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**SPACEX**

**NASA ISS Research  
Academy and  
Pre-Application Meeting**

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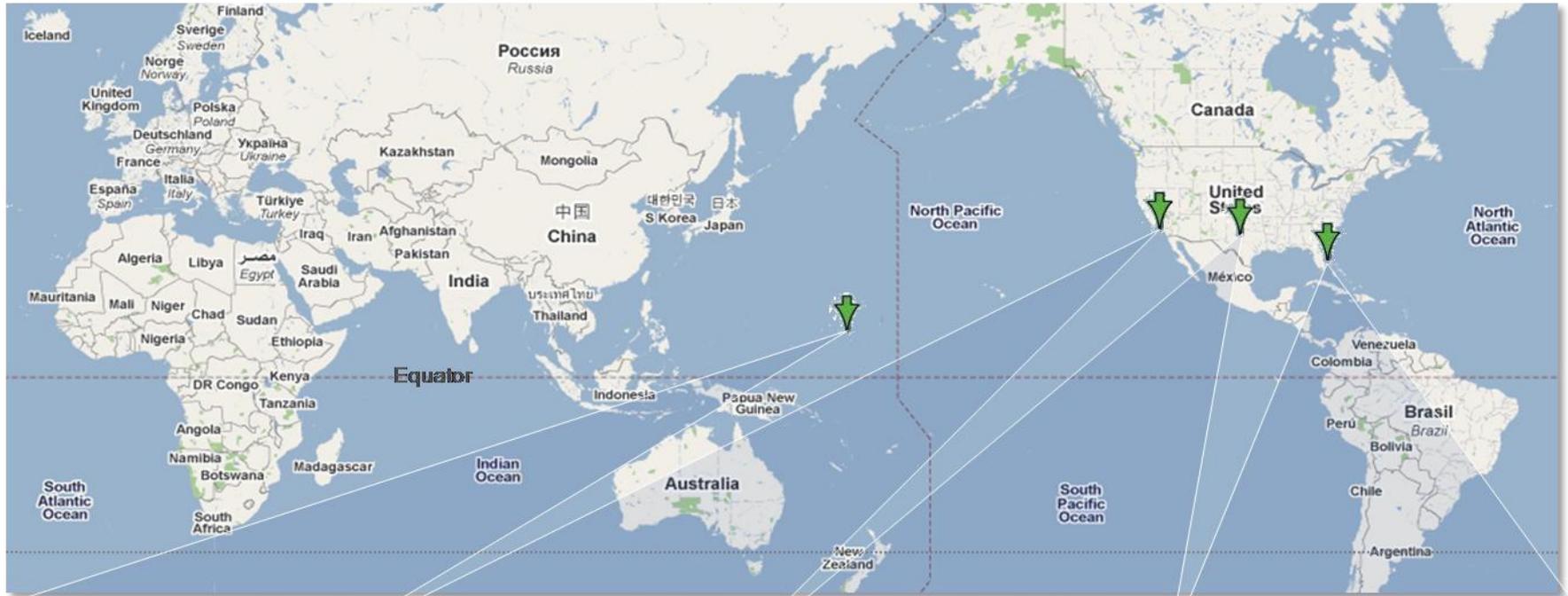
# SpaceX Overview

Founded in mid-2002 with the singular goal of providing **highly reliable, low cost** space transportation for both cargo and crew

- Over 1,150 employees and growing
- 550,000 sq ft of offices, manufacturing and production in Hawthorne, California
- 300 acre (121 hectares) state-of-the-art Propulsion and Structural Test Facility in central Texas
- Launch sites at Kwajalein and Cape Canaveral
- Developing launch site at Vandenberg



