

Report 1 of the AIAA Space Traffic Management Working Group's Task-group 1 Lexicon activity

Version 5 – 24 November 2020, with 2021 corrections.

Written by Robert J. Rovetto¹

Co-lead of AIAA STM TG1 lexicon Task.

rrovetto@terpalum.umd.edu

ontologos@yahoo.com

Contributors: Angela Peura²

Co-lead of AIAA STM TG1 lexicon task.

apeura@asrcfederal.com

Acknowledgements: Dr. Ruth Stillwell³ for reviewing this and associated documents.

Abstract

This is an initial report of the activities and input of Task Group 1 of the American Institute of Aeronautics and Astronautics Space Traffic Management Working Group (AIAA STM WG TG1) [1] Lexicon task. This report covers an approximate period from May 2020 to 20 October 2020. The activity produced an output of a preliminary catalog of STM-relevant terms and definitions, focusing on 'STM' and 'SSA' as an initial step in the activity. The spreadsheet catalog also contains some analysis and discussion. This report represents a second output document for the activity. The work is consistent with the originally-listed WG tasks in the 2019 synthesized document, having begun a few of the tasks listed in that document. Further development to continue the activity is recommended, and some future work is described.

AIAA website link to this document:

<https://engage.aiaa.org/viewdocument/report-1-v2-lexicon-task-tg1?CommunityKey=29551ad4-cfbb-4fda-9c4c-a64b3dba0485&tab=librarydocuments&LibraryFolderKey=&DefaultView=folder>

¹ NASA Datanauts. Center for Orbital Debris Education & Research, Univ. Maryland. IAF. ISO. AIAA.

Ontologist, Aerospace Terminologist, Knowledge Modeler (<http://ontospace.wordpress.com>, [Articles](#))

² NASA SCAN, apeura@asrcfederal.com

³ Lead of AIAA STM Working Group TG1. ruth.stilwell@gmail.com

Table of Contents

Abstract.....	1
1. Context.....	3
2. Overarching Goals.....	3
3. Administrative.....	3
4. Methodology.....	4
5. References & Sources of Content.....	5
6. Completed & Living Tasks.....	6
7. Findings, Input and Recommendations.....	9
7.1 Miscellaneous Findings.....	9
7.2 Findings on Domestic (USA) senses of ‘STM’ & ‘SSA’ terms.....	9
7.3 Findings from international context (considering all source material).....	10
7.4 TG1-TG3 on SSA & STM Features.....	12
7.5 Toward development of an STM Lexicon.....	14
7.6 Limitations and Obstacles.....	15
8. Sample uses of this work outside of AIAA.....	15
9. Future Work & Additional Recommendations.....	16
10. References.....	17

1. Context

There are evolving and emerging concepts of space traffic management in the global community. However, we read:

"there is no international consensus today on a characterization and delimitation of STM, leaving significant margin to adapt the concept to the various views and needs of different organizations" (p.6 of ESPI Report 71, January 2020) [2]

"With the rapidly evolving nature of the domain, there is widespread variation in definitions of core terms. Moreover, a comprehensive list of widely agreed upon capabilities that constitute SSA/STM functions is not available." (STM NAPA Report, August 2020) [3]

The AIAA STM WG Charter lists a lexicon and problem statement as output. The AIAA STM WG TG1 is tasked with lexicon/vocabulary work, as mentioned in the document entitled "[WG Task 1 synthesized notes 28Feb19.docx](#)", online at the original AIAA STM WG TG1 GoogleDrive webpage https://drive.google.com/drive/u/5/folders/1_AI4KJBjcvthYUHprKazM_QZSZpL4R9T [10]. Note that the GoogleDrive link to the AIAA STM WG is listed in reference [11].

2. Overarching Goals

- Extract high level definitions related to Space Traffic Management to determine where there is a clear understanding, whether (and where) there is divergence within the space community, and identify or recommend resolutions.
 - *Domestic sub-task*: Assessment of common understanding, or lack thereof, among relevant terms within the USA. Is there common understanding?
 - *Global perspective task*: Assessment of common understanding, or lack thereof, among relevant terms across nation-states.
 - This raises the question of what are the relevant terms (*scoping*).
- Help establish problem statement. Is there a problem?
- *Lexicon development*: identification and/or creation of a set of terms & definitions relevant to the evolving concept of STM, and/or for 'space traffic coordination' ('STC'). This goal is both in-progress, and for future work by the AIAA STM WG.

3. Administrative

Toward garnering engagement in this task, the co-leads—Angela and Robert—solicited the AIAA STM WG via the WG email list in early 2020. No response. The co-leads reiterated that call-to-participate via a follow-up email as well as live at the August 2020 AIAA STM WG meeting. The originally-listed persons on the 2019 lexicon task description (see GoogleDrive link) were also asked if they had continued interest, to which 1-2 confirmed. In September 2020, three new participants joined: Marina Hague (NOAA Affiliate, USA), Tomas Hrozensky (ESPI, Europe), Regina Peldszus (DLR, Germany).

