FOURTH INTEROPERABILITY PLENARY: LEADERSHIP FORUM

IOP-4 Leadership Forum Meeting Minutes

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IOP-4 Leadership Forum Meeting Minutes
German Space Operations Center (GSOC)
Oberpfaffenhofen, Germany
18 December 2018

Attendance:
Chair: Michael Schmidt
Secretariat: Barbara Adde, Madeleine Bronstein

Members:
ASI: Fabio D'Amico
CNES: Frederic Pradeilles, Jean-Marc Soula
CSA (teleconference): François Alain, Réal Palardy
DLR: Dr. Hansjörg Dittus, Martin Pilgram, Rolf Kozlowski
ESA: Gian Paolo Calzolari, Klaus-Juergen Schulz, Rolf Densing
JAXA: Kazuo Tachi, Shinji Ogawa
NASA: Badri Younes, Greg Mann, Phil Liebrecht

Observers:
CNSA: Gan Yong
KARI: Hyo-Suk Lim, Sangil Ahn
Roscosmos: Gudnov Vasiliy, Gulyaev Ivan
SANSA: No representative(s) present
UAESA: Adnan Alrais
UKSA: Catherine Mealing-Jones, Matthew Cosby

Presentations are available at: www.interoperabilityplenary.org.

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Welcome: Dr. Hansjörg Dittus

Dr. Dittus welcomed the delegates to the German Aerospace Center in Oberpfaffenhofen, Germany and the Interoperability Plenary Leadership Forum. He expressed hope for an interesting discussion on the many new reports and topics in space operations. Dr. Dittus noted that at the German Aerospace Center, there is the German Space Operations Center (GSOC) and one of two Galileo Control Centers which operate 26 satellites in the Galileo GNSS fleet. He also noted that there is a lot of ongoing development and research occurring for the future within DLR. DLR will open 3 more centers in Hanover and Oberpfaffenhofen for navigation and communication technology, in particular, quantum technology, and in the next few years will spend roughly 40 million euro on the development of quantum technology. In Oberpfaffenhofen, the center for GNSS technology will develop new technology with industry. This technology may be quantum key distribution and quantum communications, which may be interesting for space operations, because it is based on optical communications more than anything else. Dr. Dittus concluded his remarks and handed the meeting to the Chairman. The Chairman then asked Mr. Kozlowski to provide a brief overview of the meeting logistics.

Overview of Meeting Logistics: Rolf Kozlowski

Mr. Kozlowski thanked the delegates for their participation in the leadership forum. He reviewed the logistics for the forum and the following tour of the GSOC visitor facilities and the Galileo Control Center.

Introduction and Objectives: Chairman

The Chairman thanked Rolf for his assistance in organizing the leadership forum and asked the delegates to begin by introducing themselves. Following delegate introductions, he provided an overview of the IOP-4 agenda.

The Chairman noted that the purpose of the leadership forum is for agency leadership to exchange ideas about new topics relevant to future operations. The last IOP in 2013 organized by CNES had provided certain tasks to be accomplished and the IOAG believes it has accomplished those tasks and would like guidance on future work.

The Chairman explained that the IOAG was created in 1999 as a result of IOP-1. It was concluded at IOP-1 that there should be a forum for multilateral cooperation and discussion between space agencies. The IOAG first focused on communication policies and has since evolved to include operations concepts and cooperation. It expects the IOP to provide guidance for the future of cross support, noting that in the future there will be many complex systems operating in the space exploration area where more cooperation between agencies is needed. The IOAG can discuss these challenges not just on the communications side, but on the operations side as well. Expectations of the IOP are to acknowledge what the IOAG has done, approve or disapprove of the results of those activities, endorse the IOAG's role as a forum, and provide feedback on relevant topics for the future.

Regarding the agenda, Mr. Younes noted that he has provided Mr. Liebrecht authority to approve the IOP-4 Communique on his behalf, since he will be unable to attend the last day of the IOP.

