Wildfire Mapping and Decision Support, Capabilities, Gaps & Opportunities

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Hyspiri

From the Hyspiri web page:

"The HyspIRI mission will study the world's ecosystems and provide critical information on natural disasters such as volcanoes, wildfires and drought."

Discussion Points

- Introduction
- Fire stages and key needs
- Current & near term capabilities
- Gaps & Opportunities
- Current areas of R&D

Introduction

- Wildland fire is an important challenge facing land managers in the United States.
- In recent years, increased fire size and severity together with an increase in the number of people living in the wildland–urban interface has resulted in billions of dollars of damage to property and significant loss of life in the United States.

Fire Phases & Key Needs

- Pre-Fire
  - Pre-burn fuels mapping
- Detection / Ignition
  - Tipoff Information – Lat/Long/Level of Confidence
- Active Fire
  - Fire perimeter and active fire fronts
  - Problem areas – hot spots outside line
  - Where the fire has been
  - Lines of containment
  - Effectiveness of backfire operations
  - Hot-spots during the mop-up phase
  - Carbon flux!
  - Fire Modeling
- Post-fire
  - Burn severity and mitigation strategies

GMO

Pre-Fire Fuels Mapping

- Land managers want cost-effective methods for mapping and characterizing forest fuels quickly and accurately.
- Fuels have traditionally been mapped through extensive field inventory with sampling and statistical inference.
  - Takes a lot of time
  - Very expensive
- Data derived from remote sensing data can be input into fire models to assess fire hazard and risk, and to predict fire behavior.
- Potential remote sensing sources include:
  - LiDAR
  - Imagery (multi-spectral and hyperspectral / air & space sensors)
  - Radar (Synthetic Aperture Radar)
- Caveat: The availability of low-cost satellite hyperspectral and LiDAR datasets is currently limited.

Fire Detection

- Fast and effective detection is a key factor in wildfire fighting. Detection efforts should be focused on early response, accurate (location) results in both daytime and nighttime, and the ability to prioritize fire danger.
- Early detection methods included:
  - Fire lookout towers (early 20^{th} Century)
  - Aerial and land photography using instant cameras (1950s)
  - Infrared scanning (Developed in the 1960s).

Fire Detection

Current Methodologies

- Small area / high value assets at risk
  - The public (public hotlines, cell phones)
  - Watchtowers (manned)
  - Ground based sensor networks
- Large area / low value assets at risk
  - MODIS / satellite detection
  - Electronic lightning detection
  - Aerial patrols: planes, helicopter, and/or UAVs

Fire Detection

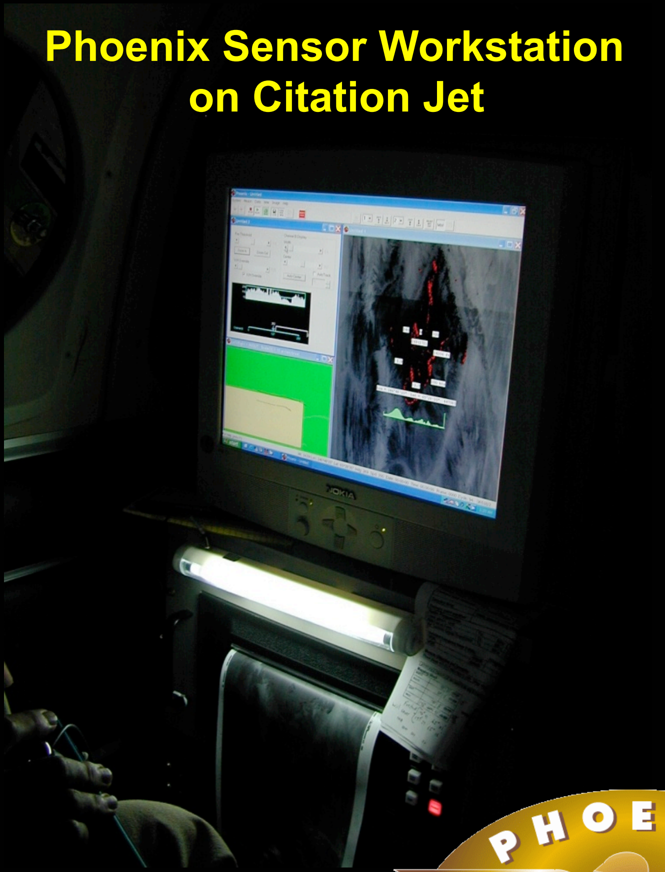
- Caveats
  - Satellite detection is prone to positional offsets.
  - Cloud cover and spatial resolution often limit the effectiveness of satellite imagery.
  - Ground and near earth observations can be expensive.
  - Improved fire detection is generally a low priority for federal land managers.
- Opportunities
  - GOES – R
  - Other future satellite systems
  - Military and IC capabilities

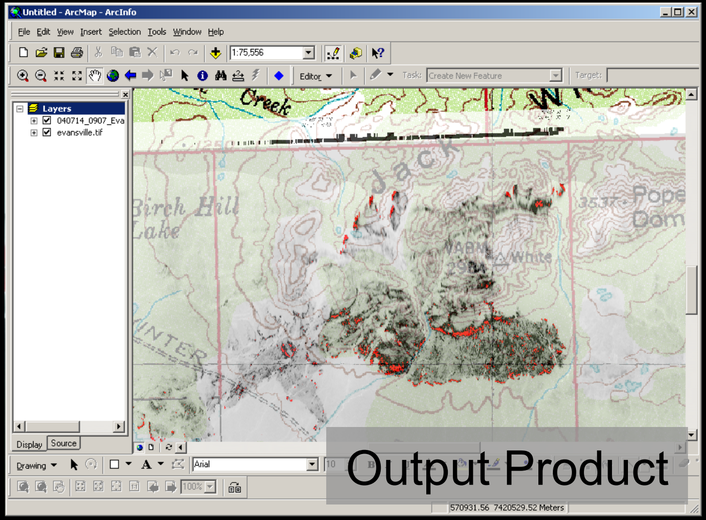
Active Fire Mapping

- Current capabilities for tactical fire mapping
  - National Infrared Operations (NIROPS)
  - Vendor aircraft
  - Military and IC assets
  - Unmanned aircraft (UAS)
  - *Commercial satellite imagery*
- Future Opportunities
  - Future satellite systems, GOES-R

