



Flight Options Analysis Tool (FLOAT)

2005 Small Payload Rideshare Conference

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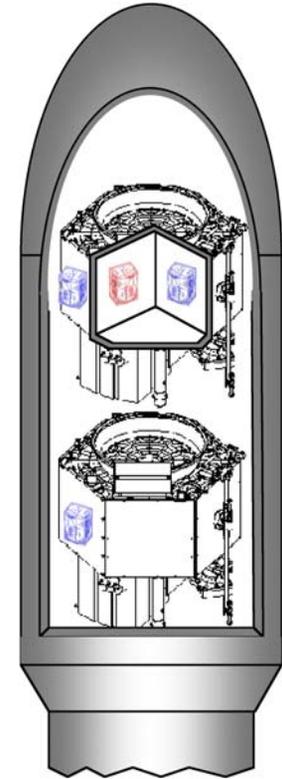
**Jet Propulsion Laboratory
California Institute of Technology**

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Agenda

- Introduction
- Background
- Study Objectives & Assumptions
- Overview of Database
 - [STP Payloads \(STP office\)](#)
 - [RSDO Spacecraft Buses \(RSDO website\)](#)
 - [NASA Launch Vehicles \(KSC website\)](#)
- Results
- Future Direction



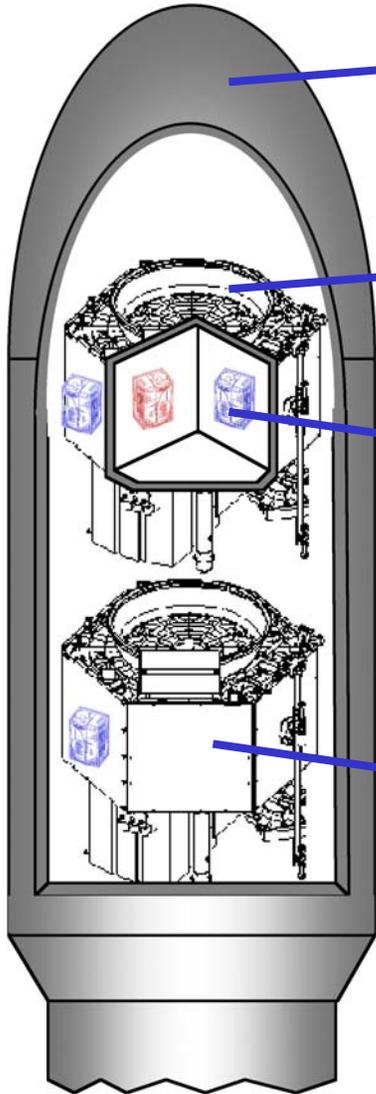


Introduction

- **Objective**
 - The Flight Options Analysis Tool (FLOAT) finds compatible flight options by comparing **Payload**, **Spacecraft Bus**, and **Launch Vehicle** parameters
- **FLOAT Development has been a New Millennium Program Task**
 - **Approximate Level-of-Effort: < 1 Person-year per year**
- **Mission Support & Case Studies**
 - **Preliminary case study for ST6 Mission**
 - **Support NMP ST8 mission analysis**
 - **Case Study for STP office (presented here)**
 - **Risk module developed**
 - **ST8 software version validated**
 - **Database expanded and enhanced**



Database Overview (for STP case study)



- **Launch Vehicles**
 - KSC Launch Vehicle Database
 - 34 unique options for reaching low Earth orbits
- **Spacecraft Buses**
 - RSDO Spacecraft Bus Catalog
 - 15 spacecraft buses provided by 5 aerospace companies
- **Payloads**
 - 23 instruments & new technologies provided by the STP office
 - 9 of these require ELV launch options to low Earth orbit
- **Secondary spacecraft (future capability)**
 - NMP mission reference list & Access to Space track launch opportunities with excess mass capability
 - These launch opportunities will be incorporated into FLOAT





Study Assumptions

- **System Elements Considered**
 - 34 NASA launch vehicle options
 - 15 RSDO spacecraft buses
 - 9 STP payloads (up to six per spacecraft)
 - **More than 3 million combinations!**
- **Principal Types of Analyses**
 - **Simple:** Schedule, mission duration, mass, telemetry, pointing, volume, & cost
 - **Complex:** Orbit, power, and risk
- **Simplifying Assumptions**
 - Power modes not considered
 - Spacecraft & launch vehicle geometry not considered
 - Only the lowest cost & compatible spacecraft & launch vehicles used
 - Cost defined simply as spacecraft bus cost + launch vehicle cost
 - No spacecraft modifications considered



