OPTICALLY DETECTING AIRCRAFT FOR IN-SKY SAFETY IN DAYLIGHT CONDITIONS

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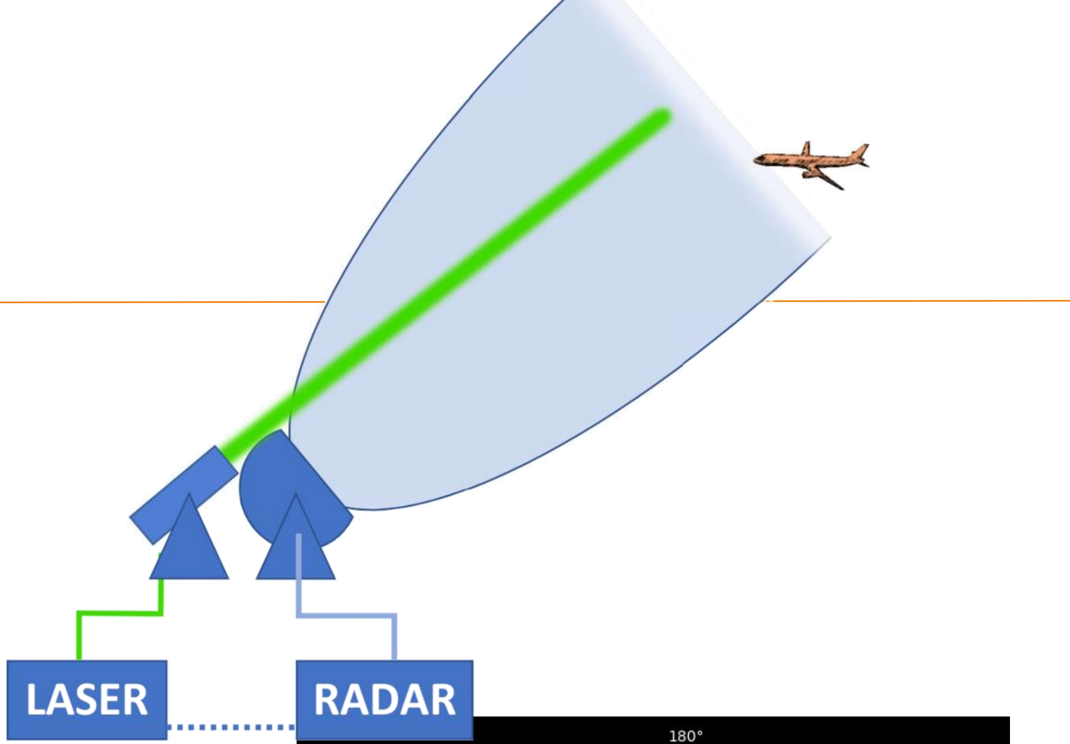
ACTIVE IN-SKY SAFETY

Emitting high-power, non-eyesafe laser pulses in to the atmosphere requires safety precautions to avoid illuminating any aircraft approaching the direction of the beam.

ACTIVE IN-SKY SAFETY

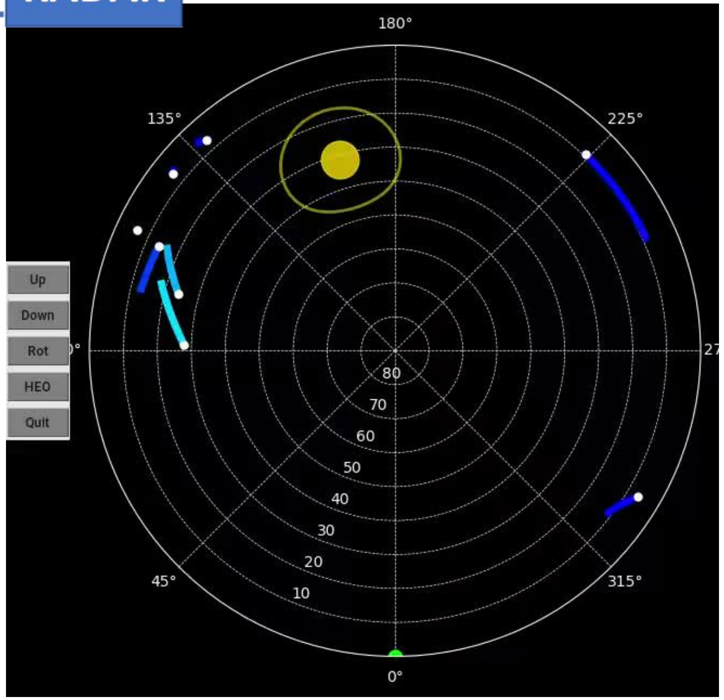
The SGF, Herstmonceux ensures in-sky safety by the means of:

1. An **active radar** that tracks with the SLR telescope. It detects reflections from aircraft as they enter a larger field of view centred around the SLR laser.
2. An **ADS-B** system called 'listen2planes' which displays aircraft and calculates approaching planes to give audible warnings to the observer.
3. An **observer** beside the telescope with a view of the sky.



Each can quickly shut off the laser if an aircraft approaches.

The radar and ADS-B see the high altitude aircraft and the observer spots lower aircraft, balloons and gliders.



DIGITAL OPTICAL CAMERA SYSTEM

An investigation is underway in to the reliability and capability of an optical in-sky safety system, designed at the SGF and called 'watch4planes'.

The early stages of this were presented on a poster at the 21st International Workshop on Laser Ranging in Canberra, Australia.

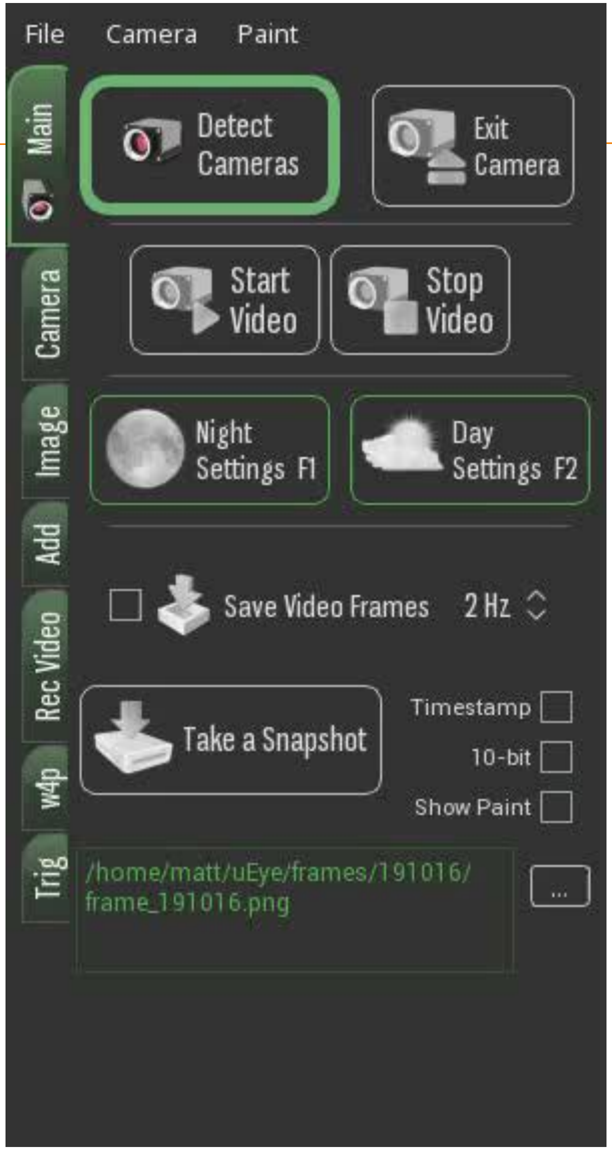
The setup was a compact, sensitive, monochrome uEye UI324xCP-M USB3.0 digital camera from IDS with a 1280x1024 pixel CMOS chip. It was mounted on the underside of the SLR telescope and pointed to align with the SLR laser beam with a 100mm focal length C-mount lens fitted, giving a field of view of approximately **5˚**.

