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TAS-I Contribution to NASA Steckler Phase II UA-CEAC LGH Project

G. Boscheri
presented by C. Lobascio

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Giorgio at work… now a TAS-I employee!

Presentation Overview

- **TAS-I Background and Interests**
- **Contribution for Steckler I Phase**
- **Contribution for Steckler II Phase**
- **LGH Equivalent System Mass (ESM) Evaluation:**
  - Introduction on ESM
  - ESM Evaluation for LGH
  - Comparison between LGH and Literature data
- **Conclusions**

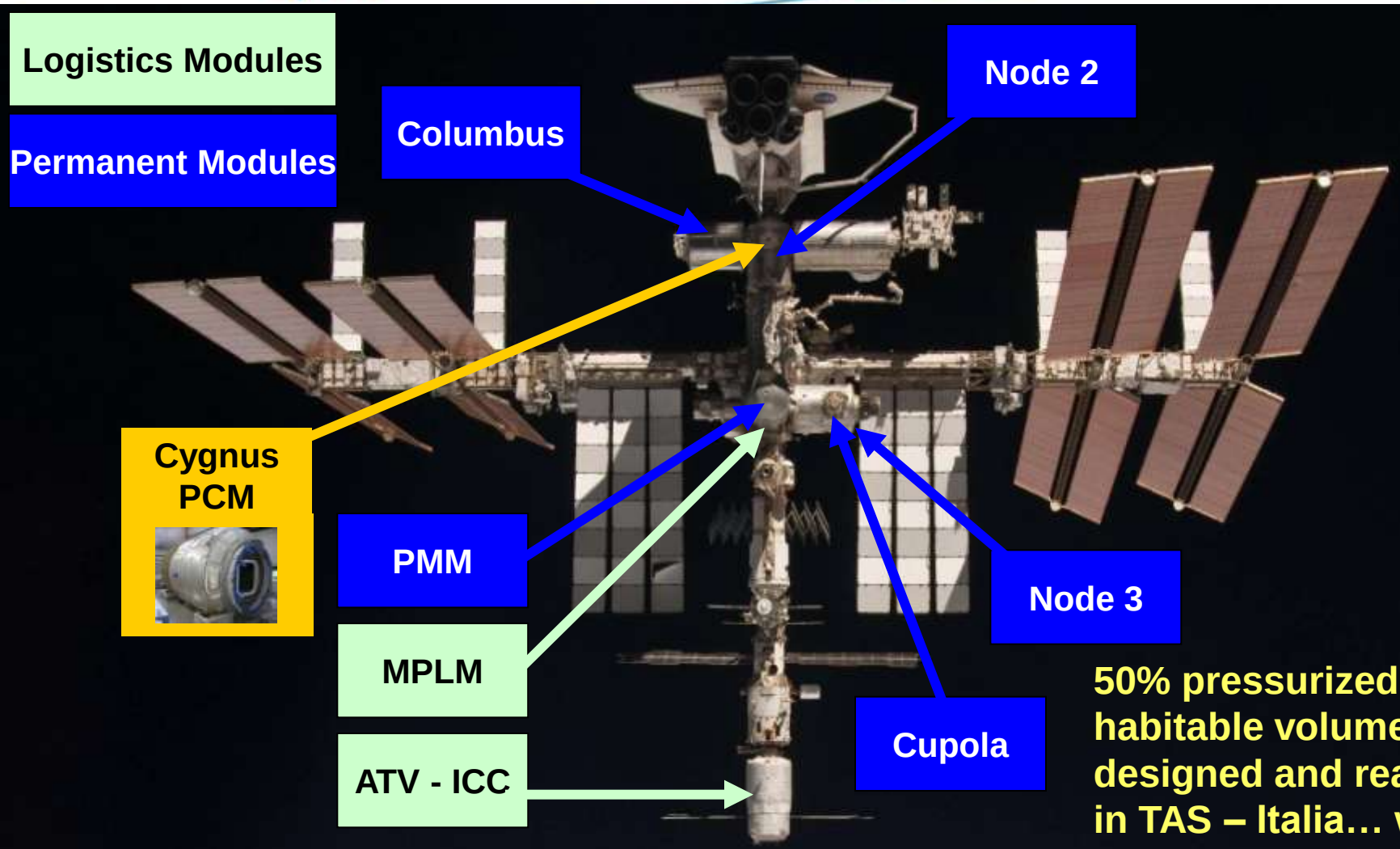
There's Italy behind the ISS!

