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Users Guide for NASA Lewis Research Center DC–9 Reduced-Gravity Aircraft Program

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National Aeronautics and
Space Administration

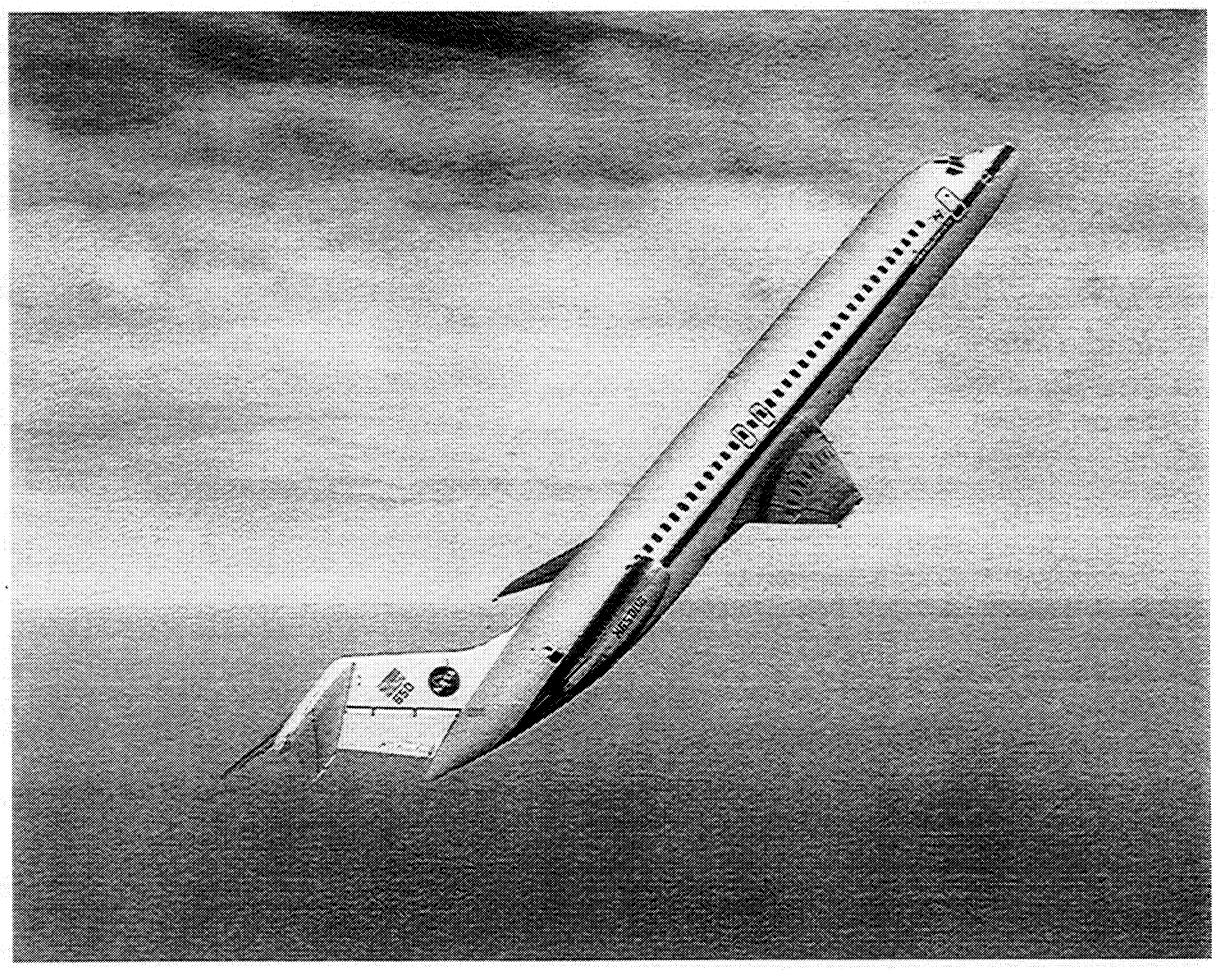
Forward

This document provides guidelines and information for users of the DC-9 reduced-gravity aircraft. It describes the facilities, requirements for test personnel, equipment design and installation, mission preparation, and in-flight procedures.

Those who have used the KC-135 reduced-gravity aircraft will recognize that many of the procedures and guidelines are the same. Additional information concerning this guide, the aircraft, test requirements, test schedules, etc., may be obtained from

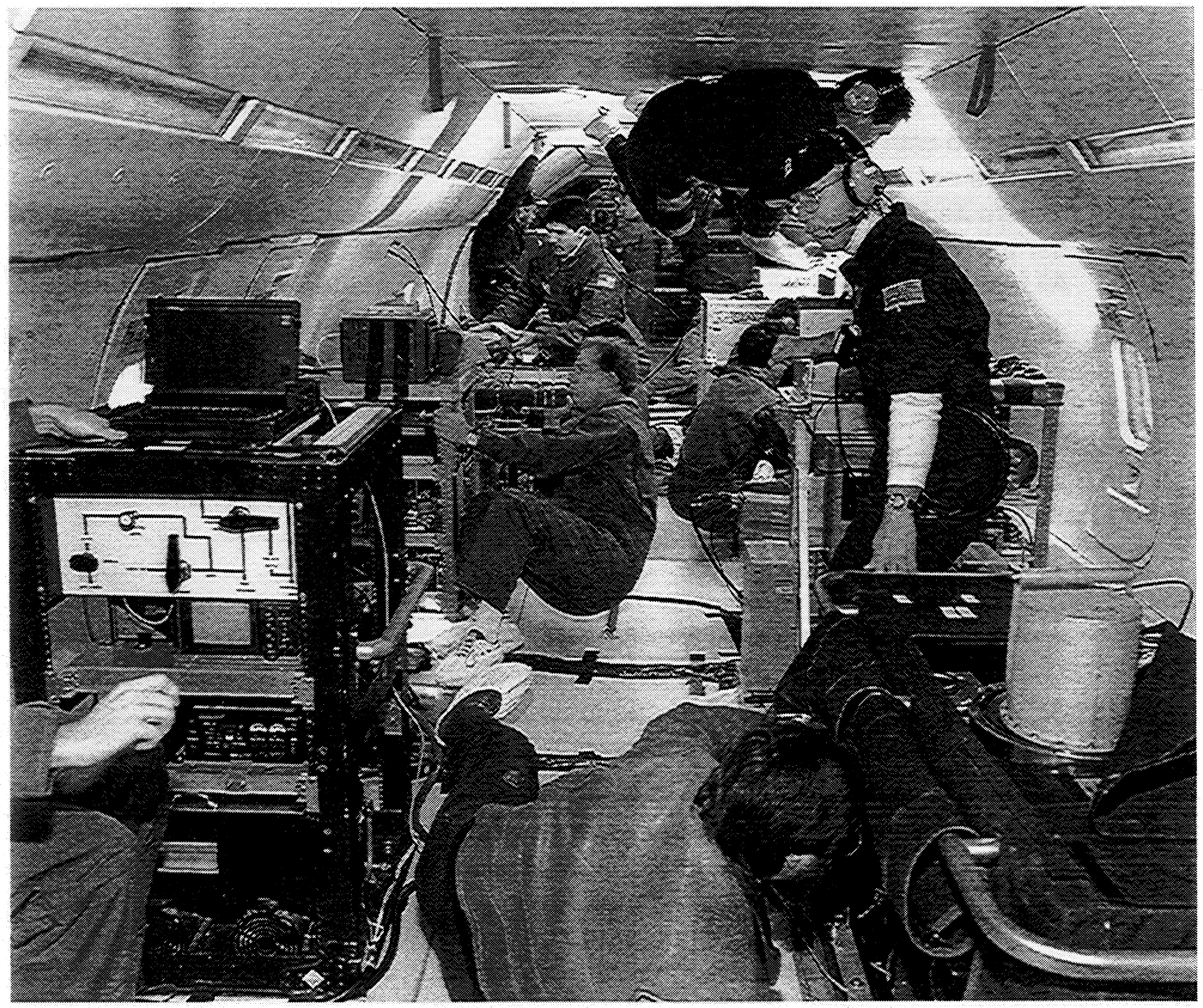
NASA Lewis Research Center
DC-9 Reduced-Gravity Office
MS 101-1
21000 Brookpark Road
Cleveland, Ohio 44135

or call 216/433-2611, 216/433-2612, fax 216/433-2614



MISSION STATEMENT

To provide a world-class, reduced-gravity research platform that emphasizes user compatibility, consistent and quality reduced-gravity levels, and a customer-oriented support organization.



1. Program Description

The DC-9 reduced-gravity aircraft, operated by the Lewis Research Center of the National Aeronautics and Space Administration (NASA), makes available a "weightless" environment, similar to the environment of space flight, to support the scientific and engineering objectives of the Microgravity Science and Applications Division (Code UG) at NASA Headquarters. The DC-9 aircraft supplies the user with electrical power, low-gravity acceleration data, compressed gas bottle racks, an overboard venting system, and documentary video-recording capabilities. (See Section 2.1 for a detailed description of the aircraft.) NASA Lewis can provide photographers for documentary still and video photography. Work space, technicians, parts, diagnostic equipment, etc., are available on the ground for assembly and preflight testing of research hardware to ensure its operation before installation in the aircraft.

2. FACILITIES

2.1. Aircraft Capabilities and Characteristics

NASA has modified the McDonnell Douglas DC-9 (N650UG) twin-engine passenger aircraft to support the reduced-gravity mission. The aircraft is equipped with a cargo door for the loading of research hardware. Because the DC-9 is not operated as a regularly scheduled common carrier, any person manifested to board the DC-9 should determine before boarding whether his or her personal life or accident insurance provides coverage under such conditions. All test participants will be informed before flight of the test plans and of risks, hazards, and discomforts inherent to such tests.

2.1.1. Environment

The aircraft can provide in excess of 45 low-gravity periods per flight. The gravity levels experienced by experiments attached to the aircraft floor are on the order of 10^{-2} g for an average duration of 18-22 seconds. Experiments which are floated can obtain gravity levels on the order of 10^{-3} g but the duration of that g is greatly reduced due to the experiment floating into the ceiling or floor prior to the end of the trajectory. The duration at that gravity level is dependent on the experiment size but is usually greatly reduced due to the experiment contacting the floor, ceiling or side walls prior to the end of the low-gravity period.

Cabin pressure is normally maintained between 5,000 ft. (12.2 psia) and 8000 ft (10.9 psia) during the parabolic maneuvers. Cabin pressure does vary during the parabolic maneuver. Unexpected loss of cabin pressure could result in a cabin pressure as low as 3.5 psia, a factor that must be considered in the design of the research hardware, specifically, pressure vessels. Normally, cabin temperature varies from 50 to 80° F in flight.

2.1.2. Cabin Dimensions

Approximately 650 in. of cabin length is available for testing purposes. A typical cross section is shown in Figure 1. The bolt-hole pattern for research hardware attachment is shown in Figure 2. The cargo door, through which research hardware is loaded is 78.5 in. high by 135 in. wide (Figure 3). Ten inches of width near the top of the cargo door is unusable because of the door-actuating mechanism (see Figure 4). Note that (1 in. = 2.54 cm)

2.1.3. Crew Provisions

The DC-9 aircraft is equipped with 20 seats aft of the test section. Emergency oxygen devices, flotation devices, first-aid equipment, and other emergency equipment are provided onboard the aircraft.

2.1.4. Overboard Vent System

Plumbing is available to allow venting of gases overboard in flight. The vent connection is a standard, 1-in. diameter, male, 37° flare fitting. Numerous adapters are available from 1/4 in. to 1 1/4 in.

2.1.5. Accelerometer Signal Data

Accelerometer signals are available to the researcher. These signals include the G_x, G_y, and G_z from each of the two accelerometer heads, located in the cabin. All accelerometer signals are buffered to prevent interference with aircraft systems and other researchers. The accelerometer signals are bipolar: G_x and G_y are 9.8 V/g and G_z is 2.5 V/g. The acceleration voltages are between +/- 10V. The acceleration signals are also filtered with a normal cut off frequency of 5 Hz. This frequency can be changed by request. Calibration data is available on request.

To connect to the aircraft accelerometers, researchers will need a DB-15 male connector. Pin designations follow:

$Gx_{for}+ \Rightarrow 2$
$Gx_{for}- \Rightarrow 10$
$Gy_{for}+ \Rightarrow 3$
$Gy_{for}- \Rightarrow 11$
$Gz_{for}+ \Rightarrow 1$
$Gz_{for}- \Rightarrow 9$
$Gx_{aft}+ \Rightarrow 5$
$Gx_{aft}- \Rightarrow 13$
$Gy_{aft}+ \Rightarrow 6$
$Gy_{aft}- \Rightarrow 14$
$Gz_{aft}+ \Rightarrow 4$
$Gz_{aft}- \Rightarrow 12$

The forward accelerometer is located at aircraft station 282. The rear accelerometer is located at station 642. Since experiment location is unknown during design, it is recommended that the cable be 20-25 feet in length.

2.1.6. Cabin Lighting

Fluorescent lamps mounted in the aircraft fuselage at the locations shown in Figure 1 provide ambient lighting in the cabin. Also the padding covering every fifth window along both sides of the aircraft can be removed to provide natural light.

2.1.7. Electrical Power and Experiment Connections

Three types of electrical power are available:

1. 115 V ac, 400 Hz (three phase), 30A per phase
2. 115 V ac, 60A source 1, 30 A source 2
3. 28 V dc, 80A

Standard MS cannon plugs are used for all power distribution connections.

Contact the DC-9 Reduced-Gravity Office for experiments which have power needs which cannot be met by the sources listed.

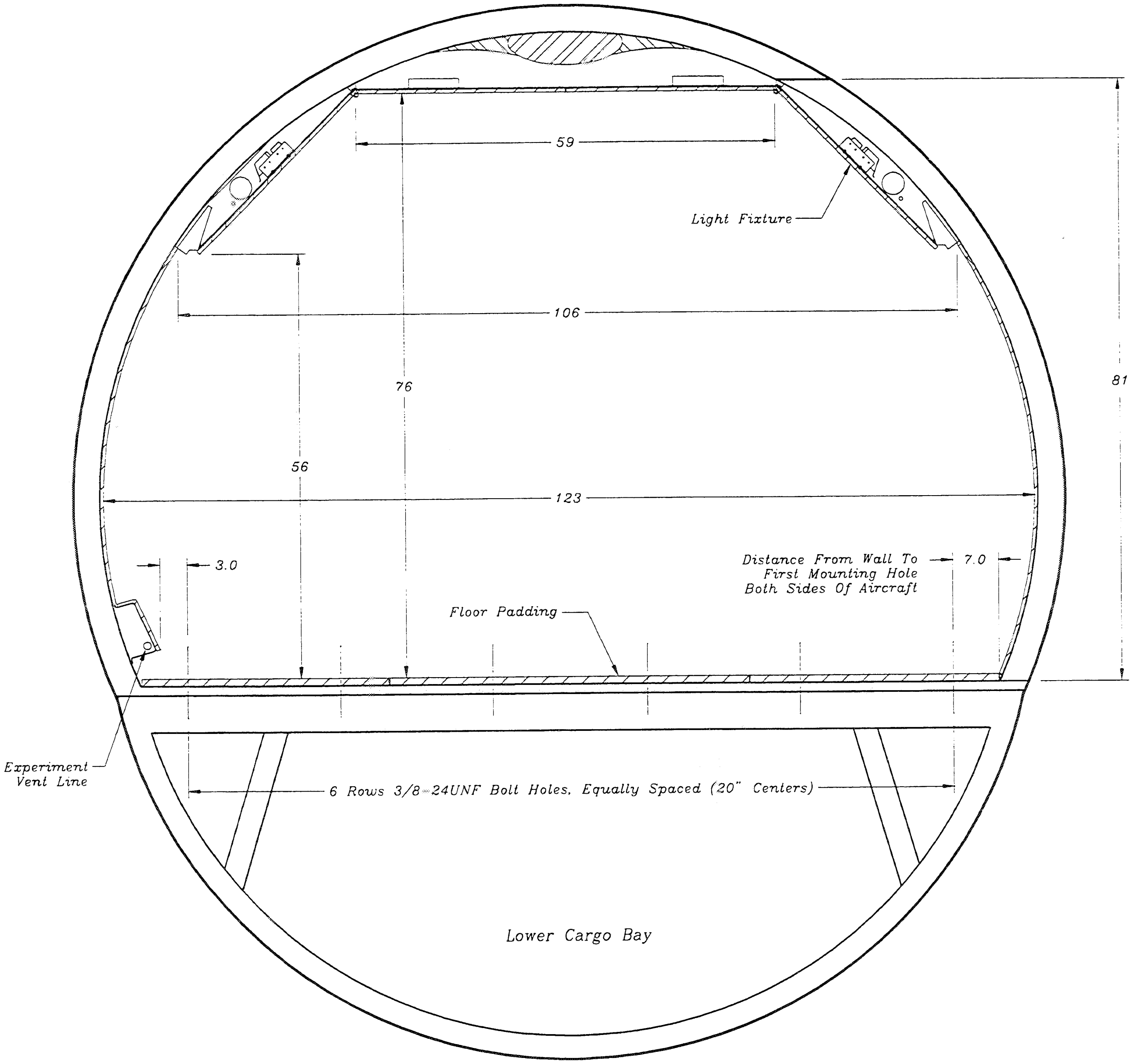


Figure 1 - Cross-sectional view of DC-9
(Dimensions are in inches.)

