

Tradeoff Study Cascading Mistakes of Omission and Commission

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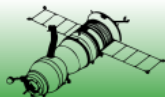
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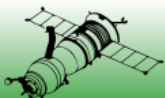
Overview

- Introduction
- Cascading Mistakes
- Omission
- Commission
- Summary

Legend

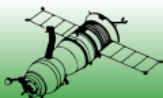
Mistakes - Bad
examples

Good examples

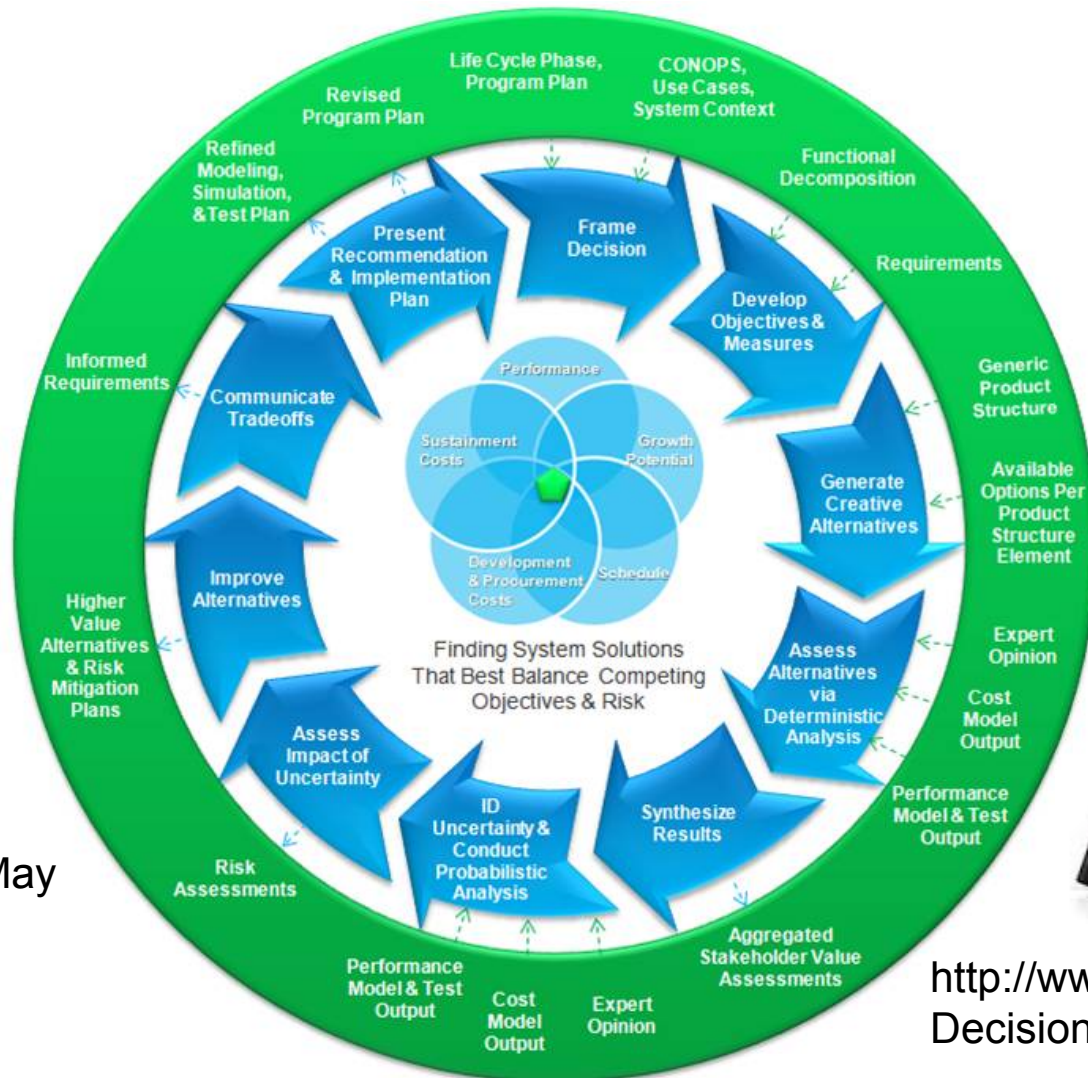


How we got started

- Demand for a guidebook on tradeoff studies from the INCOSE Corporate Advisory Board.
- Not aware of good industry information that crosses the life cycle and aligns with INCOSE process guidance (Handbook, SEBoK, ISO/IEC 15288, DAG, CMMI).
- Referred to the Decision Analysis WG as an initial product within their charter.
 - Frank Salvatore, Decision Analysis Working Group Chair
 - Dr. Dennis Buede, INCOSE Fellow
 - Mr. Matt Cilli
 - Dr. Greg Parnell, INCOSE Fellow
 - Mr. Rich Swanson
- Decision Analysis Working Group Plan
 - Revise Decision Management section of INCOSE Handbook
 - Revise Decision Management section of SEBoK
 - Present at INCOSE 2014
 - Write Guidebook



A Best Practices Tradeoff Study Process

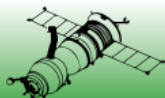


Legend
SE Products
Tradeoff Study Steps
Objectives
Purpose



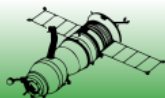
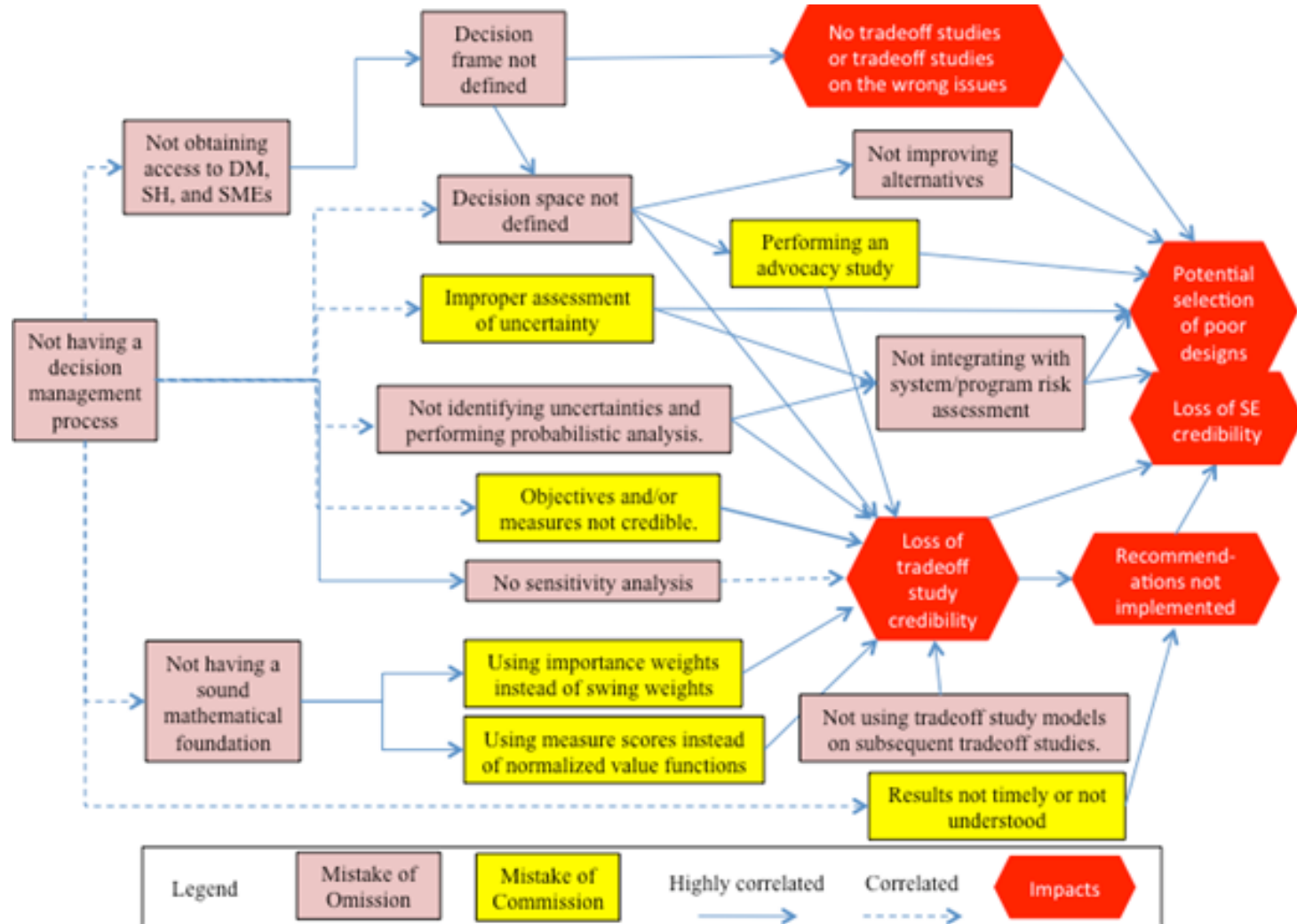
http://www.sebokwiki.org/wiki/Decision_Management

