26th annual INCOSE international symposium
Edinburgh, UK
July 18 - 21, 2016

Recommendations for Framing Multi-Stakeholder Tradespace Exploration

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Multi-Stakeholder Systems

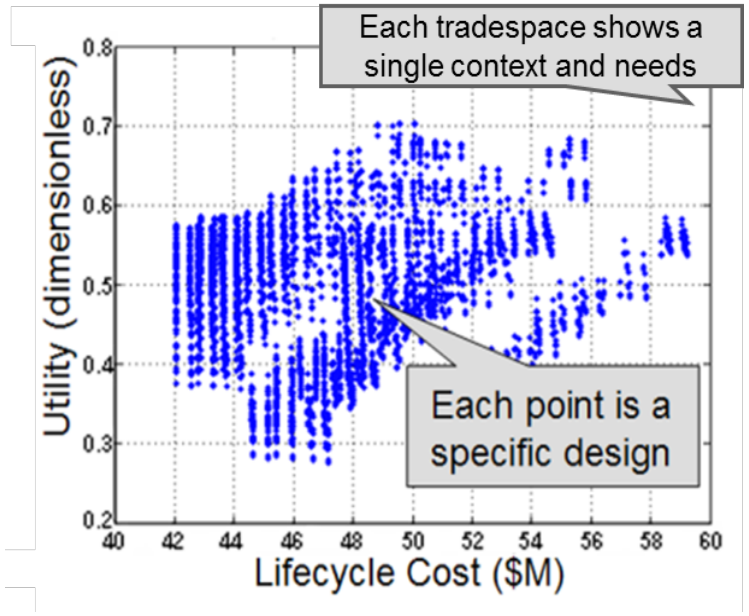
- Large, complex systems frequently have multiple stakeholders
- Moving beyond conceptual design requires those stakeholders to agree on a concept

Varying interests and needs may complicate this problem – no objective "good"

Tradespace Exploration

- TSE design paradigm
  - Many alternatives
  - Observe trends in outcome space
  - Generate problem insight / knowledge
  - Use to enable confident decisions

- MSTSE - to assist in negotiation
  - Observe trends between stakeholders
  - Use to find good group decisions
  - Applied heuristically with some success
  - Identified as key component of TSE and Resilient Systems research agenda



Multi-Stakeholder Negotiation in Tradespace Exploration

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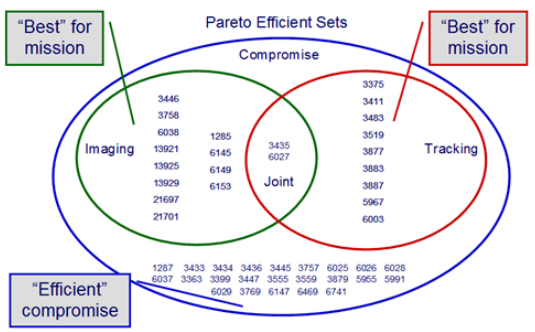
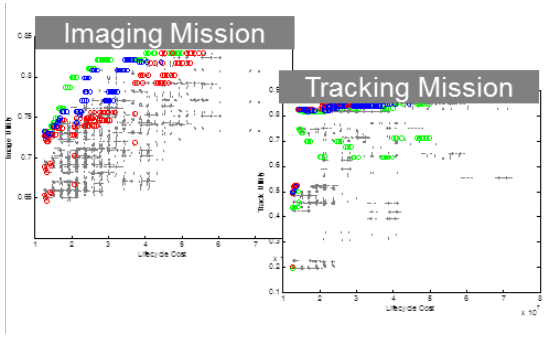
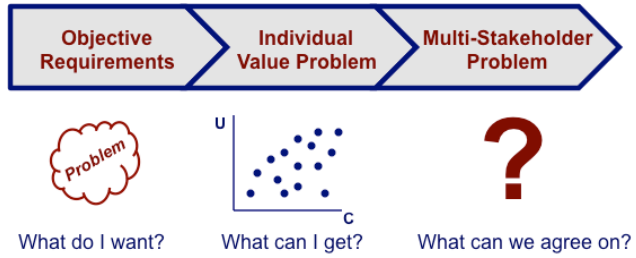
Vision: creating, using and sharing tradespace data with multiple, diverse decision makers

