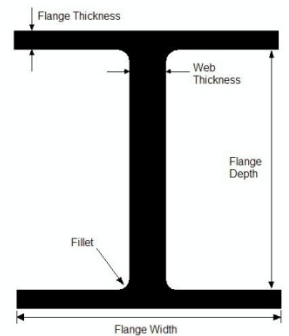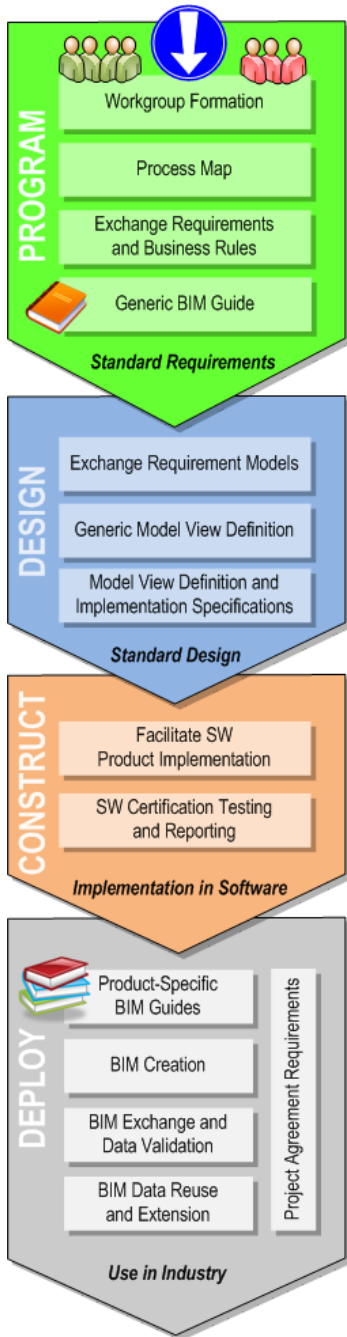# AISC – CIS/2 Project

Shiva Aram

Charles Eastman

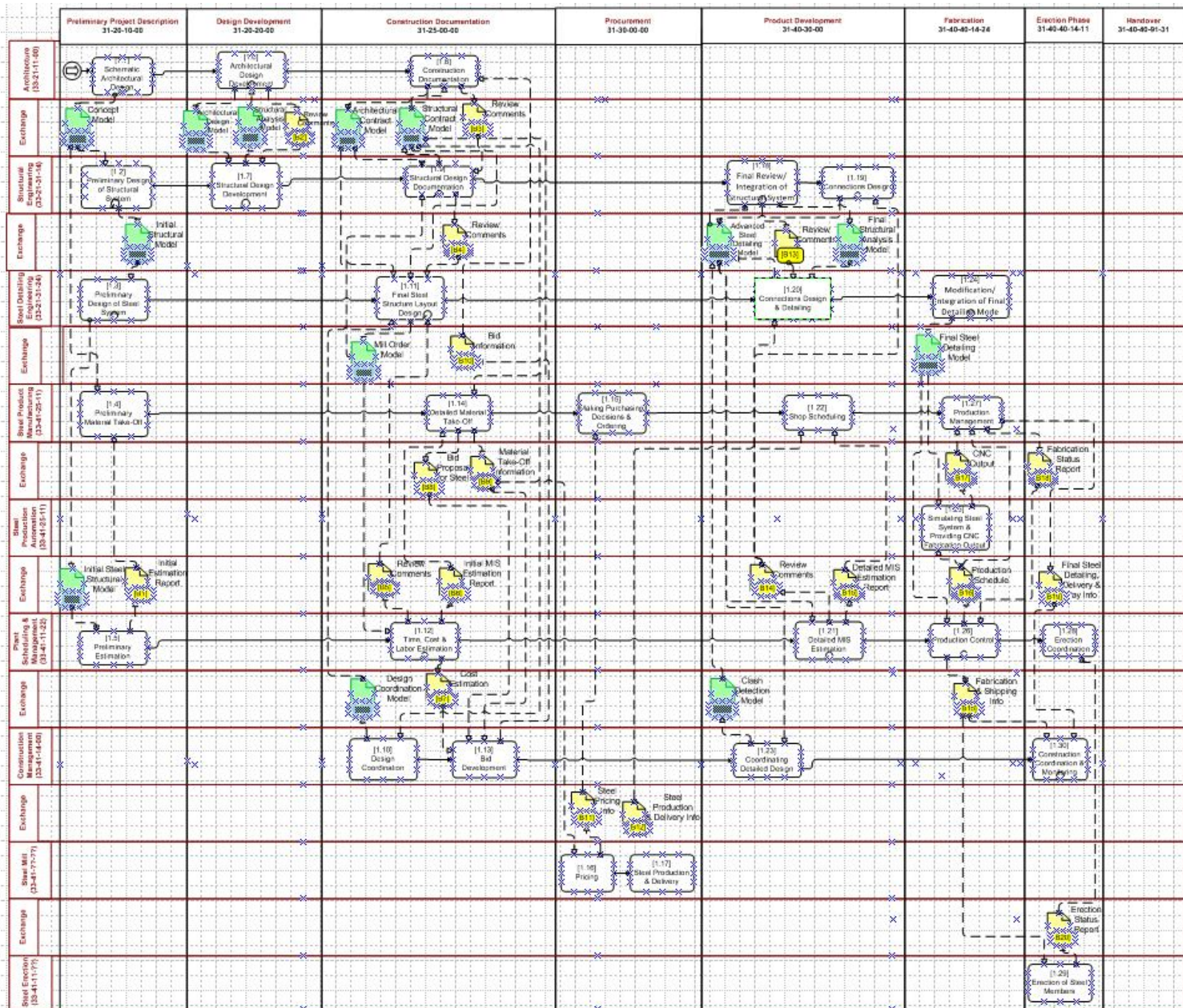**Georgia Tech**

NASCC 2010

Scope of Process Phases

Program: What is the requirement?
standard requirements definition
process model of exchanges,

Design: How to solve the requirements?
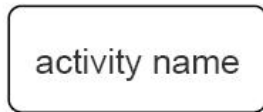*standard design documents: functional*
specification of each exchange

Construct: How to build it?
verifiable implementation in software;
development of model views for each
exchange
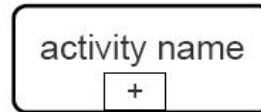
Deployment: Use in Industry
verifiable BIM data exchange

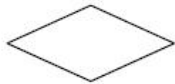Process map — Steel construction workflow (swimlane diagram)

Column headers:
- Preliminary Project Description 31-20-10-00
- Design Development 31-20-20-00
- Construction Documentation 31-25-00-00
- Procurement 31-30-00-00
- Product Development 31-40-30-00
- Fabrication 31-40-40-14-24
- Erection Phase 31-40-40-14-11
- Handover 31-40-40-91-31

Row (swimlane) labels:
- Architecture (33-21-11-40)
- Exchange
- Structural Engineering (33-21-31-14)
- Exchange
- Steel Detailing (33-21-31-24)
- Exchange
- Steel Product Manufacturing (33-41-25-11)
- Exchange
- Steel Production Automation (33-41-25-11)
- Exchange
- Plant Scheduling & Management (33-41-11-22)
- Exchange
- Construction Management (33-41-14-00)
- Exchange
- Steel Mill (33-41-77-77)
- Exchange
- Steel Erection (33-41-11-??)

