Model-Centric Decision-Making:
exploring decision-maker trust and perception of models

Erling Shane German and Donna H. Rhodes

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Overview

- Introduction and motivation
- Research approach
- Framework for model-centric decision-making
- Trust in models
- Key findings
- Future research

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Introduction

- Envisioned Future for Model-Centric Engineering
  - "[O]verarching digital engineering approach," Blackburn et al. (2017)
- Interactive Model-Centric Systems Engineering (IMCSE)
  - "*Develop transformative results through enabling intense human-model interaction,"* Rhodes et al. (2017)
- 2015 SERC IMCSE Pathfinder Workshop Findings:
  - little attention has been given to *human-model interaction*

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Interview-Based Study on Model-Centric Decision-Making

Exploratory study ongoing to gain insight into how various types of decision-makers interact with and perceive models

- Motivated by increasing need for individuals and teams to make decisions with models and model-generated information
- Examines **how decision-makers build trust in models and to what degree models are used to make decisions**
- While anecdotal stories of success and failure exist, **empirical studies are needed to truly understand** the many facets of human decision-making in model-centric engineering
- Expected to generate key insights that may inform current and future practice, and determine areas for more extensive study

- *MIT and DoD IRB Approved*
- *Investigators: German and Rhodes (PI)*

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Research Approach

- Judgmental Sampling: 30 semi-structured interviews
- Grounded Theory Method of Analysis
- Objectives
  - Identify factors leading to trust between humans and models
  - Gather empirical evidence of enablers and barriers related to model-centric decision-making

Modelers

Analysts

Architects

Program Managers

Senior Decision-Makers

Expert Population
Defense &
Aerospace

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Interview Questions

1. What **types of decisions** do you make, or help others make, with models?
2. What is the degree to which the decisions you make are based on models?
3. Do you view models as a **primary or supplementary** source in decision-making?
4. How do you **develop trust** in models?
5. How do you judge if a model can be trusted?
6. How much **transparency** do you desire?
7. What factors have led to **inappropriate trust** in models?
8. What limits your ability to use models to make decisions?
9. What **challenges or failures** have you experienced with the use of models in system decision-making?
10. What approaches or policies have been applied, or would you like to see applied, to mitigate those challenges?
11. How desirable would the ability be to **directly interact** with models real-time while making decisions?

Premise: before you can effectively change a system, you need to know how it operates and what the various actors care about

Purpose of questions: to better understand individual perspectives within the model-centric decision-making process

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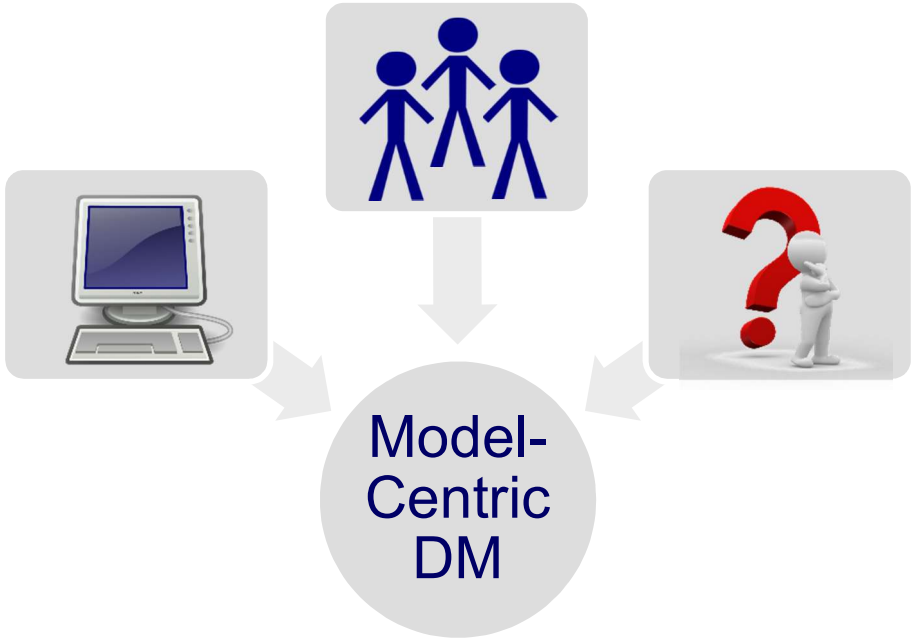
Models and Decisions

What does a model-centric decision-making process look like?

