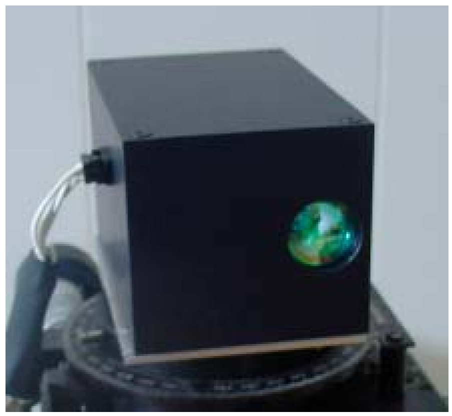
THOTH TECHNOLOGY, INC.

Argus 1000 IR Spectrometer



Owner's Manual

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Release Notes

Issue	Revisions	Date
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1 Purpose

The purpose of this guide is to provide explanations and procedures for installing, operating, maintaining and troubleshooting the Argus 1000 IR Spectrometer.

2 Scope

This document provides safety guidelines, setup information, operating instructions, troubleshooting procedures and interface and technical specifications for the Argus 1000 IR Spectrometer.

3 Symbols Used

The following symbols are used in this document.

CAUTION

Cautions identify conditions or practices that could result in damage to the instrument or other equipment.

4 Trademarks

Argus is a registered trademark of Thoth Technology Inc.

5 Important Safety Instructions

CAUTION

This guide contains important safety instructions that should be followed during handling, installation and operation of this product. Be sure to read and understand these safety instructions prior to handling.

- Before installing or using this product, read all instructions and cautionary markings located in this guide.

- The instrument should be handled with gloves in a suitable clean room environment. Care should be taken not to contact optical surfaces or instrument corners.

- Do not attempt to open or unseal the unit. This product contains no serviceable parts.
- The instrument shall be accommodated in a temperature and humidity controlled clean room of cleanliness class no worse than 100,000 during handling, assembly, integration and test.
- Anti-static grounding procedures must be observed when handling the instrument or interface electronics. Care should be taken to align connector keys prior to insertion of instrument interface.
- Do not shock the instrument physically or expose this unit to liquids of any type.

6 Package Contents

Figure 1: Argus Instrument and GSE Kit.

The Argus instrument and GSE Kit includes the following items:

Item	Location (Figure 1)	Description
1	Center	Argus unit
2	Top left	Shipping case
3	Top right	Argus ground test display laptop
4	Bottom Left	Argus power and communications interface cable, example electrical and mechanical mounting hardware.
5	Bottom Center	Laptop serial interface USB adapter
6	Bottom Center Right	Argus power USB adapter (5V)
7	Bottom Center Left	Laptop power module (19V)
8	Bottom Right	Laptop mains power cable (NEMA 5-15 3-Pin USA Plug)

7 Product Features

The spectrometer operates in the near infrared band 900 nm to 1700 nm (standard range), (or up to 2400 nm in the extended range version) and features a surface resolution of approximately 1.5 km when deployed in Low Earth Orbit (LEO). The device uses a detector array of 1x256 elements that is actively cooled. Each pixel has a native radiometric resolution of 10-bit that may be enhanced to 13-bit performance by utilizing the scan count setting to co-add successive spectra. The device includes a microcontroller, which controls the instrument's components. The device operates typically in a continuous single-pixel scanning mode with approximately 100 illuminated spectral channels. The mass of the complete spectrometer is less than 230 g.

7.1 Specifications

The technical specifications for Argus 1000 are summarised in Table 1, below.

Table 2: Technical Specifications, Argus 1000 Spectrometer

Argus 1000	Specification
1. Type	Grating spectrometer
2. Configuration	Single aperture spectrometer
3. Field of View	0.15º viewing angle around centered camera boresight with 15mm fore-optics
4. Mass	>230 g
5. Accommodation	45 mm x 50 mm x 80 mm
6. Operating Temp.	-20ºC to +40ºC operating temperature
7. Survival Temp.	-25ºC to + 50ºC survival temperature
8. Detector	256 element InGaAs diode arrays with Peltier cooler (100 active channels)
9. Grating	300 g/mm
10. Electronics	microprocessor controlled 10-bit ADC with co-adding feature to enhance precision to 13-bit, 3.6-4.2V input rail 250mA-1500mA (375mA typical)
11. Operational Modes	–Continuous cycle, constant integration time with co-adding feature –Adaptive Exposure mode
12. Data Delivery	Fixed length parity striped packets of single or co-added spectra with sequence number, temperature, array temperature and operating parameters
13. Interface	Prime and redundant serial interfaces RS232 protocol
14. Spectral Channels	100 (typical)
15. Integration Time	500 µs to 4.096 sec
16. Handling	Shipped by courier in ruggedized carrying case

7.2 Detector System

A linear gallium arsenide (InGaAs) photodiode array with high-quantum efficiency pixels in the infrared detect radiation emitted for a 1.5 km^2 surface tile that has been divided spectrally by the grating optics. The array is a hybrid InGaAs and CMOS acitve-pixel readout electronics in which the photo-current is buffered, amplified and stored according to an idealised schematic shown in Figure 3.

