Unmanned Aircraft: A Pilot's Perspective

"It's not unpiloted…"

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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".**

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…

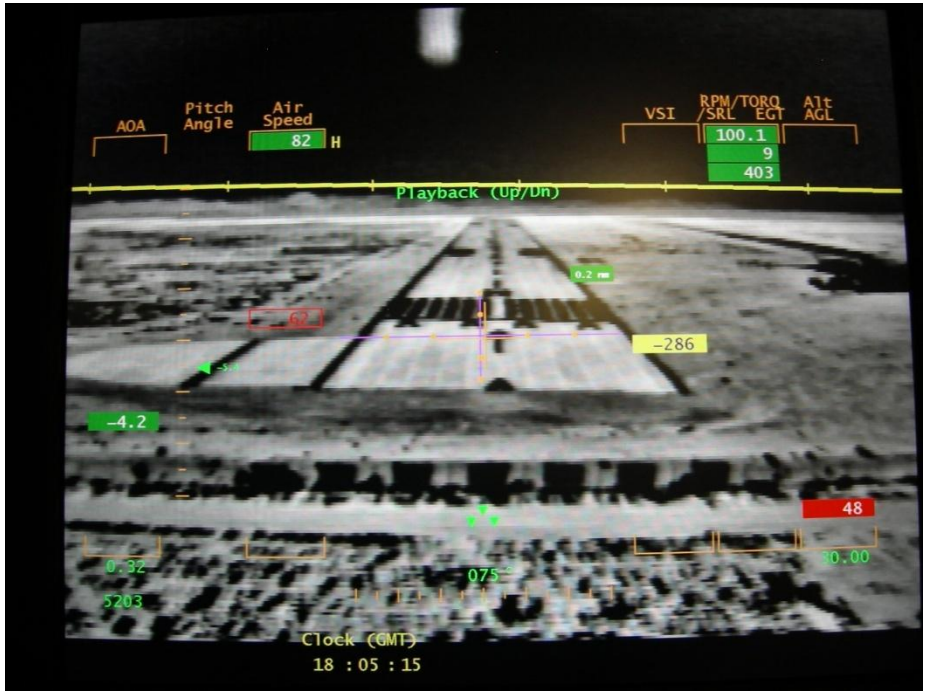
…and you lost 4 of your 5 senses?

You **only** have *vision!*

Only 1 sense?

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


AOA
Pitch Angle
Air Speed
101
81
H
VSI
RPM/TORQ /SRL EGT
89.3
27
586
Alt MSL
+1.6
-46
24978
74.54
329°
126.525


AOA
Pitch Angle
Air Speed
82
H
VSI
RPM/TORQ /SRL EGT
100.1
9
403
Alt AGL
Playback (Up/Dn)
-286
-4.2
48
0.32
5203
075°
Clock (GMT)
18 : 05 : 15

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

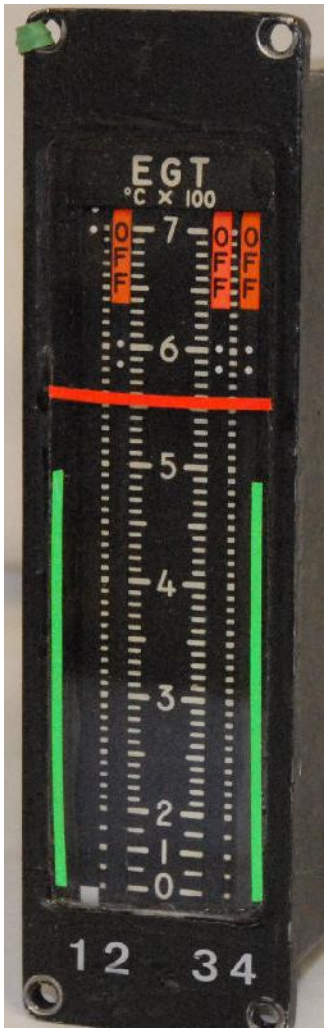
Boeing 737

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).

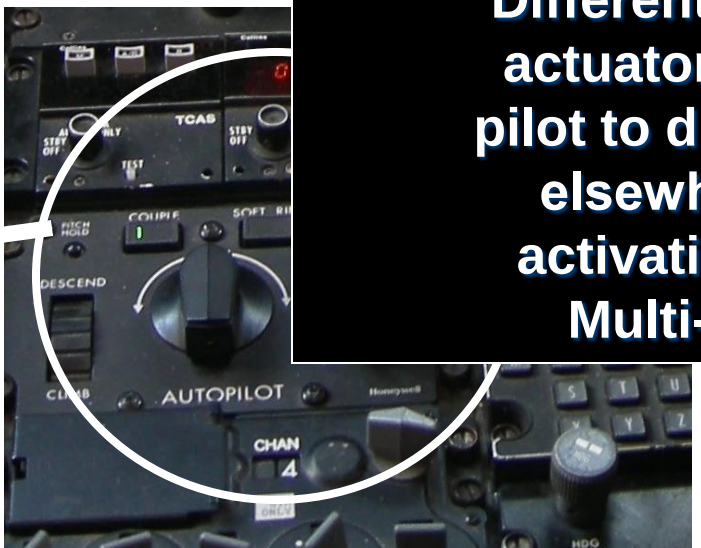
Digital display might not readily show trends and relationship to limits



