IAC-22-D3.1.2.x73702

The Space Superhighway: Space Infrastructure for the 21st Century

Deborah Tomek[a]*, Dr. Dale Arney[a], John Mulvaney[a], Christina Williams[a], Jill McGuire[a], Brian Roberts[a], Jeramie Broadway[a], Karl Stolleis[b], Josh Davis[c], Greg Richardson[c], Christopher Stockdale[d]

[a] *National Aeronautics and Space Administration, USA*
[b] *U.S. Air Force Research Laboratory, USA*
[c] *The Aerospace Corporation, USA*
[d] *Analytical Mechanics Associates, USA*
* *Corresponding Author*

Abstract

This paper introduces a concept for space infrastructure developed with input from multiple U.S. government agencies called the Space Superhighway, which could support civil, commercial, and national security space activities. The Space Superhighway is a commercial-first space infrastructure that contains three primary components: regional hubs, a sustainable transportation network, and Earth-to-orbit logistics. Civil, commercial, and national security space sectors could use this common infrastructure to support missions such as satellite servicing, Earth science, and space domain awareness, among others. It utilizes a commercial-first, “infrastructure-as-a-service” approach which contains industry-owned and operated assets with government anchor tenants for commercial services, enabling extended mission lifetime, on-orbit repair, maneuver without regret, and debris mitigation and removal. The Space Superhighway is the space infrastructure needed for the 21st century.

Keywords: Space Superhighway, Space Infrastructure, Satellite Servicing

Acronyms/Abbreviations

Commercial Lunar Payload Services	CLPS
Evolved Expendable Launch Vehicle	EELV
EELV Secondary Payload Adapter	ESPA
Geosynchronous Earth Orbit	GEO
In-space Servicing, Assembly, & Manufacturing	ISAM
International Space Station	ISS
Low Earth Orbit	LEO
Orbital Replacement Unit	ORU
Rendezvous and Proximity Operations	RPO
Space Domain Awareness	SDA

1. Introduction

Historically, spacecraft are constructed on Earth and launched as an integrated, fully functioning system on a single launch vehicle. This approach constrains the shape, volume, mass, and mission design of those systems, as they are constrained by the launch vehicle fairing and lift capacity. Additionally, the operational life of the system is indirectly limited due to an inability to perform servicing, repairs, or upgrades after deployment.

Today, there is little space infrastructure to support logistics, payload hosting, and sustainable space operations. Dedicated mission payloads are launched and are not supported by other systems through end-of-life. This does not allow for extended mission lifetime, on-orbit repair, maneuver without regret, payload upgrades, or debris mitigation and removal.

The future of spaceflight will require more ambitious missions to support the commercial space sector, expand our knowledge of the Earth and the cosmos, ensure the safety of space assets, and extend human presence throughout the Solar System. Achieving these ambitious science, security, commercial, and human exploration missions is not feasible using the traditional paradigm. For example, science and human exploration missions will require spacecraft larger than any foreseeable launch vehicle fairing, defense missions will require persistent assets that are upgradable and resilient, and commercial space missions will require cost-effective ways to update to the latest technology on orbit.

Figure 1 highlights how space infrastructure would enhance operations in space. Imagine a future where space infrastructure supports sustainable use of space for science, exploration, commerce, and security. Space would be readily accessible for developing new science missions and provide rapid demonstration and validation of cutting-edge technologies. Instead of scientists, engineers, and students walking to their labs to test new technologies, they could walk to a launch pad to test their designs in space. The opportunity to replace or upgrade instruments, subsystems, and technologies at an increased cadence would inspire and accelerate innovation by providing the means to demonstrate new sensor technology and ensure state-of-the-art observation.

Space infrastructure would bring terrestrial-like logistics capabilities to space. Material could be moved without worry of depleting propellant and shortening spacecraft lifespans. The increased activity in space would provide opportunities for space domain awareness and rapid response to avoid disasters and other threats. Importantly, common shared infrastructure would promote interoperability and partnerships, defining standards and norms of behavior for all spacefaring activities to follow.

Leveraging this new paradigm of space operations would kick-start a new space economy, enabling new industries, scientific discoveries, and national security capabilities. Leveraging space infrastructure and its ecosystem would promote even more modular spacecraft using common standards and norms, further reinforcing the potential growth. By investing in these necessary capabilities, partnerships, and standards now, the U.S. government would help create a new era in space.