DIGITAL OPTICAL CAMERA SYSTEM

The camera connects to a Linux PC running the uEye camera daemon and is operated using an extensive library of commands available in C++.

A display desktop application was built in Qt and this allows the user to:

- Adjust camera settings
- Adjust the image brightness and contrast
- Gate the camera
- Integrate images
- Zoom in on an area of interest
- Software bin pixels
- Save images
- Record video



IDENTIFYING AIRCRAFT

With this camera it is possible to see aircraft.

To the human eye it usually obvious where a plane is in a frame. However it is not so straight forward when it comes to defining criteria to determine the presence of an aircraft.

In a single frame an aircraft could be the brightest or darkest feature. The size in the image is not fixed and the shape depends on its orientation. Also, clouds appearing in the frame can obscure the aircraft.

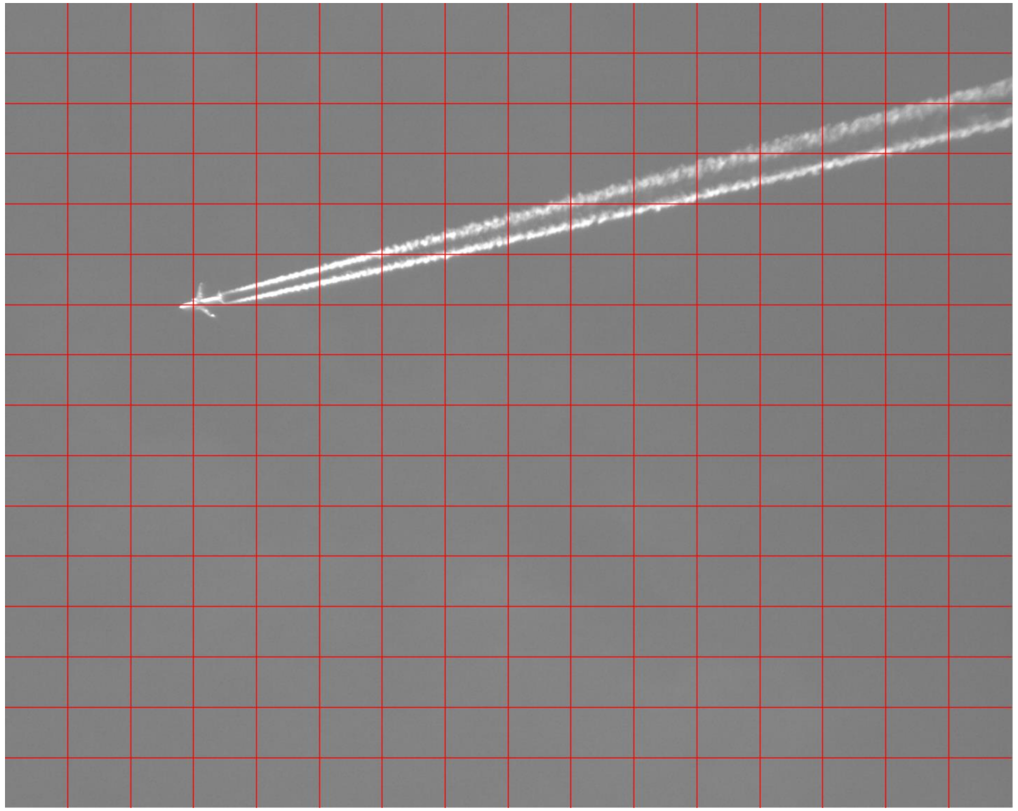
In this study, an aircraft is considered to be an object that stands out in the frame.

