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Public-private partnerships in transportation: lessons learned for the new space era

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Abstract: Entrepreneurial firms in the space sector have accomplished unimaginable feats unheard of just 20 years ago, such as reusable rockets and cargo launches to the International Space Station (ISS). Clearly, the private sector will continue to be a significant participant in the future of the space industry, partnering with governments and nations, to accomplish more with less. Likewise, the public sector must cope with decreased funding and worthy space objectives while balancing cost, risk, and return. Partnering with private enterprise is the best solution to meeting mandated objectives in space program advancement. This paper addresses partnerships in real property assets from the lens of the public sector, particularly with respect to spaceports. Data were collected on public-private partnerships (PPPs) and public-public partnerships (PuPs) in regulated transportation industries from years 1985 through 2014. As these arrangements were analysed, clear themes emerged that have implications for the new space environment.

Keywords: partnership; space; public-private partnership; PPP; public-public partnership; PuP; transportation; real property; private; public; government; risk; infrastructure; spaceport; intermodal.

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Biographical notes: Janet K. Tinoco received her PhD from the University of Central Florida, Orlando, FL, USA. She is an Associate Professor of Marketing and Management in the Department of Management, Marketing and Operations in the College of Business, Embry-Riddle Aeronautical University, Daytona Beach, FL. Her areas of teaching include strategy, leadership, and sustainability while her research centres on innovation, sustainability, and strategy in high technology industries, particularly in new space. She also holds an MA in International Business and a BS in Electrical Engineering. Her work has appeared in the *Academy of Strategic Management Journal*, *World Review of Intermodal Transportation Research*, *International Journal of Sustainable Strategic Management*, and *World Review of Science, Technology, and Sustainable Development*.

1 Introduction

The growing global space economy reached a total of \$330 billion worldwide in year 2014 with the greatest growth occurring in the space infrastructure and support industry sectors. This total was up from \$302.54 billion in 2013 and is the combined total for commercial revenues and government budgets (Space Foundation, 2015). The growth in spending was fuelled by national, federal, state, and local governments, as well as private investors and corporations. Space infrastructure and support industries, as well as commercial space products and services, are gaining the attention of airports, spaceports, and national space centres alike as they scan for possible new revenue streams and reductions in risk and cost for their space programs.

New space, or the participation of private aerospace entities in the space industry, is still relatively young, albeit growing at a rapid rate. While academicians and practitioners alike debate where we are truly in a new space era or continuing in the current era, this debate does not detract from the fact that commercial space transportation, backed by private investors and government alike, is on the dawn of a new reality. Entrepreneurial firms, such as SpaceX, have recently accomplished new feats such as flight and successful cargo launches to the International Space Station (ISS). Reusable commercial rockets, deemed unimaginable a few decades ago, have been realised. Clearly, the private sector is a significant participant now and in the future of the space industry. Meanwhile, government agencies grapple with decreased funding and worthy space objectives while balancing risk and return.

Affordable spaceport infrastructure, particularly in real property assets, is needed to support the launch and return activities of both public and private sector space interests. Costs associated with the addition of space infrastructure can be staggering and the potential return on investment (ROI) is inherently risk-filled. Time is also critical as the variables that impact the development and approval of a spaceport are many. Furthermore, in this emerging industry, the demand of such infrastructures is highly volatile (e.g., Glazier, 2012), yet infrastructure requirements themselves are still developing. Partnerships between the key entities, if carefully constructed and managed, will go a long way to reduce the costs of time and money in supporting both private and public launch and return activities.

There are more than 39 active spaceports, five spaceports in development and seven proposed spaceports worldwide (Space Foundation, 2015). These numbers are growing rapidly as various entities are examining space business as a means of revenue and economic growth. With the UK's policy shift from a single spaceport strategy through bidding to a multiple spaceport capability via licensing, one of the latest to enter the spaceport network is Glasgow Prestwick Spaceport in the UK. A partnership agreement for horizontal launch facilities and services was recently signed between the spaceport, XCOR Aerospace of the US, and the UK's Orbital Access Limited (Satnews Daily, 2016). As this agreement exemplifies, there is a need to understand the role of partnerships in new space as governments, air and space ports, port authorities, as well as, corporations and other private entities, invest and form partnerships to capture an economic portion of this industry.

This research concentrates on partnerships involving real property assets, particularly those that are translatable to multimodal spaceports with launch and return activities, and from the viewpoint of the public sector. As such, the contributions of this effort are two-fold. First, partnerships involving spaceports are in their relative infancy, but some

basic characteristics and influencing variables are emerging. Second, there is minimal research on partnerships in the space sector, particularly those involving spaceports. While there are published manuscripts on public-private partnerships (PPPs) for airports, ports, roads, railways and urban passenger transport (cf, Macario, 2010; Panova and Hilmola, 2015; The World Bank, 2017), there is a dearth of research on partnerships outside of these five transport areas. Looked at singularly, each sector has a place in the multimodal nature of the spaceport where access to water, road, rail, and air are key to success. Examination of each sector is necessary, but insufficient to fully comprehend partnerships developing with respect to spaceports. Lessons learned must be gleaned from partnerships from highly regulated areas of the transportation sector, combined with an understanding of the unique nature of the new spaceport environment.

With this backdrop, this paper flows as follows: First, a general review of transportation-based PPPs and public-public partnerships (PuPs), concentrating on PPPs with real property assets, is provided. Next, an overview of the unique issues associated with partnerships involving multimodal spaceports. Following this, an explanation of the data collection method and the results are presented. Finally, a discussion with implications for the public sector is provided.

2 Literature review and background

2.1 Public-private partnerships

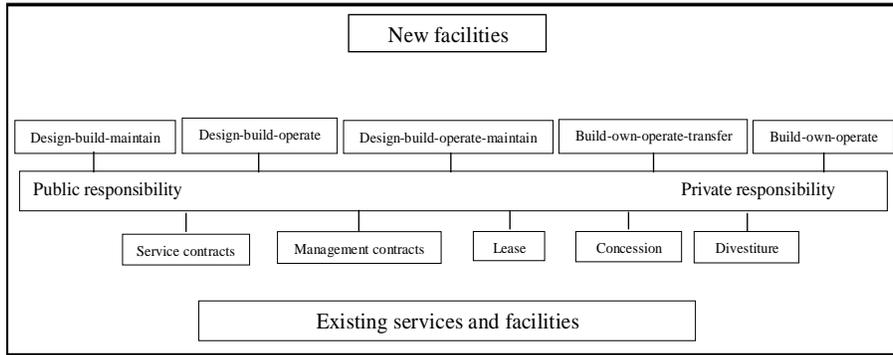
There are a multitude of definitions for a PPP, similarly for a PuP. The World Bank Group (2014, p.14) defines PPP as a “long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance”. Other research emphasises the cooperative nature of partnerships (e.g., Ke et al., 2011). For purposes of this research, we define a PPP as a long-term contractual, yet cooperative, agreement between a public agency and a private sector entity with agreed to duties, risks, and rewards (often shared) in which both the government and the private party have an interest. Clearly, a PuP between two public agencies is similarly defined.