# SpaceX Locations



Omelek, Kwajalein Atoll



Hawthorne, California

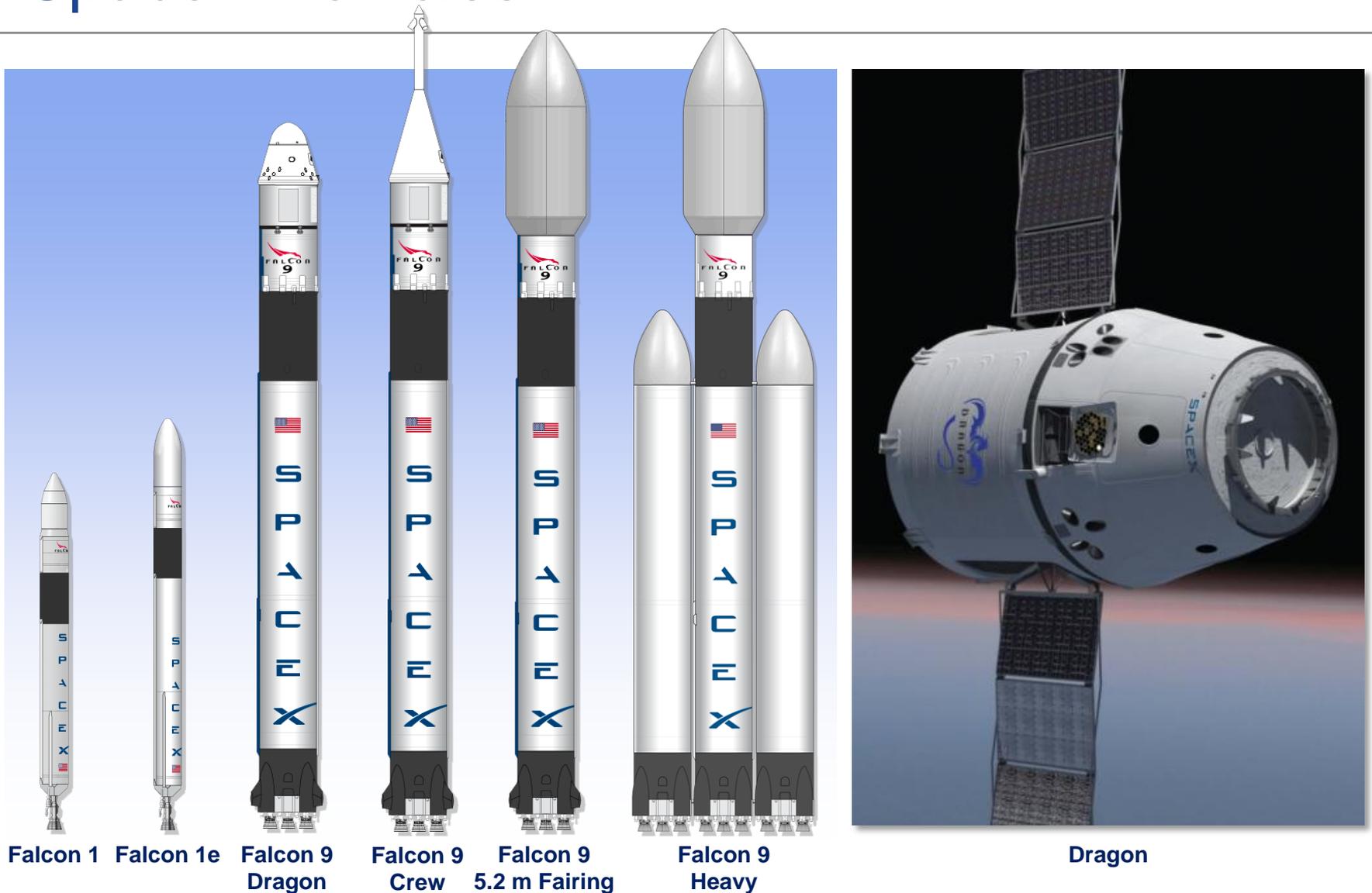


McGregor, Texas



Cape Canaveral, Florida

# SpaceX Vehicles



# SpaceX Dragon Spacecraft



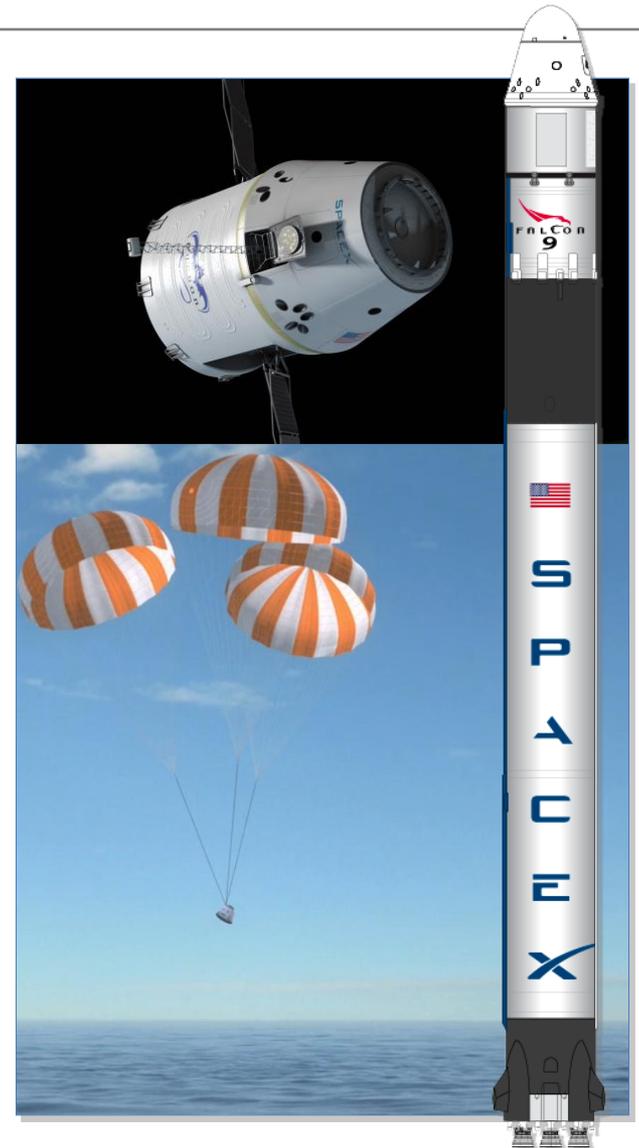
- Dragon spacecraft designed for transport of pressurized and unpressurized cargo to and from space.
- Dragon Cargo Transport
  - 3 NASA COTS flights
  - 12 NASA CRS flights
  - Payloads manifested by NASA
- DragonLab Space Platform
  - 2 missions on manifest
  - Payloads manifested by SpaceX and authorized brokers
- Dragon Crew Transport
  - Falcon 9 / Dragon system designed from the start with human safety rating margins



All structures, thrusters, most avionics and all ground systems designed and mostly built by SpaceX

# NASA Commercial Orbital Transportation Services

- Under “COTS” program SpaceX receives \$278M to demonstrate cargo services to and from the ISS
- On schedule to complete in 2010
- Demo C1, Q1 2010 – Core Functionality
  - Demonstrate basic “up & back” functionality
  - End-to-end test of all system fundamentals
- Demo C2, Q2 2010 – ISS Fly-Around
  - Approaches to within 10 km of ISS
  - Establishes command & telemetry cross-link
  - Demonstrates commanding by ISS crew
- Demo C3, Q4 2010 – ISS Berthing
  - ISS proximity operations, capture & berthing
  - Return cargo safely to Earth
  - Establishes system as operational
- “CRS” operational cargo delivery flights begin in 2011
- First “DragonLab” mission begins in 2012



