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# Section 7E

## Generic Ground Operations and Infrastructure Functions

## **Appendix 7E - Generic Ground Operations and Infrastructure Functions**

This Appendix documents two different indented lists of generic ground operations and infrastructure functions that were used to help guide and focus the ESAS Spaceport Tiger Team as it defined operations concepts and conducted cost estimations and outline requirements. The origin of these “catalogs” of generic functions is from NASA’s Highly Reusable Space Transportation (HRST) Study, the Spaceport Synergy Team, NASA’s Space Shuttle Design Root Cause Analysis (RCA), and the Advanced Spaceport technology Working Group (ASTWG).

- 1.0 LANDING/RECOVERY
  - 1.01 Facility and Equipment Preps for Vehicle Landing / Recovery
    - 1.01.01 Functional verification of ground recovery systems prior to flight element arrival commitment
    - 1.01.02 Servicing of Ground Recovery systems for arrival
    - 1.01.03 Landing Facility Contamination control
  - 1.02 Element Landing and Recovery Operations
    - 1.02.01 Activate ground landing systems and position resources for element arrival
    - 1.02.02 Position recovery equipment and provide services to vehicle element upon return
    - 1.02.03 Perform active system shutdown, safing and check out for return to spaceport
  - 1.03 Payload Removal Operations
    - 1.03.01 Internal payload item removal
    - 1.03.02 Payload handling and transport operations
    - 1.03.03 Attached payload item removal
    - 1.03.04 Crew and passenger egress
  - 1.04 Post-Flight element ground handling and transport
    - 1.04.01 Post flight element handling operations
    - 1.04.02 Element ground transport from recovery point
  - 1.05 Landing/Recovery Facility and Equipment Periodic Maintenance
    - 1.05.01 Interval Maintenance of Landing Recovery Ground Systems
    - 1.05.02 Recovery Ground System and Facility Modifications and Process Changes
  - 1.06 Remote Landing Site Recovery and Ferry Return Operations
    - 1.06.01 Flight element system preparations for ferry
    - 1.06.02 Ferry equipment and facility preps
    - 1.06.03 Flight element mate to ferry systems
    - 1.06.04 Element Ferry operations support
- 2.0 FLIGHT ELEMENT TURNAROUND
  - 2.01 Facility Preps for Vehicle Turnaround
    - 2.01.01 Functional Verification of ground systems prior to Vehicle arrival
    - 2.01.02 Servicing and staging of ground systems prior to vehicle arrival
    - 2.01.03 Contamination control
  - 2.02 Positioning Vehicle, Connection to Services, Gaining Access, and Protection
    - 2.02.01 Vehicle Transport and Alignment

- 2.02.02 Ground access equipment positioning
- 2.02.03 Connection to facility services
- 2.02.04 Establish protective enclosures and install/remove flight vehicle protective covers
- 2.02.05 Removal of flight equipment covers/panels to gain access
- 2.02.06 Opening and closing of vehicle hatches and hinged/articulated doors
- 2.03 Vehicle Element Safing
  - 2.03.01 Hazardous Fluid Safing
  - 2.03.02 Pyro/Ordnance Safing
  - 2.03.03 Vehicle Purges for Personnel/Orbiter Safety
- 2.04 Vehicle Element Systems Servicing
  - 2.04.01 Landing Gear Mechanical Servicing
  - 2.04.02 Ordnance Handling and Installation
  - 2.04.03 Maintenance of Fuselage/PLB Vent Filters & Window Cavity Purge
  - 2.04.04 Flight Crew Systems Servicing
  - 2.04.05 Acreage Tile & TPS Blanket Servicing
  - 2.04.06 TPS Moldline Penetration, Leading Edge/Nose & Aerosurface Hingeline Seal Servicing
  - 2.04.07 Fluid Drain and Deservicing
  - 2.04.08 Fluid Servicing and Fill
  - 2.04.09 Routine Vehicle Cleaning & Filter Inspections
  - 2.04.10 Flight Pressurizations
  - 2.04.11 Navigation & Instrumentation Component Servicing
  - 2.04.12 Routine Replacement of Expendable and Limited Life Items
  - 2.04.13 Vehicle electrical power application, and data processing monitoring & control operations
- 2.05 Inspection & Checkout
  - 2.05.01 Component/Subsystem Functional Verification
  - 2.05.02 Structural integrity inspections and mechanism functional verifications
  - 2.05.03 Propellant/fluid/gas system integrity verifications & inspections
  - 2.05.04 Vehicle power up/down, switch-lists, functional checks and on-board s/w config
- 2.06 Vehicle Payload Accommodations Turnaround
  - 2.06.01 Reconfigure unique payload thermal protection/insulation
  - 2.06.02 Repositioning vehicle-fixed mechanisms

