APPENDIX M: OBPR Implementation Analysis

REMAP Implementation Analysis

May 16, 2002

REMAP Implementation Assessment Objectives

ISS Research

ISS Research Maximization and Prioritization Implementation

- To provide the REMAP Task Force with analytical information which addresses how the REMAP prioritization of OBPR research can be accommodated by the US Core Complete configuration (per the Terms of Reference) and enhancements to the ISS beyond US Core Complete
- The intent of this implementation analysis is not to influence the REMAP prioritization but to enable the Task Force to focus their recommendations

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ISS Research Maximization and Prioritization Implementation

ISS Research

Considerations for the Task Force

This briefing highlights the implications that the prioritized research has on critical ISS resources.

The task force may want to consider the following questions over the course of this briefing:

- Given a significant number of "Priority 1" research areas, the task force may want to consider the extent to which these high priority research areas can be further stratified, given scientific merit, impact to broader community, relevance to NASA's mission, etc.
- Given NASA's commitment to "science-driven decisions," is there a message that the task force wants to send regarding the science requirements to be levied on the ISS, and the order and/or timeframe in which those requirement should be addressed?
- Given the science priorities, does the task force see gaps in OBPR plans for research hardware development?
- Given near term ISS constraints, the task force may want to consider if there are research areas within the "Priority 1" family that should take precedence, at least for the near term.
- Does the task force want to make any statement regarding International Partner capabilities as they relate to NASA's ability to address the science priorities?

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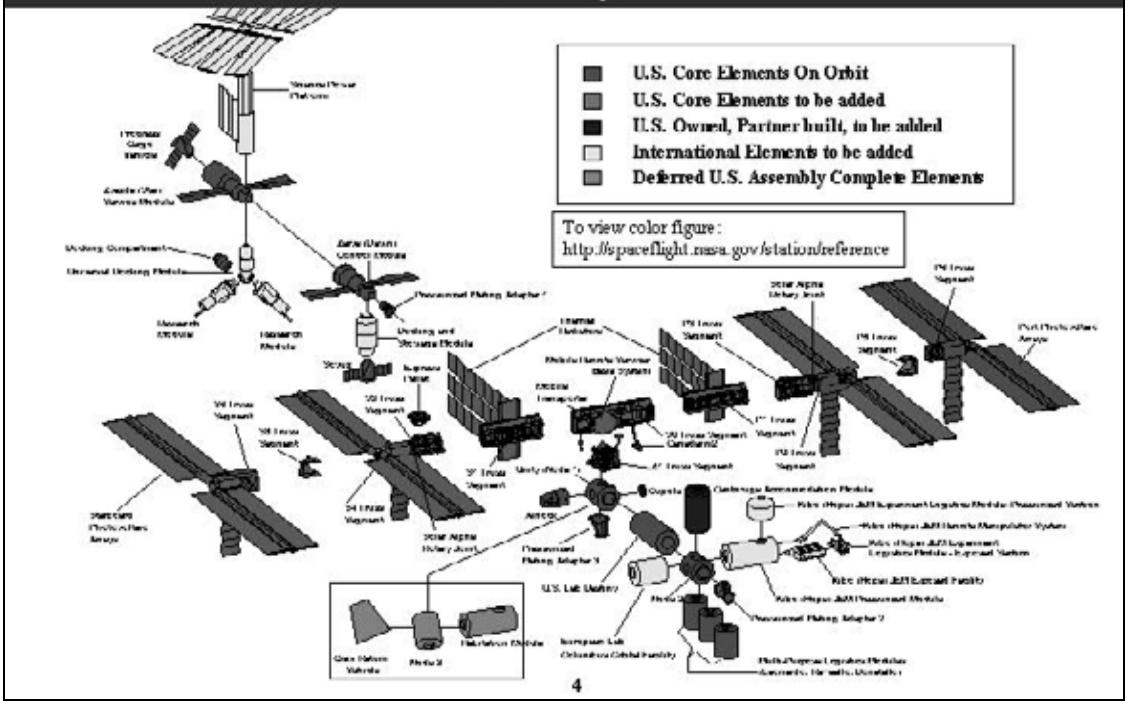
International Space Station

President's Fiscal Year 2003 Budget
"Core Complete"

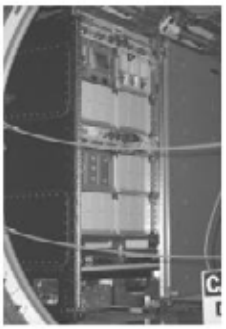


4

ISS Research

ISS Research Maximization and Prioritization Implementation

Research Racks

Multidiscipline Racks	Lab Support Racks	Specialized Discipline Racks
		
EXPRESS 5 of 8 racks currently on ISS	Freezer (1 rack) Gloveboxes (2 racks)	Human Research (2) Combustion and Fluids (2) Materials (1) Fundamental Biology (2)

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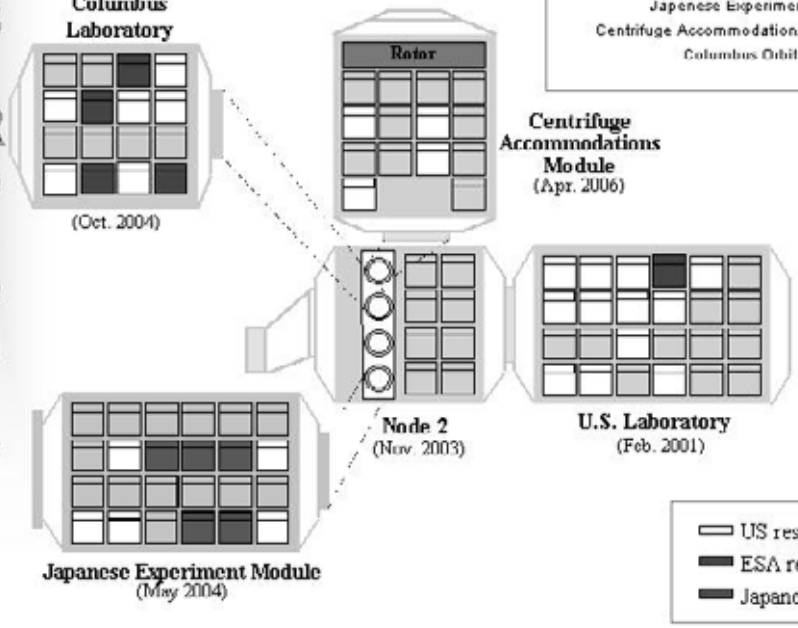
ISS Research

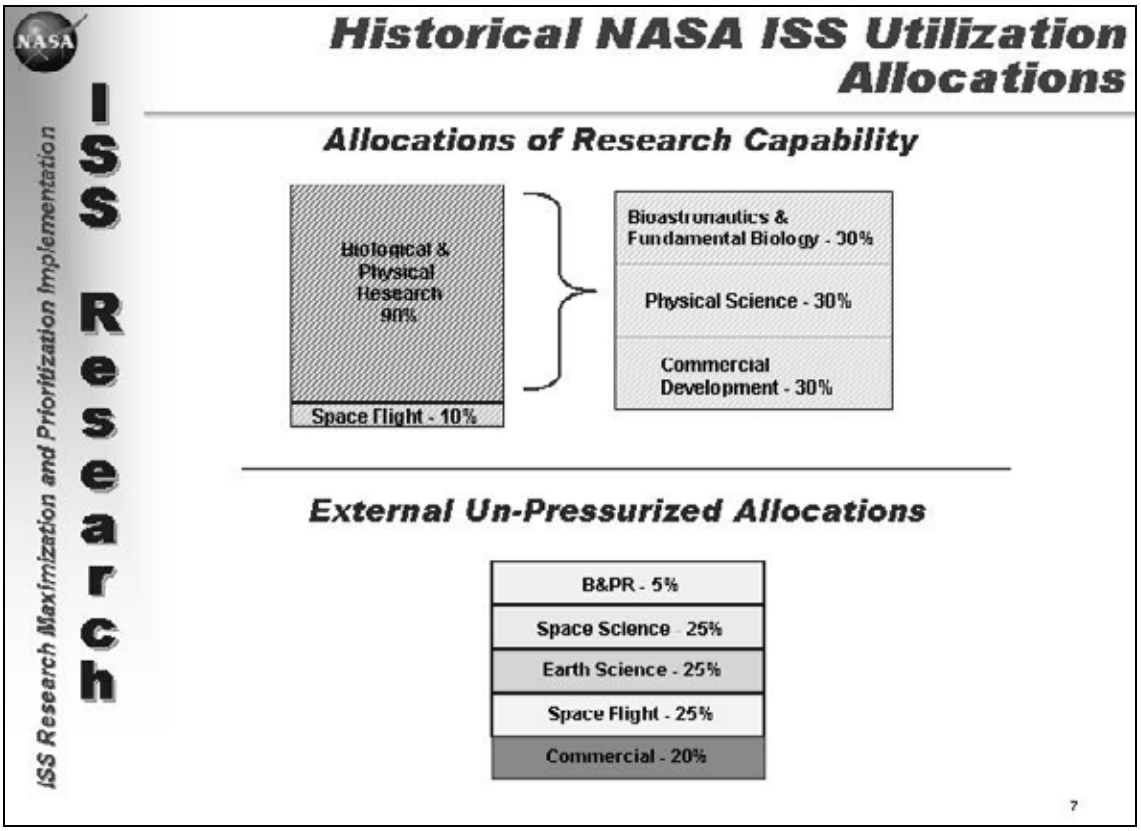
ISS Research Maximization and Prioritization Implementation

