Including spaceflight in the transportation matrix: the whole is greater than the sum of its parts

Diane Howard
Commercial Space Operations/Spaceflight Operations, Applied Aviation Sciences, College of Aviation, Embry-Riddle Aeronautical University, USA
Email: diane.howard@erau.edu

Abstract: The role of spaceflight is evolving. Innovative systems insert an increasing number of assets into orbital slots for the private and public sectors. Private space transportation systems currently transport cargo to the international space station. Private operators will soon be transporting people as well. Despite these strides forward, space transportation is only now gaining traction as the sixth mode. The paper provides policy support for this position, frames the inquiry as to spaceflight’s relationship to other modes of transportation, performs a plurality analysis and discusses the feasibility of applying some basic logistics research to help manage these intermodal relationships.

Keywords: spaceflight; spaceports; synchronodal; pluralism.

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Biographical notes: Diane Howard is an Assistant Professor in the Commercial Space Operations/Spaceflight Operations Program at Embry-Riddle Aeronautical University in Daytona Beach, Florida, USA. She is responsible for the curriculum development and teaching space law and policy courses that are core to the program. She is a licensed attorney, she received both her LLM and PhD from the McGill University’s Institute of Air & Space Law. Her LLM thesis centred upon private space law issues and her doctoral work focused upon effective spaceport regulation. She serves as an Executive Secretary of the International Institute of Space Law and she participates in numerous legal projects, both domestically (within the USA) and internationally. In addition to the IISL, she is a member of the AIAA, the International Association for the Advancement of Space Safety, the American Society of International Law, the National Space Club Florida Committee and the Florida Bar.

1 Introduction

Water, rail, road, air and pipeline: these represent the commonly accepted modes of transportation (Rodriguez et al., 2016). However, our cultural appreciation of the fundamentals of mobility is expanding, going somewhat low-tech, by including walking as a credible mode of travel and now high-tech, as we begin to discuss spaceflight as a
mode of transport rather than a futuristic fantasy available to only a select few (Wigan, 1995; 2060 Florida Transportation Plan). Not only has spaceflight earned its stripes as a viable means of transport; it should also factor into discourse on intermodal, multimodal and synchronomod modal transportation (SteadieSeifi et al., 2014), both as an effort to better appreciate the characteristics of space transportation and also to facilitate efficient coordination with other modes of transport.

The US commercial spaceflight industry is evolving. The FAA has granted to Virgin Galactic, a license to perform commercial crewed operations with paying participants aboard (Boucher, 2016). SpaceX and Orbital regularly deliver cargo to the International Space Station (ISS). Private companies Boeing and SpaceX are meeting their performance benchmarks as they ready themselves to fulfil their contractual obligations with NASA by transporting government astronauts, also to the ISS. In the Commercial Space Launch Competitiveness Act of 2015, the US Congress has acknowledged the need for regulatory oversight beyond launch, re-entry and site licenses. The FAA has tasked directorates with the integration of space operators and vehicles as users of airspace, an objective that differs from simply ceasing air traffic in deference to space users (Murray, 2014). Spaceport licenses have been granted in a variety of locations with a wide range of facilities and operational capabilities, including co-location with airports serving markets with congested airspace. Is the current transportation infrastructure positioned for spaceflight’s transitioning role in our culture?

Traditionally, space transportation has been consistently set apart from other transportation modalities. Further, scholarship about commercial space transportation has focused upon the suborbital aspect of the activity. However, this emphasis only serves to perpetuate an artificial construct – that the differences between suborbital and orbital activities are so great, these methods of transportation should be managed and regulated completely apart from one another. The inadequacy of this ultimately arbitrary distinction becomes more apparent when trying to integrate newer technologies that traverse airspace on their way to high altitudes or outer space, i.e., remotely piloted air systems (RPAS)/unmanned aircraft systems (UAS), high-altitude balloons and hybrid vehicles.

Some of the problems arising from separating suborbital and orbital transportation were apparent a few years ago, when a group of experts at the European Aviation Safety Agency (EASA) proposed that the European Commission include some suborbital activities in the aviation orbital regime. As a result, potential challenges to interoperability with US launch operators became apparent. The US licenses and permits suborbital launches within the same regulatory framework governing orbital launches. Profound differences exist in how the air regime treats liability to passengers as opposed to recoveries available to spaceflight participants in the US or elsewhere. Other differences exist in acceptable safety thresholds used in calculations for hazard analysis for aviation versus spaceflight. Even certification of airports proposed to perform suborbital launches contrasted greatly with how spaceports were licensed in the USA.

