Industrial Operations / Information Processing Convergence

Control Chain Management Body Of Knowledge

MI - Enterprise Language Standards

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Research community   www.controlchainmanagement.org

Consulting group: www.controlchaingroup.com

- **Introduction**
- **ISO15000-5 UN/CEFACT CCTS**
- **OPC UA**
- **ISO15926**
- **ISO15414**
- **ISO19440**
- **ISO62264/ISA-95 + IEC61512/ISA-88**
- **ISO11179**

Introduction

- **The Enterprise organism keeps morphing itself**
    - Achieving the Darwinian process of its existence by developing objective knowledge to its advantage
    - Fighting entropy, securing survival, enabling progress
    - Ensuring that thinking people and machines understand each other and the system they live in
- **Hypercritical complexity**
    - quantity and quality of interactions
    - spouts "emerging properties", Culture, Intelligence, Auto-organization
    - Developing new, higher ranking behavior
    - Not deductible from their individual components
- **The Syntropic Factory focuses on becoming a smarter organism**
    - Developing its "intelligence"

Conditions of intelligence

- **A product of complexity, Intelligence raises from**
  - Ability to develop knowledge
    - Enabling cycling between subjective experience and objective knowledge
  - Ability to share knowledge
    - Enabling seamless storage and access to relevant knowledge
  - Ability to interact
    - Enabling understandable communications between components
  - Individual intelligence
    - Sophisticated components performing locally
    - At the advantage of the whole system
- **Secondary level behavior**
  - Creativity
  - Risk assessment and management
    - Securing actions against uncertainty

Language

- **Objective knowledge is out of reach**
  - ➢ It exists independently of its actual understanding – by human, machines
- **Language is the means for handling knowledge**
  - ➢ Language defines basic concepts (vocabulary) and rules (grammar) for expressing knowledge
- **Existence of a language is a pre-condition for intelligence**

Enterprise knowledge

- **Covers many domains**
- **Addresses tangible and intangible information.**

For Industrial facilities operations

- Tangible knowledge
  - Resources and capabilities (equipment, people, material, energy…)
- Intangible knowledge
  - Know-how not formalized

- **Enterprise knowledge covers**
  - Public knowledge
    - Readily available
  - Private knowledge
    - Represents the enterprise essence
    - Might need to be protected from competitors' eyes

Enterprise language

- **Tangible outcome of the language:**
  - ➢ meaningful, non ambiguous messages for knowledge exchange, storage, retrieval
  - ➢ Support the description of enterprise structural and behavioral aspects on the time scale
- **Must serve both Human and IT relationship**
  - ➢ Understandable by people and machines
  - ➢ Machine, being notably stupid, need extended, precise formalism to understand

Elements of the enterprise language

- **Natural language accommodate most of human interactions**
- **Machines need more formalism**
- **The enterprise language is a formal ontology**
  - A semantic tree
  - Defining concepts associated with lexicon (translations, synonyms,)
  - Structured successively in
    - simple abstract concepts i.e. « Identifier » « Description »
    - General concepts i.e. « « activity », « Resource »
    - business concepts as references for actual business entities mentioned in messages
  - Describing relationships and value domains

Public knowledge and standards

- **Standards expose public knowledge**
  - Enterprise generic concepts (public knowledge) is well covered by available standards
- **Acquiring appropriate public knowledge is part of the enterprise knowledge / intelligence development**
  - Ignoring public knowledge forces to reinvent the wheel
  - Leveraging public knowledge
    - Saves effort and time,
    - Catalyze private knowledge development,
    - Accelerates intelligence development
- **Many overlapping standards, more or less focused**
- **This study present some relevant standards to establish an enterprise language**

Applicable standards

Reference	Title	Domains
ISO15000-5 UN/Cefact CC	ebXML - Core Componenet Technical Specification	ULO - Data structures for elementary concepts
OPC UA	OPC Unified Architecture	ULO - Neutral Upper level ontology
ISO15926	Industrial automation systems and integration – Integration of lifecycle data for process plants	ULO - Upper level ontology of enterprise concepts
ISO15414	Information Processing – Open Distributed Processing – Reference model – Enterprise language	ULO - Generic enterprise concepts Upper level ontology
ISO19440	Contructs for enterprise modelling	Generic enteprise concepts
ISO62264 IEC61512	Enterprise-control system integration Batch Control	Manufacturing operations specific concepts
ISO15531 (not studied)	Industrial automation systems and integration – industrial manufacturing management data	Manufacturing specific concepts
ISO11179	Information Technology – Metadata registries	Semantic registry

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ISO15000-5 UN/CEFACT CCTS

- **ISO 15000 : Electronic business eXtensible Markup Language (ebXML)**
  - Part 5 is the UN/CEFACT Core Components Technical Specification (CCTS)
- **UN Cefact relevant work:**
  - Core Components Data Type Catalogue
 - Core Components Technical Specification
  - XML Naming and Design Rules Technical Specification

Core Components Data Type Catalogue

Amount	Ordinal
Binary Object	Percent
Code	Picture
Date	Quantity
Date Time	Rate
Duration	Ratio
Graphic	Sound
Identifier	Text
Indicator	Time
Measure	Value
Name	Video

Core Components Technical Specification

- **Provides a way to identify, capture and maximize the re-use of business information to support and enhance information interoperability.**

- **Focuses both on human-readable and machine processable representations of this information.**

- **Semantic standardization is done in a syntax-neutral fashion.**
  - ➢ allows for the richness inherent in natural language to be used to create data and information exchange models that are devoid of computer-driven syntax limitations and requirements.

- **Captures a wealth of information about the business reasons for variation in data model and message semantics and structure.**
  - ➢ In the past, these variations have led to incompatible models and a subsequent lack of interoperability. The core components mechanism will allow identification of similarities and differences between these models.

UN/CEFACT CCTS Standards Stack
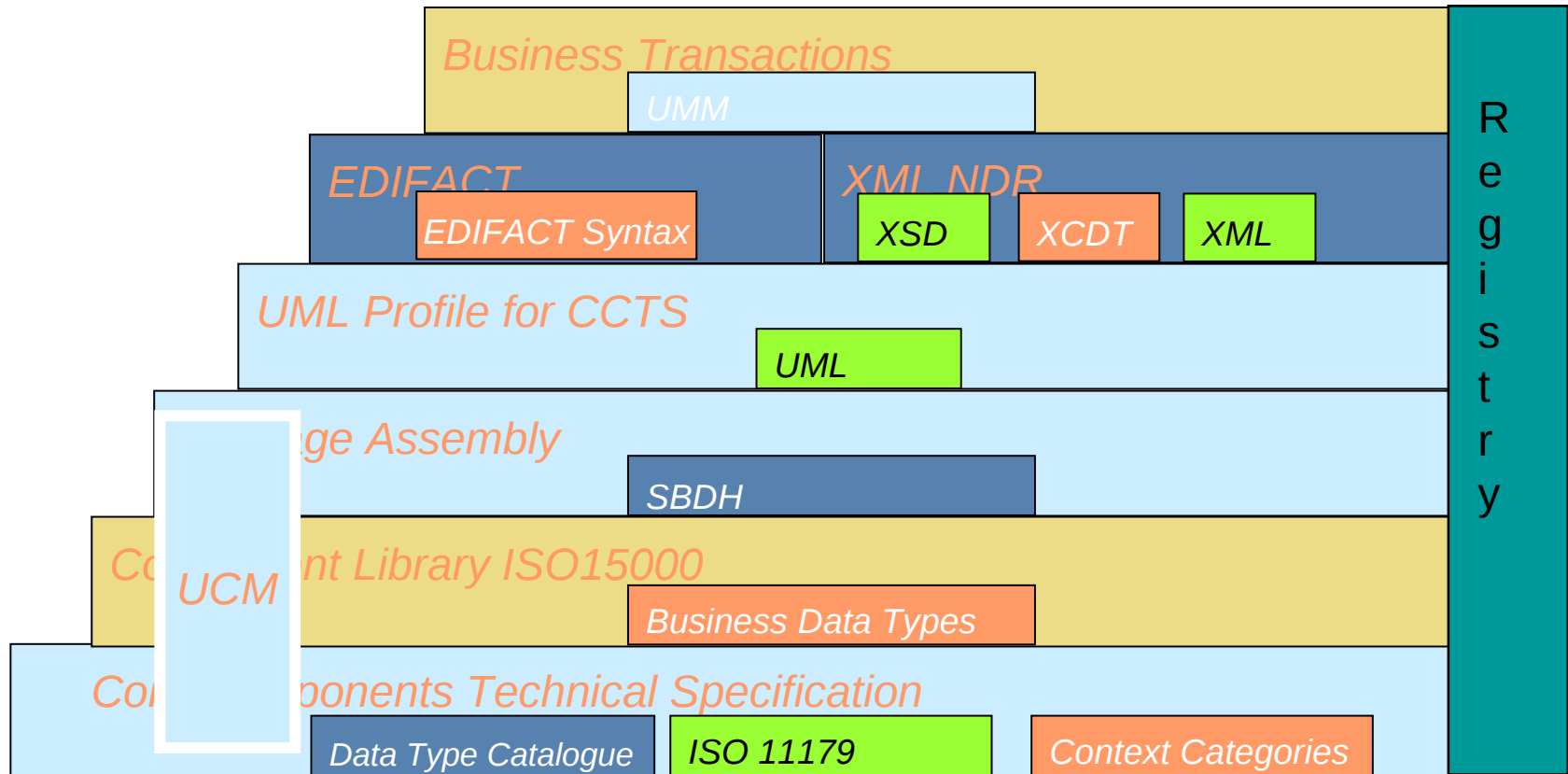
TMG (Techniques and Methodologies Group)

TBG (Trade Business Group)

ATG (Applied Technologies Group)

ICG

Implicit parts of UN/CEFACT Standards

Non UN/CEFACT Standards

Note:
UML = Unified Modeling Language
UMM = UN/CEFACT Modelling Methodology
XSD = XML Schema Definition Language
XML = Extensible Markup Language
XMI = XML Metadata Interchange
XCDT = XML Expressed Core Data Types
BCSS = Business Collaboration Specification Schema
UCM = Unified Context Methodology
SBDH = Standard Business Document Header

Relationship between core abstract and business types
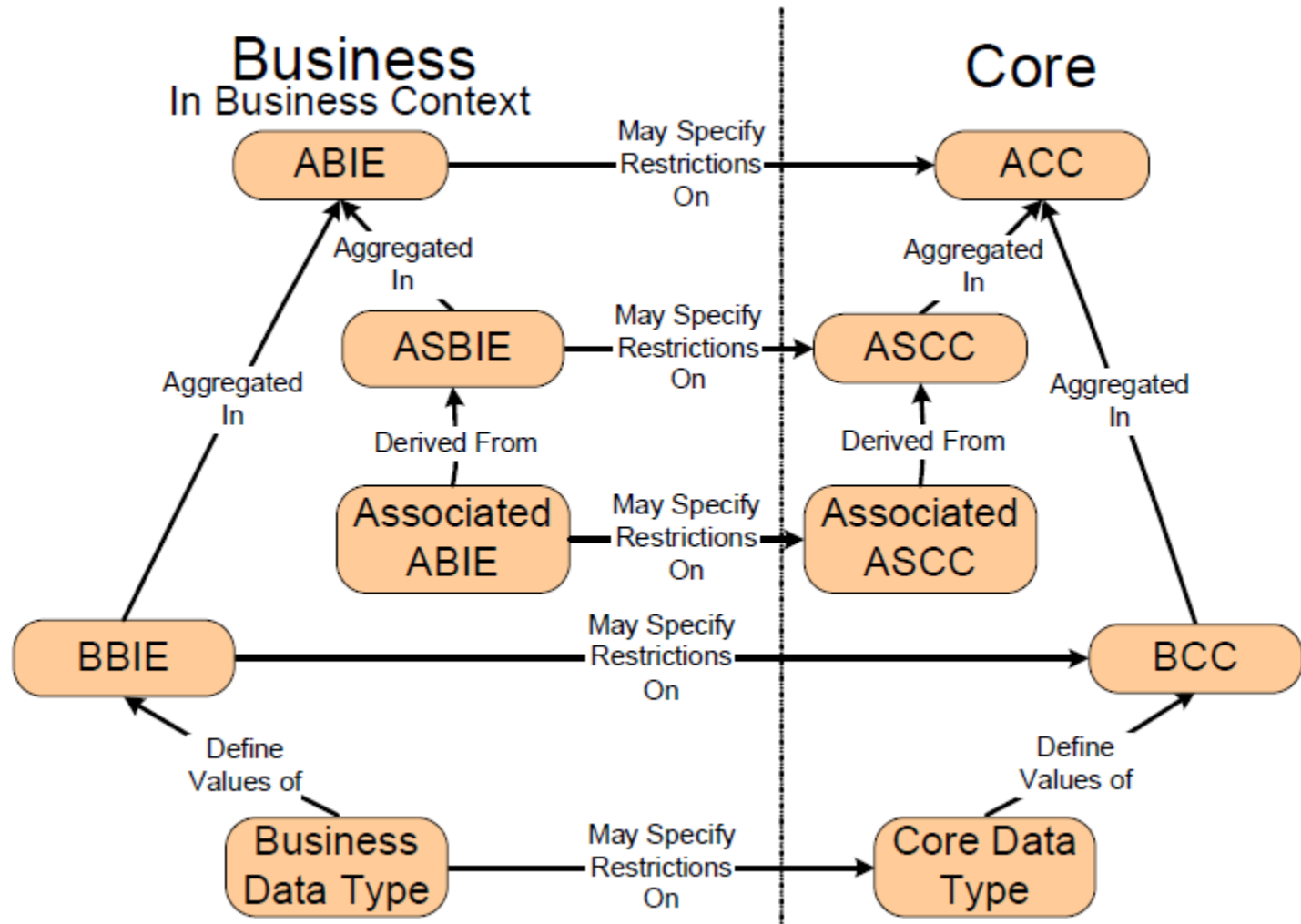
XML Naming and Design Rules Technical Specification

