**IAF Space Traffic Management Working Group – IAF STM WG**

**Terms of Reference (Draft)**

**April 1st, 2020**

*(including comments from S. Plattard, D. McKnight, D. Oltrogge, S. Lemmens, A. Kato, R. Rovetto, A. Lacroix, P. Faucher, H. Krag, L. Francillout, L. Anselmo, D. Alary, M. Skinner)*

**Objective**

The IAF Space Traffic Management Working Group (IAF STM WG) was founded following the joint action between IAA (International Academy of Astronautics), IISL (International Institute of Space Law), and IAF (International Astronautical Federation) taken on Oct. 1st, 2018 in Bremen, formalized with a Memorandum of Understanding attached as Annex 1 to this document.

IAF, IAA, and IISL join in a cooperative initiative to develop comprehensive behaviors and proposals for STM to be addressed to decision-makers on national and international level in order to promote the safe use of outer space.

To that extent, IAF STM WG contributes to the preparation of a joint “white paper” with the ambitious objective of issuing a **Final Draft by IAC 2021** in Paris. Coordination among the three entities will take place during the 2021 Spring Meetings in order to finalize the date of issue.

**Approach**

The IAF STM WG aims at synthesizing the work performed under numerous existing entities such as AIAA STM WG, ISO effort within WG3 and WG7, ECSS dedicated STM WG, AAE STM WG (Air & Space Academy), EEAS, IAASS, ESPI, SWF, SSC (Space Safety Coalition), IADC, WEF (World Economic Forum) and others… (please complete if relevant).

The goal is, therefore, not to come up with ideas which are already well-advanced, but to synthesize them and identify potential aspects in which potentially new actions are needed. As such, the focus will be in creating compelling insights and recommended behaviors over a comprehensive review of all dimensions and nuances of the STM challenge.

This Working Group serves as a platform for exchanges among experts from diverse affiliations and backgrounds.

A Forum of Exchange will be set up by IAF Secretariat as soon as possible, with a web site within which any relevant document can be shared among members of the WG.

**Membership**

The members of the IAF STM WG come from very diverse origins, including members from each of the IAF Technical Committees related to the topic, representatives from the groups mentioned above, and technical experts coming from the IAA Space Debris Committee.

Requirement for membership and participation is not tightly controlled, however, there are two factors that will be considered as we form the WG. First, we would like to avoid multiple members from the same organization that have the same role/experience. Second, it is expected that members effectively and regularly contribute to the progress of the Working Group.

A preliminary list of members will be established based on feedback to this document.

**Framework**

The activities of the IAF STM WG cover essentially all technical topics related to the general STM ecosystem, meaning:

* STM, Operational Coordination Services, Collision Avoidance (in orbit, at launch and at reentry), including the link and coordination with airspace users during launch and re-entry operations. It also includes Frequency Management and Coordination
* SSA (Space Situational Awareness), SST (Space Surveillance & Tracking) and SWE (Space Weather); ‘SSA also includes the NEO topic, but it is not relevant in the context here)
* SEM (Space Environment Management) which includes activities such as Space Debris Mitigation, Remediation (ADR (Active Debris Removal), JCA (Just in time Collision Avoidance, …), LDTM (Large Debris Traffic Management), …
* SOA (Space Operations Assurance) which incorporates SEM, SSA and STM
* The “interlinks” between topics are fundamental: effective Space Traffic Management (STM) will be difficult to execute without immediate changes in our Space Environment Management (SEM) objectives and behavior (i.e., debris mitigation and remediation).

The “non-technical” topics related to Legal framework, Policy, Regulation, Governance and Licensing are fundamental in the elaboration of the White Paper and have already been addressed through two dedicated IAA Position Papers. The continuation of these activities is logically welcomed by the IAA and IISL STM Working Groups; colleagues interested in these domains should contact Mrs. Corinne Jorgenson, and Dr. Diane Howard, respectively chairs of the IAA and IISL STM WG.

**Potential activities**

Previous works on the topic have enabled the identification of several subjects of interest associated with potential recommendations, listed below in a very non-exhaustive way.

We will need to define at the very beginning a set of priority actions – what needs to be done first and/or what can be done first that provides some immediate benefit, what can be done second that provides moderate benefit, and what will take a bit longer but provide the greatest benefit.

1. Common understanding and definitions

* Terminology
  + Definition of the classically used terms
  + Numerous definitions are currently used, slightly different: concepts of Management, Coordination, Control, Synchronization, Regulation, Harmonization
  + Understanding of how the same terms can have different meanings depending on the user or use case.
* Framework and scope of activities
* Mapping these into useful community-wide ontologies and schema that support developing digital libraries and dictionaries as well as underpinning data science/analytics.

1. Improving & Increasing knowledge of the orbital population, active or debris

* New means to do so
  + Radars, telescopes, lasers
  + Including private, e.g. private optical networks, commercial radars, commercial fusion, prediction and analytics SSA and STM centers

⮱ Potential recommendation: study and promote new systems, such as in-orbit sensors, laser detection from ground or from orbit, etc.

