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INSTALLATION DATA FOR GROUND MOVING TARGETS (GMTI/T) AND RETRANSMISSION GUIDANCE

Raytheon Company
Missile Systems Division
Hartwell Road
Bedford, Massachusetts 01730

May 1977

TECHNICAL REPORT AFAL-TR-77-49
Final Report for Period 18 June - 10 November 1976

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AIR FORCE AVIONICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
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NOTICE

This technical report has been reviewed and is approved for publication.

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Documents the requirements for the design and analysis of, and the acceptance of Class II modification data and hazard analysis report for installation of Low Cost Attack Radar modified to gather ground moving target data in an AC-130H aircraft.

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FOREWORD

This technical report documents the results of a study to design and analyze an installation for incorporating the Low Cost Attack Radar (LCAR) ground moving target measurement equipments and the retransmission equipments into an AC-130H aircraft. The work was performed by the Missile Systems Division of the Raytheon Company under Air Force contract F33615-76-C-1331. The work was monitored by Mr. T. C. Pinkerton, AFAL/RWT, Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio. The author of the report is Mr. H. F. Weisenburger, manager of Flight Test Installations.

SECTION I
SUMMARY

The Raytheon Company Flight Test Installation Department has completed a detail design and structural analysis for a Class II major modification per AFSC Regulation 80-33 to install the LCAR/GMTI radar in an AC-130H aircraft S/N 69-6577 operated by the 4950 Test Wing.

The design and analysis task was started approximately 19 April 1976 and completed and submitted 14 September 1976 to 4950/PPMEB. Independent modification review (IMR) by ASD/ENR and Safety Review Board (SRB) was completed and accepted 11 November 1976.

The AC-130H installation provides a test bed aircraft that retains the gunship fire control system with one 40 mm cannon for potential gunfire test with sufficient growth capability to accommodate the requirements of the Retran experiment as a minor modification. The 7336 lb of equipment including a 4134 lb pallet mounted on the rear ramp are readily removable as major units to enable the aircraft to return to tactical configuration without additional demodification. The Class II test equipment can also be installed in other AC-130H aircraft with minor modifications needed for electrical power interface and rear ramp treadway beef-up.

The design and analysis has been submitted as a Raytheon Company engineering data package D.N. 759347 to the 4950/PPMEB WPAFB, Dayton, Ohio.

The design as installed in the AC-130H meets all structure and flight safety requirements as specified in the contract.

SECTION II
LAYOUT AND DESIGN

The equipment required for the LCAR/GMTI experiment essentially consisted of the basic LCAR units, namely, the sensor assembly (C-1) consisting of the radar antenna, gimbal system, radome, optics, pedestal interface unit; and the structural beam and support box. The transmitter rack (C-2) is a single bay 19 in. rack structure containing the transmitter electronics. The receiver signal processor (C-3) assembly consists of the radar receiver, signal processor, and power supplies mounted in the original B-26 trapezoidal structure. This structure is mounted on top of a support structure so designed as to contain four bays of 19 in. rack equipments and reserved for the Retran experiment equipment. The GMTI receiver assembly is mounted on the side of the support structure.

The test director and radar controller console (C-4) is a double bay 19 in. rack structure containing controls, displays, computer and associated equipments. It requires two operators seated side by side. The recording equipment console (C-5) is an identical structure to the C-4 rack, and contains controls, displays, and data recording equipment. It requires one seated operator. The target simulator console is similar to the C-2 rack and contains target simulators, electronics and data recorders. The video recording equipment table (C-8) consists of an I. O. and monitor panel with two video tape recorders that are vibration isolated on a plate. Interconnect wiring and cables together with power distribution, inverters and controls complete the radar. The design is sufficient to power the Retran experiment.

The requirements for the Retran experiment growth will add a 19 in. structural rack identical to C-2 that requires a seated operator. Additional equipments will be mounted in the base structure of C-3 (one additional computer will be installed in the C-4 rack and some equipment relocated) with appropriate interconnecting cables.

The installation of the equipment in an operationally configured gunship operated by TAC and provided to 4950 TW for the experiment could not be physically accomplished without removal of some operational equipment.

Four different study layouts of the LCAR/GMTI equipment, imposing various equipment removals, were developed and studied. These were presented to ASD/SDX and 4950 TW, and design direction was given to Raytheon. USAF AC-130H gunship S/N 69-6577 was designated as the test bed A/C with the following tactical equipment removed: two forward 20 mm vulcan guns; 20 mm ammo storage container, spent brass bin, gunport aerodynamic deflectors, flak curtains covering 20 mm guns, two miniguns and their mounting pedestals, the 105 mm cannon and its floor support structure, forward and aft 105 mm ammo storage racks, 40 mm ammo storage rack, gun gantry crane including both overhead rails, crash seats on forward cargo floor and on the cargo ramp. The 40 mm gun and its associated fire control system remained in the aircraft for possible gunfire testing.