INCOSE SE
Handbook v4 20 May
2014, Decision
Management
Chapter

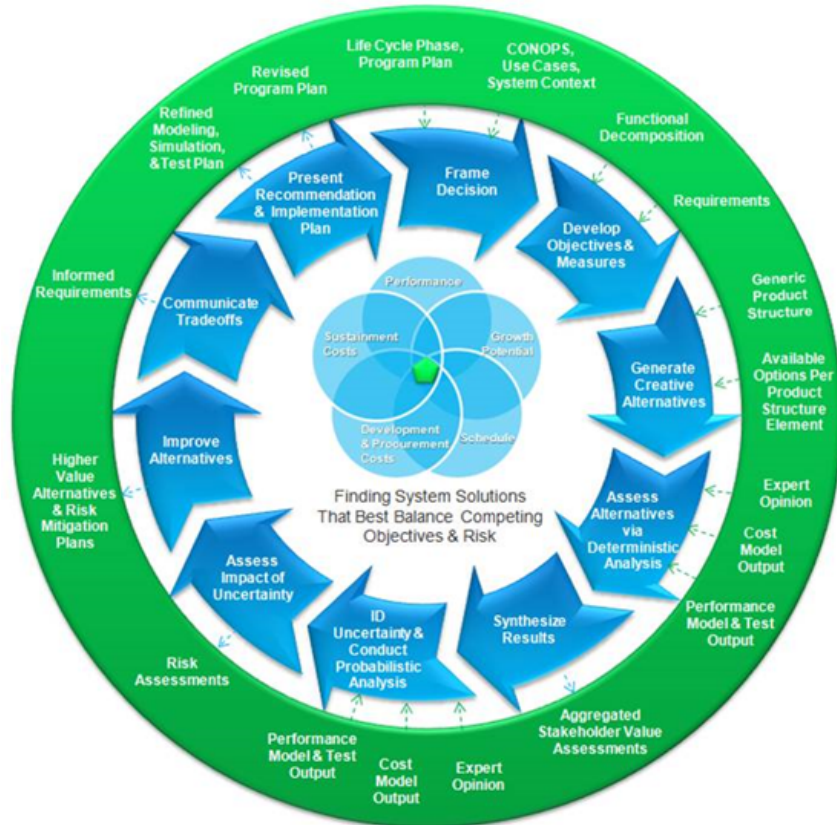


Some Tradeoff Studies Have Cascading Mistakes

Why are tradeoff studies are usually really good or really bad?



Omission: Not have a decision management process

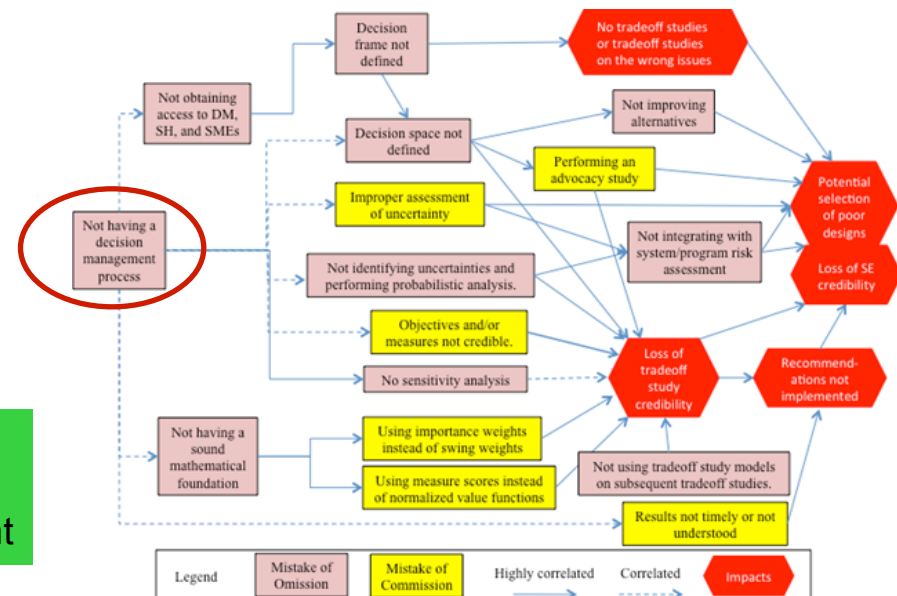


Without such a process, every engineer in the organization is free to use their own process. Unsound processes can have a long lifetime.

