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PROGRESS TOWARDS INDIAN SELF SUFFICIENCY IN SATELLITE NAVIGATION TECHNOLOGY

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Advanced space applications with high end dual use features have hither-fore been the almost exclusive domain of the technologically advanced "West". The advent of the American Global Positioning System (GPS) "Navstar" has changed the way life is lived and war waged. Clones from the erstwhile Soviet Union in the form of their similar Global Navigation System (GLONASS) swiftly followed. The European Union (EU) has been working on its Galileo system with similar capabilities to GPS and GLONASS. China has commenced launch of its Bediou constellation to provide a nationally owned advanced navigation system. Now India has commenced to put its Indian Regional Navigation Satellite System (IRNSS)'s space segment into orbit. The second satellite of the planned seven, IRNSS-1B was successfully put into orbit on 04 April 2014.[i]

BACKGROUND AND RECENT DEVELOPMENTS

The GPS system was designed and built to meet a US military requirement for accurate navigation at all points on the globe. Once the system was up and running more applications were found for it. Utilisation of the GPS signals to guide weapons accurately than had been possible before led to the fielding of GPS guided bombs and other ordnance. An important characteristic of GPS guided weapons was the fact that ignoring the cost of the "Navstar" GPs constellation of satellites and other fixed costs, GPS guided weapons were cheaper to manufacture and use than traditional guided ordnance. For instance a GPs

guided Joint Direct attack Munition (JDAM) reportedly costs just $18,000/=[ii] as compared to $ 23,700/=[iii] for a Paveway-II Laser Guided Bomb (LGB). Both weapons have comparable accuracy. Another point of difference is that while the LGB requires support from launch till impact, the JDAM is more of a fire and forget weapon. GPS also found use in accurate navigation for all kinds of airborne, marine and surface vehicles and thus enabled more accurate marshalling and arraying of forces than had been possible before. In the civil field applications of GPS include vehicle navigation, supply chain management, equipment tracking etc. Applications of GPS technology is limited only by users' imagination. Thus satellite navigation systems such as GPS have been seen to deliver greater efficiency ion the field of military activities. At the same time civil applications abound with new ways of increasing the efficiency of economies are being found regularly.

The "Navstar" GPS system is wholly owned by the US which has reserved the right to degrade the system's capabilities for non allied users going on to the ability to deny entire geographical regions access to GPS signals. Such capabilities and possibilities and need for uninterrupted access to accurate and reliable navigation signals spurred the Soviet Union, later Russia, the EU and China to develop and deploy their own similar satellite navigation systems despite the high costs.

A satellite used for GPS systems typically follows a polar orbit and is constrained to follow its orbital pattern which takes it around the entire globe incrementally. Thus at any given time one such satellite can be viewed from a limited area on the earth's surface. For deriving useful navigational fixes at least three satellites need to be in view from the observer's location. This leads to the requirement for a large number of satellites to be launched in orbit with their orbital planes inclined suitably to each other. Such a deployment gives a "train" of satellites following each other around the earth. The result is that while a single satellite may come over the same location only once in several hours, at any given time at least one satellite is likely to be over that point with at least another two visible also. The need to launch a large number of satellites arises from two imperatives. Firstly as a satellite would continue on its orbital path away from the location of interest till it starts to repeat earlier orbits, ensuring that the needed number of satellites are always

visible in order to derive useable navigational information needs multiple satellites. Secondly the need for similar coverage at all points on earth requires a large number of satellites. The US "Navstar" GPS system comprises at least 20 on orbit satellites with additional reserve satellites available in orbit as well as on ground. The Soviet/ Russian GLONASS and EU's Galileo also aim at global coverage and comprise 21 (plus three standby in orbit) and 30 satellites respectively while China's Bediou started as a local coverage system with 8 satellites to be expanded to 35 satellites, including five in geostationary orbit, for global coverage. A large number of satellites in orbit imposes costs of building all these spacecraft, launching and maintaining them and the risk of system failure if even one craft is damaged or fails.