- 2.06.03 Remove/Install mission-unique mechanisms
- 2.06.04 Reconfigure vehicle supplied fluid services
- 2.06.05 Reconfigure vehicle supplied electrical and information services
- 2.06.06 Access to Payload accommodations
- 2.06.07 Payload accommodations cleaning and closeout
- 2.06.08 Payload accommodations turnaround unplanned troubleshooting and repair
- 2.06.09 Payload Accommodations Inspections & Testing
- 2.07 Processing Support Systems & Functions
  - 2.07.01 Purge Operations & Monitoring
  - 2.07.02 Hazard Monitoring Systems Operation
  - 2.07.03 Vehicle System Reconfigurations
- 2.08 Turnaround Unplanned Troubleshooting and Repair
  - 2.08.01 Troubleshooting, Replacement, Disposition of Failed/Suspect LRUs
  - 2.08.02 Troubleshooting and Repair of Leaks
  - 2.08.03 Fluid/Pneumatic System Decontamination/Cleaning
  - 2.08.04 Troubleshooting, Retest and Repair of Electrical cables, connectors
  - 2.08.05 Repair or Replacement of Thermal Protection Systems (TPS) Hardware
  - 2.08.06 Structural Repair/Refurbishment
  - 2.08.07 Repair of Damaged Ducts, Tubes & Hoses
  - 2.08.08 Troubleshooting & Repair of Mechanisms and Thermal/Pressure Seals
  - 2.08.09 Troubleshooting and Repair of Ground Equipment
- 2.09 Modifications and Special Tests
  - 2.09.01 Flight Element Modifications and Process Changes
  - 2.09.02 Special Tests and Fleet System Checks
  - 2.09.03 Payload-Driven Flight Element Weight/CG Alterations
- 2.10 Removal of Access/Umbilicals and Closeout
  - 2.10.01 Removal of Umbilicals and Access equipment
  - 2.10.02 Flight Element System Closeouts for Vehicle and Ground Launch System Integration
  - 2.10.03 Preps for Vehicle Element Transfer
- 2.11 Turnaround Facility and Equipment Periodic Maintenance
  - 2.11.01 Interval Maintenance of Ground Systems

- 2.11.02 Ground System and Facility Modifications and Process Changes
- 3.0 FLIGHT ELEMENT ASSEMBLY
  - 3.01 Element Transport, Lift and Handling for Assembly
    - 3.01.01 Facility Preps for Element Assembly Operations
    - 3.01.02 Ground Transport of Major Element Segments
    - 3.01.03 Lift, Positioning and Connection to Assembly Facility Support Fixtures
    - 3.01.04 Activate Element Environmental and Safety Controls
  - 3.02 Element Structural Assembly
    - 3.02.01 Flight Segment Handling Operations
    - 3.02.02 Flight Segment Structural Connections
    - 3.02.03 Structural Assembly Verification and Closeout
  - 3.03 Subsystem / Component Installations
    - 3.03.01 Subsystem / Component Handling Ops
    - 3.03.02 Facility Preps for Installations
    - 3.03.03 Flight Component Installation onto Flight Element
    - 3.03.04 Non-Flight Component Installations
    - 3.03.05 Flight Component Installation Closeouts
  - 3.04 Flight Element Assembly Functional Verifications
    - 3.04.01 Passive System Verifications
    - 3.04.02 Active System Verifications
    - 3.04.03 Inspections and Alignment Verifications
  - 3.05 Assembly Unplanned Troubleshooting & Repair
    - 3.05.01 Unplanned Element Disassembly/Reassembly
    - 3.05.02 Flight Element Troubleshooting and Repair
    - 3.05.03 Flight Element Modifications and Process Changes
  - 3.06 Post-Assembly Operations
    - 3.06.01 Reconfigure/Relocate Facility and Ground Equipment
    - 3.06.02 Flight Element Preparations for Integration
  - 3.07 Assembly Facility and Equipment Periodic Maintenance
    - 3.07.01 Interval Maintenance of Assembly Ground Systems
    - 3.07.02 Assembly Ground System and Facility Modifications and Process Changes
  - 3.08 Routine Reusable Flight Element Module/Component Disassembly
    - Disassembly Preps and Attach/closeout hardware removal

