WHIPS AND CHAINS, “BRING ME A ROCK,” AND “DRIP”: A FRAMEWORK FOR UNDERSTANDING DECISION ANALYSIS AND DECISION SUPPORT INFORMATION

NDIA SYSTEMS ENGINEERING DIVISION
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ON TAP ...

- Why Worry?
- Definitions
  - Decision Analysis
  - Decision Support Information
- Scenario: Recommend a Preferred Alternative
  - Whips and Chains
  - “Bring Me A Rock”
- Scenario: Trades
  - “DRIP”
- Glossary: Decision Analysis, A to X
- Why It’s Important
WHY WORRY ABOUT DECISION ANALYSIS AND DECISION SUPPORT INFORMATION?

IT DEPENDS ... ARE YOU ADVOCATING A POSITION FOR THE DECISION?

ARE YOU RESPONSIBLE OR ACCOUNTABLE TO ACTUALLY MAKE THE DECISION?

OR ARE YOU CONSULTING ON THE DECISION?
DEFINITIONS – FOR PURPOSES OF THIS PRESENTATION

- **Decision Analysis** is a method (or a collection of methods) for evaluating a set of options against a set of established criteria, documenting each choice made along with its supporting rationale, and packaging the results (data) in a form or format that facilitates the customer's ability to make the decision at hand.

- **Decision Support Information** captures extracts from the technical and analytical knowledge base of the item(s) under review. While any individual data element by itself may be of limited – or extreme – value, the aggregation and sequencing of the elements are what produce actionable and usable information for the decision makers.
WHAT QUESTIONS DO WE WANT TO ANSWER, AND WHEN?
WHAT MATERIAL SHOULD WE PROVIDE?

- Potential Future Needs
  - What do we need to do?

- Operational Concepts
  - How do we want to do it?

- Technology
  - What can we do it with?

- Evolved Baseline
  - What do we plan to do?

- Trade Space Definition
  - How could we do it?

- Concepts & Designs
  - What might they look like?

- Design Evaluation
  - How well do they work, what do they cost, etc.?

- Stakeholder Participation
  - Industry Input
  - User/Operator Input

- Recommended Concept Solution Sets
- Concept Characterizations & Technical Data
- Technology Needs
- Baseline Solution Set Requirements

- Transition Plan
  - How do we transition to the next step?

* Modified from NSSO Architecting Process
Review requirements and assumptions
Establish overall decision context
Frame decision in terms of objectives
Identify methods and tools
Develop decision criteria (objectives/measures) and rationale

Identify and define alternatives
Analyze and assess alternatives
Synthesize results and document decisions

Analyze sensitivities

Develop decision briefing with action/implementation plan(s)
Make recommendation(s) to decision-maker(s)
WHIPS AND CHAINS

“If you torture data long enough, it will tell you anything you want to hear.” adapted from Ronald Coase, unpublished

Scenario / Task (next slide)

- Four system concepts under review
- Five evaluation factors
- Analysis team must assign weights to factors; weights sum to 10
- Analysis team must recommend a preferred alternative
ONE SCENARIO – RECOMMEND A PREFERRED ALTERNATIVE

- Time to Prototype
- Sensor Resolution
- 5-Year Cost
- Speed
- Time on Station

- 8
- 5
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- ONE SCENARIO – RECOMMEND A PREFERRED ALTERNATIVE

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INSTRUMENTS OF TORTURE

- Numerous stakeholder communities want to ensure that the decision makers consider their interests

- Numerous external entities, often with only peripheral interest in either the process or the actual decision, often exert pressure on one or both

- Worse, many of these overt and peripheral stakeholders often have conflicting – if not mutually exclusive – views

- Analysts may therefore feel pressure to manipulate and present data to depict what the audience wants or expects to see or hear
The Process Has Its Challenges ... From Start To Finish

**DOES MY LATEST ASSIGNMENT LOOK IMPOSSIBLE?**

**LET’S SEE... YOU’D NEED TO SLOW THE SPEED OF LIGHT, AND PERFECT THE ART OF HUMAN CLONING...**

**SO THERE’S HOPE?**

**ELIMINATE GRAVITY, STOP THE SUN, RE-ANIMATE THE DEAD...**

---

**WHY ARE YOU PICKING THIS OPTION?**

**I LISTED A DOZEN REASONS.**

**INDIVIDUALLY, EACH REASON WOULD NOT BE COMPELLING. BUT VIEWED AS A WHOLE, THIS IS THE BEST DECISION.**

**THIS FIRST REASON IS WEAK.**

**AND HERE WE GO.**
... And The Process Demands Integrity

**Dilbert**

**Panel 1:**
- Man: Did you read my comments on the four alternatives?
- Man: No.

**Panel 2:**
- Man: I recommended option two. Option one won’t work, and options three and four will each blow the budget.

