



NASA Launch Services Program Role in Mission Assurance

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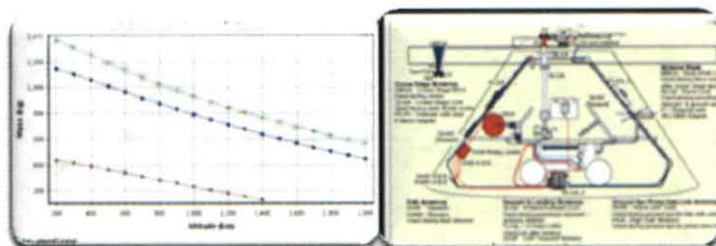


Launch Services Program Overview

LAUNCH SERVICES PROGRAM

- **NASA LSP is responsible for the acquisition and program management of Expendable Launch Vehicle (ELV) launch services for a wide variety of US government civil spacecraft**
- **NASA LSP performs mission assurance instead of buying launch insurance**
 - Approach considers initial launch failure rate and benefit of government technical evaluation
 - Keenly aware of launch vehicle failure causes and applies technical resources accordingly
- **Deeply technical, experienced, stable government civilian workforce**
 - Technical staff of approximately 200 including support contractors
 - Average government experience level in launch activities: 15 years
 - Current team has provided government go/no-go on every expendable launch vehicle (63) NASA has launched since 1998
 - 97% mission success rate since inception in 1998

Verify and validate mission engineering and analysis



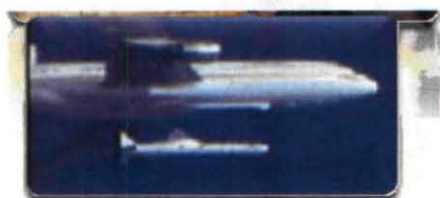
Insight and approval of production, integration, testing and processing



Manage launch vehicle to spacecraft integration



Provide technical, operational, contractual, budget and business knowledge and expertise to future missions



Certify launch systems for NASA use



Establish strategic partnerships and make investments to satisfy Agency Launch Service needs



“Launch Vehicles “On Contract” to LSP

LAUNCH SERVICES PROGRAM

- Can be awarded a qualifying contract before achieving first successful launch, but must wait until achieving a success to compete for an actual mission task order
- Falcon 1, 1E, 9, and Athena IC, IIC have not yet been awarded LSP missions
 - Are considered vehicles without significant US government involvement to date
- Delta IV was on previous contract but was not awarded a mission by LSP
- Delta II is not on the new LSP Contract
 - Was used for approximately 50% of NASA missions from 1990 to date
 - Last flight currently scheduled for October 2011





Why Perform Mission Assurance?

LAUNCH SERVICES PROGRAM

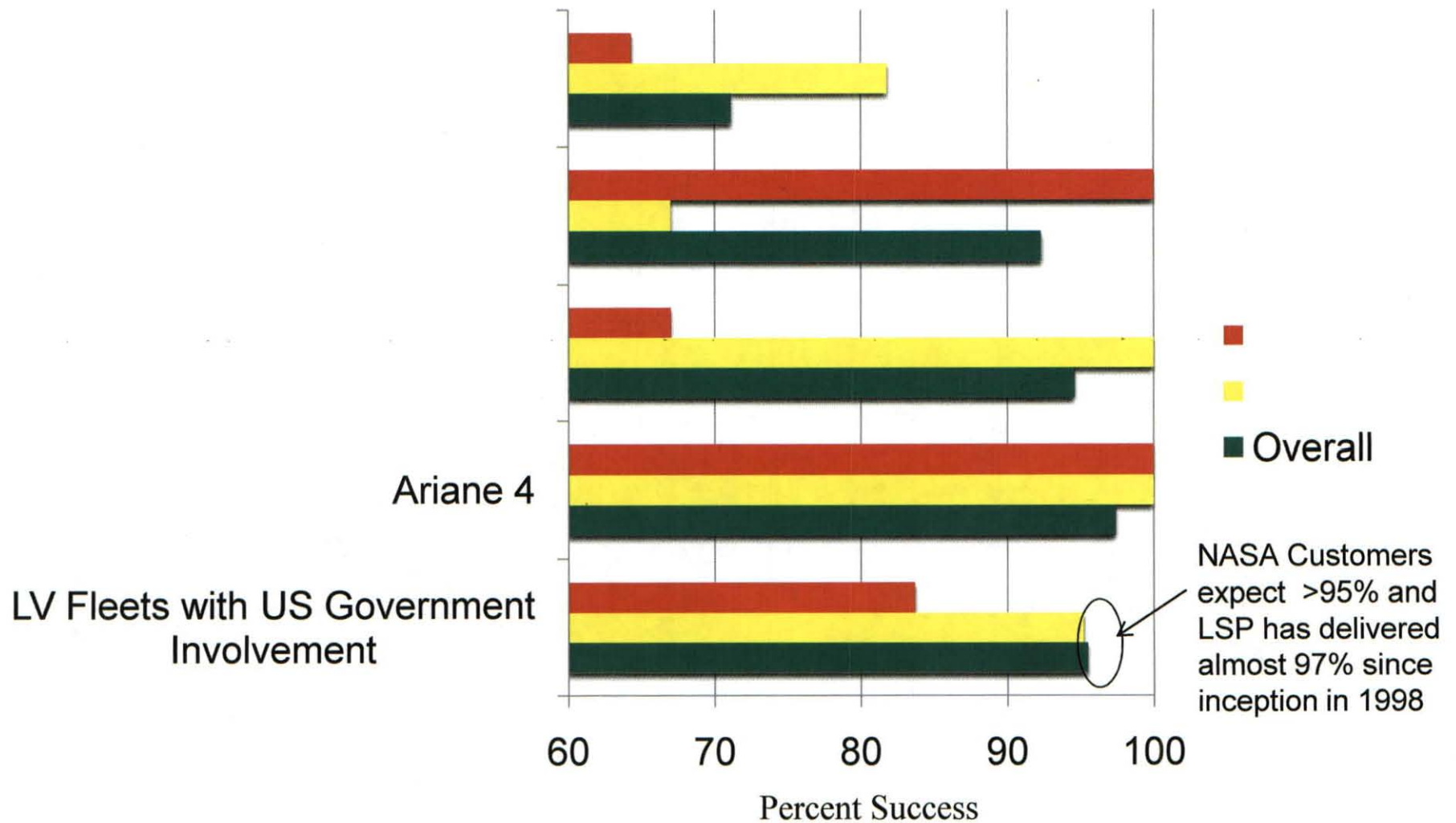
- **NASA assures mission success vs. insuring it because of overall mission value**
 - Cost of LSP mission assurance is less than insurance for moderate and high cost missions
 - Insurance payments could allow NASA to conduct another mission, but the specific mission objective would often be lost
- **Ratio of spacecraft to Launch Vehicle costs is higher than commercial industry**
 - Very few lower cost missions with spacecraft value of \$100M on a ~\$40M launch service
 - Typical spacecraft is \$400M to \$600M looking for a \$100M launch service
 - Planetary missions require larger LV's with service costs of \$150M to \$300M
 - Most expensive missions are \$1B+ (have launched a \$1B mission on an \$80M service)
- **Not allowed to directly purchase insurance**
 - In some cases have used delivery-on-orbit with a re-flight provision with assumption that the commercial launch company secures insurance to meet their re-flight obligation
 - Commercial launch companies say they insure the LSP imposed launch failure penalty of 25% of the launch service contract price
- **Commercial launch provider must have 3rd party liability insurance**
 - To the maximum amount available in "the commercial marketplace" at a reasonable cost, but NTE \$500M for each launch
 - Analogous to the FAA's insurance requirement which obligates the provider to purchase insurance for 3rd party claims to the FAA's maximum probable loss determination for licensed and permitted activities



