# Space Alert

**Volume IV, Issue 3 – July 2016**

*ORF Quarterly on Space Affairs*

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## The Spectacular Rise of the UAE Space Agency and the Challenges Ahead

*John B. Sheldon, Ph.D.*

The United Arab Emirates (UAE) has quickly established itself as one of the leading space powers in West Asia, and has made an impressive showing across the international stage. Like many space faring nations, however, it will find it difficult to sustain the successes made so far into the future without overcoming significant policy challenges over the next few years.

Of all the Gulf Cooperation Council (GCC) countries, the UAE has proven to be the most prepared and resilient in the face of persistent low oil prices and instability in its neighbourhood. The rulers of the UAE recognized years ago that an exclusively oil-dependent economy is unsustainable, and long before their GCC counterparts, took concrete action to start diversifying the economy, constituted large-scale educational reforms and the 'Emeritization' of most professional jobs in the country. Progress has been mixed, perhaps to be expected of such an ambitious reform programme, but the UAE has proven to be a remarkably resilient economy in recent years where others have been buffeted by instability.

One of the outcomes of these ambitious economic and social reforms in the UAE is the commitment by Abu Dhabi to establish the UAE as a regional hub for civil and commercial space activities. This has led to the creation of the UAE Space Agency (UAESA), headquartered in Abu Dhabi, and the Mohammed bin Rashid Space Centre (MBRSC - formerly the Emirates Institute for Advanced Science and Technology), located in Dubai.

The UAESA and the MBRSC are undertaking an ambitious project to indigenously build the Hope Mission to Mars, a spacecraft that will orbit Mars and study its climate and atmosphere. The aim is to launch the spacecraft in 2020 and have it arrive in Mars orbit in 2021 to mark the 50th anniversary of founding of the UAE. MBRSC is also building remote-sensing satellites such as KhalifaSat and DubaiSat with the aim of creating a fully autonomous and indigenous capability to design and manufacture satellites in the UAE.

The UAE is also playing a growing role in international space diplomacy by assuming prominent roles in the UN's Committee on the Peaceful Uses of Outer Space as well as by hosting a range of formal events and conferences on international space law and policy.

In the realm of space commerce, satellite communications companies Thuraya and Yahsat are already based in the UAE, and the Abu Dhabi investment fund is a 38% stakeholder in Sir Richard Branson's Virgin Galactic. There is even talk of the UAE investing in space mining ventures, such as the United States (U.S.) based company Planetary Resources, following the lead of Luxembourg which recently announced a €200 million investment in the space mining sector.

On top of this, the UAE is also establishing itself as a significant national security space player in the region. The UAE Armed Forces have a communications hosted payload on-board Yahsat communications satellites, and two Falcon Eye high-resolution reconnaissance satellites are on order from France, with the first expected to be launched in 2018. In April of 2016, the UAESA signed a space situational awareness data sharing agreement with the U.S. Strategic Command, enhancing the ability of the UAE to track and control its satellites in orbit and establishing a formal link with the world's largest and most powerful actor in national security space, the U.S.

Lastly, the UAESA has signed a large number of cooperation agreements with most of the world's leading space powers such as France, Russia, China, India, Japan and the U.S. among others, that creates the framework for

more focused and substantive cooperative space projects in the future.

All of these activities and achievements have taken place in only a matter of several years, and this in itself is impressive. Furthermore, anyone who has met officials, engineers, and scientists from both UAESA and the MBRSC are left in little doubt about their seriousness, professionalism, passion, and commitment. The UAE's space ambitions are both impressive and plausible and are obviously respected by their international peers.

Yet a persistent question arises about the future purpose and direction of UAE space activities, beyond economic diversity and providing fulfilling careers to young Emiratis. Fortunately for the UAE, this is a question increasingly applicable to the space programmes of other countries, including the U.S.

While the question of purpose and direction in space programmes is hardly unique, the answer is inherently unique to local political and economic circumstances, and therefore hard to come by. The UAE has many ambitions in space, and is certainly not lacking in vision, but will sooner or later overextend itself unless it comes up with commonsense policies and other actions, and the ability to implement them that can nurture those ambitions.

The challenges UAE space ambitions face will be familiar to many space policy experts around the world, but can only be solved by those responsible for space policy in Abu Dhabi. These challenges include:

1. Creating an interagency space policy process in Abu Dhabi: The UAE finds that space policy touches upon a range of other public policy issues which the space agency alone is not equipped to deal with. National security, trade, transportation, and energy; all interact with space policy in unpredictable ways, and in order to ensure comprehensive and adequate policy making capacity, most spacefaring countries establish a formal interagency policy process to produce a comprehensive space policy. As far as is known, the UAE does not have a formal interagency policy process to do this.

