712CD

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Original title on 712 A/B:

A Decision Support System to help Prioritize Sensor Capabilities for Lunar Landers and Planetary Rovers

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Report Documentation Page

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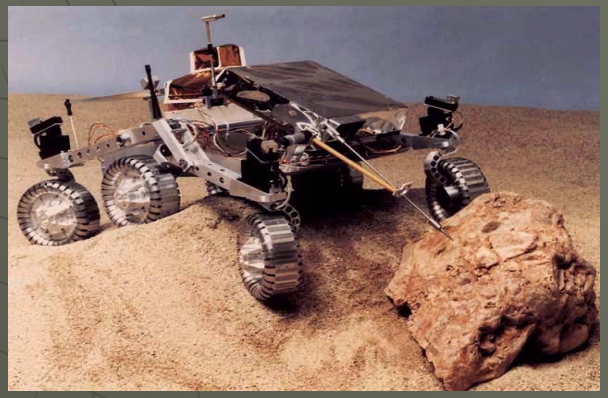
A Decision Support System to help Prioritize Sensor Capabilities for Lunar Landers and Planetary Rovers

MORS Symposium
United States Naval Academy
Annapolis, Maryland
11-14 June 2007

MAJ Ernest Y. Wong
Department of Systems Engineering
United States Military Academy

Agenda

- Background
- Initial Problem Statement
- Revised Problem Statement
- NASA's Approach
- A Value-Focused Thinking Approach
- The Decision Support System
- Additional Applications
- Conclusions



Background

- President Bush's guidance:

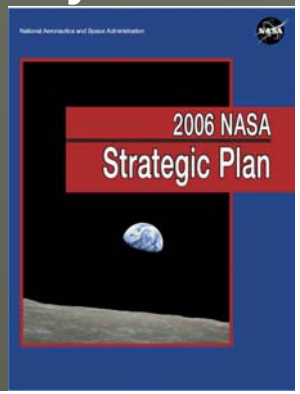
  "Our goal is to return to the moon by 2020. . . [By] establishing an extended human presence on the moon [we] could vastly reduce the costs of further space exploration, making possible even more ambitious missions."

  --January 14, 2004 address to NASA

http://www.whitehouse.gov/news/releases/2004/01/20040114-3.html

NASA's 2006 Strategic Goals

1. Fly the Shuttle as safely as possible until its retirement, not later than 2010
2. Complete the International Space Station in a manner consistent with NASA's International Partner commitments and needs of human exploration
3. Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration
4. Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement
5. Encourage the pursuit of appropriate partnerships with the emerging commercial space sector
6. Establish a lunar return program having the maximum possible utility for later missions to Mars and other destinations



http://www.nasa.gov/mission_pages/exploration/main/index.html

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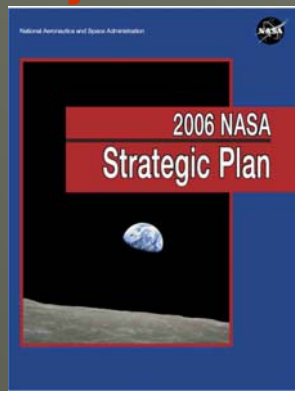

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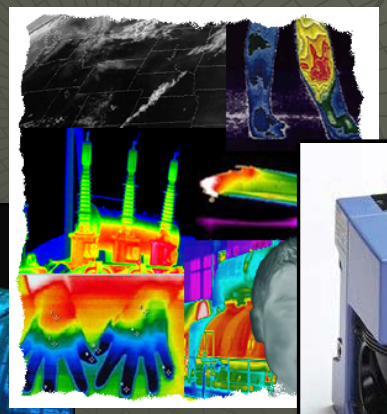
Initial Problem Statement

- NASA asked us to select the best sensor or sensor suites to improve the safety and reliability of autonomous space exploration
- Alternative focused thinking approach

