Flight Opportunities Program Overview

JPL FOP Workshop
May 30, 2012

Our Short Video Tour

This is a redirect slide for a video that resides at

https://www.youtube.com/watch?v=3pt8n_FcLRY

What is Driving NASA's Transition?

- ISS complete, STS Era Over, and we NEED NEW ACCESS TO LEO
- New Spacecraft are in Development but BUDGET REMAINS VERY TIGHT
- Resources for Large, Long-Duration, Flagship MISSIONS SHRINKING
- Commercial space offers new partnership opportunities for COST-SHARING

Lower-cost Access To Space Is Essential

What is the Transition Strategy?

- Public-Private Partnerships to Lower Costs
- Commercial space transport services for cheaper more routine access to LEO
- NASA to be a good/smart customer for industry
- Increase collaboration to leverage resources
- Pursue smaller/smarter mission architectures
- Broader participation for innovation in space exploration and technology development
- Implement the new ***Space Technology Program*** within the Office of the Chief Technologist (OCT)

Why New Space Technology?

- Smaller, smarter technology cheaper to launch
- Going beyond LEO requires new capabilities
- New technology solutions engage students, entrepreneurs, and provide societal benefits
- Need to drive high-priority cross-cutting technologies to higher Technology Readiness Levels for future applications
- Space Technology Program has 10 entities including the ***Flight Opportunities Program (FOP)***

Why a Flight Opportunities Program?

- To facilitate the advancement of research technology payloads to high TRLs via flight on suborbital platforms in space-relevant environments
- To foster growth in the emerging commercial suborbital reusable vehicle industry by funding selected payloads

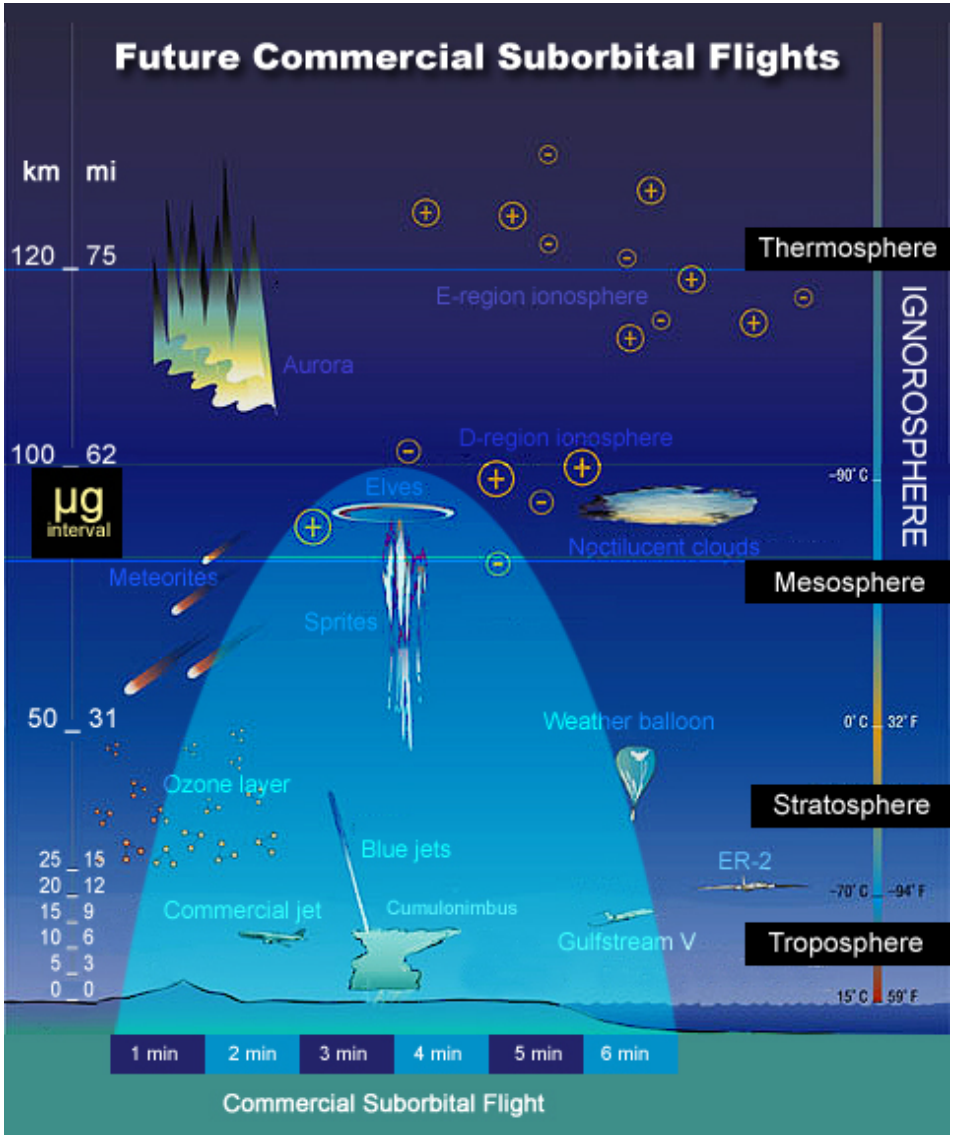
What Does FOP Actually Do?

- Competitively solicit, select, manifest and facilitate the flight readiness of technology payloads provided by researchers
- Selection based on payload readiness & technology relevance to NASA Technology Roadmaps and priorities
- Contracts with approved commercial suborbital platform providers to fly research payloads with re-fly and recycle options

What Are Some New Challenges?

