EVOLUTION OF THE FLORIDA LAUNCH SITE ARCHITECTURE EMBRACING MULTIPLE CUSTOMERS, ENHANCING LAUNCH OPPORTUNITIES

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Abstract

The impending conclusion of the Space Shuttle Program and the Constellation Program cancellation unveiled in the FY2011 President's budget created a large void for human spaceflight capability and launch activity from the Kennedy Space Center (KSC). This void created an opportunity to re-architect the launch site to be more accommodating to the future NASA heavy lift and commercial space industry. To satisfy that need, the 21st Century Ground Systems Program was created, with a goal to evolve the heritage capabilities into a more affordable and flexible launch complex. This case study will discuss the KSC architecture evolution from the trade studies to select primary launch site locations for future customers, to improving infrastructure; promoting environmental remediation/compliance; improving offline processing, manufacturing, and recovery; developing range interface and control services with the US Air Force, and developing modernization efforts for integration and launch of small class to heavy class launch vehicles. The architecture studies will steer how to best invest limited modernization funding from initiatives like the 21CGSP and other programs.

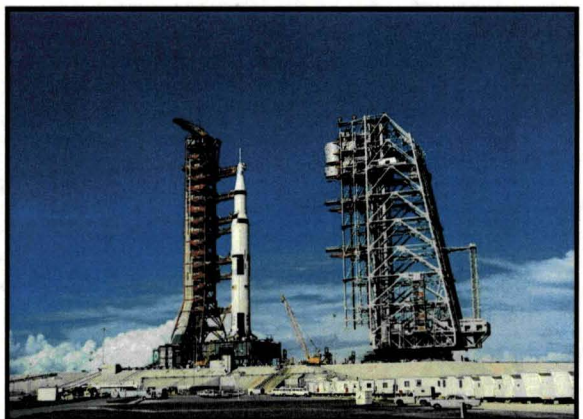
Background

The Kennedy Space Center has had a long and distinguished history in human exploration. The 1950s brought the development of ICBM row for developing the earliest launch vehicles. The 1960s and 1970s brought the Saturn V/Apollo programs for reaching the moon. Since 1983 we have seen the space shuttle program at KSC.

1950's
ICBM Row

The last few years have brought significant changes, setting a new course for KSC and the surrounding launch infrastructure referred to as the Florida Launch Site (FLS). On February 1, 2010, President Obama released his budget for Fiscal Year 2011 (FY11) and with it, came the announcement that the Constellation Program for returning man to the Moon and Mars was canceled.

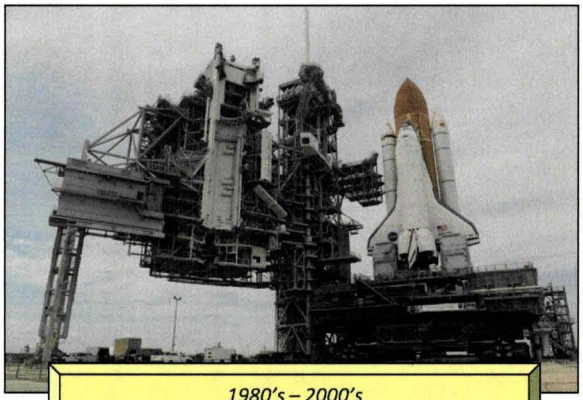
A new vision was established to promote commercial development for both cargo and crew transportation to the International Space Station and beyond Low Earth Orbit (LEO). NASA was challenged to use the entrepreneurial spirit of the commercial industry to provide more options for human exploration and to reduce the cost for accessing the far reaches.



1960's - 1970's
Saturn V - Launch Complex 39

FY11 also brought the Congressional Authorization Bill introducing the Space Launch System (SLS) and Multi-Purpose Crew Vehicle (MPCV) for launching

and transporting astronauts beyond LEO. While Congress authorized these new developments, the Appropriation Bill to fund these new efforts did not materialize in FY11. Under a yearlong continuing resolution, NASA began to plan for the closeout of the Constellation Program while funding development activities applicable to Constellation, but also extensible to the authorized SLS and MPCV programs.



1980's – 2000's
Space Shuttle - Launch Complex 39

Florida Launch Site

The idea for establishing a separate program to enhance the Florida launch capability was introduced with the FY11 President's Budget. The new budget submission recognized the substantial contribution the commercial space market could play in space exploration. The direction was given to fund infrastructure improvements and to encourage the commercial entrepreneurial spirit to provide new capabilities while reducing the cost to access space.

2010's
Florida Launch Site

The new FLS was established to lay the ground architecture to support human exploration after the retirement of the Space Shuttle and prepare for the next generation Launch Vehicle and Spacecraft. The 21st Century Ground Systems Program (21CGSP), was chartered to look at the KSC infrastructure and actively solicit commercial participation to achieve NASA's space exploration goals, while supporting America's space launch industry.

The first step was to solicit user needs from the multiple customers expressing an interest in using KSC. These user needs provided the foundation for planning the preparation of the ground infrastructure from the current Space Shuttle-centric focus into a capability to support multiple launch vehicles - many operating in non-conventional modes. The 21CGSP introduced five separate product lines to capture user needs and prepare a roadmap for recommending investments to realize the vision established by the President. The product lines were:

1. Florida Launch Modernization Infrastructure
2. Environmental Remediation & Technologies
3. Offline Manufacturing, Processing & Recovery Systems
4. Range Interface & Control Services
5. Mission Focused Modernization

Florida Launch Modernization Infrastructure focused on the supporting infrastructure, including electrical power, water, sewer, Heating Ventilation and Air Conditioning, and general facilities needs.