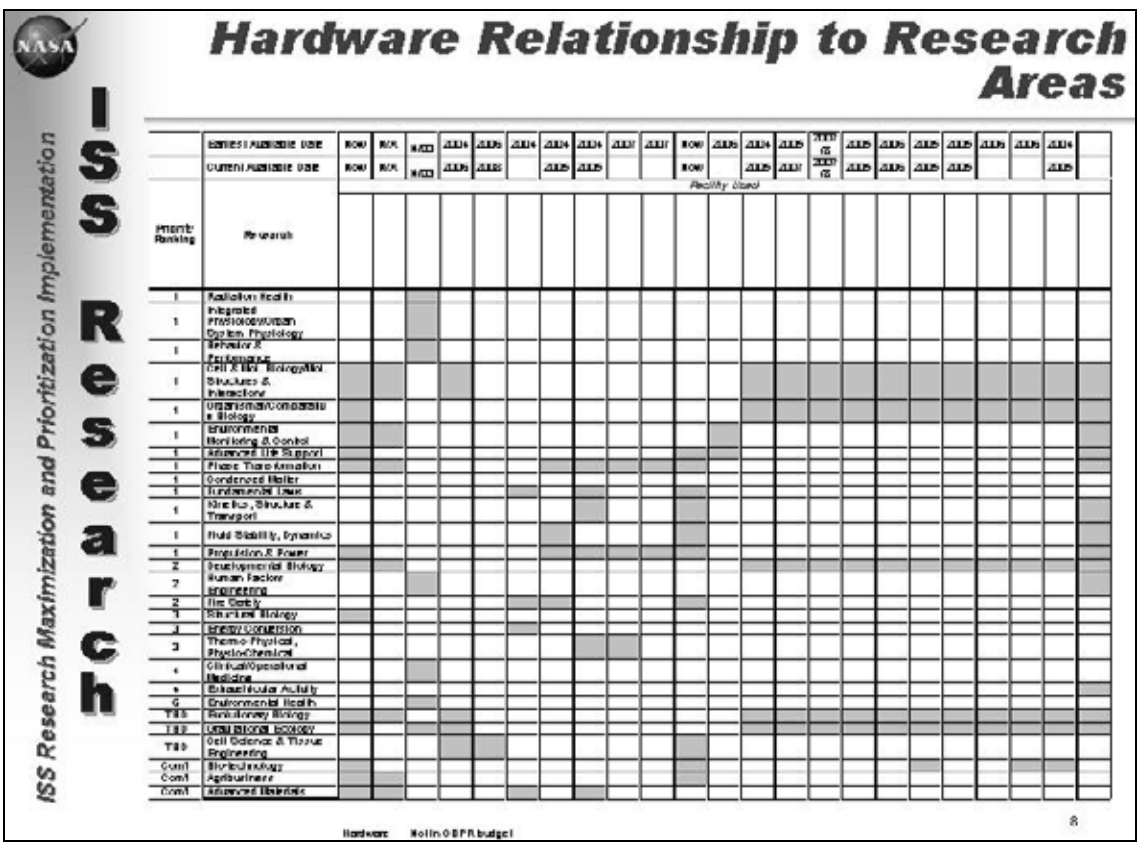
Laboratory Science - Rack Locations

Internal Pressurized Accomodations	U.S. Sites
U.S. Laboratory	13 (-1)
Japanese Experiment Module	6
Centrifuge Accommodations Module	4
Columbus Orbital Facility	5 (+1)
Total	27



6


ISS Research Maximization and Prioritization Implementation
ISS Research
Historical NASA ISS Utilization Allocations
Allocations of Research Capability
Biological & Physical Research 90%
Space Flight - 10%
Bioastronautics & Fundamental Biology - 30%
Physical Science - 30%
Commercial Development - 30%
External Un-Pressurized Allocations
B&PR - 5%
Space Science - 25%
Earth Science - 25%
Space Flight - 25%
Commercial - 20%
7


ISS Research Maximization and Prioritization Implementation
ISS Research
Hardware Relationship to Research Areas
Earliest Available Date
Current Available Date
Priority Ranking
Research
Facility Used
Radiation Health
Integrated Physiology/Organ System Physiology
Behavior & Performance
Cell & Biol. Biology/Biol. Structures & Interactions
Organismal/Comparative Biology
Environmental Monitoring & Control
Advanced Life Support
Phase Transformation
Condensed Matter
Fundamental Laws
Kinetics, Structure & Transport
Fluid Stability, Dynamics
Propulsion & Power
Developmental Biology
Human Factors Engineering
Fire Safety
Structural Biology
Energy Conversion
Thermo-Physical, Physio-Chemical
Clinical/Operational Medicine
Extravehicular Activity
Environmental Health
Evolutionary Biology
Gravitational Ecology
Cell Science & Tissue Engineering
Biotechnology
Agribusiness
Advanced Materials
Hardware Not in OBPR budget
8

ISS Research Maximization and Prioritization Implementation

ISS Research

Research Area Requirements

- **Research in any one area can be performed to differing degrees; in order to bound the resulting range of requirements, various levels of research were defined and requirements estimated for each level.**
- **Three levels of research used for this analysis**
  - ✓ ***Viable*** - A minimal level of research below which "its just not worth doing". This level will represent a minimum hardware and resource requirement.
  - ✓ ***Nominal*** - A level of research activity which will fully address the goals and questions within the research area. This level should not be constrained by any perception of resource constraints.
- **Research requirements were defined per increment.**
  - ✓ An increment on ISS begins with the arrival of a new crew and ends when they return to Earth
  - ✓ Current plan is for 2 increments per year (180 days per increment)

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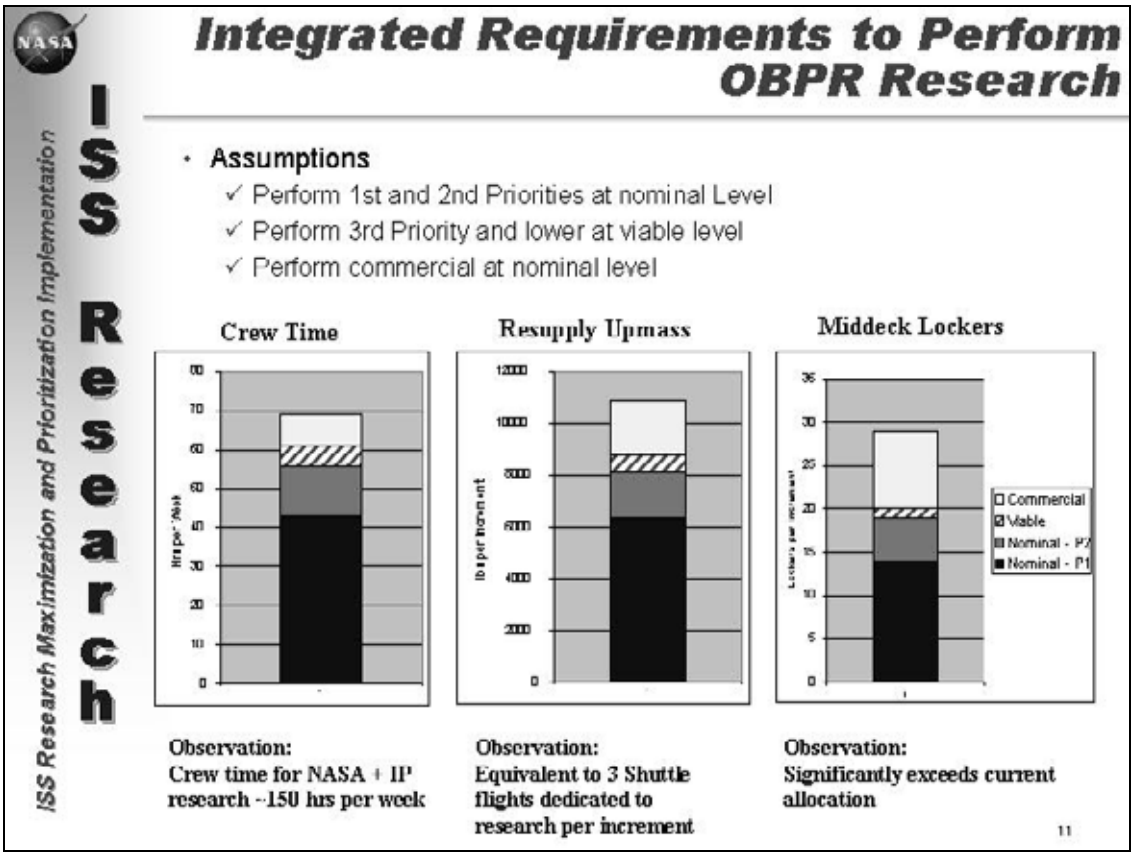
ISS Research Maximization and Prioritization Implementation