4. Methodology

- *Consider global content & context:* terms & descriptions originating from sources (persons, publications, organizations, etc.) in various nation-states, and from various types of corpus source material documents (research articles, (inter)national standards documents, etc.).
- *Consider domestic* U.S. government content as a sub-task.
- *Identify questions* relevant for the lexicon task
- *Solicit input* from AIAA STM WG: emailed solicitation, and expressed during STM meeting
- *Liase* with STM WG Task Group 3 (TG3).
- *Collect corpus material*
 - co-lead A.Peura provided a number of national/international standards documents
 - co-lead R.Rovetto provided many types of documents from his personal library & from his research during the activity time-period.
 - *September-October:* some participants provided some EU documents
 - drew on AIAA STM TG3 nation-specific folders (via original STM WG GoogleDrive webpage).
 - conducted internet searches
- *Starting point:* The co-leads decided to focus on a couple of critical terms—‘space situational awareness’ (or ‘ssa’) and ‘space traffic management’ (or ‘stm’), and expand the lexicon in future work. This starting point involved researching, locating, cataloging and comparing definitions.
 - Co-lead R.Rovetto manually reviewed & searched the approximately 50 source documents for these and other terms, identifying those explicitly defined in the source
 - manually collected terms & definitions into a spreadsheet for this task
 - extracted terms & definitions from:
 - source documents (5.ii below)
 - Prior & ongoing work [4] (see 5.i below)
 - manually researched the original source of definitions where some documents referred to other definitions
 - placed on a GoogleDoc, intended for the team to review and provide input
- When members joined the TG1, the co-leads solicited (via email and in team meetings) any recommendations, questions, and suggested terms and definitions for a potential STM lexicon
- Identification of recurrent themes and/or framing analysis in the selected terms.
- Partial conceptual analysis (Also for *future work*)
 - Conceptual, semantic, ontological, philosophical, linguistic examination (5.i below)
- Created additional spreadsheet for using ATM & other traffic management systems as model
 - To help inform and potentially structure a future lexicon
 - To help identify or create essential concepts and terms
 - Placed on a GoogleDoc for the team to add content.
- Created term groupings/categories to help organize the development of a future STM lexicon
 - To help identify or create terms falling under that grouping
 - Placed on a GoogleDoc for the team to add content.

- R.Rovetto suggested lexicon development first principles toward a systematic approach:
 - Aim for terms and definitions that closely match one another
 - One is not broader than the other
 - One is not more specific than the other
 - These may be applied in future work, including for more advanced applications.

5. References & Sources of Content

The following lists two groupings of references/source documents used: pre-existing work by a TG1 member, and additional corpus source material in the international community, etc.

- i. The lexicon catalog content, and approach to tasks, and drawn in part from, co-lead R.Rovetto's pre-existing and ongoing work to catalog, compare and conceptually analyze generic but key astronomical concepts and terms [4][5]. Both the AIAA and his efforts have overlapping goals and content. See [4][5], e.g., <https://github.com/rrovetto/Astronautics-Terminology> [4]
 - <https://purl.org/space-ontology> and <https://ontospace.wordpress.com/>[5]
 - Some of the AIAA lexicon spreadsheet content (terms & definitions) are duplicated from that work, i.e., drawn from a larger living spreadsheet [4] containing many domain terms and their definitions.
 - Similar *methodology and analysis*:
 - Examine content from multiple perspectives: conceptual, semantic, linguistic, ontological, ...
 - Ideally toward neutral, more objective, detailed, accurate and systematic task execution...
 - in order to help create accurate, comprehensible and potentially standard vocabularies (e.g., for AIAA or the broader (inter)national community).
R.Rovetto's additional interest: and to potentially create computable knowledge organization systems for the astronautics or space domain community [5].
- ii. Sources and authors of definitions are listed in the appropriate column within the resulting lexical catalog spreadsheet document. Titles, names, dates, and websites are included.

STM-relevant Corpus Source Material:

- National and international documents, e.g., U.S. government documents, Europe, etc.
- Academic, research, study articles or publications, e.g., from spaceflight conferences
- Books, glossaries, thesauri
- (Inter)national standards development documents, e.g., from:
 - CCSDS: Consultative Committee for Space Data Standards
 - ISO: International Organization for Standardization
 - ECSS: European Cooperation for Space Standardization
 - Misc.
- Internet searches/content, e.g., misc. websites

6. Completed & Living Tasks

The following summarizes completed work, and indicates living tasks which may be future work. In short, a lexicon catalog is one output document (6.i, below), and this report is another. Additionally, two approaches were set up by R.Rovetto: one is a collaborative online team environment was setup to explore potential directions to encourage participation and facilitated task-execution (6.ii). The second, is use of automated techniques to extract terms (6.iii).

i. Cataloged a non-exhaustive list of definitions of ‘SSA’ and ‘STM’ (a living task for future work)

- SSA: 39 definitions
- STM: 19 definitions

Sample cataloging of miscellaneous, but related, terms. To be determined as refinement of scope takes place. (also for future work)

OUTPUT: a spreadsheet document (images below) composed of multiple tabs/sheets containing term lists, definitions, considerations/questions, etc. A partial listing of related terms and definitions was conducted to form this lexicon catalog. A copy of the catalog document, along with this report, was provided via email to the AIAA STM WG Lexicon group (group 1) lead and other leadership. It also remains online in a GoogleDocument/GoogleDrive page.

