# Optical Identification of Blue Jets

## A Real-Time, Data Capture System for a Stratospheric Balloon

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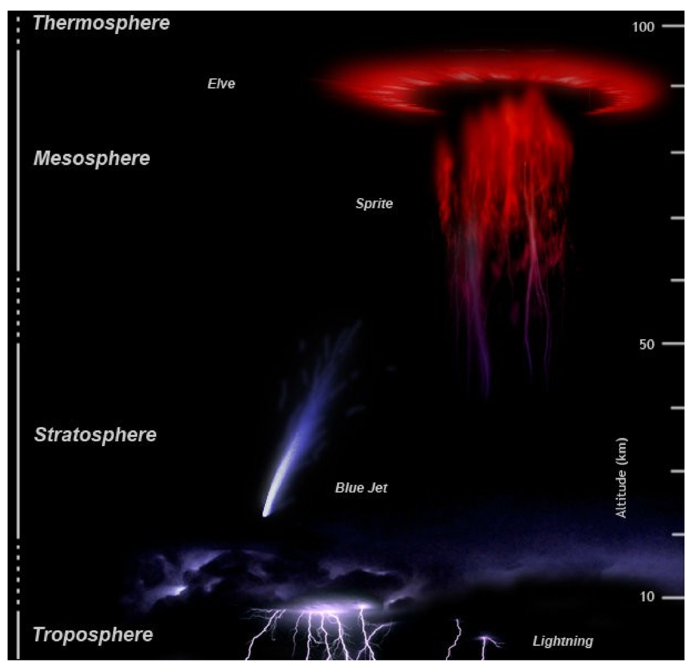
DTU

## Transient Luminous Events

TLEs are optical emissions in the upper atmosphere related to thunderstorms.

They are categorized into sprites, *blue jets* and elves.

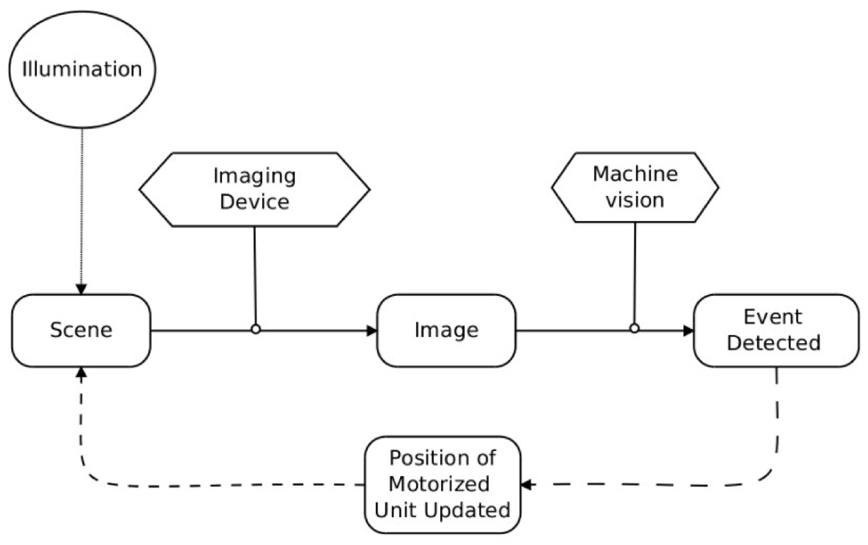
TLEs span from the top of thunderclouds to the edge of space at 100 km.




Possible effects on the atmosphere are researched such as a connection to the climate (Neubert 2003) (Carslaw et al. 2002).

Observational challenges make it difficult to image blue jets from the ground.

The occurence of blue jets can enhance the scientific knowledge of them.




## Solution Proposal

Create an imaging device capable of completely automatic detection of *blue jets* .

Operation from a stratospheric balloon, requiring a stabile camera platform and fixed pointing capabilities.

Event detection is required to minimize the high volume of data, and provide pointing information.

