

International Academy of Astronautics
 6 rue Galilée, BP 1268-16, 75766 Paris Cedex 16
 Tel 331 47 23 82 15, Fax 331 47 23 82 16

IAA Commission 3
Date: 21 Sep 2013
Venue: China National Convention Center Rm 209A

Report on the Meeting

1. Attendance:

Name	Email
G. Reibaldi	Giuseppe.reibaldi@gmail.com
Yu Lu	Luy@spacechina.com
S. Ramakrishnan	ramakrish49@gmail.com
R. X. Lenard	rlenard@planetarypower.com
Jacques Gigou	jacques.gigou@esa.int
Tanja Masson-Zwaan (part-time)	e.r.masson@law.leiden.univ.it
Hans Hoffmann	hans.e.w.hoffmann@t-online.de
Horst Rauck	horst.rauck@gmx.de
Art Dula	art@dula.com
Sommariva Andrea	andrea.sommariva@metaconsulting.com
Giancarlo Genta	giancarlo.genta@polito.it
Andreas Rittweger	andreas.rittweger2@astrium.eads.net
Christophe Bonnal	christophe.bonnal@cnes.fr
V. Adimurthy	vip.adimurthy@gmail.com
Seishiro Kibe	kibe.seishiro@jaxa.jp
Oleg Ventskovsky	oventskovsky@hotmail.com
Susan McKenna-Lawlor	stil@nuim.ie

1. Welcome & Introduction

Meeting opened by Giuseppe Ribaldi but handed over to Prof. Lu YU as new Chair of the Commission

2. Commission 3 Composition (2013-15)

Professor Lu Yu introduced the new Commission Officers.

Lu Yu, Chairman – present

Reibaldi G. Past Chairman – present

Ramakrishnan-Vice Chair – present

Roger Lenard, Secretary - present
Bruno C not present
Korepanov V not coming
Saccoccia G Not present
Kawaguchi not present
Fan Ruxiang not present
Fabreguettes L not present

All six members were not present.

It was noted that being a member of the Commission is an honor and the people should make their effort to be there or to justify themselves.

Commission members can't be excused for more than two meetings

3. Actions from Previous Meeting

No action open

4. Reports of Cosmic Studies

Study Group 3.10 Technologies for Interstellar Precursor Mission SG 3.10 Claudio Bruno

Published by the Academy in June 2013

Study Group G 3.9 Private Human Access, Vol I: Sub-Orbital W Peeters

Draft Completed July 2013

Draft being upgraded with comments and should be available for final Commission review by end of September

SAC/BoT Approval Oct 2013

Publication: Nov-Dec 2013

Study Group 3.13 "Assessment of the Technological Feasibility of Space Elevator Concept" Peter Swan

VC Study Review June 2013

SAC/BoT Approval, Sep 2013

Publication Nov/Dec 2013

One recommendation for the Academy is to develop a Space Elevator permanent committee **with the objective** to monitor and observe the status of technology. If the sponsors of the study concur, the study group chair will set the mandate for collecting, assessing and reporting of the various technologies.

Question by C Bonnal: Does this include the cleaning of space debris? Answer from Reibaldi: Yes. The mandate to be developed by P Swan and presented to the SAC for approval.

Action for P Swan: Write the mandate for and identify participants in the standing committee.

C Bonnal: the published study of SG 3.10 has not been uploaded to the website.

Action IAA Office: The webpage needs to be updated (Done).

Study Group 3.14 Private Human Access to Space (Vol II) S Di Pippo. (Reported by G. Reibaldi) They are working on this report with inputs from many countries. The Japanese contribution has been submitted. No major problems to be reported.

Study Group 3.15 Long-Term Space Propellant G Sacoccia Briefed by Professor Yu.

Professor Lu introduced the study members. Presented minutes of the meeting in Naples. A second meeting was held in Paris 3-18-2013 Finalizing of draft Oct 2013 in preparation for HoA meeting in January. A 43 page report has been completed and an on-line version is being circulated. Professor Yu briefed the status of the study. This is a White Cosmic Study, that will be presented to the HoA meeting. Action: Professor Lu to notify the Academy that Jacques Gigou will be formally assigned as a member of the propellant depot study group.

Study Group 3.16 Global Human Mission to Mars G. Genta Status briefed by G. Genta.

This report was presented verbally, there were no viewgraphs. The report will not be a study of the mission, but it will address the main critical decisions and see how to engage a global, e.g., new emerging spacefaring nations, study. The White Cosmic Study will be a 25 page synthesis document available for HoA in Washington, a draft is already available. Mission should be realistic and affordable. One of the most important points: number of people involved. Psychologists think the minimum crew count is 6, others think three is sufficient, others think as high as 12. One of the reasons for this is the analyzed probability of successful reentry as a function of vehicle size. Analysis shows smaller vehicles have a higher likelihood of successful reentry. The study group has some divisions on the issue of chemical versus nuclear propulsion in the near term. Study is in very good position, but still very far from concurrence on the entirety of the study.

Study Group 3.17 Space Mineral Resources, Art Dula chairman, presented by Art Dula.

Art Dula reported the overall report status. Report contained no viewgraphs although there was a large printed report. There are four areas to the study, the technology, what the economics, the policy and law. The law appears to be the biggest issue. The legal section is not quite complete and hasn't been vetted. One of the standard risk matrix normally used is not applicable for the commercial enterprise. Art recommended that for commercial enterprises we

need to add a third dimension, which is a risk-reward ratio axis. The socio-economic effect has to be taken into account.

The issue of funding such a program was raised by Mr. Dula, one possible approach contact people who are already interested in space resources who have a net worth in excess of \$106B. Net production world is about \$70T concentrated in about 40% of the people. Mr. Dula wanted to determine whether it's worthwhile to do the study initially, but now believes that if the study is completed well, it will be the first such report of its kind. Based on this study, the world may get use of space resources much more quickly. Art stated that we need to start mining outer space. As a figure of merit, the surface of the earth that we mine, and we go to down about a 1/10th of a mile and is the same volume as that of the asteroid Vesta.

Getting a very good response from young people although have just gone out to the whole committee about one week past. Are in a position to make recommendation to heads of agencies. Several roadmaps being completed. Lot of input from Rick Tumlinson and Colorado School of the mines. Art discussed the outline of the report and the status of these sections. One of the standard risk matrix normally used is not applicable for the commercial enterprise. Art recommended that for commercial enterprises we need to add a third dimension, which is a risk-reward ratio axis. The socio-economic effect has to be taken into account. Five recommendations but time has run out. Meeting in 203B 1600-1800 21 Sep 2013.

Study Group 3.18 Feasibility Study of Possible International Protocol to Handle Crisis/Emergency to Astronauts in LEO. S Ramakrishnan

Dr. Ramakrishnan. discussed the potential range of possibilities for rescue. Looking at obstacles, interest of stakeholders, and the response time, cost of the mission and infrastructure, standardization of interfaces and gaps within the existing legal framework. Draft report is already available and the final WCG will be available by the 25th October

Study Group 3.19 Radiation Hazards. Susan McKenna-Lawlor presented the status

The report look at astronaut career dose limits but include the effect on the human body by radiation impingement On target to meet a 25 page report. The report was presented verbally. Change the duration of radiation from 10 years to 1 year at NASA's request. The radiation dose of the various agencies are starting to converge at ~ 1 Sv. Two sources of radiation, background cosmic radiation and solar energetic events. Looked at a 400 day mission with 30 days on the surface. For this mission scenario the cosmic radiation came close to the career dose limit. The Vasimr engine could reduce trip times to ~ 3-4 months. On the surface a hard spectrum SEP event is still a concern. On target to meet a 25 page report. Hoping that by 26October will have hard-hitting report.

Study Group 3.20 Impact of Planetary Protection on Human Exploration.
G. Reibaldi provided brief overview. The report is late compared to the others, but it should be available for the 25th October.

Study Group 3.21 Disposal of Radioactive Waste in Space Oleg Ventskovsky reported the status, no charts were available. However, it is remarked that the communication has occurred between Ukrainian members of the study and the Commission 3 was not aware of the situation. This shall be avoided in the future

Action: Oleg Ventskovsky, to provide to the Commission a detailed status of the SG with the schedule of the future activities. Mr. Reibaldi reiterated that the Commissions are accountable for studies on-going and the SG requires to provide information

5.0 Symposia Status.

5.1 IAC 2013 Symposia

Discussed the numbers of papers in various symposia. It is the responsibility of the Symposia Coordinators to keep track of the papers in their sessions. Reviewed the various symposia in order to ascertain who was likely to be coming. Roger Lenard will sit in for Hans Hoffmann on D4.1 Tuesday AM.

5.2 IAC 2014 Symposia.

The Symposia were presented and are attached

Action, by end January 2014: Commission Leadership, to re-assess the Chair/Co-Chairs/Secretary of the various sessions to change the session chairs and vice chairs prior to Paris Spring meeting.

6 Commission report to the SAC.

The report was discussed

5.3 Future Conferences

Submissions for the Heads-of-Agencies summit was discussed. Study group leaders need to have reports prepared by November.

6- Acta Astronautica Not Addressed

7- IAA Heads of Space Agencies Summit:

Follow-on Activities Incorporated in review of Cosmic Studies which need to be completed in November 2013.

9- Other Business

IAA COMMISSION III MEETING

BEIJING, CHINA / 21ST SEPTEMBER 2013

AGENDA

- 1 Welcome & Introduction**
- 2 Commission – III (2013 – 15) Composition**
- 3 Actions from March '13 Meeting at Paris**
- 4 Studies Completed - Feedback**
 - # SG 3.9 Private Human Access to Space Vol.1
suborbital**
 - # SG 3.10 Interstellar Precursor Mission
Studies in progress – Status presentation**
 - # SG 3.13 Space Elevators**

IAA COMMISSION III MEETING

Beijing, China / 21st September 2013

AGENDA

- 5 Studies in Progress – Status presentation
 - # SG 3.14 Private Human Access to Space – Vol. II Orbital

 - # SG 3.15 Space Propellant Depot
 - # SG 3.16 Global Human Mission to Mars
 - # SG 3.17 Space Mineral Resources
 - # SG 3.18 Feasibility study on possible International Protocol on crew rescue from LEO
 - # SG 3.19 Feasibility study of standardized career Radiation dose limit for Astronauts in LEO
 - # SG 3.20 Implementing planetary protection during Human Space Exploration

IAA COMMISSION III MEETING

Beijing, China / 21st September 2013

AGENDA

- 6 New Study Proposals?
- 7 Briefing on Heads of Space Agencies Summit planned in January 2014
- 8 Symposia Status IAC 2013 / 2014
- 9 Report to SAC
- 10 AOB

COMMISSION COMPOSITION (2011 – '13)

Chair	:	Giuseppe Reibaldi (Italy)
Vice Chair	:	Lu Yu (China)
Secretary	:	S. Ramakrishnan (India)
Past-chair	:	J Mankins (USA)
Member	:	Claudio Bruno (Italy)
Member	:	Junjiro Onoda (Japan)
Member	:	Roger Lenard (USA)
Member	:	Christophe Bonnal (France)
Member	:	Valery Korepanov (Ukraine)
Member	:	B. Rabiou (Member)

IAA Commissions III (2013 – 15)

Chair	:	Lu Yu (China)
Vice Chair	:	Ramakrishnan S (India)
Past-Chair	:	Reibaldi G (Italy)
Secretary	:	Lenard R (USA)
Member	:	Bruno C (Italy)
Member	:	Korepanov V. (Ukraine)
Member	:	Saccoccia G (Italy)
Member	:	Kawaguchi J (Japan)
Member	:	Fan Ruxiang (China)
Member	:	Fabregette L. (France)

4. Status of Completed Studies

- **SG 3.10 “Technologies for Interstellar Precursor Missions”** **C.BRUNO**
-> Published by IAA in June 2013
- **SG 3.9 “Private Human Access, Vol I: Sub-Orbital”** **W.PEETER**
--> Draft completed , July 2013,
--> Commission review completed, August 2013
--> VC Study Review, September 2013
--> SAC/BoT Approval, October 2013
--> Publication, Nov./Dec. 2013
- **SG 3.13 “Assessment of the Technology Feasibility of Space Elevator Concept”**
-> VC Study Review, June 2013 **P.SWAN**
-> SAC/BoT Approval, Sep. 2013
-> Publication Nov./Dec. 2013

