LOCKHEED MARTIN

VOL. 26, NO. 1 January - March 1999

Service News

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A SERVICE PUBLICATION OF LOCKHEED MARTIN AERONAUTICAL SYSTEMS SUPPORT COMPANY

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SYSTEMS SUPPORT COMPANY

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Just a Reminder...

Contact information for the **Hercules Support Center** is as follows:

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Focal Point

Customer Operations and Support

Through the years, one of the hallmarks of Lockheed Martin's continued success has been our outstanding relationship with you, our customer. In an effort to refocus our attention, our Product Support organization is now Customer Operations and Support. Traditionally, Product Support has consisted of Field Service, spare parts, manuals, etc. with the focus primarily on the equipment. The new organization, while still offering the previously mentioned products and services, will focus on the customers and the things that are important to them. We want to provide complete cradle to grave support for our products, including full Contractor Logistics Support (CLS) if desired. Our goal is to be a one-stop shop - the overall programatic source for C-130J, airlift, F-22, and our other products. We will accomplish this by using the most economical sources within Lockheed Martin and externally while maintaining oversight to ensure the highest quality.

Terry A. Graham

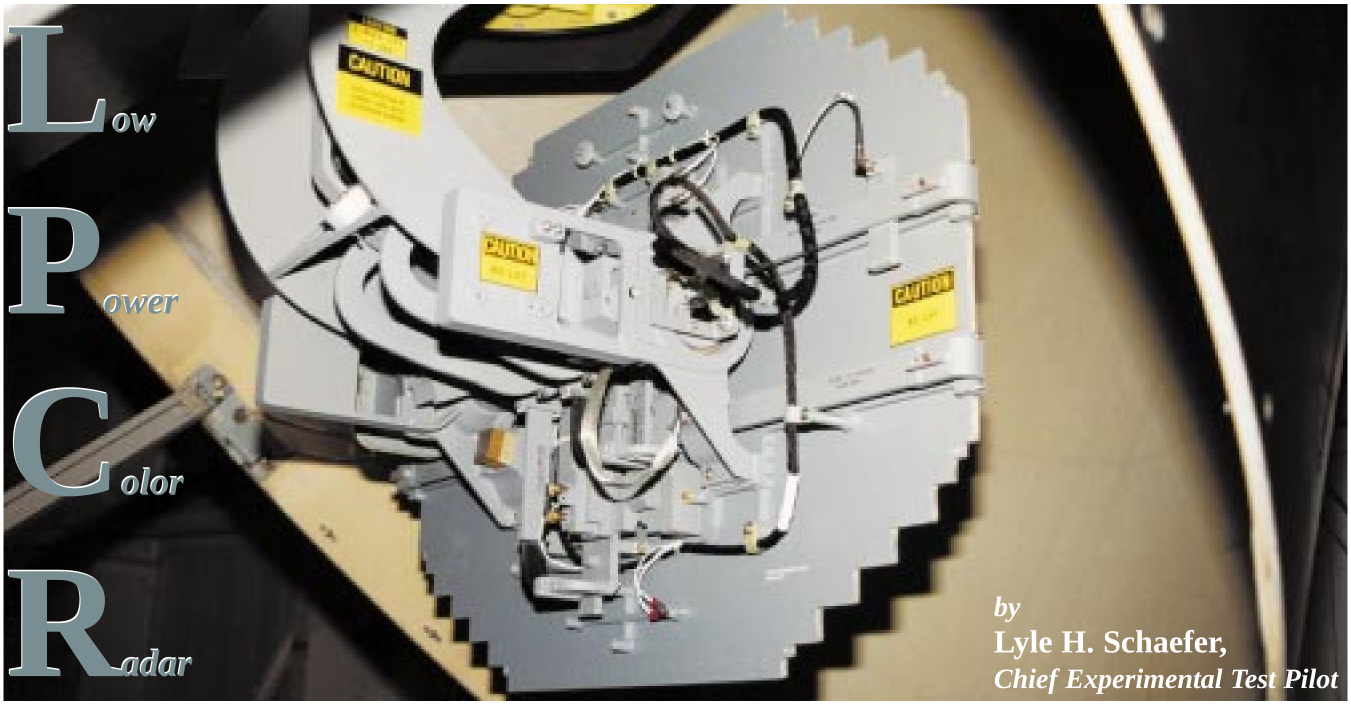
John Gaffney, who has so ably led Product Support in the past, recently announced his plans to retire. As we looked for someone to lead this new organization, we knew that it was imperative to apply the best talent possible to this opportunity. Bill Bernstein has agreed to take on this exciting new task and is now Vice President of Customer Operations and Support. Bill has extensive programatic experience with both the C-130 and the P-3 as well as an extensive Product Support background.

As our customer, you can expect to see improved response times to your inquiries and more comprehensive solutions to your problems. We want to understand any problems you may encounter and work with you to find the best solution. We want to help you keep your aircraft performing your mission requirements by providing broader, more integrated customer support. We firmly believe that our relationship with you is the key to our continued long term success, and we are committed to making that relationship the best that it can be.

Sincerely,

Terry A. Graham
Executive Vice President and
Chief Operating Officer

Front Cover: The C-130J demonstrates a maximum effort take-off at the 1998 Farnborough Air Show.
Back Cover: The C-130J flies against the backdrop of the beautiful English countryside.



Low Power Color Radar

by
Lyle H. Schaefer,
Chief Experimental Test Pilot

As long as aviators have taken to the air in their flying machines, they have wanted to extend the capability of the naked eye to view the world around them. Whether because of darkness, weather, or distances beyond the visual range, the limitations placed on the aviator to utilize the airplane safely and effectively have been linked to his ability to develop a situational awareness of the environment outside the machine. This capability has become an essential element of any airplane whose mission success as an airborne weapons system is dependent on its ability to operate in an all-weather environment.

