

Minutes of Commission III Meeting
21 march 2016-03-31
6 rue Galilee, 75116 Paris

1. The Commission III meeting was opened by Professor Ramakrishnan at 13.30 .Professor Ramakrishnan introduced the Commission members and welcomed all the invitees and thanked them for their continued support and active participation in Commission 3 discussions.
2. The first item of business was actions left over from theJerusalem meeting. There were no open action items.
3. The membership of Commission III is as shown below:
 - Chair: Ramakrishnan S. (India) (P)
 - Vice Chair: Lenard R. (USA) (A-E)
 - Past-Chair: Lu Yu (China) (A-E)
 - Secretary: Genta G. (Italy) (P)
 - Member: Huffenbach B. (Germany) (A-E)
 - Member: Kawaguchi J. (Japan) (P)
 - Member : Pacheco-Cabrera Enrique (Mexico) (P)
 - Member: FAN Ruxiang (China) (A-E)
 - Member: Razoumny Y. (Russia) (P)
 - Member: Sweet Randall (USA) (P)
 - Ex-officio Member: Tsuchida A (Japan) (A-E)
 - Ex-officio Member Reibaldi : Giuseppe (P)
 - P=Present
 - A-E=Absent excused

Invitees Present in the Meeting :

Bescond Pierre
Rittweger Andreas
Rauck Horst
Chern Jeng-Shing (Rock)
Kibe Seishiro
Kumar Krishna
Lin Wang
Bozic Ogujan
Liu Jintao
Yang Hong
Zhu Hong Lai
Takahashi Sakurako
Davidian Ken

4. Status of IAA Cosmic studies

Studies completed:

- SG 3.14: Public/Private Human Access to Space – Vol. 2- Ken Davidian/S.Di Pippo.:Submitted to IAA for arranging Peer Review.
- SG 3.15: Long Term Space propellant Depot – Saccoccia/Lu Yu.: Draft Report under review within Commission 3. Final Draft for submission to IAA yet to be presented to Commission 3 Members.
- SG 3.16 Global Human Mars System Missions Exploration – Genta. Study completed and approved , in the publication stage

Studies in Progress:

- SG 3.18 Feasibility Study of Possible International Protocol to Handle Crisis/ Emergency – Ramakrishnan. The Chair of the SG 3.18 presented the status of the study(Annexure - 1). It was noted that the final Draft Study Report has been put up for review by Commission 3 Members. Specific comments / suggestions are solicited from members before referring the document to IAA for arranging Peer Review.

- SG 3.19 Radiation Dosage Limits --S. McKenna-Lawlor. Dr. McKenna was not present (chairs another commission meeting) and the status was not presented. However, Chairman Commission 3 had an interaction with Dr Susan before the meeting and he informed that study is complete and all inputs for the compilation of final Draft Report is now available. A presentation of final report is expected at the Mexico IAA meeting during Oct 2016.
- SG 3.21 Disposal of Radioactive Waste in Space- O. Ventskovsky . – Dr Ventskovsky was not available and the study is not presented. A presentation is expected at the IAA Meeting in Mexico.
- SG 3.22 Next-Generation Space System Development Basing on On-Orbit-Servicing Concept- Y.Razoumny. Yuri Razoumny presented the status of the study(Annexure – 2). Good progress being made.Report contents and chapters with key authors identified. First Draft targetted for March '17.
- SG 3.23 Human Space Technology Pilot Projects with Developing Countries – G. Reibaldi/ F.Zhuang. Reibaldi presented the status of the study (Annexure – 3). A first draft is expected for review during next spring meeting at Paris.
- SG 3.24 Road to Space Elevator Era, Tsuchida/Raitt/Swan.--- The status of study was presented by S. Takahashi (Annexure-4). . A discussion followed. The Draft Report is expected by September 2017.
- SG 3.25 The maintainability and supportability of Deep Space manned Spacecraft – Yang Hong/Zhang Dapeng.--- The study was presented by Yang Hong (Annexure-5). A discussion followed.The Siudy is expected to take another three years for completion. Chairman of SG 3.25 was requested to identify intermediate milestones.
- SG 3.26 Space Mineral Resources # II: Authority for Extra-Terrestrial Resource Utilization and Beneficiation based on the Outer Space Treaty - Art Dula.-- Art Dula was not available to present the progress.It was noted that this is a follow-on of already completed SG 3.17 Report.

5. Proposals for new Study Groups. Two new proposals were forwarded:

- Technical Development of Efficient Management and Recycling of Space Fluid – The proposal was presented (Annexure-6). A discussion followed,in which clarification about the scope of the study and whether it concentrates on life support system or all fluid systems onboard.. A possible overlap with studies 3.15 and 3.25 was noted. After the discussion, the proposers were asked to improve the proposal bringing more clarity on scope and content and to present again at the IAA Mexico meeting.
- Towards the utilization of the Moon, preparing for mars Exploration. – proposer G. Genta. – The proposal was presented by Prof Genta (Annexure-7) A discussion followed, after which it was accepted to recommend the proposal to the SAC.

6. IAA Conferences

The stand alone conference **IAA Conference on Human Space Exploration**, Korolev, Moscow Region, Russia, 24-26 May 2016 will take place soon.

A new conference on the Future of Space Exploration is proposed. The 10th IAA Symposium on Future of Space Exploration will be planned for beginning of July 2017 in Torino, Italy

7. Publications

No news

8. IAA Heads of space agencies summits

A new summit on exploration is expected to take place in fall (possibly Movember) 2017

9. Report for the scientific activities committee

(Annexure-8)

10. Any other business

None

The meeting was adjourned at 16.00 hrs.