2. Establishing a comprehensive technological and programmatic roadmap that sustains UAE space ambitions beyond 2021: The UAESA is working on this matter and has some time to finalise its future plans. This said, however, a technological and programmatic roadmap for UAE space activities will be needed sooner rather than later in order to allow adequate planning and budget preparation for the period beyond the Hope Mission to Mars project.

Failure to agree upon a comprehensive technological and programmatic roadmap in the next year or two threatens to undo all of the hard work done until now and dissipate resources, effort, public support, and political backing away from space activities.

3. Establishing a commercial space ecosystem in the UAE: Long-term political and economic sustainability of UAE space activities will also depend upon the ability of political leaders in Abu Dhabi and Dubai to create the right conditions to encourage greater entrepreneurial participation in space commerce. If the UAE is serious about becoming a regional hub for space activities it will have to continue economic reforms and deregulation in order to incentivize and encourage entrepreneurs and investors to establish startups in the space sector, doing everything from satellite manufacturing to space services such as insurance and satellite applications.

Looking further into the future, the UAE should try to position itself as a regional space commerce powerhouse that can take full advantage of the trends starting to emerge in commercial space exploration and human spaceflight, as well as taking advantage of the UAE's geographical position as a Eurasian and Indian Ocean crossroads between Asia, Europe, and Africa.

4. Making international partnerships substantively work for UAE space: The UAESA does not lack partners in space cooperation, but does need to match these partnerships to its future priorities and a comprehensive technological and programmatic roadmap (as discussed above). The UAE is in a unique position in that it can pick and choose partners across a range of space activities since it is not as geopolitically constrained on the world stage as other space powers are.

The UAESA can cooperate with NASA on one programme, with China on another, and with India on yet another, should it choose to do so. These cooperative frameworks are likely to whither, however, without a long-term roadmap of what the UAESA should want to do in line with current wider economic and national security policies and interests.

The UAE has come a long way in space, and is more than likely to emerge as one of the leading space powers in West Asia over the long-term should it be able to address the challenges outlined above. Solving these issues is certainly within the UAE's capacity, though will not be straightforward.

For UAE's international partners, such as India, its long-term success not only as a regional space power, but also as an island of stability and positive geopolitical influence in a deeply troubled region of the world, depends on its friends as much as the policy and strategic acumen of policymakers in Abu Dhabi and Dubai. Partners such as India are already looking for areas of mutual interest to cooperate in space with the UAE, but should look beyond low-hanging fruit when looking to engage with the UAESA. Looking to cooperate over the long-term would help the UAESA further define its priorities as well as create a valuable spacefaring partner for its friends around the world.

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## India's Commercial Space Launch Conundrum

*Michael J. Listner*

A head on dispute of sorts has arisen between the commercial space industry in the United States and India with regard to the small-sat launch business. The underlying issue is the surge of private investment in the United States for small-sat ventures, including existing small-sat systems and proposed small-sat constellations.

Currently there are a few dedicated U.S. launchers for this class of satellites, but the number of dedicated small-sat launchers stands to increase between private investment in companies like Virgin Galactic, Rocket Labs and Firefly Space System and the government-sponsored Venture Class Launch Services, which is a NASA program to develop a dedicated small-sat launch system for government payloads.

The result being the vacuum of dedicated small-sat launchers will likely be filled via the commercial space industry facilitated by the private interest U.S. domestic space law creates.

At issue with this planned expansion of U.S. small-sat launchers is India's desire to enter this market with its Polar Satellite Launch Vehicle (PSLV) through the Antrix Corporation Ltd., which isthe commercial arm of India's space programme. U.S. satellite operators have been banned from launching on Indian launchers since 2005 because of failure of the U.S. and India to finalize and sign a Commercial Space Launch Agreement (CSLA), which is a proposed bi-lateral treaty between the U.S. and India designed to protect the nascent U.S. commercial space launch industry from foreign government-subsidized launch providers like Antrix Corporation.

A significant term of the CSLA is its requirement for government-owned, non-U.S. launch providers to set their minimum prices to those offered by American commercial launch providers. In other words, the CSLA would require India's government owned launch provider to set its minimum price for a launch on PSLV consistent with the minimum prices offered by the U.S. commercial launch industry.

