NSF/NCAR Aircraft Field Project Computing Handbook

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1. Integrating to the RAF Aircraft Computing Infrastructure

1.1. Basic Onboard Instrument Integration

This section describes integrating to the most commonly used features of the NCAR aircraft computing infrastructure.

1.1.1. Attaching to the network

- There is a single Gigabit Ethernet onboard for data collection and display. DHCP, DNS, routing, and firewalling are provided by an onboard router. Some of the network switches provide Power over Ethernet (PoE).

- Subnet address is 192.168.84.0
- Subnet mask is 255.255.255.0
- Broadcast address is 192.168.84.255
- Gateway and nameserver address is 192.168.84.1
- The aircraft subnet domain name is raf.ucar.edu
- The NTP timeserver is 192.168.84.10 or timerserver.raf.ucar.edu

In the hangar the aircraft is connected to the UCAR guest network and access to the internet is available. During flight, access to the internet via satcom is restricted to RAF computers.

1.1.2. Timing

There are 3 possible methods of acquiring time. Each aircraft is equipped with a network time server. These provide NTP, IRIG-B, and 1-PPS signals.

- Network Time Protocol (**NTP**)
    - Accurate to single digit milliseconds. Sub-millisecond accuracy with the chrony client.
    - Hostname is 'timeserver' and is available on both networks. The network address is 192.168.84.10.
    - Meinberg has a Windows client[1] if you want something different from the WindowsXP default.
    - Another tool[2] to setup the WinXP NTP client, with a clock.
- **IRIG-B** 123 (AM) standard. Definition PDF[3]
    - Accurate to a few microseconds.
    - This will require the purchase of an IRIG-B card.
    - Wall plate feeds are available throughout the aircraft.
- Pulse per Second (**1-PPS**)
    - Wall plate feeds are available throughout the aircraft.

It is possible to get your own **GPS antenna feed**.

- Make sure to request this far enough in advance.

1.1.3. Real-time data feed (IWG1)

- NCAR distributes the IWGADTS recommended data packet[4] on all aircraft.
- It is a UDP broadcast to 192.168.84.255 on port 7071.
- UDP to RS-232 converters can be provided. Request in advance as they need to be mounted.
- This packet has a 2-3 second delay between data acquisition and receipt to users.
- The time tag is of data acquisition.

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[1] https://www.meinbergglobal.com/english/sw/ntp.htm
[2] http://www.download32.com/windows-ntp-time-server-client-d27709.html
[3] https://www.eol.ucar.edu/raf/Software/IRIG_def.pdf
[4] http://www.eol.ucar.edu/iwgadts/products/real-time-data-feed

1.1.4. Sending Data to the NCAR Data Acquisition System

Users wishing for NCAR to record their data or make data available for display onboard or on the ground should plan on sending an ASCII packet of data. We can accept data via UDP or RS-232.

ASCII packet should be comma-separated values (CSV) with the following components:

- Instrument Key Word first
- Time-stamp (ISO-8601 compliant) second. Leave blank if you don't have one (keep as a place holder, so two commas in a row).
- CSV data points

e.g. "CFDC,20160812T120500,35.2,5,79.33"

For UDP:

- Send to host 192.168.84.2
- We will agree on a port later (above 31000).
- Newline / carriage return not needed.

1.2. Advanced Instrument Integration

This section describes more advanced features of the NCAR data acquisition and control system.

1.2.1. Acquiring data from the database

EOL is using the PostgreSQL[5] database for real-time data access and display.

- Aircraft/DatabaseTables[6] Current layout of database tables.
- Aircraft/SQLExamples[7] Some C program examples to access the database.
- On-board
- Ground

[5] https://www.postgresql.org/
[6] http://wiki.eol.ucar.edu/sew/Aircraft/DatabaseTables
[7] http://wiki.eol.ucar.edu/sew/Aircraft/SQLExamples

1.2.2. Remote Instrument Control

EOL has developed a secure communication infrastructure for remote instrument control and monitoring over low bandwidth links. Please inquire for further information.

1.2.3. Reporting Instrument Status

Instruments wishing to provide a status web page can multicast the below XML packet to 239.0.0.10 on port 30001 and the central server will pick it up.

Example:

```
<?xml version="1.0" encoding="UTF-8"?>
   <group>
     <name>dsm303</name>
     <clock>12:45:21</clock>
     <frequency>1</frequency>
     <health>Green</health>
     <status><![CDATA[<html><h1>MTP Status</h1><hr>Instrument
working awesome!<p></html>]]></status>
   </group>
```

Instrument name, something short:

```
    <name>dsm303</name>
```

Time of status:

```
    <clock>12:45:21</clock>
```

Expected frequency of this packet in seconds. This is so the receiving software can decide when the instrument is no longer reporting:

```
    <frequency>1</frequency>
```

A short overall health [Red or Green, 0 or 1 ?]:

```
    <health>Green</health>
```

This section is optional. If it exists it should contain an HTML document which will be rendered on the status web-page available at all computers onboard the aircraft:

```
    <status>
       <![CDATA[<html> A status web page </html>]]>
    </status>
```

1.3. SATCOM

Both the C130 and GV are equipped with INMARSAT 4 Swift Broadband (SBB) and Iridium.

