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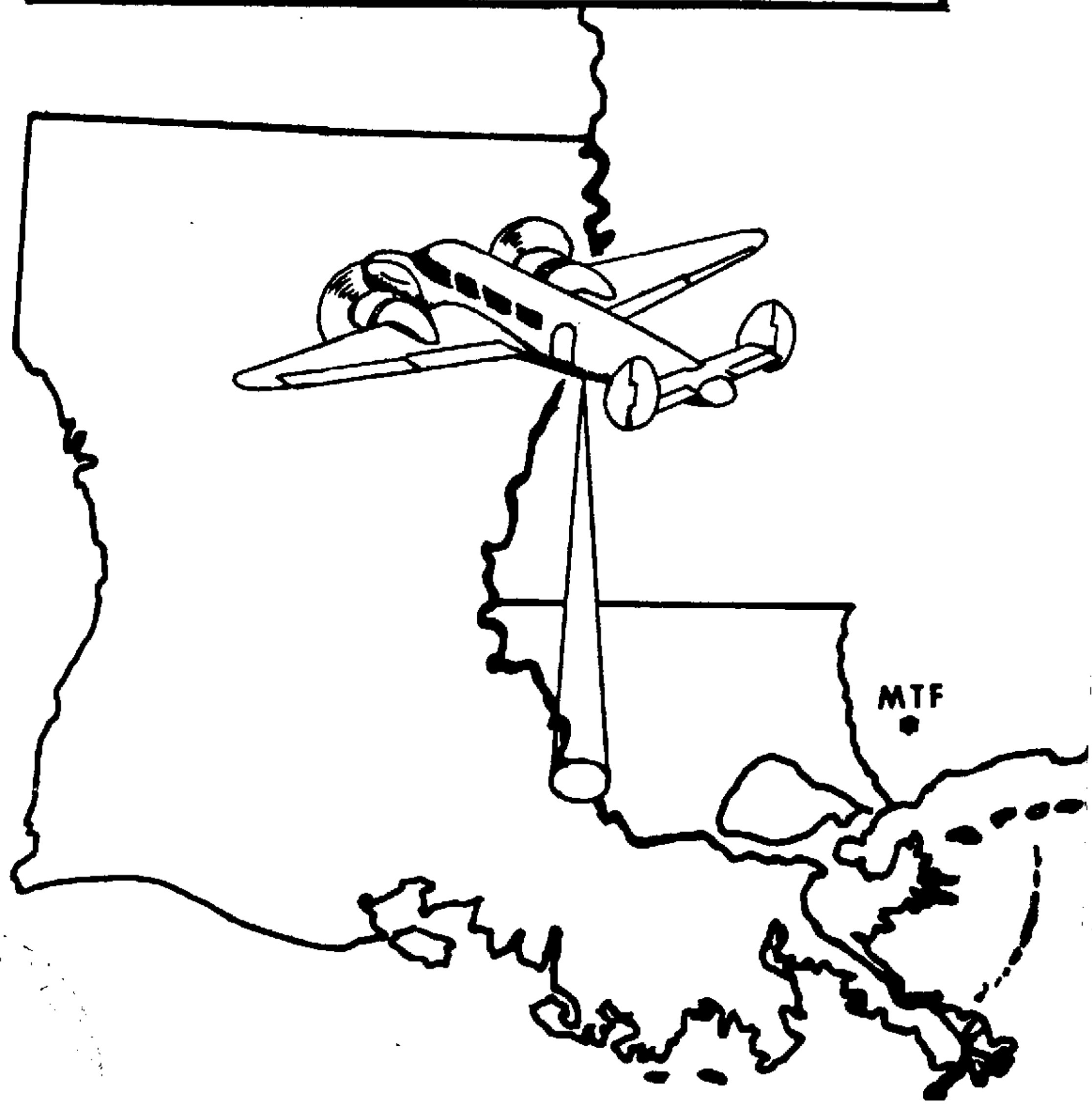
METHODS AND COSTS ASSOCIATED WITH OUTFITTING LIGHT AIRCRAFT FOR REMOTE SENSING APPLICATIONS



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JULY 4, 1973

LYNDON B. JOHNSON SPACE CENTER

METHODS AND COSTS ASSOCIATED WITH OUTFITTING LIGHT AIRCRAFT FOR REMOTE SENSING APPLICATIONS

July 4, 1973

By

O. L. Rhodes
E. F. Zetka

Report 076

I

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I. INTRODUCTION

The purpose of this document is to provide the potential user of a light aircraft remote sensor platform/data gathering system with general information on aircraft definition, implementation complexity, costs, scheduling and operational factors involved in this type of activity. The NASA Johnson Space Center Earth Resources Laboratory (ERL) located at the Mississippi Test Facility derived the majority of this information from experience by having implemented an aircraft remote sensing program during the years of 1971 and 1972. Most of the subject material was developed from actual situations and problem areas encountered during the build-up cycle and early phases of flight operations. As a result, this document should give the potential user of an aircraft an insight into what is involved and, as such, assist him to place the platform into operation realizing fewer problems and in a shorter time interval.

This document deals only with light aircraft as a platform, generally defined as "a single or twin engine aircraft having an overall gross take-off weight of 12, 500 pounds or less". There are a number of aircraft available which will satisfy remote sensing platform requirements; however, only a few are relatively inexpensive to own and operate, available and easy to modify. A light aircraft type that can be outfitted with a reasonably large complement of remote sensing equipment and crew is the somewhat old but reliable twin-engine Beechcraft C-45/E-18S series. While it is not the sole candidate, the Beechcraft is a good one and numerous sections in this document will use E-18S specifications as baseline information.

II. BACKGROUND

In early 1971 ERL made the basic decision that it needed a varied remote sensing capability to support its applications programs. In addition to remotely sensed data obtained for ERL by the major Johnson Space Center aircraft, an internal light aircraft program was needed to obtain additional multispectral data on a more frequent and localized basis. The ERL remote sensing platform/data acquistion system was to follow certain guidelines:

- Provide for frequent and flexible use
- Utilize multiple but limited sensor capability (commercially available, existing equipment)
- Reflect a modest initial cost

The development of the light aircraft program followed a logical sequence:

A. The objectives and limitations of ERL were established with respect to all potential remote sensing applications areas. From these combined objectives and limitations came a general definition for the type, quantity and frequency of data needed to support the applications areas.

B. Knowing the type, quantity and frequency of data required enabled a set of remote sensors to be selected along with defining complementary data handling and processing techniques.

C. The selected sensors determined the need for and complexity of the airborne data recording system. This, in turn, yielded the major aircraft payload weight and volume requirements, including the basic sensors, the supportive data system and the equipment crew. Also the sensor mourting considerations could be delineated.

D. With the weight and volume requirements established and the sensor interfaces defined, candidate aircraft could be screened for suitability. At this stage the original definition of data type, quantity and frequency also fixed minimums for aircraft flight performance parameters.

Thus, at this point, within the previously set guidelines, ERL could establish most of the elements in its aircraft operation:

Remote sensors
Data recording system
Aircraft payload weight
Aircraft payload volume
Airframe modification complexity
Time-in-air/range
Aircraft speed
Operational ceiling
Airborne equipment operators

Subsequent areas such as actual aircraft acquisition, aircraft modification and outfitting, maintenance, documentation and pilot requirements all evolved from implementing the mechanics of the program.

Because all of the above mentioned elements are important and must be investigated by the potential user, each topic will be discussed to some degree in later paragraphs.

III. ELEMENTS OF AN AIRCRAFT OPERATION

A. Remote Sensors

Remote sensors used in earth resources investigations, by their various detection methods, sense emitted or reflected energy across the electromagnetic spectrum -- from the ultraviolet region to the microwave region. All types of sensors generally fall into the following generic categories:

Film cameras
Video imaging systems
Fixed field radiometers
Scanning radiometers
Spectrometers

Active radar imaging systems

Passive microwave radiometers

The number of sensors available is quite large since for each type there are numerous manufacturers. The user organization must determine the necessary device from the application, method and end product desired. A synoptic listing of sensors carried on the ERL aircraft is as follows:

1. RS-18 Thermal Infrared Scanning Radiometer (Texas Instruments, Inc., Dallas, Texas)

   A device which senses emitted energy in the 8 to 14 micron region. The system uses a rotating scanning mirror and collecting optics to sense energy in a wide swath beneath the aircraft and converts this energy to an electrical signal for recording on magnetic tape. The output of this device, after processing, yields a thermal image of the target.

2. I^2S Multiband Camera (International Imaging Systems, Mountain View, California)

   A camera system which senses reflected energy in the visible region from 0.40 microns to 0.92 microns. A set of four lenses and filters collects incoming energy in four bands and focuses it on to a single nine-inch wide film roll (usually Kodak Infrared Aerographic 2424 film). The exposure of the film is the permanent recording of the scene data.

3. E-20D Spectrometer (Exotech Inc., Gaithersburg, Maryland)

   A device which senses reflected energy in the visible and near infrared region from 0.4 to 1.1 microns. The system uses collecting optics and a circular variable interference filter to sense and selectively separate the energy it receives into a number of segments. These segments or bands of energy are converted into voltage signals that are then recorded on magnetic tape.

4. PRT-5 Thermal Radiometer (Barnes Engineering Co., Stamford, Connecticut)

   A device which senses emitted energy in the 8 to 14 micron region. The radiometer system uses optics to collect energy from targets directly beneath the aircraft and converts this energy into a voltage signal. With proper calibration it is possible to relate this voltage to an apparent radiometric temperature for the target.

5. Hasselblad EL 500 Camera (Supplier-Paillard Inc., Linden, New Jersey)

   A camera system which senses reflected energy in the visible region from 0.40 to 0.92 microns. With lens and filter, this camera system records the reflected energy from terrain features on to 70 mm film. The film used can be any one of the following: Kodak Plus X Aerographic #2402; Kodak Infrared Aerographic #2424; Kodak Ektachrome MS Aerographic #2448; Kodak Infrared Aerochrome #2443.

B. Data System

The size and complexity of the airborne data recording system is largely determined by the sensor systems it supports. Where the sensors are relatively uncomplicated, the data system is accordingly small. For example, a camera system needs only a source of power and shutter-control to be an operational system, since the film is the data recording mechanism. For sensors with voltage outputs (such as the PRT-5), the data system requirement is larger but can be accomplished in more than one acceptable way; e. g, strip chart recorder, oscillograph recorder or magnetic tape. The data recording system takes a large step in size only when a larger number of sensors or a varied mixture is established for the platform. Then, in this case, timing and data correlation become key factors (in addition to data accuracy) in the method and sophistication of the data recording. The ERL data recording system elements are outlined in Figure I and discussed in the following paragraphs:

1. Wide Band Analog Magnetic Tape Recorder (Ampex Corp., Redwood City, California)

   This 14 track tape recorder (AR-700) was designed to operate in the severe environment created by an airplane, a necessary consideration for a reliable data system. The recorder uses one-inch wide tape on a 7,200 foot, 12-inch reel. The wide band Group II recording electronics in the system are necessary when the signal frequency response of sensors is quite high. The unit has internal tape speed compensation and the wow and flutter specifications are adequate.

2. Signal Processor and Calibration Unit (ERL in-house constructed)

   This unit provides the necessary signal interface buffering between the various electronic sensors and tape recorder. It also allows for simultaneous, manual or automatic step calibration of all 14 tape recorder channels.

3. Fixed Data Inserter (ERL in-house constructed)

   This unit operates in conjunction with the camera control unit to provide time correlation of electronic data with photographic data. The fixed data inserter generates an encoded signal each time a camera operates and this signal is recorded on one tape track. It also allows the insertion of certain fixed data into the encoded signal for permanent recording; e.g, mission number, date, flight numbers, etc.

4. Intercom and Communications Control Unit (ERL in-house constructed)

   This system was designed for a number of functions, the most important being voice annotation of tape calibration and flight events on to the magnetic tape. This unit also provides an intercom link between pilot and crew and allows intercom communications along with air-to-ground radio communications to be recorded on the magnetic tape.

