresA "Input_Gear System Assembly Line_Shifter (Rear)20_7" "Gear System Assembly Line")
(requiresA "Output_Gear System Assembly Line_Gear System42_8" "Gear System Assembly Line")
(requiresA "Input_Drivetrain Assembly Line_Bottom Bracket5_2" "Drivetrain Assembly Line")
(requiresA "Input_Drivetrain Assembly Line_Cassette6_3" "Drivetrain Assembly Line")
(requiresA "Input_Drivetrain Assembly Line_Chain7_4" "Drivetrain Assembly Line")
(requiresA "Input_Drivetrain Assembly Line_Chainguide8_5" "Drivetrain Assembly Line")
(requiresA "Input_Drivetrain Assembly Line_Crankset9_6" "Drivetrain Assembly Line")
(requiresA "Input_Drivetrain Assembly Line_Pedals10_7" "Drivetrain Assembly Line")
(requiresA "Output_Drivetrain Assembly Line_Drivetrain40_8" "Drivetrain Assembly Line")
(requiresA "Input_Suspension System Assembly Line_Suspension Fork32_2" "Suspension System Assembly Line")
(requiresA "Input_Suspension System Assembly Line_Suspension Rear Shock33_3" "Suspension System Assembly Line")
(requiresA "Output_Suspension System Assembly Line_Suspension System45_4" "Suspension System Assembly Line")
(requiresA "2DSCtx.Supplier BBWorld" "BBWorld")
(requiresA "4PSPCtx.Producer BBWorld" "BBWorld")
(requiresA "4PSPCtx.ManufacturedProduct BBWorld" "BBWorld")
(requiresA "4PSPCtx.Customer BBWorld" "BBWorld")
(requiresA "2DSCtx.Supplier BBWorld" "BBWorld")
(requiresA "Input_Braking System Assembly Line_Brake (Front)1_2" "Braking System Assembly Line")
(requiresA "Input_Braking System Assembly Line_Brake (Rear)2_3" "Braking System Assembly Line")
(requiresA "Input_Braking System Assembly Line_Brake Rotor (Front)3_4" "Braking System Assembly Line")
(requiresA "Input_Braking System Assembly Line_Brake Rotor (Rear)4_5" "Braking System Assembly Line")
(requiresA "Output_Braking System Assembly Line_Braking System39_6" "Braking System Assembly Line")
(requiresA "Input_Frame Assembly Assembly Line_Frame11_2" "Frame Assembly Assembly Line")
(requiresA "Input_Frame Assembly Assembly Line_Saddle12_3" "Frame Assembly Assembly Line")
(requiresA "Input_Frame Assembly Assembly Line_Seatpost13_4" "Frame Assembly Assembly Line")
(requiresA "Input_Frame Assembly Assembly Line_Seatpost collar14_5" "Frame Assembly Assembly Line")
(requiresA "Output_Frame Assembly Assembly Line_Frame Assembly41_6" "Frame Assembly Assembly Line")
(requiresA "Input_Gear System Assembly Line_Cable15_2" "Gear System Assembly Line")
(requiresA "roleManufacturedProduct" "GPN")

(requiresA "4PSPCtx.Producer BBWorld" "BBWorld")
(requiresA "4PSPCtx.ManufacturedProduct BBWorld" "BBWorld")
(requiresA "4PSPCtx.Customer BBWorld" "BBWorld")

;;;===
;;; Populating Roles (Plays Role Actor)
;;;===

(2DSCtx.playsRoleActor "Planetcan, Memphis in Project World" "2DSCtx.Supplier Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "Shimano, Taipei in Project World" "2DSCtx.Customer Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "KSB AG Frankenthal in KSB worldwide" "4PSPCtx.Producer KSB worldwide" "KSB worldwide default scenario")
(2DSCtx.playsRoleActor "Runhouse, Copenhagen in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Zaptrans, Zaragoza in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Silware, Nantes in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Retechi, Valencia in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Rankjaylex, Helsinki in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Newware, Nashville in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Planetcan, Memphis in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Koncon, Rotterdam in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "BuzzBikes Central Factory in Project World" "4PSPCtx.Producer Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "BuzzBikes Central Factory in Project World" "4PSPCtx.Producer Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "BuzzBikes Assembly Factory in Project World" "4PSPCtx.Producer Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "BuzzBikes Assembly Factory in Project World" "4PSPCtx.Producer Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "Retechi, Valencia in Project World" "2DSCtx.Supplier Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "Unotechno, Strasbourg in Project World" "2DSCtx.Supplier Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "Ventoin, Brussels in Project World" "2DSCtx.Supplier Project World" "Project World 1st scenario")
(2DSCtx.playsRoleActor "Cangreen, Paris in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Techbam, Bordeaux in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")