Delta II GPS Launch Failure Video

LAUNCH SERVICES PROGRAM

- From Youtube

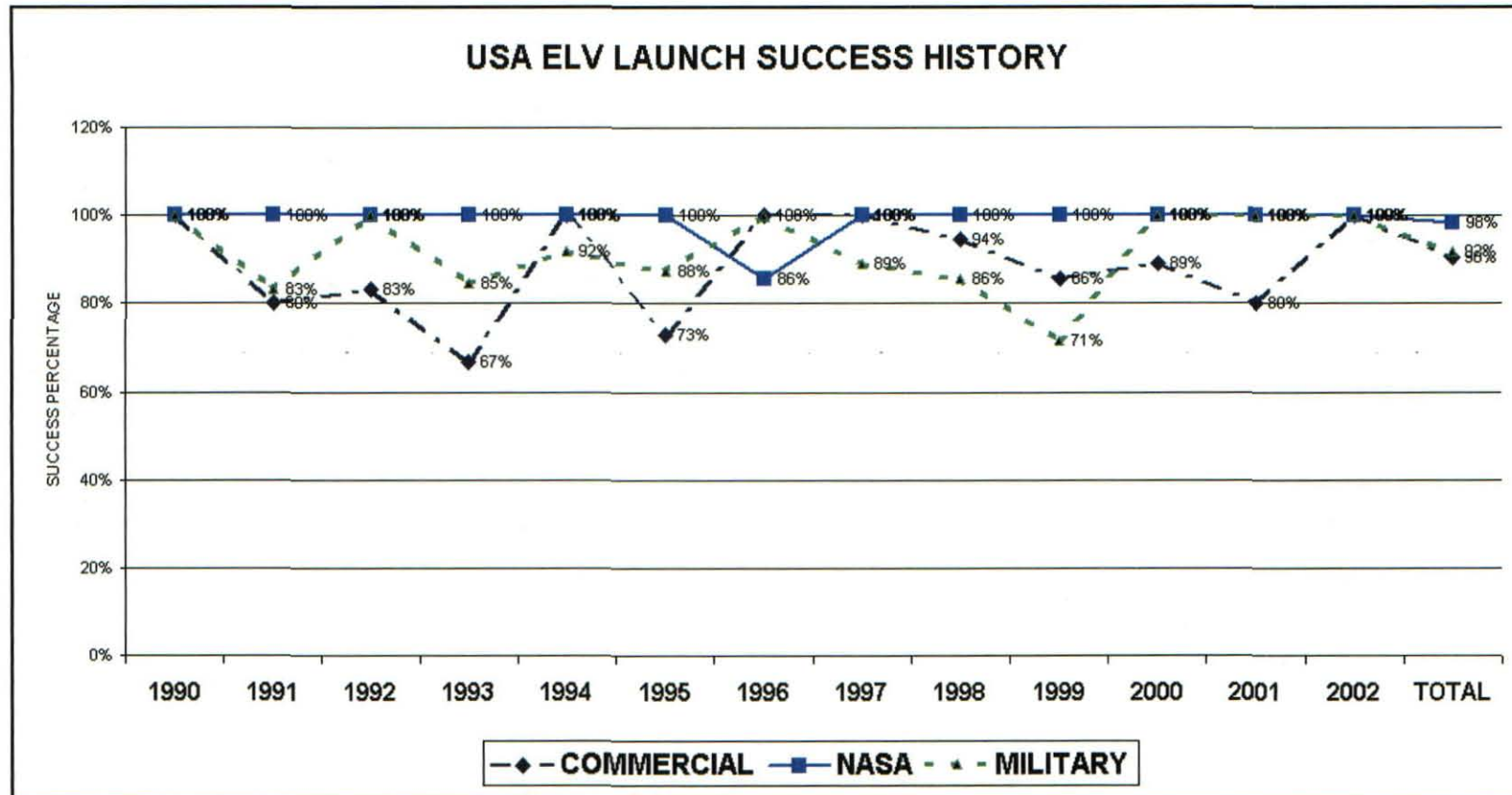


- Overall success rate for US vehicles without US Government involvement is low because these vehicles don't last in the market place and/or the US government buys them and starts to become involved
- Two recent NASA LSP failures were flights 2 and 3 of the Taurus XL bringing down the US Government rate for flights 1-3 and the overall LSP rate



World ELV Launch History

LAUNCH SERVICES PROGRAM



	1992				1993				1994				1995				1996				1997			
AGENCY	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT
SUCCESS	5	5	9	19	2	2	11	15	5	4	11	20	8	4	7	19	7	6	11	24	19	3	8	30
FAILURE	1	0	0	1	1	0	2	3	0	0	1	1	3	0	1	4	0	1	0	1	0	0	1	1
TOTAL LAUNCHES	6	5	9	20	3	2	13	18	5	4	12	21	11	4	8	23	7	7	11	25	19	3	9	31
SUCCESS %	83%	100%	100%	95%	67%	100%	85%	83%	100%	100%	92%	95%	73%	100%	88%	83%	100%	86%	100%	96%	100%	100%	89%	97%

	1998				1999				2000				2001				2002				TOTAL			
AGENCY	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT	COM	NASA	MIL	TOT
SUCCESS	17	6	6	29	12	8	5	25	8	6	10	24	4	6	7	17	6	5	1	12	104	59	103	266
FAILURE	1	0	1	2	2	0	2	4	1	0	0	1	1	0	0	1	0	0	0	0	11	1	9	21
TOTAL LAUNCHES	18	6	7	31	14	8	7	29	9	6	10	25	5	6	7	18	6	5	1	12	115	60	112	287
SUCCESS %	94%	100%	86%	94%	86%	100%	71%	86%	89%	100%	100%	96%	80%	100%	100%	94%	100%	100%	100%	100%	90%	98%	92%	93%



Failure Causes

- **Agency wide team in 2003 used LSP launch database, failure reports, USG Broad Area Review, and other industry failure studies looking back to mid '70's**
- **The predominant root cause of failures worldwide is in propulsion subsystems**
 - Many liquid propulsion failures occurred during a start of an upper stage system
 - Flight controls (software, autopilot and/or actuators) and separation systems are the next leading causes
- **The majority of failures were related to systems engineering, engineering design robustness, and/or disconnect in carrying out engineering intent as a result of process/culture problems**
- **Some of the failures studied might have been prevented by a more thorough independent analysis and review, test like you fly, attention to out-of-sequence operations, better systems engineering understanding of each component and of small changes, or better inspection**
- **Paying attention to flight data and relating it back to development activities is critical**

