March 20, 2017
IAA Office, PARIS, FRANCE

MINUTES:

1. The Commission-III Meeting commenced at 14.00 hrs with Chairman welcoming all the Members and other Invitees present for the meeting (Participants list appended).

2. The current composition of Commission-III was displayed for information (Annexure-1). The Agenda for the meeting was presented and accepted (Annexure-2).

3. The minutes of last Commission meeting held in September 2016 at Guadalajara, Mexico was reviewed.

   Chairman, Commission-III informed the members about the proposal made on behalf of Commission-III to Secretary General, IAA for commemorating Horst Rauck with an award in his name for the best Cosmic Study report (Annexure-3).

   He also apprised them about the informal feedback from Dr Contant that IAA BOT has decided sometime back not to constitute any such commemorating awards on individual member's name.

4. IAA Cosmic Studies:

4.1 Studies completed

It was noted that following two study reports are under the process of publication. (Annexure-4)

SG 3.14 Public/Private Human Access to Space –Vol.2

SG 3.15 Space Propellant depots.

The final draft of the study report **SG 3.18** International Protocol on Crew rescue from LEO is submitted to IAA for peer review.

4.2 Studies in Progress (Annexure-5):

SG 3.19 Feasibility study on standardized career radiation dose limits for astronauts:

The study Chair, Dr. .Susan McKenna-Lawlor could not be present, but she had sent the status report (Annexure-6). It was noted that Phase-1 study has been completed and presented in IAA Symposia held at Washington and Moscow, and has also been published in Acta Astronautica journal.

Phase-2 study which includes radiation hazards on Moon surface is nearing completion and the final report which contains sufficient material for a book is under compilation. Draft report for commission review expected by September 2017.

SG 3.21 Space Disposal of Radioactive Waste:

There was no presentation to the Commission by the SG. However, the status was noted as follows. The first draft report received by Commission-III Members and the revised draft is expected by April, 2017. Report to be submitted to IAA by September, 2017.

SG 3.22 Next Generation Space Systems development based on On-orbit servicing:

There was no presentation to the Commission. The status was briefed by Prof.Razoumny as follows:

Report content finalized and chapters with key contributors identified. Interim report presented in Mexico IAA meet. Revision in progress. To be ready for Commission-III review in Sept. 2017.

SG 3.23 Human Space Technology Pilot Project with developing countries.

Dr Reibaldi briefed the Commission on the progress made. The SG consisting of 27 Members from 10 countries held several skype call meetings. A draft call for proposal on Pilot Projects with space developing nations discussed in IAA Symposium held at Costa Rica. Based on feedback, a final call for proposal to be submitted to IAA with proposed agreement between IAA and UNOOSA. China, France and India have offered to provide opportunities to train students in specific Human spaceflight technology areas.

The first pilot project is expected to be initiated by March 2018.

SG 3.24 Road to Space Elevator Era:

Dr Swan briefed the Commission on the progress made so far. The study report draft (dt.Nov.16) is under review and individual research elements have been assigned to expert members of the SG. Specific technology items review was conducted in the status meeting held in Feb.2017, at Japan. The Study Group has plan to meet at Paris as part of IAA spring Meetings in March 2017.

SG 3.25 Maintainability and supportability of Deep Space Manned Spacecrafts:

The progress made and the status report on SG 3.25 has been sent by Dr ZHANG Dapeng (Annexure-7). There was no one from the Study Group to make the presentation. It was noted that the study is focusing on the requirements and constraints associated with manned space missions specifically to Mars. Supportability and sustainability of Manned Mission to Mars is addressed. The study is through Hybrid and VR simulation platforms to study activities of 3D model of maintenance equipment in space.

It is proposed to compare different schemes considering the adaptability of maintainability and supportability through multi-variable optimization techniques.

It is targeted to submit the final report of the SG by Sept. 2018.

SG 3.26 Space Mineral Resources – Phase 2

Roger Lenard, Co-chair of the SG briefed the status.

This study is a follow-on to SG 3.17 - Report on Space Mineral Resources – Challenges and opportunities.

Forty-five potential members to contribute to this SG, have been identified and the report outline defined. Skype Conference has been held and the SG proposes to meet on 22nd March 2017 at Paris.

SG 3.27 Towards utilization of Moon, Preparing for Mars Exploration

IAA has approved this new SG proposal and appointment letters have been sent. This SG is chaired by Prof. Genta who could not be present for this Commission meeting. It is noted that work is yet to commence.

SG 3.28 Strategy of Large-scale and Low-cost Access to Space:

This new study proposal from Prof. LU Yu of China has been approved by IAA. The objectives and broad outline of the proposed study report was presented to the Commission (Annexure-8).

4.3 New Study Proposals:

There were two proposals for new Study Groups.

Prof. Weimin Bao of China had proposed (Annexure-9) a study on Collision Protection from Asteroids and Comets.

Dr Zhengshi Yu who attended the meeting made a brief presentation to the Commission (Annexure-10) on the scope of study and the major objectives. The goal is to push the technologies for collision protection from concept to practice through the design of a feasible collision protection mission.

The Commission decided to recommend this new study proposal for approval by IAA.

Dr Jean Marc ASTORG from Europe had proposed (Annexure-11) a study to bring out a position report on Reusable Launchers.

The Commission members felt that this proposal requires more clarity and articulation of focus and objectives of the study. It was decided to request for a presentation to the Commission in the next meeting.

5. IAA Conferences:

The Commission noted that there are six IAA Conferences planned (Annexure-12) before the next IAC meet at Adelaide, Australia in Sept. 2017.

The 10th IAA Symposium on the future of Space Exploration planned at Torino, Italy during 27-29 June, 2017 has 'Moon Village and Beyond' as the main theme. Dr. Giuseppe Reibaldi briefed the commission members about the concept of 'Moon Village' which is gaining momentum and international attention.

6. AOB:

Under AOB, Chairman, Commission-III briefed the members about certain changes being proposed on the Commission membership, study group composition and the Commission meeting protocol which were informed by the IAA Secretary General in the closed door plenary meeting. He mentioned that formal communication on these new guidelines may be issued shortly.

7. Commission-III report to SAC (Annexure-13).

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List of participants:

Commission-III Members:

Chair: Ramakrishnan S (India)
Vice Chair: Lenard R. (USA)
Past-Chair: Lu Yu (China)
Secretary: Genta G (Italy) (Absent – Excused)
Member: Huffenbach B. (Germany) (Absent)
Member: Kawaguchi J. (Japan)
Pacheco-Cabrera Enrique (Mexico) (Absent)
Member: FAN Ruxiang (China) (Absent)
Member: Razoumny Y. (Russia)
Member: Sweet Randall (USA)
Ex-officio Member: Tsuchida A (Japan) (Absent-Excused)
Ex-officio Member: Reibaldi Giuseppe

Invitees:

Art Dula
Pete Swan
Sakurako Takahashi
Wang Xiaowei
Hatsumi Ishida
Hiroki Matsuo
Arun Misra
S. Somanth
John Mankins
Ken Davidian
Zhengshi Yu

Chair: Ramakrishnan S (India)
Vice Chair: Lenard R (USA)
Past-Chair: LU Yu (China)
Secretary: Genta G (Italy)

FAN Ruxiang (China) Member:
Kawaguchi J (Japan) Member:
Razoumny Y(Russia) Member:
Huffenbach B (Germany) Member:
Tsuchida A (Japan) Member
Pacheco-Cabrera Enrique (Mexico) Member
Sweet Randall (USA) Member

COMMISSION 3 MEMBERSHIP : 2015 – 17

ANNEXURE-1

International Academy of Astronautics

1. Welcome
2. Adoption of the Agenda
3. Review of the Minutes of Commission 3, Guadalajara Sept. 2016

4. IAA Cosmic Studies Status & New Study Proposals
5. IAA Conferences & IAA Symposia sessions in IAC 2017
6. IAA Heads of Space Agencies Summit
7. Commission 3 Report to SAC
8. AOB.