International Academy of Astronautics. Cosmic Study



**Study of possible International Protocol to handle
crisis/emergency of astronauts in
Low Earth Orbit**

ANNEXURE – 1

THE STUDY TEAM

SG 3.18	
S. Ramakrishnan	ISRO, India
Irmgard Marboe	University of Vienna, Austria
W. Michael Hawes	Lockheed Martin, USA
Bernhard Hufenbach	ESA/ESTEC, The Netherlands
Sheeju Chandran	ISRO, India
Zhang Shu	CALT, China
Unnikrishnan Nair S	ISRO, India

Study of possible International Protocol to handle crisis/emergency of astronauts in Low Earth Orbit

- Introduction
- Possible crisis situations/emergency scenario of Crew in LEO and Crew rescue methodologies
- Current International Treaties/Protocol in the area of Outer Space & Space Travel/Space systems and their implementation status
- Impediments in considering an interagency protocol on Crew rescue from space and possible mitigations
- Considerations towards evolving an Inter-Agency protocol to handle crisis/emergency of astronauts in LEO
- Conclusions and Way forward

Introduction / Background For Study

- Till date, more than 300 crewed missions have taken place and around 540 humans have become space travelers.
- Initial spaceflights were of short duration and with space stations, the duration of orbital stay has increased tremendously.
- There were accidents as well as incidents triggering extensive redesign of hardware and redefinition of approaches.
- Human spaceflight has seen a paradigm shift in recent years with an increased number of private players, primarily emphasizing and exploiting the commercial aspects of space travel.
- To make the spaceflight safer, usher transparency and protect the interest of the fare paying space traveler, well-defined space policies and regulations involving individual governments and international organizations have to be evolved.

Possible crisis situations/emergency scenario of Crew in LEO and Crew rescue methodologies

For devising suitable rescue systems and procedures, identification and understanding of possible emergency scenarios are pre-requisites.

Some of the Possible Failure Scenarios

- 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
- Spacecraft has lost all communications with the ground

Factors governing a possible space rescue mission

- Current human launch capability
- Orbital inclination
- Rendezvous & Docking/berthing systems
- Internal pressure level and air composition
- Communications and Power

CREW RESCUE METHODOLOGY & LIMITATIONS

- Effective rescue operation depends on how quickly the rescue effort can be initiated and carried out and how much standardization and interoperability exist *a priori*.
- The launch vehicles and spacecrafts have constraints of orbit altitudes and inclinations. Readiness and expertise of the crew assigned for the rescue is also very crucial.

- The rescue option/capability should be a major design consideration during mission and should be one of the design drivers of relevant hardware.

Major spacecraft past and present with main orbital parameters			
Spacecraft	Orbit (km)	Orbital period (min.)	Inclination (degrees)
Salyut	200 x 220	88.5	51.6
Skylab	434 x 442	93.4	50
ASTP	217 x 231	87.6	51.7
Mir	354 x 374	91.9	51.6
Hubble	539.8 x 543.7	95.48	28.47
ISS	409 x 416	92.69	51.65
Tiangong-1	363 x 381	91.85	42.77

- Advances in artificial intelligence and robotic capability with real time decision making can result in Specially designed rescue robots, with ability to tackle all conceivable contingencies

Current International Treaties/Protocol in the area of Outer Space Activities

- The current *corpus of treaties* was elaborated in the 1960s and the 1970s, when spaceflight in general was still in its infancy.
- The space treaties are basically governed by the principles of *Pacta sunt servanda* as well as *Lex specialis*.

No	Name of Treaty	Year of introduction
1	Declaration of Legal Principles Governing the Activities of States in the Exploration of Outer Space	1963
2	Treaty on principles governing the activities of States in exploration and use of outer space, including the moon and other celestial bodies.	1967
3	Agreement on rescue of astronauts, the return of astronauts, and the return of objects launched into outer space	1968
4	Convention on international liability for damage caused by space objects.	1972
5	Convention on registration of objects launched into outer space.	1975
6	Agreement governing the activities of States on the moon and other celestial bodies.	1979
7	ISS Crew Code of Conduct	2000
8	International code of conduct for space activities (under negotiation)	2013

- The present treaties are not applicable to all States; there is no identified 'world space authority' and are not binding/obligatory.
- For the effectiveness of any new treaty, it is highly essential to have clear definitions which would prevent ambiguities and misinterpretations by vested interests.

Impediments in considering an interagency protocol on Crew rescue

- Study of factors, which have deterred the evolution of effective obligatory international laws on crew safety and rescue, is important as most of these retain the potential to adversely affect formulation of fresh up-to-date laws.
 1. *International Standardization of manned space vehicle systems*
 2. *Sharing of cost in rescue mission*
 3. *Rescue scenario and response time*
 4. *Crew Size for future missions*
 5. *Limitations on technology transfer*
 6. *Geopolitical considerations*
 7. *Gaps in existing legal framework*
 8. *Satisfying diverse interest of stake holders/consensus among member countries*
 9. *Technology obsolescence*
- The seriousness of each of the obstacle is specific to how each country defines and perceives it.
- Any solution, which satisfactorily addresses at least a great number of the major impediments, will certainly be a giant leap forward.
- While dealing with the impediments posed by technology, it is very essential to consider the prospective induction of future technologies as well.