Predominant Launch Vehicle Failures Characteristics mid 1970's thru 2003

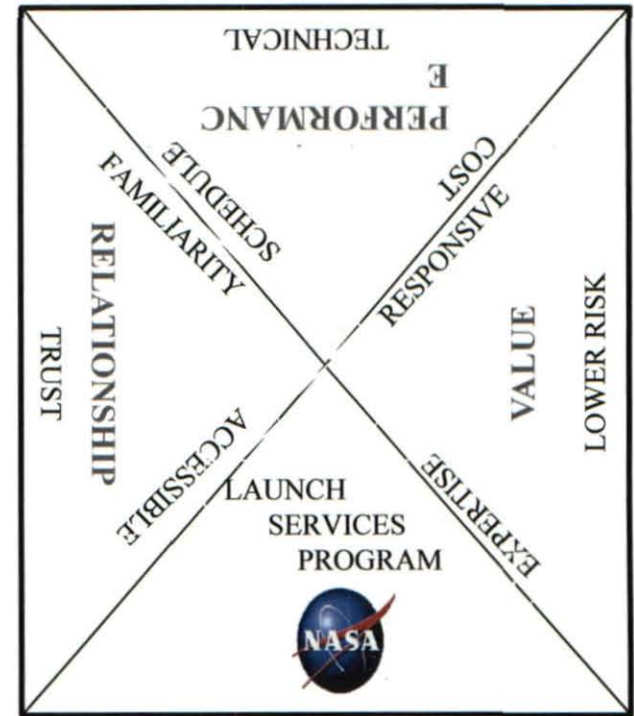
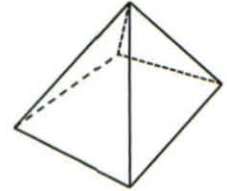
each failure can have more than one attribute	Process Culture	System Design	Operations	Reliability
Total	29	25	18	16
Liquid Core Vehicles	22	18	15	13
Vehicles w/ U.S. Gov Involvement	15	12	12	10



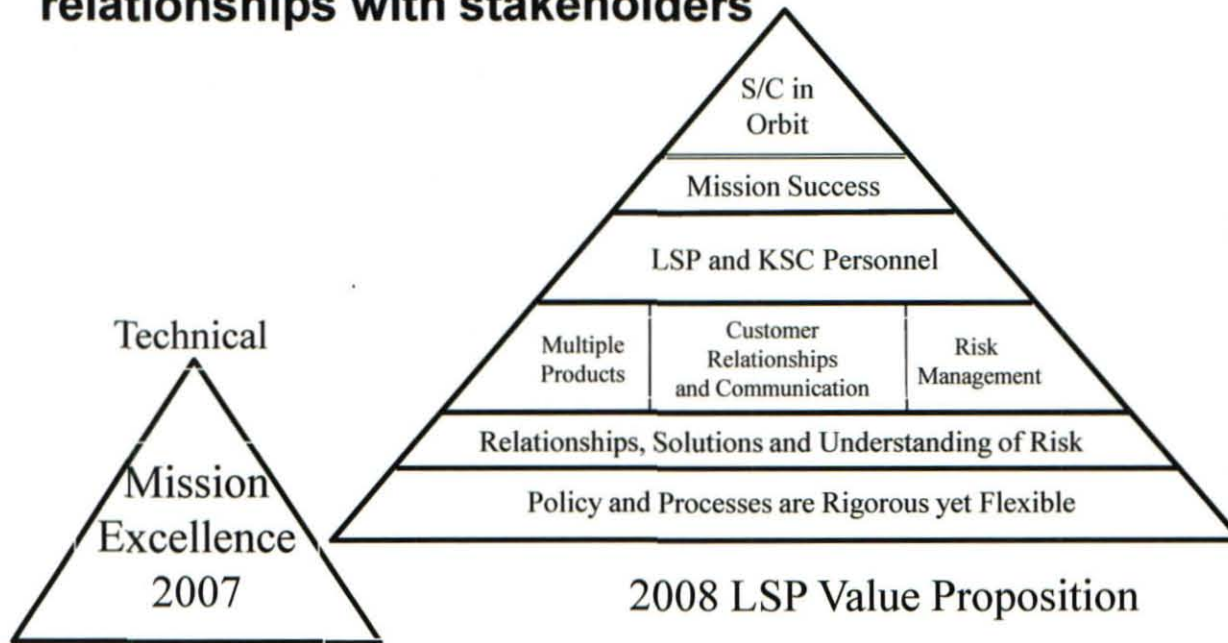
Evolution of LSP Mission Assurance into Mission Excellence

LAUNCH SERVICES PROGRAM

- \$500M for a launch service with 100% demonstrated reliability wouldn't meet all of NASA's needs, nor would \$50M for a service with <95%
- Must elevate program management functions (cost and schedule) to match technical performance for missions to be fully successful
- Must add value by lowering risk and build trust in relationships with stakeholders



2009-Present
"3 Dimensional Mission Excellence"



2008 LSP Value Proposition



Schedule Cost

2006: Created Independent Technical and Safety Authorities



Key Points for Technical Performance and NASA Oversight

LAUNCH SERVICES PROGRAM

- **NASA LSP provides common level of technical oversight over different commercial launch vehicles using independent technical assessments free from programmatic considerations**
- **Processes are strong and yet flexible, across diverse providers and missions**
- **Technical Oversight Policy Directive 8610.23 seeks to ensure “the highest practicable probability of launch success by involvement in, and control of, the launch through technical oversight” which is limited in approval but has widespread insight**
- **Program Manager has the sole authority to accept risk and can/does ask for alternate technical recommendations based on cost, schedule or mission risk posture**
- **NASA retains the right to non-concur with the contractor’s proposed actions based upon technical knowledge obtained through insight process**



LSP Technical Team

LAUNCH SERVICES PROGRAM

- **LSP has a lean, highly knowledgeable and experienced technical team**

- **LSP Engineers are required to understand the specifics of not only the relevant NASA technical standards, but also those of comparable military, commercial, and corporate-internal standards**

- **Establish partnerships with other agencies (USAF, NRO etc) on mission assurance and lessons learned from launch failures**



Technical Policy Directive 8610.7 is Used to Direct Non Recurring Assessment of New LVs

LAUNCH SERVICES PROGRAM

- NPD 8610.7 NASA Risk Mitigation Policy: " NASA launch vehicle assignment and acquisition strategy seeks to balance launch risk for individual missions with launch vehicle demonstrated flight history and NASA technical penetration consistent with overall mission risk"
- Provides a strong foundation for the LSP Insight and Approval (recurring work) as required by NPD 8610.23 (Technical Insight and Approval)

Spacecraft Classification	Launch Vehicle Category	May Launch On
<u>Class D</u> Low cost and simple Potentially "replaceable"	<u>Category 1</u> High Risk LV Not normally launched on the LSP Contract	<ul style="list-style-type: none"> - May be the first flight on a New launch vehicle configuration with no previous flight history - Very limited NASA technical review
<u>Class C (and B in rare cases)</u> Moderate cost and complexity By itself not critical to achieving a major NASA objective	<u>Category 2</u> Medium Risk LV	<ul style="list-style-type: none"> - Requires at least one success (up to 3) of a "common launch vehicle configuration" - Meaningful NASA LSP technical evaluation - Extensive verification of margins from flight data and resolution of all flight anomalies and observations
<u>Class A and B</u> High cost and/or complexity Most NASA missions are class B	Category 3 Low Risk LV Designed to assure highest practicable probability of success	<ul style="list-style-type: none"> - Requires at least 3 or 6 success of a "common launch vehicle configuration" - Major NASA technical evaluation for 3 flight method, meaningful evaluation for 6 flight method - Extensive verification of margins from flight data and resolution of all flight anomalies and observations - May require 14 consecutive successful flights in some cases without extensive technical evaluation



Key Technical Items in Certification

LAUNCH SERVICES PROGRAM

- **Conduct Launch Vehicle Hardware Qualification and Acceptance Test Engineering Review Boards**
- **Comprehensive LSP conducted independent analyses (IV&V)**
- **LSP ERB verifies that the demonstrated vehicle configuration flight met the predicted vehicle and performance parameters within three sigma criteria comparing with qualification test results**
- **Require Launch Supplier to perform a full vehicle Ishikawa Fishbone Analysis**
- **Design Certification Review is a tool that effectively requires a CDR after the basic configuration has completed build, test flight and anomaly resolution**



