Tinwisle Corporation

ISO/DIS 19439 & 19440, Framework and Constructs for Enterprise Modeling
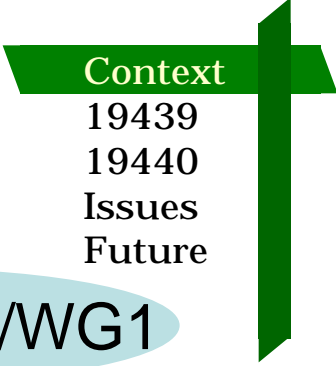
Richard A. Martin

Convener ISO TC 184/SC 5/WG 1

ISO/DIS 19439 & 19440, Framework and Constructs for Enterprise Modeling

- Context
- ISO/FDIS 19439
- ISO/DIS 19440
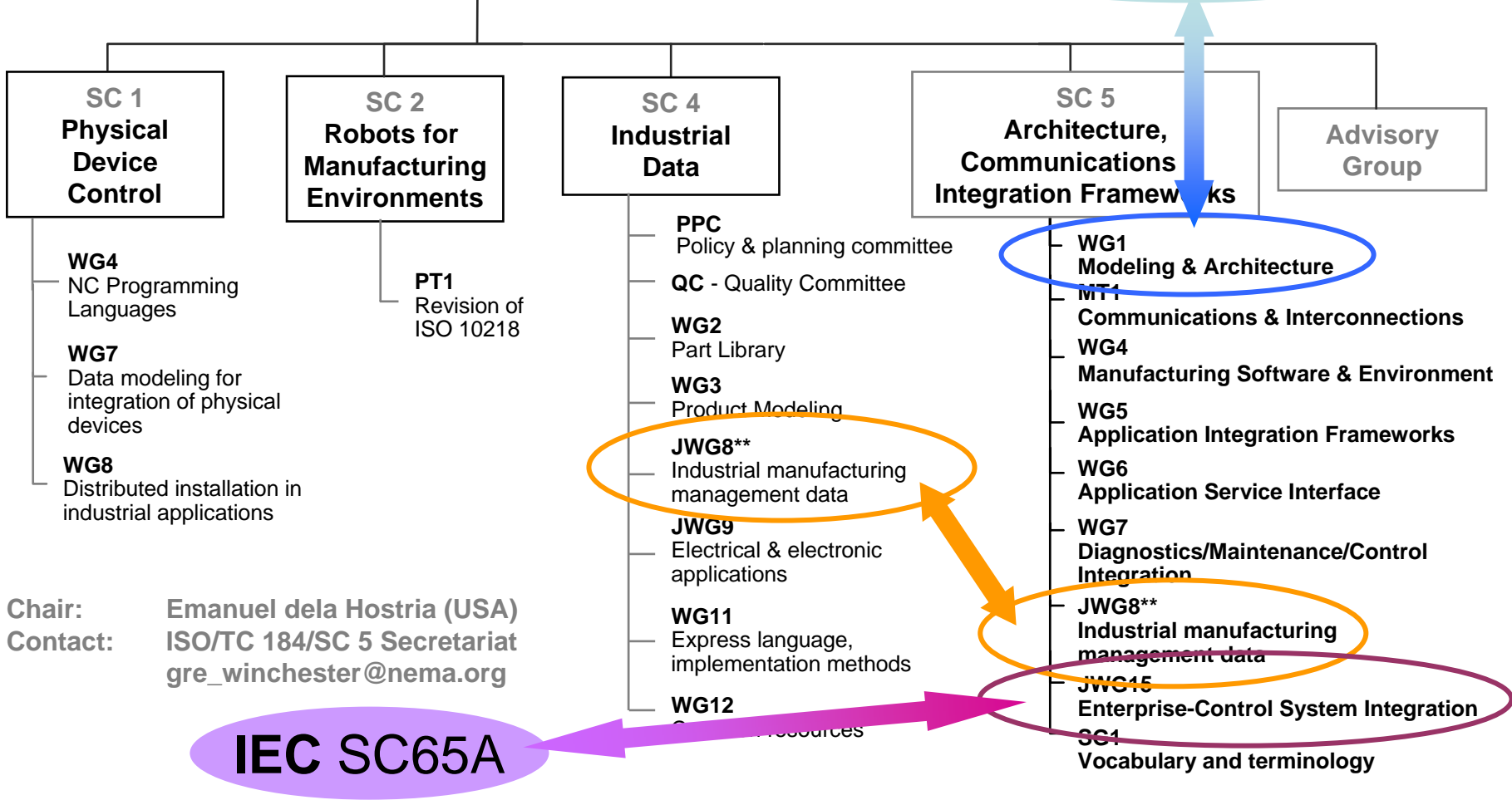- Modeling Issues
- Future Efforts

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Who's standards

ISO/TC 184
Industrial Automation Systems & Integration

CEN TC310/WG1

SC 1
Physical Device Control

SC 2
Robots for Manufacturing Environments

SC 4
Industrial Data

SC 5
Architecture, Communications Integration Frameworks

Advisory Group

WG4
NC Programming Languages

WG7
Data modeling for integration of physical devices

WG8
Distributed installation in industrial applications

PT1
Revision of ISO 10218

PPC
Policy & planning committee

QC - Quality Committee

WG2
Part Library

WG3
Product Modeling

JWG8**
Industrial manufacturing management data

JWG9
Electrical & electronic applications

WG11
Express language, implementation methods

WG12

WG1
Modeling & Architecture

MT1
Communications & Interconnections

WG4
Manufacturing Software & Environment

WG5
Application Integration Frameworks

WG6
Application Service Interface

WG7
Diagnostics/Maintenance/Control Integration

JWG8**
Industrial manufacturing management data

JWG15
Enterprise-Control System Integration

SC1
Vocabulary and terminology

Chair: **Emanuel dela Hostria (USA)**
Contact: **ISO/TC 184/SC 5 Secretariat**
         gre_winchester@nema.org

