

Unmanned Aircraft: A Pilot's Perspective



“It’s not unpiloted...”

**Mark Pestana
NASA Research Pilot
Dryden Flight Research Center, Edwards AFB, CA**

Note: The information in this presentation is the author’s and may not reflect official NASA policy

TOPICS

- **Pilot – Vehicle Interface Design**
- **Concept of Pilot / Operator**
- **Western States Fire Mission**
 - **NASA MQ-9 *Ikhana* UAS**

NASA Ikhana UAS

General Atomics, Aeronautical Systems Inc.

MQ-9 “Reaper” (Predator-B)

***Ikhana* = Native American Choctaw word for
“Intelligence”, “Learning”, “Awareness”.**



 **GENERAL ATOMICS**
AERONAUTICAL SYSTEMS

MQ-9 Ground Control Station (GCS)



Two Pilot Stations





So, what's it like to fly a UAS?

Well...What if you stepped into your cockpit...

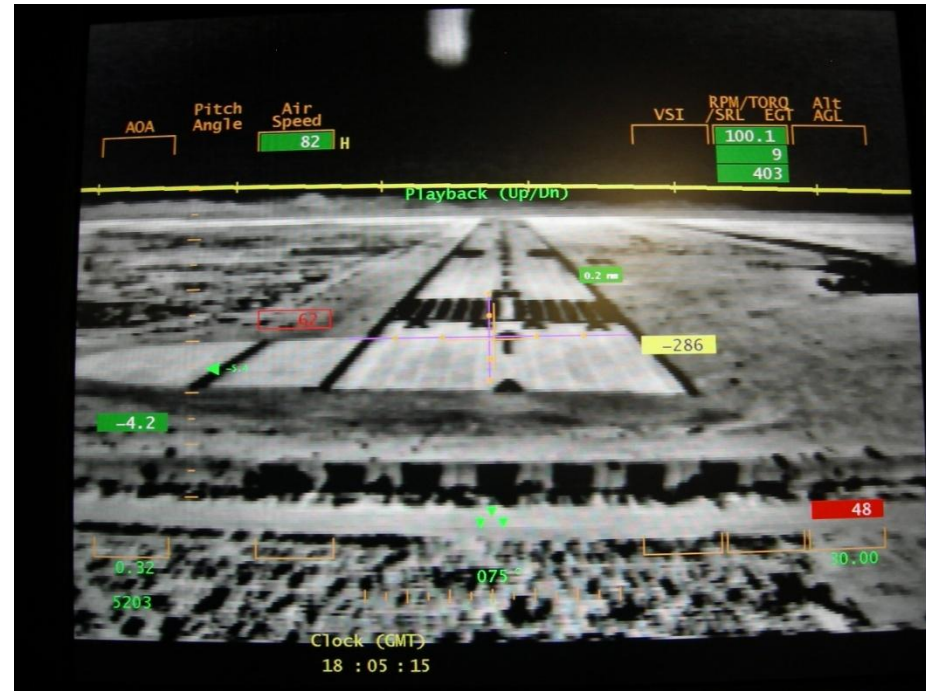
...and you lost 4 of your 5 senses?

You only have *vision!*



Only 1 sense?

- You can't hear the engine rpm fluctuating
- You can't feel vibrations, accelerations or motion
- You can't smell the fuel leak
- You can't taste the electrical fire smoke
- AND, you lose vision in one eye, 30° FOV!
- WELCOME to UAS flying!



Pilot-Vehicle Interfaces

Displays and controls

- Post WW II: analyses of many accidents pointed to poor human-machine interfaces.
- Concerted effort over several decades has established standards and best practices for cockpit design.
- Multi-function, high task environment demands that error paths be minimized/simplified.
- Humans are tactile, visual, and analog...NOT digital.
- For the most part, the UAV development community has not utilized standardization of proven interface design.
- Some UAV mishaps are attributed to this (root cause).

The nightmare of poor interface design



With decades of evolving cockpit design, today's aircraft exhibit common standard control and display formats and arrangements.

Example: The "T" arrangement
It works in many types, small and large.



Cessna 182



Boeing 737

Humans are analog, tactile, visual.

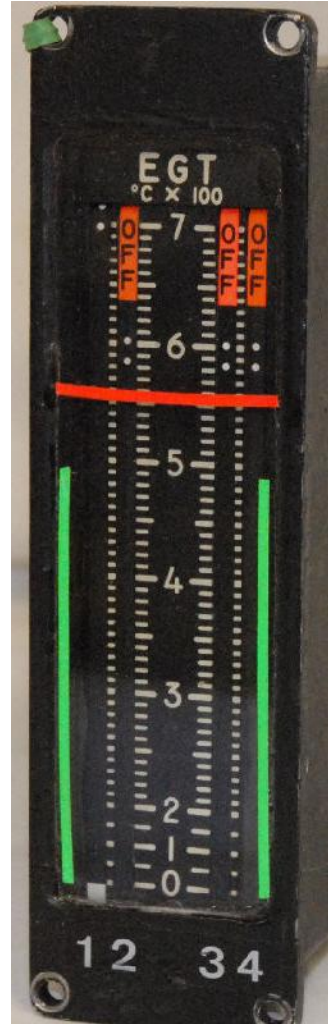
What about the displays and controls?



No need to memorize numbers if the normal range and limits are displayed (red lines, green arc).