There are many ways that partnership agreements may be structured, and the responsibility between entities is divided based on this choice. Normally, there are three stakeholders in a PPP agreement which includes the public sector, the private sector, and the users of the service, infrastructure, facility, etc. (Hashimoto, 2009). Depending on the structure of the PPP and terms of the contract, the agreement has advantages and disadvantages for each party involved.

Figure 1 illustrates at a high level the various types of PPPs based on whether the agreement encompasses an existing service or facility or a new facility, and to which sector the majority of responsibility falls. With respect to length of the contract, the term of service in operations and maintenance (O&M) contracts is generally 1–5 years. The variations of design-build (DB), including design-build-operate (DBO) or design-build-operate-maintain (DBOM) range from 15–25 years. Concessions or lease agreements are typically 10–20 years in duration (Deloitte Research, 2006). Finally, build-operate-transfer (BOT) agreements average 25 years in length (Water Partnership Council, 2003). Table 1 lists a more comprehensive list of common PPP arrangements

although the types available are broad and each PPP project is unique (National Council for Public-Private Partnerships, 2016). Although Deloitte Research (2006) identifies DBOM, BOOT, and divestiture as the most popular PPP arrangements in the transportation sector in general, The World Bank (2017) highlights BOT and concessions as common for airports; landlord port (management) for water ports; concessions, BOTs, and DBOs for road; concessions and BOTs for rail; and concession and franchises for urban transport. With this said, PPP arrangements and definitions vary among countries (The World Bank, 2014) which may account for differences.

Figure 1 Common PPP types and continuum of responsibility



Source: National Council for Public-Private Partnerships (2016)

While all PPP agreements have diverse circumstances and objectives, there are some similarities that should be addressed. First, some generalities based on funding for real property can be made. For example, the UK private finance initiative (PFI) model was introduced as a vehicle for private funding to pay for major public infrastructure projects such as schools and hospitals. It has also been used for roads, railways, and other transportation infrastructures (Demirag et al., 2011). In a PFI agreement, the private sector obtains funds to DBO a facility for the benefit of the public. In return, the public sector grants its private sector partner a long-term contract to run the facility and pays a monthly fee over the life of the project for loan repayment (Pinset Masons LLC, 2012).

Table 1 Common types of PPPs

Type	Description
Build-operate-transfer (BOT)	The private partner builds the public facility, operates it then transfers at a particular date. Private partnership often provides some financing but recoups investment via user fees. Very similar to build-transfer-operate (BTO).
Build-own-operate (BOO)	Private partner builds, owns, operates and retains title to facility. Similar is build-own-operate-transfer (BOOT).
Buy-build-operate (BBO)	Asset sale from public to private partners that includes a rehabilitation or expansion of an existing facility.
Concession	For the US, similar to DBFOM, but there is much variation.

Source: United States Government Accounting Office (GAO) (1999), The World Bank (2014)

Table 1 Common types of PPPs (continued)

<i>Type</i>	<i>Description</i>
Design-build-operate-maintain (DBOM)	Combines the design, construction of project with operations/maintenance; procured from the private section in a single contract with financing secured by the public sector (maintains ownership and some oversight).
Design-build-finance-operate-maintain (DBFOM)	DBOM plus finance responsibilities to private partner. A large amount of variation of this model in the USA, particularly with the private finance of the project. Direct user fees (tolls) are the most common revenue source.
Design-build-finance-operate-maintain-transfer (DBFOMT)	Same as a DBFOM except that the private partner owns the asset until contract end. Partnership type not common in the US.
Lease-develop-operate (LDO) or build-develop-operate (BDO)	Under LDO and BDO, the private partner party leases or buys an existing facility from a public agency; invests to upgrade, then operates it under a contract with the public partner.
Lease/purchase	Private partner finances and builds new facility, which is leased to public partner until enough equity is built up for public ownership.
Operations and maintenance (O&M)	Public partner contracts with a private partner to provide and/or maintain a specific service. Public partner retains ownership/overall management.
Sale/leaseback	While common, a unique use of this model allows sale of public facility to a public or private partner, thereby transferring some or all government liability. The public partner that sells facility, leases it back and operates.
Lease	Public partner grants private partner a lease in the facility or asset. Private partners uses, operates, maintains, makes improvements to the property in accordance with the agreement. Leasing is also called outgranting (Ketcham and Ball, 2014).

Source: United States Government Accounting Office (GAO) (1999),
The World Bank (2014)

Second, there is the element of risk and the challenge of risk allocation for both the real property asset and the partnership. Handley-Schachler and Navare (2010) identify key risks for ports as security, environmental, operational, financial with respect to loans, etc., sufficiency of demand and supply-side costs and efficiencies. These risks carry over to partnership risks in the form of regulatory, policy, inflationary, and tax risks; environmental risks; risk from man-made disasters (accidents, terrorism, etc.) beyond environmental; financial risk because of the partnership; and supply and demand. Grimsey and Lewis (2002) outline risk responsibility for infrastructure projects noting that regulatory and political risks are born by the public entity. Force majeure, revenue risk, and project defaults can be the responsibility of both the private and public partners. Risk associated with design, construction, and operation is typically the obligation of the private partner. Further, risk type and the importance of the risk shifts depending on the phase of the effort, for example, construction of an asset versus operation of the facility (Demirag et al., 2011).

Because of the broad and far-reaching consequences of real property and partnership risks, all affected parties must be aware of the range of risk types, levels of risk, and resulting implications of failure. As such, for a successful PPP, there must be a balance of scope, risk and acceptance. Risk management of the public partner is far more critical than the risk for the private partner because the public partner's responsibility to the project will always continue, regardless of the circumstances that prevail in the transference of risk (The World Bank, 2016). The concept of the PPP is to minimise risk for both partners while maximising value for both partner's stakeholders. It is achievable. However, due diligence is required to make sure that a successful outcome is achieved.

2.2 *Public-public partnerships*

The modern concept of a PuP has developed in the wake of the emergence of PPPs and their critical acclaim. As a result, the concept is best described in the context of PPPs and can be categorised by the identity of the partners and the partnership's objectives. These items are the core of PuPs, formed by the unique partners to achieve their specific goals. Thus, each PuP, much like a PPP, is unique.

Generally, PuPs have been developed and tailored for achieving the following purposes similar to PPPs:

- 1 provide improved services
- 2 build capabilities not available to one or more public partners on a standalone basis
- 3 develop capacity not feasible to one or more public partners on a standalone basis
- 4 defend against or prepare for privatisation
- 5 attain greater community support and accountability.

The goals of PuPs, advantages, disadvantages, and risks of PuPs mimic those of PPPs albeit with different stakeholders. The exceptions are those interagency and governmental partnerships that cross political boundaries. In this case, exchange of possibly sensitive data may be subject to export regulations and the exchange of proprietary documentation from industry may be limited (The World Bank, 2016), directly impacting the success of the partnership.