	A	B	C	D
1	Title of this document:	Space Traffic Management (STM) Lexical Catalog		
2	Alternative titles:	Space Traffic Coordination and Management Lexicon		
3	Version:	1 (revision 5May2020-6Oct2020)		
4	Document Status	Working Draft		
5	Author:			
6	Corresponding developer:	Robert J. Rovetto		
7	Author Email:	rrovetto@terpalum.umd.edu		
8	Author Affiliations:	AIAA STM Working Group, Task Group 1, Co-lead of STM Lexicon task. AIAA Space Architecture Committee on Standards. IAF STM Technical Committee, IAF Space Debris Committee. ISO Space Systems committees. Center for Orbital Debris Education & Research (CODER), Univ. MD. NASA Datanauts.		
9	Contributors:	Robert J. Rovetto (AIAA groups, NASA Datanauts, CODER Univ. MD) Angela Peura (NASA ScaN, ASRC Federal.), Co-lead on this AIAA STM Lexicon task, angela.peura@gmail.com		
10	Context:	"there is no international consensus today on a characterization and delimitation of STM, leaving significant margin to adapt the concept to the various views and needs of different organizations" (P6 "ESPI Report 71 - Towards a European Approach to Space Traffic Management - Full Report" (January 2020)) "With the rapidly evolving nature of the domain, there is widespread variation in definitions of core terms. Moreover, a comprehensive list of widely agreed upon capabilities that constitute SSA/STM functions is not available." (Space Traffic Management NAPA Report, August 2020) The AIAA WG Charter [1], and the "WG Task 1 synthesized notes 28Feb19" [2] document, task the WG to develop a lexicon, specifically to: Capture the Common Vocabulary (Item 3), including where the terms are found and defined (items 3a,3b); the legal or technical effect their definitions have, if any(item 3c); identifying gaps in terms and definitions; and take inventory of existing papers and research products (Item 5). This spreadsheet is part of this lexicon compilation task, assigned to Task Group 1 of the AIAA STM WG. As of the time of this writing Robert J. Rovetto and Angela Peura are co-leads for this task within TGL. This spreadsheet document is a non-exhaustive living catalog of terms and their definitions (Item 3) related to the evolving concept of space traffic management, and the existing concept of space situational awareness, including related concepts. It includes the sources of these terms & definitions, which also serves as an inventory of existing papers (Item 5).		
11	About this document:	In the course of developing this in-progress document, we aim to: (a) identify the terms and definitions relevant for the subject of STM; (b) to identify what terms need common agreement among the international community, in part by comparing definitions or lack thereof; (c) identify commonly understood or defined terms in the domestic landscape (e.g., USA); (d) develop terms where none exist. (e) provide observations and recommendations for terms and definitions, e.g., corrections, etc. [1] https://drive.google.com/file/d/1o7p7h7azpccpqpFO92e5rAkARm6F4KA/view?usp=sharing [2] https://drive.google.com/file/d/1s1NB2WFRPGC_GyW0b777Gz8kM9F1_2Q/view?usp=sharing		

Fig.1: Screen-capture of a version of the AIAA STM Lexicon Catalog

Term & Def. ID	Source	Definition or Description	Key concepts
1	United States Space "Secure World Foundation"	"the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and sustainability of operations in the space environment"	coordination of activities traffic hazard mitigation measures. Prevent hazardous events leading to
2	"Space traffic Management", Ailor, William. In the Handbook of Characteristics of Spacecraft, Space Traffic Control Service, focus on safety, best practices	"refers to measures taken to minimize or mitigate the negative impacts of the increasing physical congestion in space. The goal of STM is to try to eliminate future collisions and other incidents in space that could create additional debris or other safety risks for space activities, and to increase the safety and efficiency of space activities."	
3	"Space traffic Management", Ailor, William. In the Handbook of Characteristics of Spacecraft, Space Traffic Control Service, focus on safety, best practices	"an organized process that assures the long-term use of space and space assets without harmful interference. Space traffic management includes policies, regulations, services, and information that: <ul style="list-style-type: none"> Minimize the possibility of short- and long-term collisions, radio frequency, or other interference among orbiting objects, both operating satellites and debris Assure compliance with rules and regulations imposed by governments and with best practices adopted by launch and satellite operators Minimize interference with and by non-satellite operations such as ground-based telescopes and directed energy sources Provide warnings to minimize possibilities of loss of operations or other detrimental effects resulting from space weather and other predictable events" <i>The author, Ailor, lists these requirements for STM:</i> Knowledge of the Orbital Environment, Standard Formats for Data Exchange, Knowledge of Ownership and Operating Characteristics of Spacecraft, Space Traffic Control Service, focus on safety, best practices	a process for ensuring use of space. Policies, regs, services, information.

