

# **International Space Life Science Working Group**

**ISLSWG**

**Space Life Sciences**

**Flight Experiments Information Package  
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**A Companion Document to  
Agency Solicitations in Space Life Science**



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## **Introduction**

This supplement is a companion to the 2009 research solicitations released by agency members of the International Space Life Sciences Working Group (ISLSWG): the Italian Agenzia Spaziale Italiana (ASI), the Canadian Space Agency (CSA), France's Centre National d'Études Spatiales (CNES), Germany's Deutsches Zentrum für Luft-und Raumfahrt (DLR), the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the United States' National Aeronautics and Space Administration (NASA). The various sections of this supplement provide a common basis for proposal preparation and submission by any eligible scientist, regardless of the country of origin.

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Individuals submitting responses to agency solicitations should be aware that a Letter of Intent (LOI) to propose is requested by June 15<sup>th</sup>, 2009, and the proposal submission deadline for Research Opportunities for Flight Experiments in Space Life Sciences Research Announcement 2009 is September 14<sup>th</sup>, 2009. Please see section 5 for directions for LOI and proposal submission.

## **1.0 Anticipated Flight Opportunities for Space Life Sciences**

The experiments selected in the course of this announcement of opportunity will take place following the completion of ISS assembly. As a result a wide range of facilities and equipment will be available and up to 6 crew members to perform experiments. Nevertheless, resources such as crew time, electrical power, and refrigeration/freezing will be limited during this period. Furthermore, since the Space Shuttle will retire in 2010, transport of experiment related samples and/or hardware to and from the station will be at least initially be largely in Russian Soyuz vehicles which have limited transport capacity. It is anticipated that transportation of the crew to and from the ISS will be exclusively via the Russian Soyuz vehicle until NASA delivers the Crew Exploration Vehicle towards 2014-15.

**Flight experiment opportunities are limited and constrained in a number of ways. Proposals that require resources beyond the capabilities described in this section should NOT be submitted.**

Flight experiment proposals must represent mature studies strongly anchored in previous or current ground-based or flight research. Ground-based research may, and usually must, represent one component of a flight experiment proposal. For a flight experiment proposal, ground-based research should be limited to activities that are essential for the final development of an experiment for flight, such as definition of flight procedures, testing of experiment hardware and control activities for the flight experiment. In this case, only one (flight) proposal needs to be submitted.

Flight experiment proposals must clearly define the actual experiment duration and all requirements and conditions required to successfully complete the experiment. The investigator should allow for flexibility in the selection of the best hardware to be used to accomplish the experimental goals. Descriptions and websites of the functional capabilities of hardware available to support human and nonhuman (biology) experiments are included in Sections 2 and 3 of this document. This information should be used to develop an understanding of the available capabilities. Investigators should use this information as a guide for developing experiment requirements and procedures *rather than selecting specific hardware items*.

Some experiment proposals requirements may result in the need to develop specialized experiment-specific equipment to work in conjunction with the facilities and functional capabilities of existing hardware. Development of experiment-unique equipment will require additional funding, and individual agencies may factor this into their overall assessment of the feasibility of a proposal. Design, construction, and flight of major experiment-unique equipment hardware items or facilities usually require the commitment of large quantities of resources (power, crew time, volume). In the event that such items are proposed, they should be clearly identified.

Flight experiments definition and development generally require one to three years. It is anticipated that flight assignments for experiments selected in this AO will occur in the 2012 to 2015 timeframe.

It is expected that the experiments selected from proposals in response to this announcement will mainly be performed on the International Space Station (ISS). Pre- and post-mission studies that involve tests of the astronaut crew before launch and upon return from their space flight may also be submitted (see Section 1.2 and 1.3 for specific constraints on pre- and post-flight astronaut participation).

## 1.1 Flight Experiments

Flight experiment durations depend on the schedule of launch and return of transport vehicles to/from the ISS. In principle there is no firm upper limit for the maximum duration of an experiment, since ISS is planned to continue to operate over the next few years. However, if sample return to Earth is required then this needs to be scheduled with a return vehicle, most likely a Soyuz. The currently foreseen schedule of Soyuz rotations (subject to change) is 2 and 4 month increments – i.e. the minimum period between upload on Soyuz and download on a Soyuz is between 2-4 months. Therefore, experiments need to be designed to survive a minimum of several months inflight. Serious consideration should be given to both active and passive phases of the proposed experiment (e.g., reagent and specimen storage time and conditions) in order to define adequately the experiment requirements, procedures, and flexibility.

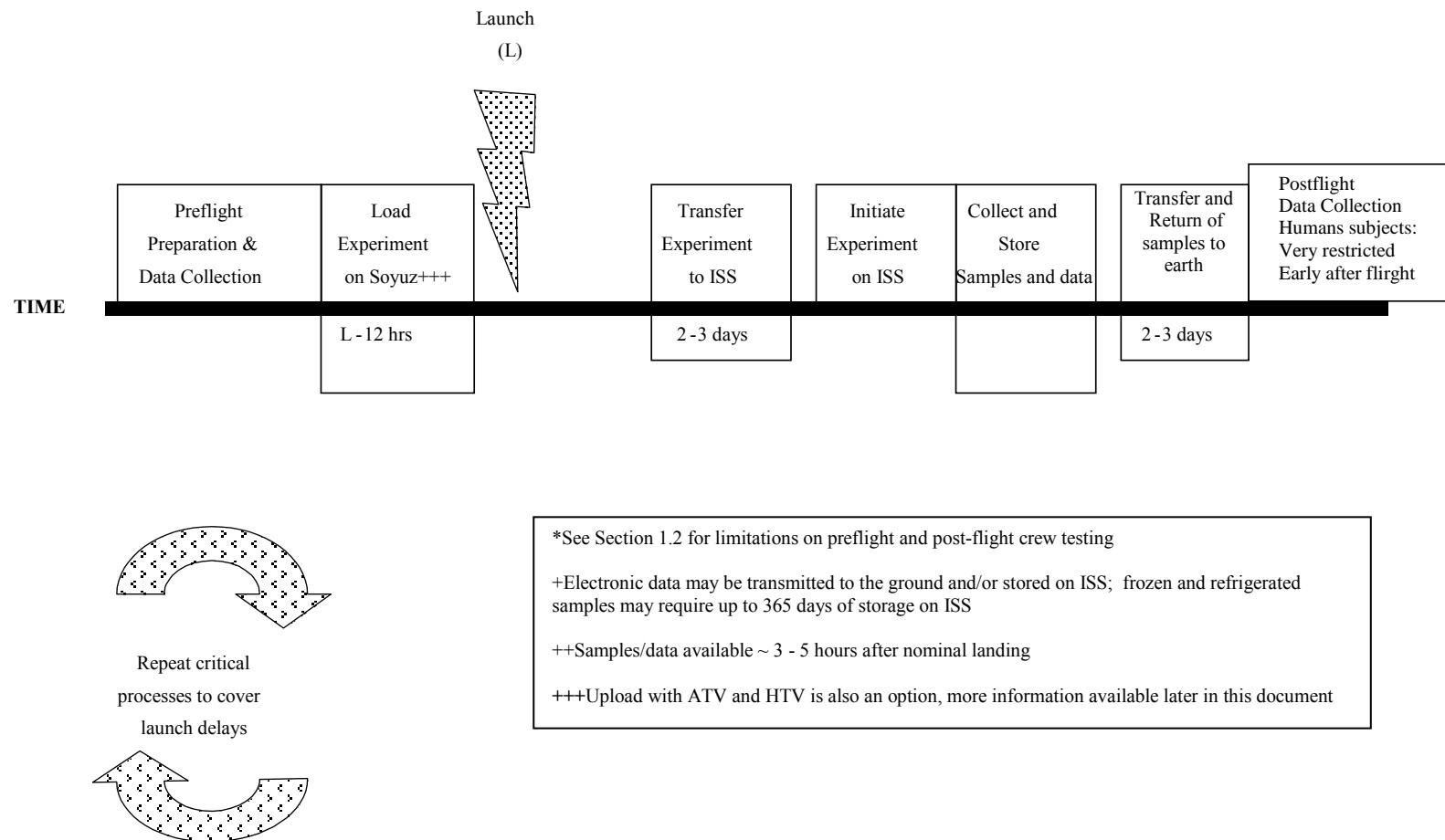
Research opportunities will be available during this operational phase of the fully assembled ISS. The research will be accomplished during ISS operational increments when the ISS crew will act as experiment operators and, if necessary, as subjects. The duration of microgravity exposure can, in theory, be indefinite, with periodic disturbances at intervals caused by U.S., Russian, European and Japanese transportation vehicle docking activities, re-boosting, and some crew activities (e.g. exercise).

It is expected that transport frequency, power during transport, and mass of transported items will all be constrained during this period. The primary opportunities to transport scientific equipment, supplies, and samples will be on Russian Soyuz vehicles, Progress vehicles, ATV, and HTV for upload and on Soyuz for return from ISS. Refrigerated and frozen transport of samples on Soyuz is not available. Samples or specimens from experiments may be returned to Earth only periodically. Depending upon the duration of the active phase of the experiment, storage of samples of at least 2-4 months must be possible since this is the minimum time between upload and download on Soyuz vehicles. There is a minimum storage period of three days before starting an ISS experiment, since Soyuz and other vehicles must travel to and dock at the ISS and the experiment must be transferred to its ISS facility (see Figure 1). The requirements necessary to preserve the integrity of an experiment during these storage periods must be described on the Space Flight Experiment Requirements Summary (Form C).

The availability of the crew for specifically timed science operations and as subjects of research will also be constrained during ISS assembly. On average, a total of approximately 70 crew hours per week will be available for all research, of which 50% is allocated to the Russian segment. A subset of this crew time will be available to support life sciences research. However, ISS crewmembers have indicated an interest in science tasks that can be performed on a time-available basis and proposers are strongly encouraged to identify objectives that can be achieved

in this manner. Estimates of crew time required to complete the experiment must include the time required for crewmembers to both operate an experiment and serve as subjects. Moreover, crew time for data collection after flight is extremely limited and consideration of current exercise countermeasure protocols is strongly recommended (see Section 2.1.3). There is no assurance that all crewmembers will agree to participate as subjects in experiments. See section 2.1 for more information regarding the use of crewmembers as subjects and the assumptions to be made in planning these types of experiments.

Figure 1: Flight Experiment Implementation Flow



## **1.2 Pre- and Post-mission Studies**

Opportunities will be available to perform experiments, collect samples, and take physiological measurements of the astronaut crew both before their space mission and following their return to Earth. Such proposals are considered flight experiments and should specify the desired activities, the timeframe in which these activities must be performed prior to and following the mission. There is no assurance that all crewmembers will agree to participate as subjects in experiments. Access to the crew immediately before and upon return is extremely limited (availability of astronauts for research tests on the day of return to Earth, or the day after, may be as little as one hour per day total. See Section 1.4).

## **1.3 Transportation**

Within the timeframe identified in this document, Soyuz launch capabilities for crew transportation will be augmented by additional payload launch vehicles such as the ESA provided Automated Launch Vehicle (ATV) and JAXA provided H-II Transfer Vehicle (HTV). Russia's Progress vehicle and the JAXA HTV will continue to provide limited transportation opportunities to the ISS. Investigators should remain aware of the capabilities and requirements associated with each of the carriers. Progress, HTV, ATV and Commercial Resupply Service (CRS) provide logistics support to the ISS but provide no return capability.

### **1.3.1 Space Shuttle**

It is currently anticipated that the research activities conducted as a result of this announcement of opportunity will take place after the nominal retirement of the Space Shuttle.