5. Camera Control Unit (ERL in-house constructed)

   This unit provides for the timing and control of up to 4 camera systems. It controls the cycle rate of the cameras and registers the frame count of each camera. It also generates the camera frame count pulse that is inputed to the fixed data inserter.

6. IRIG Time Code Generator (Systron Donner, Concord, California)

   This commercial unit generates the standard IRIG "A" time code that is recorded on one track of the recorder. It provides for time of day in increments down to the millisecond.

7. System Patch Panel (ERL in-house constructed)

   This element uses patch panels to receive incoming sensor voltage signals and selectively channel the signals through the signal processor to the tape recorder inputs or the data system oscilloscope or voltmeter.

8. Power Control Panel (ERL in-house constructed)
This unit takes the aircraft 28VDC and distributes it to the various devices needing power. It also contains a DC to AC inverter which, in turn, supplies certain devices needing 115 VAC. Integral to the control panel is a set of circuit breakers for short circuit protection.

C. Data Handling and Processing

An important facet (possibly the most critical element) in a remote sensing program is the data handling and processing required to transpose raw data into a form useable for analysis. While it is out of the scope of this document to elaborate on possible data handling and processing techniques, this point is brought to the attention of the potential user because it is so often overlooked in the early stages of platform/data systems buildup. How the data will be processed should have a direct influence on how it is acquired. For example, it would be unwise to use camera systems with 150 foot rolls of film if the processing equipment can only handle 15 foot strips. Especially with electronic data, ground handling facilities can be quickly overloaded with data if their capability and capacity was not factored into the planning of the airborne program. As a corollary to sizing the acquisition system to fit the capacity of the ground handling and processing, new data handling and processing techniques should be developed in parallel with the platform/airborne data system buildup so that the end-to-end processing of data can be implemented by the time the first bit of raw data is acquired.

D. Type of Probable Aircraft

1. Definition

In a moderately sized remote sensing program, the remote sensing platform needed is usually a light aircraft. Light aircraft is defined as a single or multi-engined aircraft having a gross take-off weight limit of 12, 500 pounds. The availability of candidate aircraft are quite numerous and run the gamut from vintage airframes to present production aircraft. Appendix I is a partial summary of light aircraft available. This listing serves to illustrate the important parameters of initial and operating cost, gross take-off weight, useful payload, and fuel (range). While newer aircraft are always the most desirable, initial unit cost forces most organizations to consider the older craft. Even so, a properly maintained aircraft is, to a high degree, ageless in terms of useful life and performance.

2. Payload - Gross Take-off Weight/Empty Weight

Empty weight figures usually mean an unfueled, fully instrumented (avionics) aircraft. This value subtracted from gross take-off weight yields useful payload. Useful payload is comprised of fuel and lubricants, aircraft crew, remote sensor crew, remote sensors and mounts, data system and accessories, safety gear and electrical cabling. After payload requirements for the specific program have been estimated, using an aircraft with a larger payload capability is desirable because:

a. Larger payload capability provides an additional safety margin between aircraft operating weight (when fully fueled) and gross take-off weight limits.

b. Payload reserve allows for expansion in the event of changing sensor/data system requirements.

The ERL aircraft has a gross take-off weight of 10,100 pounds and empty weight of 6,750 pounds. The 3,350 pounds payload, which is 33% of the gross take-off weight, is not as high as it could be due to older tube-type avionics in the aircraft. Even so, this percentage is a respectable one for light aircraft. A first order breakdown of the aircraft weights is as follows:

Aircraft empty weight	6,750 #
Aircraft fuel and oil	1,290
Pilot and co-pilot	350
Two equipment crew members	395
Remote sensors and mounts	342
Data system	409
Electrical cabling	81
Safety equipment	26
Payload reserve	457
Total	10,100 #

For a more precise weight breakdown refer to Appendix III.

3. Volume

The projected remote sensor configuration and cabin interior layout creates a volume requirement for the instrument cabin. Human engineering factors must be included in the volume requirements of the aircraft, e.g. minimum clearance for passageways, etc. The most important dimension of the aircraft cabin is its width -- the wider the better. For a point of reference, the Beechcraft

E-18S affords a minimum volume defined by the dimension of 51 inches wide, 59 inches high, and 159 inches long. Figure II presents a perspective of what can be contained in this volume.

4. Modification Complexity

Modification complexity is highly variable in aircraft. Each candidate airframe must be scrutinized for suitability. As an example, do major load carrying members need to be altered or do control cables need to be rerouted? For a given modification configuration, certain aircraft can quickly be eliminated, such as aircraft with landing gear fixed to the main fuselage cannot be easily modified (or modified at all) due to the massive amount of load carrying structure in the vicinity of the gear. In some aircraft, the dimension from cabin floor to outer fuselage mold line is too great to consider cutting sensor portholes. Each case must be reviewed on its individual merits. Additional information on ERL aircraft modifications is contained in Section V.

It is well to note that aircraft do exist with degrees of modification that may be suitable for remote sensing service. Where the sensor configuration is not complex, it is possible to find and utilize aircraft previously modified for other reasons. This is especially true with older aircraft. These old mods can be adapted at a minimal cost and usually do not require the FAA review as a new modification would.

5. Range/Time in Air

For an aircraft to be effective as a remote sensor platform, it should have at least 3 1/2 to 4 hours flight-time fuel capacity, with a 15 minute emergency reserve. Transit time to and from the target and operational constraints (e.g. lining up on flight lines, "dry runs") usually consumes a majority of this time. Any flight time shorter than 3 1/2 to 4 hours does not allow a reasonable range from home airport or time-over-target.

6. Speed

Speed range of the aircraft should be selected to complement the type of remote sensing to be conducted. Remote sensors in general are designed to operate at higher aircraft speeds with no degradation of data. While the Beechcraft E-18S has a true air speed capability from 110 to 180 knots, most ERL missions are conducted at 150-170 knots.

7. Operational Ceiling

For long term flights, the altitude at which an aircraft crew must go on oxygen supply has been established by the FAA as 12,500 ft. Logistically, flights conducted below this ceiling are the most desirable because oxygen systems are not involved (maintenance and safety problems) and the unpressurized cabin environment at flight altitude has not become unduly severe. Environmental conditioning for crew comfort is not complicated; primarily involving only a good heater system and sealing to some degree around sensors and portholes. As a general rule, the temperature differential between flight altitude and sea level is 3^{o} F per 1,000 feet altitude.

8. Engines

It has been observed that the majority of remote sensing aircraft are twin engine aircraft. The reasons are intuitively obvious:

a. The second engine gives a higher level of flight safety. In the event of airborne engine failure, a properly balanced aircraft not exceeding gross take-off limits can maintain flight without serious concern.

b. Two engines usually mean two sources of electrical power, one of which can be allotted to the remote sensor data system. This item will be discussed in later paragraphs.

9. Fuel Consumption Per Hour

Fuel consumption per hour is such a large variable among aircraft that it is difficult to provide any guidelines. The only information that can be provided is that the Beechcraft equipped with two Pratt-Whitney R985-AN14B radial engines (each rated at 450 horsepower) consume 40 to 50 gallons per hour depending on aircraft load and flight altitude. Fuel weight for mathematical purposes is 6 pounds per gallon.

10. Maintenance/Availability of Spare Parts

In order to minimize down-time and yet perform maintenance according to FAA regulations, in most cases, repair of major components is effected by direct replacement. In that respect, it is important the aircraft chosen is one for which parts are readily available. No matter how low the initial cost, don't select an "Edsel" of the aircraft industry as a remote sensor platform. There is a large number of companies in the U. S. dealing in used and rebuilt replacement parts. The trade journal, "Trade-a-plane" (Crossville, Tennessee 38555) is a good source for names of these companies.

E. Airborne Equipment Operators

For conducting flight operations with pre-determined flight lines, equipment operators should be personnel skilled sufficiently to maintain and operate the specific sensors and data system components (usually field engineers or trained technicians). Depending on system complexity, the number of operators required over and above the pilot and co-pilot will at some point increase from one to two, but rarely will three operators be required in a light aircraft size activity.

F. Pilot and Co-Pilot Requirements

As a minimum, the pilots and co-pilots utilized should have the following credentials:

1. License - "Airplane, Commercial, Land, Multi-engine, Instrument"
2. Medical Certificate - Second Class

ERL has increased its requirements for pilots and co-pilots' qualifications to raise confidence levels in the personnel involved.

1. Pilot-in-command - meets the experience level of FAR, Part 135.125 and maintains certification according to FAR, Part 135.131.
2. Co-pilot - meets the requirements of FAR, Part 135.127 and maintains certification according to FAR, Part 61.47 (a), (d).

G. Aircraft Documentation

Certain documentation should be kept on file for legal record or quick reference. In addition to the obvious documents, such as pilot's credentials, insurance policies; etc., the following paragraphs cover some less obvious, but important, documents.

1. Modification Documents/Airworthiness Certificate - After the airframe is initially modified, certain approvals must be obtained before the aircraft is returned to service. With civilian aircraft, the approvals are documented on FAA Forms 8130. 7 and 337 describing the actual work performed. Appendix II gives examples of these two documents.
2. Weights and Balances Summary - Within the limits established for a particular aircraft, the location and amount of payload weights grossly affect aircraft handling and performance. The installation of fixed equipment must be documented to provide proof that the limits are not being exceeded and loading of equipment, fuel and personnel for a specific flight have been optimized and will stay within limits for the duration of the flight. Appendix III provides an example summary of the weights and balances for equipment installed in the ERL aircraft.
3. Preflight Inspection and Operational Checklist - The utilization of preflight and cockpit checklists insure that procedures followed are thorough and repeatable. This provides confidence that overlooking an important function is unlikely to happen. Checklists should be tailored to the specific aircraft and operating situation.
Appendix IV shows representative examples of checklists.

4. Minimum Equipment List - Minimum equipment lists for a specific aircraft are usually compiled from the aircraft operations manual and FAA regulations. This list provides a valuable aid in determining if an identified aircraft malfunction is cause to immediately ground the aircraft for repairs or allow the repairs to be deferred to a scheduled time period. Appendix V shows a sample list for a Beechcraft.

H. Aircraft Maintenance

Aircraft maintenance falls into three categories: preventative, unscheduled (repair), and scheduled (periodic). The type of maintenance, who can perform the maintenance, and the facility required have a large impact on the cost and operation of the total aircraft program. The ERL program follows a maintenance program developed from Federal Aviation Regulations, Part 43 (including Appendix 43 A) and Part 91, Subpart C. These regulations should be consulted for definitions of the three types and the logistics involved in each type of maintenance.

IV. AIRCRAFT ACQUISITION - USER OWNED vs OUTSIDE CONTRACT/LEASE

The potential user of a remote sensing aircraft has two general avenues for acquiring the aircraft -- user owned and operated or outside contacted/leased. Each avenue has its merits and the following paragraphs are some considerations involved in each method.

A. User Owned

1. General

In this case, the potential user should have a background of aircraft operation or have other types of aircraft in its organization, so that the permanent acquisition of an additional aircraft will not be a new endeavor and, as such, logistically complicated. Owning the aircraft places an additional liability on the user, whereas outside contracting shifts the burden to the contractor; e. g. , insurance, pilot training, etc. The merit of the user-owned approach is that tight control can be maintained over flight schedule and operations, aircraft maintenance, safety and flight crew since these elements are all a part of the parent organization.

2. Personnel/Facilities

An early evaluation should be made of all personnel needed: pilot and co-pilot, sensor crew, maintenance and support personnel. If all of these types are not on the user's payroll, consideration must be given as to whether the program can support the increased number of employees.

If not owned by the user, the runway/hangar facilities suitable to the user can only be assessed on an individual basis, factoring in such things as:

a. Candidate airport location

b. Runway length and width

c. Availability of fuels and specialized maintenace

d. Navigational aides and radio communication (air traffic control)

e. Airport traffic volume

f. General airport maintenance and appearance

g. Hangar availability

ERL has found three points to be pertinent in airport selection:

a. Access to the hangared aircraft must be possible from 18 to 24 hours per day, 7 days a week. Installation and removal of equipment and conducting of operations does not allow for a normal 8:00 to 5:00 workday.

b. Runways that are 4,500 feet by 150 feet provide a safe margin for light aircraft operations in most weather extremes.

c. The aircraft hangar should be an enclosure with good weatherproof doors, have a well-drained, concrete floor with integral electrical grounding lugs, and provide for electrical power and a telephone in the vicinity of the aircraft.

