FireOPAL

A sovereign Australian space situational awareness solution

Phil Bland

Greg Madsen, Matt Bold, Robert Howie, Ben Hartig, Trent Jansen-Sturgeon, James Mason, Tim Payne, Dane McCormack & Rod Drury





SSA: NOT ALL SOLUTIONS ADDRESS THE 'WHY'

Need for:

- Wide angle detector, without sacrificing sensitivity
- Ability to generate self-starting catalogue
- Persistent observations
 - see same object multiple times per day
- Low latency: real-time reporting
 - enable rapid decision making



OVERVIEW – Desert Fireball Network

Fireball networks

- Track fireballs: determine orbits and fall positions of meteorites by triangulation
- Links asteroids to meteorites

DFN observatories

- Fully autonomous: 24 months in a harsh environment
- Synchronised observations to sub-ms precision
- Instantaneous triangulation
- Highly modular quick to deploy and service



OVERVIEW - Global Fireball Observatory

Internationally

- Collaboration with NASA Ames via SSERVI program
- 90 additional stations with 15 partner institutions
 - US, Canada, Morocco, UK, Saudi Arabia, Mexico, Argentina



Not just meteorites...





Tracked back to the Xichang Launch Center Beidou 3 satellite on a Long March 3C

FireOPAL - CONCEPT

- Partnership between Curtin University (Perth) and Lockheed Martin
- 6 years engineering heritage from DFN
- Build global network of standalone, weather hardened observatories
- Very wide angle, disruption tolerant network
 - deliver persistent real-time observations
- Cost effective SSA solution optimised for detecting LEO, MEO, GEO satellites



KEY FEATURES

- Synchronised observations across the whole network (sub-ms)
- Triangulated observations deliver highly accurate orbits
- Distributed network
 - disruption tolerant (unaffected by weather)
 - covers a large fraction of the sky
 - no terminator issue
 - can be scaled to arbitrary size
- Onboard image processing delivers calibrated results in seconds – low latency



1 observatory

PERFORMANCE

- See LEO, MEO, and GEO
 - one observatory sees ~80% of all known objects
 - almost every catalogued object in GEO
- Measures angular coordinates, time stamps, and light curves in seconds
- Angles to arcseconds
- Photometry to few %
- Results published to central server in seconds for triangulation
- Handoffs to DST telescope:
 - enables 'live' (mid-pass) handoffs
 - handoffs after >1 day orbit propagation
- Orbit predictions match 'future' FireOPAL observations to ~1 pixel



Spacetrack (red) versus FireOPAL (green)

AUSTRALIAN FIREOPAL

- 20 observatories
- Currently scans 6000 square degrees of sky every 10 seconds
- Detects around 1000 objects across that volume in 10 seconds
- Automatically determines orbits for those objects to arcsecond precision
- Delivers the data in realtime



6 weeks data from 6 observatories

SaVi

Created with SaVi: <u>http://savi.sourceforge.net/</u>

#+ Hill!

FireOPAL > FireOPAL Overall System Status -

> Online Status (1 panel)

> Hardware Status (5 panels)

Processing Status









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FireOPAL > FireOPAL Overall System Status -



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- FireOPAL003 - FireOPAL004 - FireOPAL005

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Hardware Status











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MAGNITUDE AGAINST APPARENT SIZE

- Selection of >400,000 observations of LEO objects
- Objects that are the same apparent size can show a variation of 4 magnitudes



MAGNITUDE vs TIME FOR ONE OBJECT

- >14,000 observations for an Atlas Centaur rocket body
- Magnitude adjusted for range and solar phase angle



• Intrinsic variations up to 3 magnitudes

GLOBAL FIREOPAL – A FOUNDATION DATASET

- 100,000 square degrees of sky every 10 seconds
- No terminator issue
- Observatories will be observing peak brightness somewhere
- 90% of the catalogue in 12 hours
- 50% in <2 hours
- Can we build a global network?
- Already done it with the GFO
- Less than the cost of a 2m telescope



Spacetrack (red) versus FireOPAL (green)

FireOPAL

Australian designed, owned, and operated sovereignty and access guaranteed Large scale passive network – Australia, then the world disruption tolerant: multiple sensors minimise coverage risk Persistent, omni-directional with depth covering LEO, MED, HEO, GEO recover objects multiple times per day Low latency, near real-time reporting of results enhances awareness, enables immediate decisions and actions Cost effective solution global network for the cost of a 2m telescope