- **Good Design Practices for XML Schemas**
  - ➢ XML Schemas architecture principles
  - ➢ Recommended usage of XSD primitives
  - ➢ XML Schema files handling
  - ➢ XML instances handling
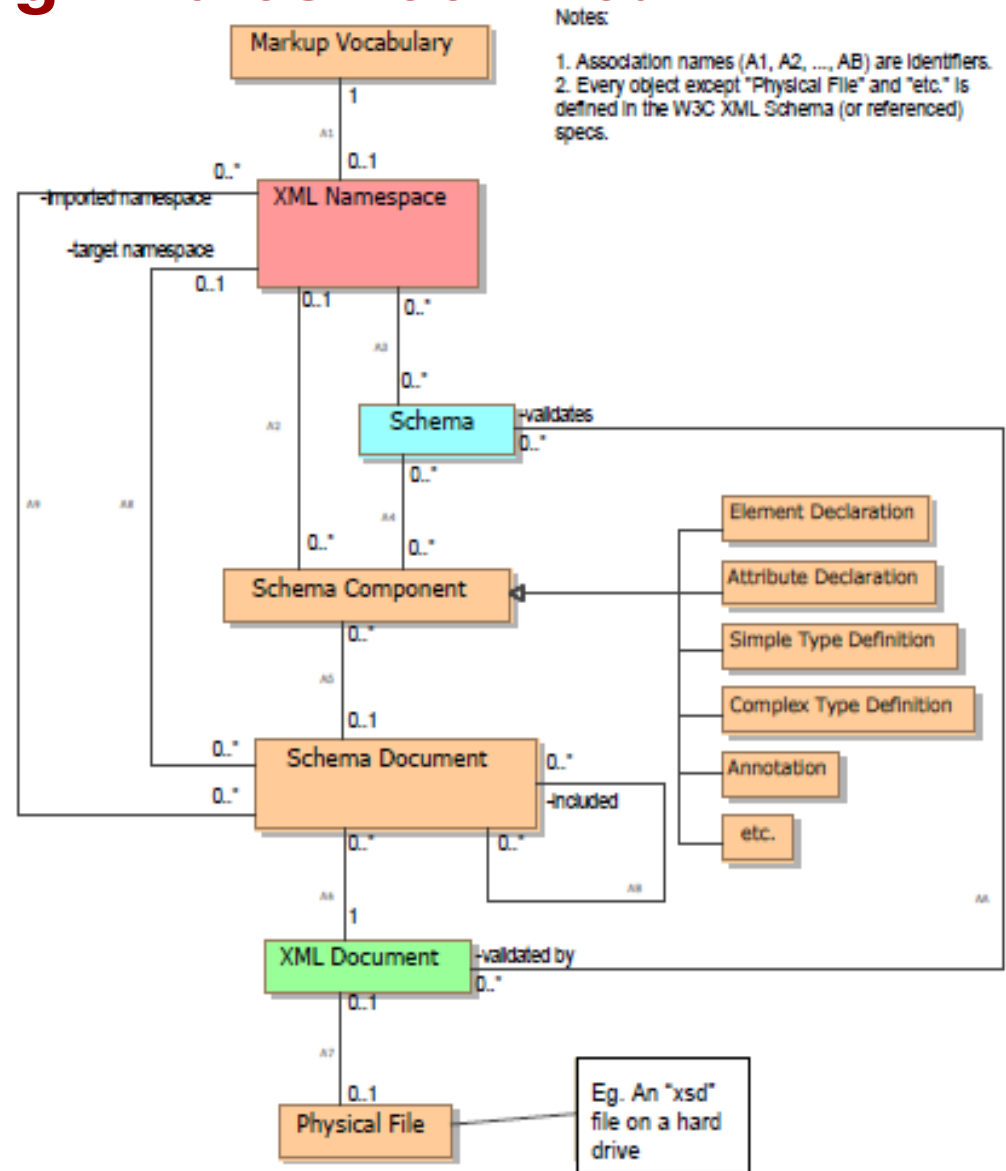
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OPC UA main modelling concepts

- **OPC UA offers an infrastructure to facilitate information exchange**
  - ➢ In industrial application areas
    - ▪ Field devices, Control systems, MES systems, ERP systems
  - ➢ Addressing
    - ▪ Modeling language for describing structures, behaviour, semantics
      - ▪ *Standard, extensible models*
    - ▪ Messaging concepts to interact between applications
    - ▪ Communication concepts to handle data transfer
- **OPC UA provides**
  - ➢ Data modelling framework
 - ➢ Service set for accessing data

Elements of OPC UA (Node classes)

Main classes	subclasses	subclasses	Defined by	Predefined
View				
Object			ObjectType	
Type Definition	ObjectType	Folder type		DataTypeSystem
		ModellingRule Type		
		EventType		*Next slides*
	DataType			*Next slides*
	VariableType		Data Types	DataTypeDictionary,
	Reference Type			*Next slides*
Variable	Property		Data Types	
	DataVariable		Data Types	
Methods				

OPC UA standard Attributes

AccessLevel	IsAbstract
ArrayDimensions	MinimumSamplingInterval
BrowseName	NodeClass
ContainsNoLoops	NodeId
DataType	Symmetric
Description	UserAccessLevel
DisplayName	UserExecutable
EventNotifier	UserWriteMask
Executable	Value
Historizing	ValueRank
InverseName	WriteMask

OPC UA Standard Reference types
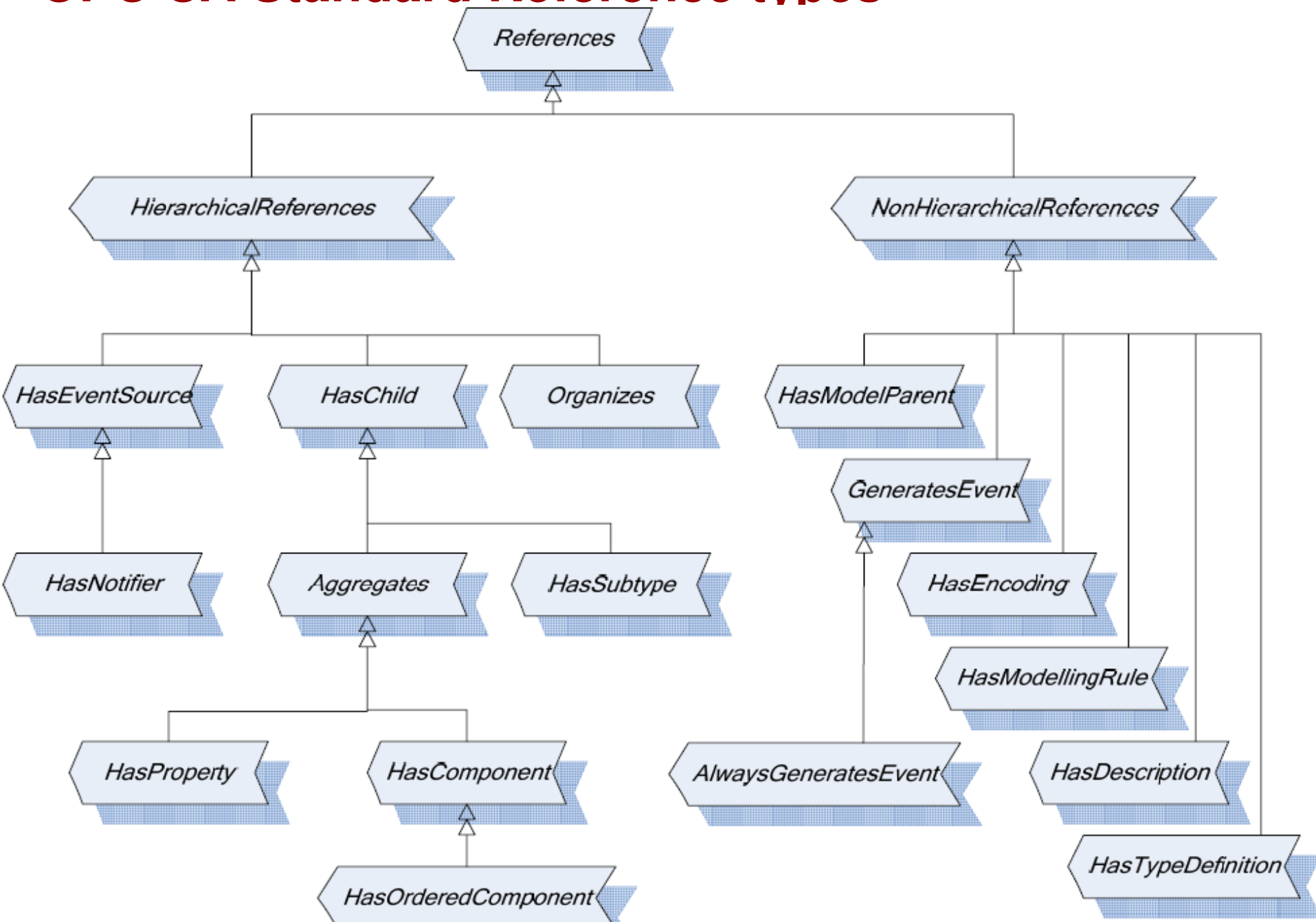
OPC UA standard event types
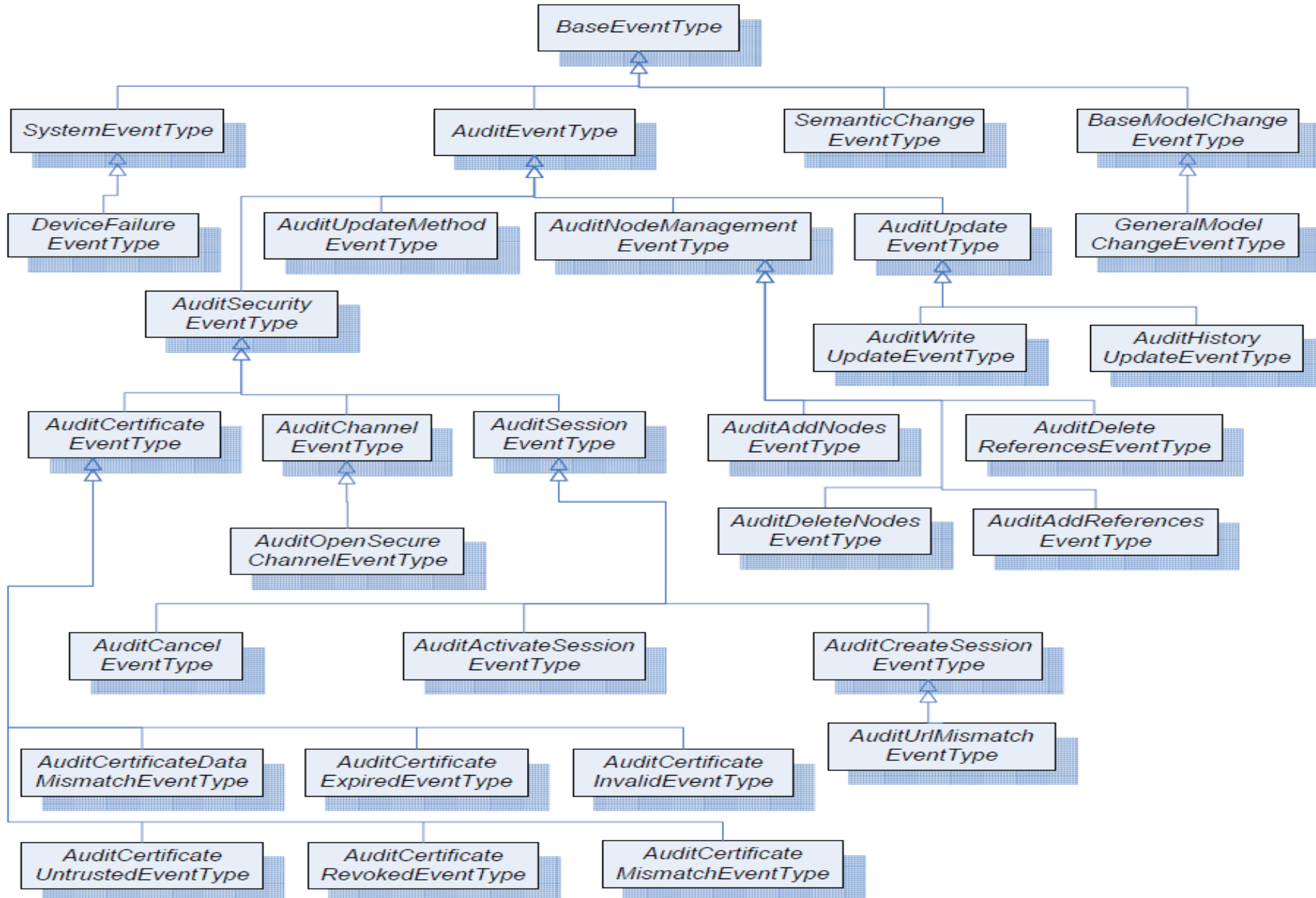
OPC UA standard Services

Service set	
Discovery	Discover Servers: FindServers, GetEndpoints, RegisterServer
SecureChannel	Open / close secure communication (lower level – protocol dependent)
Session	Open / close Session
Attribute	Read / write data (including history)
Subscription	Subscribe to data (receive data)
MonitoredItem	Subscribe to data (specifying which data to subscribe to)
View	Browsing
Query	Querying
NodeManagement	Add / delete Nodes and References
Method	Method calls

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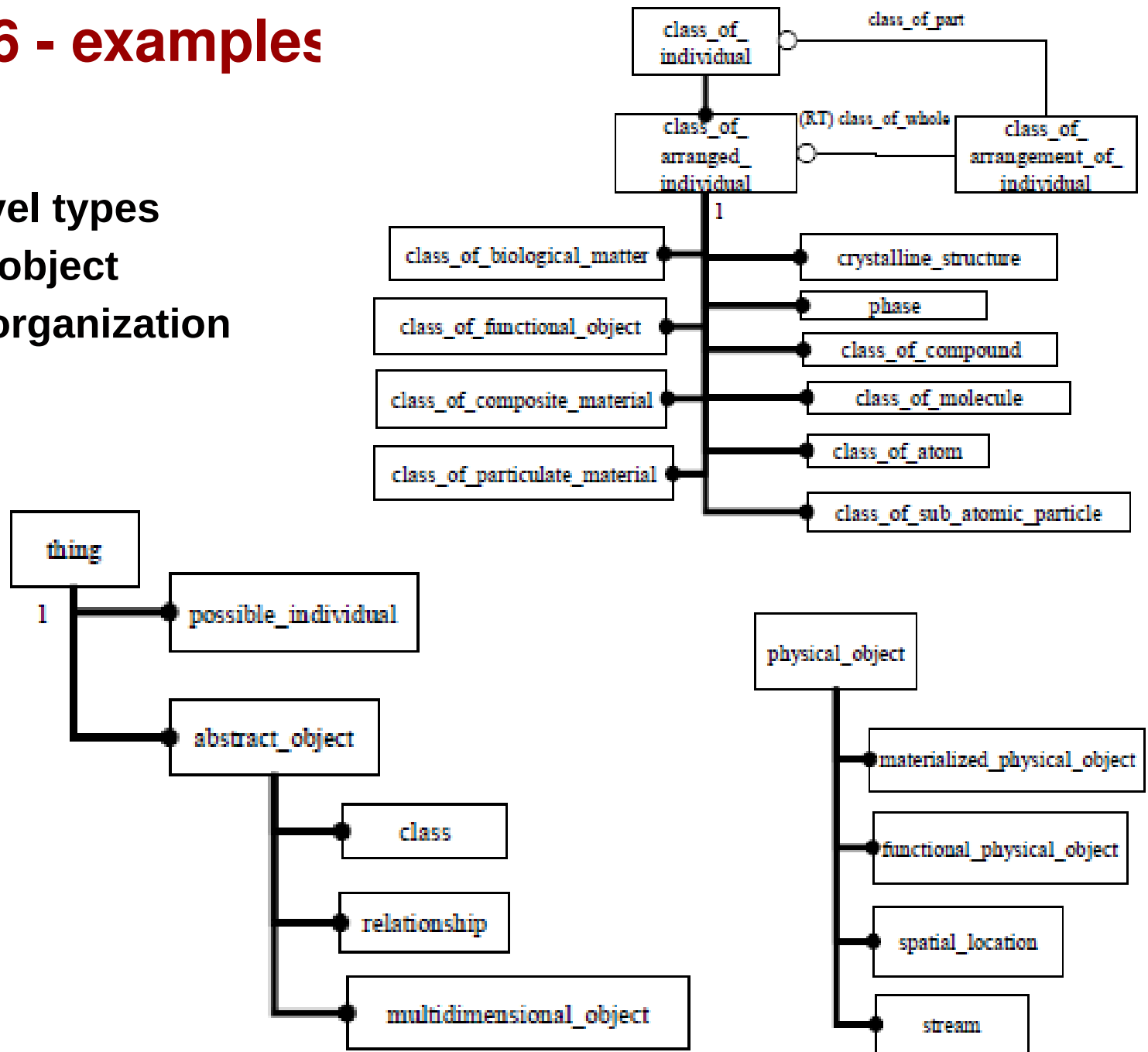- **ISO11179**

