A SYSTEMS APPROACH TO THE DESIGN ARCHITECTURE OF AN UNMANNED HELICOPTER

Ankush Rathore **Arvind Kumar Sinha**
The Sir Lawrence Wackett Center for Aerospace Design Technology
School of Aerospace, Mechanical and Manufacturing Engineering
RMIT University, GPO Box 2476v, Melbourne, Victoria 3001, Australia
(Tele: +61-03-99258091 Fax: +61-03-99258050 Email: arvind.sinha@rmit.edu.au)

ABSTRACT

Aerospace industries have diverted major resources for the design and development of Unmanned Aerial Vehicles (UAV) as a viable alternative to manned aircraft, on high-risk missions. UAVs are emerging as the next generation airborne reconnaissance & surveillance assets, due to their ability to penetrate enemy airspace and loiter on target areas for detection of lethal weapons or conduct damage assessment.

Rotary-wing UAVs also referred as “Vertical Takeoff UAVs” (VTUAVs) are presently in advanced research and development stages. The design of rotary wing aircraft (helicopters) is thus further complicated with the requirements to make it unmanned. A modified design process of helicopters is required to address the issues that emerge to make it unmanned. In this paper a systems approach is adopted for the development of an appropriate design architecture for VTUAVs.

INTRODUCTION

The design of Unmanned Aerial Systems is in an advanced stage of development for mine detection, perimetric surveillance, flight path reconnaissance and some civilian applications [1]. The traditional helicopter design methodology needs investigations from an unmanned (autonomous) perspective for suitable modification [2,3]. New design architecture needs to be developed. The components of the helicopter design process need to be re-assessed to identify components that will make it autonomous. Several VTUAVs are presently under development. Key VTUAVs for reconnaissance and surveillance are; Bell Helicopter’s Eagle Eye tilt rotor and Boeing’s Canard Rotor Wing [4].

The mission capabilities of these VTUAVs are limited and the scope for modifications to enhance the capabilities is restricted. These VTUAVs are platforms for technology demonstration. The design methodology needs to be revisited for the development of a modified methodology that is comprehensive, flexible and provides the required design analysis for wider mission capabilities [5]. In this paper a systems approach is adopted to investigate the present design architecture of helicopters, for the development of design architecture for VTUAVs.

SYSTEMS PERSPECTIVE OF DESIGN ARCHITECTURE

The present design architecture adopted for the VTUAV from the helicopter design process is viewed from a system perspective [6-10]. This is to identify the system elements of the present

VTUAV design process that is based on helicopters. The system elements identified are the following:

- **Helicopter design system**: The helicopter design process [2-3] involves a series of computations to achieve the design requirements. Several iterations of the computations are required to optimise the design for minimum size, weight and cost. The final design has to meet a set of predesignated performance parameters and design constraints;
- **Mission system**: These are the components required on board the helicopter for mission accomplishment. Based on the role and the mission for which the helicopter is being designed, off-the-shelf technology is considered. The functional characteristics of the mission systems provides the required capabilities to helicopter for mission accomplishment; and
- **Automation system**: Considering that the helicopter being designed is to be unmanned, additional systems are required on board – automation systems. These systems are to provide for automated take-off, flight, mission accomplishment and landing. The helicopter is to be controlled remotely by crew on ground.

The key inputs to the design process consist of the operational need of the VTUAV to be designed. Presently the operational needs [4-5] of the VTUAVs are for close-to-ground reconnaissance and surveillance. Of late, the operational need for combat support is also being considered. The key output of the design process is a VTUAV that provides the required mission capabilities. In the present scenario the mission is mainly for close-to-ground armed/unarmed reconnaissance and surveillance. The operational environment is threat infested, round-the-clock and in all weather.

With the identification of the system elements, inputs, outputs and the operational environment, the present design architecture of VTUAV is viewed from an input-process-output system configuration. The systems perspective of the current design architecture of VTUAVs is presented in Figure 1.