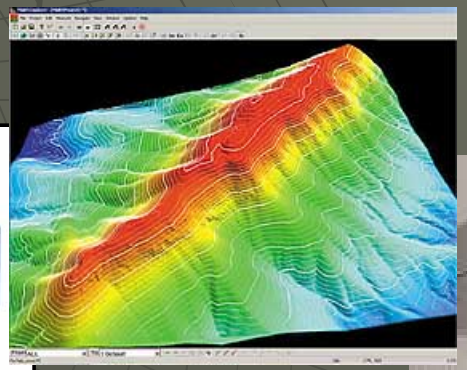
Night Vision

3D Imaging



Thermal

LIDAR



Multi-Spectral

Video

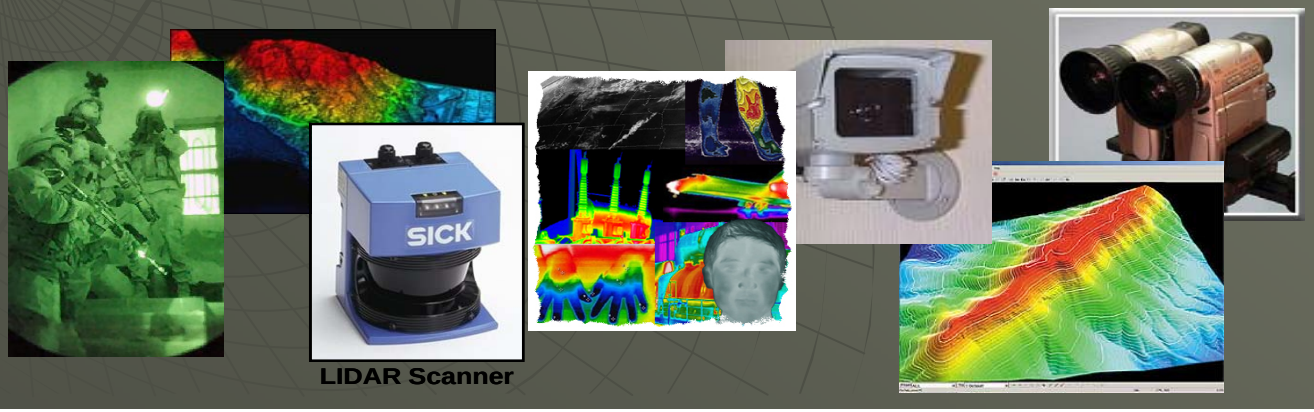
Stereoscopic

Revised Problem Statement

- Develop a decision support system to help NASA determine which sensor capabilities are most critical for autonomous space exploration
  - The model uses a value focused approach rather than an alternative focused approach
  - The model can be easily modified for varying mission requirements
  - The model segments space exploration into distinct phases in an attempt to capture overall critical mission capabilities

NASA's Current Approach

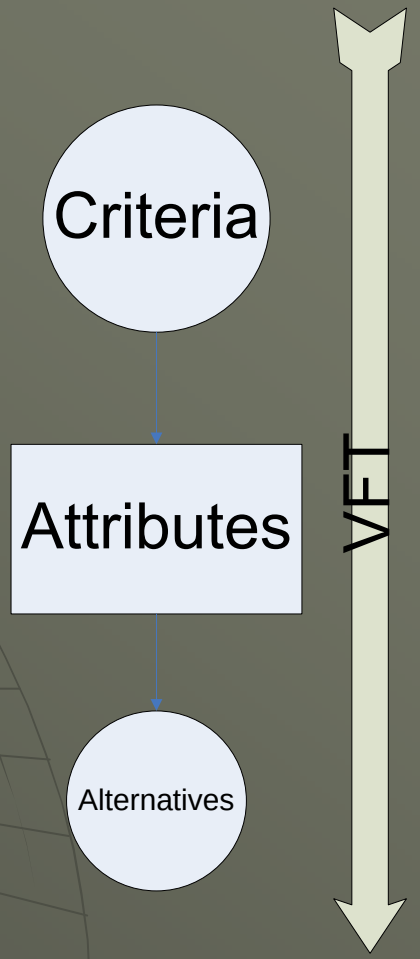
- Alternative Focused Thinking (AFT):
  - Focuses on existing solutions to the problem
  - Best sensor suite is limited to what is currently available on an existing list
  - Best sensor suite is also restricted by current technological capabilities
  - A one-size fits all approach that fails to reflect key requirements of any particular mission



