Integration and Testing of Ku Band SAR on Dornier DO- 228 Aircraft

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Abstract:

This paper discusses the integration of various sub-systems of SAR on the rack and installation of the same inside the aircraft and Antenna Stabilization Unit with antenna as payload under the belly of the aircraft. Various subsystems include Transmitter, Exciter-Receiver, Digital Unit, INS/GPS, Radar Operating Box (ROB), Display, Data Recorder, Ethernet switch, and optimized cable routing with minimum loss among various sub-systems inside and outside the aircraft. After integrating the radar on board, ground checks are performed for smooth functioning of the radar. After successful integration, radar is cleared on ground for its performance before each sortie. Ground testing includes checking of radar in transmission, reception, processing of internally simulated target data for imaging and GMTI modes, data recording and INS alignment.

***Keywords** : GMTI, SAR, INS/GPS, ROB*

I. INTRODUCTION

Synthetic Aperture Radar (SAR) is all-weather, day-night microwave imaging system. It works as Imaging as well as GMTI Radar. It consists of subsystems mainly Antenna Assembly consisting of Circulators, Antenna, RF Front Ends, ASU, Transmitter Unit, Exciter- Receiver Unit consisting of Wideband Waveform Generation Module, LO Generation Module, Up Convertor Module and Wideband Receiver Module, Digital Unit consisting of Radar Controller CSCI, Signal Processor CSCI, Radar Timing IO, Human Machine Interface (HMI) for Radar Operation Control and Display of results/health of each subsystem, Inertial Navigation System (INS) for getting platform related information to perform motion compensation on radar data, Data Recorder for recording of Raw data and results for further Analysis and lastly a Radar Operating Box (ROB) that powers On various sub-system of SAR on board the FTB. SAR for UAV system being realized is currently undergoing testing and evaluation on Dornier flying test bed for proving the technology of SAR and the associated radar performance specifications.

II. SUBSYSTEMS OF SAR

SAR produces images in Stripmap mode and Spot mode and ground moving targets' detection reports in GMTI mode. SAR consists of subsystems such as Antenna Assembly (Antenna and Antenna Stabilization Unit), Transmitter, Exciter Receiver Unit (ERU), Digital Unit (DU), Ethernet Switch, Data Recorder, Navigation Unit, Radar Operating Box (ROB) & Display. Antenna transmits the amplified Ku band signal into space with specific directivity and gain. It also receives back the return signal with gain. Ku band circulator is used to isolate the transmit and receive signals. The received signal is given to RF Font Ends for low noise amplification and filtering and then given to the receiver section of ERU. Antenna Stabilization unit with a mechanical scanned antenna positions the antenna in air based on the commands given by the Radar Controller (RC) of SAR. ASU also scans the antenna with the required scan rate and within the required sector on command from RC. Transmitter employs a Travelling Wave Tube (TWT) as final power amplifier and it delivers a peak RF power of 300W at a maximum duty cycle of 30%. The RF exciter is capable of generating a wide instantaneous bandwidth of 400 MHz required to achieve the high resolution. The receiver unit is a two-channel system based on super-heterodyne configuration. Digital unit is the processing element of SAR and down converts radar returns for processing in digital domain. Ethernet Switch has 12 Gigabit Ethernet ports with a full wire speed switching capacity of up to 37 Mbps and it offers all configuration and supervision services for switching component management. Data Recorder is High Speed Data Recording Unit to record all the necessary data when the system is in operation and retrieve the data for analysis in the lab. Navigation Unit senses the platform parameters in terms of Latitude, Longitude, Altitude and Roll, Pitch, Yaw. Radar Operating Box (ROB) is an operating panel (acts as CB panel) and provides power to various LRU's of SAR. HMI is GUI based software and used as the interface between the user and SAR. The various of LRUs comprising the SAR radar is shown in figure 1.

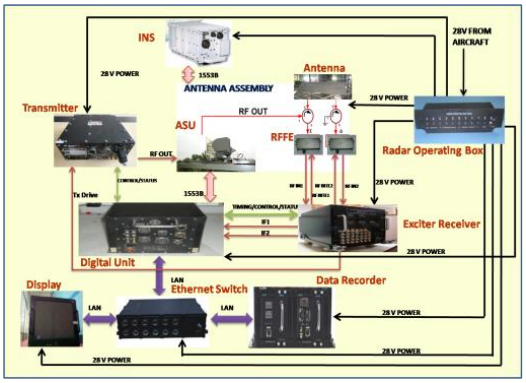

Figure 1. Various sub-systems of Ku Band

III. HARDWARE INTEGRATION & TESTING

1. Integration & Testing at Lab

SAR integration at lab comprises of establishing interconnection between the different radar subsystems and check signal and message level interfaces between all sub-systems using the human machine interface (HMI- GUI) software in the maintenance mode. P-Bit checking is initially performed to check the healthiness of various LRUs after Power On. The SAR subsystems interact with one another to fulfil the intended functionality through various interfaces. The interface diagram is shown in figure 2.