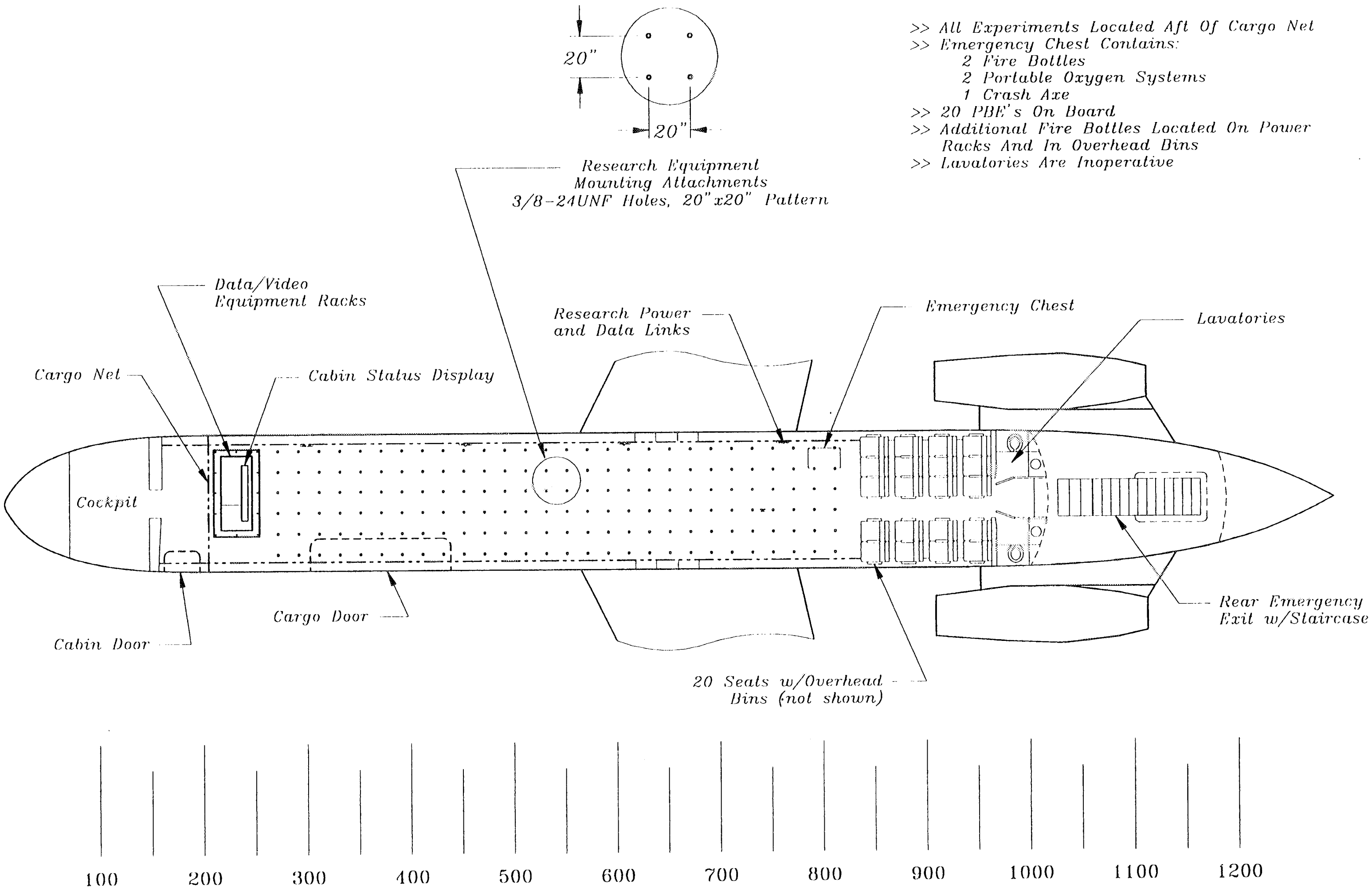


Figure 2 - Overhead View of DC-9

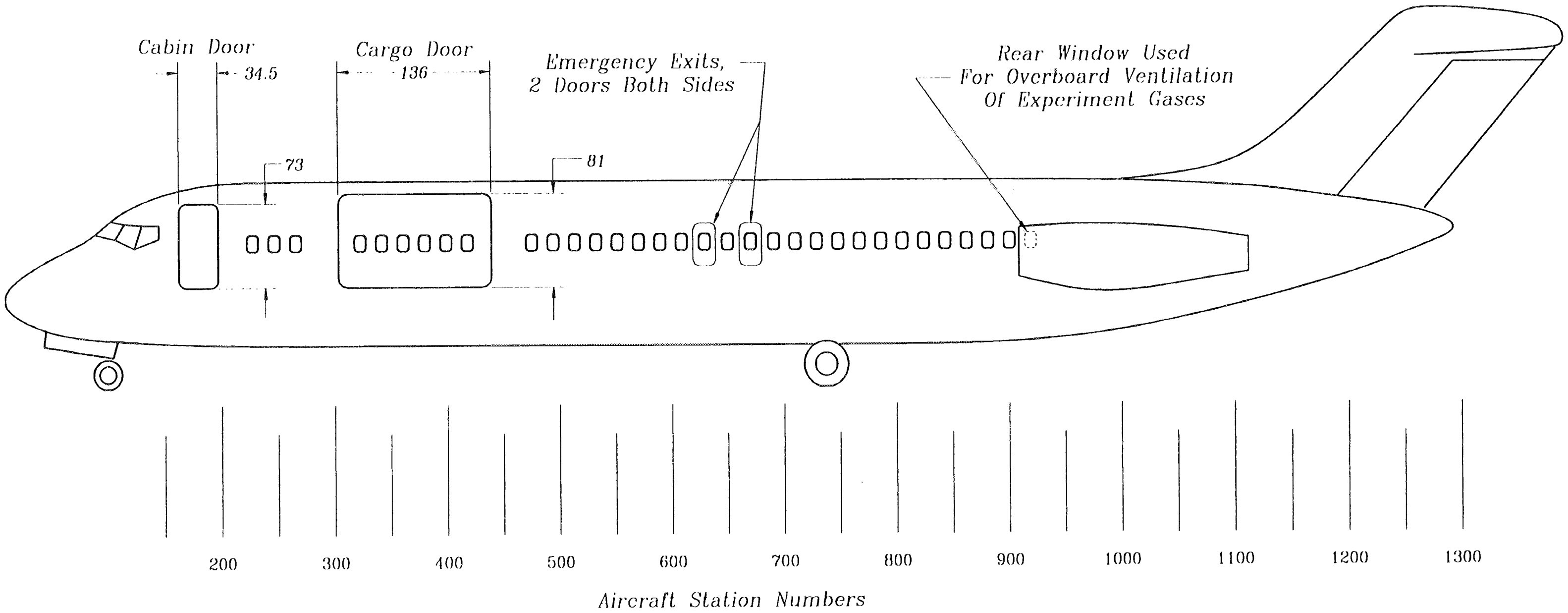


Figure 3 - Side View of DC-9
(Dimensions are in Inches)

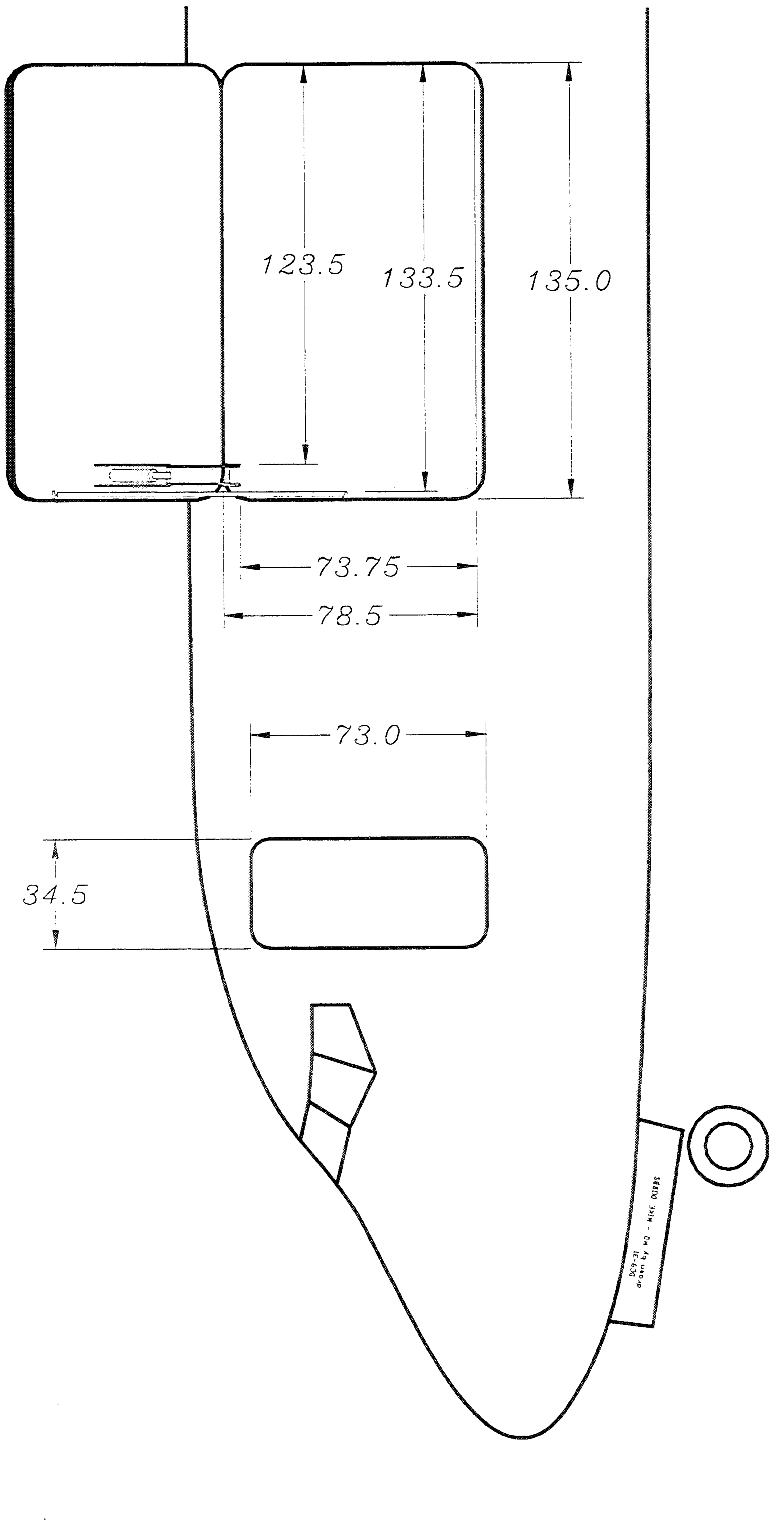


**Figure 4 - DC-9 Cargo Door Usable Opening
(Dimensions are in inches)**

15 V ac 400Hz (three phase):

Each power connection (MS cannon plug) can supply 15A maximum. Each phase has a maximum capability of 30A for all users.

The phase A power distribution connector is MS3100A14-2S (female); the experiment mating connector should be MS3106A14-2P (male).

Phase B power distribution connector is MS3100A14-2S-Y (female); the experiment mating connector should be MS3106A14-2P-Y (male).

Phase C power distribution connector is MS3100A14-2S-X (female); the experiment mating connector should be MS3106A14-2P-X (male).

On all the MS3106A14-2P, -2P-Y,and -2P-X connectors:

Pin A $\Rightarrow$ Hot
Pin B $\Rightarrow$ Ground
Pin C $\Rightarrow$ No connection
Pin D $\Rightarrow$ Neutral

115 V ac 60 Hz:

The source 1 power distribution connector is MS3100A14-1S (female); the experiment mating connector should be MS3106A14-1P (male). Source 1 can supply a total of 60A for all users. Each connection can supply 15A maximum.

The source 2 power distribution connector is MS3100A14-7S-Y (female); the experiment mating connector should be MS3106A14-7P-Y (male). Source 2 can supply a total of 30A for all users. Each connection can supply 15A maximum.

On the MS3106A14-1P and MS3106A14-7P-Y connectors:

Pin A $\Rightarrow$ Hot
Pin B $\Rightarrow$ Ground
Pin C $\Rightarrow$ Neutral

28 V dc:

The 28 V dc high-current power distribution connector is MS3100A18-10S (female); the experiment mating connector should be MS3106A18-10P (male). Each high-current power connection can supply 35A maximum.

On the MS3106A18-10P connector:

Pin A ⇒ +28 V dc
Pin B ⇒ Return
Pin C ⇒ No Connection
Pin D ⇒ No Connection

The 28-V dc standard current power distribution connector is MS3100A14-9S (female); the experiment mating connector should be MS3106A14-9P (male). Each standard current power connection can supply 15A maximum.

On the MS3106A14-9P connector:

Pin A ⇒ +28 V dc
Pin B ⇒ Return

The 28-V dc source can supply 80A for all users.

2.1.8. High Pressure Gas System

Two-bottle and four-bottle high-pressure gas bottle racks are available to provide a supply of inert gases. Standard K bottles are used. All systems must comply with the standards listed in section 5.2 of this document. The researcher is responsible for ordering and delivering all gas bottles to support his or her experiment to the DC-9 Reduced-Gravity Office (Building 101) prior to the flight dates. The following standard gases are available from Lewis stock:

1. Air: zero ultra high purity, < 1 ppm total contamination; breathing (CGA 590)
2. Air: breathing (CGA 346)
3. Argon: technical, 99.995% (CGA 580)
4. Helium: high purity, 99.997% (CGA 580)
5. Nitrogen: ultra high purity, 99.999%; technical (CGA 580)
6. Oxygen: technical, 99.5% (CGA 540)

Researchers from locations other than Lewis should inform the Reduced-Gravity Office of the type of gas and quantity needed at least **four weeks** prior to their scheduled flight dates. Those researchers who will be using nonstandard gases must arrange for shipment or delivery of their specific gases to DC-9 Reduced-Gravity Office (Building 101). Researchers must provide their own regulators with the appropriate over-pressure protective devices.

2.1.9. Data System

A data acquisition system will record g-levels, cabin temperature, and cabin pressure for the reduced-gravity periods of the flight. These data points will be recorded for post-flight examination and will be available to researchers on request. A light-emitting diode message center will display G_x, G_y, G_z, parabola count, and local time.

2.1.10. Video System

A video system consisting of three video cameras, four video cassette recorders, and a Quad video multiplexer, will record the general cabin events and environment for each flight. Two of the video cameras will be permanently located: one on top of the forward instrumentation rack facing aft; the other in an overhead storage bin facing forward. One miniature video camera can be located where needed for a particular flight. One VCR is available for researchers use upon request. Additionally, a video monitor is located in the front of the research area and is connected to the VCRs.

2.2. Imaging Services Support

NASA Lewis will provide photographers, as needed, for general documentation and scientific imaging. Requests for imaging services must be submitted to the Imaging Technology Center via the DC-9 Reduced-Gravity Office no later than **six weeks** prior to flight. Individuals requesting scientific imaging services are encouraged to contact the Scientific Imaging Group within the Imaging Technology Center at 216/433-5976 for assistance during the hardware design, buildup, and integration phases.

Services include VHS, S-VHS, Hi-8, and Betacam video formats; 16-mm motion pictures (standard and high speed); 6-cm x 6-cm negatives; 35-mm negatives; and 8 in. x 10 in. color prints as required for documentation.

Cabin lighting installed on the aircraft is sufficient for most photographic conditions requiring ambient lighting. Additional lighting equipment is available for special photographic conditions. Additional photographic information can be found in Appendix A.

2.3. Ground Support Facilities

2.3.1. Lewis Provided Support

Because the Lewis Research Center is a research facility, numerous specialized support facilities and personnel are available for visiting researchers' use. Researchers should contact the DC-9 Reduced-Gravity Office to discuss specific needs.

2.3.2. DC-9 Reduced-Gravity Office - Building 101

This facility provides visiting researchers with a work area for experiment assembly and checkout, an office, a data reduction and conference area, an aircraft power source, vacuum pumps, gas bottle storage, engineering staff, technicians, standard diagnostic equipment, minor machine tooling, general and small part supply, data processing, post-flight video replay and duplication capabilities. Mechanical and electronics technicians are also on site in Building 101 to provide assistance to visiting researchers. Building 101 is located adjacent to the Flight Research Building (Building 4). See Figure 5 for a layout of Building 101.

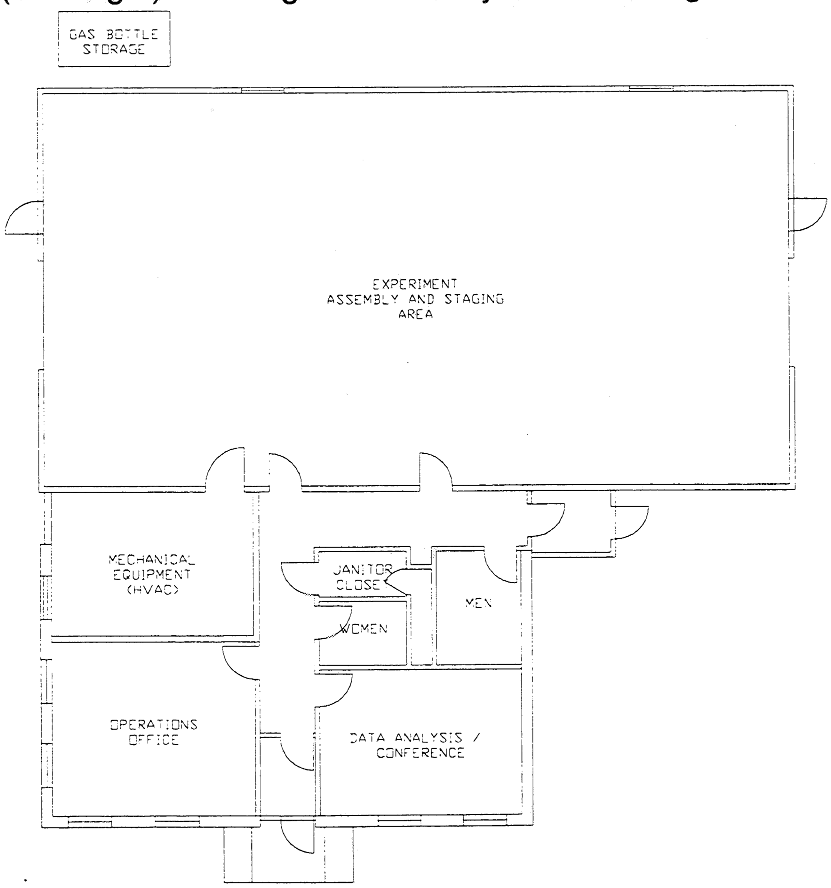


Figure 5 - Layout of DC-9 Reduced-Gravity Operations Building (Building 101)

2.3.3. Telephones

Telephones with access to FTS and commercial lines are available in rooms 107 and 108 of Building 4. All long-distance charges must be handled collect or third party by the researcher. Incoming calls for researchers should use the following numbers: 216/433-2611 or 216/433-2612. The FAX number is 216/433-2614.

2.3.4. Normal Duty Hours

The Reduced-Gravity Office (Building 101) is open for normal operations Monday through Friday from 7:30 a.m. to 4:00 p.m. Access to the Flight Research Building (Building 4) hangar floor is limited to these hours unless prior arrangements are made with hangar personnel.

2.3.5. Security

Researchers coming to Lewis who are U.S residents must contact the Reduced-Gravity Office **one week** prior to their arrivals, so that visitor badges can be processed and will be at the Lewis main gate on the day the researchers arrive.

International visitors must contact the DC-9 Reduced-Gravity Office **four weeks** prior to their arrivals, so that the paperwork (or proper procedures) can be accomplished in a timely manner (see Section 3.2.6.2.). Failing to do so will result in delays in acquiring Lewis visitor badges. While at Lewis all non-government visiting personnel must display their visitor badges and all international visitors must be escorted while on site.

Access to Lewis is restricted to properly approved (badged) persons. After- hours or weekend entrance must be coordinated in advance by with the Reduced-Gravity Office. Persons needing access after normal duty hours will be put on the "after hours" listing at the main gate with the responsible NASA person indicated and a telephone number where he or she can be reached.

2.3.6. Shipping, Receiving and Storage

All research hardware that require shipping must be sent to

NASA Lewis Research Center
DC-9 Reduced-Gravity Office
MS 101-1, Building 101
21000 Brookpark Road
Cleveland, Ohio 44135

Because limited storage space is available in the DC-9 Reduced-Gravity Office (Building 101), all research packages must be removed as soon as a test is completed. Each researcher (operator) is responsible for ensuring that his or her research hardware is packaged and the shipping documents (NASA-C-10009, Shipping Request/ Authorization) are completed **one day** prior to leaving Lewis. The DC-9 Reduced-Gravity Office will contact Lewis transportation for pickup of the research hardware. All international researchers are required to arrange for the delivery and pickup of their hardware. It is recommended that a shipping broker be employed to take care of all customs paperwork both at the shipping and receiving locations.

2.3.7. Local Area Maps and Hotel and Restaurant Information

A map and list of local hotels and restaurants and their telephone numbers are included as Figure 6. A map of the area surrounding Lewis is shown in figure 7 to give the first-time visitor to Cleveland and Lewis a feel for the area. A map of Lewis is given in Figure 8.

3. USER PROCEDURES

There is a three-part procedure for requesting flight approval. The responsible office is noted for each step of the procedure.

3.1. Test Request Procedures

3.1.1. Feasibility of Flying Inquiry

Contact the DC-9 Reduced-Gravity Office to discuss the feasibility of flying an experiment, to establish tentative dates, to request the current flight schedule, or to ask specific questions. See the Foreword for the address and telephone and facsimile numbers. In general, schedule priority is set on a first-come, first-served basis; however, program-critical experiments may be given higher priority.

3.1.2. Formal Request

Persons with new projects and experiments must submit a formal request for DC-9 reduced-gravity test support in writing to:

NASA Lewis Research Center
Microgravity Science Division
Attn: Mr. Jack Salzman MS 500-205
21000 Brookpark Road
Cleveland, OH 44135

The format for this request can be found in Appendix D.

Only new projects and experiments require initial approval. Persons with projects and experiments that have already been approved do not need to fill out the questionnaire.