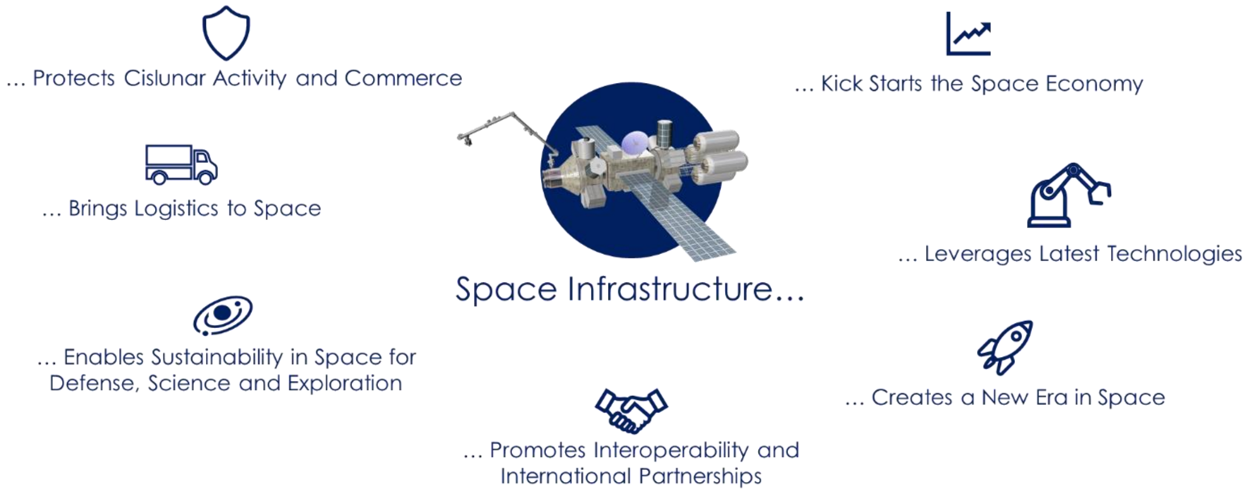

Fig. 1. Imagine a future with space infrastructure

This paper presents a concept for space infrastructure developed with input from multiple U.S. government agencies called the Space Superhighway, which would support civil, commercial, and national security space sectors. The Space Superhighway is a disaggregated, commercial-first space infrastructure concept that contains three primary components:

1. Regional hubs provide utilities to hosted payloads and logistics storage, refueling, and services to the space transportation network.
2. Sustainable transportation network provides rapid and responsive mobility, transports logistics between regional hubs, and supports responsible disposal and debris mitigation.
3. Earth-to-orbit logistics provide routine, low-cost access to space that fosters a competitive commercial launch industry.

2. Background and Motivation

Throughout its history, the United States' investments in infrastructure have transformed the country and its economy. During the 19th and 20th centuries, revolutionary infrastructure projects promoted economic growth and interconnectivity across the nation. During the 19th century, the transcontinental railroad linked sections of the nation with transit speed and regularity which was never previously thought possible. The railroad provided an interconnected infrastructure for goods and workforce mobility, which promoted the economy and spurred development in the far reaches of the nation. During the 20th century, the interstate highway system engaged the American workforce and created the backbone for the U.S. economy. The highway system, which remains the main system of transit in the U.S., improved interstate commerce, traveler safety, and defense mobility.

During the 21st century, the opportunity for a new revolutionary infrastructure is on the horizon – space infrastructure. A Space Superhighway could serve as a new interconnected infrastructure system, facilitating sustainable operations and transportation around LEO, GEO, cislunar space, and beyond. The development of this new infrastructure, in a parallel to the transcontinental railroad and interstate highway system, could provide new means of transportation, new servicing hubs and standards to support refueling and servicing, and new aggregation depots and asset pipelines to support economic growth. A phased approach to implementation would provide early, evolving capability which would in turn support future expansion.

Space activities have a pervasive impact on the lives of people around the world. Civil space operations track weather phenomena and collect data to track and help understand global climate change. The global positioning system provides navigation for global travel and its timing capability supports everyday activities such as communications and finance. Earth imaging enhances the efficient use of Earth's resources, such as agriculture, construction, and mining. Future, more ambitious space operations will require more advanced capabilities and infrastructure to be successful and sustainable.

The support for space infrastructure to achieve these goals has gained traction in the U.S. government and commercial sectors. The U.S. government maintains an interest in modular spacecraft, robust cislunar logistics networks, and improved monitoring of activities in the space domain. The U.S. Space Force views space as a key element to global infrastructure [1] and the capability of the Space Superhighway to improve mobility and logistics as an enabler to its mission [2]. The science community could leverage the Space Superhighway to enable frequent, affordable Earth science, imaging, and climate monitoring either through hosted payloads on persistent assets in orbit or by leveraging the increased ability to maneuver, extend life, and update instrumentation [3]. Commercial interests could be met through mission extension, propellant storage and transfer, repair services, technology development, and end-of-life disposal [2, 4].

3. Space Superhighway Overview

The Space Superhighway is a concept for space infrastructure that could evolve to support civil, commercial, and national security space sectors. The intention is not to specify all the systems and locations where infrastructure is needed, but rather that infrastructure in space would grow and evolve with the changing needs of the space sector. The Space Superhighway is disaggregated, meaning that many distributed, overlapping capabilities can support its customers in many ways even if a single point within the infrastructure fails. The Space Superhighway is commercial-first, meaning that industry will provide the capabilities of the infrastructure with the investment and patronage of the government as a customer and anchor tenant.

Figure 2 provides a notional diagram of the Space Superhighway concept, which consists of three primary components: regional hubs, sustainable transportation network, and Earth-to-orbit logistics.