**Panel 3:**
- Man: I already approved option one.
- Man: If you need any more help, just let me know.

**Panel 4:**
- Man: What’s this I hear about you hating the software integration analysis project?
- Dilbert: I don’t hate it. I simply mentioned both the pros and the cons. People are so conditioned to take sides that a balanced analysis looks to them like hatred.
In this scenario, the analysis team would likely recommend System 4 as the preferred alternative, even though all scores are reasonably close.

<table>
<thead>
<tr>
<th>Decision Factors</th>
<th>Time to Prototype Test</th>
<th>5-Year Cost</th>
<th>Sensor Resolution</th>
<th>Speed</th>
<th>Time on Station</th>
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<th>Scores</th>
<th>U = Utility value</th>
<th>W = Weighted value</th>
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<td>U</td>
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<tr>
<td>System 1</td>
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<td>1.5</td>
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<tr>
<td>System 2</td>
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<tr>
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<tr>
<td>System 4</td>
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<th>Weighted Totals</th>
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<td>6.75</td>
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<td>6.85</td>
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REVISED DECISION MATRIX

If the analysts think – or are led to believe – that the customer values cost more highly than time on station, they are more likely to recommend System 3.

<table>
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<td>1.2</td>
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“BRING ME A ROCK”

- Generally appears as feedback from the decision-maker(s) after the briefing or presentation
- The analysts may have attempted to accommodate (or at least not antagonize) as many interests as possible, by attempting to craft a consensus “one-size-fits-all” recommendation
- Reviewers and/or decision makers may feel dissatisfied with the adequacy of the analysis (perhaps in scope; perhaps in maturity; perhaps in detail; perhaps other aspects)
  - The difficulty is that they may not know – or be able to articulate – what specific additional information might scratch that itch
  - Analysts need to appropriately distill the feedback and determine which aspects of the analysis and associated trades need to be re-examined
  - The process tends to repeat until the decision-makers agree on what is REALLY important
SOME COMMON ROCKS ...

- “What can you do sooner?”
- You can’t schedule technology or innovation
- “It has to be different” -- bigger (smaller), faster (slower), lighter (heavier), secure (open-source), etc.
- What other parameter(s) are you willing to trade?
- “What’s a cheaper option?”

- What are you willing to trade?
STUDIES HAVE SHOWN THAT MANY COST MODELS DON’T PRODUCE NUMBERS THAT ARE ANY MORE ACCURATE OR ANY MORE USEFUL THAN NUMBERS YOU JUST MAKE UP ...

Be Careful What You Ask For ...
... Because Sometimes the Truth Hurts

I narrowed down the options to an alternative that costs too much and another that won’t work.

I didn’t do any research. It’s more of an experience sort of thing.

Next week I plan to think about the option of using technology that isn’t yet available.

Thanks to your input, the analysis had nothing in common with how things work in the real world.

This slide shows the gap between the test results and reality.

Use the analysis conclusions and test results anyway ... they’re the only data we have.

I’d like to thank all of the people who helped design the analysis and test parameters.
DATA-RICH, INFORMATION-POOR (aka “DRIP”)

- Too often, analysts’ response to vague requests for data (from either management or decision makers) is simply to inundate the requester in a flood of plots and spreadsheets.
  
- CASE STUDY: Space Situational Awareness (SSA) Architecture Characterization

Adapted from SMC/XRD “PASEP” study, 2006-2008
SSA TASK: FIND, TRACK, IDENTIFY ALL OBJECTS IN EARTH ORBIT

- What does “orbit” mean?
  - Low Earth Orbit (LEO)
  - Highly Eccentric Orbit (HEO)
  - Geosynchronous Orbit (GEO)
  - Polar Orbit

- Are there any obvious constraints?
  - How long should “Track” be maintained?
  - How much resolution is needed to “Identify”?  