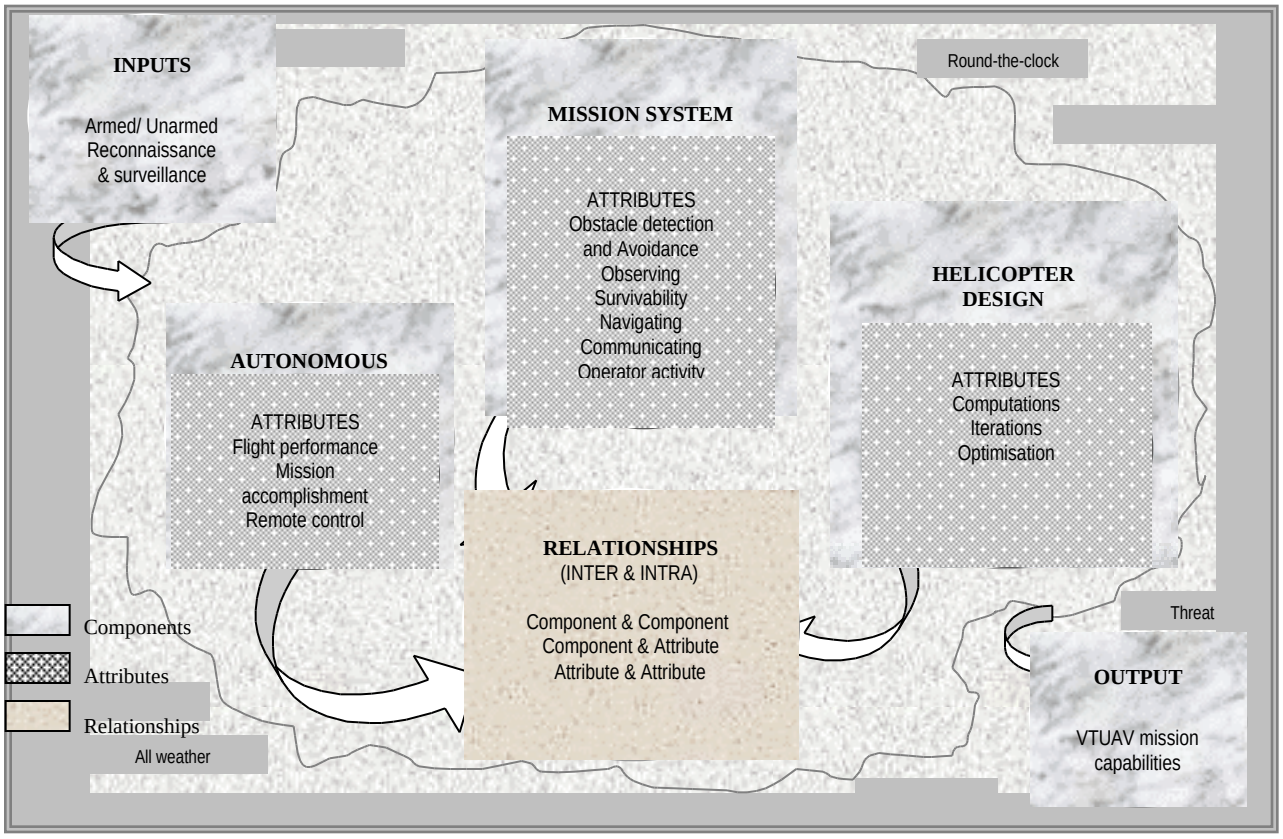

Figure 1. System representation of the current design architecture of VTUAV

The present architecture incorporates the unmanned design issues as a separate element. The design requirements to automate the flight and mission accomplishment are met by integrating the autonomous design with mission systems and the helicopter design system. Such integration involves additional iterations that add to design time.

The unmanned element needs to be incorporated with either the mission system or helicopter design system, to reduce iterations. If included in the design system the manned component of the design are to be appropriately analysed to meet the remote operation requirements. Present technology development aims at automation of the flight and mission accomplishment. With this development the unmanned design issues may be distributed between the helicopter and mission systems.