- 3.08.01
- 3.08.02 Flight Element Component disassembly, handling, and transport
- 3.08.03 Post-Disassembly
- 4.0 FLIGHT VEHICLE INTEGRATION
  - 4.01 Element Transportation, Handling, Lift and Mate
    - 4.01.01 Facility Preps for Flight Element Integration Operations
    - 4.01.02 Ground Transport of Flight Elements
    - 4.01.03 Element Lift, Position and Mate
    - 4.01.04 Post-Mate Servicing and Interface Closeouts
  - 4.02 Post-Mating Functional Verification
    - 4.02.01 Element to Ground System Interfaces
    - 4.02.02 Element to Element Interfaces
  - 4.03 Integration Unplanned Troubleshooting & Repair
    - 4.03.01 Disconnection of Flight Elements
    - 4.03.02 Interface Troubleshooting and Repair
    - 4.03.03 Post-Integration Flight Element Troubleshooting and Repair
    - 4.03.04 Post-Integration Ground Element/Equipment Troubleshooting and Repair
  - 4.04 Perform integration of payload / cargo
    - 4.04.01 Facility Preparations for Payload Installation
    - 4.04.02 Payload Installation into Vehicle
    - 4.04.03 Post Installation operations
    - 4.04.04 Payload handling and transport operations
    - 4.04.05 Payload Inspections and Testing
  - 4.05 Configure systems for Vehicle Transfer to Launch Point
    - 4.05.01 Disconnect/Stow integration and mating ground h/w
    - 4.05.02 Configure Vehicle systems for launch functions
    - 4.05.03 Preps for Integrated Vehicle Transfer/Rotation to launch position
  - 4.06 Integration Facility and Equipment Periodic Maintenance
    - 4.06.01 Interval Maintenance of Integration Ground Systems
    - 4.06.02 Integration Ground System and Facility Modifications and Process Changes
- 5.0 FLIGHT VEHICLE LAUNCH/DEPARTURE
  - 5.01 Facility/GSE, Refurbishment, Reservicing & Preps for Vehicle Arrival
    - Launch Equipment Refurbishment/Reservicing

- 5.01.01
- 5.01.02 Contamination Control
- 5.01.03 Functional verifications of ground systems prior to flight vehicle mating
- 5.01.04 Servicing of ground systems prior to flight vehicle mating
- 5.02 Position Vehicle at Launch Point, Mate to Ground Facility and Services & Provide Access
  - 5.02.01 Vehicle Transport and Alignment
  - 5.02.02 Mate Umbilicals, Environmental Protection and Access positioning
- 5.03 Functional Verif of Flt/Grd Systems for Launch
  - 5.03.01 Periodic Maintenance / Calibrations
  - 5.03.02 System Integrity Verification
  - 5.03.03 System Functionality Verification
  - 5.03.04 Human systems verification and training
- 5.04 Launch Systems Unplanned Troubleshooting/Repair
  - 5.04.01 Component Troubleshooting, Removal and Replacements
  - 5.04.02 Ground Launch Structural Systems Repair
- 5.05 Crew Ingress, Late Payload Stowage & Functional Verification for Flight
  - 5.05.01 Flight Crew Ingress/Egress
  - 5.05.02 Late Payload Stowage
  - 5.05.03 Payload Functional Verification for Flight
  - 5.05.04 Unplanned Payload Troubleshooting and Repair
- 5.06 Vehicle System Servicing at Launch Point
  - 5.06.01 Local Servicing with facility/GSE by remote control room
  - 5.06.02 Local Manual Servicing at the Launch Facility
  - 5.06.03 Ordnance Hookups
- 5.07 Access/Umbilical Removal & Closeout for Flight
  - 5.07.01 Payload Closeout tasks
  - 5.07.02 Access Removal tasks
  - 5.07.03 Umbilical Removal tasks
  - 5.07.04 Environmental Cover Removal tasks
- 5.08 Remote Automated Servicing and Propellant Loading
  - 5.08.01 Cryogenic Fluids transfer
  - 5.08.02 Thermal Management Fluid Servicing  
Tank Gaseous Pressurization