Over the years, airborne radar has been the most effective sensor for bridging the gap between the naked eye and the external world. It is true that radar has tactical limitations, such as its vulnerability to jamming and its overt radiation characteristics, but no other sensor has been able to provide the breadth of capabilities as has radar. However, great progress has been made in the development of other sensors such as Forward Looking Infrared (FLIR), Low Light Level Television (LLLTV), and Night Vision Goggles (NVG). Unfortunately, as effective as these other sensors have become for specialized applications, they still cannot do what radar does because they all possess some significant all-weather limitations. Radar has continued to expand and improve its capabilities through the infusion of digital technology.

In order to capitalize on the current radar technology and enhance overall Hercules mission effectiveness, Lockheed Martin and Westinghouse jointly took on the task of developing a digital, low power, multimode color radar for the C-130. The requirements for the new radar were tough, but achieving the goals would result in a big payoff to the end user. Lockheed Martin tasked Westinghouse to develop a radar that possessed many innovative characteristics, including those shown in the box at the bottom of the page.

As a pilot who conducted all the Lockheed Martin flight tests on the new radar, I can personally testify that Westinghouse was able to accomplish every task asked of them in record time, and they have produced an absolutely superior product. When combined with the Head Down Display on the C-130J or the liquid crystal display on the C-130H, crews flying this new radar will take a back seat to no one. Not only was the new radar designed to be retrofittable, it was also developed with growth capability in mind. Using the modular building block approach, there is room for insertion of added capability. The first C-130 to receive the new radar from the factory was

Required Features of LPCR

An order of magnitude more reliable than the former C-130 tactical radars

Achieve the required performance but still pose no hazard to ground personnel in the vicinity of the radome

Be fully integrated with the aircraft navigation system

Include a number of different operating modes - some so innovative that they had never before seen tactical applications on a military airplane

Have complete end-to-end Built-In-Test capability

Serial Number 5310, a fiscal year 1992 C-130H aircraft. Later C-130H aircraft introduced a Traffic Alert and Collision Avoidance (TCAS) overlay capability integrated with the Mode S IFF. The radar was also integrated into the C-130J.

So what does the Low Power Color Radar (LPCR) do for Hercules crews? Known initially only as the LPCR, it received the designation of the AN/APN-241 when it was officially installed in the first military C-130H. First of all, this is truly a multimode radar, possessing both tactical and air navigation modes with many user specified features that make it particularly functional for the varied missions of the Hercules. As stated earlier, Lockheed Martin began installing the AN/APN-241 on the Hercules aircraft with Serial Number 5310. The basic radar installation on the C-130H and the C-130J is the same, however, the user interface is vastly different, both for the pilots and for the maintainers. In the following paragraphs, the modes of operation and display functions will be discussed as they are implemented on the C-130H. The radar modes are common to the C-130H and the C-130J, although the display implementation and information is quite different in some areas, particularly Station Keeping Equipment (SKE) and Flight Plan. Next, items unique to the different installations will be discussed including user interfaces. Finally, information concerning retrofit kits will be presented.

The runways of Dobbins Air Reserve Base as viewed through a C-130J Head Down Display Format, expanded four times.

The features of the radar can best be described by how they are utilized by the air crew. There are seven different modes as well as three display functions called "overlays." The modes are Map (3), Weather, Windshear, Beacon, and Skin Paint. The display functions are Flight Plan, Station Keeping Equipment, and TCAS.

Map. There are three different ground mapping modes: monopulse ground mapping (MGM), doppler beam sharpening (DBS), and real beam ground map (RBGM). MGM uses monopulse processing to improve mapping resolution in azimuth. The DBS mode uses doppler processing to generate a map with significantly better azimuth resolution than MGM. The RBGM is provided during degraded operations when incomplete stabilization data is being received in the radar from the Inertial Navigation Unit (INU) or the Embedded Global Positioning System/Inertial Navigation System (EGI). In this mode the radar displays slant range rather than the normal ground range and the format is not roll stabilized. The map picture generated by this technique is eye-watering in its depiction of the objects on the ground. The fidelity of the picture rivals that of a FLIR picture and provides the operator the ability to discriminate the most difficult of targets or ground features. This mode is a tremendous asset in making all weather air drops, conducting self-guided radar approaches, or during low-level navigation. An example of the exceptional clarity afforded in the Map mode is shown in the photograph to the left. Provisions exist for the aircraft navagation system position to be updated from a known radar position using the cursor mode. The latitude and longitude of the cursor position is displayed, which allows correlation of the radar target highlighted by the cursor.

Weather. The weather mode of the radar rivals the best dedicated weather radars on the market today. It measures reflectivity of weather in several dimensions and displays it in a multicolor planned position indicator (PPI) format to the pilots. The color varies from black at <1 millimeter per hour (mm/hr) of rain to magenta for a rain rate of >50 mm/hr. Areas of turbulence are measured out to a range of 50 nautical miles and are indicated by flashing white filled area in the turbulence region. The weather mode compensates for areas of measured intervening precipitation that are equal to or less than 25 mm/hr by indicating those areas that are masked in blue.

Windshear. This is a proactive windshear alerting mode and the C-130H was the first military production airplane to incorporate this unique new technology. This is a coherent pulse doppler mode designed to detect the presence of low level microburst windshear in the take-off and landing environments. This radar is capable of measuring the particulate motions in the air, even if rain is not present. The elevation angle of the lower scan bar is positioned as a function of altitude so that it scans just above the terrain to measure the horizontal winds ahead of the aircraft. The upper scan bar looks up approximately 5 degrees to eliminate main beam clutter. The radar calculates the returns from the two bars to determine vertical and horizontal windshears to several thresholds. Alternate scans of the radar measure the weather and combine it with the windshear picture. The windshear mode displays an offset PPI sector plus and minus 30 degrees from the heading out to a maximum range of 10 miles. There are three levels of windshear generated and each has a different icon.