This request should be submitted as soon as the requirements are firm, but not later than **six months** prior to the test flight date.

3.1.3. Initial Test Request

All projects and experiments that will fly on the DC-9 aircraft must submit a completed initial test request to the DC-9 Reduced-Gravity Office a minimum of **three months** prior to flight. The request should contain general information describing the following:

1. Test objectives
2. Desired schedule (exact flight dates will be determined later)
3. Brief description of the research and associated hardware
4. Number of test personnel required for flight and a description of the requirement for each person's presence
5. Special support required or constraints, including security classification of project, if applicable
6. Preliminary hazard analysis identifying hazards and controls (any format is acceptable) as identified per PAI #220 (Appendix B)
7. Names, addresses, and telephone numbers of contacts

The initial test request should be sent to:

NASA Lewis Research Center
DC-9 Reduced-Gravity Office
MS 101-1
21000 Brookpark Road
Cleveland, OH 44135

(Note: Personnel in the DC-9 Reduced-Gravity Office are available for consultation and assistance regarding the design of experiments, hazard analysis, and preparation of experiment safety documentation.)

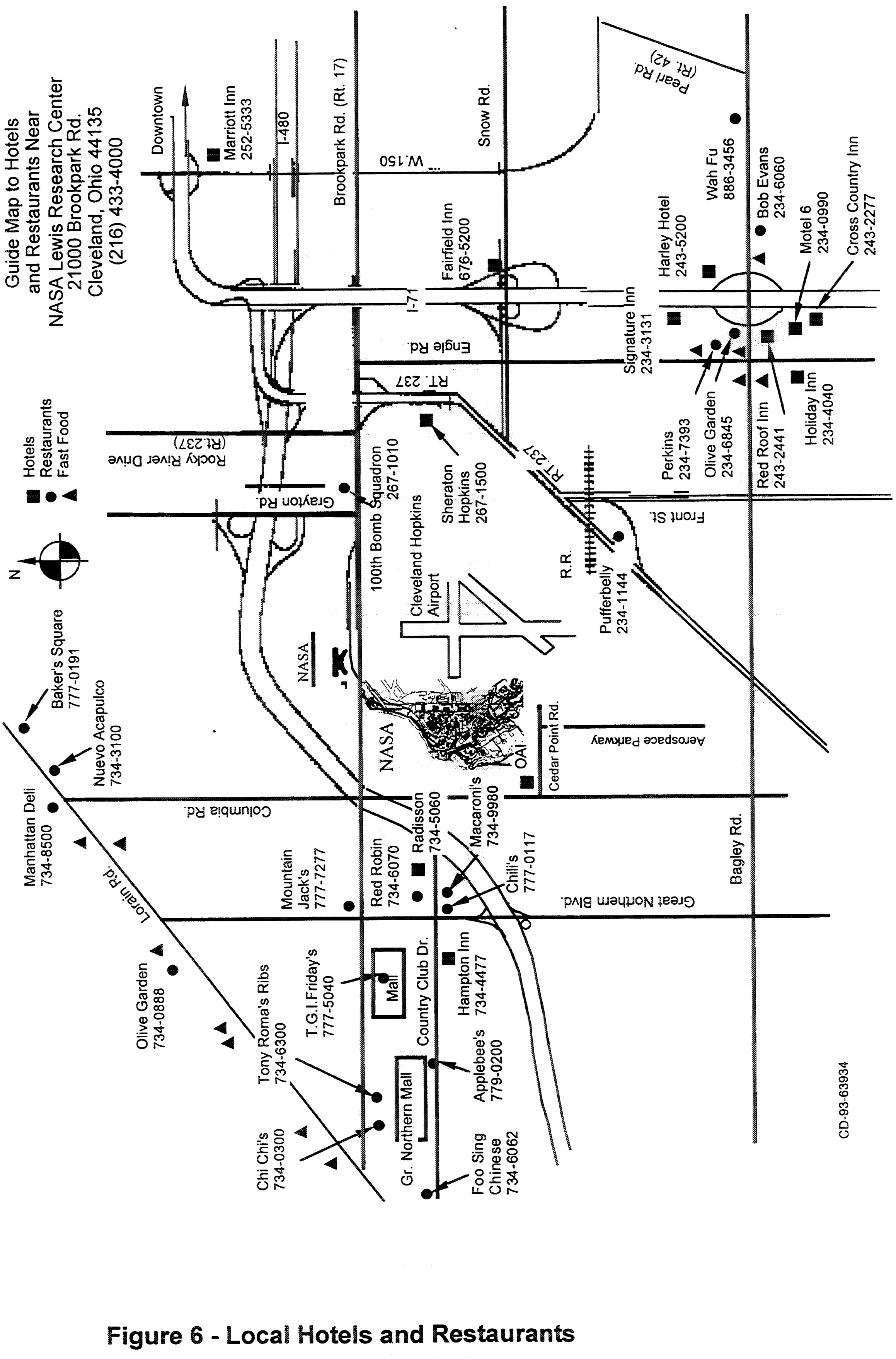


Figure 6 - Local Hotels and Restaurants

Hotels:

Hotel/Motel	Address	Phone
Cross Country Inn	7233 Engle Rd. Middleburg Hts., Ohio	216-243-2277
Fairfield Inn Marriott	16644 Snow Rd. Brook Park, Ohio	216-676-5200
Hampton Inn	25105 Country Club Blvd. North Olmsted, Ohio	216-734-4477
Harley Hotel Cleveland West	17000 Bagley Rd. Middleburg Hts., Ohio	216-243-5200
Holiday Inn-Hopkins Int'l	7230 Engle Rd. Middleburg Hts., Ohio	216-243-4040
Marriott Inn	4277 W. 150 St. Cleveland, Ohio	216-252-5333
Motel 6	7219 Engle Rd. Middleburg Hts., Ohio	216-234-0990
Radisson Inn	25070 Country Club Blvd. North Olmsted, Ohio	216-734-5060
Red Roof Inn	17555 Bagley Rd. Middleburg Hts., Ohio	216-243-2441
Sheraton Hopkins Airport	5300 Riverside Dr. Cleveland, Ohio	216-267-1500
Signature Inn	17550 Rosbough Dr. Middleburg Hts., Ohio	216-234-3131

Restaurants:

Restaurant	Address	Phone
Baker's Square	24025 Lorain Rd. North Olmsted, Ohio	777-0191
Bob Evans	17011 Bagley Rd. Middleburg Hts., Ohio	243-6060
Chi Chi's	Great Northern Plaza North Olmsted, Ohio	734-0300
Chili's	Country Club Blvd. at I-480 North Olmsted, Ohio	777-0117
Ground Round	24250 Lorain Rd. North Olmsted, Ohio	779-7173
Macaroni Grill	Country Club Blvd. at I-480 North Olmsted, Ohio	734-9980

Manhattan Deli	24180 Lorain Rd. North Olmsted, Ohio	734-8500
Mountain Jacks	Brookpark at Great Northern Blvd. North Olmsted, Ohio	777-7277
100th Bomb Squadron	20000 Brookpark Rd. Cleveland, Ohio	267-1010
Olive Garden	25984 Lorain Rd. North Olmsted, Ohio	234-0888
Olive Garden	17500 Bagley Rd. Middleburg Hts., Ohio	234-6845
Perkins	7175 Engle Rd. Middleburg Hts., Ohio	234-7393
Pufferbelly LTD	30 Depot Street (by Freeway) Berea, Ohio	234-1144
T.G.I. Friday's	5200 Great Northern Mall North Olmsted, Ohio	777-5040
Tony Romas	Great Northern Plaza North Olmsted, Ohio	777-2300
Wah Fu	15210 Bagley Rd. Middleburg Hts., Ohio	886-3456

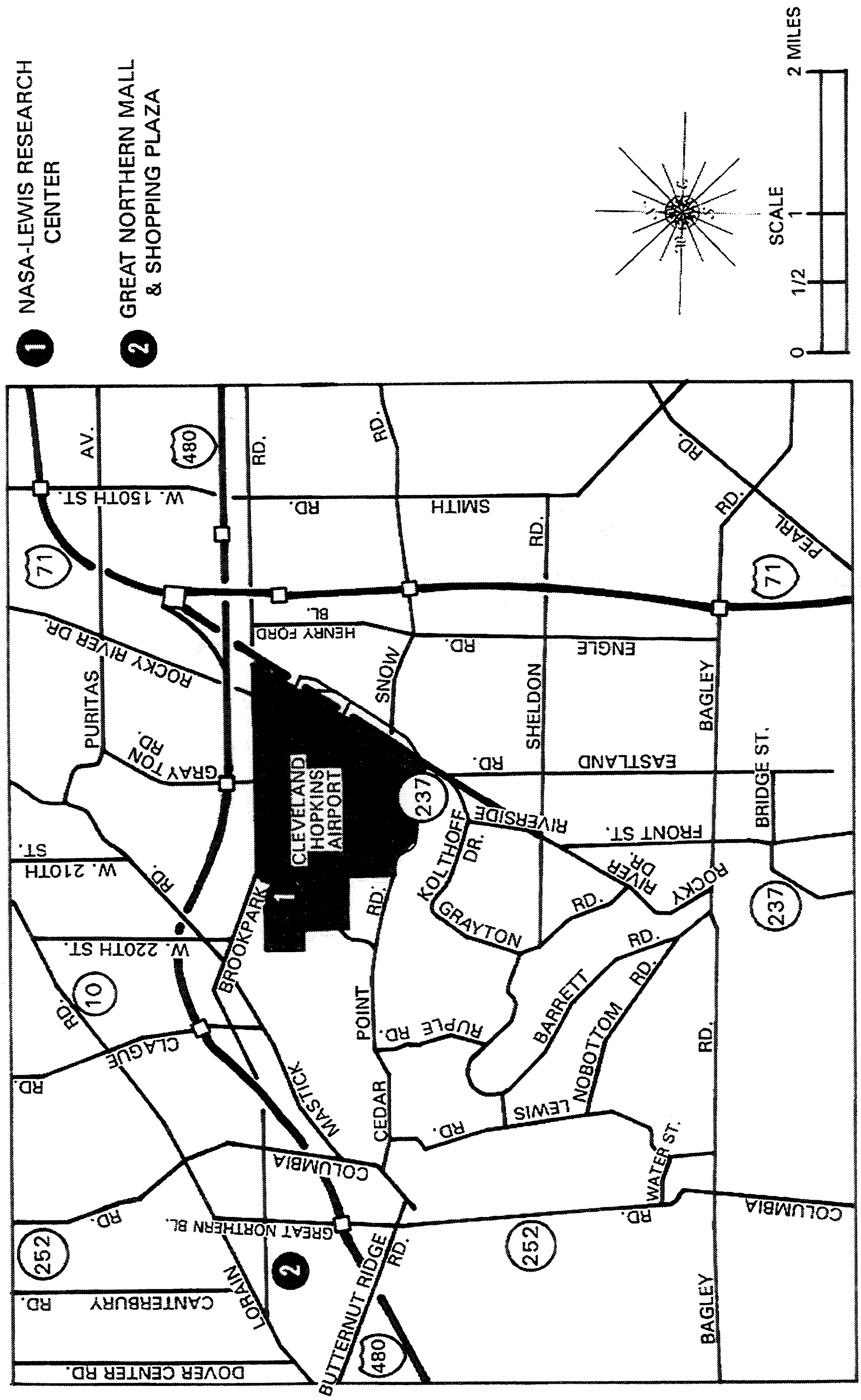


Figure 7 - Local Area Map

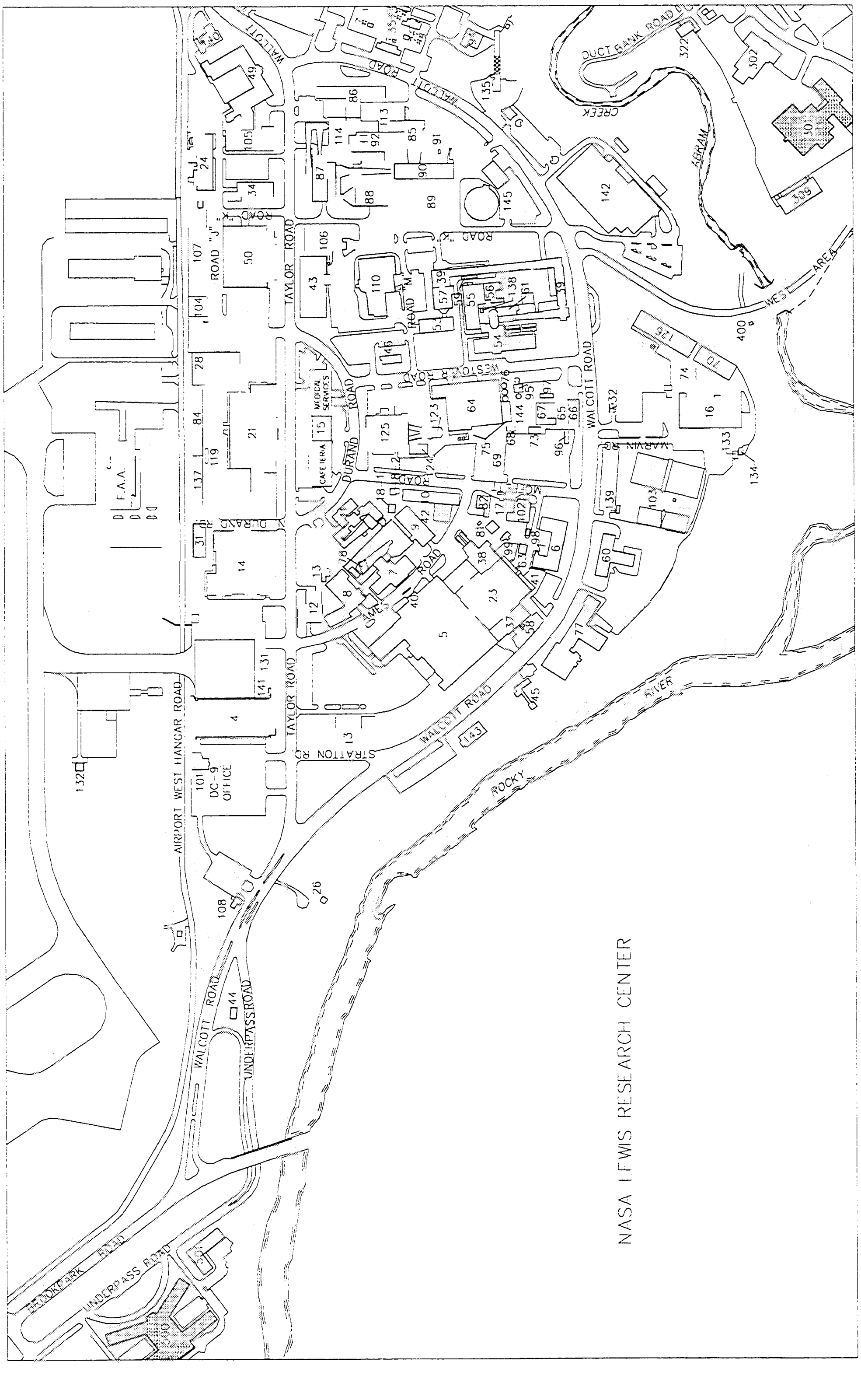


Figure 8 - Lewis Research Center Map

3.2. Test Personnel Data

All personnel manifested to fly on the DC-9 reduced-gravity aircraft at Lewis shall meet the following criteria for both medical and physiological training as a minimum.

Personnel eligible to fly are those who are directly involved in approved investigations. NASA, military, and contractor personnel must have as a minimum proof of a current Federal Aviation Administration Class III Aviation physical, other aeromedical physicals must be evaluated by the Lewis Office of Occupational Medicine Services (see section 3.2.1).

All personnel are required to wear approved flight suits during the flight. Flight suits are provided by the Lewis Aircraft Operations Office. Upon completion of the week of flying all flight suits must be returned to the Lewis Aircraft Operations Office, Personnel Equipment Custodian. It is recommended that the researchers wear clean white-soled footwear (tennis shoes). If not, researchers will be provided white clean room booties to wear while on the aircraft. Only those personnel (test directors) who handle free-floating research hardware are required to wear safety shoes.

3.2.1. Medical Requirements

All personnel shall provide the results of a current Federal Aviation Administration (FAA) Class III Aviation physical (see Appendix E) or NASA equivalent as a minimum. NASA and military personnel may obtain the FAA Class III Aviation physical at the nearest NASA or military medical facility. NASA employees assigned to Lewis may obtain the FAA Class III Aviation physical through the Lewis Occupational Medicine Services Clinic in Building 15. The FAA Class III aviation physical is good for two years.

Those contractors and researchers working under contract or grant to NASA may also obtain their FAA Class III Aviation physical from the Lewis Occupational Medicine Services Clinic. Those contractors and researchers not located at Lewis must pay for the cost of travel to Lewis for this physical.

Persons who choose to obtain the FAA Class III Aviation physical from an aeromedical examiner other than a NASA or military physician will be responsible for any cost incurred. Appendix E lists the requirements of the FAA Class III Aviation physical. FAA form 8500-8 must be filled out for the FAA Class III Aviation physical (Attachment E1 and E2). Results of physical must be sent or faxed to the Lewis Occupational Medicine Services (FAX 216/433-6529).

Persons with an aeromedical physical other than the FAA Class III Aviation or NASA equivalent must submit the results of the physical to the Medical Director at Lewis Research Center for approval.

Results of physicals must be sent to the following address at least **four weeks** prior to the flight date:

NASA Lewis Research Center
Occupational Medicine Services Clinic
MS 15-5
21000 Brookpark Road
Cleveland, OH 44135

The Medical Director of the Lewis Occupational Medicine Services Clinic is the final approval authority on whether or not a person is physically qualified to fly on the DC-9 reduced-gravity aircraft. If a physician has any questions, he or she may contact the Lewis Occupational Medicine Services Clinic at 216/433-5841.

3.2.2. Physiological Training Requirements

Crew members (i.e., pilots, flight test engineers, and test directors) of the DC-9 reduced-gravity aircraft and researchers who fly on a repetitive basis will be required to attended formal physiological training once. Personnel of the DC-9 Reduced-Gravity Office will schedule those persons that require physiological training. All persons flying on the DC-9 reduced-gravity aircraft will be required to view annually a video tape dealing with physiological effects.

3.2.3. Medical and Physiological Documentation

All medical records for persons flying aboard the DC-9 reduced-gravity aircraft will be kept on file at the Occupational Medicine Services Clinic (Building 15) at Lewis Research Center. Persons obtaining a physical from other than the Lewis Research Center's Occupational Medicine Services Clinic must send their records to the address in Section 3.2.1. and request that the flight physical memo be sent to the Lewis Aircraft Operations Office. The Aircraft Operations Office is required to have on file verification of current flight physical and physiological training for all persons participating in Lewis flight activities.

Those persons required to complete physiological training must send a copy of AF Form 1274 or JSC Form 124C to:

NASA - Lewis Research Center
Aircraft Operations Office
M.S. 4-8
21000 Brookpark Road
Cleveland, OH 44135

3.2.4. Travel Orders

All personnel flying on Lewis aircraft are required to have travel orders clearing them to fly on NASA aircraft. These travel orders are kept on file in the Aircraft Operations Office. NASA personnel will have regular travel orders and contractor personnel will have invitational orders.

Non-Lewis personnel whose NASA point of contact is located at another NASA center must provide the following information to the DC-9 Reduced-Gravity Office **four weeks** prior to flight in order to obtain travel orders.

Full name
Telephone number (work) and (home)
Social Security number
Address (work)
NASA point of contact & telephone number
Contract or grant number

3.2.5. DC-9 Safety Training

All personnel flying on the DC-9 reduced-gravity aircraft shall view, prior to their first flight and annually thereafter, a video describing the safety features of the DC-9 aircraft and hangar ground safety.

