EPRI CIM for Dynamic Models Project Report

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CIM for Dynamic Models

- EPRI project – started March 2008
- Project Objectives
  - Develop a standard way to exchange dynamic models for each generator, load or other resource in a power system network
- Technical Approach
  - Extend the CIM and develop a set of interface profiles to support the exchange of dynamic cases (dynamic models and associated static network models)
  - Builds from the EPRI CIM for Planning project extensions to the CIM UML
- Challenge
  - How to model the interconnectivity between dynamic models and their association to the static network model

Business Needs Addressed

- Enable conduct of dynamic assessment studies involving simulation for
  - Contingency analysis to ensure reliability of transmission grid
  - Post mortem evaluation of conditions leading up to a catastrophic event
  - Planning to determine where network upgrades are needed
  - New plant commissioning which may require new dynamic models from supplier
- Users include transmission planners and regional reliability organizations
  - During planning stage
  - During operational life of each resource
- Sources include
  - Transmission, generation, or other resource owners
  - Manufacturers of equipment

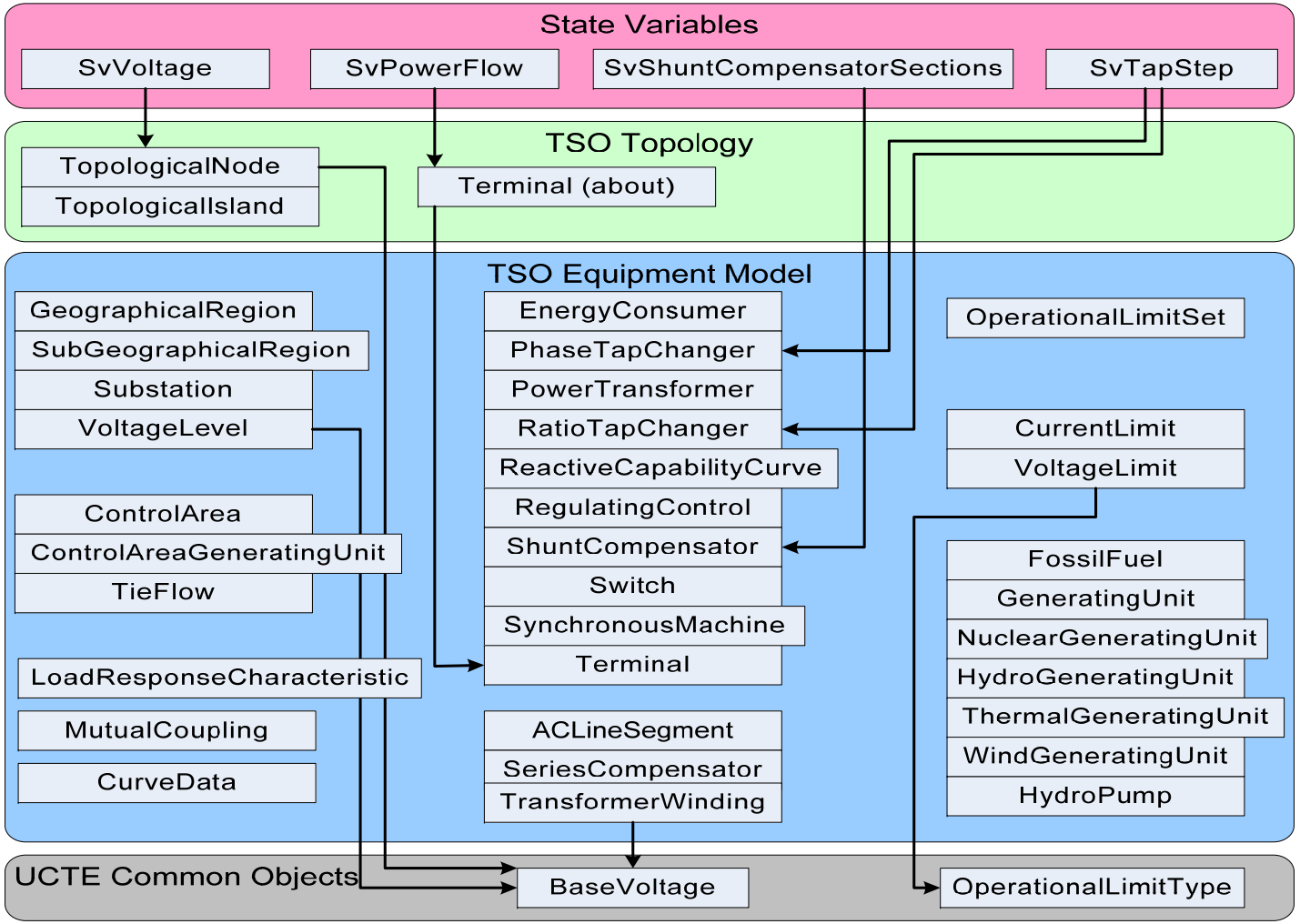
Status of Key Deliverables

- UCTE IOP Test
- Dynamic Case Definition
- Standard Model exchange
- User-Defined Model exchange
- CIM modeling

Dynamic Case Definition – Profile Contents

- The Dynamic Case Profile Group contains the following Profiles:
  - Equipment
  - Topology
  - State
  - Dynamics
- The actual Case Files used in an exchange will contain this data in separate files for each profile instance
- UCTE IOP tested the static load flow models plus network solutions

Dynamic Case Contents – UCTE Base



Dynamic Case Definition – Case Composition

- The Dynamic Case will contain Profile Data Groups as CIM XML files
  - **Common Objects File** - contains objects that are intended to be shared by all
  - **Equipment File** - describes the equipment without connectivity
    - Includes dynamic model system parameters
  - **Topology File** - contains all topology objects (result of Topology Processing) and describes how it is electrically connected
  - **State Variables File** - contains all objects required to complete the specification of a steady-state solution (i.e., the solved voltage, tap positions, etc.)
  - **Dynamic Model File** – contains all objects required to specify both standard and user-defined dynamic models
    - System parameters that are modeled as properties of PSR objects are in Equipment PDG file

