



Unmanned Aircraft: A Pilot's Perspective

"It's not un-piloted..."



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**Presented to the
83rd Annual Meeting
Aerospace Medical Assoc.
Atlanta, GA May 2012**

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

TOPICS

- **NASA MQ-9 *Ikhana* (Predator-B)**
- **Pilot – Vehicle Interface Design**
- **Defining “Pilot” in the UAS world**

NASA Dryden Aircraft Fleet

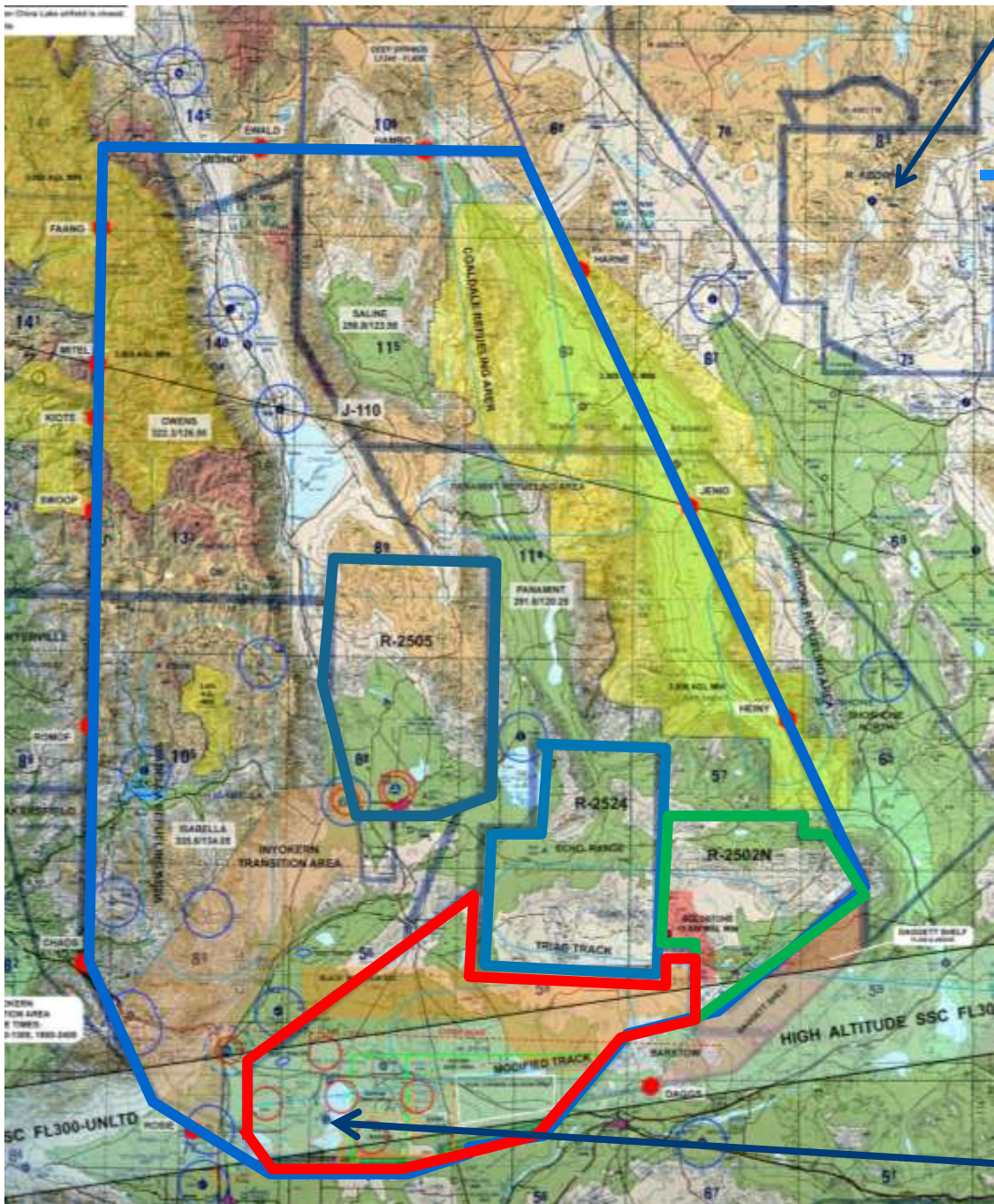


Aeronautics

Airborne Science

Dryden Aircraft Operations Facility, Palmdale





Nellis AFB Ranges

R-2508

18k' – 60k'

MOAs 200' AGL -18k'