It might be more practical to take the view that spaceflight is a sixth mode of transportation deserving its seat at the modal table along with road and rail and marine and aviation and that suborbital travel and orbital travel represent different sub-modalities within the spaceflight mode. Already, the State of Florida acknowledges this reality by allocating funding for space transportation as a sixth mode.
2 Policy support

Supporting the argument for space as a sixth mode of transport, the USA addresses its policy goals for space transportation, as well as space activities, in two recent directives issued by the executive branch. The first, and broader, of these is the US National Space Policy (2010), containing both principles and goals for US space activities. The principles clearly commit USA to encouraging and facilitating (mirroring language found in the Commercial Space Launch Act of 1984) the robustness and global competitiveness of the US space sector.

The link to transportation is expressed in terms of access to space via a launch, with the implicit understanding that space is a domain where significant amounts of private and public sector activities occur. Further, transportation is expressly listed as an identified area for enhanced international cooperation. The US Government is instructed to transfer routine operational space functions to the private sector if safety and national security will not be compromised and to encourage the use of US commercial space services in international arrangements.

The more recent and relevant edict, the US National Space Transportation Policy (2013) focuses upon space transportation as a system of capabilities. Space transportation is discussed in terms of access to ‘regions of space’, near and far, through Earth’s orbit and to deep space. Again, these regions of space are seen as areas of activity that are critical to US economic growth, as well as betterment of life on earth, scientific advancement, discovery and security. Increasingly more efficient and capable space transportation systems are seen as crucial for US leadership from a national security perspective and from the standpoint of competitiveness in the international marketplace.

Governmental departments and agencies, such as NASA and DoD, are to develop, operate and enhance infrastructure and support activities to do so extending encouragement for participation by the private sector, as well as state and local governments. “The overarching goal of this policy is for USA to have assured access to diverse regions of space, from suborbital to Earth’s orbit and deep space, in support of civil and national security measures.” (US National Space Transportation Policy, 2013)

3 The relationship between spaceflight and other transportation modes

Accepting, then, that spaceflight represents a mode of transport with societal benefits beyond scientific exploration and discovery, and that activities in space are sufficiently intrinsic to terrestrial life to justify including spaceflight in the larger transportation matrix, what is the relationship between spaceflight and the other more traditional modes?

Clearly, transportation modes do not operate in isolation. A number of terms have emerged to describe the relationships between modes of transportation. First, transportation and shipping are not interchangeable terms. Some nomenclature has developed in the shipping industry and distinctions between terms are made with respect to the bills of lading that govern the transaction. However, for the purposes of this paper,
a general definition of intermodal or multimodal transportation refers to the sequence of at least two transportation modes, transferring from one to the next at a terminal (Crainic and Kim, 2006). Intermodal is often used to reference containerised cargo moving from truck to rail to ocean, or the international movement of goods, or to a combination of private (car) and public (rail) transport. Transmodal transportation denotes combining a number of series and parallel multimodal transport links (Kirichenko and Koroleva, 2014).

Figure 1 Transmodal and intermodal operations (see online version for colours)

The European Commission’s definition of co-modality goes a step further than these concepts and suggests the optimised use of transportation modes by themselves and in combination with other modes (European Commission, INEA website). The gist of the idea is that efficient and holistic use of modes makes the overall transportation mission more sustainable and produces benefits to society economically and environmentally.

The term ‘synchromodal’ appears to refine the idea of ‘intermodal’ and ‘co-modal’. Synchromodal is used to denote a “structured, efficient, and synchronised combination of two or more transportation modes” (SteadieSeifi, 2014). It is not simply sequential movement between modes and it may or may not be the most efficient use of modes. It is used to denote a system relying on networks (Behdani, 2015). Synchromodality accepts that there may be weaknesses as well as strengths within an available mode or sequence of modes and endeavours to address those weaknesses while fortifying the strengths. This is accomplished by designing a synchronised transportation network based on available modes, the interoperability of those modes and enough transparency or visibility that
these options are known to be available (Behdani, 2015). Synchromodality could be viewed as a method to accomplish co-modal optimisation.