Considerations in evolving an International protocol to handle crew-crisis / emergencies in LEO

- To evolve a practical law, it is essential to study various realistic situations under which these would eventually be invoked and the conditions that it has to address.
 - a. Situations that trigger an obligation to assistance and/or rescue
 - b. Obligation to provide assistance and rescue
 - c. Providing assistance and rescue
 - d. Liability for damages occurring during the rescue operation
 - e. Bearing the costs of rescue mission
- Due care has to be exercised while formulating laws to ensure their wide acceptance and to avoid their potential misuse.
- Definition, terms and conditions stipulated have to be as objective as possible and should be open to periodic revision, in tune with the times.
- Options for penalizing negligent parties should be in place. Also, the laws should accommodate unavoidable damages and loss of hardware, during rescue efforts.
- Unduly harsh conditions may limit its acceptance, and too lax conditions would in effect make those laws toothless and ineffective.

Conclusions and Way forward

- With general trends of increase in Human Spaceflight activities and privatization of Space Travel as well as initiatives towards commercial exploitation of resources from celestial bodies, the time has come to establish a firm legal framework to deal with very credible situations of crisis to humans stranded in space .

Recommendation on specific Actions

Recognise Need for protocol: Considering the gaps in the existing space laws and the changed scenario of human spaceflight world-wide, there is an urgent need to bring out a protocol on rescue of crew in crisis stranded in space.

Develop international standards on vehicle systems and critical interfaces: A list of primary systems to be considered for definition of standards and design provisions from crew safety as well as crew rescue interfaces, should be generated.

Identify preferred orbital corridors for manned flights: Acknowledging the physical limitations in rescuing crew from various orbits, the feasibility of defining few preferred orbital corridors may be considered for human spaceflight activities, construction of space stations etc.

Set - up an international mechanism: Consider setting up an international body, preferably under the aegis of the United Nations, to formulate, oversee and implement crew rescue operations during such contingencies.

CURRENT STATUS

- FINAL DRAFT DOCUMENT READY AND SUBMITTED FOR COMMISSION 3 REVIEW
- WILL BE FORWARDED TO IAA TO PUT UP FOR PEER REVIEW PROCESS
- WILL BE UPDATED BASED ON PEER REVIEW INPUTS
- FINAL REPORT READINESS BY OCT 2016

Thank You

IAA Study Group Status Report

Responsible Commission: Commission 3. Space Technology & System Development

**Study Number and Title: SG 3.22. Next-Generation Space System Development
Basing on On-Orbit-Servicing Concept**

Short Study Description

Over the last years many organizations in different countries have been involved in development of various technical aspects of on-orbit satellite servicing, which to a great extent predetermines the characteristics of next-generation space systems. The problem of developing next-generation space systems basing on on-orbit servicing concept is considered as technical challenge in two main directions: making serviced satellites and space systems suitable for servicing; developing servicing satellites and space systems for the performance of the on-orbit-servicing operations. Implementation of the first direction includes a wide range of developments: unified detachable and installable satellite blocks and modules, maximal complexation of missions on-board a single satellite, internationally standardized hardware and connectors, providing the docking with the serviced satellite, selection of the satellite's period of use with regard to servicing, etc. Implementation of the second direction varies from the development of servicing methods and servicing systems to the gradual development of the space complexes for providing on-board-servicing operations. The overall goal of the study is to unite the efforts of the specialists, which have been undertaken in different countries and organizations, for discovering the most effective approaches to solving the problem.

Progress in past six months:

The table of contents of the Study was coordinated with the SG members. The draft materials of several sections were prepared.

Website Study Information up to date?

The following SG documents are included in the IAA website information:

List of SG members

Study Report Notions and Definitions

The SG Dropbox includes all the current information regarding development of the Study.

Issues requiring resolution?

1. Overall discussion of the Study Group Content and content of the several sections of the study prepared.
2. Preparation of the Sections of the Study.

Name of person providing Study Group Status (Study Group Chair or Co-Chair):

Yury Razoumny, SG Chair

Status Report Date: March 10, 2016



SG3.23

HUMAN SPACE TECHNOLOGY PILOT PROJECTS WITH EMERGING SPACEFARING COUNTRIES

Paris, 22 March 2016

Dr. Giuseppe Reibaldi, Prof. Fengyan Zhuang





Human Space Technology Pilot Projects with Emerging Spacefaring Countries

- **Leadership:** Co-Chairs; G.Reibaldi (Italy), Z.Fengyuan (China), Secretary: Dr.Nair Unnikrishnan (India)
- **Members:** 32 from 12 countries: India, China, Austria, Germany, Singapore, Japan, Malaysia, Italy, Russia, Thailand, Korea, Pakistan
- **Goals:** Define Emerging Spacefaring Countries Challenges and Opportunities in exploiting HSF technologies in Life Science and Education
 - Identify available Infrastructures, Ground and In-orbit, for implementing projects
 - Confirm need of Call for Proposal for Pilot Project
 - Pilot Projects selection, definition, implementation
 - Decision Road map in cooperation with UNOOSA
 - **Status:** Preliminary Content List defined
 - Contributions to confirmed
 - First Draft available by end 2016





Space Development Countries

- **Definition:** Countries having a government sponsored space programme
- **Preliminary List of Countries:**
 - Asia:** South Korea, North Korea, Singapore, Malaysia, Thailand, Pakistan, Bangladesh, Philippine, Vietnam, Laos, Myanmar, Indonesia
 - Africa/Middle East:** Nigeria, South Africa, Morocco, Algeria, Egypt, Saudi Arabia, Turkey
 - America:** Brasil, Argentina, Mexico, Costa Rica, Colombia
 - Pacific:** Australia





