# IR Surveillance from the Ground using COATS

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## Features

- Based on Acuitas USP-T33 elevation over azimuth platform.
- Direct motor drives
- Self-levelling
- Star calibration
- Up to four cameras
- Visible & SWIR cameras
- Filter wheels
- GPS position & Time stamps.
- Auto-track capability
- LEO, MEO, GEO, capability

# COATS

- Chilbolton Optical Advanced Tracking System
  - Alt-Az Direct Drive Mount

| | |
|---|---|
| **Azimuth Axis** | -160 $^{o}$ to +160 $^{o}$ relative to pedestal base |
| **Elevation Axis** | -10 $^{o}$ to +190 $^{o}$ |
| **Maximum Rate** | 60 $^{o}$/s (deliberately limited to protect sensor optics) |
| **Bandwidth** | 8 Hz |
| **Repeatability** | better than 1 arc-sec |
| **Calibration accuracy** | 10 to 20 arc-sec |

| | ODK10 telescope | RC8 telescope | Mirror Lens | Sony Zoom |
|---|---|---|---|---|
| **Aperture** | 250 mm | 205 mm | 100 mm | 75 mm |
| **Focal length** | f6.8 | f8 | f8 | f2.6 |
| **Camera** | Watec 910H (monochrome) | OWL 640 SWIR (monochrome) | Everfocus (colour) | Sony (colour) |
| **Horizontal FOV** | 0.224 $^{o}$ | 0.341 $^{o}$ | 0.42 $^{o}$ | 7 $^{o}$ to 0.7 $^{o}$ zoom |
| **Filters** | UV/IR cut<br>Red, Green, Blue<br>H polarisation<br>V polarisation | 808 nm<br>1064 nm<br>1319 nm<br>(Long Pass) | | |
| **Pixel resolution** | 1.1 arc-sec<br>5.3 µrad | 1.9 arc-sec<br>9.2 µrad | 0.78 arc-sec<br>3.8 µrad | 3.8 arc-sec<br>18.4 µrad |


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# SWIR Camera Installation

- Raptor OWL 640
  - Analogue PAL video output
  - Serial RS422 control
  - Bespoke control software
  - Integral Thermal Electric Cooling – down to -10 °C
  - Forced air cooling added for day time operation
  - Added filter wheel with long pass (wavelength) filters
  - Limited bad pixel correction

# MOTIVATION

- Extend Observation Periods
  - Into Late Dawn & Early Dusk
  - Into full daytime
  - Into Eclipse periods
- Remove blue, green & red part of the visible spectrum
  - Rayleigh refraction very frequency dependent
  - Mei refraction weakly frequency dependent
- IR Atmospheric Transmission Bands
  - SWIR 1 – 1.5 µm
  - MWIR 3 – 5 µm
  - LWIR 8 - 10 µm

