Jed Margolin ***3570 Pleasant Echo Dr.*** ***San Jose, CA 95148-1916***
Phone: (408) 238-4564 ***Email:*** **jm@jmargolin.com** ***June 17, 2003***

Mr. Alan J. Kennedy
Director, Infringement Division
Office of the Associate General Counsel
National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

Attn: GP(02-37016)

Dear Mr. Kennedy,

I have received your letter dated June 11, 2003.

In my contacts with NASA personnel I have repeatedly stressed my desire that this matter be resolved in a friendly manner. However, since NASA has rejected my request to consider a license proffer and in view of your letter of June 11, it is clear that NASA has decided to handle this in an adversarial manner.

Before I respond to your letter in detail, I want to make things easier for me by withdrawing my U.S. Patent **5,566,073** ***Pilot Aid Using a Synthetic Environment*** from this administrative claim in order to focus more directly on NASA's infringement of my U.S. Patent **5,904,724** ***Method and Apparatus For Remotely Piloting an Aircraft*** . However, I reserve the right to file a claim concerning the '073 patent at a later time.

(1) The identification of all claims of the patent(s) alleged to be infringed.

As I stated in my email of May 13, 2003 to Mr. Hammerle of LARC and in my fax of June 7, 2003 to you, I have no way of determining exactly which claims the X-38 project may have infringed unless NASA makes a full and complete disclosure to me of that project. I also have no way of determining if NASA has (or has had) other projects that also infringe on my patent unless NASA makes a full and complete disclosure of those projects as well.

Therefore, in order to answer your question, I must request that NASA make a full and complete disclosure to me of the X-38 project as well as any other current or past projects that may infringe on my patent.

If this information requires a security clearance (I have none) I suggest you start the required security investigation immediately. If there is further information that you require in this regard feel free to contact me.

(2) The identification of all procurements known to the claimant or patent owner which involve the alleged infringing item or process, including the identity of the vendor or contractor and the Government procuring activity.

As I stated in my fax to you of June 7, 2003, I became aware that NASA was using synthetic vision in the X-38 project in the January 2003 issue of NASA Tech Briefs, page 40, **"Virtual Cockpit Window" for a Windowless Aerospacecraft**. The article is available at: http://www.nasatech.com/Briefs/Jan03/MSC23096.html

This led me to Rapid Imaging Software, Inc. and their press release (http://www.landform.com/pages/PressReleases.htm) which states:

> *"On December 13th, 2001, Astronaut Ken Ham successfully flew the X-38 from a remote cockpit using LandForm VisualFlight as his primary situation awareness display in a flight test at Edwards Air Force Base, California. This simulates conditions of a real flight for the windowless spacecraft, which will eventually become NASA's Crew Return Vehicle for the ISS. We believe that this is the first test of a hybrid synthetic vision system which combines nose camera video with a LandForm synthetic vision display. Described by astronauts as 'the best seat in the house', the system will ultimately make space travel safer by providing situation awareness during the landing phase of flight."*

The RIS press release provided a link to an article in *Aviation Week & Space Technology*: http://www.aviationnow.com/avnow/news/channel_space.jsp?view=story&id=news/sx381211.xml

As a result of more searching I discovered a link to a Johnson Space Center SBIR Phase II award to Rapid Imaging Systems at http://sbir.gsfc.nasa.gov/SBIR/successes/ss/9-058text.html .

It includes a particularly relevant paragraph:

> *The Advanced Flight Visualization Toolkit (VisualFlight™) project is developing a suite of virtual reality immersive telepresence software tools which combine the real-time flight simulation abilities with the data density of a Geographic Information System (GIS). This technology is used for virtual reality training of crews, analysis of flight test data, and as an on-board immersive situation display. It will also find application as a virtual cockpit, and in teleoperation of remotely piloted vehicles.*

The emphasis on *virtual reality immersive telepresence* and *teleoperation of remotely piloted vehicles* is mine.

A search of the SBIR archive shows the following entries.

