UPDATE FROM OZ

by

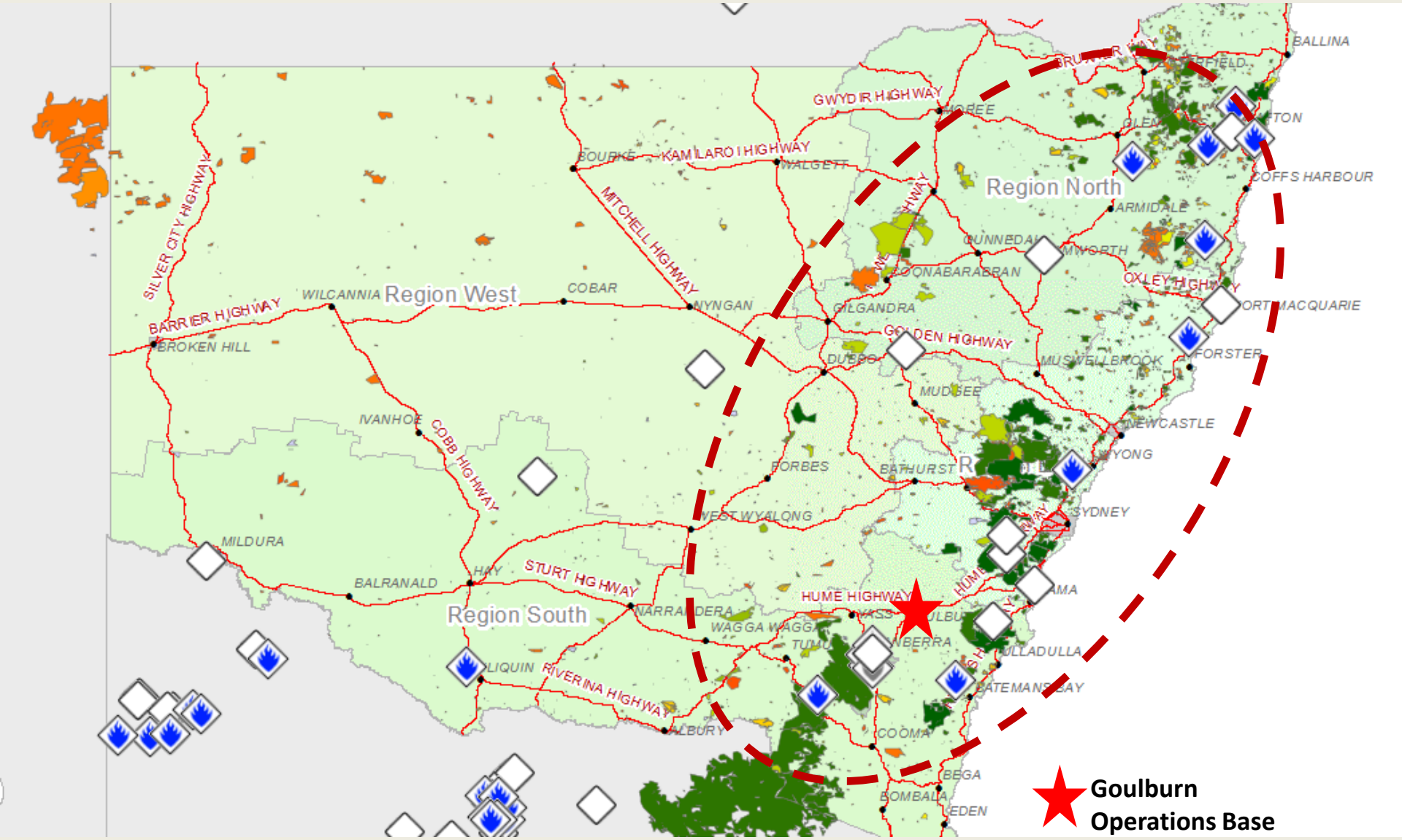
Terry Cocks

TFRSAC Fall 2015 Meeting

Presentation Overview

- The Task
- The System
- The Procedures
- The Base Products
- The “Other” Products
- The Hyperspectral Potential
- The Multi-mission Platform

Most Likely Area of Operations



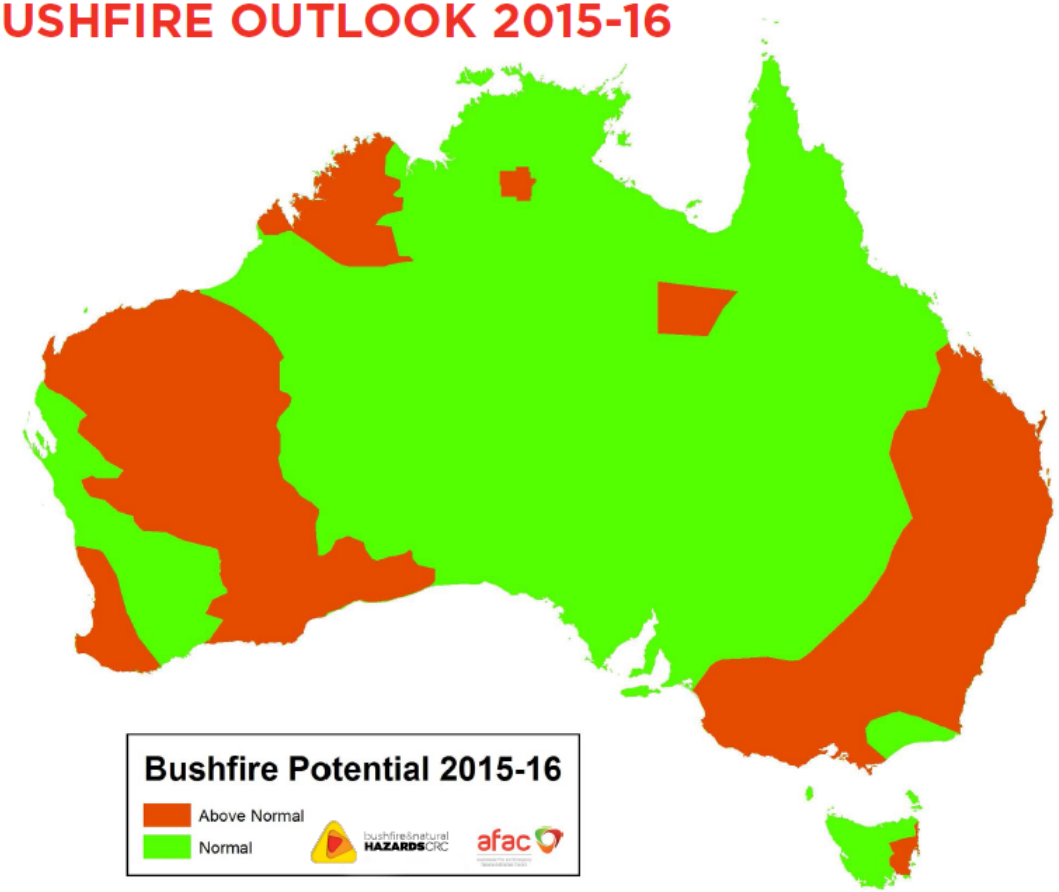
HAZARD NOTE

bushfire&natural HAZARDSCRC

ISSUE 010 SEPTEMBER 2015

TOPICS IN THIS EDITION | FIRE WEATHER | FUEL MANAGEMENT

SOUTHERN AUSTRALIA SEASONAL BUSHFIRE OUTLOOK 2015-16



The Platform : Firescan 222

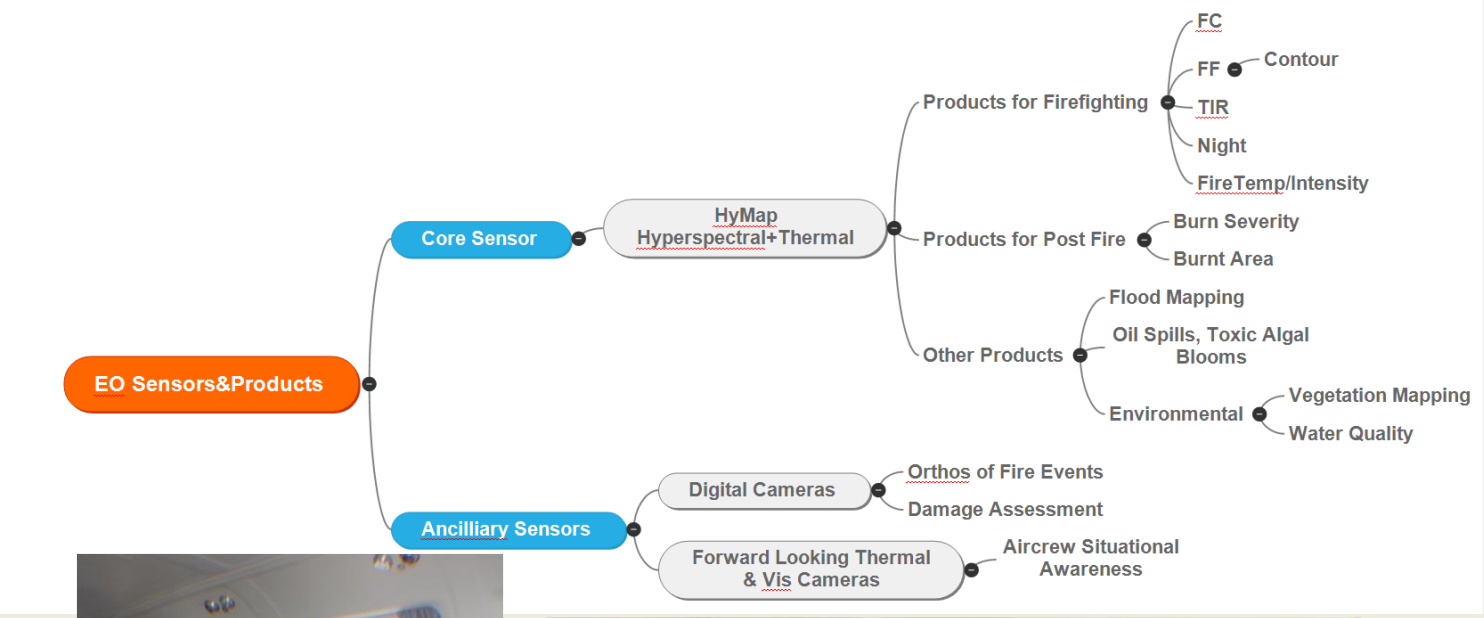
Cessna 441 Conquest

- Turboprop
- Ceiling : 35 kft AMSL
- Cruise Speed : 285 kts
- Operational Endurance : 4 hours with reserves

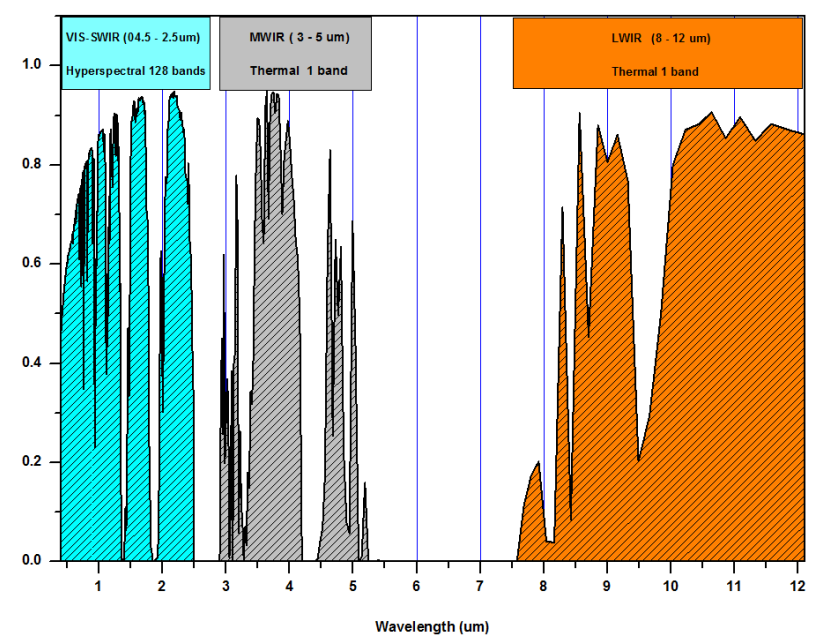
Destinations

Qld border: 90 mins
Victorian border: 35 mins
Blue Mountains: 20 mins
Narabri : 60 mins

