THE UNIVERSITY OF ARIZONA®

Convegno organizzato dalla regione Lazio e Aero-Sekur
Auditorium di Palazzo Italia
Milan Expo 2015, Milan, Italy

"Seminare nel Futuro Raccogliere nel Presente"

"Agrospace Studies Benefit Space Agriculture and Earth Applications in Food Production"

Prof. Gene A. Giacomelli, PhD

UA-CEAC
The University of Arizona
College of Agriculture & Life Sciences
Controlled Environment Agriculture Center (CEAC)

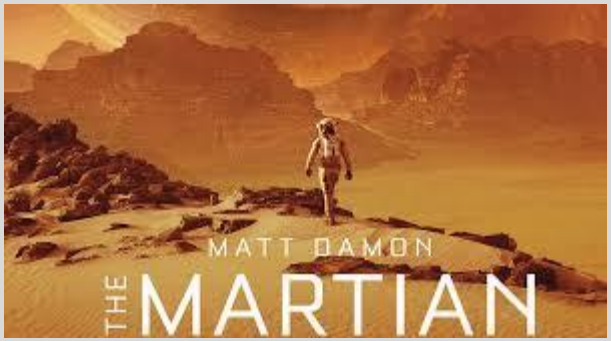
October 18, 2015

LAZIO INNOVA

REGIONE LAZIO

ARIZONA COLLEGE OF AGRICULTURE AND LIFE SCIENCES CEAC Controlled Environment Agriculture Center

AERO SEKUR



A movie with Matt Damen
and discussion of reality from Gene Giacomelli

After my introduction, play the 2 minute video at this link:
https://arizona.app.box.com/s/h9olrdjspwav5debqxbi6t97kzlqtrye/1/4914104993/39807368413/1

THE UNIVERSITY OF ARIZONA®

Arizona/NASA Ralph C. Steckler Space Grant Colonization Research and Technology Development Grant

Phase Reviews

Washington, DC

"Mars-Lunar Greenhouse Prototype for Bioregenerative Life Support System"

Tim Swindle,
Arizona NASA Space Grant PI

Susan Brew,
Arizona NASA Space Grant Program Manager

Roberto Furfaro, Principal Technical Investigator
Gene Giacomelli, Co-Principal Technical Investigator

University of Arizona

ARIZONA SPACE GRANT CONSORTIUM

NASA

Primary Collaborators

The University of
Arizona

Systems and Industrial Engineering
Controlled Environment Agriculture Center
Agricultural & Biosystems Engineering

Aero-Sekur, SpA
Sadler Machine Company
Thales Alenia-Space (TAS-I)
Hungry Planets Systems
NASA-KSC
NASA-Ames
National Research Council, Italy
University of Naples Federico II
University of Southern California
University of Tuscia
Pima Community College
Safford Middle School

Consiglio Nazionale delle Ricerche

The NASA Steckler Space Grant Prototype Mars- Lunar Greenhouse program

- 15 years research at University Arizona, UA-CEAC
- collaboration with Sadler Machine Co
  beginning with the South Pole Food Growth Chamber through Raytheon Polar Services Company and National Science Foundation (NSF),
- with continued sponsorship by NASA, various aerospace companies including Italy's Aero-Sekur and Franco-Italian, Thales Alenia Space

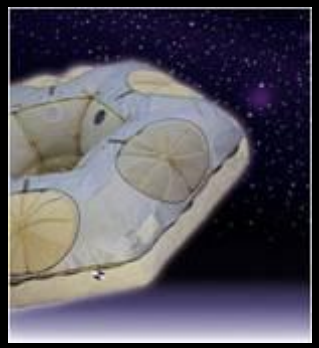
AERO SEKUR

ThalesAlenia Space
A Thales / Finmeccanica Company

Sadler Machine CO

AERO SEKUR

Aero Sekur is a specialist supplier of safety systems and advanced flexible materials to the global aerospace and defense markets. The company has extensive manufacturing and R&D facilities in Italy and representation worldwide. The core competency of the business is the design and development of advanced engineered structures using flexible materials.