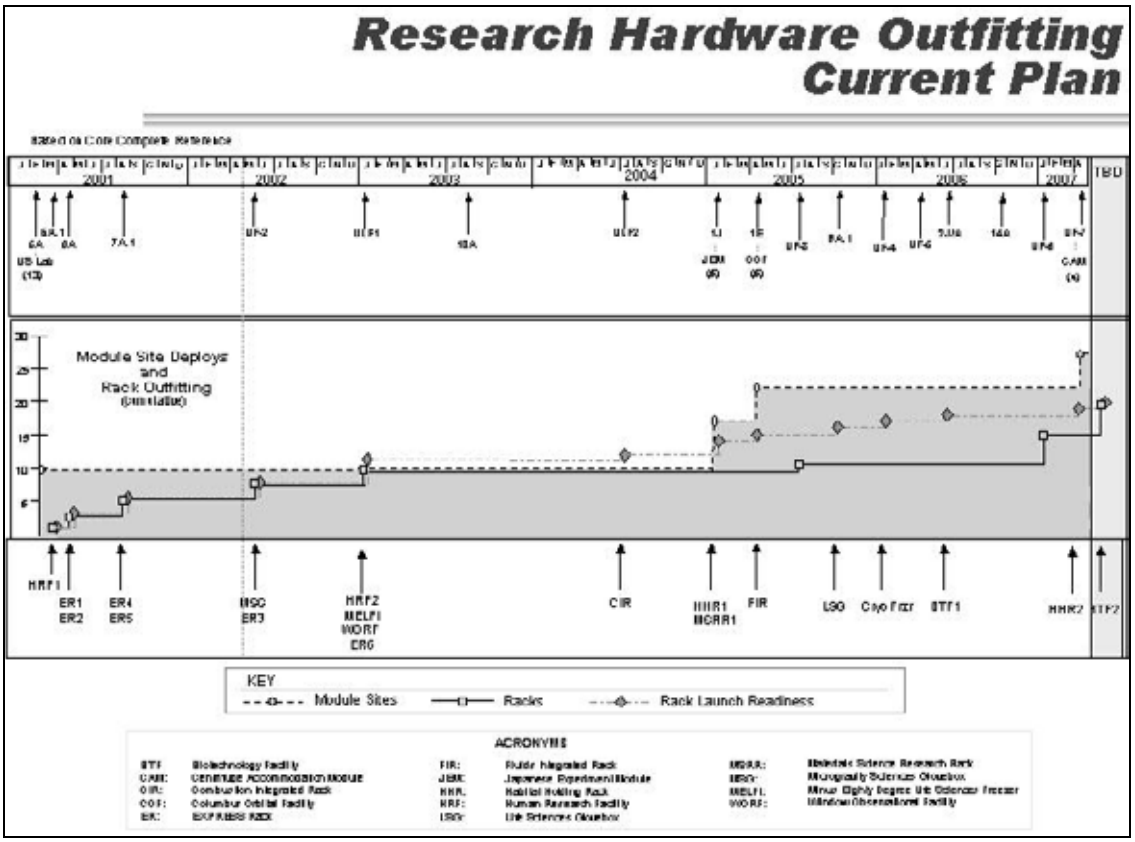
ISS Research

Critical Resources for ISS Research

- *Crew time:* Time that the ISS crew spends on research related activities
- *Resupply upmass:* Mass delivered to the ISS for payload / experiment operations
- *Powered middeck lockers:* Containers provided by the Shuttle for delivering perishable samples or material that must be loaded shortly before launch

10


Integrated Requirements to Perform OBPR Research
ISS Research
ISS Research Maximization and Prioritization Implementation
Assumptions
✓ Perform 1st and 2nd Priorities at nominal Level
✓ Perform 3rd Priority and lower at viable level
✓ Perform commercial at nominal level
Crew Time
Resupply Upmass
Middeck Lockers
Commercial
Viable
Nominal - P2
Nominal - P1
Observation:
Crew time for NASA + IP research ~150 hrs per week
Observation:
Equivalent to 3 Shuttle flights dedicated to research per increment
Observation:
Significantly exceeds current allocation
11


Research Hardware Outfitting Current Plan
2001
2002
2003
2004
2005
2006
2007
TBD
Module Site Deploys and Rack Outfitting
KEY
Module Sites
Racks
Rack Launch Readiness
ACRONYMS

ISS Research Maximization and Prioritization Implementation

ISS Research

Hardware Constraints on Initiating Priority Research

Priority Ranking	Research Area	2002	2003	2004	2005	2006	2007	2008	2009
1	Radiation Health								
1	Integrated Physiology/Organ System Physiolog								
1	Behavior & Performance								
1	Cell & Molecular Biology/Molecular Structures & Interactions								
1	Organismal/Comp e Biology								
1	Environmental Monitoring & Contr								
1	Advanced Life Support								
1	Phase Transformation								
1	Condensed Matter								
1	Fundamental Laws								
1	Kinetics, Structure Transport								
1	Fluid Stability, Dynamics								
1	Propulsion & Power								
2	Developmental Biology								
2	Human Factors Engineering								
2	Fire Safety								
3	Structural Biology								
3	Energy Conversion								
3	Thermo-Physical, Physio-Chemical								
4	Clinical/Operations Medicine								
4	Extravehicular Activity								
5	Environmental Health								
TBD	Evolutionary Biology								
TBD	Gravitational Ecology								
TBD	Cell Science & Tis Engineering								
Con'l	Bio-technology								
Con'l	Agribusiness								
Con'l	Advanced Materials								

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ISS Research Maximization and Prioritization Implementation

ISS Research

Research Hardware Observations

- **Planned hardware that is critical only for lower priority research areas (<3):**
  - ✓ Biotechnology Facility (2 racks)
- **Hardware that is not currently funded:**
  - ✓ Plant and Rodent habitats critical for full research in two Priority 1 research areas:
    - ➢ Cellular and Molecular Biology / Molecular Structures and Interactions
    - ➢ Organismal / Comparative Biology
  - ✓ Materials Science Research Racks 2 & 3 critical for full research in two Priority 1 research areas:
    - ➢ Phase Transformation
    - ➢ Power and Propulsion
  - ✓ Combustion Integrated Rack critical for research in some elements of Fundamental Laws research area (Priority 1)
  - ✓ Advanced Human Support Technology rack critical for full research in two Priority 1 research areas
    - ➢ Environmental Monitoring and Control
    - ➢ Advanced Life Support

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ISS Research

ISS Research Maximization and Prioritization Implementation

Research Hardware Provided by International Partners

- A majority of Priority 1 Research areas anticipate use of International Partner-provided hardware
  - ✓ **Japan**
    - ➢ Centrifuge Rotor, Centrifuge Accommodations Module & Life Sciences Glovebox
    - ➢ Aquatic Habitat
  - ✓ **Canada**
    - ➢ Insect Habitat
  - ✓ **European Space Agency**
    - ➢ Force Dynamometers
    - ➢ Percutaneous Electrical Muscle Stimulator
    - ➢ Muscle Atrophy Research and Exercise System
    - ➢ Pulmonary Function System
    - ➢ Fluid Science Laboratory
    - ➢ Electrostatic Levitator
    - ➢ Electromagnetic Levitator
  - ✓ **Germany**
    - ➢ Eye Tracking Device
    - ➢ Lower Body Negative Pressure Device
  - ✓ **France**
    - ➢ DECLIC (Critical Phenomena Experimental Apparatus)

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ISS Research

ISS Research Maximization and Prioritization Implementation

External Attached Payloads

- Two research areas plan to use research payloads that are attached to the ISS outside of the laboratory modules
  - ✓ Condensed Matter (100% of research content)
  - ✓ Fundamental Laws (50% of research content)
- An additional major external research payload, the Alpha Magnetic Spectrometer, is in development
  - ✓ Management assigned to OBPR, but not integrated into the Physical Sciences priorities
  - ✓ Expected launch date ~2006
- These payloads are not factored into the following assessment, but in general represent competition for outfitting the laboratories with research hardware

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ISS Research Maximization and Prioritization Implementation

ISS Research

ISS Configurations Considered

- Three configurations were defined for the purpose of bounding the range of implementation possibilities.
- This assessment focused on the steady state operations for these configurations.

Configuration	Description	Labs on Orbit	Crew Time Available for All Research
U.S. Core Complete (2004)	Build through Node 2	US Lab (12 research racks)	20 hours per week (40 hrs also evaluated)
ISS Core Complete (2007/2008)	Build through Centrifuge Accommodations Module (CAM)	US Lab (13 racks) Japanese Lab (5 racks) European Lab (5 racks) CAM (4 racks)	20 hours per week (40 hrs also evaluated)
Enhanced	Build through CAM + Additional Crew Support Systems	US Lab (13 racks) Japanese Lab (5 racks) European Lab (5 racks) CAM (4 racks)	160

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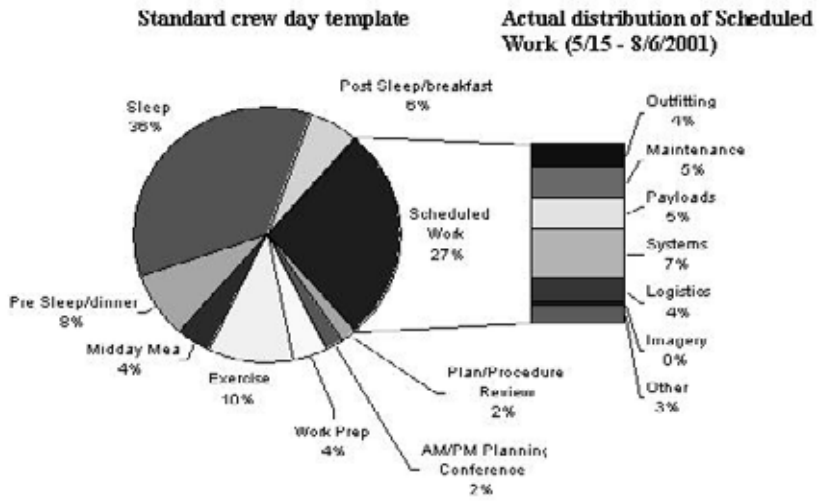
ISS Research Maximization and Prioritization Implementation

ISS Research

Crew Time Distribution of Crew Activities



ISS Research

ISS Research Maximization and Prioritization Implementation

Crew Time Assumptions and Allocations

Assumptions for Available Research Crew Time (Hours Per Week)

	U.S. Core Complete	ISS Core Complete*	Enhanced**
Total	20.0	20.0	160
Russia	9.8	7.7	61.3
NASA	9.8	7.7	61.3
Europe	0	2.6	20.5
Japan	0	1.7	13.3
Canada	0.5	0.5	3.7
OBPR Allocation	8.8	6.9	55.2
OBPR Allocation (Based on 40 total hours)	17.6	13.9	

* Based on current MOU allocations which assume crew size of 7; if crew size remains at 3 for an extended period, allocations may be renegotiated

**Total available is a rough estimate. Hours per agency are based on current MOU allocations which assume crew size of 7; if end state crew size is 6, allocations may be renegotiated