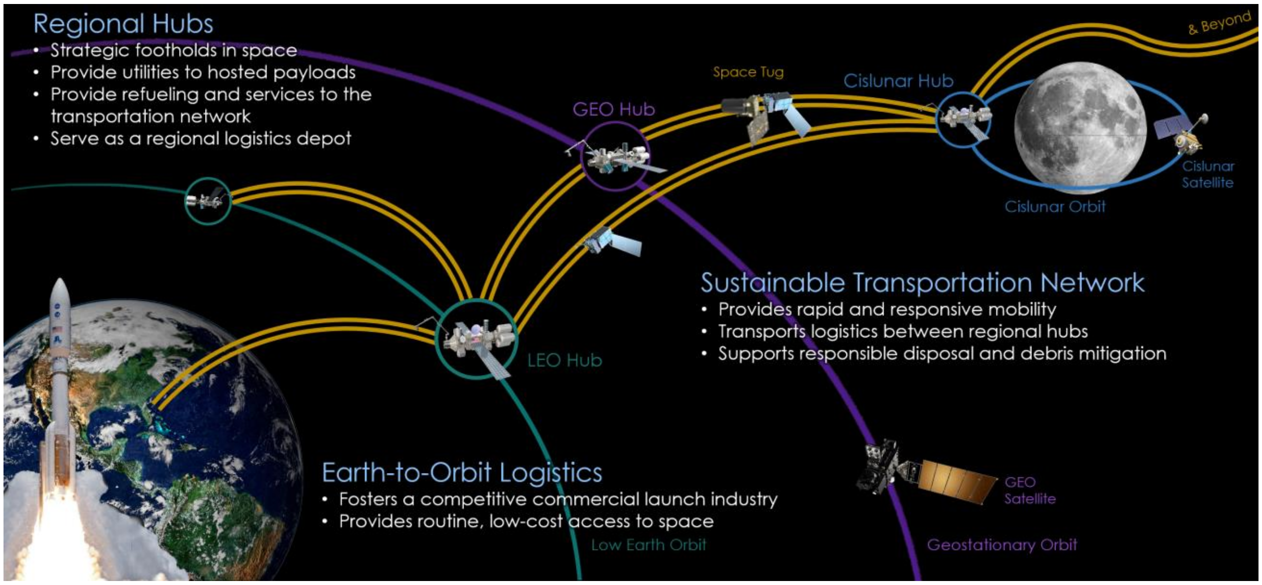

Fig. 2. The Space Superhighway concept would change the paradigm for space operations

Regional Hubs are strategic footholds in space that serve as the service stations and ports of the Space Superhighway located in multiple orbits of interest. Regional hubs provide utilities, such as power, communication, and station-keeping to hosted payloads such as science instruments, situational awareness payloads, technology demonstrations. They provide refueling and services to the tugs, servicing vehicles, and other spacecraft in the transportation network. These regional hubs will also serve as logistics depots, where logistics such as propellant or spare parts can be stored until needed. These regional hubs can take many forms depending on the market size or demand in each location and any unique requirements for that location [5].

Figure 3 presents a notional concept for one of these regional hubs. This concept leverages multiple technologies that have been recently advanced, such as space robotics, rendezvous and proximity operations, and ISAM. The regional hub is the centerpiece of space infrastructure, providing destinations that drive logistics and traffic throughout the Space Superhighway.

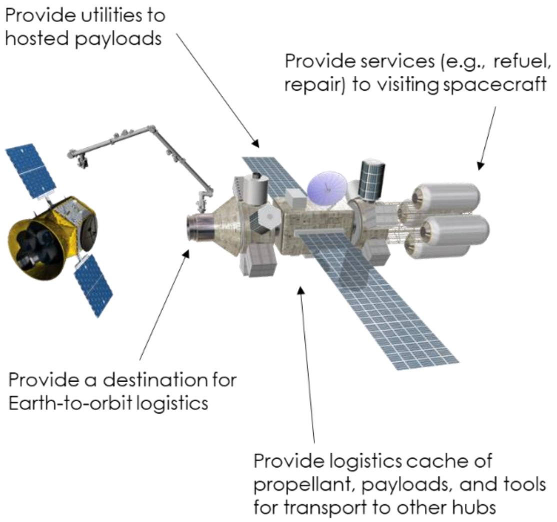

Fig. 3. Regional hubs are the centerpieces of the Space Superhighway

The Sustainable Transportation Network provides rapid and responsive mobility in space. The ability to move spacecraft, logistics, and payloads between the regional hubs and other locations allows the value of space infrastructure to scale rapidly. The transportation network would consist of tugs to move payloads between various orbits, servicing vehicles to move propellant and logistics from the hubs to different locations, and other spacecraft that can provide additional relocation services. This network would also provide vital services to space operations such as transporting cargo and propellant between regional hubs and other locations, moving payloads and instruments to higher energy orbits without the need for dedicated launch, and supporting responsible end-of-life disposal, debris mitigation, and other necessary functions to ensure sustainable operations in space.

The third component of the Space Superhighway is the Earth-to-Orbit Logistics to deliver payloads, logistics, transportation elements, and regional hubs to orbit. Well-understood space infrastructure means that payloads delivered to a regional hub in LEO would be moved to other locations by the transportation network instead of the launch vehicle, simplifying the Earth-to-orbit segment of the mission. Having a consistent orbital destination with standard modular interfaces can facilitate routine, low-cost access to space. This environment could also foster a competitive commercial launch industry that can leverage small launchers, rideshare opportunities, and dedicated launch vehicles to deliver payloads, logistics, transportation elements (tugs, servicers, etc.), and regional hub expansion to space.

