A Framework for Organizing the Planetary Science Decadal

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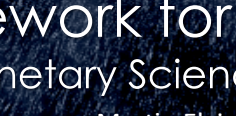
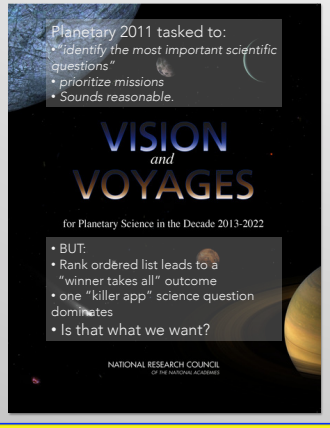


See: arXiv:1608.01004 and arXiv:1609.09428 & watch for new paper soon



Problem: "Space is Big", Cadence of planetary missions is too slow

Planetary2011 Decadal
3 Top Priorities for large missions:
1. Mars
2. Uranus
3. Europa

Only funding for 1
→30 year program
Mars2020 won
Europa Clipper: 2020s
Europa Lander: late 2020s?
Uranus: when?

New Frontiers
6 Top Priorities:
1. Comet surface sample return
2. Lunar south pole-Aitken basin sample return
3. Ocean worlds (Titan/Enceladus)
4. Saturn probe
5. Trojan tour & rendezvous
6. Venus in situ explorer

Only funding for 1 per 5 years
→30 year program
AO now out

If Uranus and Venus come last, who then will be left to do the science?
Institutional knowledge will be lost.

Improve the Decadal Statement of Task (SOT)

Design a more complex decision making structure:
- Require the Decadal to produce:

1. *Program* science requirements
   - E.g. "Visit each type of world each decade"
   - Flow down to program characteristics
- No Single Point of Failure program
   - Avoid "all our eggs in one basket" syndrome
   - → multiple missions per decade
- No Single Viewpoint failure program
   - Vigorous science needs debate
   - Multiple data streams

All point to selecting more, cheaper missions

Decadal should also:

2. Tension equal cost options
   - Compare alternate programs at same cost
   - Is a $2 B mission more productive than 2 $1 B missions?
   - Defines opportunity cost of program not chosen
3. Take into account changes in commercial space
   - Costs: 1/3 – 1/5 traditional launch cost/kg to LEO
   - → much cheaper spacecraft
   - Capabilities: affordable LEO servicing, upper stage refueling Interplanetary cubesats

More for Less

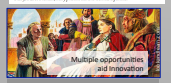
Summary

1. Program Science Requirements: Use Mission rules for whole Program

Design a more complex decision making structure:
Guide the process to be more explicit about goals, balance, choices.
Require the Decadal to produce:

1. ***Program* science requirements**
   * E.g. "Visit each type of world each decade"
   * Flow down to program characteristics
1. **No Single Point of Failure program**
   * Avoid "all our eggs in one basket" syndrome
1. **No Single Viewpoint failure program**
   * Vigorous science needs debate
   * Your tools limit the questions you can ask
   * Multiple opportunities encourage risk taking

All point to multiple missions per decade.
Each one must be cheaper



Columbus having his research proposal accepted at the 5th attempt

Steve Squyres: "the most important elements for a successful decadal survey [are] **the statement of task (SOT) and decision rules**."
(2013, quoted in *NRC Lessons Learned in Decadal Planning in Space Science, p.15.*)

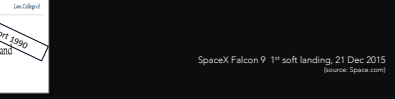
2. Tensioning: Opportunity Cost and Balance

"Tension" equal cost options:
I.e. Compare alternate programs at same cost
Is a $2 B mission always more productive than 4 $½ B missions?
Defines opportunity cost of program not chosen.

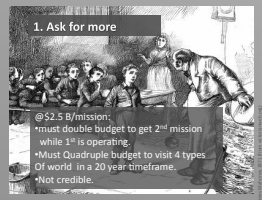
Commonly used approach in Europe. Forces tough choices. Limits insider pressuring if rationale made public.

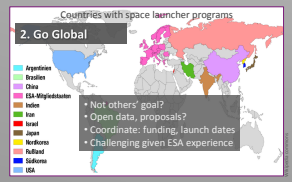
3. Commercial Space: Cheaper, more capable missions

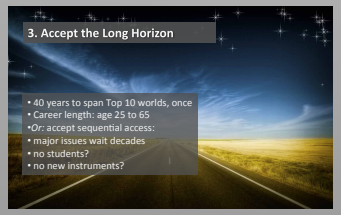
Take into account changes in commercial space
Costs: 1/3 – 1/5 traditional launch $/kg to LEO
Enables Cheaper Spacecraft:
Trade complexity for mass
Factor 3 savings? (Morgan+1990)
Capabilities: moderate cost LEO servicing,
on-orbit upper stage refueling
Interplanetary cubesats



3 ways out that don't work







Visions & Voyages (Planetary2011) Statement of Task

Required for NASA program:
Balance small (<$450M), medium ($450M-$900M), large (>$900M)*
List prioritized missions for each cost bin.
Give assumptions used to create priorities.
Give decision rules if circumstances change.
Must be executable within anticipated resources.
lLarge" assumes: capability grows faster than cost
"assumptions" less explicit than tensioning

* Lifecycle cost.