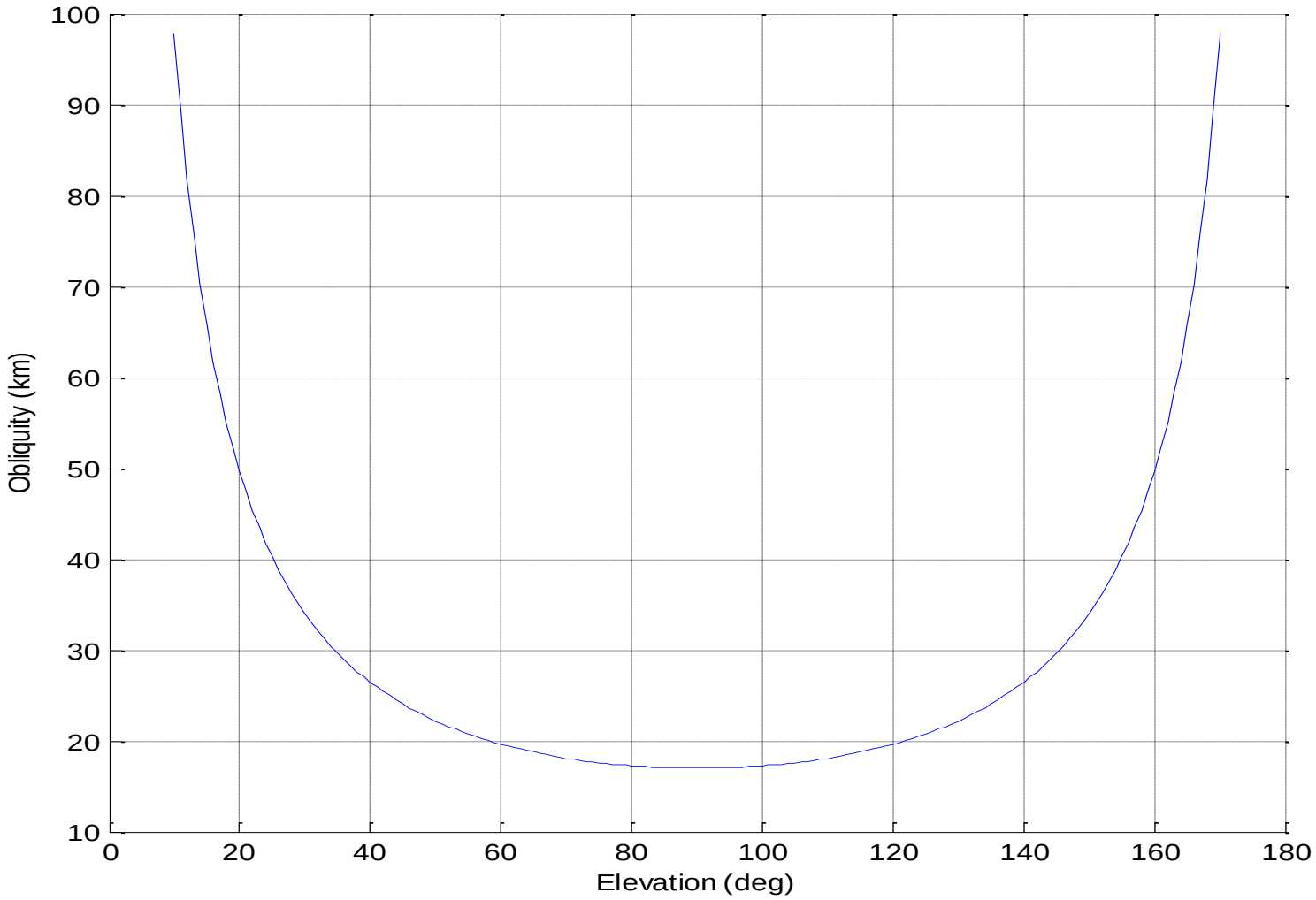
# SWIR Observations

- Raptor OWL Camera:
  - 700 nm to 1.6 µm
- LP Filters (chosen for best SNR)
  - 808 nm
  - 1064 nm
  - 1319 nm
- Range of sky conditions
  - Including cloud
- Careful choice of target positions

# Signal-to-Noise Ratio

- Target
  - Illumination (phase angle wrt Sun)
  - Size
  - Albedo at SWIR
- Sky
  - Brightness at SWIR
  - Tropospheric obliquity
  - Cloud

