The contributions of commercial best practices to the global space governance continuum

Daniel L. Oltrogge
Founder and Administrator, Space Safety Coalition
Director, Center for Space Standards and Innovation, Analytical Graphics Inc.
Space Data Center Program Manager

1. Abstract

This paper describes the role of commercial space operators and industry stakeholders within the global space governance continuum. A prime example of this commercial role is the Space Safety Coalition (SSC), which was formed exactly one year ago during AMOS 2019. The SSC is a relevant example of how the commercial space industry can make important contributions to the Long-Term Sustainability (LTS) of space activities. The Space Safety Coalition is not a legal entity, but rather an initiative undertaken by like-minded space industry entities to promote safe and efficient flight safety through technical means. Initially motivated by concerns of unpreparedness for a proliferation of large constellations, the Space Safety Coalition came together to promote the sustainability of space operations through a robust set of industry best practices. This has since evolved into a set of "living" best practices spanning all phases of spaceflight, such as mission design, launch, checkout, space operations, and disposal. These best practices are applicable to all orbit regimes, spacecraft form factors, life cycle phases and mission types.

2. Progress in global space guidelines and governance

The interactions between satellite operators, international organizations and analysis communities, international standards development organizations, satellite operator associations, and national regulatory bodies is shown in Figure **1**. This complex space governance framework is what is known as a "virtual cycle," in that all parts of this framework work together.

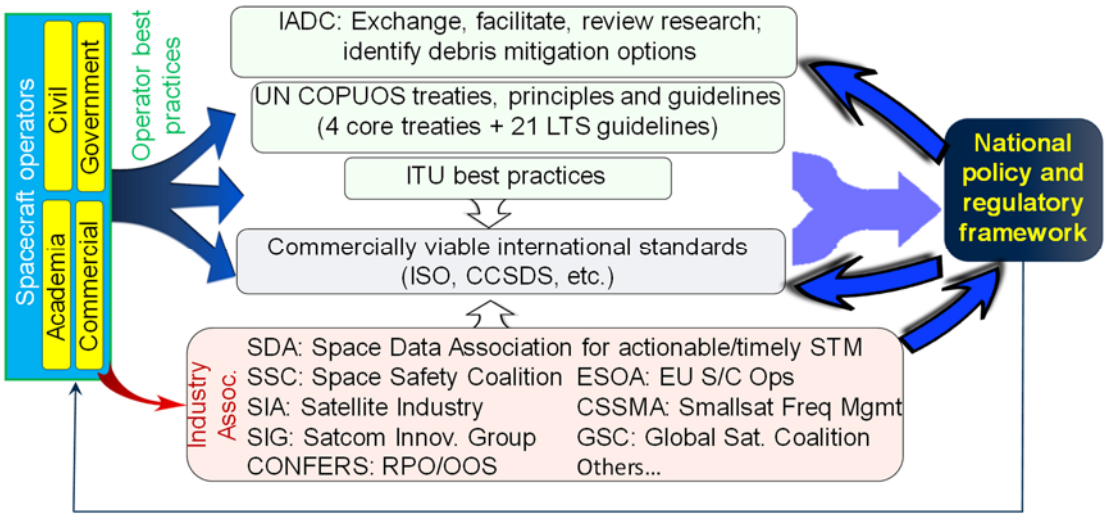

Figure 1. **Virtuous cycle interaction of global space debris mitigation activities.**

The top-center of the figure references the IADC and UN COPUOS, where 21 Long-Term Sustainability of Space Activities (LTS) guidelines were developed and welcomed with appreciation by UN General Assembly in June 2019 and are an important orbital debris mitigation step forward. Yet even with those 21 LTS guidelines, the international treaties, guidelines and standards are by and large struggling to keep up with the explosive growth and technical innovations of the burgeoning space economy and the countless ways that it is addressing human needs and activities. Treaties are designed to be broad agreements amongst state actors, with their top-level normative content designed to be interpreted and instantiated as national laws by the countries that have ratified them.

In the context of this virtuous cycle, consider the expanse of global space treaties, guidelines, standards and national regulatory instruments over our 62-year history of space activities. One way to characterize this evolution is as shown in Figure **2**, where one can assign a score along the vertical axis for how stringent or demanding the clauses of a regulation or guideline are, in relation to how compulsory those clauses are on the horizontal axis. Note the icon border color scheme at the upper right, which helps to categorize the type of policy or organization being implemented.