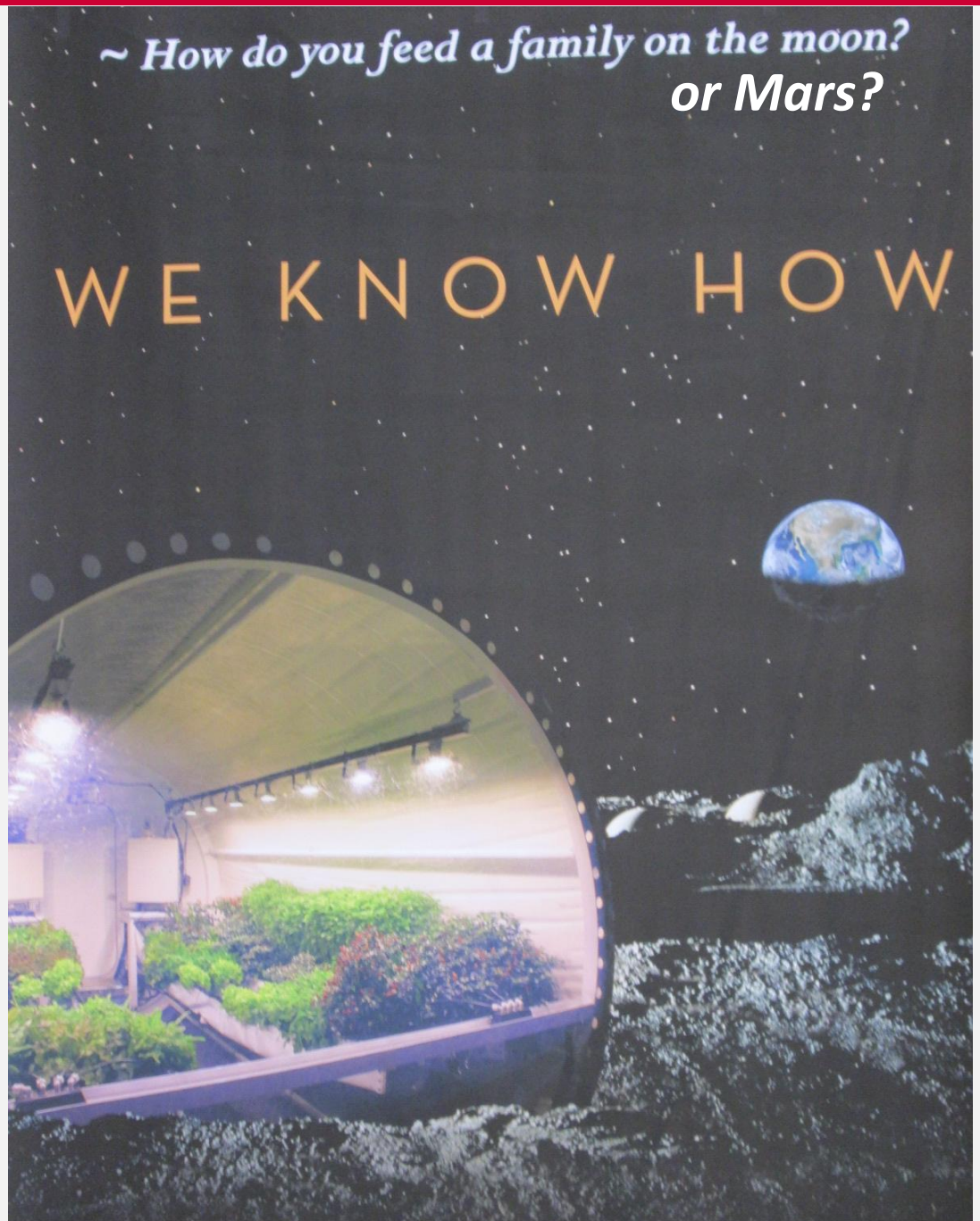


Why are we here today?

(other than the obvious!)

One cannot
Think well,
Love well,
Sleep well,
if one has not
Eaten well.