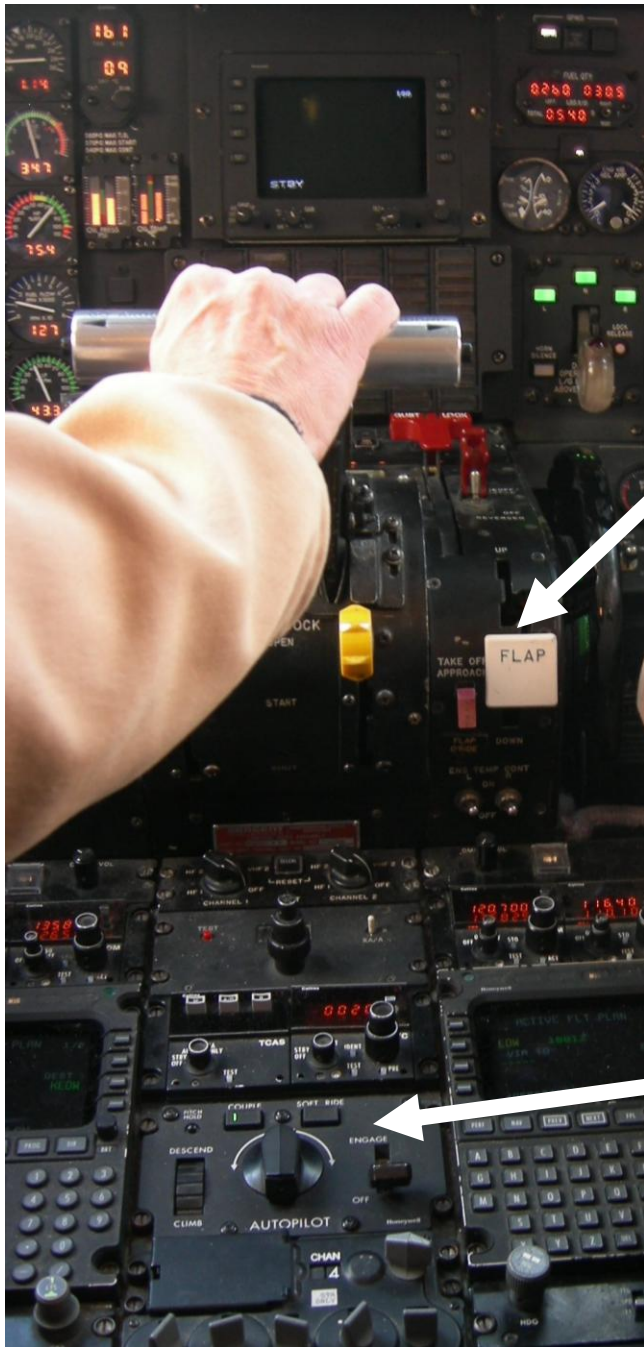
Digital display might not readily show trends and relationship to limits



Digital Information Can be displayed in Analog Format



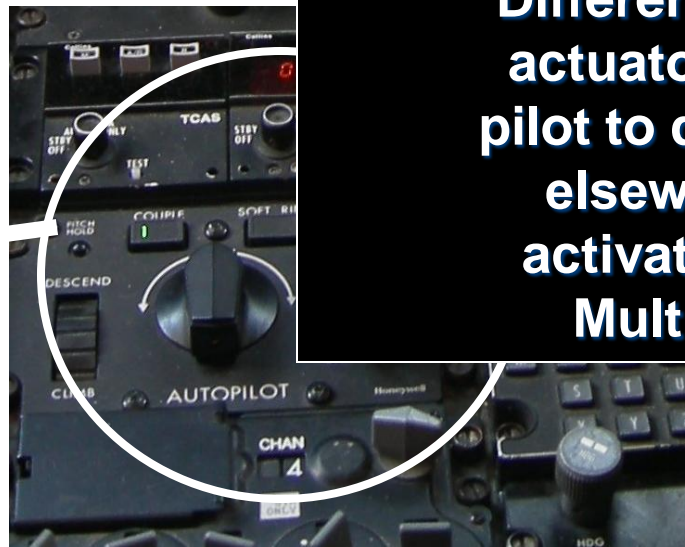
Unmanned Aircraft System
Digital /Tabular Display Format



**Use of the
Tactile sense**



**Different shapes of
actuators enable the
pilot to direct attention
elsewhere...while
activating systems.
Multi-tasking**



See and Avoid...

The FAA seeks an “equivalent level” as manned aircraft.
What are the specifications?
How do developers meet a requirement?

The challenges of “see and avoid”



Light
Contrast
Color
Texture
Distance
Motion
Shape
Reflectivity
Atmospheric
Filtering
Weather
Acuity

Peripheral vision is important, right?



How much window area is “enough”?

FAA Sim spec:

30° vert, 75° horiz

Helo

90° vert, 110° horiz

Critical to Effective SAA/CA

- UAS must be able to ***autonomously*** perform SAA, assuming loss of command & control link.
 - Data fusion is a probable feature of autonomous SAA, ***and*** for UAS pilot situational awareness.
 - Visual, IR, Radar, etc., blended with synthetic terrain data.
 - NextGen features: ADS-B, etc.
 - Superimposed supplementary data (TCAS*, WX, Instrument approaches, etc.)
- *Note: FAA does not currently allow TCAS on UAS.

Q: What's a "pilot"?

A: A NAS user?



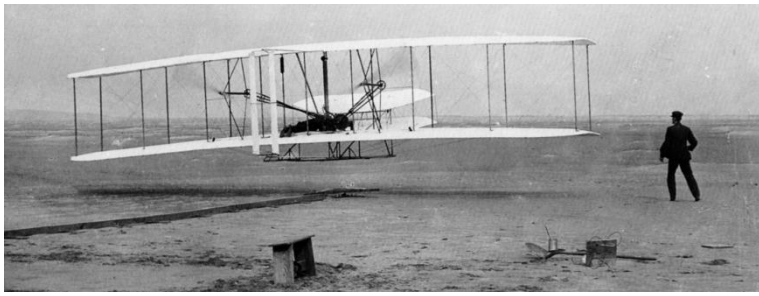


Samuel Clemens and his Pilot's Certificate

19th Century Pilot.

- Riverboat Captain
- Skills: River navigation, rudder control, soundings, shovel coal, supervisor...