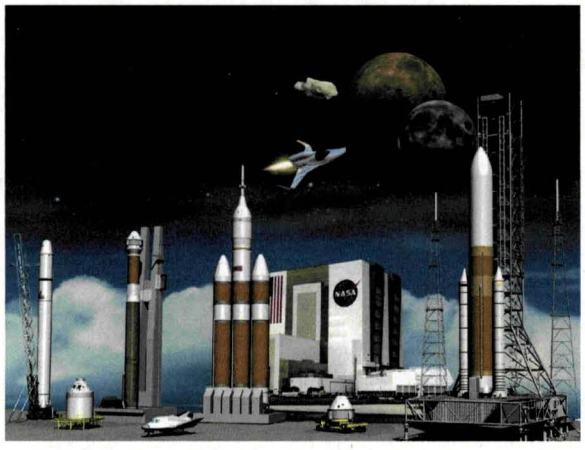
The Environmental & Remediation Technologies proposed investments to promote clean launch operations and to ensure proper environmental assessment/compliance was conducted to support the multiple users to be accommodated under the FLS.

The Offline Manufacturing, Processing, and Recovery Systems proposed investments to support manufacturing of space hardware (e.g., Orion spacecraft), processing of launch vehicles/spacecraft, and recovery of launch vehicle segments/motors or spacecraft after reentry.

The Range Interface & Control Services product line focused on supporting the FLS need for Command, Control, Communication, and Range (C3R) services to support multiple users with a quick turnaround between customers.

The Mission Focused Modernization product line supported the development of the large infrastructure required to support space exploration beyond LEO.

This product line is responsible for developing the Vehicle Assembly Building (VAB), Mobile Launch platforms (ML/MLP), and Launch Complex (LC) 39 A & B. The product line also captures the needs of smaller class vehicles, including the proposed conversion of the Shuttle Landing Facility (SLF) into a horizontal launch and landing capability.



Architecture Refinement Cycle

Developing a new FLS for multiple customers with different objectives and unique from the Space Shuttle-designed architecture required a deliberate process for conducting trade studies for determining the best approach for modernizing KSC. This new process was called the Architectures Refinement Cycle (ARC). Each ARC was conducted over a 3-4 month period. The conclusion of each ARC cycle resulted in a "point of departure" as a basis for beginning the next ARC.

The first ARC, ARC 1.0, provided the initial estimate of resources required to transition from the Space Shuttle to the Florida Launch Site addressing commercial needs and a NASA vehicle that would go beyond LEO. The estimate was used to develop the funding request beginning with FY11. ARC 1.0 was concluded March 30, 2010.

The ARC 2.0 traded where the primary launch site would be for this new mission. The FLS determined Launch Complex (LC) 39B would be the primary launch site with heavy lift launch vehicle as the "anchor tenant." LC-39A would be used to support other commercial users and test vehicles. The Cape Canaveral Air Force Station (CCAFS)/Florida Spaceport Authority's Space Launch Complex (SLC) – 36 would be used for small test vehicles or sounding rockets. ARC 2.0 was concluded July 30, 2010.

The ARC 3.0 goal was to determine "What are the launch site architectures?" The architectures focused on providing for NASA's SLS launch vehicle, the MPCV, and for multiple commercial customers. A Request For Information submitted to industry identified numerous needs including support in the areas of Vehicle Integration and Launch (VIL), Horizontal Takeoff/Horizontal Landing (HTHL), Vertical Takeoff/Vertical Landing (VTVL), offline manufacturing, processing and recovery, as well as, developing the C3R infrastructure.

ARC 3.0 identified the following findings:

a. Designated the SLF as the Kennedy Space Port for HTHL
b. Designated CCAFS LC-36B as the near-term VTVL site.

c. Selected the VAB as the primary vehicle processing facility for both SLS and Commercial Crew Vehicle.
d. Selected clean pad concept pursuing dedicated MLs for each vehicle type and commercial will use Space Shuttle MLPs.
e. Provided offline hazardous payload processing.
f. Recommended generic processing capabilities for commercial customers in Orbital Processing Bays 1, 2, and 3.
g. Recommended unallocated Space Station Processing Facility space for non-hazardous manufacturing and processing.
h. Continued use of the Operations and Checkout facility for MPCV processing.

ARC 3.0 concluded on November 22, 2010.

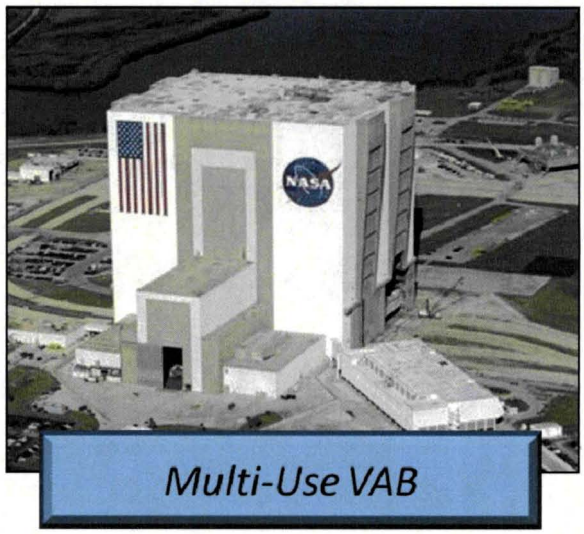
ARC 4.0 focused on the question, "How is the architecture allocated?" The objective of this ARC was to determine who will have primary "ownership" for each major facility and provide the operations and maintenance funding?

The VIL team recommended the following allocations:

a. Allocated VAB High Bay (HB) 3 to NASA's SLS launch vehicle and HB 1 for commercial use.
b. Allocated the modified Ares 1 ML for SLS
c. Allocated LC-39B for multiple mature launch providers.
d. Recommended further study to select the most cost effective solution for the launch pad emergency egress system.
e. Acknowledged CCAFS SLC 36/46 and KSC SLF to be used for small class and less mature test vehicles.

The Offline Processing and Recovery Team recommended the following allocations:

a. Allocated Multi-purpose Payload Processing Facility (MPPF) initially for non-hazardous commercial use and then for MPCV hazardous processing after modifications.
b. Allocated Orbiter Processing Facility for commercial hazardous payload processing.
c. Allocated Solid Rocket Booster processing facilities for the initial SLS processing.
d. Allocated US DoD ships to be used for nominal recovery of the MPCV.



The C3R team recommended Launch Control Center Firing Room (FR) 1 be allocated to SLS and MPCV use and FR4 be converted into four separate control rooms to support multiple commercial customers.