Method and metrics guide TSE to identify efficient tradeoffs and support negotiation



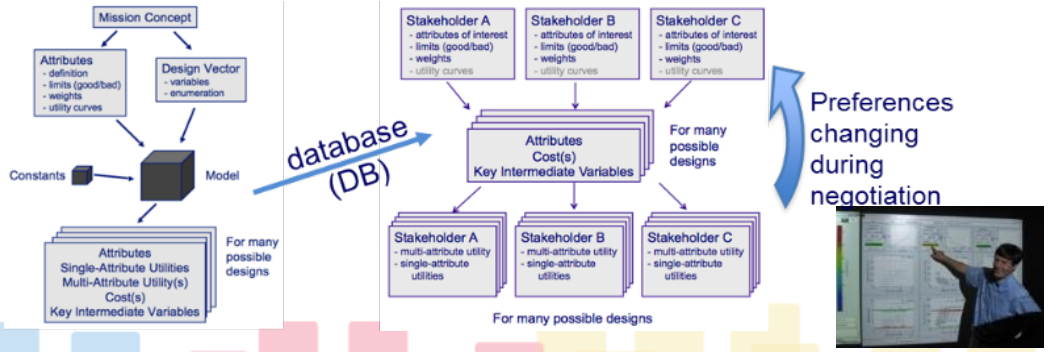




Ross et al., "Responsive Systems Comparison Method: Dynamic Insights into Designing a Satellite Radar System," AIAA Space 2009, Pasadena, CA, Sep 2009.
Fitzgerald, M.E., and Ross, A.M., "Controlling for Framing Effects in Multi-Stakeholder Tradespace Exploration," 12th Conference on Systems Engineering Research, Redondo Beach, CA, Mar 2014.

Human-in-the-loop tradespace exploration to update knowledge and beliefs

1) Find "best" designs per mission, 2) Seek "compromise" solutions across missions, 3) Vary mission priorities (weights) and repeat, 4) Vary mission acceptance ranges, 5) Vary mission contexts



Method provides quantitative approach for discovering "best" mission-specific designs, as well as "efficient" (benefit at cost) compromises across missions and stakeholders

Real-time database interaction using tradespace with multiple, simultaneous decision makers allows for feedback between preference updating and "favorite" solutions, allowing for better compromises

Ross, A.M., McManus, H.L., Rhodes, D.H., and Hastings, D.E., "A Role for Interactive Tradespace Exploration in Multi-Stakeholder Negotiations," AIAA Space 2010, Anaheim, CA, Sep 2010.

Framing Tradespace Exploration to Improve Support for Multiple-Stakeholder Decision Making