- 5.08.03
- 5.08.04 Flight Vehicle Press
- 5.08.05 Environmental Ctl purging
- 5.08.06 Engine Conditioning Purges
- 5.08.07 Remote Fuel Cell Gas Supply
- 5.09 Launch the Vehicle
  - 5.09.01 Coordinate the network of local and offsite support functions
  - 5.09.02 Activate Flight Vehicle and Ground Systems for Launch
  - 5.09.03 Obtain Weather and Range Clearances for Launch
  - 5.09.04 Configure Flight Vehicle for Terminal (Final) Launch Operations
  - 5.09.05 Final Launch Sequencing
  - 5.09.06 Configure systems for launch abort/recycle, as needed
- 5.10 Post-Launch Securing
  - 5.10.01 Post Launch System Safing Operations
  - 5.10.02 Post Launch Inspection of Facilities and Equipment
- 5.11 Launch Facility and Equipment Periodic Maintenance
  - 5.11.01 Interval Maintenance of Launch Ground Systems
  - 5.11.02 Launch Ground System and Facility Modifications and Process Changes
- 6.0 FLIGHT ELEMENT SHIPPING, RECEIVING & ACCEPTANCE
  - Element Receiving and Handling Ops
    - 6.01.01 Receiving Facility and Equipment Preps and Functional Verification
    - 6.01.02 Element Transport Receiving and Positioning Ops
    - 6.01.03 Element Offload from Transport system
  - 6.02 Element Ground Transfer and Storage Operations at the Spaceport
    - 6.02.01 Element Ground Handling equipment and fixtures
    - 6.02.02 Element Environmental Shelter and Conditioning
    - 6.02.03 Remove and Stow Transportation Hardware
  - 6.03 Element Inspection and Receiving Acceptance
    - 6.03.01 Receiving Inspection
    - 6.03.02 Hardware Inventory
    - 6.03.03 Softgoods Inventory
  - 6.04 Conditioning if required (purging, temperature and humidity control)  
Facility/GSE preps for Element Storage

- 6.04.01
- 6.04.02 Activate/Monitor Element conditioning systems
- 6.05 Perform design modifications (deferred work)
  - 6.05.01 Element/Subsystem modifications
  - 6.05.02 Fleet-wide tests & inspections
- 6.06 Receiving Inspection discrepancy resolution & repairs
  - 6.06.01 Element Repair & Rework
  - 6.06.02 Inventory Discrepancy Resolutions
- 6.07 Element Shipment from Spaceport
  - 6.07.01 Facility and Equipment Preps for Flight Element Hardware Shipment
  - 6.07.02 Shipment Kit installation on the element
  - 6.07.03 Element Handling and Connection with Transport System
  - 6.07.04 Softgoods preparation for shipment
- 7.0 FLIGHT ELEMENT, SUBSYSTEM & COMPONENT DEPOT MAINTENANCE
  - 7.01 Vehicle overhaul, inspection/verification, and modification (structural, flight controls, etc.)
  - 7.02 Modular element overhaul, remanufacture and inspection/verification
  - 7.03 Hot test propulsion hardware
  - 7.04 Spaceport software upgrades (non-flight)
- 8.0 TRAFFIC/FLIGHT CONTROL
  - 8.01 Ground/flight vehicle inter-communications systems management and control
  - 8.02 Weather advisory for launch, landing, and ground operations
  - 8.03 Vehicle-related launch/flight/landing/ground operations control and monitoring
  - 8.04 Ascent/Reentry flight safety monitor and control
  - 8.05 Audio/visual monitor of ground operations
- 9.0 OFFLINE PAYLOAD/CARGO PROCESSING
  - 9.01 Receipt
  - 9.02 Packaging
  - 9.03 Assembly
  - 9.04 Test & Checkout
  - 9.05 Encapsulation
  - 9.06 Payload Commodity Servicing
  - 9.07 Transport to Vehicle Integration location
  - 9.08 Pre-Flight support
  - 9.09 Passenger pre-flight activities
  - 9.10 Post-flight payload processing
- 10.0 SPACEPORT SUPPORT INFRASTRUCTURE
  - 10.01 Shops and Labs
  - 10.02 Photographic Services
  - 10.03 Fire Protection, Medical
  - 10.04 Security
  - 10.05 Library (technical documents)

- 10.06 Utilities
- 10.07 Roads and Grounds
- 10.08 Foods Services
- 10.09 Heavy Equipment
- 10.10 Communication/Information Services
- 10.11 Ground Transportation Services
- 10.12 Environmental Compatibility Management
- 10.13 Pyrotechnic Storage and Handling
- 10.14 Personal Environmental Protection Equipment
- 10.15 Facility Maintenance Services and Shops
  
- 11.0 FLIGHT SYSTEM-UNIQUE LOGISTICS
  - 11.01 Propellants (acquisition, storage, distribution, conditioning verification)
  - 11.02 Other fluids and gases and unique consumables
  - 11.03 LRU replacement hardware (flight and ground systems)
  