3.2.6. Visitors

3.2.6.1. U. S. Citizens

For U. S. citizens contact the DC-9 Reduced-Gravity Office one week prior to the arrival date. Provide name, company/university and Social Security Number.

U.S. citizens working for a company or corporation headquartered outside the United States will be treated as international visitors and must also complete a Non-US Citizen Access Request, NASA C-216 form (same procedure as citizens of another country attending school in the United States). People in this category are listed as "foreign representatives." .

3.2.6.2. International Visitors

International visitors must provide their respective embassies in Washington, DC, with the purposes, points of contact, and dates of their visits to Lewis. (The DC-9 Reduced-Gravity Office will supply the name of the person to be listed as the point of contact.) The embassies must receive the request for access at least **one month** prior to the actual visit; the embassies in turn will receive a confirmation from NASA Headquarters' International Planning and Programs Office when the visit has been approved. NASA Headquarters will also send the proper authorization to Lewis. International visitors must bring their passports and complete a NASA C-906 at the Lewis main gate on the first day of a visit. International visitors must carry their passports with them at all times.

Citizens of another country attending school in the United States (passport or visa status) must have NASA C-216 forms filled out by their NASA sponsors. Each sponsor and his or her division chief must sign the form; additionally, if a long-term visit (more than one week) is planned, the sponsor's directorate head must sign. The form should be sent to the Lewis Security Branch (Attention: International Visitors), MS 21-5. The form will then be sent to NASA Headquarters for their approval cycle. This process takes about a month to complete.

Persons who have a Permanent Resident Alien Card ("green card") may receive their badges directly at the Lewis main gate upon presentation of the original green card. The stamp in the passport is not sufficient; the original green card is required.

When international visitors arrive at the Lewis Main Gate, they will be required to fill out a five year history of residence and employment, NASA C-906. Passports are required. Upon completion of your visit to the Lewis Research Center, all international visitor badges **must** be returned to the Main Gate upon leaving.

3.2.7. Accident and Life Insurance Notification

All manifested DC-9 reduced-gravity personnel must be aware that the Lewis Research Center does not operate the DC-9 aircraft as a regularly scheduled common carrier. Most life and accident insurance policies cover only persons who fly on regularly scheduled airlines and do not cover persons involved in a research aircraft accident. Therefore, some life and accident policies may not cover a DC-9 reduced-gravity aircraft accident. Any person manifested to board the DC-9 reduced-gravity aircraft should determine before boarding whether his or her personal life or accident insurance provides coverage under such conditions.

3.3. User's Time-Line Summary

A user's checklist is provided in Appendix F to assist researchers in submitting the required documentation in a timely manner. A summarized time line is provided below.

Number	Time prior to flight	Activity
1	6 to 9 months	Make initial inquiry about the feasibility of flying an experiment on the DC-9 (See Section 3.1.1).
2	6 months	Submit formal test request if you are a new DC-9 aircraft user or if you have flown before but are flying a new experiment. (See Section 3.1.2).
3	3 months	Submit initial test request. (See Section 3.1.3).
4	6 weeks	Imaging services support (See Section 2.2)
5	4 weeks	Submit four copies of the experiment safety documentation (See Section 4).
6	4 weeks	International visitors (See Section 3.2.6.2)
7	4 weeks	Submit test personnel data (medical, physiological, and travel orders. (See Sections 3.2.1, to 3.2.2, and 3.2.4)
8	4 weeks	Compressed gas bottle request
9	1 week	Submit visitor request if a U.S. citizen (See Section 3.2.6.1).
10	4 working days	All new and modified research hardware arrives at DC-9 Reduced-Gravity Office (Building 101)
11	1 day	Attend test readiness review (See Section 4.3)

4. SAFETY POLICY

The Lewis DC-9 reduced-gravity aircraft is operated in accordance with established NASA safety procedures shown in the NASA Safety Policy and Requirements Document (NHB-1700.1 (Vol. 1-B)) and the Lewis Safety Manual (TM-104438, current revision). A multistage review and approval procedure consistent with both NASA and Lewis policies has been developed to ensure flight safety. The review process is coordinated by the Lewis DC-9 Reduced-Gravity Office.

4.1. Lewis Research Center Requirements

4.1.1. General

The test developer must meet and comply with all safety requirements of the providing NASA center, the NASA Safety Policy and Requirements Document (NHB 1700.1 (Vol. 1-B)), and the Lewis Safety Manual (TM-104438).

All test developers should prepare a hazard analysis using the latest version of Lewis Product Assurance Instruction (PAI) #220, Hazard Analysis Preparation (appendix B), for all hazard conditions relating to their research hardware and submit it as directed in Section 4.2 of this document.

4.1.2. Lewis Safety Permit

The researcher must submit the experiment safety documentation (Section 4.2) to the DC-9 Reduced-Gravity Office no later than four weeks before flight. Failure to submit safety documentation four weeks prior to the flight date will result in the rescheduling of experiment. The DC-9 Reduced-Gravity Office will apply for a safety permit in accordance with the Lewis Safety Manual (NASA TM-104438, Chapter 1, Paragraph 1.5). A safety permit is issued by the Lewis Area 1 Safety Committee and Air Worthiness Review Panel following a successful review of the safety permit requirements. Researcher's hardware that currently hold an approved safety permit and then is modified, must resubmit to the DC-9 Reduced-Gravity Office the experiment safety documentation explaining all changes made to the research hardware. The Lewis Area 1 Safety Committee and Air Worthiness Review Panel will then determine whether or not the current safety permit is still valid or issue a new permit.

4.2. Experiment Engineering and Safety Documentation

Five copies of the experiment safety documentation must be submitted to the DC-9 Reduced-Gravity Office not later than **four weeks** prior to flight.

The experiment safety documentation shall include the following:

1. Title page containing program or experiment title, date, author's name, telephone number, FAX number and e-mail address

2. Table of contents listing what is in the documentation

3. Objectives stating the goals of the program

4. Description of system hardware that will be used in the experiment

5. Test procedures checklist for experiment operation and emergency procedures checklist

6. Test matrix
   a. Number of flights and trajectories required
   b. Parabola requirements (time line and desired gravity level (0, 1/10, 1/3, 1/6 or 1/2)

7. Mechanical documentation
   a. Mechanical drawings
   b. Flow system schematics
   c. Structural analysis
   d. Hydrostatic certification of pressure vessels

8. Electrical documentation
   a. Electrical wiring schematics showing fuse protection and wire sizes
   b. Electrical load analysis (current draw of each component)

9. Hazards analysis
   a. Standard hazard analyses and risk assessment as formatted in Appendix B per Attachment 3.2.3
   b. Material safety data sheets for any hazardous chemicals
   c. Cabin concentration analysis assuming all chemicals or reaction (e.g., combustion) products are accidentally released into the DC-9 cabin (cabin volume is 4700 ft^3)

10. Experiment hardware layout showing all equipment and gas bottle racks
    a. Bolt down pattern
    b. Electrical connectors
    c. Interconnections between separate test articles

11. Test support requirements
    a. Bottle rack
    b. Gas bottles
    c. Documentary and scientific imaging requirements
    d. Overboard vent

12. Proposed manifest listing the researchers who will be operating the experiment on the aircraft.

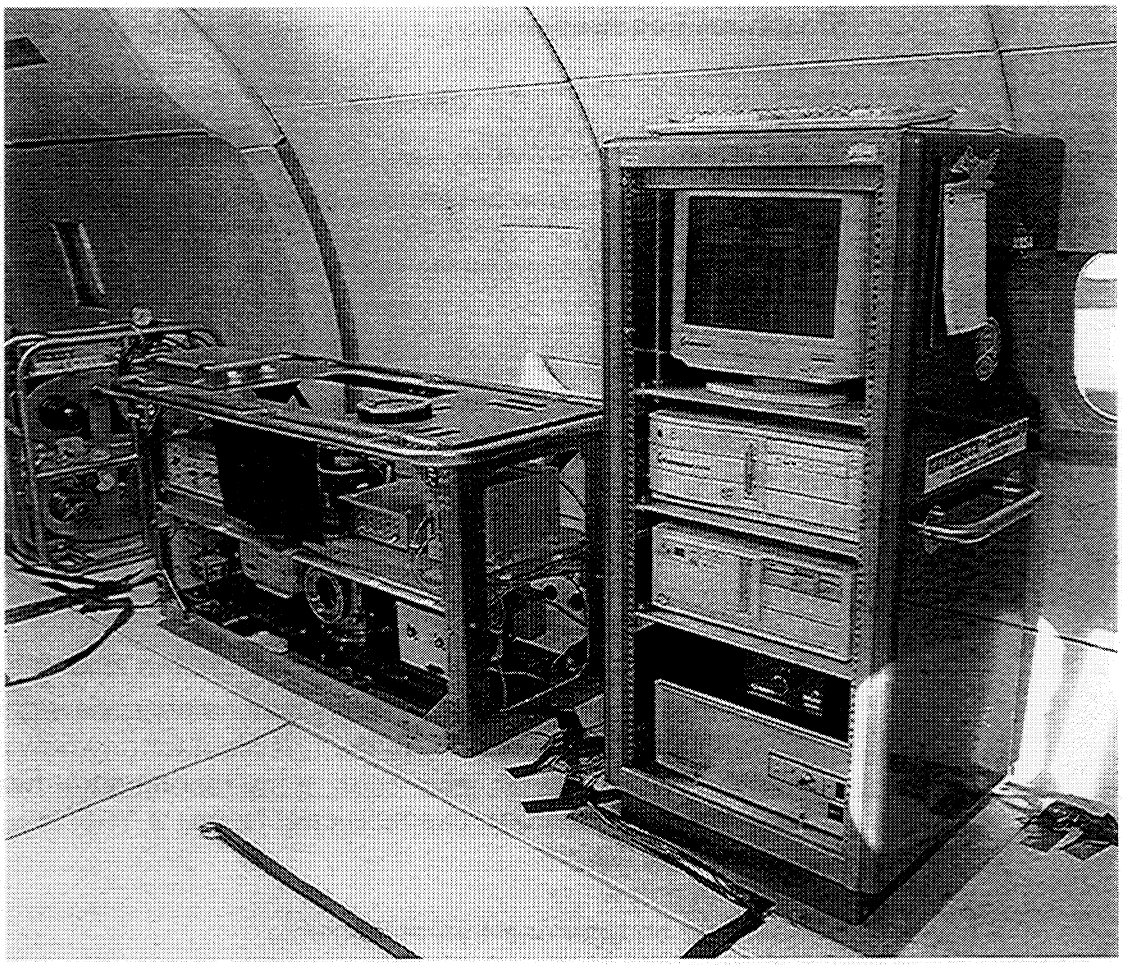
4.3. Test Readiness Review

The test readiness review (TRR) is the final safety review prior to flight and is conducted one day prior to the first flight for any new or modified experiment. It includes an inspection of the research hardware and final review of the hardware installation on the DC-9. A TRR is required for all research hardware.

The TRR will be attended by the following:

1. Aircraft operations representative
2. DC-9 test directors
3. Aircraft maintenance representative
4. Lewis Area 1 Safety Committee representative(s)
5. Test researcher (experiment operator)

The TRR officials will **approve, approve pending corrections indicated,** or **not approve** the experiment for flight. A unanimous decision is required for flight approval. Tests that have not been approved may be scheduled for a subsequent review when the deficiencies have been corrected. Experiments that have been approved pending corrections indicated do not require another TRR; however, a test director must verify that corrections have been made before the research hardware will be loaded onto the aircraft. An example of the TRR certificate form is included in Appendix C.



University of Colorado's Ignition and Combustion of Bulk Metals Experiment Hardware

5. RESEARCH HARDWARE DESIGN AND OPERATIONAL REQUIREMENTS

Research hardware intended for use in flight must conform to the requirements stated below. These requirements are separate from those of the providing center's safety organizations. If a conflict occurs, the most stringent requirement will be used. All calculations and certifications required in this section should be included in the experiment safety documentation described in Section 4.2. Researchers are encouraged to contact the DC-9 Reduced-Gravity Office for assistance in the design and fabrication of their experiments.

5.1. Structural Requirements

All research hardware must be constructed to withstand the following loads in the takeoff-and-landing configuration:

1. Forward, 9 g's
2. Aft, 1.5 g's
3. Lateral, 3 g's
4. Up, 4.5 g's
5. Down, 7.5 g's

Structural calculations for the take off-and-landing configuration should be based on the yield strength of the material. The in-flight test configuration should be designed for a possible 2.5-g downward force at maneuver entry and exit. Free-floating research hardware should be designed for a possible 2.5-g force from any direction due to possible recovery on an end, side, or top after a maneuver.

Each structural analysis must include, as a minimum, the following:

1. Structural drawings or diagrams
2. Stress calculations (in table form, including margin/or factor of safety and at least one example calculation)
3. Component weights
4. Material properties
5. Fastener and materials identification

5.1.1. Fasteners

Fasteners used to assemble hardware for flight on board the DC-9 aircraft must be of an identifiable grade. The following grades of fasteners are preferred; AN, MS, NAS, or SAE grade 5 or better conforming to SAE J429 specification. The fasteners should also be installed with some type of locking mechanism to prevent them from vibrating loose. Preferred locking mechanisms are self-locking nuts, safety wire, locking thread inserts or lock washers. Obviously, the fastener and locking mechanism requirements cannot be met in all conditions, such as the assembly of small electronic components, but the requirements should be followed wherever possible.

5.1.2. Hardware Handling Recommendations

To aid in handling and moving research hardware on the DC-9 aircraft, research hardware developers should keep the following in mind:

1. All research hardware should have handholds that are placed to ensure compliance with critical safe lifting standards (personnel

and equipment) and required ergonomic practices. For those hardware packages that will be free-floating the requirements of section 5.6 should be followed.

2. For all research hardware the centers of gravity and weight should be distinctly marked and positioned for ease of reading.

3. For those research hardware packages that exceed the allowable two-person lift capability (as defined by the Safety Assurance Office during their review of the safety permit request), a mechanical or power lift shall be required to aid in the movement of the research hardware. Hoist or lift points shall be provided and clearly marked on the hardware.

4. Experiment base plates should be clean and free of protruding nuts, bolts or screws. Also, base plate corners should be rounded to a radius of at least 0.5" and sharp corners should be eliminated. These steps, if followed, will help prolong the life of the aircraft floor padding.

5.2. Pressure Vessel Certification

Any closed or sealed system or component flown aboard the aircraft is considered a pressure vessel regardless of the pressure. All pressure vessels and pressurized systems used in the DC-9 reduced-gravity aircraft (both flight equipment and supporting ground equipment) shall be certified as safe to operate before use and shall be recertified periodically if reused. This certification verifies that the pressure vessel or system has been inspected by a pressure system engineer, that relief valves in the system are set and sized properly and are at the appropriate locations, that all pressure gauges are calibrated, and that appropriate proof pressure tests were performed.

Each pressure vessel and pressurized system shall be designed to four times the maximum allowable working pressure (MAWP), fabricated, and certified in accordance with applicable national consensus codes, such as the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code or other codes acceptable to the NASA Lewis Pressure Systems Manager and with the requirements of the Lewis Safety Manual, Chapter 7. The test developer is responsible for providing the documentation necessary to prove the certification of the pressure vessels and pressurized systems. This documentation will be reviewed by the DC-9 Reduced-Gravity Office and by the Lewis Area 1 Safety Committee.

The following is a recommended outline for pressure vessel certification as required in the experiment safety documentation:

1. System drawing or sketch

2. Component identification data:

   a. Relief devices - Set pressure, manufacturer, model number, flow coefficient (Cv) and system component number must be given for of all relief devices. Each valve should be tagged to indicate its set pressure.

   b. Components (valves, filters, regulators, check valves, etc.) - Manufacturer, model number, pressure rating, and system component number must be given for all components. Regulators should be tagged with a certification verification, and all pressure gauges should be calibrated and labeled as such.

   c. Flexible hoses - Pressure rating, size, and system component number must be given for all flexible hoses. (See Lewis Safety Manual, Chapter 23.)

   d. Pipe and tubing - Material, size, and schedule or thickness must be given for all pipes and tubing.

   e. Pressure vessels

      (1) Drawings or specifications that as a minimum specify MAWP, material thickness, material specification, head and shell geometry, and weld joint geometry.

      (2) Serial number or unique identifying number. (Note: If the vessel is ASME or Department of Transportation (DOT) certified, nameplate or stamped data will fulfill the requirements of (1) and (2) above.)

      (3) Certification tests

         (a) Pressure vessels: All pressure vessels require proof-pressure testing. Hydrostatic testing at 1.5 MAWP is preferred. Pneumostatic testing at 1.25 MAWP may be performed, except on DOT vessels, which **must** be hydrostatically tested at 5-year or 10-year intervals depending on the DOT certification requirement.

         (b) Relief valves: All relief valves require set-pressure testing. Set pressure of the relief valve in no case shall exceed the MAWP of the system.

         (c) Flexible hoses: All flexible hoses require proof-pressure testing. The only acceptable method of testing flexible hoses is a hydrostatic test at 1.5 MAWP.

(d) Systems piping: All systems piping requires proof-pressure testing. Hydrostatic testing at 1.5 MAWP is preferred, but pneumostatic testing at 1.25 MAWP may be performed. (Note: All pressure testing shall be in accordance with the Lewis Pressure Testing Handbook.)

(e) Records: A documentation file shall be provided for each pressure system. The documentation requirements are defined in the Lewis Pressure Vessel/System Recertification Handbook. (See Appendix G).

5.3. Electrical Load Analysis Information

Experiment wiring and interconnect cabling must be fabricated and installed in accordance with the National Electrical Code (NEC) at a minimum. FAA Advisory Circular (AC) No. 43.13-1A/2A, U.S. Air Force Technical Order (T.O.) 1-1A-14, and MIL-W-5088L are recommended guidelines covering wiring and installation practices for aircraft installations.

Each piece of research hardware must be adequately grounded and self-protected with an incorporated circuit breaker or other current-limiting device to protect against electrical shorts. Normal aircraft vibration, high humidity, handling, and higher than 1-g loads should be considered in connector and wiring selection.

It is strongly recommended that standard two or three prong plugs are replaced with Cannon plugs. See Section 2.1.7. If standard plugs are used, they must be secured to prevent them from working loose.

A load analysis of the research hardware must be completed. The load analysis should detail the current draw of each component. A summary of current draw for 28 V dc; 115 V ac, 60 Hz; and 115 V ac, 400 Hz should also be completed.

5.4. Aircraft Floor Loading

The following maximum floor loading should be considered in the design of the research hardware:

1. Maximum load density is 200 lb/ft^2.
2. Loads above these limits must have shoring underneath (e.g., 3/4-in. plywood sheets) to spread the load over a sufficient area.

3. Rigid test fixtures must have a flexible joint every 10 ft to avoid interference with the normal flexure of the DC-9.

5.5. Equipment Mounting

The allowable loads applied to the tie down points after considering the flight loads (such as 9 g's forward) that the equipment may experience must not exceed the maximum allowable load of the tie down point. Most equipment will apply both horizontal and vertical forces to the tie down point. The vectored sum of these two forces must not exceed the allowable load of the tie down point.

The maximum allowable load of each tie down point is 2500 lb. (ultimate reaction load). The restriction on this is that no two 2500 lb. loads may be located adjacent to each other on the same bar, except for the center two tie-down points.

The maximum allowable load on the two outboard adjacent tie-down points is 2000 lb. (ultimate reaction load).

The maximum allowable load on the two inboard adjacent tie-down points is 1750 lb. (ultimate reaction load).

