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FIREFLY SYSTEM CONCEPT

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ABSTRACT

The "Firefly" project has developed and implemented an infrared (IR) remote sensing prototype system based on the concept presented. The Firefly system produces images through smoke that will provide near real-time wildland fire information for fire management and suppression. The prototype will be tested through the 1991 fire season. Results of the testing will be incorporated into the final system design for operational use at the end of 1992.

1. INTRODUCTION

Management of wildland fires requires timely and accurate information on fire location and behavior. The "Firefly " project is building an infrared (IR) remote sensing system that will provide near real-time wildland fire information for fire management and suppression. Firefly is under development for the Forest Service, United States Department Of Agriculture at the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL). Recent technological advances in several technical areas now allow the design of an end-to-end infrared linescanner system to map and detect wildland fires. The system components will include an airborne navigation components, an infrared linescanner, automatic onboard signal and data processing, a telecommunications link, and data integration into a ground data terminal. The system will enable fire suppression and management personnel to acquire detailed information on the fire perimeter, hot spot (small fire) and thermal intensity necessary for fire management,logistics, and suppression.

The Firefly definition phase detailed functional requirements, defined system performance specifications and defined a design approach that could be utilized to build a system to meet the Forest Service fire detection and mapping mission needs [1].

The implementation phase of the Firefly project commenced with the development of the concept design that is now being tested with the prototype system. The Firefly system concept has built upon research, development, and operational use conducted over the last 25 years, and engineering studies and analyses conducted over the last 5 years [2,3].

2. DESIGN APPROACH

The Firefly system implementation design approach is to develop a remote sensing system designed to identify and locate forest fire perimeters and related hot spots using a special purpose IR sensor. The Firefly system uses information on the aircraft parameters, flight altitude, and sensor field of view to plot the location of the IR data onto a geographic data base. The design incorporates a modular system to minimize obsolescence and make use of newly developed equipment based upon existing technology. The system is designed with the fundamental requirement for ease of use with reliability and maintainability considerations foremost. The output products will be produced in a near real-time environment defined as delivery to the fire manager within thirty minutes after the data collection.

3. SYSTEM DESCRIPTION

The Firefly system design concept is depicted in Figure 1. The system consists of an aircraft unit and a ground terminal. The aircraft unit images the ground scene, detects fire spots, computes fire perimeter and hot spot locations, correlates fire data to geographic coordinates, and transmits these data to a ground terminal. The aircraft unit operation is controlled by the Firefly airborne unit operator. The operator enables the system when over the fire area, monitors system performance, and relays flight information to the pilot to optimize the flight path. The operator also has the capability to append messages to the data based upon observations of the raw infrared imagery data.

Firefly will operate from a twin engine Forest Service aircraft flying over a ongoing fire or, in the case of detection missions, over an area where fire activity is suspected. Separate outputs from a dual color infrared line scanner generate imagery which is processed to detect picture elements (pixels) which pass a fire detection criteria. This processing combines both images and