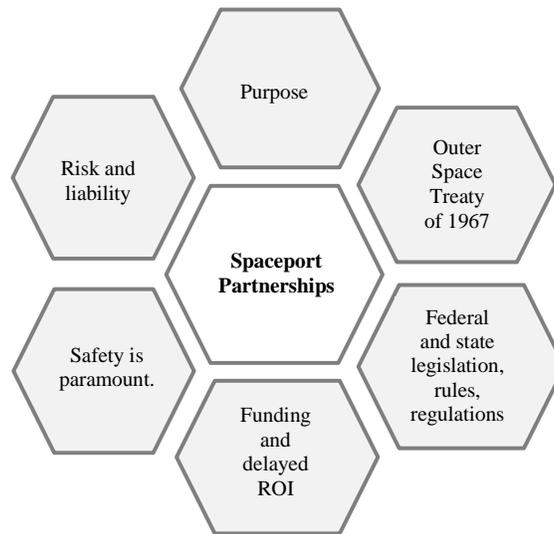
2.3 *Multimodal spaceport PPPs*

While both PPPs and PuPs have been in existence for decades, PPPs, in particular, are increasing in number and rate, especially in the space sector. Our research indicates that while there are many commonalities between other PPPs in transportation, there are some unique issues associated with spaceport PPPs. First, space is innately global. Launch and return activities transverse land, air, water, and *space* under local, state, nation and international jurisdictions. Yet, no space-faring nation holds sovereignty in outer space (United Nations, 1967). Second, these activities are intensely risk-filled and costly, more so than in any other industry. Thus, the very nature of space and space transportation complicates the development and agreement details of partnerships.

Figure 2 summarises at a high level the key areas that need to be addressed when developing spaceport partnerships, whether they be PPPs or PuPs. Each area is intertwined with another. The complexity, intensity, and interdependence of these areas is

what drives the unique environment in which these partnerships are developed. The following paragraphs summarise the key ideas presented in Figure 2, beginning with *purpose* and moving in a clockwise direction.

Figure 2 Variables impacting spaceport partnerships



Clearly, a spaceport is the starting point of space exploration and transportation. The motivations behind space advancement are scientific discovery; military development and national security, and commercial development (Dempsey, 2006), all three of which are ripe for partnerships as governments focus on each motivation for various reasons and in various levels. The *purpose* behind partnerships is their ability to aid government and private entities with construction, expansion, modernisation, and operation of launch and return pads, runways, processing facilities, etc. Innovative, non-traditional collaborative partnership agreements are critical to meet space initiatives at all stakeholder levels.

Historically, spaceports were design, built, owned, operated, and managed by government space and military agencies, including those of the military. Now, there is a blend of arrangements as the commercial sector is tapped for cargo and crew transport services to the ISS, interest in suborbital point-to-point flight transportation grows (Gulliver and Finger, 2010), and investor and government funding is being directed to and/or expended by the commercial sector to reach outer destinations such as the moon and Mars. Partnerships are the means to generating commercial space activity and growing new markets; increasing benefits to the public and economy at large; and changing the nature of space exploration (cf, National Air and Space Administration, 2011).

From the legal perspective, the *Outer Space Treaty of 1967* (emphasis added) governs nation state space activities, including those that ultimately impact spaceports and partnerships either directly or indirectly. The treaty articles outline, among others, issues including liability responsibilities, commercial activities, sovereignty (no nation has sovereignty over space), and registration of objects that launch from spaceports.

The treaty flows to national policies and other agreements and acts. For example, the US space policy outlines national guiding principles, goals, and guidelines that cover such broad topics as international law, sovereignty over outer space and celestial bodies, and space debris (United States, 2010a). It also specifies sector and industry guidelines for commercial space activities. Title 51, National and Commercial Space Programs (United States, 2010b) augments the aforementioned policy by codifying laws relating to US national and commercial space programs. Thus, the ‘degree of flexibility available to spaceports’ (and thereby partnerships) remains bounded by external limitations, such as the Outer Space Treaty, as interpreted through the government, and additional agreements (Handberg, 2002). A relevant twist to this flexibility lies in the opinions of other nations regarding commercialised activity. While the US is moving forward with significant undertakings in the commercial sector, interest in same by other spacefaring nations runs the continuum from those uninterested to those who are vehemently opposed to private entities entering the space sector.

National policies, shaped by the treaty, flow to additional *federal and state legislations, rules and regulations*, then to local municipalities. This legal regime and the contents therein will evolve as the industry advances and matures. New challenges will arise that require changes to treaties, policies, and existing laws and regulations which will further complicate long-term partnerships that span decades and increase risk to both parties.

As with all partnerships, *funding, costs, and ROI* are at the forefront of concerns and interests. However, with space, funding and costs are several orders of magnitude beyond those in other industries. Clearly, in our current economic climate, government funds are decreasing and cannot cover the exorbitant costs associated with space. Private funding is essential to support spaceport infrastructures and launch and return activities that benefit both public and private sector space interests. Yet, ROI is inherently risk-filled. The market will change based on technological advancement, regulation, policy, and as the needs of the stakeholders shift. In the USA, estimates for development of one new launch complex at traditional established spaceports are up to \$500 M USD, excluding maintenance and upgrades (Gulliver and Finger, 2010). On the other end of the spectrum, Spaceport America was funded with citizen tax dollars at an approximate cost of \$219 M USD (Boyle, 2015). With the delay in commercial space transportation capabilities of its chief tenant, Virgin Galactic, the expense of upkeep, operations, and maintenance has been significant while generated revenues are extremely low. The anticipated ROI has not yet been realised.

Financial risk is only one area of concern. Most, if not all, nations believe that safety is *paramount* above all and has far reaching consequences for the spaceport, the surrounding community, and environment. Space travel and transportation is much riskier than other forms of transportation, and stems from differences in vehicles, launch facilities, and raw materials for energy, such as propellants. The required vertical and horizontal infrastructures, airspace boundaries and control, among other variables, have to be considered. Risks stemming from safety of people, property, environment, and users impact liabilities and stakeholder responsibilities at all levels.

Financial risks are significant as the market needs and spaceport requirements change with the maturing sector. But, there is also business risk associated with timing and time needed. As noted earlier, Spaceport America was built prior to need. Time is also needed to develop a spaceport and obtain approval. According to Gulliver and Finger (2010), it takes two to three years to support a single suborbital vehicle launch without major

infrastructure modifications and four to six years to build and operate a greenfield spaceport. These estimates assume that there are no significant environmental mitigation efforts needed and no community opposition to the space-related activity. Partnerships between the key entities, if carefully constructed and managed, will go a long way to reduce the costs of time and money in supporting both private and public launch and return activities.

Lastly, partnerships involving federal property come with a unique set of terms revolving around national security and national interests. In a lease or use agreement between the private sector and a federal agency, such as National Aeronautics and Space Administration (NASA), the Government can terminate the lease at no cost when the property is needed. Even without cancellation, the tenant is required to restore the property to its original configuration once the lease has expired (Ketcham and Ball, 2014).

There are commonalities between all types of partnerships, yet certain conditions, such as regulations in force, facilities available, and services needed, favour specific types of partnerships. Variables, unique to the sector, have implications for the types and contents of agreements that are developed and managed. Regardless of the specifics of the partnership agreement, the chief advantage of such partnerships is synergy, that is, creating more for each party while sharing risk and responsibility. With an understanding of these partnerships that involve real property, the next section describes the method of data collection, as well as results of the analysis, relevant to this study.