Standard Model Team

- **Lead:** Bill Price, Consultant, GE PSLF expert
- **Members:** 17 vendors, utilities, and NERC
- **Charter**: Develop the data requirements and mapping to the CIM for the exchange of standard models

Types of Dynamic Model Exchanges

- Standard models
  - Includes multiple standard models (IEEE, WECC, etc.) interconnected in a standard way
    - Generators (including wind turbines)
    - Motors
    - Excitation systems, limiters, and compensators
    - Turbine/governor models
    - Stabilizers
    - Loads
    - Transmission devices
    - Relay and protection devices
    - HVDC and FACTS
  - Goal
    - Define standard model reference manual and list of standard models
    - Extend CIM UML to model standard dynamic models and their interconnection
    - Minimize amount of information included in dynamic case file

Standard Model Team - Status

- List of standard models – initial list complete
  - Models used by WECC, MMWG, UCTE
  - Corresponding models in IEEE, PSLF, PSS/E, PowerFactory, EUROSTAG identified
- Standard Model Reference Manual
  - EPRI published Summer 2009 IOP Version
  - Detailed descriptions of standard models
    - Standard interconnections
    - Block diagrams/equations, parameters, typical data
    - Sample step responses being added
    - CIM class/attribute mapping in process
  - More models to be added
    - Present models sufficient for initial IOP

List of Standard Models

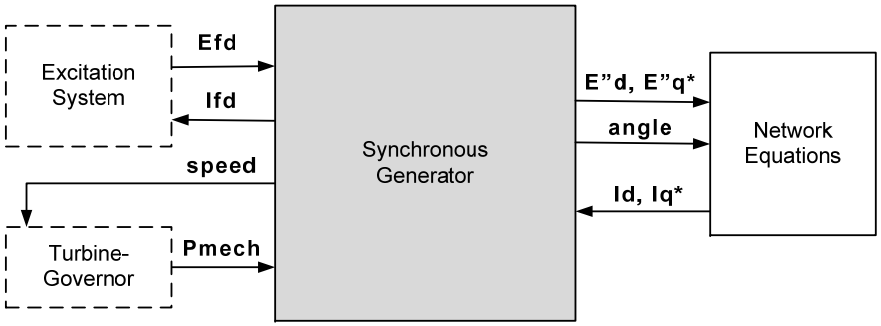
GENERATOR MODELS

CIM Model Name	GE PSLF	PTI PSS/E*	DigSILENT	Eurostag	IEEE Standard	MMWG	WECC	UCTE	Comments
genSync	genrou	GENROU	ElmSym	M2		X	X	X	Round rotor generator model, use for thermal generator models
genSync		GENTRA	ElmSym					X	Transient generator model
genSync	gensal	GENSAL	ElmSym	M2		X	X	X	Salient pole generator model, use for hydro generator models
genSync	gentpf						X	X	WECC Type F model
genSync	gentpj						X	X	WECC Type J model
genSync	gencc	GENROU					X	X	Cross-compound generator model
genEquiv	gencls	GENCLS	ElmSym	M6		X		X	"Classical" generator model - used only for small generators or gross equivalents
genLoad	"Netting"					X		X	Generator represented as a negative load
genAsync	genind, motor1	CIMTR1,CIMTR3	ElmAsm	M10, M13		X	X	X	Induction generator model
	wt1g	WT1G						X	Type 1 standard wind turbine generator model
	wt2g	WT2G						X	Type 2 standard wind turbine generator model
	wt3g	WT3G1						X	Type 3 standard wind turbine generator model
	wt4g	WT4G						X	Type 4 standard wind turbine generator model
				M1					Synchronous machine, internal parameters, full model
				M5					Synchronous machine, internal parameters, simplified model
				M11					Asynchronous (induction) machine, simplified model
				M14					Asynchronous (induction) machine, simplified model, macroblock defined torque
				M15					Double Fed induction generator, induction generator model
				M50					Converter model

Standard Model Reference Manual

Synchronous Generator Models

For conventional power generating units (e.g., thermal, hydro, combustion turbine), a synchronous machine model represents the electrical characteristics of the generator and the mechanical characteristics of the turbine-generator rotational inertia. The standard interconnection variables between a synchronous generator model and other models are shown in the following figure and table:



*** Network interface variables may differ among application programs**

Synchronous Generator Interconnection Variables

The interconnection with the electrical network equations may differ among application programs. The program only needs to know the terminal bus and generator ID to establish the correct interconnection.

Synchronous Generator Interconnection Variables

Model Type **Synchronous Generator**

Inputs:

Name	*Units*	*Description*	*Source*
Efd	p.u.	Field voltage on base of Ifag * Rfd (field resistance)	Exciter
Pmech	p.u.	Mechanical shaft power to the generator	Turbine

User-Defined Model Team

- **Lead:** Chuck Dubose, Siemens PTI, PSSE expert
- **Members:** 11 vendors, utilities, NERC, and UCTE
- **Charter**: Develop list and definition of control blocks for user-defined models, and map dynamic case data to the CIM UML

Types of Dynamic Model Exchanges

- User-Defined models
  - Includes
    - User-defined models (such as an exciter) comprising interconnected elementary control blocks
    - User-defined connectivity between control blocks
    - Various hybrid arrangements
  - Goal
    - Provide flexibility to completely specify a new model in a standard way
    - Use well-known elementary control blocks
      - Ex: time delay, step function, log, sin, etc.