Image credit:
NASA

The Italian Contribution

Logistics Modules

Permanent Modules



50% pressurized habitable volumes designed and realized in TAS – Italia… with their Life Support Systems

Image credit: NASA

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NODE 2 HARMONY, October 23, 2007

ISS016E007932 Image credit: NASA

Humans in space… inspiring

Image credit: NASA

Future:
Human Exploration

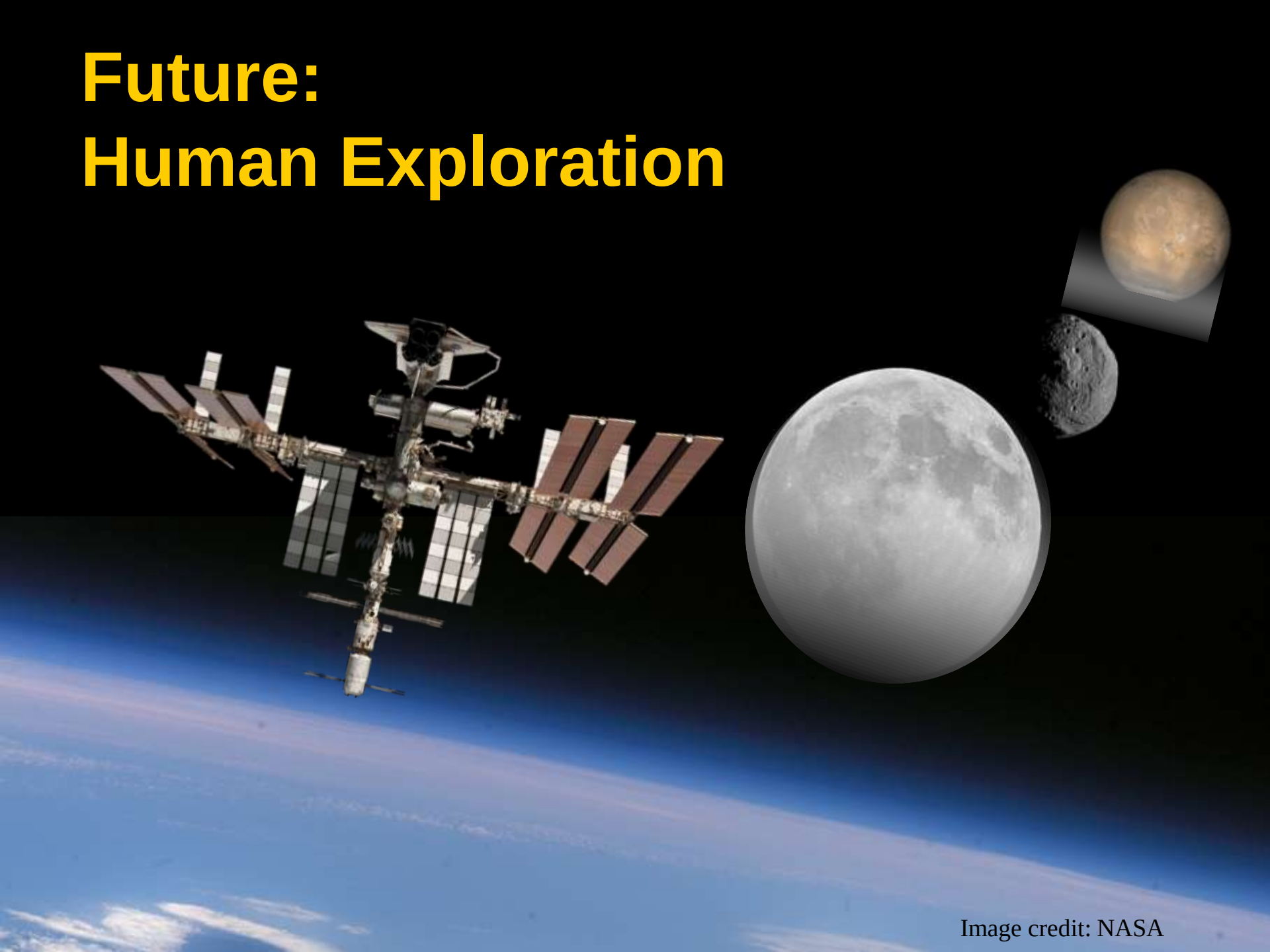
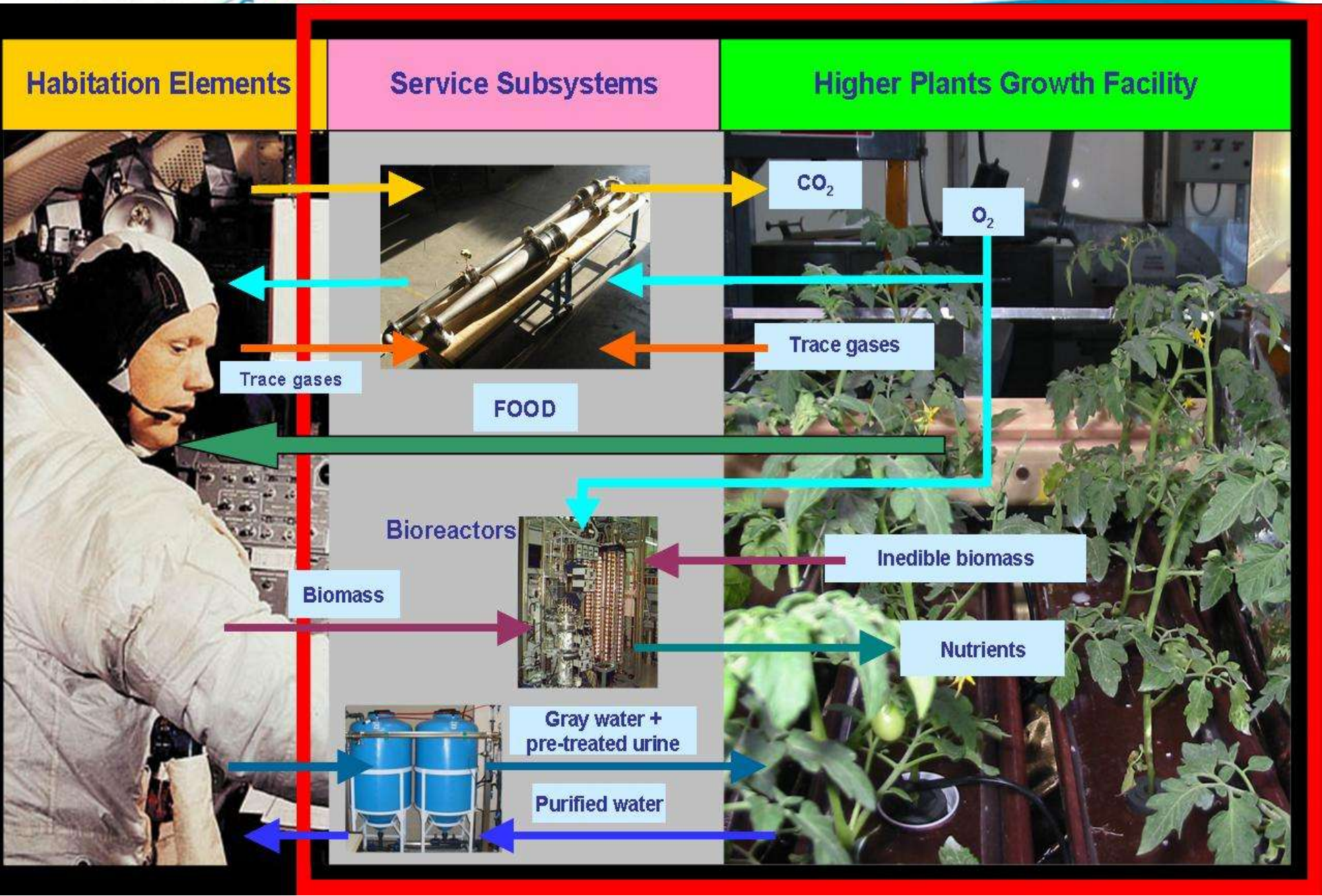