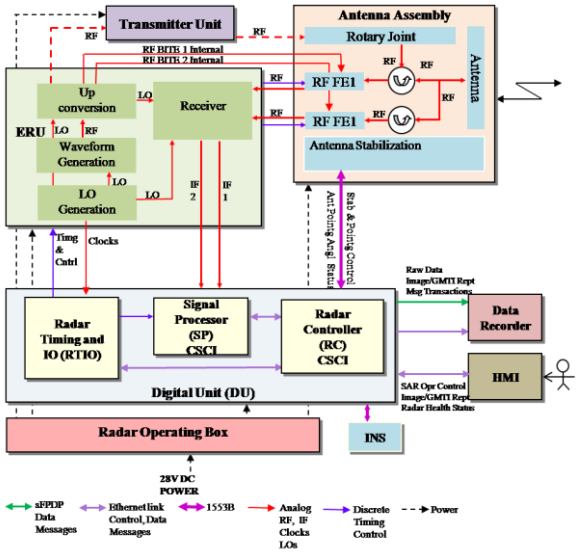

Figure 2. SAR Interface Diagram

After integrating the radar and checking the signal, message and data level interfaces, SAR is cleared for its operation in various modes by testing the radar functionality in different operational states as per the mission requirements. Power On Test, Transmit Path and Receive Path Power level Check, Transmission Test & GMTI Mode Operational test has been carried out.

2. Integration & Testing on FTB

Dornier-228(202,K series) aircraft is used as Flying Test Bed (FTB) to carry out SAR evaluation trials. This section brings out the details of the mechanical installation of SAR system on FTB. The SAR system on FTB mainly comprises of Electronic Subsystems Rack housing all the radar LRUs mentioned in the above section. The overall layout of the SAR system on FTB is shown in figure 3. Installation of SAR System in FTB includes activities related to installation of Antenna Assembly, installation of LRU Rack, installation of Transmitter and installation of INS/GPS.

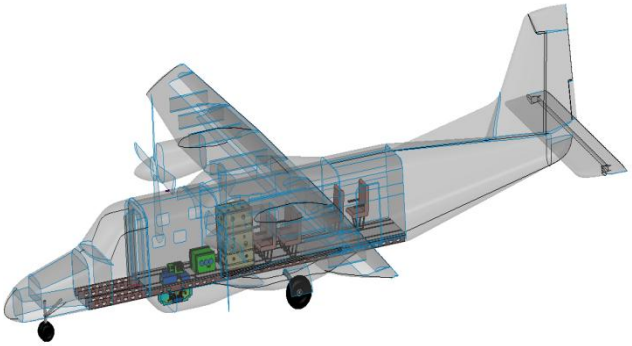

Figure 3. Layout of SAR on FTB

The Antenna Stabilization Unit along with antenna as the payload is fitted under the belly of the aircraft. The antenna assembly installation is protected by a Radome of Nomex honeycomb construction. Radar antenna centreline is aligned parallel to the a/c centre line to get correct bearing of the targets. Radar antenna will be directly mounted over aircraft structure. The aircraft seat rails are jig located. Reference is taken from seat rails to locate antenna mounting bracket assembly. This is achieved by using a specially made mounting fixture on the seat rails. The fixture is used to locate the antenna mounting bracket assembly. All the radar electronic subsystems, except transmitter, are fitted inside a customized LRU rack. Rack is installed on the LH side in the cabin. Bottom of the Rack is mounted at six places on seat rails with the help of standard pegs and retainer locking mechanisms and top of the Rack is attached at two places with the side wall of aircraft fuselage. The provision of top attachment of Rack with aircraft structure is at two points. A beam structure is provided between selected frames. Rack is attached at two places by using machined brackets. The machined brackets are attached to the beam structure through M8 bolts at each place. The designed rack is shown in figure 4.

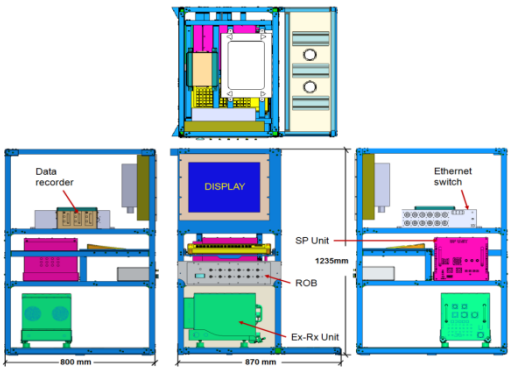

Figure 4 Design of SAR Rack in FTB

The installed rack consists of three decks carrying display on top deck on front side and Data recorder & Ethernet on rear side. Middle deck contains Signal Processing unit and ROB. The bottom compartment is occupied by Exciter-Receiver unit. A break panel mounted on the rear of the rack interfaces the power and radar signals. Figure 5 shows the rack installed on the seat rails of the aircraft and the cables are taken out from the break panel. Cable length is optimized for minimum loss while interconnecting various sub-systems both inside and outside the aircraft. After integrating the radar on Dornier aircraft, proper ground checks are performed for smooth functioning of the radar.

