EO / AI for Wildfires

ITU Webinar on "Fighting wildfires with AI-powered insights"

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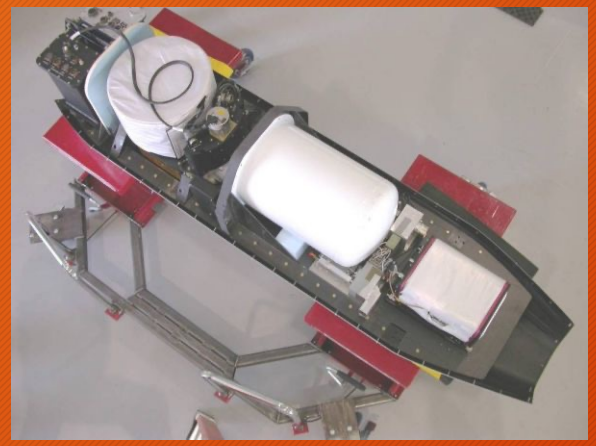
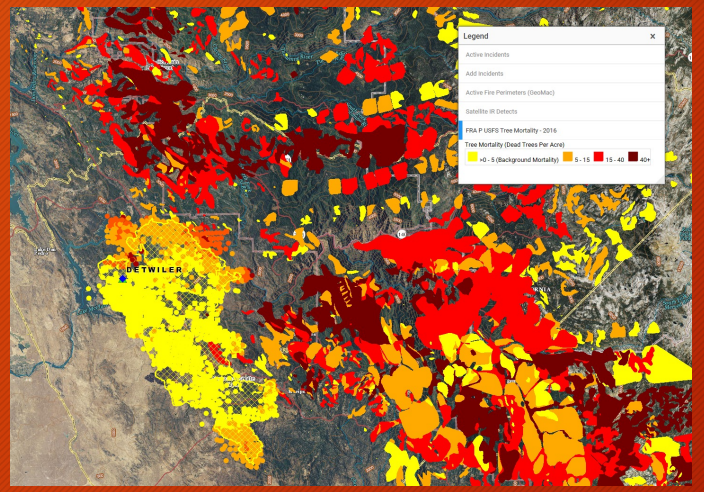




The Art of the Possible

My role: Effectively test, demonstrate, and share new technologies which support the operational information needs of the fire community.

KEY Focus Points for support to FIRE DETECTION / EARLY ATTACK / EXTENDED ATTACK

1. Fully understand the end user needs! (requirements matrix)
2. Work with the Wildland Fire Community to understand their information gaps and share with them the “Art of the Possible”.
3. Work with the tech community to develop capabilities.
4. Engage in education through direct “hand holding” as new capabilities are integrated into operational use.

Remote Sensing Capabilities (Current)

Agency Assets	National Systems
National Infrared Operations (NIROPS)	Firehawk Active Fire Mapping
Contract Aircraft (CWN / Exclusive Use)	Hawkeye Fire Detection & Reporting
	FireFly/FireGuard

