

National Aeronautics and Space Administration

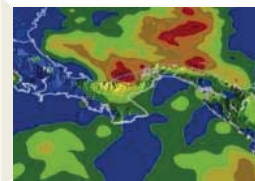
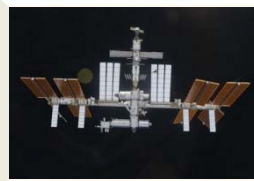


Launch Vehicle Control Center Architectures

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Space Launch System



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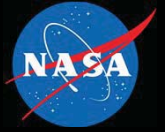
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Introduction



- This analysis is a survey of control center architectures of the NASA Space Launch System (SLS), United Launch Alliance (ULA) Atlas V and Delta IV, and the European Space Agency (ESA) Ariane 5. Each of these control center architectures have similarities in basic structure, and differences in functional distribution of responsibilities for the phases of operations
 - Launch vehicles in the international community vary greatly in configuration and process
 - Each launch site has a unique processing flow based on the specific configurations
 - Launch and flight operations are managed through a set of control centers associated with each launch site, however the flight operations may be a different control center than the launch center
 - The engineering support centers are primarily located at the design center with a small engineering support team at the launch site

Launch Vehicle Families: National Aeronautics and Space Administration (NASA) – Space Launch System



Launch Control Center (LCC) at Kennedy Space Center

- The Launch Team at the LCC has the primary responsibility for launch and controls the pre-launch Operations including Launch Commit Criteria and waivers for exceptions through T-0 for launch
- Commits the vehicle for launch



Mission Control Center (MCC) at Johnson Space Center

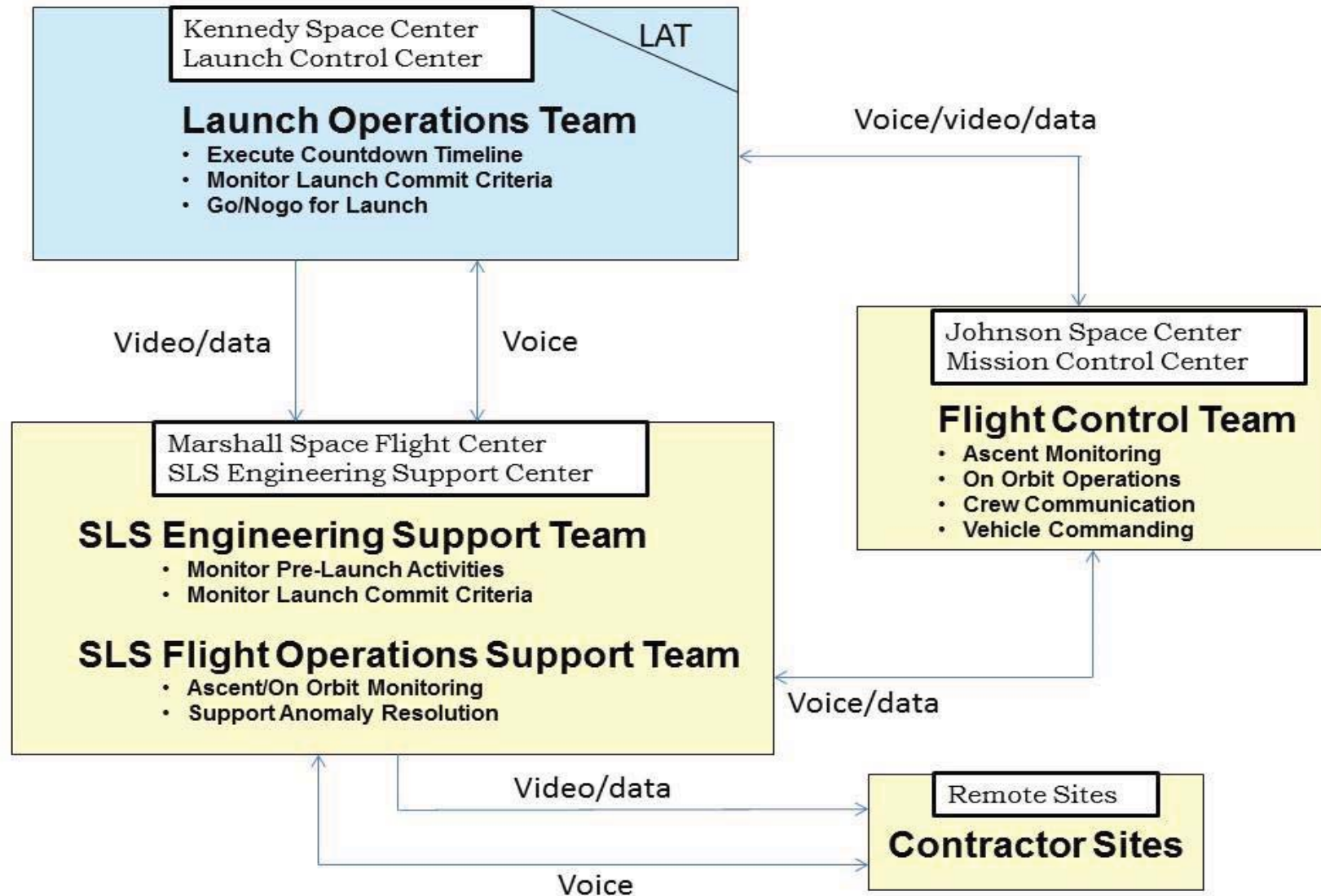
- Flight Directors and JSC Flight Operations Team at MCC control the ascent operations beginning at T-0
- The MCC-H manages the on orbit operations through landing

