INTERAGENCY OPERATIONS ADVISORY GROUP

Work Plan 2018

Prepared by: Michael Schmidt, Chair

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1 Introduction

The overall scope of the Interagency Operations Advisory Group (IOAG) is to undertake activities to establish a multi-agency coordination related to space cross support and space communications. A specific IOAG goal is the achievement of full interoperability among member space agencies.

To achieve these goals, some permanent objectives are defined in the IOAG Terms of Reference. The Inter-Operability Plenary (IOP) has also assigned specific objectives, as described in Section 2.

The Work Plan details the IOAG work objectives for 2018 and defines an associated implementation plan. The higher-level objectives for the next several years are also identified to highlight the need for continuity in some tasks or new activities that need to be initiated. It is anticipated that the IOAG Work Plan will be updated on an annual basis to remain up-to-date and provide more details on the medium-term objectives and implementation schedules.

The IOAG Work Plan 2018 responds to three overarching strategic objectives:

- Establish or enhance all elements of the IOAG organization required to achieve its role as the premier international focal point for matters related to cross support in the space communication and navigation domain.
- Continue effective and value added use of the IOAG in 2018 with achievements that foster the goals of IOAG and are of mutual benefit to the participating Agencies and interfacing organizations.
- Increase the visibility of IOAG by communicating its existence and purpose to relevant international groups and organizations and increase the stakeholder community.

2 Objectives

The objectives of IOAG are defined in its Terms of Reference (TOR) and are also driven by the IOP-2 and IOP-3 communiqués. Annex-1 includes a detailed description of the IOAG objectives.

The IOAG work for 2018 has been classified into four activity lines: (i) core tasks (section 3); (ii) tasks performed in collaborations with other existing international groups/organizations (section 4); (iii) improvement of IOAG internal processes (section 5); and (iv) reporting activities (section 6).

Annex-2 includes detailed definitions of the following: task; activity identification; implementation approach; expected outcomes for tasks for the year 2018; and, as applicable, continuation as follow-up tasks.

Annex-3 includes an overview of the participation by the IOAG agencies to the activities herein.

3 Overview of Activities in 2018

This section provides an overview of the main activities / actions relevant to 2018. Apart from the maintenance of the mission models and communications assets database the work concentrates on the interfaces to some specific organisations and the running of some working groups.

One task that is relevant to all WGs is the preparation of the IOP-4, which is planned for 2018. The execution of the IOP-4 is to be supported as required.

3.1 Interface to International Space Exploration Coordination Group (ISECG)

- ✓ A regular contact between the chairmen of IOAG and of the ISECG Architecture Working Group (WG) is to be maintained, leading to an exchange of up-to-date information.
- ✓ The IOAG is to follow the evolution of the ISECG Global Exploration Roadmap (GER) and to support the areas, which are of relevance to the IOAG.
- ✓ IOAG will follow closely the evolution of the upcoming Moon / Mars missions to identify the communication needs and the corresponding standards.

- ✓ The ISECG is to involve or consult the IOAG in areas related to communications cross-support, in particular concerning items for which standardisation might be required.
- ✓ The IOAG will be involved in the definition of the Lunar Communication Scenario by defining a relevant communications architecture.
- ✓ The IOAG Secretariat is to keep track of the interactions.

3.2 Interface to Consultative Committee for Space Data Systems (CCSDS)

- ✓ The CCSDS Liaison[1] is to regularly participate in the IOAG teleconferences and meetings and to report about the progress in CCSDS.
- ✓ The communication mechanism between the two organisations is the IOAG-CCSDS Product Agreement (ICPA), which is to be populated / prioritized by the IOAG delegates and be maintained by G.P. Calzolari / J. M. Soula and the counterpart from CCSDS.
- ✓ In addition the IOAG Chairman / Secretariat are to send IOAG progress reports to CCSDS, as required.
- ✓ The priorities defined by IOAG ("Top 10"[2] and ICPA priorities) are to be updated as required.
- ✓ The IOAG is to maintain the Service Catalogues 1 and 2 (SC#1 and SC#2).
- ✓ The IOAG is to prepare the Service Catalogue 3 (SC#3) in consultation with the corresponding WG within CCSDS.

3.3 Interface to Space Frequency Coordination Group (SFCG)

- ✓ The IOAG agency delegates are to encourage their frequency managers to continue early mission's coordination via SFCG and to participate to the International Telecommunications Union (ITU) meetings in support of the SFCG objectives. The focus is currently on the protection of crucial frequency bands for high data rate downlinks, e.g., 26 GHz, 32 GHz, and 37 GHz.
- ✓ The SFCG Liaison is to regularly participate in the IOAG teleconferences and meetings and to notify the IOAG about critical items.
- ✓ The IOAG mission model and asset database is to be made available to SFCG.

3.4 Interface to the International Committee on Global Navigation Satellite Systems (GNSS) (ICG)

- ✓ The IOAG agency delegates are to collect relevant information (space user performance needs for their GNSS constellations and on-board GNSS related characteristics) and provide the information to the IOAG Secretariat for inclusion into the corresponding database.
- ✓ The IOAG is to maintain the database with relevant information concerning on-board GNSS functions and equipment and will make it available to ICG.
- ✓ The IOAG Chairman is to maintain the contact with the ICG, either by directly participating in the relevant meetings or by coordinating the activities via the Liaison (J.J. Miller).