LIDAR Scanner

Our Team's Approach

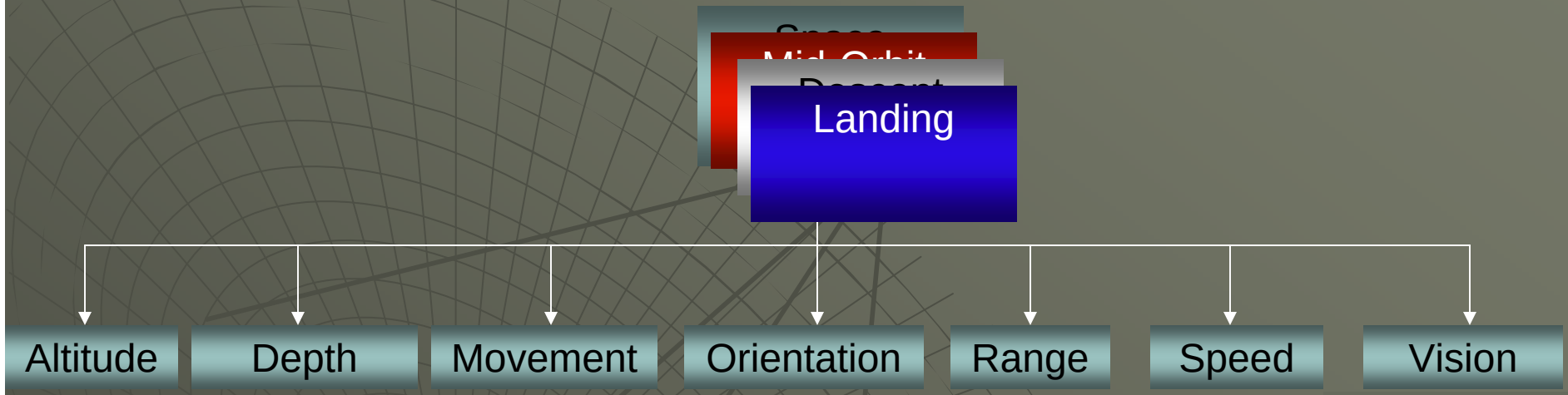
- Value Focused Thinking (VFT)
  - Values are what people desire
  - Focuses on capabilities of an ideal sensor and the limitations the sensors have to overcome.
  - VFT is markedly different than choosing alternatives and going with the one that fits the best.
  - Focuses an organization's goals and objectives into an action plan