IOAG Overview: Chairman

IOAG Role

The Chairman reiterated that the IOAG provides a forum for identifying common needs across multiple international agencies for coordinating space communications policy, high-level procedures, technical interfaces, and other matters related to interoperability and space communications. It enables safe, secure, and efficient interoperable mission operations; enables higher rate throughput for science, Earth, and exploration missions; and provides responsive networks around the Earth, Moon, and Mars to enable future exploration and science missions. The IOAG was founded by the IOP to understand issues related to interagency interoperability and other space communications matters, identify common solutions complying with IOP guidance, and recommend resolutions to the IOP for specific actions created by the IOP and put on the IOAG.

IOP Role

The IOP scope includes providing guidance for interagency interoperability to enable cross-support and facilitating communication and mission operations for future complex space systems. The IOAG expectations from the IOP are to acknowledge achievements of the IOAG regarding the previous IOP related resolutions, acknowledge and endorse or amend the role of the IOAG, acknowledge and provide guidance (as relevant) regarding the future plans for cross support defined by the IOAG, and act as a forum at leadership level for discussion between agencies regarding operations related issues relevant to cross support. At the end of IOP-4, the IOAG would like an endorsement of its role and identification of new discussion topics.

Evolution of Participating Agencies

The member agencies that participated in IOP-3 were ASI, CNES, DLR, ESA, JAXA, and NASA. The observer agencies that participated in IOP-3 were CSA, KARI, and UKSA. The current IOAG

members are ASI, CNES, CSA, DLR, ESA, JAXA, and NASA. The current IOAG observers are CNSA, KARI, Roscosmos, SANSA, UAESA, and UKSA. The Chairman noted that since IOP-3, CSA has become an IOP member, SANSA and UAESA joined as observer agencies, CNSA has participated in some of the IOAG meetings, and ISRO was removed as a member and observer of the IOP due to lack of participation and responsiveness. The Chairman emphasized that SANSA was unavailable to participate in IOP-4, but is still an observer agency. Mr. Younes asked the Chairman whether attempts have been made to engage ISRO. The Chairman responded that contact was established, but was not successful in reengaging ISRO. Mr. Younes asked the IOAG to take an action to attempt to reengage ISRO and sensitize them to the value and importance of the IOP. ISRO will be going to the moon and beyond and is an important player in space. The Chairman acknowledged and accepted this action.

IOAG Context

The Chairman explained that from the IOAG, delegates define operations drivers together with technology drivers that go into standardization. The delegates also standardize interfaces and systems which allow agencies to provide cross support and enable interoperability. When agencies are developing infrastructure, this is greatly helping them to cooperate and develop interoperable frameworks that can support cooperative missions. In the next few years and future there will be an increasing number of cooperative missions and agencies will need the communications infrastructure in place to support those missions.

IOAG Organization Chart

The IOAG is organized into working groups in which the detailed work is accomplished. The IOAG as a whole meets in person once per year with additional scheduled teleconferences, but technical work is accomplished by the working groups independently. The Chairman provided a brief overview of the working groups and noted that the working groups will provide more detailed reports on their activities during the IOP.

IOAG Products

The IOAG generates and maintains the following products: annual reports, work plans, working group reports, service catalogues, a communications assets database, mission models (Earth, Moon, Mars and others), a cross support mission model, the IOAG-CCSDS product agreement, standards infusion status and plans, GNSS receiver payload database, and websites containing inputs for the IOAG and IOP meetings and teleconferences.

The Future Role of Agencies: Moderated by Phil Liebrecht

The Chairman began the leadership forum by identifying 3 topics to be addressed in the forum as a jumping off point for discussion. Mr. Liebrecht moderated the first topic, the future role of agencies. Mr. Liebrecht noted that commercial space is rapidly changing and will continue to

change in the next 10 to 15 years. At NASA, commercial companies are delivering cargo to the space station, a solicitation has been announced for commercial payload deliveries to the moon, and testing for commercial companies to provide transportation for astronauts is starting. The U.S. has issued a mandate to enable these enterprises and it is likely that this is the case for other IOP agencies. The question is how to enable a competitive, interoperable market for services. In the past, customers have primarily been agencies, but that is now changing, so the influence of emerging space operators on the user-provider relationship needs to be addressed and discussed. It would be helpful to think about how to clarify the future role of agencies to improve relationships with providers and enable commercial space enterprises.