3 Method and results

3.1 Data collection

Applicable PPPs and PuPs in a variety of heavily regulated transportation sectors were researched across the globe. These sectors were chosen based on both the transportation relevance to a multimodal spaceport, as well as their high level of regulation similar to, but not the same as, the space sector environment. Specific transportation sectors researched were drilled down to space, air, rail, sea, and road and across multiple regions of interest: North America (Canada, the USA, Mexico), South America (all countries including Central America, but excluding French Guiana), Europe (including the UK, Austria, Denmark, France, Sweden, Norway, Netherlands, Spain, Portugal, Switzerland, Italy, Belgium, Germany, Greece, Malta, ESA/French Guiana, and European Union countries as a whole); Asia (primarily Russia, Taiwan, China, Japan, the Philippines, India, South Korea, Vietnam, Hong Kong) and Oceania (Australia and New Zealand). The first relevant partnership from 1985 was identified and established the baseline start date. Although not the focus of this research effort, partnerships in utilities were also examined as the sector is also highly regulated as would be any space activity and its associated infrastructure.

Information was gleaned from online publications, government websites, company websites, news/media sources, conference proceedings, and other reputable sites available online, as well as, from paper publications. Experts in conducting this type of descriptive research were also consulted for key word suggestions, website information, etc. Translations from the various languages encountered were sought where possible.

The most available and abundant amount of data, gained through scholarly journals and online search engines, pertained to PPPs in North America and Europe with the port, rail/road, and air sectors. For South America, online scholarly journals provided the richest data source with reliable and plentiful data on partnerships in Brazil, Chile, Peru and Argentina.

Data retrieval and data relevancy were issues that plagued the researchers. The collection of data backed by empirics proved to be a difficult task. Data collection from many emerging economies was marred by incomplete and otherwise undocumented data. Improperly classified projects, along with author bias and partner-reported findings, also proved to be inconsistent and not knowingly supported by fact. In cases such as these, several sources were used to corroborate and verify information. Information on partnerships was biased toward those that were successful although very limited information on unsuccessful partnerships was uncovered. Security also restricted the free flow of information as it pertained to PPPs, particularly in the space sector of North America and Europe. The governments' protection of information served as a filter to dilute sensitive data leaving a smaller amount of relevant data at our disposal. Nevertheless, the data collected and analysed revealed interesting results.

3.2 Results

Using the world regions and sectors noted above, 114 transportation-based real property partnerships over 29 years (1985 to 2014) were deemed applicable to this research. Figure 3 outlines the tremendous growth in partnerships over the years studied. The number of PPPs formed grew at an average of 123.7% while the growth of PuPs was minimal. Figures 4 and 5 illustrate the distribution of PPPs and PuPs by sector and region. North America, predominantly the US, formed the majority of partnerships, followed by Europe. Partnerships in ports, rail/road and airports were the most frequent. PPPs outnumber PuPs by almost 8 to 1 with the majority of PPPs and PuPs occurring between the years 2009 to 2014, highlighting the area of growth has been relatively recent. The US accounted for 45% of the PPPs formed worldwide.

With respect to PuPs, the majority of PuPs are in North America (53%) and Asia (29%), specifically in the USA and India, respectively. In these charts, the utility sectors (energy, water) are shown to illustrate that Asia focused on PuPs in utilities, followed by North America and South America. North America, particularly in the USA, formed the majority of space related PPPs and PuPs. Noticeably, sea ports were the basis of many of the partnerships throughout Europe. Finally, PPPs in Asia were found to have the most successful partnerships between government resources and private entities where societal goals were addressed. Data indicated that utilities PPPs favoured concessions, variations of DB with finance, operate, and maintain, as well as simple O&M. With respect to space, developing countries in that same region typically contract for satellite launches, but spaceport PPPs were absent.

Figure 3 Growth of PPPs and PuPs (1985–2014)

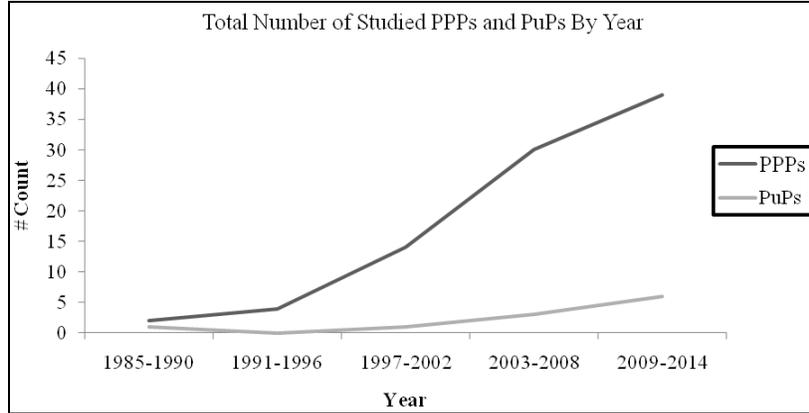
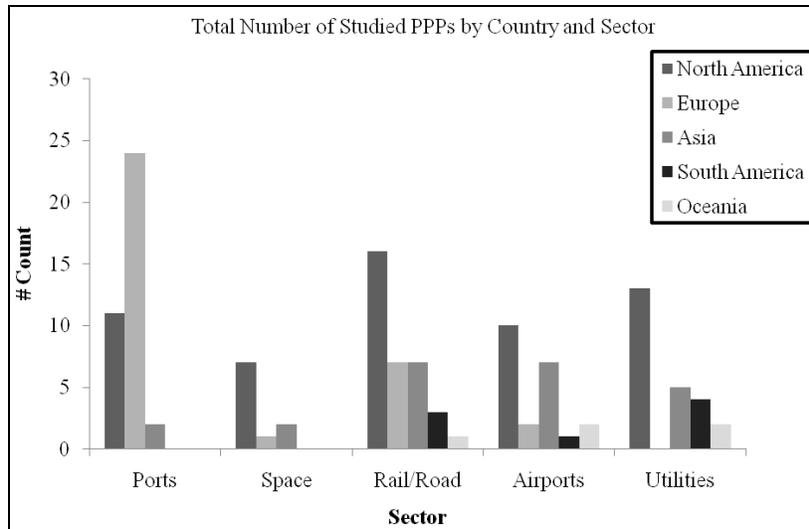


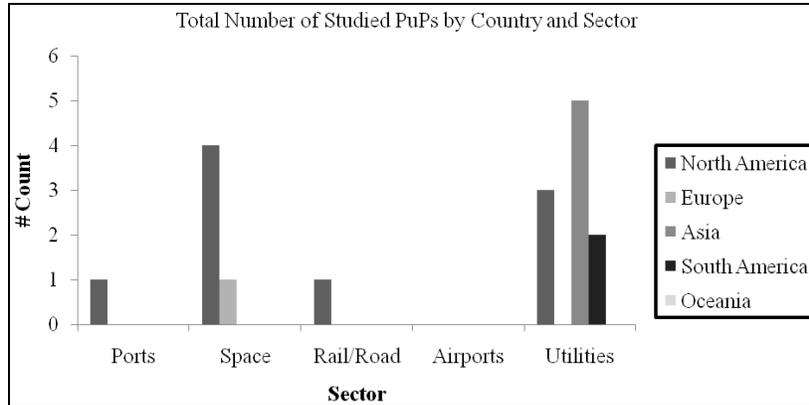
Figure 4 Total number of studied PPPs by country and sector



Note: Partnerships in utility sectors were included for comparison.