IEC SC65A
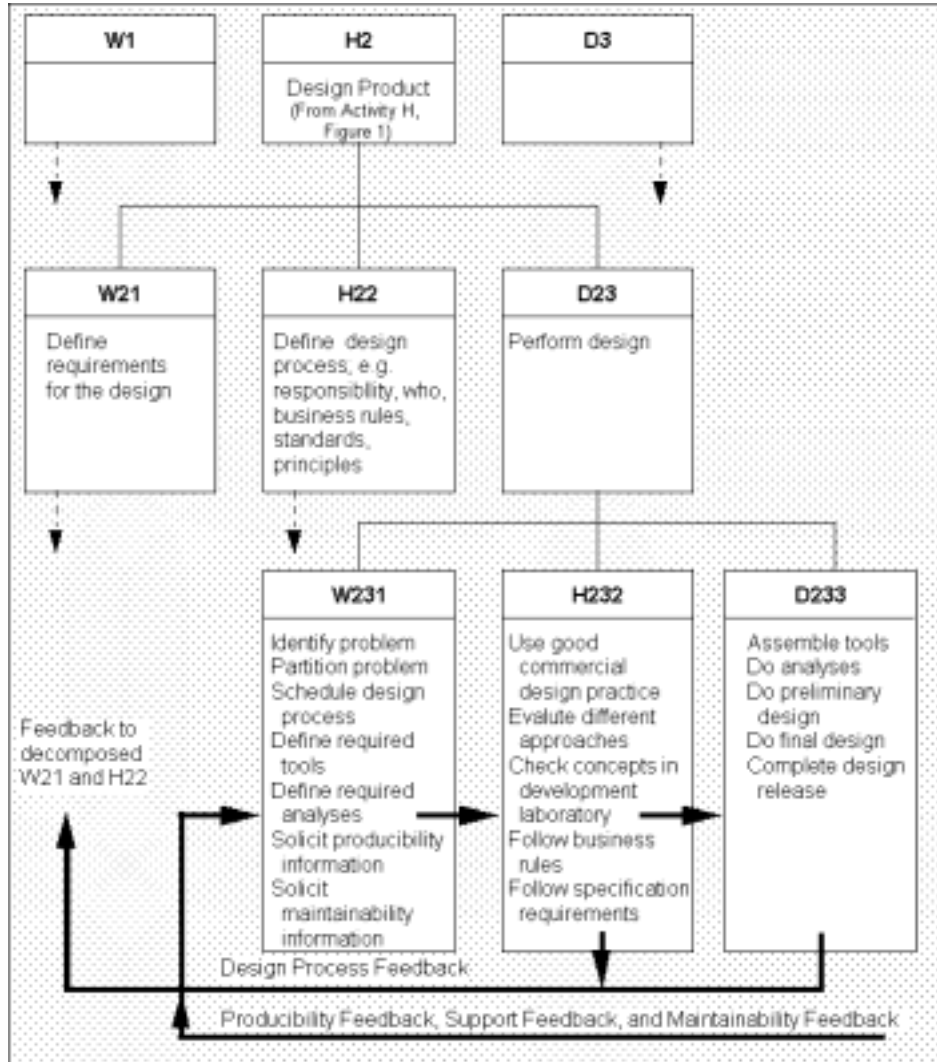
Basic concepts & rules

- ISO 14258:1998

  Industrial automation systems - Concepts and rules for enterprise models

  – Identifies basic concepts for: life-cycle, recursion, and iteration
  – Identifies concepts for structure and behavior representation using views
  – Places focus of standards for interoperability on inter-process communication.

ISO 14258:1998 Figure 3

recursion
&
iteration

ISO 14258:1998 Figure 1

Issue-solving activities / Phase	"What" Activities Activities	"How" Activities	"Do"
Plan and Build Phase (e.g., before sell/buy title transfer)	•Develop goals •Define strategy •Define product needs	•Develop Requirements •Define concept •Design product •Plan to produce product •Plan to support product	•Procure parts •Produce product •Test product •Ship product
Use and Operate Phase (e.g., after sell/buy title transfer)	•Define support needs •Define Use	•Define Use Requirements •Define Support Requirements	•Use the product •Support product
Dispose and Recycle Phase (e.g., after product is No longer useful)	•Define recycle/dispose needs	•Define recycle/dispose requirements	•Recycle product •Dispose product

Another view of Figure 1
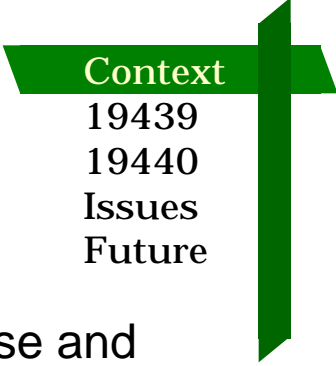
Issue-solving activities / Phase		Plan and Build Phase (e.g., before sell/buy title transfer)	Use and Operate Phase (e.g., after sell/but title transfer)	Dispose and Recycle Phase (e.g., after product is no longer useful)
		W H W W W W	W H W W W W	W H W W W W
Conceptual / Specify	"What" Activities	•Develop goals •Define strategy •Define product needs	•Define support needs •Define Use	•Define recycle/dispose needs
Logical / Design	"How" Activities	•Develop Requirements •Define concept •Design product •Plan to produce product •Plan to support product	•Define Use Requirements •Define Support Requirements	•Define recycle/dispose requirements
Physical / Build	"Do" Activities	•Procure parts •Produce product •Test product •Ship product	•Use the product •Support product	•Recycle product •Dispose product

Generalizing standards

- ISO 15704 – Requirements for enterprise-reference architectures and methodologies

- Merging of previous work - PERA, GRAI GIM, CIMOSA, and GERAM

- Presents principles for enterprise architecture

- Extends ISO 14258 with concepts for life history and genericity.