Architecture lane:
- Schematic Architectural Design
- [1.6] Architectural Design Development
- [1.9] Construction Documentation

Exchange lane:
- Concept Model
- Architectural Design Model
- Structural Analysis Model
- Review Comments [B2]
- Architectural Contract Model
- Structural Contract Model
- Review Comments [B3]

Structural Engineering lane:
- [1.2] Preliminary Design of Structural System
- [1.7] Structural Design Development
- [1.8] Structural Design Documentation
- [1.18] Final Review/ Integration of Structural System
- [1.19] Connections Design

Exchange lane:
- Initial Structural Model
- Review Comments [B4]
- Advanced Steel Detailing Model
- Review Comments [B13]
- Final Structural Analysis Model

Steel Detailing lane:
- [1.5] Preliminary Design of Steel System
- [1.11] Final Steel Structure Layout Design
- [1.20] Connections Design & Detailing
- [1.24] Modification/ Integration of Final Detailed Model

Exchange lane:
- Mill Order Model
- Bid Information [B5]
- Final Steel Detailing Model

Steel Product Manufacturing lane:
- [1.4] Preliminary Material Take-Off
- [1.14] Detailed Material Take-Off
- [1.16] Making Purchasing Decisions & Ordering
- [1.22] Shop Scheduling
- [1.27] Production Management

Exchange lane:
- Bid Proposal for Steel [B8]
- Material Take-Off Information [B6]
- CNC Output [B17]
- Fabrication Status Report [B19]

Steel Production Automation lane:
- [1.25] Simulating Steel System & Providing CNC Fabrication Output

Exchange lane:
- Initial Steel Structural Model
- Initial MIS Estimation Report [B1]
- Review Comments [B7]
- Initial MIS Estimation Report [B9]
- Review Comments [B14]
- Detailed MIS Estimation Report [B15]
- Production Schedule [B18]
- Final Steel Detailing, Delivery & Pay Info [B16]

Plant Scheduling & Management lane:
- [1.3] Preliminary Estimation
- [1.12] Time, Cost & Labor Estimation
- [1.21] Detailed MIS Estimation
- [1.26] Production Control
- [1.28] Erection Coordination

Exchange lane:
- Design Coordination Model
- Cost Estimation [B7]
- Clash Detection Model
- Fabrication & Shipping Info [B18]

Construction Management lane:
- [1.10] Design Coordination
- [1.13] Bid Development
- [1.23] Coordinating Detailed Design
- [1.30] Construction Coordination & Monitoring

Exchange lane:
- Steel Pricing Info [B10]
- Steel Production Delivery Info [B12]

Steel Mill lane:
- [1.16] Pricing
- [1.17] Steel Production & Delivery

Exchange lane:
- Erection Status Report [B20]

Steel Erection lane:
- [1.29] Erection of Steel Members

Business Process Modeling Notation

Shapes:

activity name — Activity: carried out actor, info inputs, material inputs, resources, info & material outputs

activity name + — Sub-process: more detailed description of activity

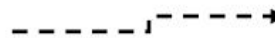Gateway: decision point actor, info & material input, info output, branching output

Events: Start, intermediate and end events

annotation — Annotation: information exchanged about material, status or other qualification