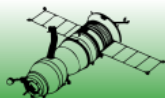
Impacts

No tradeoff studies or variable tradeoff study quality of those done

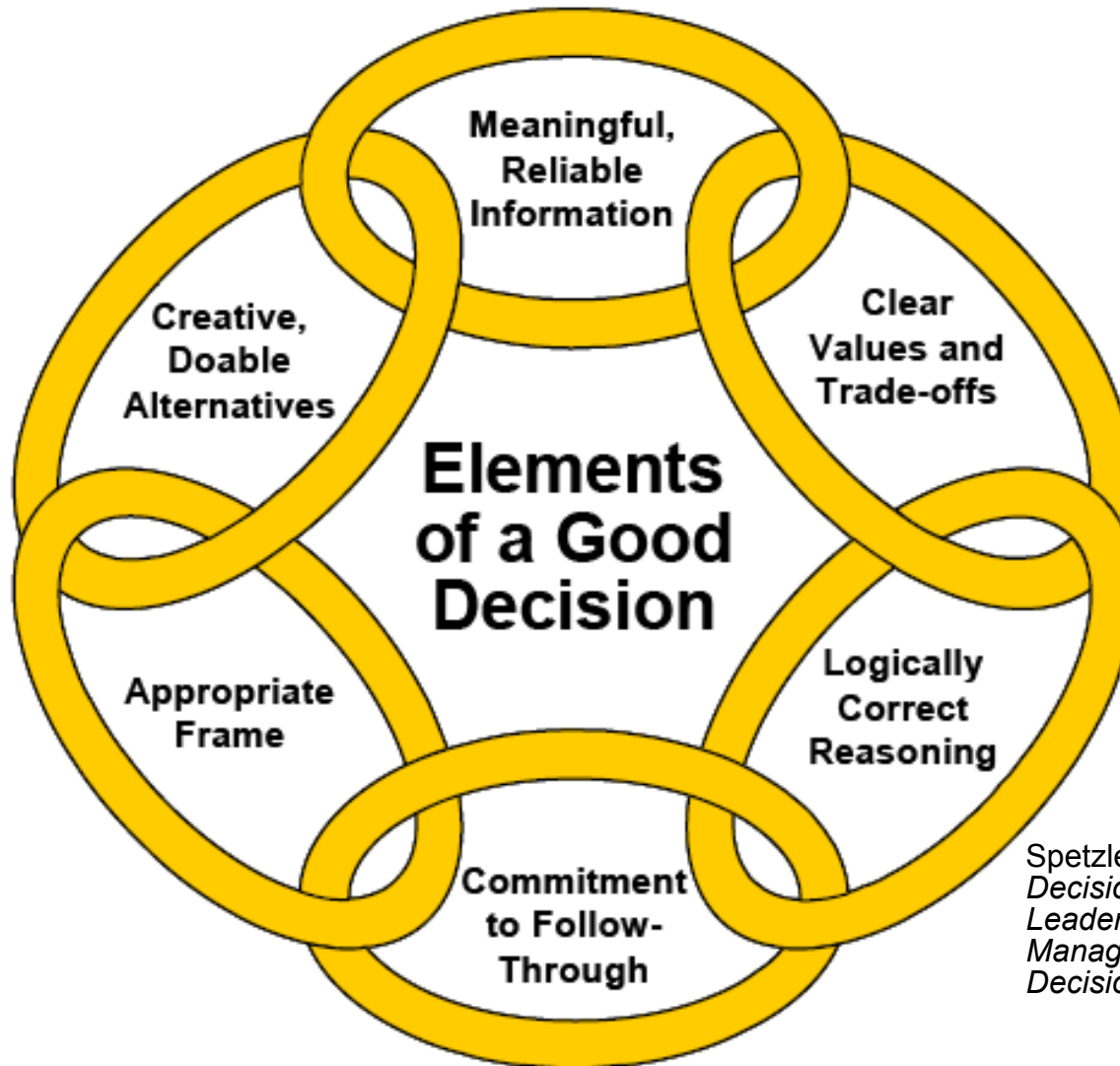
Loss of SE credibility



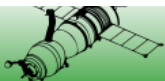
INCOSE SE Handbook v4 20 May 2014, Decision Management Chapter
http://www.sebokwiki.org/wiki/Decision_Management



Six requirements are necessary and sufficient to ensure a quality decision process.



Spetzler, C. & Keelin, T. (1992). *Decision Quality: Opportunity for Leadership in Total Quality Management*. Menlo Park: Strategic Decision Group



Not defining the decision frame.



This
decision
looks easy!

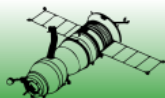


May be a
challenge

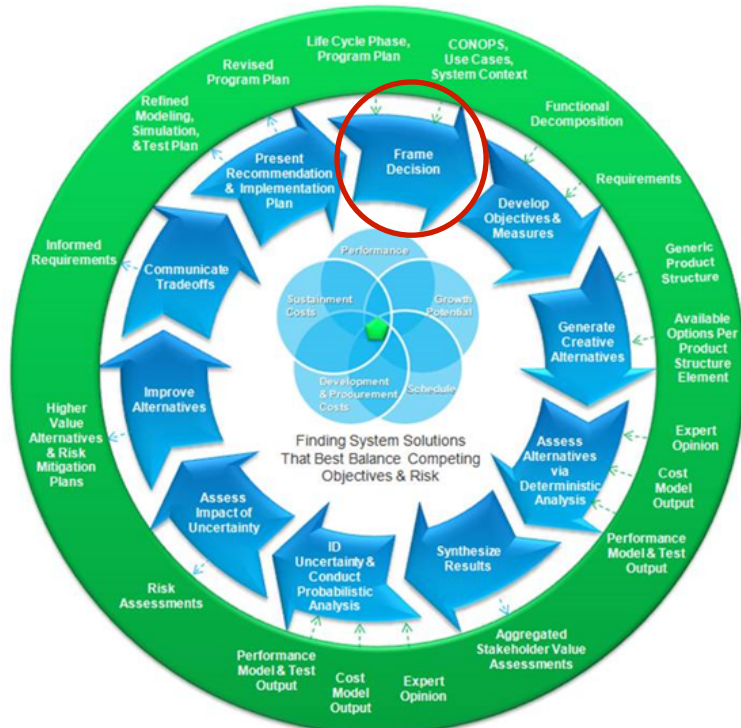


May be some big challenges

The decision frame helps us define the scope of decision.



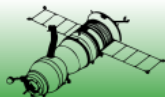
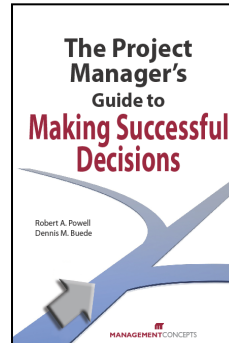
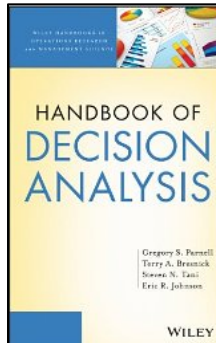
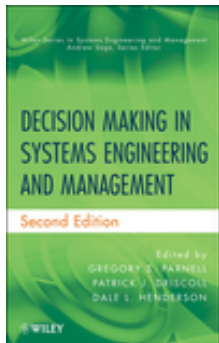
Decision Framing



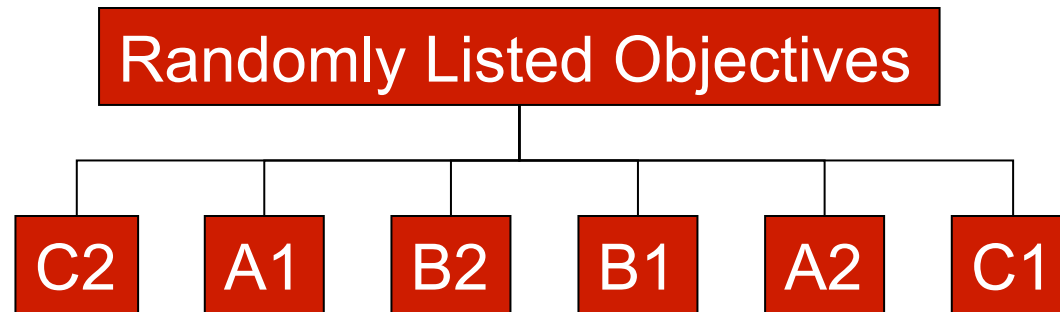
Mistakes	Omission/ Commission	Impacts
Not obtaining access to key DM and SH	Omission	No tradeoff studies or tradeoff studies on the wrong issues
Decision frame not defined	Omission	Loss of SE credibility