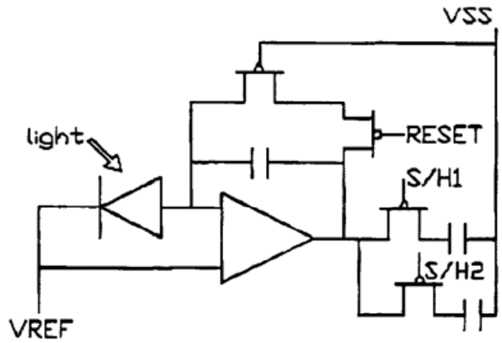

Figure 3: Principle of operation.

The readout process is clocked and triggered. Channels are differentially sampled as a form of double correlated sampling. Two values of feedback capacitor may be selected externally (the HIGH setting enhances dynamic range, the LOW setting increases sensitivity). The typical device quantum efficiency is shown in Figure 4.

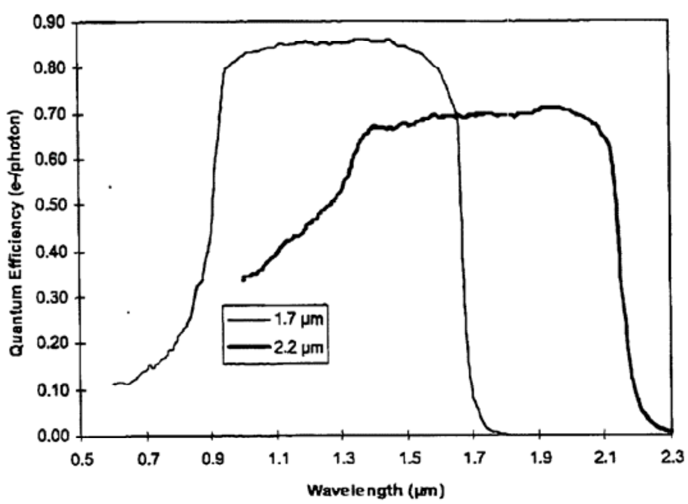

Figure 4: Detector Quantum Efficiency (1.7µm device).

7.3 Optical Design

The instrument is a single-scan pixel type observing a square surface tile and deriving 100 simultaneous independent measurements of the surface spectral emission. The fore optics comprises a telescope lens system, field stop and mirror to provide a collimated image of the surface tile onto the reflective grating. The reflective grating reflects a spectrally divided image (in the vertical plane) onto another mirror that focuses the first spectral order of the surface tile image onto the detector. The particular optical configuration is determined by Thoth's custom design tool. Spectrometers may be customized for particular spectral ranges or resolution by choice of grating type and optical element placement.

7.4 Optical Efficiency

The typical optical efficiency of Argus is shown in Figure 7 as a function of wavelength against a NIST traceable source. The variation arises because of the device's approximately constant quantum efficiency over this wavelength range.

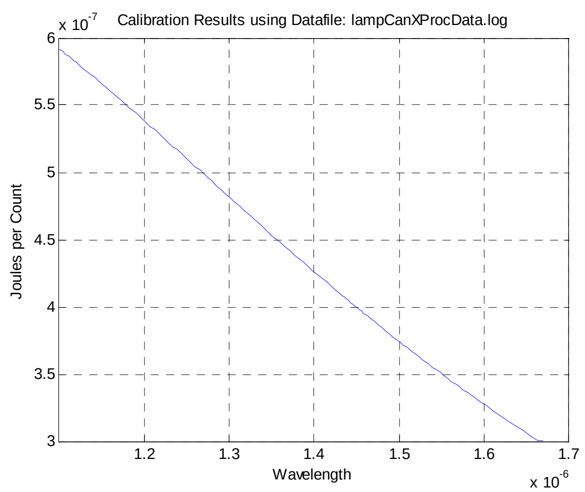

Figure 7: Spectrometer Energy Conversion Efficiency (1.6ms exposure) against NIST traceable standard screen and source (typical).

7.5 Angular Sensitivity

The angular sensitivity in response to a 1523nm collimated gas laser is shown in Figure 8. The full-width-half-maximum is estimated at 0.15°. At a typical LEO orbital height of 600 km, this corresponds to a surface tile of length 1.57 km.

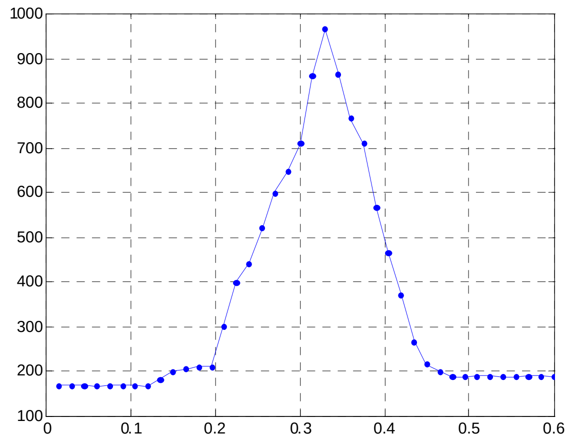

Figure 8: Angular Response in Counts *vs.* Angle in Degrees (1.6ms exposure to 1523 nm laser. FWHM estimated as 0.15°).

