Advanced Terrain Data Processor

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Abstract: The Quiet Knight Technology Demonstration Program has developed an integrated avionics system that greatly enhances covert penetration capabilities of the C-130 aircraft. The system centers around an enhanced digital map called the Advanced Terrain Data Processor (ATDP). The ATDP enhances covert capability by fusing data from different sensors and sources. Aggressive terrain following is accomplished by blending Low Probability of Intercept (LPI) Radar, Ladar, and radar altimeter with Digital Terrain Elevation Data (DTED). Accurate navigation, required by terrain following, combines data from the INS, GPS, radar altimeter, and DTED. Threat avoidance is accomplished by merging on-board and over the horizon intelligence data with DTED culminating in an automatic replan. All three functions combine to provide excellent situational awareness that keeps the aircraft safe from terrain impact and enemy engagement.

System Overview

The ATDP is interconnected with multiple avionics systems to manage the aircraft mission. Figure 1 shows the avionics tested during the various phases of the program. Covert penetration is possible due to an aggressive terrain following algorithm flying set clearances of 150 to 1000 feet and by minimizing emissions from the aircraft with sophisticated sensor control techniques. Utilizing threat detection methods which allow the aircraft to detect and locate unplanned threats prior to exposure, planning routes on the ground and in-flight which minimize exposure to all threats and improving the crew's situational awareness through multiple video displays also aid in the covert capabilities.

ATDP Description

Successful mission management is possible due to the ATDP that fuses data from several external

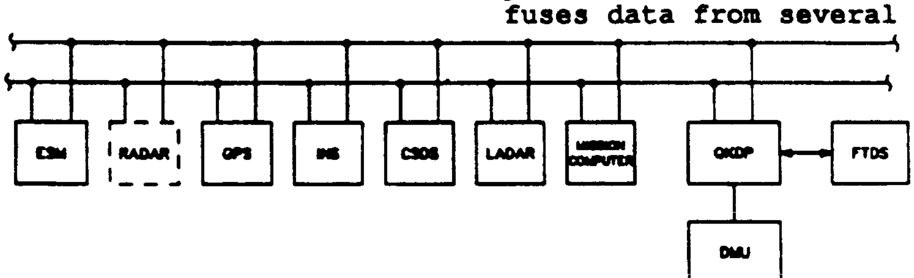

Figure 1 Quiet Knight System Diagram

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sources. Information is captured graphically for display to the crew and provides vehicle management commands to both the crew and other avionics systems. Figure 2 is a block diagram of the hardware which executes these management tasks.

Display Formats

Three video outputs are generated within the ATDP. Video Engine 1 provides the plan-view map in a redundant RGB format. The plan-view map displays either paper chart, DTED color banded, or still-picture information. Threat information is displayed with translucent shading indicating the detection or line of sight for threats and a single ring indicating the lethal range. Planned threats are shaded in white while unplanned threats are shaded with purple. The Intervisibility Engine calculates the display pixels which must be shaded in real-time based on the terrain following set clearance. Video Engine 2 provides two monochrome outputs: ridgelines and energy elevation profiles (EESCAN). The ridgeline display shows six lines at 1 nmi. spacing with a field of view of +/- 30 degrees. The EESCAN display gives the pilot vertical steering information with the elevation line indicating the terrain plus commanded set clearance for the planned aircraft route. The energy line displays the maximum climb the aircraft perform. Distance is displayed logarithmically along the x-axis from 0.1 nmi. to 20 nmi. The y-axis represents the flight path angle from +15 to -20 degrees. The elevation line includes any combination of stored DTED and obstacle information, terrain from the RADAR, and terrain and obstacle data from the LADAR.