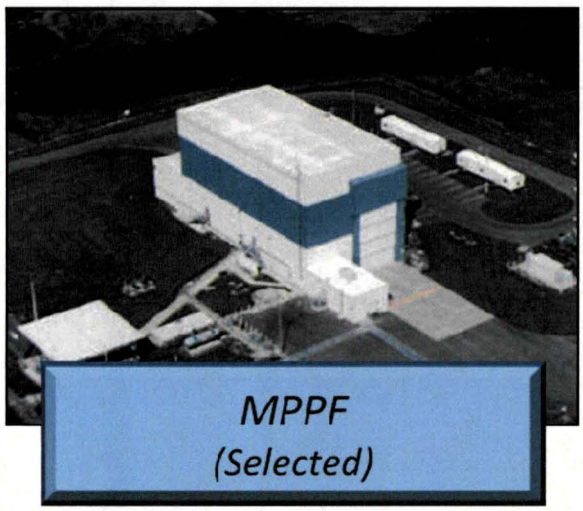
Finally, ARC 4.0 determined that the following critical high value, core KSC capabilities would be retained at KSC.

a. LC-39A and LC-39B
b. SLS Mobile Launcher
c. MLP-3
d. Crawler Transporters (CT) 1 and 2
e. Space Station Processing Facility
f. Launch Control Center
g. Rotation, Processing and Storage Facility
h. Assembly and Refurbishment Facility
i. Vehicle Assembly Building
j. Multi-purpose Payload Processing Facility
k. Shuttle Landing Facility

ARC 4.0 was concluded February 23, 2011.

The focus of ARC 5.0 focused on "Closing the Ground Operations Architecture" with emphasis on assessing the ability to support the SLS/MPCV ground infrastructure with revised fiscal guidance. ARC 6.0 confirmed previous allocations of SLS and MPCV assets, in light of projected 21CGSP budgets.

The FLS will be able to support a streamlined ability to process the SLS/MPCV. A closed architecture will be used to incorporate multiple users to share the cost of operating the streamlined architecture. These users include other NASA programs like Launch Services Program and Commercial Crew, as well as other government partners and commercial users. ARC 5.0 concluded June 1, 2011.



ARC 6.0 was concluded September, 2011, with a focus on "Optimizing the FLS Architecture." The following investment decisions were made:

a. Conversion of VAB to support SLS and commercial use.
b. Conversion of LC-39B to support SLS and commercial use.
c. Potential use of LC-39A for commercial use.
d. Convert Constellation Program ML for SLS.
e. Convert CT for SLS and commercial use.
f. Potential use of MLPs for commercial use.
g. Convert SLF for horizontal launch and landing.
h. Develop Command and Control Systems
i. Modernize Range Infrastructure.
j. Convert MPPF for MPCV and commercial use.
k. Modernize Infrastructure Spacecraft processing allocation.
l. Commercial assessments for potential KSC partners.

ARC 6.0 was completed September, 2011.

Lessons Learned

The architectural trade studies to support FLS have identified several key objectives. The launch pads will be built with a "clean pad" concept. This means no infrastructure will be built on the pad so as to preclude another customers from using the launch site. This concept is similar to an airport where aircraft may come in different sizes and different location for fueling, but they are all able to use the same basic infrastructure.

Mobile Launch Platforms will be used to provide the unique interfaces to a launch provider. Just as an aircraft has unique ground equipment to aid in servicing a particular type of aircraft, an MLP will provide the unique interfaces to a customer while leaving the launch pad in a clean configuration.

The dual launch pads 39 A/B will provide an opportunity to meet both NASA and commercial needs. The larger rockets, like the SLS, will use LC-39B leaving LC-39A for the less mature rockets conducting test operations or more hazardous launch operations without jeopardizing the significant investment made in LC-39B to support the larger, more mature launch providers.

The US Air Force and NASA are teaming to determine the needs for the future C3R infrastructure. The assessment of future user needs, coupled with an integration of future range architectures, has allowed NASA and the US Air Force to integrate precious resources focused on meeting the broad range of needs from multiple customers. The collaboration with the Federal Aviation Administration and Space

Florida has also strengthened the synergy among the range users and the modernization plans.

Conclusion

The space shuttle program became operational on April 12, 1981, with the launch of Columbia. After 30 years of successful missions the Space Shuttle program came to a bitter-sweet ending when Atlantis rolled to a stop on July 21, 2011. Even though the space shuttle is no longer flying, a tremendous wealth of infrastructure and expertise remains at KSC.

The FLS is challenged to use this extensive capability to promote the President's vision to embrace commercial creativity/capability. Likewise, the FLS capability will be required to meet the Congressional mandate for providing the next generation of human spaceflight capability beyond LEO. The FLS must provide a cost effective launch platform for the next generation of human spaceflight. If we are to harness the true power of American ingenuity we must unite the entrepreneurial commercial spirit with the decades of expertise from NASA. Nowhere will that partnership be more evident than here, at the FLS.

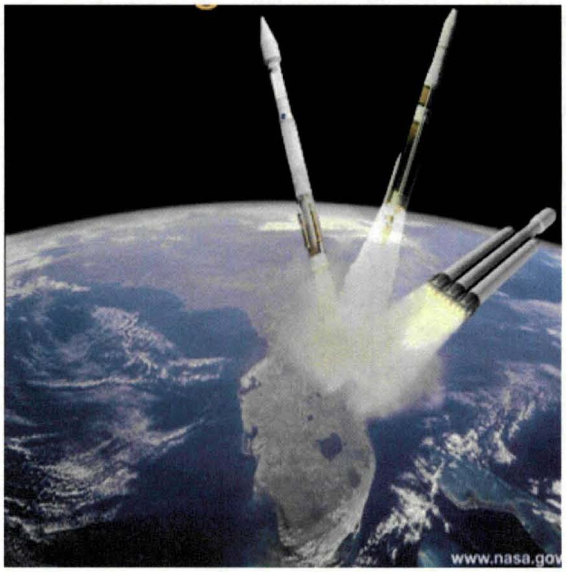
Within a couple of years, the former Space Shuttle and Saturn V/Apollo LC-39B will have been fully transformed into the world's first multi-use launch pad. The launch pad will be capable of hosting any launch vehicle from the medium lift expendable launch vehicles to the massive rockets needed to send humans to explore the celestial destinations.