For 2001 Phase I:
Rapid Imaging Software, Inc.
1318 Ridgecrest Place S.E.
Albuquerque, NM 87108-5136
Mike Abernathy (505) 265-7020
01 H6.02-8715 JSC
Integrated Video for Synthetic Vision Systems

For 2001 Phase II:
Rapid Imaging Software, Inc.
1318 Ridgecrest Place S.E.
Albuquerque , NM 87108-5136
Carolyn Galceran (505) 265 - 7020
01-2-H6.02-8715 JSC

Since my sources of information are limited to those available to the public (magazines such as *Aviation Week & Space Technology* as well as whatever I can find on the Internet) I have no way of knowing if there are other procurements, vendors, contractors, and Government procuring activity related to Claim I-222.

I believe that NASA is in a better position to know what it is (or has been) working on than I am.

(3) A detailed identification of the accused articles or processes, particularly where the article or process relates to a component or subcomponent of the item procured, an element by element comparison of the representative claims with the accused article or process. If available, this identification should include documentation and drawings to illustrate the accused article or process in suitable detail to enable verification of the infringement comparison.

I believe I have answered this in section (2) as much as I am able to without NASA's cooperation.

(4) The names and addresses of all past and present licenses under the patent(s), and copies of all license agreements and releases involving the patent.

There are no past licenses for this patent, and as of this date there are no present licenses for this patent. Naturally, I reserve the right to license this patent in the future as I see fit.

(5) A brief description of all litigation in which the patent(s) has been or is now involved, and the present status thereof.

There has been no past litigation involving this patent, and as of this date there is no present litigation regarding this patent.

(6) A list of all persons to whom notices of infringement have been sent, including all departments and agencies of the Government, and a statement of the ultimate disposition of each.

As of this date NASA is the only agency or department of the Government against which I have filed a claim.

5/11/03 – sent email to *comments@hq.nasa.gov*

I believe that NASA may have infringed on one or more of my U.S. Patents.
How do I file a claim and whom do I contact?

5/11/03 – Received reply:

Date: Sun, 11 May 2003 17:48:46 -0400 (EDT)
From: "PAO Comments" <comments@bolg.public.hq.nasa.gov>
Message-ID: <200305112148.h4BLmkhJ011314@bolg.public.hq.nasa.gov>
To: <jm@jmargolin.com>
Subject: Thank you for your email.

Thank you for your message to the NASA Home Page. The Internet Service Group will attempt to answer all e-mail regarding the site, but cannot guarantee a response by a particular time. The group will not be able to answer general inquiries regarding NASA, which should instead be sent to public-inquiries@hq.nasa.gov

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5/11/03 – Sent email to <public-inquiries@hq.nasa.gov>

I believe that NASA may have infringed on one or more of my U.S. Patents.
How do I file a claim and whom do I contact?

Jed Margolin

As far as I can tell I did not receive a response.

5/12/03 – Sent email to j.c.midgett@larc.nasa.gov (found on Web site)

I believe that NASA may have infringed on one or more of my U.S. Patents
How do I file a claim and whom do I contact?
(Or is my only recourse to sue in Federal Court?)

Jed Margolin

5/12/03 – Received reply:

Mr. Margolin,

Thank you for contacting NASA with your concerns. I have referred this matter to the Patent Counsel Office, and they will be contacting you to work with you on this issue.

Best wishes,
Jesse Midgett

5/12/03 – Given my experience with trying to contact Government officials via email (or mail, or fax) I hadn't waited for the reply from J. Midgett. I had found the web site for the LARC (NASA Langley) Patent Counsel Office, and called up. I was connected to Kurt Hammerle and we had a nice talk. I sent him an email the next day (May 13, 2003).

I received a phone call from Barry Gibbens (757-864-7141) who, apparently, was calling because of my email to to J.C.Midgett and hadn't seen the email I sent to K. Hammerle. (I explained to him what I had done.) We had a nice talk. He said he had already sent me a letter.

I received his letter and sent a reply on May 18, 2003 (USPS), adding to the email I had sent K. Hammerle.

