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STRUCTURAL MODIFICATION AND SYSTEM INTEGRATION OF CONVERTING SINGLE SEAT MANNED HELICOPTER TO AN AUTOMATED UNMANNED HELICOPTER

Bilgin ÇELİK[1]
Turkish Aerospace Industries
Ankara, TURKEY

Hasan SARAÇ[2]
Turkish Aerospace Industries
Ankara, TURKEY

ABSTRACT

The paper covers the system integration design work of converting a single seat light manned helicopter to a fully automated unmanned helicopter. The design is performed on parameters defining the aircraft maximum takeoff weight, endurance, system and payload requirements.

Structural modification refers to the stage of removing all human interface systems and secondary airframe structures; however system integration refers to the system tray and bracket design stage and their installation on the aircraft. The challenge of that study is the difficulty of covering the system and payload requirements, within a limited weight budged.

Completing the system integration, design is validated with fully automated flight tests, including take-off and landing.

Keywords: UAV, unmanned helicopter, system integration

INTRODUCTION

Unmanned Aerial Vehicles (UAV) has become one of the most popular topics in the aerospace industry for the last few decades. UAV systems are now being operated by several military forces and currently, to a more limited extent, by civilian organizations. [1] UAV expects to perform mainly missions of intelligence, surveillance and reconnaissance.

UAV’s could be either converted from a manned aircraft or designed completely as a UAV. A well-known rotary wing UAV is ‘‘Fire Scout’’; which is designed based on a commercial airframe (Schweizer Aircraft). It has a commonality of over 50 percent of the mechanical parts. This ‘‘low risk’’ approach for the airframe allows effective maturation of the entire system within a short development schedule. [2]

[1] Lead Engineer, System Installation UAV Systems Division, Email: bcelik@tai.com.tr
[2] Design Specialist, Structural Design in UAV Systems Division, Email: hsarac@tai.com.tr

Under a risk reduction and cost-savings approach, TAI, developed the project of converting a single seat manned helicopter to a rotary wing unmanned system. In the project, Mosquito XE single manned helicopter is used as a base platform. The helicopter has the following specifications: width 1828 mm, height 2133 mm, overall 6 m; gross weight of 275 kg and useful (pilot) load as 109 kg. [3]

METHOD

The converted helicopter is supposed to fly within the flight limits of the manned aircraft. Based on this fact, in this study, only secondary airframe structures are modified or removed; primary airframe structures are kept unchanged. Structural modification and system integration is performed on parameters defining the aircraft maximum takeoff weight, endurance, flight system and payload requirements.

By reverse engineering, the helicopter airframe surface geometry is scanned and a reliable solid model of the aircraft is created. Other structural details are individually modeled. All design activities are performed based on these 3D models.

Following the unmanned system identification, Space Allocation Models (SAM) for equipments is created. SAM not only shows the layout of all systems and payload but also satisfies the System Installation Requirement Document (SIRD). In addition, SAM gives the prediction of the aircraft total weight and balance requirement. Final lay out ensures the easy accessibility and removability of the equipments.

Structural modification

Structural modification refers to the stage of removing all human interface systems and secondary airframe structures. Systems such as flight display panel, control pedal, stick, pilot seat and their brackets, harness and secondary structures are disassembled. No permanent damage is given to the airframe. All removed parts are strictly measured and noted.

System Integration

System integration refers to the design of secondary structures (tray, fitting, equipment brackets ect.) and their installation to the aircraft. Tray design is an effective solution since it not only creates extra area for the equipment and harness installation but also improves the uniform load distribution to the airframe. All trays are designed to be removable in case of any system or equipment change or dimensional extension.

Trays are mounted to the keel beam and the nose box through reinforcements such as machined fittings or sheet metal brackets. Machined parts are produced from material Al 7050 T7451, whereas sheet metal brackets are from Al 2024 T3. [4] Since the airframe is composed of glass fiber composite, bracket material and fastener type selection satisfies the compatibility for composite environment. Fittings are permanently installed to the structure with blind bolts; however, nutplate on the supports enables the trays to be removable whenever necessary. A typical view of aircraft with finished tray installation is given in Figure 1.

Total weight for the new designed secondary structures like trays, fittings, equipment brackets and the systems such as flight, avionic and electric systems is declared to be within the requested weight budged.

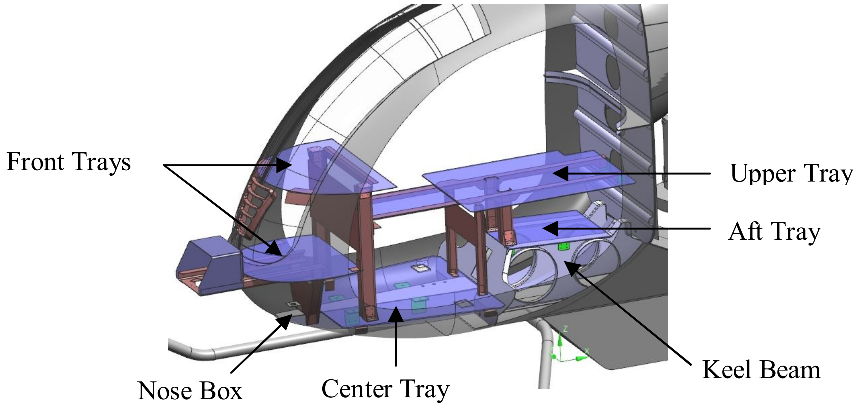

Figure 1.

