




**Small Launchers and  
Small Satellites:  
Does Size Matter?  
Does Price Matter?**

**Space Enterprise Council/CSIS - October 26, 2007**

**"... several ominous trends now compel a reassessment of the current business model for meeting the nation's needs for military space capabilities."**

**Adm. Arthur K. Cebrowski (Ret.)**

A collage of space-related images. In the top left, a satellite with solar panels is shown. In the top right, a rocket is launching with a large plume of fire. In the bottom left, a space shuttle is shown in flight. The background features a stylized American flag and a European Union flag.

One of the more worrisome trends, from a U.S. perspective, has been the declining influence of American vehicles in the global commercial launch market. Once one of the dominant players in the marketplace, the market share of U.S.-manufactured vehicles has declined because of the introduction of new vehicles and new competitors, such as Russia, which can offer launches at lower prices and/or with greater performance than their American counterparts.

*[The Declining Role in the U.S. Commercial Launch Industry, Futron, June 2005]*

# Current State of the World Launch Market

SPACEX

French Firm Vaults Ahead  
In Civilian Rocket Market

-Wall Street Journal

## 2006 Worldwide Commercial Launch Market Share

Brazil Fires Rocket in  
Bid to Revive Space  
Program

China to Map "Ev  
of Moon Surface

India to Orbit  
Spy Satellite in  
September

Russia Calls for Bu  
Lunar Base

Russia Designs Spaceport  
Complex for South Korea

-Itar-Tass

Plans to Double  
Launches Within

Multi-country

-RIA Novosti

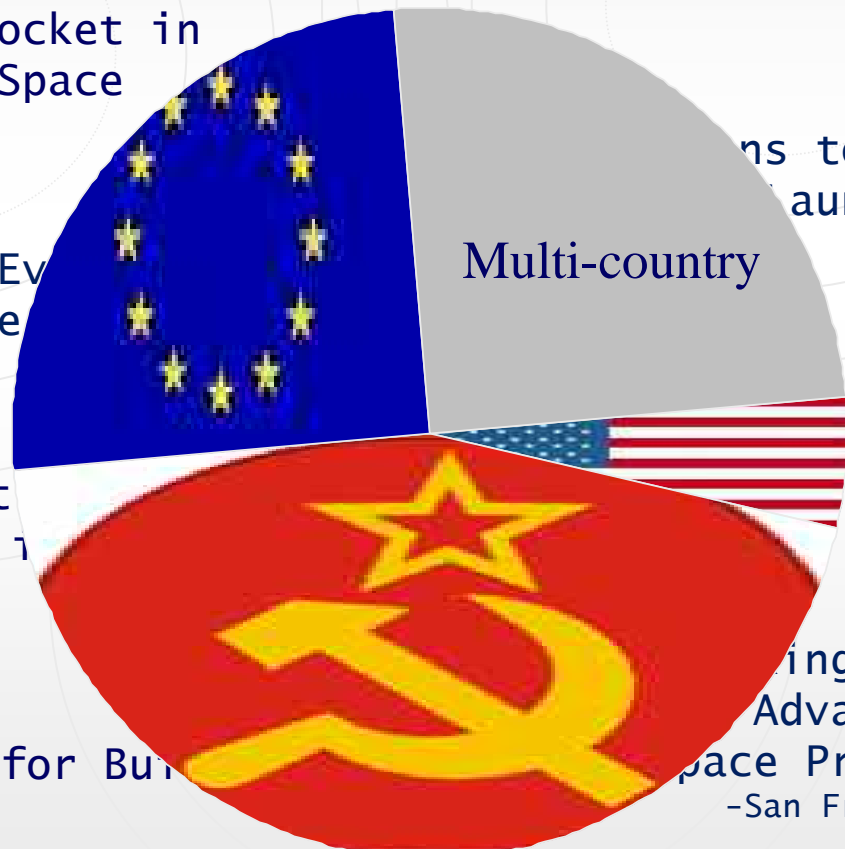
Call for Arab

-Arabian Business

ing For  
Advantage Over  
Space Program

-San Francisco Chronicle

-Itar-Tass



January 11, 2007 - Chinese SC-19 rams into a Chinese weather sat orbiting at 475 miles, scattering 1600 pieces of debris through low-Earth orbit.

