Satcam & Megacam Imaging Systems Manual

Airborne Innovations LLC

2170 Eugene Street
Hood River, OR 97031

info@airborneinnovations.com
Phone: 541-380-0928
Fax: 253-276-9765

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Revision	Date	Description
2.0.0	27 April 05	Created.
2.1.0	1 June 05	Added quickstart guides
2.1.1	7 June 05	Added Piccolo/NMEA simulation guide, documentation on WFOVDEGn, HFOVDEGn, GEOREFENABLEn, image archiving
2.2.0	30 Nov 05	Added new features documentation Resolution control, external modem configuration, realtime/burst mode

Table of Contents

1   Summary

This manual documents the technical features of the Satcam and Megacam UAV imaging systems.

2   Current functionality of Airborne Innovations imaging system

Possible image sources:

- •500+ USB digital cameras supported

- •Ethernet based imaging sensors

- •Ethernet based video capture device (NTSC or PAL)

- •Other framegrabbers / camera interfaces (user customizable)

Supported datalinks for image transmission

- •Support for image transmission over Iridium satcomm, Cloud Cap Piccolo UHF or Iridium, or other standalone UHF datalink

- •Iridium satcomm, standalone support (maximizes satellite bandwidth available)

- •Globalstar satcomm (through configurable AT command capability)

- •Cloud Cap Piccolo payload port (supports 38 kbaud+ UHF or satcomm communications), supported with 1.3.x+ Piccolo software

- •Transparent datalinks and (i.e. Freewave, MaxStream, Microhard and others)

- •TCP/IP datalinks such as WiFi and WiMAX (indirectly supported at the moment, full support coming)

- •Generic support for modem type datalinks (GPRS / Inmarsat / BGAN / other cellular and satellite communications systems)

Firsts for small UAVs:

•**Realtime video over satcomm for small UAVs!**

•Demonstrated 1 frame per second performance over a 9600 baud link (i.e. Globalstar), 1 frame per 4 seconds over Iridium satcomm.

•**<u>Enabling gimballed camera use over satcomm!</u>**

•Imaging features designed to support use of a gimballed camera.

Other features:

•Efficient high resolution image transmission: supports multi-megapixel images

•Wide range of image sizes supported (from video and below to 5 megapixel and up)

•Reliable downlink protocol ensures complete image transmission

•Multiple camera support

Multiple cameras can be switched on demand. Images can be logged, or cameras can function independently. Cameras can be of different types.

•Realtime georeferencing, image visualization

Image display, pan and zoom

Image logging (wavelet and JPEG format)

Image georeferencing using aircraft metadata (supports Piccolo avionics or NMEA data source)

Georeferencing supports GeoJPEG, Google Earth

Aircraft metadata and georeferenced image logging

Realtime image mosaic and display using aircraft metadata

3   Specifications

3.1   Image transfer performance

This table outlines the time to transmit an image over an ideal datalink.

Note that the end to end cycle time depends on:

•Image acquisition time

•Image compression time

•Image decompression time

•Image transfer time (including datalink performance)

•Georeferencing transformation time

Table: Image transfer time vs size/compression ratio

Image size	Uncompressed Image size in bytes (n)	Compression ratio	Transfer time, sec (Iridium)	Transfer time, sec (Globalstar)	Transfer time (Piccolo UHF)
x*y	n=x*y*3	k	(n/k)*1.06/240	(n/k)*1.06/960	(n/k)*1.06/3840
320*240		260	3.9 sec	1 frame per sec	
640*480		260	15.7 sec	3.9 sec	1 sec
640*480		150	27 sec	6.8 sec	
1280*1024 (1.3 megapixel)		260	66 sec	16.7 sec	4.2 sec
1280*1024		150	116 sec	28.9 sec	7.2 sec
1600*1200 (1.9 megapixel)		260	98 sec	24.5 sec	6.1 sec
2048x1536 (3.1 megapixel)		300	139 sec	34.7 sec	8.7 sec
2272x1704 (4 megapixel)		300	180 sec	42.7 sec	10.7 sec
2272x1704 (4 megapixel)		150			21.4 sec (note compression time is limiting factor)

3.2 Power consumption

 CPU board (533 Mhz)

> 2.3W, 0.46A measured at 5V (idle / data transmission)

> 4.5W, 0.90A measured at 5V (image compression) *Peak is slightly higher*

Power is supplied to two small screw wire terminals.

The duty cycle for image compression is low for a 640x480 image, about a second or two. For a 4 megapixel digital camera image it's about 25 seconds, 1.3 megapixel is 13 seconds.

The ethernet video capture device (optional) has a manufacturer stated power consumption of 0.6A at 5V. 58x28x108 mm, 4 RCA video inputs, small barrel power connector

The USB-Ethernet module has a power consumption of approximately 80 mA (5V).

Camera power consumption is another component to include (variable)

3.3 Weight

148g with image board & typical power & serial cables

17g miniature USB-ethernet module (optional)

104g video capture module, or 81g framegrabber

~10g custom ethernet crossover cable

3.4   Communications Interface

Internal / development harness

The CPU has a ribbon cable with a 6" breakout cable to two 9-pin male DB-9 serial ports, one for the Iridium modem or Piccolo payload port, and one for the GPS/attitude data port

There is also a similar ribbon cable to a standard USB connector, if using USB digital camera support. Baud rates are configurable, 2400 to 115kbaud (recommend 2400 for Iridium, 38.2 or 57.6kbaud for images over the Piccolo datalink, and 57kbaud for the gps/attitude data (piccolo).

