The Cost Impacts of Jointness:

Insights from the NPOESS Program

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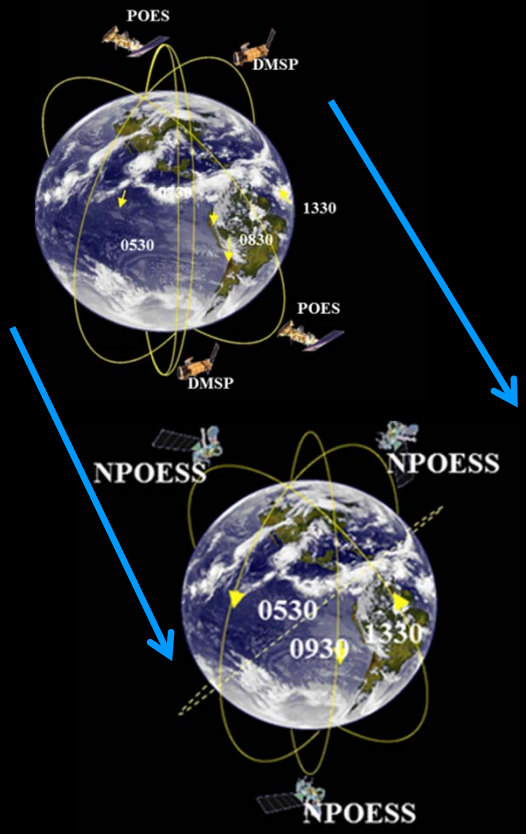
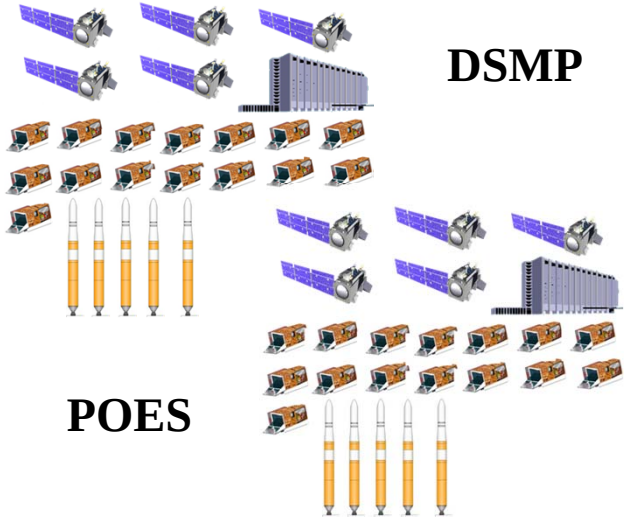
Introduction to NPOESS

Technical Aggregation

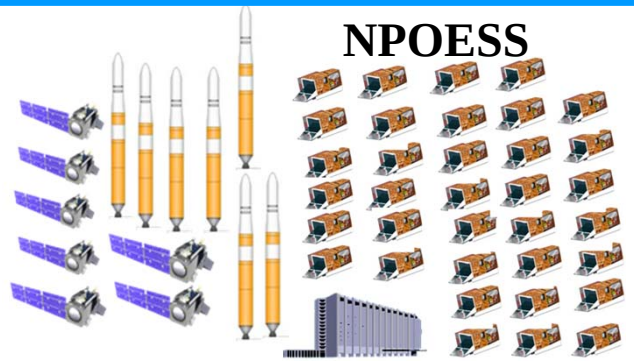


Cost savings is enabled by a program's *technical architecture*.

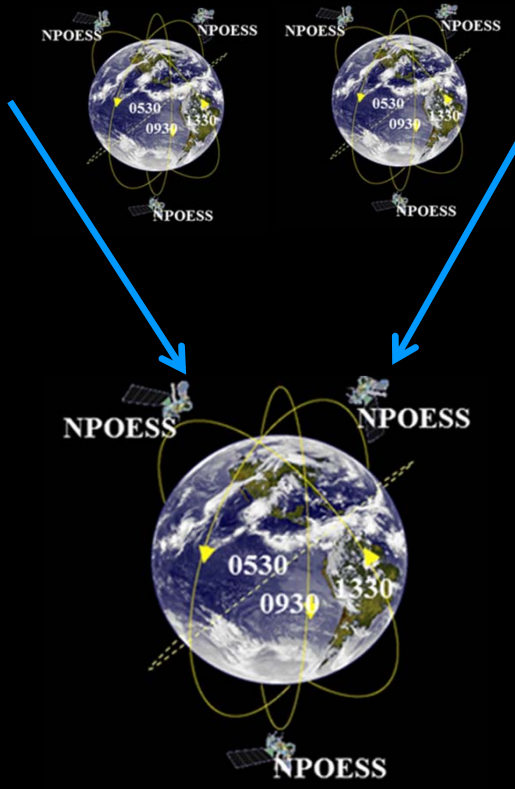
Lifecycle Cost Savings



5 sensors, 3 satellites, 1 ground system, 3 launches



Organizational Aggregation



Cost savings is enabled by a program's *organizational architecture*.