Active Fire Mapping

Citation jet at NIFC


Phoenix Sensor Workstation on Citation Jet



Output Product

PHOENIX
INFRARED FIRE DETECTION AND MAPPING

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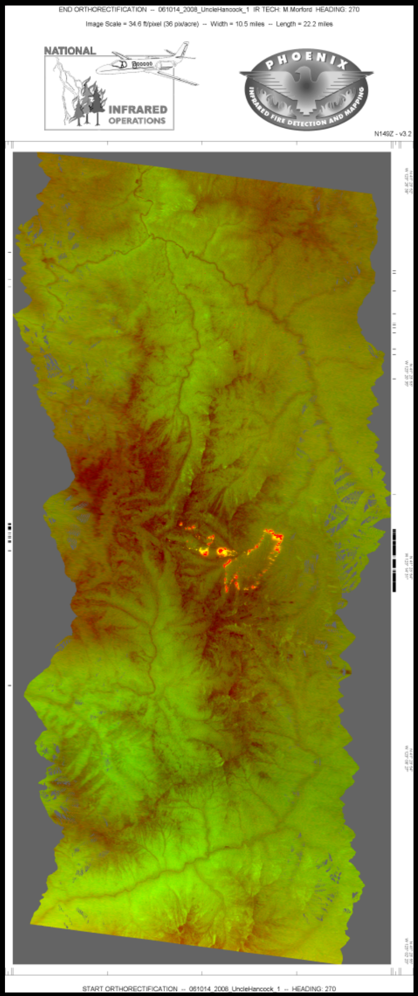
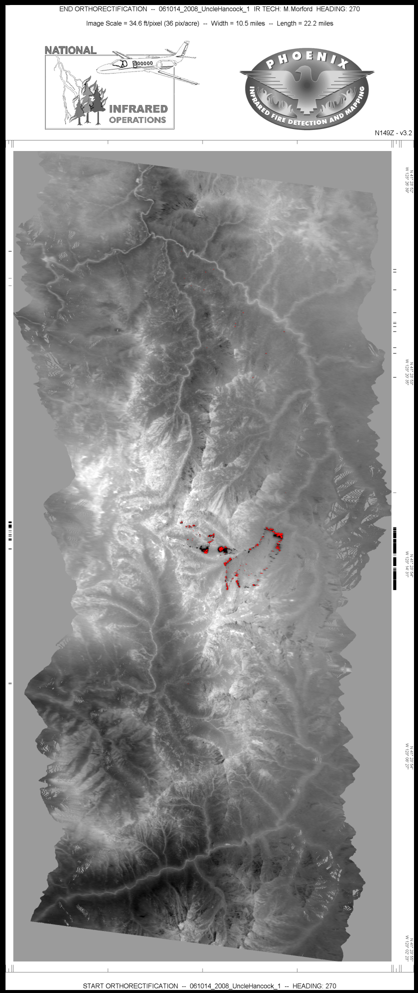
Active Fire Mapping

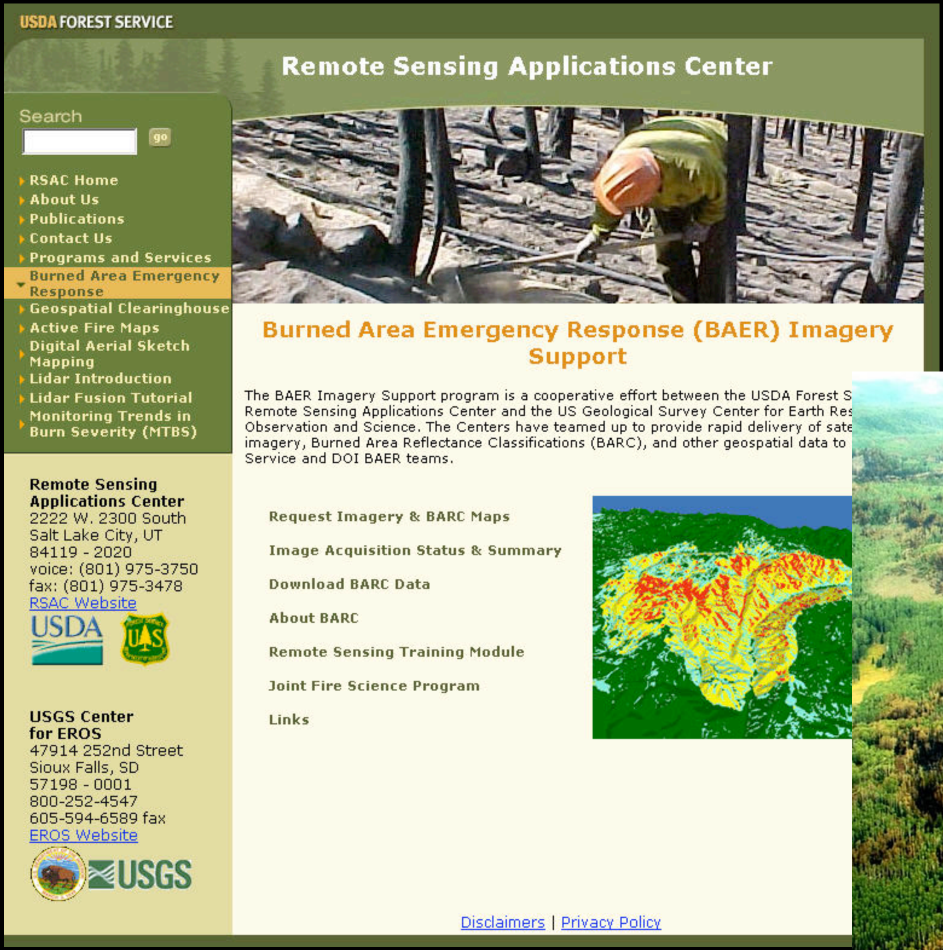
PHOENIX Output Products

- GeoTiffs
  - Color
  - Grayscale
  - "255 Pixel Layer
- JPEGS
- Mosaics
- Active Heat Areas shape file