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ISO 15704 review

- Recently added views for user specific concerns

  - Economic view and Decision view

- Systematic review to begin in 2005

  - harmonization with other SC5 efforts

  - expansion of some topics

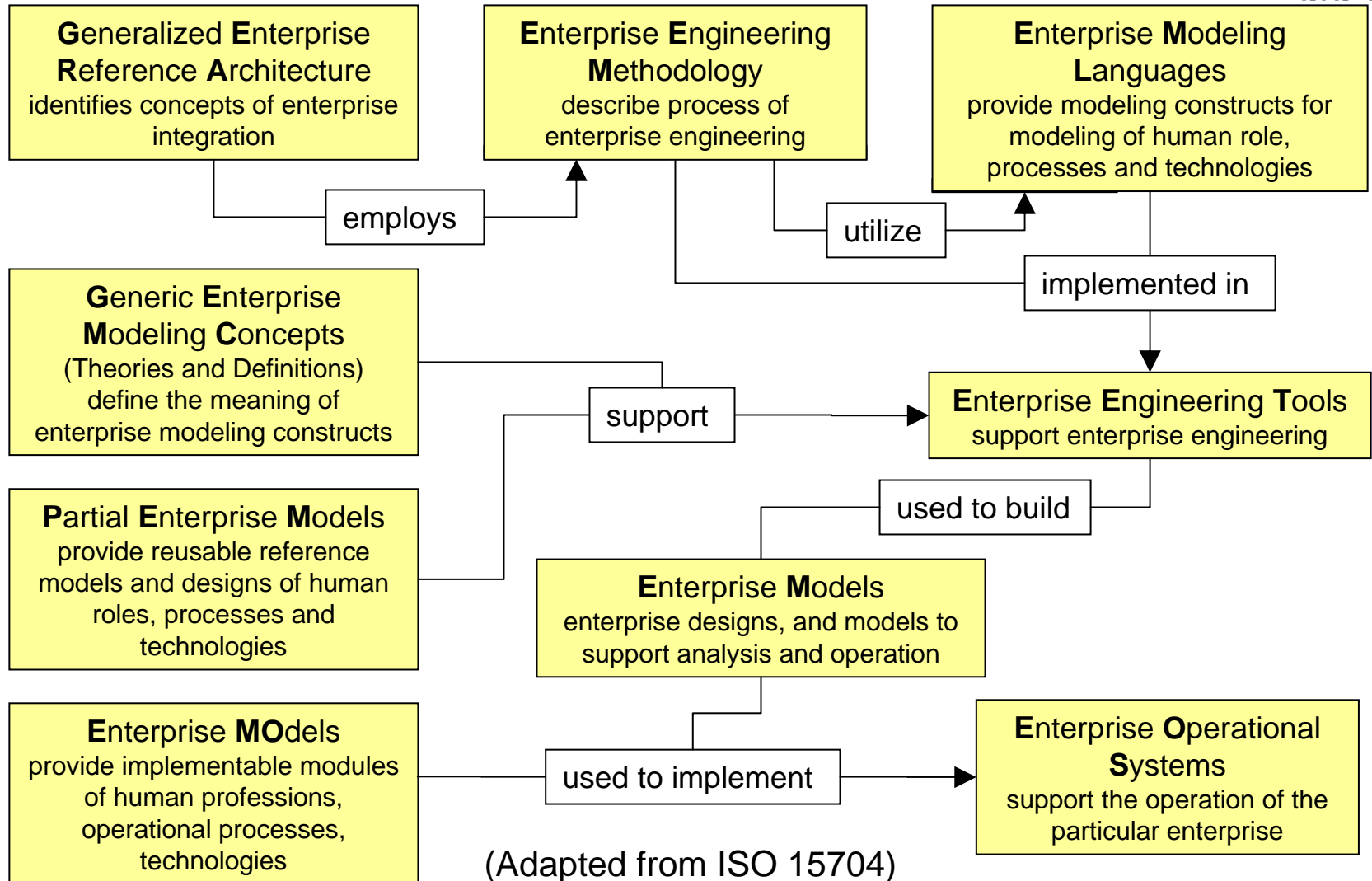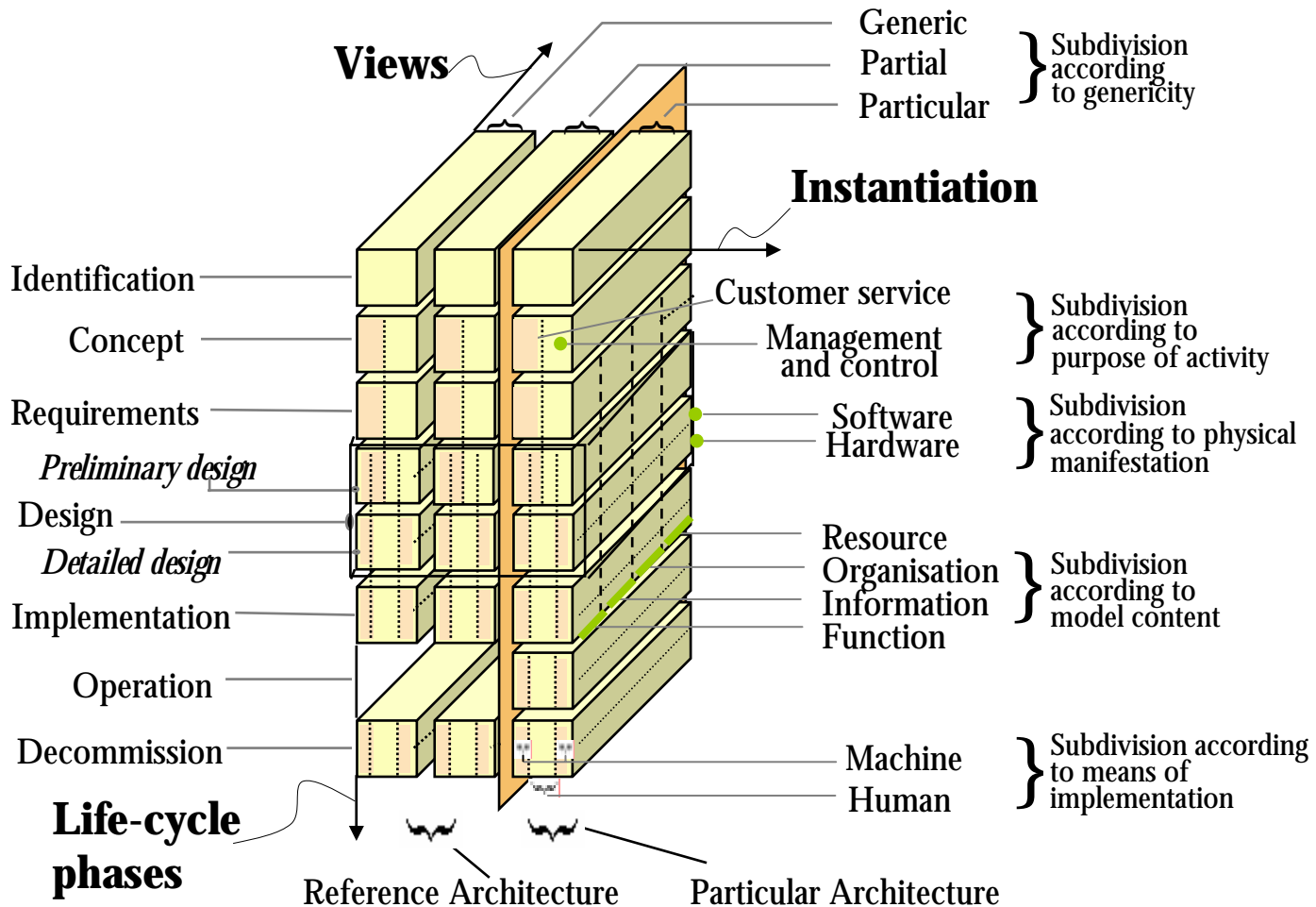- General Enterprise Reference Architecture and Methodology (GERAM) update

Scope of GERAM

Generalized Enterprise Reference Architecture
identifies concepts of enterprise integration

Enterprise Engineering Methodology
describe process of enterprise engineering

Enterprise Modeling Languages
provide modeling constructs for modeling of human role, processes and technologies

employs

utilize

implemented in

Generic Enterprise Modeling Concepts
(Theories and Definitions) define the meaning of enterprise modeling constructs

support

Enterprise Engineering Tools
support enterprise engineering

Partial Enterprise Models
provide reusable reference models and designs of human roles, processes and technologies

used to build

Enterprise Models
enterprise designs, and models to support analysis and operation

Enterprise MOdels
provide implementable modules of human professions, operational processes, technologies

used to implement

Enterprise Operational Systems
support the operation of the particular enterprise

(Adapted from ISO 15704)

