CHAPTER 7

INFORMATION COLLECTION AND TRANSMISSION SYSTEM (ICATS)

1. General Information

The on-board Airborne Science DC-8 Information Collection and Transmission System (ICATS) was designed, assembled, and programmed by the DFRC Research Instrumentation (RI) Branch. The ICATS post-flight data processing archive and data access system was developed by the DFRC Research Facilities Directorate.

Functions of the on-board ICATS include:

A. Interfacing to and processing avionics and environmental parameters derived from the navigational management system, the global positioning system, the central air data computer, the embedded GPS/INS, and analog voltage sources from the aircraft and experimenters.

B. Furnishing engineering unit values of selected parameters and computed functions for real-time video display and archiving ASCII data at experimenter stations.

C. Archiving the engineering unit values of all ICATS parameters on data storage for post flight retrieval.

The resulting post-flight archiving system provides World Wide Web-(WWW) based access with secure permission-based remote login. The data will be available anytime 24 hours/day, 7 days/week. In addition to the World Wide Web, an ftp server is also available.

2. Overview of ICATS

A. Hardware Configuration

Hardware components for ICATS consist of a prime and spare VME chassis and associated hardware. These are located in the housekeeping rack between the mission director console and the navigator station. Prime and spare Sun Ultra 80 workstations and associated hardware are located at the operator station in the DC-8.

1) VME chassis

All computations and data interfaces for the ICATS system are implemented in a 20 slot VME chassis, which presently contains a CPU controller card, MIL-STD-1553 and ARINC-429 interface cards, analog/digital converter card, and a broadcast memory card. The broadcast memory card is used to interface with the Sun Ultra 80 installed in the operator station. The Numeric Parameter Display Page routine is run in this chassis.

2) ICATS Operator Station

The ICATS operator station contains two Sun Ultra 80 workstations. The Ultra 80 will serve as a control point for all ICATS functions. Boot-up and all archiving functions are implemented in the Ultra 80. Track plot and parameter plot routines are run in this computer. Ultra 80 hard drives will be used for archiving mission binary data at one and ten samples/second and ASCII data at one sample/second.

B. Other ICATS Hardware

1) Rack-mounted PCs

The ICATS operator station contains two rack-mounted PCs. One computer will serve as a back up for logging the ASCII data generated during the flight.

2) Broadcast Memory Hub

The broadcast memory hub has been established. The Ultra 80 workstation communicates with the broadcast memory card in the VME chassis via a fiber optic line.

3) Ethernet Hub

The Ethernet hub connects the VME Chassis, Sun Ultra 80, printer, mission director’s X term, and experimenter stations.

4) RS-232 lines

The RS-232 routes data to each experimenter station.

5) **CD read/write hardware**

The CD read/write hardware will burn either ASCII and/or binary files up to 700 Mb for on-mission archiving.

6) **MDI**
The mission manager's PC, (MDI) used for keyboard entry commentary, is connected to the Ultra 80.

7) **TDC-8 network printer**

The DC-8 network printer is available for use by all DC-8 mounted experiments.

8) **NOAA Satellite Weather Pictures**

This automatic picture transmission (APT) system is located on one rack-mounted PC at the ICATS operator station. When on a remote deployment or during a flight, the onboard APT system can be used to obtain near real time observation of weather.

9) **Software Configuration**

The VME chassis utilizes the VxWorks operating system. Output of this software is described in this handbook.

3. Data Sources for the ICATS System

ICATS receives digital and analog input signals from a number of sources. All data is acquired by ICATS at 30 samples/second. This data is converted to engineering units and recorded in binary format at one and ten samples/second. The ASCII files of selected data is distributed and stored at one sample/second.

A. Digital Input Signals

- MIL-STD-1553 bus data

  Honeywell Embedded GPS/INS

  Radar altimeter (RA)

- ARINC-429 bus data

  Navigational management system (NMS)

  Air data computer (ADC)

  Global positioning system (GPS)

B. GPS Updated Time Code Receiver

Aircraft time code generator (TCG) furnishes time to all requirements on aircraft. The TCG receives updates from a GPS receiver. ICATS has a timecard reader, which continuously synchronizes the IRIG-B from TCG and inputs data to memory at 30 samples/second. Time code values are combined in ICATS and are available to users in real time and post flight as parameter “Time”. Time is available in ASCII format with a range of 00:00:00.000 to 23:59:59.999 and also is contained in the post-flight binary files. The TCG also provides time to the video distribution system, providing a time tag for selected video displays and recorded video.

C. Mission Manager’s Log

The mission manager’s log file enables the mission manager to provide time-stamped keyboard entry commentary of his/her observations or those from other sources. The logging subsystem automatically records the start and end of data runs, annotating them with present time, position, altitude and other information. ICATS provides the capability for future upgrades to the existing log file system.

D. Analog Sources

A 64-channel high-speed analog to digital converter card resides in the ICATS VME chassis for analog signals from aircraft and environmental sensors. This card will also be used for analog signals routed to the VME from the experimenters' hardware. These analog inputs are converted to engineering units and become part of the parameter database as listed in appendix C. These analog sources include the following:

- Rosemount model 1241 A6CD for cabin altitude.
- General Eastern model 1011C thermoelectric hygrometer.
- Rosemount model 102 AH2AG for total air temperature.
- Heitronic Model KT-19 infrared radiometer.
- Analog signals routed to ICATS from experimenters.

4. Output Parameters From ICATS

Appendix C lists output parameters from ICATS, which are available in the data base for use in display, computations, and archiving. This appendix identifies the (1) source for each parameter, (2) the ICATS parameter identification code (PARM ID), (3) units for the parameter (deg, ft/sec, kn, °C, etc.), (4) sign convention definition if appropriate (for example for vertical speed + for ascending, – for descending) (5) parameter range (for example, GPS alt range —1000 to 131,072 ft) (6) other comments.

Appendix C shows the ASCII parameter set and format for the ICATS parameters distributed on the 1200, 9600 and 19.2k baud rates from the RS-232 distribution systems. This set of ASCII parameters (9600/19.2k) is what will be archived at one sample/second. For each mission, additional parameters from the ICATS output parameter list may be added or substituted within the limitations of the RS-232 system.

5. Video Distribution of ICATS

A. Parameter alphanumeric displays

The DC-8 closed circuit television system displays to the on-board experimenters' choices from a number of video sources including a data page of parameters, which is generated in the ICATS system and sent out in NTSC format to the video switching system. The present format consists of two columns of seventeen parameters each. Parameter name, engineering unit's value, and units are displayed in each column.

B. Track Plot

The ICATS system generates a track plot of the DC-8 flight.

C. Parameter Plot

The ICATS system generates a parameter plot consisting of up to 6 parameters on the y-axis.

6. RS-232 Data Line to Experimenter-operator Computers

The ICATS provides the ASCII formatted engineering unit data to experimenter-operated computers via RS-232 line at a rate of one sample/second. Transmission rates of 1200, 9600 and 19.2K baud are available. Formats are shown in appendix D.

A data distribution subsystem accepts the standard RS-232-C signal outputs from the ICATS serial output interface, converts the signal to RS-422 (for noise immunity and improved signal-to-noise) and distributes the data along both sides of the aircraft. The signals are tapped at intervals and regenerated as RS-232-C at each experiment station. Each station has three DB-25 connectors, each dedicated to one of the three baud rates (1200,9600, and 19.2K) for use by the experimenters. Connectors may be used simultaneously, in any combination. The signals are opto-isolated from the main data path and the RS-232-C drivers are current-limited in order to protect the system from defective experimenter equipment or accidental shorting of output lines. The experiment station box may be configured as a modem (DCE) or as a computer (DTE). The configuration is defined by a switch setting at each experiment station box. This switch functionally exchanges pins two and three of the DB-25 connector.

7. On-deployment Data Delivery Available After Flight

During the flight mission, data output parameters discussed in section 4, are archived in both binary (one and ten samples/second) and ASCII format (one sample/second) to hard drive on ICATS Sun Ultra 80, located in the ICATS operator station.

A. Experimenter retrieval of data on aircraft on deployment:

- ICATS creates a hard copy of track plot, parameter plot or mission manager log if required.
- ICATS accesses the data through an ethernet connection to an ftp server.
- ICATS produces a CD, if required.

B. Experimenter retrieval of data off aircraft on deployment:

- Data will be made available on the World Wide Web and ftp server.
- CD.

8. Dryden-based ICATS Post-flight Data Delivery and Archiving

A. ICATS Data Archive

- NASA will utilize a Sun Ultra 80 and associated storage capacity as host for the data archive of all data referenced in section 4 of this chapter. This parameter set may change as DC-8 missions continue.
- The NASA archive will contain the ICATS DC-8 Binary files at one and ten samples/second.
- The NASA archive will contain the ICATS ASCII files at one sample/second with parameters on the 9600/19.2k baud.

B. ICATS Data Retrieval Methods

- Access to the ICATS/experimenter ftp server.
- CD.

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CHAPTER 8

FACILITY INSTRUMENTATION

1. General Information

A variety of systems are available to acquire aircraft flight parameters and related environmental data in support of the research activities. Many of these systems are standard on-board facilities; others can be provided on request. Outputs vary from real-time electrical signals distributed to experiments to post mission copies of film or magnetic tape, as outlined in the following section.

2. Standard Aircraft Systems

Data acquisition systems listed in table 8-1 are standard to the aircraft. Output signals and the formats available to experimenters are listed below.

A. Inertial Navigation System (INS)

The Delco Carousel IVA-3 Inertial Navigation System operates by sensing aircraft accelerations from a gyro-stabilized, four-gimbal, all-attitude platform. Dual two-degree-of-freedom gyros, that feature self-generating gas bearings, have very low drift characteristics and excellent turn-on repeatability. A general purpose, microelectronic digital computer is part of the system. Output functions include position information, course-line computation, steering commands, and angular pitch/roll/heading information. The system also accepts a true airspeed signal that is used to compute wind speed and direction.

The full data stream, in binary coded decimal (BCD) format, is output to a remote display unit at the mission director's console and to the ICATS. In turn, ICATS converts the data stream into separate parameters for output to experiments. Selected INS analog outputs also go to the housekeeping rack.

Table 8-1. Standard aircraft data systems available on CCTV and ICATS data stream.

System	Output Data
Inertial Navigation Systems (2)	Pitch and Roll Drift Angle Latitude and Longitude [1] Ground Speed [2] True Heading [3] Wind Vector [4] Distance to Go [5] Time to Go [6] Cross Track Distance [7] Course (desired track) [8] Track (Angle) [9] Track Error [10] Align Status [11]
GPS System (2)	Also produces items 1-11 above
Total Air Temperature Probe	Total Air Temperature
Dew/Frost Point Hygrometer	Prevailing Ambient Dew Point/Frost Point
Surface Temperature Radiometer	Surface and Cloud Top Temperature
Radar Altimeter	Absolute Altitude above Land or Water
Central Air Data Computer (2) (Flight Instruments)	Pressure Altitude & True Airspeed Mach no. & Static Air Temperature Vertical Velocity
Cabin Altimeter	Equivalent Pressure Altitude
Time Code	IRIG-B

B. Flight Management System (FMS)

The flight management system is a fully integrated navigation management system designed to provide the pilot with centralized control of the aircraft's navigation sensors and computer based flight planning. The FMS accepts primary position information from short and long-range navigation sensors. Inputs from DME, VOR, TACAN, and GPS can be utilized to determine the aircraft's position. In addition to the navigational inputs, the system also receives true airspeed and altitude information from the air data computer and heading reference from the INS. The primary position data received from the sensor is filtered within the FMS to derive a "best computed position" (BCP). Using the BCP, the FMS navigates the aircraft along the programmed flight path.

C. Global Positioning System (GPS)

The global positioning system is a system whereby GPS satellites transmit highly monitored position and timing data allowing a receiver to precisely determine its range to the transmitting satellite. By observing multiple satellites, the receiver can accurately determine and track its position in longitude, latitude, and altitude allowing precision point-to-point navigation to be performed. The DoD World Geodetic System of 1984 (WGS-84) is the convention used for all positioning and navigation purposes.