4. Use Cases

As the nation moves towards an increased reliance on space-based services, establishing the building blocks now will help enable the evolution and expansion of the space superhighway. The expansion into space will bring with it new methods of operation, which favor heightened mobility, sustainability, modularity, and resiliency. These new methods of operation include relocation services through space tugs or mission extension spacecraft, payload and replacement part logistics, payload hosting, and spacecraft upgrade or repair. The combination of the future operating methods will support civil space through the expansion of the space ecosystem, commercial space through improved spacecraft sustainability and expansion of satellite constellations, and national security through increased situational awareness.

While an active Space Superhighway environment would impact any area of the future space domain, three specific use cases were selected to explore due to the high impact on the future of space infrastructure. Spacecraft servicing, which is currently in development through missions such as Robotic Refueling Mission and Mission Extension Vehicle, focuses on providing satellites with resources for prolonged operation and extended mobility. Earth science focuses on aspects valuable to science stakeholders, such as concurrent observation and greater observation coverage of the Earth. Space domain awareness requires a servicing and relocation infrastructure to ensure observational satellites are free to move in the best interest of observation, as opposed to considering a trade of propellant quantity and observational value. An overview of these use cases and their role within the Space Superhighway infrastructure is shown in Figure 4. For each use case, the Space Superhighway would provide methods of expanding capabilities beyond those possible with the current state of the art.

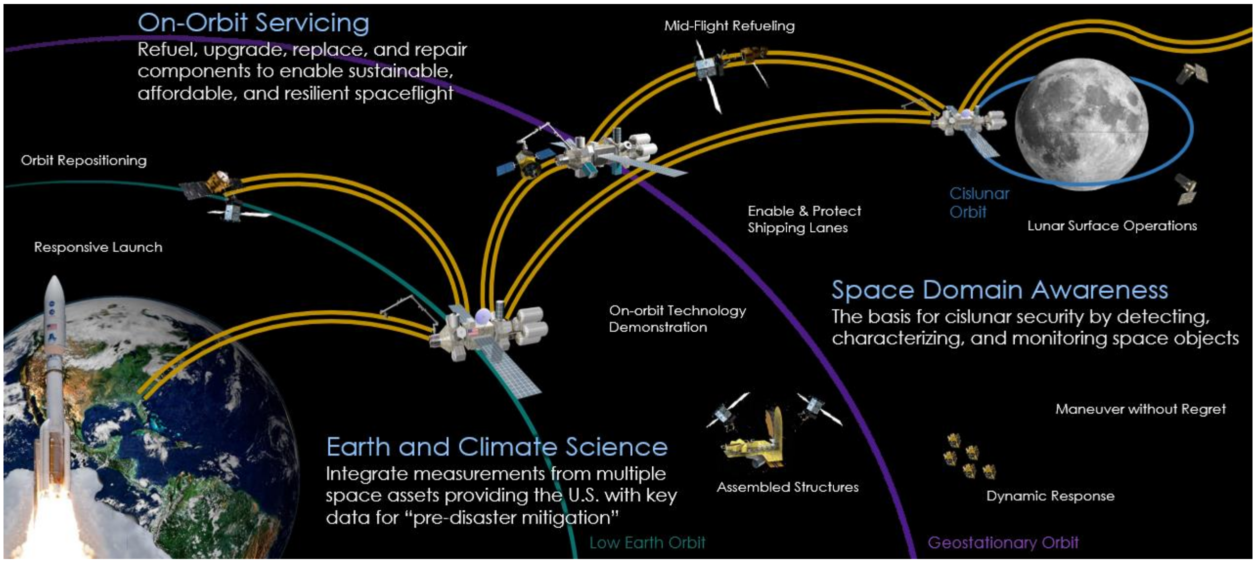

Fig. 4. The Space Superhighway supports multiple use cases

4.1 Satellite Servicing

In the current space infrastructure, satellites must be fully self-sufficient after launch. Satellite single point failures, which can include failure in deployments, electronics, software, or any critical system, can often result in mission failure before initial operations begin. Between 2000 and 2016, 41.3% of all small satellites launched failed or partially failed [6]. This high failure rate adds directly to the increasing amount of spacecraft debris and results in a financial loss by the satellite developer. The James Webb Space Telescope included 344 single point failures [7], any of which would have resulted in mission failure and an economic loss of 10 billion dollars [8]. The current solution to satellite single point failures is a heavy reliance on redundancy. While redundant systems do allow for spacecraft to continue operations in case of some specific failures, redundancy adds additional satellite mass and increases the cost and schedule of satellite development.

Another ongoing challenge in the current space infrastructure is the standard lifetime of satellites. The current lifespan of GEO satellites is typically limited to 15 years [9], mainly due to available onboard propellant for orbit maintenance and maneuvers. This lifespan promotes the generation of satellite space debris and increases expenditures by satellite developers due to satellite replacement cost. Satellite orbit changes, which are often considered costly due to the use of onboard propellant, essentially reduce the lifespan of the satellite. Deorbiting or repositioning into a graveyard orbit for end-of-life satellites also requires propellant, making these services a costly expenditure and the alternative of adding to unconsolidated space debris an environmentally unfriendly, option.

