



Integrating Your Research on ISS: An Overview of Complement Planning Past, Present and Future

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Session goals

- Maximize your science within limited resources available
 - How your research fits into a flight “complement”
 - Introduce Standard Measures cross-cutting project
 - Leverage required medical testing results
 - Processes to enhance data sharing





Flight research complement

- Unlike most ISS research, human research is voluntary

Biology & Biotechnology	Earth & Space Science	Physical Science	Technology Development
<u>Animal Biology</u> Joint Rodent Research-1 Rodent Research-5 (RR-5) Medaka Radiation Space Pup Mouse Epigenetics* <u>Cellular Biology</u> CORM MYOGRAVITY NANDRDS SERISM Cardiac Stem Cells Lung Cells Synthetic Bone Stem Cells <u>Macromolecular Crystal Growth</u> CA SIS PCG6 CA SIS PCG7 CA SIS PCG8 JAXA Low Temp PCG JAXA Medium Temp PCG JAXA PCG <u>Microbiology</u> Microbial Tracking-2 Plant Biology BRIC-22 BRIC-Light Emitting Diode (LED) Plant Habitat-01 Payload Card-X (TangoLab-1) Petri Plants-2	<u>Astrobiology & Astrophysics</u> CREAM (Ext) NICER (Ext) AMS-02 (Ext) Meteor CALET (Ext) MAXI (Ext) <u>Earth Remote Sensing</u> CATS (Ext) CER ISS RapidScat (Ext) SAGE III ISS (Ext) STP-H5 FPS (Ext) STP-H5 LIS (Ext) DESIS NREP Inserts (Ext) Near-Earth Space Environment SED-A-P (Ext) <u>Education & Outreach</u> <u>Cultural Activities</u> Music and Space <u>Educational Competitions</u> NanoRacks Module-9 SPHERES-Zero-Robotics <u>Educational Demonstrations</u> ISS Ham Radio Sally Ride EarthKAM AstroPI	<u>Combustion Science</u> A CME BA SS-II Cool Flames Investigation ATOMIZATION <u>Complex Fluids</u> A CET-8 A CET-9 A CET-6 PK4 <u>Fluid Physics</u> CFE-2 DECLIC HT-R Slosk Coating ZBOT EL Lilly-Lypholization NanoRacks-SMILE Marangoni UVP Two-Phase Flow <u>FLUIDICS</u> <u>Fundamental Physics</u> Cold Atom Lab (CAL) DOSIS-3D MARGVECTOR <u>Materials Science</u> DECLIC DSIR M SL SCA-GEDS-Germ an Strata-1 Nemak Alloys EML Batch 2 M SL SCA-Batch 2b-ESA	<u>Air, Water & Surface Monitoring</u> Water Monitoring Suite <u>Avionics & Software</u> ARAMIS Spaceborne Computer STP-H5 CSP (Ext) STP-H5 Space Cube - Mini (Ext) Telescience Resource Kit NanoRacks Module-63 SG100 Cloud Computer <u>Characterizing Expt Hardware</u> IIN SITU ROSA (Ext) MVIS Controller-1 ECHO <u>Communication & Navigation</u> Maritime Awareness SCA N Testbed (Ext) Vessel ID System (Ext) <u>Food & Clothing Systems</u> Skinsuit EVERYWEAR <u>Imaging Technology</u> HDEV (Ext) <u>Life Support Systems</u> Capillary Structures LDST MED-2 UBNT <u>Microgravity Measurement</u> STP-H5 SHM (Ext)

Key	
NA SA	(P) = Pre/Post BDC only
National Lab	(Ext) = External
JAXA	(RJR) = Russian Joint Research
ESA	(?) = Launch only
CSA	(I) = Return only

Human Research	
<u>Skin & Muscle Physiology</u>	<u>Immune System</u>
Invertebral Disc Damage (P)	Functional Immune
Print	Multi-Omics
Rain-DTI (P)	Probiotics
DOS-2	Immuno-2
MUSCLE BIOPSY (P)	<u>Integrated Physiology & Nutrition</u>
Arrow	Biochem Profile
<u>Cardiovascular & Respiratory Systems</u>	Dose Tracker
Cardio Ox	Repository
Cerebral Autoregulation	Telomeres (P)
PVI	Energy
Vascular Echo	<u>Nervous & Vestibular Systems</u>
<u>Brain Healthcare Systems</u>	Field Test (P)
Medical Consumables Tracking	NeuroMapping
kin-B	GRASP
<u>Habitability and Human Factors</u>	GRP
Body Measures	Psychometrics
Fine Motor Skills	Psychometrics in Microgravity (P)
Habitability	<u>Radiation Impacts on Humans</u>
<u>Human Behavior & Performance</u>	ESA Antine-Demonstrator
Lighting Effects	Stress
Circadian Rhythms	Fluid Shifts
Home in Space	