Where does spaceflight fit into these models? First, looking at the relationship between suborbital and orbital activities, suborbital describes a trajectory that does not result in orbit. It does not refer to a location or region of space. Orbital spaceflight is the placement of spacecraft into at least one orbit. As a result of the physics governing these two types of flights, they do not exist as sequential modes for a transport event. Hence, they are not intermodal. However, suborbital and orbital activities can occur in parallel to one another, operating out of the same infrastructure or facility.

Aviation services and spaceflight services are both parallel and sequential in nature. It is possible to launch suborbitally or orbitally from a location that also performs aviation flights, if appropriate infrastructure is in place (runway tensile strength, for instance) and safety calculations and practices satisfy the applicable FAA rules. In this scenario, aviation and spaceflight are parallel in relation to one another. There is also a sequential aspect. Spaceflight participants, crew and cargo must get to the launch site and often fly there. In the case of Spaceport America, a combination of air travel sequenced with either rail or road is necessary, as there is no airport local to the spaceport. Payloads and launch vehicles often rely on a succession of rail, road and sometimes marine, to get hardware to the launch site destination.

Suborbital and orbital activities must traverse airspace to achieve their trajectories, regardless of whether they result in orbit or not. In fact, both suborbital and orbital flights also coexist with aviation geographically in airspace for a portion of their mission as well. Stilwell (2016) makes the point that the aviation community, and more specifically the International Civil Aviation Organization (ICAO), treats space activities/operators as transit users of civil airspace. This approach provides some clarity with regard to who and how should regulate the airspace and those using it while in it (Stilwell, 2016). Airspace could be characterised as a transmodal environment, used by sequential modes and where parallel modes can co-exist.

Suborbital companies are including cargo capabilities and scientific exploration in their business plans; reliance on tourism is now seen as short-sighted. Efficiency requires coordination with the extant transportation system. Furthermore, without efficient coordination, the possible benefits accruing from fast travel, point-to-point, suborbital flight could be completely lost trying to get to the spaceport itself (Webber, 2010). Again, there are multiple aspects to the relationship between spaceflight and other modes. Point-to-point spaceflight could ultimately be a substitute for some air travel, but also could rely upon aviation simply to get passengers to the launch site. The optimisation goals and objectives of co-modality can be applied to spaceport operations servicing any, or all, orbital and suborbital activities that utilise other modalities to accomplish these objectives. The efficiency analysis would be similar to that performed for any other transport event/s.

The current logistics research in how best to synchronise the strengths and weaknesses of networked transportation modes also has utility for the space sector. In fact, the US National Space Transportation Policy discusses space infrastructure and operational support in terms of a synchromodal system. True modal synchronisation and coordination goes beyond a micro view of operations and should also include the aspects of regulation and liability exposure.
Multidisciplinary coordination (operational and regulatory) between transportation modes came under discussion in USA prior to the timeframe that the Civil Aeronautics Act of 1938 was enacted, when motor and water transport were significantly impacting rail transport. Ultimately, the Interstate Commerce Commission managed both rail and highway carriers, while air and motor carriers coordinated their operations in order to maximise the benefits of expeditious air service. Fair and Wilson (1934) described coordination as “the act of regulating and combining so as to give harmonious results, and the harmonious adjustment of the persons or things coordinated” and stated that in this coordination, each type of facility has its place. Nelson (1938) identifies several goals of coordination. First, that it is necessary to shape a public transport policy better designed to provide a more efficient transportation system and stating the “task of coordination by regulation, then is to find the proper economic sphere of each competing agency and give it the transport work to do for which it is most economically adapted.” However, policy coordination should not hinge only upon an agency’s economic purview, but should include operational competence as well.

The need for coordination between different methods of transportation was eloquently expressed by Henry Newman, Regional Director of the Southwest Region of the FAA when Dallas-Fort Worth airport was built, at the airport’s dedication in 1973. He said “We can’t afford economically, nor will society tolerate any more hit-or-miss random action designed perhaps to benefit all of aviation or some segment of it which is unmindful of other transportation modes or of society as a whole” (Newman, 1973). And in Europe, “Transport has historically been an area, where the community has been empowered to establish common policies and common rules” (Marciacq et al., 2013).