This stipulation has proven unacceptable to the Indian government. The U.S. commercial launch industry, meanwhile, moved the FAA Commercial Space Transportation Advisory Committee (COMSTAC) and the FAA to voice their dissent towards the CSLA and the US Trade Representative to recommend the ban remain in place.

The continued ban amounts to 'protectionism' not only in case of currently available U.S. commercial launch providers but also the dedicated U.S. small-sat launchers in the process of development. Otherwise, allowing the U.S. small-sat operators to take advantage of PSLV's subsidized launch prices and book their manifest on India's launcher could destroy the small-sat launcher industry before it even becomes available.

Even if domestic small-sat launchers do not come to fruition to meet the demands of the small-sat industry, launch providers such as ULA, Space X and Orbital/ATK would still be at a price disadvantage to the PSLV. There is the remote possibility if dedicated U.S. small-sat launchers do not come on line in time to meet demand, small-sat operators could lobby the U.S. government in opposition to the launch provider lobby to lift the ban and allow

them to take advantage of India's ready capability to deploy their constellations, but unless the U.S. Trade Representative decides to scrap the ban, the likelihood is it will remain in place regardless of the small-sat operator lobbying efforts as India is unlikely to acquiesce to the CSLA's pricing terms.

Despite its seeming geopolitical and protectionist characteristics, the small-sat launch dilemma and the impasse over the CSLA is not the root of the problem. Rather, the core of the discord over the small-sat launch issue resides in India's intermingled ambitions to participate in commercial space ventures and maintain government control over space activities.

This is exemplified in India's reluctance to adopt a coherentdomestic space policy and by extension a domestic space law to enact that policy. India appears indifferent to the possibility of creating a domestic space policy that would endorse the creation of a private interest in commercial space activities and allow domestic entities to develop small-sat launch capabilities through private investment and enterprise and abrogate the need for a CSLA with the U.S.

The call for an Indian domestic space policy and space law is not new. There have been appeals by academics and non-governmental organizations to develop a domestic space policy and expand India's participation into the growing commercial space community, yet India's government is seemingly disinterested. India's reluctance to adopt a space policy and create a private interest for outer space activities possibly has its roots in national security concerns, stemming from the establishment mindset about private sector handling high-tech programmes.

Nevertheless, India might be gradually moving to take advantage of the talent pool in the private sector in order to meet its growing requirements - driven by both commercial and national security interests. This move will of course be monitored carefully by China and Pakistan, as it could possibly have ramifications in the larger Asian security context.

With that said, the foremost reason has more to do with internal politics than external security and the arrangement the Indian government has with Antrix to funnel commercial launches to PSLV and the resultant revenue stream the Indian government enjoys. Dedicated small-sat launchers built by private Indian entities or foreign entities who subject themselves to India's jurisdiction would compete directly with and out-pace the current commercial space launch archetype.

Whatever the rationale for India's reluctance to adopt a space policy and a true commercial space scheme, it would pale in comparison to the long-term benefits and geopolitical effect of creating a legal and regulatory regime to allow commercial space activities by its private citizens.

India's reluctance to do is unusual considering countries like New Zealand are set to enact commercial space law and regulations to facilitate small-sat launches by Firefly Space Systems, which would compete with PSLV, and with laws passed by Denmark and future laws to be passed by the UAE, China and others, India and its space industry is setting itself up to be left behind.

India is primed to become a player in the commercial space industry with its current state of rocket technology, experience and industry. The question is will India continue to entrench its commercial ambitions with PSLV and continue to dance around its commercial space conundrum.

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## ISRO's RLV-TD: India's Attempt to Leapfrogs

*Vidya Sagar Reddy*

The Indian Space Research Organization (ISRO) had successfully demonstrated the hypersonic re-entry flight profile; structural integrity and; communication, guidance and navigation technologies of what will become an operational reusable launch vehicle (RLV) in the future. There are multiple inherent dimensions to this demonstration which need to be highlighted.

Traditionally, the launch vehicles which occupy maximum cost and risk of a space mission are discarded after burnout. The current global trend is to land these vehicles safely on ground and reuse them for next mission. Successfully launching a minimum number of reusable launch vehicles per fiscal year tends to decrease the manufacturing costs as well as increase the reliability of the launch vehicle. This strategy is aimed at offering low cost yet reliable access to space.