These challenges posed by spacecraft failure and propellant limitations can be resolved through a space ecosystem which uses a series of elements focused on satellite servicing. Space tugs and relocating satellites could be used to provide basic orbit maintenance or to perform more costly orbit changes. This would allow for the development of satellites with less onboard propellant, therefore reducing satellite launch mass and allowing for higher satellite packing efficiency during launch. Servicing vehicles could also be implemented to provide subsystem replacement in case of failure. This would allow for spacecraft design with redundancy only for mission and safety critical components and for repair in case of failure. In addition, servicing vehicles could provide hardware updates to client satellites, ensuring payloads such as Earth observing instruments remain at the cutting edge. These cases of reduced satellite developer costs and heightened capabilities could lead to a higher rate of satellite production and therefore an expansion of the space ecosystem.

In a Space Superhighway supported infrastructure, the network of satellite servicers and space tugs would be centered around a series of refueling depots and logistics hubs. Central refueling depots in conjunction with relocation satellites and space tugs would enable a fully reusable satellite transportation network without the need to launch replacement relocation satellites with their own limited propellant, as is the current state of the art. Instead, centrally located refueling depots could be supplied by a limited number of dedicated propellant launches or by secondary payload propellant caches which would provide enough propellant to support any ongoing relocation activities. Similarly, central logistics hubs could offer readily available ORUs for on-demand satellite servicing. A servicing satellite could retrieve the appropriate ORU from a logistics hub and service the client satellite, all without the dependance on launch and development timelines for a replacement subsystem or complete satellite replacement. In addition, updated science payloads could be launched to a logistics hub, co-manifested with ORUs, to allow for payload updates to be completed in a similar fashion as an ORU swap. In this ecosystem, dedicated launches to support the ongoing space infrastructure would be limited to resupply of the dedicated refueling depots and logistics hubs.

Before fully modular spacecraft embracing the Space Superhighway concept becomes standard, servicing in the near term will likely be accomplished through unplanned servicing technologies. In this context, unplanned servicing refers to servicing of legacy spacecraft without standardized interfaces. Legacy servicing satellites, such as Mission Extension Vehicle, could still rely on the Space Superhighway infrastructure for refueling at depots, however their operation would likely be specific to the client spacecraft. In order to begin the shift from the more costly and less efficient servicing of legacy spacecraft to an ecosystem with standardized satellite servicing operations, spacecraft must be designed with common interfaces and future servicing in mind. Established spacecraft servicing standards, developed alongside and adopted by industry partners, would ensure interface consistency between client satellites and servicers, thus providing a competitive atmosphere in commercial space servicing [2]. Spacecraft modularity, which relies on interface standardization, will enable more intricate spacecraft servicing, such as replacement of specific spacecraft subsystems or payloads.

An interconnected and modular space ecosystem, like the Space Superhighway, would encourage an environment of asset repair, upgrade, relocation, and refueling, consequently encouraging satellite operation flexibility and promoting asset resiliency. Space Superhighway servicing methods and their benefits are shown in Figure 5. Servicing and relocation activities, although currently in development, must rapidly advance in the near term to reach the maturity required for the emerging space economy. Robust servicing and relocation capabilities are key to a Space Superhighway infrastructure comprised of space tugs, servicing vehicles, aggregated refueling depots, and logistics hubs. Development of these capabilities will enable a sustainable, affordable, and resilient space ecosystem.