HUMAN RESEARCH

Category TBD	
NanoRacks Internal Modules	360 Camera
NanoRacks Module-52*	Aquapad
NanoRacks Module-55	Cataliss
NanoRacks Module-56	Ceres
NanoRacks Module-67*	Crisстал
NR-Caveller Space Processor*	ECHO
National Lab Airlock Cycle(s)	EPO Pesquet
ELF Investigation	ESA-EPO-TASK-LIST
ExHAM#1 (Ext)	HAPTIC S-2/INTERACT
JAXA EPO TBD	Mattis
JAXA Payloads Placeholder	SARCOLA B-3
Spirits Maturation (Ext)	SUPVIS-JUSTIN
Zebrafish Muscle 2	

OTHER RESEARCH

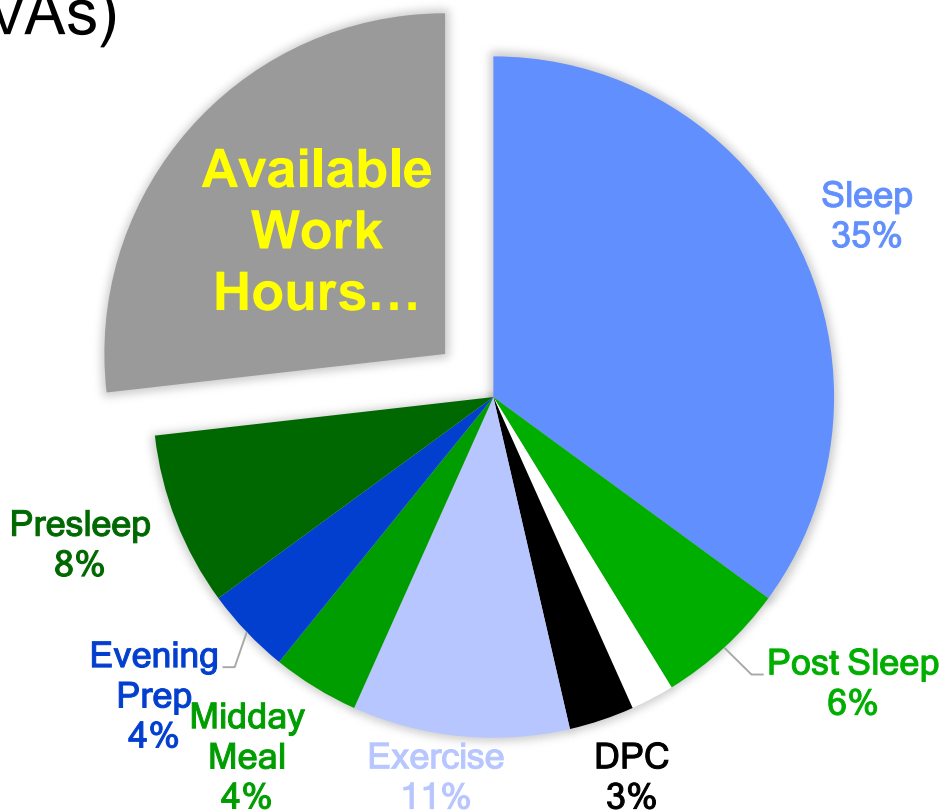


Inflight crew time

- Inflight time limits what fits in research complements
 - Crew work days 6.5 hrs with time off on weekends
 - More limited during first 2 weeks, and during other ops (e.g., vehicle docking, EVAs)

“Available Work Hours” include:

- Traffic Operations
- Medical Operations
- Onboard Training
- Routine Operations (including stowage management)
- Public Affairs Office (PAO)
- Maintenance, Resupply/Outfitting
- EVA
- **Utilization Operations = RESEARCH**