Osteria Philly, a ristorante in
S. Philadelphia, Pennsylvania, USA


~ How do you feed a family on the moon?
or Mars?
WE KNOW HOW

Phase 1 & 2 Hardware

Phase 1 & 2 Objectives Completed & Delivered

RALPH STECKLER/NASA SPACE GRANT SPACE COLONIZATION AND TECHNOLOGY DEVELOPMENT PHASES 1 AND 2: LUNAR GREENHOUSE PROTOTYPE FOR BIOREGENERATIVE LIFE SUPPORT SYSTEMS

Fundamentals:

- **Food production capability** (kg per area per time);
- **Water balance** (liquid irrigation water, biomass and water vapor);
- **Carbon balance** (gaseous carbon dioxide and biomass);
- **Energy balance** (electrical/heat/light/food calories);
- **Fertilizer consumption analysis** (kg per area per time);
- **Environmental Control Analysis** (spatial/temporal climate uniformity);
- **System operational requirements, capabilities and weaknesses, with crops (lettuce, tomatoes, sweet potato, and strawberry).**

Phase 1 & 2 Objectives Completed & Delivered

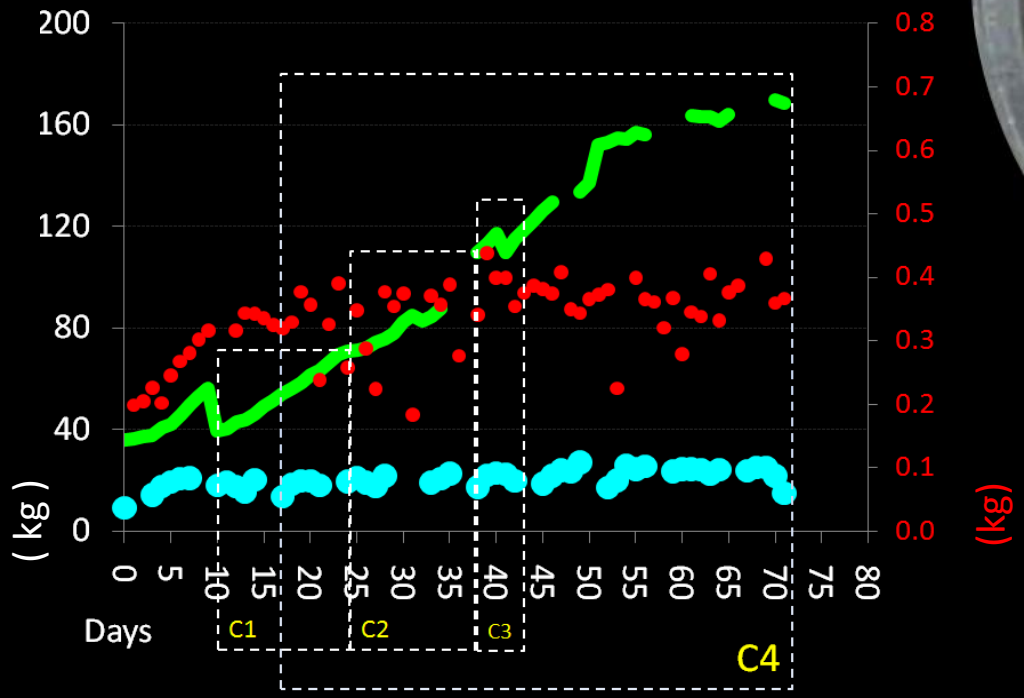
RALPH STECKLER/NASA SPACE GRANT SPACE COLONIZATION AND TECHNOLOGY DEVELOPMENT PHASES 1 AND 2: LUNAR GREENHOUSE PROTOTYPE FOR BIOREGENERATIVE LIFE SUPPORT SYSTEMS

Enhancements:

- Expand from one to four LGH Units
- Enhance Monitoring/Controls of Initial LGH
- Develop Model for Simulation and Control (MEC)
- Enhance Cable Culture Plant Growth
- Begin Compost Wick Evaporator Resource Recovery (limited results)
- Solar Energy Plant Lighting & Power System
- Remote Experts Network Decision Support System and Enhanced Telepresence
- Promote STEM Education Access & Outreach

Phase 1 LGH Life Support Production Results

Oxygen (kg)
Biomass (kg)
Water (kg)