Thursday, June 5, 2003 – Received message from B. Gibbens, asking me to call him because I should contact Alan Kennedy at NASA Headquarters (202-358-2065).

Friday, June 6, 2003 - I called B. Gibbens. Then I called A. Kennedy but he was out.

Saturday, June 7, 2003 – Sent a fax to A. Kennedy. The first number I tried (202-358-4341) only accepted 4 pages (out of 13). I tried a few times. Then I tried 202-358-2741. It turned out that 4341 was the correct number and that 2741 was another group. As a result, A. Kennedy initially only got 4 pages.

Monday, June 9, 2003 – Received message from A. Kennedy and called him back.

He had not gotten the fax so he went and found it. I learned the next day that he had only gotten 4 pages.

We had a "free and frank" discussion. I stressed that I wanted to resolve it in a friendly manner and that I preferred to have NASA buy the patent for the Government.

Tuesday, June 10, 2003 – Received a message from A. Kennedy and called him back.

He said that his Manager has turned down my request that NASA consider a license proffer and has decided to handle it as a Claim, and that the investigation would take 3-6 months.

However, NASA is not the only agency or department of the Government I have contacted.

7/5/1999 Email to: lbirckelbaw@darpa.mil
Dr. Birckelbaw, Project Manager for the UCAV contract awarded to Boeing.

Introduced myself and asked if DARPA was interested in my patent.
Response: none

7/26/1999 USPS Mail to:

Dr. Larry Birckelbaw
Program Manager, Aerospace Systems
DARPA Tactical Technology Office
3701 North Fairfax Drive
Arlington, VA 22203-1714

Introduced myself and asked if DARPA was interested in my patent. Enclosed copy of patent.
Response: none

Office of the Secretary of Defense (OSD)

Mr. E.C. "Pete" Aldridge
Under Secretary of Defense for Acquisition, Technology, and Logistics
U.S. Department of Defense
Contact Method: Email: webmaster@acq.osd.mil May 3, 2002 and June 6, 2002
Response: none

Army - AATD, Fort Eustice, VA.

Col. Wado Carmona, Commander
Applied Aviation and Training Directorate (AATD)
Army Aviation and Missile Command
Ft. Eustice, VA

Contact Method:
Email: Ms. Lauren L. Sebring lsebring@aatd.eustis.army.mil June 1, 2002
757-878-4828, fax: 757-878-0008

Phone Call Followup: She suggested I talk to Mr. Jack Tansey
Mr. Jack Tansey, Business Development 757-878-4105 June 18, 2002
Email Followup: jtansey@aatd.Eustis.army.mil June 18, 2002

Air Force Research Laboratory (AFRL)

Dr. Barbara Wilson
Contact Method: email (Barbara.Wilson@wpafb.af.mil) July 17, 2002
Response - none

Air Force Research Laboratory (AFRL)
Dr. R. Earl Good, Director,
Directed Energy Directorate
Air Force Research Laboratory
Kirtland Air Force Base, NM 87117-5776
Contact Method: Fax (505-846-0423) July 23, 2002
Response: none

Department of the Air Force
Dr. James G. Roche
Secretary of the Air Force
Washington, DC

Contact Method: Fax (703-695-8809) July 28, 2002

Response: Letter from August 13, 2002
Lt. General Charles F. Wald
Deputy Chief of Staff, Air & Space Operations, USAF

(7) A description of Government employment or military service, if any, by the inventor and/or patent owner.

I have never been employed by the U.S. Government (or any other government). Likewise, I have never been in military service (in the United States or elsewhere). In the interests of full disclosure, I worked for three summers (1967, 1968, 1969) at the RCA Astro-Electronics Division in Hightstown, NJ . (They had a summer job program for students.)

(8) A list of all Government contracts under which the inventor, patent owner, or anyone in privity with him performed work relating to the patented subject matter.

None. I did this entirely on my own dime.

(9) Evidence of title to the patent(s) alleged to be infringed or other right to make the claim.

This appears to be a two-part question. Does the patent belong to Jed Margolin, and am I that Jed Margolin?