List of All Combinations

Results								
Option #	PL#1	PL#2	PL#3	PL#4	PL#5	PL#6	S/C Bus	LV
788	STP Payload B	STP Payload K					RSDO Bus	Launch Vehicle 50
7	STP Payload B						RSDO Bus	Launch Vehicle 53
538	STP Payload B	STP Payload E	STP Payload F	STP Payload K	STP Payload O		RSDO Bus	Launch Vehicle 53
496	STP Payload B	STP Payload E	STP Payload F	STP Payload K			RSDO Bus	Launch Vehicle 53
1646	STP Payload K						RSDO Bus	Launch Vehicle 50
580	STP Payload B	STP Payload E	STP Payload F	STP Payload O			RSDO Bus	Launch Vehicle 53
484	STP Payload B	STP Payload E	STP Payload F				RSDO Bus	Launch Vehicle 53
1402	STP Payload E	STP Payload F	STP Payload K	STP Payload O			RSDO Bus	Launch Vehicle 53
1360	STP Payload E	STP Payload F	STP Payload K				RSDO Bus	Launch Vehicle 53
634	STP Payload B	STP Payload E	STP Payload K	STP Payload O			RSDO Bus	Launch Vehicle 53
592	STP Payload B	STP Payload E	STP Payload K				RSDO Bus	Launch Vehicle 53
742	STP Payload B	STP Payload F	STP Payload K	STP Payload O			RSDO Bus	Launch Vehicle 53
700	STP Payload B	STP Payload F	STP Payload K				RSDO Bus	Launch Vehicle 53
1444	STP Payload E	STP Payload F	STP Payload O				RSDO Bus	Launch Vehicle 53
1348	STP Payload E	STP Payload F					RSDO Bus	Launch Vehicle 53
676	STP Payload B	STP Payload E	STP Payload O				RSDO Bus	Launch Vehicle 53
472	STP Payload B	STP Payload E					RSDO Bus	Launch Vehicle 53
784	STP Payload B	STP Payload F	STP Payload O				RSDO Bus	Launch Vehicle 53
688	STP Payload B	STP Payload F					RSDO Bus	Launch Vehicle 53
1576	STP Payload F	STP Payload K	STP Payload M				RSDO Bus	Launch Vehicle 53
1498	STP Payload E	STP Payload K	STP Payload O				RSDO Bus	Launch Vehicle 53
1456	STP Payload E	STP Payload K					RSDO Bus	Launch Vehicle 53
1603	STP Payload F	STP Payload K	STP Payload O				RSDO Bus	Launch Vehicle 53
1564	STP Payload F	STP Payload K					RSDO Bus	Launch Vehicle 53
1615	STP Payload F	STP Payload M					RSDO Bus	Launch Vehicle 53
1540	STP Payload E	STP Payload O					RSDO Bus	Launch Vehicle 53
1336	STP Payload E						RSDO Bus	Launch Vehicle 53
1642	STP Payload F	STP Payload O					RSDO Bus	Launch Vehicle 53
1552	STP Payload F						RSDO Bus	Launch Vehicle 53
1658	STP Payload K	STP Payload M					RSDO Bus	Launch Vehicle 53
1689	STP Payload M						RSDO Bus	Launch Vehicle 53
148	STP Payload B	STP Payload C	STP Payload E	STP Payload K				
31	STP Payload B	STP Payload C	STP Payload E					
1012	STP Payload C	STP Payload E	STP Payload K					
370	STP Payload B	STP Payload C	STP Payload K					
880	STP Payload C	STP Payload E						
19	STP Payload B	STP Payload C						
1234	STP Payload C	STP Payload K						
868	STP Payload C							
822	STP Payload B	STP Payload K	STP Payload O					
856	STP Payload B	STP Payload O						
1677	STP Payload K	STP Payload O						
1706	STP Payload O							
581	STP Payload B	STP Payload E	STP Payload K					
461	STP Payload B	STP Payload E						
1445	STP Payload E	STP Payload K						
785	STP Payload B	STP Payload K						
1325	STP Payload E							
1	STP Payload B							
583	STP Payload B	STP Payload E	STP Payload K					
463	STP Payload B	STP Payload E						
1643	STP Payload K							
1447	STP Payload E	STP Payload K					RSDO Bus	Launch Vehicle 50
516	STP Payload B	STP Payload E	STP Payload F	STP Payload K	STP Payload M	STP Payload O	RSDO Bus	Launch Vehicle 53
501	STP Payload B	STP Payload E	STP Payload F	STP Payload K	STP Payload M		RSDO Bus	Launch Vehicle 53
531	STP Payload B	STP Payload E	STP Payload F	STP Payload K	STP Payload O		RSDO Bus	Launch Vehicle 50
558	STP Payload B	STP Payload E	STP Payload F	STP Payload M	STP Payload O		RSDO Bus	Launch Vehicle 53
489	STP Payload B	STP Payload E	STP Payload F	STP Payload K			RSDO Bus	Launch Vehicle 50
543	STP Payload B	STP Payload E	STP Payload F	STP Payload M			RSDO Bus	Launch Vehicle 53
582	STP Payload B	STP Payload E	STP Payload K				RSDO Bus	Launch Vehicle 50
787	STP Payload B	STP Payload K					RSDO Bus	Launch Vehicle 50
573	STP Payload B	STP Payload E	STP Payload F	STP Payload O			RSDO Bus	Launch Vehicle 50
477	STP Payload B	STP Payload E	STP Payload F				RSDO Bus	Launch Vehicle 50

