Reference 1 (1 Page)

National Aeronautics and
Space Administration

Langley Research Center

[redacted] b(6)

May 14, 2003

Reply to Attn of: 212

Jed Margolin
[redacted] b(6)

Subject: Infringement Inquiry

Dear Mr. Margolin,

I received notice of your belief that NASA may have infringed one or more of your U.S. patents. In order to address your concerns, we need to receive some more detailed information. Please provide the titles and patent numbers of any patents you feel NASA may have infringed. Please also provide a description of any actions by NASA leading to your belief of possible infringement. Finally, please specify in detail how those actions constitute infringement of your patent(s). This information will allow us to evaluate your assertion and respond and/or react appropriately. Thanks for contacting us. I look forward to hearing from you soon, and discussing your concerns further.

Cordially,

Barry V. Gibbens
Patent Attorney
Technology Commercialization
Program Office

(30009174 1)

Reference 2 (4 Pages)

Jed Margolin [redacted] ***Email:*** [redacted] [redacted]

May 18, 2003

Mr. Barry V. Gibbens
National Aeronautics and Space Administration
Langley Research Center
[redacted]

b(6)

Attn: 212

Dear Mr. Gibbens,

This is in response to your letter dated May 14, 2003.

As we discussed in our telephone conversation on May 16, the information you have requested was supplied in my email to Mr. Kurt Hammerle on May 12, 2003.

After I emailed my inquiry to Mr. Jesse Midgett on May 12, I discovered the web page for the Patent Counsel Office and contacted Mr. Hammerle by telephone.

I apologize for any confusion this may have created.

As a result of more searching I have discovered a link to a Johnson Space Center SBIR Phase II award to Rapid Imaging Software 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 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.
[redacted]

b(6)

Mike Abernathy [redacted]
Integrated Video for Synthetic Vision Systems

For 2001 Phase II:

Rapid Imaging Software, Inc.
[redacted]
b(6)
Carolyn Galceran [redacted]
Integrated Video for Synthetic Vision Systems

If there is any additional information regarding my patents that you would find helpful please let me know.

Sincerely yours,

Jed Margolin

Jed Margolin

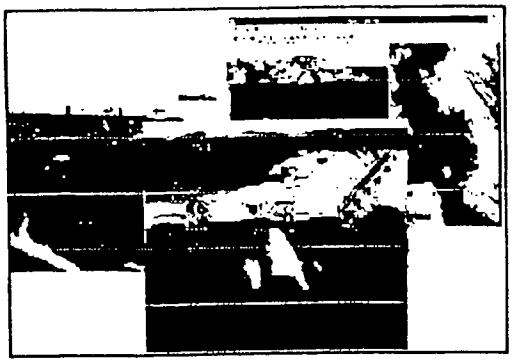
NASA SBIR SUCCESSES

Johnson Space Center
1998 Phase II

LandForm VisualFlight™

Rapid Imaging Software, Inc.

Alberqueque, NM



Optional Powerpoint file

INNOVATION

LandForm VisualFlight™ is the power of a geographic information system (GIS) and the speed of a flight simulator, accessible from any Windows application.

ACCOMPLISHMENTS

- 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.
- AFVT will enhance the ability of analysts and operators to interact with large amounts of multidimensional data using the most natural paradigm available: 3D immersion. This operator/data interaction technology will be an advancement comparable to the invention of the Heads-Up Display (HUD). AFVT will move the HUD into the third dimension.
- A simplified user interface, it will fuse real-time 3D displays of terrain with digital maps, satellite data, vehicles, flight paths, and waypoints. This unique and innovative approach will build upon recent software technology research and development from Rapid Imaging Software. VisualFlight™ permits users to construct and deploy their own immersive multidimensional display applications on Windows-based computer platforms.

COMMERCIALIZATION

- VisualFlight™ is sold as a development kit starting with 5 run-time licenses. Users who wish to distribute more applications

GOVERNMENT/SCIENCE APPLICATIONS

- The firm's VisualFlight™ System was used to fly the X-38 on it's latest test flight. The flight vehicle was piloted by astronaut (Ken Ham) using LandForm VisualFlight

using LandForm VisualFlight™ technology can purchase additional run-time licenses as needed.

- VisualFlight™ 1.0 has been available to qualified users for several months now, and the response is excellent. VisualFlight™ has been deployed to display live real-time flight data broadcast over a network. Please visit this page for the latest VisualFlight™ developments.
- **LandForm V/O Video Overlay** plug-in for LandForm C3 or Flight Vision is available for the Matrox Corona board only. The price is $4995 for a # single users license. Site license is available for $6995.

system as his digital cockpit window.

For more information about this firm, please send e-mail to: company representative

Return to NASA SBIR Success Listings

Curator: SBIR Support

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NASA X-38

From Wikipedia, the free encyclopedia
(Redirected from X-38)

The **X-38 Crew Return Vehicle (CRV)** was a prototype for a wingless lifting body reentry vehicle that was to be used as a Crew Return Vehicle for the International Space Station (ISS). The X-38 was developed to the point of a drop test vehicle before its development was cancelled in 2002 due to budget cuts. [1]

Contents

- 1 History
- 2 Development
- 3 Design
- 4 Specifications
- 5 See also
- 6 Notes
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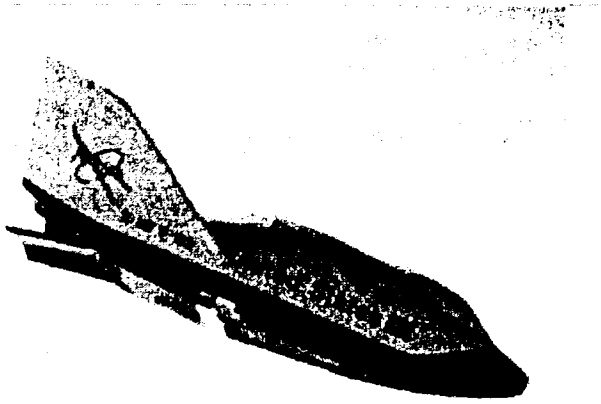
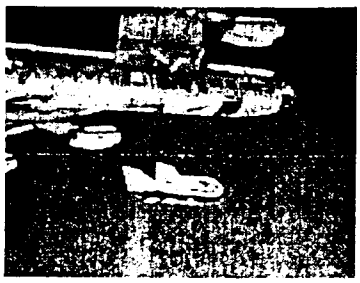
X-38



Role	Crew Return Vehicle
Manufacturer	Scaled Composites (prototypes)
First flight	1999
Status	Cancelled 29 April 2002
Primary user	NASA
Number built	2 atmospheric vehicles 1 orbital vehicle (incomplete)
Developed from	Martin-Marietta X-24

History

The crew size for the ISS depends upon the crew return capability: the crew is limited to three because the Russian Soyuz TMA vehicle that will remain docked to the ISS can only hold three people. Since it is imperative that the crew members be able to return to Earth if there is a medical emergency or if other complications arise, a Crew Return Vehicle able to hold up to seven crew members was planned from the outset: this would have allowed the full complement of seven astronauts to live and work onboard the ISS. NASA has designed several crew return vehicles over the years with varying levels of detail.[2]



The X-38 research vehicle drops away from NASA's B-52 mothership immediately after being released from the wing pylon

Development

X-38 was the program under leadership of NASA Johnson Space Center to build a series of incremental flight demonstrators for the proposed Crew Return Vehicle. In an unusual move for an X-plane, the program involved the European Space Agency and the German Space Agency DLR. It was originally called **X-35**. The program manager was John Muratore, while the Flight Test Engineer was future NASA astronaut Michael E. Fossum.

The X-38 design used a wingless lifting body concept originally developed by the U.S. Air Force in the mid-

1960s during the X-24 program, and it was Muratore's brainchild.

The X-38 program used unmanned mockups to test the CRV design. The flight models were:

- X-38 V-131
- X-38 V-132
- X-38 V-131R, which was the V-131 prototype reworked with a modified shell
- X-38 V-201, which was an orbital prototype to be launched by the Space Shuttle
- X-38 V-133 and V-202 were also foreseen at some point in the project but were never built.

The X-38 CRV prototype makes a gentle lakebed landing at the end of a July 1999 test flight at the Dryden Flight Research Center with a fully deployed parafoil.

The X-38 V-131 and V-132 shared the aerodynamic shape of the X-24A. This shape had to be enlarged for the Crew Return Vehicle needs (crew of seven astronauts) and redesigned, especially in the rear part, which became thicker.

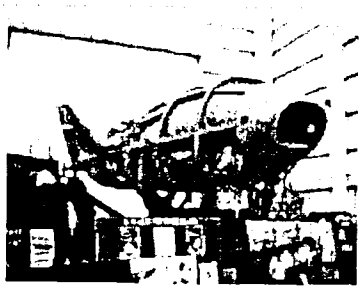
The X-38 V-131R was designed at 80 percent of the size of a CRV (24.5 ft long, 11.6 ft wide, 8.4 ft high), and featured the final redesigned shape (Two later versions, V-133 and V-201, were planned at 100 percent of th CRV size). The 80% scale versions were flown at 15,000 to 24,000 pound weight. The X-38 V-201 orbital prototype was 80 percent complete, but never flown.

In tests the V-131, V-132 and V-131R were dropped by a B-52 from altitudes of up to 45,000 ft (13,700 m), gliding at near transonic speeds before deploying a drogue parachute to slow them to 60 mph (95 km/h). The later prototypes had their descent continue under a 7,500 ft² (700 m²) parafoil wing, the largest ever made. Flight control was mostly autonomous, backed up by a ground-based pilot.

The X-38 project cancellation was announced on April 29, 2002 [1] due to budget concerns.

Design

Following the jettison of a deorbit engine, the X-38 would have glided from orbit and used a steerable parafoil for its final descent and landing. The high speeds at which lifting body aircraft operate make them dangerous to land. The parafoil would have been used to slow the vehicle and make landing safer. The landing gear consisted of skids rather than wheels: the skids worked like sleds so the vehicle would have slid to a stop on the ground.



X-38 V-201 test model located at Bldg. 220 at Johnson Space Center, Houston, Texas

Both the shape and size of the X-38 were different from that of the Space Shuttle. The Crew Return Vehicle would have fit into the payload bay of the shuttle. This does not, however, mean that it would have been small. The X-38 weighed 10,660 kg and was 9.1 meters long. The battery system, lasting nine hours, was to be used for power and life support. If the Crew Return Vehicle was needed, it would only take two to three hours for it to reach Earth.

The parafoil parachute, employed for landing, was derived from technology developed by the U.S. Army. This massive parafoil deploys in stages for optimum performance. A drag chute would have been released from the rear of the X-38. This drag chute would have been used to stabilize and slow the vehicle down. The giant parafoil — area of 687 square meters — was then released. It would open ir four stages (a process called staging). While the staging process only takes 45 seconds, it is important for a

04431

successful chute deployment. Staging prevents high-speed winds from tearing the parafoil.

The spacecraft's landing was to be completely automated. Mission Control would have sent coordinates to the onboard computer system. This system would also have used wind sensors and the Global Positioning System (a satellite-based coordinate system) to coordinate a safe trip home. Since the Crew Return Vehicle was designed with medical emergencies in mind, it made sense that the vehicle could find its way home automatically in the event that crew members were incapacitated or injured. If there was a need, the crew would have the capability to operate the vehicle by switching to the backup systems. In addition, seven high altitude low opening (HALO) parachute packs were included in the crew cabin, a measure designed to provide for the need to jettison the craft.

The fifth test drop flight of X-38. The aircraft is released from a B-52 mothership, free falls for a while, opens and fully deploys the parafoil and finally makes a gentle landing

An Advanced Docking Berthing System (ADBS) was designed for the X-38 and the work on it led to the Low Impact Docking System the Johnson Space Center later created for the planned vehicles in Project Constellation.

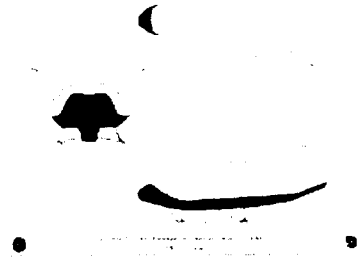
Specifications

See also

- Crew Return Vehicle
- International Space Station
- Lifting body

Related development

- Martin-Marietta X-24
- HiMAT Remotely Piloted Vehicle [1] (http://en.wikipedia.org/wiki/HiMAT)



3-View of the CRV, line art.

Comparable aircraft

- NASA M2-F1
- Northrop M2-F2
- Northrop M2-F3
- Northrop HL-10
- MiG-105

Notes

1. ^ *a b* "X-38 (http://www.fas.org/spp/guide/usa/launch/x-38.htm)". Federation of American Scientists. Retrieved on 2006-09-20.
2. ^ Marcus Lindroos. "NASA ACRV (http://www.astronautix.com/craft/nasaacrv.htm)". Encyclopedia Astronautica. Retrieved on 2007-01-05.

References

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- "NASA Dryden Fact Sheets (http://www.nasa.gov/centers/dryden/news/FactSheets/FS-038-DFRC.html)". NASA. Retrieved on 2006-09-13.
- "NASA - Current Research Projects - X-38 CRV (http://www.nasa.gov/centers/dryden/research/X38_Save/index.html)". NASA. Retrieved on 2006-09-13.
- "X38/CRV FDIR (http://ssrl.arc.nasa.gov/x38.html)". NASA's Smart Systems Research Lab. Retrieved on 2006-09-13.
- "Crew Return Vehicle (CRV) (http://www.esa.int/esaHS/ESARZS0VMOC_iss_0.html)". ESA. Retrieved on 2006-09-14.

External links

- NASA Dryden X-38 Photo Collection (http://www.dfrc.nasa.gov/Gallery/Photo/X-38/index.html)
- NASA Dryden X-38 Movie Collection (http://www.dfrc.nasa.gov/gallery/Movie/X-38/index.html)

Retrieved from "http://en.wikipedia.org/wiki/NASA_X-38"
Categories: Spaceplanes • Manned spacecraft • ISS service spacecraft • United States experimental aircraft 1990-1999 • Lifting body aircraft
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Date: 05/16/2003

Patent Number: 5904724
File History

Comments: Overnight Courier

Address: Kelly Wright
NASA Langley Research Center
Office of Patent Counsel
[redacted] (6)

Telephone Number: [redacted]

08/587,731

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN J	002055.P004

PM21/0504

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EXAMINER	
NGUYEN, T	
ART UNIT	PAPER NUMBER
3614	11

DATE MAILED: 05/04/98

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Tan Nguyen

TAN Q. NGUYEN
PATENT EXAMINER

04444

PTO-90C (REV. 2/95)

1-File Copy

☆U.S.GOVERNMENT PRINTING OFFICE 1995-319-826

Office Action Summary	Application No. 08/587,731	Applicant(s) MARGOLIN
	Examiner TAN Q. NGUYEN	Group Art Unit 3614

☒ Responsive to communication(s) filed on 3/2/98 .

☒ This action is FINAL.

☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire THREE month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) 1-9, 12-18, 21-38, and 50-53 is/are pending in the application.

Of the above, claim(s) _____ is/are withdrawn from consideration.

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) 1-9, 12-18, 21-38, and 50-53 is/are rejected.

☐ Claim(s) _____ is/are objected to.

☐ Claims _____ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on _____ is ☐approved ☐disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) _____ .

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: _____ .

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☐ Notice of References Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). 9

☐ Interview Summary, PTO-413

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

DETAILED ACTION

Notice to Applicant(s)

1. This office action is responsive to the amendment filed on March 02, 1998. As per request, claims 10, 11, 19 and 20 have been canceled. Thus, claims 1, 2, 14, and 24 are amended. Claims 50-53 have been added. Thus claims 1-9, 12-18, 21-38 and 50-53 are pending.

2. The prior art submitted on March 02 has been considered.

Drawings

3. The drawings are objected to under 37 CFR § 1.84 for the reasons set forth by the draftsman. See attached PTO-948 form for details. Correction is required. However, correction of the noted defect can be deferred until the application is allowed by the examiner.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 1-9, 14-18, 23-38, and 50-53 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Lyons et al. (an article entitled "Some Navigation Concepts For Remotely Piloted Vehicles", AGUARD Conference Proceedings No. 176 on Medium Accuracy Low Cost Navigation, September 1975, pages 5-1 to 5-15) in view of Wysocki et al. (5,381,338) or Fant (4,835,532) or Beckwith et al. (4,660,157), and further in view of Kanaly (4,405,843).

a. With respect to claims 1 and 14, Lyons et al. disclose the invention as claimed (see at least the abstract) including a remotely piloted aircraft (see figure 8, RPV), a communications system for communicating flight data between a computer and said remotely piloted aircraft, said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft (see page 5-2, section Radio Navigation Using

a Data Link, and figure 6 and the related text), a digital database comprising terrain data (see pages 5-3 and 5-4, section Terrain Map Correlation; and figure 8). Lyons et al. further disclose that the computer accesses said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide a projected image data according to said remotely piloted aircraft's orientation; a display for displaying said projected image data (see page 5-4, third paragraph, and figure 8), and a remote flight control coupled to said computer for inputting said flight control information (see figure 6).

Lyon et al. do not explicitly disclose that the computer produce a three dimensional image data from the digital database and the navigation information. However such feature is well known at the time the invention was made (for examples, see columns 6, 8; figure 1 and the related text in Wysocki et al.; see figures 1, 3 and the related text in Fant; or see figures 1, 4 and the related text in Beckwith et al.). It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of either Wysocki et al., Fant, or Beckwith et al. into the system of Lyon et al. in order to improve the system with the enhanced capability of displaying three-dimensional image of the remoted aircraft over the terrain data.

Lyons et al. disclose the claimed invention as discussed above except for the determination of a delay time for communicating said flight data between said

computer and said remotely piloted aircraft, and adjusting the sensitivity of said set of one or more remote flight controls based on said delay time. However, Kanaly does suggest delay time for communicating between the ground station and the remote airborne into account of controlling the remote airborne (see at least column 3, lines 15-24, and column 8, line 54 to column 9, line 6). It would have been obvious to incorporate the teaching of Kanaly into the system of Lyons et al. in order to improve the system with the enhanced capability of providing more accurate the remote flight controls to the remoted vehicle and receiving the accurate position and heading data of the vehicle from the remoted vehicle.