User-Defined Model Team - Status

- List of elementary control blocks – List for IOP is complete
  - Standard blocks defined to represent PTI PSSx BOSL, PowerFactory, EUROSTAG models
  - Sufficient for application cases defined for IOP
- User Defined Model Reference Manual
  - Detailed descriptions of how to model user defined models using standard control blocks
    - Standard interconnection of control blocks
    - Block diagrams with equations, parameters
    - This information will also be stored in sending/receiving applications
    - Will begin soon

List of Elementary Control Blocks

Basic Control Blocks

CIM Name	PTI PSS® x BOSL	DIgSILENT	EUROSTAG	Usage	Description
K	PROP	K	gain	y = K *x	This Block outputs the product of the input times a constant stored in the block. The Constant gain factor K is a parameter stored in the block and may be any floating point value. X is the input of the block and Y is the output of the block.
Integrater1	INT	1/sT lim	limited integrator	dy / dt = x / T	Add flags to indicate whther max and min limits will be used. Limits will be parameters of the blocks. x1 is the value of the minimum limit. x2 is the value of the maximum limit. x2 should be always larger than x1. integrator with non-windup limits.
Timelag1	DE1	1/(1+sT)	simple lag		first order time lag
Timelag2	DE2		limited simple lag		second order time lag. Non windup limits
LeadLag	PD	(1+sTa)/(1+sTb)	lead lag filter	y = x * Gain * [(1+s*T) / (1+s*T1)]	first order lead-lag with limits and gain

CIM Modeling Team

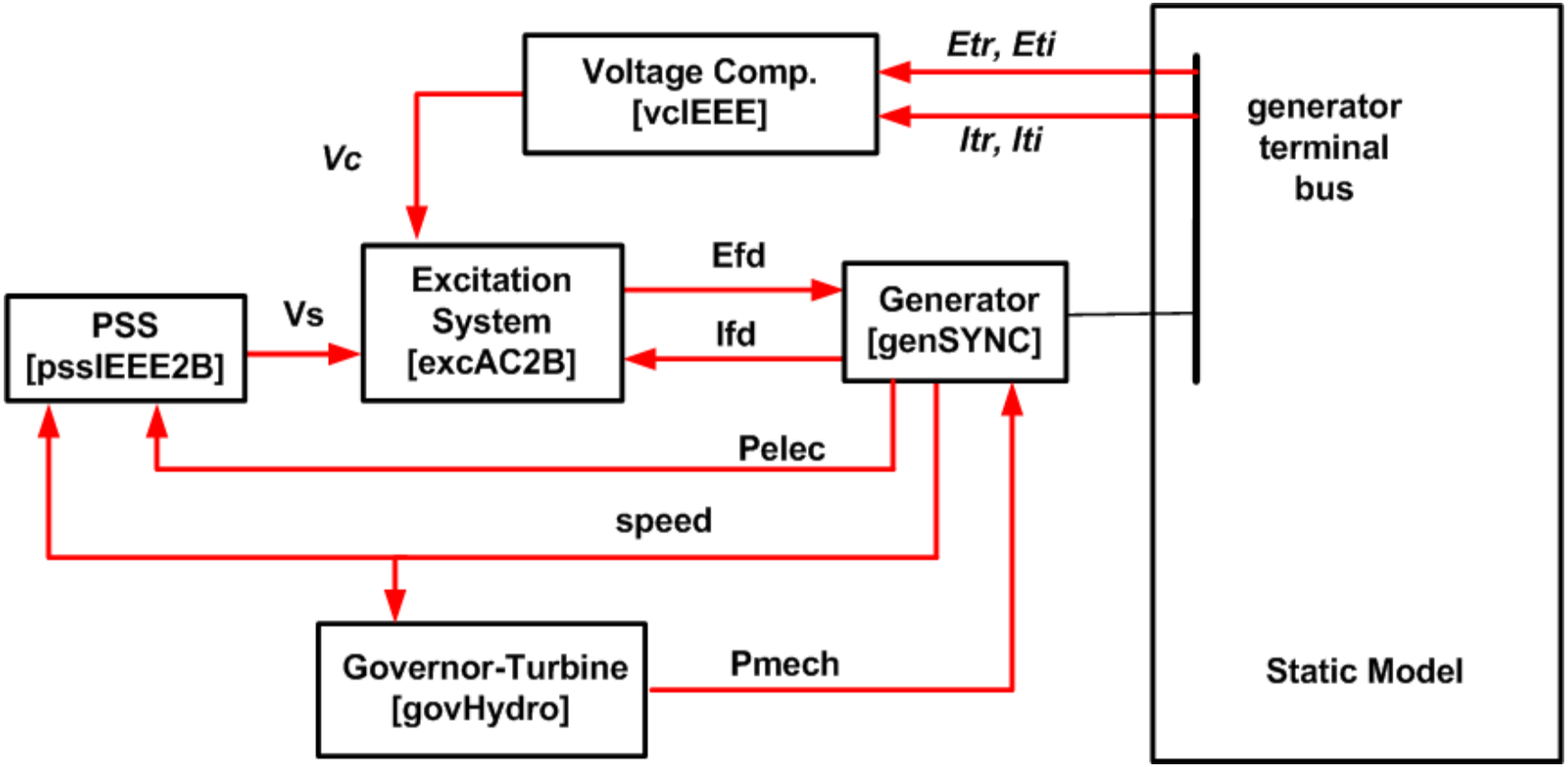
- **Lead:** Kendall Demaree, Areva, CIM Model Manager for CIM User Group and IEC TC57
- **Members:** 7 vendors and consultants
- **Charter**: Develop modeling approach to represent dynamic models and required signal connectivity in UML, building from existing CIM model

CIM Modeling Team - Status

- Standard and user-defined model interconnectivity model in UML completed as extension to CIM UML
  - To be tested with 4 application cases
- System parameters for standard models added to the CIM UML
  - Most dynamic data is not currently represented in CIM, but goal is to reuse those properties that already exist
- Profiles for data exchange progressing well
  - Static model with solved case defined and tested during UCTE IOP in March 2009
  - Next is to add PDG for dynamic models

