

# *Commercial Crew & Cargo Program Overview*

*ISS - A New National Laboratory Special Session  
AIAA Aerospace Sciences Meeting*

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*Valin Thorn  
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Exploration Systems Mission Directorate  
Johnson Space Center*





# NASA Administrator's COTS Message



**Michael Griffin**  
NASA Administrator

***"I believe that with the advent of the ISS, there will exist for the first time a strong, identifiable market for "routine" transportation service to and from LEO, and that this will be only the first step in what will be a huge opportunity for truly commercial space enterprise, inherent to the Vision for Space Exploration. I believe that the ISS provides a tremendous opportunity to promote commercial space ventures that will help us meet our exploration objectives and at the same time create new jobs and new industry.***

***The clearly identifiable market provided by the ISS is that for regular cargo delivery and return, and crew rotation, especially after we retire the shuttle in 2010, but earlier should the capability become available. We want to be able to buy these services from American industry to the fullest extent possible. We believe that when we engage the engine of competition, these services will be provided in a more cost-effective fashion than when the government has to do it.***

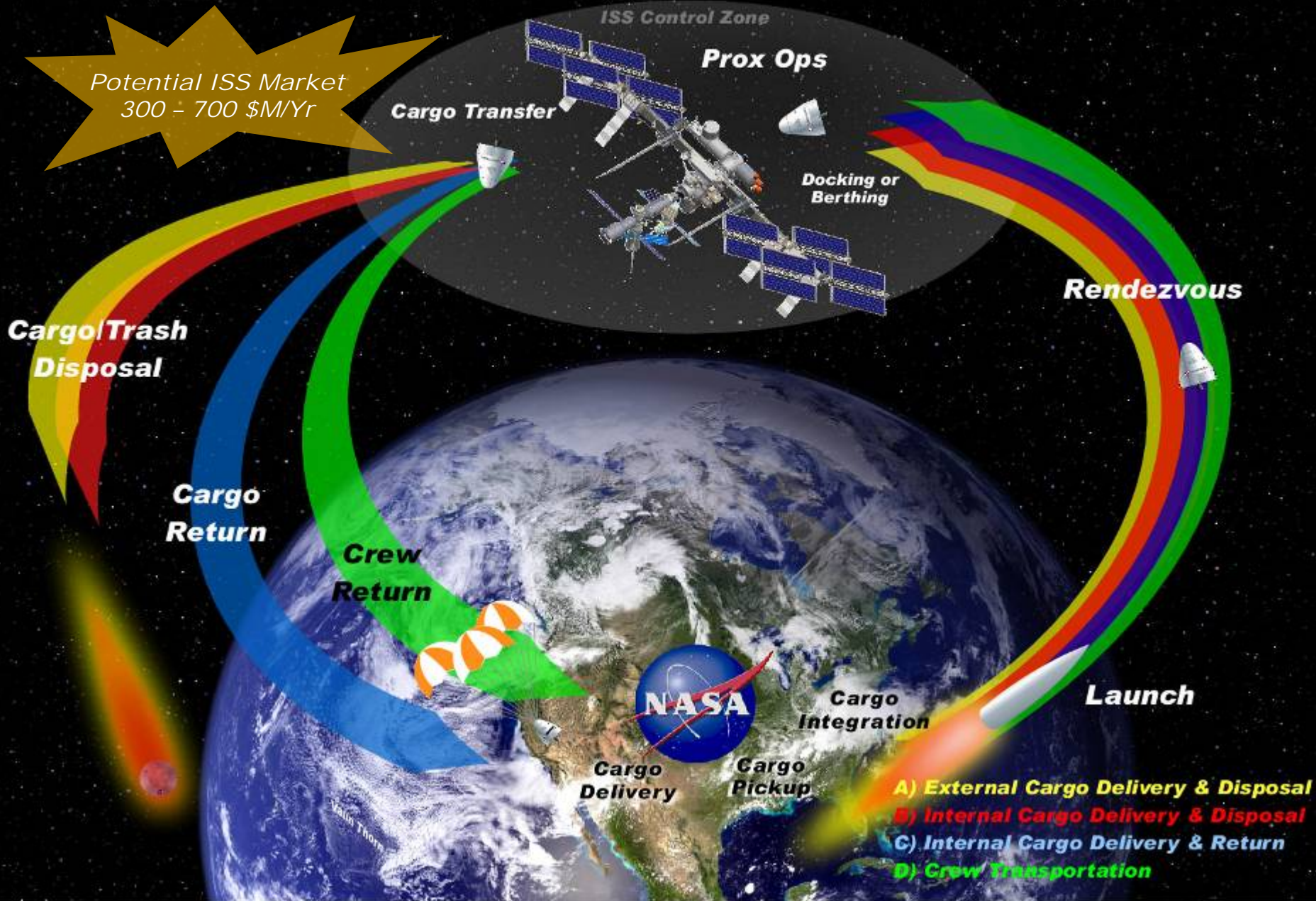
***To that end, we have established a commercial crew/cargo project office, and assigned to it the task of stimulating commercial enterprise in space by asking American entrepreneurs to provide innovative, cost effective commercial cargo and crew transportation services to the space station.***

***NASA does not have a preferred solution. Our requirements will be couched, to the maximum extent possible, in terms of performance objectives, not process. Process requirements which remain will reflect matters of fundamental safety of life and property, or other basic matters. It will not be government "business as usual". If those of you in industry find it to be otherwise, I expect to hear from you on the matter."***

*Michael Griffin*  
*American Astronautical Society Speech Excerpt*  
*November 2005*