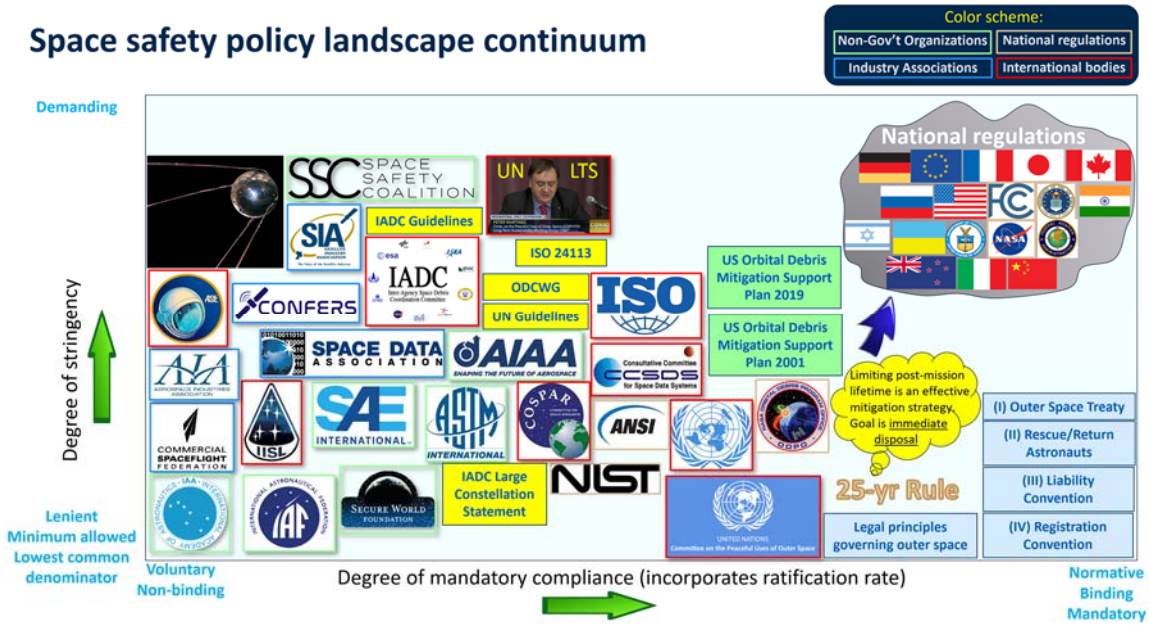

Figure 2. **Categorization of space safety policy landscape continuum.**

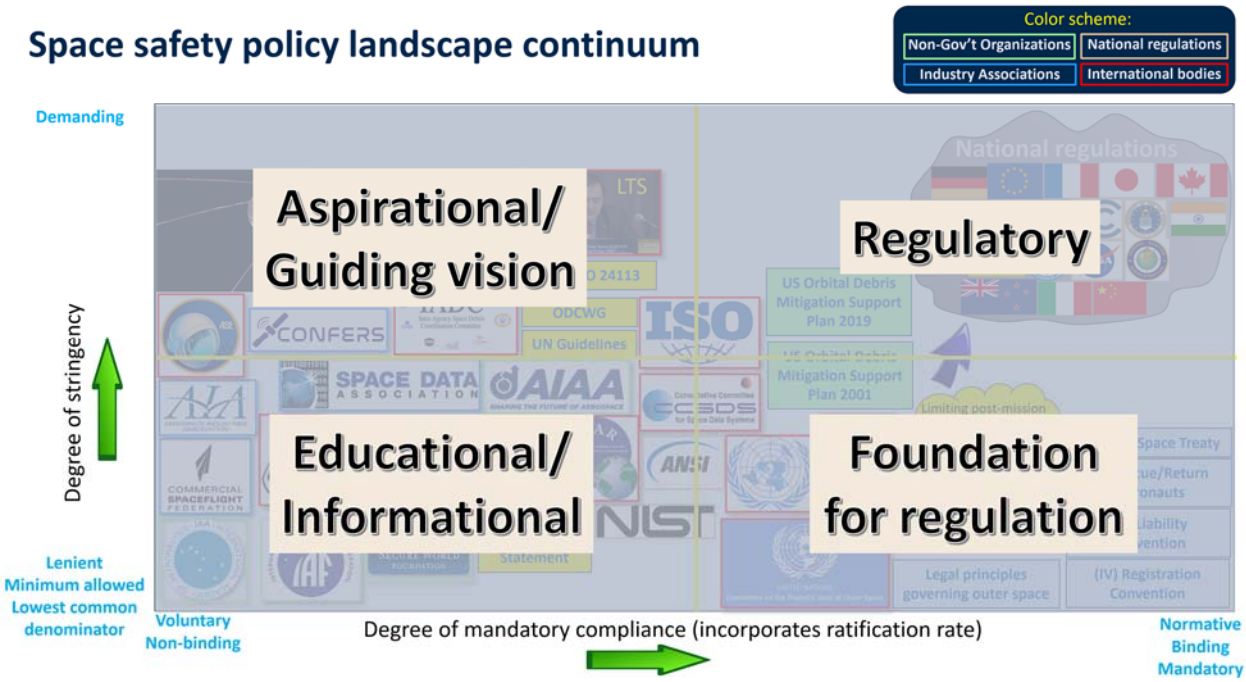

Figure 3. **Quadrant categorization overlaid on the space safety policy landscape continuum.**

Breaking the entries of Figure **2** into quadrants, we can now broadly characterize the contributions of the various space policies and organizations as shown in Figure **3**. Proceeding clockwise starting with the lower left quadrant, entities and their policies and documents can be crudely characterized as being (1) educational and informational, (2) aspirational or "guiding vision", (3) regulatory, or (4) "foundational for regulation" in nature. While we

acknowledge that this simple portrayal of the space safety policy landscape is undoubtedly incomplete and only notionally representative, it is effective as a demonstration of how the various instruments complement and interact with each other, and how entrants in each of these quadrants play a critical role in contributing to our overall space safety and the long-term sustainability of space activities.

3. The evolving use of and benefits from space activities

It's an exciting time with the much-discussed large constellations now well underway. It was only a few years ago that we "only" had an estimated 2,200 active satellites operating in space. Based upon aggregation of spacecraft applications filed with the International Telecommunications Union and the U.S. Federal Communications Commission and media announcements, 107,641 spacecraft have been applied for in the next ten years alone (with a portrayal of possible 2025 large constellation scenario shown in Figure **4**). We recently updated our estimated encounter rate statistics [1] to account for 58,000 spacecraft that had been applied for through the FCC and/or ITU as of January. We also recently released a video [2] depicting the full set of 107,641 spacecraft that have been applied for through 2029, to be operated by 68 large constellation operators. Four of those large constellation operators comprise over 90% of all large constellation applications, and U.S. and U.K. space companies account for 95% of all large constellation spacecraft applications.