This method of detecting windshear provides the aircrew with the advance warning of actual windshear by depicting its location relative to the aircraft and allowing the crew to take evasive action prior to actually entering the windshear. The first generation windshear alert systems waited until the aircraft had actually encountered a windshear and relied on a differential rate of velocity change between the inertial measurement platform and the air data system to detect a windshear encounter. By this time it is often too late to take any evasive action, and the only recourse a pilot has is to initiate preplanned windshear recovery procedures. In many cases, this evasive action is not soon enough to avoid the devastating effects of the windshear and has resulted in several airplane crashes on both landings and take-offs. This new windshear mode of the radar has finally provided an effective means of detecting and avoiding one of the most hazardous conditions that an airplane can encounter in the landing or take-off environment. On-board, proactive windshear detection provides the crews of the C-130 the means to detect and avoid one of the last undetected hazards aircraft encounter at low level in an all weather environment. The C-130 is leading the technology train in this field and in so doing is providing the aircrews a new level of safety heretofore unavailable.

Beacon. The Beacon mode provides the capability to interrogate and display responses from either an airborne or ground beacon up to 40 nautical miles. When this mode is selected, the radar defaults to a pencil beam and zero tilt, allowing the operator to adjust the tilt to the beacon of interest or select fan beam for better detection of ground beacons. The beacon is displayed as arcs and can be a stand alone display or can be overlayed on either Map, Weather, or Skin Paint.

Skin Paint. This mode is designed to provide the aircrew with information on airborne targets at or near the same altitude at ranges up to 20 nautical miles and within 60 degrees left and right of the nose. It uses a modern coherent pulse doppler mode using a clutter notch to reject main beam clutter and moving ground targets that could be detected in a look down scenario. The targets that pass a specified threshold are displayed in monochrome in an offset PPI format as a small square (filled) with a vector emanating from the edge of the box. The size of the box is proportional to the radar cross section area of the target and the vector represents the velocity the target is moving relative to the airplane. The pilot can adjust the gain to change the threshold of displayed targets, providing a declutter method in a dense target environment. Adjusting the tilt is another way of pick-

The C-130J Head Down Displays of the Digital Moving Map presentation on the left and the Centered Format Nav/Radar Display on the right with Flight Plan, Airports, Nav Aids, Radar Warning Receiver, and Tactical Plot overlays.

ing out targets at different altitudes or eliminating targets slightly above or below the airplane. This mode provides a tremendous assistance to the crew in spotting potential airborne traffic conflicts and will be valuable in multiplane tactical formations. Combined with TCAS, it provides the pilot with a complete situational awareness of all traffic within the range of both systems.

AN/APN-241 Display Functions

Flight Plan. This display function allows navigation waypoints from the aircraft navigation system, connected by line segments, to be overlayed on any radar presentation. Other symbols from the aircraft navigation system are also displayed, but not connected. This information is defaulted to dim when the system is turned on; the pilot brings it into view by selecting Flight Plan and increasing its intensity. The flight plan corresponds to the radar range scale and allows the pilot to view close range or total flight plan, comparing the intended course to weather or terrain features depicted by the radar. The Flight Plan display function is not selectable in either the Station Keeping or TCAS displays in aircraft prior to the C-130J.

Station Keeping Equipment (SKE). This display function allows data from the AN/APN-169C SKE system to be depicted on any operator's radar display. By integrating this mode with the radar display, the bulky dedicated SKE display is eliminated. The symbols for leader airplane, other airplanes, zone marker locations, and proximity strobe are provided. SKE messages and warnings are sent to the displays via a digital bus, along with range and bearing information from other SKE-equipped aircraft in the formation. The pilot can select range and display orientation to optimize the display format based on the aircraft's position in the formation (centered, offset up, or offset down). On C-130H installations, the navigator monitors the SKE formation in the PPI mode only, and cannot change the pilot selected parameters.

Traffic Alert and Collision Avoidance System (TCAS). This display function allows data from the Mode S/IFF TCAS system to be displayed on the radar display. TCAS symbols cannot be overlayed on the SKE display, but the pilot and copilot can select either independently, allowing the cockpit to monitor both systems simultaneously. The standard TCAS symbols are displayed in a horizontal format depicting Nonthreat Traffic, Proximity Traffic, Traffic Advisory, and Resolution Advisory. Relative altitude and vertical trend numerics are displayed on the integrated rate of climb instrument or primary flight display (C-130J), so that TCAS information is available continuously whether or not it is displayed on the radar scope/Head Down Display.

Other Features

On the C-130J installation, the LPCR is designed to be operated entirely by the pilot and copilot. On the C-130H installations, it is designed to be operated by a three person crew, although most of the functions needed for use by the pilot can be operated without a navigator; the pilot can display the information on the navigator's screen by simply selecting "Slave" on the controller. The radar is capable of displaying information from different modes on different displays through a process known as interleaving. During interleaving, the radar operates in different modes on alternating scans. For example, one display may be set to ground map mode while another display is operating in weather mode. Older C-130H installations typically have one display for the pilots and another for the navigator. Fiscal year 1992 and later C-130H installations have separate displays for the pilot and copilot. On the C-130J, the radar does not have a dedicated display. Instead, it can be displayed in any of the Head Down Displays (HDD), which gives the pilots a tremendous amount of versatility.