- Cost for INMARSAT
  - Full time 432Kbps and costs $5.03 per Megabyte.
  - We average approx. $200 per hour.
- Data Feed to Ground
  - A subset of parameters collected on the plane is shipped to the ground.
  - Data can be sent every N seconds (configurable on a per project/flight basis). Default is every 5 seconds.
- File Transfer to/from Aircraft
  - Unidata LDM is used to transfer files.
  - Delay is typically 60-90 seconds.
- Security, Firewalls, etc.
  - The aircraft is firewalled and so is NCAR. Only a few usable ports.
  - HTTP and Unidata LDM are currently the only 2 open ports into NCAR.
- Coverage and Dropouts
  - INMARSAT Coverage map[8].
  - Outages of 3-5 minutes are not uncommon.

[8] https://www.eol.ucar.edu/content/satellite_coverage

- In the continental United States, a 10 degree banked turn away from the Galapagos Islands is enough for the GV to lose contact.

2. Real-time Software Tools & Products

2.1. Ground Database

A subset of the aircraft database is mirrored to the ground.

- The exposed host for the aeros database is **eol-rt-data.fl-ext.ucar.edu**.

2.2. Internet Relay Chat (IRC)

Chat is available between participants of a field campaign. Personnel aboard the aircraft can communicate with ground personnel when satellite communications are operational.

- Clients include:
  - xchat for linux
  - HexChat for MS Windows
  - Lime or Aqua for Mac OS
  - Colloquy for iPhone
- Chat server is **rdcc.fl-ext.ucar.edu/6668**
  - You will need a password to connect to this.
- Configuring chat client onboard:
  - Server is acserver.raf.ucar.edu/6668
  - Turn off 'away-tracking', this generates a lot of traffic.
- Known problems / issues
  - There is no feedback when communication between aircraft and ground goes down. Messages disappear into the ether.

2.3. Display Software

- Primary real-time display program for monitoring instrument data: aeros[9]
  - ASCII and time-series, XY, skewT and track plots.

[9] https://www.eol.ucar.edu/software/aeros

    - both onboard and ground based.
    - Multi-platform: Linux, Mac OS, and Windows.
- Catalog Maps is a web based tool which provides real-time flight tracking with integrated weather products http://catalog.eol.ucar.edu/maps/operations.
    - Both onboard and ground based.

3. RAF Post-flight Data

3.1. Data Products

The Primary RAF data product is delivered as a netCDF[10] file. This file includes all scalar and most vector/histogram (PMS-1D) data. Instruments that require large bandwidth to record are typically recorded separately.

3.1.1. netCDF file

- RAF netCDF Conventions[11]
- Examples for extracting Time from the netCDF file[12]
- Display Software (ncplot and ncpp)[13]

3.1.2. PMS-2D

PMS-2D data is recorded in a separate file. Follow the 'Description' below for data formats and more.

- Description[14]
- Display Software (xpms2d)[15]

3.2. Providing Data to RAF for Integration

Data should be provided in NASA Ames Data Exchange Format (DEF). Please note the two modifications in the example below:

- How units are in parentheses at the end of the line
- The list of short variable names in the last line of comments (make sure to increase comment line count).

[10] http://www.unidata.ucar.edu/software/netcdf/
[11] http://www.eol.ucar.edu/raf/Software/netCDF.html
[12] http://www.eol.ucar.edu/raf/Software/TimeExamp.html
[13] https://www.eol.ucar.edu/analysis-software
[14] http://www.eol.ucar.edu/content/pms-2d-raw-data-format
[15] https://www.eol.ucar.edu/software/xpms2d

Sample:

```
 19 1001
Webster, Chris
NCAR Research Aviation Facility
NSF-NCAR-GV N677F
HIPPO-Global
1  1
2009 01 16  2009 03 25
1.0  Time in seconds from 00Z
4
1.0 1.0 1.0 1.0
99999 99999 99999 99999
Vertical Differential Pressure, Radome (hPa)
Attack Angle, Radome Diff. Pressure (degree)
IRS Altitude (m)
Avionics GPS Altitude (MSL) (m)
0
1
UTC      ADIFR  AKRD  ALT  ALT_G
66890 0.0071611 0 34.8615 72.3047
66891 0.0185372 0 34.8279 72.5152
66892 -0.00574668 0 34.8234 72.744
```

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4. Download Links

EOL software download page: https://www.eol.ucar.edu/analysis-software

RAF notes on building from source: http://www.eol.ucar.edu/raf/Software