SLS Engineering Support Center (SESC) at Marshall Space Flight Center

- The SLS Launch Engineering Support Team is located at the HOSC SESC at Marshall Space Flight Center and is in a supporting role for issue resolution and committing the vehicle for launch
- Will provide SLS pre-launch and ascent data to remote sites



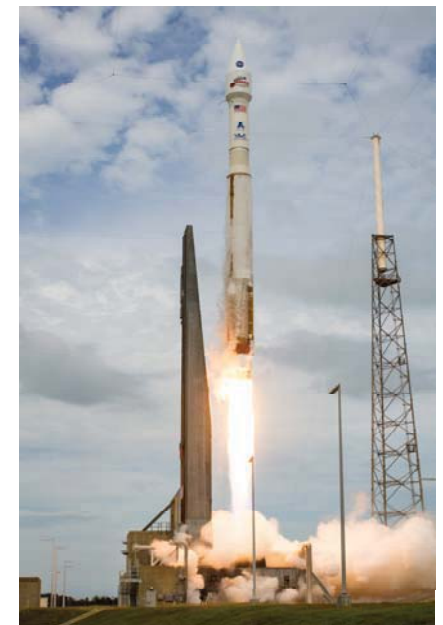
Launch Vehicle Families: Space Launch System (SLS)



Launch Vehicle Families: United Launch Alliance - Delta IV and Atlas V



- Launch operations for ULA's Delta IV and Atlas V are similar
- Both are performed from Cape Canaveral Air Force Stations (CCAFS) in Florida and Vandenberg Air Force Base (VAFB) in California
 - At CCAFS, the LCC is located in the Delta Operations Center (DOC) and the Atlas Space Operations Center (ASOC) both which contain an Engineering Support Area and a Mission Directors Center (MDC)
 - At VAFB, three LCCs are co-located in a Remote Launch Control Center (RLCC)
- The Design Center for both Atlas V and Delta IV is in Centennial, Colorado
- The Denver Operations Support Center (DOSOC) is ULA's center for launch day operations, shared by both Atlas and Delta



Launch Vehicle Families: European Space Agency - Ariane 5



- Launch operations are performed by the French National Space Studies Centre (CNES) in French Guiana at the Guiana Space Center (CSG). This includes:
 - Launch Range
 - Spacecraft preparations
 - Launch complex facilities includes facilities and services required to assemble, integrate, checkout, launch, track, and monitor Ariane 5, Vega, and Soyuz launch vehicles and payloads
 - Launch Vehicle Preparation Control Center, “Centre de Lancement”, (CDL)
 - Launch Mission Control Center (LMCC)
 - Payload Preparation Facilities (EPCU) - used by customer teams for preparing spacecraft



Centre de Lancement (CDL)