D. Weather Radar System

A Collins WXR-700C horizontal scanning, two-axis, gyro-stabilized C-band radar antenna is located in the nose of the aircraft. Color images are displayed on a multi-function display (MFD) that is also used to display the aircraft's flight instrument system. The mission director can also observe and record on videotape the same weather display the flight crew is observing.

E. Total Air Temperature System (TAT)

The Rosemount 102 AH2AG Total Air Temperature system features an accurate, quick response probe that measures the total temperature of air outside the aircraft, using a platinum-resistance sensing element. This value is warmer than static air temperature (SAT) by reason of aircraft speed. The TAT is used by the central air data computer (CADC) to compute the true airspeed. Signals from the probe electronics package are sent to the housekeeping rack, and from there they are available to both ICATS and the experimenters. The TAT sensing range is from –65 to +35 °C with an accuracy of ±1.0 °C.

F. Dew/Frost Point Hygrometer

The General Eastern 1011C is a two-stage, thermoelectric hygrometer system designed to obtain in-flight measurements of the prevailing ambient dew point or frost point temperature. It does this over a range of –75 to +50 °C by stabilizing the temperature of a mirror at the point where moisture starts to condense on its surface. Accuracy is ± 0.1 °C over entire range.

Signal outputs from this instrument is routed to indicator units in the mission director's console and to the ICATS for presentation on the CCTV and recording. Hygrometer system status is signaled to the ICATS and is coded in the data. Response time of the hygrometer systems is about 1 °C per second; and has decreasing response and depression capabilities as temperatures drop below –60 °C.

G. Surface Temperature Radiometer

A Heitronics model KT19.85 nadir-viewing infrared radiation pyrometer measures earth's surface (land or water) or cloud top temperature in the spectral band of 9.6 to 11.5 microns. The radiometer has a 2-deg field of view, and covers the range –80 to +200 °C. A signal is sent from the system electronics in the housekeeping rack to ICATS for recording and display on CCTV.

H. Radar Altimeter

A NavCom Defense Electronics, Inc., APN-232 combined altitude radar altimeter determines the aircraft's altitude above land or water (0 to 65,000 ft) by means of reflected, sub-microsecond rf pulses between 4.2 to 4.4 GHz. The specified accuracy ranges between ±1.0 to 2.0 percent, depending on altitude and whether the digital or analog output is being used. Visual readout units are located in the mission director's console, and signals are sent to ICATS for CCTV display and recording.

I. Aircraft Flight Instruments

The outputs from various flight instruments can be made available to experiments. Ordinarily, the instrument signals are processed by the CADC, sent to the housekeeping rack for conditioning, and provided to ICATS. The available parameters from the CADC are listed in appendix C.

J. Cabin Altimeter

The equivalent altitude pressure in the cabin (–1000 ft to 20,000 ft) is detected by a Rosemount Mod 1241 A5CD cabin altimeter. The signal output is sent to ICATS for recording and display on the CCTV.

K. Time Code

IRIG-B time code, in serial format, is available on video and camera displays. It is sent to ICATS for recording on experimenters' data.

3. Camera Systems

For missions requiring photographic coverage, the mission manager can arrange for various camera systems. These camera systems are frequently used to obtain photographic records of the area surrounding the aircraft's flight path. Experimenters should make their camera requirements known as far in advance as possible of the planned mission.

The camera systems can be controlled manually or automatically at frame rates to accommodate most aircraft speeds and altitudes. The automatic frame rates can be controlled by either time or percentage overlap. Film is marked with universal time (UT) code. Specific information is given below and in table 8-2.

A. Flight Research, Inc. Model 4E (Giannini Camera)

This is a 35mm camera taking 14 pictures per foot of film; capacity is 100-ft or 400-ft film magazines.

B. W. Vinton, Ltd. Reconnaissance Camera

This is a 70mm camera taking 4.8 pictures per foot of film; capacity is 100-ft or 200-ft film magazines. The camera has automatic exposure control.

C. Chicago Aerial Industries Model KS87B

The CAI KS87B uses 5 in. film taking 2.4 pictures per foot of film; capacity is 600-ft film magazines. The camera has automatic exposure control and forward motion compensation.

Table 8-2. Supplemental data systems.

FILM CAMERAS

Cameras	Film Size	Frame Size (in.)	Range of Operation
FRI-4E	35 mm	3/4 x 3/4	Frame rates variable to 20 per sec; wide selection of lenses.
Vinton	70 mm	2 1/4 x 2 1/4	Frame rates variable to 8 sec; 1 1/2-in. lens, 73 deg m FOV
CAI-KS87B	5 in.	4 1/4 x 4 1/4	Frame rates variable to 6 per sec.; 14 deg, 21 deg, 42 deg, 73 deg FOV; 18-in., 12-in., 6-in., 3-in., focal length.
WHRC-10	9 1/2 in.	9 x 9	Frame rates variable to 1 per 7 sec; 6-in. lens, 73 deg FOV or 12-in. lens, 41 deg FOV

VIDEO SYSTEM

<table>
<tr><th>Cameras</th><th>Lens</th><th>Sensor</th><th>Recorder</th></tr>
<tr><td>SSC-DC50</td><td>8-48 mm zoom
CS - mount type
f1.4 Auto Iris</td><td>CCD color;
768(H) x 494(V) Pixels
470 TVL
Composite Output</td><td>Panasonic AG 6740
VHS/SVHS; 2, 6 Hour
or Time Lapse
1 to 5/16 ips (2H mode)</td></tr>
<tr><td>EM 102 II</td><td>Non-Auto-Iris
4-24 mm</td><td rowspan="3">CCD Color
574(H) x 489(V)
Pixels 350 TVL</td><td rowspan="3">WJ-450
Panasonic
Video Splitter</td></tr>
<tr><td>EM 202 II</td><td>Auto-Iris
6-12 mm zoom
f1.0 to 1.4</td></tr>
<tr><td>EM 202 II</td><td>Auto-Iris
C-Mounted
8-48 mm zoom
f1.2</td></tr>
<tr><td>SSC-DC50</td><td>35 mm fixed
C-mount type
f1.8
Auto Iris</td><td>CCD Color;
768(H) x 494(V) Pixels
470 TVL
Composite Output</td><td>Panasonic AG 6740
VHS/SVHS; 2, 6 Hour
or Time Lapse
1 - 5/16 ips (2H mode)</td></tr>
</table>

D. Wild Heerbrugge Model RC-10

The WH RC-10 camera uses 91/2-in. film, taking 1.25 pictures per foot of film; capacity is 400 ft film magazines. The camera has a variable shutter and f-stop exposure. It can be equipped with either a 6- or 12-in. focal length lens as required.

E. Sony Video Camera Model SSC-DC50

Three small video cameras (2 5/8-in. wide, by 2 1/4-in. high, by 5 1/2-in. deep) are available for mounting at various positions within the aircraft, or at an exterior window, to record events significant to the experimenters. The cameras have color capability and use solid-state CCD imaging devices. The camera body has a "C/CS" mounting, permitting experimenters to utilize their own non-zoom lenses if necessary. Special camera mounts must be custom fabricated for each application; therefore, experimenters must make these types of requirements known early in the design phase. The three available camera assemblies have a common control panel at the housekeeping rack for remote focus and zoom. SVHS and NTSC outputs from each assembly are available.

F. Elmo mini-Video Camera Model EC 202 II

This camera is mounted on the glare shield in the cockpit, providing a view ahead of the aircraft. It is equipped with an auto-iris f 1 to f 1.4, manual 6 to 12-mm zoom lens. The output signal is available for NTSC distribution.

G. Elmo mini-Video Camera Model EC 202 II

This camera can be placed in many locations throughout the aircraft. Nadir, side, or zenith views can be obtained from various viewports. The lens is "C" mounted, auto-iris f 1.2-, 8-48-mm. The output signal is available for NTSC distribution.

H. Two Elmo Video Cameras, Model EM 102 II

These cameras can be used in very small places due to the miniature CCD lens assemblies, approximately 2.75-in. long with a 0.7-in. diameter. They are non-auto-iris with 4-, 7.5-, 15-, and 24-mm lenses available.

I. Duncan CIR Camera

The Duncan CIR (Color Infrared) camera is a 3-CCD false-color Near Infrared digital camera. It images 3 spectral bands from 400-1100 nm, producing high resolution images similar to false-color photographic film. It also provides an analog real-time NTSC video output.

J. Panasonic Video Recorder Model AG-6740

Three S-VHS/VHS format time-lapse recorders are available, which can provide 2 to 6 hours of continuous recording. Time-lapse recording is also available at a selection of interval rates. With the S-VHS/VHS format, 400 lines of horizontal resolution are available. Internal, operator-set clock time or date can be inserted on the tape record in either continuous or time-lapse mode. Audio recording is only available when operating in the continuous mode.

K. Panasonic Video Splitter, Model WJ-450

A quad video splitter is used to consolidate four video NTSC views onto one NTSC distribution cable. This can be used for comparison of related video images.

4. Dropsonde System

A launch tube for the release of standard and Vaisala radiosondes can be located in the aft portion of the cabin, at station 1390. These sondes parachute to the surface while relaying information on atmospheric conditions back to the aircraft. Experimenters must supply their own sondes, receiving, and recording instrumentation.

5. Satellite Weather Pictures

Visible and infrared channel weather images from orbiting satellites can be obtained on the aircraft in flight. An automatic picture transmission (APT) system uses the polar-orbiting NOAA satellites to obtain near real time observation of weather systems. Image availability is subject to satellite ephemeral.

6. Time Information

A. Time Code System

A Datum model 9390-6000 ExacTime GPS Time Code and Frequency Generator (TCG) has been installed in the DC-8 housekeeping rack to provide a standardized time base for the data acquisition system. Time information is available at each experimenter's station, from ICATS via the RS-232 data bus. If required, date and time information can be supplied directly from the GPS timing unit to the experimenter's instrument in IRIG B serial time code.

Prior to a data flight the TCG will be powered up. The unit automatically acquires and tracks satellites based on health status and elevation angle. Time and frequency is determined from satellite transmissions and calculations referenced to UTC through the GPS master clock system.

B. Time Displays

Small display units for universal time can be provided for experimenter’s use when a visual clock would assist experiment operation.

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CHAPTER 9

FLIGHT OPERATIONS

1. Flight Safety

Aircraft flights in general are governed by specific safety rules. Flight conditions in the DC-8 airborne laboratory are different from conditions in commercial passenger airplanes; a major difference is the presence of experimental equipment. This apparatus can pose potential hazards in the aircraft just as it does in conventional laboratories. For this reason, certain safety regulations are implemented for all flights in the DC-8, and specialized safety equipment is carried. All participants in DC-8 flights are required to abide by these regulations, which will be enforced by the command pilot and the mission director. Before flight, an inspection of equipment items in the aircraft will be conducted to assure that they conform to those regulations.

A. Safety Briefings

Safety training sessions are held at the start of each mission. Attendance by all participants is mandatory. These briefings cover the use of emergency exits, life rafts, life vests, fire extinguishers, emergency oxygen (in the event of sudden cabin depressurization), and survival methods following a ditching or Arctic surface landing.

B. Specialized Safety Equipment

The DC-8 carries safety equipment equal to, and often exceeding that carried by comparable passenger aircraft.

1) Seat Belts

All passenger seats are equipped with a combination seat belt/shoulder harness. This must be used during take-off and landing, and whenever the seat belt sign is illuminated. The pilot will indicate when its use is required. The mission director will ensure that all passengers comply.

2) Fire Protection Equipment

A wide variety of fire protection devices are located throughout the aircraft. Two fireboards with fire fighting equipment are located in the main cabin, and one fireboard is located in each cargo hold adjacent to access hatches. Each of these fire boards includes a fire extinguisher (Halon), fireproof gloves, a fire axe, a smoke mask, a seatbelt cutter, and an emergency oxygen bottle.

In addition, individual emergency passenger oxygen system (EPOS) smoke hoods, are provided for both experimenters and the flight crew. These fire hoods provide a 30-minute oxygen supply and are located in the center armrest of each seat pair.

3) Water Survival Equipment

There are four life rafts carried on all flights over water. They are located in the main cabin - two in the ceiling adjacent to the overwing emergency exits, one forward and one aft near the cabin doors. The rafts contain enough rations and gear to sustain each person for one week.