### **1.3.2 Progress**

The Russian Progress cargo module is similar in construction to the Soyuz orbital module. The cargo module carries pressurized cargo that the crew transfers into the station through the docking hatch. No power is available to experiments during upload and, during freeflight phase, cargo is potentially exposed to larger temperature variations than for vehicles with a crew. Equipment is loaded several hours to days prior to launch, although late access may be requested as for Soyuz (up to L-12h). However the retrieval on orbit may be longer. After the cargo module is unloaded, trash, unwanted equipment, and wastewater can be loaded into the Progress for disposal when the spacecraft leaves the Station.

### **1.3.3 Automated Transfer Vehicle (ATV)**

The ESA ATV is a new vehicle designed to provide additional logistics support to the ISS Program. Pressurized cargo is soft or hard mounted within rack structures mounted in the ATV. No power is available to experiments during upload and, during the freeflight phase of the mission, cargo is potentially exposed to larger temperature variations than for vehicles with a crew. Equipment is loaded several days to weeks prior to launch. Time from launch to docking might vary, days to weeks.

### **1.3.4 H-II Transfer Vehicle (HTV)**

The JAXA HTV is a new vehicle designed to provide additional logistics support to the ISS Program. Pressurized cargo is soft or hard mounted within rack structures mounted in the HTV. No power is available to experiments during upload and cargo is potentially exposed to larger temperature variations than for vehicles with a crew during the freeflight phase of the mission. Equipment is loaded several weeks prior to launch

## **1.4 Difficult Experiment Requirements to Implement on the ISS**

There are certain experimental procedures that, while not impossible to perform, are difficult to implement during ISS operations. Those requirements that may be difficult to accommodate include:

1. Experiments requiring powered operation in Soyuz or other transport vehicles.
2. The need for a large allocation of in-flight crew time (experiment procedures will take more than 6 hours per week, or 15 hours to complete the protocol (in one subject if applicable)).
3. Measurements to be made on crew members within their first couple of days on-orbit, which implies that the measurements have to be made on the Soyuz before docking with the ISS or on the return trip.
4. Intensive Early Flight Activities (Flight Day 0 to Flight Day 15): Operations that require more than 2 hour per subject per day for more than 2 days during this period are considered intensive operations.
5. Baseline Crew Data Collection on the two days after landing: Recovery+0 to Recovery+2 (R+0 to R+2). Crew Duty days and therefore testing time is also extremely limited the first week after landing.
6. Excessive Crew Training (more than 10 hours to familiarize a novice with the procedure, as experimenter and/or subject).
7. A large number of crew subjects (more than 6-8), with a significant in-flight protocol.
8. Complex or invasive inflight procedures on the crew, such as indwelling catheters, multiple hardware items that must be integrated or synchronized, precise requirements for when an experiment must be performed, and complex skills required (e.g., inflight biopsies, microneurography, etc.).
9. Download of samples or equipment will be extremely limited during this period, and specifically download of conditioned/frozen samples poses a serious challenge.
10. Large Upmass/Volume.
11. Procedures on nonhuman specimens on the day of launch or prior to docking with ISS (unless automated).
12. Procedures that require crew time before docking on the ISS or on the day of landing.
13. Complex in-flight procedures on nonhuman specimens, such as surgeries or dissections.

## **2.0 Flight Research Capabilities**

### **2.1 Research Involving Human Subjects**

The amount of time it takes to complete a study is based on the required number of subjects and crewmember participation. Investigations selected under this solicitation will be flown while there are up to six crew members on board the ISS, and it should be assumed that two Increment (six month periods) crews will be flown every year for a total of 12 potential subjects a year. In order to account for variations in subject participation and suitability, it should be assumed that two subjects per Increment will participate, for a total of four subjects per year. Therefore, if an investigation requires a minimum of six crewmember subjects, it will take a minimum of three ISS Increments (1.5 years) to complete the in-flight data collections.

Due to the limited resources (e.g., crew time, on-orbit experimental supplies, temperature-controlled sample storage) available for the conduct of ISS research, ISLSWG is pursuing the intentional formation of teams of investigators whose experiments will leverage resources by addressing different facets of the same question. ISLSWG anticipates that such intentional teaming arrangements will result in better utilization of available resources to resolve specific questions. ISLSWG strongly encourages individual investigators submitting applications in response to this solicitation to consider identifying such collaborations between individual proposals as part of the development of their individual proposals and to identify this pre-coordination in their submissions.

All use of human subjects for research must comply with [NASA Policy Directive NPD 7100.8E, Protection of Human Research Subjects](#). Informed consent of human subjects must be obtained before carrying out any study in space, and potential applicants should be aware that obtaining such informed consent will involve a uniform process regardless of the country of origin of the applicants. The availability of consenting subjects may affect the probability of achieving experiment objectives within the expected timeframe.

There are many research tools available to investigators who wish to conduct human physiological research on the ISS. The ISS Human Research Facility (HRF) is a suite of hardware that provides core capabilities to enable research on human subjects. HRF consists of instruments mounted in two racks located in the US Lab, as well as separate equipment kept in stowage and brought out as needed.

A complementary set of hardware is provided via the European Physiology Modules Facility (EPM), a multi-user facility supporting human studies. The EPM rack is outfitted with an initial complement of instruments. Due to the modular design, this initial configuration can be easily complemented and/or modified with instruments still under development or to be developed, according to the scientific needs.

HRF 1 and 2 and EPM are located in the Columbus laboratory to allow for combined experiments.

A complete list of hardware in the HRF and EPM inventories, and a web site reference for design details is provided in Table 1. General description of HRF and EPM core capabilities is provided below.

In addition to HRF and EPM equipment specifically intended for research, the Crew Health Care System (CHeCS) is also potentially available to ISS researchers. CHeCS is a suite of hardware used to maintain and monitor the crew's health onboard the ISS. CHeCS hardware can be used for research but this must be closely coordinated with the flight surgeons and cannot interfere with planned operational use. A partial list of CHeCS hardware is included in Table 1 and a general description of CHeCS capabilities is provided below.

Data collected by Medical Operations, related to maintaining and monitoring of crew health, is in principle also available for scientific use, however again close coordination with crew surgeons is key. The NASA Longitudinal Data Base (<http://lsda.jsc.nasa.gov/docs/MRID/MRIDhome.cfm>) consists of archived medical data collected previously in a standardized way, and is available to researchers in order to complement flight experiments or to be used in separate studies. How to access this data is described in detail in the URL above.

### 2.1.1 Physiological Monitoring

- **Blood Pressure:** Capabilities include noninvasive monitoring and collection of blood pressure data, both extended duration and intermittent, on human subjects. The data can be collected by manual or automated methods during periods of rest or exercise.
- **ECG/EMG/EEG:** Acquisition of human physiological data such as ECG, EMG, EEG, temperature, and skin galvanic responses is possible. Multichannel data (16 differential channels) can be collected by means of portable, crew-worn devices over extended periods of time (24 hours), or via rack-mounted devices.
- **Pulse/Blood Oxygen:** A pulse oximeter will be available to monitor the percentage of hemoglobin oxygen saturation in the blood.
- **Metabolic Activity/Pulmonary Physiology:** Three gas analyzers are available, of which one is Portable: one based on the use of mass spectrometry and the other two infrared gas analysis techniques. Combined with ancillary equipment, including gas supplies for supplying special respiratory gas mixtures, the following measurements are possible:
  1. Breath-by-breath measurements of VO<sub>2</sub>, VCO<sub>2</sub>, and VE
  2. Diffusing capacity of the lung for CO
  3. Expiratory reserve volume
  4. Forced expired spirometry
  5. Functional residual capacity
  6. Respiratory exchange ratio
  7. Residual volume
  8. Total lung capacity

9. Tidal volume
10. Alveolar ventilation
11. Vital capacity
12. Volume of pulmonary capillary blood
13. Dead-space ventilation
14. Cardiac output
15. Fractional inspiratory and expiratory volumes,  $F_{IO_2}$  and  $F_{EO_2}$ ,  $F_{CO_2}$ , and  $F_{ECO_2}$
16. Numerous other specialized tests of pulmonary function

- **Ultrasound/Doppler:** An ultrasound system is available to perform medical imaging and to measure flow rates. The system uses hand-held probes and performs functions to support cardiac, abdominal (deep organ), vascular, muscle and tendon, and transcranial ultrasound.
- **Mass Measurement:** A mass measurement device is available to measure real-time on-orbit body mass with a  $\pm 0.5$  lb [ $\pm 0.23$  kg] accuracy.

### **2.1.2 Sample Collection and Storage**

Blood, urine, and saliva samples may be collected from crew subjects before, during, and after flight. Blood, urine, and saliva collection kits for the collection, preservation, and storage of samples are available. A centrifuge capable of biological sample separation is also available for use.

The development of an on-orbit **immuno-biochemical analyser** system has been initiated. This system will allow the analysis of a variety of substances in blood, urine or saliva to be performed on ISS. The initial set of substances will be defined taking onto account the requirements of selected experiments obtained from this research announcement.

Similarly a system for **genetic analysis**, on ISS, of a variety of samples (air, liquid, surfaces (swab)) is also being developed, and also here the final design will take into account requirements from selected experiments.

### **2.1.3 Exercise**

The primary suite of equipment from the CheCS inventory available to researchers is the crew exercise equipment. Several exercise devices are/will be available for research including a cycle ergometer, an Advanced Resistive Exercise device (ARED), and two treadmills. For description, see the following web site: <http://hacd.jsc.nasa.gov/projects/ecp.cfm> Use of this equipment will require coordination with Flight Medicine to ensure appropriate and proper usage. Use of CheCS hardware, including exercise devices, must be coordinated and approved by Space Medicine so that impacts to crew health care, standard countermeasures, and exercise

prescriptions can be assessed. Under certain circumstances, use of exercise devices for research purposes may replace nominal exercise protocols.

The **cycle ergometer** provides workload, driven by the hands or feet, that is controlled by manual or computer adjustment. It operates with the subject seated or supine, and provides time-synchronized data compatible with other complementary analyses. The data output consists of work rates in watts and pedal speed (rpm) for use with a data acquisition system.

The **Advanced Resistive Exercise Device (ARED)** functions to maintain crew health in space. Crew members exercise daily on ARED to maintain their pre-flight muscle and bone strength and endurance. EVA, IVA, re-entry, and emergency egress necessitate the crew members' continued strength and endurance

The Advanced RED (ARED) has the capability to exercise all major muscle groups while focusing on the primary resistive exercise: squats, deadlifts and calf raises.

It accommodates all crew members, from the 5th percentile female to the 95th percentile male. An informative NASA technical report describing the characteristics of the ARED is at:

<http://ston.jsc.nasa.gov/collections/TRS/listfiles.cgi?DOC=TP-2006-213717>

The **treadmills** may be used for walking and running exercise. The device employs various strategies to simulate, as closely as possible, 1 g skeletal loading during exercise bouts. The treadmill will measure and display the loads exerted on the subject by restraint harnesses before, during, and after the exercise bout. The restraint system provides stabilization of the user and load distribution on the body in a weightless environment. One of the treadmills will also provide foot impact forces, with high accuracy, allowing investigations in the area of locomotion. The treadmill can be motor-driven or passively operated. As with the cycle ergometer, the treadmill provides data compatible with other complementary analyses.

#### 2.1.4 Evaluation of Muscle Strength and Exercise Capacity

A **Flywheel Exercise Device (FWED)** that can be used for evaluation of exercise capacity regarding strength and fatigue. The flywheel provides resistance when the wheel is accelerated (concentric phase) and subsequently decelerated (eccentric phase). A variety of exercises can be performed including both the upper and lower body. Continuous measurements of torque, force and, and knee joint angle can be recorded. In combination with HRF it is possible to record EMG while using the FWED. Evaluation of the FWED as a Countermeasure Device, regarding resistive exercise, is also feasible.

A **Muscle Atrophy Research and Exercise System (MARES)** can also be used to evaluate muscle strength and exercise capacity. The MARES provides active resistance (concentric and eccentric) that can be fully programmed as motion profiles.