Fig.2: Screen-capture of a version of the AIAA STM Lexicon Catalog, 'STM' tab

ii. Set up real-time visual collaboration platform:

AIAA STM WG TG1 Lexicon Team - Dynamic Work Space

Description

This Miro collaboration platform is being used as a test-bed work space for the TG1 Lexicon team execute the Lexicon task. The AIAA STM WG TG1 Lexicon task involves identifying problems, gaps, or lack thereof in terminology relevant for STM/STC, as well as the development or collection of terms for an STM Lexicon.

Note To Team

Feel free to add content, brainstorm, etc.

Target Audience

This Miro document is intended for the AIAA Space Traffic Management (STM) Task Group (TG) 1 Lexicon team and TG1 leadership. The outputs of this activity may be of interest to the spaceflight community as well as lexographers, terminology and policy practitioners, e.g., spacefaring nations, astronautical enterprises, spaceflight policy groups, academia, the linguistics discipline, etc.

Fig.3: Screen-capture of a the Miro [8] collaboration workspace for TG1

Rationale: This workspace was created to serve as a test-bed, exploring the potential utility of this tool to help in executing this task, e.g., for collaborative brainstorming, clarifying concepts, etc.

- iii. **To explore automated, possibly data mining or related, approaches. (potential future task)**
 After the above tasks were completed, a text-extraction tool was used to generate the following word cloud (and corresponding CSV document) in Sept 2020. The 2020 National Academy of Public Administration (NAPA) STM publication was used as the input document for the generator tool. The below images show 20-100 most used terms in the doc.