# NASA Commercial Crew/Cargo Project Commercial Orbital Transportation Services

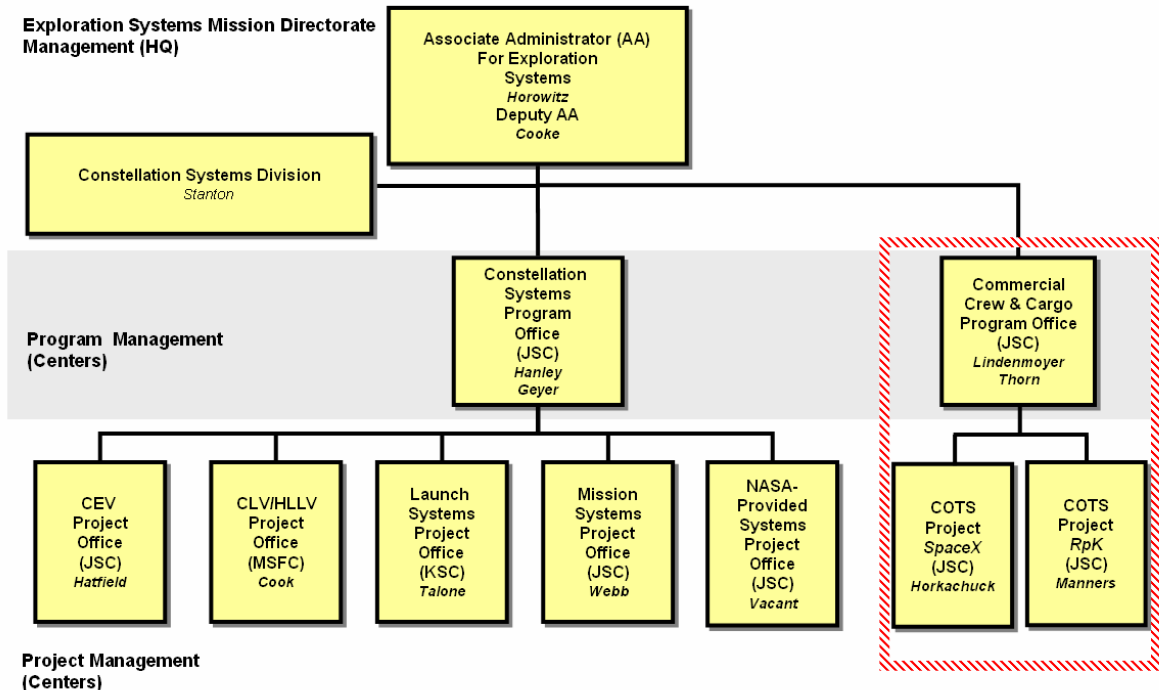
Potential ISS Market  
300 - 700 \$M/Yr





# COTS Program

- **Commercial Crew & Cargo Program Office (C3PO) established at the Johnson Space Center to implement policy**
- **COTS program objectives**
  - ◆ *Implement U.S. Space Exploration policy with an investment to stimulate commercial enterprises in space*
  - ◆ *Facilitate U.S. private industry demonstration of cargo and crew space transportation capabilities with the goal of achieving reliable, cost effective access to low-Earth orbit*
  - ◆ *Create a market environment in which commercial space transportation services are available to Government and private sector customers*



# COTS Program Implementation Strategy

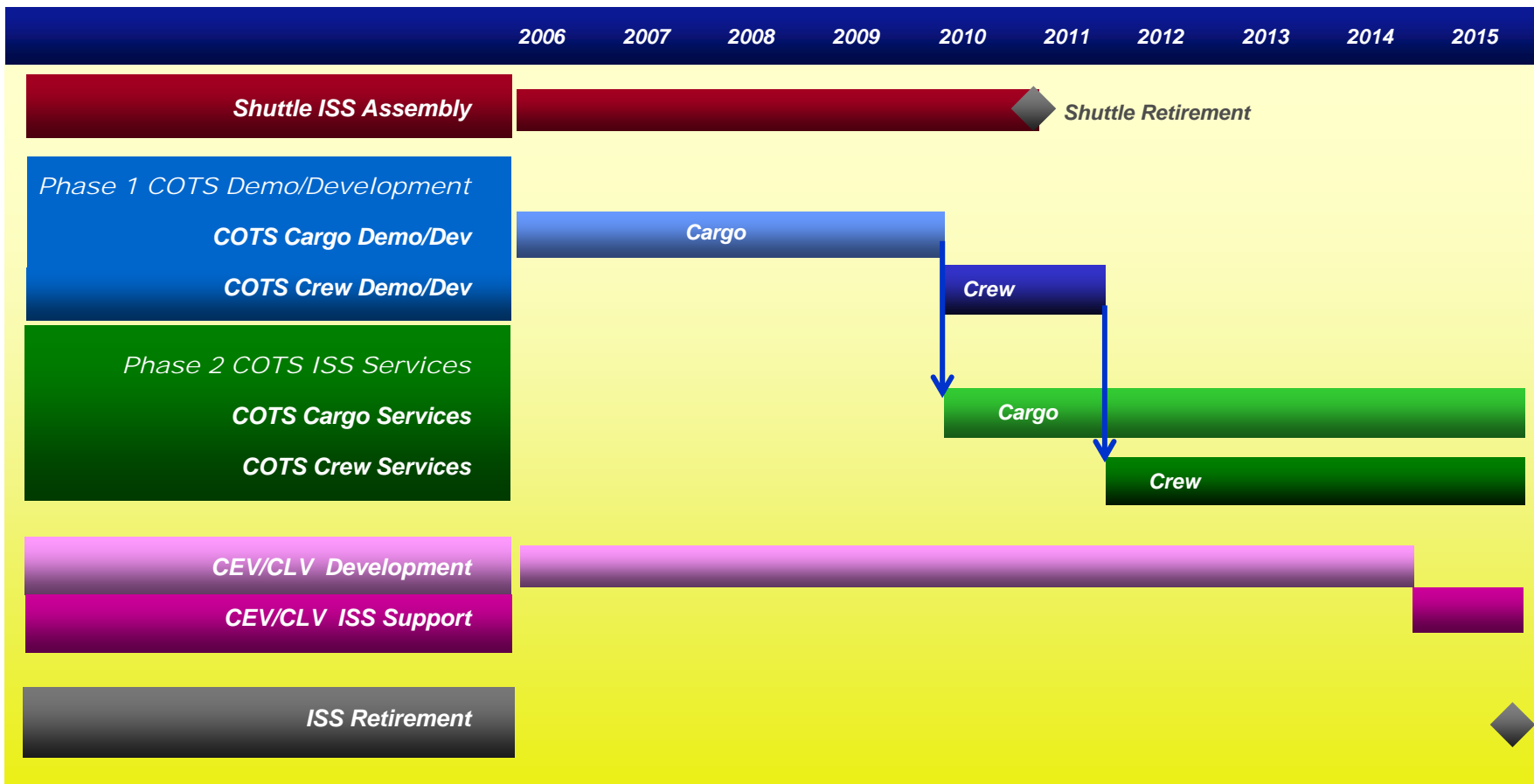


- **Basic program implementation strategy**
  - ◆ **NASA investment in privately owned space transportation systems development**
    - ✦ *Technical and funding assistance*
    - ✦ *If successful, buy services to support ISS*
  - ◆ **Phase 1: Technical Development/Demonstrations**
    - ✦ *Conduct Commercial Orbital Transportation Services (COTS) Demonstrations*
    - ✦ *Investment for demonstration/development of commercial orbital transportation capabilities*
      - ❖ *\$500M in President's FY07 budget request, thru 2010*
  - ◆ **Phase 2: Competitive Procurement of Orbital Transportation Services for ISS logistical support**