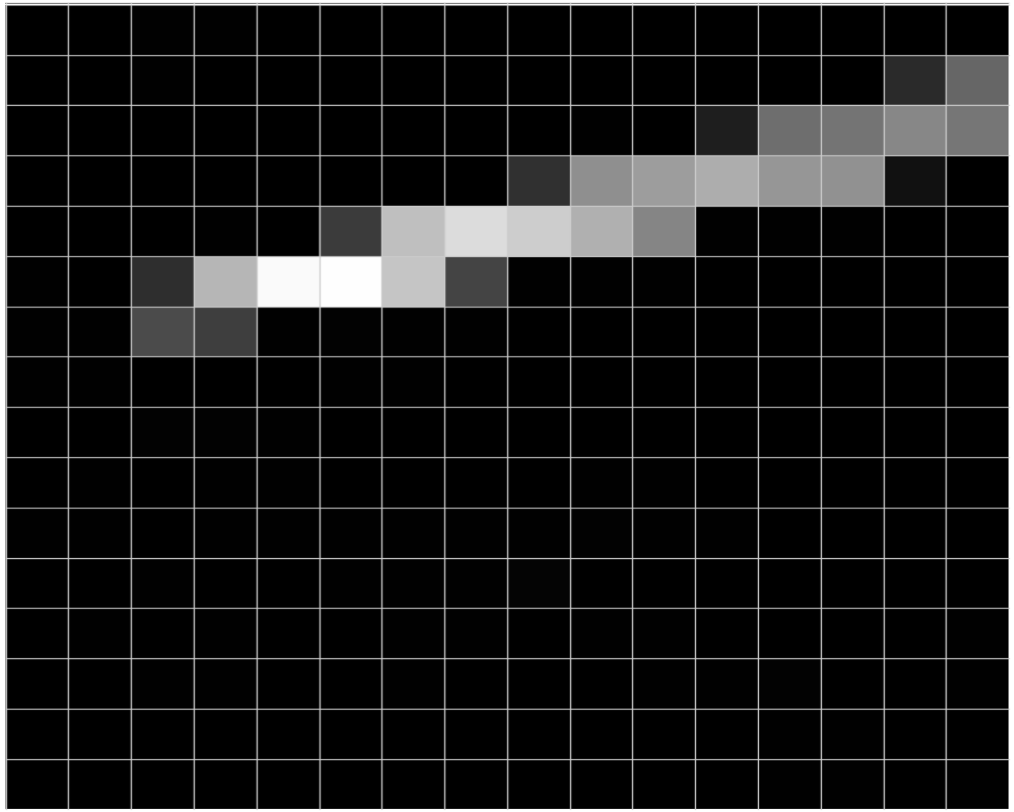
IDENTIFYING AIRCRAFT

To identify an aircraft, pixels are compared to their surrounding pixels by breaking up the frame in to a NxN grid. A standard deviation of the pixel values was calculated for each bin.

IDENTIFYING AIRCRAFT

The largest RMS was identified and a mean and RMS of the RMS values were calculated for the whole grid. A threshold was required in order to decide if an aircraft is present.





IDENTIFYING AIRCRAFT

In addition to RMS I now also use a value called ‘edge’ which sums the steps between consecutive pixels in each grid element.

This has an advantage over clouds, which are mostly more gradual in their edges.

DIGITAL OPTICAL CAMERA SYSTEM

The new set up is of a telescope-mounted, colour, 2056x1542, USB-3 uEye UI-3270LE-C-HQ camera from IDS, a wide lens with a field-of-view of 20°.

It uses the same software application built in C++ and Qt using the camera's extensive control software suite.

Mounted alongside this camera is a USB-3 uEye UI-388xLE-M camera from IDS with a zoom lens. This is being develop for night images.

IDENTIFYING AIRCRAFT

This new aircraft detection setup is different:

- The frames are in colour, which means each pixel can be considered for its red, green and blue components.
- It has a much wider field of view so that approaching planes are visible earlier.

Pixels that are more red in colour suggest the presence of an aircraft.

Clear blue skies and white/grey clouds are more distinguishable than with monochrome images.

CLOUDS

Identifying aircraft on a clear blue sky is more straight forward.