Components:

- Model
- Human actors
- Decision to be made



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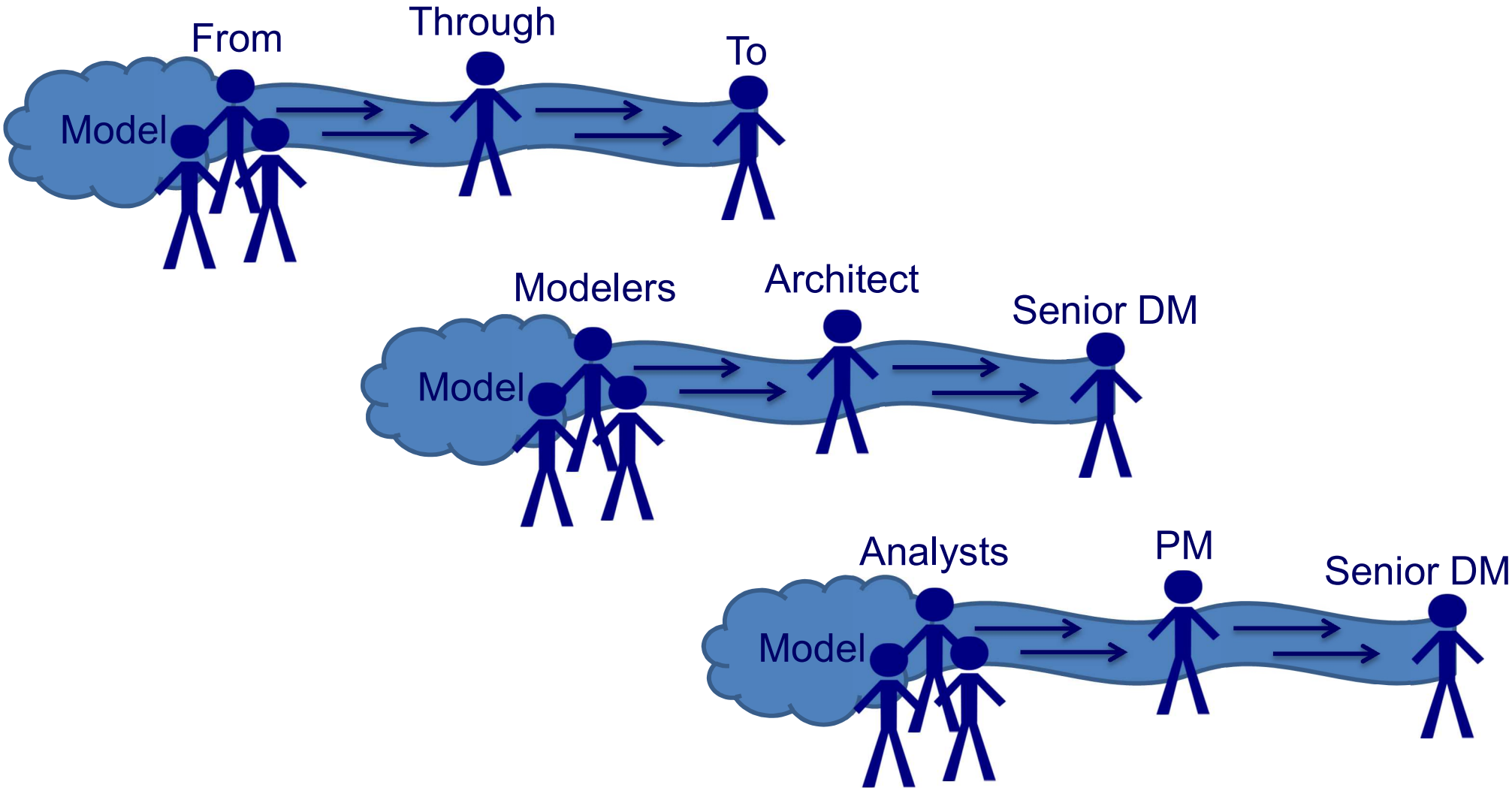
Flow of Model-Generated Information

How are these components connected?