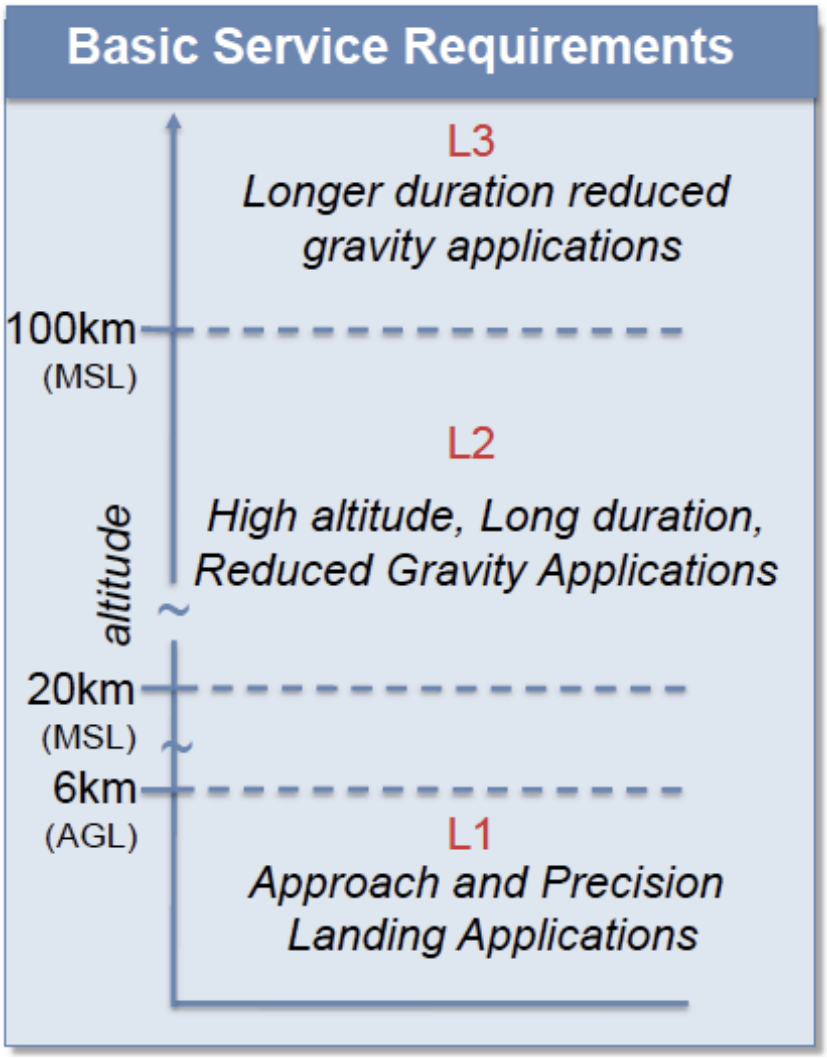
- Establish a "Payloads Pipeline" to flexibly feed payloads to flights on multiple platform types
- Develop flight platforms and operations to quickly integrate and fly (re-fly) many payloads
- Implement payload flight and recovery operations at multiple spaceports compatible with frequent transport thru the public airspace

What are Suborbital Vehicle Paths?



- ***Parabolic aircraft*** for short micro-g & variable-g exposure
- ***Balloons*** for high-altitude long-duration access
- ***Suborbital vehicles*** for transport thru atmosphere to access near-space, w minutes of micro-g, var-g, w remote sensing up & down

Reqmts for Flight Platform Providers



Performance Area	Requirement
Vendor to provide flight and payload integration on qualified vehicles	
Qualified Vehicle:	
Commercial, Reusable	80% reusable by mass, not incl. consumables
Frequent Flight	Payload 2x in 5 consecutive days
Min payload mass, volume	1kg, 1U CubeSat
Successful flight	Return payload undamaged
Customer access to payload prior to launch and post launch	3h prior to/post-hazardous op
System safety insight	Payload value
Number of successful flights at the required condition	1

Flight Opportunities Program

What Kinds of Space Technologies?