Potential Impacts of Jointness

Technical & Organizational Disaggregation

- **Disaggregate missions to reduce technical complexity & save costs** (Burch 2012)
- **Only collaborate when there are very compelling reasons to do so** (NRC 2011)

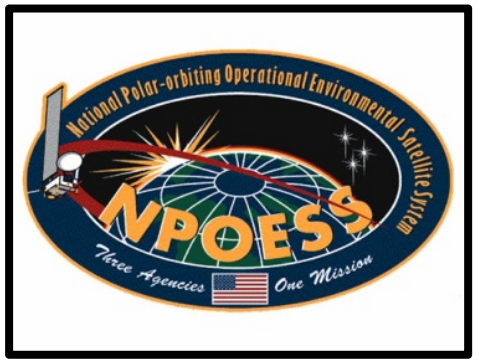
Technical Aggregation

Aggregated *technical architectures* induce unanticipated *complexity and cost*.

Organizational Aggregation

Aggregated *organizational architectures* induce unanticipated *complexity and cost*.

Technical & Organizational Aggregation



NPOESS

A Framework to Assess Impacts

Approach: Represent the program's organizational & technical architectures & quantify their complexity

Technical Complexity:

A function of the components of a system & the interactions between them.

Components	Design	Process		Architectural A	B	C	D	E	F	G	H
VIIRS	4	2	A		3	1	0	1	1	0	1
CMIS	4	1	B	3		1	0	1	0	0	1
NPOESS Bus (Early Morning)	2	0	C	1	2		0	1	2	1	0
NPOESS Bus (Mid-Morning)	0	0	D	0	0	0		0	0	0	0
NPOESS Bus (Afternoon)	2	0	E	1	2	1	0		2	1	0
NPP Bus	0	1	F	1	0	2	0	2		2	0
Ground System	N/A	0	G	0	0	1	0	1	2		1
Algorithms	N/A	2	H	1	1	0	0	0	0	1	

