ARC EMCS Experiments
(Seedling Growth-2)
Experiment Status

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Wyle Labs (FILMSS)

POIWG #37
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Experiment Hardware

All the ARC ISS Space Biology Project EMCS Experiments use the same hardware suite.
- Proven **highly successful** starting with the Tropi series of experiments in 2006.

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**EMCS Facility**

- EMCS Experiment Containers (ECs)  MWA set up for Sample Processing with ARC-developed EUE

- ARC Cassettes (5 per EC)

- EMCS Cold Stowage Bag with Cassettes
The Seedling Growth Experiments

BACKGROUND

The Seedling Growth experiment series is the result of a cooperative agreement between NASA and ESA to combine the proposals of a NASA PI and an ESA PI to maximize science return.

- NASA PI: Dr. John Kiss.
  - Emphasis on plant tropic responses using EMCS Image Data.
- ESA PI: Dr. Javier Medina.
  - Emphasis on structure and biochemistry using frozen samples.

Three Seedling Growth experiments are SG-1, SG-2 and SG-3.
- SG-1 NASA-led. (complete)
- SG-2 NASA/ESA 50/50. (RT Ops complete, on orbit awaiting SpX-5 return)
- SG-3 ESA-led. (in development, manifested Inc 45/46)
Seedling Growth-2

ARC EXPERIMENT PERSONNEL

Principal Investigators: John Z. Kiss, Ph.D., University of Mississippi, MS (NASA)
                      F. Javier Medina, Ph.D., CIB-CSIC, Madrid, Spain (ESA)

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Seedling Growth-2

**N-USOC Team Members**
- Knut Fossum
- Mona Schiefloe
- Liz Helena Coelho
- Brit-Eli Danielsen
- Knut Olav Helleseng
- Karl Eric Hancock
- Tore Martin Hauan
- Irene Karoliussen
- Basit Mohammad

**EADS/Astrium Team Members**
- Maria Birlem (SG-2 EMCS PIM)
- Reinhard Born

**MSFC POIC SUPPORT**
- Amy Haas (SG-1 & 2 PIM)
- Kevin Hargrave (Ops Lead)
- Chris Traylor (PARC)
- Entire POIC Cadre
Seedling Growth-2

EXPERIMENT SUMMARY

The objective of the Seedling Growth-2 experiment is to determine how gravity and light responses in plants influence each other and to determine the combined influences of light and gravity on plant development through the identification of changes in the mechanisms and regulation of essential cellular functions. These experiments rely in a large part on the use of known Arabidopsis thaliana mutant plants that are genetically altered in specific light-, auxin- or cell division-regulated processes.

Launch: SpaceX-4, Sept 21, 2014
Operations: Increment 41/42
Return: SpaceX-5 Feb TBD 2015

• Three 6-day runs were planned and completed:
  Nov 1-7 - Primarily supports Dr. Medina’s objectives - at 0 and 1.0 g
  • Eight ECs, used both EMCS rotors.
  • One EC (FM-030) failed to hydrate
  Nov 8-14 - Continuation of Dr Kiss’ SG-1 objectives - photo-stimulus given at 0.5 g
  • Four ECs, used 1 EMCS rotor only
  Nov 15-21 - Continuation of Dr Kiss’ SG-1 objectives - photo-stimulus given at 0.8 g
  • Four ECs, used 1 EMCS rotor only
Although much of the operation of the EMCS is under the control of scripting software and ground commanding, crew involvement is required for EC loading into EMCS and during the end of run processing. CDR Butch Wilmore performed all these activities methodically and well, and holds the speed record for processing ECs on the MWA!!
Seedling Growth-2 - Images

Images from Run 3 at 88 hours after hydration (Genotype tir 1)

Some roots get a little “lost” in micro-g, shoots are oriented by the white light above.
Seedling Growth-2 - Images

Older seedlings responding to a red light stimulus

Both roots and shoots are bending towards the red LED light source
Seedling Growth-2

EXPERIMENT SUMMARY
An additional activity was re-planned and executed to investigate the failed hydration of EC FM-030

- An additional diagnostic test and 6-day run was completed:
  Only possible with intense re-planning of activities and co-operation with ESA and NASA Management, POIC, N-USOC, EADS Airbus, PIs, Science, Engineering and Operations teams.