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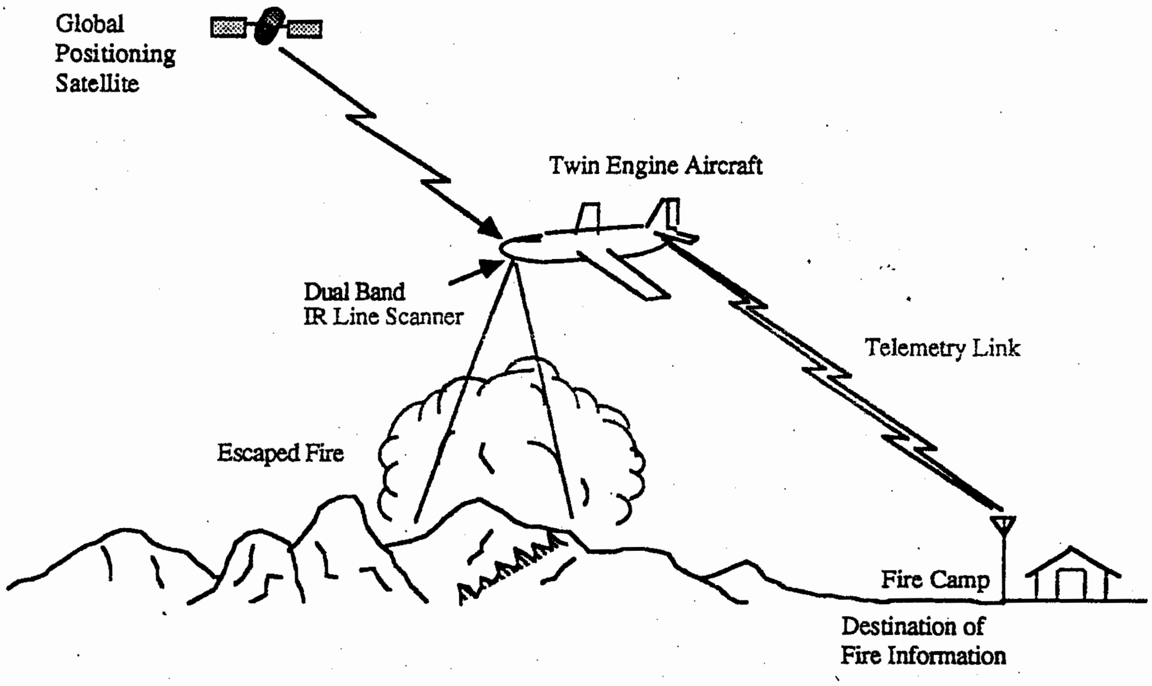

Figure 1. Firefly System Concept

quantizes each resultant pixel for comparison to known thresholds. A Global Positioning System (GPS) receiver is used to determine aircraft position, and gyroscopes are used to determine aircraft attitude and heading. The aircraft position, attitude, and heading information allows the absolute determination of the fire location along a three dimensional line of sight from the airborne sensor. The information is combined with the range (or distance) the pixel is from the aircraft, which allows the determination of the absolute position of each pixel. The georeferencing method (the procedure for locating the fire or hot spots relative to a geographic base) uses a 100 meter square elevation model data base, the aircraft altitude, and sensor look angle to solve for range and to accurately locate the fire data.

At the completion of the data gathering portion of the flight, the aircraft flies to within line of sight of the ground terminal (located at the fire camp) to allow the aircraft and ground terminal computers to transfer the results of the mission via a telemetry data link. The fire data is then available in the fire camp for plotting onto a base map or to be combined with other data in a Geographical Information System format.

4. FUNCTIONAL SYSTEM DESIGN

The Firefly system high level block diagram indicating the relationship between major system components is shown in Figure 2. The aircraft unit consists of five subsystems, which are: 1) Sensor Subsystem for remotely sensing and imaging the fire areas on the ground, 2) Navigation Subsystem for determining aircraft location, attitude and heading information, 3) Signal Processing Subsystem for combining the two sensor bands, quantizing fire spots, and integrating navigation data, 4) Data Processing Subsystem for computing the fire location, and 5) Telecommunications Subsystem for transmitting the data to the Ground Terminal. The Ground Terminal consists of the telecommunications component for receiving the aircraft sensor fire data, and the data output component for processing and displaying the fire location data.