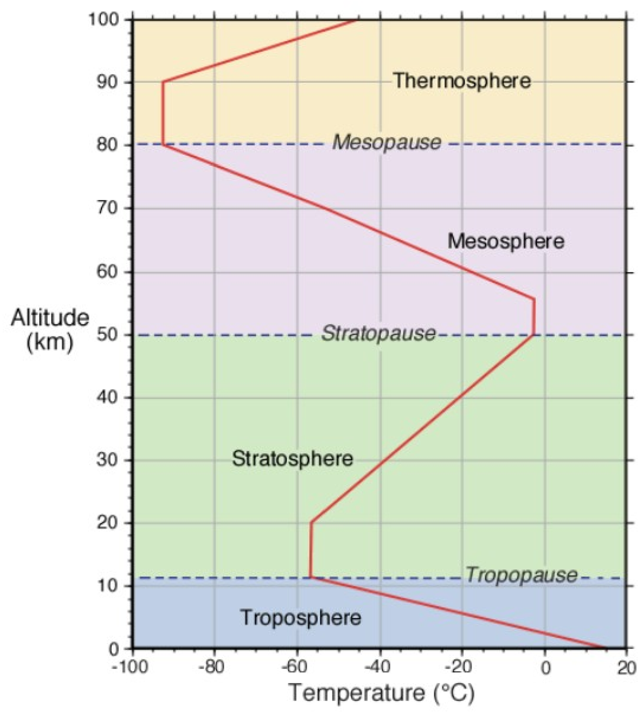
## Main Challenges

TLEs last only several milliseconds, a high frame rate is thus required.

The system must be fully automated with respect to software and hardware.

Detection and discrimination between normal lightning and TLEs is required.

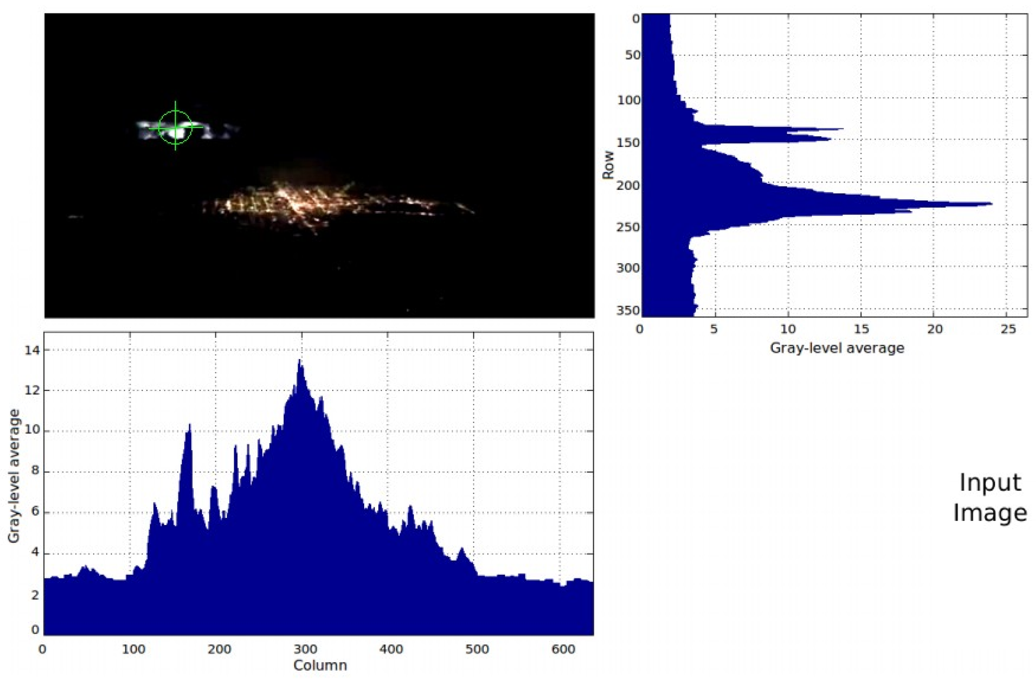
The extreme high altitude environmental conditions add extra challenges to an already complex task.