List of Combinations includes

- Payload(s), S/C, & LV
- Schedule, Power, S/C mass, and LV margins
- Compatibility result, risk, total cost, and s/c cost
- Source of incompatibility

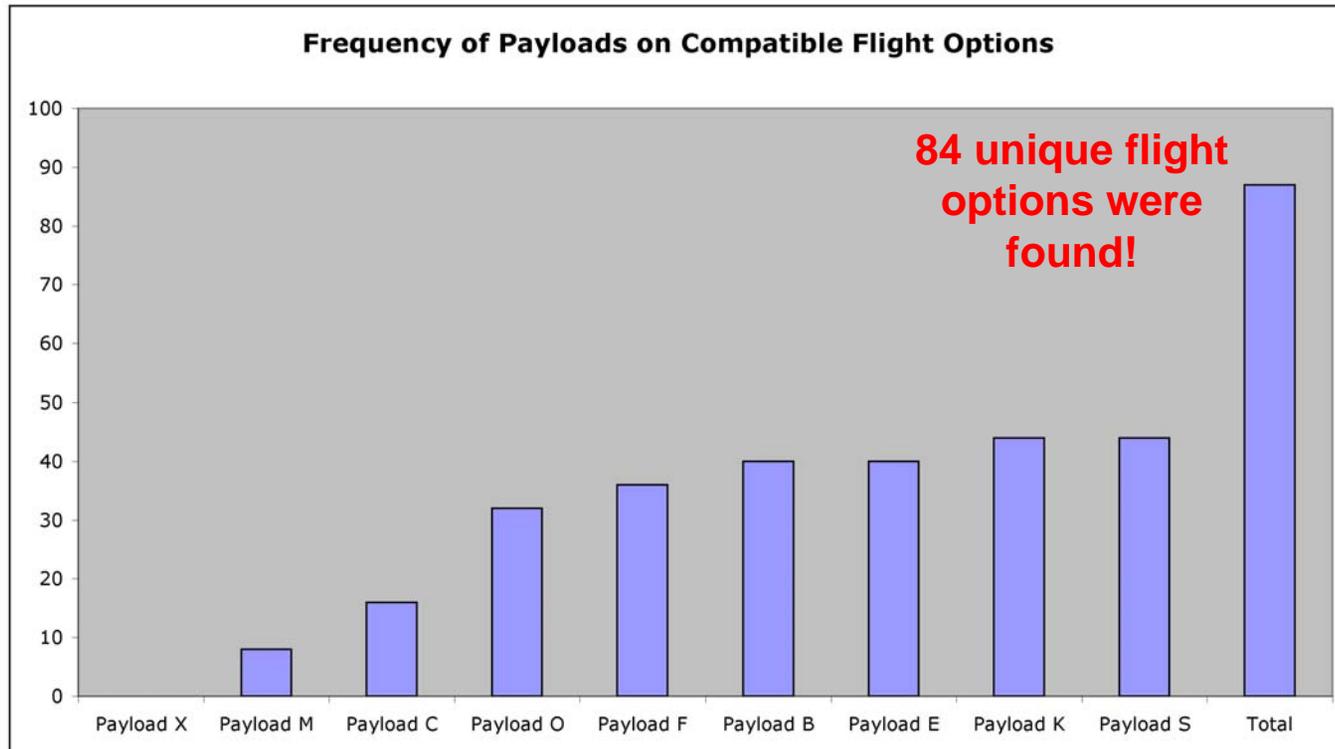
Schedule Margin (month)	S/C Power Margin	S/C Mass Margin	LV Mass Margin
?	22.0%	89.5%	33.0%
?	47.0%	83.0%	55.4%
?	71.7%	58.5%	9.9%
?	-5740.0%	-3481.0%	n/a
?	-4740.0%	-3347.7%	n/a

