ELaNa – Educational Launch of Nanosatellite
Enhance Education through Space Flight

Garrett Lee Skrobot
Launch Services Program, NASA
Kennedy Space Center, Florida; 321.867.5365
garrett.l.skrobot@nasa.gov

ABSTRACT

One of NASA's missions is to attract and retain students in the science, technology, engineering and mathematics (STEM) disciplines. Creating missions or programs to achieve this important goal helps strengthen NASA and the nation's future work force as well as engage and inspire Americans and the rest of the world.

During the last three years, in an attempt to revitalize educational space flight, NASA generated a new and exciting initiative. This initiative, NASA's Educational Launch of Nanosatellite (ELaNa), is now fully operational and producing exciting results. Nanosatellites are small secondary satellite payloads called CubeSats.

One of the challenges that the CubeSat community faced over the past few years was the lack of rides into space. Students were building CubeSats but they just sat on the shelf until an opportunity arose. In some cases, these opportunities never developed and so the CubeSat never made it to orbit. The ELaNa initiative is changing this by providing sustainable launch opportunities for educational CubeSats. Across America, these CubeSats are currently being built by students in high school all the way through graduate school. Now students know that if they build their CubeSat, submit their proposal and are selected for an ELaNa mission, they will have the opportunity to fly their satellite.

ELaNa missions are the first educational cargo to be carried on expendable launch vehicles (ELV) for NASA's Launch Services Program (LSP). The first ELaNa CubeSats were slated to begin their journey to orbit in February 2011 with NASA's Glory mission. Due to an anomaly with the launch vehicle, ELaNa I1 and Glory failed to reach orbit.

This first ELaNa mission was comprised of three 1U CubeSats built by students at Montana State University (Explorer Prime Flight 1), the University of Colorado (HERMES), and Kentucky Space, a consortium of state universities (KySat). The interface between the launch vehicle and the CubeSat, the Poly-Picosatellite Orbital Deployer (P-POD), was developed and built by students at California Polytechnic State University (Cal Poly).
Integrating a P-POD on a NASA ELV was not an easy task. The creation of new processes and requirements as well as numerous reviews and approvals were necessary within NASA before the first ELaNa mission could be attached to a NASA launch vehicle (LV). One of the key objectives placed on an ELaNa mission is that the CubeSat and P-POD does not increase the baseline risk to the primary mission and launch vehicle. The ELaNa missions achieve this objective by placing a rigorous management and engineering process on both the LV and CubeSat teams.

So, what is the future of ELaNa? Currently there are 16 P-POD missions manifested across four launch vehicles to support educational CubeSats selected under the NASA CubeSat Initiative. From this initiative, a rigorous selection process produced 22-student CubeSat missions that are scheduled to fly before the end of 2012. For the initiative to continue, organizations need to submit proposals to the annual CubeSat initiative call so they have the opportunity to be manifested and launched

Introduction

One of NASA's missions is to attract and retain students in the science, technology, engineering and mathematics, or STEM disciplines. Creating missions or programs to achieve this important goal helps to strengthen NASA and the nation's future work force as well as engage and inspire Americans and the rest of the world.

Figure 1

During the last three years, in attempt to bring back educational space flight, NASA generated a new and exciting initiative. This initiative is NASA's Educational Launch of Nanosatellite, or ELaNa, which is now in full swing.

ELaNa missions are the first educational packages to be carried on expendable launch vehicles (LV) for NASA's Launch Services Program. These missions contain small auxiliary satellite payloads called CubeSats. These CubeSats are built by students throughout America from high school to graduate level (Figure 1).

When the Glory Taurus T9 mission lit its engines, the first ELaNa mission began its journey as an auxiliary payload. As the vehicle lifted off the launch pad, hundreds of students from around the county who had worked on these CubeSats experienced a feeling of accomplishment. However, shortly into flight the students experienced one of the most devastating events in the aerospace world, the failure to reach orbit. The failure was not due to the student's efforts but rather an anomaly with the launch vehicle.

A Brief History

Before discussing the first ELaNa mission, it is important to understand a bit of the history of how ELaNa started. At the 2007 Rideshare conference LSP management tasked the small payloads team to deploy a P-POD system on a NASA ELV. In 2007 integration of a P-POD had never been performed on a NASA ELV, although small auxiliary payloads had flown with NASA primary missions before.

The first step for the team was finding a reference mission to which the P-POD could be integrated without violating 25 years worth of orbital life time policy guide lines while still remaining cost effective. After reviewing the launch manifest it was determined that the two Taurus XL missions OCO and Glory were the best candidates.

Together with Orbital Science Corporation, the team performed an integration study to determine if it was feasible to develop a system that could attach a P-POD to the Taurus without increasing risk to the Primary Spacecraft or Launch Vehicle. From this study, it was determined that a system could be attached to the aft end of the Taurus third stage and one P-POD could be attached. And so the first P-POD mission on a NASA ELV was begun.

The First Mission

The LSP team generated the first ELaNa mission CubeSat manifest during 2008. The team visited six potential CubeSat projects. The CubeSat teams were required to present a complete systems review of their project. Although no LSP personal were part of the NASA CubeSat selection team, they did attend the reviews in an advisory capacity. The members of the NASA selection team came from Goddard Space Flight Center, AMES Research Center, and Wallops Flight Facilities. Each of these NASA centers has experience with either Spacecraft (SC) or CubeSat development.

The selection team was provided criteria with which to evaluate each project. The selection criterion focused on the Goals and Vision of NASA, Technical feasibility, education and the ability to meet system requirements.

This first ELaNa mission (Figure 2) was comprised of three 1U CubeSats. These CubeSats were developed, designed and built by students at Montana State University (Explorer 1 Prime), the University of Colorado, Boulder (HERMES), and Kentucky Space, a consortium of state universities (KySat). The CubeSats were then integrated with Cal Poly's P-POD. The P-POD is a standard carrier system for CubeSats, designed and built by Cal Poly students, which has an internal volume of 10cm x 10cm x

34cm. Because P-PODs had flown previously on non-NASA missions and were recognized as the standard, the approval process was completed ahead of schedule.

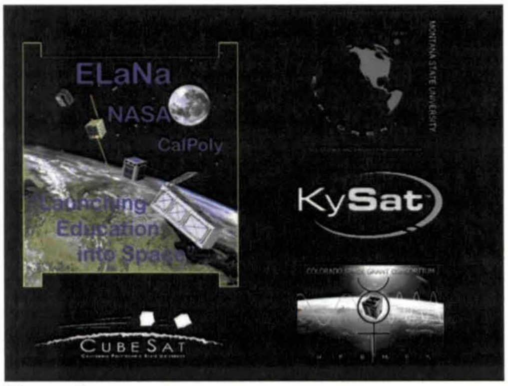


Figure 2

Cal Poly arranged for students across the globe to track the CubeSats once they had separated from the P-PODs. A total of 12 tracking stations, manned by a multitude of students, were established to receive data from the passing CubeSats. These stations would allow for over 60 minutes of coverage during each CubeSat orbit. The ELaNa I mission was a perfect execution of NASA's initiative; ideas developed by students, built by students and tracked by students.

As with all NASA projects, the ELaNa I CubeSat teams were required to attend a variety of meetings. The teams had bi-weekly telecoms to discuss and resolve possible integration issues. Before the CubeSat could continue into final P-POD integration, the CubeSat teams had to complete a Mission Readiness Review (MRR). This review was the gate to final integration of the CubeSat in to the P-POD for flight. Teams were required to present to a Review Board comprised of representatives from Cal Poly and NASA. During this review, each of the CubeSat teams were required to show compliance to mission requirements and readiness to integrate

After the successful completion of the CubeSats MRR, Cal Poly was able to start the flight integration of the CubeSat in to the P-POD. Each integrated CubeSat weighed 1kg (2.2 lb) with the completely integrated P-POD system weighing 6kg. As with most of the activities with ELaNa I, the students performed the integration of the CubeSat into the P-POD and prepared it for final vibration testing. At L-30 days before launch, after successfully completing the final testing, the integrated P-POD system was delivered to the Launch Vehicle contractor for installation on to the vehicle. The first LSP NASA P-POD mission was integrated onto the launch vehicle (Figure 3) at L-15 days before launch onto the aft end of the Taurus third stage.

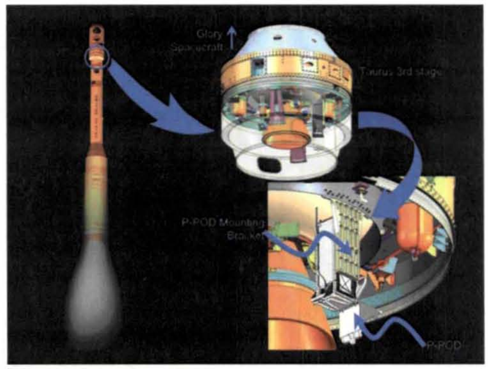


Figure 3

On March 4, 2011 at 5:09:45 a.m. EST, the Glory Taurus mission started. During ascent flight, the payload fairing failed to separate from the LV, which caused the mission to fail to reach orbit. Had the mission reached orbit, approx 13 minutes into the flight, 10 seconds after Glory separated, the third stage avionics was to send a signal to the P-POD to open the door and release the CubeSats (Figure 4). The CubeSats were to be released in the opposite direction from Glory. This was to increase the distinction between Glory and the CubeSats to ensure there was no re-contact with Glory on sequential orbits. Although the mission failed, telemetry showed that the signal was sent to the P-POD and the P-POD door opened releasing the CubeSats in a ballistic trajectory until they splashed down off the coast of Antarctica in the South Pacific Ocean.