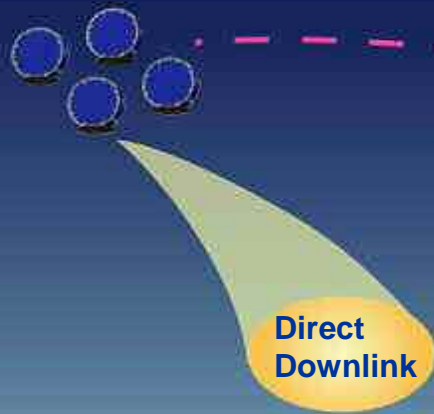


“While the existing model has served the nation well, a new business model is at hand and can now be readily grasped to propel us into the future.”

# The ORS Vision



Automatic Orbit  
Maneuvers for  
Constellation Building



Combatant Commander  
OPLAN Use  
Authorized

Launch

3-5 Days



Request Mission  
Call-Up

### Launch Team

- Precise Orbit Calcs.
- Range Safety Clearance
- SC/Payload Integration
  - PLD SW Load/Select
  - Batt. Charge, Fueling
- Final LV Integration

- JTF Commander Decides:
1. Payload Capability Needed
  2. Area of Interest
  3. Area for Direct Downlink
  4. When to Call-Up Asset

Joint  
Task Force  
Commander

Schedule of Downlink Times & Locations

# Operationally Responsive Space: Four Ideas with the Same Name\*



## "Operational Level of War vs. Strategic Mission"

- (OPERATIONALLY responsive space (Ors))
- Put combatant commanders in charge



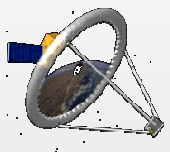
## "Change the economics of space"

- (operationally RESPONSIVE space (oRs))
- Smaller and simpler satellites in shorter timeframes
- Low-cost launch



## "Surge and Replenish"

- (operationally responsive spaceLIFT (ors-L))
- Requires responsive launch and spacecraft



## "Technology Push"

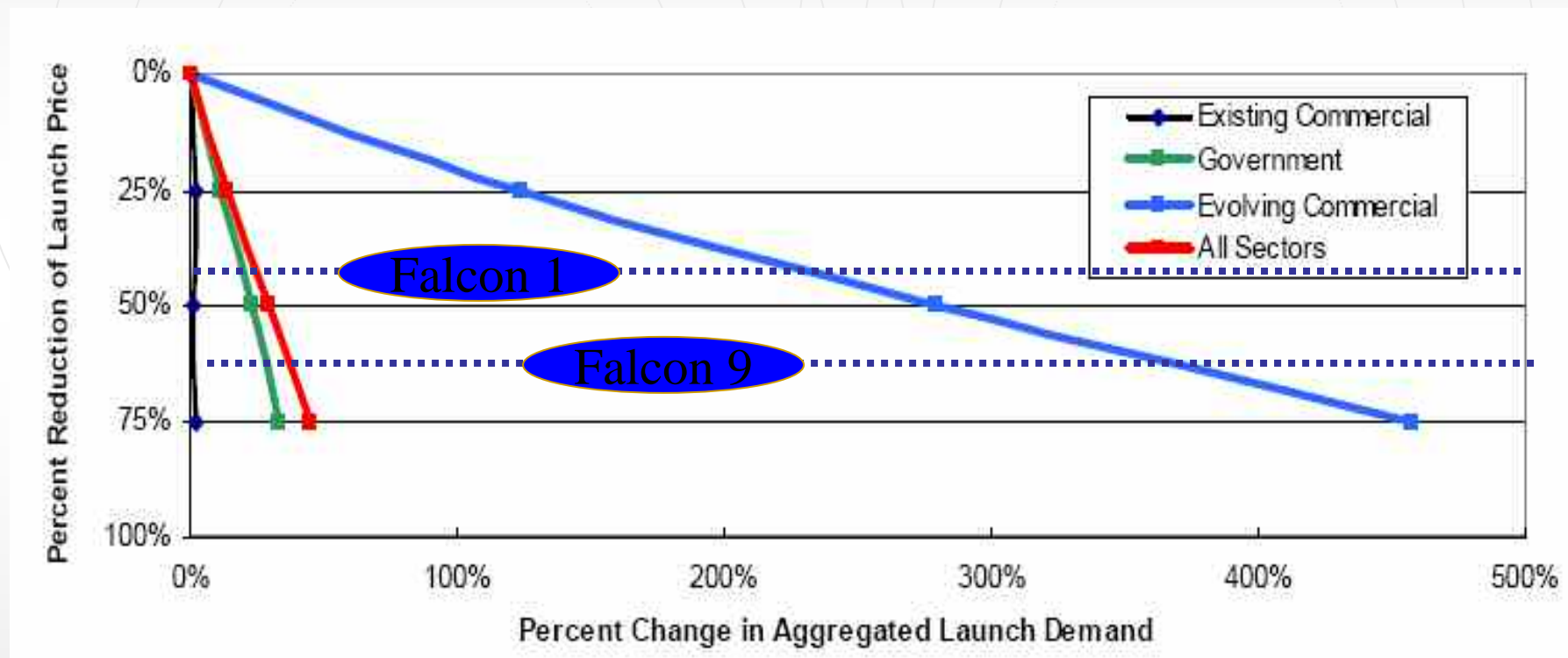
- (operationally responsive SPACE (orS))
- Use small satellites to drive technology insertion