In	Compatibility	Total Cost	Risk	Payload Cost	PL1	PL2	PL3	PL4	PL5	PL6	S/C	LV
?	Not enough data	\$43.0 M	3.3846		16	20	1	1	1	1	5	1
?	Not enough data	\$80.5 M	2.8462		16	1	1	1	1	1	8	1
?	Not enough data	\$106.2 M	4.3077		16	18	19	20	22	1	13	1
?	Not enough data	\$106.2 M	4.3077		16	18	19	20	1	1	13	1
?	Not enough data	\$43.0 M	2.8462		20	1	1	1	1	1	5	1
?	Not enough data	\$106.2 M	4.3077		16	18	19	22	1	1	13	1
?	Not enough data	\$106.2 M	4.3077		16	18	19	1	1	1	13	1

Incompatibility									
Schedule	Cost	Mass	Volume	Power	Orbit	Telemetry	Other		
0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0		
0	0	1	0	1	0	1	0		
0	0	1	0	1	0	1	0		
0	0	1	0	1	0	1	0		
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0	0	1	0	1	0	1	0		
0	0	1	0	1	0	1	0		



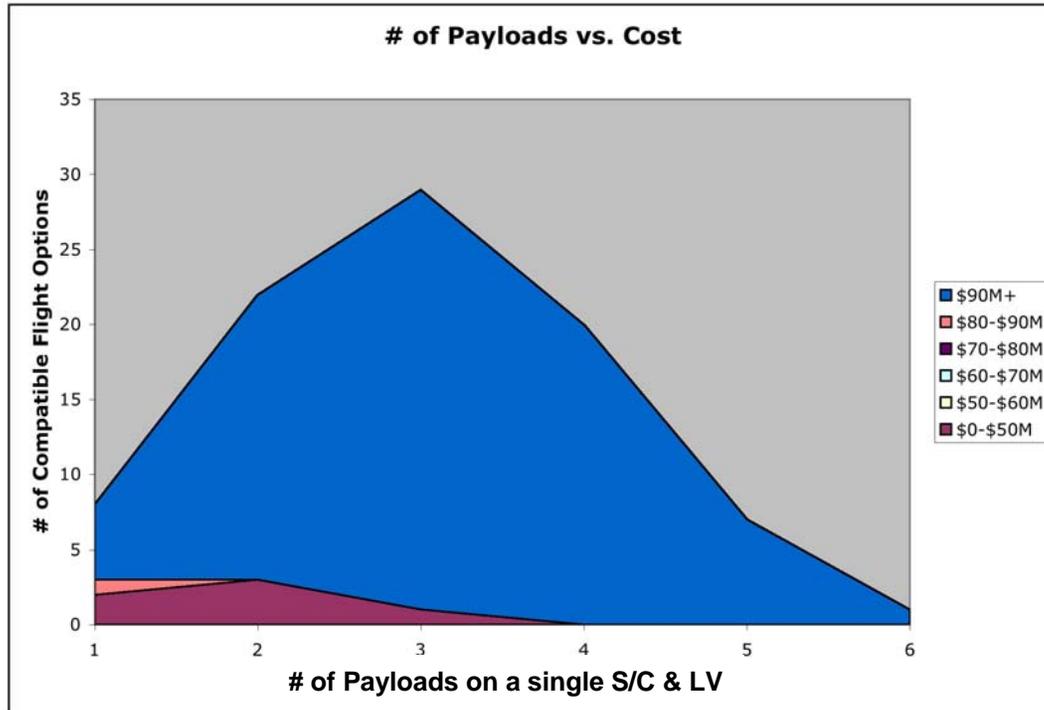
Distribution of Compatible STP Payload Combinations



- Depending on the individual payload requirements, each payload is easier or harder to integrate with other payload & spacecraft options
- Payload X requires a spin stabilized spacecraft. However, only one spin-stabilized spacecraft exists and it does not supply sufficient power
- Payload M is constrained by its high telemetry rate

