National Aeronautics and Space Administration

GROUND SYSTEMS
Development and Operations

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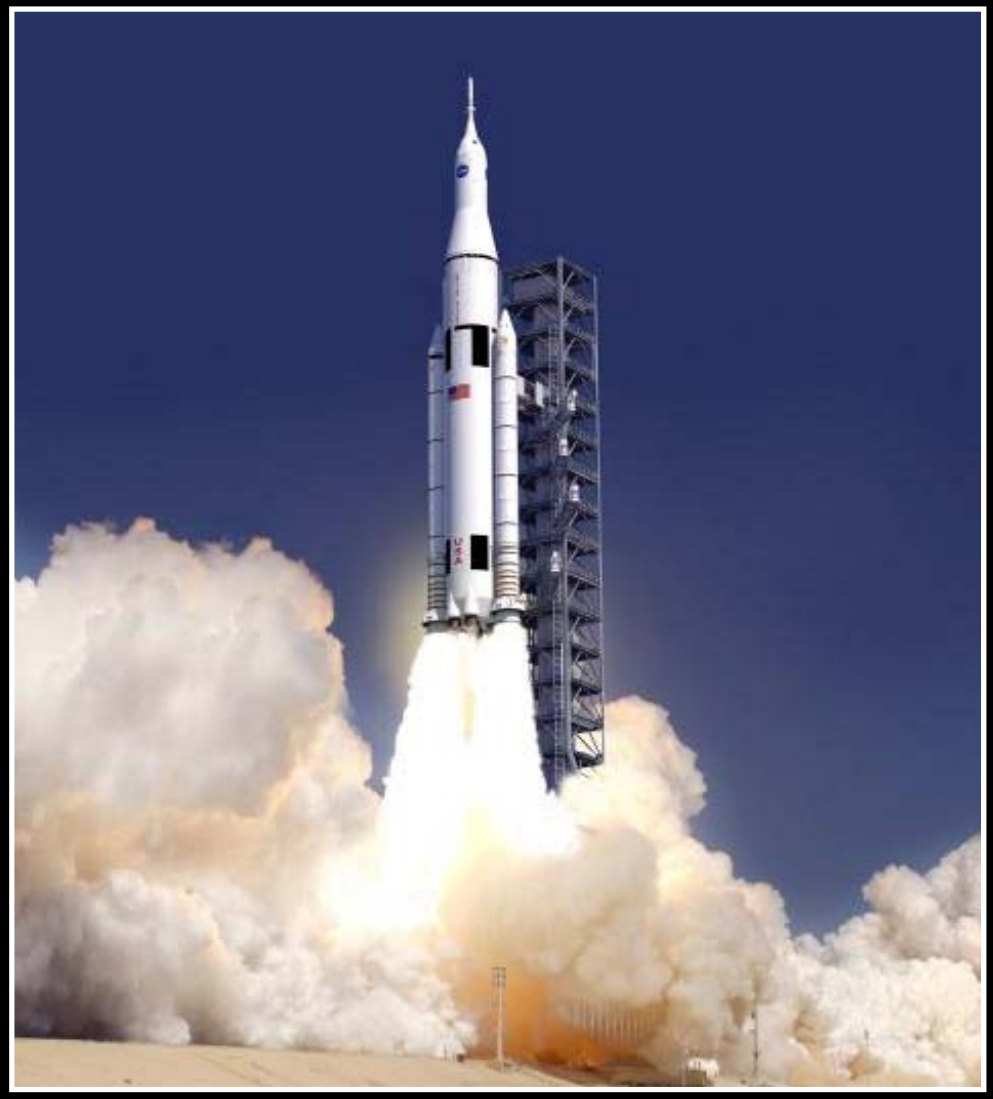
GSDO Program Manager
July 11, 2012

GROUND SYSTEMS
Development and Operations

Exploration Begins Here



DAWN OF A NEW ERA

SPACE LAUNCH SYSTEM (SLS)

Block 1 (70t)

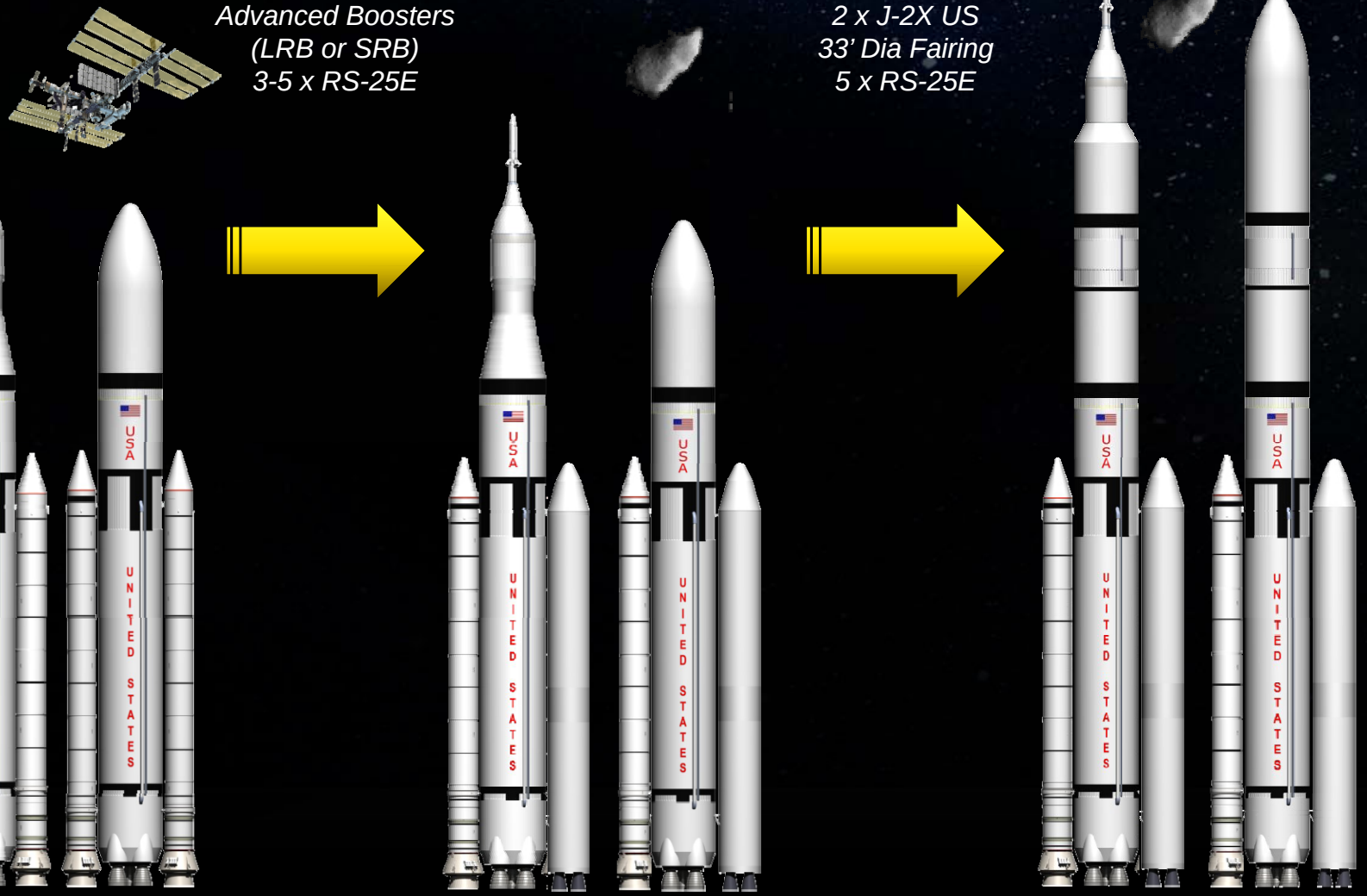
MPCV
ICPS
27.6' Dia Fairing
27.6' Core
3 -5 x RS-25D
2 x 5 seg PBAN

Block 1A (105t)

Advanced Boosters
(LRB or SRB)
3-5 x RS-25E

Block 2 (130t)

2 x J-2X US
33' Dia Fairing
5 x RS-25E

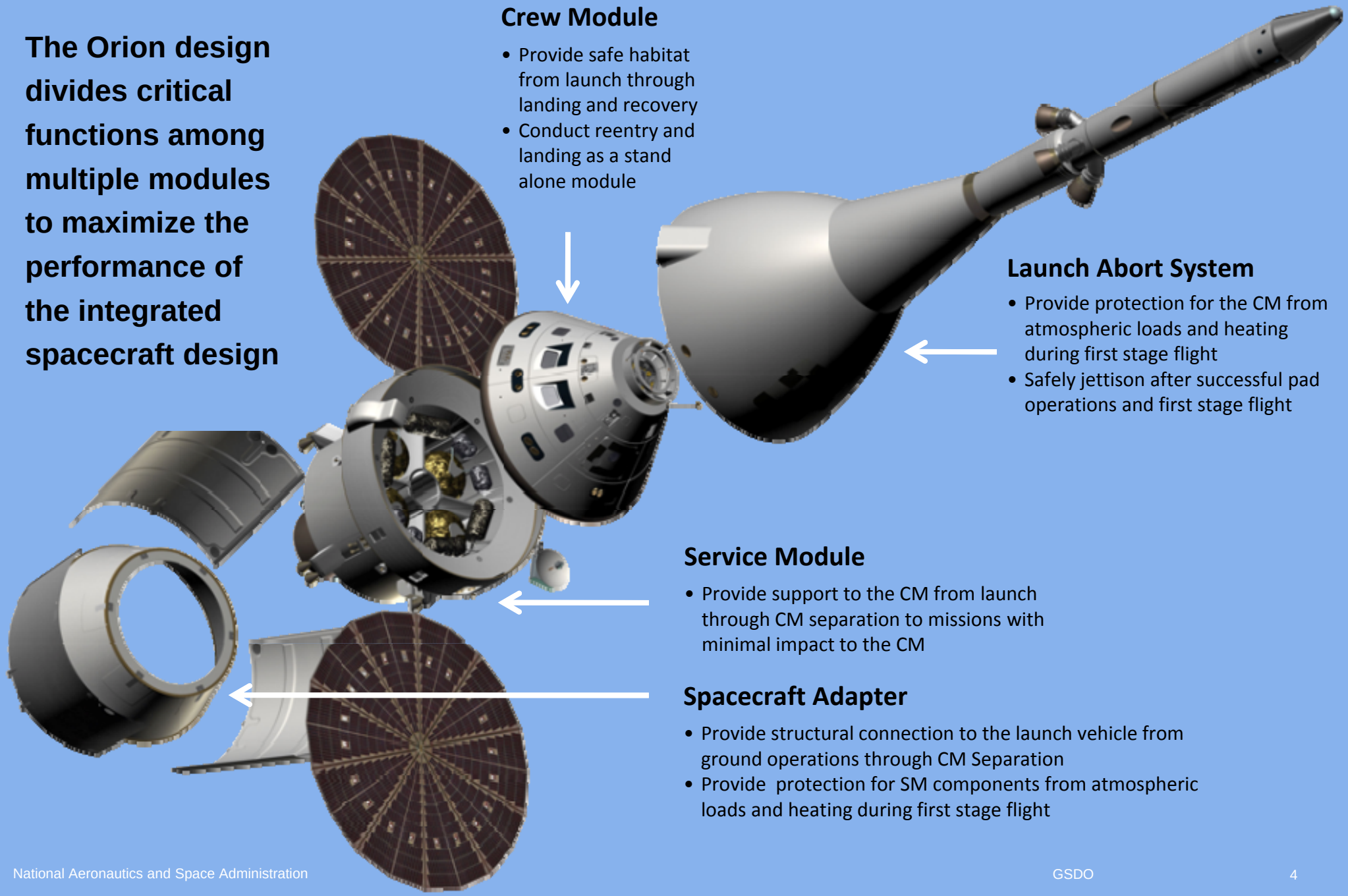


Spacecraft Overview

The Orion design divides critical functions among multiple modules to maximize the performance of the integrated spacecraft design

Crew Module

- Provide safe habitat from launch through landing and recovery
- Conduct reentry and landing as a stand alone module



Launch Abort System

- Provide protection for the CM from atmospheric loads and heating during first stage flight
- Safely jettison after successful pad operations and first stage flight

Service Module

- Provide support to the CM from launch through CM separation to missions with minimal impact to the CM

Spacecraft Adapter

- Provide structural connection to the launch vehicle from ground operations through CM Separation
- Provide protection for SM components from atmospheric loads and heating during first stage flight

Orion

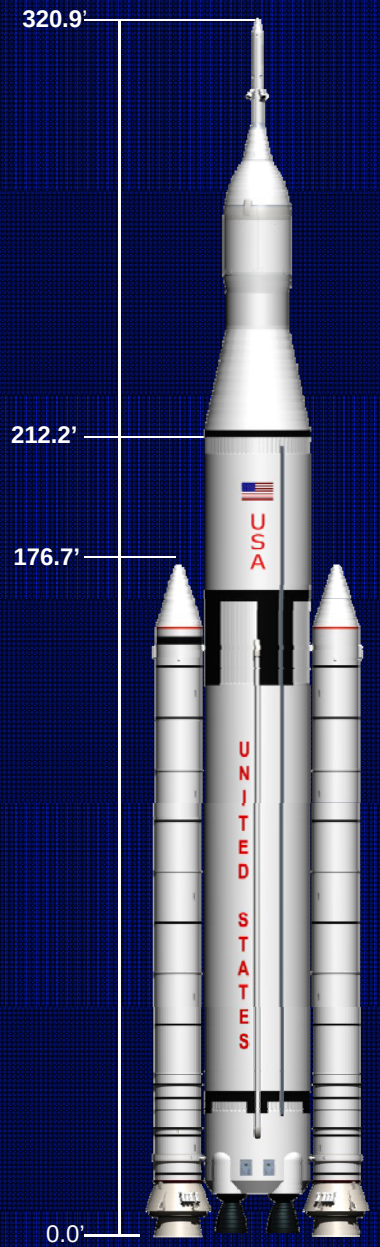
Propellants	Hypers
CM, SM Mass	53,405 lbm
LAS	16,300 lbm
# Engines / Type	1 / STS OMS
Total Mass	73,738 lbm

iCPS

Propellants	LOX/LH2/ Hypers
Propellant Mass	58,643 lbm
Dry Mass	9,275 lbm
Adapters	11,287 lbm
# Engines / Type	1 / RL10-B2
Total Mass	79,205 lbm

Boosters

Propellants	PBAN
Propellant (ea)	1,385,437 lbm
Burnout Mass (ea)	218,967 lbm
# Boosters / Type	2/ 5 Segment Steel
Total Mass (2)	3,210,032 lbm