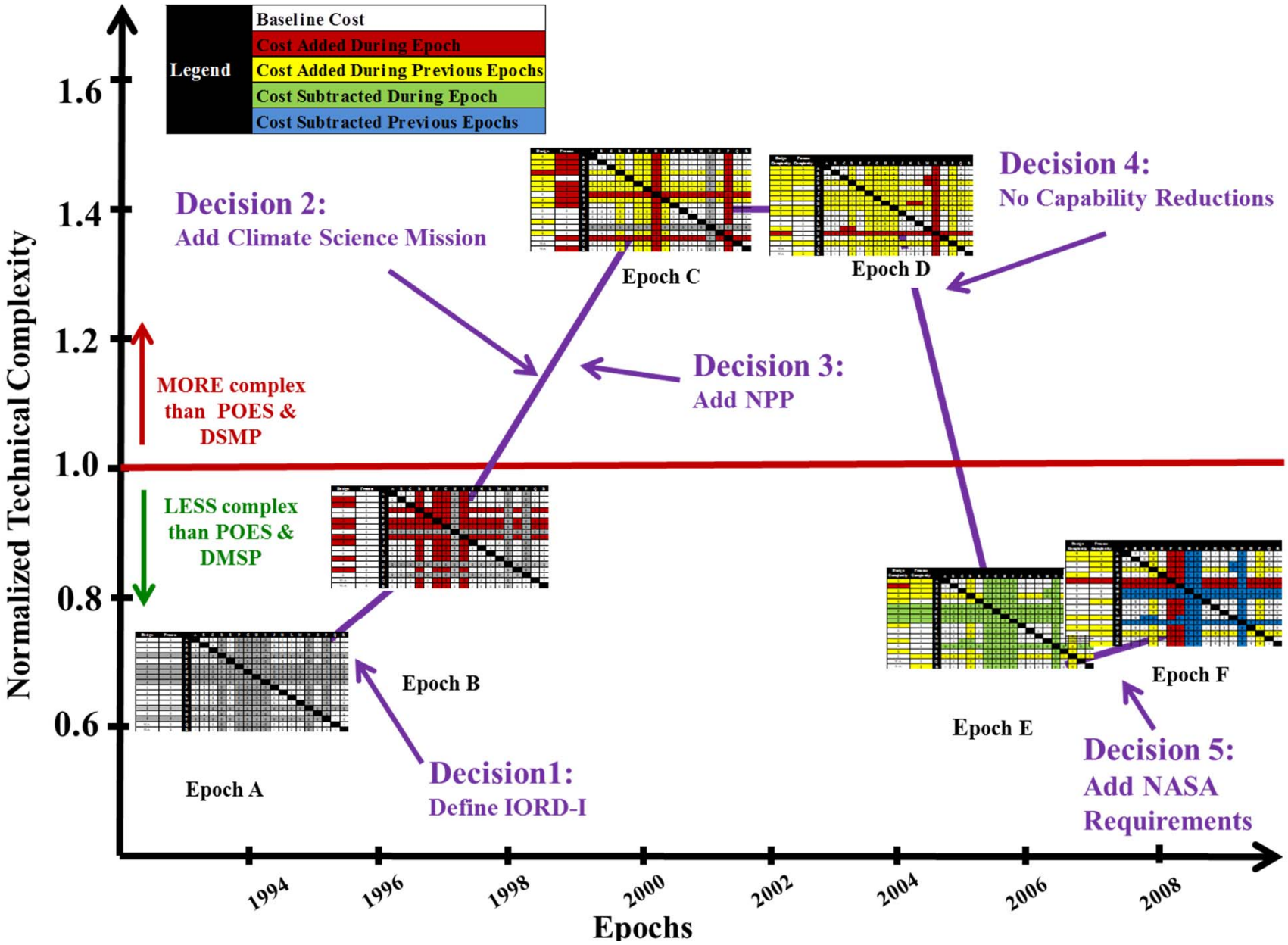
Organizational Complexity:

A function of the misalignment of mission responsibility & decision authority and factors that erode decision authority.