ISO15926 background

- **ISO 15926 "Industrial automation systems and integration—Integration of life-cycle data for process plants including oil and gas production facilities"**
  - Part of the European community program « ESPRIT »
  - EPISTLE consortium
  - Supported by POSC Caesar Association
    - Petrotechnical Open Software Corporation
    - Oil & Gas, Norway
  - OWL implementation
- **Focused on reference data lifecycle**
- **Wide applicability**
  - Focuses on describing industrial facilities
  - Based on an upper level ontology of large expressiveness
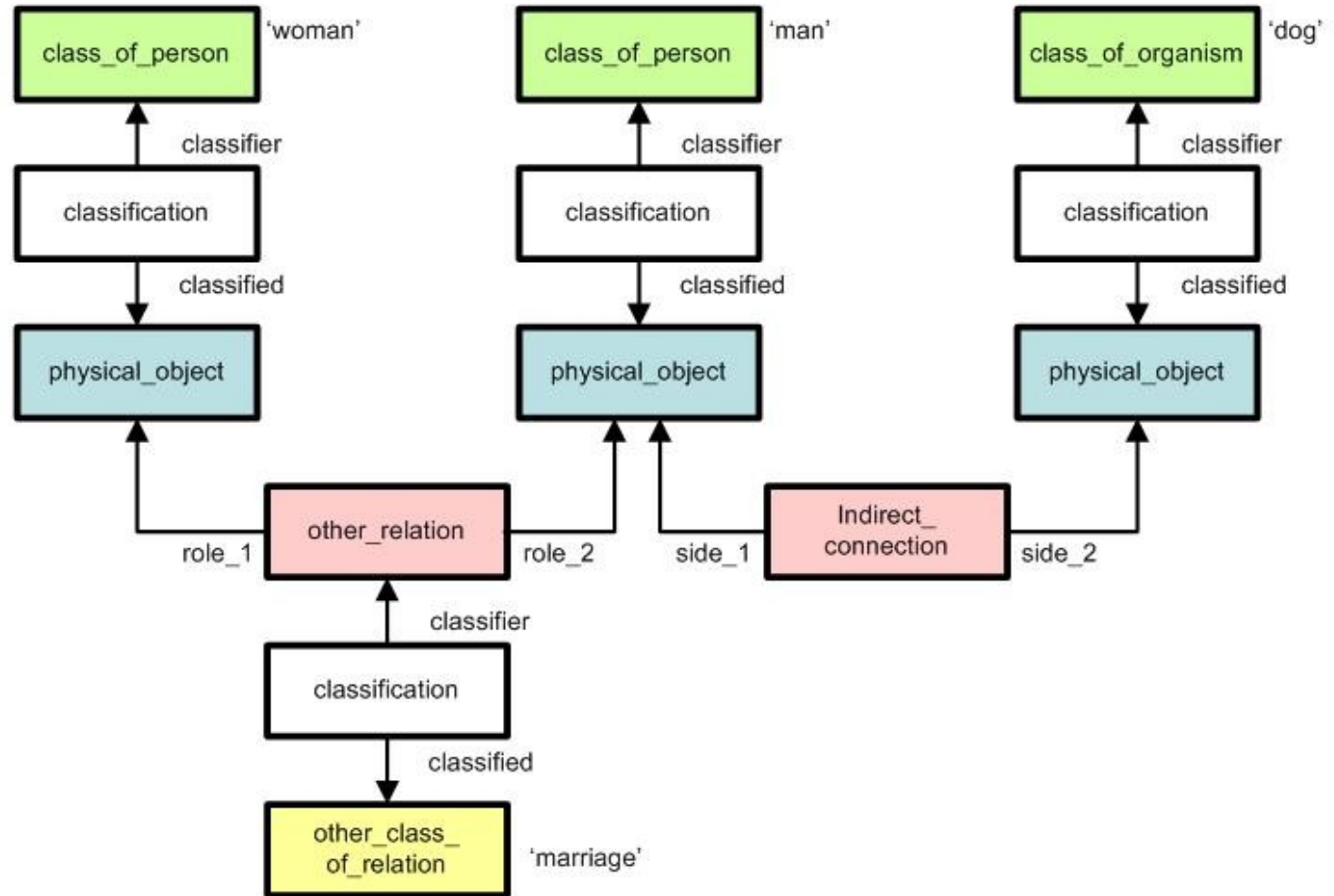
ISO15926 - Upper level types

Class				
Thing				
	Possible Individual			Pump #1234
	Abstract object			
		Class		Pump
		Relationship		Pump #1234 is member of Pump
			Composition of Individual	
			Connection of Individual	
		Multi-dimensional object		List of « Things »

ISO15926 - examples

- **Upper level types**
- **Physical object**
- **Material organization**

ISO15926 Example

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ISO15414

- **« Information Technology – Open Distributed Processing Reference model – Enteprise Language »**
- **Developed by ITU**
  - International Telecommunication Union – ITU-T X.911
- **Proposed « Enterprise language » in the more global context of RM-ODP**
  - Reference Model of Open Distributed Processing
 - ISO10746-1/2/3/4 - ITU-T X901/2/3/4
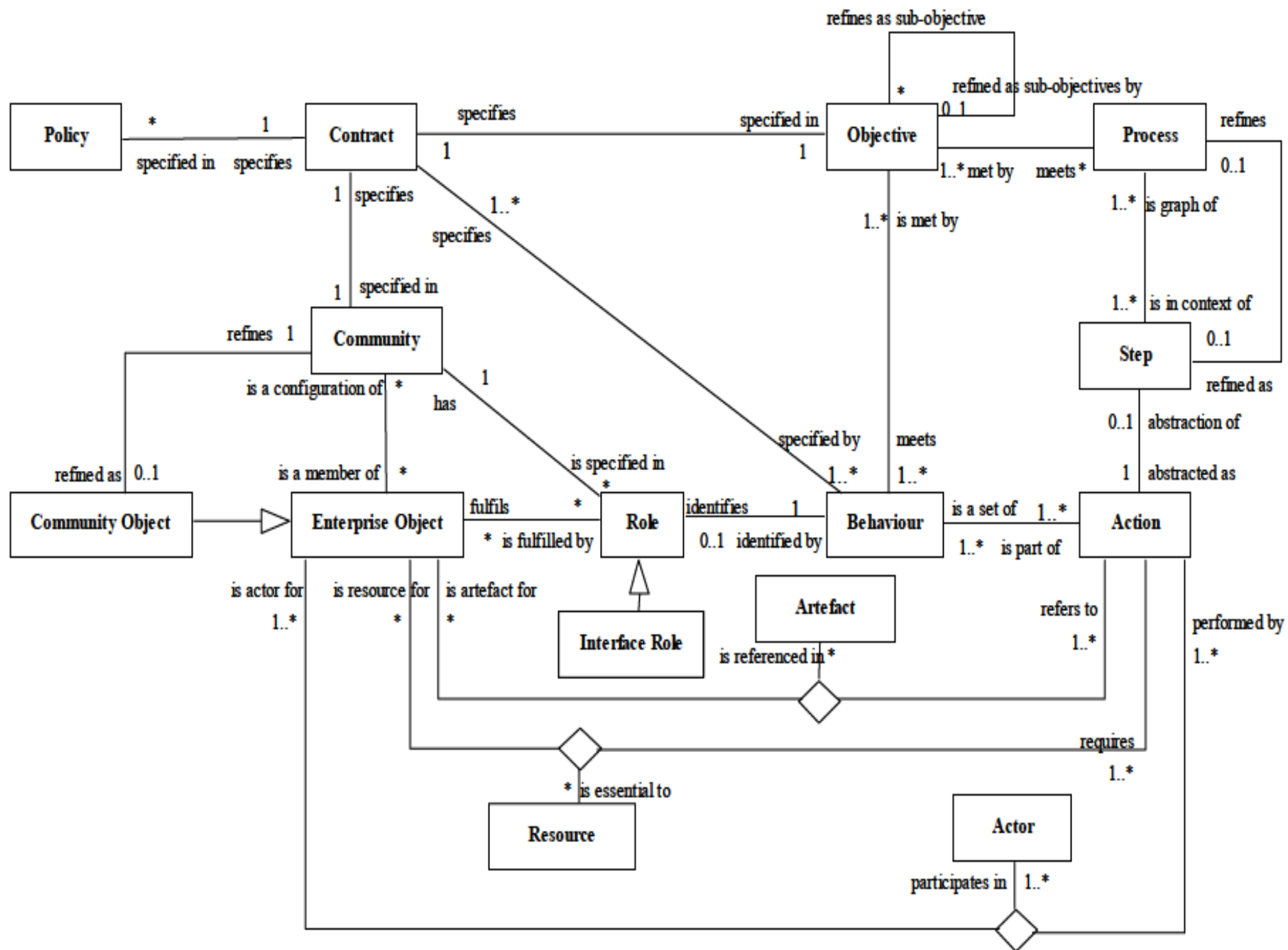
ISO15414 concepts

- **System concepts**
  - Scope, Field of Application
- **Community concepts**
  - Onjective, Community object
- **Behaviour concepts**
  - Actor, Artefact, Resource, Interface Role, Process, Step
- **Policy concepts**
  - Policy, Authorization, Violation
- **Accountability concepts.**
  - Party, Commitment, Declaration, Delegation, Evaluation, Prescription, Agent, Principal
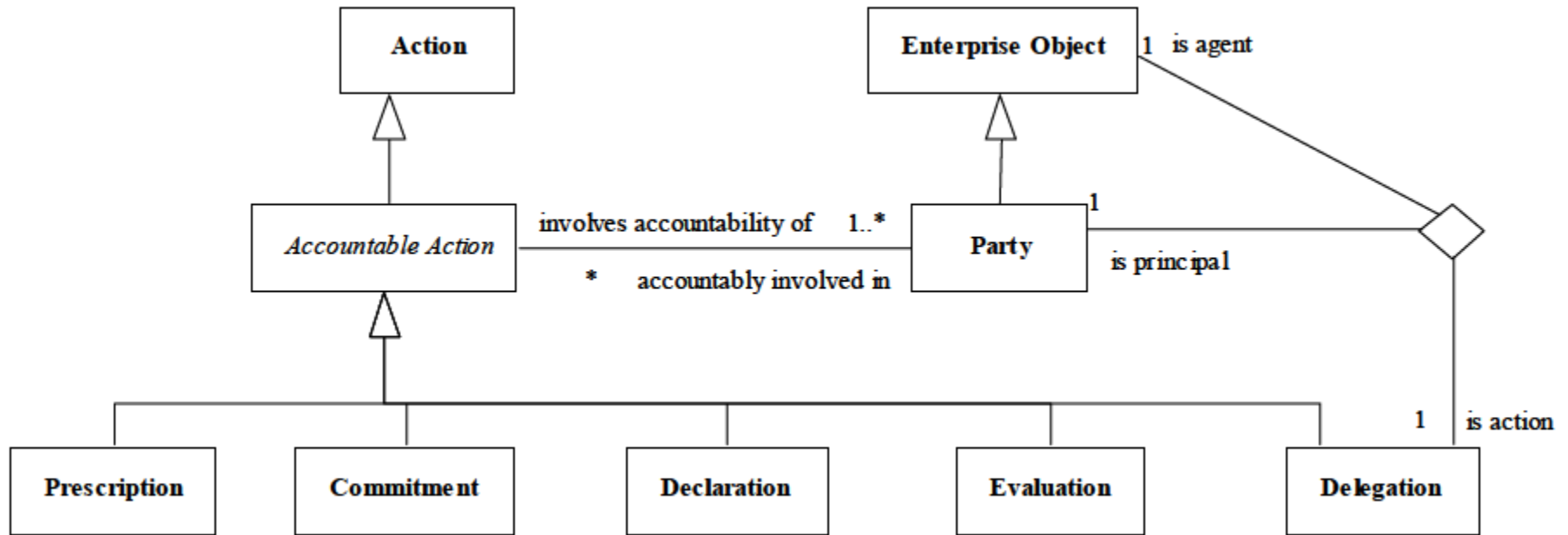
ISO15414 Structuring rules

- **Community rules**
- **Enterprise object rules**
- **Common community types**
- **Lifecycle of a community**
- **Objective rules**
- **Behaviour rules**
- **Policy rules**
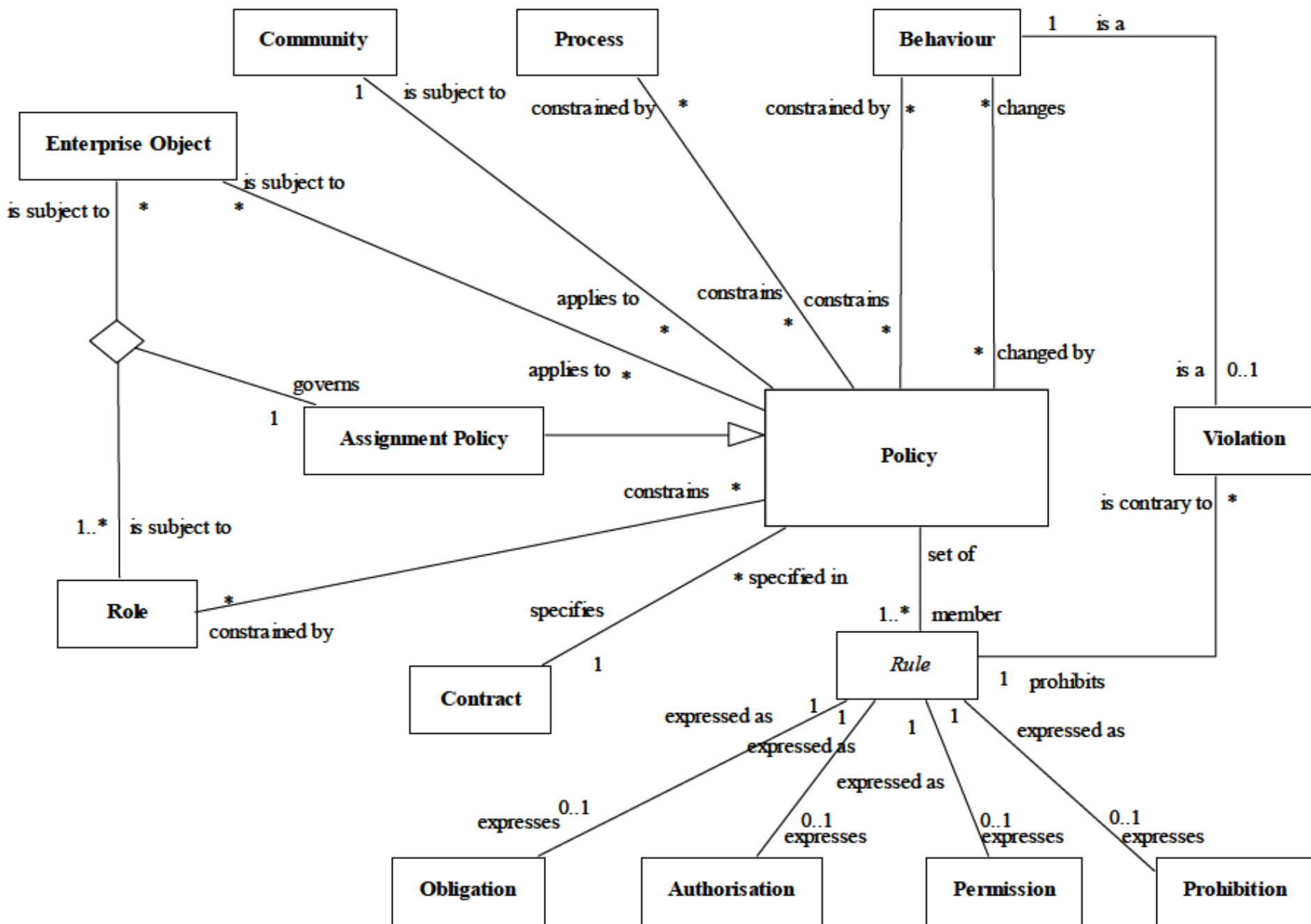- **Accountability rules**