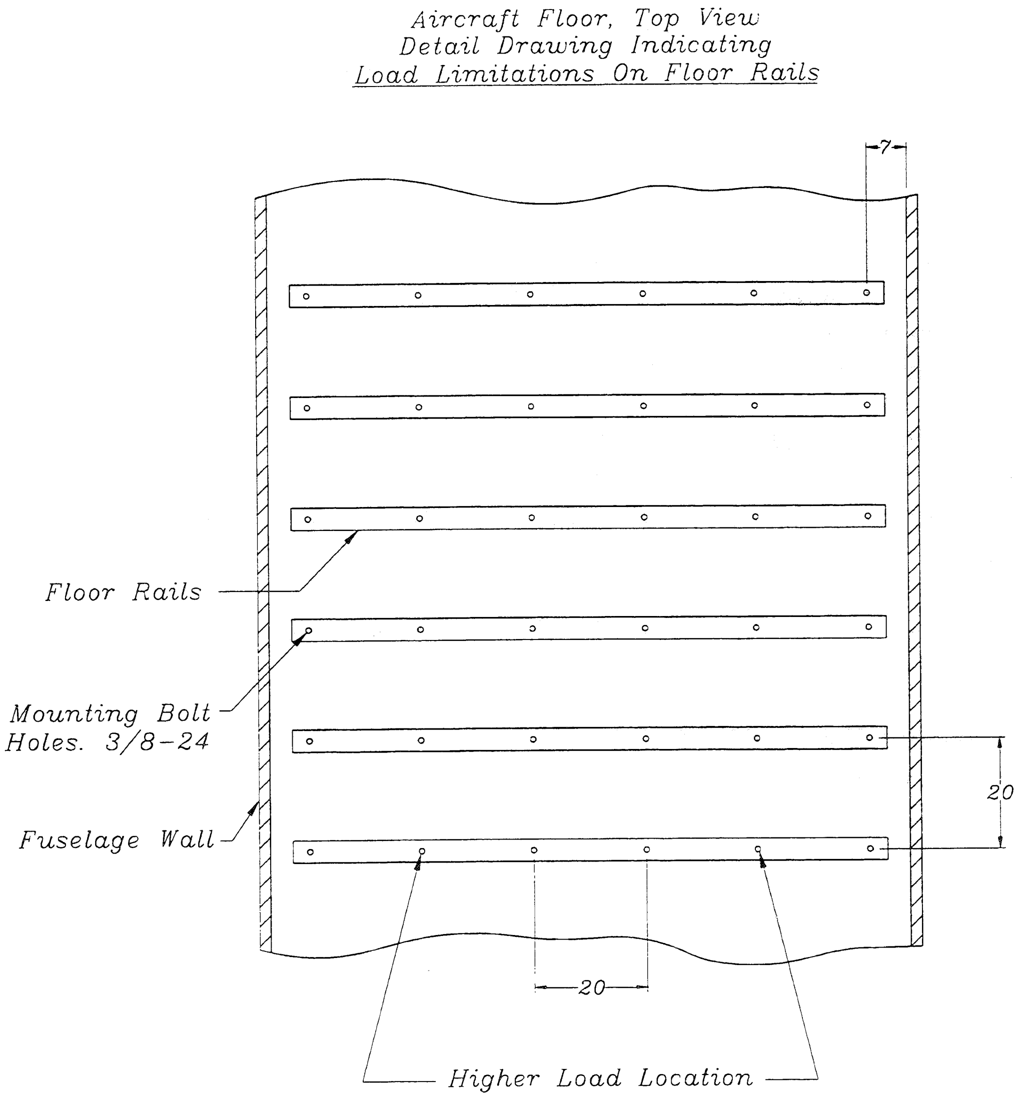
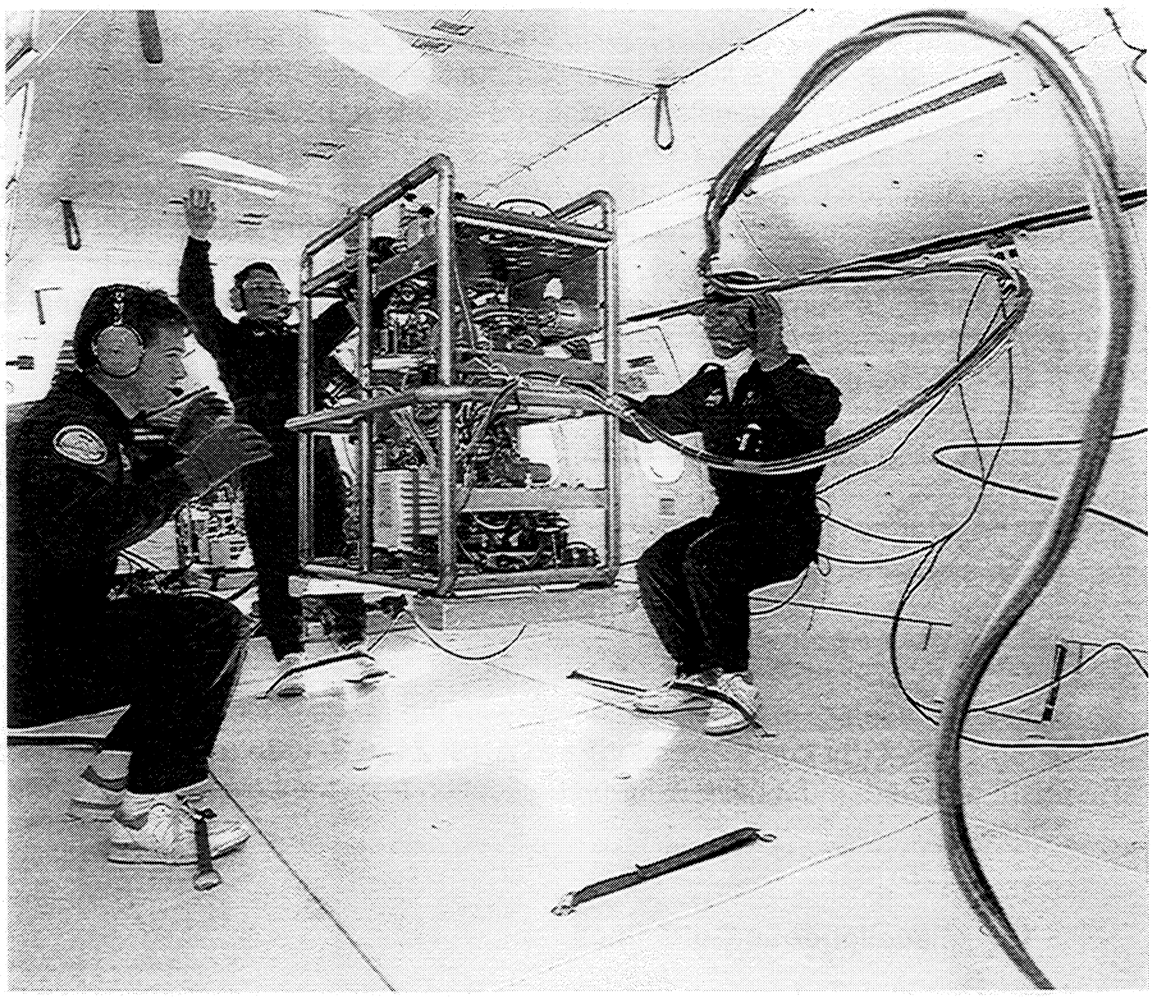


Figure 9 - Location of Tiedown points

Higher Load Location:

The maximum allowable load at the higher load location show in Figure 9 is 5000 lb. (ultimate reaction load) with the restriction that no other loads be attached to the same bar.

All research hardware should be mounted on base plates with 1/2-in. to 5/8-in. holes drilled to match the 20-in. (on center) grid pattern on the floor of the DC-9 as shown in figure 9. All mounting bolts used to secure the experiment to the floor of the DC-9 will be supplied by the Lewis Aircraft Operations Office.



Jet Propulsion Laboratory's Helium Fluid Dynamics Free-Float Experiment

5.6. Free-Floating Packages

Perturbations of the airplane can cause small "g" forces during a zero-gravity maneuver. If precise zero-gravity is required, the research package can be free-floated inside the cabin, minimizing contact with the walls, ceiling, or floor of the DC-9. Due to aircraft structural limits, free float packages cannot weigh more than 400 lbs. To provide the maximum free-float time, the package to be floated should be as compact as possible. If an umbilical is used between the floating package and tied-down support equipment, it should be at least 30 ft long to allow the package to drift freely. Handles the length of the longitudinal axis of the free-floating package should be mounted 18 in. above the package floor line and be constructed out of 1-in. to 1 1/4-in.-diameter tubing.

5.7. Hazardous Materials

If possible, avoid hazardous liquids and gases, including high-pressure, toxic, corrosive, or explosive fluids; toxic combustion byproducts; and flammable materials. If such materials are required for a test, proper containment must be provided. Early discussions with the DC-9 Reduced-Gravity Office and the Lewis Safety Assurance Office on proper use and containment of proposed hazardous materials may prevent delays in getting approval for the use of such materials. If such materials are necessary, provisions for dumping and purging in flight may be required. A current material safety data sheet (MSDS) must be supplied for each hazardous material. Proper disposal of hazardous materials after the flight testing will be the responsibility of the researcher and operator.

5.8. Cabin Air Exchange Rate

For hazardous material release calculations, the cabin volume is 4700 ft^3. The cabin air exchange rate is one cabin volume per 3.5 min.

5.9. Laser Applications

Any application of lasers must comply with the requirements of ANSI Z136.1-1993, (or current version) and ANSI Z136.2-1988 (or current version) Also, all lasers must have written certification from the Lewis Laser Safety Officer.

5.10. Miscellaneous Guidelines

1. Avoid sharp edges and corners on all research hardware. All exposed edges and corners, sharp or not, must be padded.

2. Do not use liquid electrolyte batteries of any type (battery circuits may require analysis by battery experts to avoid shock, shorts, or overheating). Leak proof design batteries which use an absorbed electrolyte system are preferred. This style of batteries fit into the gell-cell category and can be operated in any orientation necessary for reduced-gravity flights.

3. Avoid flammable materials in research hardware construction, including shrouds and coverings. Do not use flammable materials, such as plywood, in constructing any test hardware containing electrical or heat- or spark-producing equipment. (Exception: use of plywood for weight distribution). Coordinate any other arrangement with the DC-9 Reduced-Gravity Office.

4. Consider equipment or procedural failures. Provide backups or work-arounds to prevent such failures from causing hazards to personnel or the aircraft.

5. Consider the activities to be performed during the 2-g and zero-gravity portions of the parabolic maneuvers. Structure activities so as to minimize movement during the high-gravity portions. Consider the need for handholds during the zero-g portions of the flight. (Keep in mind that holding onto the experiment (rig) will cause g-jitter. It may be better to be strapped to the floor.) Velcro straps are provided on the aircraft.

6. Realize that experiments involving radioactive materials and or lasers must be handled on an individual basis, with the Lewis Radiation Safety Officer concurring on the safety analysis (through concurrence on the safety permit request).

7. Cover any glass monitor screens with Lexan or Plexiglass at least 3/16 in. thick.

8. Experiments containing liquids in any amount must show how the liquid will be contained in the event of a spill or leak.

9. The test director must be informed of any hardware that is removed from the aircraft and if any servicing of gases and fluids is going to take place in between flights.

10. Glass vials can be shrink-wrapped in plastic to contain glass in case of breakage.

11. Researchers with new hardware that has not yet flown on the DC-9 can send a video (VHS) to the DC-9 Reduced-Gravity Office prior to shipping their hardware to Lewis. This will allow the DC-9 staff to see the hardware and be able to make comments prior to shipment.

6. TEST OPERATIONS

6.1. Preflight Phase

The research hardware should be received at Lewis at least by the Friday before the intended week of flying. If the research hardware will require extensive buildup, inspection, and testing prior to the TRR , researchers should plan accordingly. The address to use for shipping is as follows:

NASA Lewis Research Center
Reduced-Gravity Office
MS 101-1 Building 101
21000 Brookpark Road
Cleveland, Ohio 44135

The buildup and checkout of research hardware is solely the responsibility of the researcher unless other arrangements are made in advance.

The TRR will be conducted in the high bay of the DC-9 Reduced-Gravity Office (Building 101) the Monday morning the week of flying. Research hardware, personnel, procedures, and documentation will be examined as indicated in Section 4.3. A simulated ground run may be required during this review whereby the researcher will demonstrate normal and contingency in-flight procedures. After approval for flight by the TRR the test hardware will be loaded on the aircraft. All research hardware must be installed in the DC-9 by approved personnel. Previously approved research hardware does not need to be reviewed unless it has been modified (which necessitates a revised safety permit request), although pressure vessels and systems will be periodically inspected. A list of modifications to previously flown research hardware and changes to test procedures must be provided.

A safety video will be shown to all flight personnel who have not previously flown on the DC-9 aircraft or to those individuals who have not viewed the video in the previous 12 months. The video will cover the emergency equipment on board the DC-9 and the emergency egress procedures. This video will be viewed annually. Flight suits will be issued on Monday morning the week of flying and can be found in the Conference Room (Room 108).

6.2. Flight Phase

All personnel on board the DC-9 aircraft shall be under the direction of the aircraft flight crew and test directors, for both normal and emergency conditions and during test operations. The lead test director is in charge of all test activities, and the aircraft commander is the final authority for all operations from boarding through deplaning. Strict adherence to the authority of these personnel will be rigidly enforced. Any deviation from the flight-test plan must be discussed with a test director before implementation.

6.3. Post-flight Phase

A post-flight debriefing will be held immediately after landing to review any problems that occurred during the flight and to discuss possible alterations to the test hardware or procedures.

Upon completion of the flight phase, the user will off-load the research hardware and prepare it for shipment. The user is responsible for ensuring that all hardware and materials used in his or her test, including compressed gas cylinders, chemicals, packing, and crating, are removed promptly from the DC-9 Reduced-Gravity Office (Building 101) to make room for incoming users.

The following is an example of a typical week of reduced-gravity missions:

Friday before week of flying

All new and modified research hardware that has not yet flown on the DC-9, both from Lewis and coming to Lewis from other locations, should arrive at the Reduced-Gravity Office (Building 101) not later than the Friday before the week of flying.

Aircraft Maintenance Quality Assurance is required to inspect all new and modified research hardware prior to installation on the DC-9.

If a researcher would like to ship their research hardware to Lewis earlier than Friday, they need to contact the DC-9 Reduced-Gravity Office to inquire about storage space availability.

Monday - week of flying

All unmodified experiments (previously flown experiments with a current safety permit) can arrive at the Reduced-Gravity Office (Building 101) not later than 8:00 a.m. Monday morning.

Research personnel are required to arrive at Lewis by Monday morning at 8:00 a.m.. However, researchers are encouraged to accompany their hardware to ensure adequate time for assembly and checkout.

All new and modified experiments must undergo a test readiness review (TRR). The TRR will be held at 9:00 a.m. Monday morning (see Section 4.3).

An aircraft-safety video will be viewed by all researchers flying who have not viewed the video during the previous 12 months.

A physiological video will be viewed by all researchers annually. Those researchers currently holding a valid altitude chamber card must provide the DC-9 Reduced-Gravity Office with the expiration date.

Research hardware and equipment is loaded onto the DC-9.

Those researchers who have requested motion sickness medication will go to the Occupational Medicine Services Clinic in Building 15 and pick up their medication.

Flights suits are issued to researchers.

Tuesday through Friday - week of flying

A preflight briefing will be held with the pilots, flight engineers, test directors, the operations project manager, and the lead researchers for each of the experiments flying. Each experiment's requirements for g-levels, number of parabolas in succession before level flight, and any other special requirements that will ensure successful data collection by the researcher will be discussed. These factors will be used to establish the mission profile that will be flown that week.

The DC-9 will be available two hours prior to flight time for researchers final preparations. (Note: The two-hour time frame will only apply when the flight time is 7:30 a.m. or 8:30 a.m. If the flight time is 9:00 a.m. or later, the DC-9 will be available to researchers at 7:00 a.m.

A typical week consists of four missions, one per day. The daily mission is normally scheduled between 7:00 a.m. and 11:00 a.m.. Each mission will be two to three hours in duration and consist of approximately 45 parabolic maneuvers. Trajectories exhibit variations in acceleration that reflect the dynamics of the flight profile and the uncertainties related to air turbulence and other flight control factors. Each parabola will include a reduced-gravity period of approximately 20 ± 5 sec. Each parabola is preceded and followed by a 1.8 to 2.0-g pull-up.

Upon landing, a post-flight briefing will be conducted. This briefing will cover the just completed mission and any changes to the mission profile that are required. The aircraft will be available for the remainder of the working day, so that researchers can prepare their experiments for the next day's flight. During the refueling operation all personnel will be required to leave the aircraft.

Friday - week of flying

Upon completion of the final mission, the DC-9 will return to Lewis, and all experiments and equipment will be unloaded. Researchers will prepare research hardware and documentation for return to their laboratories. Photographs and video are typically available 3 weeks after flying (see Section 2.2 and Appendix A)

All test developers are urged to read Appendix H for researcher's suggestions for effective use of NASA reduced-gravity aircraft.

7. FINAL COMMENTS

Communication is one of the keys to a successful test. Researchers should contact the DC-9 Reduced-Gravity Program Office early and often in the design and development process to help minimize last-minute problems. Keep in mind that no experiment hardware will fly if it cannot prove through documentation and demonstration that it is safe.

APPENDIX A

IMAGING SERVICES GUIDE

NASA Lewis will provide photographers and videographers as required for test documentation and research imaging services. The user should include a request for NASA imaging services in the experiment safety documentation (see Section 4.2.12c).

Included with the photographers are:

1. Cameras, lights, and other photographic equipment
2. Expendable supplies (film, etc.)
3. Processing and printing
4. Viewing and analysis facilities

Documentary (video and still) and scientific imaging services are available.

A.1 Documentary Imaging

A.1.1 Still photography. General events within the cabin during flight operations will be recorded by medium-format cameras, either Hasselblad (6 cm x 6 cm) or Mamiya RZ 67 (6 cm x 7 cm). These formats provide a high degree of image quality with a moderate degree of flexibility. When greater flexibility or the ability to shoot quickly is paramount, the requesters and/or the photographer may choose 35-mm format equipment. On-camera electronic flash will be used, in most instances, as the primary source of subject illumination. Upon request Digital Kodak DCS camera equipment can be utilized to produce 4-megabyte per frame color digital images.

A.1.2 Video. General video of the cabin will be recorded by three hard-mounted video cameras. Two cameras will be mounted at fore and aft positions in the cabin to provide overall coverage of the cabin environment. A third camera will be located at the midpoint of the cabin, positioned as required to support specific requests. Additional video coverage will be provided, when requested, for documenting specified research programs and for production value and public relations purposes. This coverage will consist of additional hard-mounted cameras and/or an on board videographer to cover any area of the cabin.

A.2 Scientific Imaging

Imaging for data acquisition is a specialized subset of the services offered by the Scientific Imaging Group within the Imaging Technology Center. Depending on the nature of the data to be collected, any number of imaging techniques can be employed including, but not limited to, high-speed motion picture (to 10,000 frames per second), high-speed video, standard video (VHS, S-VHS, Hi-8, and Betacam SP), time lapse, infrared, digital imaging, macro- and schlieren optics, and more.

Researchers needing these services are encouraged to consult with the Imaging Group as early into project planning and buildup as possible. This consultation will help determine in advance the quality and quantity of imaging data that can be expected and will ensure the availability of equipment and support personnel.

The topics covered in the consultation include the type of data required, the techniques necessary to obtain it, and the manner in which it will be reduced. The Imaging Technology Center is equipped to support research personnel in both the acquisition and reduction of imaging data.

APPENDIX B

HAZARD ANALYSIS GUIDELINES

The following hazard analysis guidelines were extracted from the Lewis Product Assurance Instruction (PAI) #220, Hazard Analysis Preparation, and MIL-STD-882, System Safety Program Requirements, and are targeted for experiments and systems involved with aircraft flight operations. These guidelines are intended to help the researcher define hazard analysis, identify hazards in research hardware and procedures, and prepare the hazard analysis required for the experiment safety documentation described in section 4.2 of this document. A hazard analysis is required for any hazardous condition related to the experiment or to the operation of the aircraft during the proposed experiment.