Sequence flow

Message flow

Association

Library: static source of info output, no input: catalog

Swimlanes: define actors

Server: dynamic source of info output: some input: project library

Pool: define actors

BPMN: Activity Types
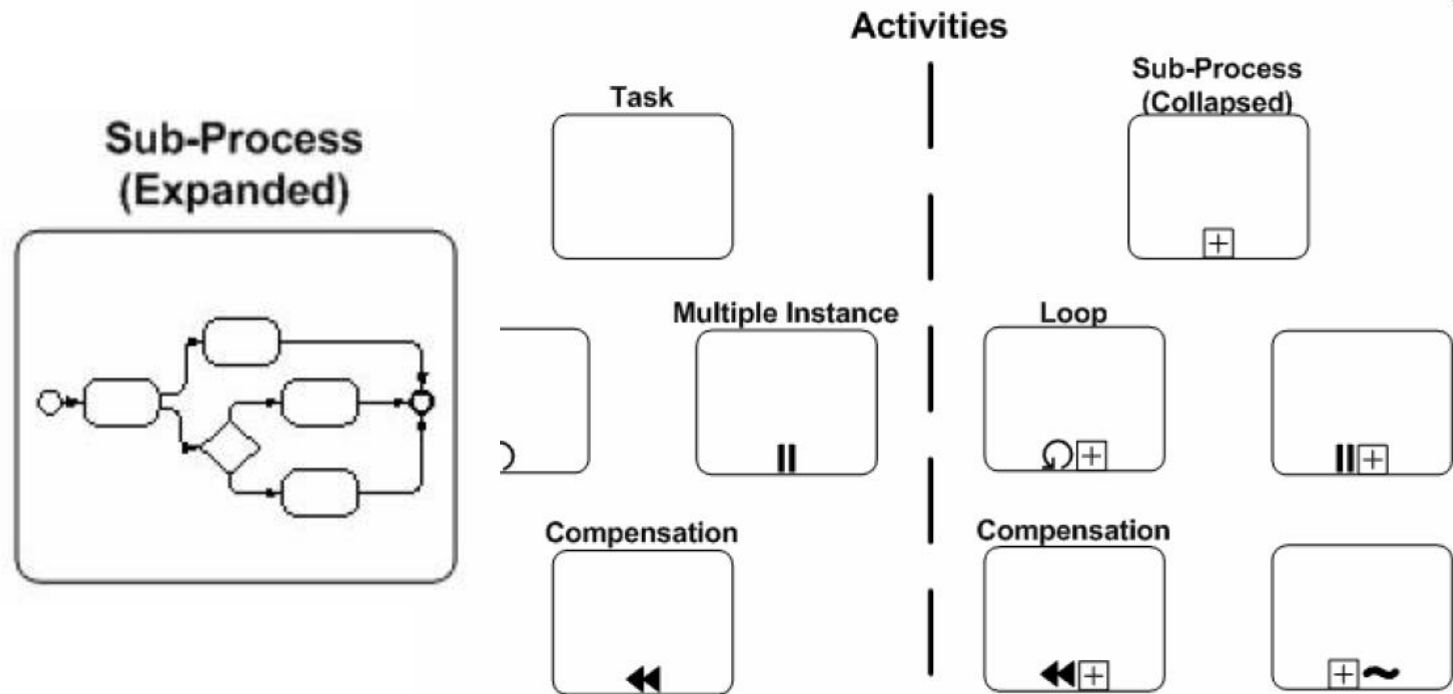
Business Process Modeling Notation