System concepts
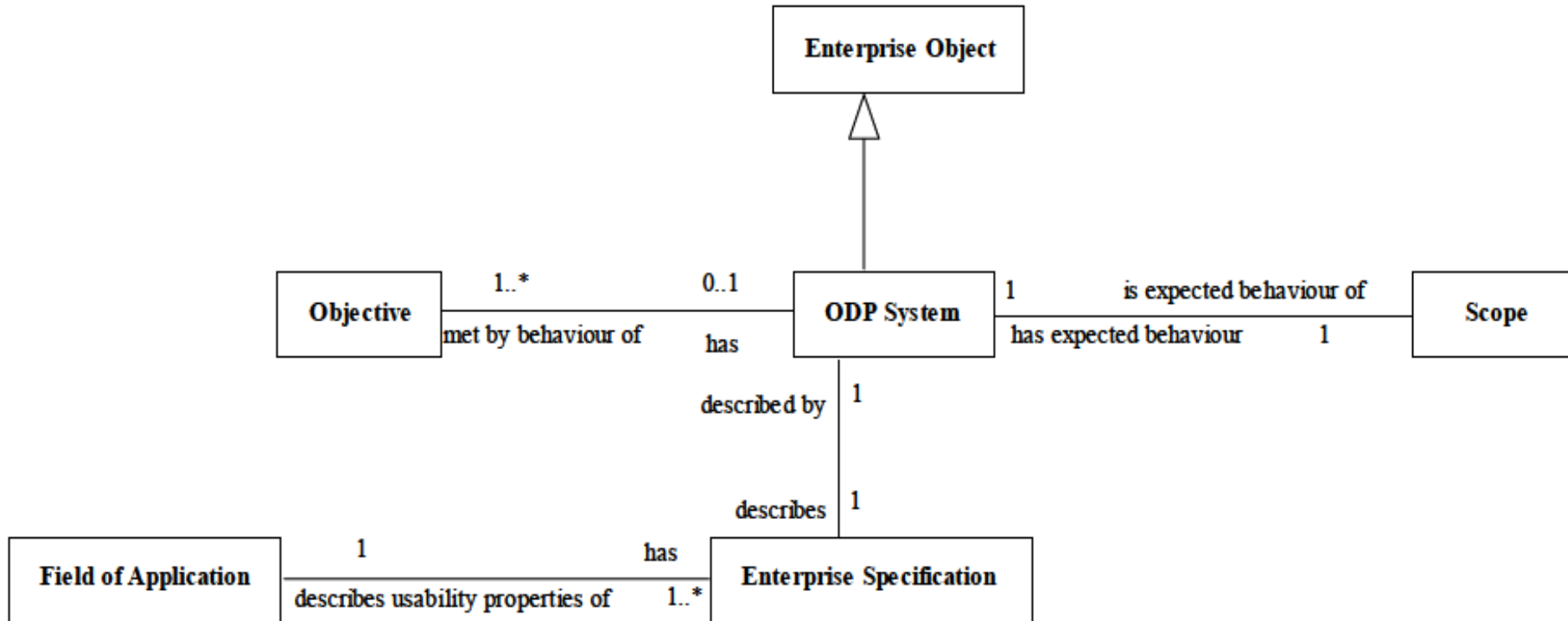
Policy concepts

Accountability concepts

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ISO19440

- **Defines the generic concepts for enterprise models**
  - provides common semantics
  - enables the unification of models developed by different stakeholders
- **These concepts can be**
  - specialized / organized for specific purposes,
  - used for developing particular models for a particular enterprise.
- **General requirements computer supported enterprise modeling**
  - Business Processes model (dynamics, functions, information, resources, organization and responsibilities)
  - Detailing and qualification of enterprise components for a specific enterprise,
  - Support for management of change,
  - end-user-oriented representation to enable operational use.

ISO19440 « constructs »

- **The standard describes in detail the following concepts**
  - ➢ Function- and process-related:
    - ▪ Domain, Business Process, Enterprise Activity, Event
  - ➢ Information-related:
    - ▪ Enterprise Object, Enterprise Object View, Order, Product
  - ➢ Resource-related:
    - ▪ Capability, Operational Role, Resource, Functional Entity
  - ➢ Organization-related:
    - ▪ Person Profile, Organizational Role, Organization Unit, and Decision Centre.
- **These concepts can be specialized**
  - ➢ Any enterprise concept shall be derivable from this list

Example of « Business Process » - Header

Construct label	['BP']
Identifier	[<model-unique string>]
Name	[name of Business Process instance in the form: <adjective> <noun>, where <noun> relates to the scope of the Business Process, <adjective> qualifies the business Process instance]]
Design Authority	[<identifier> / <name> of Organisational Unit or Organisational Cell with the authority to design/maintain this particular instance]

Example of « Business Process » - Descriptives

DESCRIPTION	[textual description]
OBJECTIVES	[non-empty list of Objectives to be fulfilled by the Business Process instance
CONSTRAINTS	['NIL' or list of Constraints imposed on the BP instance]
PERFORMANCE INDICATORS	['NIL' or list of the metrics or measures by which achievement of the objectives can be assessed]
DECLARATIVE RULES	['NIL' or list of Declarative Rules applicable to this Business Process instance]
INPUTS	[non-empty list of <identifier> / <name> of all Object View instances, occurrences of which can be received by occurrences of the Business Process instance] [non-empty list of <identifier> / <name> / <source domain> of all Events, instances of which can be received by

Example of « Business Process » - Descriptives

OUTPUTS	[non-empty list of <identifier> / <name> of all Object View instances, occurrences of which can be sent by occurrences of the Business Process instance] [non-empty list of <identifier> / <name> / <sink domain> of all Events, instances of which can be sent by occurrences of the Business Process instance]
PROCESS BEHAVIOUR	[non-empty set of Behavioural Rules expressed using the syntax defined for Process Behaviour as defined in 6.3.3]
PRIORITY	[Integer in a range <min, max> where min and max are integers representing the lowest and highest priorities respectively]

Example of « Business Process » - Relationships

WHERE USED	[<identifier> / <name> of the Domain employing this Business Process instance]
CONSISTS OF	[non-empty list of <identifier> / <name> of all Business Process and Enterprise Activity instances that are employed directly (i.e. at the next level of decomposition) by this Business Process instance]
Operation Responsibility	[<identifier> / <name> of Organisational Unit or Organisational Cell with responsibility for operation of this instance
Operation Authority	[<identifier> / <name> of Organisational Unit or Organisational Cell with authority for operation of this instance]

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ISA-88/ISA-95 set of standards

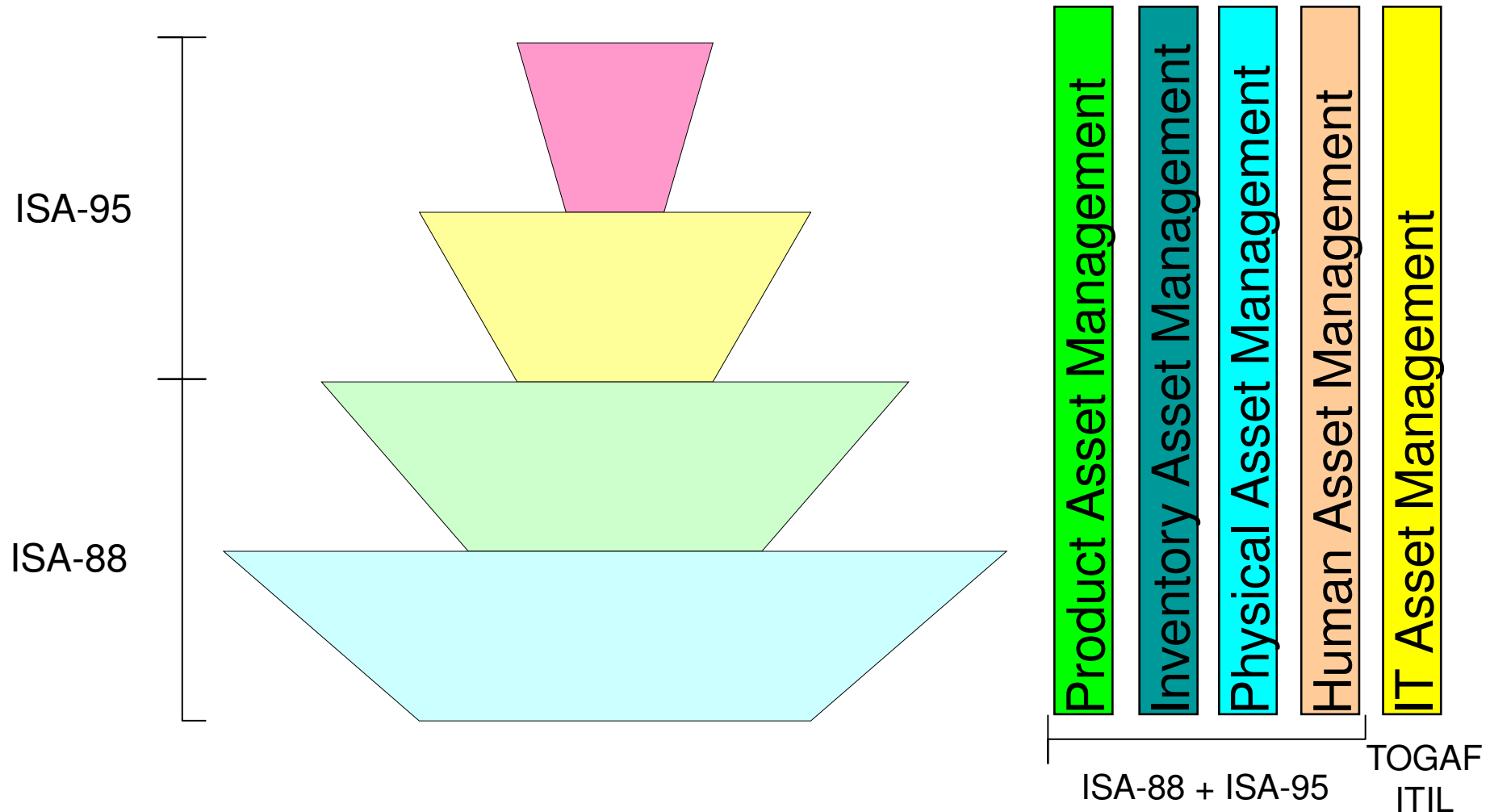| US standard	INTL Standard	Sub Title
ANSI/ISA-88.00.01: 1995	IEC61512-1: 1997	Models and Terminology"
ANSI/ISA-88.00.02: 2001	IEC61512-2: 2001	Data structures and guidelines for languages
ANSI/ISA-88.00.03: 2003	IEC61512-3: 2008	General and Site Recipe - Models and Representation
ANSI/ISA-88.00.04: 2006	IEC61512-4: 2009	Batch Production Records
ISA Draft88.00.05	-	Implementation Models & Terminology for Modular Equipment Control
ANSI/ISA-95.00.01: 2000	IEC/ISO62264-1: 2003	Models and Terminology"
ANSI/ISA-95.00.02: 2001	IEC/ISO62264-2: 2004	Data Structures and Attributes"
ANSI/ISA-95.00.03: 2005	IEC/ISO62264-3: 2006	Activity Models of Manufacturing Operations Management
ISA draft 95.00.04	-	Object Models and Attributes of Manufacturing Operations Management)
ASNI/ISA-95.00.05: 2007	IEC/ISO62264-5: 2009	Business to Manufacturing Transactions

ISA88 snapshot

- **Object Design of automation applications**
  - Reuse, Knowledge Management, Robustness
- **Flexible Design of automation applications - No programming required for**
  - Modification of recipes, making different products with the same facility
  - Using alternate equipment for the same production step
  - Sequencing production runs for different products
- **Interoperability**
  - Assembling software components from different origins
- **Product Industrialization**
  - Neutral specification of product physico-chemical transformations
  - Conversion of this specification into operating procedure for target facilities
- **Production Information**
  - Data structures for production information history
  - Includes several ISA95 models
- **Applications**
  - Initially designed for Batch processes, but applicable to any type of process
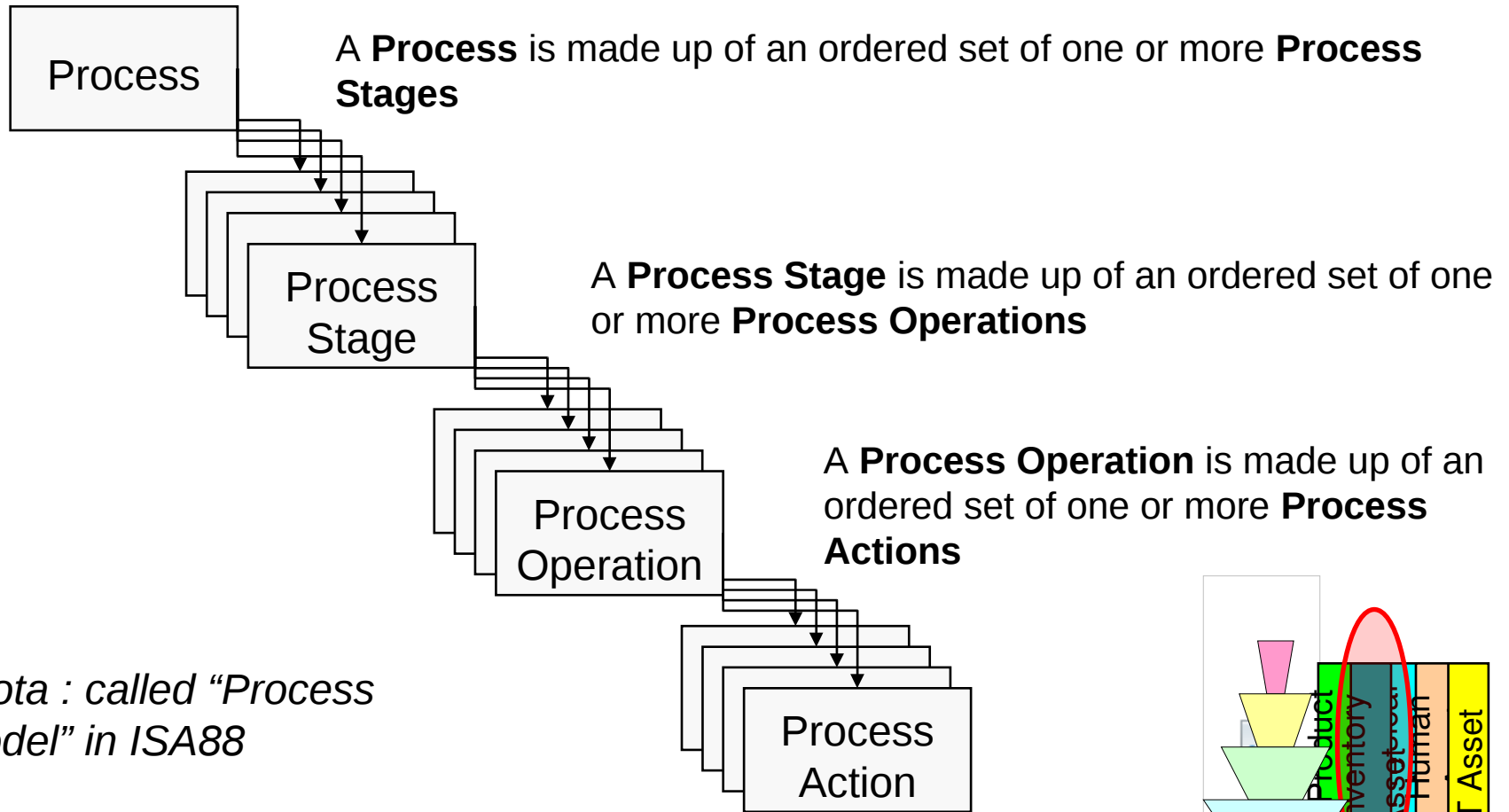 - Functional specification, batch managers, historians, PDM/PLM