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ISS Research

ISS Research Maximization and Prioritization Implementation

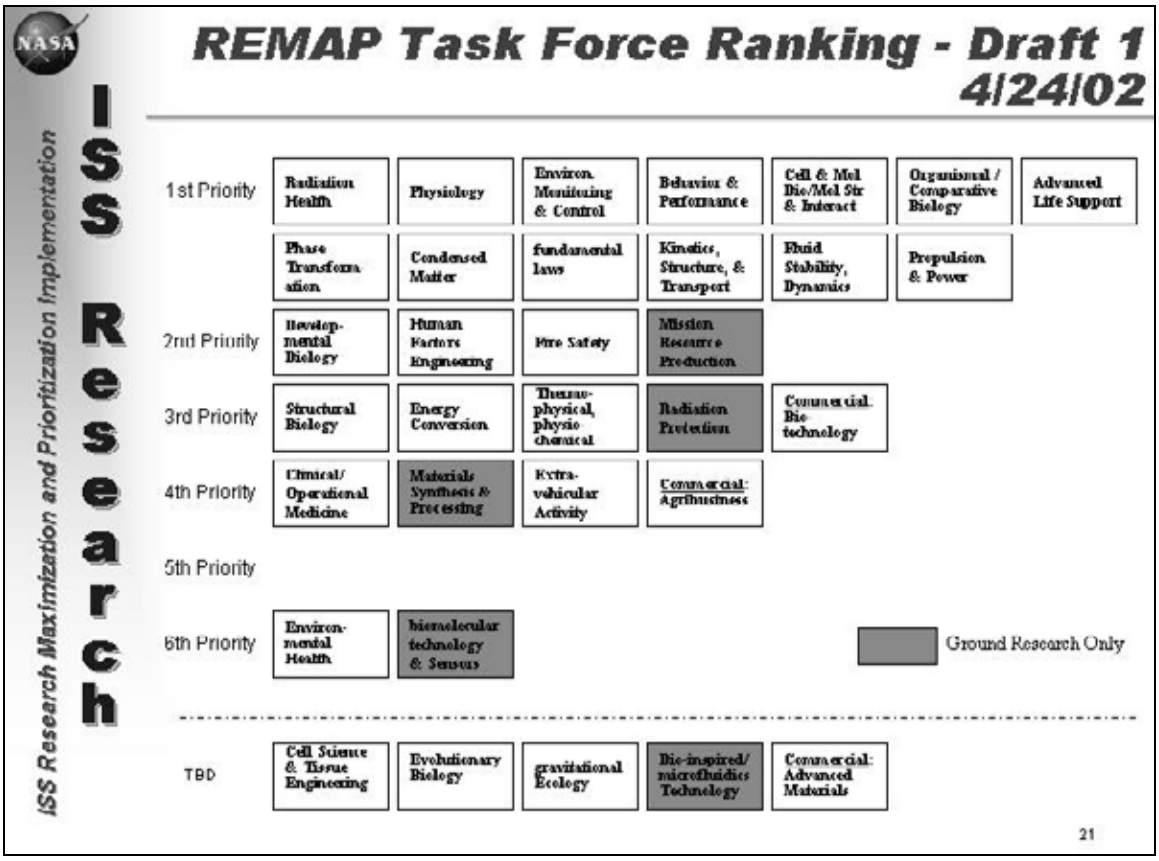
Upmass and Middeck Lockers - Assumptions and Allocations

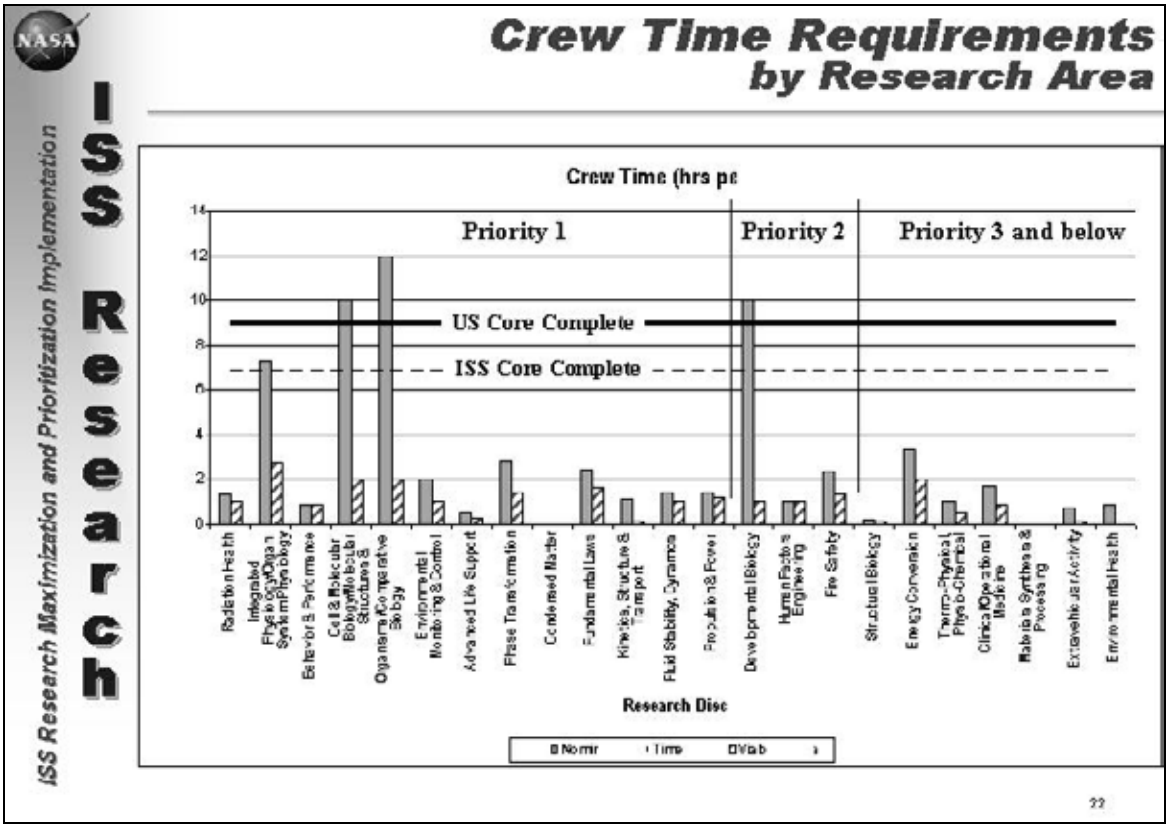
Assumptions for Annual Flight Rate to ISS

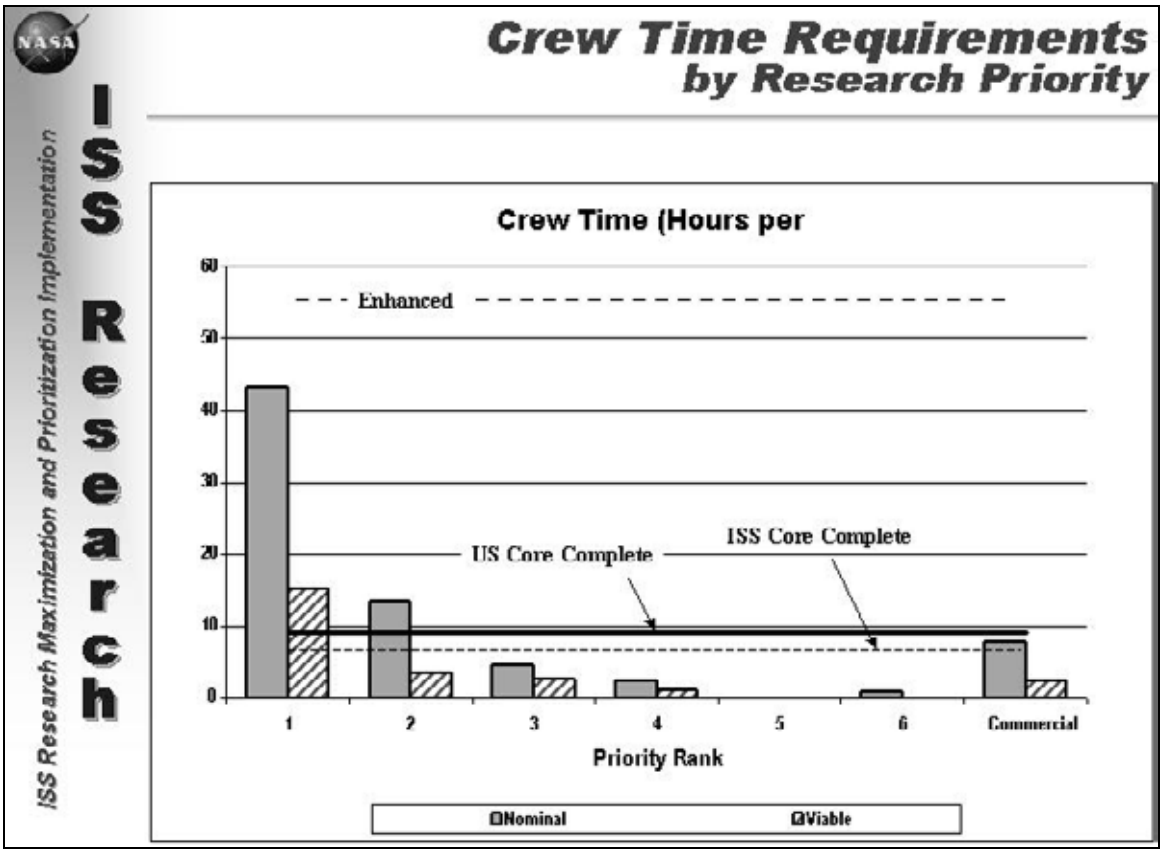
Configuration	Shuttle	Progress	Japanese HII Transfer Vehicle	European Ariane Transfer Vehicle
U.S. Core Complete	4	4	0	0
ISS Core Complete	5	4	1 (for NASA use)	0.5 (for NASA use)
Enhanced	5	4	2 (for NASA use)	0.8 (for NASA use)