Image credit: NASA

Need recycling and food production



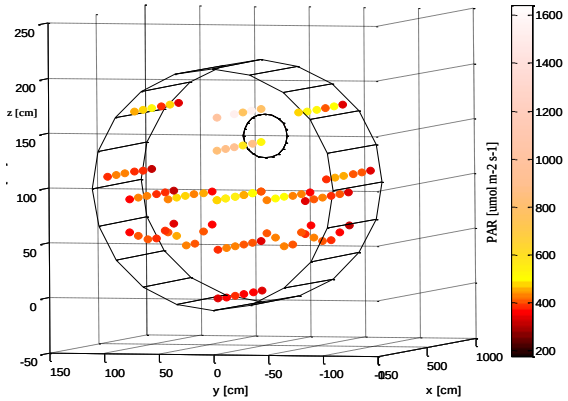
TAS-I Contribution To Steckler I

G. Boscheri at UA-CEAC (Feb-Mar 2010)

Build Collaborations

LGH HW Upgrade

LGH MEC Modeling



C. Lobascio received G. Giacomelli at TAS-I Recyclab

Build Collaborations

EDEN HW Upgrade

TAS-I Contribution To Steckler I

Results Dissemination

Agrospace WS 2010: Collaboration Build-up

ICES 2011: Steckler I Results

International Conference on Environmental Systems

AIAA

Bio-regenerative Life Support Systems for Space Surface Applications

P. D. Sadler[1], G. Giacomelli[2], R. L. Patterson[2], M. Kacira[2], R. Furfaro[3], C. Lobascio[4], G. Boscheri[4], M.Lamantea[4], L. Grizzaffi[4], S. Rodriguez[5], M. Finelli[5], S. DeFusco[6]

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41st ICES, 17-21 July 2011, Portland, Oregon

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SEKUR

CEAC

Advances in Space Research: paper accepted in 2012 on modified plant growth model

Modified Energy Cascade Model adapted for a Multicrop Lunar Greenhouse Prototype

G. Boscheri[c], M. Kacira[a,*], L. Patterson[a], G. Giacomelli[a], P. Sadler[d], R. Furfaro[b], C. Lobascio[c], M. Lamantea[c], L. Grizzaffi[c]

