Commercial OOS and Its Future: Policy and Legal Issues beyond Life Extension

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Abstract

Satellites have typically been viewed as high-cost, static platforms that once launched have a limited orbital lifetime and a physical and mechanical structure that cannot be altered or maintained (with very limited exceptions). However, in the current day, a number of technical and market innovations are being deployed by the private sector, which might change this paradigm. These include small satellites, on-orbit assembly (OOA) and modular spacecraft concepts, and on-orbit servicing (OOS) in particular.

OOS represents a number of possible changes in the traditional conceptualization of space systems and operations, and requires new policy, regulatory, and legal approaches. OOS potentially allows operators to extend the lifetime of existing, hence, traditional satellites; and in future possibly provide repair services or correct on-orbit anomalies or other servicing based on cooperative design and related standards.

Space debris is a growing concern for the use of outer space. At the dawn of the space era there was no interim solution for objects launched into space once their lifetime in orbit was over: they were either left in orbit, moved to a graveyard orbit or deorbited. OOS capabilities may become part of the solution through both life extension and de-orbiting of existing space infrastructure elements as well as debris avoidance due to new cooperative design philosophies aiming at OOS. As such OOS has implications for space debris mitigation. Requirements laid down in national legislation are important to define the extent of execution of space debris mitigation guidelines, including the end-of-life plan. However, space debris implications are only one element which must be considered in relation to OOS capabilities.

In many national jurisdictions OOS is a new application without clearly defined regulatory and licensing practices. States have an obligation to provide this authorization and supervision framework, while industry requires a permissive regulatory framework to provide legal certainty. All stakeholders are committed to preserving the safety of the operating environment.

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With that in mind, this paper analyzes the prerequisites for evolution of OOS and opportunities for market creation, provide an overview of existing boundary conditions regarding OOS policy and legal scope and its commercial implementation including risks and challenges to be address, and examine how development of technologies needed for OOS could influence insurance and serve as economic driver. Finally, the paper will try to envision the way ahead towards capacity-building for OOS.

Keywords: on-orbit servicing (OOS), on-orbit assembly (OOA), on-orbit manufacturing (OOM), active debris removal (ADR), modular spacecraft concepts, additive manufacturing, cellularization, standards, plug-and-play (PnP) interfaces, CONFERS, iBOSS, iSSI, flexibility, business model, licensing, new systems, efficiency, economy-of-scale (EoS)

1. Setting the Scene

On-orbit servicing (OOS) has been addressed by numerous projects for several decades and was mostly driven by technological aspects. First commercial OOS was proposed in the late 1990s by Vanguard and from 2002 onwards by Orbital Recovery Corporation, STC and others promoting life extension services in the first step. None of them made it into operations. Following the big space debris events end of last decade and growing demand for active debris removal (ADR) resulted in a renaissance of OOS earlier this decade, since systems and technologies needed are similar. With ViviSat in the beginning, and more recent commercial contracts for life extension ratified (by companies such as Northrop Grumman, SSL, and Effective Space Solutions), OOS is likely to take off in the near future as a viable commercial service. While several technical solutions available, both for relatively simple life extension and tug-type services as well as for more complex satellite maintenance, refuelling, and/or upgrade, warehousing of standard modules and other robotic logistics etc., attention needs to be paid for other, non-technical aspects to assure proper OOS and a sustainable space environment in the long-term. The focus is on commercially operated OOS.

1.1 Dimensions to Capture (Matrix Approach)

In a simplified approach it is suggested to capture the major drivers of commercial OOS and their impact in micro-economic as well as space societal macro terms. In essence: What enables commercially successful servicing operations and also assures compliance and proper implementation across the board.

Table 1. OOS Dimensions (Matrix Structure)

Dimensions & Values*	Role & Impact	Status Quo	Deficits & Need	To Dos & Actions
System & Technology	*e.g. ●●●	?	?	?
Innovation & Evolution	?	?	?	?
Policy	?	?	?	?
Legal & Regulatory	?	?	?	?
Economics	?	?	?	?
* Qualitative Level of Relative Strength ●●● and Key Messages				

The paper attempts to organize related perspectives and to provide a high-level reflection of this context from OOS beyond life extension.