ISA95 snapshot

- **B2M: Collaboration Business / Execution**
  - Communication between execution systems (MES/MOM, DCS, MMS, LIMS, WES, SCADA,…) and business systems (ERP, SCM)
  - Master data management
- **MES/MOM : Functional definition**
- **Data and Activity models**
  - Description of resources, capability, products, work order requests and reports
  - Definition of operation management activities (MES)
- **Applications:**
  - User requirements and functional specification of MES and B2M interfaces
  - Native B2M connectors - MES/ERP (B2MML)
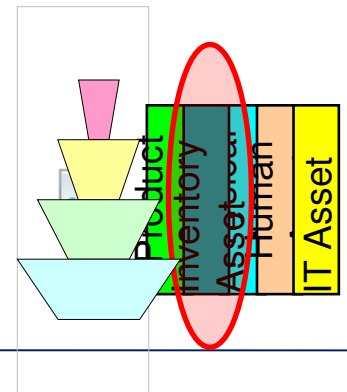 - Possible basis for developing MES applications and software…

ISA-88/ISA-95 modelling overview
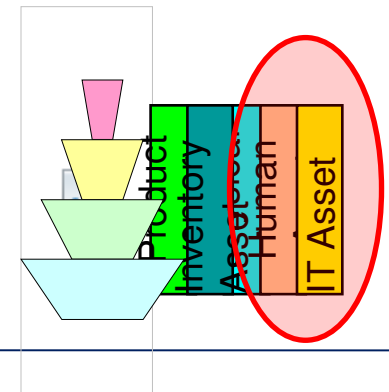

ISA-95

ISA-88

Product Asset Management
Inventory Asset Management
Physical Asset Management
Human Asset Management
IT Asset Management

ISA-88 + ISA-95

TOGAF
ITIL

ISA88 Product model* (Processing Requirement)

Process

A **Process** is made up of an ordered set of one or more **Process Stages**

Process Stage

A **Process Stage** is made up of an ordered set of one or more **Process Operations**

Process Operation

A **Process Operation** is made up of an ordered set of one or more **Process Actions**

Process Action

Nota : called "Process Model" in ISA88

Product

Inventory

Asset

Human

IT Asset

Resource models (Structural description)