Commercial tracking service providers are increasing and there is a rapid emergence of new space operators. However, their adoption of CCSDS standards is limited and many use proprietary interfaces. The problem with this is that in some cases agencies, commercial providers, and users will evolve to be compatible, but not in other cases. The potential for non-interoperable space operations systems between space agencies and commercial sectors include space communication links, ground operation systems, satellite mission operations, and others.

The first key question posed was "Would a common approach/interface to commercial providers enable a competitive marketplace for services?" Items to consider are standard technical interfaces/services (e.g. the adoption of Gateway interoperability standards), common service/contractual terms and conditions, and processes to resolve critical event conflicts perhaps resulting from differing views on priorities than agencies. The delegates should consider if this will enable or constrain commercial space and if feasible, how agencies and the IOAG should approach commerce. Most agencies have worked with their local industry, but it should be discussed if cooperation would be more effective if conducted globally. Mr. Younes added that seamless interoperability is a major aspect of this.

The second key question posed was "Given the agencies' role in leading development of new technology and standards, when is the optimal point for transfer to commerce? Should the emerging 'New Space' operators/service providers be involved in the coordination process? If so, how?"

Mr. Younes began by emphasizing that commercializing space is a key element in NASA's charter. The commercial sector is moving strongly into space and as we move into the future the two separate communities – government and commercial – will not operate independently, but play into each other and allow for more commonality and seamless interoperability between players. The agency and commercial markets are different and the agency market is small compared to the commercial, so agencies will need to approach the commercial sector. The burden will be on us to make sure our technology and capabilities can take advantage of commercial opportunities and services. However, the ability for an agency user to receive support from a

commercial entity will be limited by the footprint and type of services the commercial entity provides – they will differ from MEO to GEO and from fixed to mobile satellite service. Additionally, agencies and commercial entities also operate in two very different areas from a spectrum perspective, so there will be spectrum issues that will prevent one from jumping into the others' domain. So, the spectrum issue is a key challenge in addition to the ability of commercial satellites to track our users and be able to support them and their data in the short amount of time they're in their footprint.

NASA has pursued technology enabling us to be interoperable, such as capabilities allowing NASA to tune to commercial frequencies and additionally, optical communications to allow the agency to operate in a domain where spectrum is no longer an issue and above where the regulatory framework is governed. Pushing for this technology will allow us to operate without the burden of regulations. NASA is also starting initiatives to work with regulatory agencies to allow for some intersatellite operation and commercial spectrum, however, for us to go into commercial frequencies it may impact some of their ground operations and may not be welcomed by them. This has to be worked and addressed in the ITU to allow us to operate. So, we need to take advantage of this larger commercial market without being constrained to single provider, roam in space, and have seamless support from any provider. We need to have robustness in our operations an address challenges. The IOAG can help in moving this forward through establishing standards to allow interoperability not just between space agencies, but also to the commercial domain.

Mr. Younes recommended that the IOAG invite commercial entities to participate in IOAG standards activities and vice versa. He emphasized that agencies used to be the entities pushing technology forward, but the commercial sector is investing a lot of money in development, so agencies need to take advantage of that and extend into the commercial space environment.

Mr. Densing noted that the institutional market is very different from the commercial market, therefore there will be a crucial role for both commercial and institutional operators. In the agencies, there are highly specialized missions and they are often one of a kind where there is no business case for them. They involve flight dynamics and mission analytics to a different extent than what commercial entities can offer. The commercial operations area is mostly routine missions and earth observation.

He added that at ESOC, 70% of the work force is industry, so industry is a large part of what ESA is doing. However, industry also sometimes tries to compete against ESA. For the time being the commercial market should be left to industry and the institutional market should be left to the agencies. Mr. Densing furthered that as a matter of visibility, taxpayers finance the institutional market and deserve visibility. The funding that taxpayers are contributing is also used to drive innovation and de-risk technologies for commercial operators. Lastly, security is an issue that at some point needs discussion.

Dr. Dittus noted that private operations aren't anything new and we have learned a lot from companies, such as SES. The question is how to bring these companies into the market. The best way is through inviting companies, both large and small, to join in on joint ventures.

