



INTERAGENCY OPERATIONS ADVISORY GROUP

Work Plan 2022

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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 operations cross support and space communications. A specific IOAG goal is the achievement of full interoperability among the member space agencies.

To achieve these goals, a set of permanent objectives are defined, which are listed in the IOAG Terms of Reference and summarized in the Annex of this Work Plan. In addition, the Inter-Operability Plenary (IOP) has assigned specific objectives that are reflected in this work plan.

The Work Plan details the IOAG work objectives for 2022 and defines an associated implementation plan in form of specific tasks. Some of the tasks are of permanent nature such as the maintenance of the models, while others are aiming for one-off products such as architecture reports. The IOAG Work Plan is updated on an annual basis to reflect the achievements of the IOAG.

The IOAG Work Plan 2022 responds to overarching strategic goals:

- Establish or enhance all elements of the IOAG organization required to achieve its role as the prime international focal point for matters related to cross support in the space communication and navigation domain.
- Increase the visibility of the IOAG by establishing and maintaining links to relevant international groups and organizations and enlarge the stakeholder community.

While the body of the work plan identifies the main activities, the annexes provide details of the relevant tasks.

The IOAG work for 2022 has been arranged according to four activity lines:

- core tasks;
- tasks performed in collaborations with other existing international groups/organizations;
- improvement of IOAG internal processes as required;
- reporting activities.

The Annexes provide also an overview of the contribution of the various IOAG Agencies.

Note: IOAG is currently assessing the establishment of new Working Groups to address relevant domains (e.g. IoT communications to LEO satellites, Lunar Navigation services,...). A revision of the IOAG Work Plan 2022 is envisaged for release mid of the year to reflect the decisions on these additional WG.

2 Objectives

The overall objectives of the IOAG are defined in its Terms of Reference (TOR), see also Annex-1. In addition, the objectives are driven by the IOP, in particular IOP-4, communiqués.

Specific objectives for 2022, as derived from core tasks and the IOP-4 resolutions, are:

- Maintain the liaison with international bodies, in particular the Consultative Committee for Space Data Systems (CCSDS), the Space Frequency Coordination Group (SFCG), the International Committee on Global Navigation Satellite Systems (ICG) and the International Space Exploration Coordination Group (ISECG);
- Update the products of relevant WGs, in particular
 - Maintain the Service Catalogues as required;



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- Maintain the procedures / guidelines for the S/C Emergency Cross-Support as required and include Industry as far as appropriate;
 - Continue the work of the Sustainable Operations in Space (SOS) WG according to the agreed plans;
 - Update the report related to the Lunar and/or Moon Communications Architecture in case of new information according to the evolution of the International Space Exploration Coordination Group (ISECG);
 - Maintain the report about the utilization of higher frequency bands for deep space missions, in particular around Mars but also Moon.
- Initiate new studies via related Working Group(s) to address new relevant domains (e.g. IoT communications to LEO satellites, Lunar Navigation,...).
 - Follow the evolution of the Missions Operations Services performed by the Consultative Committee for Space Data Systems (CCSDS).
 - Follow the interaction with commercial providers and operators in the domains of the IOAG activities and organize appropriate events.
 - Assess the possibilities to enhance interactions with Academia and Emerging Space Agencies in the domains of the IOAG activities.
 - Follow the assessment of new technologies and identify the ones that are relevant to the IOAG.

3 Overview of Activities for 2022

This section provides an overview of the main activities / actions relevant to 2022. Besides the maintenance of the mission models and communications assets database, the work concentrates on the interfaces to some specific organizations and the management of active working groups. In this context the IOAG is to ensure that the objectives defined by the IOP are followed.

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) will be maintained, leading to an exchange of up-to-date information.
- ✓ The IOAG will follow the evolution of the ISECG Global Exploration Roadmap (GER) and will support the areas, which are of relevance to the IOAG.
- ✓ IOAG will follow closely the evolution of the upcoming Moon and 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.
- ✓ The IOAG will be involved in the evolution of the Lunar Communication Scenario and will maintain the corresponding architecture
- ✓ The IOAG will consolidate and maintain the appropriate communications architecture for the Mars missions.
- ✓ The IOAG will support specific ISECG WGs in its role as communications expert as required.
- ✓ The IOAG Chair and the Secretariat will keep track of the interactions.