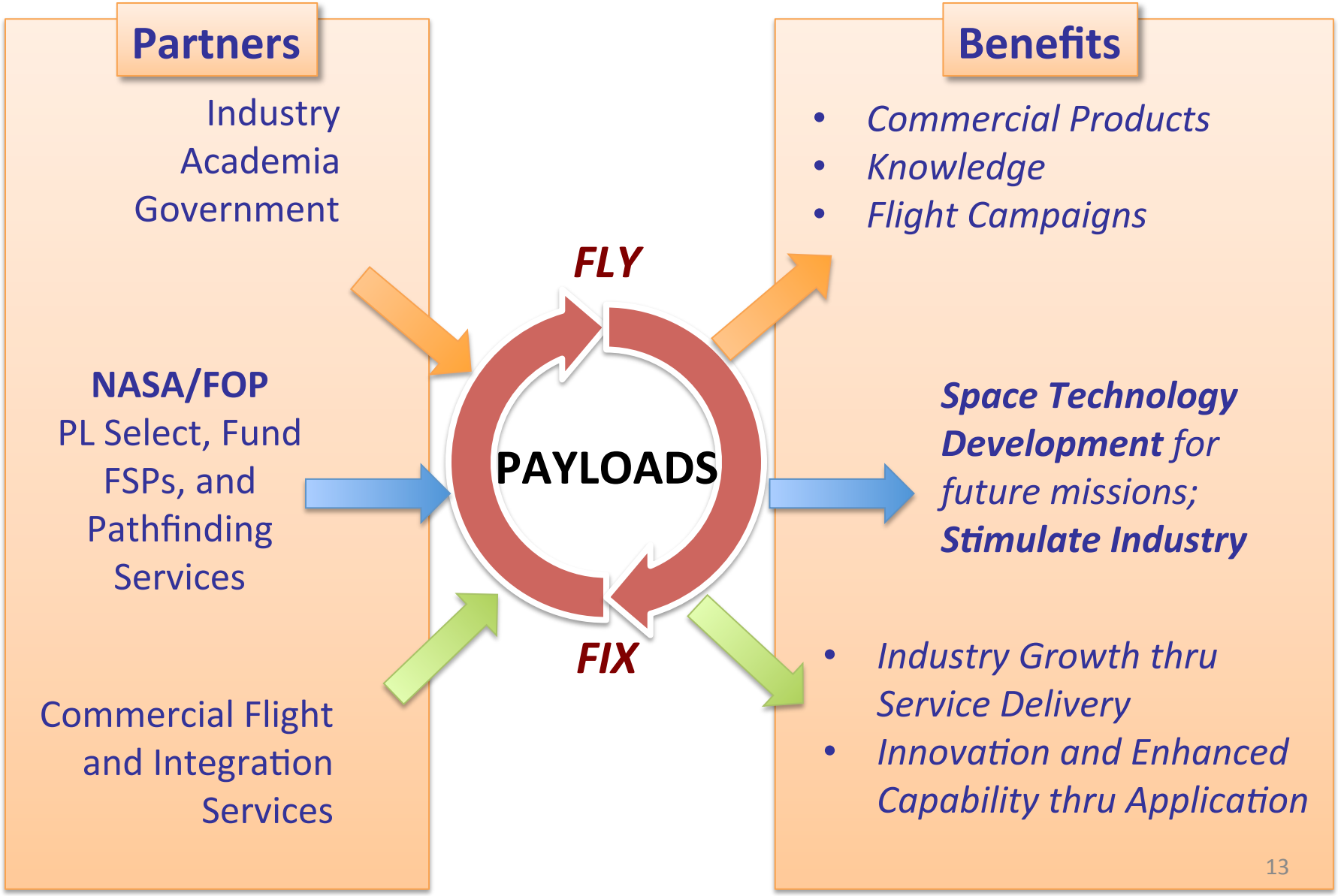
Topics from NASA Master List	
• Launch Propulsion (01) • In-Space Propulsion (02) • Space Power & Energy Storage (03) • Robotics, Tele-Robotics & Autonomous Systems (04) • Communication & Navigation (05) • Human Health, Life Support & Habitation (06) • Human Exploration Destination (07) • Science Instruments, Observatories & Sensors (08) • Entry, Descent & Landing (09)	• Nanotech (10) • Model, Sim, Info Tech & Process (11) • Mat'ls, Struct, Mech, & Manufacturing (12) • Ground & Launch Process (13) • Thermal Management (14) ***NASA Roadmaps Vetted and Space Technology Priorities Set by National Academy of Sciences***

Who Are the Key Partners?

- **NASA Flight Opportunities Program:** *solicit research payloads, fund flight providers, coordinate manifesting & facilitate flights*
- **Research Payload Providers:** *upgrade research payloads to flight platform readiness status*
- **Flight & Integration Services Companies:** *team up to ensure payload readiness, integration, flight, and return intact*
- **Spaceport Services Companies:** *support safe pre-flight ground processing, launch/reentry operations*

Flight Opportunities Program

What are Major Partner Benefits?



How Do Researchers Participate?

- Announce Flight Opportunities (AFO) 3-4x/year
- Began Dec 2010, open call thru Dec 2014
- Also solicit PLs from OCT and SMD entities
- Hosted on NSPIRES, (see link on FOP site)
- Evaluation Criteria: (*technology focused*)
  - applicability to OCT Tech Roadmaps, risk reduction
  - readiness to fly (TRL 4-5)
  - research team experience
- Awarded as unfunded Space Act Agreement or MOA
- Next opportunity window (AFO-5) TBD, 2012

A Technology-Focused Payload?

- ***Technology-focused***: validate and advance new technology in a space-like environment while making functional observations and/or relevant science measurements
- **Science-focused**: utilize a known technology to support making measurements to gain new science knowledge
- **Education-focused**: knowledge gained by students, educators & researchers while developing, flying, & analyzing payload results