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

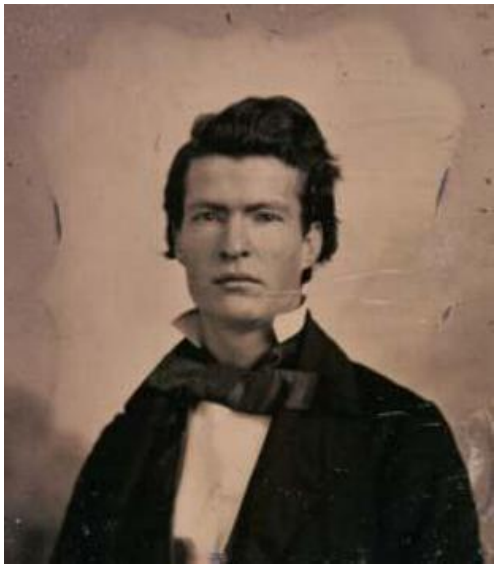
Helo
90 ° vert, 110 ° horiz

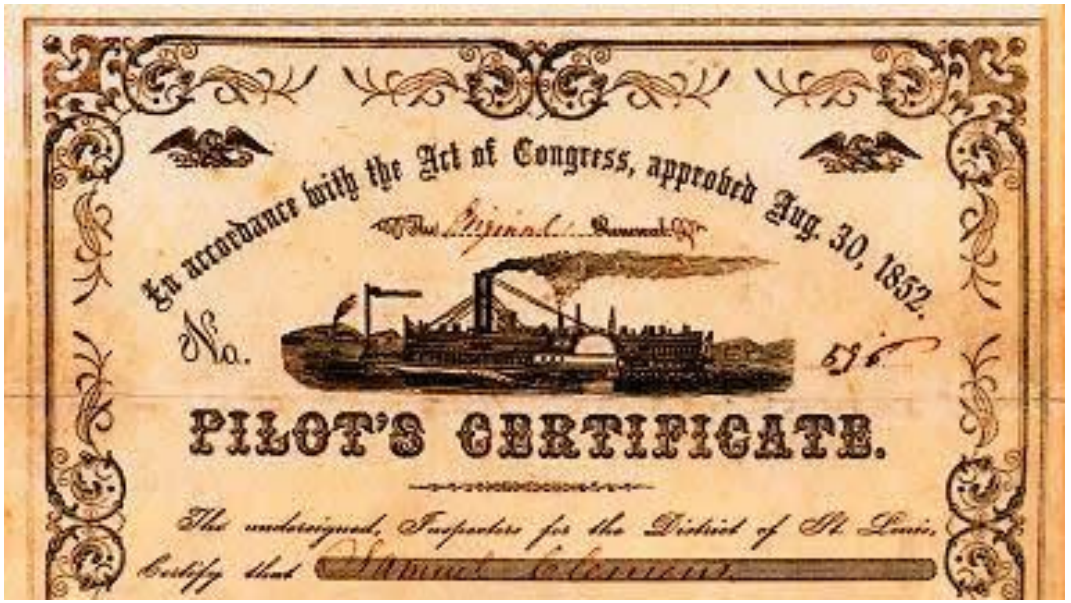
Critical to Effective SAA/CA

- 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.)

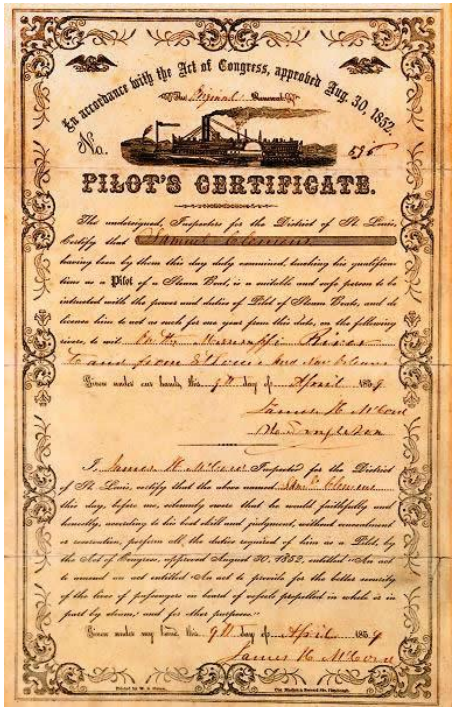
*Note: FAA does not currently allow TCAS on UAS.

Q: What's a "pilot"?
A: A NAS user?



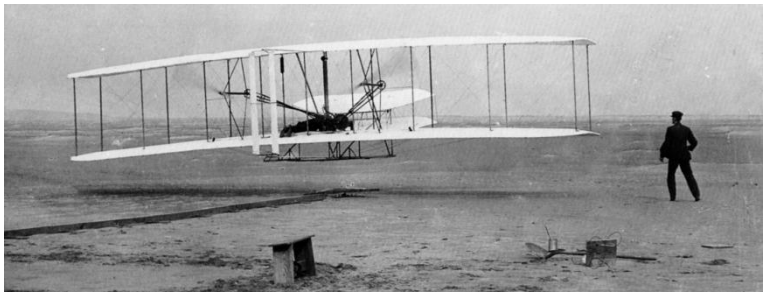


Samuel Clemens and his Pilot's Certificate



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.