The Iridium serial interface does not use carrier detect at the moment, and does drive DTR.
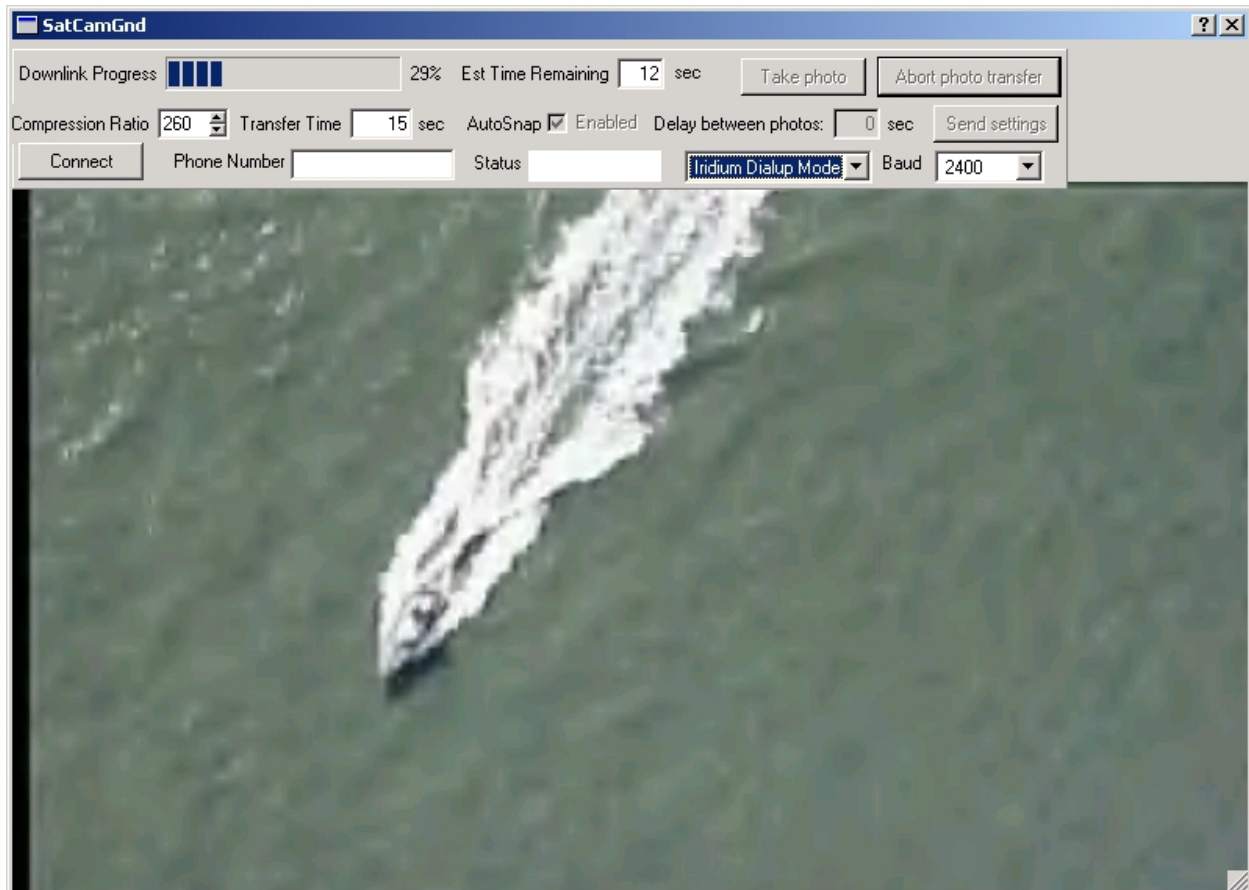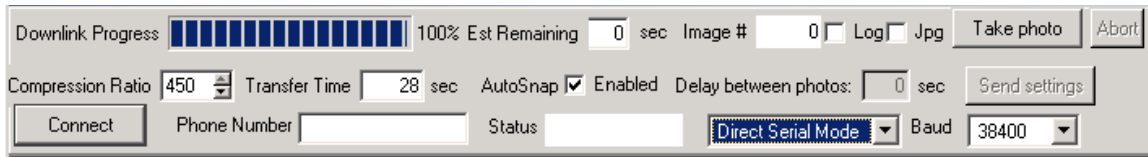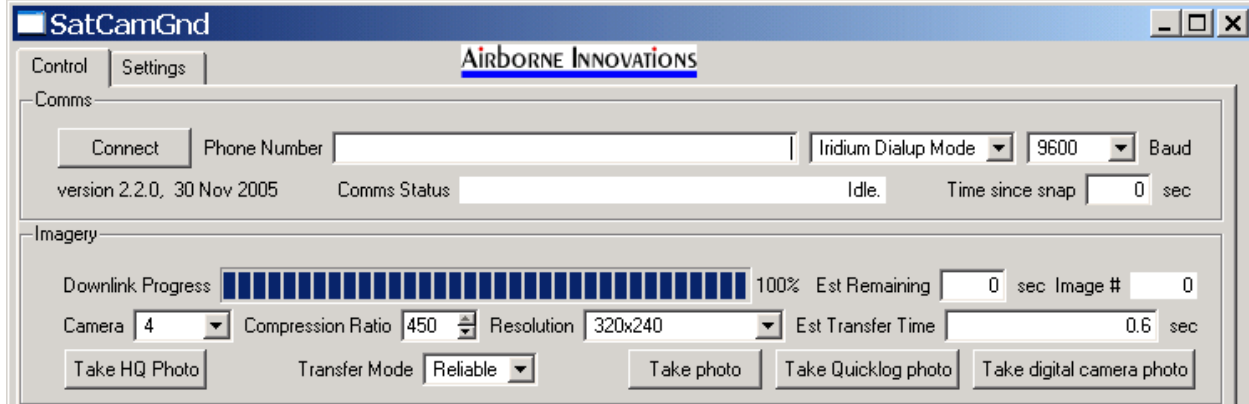
4   User Interface Documentation

Figure 1: Initial software release with 640x480 image transmitted in 15 seconds over 2400 baud (satellite) link

1.x.x interface

2.2.x interface

Note that the default is Iridium mode, which does prevent transparent serial traffic until either an Iridium connection is made, or the mode is switched to direct serial.