5 STUDIES IN PROGRESS - STATUS

- | | | | | |
|----------|-----------|-------------|---|---------------------|
| # | SG | 3.14 | Private Human Access to Space
(Vol – II (Orbital)) | S. Di Pippo |
| # | SG | 3.15 | Space Propellant Depot | G. SACCOCCIA |
| # | SG | 3.16 | Global Human Mission to MARS | G. GENTA |
| # | SG | 3.17 | Space Mineral Resources | A. DULA |

5 STUDIES IN PROGRESS - STATUS

#	SG	3.18	Feasibility Study on International Protocol for Crew Rescue from LEO	S Ramakrishnan
#	SG	3.19	Feasibility Study of Standardised career radiation dose limit for Astronauts in LEO	S Mc- Kenna
#	SG	3.20	Implementing planetary protection during Human Space Exploration	C. Conley
#	SG	3.21	Space Disposal of Radio Active Waste	

6 New Study Proposals

Members / Participants

**7 Briefing on Heads of Space
Agencies summit at Washington
in January 2014**

G. REIBALDI

8. SYMPOSIA STATUS IAC 2013

A5 HUMAN EXPLORATION OF MOON & MARS

A 5.1 Human Lunar Exploration
7 Confirmed Papers

A 5.2 Human Mars Exploration
5 Confirmed Papers

A 5.3 Jt. Session on Human / Robotic 9 Confirmed Papers

B 3.6 Space Exploration

A 5.4 Jt. Session on Going to and 8 Confirmed Papers

D 2.8 beyond Earth-Moon system 8 confirmed papers

8. SYMPOSIA STATUS IAC 2013

C 3.1 Space Based Solar Power Architectures – New concepts and Ventures 7 Confirmed Papers

D 3 BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION

D 3.1 Strategies & Architecture for Future Building Blocks in Space Exploration 7 Confirmed Papers

D 3.2 Systems and Infrastructures to to implement Future Building Blocks in Space Exploration 7 Confirmed Papers

8. SYMPOSIA STATUS IAC 2013

**D 3.3 Novel Concepts and Technologies 7 Confirmed Papers
to Enable Future Building Blocks in
Space Exploration**

**D 3.4 Space Technology and System 7 Confirmed papers
Management Practices & Tools**

Symposia organized by the Commission

IAC 2014

- New Criteria and rule for Commission Membership applied
- Change of Coordinators/Session Chairs implemented, if required
- Symposia consolidated to be complementary to past/future Studies carried out by the Commission
- Main Changes to be confirmed after Commission meetings:
 - A5 focused on Human Mars Mission and Cislunar Space
 - D3 not changed with emphasis on Nuclear Propulsion
 - D4, new session on Interstellar Precursor and Beyond created
 - C3.1 not changed

IAC 2014

- C3.1 “Space Based Solar Power Architecture...” (No change)
- D3 “Building Blocks for Future Space Exploration and development” (No change)
- D4 “Visions and Strategies for the future”
 - D4.1 “Innovative Concept and Technologies” (No change)
 - D4.2 “Contribution of Space Activities to Solving Global Societal Challenges” (No change)
 - D4.3 “Global Strategy for Space Elevator” (Emphasis on the Cosmic Study)
 - D4.4 “Strategies for Rapid Implementation of Interstellar Missions: Precursors and Beyond” (New)

9. SAC REPORT

- REPORT TO SAC



International Academy of Astronautics

IAA SG3.15

Long Term Space Propellant Depot

G.Saccoccia, LU Yu

Beijing, China

Sep. 2013



Group Composition



International Academy of Astronautics

Chair:

Giorgio Saccoccia

ESA – The Netherlands

Co-Chair:

LU Yu

China Academy of Launch Vehicle Technology (CALT)-China

Secretary:

WANG Xiaowei

CALT – China

Members:

Dallas Bienhoff

Boeing – USA

SHEN Lin

CALT – China

Christophe Bonhomme

CNES – France

Davina Di Cara

ESA – The Netherlands

Philippe Caisso

SNECMA – France

James Free

NASA (Glenn Research Center) – USA



Group Composition



International Academy of Astronautics

Members (cont.):

Guenter Langel

EADS/ASTRIUM – Germany

Jerrol Littles

Pratt & Withney – USA

Kevin Miller

Ball Aerospace – USA

Robert Mueller

NASA (Kennedy Space Center) – USA

Sebastien Bianchi

Air Liquide - France

Bill Smith

Aerojet Corp. – USA

Jim Keravala

Shackleton Energy – USA

Dettlef Hueser

OHB Space Systems – Germany

Hans E.W.Hoffmann

Germany

Ivan Ilin

Ballistic centre of Keldysh Institute of Applied Mathematics, Russian Academy of Sciences – Russia



Group Composition



International Academy of Astronautics

Members (cont.):

S. Ramakrishnan

*Vikram Sarabhai Space Centre (ISRO) –
India*

Jeroen Van den Eynde

*University of Southampton - United
Kingdom*

Alan Wilhite

Georgia Institute of Technology – USA

Young Professional Members:

Andrea Boyd

andrea.boyd@spacegeneration.org

Fatoumata Kebe

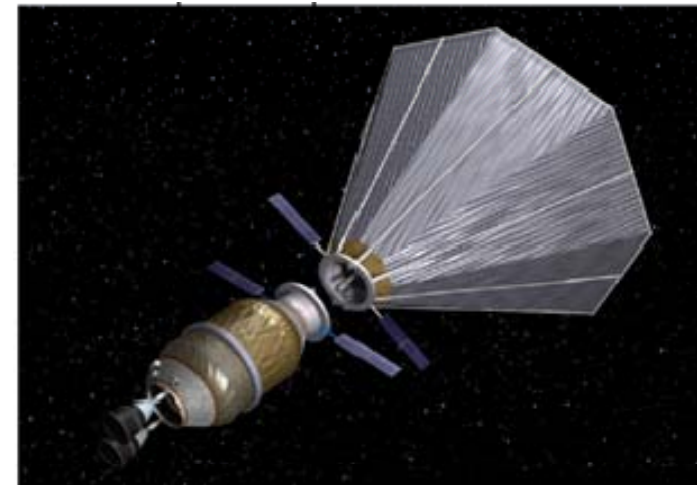
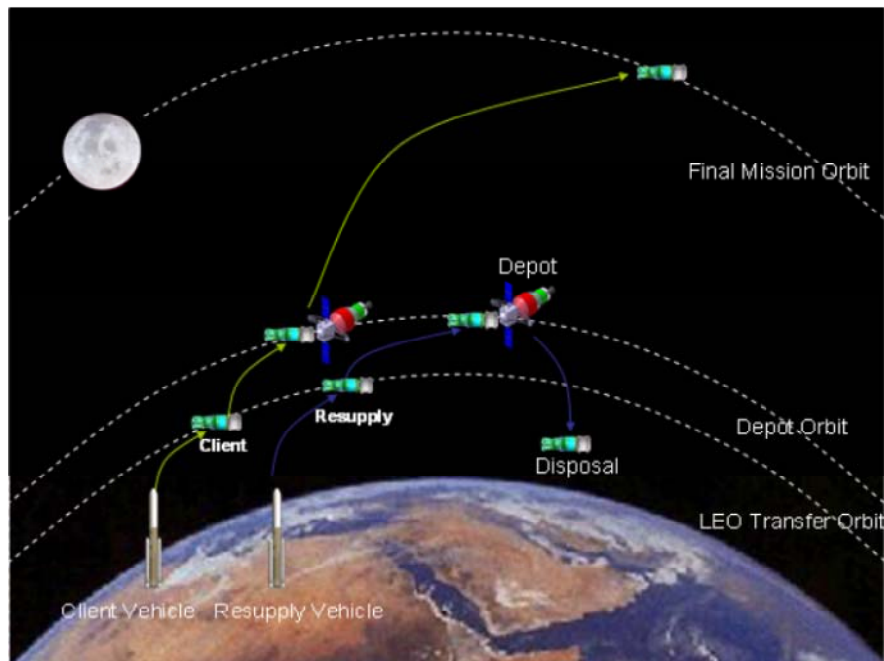
fatoumata.kebe@gmail.com

Sandra Gonzalez Diaz

sandra@sandraglez.es

Japanese IAA experts are wanted.

- **Identify requirements, concepts and opportunities for future high energy propellant space depots, identify required key technologies and define the road map for this new capability.**





Progress



International Academy of Astronautics

Start in August 2012.

1st Meeting, 30-9-2012, Naples

Minutes of Meeting:

- **Only in-orbit depot will be addressed and not surface infrastructures.**
- **A “macro” structure for the study had been discussed and the following 3 blocks had been identified (each of them might include several chapters):**
 - *Missions, “business cases, architectures, etc.: Why these concepts?”*
 - *Technologies: background (previous missions addressing some of the challenges), needs, status, challenges, schedules and costs*
 - *Implementation: private vs. institutional initiatives, international collaboration, etc.*
- **Proposed way forward:**
 - *Build a study team by proposing new members and contacting them. Deadline: End 2012*
 - *Definition of the Study Structure: Deadline: End January 2013. Last iteration and study structure completed by March 2013.*



Progress



International Academy of Astronautics

2nd Meeting, 18-3-2013, Paris

Minutes of Meeting:

- **The proposed content has been finalized.**
- **Allocation of responsibilities for study content is also completed.**
- **Schedule and actions in future are also made sure as following.**

June 2013:

- *Completion of the Preliminary Draft report for discussion*

July 2013:

- *Discussion of the Preliminary Draft*
- *3-5 July, IAA “The Future of Space Exploration” Conference in Turin, possibility to held another SG meeting*

September 2013:

- *Consolidation of the complete Draft Report*
- *Present the status of SG at the Commission III meeting in Beijing*
- *New SG Meeting.*



Progress



International Academy of Astronautics

October 2013:

- *25th October: Finalization of the Draft Report including all deliverables*
- *Send the Report to IAA*

November 2013:

- *IAA will synthesize the main part/recommendation of the report for inclusion in the HoA report*
- *IAA discuss HoA report with Space Agencies*

Taking into account the feedback from the event in Washington, the Study Report will then be finalized in 2014-15.



Progress



International Academy of Astronautics

3rd Meeting, July 4 2013, Turin

Minutes of Meeting:

- **The status of activities of our study was reviewed and next step action was discussed.**
- **More inputs from all members are needed.**
- **A online copy will be opened.**
- **Beijing face-to-face meeting will be arranged.**

Right now, A 43-page report has been completed.

And an online copy was created, so everyone can work on the current copy and we don't have multiple versions floating around. Multiple people can edit the document at the same time.