1. Purpose

1.1 To describe the correct methods, procedures, and formats necessary for the development of a hazard analysis at Lewis Research Center.

2. Scope

2.1 This procedure applies to all Lewis-prepared hazard analyses performed on spaceflight projects and the related ground support equipment.

3. General

3.1 References.

3.1.1 NHB 1700.1 (Vol. 7), NASA System Safety Handbook
3.1.2 MIL-STD-882, System Safety Program Requirements

3.2 Attachments.

3.2.1 Generic Hazard Definitions
3.2.2 Generic Hazard List
3.2.3 Risk Assessment Matrix
3.2.4 Hazard Analysis Preparation Flowchart

3.3 Definitions.

3.3.1 Hazard*:* A condition that is prerequisite to a mishap

3.3.2 Hazard Analysis*:* The evaluation and documentation of hazards and formulation of a control mechanism that can affect a facility, system, subsystem, or component

3.3.3 Mishap or Accident: An unplanned event or series of events that results in death, injury, occupational illness, or the damage or loss of equipment or property

3.3.4 Hazard severity categories: A qualitative measurement of the worst potential consequence resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, and system, subsystem, and component failure or malfunction. These categories are as follows:

1. Catastrophic - a hazardous occurrence in which the worst-case effects will cause death, disabling personnel injury, or facility or system loss

2. Critical - a hazardous occurrence in which the worst-case effects will cause severe (non-disabling) personnel injury, severe occupational illness, or major property or system damage

3. Marginal - a hazardous occurrence in which the worst-case effects could cause minor injury, minor occupational illness, or minor system damage

4. Negligible - a hazardous occurrence in which the worst-case effects could cause less than minor injury, occupational illness, or system damage

3.3.5 Hazard Frequency: the likelihood, expressed in qualitative or quantitative terms, that a hazardous event will occur

Frequent - likely to occur frequently

Probable - will occur several times in the life of an item

Occasional - likely to occur at sometime in the life of an item

Remote - unlikely but possible to occur in the life of an item

Improbable - so unlikely that it can be assumed occurrence may not be experienced

3.3.6 Risk assessment matrix (attachment 3.2.3): Hazard information is converted to risk information by evaluating the severity of the potential hazard and by evaluating the frequency probability of the hazard producing a mishap or accident. This evaluation is done by developing a matrix with hazard severity on one axis and hazard frequency on the other, with a numeric code (hazard risk index) used to represent the risk associated with each hazard.

3.3.7 Procedure: a set of sequenced actions for operating, assembling, maintaining, repairing, calibrating, testing, transporting, handling, installing, or removing a space flight assembly or system

3.3.8 Preliminary hazard analysis (PHA): usually the initial hazard analysis that begins during the conceptual or requirements definition phase and is completed prior to the preliminary design review. The goal of the PHA is to identify and characterize possible hazards early in the design phase. It identifies known hazards such as explosion, radioactive sources, pressure vessels or lines, toxic materials, and high voltages. It specifies where each will occur, their significance in the system, and the method to be used to eliminate the hazard or control the associated risk.

3.3.9 Subsystem hazard analysis/system hazard analysis (SSHA/SHA): an analysis requiring detailed studies of hazards, identified in the PHA, at the subsystem and system level, including the interface between subsystems and the environment, or by the system operating as a whole. Results of this analysis include design recommendations, changes or controls when required, and evaluation of design compliance to contracted requirements. Often subsystem and system hazards are easily recognized and remedied by design and procedural measures or controls. These hazards are often handled by updating and expanding the PHA, with timing of the SSHA/SHA normally determined by the availability of subsystem and system design data (usually began after the preliminary design review and completed before the critical design review).

3.3.10 Operating & support hazard analysis (O&SHA): an analysis performed to identify those operating functions that may be inherently dangerous to test, maintenance, handling, transportation or operating personnel or in which human error could be hazardous to equipment or people. The O&SHA should be performed at the point in system development when sufficient data are available, after procedures have been developed. It documents and evaluates hazards resulting from the implementation of operations performed by persons and considers the planned system configuration at each phase of activity, the facility interfaces, the planned environments, the support tools or other equipment specified for use, the operation or task sequence, concurrent task effects and limitations, biotechnological factors, regulatory or contractually specified personnel safety and health requirements, and the potential for unplanned events including hazards introduced by human error. O&SHA identifies the safety requirements (or alternatives) needed to eliminate identified

3.4 Results of analysis. The completed analysis should include both general and specific recommendations for hazard mitigation for the equipment, system, or facility. These recommendations should encompass the following areas as appropriate: additional analyses, inspection or testing, increased training, possible redesign options, additional design considerations, or additional hazard controls.

3.4.1 Additional analyses, such as fault-tree analyses, event-tree analysis, and software hazard analyses, may also be performed, depending on programmatic requirements and/or desired results. Specific guidance and support in these areas can be obtained by contacting the Chief of the Safety Assurance Office.

3.5 Risk categorization. When deriving results from a hazard analysis, the analyst should specifically consider the categorization performed when completing the risk assessment matrix. Hazards identified as a high risk on the matrix should be given top priority. Similarly, hazards identified as a medium risk on the matrix should be given more attention than those with a low rating.

3.5.1 Total risk*:* Although each hazard is given either a high, medium, or low risk rating, all risk must be reviewed and accepted by project management, so that the total risk of the project can be assessed, not just the high-priority hazards.

3.5.2 Updating analysis*:* In addition, the analysis should be maintained and updated as the project advances (i.e., hazard controls put in place, procedures written, etc.) as a means of hazard tracking throughout the life of the project.

3.6 Types of analysis. The three most common types of analysis are PHA, SHA, and O&SHA. Other types are described in NHB 1700.1 (V7), NASA System Safety Handbook and MIL-STD- 882, System Safety Program Requirements. These references should be used in performing a hazard analysis.

4. Procedure

The procedure described here should be followed in conjunction with the flow chart in attachment 3.2.4 to properly complete a hazard analysis. All of the analysis inputs determined from using this instruction should be systematically compiled. Any one of numerous formats (i.e. columnar/ horizontal, narrative/vertical, or data base derived) can be used to compile data, depending on the resources and desires of the developer and/or program requirements. Specific guidance and assistance can be obtained by contacting the Chief, Safety Assurance Office.

The analysis should be developed as follows:

4.1 Analysis Developer:

4.1.1 Gather information from project engineers, such as facility, system, or subsystem like descriptions, drawings, specifications, and procedures, etc., for the item or items to be analyzed.

4.1.2 Review the generic hazard definitions (Attachment 3.2.1) for familiarization with appropriate terms.

4.1.3 Review the generic hazard list (Attachment 3.2.2) for familiarization with typical hazards that are generally found in hazard analyses.

4.1.4 Perform a walk down of any associated facilities, hardware, and/or support equipment, as applicable, for the item or items being analyzed. This walk down will familiarize the analysis developer with the configuration of the item or items being analyzed.

4.1.5 Develop a listing of all systems, subsystems, or components to be analyzed.

4.1.6 For each system, subsystem, or component, list all possible hazardous conditions that can occur as a result of the following three scenarios:

4.1.6.1 Failure of the item
4.1.6.2 Improper usage of the item
4.1.6.3 Proper usage of the item (i.e., those hazards associated with nominal operations of the system, subsystem or component).

4.1.7 For each hazardous condition, list all possible hazard causes that can result in this condition (i.e., failure, improper usage, operating environment, etc.)

4.1.8 For each hazard cause, list the initial hazard severity and frequency and the hazard risk index determined through the use of guidance provided in MIL-STD-882 and Attachment 3.2.3.

4.1.9 The following five steps will assist the analysis developer in identifying possible hazard controls for each hazard cause. Each step should be performed in the listed order of precedence for each hazard cause identified in the analysis, since numerous possible hazard controls may be identified for each hazard cause. Project engineers should be included in the performance of these steps, since they have the greatest insight into the specifics of the design and operation of the item or items being analyzed.

4.1.9.1 If a hazard cause can be eliminated by a design change, this change should be listed as a proposed hazard control.

4.1.9.2 If a hazard effect can be reduced by using a safety device (i.e., relief valve for pressure systems, fuse for electrical systems, etc.), this device and its usage should be listed as proposed hazard controls.

4.1.9.3 If a hazardous condition can be detected by using a warning device (i.e., alarm, signal light, etc.), this device and its usage should be listed as proposed hazard controls.

4.1.9.4 If a hazard effect can be countered or reduced by using a special procedure, this procedure and its method of countering or reducing the hazardous effect should be listed as proposed hazard controls.

4.1.9.5 If there are other hazard controls that could eliminate or reduce the hazardous condition, cause, or effect (i.e., changing the operating environment, etc.), they should be listed as proposed hazard controls.

4.1.10 Review the hazard analysis (the compilation of system, subsystem, and component listings; possible hazardous conditions and related causes; and effects risk identifiers and possible controls) with all appropriate project engineers. Make any revisions necessary as a result of this review.

4.1.11 Develop recommendations that will reduce the hazard risk to the system, subsystem, component, or facility. Recommendations typically emphasize those proposed hazard controls that will reduce the risk to the greatest extent. They include a combination of design changes, change of operating environments, usage of safety and warning devices, and inclusion of special procedures for the performance of hazardous operation.

4.1.12 Attach all relevant information to the hazard analysis (i.e., analysis worksheets, drawings, schematics.).

4.1.13 Include hazard analysis as part of the experiment safety documentation (see Section 4.2)

ATTACHMENT 3.2.1
GENERIC HAZARD DEFINITIONS

Collision - Item breaking loose and impacting other items. (You hit it or it hits you.) Caused by structural failure, procedural error, or inadequate handling equipment.

Contamination - Release of toxic, flammable, corrosive, condensable, or particulate matter. Caused by leakage, spillage, loose objects, abrasion, growth, or component failure.

Corrosion - Structural degradation of metallic or nonmetallic equipment. Caused by leakage of reactive material, material incompatibility, or environmental conditions.

Electrical - Personnel injury or fatality due to electrical current passing through any portions of the body. Caused by contact with energized circuit, procedural error, component failure, static discharge, or environmental conditions. Can also degrade equipment operation.

Environmental/weather - Injury or hardware damage caused by conditions such as fog, rain, sleet, snow, hail, sand, dust, wind, lightning, fungus, or bacterial growth.

Explosion - A violent release of energy due to overpressurization of some component. Over-pressurization can be caused by fire, chemical reaction, excessive temperature, component failure, or procedural error.

Fire - Rapid oxidation of combustibles. Caused when fuel and oxidizer are exposed to an ignition source. Hypergolic fuels ignite without an outside source of ignition. Usually caused by fuels being raised above their ignition temperatures in the presence of oxidizer.

Loss of habitable atmosphere - Removal or displacement of oxygen to below 19.5% by volume by whatever means.

Mechanical - Sharp edges, points, or rough surfaces; parts of body being caught or entangled in pinch-points or rotating equipment; and violation of weight limits for personnel or equipment designs. Other mechanical hazards would be unstable equipment caused by overturning or toppling, ejected parts and materials from breakage of operating equipment, and moving equipment or parts of equipment that can cause injury by impact.

Pathological - Injury to personnel caused by disease, bacteria, or micro-organisms.

Psychological - Injury to personnel from mental conflicts due to sudden noises, perceived danger, etc.

Radiation - Exposure of personnel or sensitive equipment to ionizing radiation, non-ionizing radiation, ultraviolet or infrared light, lasers, and electromagnetic or radio frequency emanation. Results can be burns to personnel, structural damage to equipment, or triggering of ordnance devices.

Temperature extremes - Injury to persons or damage to equipment due to departure of temperature from normal range. Extreme heat or cold caused by fire or cryogenics due to component failure or procedural error results in burns or structural damage.

These are the typical generic hazard characteristics that could cause personnel injury and/or damage to equipment. Each system and design should be examined to determine whether or not its design, manufacture, or operation could involve such hazards. Note that there may be other, more specific, forms of hazard potential (toxicity, implosion, outgassing, etc.) that should also be considered during the hazard analysis (see attachment 3.2.2).

ATTACHMENT 3.2.2
GENERIC HAZARD LIST

Generic Hazard		Types of Hazard
1. Collision or impact	a.	Acceleration (including gravity)
	b.	Detached equipment
	c.	Mechanical, vibration, or acoustical shock
	d.	Meteoroids or space debris
	e.	Moving or rotating equipment
2. Contamination or corrosion	a.	Chemical disassociation
	b.	Chemical replacement or combination
	c.	Moisture
	d.	Oxidation
	e.	Organic (fungus, bacteria, etc.)
	f.	Particulate
3. Electrical	a.	External shock
	b.	Internal shock
	c.	Static discharge
4. Environmental or weather	a.	Fog
	b.	Fungus or bacteria
	c.	Lightning
	d.	Precipitation (fog, rain, snow sleet, or hail)
	e.	Radiation
	f.	Sand or dust
	g.	Vacuum
	h.	Wind
	i.	Temperature extremes
5. Explosion or fire	a.	Chemical change (exothermic/endothermic)
	b.	Fuel and oxidizer in presence of pressure and ignition source
	c.	Pressure release or implosion
	d.	High heat source
6. Loss of habitable environment	a.	Contamination
	b.	High pressure
	c.	Low oxygen pressure
	d.	Low pressure
	e.	Toxicity of raw chemicals and associated by-products

		f.	Low temperature
		g.	High temperature
7.	Mechanical	a.	Sharp edges
		b.	Rotating equipment
		c.	Weight stability
		d.	Ejected part or materials
		e.	Impact or shock
8.	Pathological, psychological, or physiological	a.	Acceleration, shock, impact, or vibration
		b.	Atmospheric pressure (high, low, rapid change)
		c.	Humidity
		d.	Illness
		e.	Noise
		f.	Sharp edges
		g.	Sleep, lack of
		h.	Visibility (glare, window, or helmet fogging)
		i.	Temperature
		j.	Work load, excessive
9.	Radiation	a.	Electromagnetic
		b.	Ionizing
		c.	Thermal or Infrared
		d.	Ultraviolet
10.	Temperature extremes	a.	High
		b.	Low
		c.	Variations

ATTACHMENT 3.2.3
FLIGHT RESEARCH
RISK ASSESSMENT CODE MATRIX (MIL-STD-882)

The risk assessment matrix is based on MIL-STD-882: Generally, for a hazard to be acceptable it should merit a risk code of 10 or more. Hazards with a risk code of 6 through 9 normally require additional acceptance by the Executive Safety Board for the program or experiment to be performed. Risk codes of 5 or lower indicate unacceptable hazards.

	SEVERITY			
PROBABILITY	**I CATASTROPHIC**	**II CRITICAL**	**III MARGINAL**	**IV NEGLIGIBLE**
A) Frequent	1	3	7	13
B) Probable	2	5	9	16
C) Occasional	4	6	11	18
D) Remote	8	10	14	19
E) Improbable	12	15	17	20

SEVERITY	CATEGORY	DEFINITION
Catastrophic	I	Death or system loss
Critical	II	Severe injury, severe occupational illness, or major system damage
Marginal	III	Minor injury, minor occupational illness, or minor system damage
Negligible	IV	Less than minor injury, occupational illness, or system loss

PROBABILITY	LEVEL	DEFINITION
Frequent	A	Likely to occur frequently
Probable	B	Will occur several times in life of an item
Occasional	C	Likely to occur sometime in life of an item
Remote	D	Unlikely, but possible to occur in life of an item
Improbable	E	So unlikely it can be assumed occurrence may not be experienced

ATTACHMENT 3.2.3 (2)
Flight Research Hazard Analysis
DC-9 Reduced-Gravity Aircraft Program

Experiment Title **Date**

Hazard (Describe the event that will directly produce the injury or damage. Describe the nature and extent of the injury or damage.)

Causes (Describe the circumstances and events leading up to the hazard.)

Controls (Describe design features and procedures that will be used to reduce the hazard's probability and/or severity. List any testing that will be done to verify the controls' effectiveness.)

Risk Assessment (Assess the risk by using the MIL-STD-882 matrix (Attachment 3.2.3 (1)). Base the assessment on the controls producing the planned effects of the hazard's probability and/or severity.

Severity Category:_______ Probability Level :_______ Risk Assessment Code:_______

Analysis of Final Design	Prepared by / Date	Checked by / Date	Operations Program Mgr.Date