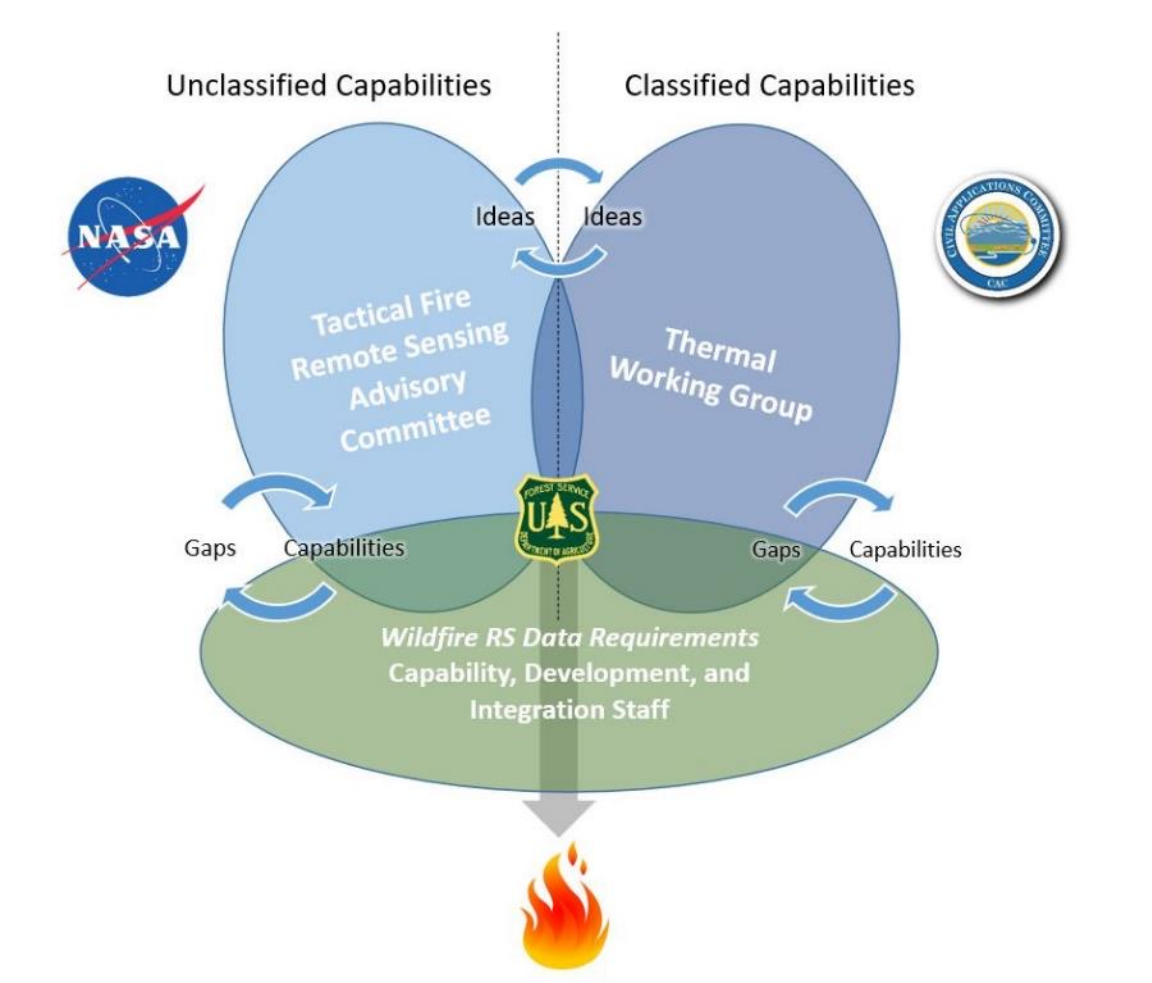
Partner Systems	Satellite Systems
Distributed Real Time Infrared (DRTI)	MODIS (Terra & Aqua) / VIIRS
Colorado\'s Multi-Mission Aircraft (MMA)	Landsat
Unmanned Aircraft Systems	Sentinel
Ground Cameras (HpWren, AlertWF)	

Aircraft & Satellites!

Remote Sensing Support to Wildland Fire

The TFRSAC is a Community of Practice and an information Sharing forum

This is where the discussion and evaluation happens.



The Thermal Working Group is a close knit working group which works to effectively leverage national systems

The TFRSAC and Thermal Working Group

- The **Tactical Fire Remote Sensing Advisory Committee** (TFRSAC) is a community of practice established in 2003. It has grown significantly over 2 decades and is a joint effort by NASA, USFS, NOAA and USGS to advance the use of earth observations in wildfire. The group meets twice each year to discuss ongoing developments, results of ongoing investigations, and provides an opportunity to daylight new and evolving capabilities that provide improved data delivery (timely, accurate, reliable, compatible).
  - Spring 2023 TFRSAC hosted this week!