Current Status



International Academy of Astronautics

■ **Table of contents:**

I. Introduction

Part 1-Feasibility and Missions

II. Scope and feasibility

III. Impact on future space systems and development

IV. Space environment

Part 2-Technologies

V. Key Technologies

Part 3-Programmatic and Implementation

VI. Roadmap for the implementation

VII. Conclusions and Recommendations



Current Status



International Academy of Astronautics

■ **Report: (43 pages)**

I. Introduction (4 pages)

a. Definition, Background and Requirements

b. Definition of goals with related criteria: Political, Scientific, Economical

c. Heritage of past experience

d. Lessons learned from the past efforts on Space Propellant Depots

e. Operational Scenarios



Current Status



International Academy of Astronautics

■ **Report: (43 pages)**

I. Introduction (4 pages)

a. Definition, Background and Requirements

b. Definition of goals with related criteria: Political, Scientific, Economical

c. Heritage of past experience

d. Lessons learned from the past efforts on Space Propellant Depots

✓ *Water to cryo depots: M. Moran, Conceptual Study of On-Orbit Production of Cryogenic Propellants by Water Electrolysis, AIAA-91-1844.*

✓ *100-200% increase in performance over existing LVs and current operational approaches if existing stages refueled in LEO vs direct insertion (D. Bienhoff, LEO Propellant Depot Concept for Outgoing Exploration, NSS ISDC, Dallas, TX, 25-28 May 2007);*

✓ *Cost differential between mission and propellant launches is essential;*

✓ *No one best propellant source in cislunar sphere of operations: D. Bienhoff, AIAA 2011-7112;*

✓ *...*

e. Operational Scenarios

■ Report: (43 pages)

I. Introduction (4 pages)

a. Definition, Background and Requirements

b. Definition of goals with related criteria: Political, Scientific, Economical

c. Heritage of past experience

d. Lessons learned from the past efforts on Space Propellant Depots

e. Operational Scenarios

✓ *Earth Orbit Transportation*

- *GTO RTV / GTO ATV / GEO RTV / GEO ATV*

✓ *Cislunar Transportation*

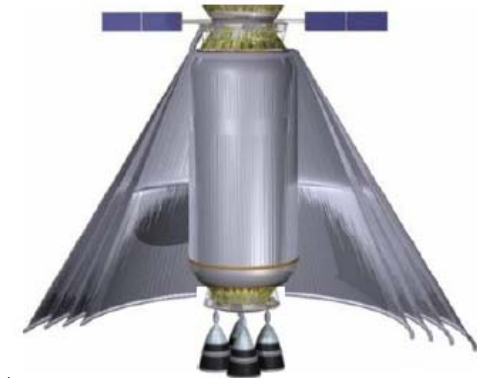
- *LEO to L1/L2 RTV / LEO to L1/L2 ATV / L1/L2 to surface LAV*

✓ *Interplanetary Transportation*

- *Expendable departure stages / Near escape RTV / Near escape Δv*

✓ *Propellant Sources*

- *Storable / cryogenic*
- *Earth Supplied / Earth or Moon Supplied / Earth and Moon Supplied / Earth, Moon, and NEO Supplied*



■ Report: (43 pages)

Part 1-Feasibility and Missions (4.5 pages)

II. Scope and feasibility (1 page)

a. Receive, store & transfer

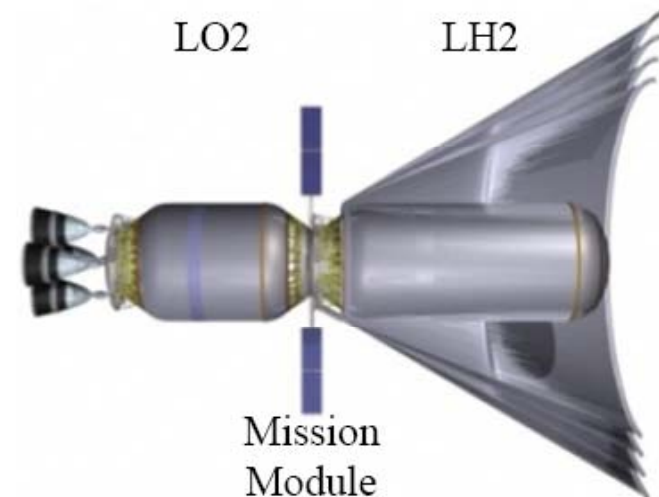
b. Water to cryogenic propellants

c. Order of Magnitude Scale

- *GTO missions – 10 to 30 mt*
- *GEO missions – 10 to 30 mt*
- *Lunar missions – 150 – 200 mt*
- *Earth departure missions – 200 to 500 mt*

d. Autonomous or on-site human operations

- *Autonomous operations with remotely operated or autonomous robotic maintenance*
- *Autonomous operations with human maintenance*
- *On-site human presence with human maintenance*



■ **Report: (43 pages)**

Part 1-Feasibility and Missions (4.5 pages)

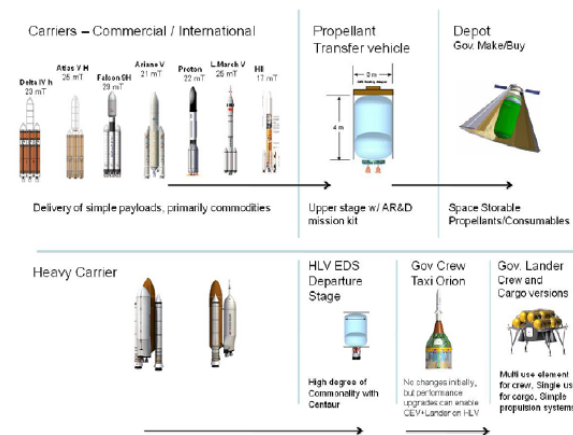
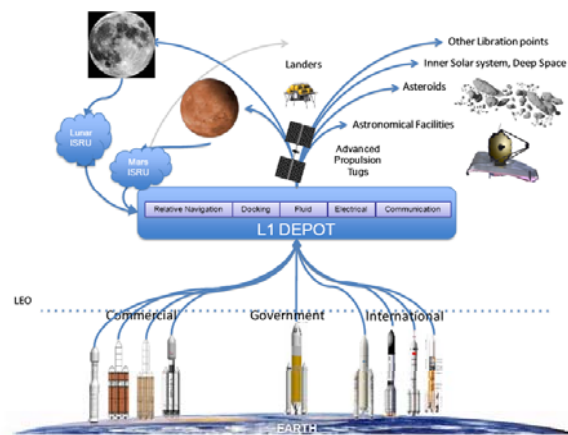
III. Impact on future space systems and development (1 page)

a. Space launch systems (Earth to Orbit)

- Reduce the propellant tanks of current transportation systems
- Bring new transportation architecture for Earth to Orbit missions

b. Cislunar space transportation systems (Earth orbit to EML2 including lunar landers)

c. Space exploration systems (for missions extending beyond EML2)



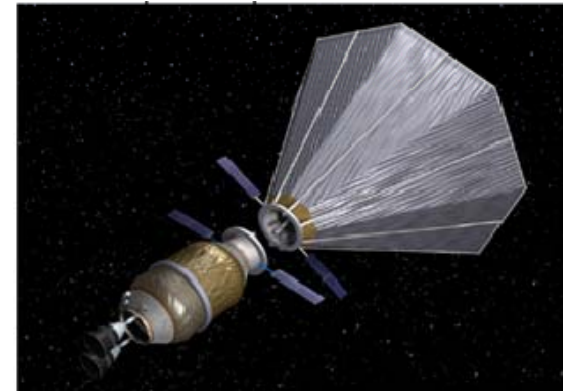
IV. Space environment (2.5 pages)

a. Prospective orbits and assessment of related environments

- *LEO, GEO, L1, L2, ...*
 - ✓ *Atmosphere*
 - ✓ *Plasma*
 - ✓ *Vacuum*
 - ✓ *Particles*
 - ✓ *Van Allen radiation belts*
 - ✓ *Thermal environment*
 - ✓ *Radiation*
 - ✓ *Dust and debris*
 - ✓ *...*

b. Impact of environment on design of Space Depots

c. Conclusion



IV. Space environment (2.5 pages)

a. Prospective orbits and assessment of related environments

b. Impact of environment on design of Space Depots

- *Thermal environment*

- ✓ *Solar radiation*

- ✓ *Earth IR*

- ✓ *Albedo*

- ✓ *Deep space IR*

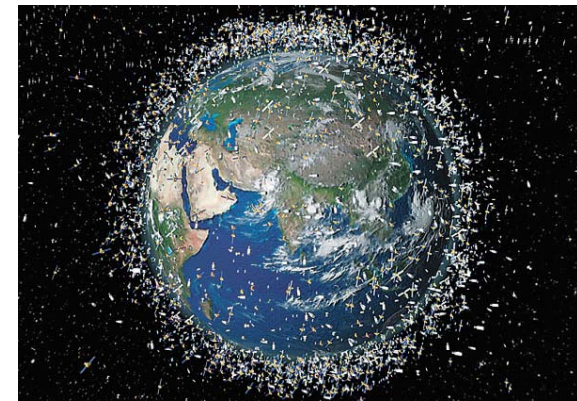
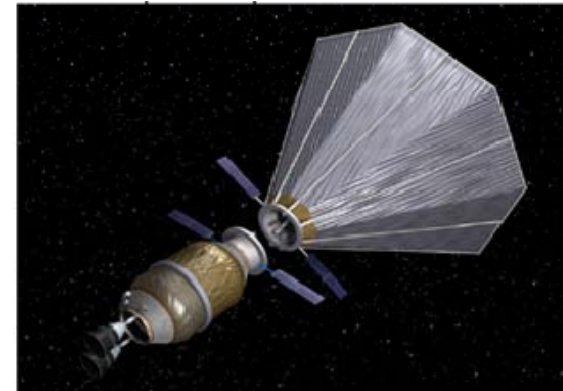
- ✓ *...*

- *Radiation*

- *Other space environment factors*

- ✓ *Space debris*

c. Conclusion



Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

a. List of the key technologies

1. The cryogenic propellant boil-off control

- a) Passive insulation*
- b) Reducing the structure heat load*
- c) Cryocoolers*
- d) Para-Ortho Conversion*
- e) Sun Shield*
- f) Subcooling propellant*

2. Cryogenic propellant transfer

3. System demonstration

4. Tank pressure control technology

5. Cryogenic propellant gauging

6. Other related technologies

- a) Low acceleration settling*
- b) Propellant acquisition*
- c) System chilldown*
- d) Autogenous pressurization*

b. Fundament and Status of key technologies

c. Spin-in and spin-off from non-space sectors

d. Risks assessment

e. Challenges

f. Potential solutions

g. Schedules and costs

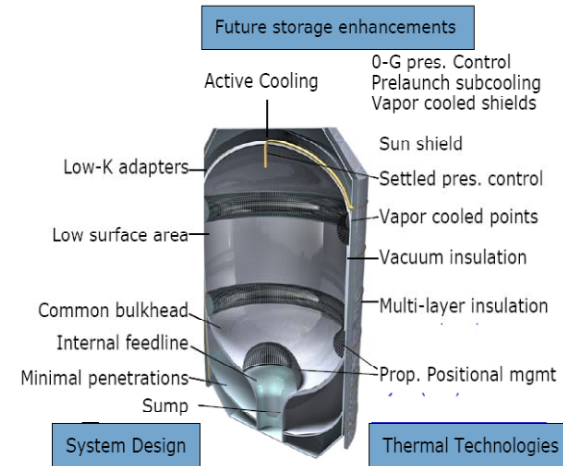
Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

a. List of the key technologies

b. Fundament and Status of key technologies

1. *The cryogenic propellant boil-off control*
2. *Cryogenic propellant transfer*
3. *System demonstration*
4. *Tank pressure control technology*
5. *Cryogenic propellant gauging*
6. *Other related technologies*
 - a) *Low acceleration settling*
 - b) *Propellant acquisition*
 - c) *System chilldown*
 - d) *Autogenous pressurization*



Centaur



Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

a. List of the key technologies

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1. The cryogenic propellant boil-off control

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4. Tank pressure control technology