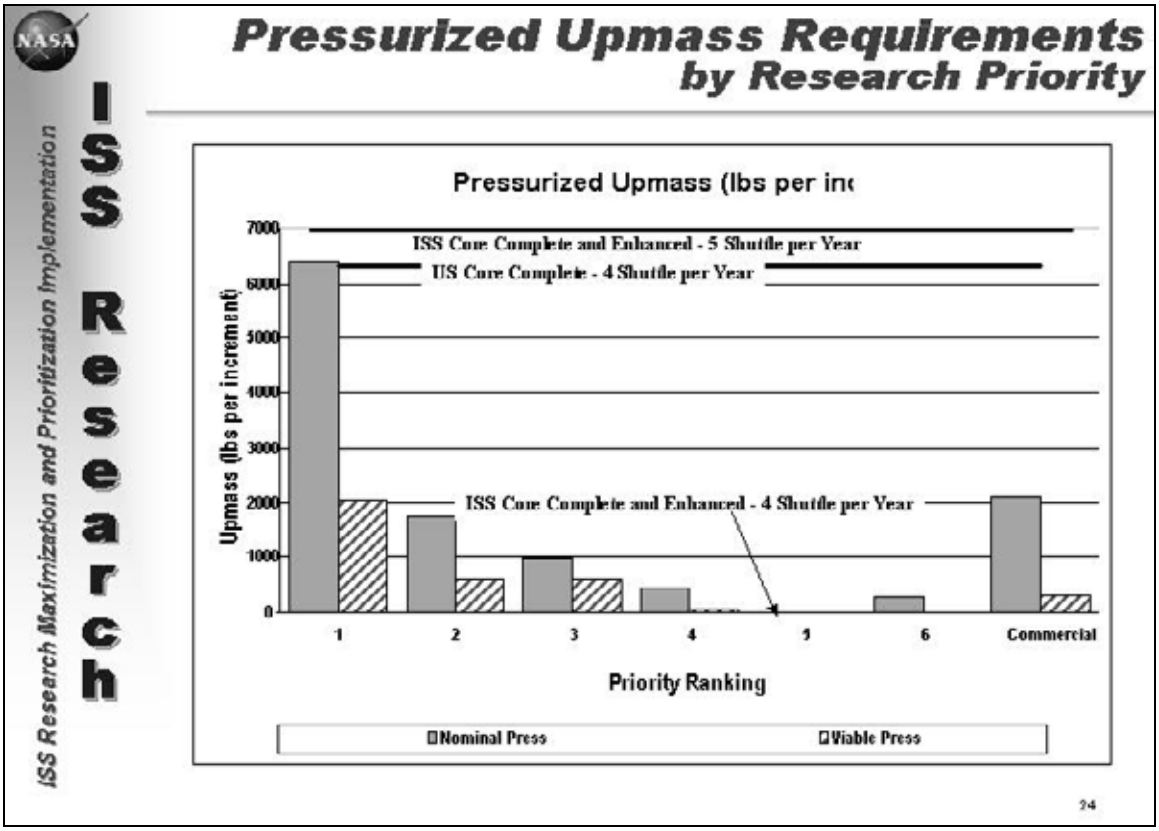
- U.S. Core Complete: If assembly stops at Node 2, some upmass previously dedicated for IP assembly elements can be used for research
- ISS Core Complete & Enhanced
  - ✓ 4 Shuttle + 4 Progress needed to keep ISS vehicle operating and maintained - additional Shuttle flight assumed to provide research upmass
  - ✓ Europe & Japan contribute to the costs of "common" operations / support of ISS
    - ➢ Both are developing vehicles to deliver supplies to ISS to use as the means of "paying" for these obligations
    - ➢ This assessment assumes ESA and NASDA flight rates to meet the current estimate of their obligations
- Current estimates for middeck lockers is 5/shuttle flight - equates to 9 lockers per increment for OBPR research

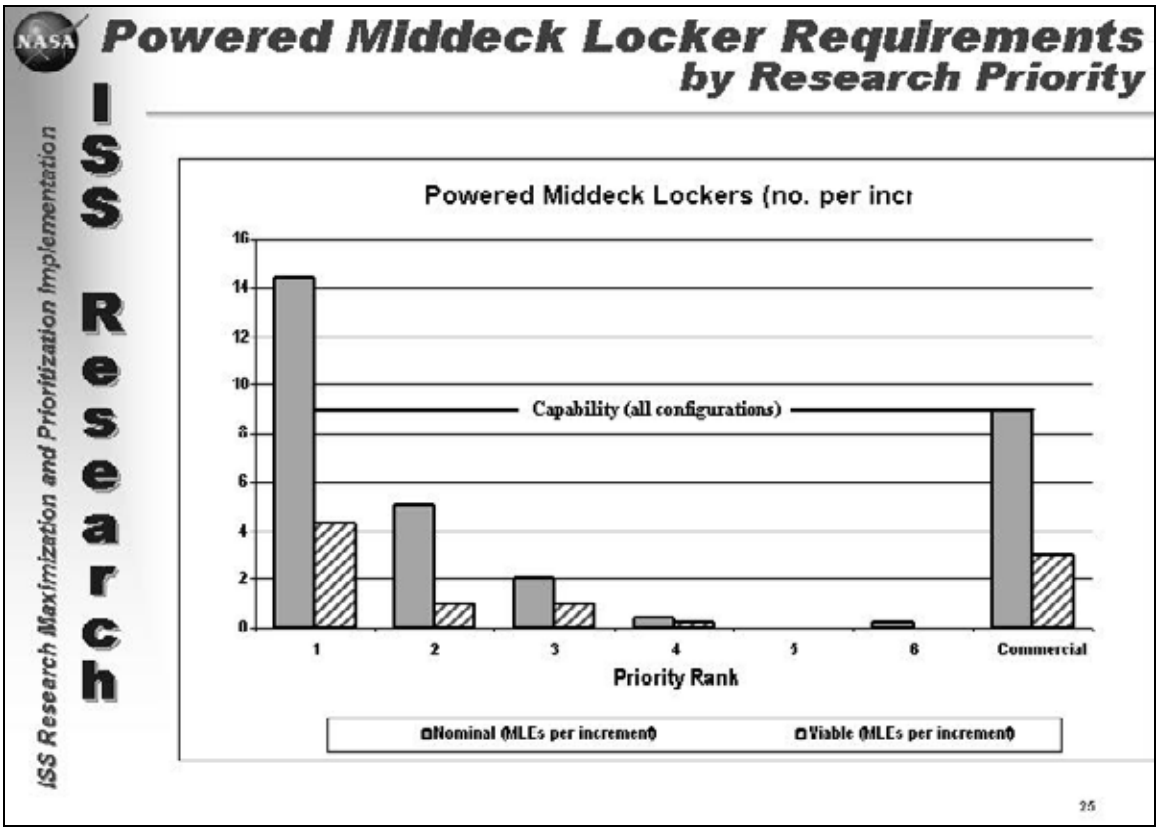
20

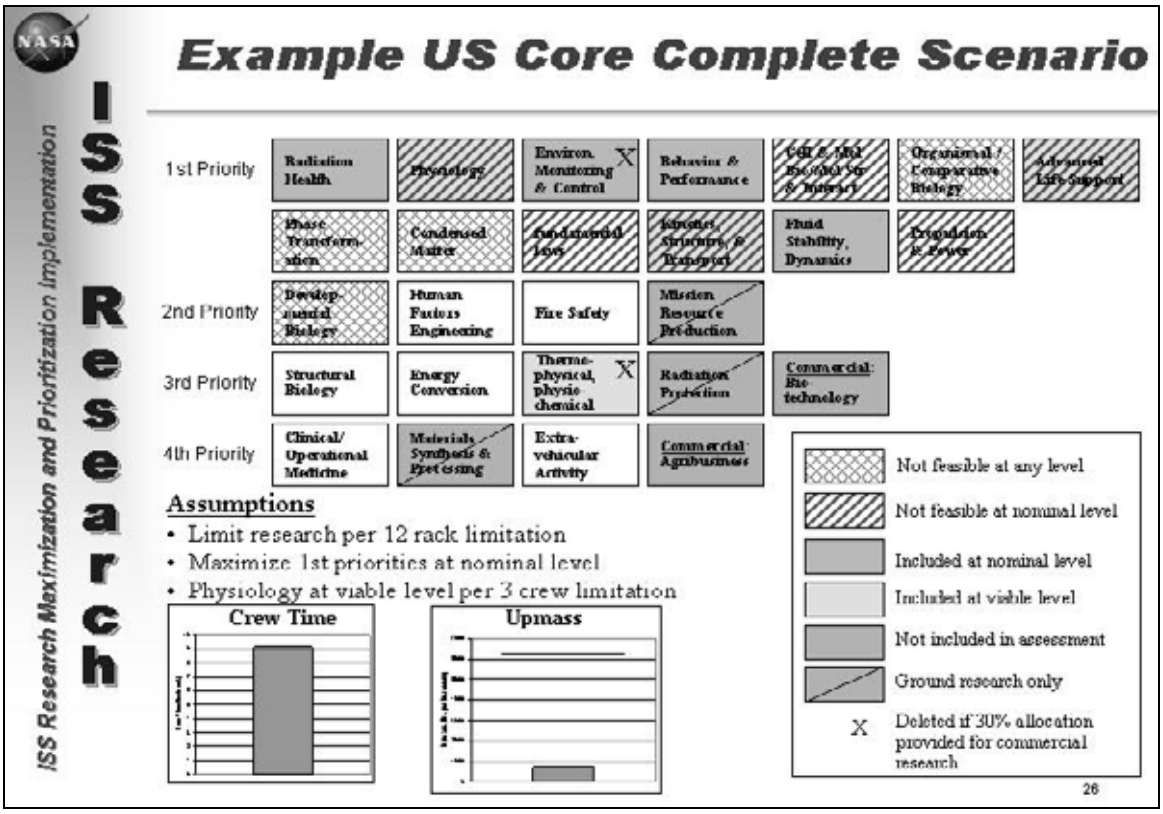

ISS Research
ISS Research Maximization and Prioritization Implementation
REMAP Task Force Ranking - Draft 1
4/24/02
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transformation
Condensed Matter
fundamental laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
Propulsion & Power
2nd Priority
Developmental Biology
Human Factors Engineering
Fire Safety
Mission Resource Production
3rd Priority
Structural Biology
Energy Conversion
Thermo-physical, physio-chemical
Radiation Protection
Commercial: Bio-technology
4th Priority
Clinical/ Operational Medicine
Materials Synthesis & Processing
Extra-vehicular Activity
Commercial: Agribusiness
5th Priority
6th Priority
Environ-mental Health
biomolecular technology & Sensors
Ground Research Only
TBD
Cell Science & Tissue Engineering
Evolutionary Biology
gravitational Ecology
Bio-inspired/ microfluidics Technology
Commercial: Advanced Materials
21