Challenges and Opportunities

- **Main Challenges:** Economic growth and sustainable development
Low Public importance of STEM
- **Opportunities:** Investment in R&D is increasing but at low peace
HST could provide high visibility for tangible and intangible benefits
- **Benefits:** Scientific/Technological
Economic
Political/Cultural
- **Possible Areas:** Medical, Biological Research,
Educational, International Cooperation





Human Space Technology Pilot Projects with Emerging Spacefaring Countries

CALL FOR PROPOSAL

- **Goal:** Select and Implement HSF Pilot Projects to support scientific and economic growth in space developing countries
- **Challenges:** Identify Opportunities in the Developed countries and select good proposals in emerging spacefaring countries
- **Possible Implementations:**
 - Students exchange projects as well as experiments on ground, on parabolic flights, on space platforms
 - Financial Coverage: Space developing countries to fund the proposal while developed countries will fund its implementation as contribution in kind
- **Opportunities:**
 - Positions in Universities in China (TBC), India (TBC)
 - Parabolic Flights in France (TBC)
 - Space Platforms by China (TBC), Japan (TBC)





Human Space Technology Pilot Projects with Emerging Spacefaring Countries

WAY FORWARD

- Confirm the Opportunities and the selection participation procedure with Developing Countries
- Identify Space Developing countries/institutions with interest in submitting proposals
- Obtain authorization from IAA for releasing the Call
- Release the Call, goal: June 2016
- Proposals due: Sept. 2016
- Selection completed: End 2016
- First project start: early 2017

Thank You



IAA Study Group Status Report

Responsible Commission: Commission III

Study Number and Title: 3.24 Road to Space Elevator Era

Short Study Description (repeat from Study Group Proposal):

This SG is the follow-up of the SG3.13 “Assessment of the Technological Feasibility and Challenges of the Space Elevator Concept” with the same baseline design assumptions.

Development of a unique space transportation system of the future, called a space elevator, should be accomplished with more international cooperation and should contribute to the overall development of space science and systems development. To accomplish these desires, projects are identified that can be accomplished in the near future leading to risk reduction and engineering enhancements. Specifically, the following practical on-orbit verification projects could be planned and promoted through this study group's activity.

- (1) Promotion of ISS (International Space Station) utilization and leveraging of Small Satellite (Cube, Micro, etc.) concepts to accomplish on-orbit verification; such as, advanced material research (ex. material exposure experiment) and development while extending tether technology development.
- (2) Promotion of space technology spin-out into industrial application (and vice versa) by the collaboration with civil engineering, architectural engineering, and space engineering experts.
- (3) Plan and execute precursor missions, leveraging existing technology, to demonstrate prototype space elevator segments. (ex. Marine Node for sub-orbital rocket launch; tether satellites for dynamics of deployment; movement around Earth-space with low thrust, high efficiency rocket motors demonstrating start-up activities.)

Progress in past six months:

- (1) 1 meeting was held in Jerusalem (October, 2015).
- (2) Gathering comments from SG members for space elevator mission definition document
- (3) To identify critical technologies, required to implement the Space Elevator, with all study group members have on the same page, relationship of “Mission Definition”, “System Requirement”, “Critical Technologies”, and “Verification “are drafted.
- (4) Developed first draft of IAA Study report

Website Study Information update: (please give any update regarding Study Group Membership, documents, Study Plan and Schedule):

- (1) On the Activities, please add the following meetings:
-Study group meeting, Monday 21 March 2016, 08h30-10h00, Paris, France

(2) On the membership, please add two new members:

Anna Guerman

Vadym Pasko

Issues requiring resolution? (recommend approach):

None

Product Deliveries on Schedule? (If modified explain rationale):

No change


Study Team Member Changes? (List any Study Team Members that you wish to discontinue, and provide names plus contact coordinates of any Members you wish to add on the second page of this Study Update form.) Note: Complete contact information including email, tel. and fax must be provided for all additions. Only Members with complete contact information will be listed and receive formal appointment letters from the IAA Secretariat.)

Yes: Anna Guerman and Vadym Pasko (SG3.24 secretary provides information above)

Name of person providing Study Group Status (Study Group Chair or Co-Chair):

Mr. Akira Tsuchida

Status Report Date: February 21, 2016



The Maintainability and Supportability of Manned Spacecrafts in Deep Space



中国航天科技集团公司五院 载人航天总体部

中国航天 Institute of Manned Space System Engineering , CAST , CASC

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1. Background
2. Problems Need to Solve
3. Goal and Approaches
4. Research Contents
5. Expected Results