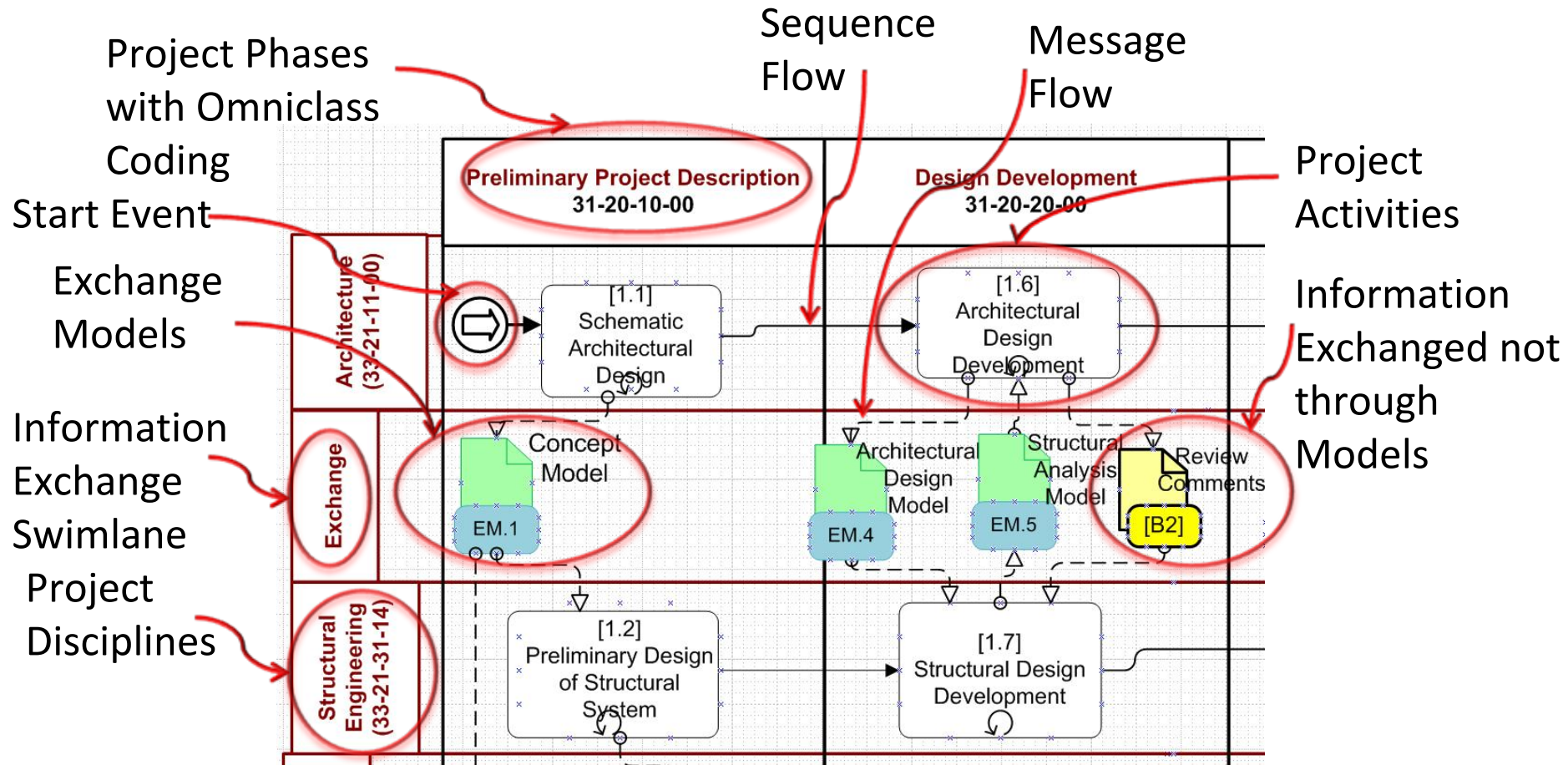
Steel Process Model
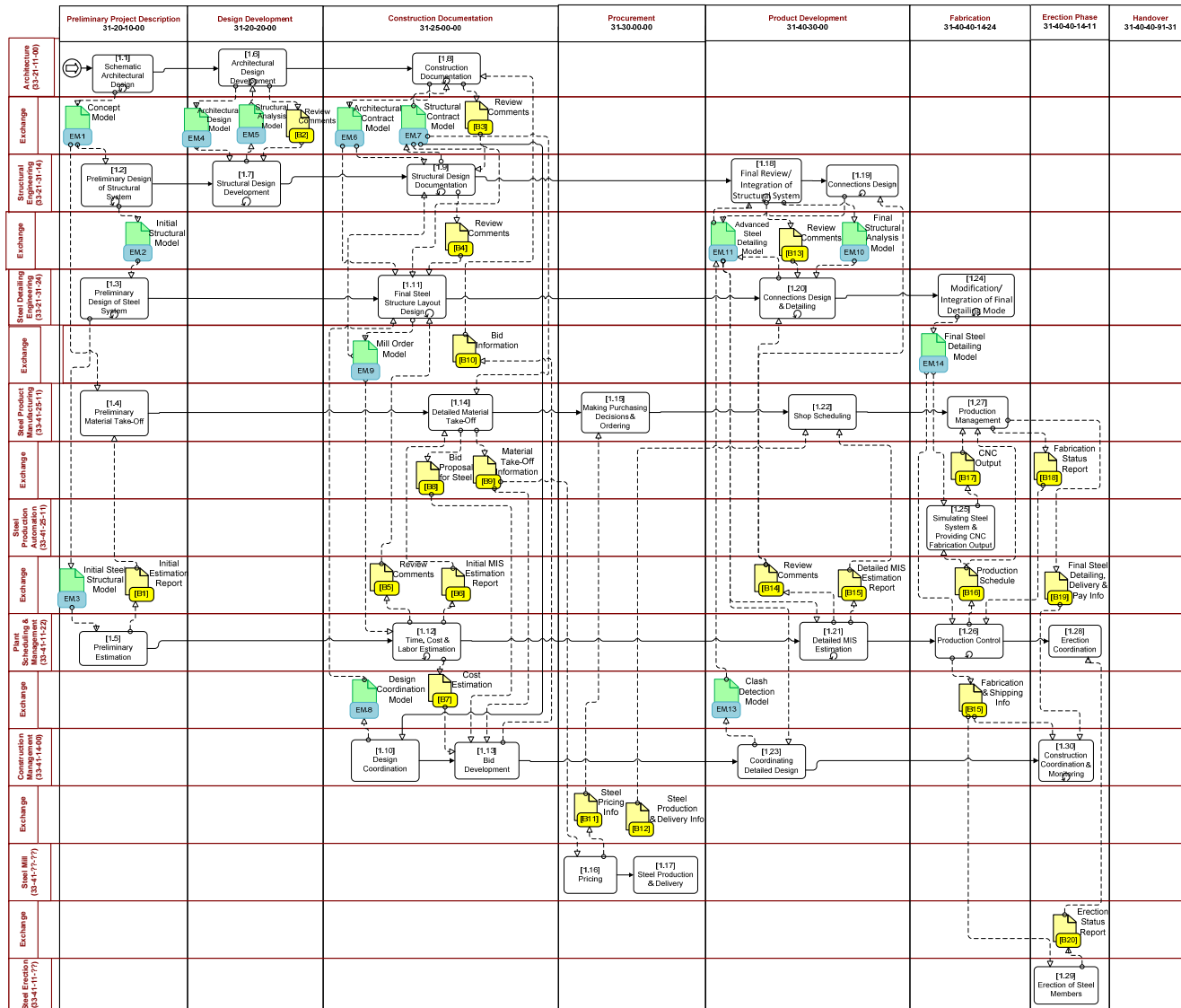
Steel Process Model
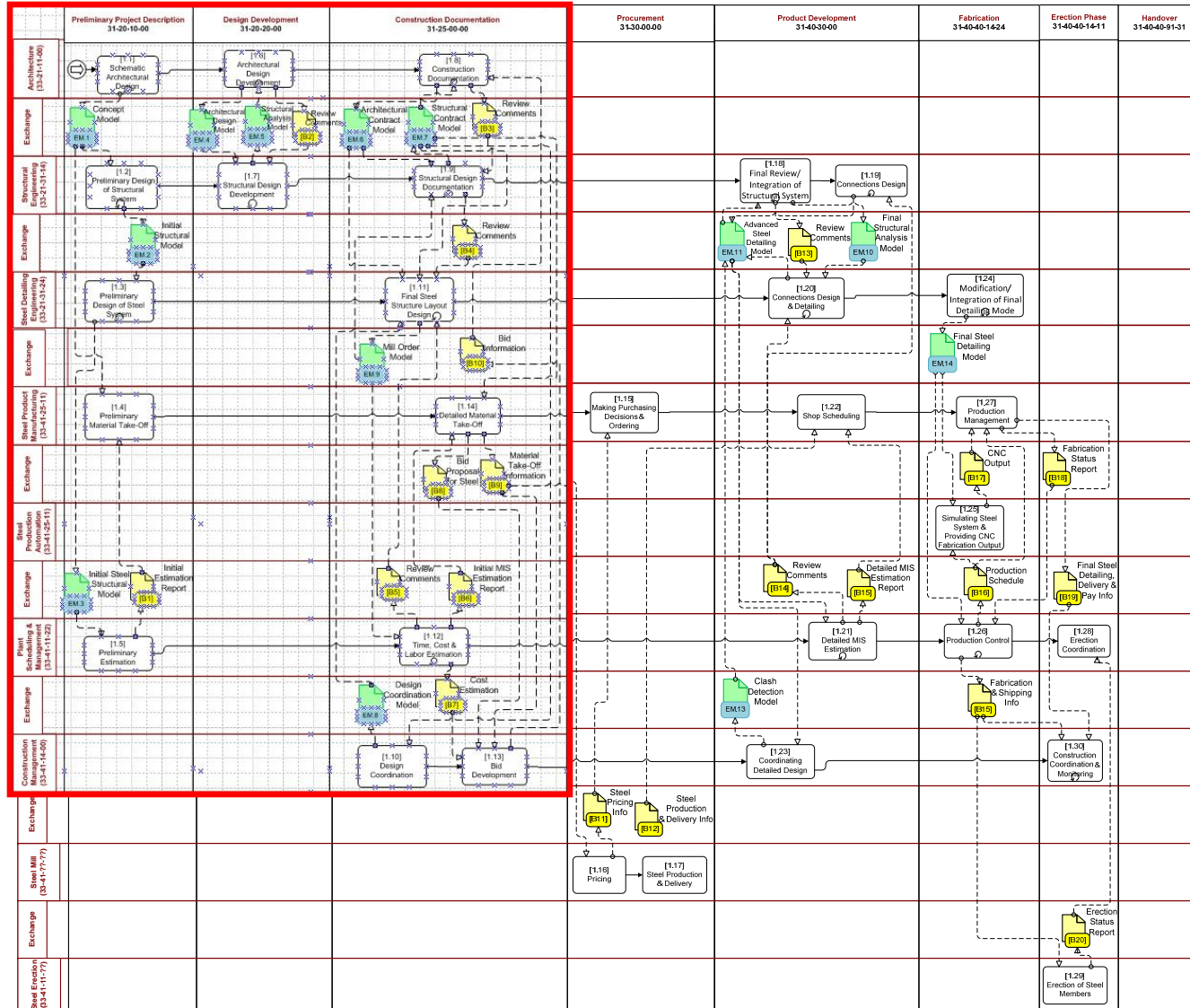
Steel Process Model
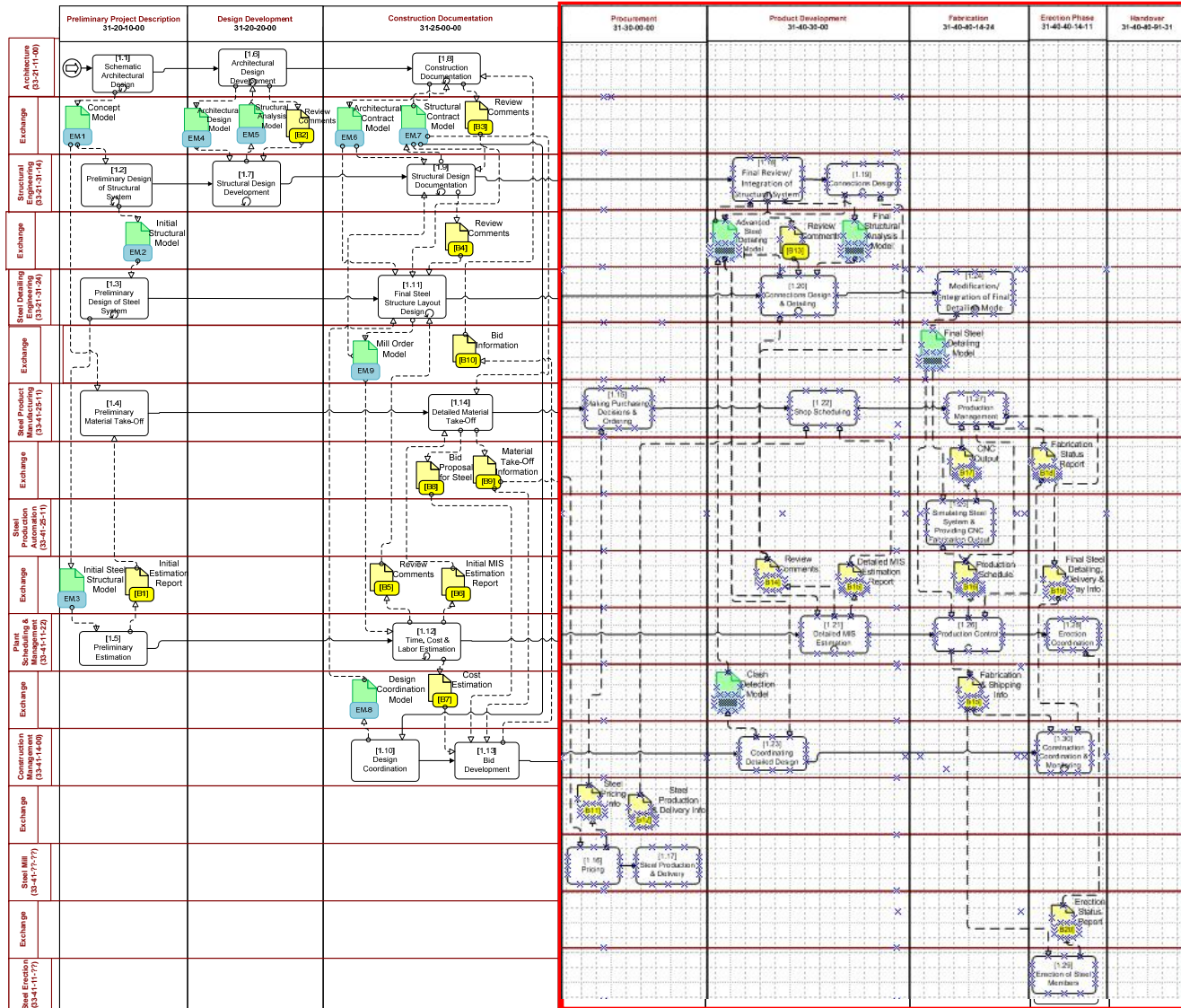
Steel Process Model
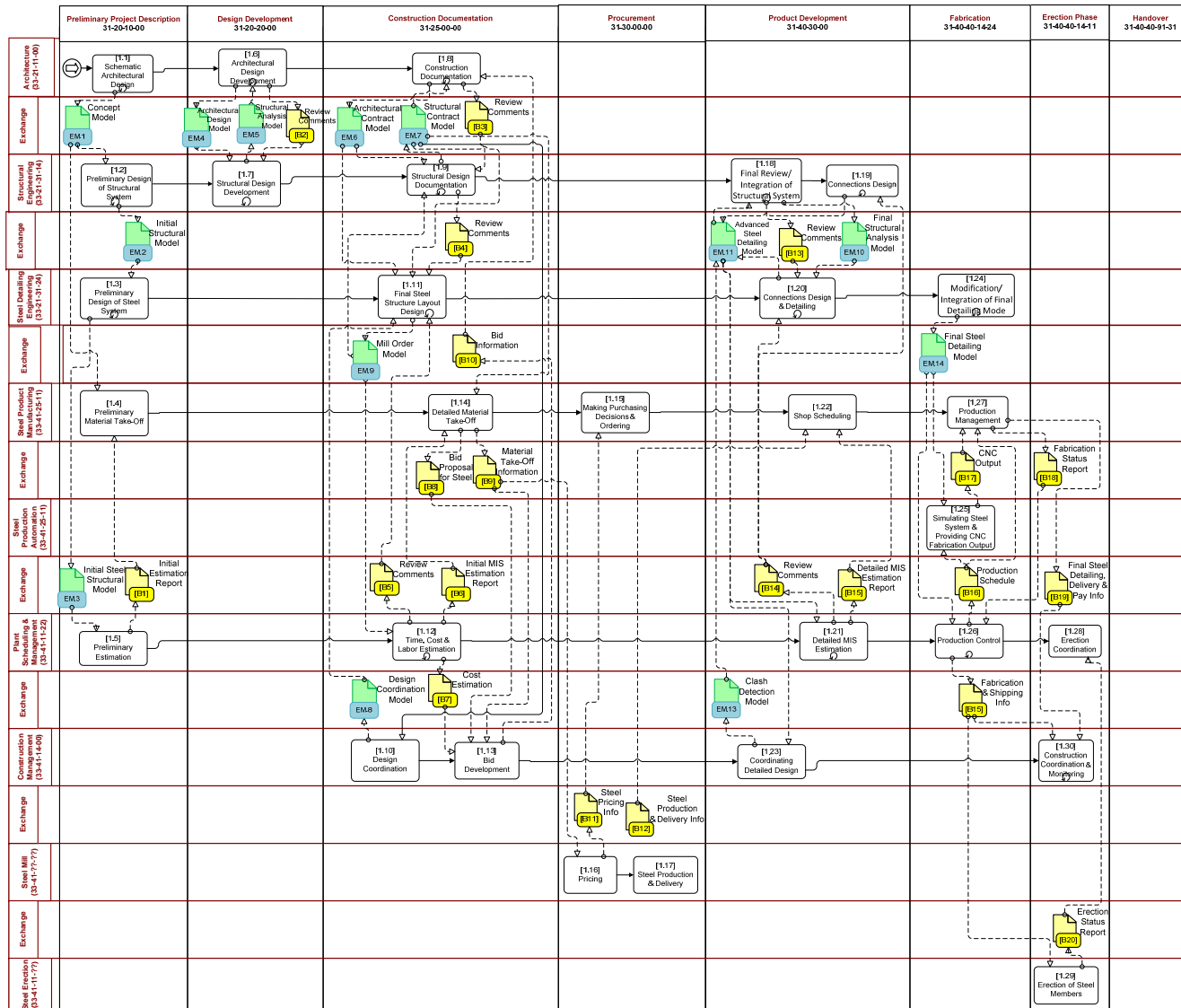
Process Descriptions