MARES supports the following capabilities:

- Measurement of the (bidirectional) torque, position, and velocity generated during programmable tests on the agonist and antagonist muscle groups of the trunk and

extremity joints including ankle, knee, hip, wrist, elbow, shoulder, trunk, whole leg, and whole arm

- Measurement of these parameters during submaximal and maximal exercises throughout the entire range of motion (except for shoulder) in the isometric, isokinetic (concentric and eccentric), and isotonic (concentric and eccentric) modes
- Simulation of ideal elements: spring, friction and inertia
- Parameter control following predefined pattern: position control, velocity control, torque/force control, power control
- Quick release of free motion
- Complex combinations of the previous modes
- Bilateral torque and angular position/velocity measurements and training on the flexion and extension of the knee, ankle, trunk, hip, shoulder, elbow and wrist, and on the supination/pronation, radial/ulnar deviation of the wrist.
- Bilateral force and linear position/velocity measurements and training on the following multi-joint linear movements:
  - i Arm press (front, overhead and intermediate trajectories)
  - ii Leg press (front, down and intermediate trajectories)
- The displays available to the subject are highly programmable, i.e., display of peak torque vs. joint angles, and average torque at specific joint angles as well as torque-velocity throughout the entire range of motion).
- The motion and experiment profiles are highly programmable (e.g., programming of variable and quantifiable velocities and resistances during training exercises, assessment of fatigue over serial contractions)

Currently, there are already several additional instruments available for:

- Measurement of hand grip strength or pinch strength as a function of time
- Local noninvasive muscle stimulation on human subjects using a high current stimulator that provides trains of pulses up to 0.8 amps, according to pre-programmed protocols. It can be connected to MARES.
- Portable measurement of full range of motion in either 1 or 2 degrees of freedom in selected joints.

### **2.1.5 Activity Monitoring**

Measurements indicative of the crew's activity level can be made using a small wrist- or ankle-worn device that can detect movement and light levels. The device is used to evaluate sleep/wake adaptation, circadian cycles, sleep quality, sleep onset, hyperactivity, and other daily routines of human activity. The device can be battery operated for up to 150 hours. Sampling rates of accelerations and light intensity are programmable.

## 2.1.6 Eye Movements

A 3-dimensional **Eye Tracking Device (ETD)** for the recording of eye movements will be available. This device may be used to measure horizontal, vertical and/or torsional eye positions by means of digital processing of the recorded eye image sequences. Furthermore, head movements will be measured by means of three orthogonally arranged angular rate sensors and three orthogonally arranged linear accelerometers. This encompasses all three degrees of freedom of eye movement (in the head) and all six degrees of freedom of head movement in space. Therefore, gaze can be reconstructed.

## 2.1.7 Movements

A **Codamotion** system, that tracks body movements is being developed for use on ISS. This system can be combined a handheld **Manipulandum** that measures pinch force, friction and acceleration. This H/W is developed for an experiment that investigates dexterous manipulation in weightlessness, but would be available for other purposes as well.

ELaboratore Immagini TEleviseive for Space, second generation (**ELITE-S2**): Elite-S2 is a system to observe body motor control during long-term exposure to microgravity.

Elite-S2 is an EXPRESS Rack drawer-type payload requiring data and video downlink. Video from the cameras is displayed on the EXPRESS Laptop Computer (ELC) for crew quick look in addition to being downlinked.

Four cameras are positioned in the US Lab. Cables are routed from the cameras to the Elite-S2 Interface Management Unit (IMU) located in the EXPRESS Rack. Cables, once installed for each EXPRESS Rack, remain installed until completion of all test objectives.

One crewmember is required for set up, execution of tests, and stow.

During tests, near real-time science data is continuously downlinked through the EXPRESS Ethernet LAN.

**Hand Posture Analayser (HPA):** A complete HPA system is composed of two sets of instruments which can be used separately to acquire data on the upper limb posture and on the ability to produce isometric grip force. The two subsystems are respectively the Handgrip Dynamometer / Pinch Force Dynamometer (HGD/PFD) for the acquisition of hand and pinch force and the Posture Acquisition Glove (PAG) and Inertial Tracking System (ITS) for the measurement of fingers position and upper limb kinematics.

This system comprises also an Interface Box (IBOX) where instruments connect through dedicated cables. The IBOX is connected to a PCMCIA card of a Laptop PC for data acquisition and a dedicated software application manages the execution of experimental protocols.

## 2.1.8 European Physiology Modules Facility (EPM)

The initial instrument complement to be accommodated includes:

**The MEEMM (Multi-Electrode EEG Mapping Module)** is designed to supporting brain and muscle activity studies by measuring EEG/EMG and evoked potentials. The main features of the MEEMM are:

- Supporting acquisition of up to 128 EEG channels (maximum sampling frequency 2.2 kHz, 0.01-580 Hz maximum bandwidth)
- Supporting acquisition of up to 32 EEG channels (maximum sampling frequency 40 kHz, 1.5 Hz-10 kHz maximum bandwidth)
- Supporting acquisition of up to 32 surface EMG channels (64 electrodes) (maximum sampling frequency 40 kHz, 1 Hz-10 kHz maximum bandwidth)
- External triggering digital signal acquisition (8 bit digital interface)

**PORTEEM (Portable EEG).** Modular instrument for ambulatory/sleep EEG measurements.  
Initial configuration :

- 12 EEG channels (0.3-70 Hz maximum bandwidth)
- 2 EMG channels (1-150 Hz maximum bandwidth)
- 1 ECG channel (1-150 Hz maximum bandwidth)
- 1 strain gauge respiratory signal (0.3-30 Hz maximum bandwidth)

**CARDIOLAB. (Cardiovascular Laboratory).** CARDIOLAB consists of a central data management system providing services to a complement of instruments (sensors and stressors), including :

- CARDIOPRES: Continuous acquisition of blood pressure (finger and arm cuffs), ECG from 1 to 7 leads derivations, thoracic and abdominal breathing patterns.
- HLTE: ECG Holter (24 hours ECG full stripes recording)
- HLTA: Arm-cuff blood pressure Holter (Systolic, Diastolic and Mean Blood Pressure measurements)
- PDOP: Portable ultrasound doppler instrument (Main arteries blood velocities measurements up to three channels at a time with 2Mhz, 4Mhz and 8Mhz pulsed wave probes).
- APLT: Air plethysmography, providing limb volume variations against venous occlusion.
- LVMD: Limb Volume Measurement Device; reconfigurable for body position determination via spine geometry measurements (continuously up to 48 h)
- PBAD: Portable Blood Analysis Device (ISTAT blood analyser) providing main electrolyte parameters analyses depending on specific cartridge sets.
- HEMO: Hemoglobinometer; measurement of hemoglobin by azide methemoglobin method; control of the status of whole blood.
- HEMC: Hematocrit Centrifuge (determination of the whole blood hematocrit by centrifugal separation of blood cells from plasma).

- CMAS: Continous Measurement Ambulatory Device for medium term (up to 8 h) ambulatory acquisition and recording of physiological signals, such as ECG, EMG, EEG, breathing patterns, body movements and activity
- CWPG: Cold/Warm pressure glove. Application of thermal stress on the forearm in a range from -5°C to 40°C with a regulation in the case of positive temperature of 0.5°C
- LACS: Leg/arm occlusion cuff system. Application at the level of the limbs of an occlusive stress in a range from 0mm of Hg to 300 mmHg (two different level/profiles of pressure on the arms and on the legs).

In addition to the devices existing on ISS, CNES and DLR as the developers of CARDIOLAB are considering to provide further modules, if required from the scientific community, such as:

- EIT: Electrical Impedance Tomography, providing non-invasive dynamic on-line registration of regional air and fluid distribution in a thoracal cross-section for analysing lung function (ventilation, perfusion, air and fluid distribution); method requires only measurements by 16 normal ECG electrodes attached around the thorax to calculate tomographic images from inside the thorax.
- Portable Echograph : Portable laptop based echocardiograph approx 7 - 9Kg, Battery self powered Device or 28v power Supply, Sector scan probe (3-5MHz) for deep organs and vessels (Cardiac, abdomen, pelvis, etc), Linear probe (5-12Mhz) for superficial structures and vessels: Peripheral vessels, muscle, Ultrasound modes: B mode, Time motion, Pulsed Doppler.
- Laser Doppler: Local microcirculation, and particularly vasomotor functions of the arterioles have a real impact on blood pressure regulation. A Laser Doppler instrument will allow the study of microcirculation through the measurement of the skin blood flow. The instrument can use 3 Laser Doppler probes in parallel, with the following characteristics: multifiber laser probes (780nm), room for the probe to receive the drug, application of an electric current (ex. 100µA over 20s) for an application on the skin of the drug by iontophoresis, local skin heating(up to 44°C), measurement of the temperature by a themocouple for the regulation of temperature

**SCK (Sample Collection Kit).** Stowage of medical and clinical equipment for blood, saliva and urine sample collection and disposal and management of used medical/biohazard items.

### **2.1.9 Head Mounted Displays (HMD) (ESA)**

HMD used for neuro-sensory and cognitive research is available, further developments with more advanced features, like eye- and head-tracking, could be considered if selected experiments require those capabilities.

### **2.1.10 ALTEA**

Anomalous Long Term Effects on Astronauts (ALTEA) is a program aimed to study the interactions between particle passages in the brain and possible brain functional transient or long

term anomalies, while monitoring the visual system status. The ALTEA space hardware is composed of six particle detectors, arranged on a helmet shaped support, one visual stimulator (with light-tight oculars), one 32-channels electroencefalographer, and a pushbutton (with three independent buttons). The helmet shaped support will be connected to an ISS express rack.

The space experiment features two different scheduled protocols: Central Nervous System Monitoring (CNSM), and DOSImetry (DOSI).

**CNSM** is a manned experiment. The astronauts wears the EEG electrode cap, slides his/her head into the helmet hosting particle detectors and visual stimulator, grabs the pushbutton, and closes the visual stimulator oculars, starting dark adaptation.