Thus, because of the motivation set forth above, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to combine the teachings of Lyon, Kanaly, with either Wysocki et al., Fant, or Beckwith et al.

b. With respect to claims 2, 50, and 51, Kanaly discloses that the remotely piloted aircraft includes a device for capture image data (see figure 3, item 74) and the image data is stored in the memory (see figure 3, item 21 and the related text).

c. With respect to claim 3, Lyons et al. disclose that the flight data communicated between said remotely piloted aircraft and said computer is secured (see page 5-2, first paragraph of the Radio Navigation Using Data Link section).

d. With respect to claims 4, 5, 7, and 15, Lyons et al. disclose that said

remotely piloted aircraft further comprises a infra red sensor image (video camera) and means for communicating and displaying video data representing images captured by the sensor image (see page 5-3, section Map Matching, and figure 8).

e. With respect to claims 6 and 16, Lyons et al. disclose that the video data is transmitted on a different communication link (wideband transmission of video signals) than said flight data (see page 5-2, first paragraph of section Radio Navigation Using a Data Link).

f. With respect to claims 8 and 17, Lyons et al. disclose that the display is a head mounted display (see figures 5 and 6).

g. With respect to claims 9 and 18, Lyons et al. also disclose that the remote flight control is responsive to manual manipulations (see figure 6).

h. With respect to claim 23, Lyons et al. disclose that the communications unit includes at least one of a communications transceiver and a simulation port (see page 5-4 and figure 6).

i. With respect to claim 24, Lyons et al. further disclose that the database representing terrain using polygons (see figure 10).

j. With respect to claims 25-28 and 30-31, the limitations of these claims have been noted in the rejection above. They are therefore considered rejected as set forth above.

k. With respect to claim 29, wherein said video data is transmitted real-time (see page 5-3, first paragraph of the section Map Matching).

l. Claims 32-38 and 52 are method claims corresponding to apparatus claims 24-31. Therefore, claims 32-38 and 52 are rejected for the same rationales set forth for claims 24-31.

m. With respect to claim 53, Kanaly disclose the step of receiving the input representing a current position of a directional control. The step of interpreting the current position relative to the horizon is not mentioned. However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to interpret the current position relative to the horizon since it is well known for the control instrument as shown in the figure 1 can be performed such function.

6. Claims 12-13, and 21-22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyons et al., Wysocki et al. or Fant or Beckwith et al., and Kanaly as applied to claims 1-9, 14-18, 23-38, and 50-53 above, and further in view of Thornberg et al. (5,552,983).

Lyons et al. disclose the claimed invention as discussed above except that the remote flight controls allows for inputting absolute pitch and roll angles. However, such feature is well known in the art at the time the invention was made. For example,

Thornberg et al. suggest a variable referenced control system for remotely operated vehicles which includes means for inputting absolute pitch and roll angles for remotely control the unmanned aerial vehicle (see at least figures 5 and 6). It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Thornberg et al. into the system of Lyons et al. in order to input the pitch and roll control signals as the flight control signals for remotely control the vehicle.

7. All claims are rejected.

Remarks

8. Applicant's arguments filed on October 27, 1997 have been fully considered but they are not deemed to be persuasive. Upon amended claims, the newly added claims, and the updated search, the new ground of rejections has been set forth as above.

9. In the amendment, applicants essentially argue that the Lyon reference "fails to teach more than just the generation of the 3D image". However, upon examination of the claims, the references cited clearly cover the subject matter AS CLAIMED by the applicants. Therefore, the rejection under 35 U.S.C. § 103 is considered to be proper.

10. Applicants also argue that none of Lyons, Wysocki, Fant or Beckwith generate a projected image using polygons. Applicant's attention is directed to figure 10 of the Lyon reference in which it discloses that the terrain model includes a plurality of polygons and in figure 1, 3, 5, and column 5, lines 42-49 of the Fant reference do suggest such feature.

11. Applicants further argue that the references cited do not disclose the determining of the delay time for communication. Applicant's attention is directed to column 8, line 54 to column 9 line 35 in which it disclose such feature. Therefore, the new rejection made is considered to be proper.

12. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of

the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Tan Nguyen, whose telephone number is (703) 305-9755. The examiner can normally be reached on Monday-Thursday from 7:30 AM-5:00 PM. The examiner can also be reached on alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, William Cuchlinski, can be reached on (703) 308-3873.

Any response to this action should be mailed to:

Box AF

Commissioner of Patents and Trademarks
Washington, D.C. 20231

or faxed to:

(703) 305-7687, (for formal communications, please mark "EXPEDITED PROCEDURE"; for informal or draft communications, please label "PROPOSED" or "DRAFT")

Hand-delivered responses should be brought to Crystal Park II, 2121 Crystal Drive, Arlington, VA., Sixth Floor (Receptionist).

Tan Nguyen

TAN Q. NGUYEN
PATENT EXAMINER

/tqn
May 01, 1998

Art Unit 3614

002055.P004 Patent

OIPE JUL 09 1998 JC24 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE #12 Req for Recon 7/13/98

98 JUL 13 AM 9:31 RECEIVED TECHNOLOGY CENTER 3600

In re Application of:
Jed Margolin

Serial No. 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft

Examiner: T. Nguyen

Art Unit: 3614

RESPONSE UNDER 37 C.F.R. § 1.116 -- EXPEDITED PROCEDURE -- EXAMINING GROUP 3614

Assistant Commissioner for Patents
Washington, D.C. 20231

RESPONSE UNDER 37 C.F.R. § 1.116
EXPEDITED PROCEDURE -- EXAMINING GROUP 3614

Sir:

Responsive to the Office Action mailed on May 4, 1998, the Applicant respectfully requests reconsideration of this application in view of the following remark:

35 U.S.C. §103 rejection, over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Kanaly

The Examiner has rejected Claims 1-9, 14-18, 23-38, and 50-53 under 35 U.S.C. §103 as being obvious over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Kanaly.

FIRST CLASS CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail with sufficient postage in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231 on July 6, 1998
(Date of Deposit)

Conny Van Dalen
Name of Person Mailing Correspondence

Conny Van Dalen
Signature

7-6-98
Date

04455

As described in more detail below, the Office Action: 1) either clearly misdescribes Kanaly or clearly asserts an improper rejection regarding Kanaly; and 2) clearly misdescribes Lyons in stating that Lyons describes an RPV that communicates "flight data ... including said remotely piloted aircraft's position" (see Office Action page 3). In addition, Applicant submits that Lyons in view of Wysoki or Fant or Beckwith, and further in view of Kanaly does not teach the claimed invention

In order to address the numerous references used to support this rejection, Applicant discusses Kanaly; then Lyons; then the combination of Lyons and Kanaly and Wysoki or Fant or Beckwith; and finally why Applicant's claimed invention is not obvious over the asserted combination.

1) The Office Action either Misdescribes Kanaly or Asserts an Improper Rejection Regarding Kanaly

The Office Action states that Lyons does not disclose "the determination of a delay time for communicating said flight data between said remotely piloted aircraft, and adjusting the sensitivity of said set of one or more one or more flight controls based on said delay time." (see Office Action page 5) Then, the Office Action states that Kanaly "does suggest delay time for communicating between the ground station and the remote airborne into account of controlling the remote airborne." Id. Either, the Office Action is: 1) incorrectly asserting that Kanaly teaches that the computer monitors the time delay and adjusts the sensitivity of the controls; or 2) asserting an improper rejection because "the prior art reference (or references when combined)" do not "teach or suggest all the claim limitations," but rather teach away.

a) Assuming the Office Action is Asserting that Kanaly Describes Monitoring the Time Delay for Communication and Adjusting the Sensitivity of the Controls Based on the Measured Time Delay

Kanaly basically teaches the inclusion of a buffer in a remotely piloted vehicle to store high resolution image data to mask the time delay for slewing a camera.[1] However, Kanaly does **not** describe that the pilot station computer determine the time delay for communication and adjust the sensitivity of the controls accordingly. In particular, the Office Action cites the following two sections of Kanaly to support the rejection:

> It also substantially increases the speed of operation of the system. Namely, a considerably shorter period of time is required to simply fetch data from memory, as compared to having to slew the camera, as in the prior art system described above. The savings in time in fetching the data from the memory permits the use of more time for digitizing , formatting, processing, etc. without delaying the image so much as to be noticeable by the console operator. (col. 3, lines 15 - 24). (emphasis added)

The above quote deals with the delay resulting from having to slew the camera, not from the communications delay.

> At the ground station the incoming signals are down converted and demodulated from transceiver 54 and modem 51 equipment to obtain display control signals. The display control signals are used to control the scanning of the image pixels of the display 31, so as to generate high resolution data only at the portion corresponding to point of observation of the operator 10 and equated with that particular portion of the overall scene data stored in memory 21 aboard the remotely piloted vehicle. It has been found that the time delay from a step change in look angle by the

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[1] Kanaly deals with a system in which a remote operator wears a helmet (on which an oculometer is mounted) that determines where the remote operator is looking. Signals indicating where the remote operator is looking are sent to the RPV. The RPV includes a camera. The prior art system over which Kanaly distinguishes is one in which the camera on the RPV provides high resolution data in the center and low resolution data on the periphery. As a result, the prior art system must move the camera in response to the remote operator's movements. This camera movement introduces a delay in the image provided to the remote operator.

To reduce or remove this delay (not measure it or adjust flight controls) due to movement of the camera, Kanaly teaches having the camera store high resolution data over the whole scene in a memory on board the RPV. The RPV transmits the high resolution imagery corresponding to the center of where the remote operator is looking and low resolution imagery (based on the stored high resolution data) corresponding to the remote operator's peripheral vision. As a result, movement of the remote operator's head merely requires the RPV adjust from where in the memory the high and low resolution data is accessed - the camera need not be moved. "Because the high resolution data is obtained from memory and not from the camera equipment directly, as in the prior art, the scheme in accordance with the present invention permits the camera to be effectively decoupled from the data link." (see col. 2, line 56 - col. 3, line 24; col. 8, line 54 - col. 9, line 6).

> operator 10 to a look angle correction by the oculometer 33 and changes to a new location in memory 21 from which new high resolution data is to be read out and its subsequent transmission and appearance on the display device 31 as high resolution imagery data may be less than 0.2 seconds using present day modulation and transmission rates. This minimum time delay is substantially less than the approximate 0.5 seconds required normally by the human eye before the operator becomes aware of the high resolution data that he is viewing. (col. 8, line 54 to col. 9, line 6).

The above quote merely indicates that it takes 0.2 seconds to perform the following: "a look angle correction by the oculometer 33," "changes to a new location in memory 21 from which new high resolution data is to be read out," "its subsequent transmission," and "its appearance on the display." Thus, Kanaly is discussing the delay of the overall system and how it has been improved, not the specific time delay required for communication from the RPV to the pilot station. In addition, Kanaly just recognizes that there is delay and that the delay is not perceptible to the human eye (In fact, Kanaly states that the required "0.2 seconds" is "substantially less" "than the approximate 0.5 seconds required normally by the human eye"). Since Kanaly's delay is not perceptible to the human eye, it is not at all surprising that no where in Kanaly is the idea of having the computer in the pilot station measure the delay and adjust the sensitivity of the controls. As such, Kanaly teaches away from the claimed invention by teaching that the delay is not perceptible to the human eye.

b) Assuming the Office Action is Improperly basing the Rejection on the Mere Fact that Kanaly indicates that there Exist Delay in His System, and that Part of that Delay is Due to Transmission of Data

The second quote from Kanaly reproduced above clearly indicates that Kanaly has determined that the delay associated with "a look angle correction by the oculometer 33," "changes to a new location in memory 21 from which new high resolution data is to be read out," "its subsequent transmission," and "its appearance on the display" is less than 0.2 seconds. This provides no support for the rejection.

According to M.P.E.P. § 2142:

> [t]o establish a primary facia case of obviousness, ... the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claim combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure." (emphasis added).

The determination by Kanaly that the delay time for his overall system is imperceptible by the human eye does not even come close to teaching or suggesting the claimed limitation of having the computer in the pilot station measure the time delay, much less doing anything about that time delay (e.g., adjusting the sensitivity of the controls). In fact, Kanaly indicates that the delay is imperceptible (0.2 is "substantially less" than 0.5 seconds), and thereby indicates no need to do anything about the delay. Thus, if the Office Action is asserting that the mere fact that Kanaly has determined a static time of 0.2 seconds for his system and that this time is imperceptible to the human eye as teaching or suggesting the claimed limitations, the rejection is improper because claim limitations that are not taught or suggested by Kanaly are being ignored. In fact, Kanaly teaches away from the claimed invention by teaching that the delay is not perceptible to the human eye.

2) The Office Action Misdescribes Lyons

Although Lyons has been extensively described in Applicant's prior responses and discussed at length in an interview, the Office Action continues to assert that Lyons describes the transmission of flight data from the aircraft, where that flight data includes the aircraft's position. This is clearly not the case.

Lyons teaches the use of dead reckoning.[2] Dead reckoning is the determination of an **estimated** or dead reckoned position that is based on various elements (including

[2] In summary, the Lyons reference teaches various techniques for updating the dead reckoned position of remotely piloted aircraft on a two dimensional moving map display available to the pilot. In particular, Lyons contemplates a RPV transmitting information to a control center (Figure 1). The control center is used by the pilot to fly the RPV. To display the position of the RPV to the pilot, the control center provides a "moving map display." As contemplated by Lyons, "the most convenient display mode for the present application is the rolling map or 'passing

scene' technique where a new line is added to the top of the display and the scene is shifted slowly downwards" (page 5-3, end of first full paragraph). In particular, Lyons contemplates using film to generate the moving map (Figure 5). The moving map is moved based on the dead reckoned positions of the RPV.

As is well known in the art, dead reckoned positions have accumulating error. To adjust for this error, Lyons describes two basic concepts: 1) map matching (Section 3); and 2) terrain map correlation (Section 4). The map matching concept requires that the RPV transmit some kind of image data to the control center. In Figure 6, the control center is shown having the moving map display and the sensor display (i.e., a display generated from the image data transmitted by the RPV). Lyons contemplates the transmission of two kinds of image data: 1) side looking radar (SLR); and 2) real time forward-looking sensors. When using the SLR system, the SLR generated image data received by the control center allows it to make a downward-looking image. The pilot watches the sensor displuy (i.e., the display generated based on the transmitted image data) for "likely update features"—landmarks. When the pilot sees a landmark in the sensor display, the pilot presses a transfer button which causes the control center to superimpose the sensor display over the moving map (Figure 5). The pilot then adjusts the moving map so that it matches the overlaid sensor display image and presses an accept button. By adjusting the moving map in this manner, the dead reckoned position of the RPV is updated in an attempt to remove the error associated with the calculation of dead reckoned positions (Page 5-3, second, third, and fourth full paragraphs). The simulated SLR/map update system is illustrated in Figures 7A and 7B.

Having described the SLR-based map matching technique, the real time forward-looking sensor technique will now be described. Lyons describes basically two techniques of updating dead reckoned RPV positions on a moving map using only real time forward-looking sensors: 1) an anamorphic projection technique (page 5-3, fifth full paragraph; figure 8); and 2) a HUD based technique (page 5-3, sixth full paragraph; figure 9). Similar to the SLR based technique, the anamorphic projection technique requires the pilot to watch the sensor display (i.e., the image generated from the transmitted data) for landmarks, press a button which superimposes the transmitted image on the moving map, adjust the moving map, and press an accept button. As described in Lyons, in order to superimpose the forward-looking transmitted image on the moving map, the forward-looking image is transformed using anamorphic projection. Lyons goes on to describe various problems with the anamorphic projection technique, and then describes the HUD based technique.

In the HUD based technique, the pilot is presented with two images: 1) the moving map display (see left-hand image of Figure 9); and 2) the sensor display generated from the image data transmitted from the real time forward-looking sensor on the RPV. The HUD technology is used to allow the pilot to mark landmarks on the forward-looking sensor based image. These HUD markings are then superimposed on the moving map, and the pilot makes the necessary adjustments to the moving map (page 5-3, sixth full paragraph).

In summary, the map matching techniques use the following: 1) the transmission of image data from the RPV to the control center; 2) a display at the control center which shows an image based on the real time image data received from the RPV; 3) a moving map display that is moved based on the dead reckoned position of the RPV; and 4) some manner of superimposing the sensor image onto the moving map to allow the pilot to update the moving map in an effort to correct the error associated with the dead reckoned positions. The sensor display's image is based on image data transmitted from the RPV, while the moving map contemplated by Lyons is a two-dimensional, top down view displayed using film (see Figures 5 and 7).

Having described the map matching techniques from Lyons, Applicant will now describe the terrain map correlation technique of Lyons. The terrain map correlation technique described in Lyons is also used for correcting the error in dead reckoned positions shown to the pilot by a two-dimensional moving map. In particular, Lyons states at page 5-3, last paragraph:

> Reconnaissance or forward-looking sensors provide a convenient method of updating the navigation system. However, these sensors required large datalink bandwidth to transmit the video picture to the control center and hence are vulnerable to ECM... Hence, an alternative method of updating the navigation system is desirable. (emphasis added)

The phrase "updating the navigation system" is used throughout Lyons to refer to the adjustment of a two-dimensional moving map in an effort to correct for error due to dead reckoning.

Rather than requiring the user to actively update the moving map display (i.e., push a button which causes the images to be superimposed, adjusting the moving map, and pushing an accept button), the terrain map correlation technique attempts to adjust the moving map (i.e., correct for the dead reckoned error) without pilot intervention using a laser range measurements and a digital elevation database. In operation, the RPV transmits to the control center a set of laser range measurements (including an altimeter reading). The control center uses dead reckoned positions to both adjust the two-dimensional moving map and to estimate the location of the RPV over a digital database map of elevation points stored in the control center (Figure 10). Based on a calculation of the possible error associated with the dead reckoned positions, a search area is identified in the digital database (Figure 12). A search is then performed within this search area to identify the position that most closely matches the transmitted laser range data. The RPV's position is then updated to the location that best matches the transmitted laser ranges in an attempt to correct the error associated with the dead reckoned positions. The moving map is then automatically adjusted (without pilot intervention) to reflect the updated RPV position.

speed, direction, etc), that has accumulating error, and that must be corrected before generating any image. As such, the Lyons paper discusses techniques for correcting or updating the dead reckoned positions. In particular, Lyons states "The objective is to make use of equipment normally carried for RPV operation to supplement a simple dead reckoning navigation system." (abstract).

