RESEARCH AVIATION FACILITY BULLETIN 13

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DESIGN, FABRICATION, AND APPROVAL OF USER-SUPPLIED EQUIPMENT FOR NCAR AIRCRAFT

Foreword

The RAF *Bulletin* series is intended to guide scientists in making effective use of NCAR aircraft. We recognize that some of the topics presented deserve more space than is available here; however, we have endeavored to present the material in a manner most useful to those having little or no experience in the use of aircraft as an observing platform. We invite comments from those who use our facilities on how we might improve this presentation.

General

This *Bulletin* sets forth the procedures to be followed for the design, fabrication, and approval of user-supplied research equipment to be flown on board NCAR/RAF aircraft. Failure to adhere to the procedures set forth herein may result in *delay* or *cancellation* of your project.

The installation of user-supplied research equipment is one of the more demanding and time-consuming aspects of airborne research. Proper design and fabrication of equipment before the installation period are most important, as design or fabrication defects usually cannot be corrected during the installation period. This is particularly important in that design deficiencies must be corrected prior to installation on board the aircraft.

All newly designed, commercially purchased, and other equipment not designed for aircraft use must be evaluated for structural integrity and, if necessary, modified or strengthened to conform to the criteria outlined in this *Bulletin*. All equipment designed for aircraft use will be reviewed for conformity also. In addition to structural considerations, any wiring in user- supplied equipment must adhere to guidelines established and outlined herein.

All equipment must be designed or modified to attach to the various instrument racks and attaching points on the specified aircraft to be used. Information on these mounting points is contained in the RAF *Bulletins* concerning each aircraft. The load-carrying capability of these racks and attaching mounts must not be exceeded.

The criteria of this *Bulletin* are strictly enforced and it is the responsibility of the user to comply. Noncompliance will cause the user's equipment not to be flown or the program to be delayed. Of course, RAF will assist the user in meeting the standards set forth in this *Bulletin.*

Design Criteria

All equipment, including racks, instruments, pallets, tie-downs, etc., to be flown inside the aircraft must be designed for the crash load conditions listed below:

Load Direction	Load Factor
Forward	9.0 g (9.0 × wt of equipment)
Up	2.0 g (2.0 × wt of equipment)
Down	5.0 g (5.0 × wt of equipment)
Side	1.5 g (1.5 × wt of equipment)
Aft	1.5 g (1.5 × wt of equipment)

The equipment's main frame structure and structural interface to the aircraft mounting points must be designed to take these loads.

All equipment, including instrument pylons, struts, pods, etc., to be attached to the outside of the aircraft must be designed for the following aerodynamic (lift and drag) loads or inertial (maneuvering) loads, whichever are greater.

Aircraft	Aerodynamic Loads	Inertial Loads
Electra	328 KIAS & sea level cond.	+ 2.5 g (down), -1.5 g (up)
Sabreliner	370 KIAS & sea level cond.	+ 3.0 g (down), -1.0 g (up)
King Air	259 KIAS & sea level cond.	+ 2.5 g (down), -1.3 g (up)

The Aeronautical Engineer at RAF should be contacted before a user undertakes the design of any externally mounted equipment.

All equipment for pressurized aircraft that must maintain the pressure differential between cabin pressure on one side and outside ambient pressure on the other (e.g., optical view ports, air sampling chambers, valves or lines) must be designed to a collapse or burst pressure of at least 1.41 g/cm^2 (20 psi).

The loads calculated for the above design criteria, for both internal and external equipment, will result in internal stresses for the structural components. These calculated stresses must not exceed the accepted yield stress values for the material used. Refer to MIL-HDBK-5B, *Metallic Materials and Elements for Aerospace Vehicle Structures*, for the accepted values.

The user should design his equipment to be as light as possible since weight is an important consideration for airborne equipment. If the analysis for structural components show large margins of safety for the design loads, the design should be redone to reduce weight.

Materials and Fasteners

The commonly accepted materials for airborne structural components are aluminum and steel, with aluminum being the most widely used. The 2024, 6061, and 7075 series of tempered aluminum alloys are the most popular. The 6061 series aluminum is the most readily available; it is also readily weldable, while the others are not. The 4130 steel is the most widely used steel alloy. Other materials, such as copper, brass, plastics, wrought iron, 0 temper aluminum, etc., must not be used for structural members.

Aircraft structural fasteners (MS, AN, or NAS standards), such as screws, bolts, nuts, and rivets, must be used for all structural members. All threaded fasteners must be secured by self-locking nuts, self-locking inserts, or safety wire. These fasteners should also be used for other elements of the equipment wherever possible. The holes for the fasteners should be sized for the specific fastener and must not be oversized or elongated. RAF can supply specifications for these fasteners.

Any threaded holes drilled and tapped in aluminum members should use inserts such as Heli-Coil or Keen Serts to eliminate thread galling and improve strength.

Bolted and riveted construction is recommended for structural members; welding is permitted, but it must be of high quality and performed according to the MIL-T-5D21C specification or equivalent. The load-carrying strength of aluminum welded joints must be reduced by 50%, since the welding process reduces the strength of the parent metal next to the weld.

Hazardous Materials and Equipment

Any hazardous materials (pyrotechnics, flammables, toxic gases or liquids, lasers, etc.,) and associated containers and handling apparatus required with user-supplied equipment must be noted by the user. These materials will be reviewed by the NCAR Safety Officer and cognizant NCAR and RAF personnel. As part of the review process, the user will be required to complete a form stating the type of material, quantities, concentrations, containers, plumbing, hazards to personnel, etc. This form can be obtained from the RAF and should be returned to the NCAR Safety Officer.