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

- ✓ The CCSDS Liaison is to regularly participate in the IOAG teleconferences and meetings and to report about the progress in CCSDS.
- ✓ The IOAG chair will participate in CCSDS meetings if considered relevant.
- ✓ The communication mechanism between the two organisations is the IOAG-CCSDS Product Agreement (ICPA), which will be populated / prioritized by the IOAG delegates and will be maintained by the chairs of the Service Catalogue WG (SCWG) and their counterpart from CCSDS.
- ✓ The priorities defined by IOAG (ICPA priorities) will be updated as required.
- ✓ The IOAG Chairman / Secretariat will send IOAG progress reports to CCSDS, as required.
- ✓ The IOAG will maintain the Service Catalogues 1 and 2 (SC#1 and SC#2).
- ✓ The IOAG will maintain the Service Catalogue 3 (SC#3) if necessary, to define its prioritization of the required Mission Operations standards, to provide both to the CCSDS and to follow the evolution of the Mission Operations Services.

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.
- ✓ 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 will be made available to the 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 will maintain the database with relevant information concerning on-board GNSS functions and equipment and will make it available to ICG.
- ✓ The IOAG Chairman will maintain the contact with the ICG, either by directly participating in the relevant meetings or by coordinating the activities via the Liaison.

3.5 Service Catalogue Working Group SCWG

Status: active

- ✓ The SCWG will support the interface to the CCSDS, by maintaining the Service Catalogues SC#1 and SC#2 and will update the ICPA as required.
- ✓ A co-chair will be nominated for 2022.
- ✓ The WG will collect inputs for updates of the existing service catalogues, will propose recommendations for updates and will discuss them with the corresponding CCSDS groups.
- ✓ The WG will prepare revisions of the existing service catalogues.
- ✓ The WG will maintain the standards / services infusion tables including the identification of their priorities.



3.6 Spacecraft Emergency Cross Support Working Group (SECSWG)

Status: active

- ✓ The SECSWG will regularly interact in order to implement common, standard processes and procedures, agreed upon by the IOAG member Agencies, for providing spacecraft emergency cross support.
- ✓ The SECSWG will establish guidelines that govern emergency cross support between the participating Agencies.
- ✓ The SECSWG Chair will continue to follow the involvement of experts from Industry if considered relevant and will check whether the guidelines could be made applicable to Industry providers and operators.

3.7 Sustainability of Operations WG (SOSWG)

Status: active

- ✓ The WG will assess the risks on operations in Space.
- ✓ The WG will identify the relevant actors and processes.
- ✓ The WG will identify deficiencies and possible improvements.
- ✓ The WG will formulate recommendations and proposals.

Note: the WG Chairs will follow the involvement of industrial providers and operators and Industry experts in the WG activities as considered appropriate.

3.8 Mars and Beyond Working Group (MBCAWG)

Status: active

- ✓ The objective of the WG is to define the communications architecture(s) that will serve as the framework for the IOAG member agencies, individually or collaboratively, to develop their communication assets that will be interoperable with each other as a minimum at the network, data link, and physical layers, to support all Mars and Beyond missions.
- ✓ The MBCAWG will interact with ISECG as required to keep aligned the communications architecture with the mission scenarios.

3.9 Lunar & Mars Mission Working Group (LMWG)

Status: closed

- ✓ The LMWG has completed its tasks by providing the Lunar and Mars missions database.
- ✓ The outputs have been considered for the communications architecture for Moon missions that was generated by the Lunar Communication Architecture WG (LCAWG), as well as the communication architecture for Mars missions that is being consolidated by the Mars and Beyond Working Group (MBCAWG).

3.10 Lunar Communications Architecture Working Group (LCAWG)

Status: dormant

- ✓ The LCAWG has completed its work by issuing a report to the IOAG and is now in a dormant status. The report will be updated every 2 to 3 years.
- ✓ The LCAWG will be activated to provide a forum for discussions and/or to update the Lunar mission database, if required.



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- ✓ The LCAWG is in principle dormant but the Chair will follow the evolution of the Moon communications within the various agencies (in the frame of relevant initiatives, e.g. LunaNet, Moonlight and others) and to provide relevant feedback to the IOAG.

3.11 Coding & Modulation Working Group (CMWG)

Status: dormant

- ✓ The CMWG has completed its work by issuing a report to the IOP and is now in a dormant status. The report will be updated every 3 to 4 years.
- ✓ The CMWG will be activated to provide a forum for discussions, if required.