Control tab:

Comms section

Connect	Control to initiate / hang up satellite connection
Phone number	Satellite telephone number
Communications mode	Select either Direct Serial Mode (for UHF transparent serial comms), or Iridium Dialup Mode for direct link to Iridium modem.
Baud:	Current baud rate setting. Typically 2400 or 9600 for Iridium, 38400 for UHF.
Comms Status	Satcomm dialup status
Time since snap	Time since last snapshot (useful to coordinate flight planning)

Imagery section:

|	
Downlink progress:	Progress bar indicating percentage of image transfer remaining
Est remaining:	Estimated remaining image transfer time
Image #:	Counter displaying current image number
Camera	Control for camera channel (USB digital, framegrabber channel 1 to 4)
Compression ratio:	Sets the wavelet compression ratio. This can range typically from 50:1 to 450:1. 100:1 is a reasonably high quality, 300:1 is usable quality
Est transfer time:	Estimated transfer time for the current compression ratio setting

Take HQ photo   Take a photo using high quality settings (transfer for an HQ image is always made in reliable mode, 'one time reliable transfer' if set to burst mode)

Transfer Mode   Transfer mode can be burst or reliable. In burst mode, images are sent as fast as possible to achieve maximum frame rate. In reliable mode, a reliable transfer protocol is used.

Take photo: Command a standard photo to be taken

Take Quicklog photo   Allows immediate acquiring and archive of imagery (no transmission)

Take digital camera photo   Take a digital camera photo
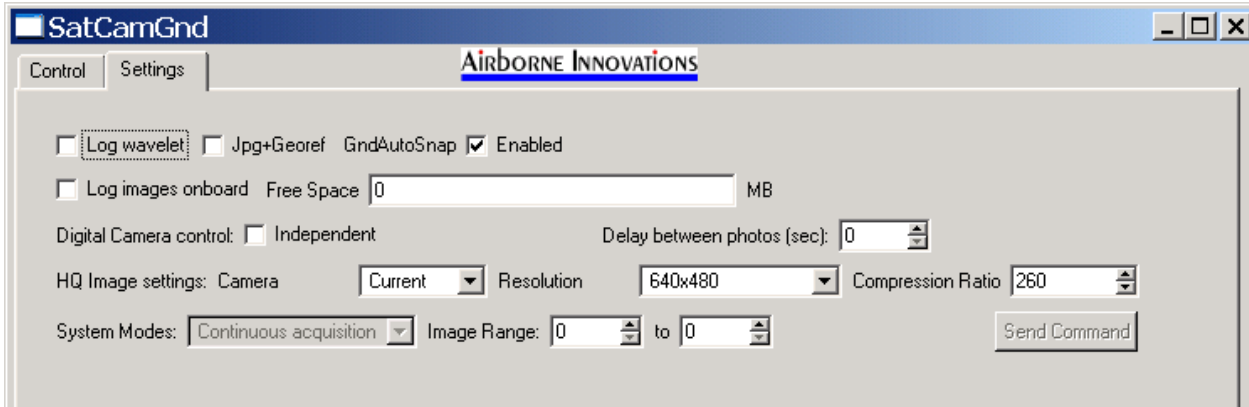
Settings Tab:

Log wavelet checkbox: Enables whether images are logged in wavelet format

Jpg+Georef checkbox: Enables whether images are logged in jpeg format (and georeferenced)

GndAutoSnap: Enable automatic continuous transmission of imagery.

Log images onboard checkbox: Enables whether images and metadata are logged onboard

Free space   Status of image archive storage space

Digital Camera control:

       Independent: Allows independent acquiring of onboard multi-megapixel imagery

       Delay between photos   Delay between photos (independent digital camera)

HQ Image Settings

                          HQ mode default settings

5   Installation

Installation of the windows applications is 'install by copy' except for below.

A number of DLLs are necessary- these can either be manually copied to a location in the path, or copied to each application's directory. There is no installer.

5.1 Windows based aircraft application

The application is called 'SatCamAir'.

To use the aircraft image simulation capability, ImageMagick 6.1.9 must be installed.

ImageMagick adds its commands to the Windows path.

An image called 'tx.jpg' should also be in the same directory as the application. This is the image source (and is overwritten if Terraserver simulation is enabled).

6 Images, Georeferencing and Geomosaicing

Images can be logged in wavelet format, JPEG format, and georeferenced format.

Georeferenced image files are created in the standard GeoJPEG format. Each georeferenced image consists of an image file Geo%n.jpg and an associated world file Geo%n.jgw.

Georeferencing and geomosaicing currently uses latitude/longitude/altitude/heading (future developments will include pitch and roll compensation in georeferencing)

Ideally true heading should be provided (incorporating a wind measurement or magnetometer). I highly recommend providing this- image mosaicing will function considerably better with it.

In the absence of true heading, GPS groundspeed direction could be used (which doesn't account for wind crab angle).

If you only have groundspeed derived heading available, it will be off by

$\theta = \arctan\left(\frac{W_x}{(V_g + W_y)}\right)$ where Wx and Wy are cross (groundspeed) track and along (groundspeed) track wind components, and Vg is the groundspeed magnitude. e.g. Wx=5 m/s, Wy=0, Vg=20 m/s, then crab angle is 14 degrees (significant).

For small winds this is not too bad. For a slow aircraft and say 10 m/s winds it does become a very significant problem (27 deg), that would make it well worth the effort to supply wind-derived heading.