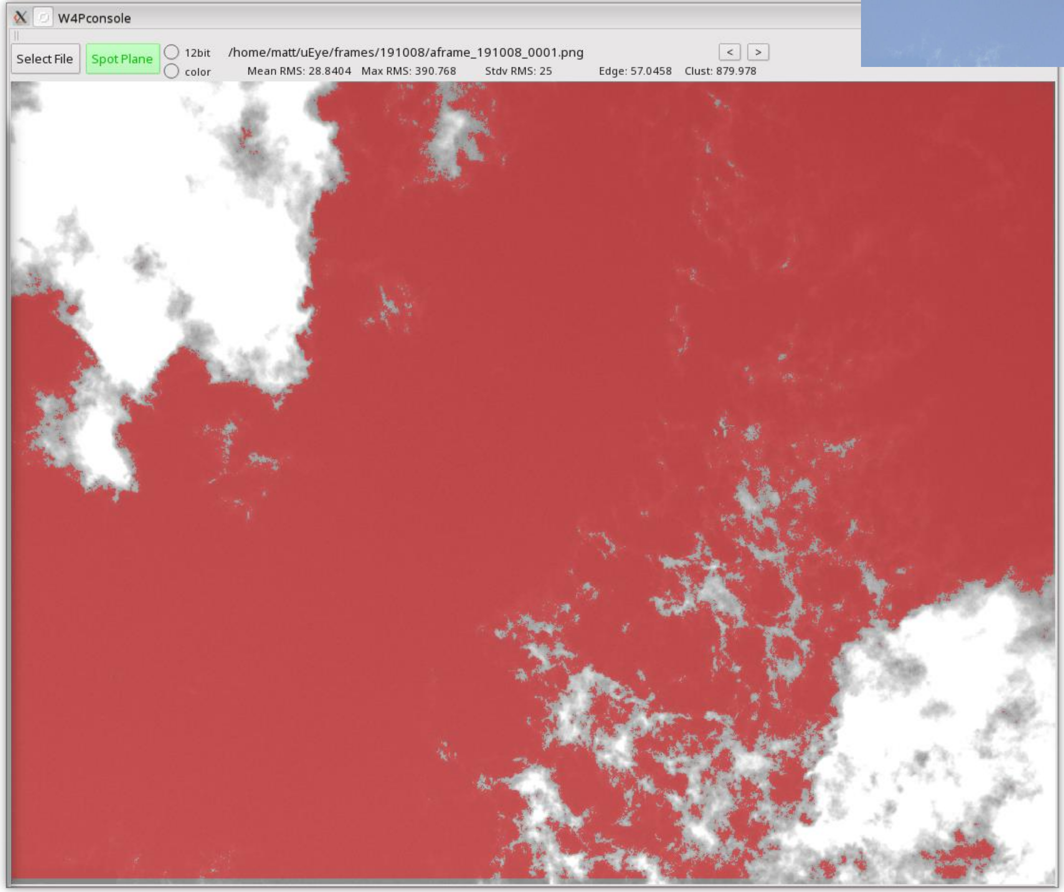
Having clouds in the frame makes things more difficult because:

1. Cloud edges can be selected as aircraft and cause false alarms.
2. Clouds can obscure the aircraft.

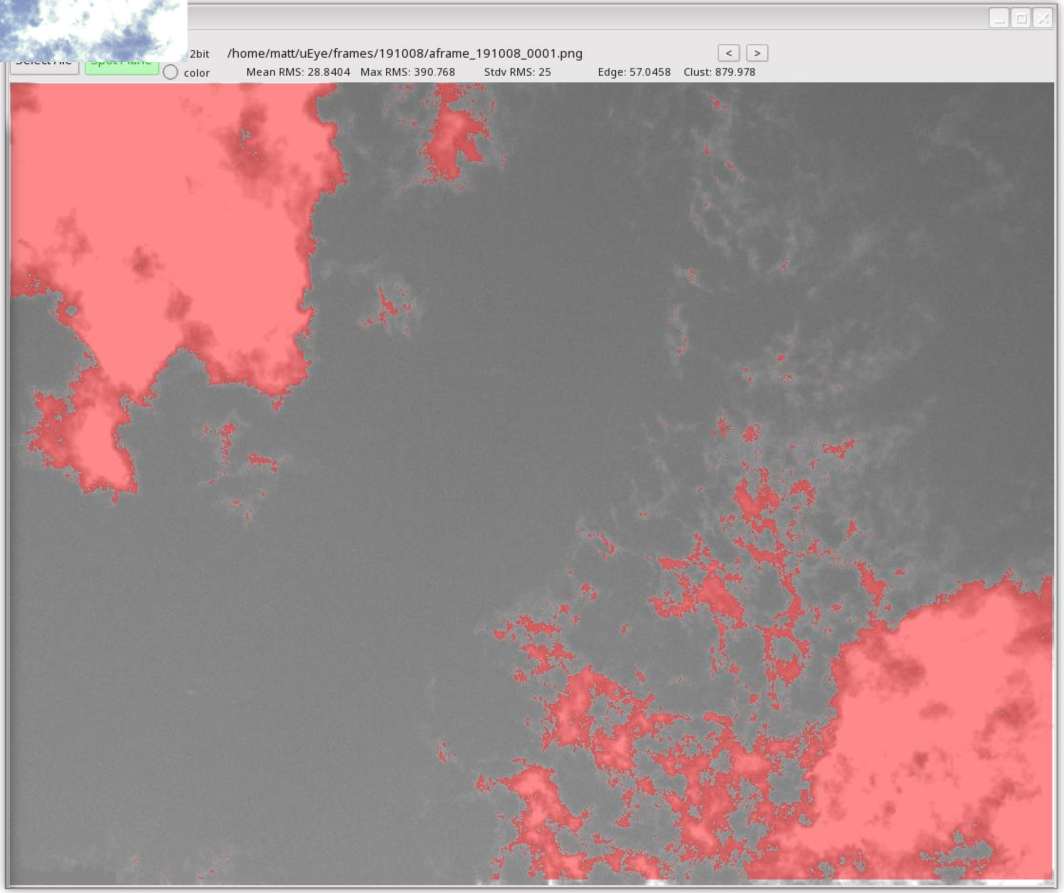
It is helpful to assess each frame by identifying the cloud from the clear sky.

CLOUDS

BLUE



WHITE



CLOUDS

Once where the cloud is in the frame has been determined an assessment can be made whether the conditions are suitable for SLR.

Cloud is further considered for aircraft detection. The frame is again broken up in to a grid and areas with high levels of cloud are not considered.

Also the sky 'level of blue' is assessed and passed on to the next frame. This has been very useful in selecting cloud in the frame.

OPERATIONAL

Using ADS-B signals it is possible to track planes passing overhead.

The camera takes frames and these frames are assessed at a rate of about 10Hz.

During SLR observing, the software can connect to the ADS-B ‘listen2planes’ server and can send a signal to shut off the laser.

LIMITATIONS

Birds will most likely be identified as aircraft and produce false alarms.

Insects too can be tracked but opening the iris and focussing the lens to aircraft heights will cause them to blur and go undetected.