The common cursor capability of the C-130J adds a dimension to the capability of the AN/APN-241 radar that integrates it into the GPS-based navigation system and moving map display unique to the C-130J. The

The AN/APN-241 Pilot Display (Center of Windscreen) in a C-130H aircraft.

cursor can be operated in three different modes: Manual, Ground, and Computer. The bearing and distance to the location of the cursor from the aircraft as well as its latitude and longitude are displayed continuously at the bottom of the NAV display. In the Manual cursor mode, the cursor remains at a fixed bearing and distance from the aircraft. In the Ground cursor mode, the cursor is stabilized at a fixed position on the ground. Combined with the accuracy of the GPS navigation system, this mode provides an extremely stable location on the radar and correlates to a corresponding position of the cursor on the moving map display. This is a very useful mode tactically for making a correlation between known map locations and radar returns and vice versa. Finally, the Computer cursor mode allows the pilot to enter into the Mission Computer the latitude and longitude of a known target and slew the cursor to that position. The pilot can also use the identifier of a known position in the Navigation database to slew the cursor to a position. A symbol is also generated on the Head Up Display (HUD) to show the location of the cursor, so that the pilot can either slew the cursor symbol to a visual target or use the cursor symbol to mark a visual target of interest. A slew control for the cursor is located on the pilot's yoke and on the center console mounted cursor control panel. From the same panel the radar ranges can be changed and the picture automatically zoomed into a 2x or 4x sector mode with a single push of a rocker switch. When combined with a cursor location, this provides rapid amplification and correlation of target location. These cursor modes will enhance the tactical utilization of both the radar and the moving map displays.

The AN/APN-241 Navigator Display in a C-130H aircraft.

Maintainer Interface

C-130H Installations. The AN/APN-241 consists of one receiver/transmitter processor (RTP), one RTP mount, one or two pilot indicators with controls, one pilot control panel, one navigator indicator, one navigator control panel, and one antenna. On the C-130H installations, the primary maintainer interface with the radar is through the Built-In-Test (BIT) capability that is accessible through the control panel. Once the test button is depressed on either the pilot's or navigator's control panel, the radar initiates a BIT sequence. At the conclusion of the test, the radar will then display any faults found as a code on the display (for example, the fault code "S16" may be displayed). The code that is displayed will correlate to a table in the appropriate technical manual, which will then give detailed troubleshooting and repair instructions. One operator of HC-130(H)N aircraft that utilizes the AN/APN-241 radar commented that the BIT feature of the radar is very reliable. They had to become accustomed to the radar's BIT pointing out the faulty part right from the start.

C-130J Installations. On the C-130J, the radar consists of one RTP, one RTP mount, and one antenna. Anytime a BIT detects a fault in the system, a message is displayed on the Advisory, Caution, and Warning System (ACAWS). The message given to the crew on the ACAWS if a fault is detected will be either "Radar Degraded", "Radar Failed", or "Radar Overheat." During each flight, the Mission Computer records all of the pertinent maintenance information on one of the Removable Memory Modules (RMM), which is located in the Dual Slot Data Transfer System (DSDTS). The information recorded on the RMMs includes the maintenance log, ACAWS messages, and the fault log. A great deal more information is stored on the RMM than is available to the pilots during the flight. At the conclusion of the flight, the RMM can be removed from the DSDTS and loaded into the Ground Maintenance System (GMS). The maintenance technicians can then use the GMS to translate the raw data on the RMM into usable information. The GMS also gives detailed instructions on how to troubleshoot and repair any problems that are present. The primary interface between the maintainer and the radar is the Portable Maintenance Aid (PMA), which can be used to run tests and otherwise troubleshoot the system.

Retrofit Kits

Lockheed Martin has installed the AN/APN-241 radar as a retrofit kit on twenty-one aircraft comprised of three different versions of the Hercules. USAF Time Compliance Technical Orders (TCTO) 1C-130H-548 and 1-C130-1545 contain all of the installation information applicable to these three versions; minor differences exist between different models. All of the retrofits accomplished thus far have included the Electronic Flight Instrumentation System (EFIS) upgrade in addition to the AN/APN-241, although the EFIS upgrade is not required for the AN/APN-241 installation.

The typical working time for the upgrade installation is ten days for a combination radar/EFIS upgrade or five days for the radar alone. All of the work can be accomplished on-site at the customer's facility. Lockheed Martin is able to complete the installations quickly for several different reasons. First, as the original equipment manufacturer (OEM), we have all of the historical data necessary to properly integrate new systems into a customer's aircraft. Our knowledge allows us to minimize installation time and avoid many of the potential problems associated with new system integration. Second, Lockheed Martin has developed specific installation tooling, including radar boresight alignment, that makes the job possible. Because of our background and through our experience we have been able to refine techniques and tooling to finish the job in a minimum amount of time.

In addition to installing the LPCR kit, Lockheed Martin can also provide aircrew and ground crew training on the operation and maintenance and provide on-site technical assistance in support of the LPCR.

For more information concerning retrofit kits, please contact Mr. Steve Widner at telephone: 770-494-4214, facsimile: 770-494-7657, or the following address:

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Marietta, GA 30063 USA
Attention: S.G. Widner

E-mail: steve.g.widner@lmco.com ❑

Hercules Operators Conference Working Group Summaries

At the 1998 Hercules Operators Conference, a total of four Working Groups met and discussed various subjects. Summaries of those Working Groups are presented here for the benefit of those who were not able to attend.

Corrosion Working Group

Co-Chairmen:
Chris Westbrook - Warner Robins Air Logistic Center
Bob Norstebon - U.S. Coast Guard
Scott Jones - Lockheed Martin

• Bob Norstebon opened the working group with complimentary words for the C-130. Chris Westbrook then gave a briefing about the T.O. 1C-130-23 updates which include the following:

1. Inclusion of C-130 Belly Tape. A Form 252 has been submitted and will be passed out at the forthcoming Corrosion Prevention Advisory Board at Warner Robins Air Logistic Center (WR-ALC). This includes inspection, repair, and removal and will be in Section 5, Chapter 3.

2. Modular Airborne Fire Fighting System (MAFFS). This will include paints for the interiors of fire fighting aircraft, bird patch information, and fastener substitution in Section 6, Chapter 3.

• David Wade and Ken Ross of Chem-Tech gave a briefing on chemical cleaning of avionics equipment. T.O. 1-1-689 (USAF) and NAVAIR 161-689 (U.S. Navy) provide for corrosion protection for units exposed to salt water environment. Chem-Tech has a process to clean these units.

• In another brief, Gerald Mojet of Munters discussed dry air protection and its benefits within the aircraft field.