Individual life vests are stowed in the center armrest of each seat pair. The bottom cushion of each seat can be easily removed and used as a flotation aid.

4) Arctic Survival Equipment

Arctic survival kits are carried on all flights over Arctic regions. These kits will sustain each person for one week. They are contained in duffels adjacent to the overwing emergency exits or the aft cabin doors. In addition, virtually all the contents of the life rafts can be used in Arctic conditions. Emergency protective clothing (outer garments) is also provided for each flight participant. These are vacuum packed in duffels stored in the cabin and cargo compartments and are for emergency use only. Arctic clothing for non-emergency ground use, and all inner clothes layering, are the responsibility of the individual.

5) Emergency Exit Lighting

In case of an emergency, a lighting system will automatically illuminate exit signs at each door. Lights located on the seats or experimenter racks will also illuminate the aisles to facilitate egress from the aircraft.

6) Automated External Defibrillator

An automated external defibrillator (AED) is mounted at the rear of the DC-8 cabin for the delivery of early defibrillation to victims of sudden cardiac arrest. Designated aircraft crewmembers are trained in the maintenance and use of this equipment.

In addition, several dedicated medical breathing oxygen bottles are available. These bottles are equipped with cup masks for comfortable use.

C. In-flight Safety

NOTE: Significant information for in-flight safety is outlined below.

1) Emergency Oxygen Equipment

Oxygen masks are located throughout the cabin in the overhead compartments or designated surface mounted boxes. They are within convenient reach of all participants when seated. Should the need arise, the bottom of the compartment or box will automatically open, and the oxygen masks will drop down. The crewmembers and the mission director have portable emergency oxygen bottles, and can assist anyone on the aircraft.

2) Intercom Regulation

The aircraft intercom system enables the mission director to monitor experimenter operations and become aware of any safety-related problem immediately. At least one member of each research group is required to be on the intercom at all times. Extra-length cables can be provided if necessary to aid experiment operations.

3) Cargo Areas

Access to cargo areas is permitted in flight, but not during take-off and landing. Also, at aircraft altitudes above 25,000 ft., the experimenter must be accompanied by an aircraft crewmember while in the cargo area. Experimenters must inform the mission director before moving into the cargo areas. They must remain on the intercom while in the cargo area, and must confirm their return to the main cabin with him/her.

4) Proper Attire

Sandals and open-toed or high heel shoes are not allowed in the Experiment Integration Facility, the hangar, or the DC-8. Also, skirts and shorts are not appropriate flight attire for the DC-8. Flight participants wearing these will be asked to change into long pants or a flight suit before being allowed to fly.

5) Airport Security

DC-8 flight participants are warned not to carry items on the DC-8 that are restricted within airport security areas (illegal substances, weapons, etc.) Keep tools aboard the DC-8. Prior to transit flights, the mission manager will check for visa, passport, and other required identification.

6) Optical Windows

An aircraft crewmember will inspect optical windows after take-off and report their status to the mission director. The mission director will then clear the windows for use (rules governing the use of safety slides are covered in chapter 4).

7) Repair Equipment

Electric motor-driven hand tools, heat guns, pencil-type soldering irons, and soldering guns cannot be used in flight. Use of volatile solvents on the DC-8 is not permitted in flight, and must be cleared for use on the ground.

8) Smoking

Smoking is not permitted at any time on the DC-8 or in any DFRC building.

D. Additional Safety Considerations

NOTE: Additional safety considerations are outlined below.

1) Engineering Check Flights

When all the experimental equipment for a mission has been installed, but prior to the scientific data flights, one or more check ("shake-down") flights are made. Experimenters may not participate in these flights.

2) Liquid Disposal

Beverage cups and open containers should not be left unattended, particularly around experimental equipment where accidental spillage could damage electronic components. Glass beverage containers are not allowed on the aircraft, and no liquids are allowed in the overhead compartments.

3) Flight Insurance

Participants must arrange for their own insurance. Please be advised that the DC-8 is operated as a public law aircraft, and as such does not have, or require, a certificate of airworthiness issued by the Federal Aviation Administration. As a consequence, many commercial riders to insurance policies may not provide insurance protection. Insurance can be purchased from commercial sources, on a yearly basis, covering flights on the DC-8 within the U.S. and overseas. Consult with your insurance agent about the coverage of policies you hold.

4) Medical Clearance

DC-8 flight participants must be free from significant medical conditions, which would put the individual at risk from flight or travel to another country. Contact the mission manager for specific requirements.

2. Flight Management

Various aspects of the DC-8 flight management regimen follow.

A. Aircraft Crew

The aircraft crew consists of the flight crew (pilot, copilot, flight engineer, and navigator), the mission director and assistant mission director, and two technicians. The mission director provides the direct link between experimenters and the flight crew. Stationed at the main control console, he/she arranges for power, gives pertinent instructions over the intercom, and provides general assistance to the experimenters.

Two technicians accompany each flight to operate the housekeeping equipment (time code generator, TV system, and recorders), to operate the ICATS, and to service the intercom and power systems, if necessary. They may be available to assist experimenters with limited in-flight repairs if the mission director permits. A photo technician is available to operate DFRC camera equipment, when necessary.

B. Flight Planning

General flight plans are developed before the start of the flight period. Experimenters should develop desired plans and acceptable alternates in consultation with the mission manager and navigator. Flight planning can be a lengthy process, and may require several iterations to develop a plan satisfactory to all personnel concerned. In addition, flight over foreign countries requires approval of specific flight plans by the host country well in advance (at least two months) of the actual flight period.

Selection of a specific flight plan should be made at least a day in advance, or in accordance with guidelines developed for each specific mission. This will allow the Airborne Science flight planners time to incorporate minor changes, update weather information, and obtain clearance, prior to pilot review and approval. Copies of the flight plans are available from the mission director.

C. Logistics

Logistical considerations (notice of flight times, flight meals, and off-base operations) are briefly outlined in the following text.

1) Flight Times

A notice will be posted in the Experiment Integration Facility, at the Airborne Science Directorate office, and on the aircraft, giving the time and date of each flight. It will also state the time for power-up and door closing. The aircraft door is closed well in advance of the take-off to permit necessary checks to be made. Any experimenter not on board by that time will miss the flight.

2) Flight Lunches

Experimenters are generally responsible for their own lunches. However, the aircraft galley may be provisioned for flights originating from locations where the purchase of a bag lunch by an individual is inconvenient. This will be announced prior to the flight. Bottled water, coffee, tea, packages of instant soup, and a microwave oven are available in the galley area at the rear of the main cabin.

3) Deployed Operations

Experiment installation and checkout are completed at DFRC before transit to a deployment site. Whenever possible, experimenters and their support team members will be accommodated on this transit flight. However, as the ground crew may also be on the transit flight, it may be necessary to limit team size. Some participants may be required to fly commercially to the deployment site. The mission manager will assign available space for experimenter teams on the DC-8. Experimenters' baggage is hand carried aboard the aircraft. Each piece should be identified with the owner’s name.

Within size and weight limits, which vary for each mission, experimenters may carry spare parts for their experiments on the aircraft. Special arrangements can be made for shipping larger amounts of spare equipment and supplies.

DFRC Airborne Science Directorate Office or the designated science-project office normally make arrangements for housing, group transportation at deployment sites, and for customs inspections in foreign countries. The mission manager will publish details of these arrangements including visa and passport requirements in an experimenters’ bulletin.

4) Housekeeping Considerations

Experimenters are responsible to pick up and clean up after themselves. Tools, while not in use, must be properly stowed away and trash or debris must be disposed of in an appropriate manner.

D. Experiment Operational Considerations

NOTE: Operational matters of concern to experimenters are included below.

1) Electrical Power Blackouts

A power interruption of a few minutes occurs when the engines are started, during the change over from ground power to aircraft power. The mission director informs all experimenters, and requires shutdown of all experiments for this period. A similar delay occurs at the end of a flight, when the engines are shut down. Prior arrangements should be made if electrical power is needed for post-flight calibration or other purposes.

2) Cabin Environment

For high altitude cruise conditions, the cabin is pressurized to an equivalent of 7,500 ft (2.286m) altitude, and temperature is maintained at 65 to 75 °F (18 to 24 °C). Relative humidity normally decreases with time in flight, from the local airfield value at takeoff to a relatively stable 10 to 15 percent within an hour or two (cargo areas are pressurized the same as the cabin, but some areas remain at a lower temperature). Cabin lighting can be controlled as required by experiments.

Special provisions should be made for the local control of temperature-sensitive and/or light-sensitive equipment. The mission manager can advise on these matters.

3) In-flight Repairs

Experimenters may work on their equipment in flight if it is necessary and can be done without affecting other experiments or creating an unsafe condition. However, the mission director's approval must be obtained before any repair work may begin. Equipment removed from its usual position must be replaced securely before landing. The use of aisle space for repairs is not permitted.

CHAPTER 10

GROUND OPERATIONS

1. General Definition

The full and continuous involvement of the experimenters and their teams is required during the mission integration and operation periods at DFRC. Experimenters are responsible for the timely completion and submittal of the "Dryden Airborne Science Investigator Questionnaire", available at http://www.dfrc.nasa.gov/airsci/question.html. Once at DFRC, the experimenter is responsible for the assembly, installation, checkout, and operation of their equipment, to specified aircraft standards. The mission manager is responsible for all the mission functions, facilities, schedules, reviews, and support resources. The mission manager and the Airborne Science staff are always prepared to assist in the solution of problems that may arise.

2. Experiment Assembly and Checkout

Assembly and checkout of all the experiments involve the following elements:

A. The Experiment Integration Facility

The Experiment Integration Facility (EIF) is located on the ground floor of Building 1623. The EIF provides an area for assembly and checkout of experiments before their installation on the aircraft. Incoming equipment is delivered to this point. The EIF manager will provide supplies and other routine services on request.

EIF facilities include: 60-Hz, 400-Hz, and 28 VDC power, compressed air, a freezer for photographic film storage, and oscilloscopes. Gaseous and liquid nitrogen and helium are available for cryogenic or other use by advance request to the mission manager. The mission manager will assure a continuing supply; however, he/she should be advised well in advance of requirements for additional amounts of liquid helium. Approved fasteners and other equipment mounting hardware are also available.

Tools belonging to NASA DFRC and Airborne Science contractor personnel are not for loan. Experimenters are encouraged to bring a complete set of needed tools with them.

All tools belonging to the experimenters are to have identification markings on them. It is expected that the tools will be inventoried and a system of control over the tools will be used during equipment installation and while on deployment.

The EIF is open in the morning at 7:30 a.m. and can be made available for evening work. For safety reasons, two or more people must be present in the EIF at all times. Requests for evening use must be coordinated with the mission manager.

B. Support Services

The mission manager will arrange engineering, fabrication, and safety resources, as needed, to support mission activities. The staff includes a DC-8 operations engineer who can assist the experimenter with the interface of equipment to the aircraft. The operations engineer is responsible for the airworthiness of the aircraft, the proper integration of the payload, and the safe disposition of aircraft maintenance and inspection issues. He/she is available for questions regarding aircraft ground operations, airworthiness approvals of experimenter equipment, and integration issues.

Technicians are located near the EIF and can assist in the interfaces between the experiments and aircraft systems such as aircraft power, ICATS, and the timing system. The technicians are assigned to the aircraft, and are not available to support work on experimental equipment. Experimenters should include an electronics technician on their team, if the need for such assistance is anticipated during experiment assembly and checkout. For special needs, it is not unusual for experimenters to arrange for electronics support from local suppliers of specific equipment.

The metal fabrication shops at DFRC are equipped to make special mounting hardware. However, unless requirements are discussed, and agreement reached during the early planning phase with the mission manager, it is assumed that the experimenter will provide such items. Requests for minor adjustments or small brackets can be handled on short notice during assembly.

NOTE: Shop facility's ability to support short notice requests or requirements may be limited by other priorities.

C. Inspection

Before any equipment may leave the EIF for installation in the aircraft, an inspection is required for its compliance with all safety requirements. The aircraft inspectors will explain any irregularities and suggest ways of handling them. A clipboard with a discrepancy sheet will be attached to each rack to indicate any problem and proper corrective actions.

