

# Multi-Band (Ku, C, Wideband - Satcom, Narrowband Satcom) Telemetry Test System for UAV Application

Murat IMAY

Turkish Aerospace Ind, Inc. Ankara, Turkey  
[mimay@tai.com.tr](mailto:mimay@tai.com.tr), [muratimay@gmail.com](mailto:muratimay@gmail.com)

## ABSTRACT

"This paper describes the design, development, production of fully autonomous UAV data link test system. The ethernet based data link systems consist of Ku-Band, C-Band, Wideband-Satcom and Narrow-Band Satcom. Ground control station and all airborne hardware systems with simulation, monitoring capability that are be integrated into these telemetry test systems. Integration of GCS, Airborne hardware system and network based telemetry system with handover capability of UAV aircraft are also included in this paper.

These test system allows to user to simulate auto adjustable data link range with real data link equipment. Test automation software and auto adjustable data link range system are used to control the execution of tests and the comparison of actual outcomes with predicted outcomes.

**Key words:** UAV, Telemetry, Flight/Ground Test, Handover, LOS/BLOS.

## INTRODUCTION of TAI UAV

Unmanned aerial vehicles (UAV) has been design and developed by Turkish Aerospace Industries to meet for customer requirements. Advanced Medium Altitude Long Endurance (MALE) class Unmanned Aerial System performs day and night, all-weather reconnaissance, target detection / identification and intelligence missions with its payloads, featuring autonomous flight capability including Automatic Take-off and Landing.

The platform is also equipped with a digital flight control system, electro-mechanical actuators, and flight control sensor systems such as GPS, pitot-static, air data computer, navigation sensor, transducers, temperature, pressure, displacement sensors, etc. Various tasks are distributed along flight management computers and auxiliary control boxes. All flight critical equipment is dual or triple redundant and emergency modes of operational scenarios are taken into consideration for fail safe design.



*Fig. 1 Command and Control*

UAV operations are supported by highly sophisticated ground control system with complete redundancy, developed by TAI. Whole mission segments of the air vehicle can be managed, monitored and controlled by a GCS. A pre-programmed mission plan can be loaded before the flight begins or can be altered during the flight. All the imagery stream of the payloads can be displayed and recorded in real time and

all the payloads can be controlled from the GCS.



*Fig. 2 UAV and CS Real/SIM System*

ATOLS allows the air vehicle to perform its operation without operator intervention, including the most critical phases which are landing and take-off.

TAI UAV has Radio Relay, electro-expulsive Ice Protection System, BLOS and LOS datalink with handover capability allowing operational security and ease.

### HANDOVER

Flight distance of TAI UAV is more than Control Station (CS) telemetry LOS range. There is boundary to how far UAV can be controlled from a CS due to loss of line of sight or distortion of the data link signal due to distance away the UAV is from the CS. Before this happens control of the CS should be handed over to another CS.

TAI UAV requires not just for local tasks Line Of Sight (LOS) to its Control Station (CS) but for long distance flights) Beyond Line Of Sight (BLOS) and for endurance station keeping duties. In both cases the UAV will need to be handed over to another CS. In the first case the UAV is in another CS closer to the area the UAV is to carry out its task. In the second case the UAV will be flying for many hours in which case the UAV is handed over to another CS at different location.



*Fig. 3 Handover BLOS Equipment Test System*

There are three types of Handover for this UAV project, the first between CSs when the UAV is to be flown out of range of what can be flown by CS1 so the H/O is to CS2. The second type of H/O is between two LOS (Ku/C Band Datalink) in the same CS avoid one LOS data link failure, all datalink system is connected with each other via network so that any of datalink system can be selected by CS. The last one is satellite (BLOS wide/narrow Satcom) handover.

Handover process of UAV from one CS to another, there are some sophisticated steps of handover. In handing over the UAV between the CSs there can be hazards and unexpected problem therefore safety risks associated with the hazards must be eliminated on ground test before flight test.

Several critical test phases will be executed in these integration system with the importance of modeling and simulation of CS/UAV for ground and flight test.

Handover of TAI UAV occurs over a communication radio. Handover plan is based on transfer of control between two CS by switching transmitters on or off.

- CS verify they are using the same frequency of communication.
- Both CS verify critical flight control commands are on the same settings
- Receiving CS report readiness to initiate the transfer.