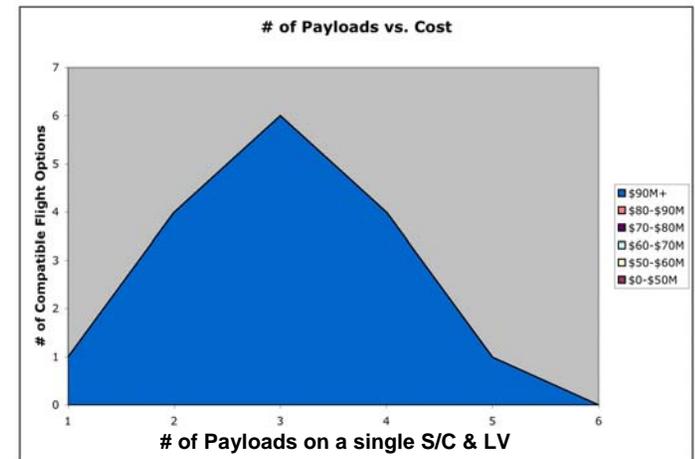
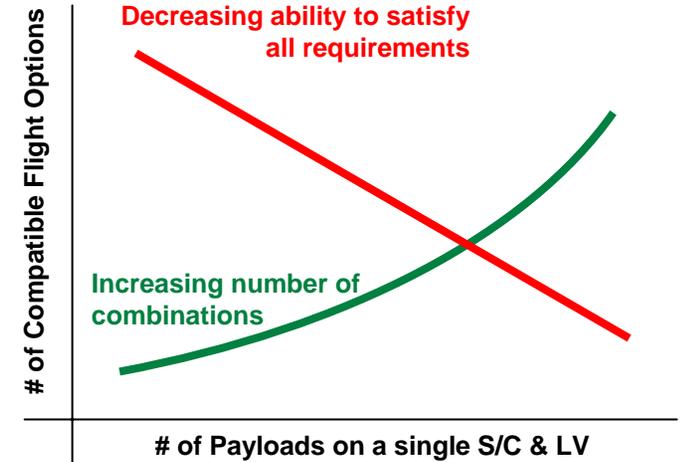


of Payloads versus Cost



All

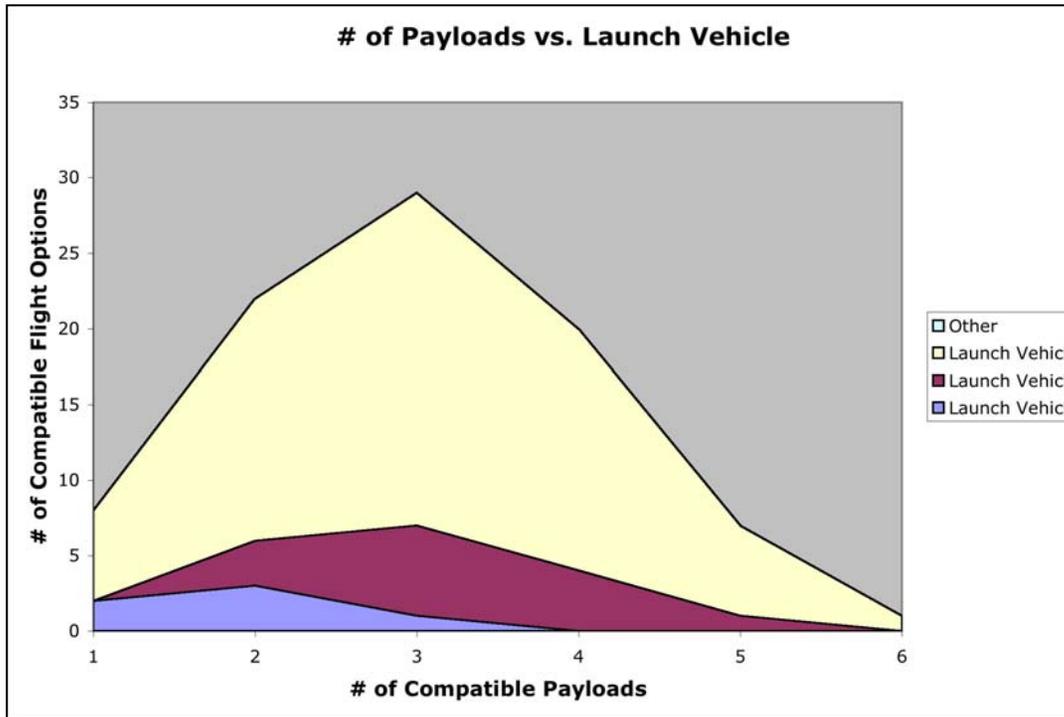
- Most flight options require > \$90M
- However, there are a few select combinations that require less than \$50M
- For a given payload, no less expensive combinations may be available