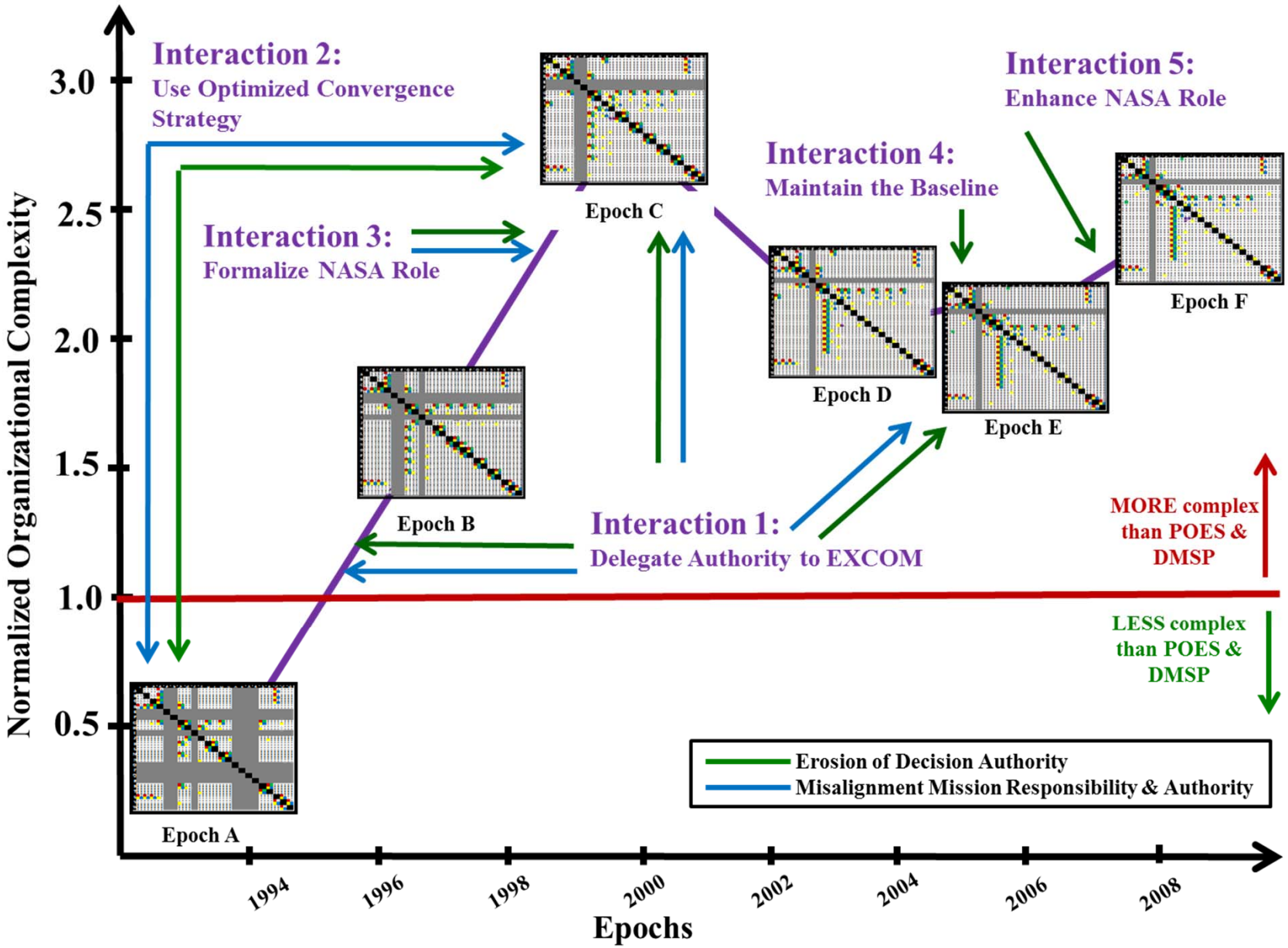
Components		A	B	C	D	E	F	G	H
NOAA	A		0 0	0 0	1 1	1 1	0 0	0 0	0 0
			0 0	1 0	1 2	0 0	0 0	0 0	0 0
DoD	B	0 0		0 0	1 1	0 0	0 0	0 0	0 0
		0 0		0 0	1 1	1 0	0 0	0 0	0 0
NASA	C	0 0	0 0		1 0	0 0	1 1	0 0	0 0
		1 0	0 0		1 1	0 0	1 1	0 0	0 0
EXCOM	D	1 1	1 1	1 0		2 1	0 0	0 0	0 0
		1 2	1 1	0 1		1 1	0 0	0 0	0 0
IPO	E	0 0	0 0	0 0	2 1		0 0	2 1	0 0
		0 0	1 0	0 0	1 1		1 0	1 2	0 0
NPP Program Office	F	0 0	0 0	1 1	0 0	0 0		0 0	0 0
		0 0	0 0	1 1	0 0	1 0		0 0	1 1
SSPR Prime Contractor	G	0 0	0 0	0 0	0 0	2 1	0 0		1 1
		0 0	0 0	0 0	0 0	1 2	0 0		1 1
VIIRS Sensor Vendor	H	0 0	0 0	0 0	0 0	0 0	0 0	1 1	
		0 0	0 0	0 0	0 0	0 0	1 1	1 1	

Goal: Observe the evolution of complexity & its relationship to cost growth, technical decisions & agency interactions over time.

Evolution of Technical Complexity



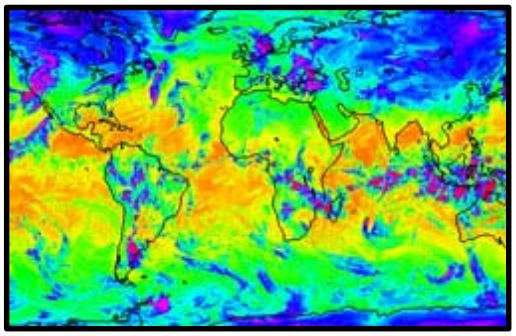
Evolution of Organizational Complexity



Technical Costs of Jointness

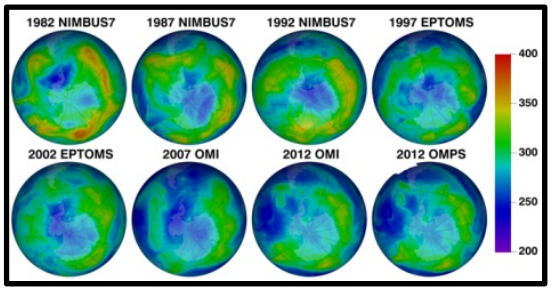
- **Requirements Aggregation**
  - Joint requirements necessitated technology development
  - Investing in multiple technology development projects increased budget uncertainty
  - Multiple agency engineering standards had to be negotiated and reconciled
- **Spacecraft Aggregation**
  - Interactions between instruments induced additional non-recurring instrument, bus, and SE costs
- **Mission Aggregation**
  - Despite its dual mission identity, NPP was developed as an operational mission