3. Restricted Use of Aircraft

If the remote sensing aircraft is to be frequently used (such as 200-300 hours per year or 50-100 flights per year), the aircraft should not be considered a utility aircraft, i. e. used for additional purposes other than remote sensing, for three possible reasons:

a. A nominal amount of equipment installed usually consumes the cabin space, making it unsuitable for passenger or cargo transport.

b. It is not wise to often remove the data system, sensors and mounts because of the time involved in reconfiguration and the repeated possibility of damage to the sensors/data system.

c. Flight schedules, along with weather contingencies and the need for scheduled maintenance, do not allow a lot of free time on the aircraft.

Note that for an organization operating its aircraft under FAA regulations, an airframe heavily modified for remote sensing is classified as "Restricted - Aerial Survey". Federal Aviation Regulations, Part 91. 39, should be consulted for a definition of operating limitations.

B. Outside Contractor

The merit of this approach is the user can acquire the aircraft for the program without making a permanent investment in capital equipment or pilot personnel. While this approach may appear the easiest, it is not without its potential problems.

1. Size of Contractor Business and Previous Experience

The user, in considering an outside contractor to furnish the aircraft, modifications to aircraft, maintenance, fuel, pilots and hangar facilities, should be thoroughly acquainted with the size of the contractor's business and past business experience. The contractor should be well established and financially stable, be safety conscious, have full time experienced pilots and co-pilots on his payroll and have well-maintained equipment. Most desirable is a contractor with past experience in the field of aerial data gathering. The lease/contract provided by the user should not constitute the major income of the contractor, since this could result in a marginal operation. The contractor should have a good reputation in the industry and have good relations at the airport selected as a base of operations.

2. Size of Airport Facility Needed

The contractor should be located at a well-established airport. All of the same considerations mentioned in the "User Owned" discussion of facilities hold true here. In addition the contractor needs a facility where maintenance can be provided without any delays and qualified aircraft mechanics are available. This will lessen the possibility of maintenance being performed by unqualified personnel and will save considerable time during scheduled and unscheduled (repair) aircraft maintenance.

3. Maintenance and Modification Records

The contractor should maintain up-to-date specifications, history, maintenance and modification records on the aircraft furnished. A review of all records should be made prior to initial lease/contract. This will appraise the user of any immediate major maintenance or modification required on the aircraft. Refer to FAR Paragraph 91.173 for additional information and to Appendix VII of this document, as an example. Continuing reviews of these documents, during the lease, insures the contractor will maintain a safe and operational aircraft.

V. BEECHCRAFT, E-18S MODIFICATIONS

A. Airframe Modifications

1. Engineering and Layout

The addition or removal of equipment involving changes in aircraft weight affects the structural integrity, weight, balance, flight characteristics and performance of the aircraft. All modifications should be engineered to utilize existing equipment supporting structures such as frames, stringers, and attachments (G load factors) imposed by weight of the new equipment installed. When an additional load is to be added to structures already supporting previously installed equipment, determine the capability of the structure to support the total load (previous load plus added load). In cutting sensor ports, avoid altering major aircraft members (stringers, ribs, etc.). Cutting major structures rapidly changes a small modification to a costly and complex one. Figure II is a layout showing location of equipment racks, sensor equipment operator seats, and ports in the ERL aircraft.

Provide adequate provisions to permit close and unobstructed examination of sensors/data system equipment or adjacent parts of the aircraft that regularly require inspection, adjustment, lubrication, etc. Do not obstruct service panels and inspection plates. Unless this is done prior to installation of the sensor equipment and associated items, many hours will be required for the unnecessary removal and reinstallation of equipment.

Install equipment so as not to adversely affect aircraft balance or center of gravity (c. g.) position. To be more specific, careful consideration must be given to the weight of each item to be installed and its location in the aircraft. If an engineering study is not made of all new equipment to be installed, the c. g. of the original aircraft could be changed to the extent that the flight characteristics and performance of the aircraft are radically affected, i. e. , the new equipment installed could cause the aircraft to be too nose heavy or tail heavy to safely fly. The equipment should be installed in a manner that will not interfere with the safe operation of the aircraft (controls, navigation equipment operations, etc.). Human engineering factors are most important when placing new equipment around existing aircraft cockpit controls. All equipment must be accounted for; i. e. , the location of all weights and moments must be known. Refer to Appendix III, FAR Form 337, which shows the compilation of all weights and moments of the ERL aircraft.

2. FAA Review/Certification

For any user operating under FAA regulations, major modification to the aircraft requires the review and approval of FAA. The modifications are to be made in accordance with paragraphs 43. 3 and 43. 7 and Appendix A of Part 43 of the FAR and approved by the FAA. The Beechcraft E-18S used by the Earth Resources Laboratory had two major modifications:

a. Sensor portholes installed.

b. Payload (gross take-off weight) capability increased.

Both of these modifications required FAA review and approval. The modification covering the installation of sensor portholes, while not of a complex or involved nature airframe-wise, did result in a "Special Airworthiness Certificate" being issued for the aircraft. This certificate placed the aircraft in a classification of "Restricted", to be used only for the purpose of "Aerial Survey". No paid passengers or anyone other than the crew members can fly on this type aircraft. Requirements, restrictions, and/or limitations of the "Restricted" type aircraft are covered under paragraphs 91.39 through 91.41 of the FAR.

The modification to increase the payload capability was accomplished under an existing "Supplemental Type Certificate". STC's have already been reviewed and approved by the FAA; modifications made under an STC are relatively easy to implement. A copy of an STC certificate is shown in Appendix VI.

3. Emergency Airworthiness Directive

As a special note, an Emergency Airworthiness Directive was issued on April 24, 1973 relative to all versions of the Beechcraft Model 18 airplanes. It relates to the possibility of wing separation due to fatigue cracks which develop in certain wing sections of the aircraft. While fatigue cracks have always been in the history of the Beech aircraft, only recently has the FAA declared it necessary to take positive and complete remedial action on wing spar potential failures. To correct this problem a nominal modification to the wing is required within 600 hours' time in service after the effective date, April 1973, of Amendment 39-1526 to the FAA Airworthiness Directive (AD) 72-20-5. A complete modification to the wing section is required within 2,000 flight hours after April 1973, but not later than May 1, 1975. These modifications will cost approximately $6,000, and must be considered as necessary for the aircraft and should be covered prior to entering into a contract to purchase or lease an aircraft. Once modified, the wing spar is no longer subject to inspection and controversy. See Appendix VII, "Emergency Airworthiness Directive" for further information on the above problem.

4. Reversible vs. Irreversible Modifications

Modifications to the aircraft required for installation of data gathering equipment may result in additional costs at the end of a contract, especially in a lease type contract, when the aircraft is to be returned to original condition after contract completion. This problem can be clarified in contract negotiations by stating that all modifications to the aircraft include costs for returning the aircraft to original condition; i. e., as existed at the start of contract if the contractor requires it. When penetrations are made in the skin of the aircraft such as clear openings for sensors, etc., this type of modification should include the cost for the owner to return the aircraft to the condition existing prior to the modification.

There are certain modifications to the aircraft which enhance its capability; e.g., increased gross take-off weight. There is no reason to return the aircraft to a lesser capability or to its original appearance when this type of modification is made. Another case is when the framework of the aircraft must be modified for certain skin penetrations, whereby the framework is made stronger than before the modification. It would not be reasonable to require that the framework be returned to its original shape and form.

B. Design and Engineering for Equipment and Mounts

1. Methods

Generally equipment racks and mounts should be engineered and fabricated having in mind that they be interchangeable. This will make for a more economical fabrication, low spare parts requirement, low maintenance costs and keep delays to a minimum. In the fabrication of all items, rounded corners and edges are a must and guards should be installed where possible to protect wiring and equipment. If possible all equipment should be fabricated to provide ease of examination, inspection and lubrication of aircraft parts, and the installation and removal of sensor equipment.

2. Portholes

To the extent possible, all portholes for sensor equipment located in the floor area of the aircraft should be sized and shaped alike. To prevent major modifications to the aircraft framework (frames and stringers), the portholes should be designed to fit between existing frames and stringers as much as possible. Finished openings of 18"x18" should be suitable for locating most sensor equipment as desired. For those portholes designed for camera operation, the portholes should be provided with optical glass to prevent loss of heat from the aircraft, prevent turbulence in the equipment area and avoid contamination of optical surfaces. Portholes should be designed with a removable protective cover to be secured when not in use to prevent stepping into portholes causing injury to personnel and damage to sensor mounts and wiring.

3. Racks

Racks which contain electronic equipment for sensors, etc., should be fabricated from light aluminum shapes for weight savings. If possible all racks should be the same external size and depth with adjustable shelving. This will provide for possible reconfiguration of equipment within the racks at a later date, when smaller and more efficient equipment becomes available.

4. Seats

For those equipment operator seats that do not face fore and aft, seats should be designed to turn 90^{o} and lock in two positions. This will allow for the operators to face either forward or backward during take-off, providing safety for the equipment operators. After the aircraft is airborne the operators can then turn their seats facing the equipment, in preparation for operating the equipment. If the above type seat cannot be located, or used in a particular aircraft due to space problems, substantial weight savings can be achieved by installing certain FAA certified seats, which are fixed and can be installed facing across the aircraft.

C. Power/Wiring

1. Electric Power Characteristics and Utilization

Aircraft electric power characteristics and utilization is a significant factor to be considered when evaluating or specifying aircraft power source quality or determining the minimum quality that can be tolerated for earth resources remote sensing equipment. This equipment is usually very sensitive to poor quality aircraft power. Noises on busses, voltage variations and electromagnetic interferences are characteristic of poor quality aircraft power. The equipment specifications will sometimes state the power quality tolerances to which it will perform. Whether this information is available or not, it is essential that the aircraft has or is equipped with high quality power. Much help can be obtained by consulting or specifying portions or all of the Military Standard, "Characteristics and Utilization of Aircraft Electric Power, MIL-STD, 704A". When twin engine aircraft are utilized, the aircraft's power plants should be such that one power plant is used for aircraft operation only. The other power plant should be for sensor equipment use, with the provision that this power plant be switched over for aircraft emergency operations if necessary. This type set-up will provide for better electrical input to the sensor equipment.

2. Cable Protection/Connectors

All electrical systems, cables, and connectors should be properly shielded to prevent electrical interferences and protected to prevent possible shock and damage to wiring. Cables can be routed around the aircraft cabin only in accordance with paragraph 43. 13 of the Federal Aviation Regulations.

VI. COSTS AND OTHER FACTORS ASSOCIATED WITH LEASE AND SERVICE TYPE CONTRACTS

This section covers costs and other factors involved specifically with the Earth Resources Laboratory's aircraft at the Mississippi Test Facility. It shows those costs that should be, and in many cases must be considered by a potential user of an aircraft used for remote sensing. Actual dollar values relate to the 1971-72 time frame.