  This was truly a team effort and provided additional science to the PI, and diagnostic data to engineering.

Dec 9 - Engineering diagnostic and repeated hydration commands
- Partial success hydrating FM-030 (3 out of 5 cassettes hydrated)

Dec 9-15 - 6-day run at 0g
- Run at 0g as FM-030 not balanced by Reference EC in A3
- Obtained additional images and biomass for PIs from 1 EC
- No Image data obtained from cassette 3 (obscured by condensation - cassette heater malfunction suspected.)
Seedling Growth-2

EXPERIMENT SUMMARY

• All four runs provided scientific return for the PIs
  • Images of seedling growth and tropic responses were captured for PI's analysis
  • Seed cassettes were removed from ECs and transferred to MELFI at the end of each run
  • Frozen samples and empty ECs are planned to return on SpX-5 (Feb 10 TBC, 2015)
    • Frozen samples return to S. California in GLACIER (or other powered CS resource)
    • ARC Representative will receive samples from JSC Cold Stowage Group at CA early access
    • Samples transferred to ARC Lab for stabilization procedure by PI representative.
    • After stabilization, ESA will arrange shipping logistics to PI lab in Spain for analysis.

• Both NASA and ESA PIs have expressed their great appreciation for the extra efforts of the entire team who made the successful performance of the Seedling Growth-2 payload possible, and provided the flexibility of planning to react to the hydration failure, providing additional science samples that will enhance the return.
## Acronyms

<table>
<thead>
<tr>
<th>ARC</th>
<th>Ames Research Center</th>
<th>MSFC</th>
<th>Marshall Space Flight Center</th>
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<tbody>
<tr>
<td>ASAP</td>
<td>As Soon as Possible</td>
<td>MWA</td>
<td>Maintenance Work Area</td>
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<tr>
<td>EADS</td>
<td>European Aeronautic Defense &amp; Space Company</td>
<td>NASA</td>
<td>National Aeronautics and Space Agency</td>
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<tr>
<td>EC</td>
<td>Experiment Container</td>
<td>NET</td>
<td>No Earlier Than</td>
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<td>EMCS</td>
<td>European Modular Cultivation System</td>
<td>N-USOC</td>
<td>Norwegian User Support Operations Center</td>
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<td>ESA</td>
<td>European Space Agency</td>
<td>OVT</td>
<td>Operations Verification Test</td>
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<td>EUE</td>
<td>Experiment Unique Equipment</td>
<td>PARC</td>
<td>Payload Activity Requirements Coordinator</td>
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<td>Experiment Verification Test</td>
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<td>Payload Developer</td>
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<td>EXAM</td>
<td>Experiment Activity Manager (N-USOC)</td>
<td>PI</td>
<td>Principal Investigator</td>
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<td>FTP</td>
<td>File Transfer Protocol</td>
<td>PIM</td>
<td>Payload Integration Manager</td>
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<td>General Laboratory Active Cryogenic ISS Experiment Refrigerator</td>
<td>POC</td>
<td>Point of Contact</td>
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<td>ISS</td>
<td>International Space Station</td>
<td>SpX</td>
<td>Space-X</td>
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<td>JSC</td>
<td>Johnson Space Center</td>
<td>TBC</td>
<td>To Be Confirmed</td>
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<td>MELFI</td>
<td>Minus Eighty Laboratory Freezer for ISS</td>
<td>TBD</td>
<td>To Be Determined</td>
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<td>Multi Mission Operations Center</td>
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Back-up Slides

The ARC Seed Cassette