7.6 Response to Collimated Monochromatic Laser Source

Figure 9 shows a typical instrument response to a 1523 nm collimated laser source.

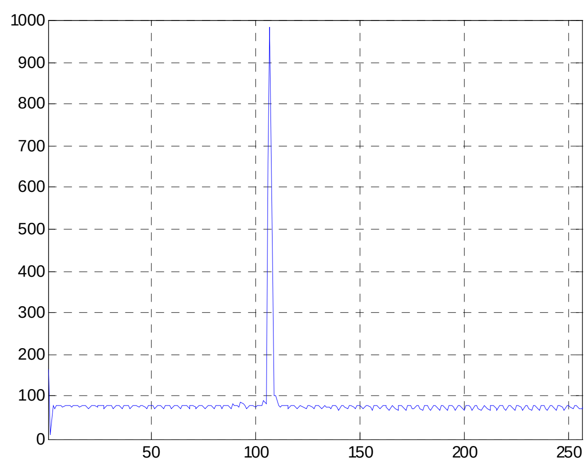

Figure 9: Response to Laser Source in Counts (1.6ms exposure to 1523 nm laser).

7.7 Functional Design

The system utilizes a microprocessor for the sequencing and processing of spectra. A functional diagram for the instrument is provided in Figure 10.

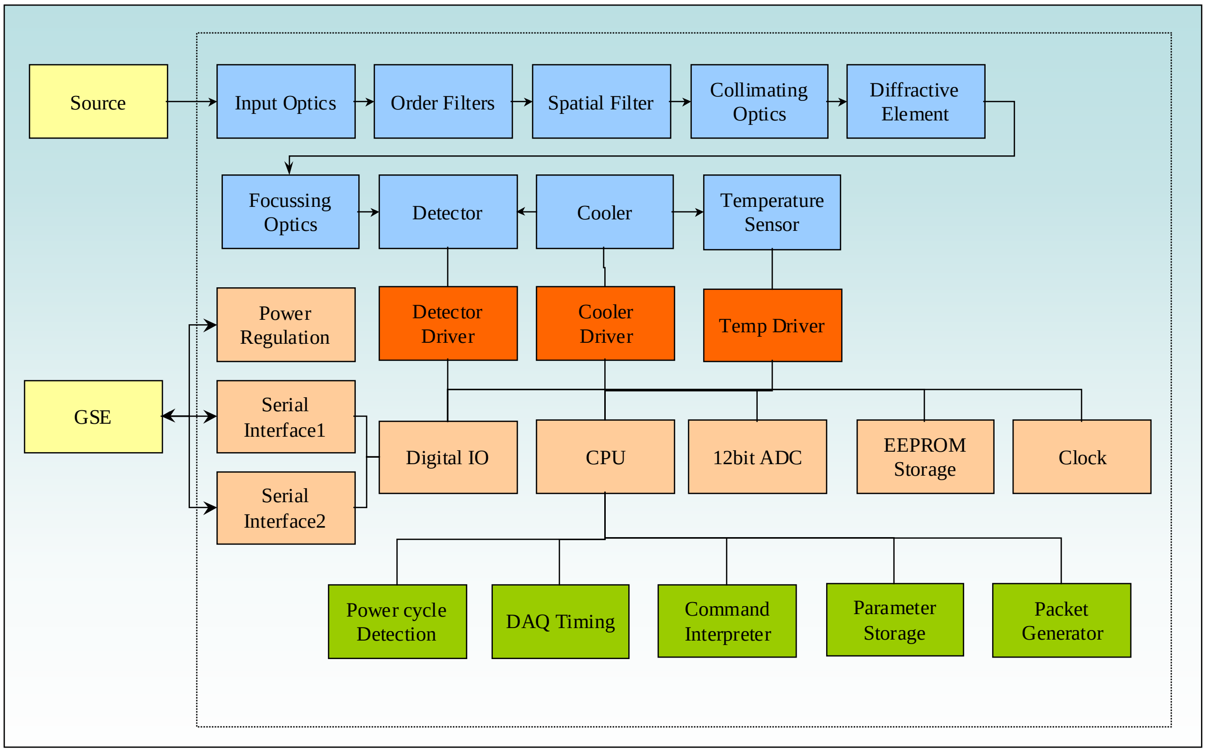

Figure 10: Argus Functional Diagram (optical train shown in blue; cooler components in red, electronics in brown and software functions in green).

7.8 Applications

7.8.1 Observing atmospheric gas species

Figure 1: Industrial Greenhouse Gas Emitters.

Argus can be utilized to map the spatial variation of greenhouse gases. Measurement interpretation requires accurate geolocation determination of the spectrometer surface pixel, application of a radiative transfer retrieval algorithm and knowledge of surface cloud conditions and topography. The spectrometer records infrared radiation emitted from the Earth's surface and atmosphere. By application of optical absorption spectroscopy, absorption and, consequently the column densities of particular atmospheric gas species may be obtained. The simplest methods such as differential optical absorption spectroscopy (DOAS) are similar to computing the intensity ratio between closely spectrally associated absorption and non-absorption features.