Decision Framing Tools

- Stakeholder analysis
- Interviews
- Focus Groups
- Surveys
- Vision statement
- Decision hierarchy
- Issue list
- Stakeholder Issue Matrix

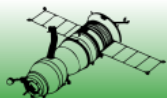


Lack of credible objectives & measures

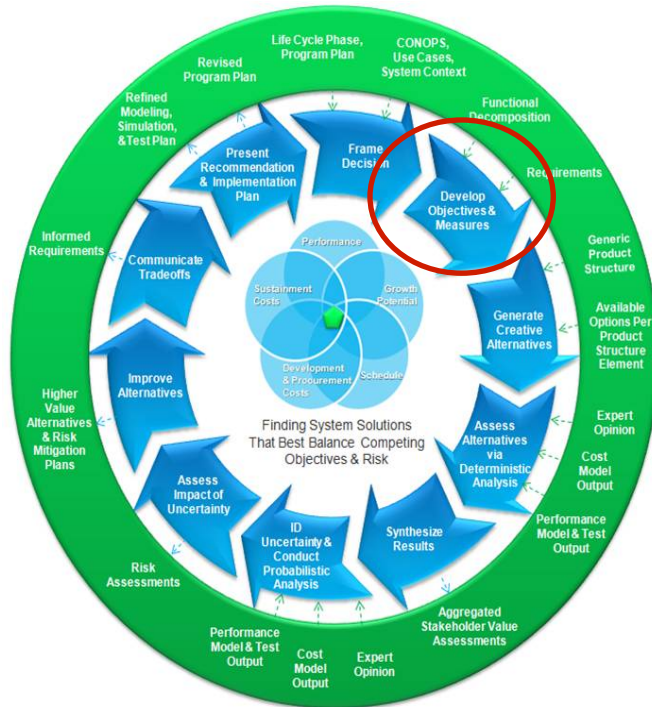


Objectives appear randomly determined

Metrics (we know data exists) are used and not value measures (we care about the measures)

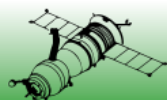
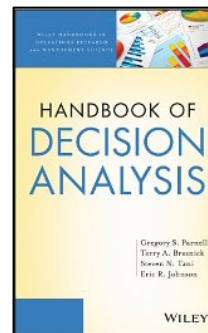
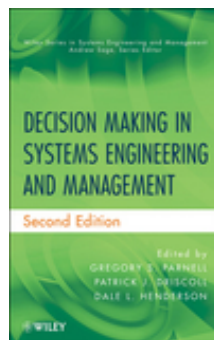
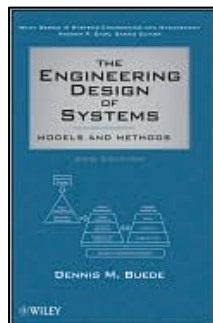
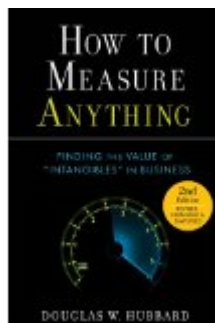
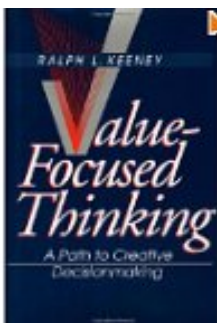


Develop Objectives and Measures



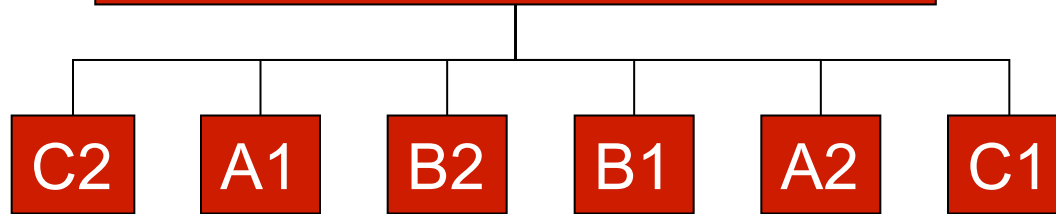
Mistakes	Omission/ Commission	Impacts
Objectives and/or measures not credible	Commission	Loss of SE credibility or potential selection of a poor design

Objective/Measure Tools
 Value/Objectives Hierarchy
 Functional Value Hierarchy
 Types of measures
 Direct vs. **Proxy**
 Natural vs. Constructed

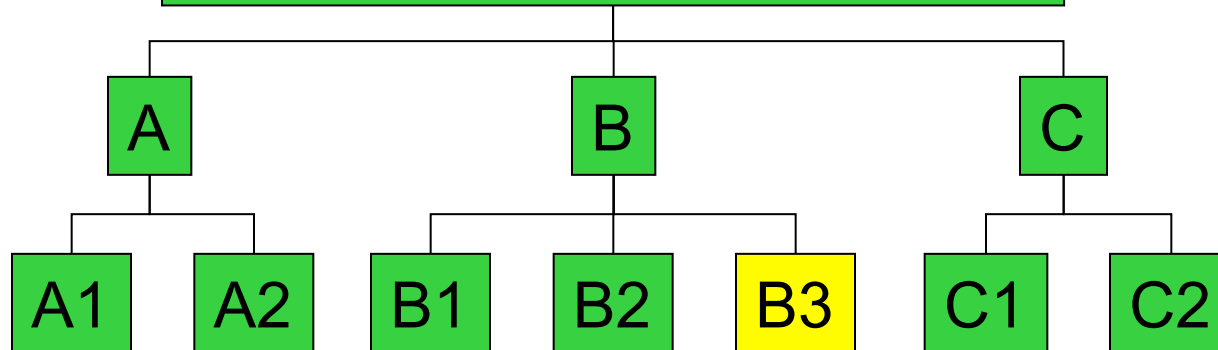


Well structured objectives

Randomly Listed Objectives

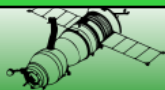
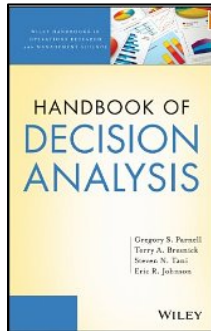


Logically Organized Hierarchy



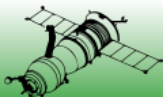
Principles

1. For functions or criteria, use a verb and an object.
2. Three to five functions (objectives) at each node.
3. Logically order the functions (objectives), e.g., time sequence., to identify missing elements.
4. Improves communication with stakeholders.