In the space of a few years, Planet, SpaceX, and OneWeb have grown to operate a quarter (751) of today's 3,000 active spacecraft population. But looking to the future, everyone wonders: (a) what portion of these applications are "real," actually leading to operational spacecraft, and (b) what will that realized population mean for Space Situational Awareness (or SSA), Space Traffic Coordination and Management (or STCM), and collision risk? While only a portion of these applications will yield an operational spacecraft, even if only 20% of these constellations are realized, we could easily see an active spacecraft population in the next decade that is ten times larger than is flying today. This year alone, we could see the active space population nearly double.

There is no doubt that these Large Constellations will have, and in fact already have had, a dramatic impact on SSA and STCM. Within ten years, we can expect up to 2.5 million close calls per year in the most congested orbital regimes, leading to over 40 collisions annually if these threats are not effectively managed and mitigated. The fact that these applications are predominantly from commercial companies means that (1) it is imperative that the global space community establish a healthy, safe collaboration with the commercial operator community; (2) the commercial community rapidly collaborate with the international community to develop, incorporate, and/or implement international guidelines, standards and aspirational best practices for data exchange and flight safety; and (3) the fact the UK and USA account for 95% of these applications makes a compelling case for the United States' continued leadership in Space Traffic Coordination and Management (STCM).