Open Items

• The cargo auxiliary vent valves were discussed in that moisture was leading to corrosion. A suggestion was made to cycle the valve after each flight.

• Discussion was held concerning cadmium plate elimination. Efforts are underway to change the base material. Drawing changes are forthcoming.

• SMP 515B - several items were briefed concerning forthcoming material changes, finish changes, and a

Qualified Parts List (QPL) for Corrosion Prevention Compounds (CPCs).

• The U.S. Coast Guard presented a briefing on problems they have had with corrosion on fuselage skin under the air conditioning scoops.

• Members of the Working Group discussed the problem of corrosion in the areas under the exhaust heat shields (breadpans) behind the engine exhausts. The sonic dampening material (foam) can become saturated with water and cause corrosion. Marshall Aerospace stated that they are using a new foam with film covering as well as paint on the surface of the wing planks. Scott Jones briefed the group on a suggestion to alodine and paint the area with gloss paint as well as use the new foam. The purpose of the foam is to provide sonic dampening to prevent cracking of the fairing.

• Other discussions dealt with corrosion in the wheelwells. Proposed changes include white polyurethane paints for baseline aircraft and new materials. New, more corrosion resistant aluminum extrusions are being used for MLG side panels.

Structural Integrity Working Group

Co-Chairmen:
Ray Waldbusser - Warner Robins Air Logistic Center
Lt. Commander Pat Dwyer - U.S. Coast Guard
Ron Birdseye - Lockheed Martin

• Ron Birdseye presented a briefing concerning structural integrity initiatives being studied by the U.S. Air Force and Lockheed Martin. Ron asked the members of the Working Group to provide specific items to be discussed. These items included the following:

1. Specific cracking associated with airdrop operations reported by one operator. A poll was conducted that revealed no other units were experiencing problems and no specific reports were discussed. The item was considered an isolated case.

2. A question was asked concerning increased life as a function of reduced fuselage pressure. It was stated that pressure is a dominant load source for the C-130 fuselage. Baseline pressure differential is 7.5 pounds per square inch gauge (PSIG). Mission length is not a factor, but cycles are the primary concern. Commercial operators routinely operate at reduced fuselage pressure to increase life.

3. Ole Nicolaisen presented a short briefing on a "Nasty Crack." The incident occurred on Serial Number 4599 between FS 477 and 517. The crack was identified as stress corrosion cracking. The briefing was for information purposes so other operators would be aware of the potential.

4. One member of the Working Group asked if there was a replacement or preferred spare for the center wing rainbow fitting. Ron Birdseye stated that there was no replacement and that the present fitting is still manufactured from 7075-T6 material. Ron also stated, however, that this, as well as the sloping longeron, was being reviewed for a possible material change in the future.

• SPAR Aviation briefed the group on the structural integrity initiatives in support of the Canadian Forces CC-130 fleet. Allan McRay presented the following topics: Data Analysis System (DAS), CC-130 DART/DAM, CC-130 Center Wing SLEP, and Aircraft Sampling Inspections (ASI).

• Ray Waldbusser of WR-ALC gave a status briefing of the C-130 Fuselage Durability Study and discussed the future of the program.

• A question was voiced from the floor concerning Lockheed Martin's position on composite repairs. Ron Birdseye replied that the subject was still being reviewed.

• Another question was voiced from the floor concerning OWS 93 cracks. The Royal Air Force has experienced several of these. SPAR stated that no cracks have been reported throughout Canada's fleet.

Propulsion Working Group

Co-Chairmen:
ADC Bart McGuire - U.S. Coast Guard
Steve Ludeman - Hamilton Standard
Bill Mitchell - Lockheed Martin

• Bill Mitchell welcomed everyone and introduced Leon Smith of Rolls Royce/Allison who gave a briefing on some of the differences between the T56 and AE 2100D3 engines. Specifically, Mr. Smith outlined the ease of maintenance/maintainability of the AE 2100D3 and the significant increase in thrust from 38,000 pounds on the T56 to 52,000 on the AE 2100D3.

• Lt. Devriendt of the Belgian Air Force asked about replacement criteria for engines that are producing less than 95% rated power. Scott Baier of Rolls

Royce/Allison gave guidelines for this condition and stated that engine wear was indicated anytime performance dropped below 95%.

• SMSgt. Randall of the U.S. Air Force Special Operations Command asked about the NT2000 Propeller program status. Steve Ludeman of Hamilton Standard responded with a short briefing that included the following about the new propeller:

Utilizes existing controls.
The valve housing is removed and replaced by an electronically controlled one.
The synchrophaser function is built into the control.

A show of hands of those who are interested in the NT2000 propeller proved to be positive.

• The Belgian Air Force asked for information about mixed configuration of valve housings. The U.S. Federal Aviation Administration Airworthiness Directive (AD) for commercial aircraft called for demodification from servo to standard governors on the outboard engines. V_{mcg} was also discussed.

• Representative of the Romanian Air Force brought up the subject of starters and interchangeability with starter control valves. Lockheed Martin representatives stated that the starters and control valves should be matched pairs.

• The U.S. Coast Guard asked about testing of the FADEC on the AE 2100D3 engine as it relates to electromagnetic interference (EMI) effects. Scott Baier of Rolls Royce/Allison responded that the same FADEC is used on the V-22 Osprey and had been subjected to extensive EMI testing as part of that program.

• A discussion concerning compressor washing was brought before the floor. It was stated that concerns over the U.S. Environmental Protection Agency (EPA) rules precluded some operators from compressor washing due to cadmium discharge. SMSgt. Randall of Kirtland Air Force Base stated that compressor washes are not authorized at Kirtland for that reason.

• A question concerning oil venting during flight was asked. The oil tank and vent valve had been replaced on a Romanian Air Force Hercules trying to correct the problem. Scott Baier of Rolls Royce/Allison stated that a commercial service letter (CSL) had been issued concerning aging engines and recurring oil venting. The CSL recommended oil system checkout and identified a checkout kit for the rear scavenge pump and associated parts.