Value-Focused Thinking

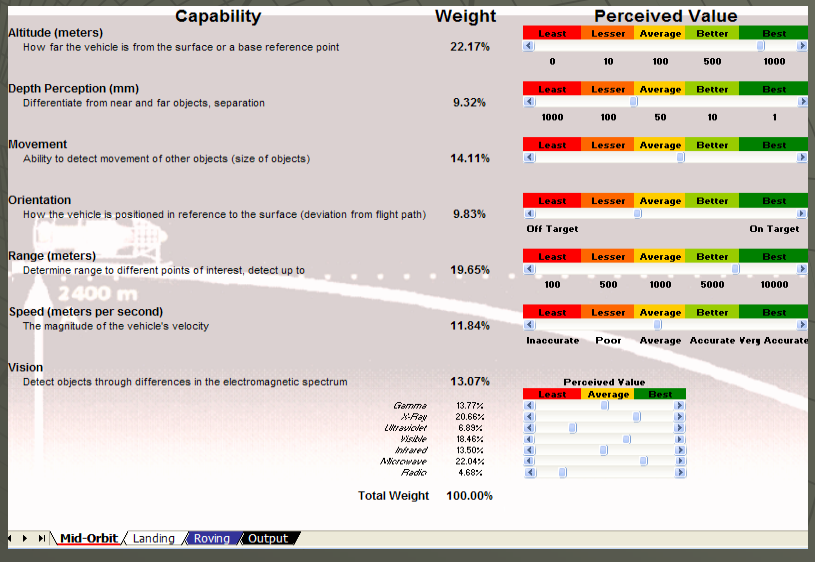
- Ralph Keeney, a pioneer in the field of VFT, introduces the concept of Constraint-Free Thinking:
  - "thinking about values is constraint-free thinking . . . it is thinking about what you wish to achieve or what you wish to have."
- Provides NASA with a new approach to its research, development and design process
- Provides NASA with a more unconstrained view of examining what sensor capabilities and requirements it values as being the most critical for future missions

Proposed Functional Hierarchy



Our Decision Support Model

- A MS Excel Decision Support System (DSS)
  - Makes decisions easier for the stakeholders
  - Links strategy with research
- Breaks a space mission down into 3 distinct phases: mid-orbit, descent, landing
- Flexible tool that can be tailored, customized, and adapted to various issues



Demo of the Model

Capability	Weight	Perceived Value
Altitude (meters)		Least / Lesser / Average / Better / Best
How far the vehicle is from the surface or a base reference point	22.17%	0 / 10 / 100 / 500 / 1000
Depth Perception (mm)		Least / Lesser / Average / Better / Best
Differentiate from near and far objects, separation	9.32%	1000 / 100 / 50 / 10 / 1
Movement		Least / Lesser / Average / Better / Best
Ability to detect movement of other objects (size of objects)	14.11%	
Orientation		Least / Lesser / Average / Better / Best
How the vehicle is positioned in reference to the surface (deviation from flight path)	9.83%	Off Target / On Target
Range (meters)		Least / Lesser / Average / Better / Best
Determine range to different points of interest, detect up to	19.65%	100 / 500 / 1000 / 5000 / 10000
Speed (meters per second)		Least / Lesser / Average / Better / Best
The magnitude of the vehicle's velocity	11.84%	Inaccurate / Poor / Average / Accurate / Very Accurate
Vision		
Detect objects through differences in the electromagnetic spectrum	13.07%	Perceived Value: Least / Average / Best
Gamma	13.77%	
X-Ray	20.66%	
Ultraviolet	6.89%	
Visible	18.46%	
Infrared	13.50%	
Microwave	22.04%	
Radio	4.68%	
Total Weight	**100.00%**	

