United Nations/Brazil Symposium on Basic Space Technology
"Creating Novel Opportunities with Small Satellite Space Missions"

Natal, Brazil, 11 - 14 September 2018

"Lean Small Satellite Missions Require Lean Access to Space"

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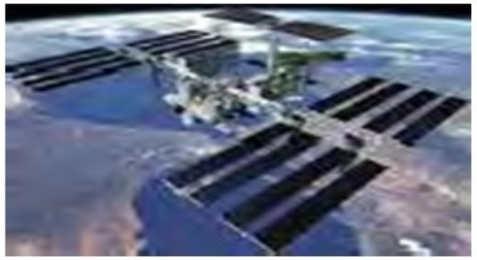
Current Access to the Environment of Space

Atlas V

Space Shuttle



Zero G Flight

High-altitude balloon

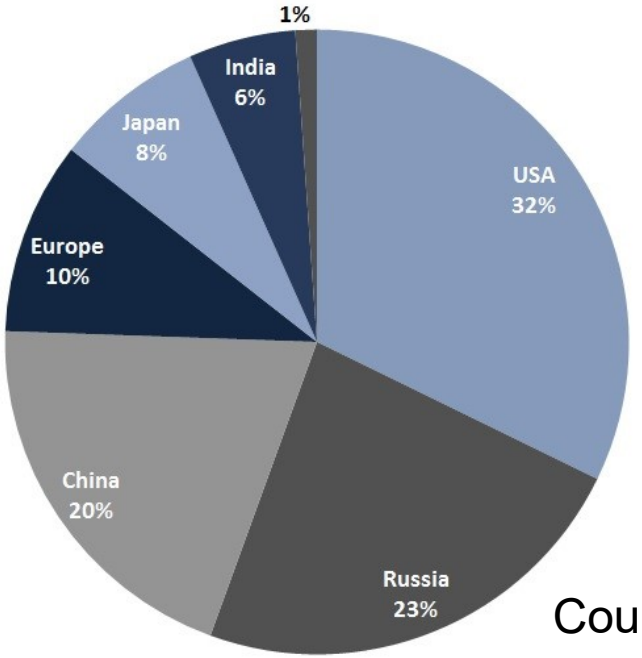
Sounding rocket

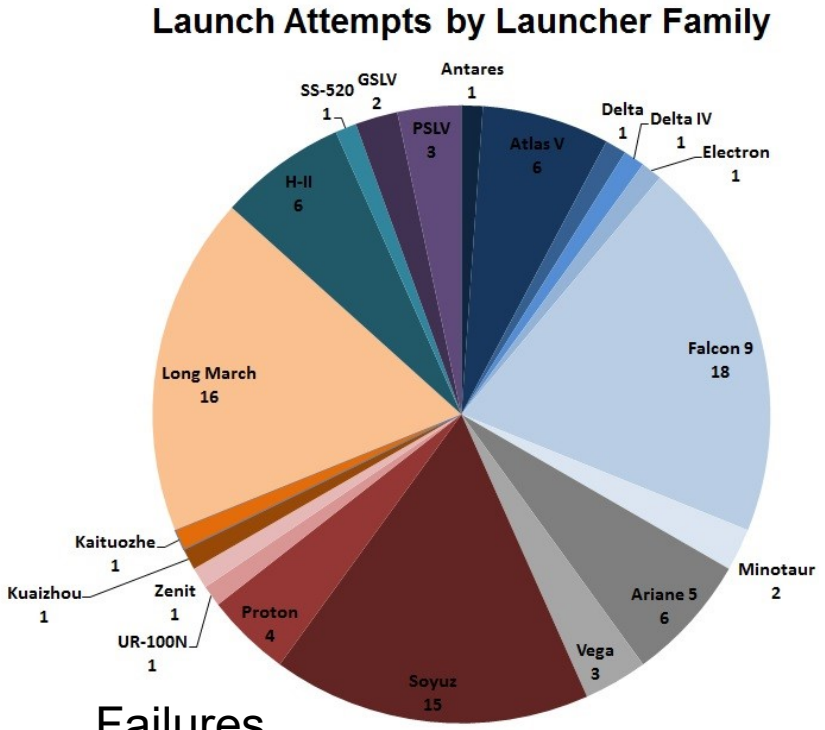
Minotaur IV

- More than 100 organizations world wide are thought to be currently developing launch vehicles
- More than 30 small launch vehicles being developed (< 500kg Payloads)
- Ridesharing opportunities have increase by a factor of 10 in the last 5 years

Status of Access to Space

Orbital Launch Attempts by Country





Country	Launches	Failures
USA	29	0
Russia	21	1
China	18	2
Europe	9	0
Japan	7	1
India	5	1
New Zealand	1*	1
Total	90	6