The inspectors and operations engineer are generally available throughout the checkout period, and they should be asked for advice and assistance regarding the need for straps, trays, or other special restraints during the process of assembly. The inspectors also look for other safety hazards, such as equipment with sharp or projecting edges, and they will request that such hazards be corrected (such as padding with a suitable material). The inspection will also cover conformity to electrical safety requirements. The inspector will check to see that all the cabling is properly secured and protected against abrasion. A check will be made to ensure proper equipment operation without tripping the ground fault interrupter (GFI) devices.

D. General Procedures

The assembly and checkout period should be used to full advantage since problems delayed until installation can impact the scheduled sequence of operations for all the experimenters. It is customary to hold daily formal group meetings, at which the experimenters discuss their progress and problems with the mission manager and operations engineer. Timely action will be initiated to resolve problems that may delay the installation schedule.

To assure a successful final inspection and corresponding safety approval, the experimenter should consult frequently with the mission manager and the operations engineer during assembly concerning the use of support hardware, fasteners, and cable ties. The operations engineer will be available to sketch small brackets for fabrication, to recommend structural changes to existing hardware, and to arrange for items to be mounted on top of racks.

Each item of equipment must be weighed and its weight marked on it (removable tape may be used). An inspector can then readily check the total calculated weight and the overturning moment of each rack. Scales are available adjacent to the EIF.

Storage bins in which small test equipment, tools, notes, tapes, etc. may be stored, are available for panel mounting on the racks. The mission manager will arrange for these bins on request.

Operation of all equipment should be checked out in the EIF. Power connectors for both 60 and 400-Hz, identical to those used in the aircraft, are available. These connectors should be used to ensure that assembled equipment, in each rack, will not trip the GFI devices in the aircraft.

E. Safety and Emergency - Hangar

CAUTION: Significant instructions for hangar safety are listed below.

At DFRC, experimenters work in an environment generally unavailable to the public. The EIF is housed in a large hangar containing a number of aircraft, and it is sometimes necessary to walk through the hangar and on to the ramp area. Therefore, a certain number of safety precautions must be observed:

1) Smoking in the hangar, on the ramp, or in any DFRC building is prohibited.

2) Look out for cables, hoses, boxes, tow bars, moving vehicles, and movement of the hangar doors when crossing the hangar floor.

3) Do not walk directly across the ramp. Travel along the edges of the ramp when entering or exiting the DC-8 outside.

4) Do not approach aircraft with engines running. Jet exhaust or prop wash is dangerous for a considerable distance behind the aircraft.

5) Wear adequate clothing and shoes that totally enclose the foot.

6) Ear protection is required while outside the aircraft when engines are running.

IN AN EMERGENCY

If a DFRC employee is not available for immediate assistance, dial this number from any telephone:

911
For Emergency Aid
Fire, Accident, Etc.

This emergency number is available at any hour. Callers should also be able to describe their location, so that emergency help can respond promptly.

3. Installation of Experiments

Following inspection and approval of equipment for aircraft installation, DC-8 technicians will transport and install it in the aircraft. They will be working to the cabin layout drawings and time schedule provided by the mission manager. The experimenters or their representative must be present during installation to advise and assist as necessary. Following the mechanical installation, the engineering technicians will work with the experimenter. They will complete the cabling installation from the aircraft systems to the experiment, and they will advise as requested on cabling between racks and other experiment equipment.

No work may be done in the aircraft unless a crewman or other designated Airborne Science representative is present (aircraft doors may not be opened or closed by any experiment personnel). The aircraft is usually available on a split-shift basis, from 7 a.m. to 7 p.m., or a two-shift basis, from 7 a.m. to 11 p.m. Additional time, including weekends, requires overtime for the ground crew and must be arranged for in advance. Budgetary limitations may preclude time in excess of two shifts on a five-day-week basis.

If special positioning of the aircraft is required for experiment alignment or checkout, the mission manager or operations engineer should be notified a week or more in advance. This will allow time for obtaining the proper approval, and scheduling of ramp activities. Laser tests require NASA and FAA approval, which often require several weeks' time.

A. Electrical Power

Power is normally available on the aircraft for checkout when the aircraft is in the hangar or parked on the ramp. At these times, power comes from the ground generators producing 400-Hz ac. The stability of these sources is not necessarily as well controlled as the aircraft engine generators used in flight. Power in 60-Hz form is obtained from the electronic converters in the aircraft, or from an external source of ground power.

CAUTION: Power distribution in the aircraft is controlled from the mission director's station. Experimenters are not authorized to switch power at this location. Upon request, only the aircraft technicians, the mission manager, his/her assistant, the operations engineer, or a member of the ground crew will switch power to the appropriate station.

Due to periodic maintenance and/or installation procedures, the ground crew may need to shut down electrical power for short periods of time. If power is needed for an uninterrupted period of time for checkout of experimenter equipment within the aircraft, the mission manager or operations engineer must be advised well in advance. This will allow the work of the ground crew on the aircraft to be coordinated with experimenter's needs.

The mission manager will designate a time for a power check of all experiments. Each experiment’s power station will be turned on sequentially to make current measurements at the mission director’s console. This procedure is necessary to balance loads among the five 60-Hz converters, and to minimize interference among experiments from power transients. This also provides an opportunity for experimenters to check for interference from other experiments.

B. Weight and Balance

Following equipment installation, before any mission flights, the aircraft will be weighed and the balance calculated to determine the center of gravity. Thereafter, weight and location of any equipment that is added or removed must be noted on the record sheet for that purpose, posted near the front door of the aircraft. No removals or add-ons will be permitted less than two hours before door-close on fly-days. This procedure is necessary to maintain the current weight and balance record. Each experimenter is responsible for his own equipment (tool boxes, boxes of manuals, etc.), and must post entries when items are removed (even for short periods of time) or returned.

C. Safety and Inspection - Aircraft

CAUTION: Significant instructions for aircraft safety are listed below.

While working in the aircraft on the ground, all participants must observe the following safety rules.

1) No Smoking in the hangar, on the ramp, aboard the aircraft, or in any DFRC buildings.

2) No electric drills or other tools with universal electric motors may be used in the aircraft.

3) Only small, pencil-type soldering irons and electronic-grade rosin-core solder may be used on the aircraft.

4) No high wattage heat guns are permitted on the aircraft. If it becomes necessary to heat shrink insulation, the material must be taken into the EIF, where such treatment can be performed safely.

5) No volatile solvents of any kind are permitted without prior approval of the mission manager.

The inspectors will recheck each experiment installation on the aircraft for full conformity with all safety regulations. Any deficiencies will be noted on an inspection sheet and attached to each rack. These must be signed-off before flight.

4. The Flight Period

Prior to the scheduled mission flights, a series of check flights will be accomplished. The operations engineer will plan and conduct an engineering “shakedown” flight, which verifies the structural integrity and loading of the newly configured aircraft. No experiments will be powered on and no experimenters will on board for this flight. The mission manager will conduct one or more experiment check flights at simulated mission conditions. The purpose of these check flights is to allow experimenters to verify the correct operation of all their equipment, and to become familiar with the flight environment and procedures. These and the subsequent mission flights are scheduled to allow the necessary ground time for aircraft and instrument maintenance procedures.

Generally, the aircraft will be open to experimenters only at stated times, to allow for both research requirements and aircraft maintenance activities.

The experimenters and their teams are expected to observe the procedures and constraints stated in this and the preceding chapters, as well as other limits that may need to be set by the mission manager.

Data processing between flights that requires DFRC support should be arranged in advance through the mission manager.

5. Post-flight Activities

When the flight period is completed, one or two days are scheduled for removal of experiments under the supervision of the operations engineer.

Equipment can be removed rack by rack, or by hand-carrying the various components, at the experimenter’s discretion. Equipment is then returned to the Experiment Integration Facility where research teams pack it for return shipment. Once the experiment team completes the packing, DC-8 shipping and receiving personnel will arrange for transport.

The mission manager will hold a mission debriefing to review results, complete requests for aircraft systems data, and to arrange for post-mission science reviews, if required. The mission manager will also provide any mission related data held in the DFRC Airborne Science Directorate files, upon request. Conversely, the Airborne Science Directorate requests that a copy of any published research results be sent to the Airborne Science Directorate office, in order that science accomplishments may be documented.

APPENDIX A

GUIDELINES FOR EXPERIMENTER RACK LOADING

1. Guidelines

Standard DC-8 experimenter racks for mounting test equipment are available in three sizes (low, medium, and high), which are illustrated in figures 5-4 through 5-6 of this handbook. This appendix presents the allowable loading limits for these racks, and the calculations for determining suitability of a proposed equipment-loading configuration.

Applicable design criteria that establish the loading limits include a 9g forward “crash” load and a 7g downward “gust” load. Overall rack limits encompass the total rack assembly and its attachment to the aircraft, and face-mounted equipment limits consider installation of individual units into the rack. The rack-loading configuration must satisfy both limits.

Table A-1 addresses the overall effects between rack and aircraft. Total allowable loading values are tabulated for each type of rack, both in terms of total weight and overturning moment (total torque). Values for vertical center-of-gravity of installed equipment must be known. Figure A-1 illustrates the rack geometry used to calculate the overturning moment. Note that maximum allowable load is reduced if unequal weight distribution between bays (left and right) offsets the lateral center-of-gravity (L) away from the center post.

Face-mounted equipment is attached to panels of standard 19 in. width and optional height. The panels bolt onto the edge flanges of either bay on each rack, and can be installed either forward- or aft-mounted (distance between forward and aft faces is 24 in.). Figure A-2 illustrates the geometric convention for panel height (H) and center-of-gravity location (L) of face-mounted equipment.

Table A-2 lists the loading limits for face-mounted equipment, as determined by panel height (H), equipment weight (W), moment (M = W x L), and direction of mounting (forward or aft). These limits affect choice of configuration required to install specific equipment. Figure A-3 presents a logic diagram to select type of mounting, whether or not a tray is required, and illustrates four resulting configurations (cases A through D).

Table A-1. Basic loading allowables for low, medium, and high racks.

	Maximum Loads	
	Low/Medium Racks (lb)	High Racks* (lb)
Total Equipment Weight per Rack Mounting Face	300	450
Total Equipment Weight per Rack Bay	300	450
Rack Total Equipment Weight	600	900
Total Moment Produced by Equipment per Rack Bay $\Sigma M = hw + h_1 w_1 + h_2 w_2 + ...$	6,000 in.-lb	9,000 in.-lb

*For rack load on high racks near limiting value, the lateral center-of-gravity (C.G.) should be located at the vertical center post. C.G. offset may reduce allowable weight:

C.G. Offset, in.	Allowable Weight, lb
3.0	780
6.0	700

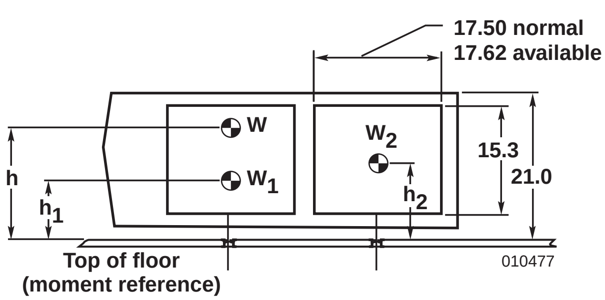

Figure A-1(a). Low rack.

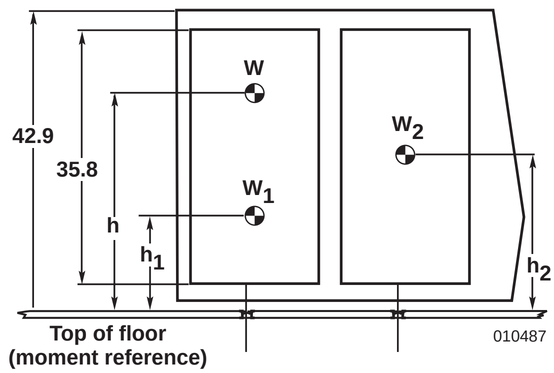

Figure A-1(b). Medium rack.