**COTS Phase 1 Demonstrations are NOT contracts for products and services –  
They are similar to venture capital pathfinder initiatives with associated risk  
tolerance and potential high return on investment**



# COTS Notional Schedule



- **COTS Crew capability is Phase 1 option and currently unfunded**
  - ◆ Potential funding start in 2009
- **Early COTS crew transport demonstration funding can close US crew transport capability gap after Shuttle retirement**



# COTS ISS Service Goals Summary

- **Internal cargo delivery**
  - ◆ **8750 kg/yr customer cargo (with packaging)**
    - ✦ 2500 kg/yr utilization cargo
    - ✦ 12 powered/cooled MLE/yr
  - ◆ **Water 1100 kg/yr**
  - ◆ **Gases 300 kg/yr**
- **Return cargo**
  - ◆ **4000 kg/yr customer cargo**
    - ✦ Mostly utilization
- **External cargo delivery**
  - ◆ **4500 kg/yr customer cargo**
    - ✦ ~2250 kg/yr utilization cargo
- **Crew Transportation**
  - ◆ **Maintain ISS US segment 3 crew compliment**





## *COTS Demo Competition*

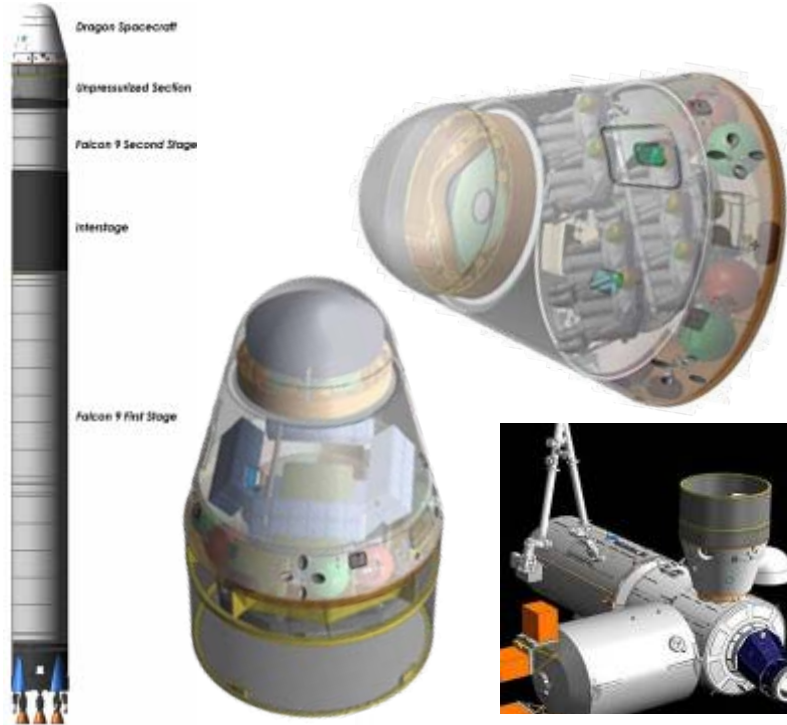
- ***Received 21 proposals from 20 companies across the full spectrum of industry***
- ***Six finalists selected***
  - ◆ ***Space Exploration Technologies (SpaceX)***
  - ◆ ***Andrews Space***
  - ◆ ***Transformational Space Corp.***
  - ◆ ***Rocketplane-Kistler (RpK)***
  - ◆ ***SPACEHAB***
  - ◆ ***SpaceDev***
- ***Two Funded SAA winners***
  - ◆ ***SpaceX***
  - ◆ ***RpK***
- ***Unfunded Space Act Agreements in work for several other competitors***
  - ◆ ***May still compete for the Phase 2 ISS Services contracts***

*Funded SAA Winners*





# Space Exploration Technologies



## Description:

- *Falcon 9 Launch Vehicle*
- *Dragon Crew/Cargo Spacecraft*

## Proposed Features:

- *Flexible crew and cargo configurations*
- *Recoverable launch vehicle and spacecraft*
- *ISS cargo delivery & return demonstration planned for completion by September 2009*
- *NASA Investment:*
  - ◆ *Cargo Capability Demo - \$278 M*
  - ◆ *Crew Transportation Demo - \$308 M*