Matthew E. Fitzgerald
Ph.D. Dissertation, MIT June 2016

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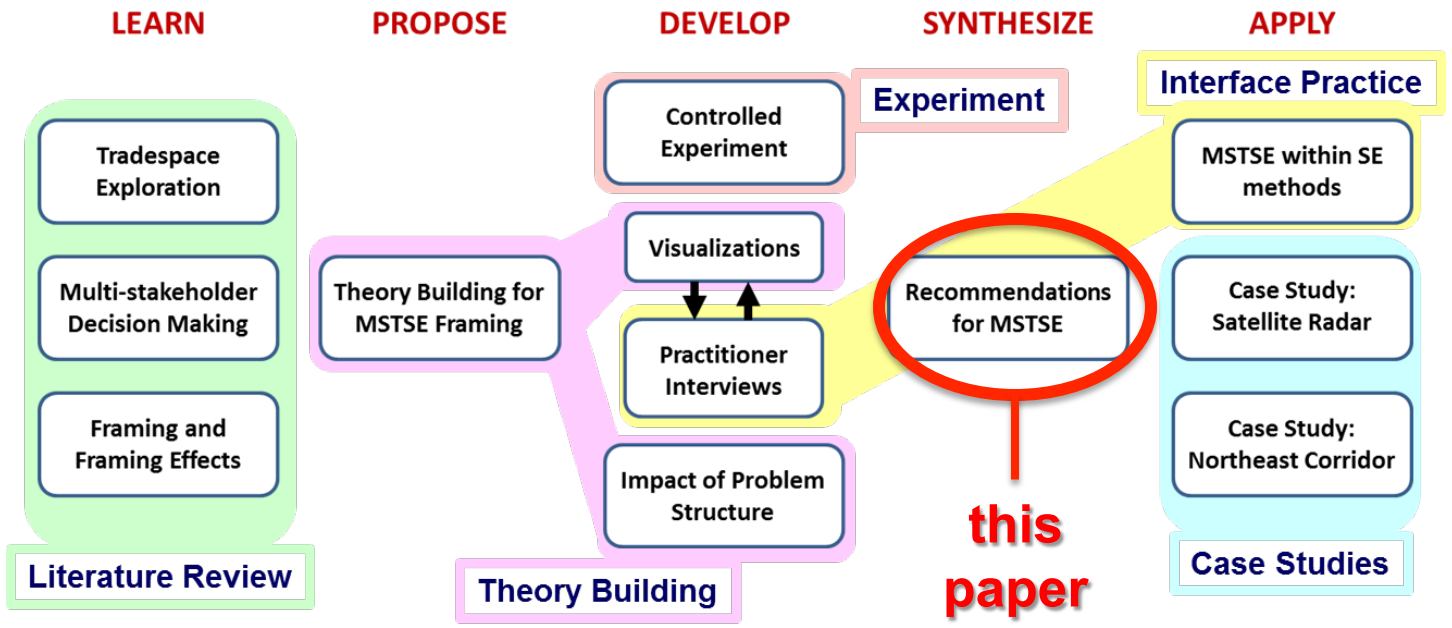
Research Questions

1. Are the principles of tradespace exploration (TSE) fundamentally aligned with those of complex, sociotechnical negotiations?
2. Has the evolution of multi-stakeholder tradespace exploration (MSTSE), as an offshoot of single-stakeholder TSE, resulted in unintentional framing effects impacting decision making, and can those effects be controlled?
3. How can MSTSE be effectively incorporated into a design process, such that it best complements the tasks required by practicing engineers and the needs of decision makers?
4. Can –ilities contribute to MSTSE as a potential avenue for creating mutual value and breaking impasses?

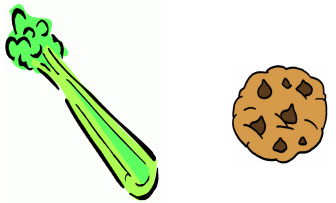


Full document posted online: http://seari.mit.edu/theses

Framing

Contextual factors can impact human perception and thus human action

- Decisions are not influenced only by objective criteria
- Framing is difficult to “see”
  - Often ignored by prescriptive decision making techniques
- Can be located inside or outside the problem



Celery, Cookies

Framing

Contextual factors can impact human perception and thus human action

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Cookies, Cake

Macro Framing

Personal beliefs and perspectives

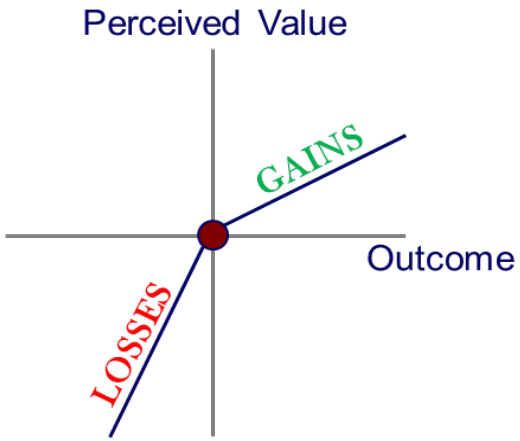
- Stakeholders may disagree on fundamental purpose for working together
- Communication challenge
  - "Talking past" each other
- Explicit reflection on assumptions that frame decision making can resolve conflicts

Why are we doing this?
What is "fair"?
Do I have interests beyond performance attributes?