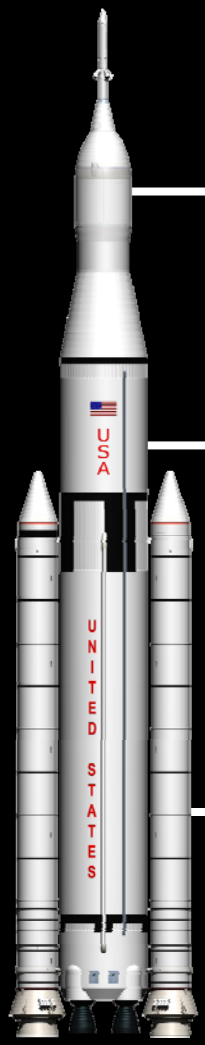


Core Stage

Propellants	LOX/LH2
Propellant	2,178,481 lbm
Dry Mass	211,614 lbm
# Engines / Type	4 / RS-25D
Total Core Mass	2,390,095 lbm

Total Wet Masses

Orion	73,738 lbm
iCPS	79,205 lbm
Boosters	3,210,032 lbm
Core	2,390,095 lbm
Total (GLOW)	5,753,070 lbm
Rollout Mass	3,515,946 lbm



Offline Spacecraft Processing

Core Stage Processing

Offline SRB Processing

Command, Control, Communications, and Range

Vehicle Integration and Launch

Landing & Recovery

SLS / MPCV Concept of Operations

Small Class Vehicle

Mobile Launcher

Launch Pad

Crawler Transporter

Vehicle Assembly Building

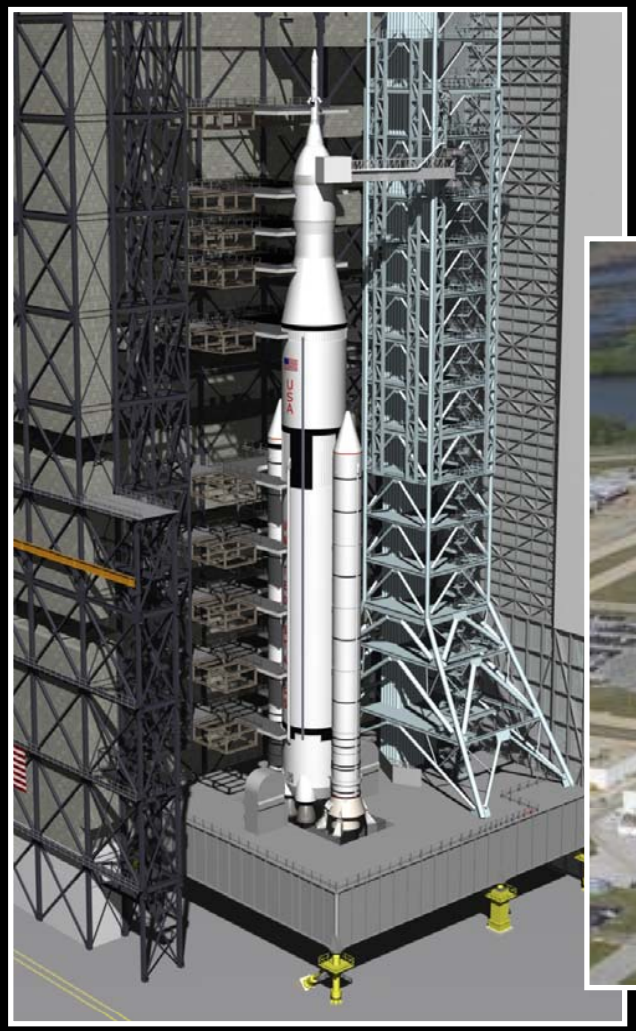
VEHICLE INTEGRATION & LAUNCH CAPABILITIES

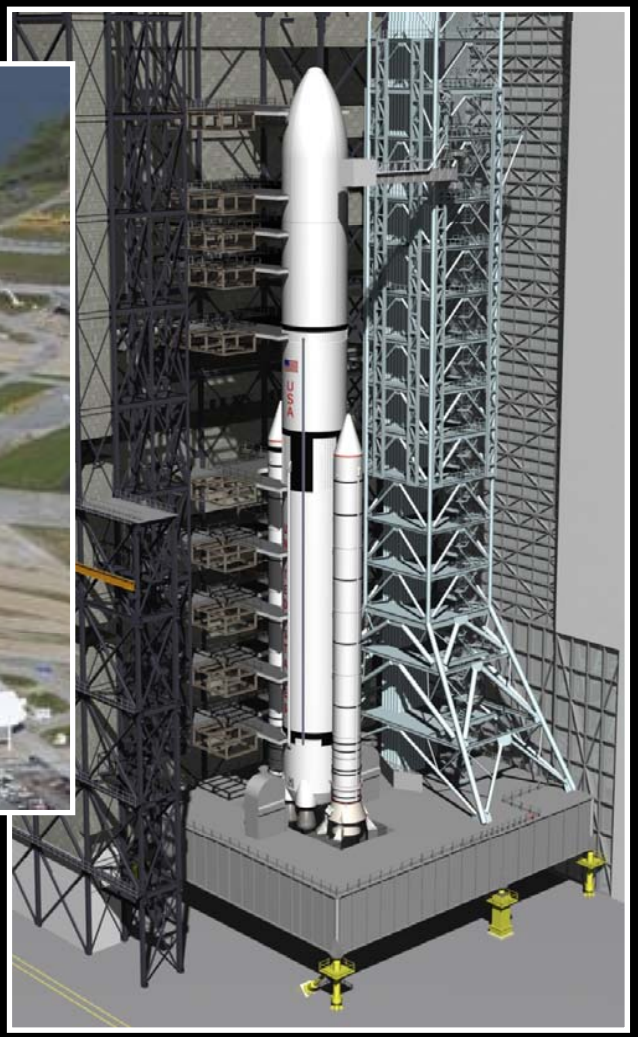
LAUNCH PAD 39A

LAUNCH PAD 39B

LAUNCH PAD

MOBILE LAUNCHER



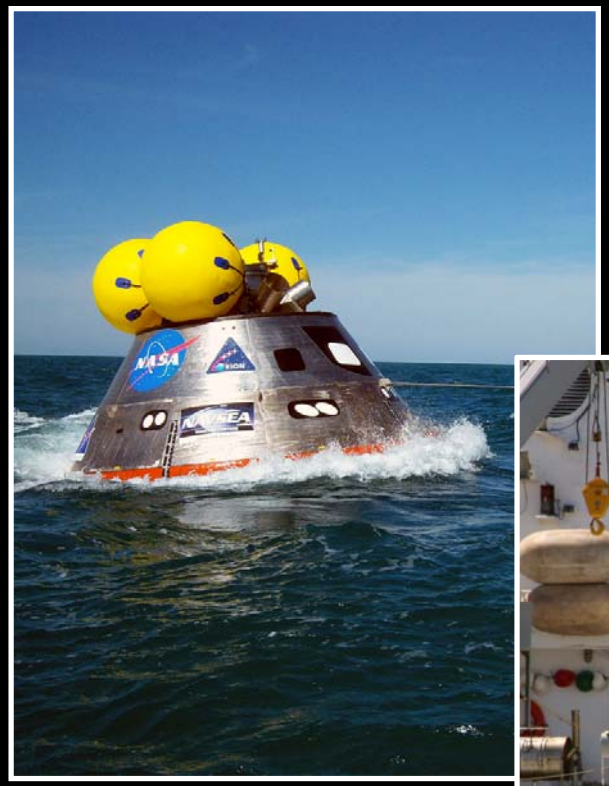


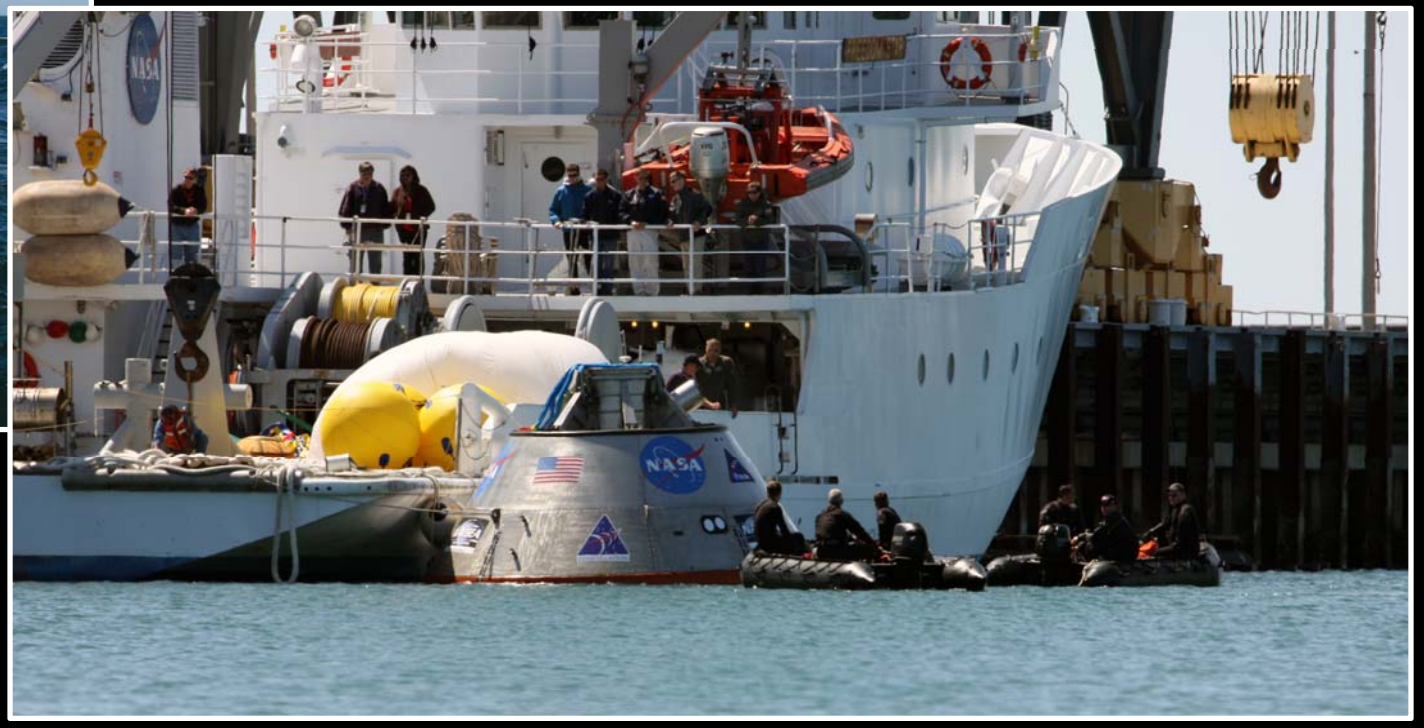
VEHICLE ASSEMBLY BUILDING

CRAWLER TRANSPORTER

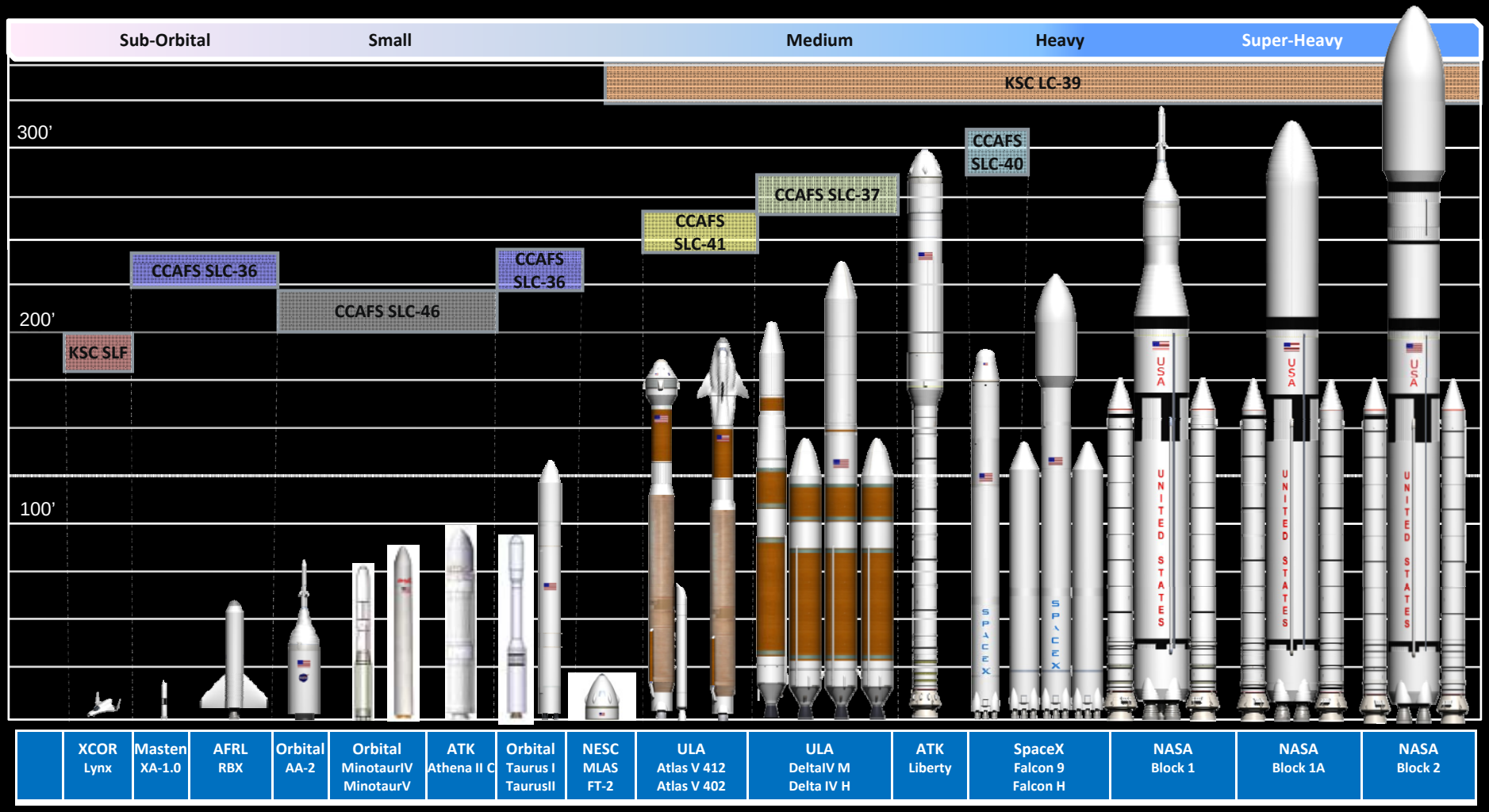
LAUNCH VEHICLE OFFLINE PROCESSING

SPACECRAFT OFFLINE PROCESSING





SPACECRAFT RECOVERY



LC-39 may support Medium lift to Super-Heavy lift vehicles

STARFIGHTERS

MORPHEUS

LYNX

DREAMCHASER

STRATOLAUNCH

SMALL CLASS VEHICLES

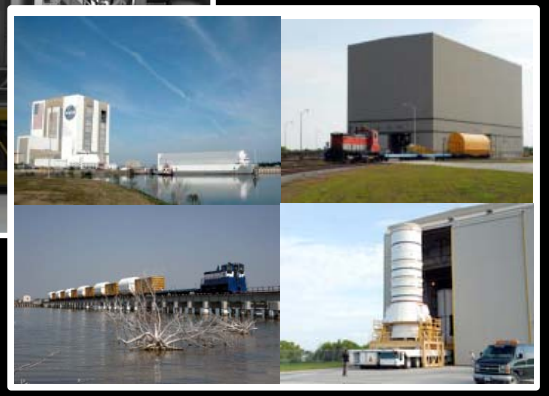
GROUND SYSTEMS
Development and Operations

Environmental & Infrastructure

Landing & Recovery

Spacecraft Offline Processing

Orion Production Ops



Launch Vehicle Offline Processing

OFFLINE PROCESSING & INFRASTRUCTURE CAPABILITIES

Environmental provides SLS and commercial launch programs a fully permitted environmental
launch facility with unencumbered land and energy, operations and maintenance savings opportunities.