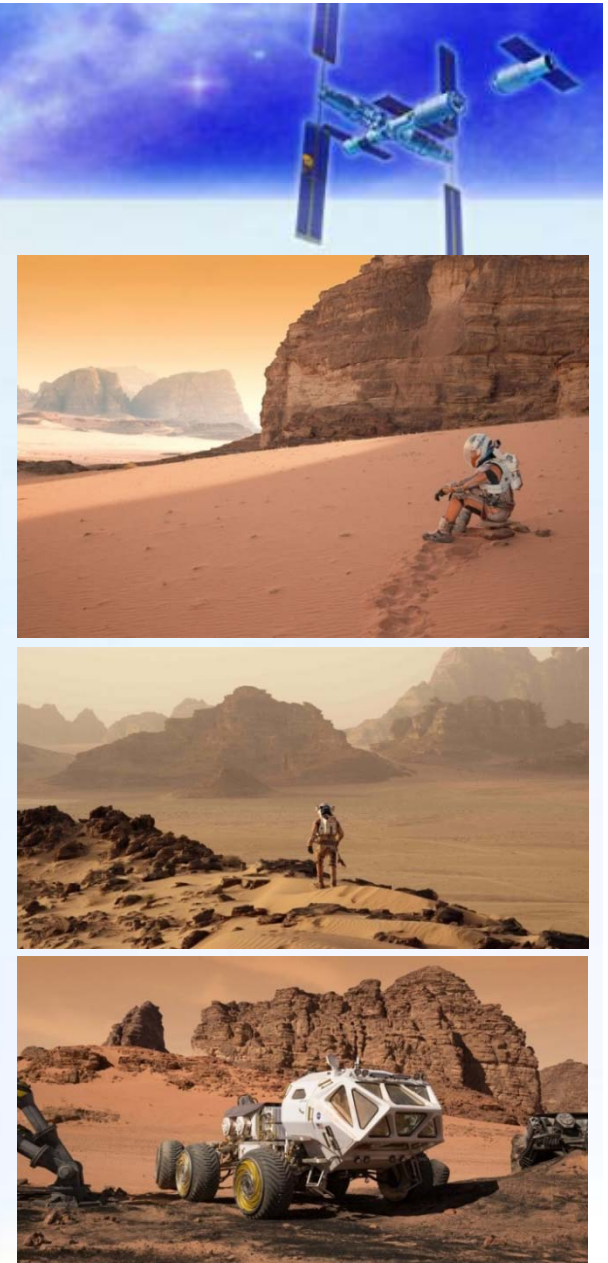
中国航天

中国航天科技集团公司五院 载人航天总体部

Institute of Manned Space System Engineering , CAST , CASC

Background

Human footsteps from the near-Earth space toward the Moon, Mars and deep space extension is inevitable for the future development of human being, however road is difficult for manned space exploring. Everyone should remember a film – “The Martian” in 2015 which shows the enormous courage and determination of human to conquer the space, but also brought us thinking, if we meet emergency situations when human beings truly realize the manned exploring in deep space, how could we make troubleshooting? How could we survive?



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Background

Therefore, there are technical challenges is faced to manned exploring in deep space, one of problems should to be solved is how to carry out maintenance and repair on manned spacecrafts in deep space, as well as providing the necessary support and logistics.

Our study group will attempt to carry out our research from two aspects: one is how to make maintenance and support analysis; the other one is how to carry out maintenance and repair better in the course of space flight.



Problems we need to solve



1. Analysis of Maintenance and Supportability

Among many challenges, it is foremost that the scale and complexity of task resulted in an increased mass of manned spacecrafts, and resulted in maintainability and supportability issues. Some aspects of mass increased as following:

- 1) It is required to carry large amounts of consumables to the flight and astronauts for long periods according to the existing technology.
- 2) Manned spacecrafts in deep space require higher reliability and security as well as in near-Earth space, redundancies and spares increased lead to increasing weight of the spacecraft system.
- 3) Equipments replacement cannot support by ground when faults occur, so spare parts and tools for replacement and maintenance are carried spacecraft itself.



Problems we need to solve

To a certain extent, the weight of consumables is fixed and take up most of the flight mass with the determining scale of manned spacecraft in deep space. It lead to the mass of spacecraft platform itself has been extremely limited, thus affect the reliability design of spacecrafts, but also the carrying and using strategies of critical spare parts.

This is a mainly contradiction how to solve the design problems of flight mass parameter with manned spacecrafts in deep space, how to allocate the system mass rationally, and how to reduce one-time carried mass of consumables by external or internal supplies, thereby increasing the mass of carried spares and equipments for maintenance, or reliability and redundancy. In addition, it is needed to make comprehensive analysis of multi-parameters including equipment life, system weight, spares, flight time, reliability, economy and other so on based on strategies with maintainability and security, and choose the best solution with the optimization parameters.



Problems we need to solve



2. Implement of Maintenance and Supportability

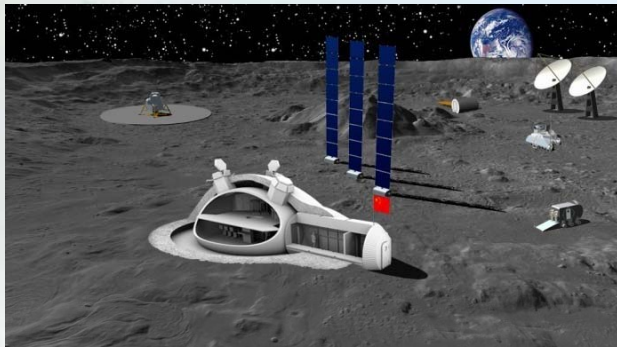
Different from manned spacecrafts with long period in near-Earth space, such as space station, there are some new issues as following faced to be solved to implement maintenance and supportability during manned flight in deep space:

- 1) The number of astronauts is limited to carry out repairs and maintenance by EVA, astronauts are confronted with risks such as radials when they carry out works in deep space, so some approaches with new technology for maintenance and repairs needed.
- 2) Suddenly abnormal incidences and unpredictable failures will be increased significantly, the monitor and operations to these faults cannot depend on ground, so it is highly required for fault monitoring, prediction, and recovery.
- 3) Maintenance level, spares style and obtained, and tools or equipments for repairs in the form of a corresponding change.



Overall Goal

Aiming at characteristics of manned exploring in deep space about long period, considering roundly the problems faced to solve with maintenance and repairs, spares carrying and supplying, reliability and fault-tolerant redundant of manned spacecrafts in deep space, carrying out analysis of maintainability and supportability with different strategies, forming multi-parameter optimization design; based on the analysis results, research the implementation of maintainability and supportability with new technologies, providing different solutions and schemes.