- 12.0 TRANSPORTATION SYSTEMS OPS PLANNING & MANAGEMENT
  - 12.01 Customer Relations
  - 12.02 Vehicle Manifesting and Scheduling
  - 12.03 Ground Systems Scheduling and Management
  - 12.04 Software Production
  - 12.05 Personnel Management
  - 12.06 Sustaining Operations Engineering Work Control
  - 12.07 Public Affairs
  - 12.08 Economic Development
  - 12.09 Business Management
  - 12.10 Advanced Planning
  - 12.11 Safety, Reliability & Quality Assurance (SR&QA)
  
- 13.0 COMMUNITY SUPPORT SERVICES INFRASTRUCTURE
  - 13.01 Shelter
  - 13.02 Connecting Utility Infrastructure
  - 13.03 Transportation Support
  - 13.04 Educational Support
  - 13.05 Community Police/Fire Protection
  - 13.06 Community Resources Infrastructure and Services
  - 13.07 Consumer Retail Support
  - 13.08 Community Medical Support
  - 13.09 Financial Institutions

**FLIGHT VEHICLE OPERATIONS**

**A1 RECEIVE AND ACCEPT FLIGHT ELEMENT(S)**

- A1.01 Element Receiving and Handling Ops
  - A1.01.01 Receiving Facility and Equipment Preps and Functional Verification
  - A1.01.02 Element Transport Receiving and Positioning Ops
  - A1.01.03 Element Offload from Transport system
- A1.02 Element Ground Transfer and Storage Operations at the Spaceport
  - A1.02.01 Element Ground Handling equipment and fixtures
  - A1.02.02 Element Environmental Shelter and Conditioning
  - A1.02.03 Remove and Stow Transportation Hardware
- A1.03 Element Inspection and Receiving Acceptance
  - A1.03.01 Receiving Inspection
  - A1.03.02 Hardware Inventory
  - A1.03.03 Softgoods Inventory
- A1.04 Conditioning if required (purging, temperature and humidity control)
  - A1.04.01 Facility/GSE preps for Element Storage
  - A1.04.02 Activate/Monitor Element conditioning systems
- A1.05 Perform design modifications (deferred work)
  - A1.05.01 Element/Subsystem modifications
  - A1.05.02 Fleet-wide tests & inspections
- A1.06 Receiving Inspection discrepancy resolution & repairs
  - A1.06.01 Element Repair & Rework
  - A1.06.02 Inventory Discrepancy Resolutions

**B1 ASSEMBLY FLIGHT ELEMENT(S)**

- B1.01 Element Transport, Lift and Handling for Assembly
  - B1.01.01 Facility Preps for Element Assembly Operations
  - B1.01.02 Ground Transport of Major Element Segments
  - B1.01.03 Lift, Positioning and Connection to Assembly Facility Support Fixtures
  - B1.01.04 Activate Element Environmental and Safety Controls
- B1.02 Element Structural Assembly
  - B1.02.01 Flight Segment Handling Operations
  - B1.02.02 Flight Segment Structural Connections
  - B1.02.03 Structural Assembly Verification and Closeout
- B1.03 Subsystem / Component Installations
  - B1.03.01 Subsystem / Component Handling Ops
  - B1.03.02 Facility Preps for Installations
  - B1.03.03 Flight Component Installation onto Flight Element
  - B1.03.04 Non-Flight Component Installations
  - B1.03.05 Flight Component Installation Closeouts
- B1.04 Flight Element Assembly Functional Verifications
  - B1.04.01 Passive System Verifications
  - B1.04.02 Active System Verifications
  - B1.04.03 Inspections and Alignment Verifications
- B1.05 Assembly Unplanned Troubleshooting & Repair
  - B1.05.01 Unplanned Element Disassembly/Reassembly