* Data fusion process
  + Merging information coming from various sensors and sources
  + Observation/data integration and aggregate utilization

⮱ Potential recommendation: share methodologies at international level

* Improvement of orbital data precision and accuracy (i.e. uncertainty quantification)
  + Improved computational means and filters
  + Self-reporting by space objects using on-board PNT receivers
  + Use of star background
  + Laser ranging from ground or orbit
  + Uncertainty represented as aleatory and/or epistemic

⮱ May be one of the top priorities

* Improvement of the UN registration (could be part of IAA-IISL WG)
  + Currently rather poor despite regulation
  + Stress the need to record end of operations
  + Determine and advocate for the Essential Elements of Information (EEI) required for a meaningful registration that supports the tenets of successful STM, specifically unique space object identification and recognition.
  + Reduce the number of objects unidentified at launch, which thus cannot be registered

⮱ Potential recommendation: could there be a systematic pre-registration prior to any launch?

* Shared catalog
  + Question of protection of the data: legal solutions?
  + Question of military systems
  + Merging (data fusion, not just using individual outputs) information coming from various independent SSA networks; utility of data sources

⮱ Question of the reference source for such catalog (or multiple sources?)

1. Use of such information

* Space capacity management
  + Space Traffic Footprint
  + Space Sustainability Rating
  + Capacity coordination
* Improvement of the collision avoidance process
  + Comprehensive examination of current and proposed Go/No-Go collision avoidance metrics, assessment algorithms, including collision probability evaluation at all levels of fidelity (linear, non-linear collision probability, incorporation of mass, size and other space object metadata, modeling of space objects as spheres vs aspherical object mappings) to achieve a shared understanding
  + Examination of the sensitivity of those Go/No-Go avoidance metrics to data quality.
  + Categorization of errors introduced as an integral part of the orbit determination process, versus those introduced during the forward prediction process, and how those errors degrade conjunction assessment and Go/No-Go metrics.
  + Specific problems associated with electric propulsion on large constellations
  + Maneuver coordination
  + Interconnection with data quality

⮱ Potential recommendation: sharing at ISO level through dedicated technical standards

* + Go/No-Go criteria thresholds
  + Data exchange protocols and standards developed at the international level (e.g., ISO SC13/CCSDS)
  + Examine existing international standards for sharing space object data, e.g., International Virtual Observatory

⮱ Determine if further harmonization of IADC guidelines and ISO standards is required.

* Use for future operations
  + Space tugs, In Orbit Servicing, In Orbit Manufacturing
  + Massive constellations
  + Sub-orbital activities
  + Ground support activities such as spaceports
  + Transits through airspace (launch and controlled/uncontrolled re-entry)
* Operations and requirements
* Enabling Technologies
* Networking among several actors, showing what is being done in different Countries
* Preparation of future activities
  + ADR: Removal of the relevant debris from crowded orbits to avoid statistical collisions
  + JCA: Nudging of a debris to avoid a predicted collision
  + LDTM: Cataloging of large orbital debris and light nudging to avoid further critical situations

⮱ Potential recommendation: identify a shared position at international level (IAA studies, IADC tasks, National studies, …)

1. Technical regulations

* Can be based on ISO
  + Converged at international level since more than 10 years
  + Coherent with IADC and National Standards established 20+ years ago
  + Already applied by ESA and China; very close to French Technical Regulation
  + Dedicated NWIP on STM within ISO WG3
* Numerous new and/or ongoing activities
  + ISO standard for collision probability calculation and impact risk assessment
  + Inclusion of recommended thresholds for human spaceflight, active spacecraft in the standard
  + ISO standard for the casualty risk calculation
  + Inclusion of a threshold in the standard
  + On-Orbit Servicing (OOS)
* But new activities required
  + Shall include elements related to Space Tugs, IOS, ADR, JCA, LDTM
  + Shall include sub-orbital
  + Can include criteria for risk based evaluations, and acceptance, of certain operations
  + May include Spaceports
* Major question: why are the Mitigation Rules so badly complied to?
  + Education: Systematic inclusion of ISO in any contract
  + Naming & Shaming
  + Immature on-board technology for mitigation
  + Compliance file prepared before any space operation, transparent follow-up by the launching state
  + Examine how changes to debris mitigation guidelines could reduce STM burdens

1. Outreach

* How to pass efficiently the messages and reach consensus over the proposed actions?
* Who should we address, when, where, at which step of discussion: An essential link to operators is required, as they will be affected most. This might require some dedicated fora / workshop with discussions on this topic as sole focus.
* Should also have outreach to satellite manufacturers regarding design for demise and disposal

Members are invited to add to this list of activities.

The WG may decide to sort the findings and recommendations following 3 parts (to be discussed):

* Part 1 towards entities responsible for Program or Projects (i.e., R&D and/or analysis)
* Part 2 towards entities in charge of Design and Manufacturing
* Part 3 towards entities in charge of Operations

**Execution of Working Group**

The work will primarily be performed using the dedicated IAF Exchange Platform which will be put in place in the coming days, as well as e-mail exchanges. Specific meetings will take place during IAC Spring Meetings and Congresses.

The Organizing Board is composed of Christophe Bonnal (IAF, nominated by IAF President), Darren McKnight (Centauri, USA), Serge Plattard (University College London, Head of IAF Space Security Committee, acting as secretary).