Part 1 - If you look at the front page of the '724 patent you will see that it was, indeed, issued to Jed Margolin, 3570 Pleasant Echo Dr., San Jose, CA.

If you contact the U.S. Patent and Trademark Office, Document Services Department (703-308-9726), you can order an Abstract of Title to verify that I own the patent. According to 37 CFR 1.12, assignment records are also open to public inspection at the United States Patent and Trademark Office.

Part 2 - If you look up Jed Margolin, 3570 Pleasant Echo Dr., San Jose, CA, in a telephone directory you will find assigned to it the telephone number 408-238-4564.

When you called me on June 9 and June 10, that was the number you called.

Other than my affirming that I am, indeed, the Jed Margolin in question, I can only suggest that you contact my cousin Lenny (oops, I mean Dr. Len Margolin) who is employed by Los Alamos National Laboratory, and ask him if he has a cousin Jed who is an engineer and an inventor, and who possesses the Margolin gene for being very persistent. (Some say stubborn.) The last time I saw him was in Ann Arbor, Michigan, after he had just passed the orals for his doctorate. (He bought me a beer at a place on South University.)

(10) A copy of the Patent Office file of the patent, if available, to claimant.

I do not have a copy of the USPTO's patent file. What I have is my prosecution file which contains, among other things, privileged communications between my patent attorney and myself.

Besides, in our telephone conversation of June 10, you stated that one of the research centers (I believe it was LARC) had already ordered the file.

(11) Pertinent prior art known to claimant, not contained in the Patent Office file, particularly publications and foreign art.

I have found no relevant prior art.

However, there is an interesting article in the June 2, 2003 issue of *Aviation Week & Space Technology* on pages 48-51 entitled **GA Riding 'Highway-in-the-Sky'** which describes, among other things, the work of Dennis B. Berlinger, lead scientist for flight deck research at the FAA's Civil Aeromedical Institute (CAMI) regarding what is called **Performance-Controlled Systems**. In the Specification of my '724 patent I call it **First Order RPV Flight Control Mode.** In Claim 18:

> 18. The station of claim 13, wherein said set of remote flight controls are configured to allow inputting absolute pitch and roll angles instead of pitch and roll rates.

An Internet search turned up Mr. Beringer's report **Applying Performance-Controlled Systems, Fuzzy Logic, and Fly-By-Wire Controls to General Aviation** as DOT/FAA/AM-02/7.

I am pleased that Mr. Beringer's May 2002 study confirms the value of Performance-Controlled Systems in piloted aircraft and I believe that teaching it in my '724 patent (filed January 19, 1999) gave an additional novel and useful aspect to my invention.

(The article also describes the Synthetic Vision system used in the FAA's Capstone program.)

If you have any further questions, please contact me.

Sincerely yours,

Jed Margolin

Enclosed: Response from General Wald
AWST article
Beringer Report
U.S. Patent 5,904,724

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC

13 Aug 02

HQ USAF/XO
1630 Air Force Pentagon
Washington, DC 20330-1630

Mr. Jed Margolin
3570 Pleasant Echo Dr.
San Jose, CA 95148-1916

Dear Mr. Margolin

On behalf of Secretary Roche, thank you for providing your ideas on ways to improve UAV control technology. As you know, we are now operating the Global Hawk and Predator systems in reconnaissance roles, and envision expanding unmanned aircraft applications into the weapons delivery mission area with the UCAV and the Predator/Predator B aircraft. Certainly we see a growing role for UAVs in the Air Force as technology advances and we gain experience in their operation. The improved control methods you have patented may well play a part in future UAV design. I suggest that you present these concepts to the various UAV manufacturers who are in the business of designing systems to meet our operational requirements. They can offer the best assessment on the overall feasibility of integrating your technology. I suggest a similar approach regarding your patented laser techniques.

Again, thank you for taking the time to offer these suggestions. I admire your ingenuity, and appreciate your desire to help us improve our national defense capabilities.