• CMSgt. Mike Christiana of the New York Air National Guard discussed engine bogdowns associated with oil cooler augmentation modifications. Lockheed Martin reported that the problem was being studied and recommendations would be provided as soon as possible.

• Rolls Royce/Allison reported that a Service Bulletin was being prepared for turbine wheels and spacers.

Avionics Working Group

Co-Chairmen:
CWO Brad Smith - U.S. Coast Guard
Larry Arnold - Lockheed Martin
Bill MacInnis - Lockheed Martin

• Because of limited time in other sessions, CASA gave a presentation concerning the Spanish Air Force Avionics Modernization Program. The system is a modification compatible with the 1553 data bus. It has built-in test capability and backup systems, and a self protection system. The Spanish Air Force opted to retain the navigator in their upgraded aircraft.

• A question was asked from the floor as to Lockheed Martin's plans to offer avionics upgrades. Bill MacInnis stated that the answer is an emphatic YES. He also stated that any upgrade system must be suitable to the customers' needs and that the Airlift Derivatives Group of Lockheed Martin is ready to discuss the program with any potential customers.

• Representatives from the Royal Australian Air Force discussed external power voltage protection. It was stated that the U.S. Navy/Marines have installed a monitoring system for the voltage/frequency protection using off-the-shelf components.

• The U.S. Coast Guard discussed wiring crimp type splices in their 1500 series aircraft. They stated that the wiring had been replaced in the outer wings of these aircraft.

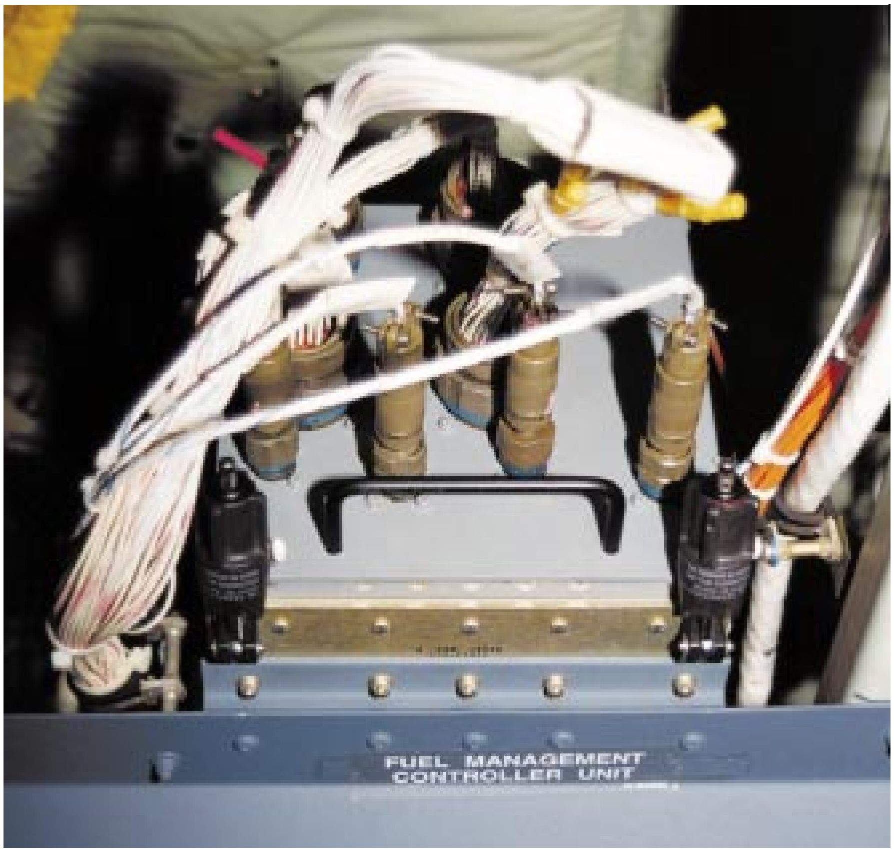
• Ray Waldbusser of Warner Robins Air Logistic Center asked whether there was a Global Air Traffic Management (GATM) kit for the C-130J. Larry Arnold stated that Lockheed Martin is currently working with the U.S. Air Force to define requirements. The process is therefore ongoing to define exactly what is needed for the kits, which will be offered at a later date. ❑

The C-130J Fuel System and Test Equipment

by
David R. Ramos
Field Service Representative

The new C-130J Hercules incorporates a digital, computer controlled, simplified fuel system. This design enables the aircraft to be refueled and defueled with only one main fuel manifold. Fuel transfer and dump functions are also simplified by this design. The design has eliminated sixteen motor driven valves and the single point refueling (SPR) controls (see photo above). The majority of the fuel system controls and all indications are located on the Fuel Control Panel, with additional controls located on the Auxiliary Power Unit (APU) Panel and the Engine Start and Fire Control Panel. All control signals are routed through the MIL-STD-1553B data bus to be processed by the Mission Computer. The Mission Computer commands an electronic unit called the Fuel Management Controller (FMC) as shown in Figure 1. The FMC, which is located in the overhead equipment rack, controls the entire C-130J fuel system by opening or closing valves, turning pumps on and off, monitoring the system, and converting discrete signals to be routed back to the Mission Computer.

Figure 1. Fuel Management Controller



Controls

The majority of the system's controls are on the Fuel Control Panel, shown in Figure 2. Left and right dump switches open or close the dump valves, depending on the weight-on-wheels information. The Fuel Level Control Valve (FLCV) Test switch initiates a check on the primary and secondary solenoids of the FLCVs. The SPR valve has three positions:

Drain. This position enables the SPR manifold to be drained by turning on the refuel and drain transfer pump, opening up the SPR valve, cross ship separation valve(s), and the refuel drain shutoff valve.

Closed. This position closes the SPR

Figure 2. Fuel Control Panel located on the overhead console.