HAZARDS IDENTIFICATION GUIDE
RESEARCH

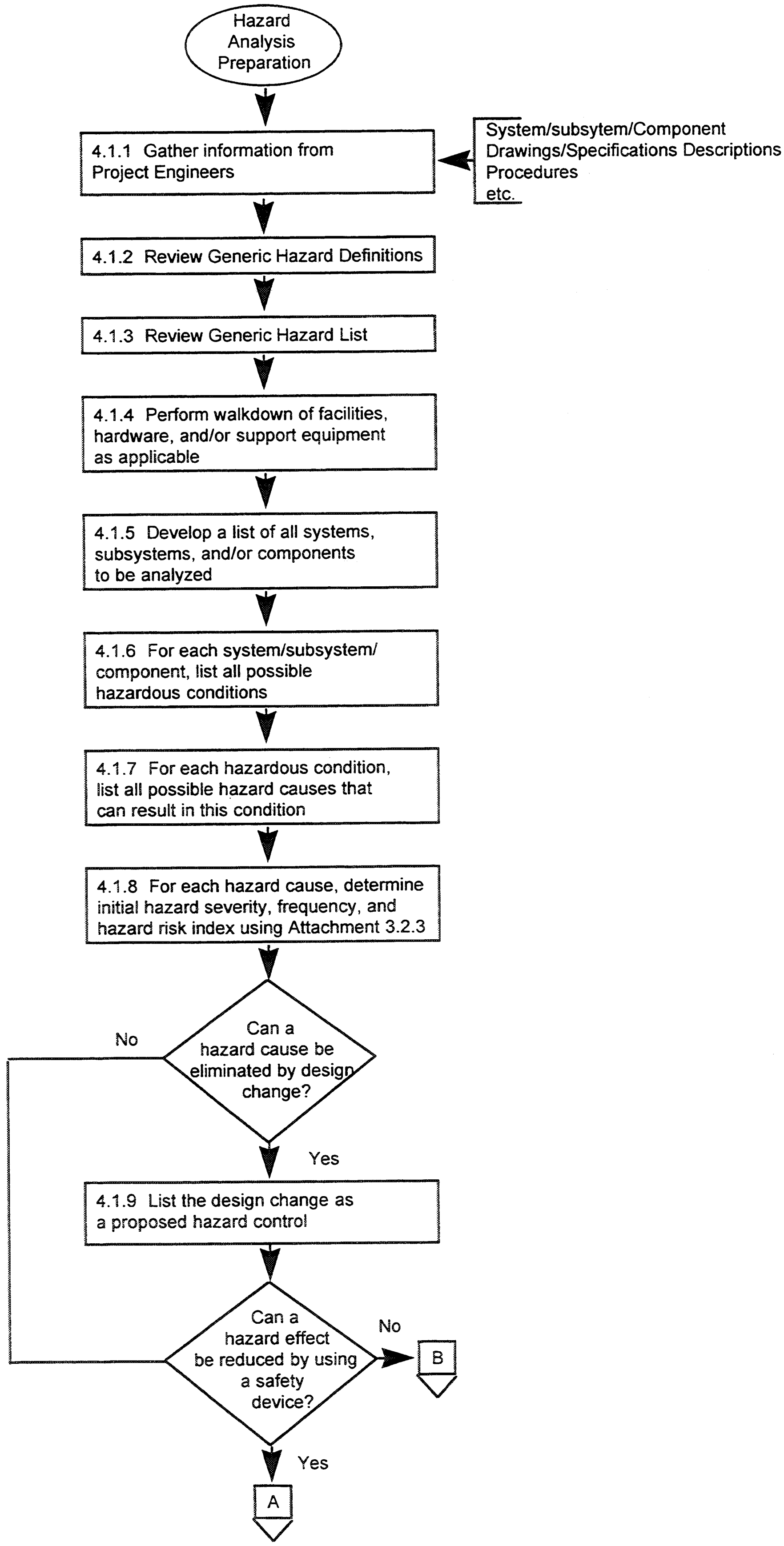
PROGRAM

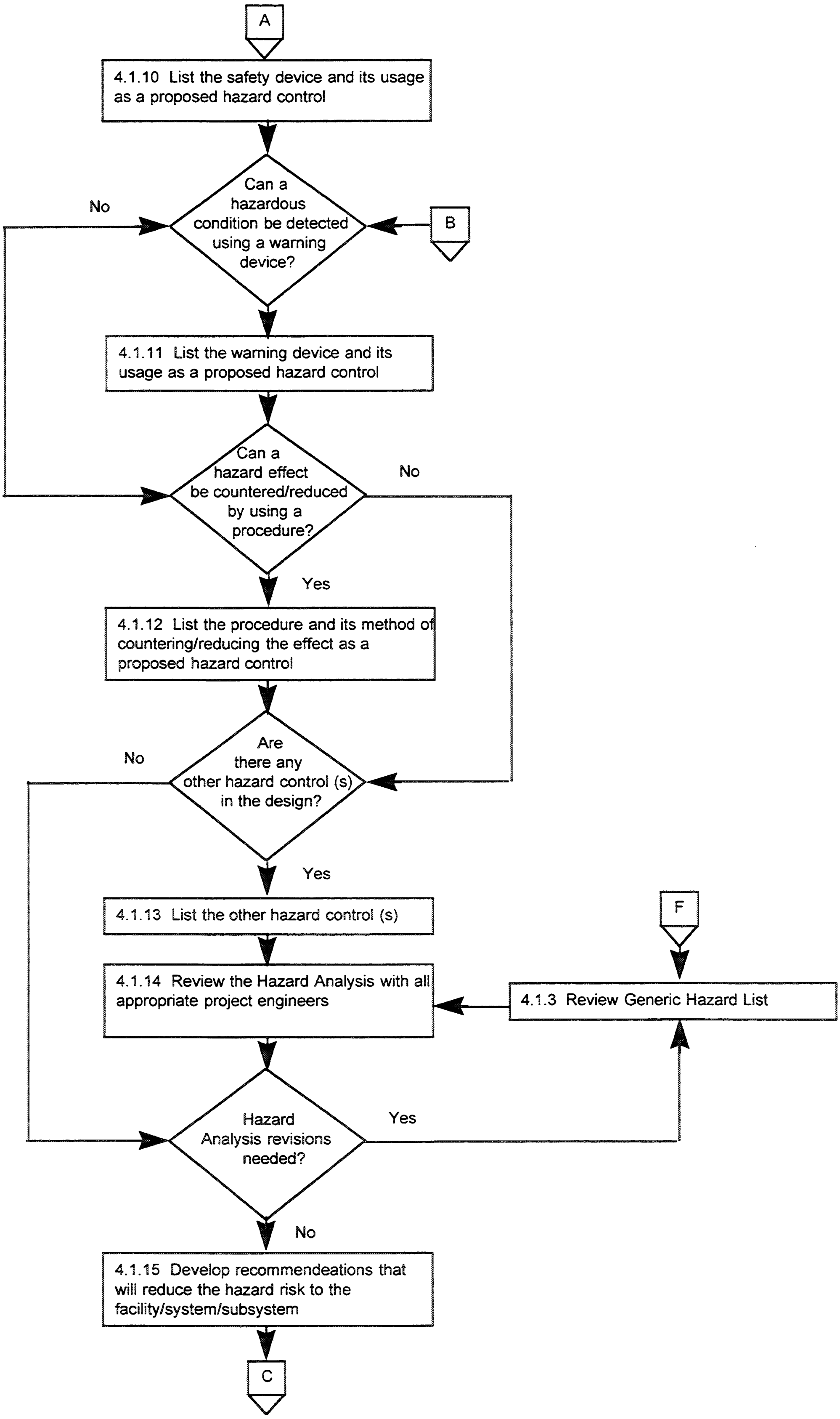
A broad topical list of experiment related areas requiring examination to identify potential hazards has been included below. Additional areas expmined will be noted in the "Other" category. Interaction with aircraft hazards must be considered.

EXAMINATION COMPLETED	HAZARD ANALYSIS REQUIRED	AREA
		Experiment Fire/ Explosion
		Experiment Structural Strength
		Loss of Power Source(s)
		Over/Under Pressure
		Overtemperature
		Overspeed
		Adequate Ventilation
		Electrical Shock
		Electrical Shielding
		Electrical Circuit Protection
		Control of Combustible or Explosive Mixture(s)
		Guards Over Live Parts
		Equipment Shielding Against Impact
		Personnel Protection
		Toxicity
		Radiation
		Bodily Injury
		Noise
		Fire
		Other
		Buddy System
		Researcher Workload
		Researcher/Aircrew Communications
		Other

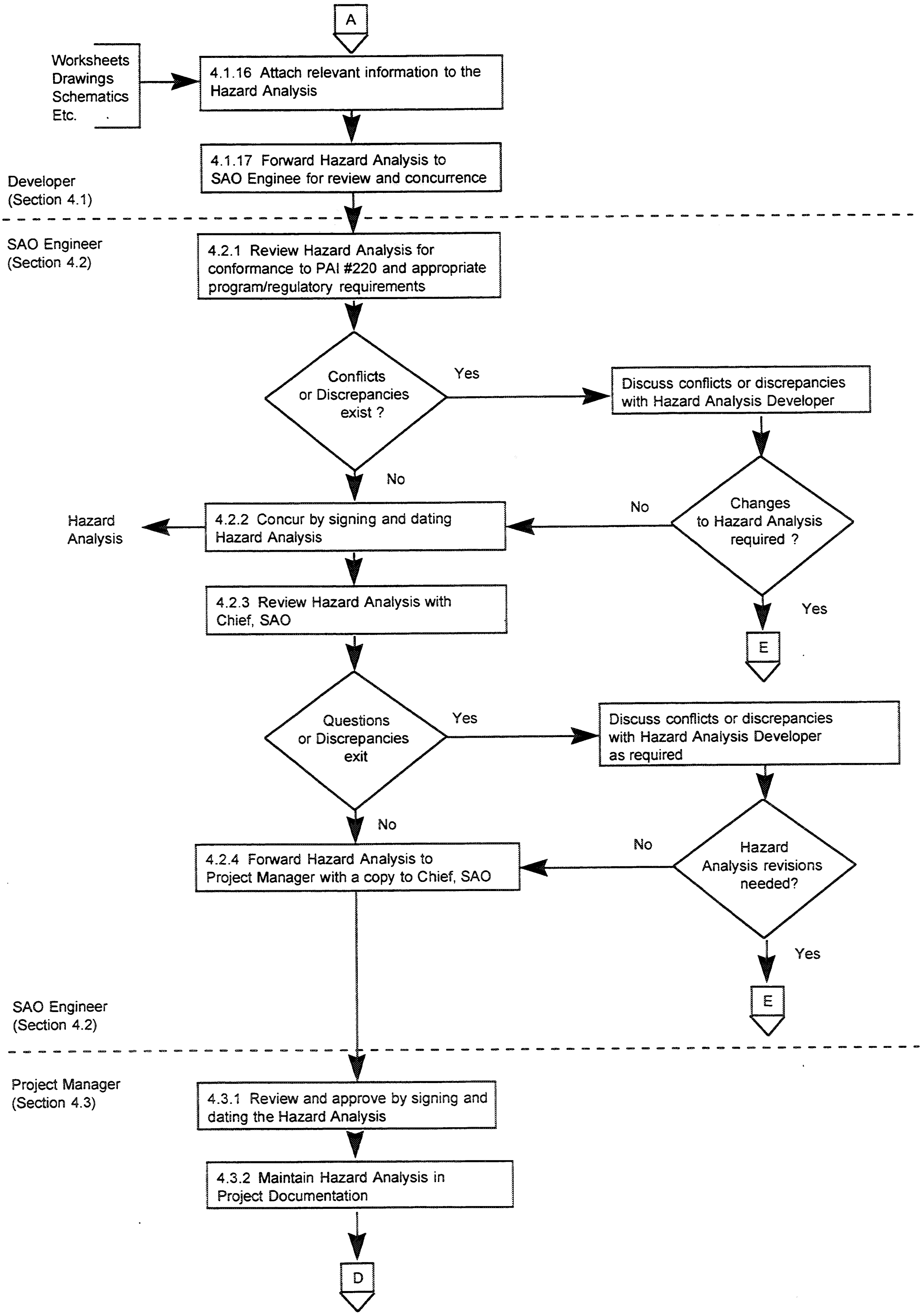
HAZARD IDENTIFICATION COMPLETED (Research Program Manager) Date

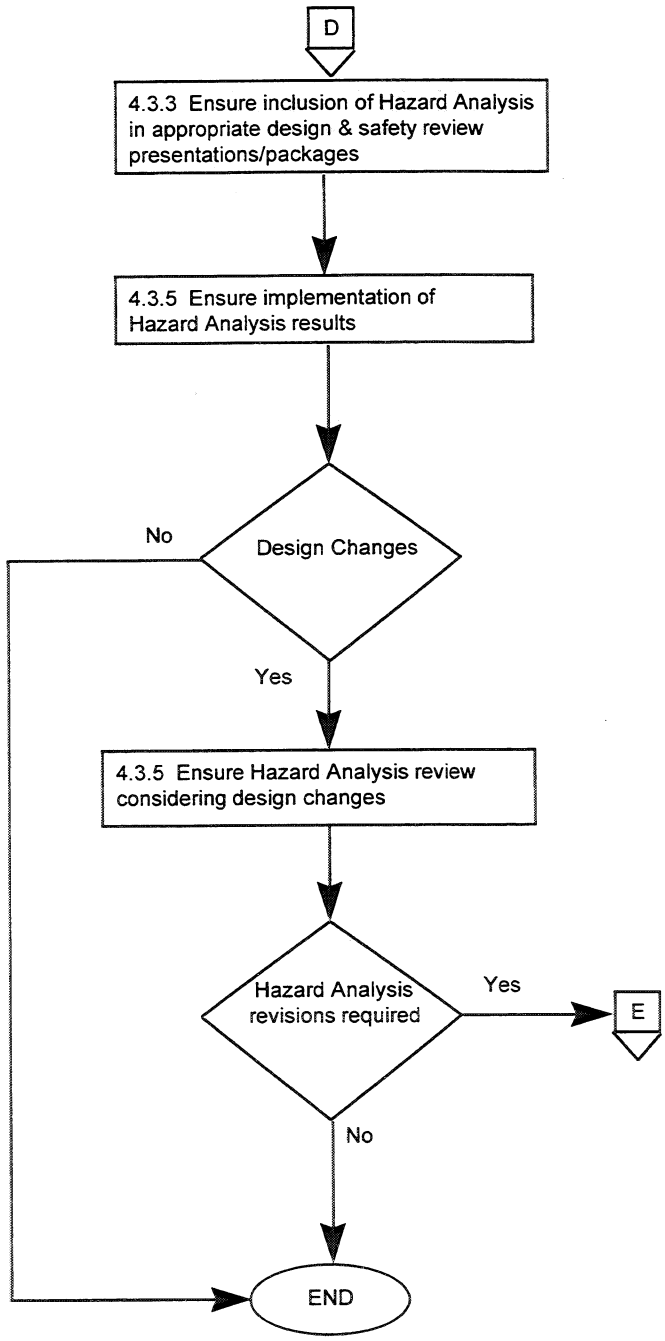
ATTACHMENT 3.2.4 (1)




A
4.1.10 List the safety device and its usage as a proposed hazard control
No
Can a hazardous condition be detected using a warning device?
B
4.1.11 List the warning device and its usage as a proposed hazard control
Can a hazard effect be countered/reduced by using a procedure?
No
Yes
4.1.12 List the procedure and its method of countering/reducing the effect as a proposed hazard control
No
Are there any other hazard control (s) in the design?
Yes
4.1.13 List the other hazard control (s)
F
4.1.14 Review the Hazard Analysis with all appropriate project engineers
4.1.3 Review Generic Hazard List
Hazard Analysis revisions needed?
Yes
No
4.1.15 Develop recommendeations that will reduce the hazard risk to the facility/system/subsystem
C

ATTACHMENT 3.2.4 (3)




D
4.3.3 Ensure inclusion of Hazard Analysis in appropriate design & safety review presentations/packages
4.3.5 Ensure implementation of Hazard Analysis results
Design Changes
No
Yes
4.3.5 Ensure Hazard Analysis review considering design changes
Hazard Analysis revisions required
Yes
E
No
END

APPENDIX C

TEST READINESS REVIEW CERTIFICATION

____

TEST TITLE

1. The following items have been reviewed or tested for safety, technical adequacy, and auditability.

   A. Personnel training, medical qualifications and documentation
   B. Research hardware
   C. Safety analysis and documentation
   D. Interfaced to aircraft systems

2. The following discrepancies shall be corrected prior to the test (indicated above) being initiated:

   A. ____________________________________

   B. ____________________________________

   C. ____________________________________

   D. ____________________________________

3. Test initiation is:
   ( ) Approved
   ( ) Approved pending correction of discrepancies noted in paragraph 2
   ( ) Not approved

__________________________ ____________________
Researcher Date

__________________________ ____________________
Test Director Date

__________________________ ____________________
Aircraft Operations Representative Date

__________________________ ____________________
Area 1 Safety Committee Representative Date

__________________________ ____________________
Chief, Safety Assurance Office Date
(Required for all offsite operations - ONLY)

APPENDIX D

DC-9 INVESTIGATION APPROVAL QUESTIONNAIRE

1. Principal Investigator:

2. Organization and address:
   (Include phone and fax number)

3. Experiment title (as shown in the MSAD bibliography):

4. Which NASA office is supporting the research (i.e., NASA HQ code SN, code C, code UG, etc.)?

5. How was the research selected for funding?
   If by proposal, give proposal title and selection date.

6. Ground-based research or flight program?
   If flight program, give scheduled flight.

7. Science objective of program:

8. Specific objectives of the intended DC-9 flights and relevance to the total program:

9. List of the hardware required:

10. Future DC-9 plans:

11. What is the approved term (i.e, length) of this research program?

    (NASA Headquarters approval is required before any research experiment is allowed to be flown on the DC-9.)

    Send the reply to these questions to:

    Mr. Jack Salzman
    NASA Lewis Research Center
    MS 500-217
    21000 Brookpark Road
    Cleveland, Ohio 44135

APPENDIX E

FEDERAL AVIATION ADMINISTRATION CLASS III AVIATION PHYSICAL

The Federal Aviation Administration Class III Aviation Physical or equivalent examination will be performed on all personnel subject to risk due to changes in barometric pressure or to variations in g-levels caused by the parabolic trajectories flown by the DC-9 reduced-gravity aircraft.

Medical standards established by law are those contained in the Federal Aviation Regulations (FAR), Part 67 (14CFR 67).

CERTIFICATION SUMMARY

Class of Medical Certification Type of Pilot	First - Class Airline Transport Pilot	Second - Class Commercial Pilot	Third - Class Private Pilot
DISTANT VISION	20/20 in each eye separately without correction or at least 20/100 in each eye separately corrected to 20/20 or better with corrective lenses (glasses or contact lenses). (See page 73.)		At least 20/50, without correction; or if vision is poorer than 20/50, must correct ot 20/30 or better with corrective lenses (glasses or contact lenses). (See page 73.)
NEAR VISION	At least 20/40 in each eye separately with or without correcting glasses. (See page 79.)		At Least 20/60 in each eye separately with or without correcting glasses. (See page 79.)
HYPERPHORIA	Maximum of 1 diopter. (See page 86.)		No Standard
ESOPHORIA & EXOPHORIA	Mazimum or 6 diopters of esophoria. (See page 86.)		No Standard
COLOR VISION	Normal color vision (See page 80.)	Ability to distinguish aviation signal red, aviation signal green and white. (See page 80.)	
AUDIOMETRY	Maximum of 40 db loss at 500 hz; 35 db in frequencies of 1,000 and 2,000 Hz, ANSI. (See page 70.)	No requirement. Audiometry may be performed as a service to the applicant with his/her permission.	
HEARING	Able to hear whispered voice in each ear separately at 20 feet. (See page 69.)	Able to hear whispered voice in each ear separately at8 feet. (See page 70.)	Able to hear whispered voice at 3 feet. (See page 70.)
ENT	No acute or shronic disease of ear, mastoid, or problem with equilibrium; no unhealed perforation of eardrum. (See page 28.)		No acute or chronic disease of ear, no acute or chronic ENT problems, including no problem with equilibrium. (See page 28.)
PULSE	At rest, maximum of 100 beats per minute. (See page 89.)		
BLOOD PRESSURE	Maximum of 160/98 at age 50 and over. (See page 86 for BP for younger pilots.)	Maximum of 170/100. (See page 87.)	
EKG	Required at age 35, and annually after age 40. (See page 91.)	Not required if cardiovascular examination in normal. (See page 91.)	
OTHER CONDITIONS	Examiner must disqualify if the applicant has an established medical history or clinical diagnosis of : (1) diabetes Mellitus requiring insulin or hypoglycemic medication; (2) angina pectoris; (3) coronary heart disease that has required treatment or, if untreated, that has been symptomatic or clinically significant; (4) myocardial infaction; (5) epilepsy; (6) alcoholism; (7) drug dependence; (8) disturbance of consciousness without satisfactory medical explanation; (9) personality disorder manifested by repeated overt acts; and (10) psychosis.		

Applicant Must Complete
This Page (Except For Shaded Areas)
PLEASE PRINT

Copy of FAA Form 8500-9 (Medical Certificate) or FAA Form 8420-2 (Medical/Student Pilot Certificate) issued. EE- 1109579

MEDICAL CERTIFICATE ____ CLASS
AND STUDENT PILOT CERTIFICATE

This certifies that (Full name and address):

Date of Birth	Ht.	Wt.	Hair	Eyes	Sex

has met the medical standards prescribed in Part 67, Federal Aviation Regulations, for this class of Medical Certificate.

Limitations

Date of Examination	Examiner's Serial No.

Examiner: Signature / Typed Name

AIRMAN'S SIGNATURE

1. Application For: ☐ Airman Medical Certificate ☐ Airman Medical and Student Pilot Certificate
2. Class of Medical Certificate Applied For: ☐ 1st ☐ 2nd ☐ 3rd
3. Last Name — First Name — Middle Name
4. Social Security Number — -
5. Address — Number/Street — Telephone Number ( ) — City — State/Country — Zip Code
6. Date of Birth (MM DD YY)
7. Color of Hair
8. Color of Eyes
9. Sex
10. Type of Airman Certificate(s) Held:
    ☐ None ☐ ATC Specialist ☐ Flight Instructor ☐ Recreational
    ☐ Airline Transport ☐ Flight Engineer ☐ Private ☐ Other
    ☐ Commercial ☐ Flight Navigator ☐ Student
11. Occupation
12. Employer
13. Has Your FAA Airman Medical Certificate Ever Been Denied, Suspended, or Revoked? ☐ Yes ☐ No If yes, give date ___ ___ (MM YY)

Total Pilot Time (Civilian only)

14. To Date
15. Past 6 months
16. Date of Last FAA Medical Application ___ ___ (MM YY) ☐ No Prior Application
17. Do You Currently Use Any Medication (Prescription or Nonprescription)? ☐ Yes ☐ No — If yes, give name, purpose, dosage, and frequency.