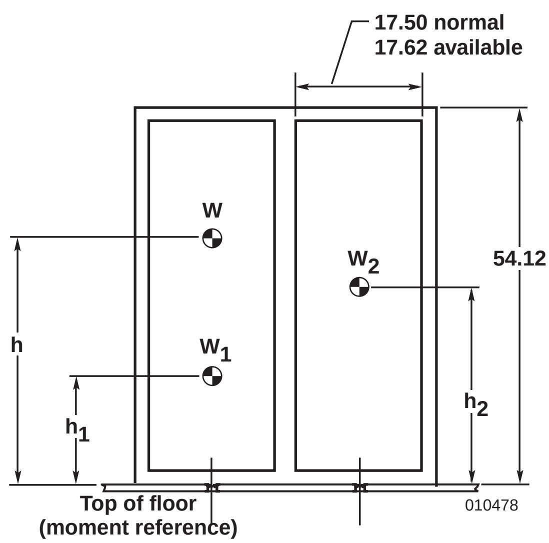

FIgure A-1(c). High rack.

Examples to illustrate usage of table A-2 and figure A-3 to determine suitability and selection of loading configurations are also presented. If questions arise concerning a particular loading configuration or applicable limits, contact the mission manager to request engineering assistance.

2. Examples

Some loading examples with calculations are presented here to illustrate the use of figure A-3 and table A-2. Figure A-3 shows rack-loading options using four types of support (cases A through D). As equipment weight increases, so does the corresponding support and restraint requirements.

The accompanying logic diagram in figure A-3 traces a decision tree to compare actual values against the limits tabulated in table A-2, and thereby determine which loading option is appropriate for each instance and within allowable limits.

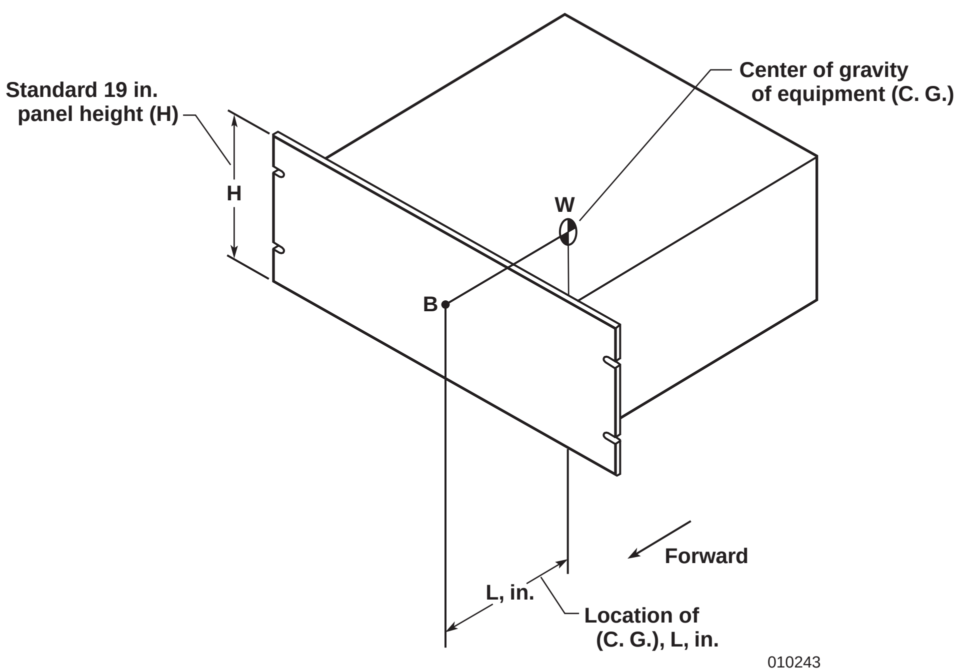

Figure A-2. Standard face mounted equipment.

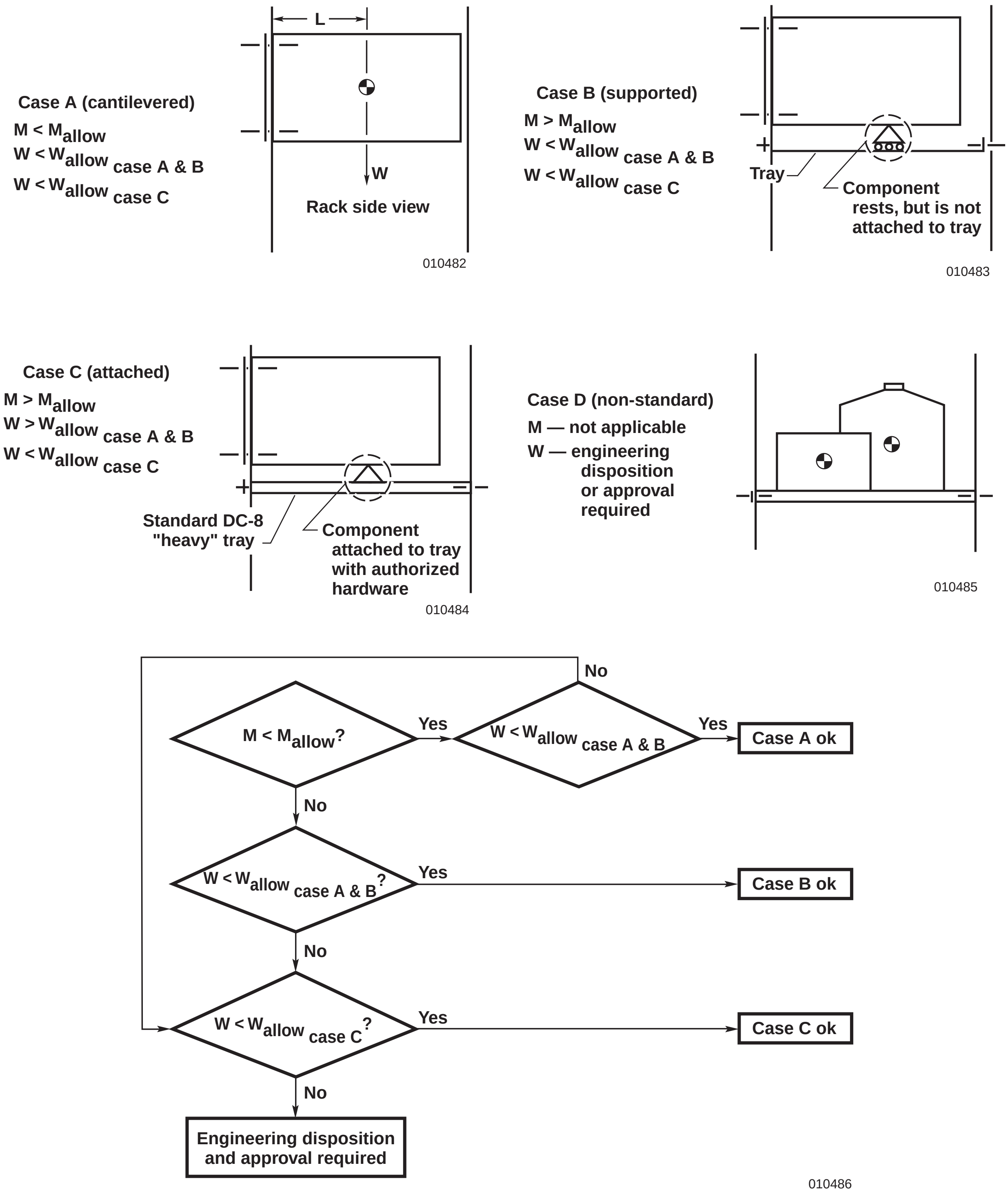

Figure A-3 . Configuration examples and flow chart.

Table A-2. Allowable loading for face-mounted equipment.

	Low and Medium Rack			High Rack		
Standard panel height (in.)	M_{allow} (in.-lb)	W_{allow} Fwd/aft-mount (lb)		M_{allow} (in.-lb)	W_{allow} Fwd/aft-mount (lb)	
	case A	cases A and B	case C	case A	cases A and B	case C
3.5	73	23/35	38/63	123	53/53	92/129
5.25	84	35/52	50/80	185	79/79	118/155
7	124	46/70	61/98	245	105/105	144/181
8.75	163	58/87	73/115	305	132/132	171/208
10.5	244	70/105	85/133	365	158/158	197/234
12.25	2912	81/122	96/150	430	184/184	223/260
14	338	93/140	108/168	490	211/211	250/287
15.75				550	237/237	276/313
17.5				615	263/263	302/339
19.25				675	290/290	329/366
21				735	316/316	355/392
	△1	△1 △2 △4	△3 △4	△1	△1 △2 △5 △6	△3 △5 △6

Case D (figure A-3) requires engineering disposition/approval when equipment weight on tray exceeds 28 lb (Low/Medium Rack, aft-mounted) or 76 lbs (high rack, aft-mounted). Reduce these allowables by 1/2 if tray is fwd-mounted.

△1 Case A (cantilevered)

△2 Case B (cantilevered, supported on standard DC-8 light or heavy tray)

△3 Case C (attached and constrained by standard DC-8 heavy tray)

△4 Values based on 30 lb/in. flange allowable (fwd-mount) and 45 lb/in. flange allowable (aft-mount) in a 9-G forward loading condition

△5 Values based on 101 lb/in. flange allowable (fwd- and aft-mount) in a 9-G forward loading condition

△6 Component lateral CG displaced 25 percent left or right of equipment bay centerline

A. Example 1 Rack type—medium

Panel height H = 5.25 in.

Equipment weight W = 12 lb.

Center of gravity L = 6.0 in

Calculate moment = W x L = 12 x 6 = 72 in.-lb

M_{allow} from column (1) of table A-2 shows an 84 in.-lb limit. W at 12 lb is less than either weight in column (2), so case A applies. The equipment can be simply face-mounted (cantilevered) in a low or medium rack, either forward- or aft-mounted.

B. Example 2 Rack type—unspecified

Panel height H = 5.25 in.

Equipment weight W = 15 lb

Center of gravity L = 6.0 in.

Calculate moment = W x L = 15 x 6 = 90 in.-lb

This equipment is only 3 lb heavier than example 1, but the 90 in.-lb moment now exceeds the M_{allow} of 84 in.-lb for case A. It is still below the weight limits of column (2), so case B applies. The equipment can be face-mounted in a low or medium rack, either forward- or aft-mounted, but a tray is needed to help support the equipment. Note that this equipment may be safely mounted in a high rack without a tray.

C. Example 3 Rack type—unspecified

Panel height H = 5.25 in.

Equipment weight W = 50 lb

Center of gravity L = 3.5 in.

Calculate moment = W x L = 50 x 3.5 = 175 in.-lb

This equipment represents a heavier load, with the center of gravity (L) closer to the face. The moment exceeds low and medium rack allowables (case A), and the weight exceeds the tray-supported limit of case B. However, it is within the aft-mounted limit (52 lb) for case B. Note that it could still be forward-mounted in a low or medium rack if it were configured as case C (attached) where 50 lb is just at the limit for forward face-mounted hardware attached to a tray. Note also that it could be cantilevered on a high rack as in case A, where the moment limit is 185 in.-lb.

D. Example 4 Rack type—unspecified

Panel height H = N/A

Equipment weight W = 120 lb

Center of gravity L = 12 in.

This case represents non-standard equipment attached directly to a tray, without any rack facing, as shown in case D. Contact the mission manager to request engineering assistance, as this type of case requires individual consideration. The method of tray installation requires adequate attachment of the tray to the flanges of the rack to properly distribute a 9-g forward load, and is dependent on the equipment configuration being installed.

APPENDIX B

DFRC AIRBORNE SCIENCE CRYOGENIC HANDLING PROCEDURES

1. Scope

Use of cryogenic liquids at DFRC is controlled by Dryden Centerwide Procedure DCP-S-039, “Cryogen Safety”. This document contains supplemental information for the use of all personnel that have a need to plan requirements, service, or handle cryogen relative to Airborne Science Directorate operations. Areas of operations are defined as any Airborne Science Directorate facility at DFRC or on any deployment, and the DC-8 aircraft and payloads.