Flight Opportunities Program

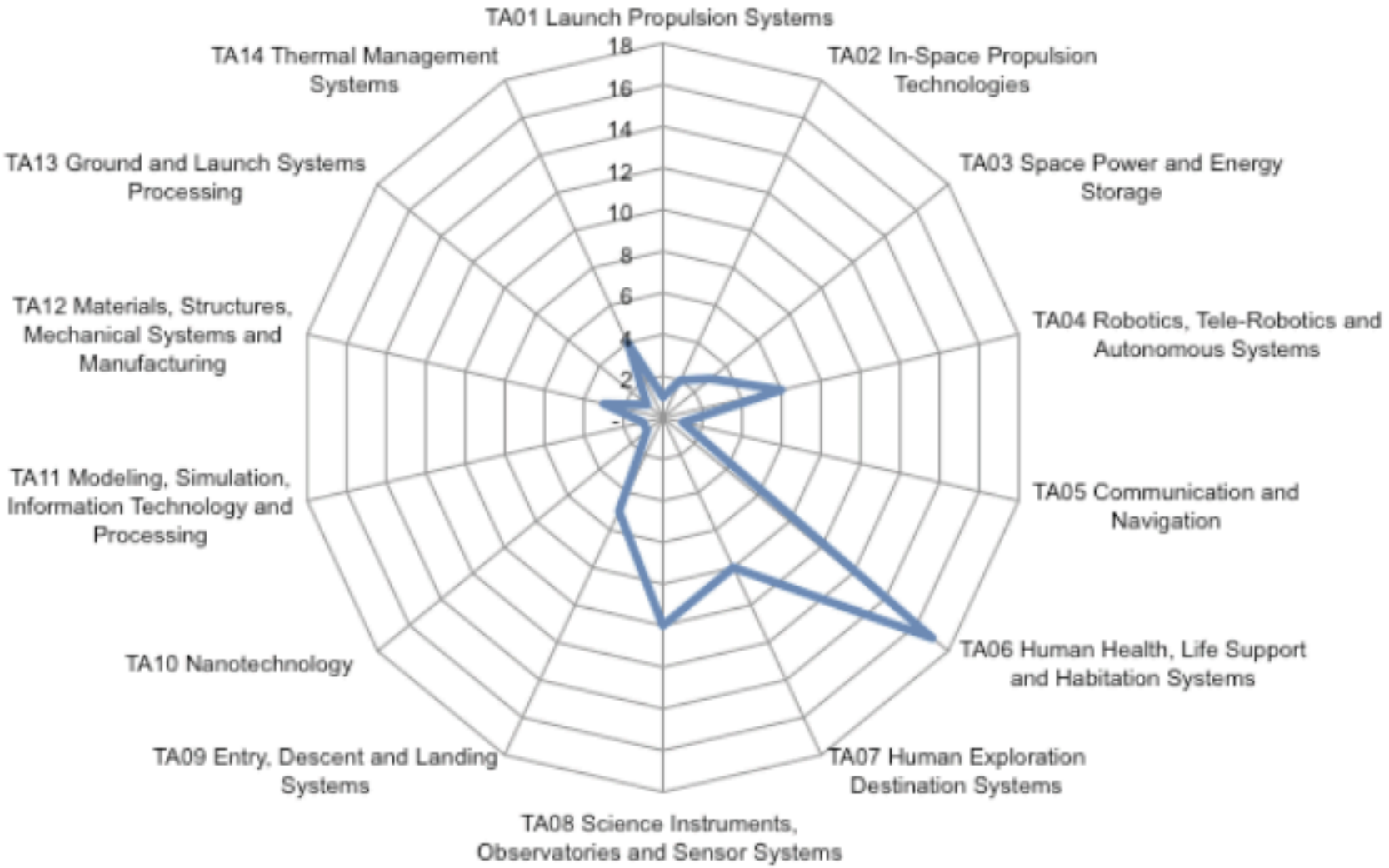
FOP Payload Solicitation Summary

AFO #	Released	Closed	Selection	# Proposals received	# Proposals selected
AFO 1	Dec 21, 2010	Feb 23, 2011	May 13, 2011	**23** - 17 parabolic - 4 sRLV - 2 parabolic + sRLV	**16** - 12 parabolic - 2 sRLV - 2 parabolic + sRLV
AFO 2	June 6, 2011	June 28, 2011	Oct 4, 2011	**11** - 5 parabolic - 5 sRLV - 1 parabolic + sRLV	**9** - 4 parabolic - 4 sRLV - 1 parabolic + sRLV
AFO 3	Nov 16, 2011	Dec 16, 2011	Mar 21, 2012	**35** - 23 parabolic - 7 sRLV - 1 parabolic + sRLV - 3 balloon - 1 balloon + sRLV	**24** - 16 parabolic - 5 sRLV - 2 balloon - 1 balloon + sRLV
TOTAL TO DATE				**69**	**49**

AFO4 Closed May 11, 2012

Flight Opportunities Program

Proposal Map to Tech Topics (AFO3)



Who Are Flight Service Providers (FSPs)?

- Currently 5 commercial FSPs providing platforms
  - NASA Reduced Gravity Office (JSC) conducts parabolic aircraft flights with Zero-G Corp (Ellington AFB, Houston, TX)
  - Masten Space Systems (Mojave Air & Spaceport, CA)
  - Near Space Corp (Tillamook, OR)
  - UP Aerospace (Spaceport America, NM)
  - Virgin Galactic (Spaceport America, NM)
- Have 3 commercial FSPs in development programs
  - Armadillo Aerospace
  - Whittinghill Aerospace
  - XCOR

Zero-G Corporation (G-Force One)

- Parabolic flight campaigns flown 4x/year
- 40 sec parabolas w 20 sec at micro-g, lunar-g, mars-g, 40 parabolas/day, 4 days/campaign, pressurized cabin
- Payloads can be large, human-tended (3-4/team), but need to fit thru loading door w forklift

Flight Opportunities Program

Masten Space Systems (Xaero)

- 12kg mass payload
- ~20 km average altitude based on payload mass
- Target is 100 km
- VTVL guided rocket
- Payloads must be self-contained, automated
- Pressure-sealed payload bay

Near Space Corp (3 Types)

- Nano Balloon System (NBS): 1kg
- Small Balloon System (SBS): 10 kg
- Hi-Alt Shuttle System (HASS): 10 kg
  - Auto-glide from altitude to targeted landing
- 30-35 km altitude, unpressurized
- Up to 6 hr duration float at altitude
- Payloads automated
- Flight opportunities available now

UP Aerospace (Spaceloft)

- 36 kg payload total to 115km
- Payloads fit in provided cylindrical canisters which stack
- Ballistic trajectory, parachute recovery
- Can provide power and trigger signals to payloads
- Payloads automated
- Flight opportunities available now
- Unpressurized

Virgin Galactic (SpaceShip Two)

- 100+ km altitude, payloads mostly automated, payload compartment is pressurized
- 3+ minutes of micro-g, lunar-g or mars-g
- Flight in summer 2013 (approximate)