A. Aircraft Outfitting Costs

Item	Cost	Totals
1. Aircraft Modifications		
Portholes, two, 18" square and two, 14" square	$5,600	
Aircraft Seats		
Seat Cost	$ 775	
Installation Cost	$ 350	
Equipment Racks		
3 Aluminum Racks (fabrication cost)	$1,374	
Installation cost	$ 100	
Electrical System		
Circuit Breaker & Relays (materials)	$ 60	
Installation	$ 75	
Aircraft Structural Modification		
Increased Gross Take-off Weight to 10,100 lbs	$2,375	$10,709
2. Aircraft Sensors		
PRT-5 Radiometer	$7,250	
I^{2}S Multiband Camera	$6,600	
Hasselblad Camera (2)	$3,400	
IR Spectrometer	$59,600	
IR Scanner	$46,000	$122,850

3. Sensor Mounts

PRT-5/Hasselblad Mount

Design Cost	80mh*	$ 720
Fabrication Cost	132mh	$1,188
Hardware Cost		$ 35
		$1,943

I^2S Camera Mount

Design Cost	80mh	$ 720
Fabrication Cost	40 mh	$ 360
Hardware Cost		$ 20
		$1,100

IR Scanner Mount

Design Cost	40mh	$ 360
Fabrication Cost	20mh	$ 180
Hardware Cost		$ 350
		$ 890

IR Spectrometer Mount

Design Cost	80mh	$ 720	
Fabrication Cost	60mh	$ 540	
Hardware Cost		$ 350	
		$1,610	$5,543

4. Aircraft Data System

Purchased Items

Magnetic Tape Recording System	$45,000
Cables & Connectors (EST)	$ 1,000
Time Code Generator	$ 3,350
Oscilloscopes (2)	$ 2,010
Counter	$ 415
Patch Panel	$ 820

Digital Voltmeter		$ 895		
Radio		$ 2,000		$55,490
In-House Built Items				
Signal Processor				
Design Cost	448mh	$ 4,032		
Hardware Cost		$ 5,960		
Fabrication Cost	520mh	$ 4,680		
		$14,672		
Fixed Data Inserter				
Design Cost	400mh	$ 3,600		
Hardware Cost		$ 2,646		
Fabrication Cost	150mh	$ 1,350		
		$ 7,596		
Power Distribution Panel				
Design Cost	100 mh	$ 900		
Hardware Cost		$ 770		
Fabrication Cost	100mh	$ 900		
		$ 2,570		
Communications Control Panel				
Design Cost	100mh	$ 900		
Hardware Cost		$ 202		
Fabrication Cost	200mh	$ 1,800		
		$ 2,902		
Camera Control Panel				
Design Cost	80mh	$ 720		
Hardware Cost		$ 1,200		
Fabrication Cost	120mh	$ 1,080		
		$ 3,000		$ 30,740
Total				$225,332

*MH = Manhours

B. Contract/Flight Hours

The following is the ERL contract breakdown of the hourly rate for aircraft use figured on the 1971 time frame.

Fuel	$ 26.00
Oil	4.00
Airframe & Engine Maintenance	8.00
Prop Overhaul	2.00
Insurance	5.00
Pilot & Co-pilot	35.00
Ground Equipment Use, Maintenance and Facilities	8.00
Ground Crew	5.00
Total before profit	93.00
Profit and Overhead	17.00
Total per Flight Hour	$110.00

The above cost was based on a minimum of 240 hours use per year. Should the number of hours flown exceed the number contracted for the contractor is paid at the hourly rate established. Should the number of hours actually flown per year be less than that contracted for, the fixed contract price is paid the contractor.

The present breakdown of costs is slightly different in some items than that originally determined, due to changes in the contractor's operations. For example, the maintenance costs have been higher, whereas, the pilot and co-pilot costs were lower than that shown. Care should be exercised in insuring that cost line items are credible at the time of contract sign off and allow for long-term escalation.

The airworthiness of the aircraft is of first priority and should not be compromised. Any and all costs for preventative, unscheduled and annual maintenance, along with design deficiences of the aircraft that require modifications, should be included in the contract price.

C. Pilot Per Diem

When missions at distant sites cannot be completed in one day (i. e. , the aircraft leaving and returning to the home base in one day), the contract should include a rate of pay per overnight stay to cover expenses including, but not limited to, per diem for pilot and co-pilot, auto rental, ramp service, telephone cost and hangar fees. The total rate per overnight stay as of 1973 was approximately $125. The maximum number of overnight stays should be provided for in the contract. If less than the maximum overnight stays specified in the contract are required during the life of the contract, the contract should be modified to reflect the actual number and the fixed price for that line item in the contract should be reduced proportionately.

D. Down Time Payments/Mission Scrubbed

During the period of a year there are a number of missions which have to be scrubbed for numerous reasons. In a lease/services type contract there should be a provision in the contract to compensate the pilot and co-pilot for reporting for a mission that is later scrubbed; because this is usually a real and discreet expense incurred by the contractor. In order to avoid what is usually a difficult contract item, a rate of pay to the contractor for scrubbed missions should be established in the contract. This should be a nominal rate of $50 to $75 per scrubbed mission, or a rate up to one-half of an established flight hour rate. The nominal standby interval should be defined (e.g., 9:00 a.m. to 2:00 p.m.). If the mission is subsequently conducted at some time during the standby period, a contract should specify in this case that no standby pay will be allowed.

ERL Aircraft Data Recording System

Block Diagram

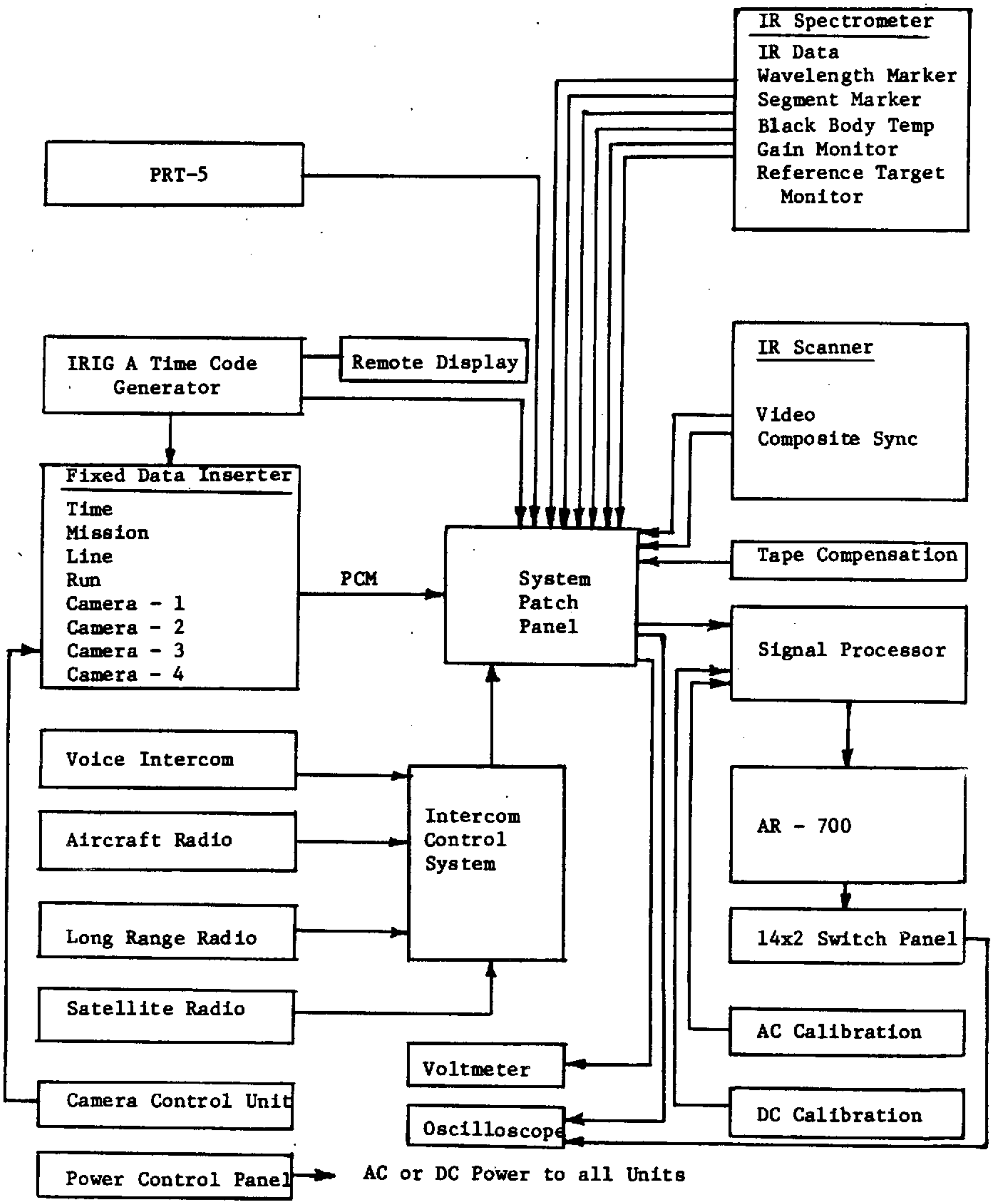
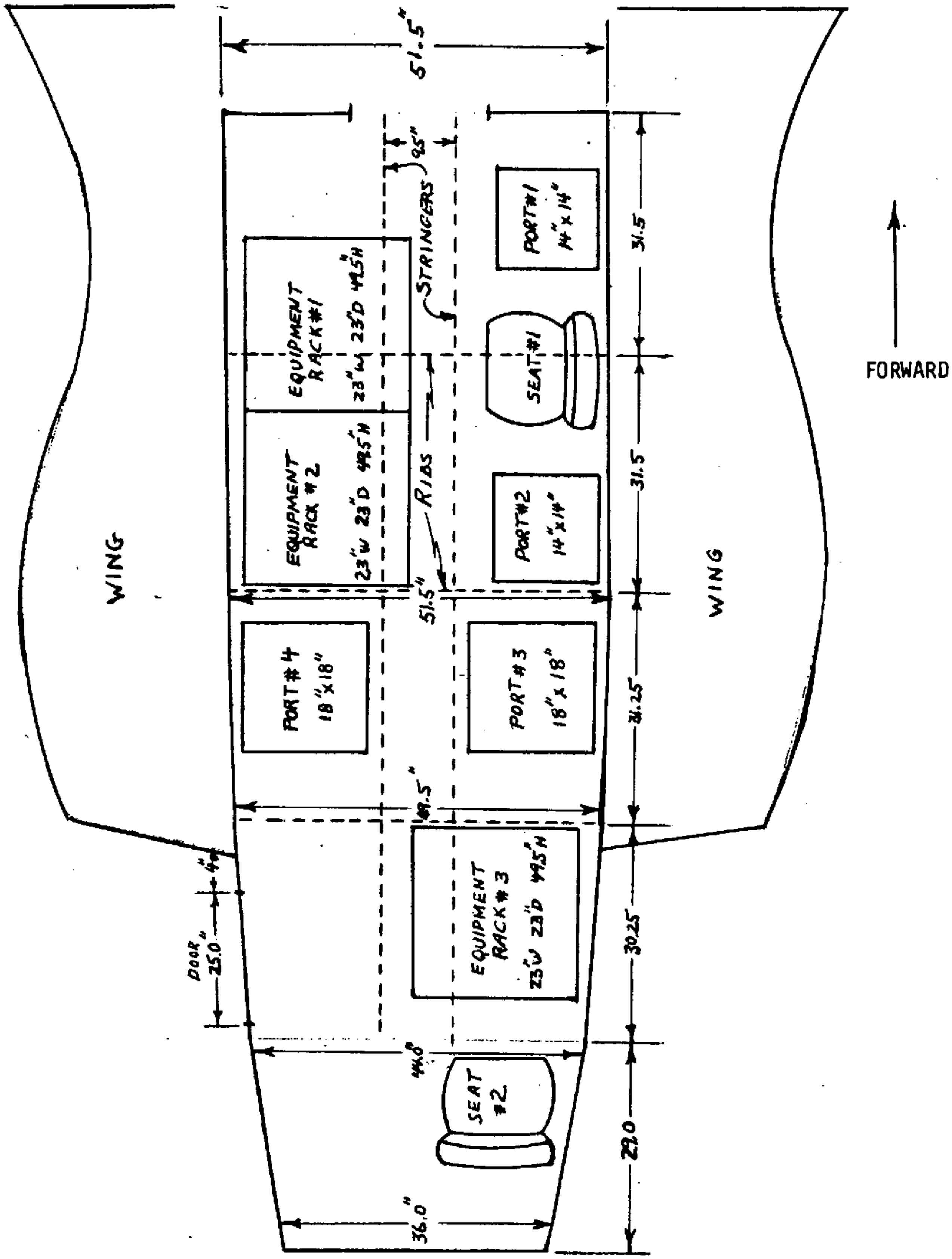


FIGURE 1



INSTRUMENTATION PORT AND EQUIPMENT LAYOUT

Figure II

APPENDIX I

SUMMARY OF AIRCRAFT COST AND PERFORMANCE

The following partial listing of light aircraft costs and performance gives the potential user a quick reference to the aircraft which can be modified for airborne platform data gathering.