20th Century Pilot

- Strapped to an airplane, direct interface to controls.
- Motor skills are primary metric of performance
- Increasing use of automation, systems management.





21st century pilot... "fly-by-wire"

- "Remotely" connected to the controls, systems management, monitor autonomous operations.

- In some cases, motor skills have little/no relevance.

**Global Hawk cockpit:
Autonomous operations.
Mouse and keyboard controls.**



What is a “pilot” ?

Knowledge, Ability, and Skill Sets

(relative relationships are not necessarily to scale)



Video Gamer

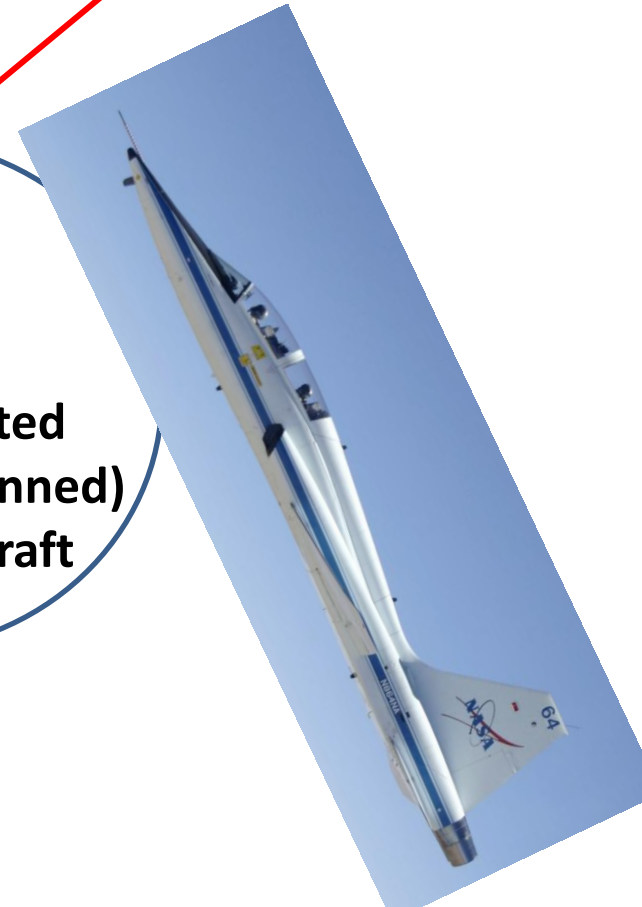


Radio Controlled
Visual Line-of-sight

Remotely
Piloted
Unmanned
Aircraft
System

Piloted
(manned)
Aircraft

What do these people have in common?



What is a “pilot” ?

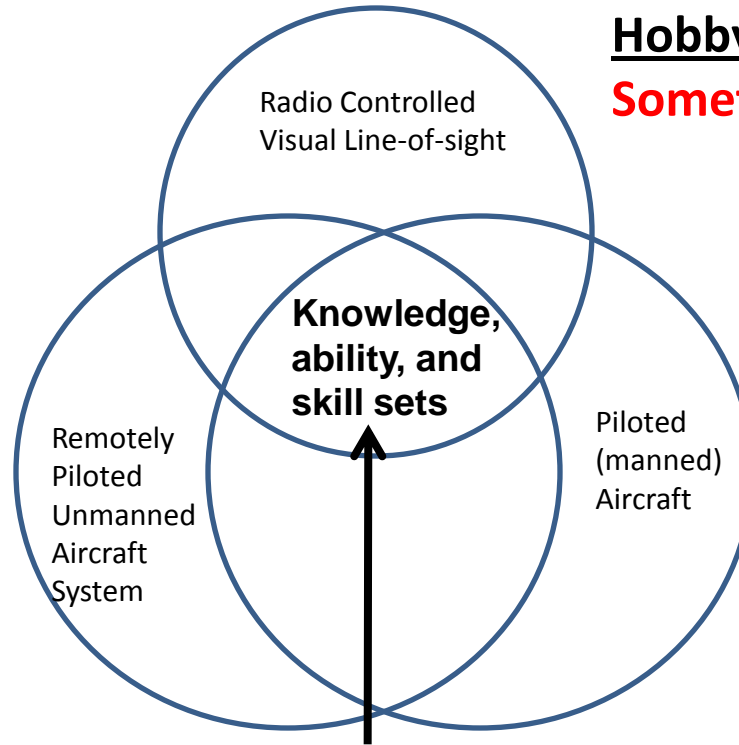
Knowledge, Ability, and Skill Sets

(relative relationships are not necessarily to scale)

Video Gamer
Reset Button

Model airplane
Hobbyist

Sometimes...left is right, and vice versa



UAV Pilot
Skill sets depend on control method

Jet Jock
Self-preservation instincts.

Airmanship / Air Sense / Knowledge: Navigation; Communication protocols; FAA Airspace Rules, Requirements, and Regulations; Terminal area procedures, Weather forecasting and alternate airfield assessment, Mission planning, Emergency procedures, aircraft systems, principles of flight, etc.

Considerations

- Classification of UAS Types = Operating Scenarios:
 - Radio Controlled Visual Line-of-sight
 - Remotely Piloted (motor skills)
 - Autonomous (**still requires “airmanship skills”**)
- Definition of “Pilot”
 - Training and qualification requirements derived from operating scenario
- Standardization of human-machine interfaces
 - Include the Air Traffic Controller