Daily operations at the launch pad will look different than at today's dedicated Space Shuttle pads. Instead of spending a month or more at the launch pad, launch vehicles will be prepared in the equivalent of hangars and will spend mere hours at the launch pad. Similar to airports, if a launch vehicle experiences a problem it will return to its hangar for repairs instead of tying up the critical launch pad resource.

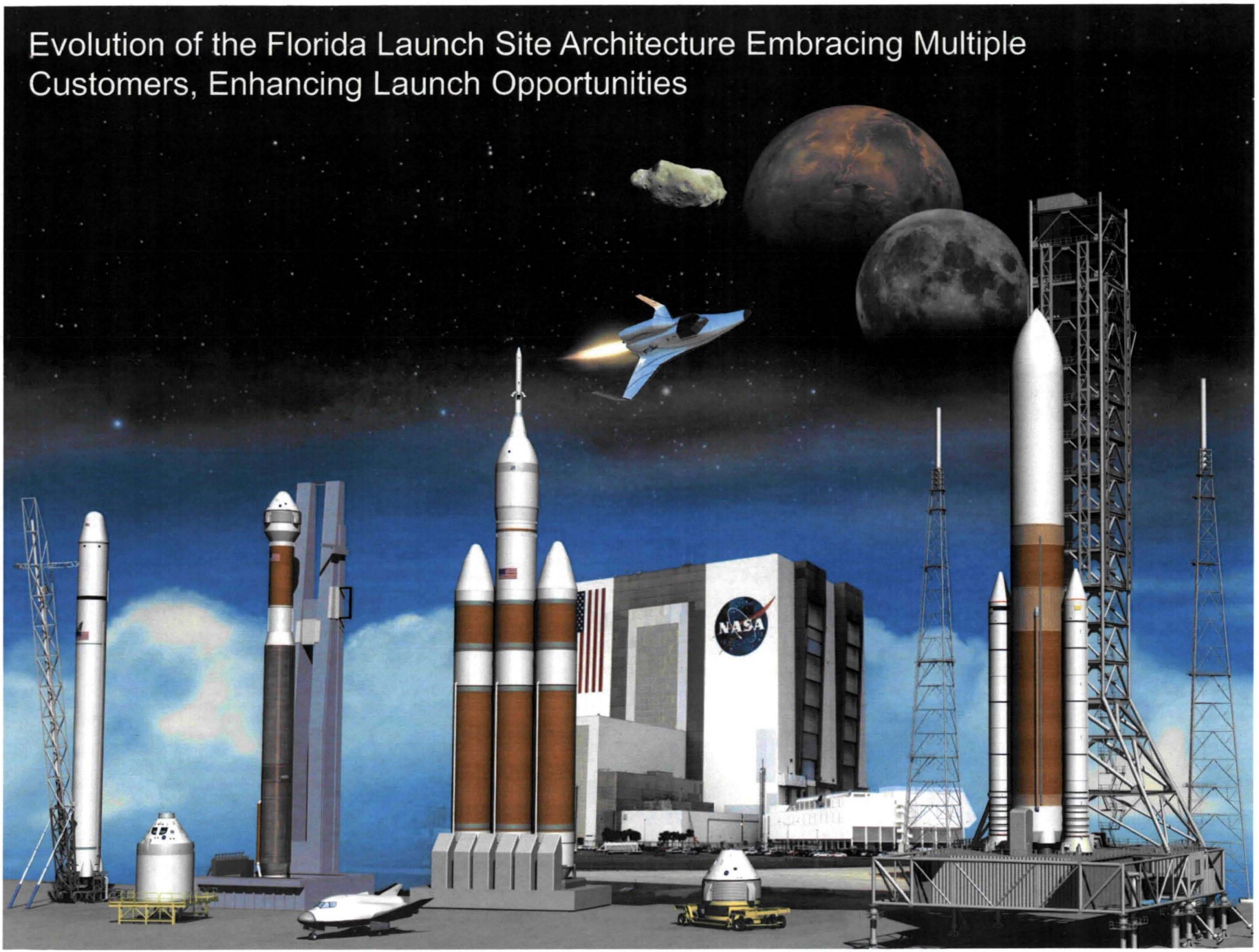
One could envision that LC-39A could be converted to a multi-use launch pad. The two launch pads could be capable of supporting several dozen launches per year. One day, a 30-story NASA rocket could rollout to the launch pad carrying a spacecraft bound for Mars. The next day, a smaller commercial rocket could arrive at the launch pad and be loaded with customers bound for a space station in LEO. The multi-use launch complex will lower the barrier of entry for entrepreneurial companies to the space launch business, spawning a new era of innovation, opening up new markets, and eventually lowering the cost of access to space.

FLS must promote the commercial use of unique KSC/CCAFS infrastructure providing facilities that would be cost prohibitive for many companies to build unilaterally, while offering KSC the opportunity to cost share the operations and maintenance. The FLS will team with the US Air Force, Space Florida, Commercial, and International Partners to optimize resources and successfully and safely execute the mission.

Kennedy Space Center has been actively involved in defining the architecture to satisfy the vision set by the US government leadership. Extensive cost benefit analysis has been conducted to optimize the FLS architecture to meet SLS, MPCV, and multiple government and commercial users. Kennedy Space Center is proud to extend the 30-year successes of the Space Shuttle program to the next generation of explorers through the FLS.



