ISS Commercial Cargo Service: Requirements & Constraints Summary

ISS Commercial Cargo Service Industry Day Conference

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Purpose & Agenda

Purpose

Present preliminary ISS Commercial Cargo Service (ICCS) requirements

Agenda

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Philosophy
Cargo Balance
  Internal Cargo Balance
  External Cargo Balance
  Water Balance
  Gas Balance
  Return Cargo
Cargo Types
ICCS Flight Rate
Late & Early Access

Power to Payloads
Mating Location Options
ISS Docking & Berthing
Vehicle Stay Time
ISS Resource Availability
Robotic & EVA Compatibility
Return Cargo
Key Req’s Summary
Conclusion
Background

- ISS commercial cargo transportation services will compensate for some cargo lost from Shuttle retirement in December 2010
- The NASA Launch Services Program Office (LSPO) at KSC is leading the acquisition effort with ISS assistance
- ISS preliminary requirements provided to LSPO (March 15th) for ICCS Draft RFP preparation
- ICCS requirements revision expected before Draft RFP release
Philosophy

Service vs. Spacecraft Acquisition

- NASA is acquiring a service, not spacecraft
- ISS requirements for integration of visiting vehicles included
  - Prox ops, docking, berthing, robotics, interfaces, attached operations, resource availability, safety, etc.
- ICCS annual cargo needs specified – maximum and minimum levels
  - Minimum level to help set contract firm commitment with options for additional service
ICCS Cargo Vehicle Flight Rate

- ICCS vehicle flight rate limited to 6 flights/year
  - Crew time impact for arrival and departure operations
  - Impact to micro-g operations, still important to ISS partners
  - Soyuz, Progress, ATV, HTV vehicles visit 10 to 12 times/year in total
- ICCS must be able to respond to a cargo service request within 180 days
  - Unexpected need for crew supplies, maintenance, utilization, etc.
ISS Cargo Categories

- Assembly hardware
  - Not ICCS requirement
- Crew Supplies
  - Food
  - Water
  - Gas
  - Flight crew equipment
- Maintenance
  - Internal & external ORUs
    - Preventative and corrective maintenance
- Utilization/Research
  - Research equipment, experiments
  - Laboratory consumables
Cargo Packaging

- Rack delivery *not* required
- Internal cargo usually in soft sided stowage bags
- Large external ORUs – CMGs, TCS pumps, etc.
  - TCS radiators excluded because of spares already in orbit and projected need
- Experiment packages
  - Express rack elements
Late and Early Cargo Access

- Various payloads, such as plants and animals require late loading into the cargo vehicle
  - Cargo service/vehicle should provide cargo access as late as 19 hours before launch

- Returning payload specimens and samples will need to be removed from the cargo vehicle shortly after landing
  - The cargo service/vehicle should provide the capability to remove the payload from the cargo vehicle within 4 hours after returning to Earth
Power to Payloads

- ICCS payload power requirements during transportation
  - 500 W average
  - 1500 kW peak
  - Return power assumed to equal delivery power needed

Example Payload: Commercial Generic Bioprocessing Apparatus
ISS Rendezvous, Prox Ops, Docking, Berthing Aids

- No existing automated rendezvous & docking system to US segment
  - ISS only provides visual aids for Shuttle prox ops/docking
  - ICCS provided AR&D system for ISS is an available solution option
- HTV automated rendezvous to robotic capture and berthing
  - DGPS & TCS navigation
  - R-Bar approach to ISS nadir capture box – robotic berthing to Node 2 nadir
- Soyuz, Progress, and ESA ATV vehicles use Russian RF based, rendezvous & docking system
  - Applicable for dockings to ISS Russian segment
    - Service Module (SM) aft
    - SM/Docking Compartment nadir
    - FGB nadir
ISS Flight Attitude

- ICCS vehicles must dock and mate with the ISS in its normal operational flight attitude
  - X VV Z Nadir TEA
    - X body axis on velocity vector
    - Z body axis down/nadir
    - TEA – Torque Equilibrium Attitude
ISS Mating Location Options

- ISS has six candidate ports available for attaching ICCS vehicles
  - The ports on the Russian Segment will be occupied continuously with Soyuz, Progress, and ATVs
    - Additional vehicles can visit these ports but will decrease the docked time of the Progress and ATV
  - The US Segment's ports have low occupancy rate
  - Attaching to the US Segment offers more flexibility
ISS Docking & Berthing

- **ISS dockings to US Segment** use Russia’s Androgynous Peripheral Attachment System (APAS)
  - +X Body: PMA2
  - +Z Body: PMA3
- **ISS module interfaces** use Common Berthing Mechanisms (CBMs)
  - ISS robotic capture & mating only
  - MPLM, HTV
Vehicle Stay Time