3.5 Low Earth Orbit (LEO) 26 GHz SG[3]

- ✓ The IOAG agency delegates are to promote the utilization of the 26 GHz band Earth Exploration Satellite (EES) services for LEO missions in their agencies that require very high data rates or that have concerns about congested bands.
- ✓ The IOAG delegates should report back to the IOAG on the progress and findings of their implementations.
- ✓ The IOAG delegates are to collect relevant information on the propagation effects and to report back to the IOAG.

[1] IOAG was informed by the CMC during IOAG-21 that the CCSDS Liaison will change from Nestor Peccia (ESA) to James Afarin (NASA).
[2] The "Top 10" identify the issues that have some priority for the IOAG. They do not only address topics that are relevant to the interface to the CCSDS but effect the overall IOAG activities.
[3] The 32 GHz aspect needs to be addressed by the IOAG but will not be dealt with by this 26 GHz WG.

- ✓ The WG should review lessons learned and define recommendations concerning the harmonisation of the relevant systems developed and implemented by the various agencies.
- ✓ The WG should also follow the evolution, with focus on the technology, of this 26 GHz frequency band for other mission types, e.g. by keeping an inventory for SR(DS) services to the Moon and planetary missions.

3.6 Mission Operations Systems Strategy Group (MOSSG)

- ✓ The MOSSG is to monitor the progress of the corresponding CCSDS WG to help inform MOSSG activities.
- ✓ The MOSSG is to update the study report, "Recommendations on a Strategy for Mission Operations System Interoperability" and submit the Service Catalogue #3 for IOAG review and approval.
- ✓ The MOSSG is to conclude its currently assigned activities with a presentation to the IOP-4.

3.7 Optical Links Study Group (OLSG)

- ✓ The IOAG delegates are to record lessons learned from the cooperation between the member agencies regarding the demonstrators, the studies on propagation effects and in general, the development of optical link communications.
- ✓ The OLSG is in principle inactive but the chairmen of the OLSG are to follow the evolution of the optical communications within the various agencies and to provide relevant feedback to the IOAG.
- ✓ The OLSG is to follow the evolution of the corresponding books that will be developed by the relevant CCSDS WG.
- ✓ The IOAG is to keep track of the evolution of the optical link communications and to report back to the IOP-4.

3.8 Space Internetworking Study Group (SISG)

- ✓ The IOAG delegates are to promote the Space Internetworking concept within their agencies.
- ✓ The SISG is basically inactive but the IOAG delegates are to record lessons learned from the cooperation between the member agencies regarding the demonstrators and the development of space internetworking communications and to provide feedback to the IOAG.
- ✓ The IOAG is to keep track of the evolution of the space internetworking and to report back to the IOP-4.

3.9 Spacecraft Emergency Cross Support Working Group (SECSWG)

- ✓ The SECSWG is to regularly interact in order to establish a common, standard process, agreed upon by the IOAG member agencies, for providing spacecraft emergency cross support.
- ✓ The IOAG delegates are to discuss the recommended guidelines within their agencies so that a common policy can be established by the IOAG that governs emergency cross support.
- ✓ The SECSWG is to execute the second phase, which consists primarily of the verification of the agreed principles using one or two selected test missions.
- ✓ The IOAG is to report back the status of the cross-support and the results of the test missions to the IOP-4.

3.10 Coding & Modulation Working Group (CMWG)

- ✓ The CMWG has basically finished its work by issuing a report and is now in a dormant status. The report will be updated in the future if required.
- ✓ The CMWG is to be kept alive to provide a forum for discussions if required.

3.11 Service Catalogue Working Group SCWG

- ✓ The SCWG is, in principle, in charge of supporting the interface to the CCSDS by maintaining the Service Catalogues SC#1 and SC#2 and to update the ICPA as required.
- ✓ The chairs are J.M. Soula and G.P. Calzolari for 2018. They will form the core of the Service Catalogue WG (SCWG), which will also comprise other representatives from various agencies.
- ✓ The WG is to collect inputs for updates of the existing service catalogues to propose recommendations for updates and to discuss them with the corresponding CCSDS groups.

- ✓ The WG is to collect requirements for new services, which can result in the creation of new service catalogues if considered appropriate.
- ✓ The WG is to prepare revisions of the existing service catalogues.
- ✓ The WG is to maintain the standards / services infusion tables including the identification of their priorities.

3.12 Lunar & Mars Mission Working Group (LMWG)

- ✓ The LMWG has finished its tasks by providing the Lunar and Mars mission database.
- ✓ The Lunar and Mars mission database will be updated with new information in preparation of the IOP-4 by the LCAWG.
- ✓ The follow-on tasks regarding the communications scenario for Moon missions will be executed by the Lunar Communication Architecture WG (LCAWG).

3.13 Lunar Communications Architecture Working Group (LCAWG)

- ✓ The LCAWG is to prepare a communications architecture relevant to the Moon Mission scenario in line with the Global Exploration Roadmap defined by the ISECG.
- ✓ The LCAWG is to interact with the corresponding sub-group of the ISECG to coordinate the activities.
- ✓ The LCAWG is to generate a report and a reference architecture.
- ✓ The IOAG is to report the outcome of this activity to the IOP-4.