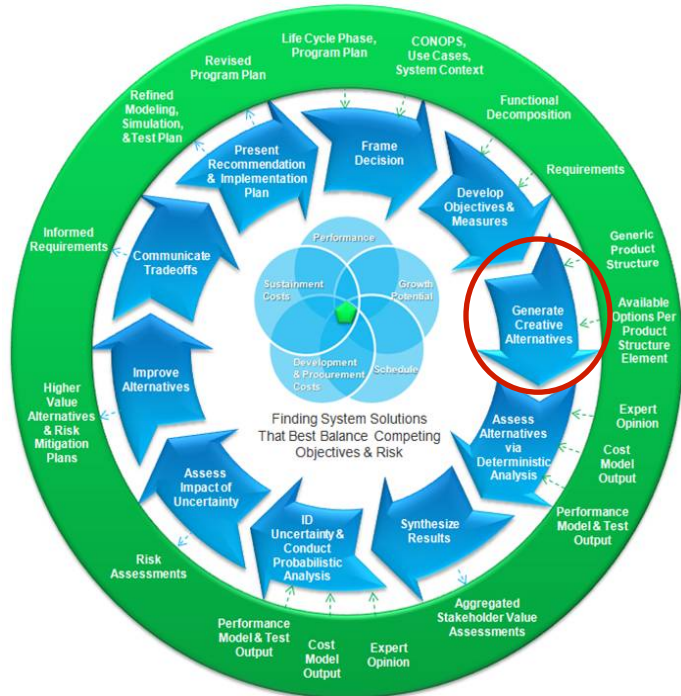


Problems with alternative generation

- No definition of the solution space
- Advocacy tradeoff study
 - Sales pitch
- The use of three alternatives
 - Terrible
 - The one being advocated
 - Wonderful but unaffordable
- Minor changes from the status quo



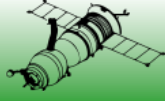
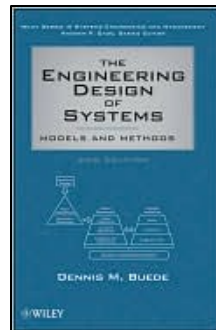
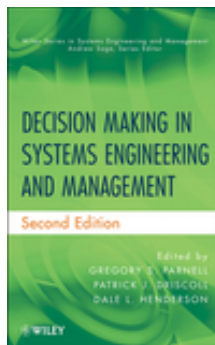
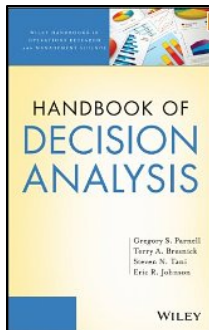
Generate Creative, Doable Alternatives



Mistakes	Omission/ Commission	Impacts
Decision space not defined Doing an advocacy study	Omission Commission	Potential selection of poor design Loss of SE credibility

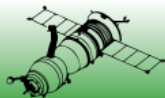
Alternative Generation Tools

Cognitive Biases
Decision Traps
Creativity Techniques
Divergent-Convergent Techniques
Zwicky Morphological Box
Strategy Table
Design of Experiments

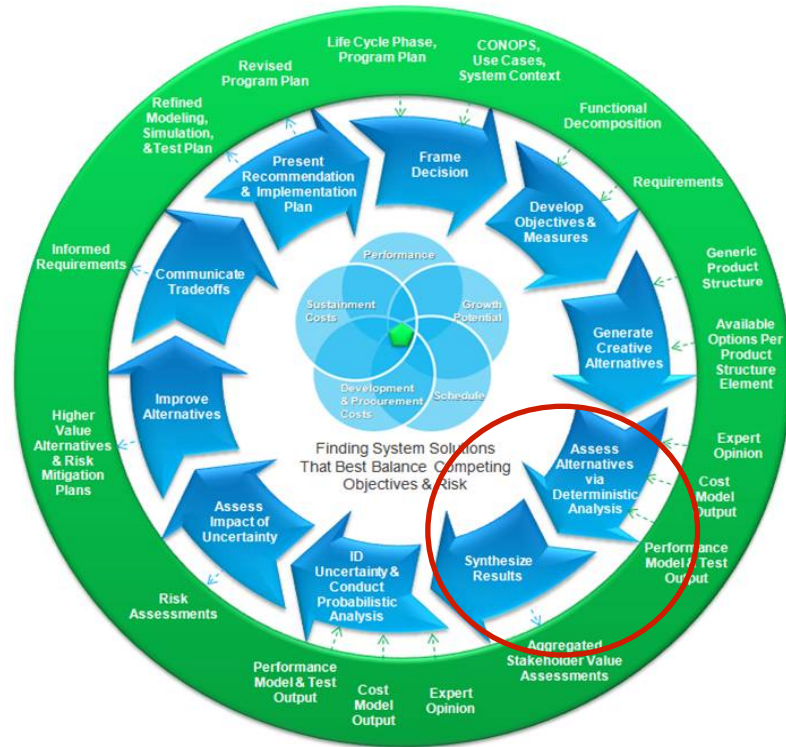


Deterministic Analysis Not Credible

- Ad hoc math
 - No mathematical foundation
- Bogus math
 - Importance weights
- Lack of credible data to justify scoring
 - No use of modeling and simulation, test data or operational data
- Lack of credible expertise
 - Experts not used
 - Opinions solicited from non-experts
- Wrong questions asked of experts
 - Top down weights
- No sensitivity analysis



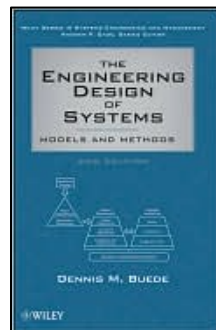
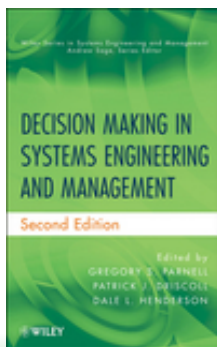
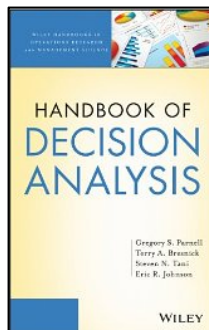
Assess Alternatives via Deterministic Analysis



Step	Mistakes	Omission/Commission	Impacts
Assess alternatives via deterministic analysis	Using Non-Normalized Value Functions	Commission	Potential selection of poor designs
	Not using swing weights	Commission	Loss of tradeoff study and SE credibility
	No sensitivity analysis	Omission	
Synthesize results	Lack of a sound mathematical foundation	Omission	Potential selection of poor designs Loss of tradeoff study and SE credibility

Deterministic Analysis Tools

Single Objective Decision Analysis
Economic analysis (e.g., NPV)
Optimization
Multiobjective decision analysis
Additive value model
Goal programming



An additive value model mathematically defines value and evaluates alternatives.

Total Value of the Alternative

Normalized swing weights for each value measure i assess importance and impact of range variation

$$v(x) = \sum_{i=1}^n w_i v_i(x_i)$$

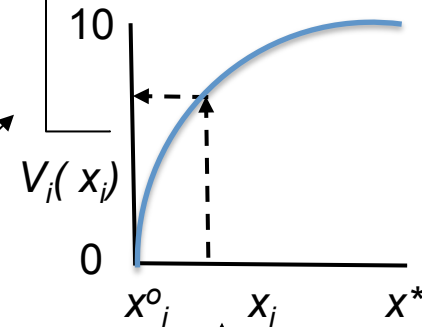
Keeney, R.L. and Raiffa H.
Decision Making with Multiple Objectives Preferences and Value Tradeoffs. New York: Wiley, 1976.