The Sensor Suite in Firescan 222

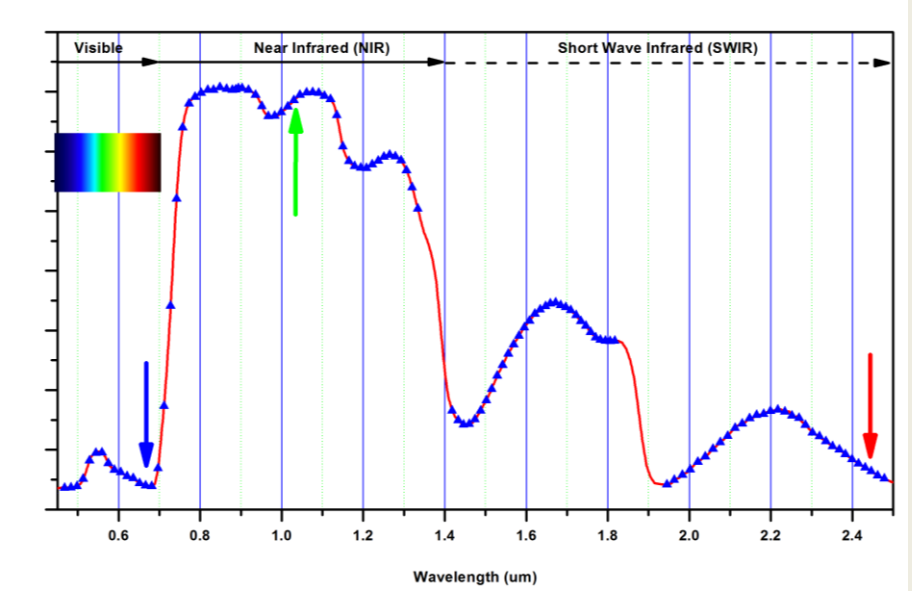


Spatial and Spectral Characteristics of Hyperspectral Sensor



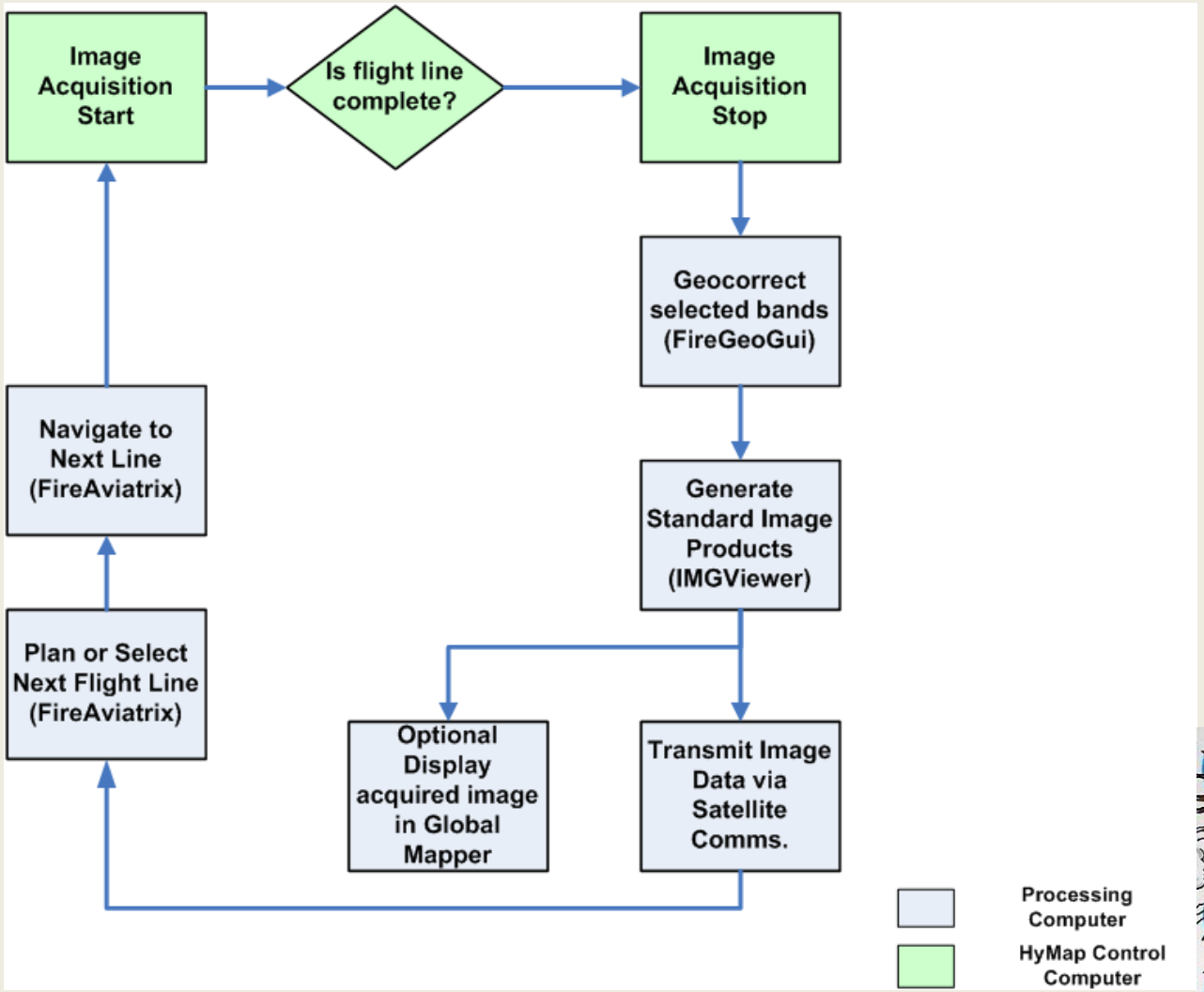
Spatial Configuration	
IFOV	2.5 mr
FOV	61 degrees (850 pixels)
Swath	2.3 km at 5m IFOV 4.6 km at 10m IFOV

Spectral Configuration			
Module	Spectral range	Bandwidth across module	Average spectral sampling interval
VIS	0.45 – 0.89 um	15 – 16 nm	15 nm
NIR	0.89 – 1.35 um	15 – 16 nm	15 nm
SWIR1	1.40 – 1.80 um	15 – 16 nm	13 nm
SWIR2	1.95 – 2.48 um	18 – 20 nm	17 nm
TIR (1)	3-12 um	Effectively 5 um	NA
TIR (2)	8-12 um	Effectively 4 um	NA



HyMap spectral bands on green vegetation reflectance and arrows indicated bands used in standard image products

Airborne Work Flow



Work flow to be completed with minimum aircrew "interactive decision making.

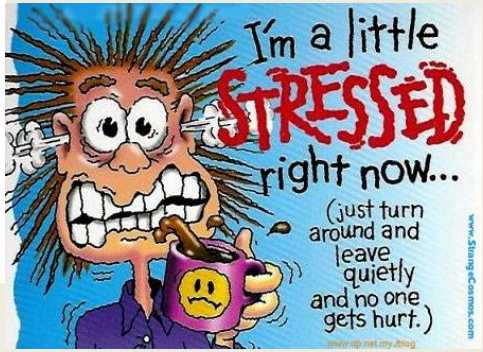
One pilot & one sensor operator….they are busy multitasking.

Reduce opportunity for errors

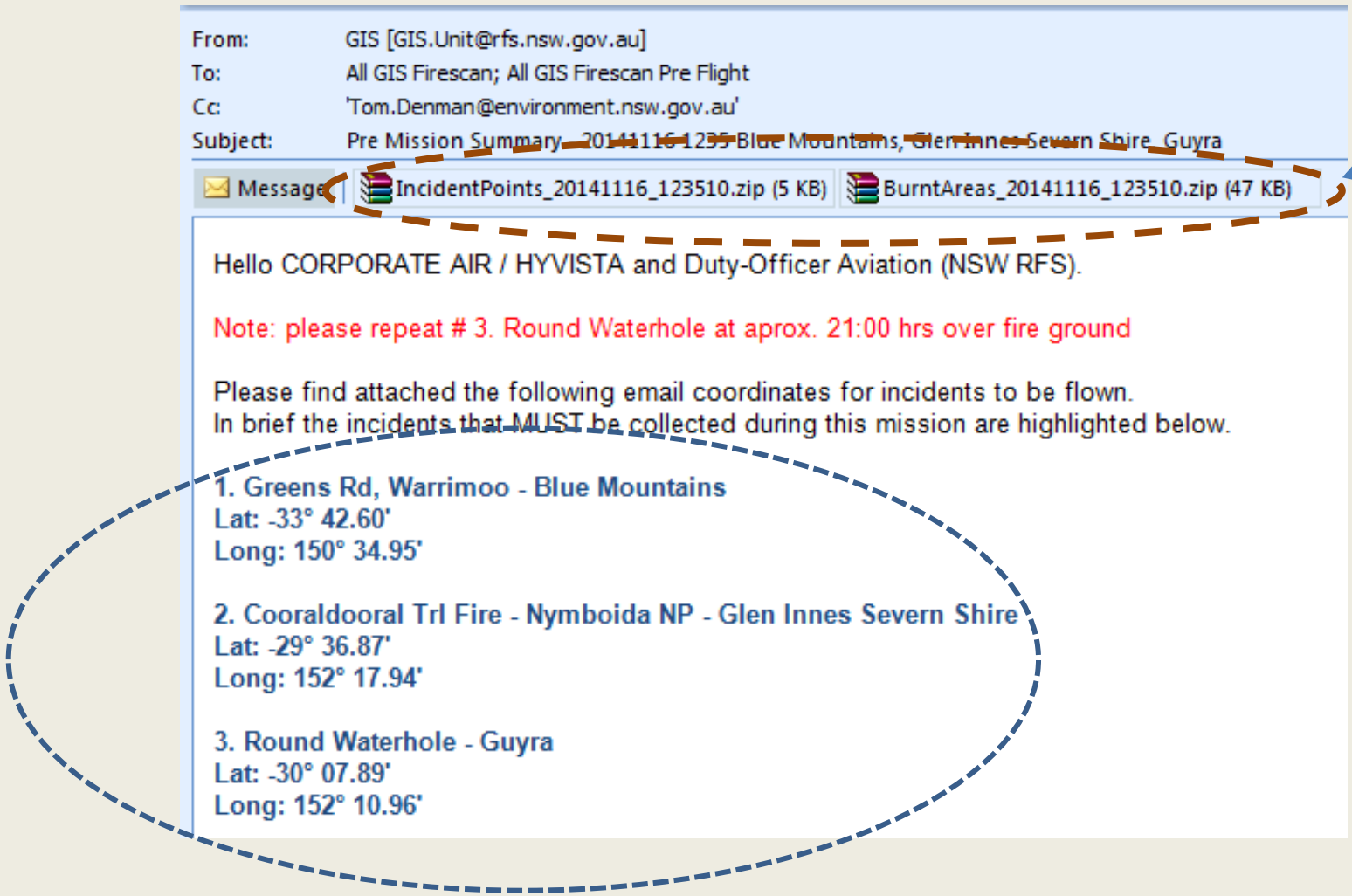
Minimise time to transmit images to NSW RFS HQ.

Some deployments from ops base can last > 6 hours (same crew)