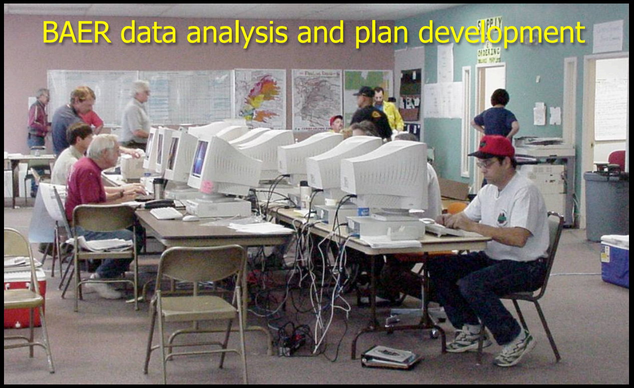


Burned Area Emergency Response



Burned Area Emergency Response

- Fast track emergency assessment
  - BAER response plan is required within 7 days of fire containment
- Utilizes change detection methods from satellite imagery
- Assess fire effects on the soil and watershed hydrologic function (erosion and flood potential)
- Prescribe and implement emergency stabilization measures to mitigate potential hazards to:
  - Life
  - Property
  - Long-term soil productivity
  - Water quality
  - Natural resources



Burned Area Emergency Response

- Post-fire situations of concern for BAER teams…

High burn severity – Robert Fire 2003 (Carl Key, USGS)

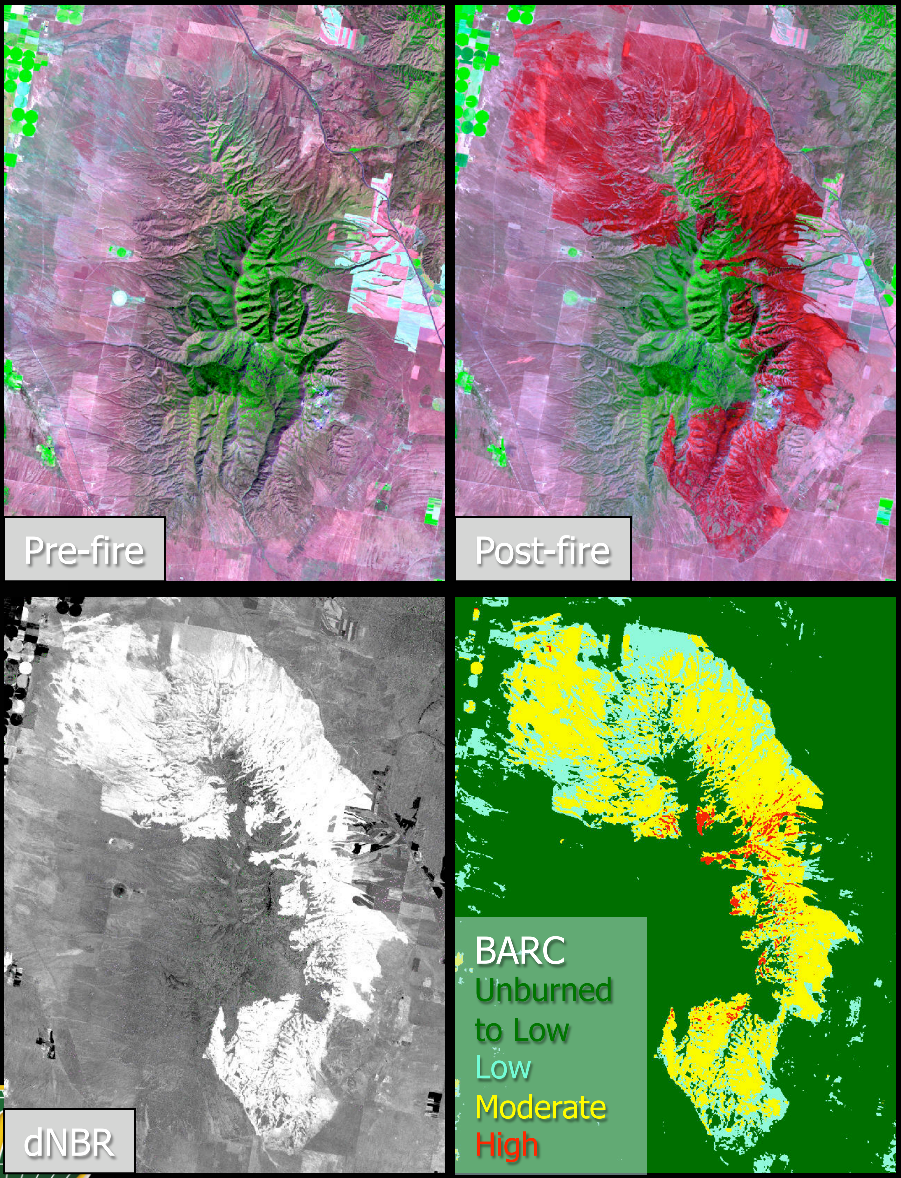
Hydrophobic soils, USFS

High burn severity – Station Fire 2009 (USGS)

Burned Area Emergency Response

- Potential consequences of unmitigated post-fire hazard situations…

Burned Area Emergency Response



- ~860 fires mapped since 2001 (~27.5 million acres)
- Imagery, BARC and other data products provided within 2 hours of receiving image from provider