Ms. Mealing-Jones commented that there is a different philosophy in the UK – everything government does is alongside industry and commercial operators. Agencies have a convening role to not just look at this borderline between institutions, but to help commercial operators work together. She suggested using the next IOAG in the UK to invite commercial entities for a preliminary discussion. Co-creation and not having separation is important. Agencies need to recognize that we are not the biggest markets, but we do have a responsibility to push standards and interoperability. Closed discussions are valuable, but opening up to the commercial entities is a good idea.

Mr. Cosby recognized Mr. Younes' point on institutional markets and noted that this is true on 5G SATCOM. Commercial entities may do this by themselves and not pick up on what the agencies are doing, going on to exploit the moon commercially. It would be helpful to have information and feedback from them. If it is welcome from the group, something can be arranged in September in conjunction with the IOAG to hold a conversation with commercial companies. The Chairman asked whether this would be invited industry or public? Mr. Cosby responded that if 5G SATCOM companies are separated and the IOAG focuses on deep space or lunar companies, then there are only a few number of companies that are providers, so it would be a small listed of invited companies. It is also possible to make it public, but that is up to the group. Mr. Cosby noted that he believes it would be sensible to target individual companies.

Mr. Vasiliy noted that 3 years ago, Roscosmos modified its structure for present needs. Roscosmos is not only an agency, it's an enterprise with combined governmental functions and functions of commercial cooperation. There are regulatory mechanisms that allow for a fully competitive environment in the Russian Federation. In this case, it is agreed that there is a need for standards and procedures for agreements on a high level. For example, sometimes 3 Russian enterprises on the same project have different conditions, which is surprising because foreign experts communicate and share information. Now we are trying to have common standards for all enterprises for commercial contracts and make recommendations for what provisions should be included in any commercial contract (e.g. foreign expert visits, tech transfer, and intellectual property). In the next few years, standards should be adopted by all companies operating with Roscosmos and for all foreign projects. For international missions, Roscosmos is working in the technical and legal committees in COPUOS. Technical and legal points of view are needed, not just political and diplomatic points of view. It is often difficult to participate with foreign colleagues on the legal and technical subcommittees because there are legal aspects when talking about projects and proposals. Roscosmos has found that politicians and those from government

entities provide the agency with a point of view that is very different from those that Roscosmos has, and that is why we are developing interoperability standards – to be in line with policy and technical ability.

Mr. Younes followed up on Mr. Cosby's comments. The idea of inviting commercial entities for discussion is very appealing, because the space community should not be operating independently. It needs to bring others in and we need to go to them. He requested that the IOAG provide recommendations on what entities to pursue. Mr. Younes noted that the IOAG can't invite single providers, because they are all competing among themselves. Regarding the information that commercial entities hold as proprietary, there are things that agencies can do, especially if we can align with commercial and establish standards to operate from a larger 5G market.

Mr. Alrais noted that UAESA is supported by the government, but the agency is now moving towards engaging industry and universities. It now has the space laws and policies in place to enable more engagement of the new space industry. He also emphasized the importance of approaching and engaging new space at an early stage to adopt standards, as well as engaging commercial and agency customers.

Mr. Pradeilles stressed that cooperation between public and private entities is very important and it should be emphasized to commercial entities that standardization is a way to remain a critical mass in the market. However, to use standardization as a lever for private companies, we have to be efficient in the way that we standardize, because otherwise industry will do it without us and agencies will have to follow their standards. There is a balance that has to be found in order to be efficient.

Mr. Yong added that agencies should continue to support tech development and improve their capacity to support common missions, especially those that are risky. They should also encourage the effective utilization of resources. He supported UKSA's proposal for discussion with industry and noted that this is a good way to explore commercial services for future operations. The IOAG and agencies should encourage commercial space enterprises to provide service not only to companies and universities, but also to national missions. As a national entity, CNSA sometimes has to formulate regulations to guide commercial activities. The IOAG could provide advice on regulations to influence national regulations.

Mr. Tachi noted that in Japan, the commercial market is still small, but he supports the proposed bridge between international and commercial entities to discuss interoperability and encourage standardization.