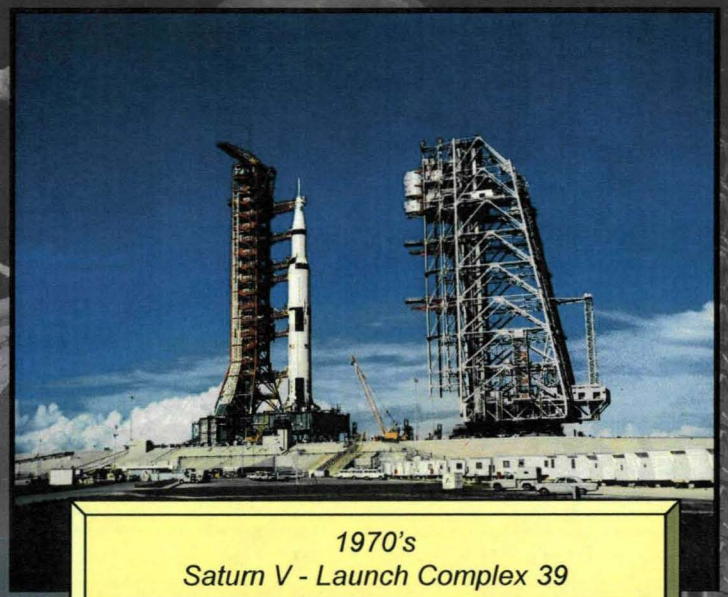
Evolution of the Florida Launch Site Architecture Embracing Multiple Customers, Enhancing Launch Opportunities



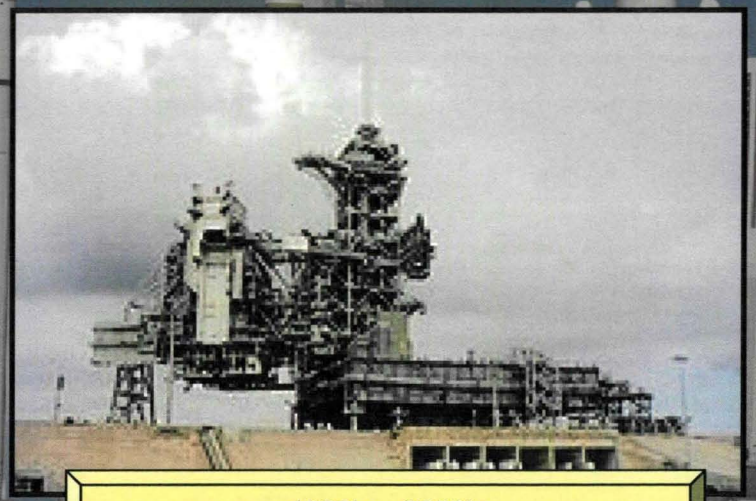
Florida Launch Site, 1950 – 2020

Embracing Multiple Customers, Enhancing Launch Opportunities

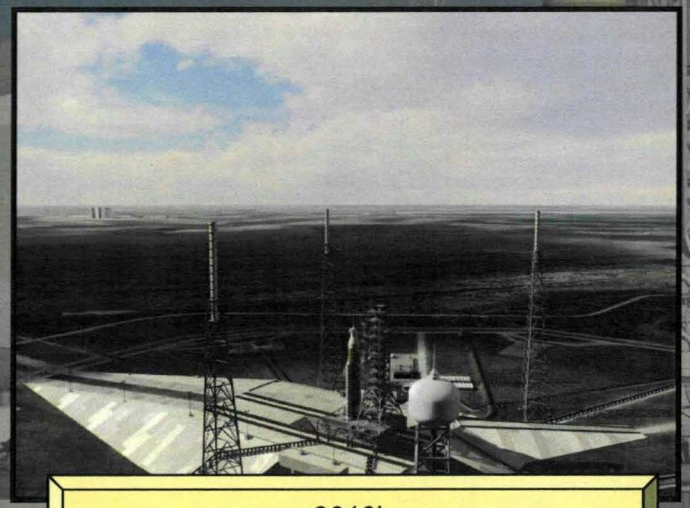
1950's
ICBM Row



1970's
Saturn V - Launch Complex 39



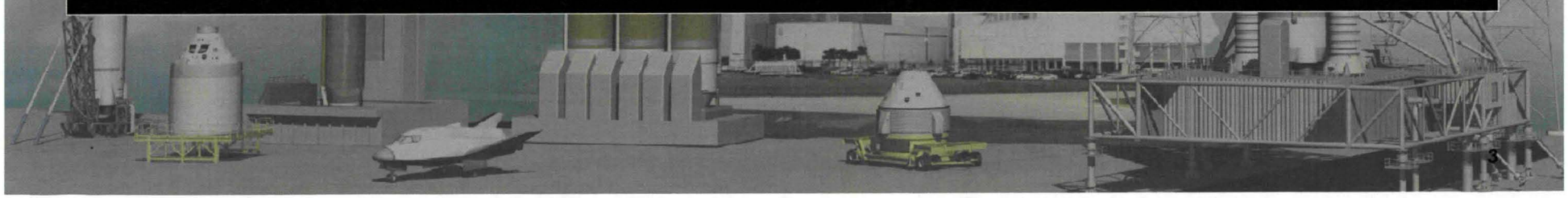
1980's – 2000's
Space Shuttle - Launch Complex 39