Micro Framing

Presentation of information and tasks

- Cognitive limitations can lead to bad or counterintuitive decisions
  - Bounded rationality
  - Prospect theory
- Framing can also affect the mental decision *process*
  - Matching mental and constructed models
  - Two-path information processing



Framing in MSTSE

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- Important to accurately represent the multi-stakeholder nature of the problem
- Framing can impact the problem in all phases of analysis

Problem Formulation	Modeling / Evaluation	Exploration / Analysis
Structuring the problem and scoping the decision	Developing and using models to assess designs	Generating insights from model outputs

Framing Recommendations

Problem Formulation

Structuring the problem and scoping the decision

- Capture Macro Frames
- Create Many Alternatives
- Record Key Elements of Problem Structure
- Determine Each Stakeholder's BATNA

Modeling / Evaluation

Developing and using models to assess designs

- Joint Fact Finding and Collaborative Modeling
- Private Information

Exploration / Analysis

Generating insights from model outputs

- Limit Individual Analysis
- Emphasize the BATNA
- Analyze Relationships
- Refer Back to Macro Frames
- Allow Stakeholders to Change Their Minds

Problem Formulation

Structuring the problem and scoping the decision

Create Many Alternatives

- Central tenet of principled negotiation and main justification for use of MSTSE
- How many?
  - Above and beyond "trade study", since we need to capture trades between stakeholders
- Evaluate more designs "behind" negotiations in case initial set does not include an attractive solution

Determine Each Stakeholder's BATNA

- Best Alternative to a Negotiated Agreement
- Critical element of structure
- Neutral "reference point" against which other designs should be evaluated

Consider:

Do-nothing (exploratory)
Existing system
Build preferred alternative alone
Pursue another opportunity

Modeling / Evaluation

Developing and using models to assess designs

Joint Fact Finding and Collaborative Modeling

- Establish credible and objective data
- Build trust in model outputs
  - Limit ability of stakeholders to dispute facts for their own benefit
- Associated with improved negotiation outcomes
  - More ownership than models simply provided by “experts”

Private Information

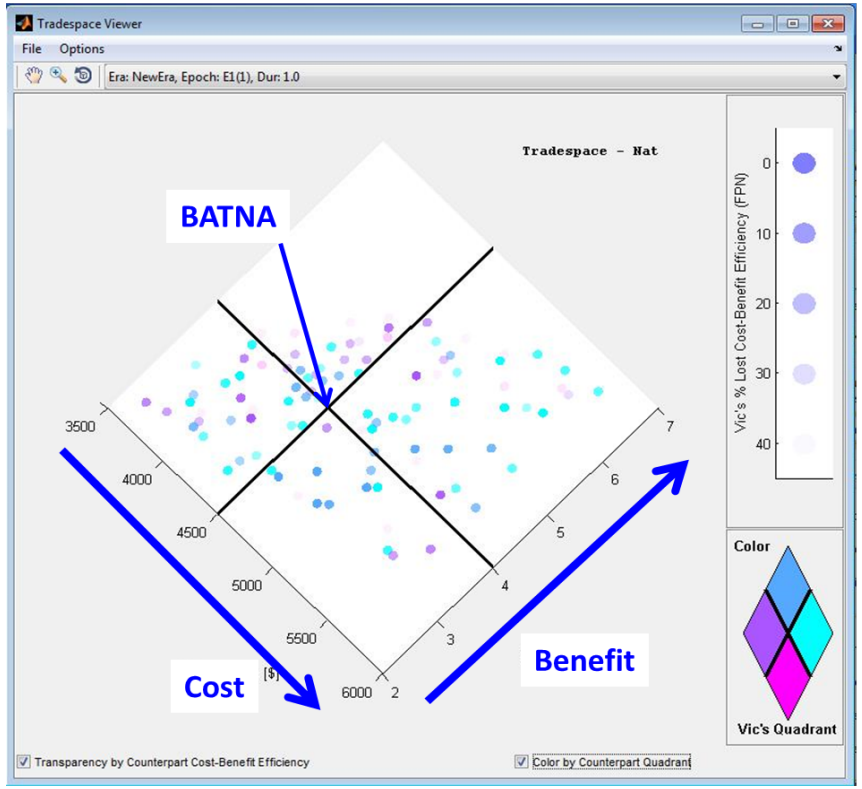
- If models already exist...
  - Ideally, they can be shared
  - Optionally, they can be black-boxed
  - Finally, consider the use of an impartial mediator
- Other alternatives create power imbalances in the negotiation where some stakeholders must simply trust the others