- Commanding CS acknowledges and report readiness to relinquish control.
- Commanding CS places its backup data link transmitter to OFF, Receiving CS places its backup data link transmitter transmitter to ON.
- Commanding CS places its primary data link transmitter to OFF, Receiving CS places its primary data link transmitter transmitter to ON.
- Receiving CS executes some maneuver (wing rock, heading change, etc.) in order to verify control

If handover is not accomplished, the first CS may assume the transfer has failed and turn its transmitter back or autopilot gets the control of UAV and it starts return to home state.

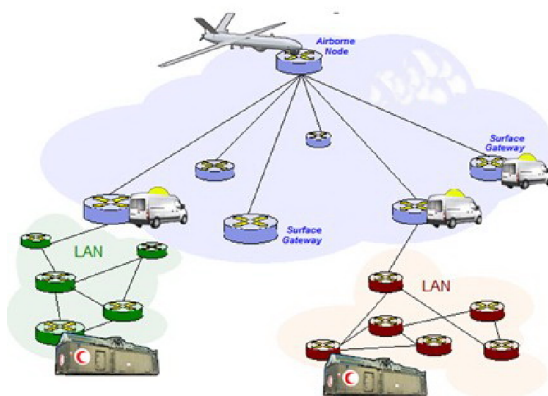
Aim of test for handover with real equipment is to identify the problems involved with the handover of a UAV between two control stations and provide mitigation to reduce the risk. In order to test all handover cases with real equipment, Architecture at Fig. 5 has been designed and produced. This system includes two air vehicle, 2 two ground station and two data link set, which are LOS and BLOS system. Simulation and monitoring system are also be included to simulate real environmental of flight.



Fig. 4 Handover LOS Equipment Test System

Using real RF equipment can be dangerous because of data link emitters in the test system environment due to hazards of electromagnetic radiation. A primary and back up data link for LOS(Ku-C)/BLOS(Wide-Narrow) are used in handover test system with attenuating the output power of RF equipment, connected air to ground via RF cable and monitoring the received signal strength. These test system provides the range and margin determined and also overturn event of a primary failure to secondary (or backup) data link. RF automatic attenuation equipment is used to simulate auto adjustable data link range with real data link equipment. Flight testing of range, loss of line of sight or distortion of the data link can be simulated with this equipment. Switching between real and simulation of LRU, data injection and equipment on/off is controlled by simulation system.

Handover test of different location of CS and same location is arranged by adjusting IP-based network domain setting.



This network for a large number of GCS can be achieved, that provides a wide range of network by using the LAN and air vehicle as the communication node. This also provides an efficient network solution to backup of CS in case of a damage on the communication infrastructure due to earthquake, flood and etc.