Last thing we want is

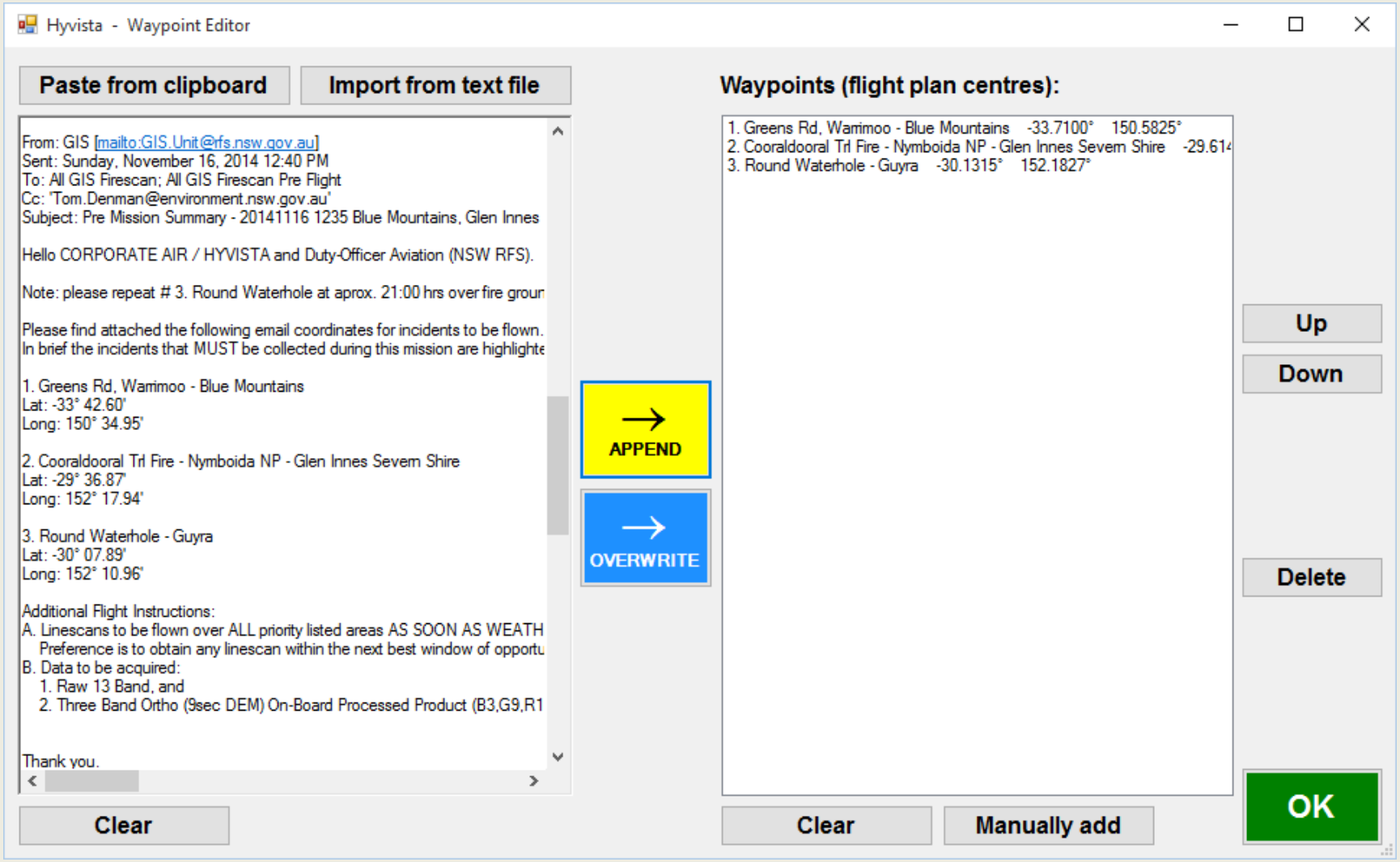


Tasking Email

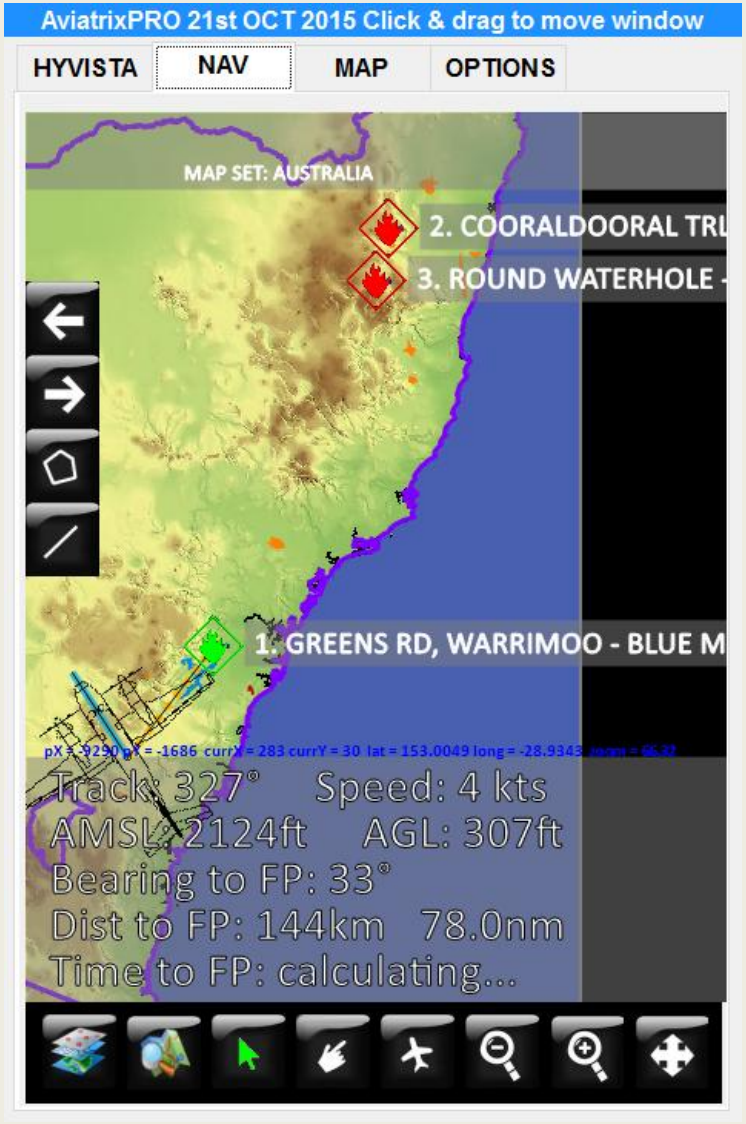


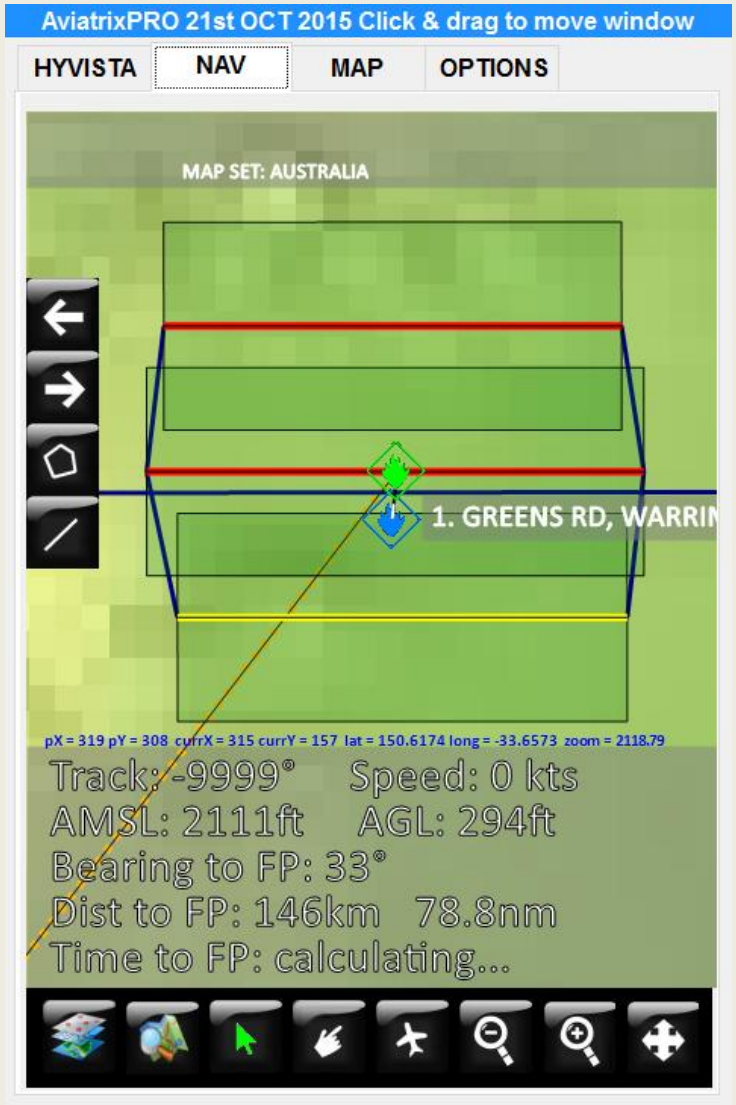
Vector Data

Flight Planning & Management : FireAviatrix



Flight Planning & Management : FireAviatrix





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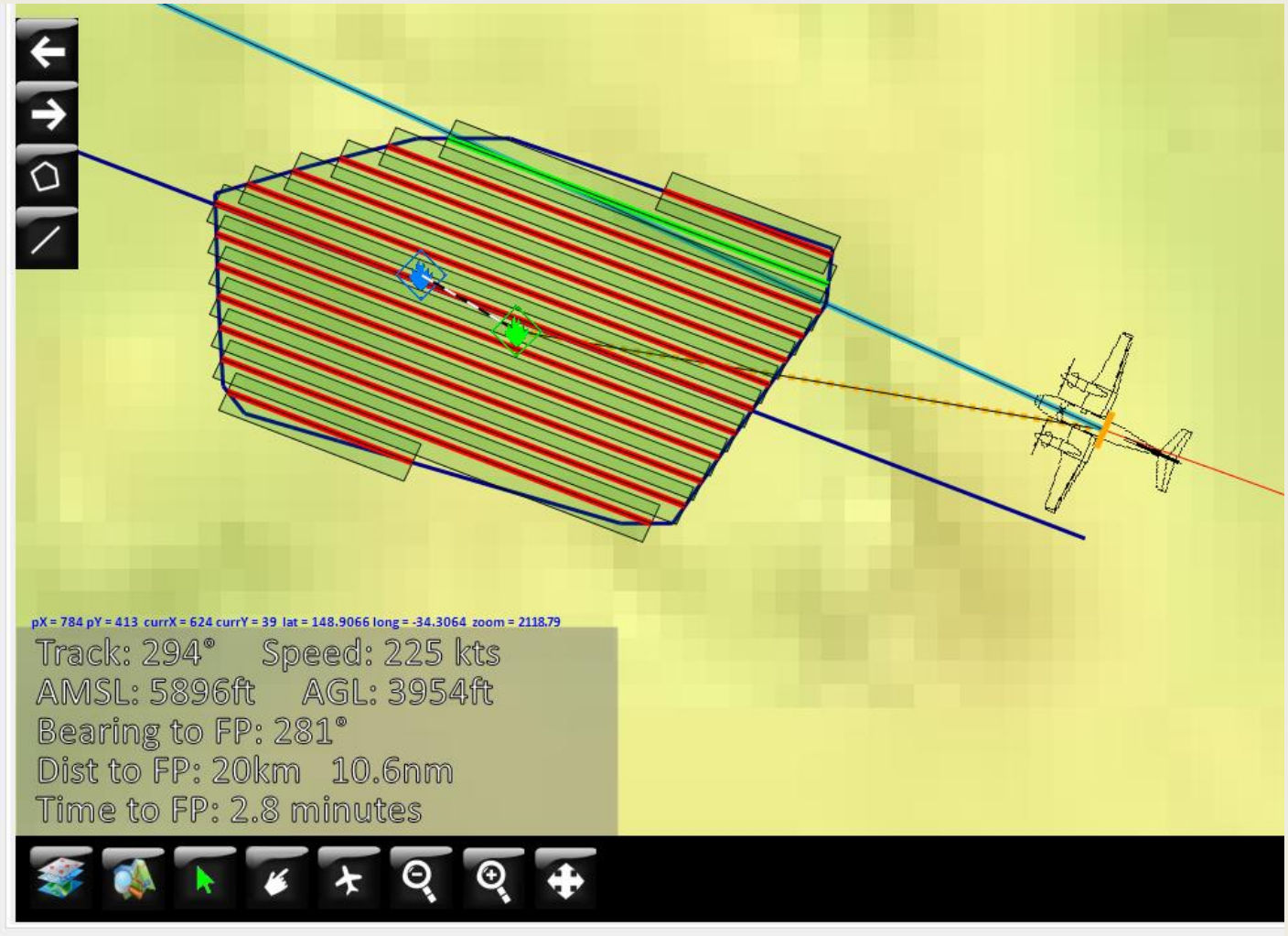
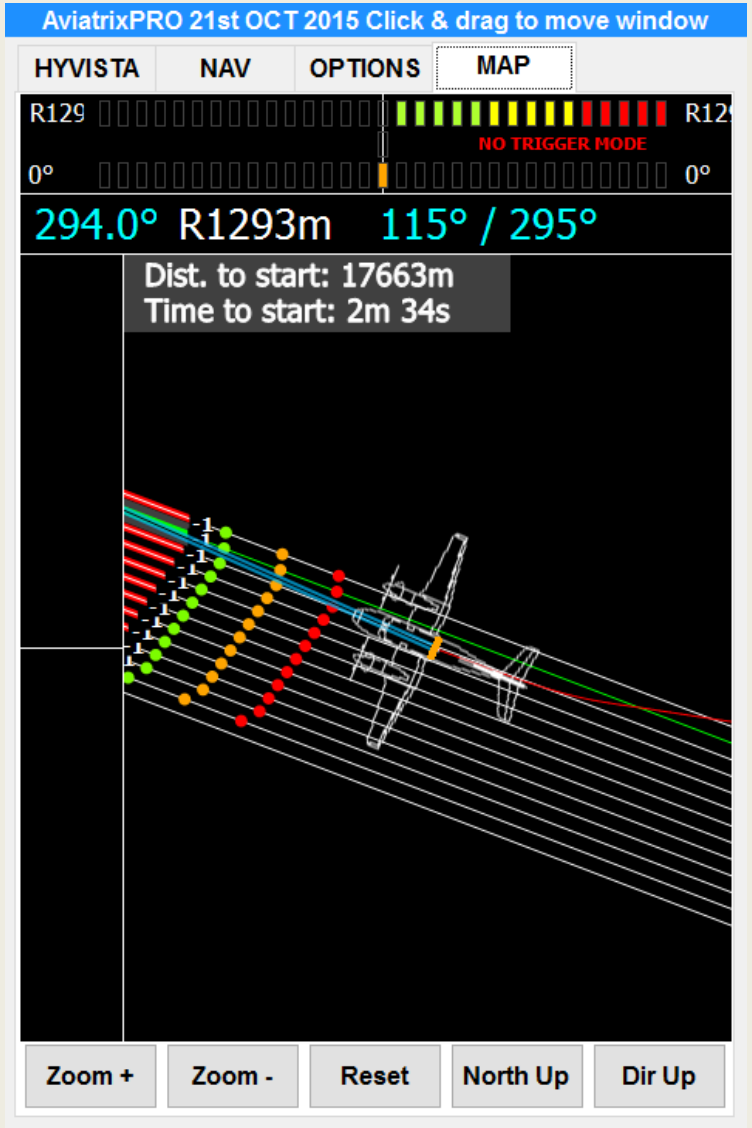
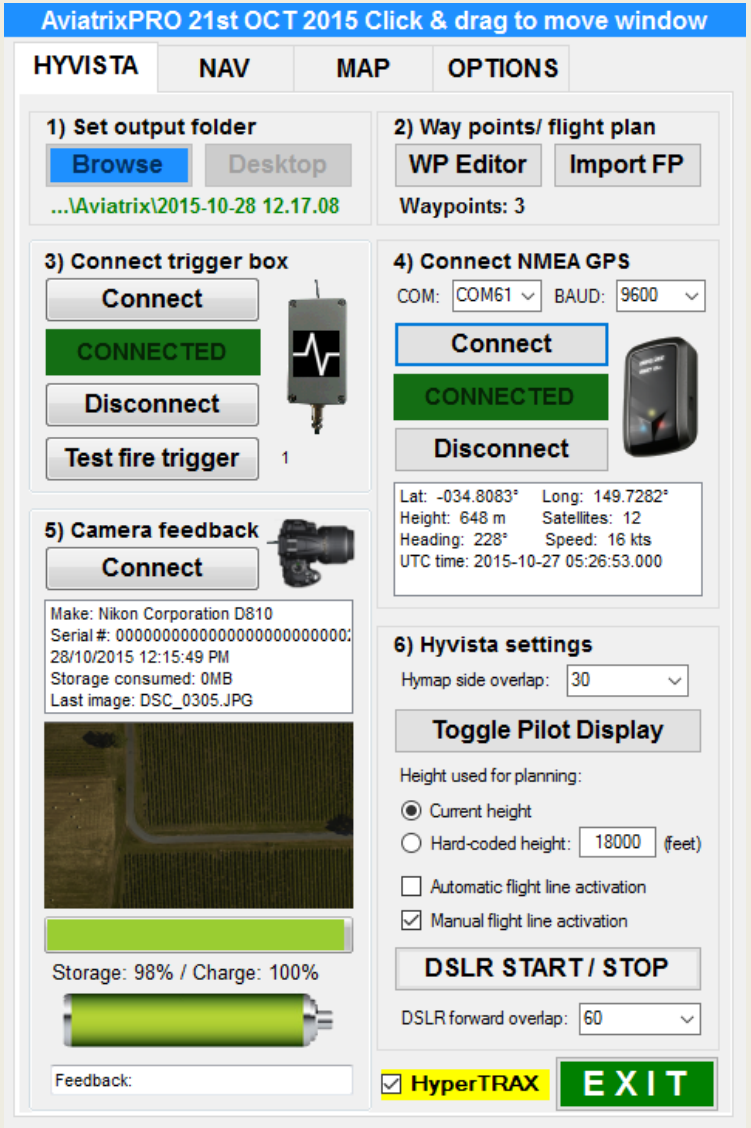
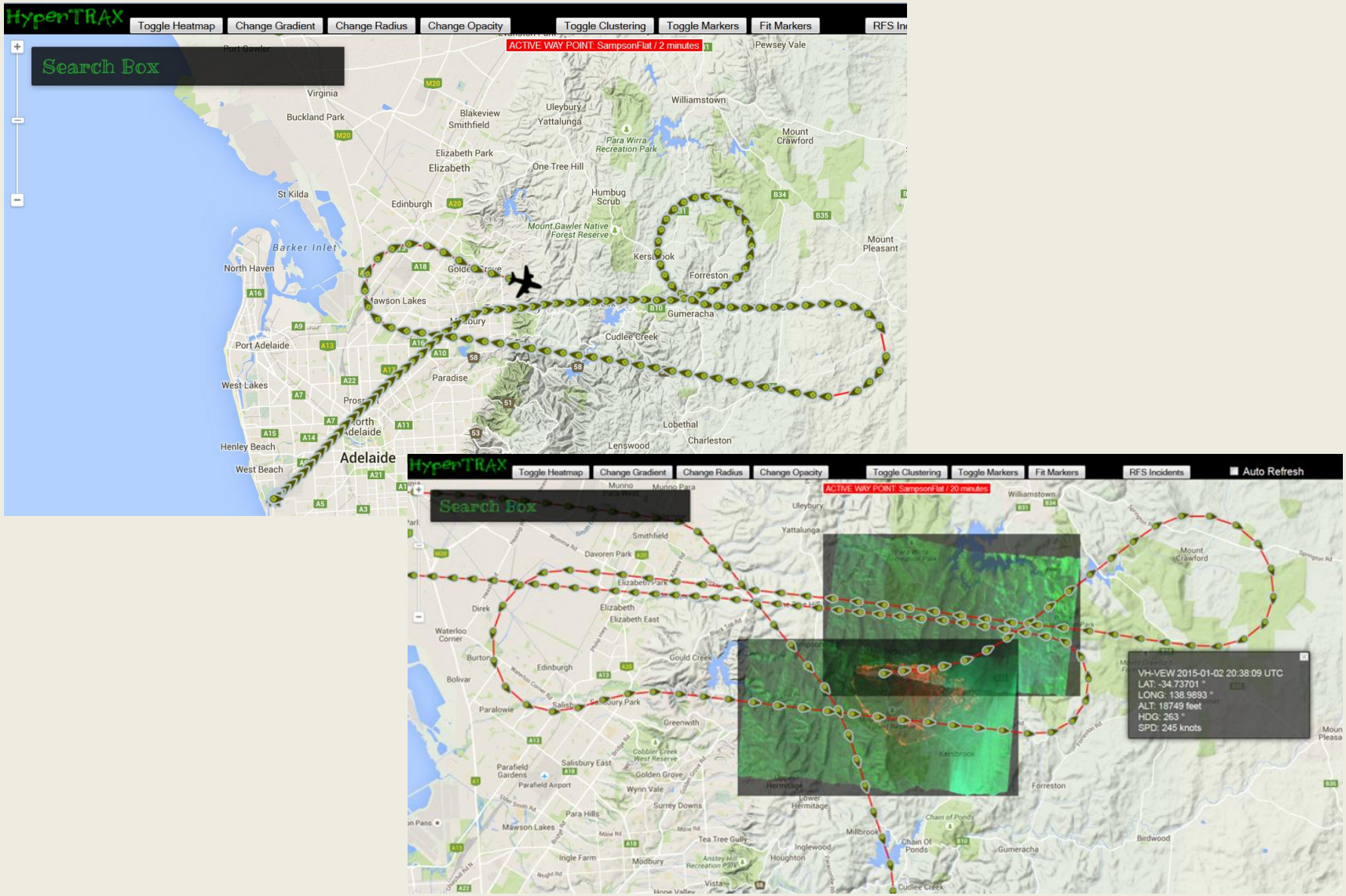