The removal of the equipment provided almost the full cargo area forward of the fire control room and all of the cargo area aft of 40 mm cannon to the rear cargo door.

Completion of the installation studies and locations of the equipment resulted in installing the sensor, C-1, through the forward 20 mm gunport similar to the original installation. The transmitter, C-2, was located just aft of C-1 and floor mounted facing aft with the video recorders (C-8) being mounted on the minigun table. None of these units are palletized but interface to existing cargo tie-down fittings on the floor and, in the case of C-8, the existing minigun tie-down bolt holes were used.

The final arrangement chosen for the C-3 installation on the cargo floor aft of the 40 mm cannon required only the use of nine cargo tie-down fittings, three on each side covering about 13 ft^2 of floor space. This small area did not justify the installation of a half size type 463L pallet covering approximately 28 ft^2 of floor space. The C-3 installation can be readily moved to a different location to accommodate the replacement of the 40 mm cannon by the 105 cannon, in which case it is moved 40 in. forward. Provisions have been made to install the Retran rack, C-10, and its operator's seat on the starboard side of the cargo floor just aft of the fire control room and forward of the jump door. The operator will face forward with the rack facing aft.

The requirements for the location of C-4, C-5, C-6 and the operators' seats were dictated by several major demands. Mandatory requirements were: keep a minimum emergency escape aisle of 20 in. width to the rear cargo door, add additional interface panels and test equipment to each rack while reducing the overall space volume occupied by each rack, two additional Unitron power supplies to the existing three and find space for them, devise a prime power system so that only the radar needs to receive ground test power and not the whole aircraft. It was also desirable to have a clear traffic corridor through the aircraft, visibility for all operators of each of the three consoles, visibility of the radar monitors by on board observers, vibration isolation of all racks and ready access to the rear of each rack for service. The result is that a full pallet was designed to fit the cargo ramp having three floor levels, the lowest of which supports C-6 on the R/H side facing inboard. The second level supports the three seat structures and has four power supplies mounted beneath. The third level mounts C-4 and C-5 side by side facing forward with a 22 in. aisle space between them on the aircraft centerline, providing the safety escape aisle.

Final design of the cable and power interconnections were resolved and submitted to the 4950th TW Mod center for approval. An exisiting gunship [illegible] support structure design was chosen to carry all cabling and interconnections overhead with drops to each rack I. O. panel. This results in a structural sheet metal cable support, tee shaped in cross section, that starts at the C-2 rack and runs straight aft on the port side to the cargo ramp where it angles up to cross the aircraft to the starboard side angling down and forward to C-6. Provisions are designed to carry it forward to C-10 for the Retran experiment. With minor exceptions, all the LCAR/GMTI and Retran cables will be supported by this cable structure.

One major requirement for the installation specifies that the LCAR/GMTI equipment be readily removable (within 24 working hours) should the aircraft be recalled for tactical needs. It was also anticipated that the radar would be removed and reinstalled several times as various projects were assigned to the test aircraft. The design meets these requirements by being removable in six major items, the radar sensor C-1 removes through the forward 20 mm gunport with the box removed from the floor tie-down. The transmitter C-2 removes as a unit, floor plate included. The receiver/signal processor C-3 detaches from its nine cargo tie-down fittings to remove as a unit. The cargo ramp pallet containing C-4, C-5 and C-6 removes as a single unit. The cable support structure used the existing gantry crane beam brackets and removes as a single item, cables included. All units can then be reconnected in the test laboratory for further development work until reinstallation in the same aircraft or similar AC-130H aircraft.

The aircraft installation is detailed on Raytheon Company Drawings 759348 Rev 3, LCAR/GMTI - AC-130H Inboard Profile, and 759308, LCAR Interconnection Block Diagram which are parts of the Raytheon Company engineering data package Drawing No. 759347 Rev A, dated 14 September 1976.

SECTION III
STRUCTURAL DESIGN

The structural requirements for the installation were defined by contract from Air Force Systems Command Design Handbook 1-X Second Edition, Revision No. 4, 20 January 1975, design note 6A2 1. 1 which specifies MIL-A-8865A Amendment 2 (USAF) dated 7 November 1973, and note 6A2 1.2 specifies an ultimate factor of safety of 1.50. This results in basic crash load factors of:

Longitudinal	16.0g forward, 16.0g aft
Lateral	8.0g right, 8.0g left
Vertical	16.0g down, 8.0g up

When the ultimate factor of safety 1.5 is applied,

Longitudinal	24.0g forward, 24.0g aft
Lateral	12.0g right, 12.0g left
Vertical	24.0g down, 12.0g up

(all loads acting separately)

the results are considered quite high in view of the fact that they are applied to a cargo aircraft whose ultimate crash loading is somewhere near 9.0g.