7 Possible configurations

The system can be configured in a number of different ways. These include different combinations of UHF, Iridium, and avionics. Here are some of the possible configurations.
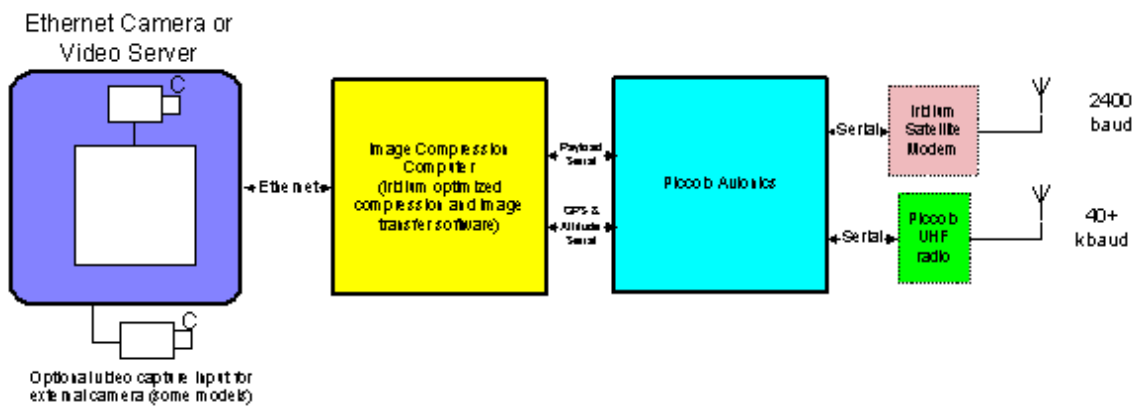
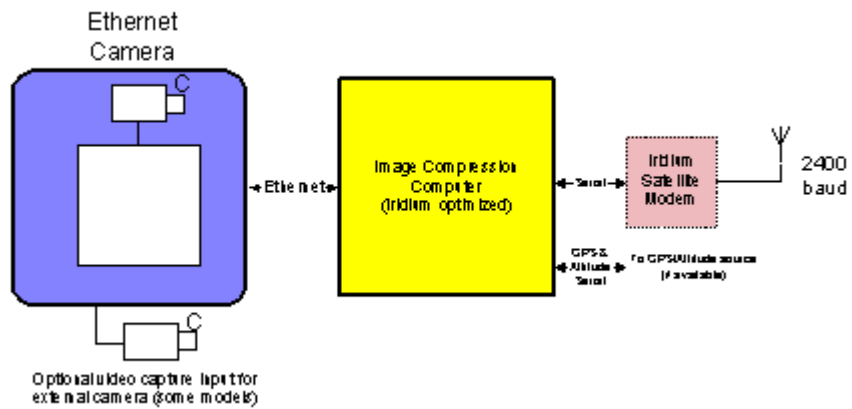**Figure 2: SatCam system integrated with Piccolo avionics**

Figure 3: Standalone Iridium imaging system
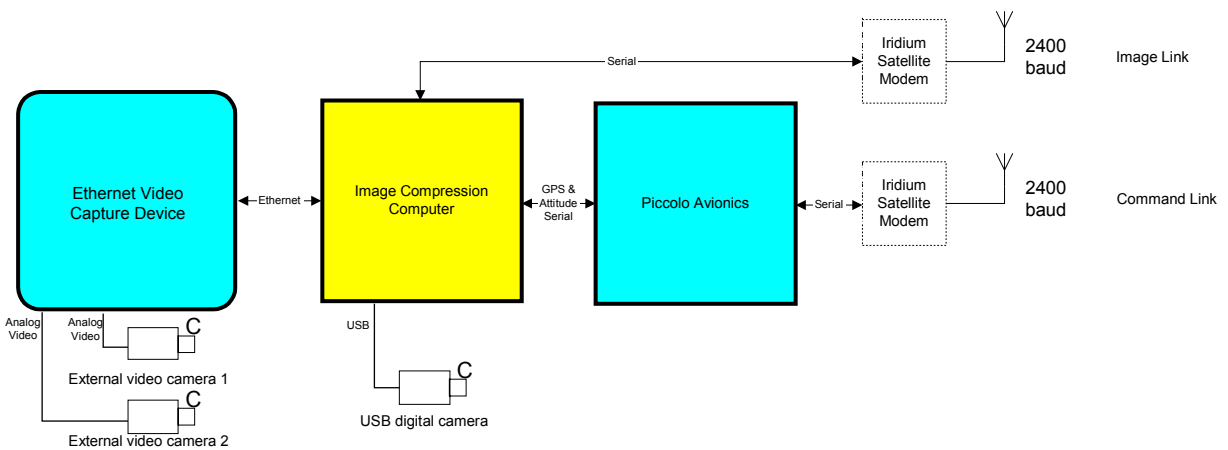
Figure 4: Dual Iridium link for separately allocated control and image satellite bandwidth
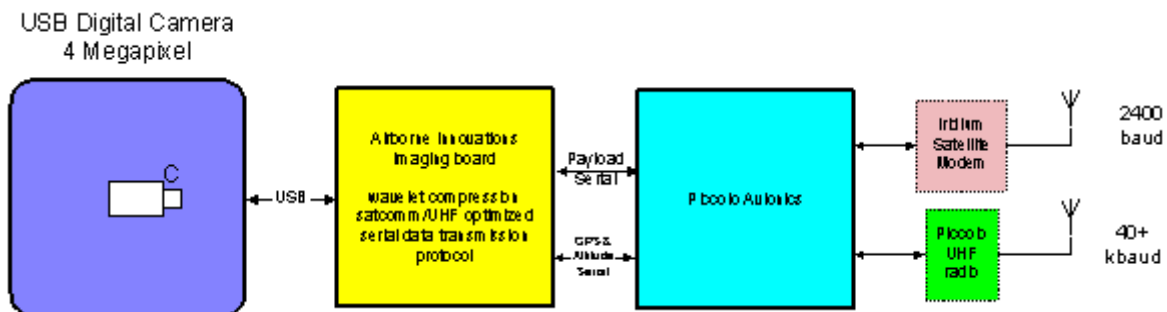
Figure 5: Megacam system with USB digital camera, 40 KBaud+ Piccolo datalink, and optional satcomm

8 Software configuration and usage

8.1 Quickstart guide: Image transfer

Extract the software to the local drive. SatCamAir and SatCamGnd are in separate directories by default.