1.2 Status Quo vs Change Drivers

Cooperative on-orbit satellite servicing appeared as a response both to environmental concerns and commercial viability to extend lifetime of certain satellites in orbit instead of replacing them by new ones (that implies additional manufacturing and launch costs). The ability to approach, inspect, grasp, manipulate, modify, repair, refuel, integrate, and build completely new platforms and spacecraft on orbit would enable new business models, innovation, and opportunities in space. This is also in line with understanding that outer space represents a limited natural resource which should be used responsibly and with due care.

Such a "conscious" use, empowered by advantages and benefits provided by OOS, is also an enabler of the long-term sustainability of space activities and free access to space of future generations (ethical aspect). It is worth noting that prerequisites for sustainable nature of space activities have been carefully examined over the last years by the Working Group on the Long-Term Sustainability (LTS) of Outer Space Activities which culminated when "the UN COPUOS member States agreed on 21 guidelines and a context-setting preambular text. The States also agreed to continue their discussions of space sustainability under a dedicated agenda item of the Scientific and Technical Subcommittee of COPUOS.1"

1 Secure World Foundation, 2018. "2018 UN COPUOS Long Term-Sustainability Guidelines Fact Sheet." https://swfound.org/media/206227/swf_un_copuos_lts_guidelines_fact_sheet_august_2018.pdf Accessed September 15, 2018

The proper implementation of OOS relies on a variety of indispensable elements and therefore has a multidisciplinary nature, where legal and policy considerations are only two of its complimentary facets. As OOS focuses on servicing of a spacecraft in orbit and consequently is conducted in the area that per se is an internationalized territory, it falls under the scope of international law. Yet at the same time, OOS activities will be regulated under domestic frameworks pursuant to Article VI obligations. Principles at the international level - such as LTS - will likely inform this regulation.
However as of today OOS falls within the set of activities that have been referred to as "non-traditional space activities" and as such lacks in many jurisdictions a stable and well-defined legal framework needed for its certain and predictable operation.

1.3 Tech Options Driving Policy and Legal Framework

On-orbit servicing (OOS) raises a number of diplomatic, legal, safety, operational, and policy challenges that need to be tackled. By its nature OOS offers both civil and military relevant capabilities and benefits. OOS and closely related capabilities to conduct spacecraft Rendezvous and Proximity Operations (RPO) entail a complex operations capacity which must be carefully conducted to mitigate potentially harmful effects or mishaps. The space community collectively has more than 50 years of experience in doing similar activities in human spaceflight programs. There are multiple countries/companies which are developing and testing "dual-use" robotic/autonomous RPO and OOS capabilities. In fielding these capabilities, we must leverage prior experience and lessons learned to inform responsible and safe operations for future capabilities.
The overarching theme is how to field both policy and legal frameworks and an industry collaborative environment that works together to enable and oversee OOS activities to develop in a way that minimizes risk to third parties and the collective operating environment in space. In short: how can policy, legal, commercial, and technical factors coalesce to support this goal?
There are several elements that should be addressed in order to do so. These might include:

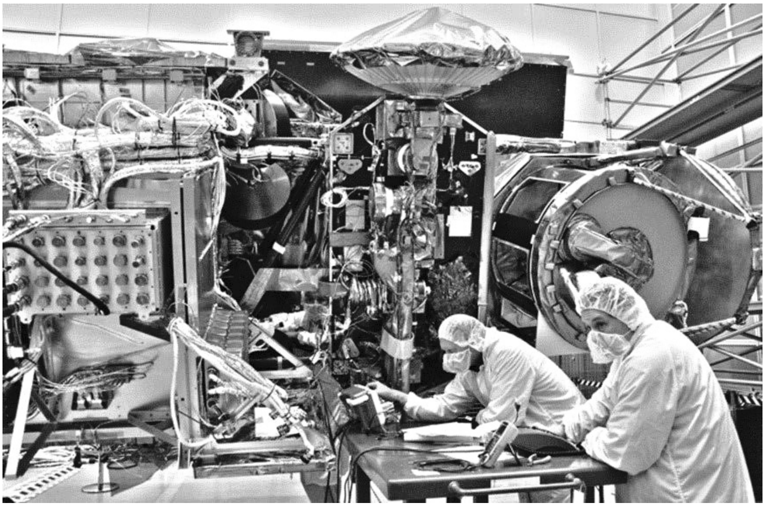
- Industry-led development of and commitment to norms of behaviour and best practice for civil/commercial satellite servicing and RPO activities;
- Agreement to specific technical and engineering factors and approaches to increase the safety and viability of satellite servicing (e.g. standards);
- Processes for information sharing between servicing companies, clients, and governments to document lessons learned and share experience; and to include integration of improved space situational awareness (SSA) info and resources as a key enabling factor of OOS concept-of-operations;

- Transparency mechanisms to reduce misperceptions and concerns about the dual-use nature;
- Addressing of policy and legal issues related to liability and government indemnification where commercial spacecraft are physically interacting with each other on-orbit;
- Treatment of ITAR, export controls, and IP concerns/issues inherent in the imaging and close approach aspects of OOS;
- Development of licensing and authorization frameworks that are consistent, clear, and effective.