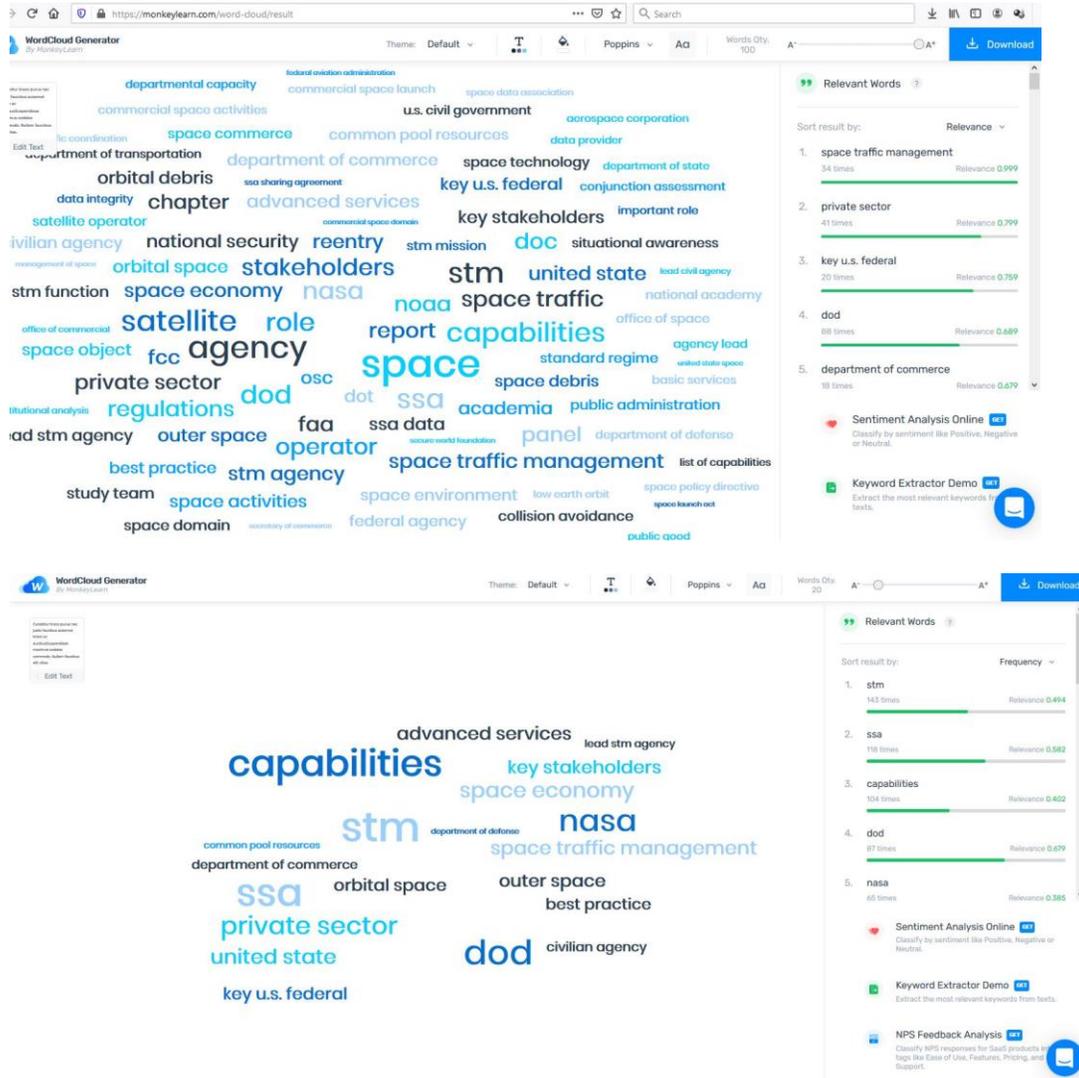


Fig.4 & 5. Screen-captures of a Word Cloud [9] results using

Rationale: This was executed to explore the potential utility of such tools to support our task.

- iv. R.Rovetto recommended comparison of traffic management systems with the concept of STM
- To identify candidate analogous features, objectives, services of STM
 - To identify term groupings, accordingly, for an STM lexicon
 - A separate spreadsheet document was created and provided to the team online

7. Findings, Input and Recommendations

The following provides preliminary findings, limitations, and input about the task thus far. Note that the provided lexicon spreadsheet also lists some input by some task group members. In all, this work activity has been consistent with the originally-listed AIAA WG TG1 tasks in the 2019 synthesized document [10], having begun a few of the tasks listed in that document; a spreadsheet, and item 3 & 5 (capturing vocabulary, and taking inventory of existing and relevant articles, publications, etc.). Future steps will continue these tasks and other activities.

7.1 Miscellaneous Findings

Re: Text-extraction tool (task 6.iii), the computer-generated word cloud tool is described as displaying popular phrases based on frequency and relevance. Limitations and caution-areas are:

- We do not know its workings or technical specification, e.g., what determines relevance for the particular tool. Consider that one user may place importance on the frequency of terms within the main body of a given document, but not the bibliography; whereas another user may include the bibliography.
- The word cloud provides an *approximate* pointer to potential STM-relevant terms, but this is not guaranteed. It requires manual verification of their relevance. For example, some terms presented in the Word Cloud are not relevant, while others are cross-disciplinary and not unique to the concept of STM. Note: the use of cross-disciplinary terms for STM may be desired, and is recommended for future work of this activity.
- After testing the results by manually searching for some of the terms displayed by the Word Cloud documents, the frequencies were found to be inaccurate, but approximate. It is possible that the paid version of the tool may provide more accurate results.

7.2 Findings on Domestic (USA) senses of 'STM' & 'SSA' terms

- I. **There tends to be similar descriptions of space situational awareness (SSA) across the selected domestic source documents** (ranging from years 2004-2020). Definitions of 'ssa' exhibit some common features. SSA is understood as involving:
 - observation/monitoring/surveillance
 - detecting, tracking, identifying orbital objects
 - acquiring past and present knowledge of the observed environment & objects
 - generating predictions / predictive knowledge
 - characterization the environment and the observed objects
 - the overarching goal of spaceflight safety

Most descriptions mention **knowledge** and **characterization** of the given environment, and either (or both) occurrences and objects therein. **Capability** is also frequently mentioned. This commonality may, in part, be due to the fact that most definitions are variations of one another (e.g., similar if not identical phrases). Many are from military sources, and thereby view SSA

through a lens of potential threats to national security. Domestically, SSA has historically been the purview of military or government, and their definitions tend to include these generic aspects. Some, but not all, definitions from government documents mention more specific aspects (e.g., the tasks, components, requirements or dependencies of SSA) such as knowing the location of observed objects, activities of spacecraft, determination of their capabilities, etc. Historically these military-centric descriptions explicitly mention **security**. But mention of **safety** appears more prevalent in recent documents. Finally, ‘space domain awareness’, recently used by the USAF, has been largely understood as SSA. This is demonstrated by the recent USAF memo to internally use the former for the latter.

The **less common features of SSA** as found in the selected government source documents are:

- information cataloging of the observed objects
- collision avoidance activities

- II. The two domestic documents mentioning ‘**STM**’ have similar descriptions. Some consider the two definitions different. One definition mentions ‘nations’, the other does not.

The **commonalities among the two STM definitions** are:

- assurance of spaceflight *safety*
- assurance of *operations* in the orbital environment
- decision-making
- *coordination* of on-orbit activities

Further data (and examination) is needed for this term.

A member in the task group (Marina Hague) expressed that although there is still disparity in term usage, it was her opinion that prior confusion of terms used in the global theatre has been partially resolved via internal dialogs (e.g., DoC and EU) after the release of SPD3.