As data collection effort ensued, it became increasingly clear that partnerships, be they PPPs or PuPs, are highly context specific. Although more data are available on PPPs than PuPs, it is important to note that the risks, rewards, advantages and disadvantages can be similar between the two types of partnerships. In the following paragraphs, more detailed information is provided on the partnerships that were examined for each sector.

Figure 5 Total number of studied pups by country and sector



3.2.1 Space

Sixteen PPPs and PuPs in the space sector were found and analysed. Table 2 lists a sample of the studied partnerships that were directly tied to space/spaceport infrastructure. Interviews with company and agency executives and tours at spaceports in the US were also conducted to understand first-hand the challenges of this industry.

Most spaceports are either greenfield operations or repurposed facilities, such as inactive/underutilised airport runways and obsolete launch pads, at general aviation (GA) airports, smaller non-primary commercial airports, or on federal spaceport property. As is shown, most of these PPPs have involved private partner lease or lease/build to support their activities. The exceptions are Kennedy Space Center and Cape Canaveral Air Force Station where there is a combination of lease, use permit (federal), and license (military) for private partners utilising existing space-related infrastructures, such as launch pads and support facilities.

There are unique risks associated with these partnerships. Based on interviews and corroborated by a review of documents, the public partner typically has a reduced staff and depends on significant contractor support, particularly as demand for commercial space services remains dynamic for the near future. Repurposed facilities that were previously operated and maintained by federal employees are now operated and maintained by private companies. These companies have their own security processes and procedures and often block federal employees from access to their facilities, causing frustrations on both sides of the partnership. Organisational culture conflicts occur between private and public sectors, especially where passions run high over national space endeavours. Principally for US spaceport infrastructure on government land, the government may cancel agreements at any time if national needs warrant it and lease/use agreements cannot include exclusive use. For greenfield operations and repurposed civil facilities, a significant danger for the spaceport is the loss of an anchor tenant due to bankruptcy or due to a strategic choice by the tenant firm to transfer activities to another spaceport.

Table 2 Selected spaceport and partnerships

<i>Spaceport/launch complex</i>	<i>Partnerships</i>
US Cape Canaveral Air Force Station	United States Air Force Space Command's 45th Space Wing and SpaceX performed extensive infrastructure improvements at Launch Complex 40 at Cape Canaveral Air Force Station. Agreements also in place with Space Florida, an economic agency supported by the state of Florida. PPPs are in form of license agreements (military), similar to user permit for civil. Allows for sub-license.
Kennedy Space Center	Multiuser facilities and infrastructure. Agreements in place with Space Florida and SpaceX. Allows for sub-permits.
Spaceport Sweden	Spaceport partnered with Spaceport America (NMSA) and Virgin Galactic to provide secondary future launch site for commercial space tourism (De Selding and Malik, 2007). There are joint actions in PPP, specifically Kiruna Airport, Progressum, Swedish Space Corporation (SSC), and ICEHOTEL (Gløersen, 2009).
US Mojave Air and Spaceport	Lease or build PPPs are prominent partnership opportunities. Current private sector partners include BAE Systems, Orbital ATK, Virgin Galactic, and XCOR Aerospace (Mojave Air and Space Port, 2016)
US Oklahoma Spaceport	Oklahoma Space Industry Development Authority (OSIDA) PPP with Rocketplane. Infrastructure funded by taxpayers, but spaceport built on an existing airport. Lost initial anchor tenant, Rocketplane, to bankruptcy causing subsequent operational issues. Currently offers lease/build.
Spaceport America	PPP between New Mexico Spaceport Authority (NMSA) and Virgin Galactic for horizontal launch; PPP between NMSA and Space X for vertical launch; PPP in the form of facilities lease and ground rent fees
Mid-Atlantic Regional Spaceport (MARS)	Virginia Commercial Space Flight Authority (VCSFA) PPP with Orbital Sciences Corporation: Agreement substantially different than the agreement between NMSA and Virgin Galactic. Orbital Sciences to develop and construct improvements at MARS in 2008 for the purpose of launching their Antares rocket. Will generate lease income and use fees for MARS. Subsequently, VCSFA and Orbital signed a second Memorandum of Understanding (MOU), which changed the PPP relationship. Whereas Orbital was originally to complete improvements to the launch facility, the Commonwealth of Virginia is responsible for funding to support the Antares launches and future customers. The VCSFA will own and operate assets not specific to the Antares missions (Spaceref, 2012)
NASA Michoud Assembly Facility (MAF)	Partnerships have been sought to sustain or enhance the facility's capabilities in addition to retaining or growing the skilled labour pool in support of the facility (Michoud Assembly Facility, n.d.). Some PuPs range from basic office space leasing to joint research programs (PuP). The facility has also developed a significant body of PPPs, often making significant use of the unique capabilities of the facility (Schleifstein, 2012), many are with private tenants – some associated with NASA operations on the site, but not required.

Not included in Table 2, but of equal importance is the ISS, developed, built, managed, financed, operated by the collaborative efforts of the USA, Russia, Canada, Japan, and the participating countries of the European Space Agency (ESA). The ISS program includes international flight crews; diverse launch vehicles; hardware and software unique to each country; globally distributed launch, control, and communications facilities and networks (National Aeronautics and Space Administration, 2016). All of which must be integrated and managed. Both public and private sectors around the world benefit from the collaborative partnerships that have been forged and will continue to be forged. Regular resupply and crew transport missions will be supported by nation state members through 2020 (Space Foundation, 2015). While not the focus of this research, much can be learned by further analysis of the ISS, its partnerships involved and subsequent arrangements, advantages, and disadvantages.

3.2.2 Ports

Partnerships in this industry have traditionally been successful because of the limitation of deep-water ports and land availability that supports the ports operations. Most ports are on public land owned by national/federal, state and local governments but operated by port authorities. The most common models found in the data were concession and DB with combinations of finance, operate, and maintain (DBOM, DBFOM, etc.).

Port authorities work closely with private customers/partners such as cargo and cruise companies to build and maintain facilities and lease land and/or facilities under standard lease agreements or under build-maintain agreements. These authorities have complete control over the land/dock use and control all private non-government leases and uses.

Research indicates that port authorities are best suited to developing new facilities, handling land clean-ups, and acquiring land and governmental financing. The private sector is better suited to handle marketing, scheduling and day-to-day operations of the facilities. The private sector has also been able to establish many private-to-private transactions that have the ability to transfer substantial risk to new private-sector tenants (Holt, 2012).

As with national space centres and spaceports, certain assets at ports are essential to national security. As such, there are ports/assets that are reserved for official government use or are reserved for immediate government use in case of national security issues. Ports or assets that are not deemed essential to national security are typically run by a government organisation such as a port authority, administration or association.