SUMMARY OF AIRCRAFT COST AND PERFORMANCE
Manufacturers Quoted Information (Jan-1972)

Aircraft	Basic New Cost	Projected Cost/Hr.**	A/C Gross Take-off Weight	Zero Fuel Wt. or Empty Weight	Useful Load	Fuel*** Weight	Possible Equip. & Crew Wt.	Gross Wt. Service Ceiling	Sea Level Max Rate Climb Ft./Min
Aero Commander 500B	92,500	33.60	6,000	4,250	1,750	520	1,230	32,000	Gross Wt. 1,700
Aero Commander 560F	--	--	7,500	4,975	2,525	881	1,544	--	--
Aero Commander 680F	258,000	38.00	8,000	5,380	2,620	881	1,739	27,400	Gross wt. 1,625
Aero Commander 680 FL	--	--	8,500	5,949	2,551	881	1,670	--	--
Aero Commander, Shrike	120,250	--	6,750	4,758	1,992	612	1,380	--	--
Britten Islander BN-ZA	--	--	6,000	3,700	2,300	650	1,650	--	--
Beagle B 206-S	--	--	7,500	5,150	2,360	792	1,568	--	--
Beechcraft Queen Air 65	--	--	7,700	5,350	2,350	792	1,558	--	--
Beechcraft Queen Air A65	--	--	7,700	5,570	2,130	792	1,338	--	--
Beechcraft Queen Air 70	--	--	8,200	5,493	2,707	792	1,915	--	--
Beechcraft Queen Air 80	--	--	8,000	5,469	2,531	881	1,650	--	--
Beechcraft Queen Air B80	181,500	50.40	8,800	5,538	3,262	881	2,381	26,800	wt. 8000 1,485
Beechcraft Super H18	--	--	9,900	6,345	3,555	1,050	2,505	--	--
Beechcraft Military C45H	N/A	--	7,500	5,100	2,400	1,050	1,350	--	--
*Beechcraft E-18S	N/A	30.00	10,100	6,750	3,350	1,293	2,057	--	1,474
Bushmaster 2000	175,000	47.00	12,500	6,800	5,700	1,740	3,960	--	--

SUMMARY OF AIRCRAFT COST AND PERFORMANCE
Manufacturers Quoted Information (Jan-1972)

Aircraft	Basic New Cost	Projected Cost/Hr.**	A/C Gross Take-off Weight	Zero Fuel Wt. or Empty Weight	Useful Load	Fuel*** Weight	Possible Equip. & Crew Wt.	Gross Wt Service Ceiling	Sea Level Max Rate Climb Ft/Min
Cessna Skymaster 337	47,500	20.00	4,500	2,995	1,505	438	1,067	--	--
Cessna 401/402	105,950	30.88	6,300	3,970	2,330	660	1,670	26,180	Gross Wt 1,610
Cessna Turbo Skymaster	55,500	23.31	4,500	2,815	1,685	--	--	30,000	Gross Wt 1,155
DeHavilland Twin Otter DHC 6-300	350,000	--	12,500	7,127	5,373	2,100	3,273	10,500	1,650
Dornier DO-28D	--	--	8,050	4,800	3,250	881	2,369	--	--
Piper Aztec PA-23	--	--	5,200	3,335	1,865	520	1,345	--	--
Piper Navajo PA-31	106,800	32.88	6,500	4,032	2,418	647	1,771	15,800	Wt 5642 1,800
Ted Smith 601	--	--	5,700	3,725	1,775	612	1,163	--	--

* ERL Aircraft - Used

** Fuel and oil, 1000 hours/year use

*** Fuel provides approximately 5 hours flight time at 120 mph

NOTE: Information compiled by Test Operations Section Lockheed Electronics Co.

APPENDIX II

This appendix shows a copy of the "SPECIAL AIRWORTHINESS CERTIFICATE" and a copy of FAA Form 337 describing the modifications made to the aircraft requiring a "SPECIAL AIRWORTHINESS CERTIFICATE".

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION – FEDERAL AVIATION ADMINISTRATION
SPECIAL AIRWORTHINESS CERTIFICATE

A	CLASSIFICATION:	RESTRICTED		
	PURPOSE:	AERIAL SURVEY		
B	MANU-FACTURER	NAME	N.A.	
		ADDRESS	N.A.	
C	FLIGHT	FROM	N.A.	
		TO	N.A.	
D	N-- 3616B		SERIAL NO. BA-11	
	BUILDER BEECH		MODEL E-18S	
E	DATE OF ISSUANCE 31 JANUARY, 1972		EXPIRY N.A.	
	OPERATING LIMITATIONS DATED N.A.		ARE A PART OF THIS CERTIFICATE	
	SIGNATURE OF FAA REPRESENTATIVE CHARLES M. CARRIER		DESIGNATION OR OFFICE NO. 7-2-04	

Any alteration, reproduction, or misuse of this certificate may be punishable by a fine not exceeding $1,000 or imprisonment not exceeding 3 years, or both. THIS CERTIFICATE MUST BE DISPLAYED IN THE AIRCRAFT IN ACCORDANCE WITH APPLICABLE FEDERAL AVIATION REGULATIONS.

FAA FORM 8130-7 (3-69) SUPERSEDES FAA FORMS 1362-B; 8100-3; 8130-5 *SEE REVERSE SIDE*

A	This airworthiness certificate is issued under the authority of the Federal Aviation Act of 1958 and the Federal Aviation Regulations (FAR).
B	This airworthiness certificate authorizes the manufacturer named on the reverse side to conduct production flight tests, and only production flight tests, of aircraft registered in his name. No person may conduct production flight tests under this certificate: (1) Carrying persons or property for compensation or hire; and/or (2) Carrying persons not essential to the purpose of the flight.
C	This airworthiness certificate authorizes the flight specified on the reverse side for the purpose shown in Block A.
D	This airworthiness certificate certifies that, as of the date of issuance, the aircraft to which issued has been inspected and found to meet the requirements of the applicable FAR. The aircraft does not meet the requirements of the applicable comprehensive and detailed airworthiness code as provided by Annex 8 to the Convention On International Civil Aviation. No person may operate the aircraft described on the reverse side: (1) except in accordance with the applicable FAR and in accordance with conditions and limitations which may be prescribed by the Administrator as part of this certificate; (2) over any foreign country without the special permission of that country.
E	Unless sooner surrendered, suspended, or revoked, this airworthiness certificate is effective for the duration and under the conditions prescribed in FAR Part 21, Section 21.181 or 21.217.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

MAJOR REPAIR AND ALTERATION
(Airframe, Powerplant, Propeller, or Appliance)

Form Approved Budget Bureau No. 04-R060.1

FOR FAA USE ONLY
OFFICE IDENTIFICATION

INSTRUCTIONS: Print or type all entries. See FAR 43.9, FAR 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form.

1. AIRCRAFT	MAKE: BEECHCRAFT	MODEL: E18S
	SERIAL NO.: BA-11	NATIONALITY AND REGISTRATION MARK: N3616B
2. OWNER	NAME (As shown on registration certificate): HEATH FLYING SERVICE	ADDRESS (As shown on registration certificate): P.O. BOX 66 WAVELAND, MISSISSIPPI

3. FOR FAA USE ONLY

The alteration identified herein complies with the applicable airworthiness requirements and is approved only for the above described aircraft, subject to conformity inspection by a person authorized in FAR Part 43, Section 43.7 (a).

1-31-72 — Date
[signature] — Signature of FAA Inspector

4. UNIT IDENTIFICATION / **5. TYPE**

UNIT	MAKE	MODEL	SERIAL NO.	REPAIR	ALTERATION
AIRFRAME	(As described in item 1 above)				X
POWERPLANT					
PROPELLER					
APPLIANCE	TYPE / MANUFACTURER				

6. CONFORMITY STATEMENT

A. AGENCY'S NAME AND ADDRESS	B. KIND OF AGENCY	C. CERTIFICATE NO.
GUY PENILTON OWEN RT BOX 78 JACKSON, MISSISSIPPI	X U.S. CERTIFICATED MECHANIC FOREIGN CERTIFICATED MECHANIC CERTIFICATED REPAIR STATION MANUFACTURER	IA1526500

I certify that the repair and/or alteration made to the unit(s) identified in item 4 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge.

DATE	SIGNATURE OF AUTHORIZED INDIVIDUAL
1-26-72	[signature]

7. APPROVAL FOR RETURN TO SERVICE

Pursuant to the authority given persons specified below, the unit identified in item 4 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is ☒ APPROVED ☐ REJECTED

FAA FLT. STANDARDS INSPECTOR	MANUFACTURER	X INSPECTION AUTHORIZATION	OTHER (Specify)
FAA DESIGNEE	REPAIR STATION	CANADIAN DEPARTMENT OF TRANSPORT INSPECTOR OF AIRCRAFT	

DATE OF APPROVAL OR REJECTION	CERTIFICATE OR DESIGNATION NO.	SIGNATURE OF AUTHORIZED INDIVIDUAL
1-26-72	1526500	[signature]

NOTICE

Weight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED *(If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)*

This aircraft floor, floor structure and belly skin altered as follows. On the right side one 14" square cut out at station center 155. One 14" square cut out at station center 160. One 18" square cut out at station center 182. These cut outs are centered in the bays between the outboard fuselage belly longeron and the center floor attach longeron.

On the left side one 18" square cut out at station center 182. Original strength for all cut outs in retained as follows. Each cut out is box reinforced from the bottom of the floor to the belly skin on all four sides using 1/8" x 1" 2024T3 511 angle, riveted to .050 2024T3 plates. This box structure is riveted to the cut original stringers and belly skin and the cut outs in the original floor are attached to the top of the box structure by screws, same as it attaches to the normal structure.

The cut belly stringers were reinforced on the right side by two 1/8" x 1" 2024T3 angles riveted to the belly skin and is the side bottom structure of the two 14" cut outs on the right side. Theseanhles are from station 104 to 168. In addition to the previously described box structure the two 18" cut out belly skin was reinforced on the outside of the belly skin with .032 2024T3 sheet metal using ariginal rivet pattern from station 199.5 to 168 on the left and 199.5 to station 166. The cut outs in the floor are closed by .080 2024T3 reinforced plates attached with machine screws and nut plates. All work accomplished in accordance with AC43.13-2 Fig.3.8 and 4.2. AC43.13-1 and Beech model 18 service manual. The owner is furnished a copy of the drawings.

☐ ADDITIONAL SHEETS ARE ATTACHED

U.S. GOVERNMENT PRINTING OFFICE : 1967 OF—273-085

APPENDIX III

This appendix shows a copy of FAA Form 337 which describes the installation of equipment and listing of weights and moments of the aircraft.

Reproduced from best available copy.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

MAJOR REPAIR AND ALTERATION
(Airframe, Powerplant, Propeller, or Appliance)

Form Approved
Budget Bureau No. 04-R060.1

FOR FAA USE ONLY
OFFICE IDENTIFICATION

INSTRUCTIONS: Print or type all entries. See FAR 43.9, FAR 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form.

1. AIRCRAFT	MAKE: Beechcraft	MODEL: E-18
	SERIAL NO.: BA-11	NATIONALITY AND REGISTRATION MARK: N 3616B
2. OWNER	NAME (As shown on registration certificate): Heath Flying Service	ADDRESS (As shown on registration certificate): P. O. Box 66, Waveland, Mississippi

3. FOR FAA USE ONLY

4. UNIT IDENTIFICATION / 5. TYPE

UNIT	MAKE	MODEL	SERIAL NO.	REPAIR	ALTERATION
AIRFRAME	(As described in item 1 above)				X
POWERPLANT					
PROPELLER					
APPLIANCE	TYPE / MANUFACTURER				

6. CONFORMITY STATEMENT

A. AGENCY'S NAME AND ADDRESS	B. KIND OF AGENCY	C. CERTIFICATE NO.
W. E. Colliver Lockheed Electronics Company, Inc. Mississippi Test Facility	X U.S. CERTIFICATED MECHANIC FOREIGN CERTIFICATED MECHANIC CERTIFICATED REPAIR STATION MANUFACTURER	2160852

D. I certify that the repair and/or alteration made to the unit(s) identified in item 4 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge.