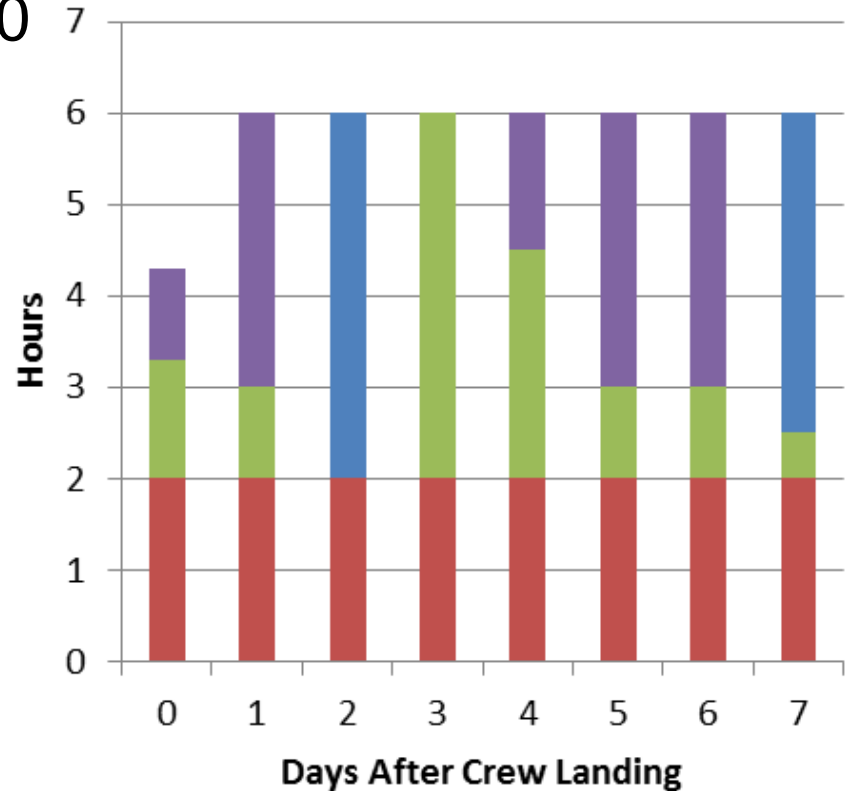




Post-flight crew time

- Postflight time limits what fits in research complements
 - Crew work day limited to 4 hours in first week for all science and medical activities
 - More limited testing on R+0

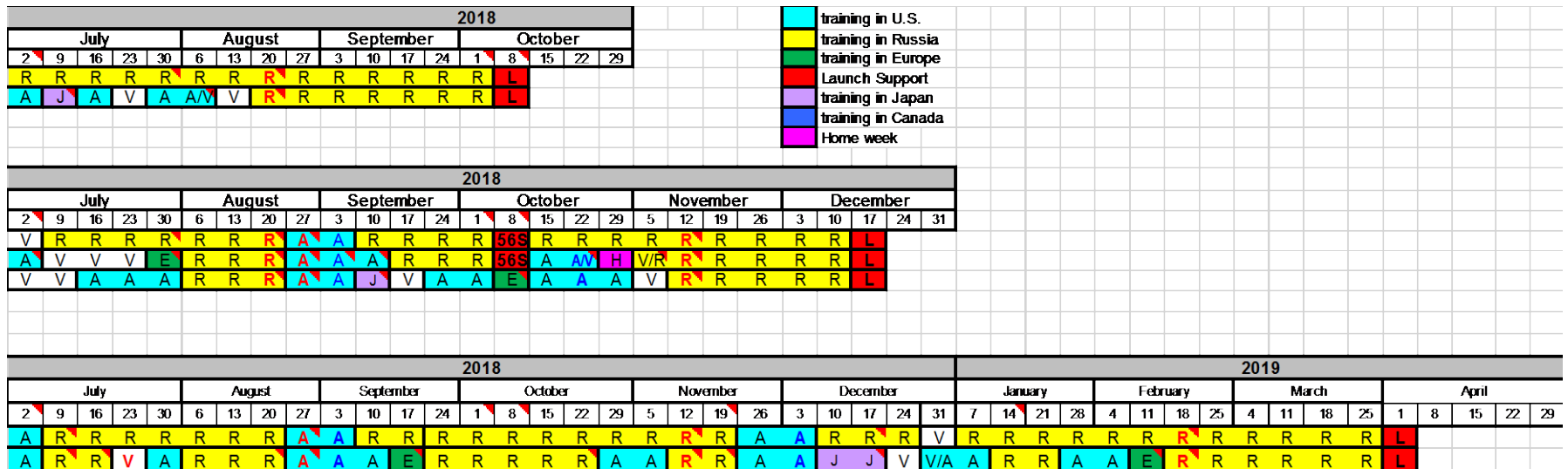
- Crew Time Off
- Science Time Available
- Medical Operations Time
- Rehabilitation Time





Pre-flight crew time

- Pre-flight time limits have not typically been limiting factors in complement planning, but have been more recently with accelerated crew training schedules
- For Soyuz flights, late preflight BDC is very limited since the crew spends the last ~6 weeks in Russia





Blood volume limits

- Blood volume requirements limit research complements
- Inflight: 450 ml total / 6 mo mission
 - 150 ml per rolling 30 day window
 - 100 ml limit per last 30 days
- Post-flight: 300 ml total blood between R+1 & R+45
 - 120ml total on R+0 includes medical testing
 - ~60 ml available for research
- Establishing overlap between other research and medical operations is critical!