[1.51] Structural Analysis and Design

Type	Task
Name	Structural Analysis and Design
Omniclass Code	31-40-30-17 Product Evaluation Phase
Documentation	Structural engineer reviews the composition of piece definitions and sizing with regard to adequacy to carry loads, sizing, spans bearing conditions and live and dead loads and lateral forces, for efficacy of the precast piece definition. Reviews issues of erection sequencing and temporary erection loads and supports.

[1.52] Precast Piece Layout

Type	Task
Name	Precast Piece Layout
Omniclass Code	31-40-30-11 Product Prototyping Phase
Documentation	The precast designer/engineer develops the final definition of precast assemblies and pieces that make up the project, dealing with architectural panel layout and joints, structural elements and their spanning and load carrying requirements, and large assemblies such as stairways and service cores.

[1.53] Construction Coordination

Type	Task
Name	Construction Coordination
Omniclass Code	31-40-40-11 Construction Start-up Phase
Documentation	The General contractor coordinates with all subcontractors regarding the sequence of construction and there for delivery and erection sequences. Initially these are at a high level. The models are used to review complex conditions needed special attention.

Information Delivery Manual

Information Delivery Manual

Information groups piece families, reinforcing. analysis model, loads, connections, finishes	Information items within category within category: Grade Beam, Pier Cap, Spread footing, Slab on Grade, Stem Wall, Retaining wall, Drilled Pier, Cassion, Pile, Pile Cap

Attribute sets relevant for category

- attributes
- attributes
- attributes

geometry

- attributes
- attributes

Structural loads

Material

Relations

Required?

Type?

Features?

Exchange model
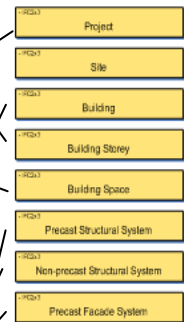
IDM Requirements

Concepts

IFC Bindings

Exchange Model MVDs

IFC Model View Definition Diagram : [PCI-001] Precast Concrete

APPLICATION NAME	APP. VERSION	EXCHANGE TYPE	DIAGRAM AUTHORS
Generic		Generic	Rafael Sacks, Chuck Eastman and Ivan Panushev