Although many experiments have been conceived in the past, the concept had not been materialized until SpaceX successfully validated it recently. SpaceX also has competitor now in the United States (US) – Blue Origin. The mechanism adopted by both these companies is to return the booster (lower) stage of launch vehicle during operational flights for reuse.

Unlike this, ISRO's design is a two stage to orbit mechanism where the booster retains its traditional form but the upper stage is transformed into a winged body akin to the retired US space shuttle that serviced the International Space Station, Sierra Nevada's Dream Chaser or the secretive X-37B.

The primary advantage of winged body design is to allow the RLV undertake a series of difficult manoeuvres during atmospheric re-entry and navigate towards the designated landing spot. During the subsequent tests, ISRO will demonstrate landing on runway as well as air breathing propulsion technology. A five kilometre long runway will be built at SriHarikota for this purpose.

The air breathing propulsion concept eliminates the need to carry oxygen onboard by allowing the launch vehicle intake atmospheric oxygen in flight. As a result, the cost of the launch vehicle will be further reduced. ISRO expects its RLV to bring down the cost of payload from $25,000 per kilogram to merely $1,000.

This makes the Indian RLV competitive in the small satellite launch industry. The advent of small satellites built with commercial off-the-shelf components has altered the nature of satellite manufacturing facilitating academia and entrepreneurs and the NewSpace, to design and launch space missions.

The NewSpace businesses are gradually increasing their claims in the global space industry. Their basic requirement is to reach multiple orbits at very low cost and the Indian RLV caters to this requirement by optimising the combination of ISRO's low cost booster manufacturing and the RLV that can place multiple satellites into different orbits.

Reusable launch vehicles also strengthen deterrence in space by demonstrating the capability to roll back the effects of anti-satellite weapons by rapidly replacing the damaged satellites, in case the adversary took the extreme step. To this effect, the US Defence Advanced Research Projects Agency has recently released its requirements for a

space plane – 10 launches in 10 straight days, a capability for showcasing deterrence.

India's economic growth and societal development is highly dependent on access to its space assets which may be threatened directly or damaged due to the cascading effects of anti-satellite weapon demonstration. These weapons are also highly likely to be employed during wartime to punch gaps in the adversary's flow of information by damaging communications, navigation and surveillance satellites.

Therefore, the Indian RLV should also be characterised to rapidly replace the damaged or destroyed satellites. Demonstrating this capability will enable and strengthen India's 'deterrence by denial' strategy in outer space.

Showcasing similar characteristics to the US space shuttle, the Indian RLV also fits neatly into the string of technologies ISRO is developing parallelly for demonstrating a manned mission. This vehicle which can guide itself to land on a runway offers greater safety and navigation solutions to the crew and sensitive equipment onboard compared to the gondola design of Russia or China used to return astronauts from space.

ISRO seem to be working towards this goal by "human-rating" the RLV under development. The American space agency National Aeronautics and Space Administration defines human-rating as specific certification of "carefully managed missions where the safety risks are evaluated and determined to be acceptable for human spaceflight." This RLV test as well as the GSLV Mk-III X / CARE mission in 2014 tested certain technologies and flight characteristics that form critical part of human spaceflight.

But the most important aspect of this test and future developments of the RLV it empowers is the pride of the ISRO in successfully demonstrating indigenously developed technology that is currently operationally available only with the US.

The ISRO certainly did develop many critical technologies indigenously but was either the fifth or the sixth in the world to do so. As a result, India is considered to be a second rate space power. The renowned scientist Dr. Sivathanu Pillai vows by the idea of *leapfrogging* in technology if India were to breakthrough these perceptions. This RLV technology demonstration is certainly the much required leapfrog in that direction.

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# FROM THE MEDIA

**Big boost to India's space mission: ISRO sets record, launches PSLV-C34 with 20 satellites**

Setting a record in its space programme, India today successfully launched 20 satellites, including its earth observation Cartosat-2 series, in a single mission on board ISRO's workhorse PSLV-C34 from the spaceport here.

Source: *Economic Times*, June 22, 2016

**AFSPC Commander announces Space Enterprise Vision**

"Operating as an enterprise as opposed to a set of independent platforms improves resiliency and is critical to the ability to survive and deliver effects in a contested environment."

Source: *Air Force Space Command*, April 12, 2016

**The Return of Kepler: NASA Brings Planet-Hunter Back From The Dead Again**

While Kepler is in safe mode, the vehicle allows one more error to take place. However, if another alarm had signalled while Kepler were in emergency mode, NASA would have lost the $600 million observatory.