Burned Area Reflectance Classification (BARC)
Normalized Burn Ratio (NBR)
Differenced Normalized Burn Ratio (dNBR)

NBR = (NIR – SWIR) / (NIR + SWIR)
dNBR = Pre NBR – Post NBR

BARC = Continuous dNBR data thresholded into severity classes

Burned Area Emergency Response

Leveraged Sensor Assets – Use Best Available

Sensor	Platform Type	Spatial Resolution (Reflectance Bands)	Temporal Resolution (per instrument)	Data Source
Landsat 5 TM	Polar orbiting	30m	16 days	USGS EROS
Landsat 7 ETM+[1]	Polar orbiting	30m	16 days	USGS EROS
AWiFS	Polar orbiting	56m	5 days	USDA-FAS-SIA
SPOT 4	Polar orbiting	20m	2-3 days (pointable)	SPOT Image/USGS EROS
SPOT 5	Polar orbiting	10m/20m	2-3 days (pointable)	SPOT Image/USGS EROS
ASTER[2]	Polar orbiting	15m/30m	4-16 days (pointable)	NASA/USGS EROS
NASA AMS	Airborne (UAV)	~ 21m	--	NASA
LDCM[3]	Polar orbiting	30m	16 days	USGS EROS

1 – SLC failure in May 2003; 2 – SWIR band issues since April 2008; 3 – launch scheduled for December 2012

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  - **Carbon flux!**
  - **Fire Modeling**
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New Technology Evaluation

- Sensors
- Platforms
- Data Distribution & Decision Support Systems
- The golden age of mapping & remote sensing
  - GPS & GIS
  - The Internet
  - Powerful desktop computing
  - National data sets
  - Decision support systems

- Working with NASA, other federal agencies, academia, commercial vendors, and international partners.

Data Delivery

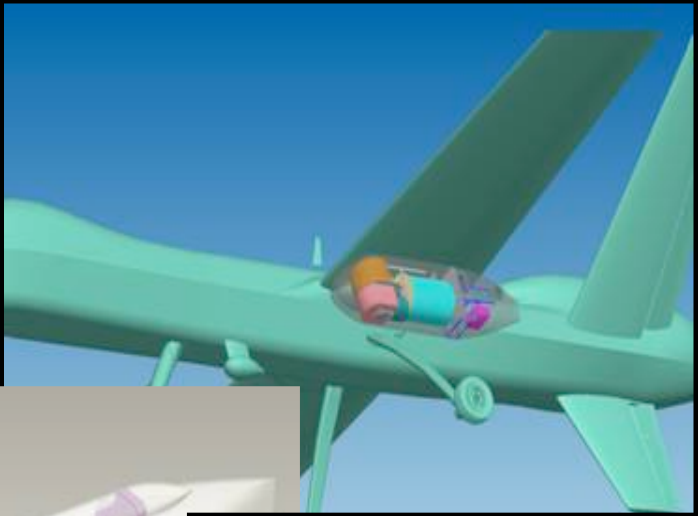
- Traditional Delivery Methods
  - "Land and Hand"
    - IRIN at central location
    - "Pod" at central location
  - Land and upload to ftp.nifc.gov/NIROPS
    - IRIN or IR technician
- AirCell Data Downlink System
  - Terrestrial based telecomm system
  - Broadband level connectivity
  - Is being installed on both NIROPS aircraft
  - Planned for use this summer
  - Phoenix data will be down linked to fitp.nifc.gov for retrieval by IRINs

gogo Inflight Internet

GMO

Autonomous Modular Sensor (AMS)

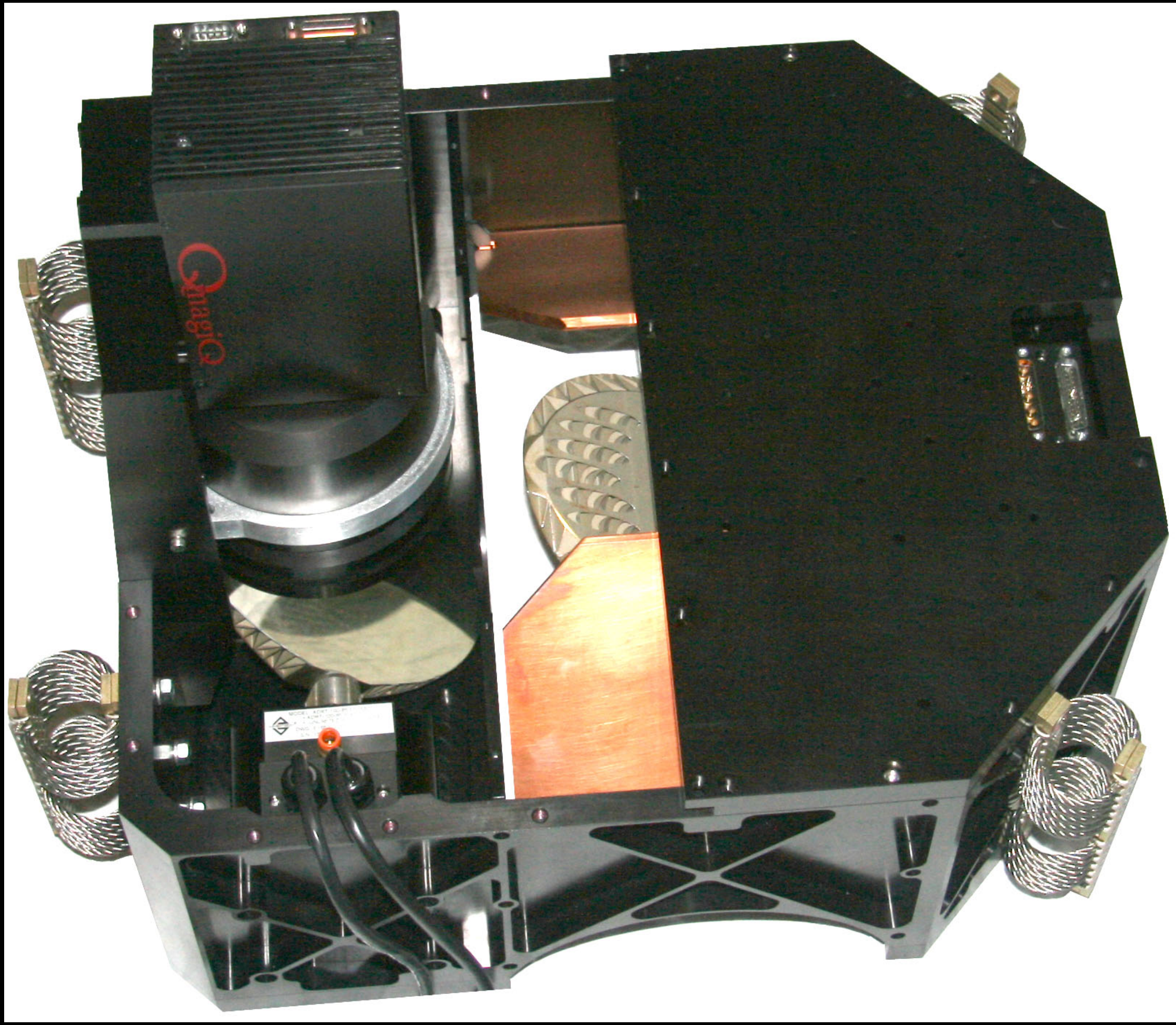
Band	Wavelength µm	
1	0.42-0.45	
2	0.45-0.52	(TM1)
3	0.52-0.60	(TM2)
4	0.60-0.62	
5	0.63-0.69	(TM3)
6	0.69-0.75	
7	0.76-0.90	(TM4)
8	0.91-1.05	
9	1.55-1.75	(TM5)
10	2.08-2.35	(TM7)
11	3.60-3.79	(VIIRS M12)
12	10.26-11.26	(VIIRS M13)