Exploration / Analysis

Generating insights from model outputs

Limit Individual Analysis

- Prevent fixation on alternatives that are very good for only a single stakeholder
- Use “small multiples” if necessary



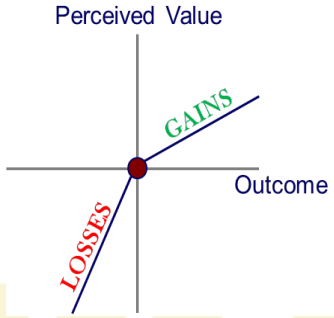
Color/Transparency correspond to a second stakeholder

Cost-Benefit Efficiency

Position relative to BATNA

Emphasize the BATNA

- Provide true neutral value as an accessible reference point

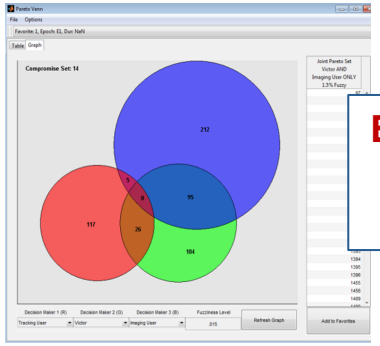


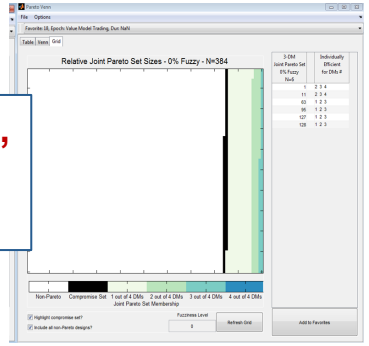
Exploration / Analysis

Generating insights from model outputs

Analyze Relationships

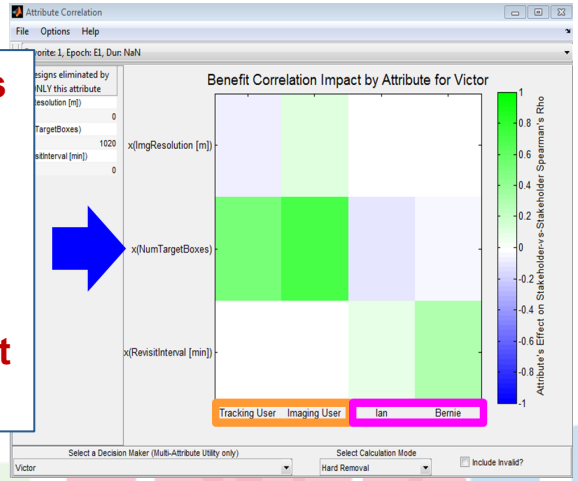
- "Interests, not positions"
- This is where the real *insight* about multi-stakeholder problems lies, and what MSTSE should extract beyond TSE





Explore shared sets of alternatives, to find derived preferences for groups of stakeholders