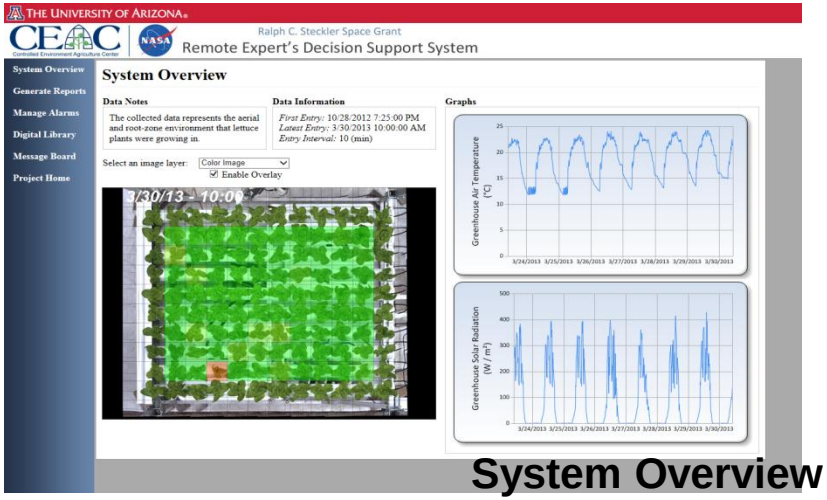
C4 = 58 Day Closure Interval

Change in growth after 58 days

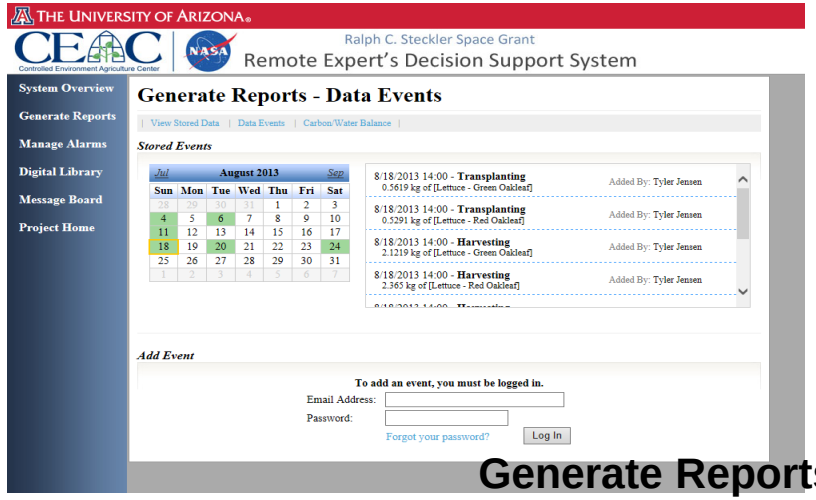
Deliverables – Decision Support System

Remote Experts Network Decision Support System (RENDSys)

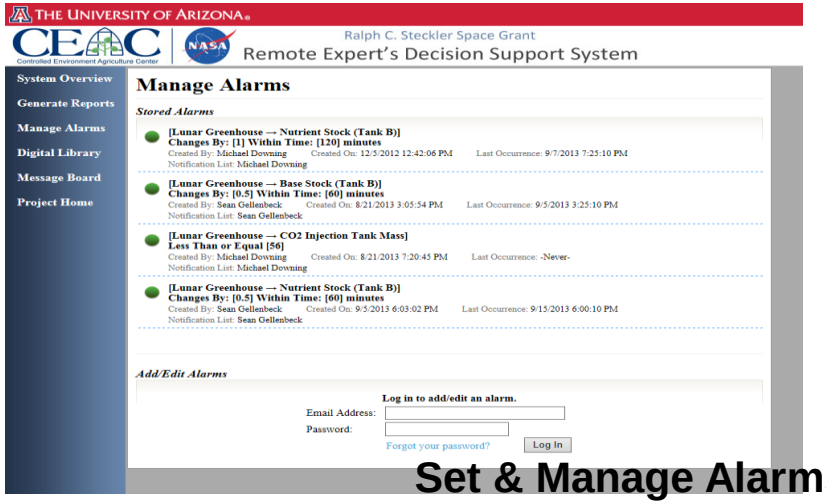
(David Story and Murat Kacira, Agric. & Biosystems Engineering)