Normalized swing weights sum to 1

$$\sum_{i=1}^n w_i = 1$$

Value function for each measure i : assess returns-to-scale and provide a 'common currency' across all measures

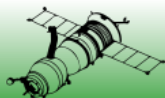
		Level of importance of the value measure		
		High	Medium	Low
Variation in measure ranges	High	3.1.1 Accuracy 100	3.2.1 Range 50	
	Medium	1.1.1 Speed of Platform 85	2.1.1 Thrust 45	1.1.2 % Grade 5
	Low	2.2.1 Number of Payloads 60	1.2.1 Number of People 20	



Score on value measure i

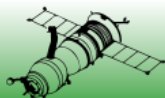
The additive value model is the most common value model used in multiobjective decision analysis.

Screening criteria

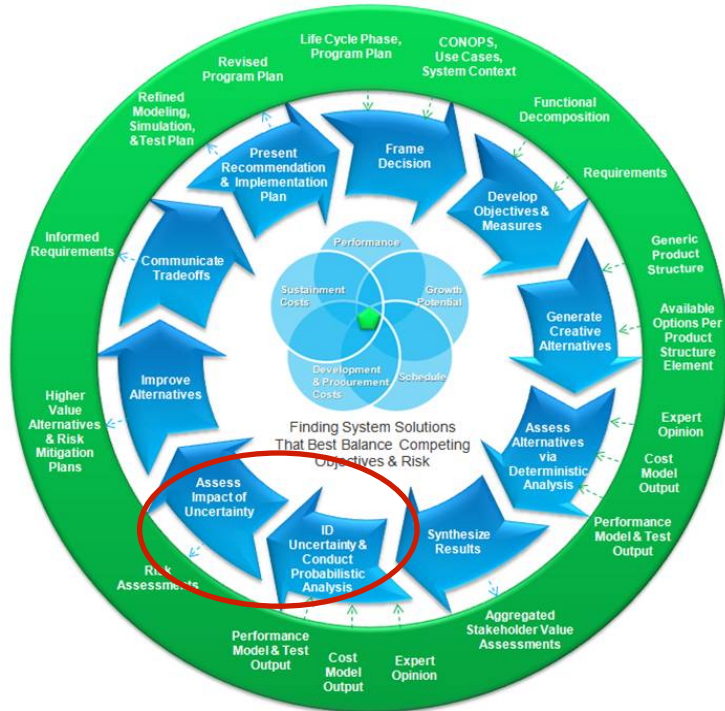


Consideration of uncertainties

- No consideration of uncertainty
- No relationship between system/program risk assessments and tradeoff studies
 - No use of risk analysis to focus tradeoff studies
 - No feedback between tradeoff studies and risk assessments
- Improper assessment of uncertainty
 - No consideration of cognitive biases
 - No use of probability assessment protocols



Identify Uncertainty and Conduct Probabilistic Analysis



Step	Mistakes	Omission/ Commission	Impacts
Identify uncertainty and conduct probabilistic analysis	Not identifying uncertainties Improper assessment of uncertainty	Omission Commission	Loss of tradeoff study and SE credibility
Assess impact of uncertainty	Not integrating with system/ program risk assessments	Omission	Potential selection of poor designs Loss of SE credibility

Probabilistic Analysis Tools

Cognitive Biases

Probability Assessment Protocols

Simulation Models

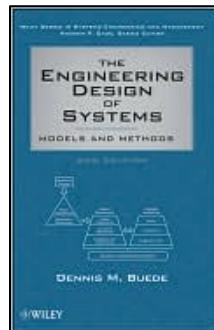
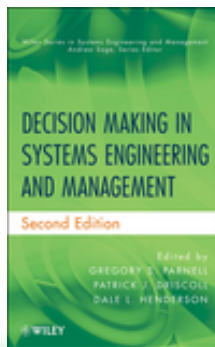
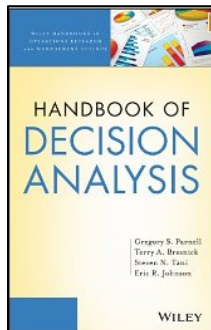
Bayes Law

Monte Carlo Simulation

Decision Trees

Value of Information

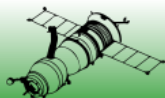
Risk Analysis (Intelligent adversary)



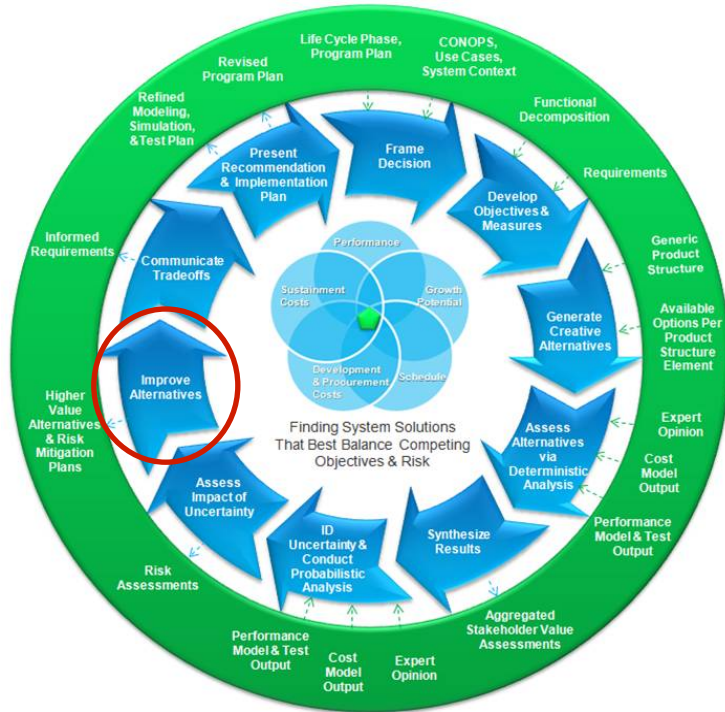
Helping identifying better alternatives is a key role for systems engineers.



If there are nothing but bad alternatives and you just evaluate alternatives, all *your analysis* focuses on determining the “**best**” **bad alternative**!