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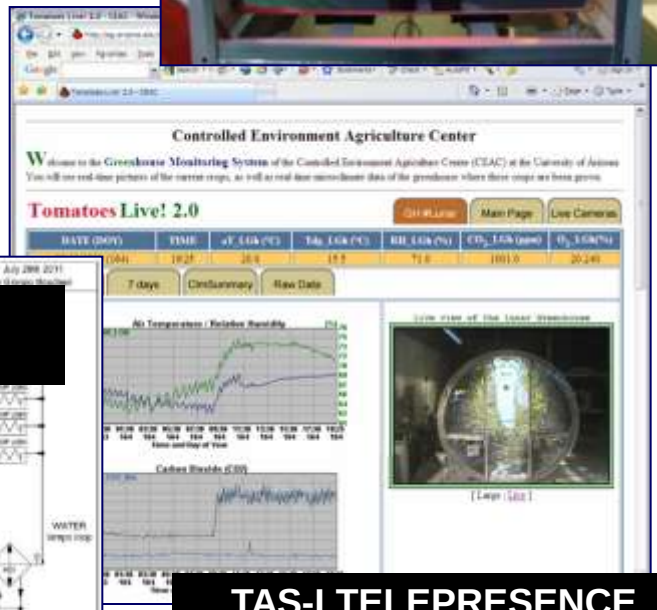
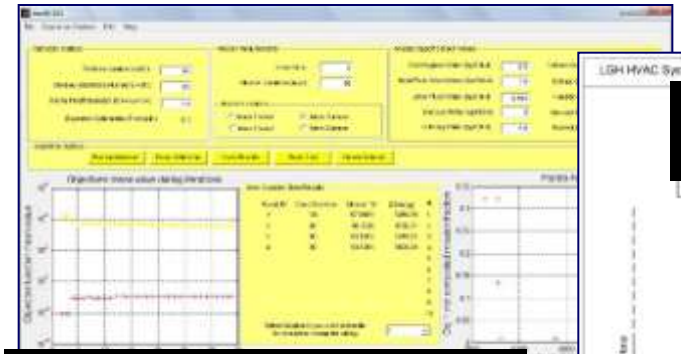
**Corresponding Author*

TAS-I Contribution to Steckler II

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

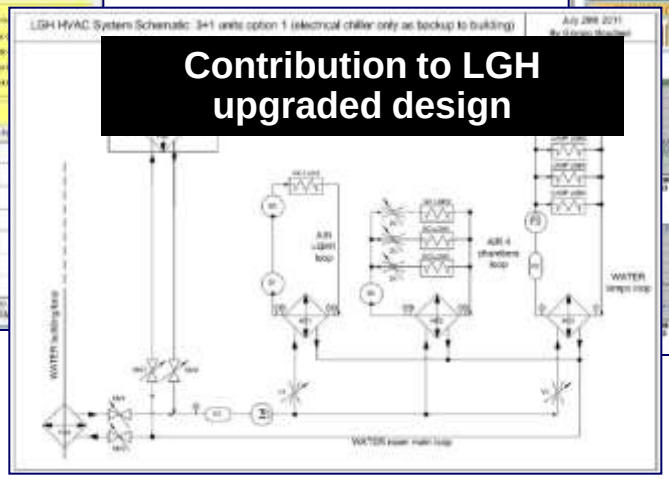
Upgraded EDEN for Tests





Modified MEC Model Upgrade to be completed

Contribution to LGH upgraded design



TAS-I TELEPRESENCE to be demonstrated

LGH Metric Evaluations Equivalent System Mass (ESM)

A Tool for Comparison of Advanced Life Support (ALS) Equipment

ALS Subsystem 1:
Mass = 10 kg
Volume = 15 L
Power = 50 W

Which one is the best choice?

ALS Subsystem 2:
Mass = 8 kg
Volume = 30 L
Power = 70 W

ESM: transform all parameters to an equivalent mass at launch of the equipment

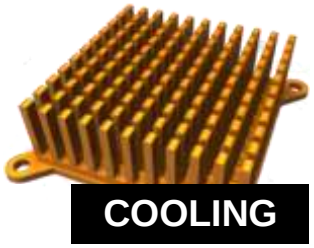
ESM = Mass +

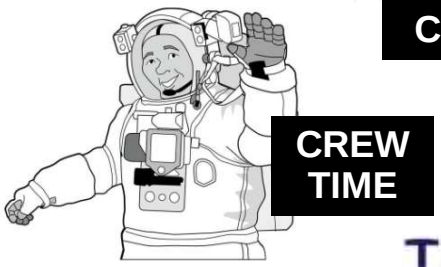
Volume x mass/volume factor +

Power x mass/power factor +

Cooling x mass/cooling factor +

Crew time x mass/ct factor





- **Literature on Plant Growth Chamber budgets is poor**
- **Good reference: NASA BVAD**
- **Mass/Volume/Power/Crew Time per m²**

Table 4.2.3 Plant Growth Chamber Equivalent System Mass per Growing Area

Component	Mass [kg/m²]	Volume [m³/m²]	Power [kW/m²]	Thermal Energy Management [kW/m²]	Crew-time [CM-h /m²•y]	Logistics [kg /m²•y]	Reference
Crops	20.0	–	–	–	13.0		From Drysdale (1999b)
Shoot Zone	3.6	0.67	0.3 [59]	0.3 [59]	–	–	
Root Zone and Nutrients	36.8	0.11	0.14	0.14	TBD	TBD	
Lamps	22.9	0.25	2.1	2.1	0.027	0.57	
Ballasts	8.4	TBD	0.075	0.075	0.032	3.24	
Mechanization Systems	4.1	TBD	TBD	TBD	TBD	TBD	
Secondary Structure	5.7	–	–	–	–	–	
Total	**101.5**	**1.03**	**2.6**	**2.6**	**13.1**	**3.81**	