# SpaceX Dragon Cargo Mission

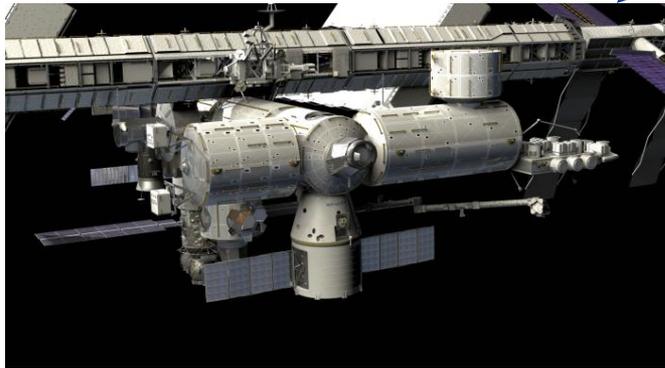
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# Dragon Spacecraft Services

## NASA's "COTS" Program

- Commercial Orbital Transportation Services
- SpaceX receives \$278M over 3.5 years
- Demonstrates cargo services to and from the ISS



## NASA's "CRS" Program

- Commercial Resupply Services
- SpaceX awarded \$1.6B for 12 cargo missions, 2010 – 2015
- Minimum of 20,000 kg delivered
- Option for additional missions

## SpaceX's "DragonLab" Program

- Free-flying recoverable platform for microgravity research & technology demo
- Regular, frequent, commercial access to space
- First mission in 2012

# SpaceX Dragon Spacecraft

## Nosecone

Jettisoned after stage separation.

## Capsule – fully recoverable

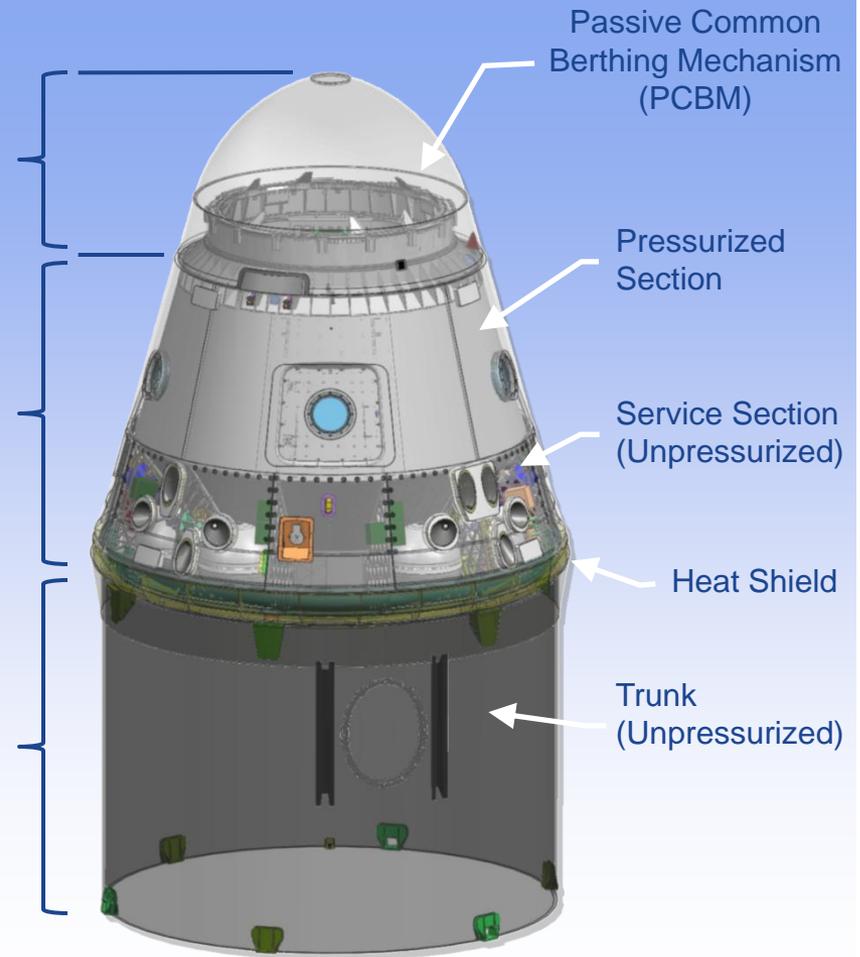
Contains pressurized cargo, experiments or crew, hatches, thrusters & propellant, parachutes and heat shield.

## Trunk – not recoverable

Contains unpressurized cargo and small deployable satellites. Supports solar panels, thermal radiator. Jettisoned before reentry.