2010's
21st Century Space Launch Complex

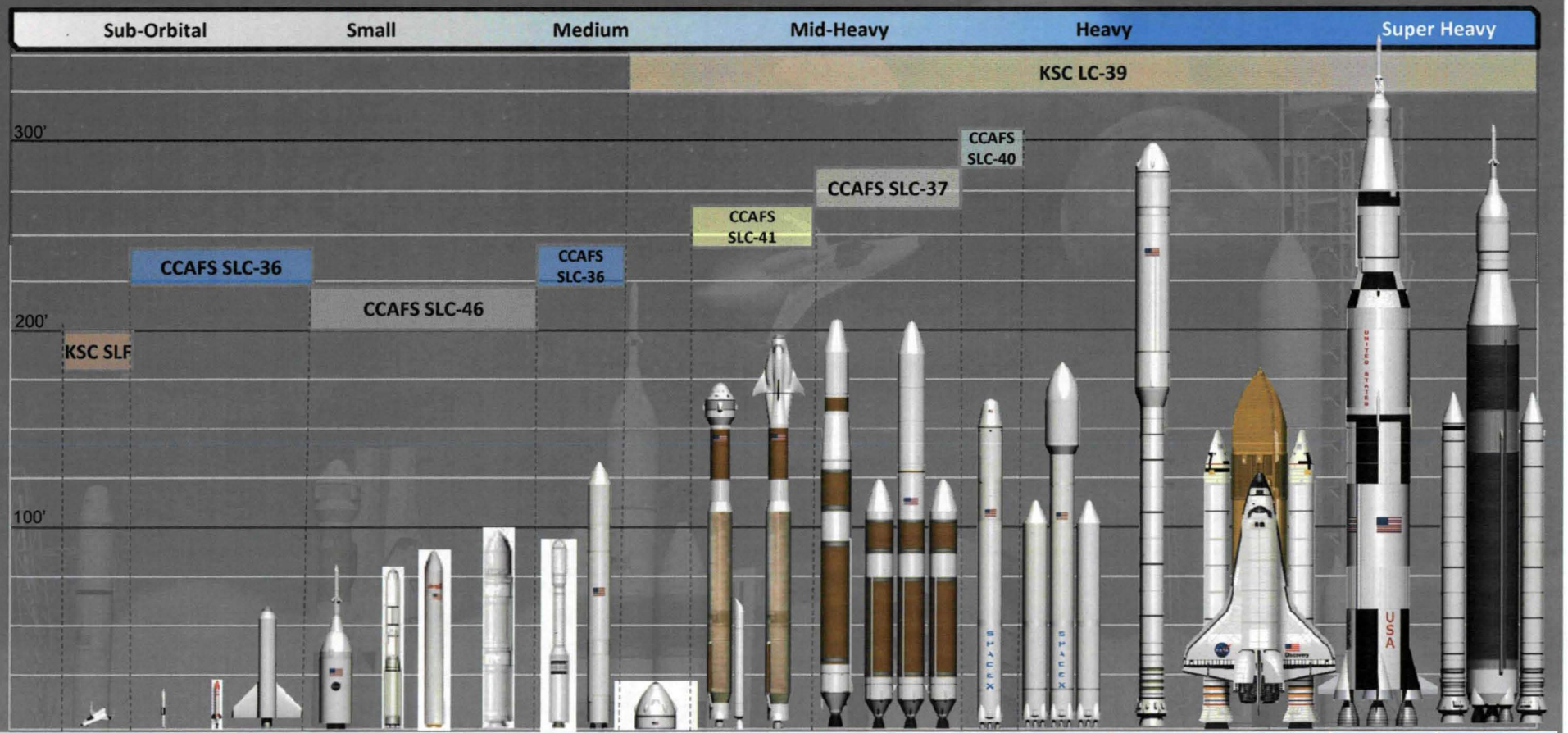
21ST CENTURY SPACE LAUNCH COMPLEX

Kennedy Space Center



Florida Launch Site

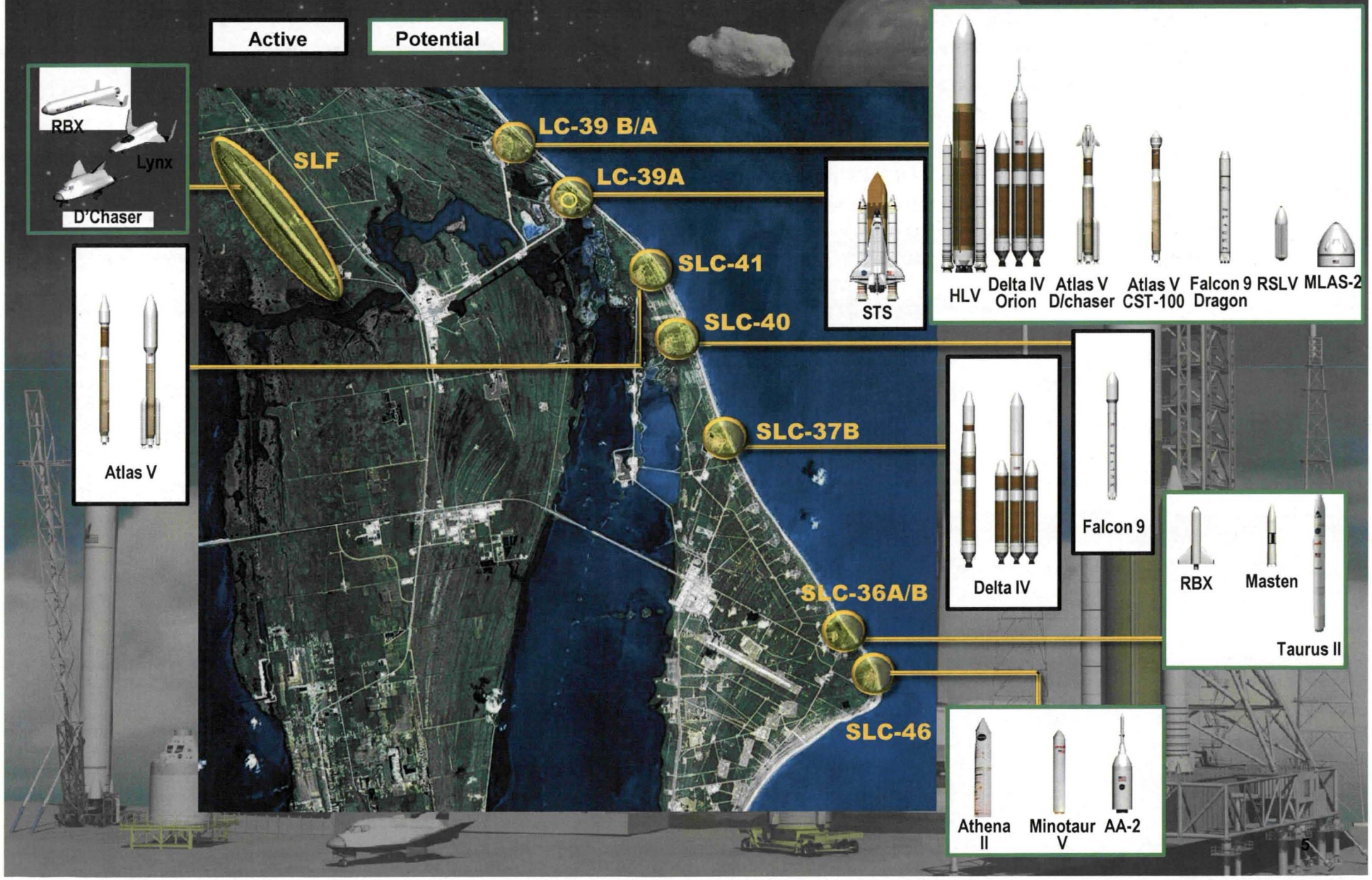
A Launch Capability for Every Vehicle



	XCOR Lynx	Masten XA-1.0	AFRL Prospector 18 RBX	Orbital AA-2	Orbital MinotaurIV MinotaurV	ATK Athena II C	Orbital Taurus I TaurusII	NESC MLAS FT-2	ULA Atlas V 412 Atlas V 402	ULA DeltaIV M Delta IV H	SpaceX Falcon 9 Falcon H	ATK Liberty	NASA Space Shuttle	NASA Saturn V	NASA SLS
Status	Proposed	Proposed	Proposed	Proposed	Proposed	Proposed	Proposed	Proposed	Active	Active	Active / Proposed	Proposed	Active	Retired	Notional
Ht. (ft)	12	15	18 / 62	80	78 / 87	95	92/131	20	171 / 194	205	160 / 180	300	184	363	321.5