On the original installation in the C-130A the "Johnson racks" were installed and stressed by 4950 TW. Raytheon was responsible for design, analysis and installation of the sensor (C-1) which was designed for a crash ultimate load factor of 16.0g fore and aft and substantiated by Raytheon LWAR structural analysis, SM 74-192 16 September 1974. Raytheon was also responsible for installing the equipment in the USAF racks and assuring that the installed equipment was flightworthy.

Raytheon had been advised that ASD/ENYO had reevaluated the "Johnson racks" and revised their rated equipment load capability down to approximately 87 lb per bay to meet the 16.0g crash condition. The racks were at that time already carrying equipment weights from 200 to 325 lb per bay and with the addition of GMTI requirements some additional weight was to be expected.

The design and analysis contract was to be accomplished concurrently with the fabrication and installation contract to meet very tight schedules. To assure that a concurrent effort would succeed without need for rework or reanalysis, consideration was given to increasing the ultimate factor of safety (MS) from MS=1.50; an MS=2.50 was chosen for all racks, substructure and interface to the aircraft structure.

Maximum weight limits of 350 lb per 19 in. rack per bay were established for analysis and evaluation.

Three rack proposals were considered for C-2, C-4, C-5, and C-6. The were:

1) Rework the "Johnson racks" to meet the revised loads
2) Design and build new racks to an existing Raytheon developed rack design
3) Fabricate new racks to a USAF 6585 TS existing design operating in 4950 TW aircraft at HAFB, NM

In two weeks the third approach was dropped because the rack could not carry the load, the Raytheon rack could meet the requirement.

The decision to rework the "Johnson rack" was chosen over the Raytheon rack in that no tooling was required and almost all the equipment installation already existed in the inner rack.

The rework of the "Johnson rack" was to remove and scrap the outer frame to lower the center of gravity and pitch moments for a bottom shock/vibration isolation mount system. The inner "Johnson racks" were then beefed up by the addition of a heavy angle at the inside bottom corners, the addition of a 0.500 in. thick faceplate on the front, a 0.375 in. thick rear-plate on the rear, a 0.375 in. thick pase plate on the bottom, a 0.188 in. thick sheet on top and sides with a 0.50 x 3.00 x 2.00 in. thick angle tieing the base plate to the front and rear plates. AN4, AN5 and AN6 bolts were used to bolt the assemblies together.

C-2 and C-6 were almost the same except for mounting orientation while C-4 and C-5 were identical.

Since C-1 had been analyzed to 16.0g crash load and stiffness had been the design requirement, no redesign except for interface and fairing consideration was required.

The upper portion of C-3 was satisfactory, having been designed to high g loads, but when the table supporting the upper section was analyzed it showed stress levels exceeding 375,000 lb. Accordingly, a new table was designed and fabricated incorporating four 19 in. bays. The extra rack space was reserved for the Retran program.

As stated previously, only one pallet was designed and built for the cargo ramp. The design picked up all existing 5000 lb cargo tie-down fittings and, when based upon the ultimate values of the two NAS 1105 bolts in each fitting, appeared to meet the structural crash loading. Concurrence was sought by Raytheon from USAF 4950 TW and ASD/ENYO for the design. This time ASD/ENYO established the ultimate load on the ramp fittings at 5000 lb each. This required that the cargo ramp treadways and the center floor panel be locally strengthened to assure meeting the imposed crash loads with a margin of safety of 1.0

Raytheon's design, as fabricated and installed in USAF AC-130H S/N 69-6577, meets positive structural margins for all equipment racks and support structure with an MS = 2.5 and interface to the aircraft structure of an MS = 1.0. It is to be noted that just days after Raytheon completed its design and was finishing its installation in the aircraft the crash load factors were reduced to half the values specified in MIL-A-008865A Amendment 2, 7 November 1973. The installation was completed to the original requirements to save the cost of additional redesign and analysis.

SECTION IV
STRUCTURAL ANALYSIS

The structural analysis documentation required by the study was performed by Raytheon and submitted in accordance with DI-E-3115B to 4950/PPMEB, as part of the engineering data package DN 759347.

The structural beam, racks, table, and pallet were analyzed for the required crash loads. The pallet considered the maximum reactions from the cabinets and chairs. A load factor of MS=2.5 was used in analysis of the rack and table structures. The margins of safety are with regard to ultimate values; and large deflections, yield, and plasticity were determined acceptable. The NASTRAN computer program was used to determine member forces and section stresses. Hand analysis was employed to evaluate connection details and to determine MS where *bending modulus of rupture* considerations are applicable. The analysis of the interfaces of the equipment to the aircraft tie-down fitting was performed for MS = 1.0.

The analysis is published as Raytheon memos; LWAR Structural Analysis, Memo No. SM-75-191, 2 August 1974, Final Structural Analysis of LCAR/GMTI Cabinets and Pallet Structure Memo No. SM-76-156, 14 September 1976, and Addendum to "Final Structural Analysis of LCAR/GMTI Cabinets and Pallet Structure" Memo No. EAM-76-059, 6 December 1976.