5. Cryogenic propellant gauging

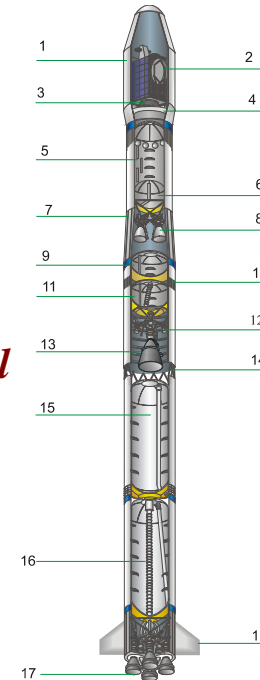
6. Other related technologies

a) Low acceleration settling

b) Propellant acquisition

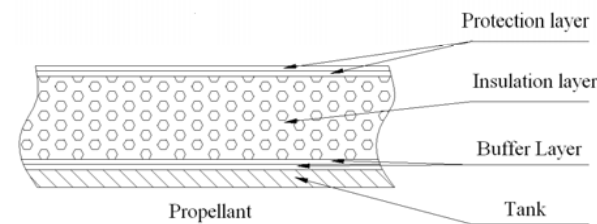
c) System chilldown

d) Autogenous pressurization



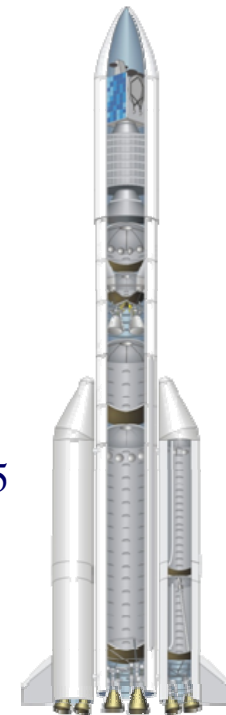
CZ-3A Series

- 1. Payload Fairing
- 2. Payload
- 3. Payload Adapter
- 4. Vehicle Equipment Bay
- 5. LH₂ Tank
- 6. LOX Tank
- 7. Inter-stage Section
- 8. Stage-3 Engine
- 9. Oxidizer Tank
- 10. Inter-stage Section
- 11. Fuel Tank
- 12. Stage-2 Vernier Engine
- 13. Stage-2 Main Engine
- 14. Inter-stage Truss
- 15. Oxidizer Tank
- 16. Fuel Tank
- 17. Stage-1 Engine
- 18. Stabilizer Fin



foam insulation structure

CZ-5



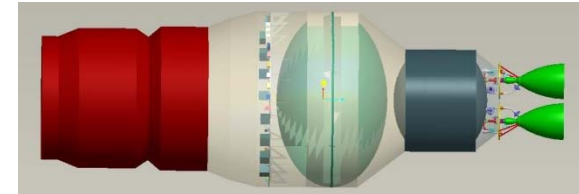
Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

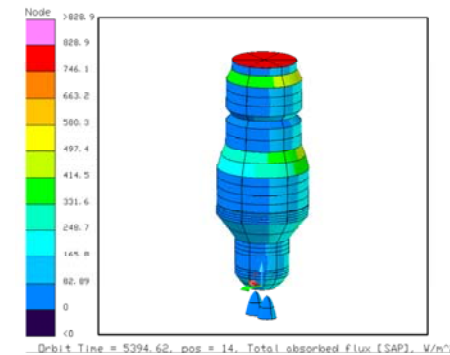
a. List of the key technologies

b. Fundament and Status of key technologies

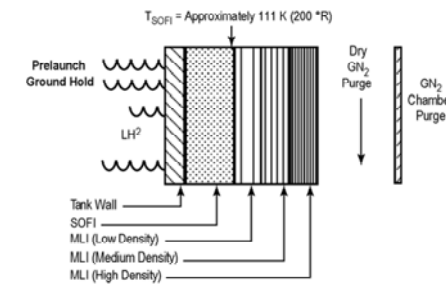
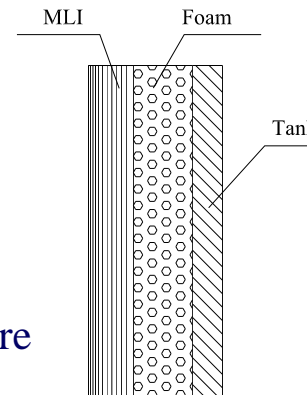
1. *The cryogenic propellant boil-off control*
2. *Cryogenic propellant transfer*
3. *System demonstration*
4. *Tank pressure control technology*
5. *Cryogenic propellant gauging*
6. *Other related technologies*
 - a) *Low acceleration settling*
 - b) *Propellant acquisition*
 - c) *System chilldown*
 - d) *Autogenous pressurization*



Chinese large cryogenic upperstage



Foam + VDMLI insulation structure



Variable density MLI

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

a. List of the key technologies

b. *Fundament and Status of key technologies*

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Many countries (US/ Russia/ EU/ China/ Japan ...) are investigating the In-Space Propellant Refueling technologies, especially for US and Russia, they have achieved significant progresses in this area.





Current Status



International Academy of Astronautics

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

a. List of the key technologies

b. Fundament and Status of key technologies

1. The cryogenic propellant boil-off control

2. Cryogenic propellant transfer

3. System demonstration

4. Tank pressure control technology

5. Cryogenic propellant gauging

6. Other related technologies

a) Low acceleration settling

b) Propellant acquisition

c) System chilldown

d) Autogenous pressurization

In support of NASA GRC the Atlas program developed a low cost, ride share flight demonstration concept that can demonstrate all aspects of cryo-transfer and CFM technologies at a relevant scale.

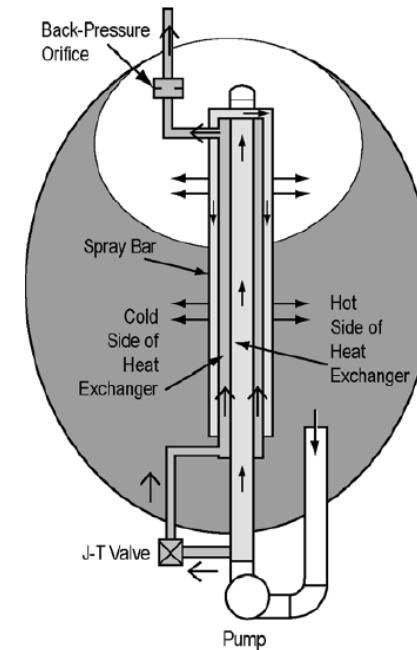
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V. Key Technologies (25.5 pages)

a. List of the key technologies

b. Fundament and Status of key technologies

1. *The cryogenic propellant boil-off control*
2. *Cryogenic propellant transfer*
3. *System demonstration*
4. *Tank pressure control technology*
 - a) *Ullage venting*
 - b) *Thermodynamic venting*
 - c) *Active cooling*
5. *Cryogenic propellant gauging*
6. *Other related technologies*



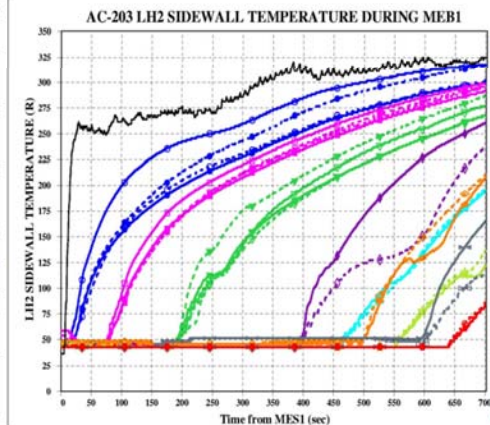
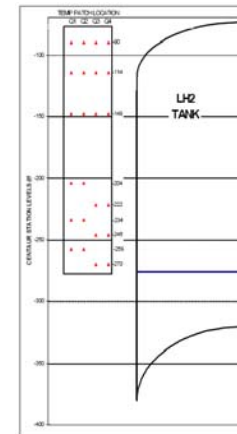
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b. Fundament and Status of key technologies

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3. System demonstration
4. Tank pressure control technology
5. **Cryogenic propellant gauging**
 - a) Low acceleration settling
 - b) Propellant acquisition
 - c) System chilldown
 - d) Autogenous pressurization



Settling provides a gas/liquid interface that can be measured to establish liquid mass. Thermocouples and gas/liquid diodes internal to the tank have proven very effective in defining the station level of the liquid/gas interface.

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

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b. Fundament and Status of key technologies

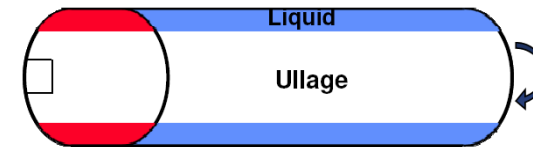
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Cryo Transfer Technology	TRL	
	0-G	Settled
Pressure Control	4	9
Ullage & Liquid Stratification	3	9
Propellant acquisition	3	9
Mass Gauging	3	9
Propellant Expulsion Efficiency	3	8
System Chilldown	8	8
AR&D	7	7
Transfer System Operation	3	6
Fluid Coupling	6	6
Passive Long Duration Storage	5	5

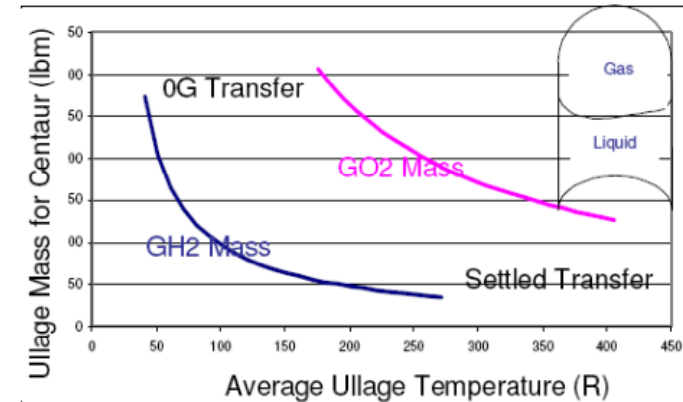
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Propellant acquisition through settling has been used reliably for all large scale cryogenic upper stages. Expulsion efficiencies well in excess of 99.5% of liquids are achieved on Centaur

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

a. List of the key technologies

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- 1. The cryogenic propellant boil-off control*
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Existing upper stages have demonstrated hardware chilldown procedures that are directly applicable to cryogenic transfer.



Current Status



International Academy of Astronautics

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

- a. List of the key technologies*
- b. Fundament and Status of key technologies*
- c. Spin-in and spin-off from non-space sectors*
- d. Risks assessment*
- e. Challenges*
 - *Architecture itself*
 - *Thermal control*
 - *Propellant sealing*
 - *Systematic integration*
 - *International cooperation*
 - ...
- f. Potential solutions*
- g. Schedules and costs*

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

- a. List of the key technologies*
- b. Fundament and Status of key technologies*
- c. Spin-in and spin-off from non-space sectors*
- d. Risks assessment*
- e. Challenges*
- f. Potential solutions***
- g. Schedules and costs*

*For instance: **System demonstration:***

Generally, for a system demonstration, there are several phases should be carried out, as following.

- ✓ *Theoretical analysis and numerical simulation*
- ✓ *Ground tests*
- ✓ *Ground system demonstration*
- ✓ *Flight tests*
- ✓ *Flight system demonstration*
- ✓ *Product flights*

For the flight test phases, some mature international cryogenic launch vehicles can be used to launch the testing payloads, such as: LM-3A series, LM-5, Ariane 5, Atlas, Titan and Proton.



Current Status



International Academy of Astronautics

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

- a. Questions to be answered with the relevant time frame*
- b. Private vs. institutional initiatives*
- c. International capabilities and possible contributions*
- d. Global set of requirements*
- e. Enabling technologies required with the required time frame*
- f. Programme and operational sustainability*
- g. Environmental impact*
- h. Policy, legal and insurance frameworks*
- i. Outreach aspects*
- j. Cooperative framework*
- k. Decision roadmap*



Current Status



International Academy of Astronautics

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

- a. Questions to be answered with the relevant time frame*
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- c. International capabilities and possible contributions*

China input:

Capabilities:

- *Cryogenic upperstage*
- *Several-day inspace stay cryogenic transfer stage*
- *Autonomous rendezvous and docking*
- *Multi-ignition technology*
- ...

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

- a. Questions to be answered with the relevant time frame*
- b. Private vs. institutional initiatives*
- c. International capabilities and possible contributions*

China input:

Capabilities:

- *Cryogenic upperstage*
 - ✓ *Foam passive insulation technology*
 - ✓ *Cryogenic propellant management technology*
 - ✓ *Cryogenic propellant gauging technology*
- *Several-day inspace stay cryogenic transfer stage*
- *Autonomous rendezvous and docking*
- *Multi-ignition technology*
- ...