Space flight experience with Argus indicates that the instrument acquires excellent nadir spectra of reflected sunlight from a 1030 sun synchronous orbit with an exposure time of approximately 150 ms. Other orbital options can be utilized; however, variation in nadir and solar angles or spacecraft altitude can effect the scene significantly and increase retrieval complexity. The instrument's integration time is programmable. This enables integration times to be adjusted for observation conditions, scene altitude and orbital parameters. For good signal-to-noise it is advantageous to set the integration time to ensure that the spectral features to be observed correspond to instrument counts of approximately two thirds of the dynamic range of the instrument.

Table 1 lists the atmospheric gas species have absorption features in the spectral interval 900 nm-2.4 μm). In this spectral region water vapor dominates the spectra and, consequently, the radiative forcing and radiation budget. Carbon dioxide is visible and well isolated at 1.57 and 1.61 μm and is clearly observable in space data. At these wavelengths absorption by carbon dioxide is approximately one hundred times greater than that of water vapour. Oxygen can also be observed; however, a shorter integration time is required than for carbon-dioxide observation. Carbon Monoxide (CO) and Hydrogen Fluoride (HF) is not detected in spectra because of feature contamination by other absorbing gases (water vapor). There is some evidence of methane (CH_4) absorption at 1.63 μm; however it is contaminated with carbon-dioxide features. The extended range detector is recommended for the observation of methane (CH_4) features at 2.25 μm. The integrated intensity is highly correlated with surface albedo. Spectra contaminated by cloud cover show typically reduced gas absorption, a blackbody-like response and increased intensity. Results of spectra acquired over Canada in 2008 are shown in Figure 2.

Table 2: Absorbing Species

Gas	Absorption Strength
Oxygen (O_2)	1.25μm (10^{-24} mol.cm^{-2})
Carbon Dioxide (CO_2)	1.57μm (10^{-23} mol.cm^{-2}) 1.61μm (10^{-22} mol.cm^{-2}) 2.05μm (10^{-21} mol.cm^{-2})
Water (H_2O)	900nm (10^{-21} mol.cm^{-2}) 1.2μm (10^{-21} mol.cm^{-2}) 1.4μm (10^{-19} mol.cm^{-2})
Carbon Monoxide (CO)	1.63μm (10^{-22} mol.cm^{-2})
Methane (CH_4)	1.67μm (10^{-20} mol.cm^{-2}) 2.25μm (10^{-20} mol.cm^{-2})
Hydrogen Fluoride (HF)	1.265μm (10^{-19} mol.cm^{-2})

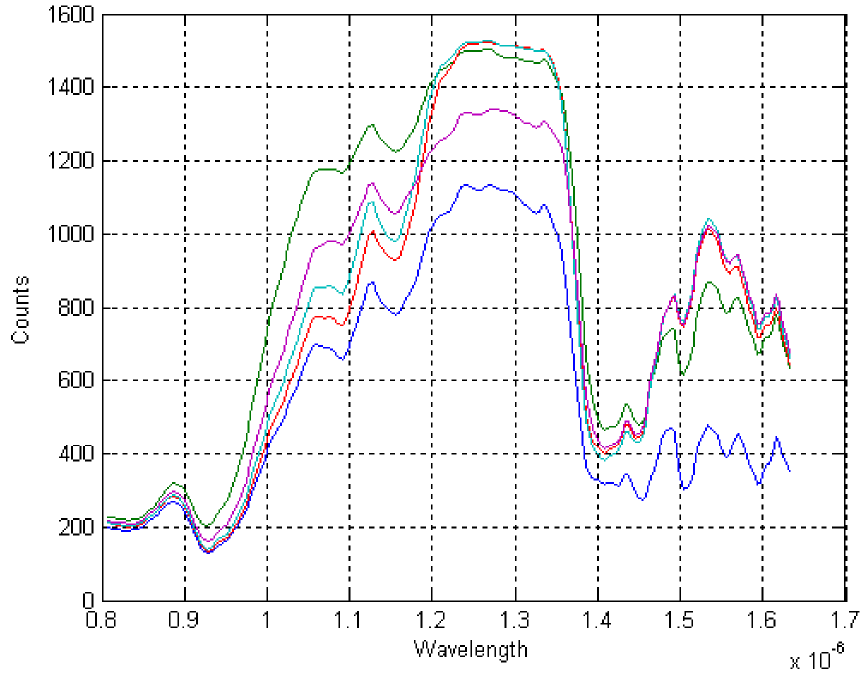

Figure 2: Data Acquired (successive spectra, smoothed features) from Argus 1000 on CanX-2 platform over Ontario, Canada, December 2008.

8 Ground System Electronics Setup

Referring to Figure 1 for item identification:

1. Setup the Argus Laptop Display Terminal and power it up.
2. Connect the blue Serial to USB converter to left (single) USB port on the laptop. Note if left port is use, serial port will mount as COM3 rather than COM4 or COM5 which require manual selection when launching 'Argus GSE'.
3. Connect the USB to power adapter (black cable) jack plug to the Power and Communications Interface Cable.
4. Place or mount the instrument unit in a safe condition.
5. Aligning the connector key on the Power and Communications Interface Cable connector mate the DF-11 plug with the instrument.
6. Connect the USB DB-9 serial port (blue connector) to the corresponding port on the Power and Communications Interface Cable.
7. From the start menu, select and run the 'Argus GSE' application.
8. Power the instrument by USB to power cable to one of the laptop USB ports.
9. After correct setup Argus GSE application will report instrument spectra and "Argus Status: In Sync" (bottom left of window).