# SPACEX

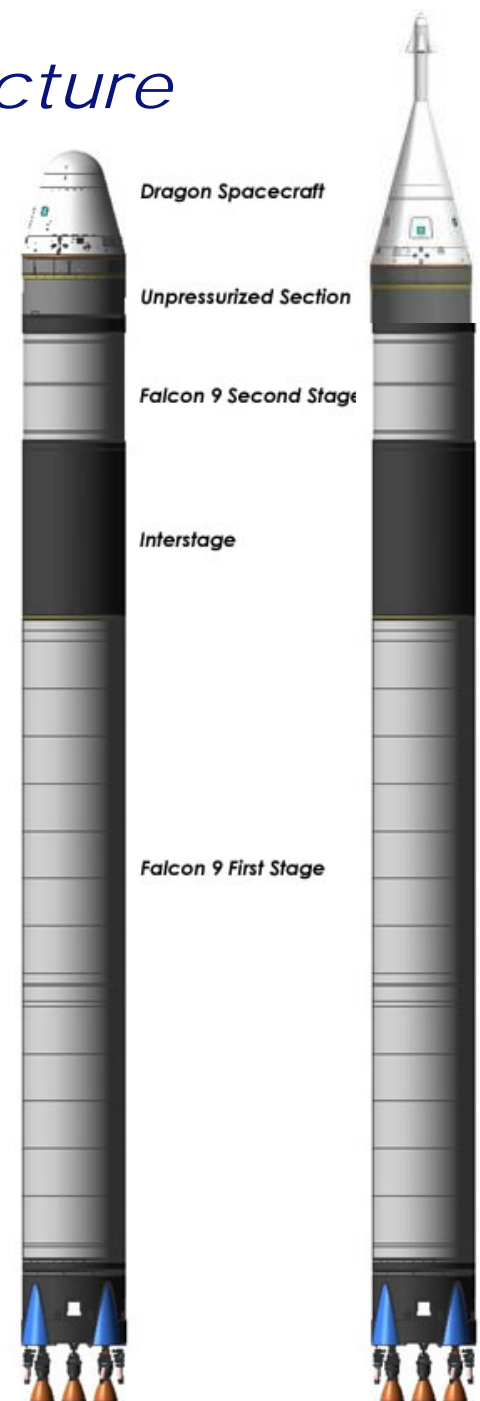
Space Exploration Technologies



# SpaceX COTS System Architecture



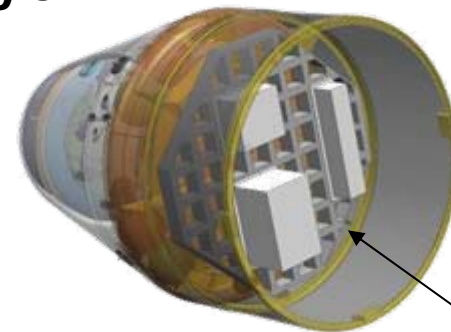
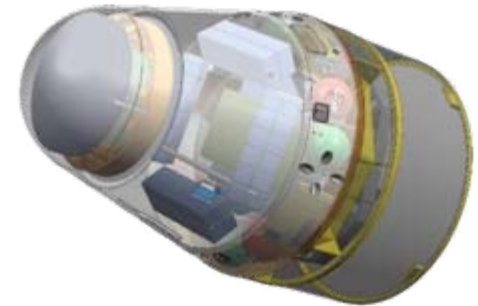
- **Standard Falcon 9 booster**
  - ◆ *Identical to commercial LEO payload version*
  - ◆ *Human-rated when combined with a Dragon & LES*
  - ◆ *8500 kg total payload capacity to ISS orbit*
    - ✦ *Allows ~3100 kg of cargo and/or crew total*
- **Dragon spacecraft**
  - ◆ *Identical whether cargo-only or crewed (except life-support & internal outfitting)*
- **Cargo accommodations**
  - ◆ *Pressurized cargo inside capsule*
    - ✦ *Standardized modular rack system, CTB/MLE based*
  - ◆ *Unpressurized cargo in the “trunk”*
- **Crew accommodations**
  - ◆ *Up to 7 crew per flight*
  - ◆ *Can trade mass between crew & cargo*



# SpaceX Dragon Features



- **Flexibility due to:**
  - ◆ **Frequent launches**
  - ◆ **Pressurized & unpressurized on each flight, trading mass**
  - ◆ **7 crew or cargo & crew combination**
  - ◆ **Minimal difference between cargo & crew spacecraft**
  - ◆ **Standard cargo loading 8~12 days before launch**
  - ◆ **Late-load cargo up to L-2 hours**
- **PCBM or Docking Adapter if desired**
- **Large pressurized down-cargo capability (equal to up-cargo)**
- **Lifting re-entry for landing precision & low-g's**
- **Intended recovery of ALL key parts allows major engineering insight & reliability analysis**



External cargo truss



# SpaceX Dragon Performance Summary

		Cargo Missions				Crewed Missions		
# flights per year		8				2		
On-station Dwell		1 month				6 months		
		Pressurized		Unpressurized		Crew	Pressurized	Unpressurized
		/ flight	/ year	/ flight	/ year			
Up Cargo	Mass	1.4MT	11.2MT	1.7MT	13.6MT	3 crew	500kg 3m <sup>3</sup>	1MT 15m <sup>3*</sup>
	Volume	8m <sup>3</sup>	64m <sup>3</sup>	15m <sup>3*</sup>	120m <sup>3</sup>			
	Power	2 x 75W	-	2 x 100W	-	7 crew	-	-
	Data	2 x >100kbps	-	2 x 100kbps	-			
	Late-load	up to 6 MLEs total (2 powered)	48 MLEs	>200kg	>1600kg			
	Packaging	>80% std MLE	-	Various	-			
Down Cargo***	Mass	1.4MT	11.2MT	1.7MT**	13.6MT			
	Volume	8m <sup>3</sup>	64m <sup>3</sup>	15m <sup>3</sup>	120m <sup>3</sup>			
	Power	2 x 75W	-	No	-			
	Data	2 x >100kbps	-	No	-			
	Early-Access	>6 MLEs	48 MLEs	N/A	-			
	Packaging	>80% std MLE	-	Various	-			

**Notes:**  
 \* limited by packing factors  
 \*\* limited in practice by FRAM placement & up/down cargo coordination  
 \*\*\* all pressurized down cargo is recovered and delivered to customer

# *SpaceX Prox Ops Video*

Dragon Boresight Camera



Simulation 30X Realtime



# SpaceX Cargo Capability Milestones

- **FY 2006**

- ◆ *Sep - Program Plan Management Review*

- **FY 2007**

- ◆ *Nov- Demo 1 System Requirements Review (SRR) & Kick-off*
- ◆ *Jan - Demo 1 Preliminary Design Review (PDR)*
- ◆ *Mar - Financing Milestone*
- ◆ *Mar - Demo 2 Requirements Review*
- ◆ *Aug - Demo 1 System Critical Design Review (CDR)*

- **FY 2008**

- ◆ *Oct - Demo 3 SRR*
- ◆ *Dec - Demo 2 PDR*
- ◆ *Feb - Demo 1 Readiness Review*
- ◆ *Mar - Financing Milestone*
- ◆ *Apr - Demo 3 PDR*
- ◆ *Jun - Demo 2 CDR*
- ◆ *Sep - Demo 1 mission*



# SpaceX Cargo Capability Milestones

## Continued



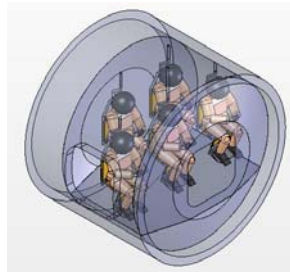
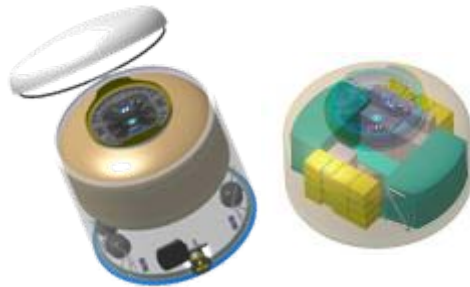
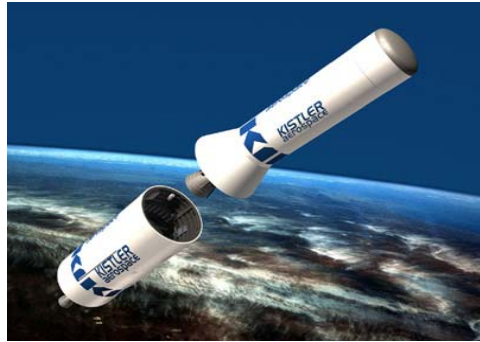
- **FY 2009**