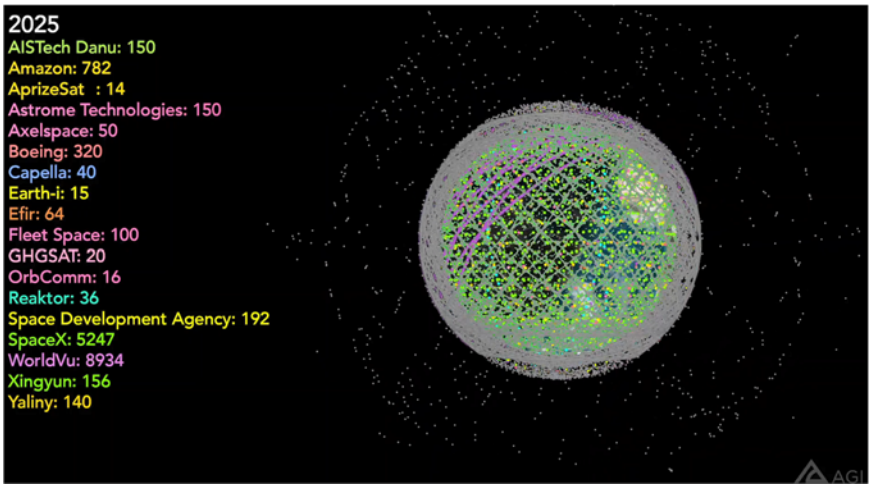

Figure 4. **An increasing spacecraft population in the New Space (Large Constellation) era.**

4. The role of commercial best practices in the global space governance context

The previous sections provide a good backdrop for how the commercial space industry can make large contributions to space situational awareness and space traffic management. Some space operators prefer to focus on the intent of consensus sustainability guidelines and standards rather than being told how they are to achieve sustainability. For this reason, some countries such as the United Kingdom have adopted the Safety Case framework [3], which is intriguing in its ability to let the spacecraft designers and operators devise ways to achieve long-term space operations sustainability without the potentially costlier or perhaps less efficient prescriptive requirements that stifle innovation and incur costs. Still other operators feel that regulations are actually good for business, in that a well-understood set of requirements can facilitate investor confidence and operational stability.

Space industry associations play a valuable role in developing space industry consensus, information sharing and promoting space industry objectives and aspirations. Their insight and influence can be invaluable in fostering responsible space operations and educating the broader space community on orbital debris mitigation best practices and expected norms of behavior. Popular examples of such entities include the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) best practices [4], the Satellite Industry Association [5] and the Space Safety Coalition [6].

The commercially-self-formed Space Data Association (SDA) was formed in 2009 to address a recognized gap in existing legacy safety of flight products and services. The Space Data Center that the COMSPOC [7] manages for the SDA is now in its tenth year of operations, providing geographic diversity, computational security, a robust legal framework, very high availability, ongoing forensics, data quality checks and comparative SSA analyses. The SDC has also evolved to be one of the largest clearinghouses globally for spacecraft operator data. The SDC pioneered many of the fundamental innovations and constructs that have stood the test of time and which have been precedent-setting for the global STCM community going forward.

5. The Space Safety Coalition

In terms of implementing the 21 new UN COPUOS LTS guidelines, the UN General Assembly well-noted that they encourage "***States and international intergovernmental organizations to voluntarily take measures to ensure that the guidelines are implemented to the greatest extent feasible and practicable***". It is precisely under this UN COPUOS encouragement that we'd like to highlight an important industry-led space sustainability activity, the Space Safety Coalition (SSC). The SSC was formed exactly one year ago during AMOS 2019; the SSC is a coalition-of-the-willing, with like-minded entities working to develop, publish and maintain a set of orbit regime-agnostic best practices for the long-term sustainability of space operations. The Space Safety Coalition is not a legal entity, but rather an initiative undertaken by like-minded space industry entities to promote safe and efficient flight safety through technical means.

Initially motivated by concerns of unpreparedness for a proliferation of large constellations, the space industry came together in 2017 to promote the sustainability of space operations through the formation and endorsement of a robust set of industry best practices. This has since evolved into the SSC's "***Best Practices for the Sustainability of Space Operations***," a set of "living" best practices that span all mission types and phases of spaceflight (i.e., mission design, launch, checkout, space operations, and disposal).