Total Upmass Capacity to ISS: 6,000 kg

Downmass Capacity: 1,700 kg



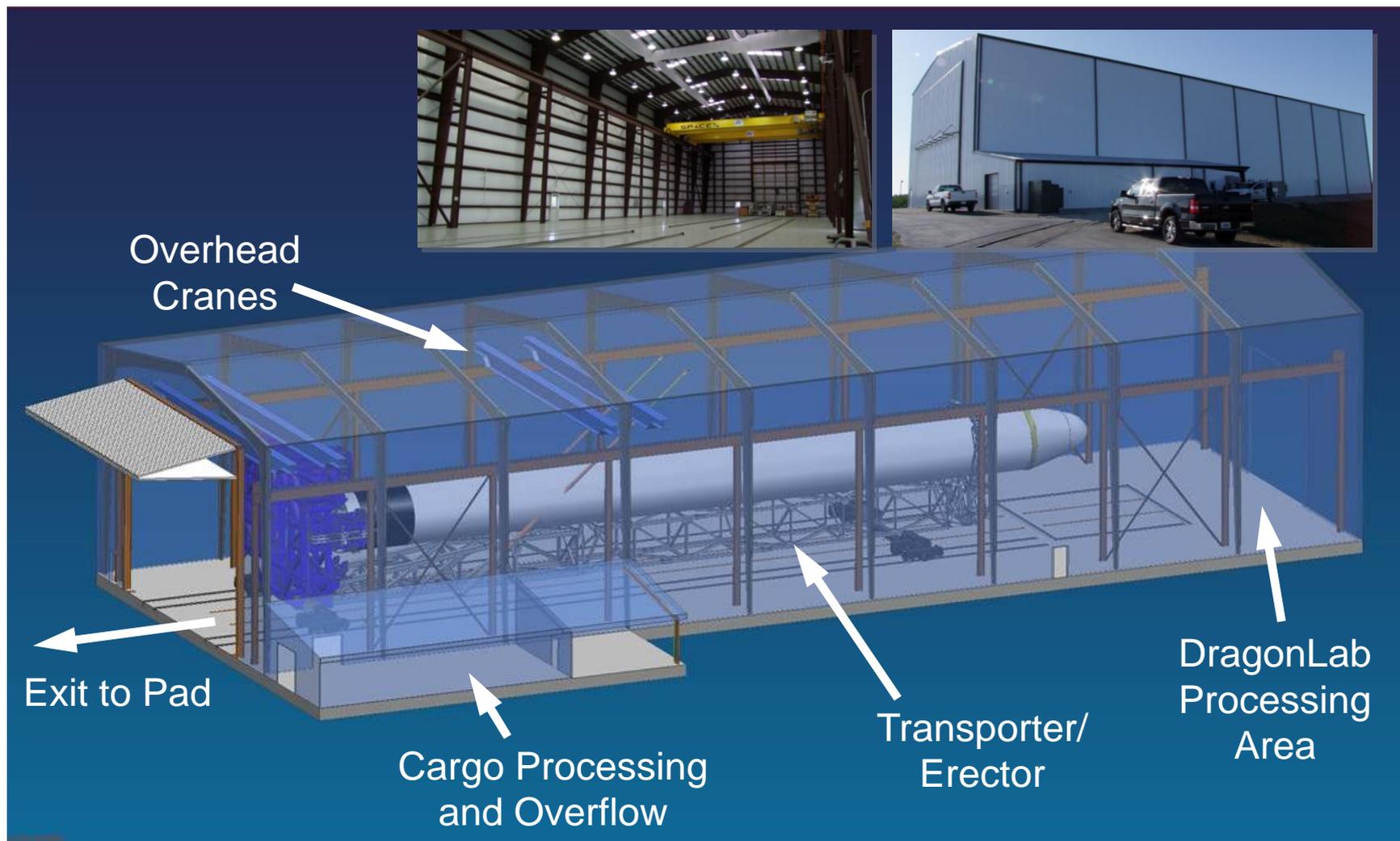
# SpaceX Dragon Spacecraft Development



# Fully Integrated Dragon Qualification Unit



# Horizontal Integration Hangar



# Cape Canaveral SLC-40 Launch Site



Flame Trench

Launch Pad

LOX Storage Area

Pneumatics

RP-1 Storage Area

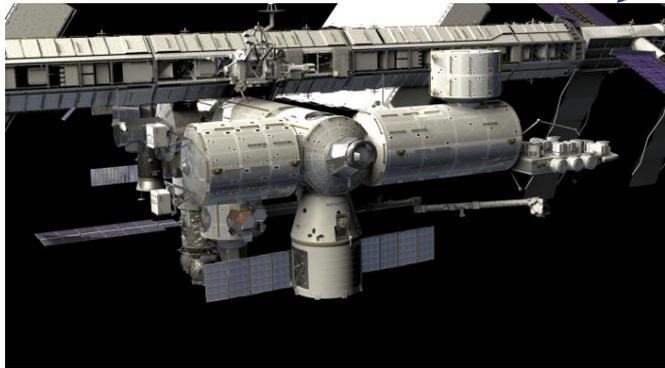
Hangar

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# SpaceX Dragon Spacecraft Services

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## NASA's "CRS" Program

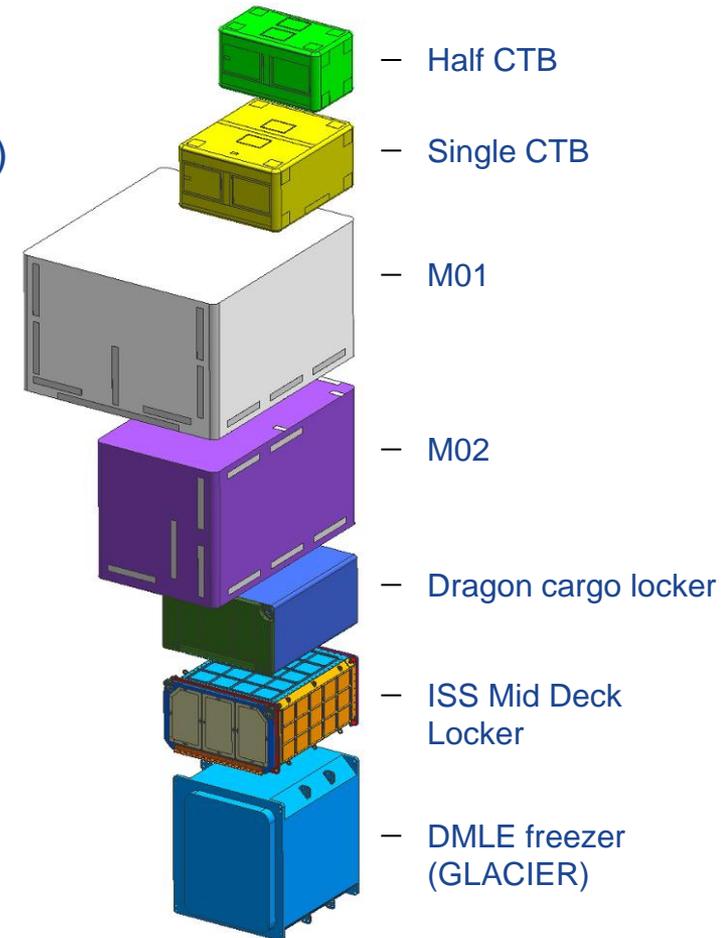
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## SpaceX's "DragonLab" Program