In particular, Lyons describes transmitting laser measurements for updating the dead reckoned position. The pilot station determines error associated with dead reckoning; identifies a search area in the digital ELEVATION database based on the dead reckoned position - where the current dead reckoned position is the center of the search area ("expected RPV position" in Figure 12) and the search area represents the locations the RPV could be due to the accumulating error in the current dead reckoned position; compares the transmitted laser measurements for various positions in the search area in an effort to locate a corrected dead reckoned position of the RPV.[3]

In fact, Lyons states the following:

> This paper discusses methods by which the navigation function for a Remotely Piloted Vehicles (RPVs) can be achieved without the need for complex specialized navigation equipment. The objective is to make use of equipment normally carried for RPV operation to supplement a simple dead reckoning navigation system. In this way significant improvements in navigation capability can be achieved with little or no added complexity in the vehicle itself. The additional processing is carried out at the control centre where restrictions on equipment size and cost are not so prohibitive. (Abstract)

Thus, the digital database of Lyons (conceptually illustrated in Figure 10) is used to update the two-dimensional moving map in an effort to correct for the error in the dead reckoned positions.

[3] In addition, the office action cites pages 5-4, third paragraph, and Figure 8 as disclosing a single system that accesses a database based on the remotely piloted aircraft's transmitted position and orientation and transforms the terrain data into a projected image. However, Figure 8 is for a first system in which the RPV uses a "forward looking sensor" to transmit a video image and the pilot station uses anamorphic projection to overlay that image on a 2D moving map, which is not generated by transforming a database of polygons (see page 5-3, paragraph 6), while pages 5-4, third paragraph describe a second system in which the RPV transmits laser measurements in lieu of a video stream - Lyons describes the advantages of using one over the other.

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Again, none of the data transmitted by the RPV (whether it be flight data for dead reckoning, the dead reckoned position, nor the laser measurements) is the position of the aircraft; everything transmitted by Lyon's RPV is data used by the pilot station to determine a corrected dead reckoned position of the aircraft through complicated processing, which corrected dead reckoned position is used for display.

Now that Applicant has put forth a more correct reading of Lyons, Applicant will address what results from combining Lyons with Wysoki or Fant or Beckwith.

3) The combination of Lyons and Wysoki or Fant or Beckwith, in further view of Kanaly

Lyons describes that the remote pilot station displays to the remote pilot a two-dimensional moving map (which is not based at all on the digital elevation database) on which the position of the remote aircraft is indicated. In particular, Lyons uses the digital elevation database in the remote pilot station in conjunction with the laser measurements for automatically updating the dead reckoned position indicated on the two-dimensional moving map.

The Office Action asserts that the combination of Lyons and Wysoki or Fant or Beckwith would result in a system that produces "a three dimensional image data from the digital database and the navigation information." First, the claims are not that the image is generated from the digital database and some vague notion of "navigation information," but require that the **transmitted** position and orientation **be used to generate the three dimension image** (as stated above, Lyons describes a very different system in which the transmitted data is not used for image generation, but that the transmitted data goes through complicated processing to generate a corrected dead reckoned position and that it is the corrected dead reckoned position that is used for image generation). Thus, the Office Action's language is improperly disregarding limitations in the claims.

Second, the combination of Lyons Kanaly and Wysoki or Fant or Beckwith would result in a system according to the following table, where the addition of Kanaly for the purposes asserted by the Office Action would merely result in making a determination of the time delay of the entire system to illustrate that the combination is better than the prior art and/or fast enough not to be perceptible by the human eye.

Lyons in view of Wysoki or Fant or Beckwith, and further in view of Kanaly	Applicant's Invention
Aircraft transmits dead reckoning information	Aircraft determines its own position and orientation, and then transmits its own position and orientation
Aircraft transmits laser measurements for automatic dead reckoned position update	
Pilot station determines error associated with dead reckoning; identifies a search area in the digital database based on the dead reckoned position - where the current dead reckoned position is the center of the search area ("expected RPV position" in Figure 12) and the search area represents the locations the RPV could be due to the accumulating error in the current dead reckoned position; compares the transmitted laser measurements for various position in the search area in an effort to locate a corrected position of the RPV.	

As modified by Wysoki, Fant or Beckwith, the pilot station would then also transform the digital database relative to the corrected dead reckoned position to generate a three dimensional image.	The pilot station transforms the digital database relative to the position and orientation transmitted from the aircraft to generate a three dimensional image.
Knowing the time delay and that it is imperceptible to the human eye	The pilot station computer measuring the time delay to communicate with the aircraft (see claims 1 & 14)
	The pilot station computer adjusting the sensitivity of the controls based on the measured time delay (see claims 1 & 14)

Thus, the asserted combination would result in forgoing Lyon's two-dimensional map, and instead using Lyons digital database to generate a three-dimensional image (through some technique in Wysoki, Fant or Beckwith) relative to a corrected dead reckoned position. The above table is a fair read of the combination of Lyons and Wysoki or Fant or Beckwith because none of Wysoki or Fant or Beckwith describe a manner of piloting of a remotely piloted aircraft; in contrast Wysoki and Fant and Beckwith describe how to generate three dimensional images from various databases (none of which store the terrain as a set of polygons).

4) The Claimed Invention is Not Obvious in view of the combination of Lyons and Wysoki or Fant or Beckwith, and further in view of Kanaly

Clearly, the above table illustrates that the combination of Lyons and Wysoki, Fant or Beckwith does not describe Applicant's claimed invention. In particular, the combination of Lyons, Kanaly, and Wysoki or Fant or Beckwith results in a system that uses transmission of dead reckoning information by the aircraft, some mechanism in the

pilot station to correct the dead reckoned positions, and some scheme to generate images based on the corrected dead reckoned position.[4]

The laser measurement system of Lyons[5] relied on by the Office Action requires the use of "terrain-referenced navigation" - that is, Lyons describes searching an elevation database in a search area (based on the estimated error in the dead reckoned position) for a match to a set of elevation based laser measurements. Terrain-referenced navigation suffers from a number of disadvantages, including an inability to function over non-unique terrain (e.g., flat terrain such as deserts, water, etc.). For example, assume that Lyons RPV is flying over water. The three or more laser measurements taken by the RPV will all indicate that the terrain over which the RPV is flying is a relatively constant elevation. According to Lyons, the three or more laser measurements would be compared to locations in an estimated error region that is a relatively constant elevation because it maps a body of water. As such, the laser measurements can no longer be used to correct the dead reckoned position. In fact, Lyons states:

> Apart from the errors involved in the actual laser measurements the accuracy of terrain representation has a considerable influence on the feasibility of the method. In addition, the technique is ineffective over the sea or over flat, featureless terrain. (section 4). (emphasis added).

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[4] Lyons states the following:

> This paper discusses methods by which the navigation function for a Remotely Piloted Vehicles (RPVs) can be achieved without the need for complex specialized navigation equipment. The objective is to make use of equipment normally carried for RPV operation to supplement a simple dead reckoning navigation system. In this way significant improvements in navigation capability can be achieved with little or no added complexity in the vehicle itself. The additional processing is carried out at the control centre where restrictions on equipment size and cost are not so prohibitive. ... Use can also be made of an on-board laser to provide range-to-terrain measurements which, when correlated with a computer stored map, enables the RPV position to be continuously updated. (Abstract)

[5] Lyons describes basically two systems: 1) a higher bandwidth system that uses dead reckoning and transmits images from the RPV to the pilot station for updating the dead reckoned positions; and 2) a lower bandwidth system that also uses dead reckoning, but uses laser measurements for updating the dead reckoned positions. Unlike the former, Applicant's claimed system does not require the transmission of images to fly the aircraft and to correct dead reckoned positions, but has the remotely piloted aircraft determine and transmit its position and generates three-dimensional images from the database in the pilot station from that transmitted position. As described in the text, unlike the later, Applicant's claimed system does not use terrain-referenced navigation.

> Where the data link is limited in bandwidth the laser/terrain correlation technique should give good accuracy and the process could be completely automated to provide a continuous indication of RPV position. Disadvantages of the system are the large amount of data storage and computation necessary at the control centre, the development work required to produce an operational system and the unsuitability of the system over featureless terrain. (section 5). (emphasis added)

Applicant's claimed invention does not use Lyons dead reckoned positions that must be corrected in the pilot station using terrain-referenced navigation, but rather Applicant's claimed invention requires the remotely piloted aircraft determines and transmits its own position to the pilot station and that it is this transmitted position and orientation that is used to generate the three dimensional images (not an untransmitted corrected dead reckoned position). Again, the asserted combination results in a system in which the digital database in the pilot station is accessed based on the error associated with the dead reckoned position, and then the digital database is accessed using the correct dead reckoned position to generate the three dimensional image (in other words, the asserted combination does not generate the three-dimensional image using the position and orientation transmitted from the RPV; in contrast the asserted combination uses a corrected dead reckoned position that was not transmitted by the RPV). Thus, none of the data transmitted by the RPV (whether it be flight data for dead reckoning, the dead reckoned position, image data, or the laser measurements) is the position of the aircraft; rather, everything transmitted by Lyon's RPV is data used by the pilot station to determine a corrected dead reckoned position of the aircraft through complicated processing, which corrected dead reckoned position is used for display. Thus, Lyons teaches away from Applicant's claimed invention in that Lyon's "objective" is to put the onus of determining the position of the RPV on the pilot station to "supplement a simple dead reckoning navigation system," whereas Applicant's claimed invention puts the onus

of determining position on the remotely piloted vehicle and uses the transmitted position to generate the three dimensional image.

In particular, Applicant's claim 32 requires "determining the current position of said remotely piloted aircraft in three dimensions; ... communicating said current position .. from said remotely piloted aircraft to a pilot station; transforming said terrain data into image data representing a simulated three dimensional view according to the current position; displaying said simulated three dimensional view using said image data." Thus, Applicant's claim 32 requires that the three-dimensional image be produced from the TRANSMITTED position, not one that is corrected or updated using some laser measurement dead reckoning scheme. Since Applicant's claimed invention requires the remotely piloted aircraft to determine and transmit its own position to the pilot station and that it is this transmitted position and orientation that is used to generate the three dimensional images, Applicant's system provides an advantage over Lyons in that Applicant's system does not have difficulty over featureless terrain.

Furthermore, Claims 1 and 14 have additional limitations that the Office Action improperly asserts are found in Kanaly. The determination by Kanaly that the delay time for his overall system is imperceptible by the human eye does not even come close to teaching or suggesting the claimed limitation of having the computer in the pilot station measure the time delay, much less doing anything about it (e.g., adjusting the sensitivity of the controls). In fact, Kanaly indicates that the delay is imperceptible (0.2 is "substantially less" than 0.5 seconds), and thereby indicates no need to do anything about the delay. Thus, Kanaly teaches away from the claimed invention by teaching that the delay is not perceptible to the human eye. In contrast, the language of claims 1 and 14 requires that the computer in the pilot station determine the delay and adjust the sensitivity of the controls. If there was a static time delay in transmission and/or the delay was imperceptible, the sensitivity of the flight controls of Applicant's system could be permanently set. However, Applicant claim language requires that the computer in the

pilot station determine the time delay of the communication and adjust the sensitivity of the controls, thereby requiring at least one real time measurement of the delay and some adjustment.

Furthermore, Applicant's claims 24 and 32 require that the database store the terrain data as polygons. As previously described, none of art used in the rejection make use of a database that stores the terrain data as a set of polygons. In particular, Lyons describes the use of an Elevation Database in which each point represents an elevation. Although Figure 10 from Lyons shows (for illustrative purposes only because Lyons does not display an image from the database) lines connecting the elevation points, the points in an elevation database are not stored as polygons. While the images generated by Wysoki or Beckwith of Fant may look like one or more polygons, the terrain is not stored in their databases as polygons.[6] In contrast, Applicant's claim 24 requires the transmitted "position and orientation" be transformed "into a three dimensional projected image of said remotely piloted aircraft's environment according to a database representing real terrestrial terrain using polygons." Similarly, Applicant's claim 32 requires "accessing a database comprising terrain data that represents real terrestrial terrain as a set of polygons." Thus, claims 24 and 32 require that the database stores the terrain as polygons.

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[6] As described above, the data in the database of Lyons is not used to generate an image, but simply to update the dead reckoned position.

With respect to Beckwith, the digital elevation data in the database is points with a constant north up position, not polygons (see col. 6, lines 52-61; col. 7, lines 30-36).

Fant describes the use of two databases: 1) the object library database which contains real-world images; and 2) the gaming area database which provides the information necessary for the placement of the contents of the object library, surfaces, and special effect on a grid or gaming area (see col. 6, line 38 - col. 7, line 10). In particular, the Fant patent is for a high performance computer graphics system that combines Computer Generated Imagery (CGI) with Computer Synthesized Imagers (CSI) to form Computer Generated Synthesized Imagery (CGSI) (see col. 2, line 53 - col. 3, line 12).

Wysoki describes a database of digital orthophotographs (see col. 4, lines 43-51). Digital orthophotographs are computerized images generated by making geometric corrections to scanned aerial photographs. In particular, an aerial photograph contains some degree of distortion. In contrast, maps maintain a constant scale, but lack the detail of an aerial photograph. Orthophotography combines the features of maps and aerial photographs. The aerial photographs are unwrapped (to remove the distortion) and fitted to a particular map projection to create an image map that has uniform scale and known accuracy.

The remaining rejected claims are each dependent on one of the allowable base claims. For at least these reasons, Applicant respectfully request this rejection be withdrawn.

35 U.S.C. §103 rejection, over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Thornberg

The Examiner has rejected Claims 12-13 and 21-22 under 35 U.S.C. §103 as being obvious over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Thornberg.

Claims 12-13 and 21-22 are each dependent on one of the allowable base claims 1 and 14. For at least this reason, Applicant respectfully submits that claims 12-13 and 21-22 are allowable.

Conclusion

Applicant respectfully submits that the rejections have been overcome by the amendments and remarks, and that the Claims are now in condition for allowance. Accordingly, Applicant respectfully requests the rejections be withdrawn and the Claims as amended be allowed.

Drawing Corrections

The drawings have been objected to by the draftsman. The Applicant will file amended drawings at the time of allowance of the present application.

Invitation for a telephone interview

The Examiner is invited to call the undersigned at 408-720-8598 if there remains any issue with allowance of this case.

Charge our Deposit Account

Please charge any shortage to our Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: 7/6, 1998

Daniel M. De Vos
Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025-1026
(408) 720-8598

0447

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JUL 09 1998
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AF/2614

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Attorney's Docket No.: 002055.P004

Patent

In re the Application of: Jed Margolin
(inventor(s))

Application No.: 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft
(title)

AMENDMENT UNDER 37 C.F.R. § 1.116
EXPEDITED PROCEDURE

EXAMINING GROUP 3614

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ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231
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SIR: Transmitted herewith is an **Amendment After Final Action** for the above application.

_____ Small entity status of this application under 37 C.F.R. §§ 1.9 and 1.27 has been established by a verified statement previously submitted.
_____ A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27 is enclosed.
__X__ No additional fee is required.
_____ **A Notice of Appeal is enclosed.**

The fee has been calculated as shown below:

	(Col. 1) Claims Remaining After Amd.		(Col. 2) Highest No. Previously Paid For	(Col. 3) Present Extra
Total Claims	* 38	Minus	** 49	0
Indep. Claims	* 3	Minus	*** 5	0
	First Presentation of Multiple Dependent Claim(s)			

SMALL ENTITY		OTHER THAN A SMALL ENTITY	
Rate	Additional Fee	Rate	Additional Fee
x11	$ 0	x22	$
x41	$ 0	x82	$
+135	$ 0	+270	$
Total Add. Fee	$ 0	Total Add. Fee	$

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.

** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.

*** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space. The "Highest No. Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Col. 1 of a prior amendment or the number of claims originally filed.

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on July 6, 1998
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Conny VanDalen
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7-6-98
Date

(LJV/cak 10/25/96).

04471

_____ A check in the amount of $_____ is attached for presentation of additional claim(s).
_____ Applicant(s) hereby Petition(s) for an Extension of Time of _____ month(s) pursuant to 37 C.F.R. § 1.136(a).
_____ A check for $_____ is attached for processing fees under 37 C.F.R. § 1.17.
_____ Please charge my Deposit Account No. 02-2666 the amount of $_____.
A duplicate copy of this sheet is enclosed.
__X__ The Commissioner of Patents and Trademarks is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 02-2666 **(a duplicate copy of this sheet is enclosed)**:
__X__ Any additional filing fees required under 37 C.F.R. § 1.16 for presentation of extra claims.
__X__ Any extension or petition fees under 37 C.F.R. § 1.17.

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP

Date: 7/6, 1998

Daniel M. De Vos

Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025
(408) 720-8598

(LJV/cak 10/25/96)

08/587,731

UNITED STATES DEPARTMENT OF COMMERCE
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Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN J	002055.P004

PM21/0724

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

EXAMINER	
NGUYEN, T	
ART UNIT	**PAPER NUMBER**
3614	13

DATE MAILED: 07/24/98

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Tan Nguyen
TAN Q. NGUYEN
PATENT EXAMINER

04473

PTO-90C (Rev. 2/95)

☆U.S.GOVERNMENT PRINTING OFFICE 1998-411-818/40276

1- File Copy

Advisory Action

Application No.	Applicant(s)
08/587,731	MARGOLIN
Examiner	**Group Art Unit**
TAN Q. NGUYEN	3614

THE PERIOD FOR RESPONSE: [check only a) or b)]

a) ☒ expires *THREE* months from the mailing date of the final rejection.

b) ☐ expires either three months from the mailing date of the final rejection, or on the mailing date of this Advisory Action, whichever is later. In no event, however, will the statutory period for the response expire later than six months from the date of the final rejection.