DATE	SIGNATURE OF AUTHORIZED INDIVIDUAL
This 337 supersedes and voids 337 dated 8-24-72. 1-29-73	William E Colliver

7. APPROVAL FOR RETURN TO SERVICE

Pursuant to the authority given persons specified below, the unit identified in item 4 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is ☐ APPROVED ☐ REJECTED

BY			
FAA FLT. STANDARDS INSPECTOR	MANUFACTURER	INSPECTION AUTHORIZATION	OTHER (Specify)
FAA DESIGNEE	REPAIR STATION	CANADIAN DEPARTMENT OF TRANSPORT INSPECTOR OF AIRCRAFT	

DATE OF APPROVAL OR REJECTION	CERTIFICATE OR DESIGNATION NO.	SIGNATURE OF AUTHORIZED INDIVIDUAL

NOTICE

Weight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED *(If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)*

1. The inner and outer covers were removed from ports No. 1, 2, 3, and 4.

2. Special mounting plates were fabricated using materials selected in accordance with AC 43.13-1, Chapter 2, Section 3, Paragraph 63 and secured using existing nuts plates around the edge of the ports with hardware selected per AC43.13-1 Chapter 5, Section 1, paragraph 121. Corrosion protection in accordance with AC43.13-1, Chapter 6, Paragraph 141a, Reference NASA drawing No. 3-141-30015, 3-141-30015-1A, and 3-141-300.

3. At Port #1, a sensor mount was fabricated using 6061-T-6 and inert welding process in accordance with aero-space standards. This mount is attached to the mount described in Item 2 above using 4 each vibration isolators Lord P/N HTC-150. The sensor (reference Texas Instrument drawing no. HB41-EG71) then attaches to this mount using 2 each AN bolts and self-locking nuts selected per AC43.13-1, Chapter 5, Section 1, Paragraph 120d, f, and 123. The longitudinal center line axis of the sensor extends below the aircraft approximately 5" and has no noticeable effect on the performance of the aircraft.

4. At Port #3 and #4, a drift plate was fabricated (reference NASA drawing No. 3-41-30029-D1) and secured to the mount plate described in Item 2 using 4 each wing type fasteners and complies with AC43.13-2, Chapter 1, Paragraph 7. A camera mount was then attached to this plate (reference Lockheed drawing no. 3-41-30029-D1 view B-B) using 4 each load vibration isolators Lord P/N HTC-150.

5. At Port #2, a sensor adapter plate was fabricated and attached to the mount plate described in Item #2 using 4 each vibration isolators Lord P/N HTC-150 and the sensor Exotech E-20 attached to this plate using hardware selected per AC43.13-1, Chapter 5, Section 1, Paragraph 120d, f, and 123.

6. Aerial survey electronic equipment was mounted in existing equipment racks (reference 337 dated January 26, 1972) using hardware selected in accordance with AC 43.13-1, Chapter 1, Section 1, Paragraph 121, 123, 124. See Item 10 for list.

7. 28VDC power to supply aerial survey equipment was taken from the down stream side of 2 relays and two 80 amp circuit breakers installed on 337 dated January 26, 1972. (Reference NASA drawing no. 3-41-30030.)

8. All circuit breakers and switches were selected per AC 43.13-1, Chapter 11, Section 2. Cabling selected per AC 43.13-1, Chapter 11, Section 3. Connectors selected per AC 43.13-1, Chapter 11, Section 5. Cable installation complies with AC 43.13-1, Chapter 11, Section 7. Thirty-four foot v antenna installation complies with AC 43.13-2, Chapter 3.

[X] ADDITIONAL SHEETS ARE ATTACHED

...ght and balance or operating limitation changes shall be entered in appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED (If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)

9. At Port #3 and #4, optical glass windows installed flush with the lower skin using materials selected in accordance with AC 43.13-1, Chapter 2, Section 3, Paragraph 63 and secured using existing rivnuts on the lower skin around the edge of the port. Additional rivnuts were installed along the inside of the port to give additional support.

Hardware was selected per AC 43.13-1, Chapter 5, Section 1, Paragraph 121.

[X] ADDITIONAL SHEETS ARE ATTACHED

NOTICE 47

Weight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED (If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)

Weight and Balance
Empty Weight

		Weight	Moment
1.	A/C empty weight per log entry 1-26-22	6750.0	726918.0
2.	Remove covers Port No. 1	- 3.0	- 360.0
3.	Remove covers Port No. 2	- 3.0	- 480.0
4.	Remove covers Port No. 3	- 3.5	- 630.0
5.	Remove covers Port No. 4	- 3.5	- 630.0
6.	Install A/C, sensor interface plate, Port No. 1	10.5	1260.0
7.	Install sensor (RS-18) Port No. 1	13.5	1620.0
8.	Install A/C, sensor interface plate, Port No. 2	7.5	900.0
9.	Install sensor adapter plate (E-20)	3.0	480.0
10.	Install sensor (E-20) Port No. 2	52.0	6760.0
11.	Install A/C, sensor interface plate, Port No. 3	3.0	540.0
12.	Install optical glass assembly, Port No. 3	8.0	1440.0
13.	Install aeroflex camera mount S/N	21.0	3780.0
14.	Install camera (I^2S) with full film	55.0	9900.0
15.	Install A/C, sensor interface plate Port No. 4	3.0	540.0
16.	Install aeroflex camera mount, Port No. 4	21.0	9900.0
17.	Install HB adapter mount with VF	7.0	1260.0
18.	Install optical glass assembly Port No. 4	8.0	1440.0
19.	Install HB cameras (2 ea.) with film	18.0	3240.0

Equipment Rack No. 1

		Weight	Moment
20.	Install blowers, power strip, rear and side cover	17.0	2720.0
21.	Install precision radiometer thermometer S/N	9.0	1440.0
22.	Install DVM panel containing fluke 8100A S/N 38586 and Data Matrics TCG S/N 87841	20.5	3280.0
23.	Install Exotech spectroradiometer control panel S/N 001	20.0	3200.0
24.	Install power control panel Lockheed S/N 001	18.0	2880.0
25.	Install Sunair ASB60 SSB HF power amp S/N 7651	9.5	1520.0
26.	Install blank panels	2.0	320.0
27.	Install side cover	4	640.0
28.	Install W128 E-20 power cable	.5	80.0
29.	Install W115 power pan to power strip	2.0	320.0
30.	Install W127 PRT-5 power cable	.5	80.0
31.	Install W124 TCG power cable	.5	80.0
32.	Install W 11L DVM power cable	.5	80.0

[X] ADDITIONAL SHEETS ARE ATTACHED

U.S. GOVERNMENT PRINTING OFFICE

Weight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED (If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)

Equipment Rack 1A
(Center Console)

		Weight	Moment
33.	Install top cover	5.0	700.0
34.	Install Fixed Data Inserter Lockheed S/N 001	11.5	1610.0
35.	Install scope panel containing HP 1701A, S/N 321, Ampex T/R remote control S/N 123 and Digital Counter S/N 88531	35.5	4970
36.	Install lower former	1.0	140

Equipment Rack No. 2

37.	Install radio control panel containing ASB60 Rec-Exciter S/N 2297 and Johnson CB S/N 89714	11.0	1320
38.	Install blowers, power strip, T/R slides, foward and rear side panel, and mounting hardware	23.5	2820
39.	Install T/R calibration panel S/N 001	9.0	1080
40.	Install trompter patch panel with patches	8.0	960
41.	Install intercom panel Lockheed S/N 001	13.0	1560
42.	Install Ampex AR-700 T/R P/N 1801999-01	71.5	8580
43.	Install Ampex AR-700 T/R monitor panel	22.0	2640
44.	Install blank panels	1.0	120
45.	Install side covers	4.0	480
46.	Install A/C radio interface attenuator panel	2.0	240
47.	Install W CB power cable	.5	60
48.	Install W 111 calibration power cable	.5	60
49.	Install W 6 Station No. 1 intercom cable	.5	60
50.	Install W 119 intercom power cable	.5	60
51.	Install W 109 T/R power cable	.5	60
52.	Install W 110 T/R monitor power cable	.5	60
53.	Install W 5 CB control	.5	60
54.	Install W 21 T/R record input cable	1.5	180
55.	Install W 38 T/R playback cable	1.5	180
56.	Install W 59 "A" Channel playback monitor	.5	60
57.	Install W 60 "B" Channel playback monitor	.5	60
58.	Install W 41 T/R input to cal panel	2.8	336
59.	Install W 68 audio intercom to patch panel	.2	24

Equipment Rack No. 3

60.	Install blowers, power strip, drier, and outboard side panel	18.0	3600
61.	Install atmospheric panel Lockheed S/N 001	8.0	1600
62.	Install IR Scanner control, Texas Instruments S/N 001 and HP 1701A S/N 413	28.5	5700

[X] ADDITIONAL SHEETS ARE ATTACHED

U.S. GOVERNMENT PRINTING OFFICE

NOTICE 49

Weight and balance or opera(limitation changes shall be entered in(appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED *(If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)*

		Weight	Moment
63.	Install camera panel Lockheed S/N 001	10.5	2100
64.	Install DVM panel 8100A with remote time	13.0	2600
65.	Install vacuum pump	7.0	1400
66.	Install IR scanner (RS-18) electronics	16.3	3260.0
67.	Install blank panels	3.0	600.0
68.	Install rear cover	4	800.0
69.	Install side cover	4	800.0
70.	Install W 125 camera panel power	.5	100.0
71.	Install W 126 DVM power cable	.5	100.0
72.	Install W128 "O" scope power	.5	100.0
73.	Install W 124 RS-18 power cable	.5	100.0
74.	Install W 65 DVM input	.5	100.0
75.	Install W 66 BB-1 monitor	.5	100.0
76.	Install W 67 BB-2 monitor	.5	100.0
77.	Install W 62 RS-18 sync monitor	.5	100.0
78.	Install W 63 RS-18 video	.5	100.0
79.	Install W 32 RS-18 control	1.5	300.0
80.	Install sensor PRT-5 head S/N	3.5	420.0
81.	Install carpet	51.5	9270.0
82.	Install Sunair ant coupler		.1299.0
	Inter Rack Cables		
83.	Install W 3 PRT-5 control cable	2.5	300.0
84.	Install W 14 PRT-5 output to patch panel	.5	70.0
85.	Install W 57 DVM input to patch panel	.5	70.0
86.	Install W 13 TCG to FDI BCD Time	1.5	225.0
87.	Install W 69 TCG IRIG out to patch panel	.5	70.0
88.	Install W 36 Exotech control	9.5	1140
89.	Install W 37 Exotech output to patch panel	2.5	350
90.	Install W 15 Exotech phase to patch panel	.5	70
91.	Install W 108 DC power to Rack 2	3.0	.420
92.	Install W 123 DC power to Rack 3	5.5	660
93.	Install W 100 A/C power to power panel	6.0	720
94.	Install W 114 Main power relay control	.5	70
95.	Install W 117 FDI power cable	.5	70
96.	Install W 118 "O" scope and counter power	.5	70
97.	Install W 2 T/R remote control	3.0	390
98.	Install W 55 "O" scope to patch panel	..5	65
99.	Install W 56 "O" scope to patch panel	.5	65
100.	Install W 61 FDI EQL to P/P	.5	65
101.	Install W 58 counter input to P/P	.5	65

[X] ADDITIONAL SHEETS ARE ATTACHED

NOTICE

Weight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED (If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)

		Weight	Moment
102.	Install W 20 camera pulse FDI	2.0	240
103.	Install W 7 intercom cable pilot	.5	50
104.	Install W 8 intercom cable copilot	1.0	100
105.	Install W 9 intercom cable camera	1.5	280
106.	Install W 18 I^2S camera control	1.0	190
107.	Install W 4 RS-18 gyro power	1.0	160
108.	Install W 33 RS-18 to head	3.5	560
109.	Install W 113 ext to P/A	.5	60
110.	Install W 110 Sunair ext to P/A	.5	70
111.	Install W 3 RS-18 video, sync, BB-1 and BB-2 to patch panel	2.5	300
112.	Install W 16 Hasselblad camera #1 control	1.0	140
113.	Install W 17 Hasselblad camera #2 control	1.0	140
114.	Install W 101 Sunair ASB 60 control	5.0	800
115.	Install 34' v antenna	1.5	300.0
116.	Install Station No. 1 head set, foot sw	2.0	280.0
117.	Install pilot headset	2.0	180.0
118.	Install copilot headset, foot sw	2.0	180.0
119.	Install rear operator headset, foot sw	2.0	480.0
	EMPTY WEIGHT TOTAL	7543.3	861372.0

☐ ADDITIONAL SHEETS ARE ATTACHED

U.S. GOVERNMENT PRINTING OFFICE

APPENDIX IV

This appendix shows a typical Aircraft Preflight Inspection Checklist and a Normal Cockpit Checklist of a C-45/E-19 Beechcraft.