R-2505 (China Lake)
SFC-UNLTD

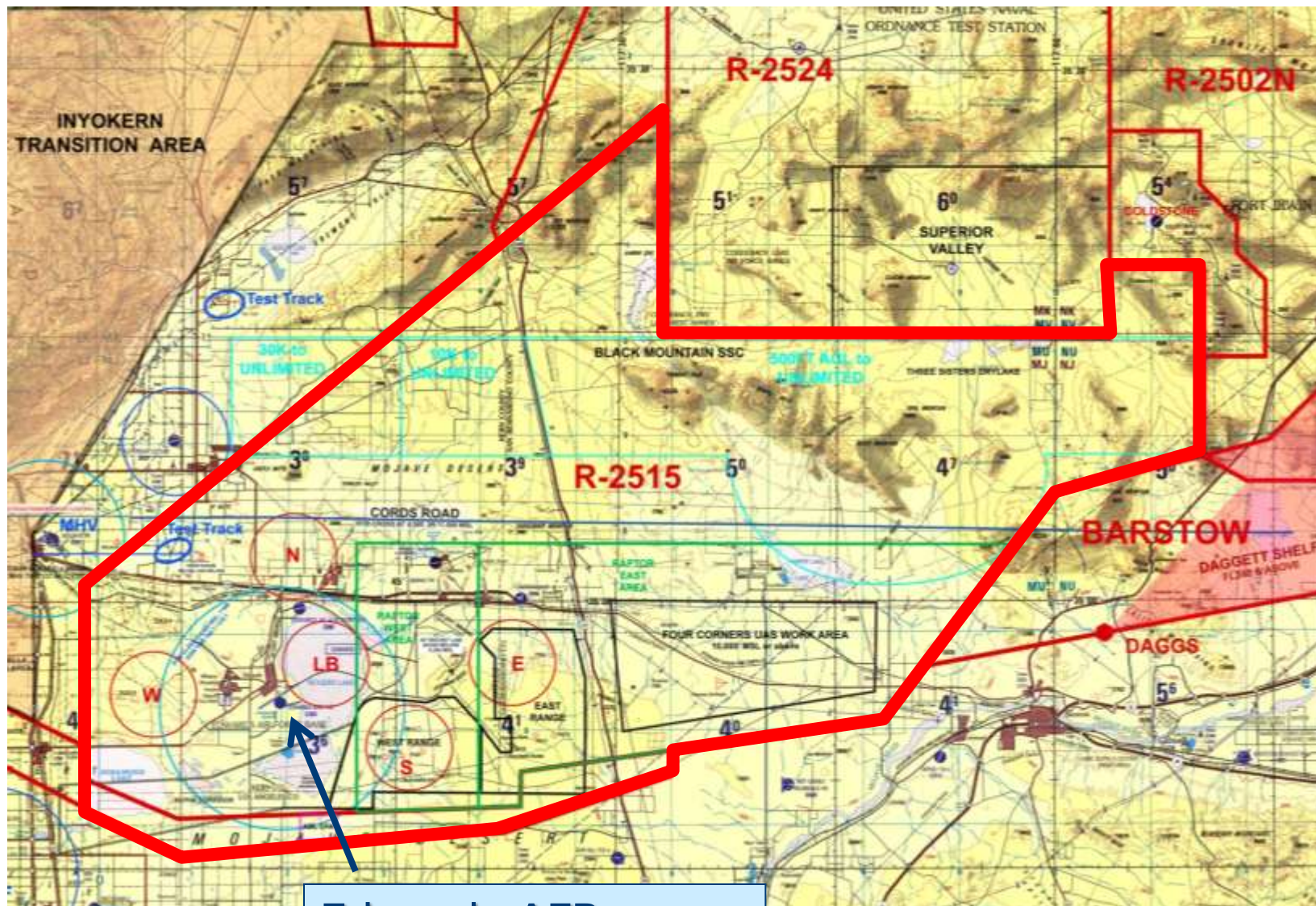
R-2524
(China Lake)
SFC-UNLTD

R-2502N (NTC)
SFC-UNLTD

R-2515 (Edwards)
SFC-UNLTD

Edwards AFB Runways

• Edwards AFB / R-2515



Edwards AFB
Main Base Runways

NASA MQ-9 *Ikhana*

Ikhana = Native American Choctaw word for...

“Intelligence”

“Learning”

“Awareness”



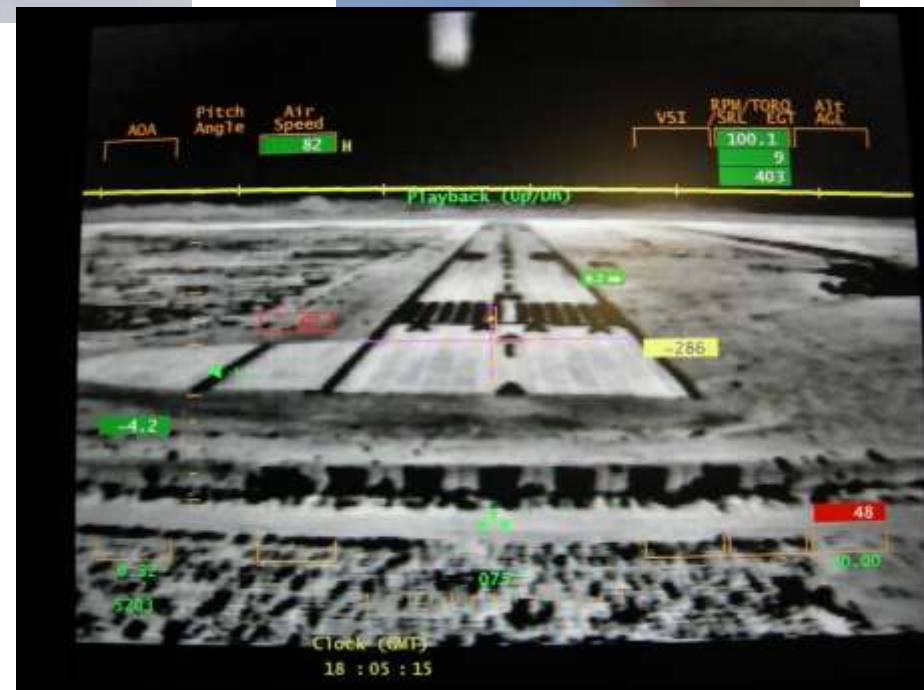
MQ-9 Reaper/ Predator-B



MQ-1 Predator -A



Two nose-mounted cameras: Color Visible & B&W Infrared



Initial power-up,
fueling, engine start,
and local area flying

C-Band
Line-of-sight antennas
and remote camera



Ground Control Station

Over The Horizon
Long Range Link
Ku-bandSatCom



MQ-9 Ground Control Station (GCS)

Two Pilot Stations





**Tracker Display
Systems Menus**

Camera View with HUD

**Systems Displays
Systems Menus**

Keyboard / Trackball

**Control Stick,
Throttle, Flaps, Rudder Pedals**



Remote Camera

Provides situational awareness of people , equipment, and vehicle movement near aircraft.