7.3 Findings from international context (considering all source material)

- III. When comparing all collected definitions of ‘**STM**’, these **additional commonalities are found**:

- *regulation* of activities
- rules, guidelines, norms, recommendations
- *coordination* of orbital and orbit-access activities
- the overarching goal of spaceflight and terrestrial *safety*
- the assurance of a *sustainable orbital spaceflight environment*

- IV. Less frequently mentioned aspects in **SSA** definitions include:

- assessing the intent of an spacecraft operator
- assessing the capabilities of a spacecraft
- space weather⁴

⁴ This can, however, be inferred from the observational aspect.

DISCUSSION: with the recent USAF use of ‘space domain awareness’ (SDA), some have distinguished it as providing location, intent and capabilities of the objects in orbit, and SSA as providing locational information in orbit. However, we must note that the current sense of ‘SDA’ has been the sense of SSA prior to the former’s introduction by the USAF. Whether a distinction or distinct terms are really needed or helpful is to be determined and open to debate. In any case, there is more to unpack, examine and clarify, conceptually and otherwise.

V. **Other terms:** There are **inaccurate definitions** of other terms.

- *Example:* ‘orbital debris’ is often defined as synonymous with ‘space debris’ and defined as artificial Earth-orbiting objects. This is incorrect from more than one perspective if adopting some terminological guidelines: the term ‘space debris’ is inherently broader than ‘orbital debris’, unless all locations in space are subject to orbital motion. If there can be debris that is not human-made, then the definition is too narrow. Finally, the term ‘orbital debris’ can be rightly used to denote debris in orbit about another celestial body, not exclusively Earth.
- *Example:* ‘space object’ is often defined as artificial orbiting objects, but this is incorrect from some perspectives as well. For example, natural celestial bodies like the Earth can correctly be described as a space object; that is, the astronomical community can use the term for any astronomical object. The generality of the term ‘space object’ and its highly generic constituent words (‘space’, ‘object’) makes it problematic to define it more narrowly in the above manner.

7.4 TG1-TG3 on SSA & STM Features

A set of attributes of SSA and STM was described by some members of the TG3 (Task Group 3) in their related work (see D.Oltrogge et al.), and a PPT was distributed to our TG1. In TG1, we ask the question whether each attribute is indeed part of SSA and STM, respectively. The following tables provide answers from TG1. The purpose of this particular activity was two-fold: one, to better link the two task groups in an effort to coordinate and utilize work or content from the overall WG; and two, to identify or designate central features and activities of STM and SSA. The second—identifying activities that are or should be accurately associated with STM and SSA—is recommended by R.Rovetto to better crystalize the concepts (and future systems) to help formulate definitions and terminology. The minimum criteria or assumption is that both STM and SSA involve ensuring spaceflight safety.

<i>Is the item listed in the left column part of SSA?</i>	
(Baseline criteria: ensuring safety of spaceflight)	
SSA attributes (as presented in a PPT distributed by TG3 Dan Oltrogge to the TG)	TG1 input
characterization of Earth-based space capabilities	TBD. The characterization of capabilities may be a national security task for each nation.
characterization of operating environment	Yes. SSA necessarily calls for understanding the operational environment--the interrelations among various aspects, not simply object tracking. However, the degree of detail may depend on the capabilities of the SSA system
characterization of space-based capabilities	TBD. The char of capabilities may be a national security task for each nation
comprehensive knowledge and status of objects	Comprehensive is relative. A minimal set of information about objects is sufficient for internationally shareable SSA information. More than that may call for capabilities that only national security agencies possess, but today commercial ventures may have.
current and future knowledge	Yes
identification of bad actors in space	Because this is an assessment, one that indicates an opinion in the context of a normative framework, it appears to be more appropriate for STM or for nation-specific authorities.
monitoring multinational space readiness	TBD. This appears to a nation-security focus. But as the concept of STM/STC evolves, it may be a function of one or more STM systems/organizations.
near-earth objects	Yes
protect assets to function as designed	A consequence of SSA is the ability to protect. But the action of protecting is the responsibility of the given nation or org.
radio emission	Yes, the awareness of these emission to the extent they provide risk to safety of flight
safe, sustainable and stable activities	Yes, but ssa affords these activities because at its core ssa is about knowledge
space and terrestrial weather	Yes, but within the limits of info that shows a causal impact on safety of flight.
space domain awareness and analysis	Historically, this had same meaning as SSA. May be the same as SSA, but additional elements such as determining capability, liability, and responsibility. Recent US mil. focus. However, some terminological/semantic problems.
threat monitoring and risk assessment	Yes
timely, relevant, accurate, actionable	Yes
understand and predict space object physical locations	Yes