2. Traditional Monolithic Satellites

Since Sputnik, satellites have significantly improved in terms of lifetime, capabilities and efficiency due to particularly technology advancements at subsystem and especially at component level while - apart from recent developments (covered below) - the design principles and philosophy have not changed, however, nor have operational concepts in generically.
Larger satellites (of more than 500 kg) are yet largely designed as they were decades ago; bespoke scientific satellites (see figure below) and other space infrastructure elements anyway. Even GEO telco serial satellites, as e.g. the Boeing 702 series, do not really represent series production, since customize payloads are the drivers, and therefore even these satellites do not look the same.
Another important circumstance is the scope of AIT (assembly integration and testing) representing up to 70% of total satellite cost.

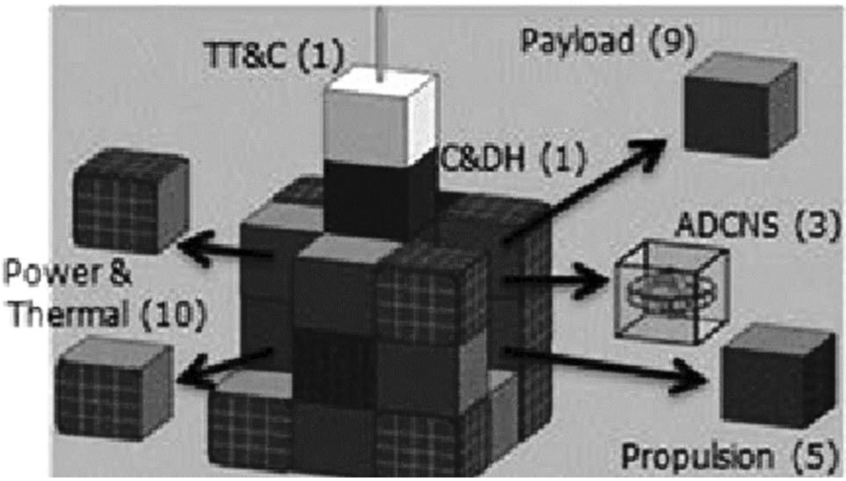
Fig. 1. GPM Assembly (NASA)



3. Cooperative Satellite Design

Cooperative satellite design comprises technical solutions enabling servicing of a satellite in different ways. Such design features can be as simple as e.g. handles for service spacecraft to grab a satellite or be rather complex as refuelling valves and modules, orbital exchange units or similar. Key of cooperative design is a modular approach, respectively building blocks enabling for plug-and-play (PnP) approaches; including associated interfaces and standards in general.
Modular approaches have been investigated and tested for decades as well as partly been introduced, typically at system level, and particularly recent by the Cubesat developments. For larger-than-Cubesat satellites and other space infrastructure modularity (or cellularization) combined with servicing can open new frontiers regarding flexibility, economics and sustainability [2]. The generic philosophy is shown here:

Fig. 2. Satellite Morphology (Prof. D. Barhart)



At the German Aerospace Center (DLR) Space Administration a useful definition has been introduced which distinguishes passive OOS and active OOS, whereby passive OOS covers exactly such cooperative design and related technologies as enabler and pre-requisite for fully-fledge, hence, active OOS which covers robotic and other interaction, conduction OOS respectively.
In this same sense of passive OOS DLR Space Administration initiated iBOSS (intelligent Building Blocks for On-Orbit Satellite Servicing and Assembly), a collaborative R&D program to develop relevant technologies and capabilities. Key elements are standardized multifunctional interfaces and

building blocks as well as supporting software tools for design and simulation.