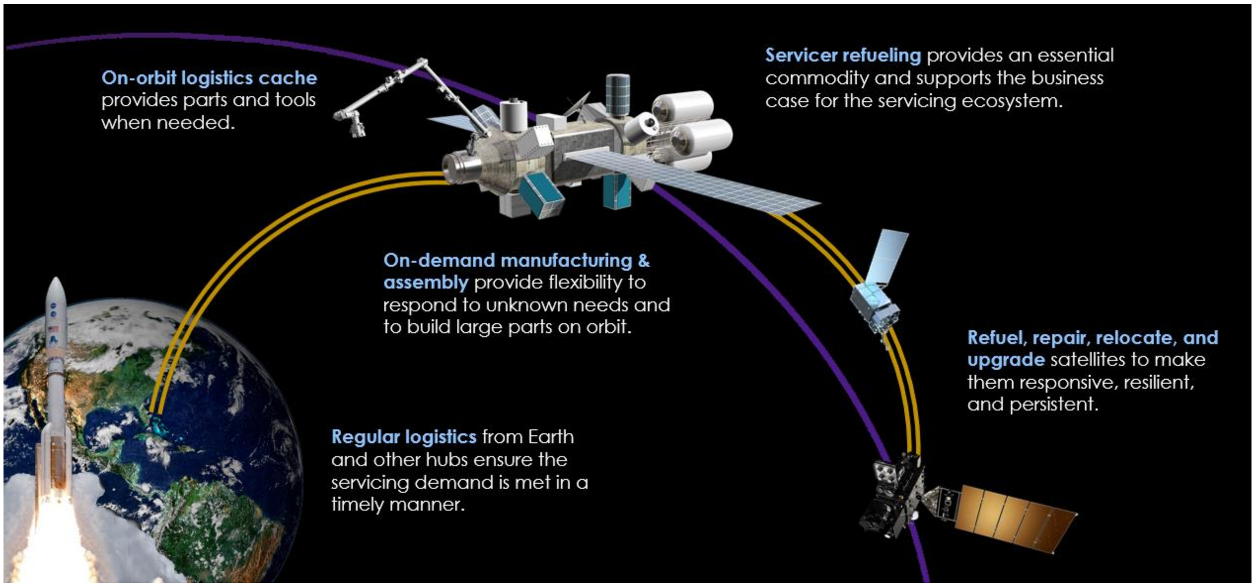

Fig. 5. The Space Superhighway supports a satellite servicing ecosystem

4.2 Earth Science

The current paradigm in Earth observation involves utilizing constellations of expensive, dedicated spacecraft or hosting payloads aboard the ISS. Without the ability to readily upgrade, service, or transport an Earth science spacecraft or instrument, future missions require that the previous spacecraft be disposed of (either in a graveyard orbit, lending to the issue of space debris; or by deorbiting the craft, thereby functionally destroying the craft and its components). This mode of operation, in addition to generating waste due to an inability to reuse or repurpose spacecraft, lacks the ability to perform rapid replacements or upgrades to instruments. For example, Earth observation would benefit from concurrent, spatially co-located observations with multiple instruments and demonstrations of new technology. The Space Superhighway could reduce the significant cost and effort of delivering new instruments and routine maintenance and repair components to space with launch to the hubs using rideshare opportunities and distribution to the client using the transportation network. Moreover, the ISS poses unique challenges for national security opportunities and co-locating instruments with humans on orbit. The high costs associated with developing, manufacturing, launching, operating, and commencing end-of-life operations for a single use spacecraft impacts Earth sciences by drastically increasing the barriers to entry.

The creation of a Space Superhighway would alter the way Earth science is conducted, as well as the returns of these scientific endeavors. By utilizing hotel slots aboard the fleet of regional hubs, as illustrated in Figure 6, Earth science instruments and payloads would be capable of conducting missions at a greater volume and have access to new capabilities such as repair, upgrade, maintenance, servicing, and robotic manipulation. In addition to the convenience of instrument and payload hosting, the regional hubs also offer the convenience of resource sharing. Allowing instruments to use hub utilities such as power, data services, and thermal regulation, provides a greater degree of freedom in terms of design, launch, as well as mission and resource requirement planning.