- Once an architectural analysis scoped the problem and determined that this SSA system should only examine objects in GEO, system-level trades assessed various characteristics of both space-based and ground-based systems

Adapted from SMC/XRD “PASEP” study, 2006-2008
DECISION TREE FOR SPACE-BASED SSA SYSTEM

Adapted from SMC/XRD “PASEP” study, 2006-2008
### KEY TRADES - ORBIT

<table>
<thead>
<tr>
<th>Metric</th>
<th>Near-Synchronous Circular Orbits</th>
<th>Synchronous Apogee, Highly Eccentric Orbits</th>
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<tbody>
<tr>
<td>Close Approach %</td>
<td>Best percentage of close approaches in a given time</td>
<td>Acceptable percentage of close approaches</td>
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<tr>
<td>Launch Delta-V</td>
<td>Normal GEO launch parameters</td>
<td>~1500 m/sec less than GEO</td>
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<tr>
<td>Wide-Field Imaging and Detection</td>
<td>Acceptable imaging performance</td>
<td>Best method for both imaging and detection</td>
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Adapted from SMC/XRD “PASEP” study, 2006-2008
<table>
<thead>
<tr>
<th>Orbit Type</th>
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<td>Circular, Near Synchronous</td>
<td>42164</td>
<td>0</td>
<td>42164 km</td>
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<tr>
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<td>42189</td>
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<td>42189 km</td>
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<td>42214</td>
<td>0</td>
<td>42214 km</td>
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<tr>
<td>Circular, Near Synchronous</td>
<td>42264</td>
<td>0</td>
<td>42264 km</td>
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<tr>
<td>Super HEO</td>
<td>42164</td>
<td>0.5</td>
<td>63246 km</td>
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<tr>
<td>Circular, Sub Synchronous</td>
<td>26600</td>
<td>0</td>
<td>26600 km</td>
<td>NA</td>
</tr>
<tr>
<td>Circular, Super Synchronous</td>
<td>67000</td>
<td>0</td>
<td>67000 km</td>
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Adapted from SMC/XRD "PASEP" study, 2006-2008
### SYSTEM AND SUBSYSTEM CHARACTERIZATION