Install ImageMagick from the archive. Reboot.

Ensure that the SatCamAir directory has the required DLLs and support files (included in the SatCamSupportDLLs directory):

Make sure the tx.jpg file in the SatCamAir directory has the image you want to use (the boat and wake image is a good one).

Ensure that the SatCamGnd directory has the following support file:

> SatCamConfig.txt

Check the configuration of the SatCamConfig files. For an initial test, try without a metadata source.

SatCamAir's SatCamConfig.txt:

```
IRIDIUMENABLE=FALSE
BAUD=2400
P=7
METADATABAUD=57600
TERRASERVERSIM=FALSE
SIMAIRCRAFT=FALSE
WFOVDEG=56.8063
HFOVDEG=44.1338
```


Ensure that the config file points to a free serial port. This example sets up SatCamAir's imaging serial port to be COM7 (I use a USB-Serial device on COM7 as a secondary COM port).

SatCamGnd's SatCamConfig.txt:

```
IRIDIUMENABLE=FALSE
BAUD=2400
P=1
```

Connect a null modem cable between the two serial ports to loop the serial connection to itself.

Now start SatCamAir and SatCamGnd (they can be run on the same machine if you have two serial ports).

In SatCamGnd, switch to the settings tab, and change the comms mode from 'Iridium Dialup Mode' to 'Direct Serial Mode'.

In SatCamAir, also switch the comms mode from Iridium to Direct Serial. This will effectively activate the image transmission.

The image should begin transmitting, and the image transfer progress bar should indicate the transmission progress. When the image is received, it is decompressed (during which the interface blocks) and displayed. At this point you can zoom in and out by clicking on the left and right mouse buttons while over the image, and pan using the scoll bars.

8.2   Quickstart guide: simulation

In this test it is definitely desirable to have SatCamAir and SatCamGnd running on different machines, due to the current crude implementation of the aircraft side software which calls wget (and results in dos boxes popping up sporadically). It's on the list to be improved..

Ensure that the machine running SatCamAir has an Internet connection.

To set up a simulation using the Terraserver simulation capability, set up the configuration files as below:

SatCamAir's SatCamConfig.txt:

change the following lines to:

```
TERRASERVERSIM=TRUE
SIMAIRCRAFT=SIN
```

This sets up a Terraserver based imaging simulation, with a sine wave aircraft flight plan somewhere in the Pacific Northwest.

The configuration settings are read at startup. You may also may want to increase the baud rate for the moment to 38400 baud, for both applications.

Start the applications as above, and enable direct serial mode.

Images will begin coming down. Change the compression ratio to something a bit better quality, like 250:1 or so. Note the first image transferred will have the default compression ratio of 450:1.

Enable the 'Jpg+Georef ' checkbox on the Settings tab.

Now as images are received the following files are written (currently to the SatCamGnd directory):

ImgN.jpg   Jpeg raw image #N

GeoN.jpg	Georeferenced GeoJPEG image #N
GeoN.jgw	Georeferenced GeoJPEG world file
GeoNMeta.txt	Metadata for image #N
GeoDat.txt	Appended metadata for all the images

If using the images in a georeferencing application, check that the initial images' .jgw files have metadata (i.e. Not all zeros).

8.3 Quickstart guide: Full imaging mission software simulation using the Piccolo software simulator and NMEA or Piccolo comms protocol.

In this configuration, several machines are used as follows:

Machine 1: Runs the Piccolo software simulator, the PiccoloPC software avionics, and GroundstationPC applications. (one serial port required)

Machine 2: Runs the Piccolo Operator Interface, SatCamGnd, and mapping visualization applications (one serial port required)

Machine 3: Runs the SatCamAir application (two serial ports required).

Download and install the latest Piccolo dev kit (e.g. 1.3.0) from www.cloudcaptech.com, on two of the machines.

Create shortcuts to allow running the Piccolo applications easily.

The PiccoloPC application should be started with the -PAYLOAD=1 option to place the payload serial port on a physical serial port, if using NMEA data. NMEA data can be configured to come from the Payload 1 port.

Start the PiccoloPC, GroundstationPC, and Simulator applications. Open the cub.txt aircraft file in the simulator.

Start Operator Interface and enter machine1:2000 in the startup network box (or start with a batch file with the -SERVER=machine1:2000 commandline option). Of course replace machine1 with the network name of Machine 1.

Configure Payload 1 to have NMEA output at the desired baud rate (for NMEA simulation), or Comm1, default protocol for Piccolo comms.

Connect a null modem cable between Machine 1 and the metadata port of machine 3 (if using serial metadata- the other option is to use network metadata with the Piccolo comms SDK protocol).

Connect another null modem cable between Machine 2 and the image port of mahine 3.

Set up the SatCamConfig.txt config files for SatCamGnd and SatCamAir, setting up the desired serial/network ports.