- ◆ **Dec - Demo 2 Readiness Review**
- ◆ **Jan - Demo 3 CDR**
- ◆ **Mar - Financing Milestone**
- ◆ **Jun - Demo 2 Mission**
- ◆ **Jul - Demo 3 Readiness Review**
- ◆ **Sep - Demo 3 Mission**





# Rocketplane Kistler COTS Concept



## Description:

- K-1 Launch Vehicle
- Orbital Vehicle
- Pressurized/Unpressurized Cargo/Crew Modules

## Proposed Features:

- Reusable launch and orbital vehicles that return to launch site
- Modular crew and cargo configurations
- Capability A/B/C demonstration planned for completion by March 2009
- NASA Investment:
  - ◆ Capabilities A/B/C - \$207 M
  - ◆ Capability D Option - \$200 M

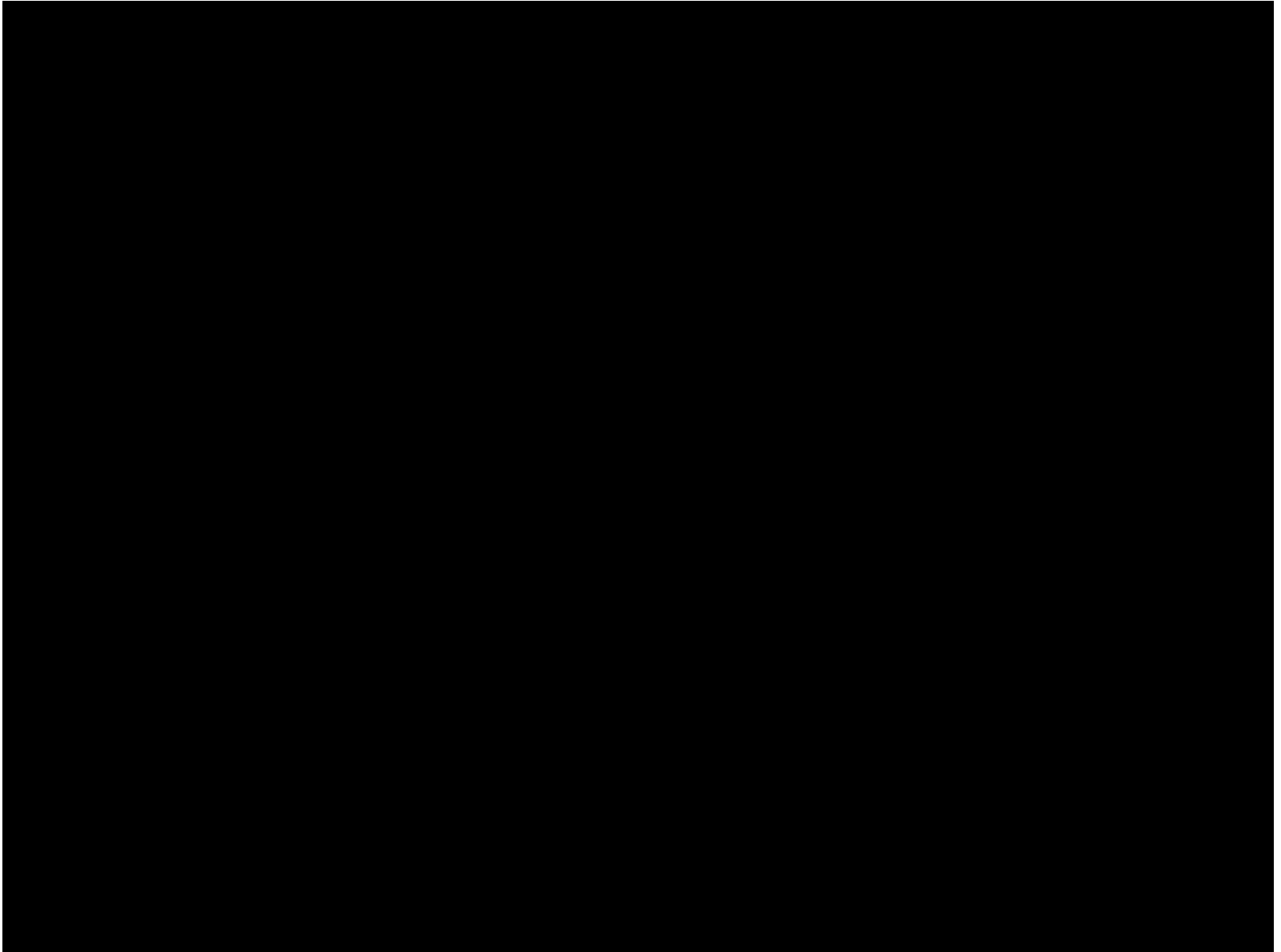