Sincerely

CHARLES F. WALD, Lt Gen, USAF
Deputy Chief of Staff
Air & Space Operations

cc:
SAF/AQ
AF/XOR

US005904724A

United States Patent [19]

Margolin

[11] Patent Number: 5,904,724

[45] Date of Patent: May 18, 1999

[54] **METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT**

[76] Inventor: **Jed Margolin**, 3570 Pleasant Echo, San Jose, Calif. 95148

[21] Appl. No.: **08/587,731**

[22] Filed: **Jan. 19, 1996**

[51] **Int. Cl.**[6] **G06F 165/00**; H04N 7/18

[52] **U.S. Cl.** **701/120**; 701/2; 701/24; 244/189; 244/190; 348/114

[58] **Field of Search** 364/423.099, 424.012, 364/424.013, 424.021, 424.022, 449.2, 449.7, 460, 439, 424.028; 340/825.69, 825.72, 967, 989, 991, 992, 993; 244/189, 190, 181, 17.13, 3.11, 3.15; 348/42, 51, 113, 114, 117, 123, 143; 382/154; 395/118, 119, 125

[56] **References Cited**

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4,760,396	7/1988	Barney et al.	342/65
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5,086,396	2/1992	Waruszewski, Jr.	364/454
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5,179,638	1/1993	Dawson et al.	395/125
5,240,207	8/1993	Eiband et al.	364/423.099
5,257,347	10/1993	Busbridge et al.	395/129
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5,406,286	4/1995	Tran et al.	342/13
5,446,666	8/1995	Bauer	364/434
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"US GeoData Digital Line Graphs", U.S. Dept. of the Interior, U.S. Geolg. Surv. Earth Sci. Info Ctr. (Factsheet) Jun. 1993.

"US GeoData Digital Elevation Models", U.S. Dept. of the Interior. U.S. Geolg. Surv. Earth Sci. Info Ctr. (Factsheet) Jun. 1993.

Shifrin, Carole A., "Gripen Likely to Fly Again Soon," *Aviation Week & Space Technology*, Aug. 23, 1993, pp. 72–73.

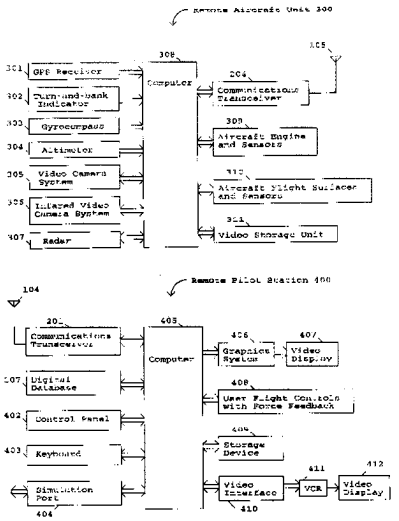
Primary Examiner—Tan Q. Nguyen

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor and Zafman LLP

[57] **ABSTRACT**

A method and apparatus that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft. According to one aspect of the invention, a remote aircraft transmits its three-dimensional position and orientation to a remote pilot station. The remote pilot station applies this information to a digital database containing a three dimensional description of the environment around the remote aircraft to present the remote pilot with a three dimensional projected view of this environment. The remote pilot reacts to this view and interacts with the pilot controls, whose signals are transmitted back to the remote aircraft. In addition, the system compensates for the communications delay between the remote aircraft and the remote pilot station by controlling the sensitivity of the pilot controls.

20 Claims, 7 Drawing Sheets



GA Riding 'Highway-in-the-Sky'

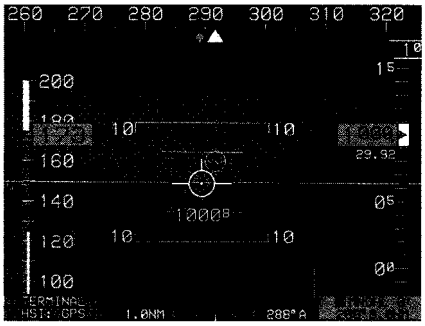
General aviation sector reaps the benefits of research originally conducted for military, commercial transport cockpits

BRUCE D. NORDWALL/WASHINGTON and OKLAHOMA CITY

General aviation aircraft are finally catching up with some of the advances found in the latest commercial transports and military cockpits, and in one particular sphere—display innovations—GA is actually taking the lead.