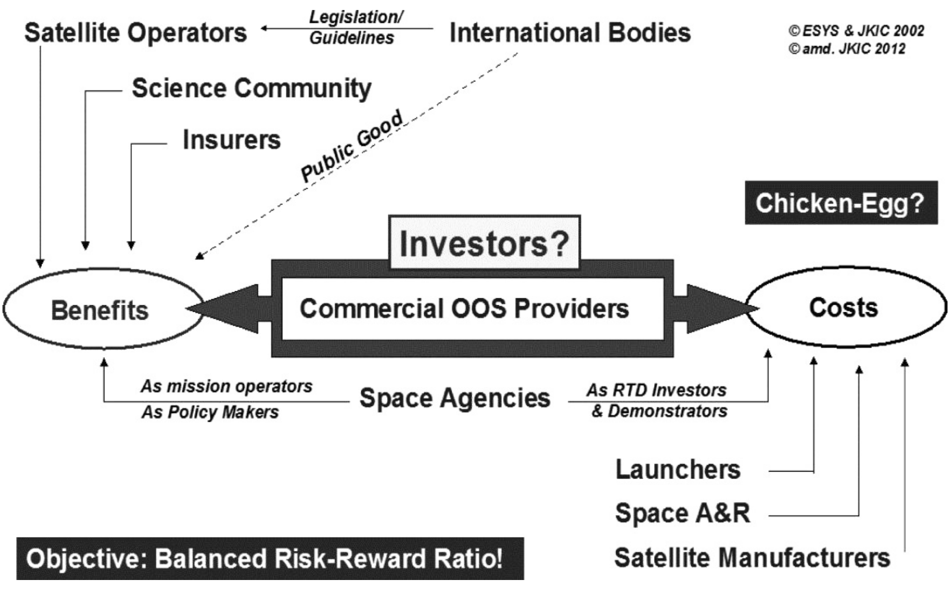
Fig. 3. iBOSS Program (since 2010) by DLR

4. Generic Options and Implications for OOS and OOA

It is useful to first distinguish two generic types of OOS: “active OOS” and “passive OOS”. Active OOS is basically the OOS service provision itself, e.g. by a robotic service spacecraft, by which a target satellite gets serviced via active manipulation, physically or remotely. Passive OOS represents technologies, design and elements of a satellite to allow for OOS, including related logistic elements. Passive OOS is therefore also a prerequisite for on-orbit assembly (OOA). Hence, there will be neither a fully-fledged OOS, nor an OOA without passive OOS, cooperative design per se.
Several high-quality publications address OOS by defining different services but also use different terminology. A common nomenclature will be paramount for focused OOS and OOA development and support the introduction of standards of any kind.
Principally OOS covers services by which an object is moved (motion-type), active manipulation of a target takes place (manipulation-type) or where a target is inspected without contact (remote-type). There will be always overlaps of definition issues though. The same applies for OOA.

In this context important to understand the scope and interrelations of OOS stakeholders as shown below:

Fig. 4. OOS Stakeholders [1]



5. Recent OOS Developments and Relevant Trends

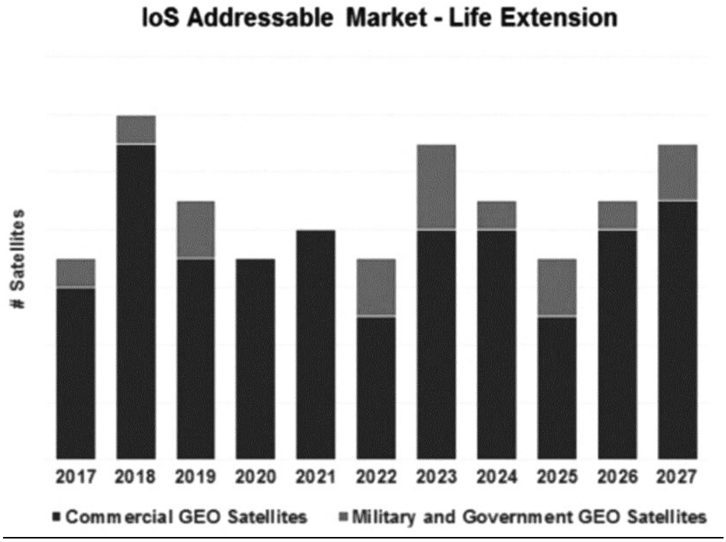
Both government and private sector maintain focused activities of OOS and OOA, and in different continents.