Specialty Areas LSP Advisory Services

LAUNCH SERVICES PROGRAM

- **Most NASA missions are best served with full launch services acquired by the LSP, however, recognize that not all missions can go this route**
- **Over the past 4 years LSP has developed areas of specific insight and offered them to a mission if a full launch service isn't purchased**
 - Offering advisory services, but not inserting ourselves without customer request
 - Document each advisory service separately to define responsibilities and resources required
 - Because mission assurance is a complex combination of the full complement of LSP services, won't take overall mission assurance responsibility when in an advisory role
- **Examples of documented advisory services**
 - GOES-O/P on Delta IV on FAA licensed mission
 - James Webb Space Telescope (JWST): Foreign Cooperative mission on Ariane V
 - Global Precipitation Measurement (GPM): Foreign Cooperative mission on H-IIA
 - COTS Phase I on Falcon 9 and Taurus 2
 - ISS Commercial Resupply Services (CRS) on Falcon 9
 - LADEE Supplemental Advisory and Risk Team (SMART) for Minotaur V
- **Is there a way for the launch insurance community to work together with NASA LSP?**
 - Advisory services could be offered if there is some benefit to the US Government
 - LSP is interested in understanding what risk items insurance community sees and how they are quantified
 - darren.m.bedell@nasa.gov



Potential back up material

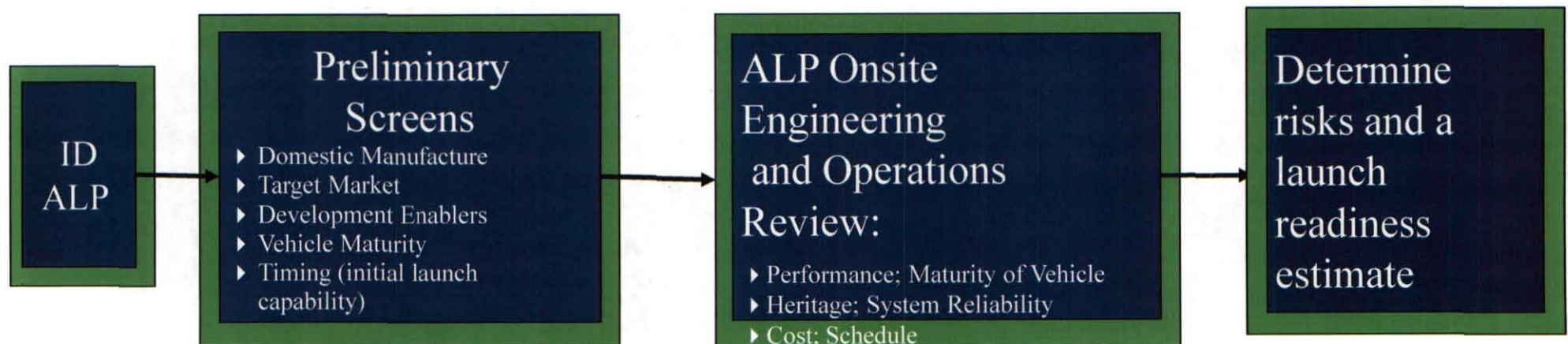


Alternate Launch Provider Approach

2006 Study of New Providers

LAUNCH SERVICES PROGRAM

- LSP offers unfunded Space Act Agreements for interested and qualified companies/vehicles
 - Criteria includes SRR maturity, supplier existing funding, viable launch date
 - No agreement for Falcon 1 or 9 needed because they are on contract
 - Existing service contractors can obtain SAA's for vehicles not on contract



Alternative Launch Provider – defined to be any launch service contractor that is not currently on contract with NASA Launch Services Program

Goal: Framework to consider Launch Service options LSP might pursue to strengthen our portfolio



Comparison of Launch Vehicle Success Rates

LAUNCH SERVICES PROGRAM

The value of independent technical evaluation is clearly shown by historical data

	ELV Fleets with Significant US Gov Involvement	US ELV Fleets without Significant US Gov Involvement	NASA Missions with full policy implemented	Ariane 4 and 5 95.95% total success		Soyuz and Molniya Family	HII, HIIA and HII B
				Ariane 4	Ariane 5		
Period of Perf	Jan 1990- March 2011	Jan 1990- March 2011	Jan 1990- March 2011	June 1988- Feb 2003	June 1996- March 2011	Jan 1990- May 2007	Feb 1994- March 2011
Success/ Total	327/341	27/38	92/95	113/116	53/56	280/283	24/26
Success Rate	95.5%	71.1%	96.8%	97.41%	94.6%	98.94%	92.3%
Infant Success							
Flights 1-3	83.7%% (36/43)	64.3% (18/28)	2 recent failures	100%	67% (4/6)		100% (8/8)
Flights 1-6	89.4%	69.2%		100%	83.3% (10/12)		85.7%
Flights 4-6	95.2% (40/42)	81.8% (9/11)		100%	100%		67% (4/6)

Note that Atlas I (3 of 6; 1990) and Pegasus XL (4 of 6; 1994) bring down the infant success rate of ELV fleets with significant US government involvement

NASA's Launch Services Program



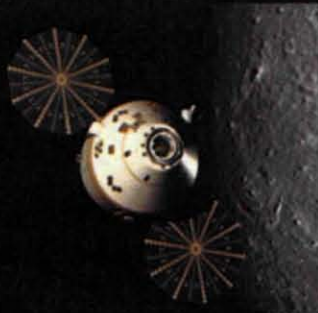
"Earth's Bridge to Space"

Darren Bedell - Program System Integration Manager

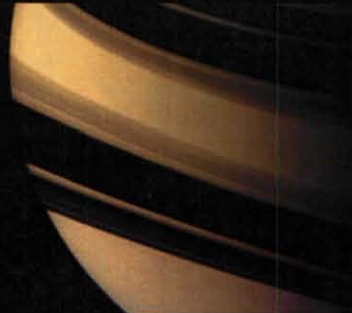
How is NASA Organized? Mission Directorates



Aeronautics



Exploration



Science



Space Operations



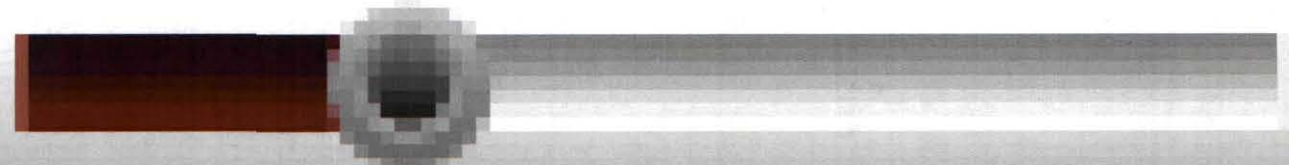
Launch Services
Program



What is the NASA Launch Services Program?



You Tube



LSP Vision

To be the recognized leader in launch services

LSP Mission

Leadership and expertise in providing on-orbit, on-time, and on-cost launch services

LSP Goals

Goal 1: Maximize Mission Success

Goal 2: Assure Long-Term Launch Services

Goal 3: Promote Evolution of a U.S. Commercial Space Launch Market

Goal 4: Continually Enhance LSP's Core Capabilities



LSP Vision

To be the recognized leader in launch services

LSP Mission

Leadership and expertise in providing on-orbit, on-time, and on-cost launch services



LSP Goals

- 2010: Maximize Mission Success
- 2010: Maximize Program Launches/Year
- 2010: Maximize Budget in FY Commercial Space Launch Market
- 2010: Maximize and Enhance Customer Support



What is our job?