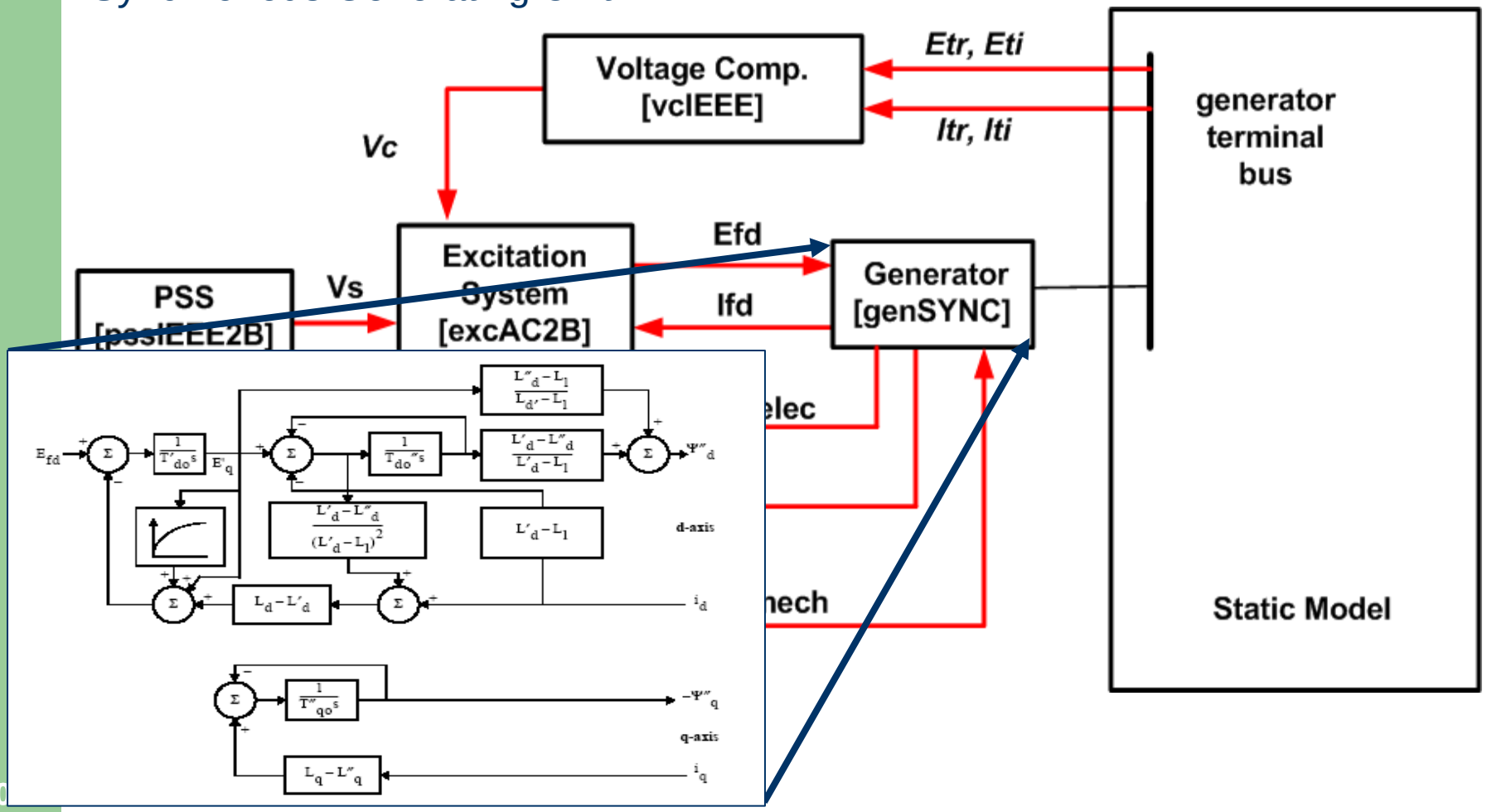
AC1 - Standard Model Example

Example: Synchronous Generating Unit

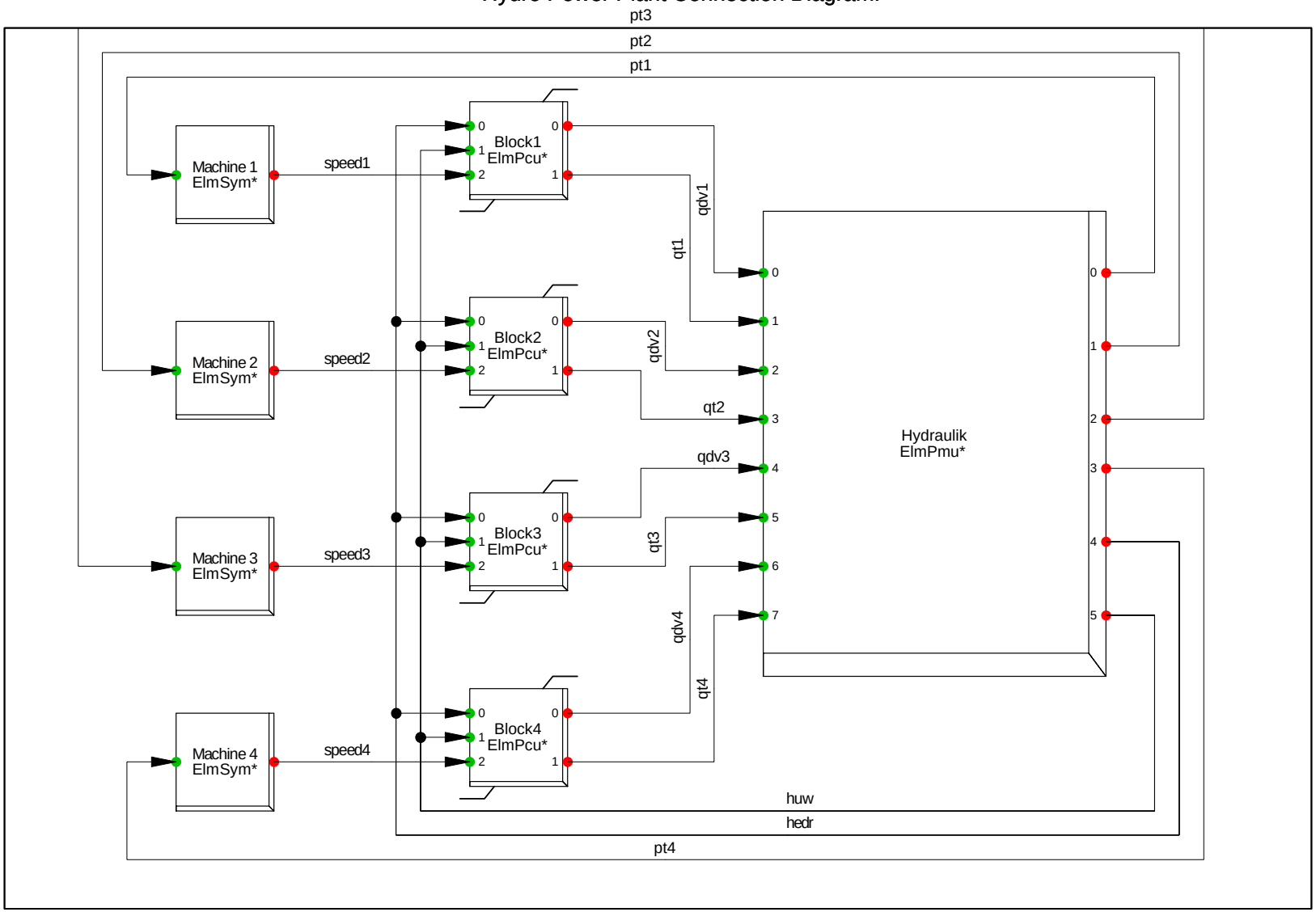