# *RpK ConOps Video*

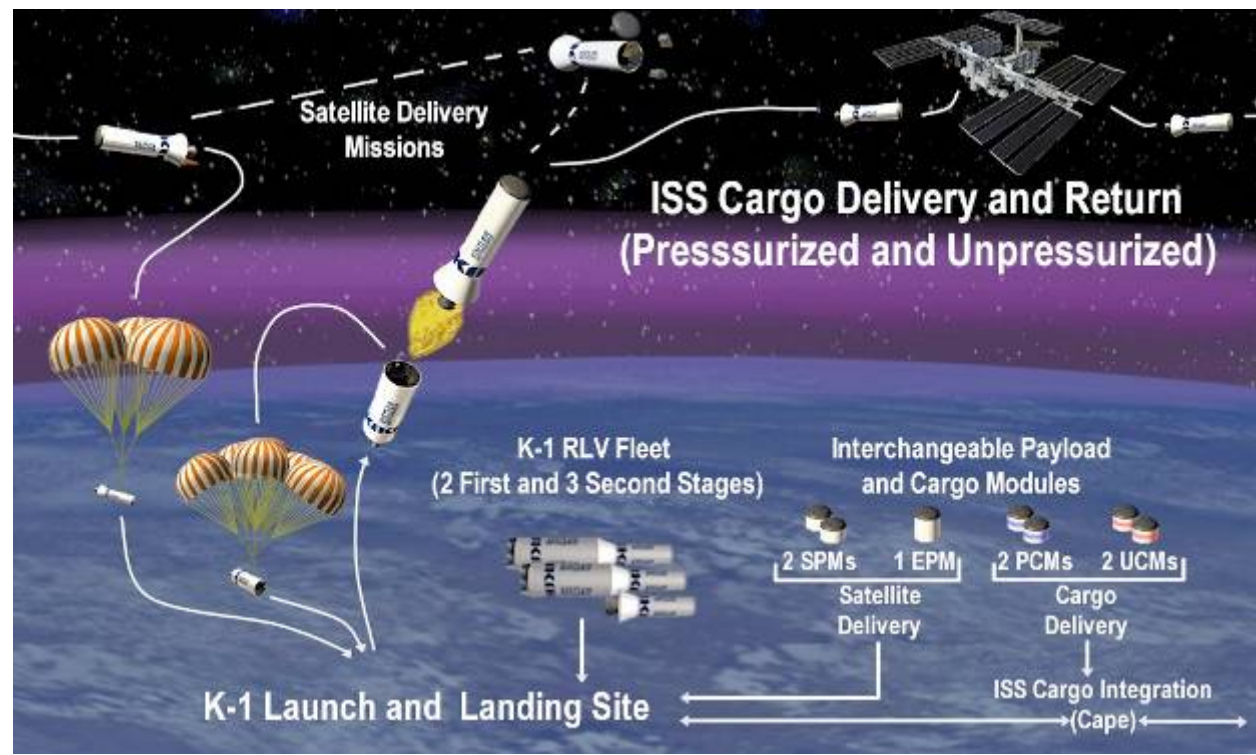
**COMMERCIAL CREW & CARGO**



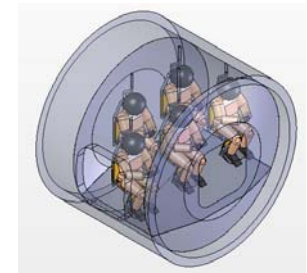


# RpK System Architecture

COMMERCIAL CREW & CARGO



+ 5-Passenger Crew Transport



+ Crew OV

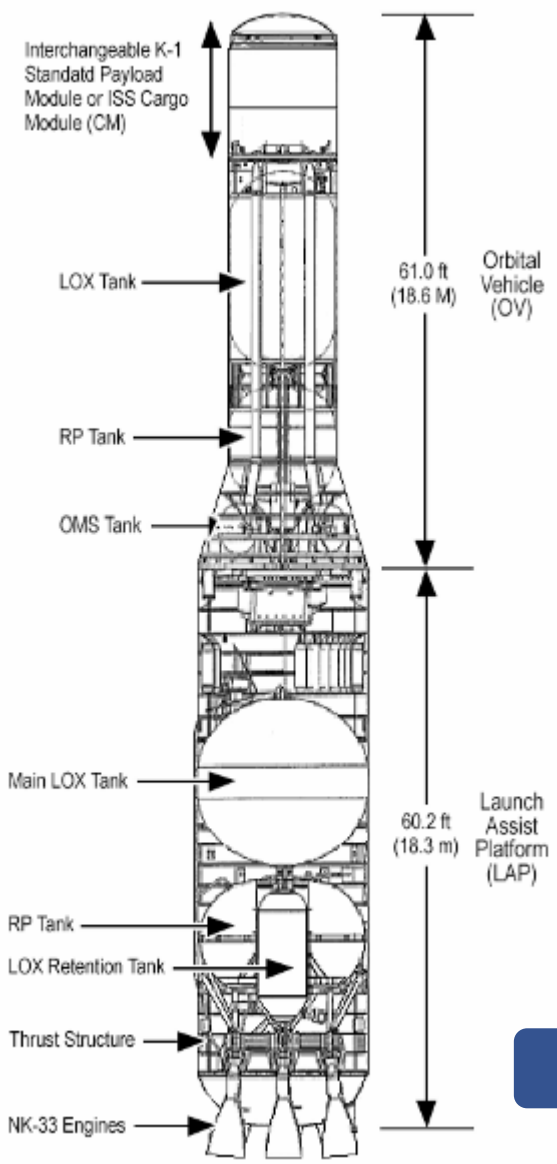


***K-1 launch-on-demand, fully reusable orbital LV that returns-to-launch-site via parachute / airbag soft landing***

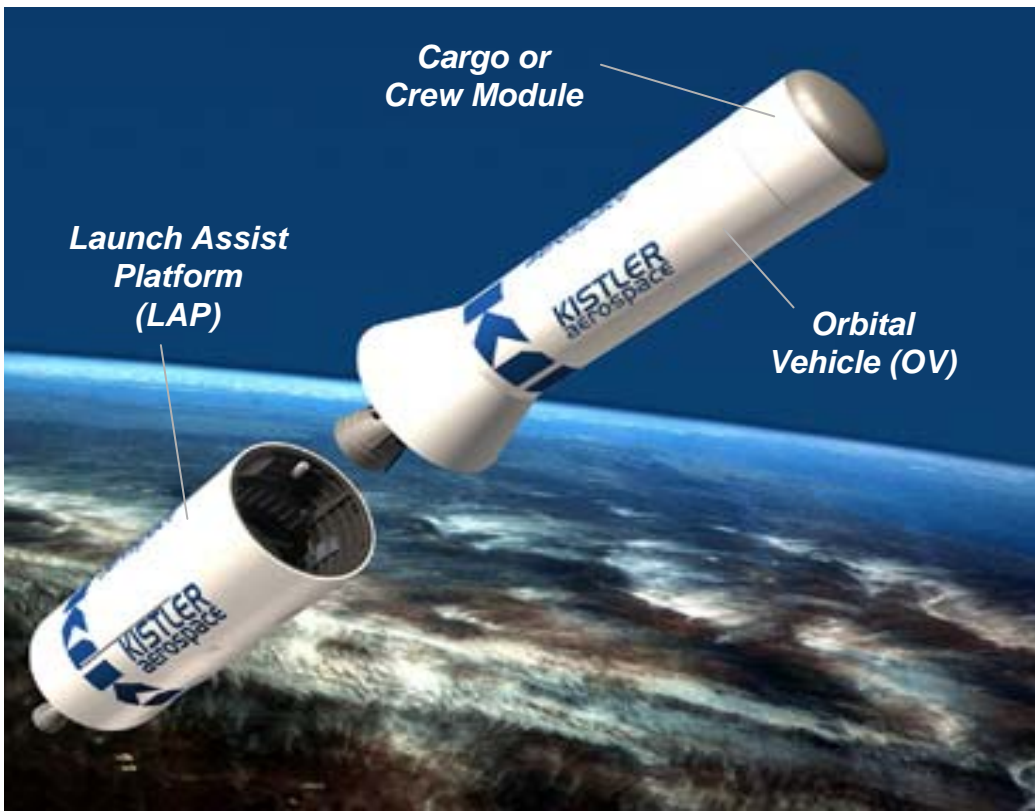


# RpK System Architecture

COMMERCIAL CREW & CARGO



**The K-1 RLV is simple and built for 100 flights**

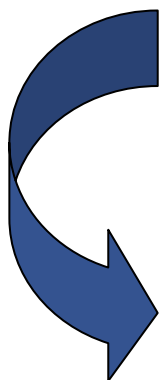


**Any LAP can fly with any OV**



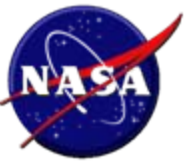