Researchers in industries and universities around the world have been pursuing a more intuitive guidance display for pilots for years. In general, this elusive presentation is referred to as highway-in-the-sky (HITS) (*AW&ST* Apr. 20, 1998, p. 58). In a twist that may foreshadow future advances, it was a general aviation aircraft that received the FAA's first certification of HITS technology for navigation guidance.

Instead of following course deviation indicators and altimeters, a pilot using this HITS presentation flies through a series of 3D boxes on a multifunction display. By maneuvering through the 400 X 320-ft. boxes spaced at 2,000-ft. intervals along the planned GPS route of flight, the pilot keeps the aircraft on course and altitude, which is particularly helpful for a descending, curved instrument approach.



Flying through "boxes in the sky" keeps pilots on course and altitude during a simulated curved instrument approach down the mountainous Gastineau Channel to Juneau, Alaska.

L.A.B. Flying Service's Piper Seneca made the first commercial revenue flight using HITS in Juneau, Alaska, on Mar. 31. It followed an optimized area navigation (RNAV) route through airspace that would be inaccessible with conventional avionics.

The system was built by Chelton Flight Systems as part of the second

phase of the imaginative Capstone program, an FAA industry/academic partnership in Alaska. The cockpit employs a Chelton FlightLogic electronic flight information system-synthetic vision (EFIS-SV) using two glass displays, one for primary flight guidance and one for navigation.

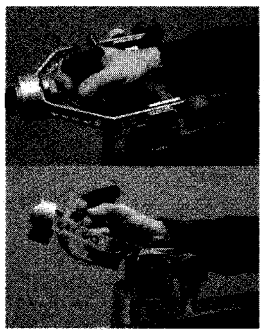
The big innovation is the use of synthetic vision symbology to present information to pilots. The initial EFIS systems digitally replicated the rudimentary attitude and flight-director symbols of electro-mechanical instruments from an earlier era. Now, in addition to the flight path, pilots see a real-time 3D view of the terrain and obstacles on the primary flight display. These are complemented by a moving map on the navigation display and by aural terrain warnings.

Among the other "firsts" claimed by Capstone Phase II on the Juneau flight were the use of forward-looking 3D terrain and HUD symbology on a certified primary flight display, and commercial use of the GPS wide-area augmentation system (WAAS).

Capstone has equipped three aircraft in Alaska with the Chelton Flight Systems' cockpit, and plans to outfit every commercial operator in SE Alaska within the next 18 months. The contract for 125 aircraft could expand to up to 200, according to Gordon Pratt, Chelton's president. The FAA is providing the equipment at no charge in Alaska to any commuter and on-demand (FAA Part 135) operator of fixed-wing aircraft or helicopters. A supplemental type certificate for helicopters was scheduled to be delivered on May 31. An additional 10 aircraft are being outfitted in the contiguous U.S., Pratt said, but at the expense of aircraft owners.

The first phase of the Capstone Program started as a demonstration that equipped a number of commuter and air taxi aircraft in the Yukon-Kuskokwim River delta area with a low-cost GPS, a terrain database, data link and Automatic Dependent Surveillance-Broadcast (ADS-B) equipment (*AW&ST* Sept. 18, 2000, p. 68). With GPS as the enabling technology, that phase indicated that a low-cost system could give bush pilots many of the safety benefits long-standard for commercial jet transports. The emphasis was on reducing controlled flight into terrain accidents for these pilots, who usually operate out of the range of navigation aids or radar help from ATC. Phase II with HITS and synthetic vision greatly expands those capabilities.

The navigation display shows GPS WAAS position and an approach not possible with conventional navigation aids due to a 20-30-deg. turn after the GASTN waypoint to align with the runway.