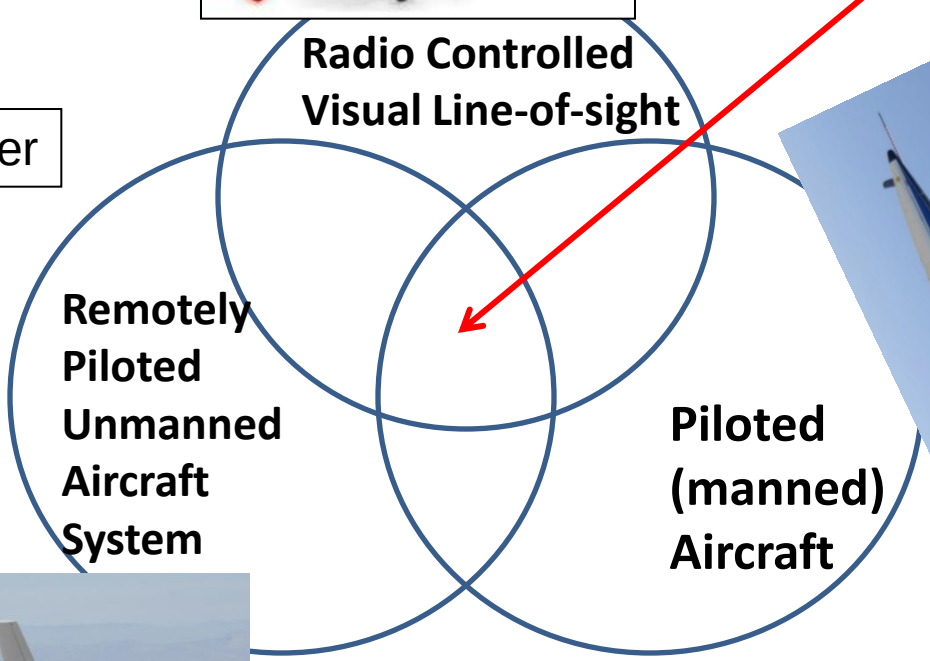
Global Hawk cockpit:
Autonomous operations.
Mouse and keyboard controls.

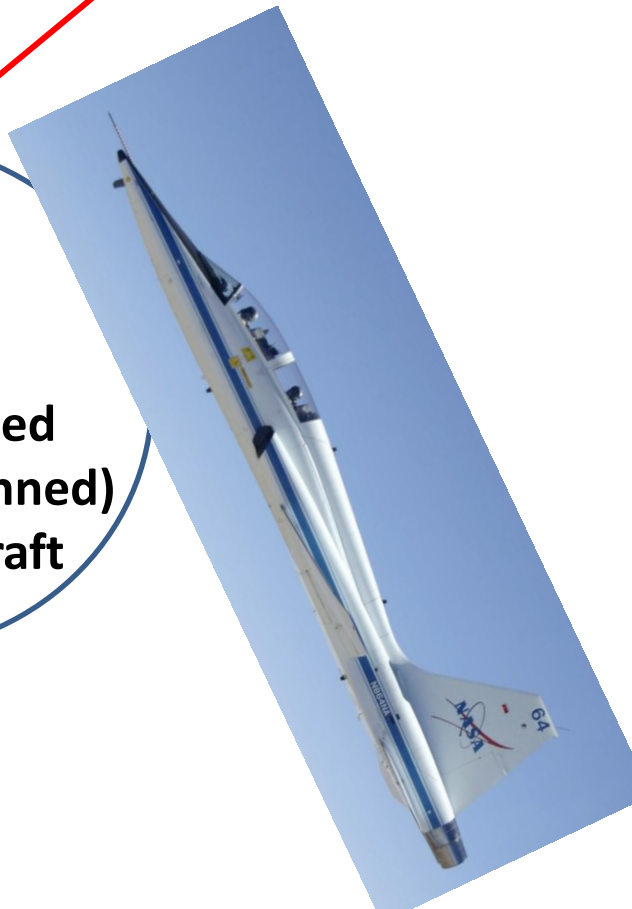
What is a “pilot” ?
Knowledge, Ability, and Skill Sets

(relative relationships are not necessarily to scale)

Video Gamer

What do these people have in common?





What is a “pilot” ?
Knowledge, Ability, and Skill Sets

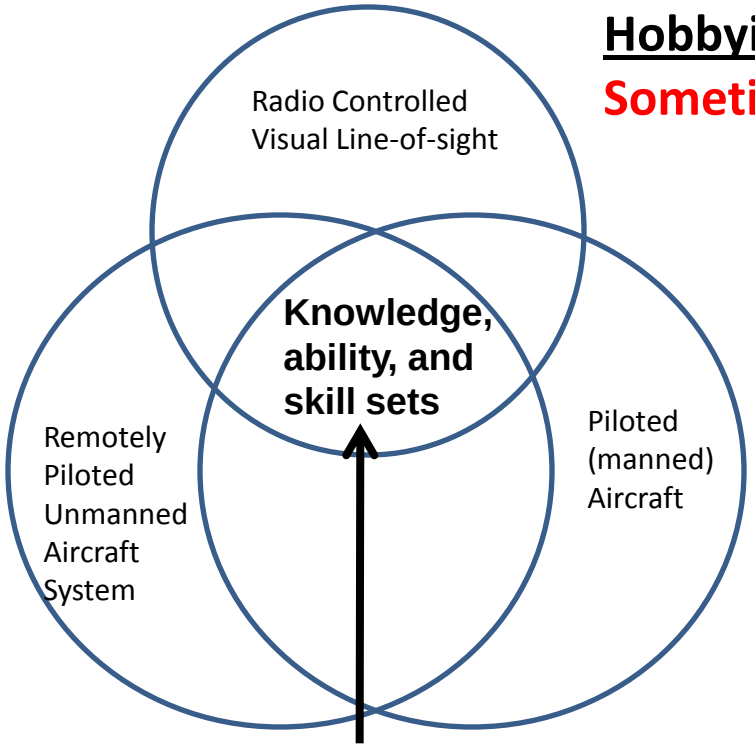
(relative relationships are not necessarily to scale)