Source: *The Tech Times*, April 16, 2016

**China testing own reusable rocket technologies**

Chinese experts have already built a prototype model to test theories on the reusable rocket booster's landing subsystems. "There is of course more than one way to do this. I believe we could see some serious results during the 13th Five-Year Plan period."

Source: *Xinhua*, April 21, 2016

**SpaceX announces plans for Dragon mission to Mars**

SpaceX announced it plans to send an uncrewed Dragon spacecraft to the surface of Mars as soon as 2018 on a technology demonstration mission aided by expertise, but not funding, from NASA.

Source: *Space News*, April 28, 2016

**Roscosmos to Set Up Marketing Firm to Manage Commercial Launches**

"The step was "logical" because it would allow Russia's state companies in the space industry to penetrate the global launch vehicle market in a more coordinated way, specifically considering how competitive it has become."

Source: *Sputnik News*, April 25, 2016

**Exotic heat-resistant gel: a spinoff from ISRO**

With its "exotic properties," silica aero gels are attractive candidates for many unique thermal, optical, acoustic, catalytic and chemical applications and are best known for their "super-insulating property."

Source: *The Hindu*, May 7, 2016

**China, U.S. hold first dialogue on outer space safety**

The two sides exchanged views on issues such as outer space policy, bilateral cooperation on space safety and multilateral space initiatives.

The discussions were “pragmatic, in-depth and fruitful,” according to the Chinese delegation.

Source: *Xinhua*, May 12, 2016

**Jilin-1: China's first commercial remote sensing satellites aim to fill the void**

China’s first domestically developed commercial Earth imaging satellites are up-and-running in orbit, and are the first step in an ambitious plan to secure a niche in a growing sector and help revitalise the Northeast China economy.

Source: *GB Times*, May 12, 2016

**ISRO transmitters to locate fishermen in distress zone**

In a bid to help the fishermen in distress at sea, the Indian Coast Guard has collaborated with the ISRO to distribute Distress Alert Transmitters among fishermen as part of its community interaction programme

Source: *New Indian Express*, May 16, 2016

**Students to map assets of rural areas for ISRO**

This is part of the ISRO’s larger project on ‘Space Based Information Support for Decentralised Planning’ across India to empower people at the grassroots. Under the project, 100 villages will be adopted for asset mapping.

Source: *The Hindu*, May 18, 2016

**India should build its own space station**

India should actively get into building its own space station in the Low Earth Orbit as its next space frontier since the time is opportune for this, a retired space scientist has said.

Source: *Business Standard*, May 18, 2016

**China to launch 30 Beidou navigation satellites in next 5 years**

The first batch of 18 satellites will be launched before 2018 to cover countries along the routes in "the Belt and Road" initiative.

Source: *Xinhua*, May 19, 2016

**NRO planning shift to smaller satellites, new ground system**

The director of the National Reconnaissance Office, which builds and operates US spy satellites, said that the agency, known for its gigantic satellites, intends to increase its use of cubesats in the near future.

Source: *Space News*, May 18, 2016

**NRO Tries New Automatic Systems That Analyze Data & Move Satellites**

“We anticipate fielding a ground system able to direct appropriate multi-int collection assets against intelligence problem observables able to redirect assets for digital collection to improve our knowledge and able to learn and adapt, all before any human sees what’s happening.”

Source: *Breaking Defence*, May 18, 2016

**India’s Reusable Launch Vehicle-Technology Demonstrator (RLV-TD), Successfully Flight Tested**

After successfully surviving high temperatures of re-entry with the help of Thermal Protection System, the RLV-TD successfully glided down to the defined landing spot over Bay of Bengal, thereby fulfilling its mission objectives.

Source: *Press Information Bureau*, May 23, 2016

### Government approves MoU between ISRO and the UAE Space Agency

The government today gave nod for signing an MoU between ISRO and the UAE Space Agency, a move that will lead to setting up a Joint Working Group between the two agencies and help in cooperation in the exploration of outer space for peaceful purposes.

Source: *Economic Times*, May 25, 2016

### ISRO plans to test air-breathing propulsion system

After successfully testing a technology demonstrator of a reusable launch vehicle, ISRO is planning to test an air-breathing propulsion system, which aims to capitalise on the oxygen in the atmosphere instead of liquefied oxygen while in flight.