Although **non-normative**, these aspirational best practices are generally applicable to all spacecraft regardless of physical size, orbital regime or constellation size. In advance of treaties and regulations, signatories endorse and agree to promote and strive to implement SSC best practices to ensure the safety and commercial viability of space activities.

At its inception, the Space Safety Coalition comprised 18 space organizations. Participation has now more than doubled with 45 space operators and relevant, global industry stakeholders having endorsed this industry-led view of the current set of policies and best practices for space operation sustainability as reflected in Figure **5** and Figure **6**.

While the largest category of SSC participants is spacecraft operators, current SSC signatories represent a global, broad and diverse set of organizations from across the space enterprise as shown in Figure **7**, including foundations, industry associations, analytical service providers, legal firms, space insurers, on-orbit servicing, active debris removal companies, Space Situational Awareness (SSA) and Space Traffic Management (STM) service providers, launch providers, manufacturers and spacecraft operators.

And while the greatest SSC participation is from the US, SSC participants also come from eleven other countries as shown in Figure **8**. This globally diverse participation allows the SSC to have a wide, international set of perspectives on relevant space safety issues.

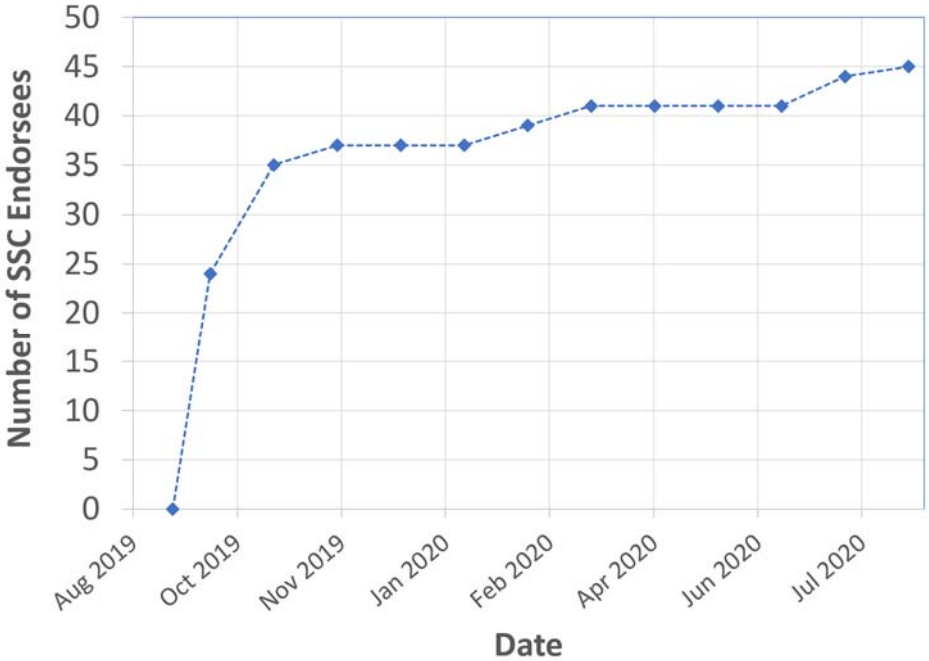

Figure 5. **Growth in number of endorsees the SSC's best practices document.**

Figure 6. **Diverse set of 45 global space entities who have endorsed the SSC's best practices document.**