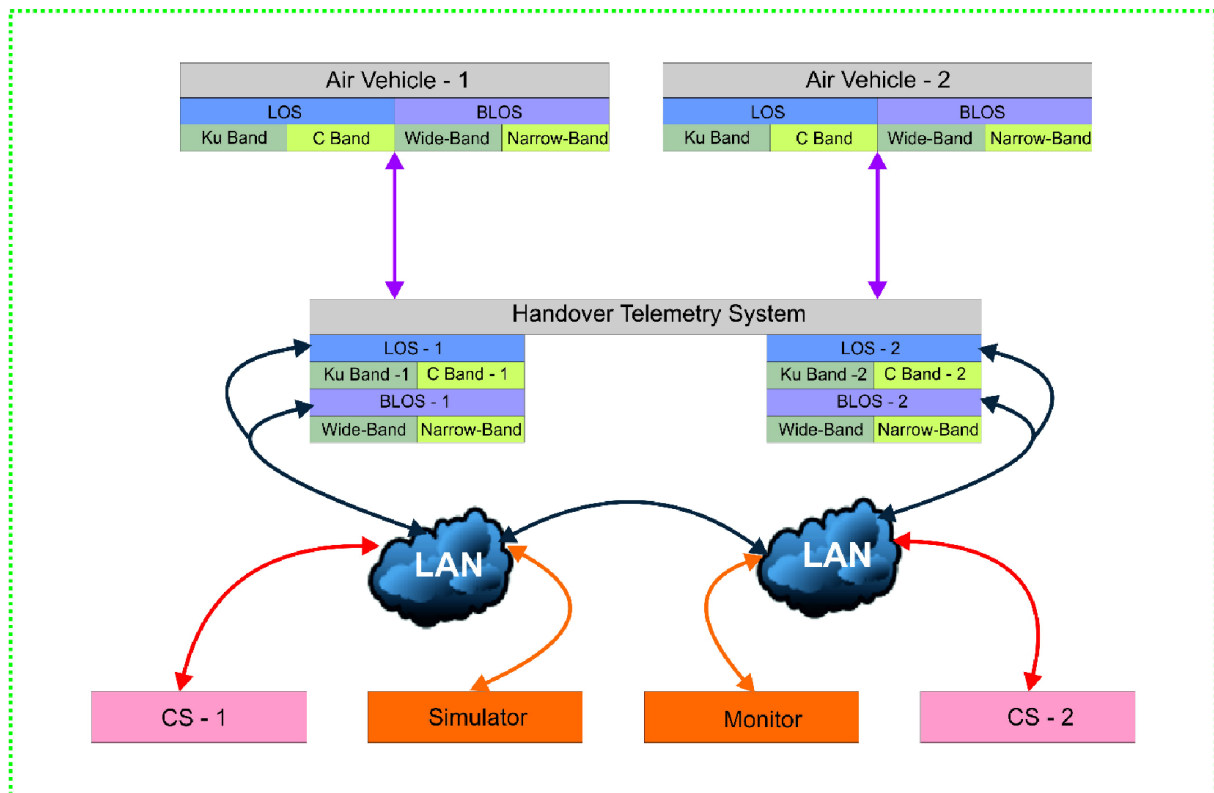


Fig. 5 Handover Architecture of TAI UAV

These test system allows us end-to-end integrated avionics and software integration, check-out, verification, and validation. This capability includes a Real-Time Environment for modeling of integration, simulation and relay interfaces system used for switching between simulation and real equipment.

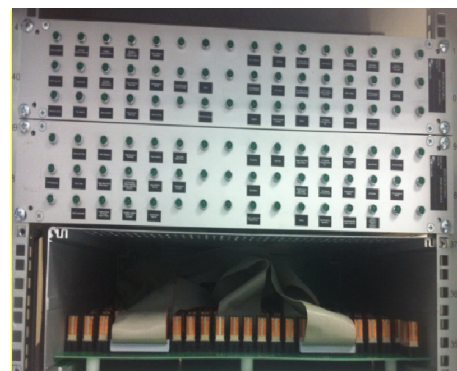


Fig. 6 Relay Panel of Handover System

Test of integration RF equipment with two CS and two air platform for handover is essential not only to reduce the risk of crash, but also to ensure that the system is technically ready for the flight testing.

These test system also allows us to understand behavior of LRU such as GPS navigation, air data computers, navigation computers, mission computers, and/or flight control computers.

This approach, using real/simulation equipment, has led to numerous advances in cost, reliability, and integration time savings. On the other hand, this approach comes with difficult problems when trying to verify functionality of RF system and UAV without flight test campaign. Because many of the functions requiring testing and

verification during flight test. Without flight all environmental must be simulated by simulation and real equipment at the same time. These test system allows to inject all of the necessity data and reading all of them to comparison of actual outcomes with predicted outcomes. It also decreases the time and effort required to find out and fix problems by allowing isolation to the message including the error.

### **TEST AUTOMATION SOFTWARE**

Special Test Automation Software has been designed and developed by TAI for execution automatically all test scenario. This software manages all real equipment and simulator for handover and also changing of RF signal strength during transmission for flight simulation of UAV. Automatic test software provides to increase the test case probability and reduce test engineer level tasking of TAI UAV project. Test engineer executes and monitors tests scenarios with this software, and provides data archiving for retrieval and analyses. This software electronically checks for air vehicle response corresponding to simulated or real data initiated at the CS/RF data link system. In some cases of UAV test can be needed inter-active test in order to simulate real environmental. The goal of automatic test software is successfully diagnosing all failure modes associated with the subsystems. In order to determine response and diagnose of whole system, these software allows inject any point of test flow numerous faults.

### **SUMMARY**

Autonomous UAV data link test system, ground control station, airborne hardware systems with simulation, monitoring, handover capability of TAI UAV are mentioned in this paper. Performing hardware/software integration, architecture of handover and related issue are identified, and associated with handover test design of UAV is also presented.

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