Video Gamer

Reset Button

Model airplane Hobbyist

Sometimes…left is right, and vice v



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

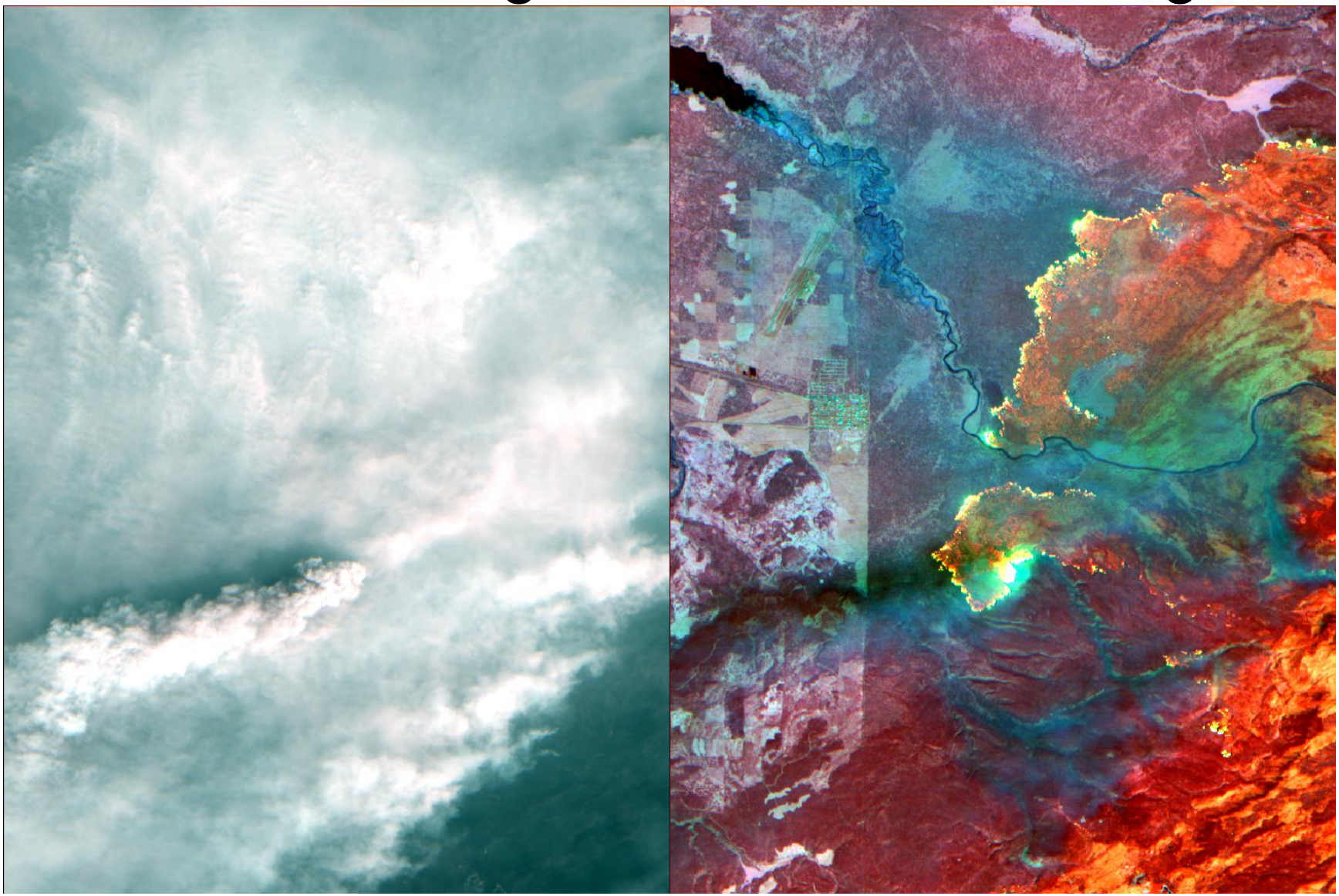