Ground Control Station:
People talk
Phones ring
People come and go

Long-duration missions.
Multiple crews: Hand-overs



Fatigue
Boredom
Complacency
Shift work = “day sleepers”



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, only 30° FOV!
- WELCOME to UAS flying!

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



**Use of the
Tactile sense**



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



Humans are analog, tactile, visual.

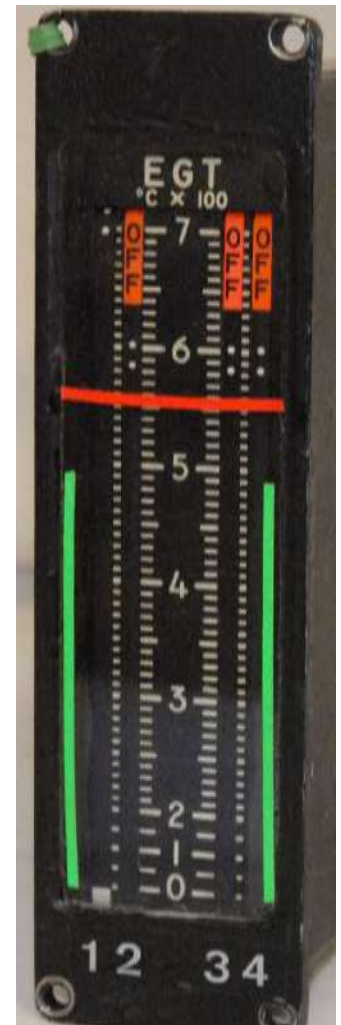
What about the displays and controls?



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

A photograph of a digital display showing a tabular list of aircraft system parameters. The display is titled "23 Flight Information" and lists various parameters with their corresponding values and status indicators (red, yellow, green).

23 Flight Information	
Roll MA	0.0 °
Compass Wb	0.0 °
Pre. Ht	0.0 ft
Ground Spd	0.0 kt
Alt	0.0 ft
Wd	0.0 ft
L/R	0.0 °
Deflect. Cnd	0.0 °
Roll Stick	0.0 °
Pitch Stick	0.0 °
Yaw Stick	0.0 °
Flap Stick	0.0 °
Roll Angle	0.0 °
Pitch Angle	0.0 °
N. Stick Temp	0.0 °C
W. Yd Temp	0.0 °C
W. Yd Temp	0.0 °C
L. Tail Temp	0.0 °C
R. Tail Temp	0.0 °C
L. Tail Bat Temp	0.0 °C
Roll MA	0.0 °
Compass Wb	0.0 °
Pre. Ht	0.0 ft
Ground Spd	0.0 kt
Alt	0.0 ft
Wd	0.0 ft
L/R	0.0 °
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L. Tail Bat Temp	0.0 °C

**Unmanned Aircraft System
Digital /Tabular Display Format**

Example of Display and Control Issues

IFF Transponder “IDENT” Task

1. Remove right hand from control stick
2. Move cursor to tracker display
3. Click on TOOLS menu
4. Scroll to IFF
5. Click to open IFF window
6. Click “IDENT” button
7. Click “APPLY”

**Accessed by trackball
and Left/Right buttons**



Example of control / display issues

Q: How do I TURN **ON**
the Fuel Heaters?

Fuel Heat Inhibit

Disable / Enable F9



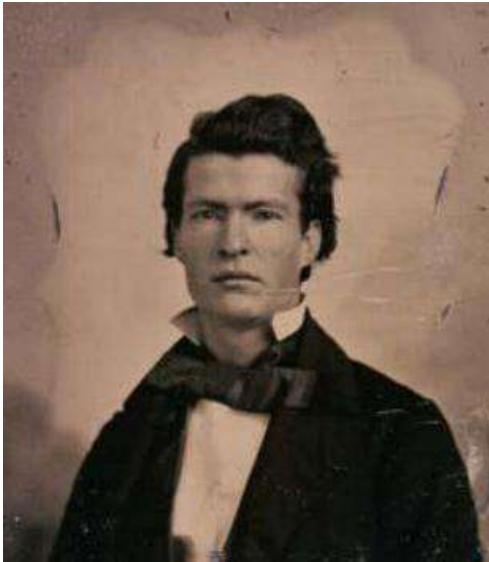
“How far can you see a plane?”