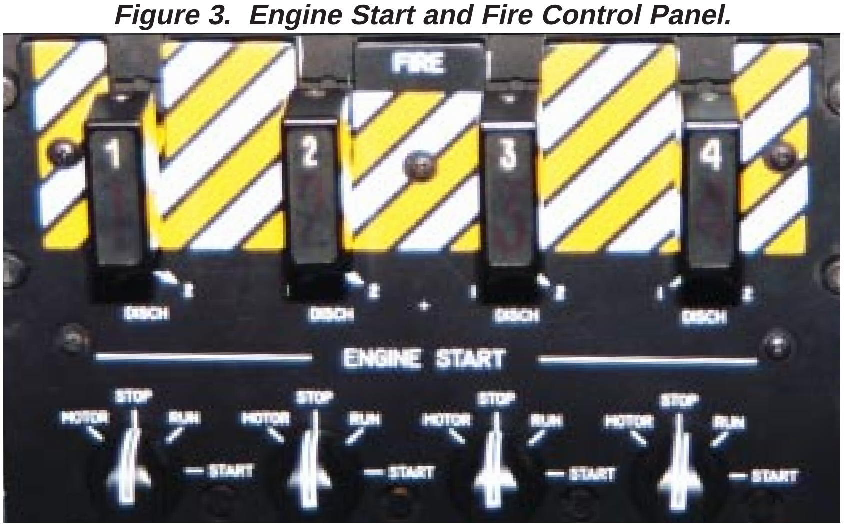
valve.

Open. This position opens the SPR valve connecting the SPR valve to the cross ship manifold. The cross ship separation switch isolates the left and right cross ship manifold in the closed (vertical) position.

The transfer switch, which is a three position switch, turns on the transfer pump when placed in the FROM position, turns off the transfer pump and deenergizes the FLCV to close in the OFF position, and energizes the FLCV in the TO position. The Engine Crossfeed switch allows the respective engine to be supplied fuel from any fuel tank. The Tank Select switch allows the selection of individual tanks or all tanks for automatic refuel or defuel operation. The Quantity Select knob allows the operator to schedule a specific fuel load for each tank during refueling or defueling.

The Engine Start and Fire Control Panel, shown in Figure 3, has additional controls for the fuel system: the Engine Start switches control the fuel boost pumps in the respective fuel tanks. The MOTOR/STOP position deenergizes the main tank fuel pump. In the START/RUN position, the main tank fuel pumps are energized. The fire handles open or close the fuel shutoff valve for their respective engines: when the fire handle is pulled, the engine fuel shutoff valve is closed; when the fire handle is pushed, the valve is opened. The Auxiliary Power Unit Panel controls the fuel needed to run the APU. The APU control switch closes the APU fuel shutoff valve in the STOP position and opens the valve in the START/RUN position. As with the engine fire handle, the APU fire handle closes the fuel shutoff valve when pulled and opens the valve when pushed.

Figure 3. Engine Start and Fire Control Panel.



Indication

Fuel quantity and pressure are indicated on the Fuel Control Panel, with additional quantity indications available on the aircraft systems status page. The indicating system is comprised of the following components: capacitance type tank units, fuel density compensators, fuel quantity displays, and the Fuel Management Controller (FMC). As in earlier Hercules models, fuel quantity can be determined using dipsticks on the main tanks and a magnetic sight gauge for the auxiliary tanks.

The fuel quantity probes and compensators in all tanks are connected to the FMC. The capacitance signal received by the FMC is converted into data words and sent to the Mission Computer via the data bus, and then sent to the fuel quantity indicators. The indicators located on the fuel control panel are monochrome, electro-optical displays for each tank. These displays are divided into upper and lower sections. The lower section indicates the actual amount of fuel in the tank to the nearest five kilograms (or pounds, depending on customer preferences).

The upper section indicates the set amount of fuel to the nearest ten kilograms (or pounds) when using the automatic refuel or defuel function. If there is invalid data or off scale data, the displays indicate dashes. As in the earlier models of the Hercules, the tank probes are distributed throughout the tank to provide maximum accuracy.

The fuel pressure indicator is located on the Fuel Control Panel and the pressure sensing transducer is in the number three dry bay. The transducer senses pressure from 0 - 120 pounds per square inch (psi) on the right side of the cross ship manifold. To sense pressure from the left side, the cross ship separation valve must be placed in the OPEN (horizontal) position.

Distribution and Storage

The plumbing, pumps, and valves for supplying fuel to the engines are included in the distribution system. Design of the distribution system permits single point refueling and defueling, crossfeed from any tank to any engine, and transfer from any tank to any other tank with only one main manifold (the refuel/defuel, crossfeed, and dump manifolds have been combined into one manifold). Standard aircraft refueling can be accomplished from the Fuel Control Panel by opening the SPR switch, which connects the SPR manifold to the cross ship manifold, opening the cross ship separation valve to connect the right to left cross ship manifold, and placing the desired tank transfer switch in the TO position. Transferring of fuel is also straightforward. Simply position the switch for the tank from which fuel is to be transferred in the FROM position and switch for the tank to which the fuel is be transferred in the TO position.

As in earlier Hercules models, the C-130J's main fuel supply is carried in four main tanks and two auxiliary tanks. With its fuel management and fuel efficient propulsion system, the C-130J can fly farther than any other Hercules with external tanks, using only the fuel in the main and auxiliary tanks (for example: C-130E: 2,490 nautical miles; C-130J: 3,150 nautical miles). The C-130J fuel system also includes provisions for the addition of external fuel tanks and in-flight refueling components for unlimited range.

Maintenance

A new Fuel Quantity Adapter Test Set (ES125111-1), shown in Figure 4, was produced for the C-130J. The Adapter Test Set enables the GTF-6 or equivalent to test aircraft tank unit compensator capacitance, individual probe capacitance and resistance, and fuel quantity harness capacitance and resistance. Calibration of the fuel quantity system can be accomplished with the Portable Maintenance Aid (PMA), which is standard aircraft equipment. This rugged laptop computer can perform maintenance diagnostics of all aircraft systems including the fuel system. Calibration of the fuel quantity indicating system using the PMA is accomplished through the Mission Computer and the FMC.