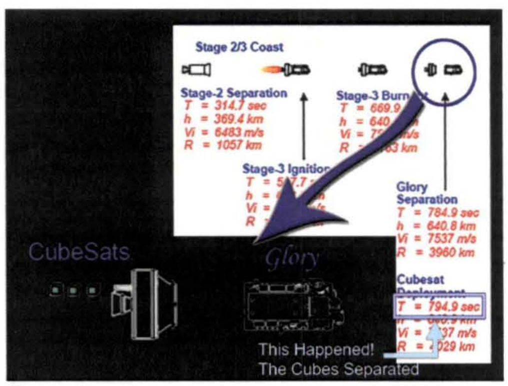


Figure 4

Certification of Flight Readiness (CoFR)

One of the questions raised during the integration of the first mission was who would provide the CoFR for the P-POD and CubeSats. This was one item that had not been address early in the process. The NASA team had to develop a process which the P-POD and CubeSats would follow to ensure that they did not increase risk to the primary mission and the launch vehicle

To identify any risk that the P-POD or CubeSat may introduce onto the primary mission, a hazard (fishbone) analysis was performed. The technical team looked at each of the possible failure scenarios that the P-POD system could introduce and developed technical rational to close these scenarios. During the development of the fishbone (Figure 5) a total of 38 possible bones were generated for review and closure.

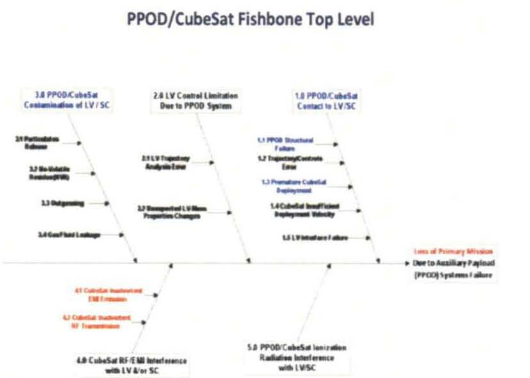


Figure 5

After the fish bone analysis had been completed, the Launch Services Program Requirements document (LSP-REQ-317.01) was developed. This is the governing document outlining the requirements which must be met in order to integrate a P-POD system on a NASA ELV. These requirements are directly mapped from the fishbone analysis and are then incorporated into the appropriate Integration Control Document (ICD).

As with all NASA ICDs, there is a requirement matrix which identifies the requirements that shall be verified by the team. There are two ICDs which govern the approval to integrate the P-POD system, the launch vehicle to P-POD and P-POD to CubeSat.

Each of the above elements, the fishbone analysis, program requirements, and ICDs, were required to undergo a NASA Engineering Review Board (ERB) to ensure that each of the hazards were identified, mitigated through a requirement and the appropriate rationale for closure was provided. During the first ELaNa mission there were 17 ERBs conducted to ensure the P-POD system did not increase risk to the primary mission (Figure 6).

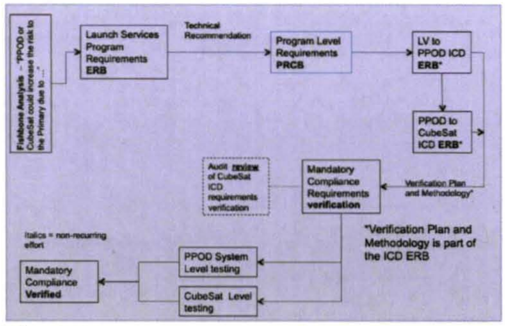


Figure 6

The Approval Process

Completion of CoFR process does not ensure approval to integrate onto the mission. The complete process must be presented at all levels within NASA. This includes the Associate Administrator from Space Operations Mission Directorate, the director of Office of Safety and Mission Assurance, the agency's Chief Engineer and then finally the NASA Flight Planning Board (FPB).

The FPB is comprised of representative from all of the NASA directorates which have an interest in manifesting payloads on NASA ELVs. When a P-POD system is to be integrated onto a NASA primary mission, the FPB must provide approval prior to integration. To date, there have been two such FPB presentations, one for the Glory mission and one for the NPP mission. Both of these presentations resulted in the approval to integrate and deploy the P-POD system.

The CubeSat Initiative

After ELaNa I had begun the approval process for flight on an Expendable Launch Vehicle, NASA realized that an official CubeSat selection process needed to be developed. This realization lead to the development of the NASA CubeSat Initiative that provided a process for future CubeSat missions selections. The initiative allows for the 'call' for CubeSat proposals. In response to the call, CubeSat projects submit proposals to NASA for consideration. The proposals are reviewed and prioritized by the CubeSat selection board. This board is chaired by the SOMD Chief Technologist and is made up of members from the Science Mission Directorate, Office of Chief Technologist, Education, SOMD, Department of Deference, and Earth Science Mission Directorate (Figure 7).

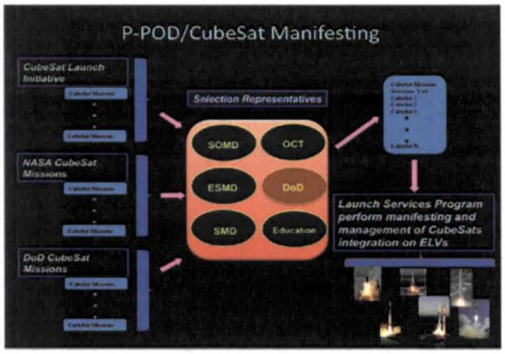


Figure 7

To date, there have been two CubeSat calls for proposals. The first call resulted in 16 proposals from which 12 CubeSats were selected for flight. A second call was released just a few months after the first selections were made. During the second call, a total of 32 proposals were submitted to the board for review. Of these 32, the board found that 20 proposals met the requirements of the announcement. The two calls produced a total of 32 CubeSat missions, which would need to be flown.

In the future, NASA will release a CubeSat Initiative announcement, or call for proposals, annually in August. CubeSat proposals must be submitted within 110 days after the announcement has been released. The August announcement coincides with the annual SmallSat Conference and the due date provides the students sufficient time to develop proposals while school is in session.

After the CubeSat selection board is complete, it falls to LSP to manifest and coordinate the integration of the chosen missions. Thus far, LSP has secured four additional LVs for the CubeSats. There are three P-POD slated on the NPP Delta II mission (2011) carrying five CubeSats, four P-PODs on CRS#2 (10 CubeSats) and five P-PODs on CRS#3 (still being manifested) Falcon 9 ISS mission (2012). LSP has partnered with Office of Space Launch of the NRO to attach three P-PODS (5 CubeSats) on their OUTSat Aft Bulkhead Carrier mission in 2012.

The Figures 8 - 11 below shows the projects that have been manifested for each mission. Approximately 26 CubeSat missions will be flown through 2012 as a result of the NASA CubeSat Initiative. While this is an impressive number of CubeSat to be manifested, there are still 13 CubeSat missions on the unassigned list. These missions have tighter requirements for orbit locations and therefore have not yet been matched with the appropriate LV. There are several possible opportunities to secure flights for CubeSats in FY13 and FY14.

Manifest

ELaNa III (10/2011) Delta II

Mission Title	University	Size	Mission Manifested
Mcubed/COVE	University of Michigan	1U	NPP
Explorer-1[PRIME] F2	Montana State University	1U	NPP
AubieSat-1	Auburn University	1U	NPP
RAX	University of Michigan/SRI	3U	NPP
DICE	Utah State University	2-1.5U	NPP

Figure 8

ELaNa IV (4/12) Falcon 9

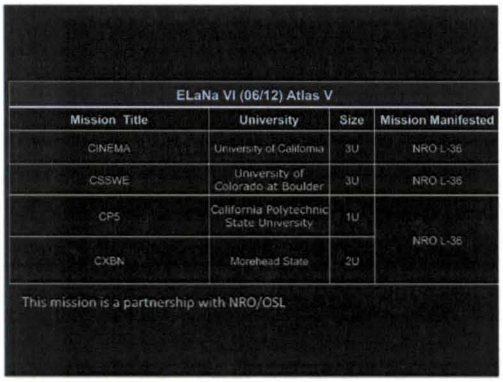
Mission Title	University	Size	Mission Manifested
Lunar Orbiter/Lander CubeSat	Vermont Technical College	1U	CRS II
Swamp Sat	University of Florida	1U	
Black Night 1	West Point	1U	
PhoneSat	ARC	1U	CRS II
SPA-1 Trailblazer	University of New Mexico/	1U	
NPS-Sat	NPS	1U	
TetherSat	STP	3U	CRS II
TJSat	Thomas Jefferson HS	1U	CRS II
DragonSat-1	Drexel University	1U	
Copper-Cube: Infrared Imagin on a CubeSat	St. Louis University/	1U	