- The **Thermal Working Group** is a coordinating body/forum for advancing and enabling the development and delivery of data, information or products derived from classified national systems to civil users. This includes enabling the integration of thermal detection, collection, processing, exploitation and dissemination for the purpose of identifying thermal events.
  - Meet frequently and as needed to support spiral improvement of capabilities
  - The group is currently working through an extensive list of on-going developments and needs

TFRSAC – Focus Areas

- Development and demonstration of improved and emerging airborne platform capabilities (manned, lighter than air, UAS).
- Demonstrate new sensor capabilities for enhanced fire discrimination.
- Demonstrate new data communication capabilities / automated processing for real-time data distribution from sensors (airborne sensor data to end-user communities on ground).
- Working with the fire management community – build a requirements matrix.
- **Foster the development of artificial intelligence & machine learning support for data processing, analysis and production of mapping products.**

Mission: Large Area Fire Detection*

End User: Local Dispatch, Unit Duty Officers, Geographic Area Coordination Centers (GACC)

Note: Aircraft equipped to fulfill this mission may also have applicability for other missions as described in this document. For example, an aircraft equipped with sensors capable of performing ISR may also be applicable for Large Area Detection.

During or following the passage of a lightning event, EO/IR equipped sensor platform performs scan over affected area.

The affected area is expected to be large scale, covering multiple national forests and partner jurisdictions. Area of coverage may be as large 400-500 miles, such as Northern California, Western Montana/Norther Idaho, the Colorado Front Range, etc.

In recent years FS has utilized DRTI and CO-MMA for these missions as a test of concept over a large area. FS NightWatch and FireWatch Air Attack platforms have been used for fire detection in California on a smaller scale. NIFC Lightning data is typically used to plan detection routes and area of interest. Also utilize IRWIN data to provide awareness of existing/known fires to avoid reporting duplication.

Sensor platform would be ordered or pre-positioned by GACC if a large lightning or wind event is forecasted.

Data on new fires is expected to be transmitted or uploaded to hosting website while aircraft is in flight for exploitation by the ordering unit. Dissemination would need to be worked out between the ordering unit and all the Agencies Having Jurisdiction (AHJ) within the flight path. Possible options for dissemination include:

- Data could be downloaded by GACC and distributed to AHJ within affected area
  –or-
- All AHJs within the affected area could be notified of the detection flight and given a link to where the data is stored for their own retrieval, exploitation, and dissemination.

FS has also been developing the HawkEye/IgPoint capability to detect new fires using space-borne sensors.

Desired Data

- GPS coordinates of new fires displayed as GIS ready points (or polygons if >10 acres) plotted on a map showing agency jurisdictional boundaries for ease in dissemination.
- Detection points will be attributed with fire size up information (i.e. size, characteristic, fuel type, adjacent fuel type, position on slope, proximity to VARs, if fire is already staffed, etc.)
- Short video or still frame grab of the new detection may be desired but is not required.

Desired Products

- Geo-rectified PDF map showing GPS location of all new fires with pre-selected base layers along with footprint of mission coverage area. The extent of the base map would be the responsibility of the ordering unit to define.
- KMZ or KML of the same data.
- Data table (MS Excel) of all new fires detected with GPS locations and size-up metadata.
- All GIS product will meet the G-STOP fire mapping standards https://gis.nwcg.gov/standards_agency.html

Deliverable Timeframes

- Notification of new fire detection with GPS coordinates as detected (instantaneous).
- Geo-rectified imagery in real time or near real time (+ 10 mins).
- Map products delivered within 30 minutes of completion of the data acquisition unless specified differently.

Fire Mapping Requirements Matrix

Basic Requirements

Manned Aircraft:

- Day or night capable. Night may require PIC and SIC flight crew.
- Turbine Engine and pressurized cabin is desired
- Meet applicable 14 CFRs (IFR, VFR, flight follow with ATC and avoidance of TFRs)
- Flight profile must avoid conflict with incident aircraft and/or TFR and Fire Traffic Area
- Capability to transmit data while in flight to a website or ground station
- Ability to communicate with ordering unit (voice, text, online chat, email, etc.)
- Capability to conduct a minimum of 4 hour mission that can cover a large area spanning 400-500 miles, or more (for example: sub-geographic area or multiple predictive service areas, etc.).