Flight Opportunities Program

Example Platform Accommodations

Specification	Zero-G	Up Aerospace	Near Space	Masten Space Systems	Virgin Galactic
Vehicle Name & Type	***G-Force One*** Parabolic Aircraft	***SpaceLoft XL*** VTHL sRLV	***Hi-Alt Balloons*** - Small/Nano - Shuttle (HASS)	***Xaero*** VTVL sRLV	***SpaceShip Two*** HTHL sRLV
Altitude & Flt. Frequency	11 km 40 cycles/day 3-4 days/wk	115 km Freq = TBD	35 km Freq = TBD	115 km Freq > daily	115 km Freq > daily
Launch Site	Ellington Field, Houston, TX	Spaceport America, NM	Tillamook, OR	Mojave Air & Spaceport, CA	Spaceport America, NM
Micro-g Environ	20 sec/cycle followed by 2g	4 min	N/A	4 min, <0.001 g	4 min, TBD
Payload Mass & Vol	> 100 kg > 27 cu ft 3-4 people	36 kg total multiple PLs in cannisters	10 kg or 1 kg	10 kg at 30 km	TBD
Power	28 vdc, 110vac	3.7 to 32 vdc	See PUG	12 or 24 vdc	See PUG

Flight Opportunities Program

Flight Service Provider Status & Schedule

Vendor * / Qualified Vehicle		Location	Flight Dates **	No. of Flights	Nominal Payloads / flight	Total Mass (kg)	Volume (m^3)	Nom. Alt. (km)
Masten	Xaero	Mojave, CA	2012	2	2 ***	5	0.016	5
		TBD	2012	8	2	5	0.016	30
Near Space Corp	HASS	TBD	2012/2013	1	1	10	0.041	30
	SBS	Tillamook, OR	~Oct 2012	2	1	10	0.096	35
	NBS	Tillamook, OR	~Jun/Jul 2012	4	1	1	0.001	30
UP Aerospace	Space-Loft XL	Spaceport America, NM	~Aug 2012	1	7	36	0.172	115
Virgin Galactic	Space Ship Two	Spaceport America, NM	2013	1	30	590	1.331	100+
Zero-G	Aircraft	Ellington Field, TX	May, Aug, Sep and Oct 2012	4 Weeks	~7 to 10			

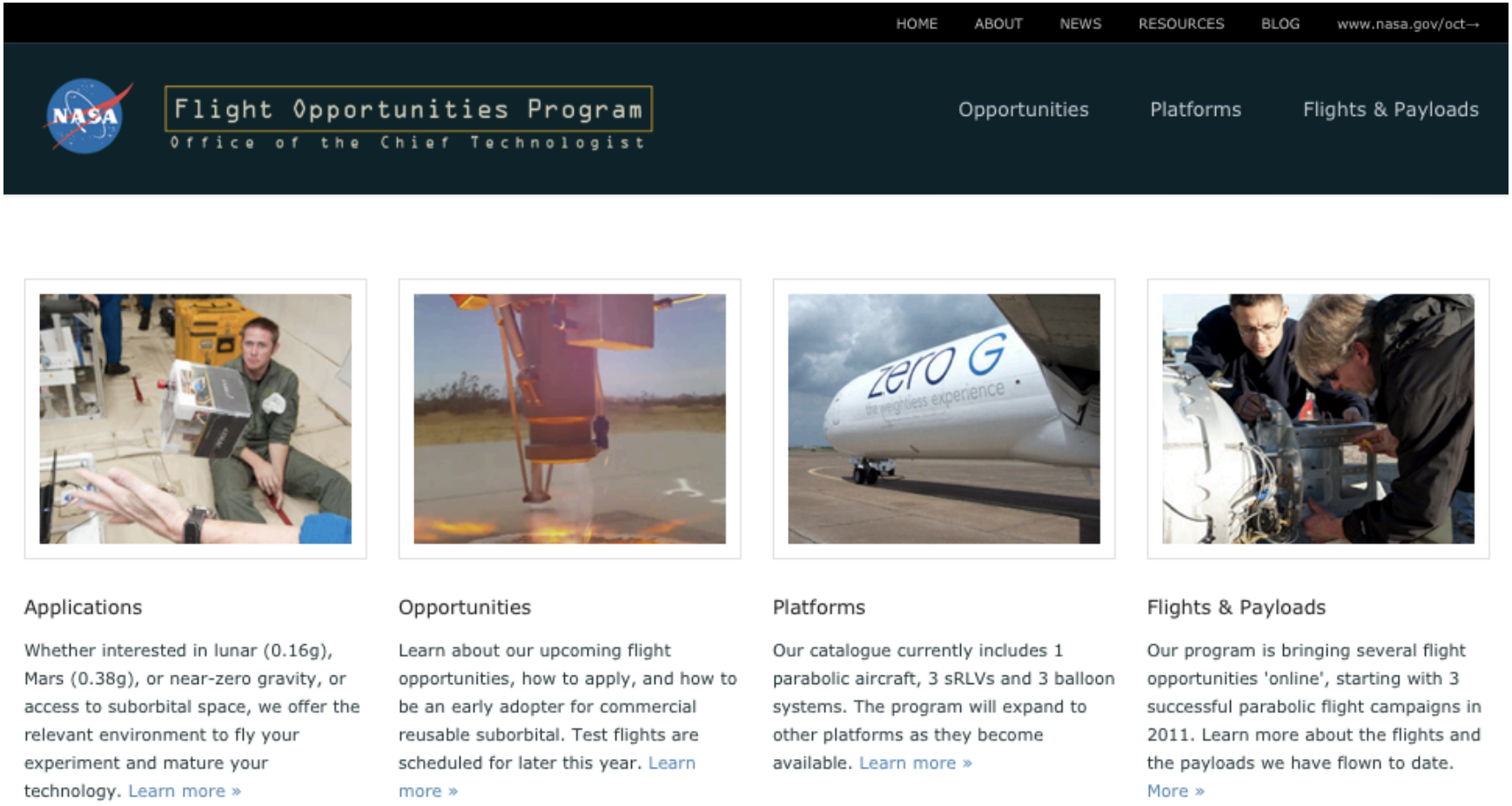
* Three other suborbital flight vendors (Armadillo, Whittinghill, and XCOR) will be tasked to provide flights once they have successfully flown their qualifying vehicles.