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

- a. Questions to be answered with the relevant time frame*
- b. Private vs. institutional initiatives*
- c. International capabilities and possible contributions*

China input:

Capabilities (cont.):

- *Cryogenic upperstage*
- *Several-day inspace stay cryogenic transfer stage*
 - ✓ *VDMLI passive insulation technology*
 - ✓ *Microgravity cryogenic propellant management technology*
 - ✓ *Microgravity cryogenic propellant gauging technology*
 - ✓ *Cryogenic tank pressure control technology*
 - ✓ *Microgravity cryogenic propellant transfer technology*
 - ✓ *Para-Ortho Conversion technology*
 - ✓ *Subcooling propellant technology*
 - ✓ *System chilldown technology*



Current Status



International Academy of Astronautics

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

- a. Questions to be answered with the relevant time frame*
- b. Private vs. institutional initiatives*
- c. International capabilities and possible contributions*

China input:

Potential contributions:

- Structure system design*
- Thermal control system design*
- Cryogenic propellant boil-off control system*
- Autonomous rendezvous and docking*
- ...*



Current Status



International Academy of Astronautics

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

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- f. Programme and operational sustainability*
- g. Environmental impact*
- h. Policy, legal and insurance frameworks*
- i. Outreach aspects*
- j. Cooperative framework*** └─ *✓ Benefit*
- k. Decision roadmap* └─ *✓ Cooperative type*
✓ Cooperative and operation characteristics

j. Cooperative framework (cont.)

- *Benefit*

- ✓ *Storable propellant depot (LEO)*

- The depot can be used by any member to extend the lives of satellites and other spacecrafts.*

- The new and emerging space faring nations or enterprises, especially for those do not have the ability of cryogenic propulsion, can use the depot to accomplish some missions they can not reached before, such as: GEO mission, lunar and asteroid explorations.*

- ✓ *Cryogenic propellant depot (LEO/GEO/L1/L2...)*

- The depot can be used in the lunar and deep space explorations to reduce the transportation scale and cost, or used to accomplish deep space explorations beyond current ability.*

- The new and emerging space faring nations or enterprises, especially for those do not have the heavy launch vehicles, can use the depot to accomplish some missions they can not reached before, such as: GEO mission, lunar and asteroid explorations.*



Current Status



International Academy of Astronautics

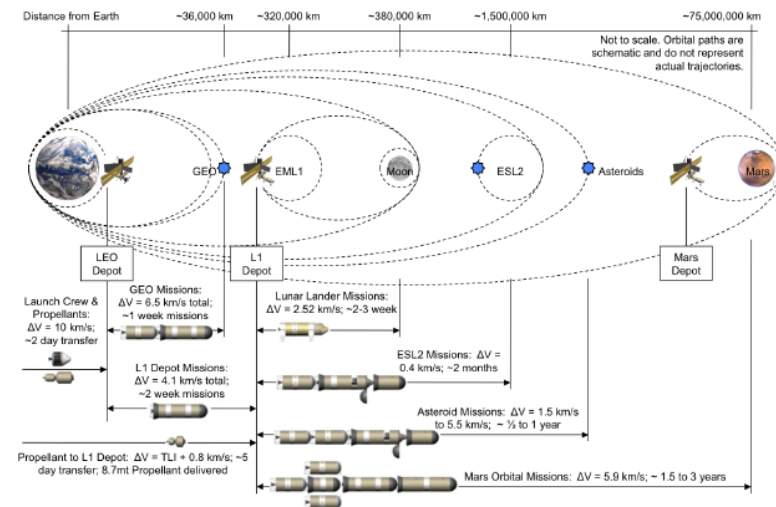
j. Cooperative framework (cont.)

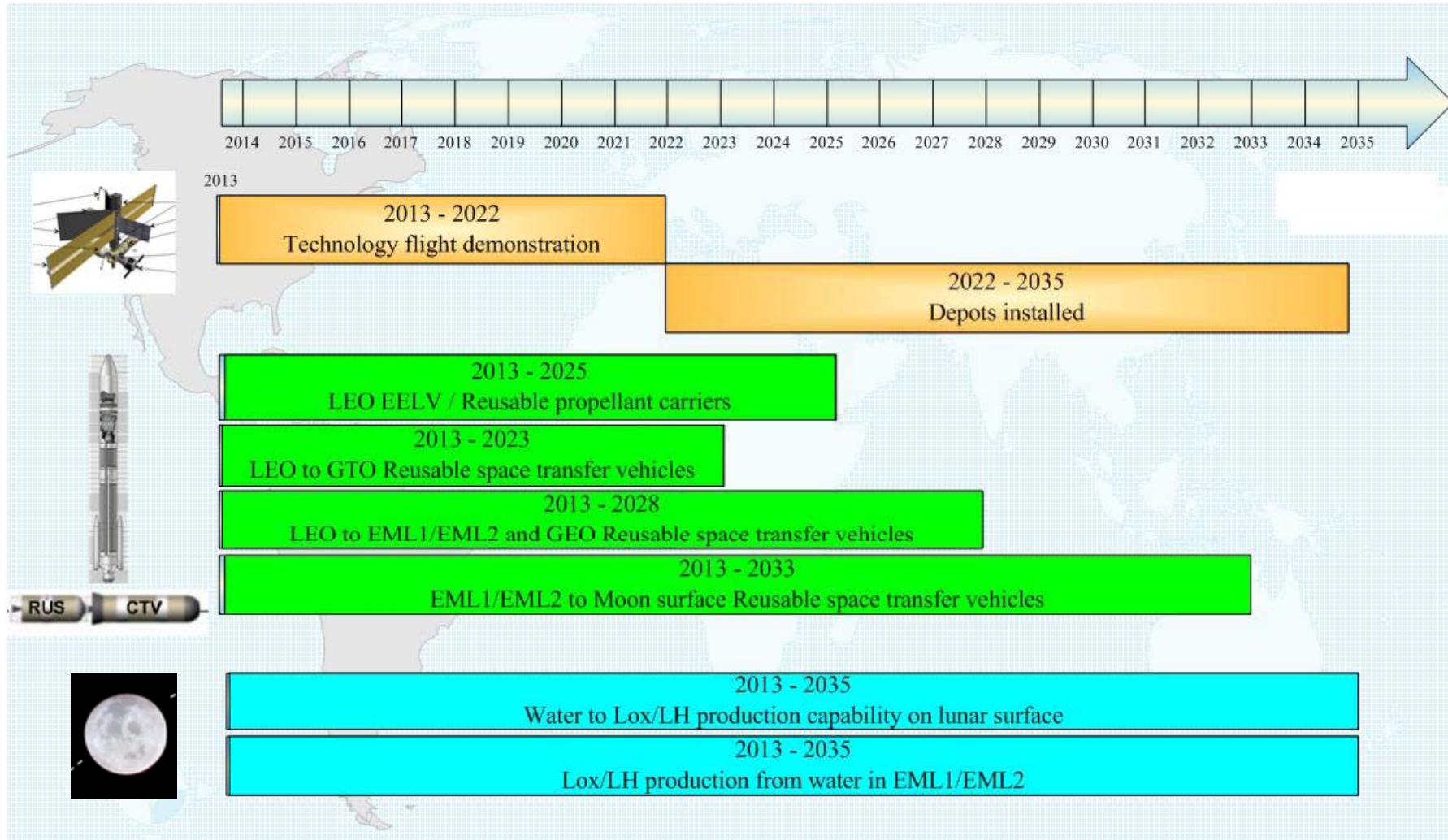
- *Cooperative type*
 - ✓ *Governmental cooperative initiative and operation*
 - ✓ *Private enterprise cooperative initiative and operation, supported by governments*
 - ✓ *Create an exclusive international enterprise, supported by governments*
- *Cooperative and operation characteristics*
 - ✓ *Propellant depots should be an open source solution with standard interfaces for receiving and providing fluids.*
 - ✓ *Buys from any source and sells to any customer.*
 - ✓ *Other related technical solutions: hardware assemblies, components, and software can be provided by those with capabilities. .*

Part 3-Programmatic and Implementation (9 pages)

VI.Roadmap for the implementation (9 pages)

- a. *Questions to be answered with the relevant time frame*
- b. *Private vs. institutional initiatives*
- c. *International capabilities and possible contributions*
- d. *Global set of requirements*
- e. *Enabling technologies required with the required time frame*
- f. *Programme and operational sustainability*
- g. *Environmental impact*
- h. *Policy, legal and insurance frameworks*
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- j. *Cooperative framework*
- k. *Decision roadmap*







Next Actions



International Academy of Astronautics

■ **Table of contents: (43 pages)**

I. Introduction (4 pages)

Part 1-Feasibility and Missions (4.5 pages) ★

II. Scope and feasibility (1 page)

III. Impact on future space systems and development (1 page)

IV. Space environment (2.5 pages)

Part 2-Technologies (25.5 pages)

V. Key Technologies (25.5 pages)

Part 3-Programmatic and Implementation (9 pages)

VI. Roadmap for the implementation (9 pages)

VII. Conclusions and Recommendations (0 page) ★ ★ (Focus)



Next Actions



International Academy of Astronautics

For the HOA Summit in Washington D.C. on 9-10 January 2014

October 2013:

- *25th October: Finalization of the Draft Report including all deliverables*
- *Send the Report to IAA*

November 2013:

- *IAA will synthesize the main part/recommendation of the report for inclusion in the HoA report*
- *IAA discuss HoA report with Space Agencies*



Next Actions



International Academy of Astronautics

March 2014:

- *Taking into account the feedback from the event in Washington, improve and complement the draft report*
- *New SG Meeting in Paris*

October 2014:

- *Sufficient inputs from all the SG members*
- *Chapter captains wrap up all the inputs, and a preliminary final report will be completed by Chairs*
- *New SG Meeting in Toronto*

March 2015:

- *Improve and complement the final report*
- *New SG Meeting in Paris*
- *Discuss and identify when to send the final Report to IAA for review*



Conclusion



International Academy of Astronautics

- 1. An international group team are formed and many inputs are received.**
- 2. Concept and opportunities for future high energy propellant space depots are preliminarily identified.**
- 3. The required key technologies are listed and analyzed preliminarily .**
- 4. Drafts of international cooperative mode and roadmap are also defined.**
- 5. The conclusion and suggestion part should be emphasized.**
- 6. More inputs from every member are wanted.**



Thanks!

IAA STUDY GROUP SG 3.16
GLOBAL HUMAN MARS SYSTEM
MISSIONS EXPLORATION

I

G. Genta¹, A.Dupas², J.-M. Salotti³

¹ Politecnico di Torino, Dept. of Mech. and Aer. Eng., Italy

² International Consultant, France

³ IMS laboratory, Institut Polytechnique de Bordeaux

IAA study group SG 3.16

Human missions to Mars have been studied by several Space Agencies over the past decades.



IAA Academy Day, Beijing, China, Sept 22, 2013

The IAA Cosmic Studies

In line with the past summit recommendations, and in preparation for the next Head of Space Agencies Summit, planned for January 2014, the IAA, has started a number of Cosmic Studies.

The study «*Global Human Exploration Mars System Missions – Goals, Requirements and Technologies*» was approved in August 2012.

Its goal is: «*The report will carry out the first worldwide assessment of a Human mission to Mars with the required technologies and roadmap. Special emphasis will be put on engaging new and emerging spacefaring nations* ».

IAA study group SG 3.16

The study aims to identify means to minimize the risks at global level, while ensuring the affordability and feasibility of human Mars exploration.

The study team has been selected and has already met 3 times in October 2012 during the IAC in Naples, in March 2013 at the IAA Headquarters in Paris and in August 2013 at the 8th IAA Symposium on the Future of Space Exploration in Turin. Responsibilities have been assigned and work is progressing rapidly.

A special 25-page synthesis document is scheduled to be available for the next Heads of Space Agencies Summit in Washington D.C. in January 2014.

Philosophy, content, organization

The deliverables of the study will be

- The 50 – 70 pages (plus appendices) final report, to be delivered
 - as a draft by September 2014
 - as a final document by September 2015
- A 25 pages synthesis for the next Summit of the Heads of Space Agencies, to be delivered
 - as a draft by October 2013
 - as a final document by January 2014 .