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



Q: What's a "pilot"?



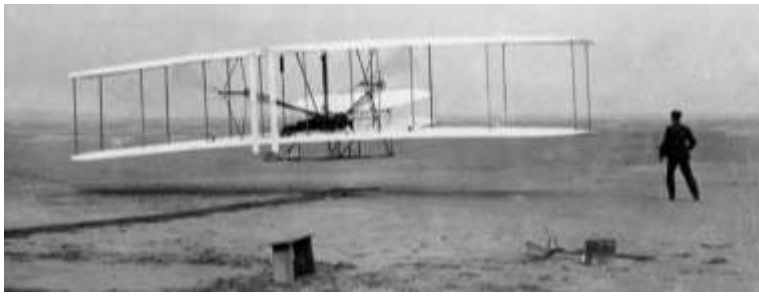


Samuel Clemens and his Pilot's Certificate

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

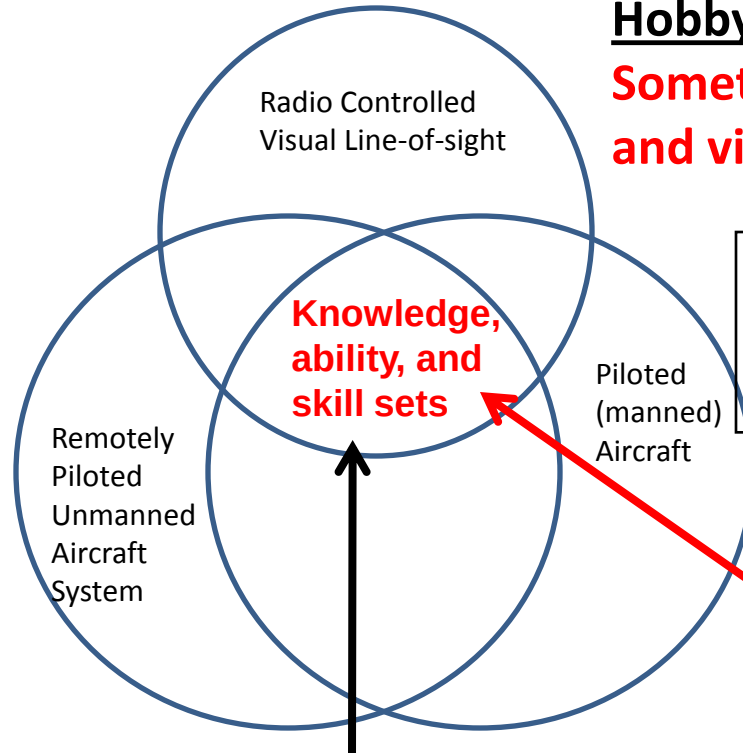
(relative relationships are not necessarily to scale)

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.**

**Plus: Judgment,
experience,
flexibility, etc.**

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

- Proven human-machine interface standards exist
 - use them / adapt to UAS as required.
- Extended duration missions and remote operations require new con-ops for multiple crews, circadian shift, etc.
- No single definition of “Pilot”
 - Hence: Training, qualification, currency, proficiency standards depend on the method of control, et al.
- Consider a future state, where multiple UAS are controlled by a single “operator”.
 - May blend the roles of pilot and air traffic controller.

Western States Fire Mission





Where do you put
Limited Resources?