000 - IFC2x4 Building	PCI-064 Absolute Placement	VBL-268 Material Name	VBL-012 Project Phase
000 - IFC2x4 Building Storey	PCI-060 Actor Assignment	PCI-130 Mesh Length	PCI-018 Pset_Precast_Building_Design_Criteria
000 - IFC2x4 Engineered Mesh	VBL-416 Aggregates Structural Analysis Models	PCI-131 Mesh Width	PCI-113 Rebar Association to Engineered Mesh
000 - IFC2x4 Grids	VBL-185 Applied Load	VBL-360 Metric Project Units	PCI-114 Rebar Association to Standard Mesh
000 - IFC2x4 Non-precast Element	PCI-059 Approval Assignment	VBL-171 Name	PCI-111 Rebar Bending Attributes
000 - IFC2x4 Non-precast Element Type	PCI-069 Arbitrary Precast Profile	VBL-013 Owner and Status Information	PCI-088 Rebar Extruded Shape Geometry
000 - IFC2x4 Precast Blockout	PCI-070 Arbitrary Precast Profile with Voids	PCI-052 Placement Relative to Grid	PCI-103 Reinforcing Element Aggregation Association to Rebar Cage
000 - IFC2x4 Precast Embed Type	VBL-307 Area	PCI-074 Precast Blockout Assignment	PCI-104 Reinforcing Element Association to Reinforcing Element Aggregation
000 - IFC2x4 Precast Embeds	PCI-009 Assigns Other Building System	PCI-138 Precast Connection Component Assignment	PCI-133 Reinforcing Mesh Attributes
000 - IFC2x4 Precast End-to-edge Connection	PCI-008 Assigns Precast Facade System	PCI-077 Precast Design Criteria	PCI-090 Reinforcing Unit Association to Piece
000 - IFC2x4 Precast End-to-end Connection	PCI-007 Assigns Precast Structural System	PCI-073 Precast Embed Assignment	PCI-063 Relative Placement
000 - IFC2x4 Precast Joint	PCI-065 Blockout Placement	PCI-141 Precast End-to-edge Connection Geometry	PCI-042 Site Contained in Project
000 - IFC2x4 Precast Joint Type	VBL-504 Building Contained in Site	PCI-135 Precast End-to-end Connection Geometry	ICC-468 Site Curve 2D
000 - IFC2x4 Precast Piece	VBL-412 Building Name	PCI-057 Precast Fabrication Attributes	VBL-410 Site Name
000 - IFC2x4 Precast Piece Type	PCI-044 Building Storey Contained in Building	PCI-079 Precast Finish	PCI-045 Space Contained in Building
000 - IFC2x4 Precast Projection	VBL-414 Building Storey Name	PCI-056 Precast General Attributes	PCI-046 Space Contained in Building Storey
000 - IFC2x4 Precast Seam Connection	PCI-110 Coating Material Properties	PCI-147 Precast Joint Attributes	PCI-109 Steel Material Properties
000 - IFC2x4 Precast Slab	PCI-097 Component Property Set Assignment	PCI-148 Precast Joint Element Assignment	PCI-094 Supplier
000 - IFC2x4 Project	PCI-096 Condition	PCI-149 Precast Joint Location	PCI-093 Surface Treatments

Cover page

```
ENTITY IfcDiscreteAccessory
    SUBTYPE OF (IfcElementComponent);
END_ENTITY;
```

Inheritance graph

```
ENTITY IfcDiscreteAccessory;
    ENTITY IfcRoot;
        GlobalId                    : IfcGloballyUniqueId;
        OwnerHistory                : IfcOwnerHistory;
        Name                        : OPTIONAL IfcLabel;
        Description                 : OPTIONAL IfcText;
    ENTITY IfcObjectDefinition;
    INVERSE
        HasAssignments              : SET OF IfcRelAssigns FOR RelatedObjects;
        IsDecomposedBy              : SET OF IfcRelDecomposes FOR RelatingObject;
        Decomposes                  : SET [0:1] OF IfcRelDecomposes FOR RelatedObjects;
        HasAssociations             : SET OF IfcRelAssociates FOR RelatedObjects;
    ENTITY IfcObject;
        ObjectType                  : OPTIONAL IfcLabel;
    INVERSE
        IsDeclaredBy                : SET [0:1] OF IfcRelDefinesByObject FOR RelatedObjects;
        Declares                    : SET OF IfcRelDefinesByObject FOR RelatingObject;
        IsTypedBy                   : SET [0:1] OF IfcRelDefinesByType FOR RelatedObjects;
        IsDefinedBy                 : SET OF IfcRelDefinesByProperties FOR RelatedObjects;
    ENTITY IfcProduct;
        ObjectPlacement             : OPTIONAL IfcObjectPlacement;
        Representation              : OPTIONAL IfcProductRepresentation;
    INVERSE
        ReferencedBy                : SET OF IfcRelAssignsToProduct FOR RelatingProduct;
    ENTITY IfcElement;
        Tag                         : OPTIONAL IfcIdentifier;
    INVERSE
        FillsVoids                  : SET [0:1] OF IfcRelFillsElement FOR RelatedBuildingElement;
        ConnectedTo                 : SET OF IfcRelConnectsElements FOR RelatingElement;
        IsInterferedByElements      : SET OF IfcRelInterferesElements FOR RelatedElement;
        InterferesElements          : SET OF IfcRelInterferesElements FOR RelatingElement;
        HasCoverings                : SET OF IfcRelCoversBldgElements FOR RelatingBuildingElement;
        HasProjections              : SET OF IfcRelProjectsElement FOR RelatingElement;
        ReferencedInStructures      : SET OF IfcRelReferencedInSpatialStructure FOR RelatedElements;
        HasPorts                    : SET OF IfcRelConnectsPortToElement FOR RelatedElement;
        HasOpenings                 : SET OF IfcRelVoidsElement FOR RelatingBuildingElement;
        IsConnectionRealization     : SET OF IfcRelConnectsWithRealizingElements FOR RealizingElements;
        ProvidesBoundaries          : SET OF IfcRelSpaceBoundary FOR RelatedBuildingElement;
        ConnectedFrom               : SET OF IfcRelConnectsElements FOR RelatedElement;
        ContainedInStructure        : SET [0:1] OF IfcRelContainedInSpatialStructure FOR RelatedElements;
    ENTITY IfcElementComponent;
    ENTITY IfcDiscreteAccessory;
END_ENTITY;
```

IfcRoot
+ GlobalId
+ OwnerHistory >
  Name
  Description

IfcObjectDefinition
HasAssignments(INV)
IsDecomposedBy(INV)
Decomposes(INV)
Has associations(INV)

IfcObject
  ObjectType
IsDeclaredBy(INV)
Declares(INV)
IsTypedBy(INV)
IsDefinedBy(INV)

IfcProduct
  ObjectPlacement >
  Representation >
ReferencedBy(INV)

IfcElement
  Representation >
  Tag
FillsVoids(INV)
IsConnectedTo(INV)
IsInterferedByElements(INV)
InterferesElements(INV)
HasCoverings(INV)
HasProjections(INV)
ReferencedInStructures(INV)
HasPorts(INV)
HasOpenings(INV)
IsConnectionRealization(INV)
ProvidesBoundaries(INV)
ConnectedFrom(INV)
ContainedInStructure(INV)