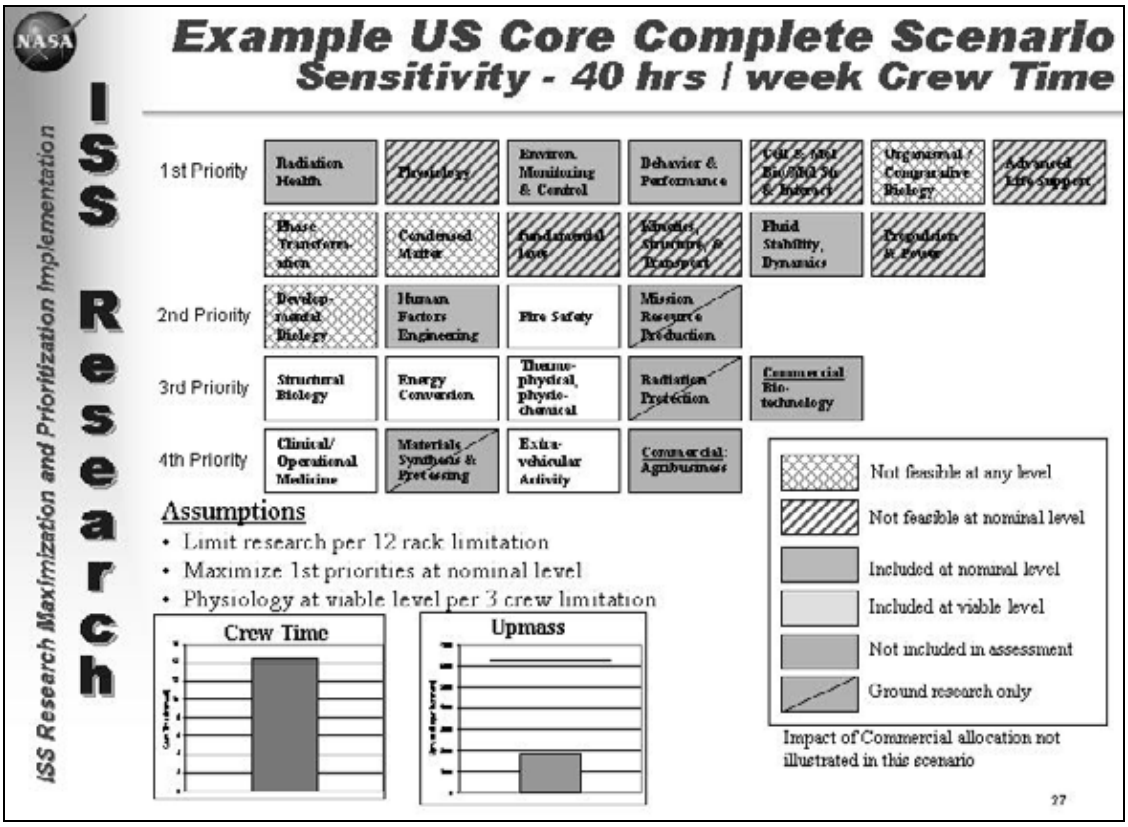

ISS Research
ISS Research Maximization and Prioritization Implementation
Crew Time Requirements
by Research Area
Crew Time (hrs pe
Priority 1
Priority 2
Priority 3 and below
US Core Complete
ISS Core Complete
Research Disc
22

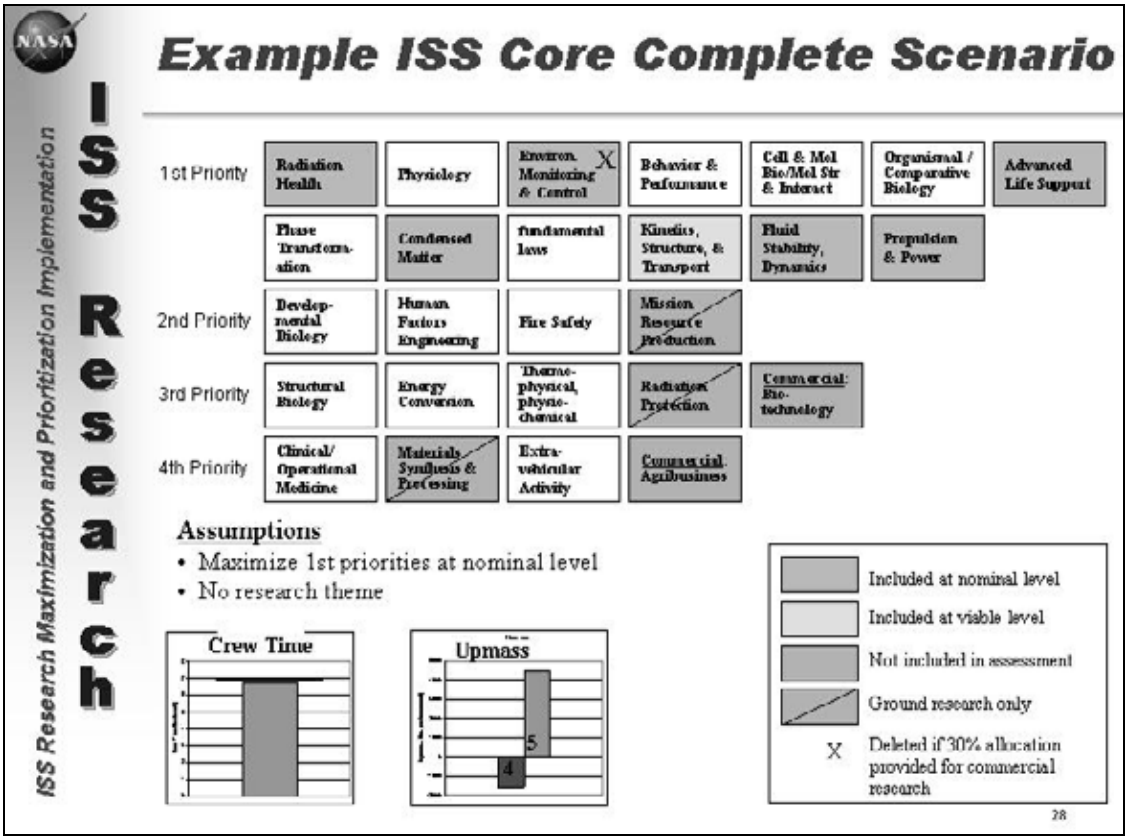

ISS Research
ISS Research Maximization and Prioritization Implementation
Crew Time Requirements
by Research Priority
Crew Time (Hours per
Enhanced
US Core Complete
ISS Core Complete
60
50
40
30
20
10
0
1
2
3
4
5
6
Commercial
Priority Rank
Nominal
Viable

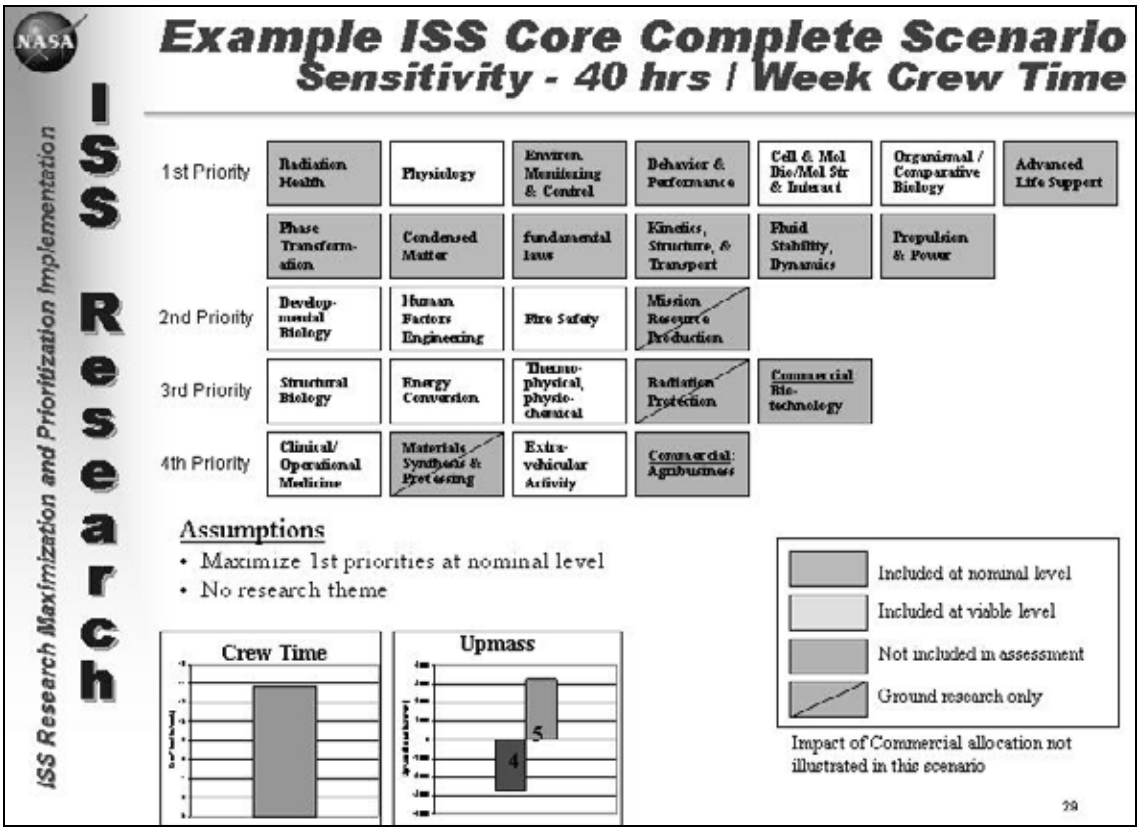

ISS Research
ISS Research Maximization and Prioritization Implementation
Pressurized Upmass Requirements
by Research Priority
Pressurized Upmass (lbs per inc
ISS Core Complete and Enhanced - 5 Shuttle per Year
US Core Complete - 4 Shuttle per Year
ISS Core Complete and Enhanced - 4 Shuttle per Year
Upmass (lbs per increment)
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
Commercial
Priority Ranking
Nominal Press
Viable Press
24