Figure 9

ELaNa V (8/12) Falcon 9

Mission Title	University	Size	Mission Manifested
CUNYSAT-1	Medgar Evers College, City University of New York	1U	CRS III
KYSat – 2 (Re-flight)	Kentucky Space	1U	
HERMES – 2 (Re-flight)	U of Colorado	1U	
LMRSat	JPL	2U	CRS III
TechCube1	GSFC	3U	CRS III
All-Star/THEIA	Colorado	3U	CRS III
FIREFLY – 1/2	GSFC	3U	CRS III
UNP-6 Radar Calibration CubeSat	University of Hawaii	3U	CRS III

Figure 10



ELaNa VI (06/12) Atlas V			
Mission Title	University	Size	Mission Manifested
CINEMA	University of California	3U	NRO L-36
CSSWE	University of Colorado at Boulder	3U	NRO L-36
CP5	California Polytechnic State University	1U	NRO L-36
CXBN	Morehead State	2U	

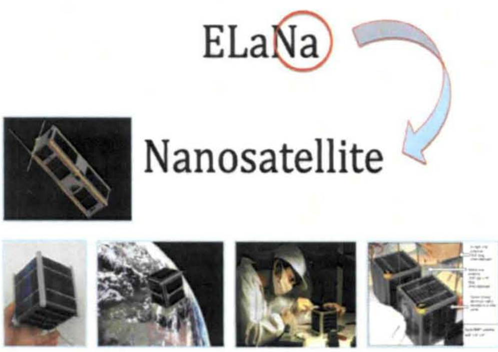
This mission is a partnership with NRO/OSL

Figure 11

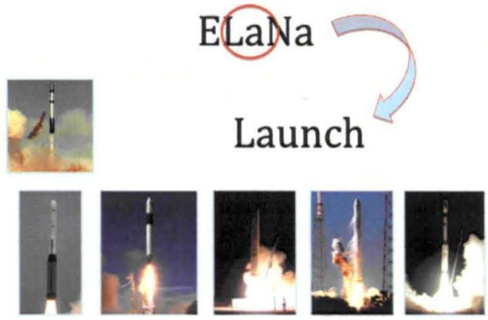
NASA LSP can manifest missions on the currently planned CRS flights if the CubeSat projects are able to satisfy their science requirements within the first 30 days on orbit. The orbit parameters for these missions are at an altitude of 325km with an inclination of 51.6 degrees. This is not the ideal orbit for long period science but there are many opportunities for CubeSats. The CRS flights will give CubeSats a greater chance to get on orbit.

Why ELaNa?

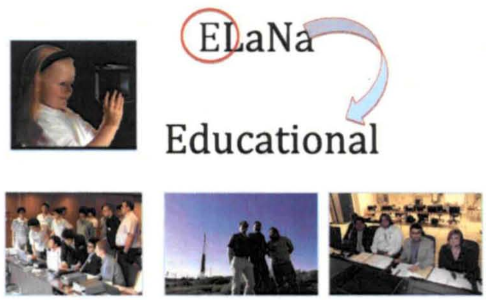
The easiest way to understand is to look at ELaNa one piece at a time, starting at the end of ELaNa and working backwards.



Na – Nanosatellite. Currently there are many organizations, including universities and high schools, building Nanosatellites. For ELaNa to continue to succeed, development and building of CubeSats will need to continue. If there are no CubeSats to fly, then NASA will assess the need to fund launches or may even reduce launches.



La – Launch. The launch is a very important part of ELaNa and LSP is tasked with providing launches for the ELaNa CubeSat missions. CubeSat have flown on seven different launch vehicles before ELaNa was created. And with in the next 12 months, there will be three additional LVs expected to be added to the list that will be carrying ELaNa missions



E – Educational. Education is the most important part of ELaNa. ELaNa's major objective is to launch the students' CubeSats and place them in orbit, however the entire process is educational not just the launch. During the ELaNa I mission process the CubeSat teams were required to interact with NASA and present the status of their project and attend several major reviews. Even if the students' CubeSats were never launched, 75 to 90 percent of the CubeSat mission could still be accomplished. Many of the CubeSat projects are technical demonstrations that can be proven while the CubeSat is undergoing testing in the lab. Once the CubeSat is launched and placed on orbit, the students will be able to complete the last portion of the CubeSat science.

Yes, the primary goal is success; however that that is not always achievable. With the flight of Glory, the CubeSat teams learned a valuable lesson, that of experiencing a launch failure. Failure is always a possibility in the aerospace field and, having experienced a failure as a student, the ELaNa I teams will be better prepared for their future aerospace careers.

Launch Systems

With the success of the first launch vehicle development for the P-POD system on the Taurus rocket, LSP continues to pursue the development of new means to fly CubeSats. Over the past three years studies have been performed on the following:
1. Delta II
2. Atlas V – Common interface
3. Delta IV – Common Interface
4. Falcon 9 – CRS
5. Falcon 9 – Fairing
6 Athena I/II

Thus far, only two of the six configurations studied have been selected to support P-PODs (Figure 12).

NASA CubeSat Carriers

Atlas V		Delta IV	Delta II	Taurus XL	Athena	Falcon 9	
Common	ABC	Common	Struts Section	Aft End	Unknown	CRS	Fairing
Studied	In Development	Studied	In Development	Flown	Studying	In Development	Studied

Figure 12

First is the Delta II P-POD system. The inaugural flight of this system will be with the NASA NPP mission in October of 2011. The Delta II configuration allows for as many as three P-PODs to be attached to the second stage struts. As with the Taurus development, the Delta team presented to an ERB, a Preliminary Design Review and Critical Design Review to ensure there is not an increase in mission risk.

The development of the Delta II system impressed NASA in part because the contractor started the process with the goal of reducing both non-recurring and recurring costs. The Delta II team looked to see how the integration processes could be reduced. One area of reduction was telecom hours. Both teams agreed to allow only 10 telecom hours per month to conduct question and answers. This drove the team to be more effective in the way it performs this task. Instead of all the engineers and managers listening to issues which did not apply to them, the system engineer would gather the questions and work to resolve them with the appropriate discipline.

The other system that will be flying soon for NASA is the Commercial Re-supply Service missions on Falcon 9. The P-POD for these missions will be located on the second stage truck and will remain with the stage after the Dragon is separated. Once the stage is in a position to avoid contact with ISS, the P-POD will be commanded to release the CubeSat. Depending on configuration of the P-PODs, the CRS mission on Falcon 9 will allow up to six P-PODs to be attached to the trunk section. Another system that could be used on Falcon 9 is the fairing system. For these non-Dragon missions, the launch vehicle incorporates a fairing to protect the primary SC during ascent. The study to develop the Falcon 9 - fairing system is complete and NASA is awaiting a selected mission to perform the development.

Because ULA now launches both the Atlas V and Delta IV, the concept of a common interface was studied. The study focused on a system that would entertain a common configuration for up to eight P-PODs on each vehicle. The common interface for a P-POD system has its advantages; it would allow the P-PODs to be interchanged between the two launch vehicles while maintaining a standard. This flexibility would improve the manifest process between the Atlas V and Delta IV and provide additional CubeSat opportunities. However, due to cost constraints, the development of this system was not initiated and currently there are no plans for initiation.

Mission Success

The first ELaNa was not a failure just because the Glory mission failed to reach orbit. All indications from the launch vehicle telemetry show that the P-POD indicator switch actuated. This means the P-POD door did open and the CubeSats were released. This proves the processes which were developed for the ELaNa I mission worked and subsequent missions are ensured to be separated as well.

What are other positive results from the first mission?
1. First NASA selected CubeSat mission, which developed an annual call for CubeSats
2. The approval by NASA to integrate P-PODs on Glory. This has lead the way for approval to fly P-PODs on NPP and being able to submit for future launches
3. Lessons Learned by the CubeSat developers', which they can implement on their future project design
4. The CubeSat teams submitted to a NASA integration process. This allows the students to be able to enter into the aerospace work forces with additional tools in their toolbox

Summary

The past three years have been very productive for the NASA CubeSat initiative. NASA went from not flying CubeSats to having a manifest with well over 30 missions. Four different launch vehicles currently integrate our P-POD carrier systems and there are plans to explore additional LVs in the future.
To reach this point, the team was required to develop processes to show there is no increased risk to the primary mission or launch vehicle. All of these processes and requirements went through the standard NASA ERB and approval processes. These processes include both Engineering and Manifesting for CubeSat and P-PODs. Allowing P-PODs to fly on NASA launch vehicles has opened the door for future CubeSat flights.

The key objective of ELaNa is to increase STEM throughout the United States by introducing educational spaceflight to college and high school students through CubeSat development. To date the ELaNa initiative has reached out to hundreds of students and continues to progress forward within the US. The Launch Services Program has developed carrier locations on several launch vehicles and continues to develop systems on all vehicles on the NASA Launch Services contract.