PROPOSED DESIGN ARCHITECTURE

Considering the design issues of automated flight and mission, the present architecture is investigated from the perspective of distribution of automation to the two systems – helicopter and mission system. To address the distribution of automation two components for the architecture is proposed as follows:

- **UAV design system:** It comprises of the helicopter design component. The key element is the helicopter design process less the manned element. The unmanned element to automate the flight is added to the design process. The system will provide the capability for remotely controlled take-off, flight and landing. It will also provide the capability to the VTUAV to fly to a preset flight profile; and

- **Mission system:** It comprises of the systems that contribute to mission accomplishment. These systems will now be remotely controlled unlike in a traditional helicopter, where it was manually controlled.

The operational environment will continue to remain the same, except that the area of loiter being of higher risk than for manned systems. Thus degree of threat will increase. The key inputs will vary in future, depending on the role and mission the VTUAV is being designed for. The output will provide the required mission capabilities defined at the commencement of the design.

With the analysis of the present design architecture (Figure 1) and the unmanned issues to be addressed; a new design architecture is proposed. The design architecture will now comprise of only two components, with in-built automation for remote control. This is based on the pattern of technology development to address UAV design issues [4,5].

Considering the system elements, inputs, outputs and the operational environment, from an input-process-output system configuration, a new design architecture for VTUAV is proposed. The systems perspective of the proposed design architecture of VTUAVs is presented in Figure 2.

RESULTS & DISCUSSIONS

The proposed design architecture offers some advantages over the present design architecture by addressing the key issue of remote control. This provides the leverage for the transformation of a design process of manned systems to unmanned systems. The proposed design architecture resulted in the following:

- **Components:** The components were reduced, by integrating the automation as part of each of these components. The autonomous attributes of mission control and flight control have been integrated in mission system and the design system respectively. This is to reduce the design iterations and save on time. It also provides for automation analysis as part of the design process. It encompasses the design flexibility by ease of insertion of advanced automation technology in the design process.

- **Inputs, outputs and environment:** The proposed architecture caters for changing operational environment. It also provides the flexibility to add-on inputs (roles and missions) and enhanced requirements of mission capabilities.

- **Systems perspective**: It provides a holistic analysis of the present design architecture, by the identification of the system elements and the issues that needs to be addressed. A systems perspective of new design architecture has been developed for further analysis.