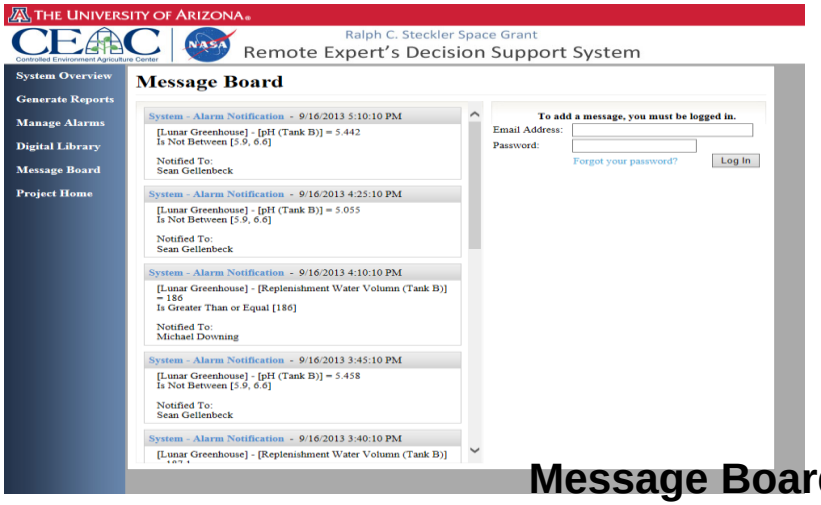
System Overview



Generate Reports



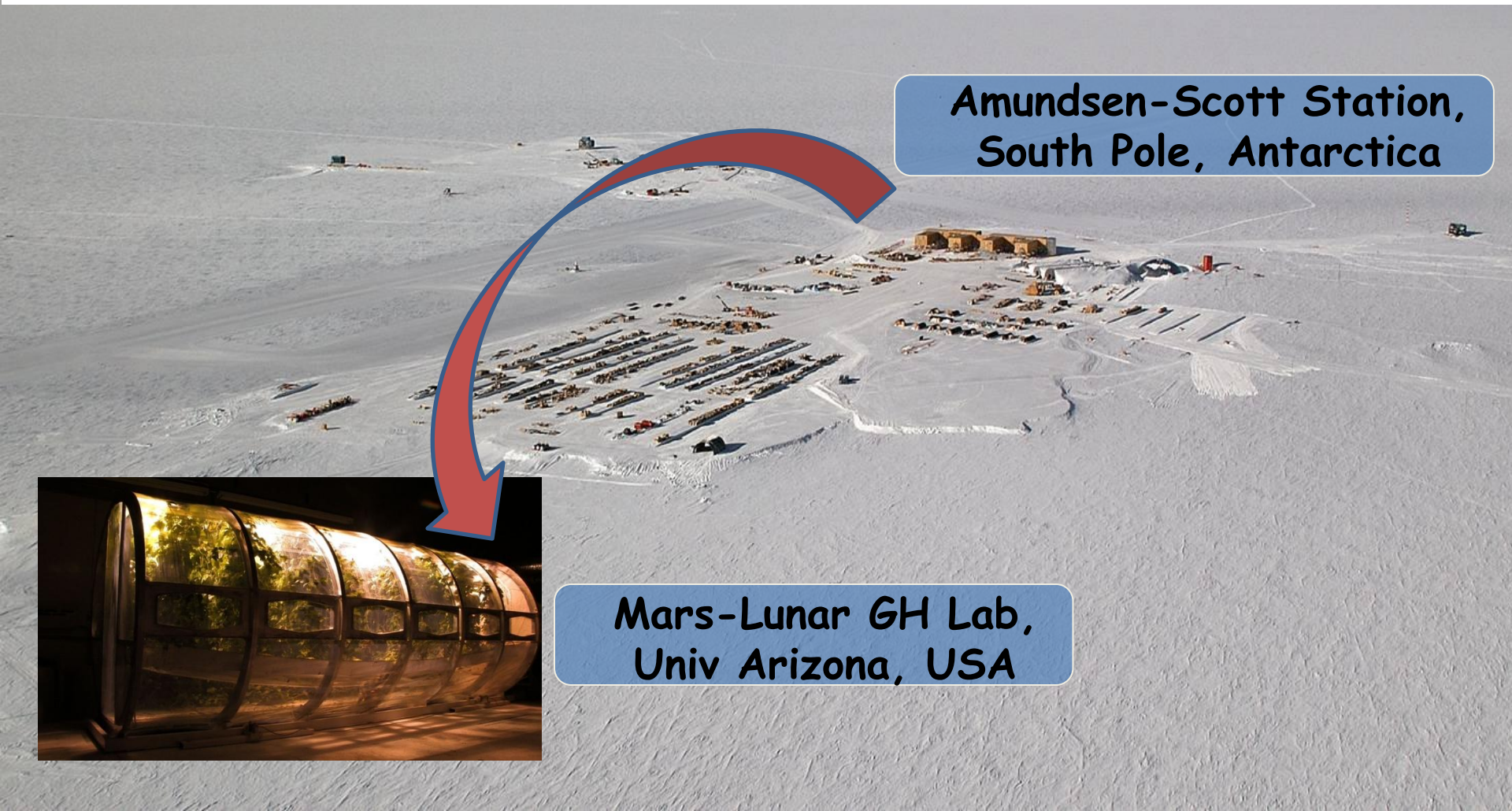
Set & Manage Alarms



Message Board

Management and Remote Control of Mars-Lunar Greenhouse from the South Pole Station, Antarctica