Source: *The Hindu*, May 26, 2016

### U.S. government close to approving private moon mission, reports say

A commercial space company could be one step closer to landing its spacecraft on the moon in a regulatory move that might help open space exploration beyond Earth orbit to private firms.

Source: *LA Times*, June 6, 2016

### Satellite operators give negative reviews of Indian regulator's satellite-TV proposal

Commercial satellite fleet operators doing business in India are reacting with surprise and concern at an Indian regulatory proposal to consolidate all satellite television broadcasts onto a couple of Indian government-owned satellites.

Source: *Space News*, June 8, 2016

### China's first high orbit remote sensing satellite put into use

China's first high orbit remote sensing satellite, Gaofen-4, went into use after six months of in-orbit testing, the State Administration of Science, Technology and Industry for National Defense announced.

Source: *Xinhua*, June 13, 2016

### China opens space station to rest of the world with United Nations agreement

China has signed an agreement with the United Nations to open its future space station to spacecraft, science experiments and even astronauts from countries around the world.

Source: *GB Times*, June 17, 2016

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# OPINIONS AND ANALYSES

Richard Stone, "A renaissance for Russian space science," *Science*, April 7, 2016

Eric Berger, "Make Mars great again: Can the 2016 election save NASA's Journey to Mars?," *Ars Technica*, April 13, 2016

Vidvuds Beldavs, Jim Crisafulli, David Dunlop and Prof. Bernard Foing, "A major role for the EU in lunar development," *The Space Review*, April 11, 2016

Bruce Dorminey, "Can Commercial Space Really Get Us Beyond Low-Earth Orbit?," *Forbes*, April 27, 2016

Meenakshi Ambwani, "As transponders lie vacant, DTH industry pitches for price cuts," *Hindu Business Line*, April 24, 2016

Mark Albrecht and Paul Graziani, "Congested space is a serious problem solved by hard work, not hysteria," *Space News*, May 9, 2016

Cody Knipfer, "Of India and ICBMs: two current concerns for American small-satellite launch," *The Space Alert*, April 25, 2016

Constance Baroudos and Loren B. Thompson, "Banning Russian Rockets Endangers U.S. Access to Space," *The National Interest*, May 10, 2016

Dick Eagleson, "The future of space economics and settlement," *The Space Review*, May 9, 2016

Jeff Foust, "When CubeSats are too big," *The Space Review*, May 16, 2016

Gary Oleson, "Effects of changing economics on space architecture and engineering," *The Space Review*, May 16, 2016

Eric Berger, "Low gravity and high radiation: Would humans remain human on Mars?," *Ars Technica*, June 11, 2016

Andy Pasztor, "How to Build Satellites Much Faster—and Cheaper," *Wall Street Journal*, June 7, 2016

Narayan Prasad, "Why won't there be a SpaceX in India unless…," *The Space Review*, June 20, 2016

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# NEW PUBLICATIONS

## REPORTS/STATEMENTS/ MULTIMEDIA

US DoD Annual Report to Congress on Military and Security Developments Involving the People's Republic of China 2016

Steven Hildreth, "National Security Space Launch at a Crossroads" Congressional Research Service, May 13, 2016

"United Nations and China agree to increased space cooperation." United Nations Information Service, June 16, 2016

Report of the US Congressional Committee on Appropriations for Commerce, Justice, Science, and Related Agencies for the fiscal year ending September 30, 2017

"Commander's Strategic Intent," US Air Force Space Command

## JOURNAL ARTICLES

Andrew A. Gonzales and Carol Stoker, "An efficient approach for Mars Sample Return using emerging commercial capabilities," *Acta Astronautica*, vol. 123, June-July 2016, pp. 16-25

Yun Zhao, "The Role of bilateral and multilateral agreements in international space cooperation," *Space Policy*, vol. 36, May 2016, pp. 12-18

Scott Pace, "Space cooperation among order-building powers," *Space Policy*, vol. 36, May 2016, pp. 24-27

## BOOKS/MONOGRAPHS/OCCASIONAL PAPERS

Fred Taylor, *Exploring the Planets: A Memoir* (Oxford University Press: UK, April 2016)

Paul Spudis, *The Value of the Moon: How to Explore, Live, and Prosper in Space Using the Moon's Resources* (Smithsonian Books: US, April 2016)

S. Chandrashekar and Soma Perumal, "China's Constellation of Yaogan Satellites & the ASBM: May 2016 Update," National Institute of Advanced Studies, May 23, 2016

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