3.2.3 Airports

These partnerships in our data were largely devoted to airport operations, rail connections, and infrastructure expansion efforts. BOT, concession, and DB with variations of finance, operate, and maintain were the common models. Although we also studied a number of privatisations, these arrangements do not necessarily fall under the partnership umbrella and were removed from further analysis. Much of what was learned in studying real property assets and partnerships in airports can be applied to the new space environment, particularly as traditional airports are looking to space activities to increase revenues.

We found that existing airport real property offers opportunities in terms of partnership agreements for land use, lease and concession arrangements. Research parks,

often already near or on airport property, are a potential for partnership development. Unfortunately, airport management is often blinded by the tunnel visions of core operations. The culture of the typical airport operating model restricts the vision, and leads to missed opportunities. Our research also supplemented the current belief that airports must adopt some cultural elements of federal spaceports and federal spaceports must learn to operate more like commercial airports. This is an element of our research that needs further development.

Airports understand their market and how they can expand to attract new clients and service, thus partnerships are key to improvement. With facilities already in existence, they also know the necessity of keeping these facilities in working order so that their clients are able to operate effectively, efficiently, and safely. That said airports often have trouble matching the project with the capital required. Long-term PPP often include agreements to maintain and/or expand existing real assets. The funding for these projects can be accomplished through the airport, the lessee, or some combination of both. This arrangement not only allows the airport to reduce its expenditures, it also expands the avenues of financing. If a lease arrangement, the lessee may have access to differing capital markets or offer a lower cost of debt, also a benefit for the spaceport industry.

The ability of an airport to profit and expand is often regulated and restricted by the government. This is also the case of the spaceport environment. The restriction of the airport essentially transfers to the long-term partner and can limit the premium the partner can earn. This limit often results in a lower premium paid to the airport's owner, and reduce or eliminates the interest in the partnership. Less interest and competition for the partnership will also drive down the revenue stream to the airport.

Our research corroborated that the complexity of the airport model, the burdens and hurdles caused by regulation and situation specific problems all translate into high transaction costs. This cost may be offset by the benefit of a large-scale project, yet a smaller project may not provide an advantage that would justify or meet the cost incurred (Pena, 2012).

3.2.4 Rail and road

In our research, rail projects included light rail and high speed rail development. For roads, partnerships focused on construction of tunnels, expressways, commuter roads and bridges. In our dataset, rail and road partnership models used to a greater degree were concessions, followed by DBFO and variations of DB with finance, maintain, and operate. The BOT model was also present.

Our data positively correlated with previous research in rail and road. As with other PPP initiatives, rail projects have used different contracting structures reflecting the risks and rewards of the project and the ultimate transportation service. Extant literature indicates that most rail initiatives involve DBFOM or BOT with full project cost/risk and full revenue risk transferred to the private sector. The public sector defines the project specification, minimum service requirements and possible fare levels (Hayward-Williams, 2009).

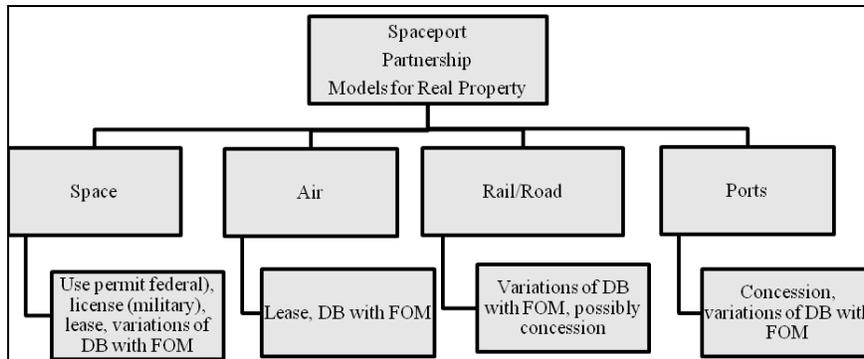
For roads, the UK PPP model is ranked second among the 'world's most desirable PPP models', shortly behind that of Canada (Pinset Masons LLC, 2012). The UK model calls for DBFO contracts, typically 30 years in length with 10% of the financing coming from the consortia (Jones, 2002).

3.2.5 Summary and integration

Our results corroborate and extend what has been examined in multiple sectors and in various geographical regions while focusing on what is relevant for the space sector. Each sector examined revealed lessons learned that are applicable to the use, development, modification, and expansion of infrastructure needed for space activity. Figure 6 integrates the results of our research on partnership models by sector for the multimodal spaceport. Clearly, as the industry moves forward, partnership models may change as requirements, technology, risks, demand, competition, legislation, national policy and security, and international issues, agreements, and treaties take shape. With the exception of space, this integration is based on partnerships in mature transportation sectors. For now, whether the partnership involves repurposed facilities or greenfield operations or federal versus non-federal property, spaceport partnership models are most likely to include combinations of lease, use permit, license (military), and DB and variations of F, O, and M based on type of facility, industry requirements, and public sector needs and wants.

It is unlikely that basic partnership models will be altered as much as the agreement specifics, strengthening the notion that each partnership is unique. These specifics must include risk mitigation clauses to account for the uniqueness of the industry, particularly the broad swath of risk type and intensity associated with space business. Still, this is a new era and with it comes a new way of doing business. Additional discussion with implications follow.

Figure 6 Integrated partnership models for multimodal spaceports



4 Discussion and implications

This research concentrated on partnerships as viewed from the public sector and with respect to real property. Additionally, we focused on highly regulated industries to ensure a stronger applicability to the new space environment, an environment in which governments are challenged to work collaboratively with private partners, meshing their space programs objectives, operations, management, and culture with those of the emerging new space industry. This is not an easy task.

As we examined partnerships, we found challenges that the space industry will have to face. These included organisational culture clashes, international implications involving treaties; and legislation, rules and regulations that are lagging or lacking in completeness. Government entities argue for more regulation due to safety concerns; private company argue for less for fear of stifling their initiatives. States and local authorities desire more enabling legislation to increase competitiveness and economic benefit. Shifting rules and regulations will complicate long-term partnerships unless risk mitigation efforts are put into place when the original agreements are made. Demand and spaceport requirements are dynamic and ever-changing. Funding, liabilities, and the multitude of risks involved highlight the combustible nature of industry. Finally, on the international level, space-faring nations are at odds over commercial involvement.

While lessons learned vary depending on the public partner involved, some generalities can be made that are applicable to a multimodal spaceport. Public partners are concerned that their schedules and needs will not be met by private companies who have their own agenda. Also, a reduction in government competencies may result from the transfer of authority and responsibility to private partners. This would ultimately lead to an unequal distribution of risk between partners, often imposing unforeseen procedural difficulties and financial deficits on the public sector (Heinz, 2006).

We found that especially for PPPs, the public partners may experience a reduction or a perception of reduction in control and influence. General research on partnerships indicates that this loss of control is a result of the situation when obtaining private cooperation. The public partner may overlook the long-term, strategic perspective and focus in favour of comparatively short-term goals. This may have been the case for Kennedy Space Center in the early days immediately following the end of the shuttle program. Facilities lying fallow needed tenants to cover the gap between NASA programs, a short-term fix. However, now, the national space centre is a model for strategic planning and the multiuser spaceport.