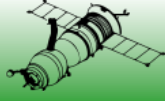
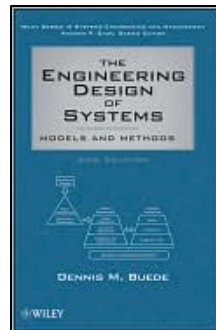
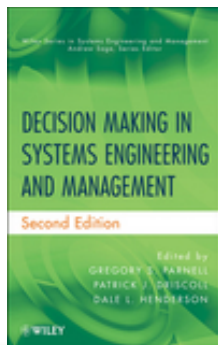
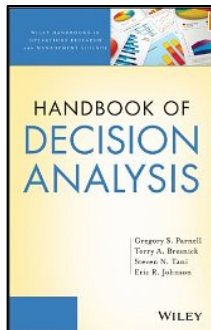


Not Improving Alternatives

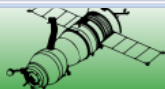
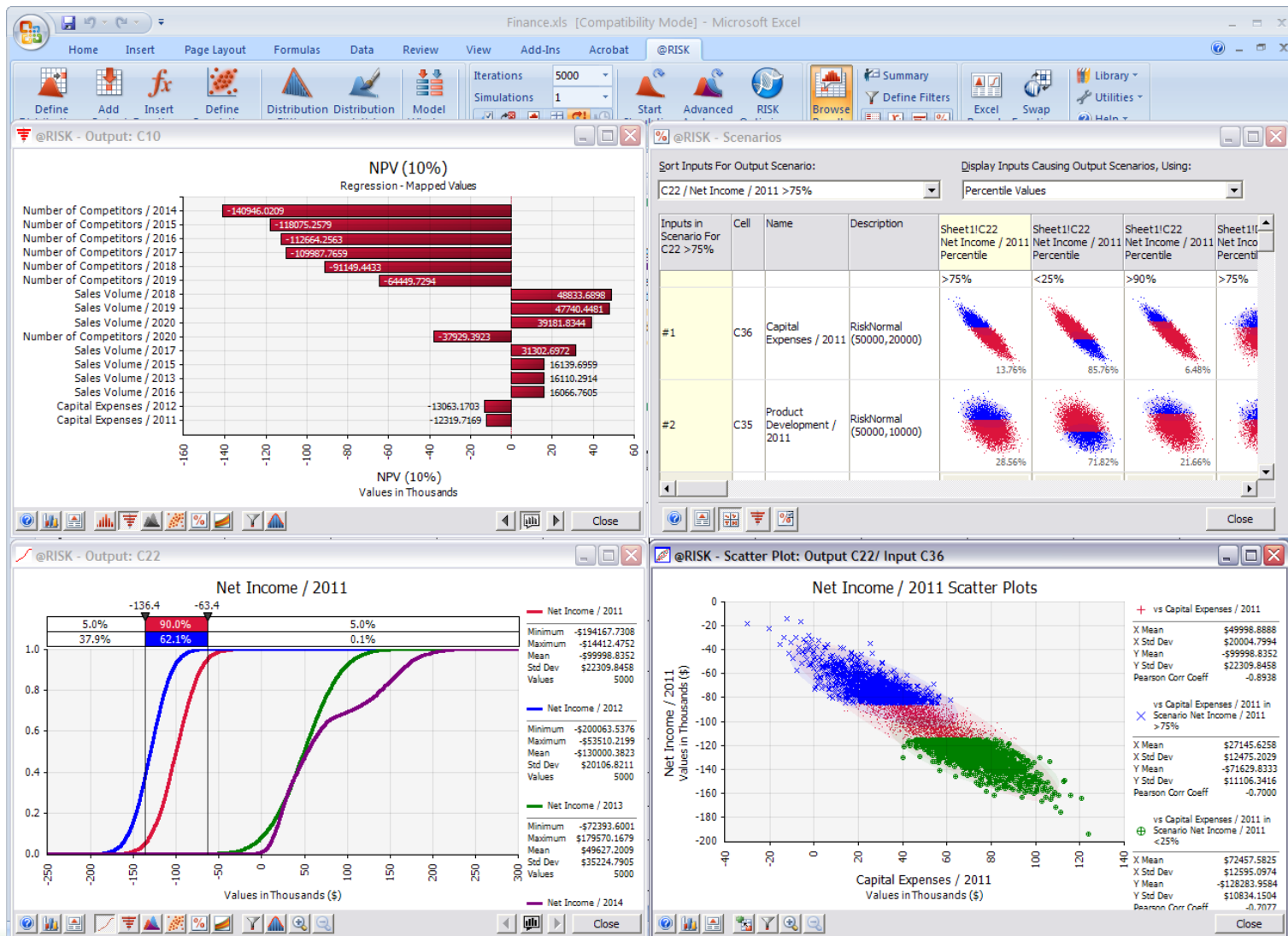


Mistakes	Omission/ Commission	Impacts
Not improving alternatives	Omission	Potential selection of poor designs

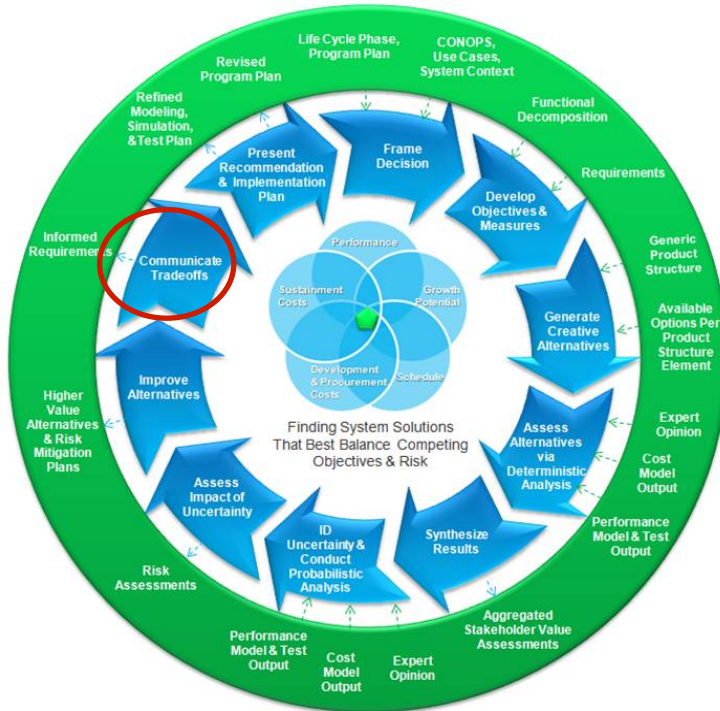
Alternative Improvement Tools
 Increase value and/or reduce risk
 Creativity Techniques
 Divergent-Convergent Techniques
 Zwicky Morphological Box
 Strategy Table



Analytical outputs are not actionable insights.



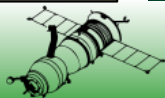
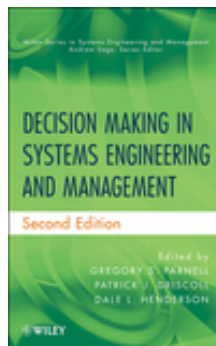
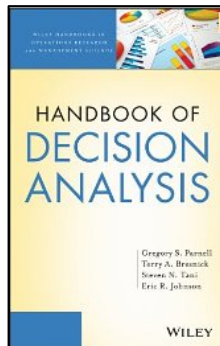
Communicate Tradeoffs



Mistakes	Omission/ Commission	Impacts
Results not timely or understood	Commission	Recommendations not implemented Loss of SE credibility