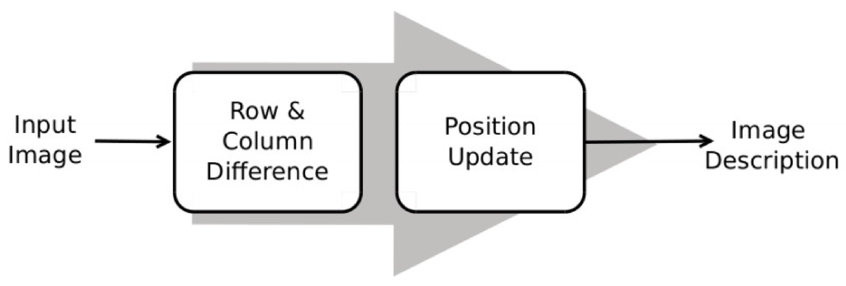



## Event Detection Algorithm

Normal lightning activity provides information on the general area to look for blue jets. Two event detection algorithms are needed, one for normal lightning detection and the other for blue jet detection.

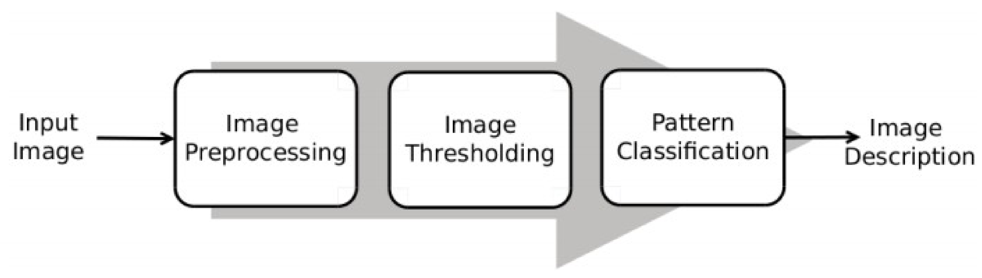
Lightning activity is detected with a basic row and column sum difference between two consecutive frames. Any abrupt changes in brightness is easilly detected. Pointing information is then provided to the camera platform as an angular position.

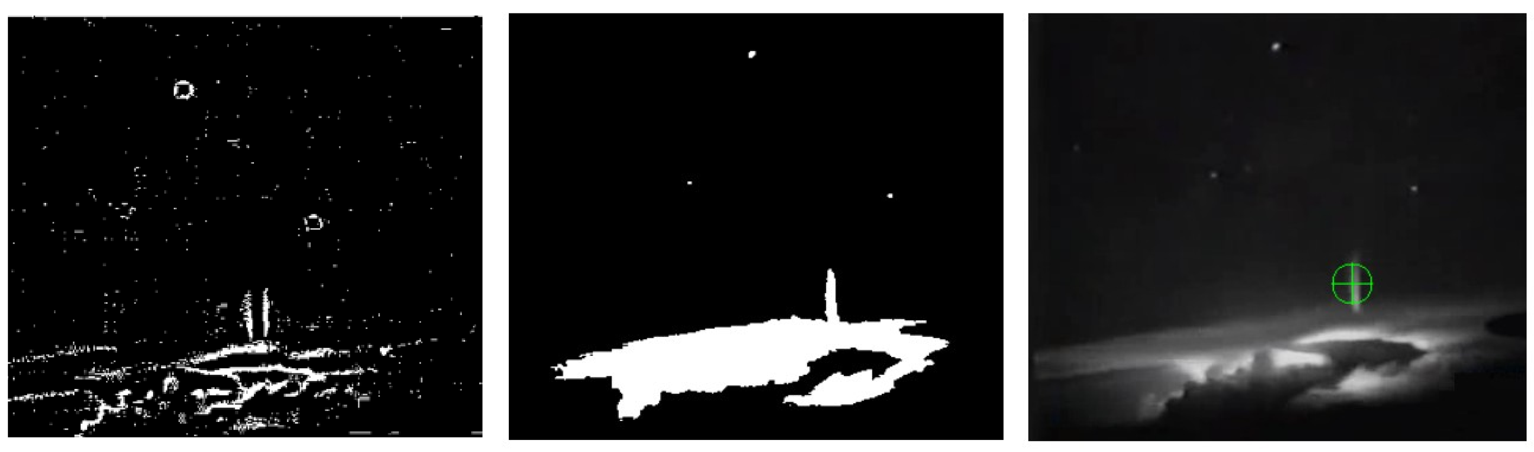



Blue jet detection is more complex. It requires segmentation of the image followed by a pattern classification.