January – November 2013



Deliverables – Solar Concentrator Power System

Himawari focusing and tracking solar collector
(located adjacent to UA-CEAC Extreme Climate Lab)

Fresnel Lens, Fiber Optic Bundle, Capture PAR for plant growth, Infrared for heat, and UV for PV electric power, separately.

MAE Progetti di grande rilevanza ITALIA -USA 2013

IBAF -CNR, Aero Sekur, Thales Alenia Space Italia, University of Arizona

Organized by Alberto Battistilli

Consiglio Nazionale delle Ricerche

Alberto and student at Mars-Lunar Greenhouse Lab

CNR is working on the plant-environment interaction to produce good, highly nutritional and safe food for astronauts in space and for farmers on Earth to contribute to consumers wellness

Student Education and Outreach to World

Chris Pagliarulo, AZ Space Grant Fellow (far upper left), and Lane Patterson, Graduate Student (far right) with visiting Sunnyside High School students.
Webcam, LGH Lab, UA-CEAC

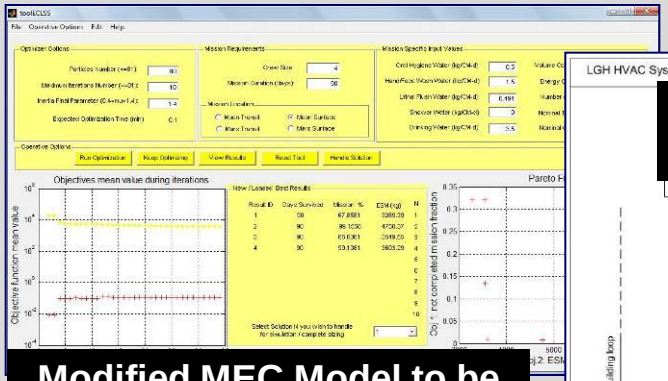
Actual "live" view from web camera located within LGH Lab

TAS-I Contribution to Steckler II

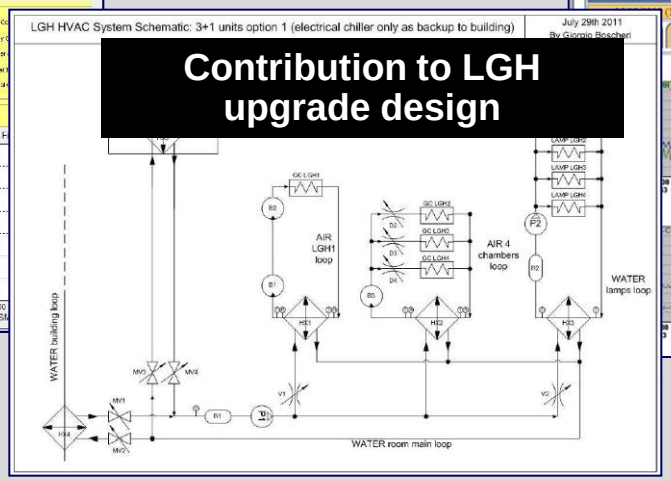
Collaborative Effort Activity List:

- Introduce space-oriented insight into LGH design
- LGH metric evaluations (ESM)
- Study on liquid streams (e.g. condensate, etc.)
- Exploitation of Phase 1 Modified MEC predictive model
- Tests in EDEN plant growth chamber
- Demonstration of tele-presence features