To provide technical, operational, contractual, budget and business knowledge and expertise to current and future missions

We are the "broker"



NASA Customers



Suppliers

Acquire Launch Services

Ce





Vehicle	Athena II	Minotaur IV/V	Delta 7320	Taurus II	Delta I
675 Sun Sync	1125	~1100	1550	~1900	3100

The NASA Launch Services Contract (NLS) is the primary contractual mechanism that allows LSP to implement its insight & approval responsibilities

Acquire Launch Services

Certify launch services for NASA



Certify launch systems for NASA use



NASA Launch Services Small Class of Launch Vehicles



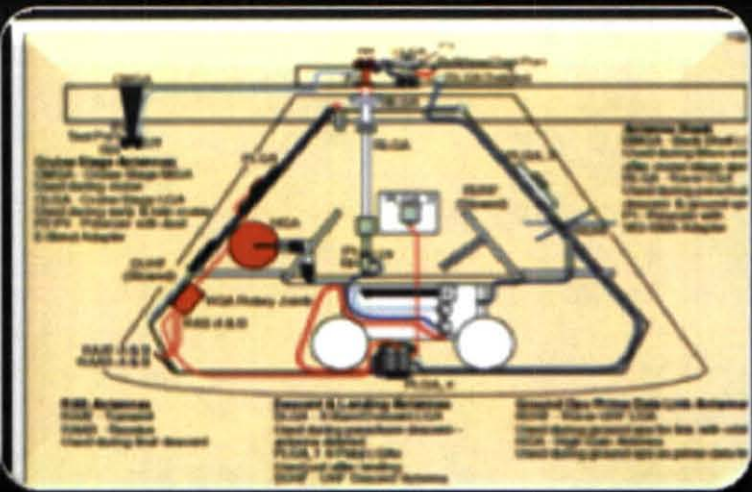
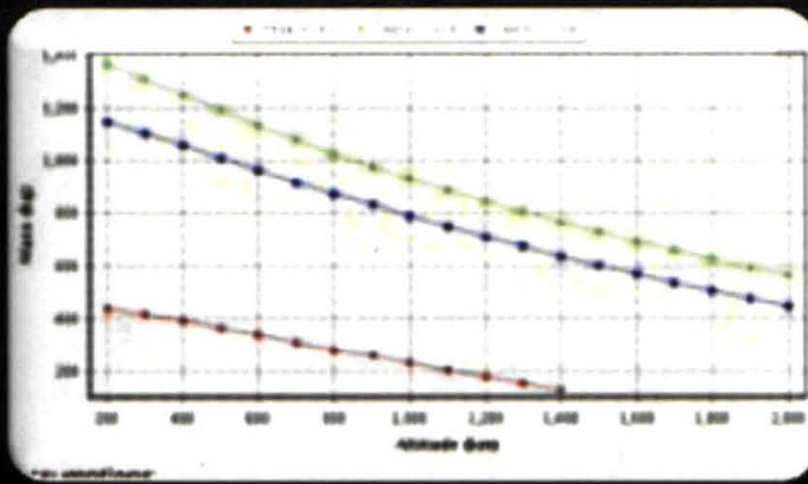
Vehicle	Falcon 1	Falcon 1E	Pegasus XL	Athena I	Minotaur I	Taurus XL	Athena II
675 Sun Sync			-225		-325	775	1125

NASA Launch Services

Medium and Large Class of Launch Vehicles

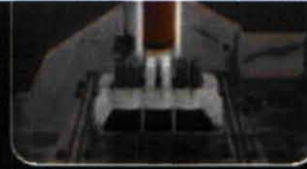


Vehicle	Athena II	Minotaur IV/V	Delta 7320	Taurus II	Delta II	Falcon 9 Block 1	Falcon 9 Block 2	Delta IV 4040	Atlas V 401
675 Sun Sync	1125	~1100	1550	~1900	3100	6350	7400	6800	6615

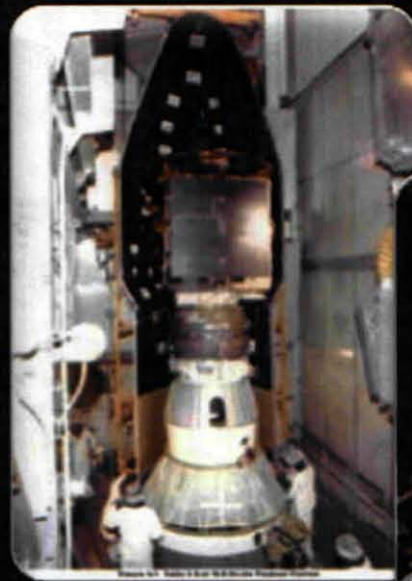


Provide mission engineering and analysis

Provide insight into
production,
integration, testing,
and processing



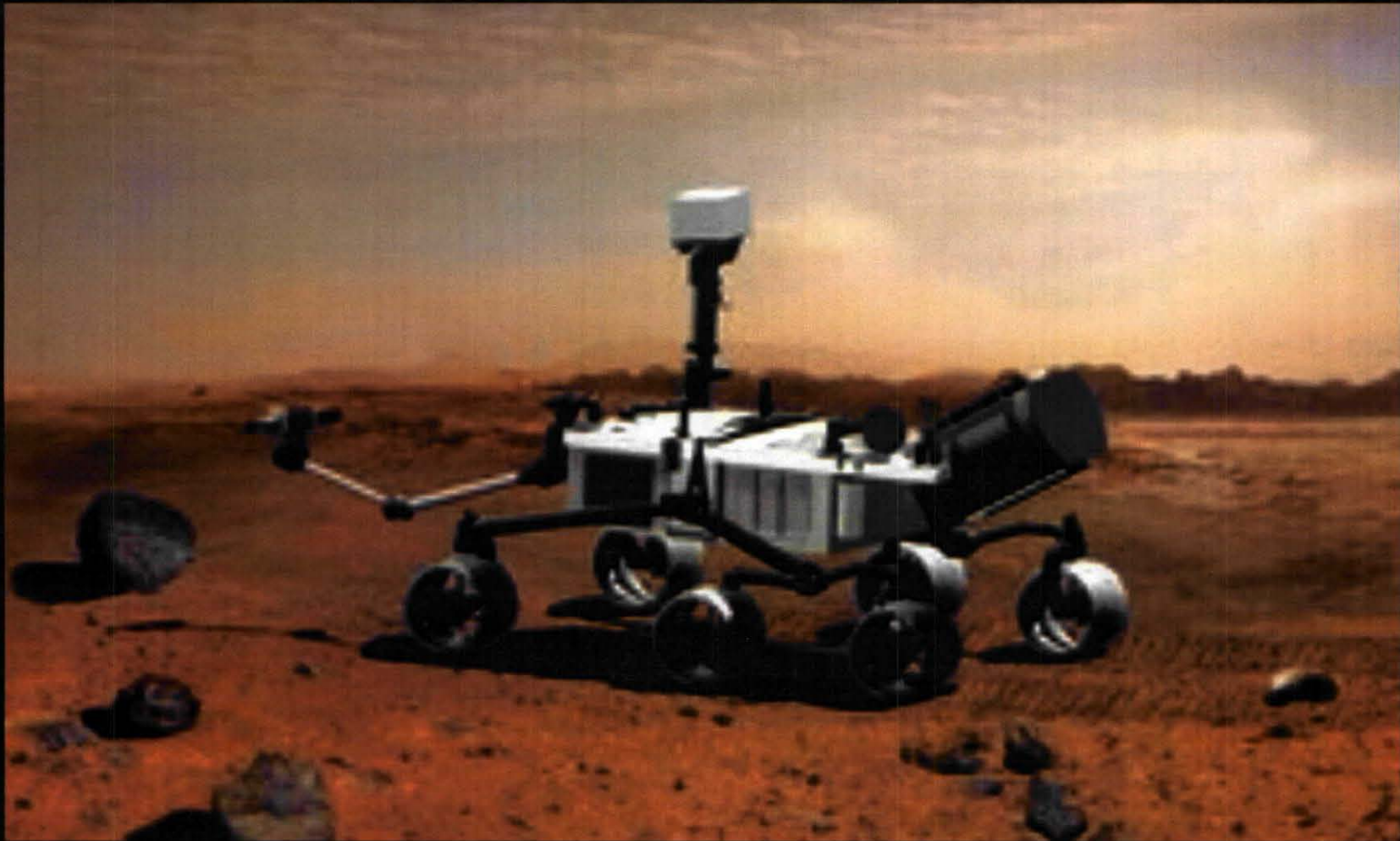
Manage launch vehicle to spacecraft integration



What LSP Really does...