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Technical Approaches

The object of our research:

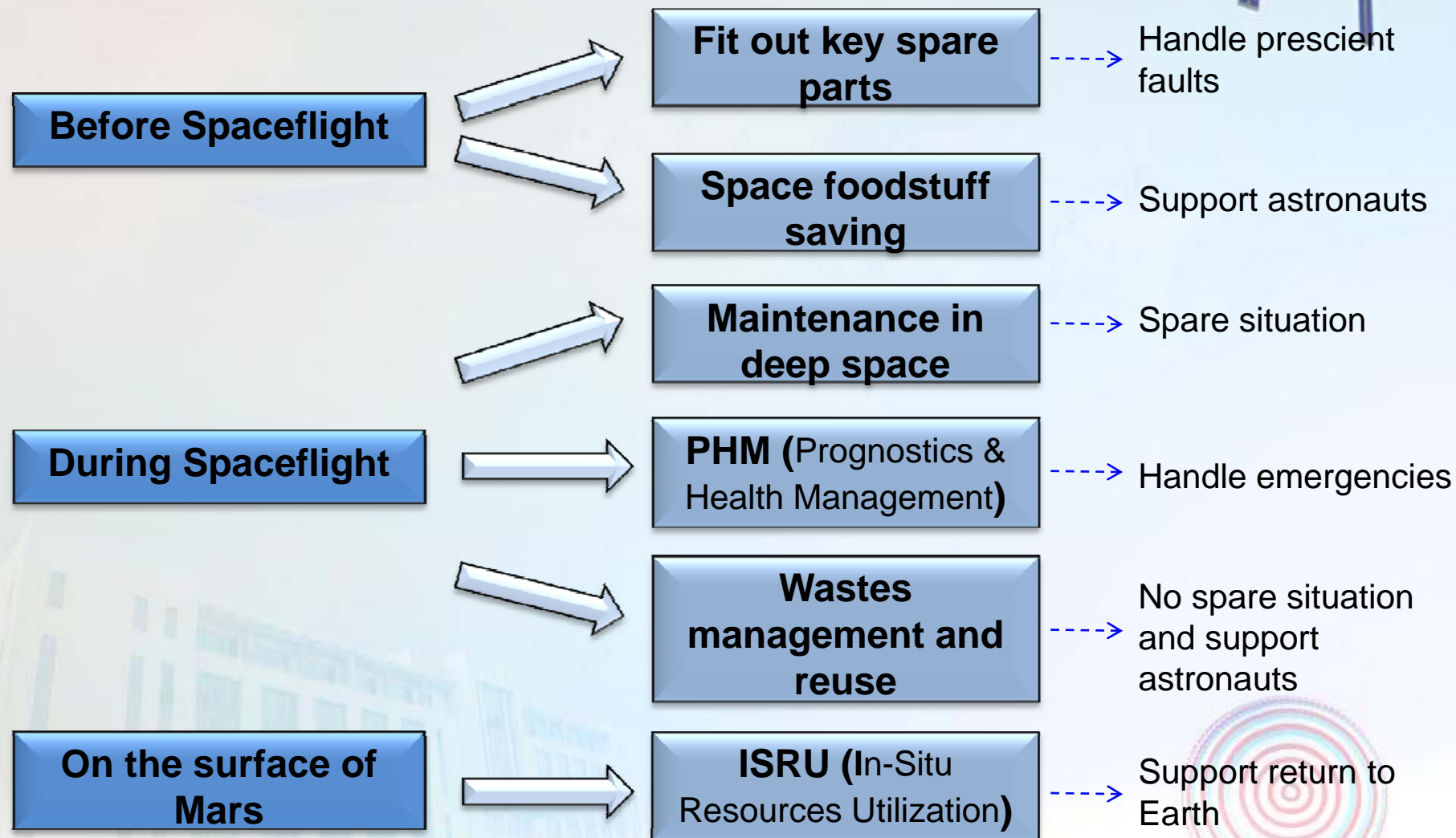
Manned spacecrafts to Mars will be as the object, we will base on the mainstream scenarios of international manned programs for Mars , analyze needs of the maintainability and supportability in manned programs of Mars and the more distant manned space exploration taken into account meanwhile, construct the maintainability and supportability system of deep space manned spacecrafts. And typical system of manned spacecrafts in deep space will be selected to make detailed analysis and design of maintainability and supportability, and implement the technology of maintainability and supportability.



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Technical Approaches

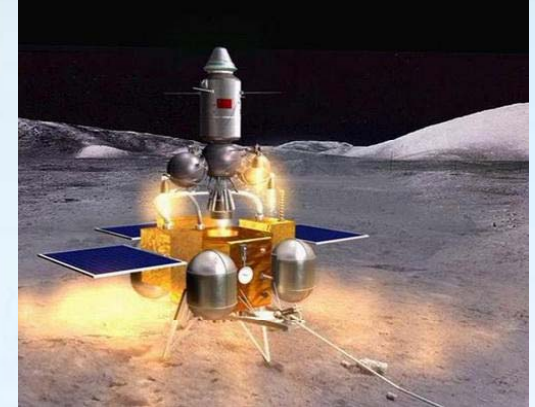


Research Contents

1. Requirement analysis and System technologies

(Manned spacecrafts for Mars as example)

- To analyze and characteristics of manned spacecrafts for Mars.
- To analyze the requirements and problems of maintainability and supportability on manned spacecrafts for Mars.
- To consider relations between different affecting actors and multi-parameters about reliability, maintainability, and supportability.
- Requirements analysis of new design and technologies for maintenance and repairs.
- To confirm the design principles and research scope for maintainability and supportability system.