Composition of the study group

Co-chairmen: Giancarlo Genta and Alain Dupas

Secretary: Jean-Marc Salotti

Members: (in alphabetic order):

Mauro Augelli

Andrew Aldrin

Nicolas Bérend

Giovanni Bignami

Christophe Bonnal

Claudio Bruno

John B. Charles

Lin Chen

Elisa Cliquet Moreno

Gabriel G. De la Torre

Nadeem Ghafoor

Alexey Grushevski

Richard. Heidmann

Bernhard Hufenbach

Les Johnson

Nick Kanas

Composition of the study group

David Kendall

Julien-Alexandre Lamamy

Kohtaro Matsumoto

Susan McKenna-Lawlor

Natalia Nikolaeva

Maria Antonietta Perino

Yury Razoumny

Stephen C. Ringler

Christian Sallaberger

Alexander Semenkin

Liu Wei

Alan Wilhite

Lu Yu

Andrey A. Kuricyn

John Logsdon

Chris McKay

Ernst Messerschmid

Gian Gabriele Ori

Viacheslav Petukhov

Pascal Renten

Andreas Rittweger

Klaus Schilling

Carol R. Stoker

Luo Wencheng

Cao Xiaohui

Philosophy, content, organization

The goal is neither to conduct detailed technical studies nor to select mission architectures.

It relies on the many technical analysis and system studies conducted by space agencies, universities, research organizations and companies, during the last decades, analyzing and putting them into perspective, to identify the most important and significant technical and non-technical issues.

The goal is providing decision-makers at the highest level a balanced assessment of the promises and risks of a human Mars mission, with recommendations in terms of rationale, R&D priorities, international framework and schedule.

Table of contents

- I. Mission rationale**
- II. Lessons learned from the past projects for Human Mars Exploration**
- III. International cooperation**
- IV. The environment**
- V. The human issues**
- VI. The space transportation system**
- VII. The planetary infrastructure and vehicles**
- VIII. The ground sector**
- IX. Roadmap for the implementation of the mission**
- X. Conclusions**
- Appendices and bibliography**

Emerging guidelines

Most material already collected tends to concentrate on the following aspects:

- Mission rationale
- Mission Architecture
- Human issues

While being too early to anticipate any result of the study, some guidelines which emerged in the meetings performed up to now can be stated.

Emerging guidelines

Some points emerged as main guidelines:

- The mission should be realistic and affordable ("sustainable") with a clear roadmap.
- International collaboration is a must
- The crew size should be as reduced as possible, keeping in mind human factors and other problems (a crew of 3 might be a starting point)
- A new trade-tree should be proposed
- A controversial issue must be faced: chemical propulsion vs. nuclear based propulsion in the interplanetary part of the journey. This should be discussed, and if an agreement is not reached, the two positions should be stated frankly and clearly.

Conclusions

Several preliminary reports presenting a synthetic view of a part of the study have already been written.

Every member of the group will soon be solicited to read these contributions and make suggestions according to his expertise.

Later on, the main conclusions will be proposed for each part, some issues will be identified and a list of the most important topics will be drawn up and discussed at the next IAC meeting in Beijing.

SG 3.18

Study group on **Feasibility Study of Possible
International Protocol to handle
crisis / emergency to Astronauts in LEO**

Status as on 19 September 2013

STUDY GROUP MEMBERS

- S Ramakrishnan, VSSC, ISRO, India – Chair
- Bernhard Hufenbach, ESA /ESTEC, The Netherlands
 - Mike Hawes, Lockheed Martin, USA
 - ZHANG Shu, CALT, China
- Member from Russia – to be identified
- Student member from Belgium-under consideration
- Prof . Irmgard Marboe, University of Vienna, Vienna
- Unnikrishnan Nair S., VSSC/ISRO, India – Secretary

► Membership changes

Discontinue:

Yury Sosyurka, Russia- New member to be identified

Add: Decision awaited

Name	Gurric De Crombrughe De Looringhe
Mailing address	Rue Comte J. de Meeus 6, 1428 Lillois, Belgium



► Overall Goal

- Study will address the feasibility to establish a protocol, for rescue of crew from LEO, who got marooned or have lost de-orbit burn capability or are left with intolerably damaged thermal protection system. The study is limited to rescue from LEO / Near earth zone as a first step.
- Rescue in the context of this protocol is considered to be those cases where external assistance is mandatory to save the lives of the crew.

► Status

- Had four telecom-15 February, 21 May, 21 June and 3 September 2013. One meeting of chair and two members held at ESA HQ on 20 March.
- Status paper made and presented in IAA conference at Turin in July
- Content list prepared and finalized after consultation with team members.
- Detailed literature collected on the topic.
- Draft chapters prepared and circulated to members. Based on input from members, chapters modified.
- A consolidated draft document prepared and circulated to members for comments. Second draft under preparation.


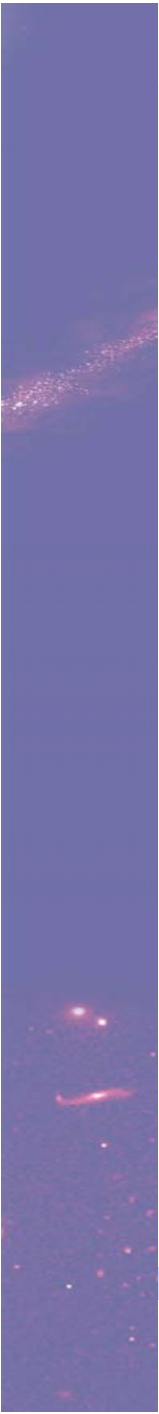
► Proposed Contents of Study Report

- Chapter 1: Introduction/Preamble
- Chapter 2: Objectives/scope of study
- Chapter 3: Possible crisis situations/emergency scenario of Crew in LEO and Crew rescue methodologies
- Chapter 4: Current International Treaties/Protocol in the area of Outer Space & Space Travel/Space systems and their implementation status
- Chapter 5: Impediments/hurdles foreseen in evolving an international protocol on Crew rescue from space and approach to overcome them
- Chapter 6: Recommendations of Study group towards evolving a protocol to handle crisis/emergency of astronauts in LEO
- Chapter 7: Conclusion & way forward
- Annexures:
 - Index of International agreements/MoU/Protocol governing activities in outer space
 - Bibliography

▶ Chapter 3 : Possible crisis situations/emergency scenario of Crew in LEO and Crew rescue methodologies

- Various crisis situations/emergency scenario and crew rescue methodologies will be discussed
 - ✓ For present systems
 - ✓ For proposed future systems

- Typical crisis/emergency situations include:
 - Stable spacecraft but loss of de-orbit capability
 - Crew is healthy but spacecraft has lost integrity
 - Crew is incapacitated but the spacecraft is functioning well
 - Crew is incapacitated and the spacecraft is not under control
 - Rescue by manned ambulance craft or using unmanned robotic craft.



▶ Chapter 4 : Current International Treaties/Protocol in the area of Outer Space & Space Travel/Space systems and their implementation status

- ❑ Current instruments relevant in the context of space travel
 - ✓ Declaration of Legal Principles Governing the Activities of States in the Exploration of Outer Space
 - ✓ Outer Space Treaty
 - ✓ Rescue Agreement
 - ✓ ISS Crew Code of Conduct
- ❑ Different scenarios and the application of existing space law will be discussed
- ❑ Current legal framework does not cover all types of space activities carried out by a number of different space actors, including emerging space faring nations and private operators
- ❑ Obligations of States in cases of distress or emergency situations occurring in LEO are not clear
- ❑ A protocol or another instrument for interpretation could be beneficial for the clarification of the outstanding questions

► Chapter 5 : Impediments/hurdles foreseen in evolving an international protocol on Crew rescue from space and approach to overcome them

Various technical, managerial, political and economical issues that can impede the evolution of a protocol for crew rescue along with approach to overcome are discussed

- ❑ Satisfying diverse interest of stake holders/consensus among member countries:
- ❑ Rescue Scenario and Rescue Response time
- ❑ Sharing of cost in rescue mission
- ❑ Crew Size for future missions
- ❑ International Standardization of manned space vehicle systems
- ❑ Technology obsolescence
- ❑ Objection to technology transfer
- ❑ Deterrent on Technology development
- ❑ Geopolitical considerations
- ❑ Inadequacies of existing legal framework



► **How to overcome impediments for a possible approach for a Protocol**

- ❑ Standardisation of space systems
- ❑ Gaps of existing legal frame work
- ❑ Sharing of cost in rescue mission
- ❑ Rescue scenario and response time
- ❑ Crew Size for future missions
- ❑ Limitations on technology transfer
- ❑ Geopolitical considerations and so on...



▶ Further work planned in the coming weeks

- ❑ Incorporation of suggestions /comments of Telecon-4 and release of revised draft
- ❑ Telecon-5 to discuss second draft
- ❑ Final document release by 20 October 2013

IAA Study Group 3.21

SPACE DISPOSAL OF THE RADIOACTIVE WASTE

STUDY SUPPOSITIONS AND BRIEF DESCRIPTION OF THE RADIOACTIVE WASTE SPACE DISPOSAL IDEA



- A problem of radioactive waste (RW) disposal is one of the three major problems of nuclear power engineering alongside with its safety and economic indicators. One of the ways to solve the problem is a disposal of a part of the RW into space.

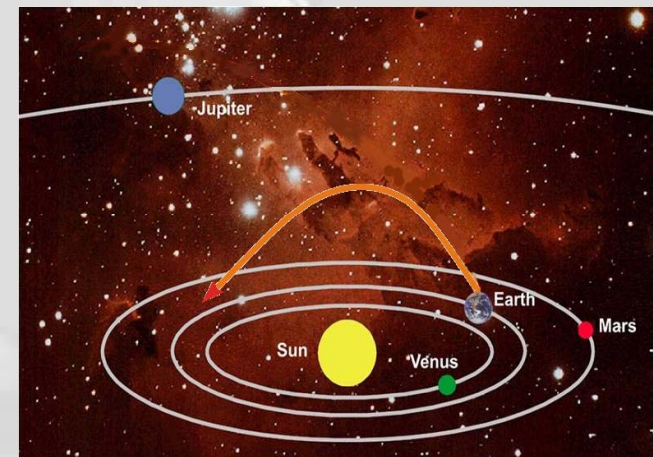
• It is supposed that the long-live isotopes having either extremely high radiotoxicity or abnormal diffusibility and which are not in demand in any existing technology, shall be extracted from a spent nuclear fuel (SNF) using radiochemical methods. The quantity of such RW comprises less than 1% of initial SNF mass.

• As a next step, the radioactive waste which is a subject to space disposal is covered by multi-barrier protection that guarantees safety in possible emergency conditions and provides acceptable radiation level on the external surface of the protection layers. After that RW is transported to the launch site, where it is installed onto the upper stage of a launch vehicle as a payload.



• The launch vehicle structure is optimized in a way to minimize probability of contact of the space-disposed RW with the biosphere in possible emergency conditions.