2. Purpose

The purpose of this document is to describe the principal hazards and appropriate safety procedures associated with cryogens that are commonly used such as liquid oxygen, hydrogen (not allowed on NASA DC-8), ammonia, nitrogen, helium, argon, fluorine, and carbon dioxide.

3. Equipment Requirements

- Gastech GX-82 three-way gas alarm or equivalent
- Gastech OX-82 oxygen indicator or equivalent
- Gloves, cryogenic
- Apron, Neoprene or heavyweight rubber coated
- Safety glasses
- Goggles
- Full face shield

4. General Properties

Because all cryogenic fluids exist as liquids only at temperatures considerably below ambient (temperatures in the range of –324 °F), normal storage facilities and fluid containment in process systems must allow for the unavoidable heat input from the environment. For ordinary operations this means good insulation, adequate pressure-relief devices, and proper disposal or recycling of the gases that are continually produced. Full containment of the fluid as a liquid at room temperature is usually not feasible: the pressure required to maintain helium at liquid density at room temperature is 18,000 psi; for nitrogen it is 43,000 psi.

The chemical properties and reaction rates of substances are changed under cryogenic conditions. Liquid oxygen, for example, will react explosively with materials usually considered to be noncombustible. Remember that condensing a cryogen from a pure gas at room temperature will concentrate the material typically 700-800 times.

Cryogenic temperatures drastically affect material properties: ductile materials become brittle, material shrinkage exceeds anticipated values, leaks can develop that are not detectable at room temperature even under considerable pressure, etc. Hence, the suitability of materials must be carefully investigated before they are employed in cryogenic service.

5. Labeling

Storage dewars, process vessels, piping, etc., shall be labeled with the common name of the contents. In many cases, it is also desirable to post emergency instructions, emergency call numbers, etc. adjacent to the equipment.

6. Pressure Relief

Heat flux into the cryogen is unavoidable, regardless of the quality of the insulation provided. Pressure relief must be provided to permit routine off gassing of the vapors generated by this heat input. Typically spring-loaded relief devices or an open passage to the atmosphere best provides such relief.

Additional relief devices should be provided as backup to the operational relief, especially when the capacity of the operational relief device is not adequate to take care of unusual or accident conditions. This may be the case if the insulation is dependent on the maintenance of a vacuum in any part of the system (this includes permanently sealed dewars), if the system may be subject to an external fire, or if rapid exothermic reactions are possible in the cryogen or a container cooled by the cryogen. In each case, relief devices capable of handling the maximum volume of gas that could be produced under the most adverse conditions must be provided. Frangible disks are recommended for this service.

Each and every portion of the cryogenic system must have uninterruptible pressure relief. Any part of the system that can be valved off from the remainder must have separate and adequate provisions for pressure relief.

All parts in contact with the fluid shall be rated for cryogenic service. Careful consideration must be given to material compatibility with respect to prevention of embrittlement at cryogenic temperatures.

7. Hazards of Oxygen Deficiency

Liquefied gases frequently have a significant potential for creating an oxygen deficiency. When expelled to the atmosphere at room temperature, they evaporate and expand on the order of 700-800 times their liquid volume. Consequently, leaks of even small quantities of liquefied gas can expand to displace large amounts of oxygen, thereby rendering an atmosphere lethal. Without adequate oxygen, one can lose consciousness in a few seconds and die of asphyxiation in a few minutes.

Calculations shall be made to determine whether a given situation of cryogen storage or use will pose an oxygen-deficiency hazard in the event of the worst possible accident. When the level of hazard potential has been ascertained, appropriate safety procedures must be taken. Where the danger is sufficient to warrant it, this may entail the use of an oxygen monitor such as an OX-82 or GX-82. Positions for oxygen monitors should include the lowest point in the area because the cold, dense, escaping gases will be heavier than the warmer ambient air, at least initially.

All employees working in the vicinity of an area where an oxygen deficiency could develop shall be trained as to the nature of the hazard and the appropriate response they should make in the event of cryogen release. Along with training, these areas shall be posted to remind the workers and alert visitors in the area to the hazard.

CAUTION: Any rescue work conducted in an oxygen-deficient atmosphere must be done in a self-contained breathing apparatus or airline equipment.

8. Hazards of Air-Freezing Cryogens

Certain cryogens, such as helium and hydrogen, are cold enough to solidify atmospheric air. The system must be pressurized in order to prevent the entry of air into such cryostats. If openings to the atmosphere exist, they are likely to become plugged by solidified air, leading to overpressure and vessel failure if they are relied on for pressure relief. Such conditions will also result in hazardous contamination of the fluid. Again, adequate pressure-relief devices must be provided to vent all gas produced in case of maximum possible heat flux into the system. Unless these fluids are handled in vacuum-jacketed vessels and piping, air will also condense on the exterior of the system. This condensate will be rich in oxygen content. The hazards created by this include frostbite from touching the cold surfaces, dripping liquid air (because it is oxygen-enriched), and exploding insulation. The latter can happen when air condenses between the metal surface and the insulating layer. On warming, the air vaporizes and can rip off the insulation with explosive force. Such insulation systems must be specially engineered to prevent air penetration.

9. Hazards of Carbon Dioxide Toxicity

In addition to producing an oxygen deficiency, carbon dioxide also affects the breathing rate because of its role in the respiratory process. A concentration of 0.5% carbon dioxide in the air will begin to stimulate a more rapid breathing rate; when 3% carbon dioxide is present in the air, lung ventilation will double; 10% carbon dioxide can be tolerated for only a few minutes. A condition of 10% carbon dioxide and 90% normal air actually has an oxygen concentration of 20.9%. This degree of oxygen deficiency would not be considered immediately dangerous to life or health if the contaminant gas were nitrogen, helium, or argon instead of carbon dioxide. Obviously it is important to measure the carbon dioxide/nitrogen concentration, especially if it is suspected that this gas may be present at levels greater than 0.5%.

CAUTION: Any rescue work conducted in an oxygen-deficient atmosphere must be done in self-contained breathing apparatus or airline equipment.

10. Hazards of Oxygen Enrichment

Cryogenic fluids with a boiling point below that of liquid oxygen have the ability to condense oxygen out of the air if exposed to the atmosphere. This is particularly troublesome if a stable system is replenished repeatedly to make up for evaporation losses; oxygen will accumulate as an unwanted contaminant. Violent reactions (such as rapid combustion or explosions) may occur if the system or process is not compatible with liquid oxygen.

Oxygen enrichment will also occur if liquid air is permitted to evaporate (oxygen evaporates less rapidly than nitrogen). Oxygen concentrations of 50 percent may be reached. Also remember that condensed air dripping from the exterior of cryogenic piping will be rich in oxygen.

11. Personal Protective Equipment

The potential for freezing by contact with the extreme cold of cryogens necessitates varying degrees of eye, hand, and body protection. When cryogens are spilled, a thin gaseous layer apparently forms next to the skin. This layer protects one from freezing, provided the contact with the cryogens involves small quantities of liquid and brief exposures to dry skin. However, having wet skin or exposure to larger quantities of cryogens for extended periods of time can produce freezing of the tissue.

The most likely cause of frostbite to the hands and body is contact with cold metal surfaces. Because there is no protective layer of gas formed, frostbite will occur almost instantaneously, especially when the skin is moist.

The damage from this freezing (frostbite) occurs as the tissue thaws. Intense hyperemia (abnormal accumulation of blood) usually takes place. In addition, a blood clot may form along with an accumulation of body fluids, which decreases the local circulation of blood. Gangrene may result if the consequent deficiency of blood supply to the affected cells is extreme.

Cooling of the internal organs of the body can also disturb normal functioning, producing a condition known as hypothermia. It is very dangerous to cool the brain or heart to any great extent.

Using safety glasses with side shields is required at all times when cryogenic fluids are present. Goggles provide the best protection for the eyes. If a cryogen is poured or if the fluid in an open container may bubble, a full-face shield is required. This additional protection is also recommended when valves are actuated on piping systems, etc., unless the operator is shielded from leaks at potential failure points.

Hand protection is primarily required to guard against the hazard of touching cold surfaces. Loose, non-asbestos insulating gloves, that can be tossed off readily in case they become soaked with cryogen, may be worn. Special gloves made for cryogenic work are required.

Cryogenic handlers should wear boots and cuff-less trousers extending over the boot. All persons handling cryogens shall wear closed-toe shoes that cover the top of the foot. Industrial clothing made of nonabsorbent material is usually satisfactory. Long-sleeved clothing is recommended for arm protection. An apron made of Neoprene or heavyweight rubber coated material is required for use with cryogens. Where exposure to drenching is possible, a full protective suit with supplied air should be considered; however, the system should be engineered to prevent the possibility of such an exposure.

Tongs or other tools should be used to lift objects out of the liquid or liquid baths.

12. Immediate Treatment for Frostbite

- Warm the affected area rapidly by immersion in water not to exceed 105 °F, with body heat, or by exposure to warm air. Safety showers with warm water should be provided where there is a sufficient probability of the occurrence of such an accident. In the event of massive exposure, remove clothing while showering. Do not expose the body to open flame. Maintain the affected area of the victim at normal body warmth until professional help arrives.

- Calm the victim and avoid aggravating the injury. People with frostbitten feet should not walk on them. Do not rub or massage the affected parts of the body.

- Prevent infection—use a mild soap to clean the affected area. Dressings need not be applied if the skin is intact.

- If affected, flush eyes with warm water for at least 15 minutes.

- Report to NASA DFRC Health Unit for medical attention promptly.

13. Training Procedures and Safety Notes

Only personnel fully aware of the properties of cryogenic fluids should handle cryogenic materials and equipment. They should be mindful of the consequences of misadventure. Operators should be selected on the basis of capability to understand the hazards and the equipment, mature judgment, and the ability to follow established procedures. Copies of the appropriate MSDS shall be posted in the vicinity of the cryogen being used, handled, or stored.

APPENDIX C

OUTPUT PARAMETERS FROM ICATS

1. Introduction

This appendix to the ICATS description document lists the parameters that are presently thought meaningful to users and selectable from the ICATS database. ICATS handles many more parameters within itself. Some are just for internal use to compute other parameters meaningful to users. Parameters on this list are selected and distributed to experimenters via RS-232 data lines. They are also selected to display on video at each experimenters rack. Column 1 lists the parameter identification code (PARM ID). Column 2 lists the engineering units for that parameter. Column 3 contains general information on the parameter, which includes: parameter description, parameter engineering unit, range, sign convention and other comments regarding the measurement when applicable.

2. Data From Time Code Generator

Note: All parameters from TCG shown below are available in ICATS database for use in display, computation and archiving.

Parameter ID	Units	Comments
year	year	Source: CPU
month	month	Source: Derived from GPS's day_of_year and year.
day	day	Source: Derived from GPS's day_of_year and year.
day-of-year	days	The day number of the present date according to GMT. Source: Datum Model 9110-663-TCG Range: 1 to 366.
time_in_hrs	hrs	Source: TCG, computed to total hours.
time_in_secs	secs	Source: TCG, computed to total seconds.
time in msec	msec	Source TCG, computed to total milliseconds.

3. Data From Honeywell Embedded GPS/INS 1553 Bus

Note: For ASCII data distributed through RS-232, time in block A and C are in break-down format HH:MM:SS.XXX and range from 00:00:00.000 to 23.59.59.999.