We take a spacecraft



oes...



And launch



Integrate it with a launch vehicle

And launch it to space!

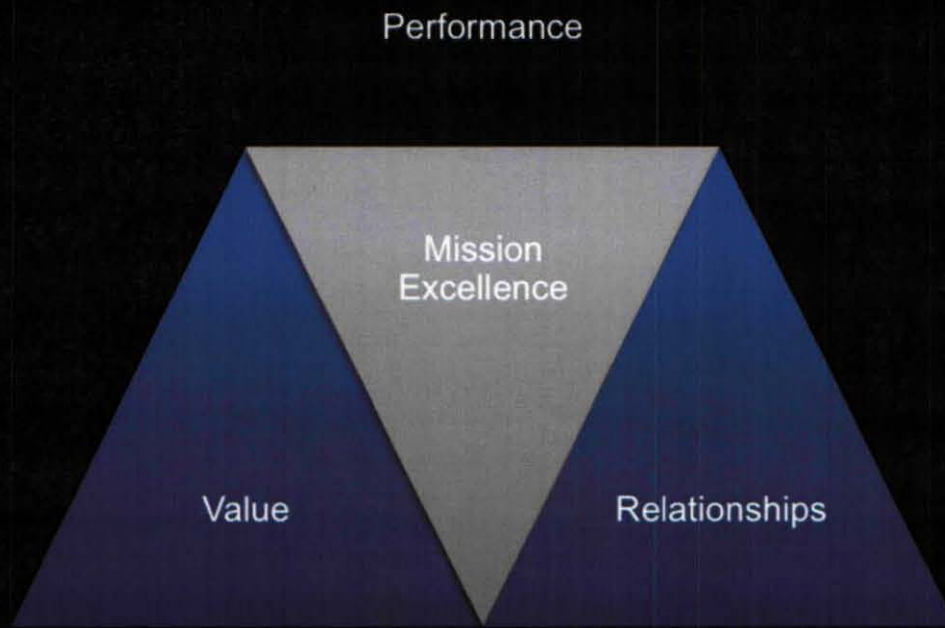


The Value That LSP Adds



expertise

The Value That LS



Trust

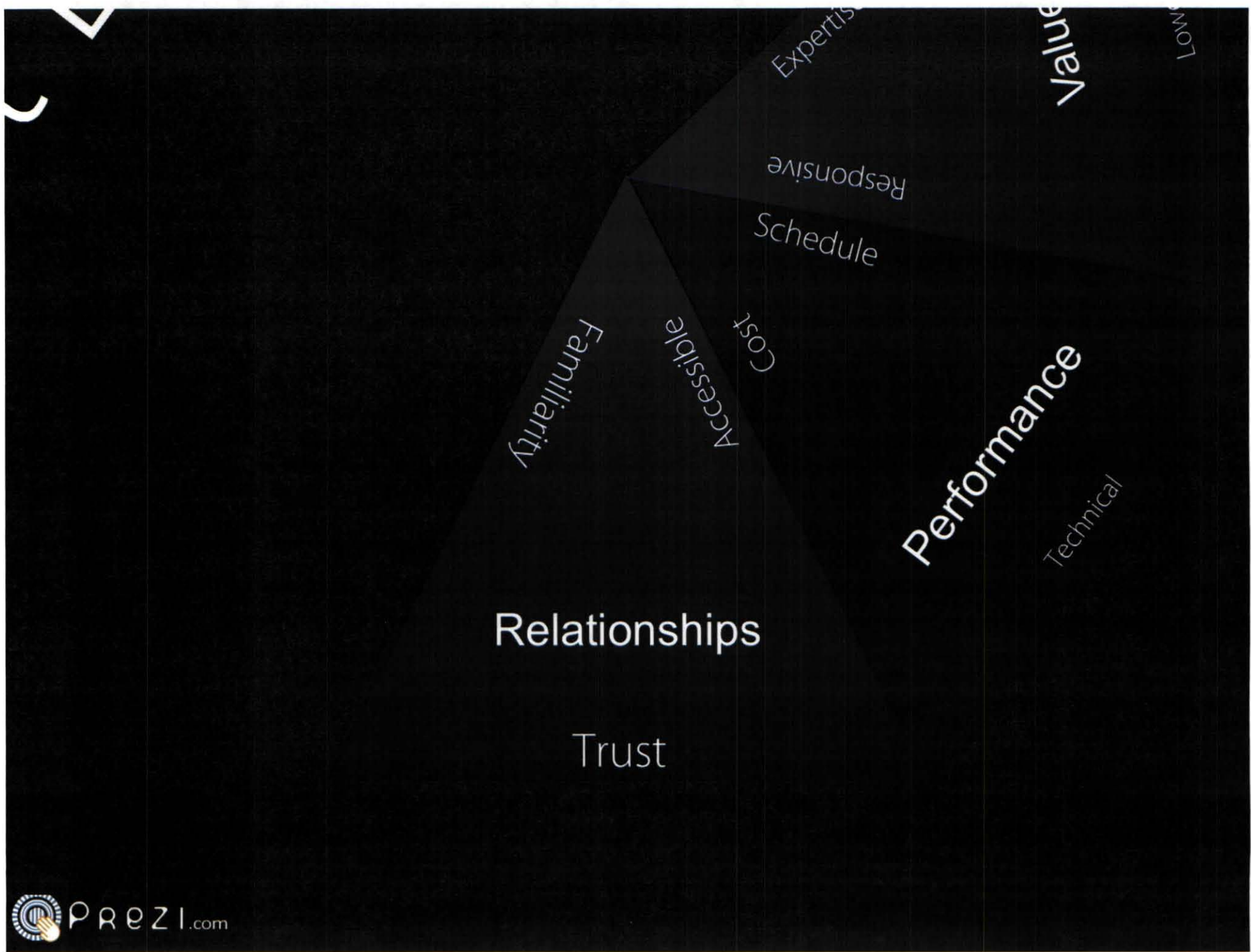
Relationships

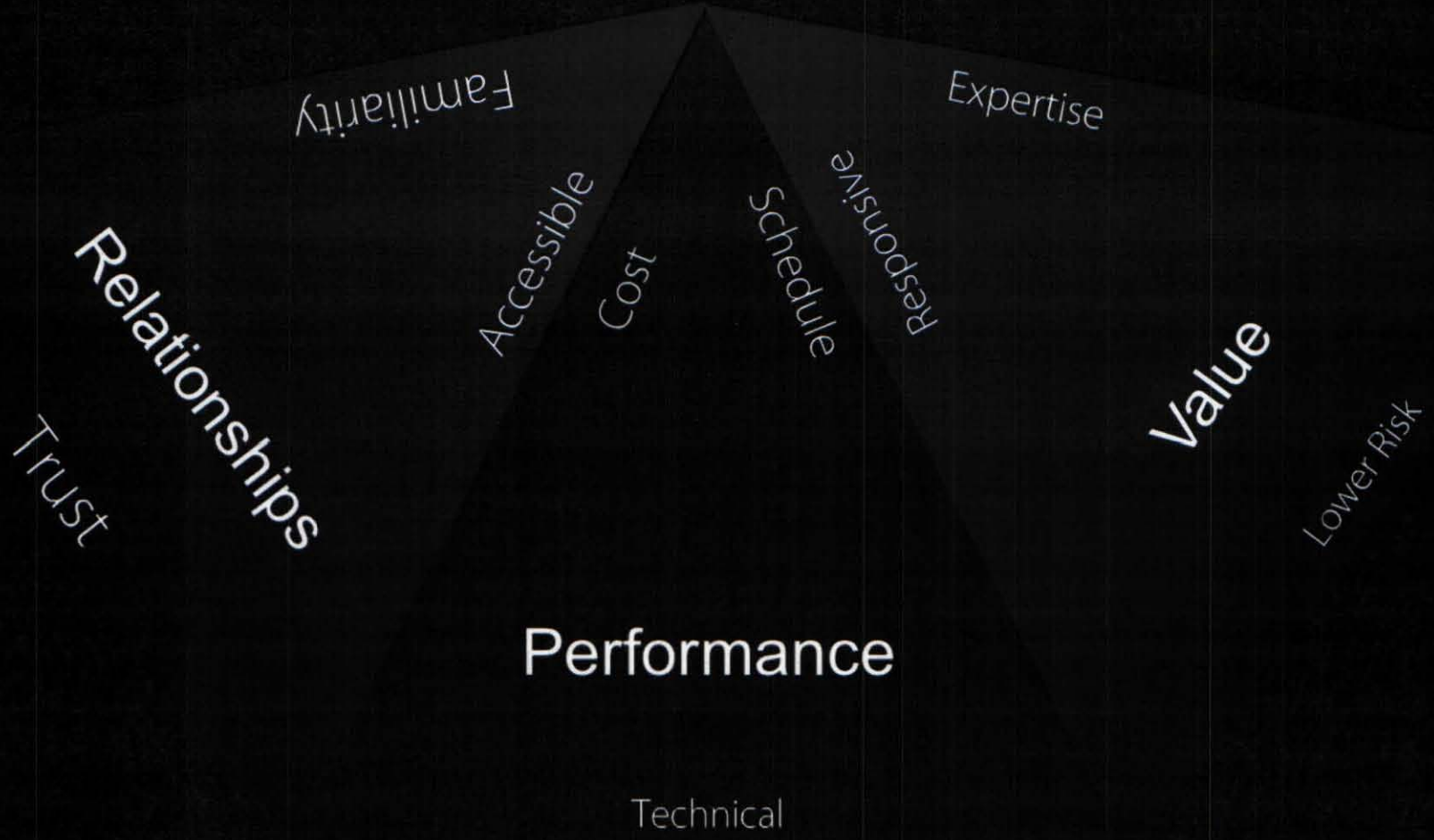
Accessible

Familiarity

Pe







1st