# RpK Vehicle Performance Summary

Alt (km)	External Cargo		Internal Cargo	
	Single Flight Goal (kg)	Capability (kg)	Single Flight Goal (kg)	Capability (kg)
278	2,900	4,665	2,775	3,927
350	2,900	4,203	2,775	3,465
410	2,900	3,832	2,775	3,094
460	2,900	3,534	2,775	2,796



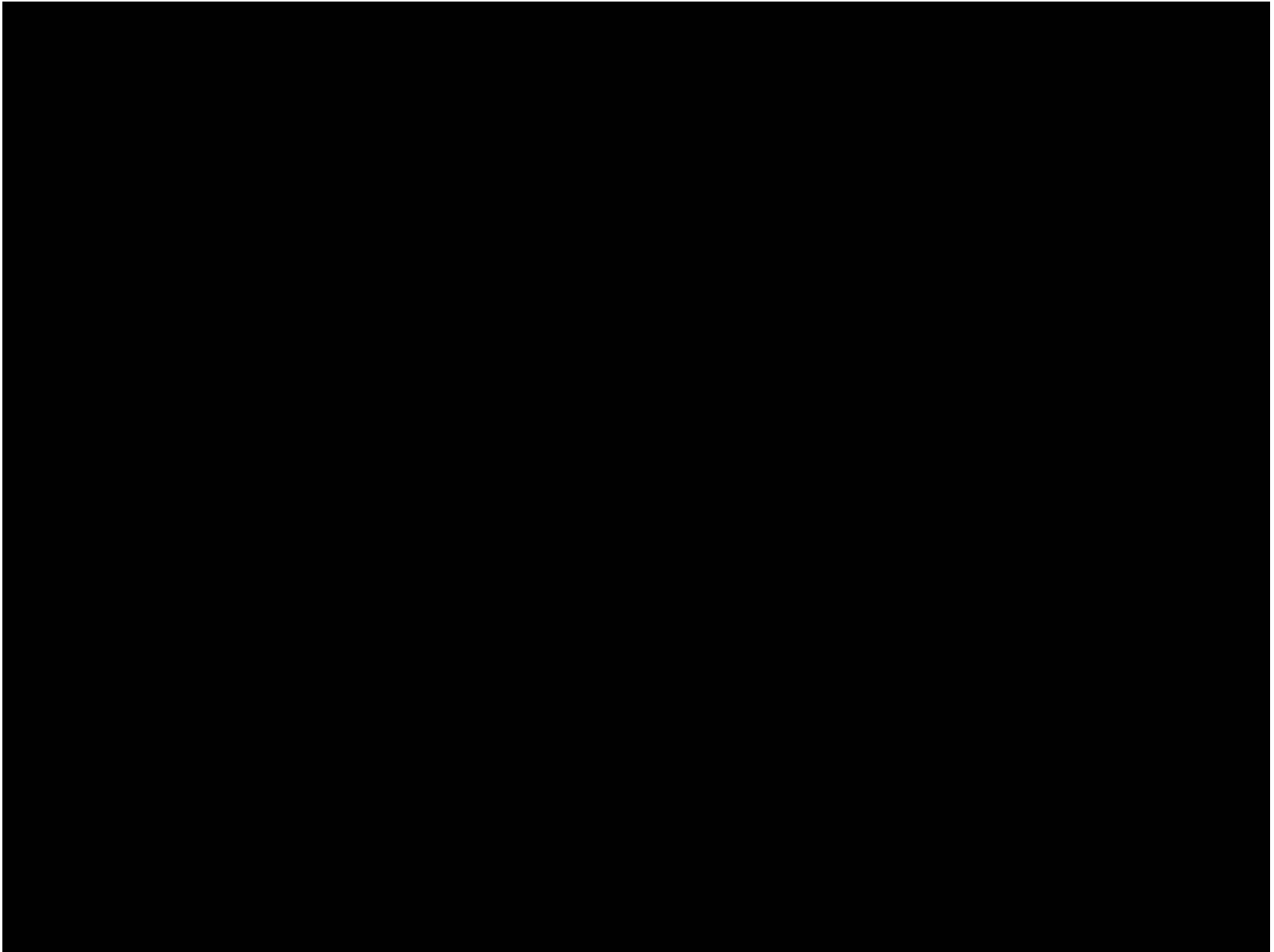
Mission ( <u>ISS @ 410 km</u> )	Capability	Margin*
<b>External Cargo</b> (P/L 2,900 kg/flight)	3,832 kg	932 kg
<b>Internal Cargo</b> (P/L 2,775 kg/flight)	3,094 kg	319 kg
<b>Crew Transportation</b> (5,303 kg CrM)	5,492 kg	189 kg

\*Performance available for planar launch window, ISS reboost, additional payload, or OMS margin