To help mitigate and minimise the chance of 'pitfalls' in partnerships, there are a number of rules the public partner should observe. First, cooperation and collaboration with the private sector should not be idealised because of the term, partnership. It must be looked upon first as a business relationship between fundamentally different entities in order to perform a given task or to provide a given service (Heinz, 2006). Nevertheless, there does appear to be a shift in the manner in the way in which the government in the US conducts its business with the commercial space sector, progressing from a transaction based one to one that truly partners in a collaborative or cooperative manner. It was noted that in some US-private company partnership arrangements, the term, partner was used in place of tenant or lessee, based on agreement. Second, the form of partnership, the procedural steps, and arrangements concerning responsibilities should not be determined by abstract models but by the concrete factors of the given location and the main aspects of the undertaking envisaged (Heinz, 2006). This reinforces the fact that every partnership agreement is unique to its own purpose. Third, the public partner often cannot make a 'profit', hence the cash inflow needs to be allocated to appropriate use and a win-win agreement should be goal. Fourth, cultural differences between private and public sector must be recognised, as well as the need for the private sector to install their own security measures. These differences are more intense for government agencies whom heretofore were the sole force behind space-based initiatives. Passions run high.

The public partner should set clear and unambiguous objectives, in order to prevent the primary aspects of the project and the activities involved from being dominated by the profit-oriented conceptions of the private partner. Public-private collaboration and cooperation are mostly based on complicated negotiations (Heinz, 2006). Public sector negotiators therefore may have to improve their strategic and technical proficiency as well as their negotiating strategies and tactics. This seems to be most relevant for public entities that are unfamiliar with the nuances of the space industry, such as airport authorities.

With regard to the costs of projects, public partners need to distinguish between short-term liquidity and long-term 'profitability'. Costing should take into account not only short-term advantages from the postponement of financial burdens, but also of the total costs accruing to the public purse (Heinz, 2006). Inability to control costs or incorrect financial projections that impact public funding have been major areas of PPP failure. Spaceport America is such an example. Because of this, more conservative and realistic estimates of demand forecasts for spaceports may be best.

There is a certain school of thought that believes PPP projects require more democratic control. The insulation of proceedings against democratically legitimised bodies and the broader public, which is often considered necessary in the interests of confidentiality and efficiency, conflicts with the statutes of local authorities can prove to be dysfunctional in the long run (Heinz, 2006). This type of 'secrecy', whether real or perceived by the public, can result in pressure on the public partner to make all dealings transparent. This transparency may result in a limit of the number of private partners willing to work on the project. Yet, the need for transparency on the government side and to benefit the public has been highlighted before (cf, Busch and Givens, 2012).

Loss of use, loss or control, and the risk of a negative outcome can be offset by revenues generated by the agreement, for example, the premium the tenant pays in a lease agreement currently standard in many spaceports we studied. The stability created by this cash inflow *if timed correctly* is an attractive incentive to what is often a cash strapped government partner. In the end success can be measured by balancing this revenue against its real and secondary non-cash costs. When faced with a capital intensive project, such as expansions, it is often advantageous for the public entity to partner with a private corporation. When the public entity partners for expansion and the public entity retains control of the asset, the benefit is flexibility in short-term planning.

Long-term PPPs of once strictly public entities often face pushback from stakeholders. The resistance is usually found from two groups. The internal resistance to change is a result of a long held culture. Fears, whether real or perceived, range from degraded safety to ineffective operations. This resistance could become a self-fulfilled prophecy if the cultures of 'old' and 'new' are not reconciled. Other pressure comes from external sources. Those in positions of power in the public body have been known to point to fears of degrading service and public safety along with a lack of control over the impact of the local area.

The key point of a successful partnership is a cooperative and mutually supporting relationship between the two parties as well as a realisation that each party has a stake in the success of the other (Lockwood et al., 2000). Without this recognition and cooperation, the partnership will be a waste of time and resources from both parties and will also fail to achieve success.

As any government turns to private sector more and more for many services and projects, there is a growing interdependence between the entities that cannot be denied.

This interdependence allows each organisation to help sustain the other and a condition of a mutual organisational sustainability is born. This mutual sustainability is tied directly to the most successful and enduring partnerships that involve the public sector. Furthermore, these partnerships, grounded in mutual sustainability, share common characteristics. These are as follows:

- Trust based on open, credible, and equal interactions with each party taking on some level of risk and with power somewhat balanced.
- The ability to change and integrate together: More specifically, shared adaptation, shared cognition, shared norms and values, combined with the ability to change and move in new and flexible directions together, contribute to the overall success of the relationship.
- Creation of social capital: Social capital creates efficiency of action and is a critical part of effectiveness in these relationships.
- A shared purpose: Shared commitment and purpose are essential ingredients for effective and continuing partnerships.
- Complementarity: Complementarity of skills and competencies, that is, the ability for each party to bring something unique to the relationship, resulting in the betterment of all parties in the partnership (Davis et al., 2012).

Finally, it should be noted that more similarities can be drawn from the dawn of the transportation sector to the new space environment allowing for a further understanding of the challenges and issues associated with partnerships in an emerging arena (Morring, 2014). The topic is broad, but it is extremely critical that researchers continue to analyse partnerships from different perspectives in order to best understand implications to the new space era.

5 Conclusions

Regardless of the type of partnership or the geographic region, the rewards of a successful partnership are many, but so are the risks. Yet more can be accomplished through the synergy created in a partnership than each organisation can often do alone. The challenge is to determine the best strategic solution in partnering with entities in the private sector or other government communities (local, state, federal) and across the globe. The public sector can learn, change and grow to overcome challenges and create synergies for the benefit of all in the new space environment.