**DOSI** is an unmanned experiment. In this case only the particle detectors are operating.

**Table 1: Hardware Available to Support Human Subject Research**

Hardware Available to Support Human Subject Research	Agency	Website
<b>Physiological Monitoring</b>		
Blood Pressure/Electrocardiograph	NASA	<a href="#">Gwyn Smith, CheCS Hardware, gwyn.e.smith@nasa.gov</a>
Automatic Blood Pressure Cuff	NASA	<a href="#">Gwyn Smith, CheCS Hardware, gwyn.e.smith@nasa.gov</a>
Continuous Blood Pressure Device	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/c_bpd.asp">https://issmp.jsc.nasa.gov/hardware/c_bpd.asp</a>
Pulmonary Function System	NASA/ESA	<a href="https://issmp.jsc.nasa.gov/hardware/pfs.asp">https://issmp.jsc.nasa.gov/hardware/pfs.asp</a> <a href="http://www.esa.int/spaceflight/pfs">http://www.esa.int/spaceflight/pfs</a>
Portable Pulmonary Function System	ESA	<a href="http://www.esa.int/spaceflight/pfs">http://www.esa.int/spaceflight/pfs</a>
Gas Analyzer Mass Spectrometer	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/gasmapping.asp">https://issmp.jsc.nasa.gov/hardware/gasmapping.asp</a>
Ambulatory Data Acquisition System (analog to digital recorder)	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/adas.asp">https://issmp.jsc.nasa.gov/hardware/adas.asp</a>
Holter Monitor	NASA/JAXA	<a href="https://issmp.jsc.nasa.gov/hardware/holter.asp">https://issmp.jsc.nasa.gov/hardware/holter.asp</a> <a href="http://kibo.jaxa.jp/en/experiment/pm/holter/holter.pdf">http://kibo.jaxa.jp/en/experiment/pm/holter/holter.pdf</a>
Ultrasound Doppler	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/ultrasound.asp">https://issmp.jsc.nasa.gov/hardware/ultrasound.asp</a>
Portable Clinical Blood Analyzer	NASA	
Space Linear Acceleration Mass Measurement Device	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/slamm.asp">https://issmp.jsc.nasa.gov/hardware/slamm.asp</a>
<b>Sample Collection and Stowage</b>		
Human Sample Collection Kits	NASA	
Refrigerated Centrifuge	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/rc.asp">https://issmp.jsc.nasa.gov/hardware/rc.asp</a>
<b>Exercise</b>		
Cycle Ergometer	NASA	<a href="#">Gwyn Smith, CheCS Hardware, gwyn.e.smith@nasa.gov</a>
Treadmill	NASA	<a href="#">Gwyn Smith, CheCS Hardware, gwyn.e.smith@nasa.gov</a>
advanced Resistive Exercise Device	NASA	<a href="#">Gwyn Smith, CheCS Hardware, gwyn.e.smith@nasa.gov</a>
Flywheel Exercise Device (FWED)	ESA	<a href="http://www.esa.int/spaceflight/fwed">http://www.esa.int/spaceflight/fwed</a>
<b>Muscle Strength, Torque, and Joint Angle</b>		
Muscle Atrophy Research and Exercise System	NASA/ESA	<a href="http://www.esa.int/spaceflight/mares">http://www.esa.int/spaceflight/mares</a>
Percutaneous Electrical Muscle Stimulator	NASA/ESA	<a href="http://www.esa.int/spaceflight/pems">http://www.esa.int/spaceflight/pems</a>
Hand Grip/Pinch Force Dynamometer	NASA/ESA	<a href="http://www.esa.int/spaceflight/hg">http://www.esa.int/spaceflight/hg</a>
<b>Activity Monitoring</b>		
Actilight Watch	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/am.asp">https://issmp.jsc.nasa.gov/hardware/am.asp</a>
<b>Coordination</b>		
3 D Eye Tracking Device	DLR	<a href="https://issmp.jsc.nasa.gov/hardware/etd.asp">https://issmp.jsc.nasa.gov/hardware/etd.asp</a>
ELITE-S2	ASI	<a href="http://www.asi.it/en/activity/medicine/iss_scientific_payloads">http://www.asi.it/en/activity/medicine/iss_scientific_payloads</a>
HPA	ASI	<a href="http://www.asi.it/en/activity/medicine">http://www.asi.it/en/activity/medicine</a>

<b>Hardware Available to Support Human Subject Research</b>	<b>Agency</b>	<b>Website</b>
		<a href="#">/iss/scientific_payloads</a>
<b>European Physiology Modules</b>		
Multi Electrode EEG Mapping Module	ESA	<a href="http://www.esa.int/spaceflight/epm">http://www.esa.int/spaceflight/epm</a>
Portable EEG (PORTEEMM)	ESA	<a href="http://www.esa.int/spaceflight/epm">http://www.esa.int/spaceflight/epm</a>
Sample Collection Kit (SCK)	ESA	<a href="http://www.esa.int/spaceflight/epm">http://www.esa.int/spaceflight/epm</a>
CARDIOLAB	ESA	<a href="http://www.esa.int/spaceflight/epm">http://www.esa.int/spaceflight/epm</a>
<b>Radiation effects</b>		
ALTEA	ASI	<a href="http://www.asi.it/en/activity/medicine">http://www.asi.it/en/activity/medicine</a> <a href="#">/iss/scientific_payloads</a>

## **2.2 Research Involving Nonhuman Subjects (Biology and Exobiology)**

The ISS now has a full complement of research facilities in the US, European and Japanese laboratory modules. These facilities potentially permit sophisticated experimentation to be performed inflight. However, the scope of any investigation is limited by the resources available to perform the experiment including upload and download , condition temperature stowage and crew time limitations. Therefore, experiments designed for use of these facilities will have to fit within limitations of the resource envelope.

A complete list of hardware for biological research and a web site reference for design details is provided in Table 2. A general description of the facilities and capabilities is provided below.

ESA Columbus facilities: The ESA Columbus module has three main facilities for biological research, KUBIK, EMCS and Biolab each of which has different capabilities

### **2.2.1 KUBIK:**

KUBIK consists of a small controlled temperature volume, which can function both as an incubator or cooler (+6°C to +33°C temperature range). Additionally, self contained automatic experiments can be performed using power provided by the facility. A centrifuge insert permits simultaneous 1.g control samples to be run in parallel with microgravity samples. Experiments interface with the centrifuge insert via small standardized containers, therefore experiments need to be designed to fit inside these containers. Alternatively, if an onboard centrifuge control is not needed it is possible to interface larger, dedicated experiment hardware with KUBIK via an interface plate. There are no data or command communication possibilities between the experiments and KUBIK, which only provides controlled temperature and electrical power to the experiments. Therefore, the experiment hardware needs to be designed to operate automatically. Alternatively, it is possible to use manually operated experiment hardware which the crew removes from the incubator for operations. KUBIK incubators can also be potentially operated powered in Soyuz providing a means of maintaining controlled temperature & perform automatic experiments from a few hours prior to launch until docking.

### **2.2.2 EMCS:**

The European Modular Cultivation System (EMCS) is a facility which permits more complex operations than is possible with KUBIK. The facility consists of an incubator (18°C – 40°C range), which contains two centrifuge rotors which can provide g-levels in the 0.001g to 2.0g range, as well as microgravity (non spinning). Experiments interface with the facility by dedicated experiment containers (EC) with a transparent cover (for observation and illumination), 4 containers can be accommodated per rotor. Each EC can provide power and data /command connections to the experiment & the facility can provide a controlled atmosphere (gas composition, humidity, ethylene removal, different gas flow rates etc) as well as water. Additionally white light and infrared illumination of the containers is possible, as well as video observation. Although EMCS was primarily designed for long term plant biology experiments, it is also well adapted for small cell biology, biotechnology and small animal (eg. insects, amphibian tadpoles) experiments.

### **2.2.3 Biolab:**

Biolab is a self contained, sophisticated facility that provides an incubator, variable g-centrifuges, cooler, freezer and glovebox capabilities for biology experiments. Experiments interface with the facility through dedicated experiment containers and can be placed on the two centrifuge rotors which can provide microgravity (not spinning) or g-levels in the 0.001g to 2g range. Like the EMCS facility it is possible to provide a controlled atmosphere (eg. O<sub>2</sub>, CO<sub>2</sub>, set humidity, ethylene removal), as well as video observation and illumination of samples. Furthermore, data can be received from the experiment and commands sent either via the computer in Biolab or to/from the ground (telescience). A glovebox is included in the facility for manual operations. This can also be reconfigured as a work bench for example digital photography. Additionally a robotic handling mechanism can be used to automatically transfer liquids to/from the experiment containers or actuate experiment hardware in the container by a push/pull/turn tool. Finally, refrigerator and cooler space is provided in separate compartment of the Biolab

JAXA Kibo module facilities:

### **2.2.4 Cell Biology Equipment Facility (CBEF)**

The Cell Biology Experiment Facility (CBEF), to be integrated in the Japanese Kibo pressurised module, has been developed for various life science experiments such as cell cultivation and plant biology. It consists of an incubator unit and a control and communication unit. The incubator unit includes a microgravity compartment and a centrifuge that provides gravity control levels between 0.1 and 2.0 g. Experiment units are placed within containment canisters and installed in the CBEF. The incubator can control temperature, humidity and CO<sub>2</sub> concentration for cultivation. Experiments can be accommodated in one of four dedicated experiment containers which contain most of the systems needed to perform an experiment directly (Biology Experiment Units). These include a plant experiment unit (PEU), adherent culture experiments (CEU) and a manual experiment unit (MEU)

### **2.2.5 Aquatic Habitat (AQH)**

The Aquatic Habitat (AQH) is a sub-rack facility that accommodates freshwater organisms (such as Medaka fish) inside the Kibo module environment. The facility is designed to accommodate experiments for up to 90 days, making it possible to conduct research ranging from early development and differentiation to individual responses in a microgravity environment.

NASA facilities:

### **2.2.6 Advanced Biological Research System (ABRS)**

The Advanced Biological Research System (ABRS) is a single locker system with two growth chambers that is compatible with both the Space Shuttle and the ISS. Each growth chamber is a closed system capable of independently controlling temperature, illumination, and atmospheric composition to grow a variety of biological organisms. The chambers can provide temperature control to 8° C below ambient temperature, atmospheric contaminant scrubbing, carbon dioxide control, relative humidity control, sample illumination, generic top-down imaging (video), power and data services for a variety of experiment unique equipment that can be mounted inside the chambers. Video and housekeeping data can be downlinked from the facility. ABRS can be used to grow plants, microorganisms, and small arthropods (insects, arachnids etc).

### **2.2.7 Beetle Kit**

Each Beetle Kit Assembly houses 32 beetles. Within the assembly, each beetle is individually enclosed in a Beetle Activity Module, which provides facilities for life support and data recording. The Beetle Kit is self-contained within an aluminum Zero Box that includes lighting and data recording. The Beetle Kit was adapted from an existing item of Russian research hardware. The beetles are not fed or watered during flight but dry oatmeal is glued to the vertical rotor wall in front and in back of the beetle for sustenance. This hardware was developed and certified for the Shuttle.

### **2.2.8 Biological Research in Canisters (BRIC-60)**

The Biological Research In Canisters (BRIC-60) hardware provides a storage container for investigations into the effects of space flight on small specimens. The BRIC-60 canister is an anodized-aluminum cylinder with an upper and lower chamber. These chambers can be flown separately as "half" BRICs or together as "full" BRICs. There are four pressure relief vents in each chamber to meet the rapid depressurization requirements of the Space Shuttle. These vents make a series of convoluted turns in order to maintain a light-tight environment inside the canister chamber. A maximum of twelve 60 mm petri dishes (total of 24 per "full" canister) or thirteen (13) Teflon tubes (total of 26 per "full" canister) can be placed inside each canister chamber. This hardware was developed and certified for the Shuttle.

### **2.2.9 Biological Research in Canisters (BRIC-100)**

The Biological Research In Canisters (BRIC-100) provides a storage container for investigations into the effects of space flight on small specimens. The BRIC-100 canister is an anodized-aluminum cylinder with threaded lids on each end which can allow passive gas exchange of oxygen and carbon dioxide through a semi-permeable membrane. The BRIC-100 is not a light-tight container. This canister provides containment and structural support for the specimen and its associated hardware. The canister can accommodate nine (9) polycarbonate 100 mm petri plates. This hardware was developed and certified for the Shuttle.

### **2.2.10 Biological Research in Canisters (BRIC-100VC)**

The Biological Research In Canisters (BRIC-100VC) provides a closed environment storage container for investigations into the effects of spaceflight on small specimens. The BRIC-100VC canister is a completely sealed, anodized-aluminum cylinder. The top and bottom lids of the canister include quick disconnect valves for gas purging. Using these valves, a specific atmosphere can be sealed inside the canister providing control of the experimental conditions. The BRIC-100VC canister accommodates standard 100 mm laboratory petri plates. The bottom of the canister has sufficient storage space for passive temperature and relative humidity recorders. This hardware was developed and certified for the Shuttle.

### **2.2.11 Biological Research In Canisters (BRIC-LED)**

The Biological Research In Canisters-Light Emitting Diode (BRIC-LED) provides illumination and fixation for small specimen samples. The canister is anodized-aluminum and will provide one level of containment to its contents. Light Emitting Diodes (LEDs) placed inside the canister deliver a specified light wavelength and intensity to each petri dish location within the canister. An interface box provides power to the canisters using an external power source. A

complement set of hardware, the Petri Dish Fixation Unit (PDFU) is a specialized holder for a standard 60 mm petri dish which delivers fixative to the sample within the petri dish. The PDFU is inserted into the BRIC-LED. Each BRIC-LED can house six (6) PDFUs. This hardware was developed and certified for the Shuttle.