GERA framework

Views

Generic
Partial
Particular
} Subdivision according to genericity

Instantiation

Identification
Concept
Requirements
Preliminary design
Design
Detailed design
Implementation
Operation
Decommission

Customer service
Management and control
} Subdivision according to purpose of activity

Software
Hardware
} Subdivision according to physical manifestation

Resource
Organisation
Information
Function
} Subdivision according to model content

Machine
Human
} Subdivision according to means of implementation

Life-cycle phases

Reference Architecture   Particular Architecture

Source: ISO 15704:2000 Annex A and Figure 10, The GERA modelling Framework of GERAM [GERAM V1.6.3 http://www.cit.gu.edu.au/~bernus](used with permission)

ISO/FDIS 19439

Enterprise integration – Framework for enterprise modelling

- Based upon CEN ENV 40003:1990
- Objective is to further enable model based execution using enactable models
- Aligned with IS 15704 (a GERA model)
- Articulates 3 dimensions of enterprise modeling as a framework
- Example from CIMOSA Baseline

19439 Dimensions

- Follows IS 15704 specification with enterprise model dimensions of:
   Phase, View, and Genericity

- A unified model with a purpose in the manufacturing domain

- Influenced by CIMOSA model and GERAM

- Partially compliant with IS 15704

Model phase -

the purposive ordinant dimension ordered
by coordinates corresponding to the phases
of the enterprise model life-cycle.

Enterprise **model phase**:
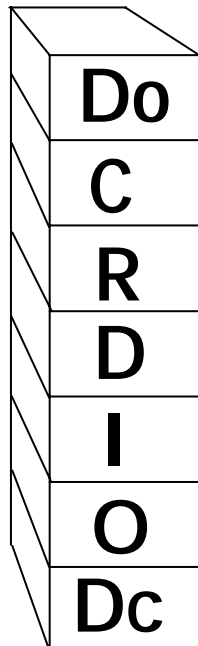
Do	– **Domain** identification
C	– **Concept** definition
R	– **Requirements** definition
D	– **Design** specification
I	– **Implementation** description
O	– domain **Operation**
Dc	– **Decommission** definition

Identify

Elaborate

Use

Dispose

Emphasize model development process for process oriented modeling.

Early phases

- **Domain identification**
  - Business objectives, functions, capabilities

- **Concept definition**
  - Enablers of objectives & operations
  - Means for achievement of functions & capabilities

- **Requirements definition**
  - Functional, behavioral, informational, and capability for service, manufacturing, management and control

- **Design specification**
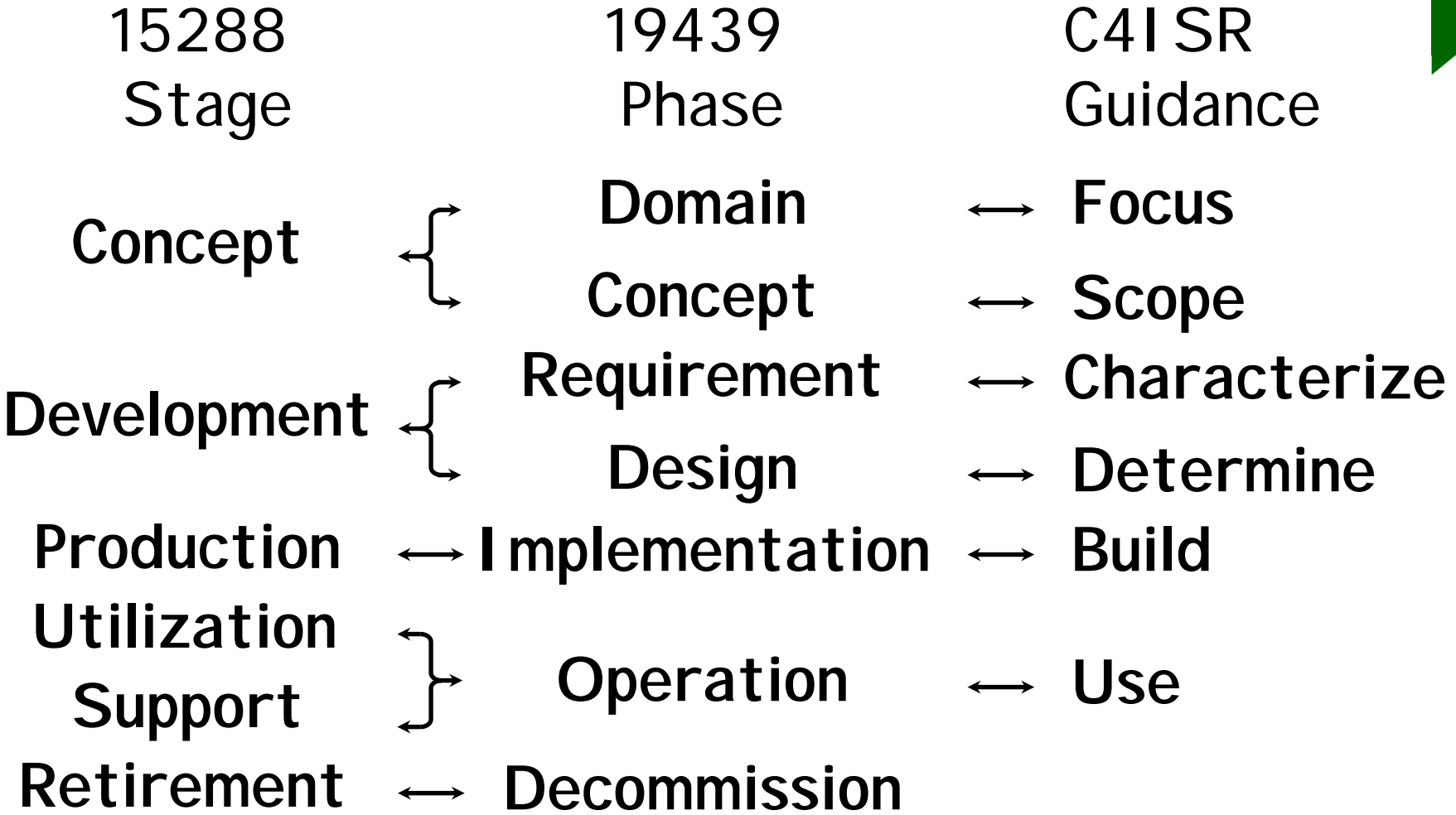 - Processes with all components necessary to satisfy requirements

Post-design phases

- **Implementation description**
  - All information needed for all tasks of operational system

- **Domain operation**
  - Operational usage of model released from implementation