FS Comm	LOX/ RP1	LOX/ IPA	LOX/ethanol LOX/ RP1	Solid	Solid	Solid	(I) Solid (II) LOX /RP1	Solid	LOX/RP1/Solid LOX/RP1	LOX/LH2	LOX/ RP1	Solid	LOX/LH2/ Solid	LOX/ RP1	LOX/LH2/ Solid
FS Thrust (lbf)	12K	3.5K	4.5K / 338K	361K	496K	383K	383K / 734K	4.2K	1.2M / 860K	650K / 1.9M	1.1M / 3.4M	2.8M	6.8M	7.6M	~8.8M

Florida Launch Site

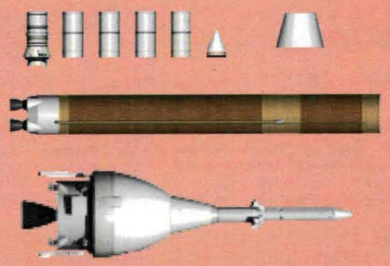
A Launch Site for Every Vehicle



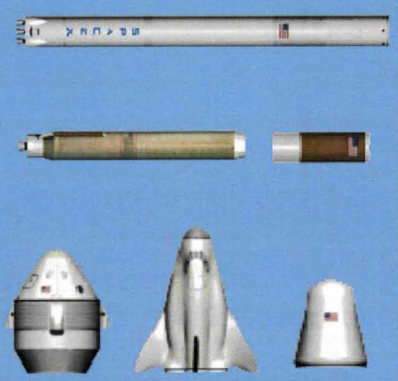
Florida Launch Site
Launch Complex 39 Concept of Operations

SUPPORTED PROGRAMS

SLS/MPCV



Commercial Programs



Test Flight Programs

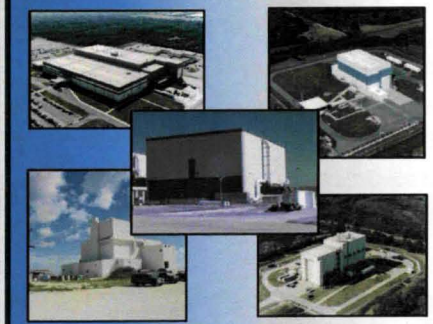
OPERATIONS AND CAPABILITIES

Delivery

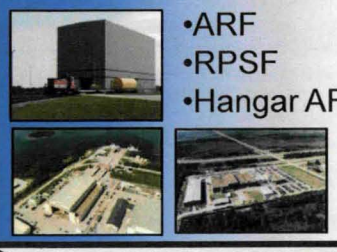
- SLF
- Rail
- Turn Basin
- Over Road Transport