3.12 Low Earth Orbit (LEO) 26 GHz SG

Status: dormant

- ✓ 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.

Note: the IOP recommended enhancing the scope of this frequency band and to accurately capture missions in all orbit regimes using 26 GHz. The IOAG is also considering the application of the technology of this 26 GHz frequency band as part of the Deep Space and Mars communications architecture.

3.13 Mission Operations Systems Strategy Group (MOSSG)

Status: active

- ✓ The MOSSG is in principle active with lower frequency of meetings, following the evolution of the MOS services.
- ✓ The MOSSG will monitor the progress of the corresponding CCSDS WG.
- ✓ The MOSSG will maintain the Service Catalogue #3 as required.
- ✓ The MOSSG will maintain the Agencies infusion plans and the priorities for development of new standards by CCSDS.
- ✓ The MOSSG will periodically report on the progress and findings of the spinoff demonstration effort conducted by 3 of the MOSSG Agencies.
- ✓ The MOSSG will interface to the Gateway / ARTEMIS Project and to ensure that the mission interoperability services are considered.

3.14 Optical Links Study Group (OLSG)

Status: dormant

- ✓ The IOAG Agency 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 OLSG Chair will follow the evolution of the optical communications within the various agencies and to provide relevant feedback to the IOAG.



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- ✓ The OLSG will follow the evolution of the corresponding books that will be developed by the relevant CCSDS WG.
- ✓ The OLSG will pursue the involvement of experts from Industry in the OLSG activities if feasible.

3.15 Space Internetworking Study Group (SISG)

Status: dormant

- ✓ The IOAG Agency delegates are to promote the Space Internetworking concept within their agencies.
- ✓ The SISG is principle inactive but the IOAG Agency 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 will keep track of the evolution of the space internetworking in particular as regards the Delay Tolerant Network (DTN).

3.16 New study domain(s)

The proposal to create new Working Group(s) has been put forward by some IOAG participating Agencies and is currently being assessed for a potential implementation in the course of 2022. This relates in particular to the topics of IoT communication to LEO satellites, Lunar Navigation services, LunaNet governance and secure communications architecture.

A decision to create new Working Group(s) is expected to be taken by IOAG in the first half of the year, including definition of the related Terms of Reference. This Work Plan 2022 document will be updated accordingly and a revision is expected to be released in June 2022.

3.17 IOAG Chair and Delegates

Beside the normal tasks as defined in the ToR, the Chair and the Delegates will engage in the following tasks for 2022:

- ✓ The IOAG Chair will follow up options to interact with commercial providers and operators relevant to the IOAG activities (without integrating them in the IOAG organisation) and will identify appropriate opportunities.
- ✓ The IOAG Chair will maintain the managerial interface with the Gateway / ARTEMIS Project regarding the utilisation and availability of required inputs and standards.
- ✓ The WG Chairs will follow up the corresponding technical interfaces with the Gateway / ARTEMIS Project.

4 Core Tasks

The following core tasks, which form the basis of the IOAG activities, have been identified for 2022:

- Core 21.1 = Improve the completeness, accuracy and visibility of the IOAG Mission Model, Cross Support Mission Model, Communication Assets Database, GNSS Payloads Database.
- Core 21.2 = Maintain the Standards Infusion Status, the Service Catalogues, the ICPA and the Coding & Modulation, as required.
- Core 21.3 = Follow-on of the evolution of dormant WGs, e.g. Solar System Internetworking Infrastructure, Optical Communications,...
- Core 21.4 = Follow-on of the evolution of the Mission Operations Services domain.



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- Core 21.5 = Follow-on of the definition of Spacecraft Emergency Cross-Support.
- Core 21.6 = Establish a communications architecture for the upcoming deep space, in particular Mars missions and maintain Lunar communications architecture.
- Core 21.7 = Assess Sustainable Operations in Space

The details of the core tasks are defined in the annex.

The Core Task 21.1 requires contributions and updates from all IOAG participants.

Though some of the WGs have in principle completed the allocated tasks, it has been agreed to keep them in a dormant state to reactivate them as necessary in order to have a forum to exchange information and to follow the evolution of the corresponding topics.

The interactions with commercial providers and operators and with academia and emerging space agencies have not been identified at the moment as a core task.

