



# Launching the Space Shuttle

*Bob Sieck  
October 2005*



## Agenda



- Background
- Engineering
- Operations
- Human Factors



## KSC Shuttle Infrastructure



Equivalent to a Small City

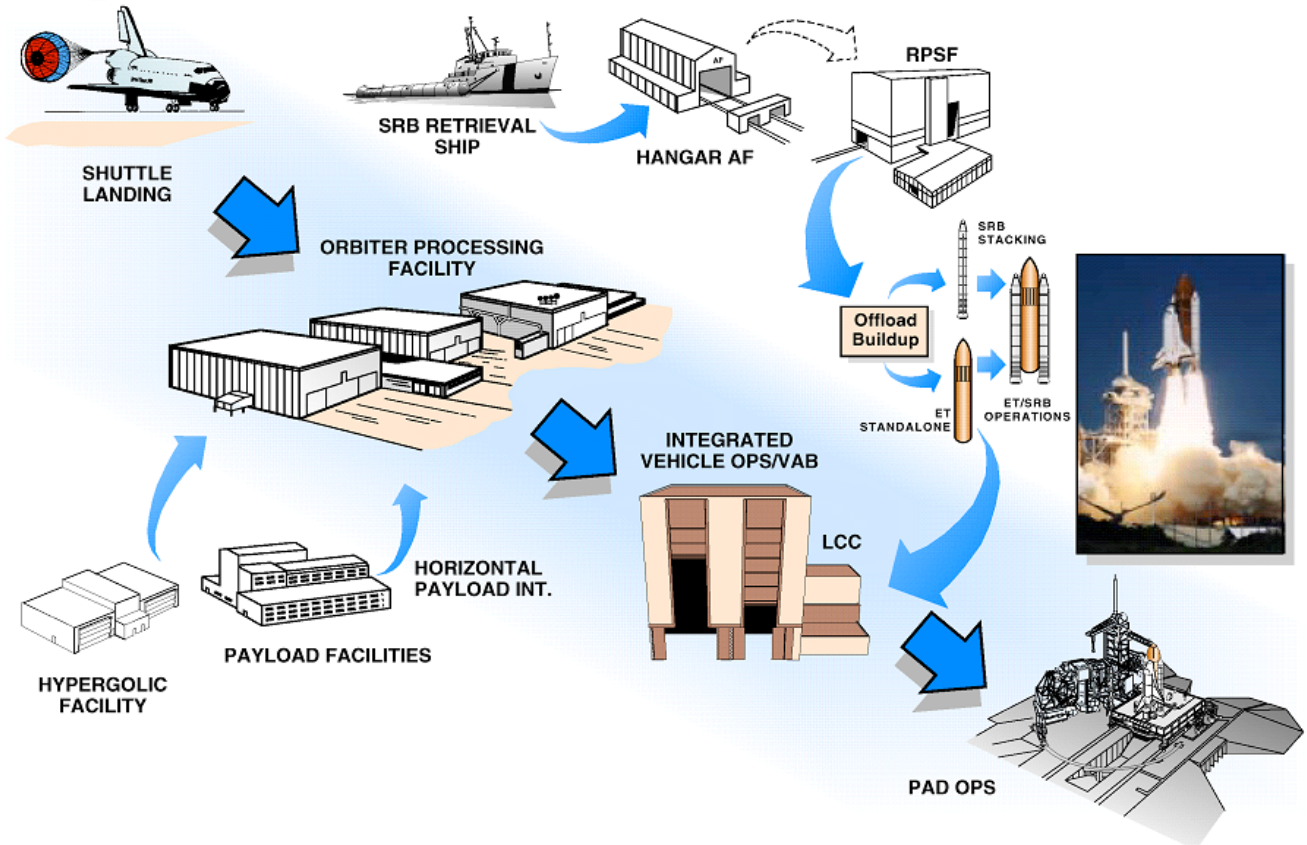
### Facilities

- Kennedy Space Center 140,000 Acres
- Vehicle Assembly Building 8 Acre Footprint, 525' Tall
- Three Orbiter Processing Facilities 30,000 SF Each
- Launch Pads A&B Fuel/Oxidizer Tank Capacity of 1.8 M Gal
- Shuttle Landing Facility 15,000' Runway, 300' Wide
- Operations Support Building 200,000 SF Office Space

### Support

- 300 Generators, 60 UPS Units, 156 Substations
- 30,000 Tons of Air Conditioning
- Over 52 Cranes, 217 Hoists, and 55 Elevators
- 100 miles of Water Distribution Lines
- 441 Pieces of Heavy Equipment
- 270 Miles of Fiber Optic Cable
- Over 900 Fiber Optic Transmitters and 900 Fiber Optic Receivers
- LC-39 TV System Includes 166 Cameras, 9 Video Recorders, and Over 7770 Monitors
- 142,000 Line Items in Inventory
- 10,000 Issues Per Month