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References

- Boyle, A. (2015) *After Virgin Galactic's Tragic Setback, Spaceport America Goes to Plan B* [online] <http://www.nbcnews.com/storyline/virgin-voyage/after-virgin-galactic-tragedy-spaceport-america-goes-plan-b-n385761> (accessed 16 August 2016).
- Busch, N.E. and Givens, A.D. (2012) Public-private partnerships in homeland security: opportunities and challenges', *Homeland Security Affairs*, Vol. 8, No. 18.
- Davis, E., Newcomer, K., Tinoco, J. and D'Alessandro, D. (2012) 'Mutual organizational sustainability (MOS): organizational interdependence in the new public service', Paper presented at the *Proceedings of the Academy of Management Conference*, Boston, MA.
- De Selding, P.B. and Malik, T. (2007) 'Virgin, Swedish spaceport sign deal for suborbital flights', *SpaceNews*, 7 February [online] <http://spacenews.com/virgin-swedish-spaceport-sign-deal-suborbital-flights/> (accessed 10 July 2017).
- Deloitte Research (2006) *Closing the Infrastructure Gap: The Role of Public-Private Partnerships* [online] [http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_ps_PPPUS_final\(1\).pdf](http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_ps_PPPUS_final(1).pdf) (accessed 22 August 2016).
- Demirag, I., Khadaroo, I., Stapleton, P. and Stevenson, C. (2011) 'Risks and the financing of PPP: perspectives from the financiers', *The British Accounting Review*, Vol. 43, No. 4, pp.294–310.
- Dempsey, P.S. (2006) 'United States Space Law: commercial space launches and facilities', in *Space Law*, Vol. S.1, American Institute of Aeronautics and Astronautics, Reston, Virginia, USA.
- Glazier, K. (2012) 'Spaceport infrastructure still an unknown frontier', *Bond Buyer*, 26 October, Vol. 121, No. 33803, pp.1–2.
- Gløersen, E. (2009) *Strong, Specific and Promising Towards a Vision for the Northern Sparsely Populated Areas in 2020*, Nordregio Report 2009, No. 2.
- Grimsey, D. and Lewis, M.K. (2002) 'Evaluating the risks of public private partnerships for infrastructure projects', *International Journal of Project Management*, Vol. 20, No. 2, pp.107–118.
- Gulliver, B.S. and Finger, G.W. (2010) *Can Your Airport Become a Spaceport: The Benefits of a Spaceport Development Plan*, 48th American Institute of Aeronautics and Astronautics (AIAA) Aerospace Sciences Meeting, 4–7 January 2010, Orlando, FL, Vol. S.1, American Institute of Aeronautics and Astronautics, Inc.
- Handberg, R. (2002) 'Creating transportation infrastructure through state spaceport initiatives: Florida and other examples', *Technology in Society*, Vol. 24, No. 3, pp.225–241.
- Handley-Schachler, M. and Navare, J. (2010) Port risk management and public-private partnerships: factors relating to risk allocation and risk sustainability', *World Review of Intermodal Transportation Research*, Vol. 3, Nos. 1–2, pp.150–166.
- Hashimoto, M. (2009) *Public-Private Partnerships in Space Projects: An Analysis of Stakeholder Dynamics*, Boston: Masafumi Hashimoto, Master of Science Thesis [online] <http://hdl.handle.net/1721.1/52751> (accessed 4 September 2017).
- Hayward-Williams, C. (2009) *Preparing an RFP: Lessons Learned from European PPP Rail Projects*, Booz Allen and Hamilton Inc., Mclean.
- Heinz (2006) *Public Private Partnerships: Principles, Opportunities and Risks*, German Institute of Urban Affairs, Cologne.
- Holt, S. (2012) 'Do North American ports remain undervalued?', *AAPA Seaports Magazine*, p.32, Gainesville, Florida, USA.
- Jones, C. (2002) *The UK Government View of Public Private Partnerships*, Association for European Transport, London.
- Ke, Y., Wang, S., Chan, A.P. and Cheung, E. (2011) 'Understanding the risks in China's PPP projects: ranking of their probability and consequence', *Engineering, Construction and Architectural Management*, Vol. 18, No. 5, pp.481–496.

- Ketcham, D. and Ball, J. (2014) 'Is space exploration best served by NASA Holding Property Assets as a landlord?', Presented at *30th Space Symposium, Technical Track*, Colorado Springs, Colorado, USA, May 21, 2014.
- Lockwood, S., Verma, R. and Schneider, M. (2000) 'Public-private partnership in toll road development: an overview of global practices', *Transportation Quarterly*, Vol. 54, No. 2, pp.77–91.
- Macario, R. (2010) 'Future challenges for transport infrastructure pricing in PPP arrangements', *Research in Transportation Economics*, Vol. 30, No. 1, pp.145–154.
- Michoud Assembly Facility (n.d.) *Do Business with Us!* [online] <http://mafspace.msfc.nasa.gov/business.html> (accessed 14 October 2012).
- Mojave Air and Space Port (2016) [online] <http://www.mojaveairport.com/directory.html> (accessed 17 August 2016).
- Morring Jr., F. (2014) 'Historical perspective', *Aviation Week & Space Technology*, 21 July, Vol. 176, No. 25, pp.20–21.
- National Aeronautics and Space Administration (2011) *2011 NASA Strategic Plan*, NASA Headquarters, Washington, DC.
- National Aeronautics and Space Administration (2016) *International Cooperation* [online] http://www.nasa.gov/mission_pages/station/cooperation/index.html (accessed 18 August 2016).
- National Council for Public-Private Partnerships (2016) *PPP Basics/Types of Partnerships* [online] <http://www.ncppp.org/ppp-basics/types-of-partnerships/> (accessed 2016).
- Panova, Y. and Hilmola, O-P. (2015) 'Justification and evaluation of dry port investments in Russia', *Research in Transportation Economics*, Vol. 51, No. C, pp.61–70.
- Pena, A. (2012) 'Public-private partnerships in the airport sector', Vol. S.1, *AIRDEV Seminar – Business Models for Airport Development*, Lisbon, Portugal, 20 October 2011.
- Pinset Masons LLC (2012) *UK Continues to Lead International PPP Market Despite Reform Uncertainty, Survey Shows* [online] <http://www.out-law.com/en/articles/2012/may/uk-continues-to-lead-international-ppp-market-despite-reform-uncertainty-survey-shows/> (accessed 4 September 2017).
- Satnews Daily (2016) *Aye, Lad! Glasgow Prestwick Spaceport, XCOR and Orbital Access Limited Sign on for Scottish Manned Space Launch* [online] <http://www.satnews.com/story.php?number=856723487> (accessed 12 July 2016).
- Schleifstein, M. (2012) *Michoud's New Orion Spacecraft to Take First Trip in 2014* [online] http://www.nola.com/science/index.ssf/2012/03/first_space_trip_for_new_orion.html (accessed 24 October 2012).
- Space Foundation (2015) *The Space Report: The Authoritative Guide to Space Activity*, Space Foundation, Arlington, Virginia.
- Spaceref (2012) *MOU Governs Relationship between VCSFA and Orbital for Cargo Missions to the International Space Station* [online] <http://spaceref.com/news/viewpr.html?pid=38584> (accessed 22 August 2016).
- The World Bank (2014) *The Public-Private Partnership Reference Guide*, Ver. 2.0, Vol. S.1., International Bank for Reconstruction and Development/The World Bank, Asian Development Bank, and Inter-American Development Bank, World Bank Publications, The World Bank, Washington, DC USA.
- The World Bank (2016) *Government Objectives: Benefits and Risks of PPPs* [online] <http://ppp.worldbank.org/public-private-partnership/overview/ppp-objectives> (accessed November 2012).
- The World Bank (2017) *Public Private Partnerships Transport Sector* [online] <https://ppp.worldbank.org/public-private-partnership/sector/transportation> (accessed 5 May 2017).

United Nations (1967) *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 10 October, United Nations, Office for Outer Space Affairs, London/Moscow/Washington.

United States (2010a) *National Space Policy of the United States of America*. Office of the President of the United States, Washington, DC [online] https://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf (accessed 2016 22 August).

United States (2010b) *Title 51, National and Commercial Space Programs*, Pub. L. 111–314, §3, 18 December. 2010, 124 Stat. 3328.

United States Government Accounting Office (GAO) (1999) *Public-Private Partnerships: Terms Related to Building and Facility Partnerships*, S.n., Washington, DC.

Water Partnership Council (2003) *Establishing Public-Private Partnerships for Water and Wastewater Systems: A Blueprint for Success* [online] http://www.nawc.org/uploads/documents-and-publications/documents/document_567764ad-b69f-4715-bc5d-eea32c304fdd.pdf (accessed 22 August 2016).