Flight Planning & Management : FireAviatrix

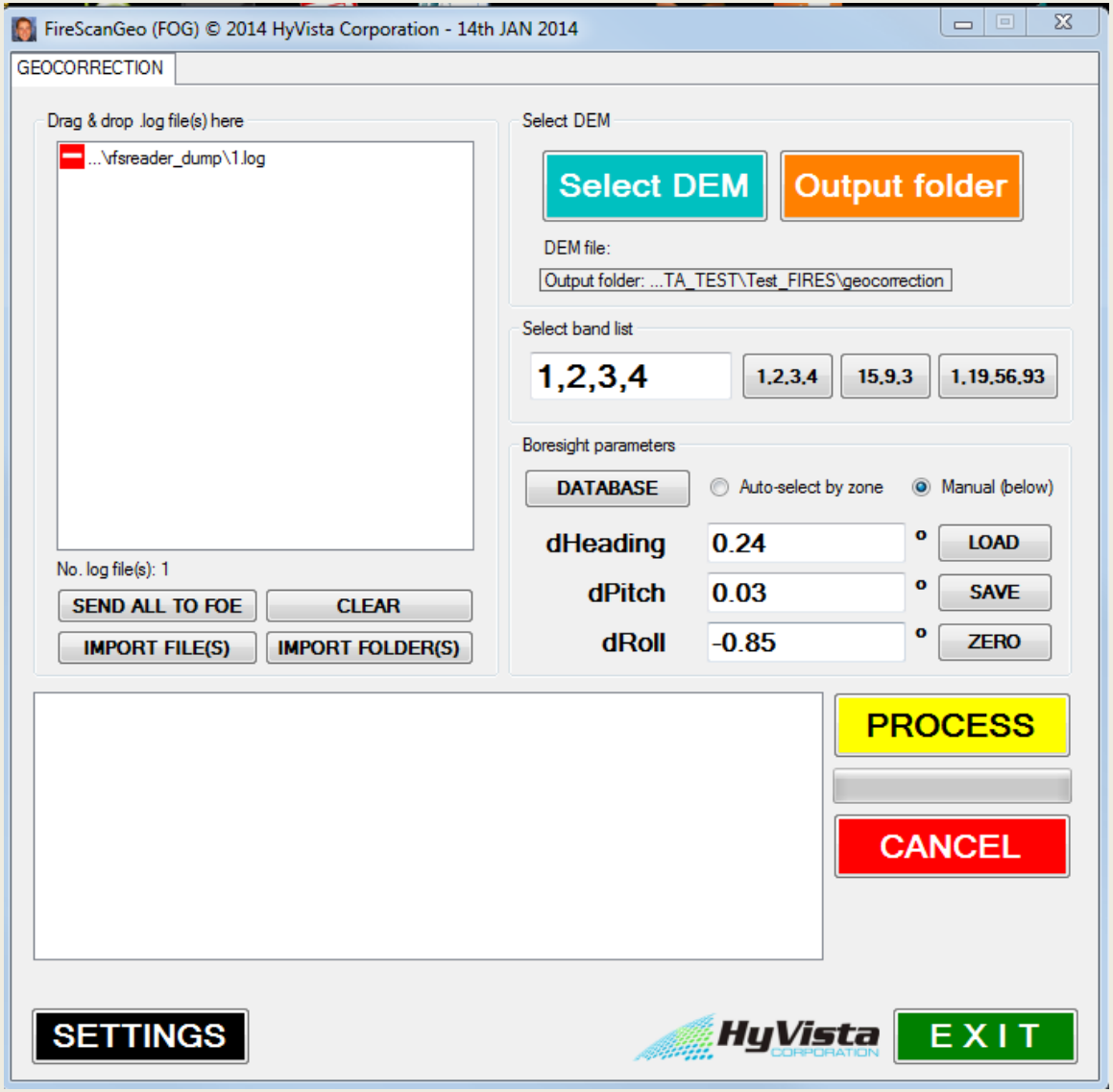




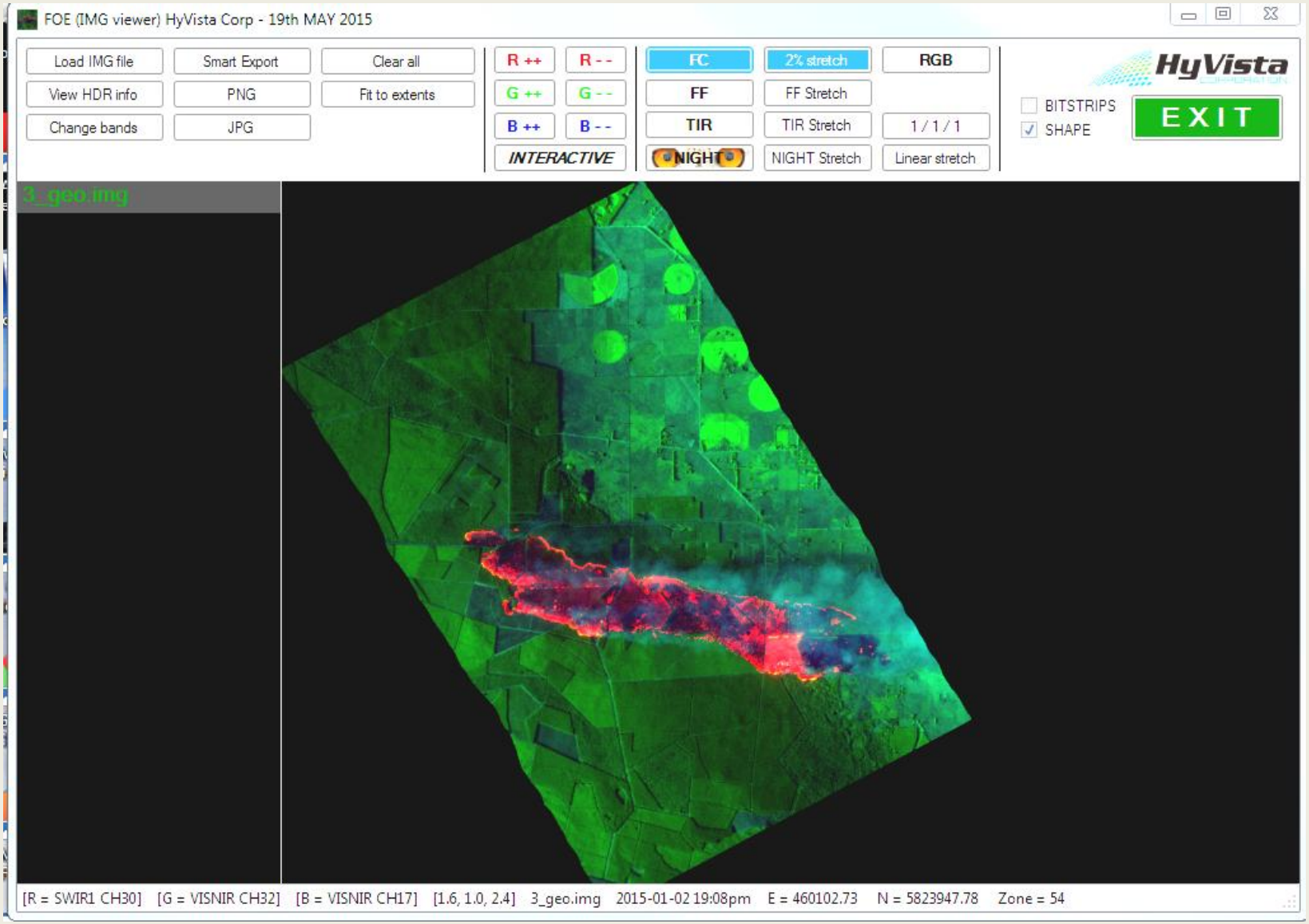
Operations Monitoring : HyperTRAX



Automated Image Product Generation : FireScanGeo

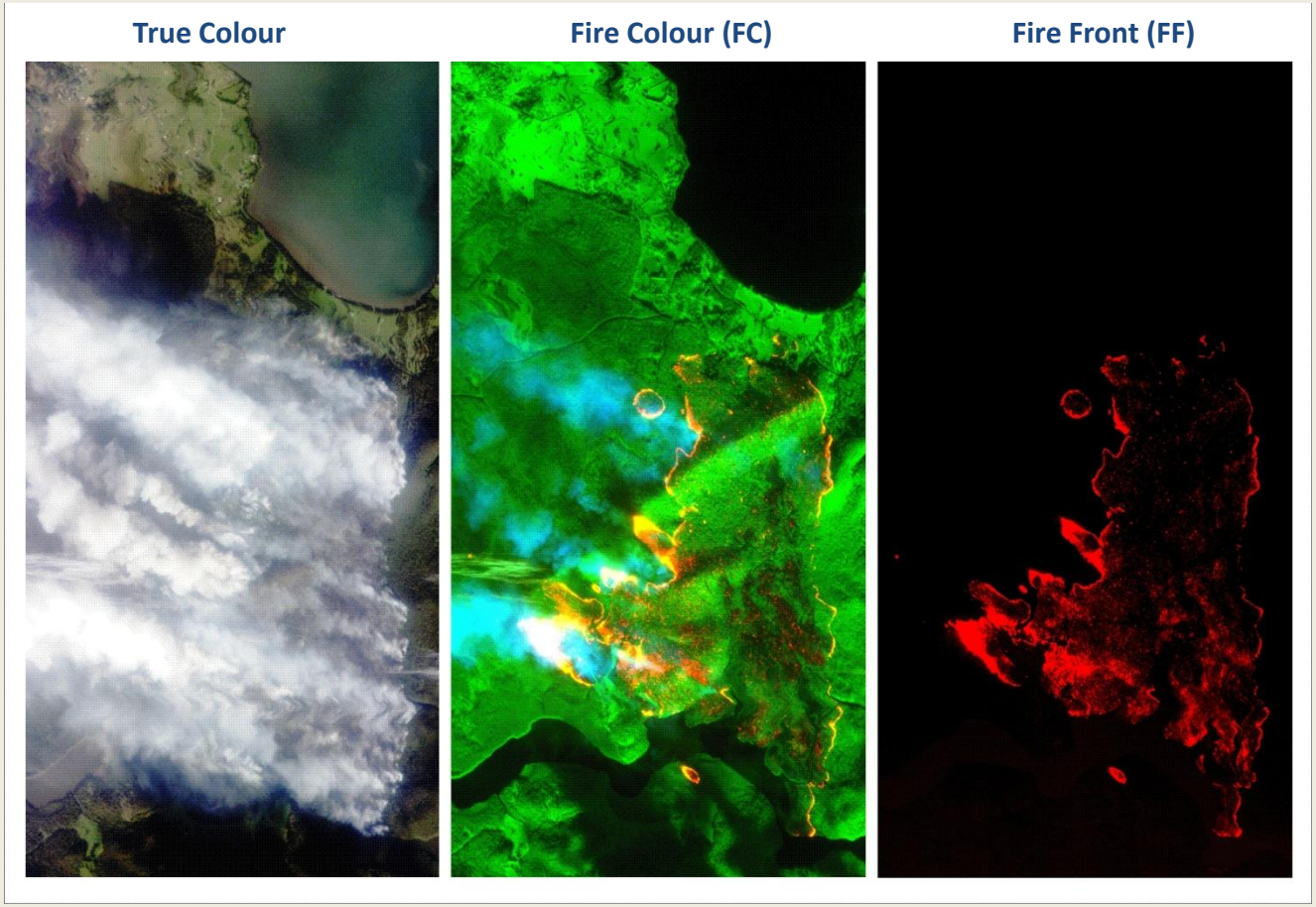


Automated Image Product Generation : IMGviewer



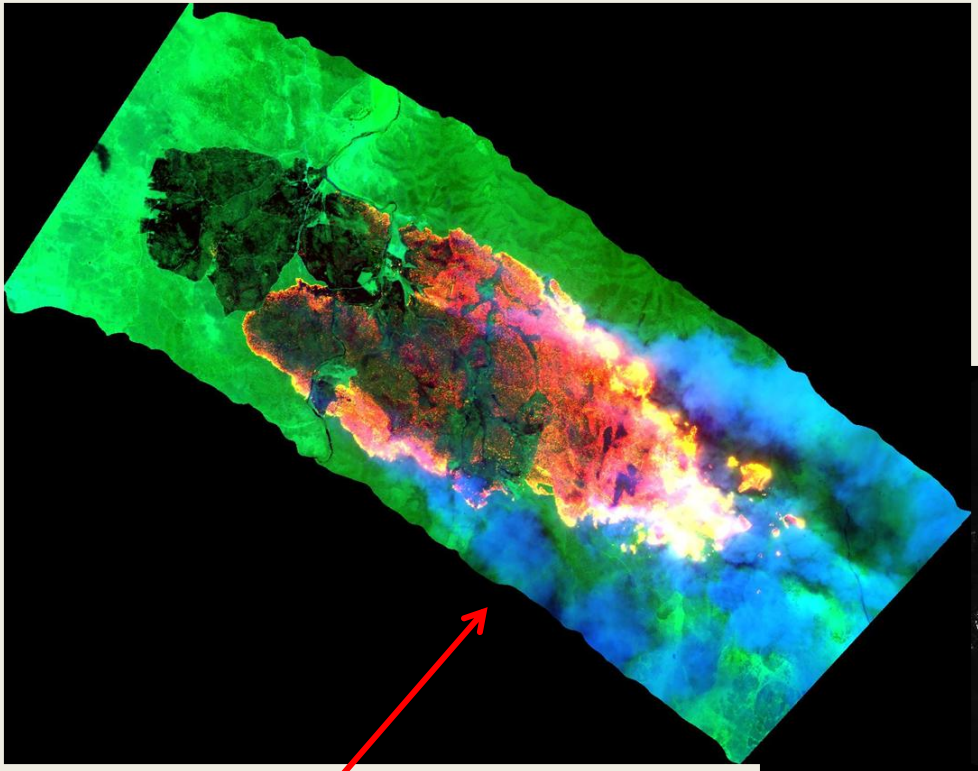
Standard Automated Products

Image Type	Description
FC (fire colour)	Active fire fronts and hot spots shown in red/yellow and background terrain in green. Burned areas show dark brown. A day time product
FF (fire front) red on black	Enhanced to just show most active fire areas without any terrain in image. Used as a basis to also create active fire contours. Day or night product
TIR (thermal infrared) panchromatic	TIR. Used either TIR band to show fire. Can also show terrain information. Day or night product.
NIGHT	Combination of the TIR bands and a SWIR band to generate an image where fire grades from red to orange as intensity increases and shows terrain (as green)
Contour	Creates a vector product which is a shape file that outlines the most active fire regions.



