Flying UAVs in Civil Airspace By Using Synthetic Vision

Jed Margolin

Introduction

Companies and Government are starting to deal with the problem of safely flying UAVs in civil airspace, especially now that they are beginning to see the potential civilian uses for UAVs.

What makes any solution difficult is that it has to work within the existing system run by the FAA which operates the national airspace system and has been slow to adopt technological advances.

The companies involved (AeroVironment, Aurora Flight Sciences, Boeing, General Atomics, Lockheed Martin, and Northrop Grumman) are taking the problem/opportunity seriously enough to spend some of their own money on a solution.

Unfortunately, they do not seem to realize that this is an opportunity to improve the national airspace system for all users and not just UAV operators.

The solution discussed in this report requires the use of Synthetic Vision as taught by my U.S. Patent 5,904,724 **Method and apparatus for remotely piloting an aircraft**.

Current Activity

From Aviation Week & Space Technology, 08/02/2004, page 54
Michael A. Dornheim Los Angeles

> ***UAV Safety Access 5 Project Seeks To Fly Drones in Civil Airspace***
> To carry out quick-reaction civil missions like wildfire spotting, UAVs must be part of the FAA system. Challenge is to make safety for others on the ground and in the air affordable.
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> In early 2002 six manufacturers--AeroVironment, Aurora Flight Sciences, Boeing, General Atomics, Lockheed Martin and Northrop Grumman--formed the UAV National Industry Team (Unite) to gain access for high-altitude long-endurance (HALE) drones. HALE aircraft were chosen because they fly above most commercial traffic, usually over sparsely populated areas, and present the lowest-risk initial step. Dann is also president and co-founder of Unite.
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> Unite approached NASA in August 2002 because it was running the Environmental Research Aircraft and Sensor Technology drone program, and the two signed a joint sponsored research agreement. This formed Access 5, so-called because of the original optimistic goal of gaining airspace access in five years. The FAA became involved as an adviser, and the Defense Dept. joined the discussion. By February

> 2003, Unite members had contributed $3-4 million and NASA had a similar amount in its budget, Bauer said.
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> Steps 1 and 2 are funded with $101 million from NASA that became available in May, covering the five years from Fiscal 2004-08, and Unite will make in-kind contributions worth at least $25 million.

Access5 has their own web site at www.access5.org .

They are planning on spending $126 million ($101 million from NASA and $25 million from Unite) for the Fiscal period 2004-08 to apply a band aid to a system that has been broken for a long time.

From Aviation Week & Space Technology, 09/13/2004, page 59 (Inside Avionics):

> **NORTHROP GRUMMAN IS WORKING**
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> Aviation Week & Space Technology
> 09/13/2004, page 59
> Edited by Bruce D. Nordwall
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> NORTHROP GRUMMAN IS WORKING with the U.S. Air Force to fuse data from a variety of sensors as a basis for collision-avoidance systems for unmanned aerial vehicles. The concept is to create an autonomous "see and avoid" system that would permit UAVs and manned aircraft to operate safely in the same airspace. Work under this contract from the Air Force Research Laboratory in Dayton, Ohio, aims to verify, through simulation, a sensing architecture designed under a previous award. The concept is to combine data from electro-optical charge-coupled-device cameras and mid-wave infrared sensors to create an integrated view of the environment, which the UAV's flight control system could use to adjust the aircraft's vector to avoid a midair collision. The simulation model will be based on the attributes of radar, traffic-alert and collision avoidance systems (TCAS) and automatic dependent surveillance-broadcast. Separately, the company is working with NASA, the Defense Dept., the Homeland Security Dept. and six industry partners to develop the policy and procedures to give UAVs access to U.S. airspace within five years.

From Aviation Week & Space Technology, 03/01/2004, 05:08:05 PM:

> **UAVs Increase in Importance**
> By Steven J. Zaloga
> UAVs remain the most dynamic segment of the aerospace market. They stole the limelight from more established technologies at the 2003 Paris air show. Nevertheless, they are still a relatively small segment of the aerospace market, about $1.25 billion in research and production funding in 2003. What attracts so much attention is the potential for a major expansion.

And, at the end of the article:

> **CIVILIAN UAV APPLICATIONS**
> UAVs have been used extensively for civilian scientific research, but this has not transitioned to much serial production. Scientific applications can be easily

envisioned for UAVs such as environmental monitoring, weather/atmospheric data collection, oceanographic data collection, agricultural monitoring and high-altitude geological mapping of magnetic, radiological and gravimetric data. Some of these research applications could become commercial. For example, the U.S. Defense Dept. has discussed contracting private firms to operate research UAVs over the Pacific to collect weather data.

From Aviation Week & Space Technology, 08/02/2004, page 50:

General Atomics, Northrop Grumman Set To Battle Over Pentagon UAV Projects
David A. Fulghum
Farnborough

Competition flares for a new category of survivable, high-altitude jet UAVs
Running Hot

Competition has just caught fire for a new category of unmanned aircraft, with an estimated market of $16-45 billion over the next 10-15 years.