18. Medical History — Have you ever had or have you now any of the following? Answer "yes" for every condition you have ever had in your life. In the EXPLANATION box below, you may note "PREVIOUSLY REPORTED, NO CHANGE" only if the explanation of the condition was reported on a prior application for an airman medical certificate and there has been no change in your condition. See Instructions Page

	Yes	No	Condition		Yes	No	Condition		Yes	No	Condition		Yes	No	Condition
a.	☐	☐	Frequent or severe headaches	g.	☐	☐	Heart or vascular trouble	m.	☐	☐	Mental disorders of any sort; depression, anxiety, etc.	r.	☐	☐	Military medical discharge
b.	☐	☐	Dizziness or fainting spell	h.	☐	☐	High or low blood pressure	n.	☐	☐	Substance dependence or failed a drug test ever; or substance abuse or use of illegal substance in the last 5 years.	s.	☐	☐	Medical rejection by military service
c.	☐	☐	Unconsciousness for any reason	i.	☐	☐	Stomach, liver, or intestinal trouble					t.	☐	☐	Rejection for life or health insurance
d.	☐	☐	Eye or vision trouble except glasses	j.	☐	☐	Kidney stone or blood in urine	o.	☐	☐	Alcohol dependence or abuse	u.	☐	☐	Admission to hospital
e.	☐	☐	Hay fever or allergy	k.	☐	☐	Diabetes	p.	☐	☐	Suicide attempt				*See v. & w. Below*
f.	☐	☐	Asthma or lung disease	l.	☐	☐	Neurological disorders; epilepsy, seizures, stroke, paralysis, etc.	q.	☐	☐	Motion sickness requiring medication	x.	☐	☐	Other illness, disability, or surgery

Conviction and/or Administrative Action History — See Instructions Page

	Yes	No			Yes	No	
v.	☐	☐	History of (1) any conviction(s) involving driving while intoxicated by, while impaired by, or while under the influence of alcohol or a drug; or (2) history of any conviction(s) or administrative action(s) involving an offense(s) which resulted in the denial, suspension, cancellation, or revocation of driving privileges or which resulted in attendance at an educational or a rehabilitation program.	w.	☐	☐	History of nontraffic conviction(s) (misdemeanors or felonies).

Explanations: See Instructions Page

For FAA Use — Review Action Codes

19. Visits to Health Professional Within Last 3 Years. ☐ Yes (explain below) ☐ No — See Instructions Page

Date	Name, Address, and Type of Health Professional Consulted	Reason

- NOTICE -

Whoever in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or who makes any false, fictitious or fraudulent statements or representations, or entry, may be fined up to $250,000 or imprisoned not more than 5 years, or both. (*18 U.S. Code Secs. 1001; 3571*).

20. Applicant's National Driver Register and Certifying Declarations

I hereby authorize the National Driver Register (NDR), through a designated State Department of Motor Vehicles, to furnish to the FAA information pertaining to my driving record. This consent constitutes authorization for a single access to the information contained in the NDR to verify information provided in this application. Upon my request, the FAA shall make the information received from the NDR, if any, available for my review and written comment. Authority: 23 U.S. Code 401, Note.

NOTE: **All persons using this form must sign it. NDR consent, however, does not apply unless this form is used as an application for Medical Certificate or Medical Certificate and Student Pilot Certificate.**

I hereby certify that all statements and answers provided by me on this application form are complete and true to the best of my knowledge, and I agree that they are to be considered part of the basis for issuance of any FAA certificate to me. I have also read and understand the Privacy Act statement that accompanies this form.

Signature of Applicant — Date (MM DD YY)

FAA Form 8500-8 (7-92) Supersedes Previous Edition — OMB Approval No. 2120-0034

NOTE: FAA's Copy of the Report of Medical Examination Must be TYPED.

REPORT OF MEDICAL EXAMINATION

21. Height (inches)	22. Weight (pounds)	23. Statement of Demonstrated Ability (SODA) ☐ YES ☐ NO Defect Noted:	24. SODA Serial Number

CHECK EACH ITEM IN APPROPRIATE COLUMN	Normal	Abnormal	CHECK EACH ITEM IN APPROPRIATE COLUMN	Normal	Abnormal
25. Head, face, neck, and scalp			37. Vascular system (Pulse, amplitude and character; arms, legs, others)		
26. Nose			38. Abdomen and viscera (Including hernia)		
27. Sinuses			39. Anus (Not including digital examination)		
28. Mouth and throat			40. Skin		
29. Ears, general (Internal and external canals; Hearing under item 49)			41. G-U system (Not including pelvic examination)		
30. Ear Drums (Perforation)			42. Upper and lower extremities (Strength and range of motion)		
31. Eyes, general (Vision under items 50 to 54)			43. Spine, other musculoskeletal		
32. Ophthalmoscopic			44. Identifying body marks, scars, tattoos (Size & location)		
33. Pupils (Equality and reaction)			45. Lymphatics		
34. Ocular motility (Associated parallel movement, nystagmus)			46. Neurologic (Tendon reflexes, equilibrium, senses, cranial nerves, coordination, etc.)		
35. Lungs and chest (Not including breasts examination)			47. Psychiatric (Appearance, behavior, mood, communication, and memory)		
36. Heart (Precordial activity, rhythm, sounds, and murmurs)			48. General systemic		

NOTES: Describe every abnormality in detail. Enter applicable item number before each comment. Use additional sheets if necessary and attach to this form.

49. Hearing	Right Ear	Left Ear		Right Ear					Left Ear				
Voice Test			Audiometer *Threshold in Decibels*	500	1000	2000	3000	4000	500	1000	2000	3000	4000

50. Distant Vision
Right 20/ Corrected to 20/
Left 20/ Corrected to 20/
Both 20/ Corrected to 20/

51. Near Vision
Right 20/ Corrected to 20/
Left 20/ Corrected to 20/
Both 20/ Corrected to 20/

52. Color Vision ☐ Normal ☐ Abnormal

53. Field of Vision ☐ Normal ☐ Abnormal

54. Heterophoria 20' (in prism diopters)	Esophoria	Exophoria	Right Hyperphoria	Left Hyperphoria

55. Blood Pressure *(Sitting, mm of Mercury)* Systolic / Diastolic

56. Pulse (Resting)

57. Urinalysis (if abnormal, give results) ☐ Normal ☐ Abnormal — Albumin | Sugar

58. ECG (Date) MM | DD | YY

59. Other Tests Given

60. Comments on History and Findings: AME shall comment on all "YES" answers in the Medical History section and for abnormal findings of the examination. (Attach all consultation reports, ECGs, X-rays, etc. to this report before mailing.

FOR FAA USE
Pathology Codes:
Coded By:
Clerical Reject:

Significant Medical History ☐ YES ☐ NO   Abnormal Physical Findings ☐ YES ☐ NO

61. Applicant's Name

62. Has Been Issued — ☐ Medical Certificate ☐ Medical & Student Pilot Certificate
☐ **No Certificate Issued** — Deferred for Further Evaluation
☐ **Has Been Denied** — Letter of Denial Issued (Copy Attached)

63. Disqualifying Defects (List by item number)

64. Medical Examiner's Declaration — I hereby certify that I have personally reviewed the medical history and personally examined the applicant named on this medical examination report. This report with any attachment embodies my findings completely and correctly.

Date of Examination	Aviation Medical Examiner's Name	Aviation Medical Examiner's Signature
MM | DD | YY	Street Address	AME Serial Number
	City State Zip	AME Telephone ( )

FAA Form 8500-8 (7-92) Supersedes Previous Editions

APPENDIX F

USERS TIME-LINE CHECKLIST

____

TEST TITLE

____

TENTATIVE FLIGHT DATE(S)

	ACTION	DATE REQUIRED	DATE ACCOMPLISHED
1,	Formal test request (new users)	6 Months prior to flight	________________
2.	Test request data (ongoing users)	3 Months prior to flight	________________
3.	Experiment safety documentation submitted Imaging support (all users)	4 Weeks prior to flight	________________
4.	Test personnel data: Medical Physiological Travel orders International visitors (all users)	4 Weeks prior to flight	________________
5.	Inform DC-9 Reduced-Gravity Program office of standard gas requirements	4 Weeks prior to flight	________________
6.	U.S. citizens visitor request for Lewis (all users)	1 Week prior to flight	________________

APPENDIX H

A RESEARCHER'S SUGGESTIONS FOR EFFECTIVE USE OF NASA REDUCED-GRAVITY AIRCRAFT

by Kurt Sacksteder

Congratulations on your good sense and good fortune to be considering or planning the use of the NASA Lewis Research Center's DC-9 Reduced-Gravity Aircraft Facility for scientific or technological experiments. This unique facility, and its sibling aircraft, the KC-135 at the NASA Johnson Space Center, may provide the closest simulation to weightless flight in a spacecraft you or the phenomena you are studying might ever experience. This user's guide provides detailed information you will need to plan, obtain approval for and conduct experiments aboard the DC-9 facility. I have been asked to provide some guidance for novices and would like to begin with some philosophical precepts.

The opportunity to fly aboard a reduced-gravity aircraft is unique and special. Only a few score of people have the chance to fly each year, and fewer still ever fly more than a few times. In addition, of course, the operation of the aircraft and the development of the experiment hardware are costly both financially and with respect to the professional efforts of many people. Thus, while many people find this work quite enjoyable, the unique opportunity is accompanied by a serious professional responsibility for sound technical and scheduler planning, punctual submissions of quality documentation, and a focused (though perhaps light-hearted) attitude during the week of flying.

While it has been mentioned elsewhere in this user's guide, it's worth repeating that this work is not free from risk. The admonishment to check your insurance coverage for this type of non-standard flying should be taken seriously since many policies would not cover an accident. You owe yourself and your loved ones conscious and informed thought on the decision to fly.

Experimenters with many years of laboratory experience fly for the first time and discover, to their surprise, that they, like their experiment, function differently in reduced gravity. Leaving aside for now the issue of motion sickness, there is something quite different about changing a test sample or manipulating a computer keyboard while floating inverted in the aircraft cabin. Your brain will unavoidably react to this stimulation in an unpredictable way during your first flight(s), perhaps to the detriment of progress on your experiment. Until you adapt to these sensations, you should plan modest test objectives for each flight. In my case, once adapted to the sensations I find that daily awareness of my own reactions to weightlessness increases my alertness, which benefits the productivity of my experiments.

Hardware

Facility selection. If you are just beginning the consideration of the DC-9 facility for performing your reduced gravity experiments there are a few things you should consider. The aircraft is one of several facility types for reduced-gravity experiments each of which has its strengths and weaknesses. The aircraft provides the longest reduced-gravity period for tests, nominally about 20 seconds, and is the only facility in which the investigator can accompany and manipulate the experiment during the test. However, the aircraft environment includes the peculiar G-jitter phenomenon that is a combination of atmospheric disturbance to the aircraft, piloting differences, and mechanical vibrations of the experimental hardware responding to the atmospheric and pilot excitations. This g-jitter prevents repeatably achieving "gravity" levels below about 0.02g while the experiment is attached to the aircraft deck, or about 0.001g in the free-float mode, where the test time is reduced to about 5 seconds before the experiment collides with the cabin wall. A tremendous advantage of the aircraft facility is that once all your hardware bugs are eliminated you might be able to conduct as many as 120-160 experiments in a single week of flying (though few experiments can be repeated on each parabola.)

Drop towers, on the other hand, provide 2-5 seconds of below 10^{-5}g, but with a landing shock of 10's of gs, limited experiment volume and electrical power, and no real-time intervention by the experimenter. Nevertheless, quite a few investigators use the Lewis 2.2 second drop tower as a first step in their studies, then move on to either the 5 second drop tower if very low g levels are critical to the experiment or to the aircraft if extending the test time is most important. In some instances, however, the characteristic time of the experiment is obviously too long for meaningful tests in the drop towers or the constraints of volume, power and landing shock cannot be accommodated. In these cases, the aircraft offers more volume and electrical power without the shock load.

If there are no differences in hardware complexity, the cost of preparing an experiment for the aircraft and the cost for the drop tower are probably comparable. Most experiments seem to require at least one year of preparation, depending upon their complexity, for either type of facility. It may be that your program schedule cannot accommodate sequential testing in drop towers then in the aircraft, so a single choice is required. Therefore, a careful study of your experiment requirements in the categories of test time, g-levels, volume, power, investigator intervention, mechanical fragility and the anticipated number of tests is the first step in a well planned program.

Hardware Preparations. Once you have determined that the aircraft facility is the best option for your testing program, there are a few guidelines to be considered. First and foremost, establish contact with the operations engineers in the DC-9 Reduced Gravity Program Office early (ie. well ahead of their stated deadlines, and before you start designing hardware) and keep them informed of your progress.

They are experienced in experiment preparation and safety analysis and can help you avoid mistakes or oversights that could jeopardize your approval to fly or your success during flight. I am quite sure that they prefer handling extra phone calls to being forced to cancel your flights due to a problem.

One design feature is so important and so often overlooked that it merits additional mention here: handles. Put handles on your experiment for loading and unloading and for the purpose of having something to grab in reduced gravity. Think about good locations for the handles, like waist-high for carrying big (and heavy) things and hand-holds near your computer, for example, for maintaining your position while you operate the experiment during a parabola.

Safety. As you will perceive from this user's guide, the safety program for flight in a NASA aircraft is comprehensive. Experienced people will review your drawings, hardware and procedures to find hazards that could pose threats to the aircraft, the people on board or the ground crew. The effort required to prepare the necessary documentation for this safety analysis is sometimes substantial and should not be overlooked in planning your schedule. Doing less than an excellent job in preparing this documentation will probably delay your flight approval, and will also bring about a greater perception of intrusion by the safety officials into the analysis of your experiment. Since I might also be on board with your experiment, I take comfort in the rigor of the safety program.

Despite the skill and experience of the safety analysts, however, there is no one better able to analyze and determine the safety of your experiment than you. Everyone on the aircraft including you depends upon you to be completely certain that your experiment is safe. The best time to start the safety analysis is before you begin building the experiment when it is easier to incorporate safety features. My strong advice is to be quite conservative in your estimation of safety hazards and their mitigation - imagine your sainted grandmother sitting next to your experiment.

Experiment Operations. While it is true that the aircraft facilities permit an investigator to bring hardware from a normal gravity laboratory directly into a reduced gravity laboratory, there are some obvious and not so obvious limitations. For example, while it is inconceivable that in your own laboratory you would position a video monitor so that you could inadvertantly kick the screen, feet are sometimes found far from the floor in the aircraft. Therefore everything must be "kick proofed", including monitors, switches, cameras and other optical components, etc. Similarly, some free-floating investigators have been known to land on their hardware and not their feet at the end of a parabola, so all protrusions or sharp edges must be eliminated or padded. There are other design features of this type that should be considered, with the help of the DC-9 facility operations engineers, related to reduced gravity operations, such as oil-less vacuum pumps, containers for small parts and tools, etc.

One required item of documentation mentioned in the user's guide is the operations checklist. This is a very useful tool for investigators, even in the design phase of the experiment preparations. While it is often appropriate in the normal gravity laboratory to tweak experiment hardware in real-time through a test, the limited time available for tests in the aircraft facility require more directed work. While there will certainly be times when quick thinking can improve the outcome of an experiment, having a well considered checklist makes experiment success routine rather than heroic. Additionally, having the checklist ensures that you understand your hardware and how it behaves so that if something unusual happens you can react quickly, correctly and safely.

Investigator Adaptations

Your first flight aboard a reduced-gravity aircraft facility will be different from anything you have experienced, period. There are hints about the sensations to be experienced from amusement park rides, commercial aircraft beginning a descent towards landing, neutrally-buoyant submerged swimming, or possibly a fast moving auto cresting a hill. The key difference is that none of these phenomena last long enough to be authentic. Aboard the aircraft, you will experience several seconds of nearly 2 times normal gravity, followed by a several second transition to reduced gravity, a period of reduced gravity lasting about 20 seconds, followed by a another transition to nearly 2g again; then perhaps some repetition of this sequence.

First flights. The fluids in your body including your blood, the contents of your stomach, and the fluid in your inner ear are affected by the 2g pullup maneuver, the reduced-gravity period and the transitions between them. Innumerable people have reported that no matter how much they heard beforehand about the sensations of these new acceleration environments, they were surprised at their reactions to their first aircraft parabola(s). The most unusual sensation is experienced during the transition between 2gs and reduced gravity when the body fluids are not simply pulled in a different direction, like standing on your head, but they are no longer pulled at all. The initial conditions for the transition period can be further complicated by heavy buoyant motion during the 2g period, especially if you move your head during this time. The result has been described like a kind of disorientation or vertigo where the balance signals from your vestibular system (inner ear) are not normal. My advice for your first few parabolas is to sit facing forward during the 2gs, allow your body to float a little during the transition while being sure to hold on to something, consciously believe your eyes, and make yourself laugh at the rest of the sensations.

As you become familiar with the sensations, gradually you can expand the envelop including free floating, free-floating in the rotationally excited mode, and free-floating in translationally excited modes - just don't forget to do your experiment. Don't expand your envelop to include collisions with other investigators, their hardware or the test directors. Remember that air is much less viscous than water, so don't try to swim. I learned from an old hand: if you kick me I will kick you back, and I've practiced. In summary, my greatest satisfaction from reduced-gravity aircraft work is obtaining unique and high-quality scientific data while at the same time enjoying the environment - the environment alone is enjoyable but not so enduring.

Motion Sickness. Something like 1/3rd of participants experience something like motion sickness during the parabolas. I've heard of no convincing predictor of who might have this additional experience, but there is apparently no correlation with either car-sickness or space adaptation sickness. I have observed F-16 pilots quickly sick (though they actually seemed to enjoy it), but have also observed someone quite prone to car sickness quite unperturbed during many reduced-gravity flights. My advice on this subject (though there are dissenting opinions) is to have a light and easily digestible meal a couple hours before the flight, be certain to keep busy during the parabolas (most important since it seems you can talk yourself into being sick), and resist the onset of sickness by distracting yourself with a mental task. If sickness is inevitable, though, accept it quickly and without loss of face (remember, even F-16 pilots...) because dwelling on it will make it worse. Think of it as an additional fluid mechanics experiment, which you must observe, control and most importantly, contain. Remember that many people are able to resume their work after being sick, and nearly everyone can expect to adapt to these sensations in no more than a few flights.

Anti-motion sickness medication will be available as a preventive measure, as described in the user's guide. These measures are effective in many, but not all people, and have some side effects which will be carefully explained to you before the medication is provided. There is a diversity of opinion on this subject, but mine is: if you can accept the possible side effects and have not flown recently or at all, use this assistance and improve the chances that you can concentrate on completing your experiments. If you will fly more than a very few times, wean yourself as quickly as you can. Of course the quickest way to adapt is to not use the medication at all, but you may lose test time during your first flights. Of course, the decision is completely yours and you should not feel (nor provide) any pressure to decide either way.

Some people who have particularly good cardiovascular exercise programs experience what seems to be pooling of blood in their legs. These folks perspire heavily and may be a little light headed during the 2gs, but don't seem to be any more prone to motion sickness than anyone else.

Final Comments

The opportunity to perform experiments aboard a reduced-gravity aircraft facility is a rare privilege. You can obtain optimal satisfaction from this experience by careful planning, learning from the experience of others, and an on board work ethic that allows you to enjoy the environment while doing serious scientific or technological research. Look for ways to improve your experiment each time you fly and to help the other experimenters around you - you will benefit from both.

I wish you good luck in your planning, preparations and flights. Perhaps we will have the opportunity to fly together, in which case I would welcome your comments on my advice.

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The document provides guidelines and information for users of the DC–9 Reduced-Gravity Aircraft Program. It describes the facilities, requirements for test personnel, equipment design and installation, mission preparation, and in-flight procedures. Those who have used the KC–135 reduced-gravity aircraft will recognize that many of the procedures and guidelines are the same. Additional information concerning this guide, the aircraft, test requirements, test schedules, etc., may be obtained from NASA Lewis Research Center, DC–9 Reduced-Gravity Office, MS 101–1, 21000 Brookpark Road, Cleveland, Ohio 44135 or call (216) 433–2611, (216) 433–2612, fax (216) 433–2614.

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