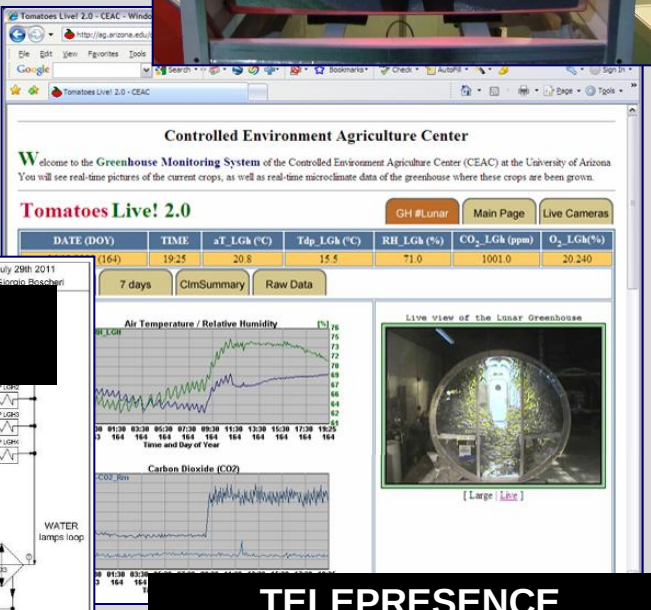
Upgraded EDEN for Tests



Modified MEC Model to be applied to phase II results



Contribution to LGH upgrade design



TELEPRESENCE demonstration

Deliverables – MEC Model

Modified Energy Cascade (MEC) Model adapted for a Multicrop Mars-Lunar Greenhouse Prototype

*Boscheri, Kacira, Patterson et. al. with colaboration from TAS-I & Arizona

Objective

Develop (and validate) an energy cascade model for a multi-crop Mars -lunar greenhouse system, validate its performance, and identify the sensitivity of the model outputs to the input parameters.

Model Predicted Values

- Biomass produced
- Net O2 produced
- Water condensate produced
- Water consumed
- Net CO2 consumed
- Fertilizer consumed

*Boscheri, G., M. Kacira, L. Patterson, G. Giacomelli, P. Sadler, R. Furfaro, C. Lobascio, M. Lamantea, L. Grizzaffi. 2012. Modified energy cascade model adapted for a multicrop lunar greenhouse prototype. Advances in Space Research, 50: 941-951

Since 2004: INTERNATIONAL AGROSPACE WORKSHOP

Developed by Aero Sekur and Supported by Lazio Region

Fondi 2004	1 day	50 persons
Sperlonga 2006	2 days	75 persons
Sperlonga 2008	2 days	120 persons + students
Sperlonga 2010	2 days	160 persons + students
Sperlonga 2012	2 days	120 persons + students

AGENCIES INVOLVED: ASI, ESA, NASA

WWW.AGROSPACECONFERENCE.COM

Earth Applications

Food Energy Water Nexus

The Challenge of the Near Future: Provide More Food with Less Resources

If we can do it on Mars, then we learn to do it on Earth

Primary Participants

Bio-Regenerative Life Support System Development for Lunar/Mars Habitats

Roberto Furfaro, Gene Giacomelli, Murat Kacira, Lane Patterson and David Story
The University of Arizona, Tucson, Arizona

Silvio Rossignoli, with Marco Adami, Marzia Pirolli and Roberta Remiddi
Aero-Sekur SpA, Aprilia, Italy

Giorgio Boscheri and Cesare Lobascio, with Mateo Lamantea & Lucia Grizzaffi
Thales Alenia Space - Italia, Torino, Italy

Phil Sadler
Sadler Machine Company, Tempe, Arizona

Madhu Thangavelu
University of Southern California, Los Angeles, California

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National Research Council, Institute Agro-environmental Biology & Forestry, Italy

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Michael Munday
Hungry Planets Systems

Alex Kallas
Agpals; San Diego Urban Homesteaders

Acknowledgements

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John Hogan, NASA-Ames Technical Support

Roberto Furfaro, UA-SIE-AME faculty, Technical PI
Gene Giacomelli, UA-CEAC faculty, Co-Technical PI
Phil Sadler, Sadler Machine Co, Primary Small Business Collaborator
Murat Kacira, UA-CEAC faculty, Co-PI
Lane Patterson, UA-CEAC, Project Engineer, Lab Manager
Cesare Lobascio, Thales-Alenia Space- Italy, Industry Collaborator
Giorgio Boscheri, Thales-Alenia Space- Italy, Industry Collaborator
Silvio Rossignoli, Aero-Sekur, Industry Collaborator
Marco Adami, Aero-Sekur, Industry Collaborator
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NASA

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Alex Kallas, Ag Pals
Claire Corcoran, Student videographer