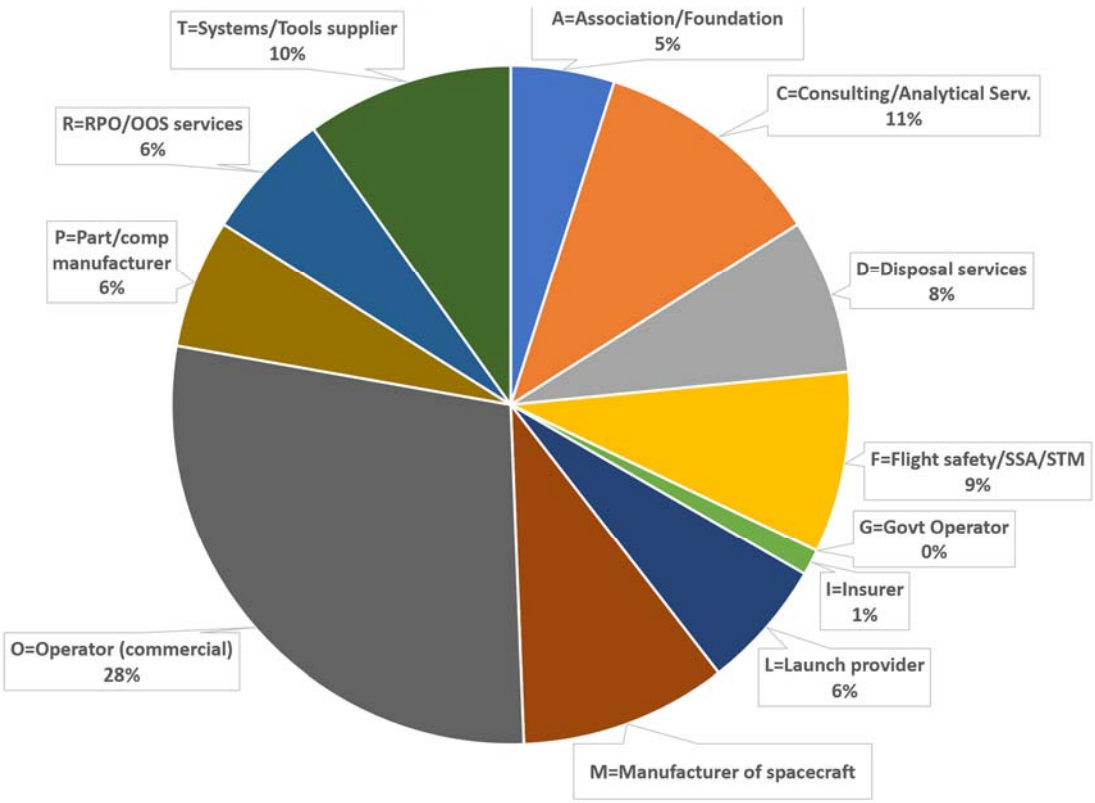

Figure 7. **SSC members by type.**

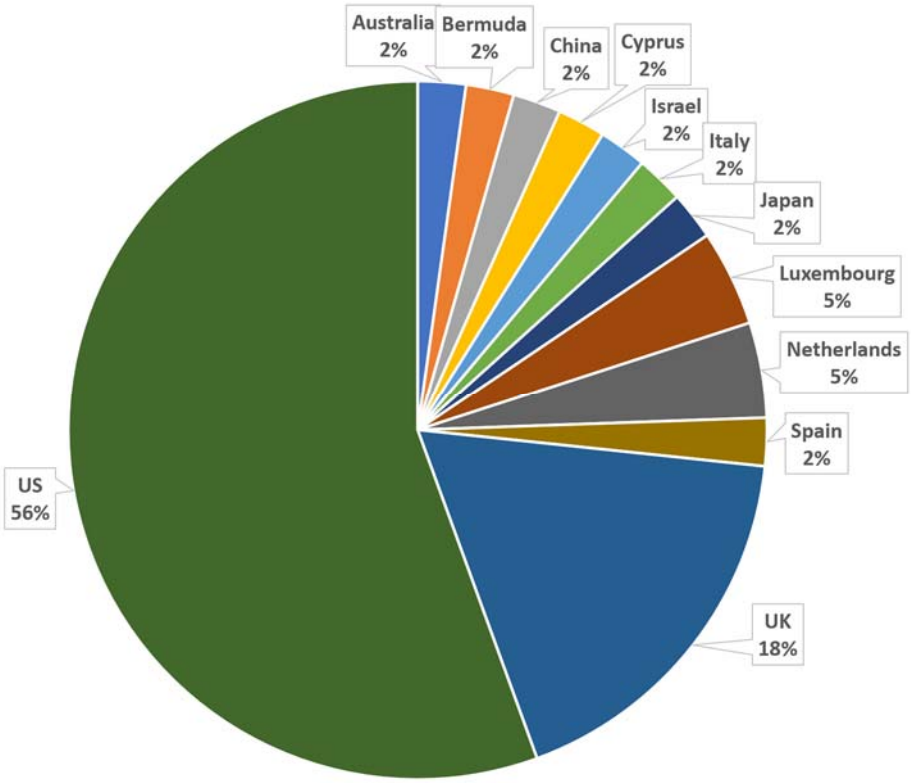

Figure 8. **SSC members by country.**

6. The Space Safety Coalition's Best Practices Document

The SSC best practices document contains two parts: (1) endorsement of existing international treaties, guidelines and standards produced by the Inter-Agency Space Debris Coordination Committee (IADC), the UN, and the International Organization for Standardization (ISO); and (2) forty-two additional, more stringent best practices to allow safety-conscious operators and stakeholders to be even more responsible in their space activities. These 42 aspirational best practices contained in the SSC's Best Practices document are also relevant to and well-aligned with the LTS guidelines.