(2DSCtx.playsRoleActor "Salin, Lisbon in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Laelectrics, Bristol in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Planetex, Reading in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Mathfase, Liverpool in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Streetcore, London in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Doublemedia, Manchester in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Ventoin, Brussels in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Kandomex, Stuttgart in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Itlam, Dortmund in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Trionix, Frankfurt in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Indigotech, MÃ¼nster in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Rankware, Rome in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Unotechno, Strasbourg in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Cantinice, Nagasaki in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Silware, Nantes in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Retechi, Valencia in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Rankjaylex, Helsinki in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Newware, Nashville in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Planetcan, Memphis in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Subplus, Tours in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Koncon, Rotterdam in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Shimano in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
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(2DSCtx.playsRoleActor "Shimano, Tokyo in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Shimano, Taipei in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "SRAM, Chicago in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Bamtech, Berlin in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")

(2DSCtx.playsRoleActor "Villaelectronics, Madrid in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Bluefinron, Stockholm in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "X-cone, Detroit in Project World" "2DSCtx.Supplier Project World" "Project World default scenario")
(2DSCtx.playsRoleActor "Laelectrics, Bristol in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Planetex, Reading in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Mathfase, Liverpool in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Streetcore, London in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Doublemedia, Manchester in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Kandomex, Stuttgart in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Kandomex, Stuttgart in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Itlam, Dortmund in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Trionix, Frankfurt in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Indigotech, MÃ¼nster in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Rankware, Rome in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Unotechno, Strasbourg in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Cantinice, Nagasaki in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Runhouse, Copenhagen in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Zaptrans, Zaragoza in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
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(2DSCtx.playsRoleActor "Shimano, Kuala Lumpur in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Shimano, Tokyo in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Shimano, Taipei in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "SRAM, Chicago in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Bamtech, Berlin in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Villaelectronics, Madrid in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Bluefinron, Stockholm in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "X-cone, Detroit in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Cangreen, Paris in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Techbam, Bordeaux in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")
(2DSCtx.playsRoleActor "Salin, Lisbon in BBWorld" "2DSCtx.Supplier BBWorld" "BBEcosystem")

;;;===
;;; Defining Indicator Values
;;;===

(2DSCtx.hasIndicatorValue 2DSCtx.LendingInterestRate_GBR (2DSCtx.% 0.5))
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;;;===
;;; Defining Basic contains Basic relationships
;;;===

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(basicContainsBasic "4PSPCtx.ProjectWorld" "null")
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(basicContainsBasic "Silware, Nantes in Project World" "Silware Supply in Project World")
(basicContainsBasic "Streetcore, London in Project World" "Streetcore Supply in Project World")
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(basicContainsBasic "Retechi, Valencia in Project World" "Retechi Supply in Project World")
(basicContainsBasic "Doublemedia, Manchester in Project World" "Doublemedia Supply in Project World")
(basicContainsBasic "Rankjaylex, Helsinki in Project World" "Rankjalex Supply in Project World")
(basicContainsBasic "Newware, Nashville in Project World" "Newware Supply in Project World")
(basicContainsBasic "Planetcan, Memphis in Project World" "Planetcan Supply in Project World")
(basicContainsBasic "Subplus, Tours in Project World" "Subplus Supply in Project World")
(basicContainsBasic "Koncon, Rotterdam in Project World" "Koncon Supply in Project World")
(basicContainsBasic "Indigotech, MÃ¼nster in Project World" "Indigotech Supply in Project World")
(basicContainsBasic "BuzzBikes Central Factory in Project World" "Smart iBike Assembly Central Factory in Project World")
(basicContainsBasic "Project World" "BuzzBikes Assembly Factory in Project World")
(basicContainsBasic "BuzzBikes Assembly Factory in Project World" "Wheel Assembly Factory in Project World")
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(basicContainsBasic "Laelectrics, Bristol in Project World" "Laelectrics Sypply in Project World")
(basicContainsBasic "Planetex, Reading in Project World" "Planetex Supply in Project World")
(basicContainsBasic "Ventoin, Brussels in Project World" "Ventoins Supply in Project World")
(basicContainsBasic "Kandomex, Stuttgart in Project World" "Kandomex Supply in Project World")
(basicContainsBasic "Rankware, Rome in Project World" "Rankware Supply in Project World")
(basicContainsBasic "Unotechno, Strasbourg in Project World" "Unotechno Supply in Project World")
(basicContainsBasic "Cantinice, Nagasaki in Project World" "Cantinice Supply in Project World")
(basicContainsBasic "Itlam, Dortmund in Project World" "Itlam Supply in Project World")
(basicContainsBasic "Mathfase, Liverpool in Project World" "Mathfase Supply in Project World")
(basicContainsBasic "Runhouse, Copenhagen in Project World" "Runhouse Supply in Project World")
(basicContainsBasic "Trionix, Frankfurt in Project World" "Trionix Supply in Project World")
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(basicContainsBasic "Project World" "Newware, Nashville in Project World")
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(basicContainsBasic "Project World" "Subplus, Tours in Project World")
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15 Annex E: Key KFL Constructs