4 Core Tasks

IOAG tasks are classified as core tasks, which form the basis of the IOAG activities.

Seven core tasks have been identified for 2018:

- Core 15.1 = Improvement of completeness, accuracy and visibility of the IOAG Mission Model, Cross Support Mission Model, Communication Assets Database, GNSS Payloads Database.
- Core 15.2 = Maintain the Standards Infusion Status, the Service Catalogues, the ICPA and the Coding & Modulation, as required.
- Core 15.3 = Follow-on of the evolution of previous WGs, i.e., Solar System Internetworking Infrastructure, Optical Communications.
- Core 15.4 = Follow-on of the evolution of Ka-band (26) mainly in the domain of LEO satellites.
- Core 15.5 = Follow-on of the evolution of the Mission Operations domain.
- Core 15.6 = Follow-on of the definition of Emergency Cross-Support.
- Core 15.7 = Definition of a communications architecture for the upcoming Moon missions.

The Core Task 15.1 requires contributions and updates from all Members of IOAG. Not all agencies have provided the relevant inputs in a timely manner in the past years. A reminder about the content of these tables has been sent also to the new member agencies.

Though some of the WGs have in principle completed the allocated tasks it has been agreed to keep them alive at a low level or to reactivate them as necessary in order to have a forum to exchange information and to follow the corresponding evolution. This is, in particular, of importance with respect to the preparation of the IOP-4, which is planned in 2018.

The IOAG TOR and Procedures Manual have been revised in 2015 and do not require further updates at this stage.

5 Tasks in Collaboration with Other Organizations

The interface of IOAG with existing groups, as directed by the IOP-3, will be primarily to coordinate space communications and navigation aspects, and to ensure the consistency of the tasks conducted by the multiple communities.

Four strategic interfaces have been identified for 2018:

- Liaison 15.1 = Continuation and improvement of the relationship with the ISECG to assess their requirements in the domain of Space Communications and Navigation and to provide recommendations in particular regarding a communications architecture for the upcoming Moon missions.
- Liaison 15.2 = Continuation and improvement of the existing liaison with the CCSDS to convey the requirements from the IOAG and the users' communities in a timely manner relative to the domain of the standards for Space Communications and Navigation, and to clarify interfaces between IOAG and CCSDS.
- Liaison 15.3 = Continuation and improvement of the existing liaison with the SFCG to convey the requirements from the IOAG and the users' communities in a timely manner relative to the domain of the frequencies and spectrum for Space Communications and Navigation.
- Liaison 15.4 = Definition and implementation of a liaison with the ICG to exchange between both parties requirements and information in the domain of Space Communications and Navigation.

6 Initiatives for Improvement of IOAG Processes

In many areas of IOAG activities, the flow of information within the IOAG with external organizations of interest and with the agencies or their partners is critical with respect to the overall outreach and efficiency of the organization. This includes also managing the interface to the organization maintaining the SANA database to ensure the consistency of the IOAG data. The special tasks assigned to the Secretariat for improvement of the tools and methods used in the various procedures of the IOAG and for better outreach on the IOAG achievements and recommendations are identified as "Process 15.1" in Annex-2.

7 Reporting Activities

The year 2018 will focus on the preparation of the IOP-4. Some WGs should finalize their activities (e.g. MOSSG, SECSWG and LCAWG) and report their progress and findings to the IOP-4. The co-Chairmen of the various WGs are to report back on their progress to the IOAG and coordinate the inputs for the IOP-4. There should be a regular exchange of reports with the liaison organization. This concerns in particular the interface to the CCSDS to consolidate standards. It is expected that the heads of delegation will report back to their corresponding agency management regarding the implementation the progress achieved by the IOAG.

The Chairman will develop, with support from the Secretariat, an Annual Report that will summarize the activities and achievements. The Annual Report will include inputs from all participating Agencies and Working Groups to report on the implementation of activities in the 2018 Work Plan.

The Annual Report will be posted on the public IOAG website (https://www.**ioag**.org) no later than January 2019.

The IOAG is to report to the IOP-4 the results of the WG's created in the context of IOP-3. In addition, the IOAG Chair will, in cooperation with the delegates, make proposals for the future activities regarding cross-support.

ANNEX-1: OBJECTIVES

According to the TOR, areas for consideration for the IOAG objectives and activities include:

ToR (a) Identifying the space and ground networks support capabilities needed by potential cooperative programs and projects to achieve their scientific objectives.

ToR (b) Maintaining a list of interoperable facilities and services operated by the space agencies.

ToR (c) Promoting the use of internationally recognized standards in the design and implementation of cooperative flight programs including: spacecraft, ground and space networks.

ToR (d) Monitoring the work of relevant standards organizations and assisting in the agreement, adoption and implementation of new standards by space agencies.

ToR (e) Identifying inconsistencies in the data transmission, capture, handling, and processing systems used by agencies. The IOAG should inform relevant standards organizations (such as the CCSDS or the SFCG) of these inconsistencies, using methods described in the IOAG Procedures Manuals, as well as IOP Members, inviting them to undertake the development of new international standards.