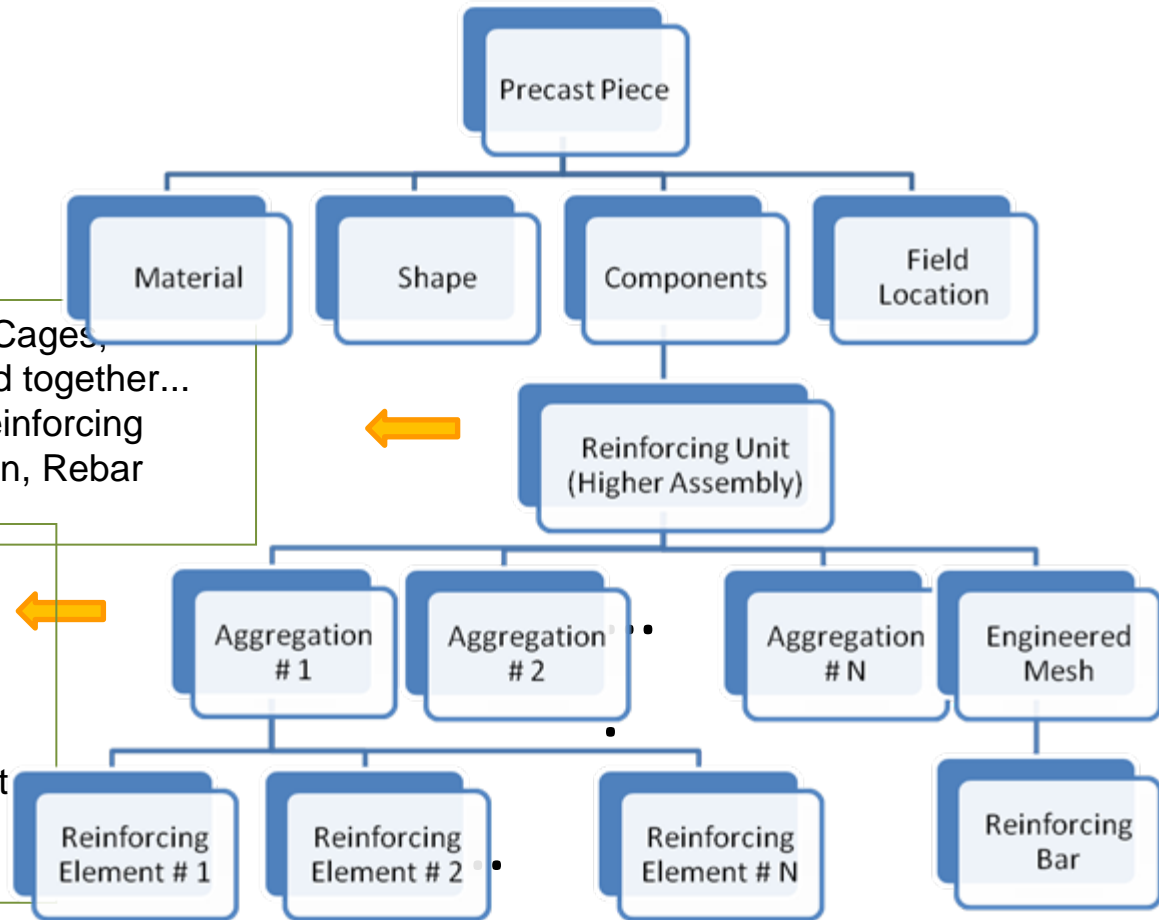IfcElementComponent

IfcDiscreteAccessory
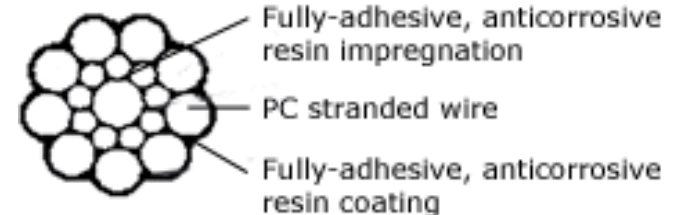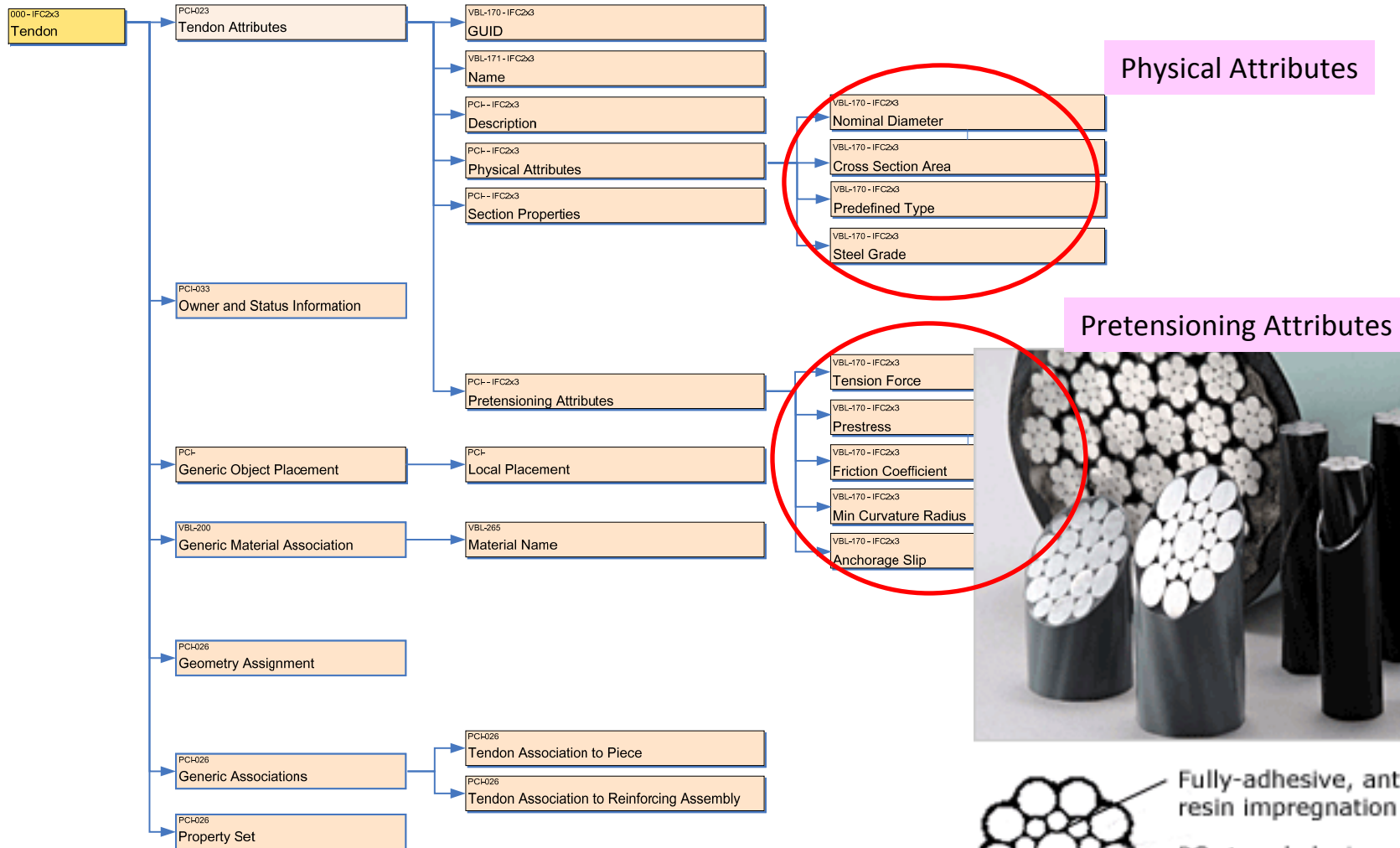
Hierarchy of Reinforcing Elements and Units

Precast Piece

Material | Shape | Components | Field Location
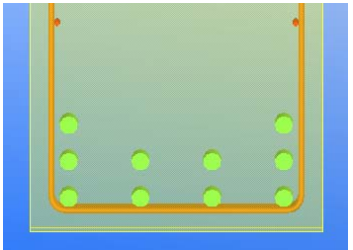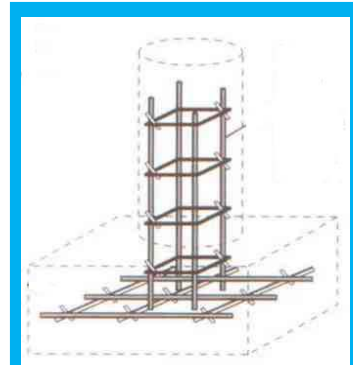
•Different Types of Cages, Meshes, aggregated together...
•Concept Name: Reinforcing Element Aggregation, Rebar Cage