Any extension of time must be obtained by filing a petition under 37 CFR 1.136(a), the proposed response and the appropriate fee. The date on which the response, the petition, and the fee have been filed is the date of the response and also the date for the purposes of determining the period of extension and the corresponding amount of the fee. Any extension fee pursuant to 37 CFR 1.17 will be calculated from the date of the originally set shortened statutory period for response or as set forth in b) above.

☐ Appellant's Brief is due two months from the date of the Notice of Appeal filed on _____ (or within any period for response set forth above, whichever is later). See 37 CFR 1.191(d) and 37 CFR 1.192(a).

Applicant's response to the final rejection, filed on *7/9/98* **has been considered with the following effect, but is NOT deemed to place the application in condition for allowance:**

☐ The proposed amendment(s):

☐ will be entered upon filing of a Notice of Appeal and an Appeal Brief.

☐ will not be entered because:

☐ they raise new issues that would require further consideration and/or search. (See note below).

☐ they raise the issue of new matter. (See note below).

☐ they are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal.

☐ they present additional claims without cancelling a corresponding number of finally rejected claims.

NOTE: _____

☐ Applicant's response has overcome the following rejection(s):

_____

☒ Newly proposed or amended claims *1-9, 12-18, 21-23, and 50* would be allowable if submitted in a separate, timely filed amendment cancelling the non-allowable claims.

☒ The affidavit, exhibit or request for reconsideration has been considered but does NOT place the application in condition for allowance because:
Upon the response filed on July 19, 1998, the arguments are partial deemed to be persuasive. Therefore, claims 1-9, 12-18, 21-23, and 50. However, the references cited do read on claims 24-38, and 51-52.

☐ The affidavit or exhibit will NOT be considered because it is not directed SOLELY to issues which were newly raised by the Examiner in the final rejection.

☒ For purposes of Appeal, the status of the claims is as follows (see attached written explanation, if any):

Claims allowed: *1-9, 12-18, 21-23, and 50*

Claims objected to: *NONE*

Claims rejected: *24-38, 51, and 52*

☐ The proposed drawing correction filed on _____ ☐has ☐has not been approved by the Examiner.

☐ Note the attached Information Disclosure Statement(s), PTO-1449, Paper No(s). _____.

☐ Other

Tan Nguyen

TAN Q. NGUYEN
PRIMARY EXAMINER
ART UNIT 3614

002055.P004

Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

OIPE
AUG 07 1998
PATENT & TRADEMARK OFFICE

In re Application of:
Jed Margolin

Serial No. 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft

Examiner: T. Nguyen

Art Unit: 3614

8-12-98
14/C

PLEASE ENTER
08/20/98
TN

RESPONSE UNDER 37 C.F.R. § 1.116
– EXPEDITED PROCEDURE -
EXAMINING GROUP 3614

Assistant Commissioner for Patents
Washington, D.C. 20231

RESPONSE UNDER 37 C.F.R. § 1.116
EXPEDITED PROCEDURE -- EXAMINING GROUP 3614

Sir:

Responsive to the Advisory Action mailed on July 24, 1998, the Applicant respectfully requests the Examiner to enter the following amendment and to consider the following remark:

AMENDMENT

In the Claims:

Please cancel Claims 24-38, 51 and 52 and 53 without prejudice.

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8/20/98

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REMARK

The Advisory Action has indicated that claims 1-9, 12-18, 21-23, and 50 are allowable and that claims 24-38, 51 and 52 remain rejected. Although Applicant disagrees

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August 4, 1998
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Name of Person Mailing Correspondence

Conny VanDalen
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8-4-98
Date

04475

with the rejection, Applicant has canceled claims 24-38, 51 and 52 to place the application in condition for allowance. Applicant currently plans on filing a continuation to further pursue the rejected claims.

Invitation for a telephone interview

The Examiner is invited to call the undersigned at 408-720-8598 if there remains any issue with allowance of this case.

Charge our Deposit Account

Please charge any shortage to our Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: 6/4, 1998

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002055.P004

Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#10/B 4/1/98

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PATENT & TRADEMARK

In re Application of:
Jed Margolin

Serial No. 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft

Examiner: T. Nguyen

Art Unit: 2304

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Assistant Commissioner for Patents
Washington, D.C. 20231

AMENDMENT AND REMARK

Sir:

Responsive to the Office Action mailed on November 28, 1997, the Applicant respectfully requests the Examiner to enter the following amendment and to consider the following remark:

AMENDMENT

In the Specification:

On page 3, line 22, please replace "many" with --may--.

On page 3, line 23, please replace "cameras" with --camera--.

In the Claims:

Please cancel claims 10, 11, 19 and 20, without prejudice.

Please amend the claims as follows:

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Conny VanDalen — 2-27-98
Signature — Date

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1. (Once Amended) A system comprising:

a remotely piloted aircraft <u>including,</u>

<u>a position determining system to locate said remotely piloted aircraft's position in three dimensions; and</u>

<u>an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space;</u>

a communications system for communicating flight data between a computer and said remotely piloted aircraft, said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft;

a digital database comprising terrain data;

said computer to access said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation;

a display for displaying said three dimensional projected image data; and

a set of one or more remote flight controls coupled to said computer for inputting said flight control information, <u>wherein said computer is also for determining a delay time for communicating said flight data between said computer and said remotely piloted aircraft, and wherein said computer adjusts the sensitivity of said set of one or more remote flight controls based on said delay time</u>.

2. (Once Amended) The system of claim 1, <u>wherein:</u>

said remotely piloted aircraft [including:] <u>includes a device for capturing image data; and</u>

<u>said system operates in at least a first mode in which said image data is not transmitted from said remotely piloted aircraft to said computer at a sufficient data rate to allow for real time piloting of the remotely piloted aircraft</u>

[a position determining system for locating said remotely piloted aircraft's position in three dimensions; and

an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space].

~~14.~~ (Once Amended) A station for flying a remotely piloted aircraft that is real or simulated comprising:

a database comprising terrain data;

a set of remote flight controls for inputting flight control information;

a computer having a communications unit configured to receive status information identifying said remotely piloted aircraft's position and orientation in three dimensional space, said computer configured to access said terrain data according to said status information and configured to transform said terrain data to provide three dimensional projected image data representing said remotely piloted aircraft's environment, said computer coupled to said set of remote flight controls and said communications unit for transmitting said flight control information to control said remotely piloted aircraft, said computer also to determine a delay time for communicating said flight control information between said computer and said remotely piloted aircraft, and said computer to adjust the sensitivity of said set of remote flight controls based on said delay time; and

a display configured to display said three dimensional projected image data.

~~24.~~ (Once Amended) ~~A remotely piloted aircraft comprising:~~

a position determining system to locate said remotely piloted aircraft's position in three dimensions;

an orientation determining system to determine said remotely piloted aircraft's orientation in three dimensional space;

a communications system for transmitting status information, including said remotely piloted aircraft's position and orientation, to a pilot station for transformation into a three dimensional projected image of said remotely piloted aircraft's environment according to a database representing real terrestrial terrain using polygons, said communications system also for receiving from said pilot station flight control information; and

a control system for adjusting said remotely piloted aircraft's flight in response to said flight control information.

Please add the following new claims:

50. (New) The system of claim 1, wherein:

said remotely piloted aircraft includes a device for capturing image data; and said system operates in at least a first mode in which said image data is not transmitted from said remotely piloted craft to said computer but stored in said remotely piloted aircraft.

51. (New) The remotely piloted aircraft of claim 24 further comprising:

a device for capturing image data, wherein said remotely piloted aircraft operates in at least a first mode in which said image data is not transmitted from said remotely piloted aircraft to said computer at a sufficient data rate to allow for real time piloting of the remotely piloted aircraft.

52. (New) The method of claim 32 further comprising the step of:

generating said flight control information responsive to said simulated three dimensional view and without any image transmitted from said remotely piloted aircraft.

53. ~~(New)~~ The method of claim 34, wherein said step of generating said flight control information in response to manual manipulations of the set of manual flight controls on said pilot station includes the step of:

receiving input representing a current position of a directional control; and

interpreting said current position relative to the horizon, rather than a rate of rotation.

REMARK

Applicant respectfully requests reconsideration of this application as amended.

35 U.S.C. §103 rejection, over Lyons in view of Wysoki or Fant or Beckwith

The Examiner has rejected Claims 1-9, 14-18, 23-32, and 34-38 under 35 U.S.C. §103 as being obvious over Lyons in view of Wysoki or Fant or Beckwith.

According to M.P.E.P. § 2142, "[t]o establish a primary facia case of obviousness, ... the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claim combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure." (emphasis added).

CLAIMS 1 and 14

Claim 1 has been amended to include the limitations of claims 2, 10 and 11. Similarly Claim 14 has been amended to include the limitations of claims 19 and 20. Thus, Claims 1 and 14 are discussed under the next rejection directed to claims 10, 11, 19, and 20.

CLAIMS 24 AND 32

1. The Office Action Misdescribes Lyons

The office action agrees that Lyons does not teach the generation of "three dimensional image data from the digital database and the navigation information." However, Lyons fails to teach more than just the generation of the 3D image.

Lyons teaches a pilot station that uses dead reckoning to estimate the location of the RPV. As is well known in the art, dead reckoned positions have accumulating error. To correct for this error, the RPV transmits some information to the pilot station. The information transmitted depends on the approach of which Lyons describes two:

1) The transmission of video or radar image data from the RPV to the pilot station. For the video and radar image data (Section 3, including Figure 8), the pilot station provides a two dimensional moving map on which the pilot station indicates the dead reckoned position. At various intervals, the pilot must use the video or radar image to correct the dead reckoned position (This is what Figure 8 shows).

2) The transmission of laser measurements from the RPV to the pilot station. For the laser measurements (Section 4, Figure 10-12), the pilot station includes a database. The pilot station identifies a search area in the database based on the dead reckoned position - where the current dead reckoned position is the center of the search area ("expected RPV position" in Figure 12) and the search area represents the locations the RPV could be due to the accumulating error in the current dead reckoned position. The pilot station then compares the laser measurement for various position in the search area in an effort to locate the correct position of the RPV. Once the database has been used to locate the correct position of the RPV, the pilot station indicates the RPVs actual position on the 2D moving map (this map is not generated based on the database).

One advantage of the laser system being that the error in the dead reckoned position is automatically corrected using the laser and database, whereas the video and radar image data system requires user intervention to update. Another advantage of the laser system is that the laser data requires less bandwidth than the video or radar image data. For a further description of Lyons, see footnote [1].

---

[1] In summary, the Lyons reference teaches various techniques for updating the dead reckoned position of remotely piloted aircraft on a two dimensional moving map display available to the pilot. In particular, Lyons contemplates a RPV transmitting information to a control center (Figure 1). The control center is used by the pilot to fly the RPV. To display the position of the RPV to the pilot, the control center provides a "moving map display." As contemplated by Lyons, "the most convenient display mode for the present application is the rolling map or 'passing scene' technique where a new line is added to the top of the display and the scene is shifted slowly downwards" (page 5-3, end of first full paragraph). In particular, Lyons contemplates using film to generate the moving map (Figure 5). The moving map is moved based on the dead reckoned positions of the RPV.

As is well known in the art, dead reckoned positions have accumulating error. To adjust for this error, Lyons describes two basic concepts: 1) map matching (Section 3); and 2) terrain map correlation (Section 4). The map matching concept requires that the RPV transmit some kind of image data to the control center. In Figure 6, the control center is shown having the moving map display and the sensor display (i.e., a display generated from the image data transmitted by the RPV). Lyons contemplates the transmission of two kinds of image data: 1) side looking radar (SLR); and 2) real time forward-looking sensors. When using the SLR system, the SLR generated image data received by the control center allows it to make a downward-looking image. The pilot watches the sensor display (i.e., the display generated based on the transmitted image data) for "likely update features"—landmarks. When the pilot sees a landmark in the sensor display, the pilot presses a transfer button which causes the control center to superimpose the sensor display over the moving map (Figure 5). The pilot then adjusts the moving map so that it matches the overlaid sensor display image and presses an accept button. By adjusting the moving map in this manner, the dead reckoned position of the RPV is updated in an attempt to remove the error associated with the calculation of dead reckoned positions (Page 5-3, second, third, and fourth full paragraphs). The simulated SLR/map update system is illustrated in Figures 7A and 7B.

Having described the SLR-based map matching technique, the real time forward-looking sensor technique will now be described. Lyons describes basically two techniques of updating dead reckoned RPV positions on a moving map using only real time forward-looking sensors: 1) an anamorphic projection technique (page 5-3, fifth full paragraph; figure 8); and 2) a HUD based technique (page 5-3, sixth full paragraph; figure 9). Similar to the SLR based technique, the anamorphic projection technique requires the pilot to watch the sensor display (i.e., the image generated from the transmitted data) for landmarks, press a button which superimposes the transmitted image on the moving map, adjust the moving map, and press an accept button. As described in Lyons, in order to superimpose the forward-looking transmitted image on the moving map, the forward-looking image is transformed using anamorphic projection. Lyons goes on to describe various problems with the anamorphic projection technique, and then describes the HUD based technique.

In the HUD based technique, the pilot is presented with two images: 1) the moving map display (see left-hand image of Figure 9); and 2) the sensor display generated from the image data transmitted from the real time forward-looking sensor on the RPV. The HUD technology is used to allow the pilot to mark landmarks on the forward-looking sensor based image. These HUD markings are then superimposed on the moving map, and the pilot makes the necessary adjustments to the moving map (page 5-3, sixth full paragraph).

In summary, the map matching techniques use the following: 1) the transmission of image data from the RPV to the control center; 2) a display at the control center which shows an image based on the real time image data received from the RPV; 3) a moving map display that is moved based on the dead reckoned position of the RPV; and 4) some manner of superimposing the sensor image onto the moving map to allow the pilot to update the moving map in an effort to correct the error associated with the dead reckoned positions. Neither the sensor display's image nor the moving map can be equated to the generation of "a three-dimensional projected image" generated based upon "a digital database" stored in the control center. The sensor display's image is based on image data transmitted from the RPV, while the moving map contemplated by Lyons is a two-dimensional, top down view displayed using film (see Figures 5 and 7).

Having described the map matching techniques from Lyons, Applicant will now describe the terrain map correlation technique of Lyons. The terrain map correlation technique described in Lyons is also used for correcting the error in dead reckoned positions shown to the pilot by a two-dimensional moving map. In particular, Lyons states at page 5-3, last paragraph:

The office action states that Lyons teaches a remotely piloted aircraft that transmits its position and orientation. However, Lyons actually teaches the remotely piloted aircraft transmitting either: 1) video or radar image data; or 2) laser measurements (see above and footnote). Neither the video/radar image or the laser measurements are the RPVs position, but are data used to either manually or automatically update the dead reckoned position of the Lyons system. Thus, Lyons does not teach the claimed transmission of the remotely piloted aircraft's position and orientation in three dimensional space (see claims 24 and 32).

In addition, the office action cites pages 5-4, third paragraph, and Figure 8 as disclosing a single system that accesses a database based on the remotely piloted aircraft's transmitted position and orientation and transforms the terrain data into a projected image. However, Figure 8 is for a first system in which the RPV uses a "forward looking sensor" to transmit a video image and the pilot station uses anamorphic projection to overlay that image on a 2D moving map, which is not generated by transforming a database of polygons (see page 5-3, paragraph 6), while pages 5-4, third

---

> Reconnaissance or forward-looking sensors provide a convenient method of updating the navigation system. However, these sensors required large datalink bandwidth to transmit the video picture to the control center and hence are vulnerable to ECM... Hence, an alternative method of updating the navigation system is desirable. (emphasis added)

The phrase "updating the navigation system" is used throughout Lyons to refer to the adjustment of a two-dimensional moving map in an effort to correct for error due to dead reckoning.

Rather than requiring the user to actively update the moving map display (i.e., push a button which causes the images to be superimposed, adjusting the moving map, and pushing an accept button), the terrain map correlation technique attempts to adjust the moving map (i.e., correct for the dead reckoned error) without pilot intervention using a laser range measurements and a digital elevation database. In operation, the RPV transmits to the control center a set of laser range measurements (including an altimeter reading). The control center uses dead reckoned positions to both adjust the two-dimensional moving map and to estimate the location of the RPV over a digital database map of elevation points stored in the control center (Figure 10). Based on a calculation of the possible error associated with the dead reckoned positions, a search area is identified in the digital database (Figure 12). A search is then performed within this search area to identify the position that most closely matches the transmitted laser range data. The RPV's position is then updated to the location that best matches the transmitted laser ranges in an attempt to correct the error associated with the dead reckoned positions. The moving map is then automatically adjusted (without pilot intervention) to reflect the updated RPV position.

Thus, the digital database of Lyons (conceptually illustrated in Figure 10) is not used to generate a three-dimensional projected image, but is used to update the two-dimensional moving map in an effort to correct for the error in the dead reckoned positions. In addition to the description in Lyons, further support for the fact that the digital database of Lyons is not used to generate a three-dimensional projected image is that the image of Figure 10 is generated using square polygons. Square polygons are not guaranteed to be planar, and therefore, typically are not used for generating images. In contrast, triangular polygons are guaranteed to be planar and are typically used for displaying images.

paragraph describe a second system in which the RPV transmits laser measurements in lieu of a video stream - Lyons describes the advantages of using one over the other.

With reference to the laser system, the database is simply used to correct for the accumulating error in the dead reckoned position. Once the actual location of the RPV is corrected using the database and laser measurements, the database is no longer used or transformed. In contrast, the image generated by Lyon's pilot station is the 2D moving map with an indication of the corrected RPV location (see footnote 1 for support). Thus, Lyons does not teach the claimed transformation of the terrain data in the database to generate a projected image based on the position and orientation transmitted by the RPV.

2. The Combination of Lyons and Wysoki or Fant or Beckwith

The office action cites Wysoki or Fant or Beckwith as teaching the generation of three dimensional image data from a digital database. However, the claimed invention requires that the database represent the terrain using polygons (see Applicant's claim 24, lines 9 - 10 and claim 32, lines 10-11). None of Lyons, Wysoki, Fant or Beckwith generate a projected image using polygons[2]. Furthermore, none of Wysoki, Fant or Beckwith teach the limitations of the claims discussed above with reference to Lyons. Therefore, the combination does not teach the transmission by the RPV of its position and orientation in three dimensional space, and the pilot station using the received position and orientation to transform a database representing real terrestrial terrain using polygons into a three dimensional projected image of the remotely piloted aircraft's environment.