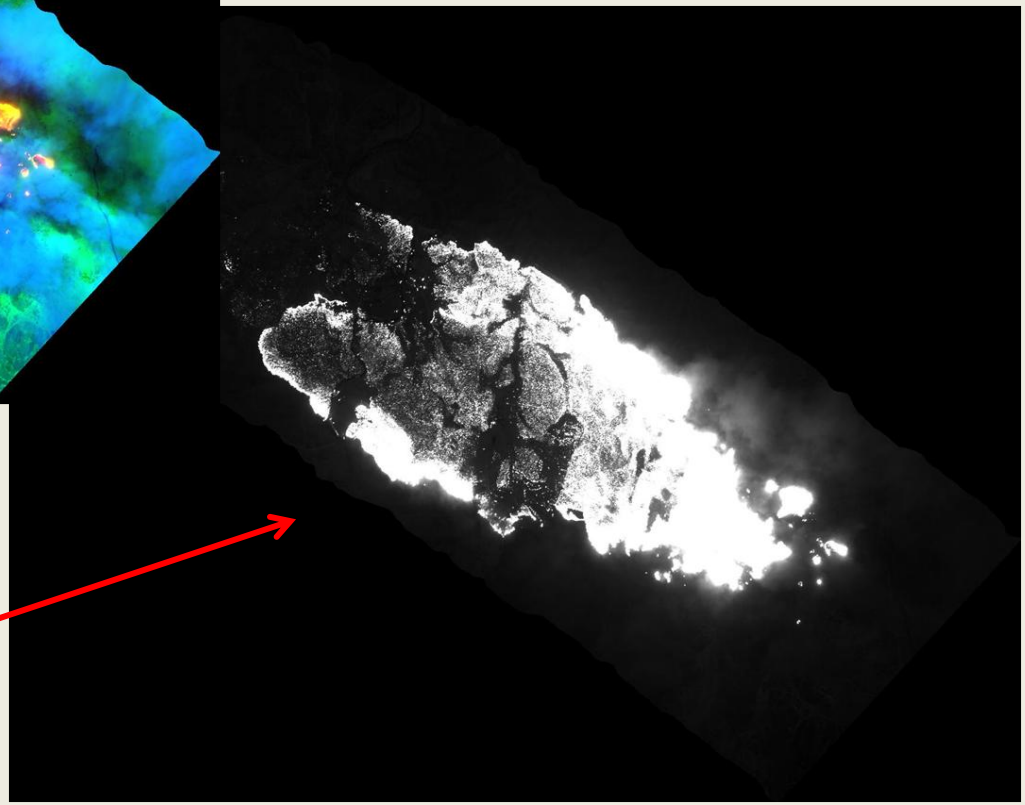
The left panel shows a true colour band combination and the centre panel shows a FC image product. The panel on the right shows a FF image product (red on black)

Products for Tactical Fire Fighting : Standard Products



Examples of fire front mapping products

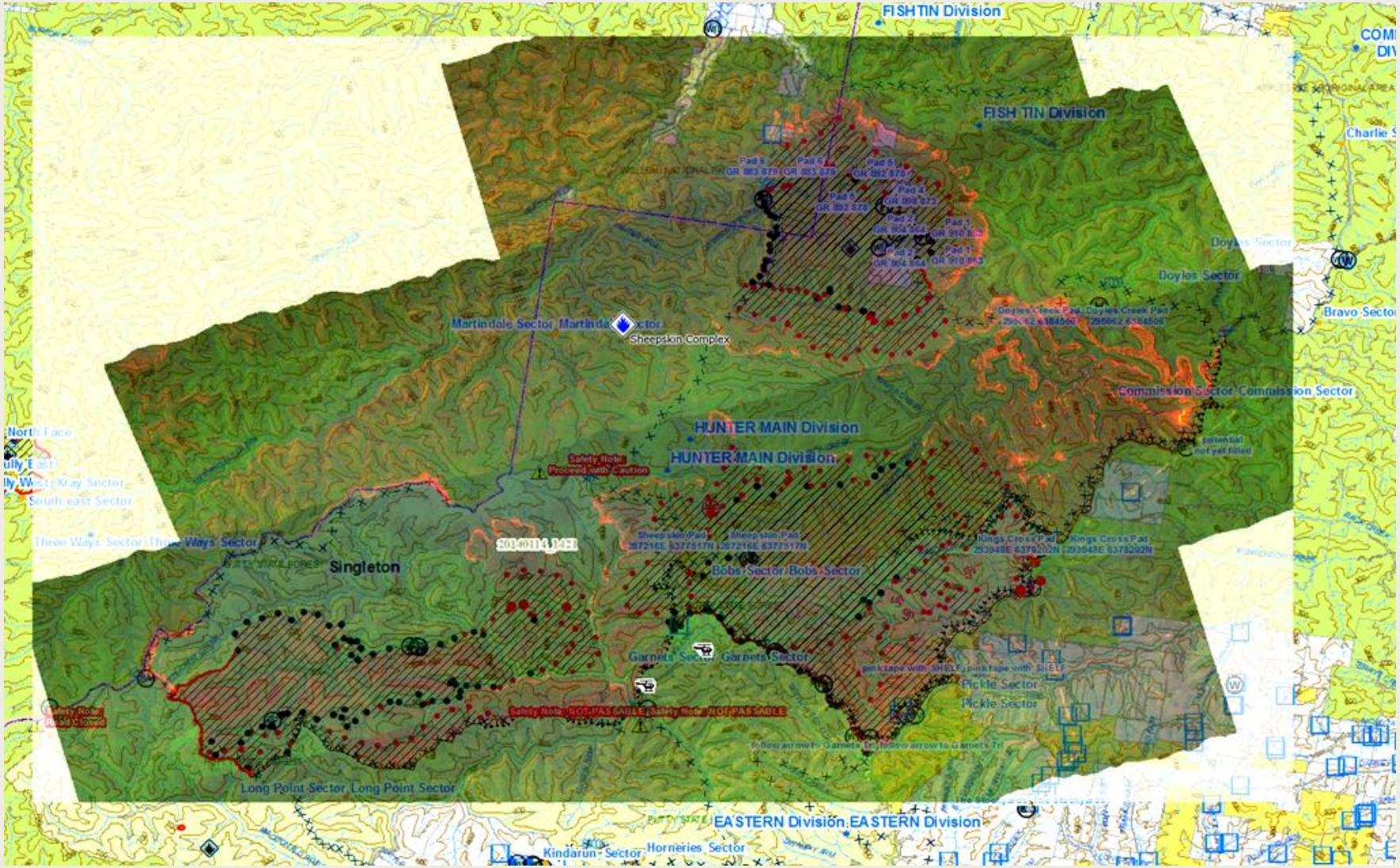
Imagery is processed in near real time (including geo-referencing) and transmitted by satellite link to incident command centers within minutes of acquisition.



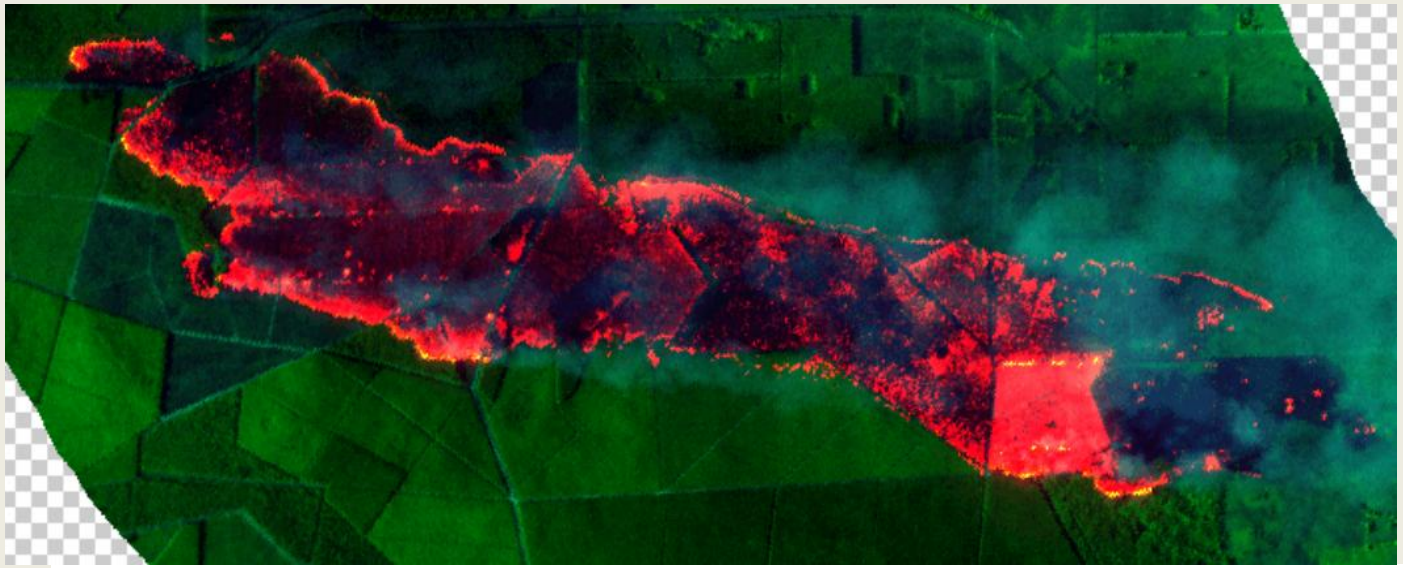
Color composite image showing terrain, active fire fronts and burned areas.

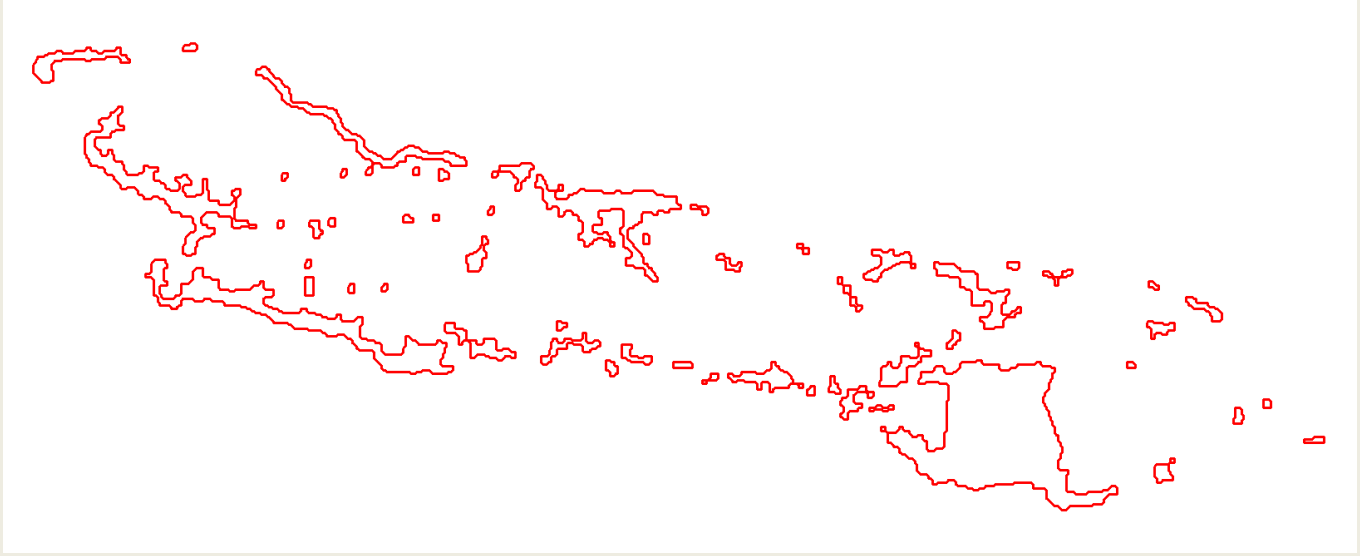
Infrared image that isolates active fire fronts and highlights hotspots and small fires generated by airborne ash ahead of main fire

Airborne Imagery on the NSW RFS Common Operating Picture (COP)