4.1. Navigation Subsystem

The airborne Navigation Subsystem measures the aircraft position, attitude and heading for real-time determination of vectors to objects in the infrared imagery. The subsystem consists of a Global Positioning System (GPS) receiver for determination

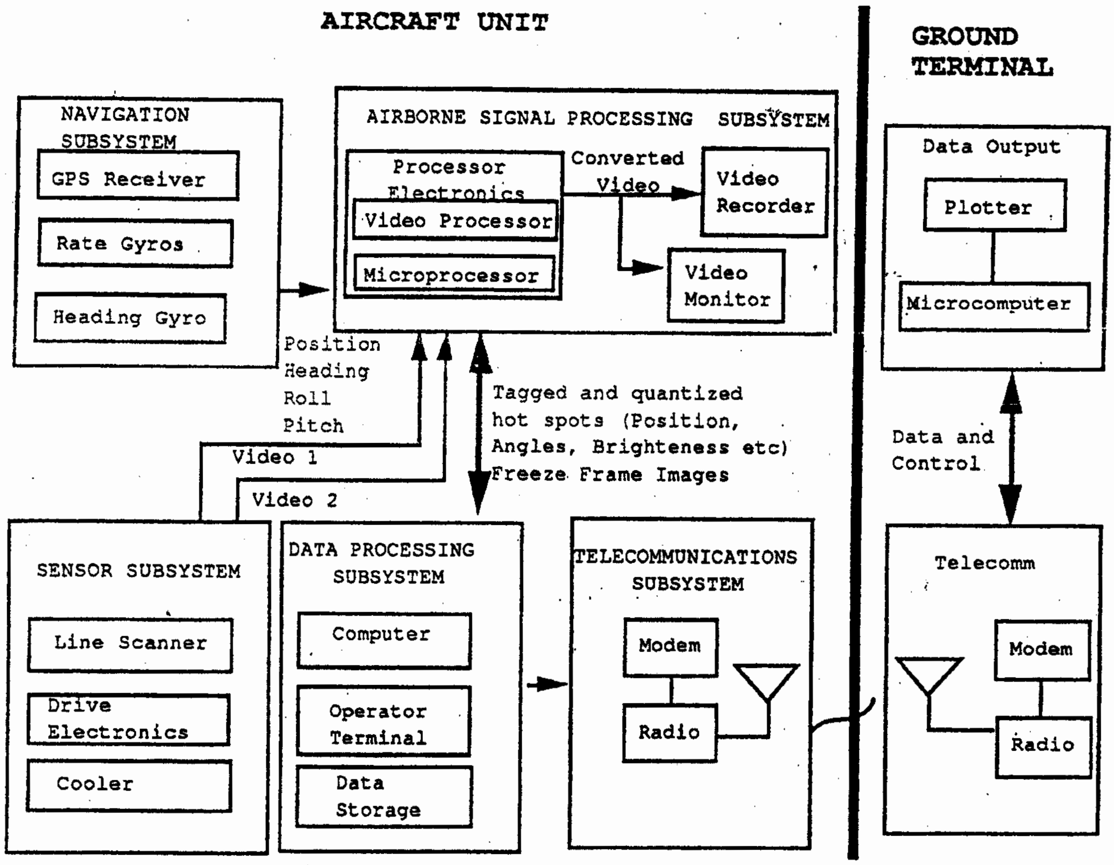

Figure 2. Firefly System Block Diagram

of aircraft position, and gyroscopes for aircraft heading and attitude determination. In addition, pressure altitude is measured for comparison and check of the GPS receiver.

For attitude measurements, rate gyros are used and integrated to generate angular motion. For initialization, and for offsetting rate gyro DC errors, a pendulum is used and combined through a servo loop with a slow (> 60 sec) time constant. The integration process and servo loop are implemented in firmware using a 16 bit microprocessor which samples the signals each 10 milliseconds. The use of a microprocessor in this situation enables the entire process to be integrated using standard off-the-self computer hardware. No special electronics are necessary which will ease maintenance requirements and allow easy reproduction of the system. Attitude accuracies are 0.5°.

Heading measurements are taken with a directional gyro and north seeking compass. A servo loop is implemented by combining the two outputs through differing time constants. Initially, both instruments are read to define an arbitrary offset as determined by the start up condition of the gyro. The gyro will then serve as the primary output for heading. To correct for gyro drift, a servo loop will be implemented by differencing the gyro (plus offset) and the compass. The servo filter will be slow (> 60 seconds) to properly average out short term compass errors caused by airplane lateral accelerations. The servo correction is then implemented by varying the gyro offset. A microprocessor will be used to control the servo function. Heading accuracies are 1.0°.