The IOAG ToR and Procedures Manual have been revised in 2014. The ToR and the Procedures will be reviewed in the course of the year and potential updates assessed.

5 Tasks in Collaboration with Other Organizations

The interface of IOAG with existing groups, as directed by the IOP-4, will be primarily focused on the coordination of the space communications, navigation and mission operations aspects, and on ensuring the consistency of the tasks conducted by the multiple organizations.

Four strategic interfaces have been identified for 2022:

- Liaison 21.1 = Continuation 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 and Mars missions. Other topics that might become relevant such as Missions Operability and S/C Emergency Cross-Support are to be dealt with when required.
- Liaison 21.2 = Continuation 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.
- Liaison 21.3 = Continuation 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 and to ensure the protection of critical frequency bands.
- Liaison 21.4 = Maintaining the 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 and maintenance 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 21.1" in Annex-2.



7 Reporting Activities

The year 2022 will focus on the continuation of the ongoing activities. Some of the WGs will stay in a dormant state and the corresponding WG chairs are to report the status to the IOAG mainly during the face-to-face meeting. The chairs of the active WGs are to report regularly to the IOAG during the telecons and the face-to-face meeting. New study activities and related Working Group(s) are being considered in specific domains. The place and time of the face-to-face meeting in 2022 have not yet been identified considering the ongoing Corona crisis. There will be a regular exchange of reports with the liaison organizations. This concerns in particular the interface to the CCSDS to consolidate standards. It is expected that the heads of IOAG delegation will report back to their corresponding agency management regarding 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 document the progress on the implementation of activities in the 2022 Work Plan. The Annual Report will be posted on the public IOAG website (<https://www.ioag.org>) no later than end January 2023.



Annex 1. IOAG OBJECTIVES

According to the Terms Of Reference, areas for consideration for the IOAG objectives and activities include:

- ToR (a) Identifying the space and ground communication and navigation support capabilities needed by potential cooperative programs and projects to achieve their scientific objectives, and maintaining a corresponding cross support mission model.
- ToR (b) Identifying the space and ground mission operation systems and services needed by potential cooperative programs and projects to achieve their scientific objectives, and maintaining a corresponding cross support mission model.
- ToR (c) Maintaining a catalogue of recommended cross supported services and associated interoperable ground and space facilities deployed and operated by the space agencies.
- ToR (d) Promoting the use of internationally recognized standards (for communications, navigation, and mission operation standards) in the design and implementation of cooperative flight programs including spacecraft, ground and space-based communication assets.
- ToR (e) Monitoring the work of relevant standards organizations and assisting in the agreement, adoption and implementation of new standards by space agencies.
- ToR (f) Based on identified future cross support scenarios, or based on practical experience and feedback from actually performed cross support, IOAG shall ascertain inconsistencies in cross support services and standards, and inform relevant standards organizations (such as the CCSDS or SFCG), using methods described in the *IOAG Procedures Manuals*, inviting them to update existing standards or to develop new international standards.
- ToR (g) Establishing recommendations for priorities for the implementation of cross supported services and associated interoperable ground and space facilities needed to achieve full interoperability and enunciating policies furthering interoperability. Such IOAG priorities and policies should be passed for consideration to relevant organizations and to the IOP Delegates, using methods described in the *IOAG Procedures Manual*.
- ToR (h) Assessing the resources needed to implement these requirements and inviting IOP Delegates to make these resources available within their agencies.
- ToR (i) Working with other bodies (such as ISECG) to establish technical or reference architectures that will enable operations interoperability and cross support across the member space agencies.
- ToR (j) Encouraging the sharing and distribution of operational techniques to accelerate the deployment of interoperable solutions.

At the 4th Inter-Operability Plenary meeting (IOP-4), held in Oberpfaffenhofen and Andechs in December 2018 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 encouraged the IOAG to deal also with other issues that are relevant to the operations related interaction between the member agencies such as the impact of new technologies on the mission operations and the sustainability of space operations.
- The IOP requests the IOAG to maintain the close interaction with the various international coordination groups (CCSDS, SFCG, ISECG and ICG).
- The IOP encouraged the IOAG to establish contacts with commercial providers and operators, academia and emerging space agencies and to foster the achievements of the IOAG.

The above resolutions require the IOAG delegates to promote the achievements of the IOAG and the IOAG Chair to expand the participation to the IOAG activities.