** More definitive flight dates will be available after completion of payload manifest.

*** ADS-B (FAA) and SFEM (ARC) payloads have been selected to fly on Masten developmental flight.

Flight Opportunities Program

FOP Web Site (Home)



Flight Opportunities Program

FOP Site (Flights & Payloads)

HOME ABOUT NEWS RESOURCES BLOG www.nasa.gov/oct→

Flight Opportunities Program
Office of the Chief Technologist

Opportunities Platforms Flights & Payloads

Parabolic Flight Week May 2012

MAY

May 14-18 2012
CAMPAIGN

Zero Gravity Corporation
COMMERCIAL FLIGHT PROVIDER

Ellington Field, Houston, TX
LOCATION

8
NUMBER OF EXPERIMENTS

4
NUMBER OF FLIGHT DAYS

30-40
NUMBER OF PARABOLAS PER FLIGHT DAY

OSIRIS Payload (Pentachart)

042-P OSIRIS-REx Low-Gravity Regolith Sampling Tests

Problem Statement

- How to sample asteroids and comet nuclei
- The technology being tested is regolith fluidization and collection by gas injection
- This flight opportunity will test 5 sampler head regolith combination/flight to determine sample collection in low gravity
- Missions to sample asteroids e.g. OSIRIS-REx, and to sample comet nuclei

Technology Development Team

- Joe Vellinga is Principal Investigator, email: joseph.m.vellinga@lmco.com, Lockheed Martin Space Systems Company
- Arlin Bartels, GSFC, OSIRIS-REx Contract #NNG12FD66C with LMSSC
- GSFC, University of Arizona

Proposed Flight Experiment

Experiment Readiness:

- Ready for May 15 – 18, 2012 Flights; all equipment shipped 5/7/12

Test Vehicles:

- Parabolic aircraft

Test Environment:

- Sampling system flown in reduced gravity in 2007 and on FAST flights in 2009.
- Request reduced gravity parabolic flights at near zero gravity

Test Apparatus Description:

- One of 3 test fixtures shown (test chamber left, pressure control right); two additional test fixtures with two chambers each; five test chambers/flight

Technology Maturation

- TRL 6 achieved when sample collection of representative regolith demonstrated in the relevant environments
- Ground testing: ambient, vacuum, hot, cold
- Reduced gravity tests correlated with ground tests
- TRL 6 by 3/15/13 OSIRIS-REx PDR

Objective of Proposed Experiment

- Conduct sampling tests: 5 tests planned / flight with a range of regolith simulants
- Flight data is the sample collected of the range of regolith simulants
- Data to be compared to ground test data

Technology Areas addressed by this technology: 4.1.5 Robotics..& Autonomous Systems , 7.1.2 Resource Acquisition , 7.5.3 Remote Mission Operations

Heat Exchanger Payload (Pentachart)

005-P Development and Validation of Design Tools for Advanced, Two-Phase, Space Heat Exchangers

STATUS QUO

- Single phase heat exchangers are currently used for cooling on ISS and other space platforms.
- Two-phase heat exchangers can be more compact, more efficient , and lower weight
- Questions regarding the effect of gravity on two-phase heat exchanger performance prevent their use.
- Current methods of measuring heat transfer during flow boiling are limited to area averaged heat transfer and temperature.

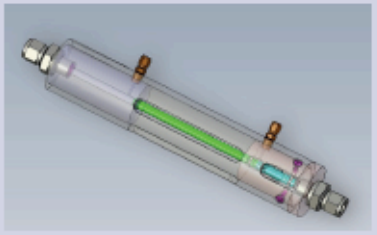
NEW INSIGHTS

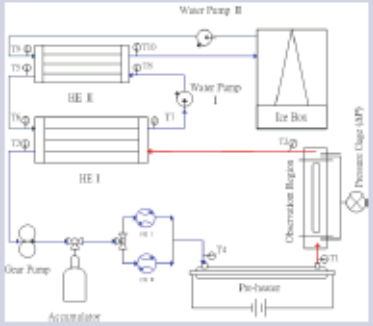
Technology Focus Area: Fluid Physics

A silicon tube 6 mm ID and 1 mm wall thickness is used in con-junction with an IR camera to measure temperature distributions on the wetted wall and to visualize the flow. Half the inner circum-ference is coated with a black opaque paint and the other half is left clear. Mirrors are used to obtain temperature and flow visualization simultaneously.

TEST APPARATUS OVERVIEW:

A closed flow loop has been constructed whereby flow boiling measurements can be made in low-g environments. The experiment is contained within a single test rack (100 cm wide x 750 cm high x 650 cm deep) bolted to the floor of the aircraft. The mass of the apparatus is about 118 kg.





QUANTITATIVE IMPACT

Requested Zero-G conditions

- Up to 30 1.8 g to zero-g parabolas per day
- 4 days of flying

Test Parameters to be varied

- Heater power
- Inlet liquid subcooling
- Inlet mass flow rate
- Heater power

No. of Personnel:

- 3 test personnel per flight

END-OF-PHASE GOAL

Project Impact:

- Results of the tests will allow current models of flow boiling to be tested using local data.
- The data will help develop criterion that will allow the effects of gravity on boiling to be quantified
- The appropriate velocity above which gravity effects can be neglected will be determined

The current experiment allows the local temperatures and heat transfer to be measured with unprecedented spatial and temporal resolution, allowing flow boiling models to be verified.

FOP Site (Platforms – balloons)

High Altitude Shuttle System

Near Space Corporation

HIGH ALTITUDE SHUTTLE SYSTEM

SMALL AND NANO BALLOON SYSTEM

High Altitude Shuttle System. Credit: Near Space Corporation

PLATFORM

NSC's patent pending High Altitude Shuttle System (HASS) combines an innovative Tactical Balloon Launch System with a special high altitude unmanned Shuttle for payload recovery.