4.2. Sensor Subsystem

The Sensor Subsystem detects infrared radiation from the fire and converts this radiation into electrical signals for subsequent processing in the Signal Processing Subsystem.

The Sensor Subsystem consists of a special purpose IR linescanner to detect and locate fire and flame hot spots on the ground. Infrared scene emittance is gathered in two IR spectral regions to provide false alarm rejection with optimum sensitivity detection. The requirements for bi-spectral imaging (3-4.8 μm and 8.5-12.5 μm), large field of view (>80 degrees cross track), and high spatial resolution (<= 2.5 mrad) make an IR linescanner the sensor of choice.

Functionally, the IR Sensor Subsystem must address the two primary Firefly tasks of mapping established fires, and detection of point fires ("hot spots"). Both tasks imply requirements which must be met by the sensor. Mapping large fires requires large field of view (FOV) and high sensitivity in the long wave IR (LWIR) channel for terrain imaging. Hot spot detection requires bi-spectral imaging for false alarm rejection, wide FOV to maximize the area searched, and high sensitivity in both spectral channels.

The required sensitivity was calculated with a model developed for the Firefly project at JPL. Due to the very small size of a hot spot, detection requires a relatively small IFOV combined with sensitivity. The sensor must detect a 1/2 square foot hot spot (600° C) at altitudes of 10,000 feet. Hot spots of very high temperature are distinguished from warm terrain features by their spectral characteristics. A threshold (or multiple thresholds) is implemented at a standardized output signal level. Signals above the established threshold standard are considered fire targets. Mapping large fires requires sensitivity in the LWIR band, to allow identification of terrain features by the operator.

Both detection and mapping missions are accomplished at a variety of aircraft altitudes and speeds. The extreme requirement on sensor V/H (the velocity to height ratio) comes from the low altitude mapping mission, at 2000 feet altitude and 120 knots. The scanner V/H is sufficient to allow for 50% overlap on successive scans, which allows double detection of small fires and rejection of spurious noise spikes. The scanner V/H is sufficient to meet the requirements over the range of aircraft operational conditions.

4.3. Signal Processing Subsystem

The airborne Signal Processing Subsystem is responsible for the real-time processing of the imaging sensor output. This includes the image combination of both wavebands, sensor calibration, fire identification in the image, and real-time operator input which identifies selected features.

The airborne Signal Processing Subsystem consists of a specialized microcomputer, video processing electronics, video monitor and video recorder. The subsystem accepts the dual channel sensor data from the Sensor Subsystem, digitizes and mathematically combines them to produce quantized levels of thermal brightness values. The dual band data is combined in a manner which minimizes the possibility of false alarms caused by warm background objects (< 600° C) and solar reflection. The Signal Processing Subsystem also interfaces with the Navigation Subsystem and Data Processing Subsystem. The brightness values which are determined to identify a fire or hot spot are tagged with navigation and ancillary sensor data for georeferencing by the Data Processing Subsystem.

Video processing utilizes frame grabbers and video processors. The video processing electronics allow the sensor output to be either digital or analog video. A frame grabber digitizes the incoming sensor imagery in real-time. After completed processing of the imagery, video encoders reproduce the processed video signal from the digital data. All of the video electronics are fully compatible with standard monitors and displays. Pipeline architecture processors utilize internal processing of the dual band sensor data. The pipeline structure allows the individual steps of a sequential process to be done in parallel. The structure allows for the execution of complex computations with a speed commensurate with video imagery data rates (10 Mega pixels per second).

