

UAV-Based Flight Inspection System

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BIOGRAPHY

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ABSTRACT

Unmanned Aerial Vehicle (UAV) is being developed into a new era, with more load capability, longer cruising range (hours), but less cost. It is an ideal air-based platform to install compact airborne system and perform special missions, such as flight inspection of nav aids. With the unique features of cost-effective, lower airport criteria, fast modification, modular deployment and etc., the UAV-Based Flight Inspection System (UFIS) is a good option to achieve routine inspection work in the general aviation airports or work as the supplement of conventional flight inspection aircraft.

This paper presents a UFIS prototype installed on a fixed-wing UAV. This prototype contains flight inspection sensor, airborne processing unit, air-ground data link unit, positioning module, antennas and the control unit. On the ground, the supporting platform contains an RTK station, a data link unit, a flight inspection processing unit and a UAV tracking, a telemetering and command (TT&C) vehicle. A series of demonstration flights will be completed in China by this year, which will be promising to validate the feasibility of UFIS concept and the performance of UFIS to inspect ILS, VOR, DME etc.

INTRODUCTION

China's aviation industry has been steadily growing at a solid pace, as new airports been built and opened. China's flight inspection industry, as a result, facing increasing mission requests with limited operational capacity. At the same time, UAV platforms in China are developing in all aspects, ranging from commercial UAVs to industrial UAVs. UAVs are capable of lowering the cost of flight inspection missions, provide higher safety threshold value, and numerous other engineering and modification convenience.

Fixed-wing industrial UAVs normally have an average of 10-20 hours of airborne endurance, and load capacity ranging from 50 to 150 kg, and cruising airspeed at 120-150 km per hour. The fixed-wing UAV platforms we selected for UFIS are tested in real flight missions and accumulated considerably long flight hours, proven capable of operating flight inspection missions in general and civil airports within proper supervision, as our research and investigation indicate.

However, the transformation from manned flight inspection system to a UAV platform requires vast modification in current airborne avionics, downing-sizing, tighter antenna layout, and challenges in data links and TT&C ground stations. In our UAV-Based Flight Inspection System (UFIS), steps are taken to tackle those challenges.

UAV-BASED FLIGHT INSPECTION SYSTEM LAYOUT

UFIS system contains 5 major sub-systems, UAV platform, ground station and TT&C, data link and ground surveillance center, as shown in *Fig.1*. Apart from major sub-systems, efforts are made to ensure operation safety as well as management under certain regulations, providing feasibility and sustainability in the long run.

UAV platform includes antennae, acquisition system, reference RTK, and video camera, all installed onto the UAV, fitting the requirement of the load capacity and aerodynamics. Ground station includes TT&C and inspection platform (measurement and control), where inspection operator and pilots are positioned. It is obvious that as they are physically separated from the

airborne platform, a robust data link which combines flight control and inspection mission control is required as a must. Typical UAV data link contains limited data bandwidth, where on the UFIS, it is modified to a higher bandwidth and performs flight and inspection data uplink and downlink with premium real-time capability. UFIS is not only a UAV platform with avionics mounted on but also to meet the safety requirements of operating in civil airports and other complex environments. Ground surveillance sub-system is designed to meet those needs, containing 3D terrain displaying, SSR and ADS-B, ground communication and scene surveillance, where on-ground personnel, vehicles' positions can be monitored in real-time.