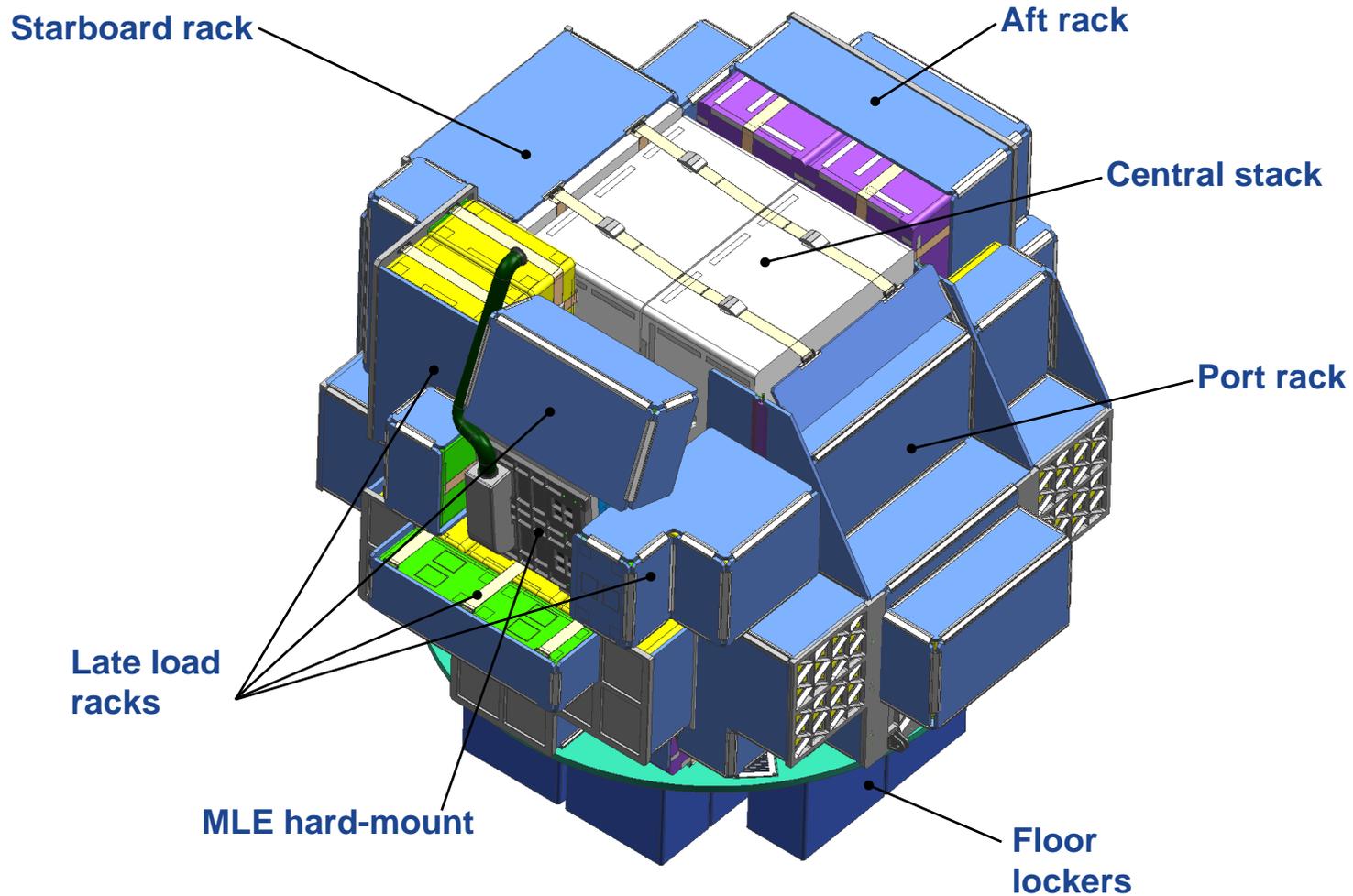
- Free-flying recoverable platform for microgravity research & technology demo
- Regular, frequent, commercial access to space
- First mission in early 2011

# CRS Pressurized Cargo Accommodations

- Need to accommodate a wide range of NASA-standard pressurized cargo packaging
  - Single, double & triple Crew Transfer Bags(CTBs)
    - M01, M02 & M03
    - Single & Dual Mid-deck Locker Equivalent (MLE) hard cases (e.g. freezers)
- ISS Dragon provides:
  - At least two MLE mounting locations are provided near side hatch for late-load and early-access powered cargo
  - 2 x 75 W (28 VDC) to pressurized cargo
  - 100 kbps RS-422 interface to each powered cargo item, with comm link to ground
  - DragonLab provides upgraded performance for both power and communications.