ANNEXURE-2

ANNEXURE -3

PROPOSAL TO COMMEMORATE HORST RAUCK

1 message

Ramakrishnan Sundaram <ramkrish49@gmail.com> Thu, Feb 9, 2017 at 11:01 PM
Reply-To: ramkrish49@gmail.com
To: sgeneral@iaamail.org, IAA Office <office@iaamail.org>
Cc: Roger Lenard <rxlenard@gmail.com>, Genta Giancarlo <d000485@polito.it>, luy <luycalt@163.com>, "giuseppe.reibaldi" <giuseppe.reibaldi@gmail.com>

Dear Dr Contant,

My Greetings to You !

Hope this finds you in good cheer. You should be busy organising the forthcoming IAA Spring meetings and the Academy Day in Paris.

As you are aware, we lost a veteran academician and an active member of IAA in the sudden demise of Horst Rauck on June 19th, 2016.

Horst Rauck had a distinguished professional career spanning over four decades , shouldering various responsibilities in European industries.

His services in vital areas have been recognized and he had the unique distinction of being honoured by the German , French and Russian Governments. (Encl-1)

He participated in all IAA activities with zeal and significantly contributed in furthering the interests of the Academy. His simplicity, enthusiasm and positive attitude endeared him to one and all. He was past- Chair of Commission 3 and has continued to attend all the Commission meetings, giving us the benefit of his wisdom and experience. We all will miss him in the future Academy meetings.

It will be a befitting gesture from the Academy to commemorate Horst Rauck by instituting an Award in his name. On behalf of Commission 3, I convey a proposal to create an IAA Award (Annual / Bi-annual) to the best Cosmic Study Report published during that period. You may please consider this proposal in IAA governig fora for approval and appropriate action.

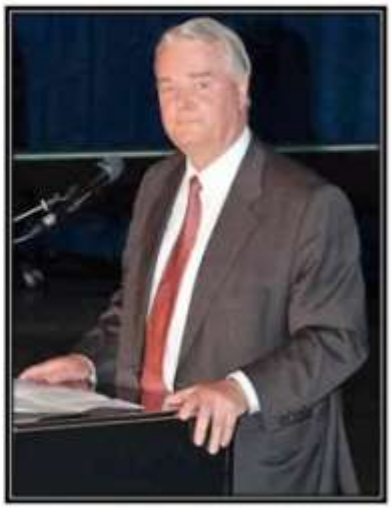
Hoping to meet you in Paris in March,

With Best Regards Sundaram Ramakrishnan

Chairman , Commission 3

To: Secretary General,IAA

Horst Rauck, Germany (22.05.1938 Offenbach am Main - 19.06.2016 Weßling,)



http://iaaweb.org/content/view/170/638/
We regret to inform you of the passing of Mr Horst Rauck, Germany, member of Engineering Sciences section, on June 19, 2016. Born on May 22, 1938 in Offenbach am Main, Horst Rauck studied Mechanical and Aerospace Engineering at the Technical University Darmstadt. He joined the newly founded space division of MAN-Turbo. In 1969, he became head of energy and space technology. He served as a member of the Executive Board, and then chair, MAN Technologie AG. In 2002 he moved to the Supervisory Board of MAN Technologie where he stayed until the company was sold to OHB/Apollo Capital Partners in 2005. His duties at MAN included the development and early production of the gas centrifuge for uranium enrichment, renewable energy systems and the Ariane launcher family, which brought him into close contact with French industry. From 1987 to 2003 he also was at the Arianespace board.
Horst Rauck was also a Vice-Chair of the German Aerospace Centre (DLR) Senate. From 1991 to 2003, he acted as co-chair of the German-Russian council of cooperation in aerospace.

Awards and merits (short list)
La Légion d'Honneur de la République Française, 2006
http://www.legiondhonneur.fr/fr/page/les-ordres-nationaux-et-les-decorations/37
Order of Merit of the Russian Cosmonautic Administration (RKA), 2001
http://en.roscosmos.ru/
Order of Merit of the German Federal Republic, 2000
http://www.bundespraesident.de/DE/Amt-und-Aufgaben/Orden-und Ehrungen/Verdienstorden/verdienstorden.html
International Academy of Astronautics, Paris 2000, Full Member
http://iaaweb.org
Académie de l'Air et de l'Espace, France, Full member
http://www.3af.fr/partenaire/academie-de-l-air-et-de-l-espace

Studies Completed
(Under Publication)

3.14 Public/Private Human Access To Space – Vol 2 : Di Pippo / Davidian / Dupas

3.15 Space Propellant Depots : Saccoccia / Lu Yu

ANNEXURE-4

International Academy of Astronautics

Study Report Submitted
(For Peer Review)

SG 3.18 Feasibility of International Protocol on Astronaut rescue from LEO :

Ramakrishnan / Unnikrishnan nair

ANNEXURE-4

Studies In Progress

Study Group 3.19 Chair or representative: Mckenna-Lawlor

Feasibility study of Standardized Career Dose Limits in LEO and outlook for BLEO

Study Group 3.21 Chair or representative: A. Degtyarev

Space Disposal of Radioactive Waste

Study Group 3.22 Chair or representative: Razoumny/Agrawal/Ji Simei

Next-Generation Space System Development Basing on On-Orbit-Servicing Concept

Study Group 3.23 Chairs: Reibaldi/Zhuang/Unnikrishnan Nair

Human Space Technology Pilot Projects With Developing Countries

Study Group 3.24 Chairs: Tsuchida/Raitt/ Swan/Takahashi

Road to Space Elevator Era

Study Group 3.25 Chair or representative: Yang Hong et al.

The Maintainability and Supportability of Deep Space Manned Spacecrafts

Study Group 3.26
Dula / Zhang Z / Lenard

Space Mineral Resources # 2

Study Group 3.27
Genta / Ventskovsky

Towards Utilisation of Moon, Preraring for Mars Exploration

Study Group 3.28
Lu Yu / Reibaldi

Low Cost Large Scale Access To Space

ANNEXURE-6

Space Technology (Ireland) Ltd.

Status report for the Spring Meeting of Commission 3 of the IAA for SG. 3.19:

Feasibility study of astronaut standardized career dose limits in LEO and the outlook for BLEO; biological response of humans to the impingement of high energy particle radiation

Susan McKenna-Lawlor

Space Technology Ireland, Ltd., Maynooth, Co. Kildare

Space Technology (Ireland) Ltd.

Differences between the values of career dose limits adopted for their astronauts by individual space agencies were investigated during Phase 1 of the study. Also, the biological response of humans to the impingement of high energy particle radiation under microgravity conditions were investigated.

Publications:

S. McKenna-Lawlor and the SG 3.19 Team "Feasibility study of astronaut standardized career dose limits in LEO and the outlook for BLEO, Acta Astronautica, 104, 565- 573, 2014.

S. McKenna-Lawlor and the SG 3.19 Team " Recommendations to mitigate against human health risks incurred due to energetic particle irradiation beyond low earth orbit/BLEO, Acta Astronautica, 109, 182-193, 2015.

Presentations:

Presentations on Phase I of the study were made at IAA Symposia in Washington and Moscow.

Phase 2 -Change of direction

Space Technology (Ireland) Ltd.