The interface and cable setups are configured for a particular Argus GSE and instrument and are not designed to be interchangeable with other Argus instruments. For reliable operation and as a condition of warranty it is not recommended that the Argus GSE laptop terminal be connected to the internet either wirelessly or by LAN connection or that other applications be installed or operated on the Argus GSE laptop. Thoth recommends that the display terminal be dedicated solely to instrument operation.

9 Argus GSE Test Application

Software for the operation of Argus is provided on the ground station laptop. Launch the "Argus GSE" application from the start menu or by shortcut to access a data display terminal developed for testing purposes. This terminal is not intended for data analysis but provides a means to command the instrument and check basic functionality.

The application comprises two windows. The left pane shows the instrument status. The right pane shows the spectra as a function of counts against frequency number.

9.1 Argus Status Message

The Argus Status message is displayed in the bottom left of the application window. "Argus Status: Lost Sync" occurs if Argus GSE has lost contact with Argus or is waiting for a frame with an integration time exceeding 0.5 seconds. "Argus Status: In Sync" is indicated when the Argus GSE application is in communication with the instrument.

9.2 Adjusting Spectrum Pixel Range

The spectral pixel range may be adjusted by right-clicking with the cursor on the spectral display pane. The upper pixel and lower pixel display range may be set using the increment buttons or by inserting a value between 0 and 255.

9.3 Commanding the Instrument Settings

The instrument may be commanded by selecting the settings tab. Note that the pane containing the Argus ID must be active (selected by the cursor) in order to command the instrument. Exposure time, Number of Scans, Capacitor, Temperature, Adaptive exposure and Load/Save Defult settings may be programmed from the window menus.

9.4 Data Logging

The Argus GSE application may be used to log instrument data using the "Data Logging" tab. The data logging interval to create a new file with automatic time-stamped file name can be set as 1 min, 10 min or 60 min. Raw data is recorded, preceded by a windows standardized time stamp encoding the packet write time. Alternate serial port logging programs may be utilized if raw-only data is required.

9.5 Communications

The Argus GSE applications defaults to standard instrument communications settings on startup and utilizes a serial to USB converter port on COM3. Other settings may be specified using the "communications" tab.

10 Integration

10.1 Power Interface

10.1.1.1 The spacecraft shall provide a continuous feed of 572mA (375mA typical) at 3.5 - 5.0V (nominally 3.6 - 4.2V), while the instrument remains powered.

10.1.1.2 This feed may be switched on and off by the main On Board Computer (OBC).

10.1.1.3 In-rush current transients settle within 10ms of payload activation.

10.1.1.4 The instrument casing shall be maintained at ground potential.

10.2 Communications Interface

10.2.1.1 The instrument features two asynchronous serial ports using standard RS232 voltage levels.

10.2.1.2 The protocol used to communicate between the instrument and OBC is RS-232. The data format is 8N1.

10.2.1.3 One serial port shall be connected to the main OBC and configured at 115,200 baud, 8 bits, one stop bit, no parity. Commands shall be sent to the instrument from the main OBC through this port. The instrument shall also send engineering data to the main OBC through this port.

10.2.1.4 The second serial port shall be connected to the payload OBC, and shall be used by the instrument to send data to the payload OBC. The port will be configured at 115,200 baud, 8N1.

10.2.1.5 The maximum data rate between the instrument and either OBC is 230kbps

10.2.1.6 The payload electronics is designed to tolerate a constant logic high on its inputs, even when the unit is powered off.

10.3 Timing of Spectra Acquisition and Co-Adding Feature

10.3.1.1 The instrument shall acquire spectra for duration determined by the Integration_Time_Setting and then packetize and transmit this data in a subsequent 100 mS time slice. Where the Number_of_Scans_Setting setting is set to between $n = 2$ and 9, the instrument shall acquire n successive spectra co-adding them to a maximum precision of 16-bit before transmitting them in a subsequent 100 mS timeslice according to the following example timing diagram:

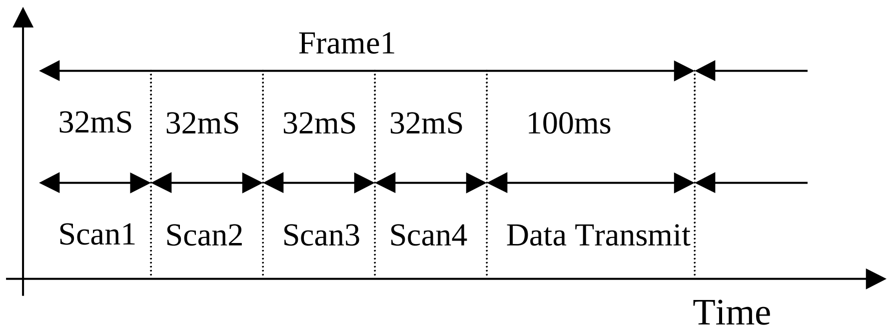

Figure 11: Spectra Acquisition Timing Example for 32mS integration time and number of scans set to 4 resulting in a 128mS total integration time at a resolution of 12-bit.