ToR (f) Establishing priorities for the implementation of systems and services needed to achieve full Inter-Operability and enunciating policies furthering Inter-Operability. Such priorities should be passed to relevant organizations and to the IOP Delegations.

ToR (g) Assessing the resources needed to implement these requirements and urging IOP Delegations to make these resources available within their agencies.

ToR (h) Defining and maintaining a reference architecture that will enable Inter-Operability and cross support across space agencies.

ToR (i) Encouraging the distribution of communication and navigation techniques to accelerate the deployment of interoperable solutions.

At the 3rd Inter-Operability Plenary meeting (IOP-3), held in Toulouse in June 2013 several resolutions were adopted, which can be summarized as follows:

- The IOP endorses the role of the IOAG as a focal point regarding the communications related cross-support of the participating space agencies.
- The IOP requests the IOAG to maintain the close interaction with the various international coordination groups (CCSDS, SFCG, ISECQ and ICG).
- The IOP encouraged the IOAG to establish contact with other space agencies and to foster the achievements.

The above resolutions mean that the IOAG delegates are to promote the achievements of the IOAG and that the IOAG chairman should try to expand the participation to the IOAG activities.

ANNEX-2: TASK DEFINITIONS

WP-Core-15.1: Improvement of completeness, accuracy and visibility of the IOAG Mission Model, Cross Support Mission Model, Communication Assets Database, GNSS Payloads Database.

Definition:	The IOAG Mission Model, the IOAG Cross Support Mission Models, the Communication Assets and the GNSS tables list need to be maintained up to date. A table with Communication Assets including items belonging to non-IOAG members was established in 2012 and need to be maintained up to date.
Activities :	1. Continue to collect the inputs from the IOAG Members to fill the IOAG tables with information pertaining to assets and missions of their Agencies. 2. Continue to collect the inputs to fill the IOAG tables with information pertaining to assets and missions of commercial providers. 3. Keep the above elements up to date on the website and in the SANA database.
Implementation:	The IOAG Secretariat is responsible for collecting the inputs from the Agencies. The Secretariat is also in charge of managing these elements and their subsequent updates on the website. This will be coordinated via email with the objective to have all information available on the website at IOAG-22 (3rd Quarter 2018). The SANA database will be used to store the provided data and to ensure an appropriate configuration control. The Heads of Delegations will ensure that the information required to fill these tables is provided in due time by their Agency. They will provide updates as required so that the information on the web pages is always current.
Expected Outcomes:	1. Current and complete IOAG tables and graphics available on the public website. 2. A Communication assets table with some inputs from commercial providers available on the private web site. 3. A database that collects relevant GNSS related data that can be provided to the ICG. 4. A SANA database that is up-to-date with the relevant data.
Next steps:	The cross support services are mainly those required by the current point-to-point and simple multipoint internetworking cross support scenarios. To keep the tables up to date is a collective permanent action of the IOAG delegates, under coordination by the secretariat. It will be a pre-requisite for the new members to provide the information related to their agency before they are formally admitted to IOAG and for the members to maintain their membership status.

WP-Core-15.2: Maintain the Standards Infusion Status, the Service Catalogues, the ICPA and the Coding & Modulation as required.

Definition:	There is a need to clearly point out the services and supporting standards agreed upon by the IOAG Member Agencies. Such services and standards must be known and their infusion status must be provided by all Member Agencies: This refers to the 2010 Service Catalog #1 and the 2011 Service Catalog #2, which was updated in 2017. Those references serve for the evaluation of the agencies' infusion plans. This core activity comprises also the maintenance of the ICPA and the update of the Coding & Modulation list as required.
Activities :	1. Synthesize the inputs from the IOAG Members in the table showing the infusion status and plans of the recommended standards, and derive the information required to populate the IOAG-CCSDS Product Agreement (ICPA). 2. Maintain the Service Catalogues based on the evolution of the services incl. new services and in close cooperation with the relevant CCSDS working groups. 3. Keep the above elements up to date on the website.
Implementation:	The two IOAG responsibles for the ICPA (J.M. Soula and G.P. Calzolari) shall maintain the Infusion Tables based on the information provided by the agencies. They shall also maintain the ICPA in close cooperation with the counterpart at CCSDS. In addition they shall maintain the two Service Catalogues 1 & 2 with the support of the SCWG. The update of the list of the Coding & Modulation recommendation shall be performed if required. The corresponding experts are to be involved as needed.
Expected Outcomes:	1. A report on infusion status and plans that may be used to populate the IPCA in interface with CCSDS. 2. Updates of the Service Catalogues reflecting the evolution of the relevant services. 3. An update of the list of Coding & Modulation recommendations if considered necessary.
Next steps:	The various products that govern the interface between IOAG and CCSDS need to be regularly maintained considering the evolution within the CCSDS and changed needs identified by the IOAG. A check should be performed concerning the evolution of Coding & Modulation in 2018 in preparation for the IOP-4.