John F. Kennedy Space Center

LAUNCH SERVICES PROGRAM

2011 AIAA/USU Small Satellite Workshop

ELaNa

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Enhanced Education through Space Flight

Garrett Skrobot

Mission Manager

Launch Services Program

NASA

John F. Kennedy Space Center

ELaNa

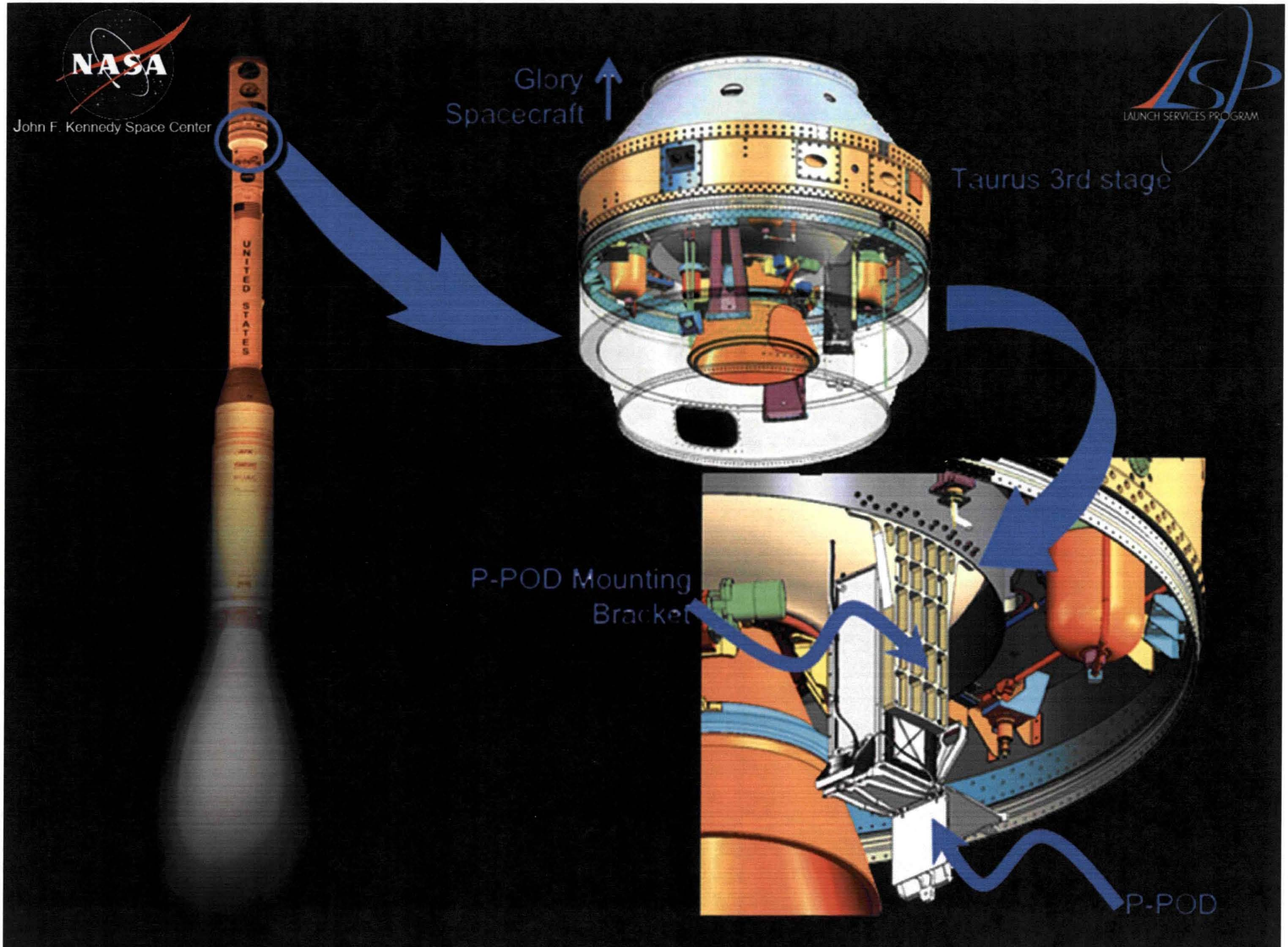
LAUNCH SERVICES PROGRAM

Educational Launch of Nanosatellite

"Science, Technology, Engineering, and Mathematics"

"Launching Education into Space"


NASA
John F. Kennedy Space Center
ELaNa
NASA
CalPoly
"Launching Education into Space"
CUBESAT
California Polytechnic State University
PRIME
EXPLORER I
SPACE SCIENCE AND ENGINEERING LABORATORY
MONTANA STATE UNIVERSITY
LAUNCH SERVICES PROGRAM
KySat™
COLORADO SPACE GRANT CONSORTIUM
H E R M E S


John F. Kennedy Space Center
LAUNCH SERVICES PROGRAM
Glory
Spacecraft
Taurus 3rd stage
UNITED STATES
P-POD Mounting
Bracket
P-POD

NASA

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Glory - **ELaNa 1**
Taurus XL T9

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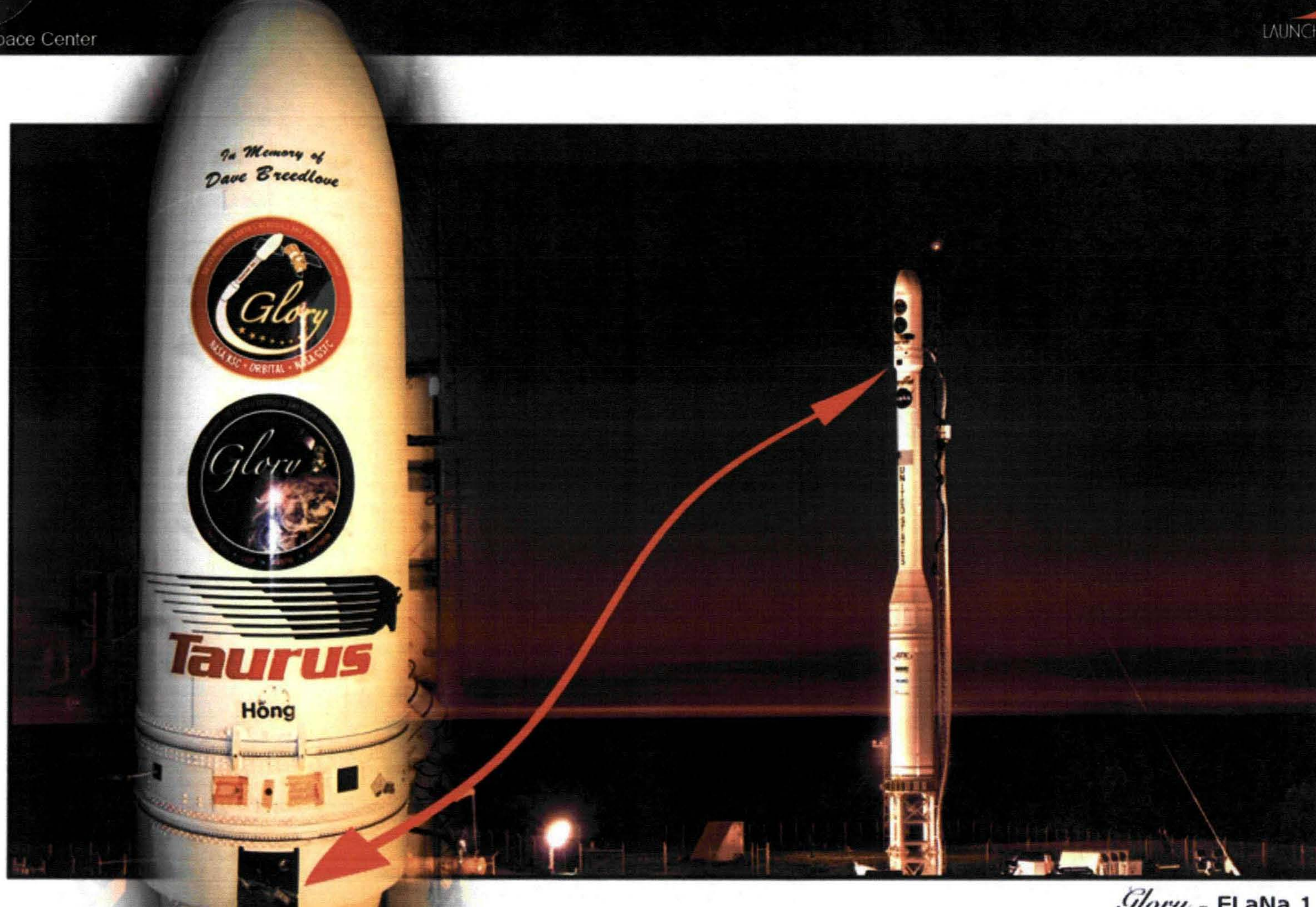
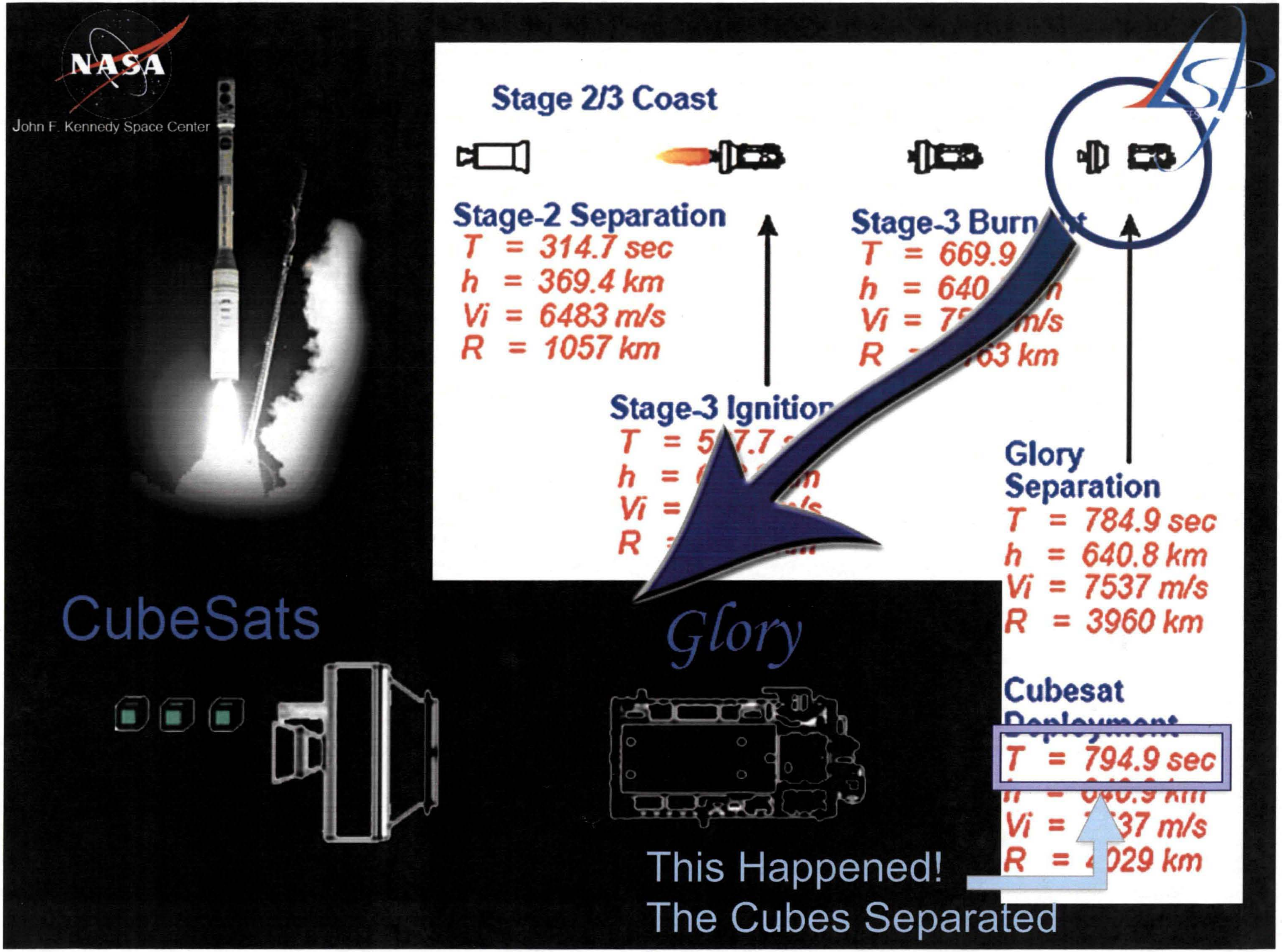