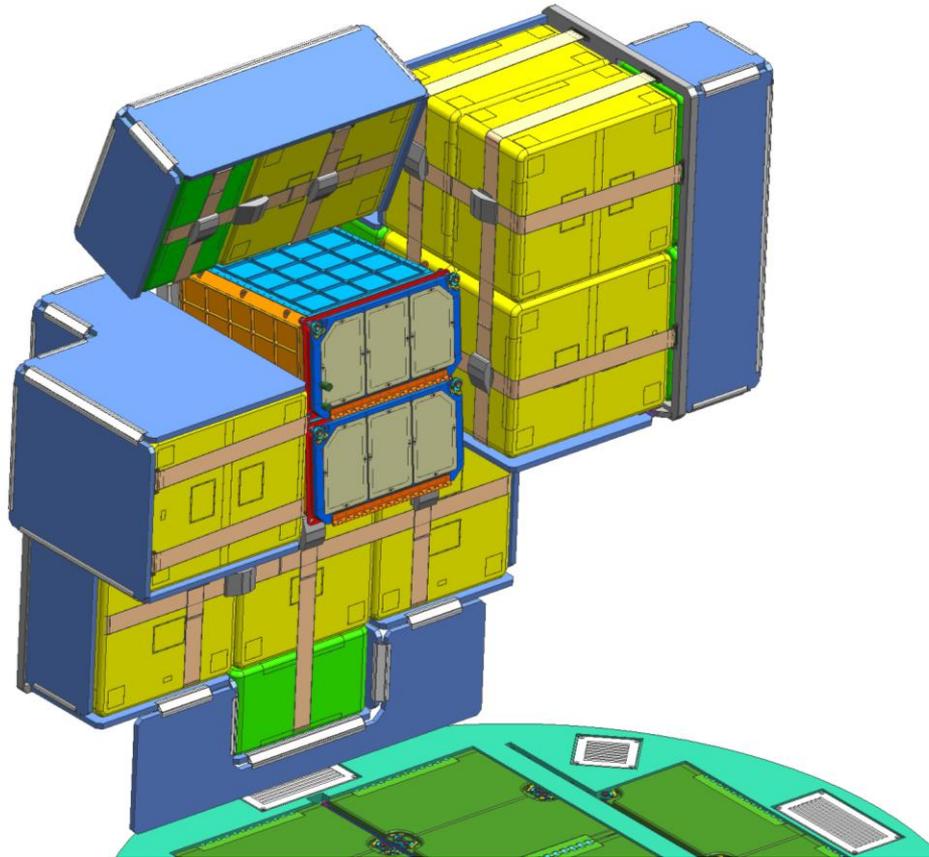
# CRS Pressurized Cargo Racks



# CRS Late Load / Early Access

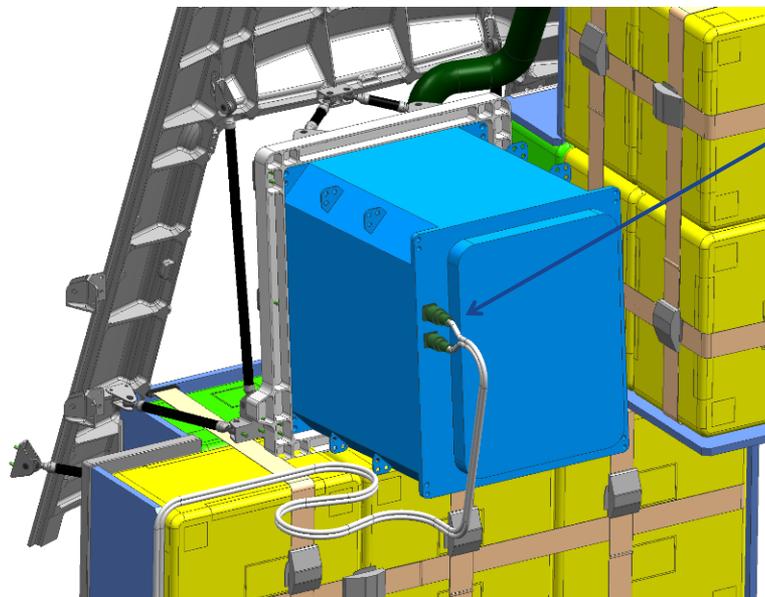
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- Baseline: 2x MLE, 10x Single CTB, 8x Half CTB
- Access through side hatch up to L-9 hours

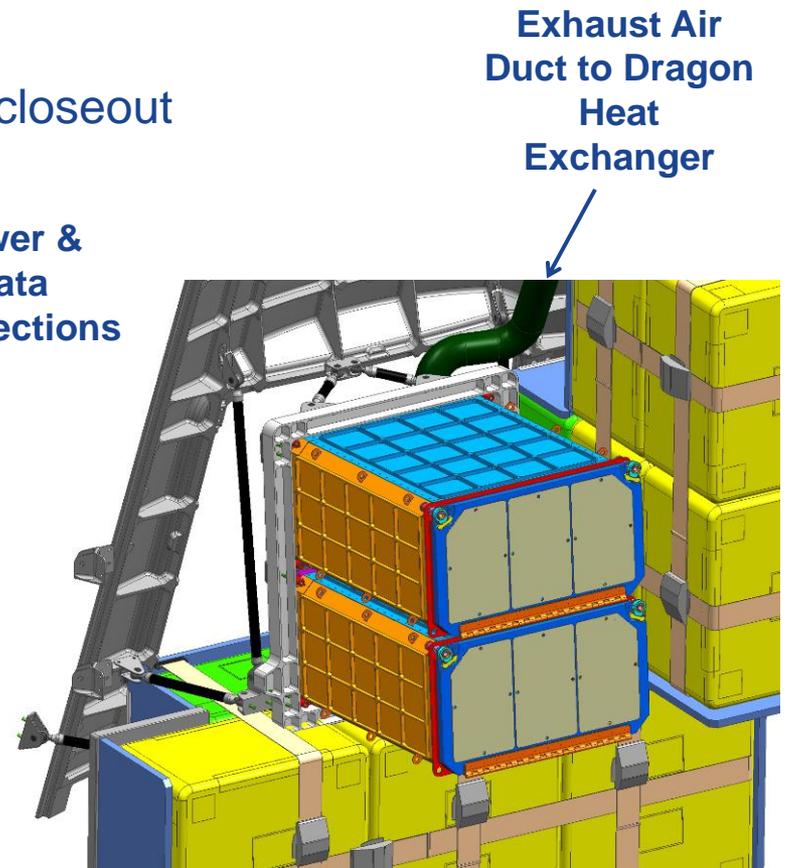


# CRS MLE Hard-Mount

- MLE hard-mount either
  - 1x Double MLE
  - 2x Single MLE
- Late load
  - Last item loaded before side hatch closeout