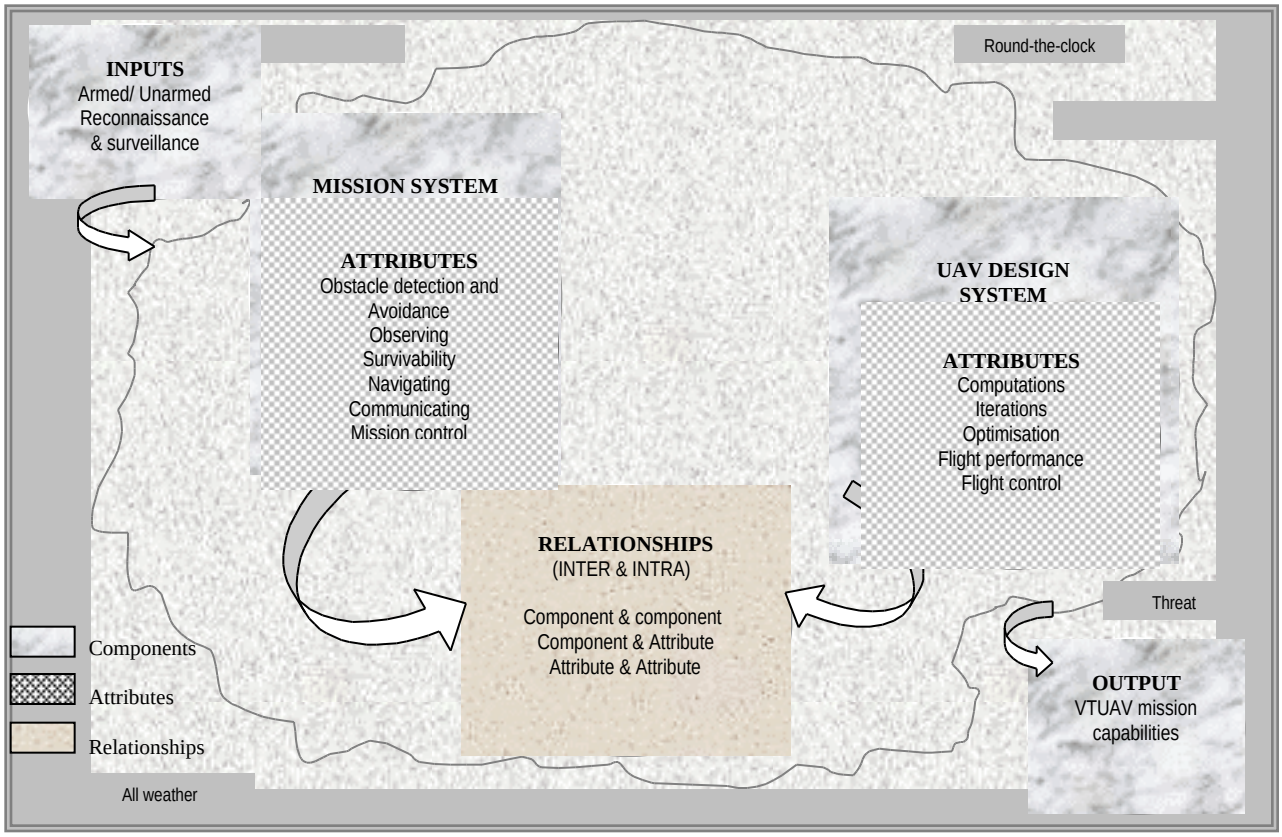

Figure 2. Systems perspective of the proposed design architecture of VTUAVs

CONCLUSION

Systems approach provides an avenue for the study of design architecture of VTUAVs. The key issue of remote control of manned helicopters can be addressed by incorporating the automation as part of the design components. It also provides growth by the insertion of advanced autonomous technology. The new design architecture prosed in this paper needs to be further investigated for application in a design process of VTUAV.

REFERENCES

1. Van Blyenburg, P., 2001, 'UAVs: A Review of the current situation with a focus on Europe', 16th International UAV Systems Conference, 2-4 April, Bristol, U.K
2. Sinha, A. K., 2002, 'Introduction to Preliminary Helicopter Design', Department of Aerospace Engineering, RMIT, Melbourne, pp. 12-59.
3. Prouty, R.W., 1998, Helicopter Performance Stability and Control, PWS Publishers, Boston
4. "A Systems Approach to the Design of Multi-mission Payload for Futuristic VTUAV", Yuen, Y.C.Y, Sinha, A.K. & Kusumo, R. AHS Conference, 8-10 April 2002, Bristol, UK.
5. "A Systems Approach to the Design on Multi-mission Airframe for Unmanned Air vehicles systems", Sinha, A.K., Scott, M.L., Kusumo, R.& Yuen, Y.C.Y, AHS Conference, 8-10 April 2002, Bristol UK.
6. "A Systems Approach to the Design on Multi-mission Airframe for VTUAVs", Sinha, A.K., Scott, M.L., Kusumo, R.& Yuen, Y.C.Y, 23rd International Congress of the Aeronautical Science, ICAS, 8-13 September 2001, Toronto Canada.
7. Sinha, A.K., Kam, B.H. and Wood, L.A. "A Design Decision Support System for Helicopter Multi-Mission Modifications". Proceedings of the First Australian Systems Conference, May 1995. Perth, W.A.
8. Sinha, A.K., Kam, B.H., Wood, L.A., Caterson, J. and Flood, R. "A Systems Perspective of Multi-Mission Helicopter Design". Proceedings of the 2nd Australian Systems Conference, September 1996, Melbourne, VIC.
9. Kusumo, R., Sinha, A.K. and Scott, M.L. "A System Approach to Automate Decision Support in Aircraft Upgrades for System Effectiveness". 7th Australia and New Zealand Systems Conference, 27-28 November 2001, Perth, W.A.
10. Kusumo, R., Sinha, A.K. and Scott, M.L. "A System Approach to Identify Optimum Design for Aircraft Upgrades". 2nd International Conference on Systems Thinking in Management, 03-05 April 2002, Salford, UK.