While it is prudent to acknowledge the pronounced differences between suborbital and orbital flight from an operational perspective, separating the regulatory treatment of the two likely provides another potential hindrance to co-modality, both within space as a sixth mode and between space and other modes, in particular aviation. This interoperability can adversely impact international interoperability between launch sites and airports sited in different jurisdictions.

At one time, EASA formed a group tasked with the how best to oversee European suborbital winged flight (Marciacq et al., 2010). The group’s proposal included a number of options, one of which (and the one which garnered the most attention for a few years) recommended treating these activities as part of the aviation regime and as completely separate from orbital spaceflight (Marciacq et al., 2013).

Likely, this recommendation had something to do with EASA’s competency to oversee methods of transport such as aviation but not space travel which is left to the sovereign member states to manage as they see fit. Modes of transport such as aviation allow European Union law to trump or to suppress national law. The European Economic Community must establish common policy and common rules for transport. There is an implicit distinction made by the Treaty on the functioning of the European Union, allowing shared competence for some space activities thought not as part of transport – for instance, global navigation satellite systems and earth observation constellations. This runs counter to inter-modality and co-modality between space transportation and other modes of transport. The European Commission makes no distinction for commercial activities as opposed to exploration or science, simply between space and transport.

Scholars Masson and Moros-Aguilar (2013) find the segmentation in the described EASA proposal undesirable on grounds of practicality as it would mean completely different regimes not only for suborbital and orbital transportation but also for horizontal
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takeoff or air launch/horizontal landing and vertical rocket launches (regardless of destination). EASA’s now defunct proposal was silent on how to accommodate both suborbital and orbital transportation from the same site and for this reason it was not clear whether a multi-modal spaceport was possible or even legal under this option and how an operator would proceed. Fortunately, the European Commission tabled a decision until operations were more imminent.

In a more recent study commissioned by the European Commission to evaluate the European market potential for commercial spaceflight, the short-term interest for European spaceports was to garner US-produced vehicle operations at their facilities and, as a result, a regulatory framework aligned with the US regime would facilitate this goal with greater ease (European report, 2013). The US operators, in turn, would operate from EU spaceports, but stated preference for those spaceports in jurisdictions that have some national legislation providing regulatory alignment and facilitating coordination.

In fact, UK did an in-depth study of how best to proceed, from a regulatory and policy standpoint, as it begins to develop and support a commercial spaceflight economy of its own. (UK report, 2014) Ultimately, UK recommended aligning its regulation with that in USA – to foster innovation, to avoid unnecessary burdens upon start-ups – and to be able to work with US operators. This decision by UK aligns well with policy goals of international cooperation and global competitiveness, shows concern for social values of economic health, innovation and safety, and allows for inter-modality between USA and UK.

Managing multiple modes of transportation, often with overlapping jurisdiction for agencies tasked with regulation of this shared legal space is an exercise in pluralism. This is particularly true because of the differences in how different transportation modes assign liabilities.

4 Plurality: shared jurisdictions

Merry (1988) defines legal pluralism as a situation in which two or more legal systems coexist in the same social field; legal systems can be found in every functioning subgroup and a subgroup’s legal system is, by necessity, unique in some way (Merry, 1988; Griffiths, 1986; Moore, 2009) The various multimodal relationships described in this paper represent plurality, by nature.

Managing the hybridity of these relationships will be a key to integrating space transportation and infrastructure with that of the five more traditional modes of transportation. According to Macdonald (1988), “inquiry into the resistance and accommodations of legal-political culture to deeper integration and international trading regimes is the stock-in-trade of a legal pluralistic analysis.”

In particular, viewing airspace as a transmodal environment, there are conflicting and sometimes competing authorities. Sometimes, benefits accrue from multiple assertions of jurisdiction and authority. For instance, Cover (1981) lists greater possibility for error correction, a more robust field for norm articulation, and a larger space for creative innovation.

Involving diverse stakeholders is powerful and useful. Hybridity of membership exists in some of the intergovernmental and nongovernmental organisations and advisory groups that interface with lawmakers and regulators of all types of transport.
Non-governmental actors, in the form of industry stakeholders, currently participate in the International Telecommunications Union and the International Convention on Global Navigation Satellite Systems, internationally and in USA, COMSTAC and other advisory groups. The United Nations Office of Outer Space Affairs (UN OOSA) is currently planning its initiative, UNISPACE+50, which includes the private sector as an intrinsic and valued participant driving space applications that improve terrestrial life.