- **Decommission definition**
  - Tasks and resources for retraining, redesign, recycling, preservation, transfer, disbanding, disassembly, disposal
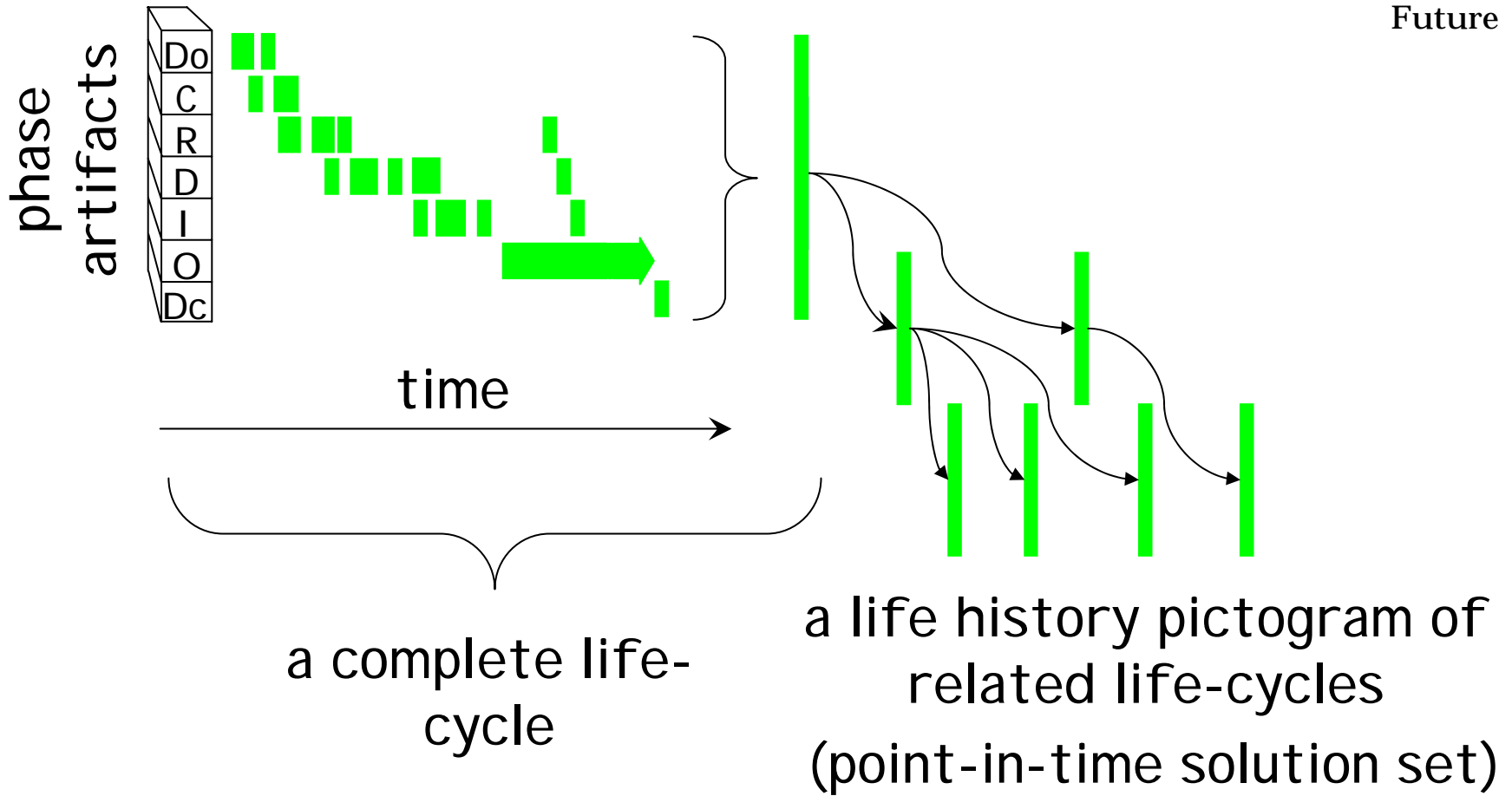
Many possible coordinates

15288 Stage	19439 Phase	C4ISR Guidance
Concept	Domain	⟷ Focus
	Concept	⟷ Scope
Development	Requirement	⟷ Characterize
	Design	⟷ Determine
Production	⟷ Implementation	⟷ Build
Utilization	Operation	⟷ Use
Support		
Retirement	⟷ Decommission	

Recursion with 19439

Enterprise operations can model new enterprises either from its own particular models or using reference constructs and partial models.

Enterprise A (operational)

$Do_A \supseteq Do_B$

(new) Enterprise B

reference catalog R

$Do_R \cup Do_A \supseteq Do_C$

(new) Enterprise C

Life history with 19439

phase artifacts

Do
C
R
D
I
O
Dc

time

a complete life-cycle

a life history pictogram of related life-cycles

(point-in-time solution set)
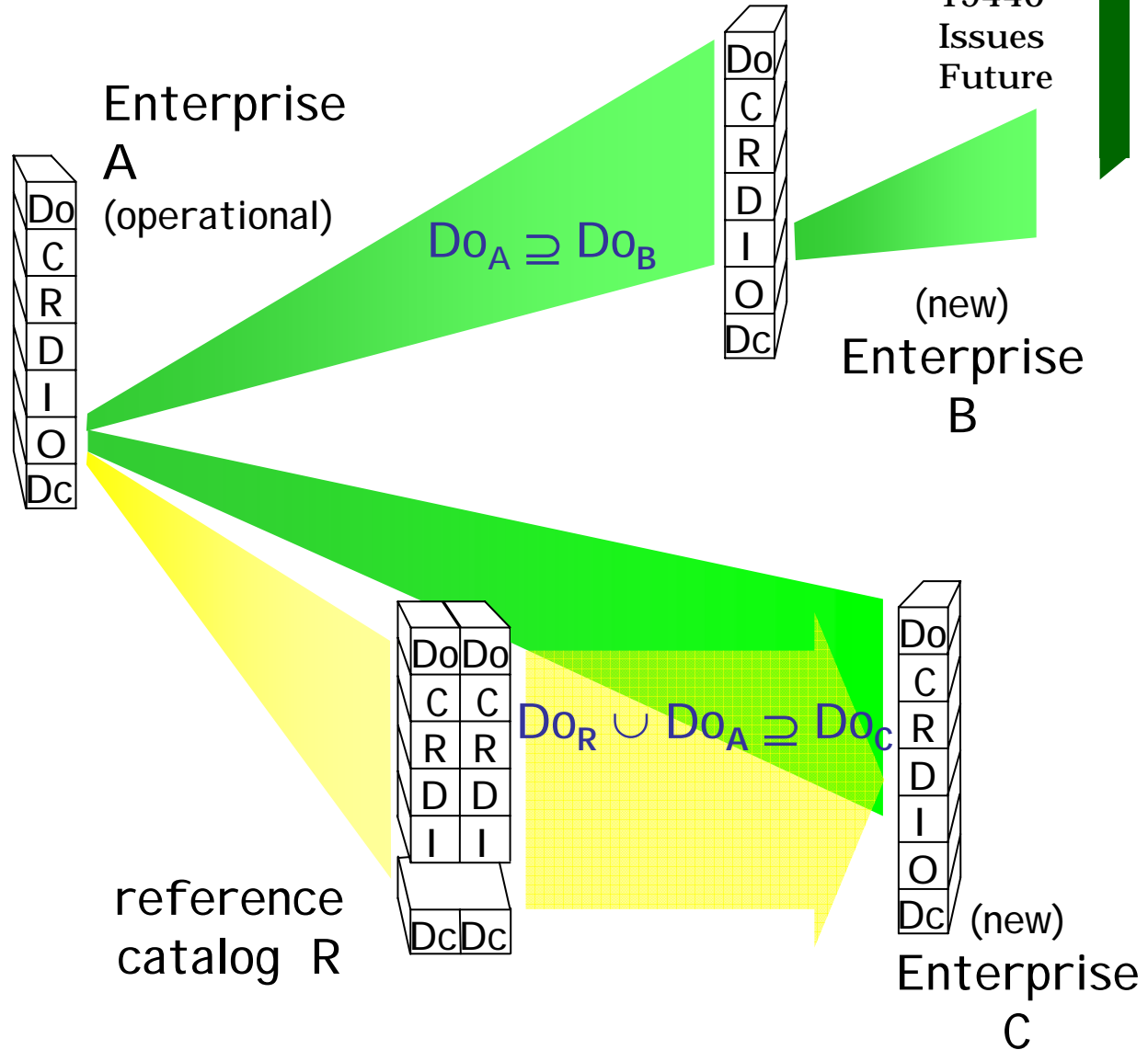
Adapted from P. Bernus, Griffith University, Australia