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Trust in Models

- Model-Centric Goals for Truth
  - Blackburn et al. (2017): “single point of truth”
  - West and Pyster (2015): “definitive repository of *authoritative* information”
- A good decision “is one based on a trusted, truthful representation of both reality and values.” (Ricci et al., 2014)
- Trust: “the attitude that an agent will help achieve an individual’s goals in a situation characterized by uncertainty and vulnerability.” (Lee and See, 2004)

Calibration is necessary for appropriate trust in models

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Interim Key Findings

- Sociotechnical Factors Influencing Trust
- Communication
- Transparency
- Assumptions & Uncertainty
- Documentation
- Common Biases
- Primary vs. Supplemental
- Independent Review
- Real-Time Interaction
- Humans Endogenous to Model-Centric Environment

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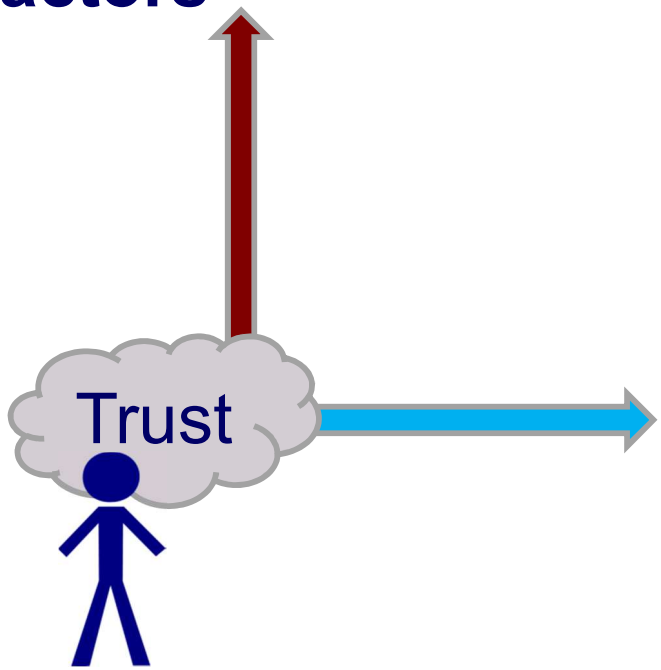
Sociotechnical Factors Influencing Trust

"Trust is terribly important…"

Technological Factors

- Transparency
- Documentation
- Uncertainty
- Referent Data
- Model Code
- …



Social Factors

- Credibility
- Personal Relationships
- Word of Mouth
- Model Origin
- Expert Opinion
- …

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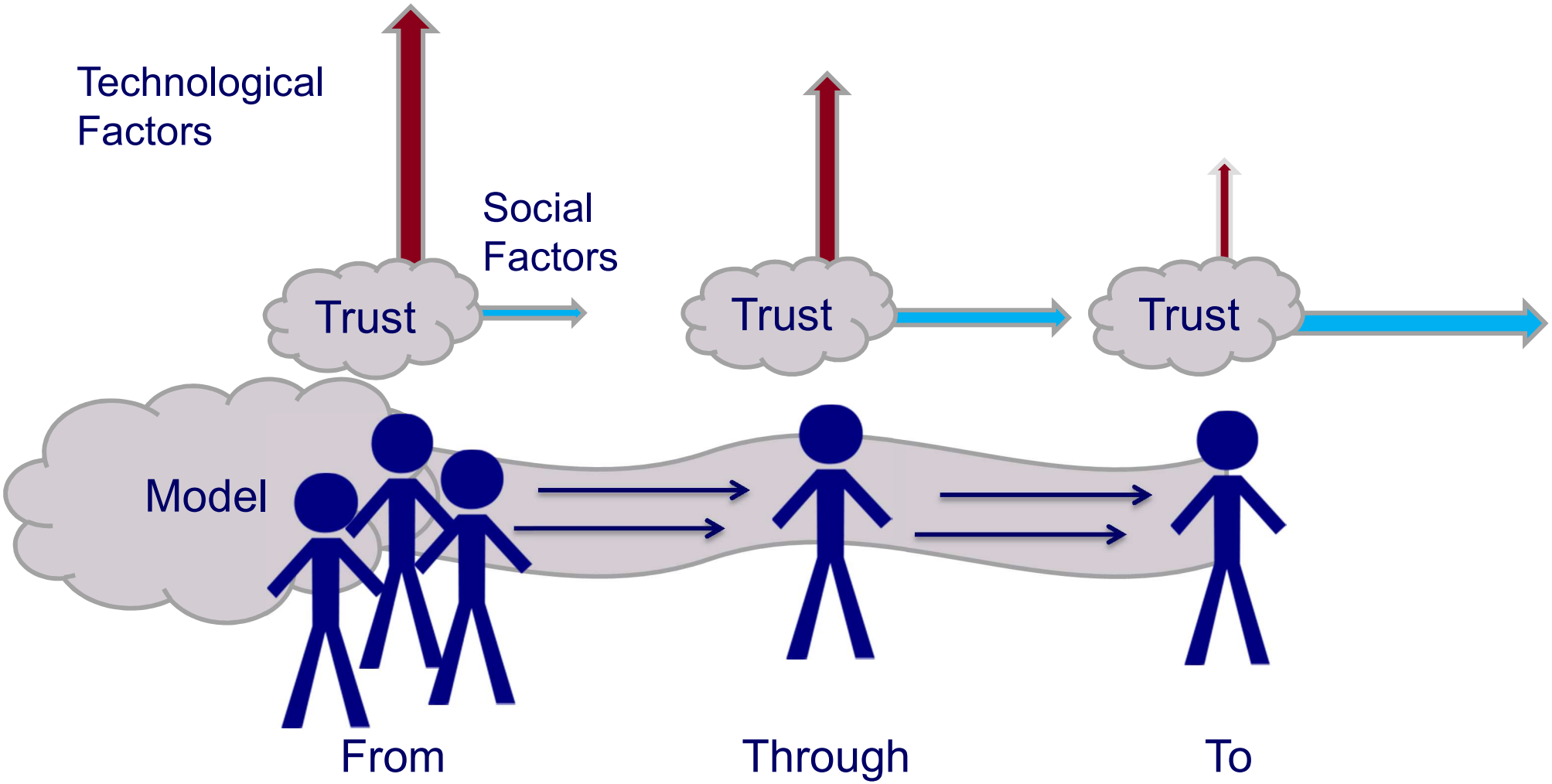
Sociotechnical Factors Influencing Trust



