Extending Flight Testing of an Intelligent, Autonomous UAV Capability to Teamed Vehicles

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As part of an ongoing joint research program run by the Defence Science and Technology Organisation, Australia (DSTO) together with Agent Oriented Software and The University of Melbourne, the Codarra Avatar light-weight UAV has been provided with capability for autonomous operation. The goal of the program is to provide a research test bed suitable for studying the impact of UAV autonomy. The background to the program has been reported at Unmanned Unlimited 2003 [Lucas, 2003] and the results of single-vehicle flight trials at Unmanned Unlimited 2004 [Lucas, 2004].

As the second step, the intelligent, autonomous approach can be extended to multiple UAVs operating autonomously and collaboratively in a highly flexible manner. This enables a number of vehicles to work together with humans as a single team. Such a team might include autonomous aircraft, ground vehicles and surface vessels working together. Each UAV team member is capable of dynamically assuming various roles defined within the team hierarchy, according to the capability of the UAV to fulfil those roles. The ability of team members to coordinate roles allows for a robust, efficient, and flexible team structure.

The operational case for autonomy has several aspects. The principle is to delegate a vehicle or vehicles to undertake a mission on behalf of the human commander, and for these vehicles to possess the ability to work in teams. This capability can offer reduced operating costs and manpower efficiency – "From 20 personnel per UAV to 20 UAVs per person", is the sometimes quoted long-term goal. Cost saving and reduced risk can come from operating multiple low-cost UAVs with complementary capabilities, working as a team, rather than a single, high-value, multi-sensor vehicle. Improved capability comes with increased autonomy – UAVs can increase manned A/C effectiveness, e.g distributed EW. Also, UAV can penetrate high-risk environments. Finally, lower manpower and control and management workload requirements open up new deployment options, e.g. working with manned aircraft or small ships. Of course these improvements are not specific to UAVs, but are generic to the new class of UVS, including ground and underwater vehicles.

This paper reports on the current status of the research program, including the initial flight trials with two vehicles operating as a team. In addition to the teaming capability, the UAV development focuses on two distinct areas: aircraft platform management – including air and flight worthiness, health monitoring and cost of ownership; and autonomous software development issues – including validation and verification, architectures for coordinated autonomous behavior, and autonomous controllers inspired by models of human cognition. This paper includes details of the first round of teamed UAV flight trials, the software and hardware architectures, and the aircraft platform management research. Flight tests of the teamed vehicles was conducted at the same Australian Army Graytown Range (restricted airspace) as the single-vehicle testing.

The first set of teamed trials was conducted in February2005. As part of the development of the technical approach, additional flight safety monitoring was built into the on-board agents on the vehicles. The flight test program included:

- Radio signal strength monitoring and management
- Coordinated team surveillance

- Cooperative thermal detection, reporting and exploitation

These initial trials successfully demonstrated the flight safety monitoring function. However problems with the vehicle communications prevented completion of the teamed UAV trials in this series of tests. A further series of trials is planned mid-year to cover the teaming missions.

Figure 1. Team vehicles undergoing communications tests prior to launch

The teamed UAV technology is based on use of the JACK Teams framework, which introduces the notion of teams as separate reasoning entities. The behavior of a team, and in particular the coordinated activity of the team members, is defined directly for the team entity. JACK Teams has been deployed in real-time control applications, most notably robotic assembly and the control of mobile robots. Teamed intelligent agent technology is designed to explicitly model military team characteristics, including the C2 structure and with roles assigned according to the vehicles' capabilities. We highlight the difference between this and the "swarming" approach to multi-vehicle collaboration, which lacks a defined team structure.

The paper will describe the various alternative team architectures considered, and the reasons for using the one selected for this trial. It will also describe plans for more extensive teamed autonomy trials, including flight tests with three aircraft, and evaluation of alternative autonomous flexible command and control approaches.

This program continues to provide valuable practical experience of agent-based teamed autonomy. In addition it exposes military users and UAV designers to first-hand practical experience of truly autonomous UAV operations in a very short timescale.

[Lucas et al, 2004] Andrew Lucas, Ralph Rönnquist, Phillip Rechter, Clint Heinz, Stephen Van Der Velden, Ian Powlesland, Samin Karim "Development & Flight Testing of an Intelligent, Autonomous UAV Capability", AIAA Unmanned Unlimited, Washington, 2004

[Lucas et al, 2003] Andrew Lucas, Peter Corke, Ralph Rönnquist, Pavan Sikka, Magnus Ljungberg, Nick Howden "Teamed UAVs – A New Approach with Intelligent Agents", AIAA Unmanned Unlimited, San Diego, 2003