Parameter ID	**Units**	**Comments**
eo06_egr_lat	deg	EGR latitude
eo06_egr_lon	deg	EGR longitude
eo06_egr_alt	ft	EGR altitude
eo06_egr_vel_east	ft/sec	EGR velocity east
eo06_egr_vel_north	ft/sec	EGR velocity north
eo06_egr_vel_up	ft/sec	EGR velocity up
eo17_mode_word1	n/a	message 17 mode word1
eo17_velocity_x	ft/sec	message 17 velocity x
eo17_velocity_y	ft/sec	message 17 velocity y
eo17_velocity_z	ft/sec	message 17 velocity z
eo17_platform_az	deg	message 17 platform azimuth
eo17_roll_angle	deg	message 17 roll angle
eo17_pitch_angle	deg	message 17 pitch angle
eo17_pres_true_hdg	deg	message 17 present true heading
eo17_pres_mag_hdg	deg	message 17 present magnetic heading
eo17_accel_x	ft/sec^2	message 17 acceleration x
eo17_accel_y	ft/sec^2	message 17 acceleration y
eo17_accel_z	ft/sec^2	message 17 acceleration z
eo17_msl_alt	ft	message 17 altitude mean sea level
eo17_mode_word2	n/a	message 17 mode word^2
eo17_roll_rate	deg/sec	message 17 roll rate
eo17_pitch_rate	deg/sec	message 17 pitch rate
eo17_yaw_rate	deg/sec	message 17 yaw rate
eo19_lon_accel	ft/sec^2	message 19 longitudinal acceleration

Parameter ID	Units	Comments
eo19_lat_accel	ft/sec^2	message 19 lateral acceleration
eo19_normal_accel	ft/sec^2	message 19 normal acceleration
eo19_roll_ang_accel	deg/sec^2	message 19 roll angular acceleration
eo19_pitch_ang_accel	deg/sec^2	message 19 pitch angular acceleration
eo19_yaw_ang_accel	deg/sec^2	message 19 yaw angular acceleration
eo19_blended_lat	deg	message 19 blended mode’s latitude
eo19_blended_lon	deg	message 19 blended mode’s longitude
eo25_true_air_spd	kn	message 25 true air speed
eo25_pres_mag_gnd_trk	deg	message 25 present magnetic ground track
eo25_pres_drft_ang	deg	message 25 present drift angle
eo27_pres_pos_lat	deg	message 27 present position latitude
eo27_pres_pos_lon	deg	message 27 present position longitude
eo27_wind_direction	deg	message 27 wind direction
eo27_wind_velocity	kn	message 27 wind velocity
eo27_pres_gnd_spd	kn	message 27 present ground speed
eo27_pres_true_gnd_trk	deg	message 27 present true ground track
eo27_predicted_gnd_spd	kn	message 27 predicted ground speed
eo27_position_err_north	nmi	message 27 position error north
eo27_posi_error_east	nmi	message 27 position error east

4. Data From Radar Altimeter 1553 Bus

Parameter ID	Units	Comments
ra_01_mode_word	n/a	Radar altimeter mode word
ra_01_rada_alt	ft	Radar Altitude - Aircraft altitude in feet above land or water as measured by radar. Source: Honeywell APN-222 electronic altimeter system. Range: 0 to 70,000 ft
ra_01_rada_alt_rate	ft/sec	Radar altitude rate

5. Data From Navigational Management System ARINC-429

Primary source for NMS data will be from NMS1. NMS2 could be selected during flight should one fail. Also mission manager and ICATS operator can select NMS1 or NMS2 during flight for data source.

Parameter ID	Units	Comments
nms_dist_go	nmi	Distance to go- the distance measured along a great circle path with respect to the aircraft's present position and the next selected waypoint. Range: –4,096 nmi Orientation: + to selected waypoint – from selected waypoint
nms_time_go	min	Time to go to the next waypoint.
nms_x_trk	nmi	Cross track distance: The distance left or right from the desired track to the aircraft's present position measured perpendicular to the desired track. Range: –128 nmi Orientation: + right of desired track – left of desired track
nms_des_trk	deg	Desired track. Range: 0 to 360 deg
nms_drft_ang	deg	Drift angle: The angle between the desired track and the aircraft's heading. Range: –39.9 deg Orientation: + desired track right of aircraft heading – desired track left of aircraft heading

Parameter ID	Units	Comments
nms_lat	deg	Latitude: The aircraft's present latitudinal position over the surface of the earth relative to the equator. Range: ±90 deg Orientation: + north of the equator – south of the equator
nms_lon	deg	Longitude: The aircraft's present longitudinal position over the surface of the earth relative to the prime meridian. Range: ±180 deg Orientation: + east of the prime meridian – west of the prime meridian
nms_grnd_spd	knots	Ground speed: The aircraft's speed over the ground in knots. Range: 0 to 2,000 knots.
nms_trk_ang	deg	Track angle: The actual path of the aircraft over the surface of the earth measured with respect to true north through 360 deg. Range: 0 deg to 360 deg
nms_true_hdg	deg	True heading: The angle between true north and the longitudinal axis of the aircraft. Range: 0 to 360 deg
nms_wind_spd	knots	Wind speed: The horizontal velocity of the air mass at aircraft's present position. Range: 0 to 256 knots
nms_wind_dir	deg	Wind direction: The direction the wind is coming from as measured from the north. Range: 0 to 360 deg
nms_ns_vel	knots	North-South vector velocity: The north-south vector velocity component of the aircraft's ground speed. Range: ±2000 knots Orientation: + north – south
nms_ew_vel	knots	East-West vector velocity: The east-west vector velocity component of the aircraft's ground speed. Range: ±2000 knots Orientation: + east – west

Parameter ID	Units	Comments
nms_wind_nose	knots	Wind on nose. Orientation: + head wind – tail wind
nms_pres_alt	ft	Present altitude.
nms_dist_dest	nm	Distance to destination (end of the flight plan).
nms_time_dest	minutes	Time to go to the end of the flight plan.
nms_towypt_lat	deg	To-waypoint latitude: The latitude of the to-waypoint. Range: ±180 deg Orientation: + north of the equator – south of the equator
nms_towypt_lon	deg	To-waypoint longitude: The longitude of the to-waypoint Range: ±180 deg Orientation: + east of prime meridian – west of prime meridian
nms_frwypt_lat	deg	From-waypoint latitude: The latitude of the from-waypoint. Orientation: + north of the equator – south of the equator
nms_frwypt_lon	deg	From-waypoint longitude: The longitude of the from-waypoint. Range: ±180 deg Orientation: + east of the prime meridian –west of the prime meridian
nms_tac_freq	MHz	TAC frequency
nms_vor_freq	MHz	VOR frequency
nms_dme_freq	MHz	DME frequency
nms_cal_timetogo	min	Calculated time to go to next waypoint. Calculated from distance-to-go and ground-speed.
nms_trk_ang_err	deg	Track angle error calculated from current track angle and the desired track
nms_to_wyptnum	n/a	To-waypoint number.
nms_fr_wyptnum	n/a	From-waypoint number.

6. Data From Air Data Computer ARINC-429

Parameter ID	Units	Comments
adc_palt	ft	Pressure altitude: Aircraft pressure altitude in ft corresponding to U.S. Standard Atmosphere. Range: –1,871 to 57,343 ft
adc_balt	ft	Barometric altitude Range: –1 ,871 to 57,343 ft
adc_sat	°C	Static air temperature: Ambient air temperature at aircraft's present position. Range: –99 °C to 60 °C
adc_mach	n/a	Mach Number: The aircraft's speed as a ratio to the speed of sound. Range: 0.1 to 0.99
adc_vert_spd	ft/min	Vertical speed: Vertical climb rate of the aircraft, measured in ft/min. Range: ±20,480 ft/min Orientation: + ascending – descending
adc_tat	°C	Total air temperature.
adc_ias	knots	Indicated airspeed: Indicated airspeed corrected for airspeed indicator instrument error and static pressure source. Range: 30 to 510 knots
adc_tas	knots	True airspeed: The actual speed of the aircraft through the air – computed airspeed corrected for density altitude.

7. Data From Global Positioning System (GPS) ARINC-429

Parameter ID	Units	Comments
gps_lat	deg	GPS latitude: The aircraft's present latitudinal position over the surface of the Earth relative to the equator.
gps_lon	deg	GPS longitude: The aircraft's longitudinal position over the surface of the Earth relative to the prime meridian.
gps_alt_msl	ft	GPS altitude mean sea level. Range: –1000 to 131,072 ft

Parameter ID	Units	Comments
gps_time_hr	hr	GPS time in total hours. Can be converted to hh:mm:ss.sss format for ASCII data and display.

8. Data From Analog Sources and Computed Functions

Parameter ID	Units	Comments
df_point_2	°C	Dew frost point—2 stage: Ambient dew or frost point in °C. Source: General Eastern 1011C two-stage thermoelectric hygrometer system Range: –75 °C to 50 °C
ir_surf_temp	°C	IR surface temperature: The infrared temperature of the surface of the Earth or cloud top beneath the aircraft. Source: Heitronic Model KT-A Nadir viewing, infrared radiometer Range: –65 °C to 55 °C Note: Analog parameter
sat_cpted_fr_mach	°C	Computed static air temperature: Ambient air temperature at aircraft's present position as calculated from total air temperature corrected for aircraft speed. Range: –99 °C to 33 °C Source: Calculated from total air temperature and Mach no.
atm_pressure	mb	Ambient atmospheric pressure at aircraft's present position as calculated from pressure altitude. Source: Calculated from pressure altitude. Range: 114 to 1,050 mb
part_pres_h2o	mb	Partial pressure of water vapor: The pressure of water vapor as a component of the total atmospheric pressure. Source: Calculated parameter from selectable dew frost point. Range: 0.0012 to 388 mb

Parameter ID	Units	Comments
specific_hum	g/kg	Specific humidity: Ambient specific humidity at aircraft's present position as calculated from partial pressure of water vapor and atmospheric pressure. Source: Calculated from partial pressure with reference to H_2O pressure Range: 0 to 20g H_2O/kg air
h2o_sat_vp_watr	mb	Saturated vapor pressure with respect to water: The pressure exerted by water vapor in equilibrium with water when the air mass is over a plane surface of water at the same temperature and pressure. Source: Calculated from static air temperature Range: 0.00004 to 125 mb
h2o_sat_vp_ice	mb	Saturated vapor pressure with respect to ice: The pressure exerted by water vapor in equilibrium with ice when the air mass is over a plane surface of ice at the same temperature and pressure. Source: Calculated from static air temperature Range: 0.00002 to 200 mb
rel_hum_watr	%	Relative humidity with respect to water: Ambient relative humidity with respect to water at aircraft's present position. Source: Calculated from partial pressure H_2O and saturated vapor pressure with respect to water Range: 0 to 100%
rel_hum_ice	%	Relative humidity with respect to ice: Ambient relative humidity with respect to ice at aircraft's present position. Source: Calculated from partial pressure H_20 and saturated vapor pressure with respect to ice. Range: 0 to 100%

Parameter ID	Units	Comments
local_siderl_time	rad	Local sidereal time: The time defined by the daily rotation of the Earth with respect to the equinox. Uses the local meridian as the terrestrial reference. Source: Calculated from year, day, time, longitude Range: 0 to 2 pi radians
sun_ra	rad	Sun right ascension: The arc of the celestial equator measured eastward from the vernal equinox to the foot of the great circle passing through the celestial poles and the Sun. Source: Calculated from year, day, time
sun_dec	rad	Sun declination: The angular distance of the Sun from the celestial equator. Source: Calculated from year, day, time Range: ± pi/2rad Orientation: + north of the celestial equator – south of the celestial equator
sun_el_earth	deg	Sun elevation relative to earth; Sun elevation relative to the horizontal plane of the earth. Source: Calculated from 1st, ra_sun, dec_sun, latitude Range: ±90 deg Orientation: + above the horizontal plane of the earth – below the horizontal plane of the earth
sun_az_earth	deg	Sun azimuth relative to Earth: The Sun azimuth relative to true north. Source: Calculated from lst, ra_sun, dec_sun, latitude Range: 0 to 360 deg

Parameter ID	Units	Comments
sun_el_ac	deg	Sun elevation relative to aircraft: The Sun elevation relative to the horizontal plane of the aircraft. Source: lst, ra_sun, dec_sun latitude, pitch, roll, true heading Range: ±90 deg Orientation: + above the horizontal plane of the aircraft – below the horizontal plane of the aircraft
sun_az_ac	deg	Sun azimuth relative to aircraft: The Sun azimuth relative to the nose of the aircraft. Source: Calculated from lst, ra_sun, dec_sun latitude, pitch, roll, true heading Range: ±180 deg Orientation: + right from nose of aircraft – left from nose of aircraft
sun_el_rf_ac	deg	Sun elevation corrected for refraction relative to aircraft. The Sun elevation corrected for refraction relative to the horizontal plane of the aircraft. Source: Calculated from sun_el_ac, pressure, static air temperature Range: ±90 deg Orientation: + above the horizontal plane of the aircraft – below the horizontal plane of the aircraft
sun_el_rf_ea	deg	Sun elevation: Corrected for refraction relative to Earth. The Sun elevation corrected for refraction relative to the horizontal plane of Earth. Source: Calculated from sun_el_ea, pressure, static air temperature Range: ±90 deg Orientation: + above the horizontal plane of earth – below the horizontal plane of earth