Figure 5 Installation of SAR Rack in FTB

Before the initiation of each sortie, radar is successfully integrated and cleared on ground for its performance. Ground testing includes powering 'ON' of the radar using ROB and checking the P-BIT health status of all LRUs.

INS is then aligned & initialized using GPS co-ordinates. It is then configured to 'Navigation' mode. The three functional tests used to clear the SAR system on ground before flight are checking of radar in transmission, reception, processing of internally simulated target data for imaging and GMTI mode data recording.

IV. TEST REULTS

After installation of the radar on FTB, the following checks were carried out on the radar system. The radar was switched on using the ROB and the LED status on ROB was checked. The health status of the various LRUs was checked on the HMI. After configuring INS to 'NAV' mode, the correctness of display of the INS parameters mainly latitude, longitude and altitude were cross verified using a hand-held GPS. The display of the homing position of scanner (ASU at 90° to the longitudinal axis of the aircraft) was checked on the HMI. The status of transmitter (Default – in standby state) along with the centre frequency of transmitted waveform and bandwidth were checked for correctness as they were displayed on HMI. Recording of data in data recorder was ensured by checking the status of data recorder on display. The functional checks carried out on the radar along with the results and observation is shown in Table 1. Figure 6 is a sample screenshot of the HMI display indicating the health status of the subsystems. Radar status is displayed in the status bar of the operational main screen. Figure 7 is the screen shot of the HMI display showing GMTI target detection report in the internal injection mode.

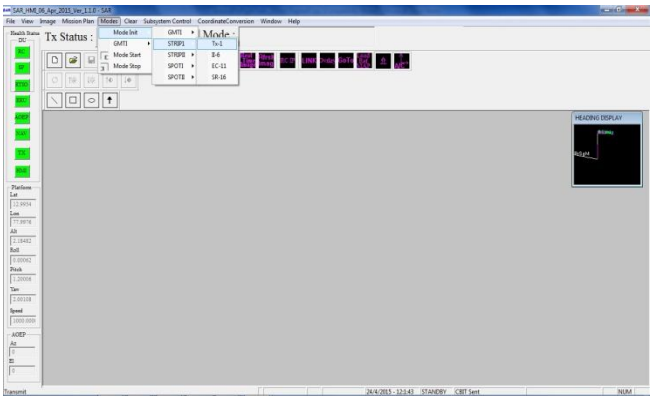

Figure 6 SAR HMI Operational Main Screen Installation

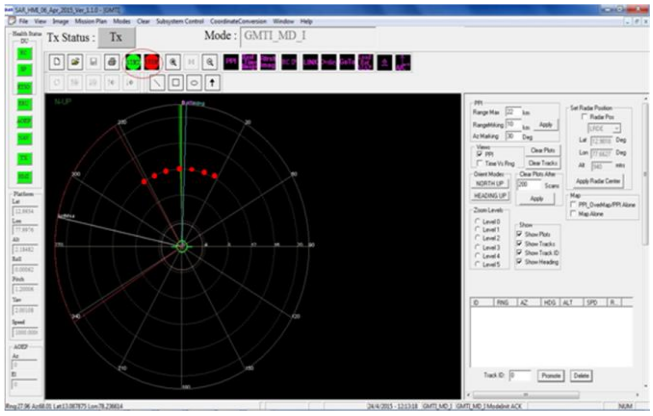

Figure 7 SAR HMI Display showing GMTI Target Detection

SNo	Test Parameter	Result
1	Display of PBIT status at GES	**All bit status indicators on display shown green**
2	Display of Radar Standby state at GES	**Radar status displayed as 'STANDBY' on HMI display**
3	Display of INS Parameters at GES Aircraft parked at CABS Hangar	INS parameters by hand held GPS Lat : **12.94°** Long: **77.66°** Alt: **817m** INS parameters at GES display Lat : **12.9479°** Long: **77.6634°** Alt: **818m**
4	Display of scanner homing position	Commanded Homing Position: Az: **0 °** El : **15°** Scanner parameters at GES display: Az: **0 °** El : **14.99 °**
5	Transmission test (Strip map mode I)	Centre Frequency: **Ku Band**; Bandwidth: **40 MHz**
	Centre Frequency Ku Band; Bandwidth of 40 MHz	
6	Subsystem Health Status	**Status buttons turned green on Display implying all status ok**
7	Targets on GES Display (BITE Injection in GMTI Mode)	BITE injection range : **12 Km** Tgt range observed at display: **12.11Km**
8	Target Strength	IFOUT Monitor : **-34dBm**
9	Data Recording and Retrieval	File name : **EDET0001** File size :**3472 MB** Date :**04-11-2015** Time: **9.00 hrs 10 mins**

Table 1 Ground Check Results of SAR on FTB

V. CONCLUSION

All the subsystems have been successfully integrated in an optimized way for its location inside the rack as well as cable lengths between them on FTB. After integration on board, the entire system has been checked thoroughly on ground for its functional performance as brought out in the table above. The entire system has been flown successfully and good SAR images have been obtained.

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