<table>
<thead>
<tr>
<th>Configuration 1</th>
<th>Configuration 2</th>
<th>Configuration 3</th>
<th>Configuration 4</th>
<th>Configuration 5</th>
<th>Configuration 6</th>
<th>Configuration 7</th>
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<tbody>
<tr>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
<td><strong>Mass</strong></td>
</tr>
<tr>
<td>kg</td>
<td>lbm</td>
<td>kg</td>
<td>lbm</td>
<td>kg</td>
<td>lbm</td>
<td>kg</td>
<td>lbm</td>
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<tr>
<td>Payload Total</td>
<td>106</td>
<td>233</td>
<td>106</td>
<td>233</td>
<td>69</td>
<td>152</td>
<td>69</td>
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<tr>
<td>50 cm Imager</td>
<td>65</td>
<td>143</td>
<td>65</td>
<td>143</td>
<td>33</td>
<td>73</td>
<td>33</td>
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<tr>
<td>10 cm Imager</td>
<td>27</td>
<td>59</td>
<td>27</td>
<td>59</td>
<td>27</td>
<td>59</td>
<td>27</td>
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<td>Payload Comm.</td>
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<td>30</td>
<td>14</td>
<td>30</td>
<td>9</td>
<td>20</td>
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<td>Spacecraft</td>
<td>319</td>
<td>704</td>
<td>391</td>
<td>863</td>
<td>305</td>
<td>674</td>
<td>376</td>
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<td>Propulsion</td>
<td>50</td>
<td>110</td>
<td>56</td>
<td>122</td>
<td>46</td>
<td>101</td>
<td>56</td>
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<tr>
<td>Attitude</td>
<td>25</td>
<td>54</td>
<td>39</td>
<td>86</td>
<td>25</td>
<td>54</td>
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<td>Telemetry</td>
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<td>11</td>
<td>24</td>
<td>11</td>
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<td>Thermal</td>
<td>10</td>
<td>22</td>
<td>12</td>
<td>26</td>
<td>9</td>
<td>19</td>
<td>10</td>
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<tr>
<td>Power</td>
<td>65</td>
<td>143</td>
<td>80</td>
<td>176</td>
<td>64</td>
<td>140</td>
<td>80</td>
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<td>Structure</td>
<td>84</td>
<td>186</td>
<td>104</td>
<td>228</td>
<td>79</td>
<td>175</td>
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<td>Spacecraft Con.</td>
<td>64</td>
<td>141</td>
<td>78</td>
<td>173</td>
<td>61</td>
<td>135</td>
<td>75</td>
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<tr>
<td><strong>Dry Mass</strong></td>
<td>425</td>
<td>937</td>
<td>497</td>
<td>1096</td>
<td>374</td>
<td>826</td>
<td>445</td>
</tr>
<tr>
<td><strong>Wet Mass</strong></td>
<td>565</td>
<td>1247</td>
<td>749</td>
<td>1652</td>
<td>498</td>
<td>1097</td>
<td>670</td>
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<tr>
<td>Orbit Insert.</td>
<td>0</td>
<td>8</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>On-Orbit Prop.</td>
<td>140</td>
<td>309</td>
<td>243</td>
<td>536</td>
<td>123</td>
<td>271</td>
<td>217</td>
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<tr>
<td>Pressurant</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Launch Vehicle</strong></td>
<td><strong>Delta IV M</strong></td>
<td><strong>Delta IV M (4,0)</strong></td>
<td><strong>Delta IV M</strong></td>
<td><strong>Delta IV M (4,0)</strong></td>
<td><strong>Delta IV M</strong></td>
<td><strong>Delta IV M (4,0)</strong></td>
<td><strong>Delta IV M</strong></td>
</tr>
<tr>
<td>PAF Mass</td>
<td>113</td>
<td>250</td>
<td>113</td>
<td>250</td>
<td>25</td>
<td>55</td>
<td>113</td>
</tr>
<tr>
<td><strong>Total Launch Mass</strong></td>
<td>679</td>
<td>1497</td>
<td>862</td>
<td>1902</td>
<td>523</td>
<td>1152</td>
<td>784</td>
</tr>
<tr>
<td>Performance</td>
<td>1138</td>
<td>2509</td>
<td>2700</td>
<td>5954</td>
<td>1138</td>
<td>2509</td>
<td>2700</td>
</tr>
<tr>
<td>Launch Mass Margin</td>
<td>459</td>
<td>1013</td>
<td>1838</td>
<td>4052</td>
<td>615</td>
<td>1357</td>
<td>1916</td>
</tr>
<tr>
<td>Spacecraft (S/C) per Launch</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Launch Vehicle (LV) Percent Margin</strong></td>
<td>40.4%</td>
<td>68.1%</td>
<td>54.1%</td>
<td>71.0%</td>
<td>30.3%</td>
<td>66.2%</td>
<td>43.1%</td>
</tr>
</tbody>
</table>

Adapted from SMC/XRD “PASEP” study, 2006-2008
DECISION TREE FOR GROUND-BASED RADAR

Adapted from SMC/XRD “PASEP” study, 2006-2008
## KEY TRADES - FREQUENCY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>X-Band</th>
<th>Ka Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter Power (MW)</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Aperture Area (m²)</td>
<td>50</td>
<td>16</td>
</tr>
<tr>
<td>Beamwidth (deg X deg)</td>
<td>0.177 x 0.354</td>
<td>0.126 x 0.126</td>
</tr>
<tr>
<td>Number of Transmit/Receive (Tx/Rx) Modules</td>
<td>222,222</td>
<td>871,000</td>
</tr>
<tr>
<td>Tx/Rx Module Power (W)</td>
<td>10</td>
<td>3.5</td>
</tr>
<tr>
<td>Power Density (kw/m²)</td>
<td>50</td>
<td>156</td>
</tr>
<tr>
<td>Availability</td>
<td></td>
<td>At least 10 dB more attenuation in clouds, fog, and rain</td>
</tr>
<tr>
<td>Cost</td>
<td>$x</td>
<td>&gt; $4x</td>
</tr>
</tbody>
</table>