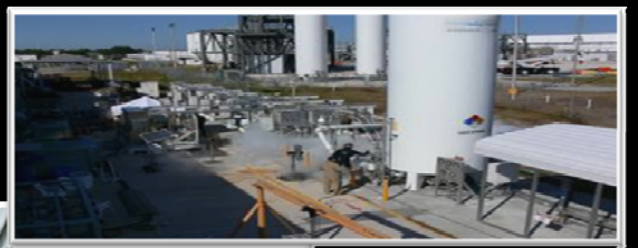
Infrastructure focus is on improvements and enhancements of infrastructure systems critical to payload processing and launch operations.

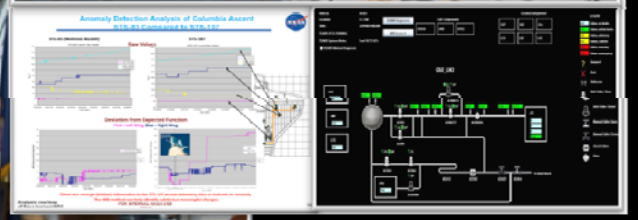
ENVIRONMENTAL / INFRASTRUCTURE

GROUND SYSTEMS
Development and Operations

End to End
Command and Control

Advanced Ground Systems
Maintenance





Communications Systems

Range Systems

COMMAND CONTROL COMMUNICATIONS & RANGE

GROUND SYSTEMS Development and Operations

GSDO PROGRAM PROGRESS

2009	2010	2011	2012	2013
		GSDO Program Office Stand Up 15Jun; MCR Board 30Nov	KDP-A 17JAN; SRR/SDR Board 30AUG	EFT-1 Dec

Program Progress

Lightning Protection Completed at Launch Pad 39B

Mobile Launcher Construction

Service Structures Demolition at Launch Pad 39B

Orion Access Demonstration at Multi-Purpose Processing Facility (MPPF)

Firing Room 1 Complete at Launch Control Center (LCC)

Refurbishment Complete at Launch Equipment Test Facility (LETF)

Mobile Launcher Rollout Interface Test at LC-39B

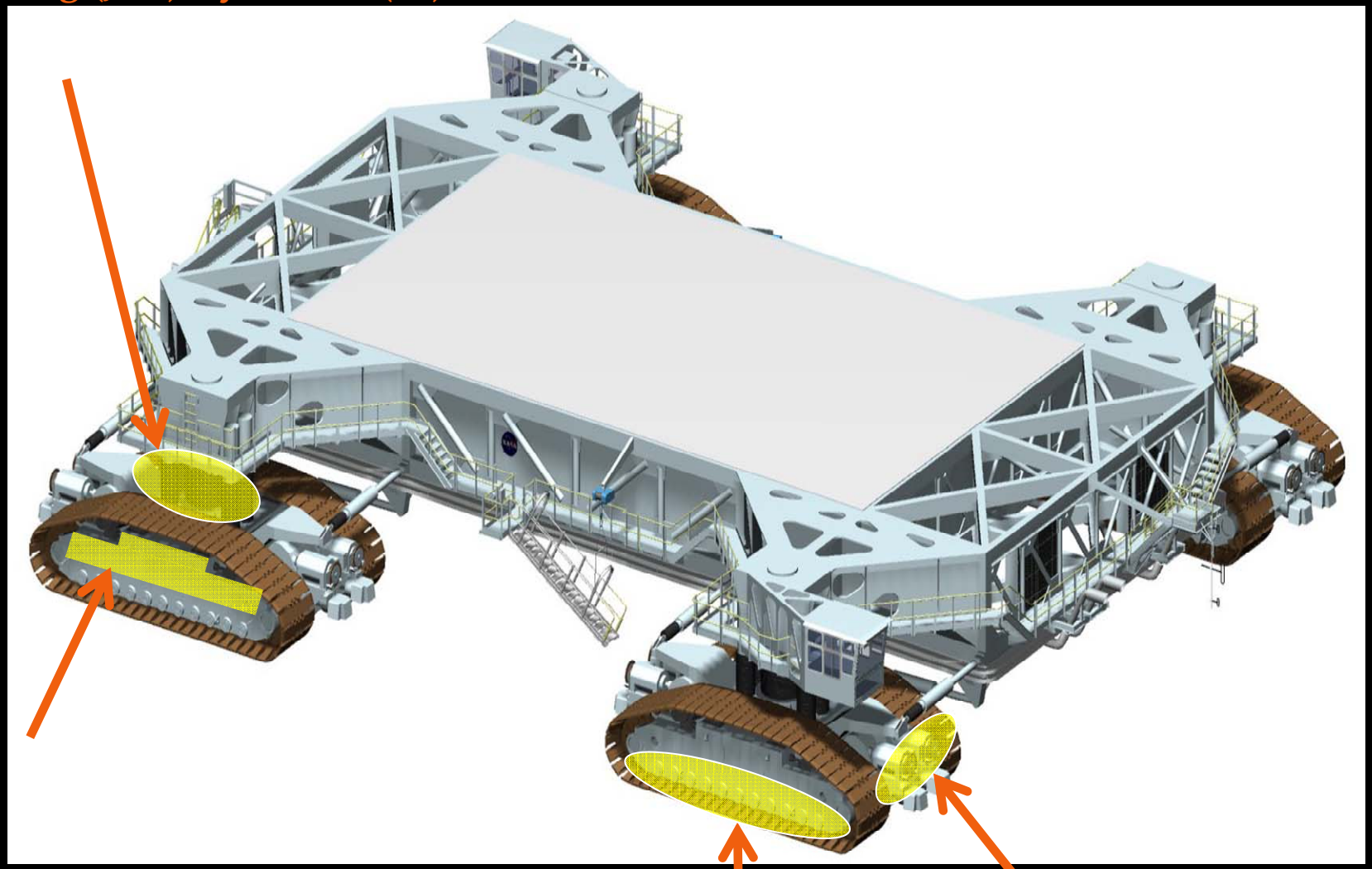
Orion CM-2 Arrival at Multi-Purpose Processing Facility (MPPF)

Morpheus Flight Testing at Shuttle Landing Facility (SLF)

Exploration Flight Test (EFT-1) at SLC-37B

CRAWLER TRANSPORTER MODS

Jacking, Equalization and Leveling (JEL) Cylinders (16)

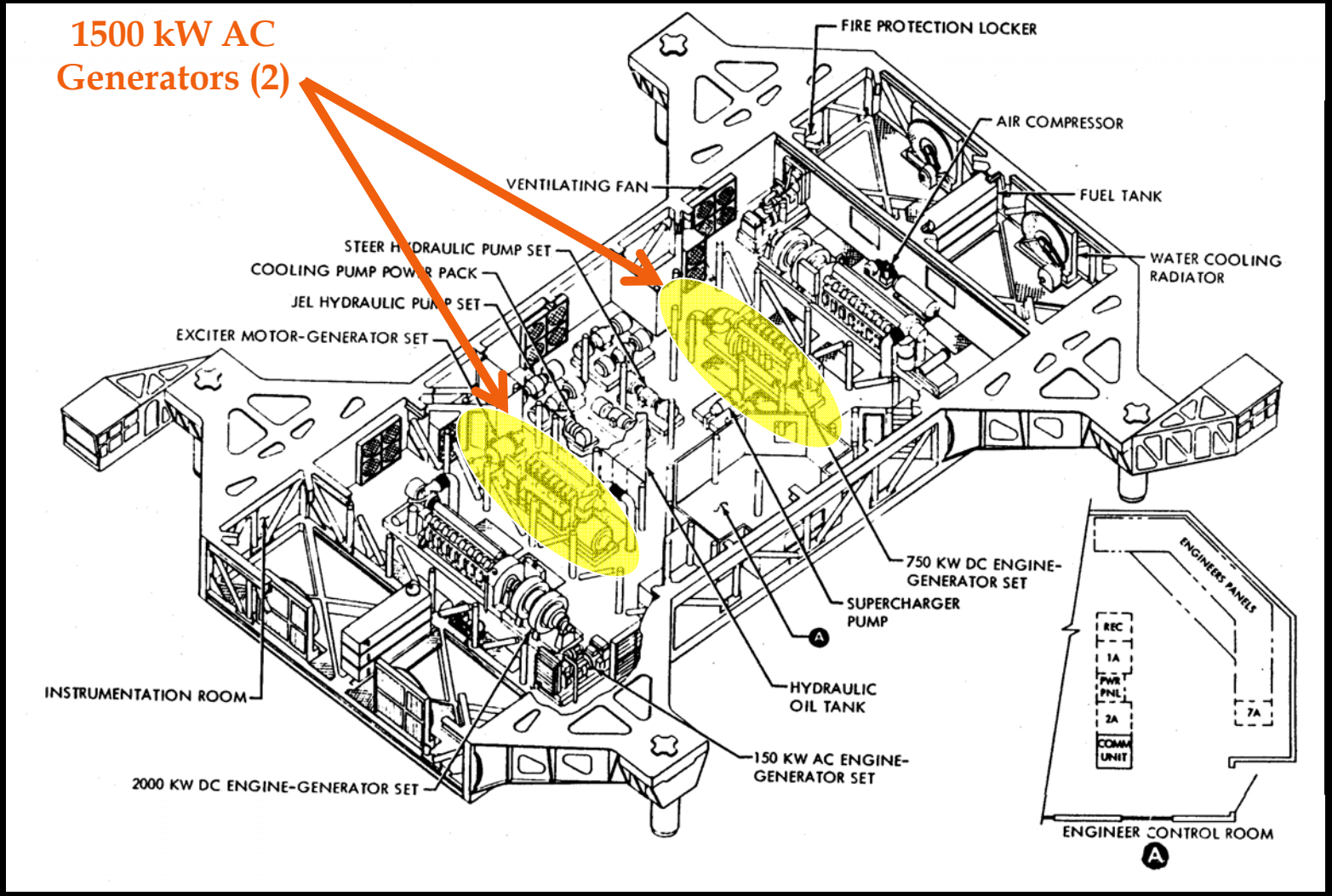


Shear Webs Reinforcement (complete)

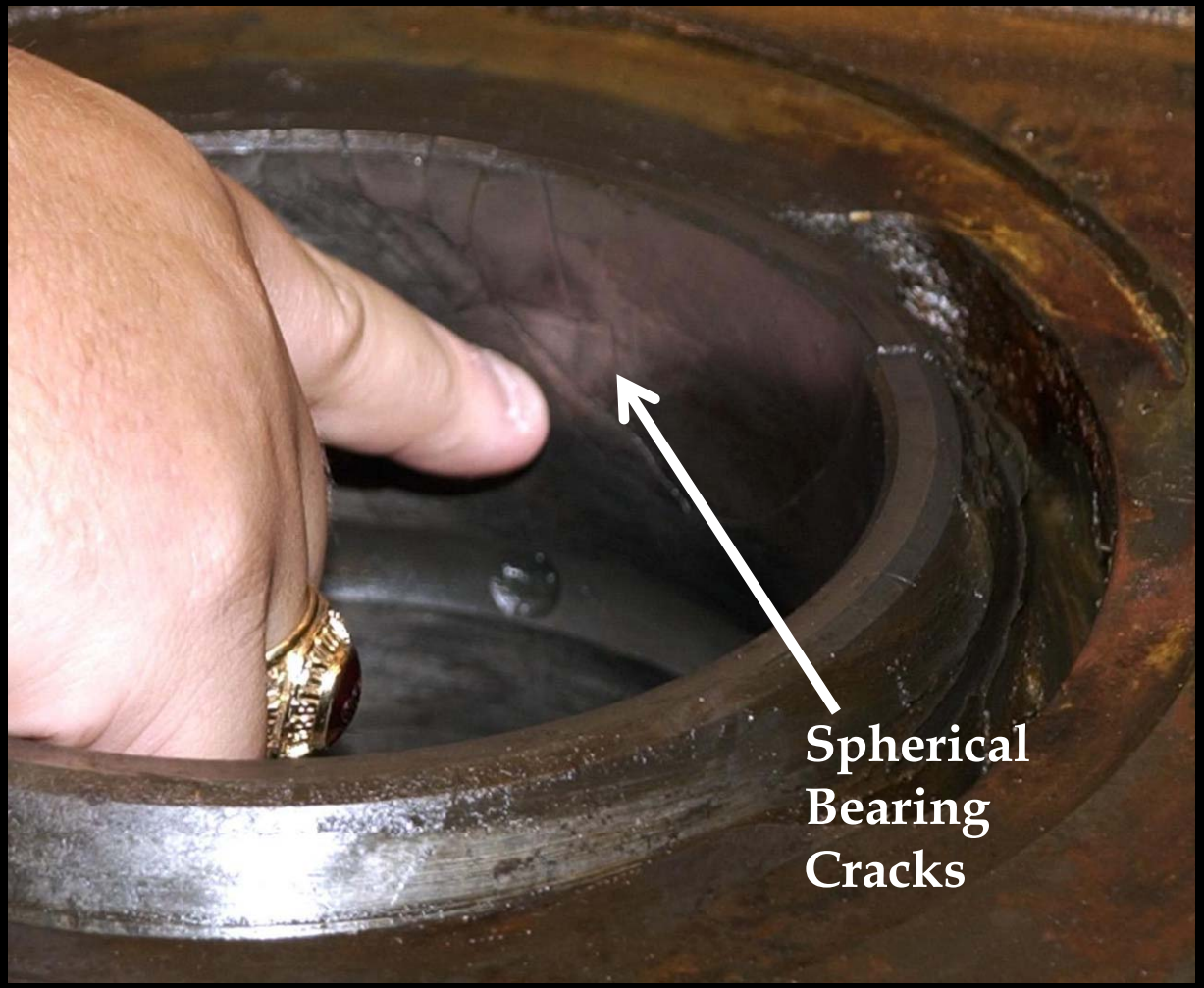
Roller Bearings (88)

Brakes (16)