Combinations that include Payload C

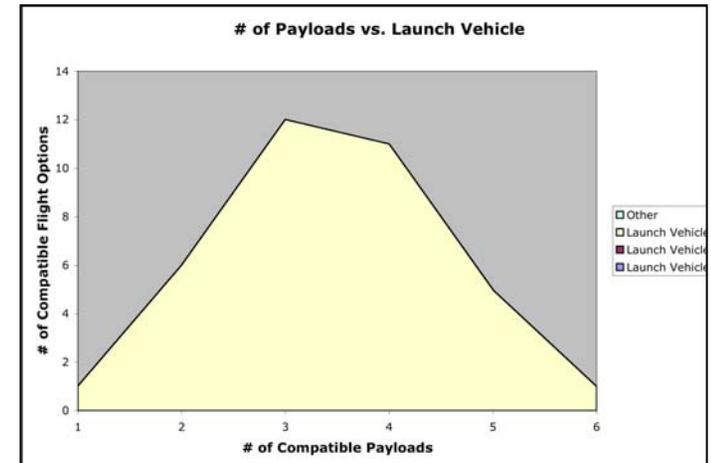


of Payloads vs Launch Vehicle

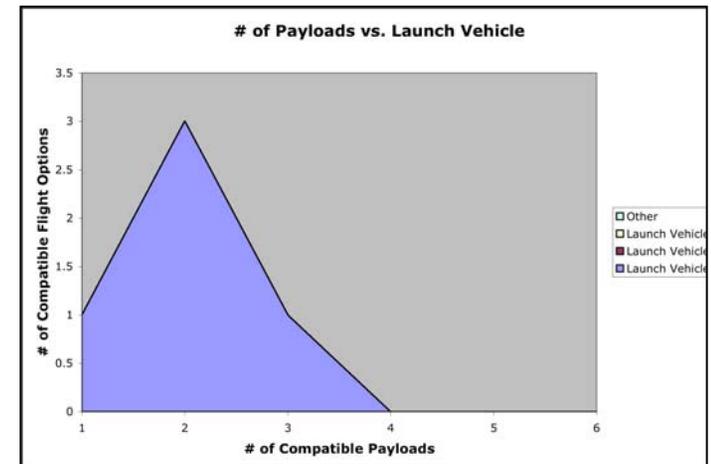


All

- All combinations of compatible payloads fit on one of three launch vehicles
- Depending on the characteristics of the payload or spacecraft bus, a single launch vehicle may be the only option