Glory - **ELaNa 1**
Taurus XL T9


NASA
John F. Kennedy Space Center
Stage 2/3 Coast
Stage-2 Separation
T = 314.7 sec
h = 369.4 km
Vi = 6483 m/s
R = 1057 km
Stage-3 Ignition
Glory
Separation
T = 784.9 sec
h = 640.8 km
Vi = 7537 m/s
R = 3960 km
Cubesat
T = 794.9 sec
CubeSats
Glory
This Happened!
The Cubes Separated

NASA
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LAUNCH SERVICES PROGRAM

Approval Process

Process

LSP P-POD CoFR Process Status

This process has been pre-briefed to the following

SOMD – July 1, 2009

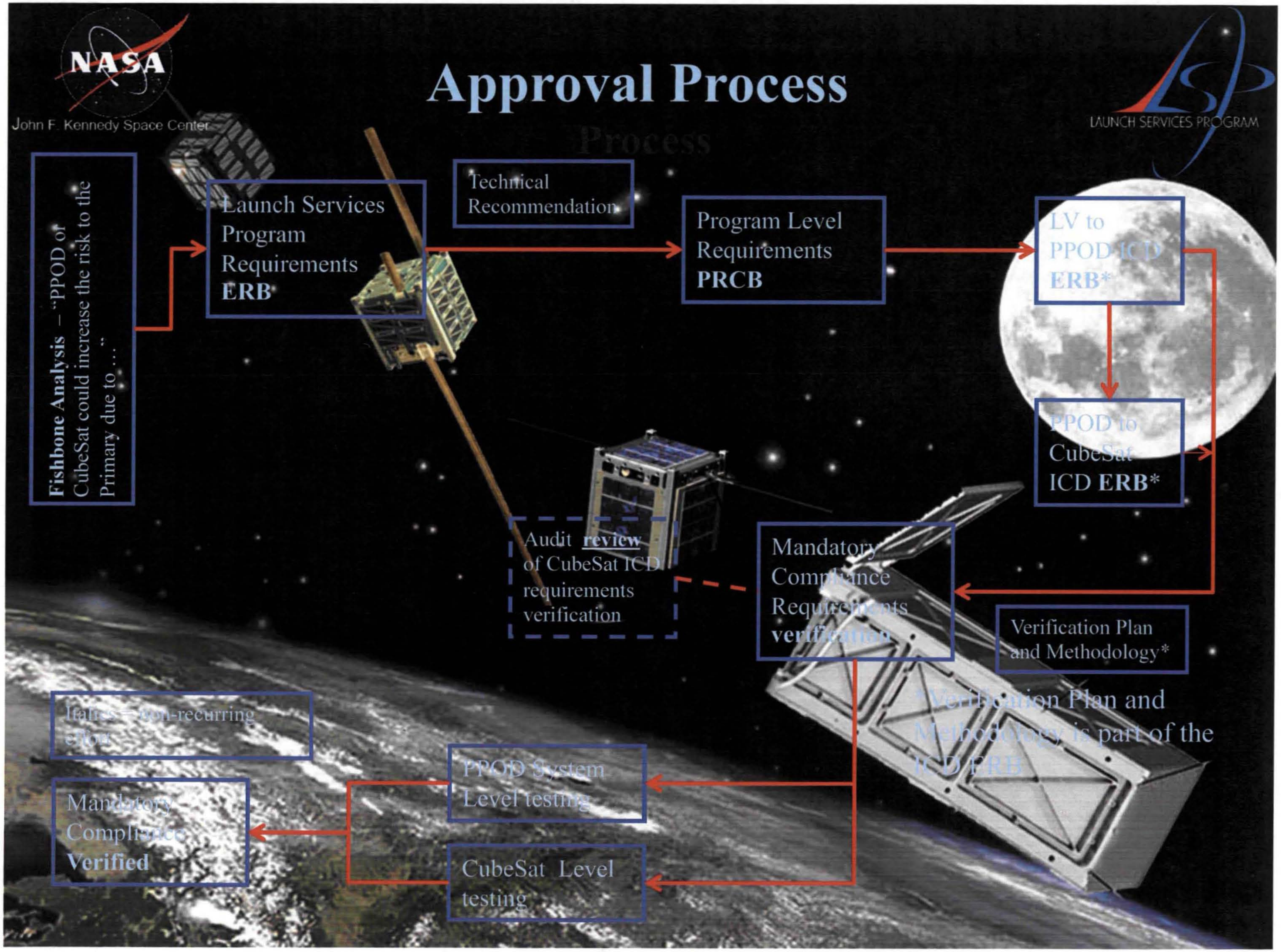
SMD – August 4, 2009

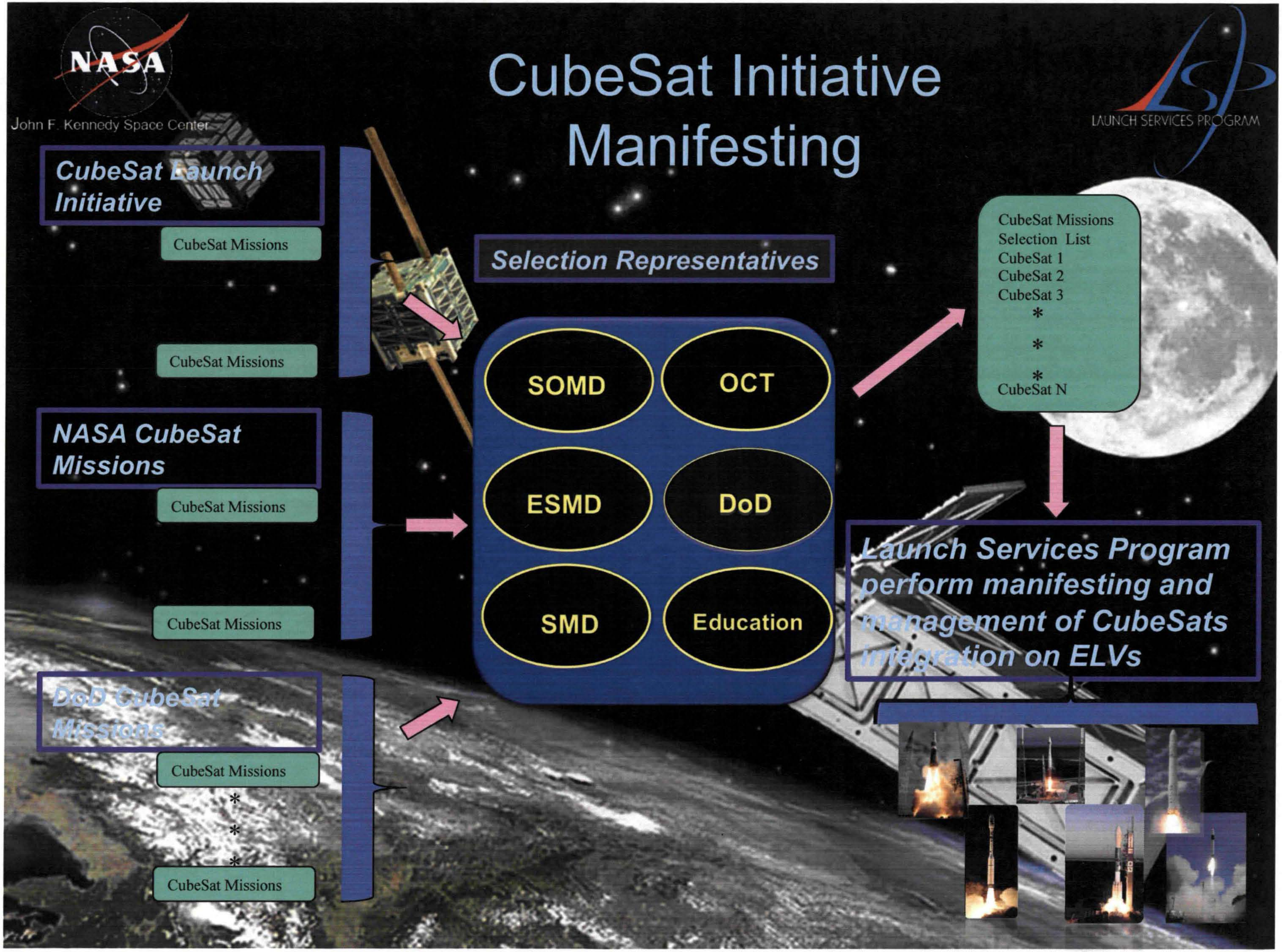
OCE (charts only) – October 16, 2009

OSMA – October 28, 2009

Approved

Special FPB - January 6, 2010


NASA
John F. Kennedy Space Center
Approval Process
LAUNCH SERVICES PROGRAM
Fishbone Analysis – "PPOD or CubeSat could increase the risk to the Primary due to . . . "
Launch Services Program Requirements ERB
Technical Recommendation
Program Level Requirements PRCB
LV to PPOD ICD ERB*
PPOD to CubeSat ICD ERB*
Audit review of CubeSat ICD requirements verification
Mandatory Compliance Requirements verification
Verification Plan and Methodology*
* Verification Plan and Methodology is part of the ICD ERB