The SSC initiative provides an effective, grassroots, working-level implementation of a majority of the LTS guidelines in an aspirational construct. This implementation includes guidelines for the sharing of space data, active collision avoidance, using responsible launch service providers, minimizing casualty risk, supporting space debris and mitigation research, registration of space objects, international cooperation and capacity building and awareness.

These best practices support and are also well-aligned with the mandates of U.S. Space Policy Directive-3 (SPD-3), by augmenting the new U.S. Orbital Debris Mitigation Support Plan (ODMSP, published in 2019) with "other standards and best practices to ensure the safe operation of U.S. space activities" as required by SPD-3.

Figure **9** reflects the current and planned broad categories of the SSC's best practices document, with blue bars indicating current best practices, yellow reflecting additional areas that SSC participants want to prioritize developing best practices for, and white denoting additional planned content. It is revealing that SSC participants set as their top two priorities the addition of best practices that (1) intentional fragmentations in space should be condemned; and (2) covariance realism should be improved, using advanced analytics and standardized covariance realism metrics.

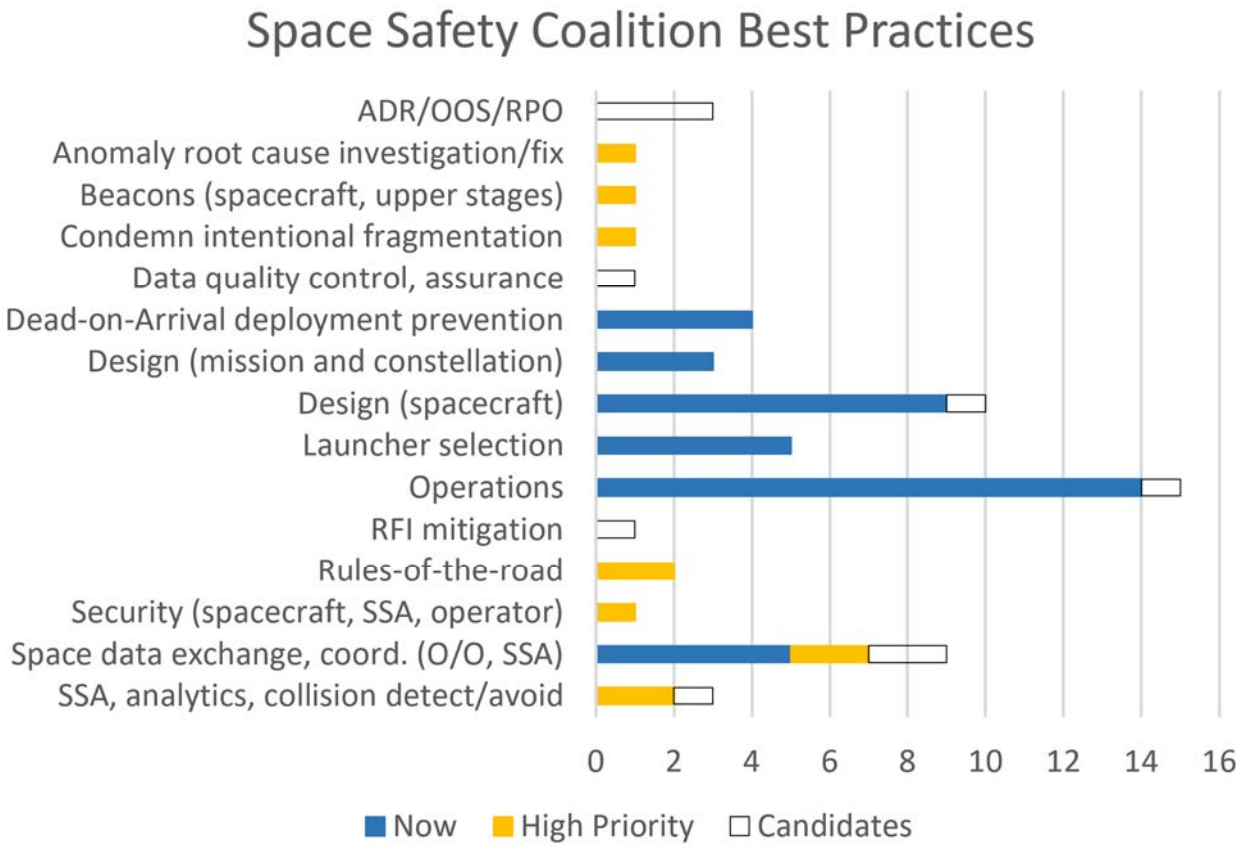

Figure 9. Categorization of SSC's best practices, both now (in blue bars) and planned for the future (gold and white).

7. A word about the importance of an Open Architecture Data Repository

It's no surprise that "Operations" and "Design" are the two largest categories for best practices both now and in the future. But as Figure **9** shows, the next highest category for the current and planned development is that of space data exchange and coordination. This stresses the importance and value that SSC participants place on this important enabler for space flight safety. In the U.S. government approach for Space Traffic Coordination and Management, the framework being developed to accommodate and enable such data exchange is, per SPD-3, the Open Architecture Data Repository (OADR).

Humanity has solved or addressed many vexing problems using data exchange, "data lake" models such as the Space Data Center, crowd-sourcing and data fusion techniques. Our national weather infrastructure, housed within the U.S. Department of Commerce, gathers weather observations today using data gathering and fusion. The Oxford English dictionary, as revealed in the story and movie, The Professor and the Madman, was similarly dependent upon the crowdsourcing of tasks and observations from ordinary readers of London newspapers.