10.4 Data Packet Format

10.4.1.1 The spectrometer provides data over the serial communications interface to an Onboard Computer or listening device in 532 byte unsigned 8-bit words. Data packets are transmitted continuously at a cycle period determined as (100mS+Integration_Time_Setting * Number_of_Scans_Setting). The packet format is shown in Table 3.

Table 3: Argus Data Packet Format.

Word Number	Description
1 – 2	Synchronization Characters '(' and ')' provided to indicate packet start.
3	Device ID identifies Argus Instrument serial number [3].
4 – 5	Last command received provided in two-character format [4] [5] (see section 2.2).
6 – 7	Command acknowledgement and errors provided in two-character format: [6] [7]. (see section 2.2).
8 – 11	Frame or Packet counter/ID computed as: [8]x(256^3) + [9]x(256^2) + [10]x(256) + [11].
12	Integration Time for Exposure in Seconds computed as: 2^[9] x 0.0001.
13	Number of scans to co-added before data transmission.
14	8-bit binary word comprising: [11 Bit 1] Cooler Temperature Setting 0 = High Temp, 1 = Low Temp. [11 Bit 2] Dynamic Range Setting 0 = High Sensitivity, 1 = High Dynamic Range. [11 Bit 3] Auto-exposure time setting 0 = Mode OFF, 1 = Mode ON.
15 – 16	Detector Temperature (DT) computed in degrees Celsius as: V0=3.25*([15]*256 + [16])./1023; Rt=26.7e3*(3.22-V0)./(V0+1.78); DT=1/(1.289e-3 + 2.3561e-4 * ln(Rt) + 9.4272e-8 * (ln(Rt)^3));
17 – 18	Lifetime power ups computed as: [17]*256 + [18].
19-20	Adaptive exposure mode: pixel range for adaptive exposure defined as lower pixel number [20] to upper pixel number [19] to include.
21-22	Adaptive exposure mode: upper [21] and lower [22] thresholds to trigger changes in integration time expressed in percent of full dynamic range.
23 – 534	spectral data encoded as 512-bytes in repeating unsigned MSB and LSB 8-bit words [MSB]*256 + [LSB].
535	Parity word computed bitwise as: ∑ (I=1...534) XOR(byte_i, byte_i+1)

10.4.1.2 The electronics reads the detector thermistor resistance and record this data with every spectra. The thermistor reading will be conditioned to a temperature in °C according to the algorithm given in Table 3.

10.5 Connectors

10.5.1.1 The spacecraft shall provide all necessary external harnessing.

10.5.1.2 Connectors are located on the -Y face within the area indicated below:

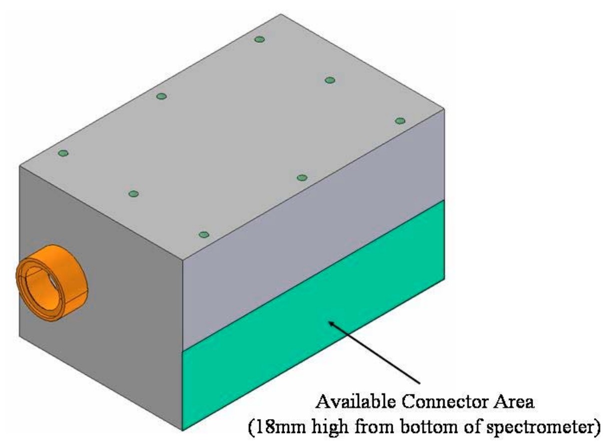

Figure 11: Connector mounting location (15mm from bottom edge towards optical input).

10.5.1.3 The instrument has a bulkhead mounted Hirose DF11 type connector with 6 pins. Hirose 6-pin DF-11 (part number H2021-ND) are required for mating to the instrument.

10.5.1.4 The pinouts are as follows:

Table 4: Power Connector Pinouts

Signal Description	External Pin No.	Connections
GND	5	Ground
Power	2	Power Vbattery (switched)
TXD1 (from instrument)	6	Main OBC RXD
RXD1 (to instrument)	2	Main OBC TXD
TXD2 (from instrument)	4	Payload OBC RXD
RXD2 (to instrument)	1	Payload OBC TXD

10.6 Mechanical Interfaces

10.6.1.1 The instrument mechanical axes are defined as follows:

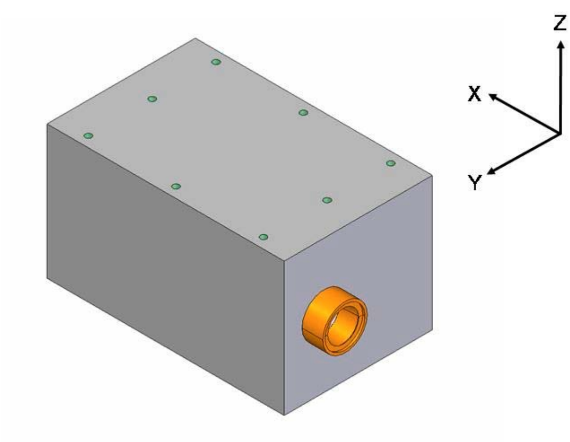

Figure 12: Mechanical Axes.