Mr. Liebrecht concluded the discussion by asking the delegates if they support the UKSA's proposal to engage industry at IOAG-23. Mr. Younes responded that NASA supports this proposal,

but it needs to be discussed further who will be invited. He proposed sending invitations for the first discussion and perhaps opening it up more in the future. Mr. Densing disagreed and expressed his view that agencies and industry don't mix well. There are routine commercial operations and agencies have one-of-a-kind operations. He is reluctant to extend the IOAG, but agrees that there should be interfaces to industry. Mr. Cosby agreed with Mr. Younes to start off small and slowly extend discussion with industry. Mr. Younes responded to Mr. Densing that he has no problem keeping the two separate, but there needs to be focus on industry groups for standards. The two groups can be infused gently. Mr. Liebrecht proposed for the IOAG to work with CCSDS on how to engage industry. Mr. Younes added that in the meantime, the IOAG should discuss common objectives and form a clear plan for forward work.

Future Trends and the Evolution of Agencies: Moderated by Klaus-Juergen Schulz

Mr. Schulz introduced the topic of future trends and the evolution of agencies by suggesting the delegates consider and discuss the science and exploration trends and technologies that will drive missions and infrastructure evolution, trends of the agencies regarding key technologies and opportunities for interoperability, and the future technology opportunities that agencies should be investigating.

The first key question Mr. Schulz posed to the delegates was "What will be the new driving mission and operations concepts that will benefit from coordinated technology and standards insertion?" Various applications would include constellations of 10s, 100s, or 1000s of small satellites; larger and more collaborative missions; more complex human and robotic interaction; increasing automation and autonomy; humans in other planetary systems including precision EDL; and complex rendezvous and sample return.

The second question was "What are the key standards and technologies we should be inserting in the next ten years?" Examples of this include, higher frequency bands (e.g. 26 GHz and optical communications), space internetworking, collaborative mission operations systems, and improved PNT (especially in situ).

The third question posed was "What are the technologies we should be studying for insertion beyond ten years?"

Mr. Densing asked the delegates to consider what should be brought to future missions proactively. We are at a point today where we have self-driving cars and yet to operate a handful of missions at ESOC it takes 900 people. From an efficiency point of view, there is a lot of room for improvement and as satellites become a commodity in the commercial market, platforms may be a commodity, then operations will have to become more of a commodity as well. The rate of efficiency may be augmented reality, artificial intelligence, automation, or machine learning. Another thing we may go to is automated collision avoidance. It's a challenge of a different magnitude in space than on the streets, but collisions could impact all of us. One day, space may

be unusable. Today, we have 400,000 objects in space and a lot aren't operational. The number of objects in space is rapidly increasing.

Mr. Younes seconded the notion about automation and efficiency. In order to do that, there needs to be higher data rates. NASA is undertaking initiatives to increase efficiency, especially with the Deep Space Network. A single station can now remotely operate the other two stations during the day and NASA is also transitioning from one link per operator to three links per operator in order to maintain a healthy set of standards with customers. In the future, we see phased array Ka-band and optical to be the main engines. In the years 2020-2030 everything will primarily rely on optical communication, so aligned with that began the investigation of quantum networking and building tech that will allow us to transition to a quantum network as soon as we have the optical capability in place. NASA is looking at the prospect of more adaptive networking in space and evolving cognitive technology is allowing us to do so. NASA is pursuing types of cognitive capabilities allowing for more adaptive routing in space and reconfiguring radios to frequencies and waveforms required for particular providers.

Mr. Younes furthered that among these technologies, the key technology that needs to be focused on is optical, because without optical, we can't move beyond to other things such as quantum. He noted that he would like to see work going into quantum parallel to what is occurring with optical. Activities around the Moon will require PPM and we have already finalized that. Mr. Younes expressed interest in a concept for a deployable network of smallsats that can be deployed on demand in any planetary environment to provide communications and navigation support at a high data rate. This should be pursued as interoperable technology to be worked for the future.

In addition, in order for agencies to be interoperable with commercial entities and overcome regulatory burdens, we need to make sure radios can conform to not only different waveforms, but frequencies. NASA is working on wideband radios to allow them to operate across a large bandwidth to have flexibility for different providers in space.

Dr. Dittus noted that the key problem is secure transfer. Quantum key distribution is a very complicated technology and it can't be adopted in the next ten years. Cybersecurity of satellites and control centers will become more intensified and the key question to address is how secure satellite communications is. Mr. Younes clarified that he was referring to quantum networking, not quantum key distribution. Quantum networking and unlimited bandwidth to all users is the focus. NASA is currently working on this in DTN protocol and security protocol within DTN and he would like to see DTN implemented on all future platforms and missions, as well as the security element completed and implemented by 2023-2025.