AC2: User Defined Model Substitute for Standard Model

Synchronous Generating Unit

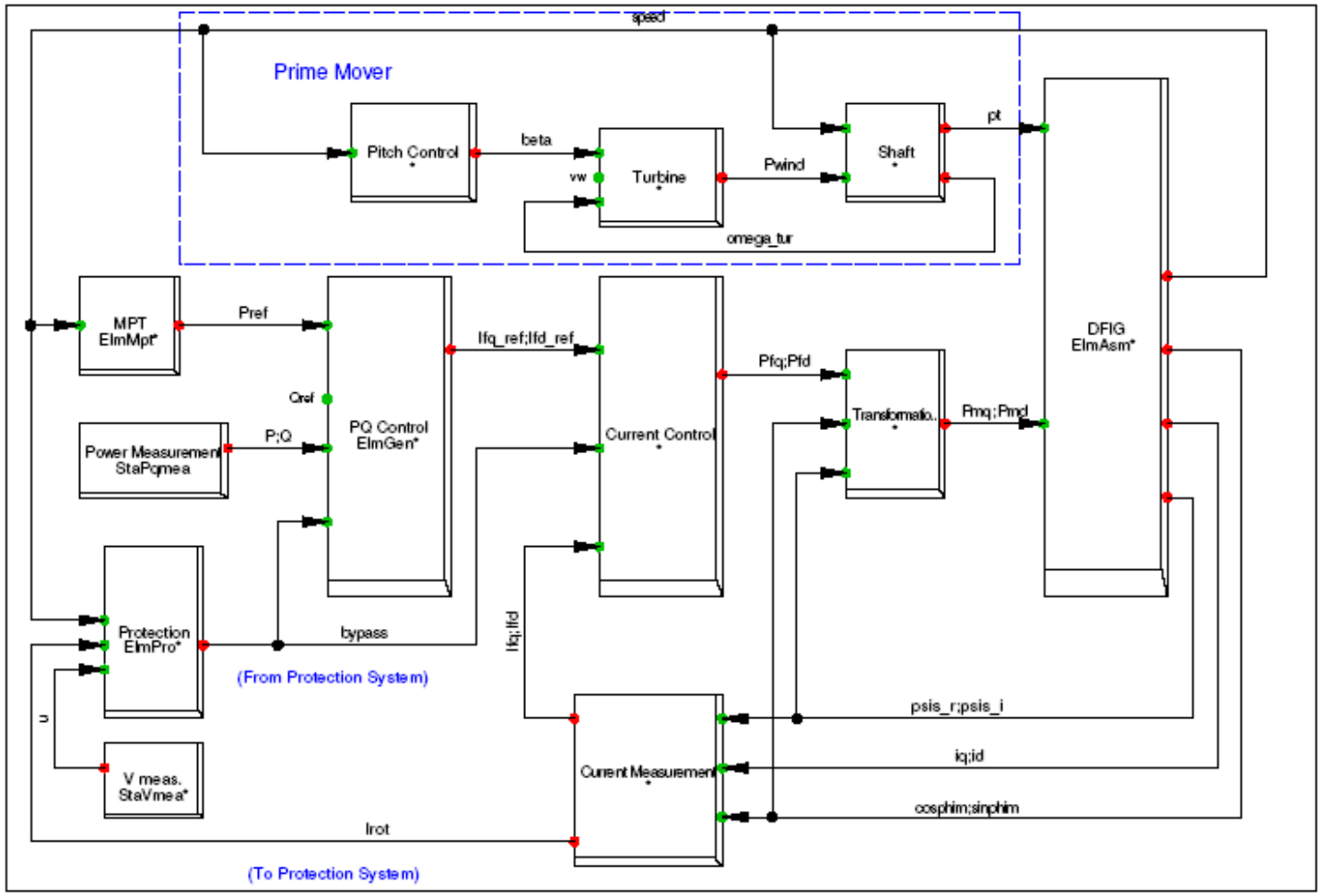


AC3 – Standard Models, User Defined Interconnection