The leader of Study Group 3.19 was personally informed by the Human Space Flight Coordinating Group of the IAA that, since a human presence on Mars would not be technically possible for some decades, the SG 3.19 report should provide in Phase 2 an emphasis on the radiation hazard incurred on the Moon, which is presently an eminent exploration target. This topic had not hitherto been addressed by the group.

A paper was presented by SMcKL at an IAA Symposium on Human Space Flight in Prague, 2015 that incorporated the lunar theme.

Space Technology (Ireland) Ltd.

At the present time a 30 page report emerging from that part of the study conducted during Phase I is being merged with the new material collected during Phase 2. When this was reported to Commission III in Guadalajara it was decided that sufficient time should be given to SG 3.19 to complete the study, which is expected to contain enough material for a book.

When this matter was later brought up at the SAC, the Sec. General noted that, while the results from Phase I already published in Acta Astronautica should be included in the final version, the same wording should not be used as that employed in Acta Astronautica.

Space Technology (Ireland) Ltd.

The final report is now under active completion. It was noted by SMcKL that the names of several persons who had contributed to the study had not in fact received formal invitations from the Academy in this regard and Fabrice was requested to send out the necessary documents so that these people could be included in the final author list.

spais teicneolaíocht éire teoranta
Space Technology (Ireland) Ltd.

Go raibh maith agaibh go léir

ANNEXURE - 7

The Maintainability and Supportability of Manned Spacecrafts in Deep Space

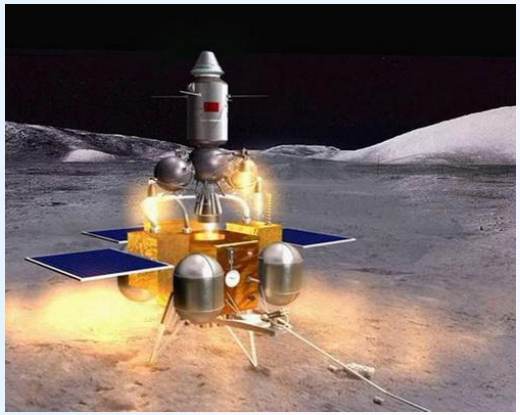
（SG3.25）

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

Research Status

To continue the requirements analysis and restriction analysis to the flight mode of Mars manned spacecrafts

- To analyze the crew's number for Mars.
- To design and analyze the Orbit of the mission.
- To analyze the times of launch
- To consider the scale of spacecraft.
- Requirements analysis of the manned Mars mission



Research Status

We have Identified factors of supportability and sustainability during Manned mission to the Mars .

- Flight mode
- Crew's supplies
- Propellant
- Maintenance & repairing
- ECLSS
- Martian atmosphere application

Research Status

- We have built Hybrid simulation platform by combining the Motion capture system and 3D virtual simulation system based upon VR technology. The simulation of detailed operation is realized through that motion capture device and data gloves collect participants' motion. The movements of human and things can be controlled by the algorithm. The activities of 3D model of maintenance equipment can be controlled by simulation software.
- We have used this system to do a lot of simulation verification works, such as the reasonability of maintenance process and path planning in space, and the visuality, accessibility and operability of the maintenance object.

Research Status

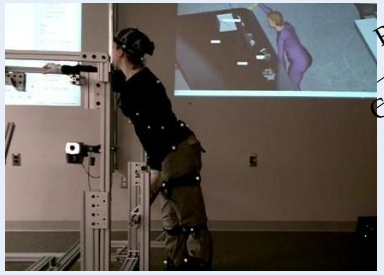
Cameras

LAN

CatchPoints location

Data processor

Body move information



Motion capture suit

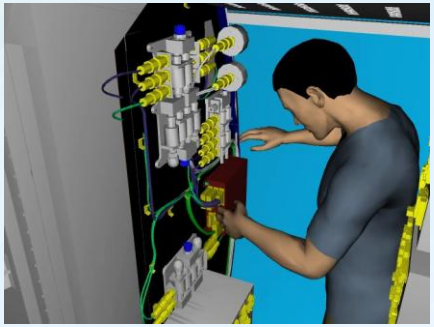
RF

CatchPoints No.

Data Gloves

USB

Hand Joints Data



Simulation Software

Hardware captures Body detailed operation

Drive the body-model move

Large scale movements

Weightlessness in space

Software set body movements

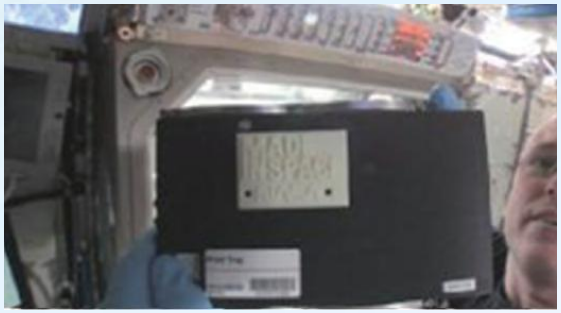
Keyframe fitting method

Software can simulate the large scale movements and weightlessness in space

Research Status

To carry out the technical index and parameters of 3D printing in space

- Materials of 3D printing in Space
- Environment requirements of 3D printing in Space
- Energy demand of 3D printing in Space
- Weight & measurement of 3D printing equipments

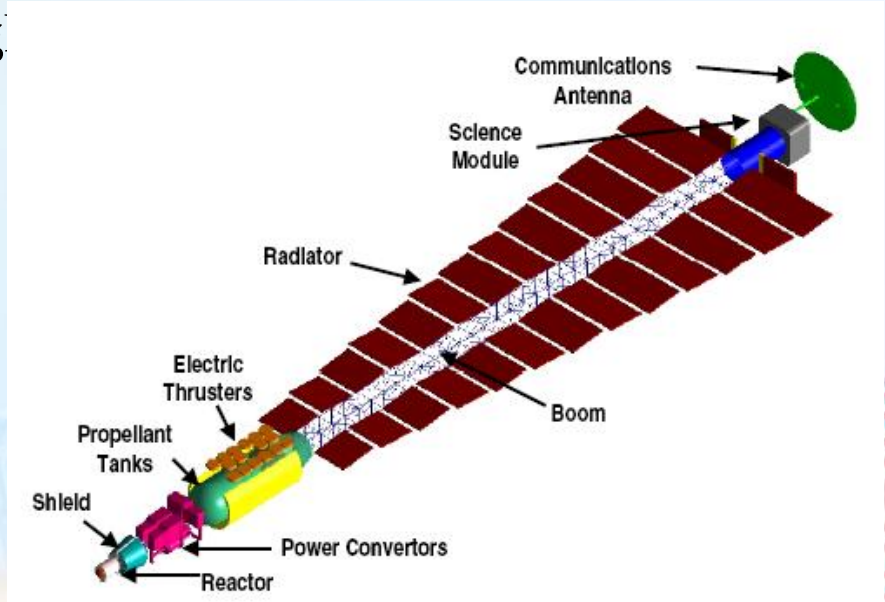


Research Contents in Future Plan

Comparison of advanced propulsion system

To analyze and compare different propulsion advanced propulsion system，considering manned Mars-landing mission

- Propulsion system based on rarefied gas in space
- Propulsion system based on waste reclamation
- Chemical propulsion with hig
- Electric propulsion
- Nuclear propulsion