Steering Commands

The ATDP provides passive pitch and roll commands to the pilot on the ADI. The roll is based on the preplanned route and

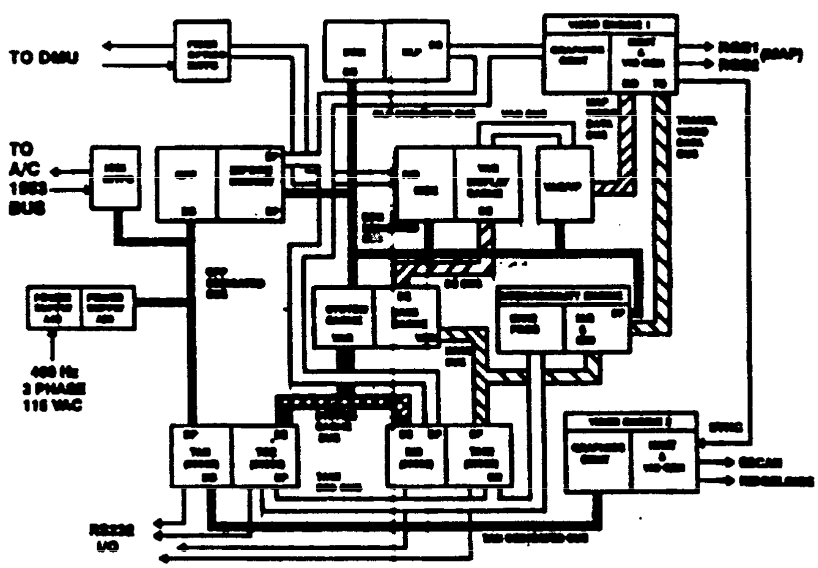

Figure 2 ATDP Block Diagram

aircraft characteristics and attempts to minimize cross-track errors while the pitch commands are generated by an ADLAT algorithm tailored to a C-130 vehicle. The pitch commands attempt to maintain the commanded set clearance at all times.

Elevation Profile

The elevation profile input to ADLAT for vertical steering and the EESCAN display format is fused from a variety of sources. The baseline profile is based on stored DTED data provided by the Defense Mapping Agency. Blended with this data is information from forward looking sensors. RADAR and LADAR data can be blended into the DTED profile. The forward looking sensors are commanded by the ATDP to scan a limited region ahead of the aircraft. This blending mechanism provides two important enhancements to the vehicle management. First, by blending sensor data with DTED, the sensors need only scan 1.8 nmi. ahead of the aircraft and can reduce their emitting power. The scan region is further limited to the planned route which significantly reduces the detection probability. Secondly, the forward looking sensor improves flight safety concerns by correcting or verifying the DTED data.

Threat Avoidance

The ability to respond quickly and efficiently to in-flight threats is critical to maintaining covert status. The on-board Electronic Support Measures (ESM) can detect threats prior to entering line-of-sight. ESM detected threats are sent to the Constant Source Data System (CSDS) for correlation to the present threat database. CSDS also receives broadcast threat information and performs the same correlation function. The CSDS will update known threats or issue new threats to the ATDP as necessary. When the ATDP receives a new threat, it updates its database, calculates the line-of-sight for the threat that will be displayed on the planview map, and determines if evasive action is required. The ATDP is constantly searching the planned route for intersections with unplanned threats. Should an intersection be detected within 25 nmi. of present position, an in-flight mission replan can be invoked. The in-flight replan is identical to the ground based route planner and is a modified A-Star algorithm. The route generated will be the lowest cost route based on exposure to a threat's detection and lethal regions, path length, path vertical changes, and a measure of each point on the path's vulnerability.

Navigation

An highly accurate navigation solution is key to safely executing the previous functions. The ATDP includes an 18 state Kalman filter that blends INS, GPS, and terrain referenced measurements to correct for INS errors. The incorporation of both GPS and terrain referenced measurements gives this navigation filter the unique ability to correct for errors in the DTED database, further improving safety of flight.

Summary

The ATDP is a vehicle management system. It controls the scan patterns and power of the forward looking sensors. It also issues steering commands along a planned route which minimize exposure to threats and has been determined to be safe for low level terrain following. The aircraft survivability is dramatically improved since the ingress, mission task, and egress have been made safer due to the enhanced situational awareness and improved terrain following. This system increases the likelihood that both the aircraft and its crew will return from each and every mission, and that is a feature whose value is immeasurable.