WP-Core-15.3: Follow-on of the definition of a Solar System Internetworking Infrastructure, Optical Communications

Definition	During the IOP-3 the results of the SISG were presented. The main outcomes were an Operations Concept and a draft consolidated architecture. The outputs were taken into account by the CCSDS for the work of the corresponding WGs. It is agreed to keep the SISG group formally alive in order to have a forum to exchange information and to follow the evolution of the SSI if required. A similar arrangement has been agreed for the WG on Optical Communications. It also has concluded its work with a report that was passed to the CCSDS for consideration. Also this WG will be formally kept alive to have a forum to exchange information, to follow the work of the CCSDS and to prepare the report to the IOP-4.
Activities	1. to exchange information on the progress of the evolution of the Space Internetwork and the optical links; 2. to follow the optical link experiments and their outcome; 3. to follow the implementation of relevant standards in the CCSDS; 4. to report back to the IOAG as relevant; 5. to report to the IOP-4.
Implementation	Neither the SISG not the OLSG will regularly meet in 2018. The activities are mainly performed by the implementing agencies and by CCSDS developing the relevant standards. The IOAG only has a monitoring role. The key members of the previous WGs will exchange information on the progress of the evolution of the SSI or the optical communications as needed and to verify that the IOAG recommendations are properly considered by the implementing organizations. In addition it might be necessary to start preparing the report for the IOP-4.
Expected Outcomes	Regular reports to IOAG as relevant.
Next steps	The CCSDS will work on the corresponding standards and the concerned agencies will implement the SSI and optical link communications considering the various standards and concepts. The IOAG is to follow the evolution and to check that the agreed IOAG recommendations are considered. Besides the IOAG is to compile a report that will be provided to the IOP-4.

6.

WP-Core-15.4: Follow of the evolution of Ka band (26 GHz) in the domain of LEO satellites.

Definition	At IOAG-15b it has been decided to create the LEO26SG to facilitate the utilization of 26 GHz Ka-Band i.e. (25.5-27.0 GHz) direct space to Earth data downlink for future LEO missions, in the context of cross-supports. The results of the 26 GHz WG were presented to the IOP-3. The group has been reactivated to revise the report to take into account the latest evolution of the 26 GHZ band. The 26 GHz group is kept alive to provide a forum for the discussion concerning the evolution and harmonization of the 26 GHz practices. In addition the scope of the WG has been widened a bit. The group should concentrate on the LEO missions but should also look at other applications of the 26 GHz band.
Activities	The LEO26SG will: 1. exchange information on the progress of the evolution of the Ka-band links; 2. follow the Ka-band link experiments and their outcome, in particular for what regards the propagation effects; 3. follow the implementation of relevant standards in the CCSDS; 4. report back to the IOAG; 5. report to the IOP-4.
Implementation	The Ka-band link experiments will be conducted in the upcoming years. The Agencies will report on its progress at the IOAG meeting and the subsequent telecons.
Expected Outcomes	Apart from reports to IOAG no specific output has been defined.
Next steps	The IOAG is to follow the evolution of the Ka-band link experiments and relevant standards. The tasks in 2018 comprises among others an interaction with the relevant CCSDS WG. At a later stage it might be possible that the IOAG may need to adapt its service catalogues and its reference tables accordingly.

WP-Core-15.5: Follow-on of the evolution of the Mission Operations domain	
Definition	The Mission Operations Services Coordination Group (MOSCG) has provided a report of the potential benefits of Mission Operations Services to IOP and the IOP has agreed to establish the Mission Operations Services Strategy Group (MOSSG). The MOSSG has created a report and is currently working on a Service Catalogue #3
Activities	The MOSSG is finalizing the report and is working on a Service Catalogue #3. The main activities are: 1. To finalise the report; 2. To complete Service Catalogue #3 and bring the document to a state so that the IOAG can provide it to and discuss it with the CCSDS; 3. To follow the work in CCSDS on Mission Operations Services; 4. To report back to IOAG; 5. To report back to IOP-4.
Implementation	The MOSSG is to interact regularly in the course of the year. The interaction should comprise regular telecons and potentially one face-to-face meeting if considered relevant. The MOSSG is to report back to the IOAG meeting and at the telecons if progress is to be reported. The result of the MOSSG is to be provided to the IOP-4.
Expected Outcomes	The initiative is to conclude with a report and a draft version of the SC#3 latest at IOAG-22. The MOSSG is to provide the results of the initiative to the IOP-4. The activities on this subject will be stopped afterwards.
Next steps	The MOSSG is to finalise the report and complete SC #3 in response to IOAG comments. The IOAG should interact with the CCSDS as deemed necessary to agree on the approach such that it will be possible to stop the work on this initiative latest with the IOP-4.