Research Contents in Future Plan

Comparison of advanced ECLSS

1) Confirm influencing actors and parameters

a. Consuming modeling of consumes

b. Influencing actors for reliability, maintainability, and supportability

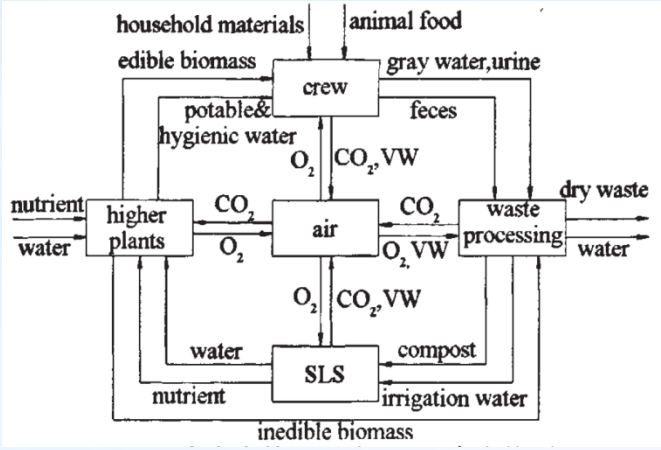
2) Comparison of different ECLSS

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

a. Bio-regenerative ECLSS

b. Physical and chemical regeneration ECLSS

c. Mixed regenerative ECLSS



Research Contents in Future Plan

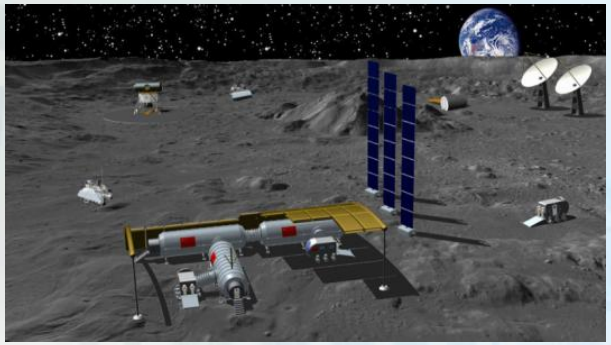
Study of the Martian atmosphere comprehensive application technology

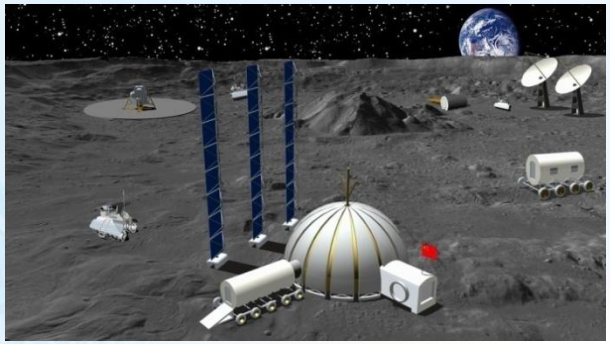
- To analyze the possibility of decrease the spacecraft's mass by applying Martian atmosphere
- To apply the Martian atmosphere as propellant

Research Contents in Future Plan

General research of mission mode of manned Mars-landing based on maintenance and supportability

- To analyze the adaptability of the maintainability and supportability with different schemes
- To put forward a workable overall plan which requires the least resources according to TRL(Technology Readiness Level)





Modified Plan

The research schedule is needed to be modified, because we adjust the part contents on analysis of maintainability and supportability, we need consider the advanced propulsion scheme, and we would complete the multi-parameters optimization and scheme selected.

- we will analysis parameters and index of the factors of supportability and sustainability during Manned mission to the Mars .
- Then we will compare different schemes considering the adaptability of the maintainability and supportability based upon multi-variables optimization and analysis.
- Finally we will put forward a workable overall plan which requires the least resources according to TRL(Technology Readiness Level).

Modified Plan

The plan will be adjusted as follows:

Apr. 2017 — Jun. 2017: implementation of maintainability and supportability with manned spacecraft in deep space

July 2017 — Sep. 2017: an interim report to the IAA.

Oct. 2017 — Mar. 2018: To complete the Comparison of advanced propulsion systems and advanced ECLSS systems, and research the Martian atmosphere comprehensive application.

Apr. 2018 — Jun. 2018: To complete the multi-parameters optimization and scheme selected.

July 2018 — Sep. 2018: submission of a final report to the IAA.


Thanks for your Attention!
谢　谢！
一切为载人，全力保成功

Strategy of Large-Scale and Low-Cost Access to Space in Future

(ANNEXURE – 8)

1. Introduction LU Yu

With the development of human society and economy, and aerospace technology and industry, the requirement access to space becomes large and larger. Especially, micro and small satellites begin blowout in these years. How to meet this kind requirement of large scale access to space and how to launch thousands payloads with low cost are a tough problem we are facing. This study will focus this problem. And the corresponding technologies and methodology will be studied.

Overall Goal of this study is to identify the requirement of access to space and exploration payload in future, and required key technologies and methodology to meet this kind of requirement.

Large-scale and low-cost access to space has been an important trend. This project will explain the necessity and significance of this study and illustrate the main frame, contents and conclusions.

2. Demand and technology analysis of large-scale access to space in future

(1) Mission demand analysis of access to space (aiming at 2030, 2050)

- low-earth orbit mission
  - ✓ Robotics exploration (explosive growth in demand of small and micro satellites)
  - ✓ human space flight exploration (two space stations, commercial)
- Robotic deep space mission
- Human lunar, asteroids, Mars exploration and other manned deep space mission
- Construction of space infrastructure, such as, space solar power station
- On-orbit service and maintenance
- Space tourism

(2) Limitation analysis of current technologies for access to space（launcher and spacecraft, delivery system）

(3) Method for low-cost access to space LU Yu

- Launch vehicles
  - ✓ Low-cost design of expendable launch vehicles and reusable design
  - ✓ Interface standardization, etc.
-
-
- Others

3. Key technologies of large-scale and low-cost access to space

(1) Launch vehicles

□• Low-cost design of expendable vehicles and delivery system

□• Reusable technology

(2) On-orbit refueling

(3) Electro-magnetic launcher

(4) Nuclear thermal propulsion vehicle

(5) Space Elevator

(7) Spin - in and Spin - off

• Other perspectives all over the world; what is spin - in/spin - off.

4. Task mode and solution for large-scale and low-cost access to space

(1) Mission mode

□√ Reusable technology

□√ Piggyback launch

□√ Launch by small launch vehicle

□√ Network launch (delivery system)

(2) Operation mode

This part will put forward cost estimation methods and operation programs of mission mode for access to space. Based on the comprehensive analysis of payload and transport efficiency, the combination of cost and risk, and the integration of large-scale and low-cost factors, choice and match relationship between task mode and vehicles will be studied.

5. Operation management and international cooperation innovation mode of large-scale and low-cost access to space in future

(1) Marketing and positioning of large-scale and low-cost access to space in future

□• Commercial market analysis and positioning

□• Non-commercial market analysis and positioning

(2) Commercial operation management of large-scale and low-cost access to space in future

□• Business operation mode

□• Investment and financing management

□• Operational risk assessment (inculding launcher and delivery system, human risk)

(3) International cooperation and development innovation of large-scale low-cost access to space in future

□• Present situation of international cooperation

□• Development of international cooperation

□ √ Inter- government international cooperation and development

□ √ Inter-nongovernment international cooperation and development

6. Relevant laws and policies

(1) Space debris

Large-scale access to space is required to be managed and approved. Otherwise, disastrous chain reaction and space pollution will be formed.

(2) Disposal measures

- ✓ Laws and responsibilities of the vehicles
- ✓ Rules of the development of small satellites
- ✓ Licensing standards
- ✓ IADC: control large constellations into space, cleanup measures and analysis model.
- ✓ Put forward questions and macro principles (principles ruled by IADC).
- ✓ Relations between protecting the earth, protecting humans, space rescue and entering and protecting space.