The C-130J fuel system is a well-designed user friendly improvement for the operator and maintainer. This design will significantly reduce maintenance man-hour per flight hour, while improving the efficient performance of the aircraft. ❑

Figure 4. Fuel Quantity Adapter Test Set.

U.S. Coast Guard HC-130 Engine Conversion

by
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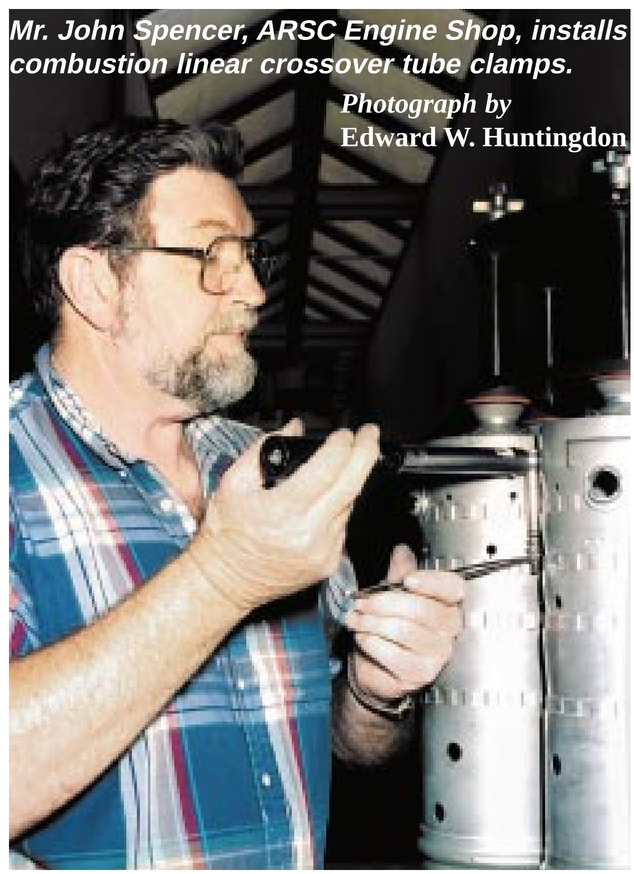
The United States Coast Guard operates a fleet of thirty HC-130H long range search aircraft. Ten of the aircraft were originally delivered with T-56A-7B engines while the remaining twenty were delivered with the newer T-56A-15 engines. Shortly after one of the HC-130H aircraft experienced an uncontained engine failure over Guam in 1993, the Coast Guard began investigating the possibility of upgrading all of the -7 engines to the newer -15 configuration. In addition to a history of turbine failures, the -7 engines have become increasingly difficult to support for the Coast Guard due to the engine no longer being in production.

Several different approaches to the engine conversion were investigated including obtaining quotes from civilian repair facilities, which were dismissed due to the high cost ($750,000 - $900,000 USD per engine). Another option considered was to identify components common to both engines and only replace those that are not interchangeable. This approach was actually carried through to completion on one engine by ordering all of the necessary parts through the Federal Supply System (FSS). Full implementation of this approach on all ten aircraft was abandoned, however, due to the FSS being unable to provide the necessary quantities of the parts. However, the Coast Guard obtained valuable experience on this one conversion that reinforced the idea that the conversion could be successfully completed. The FSS quantity limitations also precluded the conversions from being accomplished during overhaul at Kelly Air Force Base.

After a search, the Coast Guard found a T-56 engine conversion kit available commercially through Allison Engine Company. A problem existed with the kit, however. It was designed to provide a complete upgrade of not only the engine, but also the reduction gearbox and torquemeter assemblies. The Coast Guard had previously upgraded all T-56 reduction gearboxes to the newer A-15 configuration in the 1970s, and the compressor assembly upgrade began in 1991. This left only the combustion section, turbine module, and fuel control to be upgraded. Through negotiations with Allison, the kit was tailored to meet the Coast Guard's specific requirements including removal from the kit of



Mr. John Spencer, ARSC Engine Shop, installs combustion linear crossover tube clamps.

Photograph by
Edward W. Huntingdon

From left to right, Mr. Richard Harmon (Allison Engine Company), CWO2 Luis Segovia (Project Manager), CWO3 Alan Larkin (Project Originator), Mr. Kenneth Bly (Project Item Manager), Mr. Thurl Pursell and Mr. John Spencer (both of ARSC Engine Shop).

the following items: reduction gearbox, torquemeter, compressor, and all turbine and combustion components found to be interchangeable with the A-7B engine. To ensure the completeness of the kit, all consumables, including gaskets and miscellaneous hardware, were included.

Through these efforts, the final kit cost was trimmed by approximately one half. Due to the numerous benefits associated with the modification, the project was approved and a contract awarded to Allison Engine Company for the kits.

Benefits that will be realized with the upgraded engines are are shown in the accompanying illustration.

Benefits of Upgraded Engines

Enhanced short field and hot day take-off capabilities

Improved safety margins

Substantial reductions in inventory for spare engines, parts, and special tooling ($17 million USD in savings)

Complete interchangeability of all engine components and support equipment throughout the fleet

Decreased fuel consumption

Increased available power (20%), which allows higher cruise altitudes or increased cargo capacity

Substantially improved engine reliability while reducing inspection requirements

Publication simplification

The prototype upgrade using the Allison provided kit was accomplished at the Coast Guard Aircraft Repair and Supply Center at Elizabeth City, North Carolina. It went exceptionally smoothly and required only minor kit modification. To date, five aircraft from Coast Guard Air Station Sacramento have been modified. The other five aircraft from Coast Guard Air Station Kodiak are scheduled to be modified within the next year. ❑

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