Yet another example of the successful use of data exchange pertains to the derecho (meaning "straight") storm, which is the weather phenomena that destroyed many cities and crops in Iowa and surrounding states this summer. There is, I think, a space safety-relevant back story to this. German immigrant Gustavus Hinrichs set up Iowa's first weather service in 1875 [8] and, in that position, discovered and named the derecho storm. Central to his discovery was the network of weather "spotters" across Iowa who would send in their "observations" on postcards, and then Hinrichs would then assemble all of the postcards together like a giant jigsaw puzzle to discern overall weather phenomena. Space safety is no different, being critically dependent upon the gathering of observations and information from those who are the "local" experts, if you will (State Actors, commercial spacecraft designers and operators, launch providers, SSA service providers), to form the best comprehensive picture of collision threats in space. Then, of course, we need the Hinrichs of the world to piece it all together. This is an area where, as a space community, we have seriously fallen short: We have not had a Lead Agency for flight safety, and we haven't brought existing operational tools for data fusion, advanced analytics and metrics, and best-available data sources and services together in a comprehensive manner to address global space safety needs.

8. Conclusions

As a global space community, we need to get to a state where resources, crowd-sourced space data exchange, international standards, commercial best practices and innovation, research, and advanced sensors and analytics for SSA and Space Traffic Coordination and Management (STCM) are all brought together to form the best, most accurate and timely system. Entities like the Space Safety Coalition play a key role in codifying and promoting established commercial best practices for all phases of the spacecraft life cycle.

We need to take a holistic approach to realizing the global imperative of the Long-Term Sustainability of Space Activities. It's not just about treaties, guidelines and standards. It is all of those, plus commercial best practices with aspirational goals of not only meeting but exceeding minimum consensus requirements. It is also about quickly transitioning existing commercial advanced capabilities and analytics into operations coupled with comprehensive comparative SSA and quality control to move the needle on ensuring the long-term sustainability of space activities. The time to address the many gaps in our LTS strategies is now, especially in view of our ever-increasing commercial use of space – and the commercial space community is taking the steps it can to contribute to addressing these gaps.

9. References

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[7] Oltrogge, D.L., "The Commercial Space Operations Center (ComSpOC)," ITU Satellite Communication Symposium 2017, 29-30 May 2017, Bariloche, Argentina.

[8] Alma Gaul, "Man who discovered 'derecho' lived in Davenport [Iowa]", Quad City Times, 17 August 2020.