Western States Fire Mission





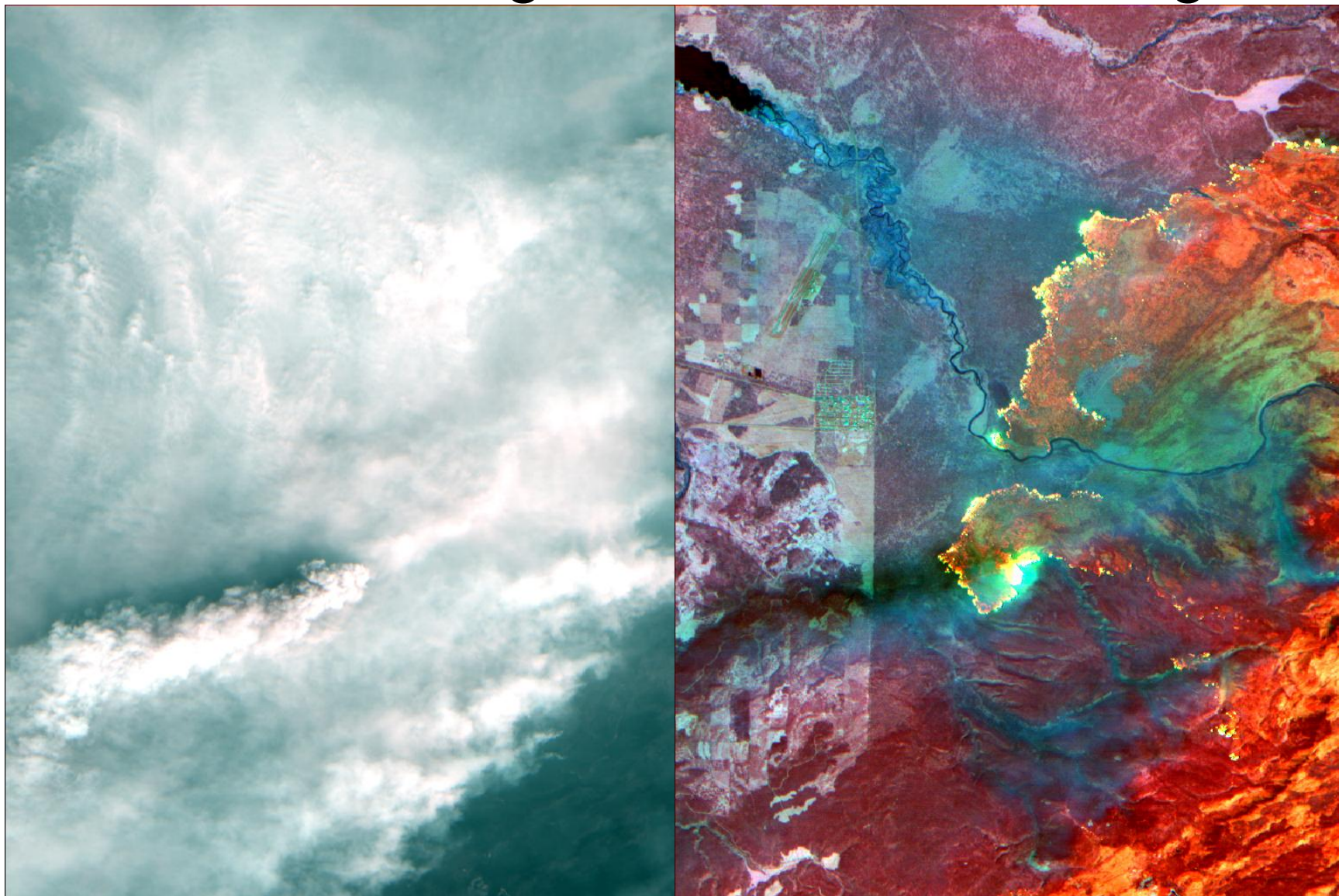
Where do you put
Limited Resources?