7. Conclusions and suggestions LU Yu

Proposal for Forming an IAA Study Group

(ANNEXURE – 9)

Title of Study:
Strategy and Feasibility Assessment of Collision Protection from Asteroid and Comet: Concept, Technology, and Prospect

Proposer(s):
Weimin Bao
Primary IAA Commission Preference: COMMISSION 3 Space Technology & System Development
Secondary IAA Commission Interests: COMMISSION 4 Space Systems Operations & Utilization

Members of Study Team
Chair(s): Prof. Weimin Bao (China)
Secretary: TBD
Other Members:
China: Prof. Weiren Wu, Prof. Pingyuan Cui, Prof. Dong Qiao, Dr. Haibin Shang, Dr. Rui Xu, Dr. Shengying Zhu, Dr. Ai Gao, Dr. Zhengshi Yu, Dr. Juan Dai, Dr. Yang Liu
USA: Prof. Daniel J. Scheeres, Prof. John L. Crassidis
France: Prof. M. A. Barucci, Prof. M. Fulchignoni
Netherland: Prof. Pieter Visser

Short Description of Scope of Study
Protecting the Earth from probable collision of asteroid and comet is one of the main purpose of the small body exploration. Although the threat of asteroid and comet to the Earth has been analyzed and the potential protection concept has been proposed, the detailed technologies and the feasibility assessment are not investigated thoroughly. This proposal will make effort to push the technologies of collision protection from concept to practice. Based on the potential concepts and strategies of collision protection, the corresponding state-of-the-art technologies such as orbit optimization and design, GNC, propulsion, and remote operation are developed, and the feasibility of different kinds of strategies are investigated. With the consideration of present technology development, a micro and low cost collision protection mission is proposed and designed. Furthermore, the prospect of collision protection strategy in the next 10 years is previewed, which may lead the technology development and the international cooperation.

Overall Goal:
Advancing the new technologies for collision protection from asteroid and comet, as well as investigating the feasibility of different potential strategies. Leading the trend of technology development for the potential collision protection strategy in the near future. Based on the progress of study group, an international research team on

small body exploration will also be built, which will further increase the international cooperation.

Intermediate Goals:

- Systematically improve and perfect the potential collision protection concepts such as gravity trailer, solar sail drag, kinetic impact, and nuclear explosion.
- Build the feasibility assessment model of each strategy based on the orbit divergent capability, early warning time, and potential cost.
- Identify and develop the underlying key technologies such as orbit optimization and design, guidance, navigation, and control.
- Initiate an international cooperation frame for collision protection from asteroid and comet.

Methodology:

- Proposing an international study group, drafting a detailed objective and timeline of the study.
- Assigning individual responsibility for the study report.
- Holding seminar and symposium regularly in order to discuss the progress and gather data to write the report.
- Attending the annual International Astronautical Congress or the IAA Spring meeting to improve the communication.
- Monitoring and supervising the progress of study for the study report.

Time Line:

- Assemble the study team: Dec. 2017
- Draft outline of report: Dec. 2018
- First draft of report: Dec. 2019
- Final report: Jun. 2020

Final Product (Report, Publication, etc.):

Publishable report which will be distributed to the International Space Community

Target Community:

International space community, related universities

Support Needed:

Conference and workshop opportunities

Potential Sponsors:

CNSA CASC CEA

ANNEXURE - 10

Strategy and Feasibility Assessment of Collision Protection from Asteroid and Comet: Concept, Technology, and Prospect

Proposer: Prof. Weinmin Bao

March 20th 2017

Background of Study

- *Population and size of dangerous near-Earth objects*

Near-Earth objects (NEOs) are classified as asteroids or comets depending on size and composition.

As of 5 February 2017, 15,727 NEOs have been discovered: 106 near-Earth comets and 15,621 near-Earth asteroids.

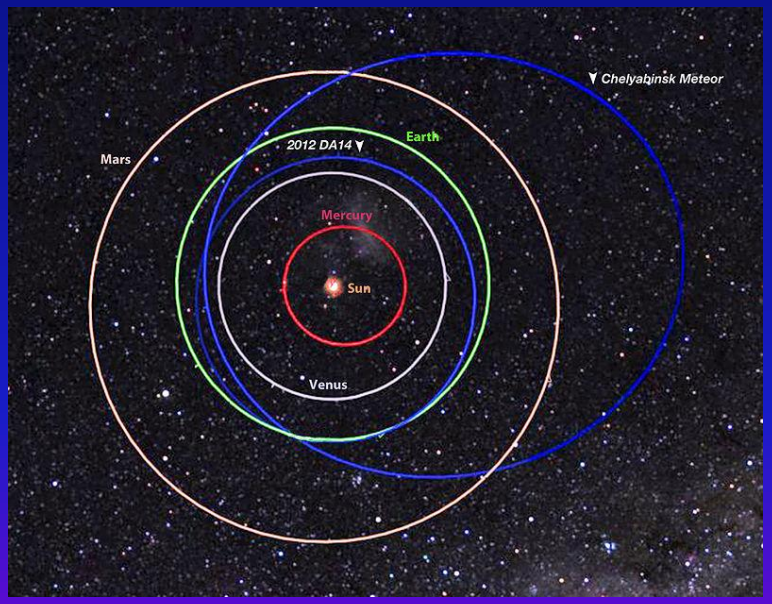
Really Risky!

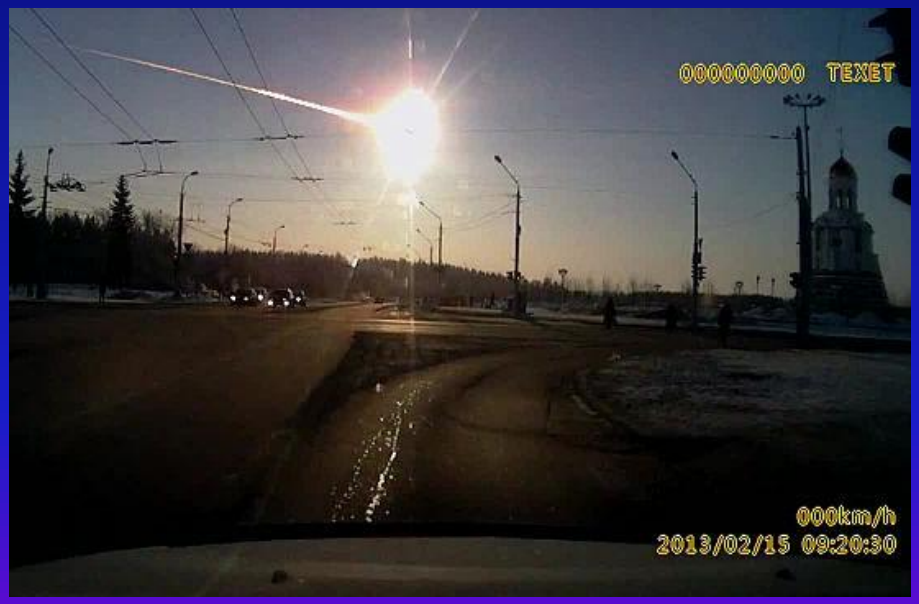
➢ *Chelyabinsk meteor*

The latest large impact event.

The Chelyabinsk meteor was an approximately 20-metre near-Earth asteroid that entered Earth's atmosphere on 15 Feb. 2013.

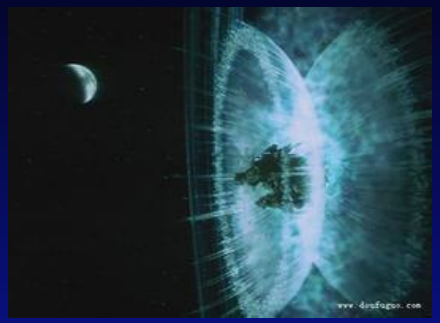
About 1,500 people were injured seriously.
Some 7,200 buildings were damaged by shock wave.