From Dr. S. Huybrechts, OASD(NII),  
"Thoughts on Space Power in the 21<sup>st</sup> Century"

# Does Price Matter?

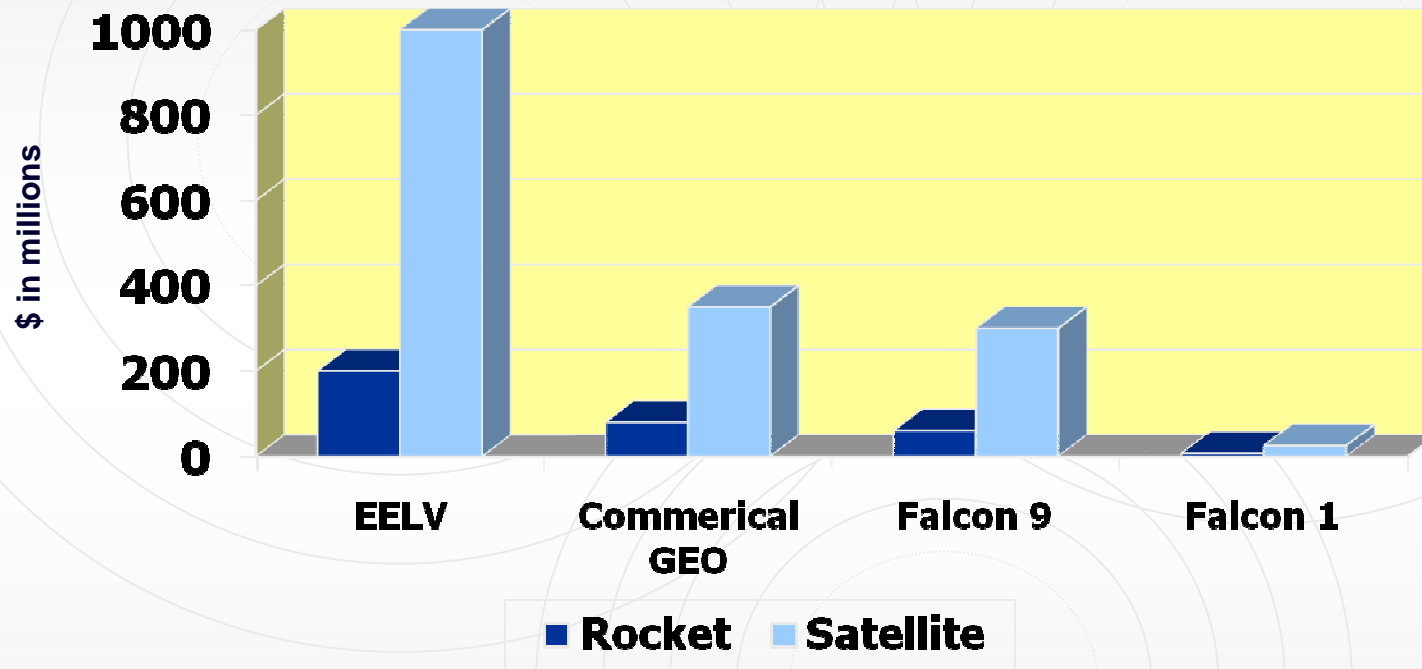


## Launch Price Elasticity (by sector type)



Source: Futron (1/31/03)

# Relationship Between Satellite and Launch Cost



**“If we had launchers that were cheap, we would have satellites that were less expensive.”**

David McGlade  
CEO Intelsat  
Space News  
September 17, 2007

# SpaceX Overview

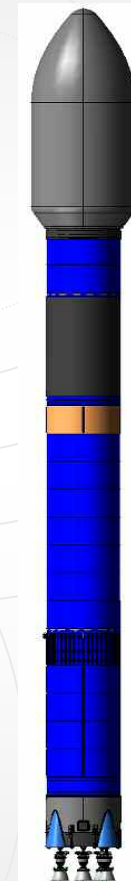


- Founded in 2002 to provide high reliability, low cost space transportation
- Initial market is government & commercial satellites to minimize market risk -- transition to human transportation once technology is proven
- Launch Vehicles and Spacecraft:
  - Falcon 1, Falcon 9, Dragon
  - Transition to human transportation once technology is proven
- Company structure and operation
  - Flat hierarchy, high engineer to manager ratio
  - Rapid prototype iteration, best idea wins
  - Quick decision and approval process
- Located in Southern California
  - Over 325 employees
  - 500,000 sq.ft. headquarters and production facility