# Standard Work Flow





➤ **Shuttle Processing Team**

- Space Flight Operations Contractor – United Space Alliance
  - Responsible for processing Orbiter, External Tank (ET), Solid Rocket Boosters (SRB) and Re-usable Solid Rocket Motors (RSRM)
  - Responsible for facility and Ground Support Equipment (GSE) maintenance
  - Additional support provided by development and institutional contractors
  
- **NASA Shuttle Processing Director is the designated Technical Manager for:**
  - Management of NASA shuttle support at KSC
  - Disposition of technical issues for KSC equipment
  - Validating contractor processes meet NASA requirements
  
- **NASA Launch Director is responsible for:**
  - Management of launch count, landing and recovery operations



## NASA Shuttle Processing Responsibilities



### Engineering

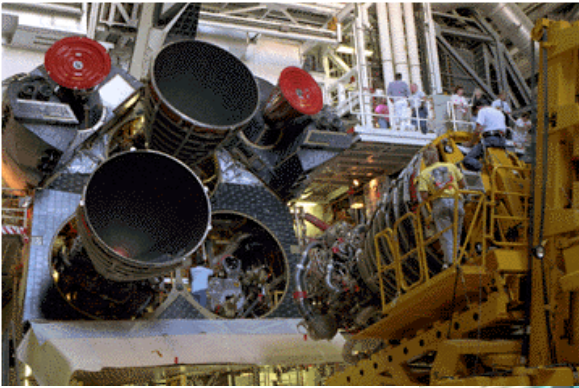
- Approve
  - Non conformance to Program Requirements
  - New/Changed Requirements
  - Implementation Procedures
  - NASA Managed Activities
- Analyze Test Data
- Observe Critical Procedures / Tasks
- Audit Requirements Implementation
- Assess Contractor Metrics

### Operations Integration

- Lead NASA Managed Activities / Approve Procedures
- Lead Vehicle Flow Planning
- Approve Requirements
- Observe Critical Integrated Procedures / Tasks
- Observe Day-to-Day Operations
- Assess Contractor Metrics
- Manifest (Flight Schedule) Development



# Orbiter Processing Facility (OPF) Operations





## Orbiter Processing Facility (OPF)



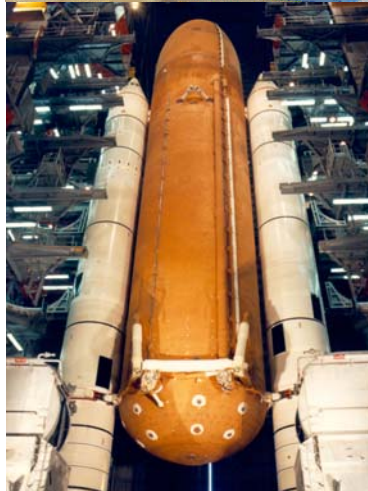
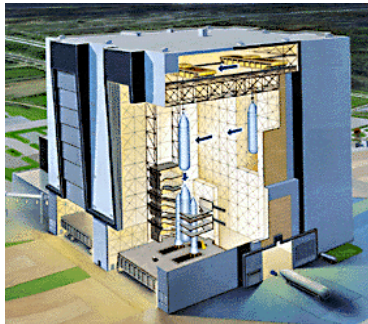
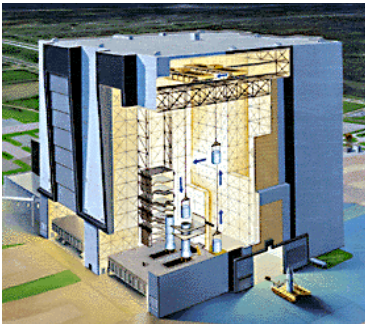
### ➤ Operations

- Initial access and safing
- Post-flight hardware problem resolution
- Thermal Protection System maintenance, replacement and repair
- Space Shuttle Main Engine (SSME) removal and installation
- Payload bay operations
  - Down mission payload removal
  - Mission kit reconfiguration
  - Up mission horizontal payload configuration and installation
- Orbiter modifications
- Orbiter sub-system design requirement re-verification
- Orbiter preparation for roll over to VAB (Vertical Operations)