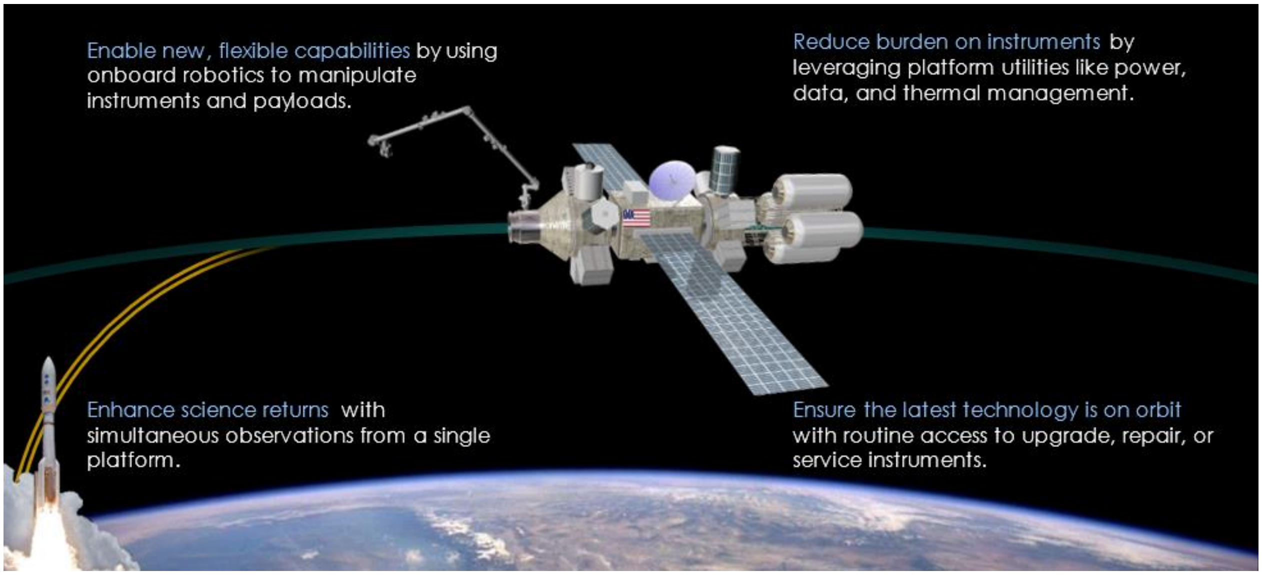

Fig. 6. The Space Superhighway enhances the ability to perform Earth science

While those Earth science payloads hosted aboard the regional hubs would enjoy a great deal of benefits, so too would independent spacecraft that would be operating within this new ecosystem. Regional hubs, acting not only as instrument hosting platforms but also as logistics depots for space tugs and servicing vehicles, would afford dedicated Earth science spacecraft a similar degree of flexibility. Operators now need not plan a spacecraft that is completely self-contained, and a launch that places it into its final orbit, never to be touched again. Instead, missions that leverage the Space Superhighway would launch to a regional hub, relocate to the desired orbit via a tug, and begin operations with the assistance of the space infrastructure (should anything during deployment and operations fail or need upgrading). During its lifetime, the spacecraft would be able to leverage a variety of Space Superhighway services to increase its operational effectiveness. These could include elements such as relocation services that alter the spacecraft's orbit in order to observe new locations or respond to climate crises; or mission extension services such as refueling or recharging the spacecraft, or by the repair, upgrade, and maintenance of damaged or obsolete instruments.

4.3 Cislunar Space Domain Awareness

When Sputnik launched in 1957, its operators did not have to worry about collisions between artificial satellites. There were micrometeoroids and other natural pieces of debris near its orbit around Earth, but when it came to collision avoidance, being first had its privileges. Every satellite, spacecraft, rocket, and human exploration mission that has launched since Sputnik has had to worry about avoiding collisions with other artificial objects in space. Over time, the standards for identifying, tracking, and characterizing objects in orbit have become codified in processes within the field of SDA. SDA encompasses the observation of all space objects – natural and artificial – to determine where objects are, so that operators can determine when the orbits that each object occupy have the potential for a collision.

SDA in Earth orbits – from LEO to GEO – is an operational mission of U.S. Space Command. Earthbased sensors create observations of space objects using passive systems like telescopes and active systems like laser ranging. Similar sensors are employed by radiofrequency systems using passive antennas and active radars. By tying together multiple observations of the same object at different times and different parts of its orbit, operators can create an estimate of that object's trajectory, which allows them to project its location into the future.

For SDA of objects in cislunar space, detection and tracking are significantly more difficult because lunar distances increase the search/track volume by a factor of 1000 over the equivalent volume in GEO. Objects appear fainter at these distances, stressing the performance limits of passive optical sensors, and they move more slowly, so more observations are required over a longer time scale to see significant fractions of their orbit. In addition, the Moon is bright and opaque, making it harder for optical systems to track objects close to the Moon and masking key traffic lanes. To achieve full cislunar coverage – including assets operating on the far side of the Moon – the SDA architecture needs sensors in novel and varied orbits within cislunar space.

One solution for cislunar SDA involves a disaggregated architecture in which small, highly maneuverable spacecraft collaboratively perform search, characterization, tracking, and attribution of all objects. Once an object is identified, clusters of small satellites rapidly respond by maneuvering closer to better characterize the object. These SDA spacecraft would maneuver frequently, depleting their onboard propellant as they maneuver from object to object.

The Space Superhighway provides the infrastructure needed to store and deliver logistics where they are needed. This logistics support function would allow the SDA spacecraft to maneuver without regret, knowing it could refuel as needed to extend their on-orbit lifetime. In this context, the Space Superhighway would become a critical enabler for cislunar SDA. SDA sensors could also be hosted on multiple regional hubs within the Space Superhighway to expand the net of detection. Each hub would also act as a propellant depot, storing propellant that could be delivered to the SDA spacecraft with a servicing vehicle, or allowing an SDA spacecraft to dock and directly refuel. This servicing infrastructure could also provide other types of services to both the SDA and other spacecraft in cislunar space, performing scheduled maintenance, repair, or hardware upgrade.

Successful cislunar operations will require a logistics train to transport a ready supply of propellant, hardware, and robotic infrastructure from Earth. Utilizing small launch and rideshare opportunities, logistics could be launched quickly and responsively to a LEO regional hub. Once in space, the in-space transportation network could move the supplies from LEO to more distant hubs, providing an efficient and effective method of supporting cislunar SDA. Figure 7 is a depiction of how the SDA architecture could leverage the Space Superhighway.