It happened before. It will happen again. It's just a question of when…

- *Many potential protection strategies have been proposed.*



Solar sail drag

Nuclear explosion

Kinetic impact

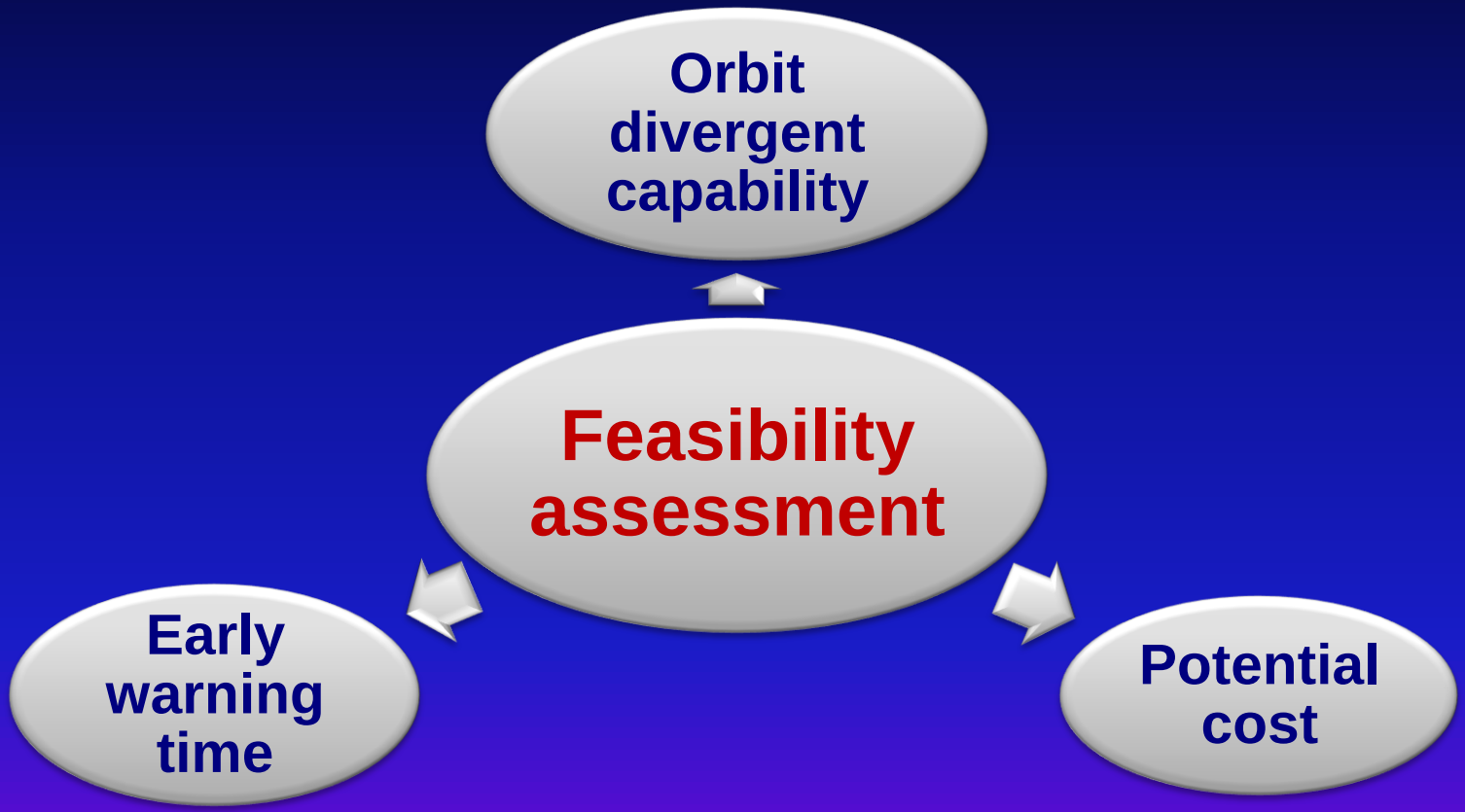
Gravity trailer

Orbit divergent

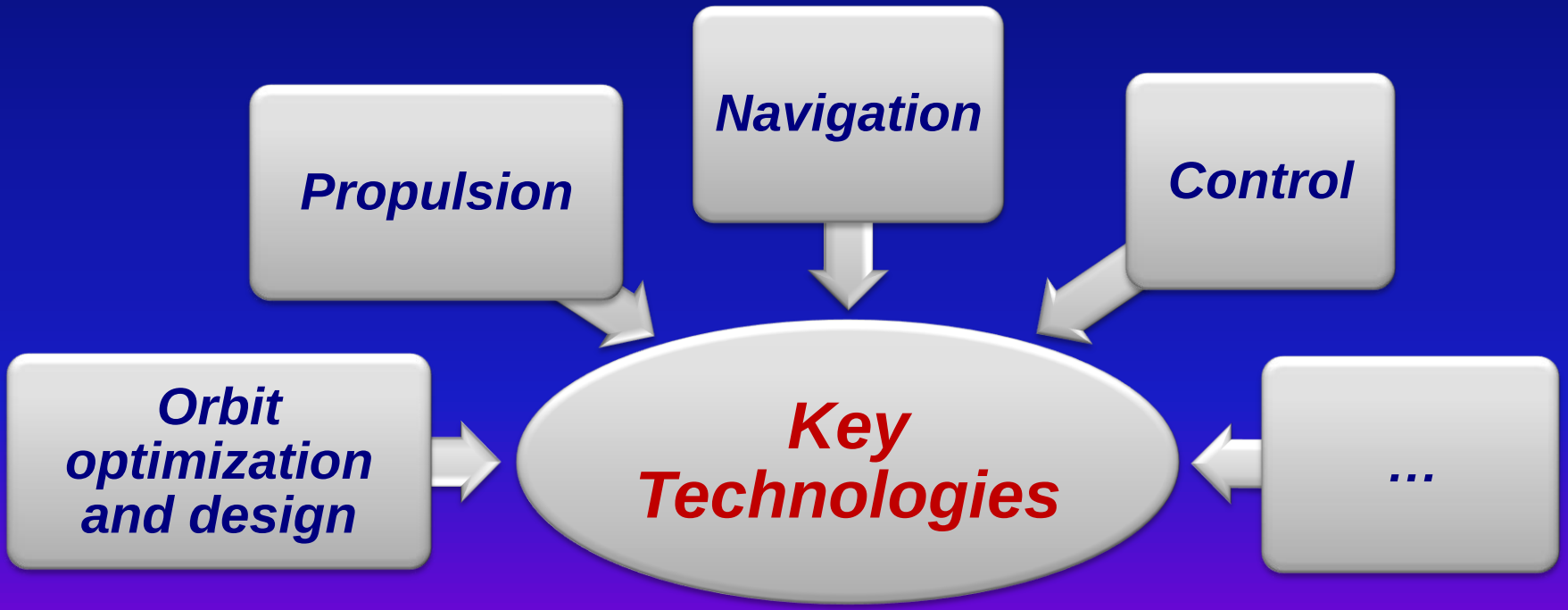
…

- *Expect for kinetic impact, none of other strategies has been demonstrated !*

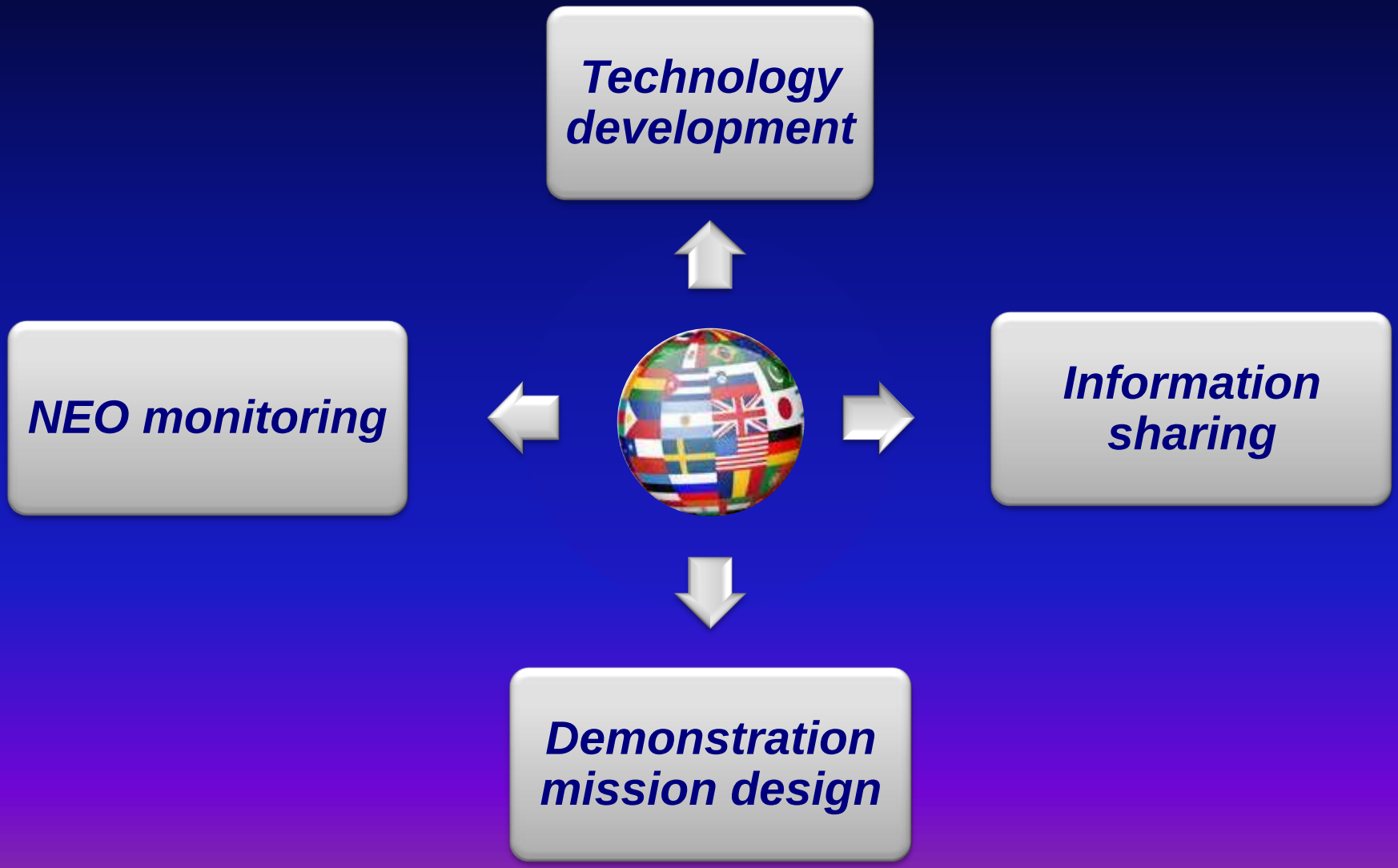
- *Which strategy should be used?*
  —feasibility assessment



- *Underlying key technologies such as orbit optimization and design, propulsion, navigation, and control should be further developed.*



- *International cooperation is indispensable to protect the Earth from the collision of asteroids and Comets.*



Short Description of Scope of Study

- *Make effort to push the technologies of collision protection from concept to practice.*
- *Develop the state-of-the-art technologies for collision protection and investigate the feasibility of different kinds of protection strategies.*
- *Propose and design a feasible and achievable collision protection mission.*
- *Preview the prospect of collision protection strategy in the next 10 years, which may lead the technology development and the international cooperation.*

Goals

- *Advancing the new technologies for collision protection from asteroid and comet, as well as investigating the feasibility of different potential strategies.*
- *Leading the trend of technology development for the potential collision protection strategy in the near future.*
- *Provoking the international cooperation for the establishment of collision protection demonstration mission in the next 10 years.*

Members

Chair(s): Prof. Weimin Bao (China),

IAA Member
Academician of the Chinese Academy of Sciences
China Aerospace Science and Technology Corporation (CASC)
Dynamic and Control

Members from China:

Prof. Weiren Wu

IAA Member
Academician (Chinese Academy of Engineering)
Luna Exploration and Space Engineering Center
Space tracking and telecommunication

Prof. Pingyuan Cui

Director of Institute of Deep Space Exploration
Beijing Institute of Technology
Guidance, navigation, and control

Prof. Dong Qiao
Dr. Shengying Zhu
Dr. Juan Dai
Dr. Rui Xu