Technology and Solutions towards series production and higher lot sizes creating EoS effects, space tugs and tool boxes and more, for e.g. ISS and other platforms with robots, so what is the market?

5.1 Commercial Proof of Concept

Over the last couple of years, a hand full of commercial OOS providers evolved and within the last 2 years four companies were able to sign commercial contracts for the provision of multi-year life extension services. NSR estimates that global revenue from OOS will approach $700 M annually by 2027. Within this figure NSR expects 60% of revenue to be from life extension services, 20% from robotics, 11% from de-orbiting services, and 9% from salvage. NSR expects 75% of revenue to originate from commercial customers and 25% from government customers. The NSR analysis considered only GEO markets and did not include potential OOS-related services in LEO.[2]

Fig. 5. OOS Market for Life Extension as Forecast by Northern Skies Research. [3]



Is there a commercial proof of concept yet? Actually not! Although current contracts are in the range of half a billion dollars total, OOS has not yet been demonstrated with the undersigned clients. Moreover, the business case for the OOS service providers has to close and become sustainable and profitable, a return on investment have to be generated as tangible proof.

5.2 Smallsat and Cubesat Revolution

The smallsat sector experiences an enormous upswing driven by the LEO mega constellations proposed and brings series production and thereby higher lot sizes as well as new quantity structure into the game. While basically not taking into consideration OOS or OOA, primarily due to relatively low asset value and lifetime in LEO, interesting learning curves occur with regards to principles of economy-of-scale (EoS). That is similar

2 C. Belle, "Remarks on AIAA Space 2018 Panel: On-orbit Servicing Status and Progress of A Revolutionary Capability." AAA Space 2018, Orlando, Florida, September 17, 2018. https://livestream.com/AIAAvideo/space2018/videos/180445220 Accessed September 20, 2018

3 Northern Skies Research (NSR). "In-orbit Servicing Markets," January 2018. https://www.nsr.com/research/in-orbit-servicing-markets-iosm/ Accessed September 20, 2018

with Cubesats, which have established standards and facilitate numerous processes compared to traditional and monolithic satellites. For both OOS and OOA these are very relevant developments and should serve as important inputs. The smallsat approach is also a key driver of the planned deployment of a number of large LEO satellite constellations. These constellations represent a potential market of OOS-related services in the form of satellite end of life services – the de-orbiting of failed satellites.

5.3 NewSpace Driving Robotics and Modularity

With NewSpace - enabled by miniaturization and reduced space access cost, hence the ability to fly more and more often and addressing orbital and planetary missions and beyond - the role of robotics and system modularity is becoming more important than ever before, and OOA and OOM as well as 3D-printing and other manufacturing and composition techniques will shift paradigms for future space.

Moreover, planetary and other exploration and exploitation missions consider massive launch capabilities and advanced mission architectures. A combination of OOS, OOA and OOM supported by robotics and AI can cause fundamental changes in the way space projects and infrastructure are planned, designed, operated and their economics will be assessed.

Active and passive OOS, and hence modularity and robotics will evolve as ley capabilities in the near-term.

5.4 Space Policy and Law Taking It Up

Even though it would be wrong to say that OOS is developing in legal limbo, still there are many substantial missing points in its adequate regulation.

The problem appears to be also in a variety of hypostases of OOS, different shapes and approaches applied to it. The absence of a clear and unified, generally recognized understanding (and ultimately definition) of this notion, as well as the list of its main criteria and constituent elements (in addition to presence of a second spacecraft, conduct of rendezvous and proximity operations, high risk of collisions ...) does not foster further development and capacity-building of a special legal framework.