CRAWLER TRANSPORTER MODS

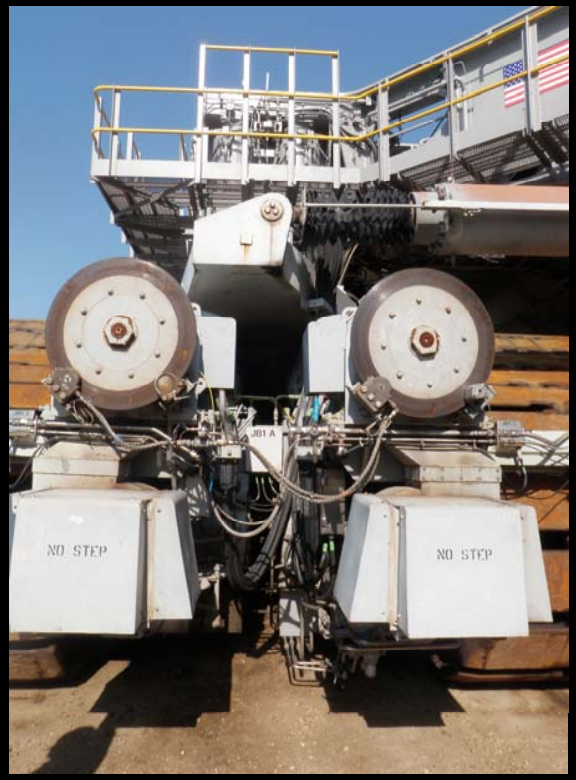


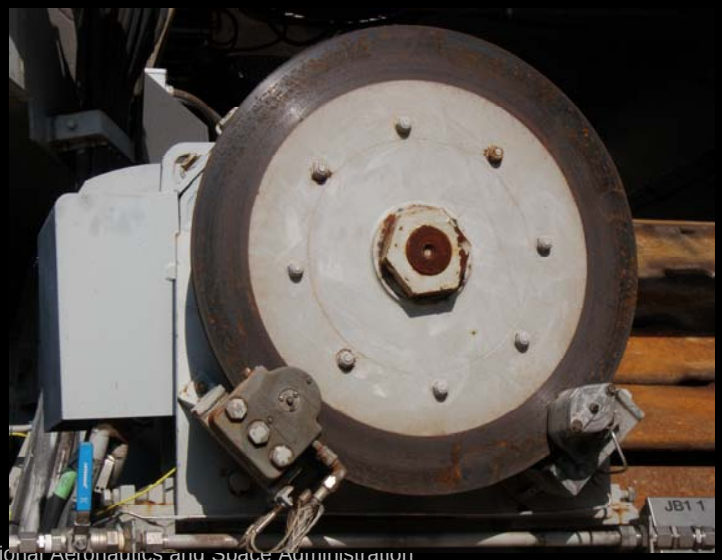
OLD JEL Design



CRAWLER TRANSPORTER MODS

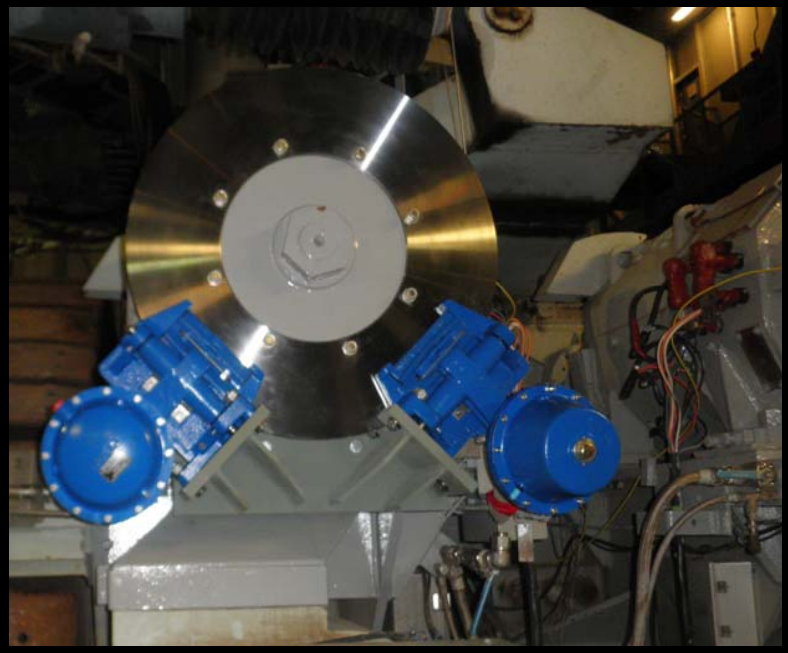
OLD Design



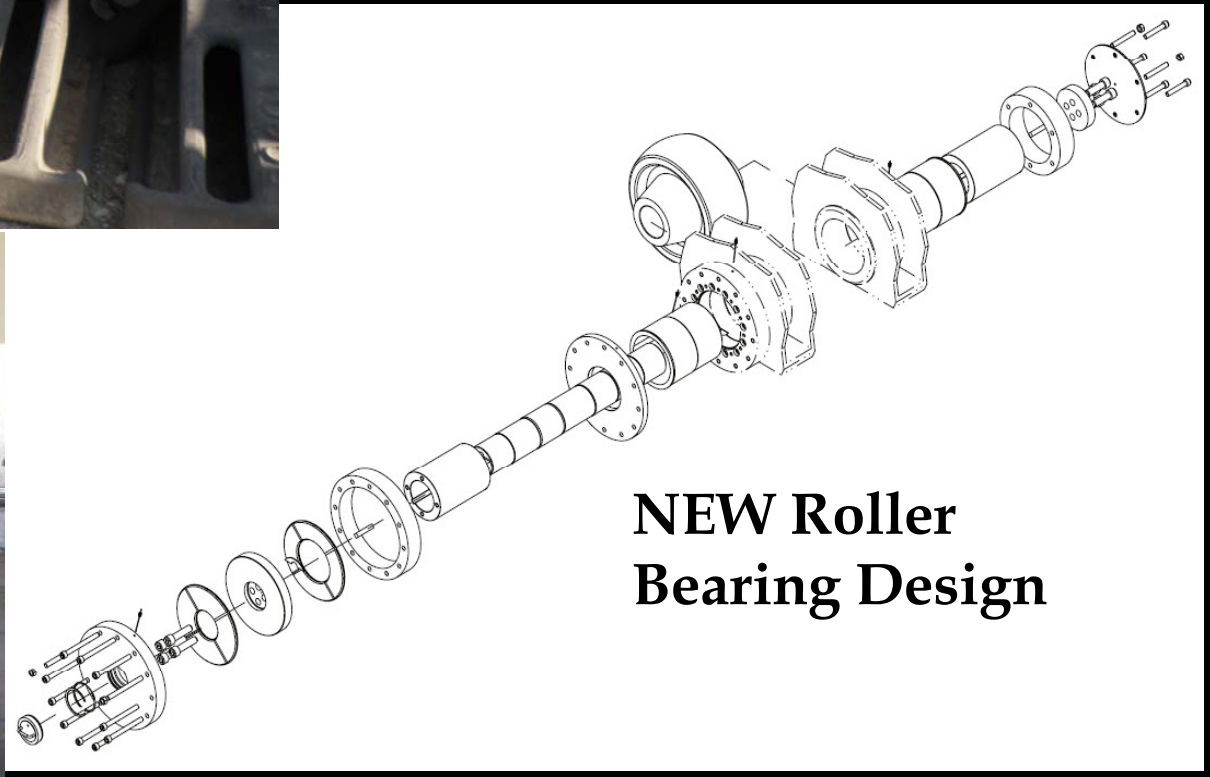


Brakes from Hydraulic to Pneumatic

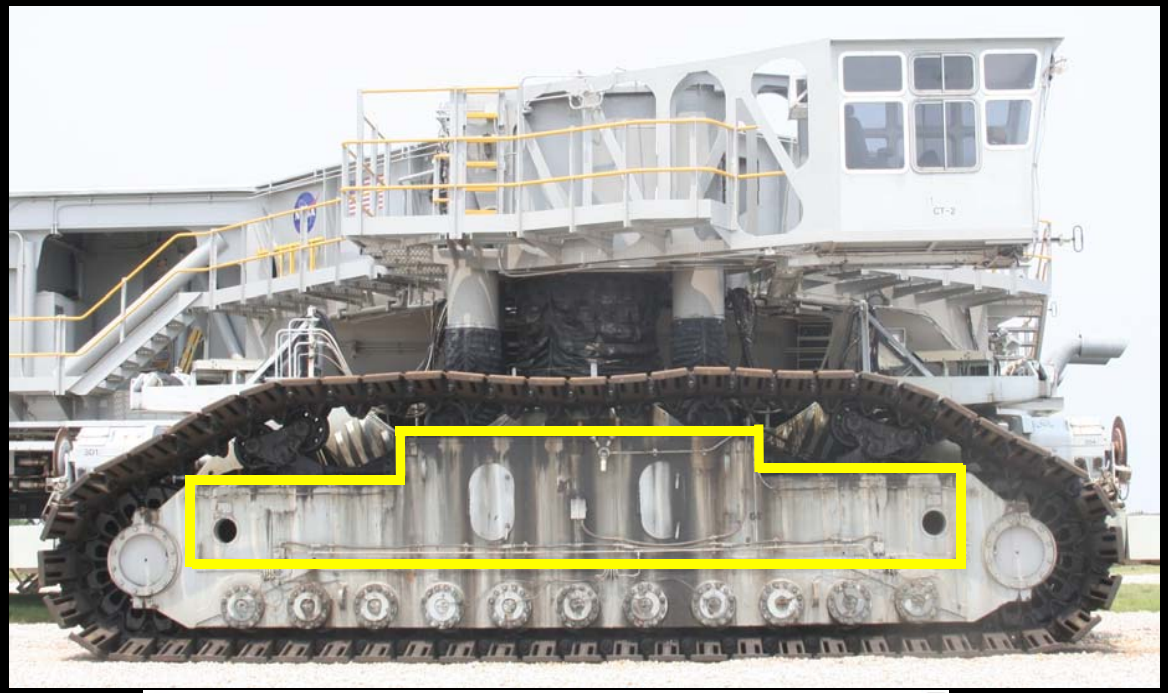
NEW Design



CRAWLER TRANSPORTER MODS



CRAWLER TRANSPORTER MODS



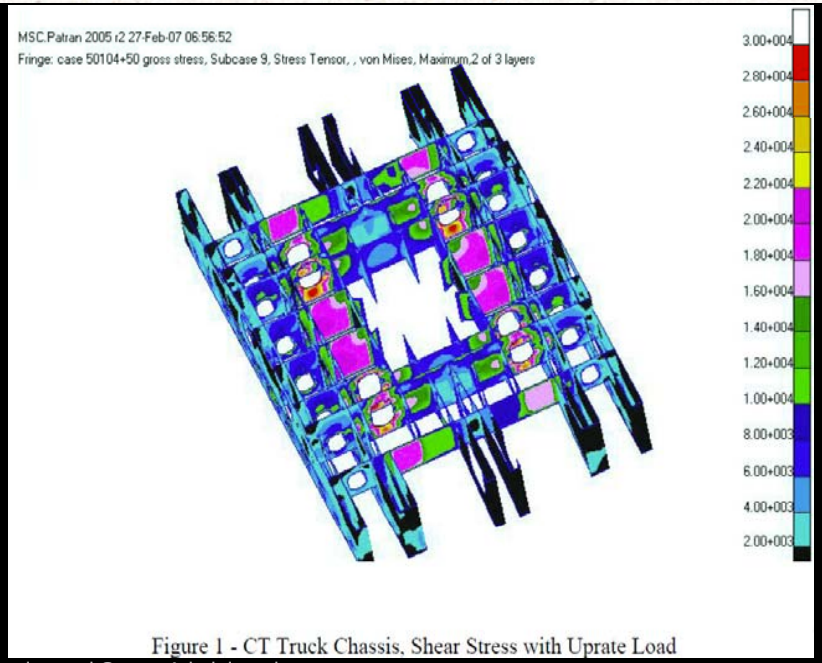


Figure 1 - CT Truck Chassis, Shear Stress with Uprate Load

Shear Webs Internal Steel Reinforcement

Crack Repair

CRAWLER TRANSPORTER MODS

OLD Design

OLD 750 kW AC Generators

NEW Design

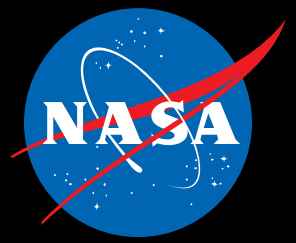
NEW Automatic Transfer Switches

NEW 1500 kW AC Generators

CRAWLER TRANSPORTER MODS

Y = Yes, P = Proposed	CT-2	CT-1	Spares
Parking/Service (Uprade) - From Hydraulic to Pneumatic	Y	P	
Vibration Isolation Pads for ALCO/Generators	Y	P	
VFD Upgrade	Y	P	
Onan Engine Upgrade	Y	P	
ACTD Refurbishment	Y	P	
Replace Armature Cables & Cable Trays	Y	P	
Replace DC Generator Flex. Copper Bus Bars/Brush Holders/Insulators	Y	P	
JEL Valve Replacement	Y	P	
Spare JEL & Steering Motor Refurbishment	Y	Y	Spares
Replace Propel Electronic Cards	Y	P	
DC Generator Pedestal Electrical Isolators	Y	P	
Replace Control Room Consoles	Y	P	
New Display Units	Y	P	
PLC System Improvements	Y	P	
New Laser System	Y	P	
ALCO E1 & E2 Engine Panel Upgrade	Y	P	
Fire System Wiring	Y	P	
Upper Cable Trays	Y	P	
Guide Tube Corrosion Control	Y	P	
93 Update S&T	Y	P	
PROCURE New Generator Sets (E3 & E4) & Installation Hardware Engines	Y	Y	
AC Gen Sets CT-2 & CT-1	Y	Y	
Inspect ALCO Oil Coolers	Y	P	
Inspect ALCO Turbochargers	Y	P	

Y = Yes, P = Proposed	CT-2	CT-1	Spares
Drain/Clean Fuel Oil Tank	Y	Y	
Upgrade Starters/Oilers	Y	P	
Redundant Height XDCR	Y	P	
Replace Manometer Sight Glass Mechanisms	Y	P	
Drain & Clean Hydraulic Reservoir	Y	P	
Guide Tube Steering System Upgrade	Y	P	
Tubing Upgrade	Y	P	
Retube - Air supply lines, hydraulic lines, lubrication	Y	P	
Belt Pin Lube System	Y	P	
Cab Console Refurbishment	Y	P	
Field Device Wiring	Y	P	
Instrumentation Upgrade	Y	P	
New Scope - Corrosion Control & Misc Mods/procurements	Y	P	
Closed circuit TV and Security System	Y	P	
Gear Box Refurb	Y	P	
Provide Four (4) Tread Belts	Y	Y	Spares
Procure DCC Cabinet Instrumentation	Y	P	
DCC Cab Instrumentation	Y	P	
Procure New Steering Corner Valves	Y	P	
Steering Corner Valves	Y	P	
Lighting Upgrades	Y	P	
Work Stands	Y	Y	Spares
JEL Cylinder Upgrades	Y	P	
Roller Bearing Upgrades	Y	P	
Shear Web Modifications CT-1 & CT-2	Y	Y	


NASA

Key Points:

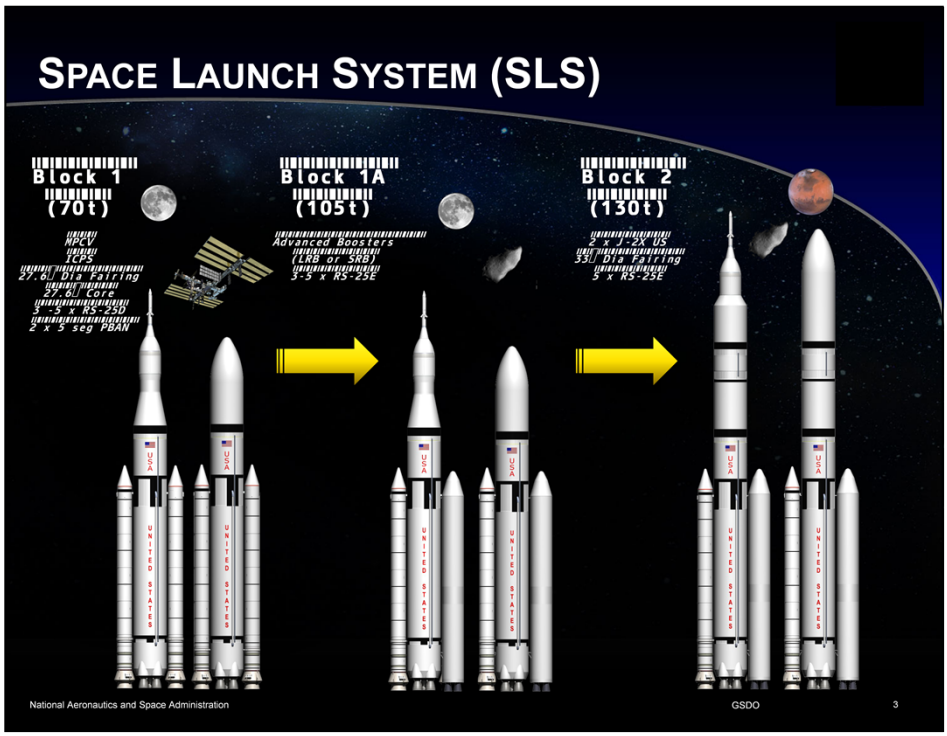
- The Ground Systems Development and Operations (GSDO) Program Vision: Launching the world's most powerful, advanced launch vehicles and spacecraft.
- The GSDO Program Mission: To be the driving force that transforms Kennedy Space Center into the world's premier multi-user launch and landing spaceport.

Background Info:

- The Ground System Development and Operations (GSDO) program was established to develop and use the complex equipment required to safely handle rockets and spacecraft during assembly, transport and launch.
- The program's mission is to prepare the center to process and launch the next generation of rockets and spacecraft in support of NASA's exploration objectives by developing the necessary ground systems, infrastructure and operational approaches
- For more info visit: http://www.nasa.gov/pdf/638587main_20120425_GSDO.pdf

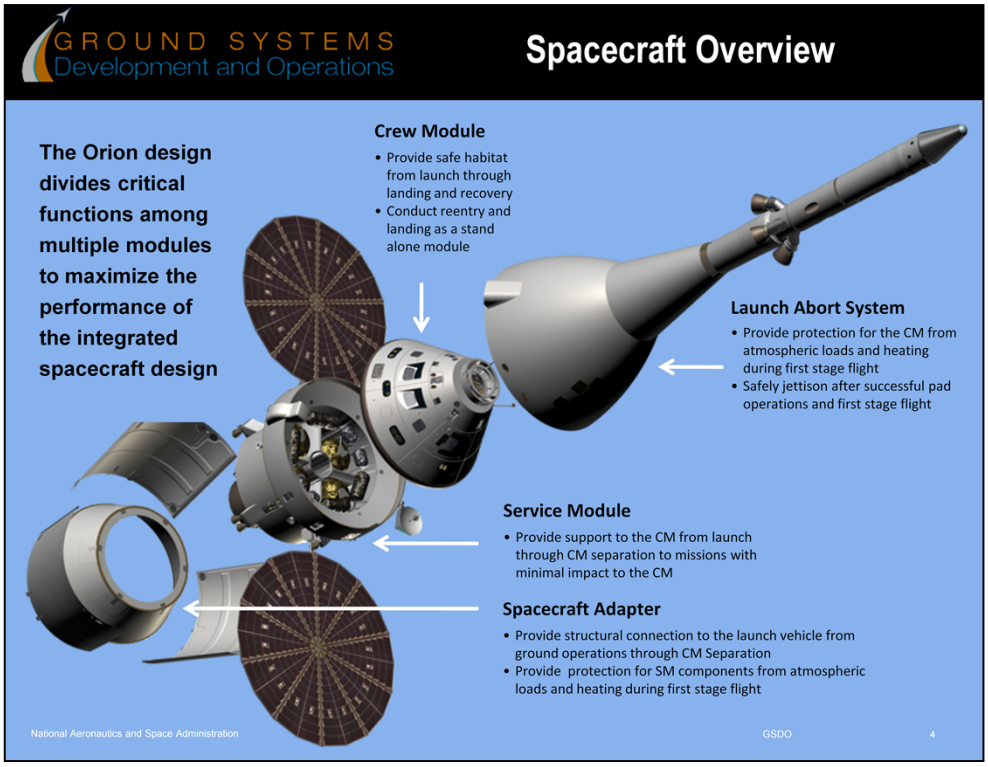
Key Points:

- GSDO is supporting the President's direction for space exploration, by developing ground systems that support the new Space Launch System (SLS) launch vehicle and Multi-Purpose Crew Vehicle (MPCV) spacecraft.
- This marks a new era in space exploration, as this launch vehicle and spacecraft replace the Space Shuttles.



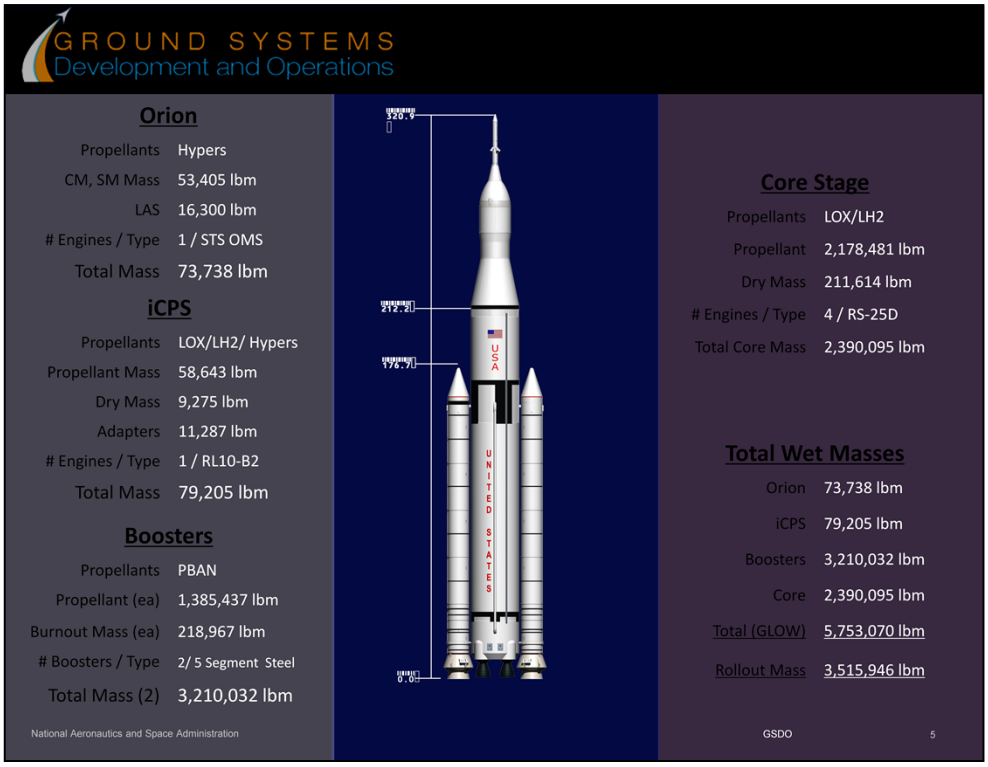
Key Points:

- TBD



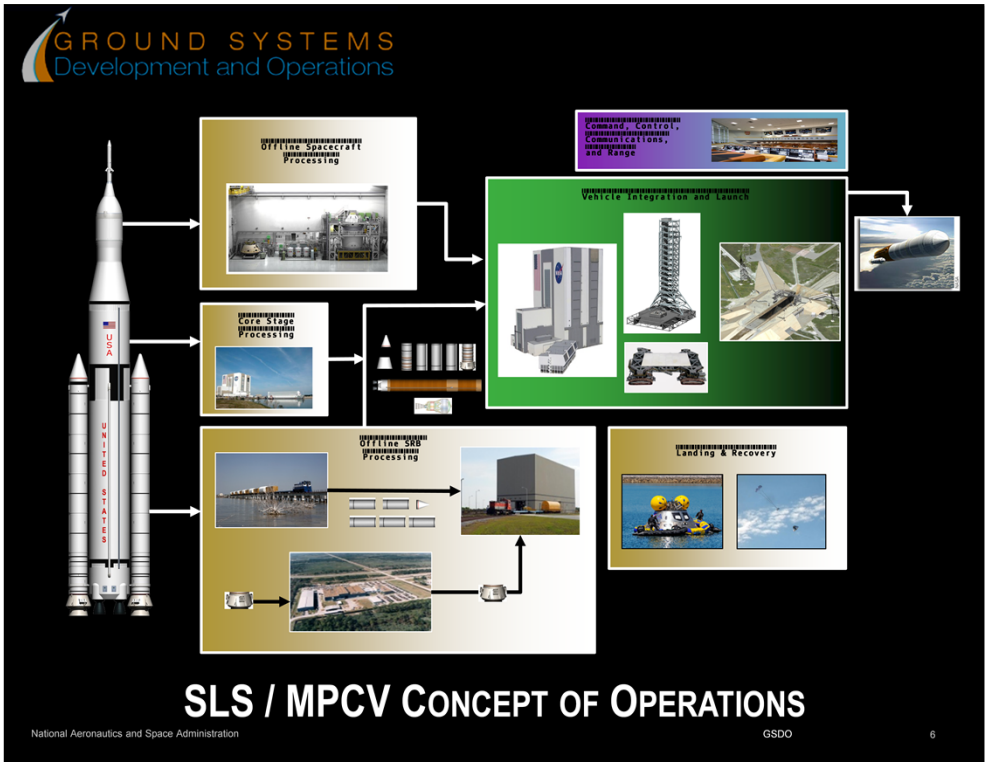
Key Points:

- TBD



Key Points:

- TBD



Key Points:

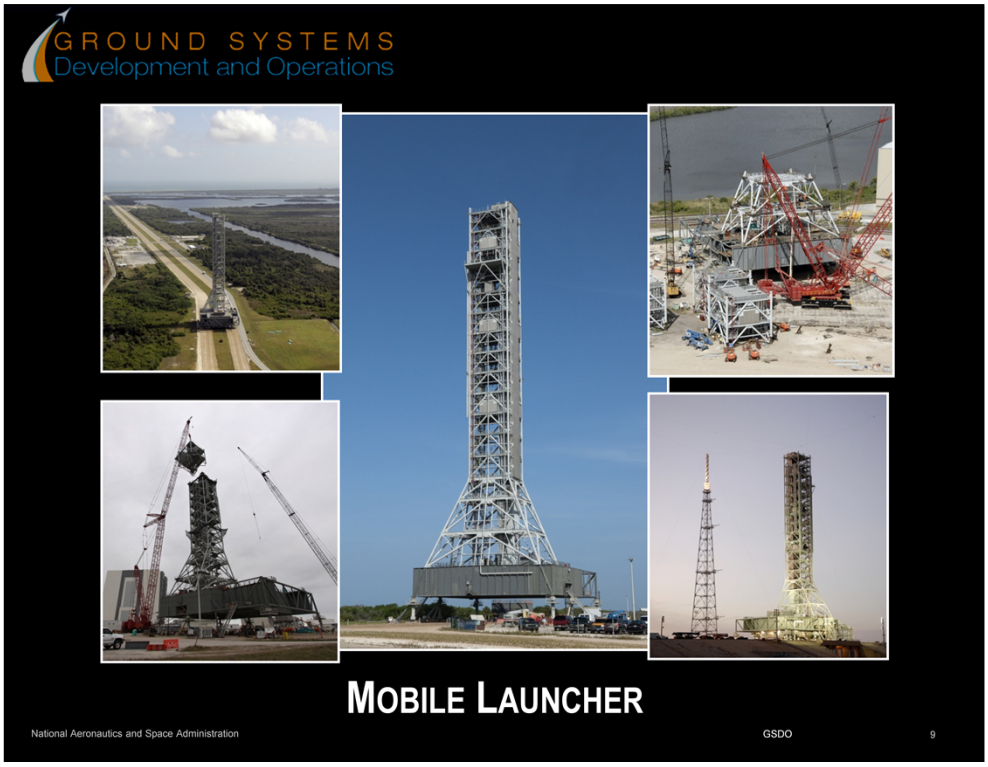
- This charts shows the current path that each part of the vehicle and spacecraft will take during build-up for launch.
- This includes the solid rocket boosters (SRBs), core stage, and Orion spacecraft.

Key Points:

- GSDO consists of three major components. The first is Vehicle Integration & Launch (VIL).
- The **Vehicle Integration and Launch** team focuses on the equipment, management and operations required to safely connect a spacecraft with a rocket, move the launch vehicle to the launch pad and successfully send it into space.
- VIL includes vehicle integration, a mobile launcher platform to support build-up and launch, transportation to the pad via the crawler transporter, and a launch pad.
- Also Kennedy Space Center is developing small class vehicle capability to support commercial users.