Relationships

Familiarity

Accessible

Cost

Schedule

Responsive

Expertise

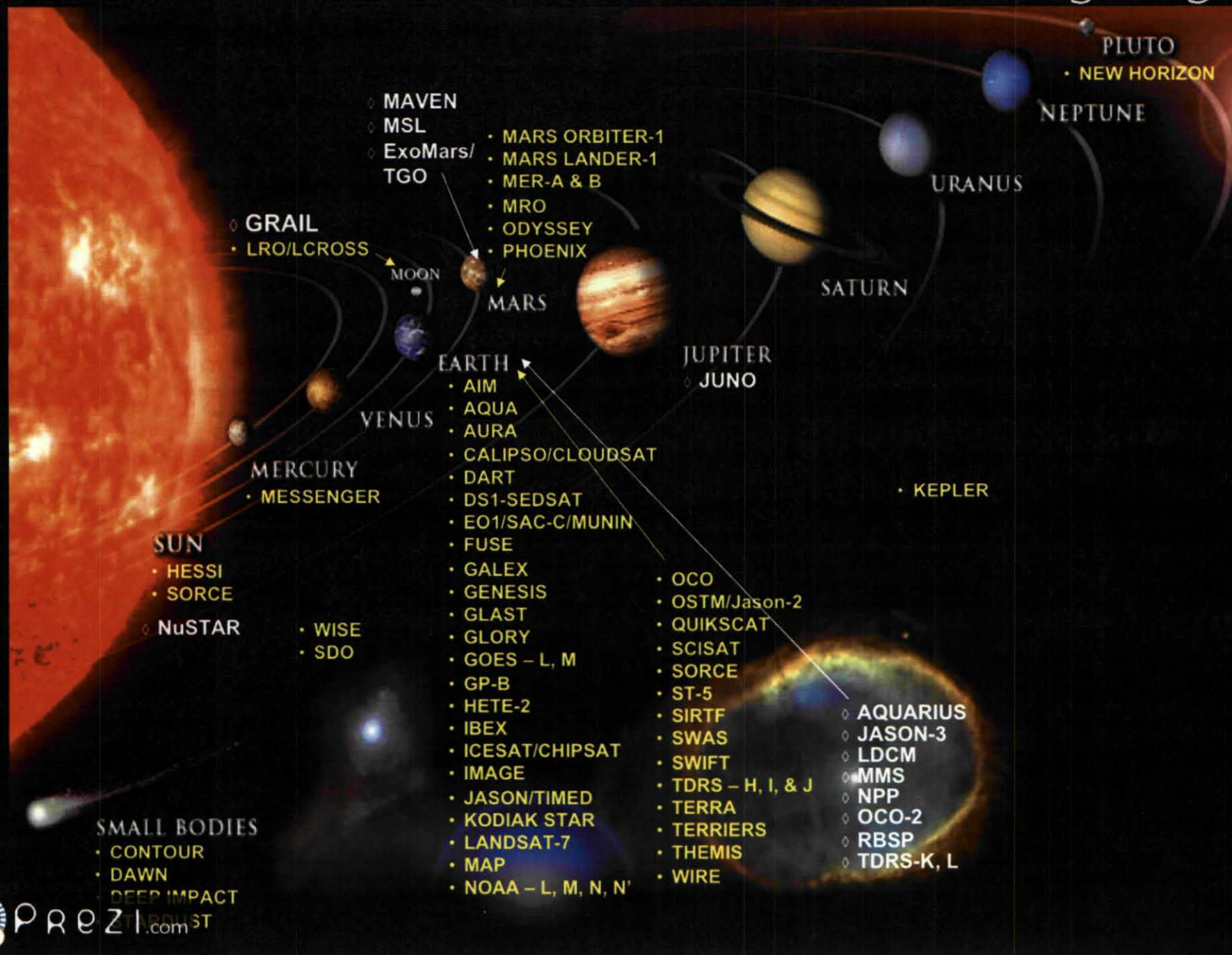
Performance

Technical

Value

Lower Risk

Where we have been and where we are going



SMALL BODIES
CONTOUR
DAWN
DEEP IMPACT
STARDUST

- IBEX
- ICESAT/CHIPSAT
- IMAGE
- JASON/TIMED
- KODIAK STAR
- LANDSAT-7
- MAP
- NOAA – L, M, N, N'