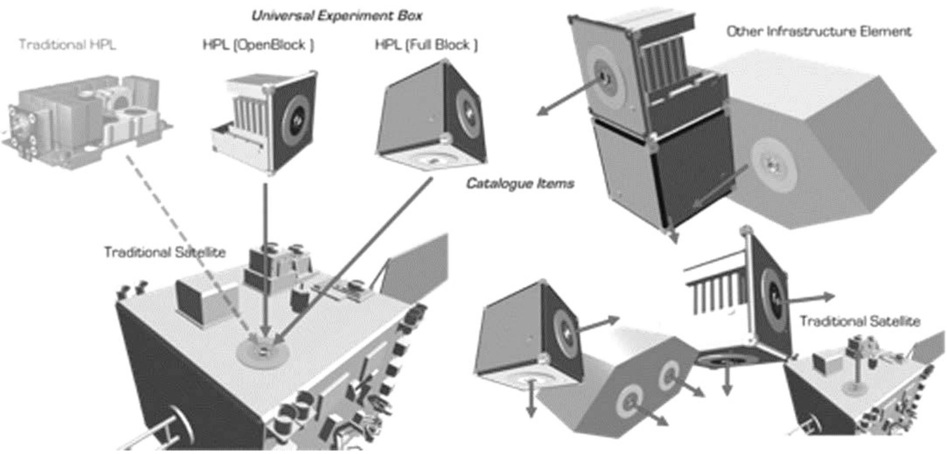
What we currently observe is a boosting development of OOS technologies detached from expected legal and policy considerations what could be somewhat explained by insignificant governmental interest and consequently involvement in these types of activities. As practice shows, legal framework to be efficient should be a transposition of political will and respective policy. If such a decision is missing, it is hard to raise an issue of legal drafting of a completely new set of rules required for implementation of cutting-edge technologies.

More likely the developments will have a bottom up approach where legal building blocks needed to pave the legal way for OOS implementation will be designed based on best practices and standards of commercial entities and will have the form of guidelines.

6. New Tech, System Standards and Building Blocks in the Making

This section will cover some high-level considerations and will elaborate on specific examples. Generic usability and manifold application of modular approaches and OOS as well as advantages are principally understood and partially appreciated by space community while their implementation is still to come.
Particularly over the last decade multiple approaches and solutions have been brought forward. Below is a sketch visualising options based on the above-mentioned iBOSS approach, which is one of several related smart technologies in development.

Fig. 6. ISSI (intelligent Space System Interface) and iBLOCK (intelligent Functional Building Block) [3]



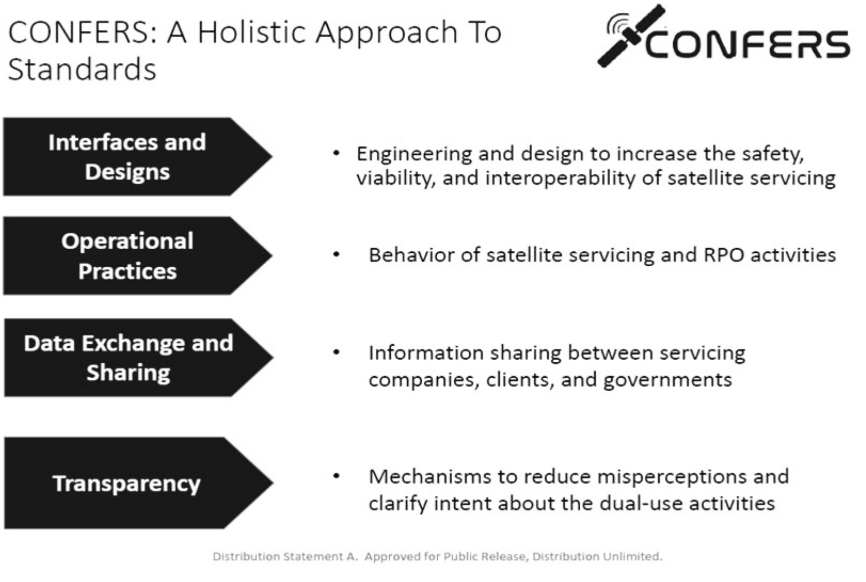
Other examples comprise the Kaber and Gold interfaces used aboard the ISS (e.g. by Nanoracks) or the Magsafe connector (by Altius Space Machines). Another rather prominent set of technologies are the Satlets and PACs (by Novawurks) as well interface developments like SIROM (EU H2020, Peraspera, by SENER et al). Widely known is also the Modular Common Spacecraft Bus (MCSB, by NASA) as a satellite solution.

7. The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)

Cooperative on-orbit satellite servicing (OOS) and rendezvous and proximity operations (RPO) have the potential to foster the next economic revolution in space. However, the lack of clear, widely accepted technical and safety standards for responsible performance of OOS and RPO involving commercial satellites remains a major obstacle to satellite servicing becoming a major industry, and could lead to mishaps that would put long-term sustainability of space itself at risk.[4]

The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)5 is an industry-led initiative with initial seed funding provided by DARPA (and technical support provided by NASA) that aims to leverage best practices from government and industry to research, develop, and publish non-binding, industry consensus-derived principles, best practices and technical & operations standards for OOS and RPO. These standards are intended to provide the foundation for a new commercial repertoire of robust space-based capabilities and a future in-space economy. In addition to its efforts to develop standards and best practices, CONFERS will serve an industry advocacy role for the emerging satellite servicing segment: acting as platform for exchange of information with the broad space community.