Italics = non-recurring effort
PPOD System Level testing
CubeSat Level testing
Mandatory Compliance Verified


NASA
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LAUNCH SERVICES PROGRAM
CubeSat Initiative Manifesting
CubeSat Launch Initiative
CubeSat Missions
CubeSat Missions
NASA CubeSat Missions
CubeSat Missions
CubeSat Missions
DoD CubeSat Missions
CubeSat Missions
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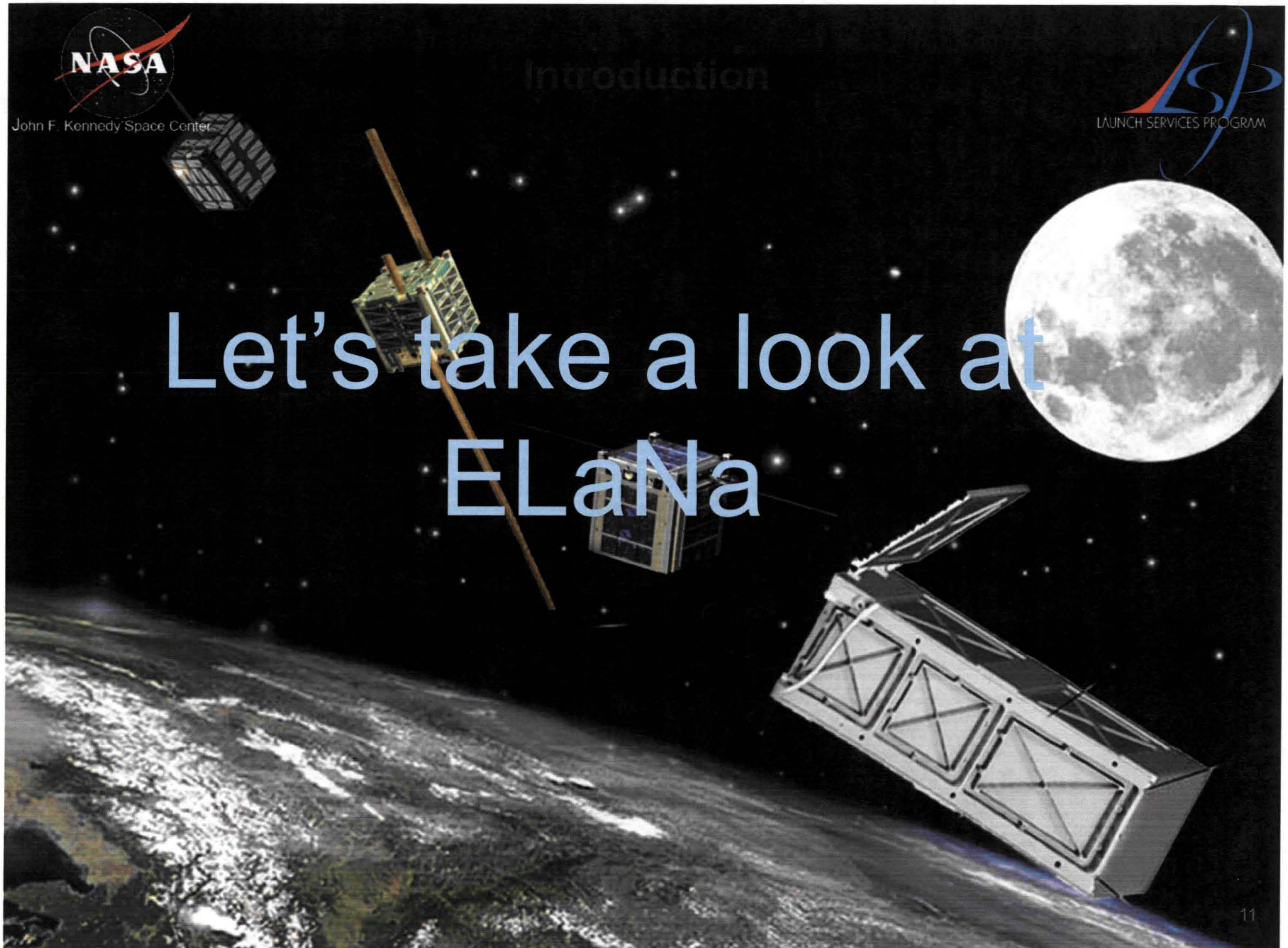
CubeSat Missions
Selection Representatives
SOMD
OCT
ESMD
DoD
SMD
Education
CubeSat Missions Selection List
CubeSat 1
CubeSat 2
CubeSat 3
*
*
*
CubeSat N
Launch Services Program perform manifesting and management of CubeSats integration on ELVs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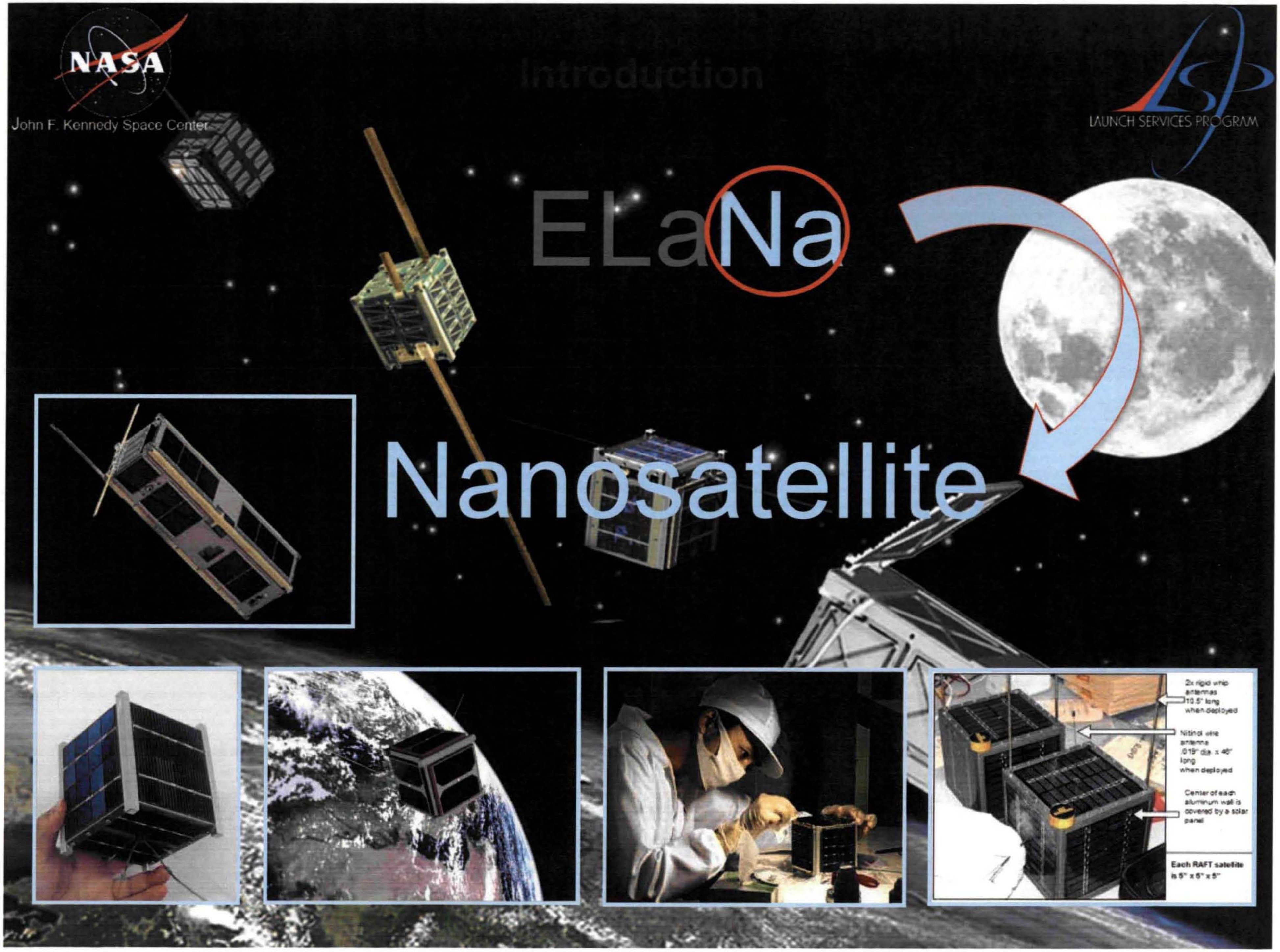
Introduction
LAUNCH SERVICES PROGRAM
Let's take a look at
ELaNa
11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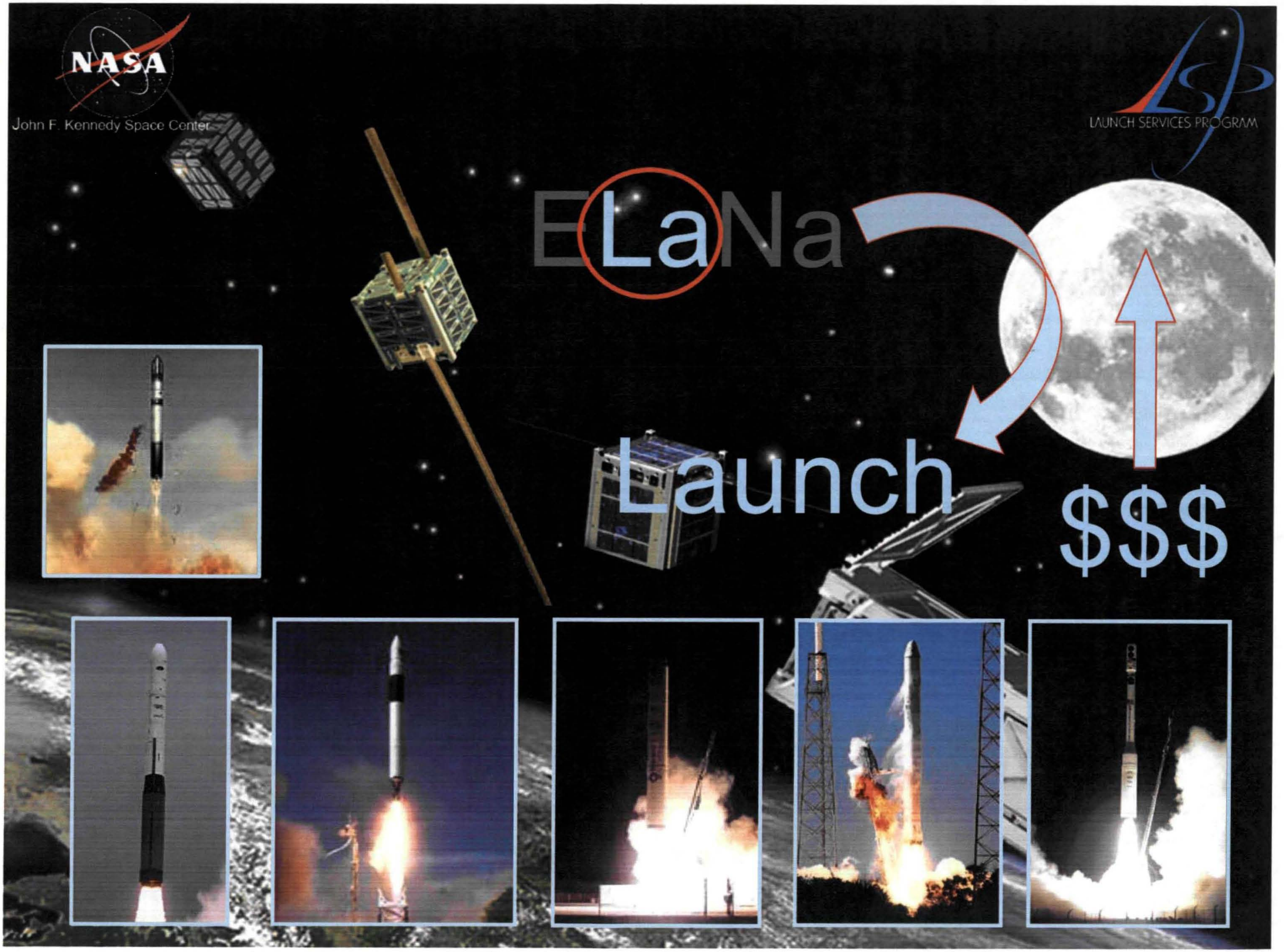
ELaNa
Nanosatellite
2x rigid whip antennas 10.5" long when deployed
Nitinol wire antenna .019" dia. x 48" long when deployed
Center of each aluminum wall is covered by a solar panel
Each RAFT satellite is 5" x 5" x 5"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Launch
$$$