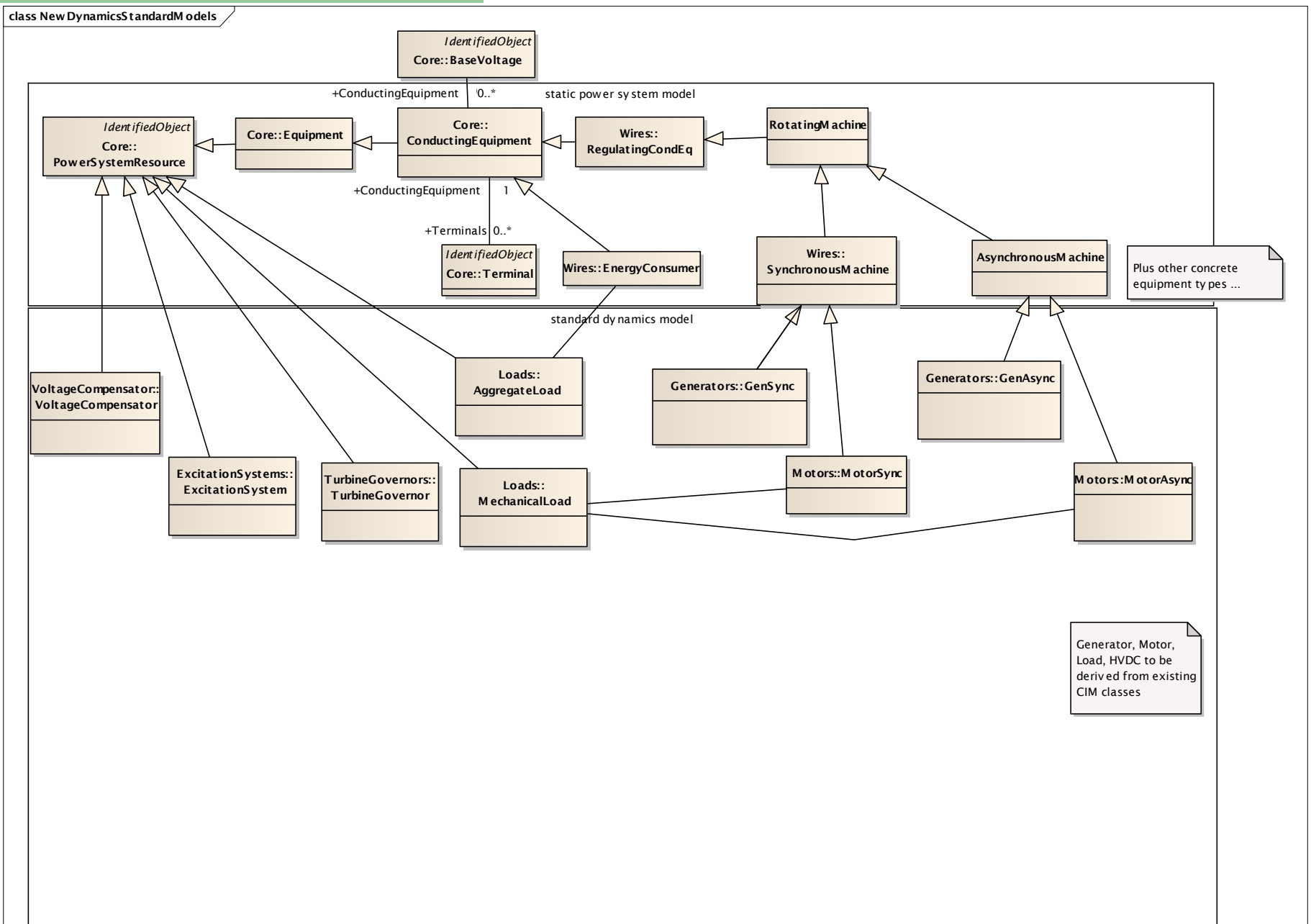


App Case 4 - Complete User Defined Model

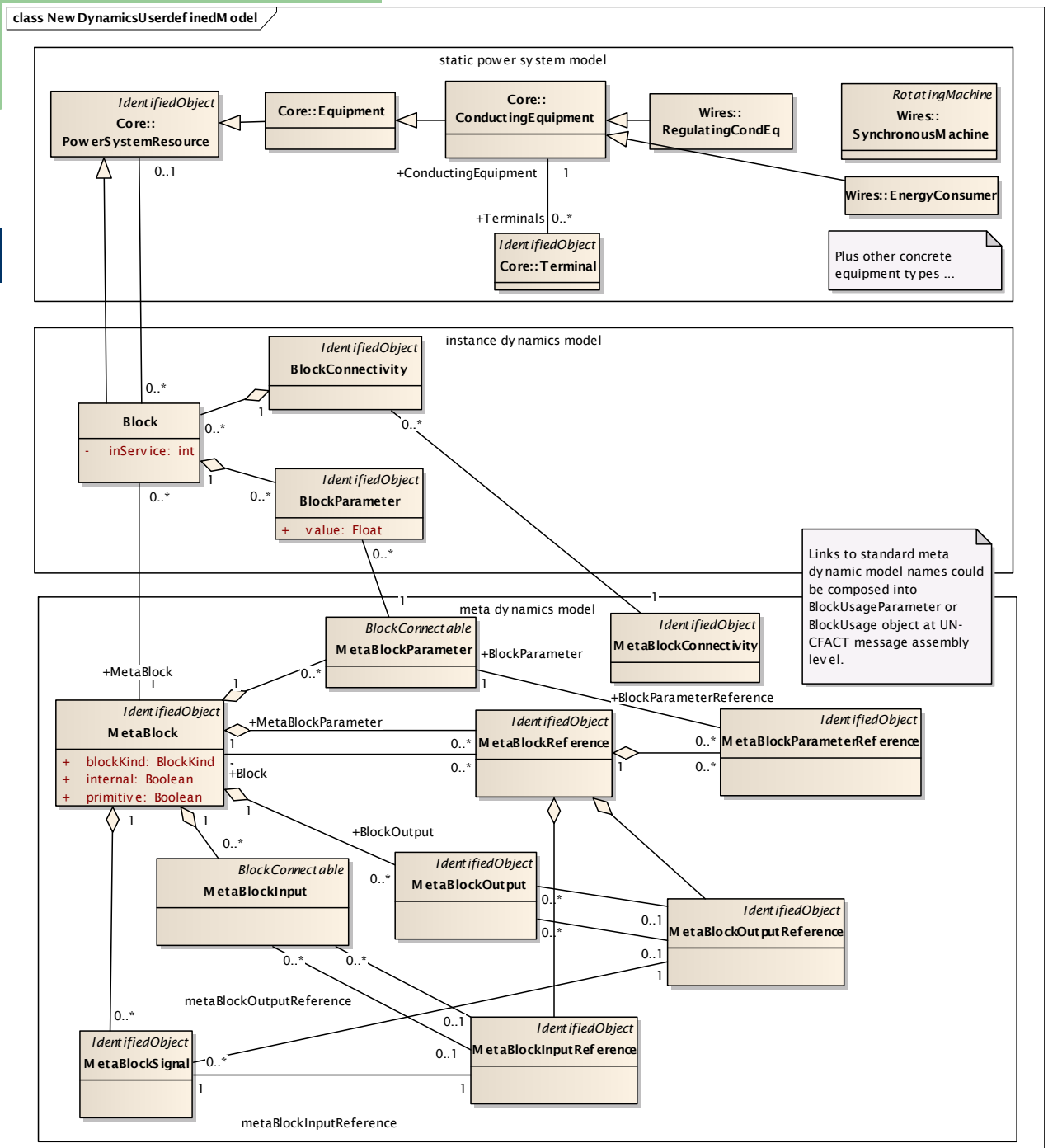
Wind Turbine Connection Diagram:



EPRI CIM for Dynamic Models



EPRI CIM for Dynamic Models



Key Artifacts to be Produced

- List and reference manual for standard dynamic models and control blocks for user-defined models
- Extensions to CIM UML information model to support dynamic case exchanges
- UML modeling approach to handle dynamic models with linkage to static load flow models
- Template for equipment suppliers to provide dynamic models
- New exchange profiles for the various exchanges
- Interoperability test results
- Presentation and handover to IEC TC57

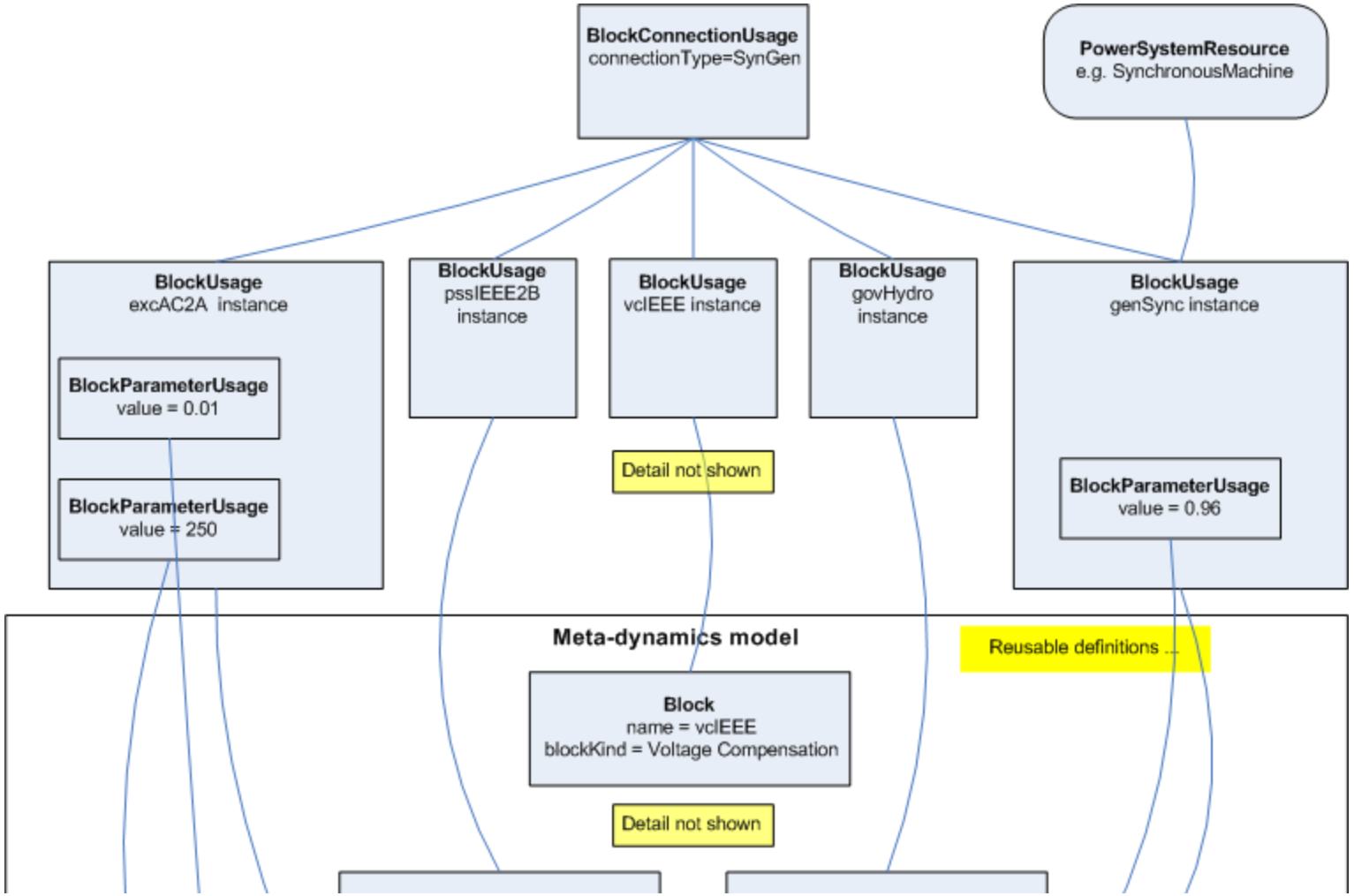
Milestone Schedule

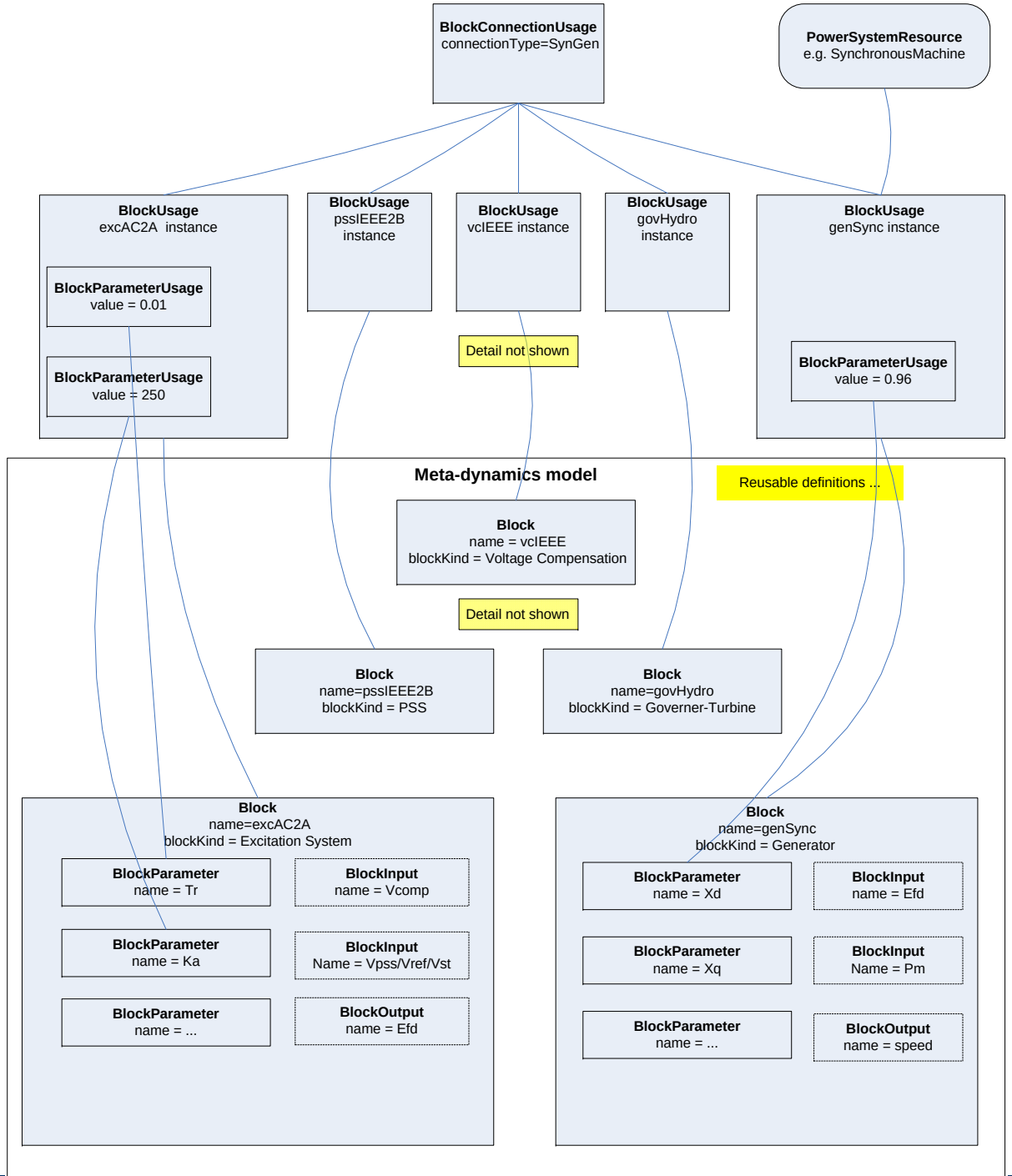
Description	Date
Solved Case Exchange (UCTE)	
IOP Training Lab	Completed
Exchange profile and test procedures for IOP	Completed
UCTE IOP	Completed
Dynamic Modeling	
CIM UML with dynamics model extensions for review	Complete
List of standard models for IOP	Complete
List of standard control blocks	Complete for IOP
Sample model files for IOP software developers	4/15/2009
Standard Model Reference Manual	Complete for IOP
Dynamic model exchange profile	10/15/2009
User Defined Model Control Block Reference Manual	Future
Dynamic case for model exchange	10/1/2009
Dynamics IOP	11/25/2009

Next Steps

- IOP test for more complex user defined models