SLS CAPABILITY AVAILABILITY

SLS Block 1
As Early As 2020

Provides

Initial Heavy-Lift Capability

Enables

Orion Test

SmallSats to Deep Space

SLS Block 1B Crew
As Early As 2023

Provides

105 t to LEO capability via Exploration Upper Stage

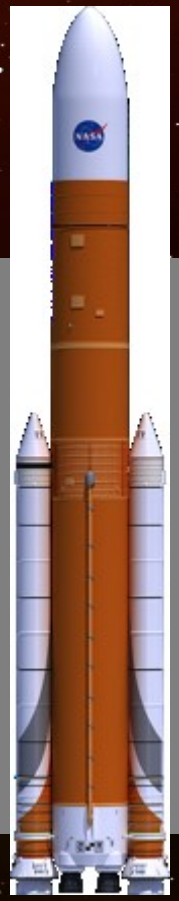
Co-manifested payload capability in Universal Stage Adapter

Enables

Deep Space Gateway

Larger CubeSat- and ESPA-Class Payloads

SLS Block 1B Cargo
As Early As 2023



Provides

8.4-meter fairings for primary payloads

Enables

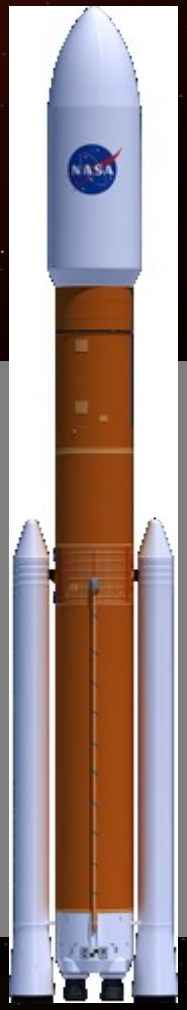
Europa Clipper/Lander

Deep Space Transport

Ice or Ocean Worlds Missions

Large-Aperture Space Telescopes

SLS Block 2
As Early As 2028



Provides

130 t to LEO capability via advanced boosters

10-meter fairings for primary payloads

Enables

Crewed Mars Orbit Missions

Crewed Mars Surface Missions

SLS Crew Launch Configurations

A Propulsive Payload Carrier as a Rideshare Capability for Secondary Payloads with a Co-Manifested Payload

Orion Spacecraft

Spacecraft Adapter

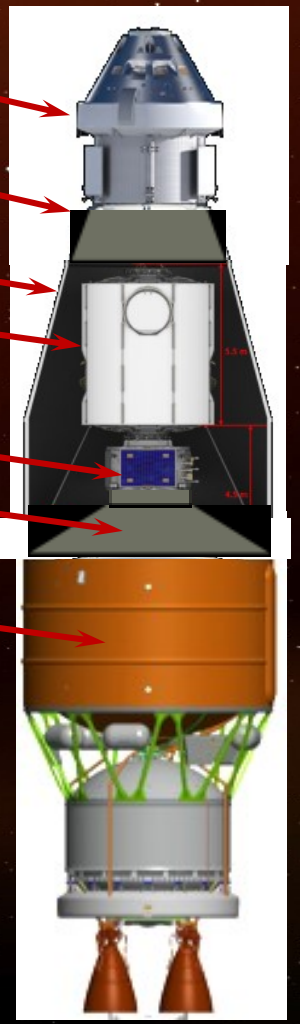
Universal Stage Adapter (USA)

Co-Manifested Payload (CPL)

Propulsive Payload Carrier (PPC)
w/ Attached Secondary Payloads

Payload Adapter (PLA)

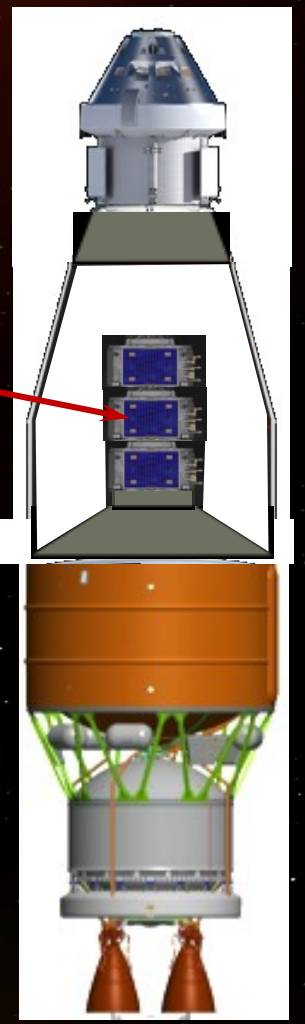
Exploration Upper Stage (EUS)
Reference



or

Multiple Propulsive/ESPA Payload Carriers with Secondary Payloads as a Dedicated Co-Manifested Payload