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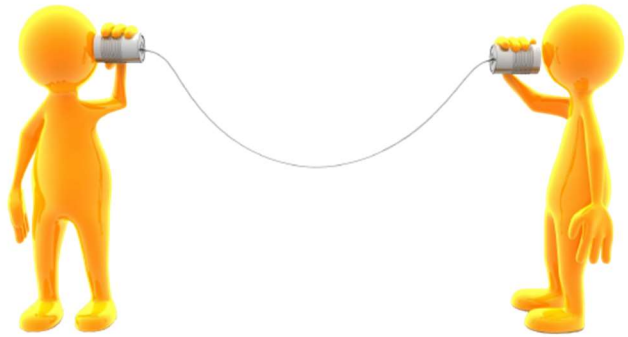
Communication

Communication

- Iterative, 2-way communication a key attribute of effective model-centric decision-making
  - DMs must clearly express the problem
  - Upstream actors must actively update DMs
- Challenge of “language barriers”
  - Requires “translation between output to decision-maker speech”
- DMs “walking” modelers to the solutions



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Transparency

Transparency

- Nearly everyone wants “full transparency,” although not necessarily for themselves

- Differences in leveraging transparency
  - “I want full transparency”
  - “I trust the people below me”
- Further along the flow, **trust shifts** to depending on others to investigate the model for them

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Assumptions & Uncertainty and Documentation

Assumptions & Uncertainty

- All models are created with assumptions for specific contexts
  - This bounds model applicability
  - Introduces potential for model misuse
- *All models are wrong, but some are useful,* and before any can be useful, their limitations must be understood

Documentation

- Documentation is the process of making the assumptions and limitations of a model explicit
  - Must be accessible for a model to be reusable
- Allows for "calibration" of decision-maker mental models
- Multiple types of documentation
  - Documentation of model code
  - Conceptual, "white board" artifacts provide insight into the decision-making behind the model

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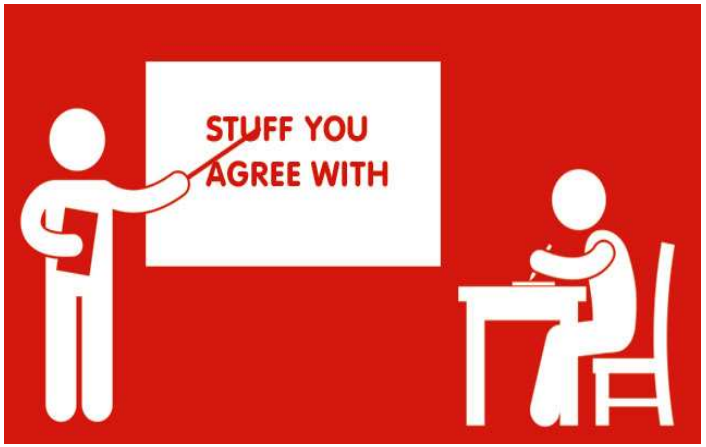
Common Biases