Non-governmental actors influence state actors a number of ways: by internalising international norms as in the context of a multinational corporation, for its own self-interest, supporting the Kyoto protocol on global climate change despite a lack of formal state support for same, and, in turn, influencing the state to re-evaluate its position (Berman, 2006) or when government agencies commission academia to draft reports that make normative recommendations.

Berman (2007) offers us fundamental principles to guide a pluralistic approach to coordination. They are:

1. Managing hybridity should not attempt to erase the reality of that hybridity.
2. A pluralist framework recognises that normative conflict is unavoidable and attempts to manage it through procedural mechanisms, institutions and practices that draw the participants into a shared social space.
3. To create that shared social space, those mechanisms, institutions and practices should encourage decision-makers to deal with issues of multiple community affiliation and transborder effects instead of suppressing or ignoring normative differences.
4. It should compel consideration of the independent benefit that accrues when domestic judicial and regulatory decisions acknowledge the big picture advantage of a smoothly functioning overlapping international legal order.
5. Public policy exceptions, when faced with one faction’s law that is abhorrent to the others, should be accompanied by equally strong normative commitments that help shape the contours of the public policy favoured.
6. This pluralist framework should always be understood to be a middle ground between the poles of strict state-centric territorialism, on the one side and universalism on the other.

One of Berman’s principles recommends maintaining the hybridity of regimes, another recommends managing inevitable conflicts through agreed upon protocols and another suggests acknowledging the effects of these differences and transborder activities rather than trying to suppress them. A notable challenge inherent to these interrelationships between modes, particularly when sharing an environment in parallel or a mission in sequence, is that which arises when damage occurs. This is particularly true when different modes may provide for disparate recoveries. How best to deal with a hybrid series of modes, cutting across several regimes? Toivonen (2015) implicitly addresses these principles in her discussion of how to handle liability issues in multimodal transport, given that at present no uniform international instrument governs these activities.

She claims that a prospective uniform convention “denotes that the same provisions and the liability of a carrier concern the whole transport regardless of the stage of
transport at which the damage occurs.” Toivonen (2015) recommends regional management in the absence of such a unifying instrument and analyses both the network principle, as per UNCTAD/ICCA, or a modified system representing a compromise between uniform liability and the network principle. The Geneva Convention on Intermodal Transport of Goods, which failed to enter into force, is an example of a modified system, allowing imposition of different provisions and liability limits depending upon the stage of transport where/when the damage occurs.

There are pitfalls to all three of these options. A good example of the downside in applying the network system to multi-modal transport is found in the conflicts arising between the aviation liability regime and the space liability regime as per the Outer Space Treaty and the Liability Convention. The transport event is dissected into discrete chunks and the applicable international frameworks applicable to only one mode are applied. This is not optimisation of modes nor is it synchronisation of modes, from a regulatory standpoint. Suborbital flight poses this conundrum as well, more so when we consider the possibility that one jurisdiction could assign these activities to the space liability regime and another to the aviation framework.

However, we can apply to this predicament Berman’s (2008) principles to allow for separate modal liability regimes, acknowledge conflicts and manage them with agreements and protocols. Parties can agree to *sui generis* rules. Respecting the reality of the hybrid nature of multimodal relationships, this may be the best that can be hoped for at this juncture.

Examination of how airports and spaceports can be successfully managed in one facility is helpful in illustrating the parallel and transmodal aspect of the relationship between orbital and suborbital spaceflight and aviation when co-located at a spaceport/airport or in the airspace.

Port Canaveral in Central Florida is currently developing a multi-modal transportation hub linking up rail, sea, air, motor and space. NASA’s 20-year strategic plan for infrastructure at the Kennedy Space Center is for multi-user activity, integrating suborbital and orbital, other modes of transport, government and industry and functioning more ‘like an airport’ than a launch site. This reality simply extends the modern intermodal transfer facility.

If we look inside a typical modern airport, we might find one aviation hub connected to multiple airlines (domestic and international) as well as fast rail and a metro. The airport may house a bus terminal and a rental car centre, could service shuttles to and from local hotels, accommodate taxi stands, and contain a parking lot for passenger vehicles. It likely has a cargo facility. These may be operating in parallel from an operational standpoint. They may have a sequential relationship depending upon the transport objectives. This example is not a hypothetical. It is a reality in many locations around the globe. Ronald Reagan National Airport in Washington DC, Vienna International Airport, Charles DeGaulle Airport in Paris France, JFK Airport in New York City and Miami International Airport, all represent airport infrastructure providing access to multiple modes of transportation.