Western States Fire Mission

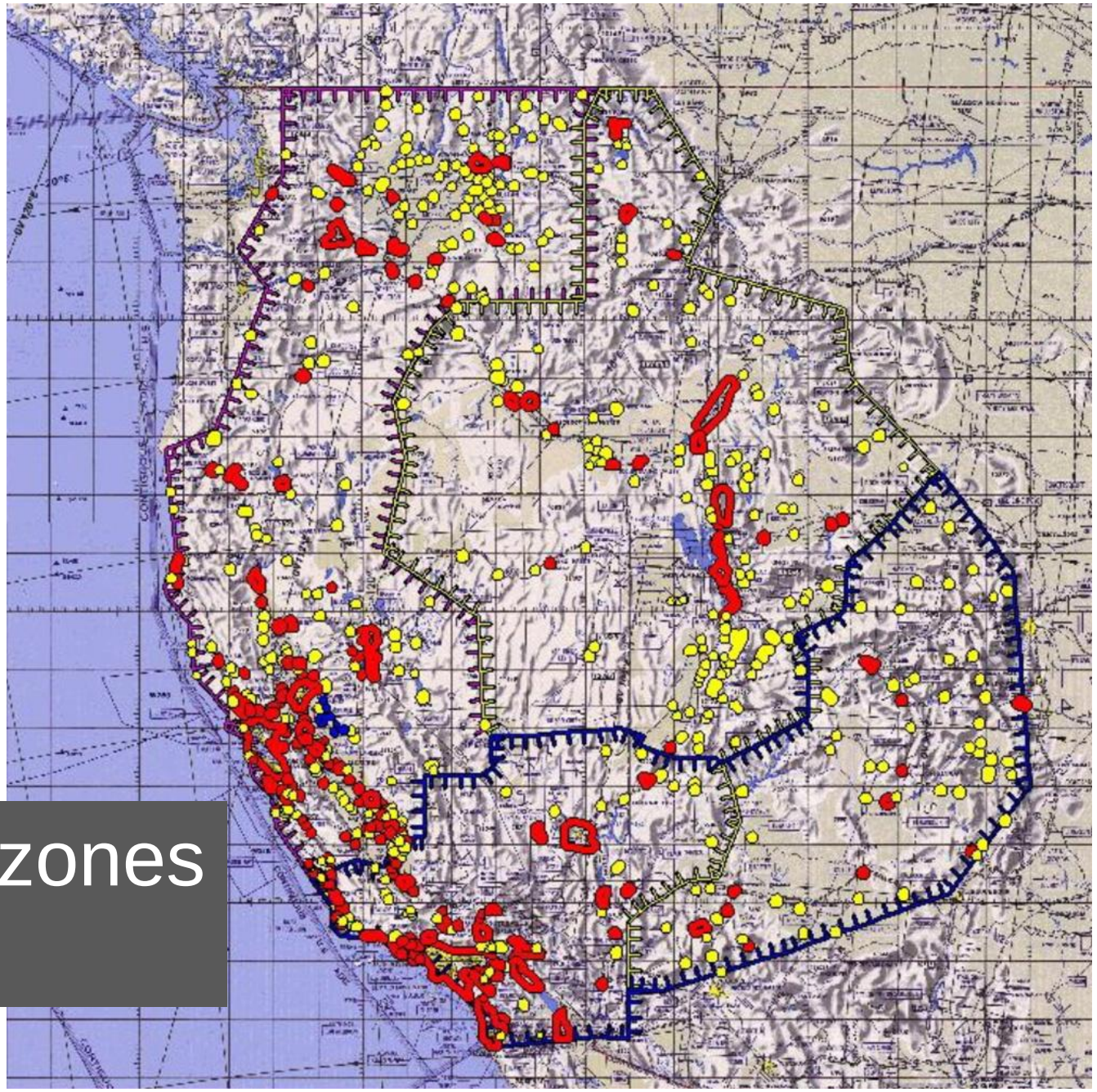
GENERAL ATOMICS
AERONAUTICAL SYSTEMS

Where do you put Limited Resources?

…and keep them Safe!