Frame grabbers are used to input the two channels of line scanner data for digital or analog input. The data is stored separately in two image buffers. The next sequence in the pipeline utilizes a lookup table to generate the combined image (including thresholded image which identifies fire areas and brightness), and the original long waveband image for operator imagery display. Separate image buffers store the data as 1024 x 1024 pixel images. The operator imagery is generated by displaying the long wave band in monochrome, with a red overlay indicating fire areas. Additionally, the thresholded data is routed to a convolution filter which performs two minimum/maximum operations to eliminate noise spike false alarm, and reduce the data quantity to the Data Processing Subsystem computer. A parallel data path from the frame grabber image buffers allows brightness histogram processing for line scanner calibration.

4.4. Data Processing Subsystem

The primary purpose of the Data Processing Subsystem is to collect fire location information from the Signal Processing Subsystem and register it for plotting onto a standard United States Geological Survey map projection. As the Data Processing Subsystem receives the fire data from the Signal Processing Subsystem, it requests aircraft position and orientation information from the Navigation Subsystem at the time the fire data was collected. Once the Data Processing Subsystem has this information it calculates the true latitude/longitude coordinates for construction of the fire perimeter and hot spots map plot. The operator controls the transmission of the fire plots to a ground terminal for plotting.

The Data Processing Subsystem consists of the computer, data storage, operator terminal, and software that is needed to georeference the tagged fire and hot spot data. The Data Processing Subsystem accepts the tagged fire and hot spot data and generates graphical data sets in order to compute the ground position of each point. In addition, this subsystem provides the primary control interface between the aircraft unit and the Firefly system operator. The subsystem graphical georeferenced output is the fire perimeter data sent to the Telecommunications Subsystem for transmission to the Ground Terminal.

The Data Processing Subsystem will allow the operator to request a freeze frame of the currently displayed linescanner data. Upon receiving a request the freeze frame will be digitally sent from the Signal Processing Subsystem to the Data Processing Subsystem to be displayed. The operator will overlay the fire plot on the freeze frame. At this point the operator can easily annotate the plot to high-light landmarks visible in the linescanner image. The annotated plot is transmit to the ground terminal.

4.5. Telecommunications Subsystem

The Telecommunications Subsystem has components (telemetry modems, transceivers and radios) at both ends of the telemetry link, in the aircraft and at the ground terminal. The telecommunications interface will be a serial computer using standardized communication protocols and software to eliminate the need for manual operation. At the request of the Firefly operator, automatic data transmission and error checking occurs when radio frequency line-of-sight conditions exist.

4.6. Ground Terminal Subsystem

The purpose of the Ground Terminal Subsystem is to generate a plot output of the Firefly data. The Ground Terminal Subsystem consists of telecommunications equipment, a microcomputer, plotter and power conditioning equipment. The computer is the primary interface to the operator for initializing the unit and reporting status. Once the ground computer receives the fire data, a plot file is created for output of the fire data onto a map base. The fire map is distributed to the fire management personnel in the fire camp and on the fire line.

5. CONCLUSIONS

The system design concept provides for flexibility in the acquisition and integration of requisite information into a high resolution, user-friendly system which will perform fire mapping and detection on a near real-time basis.

6. ACKNOWLEDGEMENT

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7. REFERENCES

1. Nichols, J. David, Forest Fire Advanced System Technology (FFAST) Task Definition Phase Final Report. (JPL Internal Document) Jet Propulsion Laboratory, Pasadena, CA., July, 1988.
2. Warren, John R., and Wilson, Ralph A., Airborne Infrared Forest Surveillance - A Chronology of USDA Forest Service Research and Development. USDA, Forest Service, General Technical Report INT-115, Washington, D.C., August, 1981.
3. Nichols, J. David, Gary S. Parks, Jeffery M. Voss, Robert A. Mortensen, and Thomas L. Logan, "Designing An Infrared System To Map And Detect Wildland Fires", Sensor Fusion II, Charles B. Weaver, Editor, Proceedings SPIE 1100, pp. 7-14, 1989.