Integration of IRNSS on IAF Fighter Aircraft

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INTRODUCTION

Flying an aircraft from one point to another is the most important part for any kind of mission. It assumes even greater importance when fighter aircraft use this navigational data for accurate navigation to the target area, target identification and subsequently for targeting with lethal weapons.

Almost all fighter aircraft use IN-SNS (Inertial Navigation System—Satellite Navigation System) as a primary onboard navigational aid. The accuracy of the system depends on accurate update from SNS. Assured services and desired accuracy are at the behest of owner country's policies which may not always align with our own. This is the most probable reason for all competent nations to develop their own SNS.

India too has its very own SNS known as IRNSS (Indian Regional Navigation Satellite System). The system is fully operational providing coverage over the Indian subcontinent. The integration of IRNSS on fighter aircraft and other weapon systems will nullify dependency on foreign SNS. IRNSS being

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an indigenous navigation system designed specifically to give coverage over Indian subcontinent will be more accurate and receivers so designed would be more resistant to jamming. It would not only improve the accuracy of our nav systems but also make them more robust.

IN-SNS NAV SYSTEMS

Inertial Navigation System. INS is a self-contained nav system which determines the position and orientation of an object relative to a known starting point, orientation and velocity. For this it processes the signals provided by three octagonal accelerometers and three octagonal rate-gyroscopes. It doesn't require any input from external source and hence the system is jam free and available over any part of the world. However, the system suffers from integration drift. Small errors in measurements of acceleration are integrated into progressively large errors in velocity which are further integrated into still greater errors in position. Since, the new position is calculated from the previously calculated position, these errors accumulate proportional to the time from initial position input. The error experienced by even the most sophisticated INS is of the order of 1 Nautical mile/hour. The error is overcome by taking regular updates from other nav systems with Satellite Navigation System (SNS) being the most preferred due to its availability even at remote places. Hence, the name IN-SNS which has now become the main navigation system onboard fighter aircraft.

Satellite Navigation System. SNS uses satellites to provide autonomous geospatial positioning. It allows small electronic receivers to determine their location using time signals transmitted along a line of sight by radio signals from satellites. The services provided are collectively known as Positioning, Navigation and Timing (PNT). An SNS system with global coverage is called Global Navigation Satellite System. Presently, the United States'

Global Positioning System (GPS), Russia's Global Navigation Satellite System (GLONASS), China's BeiDou Navigation Satellite System and the European Union's Galileo are fully operational GNSSs. Of these, GPS is widely used for civilian as well as military use. GPS is also used as the primary SNS to update the INS and hence IN-GPS is the preferred mode for using IN-SNS nav system.

USE OF IN-SNS FOR STRIKE MISSIONS

Navigation. Accurate navigation is the first and the central objective of any strike mission. The planned route is fed to the mission computer before the launch of mission. During mission, it is the interface between IN-SNS and mission computer which ensures accurate navigation. Therefore, accurate navigation is the direct result of onboard IN-SNS navigational system.

Target Acquisition. Timely and precise target acquisition forms the basis for every successful strike mission and accurate weapon delivery. The target coordinates are fed into the Mission Planning System during planning phase of strike mission. During flight, the mission computer takes input from IN-SNS to display own location and determines relative position of the target which is also displayed for pilot's interpretation. The display is also duplicated on the Head Up Display where a cross-hair appears indicating the expected position of the target on ground. Pilot utilises this input from the onboard nav system to visually acquire the target.

Weapon Solution. In Air-to-Ground strike missions, the mission computer requires two critical inputs, namely, forward throw of own weapon and range to the target. Forward throw which depends on own aircraft flight parameters is computed instantaneously by the mission computer. Accurate range to the target could be obtained by use of Laser Ranging or Nav Ranging.

- **Laser Ranging.** Laser ranging is obtained either with LRF (Laser Range Finder) inbuilt on the aircraft or LDP (Laser

Designation Pod) carried externally by the aircraft. LRF has limited FOV and range which restricts its effective utilisation only in dive attacks. LDP on the other hand has wider FOV and longer ranges which allows it to be utilised even in level attacks at varying altitudes. Since the LDP is caried externally, the flight envelope of the aircraft is adversely affected which imposes speed, G and AoA limits. Additional restrictions are imposed in terms of number of weapons being carried. It therefore affects conduct of air operations to an appreciable extent.

- **Nav Ranging.** Nav ranging is calculated by the mission computer after taking input of its own position obtained from IN-SNS and then calculating the range to the target coordinates. Weapon solution in this method is achieved when the forward throw and the range to the target determined by mission computer equals. The accuracy of this method of bombing apart from flying accuracy and smoothness depends upon accurately determining own position by onboard nav system.

