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POTENTIAL SECURITY GAINS OF INDIAN SPACE TECHNOLOGY DEVELOPMENT

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Introduction

India's space agency, the Indian Space Research Organisation (ISRO) has in the years since its inception in 1969[1] chalked up a large number of high technology feats that easily rival the best in space technology available from more scientifically advanced nations. ISRO's early experiments with relatively simple imported sounding rockets led on to its eventual development of its own Satellite Launch Vehicle (SLV), Augmented SLV (ASLV), Polar SLV (PSLV), and Geosynchronous SLV (GSLV) space launch rockets. While the original SLV could launch a mere 40 kg payloads to low earth orbit, the most advanced, under development, GSLV variants are planned to carry over 4000 kg to geosynchronous orbit[2]. ISRO has also developed a series of ever more advanced and complicated satellites. Today India is self-sufficient in a wide variety of satellites ranging from those for earth observation, communication, mapping, etc. ISRO continues to develop ever more advanced technologies for application towards the country's development and economic betterment. ISRO has achieved one mission to the moon, Chandrayaan-1, in 2008. This was followed by the Mars Orbiter Mission (MOM) in 2014. While advancing its technological expertise ISRO has usually favoured cost effective means of executing its tasks. Hence, it has consistently demonstrated very good accuracy of satellite insertion into orbit. Such accurate insertion into orbit helps extend the on station life of satellites as accurate orbit insertion obviates the need to expend the limited fuel on board for orbit correction manoeuvres. As covered on this website in earlier articles, ISRO also has the lowest satellite launch costs in the world.

Recent Achievements by ISRO

Recent achievements by ISRO include the testing of technology for its prospective Reusable Launch Vehicle (RLV) which was written about on this website earlier; and the successful flight testing of ISRO's supersonic combustion ramjet

(scramjet) engines. While developing such futuristic launch vehicle technologies ISRO has continued to refine and further improve its legacy rocket launch vehicles. The PSLV has emerged as ISRO's reliable workhorse launch vehicle. The GSLV continues to be under development and development flights of the GSLV Mk-III, ISRO's heaviest launch rocket are expected later this year.

GSLV Mk-III will help enhance ISRO's single launch lift weight to above 4000 kg, considerably higher than the present 1500 to 2500 kg for the PSLV and GSLV respectively. While the ability to lift heavier payloads to orbit is an important capability, the optimisation of lighter weight rockets is also important.

Modern military forces rely, to an ever increasing extent, upon space based capabilities for effective execution of their national security tasks. In addition, space based applications play an important part in efficient functioning of modern nation states. These civil applications provide communication, remote sensing for myriad tasks, accurate navigation, voice and data broadcast and transfer facilities, etc. The increasing importance of space technology for efficient functioning of modern states in peace and war makes optimal utilisation of scarce resources increasingly important. Satellites have a limited life on station and require to be replaced at intervals. Moreover, it is possible that a hostile state, during times of heightened tension, may intentionally degrade and / or destroy friendly satellites to degrade our normal functioning and to reduce our military capabilities to his advantage. In such cases there could be a need to replace degraded space assets quickly in order to retain required capabilities and the ability to function effectively. This capability would require a suitable launch vehicle and the required types and numbers of replacement satellites kept ready for launch at short notice. If a single rocket were to carry just one satellite, a larger number of rockets would be required to be manufactured and stored for use in emergencies. Such an investment could prove very expensive. However, if a single rocket has the capability to insert more than one satellite into orbit, the cost of the backup could reduce considerably while the speed of deployment of replacements increases. In case small micro or nano satellites can be manufactured as emergency replacement satellites for essential services, these costs could come down even more.

The PSLV C-37 Mission

On 15 February 2017, at 0928h Indian Standard Time (IST) ISRO carried out the launch of its PSLV C-37 mission. This rocket carried India's Cartosat-2D, weighing 714 kg, as its main payload[3]. In addition it carried the Indian Nano Satellite (INS)-1A and INS-1B, each weighing 8.4 kg and 9.7 kg respectively[4]. The rest of the available space and payload weight on board was

taken up by a further 101 nano satellites. Of these 101 nano satellites, 96 were from the US, including 88 dove satellites forming flock 3p from the Planet Labs, 08 Lemur-2 nano satellites from Spire Corporation of US, the Al-Farabi satellite from Kazakh National University, Kazakhstan, the BGUSat from Ben Gurion University, Israel, Nayif-1 from Emirates Institution for Advanced Science and Technology (EIAST), UAE, the DIDO-2 nano satellite from Israel and Switzerland, and the PEASS nano satellite from PEASS Consortium (Netherlands, Germany, Belgium, and Israel). The uniqueness of the mission came from the need to deploy these 104 satellites in very precise orbits[5]. 88 of these nano satellites form part of one constellation of satellites with a specific earth observation task that requires precise inter-satellite positioning. The deployment of the Cartosat and INS satellites which came first in deployment sequence was quite straightforward. The remaining 101 satellites required, in comparison, very high precision and accuracy in ejection from the rocket. With such large numbers of satellites being deployed in quick succession, even a very small error in the execution of the deployment sequence could potentially result in interference between satellites. In the worst case collisions between satellites could occur. In the event as it transpired PSLV C-37 was able to deploy all 104 satellites in the planned manner without any discernible error. This is a commendable feat.