The Knowledge Frame Language (KFL) is a Common Logic based ontology development language which has been used for this research work. KFL uses directives to specify the ontology code whereas each directive starts with colons followed by a keyword and certain arguments. In order to understand KFL, the following concepts need to be understood.

- Contexts
- Properties
- Relations
- Functions
- Logic, Rules and Integrity Constraints

These are explained in the following sections.

15.1 Contexts

Contexts are very important in creating ontologies as they define specific point of view. Although we can create ontologies in IODE with a predefined context called Middle Level Ontology (MLO) however it is more convenient to define one's own context. We can create new context by writing a simple code in KFL as shown below. The first three fields (Ctx, Inst, supCtx) are mandatory for defining a new context in ontology while the last two are optional.

```
:Ctx ARO

:Inst UserContext

:supCtx MLO

:name "Assembly Reference Ontology"

:rem "The ARO context is used for the assembly domain"
```

Ctx (stands for context) defines the name of new concept (ARO in current case). We use UserContext as an instance of new context rather than SystemContext because we are defining our own context. The third field "supCtx" stands for super context of and we place MLO as super context of the ARO because it was default context. In the last two fields: name and rem (remarks), we can write anything within the inverted commas to elaborate the context code.

Once the context is defined, then we can use this context by writing the use directive as shown below.

```
:Use ARO
```

15.2 Properties

The term property refers to any taxonomic component while building an ontology in IODE. The term property is sometimes called class or category in other ontology development environments. Any

concept/term is first represented as property in IODE and then relations, functions and logics are applied. When writing properties in KFL format, a user needs to write the following directives.

:Prop HandlingAF

:Inst Type

:sup AssemblyFeature

:name "Handling Assembly Feature"

:rem "Handling AF is used in resource evaluation"

The first three directives in the above code are mandatory while others are optional. Prop refers to property and represent the main concept e.g. HandlingAF in this case. Inst stands for "instance of" and represents property type. It has two kinds of properties in Upper Level Ontology (ULO) which are (1) Type and (2) MaterialRole. Types correspond to properties which do not change with the passage of time while MaterialRoles can change their status after sometime. In this work all the properties are instantiated under Type.

The third directive "sup" refers to super property relation and defines hierarchies of properties by this relation. For a property x to be super property of y, every instance of y should be an instance of x. For example an assembly feature is super property of handling AF as every instance of handling AF is an instance of the assembly feature.

The fourth and fifth directives are optional for properties where names and remarks (rem) define additional information related to the property as shown in the above example.

15.3 Relations

Properties are held together with the help of relationships. The sup property only defines hierarchy of properties and does not account for other relationships. A relation declaration consists of following directives.