Total Field of View: 42.5 or 85.9 degrees (selectable)
IFOV: 1.25 mrad or 2.5 mrad (selectable)
Spatial Resolution: 3 – 50 meters (variable)

EnablingTechnologies

New Fire Mapping Sensors



Unmanned Aircraft

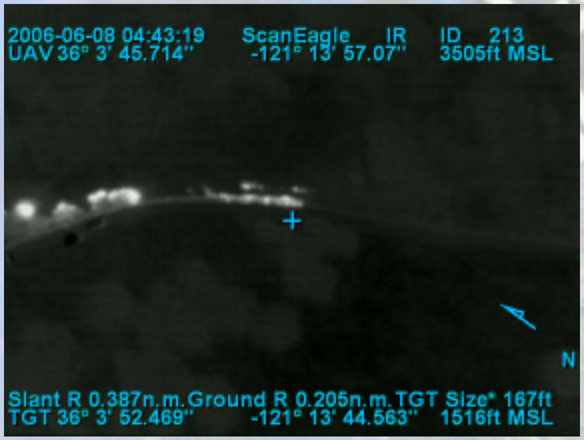
Two Track Approach

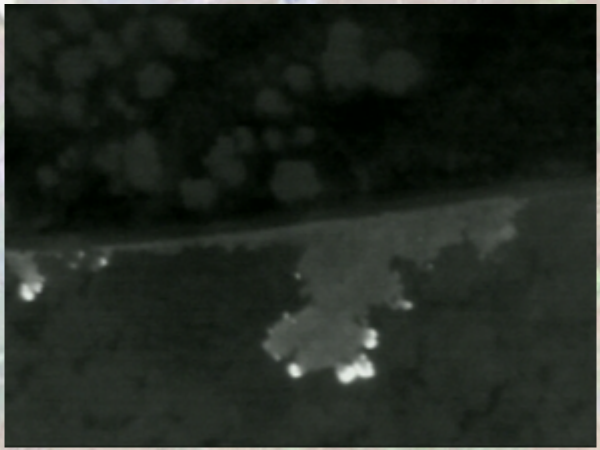
Small UAS

Desired Features

- Fully autonomous takeoff and landing
- Operable from small, unimproved locations!!
- Man or light truck portable
- Capable imaging systems and guidance systems
- VTOL Preferred