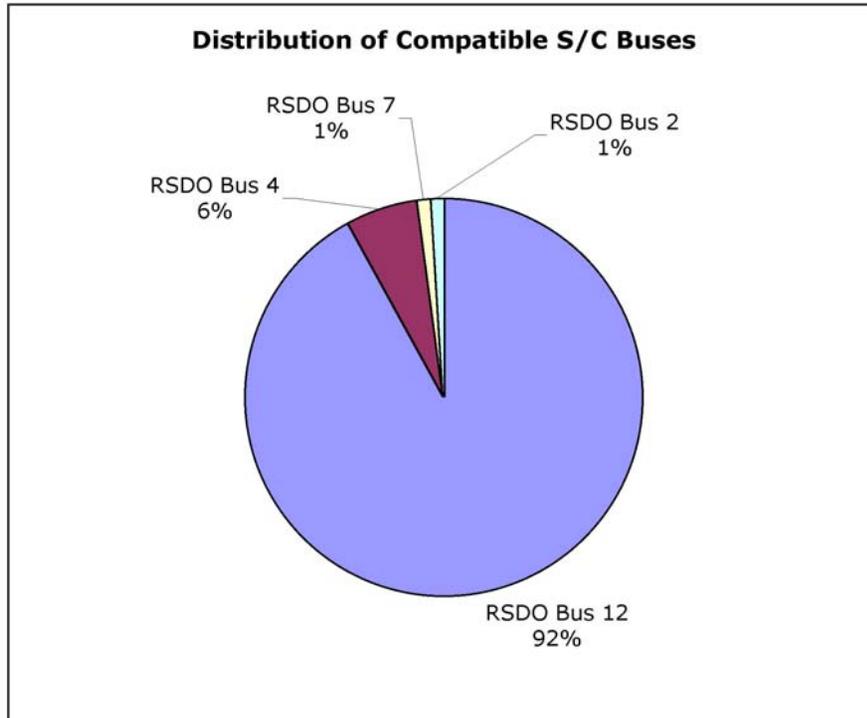
Combinations that include Payload F



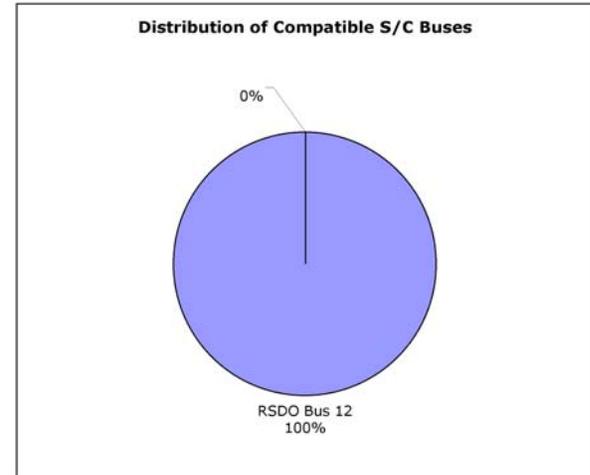
Combinations that include RSDO Bus 4



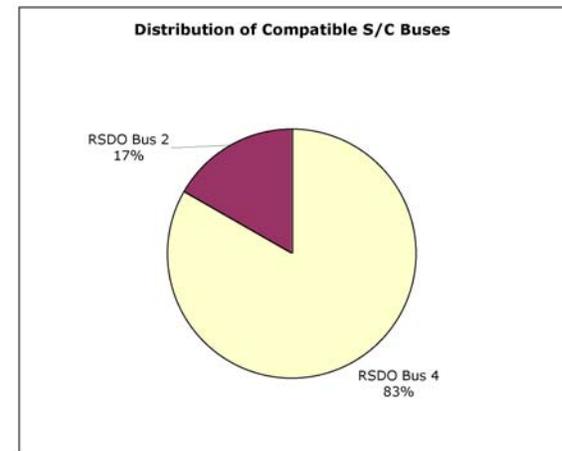
Distribution of Compatible S/C Buses



All



Combinations that include Payload C

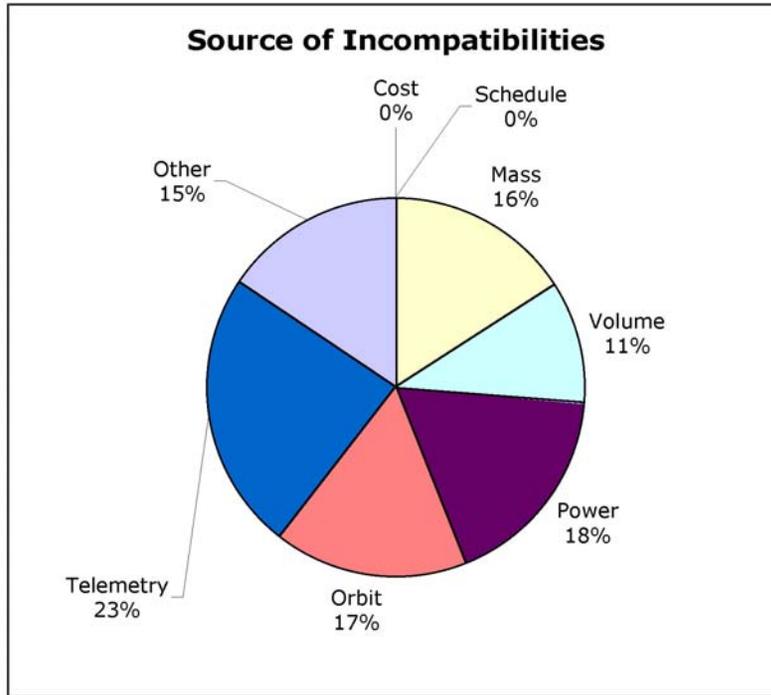


Combinations that are less than \$50M

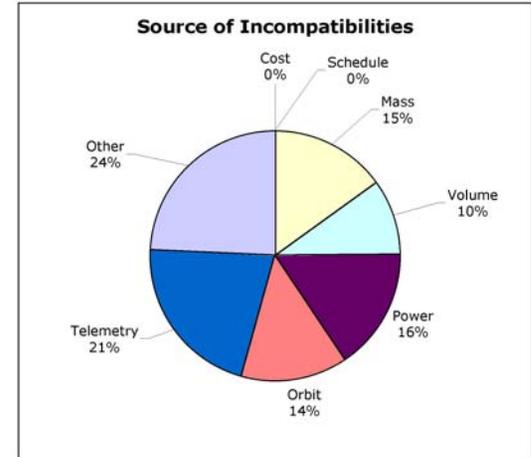
- A single bus (RSDO Bus 12) proved to be the most compatible
- Depending on what individual payloads are selected, the bus selection may be severely constrained



