Lessons in applying Model-Based Design for systems and controls engineering in alternative energy startup environment

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Steel production is the largest source of the industrial CO2 – 7% of global emissions

2.1 gigatons CO₂ per year

0 CO₂ per year
Engineering Startup Needs

Scale up technology quickly with limited resources

- Small engineering team
- Aggressive timelines
- Limited budget
- Uncertainty
- Complexity
Adopted Solution

Mathworks Model-Based Design for Systems and Controls Engineering

- Facilitate communication between highly specialized functional teams
- Handle system complexity and reduce requirements uncertainty
- Perform trade space analysis for concept selection
- Adopt agile methodologies for control system development, automate!
- Minimize building expensive hardware prototypes through “virtual prototyping”, perform continuous verification, find defects early
- Build insight into system behavior, perform “what-if” analysis, inform system design
How do I systematize the use of various Mathworks MBD tools?

Apply systems thinking to product / controls development process with Mathworks MBD tools

- Treat product / controls development process with Mathworks MBD tools as a system - a set of interrelated entities

- Identify the MBD system entities form and function and their interaction with each other

- Create the MBD system model to map form onto function and demonstrate the process

- Use Object-Process Methodology for MBD system modeling
What is Object-Process Methodology (OPM)?

OPM is a conceptual modeling language for capturing knowledge and designing systems.

Object-Process Diagram (OPD): formally capturing function, structure and behavior of the system

Object or Operand (e.g. Cow)

Operator or Agent (e.g. Farmer) handles Process or Function (e.g. Milking).
Structural Relationship (e.g. Milking Parlor) hosts Instrument or Form (e.g. Milking Machine).
Part (e.g. Milk Tank) exhibits Property (e.g. Milk Tank Size).
Specialization (e.g. Fully Automatic Machine) is an Instrument or Form (e.g. Milking Machine).
Specialization (e.g. Fully Automatic Machine) consists of Part (e.g. Milk Tank).

Process or Function (e.g Milking) requires Instrument or Form (e.g. Milking Machine).
Process or Function (e.g Milking) consumes Object or Operand (e.g. Cow).
Process or Function (e.g Milking) yields Object or Operand (e.g. Milk).

Object-Process Language (OPL): a set of automatically generated (from OPD) sentences in a subset of English
Mathworks MBD System Object-Process Model
System Requirements Engineering - OPM
System Architecture Development - OPM

[Diagram of System Architecture Development with labels and connections]
Controls Software Design and Implementation - OPM
Controls Software Model-in-the-Loop Testing & Verification - OPM
Controls Software Target-in-the-Loop Testing & Verification - OPM
Mathworks MBD System Object-Process Model
Thank you!

Questions?