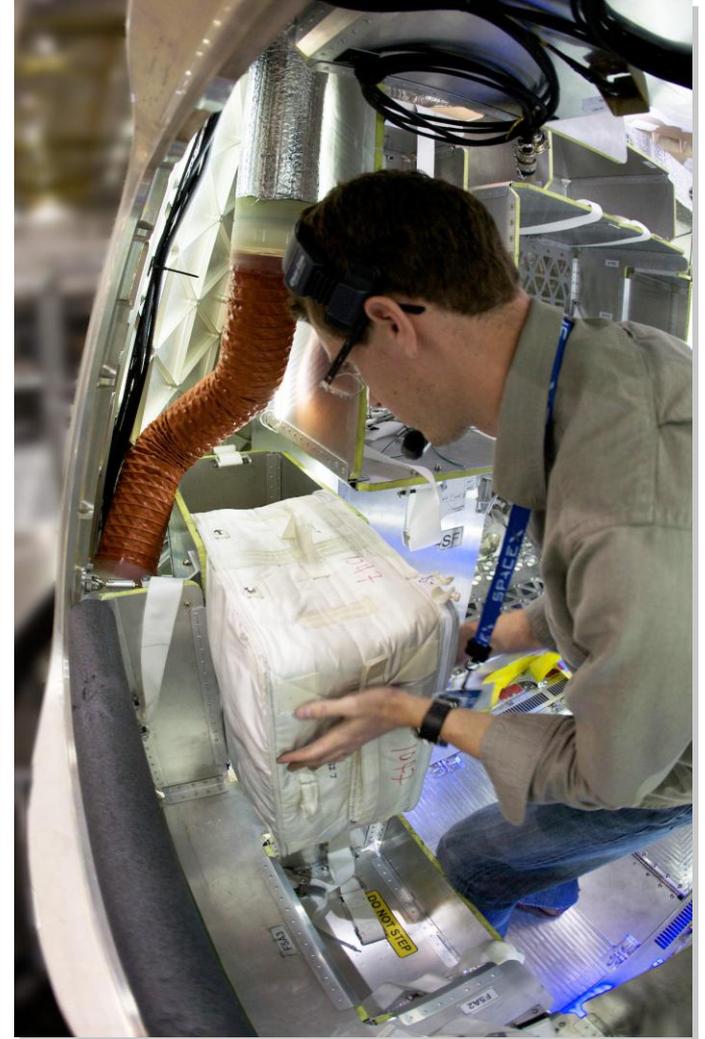


Power &  
Data  
Connections



Exhaust Air  
Duct to Dragon  
Heat  
Exchanger

# CRS Dragon Cargo Loading



# SpaceX Dragon Spacecraft Services

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# Non-ISS Applications: DragonLab

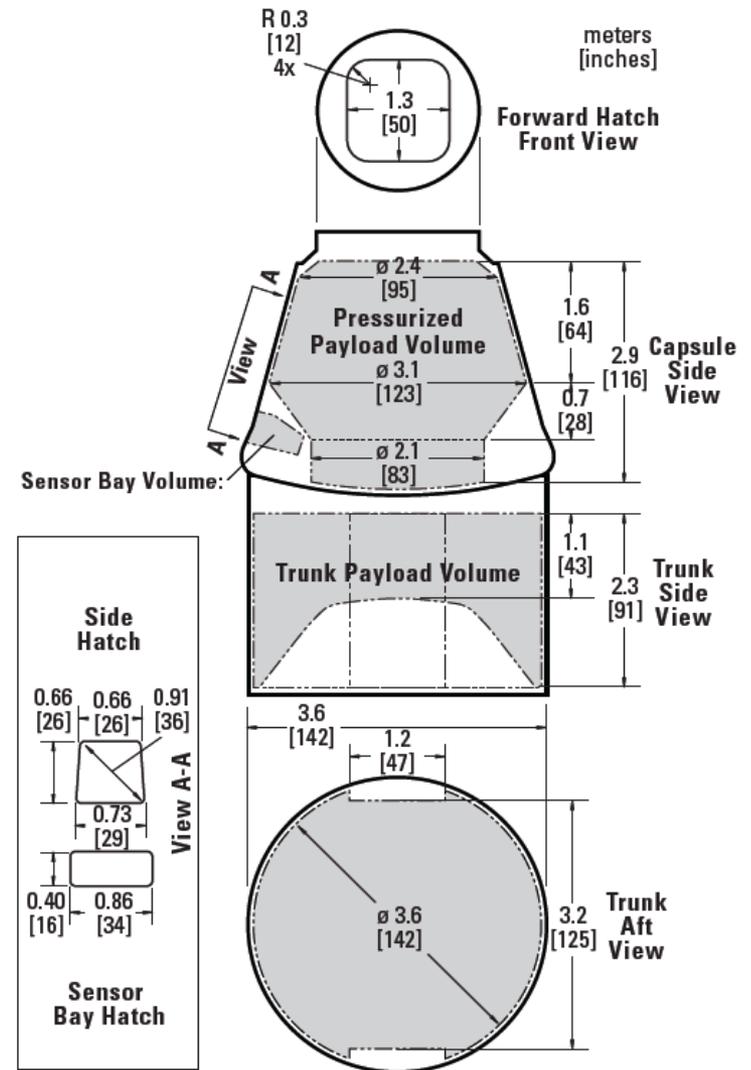
For payloads/experiments that don't require crew interaction...