## Vehicle Assembly Building (VAB) Operations





## Vehicle Assembly Building (VAB)

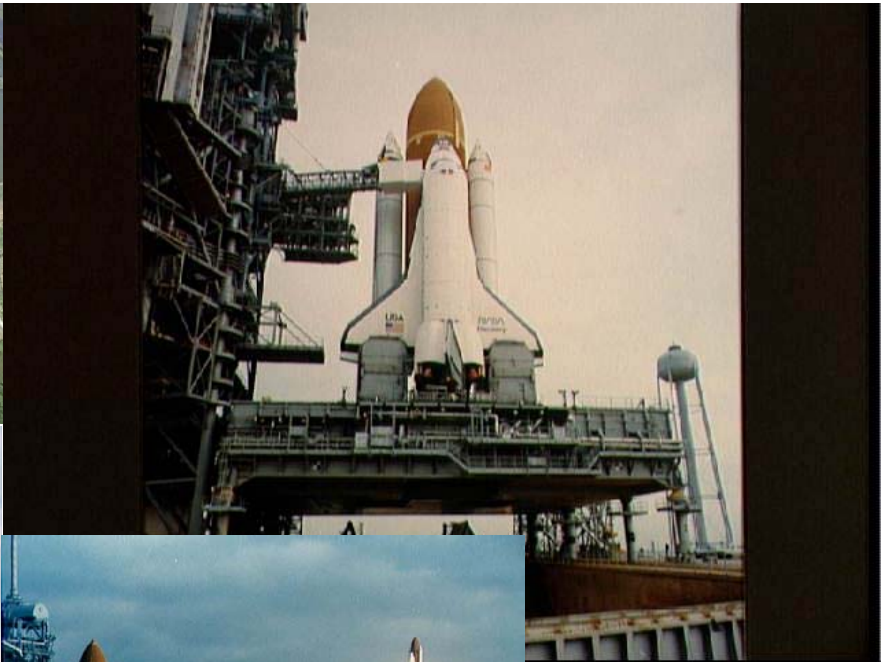


### ➤ Operations

- Perform External Tank (ET) checkout
- Solid Rocket Booster stacking requires approximately three weeks
- ET mate and closeout requires approximately two weeks
- Orbiter mate requires approximately one week
- Test interfaces between Shuttle elements
- Perform structural closeout



# Launch Pad





## Launch Pads 39A and 39B

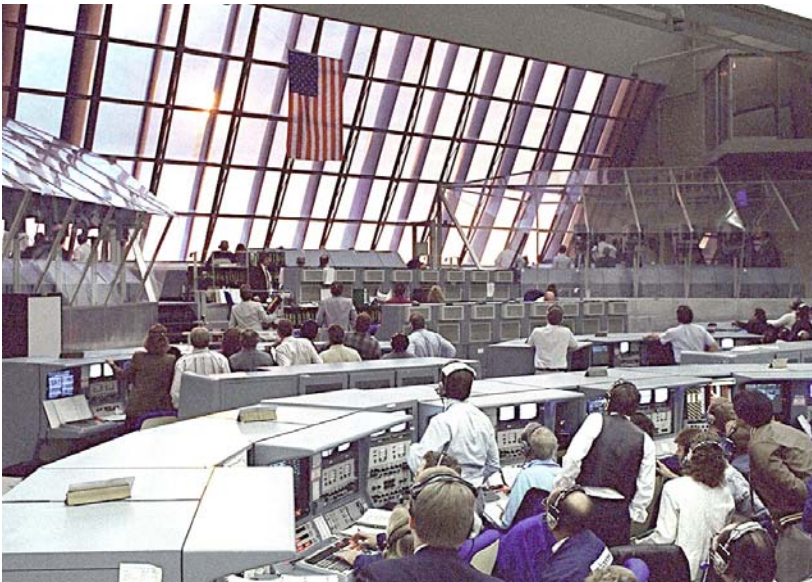


### ➤ Operations

- Pad processing takes approximately 4 weeks
- Payload transfer from payload canister to Payload Change-out Room (PCR) to Orbiter
- Shuttle/Pad system validation
- Simulated launch count with astronauts
- Final preparations to vehicle for launch countdown



## Launch Processing System (LPS) / Control Room





## Launch Processing System (LPS) / Control Room



### ➤ Description

- Automated and computer controlled Shuttle launch and checkout system
  - Customized hardware for Shuttle
  - Custom language used for application software
- Linked to orbiter, External Tank, and Solid Rocket Booster, and Ground Support Equipment at all processing locations

### ➤ Operations Support

- Automated checkout of Shuttle and associated Ground Support Equipment during preparation for launch
- Problem resolution and data reduction



