I^2R's Research Activities on Communication and Radar for Aviation Applications

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The mission of Satellite, Aviation and Maritime (SAM) Division of I^2R is to develop translational research capabilities and cutting edge technologies on communication, navigation and remote sensing for satellite, aviation and maritime sectors. In this presentation, our research activities on communication and radar for aviation applications are introduced, which include the following two main topics:

1. Space-based VHF communication system for air traffic management

Very High Frequency (VHF) communication is the primary form of communications in aviation between pilots and Air Traffic Control Officers (ATCOs) due to its lower cost (no usage charges for airlines), quick call establishment time, reliability and good voice quality. However, the current ground-based VHF communications are limited by range and line-of-sight. Space-based VHF communications, by relaying the voice/data signal via satellites, will expand the range of communications between ATCOs and pilots, enabling better voice coverage within Singapore's Flight Information Region (FIR), without requiring new avionics. Unfortunately, routing the VHF signal through space presents its own unique technical challenges: (i) the scintillation effects of ionosphere on the audio quality of VHF voice communication signals; (ii) the Doppler offset effects due to the motion of satellite on the demodulation of VHF communication signals. This project aims to (i) perform the scintillation phenomenon study and develop the signal processing techniques to solve these technical challenges, (ii) produce the design of satellite payload suitable for technology demonstration of space-based VHF communication in a cost-effective manner, and (iii) conduct co-existence study to ensure compatibility of space-based VHF with existing primary services in band and in adjacent frequency bands as defined in ITU Radio Regulations. The outcomes of this project will lead to the future in-orbit technology demonstration of space-based VHF communication, which could potentially enhance the efficiency and capacity of air traffic control as well as the safety of airspace users.

2. Landing runway detection with millimeter-wave radar sensor

Air transportation is one of the fast growing industries in both Asia-Pacific region and the world. A problem facing in civil aviation industry is the aircraft's landings in poor visibility conditions. Today's existing solutions for landings with poor Runway Visible Range (RVR <

2400 ft) are based on complex and expensive ground infrastructures (e.g., ILS CAT II and CAT III), that limits their implementations solely in some main airports, thus forcing secondary airports to close when visibility becomes too weak. For years, regulatory organizations (e.g., Federal Aviation Administration of US, and European Aviation Safety Agency) are pushing for airborne autonomous solutions allowing Equivalent Visual Operations for aircrafts based on Enhanced Vision System (EVS) or Synthetic Vision System (SVS). EVS based technologies today rely mainly on infrared sensors but their performances are still weather-dependent and not enough efficient to allow operations in all weather conditions, particularly in presence of rain/fog which represent the operational scenario where instrument landing is more useful. Moreover, replacement of incandescent runway lights by LED lights for power consumption reasons reduces the efficiency of infrared sensors. SVS based solutions rely on GNSS positioning and databases accuracies, that don't allow near to the ground operations without visibility. Thus, there's a real need to develop a novel airborne autonomous solution, more specifically, a novel runway detection sensor which is not weather dependent and thus allowing zero visibility operations for aircraft auto-landing. Millimetre-wave radar sensors, which are much less dependent on weather conditions, have been widely used in many industry applications such as autonomous driving (detecting vehicles and other road users), coastal surveillance (detecting surface vessels), and air surveillance (detecting drones). It has the potential for runway detection, however, there are still many technical challenges to be solved. In this project we aim to develop a solution based on millimetre-wave radar sensor with far less weather dependency than the current EVS and better accuracy than the current SVS. Based on the experimental data collected by project sponsor Thales in flight trials, innovative algorithms are investigated to detect the runway from millimetre-wave radar data and estimate the aircraft position/attitude relative to the runway. Potentially it will give aircrafts the capability to land in any weather conditions without the supports from ground infrastructures. It will help traffic densification by avoiding aircraft re-routing, or aircraft go-around maneuvers, hence generating savings for Airlines, limiting delays for airlines' passengers and reducing flights environmental impact.