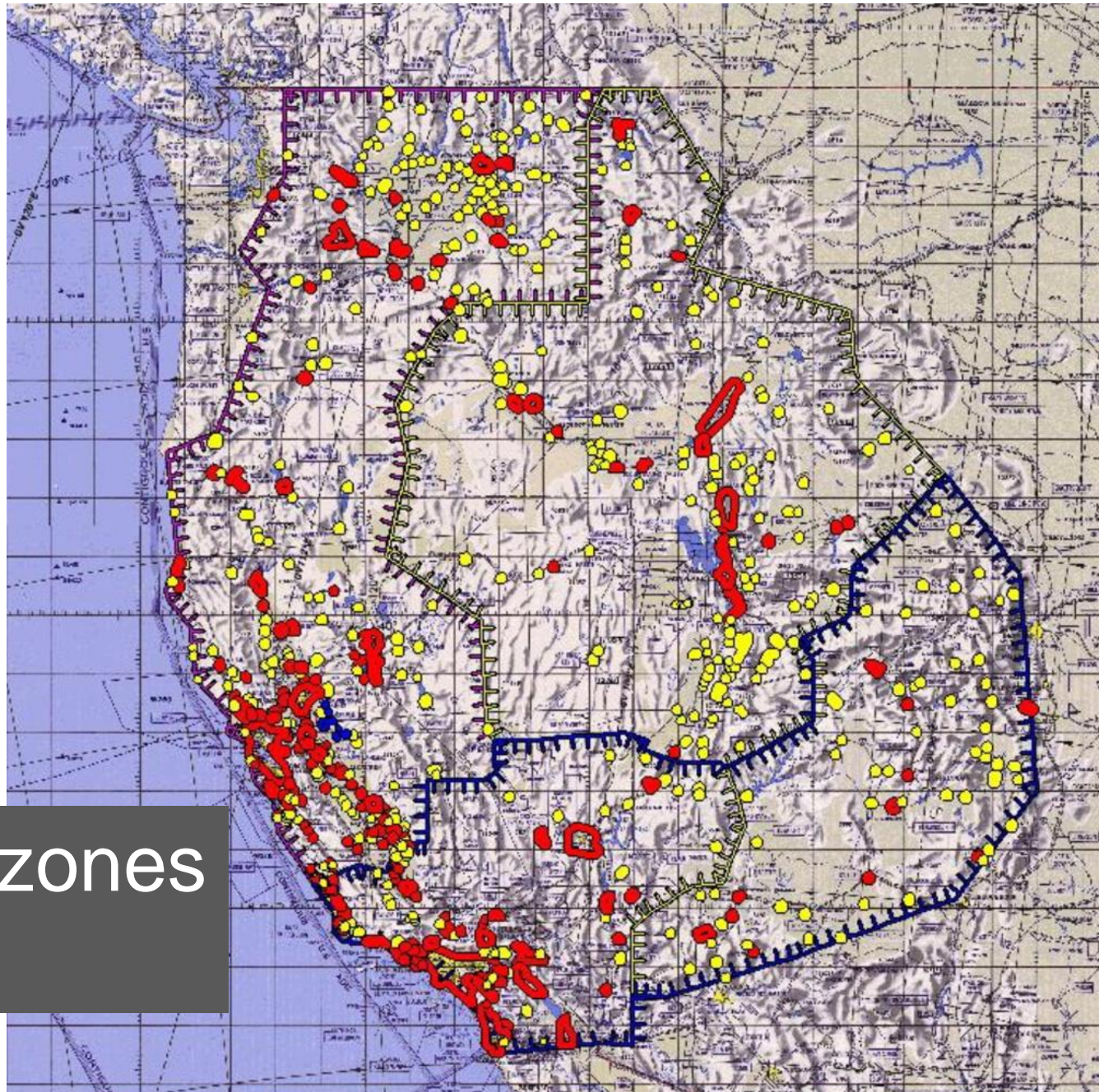


...and keep them
Safe!