JSC 47804

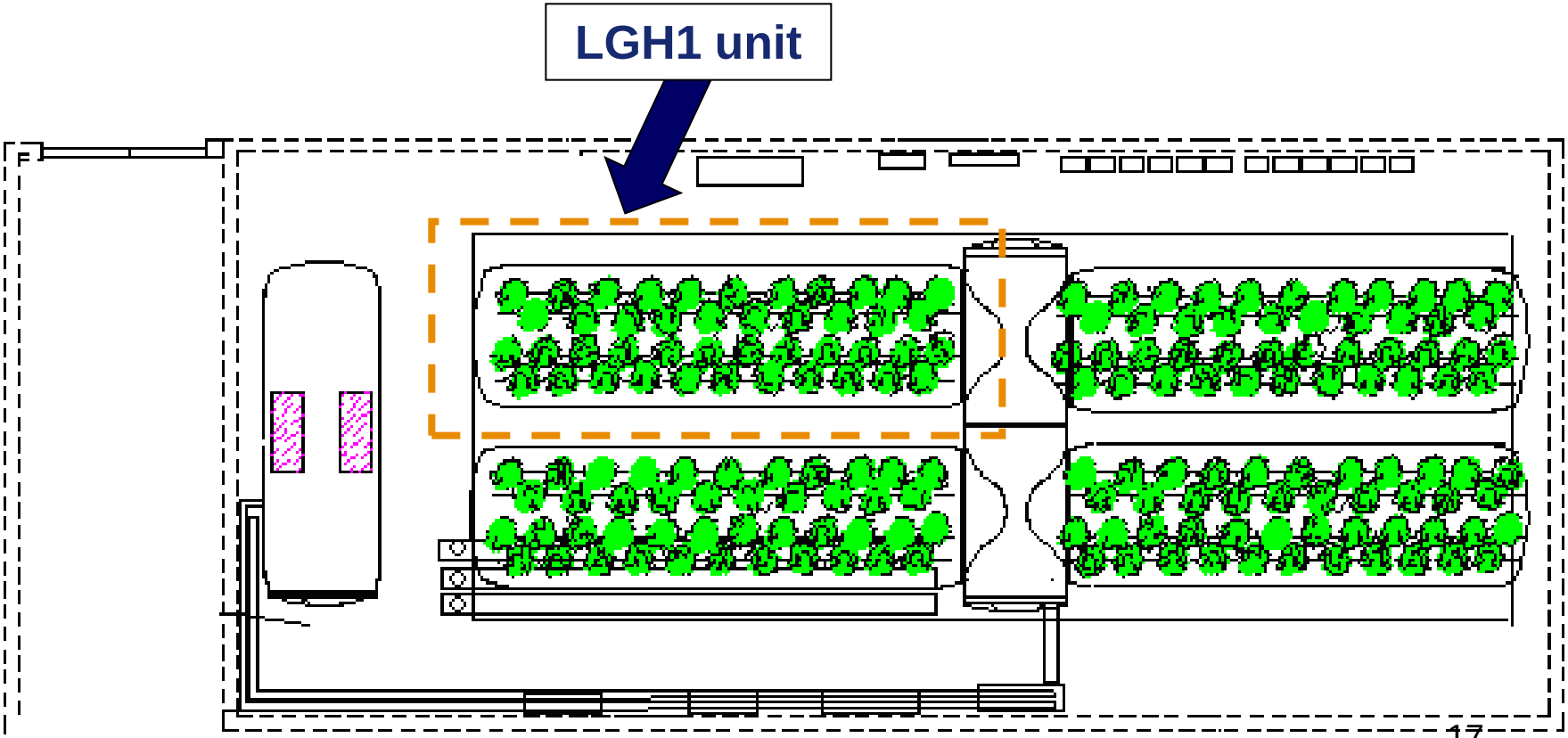
CREW AND THERMAL SYSTEMS DIVISION
NASA–LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

Advanced Life Support
Baseline Values and Assumptions Document

Document Number CTSD-ADV-484 A Date 16 August 2004

PREPARED BY:	A. J. Hanford, SIMA Deputy
APPROVED BY:	M. K. Ewert, SIMA Element Lead
APPROVED BY:	B. M. Lawson, ALS Project Manager

1 of the 4 LGH modules ESM calculated (LGH1)