For SatCamAir, use something like the following, making sure the options are what you want.

```
IRIDIUMENABLE=FALSE
BAUD=38400
P=8
```

```
METADATABAUD=57600
NMEA=1
TERRASERVERSIM=TRUE
SIMAIRCRAFT=FALSE
WFOVDEG=56.8063
HFOVDEG=44.1338
```

or, if using Piccolo CommsSDK serial protocol,

Remove the NMEA=1 line and replace it with

```
PICCOLO=1
```

or, if using the Piccolo network protocol (currently SatCamAir win32 only),

use:

```
SERVER=machine2:2000
```

Start the simulator and make sure it connects to the PiccoloPC application (external/AP Simulation points to localhost by default.

Start the simulator and ensure the aircraft is flying normally, say 20 m/s, tracking a flight plan, 700m altitude.

Start SatCamGnd (also making sure the startup options are correct).

Switch to direct serial mode in SatCamGnd.

Start SatCamAir, and switch to direct serial mode. SatCamAir should begin transmitting images (from Terraserver if so configured, otherwise it just transmits tx.jpg in the local directory).

Now you can start the mapping visualization application (see Imaging Visualization Software.pdf). Make sure the path points to the directory SatCamGnd is running from, and start the Realtime Update script. Images will be automatically mosaiced as they arrive from the aircraft.

8.4   Configuration Files

The aircraft application, simulated aircraft application, and ground application use a configuration file to select startup options.

Parameters may be commented out by inserting a ';' or '#' character at the beginning of the line.

The following parameters are relevant for each application:

Aircraft application

BAUD, IRIDIUMENABLE, DEFAULTCAMERA, PICCOLO, NMEA, METADATABAUD, WFOVDEG, HFOVDEG, WFOVDEGn, HFOVDEGn, ARCHIVEPATH, ARCHIVEDEVICE

Ground application

BAUD, IRIDIUMENABLE, DEFAULTCAMERA, GROUNDELEVATION, WFOVDEG (overrides aircraft if present), HFOVDEG (overrides aircraft if present), GEOREFENABLEn

Simulated aircraft application

BAUD, IRIDIUMENABLE, DEFAULTCAMERA, TERRASERVERSIM, SERVER, PICCOLO, NMEA, METADATABAUD, SIMAIRCRAFT, GROUNDELEVATION, WFOVDEG, HFOVDEG

The configuration file is called SatCamConfig.txt and it resides in the same directory as the application.

The file can include the following parameters:

DEBUG=n   Enable debug messages at debug level parameter n. Typically, each debug level is implemented as a bit in the n parameter. For example, most standard image protocol messages are level 1, HQ and command bit messages are level 2, satellite modem connect/disconnect messages are level 4, and you could enable some combination by adding them together i.e. DEBUG=(1+2+4)

DEBUG   same as DEBUG=255

8.4.1   Communications related messages

P=serial port #   Select image serial port. This is the port used to transmit imagery (which may be connected to a satellite modem or to a UHF radio / avionics payload port).

BAUD=baud rate   serial port baud rate [300 to 115200]

IRIDIUMENABLE=   TRUE to enable the Iridium state machine [TRUE or FALSE]

PHONENUMBER=   Default phone number to use (Ground).

EXTMDMDIALINITSTR=   Externally supplied modem dial init AT command string. An Iridium init string is used by default, but you can override the string to support other modem-like communications links such as Globalstar satcomm. This is the configuration message sent by the dialing (ground) side to set up the modem with the proper configuration before dialing.

EXTMDMANSINITSTR=   Externally supplied modem answer init AT command string. Sent to configure the modem on the answer (air) side.

DEFAULTCAMERA=n   Default camera number [1 to 5]. Used by the aircraft until a valid configuration is sent from the ground, and by the ground to set the default UI setting for this parameter.

DEFAULTRESOLUTION=n   Default resolution setting. Use primarily on ground side.

see resolution setting table:

Resolution table

Resolution setting	Image dimensions
0	176x144
1	352x288
2	320x240
3	640x480 0.3MP
4	720x480

Resolution setting	Image dimensions
5	704x576 PAL
6	1024x768 0.8MP
7	1280x1024 1.3MP
8	1600x1200 1.9MP
9	1920x1080 HD
10	2048x1536 3.1MP
11	2272x1704 3.9MP
12	2592x1944 5.0MP
13	3008x2000 6.0MP
others	as desired

These resolution settings are primarily used by the imaging system to set the desired resolution via a script, and for convenience. They are not used in georeferencing.

DEFAULTHQCAMERA=   Camera used when Take HQ Photo button is pressed. Ground side.

DEFAULTHQRESOLUTION=   Resolution used when Take HQ Photo button is pressed.

DEFAULTHQCOMPRESSIONRATIO=   Compression ratio used when Take HQ Photo button is pressed.

8.4.2   Metadata related messages

Choose one of the following sources of aircraft metadata:

SERVER=machine:port   Piccolo CommSDK Server and port to connect to for Piccolo telemetry (primarily used in simulation) [machine:port or 'disabled']

PICCOLO=serial port number   Serial port to connect to for Piccolo telemetry

NMEA=serial port number   Serial port to connect NMEA telemetry

METADATABAUD=   metadata baud rate, applies to both Piccolo and NMEA serial data, default is 57600 if not specified.

SIMAIRCRAFT=   If this parameter is present, simulated aircraft gps and heading will be provided instead of coming from the Piccolo (only however if TERRASERVERSIM is also enabled).. In CIRCLE/TRUE mode, a simulated circle flight is performed, in Sin mode a sine wave flight is simulated. [CIRCLE / SIN / TRUE]

8.4.3

8.4.4   Other simulation related messages

TERRASERVERSIM=[TRUE or FALSE]   Enable terraserver simulation mode (retrieves simulated aircraft view images from Terraserver.

8.4.5   Imaging parameters

GROUNDELEVATION=   Ground elevation in meters. This is a simple ground datum which is used by the georeferencing calculations, pending a digital elevation map. Default is 0.