Visible Light...vs...Infrared Image



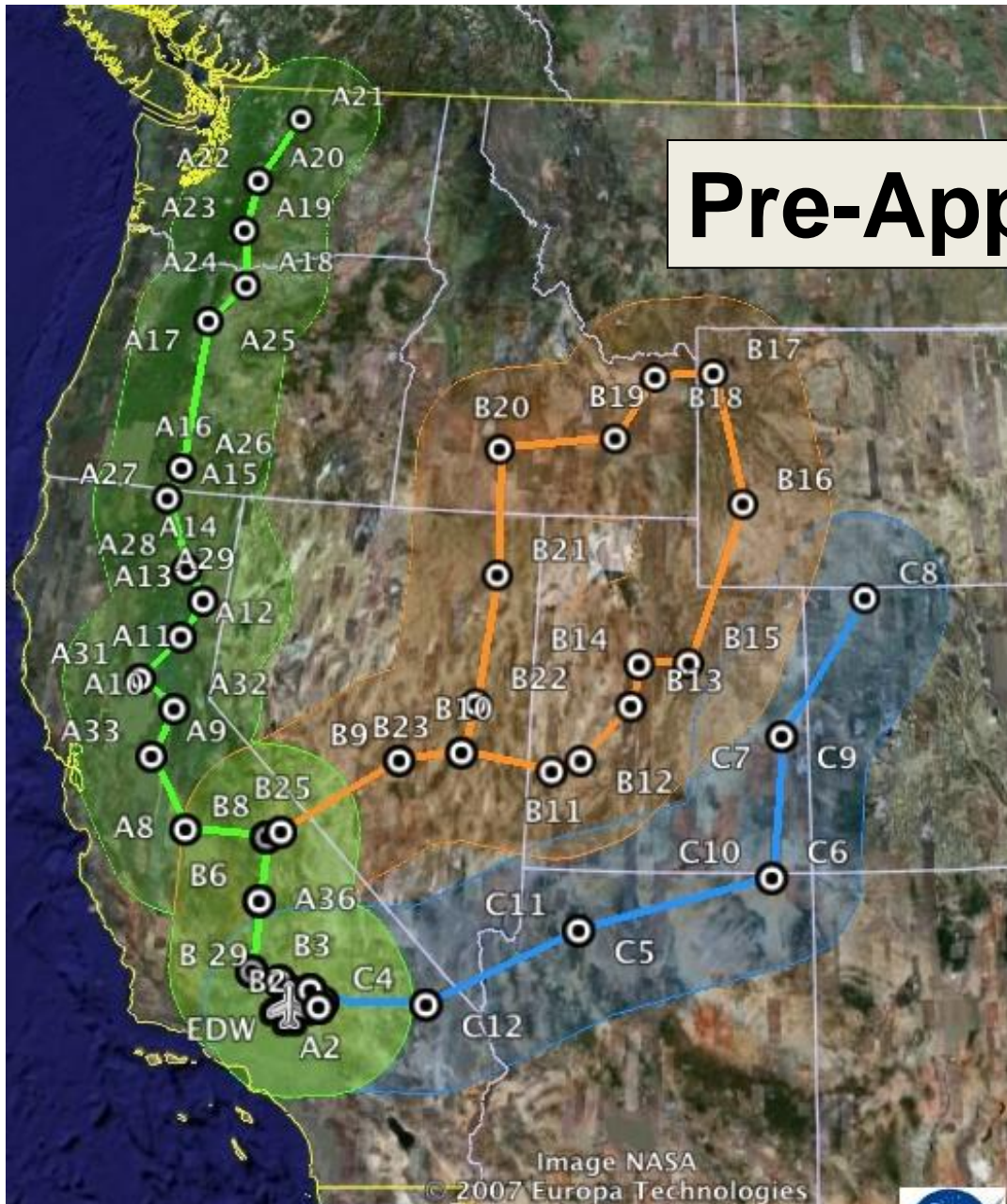


Keep-out zones

Challenges and Requirements

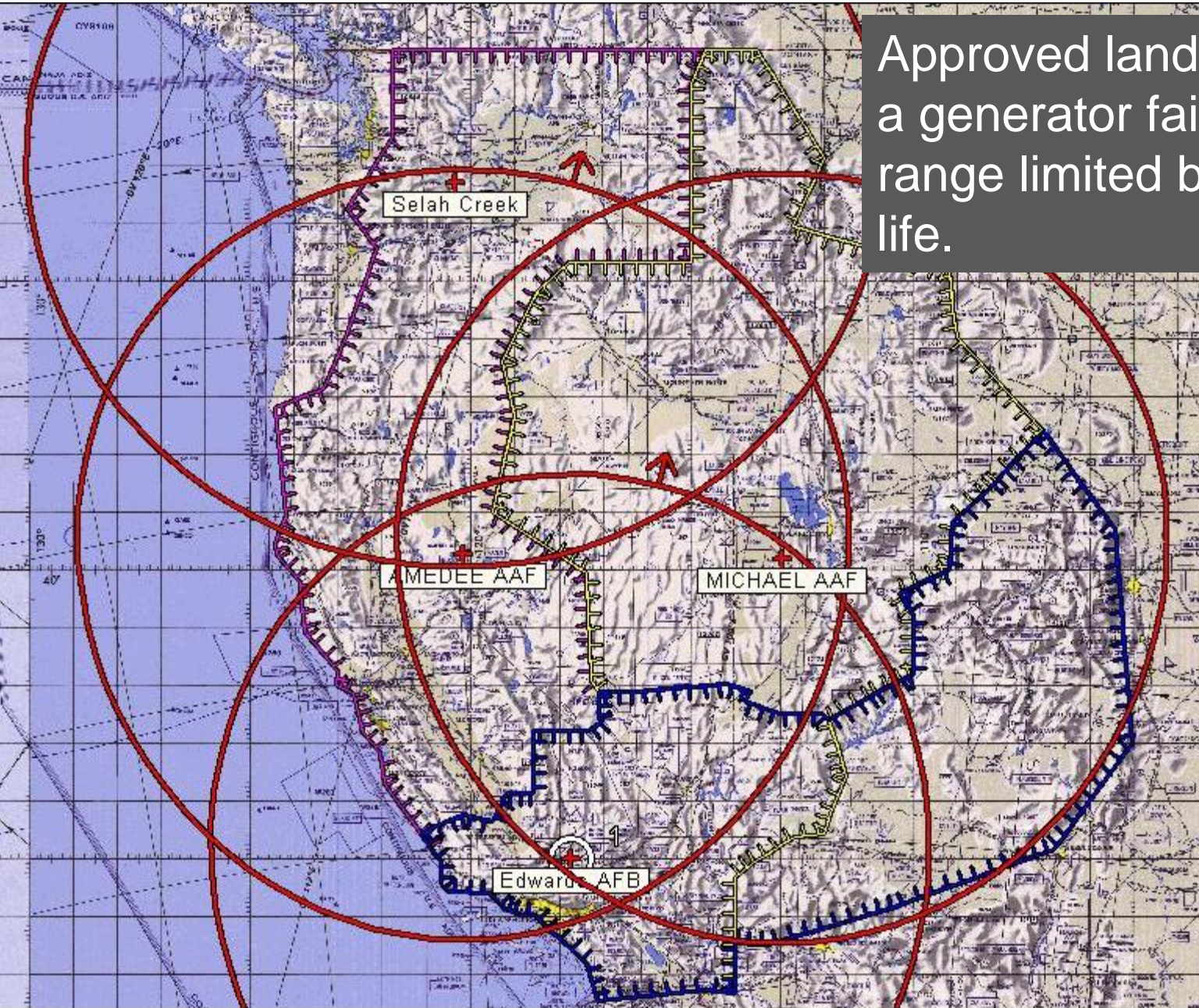
- Integration of the systems: airplane-sensor-data delivery
- End-to-end testing
- Satisfy customer requirements: timely geo-location of fire lines and hot spots
- Satisfy FAA provisions and restrictions...the COA
 - Only 3 routes, with deviations <75 nm
 - File flight plan 3 days in advance of flight
 - No emergency landings at public airports
 - One altitude (FL 230), no climbs/descents
 - “see and avoid” capabilities?
 - No flight in to forecasted “moderate or severe” turbulence
 - No flight in area where convective SIGMET has been issued
 - No flight in area of know or forecast icing
 - Lost link procedure: continue on route for 15nm, right turn, return home.
 - No flight in area affected by GPS testing