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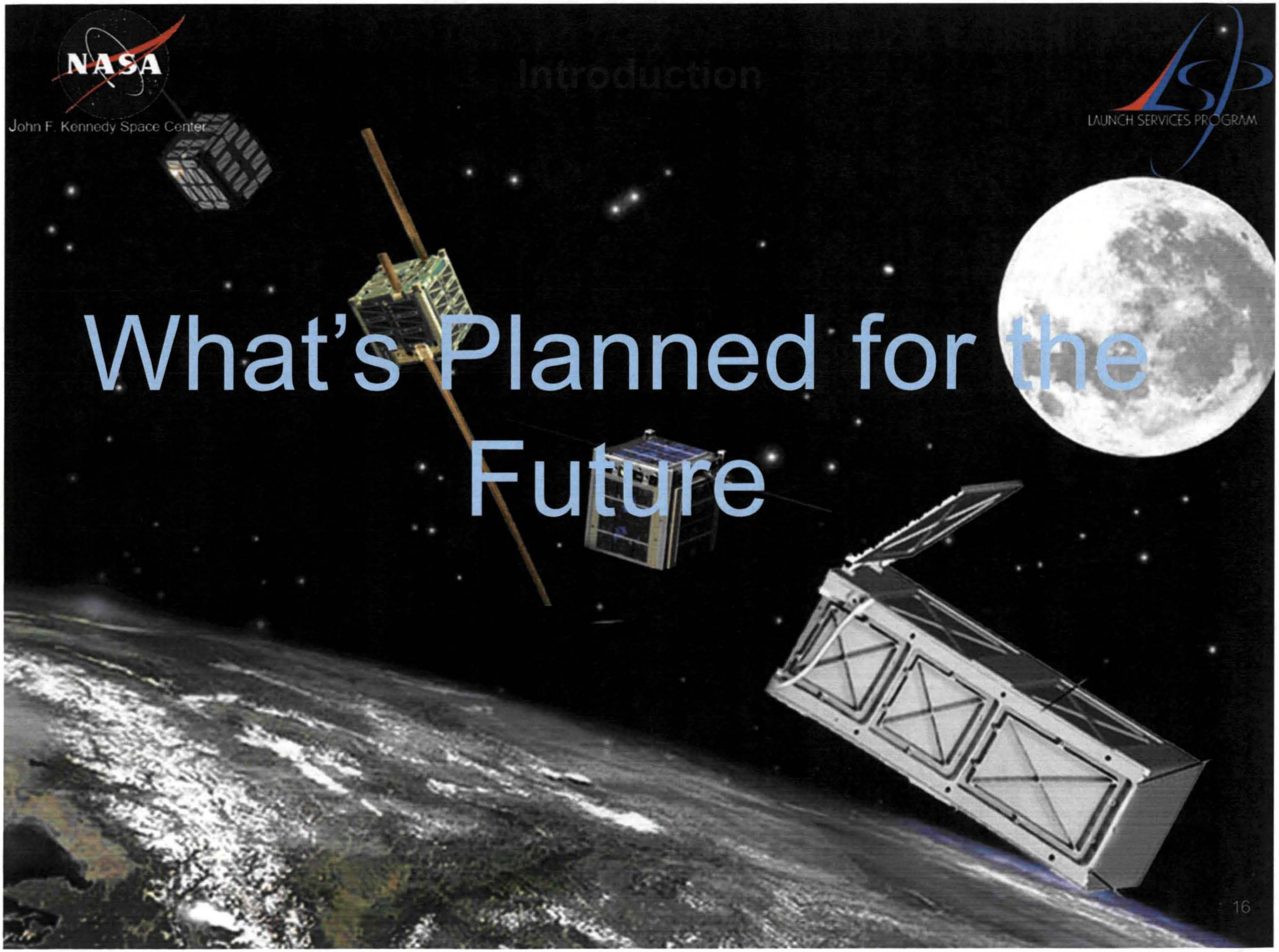
ELaNa
Educational

Was ELaNa I a Success?