Reinforcing Unit (Higher Assembly)

•Different Types of rebar and tendon arrays, engineered meshes,...
•Concept Name: Reinforcing Element Aggregation, Engineered Mesh

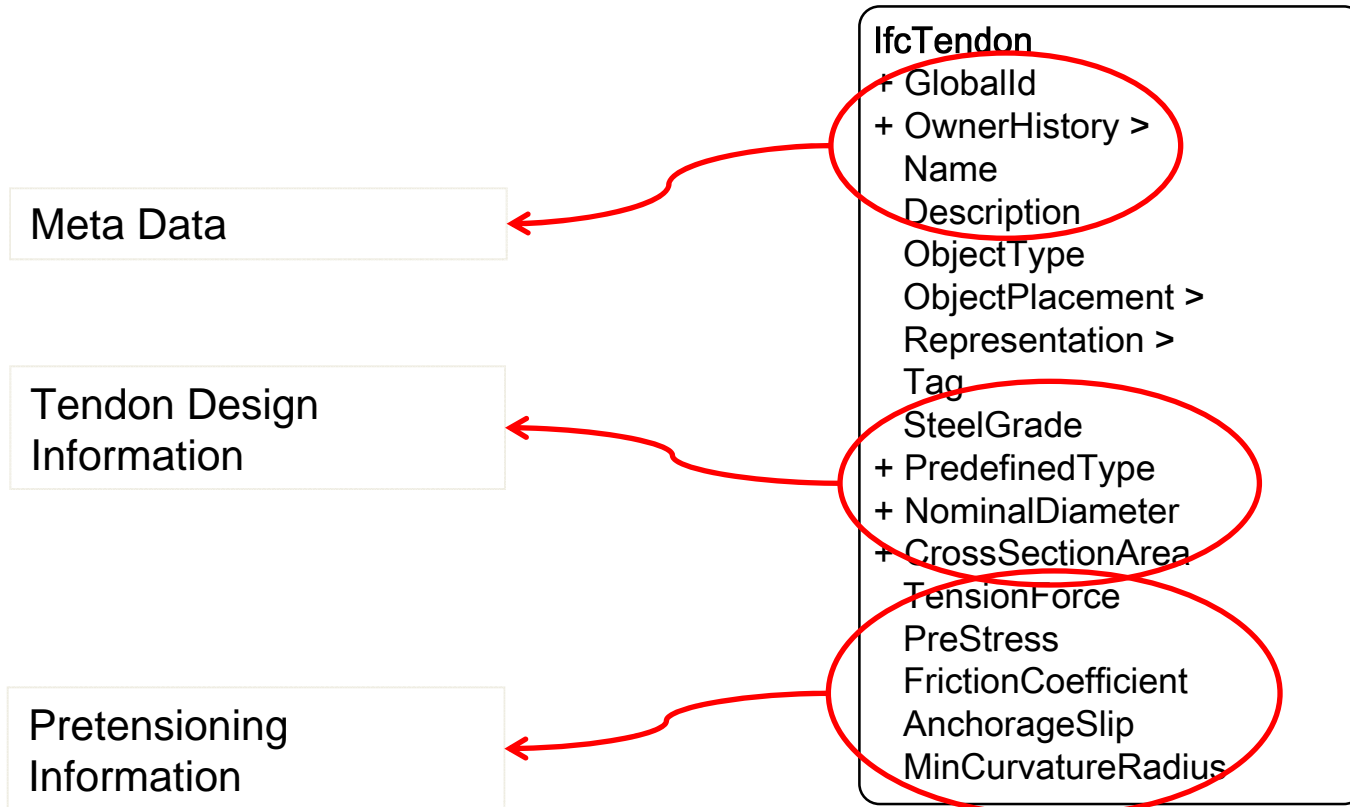Aggregation # 1 | Aggregation # 2 | Aggregation # N | Engineered Mesh

Reinforcing Element # 1 | Reinforcing Element # 2 | Reinforcing Element # N | Reinforcing Bar

•Reinforcing Bars ,Tendons, and Standard Meshes
•MVD Concept Name: Reinforcing Bar , Tendon , and Standard mesh

Tendon Type

IfcTendon

Meta Data

Tendon Design Information

Pretensioning Information

IfcTendon
+ GlobalId
+ OwnerHistory >
  Name
  Description
  ObjectType
  ObjectPlacement >
  Representation >
  Tag
  SteelGrade
+ PredefinedType
+ NominalDiameter
+ CrossSectionArea
  TensionForce
  PreStress
  FrictionCoefficient
  AnchorageSlip
  MinCurvatureRadius

Tendon Shape Representation

IfcTendon
+ GlobalId
+ OwnerHistory >
  Name
  Description
  ObjectType
  ObjectPlacement >
  Representation >
  Tag
  SteelGrade
+ PredefinedType
+ NominalDiameter
+ CrossSectionArea
  TensionForce
  PreStress
  FrictionCoefficient
  AnchorageSlip
  MinCurvatureRadius

(INV) IsDefinedBy

IfcLocalPlacement
  PlacementRelTo >
+ RelativePlacement >

(INV) PlacesObject

IfcProductDefinitionShape
  Name
  Description
+ Representations >

(INV) ShapeOfProduct

IfcShapeRepresentation
+ ContextOfItems >
  RepresentationIdentifier
  RepresentationType
+ Items >

(INV) OfProductRepresentation

IfcCompositeCurve
+ Segments >
+ SelfIntersect

IfcRelDefinesByProperties
+ GlobalId
+ OwnerHistory >
  Name
  Description
+ RelatedObjects >
+ RelatingPropertyDefinition >

Tendon Type

IFC Solutions Factory
The Model View Definition site

Design to Quantity Takeoff	BSA-001
Extended coordination view	ISG-001
Extensibility	VBL-003
Indoor climate simulation to HVAC design	HUT_HVAC-001
Landscape design to road design	CRC_CI-002
Precast Concrete Design to Precast Detailing	PCI-001

Requirements	Exchange Requirements
Definition	Overview
Bindings	IFC2x3 : Overview Diagram
Status	Draft

Information Delivery Manual for precast Concrete

CMVDs and Concepts

Organizations

Name	Contact Person	Project role	Participation level
Precast Concrete Institute	Chuck Eastman	Project owner	
Georgia Institute of Technology	Manu Venugopal	Author	Active
	Shiva Aram	Author	Active
	Ivan Panushev	Author	Active
	Chuck Eastman	Project leader	Active
Israel Instutue of Technology	Rafael Sacks	Author	Active

Main concepts | Building, Building Storey, Grid, Non-Precast Element, Non-Precast Element Type, Precast Piece, Precast Piece Type, Precast Slab, Project, Site

Road design to landscape design	CRC_CI-001
Space Requirements and Targets to Thermal Simulation	HUT_HVAC-002
Structural design to structural analysis	VBL-001
Structural Design to Structural Detailing (ATC-75)	ATC-001