ANNEX-2: IOAG TASKS DEFINITIONS

WP-Core-21.1: Improvement of completeness, accuracy and visibility of the IOAG Mission Model, Cross Support Mission Model, Communication Assets Database, GNSS Payloads Database.

| | |
|----------------------|--|
| Definition & Status: | <p>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.</p> <p>A table with Communication Assets including items belonging to non-IOAG members was established in 2012 but has not been kept up-to-date. It has been decided that only the elements of the database that are maintained by the agencies will be made public.</p> |
| Activities: | <ol style="list-style-type: none">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 that are considered relevant.3. Keep the above elements up to date on the website and in the corresponding database. |
| Implementation: | <p>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 up to date information available on the website at IOAG-25. A database will be used to store the provided data and to ensure an appropriate configuration control.</p> <p>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.</p> |
| Expected Outcomes: | <ol style="list-style-type: none">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: | <p>The cross support services are mainly those required by the current point-to-point and simple multipoint internetworking cross support scenarios.</p> <p>To keep the tables up to date is a collective permanent action of the IOAG delegates, under coordination by the secretariat. This concerns also new members.</p> |



WP-Core-21.2: Maintain the Standards Infusion Status, the Service Catalogues, the ICPA and the Coding & Modulation as required.

| | |
|----------------------|---|
| Definition & Status: | <p>There is a need to identify 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 Service Catalog #1 and the Service Catalog #2, which were recently updated in 2022. Those references serve for the evaluation of the agencies' infusion plans.</p> <p>This core activity comprises also the maintenance of the ICPA and the update of the Coding & Modulation list as required.</p> |
| Activities: | <ol style="list-style-type: none">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: | <p>The chairs of the SCWG 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 but is not considered relevant for 2022. The corresponding experts are to be involved as needed.</p> |
| Expected Outcomes: | <ol style="list-style-type: none">1. A report on infusion status and plans that may be used to populate the ICPA 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: | <p>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.</p> <p>The next check of the Coding & Modulation schemes is considered relevant in 2023.</p> |



WP-Core-21.3: Follow-on of the definition of a Solar System Internetworking Infrastructure, Optical Communications, 26 GHz frequency band for LEO missions, Lunar Communications Architecture

| | |
|---------------------|---|
| Definition & Status | Various WGSs presented their status during the IOP-4 or concluded their work in 2019. The following WGs have reached a status that allowed entering a dormant state: SISG, OLSG, LEO26SG. The groups could be reactivated to have a forum for the follow on of the evolution of the corresponding technologies and of the generation of corresponding standards by the CCSDS. |
| Activities | <ol style="list-style-type: none">1. to exchange information on the progress of the evolution of the Space Internetwork, optical links and 26 GHz for LEO missions;2. to follow the optical link experiments and their outcome;3. to follow the DTN experiments and their outcome;4. to follow the experience gained with LEO missions using the 26 GHz band;5. to follow the evolution of the Lunar mission scenarios and the impacts on the communications;6. to follow the implementation of relevant standards in the CCSDS;7. to keep the IOAG informed as required. |
| Implementation | None of the WGs will regularly meet in 2022. The WG chairs are to follow the corresponding evolution of the various items. 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 as needed and to verify that the IOAG recommendations are properly considered by the implementing organizations. |
| Expected Outcomes | 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. |



WP-Core-21.4 Follow-on of the evolution of the Mission Operations domain

| | |
|---------------------|--|
| Definition & Status | The Mission Operations Services Strategy Group (MOSSG) has provided a report and a Service Catalogue #3 that has been formally approved by the IOAG. The Service Catalogue # 3 is to be converted into standards as considered appropriate. Experiments are to be executed to prove the applicability of the MOS concept. |
| Activities | <p>The MOSSG is to interact with the CCSDS and with the Gateway / ARTEMIS project as required. The main activities are:</p> <ol style="list-style-type: none">1. To maintain the Service Catalogue #3 if required based on feedback from the CCSDS;2. To collect infusion plans from the Agencies, to establish priorities for the development of missing standards and to populate the ICPA with IOAG inputs on MO's;3. To follow the work in CCSDS on Mission Operations Services;4. To execute relevant experiments and to produce a report of the findings;5. To interact with the Gateway / ARTEMIS Project to ensure the mission operations services are considered by the Project where appropriate;6. To report back to IOAG. |
| Implementation | <p>The work of the MOSSG is mainly performed at chair level. The group will be consulted by the chair as considered necessary. The MOSSG should maintain contacts with the relevant CCSDS WGs and with the gateway / ARTEMIS Project.</p> <p>The MOSSG is to report back to the IOAG meeting and at the telecons if progress is to be reported.</p> |
| Expected Outcomes | The Service Catalogue #3 has been provided to the CCSDS. The remaining steps concern the execution of demos and the relevant update of the ICPA and the Infusion Plan. Afterwards the activities on this subject will continue on low level to follow the evolution of standards as appropriate. In addition, support is to be provided to the Gateway / ARTEMIS Projects if they decide to embark on the utilization of Mission Operations Services. |
| Next steps | The MOSSG is to interact with the Gateway / ARTEMIS Project to identify the required support regarding mission operations services. |