# Sky Brightness at SWIR

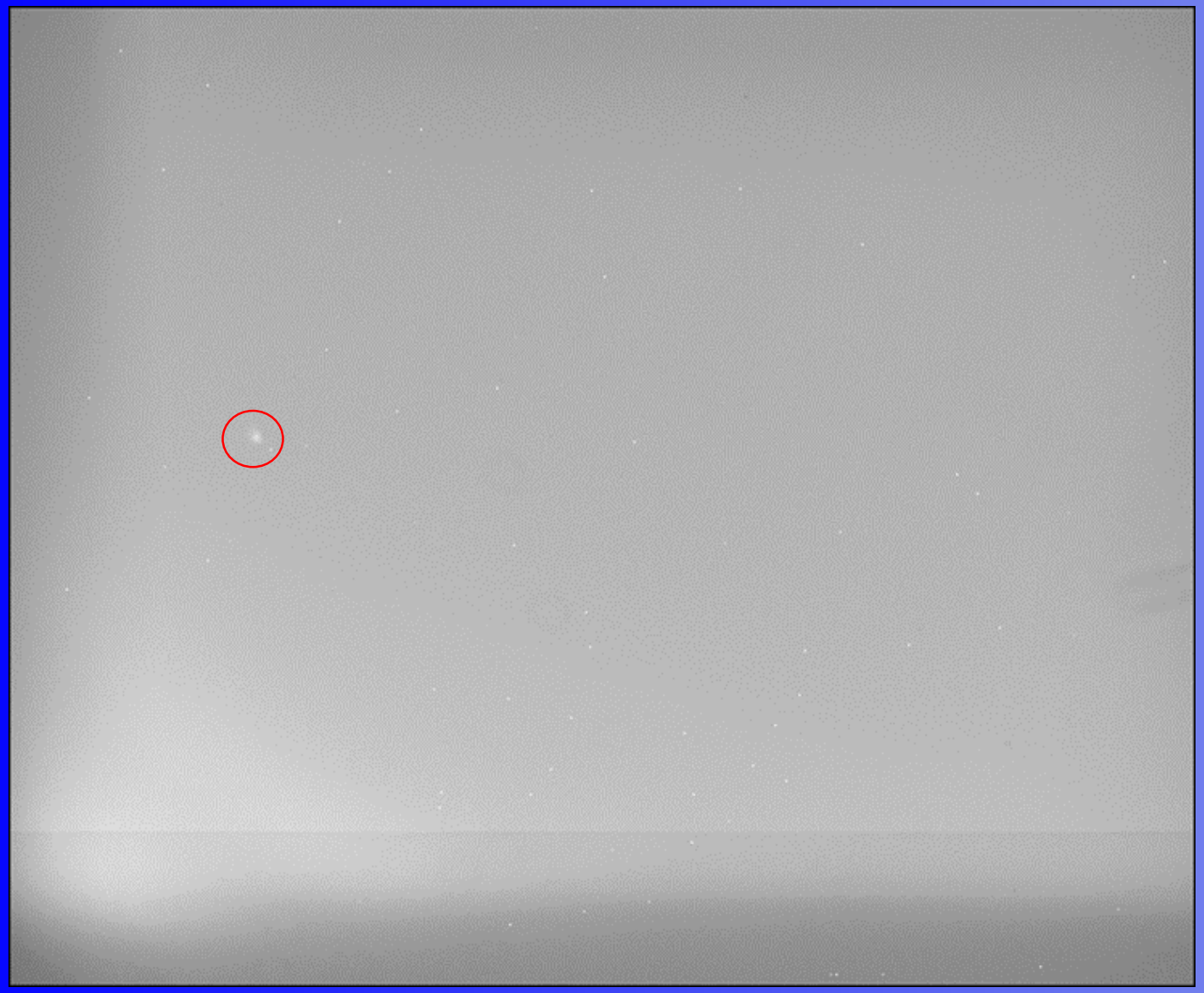


# Observations

- SV 23405
- SL 16 R/B
- 15th March
- 1654 UTC

- SNR 11 dB
- Visual Mag 3.5

- 06:24—18:07 — daylight
- 18:07—18:10 — sunset
- 18:10—18:43 — civil twilight
- 18:43—19:22 — nautical twilight
- 19:22—20:02 — astronomical twilight



- SV 21423
- SL-14 R/B
- 15th March
- 1620 UTC

- SNR 4.5 dB

- Visual Mag 5.5

- 06:24—18:07 — daylight
- 18:07—18:10 — sunset
- 18:10—18:43 — civil twilight
- 18:43—19:22 — nautical twilight
- 19:22—20:02 — astronomical twilight

- SV 27422
- ARIANE R/B
- 15th March
- 1703 UTC

- SNR 5 dB
- Visual Mag 4.5

- 06:24—18:07 — daylight
- 18:07—18:10 — sunset
- 18:10—18:43 — civil twilight
- 18:43—19:22 — nautical twilight
- 19:22—20:02 — astronomical twilight

- SV 32382
- RADARSAT 2
- 22nd March
- 1626 UTC

- SNR 4 dB
- Visual Mag 4.7

- 06:04—06:08 — sunrise
- 06:08—18:19 — daylight
- 18:19—18:22 — sunset
- 18:22—18:55 — civil twilight

- SV 32382
- RADARSAT 2
- 22nd March
- 1628 UTC

- SNR 4 dB
- Visual Mag 4.7

- 06:04—06:08 — sunrise
- 06:08—18:19 — daylight
- 18:19—18:22 — sunset
- 18:22—18:55 — civil twilight

- SV 22079
- ARIANE 42P R/B
- 22nd March
- 1801 UTC

- SNR 6 dB
- Visual Mag 4.3 ~ 5

- 06:04—06:08 — sunrise
- 06:08—18:19 — daylight
- 18:19—18:22 — sunset
- 18:22—18:55 — civil twilight

- SV 16326
- COSMOS 1707
- 22nd March
- 1813 UTC

- SNR 2 dB
- Visual Mag ~5

- 06:04—06:08 — sunrise
- 06:08—18:19 — daylight
- 18:19—18:22 — sunset
- 18:22—18:55 — civil twilight

- SV 32382
- RADARSAT 2
- 28th March
- 0707 UTC

- SNR > 11 dB
- Visual Mag 4.7

- 06:17—06:51 — civil twilight
- 06:51—06:54 — sunrise
- 06:54—19:29 — daylight
- 19:29—19:32 — sunset
- 19:32—20:05 — civil twilight

- SV 28931
- ALOS
- 28th March
- 0827 UTC

- SNR > 10 dB
- Visual Mag 2.4

- 06:51—06:54 — sunrise
- 06:54—19:29 — daylight
- 19:29—19:32 — sunset
- 19:32—20:05 — civil twilight

- SV 28931
- ALOS
- 28th March
- 0829 UTC

- SNR 6 dB
- Visual Mag 2.4

- 06:51—06:54 — sunrise
- 06:54—19:29 — daylight
- 19:29—19:32 — sunset
- 19:32—20:05 — civil twilight

- SV 25544
- ISS
- 22 June 2018
- 1320 UTC

- Visual Mag -5.9

- 04:51—04:56 — sunrise
- 04:56—21:21 — daylight
- 21:21—21:26 — sunset

# MWIR Observations

- Thermacam PM290
  - 90 mm aperture
  - Manual control
  - No operator’s manual
  - Stirling cooling engine struggling
- Camera fitted to 200 mm Richey-Chretien telescope
  - Unsuccessful – no satellites observed.
  - Image of the Moon

# PM20 MWIR Camera

# The Moon

## MWIR Image

## Visible Image[1]

(1. Courtesy Dr Stuart Eves)

# The Way Ahead?

- Successful daytime observations with SWIR
  - Choose targets carefully
  - Visual magnitude < 5
  - Extended observations into daytime
- Combination of Visual, SWIR & MWIR

# Questions