10.6.1.2 The instrument dimensions are as follows:

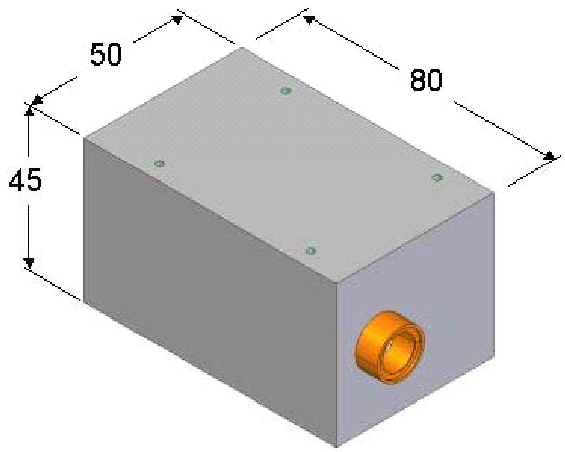

Figure 13: Spectrometer External Dimensions (Argus 1000 configuration). . The volume marked in orange must be free of obstructions.

10.6.1.3 The instrument is mounted using 4-40 taped and helicoiled holes in the base of the instrument. WARNING: Mounting hardware must be sized so as to avoid exceeding the maximum thread depth of 5.0mm. Example 4-40 threaded mounting hardware is included; however, actual hardware must be correctly sized for the depth of the mounting fixture and countersink (if applicable). The instrument should be retained by a minimum of six of the eight mounting points. Do not over torque or exceed maximum thread depth as damage to instrument may result. The mounting-hole configuration is shown below. Note: center left hole has limited clearance due to optics and its use is optional.

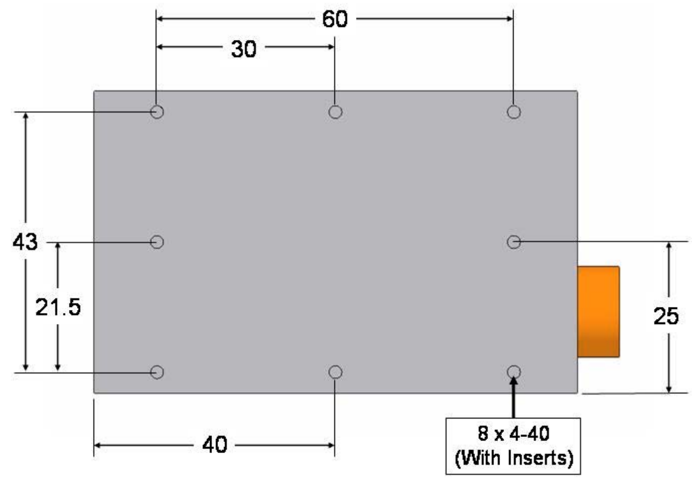

Figure 14: Spectrometer Mounting-hole Locations (ANSI/ASME 4-40 threads). Mounting hardware should not extend more than 5.0mm into threads. Do not over torque.

10.6.1.4 The entrance aperture is on the -X face. Its center is located 10mm from the edge of the +Y side and 22.5 mm from the +Z side. The spectrometer entrance aperture is 15mm diameter. The instrument has no outer protrusions (except the power connector) and should be mounted under the spacecraft skin, co-aligned with a 16mm circular aperture to allow light entry. Optimally, the 16mm circular aperture port should be between 10mm and 50mm from the front face of the instrument and should have blackened edges. Spectrometer faces other than the mounting face should have no physical contact with other spacecraft components. A minimium 2 mm gap on all external spectrometer faces is recommended.

10.6.1.5 The connector is on +X, with its center 13mm from the +Y face and 5mm from the -Z face.

10.6.1.6 The approximate instrument mass is 215 g.

10.7 Environment

10.7.1.1 The spacecraft will maintain the instrument within specified tolerances for operation and survival (see Table 2).

10.7.1.2 The instrument shall be capable of surviving a vibration load of at least 10g rms random and sinusoidal on all axes.

10.7.1.3 The instrument is composed of materials that exhibit a total mass loss of no more than 1% of the component's initial mass, and that contain no more than 0.1% collected volatile condensable material.

10.7.1.4 The instrument shall be accommodated in a clean room of cleanliness class no worse than 100,000 during assembly integration and test; class 10,000 recommended.

11 Operation

11.1 Command format

A command string consists of five bytes arranged as follows:

Header	Header	Parameter	Setting	Parity

The header is two bytes in length and is the characters '(', ')'. The parity byte is the logical XOR of the bytes making up the command string, excluding the parity byte. As an example, the command to set the exposure time to 2048mS is as follows:

(	)	x	<	0x65? 0x45?