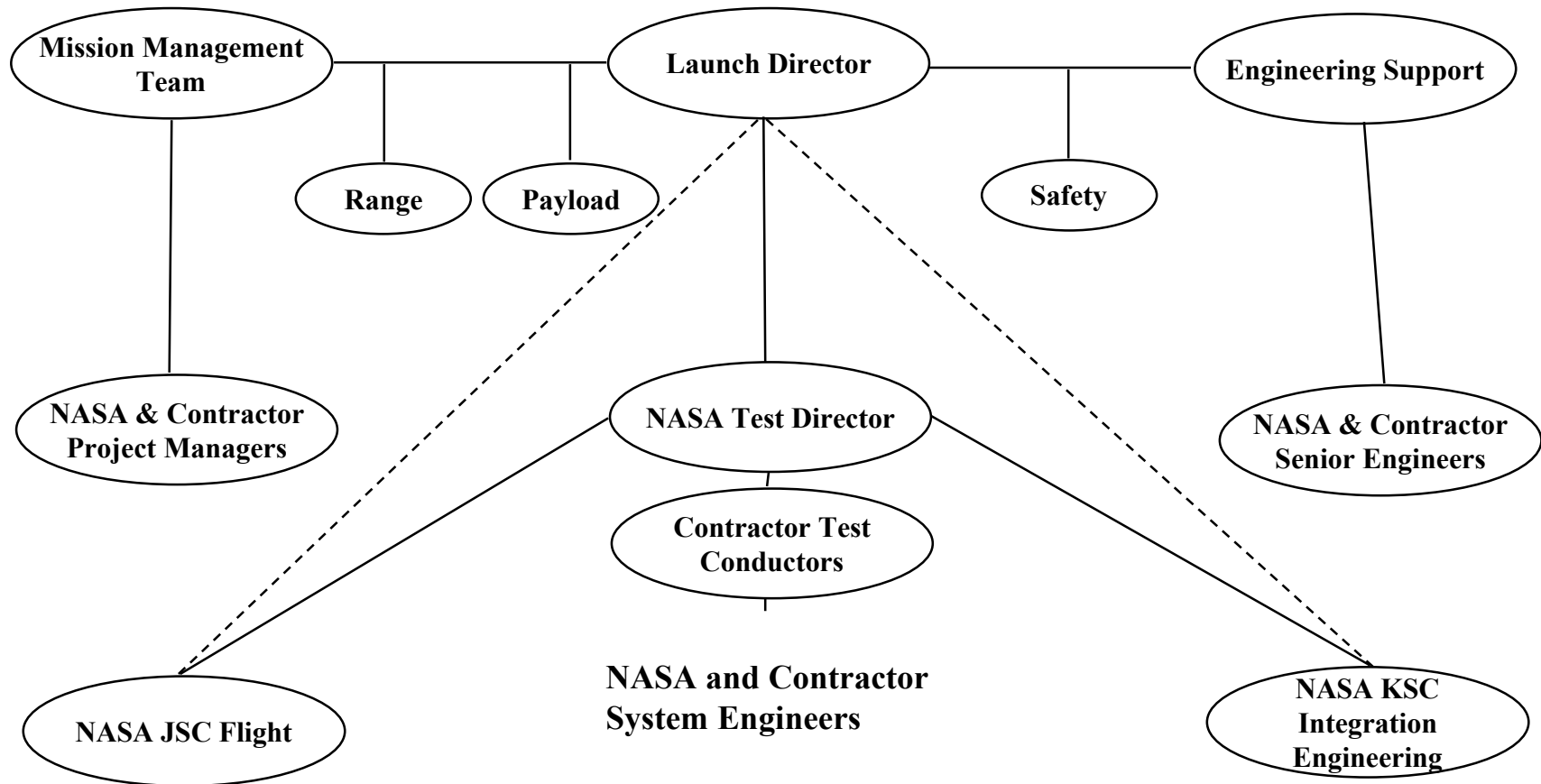
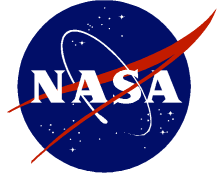
## Engineering Approach



- Engineering Requirements – Demonstrate the “as built ready to launch shuttle” is the same “as designed and certified”
  - Development / design organizations establish requirements implemented at KSC
    - Requirements dictate hardware / software performance and limitations in ground tests and inspections
  - Verified by review of documents used to assemble, inspect and test
  - Periodic management reviews certify readiness
- Launch Count Requirements
  - Requirements documented in engineering drawings, NASA Program documents and Launch Commit Criteria
  - Acceptable limits for the system performance and the configuration of the hardware and software
- System Engineers develop procedures and software to implement requirements
  - Approximately 500 requirements with approximately 2000 associated measurements
  - Launch count procedures: Approximately 20 documents totaling 5000 pages
  - Approximately 500 software programs