Multiple PPC/ESPA Type Carriers as a Dedicated Co-Manifested Payload (CPL)
w/ Attached Secondary Payloads



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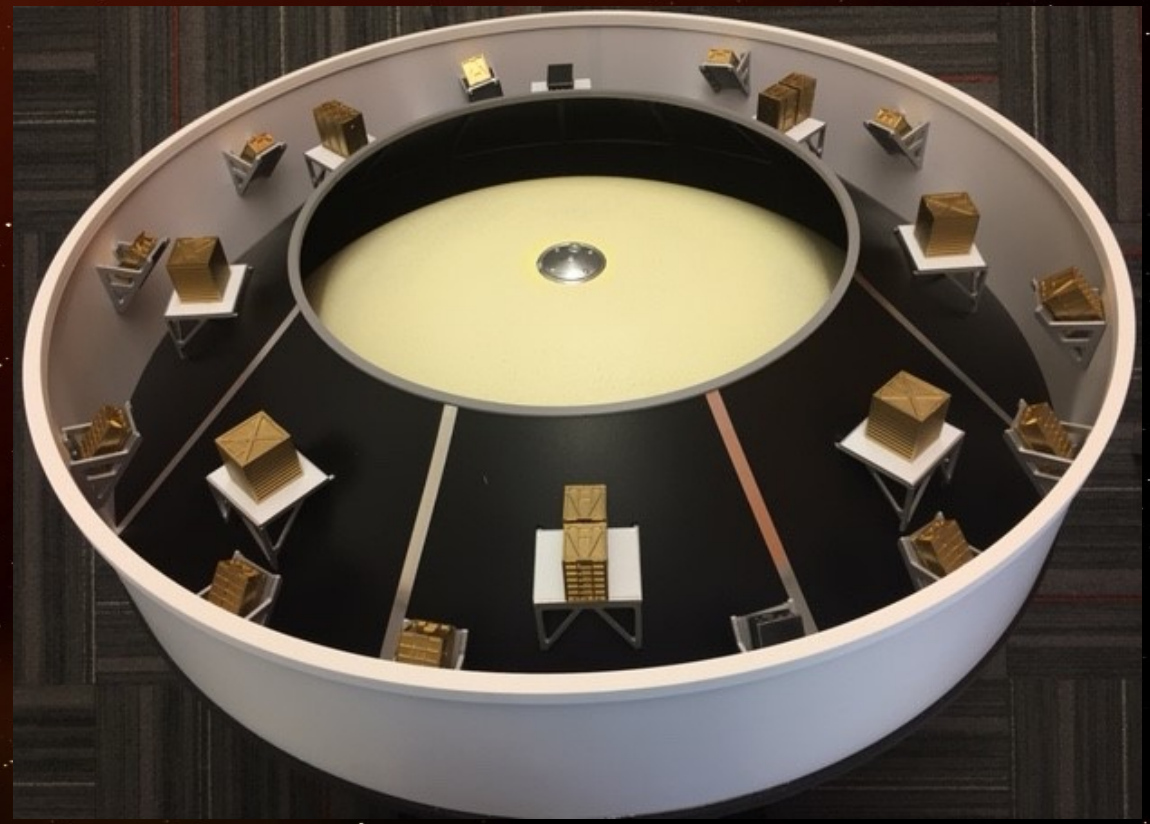
SLS B1B Secondary Payload Accommodation Concept

- Mounting on the Payload Adapter and Universal Stage Adapter (USA)
- Possible Complement
  - 22 – 6U
  - 2 – 12U
  - 2 – 27U
- Mounting on the aft portion of the Payload Adaptor has been shown to be the optimal mounting location

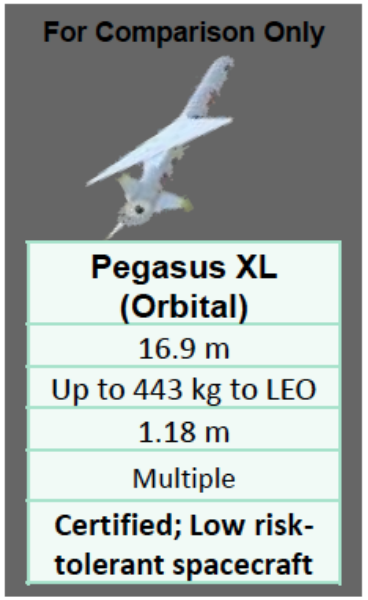


Lean Access to Space

- Improved CubeSat manifesting via NASA's CubeSat Launch Initiative (CSLI)
- As reliability is demonstrated, some providers may be appropriate for future less risk-tolerant NASA missions
- Milestones-based payment structure; ***limited*** LSP insight through milestone reviews
- A ***single demonstration*** flight was awarded to Firefly, Rocket Lab, and Virgin Galactic
- Statement of Work: Minimum 60kg to LEO (425km), orbit inclination 33 to 98 degrees, launch date no later than April 15, 2018
- Companies are responsible for LV development costs

