A SYSTEMS APPROACH TO INTEROPERABILITY ISSUES OF UNMANNED AERIAL VEHICLES: ENVISIONED PROJECT PLAN

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Abstract

The capabilities of Unmanned Systems (US), whether aerial, ground, surface, or underwater, are under various stages of technological demonstration; from prototype development to induction trials, both for civil and military applications. One of the technological challenges ahead is the issue of interoperability – a) inter: between USs; and b) intra: with manned systems.

In this research, various parameters that need to be addressed during the design process for inter and intra operability will be investigated. The methodology to address these design parameters in an aircraft design process will be developed and demonstrated through a case study. The case study will comprise of an unmanned helicopter (Vertical Takeoff Unmanned Aerial Vehicle – VTUAV) being used for the induction of an Unmanned Ground Vehicle (UGV) in a high threat operation zone for land mine detection missions.

Introduction

The transformation of warfare from conventional to unconventional has led to changes in military doctrines. This has resulted in technology growth or modifications to meet the new mission requirements emanating from the doctrines. Unmanned systems (USs) technology has demonstrated operational effectiveness on dull, dirty, and/or dangerous missions. As technology grows and matures, the roles of USs will widen in three-dimensions (Air – UAV, Land – UGV, and Sea – UUV) alongside manned systems [1]. With the widening of unmanned missions, interoperability will be critical for mission enhancement/accomplishment.

To address the issue of operational integration (unmanned and manned systems), the design process needs to be modified at the mission analysis stage for drawing the appropriate mission requirements for the design of mission payloads. In this research, a modified design methodology will be developed that incorporates operational integration of unmanned aerial vehicles with manned and unmanned systems as part of the FCS.

Design Project

Posing Problem. The defence forces, in recent years, have made strategic investments for the design, development, and induction of USs to replace manned systems on dull, dirty, and dangerous missions; to enhance mission effectiveness. UAVs are seen as force multipliers for surveillance missions, which would normally require more manned aircrafts (the dull). Similarly, a UGV could operate in potentially contaminated zones (radiological, chemical, or biological agents - the dirty), or operate in mine countermeasure roles (the dangerous) [2, 3].

The "Unmanned Aerial Vehicles Roadmap 2002 – 2027" [2] presents a foresight into the future of UAVs technologies and capabilities. It provides the futuristic operational doctrines that are to be addressed when operating UAVs with unmanned and manned assets that will meet the requirements of the defence force for the future.

The FCS will comprise of several USs, interacting directly (inter or intra), and hence the interoperability of these systems is critical. Future Unmanned Underwater Vehicles (UUVs) might themselves deploy an UAV or an UAV airdropping an UGV. 'Project STORK' demonstrated a Fixed Wing UAV (FW-UAV) deliver a UGV into an urban environment (via parachute). The UAV acted as a communication link and extended the control range of the UGV beyond the standard systems [3]. 'Forward Look' experiment, show cased four dissimilar UAVs operating in a network to prosecute ground targets [4].

The issue of interoperability by UAV systems is presently addressed by the use of proprietary air vehicle software and, in some cases, unique hardware. Customised interfaces are required for interoperability with existing command-and-control systems [4]. The projects and experiments conducted to-date used modified software and hardware to existing UAVs and USs, to achieve interoperability. This is time consuming, costly, and a short-gap solution. Interoperability of future USs needs to be addressed in the conceptual design process of the UAV for an effective in-service induction with low life-cycle costs.

Resolution. This research will adopt a systems approach to identify the envisaged design parameters required for inter- and intra- operability. Accordingly, the traditional helicopter design methodology will be reviewed and modified for the conceptual design of an interoperable VTUAV.

The research will build upon the comprehensive "Preliminary Helicopter Design Methodology" developed by Sinha [5] and "Preliminary Design of a Helicopter" by Prouty [6, 7], by encompassing interoperability design issues in the mission analysis phase. This will holistically address the mission requirements analysis for identification of an advanced mission payload – one that meets inter- and intra- operability. Potential operational doctrine on mission integration of VTUAVs with unmanned and manned systems shall be investigated based on the UAV Roadmap [2]. Interoperability capabilities derivable from state-of-the-art mission systems will be investigated for the design of the mission payload [8] from a manned and unmanned perspective. The mission payload of unmanned systems in a rotary wing configuration will be used for the initial sizing and conceptual design of an interoperable VTUAV.

This modified design methodology will be validated through a case study by the application of the designed VTUAV. The case study will demonstrate VTUAV's capability in the precise induction and recovery of UGVs in and out of a threat zone on land mine detection missions.

Project Activities and Schedule

1. Literature Review:
   - Systems concepts for holistic analysis of design problems will be reviewed.
   - State-of-art mission systems will be reviewed.
   - Interoperability issues will be analysed.
   - Design methodology of helicopter will be studied.

2. Mission Analysis:
   - The future roles and missions of interoperable VTUAVs will be identified to formulate mission requirements.

3. Identification Of Critical Design Parameters:
   - Critical design parameters that need to be addressed in the design of interoperable VTUAVs will be identified

4. Mission Systems Analysis:
   - State-of-the-art mission systems off-the-shelf and on board rotary wing helicopters, and unmanned aerial vehicles that provide interoperability capabilities will be identified.

5. Design Methodology Modification:
   - The traditional helicopter design methodology will be modified for the design of interoperable VTUAVs.

6. Validation of Modified Design Methodology:
   - The modified design will be validated through a case study by the conceptual design of an interoperable VTUAV capable of induction and retrieval of a UGV from threat zones.

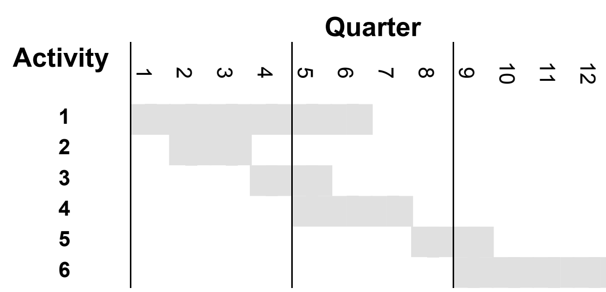

Figure 1 – Proposed schedule of activities.

Concluding Remarks

Unmanned Systems (US), whether aerial, ground, surface, or underwater, are under various stages of technological demonstration; from prototype development to induction trials, both for civil and military applications. One of the technological challenges ahead is the issue of interoperability of these USs.

By modifying the traditional helicopter design methodology to encompass interoperability, this research will benefit the operators and industry as it addresses the FCS requirement of interoperable

USs. The knowledge produced, being a holistic analysis of future missions, will provide a generic base for customisation to specific mission requirements of the unmanned family of vehicles. The modified design methodology will provide the architecture for automation to achieve an optimal conceptual design process in the industry.

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