WP-Core-15.6: S/C Emergency Cross-Support

Definition	The S/C Emergency Cross Support Working Groups (SECSWG) has been installed based on a recommendation that was made during IOP-3. The objective is to establish a common, standard process, agreed upon by the IOAG member agencies, for providing spacecraft emergency cross support among the participating agencies.
Activities	The SECSWG has been created during IOAG-18 based on a recommendation from the IOP-3. The main activities are to: 1. Identify the specific problem(s), weakness/deficiency, and/or areas for improvement in the inter-agency emergency cross support, past and present. 2. Define the operational process executed by both the service provider and service users in time of the spacecraft emergency. Focus on the standardization, enhancements, and readiness of the communications and navigation operational activities. 3. Define the common policy that governs emergency cross support agreements among the IOAG member agencies. The policy statements shall cover at least support priorities, constraints (e.g. uplink RF licenses), and programmatic accountability. 4. Identify the key characteristics of the relevant CCSDS cross support services, needed for interoperability, that are unique to spacecraft emergency cross support. Assess these characteristics to determine potential new requirements and/or interfaces for the service providers and service users to comply. 5. Prepare a Guidelines report that can be discussed by the IOAG delegates with their corresponding agency management. 6. Define the relevant procedures and system updates. 7. Select test missions and validate the procedures and settings using these test missions.
Implementation	The WG is now entering the second phase, which mainly consists of validating the findings using a selected test mission. The SECSWG is to interact regularly in the course of the year. The interaction should comprise regular telecons and potentially one face-to-face meeting if considered relevant. The SECSWG is to report back to the IOAG at the IOAG meeting and at the telecons if progress is to be reported. The WG shall also report to IOP-4, which should finalise the activity.
Expected Outcomes	The initiative is to conclude with a report to the IOP-4.
Next steps	The SECSWG has selected GAIA (ESA) and Hayabusa-2 (JAXA) as suitable test missions. The required procedures and the updates of the ground segment settings (e.g. database) are to be implemented. Then the approach is to be verified using a selected test mission.

WP-Core-15.7: Lunar Communications Architecture

Definition	The Lunar Communications Archiecture Working Groups (LCAWG) has been installed based on a recommendation that was made during the Mini-IOAG meeting in Marseille. Considering the lack of an appropriate communications architecture for the upcoming Moon Exploration missions the objective is to define a Lunar Communications Architecture that will serve as the framework for the IOAG member agencies, individually or collaboratively, to establish their Lunar network(s)so that communication assets in the network(s) will be interoperable with each other at the network, data link, and physical layers.
Activities	The LCAWG has installed a study plan with the following main activities: 1. Update Lunar mission sets and profile created by the Lunar & Mars [4]Mission WG. 2. Collect the relevant mission requirements concerning the communications scenario. 3. Identify the appropriate frequency bands considering the evolution trends. 4. Define required relay services. 5. Define the appropriate Lunar Relay incl. surface network. 6. Define the relevant Lunar – Earth Space Internet. 7. Define the appropriate service types. 8. Elaborate the corresponding communications architecture.
Implementation	The WG has agreed on its composition and the study approach incl. the working timeline. The WG is to interact regularly in the course of the year. The interaction should comprise regular telecons and potentially one face-to-face meeting if considered relevant. The LCAWG is to report back to the IOAG at the IOAG meeting and at the telecons if progress is to be reported. The WG shall also report to IOP-4.
Expected Outcomes	The WG shall define the architecture requirements for Lunar Communications Architecture and to prepare a Concept paper for complementing, connecting, and harmonizing the study results from multiple communications and navigation efforts such as ISS Exploration Capability Study Team (IECST) and International Space Exploration Coordination Group (ISECG).
Next steps	The LCAWG is to consolidate the requirements and to prepare a concept paper that could be used as an input for the ISECG. In addition the information is to be provided to the Deep Space Gateway (DSG) Project.

[4] The Mars is not directly in the scope of this WG. However, it is expected that most of the findings of this WG are also relevant for the future Mars missions.

WP-Liaison-15.1: Continuation and improvement of the relationship with the International Space Exploration Coordination Group (ISECG)	
Definition	The IOP-2 has identified the International Space Exploration Coordination Group (ISECG) as a crucial organization to interface with the IOAG and to represent the user community of the Space Exploration missions. The IOP-3 has confirmed its interest to maintain the interface between IOAG and ISECG. The ISECG maintains a roadmap that identifies the scenarios for the exploration missions and highlights fundamental benefits which are expected to flow from continued investment in the missions and activities. The IOAG and ISECG chairs remain in contact with each other to make sure that the IOAG recommendations in the domain of Space Communications and Navigation are taken into account in the ISECG roadmap and subsequent work.[5]
Activities	The activity mainly consists of an exchange of status information between the two groups for the time being. 1. Make sure that the ISECG is aware and kept updated on the IOAG recommendations and capabilities so that ISECG do not duplicate activities unnecessarily. 2. Follow the evolution of the upcoming Moon & Mars missions and ensure that the communication scenarios are in line with the IOAG approach. 3. The IOAG is to draft a communications architecture for the upcoming Lunar missions that is to be made available to the ISECG and used by ISECG for the Global Exploration Roadmap.
Implementation	For the activities (1) and (2), ISECG and IOAG will contribute to each other's activities with liaison interface, documents, and presentations in meetings, as appropriate and according to opportunities.
Expected Outcomes	No duplication of activities on communications and navigation within the ISECG. A written report is not expected for this activity.
Next steps	The interface with ISECG being potentially permanent, the activity (1) is expected to be iterated and the exchanges will be as frequent as required to reflect the improvements in the definition of the exploration architecture to be reflected in subsequent versions of the roadmap. The interaction between the two organisations will be mainly at the level of the chairs. The reporting to either organization will be made, as felt appropriate, on the occasion of an ISECG or an IOAG meeting.

[5] IOAG can also provide support in the Mission Operations domain, e.g. emergency cross-support.

