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
Background
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

Strategic Planning & Requirements
Valin Thorn
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 V V 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 Vehicle Traffic & Port Utilization
Post Shuttle Retirement Example

<table>
<thead>
<tr>
<th>Soyuz A</th>
<th>Soyuz B</th>
<th>Soyuz C</th>
<th>Soyuz D</th>
</tr>
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<tbody>
<tr>
<td>Node 2</td>
<td>Node 1</td>
<td>ATV</td>
<td>Node 1</td>
</tr>
<tr>
<td>Node 3</td>
<td>Node 2</td>
<td></td>
<td>Node 3</td>
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<tr>
<td>Node 4</td>
<td>Node 4</td>
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<td>Node 4</td>
</tr>
</tbody>
</table>

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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**
Robotic & EVA Compatibility

- ICCS external cargo must be compatible with ISS US Segment robotic systems and EVA handling
  - SSRMS
  - Special Purpose Dextereous 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
ISS Cargo Supply Balance

ISS Assembly

ISS Assembly Complete

3 ISS Crew

6 ISS Crew

U.S. - Russian Bilateral Obligations

External Utilization

Comm Max Capability

30,000

25,000

20,000

15,000

10,000

5,000

0

Mass (Kg)


Year

Internal Utilization

Augmented Capability

External Maintenance

Baseline Capability

Internal Maintenance and EVA Hardware

Crew Supplies, Water, and Gas

Remove Blue and Red Lines

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

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ISS NASA/JAXA/ESA/CSA Cargo

Internal Demand/Delivery Balance

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External Demand/Delivery Balance

- Assembly Hardware is not included
- Accommodation masses are not included
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Water Demand/Delivery Balance

- Accommodation masses are not included

Fiscal Year

Baseline Capability

Augmented Capability

Comm Min Capability

Comm Max Capability

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Gas Demand/Delivery Balance

- Accommodation masses are not included
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Return Cargo

ISS Assembly

ISS Assembly Complete

3 ISS Crew

6 ISS Crew

6 ISS Crew

U.S. - Russian Bilateral Obligations

External Utilization

Internal Utilization

External Maintenance

Internal Maintenance and EVA Hardware

Crew Supplies, Water, and Gas

Comm Max Capability

Augmented Capability

Baseline Capability

Comm Min Cap

Year
## Key ICCS Requirements Summary

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<tr>
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<tbody>
<tr>
<td></td>
<td><strong>Internal Cargo (MT/yr)</strong></td>
<td><strong>External Cargo (MT/yr)</strong></td>
<td><strong>Water (MT/yr)</strong></td>
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<tr>
<td><strong>Max Requirements</strong></td>
<td>13.4</td>
<td>4.5</td>
<td>0.8</td>
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<tr>
<td><strong>Min Requirements</strong></td>
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<td>2.2</td>
<td>0.8</td>
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<tr>
<th>Requirement</th>
<th>150 Days</th>
<th>&lt;= 0 yr</th>
<th>US Segment</th>
<th>&gt;= 7 Days</th>
<th>500 W AV / 1600 W PE</th>
<th>Lack 19 Hz</th>
<th>200 kg / 2 m³</th>
<th>Lego 4 PI 200 kg / 2 m³</th>
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<tr>
<td>Parameter</td>
<td>Launch On Need</td>
<td>Flight Rate</td>
<td>Dock Berth</td>
<td>Stay Time</td>
<td>Power</td>
<td>Late Access</td>
<td>Early Access</td>
<td>EVA &amp; Robotic Capability</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