From that one multi-modal airport, a person can fly to another similar facility located in another country. That second facility may be limited to a few gates and a bus stop, a taxi stand and a parking lot. The fact that the first facility offers far more sequential options representing many more modes of transportation does not hinder a traveller from
travelling between these two locations, nor does it prevent an air carrier from landing and taking off from both. These facilities are interoperable to an extent.

Nor does the fact that one facility could be subject to more regulations by virtue of these increased transportation options render it off limits to passengers arriving from a facility with significantly lesser amenities. For instance, an airport without light rail would not be subject to rail’s relevant operational and regulatory issues. Each of these two facilities would be responsible for its specific operations.

Much of the responsibility for operations falls to the direct operator of the transport mode. The facility operator is responsible for providing a safe structure with clear and practical procedures. However, the activities that are common to both facilities benefit from a level of coordination. The questions are what aspects should serve as a baseline, how that baseline should be applied and by whom. These inquiries do not change when spaceflight is included in the mix. They are simply expanded.

Optimal use of agreements and contracts to manage the governance of multiple modal relationships is an idea that has been examined in the context of logistics management in ports (Bergqvist and Monios, 2014) and airports (Tinoco and Sherman, 2014). Cooperative agreements between consortia of partner airlines and airports are suggested as a mechanism suited to manage shared responsibilities for facilities and equipment (Tinoco and Sherman, 2014). Port governance research includes study of the taxonomies of different port models based upon sources of funding (public or private or a combination of both) and resulting roles and responsibilities; governance model; and scope of facilities, assets and services (Berquvist and Monios, 2014). The governance of the relationship between logistics platform (or for our purposes, air/space port) and site tenant is typically managed by contracts. As with managing the conflict of liability laws apparent in some intermodal activities, private agreements can provide sufficient specified certainty between parties. This ad hoc approach does not provide one size fits all, standardised certainty across an industry or set of industries but it can provide a greater degree of clarity and certainty between the parties along a particular logistic multimodal chain. And because of the greater flexibility, these agreements can be drafted with respect to synchronising optimally with respect to cost and risk allocation.

5 Conclusions

Synchromodal coordination or at the very least co-modal optimisation, is a worthy goal for spaceflight policy (and regulation) for several reasons. First, cooperation in space activities is a legacy principle first found in the preamble and principles 4 and 6 of the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space and again in the preamble of the Outer Space Treaty and in Articles I, III and XI. Cooperation is a function of coordination.

Second, Galloway (1983) identified coordination as the main organisational problem in early space activities and regulation because of the division of responsibility between agencies with separate mandates but similar programs simultaneously operating with joint activities. We see this situation still today, with UN COPUOS and ICAO and between directorates in the FAA in USA, and shared competencies for spaceflight and transport in Europe. Interoperable coordination of at least spaceport operations into the existing transportation infrastructure, along with coordination of regulation, is a worthy goal in keeping with Galloway’s initial insight.
Third, in its work identifying the elements of effective regulation, the Organization for Economic Coordination and Development (OECD) (1995) has implicated coordination in the articulation of two of its guiding principles:

1. requiring consistency with other regulations and policies and
2. demanding that regulations should afford the greatest degree of practicable compatibility with competition, trade and investment drivers at domestic and international levels.

Acknowledging the transportation aspect of spaceflight is the first real step in acknowledging spaceflight’s role in transportation and the logical next step of integrating it with other modes of transport. Orbital spaceflight is already transportation. SpaceX and Orbital Sciences deliver cargo to the International Space Station, a function of transportation. The imminence of US commercial crew transport to the ISS is yet another. Suborbital vehicles plan to carry people and to launch payloads, both functions of transportation.

Allowing any disconnect between aviation and space activities, or orbital and suborbital aspects of space activities, or between any means of transport, runs counter to current law and policy. Worse, that disconnect could be debilitating for the space sector but could also render the far more mature aviation industry less safe or less efficient. Looking at some of the best arguments for pluralism, we find the possibility for diversity of experience and the broadening of alternatives are both available to aid the efficient integration of space into the existing transportation infrastructure. This coordination will provide benefits that exceed summation of each mode’s value when standing alone.

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