Powered Middeck Locker Requirements
by Research Priority
ISS Research
ISS Research Maximization and Prioritization Implementation
Powered Middeck Lockers (no. per incr
16
14
12
10
8
6
4
2
0
Capability (all configurations)
1
2
3
4
5
6
Commercial
Priority Rank
Nominal (MLEs per increment)
Viable (MLEs per increment)
25


Example US Core Complete Scenario
ISS Research
ISS Research Maximization and Prioritization Implementation
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
X
Behavior & Performance
Cell & Mol Biology/Gen & Genetics
Organismal / Comparative Biology
Advanced Life Support
Phase Transformation
Condensed Matter
Fundamental Laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
Propulsion & Power
2nd Priority
Developmental Biology
Human Factors Engineering
Fire Safety
Mission Resource Production
3rd Priority
Structural Biology
Energy Conversion
Thermo-physical, physio-chemical
X
Radiation Protection
Commercial: Bio-technology
4th Priority
Clinical/ Operational Medicine
Materials Synthesis & Processing
Extra-vehicular Activity
Commercial: Agribusiness
Not feasible at any level
Not feasible at nominal level
Included at nominal level
Included at viable level
Not included in assessment
Ground research only
X
Deleted if 30% allocation provided for commercial research
Assumptions
• Limit research per 12 rack limitation
• Maximize 1st priorities at nominal level
• Physiology at viable level per 3 crew limitation
Crew Time
Upmass
26


ISS Research
ISS Research Maximization and Prioritization Implementation
Example US Core Complete Scenario
Sensitivity - 40 hrs / week Crew Time
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transforma-tion
Condensed Matter
Fundamental Laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
Propulsion & Power
2nd Priority
Develop-mental Biology
Human Factors Engineering
Fire Safety
Mission Resource Production
3rd Priority
Structural Biology
Energy Conversion
Thermo-physical, physio-chemical
Radiation Protection
Commercial Bio-technology
4th Priority
Clinical/ Operational Medicine
Materials Synthesis & Processing
Extra-vehicular Activity
Commercial: Agribusiness
Not feasible at any level
Not feasible at nominal level
Included at nominal level
Included at visible level
Not included in assessment
Ground research only
Assumptions
• Limit research per 12 rack limitation
• Maximize 1st priorities at nominal level
• Physiology at viable level per 3 crew limitation
Crew Time
Upmass
Impact of Commercial allocation not illustrated in this scenario
27


ISS Research
ISS Research Maximization and Prioritization Implementation
Example ISS Core Complete Scenario
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
X
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transforma-tion
Condensed Matter
fundamental laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
Propulsion & Power
2nd Priority
Develop-mental Biology
Human Factors Engineering
Fire Safety
Mission Resource Production
3rd Priority
Structural Biology
Energy Conversion
Thermo-physical, physio-chemical
Radiation Protection
Commercial: Bio-technology
4th Priority
Clinical/ Operational Medicine
Materials Synthesis & Processing
Extra-vehicular Activity
Commercial: Agribusiness
Assumptions
• Maximize 1st priorities at nominal level
• No research theme
Included at nominal level
Included at visible level
Not included in assessment
Ground research only
X
Deleted if 30% allocation provided for commercial research
Crew Time
Upmass
5
4
28


ISS Research
ISS Research Maximization and Prioritization Implementation
Example ISS Core Complete Scenario
Sensitivity - 40 hrs / Week Crew Time
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transform-ation
Condensed Matter
fundamental laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
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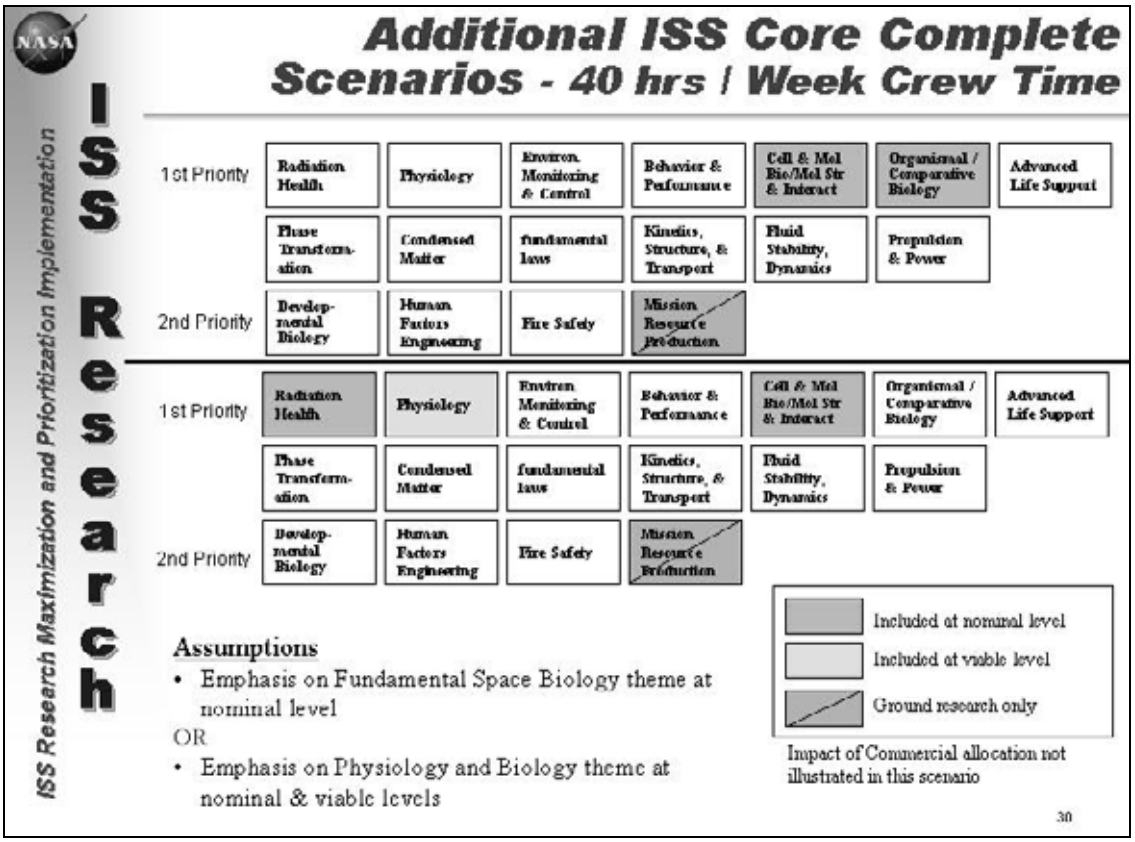
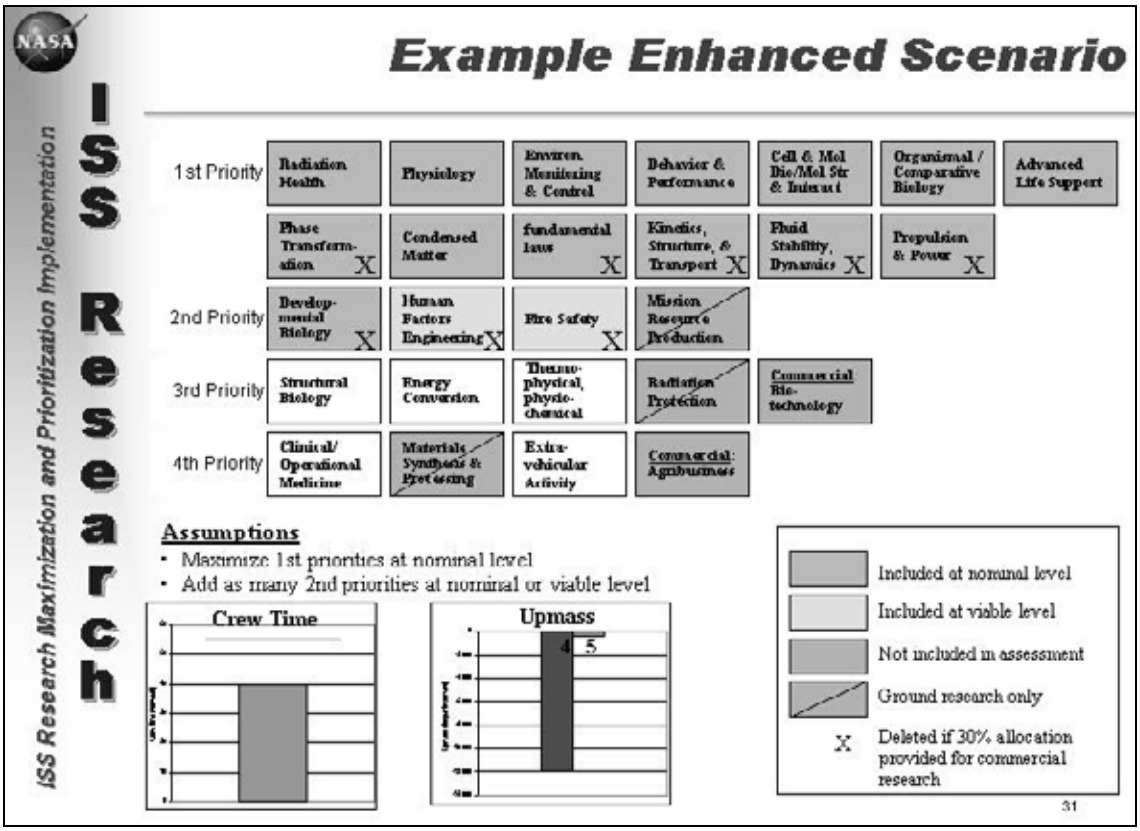
Fire Safety
Mission Resource Production
3rd Priority
Structural Biology
Energy Conversion
Thermo-physical, physio-chemical
Radiation Protection
Commercial Bio-technology
4th Priority
Clinical/ Operational Medicine
Materials Synthesis & Processing
Extra-vehicular Activity
Commercial: Agribusiness
Assumptions
• Maximize 1st priorities at nominal level
• No research theme
Crew Time
Upmass
5
4
Included at nominal level
Included at viable level
Not included in assessment
Ground research only
Impact of Commercial allocation not illustrated in this scenario
29