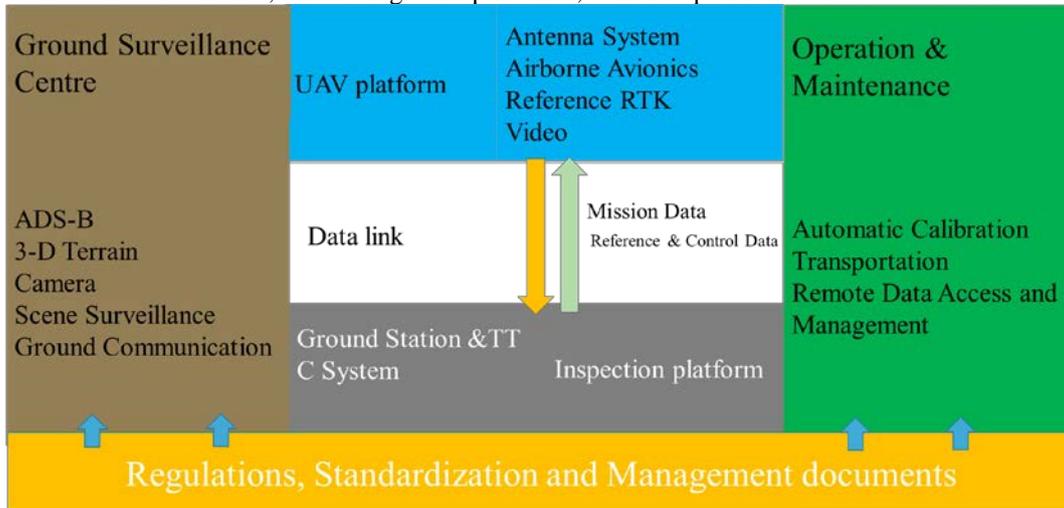


Fig.1 UFIS System Layout Diagram

UAV PLATFORM

UAV System

The assigned UAV, named as UFI-01 model, is a fixed-wing UAV, with main parameters given below in *Table.1*.

Wingspan:	7.8m
Max. Take-off Weight:	350kg
Max. Payload:	50kg
Service Ceiling:	5000m
Cruising Speed:	120-140km/h
Max. Endurance:	10hr
Data Link Coverage:	100km

Table.1 UAV parameters.

With its relatively medium size and load capacity, UFI-01 model is designed to cover major inspection procedures with favorable operation and maintenance cost. It is also designed to be operational within the majority of the airports in the world, as only few plateau airports as exceptions. For specific inspection procedures or plateau airports, those shortcomings can be solved by introducing another special mission UAV model with higher service ceiling and larger payload, which will not be further explained in this paper.



Fig.2 UAV system photo (on the ground)

Airborne Systems

Airborne systems include antennae, mission payload avionics (RTK, signal acquisition), and camera. Those are clearly the key of the UFIS. **Fig.4** shows the all ready stand-by status of UAV platform, as all airborne systems mounted and functional.

Antennae

Antennae system does not distribute a lot to the total payload, but the layout is designed specifically for this UAV, as its main body is small for all the antennae installed. A simulation of EMC is thoroughly analyzed and a robust overall layout is then confirmed. As shown in **Fig.3**, each installed antenna indicate capability for corresponding inspection procedure. Tests have been carried out multiple time, proving all antennae in working condition, with details given in the following section.

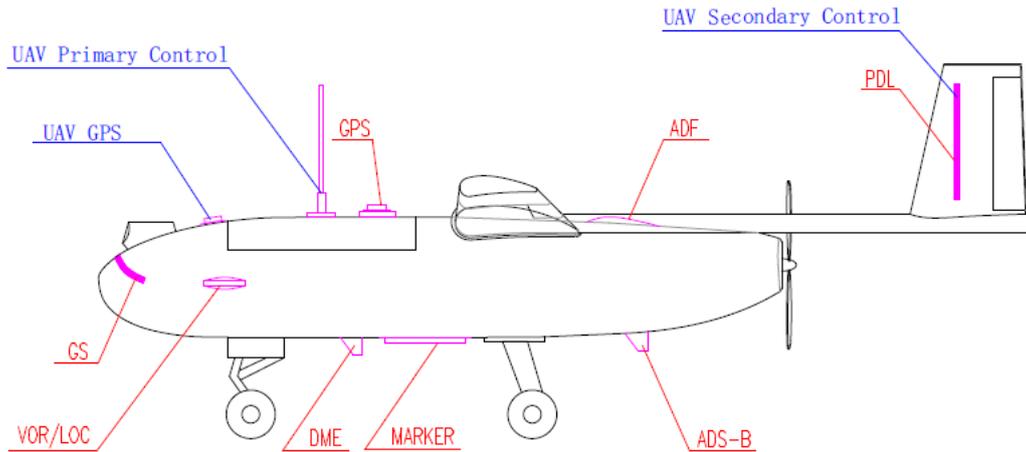


Fig.3 UFIS Antennae Layout

Mission Payload

Mission payload is located in the center cabin of the UAV, under the primary control antenna. As the rear part of the UAV is mounted with engine and flight control avionics, the overall size of the UFIS mission payload is limited to a 50cm cubic area and a total weight of 50kg.