- **The resource asset models (Personnel, Equipment, and Material) are based on the ISA95 breakdown.**
- **All these resources share a similar pattern. Equipment and Material are indeed the same entity: A "machine" can be:**
  - ➢ A "Physical Asset" for the company that makes products with it,
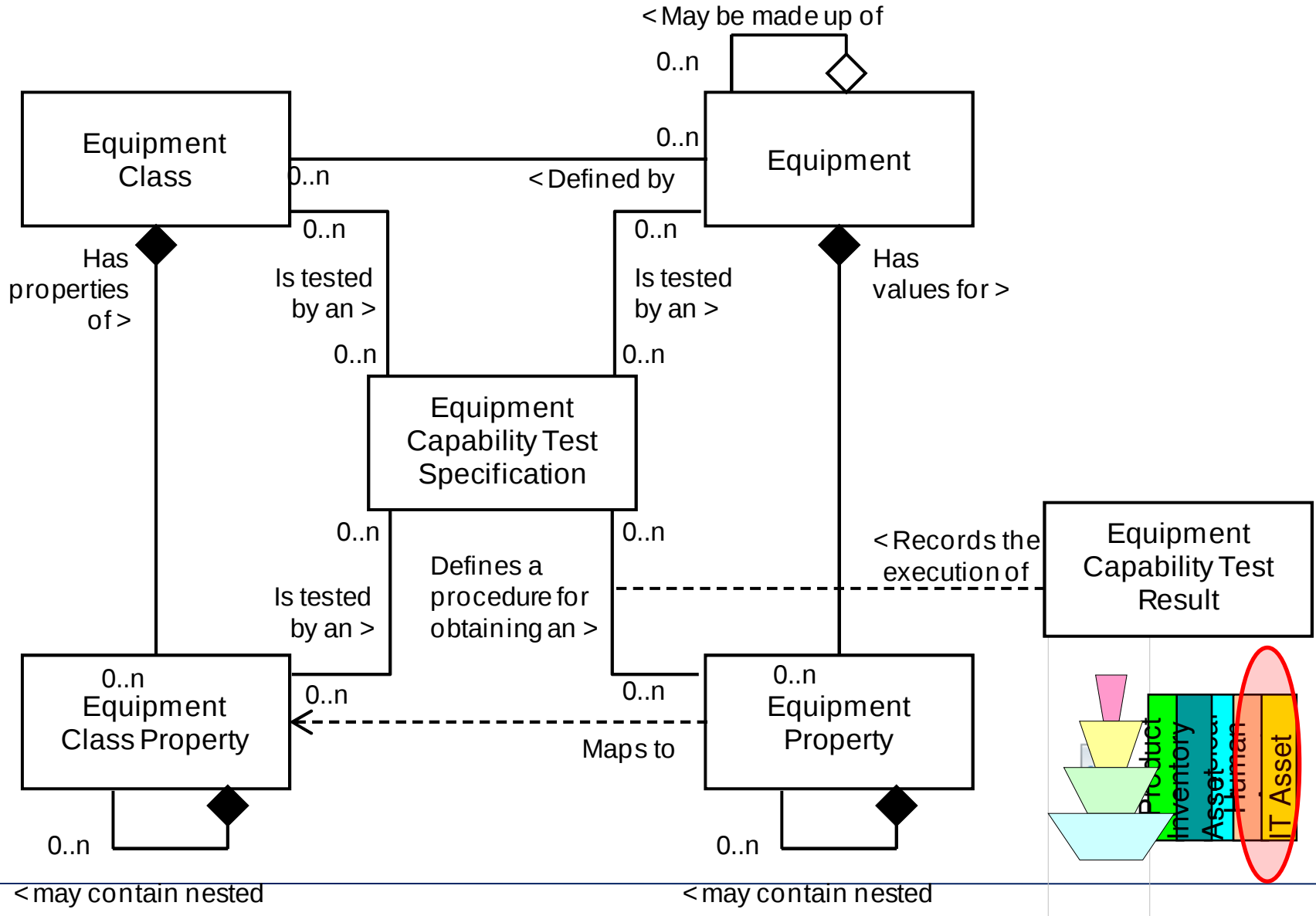 - ➢ An "Inventory Asset" for the company that makes them (finish product) or sell / distributes it
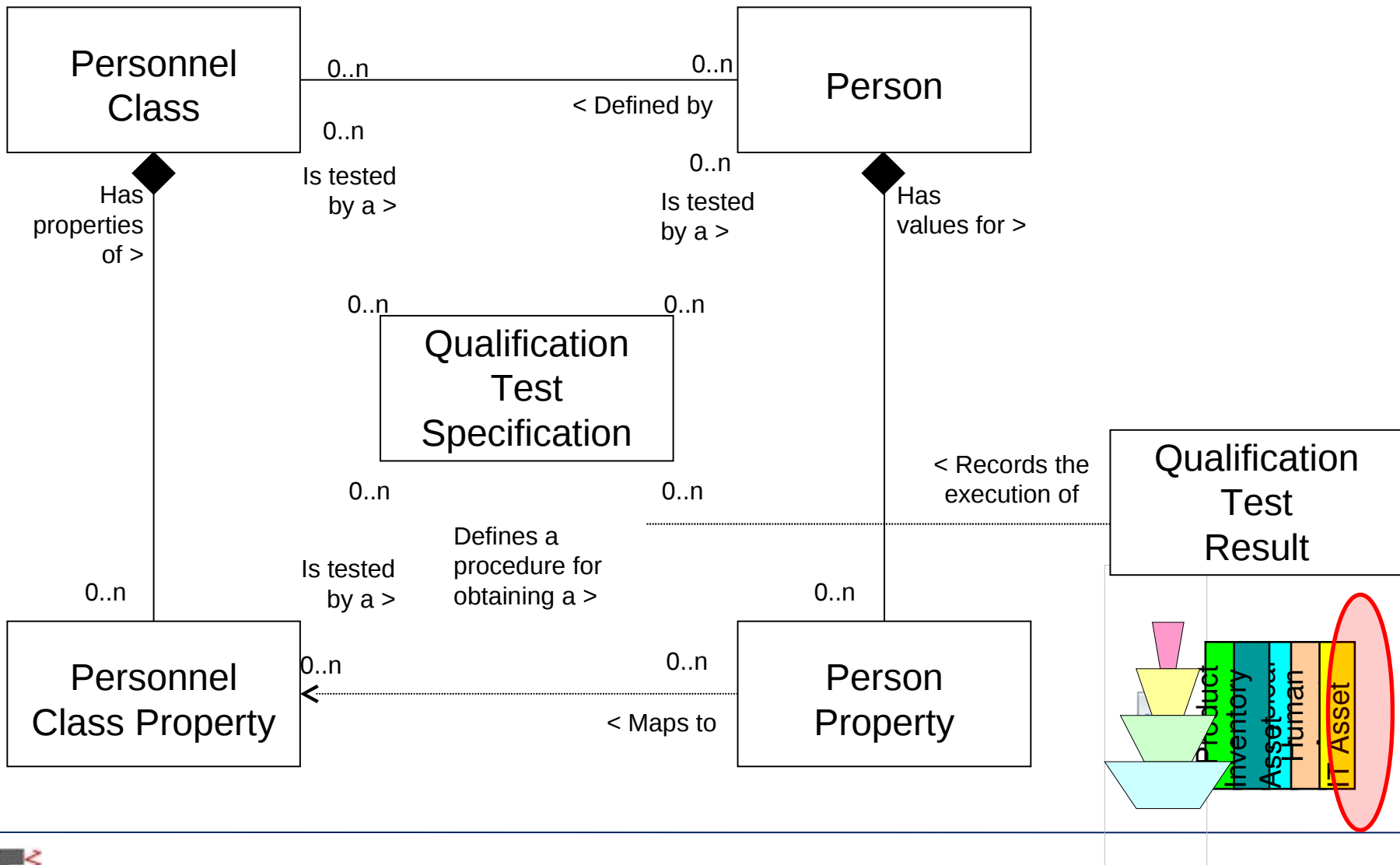
ISA95 Material Model
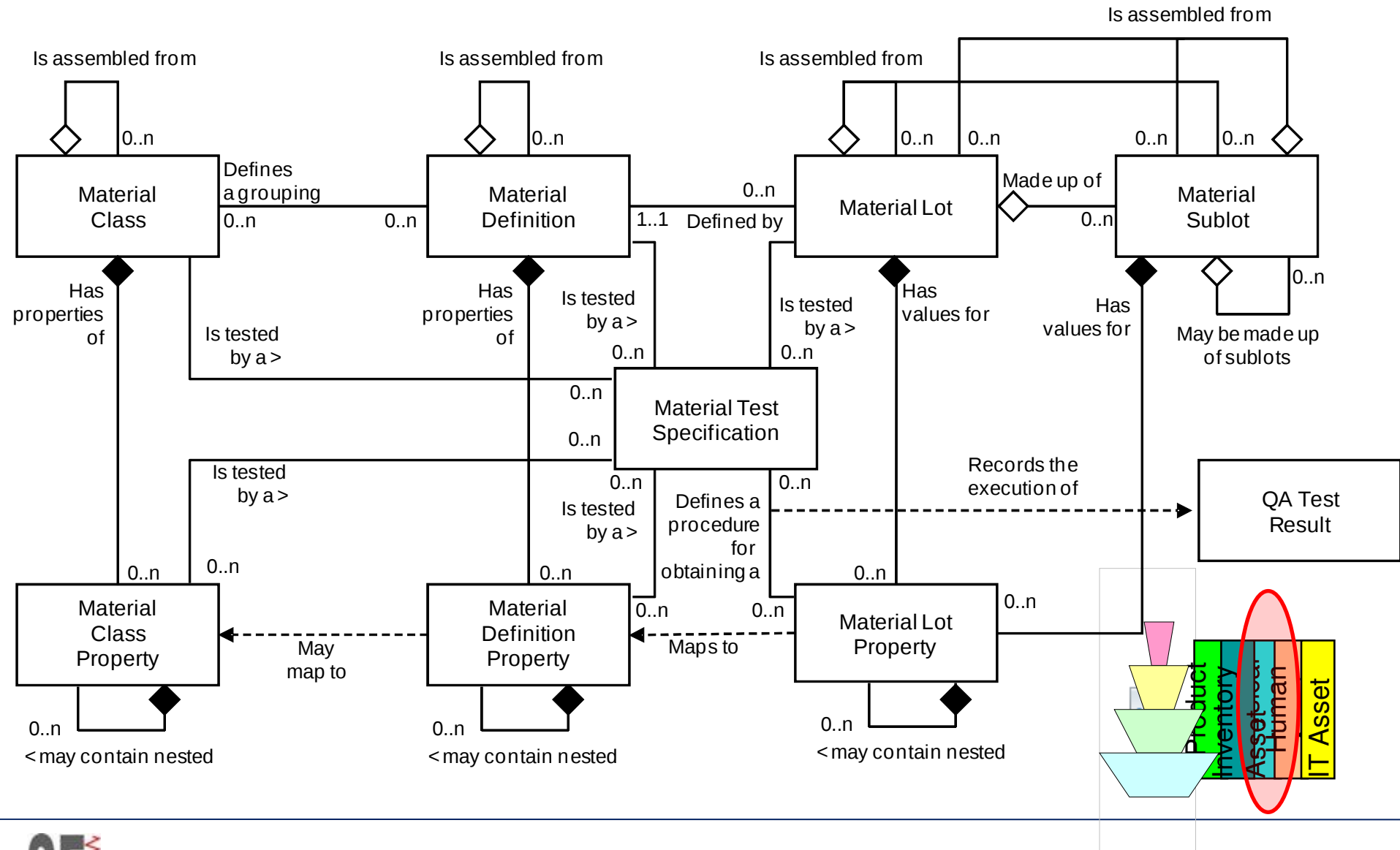
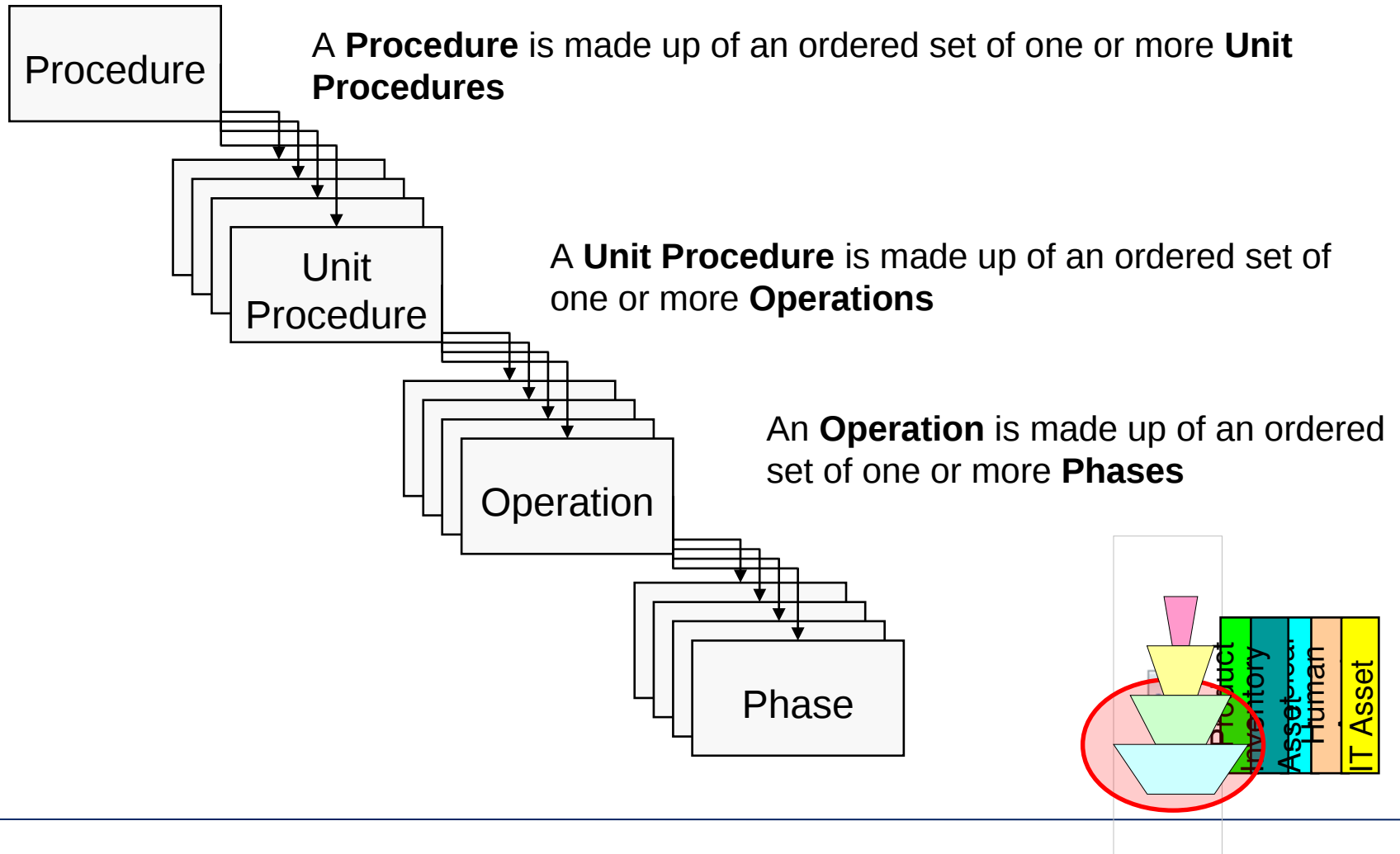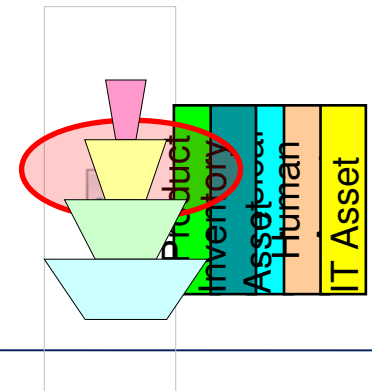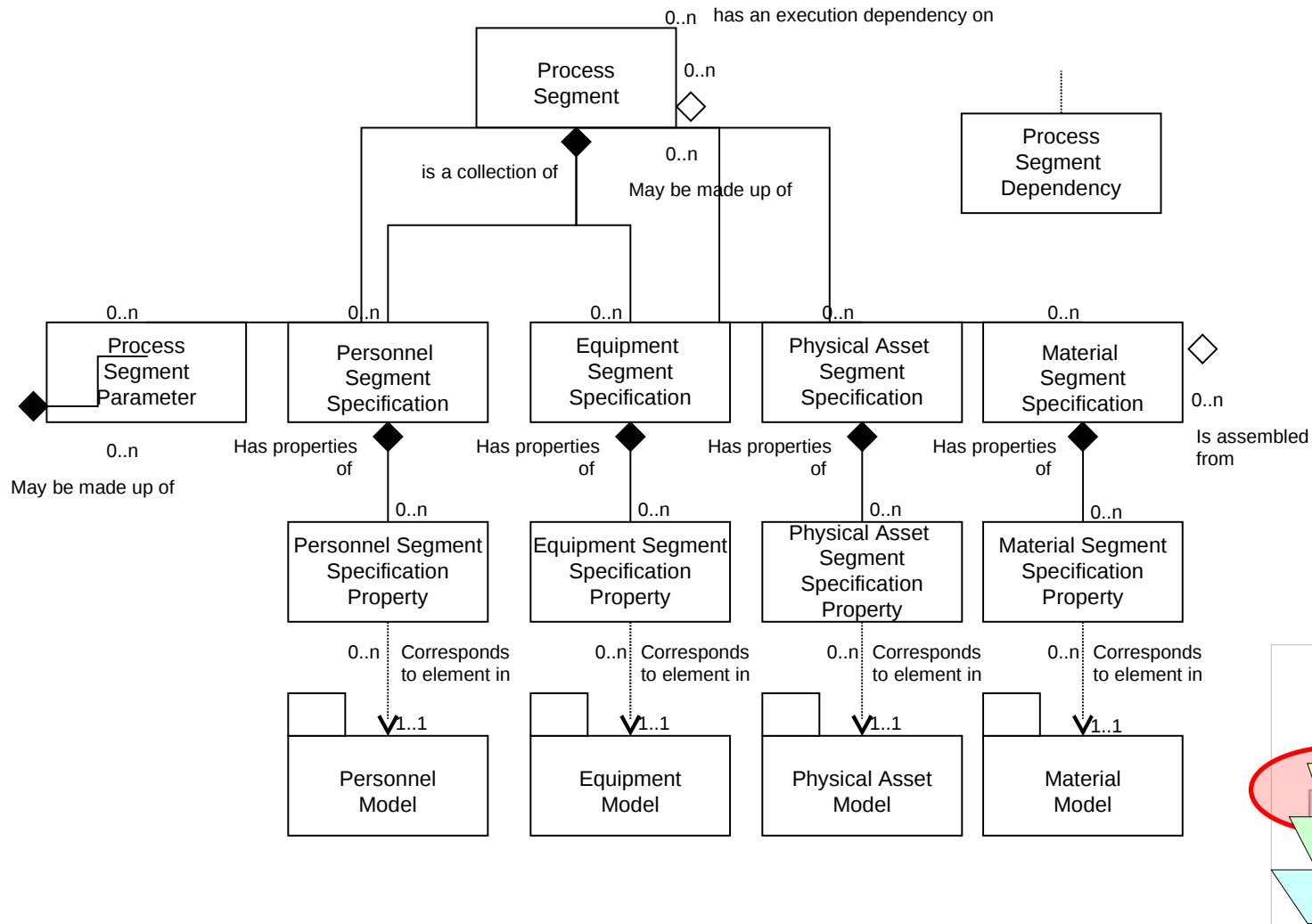# ISA95 extended physical model (Actual Facility layout)
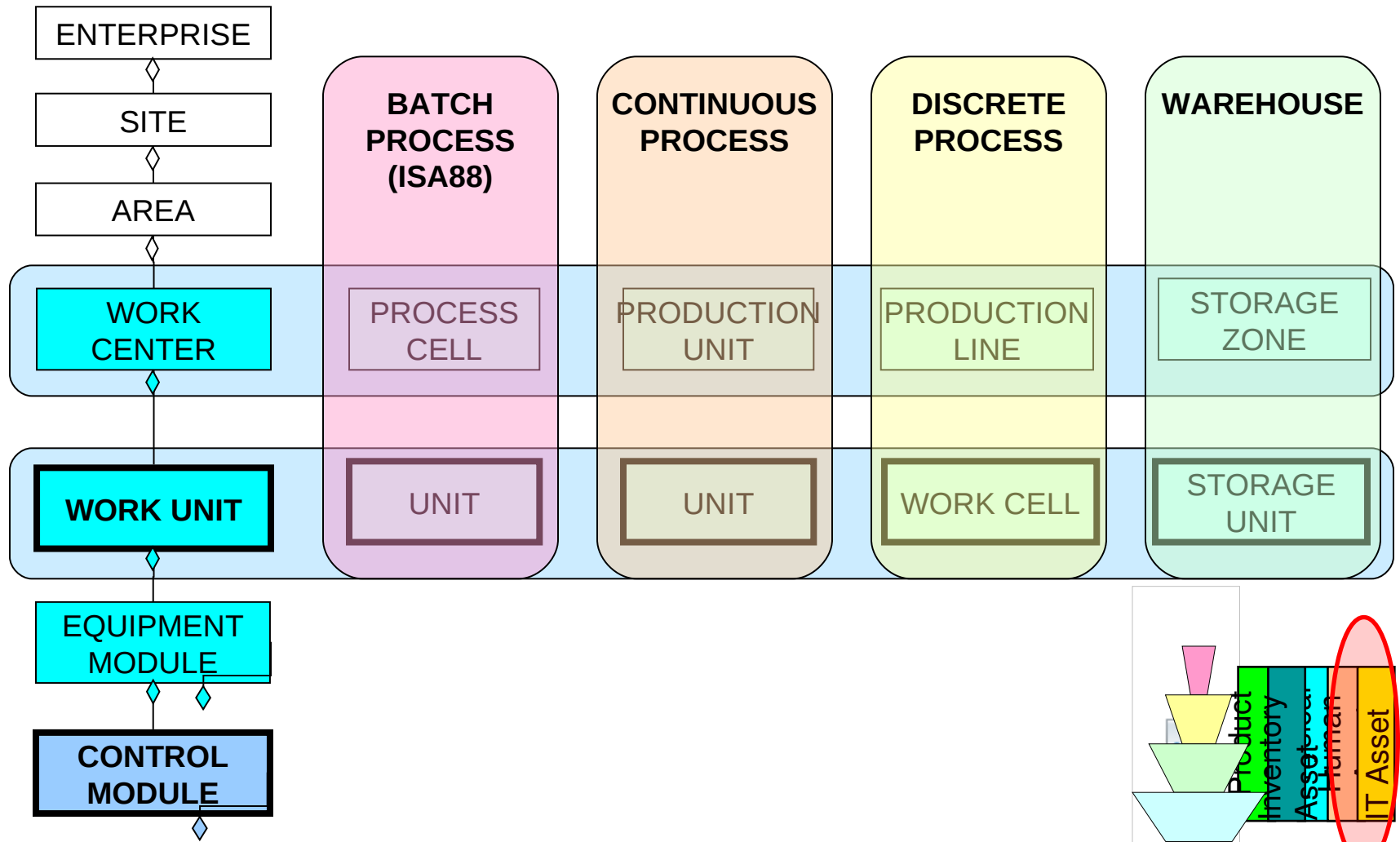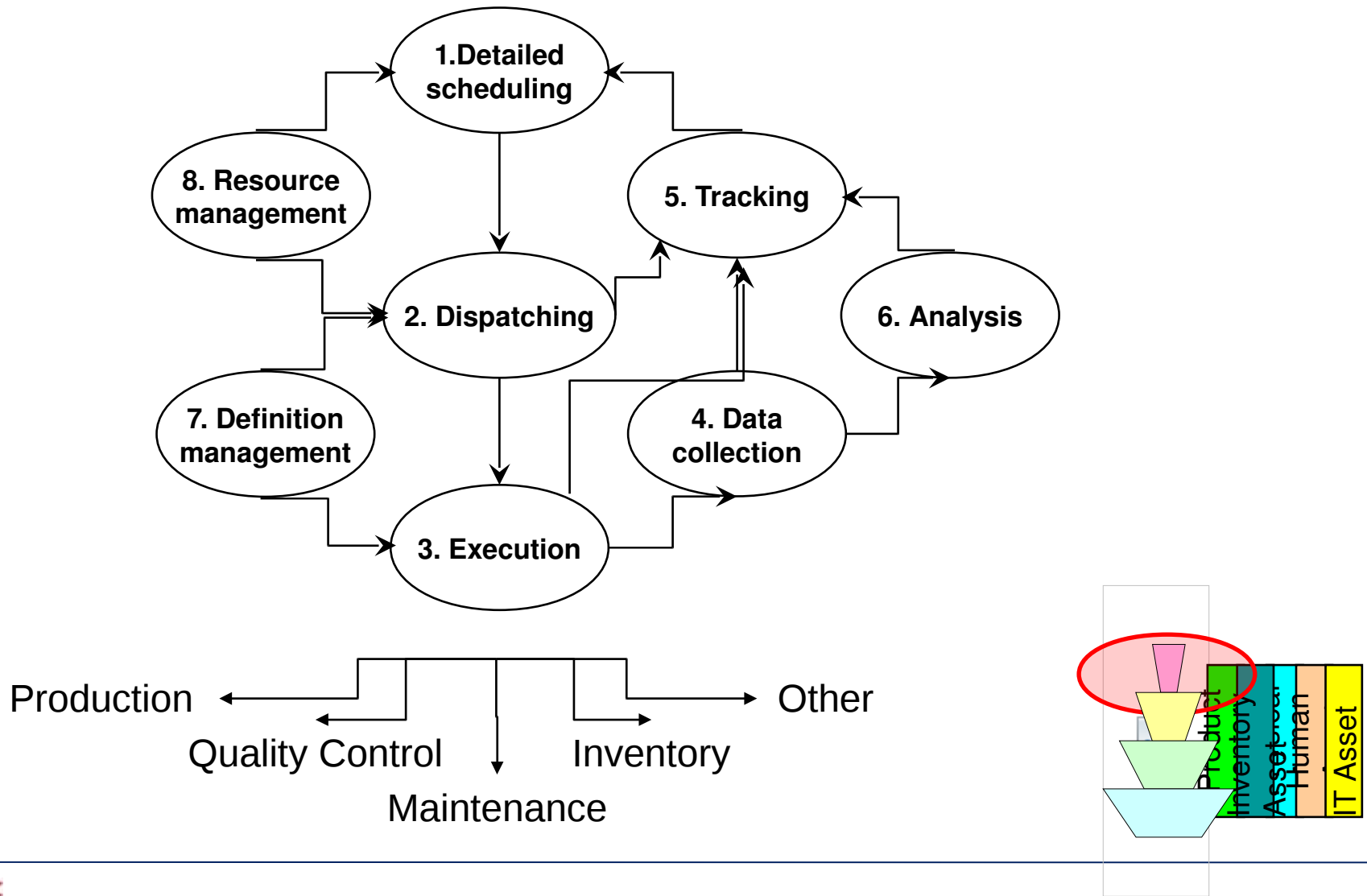
ISA95 Equipment Model