Potential Technology Gains and Spin-Offs of the PSLV C-37 Mission

Multiple Independently Targeted Re-entry Vehicle (MIRV)[6] is a technology to utilise a single missile to carry multiple nuclear warheads for delivery at different targets. The basic principle involves placing a number of independent warheads inside the heat shield of a ballistic missile. These warheads are released one by one at very carefully computed release points such that each of these warheads follows its separate ballistic trajectory to impact at a different target. Thus a single MIRV missile can launch attacks on several different targets that are geographically widely separated from each other. The essence of MIRV technology is the ability to precisely release each of the multiple warheads at accurate times and locations without any interference with the remaining warheads. The design and functioning of the payload ejection mechanism and its practical working in the real world, combined with the ability to vary the speed and altitude of the rocket platform carrying the warheads, forms the basis for this technology[7]. Of course miniaturisation of warheads and their weight reduction to enable multiple warheads to be placed on a single missile is a separate but another essential requirement for MIRV capability. India's DRDO has tested several long range missiles of the Agni series that can reach distances of 2500 km to 5500 km[8]. These Agni missiles can carry payloads of up to 1000kg to these distances[9]. No information is available in

the public domain about the actual size and weight of India's nuclear warheads. However, stray reports by knowledgeable sources in academia and in strategic circles state that the needed miniaturisation has been achieved. Testing of a MIRV missile in flight is yet to take place. The basic payload ejection technology utilised in multiple satellite rocket launches is very similar to that needed in a MIRV missile. The fact that ISRO has carried out several successful rocket launches with multiple satellites on board could be taken as an indication that the needed payload ejection skills and technology for MIRV are available in the country. ISRO has also switched off the launch rocket engine and reignited it remotely to place satellites in different orbits during multiple satellite launches[10].

ISRO's PSLV C-37 launch on 15 February 2017 in which 104 satellites were successfully placed in orbit by a single rocket could be taken as an extreme demonstration of total mastery of the science and mechanics of precise ejection of multiple payloads from a single vehicle. ISRO remains a fully and totally civil space research organisation. However, skills and expertise developed by ISRO in cooperation with its space vehicle component supply companies and entities are capabilities available in India and these could potentially be tapped by other organs of the state as well. In this context it could be said that PSLV C-37 has demonstrated the ability of India to field MIRV ballistic missiles at a future date as and when decided by the Government.

The PSLV C-37 has also demonstrated the country's ability to rapidly replace space based assets if and when required. This specific capability would of course require the foresight to have the spacecraft and launcher prefabricated and stored for such an eventuality.

On a purely economic angle, the PSLV C-37 has shown that ISRO has the capability to use the full lift capability available from its rockets. ISRO can achieve this by carrying other payloads of appropriate weight and size if the size and weight of the primary payload of the mission leaves spare space and weight from the total lift capability of that mission.

Conclusion

ISRO, at regular intervals, has demonstrated several world class space technology capabilities. The launch of PSLV C-37 is yet another commendable achievement demonstrated by ISRO. The technological capabilities demonstrated by the PSLV C-37 launch on 15 February 2017 shows that ISRO can further reduce per satellite launch cost by injecting several satellites from a single rocket. In addition ISRO can potentially replace needed satellites rapidly by carrying several on a single rocket. The precise payload release capabilities and multiple burn of the in-flight rocket engine technology could find utilisation in other fields

such as MIRV missiles. ISRO, while remaining dedicated fully to a purely civil pursuit of space technology and capabilities thus serves to enhance India's security and advancement on multiple fronts from the purely economic and technological to security as well.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

Notes

[1] Isro.gov.in, "Genesis", http://www.isro.gov.in/about-isro/genesis, accessed on February 15, 2017.

[2] Isro.gov.in, "Launchers", http://www.isro.gov.in/launchers/gslv, accessed on February 15, 2017.

[3] Ravi Sharma, "ISRO Creates Record by Launching 104 Satellites: Here's the List of Satellites on Board", http://gadgets.ndtv.com/science/features/isro-launches-pslv-c37-rocket-heres-the-list-of-104-satellites-on-board-1659740, accessed on February 16, 2017

[4] Ravi Sharma, N-3

[5] Ravi Sharma, N-3

[6] Fas.org, "the Origin of MIRV", https://fas.org/man/eprint/leitenberg/mirv.pdf, accessed on February 16, 2017.

[7] Ibid.

[8] Army-technology.com, "Agni Ballistic Missile System, India", http://www.army-technology.com/projects/agniballisticmissile/, accessed on February 16, 2017; and Pallava Bagla, "Agni 5, India's Longest Range Nuclear Capable Missile, Successfully Test Fired: 10 Points", http://www.ndtv.com/india-news/india-to-test-its-longest-range-agni-5-missile-1641785, accessed on February 16, 2017.

[9] Army-technology.com, N-8

[10] Ndtv.com, "Isro Successfully Tests Multiple Burn PSLV Engine on Wednesday", http://gadgets.ndtv.com/science/news/isro-successfully-tests-multiple-burn-pslv-engine-on-wednesday-779156, accessed on February 16, 2017.