WP-Core-21.5: S/C Emergency Cross-Support

| | |
|---------------------|--|
| Definition & Status | 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. The Standard Operations Procedure (SOP) has been defined and demonstrations have been executed to validate the concept. |
| Activities | The main activities are to: <ol style="list-style-type: none">1. Implement and maintain the <u>operational process</u> to be executed by both the service provider and service users. Focus on the enhancements, and readiness of the communications and navigation <u>operational activities</u>.2. Maintain the <u>common policy</u> 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. Maintain the relevant procedures and system updates.6. Continue involving Industry experts as considered appropriate and enhance the involvement of the user community. |
| Implementation | The WG is in a phase, which mainly consists in consolidating the findings and improving the data and information exchanges. The SECSWG is to interact in the course of the year as considered necessary. The SECSWG is to report back to the IOAG at the IOAG meeting and at the telecons if progress is to be reported. |
| Expected Outcomes | The initiative is to conclude with a consolidation of the findings and the procedures. |
| Next steps | When the procedures have reached the appropriate steps the initiative can be concluded. |



WP-Core-21.6: Deep Space Communications Architecture

| | |
|---------------------|---|
| Definition & Status | The Lunar Communications Architecture Working Groups (LCAWG), which has been installed in 2017, has provided an appropriate communications architecture to the ISECG. Considering the lack of an appropriate communications architecture for the upcoming deep space exploration, in particular Mars, missions a new WG (Mars and Beyond Communications Architecture WG – MBCAWG) has been established with the objective to define and maintain a Deep Space Communications Architecture that will serve as the framework for the IOAG member agencies, individually or collaboratively, to establish their network(s) so that communication assets in the network(s) will be interoperable with each other at the network, data link, and physical layers, to support all Mars and Beyond missions. |
| Activities | <p>The MBCAWG will follow in principle a study plan with the following main activities:</p> <ol style="list-style-type: none">1. Establish relevant mission sets and profile¹.2. Generate the relevant communications architecture.3. Generate the corresponding report.4. Consolidate required relay services.5. Consolidate the appropriate service types.6. Define the relevant Mars – Earth Space Internet. |
| Implementation | <p>The WG will consider the parts of the Lunar Communications Architecture that are also applicable for the Mars missions and to maintain the list of missions that are to be considered in this context. The WG is to closely cooperate with the corresponding WG of ISECG to produce the corresponding report and to maintain the defined communications architecture.</p> <p>The WG is to interact regularly in the course of the year. The interaction should comprise regular telecons and potentially a face-to-face meeting if considered relevant.</p> <p>The MBCAWG is to report back to the IOAG at the IOAG meeting and at the telecons if progress is to be reported.</p> |
| Expected Outcomes | The WG has produced and will maintain a communications architecture similar to the one for the Moon scenario including a concept paper for complementing, connecting, and harmonizing the study results from other sources and groups. |
| Next steps | The MBCAWG is to consolidate its composition to consider also new member agencies. The link to the corresponding group of ISECG is to be maintained to consolidate the requirements to be considered. |

¹ Though the Mars is not the only target the mission set will mainly deal with the Mars Exploration Programme.