Technical aggregation **induced non-recurring cost growth but had the** ***potential to save lifecycle costs*** **if it had been effectively managed.**



CrIS (Image: NASA)

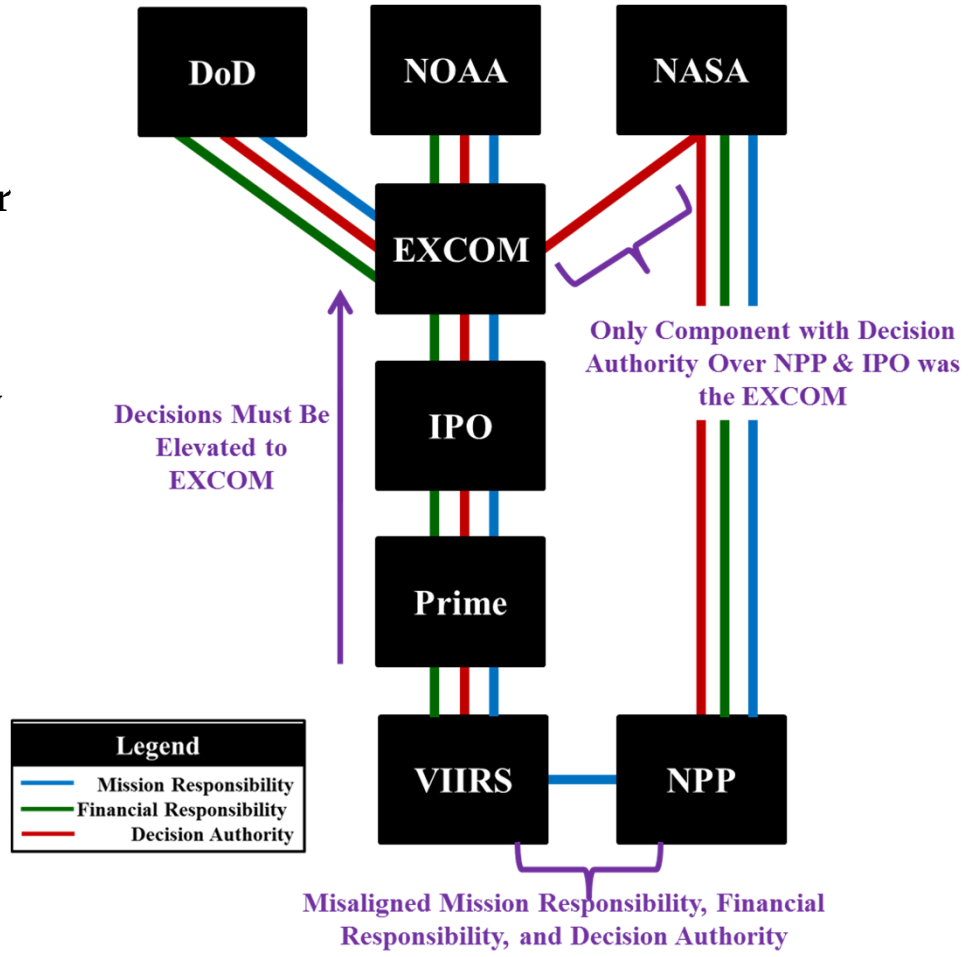
VIIRS (Image: NASA)



OMPS (Image: NASA)