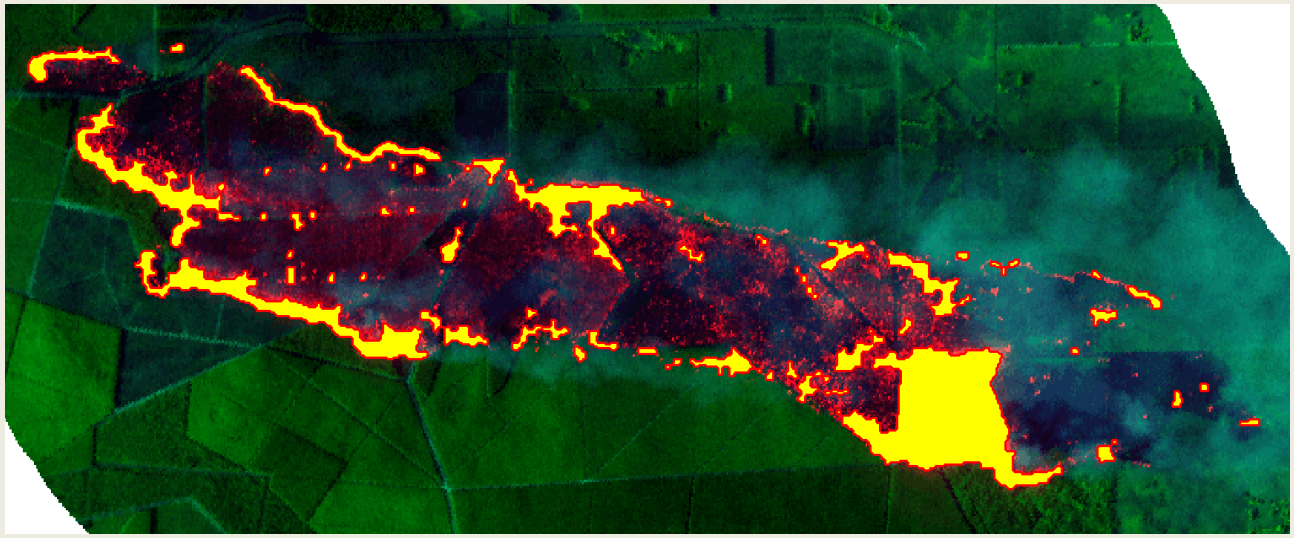


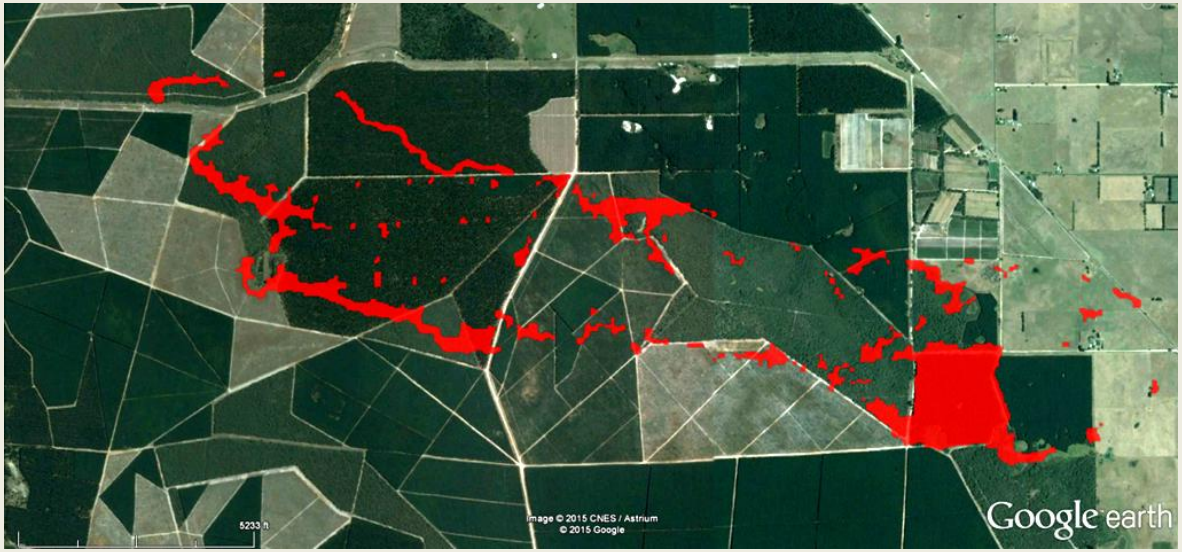
Vector Products : Burning Areas





Vector Products : Burning Areas



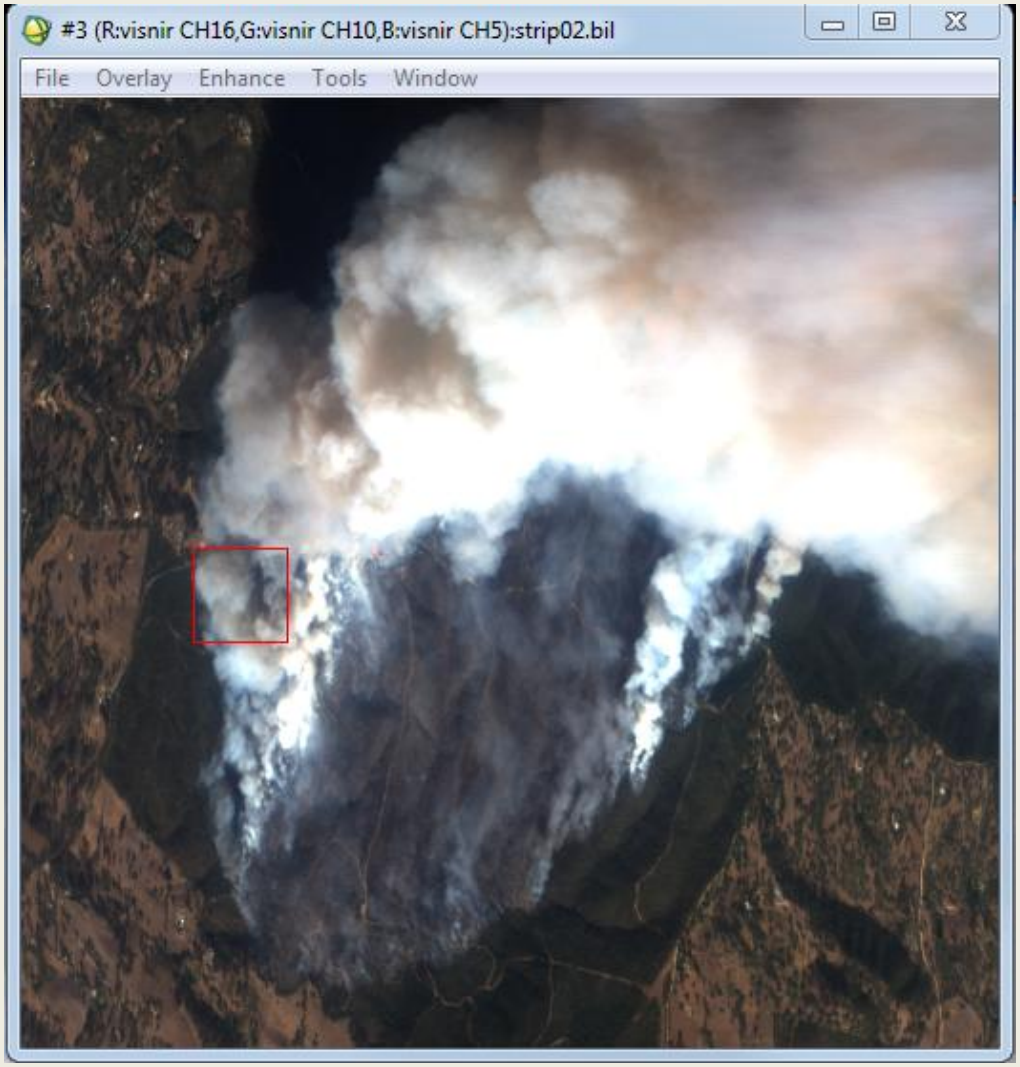


A product for measurement of fire front speed (?)

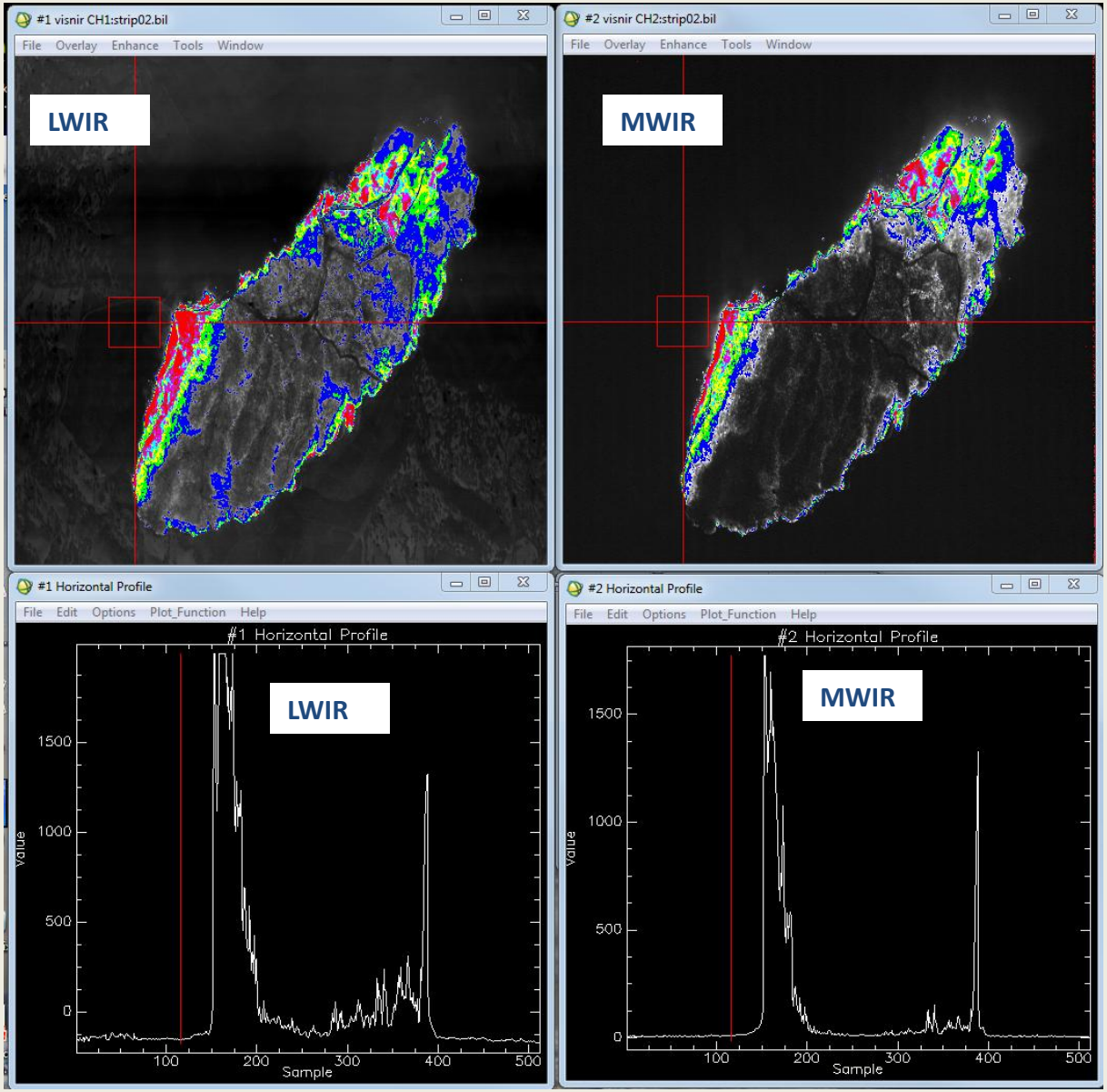
Other Products : Fire Intensity

Example from Sampson Flat Fire, South Australia, 3rd January 2015

The right side image is a screen grab (ENVI) of a true colour representation from HyMap bands in the VIS module.
Images derived from the LWIR and MWIR thermal bands on the following page are of this area.



Other Products : Fire Intensity



Hyperspectral remote sensing adds information at all stages of wildfires

Pre-fire

- Vegetation species and fire fuel mapping
- Biomass
- Fuel condition (e.g. moisture)
- Risk assessment
- Monitoring effectiveness of prescribed burns

During fire

- Fire front and spot fire mapping
- Fire intensity and temperature
- Smoke hazard assessment
- Fuel condition and moisture in adjacent areas

Hyperspectral remote sensing adds information at all stages of wildfires

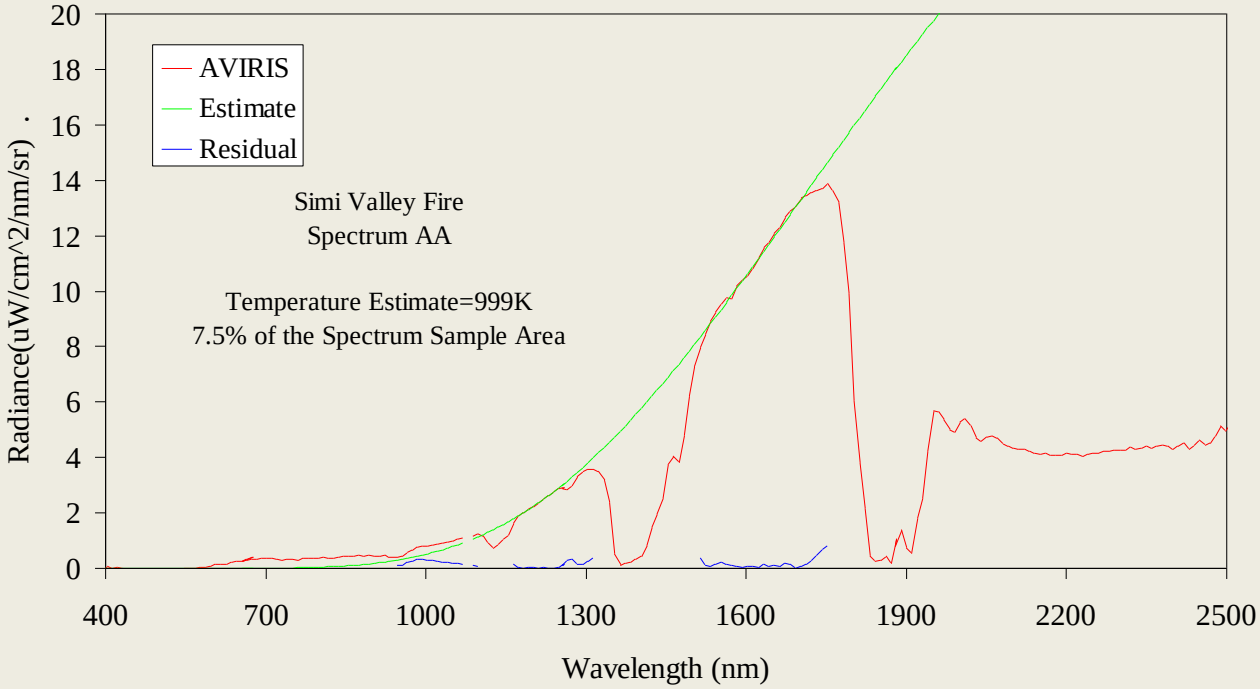
Post-fire

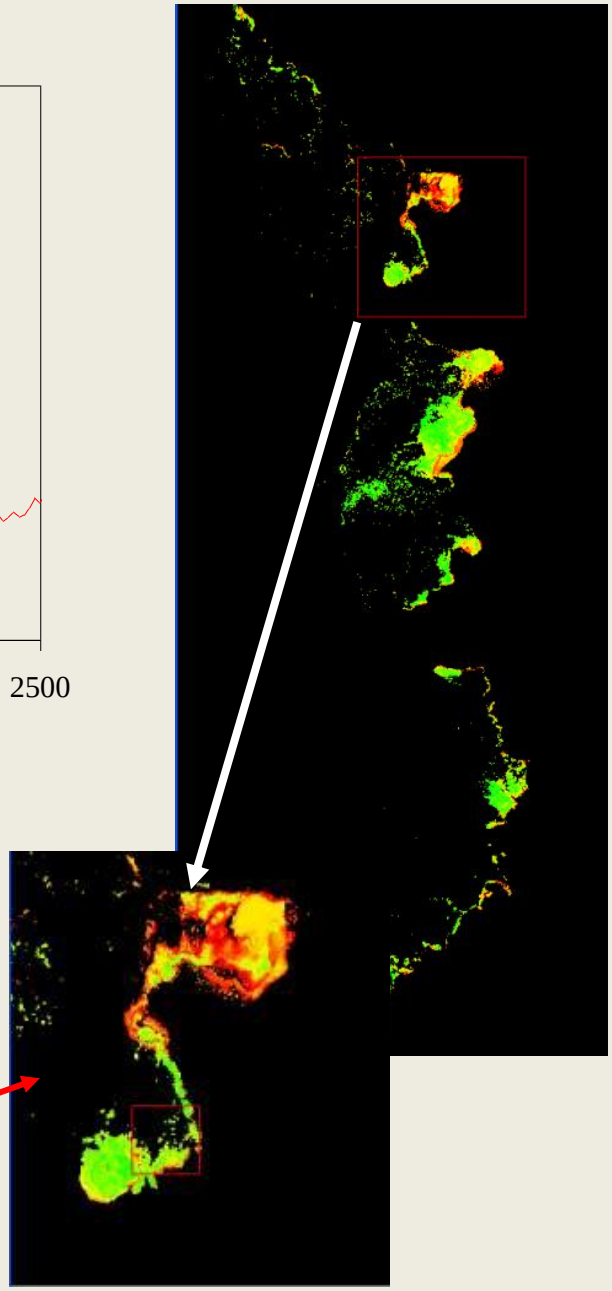
- Burnt area and burn severity mapping
- Ash distribution
- Soil condition
- Remaining ground cover
- Hazard assessment (erosion, water pollution)

Long Term Monitoring

- Multi-temporal measurements
- Soil erosion
- Effects on ecosystem and bio-diversity
- Invasive weeds

Hyperspectral Applications : Fire Temperature





The red curve in the above figure shows the radiance recorded by NASA's AVIRIS hyperspectral sensor in the NIR-SWIR2 region while flying over a wildfire in southern California.

The signal in the SWIR2 region (1900—2500 nm) is saturated by the black body radiation of the fire. However in the NIR and SWIR1 region (800—1800 nm) the signal does not saturate.

Since the sensor is radiometrically calibrated, one can fit a blackbody curve (shown in green) to the radiance data and thus estimate the fire temperature.

The HyMap sensors operated by HyVista Corp have equivalent capabilities to the NASA AVIRIS sensor and the following pages show examples of smoke penetration and fire intensity mapping using a HyMap.