WP-Liaison-15.2: Continuation and improvement of the liaison with the Consultative Committee for Space Data Systems (CCSDS)

Definition	The IOAG has established since 2004 a permanent liaison with the CCSDS. In the past the CCSDS Engineering Steering Group (CESG) co-chairs served as liaison agents between the two organizations. Nowadays a permanent CCSDS representative is nominated. He attends regularly the IOAG meetings and reports on the statements that are collected on the CCSDS side, during the CCSDS Management Council meetings. Also, he conveys the IOAG messages back to CCSDS Committees. This interaction was confirmed by the IOP-3.
Activities	1. Continue to use the liaison as the main support for the exchanges between the two organizations. James Afarin (NASA) acts as liaison officer between IOAG and CCSDS. 2. Update the "IOAG – CCSDS Product Agreement" tool (ICPA) for the two organizations to formulate priorities on the development of standards (IOAG) and to report on the progress made to take such requests are taken into account (CCSDS) so as to identify any issue in this process and to concentrate on their resolution. J.M. Soula and G.P. Calzolari have been tasked to maintain the ICPA on the IOAG side and to interact with the CCSDS accordingly. 3. Hold intermediate meetings between IOAG annual plenary meetings, via tele/video conference, scheduled in a way that will allow to efficiently convey requests and report messages between the two organizations, via the liaison officer. 4. Continue the work of the Service Catalogue WG with the aim to come up with a better definition of the standards supporting the services defined in the service catalogues. 5. Potentially revise the service catalogues (see dedicated Service Catalogue WG) based on the outcome of studies, e.g. concerning the RF modulation and codes, and concerning the results of the other IOAG WGs, e.g. MOSSG.
Implementation	The activities (1) and (2) are under the responsibility of the nominated liaison officer. The activities (3) and (4) will be coordinated by the chairs of the SC WG together with the liaison officer. The liaison activities are expected to be summarized at the IOAG-22. In addition a report of the status is to be provided to IOP-4.
Expected Outcomes	Appropriate coordination on the development of the standards needed by the projects. Effective implementation of the ICPA and appropriate exchange of information between the two organizations. Regular reports are to be provided to the IOAG.
Next steps	The liaison with CCSDS being permanent, the activities are expected to be continuous and the exchanges will be as frequent as required and the reporting to either organization will be made, at the minimum once a year, on the occasion of CCSDS or IOAG meetings and during telecons as appropriate. A close interaction is required with respect to the preparation of the IOP-4.

WP-Liaison-15.3: Continuation and improvement of the liaison with the Space Frequency Coordination Group (SFCG)	
Definition	The IOAG has established since 2005 a permanent liaison with the Space Frequency Coordination Group (SFCG). From then, a member of SFCG serves as liaison officer between IOAG and SFCG. The liaison officer attends the IOAG or SFCG meetings and reports on the statements that they collect on the other side. The coordination is established to reach agreement on how to address the spectrum and frequency issues that may arise on the SFCG or ITU sides. This interaction was confirmed by the IOP-3.
Activities	1. Enrico Vassallo (ESA) acts as liaison officer between IOAG and SFCG and the main support for the exchanges between the two organizations. In the short term, this activity will concentrate on the preparation of the relevant ITU WRC conferences and the positions of the IOAG agencies. 2. SFCG liaison participates to check completeness or discrepancies, to correctly interpret inputs and to provide comments to the IOAG mission model. 3. Collect the suggestions of the SFCG for future improvements of the interface, in particular on the expectations of the SFCG on inputs to their works. 4. Contribute to each other's activities with liaison statements, documents, and presentations in meetings, as appropriate.
Implementation	The activities (1, 2, 3 and 4) are under the responsibility of the nominated liaison officer: Enrico Vassallo (ESA). The activities (3) and (4) will be conducted with the support of the IOAG Secretariat. The liaison activities are expected to be summarized at the IOAG meetings or telecons as appropriate in order to consolidate a way forward on the related subjects.
Expected Outcomes	Coordination made on the items on the agenda of the relevant ITU WRC conferences. Common approach regarding the protection of endangered frequency bands. Improved IOAG Mission Model that better reflects the mission profiles of SFCG interest. Improved processes and relationship between SFCG and IOAG.
Next steps	The liaison with SFCG being permanent, the activity (4) is expected to be continuous and the exchanges will be as frequent as required and the reporting to either organization will be made, at least once a year, on the occasion of a SFCG or an IOAG meeting (or videoconference). In addition the status of the IOAG – SFCG interaction will be presented to the IOP-4.