Pilot controlled systems are replaced with servo actuators. UAV is controlled by five actuators, defined as collective, roll, pitch, pedal and throttle servo. Specific actuator brackets are designed and installed on the trays. A view of servo actuator installation layout is given in Figure 2.

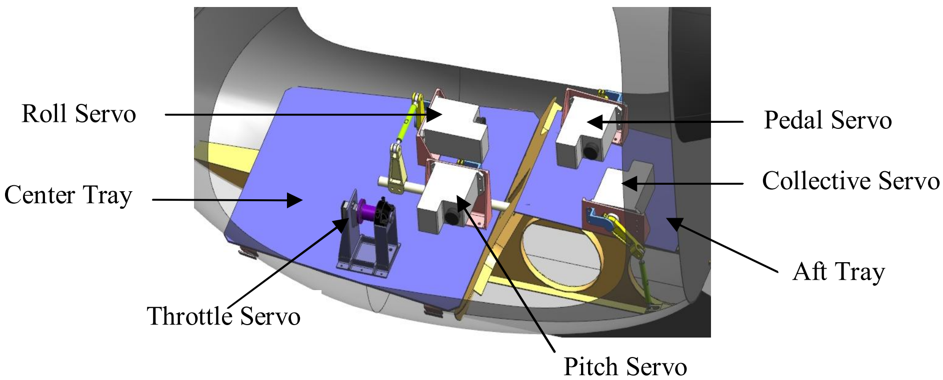

Figure 2.

Payload (EO Camera) integration is another challenge. Structural enforcement is applied at the nose region for the payload. Symmetrical C shaped sheet metal supports are fastened with bolt/nut type fasteners to the lower side of the front tray. An interface plate is designed for better removability of the Camera. Payload integration layout is given in Figure 3.

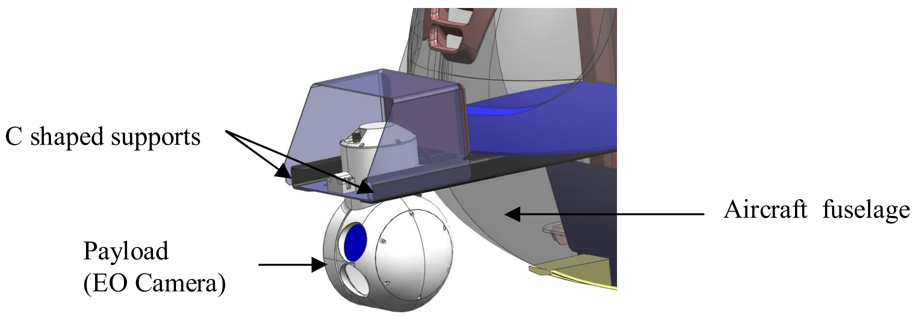

Figure 3.

Typical stress calculation for the payload attachment is described. Free body diagram for the payload is shown below in Figure 4.

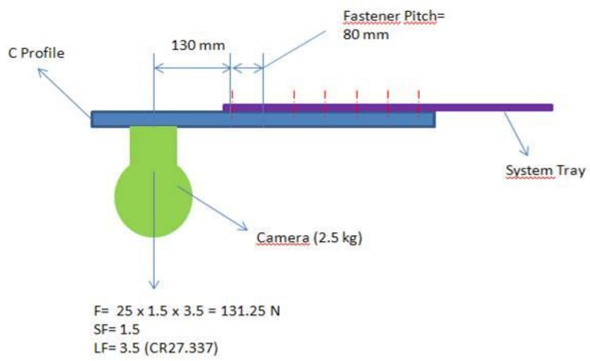

Figure 4.

Attachment analysis

Total Moment acts on C profiles is calculated as:
M= 130 x 131.25 = 17062.5 Nmm Ix=25596.

Stress on one C profile upper cap is,
P= Mc/I = 8531.25 x 16.2 / 25596 = 5.4 Mpa in tension << Material Allowable

C Profile is attached to tray with seven pieces of fasteners however, only first two fasteners are assumed to carry the load. Pitch distance b/w the fasteners is assumed to be 80mm.

M= F x Pitch 8531.25= F x 80 F= 106 N << Fastener tension allowable

As it is shown, payload attachment proves to be statically safe.

Completing all the system integration, design is validated with fully automated flight tests, including take-off and landing. A view of aircraft with finalized system integration is given in Figure 5.

Figure 5.

CONCLUSIONS

This study shows that with limited structural modification and operative system architecture, converting a manned aircraft to an unmanned aircraft is an effective and risk reduction approach. TAI, succeeded to develop a fully automated rotary wing unmanned system based on a single seat manned helicopter. All the system integration is accomplished within the given weight budged, system and payload requirements.

Learned lessons from this study are supposed to give the designers an opportunity to realize the technical challenges for new projects. Following the global trends, TAI, aims to include upper class rotary wing UAV's with higher performance and payload capacity in her product family. Actually, SSM (Turkish Undersecretariat for Defence Industries) has future plans and project targets for ship-based rotary wing unmanned systems that could perform automated vertical takeoff and landing. [5]

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