WP-Core-21.7: Sustainability of Operations in Space

| | |
|---------------------|---|
| Definition & Status | <p>The Sustainability of Operations in Space WG (SOSWG) has been installed after IOP-4. This WG is a response to the changing space environment such as a rapid increase in the population of operational satellites (e.g. cubesats, constellations) with the consequence of a growing population of debris. The WG is to assess the corresponding risks and to provide a situational report including recommendations. The Terms of Reference of the WG have been agreed and the scope and composition of the WG have been consolidated.</p> |
| Activities | <p>The SOSWG has agreed on the following approach:</p> <ol style="list-style-type: none">1. Assess the risks on operations in space (disposal operations, collision avoidance, maneuver coordination, space weather, re-entries, spectrum, interferences, in orbit servicing, proximity operations, etc...);2. Identify the existing actors and processes;3. Identify deficiencies and possible improvements;4. Formulate recommendations and proposals5. Elaborate the role of IOAG with respect to the SOS issues. |
| Implementation | <p>The WG is to complete the report, already drafted in the course of 2021, with the results of the above activities. In addition, the WG should assess how far experts from Industry could contribute to the work as there is a high interest at Industry in particular regarding the collision avoidance mechanism.</p> <p>The WG is to interact regularly in the course of the year. The interaction should comprise regular telecons and potentially a face-to-face meeting if considered relevant.</p> <p>The SOSWG is to report back to the IOAG at the IOAG meeting and at the telecons if progress is to be reported.</p> |
| Expected Outcomes | <p>The WG shall provide a report that describes the current situation and the future risks. In addition, the report shall comprise recommendations and proposals on how the risks shall be dealt with and which role the IOAG could play in this context.</p> |
| Next steps | <p>The SOSWG is to formulate recommendations and proposals and to consolidate the role of the IOAG in this process.</p> |



WP-Liaison-21.1: Continuation and improvement of the relationship with the International Space Exploration Coordination Group (ISECG)

| | |
|---------------------|--|
| Definition & Status | <p>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.</p> <p>The IOP-3 and IOP-4 have confirmed their interest to maintain the interface between IOAG and ISECG.</p> <p>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.</p> <p>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. The IOP-4 acknowledged that there are also other areas that could be of interest for the future Exploration missions such as the Emergency cross-support.</p> |
| Activities | <p>The activity mainly consists of an exchange of status information between the two groups for the time being.</p> <ol style="list-style-type: none"> 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 maintain a communications architecture for the upcoming Lunar and to define a communications architecture for the Mars missions that are to be made available to the ISECG and used by ISECG for the Global Exploration Roadmap. 4. The IOAG is also to support the ISECG in areas that are of operational relevance such as the cross-support in case of S/C emergencies and the implementation of mission operations services. |
| Implementation | <p>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. The IOAG will also follow the activities of ISECG sub-groups as far as relevant to the above activities.</p> |
| Expected Outcomes | <p>No duplication of activities on communications and navigation within the ISECG. Generation of the appropriate communication architectures.</p> <p>Written reports are not expected for this activity.</p> |
| Next steps | <p>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.</p> <p>The interaction between the two organizations will be mainly at the level of the chairs who are to ensure that the appropriate contacts at working level will be established. The reporting to either organization will be made, as felt appropriate, on the occasion of an ISECG or an IOAG meeting.</p> |



WP-Liaison-21.2: Continuation and improvement of the liaison with the Consultative Committee for Space Data Systems (CCSDS)

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| Definition | <p>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 / she 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 / she conveys the IOAG messages back to CCSDS Committees.</p> <p>This interaction was confirmed by the IOP-4.</p> |
| Activities | <ol style="list-style-type: none"> 1. Continue to use the liaison as the main support for the exchanges between the two organizations. 2. To identify any issue in the ICPA process and to concentrate on their resolution. 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. 6. The CCSDS is to be involved in the interaction with the Gateway / ARTEMIS project as far as the mission operations services are concerned. |
| Implementation | <p>The activities (1) and (2) are under the responsibility of the nominated liaison officer.</p> <p>The activities (3) and (4) will be coordinated by the chairs of the SC WG together with the liaison officer.</p> <p>The activity (6) should be coordinated by the chair of the MOSSG.</p> <p>The latest status of the liaison activities are expected to be summarized at the IOAG-25.</p> |
| Expected Outcomes | <p>Appropriate coordination on the development of the standards needed by the projects.</p> <p>Effective implementation of the ICPA and appropriate exchange of information between the two organizations.</p> <p>Regular reports are to be provided to the IOAG.</p> |
| Next steps | <p>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.</p> |