ISA95 Personnel Model

Personnel Class

0..n — < Defined by — 0..n Person

0..n Is tested by a >

Has properties of >

0..n Is tested by a >

Has values for >

Qualification Test Specification

0..n — 0..n

0..n — 0..n

< Records the execution of

Qualification Test Result

Defines a procedure for obtaining a >

Is tested by a >

0..n

Personnel Class Property

0..n — < Maps to — 0..n Person Property

0..n

ISA88 Procedural model (Equipment/Product Interactions)

Procedure

A **Procedure** is made up of an ordered set of one or more **Unit Procedures**

Unit Procedure

A **Unit Procedure** is made up of an ordered set of one or more **Operations**

Operation

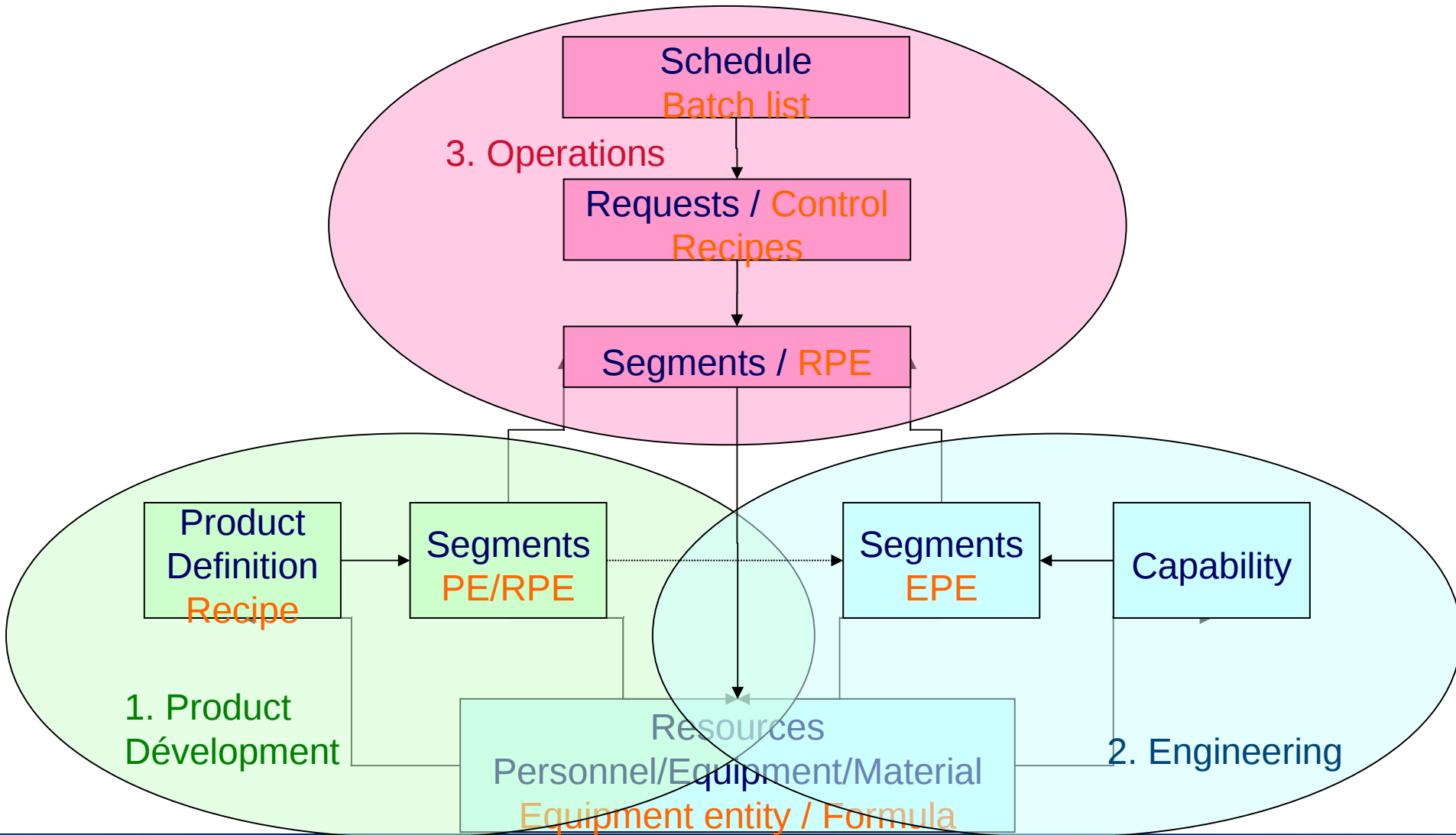An **Operation** is made up of an ordered set of one or more **Phases**

Phase
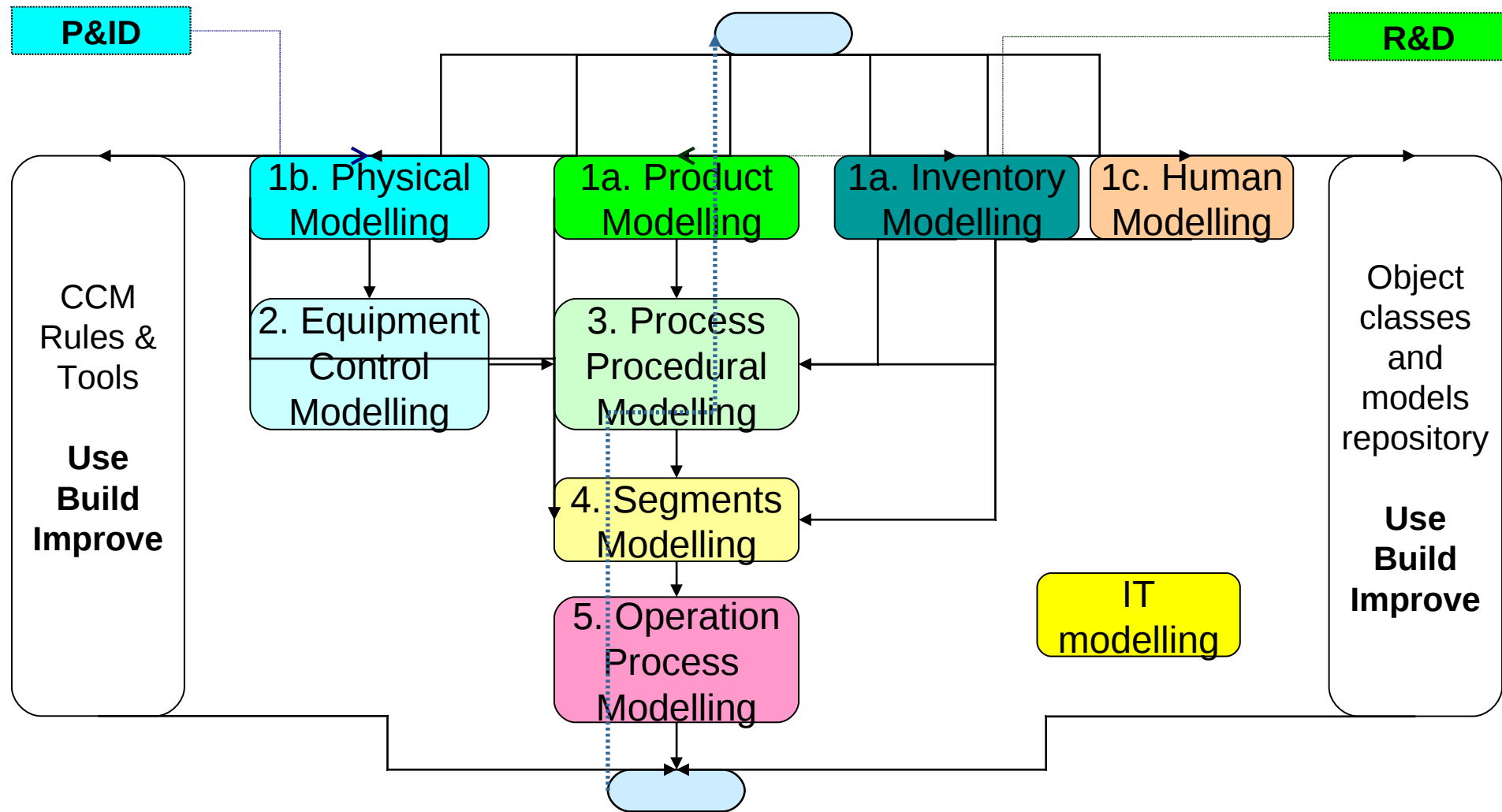
ISA95 Segment Model

ISA95 Operational Activity Model

ISA88 & ISA95 Objects in Production Lifecycles

Continuous modeling workflow

P&ID

R&D

1b. Physical Modelling

1a. Product Modelling

1a. Inventory Modelling

1c. Human Modelling

CCM Rules & Tools

Use Build Improve

2. Equipment Control Modelling

3. Process Procedural Modelling

Object classes and models repository

Use Build Improve

4. Segments Modelling
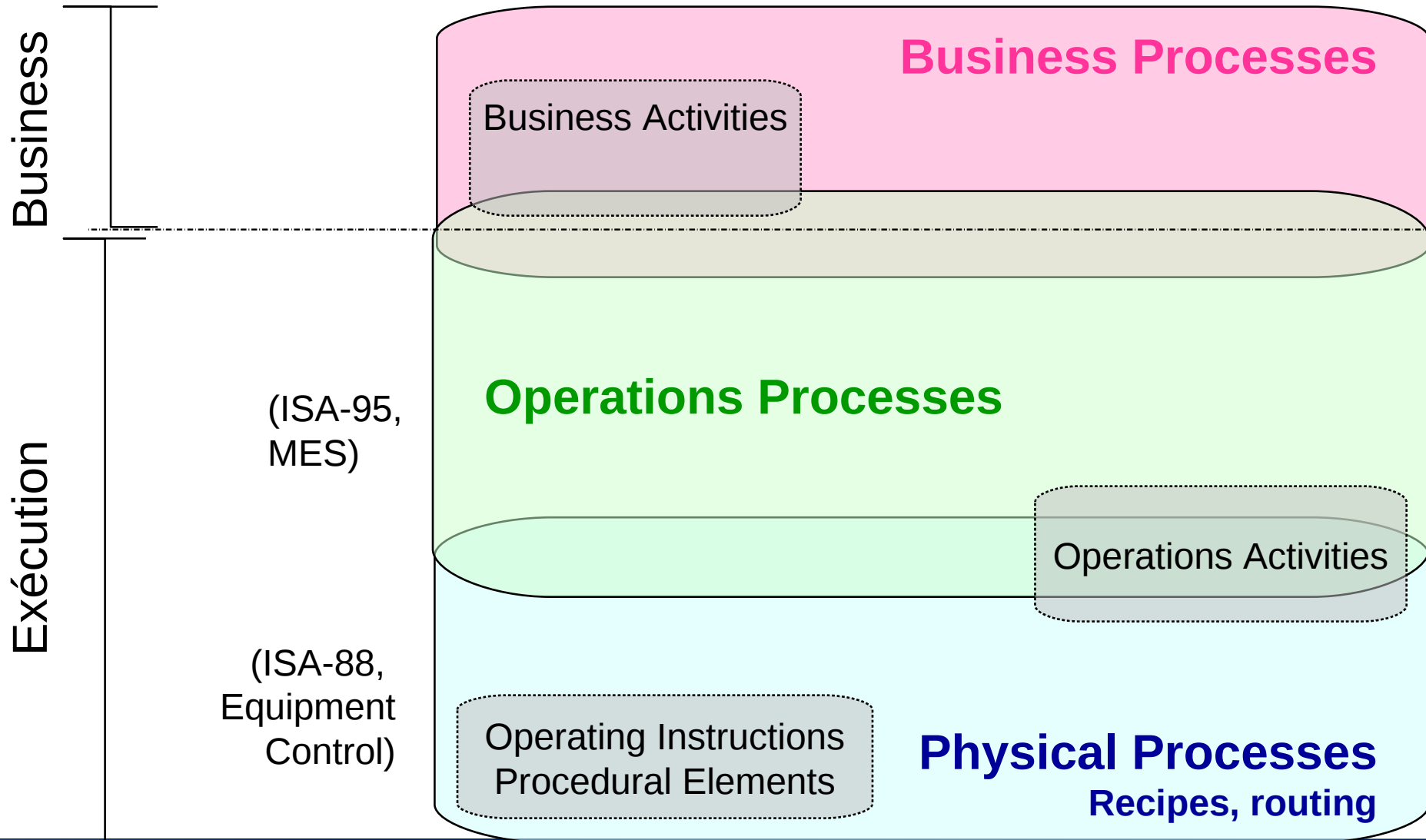
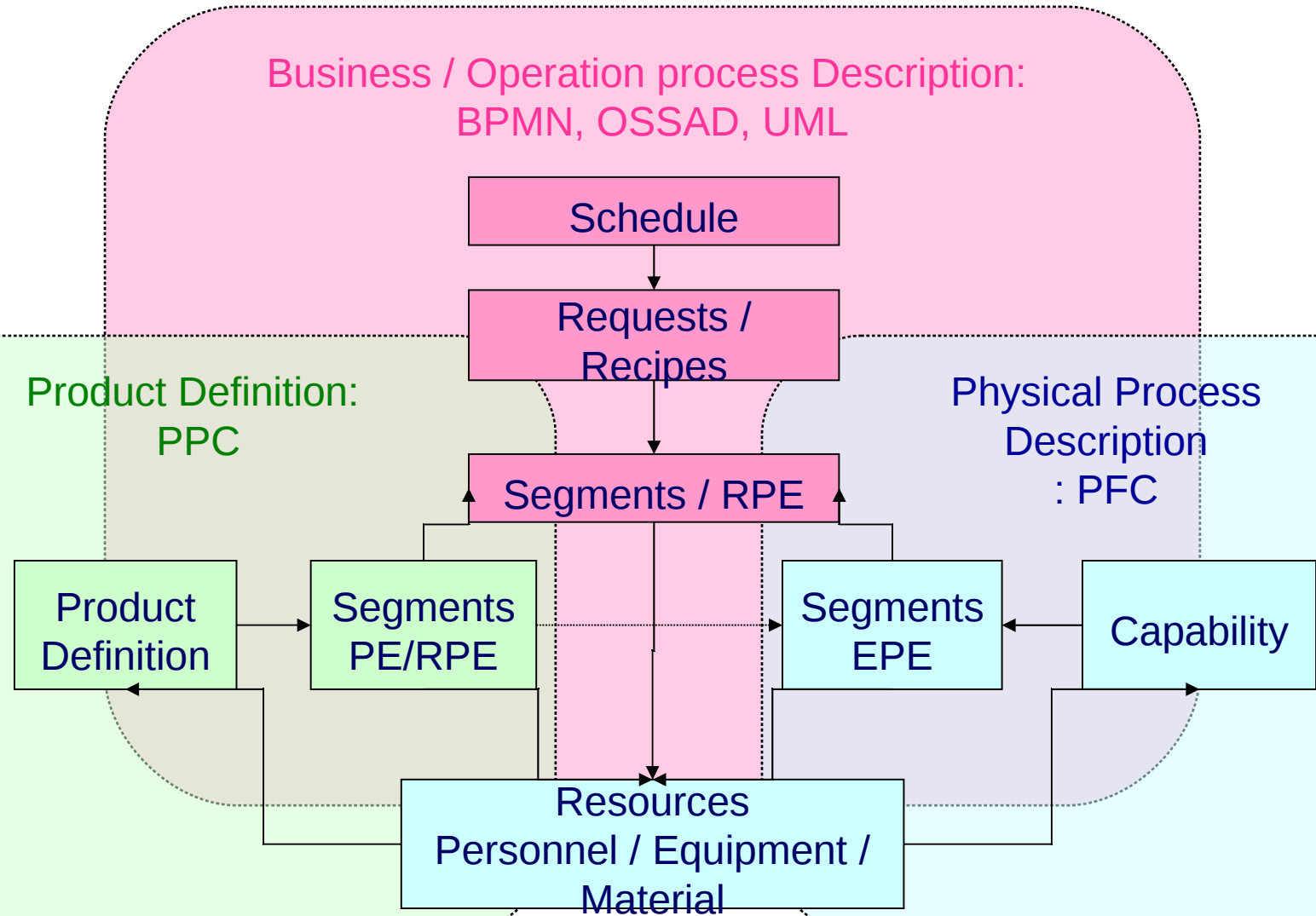5. Operation Process Modelling