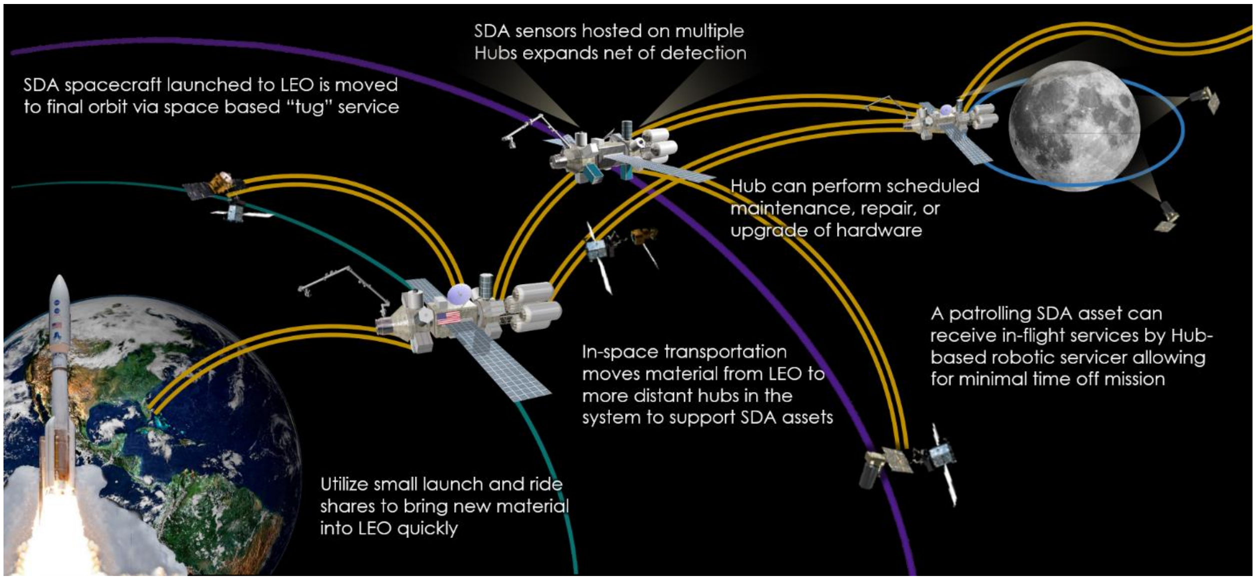

Fig. 7. The Space Superhighway would be a critical enabler for cislunar space domain awareness

5. Commercial-First Infrastructure-as-a-Service

The Space Superhighway would leverage industry innovation and scalability to establish a commercial-first space infrastructure that can be leveraged as a service. The government would not own and operate most of the regional hubs or transportation systems. Instead, it would leverage public-private partnerships to establish and evolve "infrastructure-as-a-service," which could provide needed services and capabilities in space where needed. Even initially, the Space Superhighway would consist of industry owned and operated assets with government anchor tenants for commercial services. A successful example of this type of partnership is the Commercial Crew and Cargo Program [10], where NASA incentivized the development of logistics and crew delivery to the International Space Station.

Structuring space infrastructure in this manner provides many benefits compared to a government owned and operated infrastructure. This model fosters and promotes commercial innovation and allows the Space Superhighway to grow as the market demands. If there is a business case for services in a location in space, the industry partners can expand the network to meet that need. The Space Superhighway would also generate opportunities for underserved entities, including academia, start-up companies, and countries that could not support a space program themselves.

The first step toward space infrastructure is to understand the national infrastructure needs. From there, the community can create the logistics and operations concept, understand the standards and policy implications, and define the strategy to leverage public-private partnerships to build and utilize the Space Superhighway.

Previous investments in ISAM, robotics, and rendezvous and proximity operations have prepared the space community to embark on such an endeavor. Building confidence in this model could start small with ESPA-class capability demonstration missions that could host science instruments or new technologies. These initial demonstrations can leverage rideshares, partner with dedicated servicing missions that government and industry are already pursuing, and more. The Space Superhighway could even bootstrap from existing investments, such as commercial rideshares [11], ISS, Commercial LEO Destinations [12], and Gateway [13]. It is important that a demand exists to utilize space infrastructure, and this demand can be kick-started with government activities like the CLPS missions [14], payload hosting on ISS [15], commercial crew and cargo [10], and Commercial LEO Destinations [12].

The risks of relying on this concept for space infrastructure are real and must be addressed as it is being developed. Mission designers are not inclined to increase the risk on their system by relying on capabilities of external systems, especially those that are nascent like space infrastructure, and those systems may impose new challenges, such as interference with adjacent payloads on a persistent platform or limitations of the infrastructure that would be imposed on operators. Ensuring interoperability across the infrastructure and the systems using the infrastructure will be a challenge, so standards, policy, regulations, and norms of behavior will need to be addressed early in the formulation of the Space Superhighway. Finally, reliance on industry investment and development could fail to deliver the needed capabilities on time, within budget, or at the required performance. These risks will need to be mitigated early in the development of the Space Superhighway and will need constant attention as these and new risks evolve with the infrastructure itself.

6. Conclusions

The Space Superhighway is the space infrastructure needed for the 21st century. Its three components – regional hubs, transportation network, and Earth-to-orbit logistics – combine to provide an ecosystem of capabilities that would change space operations in the future. By including capabilities like refueling, repair, upgrade, transportation, and logistics, space operations become more pervasive, more capable, and more sustainable.

Satellite servicing, Earth science, and space domain awareness are just three examples of the many ways in which the Space Superhighway could improve and expand space operations for civil, commercial, and national security space. While each leverages the Space Superhighway in different ways, the inclusion of space infrastructure enhances, and in some cases, enables these new missions.

With the advancements in technologies such as ISAM, robotics, RPO, and autonomy, this infrastructure is ready to be established. A commercial-first approach, where industry owns and operates much of the infrastructure, and government leverages this infrastructure-as-a-service, will allow the Space Superhighway to adapt, innovate, and grow where it is needed. The nations that lead the development of space infrastructure will define norms of behavior, develop needed capabilities for future space operations, and provide international leadership on the sustainable use of space.

Acknowledgements

The authors would like to acknowledge and express appreciation for the contributions to this paper from the United States Space Force, including from Dr. Joel Mozer, Dr. Michele Gaudreault, Major General John Olson, and Ken Hampsten.

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