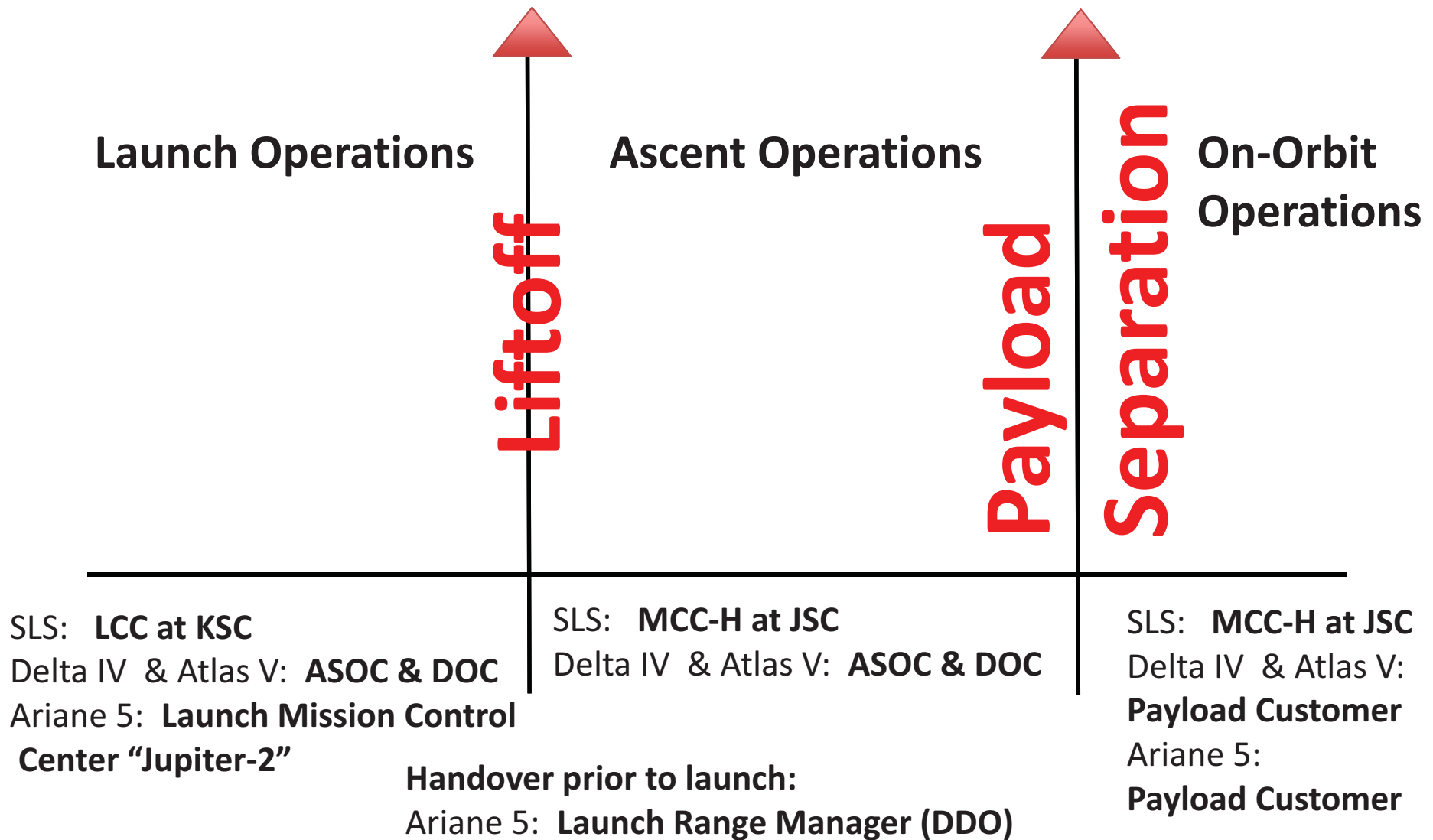


Launch Families Commonalties: Details



- **The operational teams follow pre-established countdown procedures** for configuring, checking and readying the launch system & range for lift-off
- **The engineering teams** monitor the countdown progress, analyzing potential deviations from the expected system behaviour, and **providing ways forward (waivers) to the operational team** resolve deviations
- **The management teams take responsibility on the final decisions and authorizations** (in particular, non-nominal situations).

Launch Control Comparison



Launch Families Comparison Chart



	Launch Control: Prelaunch and Launch Operations at Launch Site	Engineering Support Center: Located at Design Center/Corporate Engineering Site	Payload Control Center: Various Corporate Payload Locations
SLS	X	X	X
Delta IV	X	X (Small Contingent in LCC)	X
Atlas V	X	X (Small Contingent in LCC)	X
Ariane 5	X	X	X

Launch Vehicle Control Center Architectures: Summary



- **Common control center operational functions across the various launch vehicles considered:**
 - Launch operations – launch control centers are located at the launch sites
 - Human rated operations plays a role where crewed vehicle and launch vehicle operations are combined to provide an integrated Flight Control Team working both vehicle and crew constraints during ascent flight
 - Payload Operations – located at various Payload Operations Centers
 - Located in long-term facilities
 - Access to skilled personnel
 - Good community support
 - Reliable communications infrastructure
- **Engineering Support Center locations:**
 - SLS has their engineering support at HOSC
 - Delta IV and Atlas V have their engineering support at DSOC with small team in launch control center
 - Ariane 5 has their engineering support in the CDL with access to main engineering support in an off-line fashion