#### **2.2.12 Biological Research in Canisters for OptiCells® (BRIC-Opti)**

The Biological Research In Canisters-BRIC-Opti system is designed to provide a closed environment with an atmosphere of known initial composition for microbial growth; provide a support structure for four self-contained OptiCell® culture chambers; provide two redundant levels of containment for potentially hazardous materials; and provide autonomous temperature data logging at each of three physical locations within each canister.

The BRIC-Opti is a sealed aluminum container providing two levels of containment during all phases of operation. The BRIC-Opti has no active thermal control, and specimens are specifically selected to be tolerant of the ambient thermal environment onboard spacecraft. Each BRIC-Opti contains four subelements called OptiCells® that are commercially available from BioCrystal, Ltd. The OptiCell® (P/N 1100) comprises a sealed polystyrene frame with two gas-permeable polystyrene windows. Two self-sealing septa permit introduction of media and inoculum into the interstitial space between the membrane windows.

#### **2.2.13 Biomass Production System (BPS)**

The Biomass Production System (BPS) is a plant growth system that operates in the EXPRESS rack. It includes four independent growth chambers, a nutrient delivery system, a temperature/humidity control system, airflow and atmospheric control systems, a video system and a data-processing system. Each plant growth chamber has a growing area of about 42 square inches (260 square centimeters) and a height of over 6 inches (15 centimeters).

#### **2.2.14 Drosophila Containers and Platforms**

The Drosophila Containers and Platforms provide housing and food for fruit flies. The platform provides the capability to change out food and transfer old food trays with larvae to new clean food tray containers in support of multi-generational studies. This hardware was developed and certified for the Shuttle.

#### **2.2.15 Microbial Cryogenic Canister Assemblies**

The Microbial Cryogenic Canisters provide containment for three 8 ml Cryovials that can be used for microbial growth. The Cryovials are inserted into aluminum vial jackets to provide efficient thermal transfer from the canister to the specimens. The canisters containing the Cryovials can be stored in temperature controlled environments during ascent, on-orbit, and descent.

#### **2.2.16 Plant Growth Experiment Containers (EC) for the EMCS**

The Plant Growth Experiment Containers (EC's) work with the European Modular Cultivation System (EMCS). Each EC has an internal volume of 60 x 60 x 160 mm with a transparent cover and up to 8 of these EC's can be integrated into the EMCS. The EC's work with the EMCS to provide lighting, water, environmental control and monitoring, video, and digital still image capture.

### **2.2.17 Kennedy Space Center Fixation Tube (KFT)**

The Kennedy Space Center Fixation Tube (KFT) is a system designed to contain plant or other small biological samples during flight and chemically fix and stain the tissue samples.

### **2.2.18 Passive Dosimeter System (PDS)**

The Passive Dosimeter System (PDS) hardware consists of two kinds of radiation dosimeters and an electronic "reader." The dosimeters can be placed anywhere in the ISS to provide an accurate point measurement of the radiation at their locations. One of the radiation dosimeters is a thermoluminescent detector, or TLD. These detectors are used to measure incident ionizing radiation (protons, neutrons, electrons, heavy charged particles, gamma and x-rays.) The other type of dosimeter is a set of Plastic Nuclear Track Detectors (PNTDs). The PNTDs are used to measure heavy charged ions radiation. This information is used to improve the accuracy of the radiation dose the TLDs have recorded and to improve the estimate of the biological effects of the radiation.

ESA Exposure facilities:

**2.2.19 EXPOSE:** The EXPOSE facility permit exposure of biological and chemical samples to the direct space environment (incl. vacuum, solar UV, ionizing radiation). Samples are contained in small wells in a variety of different sample carriers, under a small window. The windows are either made of MgF<sub>2</sub> glass which permits exposure to solar UV radiation down to 110nm or quartz, which only passes UV longer than 200nm wavelength simulating the Martian UV environment. The sample wells can be vented to the space vacuum or sealed with an argon or simulated planetary atmosphere (eg. Mars CO<sub>2</sub> atmosphere). Samples can be exposed to the space environment for over 1 year. A typical EXPOSE experiment passively undergoes its mission in orbit: there are no telecommanding or telemetry capabilities provided, neither can the experiments be manipulated by the crew. However, active and passive dosimeters on the facility can record the cosmic and solar UV radiation flux

**Table 2: Hardware Available to Support Biology & Exobiology Research**

For further details and other ISS facilities see the below ISS links.

ISS facilities by Hardware Type:

[http://www.nasa.gov/mission\\_pages/station/science/experiments/Facility\\_Cat.html](http://www.nasa.gov/mission_pages/station/science/experiments/Facility_Cat.html)

Facilities List by Discipline Emphasis Summary:

[http://www.nasa.gov/mission\\_pages/station/science/experiments/Discipline.html](http://www.nasa.gov/mission_pages/station/science/experiments/Discipline.html)

Hardware Available to Support Biology & Exobiology Research	Agency	Website
<b>Biology</b>		
KUBIK	ESA	<a href="http://www.esa.int/spaceflight/kubik">http://www.esa.int/spaceflight/kubik</a>
EMCS	ESA	<a href="http://www.esa.int/spaceflight/emcs">http://www.esa.int/spaceflight/emcs</a>
BIOLAB	ESA	<a href="http://www.esa.int/spaceflight/biolab">http://www.esa.int/spaceflight/biolab</a>
CBEF	JAXA	<a href="http://kibo.jaxa.jp/en/experiment/pm/cbef/">http://kibo.jaxa.jp/en/experiment/pm/cbef/</a>
AQH	JAXA	<a href="http://kibo.jaxa.jp/en/experiment/pm/aqh/">http://kibo.jaxa.jp/en/experiment/pm/aqh/</a>
ABRS	NASA/CSA	<a href="http://www.nasa.gov/mission_pages/station/science/experiments/ABRS.html">http://www.nasa.gov/mission_pages/station/science/experiments/ABRS.html</a>
Beetle Kit	NASA	<a href="#">Cecilia Wigley, cecilia.l.wigley@nasa.gov</a>
BRIC-60	NASA	<a href="http://www.lssc.nasa.gov/fs/lsda/bric60.php">http://www.lssc.nasa.gov/fs/lsda/bric60.php</a>
BRIC-100	NASA	<a href="http://www.lssc.nasa.gov/fs/lsda/bric100.php">http://www.lssc.nasa.gov/fs/lsda/bric100.php</a>
BRIC-100VC	NASA	<a href="http://www.lssc.nasa.gov/fs/lsda/bric100vc.php">http://www.lssc.nasa.gov/fs/lsda/bric100vc.php</a>
BRIC-LED	NASA	<a href="http://www.lssc.nasa.gov/fs/lsda/bricled.php">http://www.lssc.nasa.gov/fs/lsda/bricled.php</a>
BRIC-Opti	NASA	<a href="http://www.lssc.nasa.gov/fs/lsda/BRI_C-Opti.pdf">http://www.lssc.nasa.gov/fs/lsda/BRI_C-Opti.pdf</a>
BPS	NASA	<a href="#">Cecilia Wigley, cecilia.l.wigley@nasa.gov</a>
Drosophila Containers and Platforms	NASA	<a href="#">Cecilia Wigley, cecilia.l.wigley@nasa.gov</a>
Microbial Cryogenic Canister Assemblies	NASA	<a href="#">Cecilia Wigley, cecilia.l.wigley@nasa.gov</a>
EC	NASA	<a href="#">Cecilia Wigley, cecilia.l.wigley@nasa.gov</a>
PDS	NASA	<a href="#">Cecilia Wigley, cecilia.l.wigley@nasa.gov</a>
<b>Exobiology</b>		
EXPOSE	ESA	<a href="http://www.esa.int/spaceflight/expose">http://www.esa.int/spaceflight/expose</a>

## 2.2.20 Biology experiment mission scenarios

Most biology experiments typically require launch and upload of experiment samples & reagents in a dormant or quiescent state, activation and cultivation of the experiment on orbit with possibly sampling, real time measurements/ recordings, fixation then storage of the samples.

Data recorded inflight can be downlinked and samples are returned for postflight analysis. The feasibility of performing an experiment onboard ISS is therefore driven by the available resources for transport of the experiment to/from the station, conditioned temperature stowage, crewtime and experiment and/or facility constraints.

The mission phases of a typical biology experiment are the following:

Preflight preparation: There are several scenario's for preflight preparation. If the preparation of the biological material is not time critical, the experiment can be prepared in the investigators home laboratory or a user support operation center (USOC). Alternatively, if the experiment samples have a limited lifetime (eg. live cell cultures) then it may be necessary to perform the preparation at or near the launch site. In either case the requirements of shipment of the experiment, samples, reagents and equipment need to be considered (eg. time of transport, temperature requirements etc). At the launch site a laboratory facility may be required for experiment preparation, however it is very difficult to provide the same level of facilities as in the investigators laboratory. For example at Baikonur a small laboratory facility is available, with tissue culture capabilities (eg. laminar flow hood, incubator, centrifuge, microscope), but all consumables and specialized equipment needs to be brought to the site by the investigator. Therefore, the preparation activities should be simplified as much as possible to minimize the laboratory requirements.

Preflight installation, launch and transfer to ISS (upload phase): The timeline of this phase of the mission and the conditions available for the experiment vary depending on the launch vehicle. For a Soyuz launch vehicle, the experiment can be loaded as late as 14h prior to launch if required and typically the flight time from launch until transfer to the ISS is in the order of 55-60h. During this time the experiment is exposed to ambient cabin environment (typically in the range of 15-30°C). If a finer temperature tolerance is required it is possible to package the experiment samples in phase change gels or in exceptional cases, a powered incubator (eg. KUBIK) is used. Other vehicles without a crew such as Progress, ATV and HTV typically have late access times of several days before launch and may take several days more to reach station. Furthermore, the experiment may be subject to wider temperature extremes than in the Soyuz.

Operations onboard ISS: Following docking of the transport vehicle, the experiment is transferred to ISS. If the start of the experiment is not time critical, then the experiment equipment and samples will be transferred to stowage. Conditioned temperature stowage can be provided for some samples, including refrigerated (+4°C) and frozen stowage (-80°C). In case the experiment samples have a limited lifetime, the experiment will need to start shortly after arrival at ISS. However, it is very difficult to perform complex activities on the day the transport vehicle arrives at ISS, therefore realistically the first major experiment operations usual can only start the day after docking. The preference is to perform experiment operations with as much automation as possible (eg. automated experiment hardware, automatic facility operations controlled from the ground), although manual experiment operations (eg. Glovebox operations) are also possible. Even with automatic experiment operation some crew activity is required, for example to transfer experiment containers. It is important to have some flexibility in the timing of experiment activities requiring the crew, to facilitate fitting the experiment within the general crew schedule. The current scenario for Soyuz crew rotations foresees a period of 2-4 months between the upload of experiments and download. Therefore, the experiment must be able to survive this period of time on orbit including pre-experiment storage, operations and post-experiment storage.

Return from ISS and early retrieval: The current baseline method for sample retrieval is download in a returning Soyuz vehicle, although other return vehicles may become available at a later phase in ISS operations. Typically, samples are transferred to Soyuz 24-36h prior to landing and maintained at ambient temperature (15-30°C). Some limited passive conditioned temperature stowage (eg. phase change gels) may be available for small samples. Following a nominal landing, samples can typically be transferred to conditioned transport containers within 2-3h and handed over to investigators in Moscow approximately 12-18h after landing.