AIRCRAFT PREFLIGHT INSPECTION (C-45)					DATE
To be accomplished prior to each flight except: (1) Daily/postflight is accomplished immediately prior to flight; (2) Crew remains with aircraft during intermediate stops.					
AIRCRAFT		STATION			
PREPARATORY ACTION (check aircraft log for maintenance and flight record. Insure all cockpit switches are off or in position as required for inspection.)					
1. Fuel Added		2. Oil Added (Quarts)		3. Anti-ice Fluid Added	
a. L/F -	b. R/F -	a. Left	b. Right		
c. L/R -	d. R/R -				
4. Total	5. Total	6. Total Oil		7. Total	

EXTERIOR INSPECTION (For condition and security)

	ITEM	MECH. INITIALS LEFT	MECH. INITIALS RIGHT
WINGS	1. Skin condition		
	2. Access covers secure		
	3. Flaps		
	4. Aileron Tab		
	5. Aileron		
	6. Navigation & Taxi Light		
	7. Deicer Boots		
	8. Landing Light		
ENGINES LANDING GEAR WHEEL WELL	9. Exhaust Stacks		
	10. External Power Receptable		
	11. Cowl Flaps & Fasteners		
	12. Visual Check Through Cowl Flap Opening		
	(1) Accessory Section		
	(2) Carburetor Elbow Intake Pipe		
	13. Wheel Brake Components. Tire Press - 30 PSI		
	14. Landing Gear Shock Strut (2¼ inch Max., 1½ inch min)		
	15. Wheel Well Area		
	(1) Deicer Distributor Valve & Filter		
	(2) Heater C/B & Hoses		
	(3) Oil "Y" Drain Off		
	(4) Oil Bypass Valve & Control Cable		
	(5) Landing Gear Chain		
	(6) Slide Tube (Below L/G Chain)		
	(7) Landing Gear Up & Down Lock Switches		
	(8) Prop Feathering Pump		
	(9) Wheel Doors		
	(10) Landing Gear Strut Weld Joints		
	16. Prop Condition		
	17. Prop Anti-Icer Line		
	18. Engine Nose Section		
	19. Ignition Harness		
	20. Oil Caps Secured		
INBOARD WINGS UNDERSIDE OF A/C NOSE SECTION	21. Engine Oil Shutter Flapper		
	22. Ventilation Air Intake		
	23. Battery Vents		
	24. Belly Antenna		
	25. Anti-Collision & Fuselage Lights		
	26. Fuel Sump Drains & Fuel Caps Secured		
	27. Fuselage Access Door		
	28. Pitot Tubes		
	29. Nose Door		
	30. Nose Fuel Tank Filler Cover		
	31. Engine Fire Extinguisher Blow-Out Disk		

	32. Hydraulic Fluid	
AFT FUSELAGE	33. Skin & Windows, Condition	
	34. Emergency Exit Hatch	
TAIL OF AIRCRAFT	35. Tail Wheel Assembly (1) Shock Strut Extension (3 to 6 inches)	
	(2) Shock Strut Weld Joints	
	(3) Lock & Pin	
	(4) Tire & Pressure 45 PSI	
	(5) Tail Ground Wire	
	36. Empennage (1) Rudders	
	(2) Deicer Boots	
	(3) Elevator & Rudder & Tabs (Skin Condition)	
	(4) Hinges	
	(5) Surface Travel Unobstructed	
	(6) Tail Position Lights	
	(7) Tail Cone	
	INTERIOR	
INSIDE MAIN CABIN	37. Windows	
	38. Entrance Door Emergency Release	
	39. Hand Fire Extinguisher	
	40. First Aid Kits	
	41. Radio Racks	
	42. Fire Detector	
	43. Lights (Battery On)	
	44. Instruments	
	45. Flt. & Eng. Controls (Free & Full Travel)	
	46. Seats & Seat Belts	

Maintenance Release (Signature & Title)	Date
Inspector (Signature)	Date
Pilots Acceptance (Signature)	Date

C-45H BEECHCRAFT, NORMAL COCKPIT CHECKLIST - MARCH 12, 1970

START CHECK LIST

PRE-STARTING

PRE-FLT. INSP....................CPT
CHOCKS..........................OUT
BRAKES..........................SET
ANTI-ICING FLUID QTY............CKD
CIRCUIT BREAKERS................CKD
HEATERS.........................OFF
TRANSPONDER.....................OFF
FIRE EXT.............OFF & SAFETIED
OIL SHUT-OFF..................2 OPEN
OIL BY-PASS.................2 AS RQD
FUEL...........................MAIN
LANDING GEAR...................DOWN
COWL FLAPS.....................OPEN
WING FLAPS.......................UP
OIL SHUTTERS.................AS RQD
MANIFOLD HEAT..................COLD
PROPELLERS........FULL INCREASE RPM
MASTER RADIO/ELEC. SWs..........OFF
IGNITION........................OFF
ATTITUDE INDICATOR............CAGED
BATTERIES (ONE AT A TIME)........ON
GENERATORS.......................ON
FUEL QUANTITY...................CKD
PROP ANTI-ICING...........CKD & OFF
SEAT BELT SIGN...............AS RQD
WARNING LIGHTS..................CKD
POSITION/COCKPIT LIGHTS......AS RQD
DOOR........................SECURED

ABBREVIATED PRE-STARTING

BRAKES..........................SET
CHOCKS..........................OUT
LANDING GEAR...................DOWN
FUEL...........................MAIN
COWL FLAPS.....................OPEN
MANIFOLD HEAT..................COLD
PROPELLERS........FULL INCREASE RPM
MASTER RADIO/ELECT. SWs.........OFF
IGNITION........................OFF
ATTITUDE INDICATOR............CAGED
BATTERIES........................ON
GENERATORS.......................ON
FUEL QUANTITY...................CKD
SEAT BELT SIGN...............AS RQD
DOOR........................SECURED

STARTING ENGINES

MANIFOLD PRESSURE..............NOTE
THROTTLES.......................SET
MIXTURES........................SET
PROPELLERS....................CLEAR
ENGINE SELECTOR..............AS RQD
ENGINE........................START
OIL/FUEL/VACUUM/VOLTS...........CKD
RADIOS/TRANSPONDER...........ON/CKD
INVERTERS.......................CKD
ALTIMETERS......................SET

TAXI

BRAKES..........................CKD
FLIGHT INSTRUMENTS..............CKD

ENGINE CHECK

BRAKES..........................SET
ENGINE INSTRUMENTS..............CKD
RPM............................1700
PROPELLERS..................EXERCISED
FEATHERING......................CKD
MANIFOLD HEAT............CKD & COLD
POWER CHECK..........FIELD BAROMETRIC
IGNITION........................CKD
GENERATORS......................CKD
PITOT HEAT......................CKD

BEFORE TAKE-OFF

CONTROLS.................FREE & CKD
TRIM......................CKD & SET
WING FLAPS...................AS RQD
FUEL...........................MAIN
OIL BYPASS.................DOWN 2 SET
OIL SHUTTERS..................2 SET
MANIFOLD HEAT................AS RQD
MIXTURES.......................RICH
PROPELLERS........FULL INCREASE RPM
INSTRUMENTS/RADIOS/D.G.......CKD & SET
BOOST PUMPS.................ON & CKD
CREW BRIEFING...................CPT
COWL FLAPS....................TRAIL
TRANSPONDER.................ON & SET
ROTATING BEACON..................ON
ANTI-ICING...................AS RQD

C-45H BEECHCRAFT, NORMAL COCKPIT CHECKLIST - MARCH 12, 1970

AFTER TAKE-OFF AND CLIMB

LANDING GEAR..............UP & CKD
POWER..........................SET
AUTO-PILOT MASTER...........AS RQD
SEAT BELT SIGN..............AS RQD
BOOST PUMPS....................OFF

CRUISE

COWL FLAPS.....................SET
POWER..........................SET
MIXTURES....................AS RQD
SEAT BELT SIGN..............AS RQD

INRANGE DESCENT

ALTIMETERS/D.G.................SET
MIXTURES......................RICH
FUEL QUANTITY..................CKD
FUEL..........................MAIN
GENERATORS.....................CKD
CIRCUIT BREAKERS...............CKD

BEFORE LANDING

BOOST PUMPS.....................ON
PROPELLERS.....................SET
AUTO-PILOT..................AS RQD
LANDING GEAR............DOWN & CKD
SEAT BELT SIGN..............AS RQD
WING FLAPS..................AS RQD
MANIFOLD HEAT.................COLD
HEATERS........................OFF
PROPELLERS (ON FINAL).........FULL
....................INCREASE RPM

AFTER LANDING

WING FLAPS.......................UP
PITOT HEAT......................OFF
COWL FLAPS.....................OPEN
BOOST PUMPS.....................OFF
TRANSPONDER.....................OFF
ROTATING BEACON.................OFF

SECURE

BRAKE...........................SET
NAVIGATION RADIOS...............OFF
IGNITION SAFETY CHECK.........CPT
IDLE MIXTURE CHECK............CPT
MIXTURES........................OFF
IGNITION........................OFF
ELEC. & RADIO SWs...............OFF
BATTERIES/GENERATORS............OFF
CONTROL LOCKS................AS RQD
CHOCKS..........................SET
BRAKES.....................RELEASED

*LAST FLIGHT OF THE DAY

APPENDIX V

This appendix shows the Minimum Equipment List of a typical twin engine Beechcraft. It shows the standard equipment, and minimum operating equipment required prior to a flight.

TWIN BEECHCRAFT MINIMUM EQUIPMENT LIST

Page

TWIN BEECHCRAFT

MINIMUM EQUIPMENT LIST

SYSTEM AND COMPONENTS	Standard equipment	Minimum equipment	SUPPLEMENTAL PROCEDURES
1. ELECTRICAL SYSTEM			
Generators - DC	2	1 A	A. Restricted to day VFR flight with one inoperative generator. Related loadmeter and voltmeter must be functional. AC electrical system must be operating normally.
Loadmeters - DC	2	1 A	
Voltmeters - DC	2	1 A	
Batteries	2	2	
Inverter - AC	2	1 B	B. Restricted to VFR flight with one inoperative inverter. DC electrical system must be operating normally.
2. ENGINE INSTRUMENTS & CONTROLS			
Carburetor Air Temp. Indicator	2	0 A	A. Both manifold heat controls must be operative.
Cylinder Head Temp. Indicator	2	1 B	B. Not more than one of the 12 instruments marked "B" may be inoperative at any one time.
Manifold Pressure Indicator	2	1 B	
Oil Pressure Indicator	2	1 B	
Oil Temperature Indicator	2	1 B	
Tachometer	2	1 B	
Fuel Pressure Indicator	2	1 BC	C. If fuel pressure gage inoperative related fuel pressure warning light must be functional.
Fuel Pressure Warning Light	2	0 C	
Cowl Flaps	2	2	
Manifold Heat	2	0 DA	D. CAT must be operative and carburetor icing conditions avoided.
Oil Shutters	2	2	
Oil Dilution	2	0	
Oil Emergency Shut-off	2	2	
Oil Cooler By-pass Valve	2	0 E	E. One or both may be inoperative provided proper oil flow is maintained through the oil cooler and oil temperature can be controlled by use of manual oil shutters. Related oil pressure and temperature indicators must be functional.