The distinct elongated shape of blue jets along with a certain height-to-width ratio form the basis for the pattern classification. Several methods were designed and compared to determine the most robust algorithm.



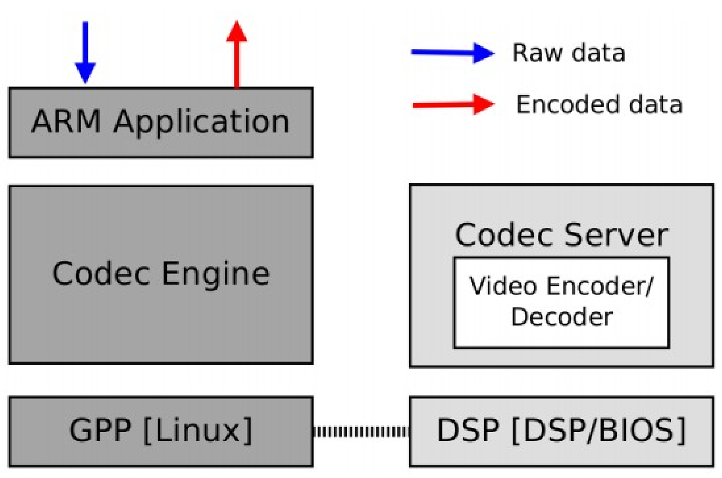



## Implementation and Results

The system setup was composed of mainly two monochromatic near infra-red cameras and a TI Davinci digital video processor, used to obtain short computation time.

Software was written in C, and image analysis algorithms implemented in the DSP core of the processor to optimize for speed. Computation times as low as 16 ms per frame for a 640x480 pixel image were acheived.

Evaluation of the system was performed using blue jet footage obtained from an airplane over Arkansas (Sentman et al. 1995)(Wescott et al. 1995). Robust blue jet detecting and a low false positive count gave promising results.



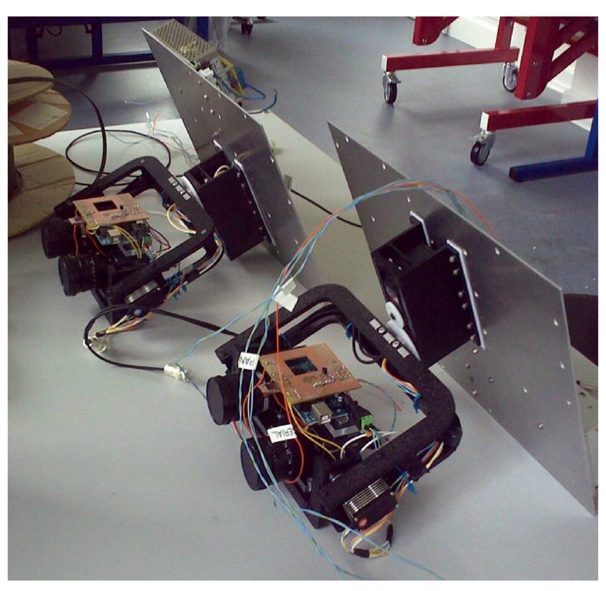

## TRO-Pico 2012, Brazil

A prototype was tested in Brazil 2012 during an atmosperhic research campaign. The sytem was launched at night time during thunderstorm season, and the flight duration was 5 hours.

The system functioned as intended, sucessfully detecting lightning activity and maintaining fixed pointing and stabilization during the entire flight.

Unfortunatly no TLEs were documented, but a proof of concept and system verification was acheived.

This project is an ongoing project at DTU Space led by Torsten Neubert.



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