Pre-Approved Routes



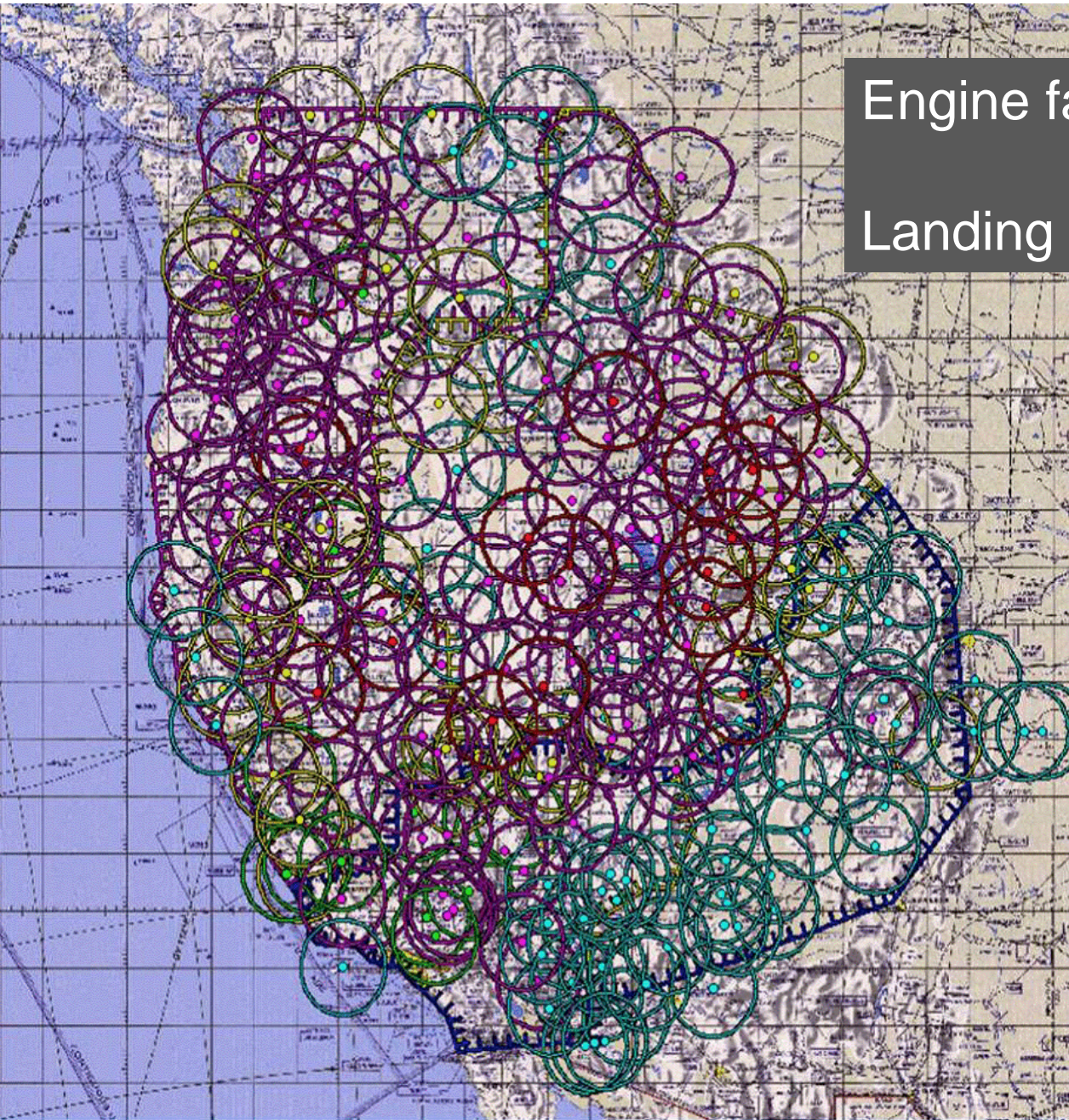
Actual flight route negotiated in real-time to acquire data over fires.

Approved landing sites for a generator failure and range limited by battery life.