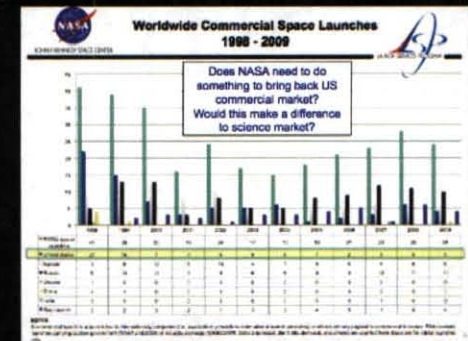
- SIRTIF
- SWAS
- SWIFT
- TDRS – H, I, & J
- TERRA
- TERRIERS
- THEMIS
- WIRE

- ◇ AQUARIUS
- ◇ JASON-3
- ◇ LDCM
- ◇ MMS
- ◇ NPP
- ◇ OCO-2
- ◇ RBSP
- ◇ TDRS-K, L

- LSP has had 63 launches since Program inception in 1998
- Currently 11 manifested missions on contract for the future

Challenges Facing the Launch Services Program

- U.S. not competitive in launch industry
- High prices of launch services may lead to the cancellation of NASA Programs
- LSP is insignificant in terms of business compared to NRO and the Air Force
- NASA budget uncertainty
- New and developing launch services providers



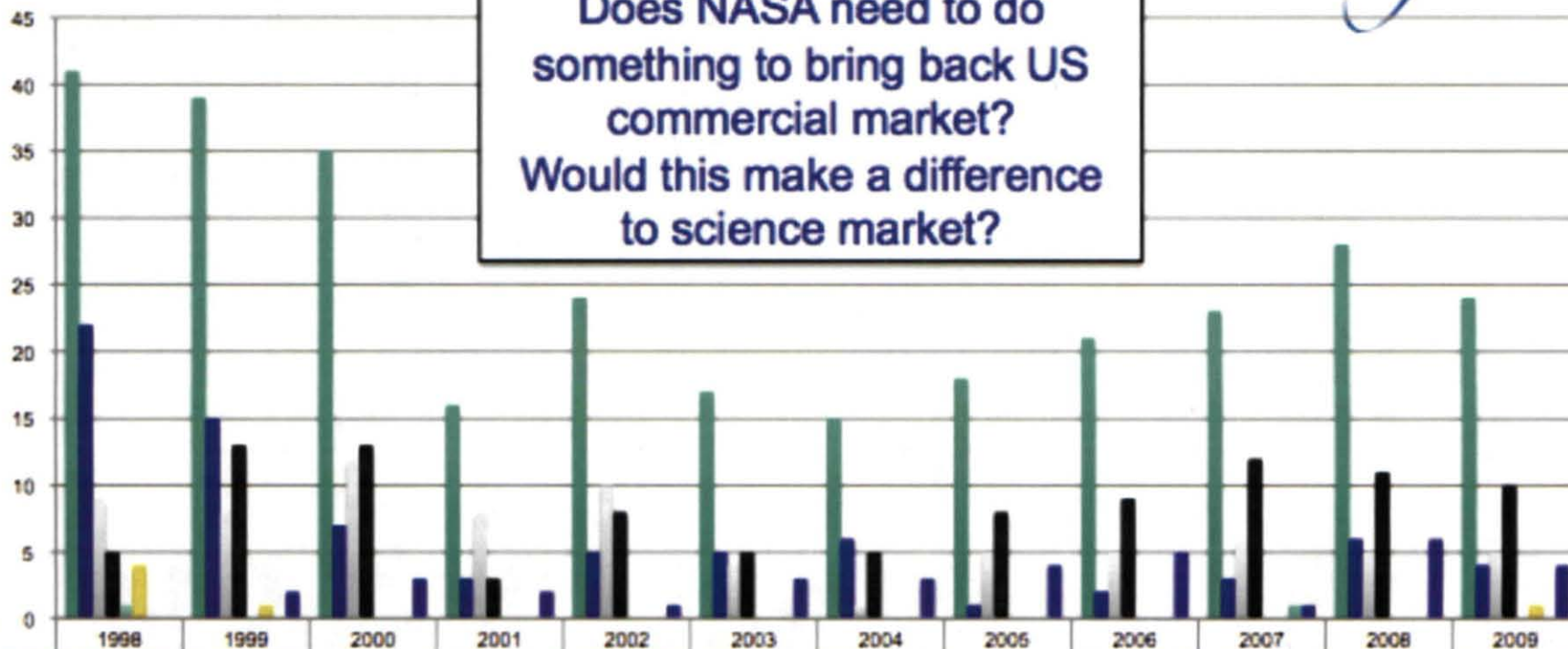


JOHN F. KENNEDY SPACE CENTER

Worldwide Commercial Space Launches 1998 - 2009



Does NASA need to do something to bring back US commercial market?
Would this make a difference to science market?



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL space launches	41	39	35	16	24	17	15	18	21	23	28	24
United States	22	15	7	3	5	5	6	1	2	3	6	4
Europe	9	8	12	8	10	4	1	5	5	6	5	5
Russia	5	13	13	3	8	5	5	8	9	12	11	10
Ukraine	1	0	0	0	0	0	0	0	0	0	0	0
China	4	1	0	0	0	0	0	0	0	0	0	1
India	0	0	0	0	0	0	0	0	0	1	0	0
Sea Launch	0	2	3	2	1	3	3	4	5	1	6	4

NOTES

Commercial launch is a launch that is internationally competed (i.e., available in principle to international launch providers) or whose primary payload is commercial in nature. FAA-licensed government (NASA and DOD) or industry payloads (ORBCOMM, Delta 3 demosat, Zenit 3SL demosat, and others) are counted here. Data are for orbital launches

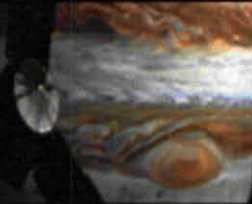


LSP 2011 Outlook

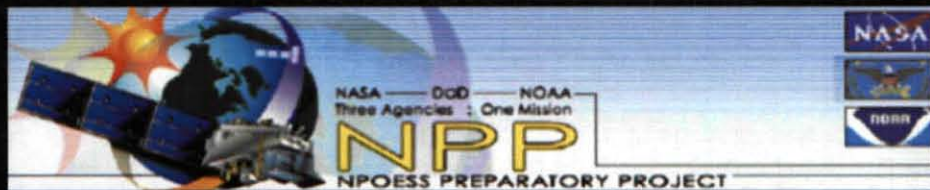


Juno

Unlocking Jupiter's Mysteries



CubeSats



NASA's Next Mission to the Moon



Mars Science Laboratory



LSP Future Launches



OCO - Orbiting Carbon Observatory



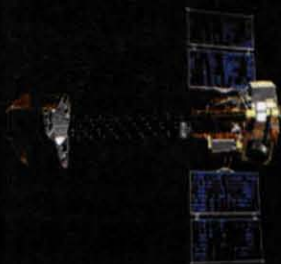
RBSP - Radiation Belt Solar Probes



LADEE - Lunar Atmosphere and Dust Environment Explorer



GEMS - Gravity and Extreme Magnetism Small Explorer



NuStar - Nuclear Spectroscopic Telescope Array



IRIS - Interface Region Imaging Spectrograph



MAVEN - Mars Atmosphere and Volatile Evolution



LDCM - Landsat Data Continuity Mission



MMS - Magnetospheric MultiScale



GPM - Global Precipitation Measurement



TDRS K&L - Tracking and Data Relay System



JWST - James Webb Space Telescope

You Tube



Prezi.com