Parameter ID	Units	Comments
sun_az_left	deg	Sun azimuth relative to left side of the aircraft. Source: Calculated from sun_az_ac Range: ±180 deg Orientation: + right from left of aircraft – left from left of aircraft
sun_az_right	deg	Sun azimuth relative to right side of the aircraft. Source: Calculated from sun_az_ac Range: ±180 deg Orientation: + right from right of aircraft – left from right of aircraft
solar_zenith	deg	Solar zenith: The angular distance of the Sun from zenith. Source: Calculated from sun_el_ea Range: 0 deg to 180 deg
ra_moon	rad	Moon right ascension: The arc of the celestial equator measured eastward from the vernal equinox to the foot of the great circle passing through the celestial poles and the Moon. Source: Calculated from year, day, time Range: 0 to 2 pi radians
dec_moon	rad	Moon declination: The angular distance of the Moon from the celestial equator. Source: Calculated from year, day, time Range: ±pi/2(radian) Orientation: + north of the celestial equator – south of the celestial equator
moon_el_ea	deg	Moon elevation relative to Earth: The Moon elevation relative to the horizontal plane of the Earth. Source: calculated from 1st, ra_moon, dec_moon latitude Range: ±90 deg Orientation: + above the horizontal plane of earth – below the horizontal plane of earth

Parameter ID	Units	Comments
moon_az_ea	deg	Moon azimuth relative to Earth: The Moon azimuth relative to true north. Source: Calculated from 1st, ra_moon, dec_moon, latitude Range: 0 to 360 deg
moon_el_ac	deg	Moon elevation relative to aircraft: The Moon elevation relative to the horizontal plane of the aircraft. Source: Calculated from 1st, ra_moon, dec_moon, latitude, pitch, roll, true heading Range: ±90 deg
moon_az_ac	deg	Moon azimuth relative to aircraft: The Moon azimuth relative to the nose of the aircraft. Source: calculated from 1st, ra_moon, dec_moon, latitude, pitch, roll, true heading Range: 0 to 360 deg
moon_el_rf_ea	deg	Moon elevation: Corrected for refraction relative to Earth. The Moon elevation corrected for refraction relative to the horizontal plane of the Earth. Source: calculated from moon_el_ea, pressure, static air temperature Range: ±90 deg Orientation: + above the horizontal plane of earth – below the horizontal plane of earth
moon_el_rf_ac	deg	Moon elevation corrected for refraction relative to aircraft. The Moon elevation corrected for refraction relative to the horizontal plane of the aircraft. Source: calculated from moon_el_ac, pressure, static air temperature Range: ±90 deg Orientation: + above the horizontal plane of the aircraft – below the horizontal plane of the aircraft

Parameter ID	Units	Comments
moon_az_left	deg	Moon azimuth relative to left of aircraft: The Moon azimuth relative to the left side of the aircraft. Source: calculated from moon_az_ac Range: ±180 deg Orientation: + right of the left side of aircraft – left of the left side of aircraft
moon_az_rt	deg	Moon azimuth relative to the right side of the aircraft. Source: calculated from moon_az_ac Range: ±180 deg Orientation: + right of the right side of aircraft – left of the right side of aircraft
lunar_zenith	deg	Lunar zenith: The angular distance of the Moon from zenith. Source: calculated from moon_el_ea Range: 0 to 180 deg
potential_temp	Kelvin	Potential temperature: The temperature that a dry air parcel would have if lowered adiabatically to a level of 1,000 mb pressure Source: Calculated from static air temperature computed pressure Range: 171.7K to 601K
pres_alt_metric	meter	Pressure altitude in meters: Aircraft pressure altitude in meters corresponding to U.S. Standard Atmosphere, 1962. Source: Calculated from pressure altitude
cabin_alt	ft	Cabin altitude: Effective altitude of the aircraft cabin as a function of cabin pressure as it relates to sea-level. Source: Rosemount Mod 1241 A6CD Range: –1000 to 20,000 ft

Parameter ID	Units	Comments
nms_ap_cmd	n/a	Autopilot command status: Computed function returns a flag value which tells which NMS (if either) is currently in command of the autopilot. Output message: If output = 1, then NMS1 is in command of autopilot If output = 2, then NMS2 is in command of autopilot If output = 3, then autopilot is off If output = 4, then an error was detected
total_air_temp	°C	Total air temperature Source: Analog data_raw
radar_alt	ft	Radar altitude selected from 1553 or analog source.
pitch_msrc	deg	Pitch angle selected from EGI 1553 or AC INS synchro signal.
roll_msrc	deg	Roll angle selected from EGI 1553 or AC INS synchro signal.

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APPENDIX D

ICATS SERIAL OUTPUTS TO EXPERIMENTS

1. Introduction

The DC-8 ICATS serial transfer of housekeeping data is available to allow easy access to aircraft data by experimenter-operated computers. The data is transferred at one-second intervals with transmission rates of 1200, 9600, and 19.2K baud.

2. 1200 Baud

Data is transferred once per second at 1200 baud in two 56-character blocks, each of which begin with a unique character identifier and end with an ASCII carriage return and line feed. The total number of characters available every second with this configuration is 112. See the following table for the configuration of the 1200-baud serial data blocks.

Identifier	Parameters	Field Format	Units
A	day	aaa	day of yr
	time	bb:bb:bb.bbb	hr:min:sec (UT)
	latitude	+cc cc.c	deg and min
	longitude	+ddd dd.d	deg and min
	pitch	eee.e	deg
	roll	ffff.f	deg
	wind speed	ggg	knots
	wind direction	hhh	deg
	true air speed	iii	knots
B	ground speed	jjjj	knots
	true heading	kkk.k	deg
	drift angle	lll.l	deg
	pressure altitude	mmmmm	feet
	radar altitude	nnnnn	feet

Identifier	Parameters	Field Format	Units
	dew/frost point temperature (GE		
	1011 hygrometer), 2 stage	ooooo.o	deg C
	SPARE		
	static air temperature	qqq.q	deg C
	total air temperature	rrr.r	deg C
	IR surface temperature	sss.s	deg C

Parameter fields within each block are not separated by a space, but there may be one or more blanks at the end of a block (before the carriage return and line feed) to pad the length to 56 characters. Following is an example of the 1200-baud block format.

A aaabb:bb:bb.bbb+cc cc.c+ddd dd.deee.effff.fggghhhiii <cr><lf>

B jjjjkkk.klll.lmmmmmnnnnnooooo.oppppp.pqqq.qrrr.rsss.s<cr><lf>

A 32101:22:45.105+34 25.0-122 03.0-10.3 -45.6110270450 <cr><lf>

B 425212.3 5.12800024050-1012.4-1012.7-10.1 14.6-15.9<cr><lf>

3. 9600/19.2K Baud

Data is transferred once per second at 9600 and 19.2K baud in seven 56 character blocks, each of which begin with a unique character identifier and end with an ASCII carriage return and line feed. The contents of the first five blocks (identifiers C through G) are fixed. The contents of the last two blocks (identifiers H and I) are at the discretion of the mission manager and may change from mission to mission. The total number of characters available every second with this configuration is 392. Following is the configuration of the 9600/19.2K baud serial data blocks.

Identifier	Parameters	Field Format	Units
C	day	aaa	day of yr
	time	bb:bb:bb.bbb	hr:min:sec (UT)
	latitude	+cc cc.c	deg and min
	longitude	+ddd dd.d	deg and min
	pitch	eee.e	deg
	roll	ffff.f	deg
	wind speed	ggg	knots
D	wind direction	hhh	deg
	true air speed	iii	knots
	ground speed	jjjj	knots
	true heading	kkk.k	deg
	drift angle	lll.l	deg
	pressure altitude	mmmmm	ft
	radar altitude	nnnnn	ft
	dew/frost point temperature (GE		
	1011 hygrometer), 2 stage	ooooo.o	deg C
	SPARE		
E	static air temperature	qqq.q	deg C
	total air temperature	rrr.r	deg C
	IR surface temperature	sss.s	deg C
	static air temperature, calculated	ttt.t	deg C
	indicated air speed	uuu	knots
	vertical speed	vvvvvv	ft/min
	distance to go	wwwww.w	nm
	time to go	xxxx.x	min
	align status	yy	

Identifier	Parameters	Field Format	Units
F	cabin altitude	zzzzz	ft
	static atmospheric pressure	JJJJ.J	mb
	Mach number	K.KKK	
	cross track distance	LLLLL.L	nm
	desired track	MMMM.	deg
	track angle error	M	deg
	track angle	NNNN.N	deg
	specific humidity	OOO.O	g H2O/kg air
		P.PPP	
G	Partial pressure H2O	QQ.Q	mb
	Relative humidity with respect to ice	RR.R	%
	Relative humidity with respect to water	SS.S	%
	Saturation vapor pressure of water	TT.TT	mb
	Saturation vapor pressure of water relative to ice	UU.UU	mb
	Sun elevation in ground reference frame, refracted	VVV.V	deg
	Sun elevation in aircraft reference frame, refracted	WWW.W	deg
	Sun azimuth in ground reference frame	XXX.X	deg
	Sun azimuth in aircraft reference frame relative to the nose of the aircraft	YYYY.Y	deg
H	Contents of this block are subject to the mission manager's discretion.		
I	Contents of this block are subject to the mission manager's discretion.		

Parameter fields within each block (including the start-of-block character) are separated by at least one space, and there may be one or more blanks at the end of a block (before the carriage return and line feed) to pad the length to 56 characters. Following is an example of the 9600/19.2K block format.

```
C aaa bb:bb:bb.bbb +cc cc.c +ddd dd.d eee.e ffff.f ggg<cr><lf>

Dhhh iii jjjj kkk.k lll.l mmmmm nnnnn ooooo.o ppppp.p<cr><lf>

E qqq.q rrr.r sss.s ttt.t uuu vvvvvv wwwww.w xxxx.x yy<cr><lf>

F zzzzz JJJJ.J K.KKK LLLLL.L MMMM.M NNNN.N OOO.O
P.PPP<cr><lf>

G QQ.Q RR.R SS.S TT.TT UU.UU VVV.V WWW.W XXX.X YYYY.Y
<cr><lf>

H ******************************************************<cr><lf>

I ******************************************************<cr><lf>
```

```
C 321 01:22:45.105 +34 25.0 -122 03.0 -10.3  -45.6 110<cr><lf>

D 270 450  425 212.3   5.1 28000 24050 -1012.4 -1012.7<cr><lf>

E -10.1  14.6 -15.9  -9.4 410  -1250  -332.6   50.8 45<cr><lf>

F   5100  466.7 0.714   332.0  240.7  -11.8 202.0 0.269<cr><lf>

G 13.4 15.2 20.2 34.22 37.66  10.6  13.7 252.3 -160.2 <cr><lf>

H ******************************************************<cr><lf>

I ******************************************************<cr><lf>
```

4. Parameter Format Information

All data parameters are in engineering units. For integer formats, the number of digits in a field may vary from one to the number shown in the field format. For non-integer formats, the placement of the decimal point within the field and the number of digits to the right of the decimal point are guaranteed as illustrated in the field format. However, the number of digits to the left of the decimal point may vary from one to the number shown in the field format. Unused leading digits are padded with either blanks or zeroes. Units are not included in the data stream.

Individual parameter fields will be filled with special characters for the following reasons:

Condition	Special Character
Data was too big for parameter field	>
Data was too small for parameter field	<
Data formatting error occurred	?

Additionally, invalid or unavailable data may be replaced by question marks (?), however, the absence of question marks in a parameter field does not guarantee the validity of the data.

5. RS232 Format Key

<cr> — ASCII carriage return.

<lf> — ASCII line feed.

**** — Block content subject to mission manager's discretion.