- B1.05.02 Flight Element Troubleshooting and Repair
- B1.05.03 Flight Element Modifications and Process Changes
- B1.06 Post-Assembly Operations
  - B1.06.01 Reconfigure/Relocate Facility and Ground Equipment
  - B1.06.02 Flight Element Preparations for Integration
- C1 SERVICE AND CHECKOUT FLIGHT ELEMENT(S)
  - C1.01 Vehicle Element Systems Servicing
    - C1.01.01 Landing Gear Mechanical Servicing
    - C1.01.02 Ordnance Handling and Installation
    - C1.01.03 Maintenance of Fuselage/PLB Vent Filters & Window Cavity Purge
    - C1.01.04 Flight Crew Systems Servicing
    - C1.01.05 Acreage Tile & TPS Blanket Servicing
      - TPS Moldline Penetration, Leading Edge/Nose & Aerosurface Hingeline Seal
    - C1.01.06 Servicing
    - C1.01.07 Fluid Drain and Deservicing
    - C1.01.08 Fluid Servicing and Fill
    - C1.01.09 Routine Vehicle Cleaning & Filter Inspections
    - C1.01.10 Flight Pressurizations
    - C1.01.11 Navigation & Instrumentation Component Servicing
    - C1.01.12 Routine Replacement of Expendable and Limited Life Items
      - Vehicle electrical power application, and data processing monitoring & control
    - C1.01.13 operations
  - C1.02 Inspection & Checkout
    - C1.02.01 Component/Subsystem Functional Verification
      - C1.02.02 Structural integrity inspections and mechanism functional verifications
      - C1.02.03 Propellant/fluid/gas system integrity verifications & inspections
      - C1.02.04 Vehicle power up/down, switch-lists, functional checks and on-board s/w config
    - C1.03 Removal of Access/Umbilicals and Closeout
      - C1.03.01 Removal of Umbilicals and Access equipment
        - Flight Element System Closeouts for Vehicle and Ground Launch System
      - C1.03.02 Integration
      - C1.03.03 Preps for Vehicle Element Transfer
- D INTEGRATE FLIGHT SYSTEM AND PAYLOAD
  - D.01 Element Transportation, Handling, Lift and Mate
    - D.01.01 Facility Preps for Flight Element Integration Operations
    - D.01.02 Ground Transport of Flight Elements
    - D.01.03 Element Lift, Position and Mate
    - D.01.04 Post-Mate Servicing and Interface Closeouts
  - D.02 Post-Mating Functional Verification
    - D.02.01 Element to Ground System Interfaces
    - D.02.02 Element to Element Interfaces
  - D.03 Integration Unplanned Troubleshooting & Repair
    - D.03.01 Disconnection of Flight Elements
    - D.03.02 Interface Troubleshooting and Repair
    - D.03.03 Post-Integration Flight Element Troubleshooting and Repair
    - D.03.04 Post-Integration Ground Element/Equipment Troubleshooting and Repair

- D.04 Perform integration of payload / cargo
  - D.04.01 Facility Preparations for Payload Installation
  - D.04.02 Payload Installation into Vehicle
  - D.04.03 Post Installation operations
  - D.04.04 Payload handling and transport operations
  - D.04.05 Payload Inspections and Testing
- D.05 Configure systems for Vehicle Transfer to Launch Point
  - D.05.01 Disconnect/Stow integration and mating ground h/w
  - D.05.02 Configure Vehicle systems for launch functions
  - D.05.03 Preps for Integrated Vehicle Transfer/Rotation to launch position
- D.06 Position Vehicle at Launch Point, Mate to Ground Facility and Services & Provide Access
  - D.06.01 Vehicle Transport and Alignment
  
  - D.06.02 Mate Umbilicals, Environmental Protection and Access positioning
- E EXECUTE DEPARTURE OPERATIONS
  - E.01 Functional Verif of Flt/Grd Systems for Launch
    - E.01.01 Periodic Maintenance / Calibrations
    - E.01.02 System Integrity Verification
    - E.01.03 System Functionality Verification
    - E.01.04 Human systems verification and training
  - E.02 Launch Systems Unplanned Troubleshooting/Repair
    - E.02.01 Component Troubleshooting, Removal and Replacements
    - E.02.02 Ground Launch Structural Systems Repair
  - E.03 Crew Ingress, Late Payload Stowage & Functional Verification for Flight
    - E.03.01 Flight Crew Ingress/Egress
    - E.03.02 Late Payload Stowage
    - E.03.03 Payload Functional Verification for Flight
    - E.03.04 Unplanned Payload Troubleshooting and Repair
  - E.04 Vehicle System Servicing at Launch Point
    - E.04.01 Local Servicing with facility/GSE by remote control room
    - E.04.02 Local Manual Servicing at the Launch Facility
    - E.04.03 Ordnance Hookups
  - E.05 Access/Umbilical Removal & Closeout for Flight
    - E.05.01 Payload Closeout tasks
    - E.05.02 Access Removal tasks
    - E.05.03 Umbilical Removal tasks
    - E.05.04 Environmental Cover Removal tasks
  - E.06 Remote Automated Servicing and Propellant Loading
    - E.06.01 Cryogenic Fluids transfer
    - E.06.02 Thermal Management Fluid Servicing
    - E.06.03 Tank Gaseous Pressurization
    - E.06.04 Flight Vehicle Press
    - E.06.05 Environmental Ctl purging
    - E.06.06 Engine Conditioning Purges
    - E.06.07 Remote Fuel Cell Gas Supply
  - E.07 Launch the Vehicle
    - E.07.01 Coordinate the network of local and offsite support functions
    - E.07.02 Activate Flight Vehicle and Ground Systems for Launch
    - E.07.03 Obtain Weather and Range Clearances for Launch
    - E.07.04 Configure Flight Vehicle for Terminal (Final) Launch Operations