UAS: Image Products



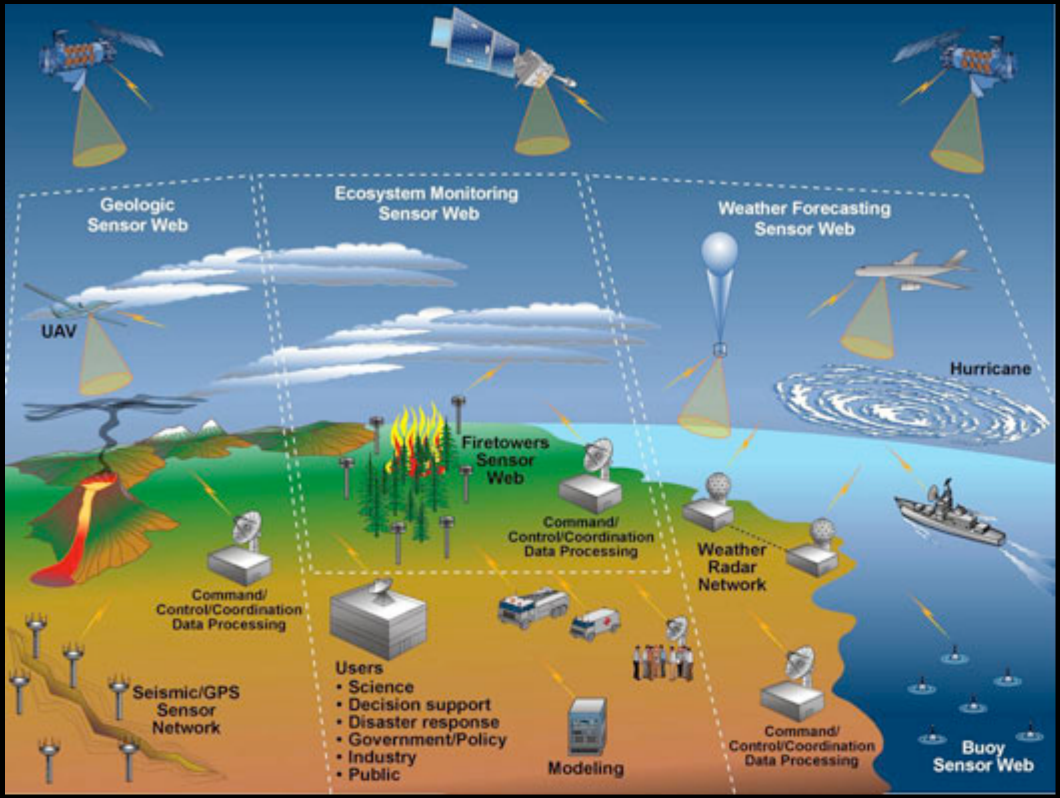


NASA Ikhana

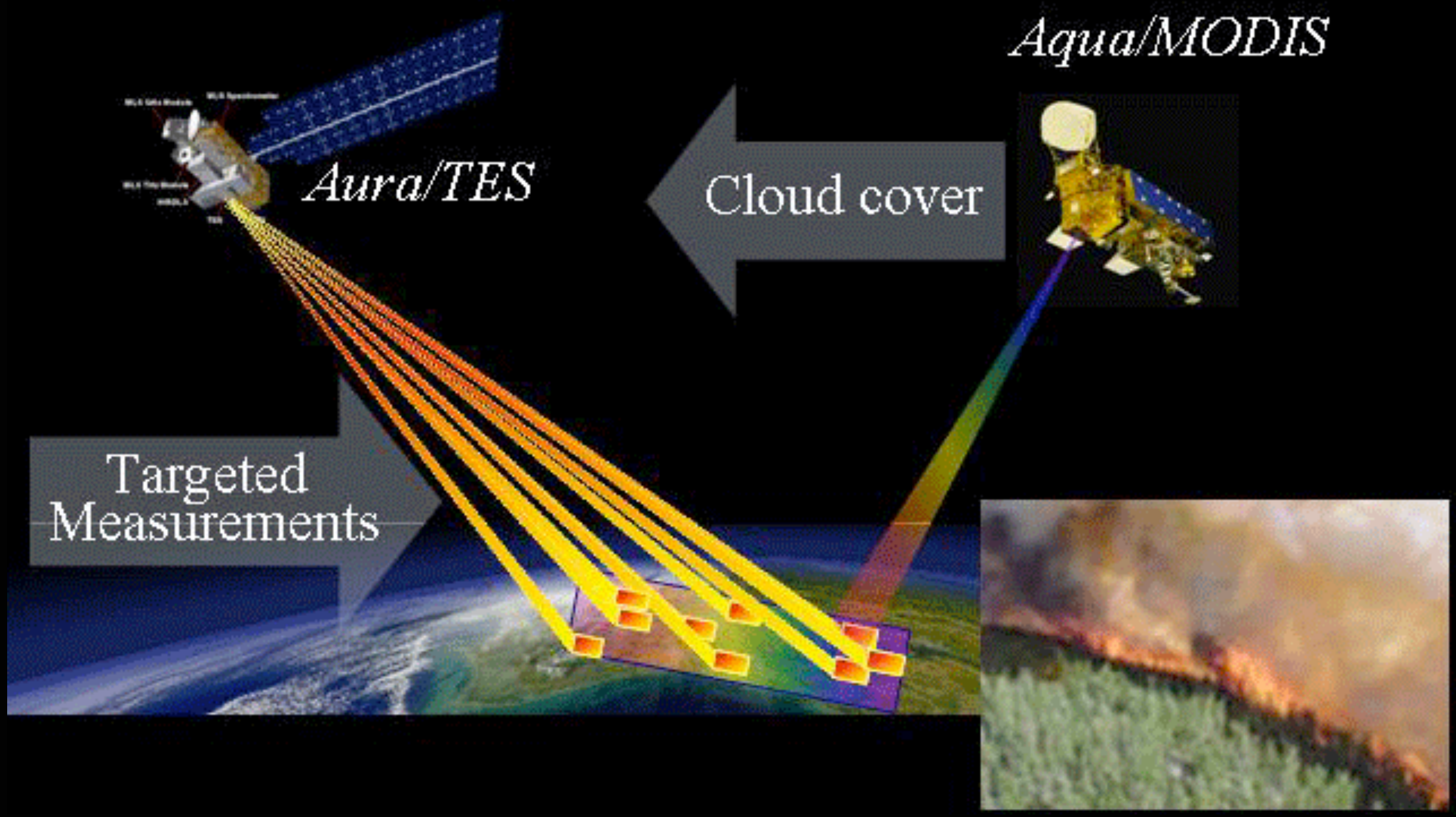
- Continuation of objectives in-place from 2007-2009 missions.
- Missions using NASA Ikhana UAS in 2007, 2008, and 2009.
- Ikhana on standby and funded for emergency fire response in 2010