- **ICCS vehicles must be capable of staying at the Station at least 7 days**
  - Minimum time required to handle cargo transfer operations
  - Results of recent HTV studies may increase this minimum time
- **Maximum stay time dependent on ISS operational vehicle traffic and port utilization plans**
  - Longer stay time improves operational flexibility
ISS Resources for ICCS Vehicles

- **Power**
  - Allocation of 500 W average, 1500 W peak for ICCS
  - Typically 3 KW capacity

- **Thermal**
  - Thermal water loops available at Node 2 Nadir, Node 3, and Node 1 port side CBMs
    - ~ 3 KW capacity
  - Allocation of 500 W average heat rejection

- **Inter-module ventilation**

Typical Interfaces at CBM Vestibule

Strategic Planning & Requirements
Vella Thorn
Robotic & EVA Compatibility

- ICCS external cargo must be compatible with ISS US Segment robotic systems and EVA handling
  - SSRMS
  - Special Purpose Dexterous Manipulator (SPDM/Dextre)
  - Mobile Transporter
Cargo Return & Disposal

- **ICCS vehicles must have the capability to safely return cargo to Earth**
  - Internal cargo: 11 MT/yr max, 1 MT/yr min
  - External cargo: 3.3 MT/yr max, 0 min
  - Return cargo delivery to NASA within 14 days of landing
    - 4 hours for critical cargo

- **Cargo disposal required for large portion of ISS cargo**
  - Safe disposal requirements for expendable vehicles must be satisfied
  - Internal cargo: 8.3 MT/yr max, 400 kg/yr min
  - External cargo: 2.2 MT/yr max, 1400 kg/yr min
Philosophy

Maximum Cargo Requirements

- ICCS maximum cargo requirements
  - Based on making up shortfall from baseline partner cargo delivery contribution
  - Includes latest available updates in need for crew supplies, maintenance, utilization, gas, & water
    - New NASA ISS USOS utilization requirements official update expected in coming weeks from ESMD – preliminary requirements received recently
- Return Cargo
  - Maximum return capability of ~15,000 kg/yr
Philosophy

Minimum Cargo Requirements

- **ICCS minimum cargo requirements**
  - Based on making up shortfall from baseline partner contributions and ISS cargo needs with reductions in maintenance & utilization
  - **Crew Supplies**
    - No further reduction, already at minimum acceptable level
  - **Maintenance (L&M provided minimum requirement)**
    - Internal maintenance reduced 20%
    - External maintenance
      - Assumes 57 FRAM Eq of pre-positioned maintenance/spare ORUs at Shuttle retirement
      - Reduced failure rates
  - **Utilization**
    - NASA program
      - Internal: 2000 kg/yr internal cargo delivery
      - External: Zero
    - IP Research Program
      - Internal: 2650 kg
      - External: 440 kg
  - **Return Cargo**
    - 1000 kg/yr – internal cargo only
ISS NASA/JAXA/ESA/CSA

Cargo Demand/Delivery Balance Summary

- Assembly Hardware is not included
- Accommodation masses are not included
- Crew rotation mass not included
ISS NASA/JAXA/ESA/CSA Cargo

Internal Demand/Delivery Balance

- Assembly Hardware is not included
- Accommodation masses are not included
- Crew rotation mass not included

Fiscal Year

Mass (Kg)

- Crew Supplies, EVA Equip, and Russian Barter
- Maintenance
- Utilization

Comm Max Capability
Comm Mini Capability
Augmented Capability
Baseline Capability
ISS NASA/JAXA/ESA/CSA Cargo

Water Demand/Delivery Balance

- Accommodation masses are not included
ISS NASA/JAXA/ESA/CSA Cargo
Gas Demand/Delivery Balance

- Accommodation masses are not included
### Key ICCS Requirements Summary

<table>
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<tr>
<th>Parameter</th>
<th>Launch On Need</th>
<th>Flight Rate</th>
<th>Dock Berth</th>
<th>Stay Time</th>
<th>Power</th>
<th>Late Access</th>
<th>Early Access</th>
<th>EVA &amp; Robotic Capability</th>
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<tbody>
<tr>
<td>Requirement</td>
<td>150 Days</td>
<td>&lt;= 0 Yr</td>
<td>US Segment</td>
<td>&gt; 7 Days</td>
<td>500 W A V</td>
<td>1600 W Pk</td>
<td>Lift 19 Hr.</td>
<td>200 lb. 200 ft. 2 m³</td>
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<th>Cargo Delivery</th>
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<td>Requirements Summary</td>
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<td><strong>Max Requirements</strong></td>
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<td><strong>Min Requirements</strong></td>
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Conclusion

- The fundamental requirements necessary to begin acquisition of an ISS Commercial Cargo Service are complete
  - The “ICCS Commercial Maximum” satisfies current projections for NASA/JAXA/ESA/CSA cargo delivery demand
  - The “ICCS Commercial Minimum” may be acceptable if key risk areas have optimistic outcomes and utilization cargo need is substantially reduced
- ICCS requirements revision planned after official utilization requirements update -- expected in coming weeks