Dr. Ai Gao
Dr. Yang Liu
Dr. Haibin Shang
Dr. Zhengshi Yu

Beijing Institute of Technology

Members from USA:

Prof. Daniel J. Scheeres

University of Colorado
Aerospace Engineering

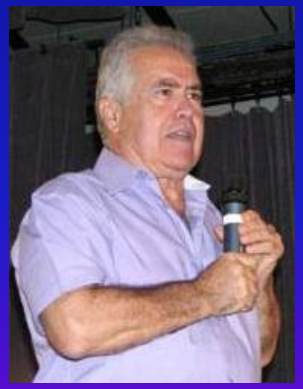
Prof. John L. Crassidis

University at Buffalo
Aerospace Engineering

Members from France:

Prof. M. A. Barucci

Observatoire de Paris
Planetary and Space Science



Prof. M. Fulchignoni

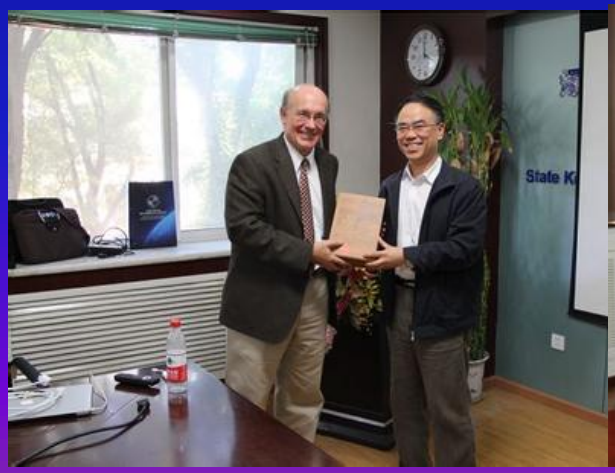
Observatoire de Paris
Planetary and Space Science

Members from Netherland:

Prof. Pieter Visser

Delft University of Technology
Aerospace Engineering

A solid cooperation relationship has been built



Methodology

- *Propose an international study group, draft a detailed objective and timeline of the study.*
- *Assign individual responsibility for the study report.*
- *Hold seminar and symposium regularly in order to discuss the progress and gather data to write the report.*
- *Attend the annual International Astronautical Congresses or the IAA Spring Meetings to improve the communication.*
- *Monitor and supervise the progress of study for the study report.*

Time Line

- *Assemble the study team: Dec. 2017*
- *Draft outline of report: Dec. 2018*
- *First draft of report: Dec. 2019*
- *Final report: Jun. 2020*

Final Product

- *Publishable report be distributed to the International Space Community*
- *If possible, the report will be published in both English and Chinese to extend the influence of both IAA and our Study Group*

The difference with SG 3.5

(DEALING WITH THE THREAT TO EARTH FROM ASTEROIDS AND COMETS)

- *Our group not only focuses on the concept of collision protection, but also the key technologies that push the strategy of collision protection from concept to practice.*
- *The feasibility of different strategies is assessed and analyzed, which is useful for practical implementation.*

- *A feasible micro and multi-target small body demonstration mission in the next 10 years will be designed which may provoke the international cooperation.*
- *More importantly, an international research team will be built, and new ways of cooperation between universities and industrial organizations will be proposed.*

Thanks for your attention!