Research Contents

2. Analysis of Maintainability and Supportability (ECLSS as example)

1) Confirm influencing actors and parameters

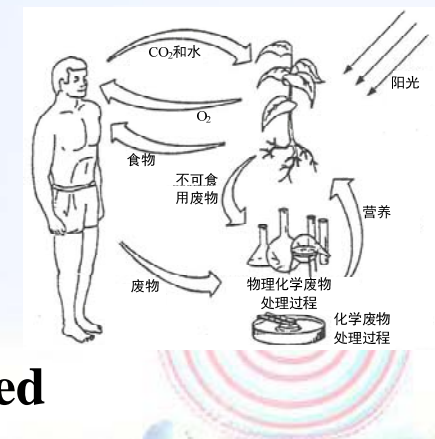
- Consuming modeling of consumes
- Analysis with maintenance level and critical level of spares
- Influencing actors for reliability, maintainability, and supportability

2) Analysis and design

RMS analysis and multi-parameters allocating especially mass with different mode, including:

- Non-regenerative ECLSS
- Regenerative ECLSS
- Closed-loop ecosystem
- External supply from relay station

3) Multi-parameters optimization and scheme selected



Research Contents

3. Implementation of Maintainability and Supportability

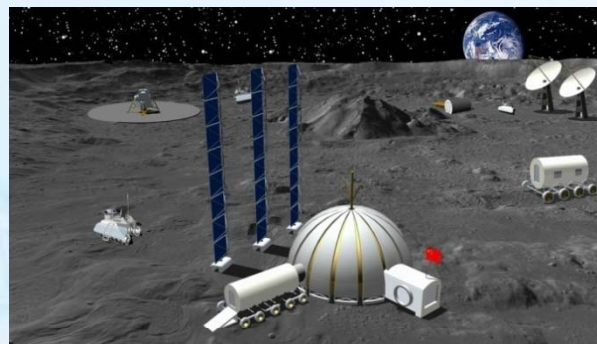
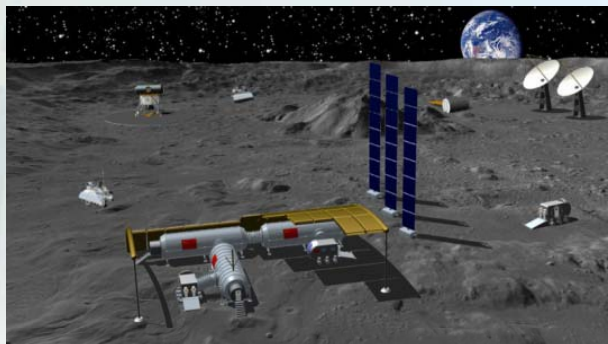
- Supply chains design for maintenance and supportability based-on in-situ resources utilization (ISRU).
- Waste management and recycling and 3D print technology
- Virtual reality (VR) for maintenance in deep space.
- Astronauts and robots integrated operation for maintenance and repairs.
- Prognostics & health management (PHM) for maintenance and supportability.
- Spares reduction and component-level repair maintenance technology



Research Contents

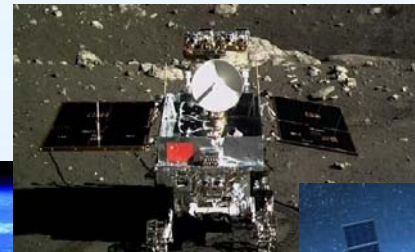
4. Adaptability Analysis for Different Missions

- To analyze the adaptability of the maintainability and supportability with different manned deep-space missions
- To analyze above research results to apply for manned near-Earth spacecrafts, Earth-Moon space, or asteroid exploring.



Expected Results

- To design the maintainability and supportability system and according strategies of manned spacecrafts in deep space.
- To obtain new technical approaches for maintenance and repairs for manned spacecrafts in deep space.
- To form a set of analysis method of manned spacecrafts in deep space.
- To promote technology development of maintainability and supportability at present and in the future.





Thanks for your Attention!

谢谢!

一切为载人,全力保成功



Proposal for a new Cosmic Study

TOWARDS THE UTILIZATION OF THE MOON, PREPARING FOR MARS

Paris, 22 March 2016

Prof. Giancarlo Genta





Towards the utilization of the Moon, Preparing for Mars Exploration

- **Leadership:**
- Co-Chairs; G. Genta (Italy), Oleg Ventskovsky (Ukraine),
- Secretary: Les Johnson (USA)
- **Proposed Members (all TBD):** *Art Dula, Bernhard Hufenbach, Nick Kanas, Susan Mc Kenna, Maria Antonietta Perino, Christian Sallaberger, Jean-Marc Salotti plus others*





Towards the utilization of the Moon, Preparing for Mars Exploration

Goals: The goal of the proposed study is clarifying to address of answer the following questions:

- Is it useful to proceed to lunar exploration and utilization before attempting human Mars exploration?
- Does it increase substantially the time required to mount a Mars exploration?
- Is it affordable to proceed to the exploration of both worlds?
- How is exploration goals synergetic with the economic utilization of the Moon?
- What are the appropriate roles of governments and private organizations in Moon and Mars exploration?

A further aim of the study is to supply recommendations about the technological and scientific effort which is deemed as required for reaching the mentioned goals.