Adapted from SMC/XRD “PASEP” study, 2006-2008
## KEY TRADES - ANTENNA TYPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Phased Array</th>
<th>Gimbaled Dish</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight</strong></td>
<td>Less structural metal, no gimbals</td>
<td>Less signal processing equipment</td>
</tr>
<tr>
<td></td>
<td>Future improvements in Tx/Rx module packaging and power efficiency will reduce weight</td>
<td></td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td>Generally less than dish and gimbals</td>
<td></td>
</tr>
<tr>
<td><strong>RF Losses</strong></td>
<td>Future improvements in materials and packaging will reduce losses</td>
<td>Lower losses due to no need for element combining networks</td>
</tr>
<tr>
<td></td>
<td>Cryogenic cooling can help reduce losses</td>
<td></td>
</tr>
<tr>
<td><strong>Tracking</strong></td>
<td>Tracking speed set by computational speed</td>
<td>Tracking speed set by mechanical scan rate</td>
</tr>
<tr>
<td></td>
<td>Parallel processing and combining multiple digital signal channels allow simultaneous tracking of multiple targets</td>
<td></td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>Tx/Rx modules produce ~10W each at X-band</td>
<td>For similar aperture size, transmit power is greater than PA antenna</td>
</tr>
<tr>
<td><strong>Gain</strong></td>
<td>Loses effective area due to gaps/edges between elements</td>
<td>Loses effective area due to blockage by feed</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>Large number of elements enables advanced adaptive processing</td>
<td></td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>High cost of Tx/Rx modules (NOTE: DARPA research projecting unit cost decrease from ~$100 to ~$10 over next 10 years)</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from SMC/XRD “PASEP” study, 2006-2008
THE CONUNDRUM – WHEN SHOULD I MAKE THE DECISION? (or “How Much Data Is Enough?”)

- Excessive short-term cost consciousness (or “affordability-awareness”; the situation is not unique to DoD, though) leads to corporate reluctance to commit resources

- An option that looks promising at one point in time may look less so later

- A risk-averse decision environment often means no decision at all: advocates have to bring a case that is technically and statistically sound, complete, current, relevant, rational, etc. in terms of making the case for investment
TOP 10 DA CONSIDERATIONS THROUGHOUT THE LIFE CYCLE

- UNIVERSAL
  - Applies to all domains, industries, product areas, research areas …
  - One size (policy, process, procedure, prior idea …) seldom fits all

- COLLABORATIVE
  - Understand the realities of -- and constraints imposed by -- external factors and influences (government, industry, academia)
  - The human is an external factor, and always introduces uncertainties

- NOT FOR THE NEOPHYTE – REQUIRES MORE THAN BASIC INTELLIGENCE
  - Know what you want, and measure smartly … Accuracy ≠ Precision
  - Beware of “DRIP” -- especially in response to requests for Rocks

- RESPONSIVE, BUT REALISTIC
  - Customers often press for immediate solutions over rigorous process
  - “Then a miracle occurs” should NEVER be an acquisition or transition strategy

- ALL ABOUT SMART CHOICES
  - Early decomposition / allocation decisions (i.e., focus on either hardware or software first) are a huge driver in defining the rest of the solution trade space
  - Do it right, do it early; do it early, do it right: Decision Analysis and Decision Support Information represent Systems Thinking – to be supplemented by Systems Engineering
WHY IT’S IMPORTANT – KEY DoD ISSUES

- **Myriad external influences**
  - Dynamic global adversaries and threats
  - National fiscal imbalance
  - Increased Congressional oversight
  - Politically-driven climate

- **Hard to shift long-standing cultural paradigms**
  - Resistance (or unwillingness, or inability) to commit to prioritizing resources by capability
  - Resistance to cross-service resourcing
  - Continued focus on large platforms and systems
  - Reactive decision environment

- **Theoretical, more than practical / realistic, understanding of what is needed for comprehensive planning / management of complex systems and systems of systems**
  - Networks, service-oriented architectures (SOA), enterprise systems; emergent behaviors; etc.
  - Inconsistent application to programs, both within and across Services and Agencies