Visible Light….vs…Infrared Image

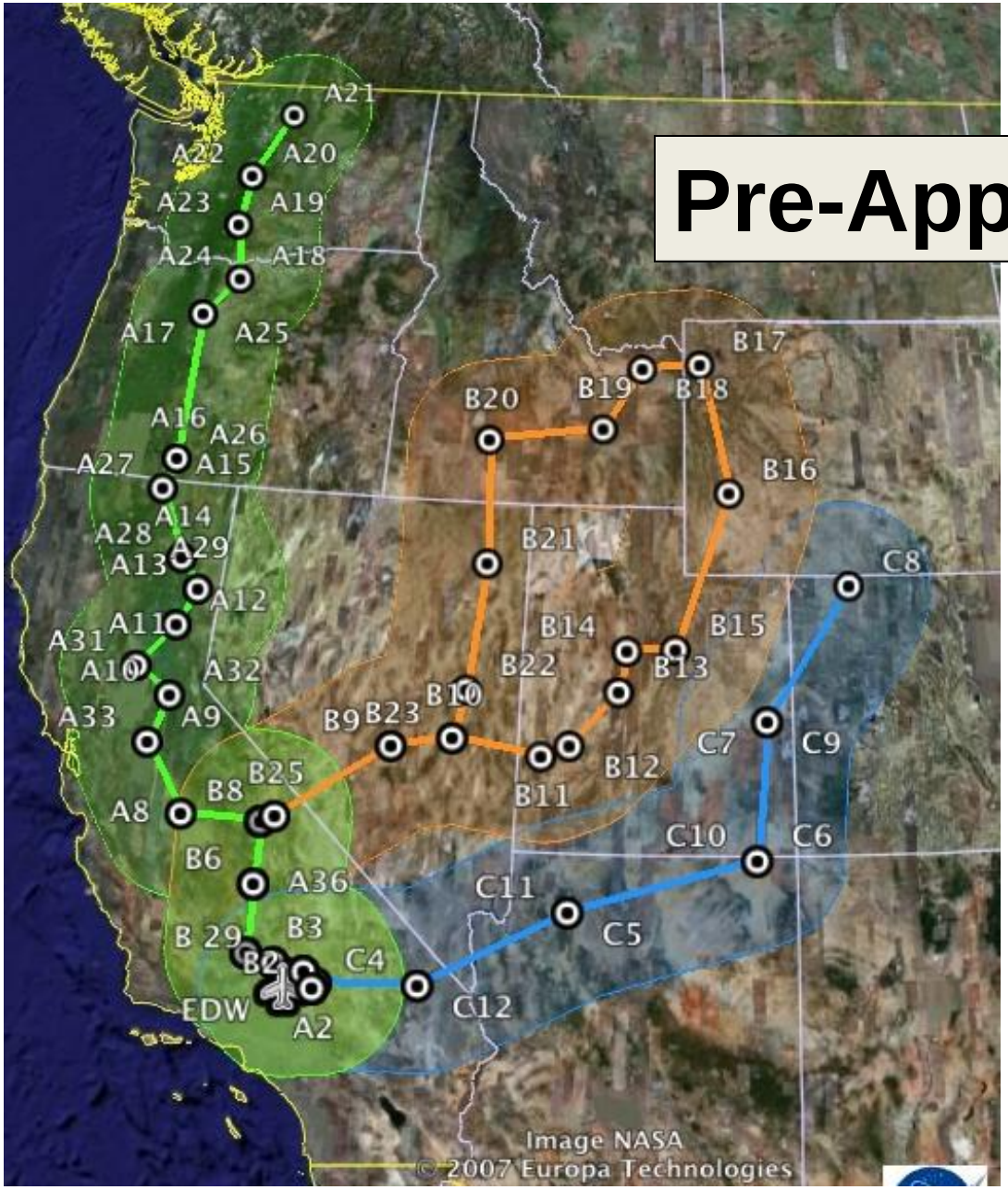




Keep-out zones

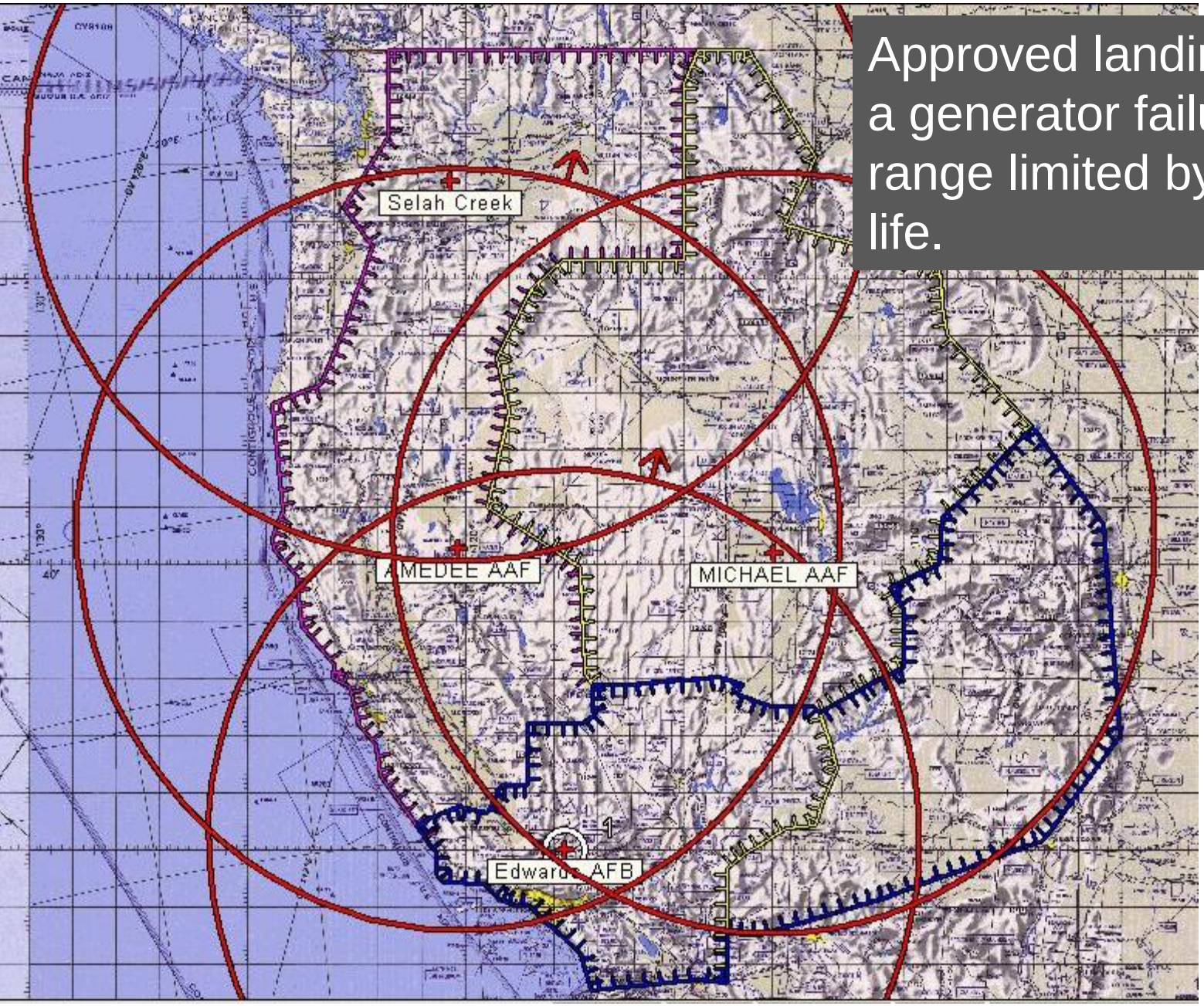
Challenges and Requirements

- 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