<i>Is the item listed in the left column part of STM?</i>	
(Baseline criteria: ensuring safety of spaceflight)	
STM attributes (as presented in a PPT distributed to the TG)	TG1 Input
Practices, standards, tech	yes
Free from physical interference	yes (an STM system/org. would presumably/minimally provide information about actual & potential physical interference. But resultant actions likely up to each nation/operator.)
Free from RF interference	yes (STM system/org. minimally provides information about actual/potential RF interference. But any resultant actions likely up to each nation/operator)
Info security	yes (STM system/org. minimally provides information about info security. But any resultant actions likely up to each nation/operator)
Monitoring & notifications	yes (those notifications that are common and needed across nations)
On-orbit collision avoidance	yes (STM system/org. minimally provides information about this. But more detailed information conceivably provided by national security orgs)
Plan, coordinate, synchronize activities	Yes
Pre-launch risk assessment	yes, but in concert with local launch authorities and jurisdictions
Safe launch	yes in sense of providing information to ensure safe launch, info sharing with local launch authorities
Safe Orbit operations	yes, but in concert with local launch authorities and jurisdictions
Safe return from space	yes, but conceivable that STM purview is orbital space, and handed over once within atmosphere
SSA	yes. A prerequisite to ensure safety. But sources of SSA is to be determined.
Licensing and allocation	Yes, but they are common international aspects. In concert with nation-specific licensing
Regulatory	Yes
Rules of the road	yes, but orbital traffic rules should be established internationally, analogous to maritime navigational rules.
Traffic control/enforcement	TBD. Enforcement may be a national responsibility, but STM should aim to encourage conformance to an international traffic patterns to ensure safety. What form it will take is TBD.

7.5 Toward development of an STM Lexicon

- VI. An STM lexicon *may be designed in at least two ways*:
- As a selection of relevant terms used in other disciplines, e.g., ‘spacecraft’, ‘orbital debris mitigation’ with no claim to being unique to the concept of STM/STC.
 - As an STM-specific lexicon or controlled vocabulary: a set of terms unique to STM, which may partially or entirely consist of custom-made terms and their definitions.
- VII. Strategy (b) may be needed if and when actual STM systems or organizations are created. These future systems/orgs. may develop jargon unique or internal to their enterprise. They may modify existing cross-disciplinary terms for their own use.
- VIII. *An STM-specific lexicon will partially depend on the future*, i.e., on what STM systems or organizations will look like: their specific services, objectives, organizational structure, whether they have a need for internal jargon, etc. This is one reason R.Rovetto recommends considering activities of STM (and SSA) as an early task. However, this does not prevent us, now, from proposing a STM lexicon by either VI.a or VI.b.
- IX. For example, terms relevant for STM/STC may partially depend on a future state, as well as our current concepts about STM/STC, e.g., terms about...
- the objectives, functions, and services of and STM system/org.,
 - the regulations/guidelines recommended or required by an STM system/org.
 - communications protocols and procedures by STM system/org,
 - SSA activities of an STM system/org.
 - traffic and vehicle terms used by an STM system/org.
- These bullet-points (or variations thereof) represent candidate groupings of terms (mentioned in sections 4 and 6.iv of this report) to systematically formulate and organize a future STM lexicon.*
- X. Until STM systems or organizations are created, we have available *cross-disciplinary terms* that are *not* unique to the concept of STM/STC, but relevant to it.
- These cross-disciplinary terms may be used or defined in a specific fashion within an STM system or org. Time will tell.
- XI. Identifying the common goals and features of *traffic management* (in general), and air, ground and marine traffic management (specifically), can inform the crystallization of an STM/STC concept. R.Rovetto recommends this as another approach.
- XII. *Terms relevant for STM, or for an STM lexicon, will dynamically evolve* as the currently evolving concept of STM/STC develops and crystalizes.

- XIII. The fundamentals of SSA and STM/STC appear to be relatively and clearly understood.
- **A fundamental safety objective:** ensuring safety is, or should be, a common and indisputable thread between SSA and STM (and STC). One can argue that even a concept of military SSA has safety (for mil. and domestic assets) as an essential goal, despite the fact that security rather safety may be more frequently mentioned.
 - **Decision-support** is a necessary goal of STM and STC, but has a stronger stripe toward regulation and adherence to consistent behaviors for mutual safety.
 - **The observation/monitoring/surveillance and tracking**—by national, international, commercial and private actors—are necessary prerequisites for STM and STC.
 - Some existing definitions are incorrect or inaccurate. They may suffice context-specifically (e.g., for the purposes of a specific document), but not more broadly or universally; their context-specific meaning may not be more widely applicable.
- XIV. As an evolving concept, STM calls for further development and understanding in any case.

7.6 Limitations and Obstacles

Limitations and obstacles included the finite set of source documents, finite human resources, minimal response, and the classic challenges of terminology agreement. For example, the initial solicitations for participation in the task-group did not yield replies. Three new members joined a month prior to the end of the activity time-period. Delegation of tasks and consensus-building in a small team was thereby challenging. In all, input was limited. The overall lack of response may or may not have been due to such things as: lack of interest on part of those solicited, other priorities, lack of knowledge/expertise on the topic, etc. A wider call for participation on aerospace listserves may have produced more interest, and is therefore a potential action for future continuation of this activity. For future work, R.Rovetto, who has a focus on aerospace terminology [4] and semantic modeling [5-7], can also recommend additional formal and systematic methods to vocabulary development, concept system formation, and conceptual analysis.