Model View -

an unordered ordinant dimension with pre-defined coordinates that partition facts in the unified model relevant to particular interests and context.

- A prescriptive partition of model content with distinct aspects considered sufficient for most discrete manufacturing

- View content varies with life-cycle model phase

- Supports additional views prescribed by users

Function view of 19439

Function

- Enables representation and modification of the processes of the enterprise, their functionalities, behaviors, inputs and outputs

- Emphasis on system behavior, mutual dependencies, and influence of elements during function execution

- Includes decisional, transformational and support activities

- Identifies all entities (material, information, resources and control) required for function execution

Other views of 19439

Information

- the material and information related objects used and produced in the course of operations

Resource

- capabilities of people and technological component assets

Organization

- authority and responsibility during operations
- expresses decision support structure

Model Genercity -

an ordered ordinant dimension that reflects 19439 as a "standard" framework.
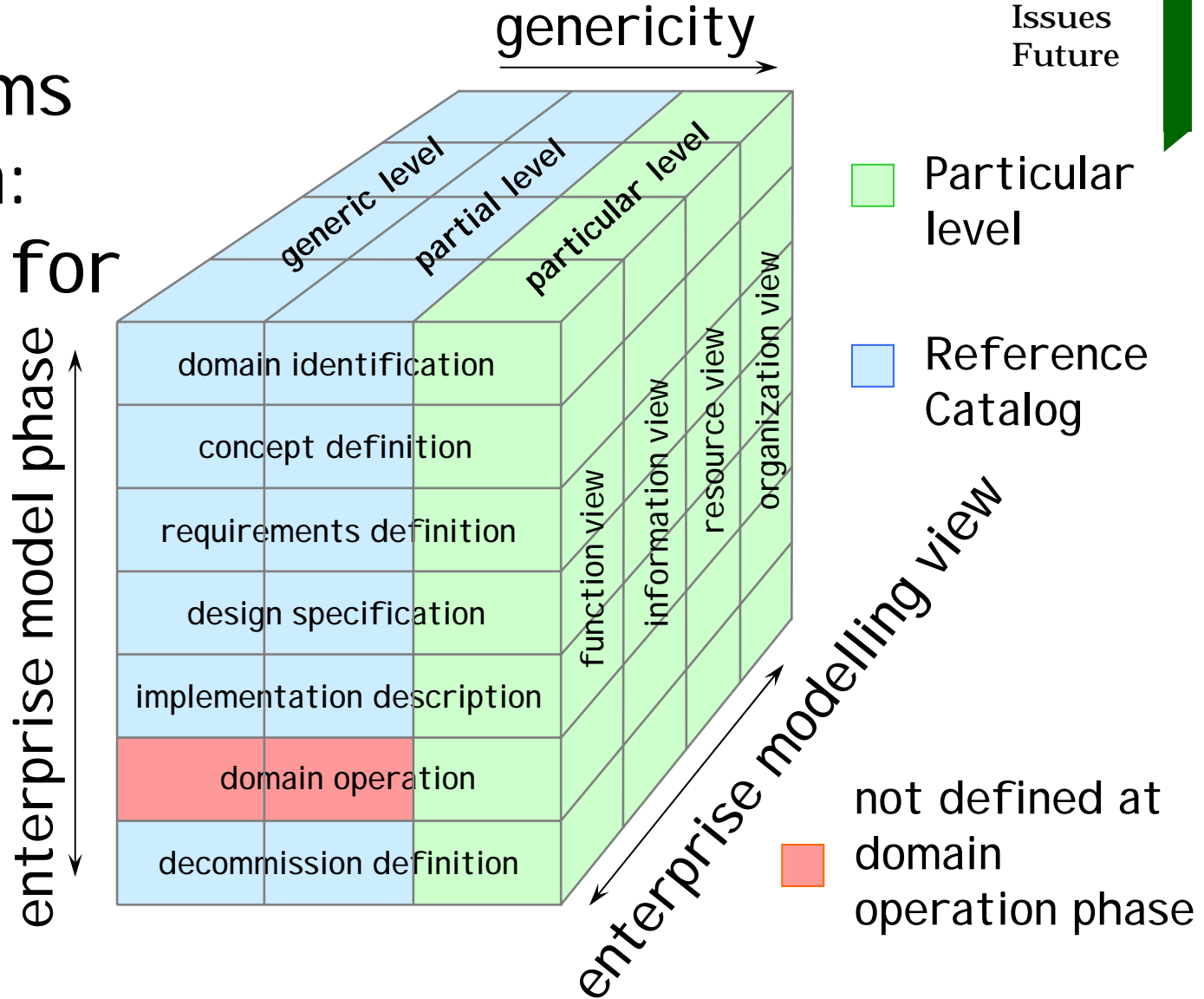
Enterprise **genericity level**:

- **Generic** – reusable modeling language constructs

- **Partial** – prototype models of industry segment or industrial activity

Reference catalog

- **Particular** – models of a particular enterprise domain

Graphic 19439 dimensions

CIM Systems Integration: Framework for Enterprise Modelling

genericity

generic level partial level particular level

enterprise model phase

domain identification
concept definition
requirements definition
design specification
implementation description
domain operation
decommission definition

function view information view resource view organization view

enterprise modelling view

Particular level

Reference Catalog

not defined at domain operation phase

Conformance to 19439

- Shall have function and information view

- Shall be able to derive resource and organization view

- Shall provide distinct model phases

- Shall provide for derivation of partial and particular model from generic constructs

- Shall propagate model changes to all views

ISO/DIS 19440

Enterprise integration – Constructs for enterprise modelling

- Based upon CEN ENV 12204:1996

- Aligned with 15704 (an EML artifact)

- Articulates modeling constructs for manufacturing automation

- Elaborates the CIMOSA Baseline example of 19439 with constructs

ISO/DIS 19440 (cont.)