Mr. Tachi noted that JAXA is looking at an optical downlink in response to growing data rates.

Mr. Vasiliy agreed with NASA on the need for new technology for data transfer and stronger encryption systems. He added that at the same time, there needs to be a way to transmit data in spite of interference (and natural interference) for long distance space missions. There are two

ways we could increase the amount of channels: increase frequencies or apply other kinds of technologies. Support points for data transmission and vulnerability should also be addressed.

Mr. Vasiliy also noted that technology should be improved for proximity operations and rendezvous to avoid collision and increase preciseness. To be discussed further in the STM topic, to manage traffic we need information on objects and behavior, events in space, operations on space debris removal, a comprehensive database, improvement of registration, and exchanging data on objects in space.

Mr. Younes concluded the discussion by emphasizing that it is critical for future operations that software defined radios and portability of waveforms is addressed. NASA has conducted testing with ESA on board the space station and he suggested more of this testing in the future for software defined radios.

Space Traffic Management: Moderated by Jean Marc Soula

Mr. Soula noted that there is a rapid increase in spacecraft and potential debris from new projects, initiatives, industries, and agencies as well as different utilizations of space. Examples include constellations of thousands of commercial LEO spacecraft; an explosion of cubesats from academia, industry, and agencies; and an increase in commercial space launch and missions.

There is interest growing on space traffic management and initiatives to address this at a high level with space policy and discussions at the international level. One example of this is U.S. Space Policy Directive-3. The NASA roles in this directive are similar to IOAG, SFCG, CCSDS, and ICG roles.

From an IOAG point of view, the question is "Do we efficiently manage space traffic across the globe in agencies, industry, and academia?" Mr. Soula suggested speaking about the risk this community of satellite operators have for sustainability, security, and threats to activities as well as who takes care of these threats. It is important to verify the understanding of what needs to be managed and possibly regulated. Spectrum is addressed in the WRC, but Mr. Soula suggested the delegates discuss whether all the issues satellite operators are concerned about are addressed. The rules and limitations aren't the same for all the orbit regimes. In addition, debris, space weather, re-entries, and in-orbit servicing should be addressed and determined whether these topics and others are under the risks agencies have to sustain operations. The delegates should also discuss the definition of traffic management and whether delegates share the same understanding of what other risks there are and who addresses those risks. Some aspects are well controlled, while in others improvements may be needed. There are many individual initiatives to solve some of these issues, but is everything covered? This topic is not strictly in the IOAG charter, but is this something the IOAG should be concerned about?

The key questions for the delegates to consider are: Which areas need to be managed and possibly regulated? Are all areas covered adequately today, and if not, what areas could be improved? Should the IOAG have an enabling and/or liaison role in space traffic management, and if so, what? The organization that will manage space traffic in the future could help identify the risk, put more clear definitions on the threats, and have a panorama of what the initiatives are today concerning these different threats.

Mr. Vasiliy noted that there are certain guidelines adopted by COPUOS that include recommendations for space actors on how to manage space collisions among other things. In general, we still don't have any complex understanding of what traffic management means. For the first time, it was presented in the technical subcommittee 3 years ago by DLR as part of global space governance and the subcommittee managed to make a decision on standards which include the point of view of all space-faring nations. As a part of the scientific and technical solutions, the subcommittee would like experts to present at the next meeting in Vienna in February/April of 2019. The Germans had made a proposal to create a special working group in COPUOS on space traffic management to answer questions: What does it mean? What does it concern? What kind of missions should it cover? Because STM is so general, there is currently a lot of contradiction between delegations during discussion. There is new legislation from the U.S. but we still have gaps at the international level on applying international mechanisms different from national legislation. It is difficult to change national legislation, because those are legally binding mechanisms. If the international community adopts a special regime for traffic management, then legislation has to be changed at the national level, which is why we are proposing this is the right time to discuss this issue on an international level. If we receive national regulations, it would be very difficult to bring them together later at the international level. Mr. Vasiliy proposed that this question of what should be included in traffic management policies be distributed to agencies and operators.

