Chapter 3

UNMANNED AERIAL VEHICLES: AUTONOMOUS CONTROL CHALLENGES, A RESEARCHER’S PERSPECTIVE

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Abstract
AFRL is pressing ahead with development of truly autonomous UAV control systems. As we go from systems where the human is the pilot, through systems where the human is the operator, to systems where the human is the supervisor; with the ultimate goal simply to have the human as customer of UAV ops, we are running into numerous challenges. Yes, we face the typical technological questions of “What types of human tasks can we replace with on-board algorithms?” and “How big of a processor is required on-board to do this?” What are usually not asked are other questions, maybe not technically exciting, but with enormous practical impact: “How can we affordably add more code to already costly flight critical s oftware programs?” “How do I flight certify a system that has non-deterministic attributes?” “What is the impact of implementing distributed, coordinated, info-centric control systems that now have flight critical data links susceptible to electronic and information warfare?” “How do I convince the FAA, and foreign governments, that it’s safe to let autonomous vehicles roam the skies?” These, and other questions, have just as great, if not greater, impact on systems development as the raw autonomous technology itself. This paper examines some of these challenges, how current AFRL research is addressing them, and points the way to future research that will allow truly autonomous operations.

Keywords: unmanned vehicles, autonomous control

R. Murphey and P.M. Pardalos (eds.), Cooperative Control and Optimization, 35–53.
1. Introduction

Autonomous UAVs, these conjure up a host of visions in the minds of various researchers and developers. If one were to ask us what our vision of autonomous UAVs would be, we would refer them to the “flying monkeys” scene of the Wizard of Oz. Those “autonomous UAVs” exhibit behaviors that we would like to instill in our UAV development:

- They are self-organizing, taking high level goals “Get the Ruby Slippers” and translating them into the tasks required “fly there, find prey, capture, etc.” without explicit instructions from the user.
- They are self-executing, not relying on external input to initiate behaviors.
- They are self-deconflicting, not relying on any external communications to keep from running into each other.
- They show battlefield management, are aware of targets and the threats in the terminal area, and take appropriate team action to achieve goals (scatter the Strawman, steal the Tin Man’s axe, etc.).
- Oh, and they swarm!

Il kidding aside, our goal is to enable autonomous UAV operations for any USAF mission. Whether or not the missions are executed that way will be up to the policy makers, but they will have the technology needed if chosen. This is the view of autonomy development from a "shop" that accomplishes the transition of control technologies from basic research to technology demonstrations, in Department of Defense "lingo" from 6.1 to 6.3.

2. Background

Before I press on to the challenges we face in enabling autonomous UAVs, I’d first like to cover a couple of definitions:

What are unmanned aerial vehicles?

The definition of "unmanned" simply means that a human is not aboard actively piloting or directing the aircraft. It might be carrying human cargo, but the control functions are either indigenous (on-board computer), or off-board (computer or remote pilot). We used to (up to about a year ago), use the term "uninhabited" rather than unmanned to be politically correct. We didn’t want the audience to think that a human wasn’t somewhere in the command & control process. Thankfully we’ve given that up!