Experiment interactions

- Conflicts and constraints with competing human research and medical operations limit research complements
- Balancing flexibility with experimental control in developing constraints (“Goldilocks” approach)
- Aligning time points for common sampling (e.g., blood draws) will maximize the number of complement scenarios that a study can fit into
- See Standard Measures and MedB presentations next!



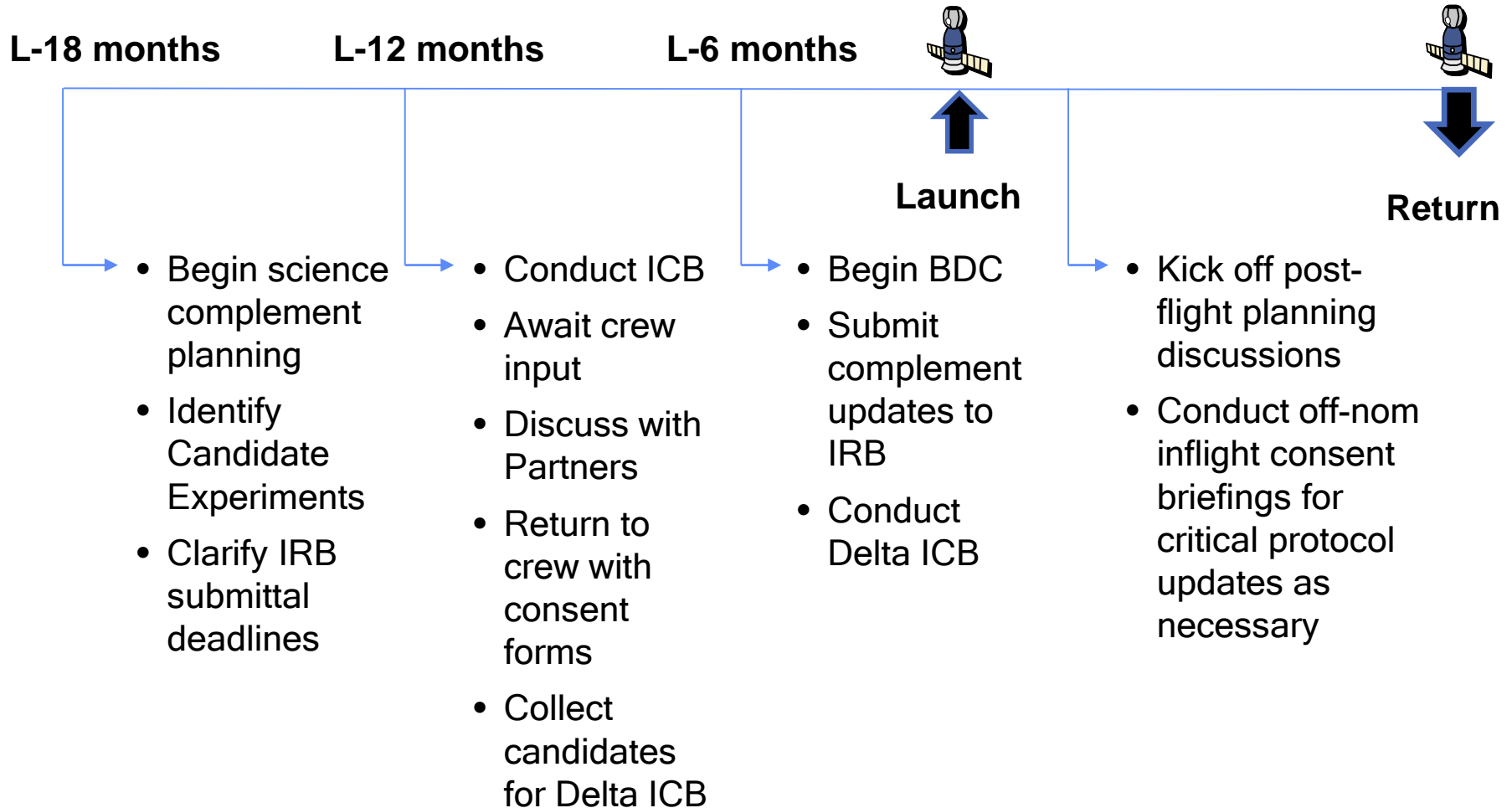


Before the complement planning

- ISSMP assigns an Experiment Support Team (EST) to work with the PI from definition to completion
- Feasibility assessments are conducted prior to Select for Flight, and will identify opportunities to leverage resources
- Experiment Documents (ED) detail the official requirements for implementation, and must be kept in synch with Institutional Review Board (IRB) approved protocols as changes are implemented
- The EDs serve as a basis for building flight research complement scenarios with international partners when determining what experiments fit together