- E.07.05 Final Launch Sequencing
- E.07.06 Configure systems for launch abort/recycle, as needed
- F MONITOR AND MANAGE THE FLIGHT
  - F.01 Ascent/Reentry flight safety monitor and control
- G LAND/RECOVER FLIGHT ELEMENT(S) AND PAYLOAD
  - G.01 Facility and Equipment Preps for Vehicle Landing / Recovery
    - G.01.01 Functional verification of ground recovery systems prior to flight element arrival
    - G.01.02 Servicing of Ground Recovery systems for arrival
    - G.01.03 Landing Facility Contamination control
  - G.02 Element Landing and Recovery Operations
    - G.02.01 Activate ground landing systems and position resources for element arrival
    - G.02.02 Position recovery equipment and provide services to vehicle element upon return
    - G.02.03 Perform active system shutdown, safing and check out for return to spaceport
  - G.03 Payload Removal Operations
    - G.03.01 Internal payload item removal
    - G.03.02 Payload handling and transport operations
    - G.03.03 Attached payload item removal
    - G.03.04 Crew and passenger egress
  - G.04 Post-Flight element ground handling and transport
    - G.04.01 Post flight element handling operations
    - G.04.02 Element ground transport from recovery point
  - G.05 Remote Landing Site Recovery and Ferry Return Operations
    - G.05.01 Flight element system preparations for ferry
    - G.05.02 Ferry equipment and facility preps
    - G.05.03 Flight element mate to ferry systems
    - G.05.04 Element Ferry operations support
- H1 PREPARE FLIGHT ELEMENT(S) FOR TURNAROUND
  - H1.01 Facility Preps for Vehicle Turnaround
    - H1.01.01 Functional Verification of ground systems prior to Vehicle arrival
    - H1.01.02 Servicing and staging of ground systems prior to vehicle arrival
    - H1.01.03 Contamination control
  - H1.02 Positioning Vehicle, Connection to Services, Gaining Access, and Protection
    - H1.02.01 Vehicle Transport and Alignment
    - H1.02.02 Ground access equipment positioning
    - H1.02.03 Connection to facility services
    - H1.02.04 Establish protective enclosures and install/remove flight vehicle protective covers
    - H1.02.05 Removal of flight equipment covers/panels to gain access
    - H1.02.06 Opening and closing of vehicle hatches and hinged/articulated doors
  - H1.03 Vehicle Element Safing
    - H1.03.01 Hazardous Fluid Safing
    - H1.03.02 Pyro/Ordnance Safing
    - H1.03.03 Vehicle Purges for Personnel/Orbiter Safety
  - H1.04 Processing Support Systems & Functions

- H1.04.01 Purge Operations & Monitoring
- H1.04.02 Hazard Monitoring Systems Operation
- H1.04.03 Vehicle System Reconfigurations
- H1.05 Routine Reusable Flight Element Module/Component Disassembly
  - H1.05.01 Disassembly Preps and Attach/closeout hardware removal
  - H1.05.02 Flight Element Component disassembly, handling, and transport
  - H1.05.03 Post-Disassembly
- II RESTORE FLIGHT ELEMENT(S)
  - I1.01 Troubleshooting, Replacement, Disposition of Failed/Suspect LRUs
  - I1.02 Troubleshooting and Repair of Leaks
  - I1.03 Fluid/Pneumatic System Decontamination/Cleaning
  - I1.04 Troubleshooting, Retest and Repair of Electrical cables, connectors
  - I1.05 Repair or Replacement of Thermal Protection Systems (TPS) Hardware
  - I1.06 Structural Repair/Refurbishment
  - I1.07 Repair of Damaged Ducts, Tubes & Hoses
  - I1.08 Troubleshooting & Repair of Mechanisms and Thermal/Pressure Seals
  - I1.09 Troubleshooting and Repair of Ground Equipment
- J RESTORE GROUND SYSTEMS FOR REUSE
  - J.01 Post-Launch Securing
    - J.01.01 Post Launch System Safing Operations
    - J.01.02 Post Launch Inspection of Facilities and Equipment
  - J.02 Facility/GSE, Refurbishment, Reservicing & Preps for Vehicle Arrival
    - J.02.01 Launch Equipment Refurbishment/Reservicing
    - J.02.02 Contamination Control
    - J.02.03 Functional verifications of ground systems prior to flight vehicle mating
    - J.02.04 Servicing of ground systems prior to flight vehicle mating