Mid-Orbit | Landing | Roving | Output

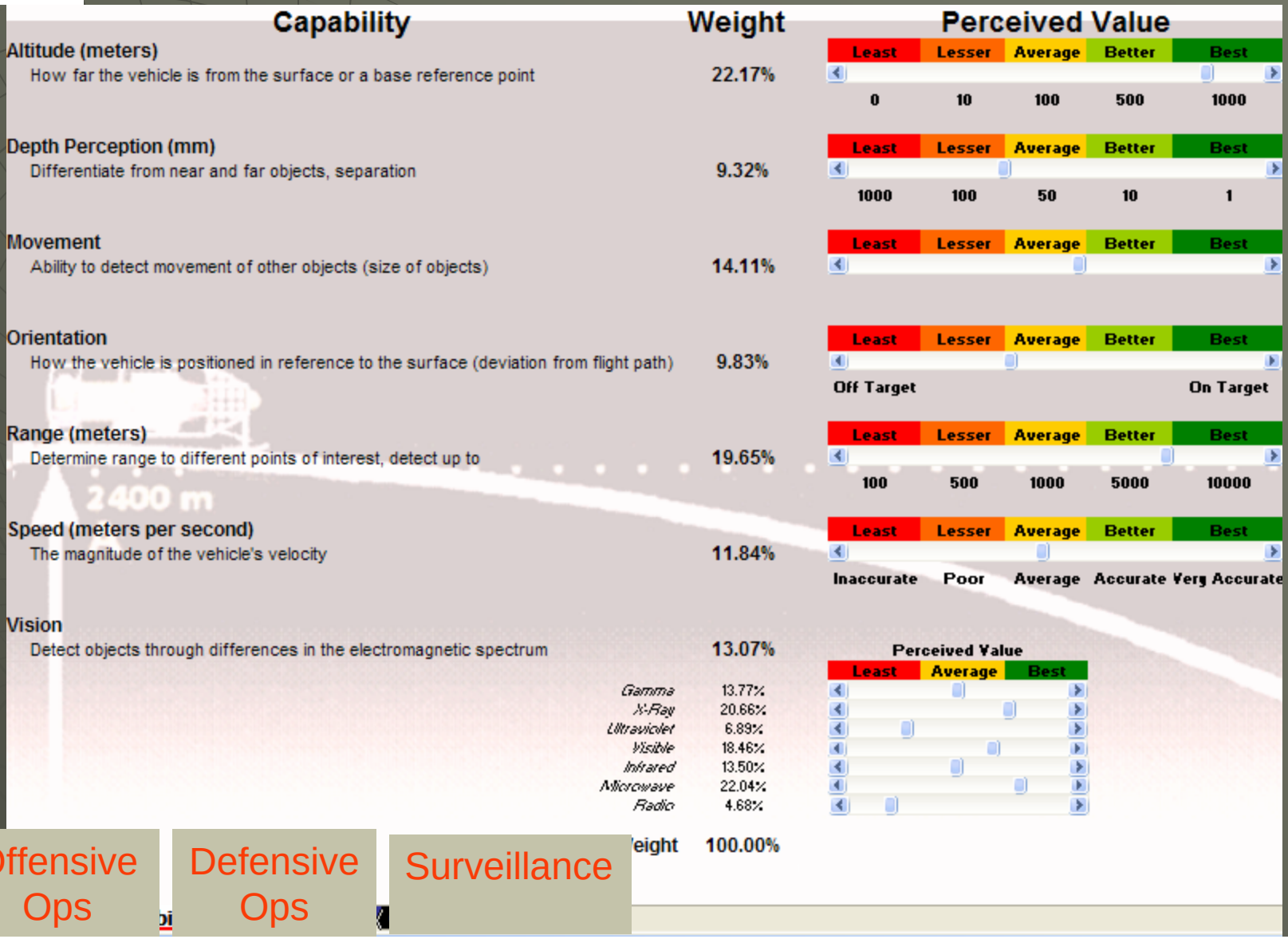
Additional Applications

- Easily modified for various applications
- Marine Corps Combat Development Command (MCCDC)
  - Approx. $20K for a 3rd party to develop a similar product for a Marine Corps Personnel Carrier

Additional Applications

- Future Weapons Systems
  - Unmanned Ground Vehicle
  - Similar to NASA's rovers

Additional Applications



Offensive Ops

Defensive Ops

Surveillance

Conclusions

- Help identify capabilities and close the gaps for the organization
- Helps direct R&D funding, more focused approach
- Provided our stakeholder with a different approach to their problem (value focused as compared to alternative focused)
- Multi-phase approach vs. single static approach
- Flexible tool that has multiple applications
- Sensitivity Analysis
  - Next step in the project

Documentation

- http://www.nasa.gov/mission_pages/exploration/main/index.html
- Ralph L. Keeney. (1992). Value-Focused Thinking. Massachusetts: Harvard University Press.
- Google Images
- Discovery Channel Future Weapon Systems