INS onboard modern aircraft have matured to their best ability; therefore, the accuracy now solely depends on the kind of update available to such systems from SNS. Accurate the update from SNS, accurate is the position determined by the nav system. Accurate the position, accurate is the range computed by the mission computer and hence, accurate is the bombing.

It is also important to note that this method of bombing doesn't impose any limitations on flight or weapon delivery envelope. And, therefore could be employed in any mode of attack from any altitude. Moreover, any aircraft which doesn't have its inbuilt LRF or unable to carry LDP will be able to execute this method as long as it has onboard nav system and mission computer. Therefore,

this method of bombing gives maximum flexibility to planners as well as executioners.

AIR OPERATIONS USING IN-GPS

GPS has grown into global utility with multi-use services integral to security, economic growth, transportation safety and are an essential element of the worldwide economic infrastructure. GPS provides two types of services. The Precision Positioning Service (PPS) is available primarily to the military of the United States and its allies for users properly equipped with PPS receivers. The Standard Positioning Service (SPS) provides civilian users with less accurate positioning capability than PPS, through a technique known as Selective Availability (SA).[1] In May 2000, at the direction of President Bill Clinton, the US government ended its use of Selective Availability in order to make GPS more responsive to civil and commercial users worldwide.[2]

However, the age-old proven maxim "In international relations, there are no permanent friends or no perennial enemies; only permanent national interests" keeps everyone cautious of other nation's actions. The same belief is cemented by the very fact that the allies and non-allies of the US alike have embarked on the costly affair of developing their own GNSS.

Availability of GPS Services. It may not be prudent to assume non-degraded availability of GPS services during the times of crisis and war. The interests of owner country may not

1. Department of Navy, United States of America, "GPS INFO", at https://www.cnmoc.usff.navy.mil/Our-Commands/United-States-Naval-Observatory/Precise-Time-Department/Global-Positioning-System/Global-Positioning-System-Overview/. Accessed on October 2, 2022.
2. Official US government information about the Global Positioning System (GPS) and related topics, "Selective Availability", at https://www.gps.gov/systems/gps/modernization/sa/. Accessed on October 2, 2022.

align with our own interests due to varied reasons in an ever-changing geopolitical situation both at domestic and world stage. Uninterrupted and uncompromised GPS services should not be taken for granted. Therefore, one must look for alternate SNS which guarantees services to support our cause.

Lack of Clarity. There is lack of clarity amongst the operators about the kind of positioning services being provided by GPS for undertaking air operations. Also, the reliability with which these services will be available during times of crisis and war is not certain for planners and executioners. Better awareness in the environment would go a long way in putting these doubts to rest and boosting confidence of operators in the warfighting systems.

GPS Jamming. GPS receivers are susceptible to jamming by GPS jammers. Recent proliferation of cheap jammers should be treated with concern. These GPS jammers may not be effective to affect accurate navigation but certainly can play a decisive role during targeting phase of the mission. Effect of GPS jammers on conduct of air operations should be taken into account while training ourselves. Even the USAF has undertaken several air exercises in GPS denied environment.[3] Therefore, there is a need to conduct regular exercises simulating non-availability of SNS services.

Jamming Resistant. User country doesn't have adequate insight into the exact working of a foreign SNS and therefore, may not be able to develop jam resistant receivers. The limitation is overcome if we have adequate insight which is possible for only an indigenous SNS. Intimate insight provides for developing jam resistant receivers allowing uncompromised use of SNS services for conduct of air operations.

3. Giancarlo Casem, "Fest tests Air Force systems in GPS-denied environment", *Air Force Material Command*, December 10, 2019, at https://www.afmc.af.mil/News/Article-Display/Article/2037323/fest-tests-air-force-systems-in-gps-denied-environment/. Accessed on July 22, 2022.

IRNSS

The Indian Regional Navigation Satellite System (IRNSS), with an operational name of NavIC (acronym for Navigation with Indian Constellation), is an autonomous regional satellite navigation system. It is designed to provide position, navigation and timing services same as GPS over Indian subcontinent extending up to 1,500 km around Indian mainland as primary service area. Secondary service area extends further till 30 deg South to 50 deg North and Longitude 30 deg East to 130 deg East. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users.[4]

Adequacy of IRNSS. Keeping in mind the present security challenges and no expeditionary ambitions of India, the primary service area of IRNSS would be adequate for undertaking all air operations. Even if we consider the extended maritime area of interest of India, the coverage provided by IRNSS would meet the desired requirements.