New Processes

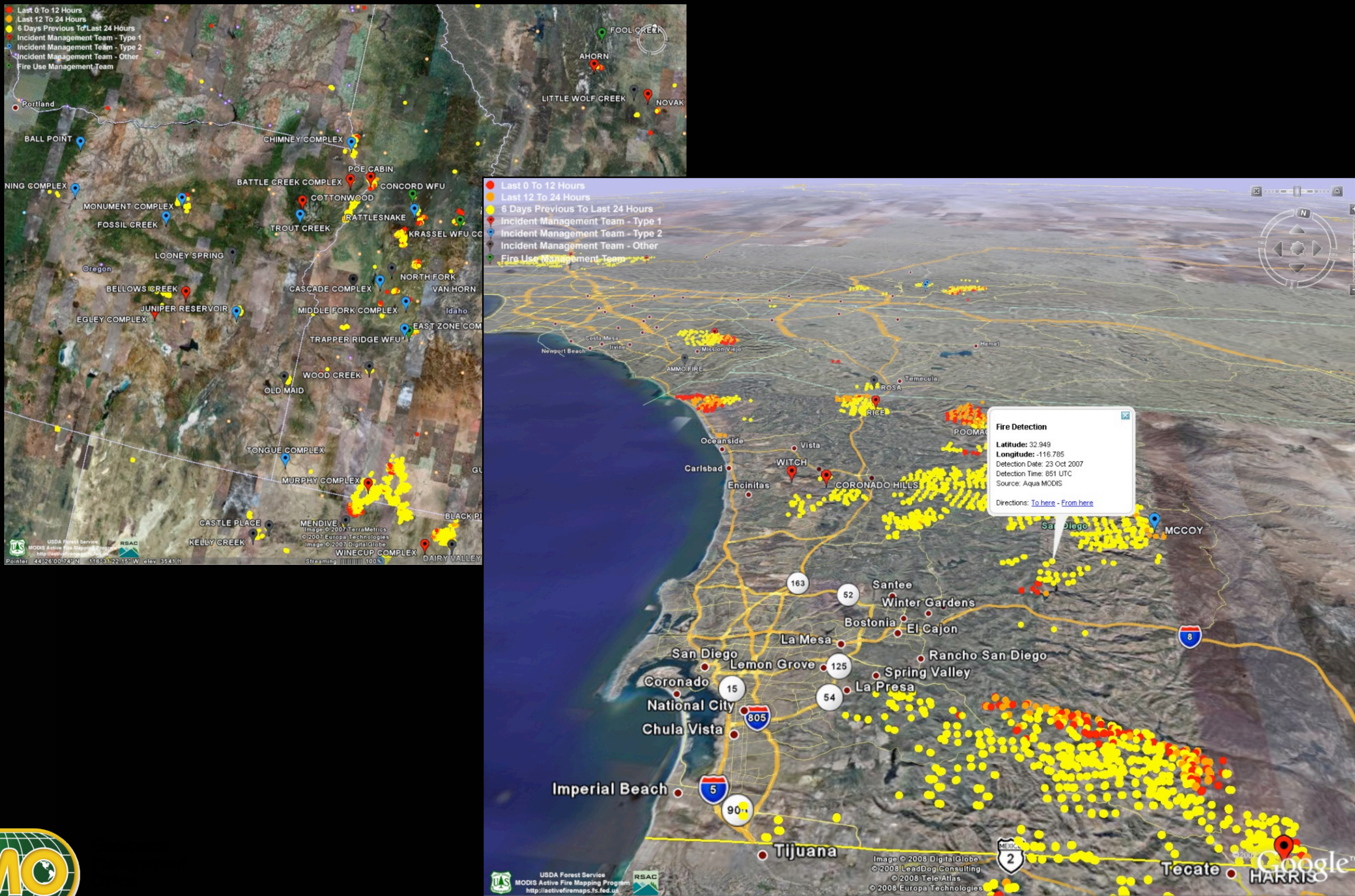
- Multiple sensing systems working together can be used to merge satellite data, aerial imagery, and personnel GPS position/imagery into a collective whole for near-realtime use by Incident Command centers.
  - Decision support tools / geospatial mash-ups
  - NASA's SensorWeb concept!