Satellite:

- Sufficient coverage to provide imagery at nadir or no greater than 30 degree side scan
- 2 hour or less latency from image acquisition
- Post-processing of imagery to include geo-rectification and terrain correction,
- Mix of National System, NASA, NOAA, HDDS, and commercial satellites that possess thermal sensors capable of deriving heat signatures
- Ability to differentiate false positives

Sensor and On-board Processor:

- Gimbaled mounted EO/IR camera system
- Multi-band IR capability MWIR (3 - 5 μm) and LWIR (8 - 14 μm) required, other bands such as SWIR, and NIR are desirable
- Wide and Narrow EO
- Inertial Measurement Unit stabilized sensor
- Geo rectified Nadir and geo tagged side scan
- Zoom capability to aid with discriminating heat detects from non-fire events.
- Data is capable of being retrieved and exploited in real time or near real time as per the Deliverable Timeframes
- Geo-tagged or geo-rectified target image
- Positional accuracy of detected new fire: meets ASPRS 1:100,000 map accuracy standards.
- Resolution: National Imagery Interpretability Rating Scale (NIIRS) Standard 6 or 7
- Sensitivity: Able to detect a 4" x 4" red hot coals (600 degrees C) from 10,000 ft. AGL at a distance of at least 5 miles
- Capable of providing GPS coordinates, GIS ready points/polygons/lines, and KMZ/KML.
- Capability to provide video or still imagery of new fire detections
- Real time EO video quality of 720p with recording capability
- Ability to see through smoke

Why the TFRSAC is Successful

- The TFRSAC is a community of practice (CoP) with a well-defined problem set. This problem set is a nationally recognized priority.
- The TFRSAC has champions – champions are people who are passionate about leading the effort and are willing to put in the work.
- Has strong participation from the end-user community, which is critical to identifying needs/gaps and informing solutions.
- The group has a large and growing, diverse group of participants (currently 520 people).