WFOVDEGn=   Width field of view in degrees of camera n (horizontal image dimension). Repeat for each camera. WFOVDEG= indicates camera 0.

HFOVDEGn=   Height field of view in degrees of camera n (vertical image dimension). Repeat for each camera. HFOVDEG= indicates camera 0)

These values should be calibrated for the camera and zoom setting in use. This can be done by aiming the camera at a known target and measuring the geometry.

There is support for field of view for multiple cameras.

Use one line each for WFOVDEGn=k1n and HFOVDEGn=k2n where n=(0,1,2,3,4), and k1n and k2n are the FOV's.

i.e.

WFOVDEG0=45

HFOVDEG0=30

WFOVDEG1=... etc.

HFOVDEG1= ... etc.

WFOVDEG= and WFOVDEG0= are equivalent.

XRESn=xres   Set the x resolution for camera n. This is only necessary to be able to georeference the digital camera in independent mode, where georeferencing files are created onboard and archived, otherwise if the image is available the image dimensions will be read from the image file, and this is unnecessary.

YRESn=yres   Set the y resolution for camera n. As above.

INDEPENDENTDIGICAM   Independent Digital Camera Control Enabled. This allows independent control of an attached digital camera for onboard logging, without downlinking the images. In independent mode, the images are either timed or manually controlled as necessary. This mode can be turned on and off from the ground.

GEOREFENABLEn=TRUE/FALSE.   This allows disabling georeferencing for a particular camera channel if desired. This is done on the ground side at the moment. The default is that georeferencing is enabled for all camera channels.

8.4.6   Image archiving

ARCHIVEPATH=/satcamarchive

ARCHIVEDEVICE=/dev/doc1

ARCHIVEENABLED=[TRUE/FALSE]

MINFREEMEGS=   Set minimum free megabytes for archiving (Default 5)

These commands set the archive path and specify the archive device (which is used when reading free disk space).

Image archiving is controlled in the SatCamGnd UI through the 'Log images onboard' option.

Enabling this option will send a flag to the aircraft application the next time a photo command is sent.

Jpeg images are logged with the filename format 'Img%dHQ.jpg'.

Metadata is also logged onboard..

A disk space check is performed before logging the image; a minimum of 5 megabytes of disk space is required before an image will be logged.

The current image numbers are saved in nonvolatile storage (as files in the archive path). This allows the imaging system to be powered up in flight / shut off again without destroying previously logged images.

9   Aircraft software and hardware environment

9.1   Overview

The aircraft software runs on a low power, high speed x86 compatible Linux based processor. The application is called satcamairlinux, and starts automatically on powerup.

9.2   Windows based aircraft imaging application

A windows application is also provided, called SatCamAir, which runs the same compression and image transfer code as the Linux application. It can be used to simulate imaging missions and to test datalinks without requiring the imaging hardware. It does not however have the same script snapshot interface or access to USB digital cameras.

The windows application transfers an image called 'tx.jpg' located in the same directory as the application. You may replace this image with another, or use a simple external webcam type application to replace the image with another.

An excellent freeware webcam application which works well with the system is Dorgem, which can be downloaded at http://dorgem.sourceforge.net/

9.3   Imaging simulation

The application supports a simulation mode which can generate simulated imagery by using the Terraserver database of USGS satellite and aerial imagery.

This can be activated by enabling TERRASERVERSIM=TRUE.

Typically a network connected machine is devoted to aircraft imagery simulation, and the ground application runs on another machine.

The currently supported version of ImageMagick is 6.1.9, and for the Linux application, 5.4.6.

Using the simulation under Linux is not a preferred mode of operation.

It is worth noting that the Terraserver database is primarily US-centric, and imagery is not available everywhere.

9.4   Aircraft Metadata sources

Aircraft metadata can be taken from a number of different sources:

a Piccolo or simulated Piccolo (PiccoloPC) via a serial port using the Piccolo communications protocol,

a serial port generating NMEA data (again, this could be a Piccolo/PiccoloPC generating NMEA data out the payload port). The GPGGA and GPRMC NMEA messages are supported. If NMEA is used, GPS course is used as aircraft heading.

a network connection to a Piccolo Operator Interface (which may be connected to a Piccolo or PC running PiccoloPC in HWIL and/or software simulation) (Currently SatCamAir only),

or simply a simulated changing lat/lon in the Hood River OR region (an aircraft flying a circle or sine wave pattern).

Note a complete set of aircraft simulation software including everything needed for a software aircraft simulation can be freely downloaded at the Cloud Cap Technology web site, http://www.cloudcaptech.com

Payload transfer over the Piccolo link can also be performed either with a Piccolo or with the PiccoloPC software simulation.

Transparent payload serial communications currently requires the Piccolo PayloadDecode application to relay transparent serial data to the ground application.

9.5   Multiple camera support

One potential configuration of the system is to connect multiple video cameras and a USB digital camera.

The system now supports multiple cameras. It allows switching between cameras as desired, and georeferencing can be applied or not applied to each image appropriately.

Georeference true/false flag is taken from config file- this allows forward-looking cameras to be ignored for georeferencing, and down-looking cameras to be automatically georeferenced as desired. The cameras can then be distinguished and only appropriate images mosaiced. If this is not done the mosaicing application will not be able to distinguish the images and will (inappropriately and erroneously) mosaic forward-looking images.

Rescaling digital camera images for satcomm can be done by adding this capability to the script.

It is of considerable benefit to transmit higher quality images than 640x480. A 1.3 megapixel image (1280x1024) could be sent at 260:1 (very usable) compression ratio over Iridium in just over a minute. This is over 4 times more resolution, and would probably make imagery customers considerably happier. If a higher resolution camera is carried onboard (i.e. 5 megapixel camera), it would be necessary to rescale the images to a smaller size more appropriate for Iridium. High quality images can be kept onboard the camera or onboard the image processor's flash storage.   Metadata is stored in the image archive area.