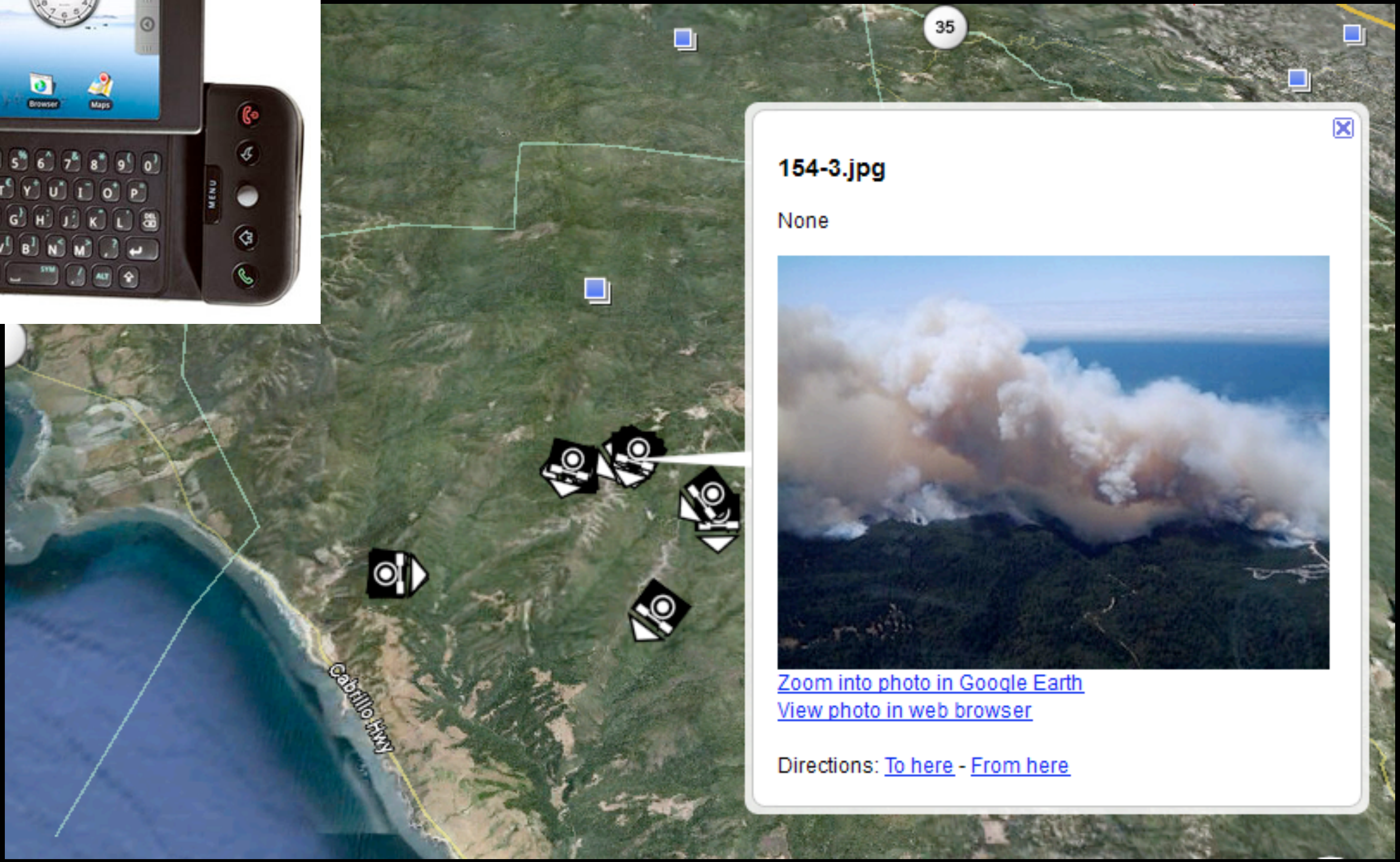
SensorWeb

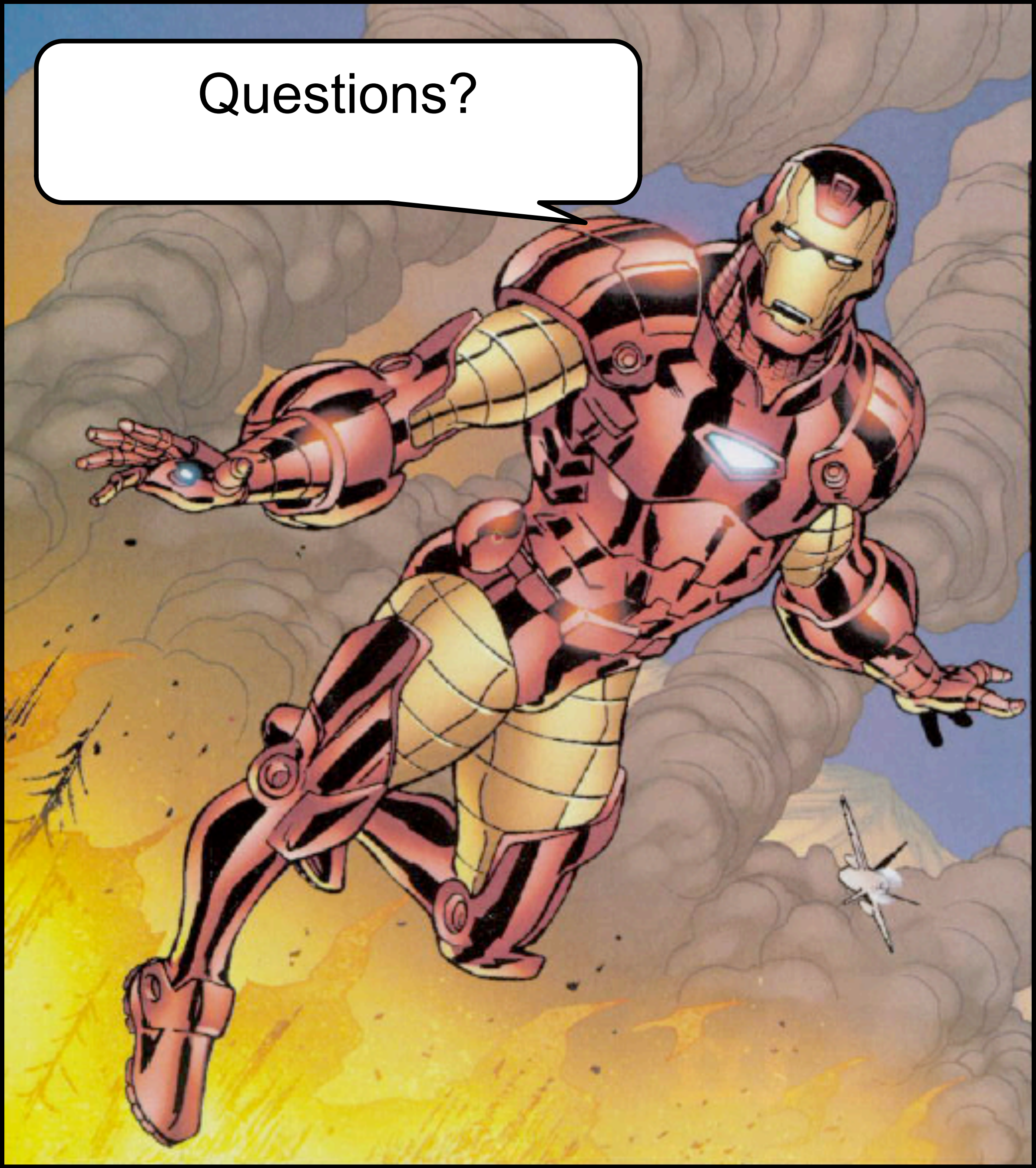


Enabling Technologies: Google Earth



Enabling Technologies: GPS Enabled Phones




Questions?