Fig. 7. The CONFERS Approach



4 CONFERS, "CONFERS One Pager," https://www.satelliteconfers.org/wp-content/uploads/2018/07/OnePager-062018.pdf Accessed September 12, 2018.
5 CONFERS, "CONFERS Website," www.satelliteconfers.org

Since October 2017 CONFERS has been working to research existing practices on OOS and RPO6, and to develop a multi-stakeholder process that brings together international experts from industry, academia, and government, to draft initial standards. Beginning in May 2018 a series of workshops has been held to begin the process of developing consensus standards and best practices. Participants in the workshops have represented a cross-section of the satellite servicing community including both established and early-phase companies from North America, Europe, and Asia. These companies represent multiple business segments including robotics, satellite life-extension, active debris removal and satellite end-of-life services, satellite operators, and satellite manufacturers participated. Participants in the workshops have identified the initial focus areas for the Consortium's first draft publication, which will focus on shared principles and best practices that will help commercial RPO and OOS operations mitigate harmful interference to other space activities.7
CONFERS is open to participation by private sector stakeholders in the international satellite servicing community. All companies and academic institutions developing, operating, insuring, and purchasing OOS and RPO capabilities are encouraged to join and contribute their experience and expertise. CONFERS is being facilitated by a team of private sector organizations with initial funding from the Defense Advanced Research Projects Agency (DARPA). Advanced Technology International (ATI) is providing overall program management. Technical expertise and project execution support is being provided by the Secure World Foundation (SWF), the University of Southern California's Space Engineering Research Center (SERC), and the Space Infrastructure Foundation (SIF).

8. Space Policy and Space Law

The development of new experimental technologies every time challenges an established space law system that was designed at the dawn of space era. How reactive / responsive it will be in every specific case highly depends on a conscious recognition and acknowledgement of a need to develop new instruments and respectively legal regimes in which technologies will operate and activities with their application conducted [6] - [9].
However as initial starting point it would be expedient to analyze what is currently in place and where can specific provisions be distilled from.

6 Barnhart, D. et. Al, "Using Historical Practices to Develop Safety Standards for Cooperative On-Orbit Rendezvous and Proximity Operations." IAC-18-D1.5.8. Paper presented at the 69th International Astronautical Congress (IAC), Bremen, Germany, 1-5 October 2018

7 Christensen, Ian, "Workshop Establishes Initial Topic for Standards Development." CONFERS *Newsletter – Third Quarter 2018 Edition,* https://www.satelliteconfers.org/july-2018-confers-newsletter/

8.1 Arising policy and legal issues

As all space activities, and in particular the new ones, the OOS is extremely risky in nature and subsequently requires generally recognized regulations specific to it. Such a legal determination is the must especially when considering the liability issue.

Pursuant to art. VI of the OST the States bear international responsibility for national space activities whether such activities are carried on by governmental agencies or non-governmental entities. We are of the view that prevailing part of OOS activities will be conducted by commercial sector which activities require authorization and continuing supervision of specific State as further specified in aforementioned art. VI. As regards the international liability for damage to another States or its natural or juridical persons by a servicing or serviced satellite or their component parts, it extends to all launching states (art. VII OST) to which refer a State which 1) launches such a satellite or 2) procures its launching; or 3) from whose territory or 4) facility a satellite is launched (art. I Liability Convention).

When projecting possible situations entailing “damage”, a variety of probabilistic scenarios should be envisaged, e.g. collision of servicing and serviced satellites that causes damage to both objects or their component parts as well unintentionally removes a serviced satellite from its initial position, collision of servicing satellite engaged in OOS activity with a third-party satellite that in addition to a physical damage undermines the fulfilment of obligation to provide OOS etc.

From a liability perspective each case of occurred damage may involve several launching states. However as specified by provisions enshrined in Liability Convention, namely art. III, to activities in space only fault liability can be imposed.