IAF regularly participates in international exercises wherein aircraft are required to operate from friendly foreign nations. Due to their geographic location, they are likely to be beyond the coverage area of IRNSS. However, one must make a note that it would be only exercises and not actual wartime air operations. Also, during such exercises the current option of using foreign SNS remains viable. Therefore, it could be concluded that even with present coverage limitations of IRNSS, all the SNS service requirements of IAF would be met.

4. Government of India, Department of Space, Indian Space Research Organisation, U R Rao Satellite Centre, "IRNSS—Indian Regional Navigational Satellite System", at https://www.ursc.gov.in/navigation/irnss.jsp. Accessed on May 1, 2022.

Integration of IRNSS. Mobile chipset manufacturers like Qualcomm, MediaTek and Broadcom support NavIC across various chipset platforms. Qualcomm announced several mobile platforms which come equipped with NavIC. With the government pushing for embedding support for home-grown navigation in made-in-India smartphones, some smartphones from Xiaomi, Realme, Oppo, Vivo, and OnePlus, with NavIC support, are already available in the Indian market.[5] This goes to show that the integration of IRNSS receivers and further usage by mission computer onboard fighter aircraft is a possibility which must be explored. Suggested approach would be to identify fleets with long residual life. Then undertake modification on trial bases on some aircraft of this fleet to integrate IRNSS. Subsequently, all aircraft of the fleet could be modified in most suited manner.

All the limitations on IAF fighter aircraft discussed so far are equally applicable to other IAF aircraft and weapon systems which rely on foreign SNS. Therefore, it would be logical to undertake such modification on other IAF aircraft and weapon systems. Also, all future inductions must be mandated to be compatible with IRNSS.

Advantages of IRNSS. There are definite advantages that will accrue with the integration of IRNSS on IAF fighter aircraft. These are listed as follows:

- **Assured Availability.** IRNSS will be under complete control of the Government of India. This ensures access to the Restricted Service of IRNSS with improved accuracy being available for undertaking all types of air operations. It will also instil confidence in operators during planning and execution phase.

5. Nidhi Singhal, "22 million NavIC-supported smartphones shipped in India between Jan 21-June 2022", *BusinessToday.In*, at https://www.businesstoday.in/technology/story/exclusive-22-million-navic-supported-smartphones-shipped-in-india-between-jan-21-june-2022-348298-2022-09-27. Accessed on October 1, 2022.

- **Better Suited for Mountainous Terrain.** GPS satellites revolve in Semi-Geosynchronous orbit. The orbit is at an approx. height of 20,000 km (Medium Earth Orbit).[6] For IRNSS, three satellites revolve in Geostationary orbit and remaining four revolve in Geosynchronous orbit, all orbiting at a height of 35,000 km approx. (High Earth Orbit).[7] Although GPS has a greater number of satellites, it is more prone to blocking of signals by high mountains and peaks, especially on the horizon. This is due to the placement of GPS constellation in relatively lower earth orbit. IRNSS satellites are not subject to this constraint and the signals can be obtained even in steep valleys. Therefore, IRNSS would be better suited for undertaking air operations in mountainous terrain.
- **Improved Accuracy.** The orbital path of IRNSS has been specifically designed to provide SNS services over Indian subcontinent and therefore, expected to give better accuracy than GPS. Additionally, the military use IRNSS receivers would be equipped to receive signals on two different frequencies which would overcome propagational error inherent in any SNS.
- **Resistant to Jamming.** IRNSS being the indigenous SNS, India would have precise insight into its operations. Therefore, military use IRNSS receivers could be designed so as to be more resistant to jamming as compared to receivers of foreign SNS.
- **Promoting "Self-Reliant India".** Government of India has launched the "Self-reliant India" initiative which has been well accepted by the entire nation. Successful integration and exploitation of IRNSS by IAF would definitely give fillip to the initiative. This lead by IAF fighter aircraft could further

6. Department of Navy, United States of America, n. 1.
7. Government of India, Department of Space, Indian Space Research Organisation, U R Rao Satellite Centre, n. 4.

be followed by all IAF aircraft and eventually a mandatory requirement for all weapon systems of IAF.

CONCLUSION

IN-SNS has become the primary onboard navigation system being used by the modern fighter aircraft. The system is also used for target acquisition and achieving weapon solution. Needless to say, the accuracy of such targeting would directly depend on the accuracy and reliability of uncompromised functioning of the system.

All the competent nations of the world have embarked on developing their own Satellite Navigation System. This is primarily because access to foreign government controlled SNS is not guaranteed in hostile situation in pursuit of own nations' objectives. India too has developed its own indigenous IRNSS providing coverage over and beyond the area of interest of Indian armed forces. The integration of IRNSS on IAF fighter aircraft and other weapon systems would ensure assured SNS services with improved accuracy along with giving impetus to achieving self-reliance in defence.