FLIGHT PROFILE

The Tactical Balloon Launch System (TBLS) provides an unprecedented level of launch flexibility and responsiveness. Launching conventional stratospheric balloons typically requires relatively calm winds, established launch sites, and large support teams. The TBLS allows 2-3 persons to launch balloon-borne payloads from undeveloped remote launch sites in winds of up to 30 kts. This enhances the ability to overfly specific targets or fly desired

Ongoing
COMMERCIAL OPERATIONS

Starting April, 2012
PROGRAM FLIGHTS AVAILABLE

High Altitude Shuttle System
KEY SPECIFICATIONS

UAV / unpiloted
TYPE

Up to 30 km
MAXIMUM ALTITUDE

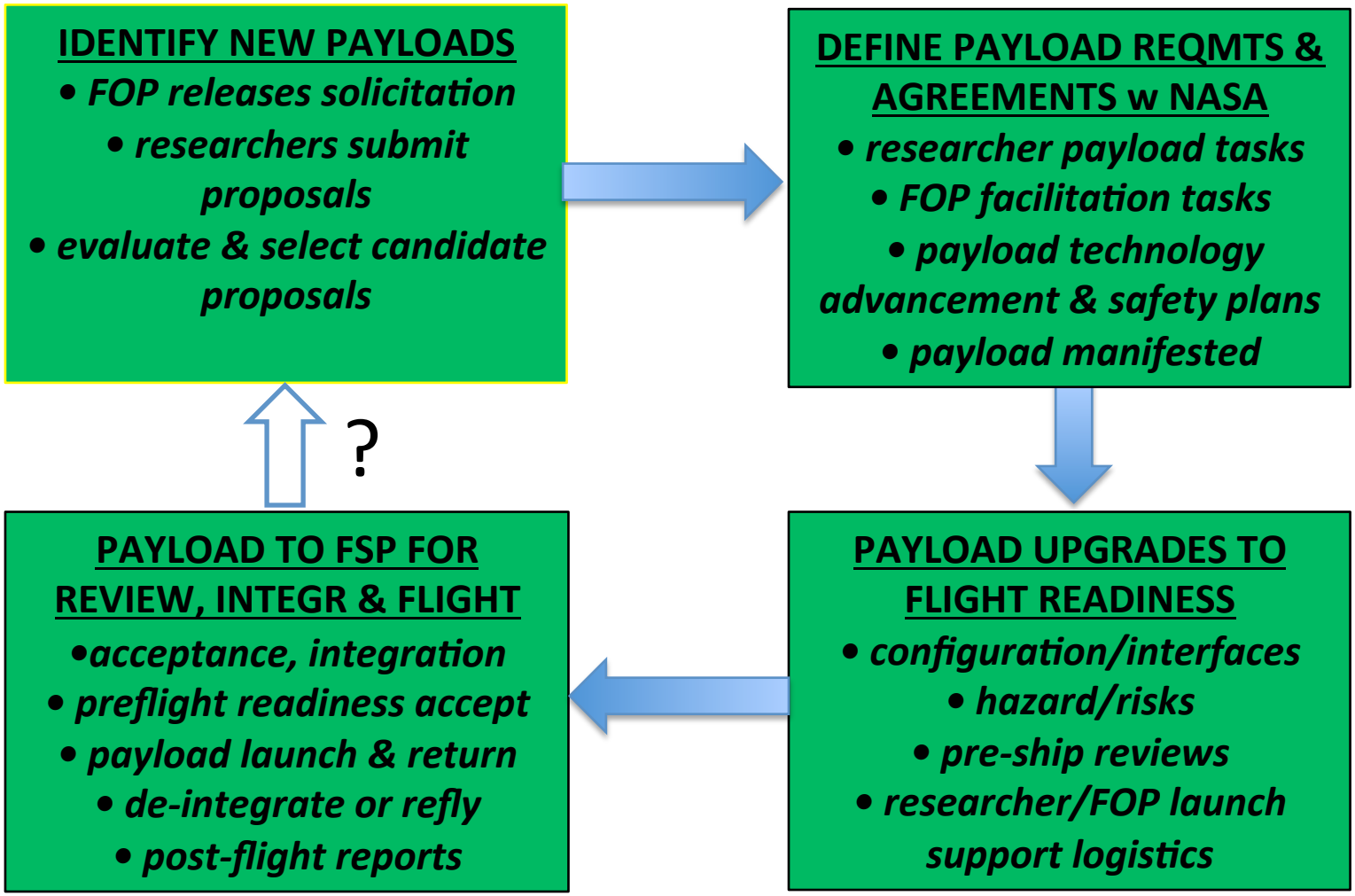
24+ hours (~6 hrs Standard)
MAXIMUM FLIGHT DURATION