- Final edition – Standard Model Reference Manual
- User-Defined Model Reference Manual
- HVDC and FACTS models
- Proprietary model exchange - testing
- Repository for dynamic model management
- Promote use of new dynamic model standards by manufacturers and software vendors

Standard Model UML Structure

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connectionType=SynGen
PowerSystemResource
e.g. SynchronousMachine
BlockUsage
excAC2A instance
BlockParameterUsage
value = 0.01
BlockParameterUsage
value = 250
BlockUsage
pssIEEE2B
instance
BlockUsage
vcIEEE instance
BlockUsage
govHydro
instance
Detail not shown
BlockUsage
genSync instance
BlockParameterUsage
value = 0.96
Meta-dynamics model
Reusable definitions ...
Block
name = vcIEEE
blockKind = Voltage Compensation
Detail not shown
Block
name=pssIEEE2B
blockKind = PSS
Block
name=govHydro
blockKind = Governer-Turbine
Block
name=excAC2A
blockKind = Excitation System
BlockParameter
name = Tr
BlockInput
name = Vcomp
BlockParameter
name = Ka
BlockInput
Name = Vpss/Vref/Vst
BlockParameter
name = ...
BlockOutput
name = Efd
Block
name=genSync
blockKind = Generator
BlockParameter
name = Xd
BlockInput
name = Efd
BlockParameter
name = Xq
BlockInput
Name = Pm
BlockParameter
name = ...
BlockOutput
name = speed