ISS Research
ISS Research Maximization and Prioritization Implementation
Additional ISS Core Complete Scenarios - 40 hrs / Week Crew Time
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transform-ation
Condensed Matter
fundamental laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
Propulsion & Power
2nd Priority
Develop-mental Biology
Human Factors Engineering
Fire Safety
Mission Resource Production
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transform-ation
Condensed Matter
fundamental laws
Kinetics, Structure, & Transport
Fluid Stability, Dynamics
Propulsion & Power
2nd Priority
Develop-mental Biology
Human Factors Engineering
Fire Safety
Mission Resource Production
Assumptions
• Emphasis on Fundamental Space Biology theme at nominal level
OR
• Emphasis on Physiology and Biology theme at nominal & viable levels
Included at nominal level
Included at viable level
Ground research only
Impact of Commercial allocation not illustrated in this scenario
30


ISS Research
ISS Research Maximization and Prioritization Implementation
Example Enhanced Scenario
1st Priority
Radiation Health
Physiology
Environ. Monitoring & Control
Behavior & Performance
Cell & Mol Bio/Mol Str & Interact
Organismal / Comparative Biology
Advanced Life Support
Phase Transform-ation X
Condensed Matter
fundamental laws X
Kinetics, Structure, & Transport X
Fluid Stability, Dynamics X
Propulsion & Power X
2nd Priority
Develop-mental Biology X
Human Factors Engineering X
Fire Safety X
Mission Resource Production
3rd Priority
Structural Biology
Energy Conversion
Thermo-physical, physio-chemical
Radiation Protection
Commercial Bio-technology
4th Priority
Clinical/ Operational Medicine
Materials Synthesis & Processing
Extra-vehicular Activity
Commercial: Agribusiness
Assumptions
• Maximize 1st priorities at nominal level
• Add as many 2nd priorities at nominal or viable level
Crew Time
Upmass
4
5
Included at nominal level
Included at viable level
Not included in assessment
Ground research only
X Deleted if 30% allocation provided for commercial research
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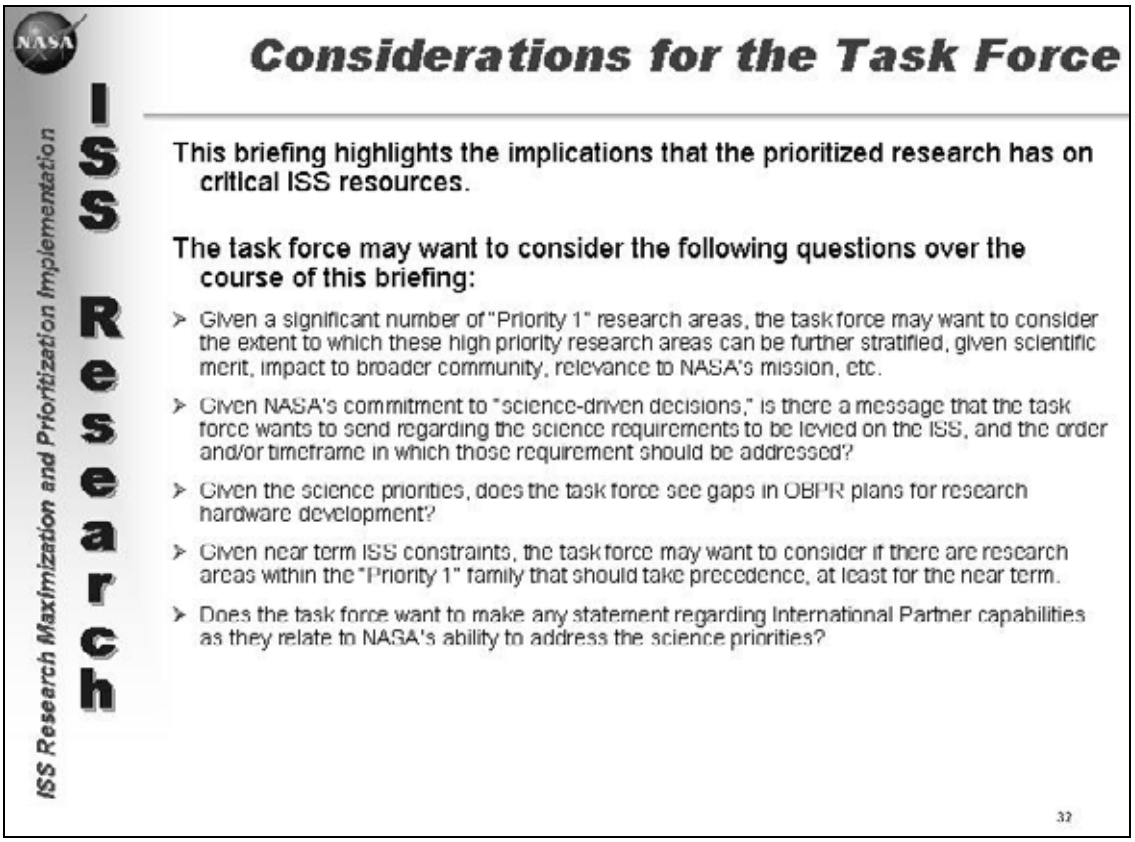
ISS Research
ISS Research Maximization and Prioritization Implementation
Considerations for the Task Force
This briefing highlights the implications that the prioritized research has on critical ISS resources.
The task force may want to consider the following questions over the course of this briefing:
➢ Given a significant number of "Priority 1" research areas, the task force may want to consider the extent to which these high priority research areas can be further stratified, given scientific merit, impact to broader community, relevance to NASA's mission, etc.
➢ Given NASA's commitment to "science-driven decisions," is there a message that the task force wants to send regarding the science requirements to be levied on the ISS, and the order and/or timeframe in which those requirement should be addressed?
➢ Given the science priorities, does the task force see gaps in OBPR plans for research hardware development?
➢ Given near term ISS constraints, the task force may want to consider if there are research areas within the "Priority 1" family that should take precedence, at least for the near term.
➢ Does the task force want to make any statement regarding International Partner capabilities as they relate to NASA's ability to address the science priorities?
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ISS Research Maximization and Prioritization Implementation

ISS Research

Back-up Charts

- Acronym List
- Rationale for Using ISS as Primary Research Platform
- Current ISS Research in Flight Manifest
- Integrated Requirements to Perform OBPR Research (2nd Priority @ Viable)

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ISS Research Maximization and Prioritization Implementation

ISS Research

Acronyms

AHST:	Advanced Human Support Technology
B&PR:	Biological & Physical Research
BTF:	Biotechnology Facility
CAM:	Centrifuge Accommodations Module
CIR:	Combustion Integrated Rack
COF:	Columbus Orbital Facility
ER:	EXPRESS Rack
ESA:	European Space Agency
FCF:	Fluids Combustion Facility
FIR:	Fluids Integrated Rack
JEM:	Japanese Experiment Module
HHR:	Habitat Holding Rack
HRF:	Human Research Facility
IP:	International Partner
ISS:	International Space Station
LSG:	Life Sciences Glovebox
MLE:	Middeck Locker Equivalent
MOU:	Memorandum of Understanding
MSRR:	Materials Science Research Rack
MSG:	Microgravity Sciences Glovebox
MELFI:	Minus Eighty Degree Life Sciences Freezer
NASDA:	National Space Development Agency of Japan
OBPR:	Office of Biological and Physical Research
WORF:	Window Observational Facility

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ISS Research

ISS Research Maximization and Prioritization Implementation

Rationale for Using ISS as Primary Research Platform

Research Area	Primary Needs for Using ISS			
	Crew Intervention/ Crew as a Research Subject	Long Duration Experiment	Repetition of Experiment	Large/Facility Class Hardware
Radiation Health	•	•	•	•
Integrated Physiology/Organ System Physiology	• / •	• / •	• / •	• / •
Behavior & Performance	•	•	•	•
Cell & Molecular Biology/Molecular Structures & Interactions	• / •	• / •	• / •	• / •
Organismal/Comparative Biology	•	•	•	•
Environmental Monitoring & Control	•	•	•	
Advanced Life Support	•	•	•	•
Phase Transformation	•	•	•	•
Condenzed Matter		•	•	•
Fundamental Laws	•	•	•	•
Kinetics, Structure & Transport	•		•	•
Fluid Stability, Dynamics	•	•	•	
Propulsion & Power	•	•	•	•
Developmental Biology	•	•	•	•
Human Factors Engineering	•	•	•	
Fire Safety	•		•	•
Structural Biology		•	•	
Energy Conversion	•		•	•
Thermo-Physical, Physio-Chemical	•		•	•
Clinical/Operational Medicine	•	•	•	•
Extravehicular Activity	•		•	
Environmental Health	•	•	•	•
Evolutionary Biology	•	•	•	
Gravitational Ecology	•	•	•	•
Cell Science & Tissue Engineering	•	•	•	•
Com'l: Remote Sensing & Autonomous Systems		•	•	
Com'l: Telecommunications		•	•	
Com'l: Thermal Control		•	•	
Com'l: Power Generation, Storage & Distribution		•	•	
Com'l: Robotics & Structures		•	•	
Com'l: Propulsion		•	•	
Com'l: Bio-technology	•	•	•	
Com'l: Agribusiness		•	•	
Com'l: Advanced Materials		•	•	•

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ISS Research

ISS Research Maximization and Prioritization Implementation

Current ISS Research in Flight Manifest*

Data for Increment 0 through 6

- Increment 4 is on orbit right now, ending June 2
- Increment 6 ends in Jan, 2003

A total of 48 Code U Investigations supported

(not all are complete with a number of subjects or test runs yet).

- 8 or 17% - Commercial
- 23 or 48% - directly from, or indirectly support Priority 1 Research Areas
- 3 or 6% - from Priority 2 Research Areas
- 5 or 10% - from Priority 3 Research Areas
- 2 or 4% - from Priority 4 Research Areas
- 7 or 15% from the TBD area

* Represents first order mapping of PI investigations to research area "boxes".

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