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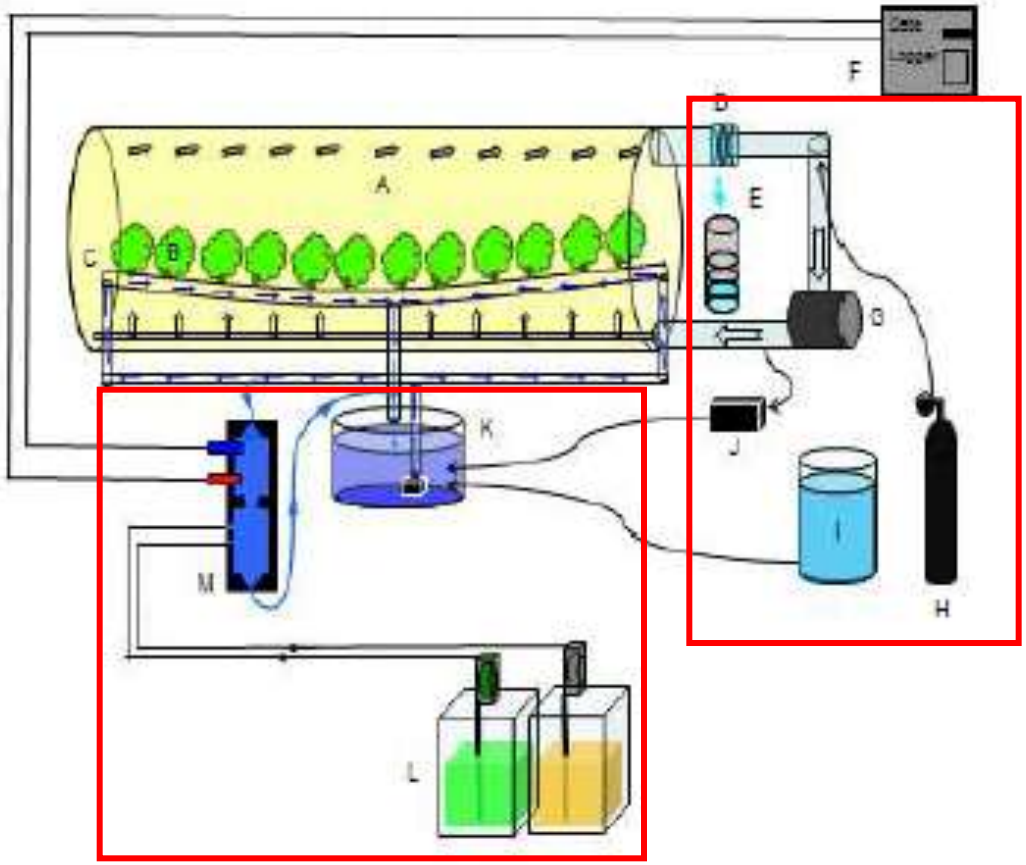
ESM Calculation for UA-CEAC LGH

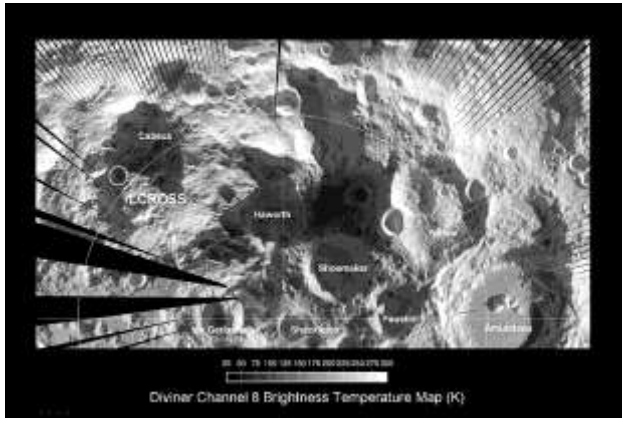
Mass/volume/power of equipment outside of LGH1 module common to all 4 modules was considered per ¼



ESM Calculation for UA-CEAC LGH

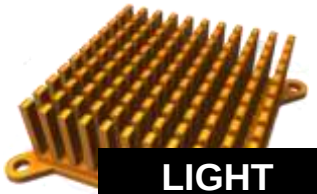
PV POWER GENERATION

A mass/power cost factor of 62 kg/kW was applied as per BVAD, assuming PV solar energy



Data assumed for Lunar Surface Polar Site

A mass/cooling cost factor of 77 kg/kW was applied as per BVAD, assuming light weight radiators