#### **PAYLOAD ELEMENT OPERATIONS**

- A2 RECEIVE AND ACCEPT PAYLOAD ELEMENT(S)
  - A2.01 Payload Element Receipt
- B2 ASSEMBLY PAYLOAD ELEMENT(S)
  - B2.01 Payload Element Packaging
  - B2.02 Payload Element Assembly
- C2 SERVICE AND CHECKOUT PAYLOAD ELEMENT(S)
  - C2.01 Test & Checkout
  - C2.02 Encapsulation
  - C2.03 Payload Commodity Servicing
  - C2.04 Transport to Vehicle Integration location
  - C2.05 Pre-Flight support
  - C2.06 Passenger pre-flight activities
- H2 PREPARE PAYLOAD ELEMENT(S) FOR TURNAROUND OR DISPOSAL
  - H2.01 Vehicle Payload Accommodations Turnaround
    - H2.01.01 Reconfigure unique payload thermal protection/insulation
    - H2.01.02 Repositioning vehicle-fixed mechanisms
    - H2.01.03 Remove/Install mission-unique mechanisms
    - H2.01.04 Reconfigure vehicle supplied fluid services



- H2.01.05 Reconfigure vehicle supplied electrical and information services
- H2.01.06 Access to Payload accommodations
- H2.01.07 Payload accommodations cleaning and closeout
  
- H2.01.08 Payload accommodations turnaround unplanned troubleshooting and repair
- H2.01.09 Payload Accommodations Inspections & Testing
- H2.02 Post-flight payload processing

I2 RESTORE PAYLOAD ELEMENT(S)

**FLIGHT & GROUND TRAFFIC CONTROL AND SAFETY OPERATIONS**

K TRAFFIC CONTROL AND SAFETY

- K.01 Ground/flight vehicle inter-communications systems management and control
- K.02 Weather advisory for launch, landing, and ground operations
- K.03 Vehicle-related launch/flight/landing/ground operations control and monitoring
- K.04 Audio/visual monitor of ground operations

**ENABLING OPERATIONS**

L SPACEPORT LOGISTICS

M1 MANAGEMENT OF FLIGHT SYSTEM OPERATIONS

M2 MANAGEMENT OF THE SPACEPORT

N SPACEPORT-PROVIDED SUPPORT SERVICES

O OFF-LINE MAINTENANCE, REPAIR, AND OVERHAUL

- O.01 Landing/Recovery Facility and Equipment Periodic Maintenance
  - O.01.01 Interval Maintenance of Landing Recovery Ground Systems
  
  - O.01.02 Recovery Ground System and Facility Modifications and Process Changes
- O.02 Mods & Special Tests
  - O.02.01 Flight Element Modifications and Process Changes
  - O.02.02 Special Tests and Fleet System Checks
- O.03 Turnaround Facility and Equipment Periodic Maintenance
  - O.03.01 Interval Maintenance of Ground Systems
  - O.03.02 Ground System and Facility Modifications and Process Changes
- O.04 Assembly Facility and Equipment Periodic Maintenance
  - O.04.01 Interval Maintenance of Assembly Ground Systems
  
  - O.04.02 Assembly Ground System and Facility Modifications and Process Changes
- O.05 Integration Facility and Equipment Periodic Maintenance
  - O.05.01 Interval Maintenance of Integration Ground Systems
  
  - O.05.02 Integration Ground System and Facility Modifications and Process Changes
- O.06 Launch Facility and Equipment Periodic Maintenance
  - O.06.01 Interval Maintenance of Launch Ground Systems
  
  - O.06.02 Launch Ground System and Facility Modifications and Process Changes
- O.07 Vehicle overhaul, inspection/verification, and modification (structural, flight controls, etc.)
- O.08 Modular element overhaul, remanufacture and inspection/verification

- O.09 Hot test propulsion hardware
- O.10 Spaceport software upgrades (non-flight)

P PUBLIC AND COMMUNITY SUPPORT SERVICES

- P.01 Shelter
- P.02 Connecting Utility Infrastructure
- P.03 Transportation Support
- P.04 Educational Support
- P.05 Community Police/Fire Protection
- P.06 Community Resources Infrastructure and Services
- P.07 Consumer Retail Support
- P.08 Community Medical Support
- P.09 Financial Institutions