RT - 177
Interactive Model-Centric Systems Engineering

Donna H. Rhodes, PI
Adam M. Ross
Massachusetts Institute of Technology

SYSTEMS ENGINEERING RESEARCH CENTER

SEA RI — Systems Engineering Advancement Research Initiative — MIT

Research Task / Overview

Models have significantly changed systems engineering practice over the past decade and continue to do so…

Significant progress on theory/practice of model-based systems engineering, insufficient focus on human-model interaction

IMCSE research program seeks to inform and contribute methods, processes and tools to improve interactivity of humans and models in support of decision-making

Interact with models individually and in teams

Goals & Objectives

Develop transformative results through enabling **intense human-model interaction**, to rapidly conceive of systems and interact with models in order to make rapid trades to decide on what is most effective given present knowledge and future uncertainties, as well as what is practical given resources and constraints

…ultimate goal is achieving effective "human-model teaming"

Research Activities

Recent and ongoing research seeks to address fundamental questions through empirical studies, experiments, prototypes, and case studies….

o *How do humans interact with models and model-generated information?*
o *How do humans interact with each other through using models?*
o *How can decisions be improved through model interaction?*
o *What cognitive challenges exist for model-informed decision-making?*
o *What are essential human roles in model-centric environments?*

Models are "abstractions of reality" … gap between model and system is narrowing

Higher probability errors and omissions in a model lead to system failures

Humans need to be endogenous to interactive model-centric environments

Interactive Epoch-Era Analysis
o Mature framework with associated supporting tools to a case analysis including various types of uncertainties
o Case application to elicit feedback on relevance, ease of use, feasibility, tractability of data scaling and visualization techniques
o Develop interactive visualization demonstration prototypes

Human-Model Interaction
o Investigate relevant research studies and lessons from relevant past cases
o Conduct interview-based study of model-centric decision making
o Generate preliminary heuristics/design principles for human-model interaction
o Synthesize knowledge as guidance for model developers, model users, decision makers

Curation of Model-Centric Environments
o Investigate need and opportunities for curation role to address challenges and needs in model-centric enterprises
o Research and develop roles and responsibilities, and alternative organizational forms for model curation leadership
o Engage research stakeholders in capturing a standard for "model pedigree"

SERC TALKS

Prior Research Webinar
December 7, 2016
"Why is Human-Model Interactivity Important to the Future of Model-Centric Systems Engineering?"
Available at www.sercuarc.org/serc-talks

Glimpses of Ongoing Work

Interview-based study of model-centric decision making

Study explored use of models in decisions, and issues of trust and perception of models

Areas of the study findings are listed

Three actor decision flow
Importance of intercommunication
Transparency and trust
Understanding of assumptions and uncertainty
Technological and social factors influencing trust
Importance of model-related documentation
Factors limiting model-centric decisions
Using models as primary versus supplementary
Model pedigree
Non-advocate role in reviews
Model investment bias and confirmation bias
Real-time interaction with models
Viewing humans as endogenous

Investigating a "chief model curation officer" role

Paradigm Shift	Leadership Approach	Enterprise Characteristics Include…
Model Use Throughout Program	"Local" model management	• Models are primary artifacts replacing documentation • Limited reuse of models • Organization embraces importance of models
Model Reuse Across Programs	Model leadership responsibilities	• Models-based engineering as standard practice • Models are reused across programs in business unit • Model-centric enterprise culture
"Digital Twin" Throughout System Lifecycle	CMCO as enterprise leadership role	• System "digital twin" maintained through lifecycle • Enterprise practices for model architecture (modularity, ease of composability) • Model-centric culture embedded across enterprise
IP Inversion in Enterprises	CMCO as top tier executive	• Models (Digital Twins) are key deliverables • Model IP is more valuable than product, models are sold, exchanged, loaned • Innovations emerge from composability of models

Semi-structured interviews indicate enterprise leaders recognize the need for enterprise-level leadership for strategically managing model assets and model-centric environments

Heuristics for model-centric enterprises

Informed by empirical studies, ongoing research is leading to a set of heuristics for use in education, guiding teams, and informing model-centric enterprise policies and practices

Models do not have agency -- the ultimate responsibility for decisions must be upon humans

• Ultimate decision-making authorities are people, and blame cannot be placed upon models for poor decisions
• Model developers, users, and decision-makers have the responsibility to ensure that models are properly understood and appropriately used
• Individuals should be aware of the potential for improperly diffusing responsibilities for decisions upon models
• Policies should clearly establish the responsibilities for which individuals are held accountable in model-centric enterprises

---

Future Research

o Continue empirical investigation of model-centric decision making and understand patterns of interaction using dynamic models
o Publish state of practice report on human-model interaction, with study results and updated research roadmap
o Form partnerships to transition model curation research outcomes into broader community initiative
o Further develop heuristic guidance for use in practice

Contacts/References

Dr. Donna H. Rhodes, PI
rhodes@mit.edu
Research reports available on SERC website
Recent papers and prototypes available at seari.mit.edu