**2.2.21 Exobiology experiment mission scenario's:** The mission scenario's for exobiology experiments are similar to those for biology experiments, in terms of preflight preparation, upload and download. Deployment of the samples on orbit will usually require an EVA and a separate EVA to retrieve the samples. Therefore, the external exposure time will be less than the total flight time onboard ISS due to the constraints associated with EVA scheduling.

## 3.0 General Support Capabilities

### 3.1 Temperature-Controlled Storage

There are a number of hardware systems and methods for the maintenance of specific temperatures for specimens or preserved samples:

- Ambient Storage (approximately 20°C – 28°C)
- Refrigeration (+4°C)
- Freezing (-20°C to -196°C)

Storage at temperatures outside these ranges can be done, but only for a limited amount of time (few days) (passive temperature control)

Experiment operational requirements, hardware availability, and sample volumes dictate which system or combination of systems is used to accommodate specific experiment objectives.

**Table 3: Hardware Available for Temperature-Controlled Storage**

	Agency	Website
Minus Eighty Degree Life Sciences Freezer	NASA/ESA	<a href="http://www.spaceflight.esa.int/users/index.cfm?act=default.page&amp;level=11&amp;page=1725">http://www.spaceflight.esa.int/users/index.cfm?act=default.page&amp;level=11&amp;page=1725</a>
Passive Thermal Cooling Unit (PTCU)	ESA	

### 3.2 Chemical Fixation

Several options are available to chemically preserve specimens prior to return to Earth for analysis. Fixation cocktails would need to be tested in the specific hardware for biocompatibility. Previous flights have allowed chemical fixation with glutaraldehyde- and formaldehyde-based cocktails, and stabilization with “RNAlater”. The investigator is encouraged to suggest less toxic chemical fixatives to decrease the use of hazardous materials.

**Table 4: Hardware Available for Chemical Fixation**

	Agency	Website
KSC Fixation Tube (KFT)	NASA	<a href="http://www.lssc.nasa.gov/fs/lssa/kft.php">http://www.lssc.nasa.gov/fs/lssa/kft.php</a>

### 3.3 Mass Measurement

The ISS will have the capability to measure the mass of the human body.

**Table 5: Hardware Available to Measure Mass**

	Agency	Website
Body Mass Measurement Device (human)	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/slamm.asp">https://issmp.jsc.nasa.gov/hardware/slamm.asp</a>

### 3.4 Computers

Laptop computers outfitted with mass storage devices, communication adapters, power supplies and cables, and custom-built software are available for use. These laptops support software compatible with a Microsoft Windows operating system.

### 3.5 Radiation Monitoring

A **passive** dosimeter system will be available on the ISS to determine the space radiation dose for payloads. It uses thermoluminescent detectors (TLDs) in combination with plastic nuclear track detectors (PNTDs). The TLDs will be co-located with the PNTDs, and will be distributed throughout the ISS. Typically, neither the TLDs nor the PNTDs can be read-out on board; they have to be returned to the ground to be processed and analyzed in a laboratory. The passive detectors will provide the total radiation dose as absorbed during their stay onboard, as well as the average linear energy transfer (LET) spectrum. The passive detector can accumulate data for periods spanning as long as one year.

Complementing the passive detectors, a number of **active** dosimeter systems will be available on the ISS. Featuring time resolution, the active dosimeters can provide the history of irradiation by cosmic particles. Some active dosimeters deliver real-time or near-real time information. Examples are a tissue equivalent proportional counter (TEPC), and two charged particle directional spectrometers (CPDSs). The TEPC will be moved around the pressurized volume of ISS. The CPDSs have limited real-time data collection capability. One will be housed inside the Habitation Module, and the other, a triple CPDS with 3-axis sensitivity, is located outside on the S0 truss. The intravehicular CPDS is moved from module to module to conduct surveys. Initially, the instruments' first priority will be to support operational measurements, including contingencies. Eventually, the data is expected to become available for payload users.

**Table 6: Radiation Monitoring Tools**

	Agency	Website
Tissue Equivalent Proportional Counter (TEPC)	NASA	
Charged Particle Directional Spectrometer (CPDS)	NASA	
Passive Dosimeter System (RAMs)	NASA	<a href="http://www.shuttlepresskit.com/sts-102/payload86.htm">http://www.shuttlepresskit.com/sts-102/payload86.htm</a> <a href="http://flighthardware-spacebiosciences.arc.nasa.gov">http://flighthardware-spacebiosciences.arc.nasa.gov</a>
Passive Dosimeter System (PADLES)	JAXA	<a href="http://kibo.jaxa.jp/en/experiment/padles/">http://kibo.jaxa.jp/en/experiment/padles/</a>
Passive Dosimeter System (CRDP)	ESA	

### 3.6 Video Imaging

Activities may be documented using video and still cameras. Most habitats for nonhuman specimens provide both data and video downlink.

Various image data taken by video or digital cameras inside of experiment hardware will be accepted by the Image Processing Unit (IPU) through the ISS data network. IPU will encode or edit the image data. NTSC video image inputs will be digitized into MPEG2. Still images will be compressed to TIFF/LZW format and downlinked. The IPU also has capability to store images in removable hard disks.

**Table 7: Video Imaging**

	Agency	Website
Cameras	Various	
Image Processing Unit	JAXA	<a href="http://kibo.jaxa.jp/en/experiment/pm/ipu/">http://kibo.jaxa.jp/en/experiment/ pm/ipu/</a>

### 3.7 Centrifuges

In addition to the centrifuges that are built into various habitats and facilities and the EPM hematocrit centrifuge, a refrigerated centrifuge will be available for processing of biological samples such as blood and saliva.

**Table 8: Centrifuges**

	Agency	Website
HRF Centrifuge	NASA	<a href="https://issmp.jsc.nasa.gov/hardware/rc.asp">https://issmp.jsc.nasa.gov/hardware/rc.asp</a>

### 3.8 Gloveboxes and Specimen Manipulation

Gloveboxes provide an enclosed environment to conduct manipulations of specimen, chambers, other materials, and the science support equipment necessary to conduct experiments in orbit. These gloveboxes have been designed to isolate the crew from potentially hazardous materials used during experiment operations (such as fixations, injections, waste removal, and dissections) while maintaining an internal environment suitable for specimen manipulation. There are also a large number of tools, surgical instruments, and kits designed for a wide range of applications in support of on-orbit biomedical and fundamental biology investigations.

**Table 9: Gloveboxes and Specimen Manipulation**

	Agency	Website
Microgravity Science Glovebox	NASA/ESA	<a href="http://www.nasa.gov/mission_pages/station/science/experiments/MSG.html">http://www.nasa.gov/mission_pages/station/science/experiments/MSG.html</a>
ESA Portable Glovebox	ESA	<a href="http://www.bradford-space.com/pdf/be_datasheet_pgb_sep2006.pdf">http://www.bradford-space.com/pdf/be_datasheet_pgb_sep2006.pdf</a>
BIO LAB Glovebox	ESA	
JAXA Clean Bench	JAXA	<a href="http://kibo.jaxa.jp/en/experiment/pm/cb/">http://kibo.jaxa.jp/en/experiment/pm/cb/</a>

### 3.9 Microscopes

The ISS will provide advanced microscopy capabilities for specimen manipulation and observation with the Light Microscopy Module (LMM). Please see

<http://spaceflightsystems.grc.nasa.gov/Advanced/ISSResearch/Investigations/LMM/documents/LMM.pdf>. This microscope is a modified commercial research imaging light microscope. Objective lenses include 10X (NA 0.3), 40X (NA 0.85), 50X (NA 0.55), 63X (NA 0.7), and 100 X (NA 1.40). However, the 63X and 100X lenses will not be usable until successful demonstration on orbit. Other features include color video microscopy, brightfield, and fluorescence imaging. Wide field fluorescence imaging is supported using the fiber-coupled output of the Nd:YAG laser operating at 532 nm, the 437 nm line of a mercury arc, or appropriate narrow-band filter of the Fluids Integrated Rack (FIR) provided metal halide white light source. The LMM provides an enclosed work area (Auxiliary Fluids Container, AFC) with gloveports and a configurable Equipment Transport Module for transfer of specimens to the LMM. The AFC is sealed to provide a clean working environment and one level of containment.

Future LMM capabilities include darkfield, phase contrast, differential interference contrast (DIC), and confocal microscopy combined in a single configuration. Confocal imagery is accomplished using a Nipkow disk and fluorescence excitation at 532 nm. Confocal microscopy capability is planned to be delivered to the ISS by 2015.

## 4.0 Flight Proposal Evaluation Process

This section describes the evaluation and selection process that will be used for flight experiment proposals submitted to any member agency of the International Space Life Sciences Working Group (ISLSWG) in reply to the coordinated 2009 Space Life Sciences Research Announcements.

Each research proposal must be a complete response to the appropriate individual space agency's official solicitation. In that solicitation, an agency may define a number of critical constraints that proposals must satisfy to be considered for selection. For example, an agency may not accept proposals for work in certain discipline areas. Proposals to these agencies to carry out work that is not responsive to their solicitation will be returned without further review. For this reason, individuals are advised to communicate with their agency officials before submission if there is any doubt of the acceptability of a proposal by the agency in question.

Compliant proposals submitted in response to the Space Life Sciences Research Announcements will undergo an intrinsic scientific merit review. Proposals that receive a passing score in this review will then undergo additional review(s) as follows:

- Flight feasibility review
- Relevance to the programs of the soliciting agencies
- Cost (applicable to proposals submitted to NASA, JAXA, and CSA only)

Proposals will undergo the following three-tiered review process to assess these factors.

### 4.1 Scientific Merit Review

The first review will be a merit review by a panel of international scientific or technical experts. The number and diversity of experts required will be determined by the response to this research announcement and by the variety of disciplines represented in the proposals. The merit review panel will assign **a score from 0 to 100** or a designation of "not recommended for further consideration" based upon the intrinsic scientific or technical merit of the proposal. This score will reflect the consensus of the panel.

The score assigned by this panel **will not be affected by the cost of the proposed work, nor will it reflect the programmatic relevance of the proposed work**. However, the panel will have the opportunity to include in their critique of each proposal any comments they may have concerning the proposal's budget and relevance.

The following will be used to determine the merit score:

- **Significance:** Does this study address an important problem? If the aims of the application are achieved, how will scientific knowledge or technology be advanced? What will be the effect of these studies on the concepts, methods, or products that drive this field?

- **Approach:** Are the conceptual framework, design, methods, and analyses adequately developed, well integrated, and appropriate to the aims of the project? Does a flight proposal build upon a successful foundation of ground studies? Is the proposed approach likely to yield the desired results? Does the applicant acknowledge potential problem areas and consider alternative tactics?
- **Innovation:** Does the project employ novel concepts, approaches, or methods? Are the aims original and innovative? Does the project challenge existing paradigms or develop new methodologies or technologies?
- **Investigator:** Is the investigator appropriately trained and well suited to carry out this work? Is the work proposed appropriate to the experience level of the Principal Investigator and any Co-investigators? Is the evidence of the investigator's productivity satisfactory?
- **Environment:** Does the scientific environment in which the work will be performed contribute to the probability of success? Do the proposed experiments take advantage of unique features of the scientific environment or employ useful collaborative arrangements? Is there evidence of institutional support?

## 4.2 Flight Feasibility Review

A second review will be an evaluation of the feasibility of the proposed work using available facilities on a space platform. The flight feasibility review will be conducted for each flight experiment proposal that receives a scientific merit score greater than a threshold score agreed upon by the ISLSWG Steering Committee. An international team of engineers and scientists experienced in the development, integration and operation of space flight experiments will conduct this review. For this reason, experimental requirements and procedures should be clearly and succinctly explained in terms that a layperson can understand.

In addition to the actual proposal, the information requested in Form C is essential to the flight feasibility review. Flight experiment proposals submitted without the information requested in Form C will not be evaluated.