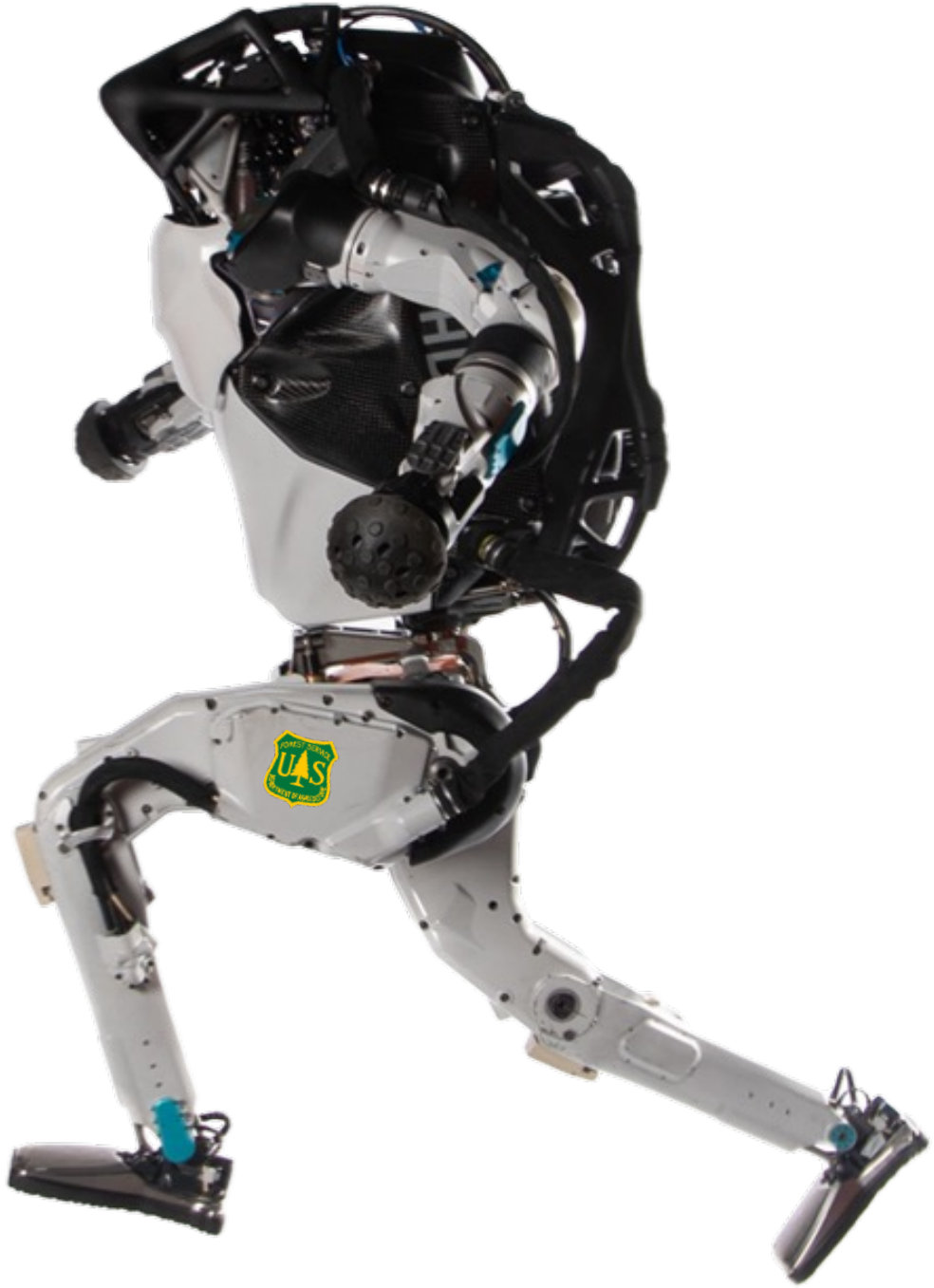
Looking Ahead – What do we need? What do we see?

- Need: real-time / near real time intel on dynamic fires
- Need: higher resolution / higher frequency revisits
- Need: Remote Sensing support to pre-fire risk reduction efforts
- Increasing use of Unmanned Aircraft on incidents – more sophisticated UAS
- Increasing reliance on on-orbit systems
  - Microsat Constellations for pre-fire risk, fire detection, active fire monitoring
  - Canadian Wildfire Satellite
  - Increasing use of Edge computing (pushing product, not raw data)
- **Increasing use of artificial intelligence / machine learning**
  - Fire Detection – Sensor Web
  - Active Fire Mapping
  - Predictive Fire Behavior – improving behavior models
    Coupled Atmosphere-Wildland Fire-Environment (CAWFE) model
- On the horizon: Use of Radar including synthetic aperture radar (SAR)
- On the horizon: Citizen science – more leveraging of citizen science

Artificial Intelligence Machine Learning

AI and ML **are critical** to more efficient use of remote sensing in the near and far term.

Things to consider: how do we integrate AI/ML into image analysis, map-making and map dissemination? Who builds and owns the models.