TWIN BEECHCRAFT

MINIMUM EQUIPMENT LIST

SYSTEM AND COMPONENTS	Standard equipment	Minimum equipment	SUPPLEMENTAL PROCEDURES
3. FIRE PROTECTION SYSTEM			
Fire Agent Bottle	1	1	
Control Switches	2	2	
Portable Extinguisher	1	1	
4. FLIGHT CONTROL SYSTEM			
Aileron Trim	1	0	
Aileron Trim Indicator	1	0	
Elevator Trim	1	1	
Elevator Trim Indicator	1	0	
Rudder Trim	1	1	
Rudder Trim Indicator	1	0	
5. FUEL SYSTEM			
Boost Pumps	2	1 A	A. Fuel suction cross-feed system must be operative.
Fuel Suction Cross-Feed	1	0 B	B. Must be operative if one boost pump is inoperative.
Quantity Indicator	4	0 C	C. Fuel quantity must be visually verified prior to each flight. Both boost pumps, fuel pressure indicators and fuel pressure warning lights must be operating normally.
Tank Selector Valves	2	2	
Tanks - Main	2	2	
Tanks - Rear	2	0 D	D. Fuel quantity indicators (main) must be operating normally.

TWIN BEECHCRAFT

MINIMUM EQUIPMENT LIST

SYSTEM AND COMPONENTS	Standard equipment	Minimum equipment		SUPPLEMENTAL PROCEDURES
6. HEATERS, CABIN	2	0		
7. FLAP SYSTEM				
Emergency Manual Crank System	1	1		
Flap Motor	1	0		
Position Indicator	1	0		
Selector Switch	1	0		
8. LANDING GEAR SYSTEM				
Emergency Manual Crank System	1	1		
Motor	1	1		
Position Indicators	3	3		
Unsafe Warning Light	1	0		
Unsafe Warning Horn	1	0		
Selector Switch	1	1		
9. LIGHTING				
Cabin Lights			A	A. Sufficient illumination shall be available to provide for the safety and comfort of the passengers and crew.
Cockpit and Instrument Lights			B	B. Sufficient illumination shall be available to make all controls and instruments easily readable for safety of flight during night operations.
Flashlights	2	1		
Landing Lights	2	0	C	C. One required for night operations.
Rotating Beacon	1	0		
Position Lights	3	0	D	D. All required for night and instrument operations.
Taxi Light	1	0		

TWIN BEECHCRAFT

MINIMUM EQUIPMENT LIST

SYSTEM AND COMPONENTS	Standard equipment	Minimum equipment		SUPPLEMENTAL PROCEDURES
10. PROPELLER SYSTEM				
Anti-Icing	2	0	A	A. Restricted to non-icing operation conditions.
Feather System	2	2		
11. RADIOS AND FLIGHT INSTRUMENTS				
a. COMMUNICATIONS				
UHF	1		A	A. Transceivers: IFR: Two required VFR: One required
VHF				
Audio Panel	1	1		
Headsets	3	2		
Speakers	2	0		
b. NAVIGATION				
VOR Receivers and Indicators	2		A	A. Sufficient navigation equipment must be operating to conduct required navigation.
ADF Receiver and Indicator	1		A	
Marker Beacon	1		A	
ILS Receiver (Glideslope)	1		A	
ILS Indicator (Glideslope)	2		A	
Transponder	1		AB	B. Required for operation in positive control area and if aircraft is to be flown in/forecast thunderstorm, hail or tornado conditions.
Auto Pilot	1	0	A	A. Must be operative for one pilot limited IFR operation.
Pitch Control	1		A	
Roll Control	1		A	
Yaw Control	1		A	
Approach Coupler	1	0		
Altitude Control	1	0		
Emergency Release	1		AB	B. Must be operative if auto-pilot is engaged.

TWIN BEECHCRAFT

MINIMUM EQUIPMENT LIST

SYSTEM AND COMPONENTS	Standard equipment	Minimum equipment	SUPPLEMENTAL PROCEDURES
11. (CONTINUED)			
c. FLIGHT INSTRUMENTS			
Attitude	2	1 A	A. Two required for IFR flight.
Airspeed	2	B	B. Unrestricted flight authorized provided that: (1) Not more than one instrument is inoperative at one time. (2) All components of aircraft AC-DC electrical and vacuum system operating normally.
Altimeter	2	B	
Vertical Speed	2	B	
Turn and Bank	2	B	
Compass Magnetic (Standby)	1	O C	C. Flight restricted to VFR. Gyrosyn compass and directional gyro required. Elect. AC-DC and vacuum sys. operating normally.
Compass (Gyrosyn)	1	O D	D. Flight restricted to VFR. Compass magnetic and directional gyro required. Elect. AC-DC and vacuum sys. operating normally.
Directional Gyro	1	O E	E. Flight restricted to VFR. Compass magnetic and Gyrosyn compass required. Elect. AC-DC and vacuum sys. operating normally.
Clock	1	O F	F. One clock/watch of equivalent accuracy with sweep second hand and carried by pilot required.
Pitot Tubes	2	1 G	G. Must be paired with complete set of instruments.
Pitot Heaters	2	1 G	
Static System	1	1	
Outside Air Temperature	1	O H	H. Both CAT and Manifold heat must be operating normally if icing anticipated.
Vacuum Pumps	2	1 J	J. Refer to supplemental procedures B,C,D,E above.
Vacuum Pressure Indicator	2	1 J	
Vacuum Pump Warning Light	2	O K	K. Vacuum pressure indicator must be operative.

TWIN BEECHCRAFT

MINIMUM EQUIPMENT LIST

SYSTEM AND COMPONENTS	Standard equipment	Minimum equipment	SUPPLEMENTAL PROCEDURES
12. MISCELLANEOUS EQUIPMENT			
Ash Trays	6	A	A. If regular ashtray is not installed, receptacle shall be covered to prevent inadvertent use.
First Aid Kit	1	1	
Passenger Seats and Belts		B	B. Operable seat and belt required for each seat occupied.
Aircraft Commander and First Pilot Seats and Belts		C	C. Both must be fully operable or permanently fixed in position satisfactory for person using.
Cockpit Check List	1	1	
Emergency Cockpit Check List	1	1	
Airplane Flight Manual	1	1	
Seat Belt No Smoking Sign	1	O D	D. Passengers must be properly briefed if inoperative.

APPENDIX VI

This appendix shows a copy of the "Supplemental Type Certificate" issued after the aircraft was modified to increase the gross take-off load to 10,100 pounds of the ERL equipped Beechcraft E-18S.

United States of America 65

Department of Transportation — Federal Aviation Administration

Supplemental Type Certificate

Number SA572WE

This certificate, issued to Hamilton Aircraft Company, Inc.

certifies that the change in the type design for the following product with the limitations and conditions therefor as specified hereon meets the airworthiness requirements of Part 03 *of the* Civil Air *Regulations*, effective 13 November 1945.

Original Product — Type Certificate Number: A-765

Make: Beech

Model: 3N, 3NM, 3TM, D18S, TC-45J (SNB-5), C45G, C45H, TC-45G, TC-45H, E18S, E18S-9700, G18S, H18

Description of Type Design Change:
Increase in gross weight to 10,100 pounds when aircraft has been modified in accordance with FAA sealed Hamilton Aircraft Company, Inc. Summary Drawing Number 25600. Installation of nacelle vent manifold per Hamilton Drawing 256021A, optional.

Limitations and Conditions The approval of this change in type design applies basically to Beech Models 3N, 3NM, 3TM, D18S, TC-45J (SNB-5), C45G, C45H, TC-45G, TC-45H, E18S, E18S-9700, G18S, H18 aircraft only. This approval should not be extended to other specific airplanes of these models on which other previously approved modifications are incorporated unless it is determined by the installer that the interrelationship between this change and any of those other previously approved modifications will introduce no adverse effect upon the airworthiness of that aircraft.
FAA approved Airplane Flight Manual, Hamilton Aircraft Co. Document D129, required.

This certificate and the supporting data which is the basis for approval shall remain in effect until surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: 18 June 1963

Date reissued:

Date of issuance: 26 December 1963

Date amended: 15 March 1964, 16 October 1968
14 September 1971

By direction of the Administrator

(Signature)

Acting Chief, Aircraft Engineering Division

(Title)

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

This certificate may be transferred in accordance with FAR 21.47

FAA F 8110-2(10-68)

APPENDIX VII

This appendix shows a copy of an "Emergency Airworthiness Directive" dated April 24, 1973 on Beechcraft Model 18 airplanes. This directive has to do with a change requirement to the wing of the above mentioned aircraft.

EMERGENCY AIRWORTHINESS DIRECTIVE

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AERONAUTICAL CENTER
P.O. BOX 25082
OKLAHOMA CITY, OKLAHOMA 73125

April 24, 1973

Dear Sir:

Our records indicate that you are the owner of one or more versions of Beech Model 18 airplanes. Pursuant to the authority of the Federal Aviation Act of 1958, as amended, delegated to me by the Administrator, Airworthiness Directive (AD) 72-20-5, Amendment 39-1526, is amended as hereinafter set forth, applicable to all versions of the Beech Model 18 airplanes as specified in the original AD and is effective immediately, unless already accomplished or exempted from this AD by Paragraph F, upon receipt of this letter.

The immediate adoption and effectiveness of this amendment is necessary because of undetected fatigue cracks at wing stations 73 and 81. Failure to detect these cracks by X-Ray and visual/magnetic or penetrant methods leads to complete failure of the front spar lower cap and results in wing separation.

Since this condition is likely to exist or develop on these model airplanes, the following Amendment to AD 72-20-5, Amendment 39-1526, is issued effective immediately, unless already accomplished or exempted, applicable to all versions of Beech Model 18 as specified in AD 72-20-5.

Paragraph D of AD 72-20-5, Amendment 39-1526, is amended so that it now reads as follows:

D) 1. A special inspection at wing station 73 and 81 is required within 25 hours' time in service after the effective date of this amendment regardless of previous time in service since last inspection and thereafter at intervals not to exceed 100 hours' time in service. Visual and either magnetic particle or penetrant methods must be used while the wing is simultaneously flexed.

2. Within 48 hours after the effective date of this amendment, transmit by most rapid means copies of X-Rays of the two most recent inspections taken in accordance with AD 72-20-5 or predecessor AD's to DOT/FAA, Engineering and Manufacturing Branch, Hangar #10, Wichita Municipal Airport, Wichita, Kansas, 67209. Evaluation of inspection facility's findings will be transmitted to sender as soon as possible.

3. Within 600 hours' time in service after the effective date of this amendment, modify wing stations 73 and 81 in accordance with Beech Aircraft Corporation Kits 18-4024, 792 or any equivalent approved by Chief, Engineering and Manufacturing Branch, FAA, Central Region.

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4. Within 2,000 hours after the effective date of this amendment, but not later than May 1, 1975, modify wing stations 32, 57 and 64 in accordance with Beech Aircraft Corporation Kits 18-4024 and 791, or any equivalent approved by Chief, Engineering and Manufacturing Branch, FAA, Central Region.

JOHN M. CYROCKI
Director, Central Region

NOTE: Address inquiries regarding this AD to:

DOT, Federal Aviation Administration
Engineering & Manufacturing Branch, ACE-210
601 East 12th Street
Kansas City, Missouri 64106

EMERGENCY AIRWORTHINESS DIRECTIVE

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
OFFICIAL BUSINESS

Emergency
Airworthiness Directive

POSTAGE AND FEES PAID
FEDERAL AVIATION ADMINISTRATION

AIR MAIL

SUPERVISING INSPECTOR
FAA
PEARL STATION
JACKSON MS 39208

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