---

[2] As described above, the data in the database of Lyons is not used to generate an image, but simply to update the dead reckoned position.

With respect to Beckwith, the digital elevation data in the database is points with a constant north up position, not polygons (see col. 6, lines 52-61; col. 7, lines 30-36).

Fant describes the use of two databases: 1) the object library database which contains real-world images; and 2) the gaming area database which provides the information necessary for the placement of the contents of the object library, surfaces, and special effect on a grid or gaming area (see col. 6, line 38 - col. 7, line 10). In particular, the Fant patent is for a high performance computer graphics system that combines Computer Generated Imagery (CGI) with Computer Synthesized Imagers (CSI) to form Computer Generated Synthesized Imagery (CGSI) (see col. 2, line 53 - col. 3, line 12).

Wysoki describes a database of digital orthophotographs (see col. 4, lines 43-51). Digital orthophotographs are computerized images generated by making geometric corrections to scanned aerial photographs. In particular, an aerial photograph contains some degree of distortion. In contrast, maps maintain a constant scale, but lack the detail of an aerial photograph. Orthophotography combines the features of maps and aerial photographs. The aerial photographs are unwrapped (to remove the distortion) and fitted to a particular map projection to create an image map that has uniform scale and known accuracy.

As a result, in certain embodiments of the invention, the remote pilot can fly the RPV without any image data being transmitted by the RPV, but based on the 3D projected image generated by transforming the database, with respect to the RPV position and orientation received by the pilot station from the RPV, into a 3D image. In other words, the pilot in the claimed system need not rely on image data transmitted from the RPV to fly the RPV. For at least this reason, it is respectfully submitted that these claims are allowable over the cited prior art.

35 U.S.C. §103 rejection, over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Kanaly

The Examiner has rejected Claims 10, 11, 19, 20, and 33 under 35 U.S.C. §103 as being obvious over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Kanaly.

As stated above, claim 1 has been amended to include the limitations of claims 2, 10 and 11. Similarly Claim 14 has been amended to include the limitations of claims 19 and 20. Thus, Claims 1 and 14 are discussed under this rejection.

Similar to the limitations of Claims 24 and 32, Claims 1 and 14 require that the RPV transmit its position and orientation in three dimensional space to the pilot station and that the pilot station transform the terrain data with respect to the position and orientation to generate a three dimensional projected image. As previously stated, the combination of reference does not teach these limitations.

In addition, Claims 1, 14 (as amended) and claim 33 include the limitations of determining the delay time for communication between the pilot station and RPV, as well as adjusting the sensitivity of the flight controls based on the determined delay time.

Kanaly does not teach or suggest these limitations. In contrast, Kanaly deals with a system in which a remote operator wears a helmet (on which an oculometer is mounted) that determines where the remote operator is looking. Signals indicating where

the remote operator is looking are sent to the RPV. The RPV includes a camera. The prior art system over which Kanaly distinguishes is one in which the camera on the RPV provides high resolution data in the center and low resolution data on the periphery. As a result, the prior art system must move the camera in response to the remote operators movements. This camera movement introduces a delay in the image provided to the remote operator.

To reduce or remove this delay (not measure it or adjust flight controls) due to movement of the camera, Kanaly teaches having the camera store high resolution data over the whole scene in a memory on board the RPV. The RPV transmits the high resolution imagery corresponding to the center of where the remote operator is looking and low resolution imagery (based on the stored high resolution data) corresponding to the remote operator's peripheral vision. As a result, movement of the remote operator's head merely requires the RPV adjust from where in the memory the high and low resolution data is accessed - the camera need not be moved. "Because the high resolution data is obtained from memory and not from the camera equipment directly, as in the prior art, the scheme in accordance with the present invention permits the camera to be effectively decoupled from the data link." (see col. 2, line 56 - col. 3, line 24; col. 8, line 54 - col. 9, line 6).

Thus, Kanaly does not teach the measurement of a communication delay in order to adjust the sensitively of flight controls based on that delay (see claims 1, 14, and 33). For at least this reason, it is respectfully submitted that these claims are allowable.

35 U.S.C. §103 rejection, over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Thornberg

The Examiner has rejected Claims 12-13 and 21-22 under 35 U.S.C. §103 as being obvious over Lyons in view of Wysoki or Fant or Beckwith, and further in view of Thornberg.

Claims 12-13 and 21-22 are each dependent on one of the allowable base claims 1 and 14. For at least this reason, Applicant respectfully submits that claims 12-13 and 21-22 are allowable.

New claims 50 -53

Claims 50 - 52 each require that the remotely piloted aircraft include some device for capturing image data but that the system operate in at least a first mode in which that image data is not transmitted and/or not used to pilot the aircraft. In other words, the pilot in the claimed system cannot rely on image data transmitted from the RPV (as in certain systems of Lyons - radar and video data) to fly the RPV. In certain embodiments of the invention, the remote pilot can fly the RPV based on the 3D projected image generated by transforming the database with respect to the RPV position and orientation received by the pilot station from the RPV. Of course, additional information that is not image data could also be transmitted.

Claim 53 specifies the manner in which the flight controls used to pilot the aircraft are operated. In particular, certain joystick controls on aircraft operate to indicate a rate of rotation (e.g., pushing a joystick to the right means the aircraft should start turning right at the speed indicated by the orientation of the joystick - if the position is held, the plane will roll). However, the claimed manner of operation requires the joystick position indicate the orientation of the aircraft with respect to the horizon (e.g., joystick centered causes the aircraft to fly straight; joystick pushed to the right causes the aircraft to bank to the right at the angle indicated by the joystick - not roll; etc.).

Conclusion

Applicant respectfully submits that the rejections have been overcome by the amendments and remarks, and that the Claims are now in condition for allowance.

Accordingly, Applicant respectfully requests the rejections be withdrawn and the Claims as amended be allowed.

Drawing Corrections

The drawings have been objected to by the draftsman. The Applicant will file amended drawings at the time of allowance of the present application.

Invitation for a telephone interview

The Examiner is invited to call the undersigned at 408-720-8598 if there remains any issue with allowance of this case.

Charge our Deposit Account

Please charge any shortage to our Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: 2/27, 1998

Daniel M. De Vos
Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025-1026
(408) 720-8598

13 Sheets

Jed Margolin
Phone: [redacted] ***Email:*** [redacted]

[redacted]

June 7, 2003

Mr. Alan J. Kennedy
Office of the General Counsel
National Aeronautics and Space Administration
[redacted]
Fax [redacted]

b(6)

Dear Mr. Kennedy,

Mr. Barry Gibbens of your Langley Research Center suggested I contact you. I missed you when I called on Friday so I am sending this fax to provide background.

I believe that NASA may have used one or more of my patents in connection with the X-38 project and may be using one or more of my patents in other projects using Synthetic Vision.

This fax contains a number of Internet links. If you would like an email version of this fax containing active links please send me an email [redacted] with your email address.

b(6)

Summary

In Synthetic Vision (NASA's term), the aircraft's position and orientation are used with a terrain database (such as the Digital Elevation Database) to produce a 3D projected view of the terrain over which the aircraft is flying. One of the advantages of this system is that the pilot is able to "see" the terrain regardless of weather conditions or whether it is day or night.

My U.S. Patent that pertains to this use of synthetic vision is: **U.S. Patent 5,566,073 Pilot Aid Using a Synthetic Environment** issued October 15, 1996 to Margolin. (I am the inventor and owner of the patent.) The patent application was filed August 9, 1995, and was a continuation of Application Ser. No. 08/274,394, filed July 11, 1994.

With synthetic vision it is not necessary for the pilot to be in the aircraft. I believe the X-38 project used this method.

My U.S. Patent that pertains to this use of synthetic vision is: **U.S. Patent 5,904,724 Method and Apparatus For Remotely Piloting an Aircraft** issued May 18, 1999 to Margolin. (I am the inventor and owner of the patent.) The patent application was filed January 19, 1996.

X-38 Project

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 have 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 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.
[redacted] b(6)
Mike Abernathy
Integrated Video for Synthetic Vision Systems

For 2001 Phase II:
Rapid Imaging Software, Inc.
[redacted] b(6)

Carolyn Galceran [redacted] b(6) 3

Integrated Video for Synthetic Vision Systems

My U.S. Patent that pertains to this use of synthetic vision is: **U.S. Patent 5,904,724 Method and Apparatus For Remotely Piloting an Aircraft** issued May 18, 1999 to Margolin. (I am the inventor and owner of the patent.) The patent application was filed January 19, 1996.

The patent can be downloaded from the UPTO Web site (www.uspto.gov) in html (no drawings) or in an odd tif format (with the drawings) that requires a special viewer.

An easier way to view and download the patent is through my Web site, on which I have posted the patent in PDF format. The link is http://www.jmargolin.com/patents2/rpv.htm .

While I have no way of knowing exactly what method(s) NASA used in controlling the X-38 (unless you are willing to make a full disclosure) my patent covers techniques as exemplified by claim 1.

1. A system comprising:

a remotely piloted aircraft including,

a position determining system to locate said remotely piloted aircraft's position in three dimensions; and

an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space;

a communications system for communicating flight data between a computer and said remotely piloted aircraft, said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft;

a digital database comprising terrain data;

said computer to access said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation;

a display for displaying said three dimensional projected image data; and

a set of one or more remote flight controls coupled to said computer for inputting said flight control information, wherein said computer is also for determining a delay time for communicating said flight data between said computer and said remotely piloted aircraft, and wherein said computer adjusts the sensitivity of said set of one or more remote flight controls based on said delay time.

Although the X-38 project has been canceled, the methods developed to fly it are too good to waste and should be used in follow-up projects like CRV.

Synthetic Vision

I became aware of NASA's Synthetic Vision program perhaps two years ago from a program on NASA TV. I was unable to follow it up at that time due to health problems and the demands of my other patenting activity.

According to the NASA Aviation Safety Program Web site (http://avsp.larc.nasa.gov/program_svs.html)

Synthetic Vision Systems

TECHNOLOGY WOULD REDUCE AIRLINE FATALITIES
Synthetic Vision would give pilots clear skies all the time

A revolutionary cockpit display system being developed with seed money from NASA would help prevent the world's deadliest aviation accidents.

And I agree.

My U.S. Patent that pertains to this use of synthetic vision is: **U.S. Patent 5,566,073 Pilot Aid Using a Synthetic Environment** issued October 15, 1996 to Margolin. (I am the inventor and owner of the patent.) The patent application was filed August 9, 1995, and was a continuation of Application Ser. No. 08/274,394, filed July 11, 1994.

The patent can be downloaded from the USPTO Web site (www.uspto.gov) in html (no drawings) or in an odd tif format (with the drawings) that requires a special viewer.

The patent can also be downloaded from my Web site in PDF format at:
http://www.jmargolin.com/patents2/pilot.htm

As with the X-38 program I have no way of knowing exactly what method(s) NASA used in its Synthetic Vision program (unless you are willing to make a full disclosure). My patent covers techniques as exemplified by claim 1.

> *1. A pilot aid which uses an aircraft's position and attitude to transform data from a digital data base to present a pilot with a synthesized three dimensional projected view of the world comprising:*
>
> *a position determining system for locating said aircraft's position in three dimensions;*
>
> *a digital data base comprising terrain data, said terrain data representing real terrestrial terrain as at least one polygon, said terrain data generated from elevation data of said real terrestrial terrain;*
>
> *an attitude determining system for determining said aircraft's orientation in three dimensional space;*
>
> *a computer to access said terrain data according to said aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said aircraft's orientation; and*
>
> *a display for displaying said three dimensional projected image data.*

NASA's Visits to My Web Site

There is good reason to believe that NASA was aware of my work in these areas through visits to my Web site. NASA has been visiting my Web site (www.jmargolin.com) regularly since I started it in December 2000. (I have no objection to NASA's visits; I am flattered that NASA considers my Web site worth visiting.)

A listing of NASA access statistics follows the end of this fax.

I also have regular visits from http://cap.nipr.mil, which I understand is a secure gateway to other military networks. I don't know if NASA uses nipr so I have not included it in my listing.

The Web Statistics software provided by my Web Hosting Service tell me who is visiting my Web site and what people are looking at but not who is looking at what, (In January of this year I discovered there are raw Web log files containing this information but my Web Hosting Service does not keep backup log files older than the previous month.)

I am including an example of the detailed Web log data; it's understandable why my Web Hosting Service abstracts it into a less detailed form.

The article being referenced is **Unit Vector Math for 3D Graphics**
(www.jmargolin.com/uvmath/uvmenu.htm)

Now that I can see what people are looking at I have noticed a great deal of interest in this article as well as **The Relationship between Unit Vector Rotations and Euler Angle Functions** .
(www.jmargolin.com/uvmath/euler.doc)

These articles also seem to interest military contractors like Lockheed Martin (lmco.com), Boeing (boeing.com), Northrop Grumman (northgrum.com), and SAIC (saic.hq.nasa.gov) as well as a large number of educational institutions.

Some accesses are obviously just for fun, to articles such as to **Gas Music From Jupiter**
(www.jmargolin.com/gmfj/gmfj.htm)

There are also visits from most of our national labs. I expect they are interested in **U.S. Patent 6,377,436 Microwave Transmission Using a Laser-Generated Plasma Beam Waveguide** issued April 23, 2002 to Jed Margolin.

Abstract

A directed energy beam system uses an ultra-fast laser system, such as one using a titanium-sapphire infrared laser, to produce a thin ionizing beam through the atmosphere. The beam is moved in either a circular or rectangular fashion to produce a conductive shell to act as a waveguide for microwave energy. Because the waveguide is produced by a plasma it is called a plasma beam waveguide. The directed energy beam system can be used as a weapon, to provide power to an unmanned aerial vehicle (UAV) such as for providing communications in a cellular telephone system, or as an ultra-precise radar system.

There is a possibility that this device could be used to make a linear Tokamak.
(www.jmargolin.com/debs/debs.htm)

04494

Conclusion

I realize this is a great deal of material to wade through, but I would appreciate confirmation that you have received it and, if possible, an estimate as to when I can expect to hear NASA's decision on this claim.

Hopefully, then we can discuss compensation. The '724 patent is available for sale if NASA wishes to purchase it to avoid setting the precedent of the U.S. Government paying compensation for each flight of an aircraft using my patent. (I don't think this would be popular with DOD.) I expect that the first UAV to crash due to Pilot Induced Oscillation (or just Flight Computer Induced Oscillation, as occurred in the first flight of the Predator) would cost more than the cost of buying my patent. I believe this patent also has commercial applications like using UAVs for traffic reporting and in Law Enforcement so your Commercialization Department may be able to generate income with it.

Sincerely yours,

Jed Margolin

Jed Margolin
[redacted]
Phone: [redacted]
Email: [redacted]

b(6)

Here are NASA's visits to my Web site:

June 2001
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
2	0.02%	1	2	73232	0.02%	[redacted]

July 2001
nasa.gov

b(6)

Total hits		Files	Pageview	Bytes sent		Hostname
24	0.27%	24	1	216909	0.08%	[redacted]
1	0.01%	1	1	96274	0.04%	
25	0.28%	25	2	313183	0.11%	

August 2001
nasa.gov

Total hits	Files	Pageview	Bytes sent	Hostname

40	0.38%	40	1	184514	0.06%	[redacted]
24	0.23%	24	1	216909	0.07%	[redacted]
64	0.61%	64	2	401423	0.12%	

October 2001
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
1	0.01%	1	1	549657	0.11%	[redacted]

November 2001
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
48	0.39%	24	2	216909	0.06%	[redacted]
42	0.34%	42	1	532111	0.14%	[redacted]
1	0.01%	1	1	21505	0.01%	[redacted]
91	0.73%	67	4	770525	0.21%	

b(6)

December 2001
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
1	0.01%	1	1	90494	0.01%	[redacted]

February 2002
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
1	0.01%	1	0	120832	0.03%	[redacted]
1	0.01%	1	1	504805	0.11%	[redacted]
2	0.01%	2	1	625637	0.13%	

March 2002
nasa.gov

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1	0.01%	1	0	120832	0.02%	[redacted]

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April 2002
nasa.gov

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1	0.01%	1	0	120832	0.02%	[redacted]
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May 2002
nasa.gov

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1	0.00%	1	0	120832	0.02%	[redacted]
1	0.00%	1	1	96274	0.02%	[redacted]
6	0.03%	2	1	217106	0.03%	

b(6)

June 2002
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
3	0.02%	1	1	96694	0.02%	[redacted]

July 2002
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
43	0.19%	43	4	190275	0.03%	[redacted]
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1	0.00%	1	1	93686	0.02%	[redacted]
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August 2002
nasa.gov

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September 2002
nasa.gov

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7	0.03%	3	0	528056	0.08%	

October 2002
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
98	0.45%	98	14	827297	0.11%	[redacted]
1	0.00%	1	1	49690	0.01%	[redacted]
1	0.00%	1	0	120832	0.02%	[redacted]
1	0.00%	1	0	285696	0.04%	[redacted]
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b(6)

November 2002
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
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1	0.00%	1	1	350096	0.04%	[redacted]
37	0.17%	35	6	2057408	0.26%	

December 2002
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
7	0.03%	7	2	45269	0.01%	[redacted]

January 2003
nasa.gov

Total hits	Files	Pageview	Bytes sent	Hostname

2	0.01%	2	2	29129	0.00%	[redacted]

February 2003
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
2	0.01%	2	2	29138	0.00%	[redacted]

b(6)

April 2003
nasa.gov

Total hits		Files	Pageview	Bytes sent		Hostname
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5	0.02%	1	0	121528	0.01%	
4	0.02%	3	3	63471	0.01%	
3	0.01%	3	3	29881	0.00%	
60	0.25%	52	11	439606	0.05%	

Example of Detailed Web Log Data

This is an example of the detailed Web log data, so it's understandable why my Web Hosting Service abstracts it into a less detailed form.