Of particular concern regarding the feasibility of a proposal is the identification of risk factors which could affect the implementation of an otherwise meritorious proposal. Therefore, the feasibility of implementing the proposal and associated risks will be evaluated using the following technical criteria:

- **Functional Requirements:** Will the planned flight and ground hardware meet the requirements of the experiment? What experiment-unique hardware will be required, and can it be developed in time for projected flight opportunities? Are the number of subjects or specimens required attainable within a reasonable period of time (1-2 years for non-humans, 2-3 years for human subjects) considering projected flight opportunities and other competition for those flight opportunities?
- **Operational Feasibility:** How complex are the experimental procedures? Will the crew have sufficient time to be trained to perform the experiment? Will they have sufficient time in their schedule to perform the experiment? Are the requirements for launch

vehicle loading and unloading of the experiment specimens compatible with the capabilities of these vehicles? Can requirements for data collection on human subjects be accommodated in the preflight and postflight schedules for the astronauts? Has the experimental protocol taken into account the unavoidable period of time between the launch of an experiment and the actual initiation of the experiment? Will the experiment requirements for crew time, experiment volume, mass, power, or other features of on-orbit operations (such as temperature-controlled storage) affect the completion of this or other experiments? What other impacts will the experiment have on activities or experiments planned for the same mission?

- **Environmental Health and Safety:** Are there elements of the proposed ground or flight activities that pose concerns for the health and safety of personnel and/or the environment? For experiments that utilize the crew as research subjects, could the implementation of these experiments, even if considered safe, lead to an impact on their performance with respect to their other crew duties? Is it possible that specific restrictions on the human subjects (such as diet, exercise, etc.) will interfere with their other activities?

Using the risk factors identified in the evaluation, a score will be assigned to indicate this level of uncertainty. The risk assessment score categories are:

**Low Risk:** minimal risk to the successful achievement of objectives

**Medium Risk:** moderate risk to the successful achievement of objectives

**High Risk:** extreme risk to the successful achievement of objectives

The Principal Investigators will not be provided the risk assessment score, but in cases where the decision to not select a proposal is based in part on the technical evaluation, a description of the identified risk factors will be provided.

#### **4.3 Evaluation of Programmatic Relevance and Cost**

A third review will evaluate the programmatic relevance and cost of proposals that meet scientific/technical merit and flight feasibility criteria. This review will be conducted independently by program scientists and managers from each soliciting agency for proposals submitted to their specific solicitations. Programmatic relevance is determined by the contribution of the proposed work to the balance of scientific and technical issues identified by agencies in their research announcements. Review of cost is applicable to proposals submitted to only CSA and NASA. Evaluation of cost will also be performed for proposals submitted to other agencies that include a component requiring CSA or NASA funding. Evaluation of the cost of a proposed effort will include consideration of the realism and reasonableness of the proposed cost and the relationship of the proposed cost to available funds.

#### **4.4 Recommendation for Selection for Further Definition**

The results of the three levels of review will be used to prepare a recommendation for selection for further definition developed by each of the soliciting agencies. This recommendation will be based on:

1. The numerical merit score from the peer review panel
2. The results of the flight feasibility review
3. The programmatic relevance
4. Cost (applicable as described in Section 5.9)

A high merit score does not guarantee selection. A proposal must also be feasible to implement, have programmatic relevance, and have reasonable projected costs to be selected. The members of the ISLSWG will meet to ensure appropriate coordination of all their selections to optimize science return and resource utilization. For example, the composite selection will not greatly exceed the projected flight opportunities. In addition, it may be more efficient or effective to form international teams of researchers requiring similar resources to address overlapping questions than to have individuals competing for the use of the same specimens or test subjects. Such teams are best formed at the time of selection and early in the experiment definition period, rather than later during the flight experiment development process.

Following this coordination meeting of the ISLSWG, each agency will finalize and announce its own selections.

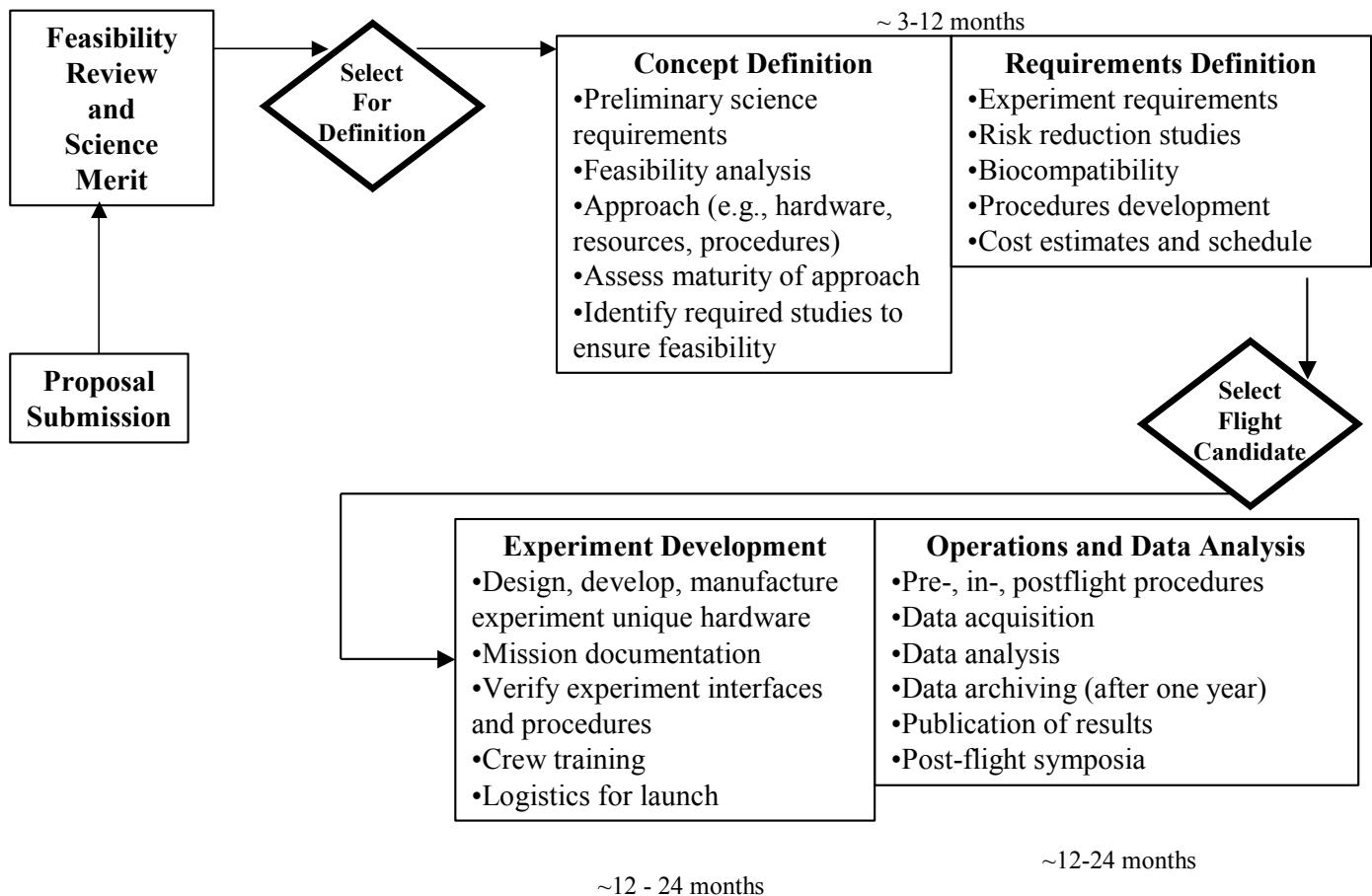
#### **4.5 Flight Experiment Implementation**

Applicants should be aware that flight experiment implementation is a multi-step process (Figure 2). Following the complete review of flight proposals, successful investigators will receive a letter informing them that their experiment has been selected for entry into a definition period. During the definition period, the agency with management responsibility for the experiment will interact with the investigator to determine specific hardware and operational requirements needed to achieve the proposed objectives. Identification of issues that will affect implementation of the space flight experiment and refinement of the funding requirements are key components of the definition period. After successful completion of the definition period, the experiment will be selected for flight and will enter a development period, leading eventually to implementation on a space mission. Detailed budgets will be refined or negotiated for each flight experiment during each period. The flight experiments selected will be reviewed every year and may be deselected based on the policy of each agency for deselection. One or more of the following conditions may warrant deselection:

1. Definition activities have indicated that the experiment is technically infeasible or so high risk that successful completion is unlikely.
2. Ground-based studies conducted as part of the definition period, or related research in the field, produce results that demonstrate the hypothesis of the flight experiment to be flawed.

3. The projected costs of the experiment, as determined during definition, are significantly greater than anticipated funding levels will support.
4. The investigator does not maintain a reasonable publication record in peer-reviewed journals in the specific research area to which the flight experiment is directed or with the results from previous flight experiments.
5. The experiment has been in the definition period for three or more years, due to either the lack of flight opportunities or the failure on the part of the investigator to complete definition activities.
6. Weaknesses identified in the scientific evaluation of the original proposal were not addressed during the definition period.
7. Funding limitations require reduction in the flight program. In such cases, the original proposal and critiques, the cost of the investigation, the ongoing publication record, and the length of time the investigator has been in definition will be considered in determining which experiments will be deselected.

Figure 2: Experiment Definition and Selection for Flight Process



## **5.0 International Application Forms and Instructions for Proposal Preparation**

This section contains the general instructions for submission of a letter of intent, proposal preparation, and the specific forms required to agency solicitations for flight experiments in the Space Life Sciences for 2009. *Applicants are also referred to Agency specific Announcements for further instructions.*

The following forms are included at the end of this section:

- Biographical Sketch
- Space Flight Experiment Requirements Summary

### **5.1 Letter of Intent**

A letter of intent (LoI) to submit a proposal is requested by **June 15<sup>th</sup>, 2009**. LoIs should be submitted online through the European Science Foundation (ESF) web site (URL below). Note: U.S. applicants should submit their LoIs through NASA's Proposal System NSPIRES.

**<http://www.esf.org/loi/ilsra>**

LoIs include the following information:

Science Team Coordinator's contact details and institution  
Science Team Members' contact details and institutions  
Project Title, acronym and abstract  
Project Summary  
Keywords and research area(s)

### **5.2 General Instructions for Proposal Preparation**

The information contained in these instructions is specific to the research solicitations and repeats or supplements the general guidance provided in agency specific announcements.

Proposals should be submitted online through the European Science Foundation (ESF) web site (URL below) by **September 14<sup>th</sup>, 2009**. Note: U.S. applicants should submit their proposals through NASA's Proposal System NSPIRES.

**<http://www.esf.org/ilsra>**

The online submission process includes several steps, during which proposers will be asked to fill in the proposal title, acronym, abstract and science team contact details (proposers will be asked to fill in online the names and full contact details of the Science Team Coordinator and all Science Team Members, specifying the members' institutional affiliations). Mandatory fields are specified in the forms (see § 5.3). A signature version of this form will not be requested.

The information submitted will then be compiled by the system. Proposers will then be required to upload their proposal, established following participating agencies' guidelines. The compiled information and the uploaded proposal will then be automatically merged and

forwarded to proposers. This document, stored in the ESF database, will represent the reference document for future queries.

**All international proposals to be uploaded by proposers must be contained in one single and non-protected pdf document, and include the following material, in this order:**

- (1) Project Description (see § 5.4)
- (2) Management Approach (see § 5.5)
- (3) Biographical Sketches (see § 5.6)
- (4) Special Matters: specific information on human subjects protocol approval required, if applicable and with signature (see § 5.7)
- (5) Appendices, if any; reviewers are not required to consider information presented in appendices (see § 5.9)
- (6) Space Flight Experiment Information Summary (see § 5.10)

Additional information may be requested by certain agencies.