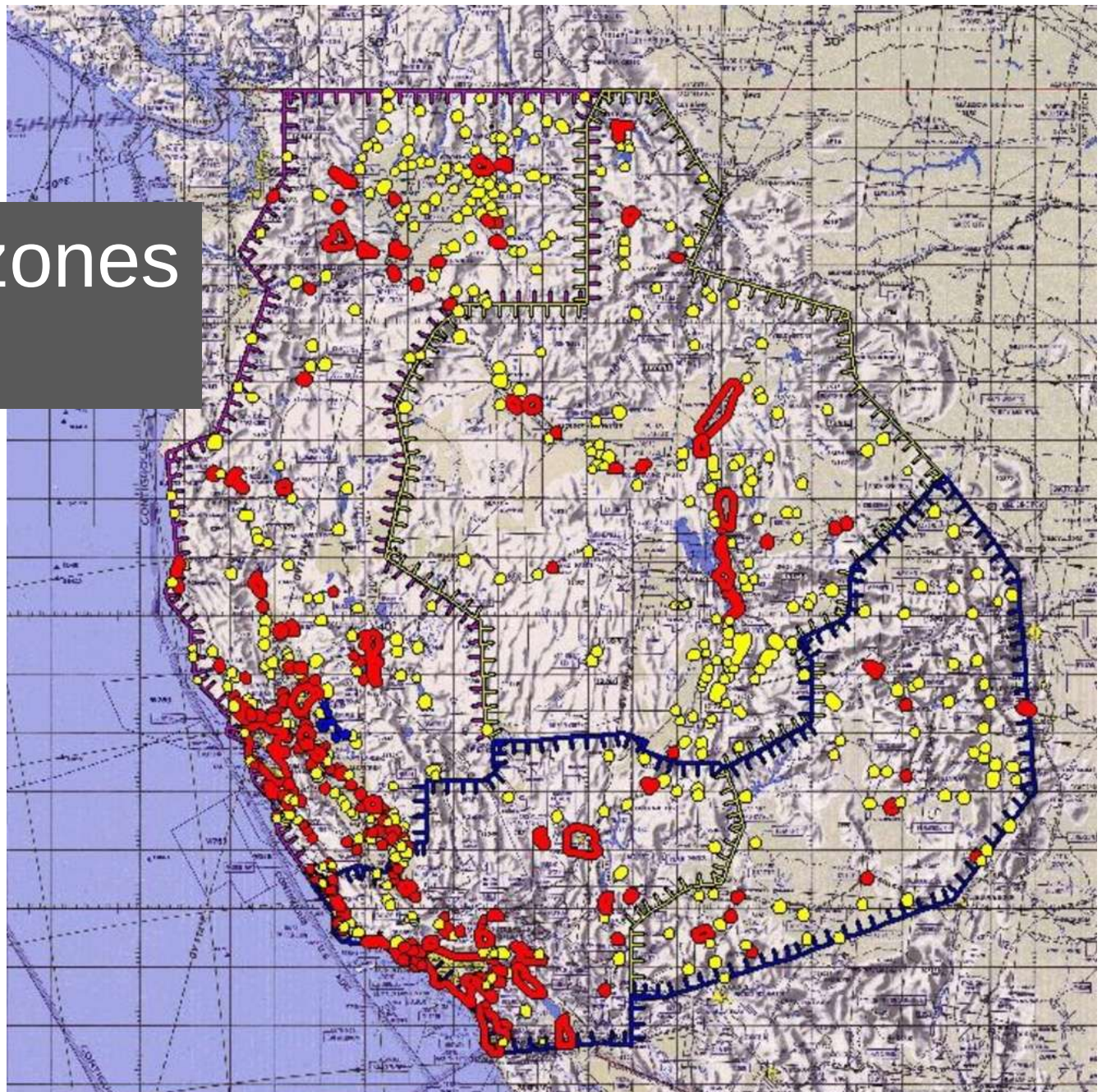
...and keep them
Safe!