The article being referenced is Unit Vector Math for 3D Graphics (www.jmargolin.com/uvmath/uvmenu.htm)

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klhgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/fig1.gif HTTP/1.1" 200 2590 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

klhgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m1.gif HTTP/1.1" 200 2237 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

klhgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m2.gif HTTP/1.1" 200 1464 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

klhgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m3.gif HTTP/1.1" 200 715 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

klhgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m4.gif HTTP/1.1" 200 1720 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

khgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m5.gif HTTP/1.1" 200 1738 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

khgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m7.gif HTTP/1.1" 200 1549 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

khgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m8.gif HTTP/1.1" 200 1939 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

khgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m6.gif HTTP/1.1" 200 1762 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

khgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m9.gif HTTP/1.1" 200 4152 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

khgmac.larc.nasa.gov - - [01/Apr/2003:09:32:14 -0500] "GET /uvmath/m10.gif HTTP/1.1" 200 2732 "http://www.jmargolin.com/uvmath/uvmath.htm" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0; Q312461; .NET CLR 1.0.3705)"

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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

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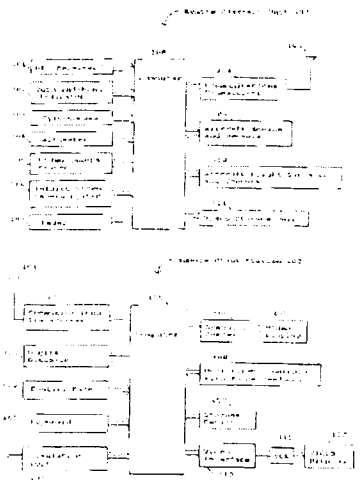
Primary Examiner—Tan Q. Nguyen

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



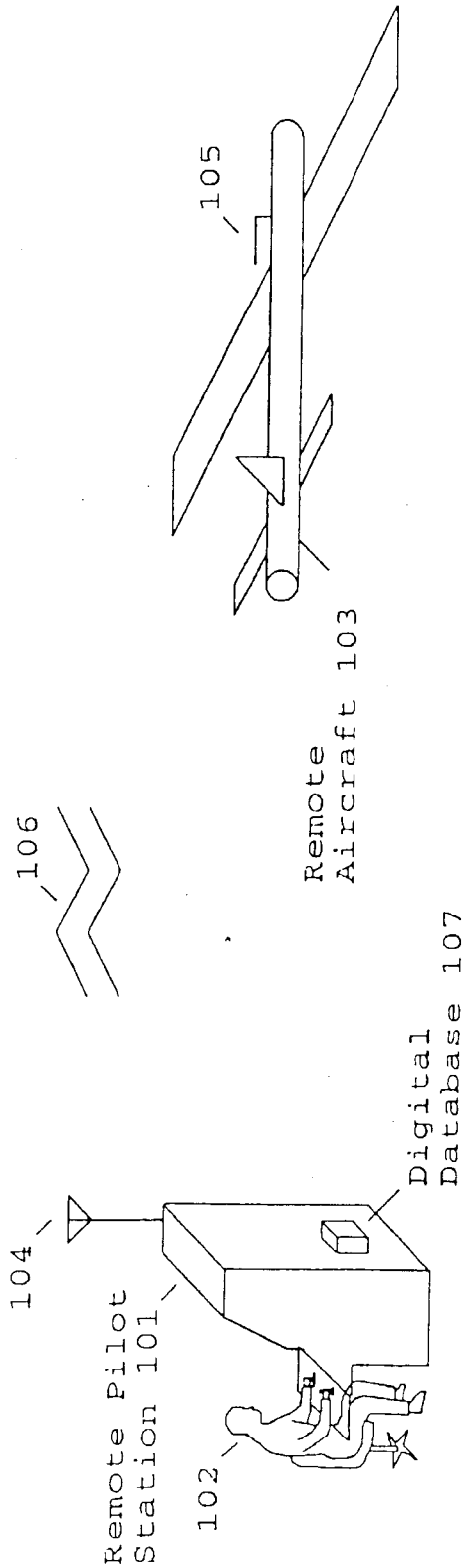

105
Remote Aircraft 103
106
Digital Database 107
104
Remote Pilot Station 101
102

Fig. 1

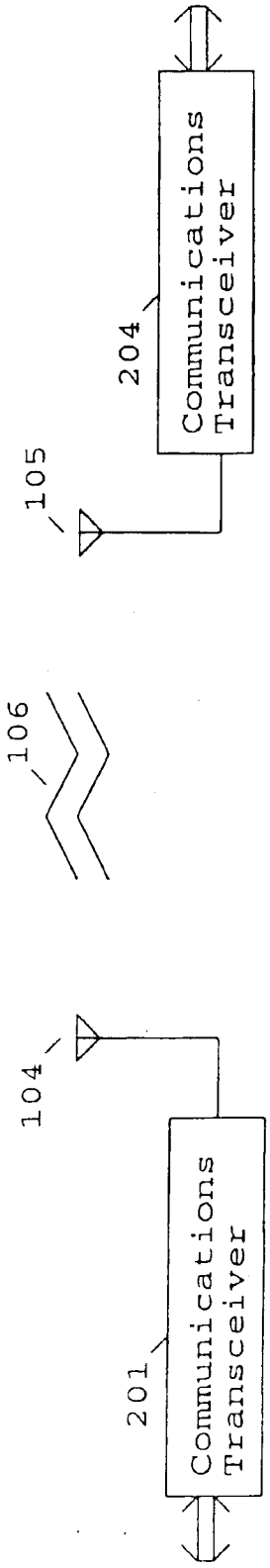

Communications Transceiver
204
105
106
104
Communications Transceiver
201

Fig. 2

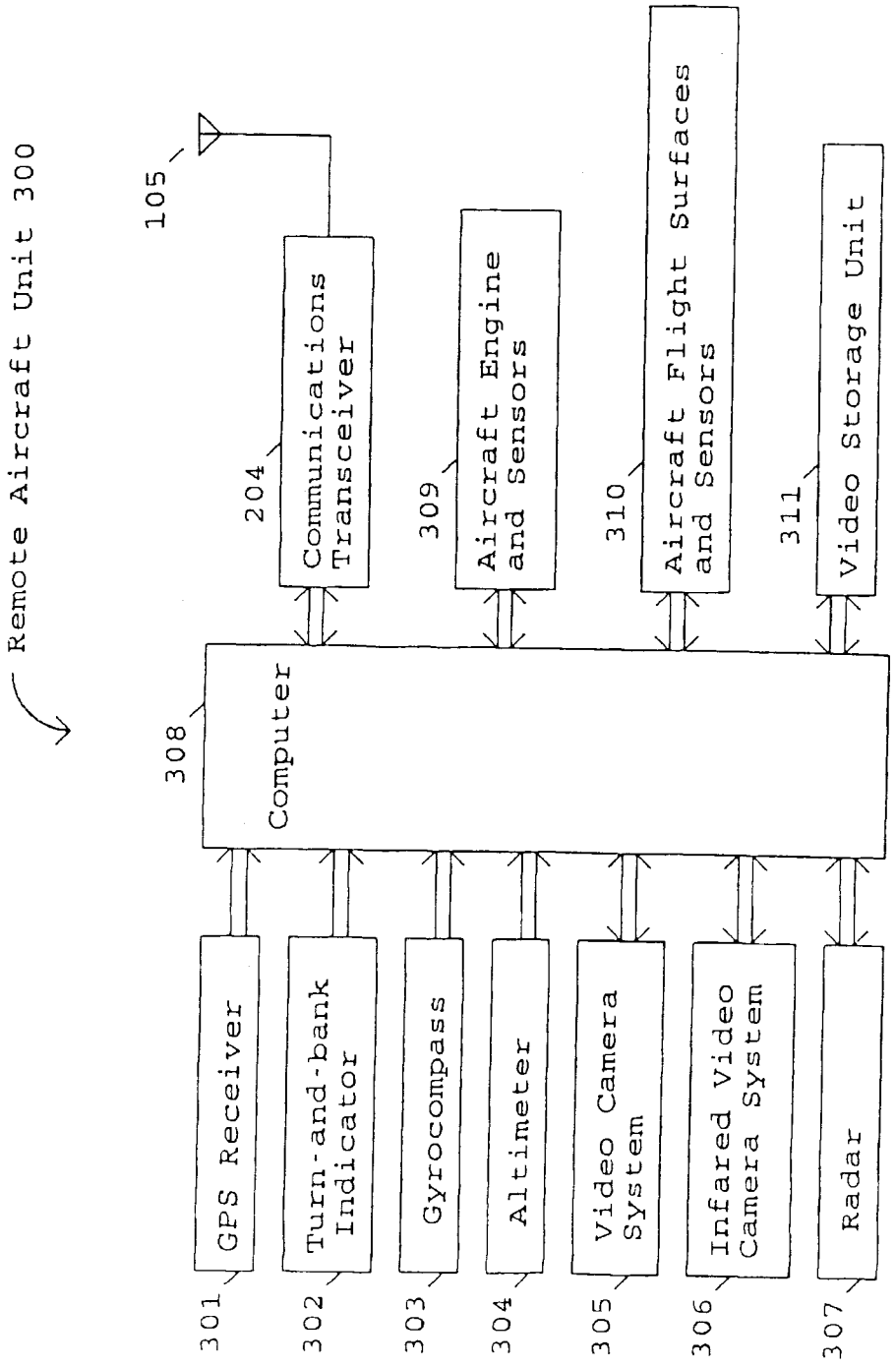

Remote Aircraft Unit 300
105
204
Communications Transceiver
309
Aircraft Engine and Sensors
310
Aircraft Flight Surfaces and Sensors
311
Video Storage Unit
308
Computer
301
GPS Receiver
302
Turn-and-bank Indicator
303
Gyrocompass
304
Altimeter
305
Video Camera System
306
Infared Video Camera System
307
Radar

Fig. 3

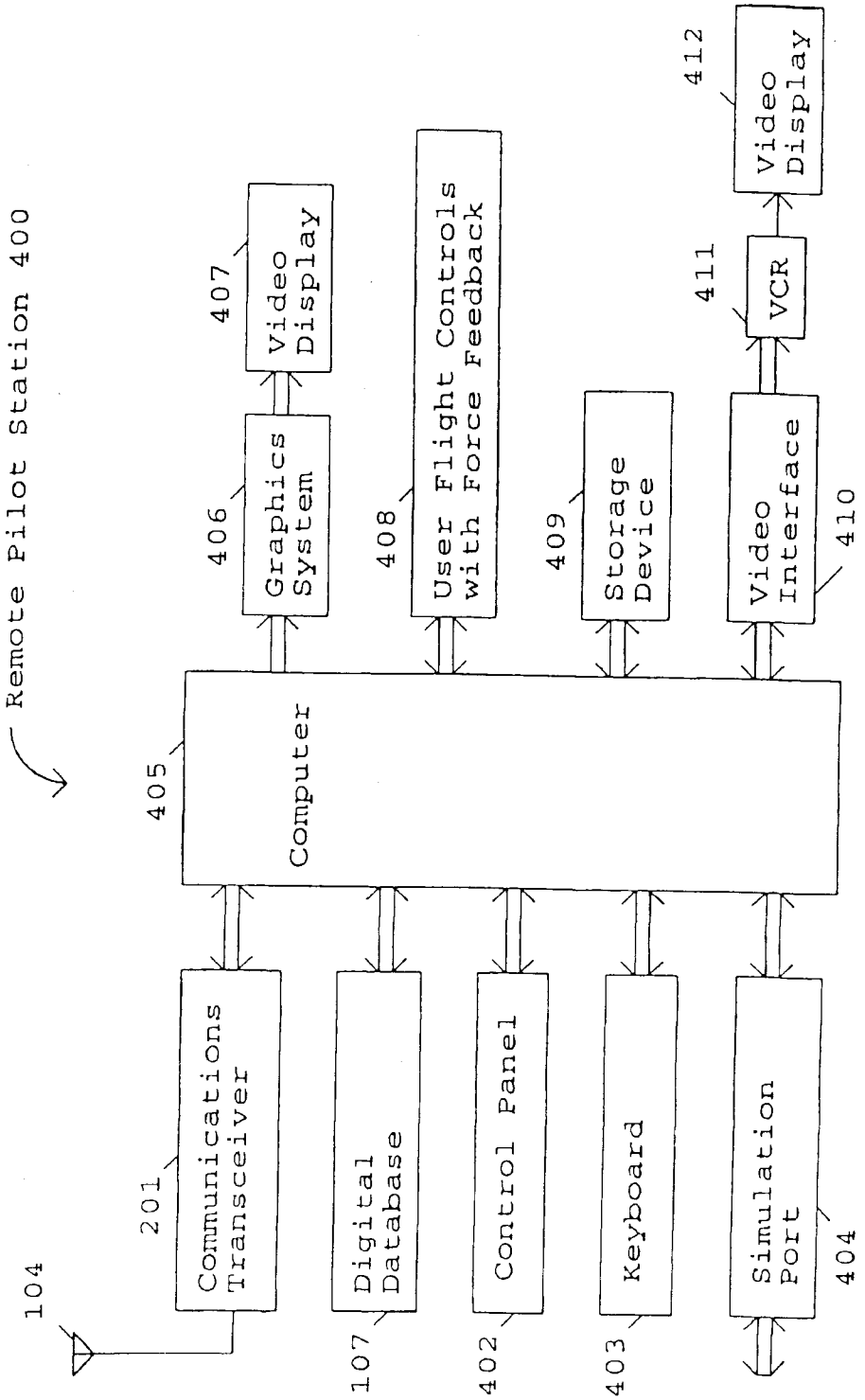
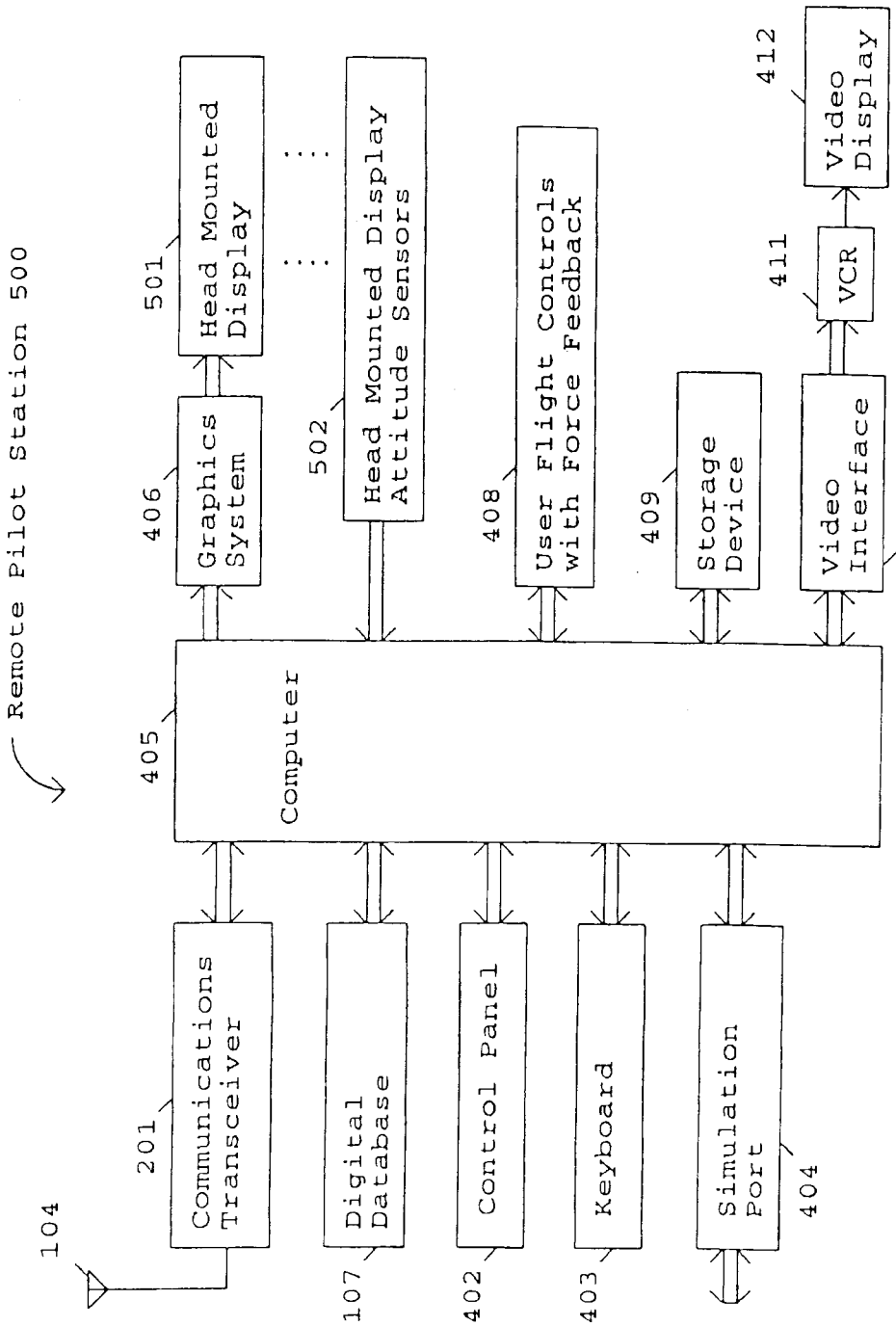

Remote Pilot Station 400
104
201
Communications Transceiver
107
Digital Database
402
Control Panel
403
Keyboard
404
Simulation Port
405
Computer
406
Graphics System
407
Video Display
408
User Flight Controls with Force Feedback
409
Storage Device
410
Video Interface
411
VCR
412
Video Display

Fig. 4


Remote Pilot Station 500
Computer
405
Communications Transceiver
201
Digital Database
107
Control Panel
402
Keyboard
403
Simulation Port
404
Graphics System
406
Head Mounted Display
501
Head Mounted Display Attitude Sensors
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User Flight Controls with Force Feedback
408
Storage Device
409
Video Interface
410
VCR
411
Video Display
412
104