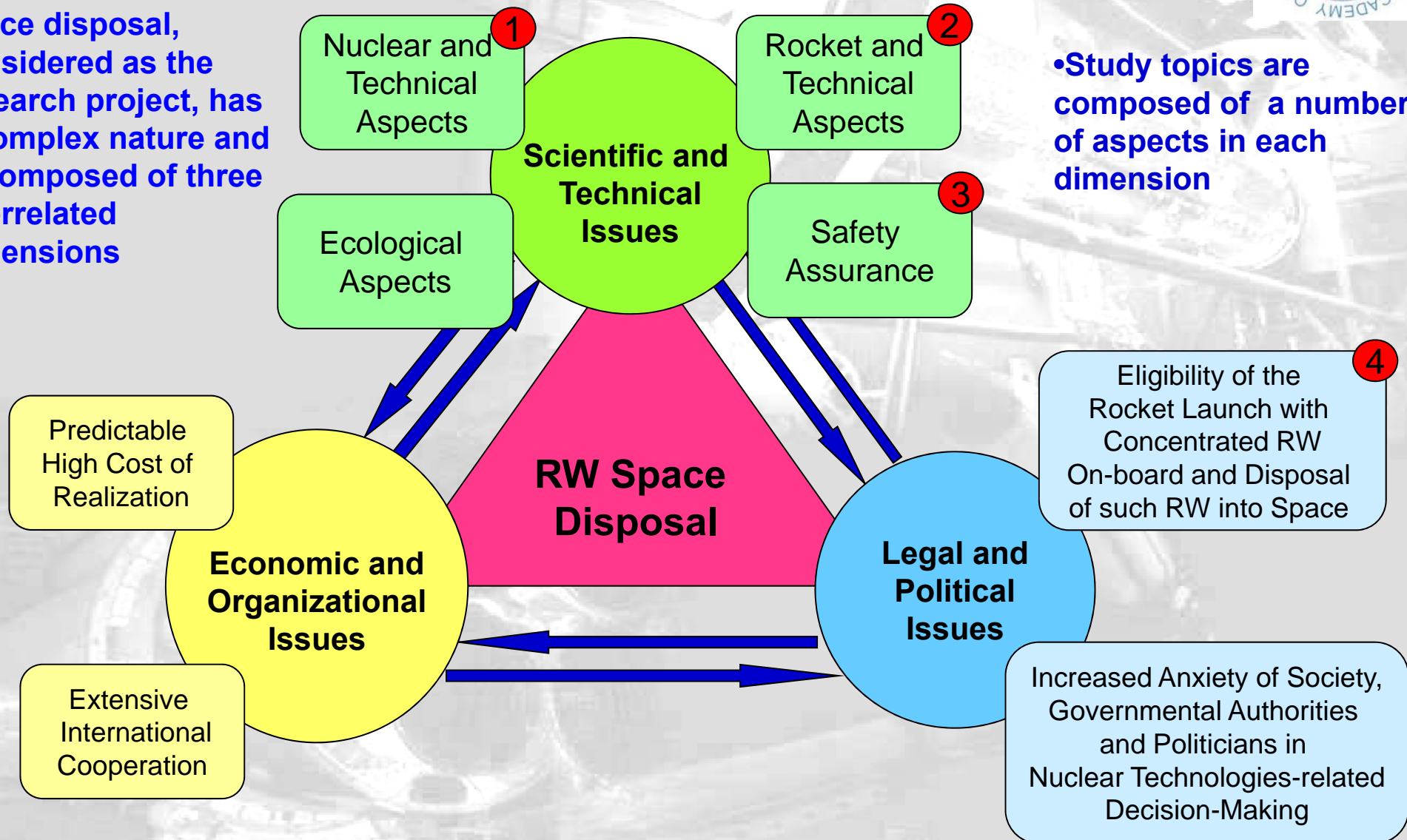
• In case of the successful launch of a capsule containing RW into space it will be delivered into a burial orbit, where it will stay for an indefinite long period of time.



STUDY TOPICS

• The idea of RW space disposal, considered as the research project, has a complex nature and is composed of three interrelated dimensions

• Study topics are composed of a number of aspects in each dimension



KEY ASPECTS OF THE STUDY

In order to implement the ideas of RW space disposal, acceptable decisions would be made on four groups of issues:

1. Radiation-chemical utilization of the spent nuclear fuel (SNF) for extraction of isotopes mixture for further disposal; bringing the isotopes to the condition suitable for use as a payload of space vehicle; a technology of handling such payload at all phases, including possible emergency situations.
2. Determination of burial orbit and development of space rocket transportation system, competitive with alternative burial options by cost and safety criteria, for injection of conditioned RW into this orbit.
3. Personnel, public, environmental safety assurance (acceptable risk levels), both during ground operations with RW and in possible emergency situations during injection into the burial orbit.
4. Development of international legal basis for practical launching of space vehicles containing RW; providing inter-state legal and political decision making to support the aforesaid programs.

EXPECTED RESULTS OF THE STUDY

- **Determination of the research & development as well as design & construction works for the purpose of creation of space rocket system for RW space disposal deployment expediency; specification of their directionality, scope of works and possible due dates;**
- **Proposals on basic engineering solutions for the second and third groups of issues;**
- **Overview and statement of the conceptual approaches for the first and fourth groups of issues (the results of this item will significantly depend upon the possibility of involvement of appropriate experts into these works);**
- **Full-scale implementation of the Project cost estimation;**
- **Proposals on the content of international scientific and industrial cooperation, required for the Project realization.**

PROPOSED CONTENT OF THE STUDY (1)



- 1. Problem of RW and suppositions for space disposal of a part of the waste**
 - 1.1. Possible approaches to the choice of the target isotopes, subjected to the space disposal**
 - 1.2. Capabilities of extracting of target isotopes from SNF**
 - 1.3. Capabilities of conditioning and immobilization of the target isotopes**
 - 1.4. Transportation of RW from a radiochemical plant to burial orbit**
 - 1.5. Safety issues at all phases of RW handling**
- 2. Definition of the burial orbits and launch vehicles**
 - 2.1. Requirements to the burial orbits, definition of the orbits**
 - 2.2. Possible schemes of RW delivery into burial orbit**
 - 2.3. Performance capabilities of launch vehicles**
 - 2.4. Choice of a launch site**

PROPOSED CONTENT OF THE STUDY (2)

- 3. Design view of space launch complex for space disposal**
 - 3.1. List of the design accidents and functional requirements to the complex components**
 - 3.2. Aerodynamic capsule**
 - 3.3. Sealed force container**
 - 3.4. Emergency recovery system**
 - 3.5. Launch facilities**
 - 3.6. Outline processing procedure**
- 4. Proposals on design accidents counteracting. Risk assessment**
- 5. Scientific and technical problems and possibilities of their solution**
- 6. Legal and political problems of RW space disposal and possibilities of their solution**
- 7. Cost estimations**
- 8. Proposals on possible scientific and industrial cooperation**

STUDY UNDER THE AEGIS OF IAA

- The Study initiated under the aegis of International Academy of Astronautics will allow to join efforts of international experts in space rocket and other fields of science in order to elaborate proposals on key aspects of the Study.
- It is suggested to focus on the second and third groups of issues within the frame of IAA. Major contribution to the subject should be made by space rocket experts. Their participation is also required to elaborate solutions for the first and fourth groups of issues.
- The level of study on the first and fourth groups of issues within the proposed effort will considerably depend upon the possibility of involvement of qualified experts in the field of nuclear technology and international law.

SPACE ROCKET SPECIALISTS, EXPERTS IN THE FIELD OF NUCLEAR POWER, RW HANDLING, RADIOCHEMISTRY, SAFETY ISSUES, ECOLOGY, RISK ASSESSMENT, INTERNATIONAL SPACE AND NUCLEAR LAW AND INTERNATIONAL RELATIONS ARE INVITED TO TAKE PART IN THE WORK UNDER THE STUDY.



IAA COMMISSION III

REPORT TO SAC

Beijing, 21 September 2013

Content List

- Commission Proceedings
- Status of On-going Studies
- Scientific Activity Plan 2013/15
- Symposia organized by the Commission in 2013/2014
- Increase support to Commission activities
- Annex I

Commission Proceedings

- Commission meeting held today
- Leadership discussed regularly the status of the actions to insure completion
- 4 New Members for the Commission will be coached
- The Commission established an agreement with the Space Generation Advisory Council (SGAC) selecting 3 members of SGAC for participating in 3 Study Groups.
(ei.3.14,3.15, 3.16)

Status of On-going Studies (1/2)

- **SG 3.10 “Technologies for Interstellar Precursor Missions”**
 - > Published by IAA in June 2013
- **SG 3.9 “Private Human Access, Vol I: Sub-Orbital”**
 - > Draft completed , July 2013,
 - > Commission review completed, August 2013
 - > VC Study Review, September 2013
 - > SAC/BoT Approval, October 2013
 - > Publication, Nov./Dec. 2013
- **SG 3.13 “Assessment of the Technology Feasibility and Challenges of the Space Elevator Concept”**
 - > VC Study Review, June 2013
 - > SAC/BoT Approval, Sep. 2013
 - > Publication Nov./Dec. 2013
- **SG 3.21 “Space Disposal of Radioactive Waste”**, New Proposal approved, but no activity has been initiated.

Status of On-going Studies (2/2)

- **SG3.14 “Private Human Access to Space – Vol. 2: Orbital”**
- **SG3.15 “Long Term Space Propellant Depot”**
- **SG3.16 “Global Human Mars Reference Mission and Technologies”**
- **SG3.17 “Space Mineral Resources – Challenges and Opportunities”**
- **SG3.18 “Possible International Protocol to handle Crisis/Emergency of Astronauts in Low Earth Orbit”**
- **SG3.19 “Feasibility study of Standardized Career Dose Limits in LEO and outlook for BLEO”**
- **SG3.20 “Expanding Options for Implementing Planetary Protection during Human Space Exploration”**
 - > Draft Reports (White Cosmic Study) to be delivered by 25 October 2013
 - > Published by IAA for the Summit in January 2014
 - > Final Reports (Cosmic Study) published in 2015

Scientific Activity Plan 2013/15

- Cosmic Studies to be published:
 - SG3.9, done in June; SG3.10, SG3.13 by end 2013
 - SG 3.14,3.16, 3.15, 3.17, 3.18, 3.19, 3.20; White Cosmic Study in 2014
 - SG 3.14,3.16, 3.15, 3.17, 3.18, 3.19, 3.20; Cosmic Study by 2015
- First version Cosmic Studies will be available in support of HoA Summit
- IAA Conferences will be used to present preliminary SG status and recommendations
- Thematic Symposia will be proposed for 2014/15, after discussion within the Commission, ei. Space Mineral Resources, Interstellar Technologies

Symposia organized by the Commission IAC 2013

- Commission III responsible for the following Symposia:
 - > A5 “Human Exploration of the Moon and Mars”(4 Sessions)
 - > C3.1 “Space Based Solar Power Architecture..” (1 Session)
 - > D3 “Building Blocks for Future Space Exploration..”(4 Sessions)
 - > D4 “Vision and Strategies for the Far Future” (4 Sessions)
- Average is 10 papers for 13 sessions to be presented

Symposia organized by the Commission

IAC 2014

- New Criteria and rule for Commission Membership applied
- Change of Coordinators/Session Chairs implemented, if required
- Symposia consolidated to be complementary to past/future Studies carried out by the Commission
- Main Changes to be confirmed after Commission meetings:
 - A5 focused on Human Mars Mission and Cislunar Space
 - D3 not changed with emphasis on Nuclear Propulsion
 - D4, new session on Interstellar Precursor and Beyond created
 - C3.1 not changed
- Details of the 2014 Symposia are in Annex 1

Increased support to Commission Activities

- Participation to the activities is open to all technical professional world wide especially for the Study Groups just initiated.
- Young Professionals are welcome since there is a need of fresh “blood” to bring new ideas to the Studies and prepare the future Academicians.
- Beside the 10 official Members of the Commission, the position of Expert should be created, by IAA, for internationally recognized professionals participating in the Commission activities but not yet appointed Academician.
- The possibility to join the Commission face--to-face meetings, in a virtual fashion, will be also investigated

Annex I (1/2)

IAC 2014 Symposia

- A5 “Human Exploration of the Moon and Mars”
 - A5.1 “Near Term Strategies for Cislunar/ Lunar Surface Infrastructures” (Change Proposed)
 - A5.2 “Human Mission to Mars, Reference mission/technologies” (NEW)
 - A5.3 Joint session on Human and Robotic Partnership (No Change)
 - A5.4 “Going Beyond the Cislunar System: Libtation Point, NEOs (Change Proposed)

Annex I (2/2)

IAC 2014

- C3.1 “Space Based Solar Power Architecture...” (No change)
- D3 “Building Blocks for Future Space Exploration and development” (No change)
- D4 “Visions and Strategies for the future”
 - D4.1 “Innovative Concept and Technologies” (No change)
 - D4.2 “Contribution of Space Activities to Solving Global Societal Challenges” (No change)
 - D4.3 “Global Strategy for Space Elevator” (Emphasis on the Cosmic Study)
 - D4.4 “Strategies for Rapid Implementation of Interstellar Missions: Precursors and Beyond” (New)