  - 300 acre propulsion and structural test facility in Texas
  - Launch complexes in Kwajalein, Vandenberg and Cape Canaveral



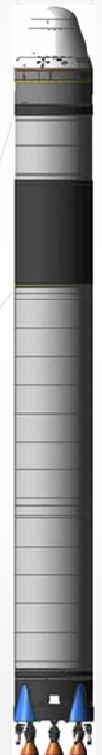
Falcon 1  
Light Lift

\$7M



Falcon 9  
5m Fairing  
Medium to heavy lift

\$35M



Falcon 9  
Dragon  
Crew/Cargo

\$75M

# SpaceX Launch Manifest



<u>Customer</u>	<u>Launch</u>	<u>Vehicle</u>	<u>Launch Site</u>
Demo Flight 1*	Q1 2006	Falcon I	Kwajalein
Demo Flight 2*	Q1 2007	Falcon I	Kwajalein
Flight 3 TBD	Q1 2008	Falcon I	Kwajalein
Malaysia Razaksat	Q1 2008	Falcon I	Kwajalein
US Government	Q4 2008	Falcon 9	Cape
NASA COTS 1	Q4 2008	Falcon 9	Cape
Canada MDA Corp.	Q1 2009	Falcon 9	Cape
Avanti HYLAS (GTO)	Q2 2009	Falcon 9	Cape
NASA COTS 2	Q2 2009	Falcon 9	Cape
SpaceDev	Q3 2009	Falcon 1	Kwajalein
NASA COTS 3	Q4 2009	Falcon 9	Cape
MDA Canada Corp	Q1 2010	Falcon 1	Kwajalein
Swedish Space Corp	Q1 2010	Falcon 1	Kwajalein
Bigelow Aerospace	Q2 2010	Falcon 9	Cape

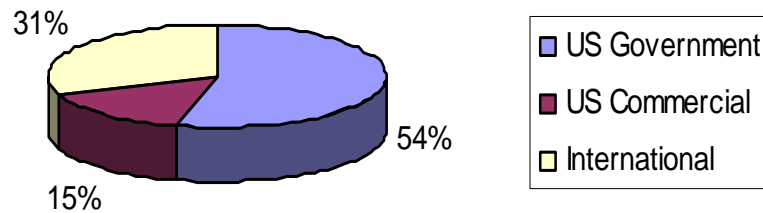
Contract options include SDTW IDIQ Falcon I contract  
Also in process of on ramping to NASA Launch Services