A future desirable feature would be a dynamically selected output resolution.

9.6   Script based image snapshot commands

The Linux application calls scripts to take camera snapshots.

One script is used with commandline parameter to set the camera channel and resolution setting.

These scripts are called with the convention:

snappic camera# resolution# quicksnapflag

See the resolution table to lookup the resolution#.

qucksnap flag is 0 to write the file to /ramdisk/tx.jpg, or 1 to write the file to /ramdisk/quicksnap.jpg

i.e.

snappic 1 3 0   will use camera 1 to take a 640x480 snapshot.

Camera 0 (generally defined as the USB digital camera). Currently the snappic script will call the snappicdig script (also with 3 parameters).

Camera 1- Camera 4 (Ethernet / framegrabber / other)

Each script may call an external program, and should return a JPEG image in the file /ramdisk/tx.jpg. Samples are provided for both USB and Ethernet based imaging devices.

9.7   Digital camera control

Resolution control is now also available for the digital camera. The snappicdig script can be customized to support the native resolutions of the digital camera (and to resize the image if non-standard resolutions are desired), and can be configured to autodetect the camera if desired (specifying the camera does speed things up slightly).

There is another script initdigicam, which can be used to configure the digital camera (turn off the flash, configure the shutter speed / focus mode / other settings as supported. It is run at powerup.

9.8   Independent digital camera support

In general this is used when a 'store-in-camera' snapshot mode is needed.

Timed shots can be taken, controlled by a delay set in the user interface.

A snapshot button also allows on demand photos to be taken.

The independent digital camera has its own script, no parameters.

snappicinddig

This script might trigger hardware using the parallel port, or use USB to trigger a snapshot.

9.9   Linux environment

The board runs Linux 2.4.18 kernel and libc5.

It runs http, ssh, smb, telnet, and ftp servers.

Accounts: guest:guest

root:satcam

9.10 Ethernet support

A driver has been added to support the Hawking HUF11 USB to Ethernet module, a miniature Ethernet interface. This must be present at boot in order for ethernet to function over USB. Since there is only one USB port available, a miniature USB hub (or standalone ethernet card) may be used if both USB and Ethernet imagers are desired simultaneously. The interfaces will not typically be used simultaneously in the standard configuration.

Figure 6:   Hawking HUF11
USB to Ethernet interface

Support also exists for standalone NE2000 ethernet boards.

On boot, a fixed IP address is used, which is 192.168.254.17 for an NE2000 board, or 192.168.254.18 for the USB to Ethernet module.

If connection to an ethernet imaging device is necessary, an ethernet crossover cable should be used.

10 Metadata documentation

Metadata is sampled by the aircraft when it performs a photo snapshot. The system sends metadata to the ground as part of an image status packet. After the image is decompressed and any georeferencing is performed, the ground application writes a metadata file to disk.

The metadata file is named Geo%dMeta.txt where %d is replaced by the current image number.

Each metadata file has a text header, for example:

```
%<Imagefilename> <cameranumber> <ctrlat> <ctrlon> <altitude> <heading> <roll> <pitch>
<xdegperpixel> <ydegperpixel> <upperleftlat> <upperleftlon> <lowerrightlat> <lowerrightlon>
<wfovdeg> <hfovdeg> <latspan> <lonspan> <LocalTimestamp> <AvionicsTimestamp> <CameraTimestamp>
```

The header line is a list of data included in the metafile. Ideally it should be parsed and items enclosed in <> should be added to the list of data included in the file. The format may change so providing a parsed list of data is a way to increase operability with different versions of the metadata file.

Metadata Items:

Imagefilename	the filename of the georeferenced world file, i.e. Geo%d.jgw
cameranumber	the camera number associated with this image
ctrlat	center latitude of the image, fractional degrees
ctrlon	center longitude of the image, fractional degrees
altitude	aircraft altitude, meters
heading	heading Euler angle, fractional degrees
roll	roll Euler angle, fractional degrees
pitch	pitch Euler angle, fractional degrees
xdegperpixel	x degrees per pixel in the georeferenced image
ydegperpixel	y degrees per pixel in the georeferenced image
upperleftlat	georeferenced image upper left corner latitude, degrees
upperleftlon	georeferenced image upper left corner longitude, degrees
lowerrightlat	georeferenced image lower right corner latitude, degrees
lowerrightlon	georeferenced image lower right corner longitude, degrees
wfovdeg	width field of view, degrees
hfovdeg	height field of view, degrees
latspan	latitude span of the image, degrees
lonspan	longitude span of the image, degrees
LocalTimeStamp	local time stamp of the avionics
AvionicsTimeStamp	avionics time stamp
CameraTimeStamp	camera generated timestamp for the image

Note on time stamps:

The current time stamp format is identical to the datenum format used by Matlab. This is expressed in fractional days, and a float64 variable (double) has millisecond level precision. Contact Airborne Innovations for source code to convert to/from this format.

This may be output to the file in a more human readable format in the near future (year month day hour minute second)

11 Future Roadmap

Improved georeferencing / orthorectification

Full TCP/IP datalink option

12 Hardware configuration

One possible configuration:

Single board CPU.

Ethernet support if needed via a small USB-Ethernet dongle.

DB-9 / ribbon cable connection to an Iridium modem, transparent UHF radio, or avionics payload port.

DB-9 / ribbon cable connection to an avionics source for aircraft metadata.

Video capture: The image system will retrieve images from the Ethernet video capture device.

Connection to a video camera (or multiple cameras, if desired)

A ground PC running Windows and the SatCamGnd application will connect directly to an Iridium modem and antenna.