WP-Liaison-21.3: Continuation and improvement of the liaison with the Space Frequency Coordination Group (SFCG)

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| Definition | <p>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.</p> <p>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.</p> <p>This interaction was confirmed by the IOP-4.</p> |
| Activities | <ol style="list-style-type: none"> 1. Continue to use the liaison officer between IOAG and SFCG as 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 | <p>The activities (1, 2, 3 and 4) are under the responsibility of the nominated SFCG liaison officer to IOAG.</p> <p>The activities (3) and (4) will be conducted with the support of the IOAG Secretariat.</p> <p>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.</p> |
| Expected Outcomes | <p>Coordination made on the items on the agenda of the relevant ITU WRC conferences.</p> <p>Common approach regarding the protection of endangered frequency bands.</p> <p>Improved IOAG Mission Model that better reflects the mission profiles of SFCG interest.</p> <p>Improved processes and relationship between SFCG and IOAG.</p> |
| Next steps | <p>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).</p> |



WP-Liaison-21.4: Continuation and implementation of a liaison with the International Committee on Global Navigation Satellite Systems (ICG)

| | |
|-------------------|--|
| Definition | <p>At IOAG-14 the proposal 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.</p> <p>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.</p> <p>The IOP-3 and IOP-4 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,</p> |
| Activities | <ol style="list-style-type: none"> 1. The IOAG Chair will interact with the ICG with the support of Joel Parker (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 | <p>The activity (1) is under the responsibility of the IOAG Chair and the nominated liaison officer.</p> <p>The activities (2) and (3) will be conducted with the support of the IOAG Secretariat.</p> <p>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.</p> |
| Expected Outcomes | <p>Navigation Mission Model (in form of a database) submitted by the IOAG Agencies to the ICG.</p> <p>A further presentation about the IOAG status to ICG is not currently envisaged.</p> |
| Next steps | <p>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.</p> |



WP-Processes-21.1: Improvement of the IOAG internal processes

| | |
|--------------------|---|
| Definition | <p>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.</p> <p>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.</p> |
| Related Objectives | <p>This is a continuous activity within IOAG.</p> |
| Activities | <ol style="list-style-type: none"> 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 | <p>The Secretariat is in charge of the improvement of all processes and tools. 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.</p> |
| Expected Outcomes | <p>Up-to-date website.</p> <p>Reliable tools and processes.</p> <p>Better knowledge of IOAG activities, achievements and recommendations, inside and outside the IOAG community.</p> |
| Next steps | <p>New objectives will be established every year so as to improve the outreach of IOAG and its internal efficiency.</p> |

ANNEX-3: IOAG PARTICIPATION OF AGENCIES

| X: x: | Lead Function Participant | Secretariat | Chair | ASA | ASI | CNES | CSA | DLR | ESA | JAXA | NASA | CNSA | ISRO | KARI | ROSCOSMOS | SANSA | UAESA | UKSA |
|------------------------|--|--------------------|--------------|------------|------------|-------------|------------|------------|------------|-------------|-------------|-------------|-------------|-------------|------------------|--------------|--------------|-------------|
| | Mission models, Communication Assets and Standards Infusion | X | | x | 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 |
| | Deep Space Comms Architecture WG (DSCAWG) | | | | x | x | x | | X | x | X | | | x | x | | | x |
| | Sustainability of Operations WG (SOSWG) | | | | X | x | x | x | X | x | x | | | x | | | | |

Table 1 Involvement in Core Tasks and Working Groups



IOAG Work Plan 2022

| X: x: | Lead Function Participant | Secretariat | Chair | ASI | CNES | CSA | DLR | ESA | JAXA | NASA | CNSA | ISRO | KARI | ROSCOSMOS | SANSA | UAESA | UKSA |
|----------|------------------------------|-------------|-------|-----|------|-----|-----|-----|------|------|------|------|------|-----------|-------|-------|------|
| | | | | | | | | | | | | | | | | | |
| | Interface with ISECG | x | X | | | | | | | x | | | | | | | |
| | Liaison with CCSDS | x | x | | | | | | | X | | | | | | | |
| | Liaison with SFCG | x | x | | | | | X | | | | | | | | | |
| | Interface with ICG | x | X | | | | | | | x | | | | | | | |

Table 2 Collaboration with other organisations



IOAG Work Plan 2022

ANNEX - 4: IOAG Organizational Relationship