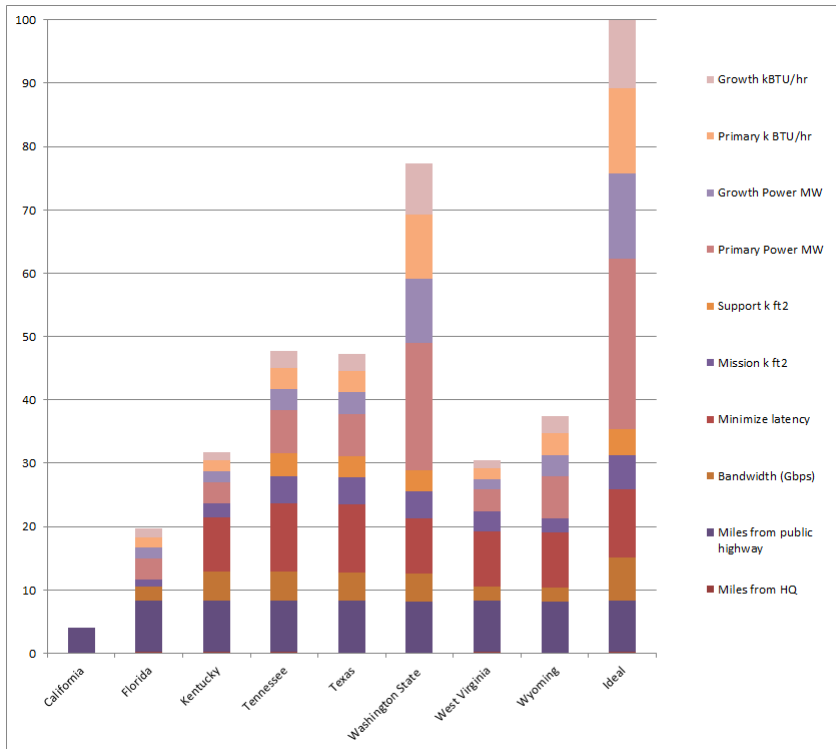
Communication

Deliver by decision need date
Use bottom line up front
Tell a story
Design for the audience



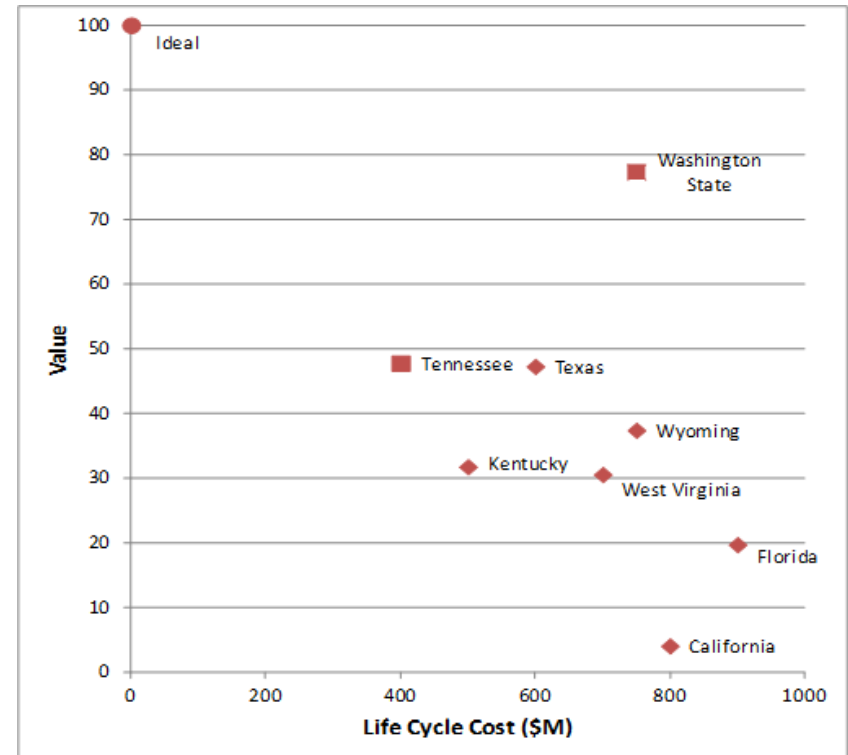
Use charts that provide insights

Value Component

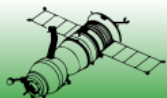


This chart shows opportunities to improve the best solution.

Cost-Benefit

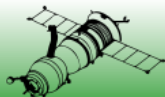


This chart shows non-dominated and dominated solutions.

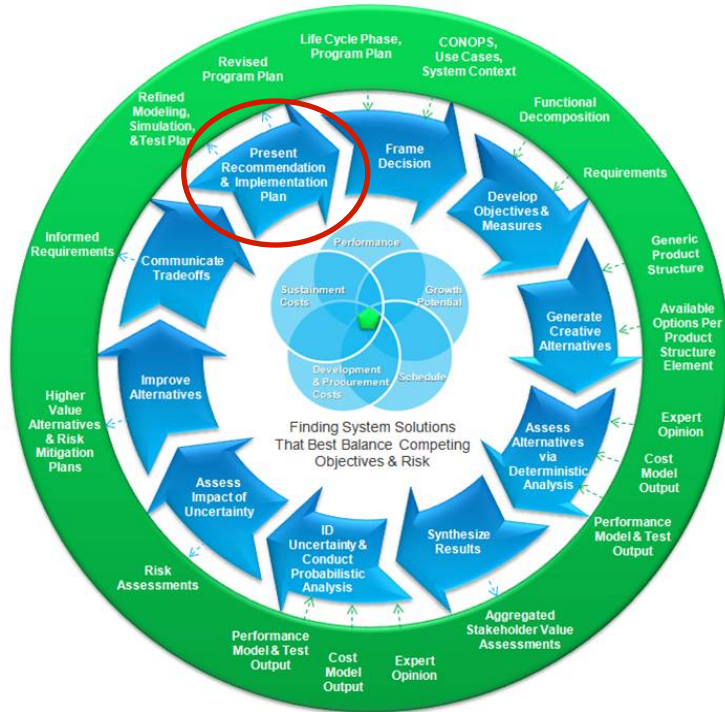


Tradeoff Study Recommendations Not Implemented

- Tradeoff Study Problems
 - Changing Requirements
 - Lack of access to DMs and SHs
 - Wrong decision frame
 - Analysis not credible
 - Analysis not compelling
 - Analysis not understandable
 - Results delivered too late
 - Implementers not involved
- Issues with Decision Maker(s)
 - Not involved in study
 - Analysis results not understand
 - Recommendations not affordable
 - Results not aligned with previous commitments



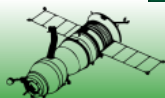
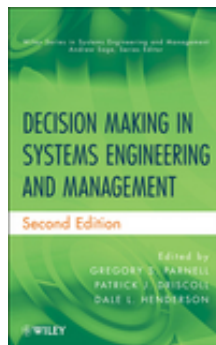
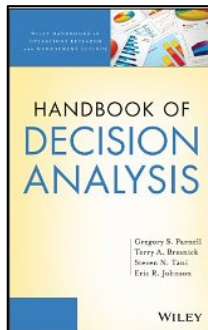
Present Recommendations and Implementation Plan



Mistakes	Omission/ Commission	Impacts
Recommendations not implemented	Commission	Loss of tradeoff study and SE credibility

Implementation

Involve implementers in the tradeoff study
Consider implementation risks
Develop implementation plan



Summary: Improve Tradeoff Studies by Using Best Practices & Avoiding Cascading Mistakes