Fig. 5

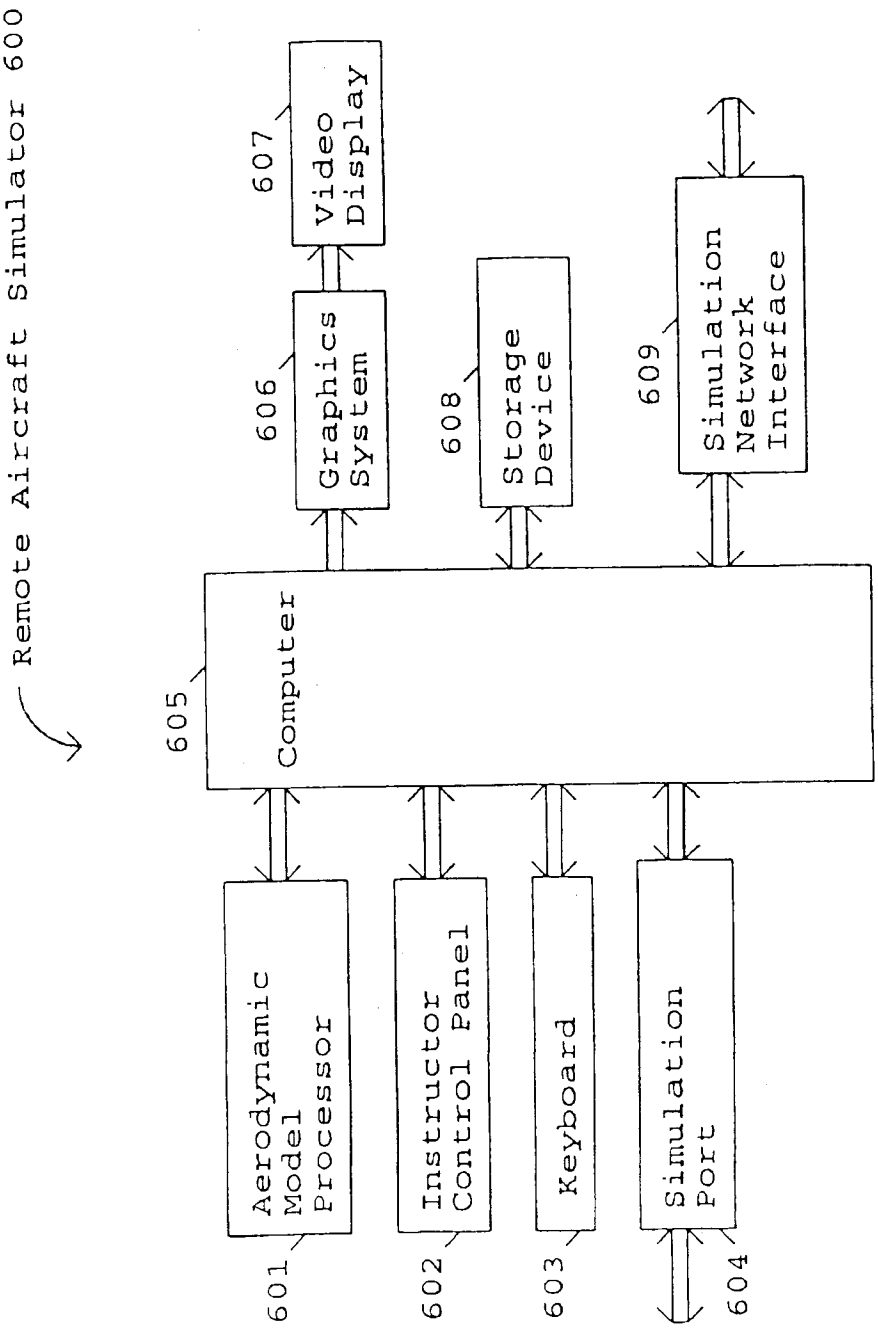
Remote Aircraft Simulator 600
605
Computer
601
Aerodynamic Model Processor
602
Instructor Control Panel
603
Keyboard
604
Simulation Port
606
Graphics System
607
Video Display
608
Storage Device
609
Simulation Network Interface

Fig. 6

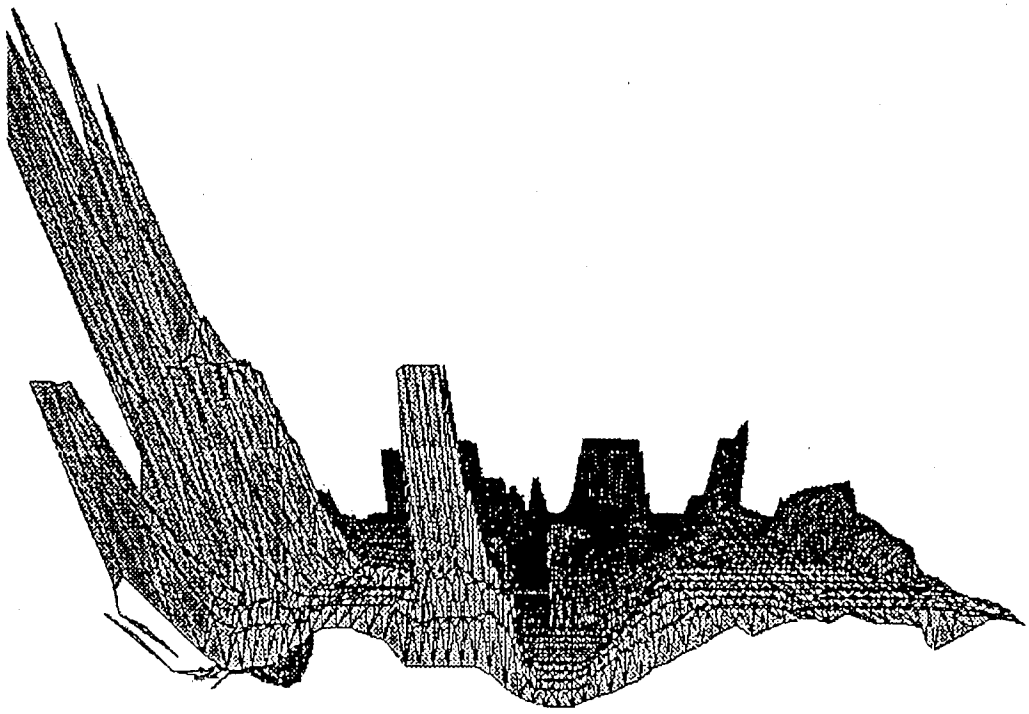

Figure 7

METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

BACKGROUND OF THE INVENTION—CROSS REFERENCES TO RELATED APPLICATIONS

"Pilot Aid Using a Synthetic Environment", Ser. No. 08/274,394 filed Jul. 11, 1994. "Digital Map Generator and Display System", Ser. No. 08/543,590, filed Oct. 16, 1995.

1. Field of Invention

This invention relates to the field of remotely piloted vehicles (RPVs) and unmanned aerial vehicles (UAVs).

2. Discussion of Prior Art

RPVs can be used for any number of purposes. For example, there is a large organization that promotes the use of remote controlled planes. Certain RPVs are controlled by viewing the plane with the naked eye and using a hand held controller to control its flight Other RPVs are controlled by a remote pilot using simple joysticks while watching the video produced by a camera in the remote aircraft. This camera is also used to produce the reconnaissance video. There are tradeoffs involving the resolution of the video, the rate at which the video is updated, and the bandwidth needed to transmit it. The wider the bandwidth the more difficult it is to secure the signal. The freedom to balance these tradeoffs is limited because this video is also used to pilot the aircraft and must therefore be updated frequently.

Certain UAVs are preprogrammed to follow a predetermined course and lack the flexibility to deal with unexpected situations.

The 1983 patent to Kanaly (U.S. Pat. No. 4,405,943) shows a control and communications system for a remotely piloted vehicle where an oculometer determines where the remote operator is looking and signals the remote vehicle to send the high resolution imagery corresponding to the area around where the remote operator is looking and low resolution imagery corresponding to the remote operator's peripheral vision. The objective is to minimize the bandwidth of the information transmitted to the remote operator.

SUMMARY

A method and apparatus is described 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 system is used that includes an aircraft and a remote pilot station.

The aircraft uses a communications link to send its location, attitude, and other operating conditions to the remote pilot station. The remote pilot station receives the data and uses a database describing the terrain and manmade structures in the remote aircrafts environment to produce a 3D view of the remote aircraft environment and present it to the remote human pilot.

The remote pilot responds to the information and manipulates the remote flight controls, whose positions and forces are transmitted to the remote aircraft. Since the amount of data is small, it can be readily secured through encryption and spreadspectrum techniques.

Also, because the video reconnaissance cameras are no longer needed to remotely pilot the aircraft there is great flexibility in their use. To minimize bandwidth and reduce the possibility of being detected, the video data can be sent at a slow update rate. The data can also be stored on the remote aircraft for later transmission. Alternatively, low resolution pictures can be sent in real-time, while the corresponding high resolution pictures can be at a later time. The reconnaissance video can even be transmitted through a different communications link than the control data. There may also be more than one reconnaissance camera.

The delay in the control link must be minimized in order that the remote aircraft can be properly flown. The system can measure the link delay and make this information available to the pilot. This delay link measurement can also be used to modify the control software through which the remote pilot flies the remote aircraft. This is to prevent pilot-induced-oscillation.

The computers in the system allow for several modes of operation. For example, the remote aircraft can be instructed to fly to given coordinates without further input from the remote pilot. It also makes it possible to provide computer assistance to the remote pilot. In this mode, the remote flight control controls absolute pitch and roll angles instead pitch and roll rates which is the normal mode for aircraft In addition, adverse yaw can be automatically corrected so that the resulting control laws make the remote aircraft extremely easy to fly. Because this comes at the expense of being able to put the remote aircraft into unusual attitudes, for complete control of the remote aircraft a standard control mode is provided to give the remote pilot the same type of control that is used to fly a manned aircraft. Since the remote aircraft is unmanned, the remote pilot can subject the remote aircraft to high-G maneuvers that would not be safe for a pilot present in the aircraft.

To facilitate training, a simulated remote aircraft is provided that allows an instructor to set up the training mission and parameters. This is especially useful in giving remote pilots experience flying with different control link delays. In this simulated mode, the system can be further linked to a battlefield simulator such as SIMNET.

In the first embodiment, the remote pilot is provided with a standard video display. Additional display channels can be provided to give the remote pilot a greater field of view. There can even be a display channel to give a rearward facing view.

A second embodiment uses a head mounted display for the remote pilot instead of a standard display. This permits the remote station to be made more compact so that it can be used in a wider variety of installations. An example would be in a manned aircraft flying several hundred miles away.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by referring to the following description and accompanying drawings which illustrate the invention. In the drawings:

FIG. 1 is a general illustration showing a remote pilot at a remote pilot station operating a remote aircraft according to one embodiment of the invention.

FIG. 2 is a block diagram showing the communications link between a remote pilot station and a remote aircraft according to one embodiment of the invention.

FIG. 3 is a block diagram of a remote aircraft according to one embodiment of the invention.

FIG. 4 is a block diagram of a remote pilot station according to one embodiment of the invention.

FIG. 5 is a block diagram of a remote pilot station according to another embodiment of the invention.

FIG. 6 is a block diagram of a remote aircraft simulator used for training remote pilots according to one embodiment of the invention.

FIG. 7 is an example of a three dimensional projected image presented to a remote pilot by a remote pilot station according to one embodiment of the invention.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the invention.

A method and apparatus is described 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. Since the video from a reconnaissance camera located on the remote aircraft is not used to pilot the remote aircraft, the amount of data transmitted between the remote aircraft and the remote pilot is small. This provides greater flexibility in how the remote aircraft is used and allows the transmitted data to be made more secure. The remote aircraft may be of any type, for example a remote control plane or helicopter as used by recreational enthusiast.

FIG. **1** is a general illustration showing a remote pilot at a remote pilot station operating a remote aircraft according to one embodiment of the invention. FIG. **1** shows Remote Pilot **102** interacting with Remote Pilot Station **101** and controlling Remote Aircraft **103**. Remote Pilot Station **101** and Remote Aircraft **103** respectively include an Antenna **104** and an Antenna **105** for communicating Information **106**.

In one embodiment, Information **106** includes status information concerning the status of Remote Aircraft **103** and flight control information for controlling the flight of Remote Aircraft **103**. The status information is generated by Remote Aircraft **103** and includes the three dimensional position and the orientation (also termed attitude, and comprising heading, roll, pitch) of Remote Aircraft **103**. The status information may also include information concerning the flight surfaces, the engine, an additional altitude reading, etc. Remote Pilot Station **101** uses this status information to retrieve data from a Digital Database **107** which contains a three-dimensional description of terrain and manmade structures over which Remote Aircraft **103** is flying. Based on the three dimensional data retrieved from Digital Database **107**, Remote Pilot Station **101** projects a synthesized three-dimensional projected view of the terrain and manmade structures in the vicinity of Remote Aircraft **103**. Based on this view of the terrain and manmade structures, the Remote Pilot Station **101**, on its own and/or in response to input from Remote Pilot **102**, generates and transmits flight control information to Remote Aircraft **103** which adjusts its flight accordingly.

In one embodiment, the Remote Aircraft **103** is a remote controlled plane or helicopter used for recreational purposes. Since remote controlled planes and helicopters tend to be small in size, the circuitry in such remote aircraft to generate and receive Information **106** is minimized. In such systems, the Remote Pilot Station **101** may be implemented by including additional attachments to an existing portable computer. This allows the user to easily transport the remote aircraft and pilot station to an appropriate location for flight.

FIG. **2** is a block diagram showing a bi-directional communications link between a remote pilot station and a remote aircraft according to one embodiment of the invention. FIG. **2** shows Communications Transceiver **201** coupled to Antenna **104** of Remote Pilot Station **101**, as well as Communications Transceiver **204** coupled to Antenna **105** of Remote Aircraft **103**. In addition, FIG. **2** shows Information **106** being communicated between Antenna **104** and Antenna **105**.

FIG. **3** is a block diagram of a remote aircraft unit used in the remote aircraft according to one embodiment of the invention. FIG. **3** shows Remote Aircraft Unit **300** including Computer **308** coupled to GPS Receiver **301**, Turn-and-bank Indicator **302**, Gyrocompass **303**, Communications Transceiver **204**, Aircraft Engine and Sensors **309**, and Aircraft Flight Surfaces and Sensors **310**. GPS Receiver **301** receives signals from the satellites that make up the global positioning system (GPS) and calculates the aircraft's position in three dimensions. Turn-and-bank Indicator **302** and Gyrocompass **303** provide the aircraft's orientation which comprises heading, roll, and pitch. This data is sent to Computer **308** for transformation into the previously described status information. Computer **308** transmits this status information to Communications Transceiver **204** which produces a radio signal and supplies it to Antenna **105**.

The Aircraft Engine and Sensors **309** are coupled to control the aircraft's engine, while the Aircraft Flight Surfaces and Sensors **310** are coupled to control the aircraft's flight surfaces. The flight control information is received from the remote pilot station by Computer **308** through Antenna **105** and Communications Transceiver **204**. This flight control information is processed by Computer **308** into the necessary signals for transmission to Aircraft Engine and Sensors **309** and Aircraft Flight Surfaces and Sensors **310** to control the aircraft's engine and flight surfaces, respectively. The operation of the aircraft's flight control surfaces will be later described with reference to FIG. **4**.

In order to protect against ECM, the communications link between the Remote Pilot Station **101** and the Remote Aircraft **103** may be secured. While any number of different techniques may be used to secure this link, in one embodiment Computer **308** is implemented to encrypt/decrypt the data transmitted and Communications Transceiver **204** is implemented to use spread spectrum techniques.

Computer **308** may optionally be coupled to Altimeter **304**, Video Camera System **305**, Infrared Video Camera System **306**, Radar **307**, and/or Video Storage Unit **311**. Altimeter **304** provides an output of the aircraft's altitude as a safety check in the event GPS Receiver **301** malfunctions. Thus, this additional altitude reading may also be transmitted to Remote Pilot Station **101** as part of the status information.

Video Camera System **305** is controlled by Computer **308** which determines where the camera is pointing as well as focusing and the zoom factor. The video produced by the camera is not used by the remote pilot for flying the remote aircraft, so there is more flexibility in using the video. As a result, any number of techniques can be used for receiving the images captured by Video Camera System **305**. As examples:

1. High resolution, high update images may be sent back in real-time through the Communications Link, when the high bandwidth needed can be tolerated.
2. High resolution, low update images may be sent back in real-time through the Communications Link to reduce the bandwidth.
3. The video may be recorded in Video Storage Unit **311** for later transmission.
4. The video may be transmitted through a separate communications link.
5. There may be multiple video cameras.

Infrared Video Camera System **306** is similar to Video Camera System **305** and has the same operating modes.

Radar **307** in Remote Aircraft **103** may be passive or active. It may scan a particular pattern or it may track a

selected object. Radar **307** may consist of several Radar units. The information from Radar **307** is processed by Computer **308** so that only the desired information is transmitted over the communication link to the Remote Pilot Station **101** for display.

FIG. **4** is a block diagram of a remote pilot station according to one embodiment of the invention. FIG. **4** shows a Remote Pilot Station **400** including a Computer **405** coupled to Communications Transceiver **201**, Digital Database **107**, Graphics System **406**, User Flight Controls with Force Feedback **408**, and a Storage Device **409**. The Storage Device **409** represents one or more mechanisms for storing data. For example, the Storage Device **409** may include read only memory TROM), random access memory (RAM), magnetic disk storage mediums, optical storage mediums, flash memory devices, and/or other machine-readable mediums. Of course, Digital Database **107** may be stored in one or more machine-readable mediums and/or in Storage Device **409**.

As previously described, Antenna **104** receives the radio signals transmitted by Remote Aircraft **103** representing the status information of Remote Aircraft **103**. These radio signals are transformed by Communications Transceiver **201** and sent to Computer **405**. Communications Transceiver **201** is set to the same mode as Communications Transceiver **204**, so that if, for example, spread spectrum techniques are used, the signal will be transparently received. Computer **405** recovers the data (de-encrypting, if required) so that the data communications from Computer **308** in the Remote Aircraft to Computer **405** in the Remote Pilot Station is transparent. Thus, the bi-directional communications link comprises the combination of Communications Transceiver **201**, Antenna **104**, Antenna **105**, and Communications Transceiver **204**.