# Current SpaceX Market

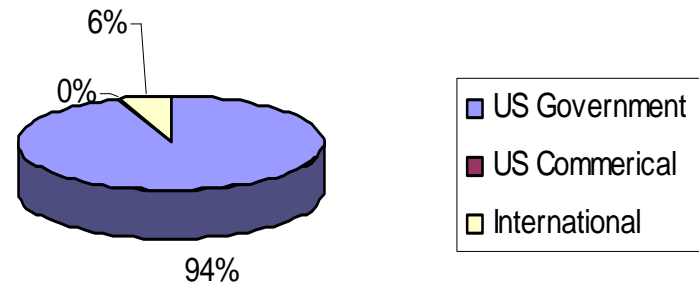


- Current business model focuses largely on providing satellite launch services
  - Only proven space transportation market
  - International satellite launch market worth approximately \$4 billion per year
  - SpaceX Falcon is only US launch vehicle that is competitive in the international market.

**Current SpaceX Launch Business**



**Rest of US Orbital Launch Industry (2006)**



# Falcon 1 Overview

SPACEX

- 2-stage LOX/RP1 small launch vehicle
- 1<sup>st</sup> Stage Merlin engine
- 2<sup>nd</sup> Stage Kestrel engine
- Diameter 5.5'; Length 68'
- \$7.0M per launch
- Launch from Kwajalein and Vandenberg
- 1st Stage Parachute/Water Recovery

Launched March 21, 2007 (local)

- From: RTS, Omelek, Kwajalein Atoll
- Customer: DARPA/USAF
- All major flight events were successfully demonstrated except Payload Separation & Coast/Restart
- Majority of Mission Objectives were achieved



Photos courtesy of USAKA

**Falcon 1 reached space, but not orbit**  
289km altitude; 5.1 km/s

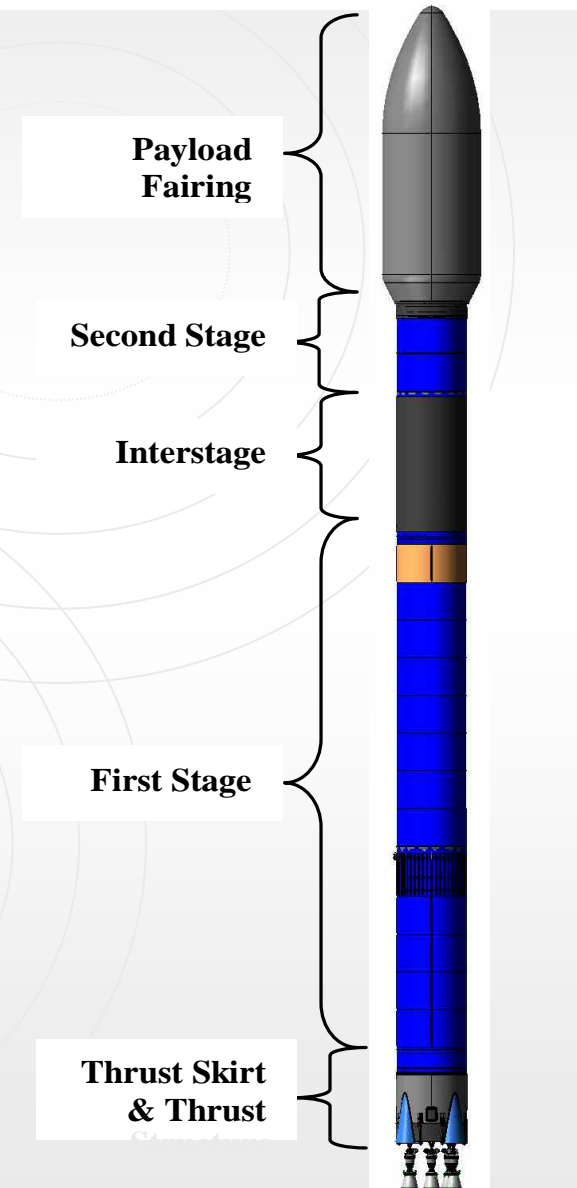
# Falcon 9 Overview

SPACEX

- Design goals:
  - Lowest cost, most reliable medium/heavy lift LV available
  - Meet EELV and NASA man-rated requirements
  - Fully reusable
- The Falcon 9:
  - Clean-sheet design (but draws on Falcon 1)
  - 2 stages, LOX/RP-1 propellants, 9 Merlin engines
  - Common dome tank architecture
  - 5.2 m fairing/Dragon capsule