- **Customer / user expectations for mission success and meeting cost / schedule targets**
  - Difficult to reconcile risk-averse behavior and decisions
GLOSSARY – DECISION ANALYSIS, A TO X

- **Affordability**
  - Top dog in DoD at present; it has both a planning component (thinking about what options will best fit in the overall portfolio) and an execution component (thinking about how best to manage current contracts and resources)

- **Biases**
  - Can be imposed by analysts to scope work, or directed by decision-makers

- **Constraints**
  - Similar to biases in that they limit objectivity by including or excluding parts of the trade space

- **Dependencies**
  - Everything touches pretty much everything else; the difficulty is in figuring out which touch points merit attention at which decisions

- **Enterprise**
  - The unseen partner in everything; particularly significant in today’s information-driven environment where real-time decisions rely on timely availability of accurate data

- **Feasibility**
  - “Then a miracle is going to occur and there will be a new wrinkle in the laws of physics!” isn’t really a good technology maturation, acquisition, or transition strategy

- **Generalizations**
  - Taking for granted that dependencies and enablers will always be available is a recipe for failure
Help

“We don’t have time to bring in the experts, so we’ll just take our best guess!”

Integration

Things work better together when they are designed to work together ... many new efforts are actually modernizations and upgrades of legacy systems/platforms, few of which were really designed with future integration in mind.

“Just A Little More”

Trying to optimize (or enhance) one attribute of the system almost always sub-optimizes the system as a whole.

Knowledge

It’s not so much “knowledge” per se, but rather how the knowledge base is to be established, populated, maintained, and transitioned from the first users (capability planners and concept developers) to the downstream stakeholders.

Latency

Data have a finite effective/usable life span ... if you don’t meet the milestone review within, say, a year after the analysis is complete, the decision-makers are likely to question whether the cost data (or the operational scenarios, vignettes, etc.) are still valid.

Maturity

How much thought went into the systems/concepts under consideration? Can the analysts (to say nothing of the decision makers) make “apples-to-apples” comparisons with respect to key attributes? Is any concept just a couple of PowerPoint slides and a back-of-a napkin sketch?
Novelty
- It’s okay – in fact, it’s probably a really good idea – to think “outside the box” (especially in emerging realms such as cyber)

Operational Context and Operating Concept
- Similar-sounding terms, but very different things: Context is more about the environment in which the system will exist and operate; concept is more about what the user expects to do with the system, and how it will benefit the ability to accomplish missions and objectives

Pressure
- Comes in many different forms; one of the most common is the customer/user clamoring for something to improve operational capabilities ASAP; other sources are availability or unavailability of resources (e.g., money, people, range time, etc.), the political environment, the promotion/PCS cycle, etc.

Quick
- Moore's Law – computing power doubles approximately every 18 months – still applies to IT, and more so to cyber; cyber adversaries are exceptionally versatile, agile, and innovative

Reusability
- Options to reconfigure, reallocate, or re-engineer need to receive objective consideration if they make technical, technological, and economic sense

System-of-Systems Awareness
- Very little gets done by a “one-of” product/system/platform/asset – or individual
Transition

What if any thought has been given to moving to the next step or steps? This applies to both life cycle phases and process steps, and to elements of the knowledge base.

Unanticipated Consequences

Nothing is EVER going to be perfect, and nobody is 100% prescient in guessing how the future will look ... some implications of tomorrow’s decisions might not bubble to the surface for 10 or 15 years; some of those may validate today’s assumptions, and some may cause people to wonder what we were thinking when we made those decisions.

Value Added

Did the information contribute to the discussion and the decision? Or was the outcome pretty much a foregone conclusion?

“What-If?”

Sensitivity analysis is an important part of a decision support information package (of course, it helps to know what factors the decision-makers consider most significant; see “Biases” and “Constraints” above).

X

The ever-present unknown – but not necessarily a bad thing, as long as the analysts and the decision makers are aware that it exists, and as long as the information identifies it as such; early technical planning should convert “Unknown Unknowns” into “Known Unknowns”.

GLOSSARY — DECISION ANALYSIS, A TO X
Not Everything Is In Your Control
“We demand rigidly defined areas of doubt and uncertainty!”

Douglas Adams, *The Hitchhiker's Guide to the Galaxy*