COMMISSION 3 SYMPOSIA AND CONFIRM PAPERS

D4: VISION AND STRATEGIES FOR THE FAR FUTURE

1. <u>Novel Concepts and Technologies</u>	<u>5 Confirmed Papers</u>	2013-09-24 09:45	208B
2-E6.4. <u>Joint Session on Global Public/Private Innovative Initiatives in Spaceflight</u>	<u>4 Confirmed Papers</u>	2013-09-24 14:45	208B
3. <u>Space Elevator Design and Impact</u>	<u>9 Papers Confirmed</u>	2013-09-26 14:45	208B
4. <u>Contribution of Space Activities to Solving Global Societal Challenges</u>	<u>8 Confirmed Papers</u>	2013-09-27 09:45	208B

D3: BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION

1. Strategies & Architectures as the Framework for Future Building Blocks in Space Exploration and Development	<u>7 CP</u>	2013-09-23 15:15	208B
2. Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development	<u>7 CP</u>	2013-09-25 09:45	208B
3. Novel Concepts and Technologies for Enable Future Building Blocks in Space Exploration and Development	<u>7CP</u>	2013-09-26 09:45	208B
4. Space Technology and System Management Practices and Tools	<u>7CP</u>	2013-09-27	208B

		13:30	
C3.1 Space-Based Solar Power Architectures – New Governmental and Commercial Concepts and Ventures	7CP	2013-09-25 13:30	North Foyer

A5 HUMAN EXPLORATION OF THE MOON AND MARS

1. Human Lunar Exploration **7CP**

2. Human Mars Exploration **5CP**

3-B3.6. Joint Session on Human and Robotic Partnerships to Realise Space Exploration Goals **9CP**

4-D2.8. Joint Session on Going To and Beyond the Earth-Moon System: Human Libration Points and NEO's **8CP**

IAC 2014 Technical Programme

Call for Inputs

Please submit the filled-out form to support@iafastro.org before 23 July (12:00 CET)

PROPOSER(S)

<u>Name(s)</u>	
<u>Committee(s)</u>	<u>IAA Commission 3</u>

SYMPOSIUM INFORMATION

Symposium	D4	
Symposium Name	12th IAA Symposium on Visions and Strategies for the Future	
Description (max. 200 words)	This 12 th Symposium is organized by the International Academy of Astronautics. In Space Activities the focus is usually kept on the short term developments, at the expense of future goals. The Symposium will discuss topics with at least 20 to 30 years prospective lead time and identify technologies and strategies that need to be developed. These developments will be examined with the goal to support also short/medium term projects and to identify priorities required for their development. The Sessions in the Symposium will address innovative technologies and Strategies to develop Space Elevator as well as Interstellar Precursor Missions. A session will address also how Space activities can contribute to the resolution of World Societal Changes as well as to increasing the countries engaged in space activities.	
Coordinator 1	Name:	Giuseppe Reibaldi
	Organisation:	IAA
	Country:	France
	Email:	giuseppe.reibaldi@iaamail.org
	Phone:	
Coordinator 2	Name:	Hans Hoffman
	Organisation:	ORBComm Inc
	Country:	Germany
	Email:	Hans Hoffmann <Hans.E.W.Hoffmann@t-online.de>
	Phone:	

SESSION(S) INFORMATION

Session 1	D1	
Session Name	Innovative Concepts and Technologies	
Description (max. 200 words)	<p>In order to realize future, sustainable programmes of space exploration and utilisation, a focused suite of transformational new system concept and supporting technologies must be developed during the coming decade. The technical objectives to be pursued should be drawn from a broad, forward looking view of the technologies and system needed, but must be sufficiently focused, to allow tangible progression and dramatic improvements over current capabilities. This session will address cross cutting considerations in which a number of discipline research topics and/or technologies may be successful developed to support transformational new system concept. Papers are solicited in these and related areas</p>	
Keywords describing the session best	<ol style="list-style-type: none"> 1. Transformational technology 2. Sustainable space exploration 3. 4. 5. 	
Chair 1	Name:	Roger Lennard
	Organisation:	United Technology Research Center,
	Country:	USA
	Email:	RLenard@planetarypower.com
	Phone:	
Chair 2	Name:	Giorgio Saccoccia
	Organisation:	ESA
	Country:	Netherlands
	Email:	giorgio.saccoccia@esa.int
	Phone:	
Rapporteur 1	Name:	Paivi Jukola
	Organisation:	Helsinki University of Technology
	Country:	Finland
	Email:	paivi.jukola@aalto.fi
	Phone:	
Rapporteur 2	Name:	
	Organisation:	
	Country:	
	Email:	
	Phone:	

Session 2	D2	
Session Name	Contribution of Space Activities to Solving Global Societal Issues	
Description (max. 200 words)	The session will discuss the contributions, in the future, of space exploration and utilisation to the solution of global challenges (e.g. energy, population, sustainable development) and how the space systems will support the understanding of the global societal issues. The session will include also the identification of the related technologies that needs to be developed. The definition of a roadmap will be encouraged. Environmental issues including global climate change will not be covered in this particular session	
Keywords describing the session best	<ol style="list-style-type: none"> 1. Global Challenges 2. Sustainable development 3. Technology 4. 5. 	
Chair 1	Name:	John C.Mankins
	Organisation:	Artemis Innovation
	Country:	USA
	Email:	john.c.mankins@artemisinnovation.com
	Phone:	
Chair 2	Name:	Giuseppe Reibaldi
	Organisation:	IAA
	Country:	France
	Email:	giuseppe.reibaldi@iaamail.org
	Phone:	
Rapporteur 1	Name:	Hans Hoffman
	Organisation:	ORBComm
	Country:	Germany
	Email:	Hans.E.W.Hoffmann@t-online.de
	Phone:	
Rapporteur 2	Name:	
	Organisation:	
	Country:	
	Email:	
	Phone:	

Session 3	D3	
Session Name	Global Strategy for Space Elevators	
Description (max. 200 words)	The recently completed IAA study, "Space Elevators – Feasibility and Next Steps," looked at engineering, operational, and funding steps towards an operational capability. This session will suggest strategies to implement the space elevator infrastructure. In addition, the session can accept the strategies to leverage this remarkable transportation capability of routine, inexpensive and safe access to our solar system. Some answers could include satellite designs, new businesses in space, new missions for governments and new opportunities to colonize.	
Keywords describing the session best	<ol style="list-style-type: none"> 1. Space Elevator 2. Low Cost Access to Space 3. Strategy 4. 5. 	
Chair 1	Name:	Peter Swan
	Organisation:	South West Analytic
	Country:	USA
	Email:	dr-swan@cox.net
	Phone:	
Chair 2	Name:	Robert E. Penny
	Organisation:	Challa Space Systems
	Country:	USA
	Email:	
	Phone:	
Rapporteur 1	Name:	Bruce Chesley
	Organisation:	Boeing Space and Intelligent Systems
	Country:	USA
	Email:	
	Phone:	
Rapporteur 2	Name:	
	Organisation:	
	Country:	
	Email:	
	Phone:	

Session 4	D4	
Session Name	Strategies for Rapid Implementation of Interstellar Missions: Precursors and Beyond	
Description (max. 200 words)	<p>Knowledge about space beyond our solar system and between the stars—that is interstellar space—is lacking data. Even as IBEX, NASA’s Interstellar Background Explorer, studies the edge of our solar system, it still is confined to earth orbit. Arguably, some of the most compelling data to understand the universe we live in will come from sampling the actual environment beyond our solar system as Voyager 1 and Voyager 2 spacecraft are on the threshold of doing. In the 36 years since the Voyager probes’ launches, significant advances in materials science, analytical chemistry, information technologies, imaging capabilities, communications and propulsion systems have been made. The recently released IAA study: <i>“Key Technologies to Enable Near-Term Interstellar Scientific Precursor Missions”</i> along with significant initiatives like the DARPA seed-funded 100 Year Starship, signal the need, readiness and benefits to aggressively undertaking interstellar space missions.</p> <p>This session seeks to define specific strategies and key enabling steps to implement interstellar precursor missions within the next 10-15 years. Suggestions for defined projects, payloads, teams, spacecraft and mission profiles that leverage existing technological capacities, yet will yield probes that generate new information about deep space, rapidly exit the solar system and which can be launched before 2030 are sought.</p>	
Keywords describing the session best	<ol style="list-style-type: none"> 1. Interstellar Mission 2. Interstellar Precursor 3. 4. 5. 	
Chair 1	Name:	Mae Jemison
	Organisation:	100 Year Starship
	Country:	USA
	Email:	drmae@100yss.org
	Phone:	
Chair 2	Name:	Louis Friedman
	Organisation:	The Planetary Society,
	Country:	USA
	Email:	louis.friedman@planetary.or
	Phone:	
Rapporteur 1	Name:	Stephanie Wilson
	Organisation:	University of Boston
	Country:	USA

UN/CHINA HUMAN SPACE TECHNOLOGY WORKSHOP

16-20 September 2013

Recommendations [Draft]

Address to HSTI:

1. It is proposed that UNOOSA plays a role in facilitating coordination of the member states to pursue common goals within a long-term perspective, identify opportunities for international cooperation and put forward proposals. Member states realize the common goals by reference to these proposals.
2. The public information resource of UN should be extended to include information on the latest development of HSE.
3. HSTI should contribute to identify possible opportunities for international cooperation in space exploration and especially foster the participation of emerging countries interested in space activities.
4. UN should consider establishing more research centres in developing countries, especially devoted for HSE.

Address to HSTI/Governments/Institutions

5. HSTI/nations/institutions shall be encouraged to strengthen international cooperation in capacity building efforts in HSE through workshops, seminars, and training courses.
6. HSTI/nations shall be encouraged to establish more educational institutions and UN regional centers incorporating HSE, and to provide relevant educational facilities/ equipment /materials.
7. HSTI/nations/institutions shall promote experts in HSE/astronauts forums, particularly in developing countries to assist professionals and to inspire students/academia/public.

Address to Governments/Institutions:

8. All countries and particularly emerging countries should be involved in the understanding and definition of common global Goals&benefits of HSE.
9. Human space exploration is an activity with multi-level involvements, to which any one and any nation can contribute. Developing countries are encouraged to participate in HSE.
10. Synergies between HSE technologies, developed for habitation in outer space and on other planets and the UN Millennium Goals should be exploited for applications on Earth.
11. Governments, institutions, companies and individuals are encouraged to participate in the global human exploration endeavour, which will inspire young people by exposing them to new discoveries in science and technology and will enhance international cooperation by pursuing common goals of humanity.
12. It is proposed to foster the involvement of emerging countries in the preparation of HSE activities, such as the demonstration of enabling technologies on space stations, ground-based research facilities, etc., as, eg., identified in IAA Cosmic Studies.

13. There is an extensive use of various **ground-based microgravity simulation instruments** in biological sciences. A better understanding on their physical principles and operational parameters might lead to a more standardized use in order to improve their relevance and application. Spaceflight research should incorporate a sound ground based program, including mathematical modeling.
14. Long duration flights in man-tended space stations or inter-planetary missions have adverse effects on the human physiology and psychology. The application of **artificial gravity** might mitigate such effects. A broad international collaboration toward such an approach is prudent.
15. While several **databases** do exist, there is a clear need for a comprehensive, transparent and open database of microgravity studies in life and physical sciences research that have been performed in the past in order to learn and draw upon for future generation research.
16. HSTI/Nations/institutions shall create **database/Web-based interactive forums** for HSE including scientific/technical /legal information to promote the dissemination and exchange of information.
17. There is a well-established **pan-Asian coordination** for technological and operational un-manned spaceflight activities. The initial initiatives for a more scientific collaboration in the field of microgravity, life and physical sciences within this region should be fostered.

Address to Governments:

18. The Alpha Magnetic Spectrometer currently attached to the International Space Station, is recognized as an example of **true international cooperation** in manned space flight and technology and provides a blue print to build upon future scientific international collaboration and friendship for planned spaceflight research.
19. Nations shall be encouraged to promote space/HSE education in primary/secondary schools by developing appropriate **curriculums**, as well as **train-the-trainers**.
20. Developing countries need to establish space agencies or similar organizations to carry out space activities.