<b>Length:</b>	<b>53 m (178 ft)</b>
<b>Width:</b>	<b>3.6 m (12 ft)</b>
<b>Dry Mass:</b>	<b>325,000 kg (716 klb)</b>
<b>Thrust on liftoff:</b>	<b>4.60 MN (1,035 klbf)</b>

<b>Mass to LEO:</b>	<b>9,900 kg (21,780 lbs)</b>
<b>Mass to GTO:</b>	<b>4,900 kg (10,780 lbs)</b>



# Why is Falcon 9 Low Cost?



- Systemic
  - Vertically integrated to control costs
  - Same propellant and lowest cost propellant used in all stages
  - Fewest number of stages (two) proven to be reliable
  - Truly commercial company vs. government or quasi-government heritage
- Propulsion
  - Merlin design is simplest form of a pump fed rocket engine
  - Same engine on Falcon 1 1<sup>st</sup> stage, Falcon 9 1<sup>st</sup> and 2<sup>nd</sup> stages, so economies of scale
- Structures
  - Both first and second stage tanks are friction stir welded \
  - Common bulkhead design avoids need for intertank structure
- Avionics
  - Designed in the 21<sup>st</sup> century and not burdened with legacy electronics
  - Significant number of in house components
- Launch Operations
  - Horizontal integration, only rotates vertical on launch pad
  - Highly automated countdown and checkout procedures
- Overhead
  - Lean operation with high worker to manager ratio
  - Minimal bureaucracy and overhead per launch

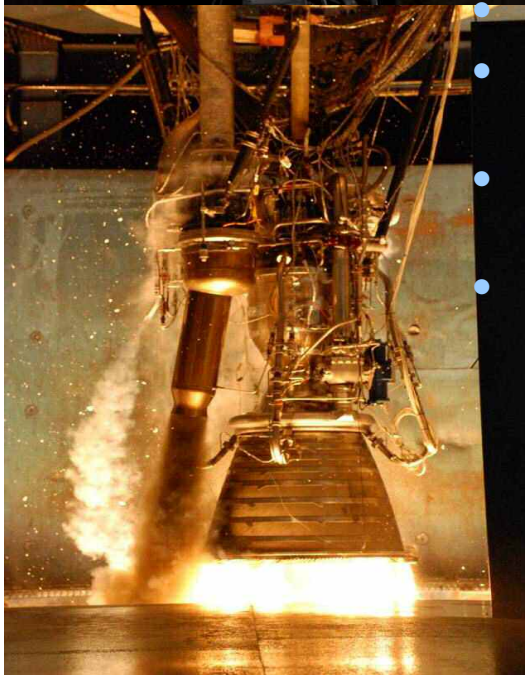
# SpaceX Progress: In five years:

SPACEX



*Photos courtesy of  
USAKA*

- Designed, developed and qualified a brand new launch system, including only the 2<sup>nd</sup> American booster engine in 25 years.
- Executed 2 Demonstration Falcon 1 flights
- Initiated development and made substantial progress on Falcon 9 and Dragon
- Have 12 flights on the current manifest (5 Falcon 1s and 7 Falcon 9s)
- Developed 2 full launch pads and begun the third (LC-40 at CCAFS)



## SpaceX Success Serves both National Security and US Economic Stability



- Reliable access to space is critical to national security and will become increasingly critical to economic stability
- Being able to augment capability on short-notice is increasingly important and requires responsive launch capability
- It is important for this nation to have domestic vehicles competitive on the international market (not through subsidies)
- It is important for the US to foster emerging providers and not shut out competition