Temperatures 800 – 1450K

Hyperspectral Applications : Fire Temperature

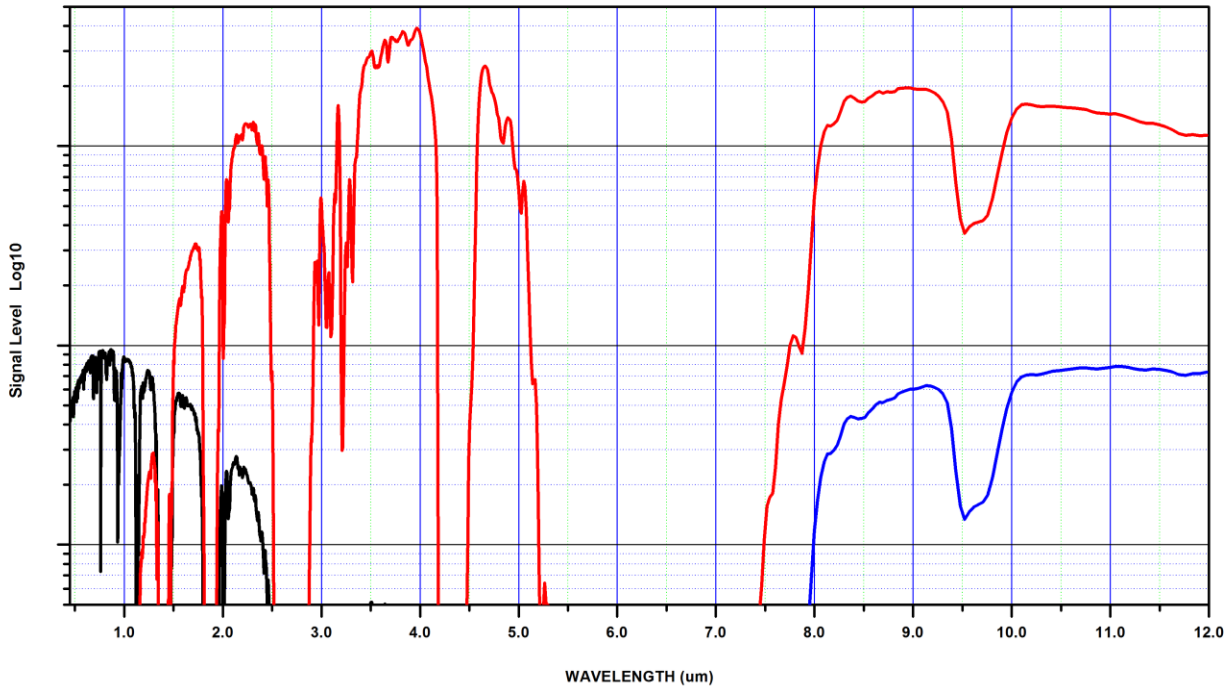
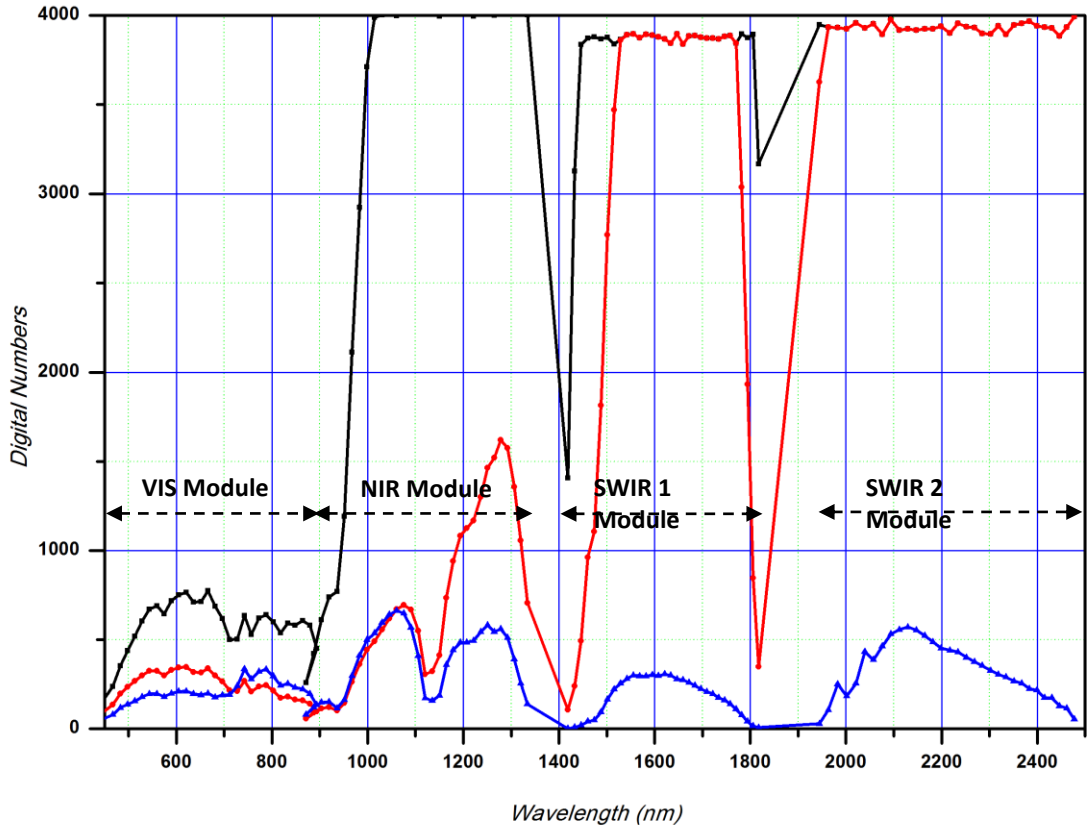


Figure above shows results of a computer model of "at sensor" photon flux.
The lack curve is the flux from a sunlit target of 50% albedo with a solar zenith angle of 30 degrees.
The blue curve represents the earth surface at 300 K and the red curve for 800K

Hyperspectral Applications : Fire Temperature ?????



Sample DN spectra from Yarrabin Fire (Jan 2013)

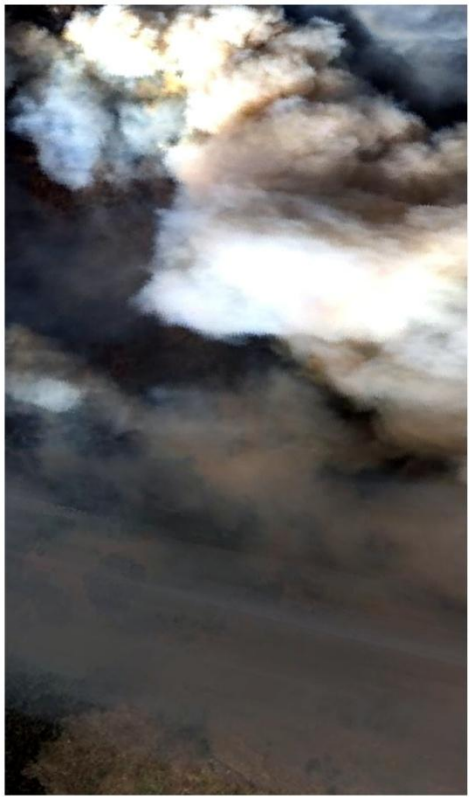
Operational Limitations:

- **Sensor Saturation**
- **Radiance contributions from sunlit ground and clouds**
- **At higher temperatures, need to rely on shorter wavelength (NIR) but they have less smoke penetration**

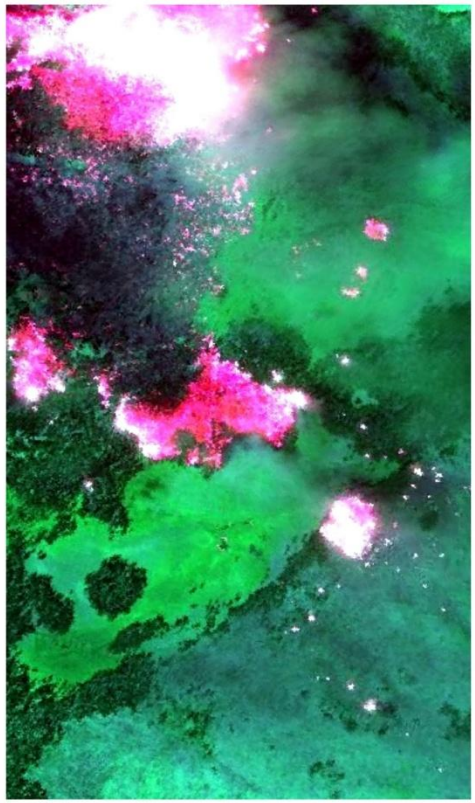
HyVista CORPORATION

Hyperspectral View of Wildfire

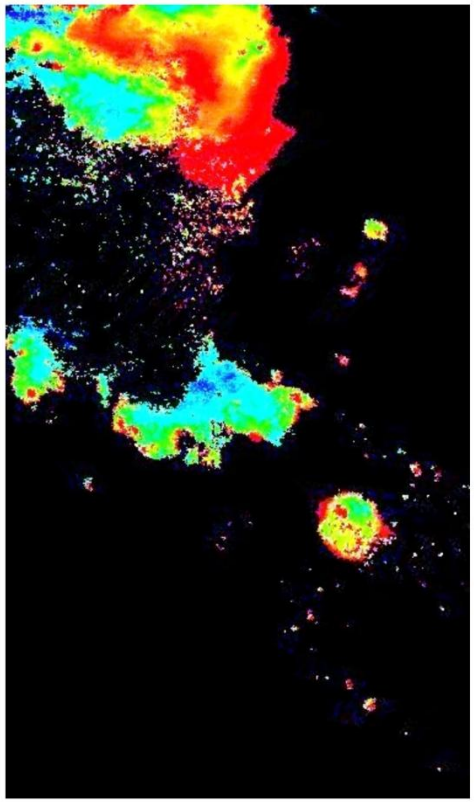
Bear Creek, Idaho



True Colour Image



SWIR Image
(2228 nm, 1260 nm, 1650 nm)

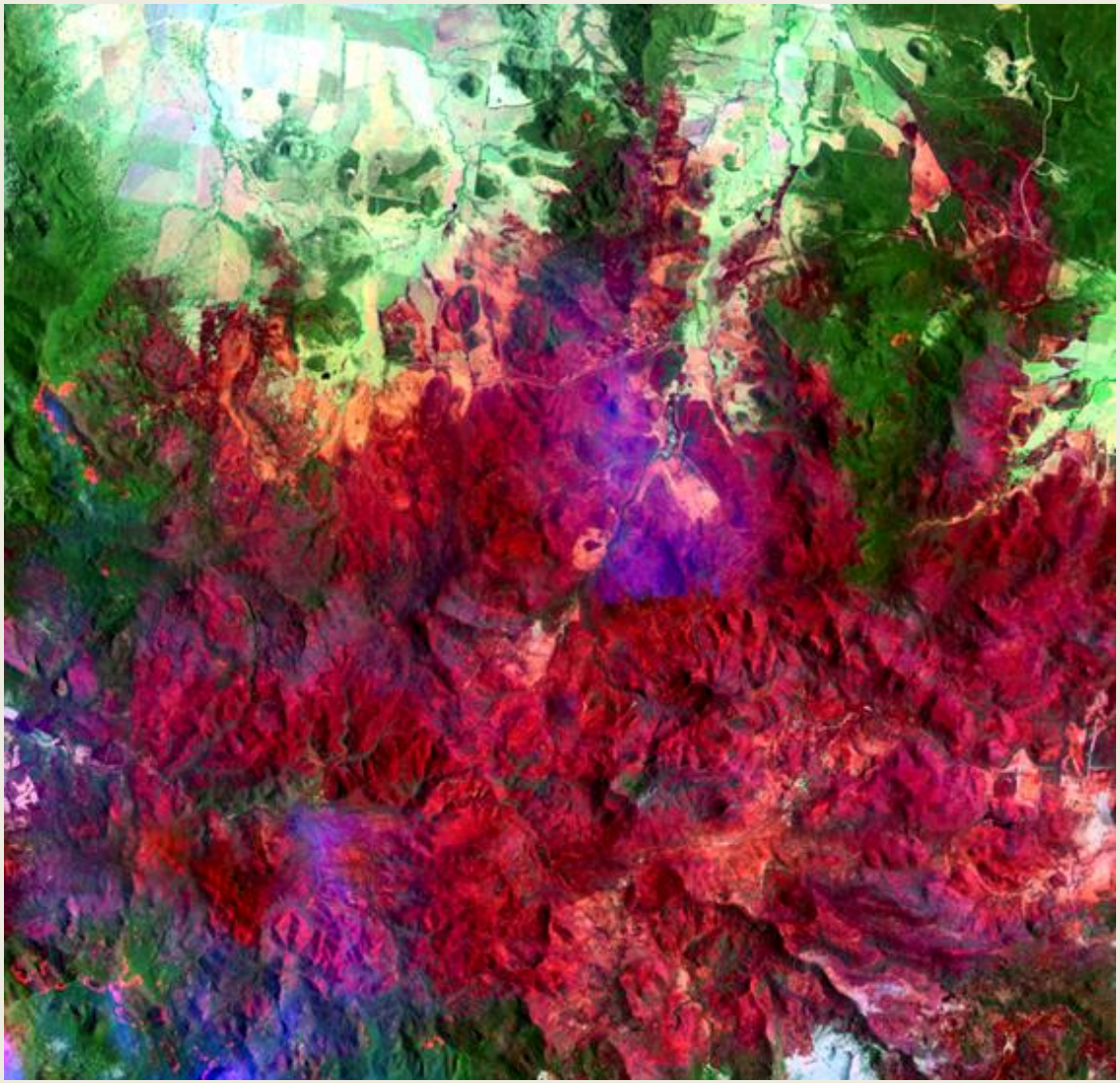


Fire Intensity Index

Hyperspectral Applications : Creating Shape Files of Burned Area

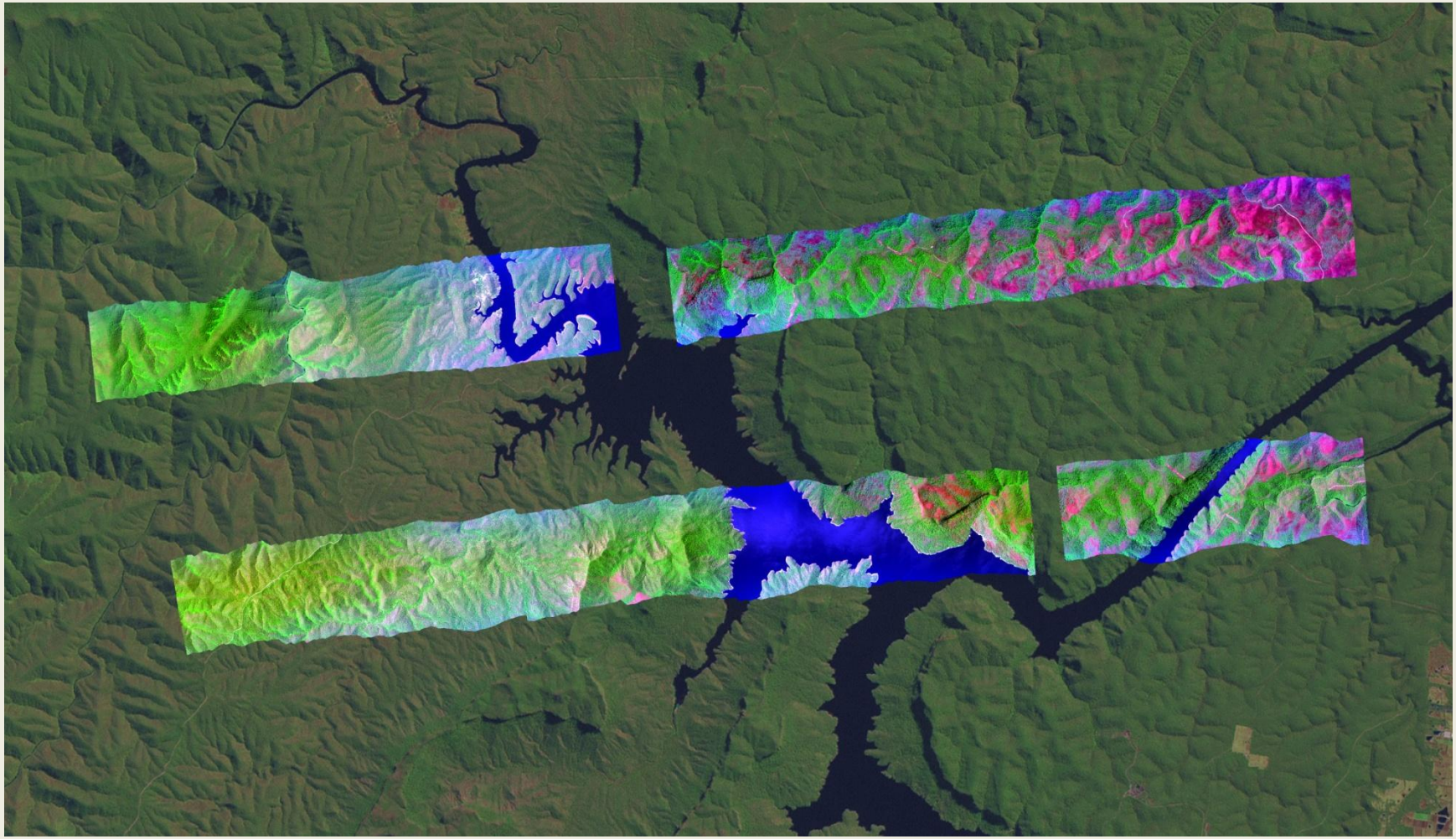
A large fire in a national park in Central-North NSW (2013) generated a pyro-cumulus nimbus cloud which poses some threat to aerial mapping missions.