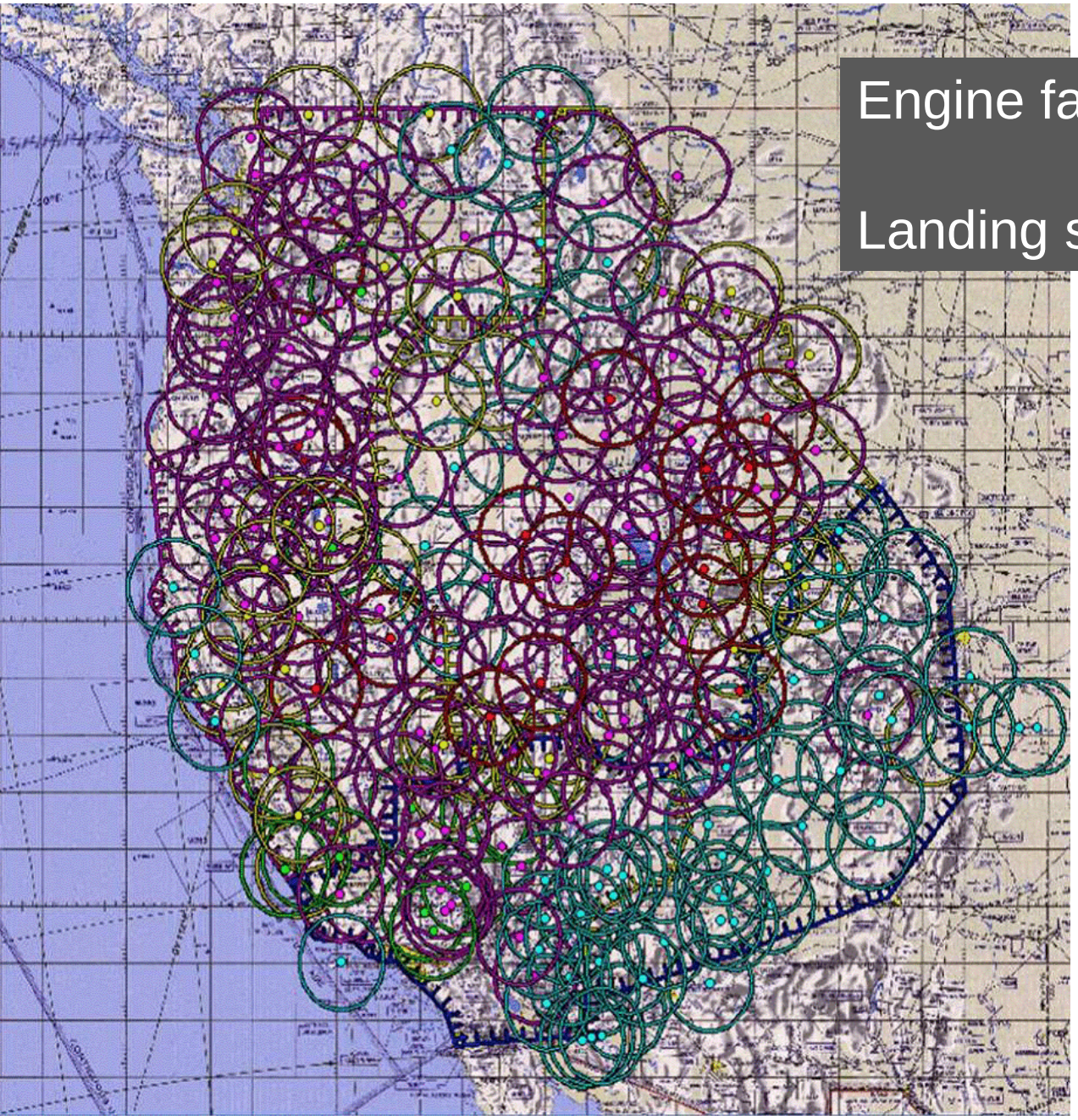


Pre-Approved Routes

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



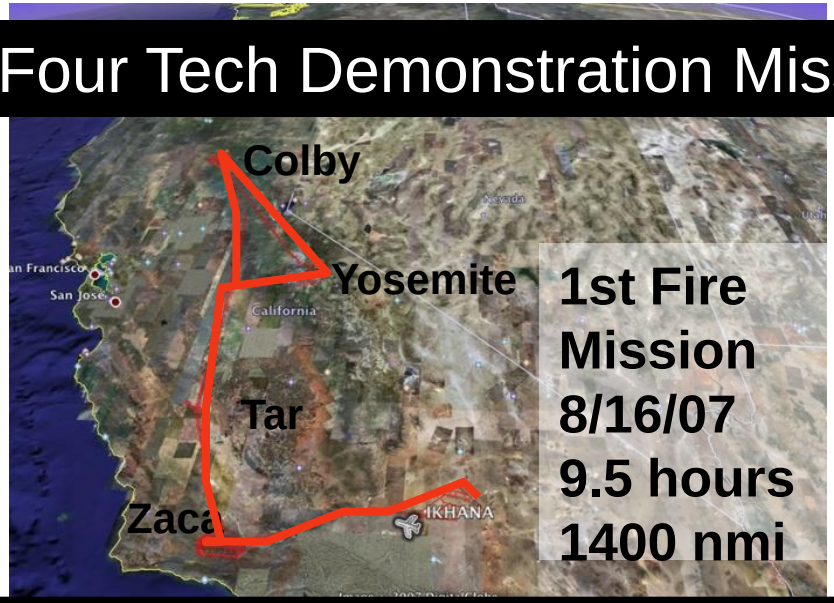
Approved landing sites for a generator failure and range limited by battery life.