IT modelling

Continuous modeling workflow
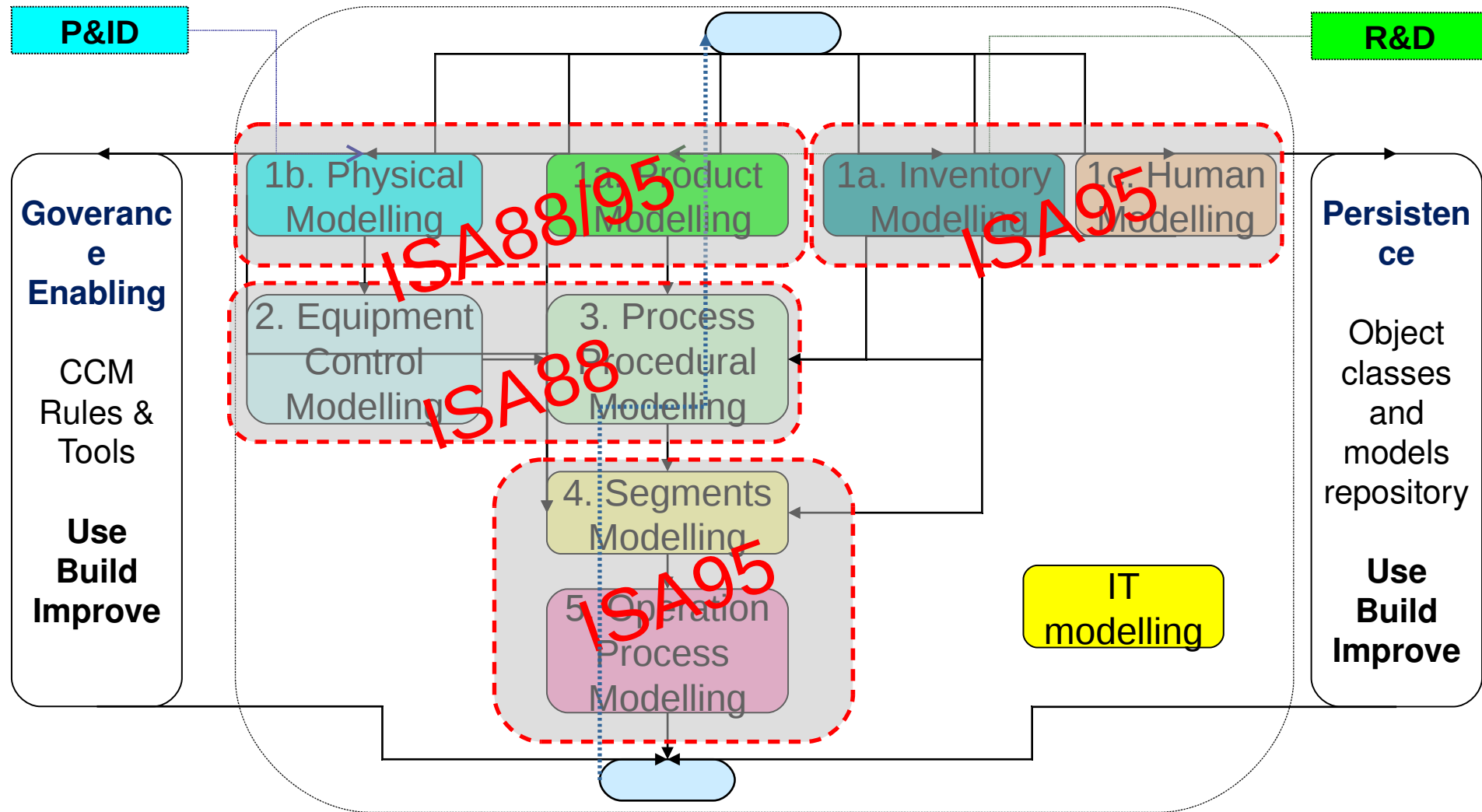
Interactions Hierarchy

Examples of Description standards

ISA-88/95 Modeling elements

| Domain	Model	Std	Information elements
Product Asset	Process Product	ISA88 ISA95	Product Hierarchy Product Definition
Inventory Asset	Material	ISA95	Material Resources
Equipment Asset	Physical Equipment	ISA88 ISA95	Equipment Hierarchy Equipment Resources
Human Asset	Personnel	- ISA95	Personnel Hierarchy Personnel Resources
Equipment Control	Procedural	ISA88	Functional Hierarchy Equipment Procedural Elements
Physical Process Control	Procedural	ISA88	Physical Processes / Procedural Elements Physical Process Transform Components
Physical Process Mngt	Segment	ISA95	Segments
Operation Process Mngt	Operation Activity	ISA95	Operation Processes Activities / Tasks

Cliquez sur l'icône pour ajouter un tableau

- **Introduction**
- **ISO15000-5 UN/CEFACT CCTS**
- **OPC UA**
- **ISO15926**
- **ISO15414**
- **ISO19440**
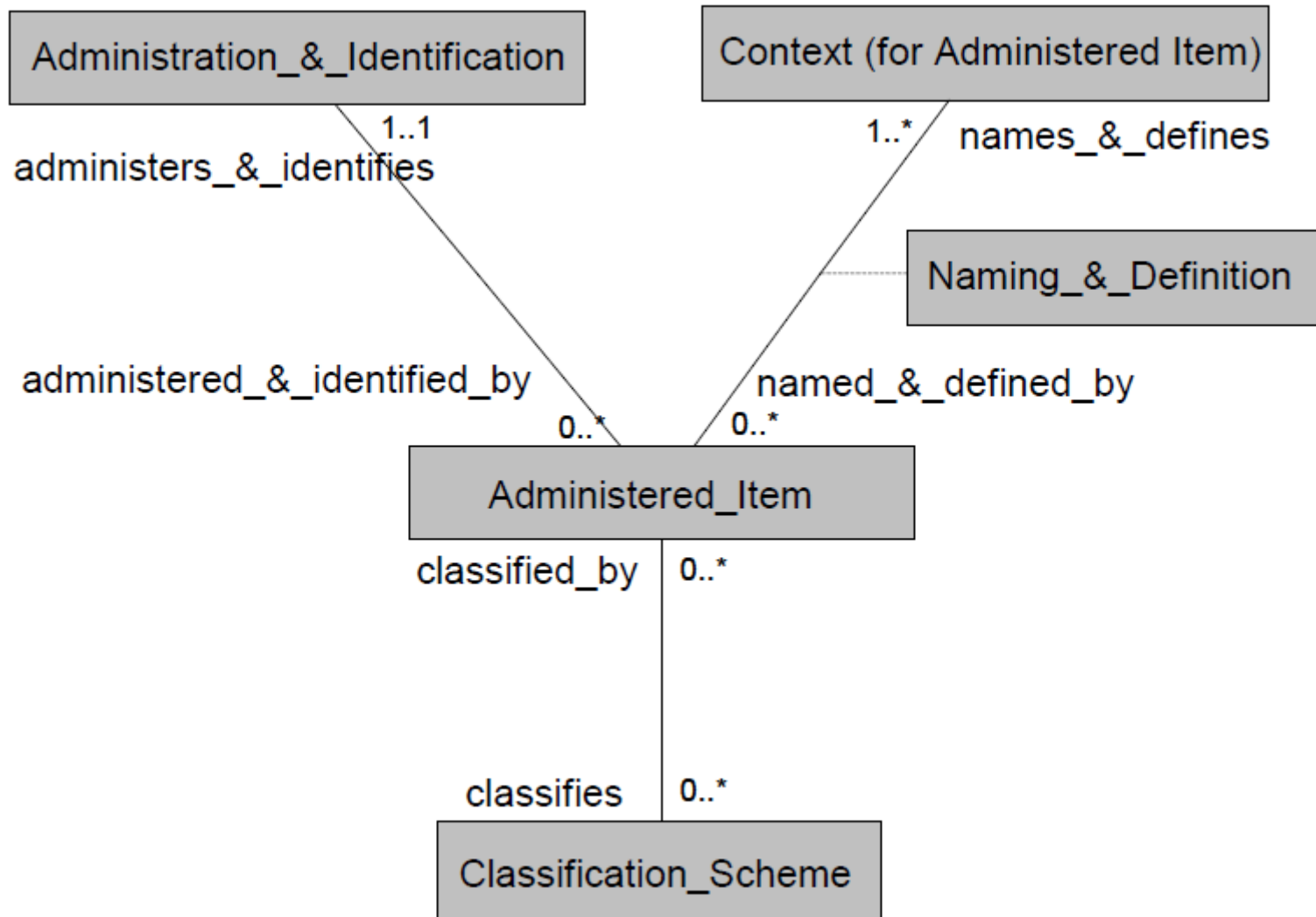- **ISO62264/ISA-95 + IEC61512/ISA-88**
- **ISO11179**

ISO11179

- **A semantic registry records all concepts as lexicon of unique terms**
- **They can be categorized i.e.**
  - Basic vocabulary
  - Abstract concepts (not specific to a particular business context)
    - Simple, Enumerated or Non enumerated
    - Complex
  - Business concepts (meaningful in specific situations)
- **ISO11179**
  - Supports semantic definition
  - Also register data representation
    - occurrences of concepts in actual situations – IT solution, local terminologies
  - Handles reference data management
  - Define principles for consistent naming and clear descriptions

ISO 11179

- **Titre: Information technology — Metadata registries (MDR)**
  - Part 1: Framework
    - Vue d'ensemble
  - Part 2: Classification
    - Extrait du méta-modèle partie 3 concernant la classification
  - Part 3: Registry metamodel and basic attributes
    - Définit le meta-modèle pour gérer les données de référence
  - Part 4: Formulation of data definitions
    - Définit des principe pour exprimer clairement les définitions
  - Part 5: Naming and identification principles
    - Définit des principes d'identification et de nommage
  - Part 6: Registration
    - Définit le processus d'enregistrement des méta-données

ISO11179 meta model
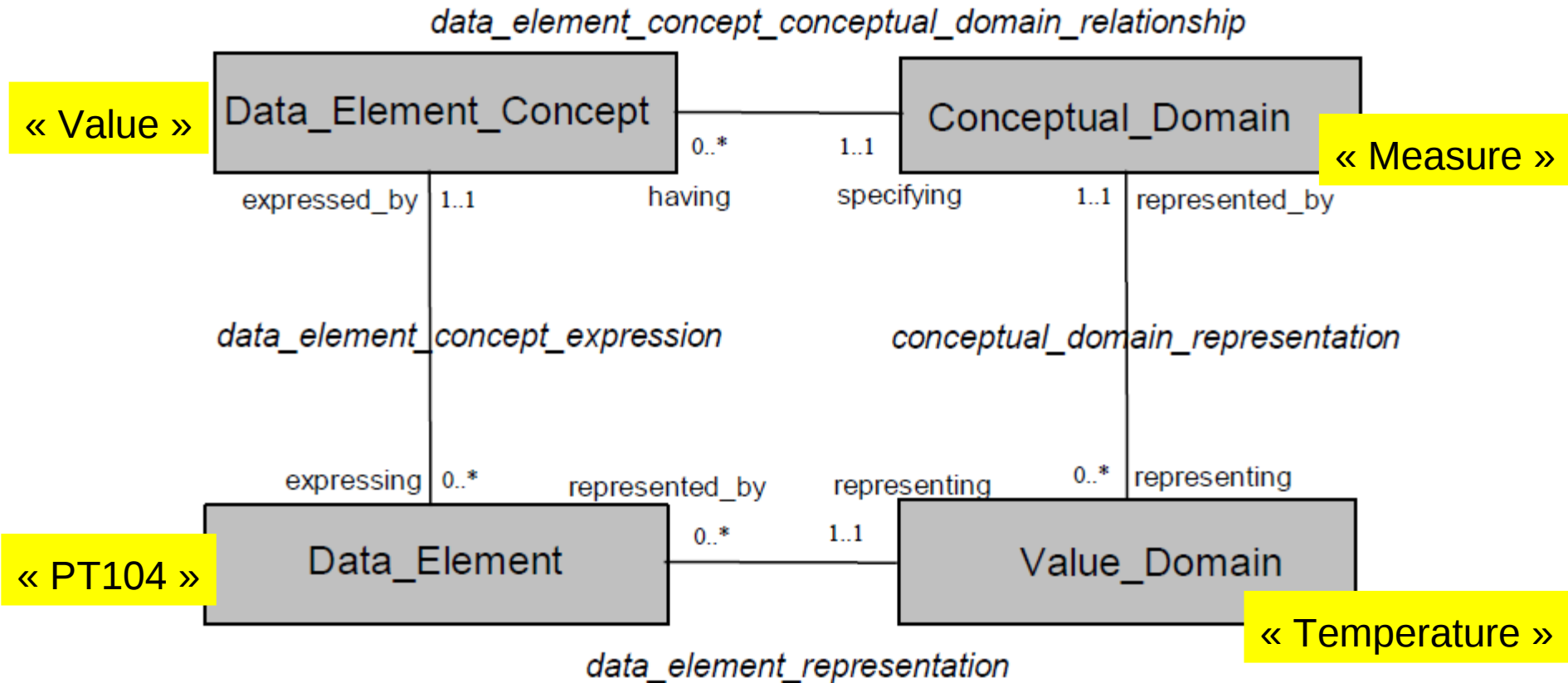
ISO11179 data administration

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- **ISO19440**
- **ISO62264/ISA-95 + IEC61512/ISA-88**
- **ISO11179**
- **Next steps**

- **Interoperability is a key element for enabling interactions**
  - ➢ Developing knowledge and systemic intelligence of the enterprise
- **Language**
  - ➢ Is the precondition for intelligence
  - ➢ Transform interfaces in intereactions
- **A significant public knowledge is available**
  - ➢ From ISO and other standardization bodies
  - ➢ Helping to set a consistent basis for an Enterprise language
- **Enterprise language**
  - ➢ Allows to manage and leverage enterprise knowledge
    - ▪ Including Master Data
  - ➢ Provides global semantic reference refered to in collaboration
  - ➢ Provides formal concepts for interoperability
    - ▪ Meaningful messages between actors – People and IT

Thank You !