CAMI tested a four-axis side-arm controller in a simulator as a replacement for stick and throttle in a fly-by-wire performance control system.

The next major safety enhancement for GA aircraft could come from "performance control," according to Dennis B. Beringer, lead scientist for flight deck research at the FAA's Civil Aeromedical Institute (CAMI) in Oklahoma City. While known more for assisting FAA's Aircraft Certification Service and Flight Standards in defining requirements for both aircraft and pilots, CAMI is also an active partner in human factors research to improve cockpits.

With **performance control,** non-pilots could learn to fly a *simulator in 15 min.*

The performance-control concept was introduced in the 1970s, before electronics were sufficiently advanced for implementation. Beringer said that now some of the fly-by-wire military and commercial aircraft use what could be legitimately called performance-control logic, which not only make aircraft easier to fly, but can also add flight envelope protection.

With conventional flight controls, a pilot has direct command of the aerodynamic surfaces. With performance control, his movements would be transmitted via a fuzzy-logic controller to a flight management system or an auto pilot that would guide the aircraft to carry out the desired performance goal. But unlike a simple autopilot, which directs a change in heading at a limited rate of turn, performance-control logic changes control laws so that a pilot commands the rate of turn and bank, and rate of climb or descent. It simplifies command of more complicated maneuvers, and is a compromise between automated maneuvering and manual flight control, Beringer said. Safety is further enhanced using a self-centering (spring-loaded) side stick which returns to the centered position when the pilot relaxes pressure, thus bringing the aircraft to straight and level flight.

The reduced number of control movements is one reason flying is easier. Going into a turn with conventional controls, the pilot has to initiate the roll, and then neutralize the ailerons when he achieves the desired bank angle. But with performance controls, one movement establishes the desired bank angle/turn rate. One downside to performance control with envelope protection is the inability to do aerobatics, such as an aileron roll or loop, Beringer said.

In the four-axis side-arm controller (above), rotating the wrist governs the rate of turn, flexing the wrist vertically directs the rate of climb or descent, and fore and aft movement varies the airspeed. Interest in performance controls was renewed with NASA's Agate (Advanced General Aviation Transport Experiments) program, which was concerned with simplifying the flight task and reducing ab initio training requirements. Agate has also been a strong supporter of HITS.

Researchers had previously found that with performance control, non-pilots could learn to fly a simulator in 15 min. Beringer tested the system in a simula-

tor configured as a Piper Malibu at CAMI. It used HITS displays and a four-axis side-arm controller. Twenty-four individuals with varying flight experience participated: six high-flight-time pilots; six low-flight-time pilots; six student pilots, and six non-pilots. Each flight involved a takeoff into instrument conditions, a continuous climb while turning downwind, a turn to intercept the instrument landing system glidepath, and a descent to landing. Flights were divided between use of a conventional yoke and the side-arm controller.

The findings were consistent. The aircraft was more stable and had less variations in course and altitude using performance control than with conventional controls. Although experienced pilots always outperformed less-experienced individuals, with either system, all agreed the effort required was nearly halved.

The big innovation is use of synthetic vision symbology

Performance control is not apt to be seen in Piper Cubs, but perhaps in Beech Bonanzas and Piper Malibus. A lot of them already have two- or three-axis autopilots, so a significant capability could be achieved by rigging a side-stick control to the autopilot, Beringer said.

But two large problems must be overcome for performance controls to appear in the next generation of GA aircraft. The first is cost. Affordable and certifiable computer controls and servos would have to drop to a level competitive with more conventional systems.

Second, a fly-by-wire debate must be resolved. Could an affordable system be built with sufficient reliability using triple- or quad-redundancy, or would a costly manual-reversion be required? A mechanical backup would add cost for installation and for training pilots to operate the two systems.

Complicating that issue is the question of the level of reliability required. The FAA's current standard for a flight-critical system is a failure rate of 10^{-9}. While this is a standard for NASA, it might not be reasonable for general aviation aircraft. Beringer points out that the failure rate for humans is about 10^{-3}.