Engine failure glide range

Landing sites

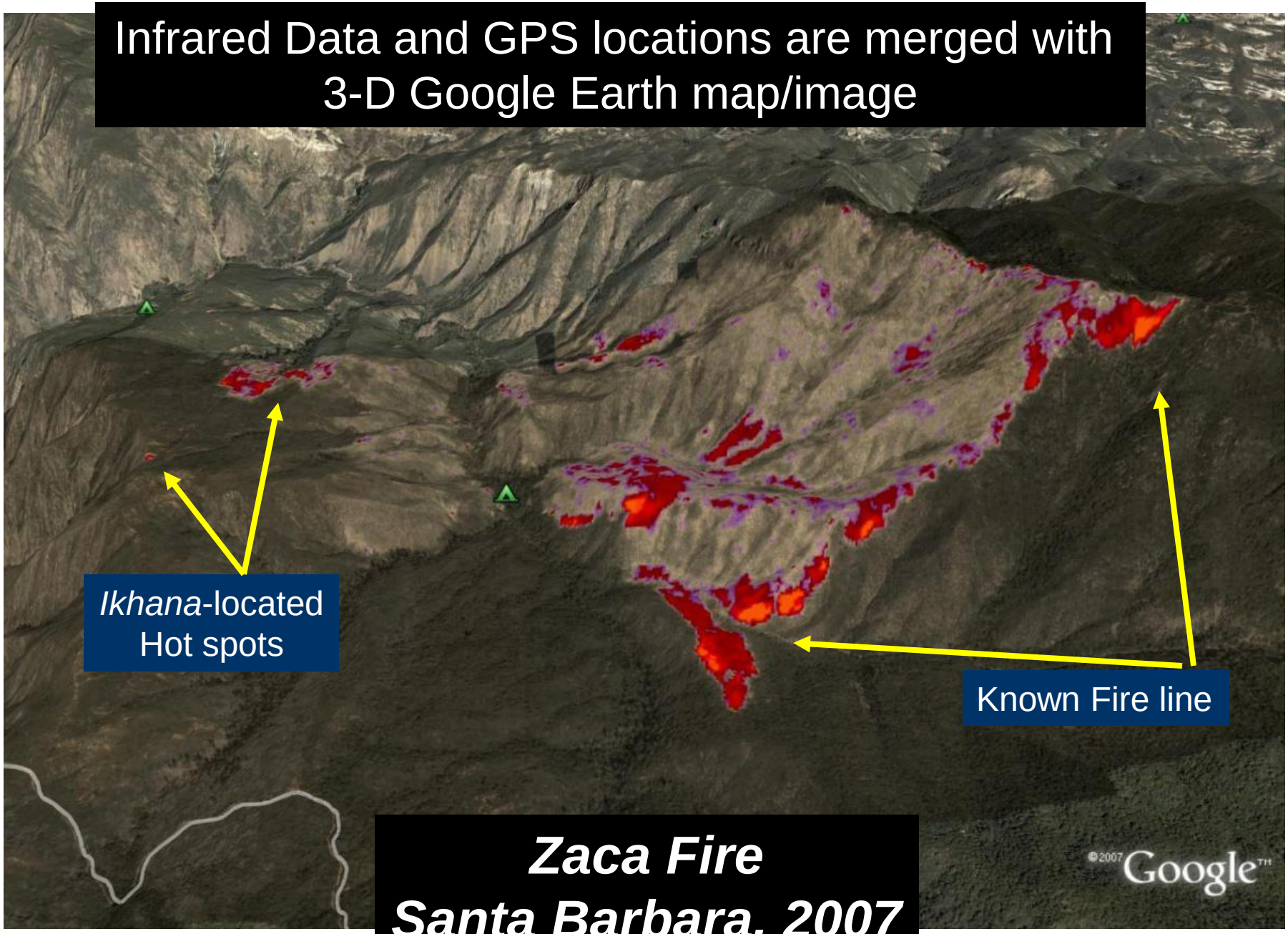
Four Tech Demonstration Missions



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
©2007 Google™

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