Offline Payload and Spacecraft Processing

- SSPF
- EPF
- MPPF
- PHSF



Offline SRB Processing



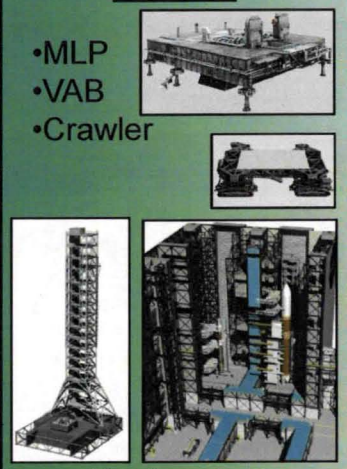
- ARF
- RPSF
- Hangar AF

Vehicle Integration and Launch

Integration

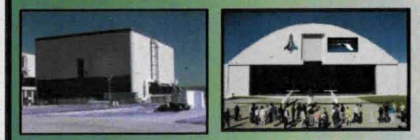
Vertical

- MLP
- VAB
- Crawler



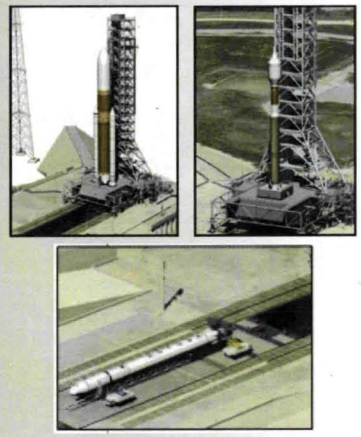
Horizontal

- OPF
- SLF Hangar



Launch

Launch Pad 39A/B

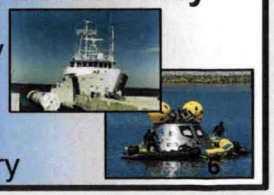


SLF

CCC & Range

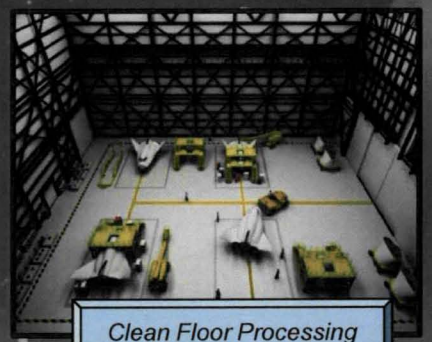
Landing & Recovery

- CM Recovery
- Horizontal Landing
- SRB Recovery



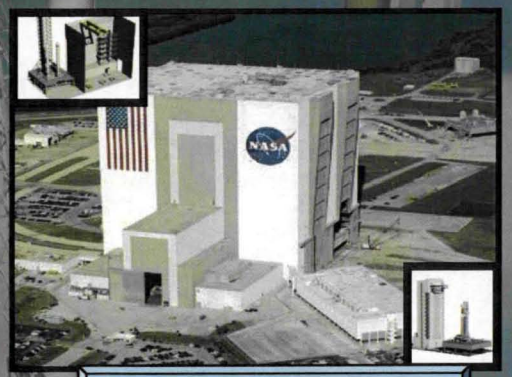
Florida Launch Site
A Flexible Approach

Horizontal Launch & Landing

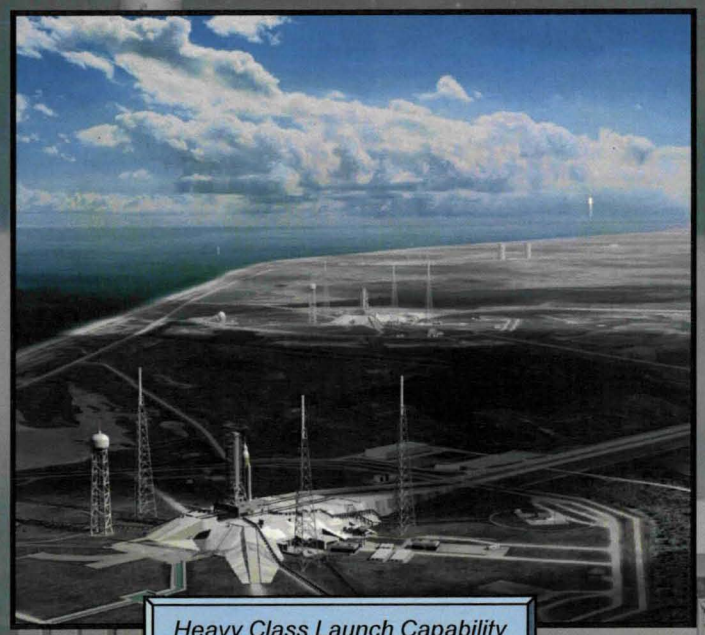


Clean Floor Processing

Small Vehicle Launch



Multi-Use Integration

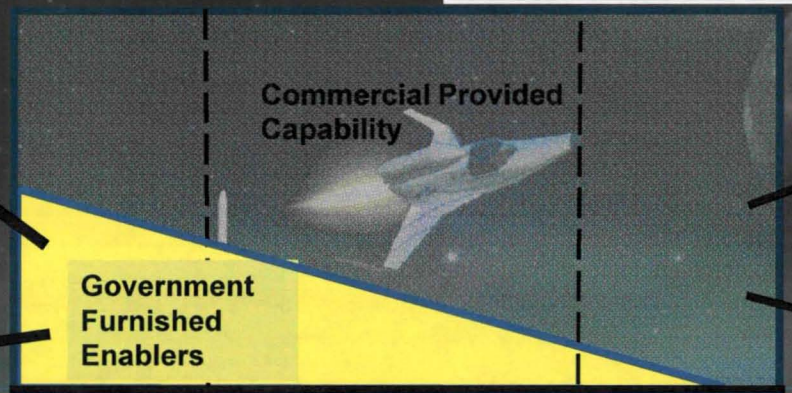


Heavy Class Launch Capability

Flexible Launch Capability

Florida Launch Site
Command & Control Strategy

Enabling Capabilities Catalog



Commercial Provided Capability

Government Furnished Enablers

Virtual Customer

Support SLS* Development & Test

*Space Launch System (SLS)

Customer Brings own C&C

Common Infrastructure (Government Furnished)

Continual Process of reducing O&M Costs

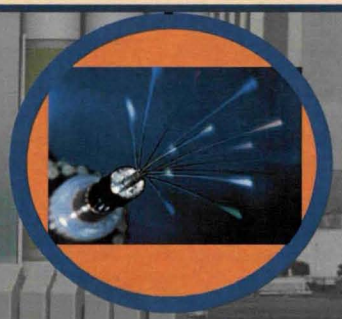
Unproven Technology

Payload Launch Experience

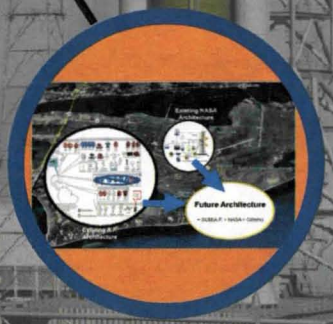
Critical Payload Launch Experience

Commercial Provider Maturity

Transform Launch Control to small projects that provide basic capability when needed



Integrated Network Services



Increased Range Capacity & Flexibility

Government Core Capabilities for safety and risk mitigation

Florida Launch Site
Summary

- **Features of a 21st Century Space Launch Complex**
  - Flexibility to support evolving launch vehicles and spacecraft
  - Standard interfaces to support multiple customer needs
  - Enhanced Range capacity and flexibility
  - Reconfigurable processing areas and control rooms
  - Revitalized infrastructure

- **KSC is open for Business**
  - Continuing to work with industry to better understand needs and potential requirements
  - Gaining understanding of evolving requirements from Commercial Customers
  - Implementing technologies to overcome constraints for flexible, multi-use concepts and cost sharing
  - Collaborating with NASA, DoD and commercial0 Programs