LIGHT WEIGHT RADIATOR COOLING

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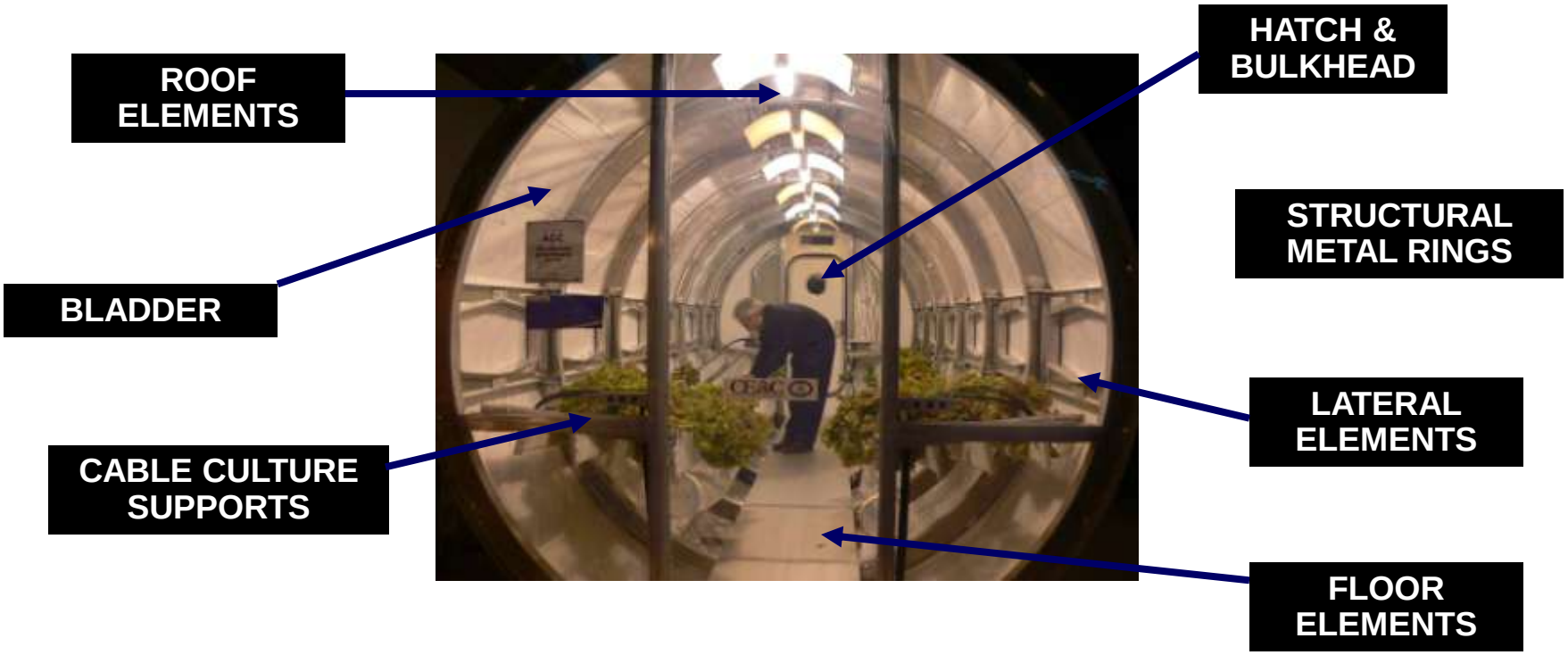
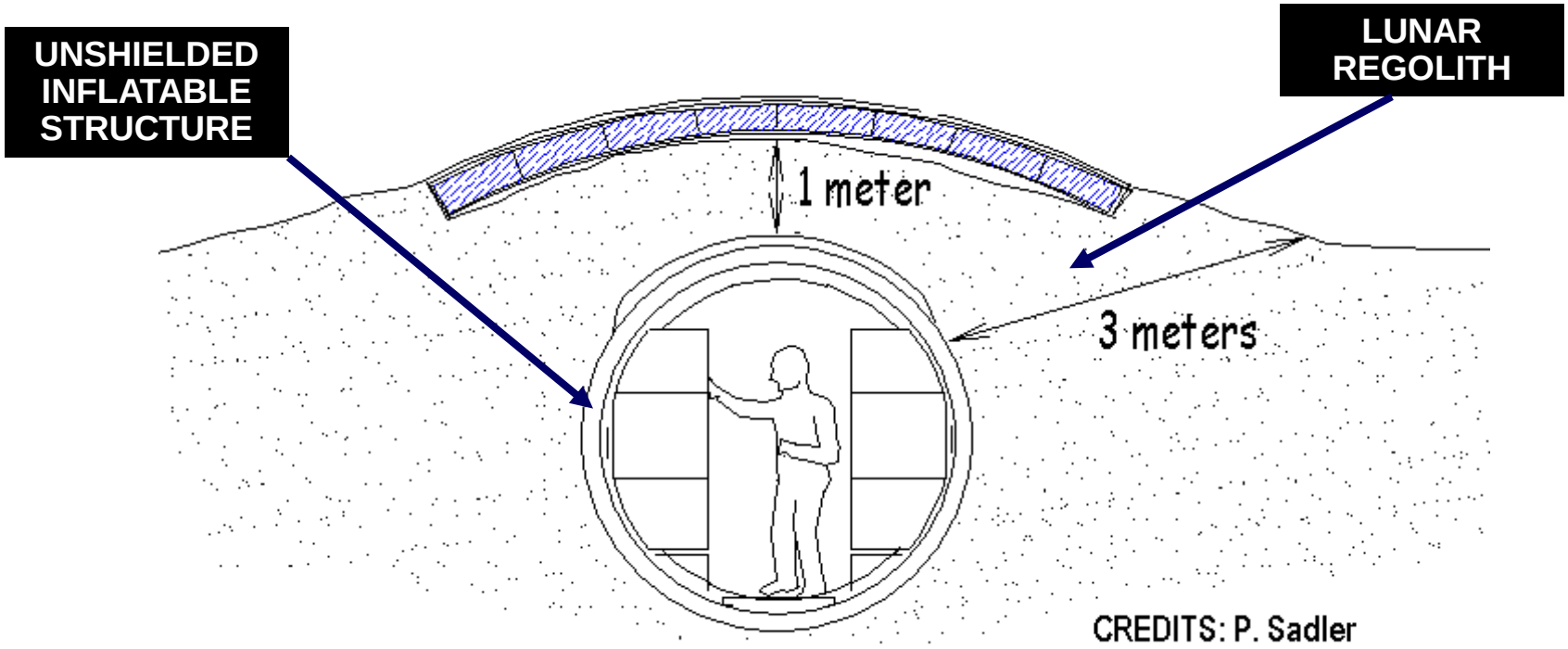
Volume of equipment placed inside the LGH1 module not considered as additional equivalent mass

