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NaVIC User Segment Potential, Possibilities and Challenges

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Navigation over Indian Continent (NaVIC), is a regional navigation satellite constellation. As with any other Global Navigation Satellite System (GNSS) constellation, NaVIC would transmit signals for the civilian community and specifically for the defence sector. Currently, the signals are beamed in L5 (1176.45 MHz) and S-band (2492.028 MHz) with seven operational satellites [1]. Similar to other constellation, signals employ Code Division Multiple Access (CDMA) with data Binary Phase Shift Key (BPSK) modulated onto the code. The symbol rate is 50 symbols per second with rate ½ Forward Error Correction (FEC). With seven satellite constellation, foot-print of NaVIC is expected to reach 1500 km from the Indian borders. The expected accuracy in dual frequency mode of operation is around 5 m and in single frequency, 20 m, (1 -sigma). Similar to other global constellations, NaVIC has Space, Control and User segments, with its own challenges. Further, there is a roadmap of NaVIC beaming signals in L1 band, in near future [2]. The Space and Control segment is operated and maintained by Indian Space Research Organization (ISRO). User segment, with its own challenges, throws open new opportunities to the various GNSS companies. This presentation/talk brings about various opportunities in NaVIC user segment and presents some challenges at a very top-level.

The user segment can be broadly classified as civilian and military receivers. Civilian receivers can be classified under High Sensitivity, Aerospace, High Accuracy and High Dynamics. Military receivers, typically need to operate in high dynamics conditions, in addition to the hostile RF environment w.r.t jamming and spoofing. Further, receivers are used in conjunction with other sensors for multi-sensor fusion, for example: GNSS + INS integration and GNSS + Timing applications etc.

The need for high sensitivity receivers gained momentum in last 15 years when GPS receivers were started to be used in automobiles and later in mobile phones. These application demand receivers to operate in urban canyons, where availability of the GPS satellites posed a major problem. With technology evolution, sensitivities of -167 dBm have been demonstrated by many OEMs. Further, with assisted GPS (AGPS), receivers have flooded into the mobile market as well. With the advent of NaVIC, the availability of satellites in conjunction with GPS or another constellation has enhanced. With relatively high inclination of NaVIC satellites, there is a good possibility of standalone position in city environment as well. In addition, regionally there is an opportunity for A-IRNSS networks to emerge as well. This implies that the receiver and the telecom sector would have scope to work on this concept. Additionally, NaVIC being Indian and when used in automobiles, would eliminate the threat, if any, of GNSS from other countries being denied at times, which could have a significant bearing on civilian applications. Academically, there could be some research in the area of extended ephemeris for NaVIC, which could find some use in A-IRNSS network.

GPS receivers have been used as a part of the aviation sector in last decade, which demands relatively higher levels of integrity. Federal Aviation Administration (FAA), has mandated Minimum Operation Standards (MOPS) for utilizing GPS onboard civilian flights, which include signals from Satellite based augmentation system (SBAS) to be employed by the onboard GPS receivers. India, on its part has deployed three GPS Aided Geo Augmented Navigation (GAGAN) satellites to cover the foot-print between EGNOS of Europe and MSAS of Japan. With NaVIC, there could be a mandate by Indian government to employ receivers employing its signals. Further, with the potential of L1 signal, it might become seamless to use NaVIC as additional signals along with GPS L1 and enhance the availability in Indian subcontinent. All these are excellent opportunities for the receiver manufacturing companies. Further, for research organizations, this would through up some challenges in the area of integration and Receiver Autonomous Integrity Monitoring (RAIM) algorithms for combined solution.

GPS Receivers output measurements based on code phase, which are typically used for user position estimation. In addition, advanced GPS receivers also output measurements based on carrier Doppler, which are relatively more precise than the code phase measurements. Typically, user position estimate derived out of carrier phase measurements are of the order of centimeters and few millimeters as well. Such accuracies are demanded in survey applications. In addition, there measurements demand estimates from base station to resolve carrier cycle ambiguities. One of the challenge in carrier phase position with GPS is estimating the ambiguity of the carrier cycles whenever a new satellite appears. However, with NaVIC and in Indian subcontinent, this issue would not

be present, which could be a great advantage for many real time carrier phase applications. Though antenna design would pose a major challenge for this market, industry would definitely evolve solution in coming years. Studies could be attempted in the area of S-band based carrier phase positioning, which is very unique with NaVIC as other constellations are restricted to L-band only [4].

GPS receivers available from the OEMs are restricted in signal dynamics, one reason attributed due to export restrictions. However, some applications demand signals to be tracked with relatively higher signal dynamics (either in Doppler and/or rate of change of Doppler). NaVIC based receivers should also employ methods and techniques to be used in such applications. Such receivers also demand multi-antenna and Fast Time to First Fix (TTFF). NaVIC receivers with low data rate, effectively poses challenges in cold start TTFF. This would pose a good problem to the industry and academia to evolve means to minimize the time required to output position in NaVIC [3].

Next category of receivers are those which are used in military applications. Similar to any global constellation, NaVIC also transmits Restricted Service (RS) signals. Most military applications would demand receivers which employs RS signals only. Though clear picture does not exist about the roadmap of these receivers w.r.t development, there could be a point when qualified private industries would also be employed in the design and development of these receivers as in other countries. Technically, these receivers should demonstrate the capability of being operated in vulnerable situations such as jamming and meaconing. Further, these receivers should be miniaturized to ensure that they are available for handheld applications. One major problem would be miniaturizing the antenna for anti-jam applications and further include both bands of NaVIC signals for positioning [3].

The presentation would focus on opportunities NaVIC provides to OEM developers and to academia highlighting technical challenges to go with it.

1. ISRO, “IRNSS - Indian Regional Navigation Satellite System,” 28 April 2016. Available: http://www.isac.gov.in/navigation/irnss.jsp.

2. I. S. R. O. ISRO Satellite Centre, “Indian Regional Navgation Satellite System, Signal In Space ICD for Standar Positioning Service,” Indian Space Research Organization, Bangalore, India, 2017.

3. G. A.S., “Overview of GNSS and Indian navigation program,” ISRO Satellite Centre, Bangalore, 2012.

4. V. Guru Rao, G. Lachapelle and V. S.B., “Analysis of IRNSS over Indian Subcontinent,” in *ION ITM 2011*, San Diego, CA, 2011.