Please contact me if you are interested in this Study Group

Secretary: Zhengshi YU Ph.D.
yuzhengshi@gmail.com

Instructions and application form: see: "Scientific Activity" section at http://iaaweb.org/content/view/256/393/

Proposal for Forming an IAA Study Group

Title of Study: Position report on reusable launchers

Proposer(s): Jean-Marc ASTORG
(Must be member(s) of the Academy M or CM)

Primary IAA Commission Preference: 3
(From Commission 1 to Commission 6)
Commissions: 1 Space Physical Sciences, 2 Space Life Sciences, 3 Space Technology & Systems Development, 4 Space Systems Operations & Utilization, 5 Space Policy, Law & Economics, 6 Space and Society: Culture and Education
Secondary IAA Commission Interests: 4,5
(From Commission 1 to Commission 6)

Members of Study Team

Chair(s): Jean-Marc ASTORG
(Must be member(s) of the Academy, M or CM)

Secretary: Jérôme VILA

Other Members: to be determined during our discussion
(Open to members and non- members of the Academy)

Short Description of Scope of Study

Overall Goal: to issue a position report on reusable launchers, including a summary of history of reusability, presentation of current vehicles, current projects, economic equation and possible developments
(Expected scientific or practical benefit of the study group's efforts)

Intermediate Goals: to issue a draft report by IAC 2019 and a final by IAC 2020.

Methodology:

(Email works, workshops, stand alone conferences, interim publications, etc.)

Plenary kick-off meeting during IAC 2017 (if approved)
Work by email till March 2018.
Meeting in March 2018 and IAC 2018

Draft table of contents:

Introduction, recall of scope, contents
Different modes of recovery
Brief history of reusability in the space age
The Space Shuttle
Revisiting launch vehicle reusability today
Technical challenge of reusability
Design for reusability
The economic equation of reusability
Future developement

Time Line: IAC 2020

(Cannot exceed three years)

Final Product (Report, Publication, etc.):

IAA position report on reusable launchers

Target Community:

Very wide: space agencies, industry, academics. All people interested in the subject.

Support Needed:

none

Potential Sponsors:

none

Instructions and application form: see: "Scientific Activity" section at http://iaaweb.org/content/view/256/393/

To be returned to the IAA Secretary General Paris *by fax: 33 1 47 23 82 16 or by email: sgeneral@iaamail.org*

Date: 7/3/2012

Name: ASTORG JM

(No Signature required if document authenticated).

Instructions and application form: see: "Scientific Activity" section at http://iaaweb.org/content/view/256/393/

Follow-up Section for IAA use only

Initial Phase

Application received:

Commission Approved:

SAC Approved:

Web Site Section opened:

Members Formally Appointed by IAA:

Final Phase

Peer Review by Commission Completed:

Recommended by the Commission:

Final Report Received:

SAC Approved:

BOT Accepted:

Publisher Selected:

Study Published:

I A A Conferences

- 07-10 March 2017, 1st IAA Latin American Symposium on Small Satellites: Advanced Technologies and Distributed Systems, San Martín, Buenos Aires, Argentina

- 18-21 April 2017, 7th European Conference on Space Debris, Darmstadt, Germany

- 24-28 April 2017, 11th IAA Symposium on Small Satellites for Earth Observation, Berlin, Germany

- 15-19 May 2017, 5th IAA Planetary Defense Conference, Tokyo, Japan

- 29 May-01 June 2017, 3rd IAA Conference on Dynamics and Control of Space Systems (DYCOSS), Moscow, Russia

- 27-29 June 2017, 10th IAA Symposium on The Future of Space Exploration - Towards the Moon Village & Beyond, Torino, Italy

- 15-17 August 2017, 12th IAA Low-Cost Planetary Mission Conference, Pasadena, USA

- 24 September 2017, IAA Academy Day, Adelaide, Australia

- 25-29 September 2017, 68th IAC International Astronautical Congress, Adelaide, Australia

IAA Commission 3 Space Technology & System Development

Scientific Activities Committee Report

20 March 2017
6, rue Galilée, 75116 Paris

Chair: Ramakrishnan S (India)
Vice Chair: Lenard R (USA)
Past-Chair: LU Yu (China)
Secretary: Genta G (Italy) EA

FAN Ruxiang (China) Member A
Kawaguchi J (Japan) Member:
Razoumny Y(Russia) Member:
Huffenbach B (Germany) Member A:
Tsuchida A (Japan) Member
Pacheco-Cabrera Enrique (Mexico) Member A
Sweet Randall (USA) Member

COMMISSION 3 MEMBERS ATTENDANCE FOR THIS SESSION

IN ADDITION 17 ACADEMICIANS / INVITEES PARTICIPATED

- **Current Studies**

  - Study Group 3.18 Chairs: Ramakrishnan/Unnikrishnan Nair

  Possible International Protocol to handle Crisis/Emergency of Astronauts in Low Earth Orbit

  => Status : **Report Submitted 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 a paper published in Acta Astronautica. Phase two including radiation hazard on the Moon surface has been completed. Enough study material to bring out a book on this topic generated and under compilation,**

  Report to be ready for Commission 3 Review by Sept 2017.

- Study Group 3.21 Chair or representative: A. Degtyarev

Space Disposal of Radioactive Waste – No Representative

⇒Status : **First Draft Report Reviwed by Commission 3. Second Draft with review inputs to be ready by April '17. Submission to IAA – Sept.**

* 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 . Interim details presented at Mexico IAA meet. Second revision in progress**

* Study Group 3.23 Chairs: Reibaldi/Zhuang/Unnikrishnan Nair - Human Space Technology Pilot Projects With Developing Countries

⇒Status : **Pilot projects with Space Developing Countries – Final call for proposal to be submitted to IAA along with proposed UNOOSA/ IAA Agreement - Conclusion of Study by March'18.**

- Study Group 3.24 Chairs: Tsuchida/Raitt/ Swan/Takahashi

Road to Space Elevator Era

•=> Status : **Space Elevator Mission Definition Dicument draft (Nov 2016) under review. Specific research items status review meeting held .**

- Study Group 3.25 Chair or representative: TBC

The Maintainability and Supportability of Deep Space Manned Spacecrafts

=> Status : **Study Group focuses on reqts. for manned mission to Mars. Interim milestones to be identified. First draft report slated for Sept '17.**

* Study Group 3.26 Chair or representative: Dula/Zhuang F./Lenard

Space Mineral Resources #2:

⇒Status : **Study Held meeting in Denver Feb 17, meeting scheduled for Mar 21st, Meeting scheduled IAC-2019, team members selected, outline generated**

International Academy of Astronautics

Commission 3 Report To SAC

Study Groups Approved By IAA:

3.27 Towards Utilisation of Moon / Preparing for Mars - Prof Genta et al.

3.28 Large scale , Low cost Access to Space – Prof. Lu Yu et al.

New Study Proposals

1. Position Report on Reusable Launchers:
Jean-Marc ASTORG

2. Collision Protection From Asteroids & Comets
Prof Weimin Bao China