8. Sample uses of this work outside of AIAA

This activity was mentioned in the AIAA ASCEND conference by Dr. Stillwell, where preliminary results were presented. www.ascend.events/timetable/event/roadmap-governance-and-operational-demonstration-of-space-traffic-coordination-and-management/

As of 2021, this work has been cited and used in the ongoing International Astronautical Federation (IAF) Space Traffic Management Technical Committee terminology sub-group.

9. Future Work & Additional Recommendations

Future work for the AIAA STM WG TG1 lexicon task should involve such things as expanding the STM lexicon catalog, examining and collecting additional terms relevant to the STM construct, forming terms or definitions were needed, detailed gap analysis, and the below recommendation. Tasks may, for instance, be conducted in a similar manner as TG1 performed with the terms ‘space traffic management’ and ‘space situational awareness’. If desired, the task-group can then recommend a particular definition of each for the AIAA or other communities. The first step of focusing on SSA and STM definitions provides a starting point and focus from which further development can continue.

A particular recommendation for future work is as follows.

Desiderata / Recommendation: Find actual examples and first-hand cases of communication or terminological problems between actors in the SSA and spacecraft operations domain. Ask questions such as:

- Have specific agencies or aeronautical companies had problems with regard to terminology?
- Have agencies or companies had problems with communicating with one another due to terminological issues?
- Can these actors share information about the problems? (or what is needed to attain detailed information, from the actors, about problems they faced)

Potential Examples of problems or causes of problems include: unclear terms, confusion over meaning of a term, problems in electronic exchanges, difficulty in expressing the meaning of data elements or terms in electronic communications, etc.

Executing this recommendation in future work will help determine, with greater confidence, if there is a problem, what challenges it has caused, and how to resolve it (i.e. the problem statement overarching goal mentioned in section 2, above).

Finally, discussions and brainstorming (among AIAA STM WG members, AIAA, and astronautics stakeholders more broadly) on the concept of STM and future systems will likely aid in the formation of a lexicon.

10. References

- [1] AIAA STM WG online portal via AIAA Engage website
<https://engage.aiaa.org/communities/community-home?CommunityKey=bc9023a2-a293-4218-a6a9-1b949409437f>
Task-Group 1 AIAA webpage:
<https://engage.aiaa.org/communities/community-home?CommunityKey=29551ad4-cfbb-4fda-9c4c-a64b3dba0485>
- [2] “Towards a European Approach to Space Traffic Management - Full Report”, European Space Policy Institute (ESPI) – Report 71 (January 2020). Online: <https://espi.or.at/publications/espi-public-reports>
- [3] “Space Traffic Management: Assessment of the Feasibility, Expected Effectiveness, and Funding Implications of a Transfer of Space Traffic Management Functions”, National Academy of Public Administration (NAPA) - For the Office of Space Commerce, the Department of Commerce (August 2020).
- <https://www.napawash.org/studies/academy-studies/united-states-department-of-commerce-office-of-space-commerce>
 - https://www.napawash.org/uploads/NAPA_OSC_Final_Report.pdf
- [4] Astronautics Terminology Catalog, Robert J. Rovetto. <https://github.com/rrovetto/Astronautics-Terminology>
- [5] Orbital Space Domain Knowledge Modeling, Robert J. Rovetto.
Online: <https://purl.org/space-ontology> and <https://ontospace.wordpress.com/>
- [6] “Orbital Debris Ontology, Terminology, and Knowledge Modeling”, T.S. Kelso, and D.A. O’Neil, and R.J. Rovetto. Presented at *1st International Orbital Debris Conference* (2019). In *Journal of Space Safety Engineering* (2020)
- NASA NTRS: <https://ntrs.nasa.gov/citations/20200000988>
 - Journal SSE: <https://www.sciencedirect.com/science/article/abs/pii/S2468896720300720>
- [7] “An Ontological Architecture for Orbital Debris Data”, Rovetto, R.J. (2015) *Earth Science Informatics*, 9(1), 67-82. DOI: 10.1007/s12145-015-0233-3. <http://link.springer.com/article/10.1007/s12145-015-0233-3>
- [8] Miro, online visual collaborative platform for teamwork. <https://miro.com/>
- [9] Word Cloud generator from Monkeylearn.com. <https://monkeylearn.com/word-cloud/>
- [10] AIAA STM WG document, “WG Task 1 synthesized notes 28Feb19.docx”,
https://drive.google.com/drive/u/5/folders/1_Al4KJBjcvthYUHprKAzM_QZSzpL4R9T
- [11] AIAA STM Working Group GoogleDrive.
<https://drive.google.com/drive/u/7/folders/1oqzz-GGhIRd1b55tSluN8mo9nN586rLE>