10 kg (22 lbs)
USEFUL PAYLOAD MASS

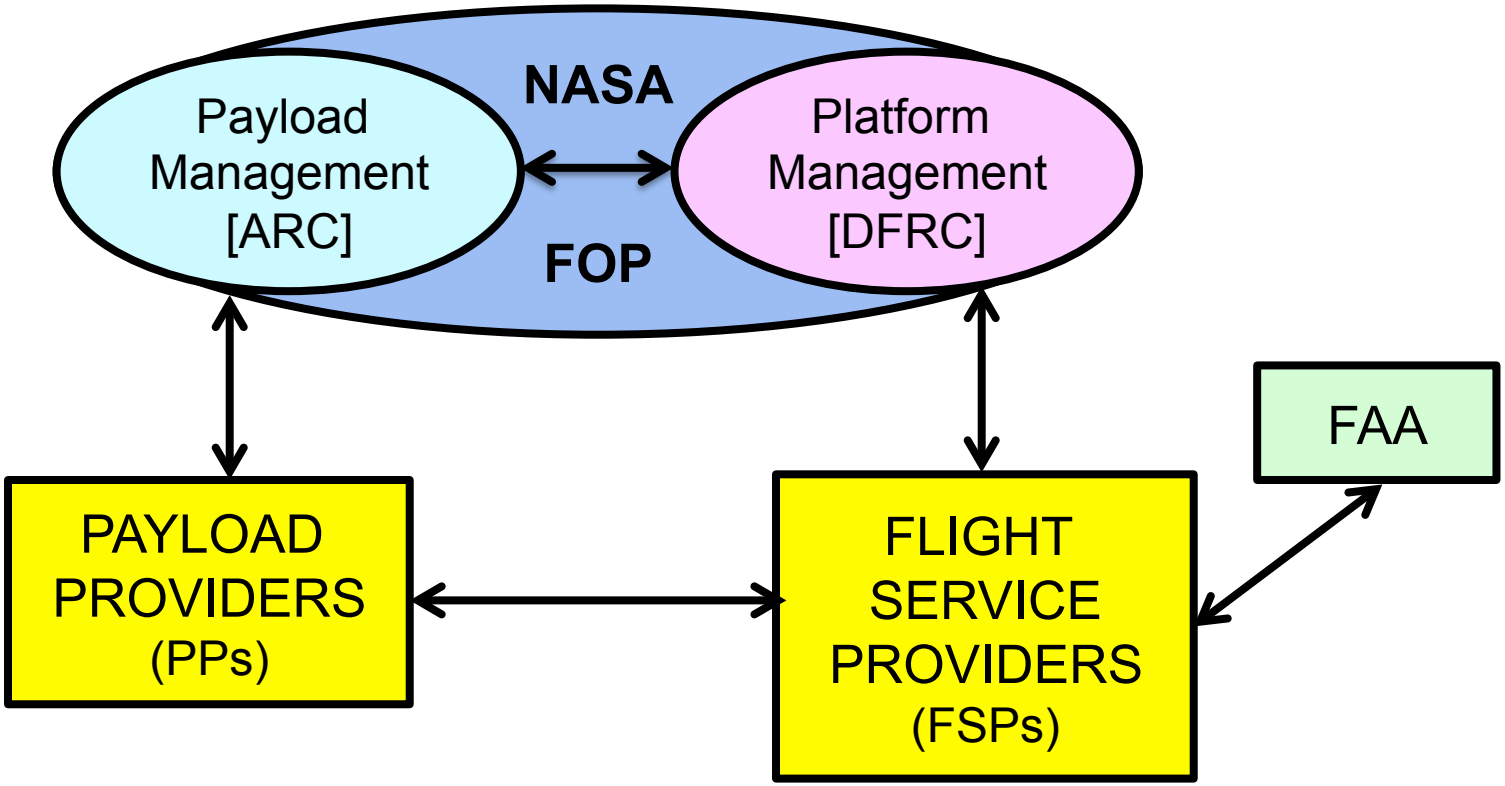
Tillamook, Oregon
INITIAL SPACEPORT

HASS Payload User's Guide (PUG) »
MORE INFORMATION

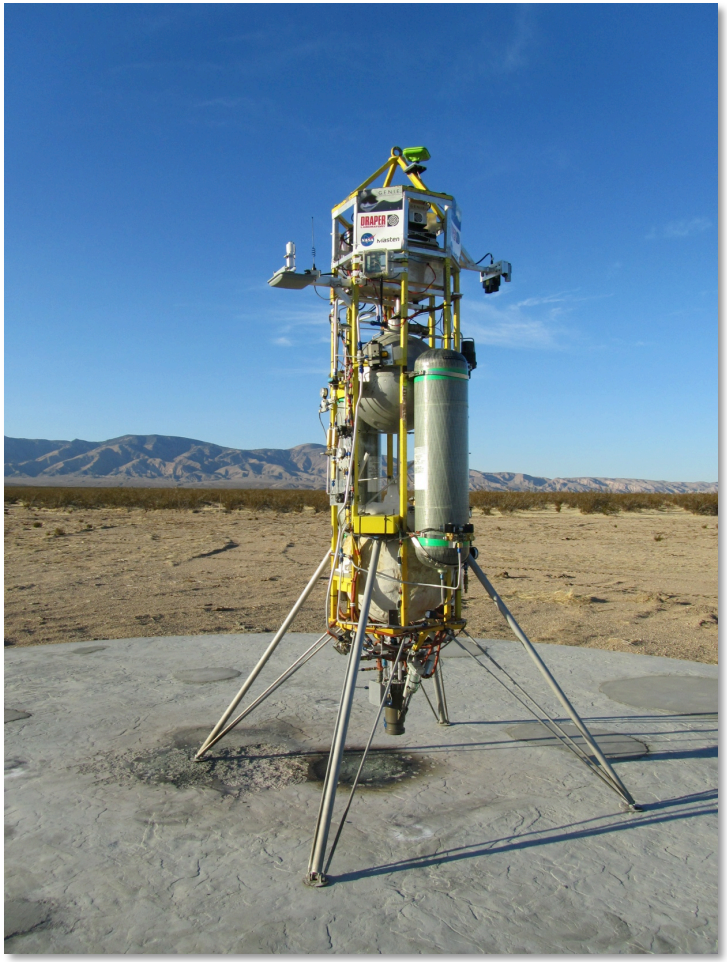
What's Our Simplified Payload Flow?



How Do Stakeholders Interact?



Questions?



Potential Research Payload Providers, Contact:

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Flight Opportunities Program Website:
flightopportunities.nasa.gov/

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