- Microgravity Research
  - Biology & Life sciences
  - Biotech/pharmaceutical
  - Materials
  - Fluids & micro-fluidics
  - Combustion physics
  - Fundamental physics
- In-space Research
  - Space environments
  - Radiation effects
  - Space physics & relativity
- Instrument & sensor developers
  - Technology demonstration / risk retirement
- Orbital bus
  - Earth science & observation
  - Space weather & heliophysics
- **Mission Duration: hours to >2 years**



# DragonLab Payload Accommodations

- Mechanical specs
  - ~10 m<sup>3</sup> pressurized volume (recoverable)
  - ~14 m<sup>3</sup> unpressurized volume (not recoverable)
    - Option to extend up to ~34 m<sup>3</sup>
  - ~0.1 m<sup>3</sup> Sensor Bay (recoverable)
  - Highly adaptable configurations
    - Space Shuttle Middeck locker is de-facto standard for pressurized
    - Other packages and standards may be more efficient
  
- Temperature & Pressure
  - Pressure vessel
    - Active air circulation & air temp control
      - Temp: 10-46C
      - Relative Humidity: 25~75%
      - Pressure: 13.9~14.9 psia
    - Pumped fluid loop taps available
    - Cold plates available
  - External thermal Control
    - MLI & heaters
    - Pumped fluid loop taps available
    - Cold plates available

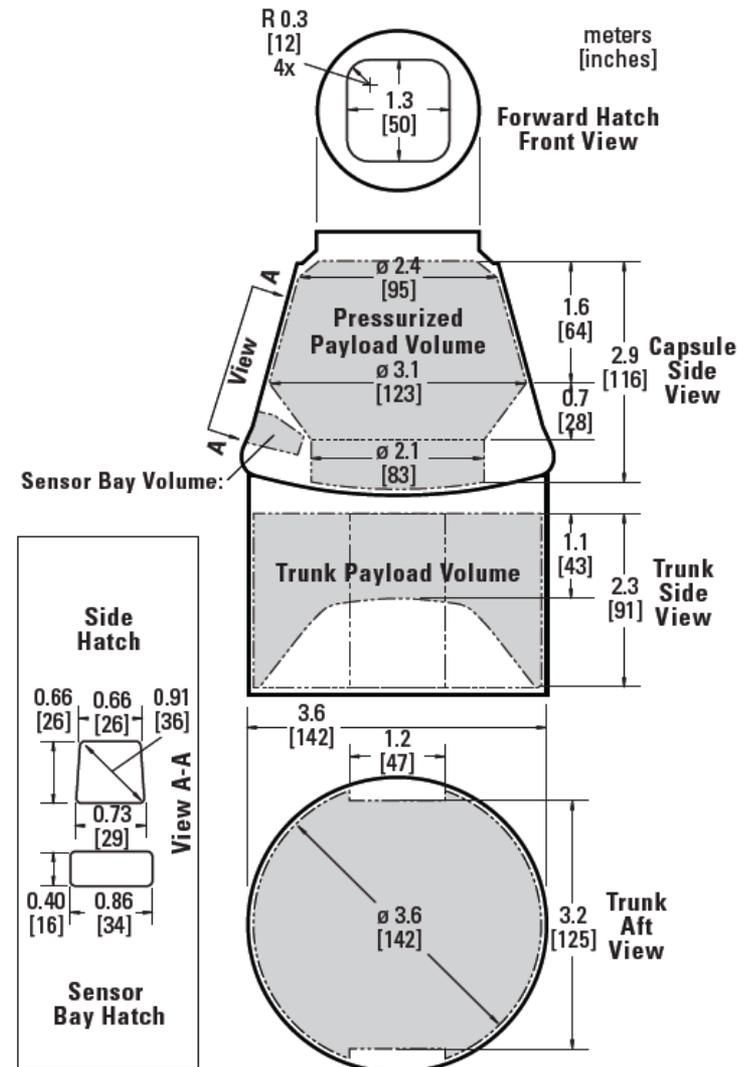


# DragonLab Payload Accommodations

- **Electrical Power**
  - Unregulated 28 VDC and 120 VDC
  - ~2000 W avg. payload power
  - ~4000 W peak payload power
  - ~16 kWh storage on-board
- **Data services**
  - IP addressable payloads
  - Up to 300 Mbps downlink rate\*
  - Up to 300 kbps uplink rate\*
  - RS-422, 1553 and Ethernet
- **Microgravity levels**
  - For nominal operations @ 300 km

<b>g</b>	<b>Below this value...</b>
1.0E-01	At all times while in orbit
6.0E-03	Exceedance twice per orbit
1.0E-04	Exceedance once per 20 s for less than 250 ms
1.0E-06	-

  - Lower levels achievable under certain circumstances



# SpaceX Manifest

	Customer	Date†	Vehicle	Launch Site
	NASA COTS - Demo C1	2010	Falcon 9/Dragon	Cape Canaveral
	NASA COTS - Demo C2	2010	Falcon 9/Dragon	Cape Canaveral
	NASA COTS - Demo C3	2010	Falcon 9/Dragon	Cape Canaveral
	Falcon 1e Inaugural Flight	2010	Falcon 1e	Kwajalein
	ORBCOMM – Multiple Flights	2010 to 2014	Falcon 1e	Kwajalein
COTS	MDA Corp (Canada)	2011	Falcon 9	Cape Canaveral
	NASA CRS ISS Resupply – Flight 1	2011	Falcon 9/Dragon	Cape Canaveral
CRS	DragonLab – Mission 1 & 2	2012 & 2013	Falcon 9/Dragon	Cape Canaveral
	Spacecom (Israel)	2012	Falcon 9	Cape Canaveral*
DragonLab	CONAE (Argentina) – Two Flights	2012 & 2013	Falcon 9	Vandenberg*
	NSPO (Taiwan)	2013	Falcon 1e	Kwajalein
	Space Systems/Loral	2014	Falcon 9	Cape Canaveral*
	Astrium (Europe)	2014	Falcon 1e	Kwajalein
	Bigelow Aerospace	2014	Falcon 9	Cape Canaveral
	NASA CRS ISS Resupply – Flights 2 thru 12	2011 to 2015	Falcon 9/Dragon	Cape Canaveral
	Iridium – Multiple Flights	2015 to 2017	Falcon 9	Vandenberg

† Hardware arrival at launch site.

\*Or Kwajalein, depending on range availability.



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*Thank You*  
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