- First NASA Selected CubeSat mission → Annual Call for CubeSats
- Approval to fly on Glory → Lead the way to launch on other NASA vehicle
- The design and build of CubeSat → Lessons Learned applied to future mission
- Educational experience of working through a NASA Integration cycle → Students are prepared to enter the aerospace workforce

What's Planned for the Future



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NASA CubeSat Initiative

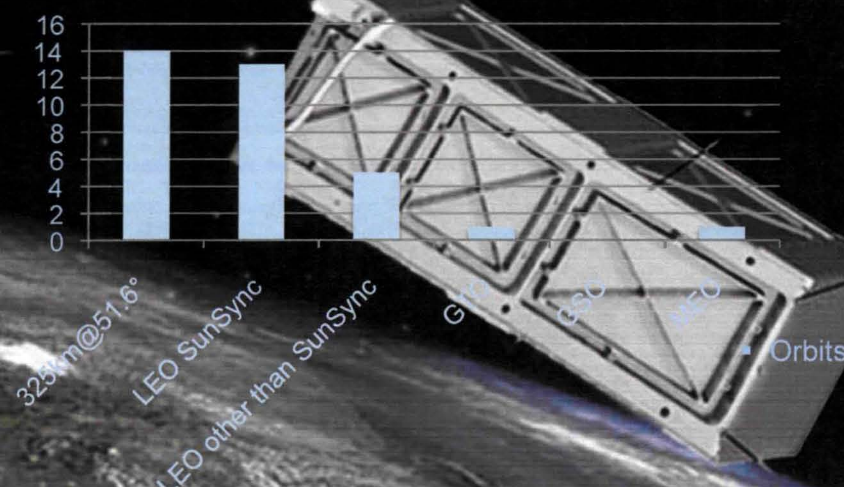
Number of CubeSats

First Selection	First Initiative	Second Initiative	Prior Selected	Total	First Flight	Re-Flight	Still to Fly
4	12	20	1	37	3	2	36

CubeSat by Orbits

325km@51.6°	LEO SunSync	LEO other then SunSync	GTO	GSO	MEO
14	13	5	1	0	1

LEO is a Range of 350km to 650km



Number of CubeSats Manifested

Currently Manifested
26

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NASA CubeSat Carriers

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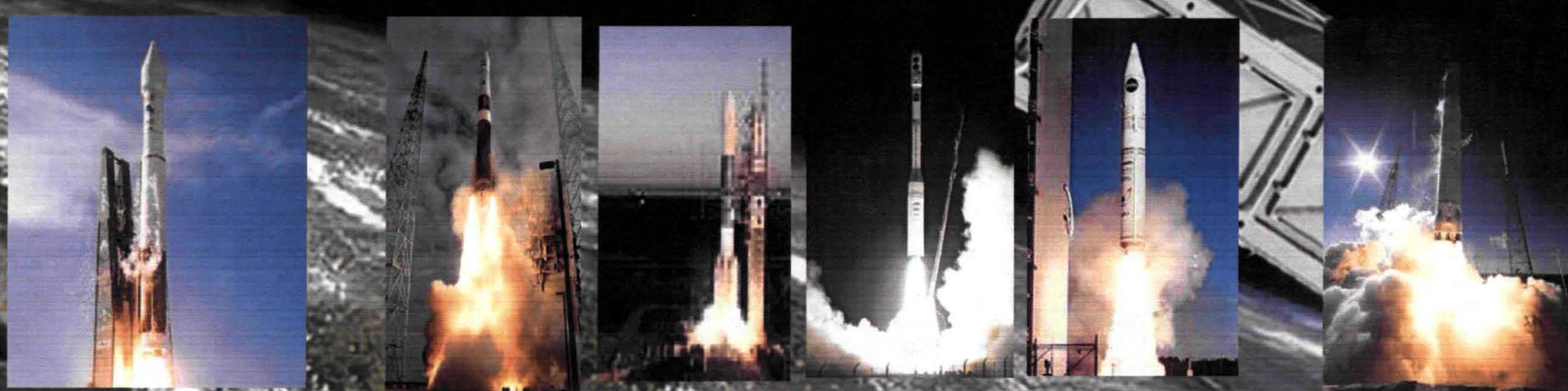
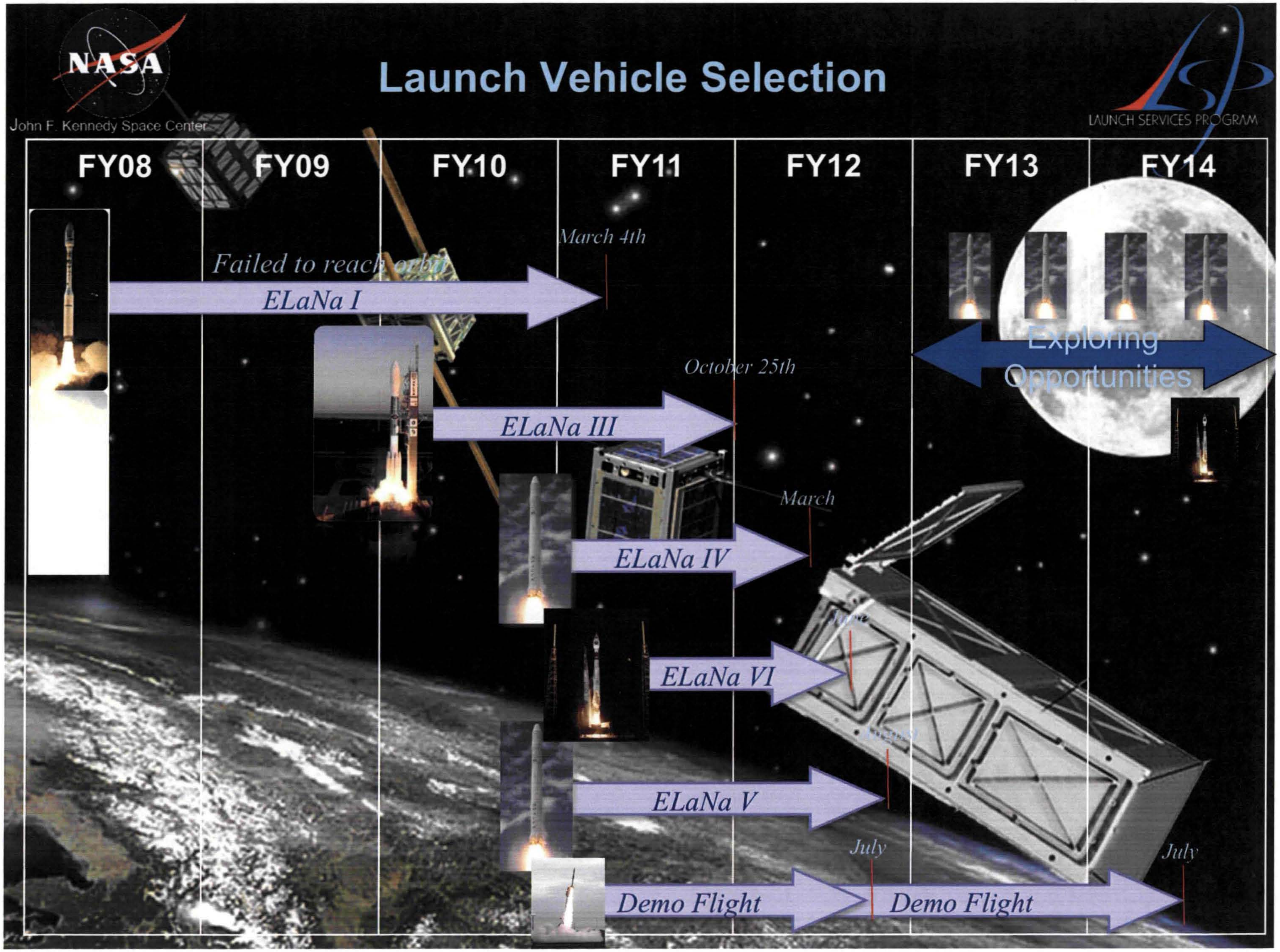
Atlas V		Delta IV	Delta II	Taurus XL	Athena	Falcon 9	
Common	ABC	Common	Struts Section	Aft End	Unknown	CRS	Fairing
Studied	In Development	Studied	In Development	Flown	Studying	In Development	Studied

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Launch Vehicle Selection
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FY08
FY09
FY10
FY11
FY12
FY13
FY14
March 4th
Failed to reach orbit
ELaNa I
October 25th
ELaNa III
Exploring Opportunities
March
ELaNa IV
ELaNa VI
ELaNa V
July
July
Demo Flight
Demo Flight


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Don't rest on your laurels
...don't dwell on failure
Let's Keep Moving Forward!