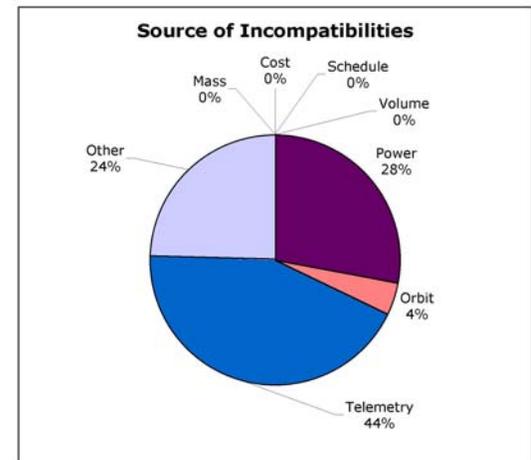
Sources of Incompatibility



All



Combinations that include Payload X

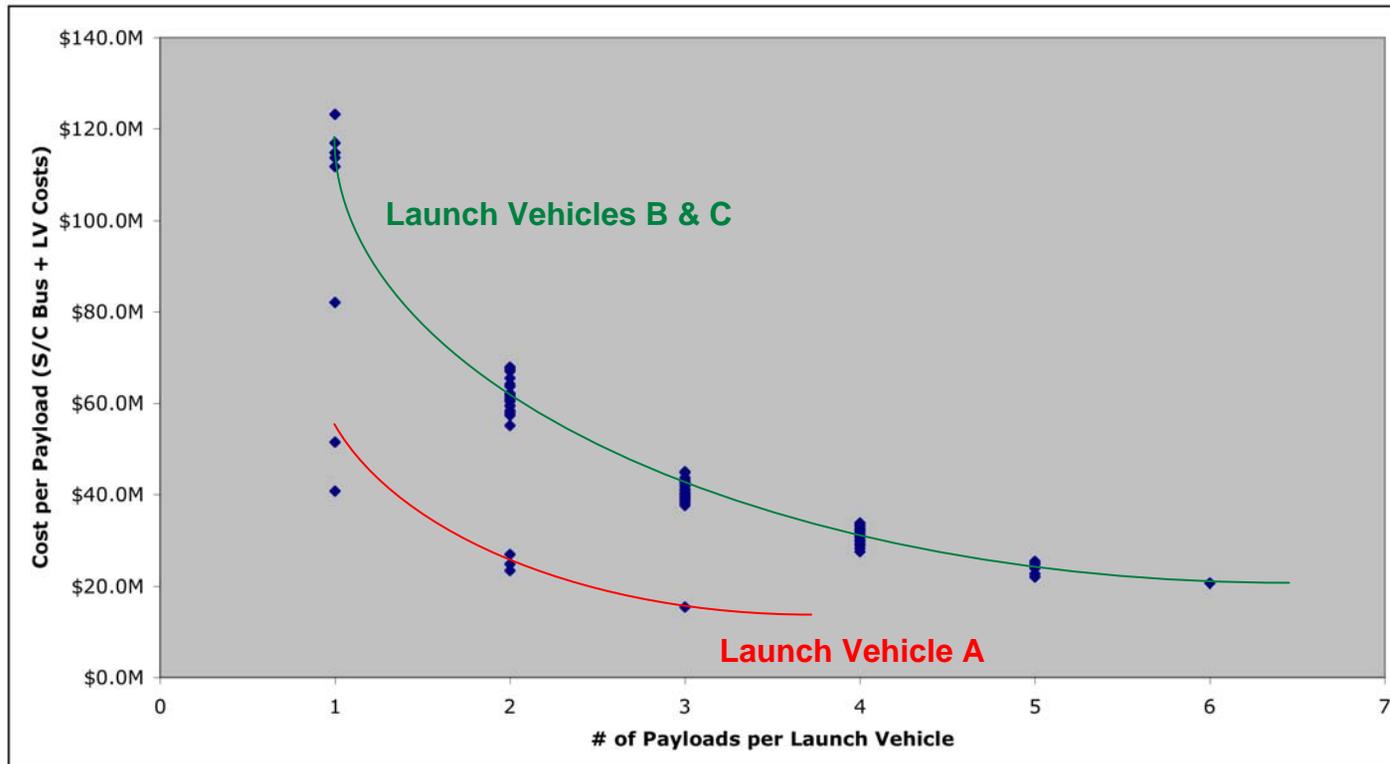


Combinations that include RSDO Bus 4 & < \$50M

- Incompatibility was based on a variety of factors, rather than a single key constraint. (This is in contrast to the ST8 study, where power was most often constraining matches.)
- Payload X was limited by both ACS control (listed as “other”) and many other factor
- For a specific bus & cost cap (see right), power & telemetry proved to be the most constraining parameters.



Cost Savings from Rideshare Options



Note: Only spacecraft bus & launch vehicles costs are considered

- Rideshare options seek s/c & launch vehicle savings
- The challenge is in finding the right payload combination combined with the right launch vehicle (FLOAT helps identify this trade space!)