Use correlations between stakeholder interests to identify coalitions and the interests that unite them

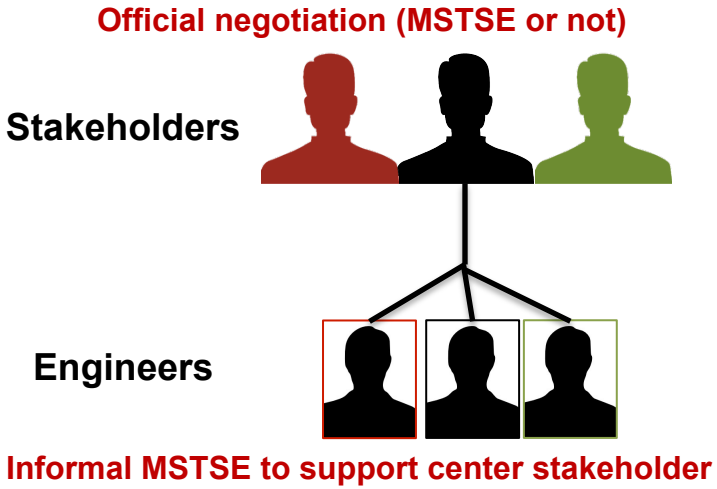


Informal MSTSE

- MSTSE without stakeholder participation
  - Enable engineers to better extract and communicate insight back to stakeholders in preparation for official decision making process

- Lower barrier to entry
- Limits some activities

Macro frames very hard to predict
Estimated value models + no emergent modification
Predict course of action without an agreement (for BATNA)
Unable to perform Joint Fact Finding



Summary

Remember: manage framing throughout decision process

- Being aware of the potential impact of framing is the key first step
- Not done yet – there are many more ways decisions are framed

Phase	Recommendation	Informal MSTSE
Problem Formulation	Capture macro frames	All of these apply except for capturing macro frames of other stakeholders. Make best estimates for stakeholders' BATNAs and value models.
	Create many alternatives	
	Record key elements of problem structure	
	Determine each stakeholder's BATNA	
Modeling / Evaluation	Joint Fact Finding	Treat modeling as normal TSE
	Private information	
Exploration / Analysis	Emphasize the BATNA	Continue to use BATNA-centric visualizations and analyze relationships, but limit activities related to changing stakeholder value models without their participation.
	Limit strictly individual analysis	
	Analyze relationships	
	Allow stakeholders to change their mind	
	Refer back to macro frames	

Conclusion

- MSTSE uses the TSE framework in order to capture insights about multi-stakeholder problems
- Explicitly managing framing helps by reducing opportunities for breakdown
  - Macro: Stakeholder-Stakeholder interaction
  - Micro: Stakeholder-Data interaction

Understanding the impact of context on decisions can help us create better processes and visualizations

Thank You

Questions?

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Backup Slides

Problem Formulation

Structuring the problem and scoping the decision

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Record Key Elements of Problem Structure

- Problem structure can impact appropriate visualization and analysis techniques
- Emphasis on elements that are characteristics of multi-stakeholder systems

Consider:

Divisible attributes
Relationships between stakeholders
Constituencies of stakeholders
Available time for negotiation

Capture Macro Frames

- Necessary to support prescriptive decisions
  - There is no "correct" choice of perspectives
- Open-ended
  - "Relationship building" and "information sharing" goals of Multi-Stakeholder Dialogues

Consider:

Purpose for MSTSE
Relative desire for low-cost vs. high-benefit
Relative desire for passively robust vs. actively flexible

Exploration / Analysis

Generating insights from model outputs

Refer Back to Macro Frames

- Decisions ultimately must narrow down to individual alternatives
- Use knowledge of macro frames to "translate" arguments for why designs are good or bad into objective data

Allow Stakeholders to Change Their Minds

- Exposure to new information may alter preferences
- Allow interactive refinement of value models to speed up iterative design loop