# *RpK Hardware & Team Video*

**COMMERCIAL CREW & CARGO**

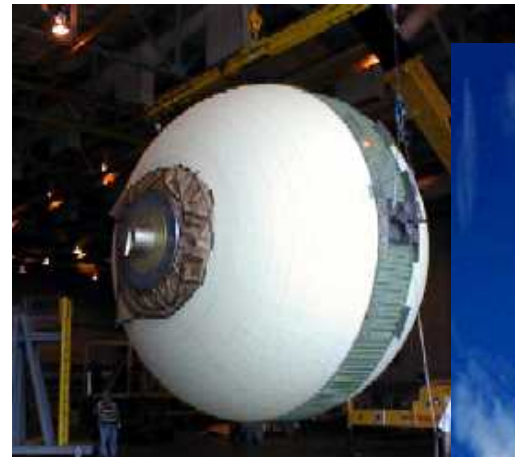


# RpK Cargo Capability Milestones

## Cargo Transportation to and from ISS

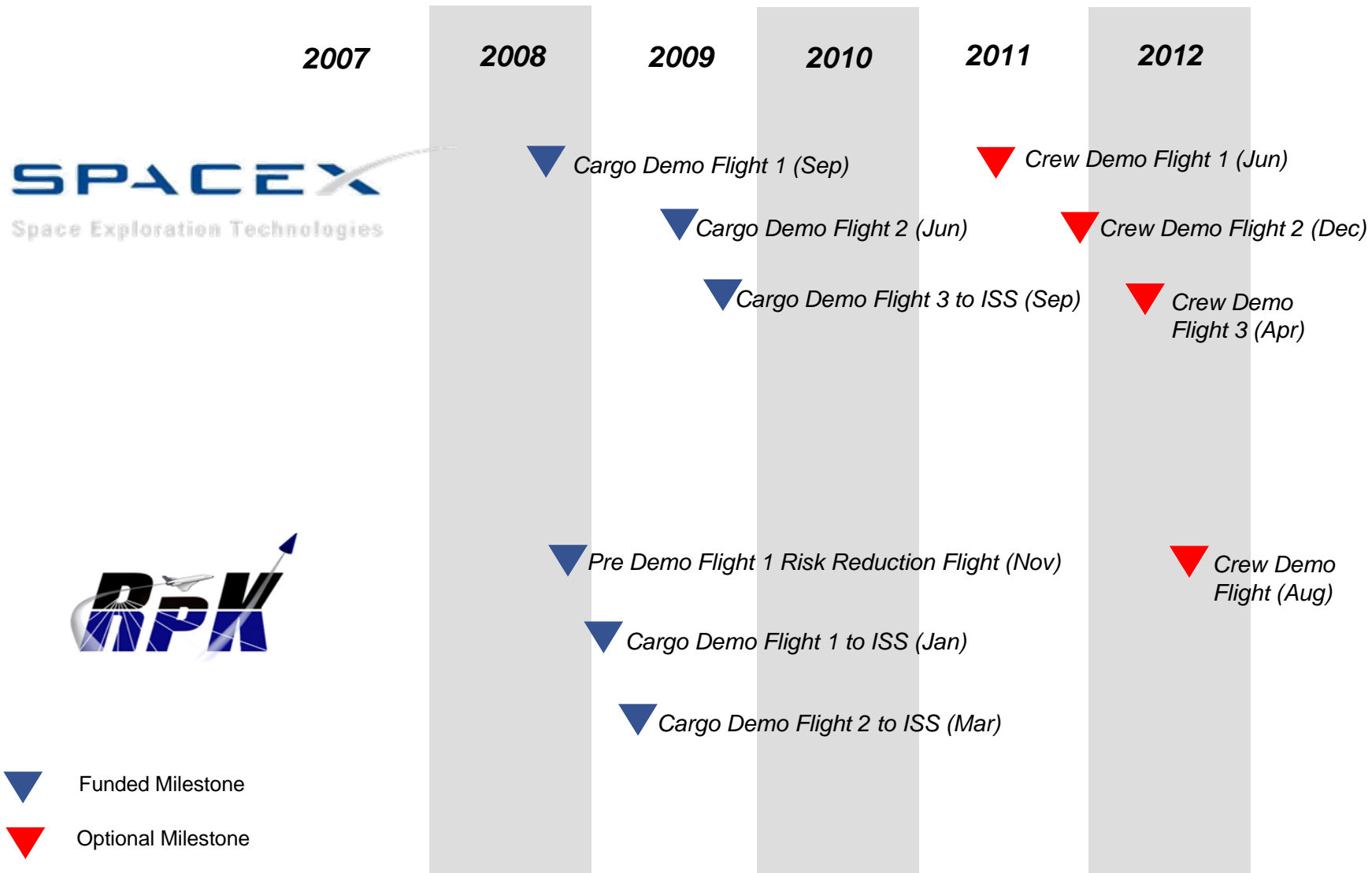


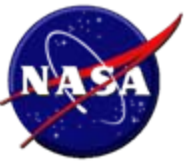
- **FY 2006**
  - ◆ *Sep - Program Implementation Plan Review*
- **FY 2007**
  - ◆ *Feb - SRR*
  - ◆ *Feb - Financing Milestone*
  - ◆ *Aug - Pressurized Cargo Module CDR*
  - ◆ *Sep - Unpressurized Cargo Module CDR*
- **FY 2008**
  - ◆ *Oct - ISS TRR*
  - ◆ *Feb - Rendezvous S/W TRR*
  - ◆ *Feb - Financing Milestone*
  - ◆ *May - PCM TRR*
  - ◆ *Jul - K-1 ship to Woomera*
  - ◆ *Sep - CoFR*
- **FY 2009**
  - ◆ *Nov - Flight*
  - ◆ *Jan - 1st Demo Flight*
  - ◆ *Mar - 2nd Demo Flight*





# COTS Flight Demonstrations





# COTS ISS Service Price Estimates

- **COTS services expected to reduced ISS logistics support costs by a factor of 10 when compared to the Space Shuttle**
  - ◆ \$300 to \$700M per year
- **COTS ISS services expected to significantly improve ISS cost/benefit trade**
  - ◆ Improve likelihood of extending ISS service life







## Summary

- ***National space policy requires pursuit of commercial opportunities for providing transportation and other services supporting the International Space Station and exploration missions beyond low Earth orbit***
- ***COTS Program established to implement policy***
- ***COTS strategy***
  - ◆ *Phase 1 -- Assist industry with system development/demonstrations (COTS Demos)*
  - ◆ *Phase 2 – Procure commercial services for ISS logistics support*
- ***COTS Demonstrations competition completed in 10 months***
- ***Just selected two industry partners for funded Space Act Agreements***
  - ◆ *SpaceX & Rocketplane-Kistler*
  - ◆ *Unfunded Space Act Agreements in work with other competitors*
- ***Flight demonstrations planned for 2008 and 2009***
- ***Commercial cargo transportation services potentially available as early as 2009-2010***
- ***Successful COTS Partners will affordably service the ISS's critical logistics needs and open new space markets – begin a new era in human spaceflight***



**NASA  
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