Plant Habitat (PH)

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General Overview

- Plant Habitat (PH) is a large enclosed environmentally controlled chamber that will support research on larger plant species.
  - Designed for longer duration generational genetic studies
  - Tracking and controlling environmental parameters: Temperature, Relative Humidity, CO$_2$ Levels, Light Intensity, Spectral Quality

- PH was designed to maximize science.
  - Quad-Locker size Payload
  - Planned to be installed in EXPRESS Rack #5 (Locker locations 3, 4, 7, and 8)
  - Will utilize a powered ISIS location
  - The APH utilizes a distributed architecture allowing ease of replacement of Orbital Replaceable Units (ORU’s) as well as the potential for future updates for custom applications.
  - Science Growth Area: 1,708 cm$^2$ (Shoot Height 45 cm; Root Height 5 cm)
  - Science Growth Volume: 112,500 cm$^3$

- PH Facility is manifested on OA-7 (Dec 2016)
- PH-01 (first science experiment) is manifested on SpaceX-13 (Sept 2017)
General Overview

APH Flight Unit #1 in GSE Cart

APH in EXPRESS Rack #5
Exploration Research and Technology Programs

Utilization and Life Sciences

General Overview

- APH to launch within 7-8 soft stowage bags - images to the right show each separately launched item
  1. M03 size bag for the SMA and ORU Component Drawer
     - ORU Component Drawer includes all ORUs installed inside
  2. M01 size bag for the Growth Chamber
  3. Science Carrier will launch within a separate bag (size TBD) along with any experiment unique equipment (EUE)
  4. Growth Light Assembly
  5. ISIS Drawer
  6. AFA Drawer
  7. Two ECS Units, plus a 3rd spare
  8. Bottom Pan
     - Can launch upside-down inside the SMA to conserve up-mass

External cables/hoses and sample kits will be stowed within the Growth Chamber, otherwise another bag will be used
General Overview

- EXPRESS Rack Resources Requirements:
  - Four 28 VDC power feeds with maximum 1500 W total power
  - Avionics Air Assembly (AAA) Fans
  - Moderate Temperature Loop (MTL) with 140 lbs./hr. flow
  - Rack Interface Controller (RIC) Ethernet
  - Gaseous Nitrogen
  - EXPRESS Laptop Computer (ELC)
APH provides accurate control and/or monitoring of:
- Temperature
- Relative Humidity
- CO₂ Concentration
- Ethylene Scrubbing
- Light Level, Quality, and Photoperiod
- Water Delivery
- O₂ Concentration
- Chamber Pressure
- Ventilation Flow Rate (.3 to 1.5 m/s)

APH also provides:
- Data Acquisition
- Imaging
Environmental Control System
Temperature and Humidity

- **Temperature:**
  - Provides Control of temperature from 18 °C to 30 °C.
  - Control of temperature is to within +/- 1 °C.

- **Humidity:**
  - Provides Relative Humidity control over the range from 50% to 90%.
  - RH control accuracy of +/- 5%.
Environmental Control System
Carbon Dioxide and Ethylene

- Carbon Dioxide:
  - 400 ppm $\rightarrow$ 5,000 ppm (50 ppm or 3%).

- Ethylene:
  - $< 25$ ppb
Environmental Control System
Carbon Dioxide and Ethylene

- Powered ISIS Drawer:
  - Provides structure and access to the two CO$_2$ Bottles for the ECS subsystem

- Air Filtration Assembly (AFA):
  - AFA Drawer contains CO$_2$ and C$_2$H$_4$ scrubbing system
Growth Light Assembly

- Provides light required for plant growth via an array of high-power light-emitting diodes (LEDs)
  - Blue: 0-400 µmol m-2s-1 +/- 5%
  - Green: 0-100 µmol m-2s-1 +/- 5%
  - White: 0-600 µmol m-2s-1 +/- 5%
  - Far red: 0-50 µmol m-2s-1 +/- 5%
  - Infrared: Fixed value between 80 and 150 µmol m-2s-1
  - Maximum integrated level: 1000 µmol m-2s-1
Water Recovery and Distribution System

- Capable of providing up to 2.6 Liters/Day of fluid while controlling to a pressure setpoint (for plants this would be delivered to a Science Carrier).
- Control can be distributed to up to 4 independent lines (for plants this allows for four independent control zones).
- Flow can be up to ~1.6 Liters/min, for a limited time (1-20 seconds).
- Pressure control range: -5 kPa to +2 kPa.
- Two reservoirs:
  - Distribution Reservoir volume: 2 Liters.
  - Recovery Reservoir volume: 1 Liter.
  - Ability to transfer fluid between reservoirs.
- Front panel fill, drain/sampling of reservoirs.
- Compatible with water/nutrient solutions and select biocides.

WRADS
in ORU Drawer
Growth Chamber

- Oxygen control - Maintains the growth chamber atmospheric oxygen concentration between 18% and 24%. (utilizes Nitrogen injection for reduction of O2 levels)
- Chamber internal pressure - Maintains the growth chamber pressure to within ± 3.4 kPa of ISS cabin pressure.
- Air speed - 0.3 to 1.5 m/s +/- 0.1 m/s
  - Chamber Air Exchanges (5-26 per min)
Growth Chamber Imaging

- 3 Independent Cameras:
  - 1 Overhead View (Color – limited Infrared)
  - 2 Side View (Color and Infrared)
- Imaging provides investigators with ability to gather visual information on experiment.
- Visual indicators within chamber.
Science Carrier

- Baseline Configuration includes:
  - Temperature sensing
  - Moisture sensing
  - $O_2$ concentration sensing
- Science Carriers are Experiment Unique, due to modular architecture.
- Custom experiment configurations are possible (including non plant based).

Flight Science Carrier

Prototype Science Carrier
Dwarf Wheat
Summary

- Plant Habitat will be the largest plant growth chamber on ISS responding to the NRC Decadal Survey & SLPS strategic plan.
- Plant Habitat will conduct fundamental plant biology testing which could include plant based life support development.
- Plant Habitat can be utilized to support other science investigation requiring precise and accurate control of environmental parameters:
  - Microbial and other biological organism research
  - Biotechnology research
  - Materials experiments