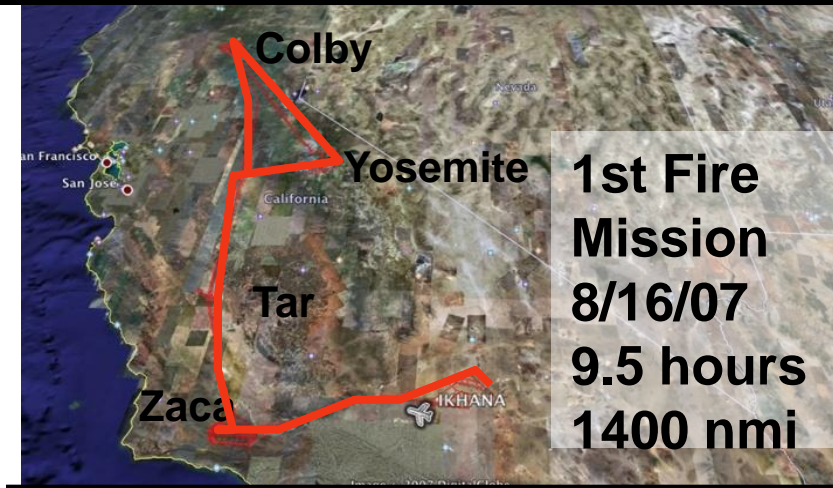


Engine failure glide range

Landing sites



Four Tech Demonstration Missions

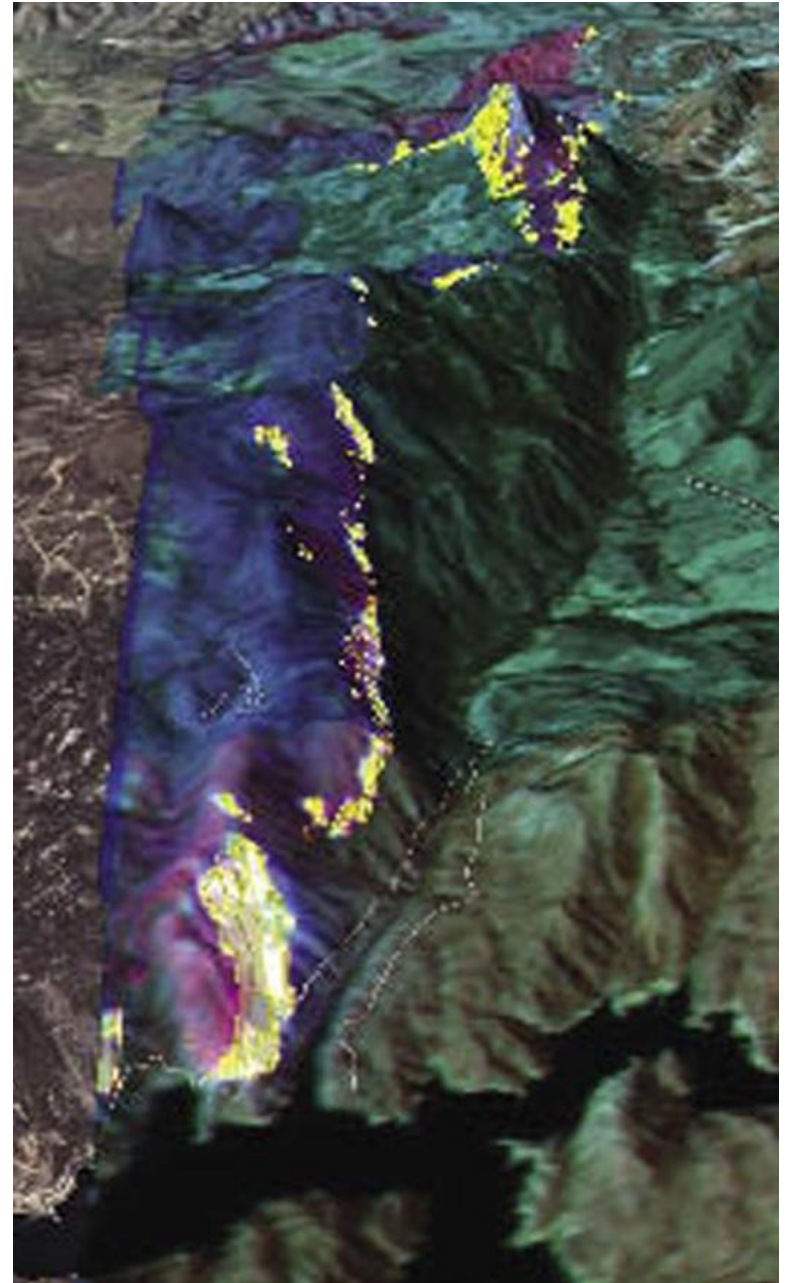




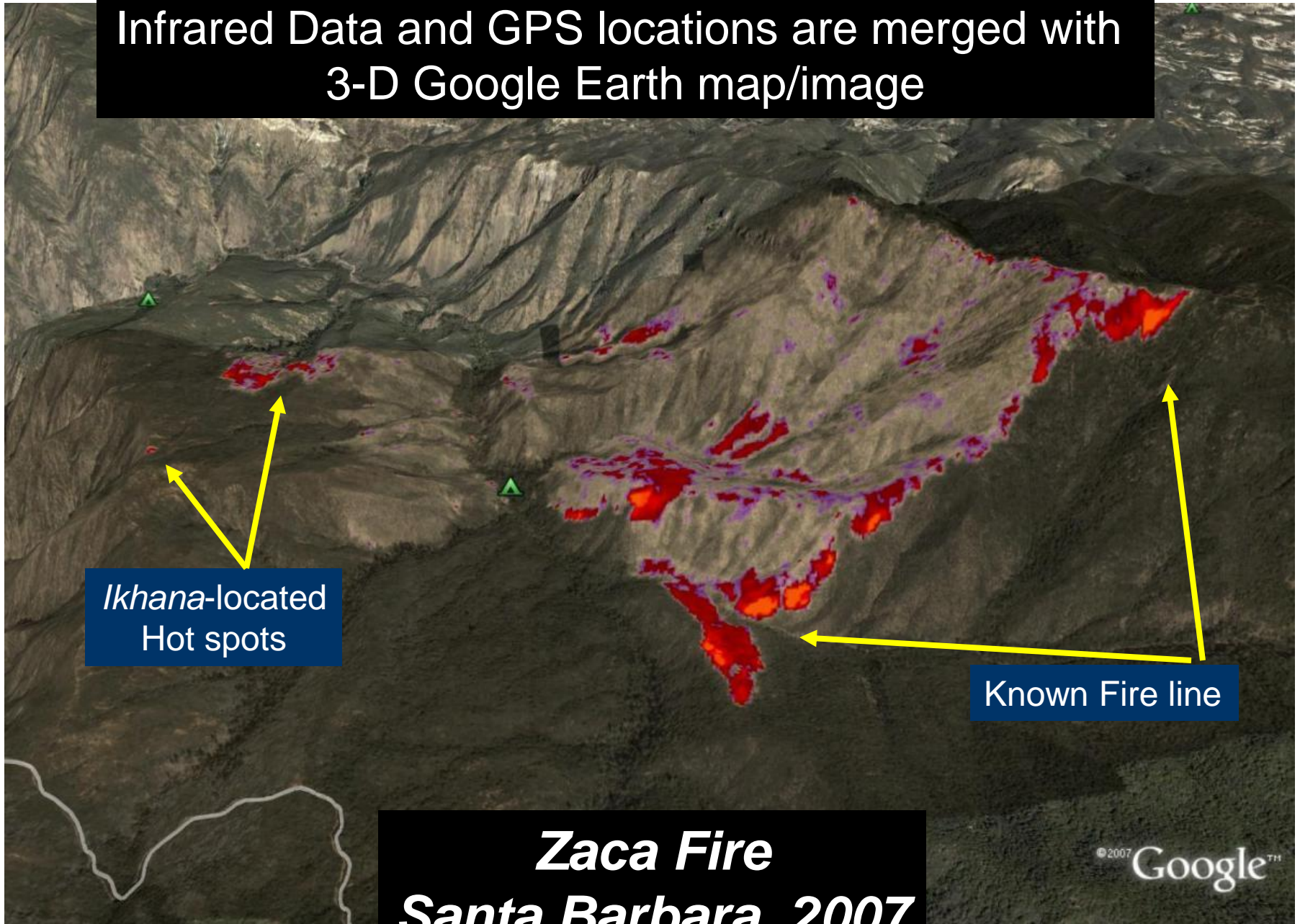
The end product:

Infrared data “draped” on Google Earth 3-D terrain maps.

Delivered to the Fire Incident Commander in less that 10 minutes.



Infrared Data and GPS locations are merged with
3-D Google Earth map/image



Ikhana-located
Hot spots

Known Fire line

Zaca Fire
Santa Barbara, 2007

Successful Results

Quotes from the Fire Incident Commanders:

- “10,000 residences saved today, thanks to NASA...”
- “...fire-fighting resources effectively applied...”
- “I’ve seen the future, and it’s here.”

Considerations

- **Cockpit design: Learn from history**
- **Define “Pilot”. MORE than a systems operator.**
- **Optimize Situational Awareness**
- **Include the Air Traffic Controller in system interface design...it’s a total system.**
- **Minimize pathways to errors...and mishaps**
- **Reduce Risk...Increase Safety**