:Rel hasTolerance

:Inst BinaryRel

:Sig Object Tolerance

:Args "Assembly Feature" "Tolerance"

Like properties, the first three directives are compulsory for relations. The :Rel line describes the wording of relationship e.g. what relation a property has with the other one. :Inst directive defines the kind of relation depending upon the arity (number of arguments) of the relation. For example, BinaryRel (binary relation) in the above example connect two properties (Object and Tolerance) with each other. There are also other types of relations which are

- UnaryRel (one arguement)
- TernaryRel (three arguments)

- QuaternaryRel (four arguments)
- QuinaryRel (five arguments)
- Relation (Any number of arguments)

The :Sig directive should have a property for every argument position e.g. Object and Tolerance are two properties which have "hasTolerance" relationship.

15.4 Functions

Functions provide additional entities from one or more parameters and semantically differentiate between a description and what is described. Functions also allow parameters to be used for reasoning. Entities like fivePointTwoGrams or threePointTwoCentimetres would further complicate the model and make the parameters vague and unclear. KFL describes function in the following format to avoid the issues discussed above.

:Fun cm

:Inst UnaryFun

:Inst MeasureFun

:Sig RealNumber -> LengthDimension

This allows writing functions that describe length dimensions e.g. (cm 3.2). Similar to properties and relations, functions have three required directives which are Fun, Inst and Sig. It is also pertinent to note that except the first directive (Fun), the difference between a relation and function is the arrow in the :Sig directive. The text on the left side of arrow represents arguments to the function and text on the right side describes property instantiated by the function. Finally similar to relations, functions can also be classified by arity as follows.

- UnaryFunl (one arguement)
- BinaryFun (two arguments)
- TernaryFun (three arguments)
- QuaternaryFun (four arguments)
- QuinaryFun (five arguments)

15.5 Logic

Logics in KFL consist of rules and constraints. These rules and constraints are the mandatory part of heavyweight ontologies and thus differentiate the latter from the lightweight ontologies. Rules help to infer the existing information and create new information while constraints pre-empt any data inconsistency. Constraints in turn enhance the data quality and speed up the query response times. Rules and constraints will be extensively used in this research along with properties, relations, and functions.

15.5.1 Rules

As described above, rules infer new information from the existing statements and use implications. The implication operator is made up of an arrow and an equal size (as shown in the rule below). A rule consists of the antecedent and the consequent. The antecedent/s is/are the clause/clauses which help to infer new information. The consequent is the conclusive statement or the statement which is inferred using antecedents.

In KFL, the consequent will only be deduced if all the antecedent statements are true. For example in the following rule, the conclusive statement ((hasMinAllowableDimension ?p ?q+lower) will only be true if all the antecedent statements are true.

```
(<= (hasMinAllowableDimension ?p ?q+lower)
(and (Object ?p)
(hasDimensionWithTolerance ?p ?q (?tol ?lower ?upper))
(measurePlus ?q ?lower ?q+lower)
(or (= ?tol tolerance)
(= ?tol f7)
(= ?tol H8)
(= ?tol k6)
(= ?tol H7)
(= ?tol p6))))
:rem "The Object ?p has a minimum allowable dimension which is equivalent to its nominal dimension plus its lower deviation."
```

The above mentioned rule has also used conjunction and disjunction operators. The conjunction operator "and" combines two or more than two clauses to form the argument. The conjunction operator is true when all the clauses are true. The disjunction operator "or" combines two or more clauses and is true when at least one of the clauses is true.

15.5.2 Integrity Constraints (ICs)

Integrity Constraints (ICs) seem like rules apart from the fact that the IC directive starts with :IC. The IC directive represents the strength of the constraint and it shows the error messages in case of violation of constraints. The strength of IC can be categorized as

- Weak ICs
- Soft ICs
- Hard ICs
- Adamant ICs

A weak IC only shows an irregularity and does not indicate any problem. Soft IC is stronger than weak IC however it does not rollback a transaction. Hard IC is stronger than both of weak and soft ICs and could rollback a transaction. Adamant IC is strongest of all ICs and any violation of adamant IC could harm the integrity of logic engine. An example of hard integrity constrain is given below.

(=> (hasTolerance ?x (tolerance ?q1 ?q2))

(and (Object ?x)

(Dimension ?q1)

(Dimension ?q2)

(measureLT ?q1 ?q2)))

:IC hard "The lower deviation quantity of a Tolerance must always be less than its upper deviation quantity."

The above mentioned IC will prevent any attempt to assert first quantity of tolerance which is larger than the second quantity of tolerance.