- Constructs for enterprise modelling
  - common semantics enable model unification
  - usable across phases of model development
  - support process-oriented approach
- Organization and specialization using templates into structures for a specific purpose
- No mapping between functional operations and capabilities
- No explicit versioning mechanism

Construct template

- Common format
  - Header
    - Type label
    - Identifier unique to model
    - Name
    - Authority for design of construct
  - Body
    - Descriptives in textual form
    - Relationships specified by reference

Construct descriptives

- Predefined for each construct
- User-defined by extension
- May be qualified (e.g. mandatory or optional)
- Possibly XML schemas or EXPRESS notation
- Attributes
  - Name (meaningful in domain)
  - Data type (simple or complex)
- Complementary Concepts

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Complementary concepts

are not fully developed as constructs but have particular significance and semantics for the purpose of enterprise modeling

- Behavior rule
- Capability element
- Constraint
- Declarative rule

- Functional operation
- Integrity rule
- Objective
- Performance indicator

Construct relationships

- Model the dynamics between run-time instances
- Types of relationship
  - Operational authority and responsibility
  - Membership in specialization
  - Part of an aggregation
  - Consist of an aggregation
  - Other associations
- Possibly reflexive

Construct and roles

A construct may have different roles in different contexts and at different times over its life-cycle

- Human organizational role captures assigned responsibilities and required capabilities (skills)

- Human operational role captures the operational capabilities of person assigned to a task

- Machine operational role captures the operating capabilities of machine assigned to a task

- Machine product role captured by attributes that describe input and output of activities to change state.

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Constructs of 19440

Domain

Business Process

Enterprise Activity

Event

Enterprise Object

Object View

Product

Order

Resource

Functional Entity

Capability

Organizational Unit

Organizational Role

Decision Centre

19440 Figure B.3 – Information aspects

Object View construct

information only construct about another construct

- A means to represent:
  - a portion of an Enterprise Object or specialization thereof (other EO's, Product, Order, Resource) for a particular purpose
  - information about an Event
- A temporally defined view of construct content
- Usually descriptive attributes plus relationship to source (Event or Enterprise Object) and operational relationships

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Domain construct - H

describes the parts of the enterprise to be modelled and their relationships with the external environment from a high-level management-oriented point of view

Construct label	DM
Identifier	<model-unique string>
Name	[<adjective><noun>] – the name of Domain, where <noun> indicates the functionality or purpose, <adjective> indicates the scope
Design Authority	[<identifier>|<name>] of Organization Role or Organizational Unit with authority to design or maintain this particular instance

Domain construct –A1

A1 Descriptives relevant for all enterprise model phases

Description	short textual description of the Domain
Process Description	[<name> <short textual description>]+ – of the Business Processes required to achieve the Domain objectives

The following five descriptives are described at a level of detail appropriate to the enterprise model phase

Objectives	[<objective>]+ – strategic and operational business objectives of the Domain instance
Constraints	[<constraint>]* imposed on the Domain instance

Inputs/Outputs

Object View Inputs	[<origin domain> ":" <identifier> "/" <name>]+ of Object Views, instances of which can be received by occurrences of the Domain instance
Event Inputs	[<origin domain> ":" <identifier> "/" <name>]+ of all Events) , instances of which can be received by occurrences of the Domain instance
Object View Outputs	[<identifier> "/" <name> ":" <destination domain>]+
Event Outputs	[<identifier> "/" <name> ":" <destination domain>]+

Domain construct – A2

A2 Descriptives relevant for different enterprise model phases
A2.1 applicable at concept definition and later phases

Domain Characterization	short textual description of the Mission, Vision and Values of the Domain
Domain Operation	short textual description of the strategies, policies, operational concepts, business plans of the Domain
Decisional Authority	Decision Function[<verb> <noun>] - name of the decision function to which the Domain belongs, describing the decision function. A decision function is a set of decision activities or decision centres having the same category of subjects
Decision Level	[<horizon> <period>]. where <horizon> specifies the time interval in days, weeks, months or years upon which a decision taken stands and <period> specifies the reviewing frequency in days, weeks or months at the end of which a decision taken is to be revised.

A2.2 applicable at requirement definition and later phases

Performance Indicators	[<metric>	<measure>]* by which achievement of the objectives can be assessed

Domain construct - B

B1 Relationships relevant for all enterprise model phases

Business Processes   [[NIL | <domain> ":"] <identifier> "/"
<name>]+ of Business Processes contained in
this or a designated Domain instance

B2 Relationships relevant for different enterprise model phases

B2.1 applicable at concept definition and later phases

Not applicable

B2.2 applicable at requirements definition and later phases

Not applicable

B2.3 applicable at design specification and later phases

Operational Relationships

Operation Responsibility [<identifier> "/" <name>] of Organizational Role
or Organizational Unit with responsibility for
operation of this instance

Operation Authority   [<identifier> "/" <name>] of Organizational Role
or Organizational Unit with authority for
operation of this instance

Enterprise Activity – A2.3

A2.3 applicable at design specification and later phases
Inputs/Outputs

Resource Inputs [[NIL | <origin domain> ":"] <identifier> "/" <name>]+ of Resource instances required by occurrences of this Enterprise Activity instance

Resource Outputs [<identifier> "/" <name> [NIL | ":" <destination domain>]]* of Object View instances describing the characteristics of Resources after the execution of occurrences of the Enterprise Activity instance

Input Events [[NIL | <origin domain> ":"] <identifier> "/" <name> | <origin domain>]+ of all Events, instances of which can be received by occurrences of the Enterprise Activity instance

Output Events [<identifier> "/" <name> [NIL | ":" <destination domain>]]*

Ending Statuses [<value> <priority>]+ – ending status values produced by occurrences of this Enterprise Activity instance, where <value> is a mandatory 0-argument predicate and <priority>) is an integer in a range <min, max>. By default, highest priority

Duration [<duration> <qual>] –an attribute pair defining the duration of occurrences of the Enterprise Activity instance, where <qual> is a code representing one of 'average', 'minimum', 'maximum', 'actual'

Enterprise Object – H & A

Construct label   EO
Identifier   <model-unique string>
Name   name of the Enterprise Object instance
Design Authority[<identifier> "/" <name>] of Organizational Role or Organizational Unit with authority to design or maintain this particular instance

Body*A1 Descriptives relevant for all enterprise model phases*

Description   short textual description
Nature   PHYSICAL | INFORMATION
Attributes   [<property_name><property_value>]* – elements representing properties and their values for the entity represented by the Enterprise Object instance
Constraints   [<constraint>]* imposed on selected named Attributes of the Enterprise Object instance

A2 Descriptives relevant for different enterprise model phases

A2.1 applicable at concept definition and later phases

Not applicable

A2.2 applicable at requirements definition and later phases

Integrity Rules   [<integrity rule>]* applicable to ATTRIBUTES of the Enterprise Object instance in the requirements definition phase

Enterprise Object – B1

B1 Relationships relevant for all enterprise model phases

Class Relationships – list of Enterprise Object relationships in the form:

Is_A   [<identifier> "/" <name>]* of Enterprise Object classes which are a generalization of this particular instance.