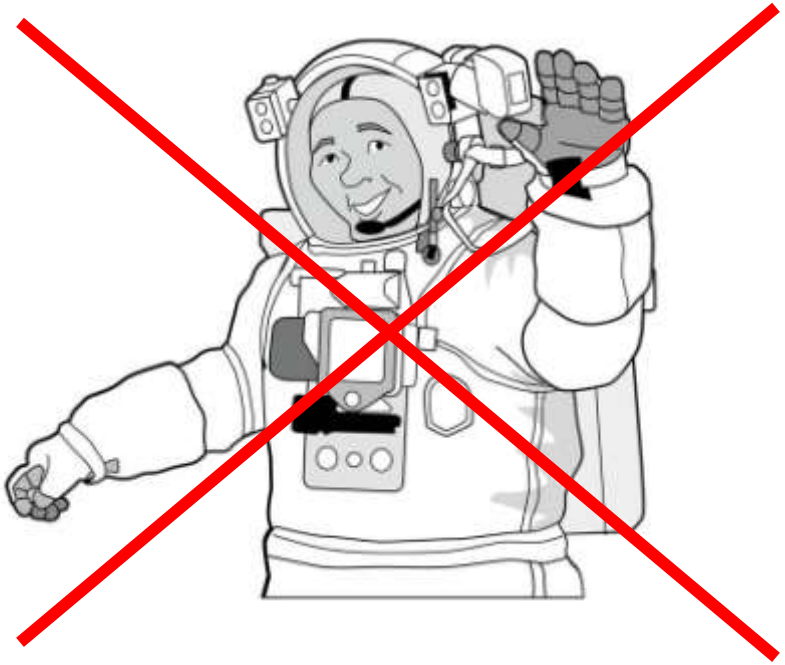
Mass/volume cost factor already covered by mass of LGH primary and secondary structures



Mass/volume cost factor of 13.4 kg/m^3 applied to equipment placed outside the LGH1 module as per BVAD, assuming Lunar surface site and inflatable unshielded primary structure (to be covered with regolith)



Crew time equivalent mass not considered for the LGH ESM evaluation



ESM Comparison with literature data

NASA data from BVAD (not optimized food production unit)

LGH data calculated assuming 11.2 m^2 of crops (minimum from ICES 2011)

Subsystem/Component	NASA ref. system	LGH-like system
Primary Structure Mass [kg/m^2]	**15.3**	**23.5**
Secondary Structure Mass [kg/m^2]	**5.7**	**0.50**
Outfitting/equipment		
Mass [kg/m^2]	75.8	43.7
Volume [m^3/m^2]	1.03	0.105
Power [W_e/m^2]	1.19	0.57
Cooling [W_{th}/m^2]	1.19	0.57
ESM [kg_{eq}/m^2]	**275**	**149**

Volume shall not be compared at this level

Much higher LGH power efficiency

ESM analysis: LGH system viable concept for space applications

ESM Evaluation results presented to ICES 2012

Next TAS-I Steckler II support activities to follow in agreement with UA-CEAC needs, depending on:

- Composter activity status
- Telepresence activity status
- Plants modeling activity status

We are enjoying the collaboration!


THANK YOU
LOVE FROM ITALY
TYRRHENIAN
SEA

Main Considerations Summary:

- 1 of the 4 LGH modules ESM calculated (LGH1)
- Mass/volume/power of equipment outside of LGH1 module common to all 4 modules considered per ¼
- Mass/power cost factor of 62 kg/kW applied as per BVAD, assuming Lunar polar site and PV solar energy
- Mass/cooling cost factor of 77 kg/kW applied as per BVAD, assuming Lunar polar site and light weight radiators
- Volume of equipment placed inside the LGH1 module not considered as additional equivalent mass, since mass/volume cost factor already covered by the mass of the LGH primary and secondary structures
- Mass/volume cost factor of 13.4 kg/m3 applied to equipment placed outside the LGH1 module as per BVAD, assuming Lunar surface site and inflatable unshielded primary structure (to be covered with regolith)
- Crew time equivalent mass not considered for the LGH ESM evaluation