The Project Description section is limited to twenty (20) pages. Pages beyond the 20-page limit in this section will not be reviewed. There is no specific page limitation on other sections of submitted proposals. However, every effort should be made to keep proposals as brief as possible. *The name of the Science Team Coordinator should appear in the upper right hand corner of each page of the proposal, except on the forms in this document where special places are provided for this information.*

The following paragraphs provide instructions for completing the applications.

### **5.3 Online submission forms**

Proposers will be asked to fill in online the names and full contact details of the Science Team Coordinator and all Science Team Members, specifying the members' institutional affiliations. Mandatory fields are specified in the forms. A signature version of this form will not be requested. Furthermore proposers must provide an abstract and proposal acronym, and specify relevant keywords and research areas. The information requested in this part of the form is essential to the review of the proposal.

### **5.4 Project Description**

The length of the Project Description section of the proposal should not exceed twenty (20) pages using regular (12 point) type. The proposal should contain sufficient detail to enable a reviewer to make informed judgments about the overall merit of the proposed research and the probability that the investigators will be able to accomplish their stated objectives. The proposal should clearly indicate the relationship between the proposed work and the research emphases defined in the agency-specific solicitations. The development of a clear hypothesis, along with the available data evidence, should be emphasized in this section. In addition, the proposal should provide evidence of completed or planned ground research to justify the flight experiment. In particular Science Team Coordinators should refer to agency-specific solicitations for instructions regarding additional information that should be included in the proposal.

## **5.5 Management Approach**

Each proposal must specify a single Science Team Coordinator who is responsible for carrying out the proposed project and coordinating the work of other personnel involved in the project. In proposals that designate several senior professionals as key participants in the research project, the management approach section should define the roles and responsibilities of each participant and note the proportion of each individual's time to be devoted to the proposed research activity. The proposal must clearly and unambiguously state whether these key personnel have reviewed the proposal and endorsed their participation.

## **5.6 Personnel/Biographical Sketches**

The Science Team Coordinator is responsible for direct supervision of the work and must participate in the conduct of the research regardless of whether or not compensation is received under the award. A short biographical sketch of the Science Team Coordinator, including his or her current position title, educational background, a list of major publications, and a description of any exceptional qualifications, must be included. In chronological order (concluding with present position), list previous employment, experience, and honors. Include present membership on any government public advisory committees. List, in chronological order, the titles, all authors, and complete references to all publications during the past three years and to representative earlier publications pertinent to this application. If the list of publications in the last three years exceeds two pages, select the most pertinent publications. Do not exceed two pages. Omit personal information that does not merit consideration in evaluation of the proposal. Complete this part of the application for other senior professional personnel who will be directly associated with the project. Provide the names and titles of any other scientists and technical personnel associated substantially with the project in an advisory capacity. Universities should list the approximate number of students or other assistants, together with information as to their level of academic attainment. Any special industry-university cooperative arrangements should be described.

## **5.7 Special Matters**

The Special Matters section must contain appropriate statements regarding human subject provisions. Investigators should refer to agency-specific solicitations for instructions on this section.

## **5.8 Letters of Collaboration/Support**

Include letters of support from collaborators. Please refer to the individual agency's Space Life Sciences Research Announcement about including a **Letter of Assurance of Foreign Support**.

## **5.9 Appendices**

*Appendices may be included, but investigators should be aware that reviewers are not required to consider information presented in appendices.*

## **5.10 Space Flight Experiment Requirements Summary**

All applicants proposing space flight research must provide the information requested on this form. The information on this form is essential for the technical evaluation of the feasibility of the proposed study. In addition, it should be used by the investigator to determine all required components of the flight experiment, from preflight preparation and data collection to tests and data/specimen processing. Before filling out this form, applicants should read Sections 1 and 2 of this document carefully to make certain that they understand the constraints that are associated with flight experiments. This form is used primarily by a team of technical experts which does not necessarily have expertise in every area of science. Be sure to clearly and succinctly explain all experiment requirements, from trivial to grand, in terms that an intelligent non-scientist can understand. The Science Team Coordinator should contact the appropriate Agency Point of Contact for questions or clarification before submitting a proposal.

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### **BIOGRAPHICAL SKETCH**

Provide the following information for the key personnel.  
Photocopy this page or follow this format for each person.

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NAME	POSITION TITLE

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training).

INSTITUTION(S) AND LOCATION	DEGREE(S) (if applicable)	YEAR(S)	FIELD(S) OF STUDY

RESEARCH AND PROFESSIONAL EXPERIENCE: Concluding with present position, list, in chronological order, previous employment, experience, and honors. List, in chronological order, the titles, all authors, and complete references to all publications during the past three years, and to representative earlier publications pertinent to this application. If the list of publications in the last three years exceeds two pages, select the most pertinent publications. **DO NOT EXCEED TWO PAGES.**

## SPACE FLIGHT EXPERIMENT REQUIREMENTS SUMMARY

In addition to the actual proposal, this part of the proposal is required for the Flight Feasibility Review. This form has been designed for a description of all pre-flight, in-flight and post-flight components of the flight experiment. It consists of two sections:

- A section to be completed only for experiments that require human subjects, and
- A section to be completed only for experiments that require non-human specimens i.e. biology and/or exobiology experiments.

If an experiment requires both human and non-human specimens, both forms must be completed. If no specimens are required (e.g., radiation dosimetry), complete applicable hardware and procedures questions as required. If the proposal consists of distinct segments with different requirements, fill out multiple forms to fully describe all segments. **This form is mandatory for flight experiments.** Flight experiment proposals submitted without this completed form will not be evaluated.

Please read the questions carefully and keep answers brief but thorough, ensuring that all requested information has been provided. Expand tables/response space as needed.

## Part I: Research Involving Crewmembers as Subjects

Science Team Coordinator name: \_\_\_\_\_

Proposal title: \_\_\_\_\_

---

1. Subjects
  - a. Number of subjects required for statistical significance:
  - b. Special requirements (e.g., gender, age, etc.):
  - c. Are inflight procedures needed?
  - d. Are pre- and post-flight procedures needed?
2. List all human subject restrictions (*e.g., specific dietary regimens, fluid intake regulation, work/rest cycles, exercise, etc.*). *Indicate the impact on scientific outcome if restrictions cannot be met.*
3. Is loading of experiment supplies or equipment less than 90 hours before launch required? If so, explain why.
4. Is removal of the experiment samples, data, or equipment less than 24 hours after landing required? If so, explain why.
5. What procedures will the crew need to learn in order to perform their role as subjects for the experiment?  
*List and briefly describe each procedure separately. Be sure to rate the difficulty of learning each procedure (1=easy; 10=difficult) and indicate when each procedure will be used (e.g., preflight, inflight, post-flight). Assume that the crewmembers do not have a medical background or prior experience with these kinds of experiments.*

6. Does the experiment require a person to assist (operator) with data collection? If so, what procedures will be performed by this person?

*List and briefly describe each procedure separately. Be sure to rate the difficulty of learning each procedure (1=easy; 10=difficult) and indicate when each procedure will be used (e.g., preflight, inflight, post-flight). Assume that the crewmembers do not have a medical background or prior experience with these kinds of experiments.*

7. Equipment for human subject measurements

*Add more lines if necessary.*

a. Pre- and Postflight

What Variable will be Measured?	Equipment Needed for Measurement	Equipment Provider (Agency or PI)
1.		
2.		
3.		
4.		

b. Inflight (*List ALL needed inflight equipment for measurement, sample collection, or storage.*)

What Variable will be Measured?	Equipment Needed for Measurement	Equipment Provider (Agency or PI)
1.		
2.		
3.		
4.		

8. Is real-time data transmittal either required or highly desirable? (*“required” means that the experiment cannot be performed if downlink is not available; “highly desired” means that the experiment data will be transmitted if the downlink is available.*)
  
9. List special requirements for sample accommodation or manipulation.
  
10. Biological samples collected on the ISS may have to be stored on the station for a year or longer.. *Describe the requirements for preserving those samples (thermal control, preservatives, etc.).*
  
11. List each procedure that must be performed on each (crewmember) subject to meet experimental objectives. *Indicate the timeframe (e.g., launch minus 60 days (+/- 5 days)) and estimated procedure duration (e.g., 60 minutes). Specifically state if data must be collected on landing day (R+0) or if R+1 or 2 day will suffice.*
  - a. Pre-/ Postflight procedures
  
  - b. Inflight procedures

## Part II: Research: Biology & Exobiology

Science Team Coordinator name: \_\_\_\_\_  
Proposal title: \_\_\_\_\_

Use the table below to list the requirements for non-human specimens. *Add more rows if necessary.*

Biological sample / Specimen type (eg. species, strain, age etc)	Treatments / conditions (eg. activators, drugs, tracers, fixatives)	Required g-levels	Number of samples required for each g-level / condition

General description of experiment protocol: *Describe in general terms the types of procedures required for the experiment from preparation of the experiment in the lab until postflight handover of the sample to the investigator.*

- Parameters measured: *Describe the type of parameters measured inflight, such as realtime / recorded measurements (eg. temperature, with accuracy & time resolution, timing of experiment steps) and parameters measured in postflight analysis*
  - *Inflight parameters measured;*
  - *Postflight parameters measured*
- Imagery requirements: *List any requirements for photography or video observation / recording of samples*
  - Photography:
  - Video
- Requirements on telemetry / data downlink / storage: *List any potential requirements for telemetry downlink (e.g. fluorescence measurements, facility housekeeping data, downlink of photo's)*
- Requirements on commands uplink: *List any potential need for remote command of the experiment & whether this is dependant on downlink of telemetry from the experiment (eg. modification of experiment timeline based on results of video observation)*

Ground reference experiment(s): *Indicated whether a ground control reference experiment*

Pre-launch late access: Specify the maximum and preferred period in hours that can be accepted between hand-over of the experiment and transfer to either ISS stowage or activation on orbit

Early retrieval: Specify the maximum and preferred time in hours between landing & hand-over of the experiment samples that can be accepted.

Describe the method for delaying experiment activation until it is installed on the ISS (eg. dry unactivated seeds or cultures, freezing).

Describe the method for preserving samples after the experiment run for up to 365 days, or longer, on the ISS (eg. freezing, refrigeration, dessication).

Hazardous materials and controlled/radioactive substances used in experiment

What is the preferred sample layout for the experiment? (Number of samples per condition) What is the minimal sample layout?

What is the estimated mass and volume of each sample?

**Experiment Steps:** Use the table below to list the experiment steps from prelaunch experiment hand-over until postflight retrieval, with the required environmental parameters & allowable range for each parameter. Add rows as necessary:

Experiment Step description	Duration (preferred, min & maximum) *1	Temperature (preferred, min & maximum) *2	Gravity requirements (eg. micro-g or 1.g control) *3	Humidity & gas composition requirements (eg. CO2, ethylene) *4	Light requirements *5	Data, imagery or other requirements *6

\*1 - Specify duration of experiment step, including margins (i.e preferred time, minimum & maximum acceptable times if known)

\*2 - Specify required temperature of experiment step, including margins (i.e. preferred temperature, minimum & maximum temperature if known)

\*3 - Specify required g-levels (ie. Microgravity, 1.g reference control, intermediate g-level & any requirements on quality of g-level)

\*4 – Specify any requirements for humidity control, (including preferred, maximum and minimum rh if known), gas composition, including oxygen and CO2 concentrations / pressure. Also indicate if there are any requirements concerning maximum allowable trace gas concentrations (eg. Ethylene)

\*5 – Specify light requirements, flux, quality / spectrum, light dark cycles as applicable. For exobiology experiments include the solar UV wavelength ranges desired (eg. >110nm, or >200nm to simulate Martian conditions)

\*6 – Specify data requirements, such as temperature logging , imagery requirements, eg. Photo / video, frequency of imaging, and any additional requirements not covered by the other columns in the table