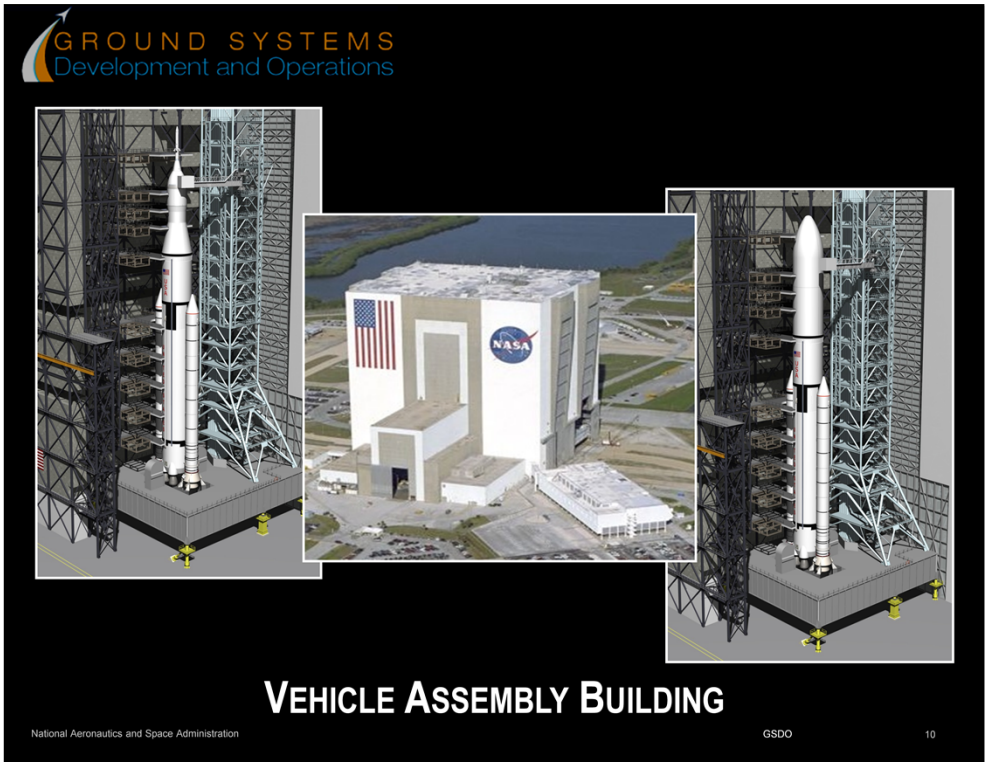
Key Points:

- The Vehicle Assembly Building (VAB) is the place where the vehicle is assembled on the Mobile Launcher, prior to rollout and launch.
- The VAB consists of four high-bays and multiple low-bays and at one time was the largest building.
- The figure on the left shows the SLS/MPCV in the high-bay, on the Mobile Launcher.
- The figure on the right shows the SLS with a cargo payload.



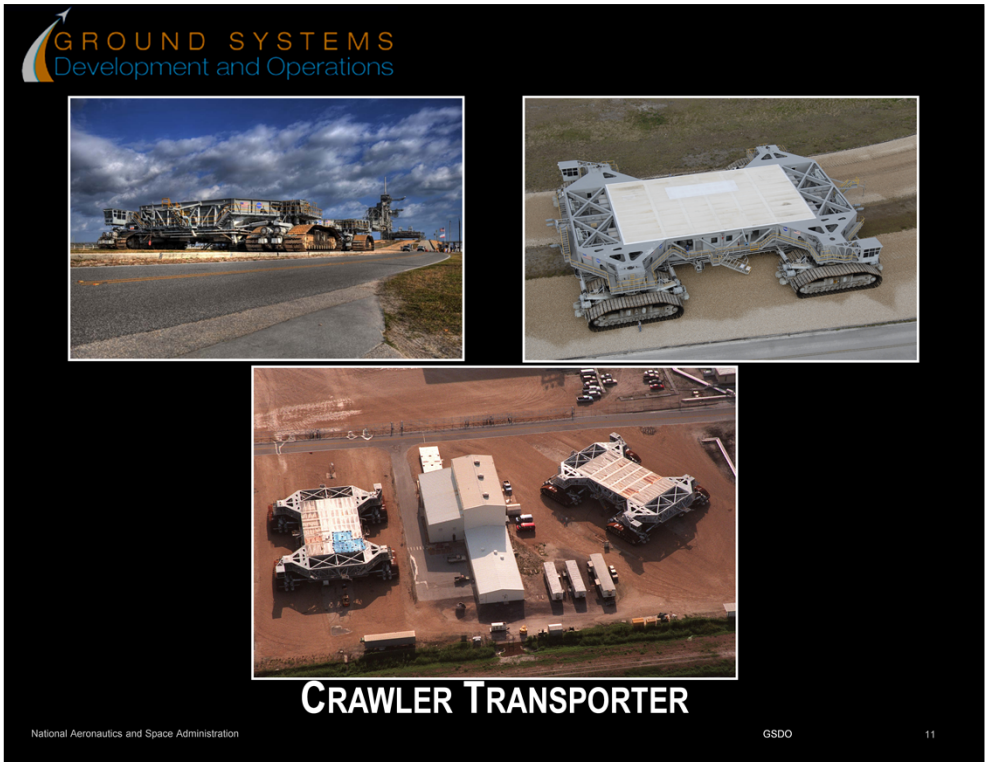
Key Points:

- The SLS Mobile Launcher is used for stacking the vehicle, transporting the vehicle to the pad, and as a launch platform.
- The mobile launcher consists of a base and a tower and provides all commodities to the vehicle prior to launch.



Key Points:

- TBD

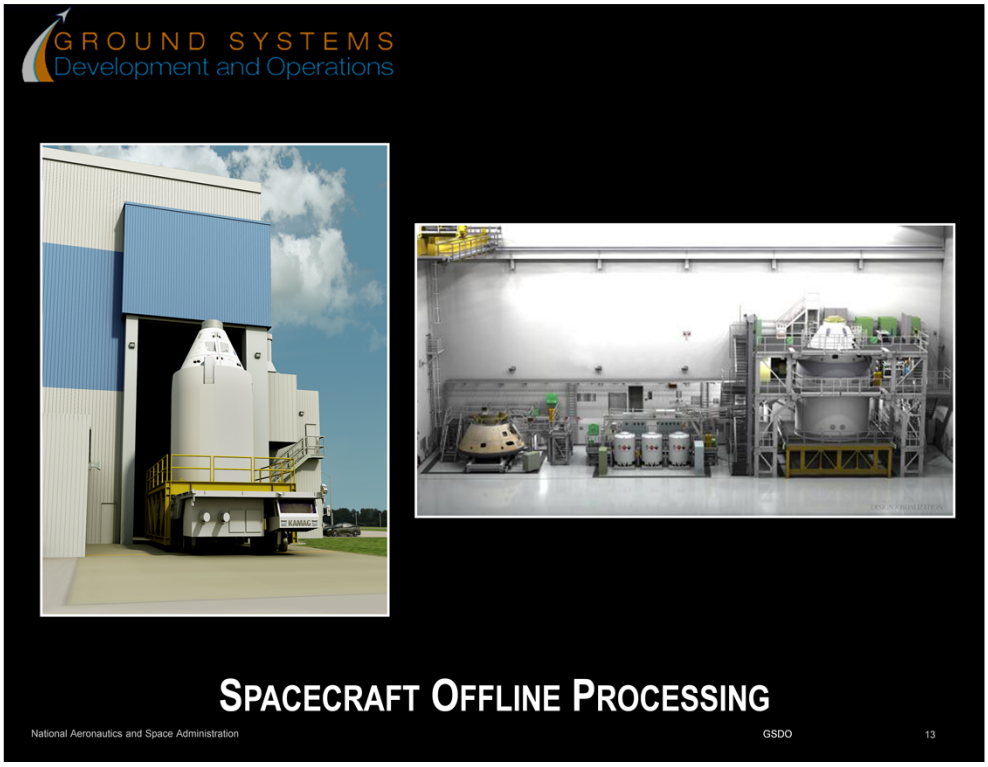


Key Points:

- GSDO currently has two launch pads.
- Launch Pad 39B is for SLS/MPCV and commercial users.
- Launch Pad 39A is available for other commercial vehicles.

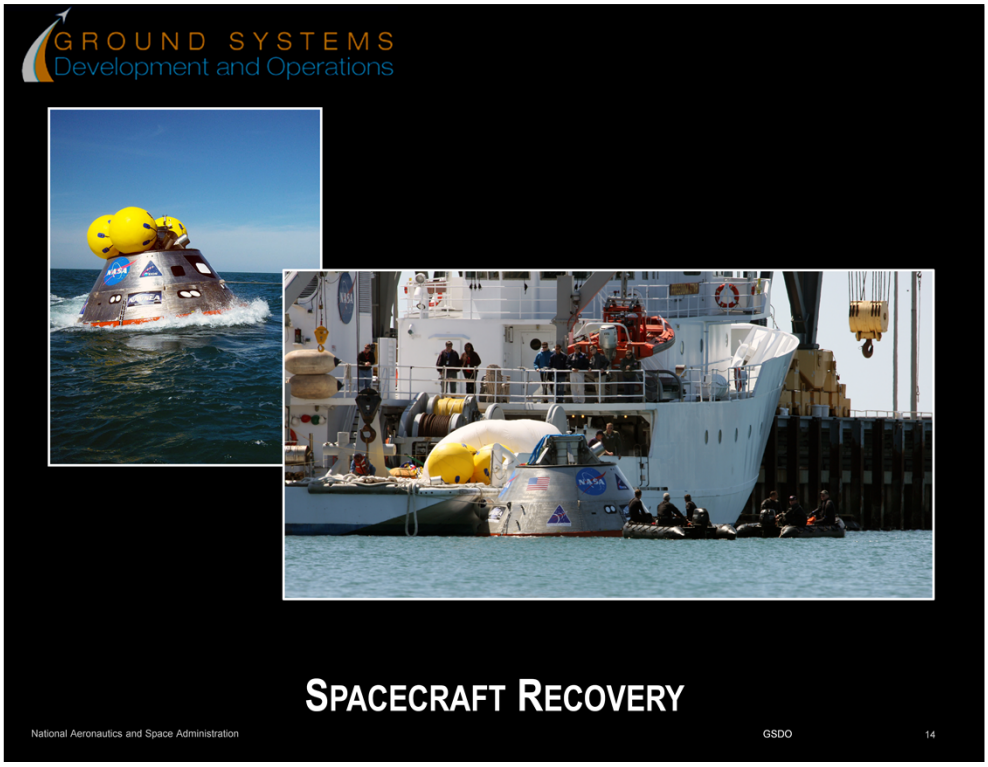
Key Points:

- TBD



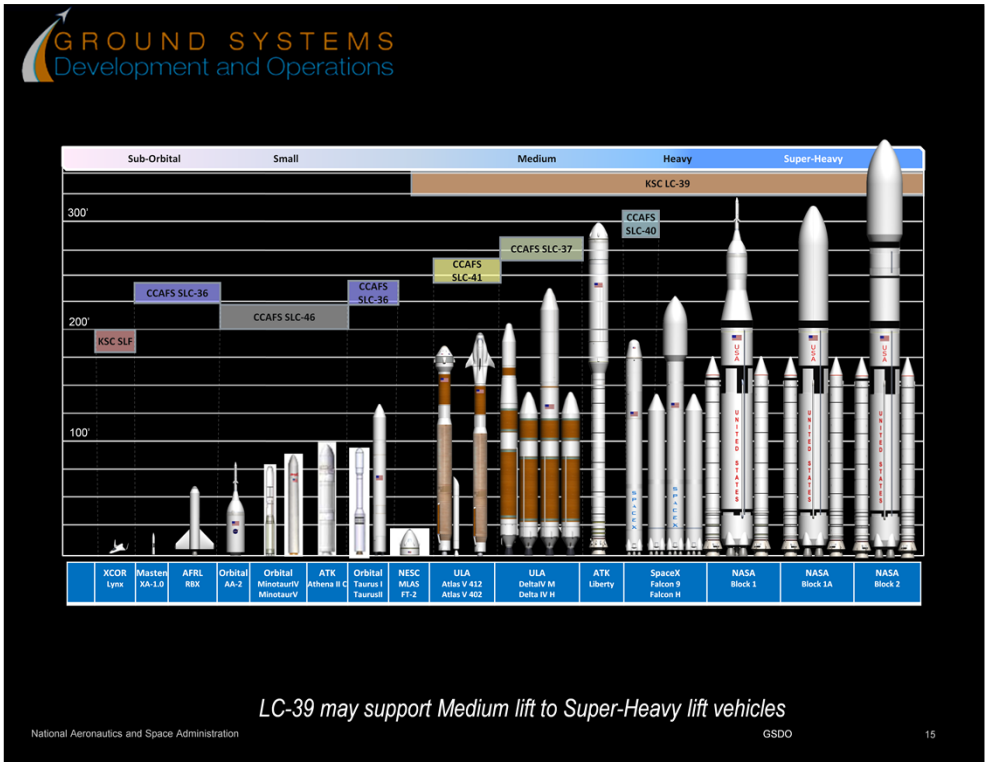
Key Points:

- TBD



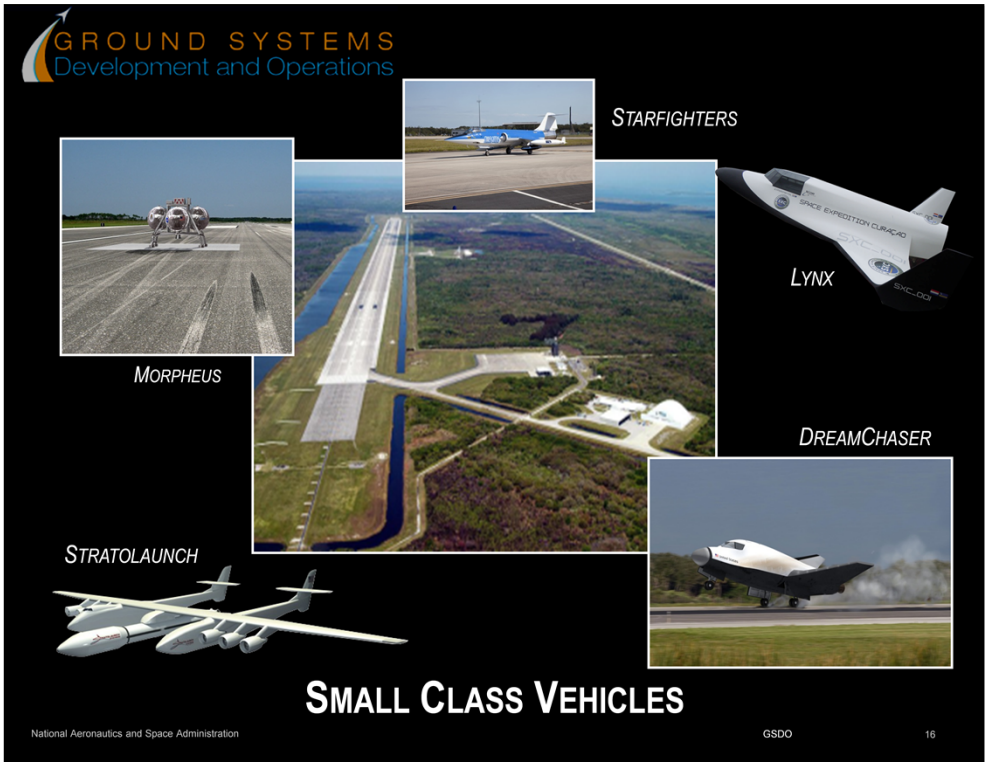
Key Points:

- TBD



Key Points:

- This chart shows potential launch vehicles and launch complexes (pad locations).
- LC-39 (Launch Complex 39) is capable of supporting Medium lift to Super-Heavy lift vehicles.