**International
Academy of
Astronautics**

IAA Commission 3 Space Technology & System Development

Scientific Activities Committee Report

**21 March 2016 – 16h00-18h00
6, rue Galilée, 75116 Paris**



Chair: Ramakrishnan S (India) **P**

Vice Chair: Lenard R (USA)

Past-Chair: LU Yu (China)

Secretary: Genta G (Italy) **P**

Member: FAN Ruxiang (China)

Member: Kawaguchi J (Japan) **P**

Member: Razoumny Y (Russia) **P**

Member: Huffenbach B (Germany)

Member: Tsuchida A (Japan)

Member: Pacheco-Cabrera Enrique
(Mexico) **P**

Member: Sweet Randall (USA) **P**

COMMISSION 3 MEMBERSHIP : 2015 – 17 **P – Present**

In addition to members 15 invitees also participated in the Meeting



- **Current Studies**

- Study Group 3.14 Chair or representative: Di Pippo/Davidian/Dupas
Public/Private Human Access to Space - Vol. 2 - Earth Orbit and beyond
=> Status : **Study Complete and Report approved by Commission -3. Referred to IAA for arranging Peer review.**
- Study Group 3.15 Chair or representative: Saccoccia/Lu Yu/Wang Xiaowei
Long Term Space Propellant Depot
=> Status : **Draft Report ready, Final version to be submitted for Commission 3 review .**
- Study Group 3.16 Chair or representative: Genta/Dupas/Yamazaki/Salotti
- Global Human Mars System Missions Exploration – Goals, Requirements and Technologies
=> Status : **Report under publication by IAA**



- **Current Studies (*continued*)**
 - Study Group 3.18 Chairs: Ramakrishnan/Unnikrishnan Nair
Possible International Protocol to handle Crisis/Emergency of Astronauts in Low Earth Orbit
=> Status : **Report ready and is put up for review by Commission 3 Members.**
To be referred to IAA for Peer review process.
 - Study Group 3.19 Chair or representative: Mckenna-Lawlor
Feasibility study of Standardized Career Dose Limits in LEO and outlook for BLEO
=> Status : **First Phase Study completed and all inputs for Draft Report ready.**
Report to be presented to Commission 3 in Oct '16 meeting.



- **Current Studies (*continued*)**
 - Study Group 3.21 Chair or representative: A. Degtyarev
Space Disposal of Radioactive Waste
=> Status : **First Draft Report under progress (June 2016)**
 - Study Group 3.22 Chair or representative: Razoumny/Agrawal/Ji Simei
Next-Generation Space System Development Basing on On-Orbit-Servicing Concept
=> Status : **Report Content finalised and Chapters with key contributors identified**
 - Study Group 3.23 Chairs: Reibaldi/Zhuang/Unnikrishnan Nair
 - Human Space Technology Pilot Projects With Developing Countries
=> Status : **Discussions among Study Group members initiated and first draft report under preparation**



- **Current Studies (*continued*)**

- Study Group 3.24 Chairs: Tsuchida/Raitt/ Swan/Takahashi
Road to Space Elevator Era

- => Status : **Space Elevator Mission Definition Document first draft under review**

- Study Group 3.25 Chair or representative: TBC
The Maintainability and Supportability of Deep Space Manned
Spacecrafts

- => Status : **Study Group recommended by Commission 3 for approval by IAA.
Study plan and proposed report contents presented to Commission 3.
Interim milestones to be identified.**

- Study Group 3.26 Chair or representative: Dula/Zhuang F./Lenard
Space Mineral Resources #2: National Authority for Extra-Terrestrial
Resource Utilization & Beneficiation based on the Outer Space Treaty
=>Status : **Study Group approved by IAA. Title of Study report under discussion**



Commission 3 Report to SAC

- **New Studies Proposals**

- # *Technical Development of Efficient Management and Recycling of Space Fluids*

Proposal reviewed by Commission 3. Advised to put up a revised study plan with more clarity on scope of study taking into account already ongoing studies in allied areas.

- # *Towards utilization of Moon, Preparing for Mars exploration*

Commission 3 recommends IAA authorisation of this study of current relevance.

- # *Strategy and feasibility assessment of Collision protection from Asteroids / Comets*

- Could not be discussed as the proposer was not available to make presentation.



- **Current IAA Conferences**

- 24-26 May 2016, IAA Conference on Human Space Exploration, Korolev, Moscow Region, Russia

- Program Committee Chair or representative: A. Perminov

- 07-11 March 2016, UN-IAA Costa Rica Workshop on Human Space Technology, San José, Costa Rica

- Program Committee Chair or representative: G. Genta

- May 2017, 6th IAA Conference on Space Technologies, Dnepropetrovsk, Ukraine

- Program Committee Chair or representative: A. Degtyarev



- **Current IAA Conferences**

- July 2017, 10th IAA Symposium on the Future of Space Exploration, Torino, Italy

- Program Committee Chair or representative: G. Genta

November 2017, 7th CSA-IAA Conference on Space Technology Innovation
Shanghai, China

Program Committee Chair or representative: TBD

3rd IAA Conference on Dynamics and Control of Space Systems (DYCOSS)

Date, Place: TBD

Program Committee Chair or representative: TBD



- **Current IAA Conferences**

- IAA symposia at IAC

- 19th IAA Symposium on human exploration of the solar system, Guadalajara, Mexico (IAC A5)

- Program Committee Chairs or representatives: C. Sallaberger, M.A. Perino

- 13th IAA symposium on building blocks for future space exploration and development, Guadalajara, Mexico (IAC D3)

- Program Committee Chairs or representatives: A. Pradier, J. Mankins

- 14th IAA symposium on visions and strategies for the future, Guadalajara, Mexico (IAC D4)

- Program Committee Chairs or representatives: G. Reibaldi, H. Rauck