In order to fit in the given cabin space and meets the weight requirement at the same time, a thorough and robust redesign of the inspection avionics is executed. Downsizing, integration, and modulization are the key concepts. By following those concepts, avionics are modeled based on ARINC 600 packaging standard, with multiple data bus standard compatible: ARINC 429, RS232/422/485, LAN, making it possible to fit in the center cabin, and removed easily as well. Integrated avionics, possess the ability of synchronized acquisition and processing of real-time multi-source data, including ILS, VOR/DME, NDB, MARKER, SSR/ADS-B, PAPI, and downlinked through data link communication. Camera slot is also designed, providing visual guidance for PAPI inspection and onboard monitoring purposes.



Fig.4 UAV Platform Stand-By Status

DATA LINK

Typical UAV data link provide limited bandwidth for UAV control and video downlink capabilities. With UFIS mission requirements, real-time response and processing of mission data, including inspection data(downlink), HD video data (downlink), TT&C data (uplink and downlink), RTK data etc. is required throughout UFIS data link communication, which set up a challenge.

Bandwidth broaden is executed first, and the merging unit of mission data into UAV flight control unit is designed and applied, making it possible for all data required to be processed and transmitted through the data link port to the ground station and ground surveillance center. Data link has been tested in various conditions with simulation inspection data, proven to be functional with expected performance.

GROUND STATION

Ground station is designed as a mobile cabin, mounted on civil lorry chassis for better mobility. Data link antenna and other receivers are integrated into the cabin, with power generator provided for field operation. With 100km data link coverage, the UAV platform will normally be controlled by instrument flying. However, its mobility allows it to be deployed near the runway for visual observation as a supplement.

The overall layout of the cabin interior is demonstrated in *Fig.5*. Two pilot seats and a flight inspection operator seat are provided. The cabin room can be extended, providing extra flight inspection seats and trainee seat for simulation and training purposes. Ground station is also performing as the outpost of inspection and flight data, while all those data can be uploaded to surveillance center and a cloud server throughout secured network.

Inspection processing software is integrated into the ground station, providing real-time monitoring and processing of the inspection data received from UAV platform. The software is built based on the ICAO 8071, Annex 10, FAA 8200.1c etc.



Fig.5 Ground Station Pilot and Inspection Operator Seats

GROUND SURVEILLANCE CENTER

Ground surveillance center is the headquarter of each UFIS mission, which can be set up in any given room with power and internet access. A mobile center solution is also available where a van is modified and mounted with power supply and hardware needed, for general aviation airport or other situation as requested.

This center collects all sub-systems' data in real-time, and provide full-on monitoring and command capabilities. As shown in *Fig. 6*, including inspection mission monitoring, UAV status monitoring, and airfield situation awareness. ADS-B and other ATM functions are also provided.

Ground surveillance center will be the key role of UFIS operation and management, as data can be real-time displayed as well as stored into center server, for further use and replay. With further development, ground center can be linked to a data center or a cloud server, as part of a UFIS network structure.



Fig.6 Ground Surveillance Center Layout

TEST PROGRESS OF UFIS

By the end of April, 2018, UFIS has been carried out several ground tests and joint tests, including the UAV platform reliability and feasibility, and the data linkage between all stations and the UAV platform.

Results showing that UAV platform functional as expected and all airborne mission payload performing normally. As for UAV system, several taxiing in test airfield and Dongying Airport is executed, UAV performed solidly in low and high-speed taxiing. Numerous test flights are scheduled in 2018, as inspection profiles including ILS, VOR/DME, RNAV etc. will be tested.



Fig.7 Ground Testing and Taxiing in Dongying Airport Runway

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