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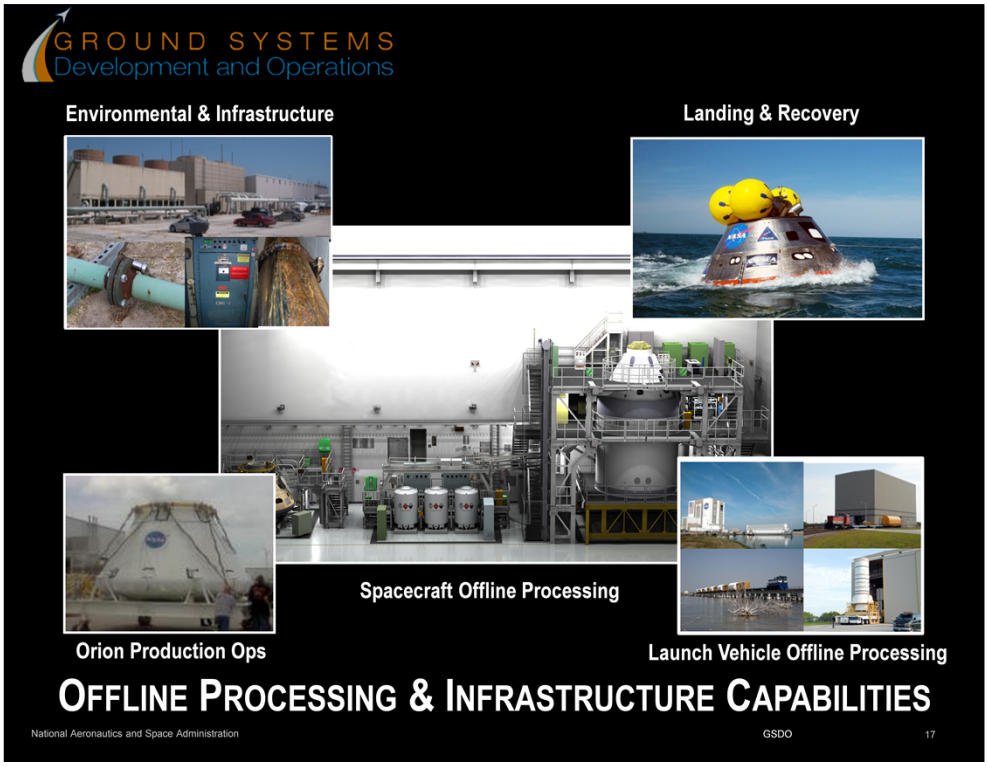
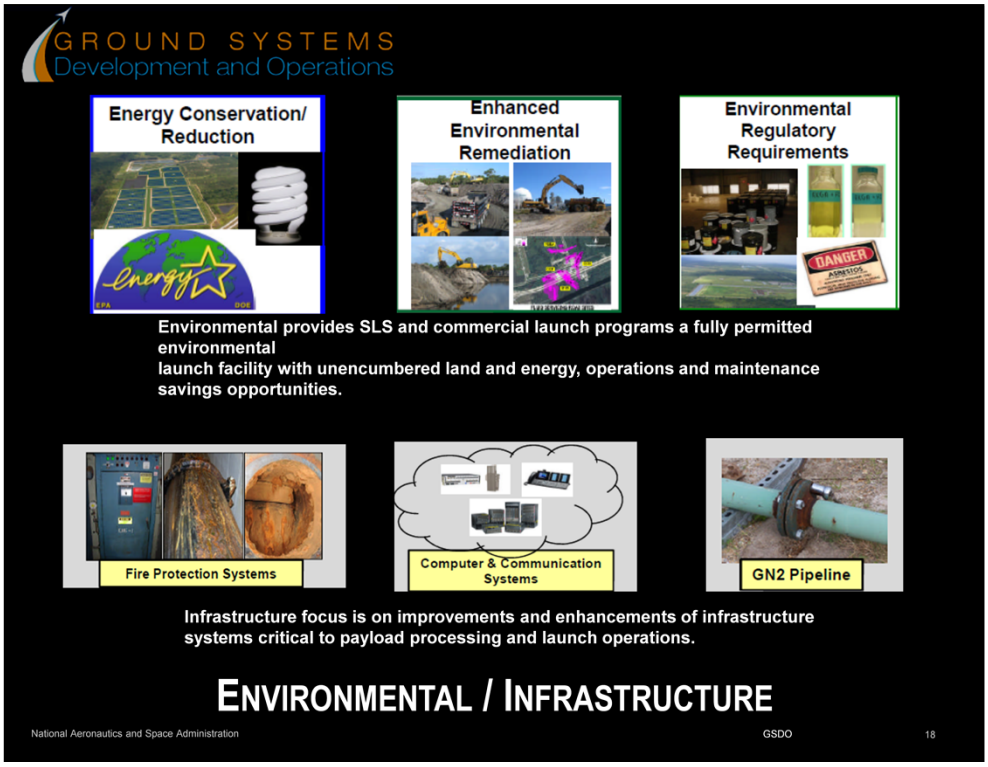


Key Points:

- The **Offline Processing and Integration** team will develop ways to handle the Orion spacecraft, rocket stages and launch abort system before they are all assembled into one vehicle.



Key Points:

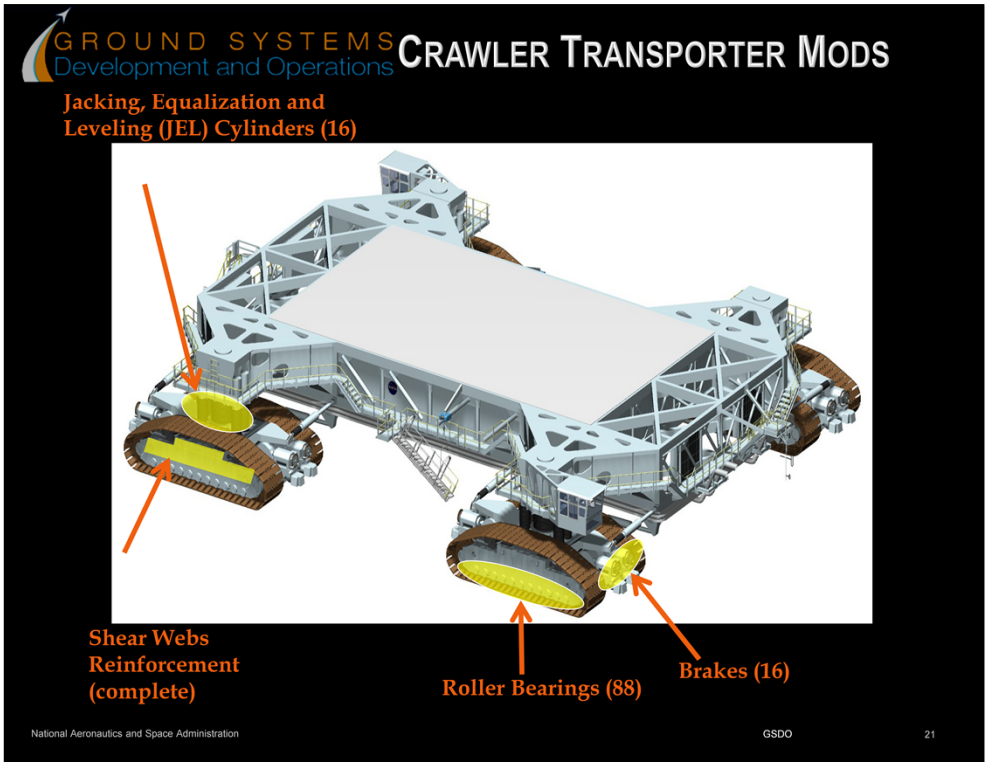
- TBD

Key Points:

- The **Command Control Communications and Range systems** team is creating systems that can handle several different kinds of spacecraft and rockets. The team will use computers, antennas and software meant to reduce the need for a large launch team.

Key Points:

- TBD



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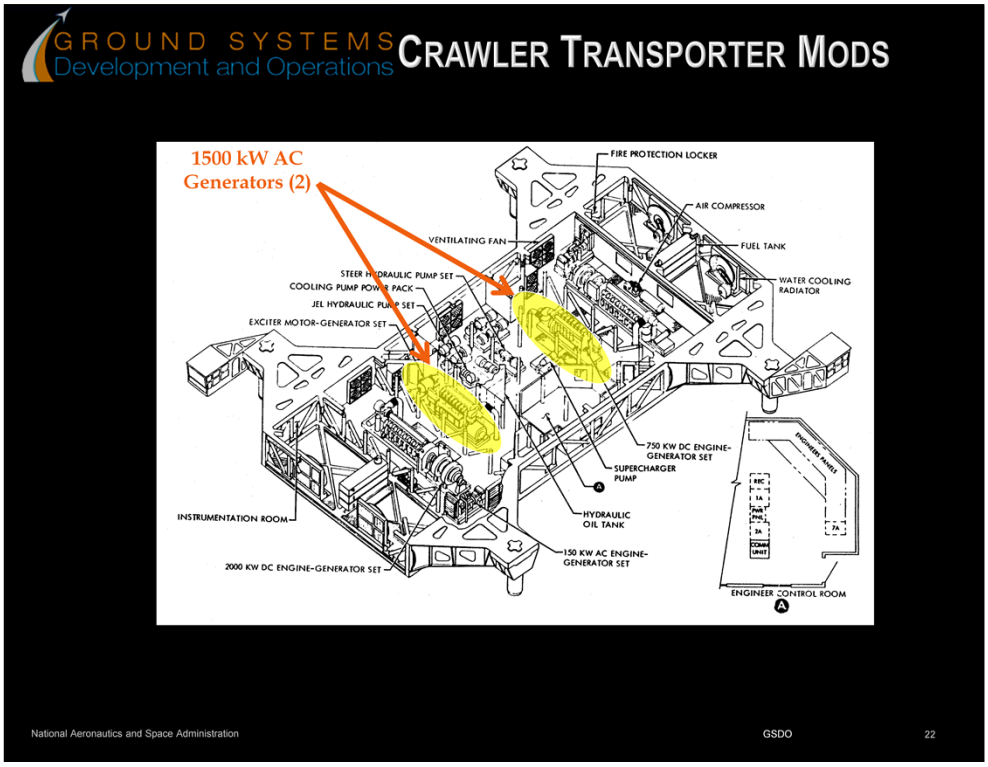
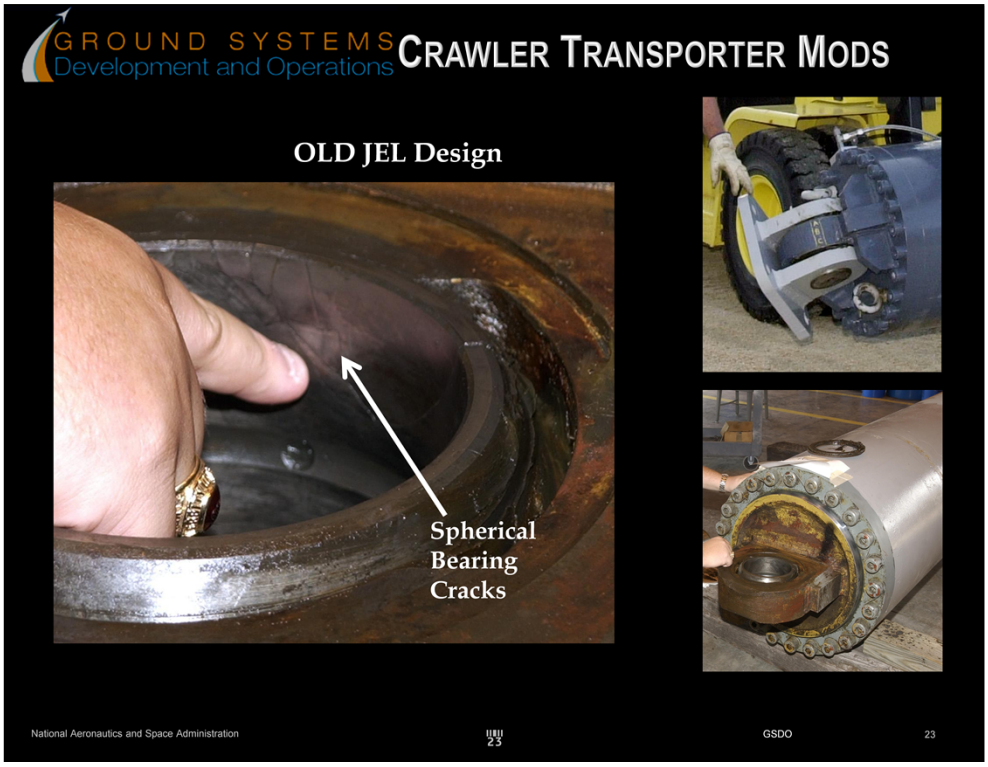


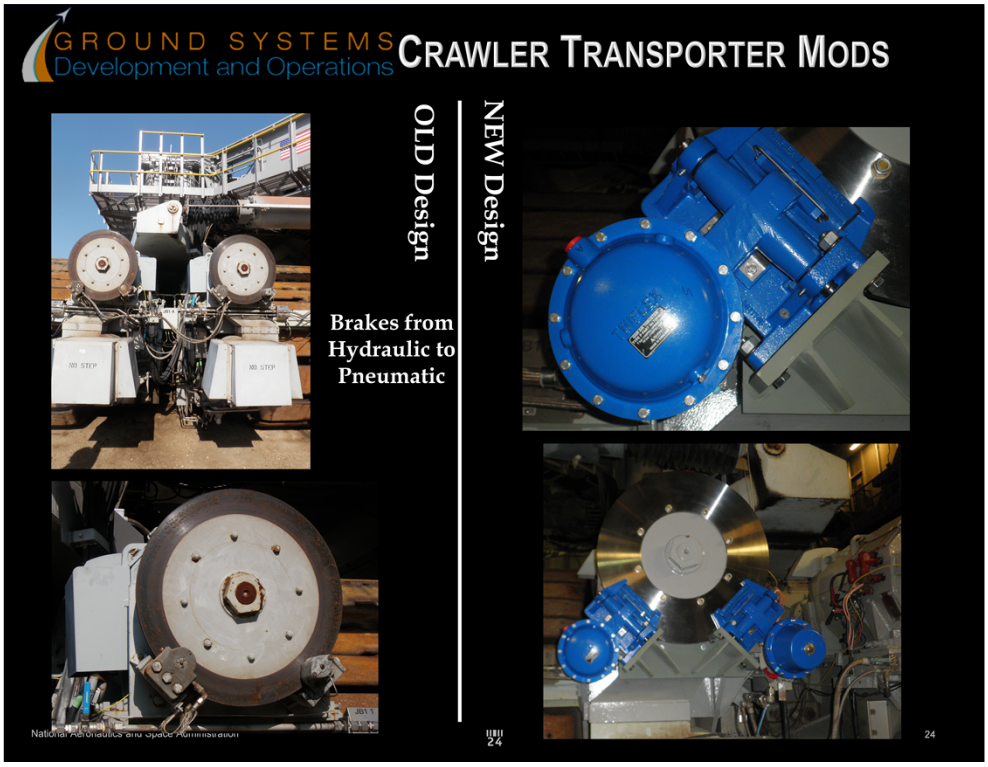
Key Points:

- TBD



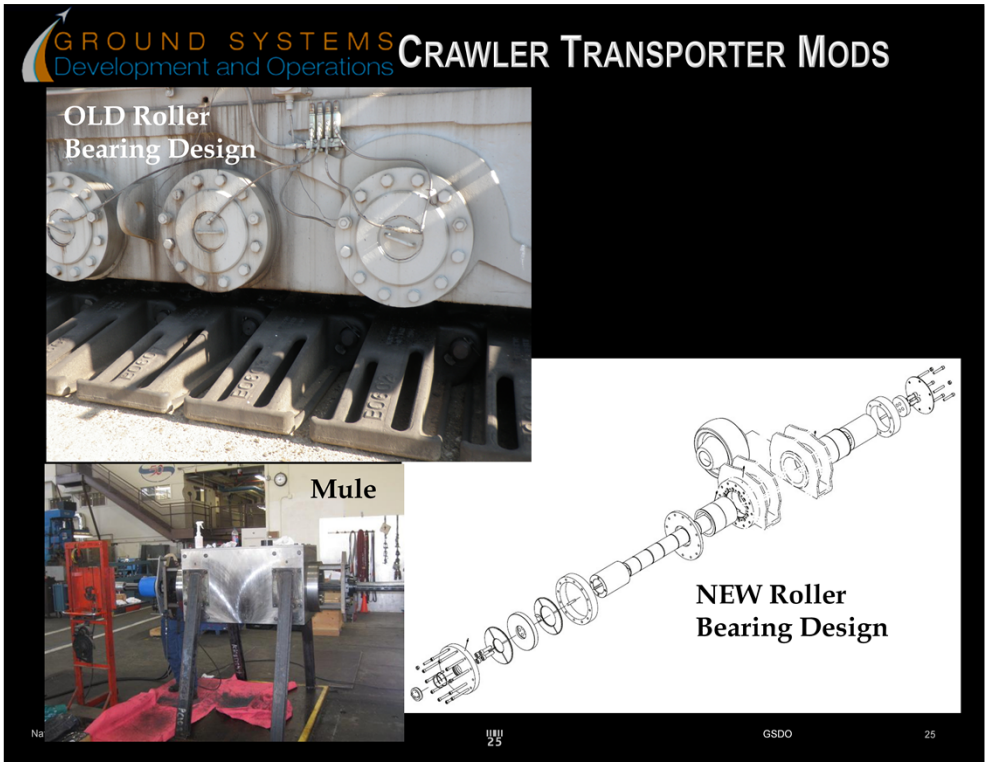
Key Points:

- TBD



Key Points:

- TBD



Key Points:

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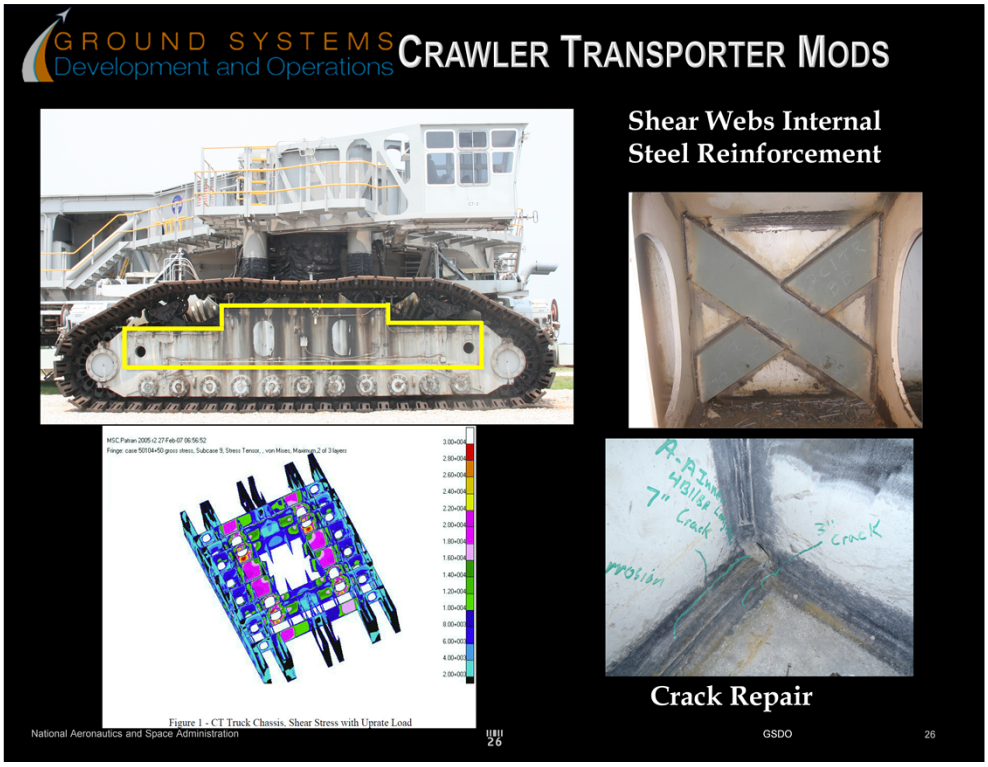
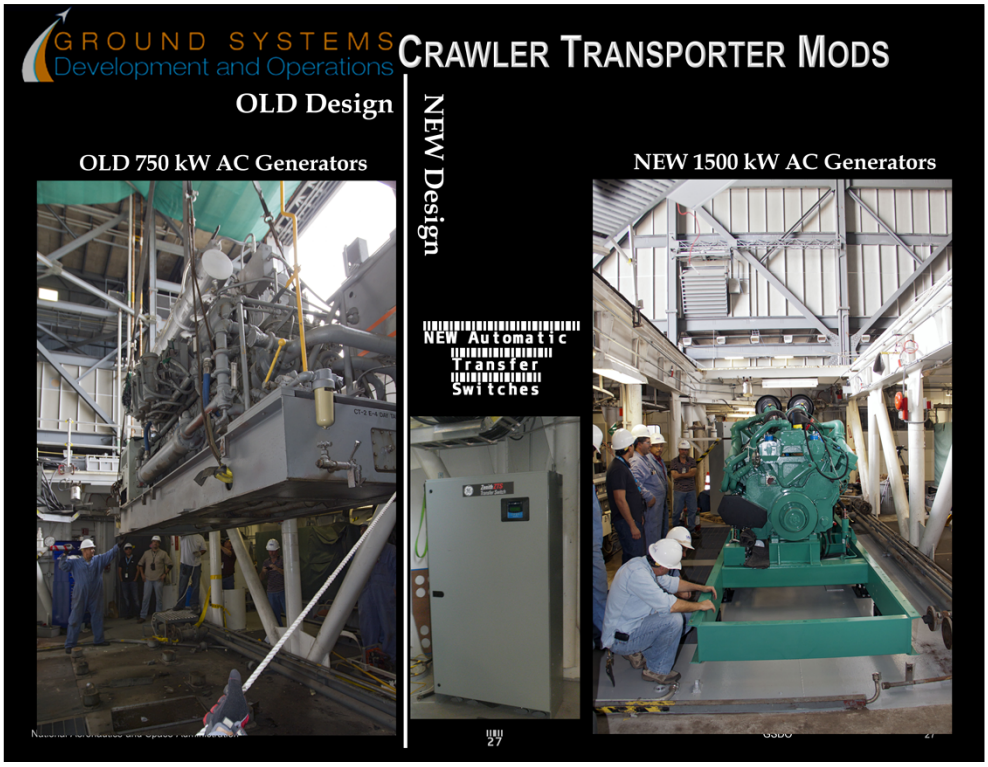


Key Points:

- TBD



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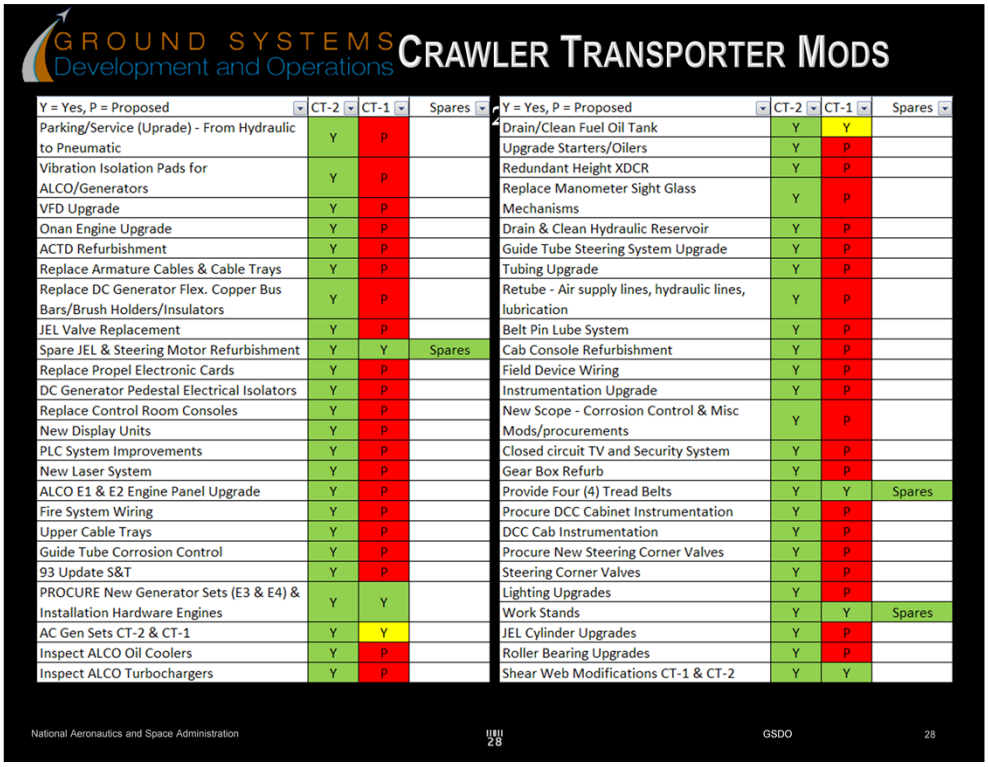

Y = Yes, P = Proposed	CT-2	CT-1	Spares
Parking/Service (Uprade) - From Hydraulic to Pneumatic	Y	P	
Vibration Isolation Pads for ALCO/Generators	Y	P	
VFD Upgrade	Y	P	
Onan Engine Upgrade	Y	P	
ACTD Refurbishment	Y	P	
Replace Armature Cables & Cable Trays	Y	P	
Replace DC Generator Flex. Copper Bus Bars/Brush Holders/Insulators	Y	P	
JEL Valve Replacement	Y	P	
Spare JEL & Steering Motor Refurbishment	Y	Y	Spares
Replace Propel Electronic Cards	Y	P	
DC Generator Pedestal Electrical Isolators	Y	P	
Replace Control Room Consoles	Y	P	
New Display Units	Y	P	
PLC System Improvements	Y	P	
New Laser System	Y	P	
ALCO E1 & E2 Engine Panel Upgrade	Y	P	
Fire System Wiring	Y	P	
Upper Cable Trays	Y	P	
Guide Tube Corrosion Control	Y	P	
93 Update S&T	Y	P	
PROCURE New Generator Sets (E3 & E4) & Installation Hardware Engines	Y	Y	
AC Gen Sets CT-2 & CT-1	Y	Y	
Inspect ALCO Oil Coolers	Y	P	
Inspect ALCO Turbochargers	Y	P	

Y = Yes, P = Proposed	CT-2	CT-1	Spares
Drain/Clean Fuel Oil Tank	Y	Y	
Upgrade Starters/Oilers	Y	P	
Redundant Height XDCR	Y	P	
Replace Manometer Sight Glass Mechanisms	Y	P	
Drain & Clean Hydraulic Reservoir	Y	P	
Guide Tube Steering System Upgrade	Y	P	
Tubing Upgrade	Y	P	
Retube - Air supply lines, hydraulic lines, lubrication	Y	P	
Belt Pin Lube System	Y	P	
Cab Console Refurbishment	Y	P	
Field Device Wiring	Y	P	
Instrumentation Upgrade	Y	P	
New Scope - Corrosion Control & Misc Mods/procurements	Y	P	
Closed circuit TV and Security System	Y	P	
Gear Box Refurb	Y	P	
Provide Four (4) Tread Belts	Y	Y	Spares
Procure DCC Cabinet Instrumentation	Y	P	
DCC Cab Instrumentation	Y	P	
Procure New Steering Corner Valves	Y	P	
Steering Corner Valves	Y	P	
Lighting Upgrades	Y	P	
Work Stands	Y	Y	Spares
JEL Cylinder Upgrades	Y	P	
Roller Bearing Upgrades	Y	P	
Shear Web Modifications CT-1 & CT-2	Y	Y	

Key Points:

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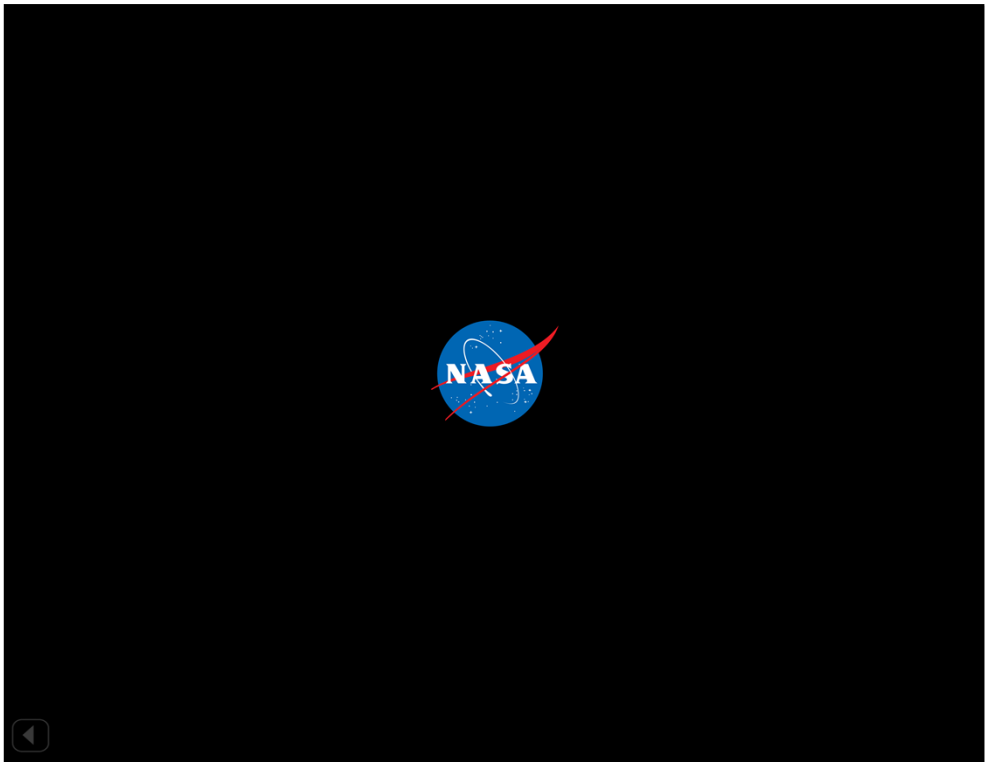

The End.