WP-Liaison-15.4: Continuation and implementation of a liaison with the International Committee on Global Navigation Satellite Systems (ICG)	
Definition	At IOAG-14 the idea of a new liaison with the International Committee on Global Navigation Satellite Systems (ICG) to exchange information on the user requirements and possible services in the domain of Positioning, Navigation and Timing (PNT), in particular for the GNSS Space Service volume, was approved. In 2011, the IOAG was given a position of Observer with the ICG. Exchanges of views were initiated up to IOAG-16 and actions were identified then to prepare for a reporting to the ICG, on the Navigation Mission Model. In 2013 the IOP-3 requested the IOAG to maintain the interaction with the ICG. The IOAG chairman participated in the ICG-8 and -9 meetings and clarified the relationships,
Activities	1. The IOAG chairman, M. Schmidt, will interact with the ICG with the support of James Miller (NASA) as liaison officer. The participation to ICG meetings will be decided on a case by case basis. In the short term, this activity will concentrate on the Navigation Mission Model and the requirements for the GNSS Space Service Volume. A list of the issues to be addressed in the short, medium or long term, under this liaison, should be established and updated to support the reporting on both sides. 2. Establish processes and organization within IOAG that enables the reception and processing of special requests from the ICG. 3. Contribute to each other's activities with liaison statements, documents, and presentations in meetings, as appropriate. 4. The IOAG is to maintain a database with the relevant GNSS information from the various missions and Payloads and to make the database available to the ICG.
Implementation	The activity (1) is under the responsibility of the IOAG chairman and the nominated liaison officer. The activities (2) and (3) will be conducted with the support of the IOAG Secretariat. The interface activities are expected to be summarized at the IOAG meetings or telecons in order to consolidate a way forward on the related subjects. In addition a report to the IOP-4 is envisaged.
Expected Outcomes	Navigation Mission Model (in form of a database) submitted by the IOAG Agencies to the ICG. A further presentation about the IOAG status to ICG is currently not envisaged.
Next steps	The relationship with ICG being potentially permanent, the activities are expected to be continuous and the exchanges will be as frequent as required and the reporting to either organization will be made, at least once a year, on the occasion of an ICG meeting.

WP-Processes-15.1: Improvement of the IOAG internal processes	
Definition	The IOAG Secretariat supports the organization in many of its areas of activities and plays a central role in the flow of information within the IOAG, with external organizations of interest and with the agencies or their partners. The tools utilized by IOAG and managed by the Secretariat need to be kept as efficient as possible so as to facilitate the activities of all.
Related Objectives	This is a continuous activity within IOAG.
Activities	1. Continue to improve the IOAG website on the public side, to reflect the role, activities and achievements of the IOAG. The final outcomes of the IOAG core tasks in the present Work Plan should be displayed on the public website of IOAG. 2. Continue to improve the IOAG website, on the secure side, to provide tools for the members to access the documentation related to each meeting. Special areas of interest are the action items (lists, elements of progress or closure), the resolutions submitted for discussion, the documents submitted for review and comments, the announcements of events in the IOAG domain of interest, the schedules for next IOAG videoconferences or meetings. 3. Identify opportunities and propose ways to support the promotion of the services selected by the IOAG to support the cross support scenarios, through presentations at workshops or conferences. 4. Identify how to efficiently exchange information with the organizations having liaisons with IOAG: initially, ISECG, CCSDS, SFCG and ICG. Also, the schedules of the meetings of such organizations could be integrated into a global IOAG schedule (2 year horizon). 5. Interact with the organization maintaining the SANA database and with the IOAG delegates who are to be provide the relevant inputs to ensure the consistency of the IOAG data.
Implementation	The Secretariat is in charge of the improvement of all processes. The schedule of implementation of the different tasks is made by the Agency funding the Secretariat. The implementations may need an acceptance by the IOAG Chairman only or by the members, depending upon the case.
Expected Outcomes	Up-to-date website. Reliable tools and processes. Better knowledge of IOAG activities, achievements and recommendations, inside and outside the IOAG community.
Next steps	New objectives will be established every year so as to improve the outreach of IOAG and its internal efficiency.

ANNEX-3: PARTICIPATION OF AGENCIES

X: Lead Function x: Participant	Secretariat	Chairman	ASI	CNES	CSA	DLR	ESA	JAXA	NASA	CNSA		KARI	RFSA	SANSA	UAESA	UKSA
	CORE TASKS and Working Groups															
Mission models, Communication Assets and Standards Infusion	X		x	x	x	x	x	x	x	x		x	x	x	x	x
Solar System Internetwork (SISG)				x			X	x	X							x
Optical Links Study Group (OLSG)				x			X		X							
Mission Operations Services Strategy Group (MOSSG)				x	x		x	x	X							
LEO 26 GHz Study Group (LEO26SG)			x	x			X	x	X							
S/C Emergency Cross Support WG (SECSWG)			x	x	x	x	X	x	X			x	x			x
Coding and Modulation WG (CMWG)				x		x	X		X							
Service Catalogue WG (SCWG)			x	X	x		X	x	x							x
Lunar Mars Mission WG (LMWG)			x	x	x		X	x	X			x				x
Lunar Communications Architecture WG (LCAWG)			x		x		x	x	X			x	x			X

Table 1 Involvement in Core Tasks and Working Groups

X: Lead Function x: Participant	Secretariat	Chairman	ASI	CNES	CSA	DLR	ESA	JAXA	NASA	CNSA	ISRO	KARI	RFSA	SANSA	UAESA	UKSA
	COLLABORATIONS WITH OTHER ORGANIZATIONS															
Interface with ISECG	x	X							x							
Liaison with CCSDS	x	x					x		X							
Liaison with SFCG	x	x					X									
Interface with ICG	x	X							x							

Table 2 Collaboration with other organisations

ANNEX - 4: Organizational Relationship

IOAG Organization Chart