Part_Of   [<identifier> "/" <name>]* of Enterprise Object instances in which this particular instance is involved in an aggregation.

Consists_Of   [<identifier> "/" <name>]* of all Enterprise Object instances of which this Enterprise Object instance is aggregated.

Related_To   [<identifier> "/" <name > <multiplicity>]*, defining the Enterprise Object instances that are related to this Enterprise Object instance, and where multiplicity is one of [0..*] (only for early modelling phases) or [1..1] or 1..*] or [m..n,]

19440 Figure B.4
Functional aspects
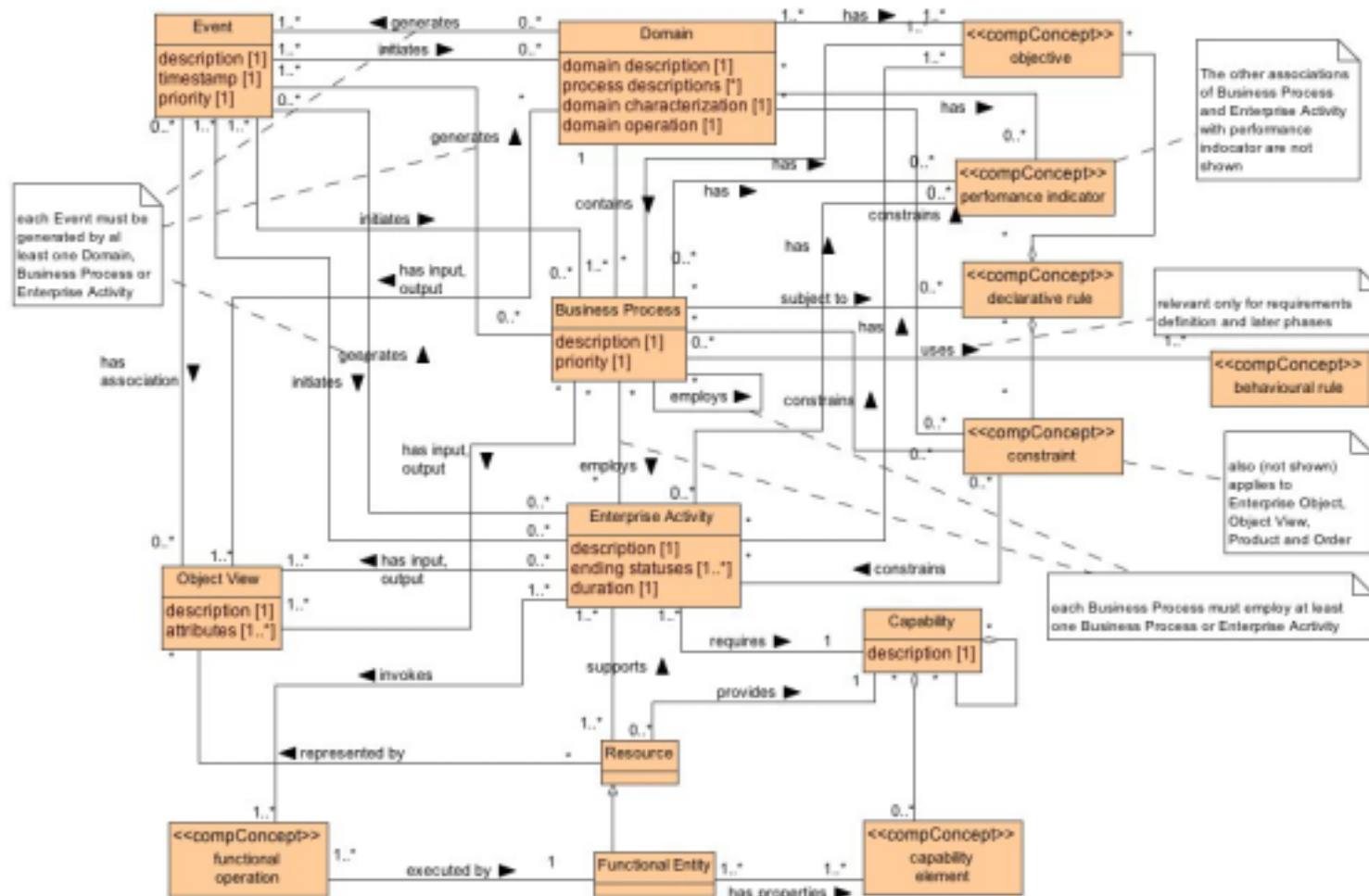
Conformance to 19440

- Shall either use the constructs as defined or be able to map to the constructs

- Can claim qualified compliance by using a subset of constructs or mapping to a subset of constructs

- Be a valid construction of a compliant modeling language

- Shall identify construction and model execution testing levels

Modeling challenges - 1

- Operationalizing the constructs
  - Representing the same thing at different phases as a unified construct: the endurant vs. perdurant distinction
  - Transforming the behavioral rules of a business process into executables
  - Maintaining proper relationships as constructs are decomposed along life-cycle
  - Ensuring consistency of aggregations and Complementary concept use

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Modeling challenges - 2

- Identifying tool ready meta-models
  - Validate the meta-model of Annex B
  - A robust meta-model for Object View creation and use in real-time
  - Matching required functional operations with capabilities of a Functional Entity

- Transcribing existing partial models into 19440 terms and syntax

- Articulating a methodology for use

Future actions

- ISO/FDIS 19439 to enter ballot this summer with 2005 publication expected
- ISO/DIS 19440 to enter ballot this summer - comment resolutions to occur 2005 – 2006 & publication in late 2006
- ISO 15704 systematic review begins this summer with revision target 2007
- NWIP for Process Analytics View using 19439 framework and 19440 constructs

Collaboration

- Identify aspects of ISO work beneficial to BEIDTF efforts

- Submit BEIDTF work products as input to ISO working groups in TC184/SC5 and perhaps ISO/IEC JTC1

- Formalize liaisons or identify appropriate representatives to allow comment submissions