Preflight complement planning





Changes with commercial flight

- Following ISS assembly phase, we have relied on Soyuz for launch and return of crewmembers
- Except for field-type activities and limited bio-sampling, direct return of crewmembers to US allows for postflight data collection in the US around 24+ hrs post-landing
- Commercial Boeing and SpaceX missions will launch from KSC and also plan for direct return of crewmembers to JSC





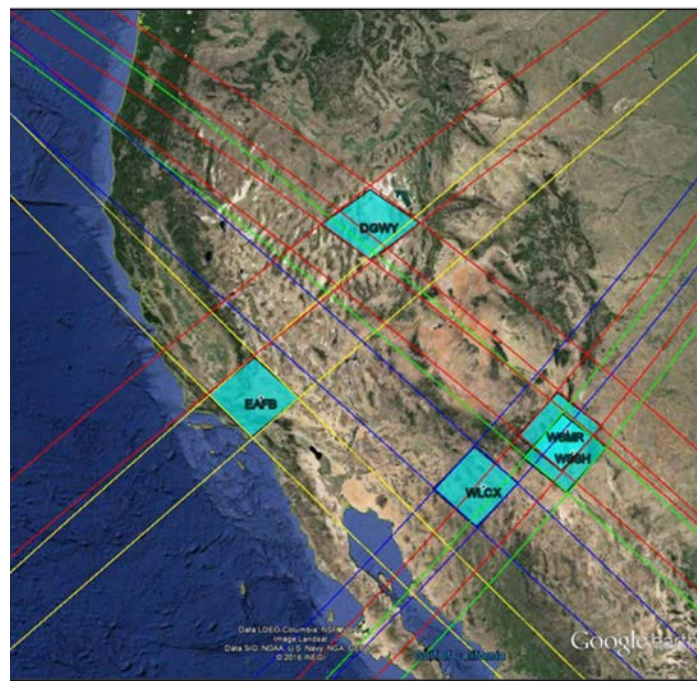
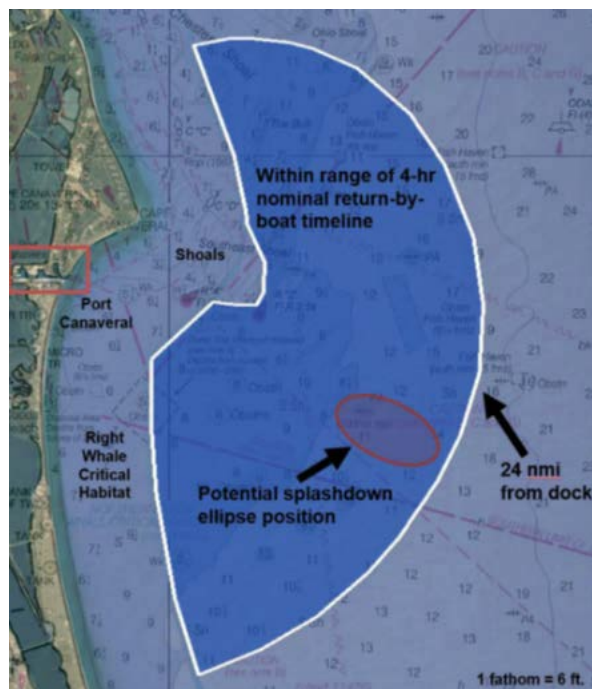
Changes with commercial flight

- Preflight USCV crew quarantine will begin at L-14 days
- The crew will be transported to KSC no later than L-7 days
- Similar to current Soyuz, rendezvous and docking will typically occur on flight day 1
- Un-crewed demo flights are planned for 2019, followed by crewed demo flights that do not currently include HRP studies
- It has not yet been determined whether the first US commercial vehicle will be SpaceX or Boeing



Commercial post-flight return

- Crewed SpaceX Dragon missions will nominally land in the water off the coast of Cape Canaveral, Florida (alternate water landing sites include Gulf of Mexico)
- Crewed Boeing CST-100 missions will nominally land at one of five designated landing sites in the western US





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