The system will respond with the message:

(	)	A	K	0x0B

Indicating the command has been received and executed. An acknowledgement of a command is returned by the spectrometer in the subsequent telemetry packet. If an error occurred during the command reception/execution process the system will respond with one of the following messages

Message Description	Packet Start Characters
NO STATUS MESSAGE TO COMMUNICATE	"◊00"
PARAMETERS LOADED SUCCESSFULLY	"◊PL"
POWER UP INITIATED	"◊PU"
COMMAND ACKNOWLEDGED	"◊AK"
RESET TO DEFAULT PROGRAM	"◊DP"
ERROR RX TIMEOUT	"◊EC"
ERROR EXPOSURE OUT OF RANGE	"◊XR"
ERROR BAD PARITY	"◊BP"
ERROR INVALID PARAMETER	"◊IP"
ERROR SCAN COUNT OUT OF RANGE	"◊SR"
ERROR CAP SELECT OUT OF RANGE	"◊CR"
ERROR COOLER SELECT OUT OF RANGE	"◊TR"

11.1.1 Command List

11.1.1.1 Exposure Time

Parameter: ‘x’

Setting:

‘0’	500uS
‘1’	1.0mS
‘2’	2.0mS
‘3’	4.0mS
‘4’	8.0mS
‘5’	16.0mS
‘6’	32mS
‘7’	64mS
‘8’	128mS
‘9’	256mS
‘:’	512mS
‘;’	1024mS
‘<’	2048mS
‘=’	4096mS

11.1.1.2 Select Capacitor Setting

Parameter: ‘c’

Setting: ‘0’ High Sensitivity
‘1’ High Dynamic Range

11.1.1.3 Select Cooler Temperature Setting

Parameter: ‘t’

Setting: ‘0’ High temperature setting, (reduced current draw by 70 mA)
‘1’ Low temperature setting, (100mA cooler current draw)

11.1.1.4 Set Number of Scans to Count

Parameter: ‘s’

Setting: ‘1-9’ Number of spectra to co-add before data transmission.

11.1.1.5 Load Default Settings

Parameter: ‘<’

Setting: Not required.

11.1.1.6 Save Current Settings as Default

Parameter: ‘C’ [CAPITAL C]

Setting: Not required.

11.1.1.7 Set Adaptive Exposure Mode

Parameter: ‘a’

Setting: ‘0’ is OFF ‘1’ is ON.

11.1.1.8 Load Factory Parameters

Parameter: ‘i’

Setting: Not required.

11.1.1.9 Set Adaptive Exposure Mode Upper Threshold

Parameter: ‘u’

Setting: Threshold value in percent (%).

11.1.1.10 Set Adaptive Exposure Mode Lower Threshold

Parameter: ‘l’

Setting: Threshold value in percent (%).

11.1.1.11 Set Adaptive Exposure Mode Upper Pixel

Parameter: ‘e’

Setting: Pixel Number.

11.1.1.12 Set Adaptive Exposure Mode Lower Pixel

Parameter: ‘b’

Setting: Pixel Number.

12 Troubleshooting

The following table provides information on identifying and resolving possible problems when using an Argus 1000 Spectrometer.

Problem	Possible Cause	Solution
'Argus Status: Lost Sync' reported by Argus GSE application.	Serial communications Not connected. Instrument not powered. Instrument interface not mated. Long Integration Time setting. Communication lost by Argus GSE.	Connect Serial to USB converter (blue cable). Connect USB power jack to Argus Interface Cable. Mate instrument interface. Wait for integration to complete. Restart Argus GSE application.
Argus Communication settings pop-up window appears when Argus GSE launched	Argus USB to serial adapter not plugged in to laptop's left-hand USB port.	Move adapter to left port or select COM4: or COM5: to use adapter in other USB ports.
Settings menu inoperable (grayed out)	Argus Parameter Pane (Left Window) not active.	Select Instrument pane. Reselect from settings menu.

13 Warranty

This limited warranty is provided by Thoth Technology Inc. ("the Company") and covers product defects in your Argus 1000 IR Spectrometer. In case of delivery of faulty merchandise, especially faulty construction, defective material, or defective manufacture, the Company shall, at its reasonable discretion, repair or replace the merchandise provided that the Customer notifies the Company of faults in writing within ten (10) days of delivery; in such cases, the faulty merchandise becomes the property of the Company.

There shall be no warranty for damages arising from normal wear, improper use, improper handling, faulty installation or startup by the Customer or by a third party or for deficient building provisions, including but not limited to unsuitable electrical provisions, exposure to fire, exposure to water or other liquids, or other unsuitable site properties. If, on inspection by the Company of returned merchandise within the warranty period, it becomes apparent that a fault is due to improper handling or use by the Customer, the Company may offer to fix the merchandise, and the costs of repair shall be borne by the Customer.

Any repair or modification to the merchandise performed by the Customer or by a third party without the prior written permission of the Company invalidates any warranty for faulty merchandise.

13.1 Disclaimer

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The Company makes no warranty that the items described herein are suitable or fit for a particular purpose. The Company makes no representation as to condition or character of the merchandise and in no event will be liable for any special, direct, indirect, incidental or consequential damages, losses, costs or expenses however arising whether in contract or tort including without restriction any economic losses of any kind, any loss or damage to property, any personal injury, any damage or injury arising from or as a result of misuse or abuse, or the incorrect installation, integration or operation of this product.