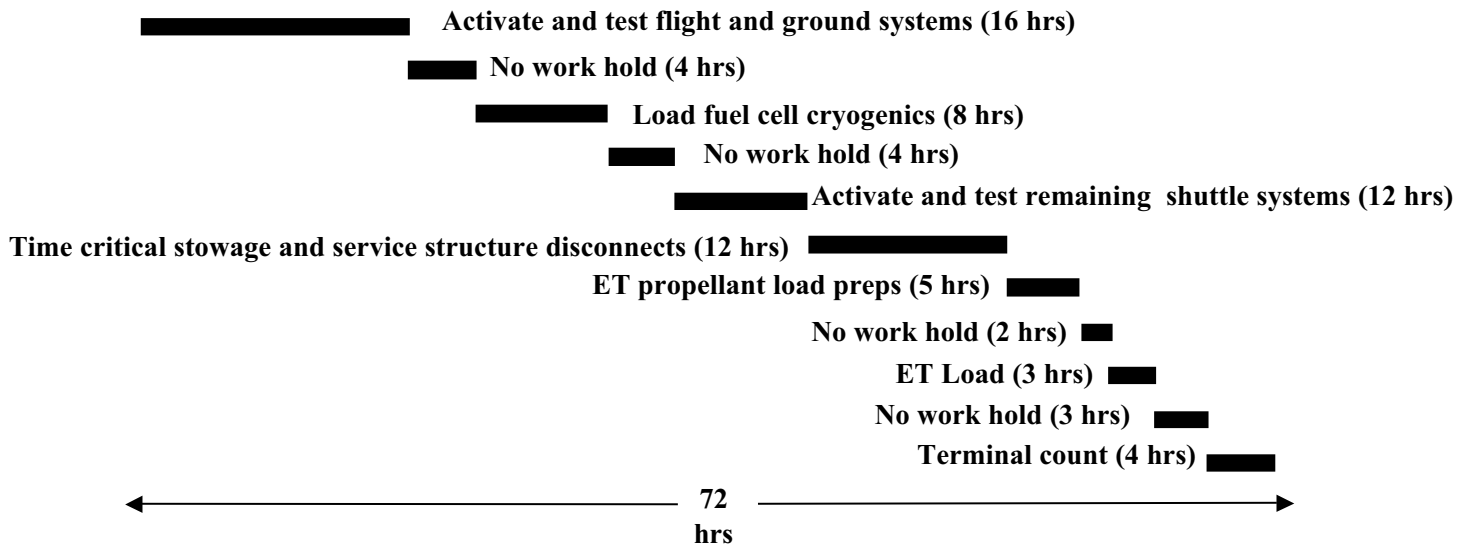
# Launch Team Structure







## Shuttle Launch Operations Summary



### ➤ Operations Sequenced to:

- Provide orderly closeout of vehicle and launch accessories
- Activate and verify systems meet requirements
- Minimize hazards to personnel and equipment
- Scheduled hold time to allow work to catch up



## Shuttle Launch – Terminal Count Phase



- T-3 hrs
  - Crew ingress
  - Communications tests
  - Crew cabin closeout and integrity test
  - Guidance systems initialization
- T-20 min
  - 10 minute hold
  - Orbiter computers sequencing initialized
- T-9 min
  - 45 minute hold
  - Final poll of management, operations, engineering, weather, range safety and flight teams
- T-7 min
  - Retract crew access arm
- T-4 min
  - Automated test of orbiter flight controls
- T-2:55
  - Pressurize ET oxygen tank
- T-1:57
  - Pressurize ET hydrogen tank
- T-0:31
  - Activate SRB systems
  - Initiate Orbiter sequencer
- T-0:10
  - Final automated “Go” to orbiter computers
  - Verification of critical ground system activation



## Launch Count - Controls



- The Ground Launch Sequencer (GLS) is the software supervisor of critical command sequencing and measurement verification for terminal launch countdown
  - Issues or delegates all ground initiated commands to the Shuttle and Ground Support Equipment (GSE) from T-9 min
  - Initiates critical activities performed by software at other firing room system consoles
  - Monitors all measurements whose violation require immediate reaction
  - Monitors all measurements associated with GLS issued commands
  - Performs critical safing
  - Controls ground and onboard clocks – sets liftoff time



## Human Factors



- Automation vs. Manual Control
- Responsibility
- Teamwork Dynamics
  - Decision making process
  - Communication
  - “Launch Fever”