Deriving from the premise that OOS constitutes the provision of service, the regulations should envisage multiple scenarios, including but not limited to, the service provided by 1) the same entity that operates / owns the satellite, 2) the different entity under the jurisdiction of state of registry on the request of operating entity / satellite owner, 3) the different entity outside of jurisdiction of state of registry on the request of operating entity / satellite owner. The key in this is the State of Registry as it is the one that under the international law retains jurisdiction and control over the object (art. VIII OST).

Additionally, as OOS implies proximity operations, its conduct should ensure certain level of transparency, foreseen by the Outer Space Treaty and enhanced by the Report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities. As OOS might potentially cause harmful interference with activities of other States, the State under the jurisdiction of which the nationals of planned activities are, should undertake appropriate international consultations prior to the start of its conduct (art. IX).

8.2 Necessary Legal Framework and Solutions

We acknowledge the fact that institute of liability is to a certain extent sufficiently defined in the Outer Space Treaty and Liability Convention as well as further specified in the ILA principles, however as OOS is rather seen as on-demand service the issue of liability should be additionally clarified and differentiated regime should be developed depending on the type of OOS provided and legal status of actors involved.

In contractual relations between the customer and OOS service provider one should consider an option of a cross-waiver liability keeping in mind that such activity should be conducted on request and with permission (explicit consent) of the party being served.

The OOS should also entail changes to the existing national legislation and licensing process. Even though OOS technologies can contribute to solving the space debris problem and therefore should be positively perceived, still its nature is dual-use with all following implications, including national security and export control concerns due to direct contact with an object.

9. Conclusion and Recommendation

Commercial OOS is in the making (while OOA is not), but yet limited to life extension. More sophisticated approaches both technical and business-wise are yet in nascent stages. The introduction of reliable technology standards and associated processes will be paramount to pave the way towards routine OOS and OOA, and to involve more companies and competition, which in turn will increase innovation, efficiency and sustainability for future space infrastructure and its operations. Innovators and industry need clear guidance and other support to roll out their innovations. It should be stressed, that OOS and OOA will enable entirely new and more flexible missions and space infrastructure at large [4].

In the course of CONFERS multiple issues have been addressed and the consortium and its activities are growing in members and scope. Important ground work has been conducted, while currently still dominated by US actors, however, more and more non-American players enter the scene and corresponding activities are in the making overseas as well. It is expected that industry-led propositions will enable for new and well-defined OOS both technically and economically, both with horizontals and verticals of the OOS ecosystem with significant mid- and long-term impact on space mission architecture and operations. Interestingly the evolving and organized OOS landscape comprises competitive service providers and technical solutions as well as non-competing since mutually useful and beneficial technologies as e.g. interfaces [5] and other key tech.

The OOS implementation lacks an appropriate, clear and transparent legal regime without which it will remain in the category of experimental activities requiring skilful application of the existing general provisions and contractual clauses between the concerned parties. There will be a chance to start talking about a basic certainty only when the procedure / rules of the game will be internationally agreed and globally acknowledged.

Earlier in this paper a matrix was induced to characterize status and needs for the development of OOS. In Table 2, below, this matrix is completed to summarize interim key findings of this paper.

Table 2. OOS Dimensions Matrix (Interim Capture)

Dimensions & Values*	Role & Impact	Status Quo	Deficits & Need	To Dos & Actions
System & Technology	●●	●	Modularity + Standards Building Blocks ConOps	In-Orbit Demo of Core Tech & Key Service
Innovation & Evolution	●●●	●●	New Standards Logistics Toolboxes	Beauty Contests Pathfinder Projects
Policy	●●●	●●	Strategy Industry Incentives	Global Task Force
Legal & Regulatory	●●●	●●	Rules of the Road Civil SSA/STM	Binding Guidelines for Passive and Active OOS incl. Con Ops OST Art. VI processes in Key states
Economics	●●●	●	Proof & Showcase	Global OOS Prize
* Qualitative Level of Relative Strength ●●● and Key Messages				

The summary matrix highlights selected items, but obviously shows that additional work is to be conducted to best materialize on the potential associated with OOS and OOA for the benefit of the global space community.

At this stage it is suggested, e.g. to conduct timely in-orbit demonstrations of related key technologies to accelerate the learning curve at technical and regulatory and operational levels and to support a proper OOS ecosystem development, while a task force should steer relevant developments globally (beyond CONFERS) – this to name only a few. Moreover, table 2 also highlights the impact potential vs. status quo of key dimensions and values of OOS, associated deficits respectively, and the reasoning of before-mentioned action items.

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