Organizational Costs of Jointness

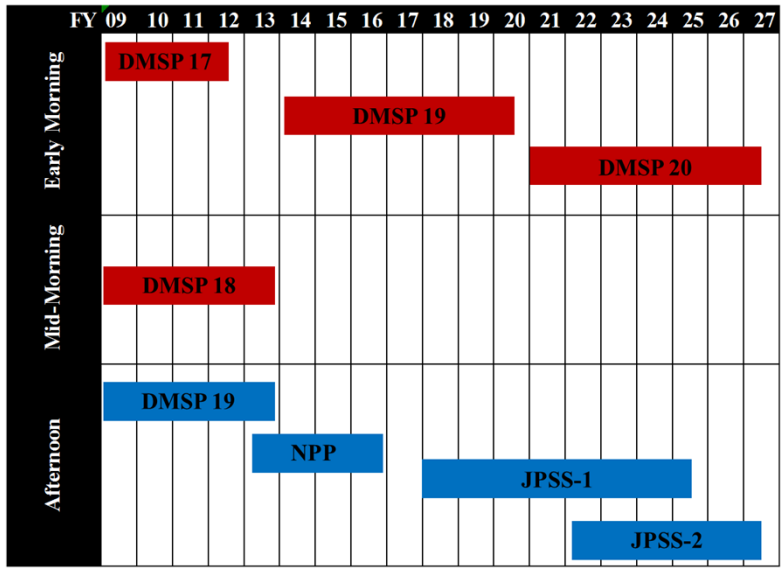
- **Misalignment of Mission Responsibility & Decision Authority**
  - Optimized convergence strategy separated TSPR-like prime contractor from the components & interfaces for which it was ultimately responsible
  - Separate NPOESS & NPP program offices fractionated decision authority & crippled decision-making from instrument vendors through agency leadership
- **Misalignment of Mission & Financial Responsibility**
  - NPP program office's ability to make cost-risk trades was impeded by its lack of financial responsibility for the program's instruments



Most of the program's organizational complexity & non-technical cost growth was a result of the *disaggregation*, rather than the aggregation, of critical relationships between organizational components.

A Future for Jointness?

- **Technical Strategies to Mitigate Cost Growth**
  - **Recognize that joint requirements hinder a program's ability to leverage individual agencies' heritage capabilities and budget for technology development**
  - **Utilize common standards or invest in non-recurring system engineering effort to reconcile different standards**
  - **Budget for interactions between instruments and for the cost of spacecraft aggregation**
- **Organizational Strategies to Mitigate Cost Growth**
  - **Award contracts early in the system's lifecycle and concurrently for all of the system's components**
  - **Fully integrate responsibility, authority, and technical capability into a single program office**
  - **Institute a PEO-like authority structure over the user community to enable capability reductions**

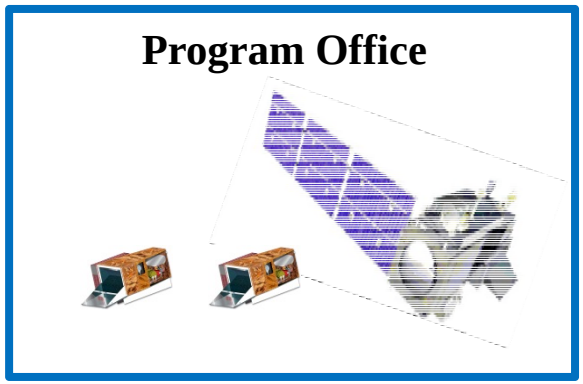


Planned fly-out of existing environmental satellites in low-earth orbit: An opportunity for another joint program? (Image: NOAA 2013)

Key Recommendation

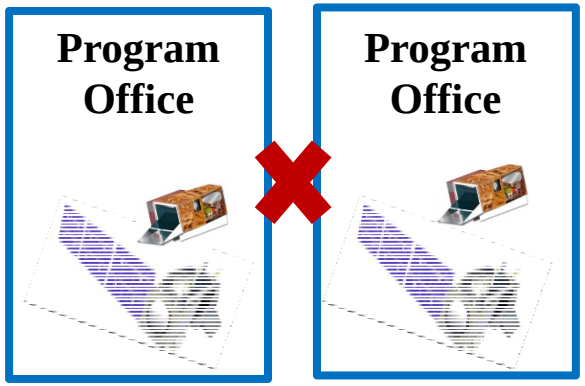
Both aggregated and disaggregated programs can be developed cost effectively as long as their organizational & technical architectures *match*.

Aggregated System



Aggregated systems should be developed by fully aggregated organizations with single program offices.

Disaggregated System



Disaggregated systems should also be developed by single program offices and these offices should be disaggregated from one another.

Thanks!

Please email mdwyer@mit.edu with questions.

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Image Citations

- **Title Slide & Slide Headers**
  - Image of NPOESS Satellite: Wikapedia. Available online: http://en.wikipedia.org/wiki/File:NPOESS_illustration_2006.jpg. Accessed 12/8/2013
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