Any pressurized containers, valves, and plumbing must be capable of sustaining at least twice the operating pressure needed for use. Any gas cylinders used must have a current hydrostatic testing date (as per Department of Transportation regulations pertaining to gas cylinders).

Any cylinders containing toxic or flammable gases will require an enclosure over the cylinder top and regulator such that in the event of a leak, the gases will be vented from the aircraft.

The decision to permit hazardous materials and/or instruments to be used on board NCAR aircraft will be made by the RAF Safety Committee after a complete review of the materials and equipment involved. The committee will ensure that the aircraft and the personnel on board are not subject to unreasonable hazards under conditions which can be expected during the conduct of the operation. The committee will specify safeguards when appropriate.

Certain types of wire such as solid wire and rubber covered wire are not acceptable for use in equipment mounted on board the aircraft. Acceptable types of wire include, in order of preference: stranded copper wire with woven fiberglass and teflon covering, stranded copper wire with teflon and nylon covering, and stranded copper wire with teflon covering. Wire size relative to current capacity is also a safety concern. The following table gives guidelines for this.

Wire size (gauge)	Current Capacity (amps)
14	20
16	15
18	12
20	9

In general, workmanship in the wiring of user-supplied equipment shall be of the highest quality possible. Items such as insufficiently soldered joints, cold soldering joints, poor or inadequate insulation, and improper crimping are examples of unacceptable workmanship. User-supplied equipment with substandard wiring will be repaired by the user and reinspected by the RAF prior to installation on the aircraft.

Design Review and Changes

It is the user's responsibility to design, fabricate, or modify his equipment in accordance with the criteria of this *Bulletin.* The user is required to submit detailed drawings of his equipment, including commercial or existing equipment, which show dimensions, fasteners and fastener pattern, materials, and estimated weights. A description of power requirements is also required. Photographs should also be furnished if they are available. Loads and stress analysis must accompany the drawings and must include at least an analysis of the basic structure and the support and tie-down to the aircraft mounts.

Actual load testing of the equipment to simulate in-flight conditions for verification of the design criteria is not recommended, as equipment can easily be destroyed or damaged by the test. Any test plans must be approved by RAF if actual load testing is to be used.

All design data must be submitted at least three months in advance of the installation of the equipment on board the aircraft. Longer lead times may be required for complex equipment and installations. RAF will review and approve or suggest changes to the design as needed. Approval of RAF must be obtained before the equipment is constructed or shipped. Delays in meeting this schedule can result in project *delay* or *cancellation.* In addition, RAF requires that equipment be made available for installation on the aircraft at least 30 days in advance of the project start date.

The RAF Safety Committee reviews all safety aspects of a program, including instrumentation and equipment, and must approve each project for safety prior to its execution. The user should be aware that once a program has been reviewed by the RAF Safety Committee, any user-initiated changes involving instrumentation or equipment will require another complete review. These changes could delay the program or cause late equipment additions to be unacceptable.

Aircraft Modifications

The user is strongly urged to design his equipment to use the existing capabilities of the RAF aircraft (refer to the specific NCAR RAF *Bulletin* for the aircraft of interest). Any modification of existing capabilities or new modification to the aircraft is in most cases extremely expensive and time-consuming. The user is cautioned that he may be required either to share the cost, or to assume the total cost of any requested modifications.

Since the aircraft could be removed from service to other users for extended periods of time, any modifications required will be handled by RAF.

Equipment Inspection and Acceptance

User-supplied equipment will be inspected under the RAF inspection program when it arrives at the Facility and before it is installed on the aircraft. This inspection will verify the design, construction, weight, and general condition of the equipment to determine its conformance to the previously approved design data. Minor discrepancies can be corrected at this time. As pointed out earlier, major discrepancies probably cannot be corrected at this time and such discrepancies could cause the equipment not to be flown or the program to be delayed or cancelled.

Weight Control on RAF Aircraft

An accurate estimate of the weight and size of user equipment to be installed on the aircraft is a critically important requirement in the initial request for aviation support. Estimated weights and sizes must also include any support equipment (e.g., gas cylinders), spares, tools and supplies, which are to be carried on the aircraft during ferry or research flights. RAF's feasibility evaluation of a program is based on these inputs. Any changes to the original proposal will require a reevaluation of the proposed flight profiles, and possibly require changes in the cabin layout to comply with aircraft balance requirements.

Prior to installation of user equipment on the aircraft, all equipment will be weighed and identified by an appropriate tag and entered in the instrumentation log book. Prior to departure, all spares, supplies and associated gear, including personal baggage, will also be weighed and properly marked. These actual weights will be used in the weight and balance calculations required for the safe operation of the aircraft. Strict compliance is mandatory. Any unweighed and unmarked items will be removed from the aircraft.

Equipment Installation

At least four weeks should be allowed for installation of approved equipment on board the RAF aircraft, and the installation will be supervised by cognizant RAF personnel. More time may be required for installation of complex equipment. Some of the necessary incidental hardware can be supplied by RAF. FAA approval of the installations will be obtained at this time and will be handled by RAF.

During flight, any removal or disassembly of equipment from their approved installation is prohibited since such alterations and repairs can create potentially hazardous conditions.

Flight Tests

Flight tests are sometimes required, especially in the case of externally mounted equipment, to evaluate flutter or vibration characteristics and effects on aircraft performance and handling. This requirement can usually be assessed early in the program,

at the time the user's proposal is reviewed by RAF. RAF will lay out the flight test program, if required, in conjunction with the user and will conduct the test.

Further Information

Investigators interested in discussing the procedures and standards covered in this *Bulletin* may contact the RAF Aeronautical Engineer at (303) 497-1062 or the Deputy Manager for Field Projects at (303) 497-1036.