GAGAN & IRNSS

ISRO's GPS Aided Geo Augmented Navigation (GAGAN) is often confused with the IRNSS. It is impotent to understand the difference between these two systems. The former is basically an elaborate "differential GPS system designed to cover the entire Indian landmass. Here GPS signals received are compared with the known surveyed location of specific ground based receivers. The error is calculated and a correction signal computed. This correction signal is then uploaded to satellites that transmit it to all users in that area. Thus the error in GPS signals is corrected for to obtain higher accuracy. GAGAN would be inoperative if GPS signal selective sector denial were to be initiated by the US as it requires the GPS signal to work. It should be possible to configure GAGAN to work with GLONASS, Bediou or Galileo signals in a similar manner. IRNSS on the other hand is a totally stand alone system that provides independent navigation services.

UNIQUE ARCHITECTURE OF IRNSS

India's Indian space Research Organisation (ISRO) has developed plans for its IRNSS which follows a unique structure. Costs are aimed to be controlled through limiting the number of satellites to as few as 7. This is facilitated firstly through the requirement for the system coverage to be the Indian mainland and up to 1500 km beyond national borders

and coastlines. Elimination of global coverage still imposes the tyranny of satellite orbital progression and revisit time lags. The really unique feature is that IRNSS uses a mix of satellites in equatorial geostationary orbit and inclined orbits at geostationary height off the equator. This unique satellite deployment gives three satellites in equatorial geostationary orbit, whose position remains fixed with relation to points on the surface (each is always above the same surface location). The other four satellites in "quasi-geostationary" orbits move in what appears to be a figure of 8 above the surface as observed by an observer on earth. This restricted movement delivers the benefit of adequate satellites visible to obtain highly accurate fixes for navigation purposes. At the same time as the figure of 8 satellites do not go around the earth as satellites in lower orbits typically used for navigation purposes do, no more are needed. This unique solution delivers capability required by users within reasonable costs and with low technical risk. ISRO has demonstrated its ability to deliver cutting edge capabilities at low cost and risk yet once again. This bodes well for further exploitation of space based assets for National defence and for the economy. The Indian military would after oerationalisation and attainment of stabilised operation of IRNSS be totally independent of dependence on the US "Navstar" GPS, Russian GLONASS and EU's Galileo. Thus military operations that require accurate reliable navigation signals would be able to proceed without fear of denial / wilful degradation of service. Apart from delivering total reliability and strategic autonomy to the country, spin off applications of IRNSS signals should be able to contribute to the economy in myriad ways just as the GPS does today. Moreover, neighbouring friendly countries that fall within

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IRNSS' footprint could be offered access to the system thus cementing relationships between the countries. In addition the unique configuration of the IRNSS system architecture, that reduces required numbers of satellites by a great number, serves to showcase India's frugal scientific execution frugal engineering skills. Potentially the proven demonstration of a fully functional IRNSS could lead to opportunities of scope in similar systems being put in place for friendly countries at reasonable costs and low technical risk further enhancing India's scientific prestige and influence. It should be borne in mind that the IRNSS could be expanded to deliver global coverage if the need arises through addition of more satellites operating in a similar manner to the seven initially planned to both the East and West of the currently planned space segment.

CONCLUSION

Overall the commencement of putting the IRNSS space segment is a major milestone for India and ISRO. IRNSS demonstrates India's high end scientific and engineering capabilities, but more importantly it shows that India has the ability to go beyond just blindly copying original work done by others. In this context, the Russian GLONASS, EU's Galileo and Chinese Bediou all basically copy the architecture used by the US "Navstar" GPS system, differing only in relatively minor details. IRNSS on the other hand utilises a totally original solution to building a cost effective and efficient regional navigation system. In addition to delivering obvious benefits to the Indian military forces and the economy in general, IRNSS serves to showcase India's high end scientific and engineering capabilities to as great an extent than the launch of the country's first totally home designed and built aircraft carrier and the Mars Orbiter Mission (MOM) did in the past few months.

(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)

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[i] Ishan Srivastava, "ISRO successfully launches navigation satellite IRNSS-1B", http://timesofindia.indiatimes.com/india/Isro-successfully-launches-navigation-satellite-IRNSS-1B/articleshow/33240651.cms, accessed on 10 Apr 2014.

[ii] "Joint Direct Attack Munition (JDAM) GBU-29, GBU-30, GBU-31, GBU-32", http://www.fas.org/man/dod-101/sys/smart/jdam.htm, accessed on 11 Apr 2014.

[iii] "Guided Bomb Unit-10 (GBU-10) Paveway II", http://www.fas.org/man/dod-101/sys/smart/gbu-10.htm, accessed on 11 Apr 2014.