Specification *	Alpha 1.0 (Firefly)	Electron (Rocket Lab)	LauncherOne (Virgin Galactic)
Length	23 m	17 m	20 m
Payload Mass	200 kg	150 kg	300 kg
Payload Diameter	1.45 m	1.1 m	1.3 m
Orbit	500 km (Sun Synchronous)	500 km (Sun Synchronous)	500 km (Sun Synchronous)
LV Certification	No certification High risk-tolerant spacecraft		

Comparison Only



Pegasus XL (Orbital)
16.9 m
Up to 443 kg to LEO
1.18 m
Multiple
Certified; Low risk-tolerant spacecraft

VECTOR (new)

* LSP recommends a 25% reduction from published specifications for vehicles of this size and maturity until successfully demonstrated

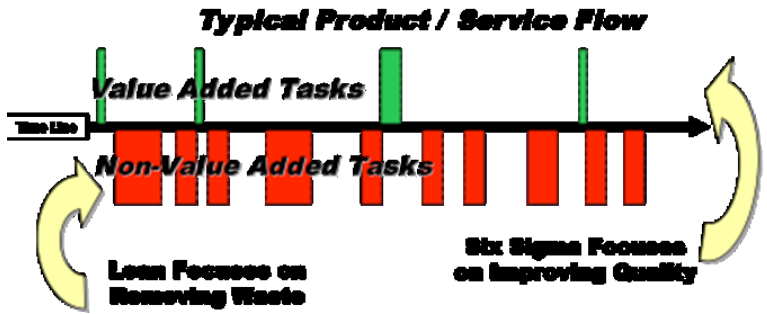
"Lean" Small Satellite Missions Concept

- The concept of "lean satellite missions" was born from the creation and evolution of the practices of lean manufacturing, lean engineering, lean satellites , lean launch and lean operations
- "Lean" is a both technical and management approaches to the "risk and reward" considerations, it is not a standard by itself
- Lean and Six Sigma are widely used in industry as continuous improvement best practices

  - They can also be very **complementary** in nature and, if performed properly, can produce unprecedented results

  - Lean focuses on eliminating non-value added activities in a process and Six Sigma focuses on reducing variation from the remaining value-added steps

  - Lean provides speed ensuring products and services flow without interruption while Six Sigma ensures that critical product / service characteristics are completed correctly the very first time we do them.



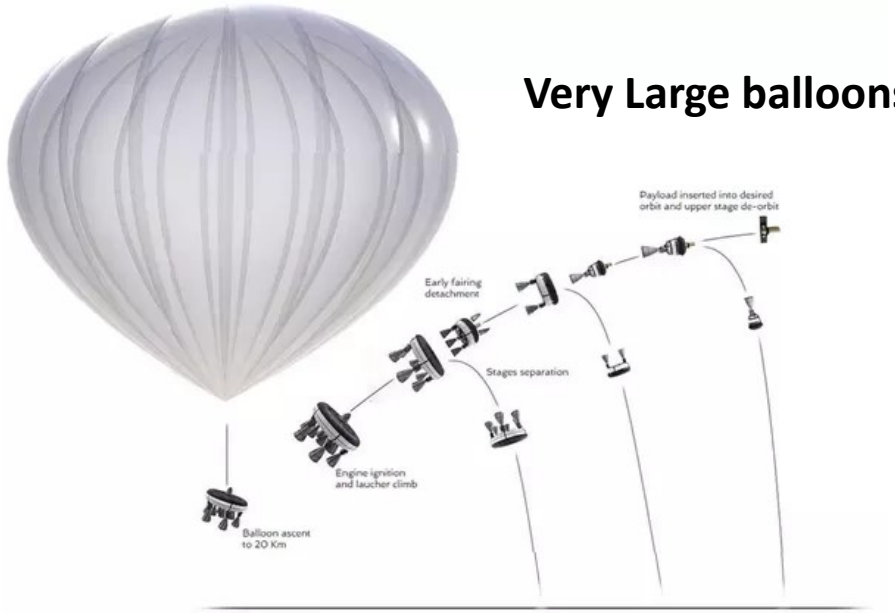
What does the Future Hold for Opportunities to Gain Access to Space ?

Space elevator -

Mega Rail Gun

Space Planes

Very Large balloons



Questions

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