As previously described, the status information received by Computer **405** includes the three dimensional position and the orientation of Remote Aircraft **103**. The status information may also include information concerning the flight surfaces, flight sensors, the engine, an additional altitude reading, etc. Computer **405** uses this status information to retrieve data from Digital Database **107** which contains a three-dimensional description of terrain and manmade structures over which Remote Aircraft **103** is flying. The composition and creation of the Digital Database **107** is further described later. Based on the three dimensional data retrieved from Digital Database **107**, Computer **405** performs the mathematical operations to transform and project the three dimensional data to generate video data representing a synthesized three-dimensional projected view of the terrain (and, if desired, manmade structures) in the vicinity or environment of Remote Aircraft **103**. This video data is transmitted to Graphics System **406**, which displays the synthesized three-dimensional projected view on Video Display **407**.

Since the image is generated from the digital database, virtually any image of the environment of the Remote Aircraft **103** can be generated. As examples, the pilot may select the environment to be: 1) a simulated image of what would be seen out of the cockpit of a manned aircraft on a similar flight path; 3) a simulated image of what would be seen when looking in any direction (e.g., backwards, out a side window, etc.); 3) a simulated image of what would be seen if a camera were tailing the remotely piloted aircraft; etc. In addition, the simulated image may be set to any magnification. Thus, the phrase environment of Remote Aircraft **103** is intended to include any image generated with reference to the remote aircraft's position.

The User Flight controls with Force Feedback **408** are used by the remote pilot to input flight path information. The User Flight Controls may be of any number of different types, some of which are further described later herein. The status information received by Computer **405** also includes information received from Aircraft Flight Surfaces and Sensors **310**. This information is used to actuate force feedback circuitry in User Flight Controls With Force Feedback **408**. Remote Pilot **102** observes the synthesized three-dimensional environment displayed on Video Display **407**, feels the forces on User Flight Controls With Force Feedback **408** and moves the controls accordingly. This flight control information is sent through the communications link, to Computer **308**, and is used to control the aircraft flight surfaces in Aircraft Flight Surfaces and Sensors **310**. Remote Pilot **102** also receives data from Aircraft Engine and Sensors **309** through the communications link and is able to send data back to control the engine.

Flight Control

To illustrate the operation of the remote aircraft, a fixed-wing airplane will be described as an example. However, the basic principles apply to other types of aircraft as well. The basic control surfaces of an airplane consist of the ailerons, the horizontal elevators, and the rudder. The ailerons are moved differentially (one up, one down) to rotate the airplane around its roll axis; the horizontal elevators cause the airplane to rotate around its pitch axis; and the rudder causes the airplane to rotate around its yaw axis.

When the ailerons are used to modify the lift characteristics of the wings, one wing creates more lift while the other wing creates less lift. This also changes the drag characteristics of the wings and results in a yaw force that is opposite to the yaw force that results from the tail section causing the airplane to weather-cock into the relative wind. It is this yaw force caused by the airplane weather-cocking into the relative wind that causes a banked airplane to turn. The opposite yaw force produced by using the ailerons is called adverse yaw; the rudder control is used to counteract this force to produce a coordinated turn.

The simplest type of flight control consists of a joystick and a set of rudder pedals. The controls are directly connected to the flight control surfaces. With a joystick, moving the stick left and right moves the ailerons, while moving the stick forward and backward moves the horizontal elevators. The rudder is controlled by two foot pedals, one for each foot, that are mounted on a common shaft and hinged in the middle like a seesaw. Pressing one foot pedal forward causes the other foot pedal to move backward and causes the rudder to also move in one direction. Pressing the other foot pedal causes it to move forward and the opposite pedal to move backward and causes the rudder to move in the opposite direction.

An alternative to the joystick is the control yoke which consists of a wheel attached to a shaft that moves in and out of the control housing. Turning the wheel clockwise or counterclockwise moves the ailerons; moving the wheel shaft in and out moves the horizontal elevators. The rudder pedals as the same as those used with a joystick.

In order to aid in a description of remote aircraft operation, it is thought worthwhile to first describe the operation of non-remotely piloted vehicles. Non-remotely piloted vehicles can be operated in one of two ways (also termed as flight control modes); direct control or computer control (also termed as computer mediated).

Direct Control Non-Remotely Piloted Vehicles

When the flight controls are connected directly to the control surfaces the result is a second order system. Using

the joystick as an example, moving the joystick left or right establishes a roll rate. The airplane continues to roll until the joystick is returned to the center position, after which the airplane remains in the bank angle thus established. The foot pedals are used to counteract the adverse yaw as previously described. Moving the joystick forward or backward establishes a pitch rate. The airplane continues to pitch until the joystick is returned to the center position, after which the airplane remains in the pitch angle thus established. Both the roll rate and the pitch rate are subject to the limits of the airplane's design.

Since the joystick is directly connected to the control surfaces, the aerodynamic forces on the control surfaces are transmitted back to the pilot, giving him or her valuable feedback on how the airplane is flying.

The successful operation of the second order system with the pilot in the loop depends on several factors such as the area and placement of the control surfaces, how much the control surfaces move in response to the movement of the pilot controls, and how long the airplane takes to respond to changes of the control surfaces. The total system characteristics also depend on the reaction time of the pilot. If the resulting system is poorly designed it may be unstable, which means it may not be possible for a human pilot to fly it safely. An example of an unstable system is where the pilot desires to perform a gentle roll to the right and so moves the joystick to the right, the airplane's roll rate is faster than the pilot desires so he/she attempts to compensate by moving the joystick to the left, the airplane rolls left at a rate that is faster than the pilot desires so he/she moves the joystick to the right, and so on, with the pilot constantly overcorrecting and with the aircraft's rolling motions constantly getting larger and larger until the aircraft gets into a condition from which it may not be possible to recover, (e.g., spinning into the ground). The type of loss of control described is usually referred to as 'pilot induced oscillation' and although it may be caused by an inexperienced or inattentive pilot, it is more often caused by poor airplane design. Therefore, new airplane designs are extensively tested to make sure they can be safely flown. Examples of airplanes that use direct control of the control surfaces (Direct Control Second Order Systems) are the Cessna 150 and the Piper Cub.

Computer Mediated Non-Remotely Piloted Vehicles

Computer mediated control systems use a computer between the pilot controls and the control surfaces. The pilot controls are read by the computer, the data are modified in a particular way, and the computer sends control signals to the control surfaces. The computer may also sense the forces on the control surface and use it to control force feedback to the pilot controls. This type of computer mediated control may be used to fly an airplane that would otherwise be unstable, such as the F16 or the F117. Aircraft such as the F16 and F117 are also second order systems because the position of the pilot's joystick represents rate of rotation.

There are risks inherent in a computer mediated system. Although the program can be simulated extensively before using it in an actual airplane, the computer program may be quite large and therefore difficult to simulate under all possible conditions. An example of this is the Swedish JAS 39 Gripen Fighter. Despite extensive simulation of the flight control system, during a test flight a Gripen crashed due to "... the flight control system's high amplification of stick commands combined with the pilot's" large, rapid stick movements"." The pilot had entered a low-speed high-banked turn at a 280 meter altitude with lit afterburners and was leaving the turn when his actions led to 'pilot-induced oscillation'. (Aviation Week & Space Technology, Aug. 23, 1993, pages 72–73).

Having described techniques for operating non-remotely piloted vehicles, the Fight Control Modes for RPVs will be described.

Second Order RPV Flight Control Mode

A second order control system for an RPV is inherently computer mediated because the remote pilot must interact through two computers: the computer in the remote aircraft and the computer in the remote pilot station.

Flying an RPV is further complicated because there are additional time delays in the loop. The computer in the remote aircraft must first determine the aircraft's position and orientation. The additional processing for transmitting a secure signal by encryption and/or spread spectrum techniques may create additional delays. Transmission delay of signals between the remote aircraft and remote pilot station is negligible for a direct path. However, if the signals are relayed through other facilities the delay time may be appreciable, especially if an orbiting satellite is used. There are additional delays in the remote pilot station as the remote aircraft's position and orientation are used to transform the data from the digital database to present the pilot with the synthesized 3D projected view from the remote aircraft. In one embodiment, the RPV system measures the various delays and modifies the control laws used by the computer in the remote pilot aircraft and in the feedback provided by the computer in the remote pilot station to the remote pilot. For example, the computer may adjust the sensitivity of the User Flight Controls **408** according to the delay (e.g., as the delay increases, the computer will decrease the sensitivity of the flight controls). The system also displays the measured delay to the remote pilot.

First Order RPV Flight Control Mode

The stability of the flight control system, and thus the flyability of an RPV, can be improved considerably by using a first order system. In one embodiment of such a first order system the position of the remote pilot's joystick represents an angle relative to the horizon, instead of representing a rate of rotation as in a second order system. The position of the joystick is transmitted to the computer in the remote aircraft which moves the control surfaces as required to place the remote aircraft in the requested orientation. The control system in the remote aircraft is still a second order system but the delays in the communications link and the remote pilot station are no longer a part of the system's loop.

When a joystick is centered, the remote aircraft will fly straight and level. When the joystick is to the right of center the remote aircraft will be in a right banked turn. When the joystick is to the left of center the remote aircraft will be in a left banked turn. When the joystick is backward from center the remote aircraft will be in a pitch up orientation. When the joystick is forward of center the remote aircraft will be in a pitch down orientation.

The amount of bank and pitch permitted depends on the design of the remote aircraft. A high performance remote aircraft will be capable of a greater amount of pitch and bank than will a low performance remote aircraft.

Referring again to FIG. **4**, Computer **405** may optionally be coupled to Control Panel **402**, Keyboard **403**, Simulation Port **404**, Video Interface **410**, VCR **411**, and/or Video Display **412**. In one embodiment, Control Panel **402** con-

tains specialized lights, displays, and switches to allow a quicker response to situations than can be provided by Keyboard **403**. Control Panel **402** can be arranged to approximate the look and feel of an actual aircraft cockpit. Keyboard **403** allows the remote pilot to select various operating modes. For training purposes, Simulation Port **404** allows the remote pilot station to be connected to a remote aircraft simulator instead of an actual remote aircraft. The remote aircraft simulator will be further described with reference to FIG. **6**. Storage Device **409** allows the flight data to be recorded. During playback this previously recorded data is substituted for real-time data from the remote aircraft to replay the mission for analysis. Any video received from any reconnaissance cameras on the Remote Aircraft **103** is converted by Video Interface **410** so that it can be recorded on VCR **411** and displayed on Video Display **412**. VCR **411** can also operate in straight-through mode so that the reconnaissance video can be viewed in real time.

FIG. **5** is a block diagram of a remote pilot station according to another embodiment of the invention. FIG. **5** shows Remote Pilot Station **500**. Remote Pilot Station **500** is similar to Remote Pilot Station **400** of FIG. **4**, except Video Display **407** is replaced by Head Mounted Display **501**. In addition, Head Mounted Display Attitude Sensors **502** are coupled to Computer **405**. Head Mounted Display Attitude Sensors **502** measure the attitude of Head Mounted Display **501**. This information is used by Computer **405** to produce an additional three dimensional transformation of the data from Digital Database **107** to account for the attitude of the remote pilots Head Mounted Display **501**. This does not require any additional data from the remote aircraft. Of course, alternative embodiments could include both a video display and a head mounted display.

FIG. **6** is a block diagram of a simulated remote aircraft used for training remote pilots according to one embodiment of the invention. FIG. **6** shows Remote Aircraft Simulator **600** including Computer **605** coupled to Aerodynamic Model Processor **601**, Instructor Control Panel **602**, Keyboard **603**, Simulation Port **604**, Graphics System **606**, Storage Device **608**, and Simulation Network Interface **609**. Remote Aircraft Simulator **600** communicates with Remote Pilot Station **400** or **500** through Simulation Port **604**. Aerodynamic Model Processor **601** executes a mathematical model that simulates the behavior of a remote aircraft. An instructor uses Instructor Control Panel **602** and Keyboard **603** to select various training scenarios. Graphics System **606** and Video Display **607** are used to observe the operation of the system. Storage Device **608** is used to record the training session for later evaluation of the session. In addition to proficiency training, the Remote Aircraft Simulator can also be used to practice a proposed mission. The data communicated to the remote pilot station can include training and evaluation data for processing and/or display. This training and evaluation data can include any relevant information, such as flight path accuracy, etc.

Simulation Network Interface **609** permits participation in a battlefield simulation system such as SIMNET, mixing aircraft, tanks, and ground troops for training in the coordination of mixed forces. Thus, the system is designed to allow for the communication of this battlefield simulation information between the remote aircraft simulator and the remote pilot station. This allows the remote pilot station to display one or more other simulated entities (e.g., tanks, ground troops, other aircraft, etc.) described by the battlefield simulation information.

The Database

The Digital Database **107** can be comprised of any type of data from which a three dimensional image can be generated. For example, the U.S. Geological Survey (USGS) makes available various databases, two of which are of particular interest The first is the Digital Elevation Model data which consist of an array of regularly spaced terrain elevations.

The other USGS database is the Digital Line Graph data which includes: political and administrative boundaries; hydrography consisting of all flowing water, standing water, and wetlands; major transportation systems consisting of roads and trails, railroads, pipelines, transmission lines, and airports; and significant manmade structures. The Digital Line Graph data is two-dimensional. In the present invention features such as water, roads, railroads, and pipelines are represented as polygons with elevations determined from the Digital Elevation Model data. Transmission lines and significant manmade structures are defined as three-dimensional objects made of polygons and are placed according to the elevations determined from the Digital Elevation Model data. The different types of objects are tagged so that the remote pilot can select them to be highlighted by category or by specific object.

Data from additional digital databases can also be incorporated. An example of such a database is from Jeppesen Sanderson whose NavData Services division provides aeronautical charts and makes this information available in digital form.

The procedure for generating the synthesized three-dimensional view from the Digital Database may use any number of techniques, including those disclosed in the 1987 patent to Beckwith et al. (U.S. Pat. No. 4,660,157 REAL TIME VIDEO PERSPECTIVE DIGITAL MAP DISPLAY METHOD), and the 1993 patent to Dawson et al. (U.S. Pat. No. 5,179,638 METHOD AND APPARATUS FOR GENERATING A TEXTURE MAPPED PERSPECTIVE VIEW). One disadvantage of generating the synthesized three-dimensional view from these elevation databases in real time is the amount of storage space they require. To avoid this large amount of data storage, one embodiment of Digital Database **107** is composed of terrain data that represents the real terrain using polygons. This database may be generated using any number of techniques. For example, this database may be generated by transforming one or more elevation databases into a polygon database using the technique taught in "Pilot Aid Using a Synthetic Environment", Ser. No. 08/274,394 filed Jul. 11, 1994. Another method for transforming one or more elevation databases into a polygon database is taught in "Digital Map Generator and Display System", Ser. No. 08/543,590, filed Oct. 16, 1995. An example of a three dimensional projected image created from this database is shown in FIG. **7**.

While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The method and apparatus of the invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of limiting on the invention.

What is claimed is:

1. A system comprising:

a remotely piloted aircraft including,

a position determining system to locate said remotely piloted aircraft's position in three dimensions; and

an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space;

a communications system for communicating flight data between a computer and said remotely piloted aircraft,

said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft;

a digital database comprising terrain data;

said computer to access said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation;

a display for displaying said three dimensional projected image data; and

a set of one or more remote flight controls coupled to said computer for inputting said flight control information, wherein said computer is also for determining a delay time for communicating said flight data between said computer and said remotely piloted aircraft, and wherein said computer adjusts the sensitivity of said set of one or more remote flight controls based on said delay time.

2. The system of claim **1**, wherein:

said remotely piloted aircraft includes a device for capturing image data; and

said system operates in at least a first mode in which said image data is not transmitted from said remotely piloted aircraft to said computer at a sufficient data rate to allow for real time piloting of the remotely piloted aircraft.

3. The system of claim **1**, wherein the flight data communicated between said remotely piloted aircraft and said computer is secured.

4. The system of claim **1**, wherein said remotely piloted aircraft further comprises a set of one or more video cameras.

5. The system of claim **4**, wherein said communications system is also for communicating video data representing images captured by said set of one or more video cameras, said video data for displaying said images.

6. The system of claim **5**, wherein said video data is transmitted on a different communication link than said flight data.

7. The system of claim **4**, wherein at least one camera in said set of one or more video cameras is an infrared camera.

8. The system of claim **1**, wherein said display is a head mounted display.

9. The system of claim **1**, wherein said set of one or more remote flight controls is responsive to manual manipulations.

10. The system of claim **1**, wherein said set of one or more remote flight controls allows for inputting absolute pitch and roll angles instead of pitch and roll rates.

11. The system of claim **1**, wherein said computer is also used for correcting adverse yaw without requiring input from said set of one or more remote flight controls.

12. The system of claim **1**, wherein:

said remotely piloted aircraft includes a device for capturing image data; and said system operates in at least a first mode in which said image data is not transmitted from said remotely piloted craft to said computer but stored in said remotely piloted aircraft.

13. A station for flying a remotely piloted aircraft that is real or simulated comprising:

a database comprising terrain data;

a set of remote flight controls for inputting flight control information;

a computer having a communications unit configured to receive status information identifying said remotely piloted aircraft's position and orientation in three dimensional space, said computer configured to access said terrain data according to said status information and configured to transform said terrain data to provide three dimensional projected image data representing said remotely piloted aircraft's environment, said computer coupled to said set of remote flight controls and said communications unit for transmitting said flight control information to control said remotely piloted aircraft, said computer also to determine a delay time for communicating said flight control information between said computer and said remotely piloted aircraft, and said computer to adjust the sensitivity of said set of remote flight controls based on said delay time; and

a display configured to display said three dimensional projected image data.

14. The station of claim **13**, wherein said communications unit is also configured to receive video data representing images captured by a set of video cameras on said remotely piloted aircraft, said video data for displaying said images.

15. The station of claim **14**, wherein said video data is transmitted on a different communication link that said flight control information and said status information.

16. The station of claim **13**, wherein said display is a head mounted display.

17. The station of claim **13**, wherein said set of remote flight controls is responsive to manual manipulations.

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.

19. The station of claim **13**, wherein said computer is also configured to correct adverse yaw without requiring input from said set of remote flight controls.

20. The station of claim **13**, wherein said communications unit includes at least one of a communications transceiver and a simulation port.

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