Mr. Younes commented that NASA sees the environment getting more complex and the U.S. recently recognized that there needs to be traffic management. The U.S. has a space policy that asked the agencies to study traffic management. NASA will have a large role with coordinating with other agencies to scope out the problem and come up with regulations and policies. It will report to the IOAG on any progress that's made. Mr. Younes emphasized that the capabilities to regulate will be so tremendous that no existing international body can do it. Regulation will be based on the good will of member states, because if there is a collision everyone will be hurt and the space environment belongs to the global community. From the NASA perspective it will study this and we invite everyone else to do it in their own agency so agencies can then compare notes on regulations. This is already done to a large extent from a frequency perspective at the ITU. Because the issue is so complex, we are not setting up anything until we understand the scope of the problem.

The Chairman responded that it is not his suggestion that IOAG becomes the regulatory body, but could contribute to other regulatory bodies.

Mr. Younes noted that he agrees that he does not look at the IOAG as a managing or regulatory body, but as a coordinating body that translates into work to be distributed among participating groups and providing synchronization of activities.

Dr. Dittus added that the IOP is not a group that can regulate, but on other side, we have regulations that aren't implemented in a legal framework. The IOAG can only give recommendations that something should be adapted, so a country isn't drawn into a legal framework that hasn't been negotiated. There are both legal and technical problems and it should be discussed how it can be treated from a technical point of view, because the legal framework is a matter for individual governments.

Mr. Younes responded that there has been recognition by the U.S. government that space traffic management is going to be a serious issue. Because of the probability of accidents is increasing, we are doing something about it at the national level and coming out with findings that can be discussed at the international level.

Mr. Vasiliy recommended that an assessment by governmental bodies include the definition of STM, what is needed to solve the problem, what kind of assets and resources are needed to face this problem, and which items should be discussed internationally. Because of the increasing number of satellites in constellations, agencies need to be able to combine abilities and facilities as well as establish procedures for distributing information. The recommendations should be useful for space agencies and government bodies of every state to bring their attention to this problem. In the next ten years, there will be huge constellations, so it is necessary to solve the problem of debris removal and STM.

Mr. Yong furthered that this is a very complex process and agreed with Dr. Dittus that the IOAG should try to establish principles to guide activities, but there can only be recommendations at the most – not legal framework. He also asked if any agencies or organizations had verified the results of a US report on the possibility of collision.

Mr. Vasiliy commented that regarding controlled reentry, there are established links between foreign ministers and an established special connection between Roscosmos and NASA. There are also established communications with governments of most states whose territory could be affected during reentry. The problem with this is that sometimes members of those governments react in a different manner, because they are politicians, not technical. We need these types of procedures, but there are a lot of issues for global governance.

The Chairman concluded the Leadership Forum by noting that there can be further discussion on the aforementioned points and topics during the IOP.

Appendix A: Actions

AI 4-01: Contact ISRO to reengage them in the IOAG and IOP. [Assigned to: NASA. Due date: 5 April 2019]

Appendix B: Acronyms

ASI	Italian Space Agency
CCSDS	Consultative Committee for Space Data Systems
CNES	Centre National d'Etudes Spatiales
CNSA	China National Space Administration
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
CSA	Canadian Space Agency
DLR	German Space Agency
DTN	Disruption Tolerant Networking
EDL	Entry, Descent, and Landing
ESA	European Space Agency
ESOC	European Space Operations Centre
GEO	Geosynchronous Orbit
GNSS	Global Navigation Satellite System
GSOC	German Space Operations Center
ICG	International Committee on GNSS
IOAG	Interagency Operations Advisory Group
IOP	Interoperability Plenary
ISRO	Indian Space Research Organisation
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
KARI	Korean Aerospace Research Institute

LEO	Low Earth Orbit
MEO	Medium Earth Orbit
NASA	National Aeronautics and Space Administration
PNT	Positioning, Navigation, and Timing
PPM	Pulse-Position Modulation
SANSA	South African National Space Agency
SATCOM	Satellite Communications
SFCG	Space Frequency Coordination Group
STM	Space Traffic Management
UAESA	United Arab Emirates Space Agency
UKSA	United Kingdom Space Agency
WRC	World Radiocommunication Conference