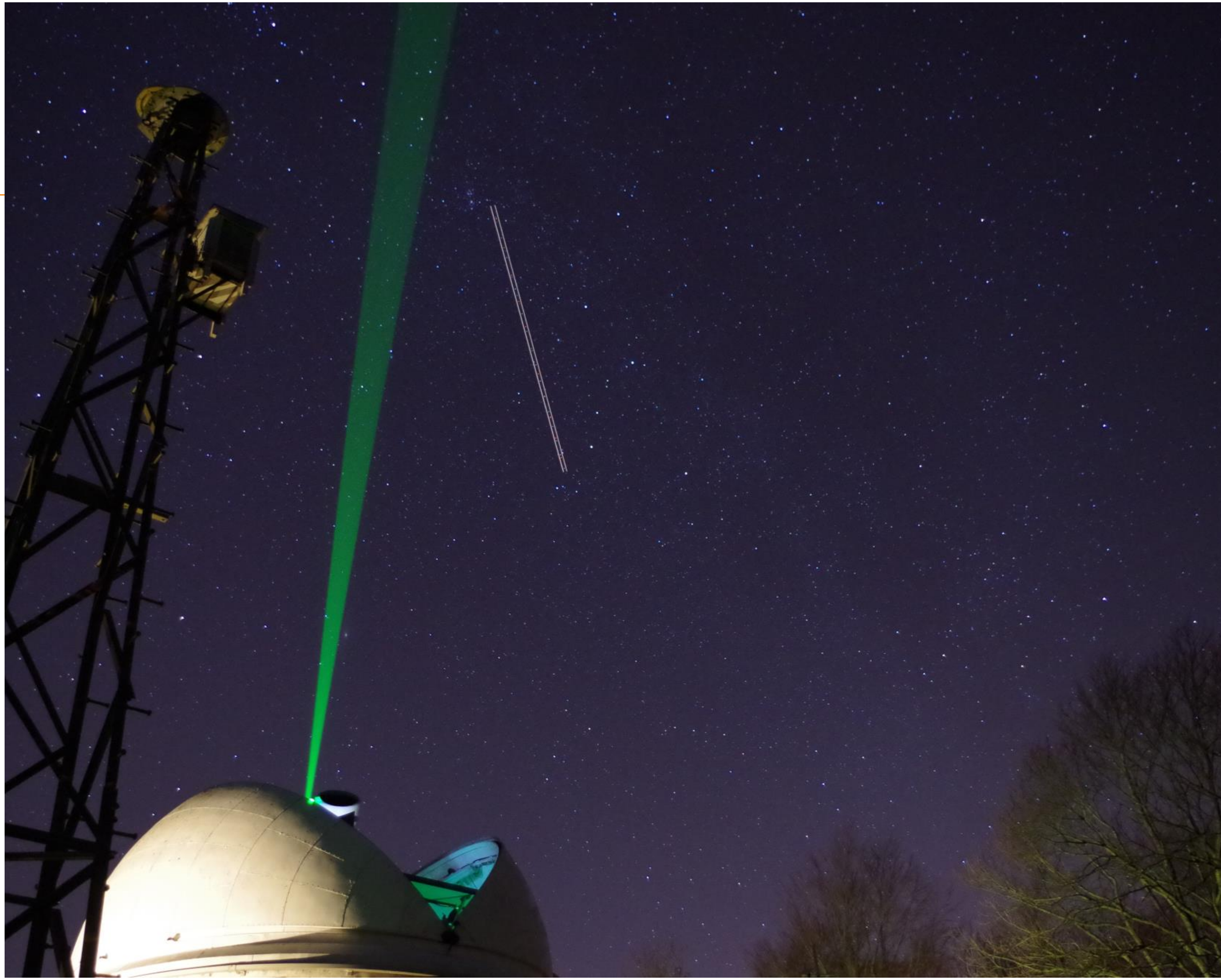
The larger field of view of 20˚ means that distant aircraft at lower elevations are not as well imaged.

NIGHT OPERATION

The aircraft detection described here was designed to work in daylight conditions.

Detecting aircraft at night would rely on the brightness of the aircraft lights, which are much brighter than stars.

However, the laser beam would need to be screened, probably using a 'notch filter' centred on 532nm green.



CONCLUSIONS

The addition of a responsive digital camera mounted on the SLR telescope and aligned to the direction of the laser beam to watch the surrounding area of sky for aircraft is a potentially useful addition to in-sky safety.

Such a system would see small aircraft, gliders and hot air balloons that do not carry ADS-B transmitters and are unlikely to be detected by active radar.

Variable sky conditions complicate the detection and can lead to false alarms or failure to alarm. This is still acceptable if:

- False alarms are minimised, but some level is allowed.
- Sky conditions are assessed and it is decided if it is reasonable to expect aircraft detection to work.

The method for detection will be further tested and refined as more frames are collected.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