Confirmation Bias

- DMs may use models to confirm what they expect or want to see
- Means of furthering preconceptions or agendas
- Dual responsibility
  - Upstream actors must guard against biasing solutions towards what DMs want
  - DMs must honestly seek truthful solutions



Model Investment Bias

- No choice but to accept a model's answers "given the resources that were spent"
- Money does not ensure applicability
- Political pressure to use results
  - Sunk cost fallacy

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Primary vs. Supplementary

Q: Should models be a primary or supplemental source in decision-making?

A: It depends

- They "should be used as the primary source"
- They "should always be a secondary source"

- Dependent upon models users and DMs
- Dependent upon the modeling and decision-making context

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Independent Review

- Model Verification and Validation aims to catch errors, but is liable to errors of its own

- People have different mental models and will stress a model in different ways

- Use independent SME's as a model "forensics team"

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Real-Time Interaction with Model

Real-Time Interaction

- Viewed as highly desirable
  - Short-circuits asking “what-if” questions
  - Used to gain insight, build intuition, speed innovation
- Requires caution
  - “I can get lots of results real quick, and I can make lots of bad decisions real fast.”
  - “If you make it so fools can use it, fools will use it.”

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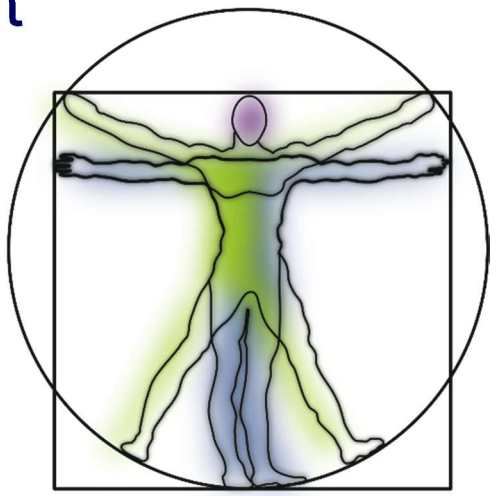
Humans Endogenous to Model-Centric Environment

- How do Senior DMs trust complicated models?
  - "The answer is, they trust the people"
  - Emphasizes importance of having skilled and trustworthy up-stream actors
- Senior DMs also must have ability to "sniff out" wrong answers
- Skilled and experienced individuals are necessary throughout all parts of the flow



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Future Research

- Complete current empirical study
- Develop guiding principles/heuristics from:
  - Key findings
  - Case studies
  - Normative decision-making research
- Validate heuristics through “blue-chip” actors
- Identify implications for policy and practice

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Questions?

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References

Blackburn et al. “Transforming System Engineering through Model-Centric Engineering.” Stevens Institute of Technology, SERC-2017-TR-101, Jan. 2017.

Gass, Saul I, and Lambert S Joel. “Concepts of Model Confidence.” *Computers and Operations Research*. 8, No. 4, 341-346.

Lee, John D, and Katrina A See. “Trust in Automation: Designing for Appropriate Reliance.” Humans Factors. 2004: vol. 46, no. 1, 50-80.

Rhodes et al. “Interactive Model-Centric Systems Engineering (IMCSE) Phase 4.” Stevens Institute of Technology, SERC-2017-TR-103, Mar. 2017.

Rhodes, Donna H, and Adam M Ross. “Interactive Model-Centric Systems Engineering.” Pathfinder Workshop Report, Feb. 2015.

Ricci, Nicola, Michael A Schaffner, Adam M Ross, Donna H Rhodes, and Matthew E Fitzgerald. "Exploring Stakeholder Value Models Via Interactive Visualization." 12th Conference on Systems Engineering Research, Redondo Beach, CA, March 2014.

West, Timothy D, and Art Pyster. “Untangling the Digital Thread: The Challenge and Promise of Model-Based Engineering in Defense Acquisition.” INSIGHT 2015; vol. 18, 45-55.

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