General Atomics Aeronautical Systems started the blaze with the still unannounced construction start of an all-jet Predator C, and Northrop Grumman is fanning the flames with advanced planning for a competing aircraft that's expected to be a departure in design from the more sophisticated Global Hawk.

According to an article in Aerospace Daily & Defense Report 10/13/2004 09:13:12 AM “Use Of UAVs In War On Terror Expanding, Weatherington Says”:

“The DOD plans to spend $2.2 billion on UAVs in fiscal year 2005 and $13 billion total from FY '04 through FY '09, with strike UAVs accounting for half of that number. Annual UAV spending is projected to reach about $3 billion by FY '08-09. The Pentagon's latest UAV roadmap (DAILY, June 3) is expected to be released early next year."

My Proposed Solution

Definitions

Unmanned Aerial Vehicle (UAV) is an aerial vehicle without an onboard human pilot.

Problem

Flying (including taking off and landing) a UAV in an airspace shared with other independent aircraft, both civilian and military, which are not under the direct control of the entity controlling the UAV, and avoiding midair collisions during all phases of flight.

Proposal

1. UAVs flying beyond a specified range from a Terminal Control Area (TCA) or other designated area and flying above a specified altitude may be flown autonomously using an Autonomous Control System (ACS) as long as the following conditions are met:

(a) A remote operator must monitor the operation of the UAV at all times. A remote operator may monitor several UAVs simultaneously once it is established that this practice may be safely performed by a single operator. For example, it may be preferable to have two remote operators to work as a team to monitor ten UAVS than to have each remote operator separately monitor a group of five UAVs.

(b) The ACS must use radar (either active or passive) to detect the range and altitude of nearby aircraft in order to perform "see and avoid" actions. An example of a passive radar system is taught by Reference 2 [U. S. Patent 5,187,485 **Passive ranging through global positioning system**].

(c) The ACS must periodically transmit its identification, location, altitude, and bearing. This may be done through the use of a speech synthesis system on a standard aircraft communications frequency. This is for the benefit of pilots flying aircraft sharing the airspace. It may also be done through an appropriate digital system such as the one taught in Reference 3 [U.S. Patent 5,153,836 **Universal dynamic navigation, surveillance, emergency location, and collision avoidance system and method**.]

(d) The ACS must provide a means for the pilots of other aircraft to communicate directly with the remote operator. This may be accomplished by having the communication link between the remote operator and the UAV relay communications with a standard aircraft transceiver onboard the UAV.

2. UAVs flying below a specified altitude or within a specified range from a TCA or other designated area (at any altitude) must be flown using a synthetic vision system as taught in Reference 1 [U.S. Patent 5,904,724 **Method and apparatus for remotely piloting an aircraft**].

Each UAV flown under these conditions must be under the direct control of a remote operator/pilot whose sole responsibility is the safe operation of that UAV. The rules will be similar to those for operating piloted aircraft with automatic pilot systems including those with autoland capability.

The preferred method for flying a UAV from one airport to another, such as in ferrying UAVs, would be to have the remote operator/pilot at the originating airport be responsible for taking off and flying the UAV to the specified altitude. A remote operator/pilot at the arrival airport would be responsible for having the UAV descend and land. In between, once the UAV has reached the specified altitude the remote operator monitoring the flight can be at any convenient location.

Long delays in the communications link (such as through geosynchronous satellites) make flying the UAV by direct control using synthetic vision more difficult and should be avoided.

The method described does not require any changes in the present air control system. It would also make UAV flights safer than most existing piloted flights where "see and avoid" is accomplished by looking out small windows providing a limited field of view and hoping you see any nearby aircraft in time to avoid a collision.

Patent References

[Ref 1] U.S. Patent 5,904,724 **Method and apparatus for remotely piloting an aircraft**, Jed Margolin, May 18, 1999. Link to patent at USPTO website

The patent teaches the use of synthetic vision to remotely pilot an aircraft.

[Ref 2] U. S. Patent 5,187,485 **Passive ranging through global positioning system**, Tsui, et al., February 16, 1993. Assignee: The United States of America as represented by the Secretary of the Air Force. Link to patent at USPTO website

The patent teaches a method for determining the distance from a target to an observation station, using four GPS satellites as radiation sources, and a GPS receiver at the observation station to form a bistatic radar system, wherein an angle of arrival (AOA) of the target to the observation station has been measured first.

[Ref 3] U.S. Patent 5,153,836 **Universal dynamic navigation, surveillance, emergency location, and collision avoidance system and method**, Fraughton, et al., October 6, 1992. Link to patent at USPTO website

Each vehicle continuously transmits its location, identification, and other information, so everybody with the appropriate receiver knows where everybody else is. {The patent is 135 pages long.}

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