Space Mission Concept Design

at the NASA Ames Mission Design Center (MDC)

Telecom with JAXA

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Agenda

• Space Mission Concept Design at NASA Ames
  • What the Ames MDC is
  • A framework for space mission ideas – The Concept Maturity Levels
  • Aeolus: an example of a mission concept study for Mars
  • What’s next

• Summary & Conclusion
Mission Design Center - What is it?

https://www.nasa.gov/centers/ames/engineering/mission-design-center/about
A framework for space mission ideas
The Concept Maturity Levels

From: Space Mission Concept Development Using Concept Maturity Levels, Wessen et al., 2013

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Aeolus: an example of a mission concept study for Mars
CML 1
“Cocktail Napkin”
Aeolus: an example of a mission concept study for Mars

CML 1
“Cocktail Napkin”

June 10, 2001  July 31, 2001
Meaningfulness & Uniqueness
Identify Knowledge Gaps

State Broad Science Objective

One-sentence description of measurement(s)
Aeolus: an example of a mission concept study for Mars

CML 1
“Cocktail Napkin”

CML 2
Feasibility
Does any solution exist?

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Draft of Science Traceability Matrix
Mission Architecture – main elements
Environmental driving parameters
Identify required tech development
Launch opportunities
Delta-V calculations
Orbital solutions
Mission ops
Spacecraft CAD model
Rough cost estimate
Rough schedule
Initial risks & mitigation identified
Future trades identified
Aeolus: an example of a mission concept study for Mars

CML 1
“Cocktail Napkin”

CML 2
Feasibility
Does any solution exist?

CML 3
Expanded Trade Space
What other solutions exist?

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CML 3: Expanded Trade Space

Divergent Phase:
Explore different mission architectures
primary vs. secondary launch options
number of spacecrafts et cetera

Convergent Phase:
Identify rejection criteria & pick architectures to pursue.

Iteration:
Repeat CML 2 as needed on selected architectures
Aeolus: an example of a mission concept study for Mars

CML 1
“Cocktail Napkin”

CML 2
Feasibility
Does any solution exist?

CML 3
Expanded Trade Space
What other solutions exist?

CML 4
Point Design
What is a good approach, given our circumstances?

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CML 4: Point Design

Science Traceability Matrix
Mission Architecture
  Driving environmental parameters
  Launch vehicle
  Delta-V calculations
Orbital solution
Radiation Analysis
Mission ops
Identify required tech development
Spacecraft CAD model
Power Analysis
Thermal Analysis
Better Cost Estimate
Refined Schedule
Risks Matrix & Mitigation

Thermal analysis

Power analysis

Schedule
Science Traceability Matrix
Mission Architecture
   Driving environmental parameters
   Launch vehicle
   Delta-V calculations
   Orbital solution
Radiation Analysis
Mission ops
Identify required tech development
Spacecraft CAD model
Power Analysis
Thermal Analysis
Better Cost Estimate
Revised Schedule
Risks Matrix & Mitigation

**Refined orbit design**

Orbit precesses over all *local times* within 2 months

Global spatial coverage every 10 days
CML 4: Point Design

Science Traceability Matrix
Mission Architecture
  - Driving environmental parameters
  - Launch vehicle
  - Delta-V calculations
  - Orbital solution
  - Radiation Analysis
  - Mission ops
  - Identify required tech development
Spacecraft CAD model
Power Analysis
Thermal Analysis
Better Cost Estimate
Revised Schedule
Risks Matrix & Mitigation

Refined Flight system capabilities

+Z (Zenith)
+X (along track)
-Y (cross-track)
Maturation of a Concept from CML 1 to CML 4

CML 1

Telescope FOVs can sweep through multiple altitudes in a single orbit, by rotating the satellite end-over-end.

CML 2

CML 4

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What’s Next

• Updating Concurrent Engineering Tool

• New Training for Personnel involved in MDC studies

• Integration of a Parametric Cost Tool into the Concurrent Engineering Tool

• Improvement of Methodology and Processes
Summary & Conclusion

- NASA Ames MDC uses the CML framework for Mission Concept Studies
- MDC focuses on CML 1 to 4
- Technical focus is on small (up to ~ 200 kg) spacecraft platforms, both Earth orbiting and deep space
- Highly integrated with Ames Flight Dynamic team
- Current focus is on improving current Concurrent Engineering capabilities