The image to the right is a mosaic of several HyMap image strips and the large burnt area is readily identifiable (red-brown) and active fire fronts can be seen on the NW and SW edges of the area.



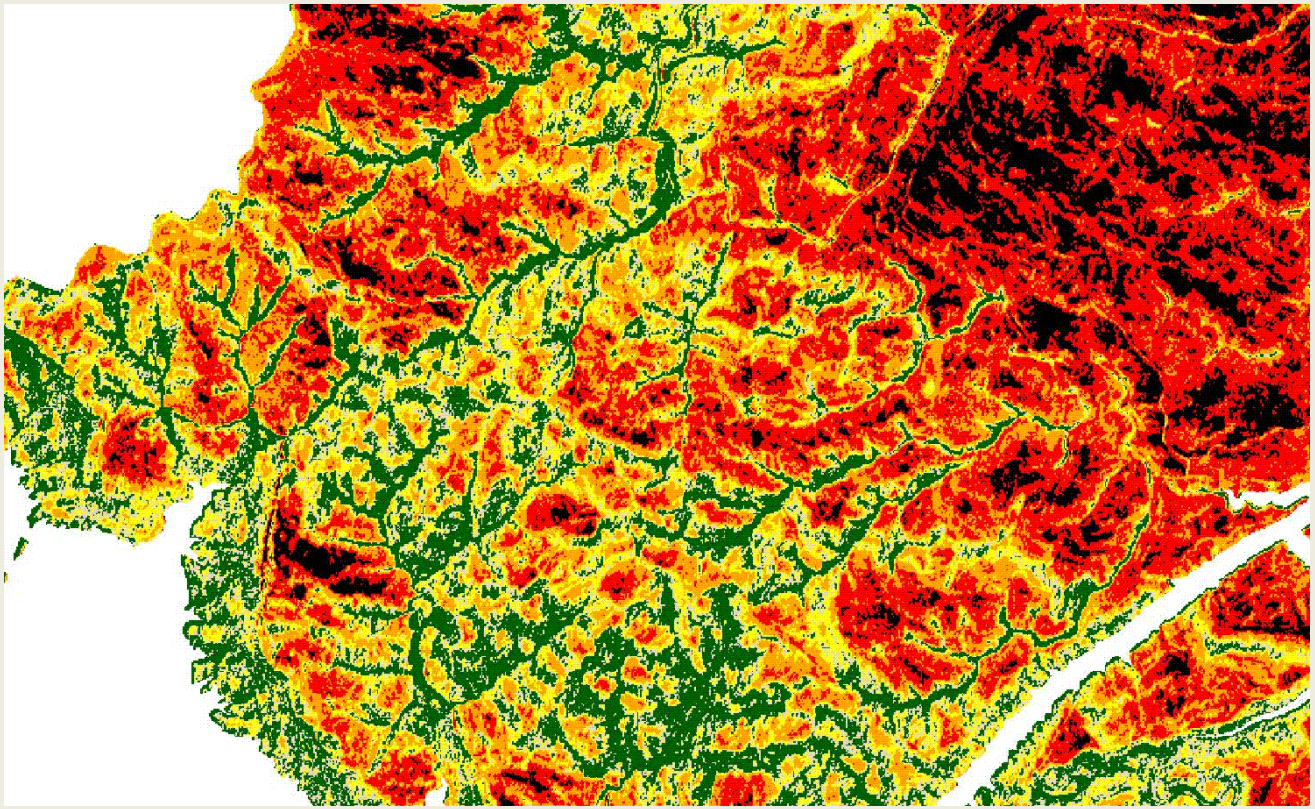
Hyperspectral Applications : Burn Severity Mapping

Sydney Christmas 2001 Fires--- area of interest near Warragamba Dam



SPOT Imagery 1 Nov 2001, 7 Jan 2002 // HyMap Acquisition 7 March 2002

Hyperspectral Applications : Burn Severity Mapping



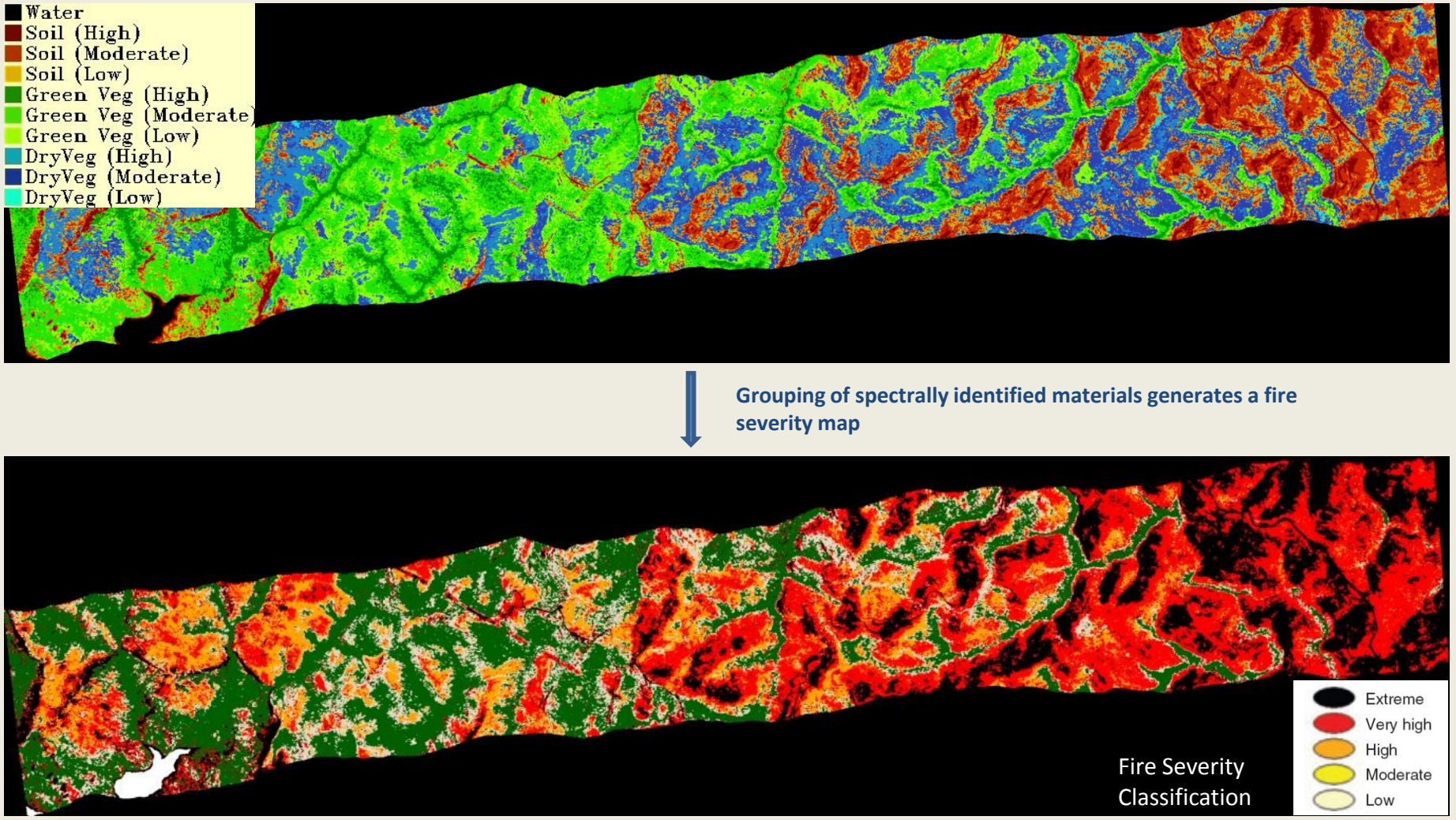
Analysis by Sydney Catchment Authority using pre & post SPOT imagery

Fire Severity Classification

Hyperspectral Applications : Burn Severity Mapping

Spectrally-driven Classification of HyMap Imagery

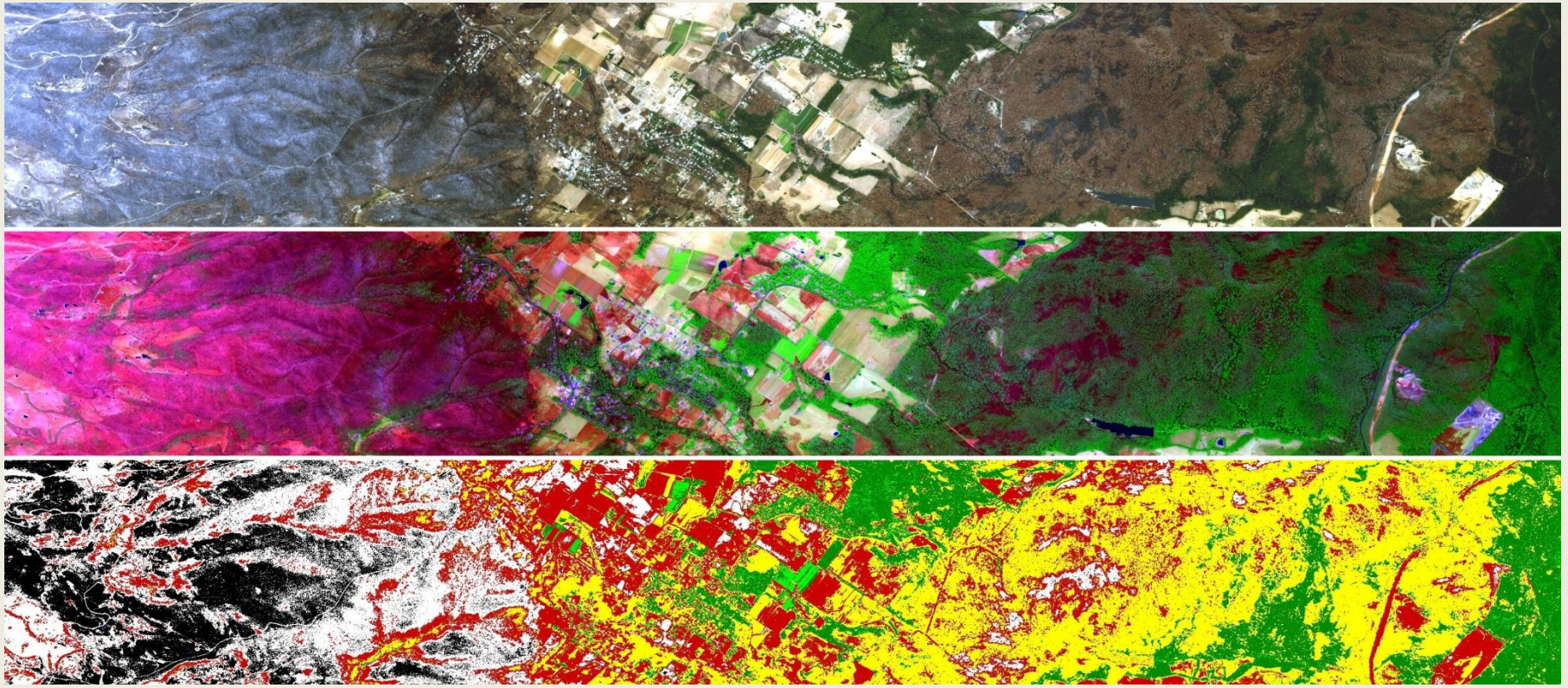
Sydney Christmas 2001 Fire



The above is equivalent to the BAER maps used in the US

Burn Severity Mapping :Hyperspectral Classification of Surface Materials

Kinglake, Victoria



A : true colour

B : LANDSAT 741 equivalent

C : Spectrally classified surface materials

No ground truth !!! Under total cloud cover !!!

HyVista CORPORATION

"UPDATE FROM OZ" : TFRSAC Fall 2015 Meeting

Multi-Mission Platform

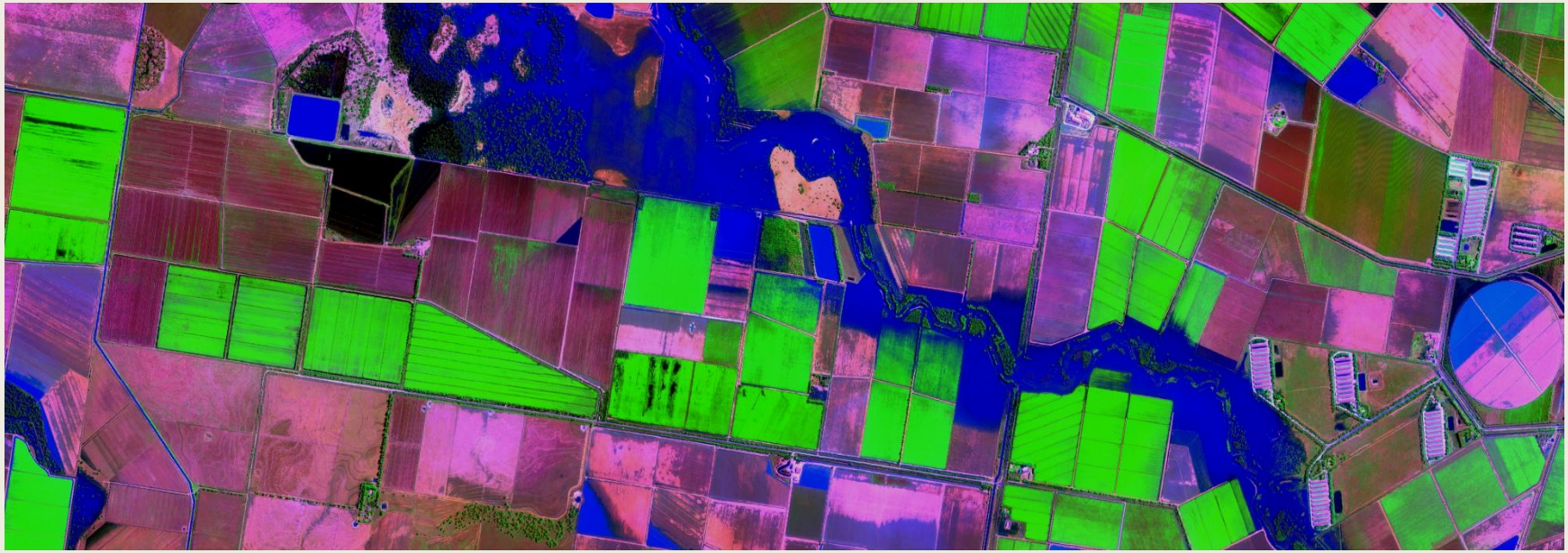
With the sensor suite on board, a multi-mission platform is available

One flight: multiple targets & multiple products

Outside of wild fire applications, the sensor suite is suitable for

- **High resolution ortho-photography**
- **Oil and chemical spills**
- **Mine site contamination**
- **Floods**
- **General environmental applications**
- **SAR**

March 2012 : Floods near Griffith, NSW : HyMap Image as LANDSAT 7-4-1 colour



Hyperspectral classification can easily discriminate between standing water and moist soil

Digital Cameras for Synoptic View

Samples of Imagery from on-board 40MP Digital Camera

Digital Camera Products for Immediate Post-fire Damage Assessment

10 cm pixel

Thank you for your attention

The voyage of discovery is not in seeking new landscapes but in having new eyes.~ Marcel Proust (1871-1922)

Front & back images from ABC
Sampson Flat Fire, South Australia, 3rd January 2015

Hopefully all fire aerialist efforts will help us see less of this