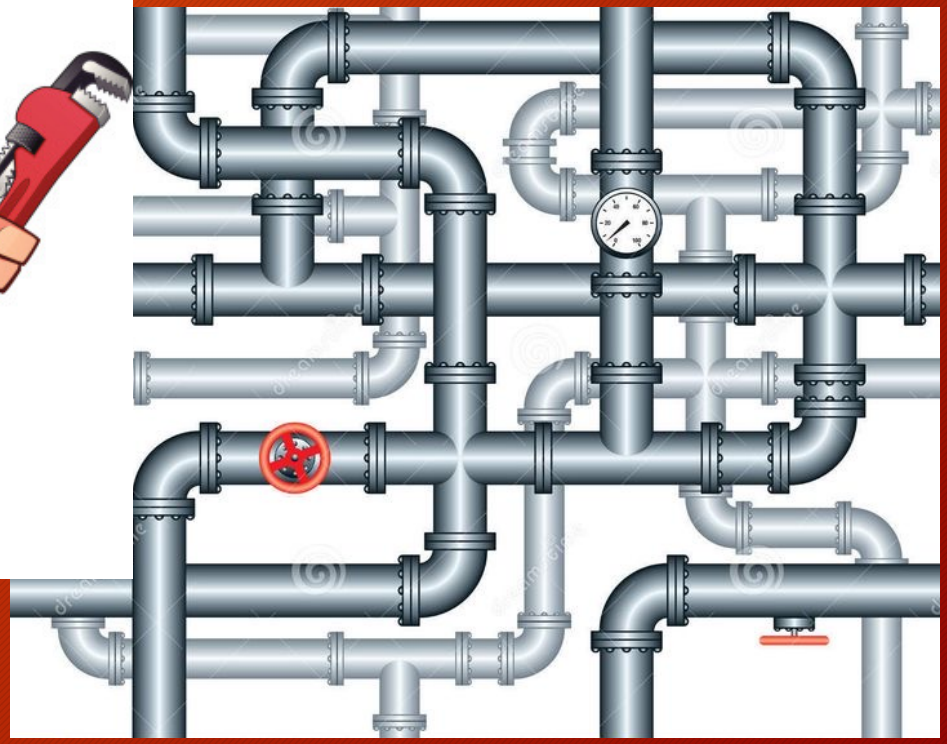


Data management is basically plumbing

In the use of remotely sensed data, we want our path from data acquisition to product delivery to be as short as possible.

Especially for disaster support when time is of the essence.

AI/ML can help us to keep the pipeline short while minimizing errors.



Why do we need AI/ML?
Data Volume, Timeliness, Cost Reduction

- Increasing number of sensors and satellite constellations
- Increasing footprint of daily and archived data volume
  - Era of "Big Earth Data" or "Big Data from Space"
- Future missions have larger data footprints
  - Surface Water and Ocean Topography (SWOT): 20TB daily
  - NASA-Indian Space Research Organization Synthetic Aperture Radar (NISAR): 80 TB daily

# of EO Satellites*	
1972	1
1982	8
1992	20
2002	39
2012	83
2013	102
2022	850 to 1,000

* Belward and Skøien, 2015; Union of Concerned Scientists, 2022

EO Data Collection Rates/Archive Volume		
	Daily Data Collection Rate	Archived Data
NASA	~12 TB (FY19)	~59 PB (FY21)
NOAA	~20 TB (FY18)	~37 to ~160 PB (FY21)
Copernicus (ESA)	~16 TB (FY21)	~30 PB (FY20)
Commercial	~100 TB (FY20)	> 100 PB (FY21)

Where will we use AI/ML?

1. Fire Detection – improved fire detection. Further minimizing errors of omission and commission.
2. Active Fire Mapping – Drawing points, lines and polygons on thermal imagery. Currently done by analysts. Costly and time intensive!
3. Predictive Fire Behavior – Improve our fire behavior models by careful forensic evaluation of prior fires. Requires high intensity data series!!
4. Sensor Web – comparing data from different sensors to reduce false alarms and deconflict data incongruities.

Risks & Challenges with the use of RS data

1. Not fully understanding data gaps and needs
2. Integrating new data streams or technology which are inappropriately used causing unanticipated problems (loss of life, etc).
3. Failing to integrate useful technologies due to bureaucratic or funding roadblocks.
4. Tradition – We keep doing what we're doing because this is how we've always done it.
5. Fear of new technology (see 2 above)

Questions

NASA Ikhana UAV in Marvel Comics 2009

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