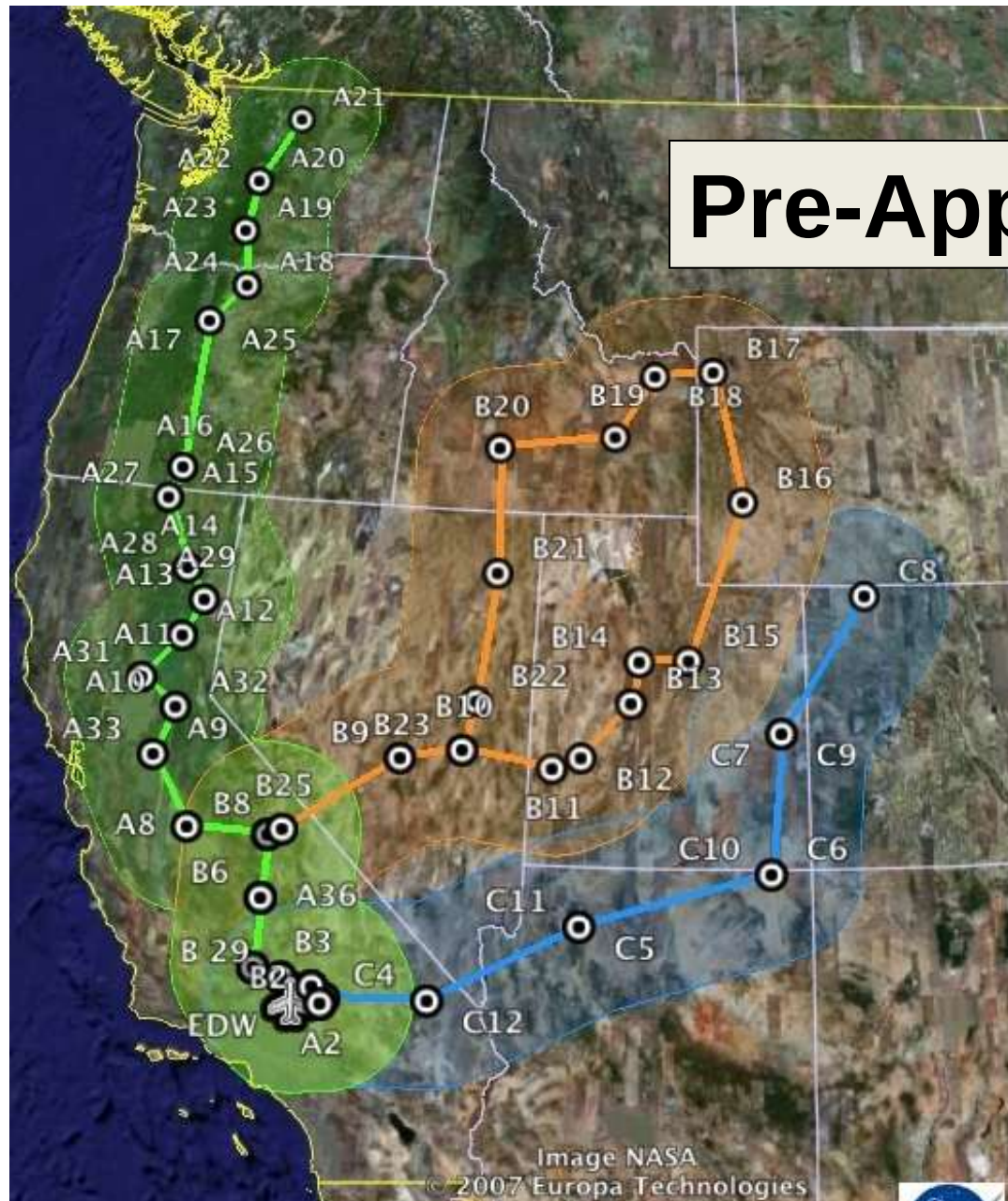
FAA Provisions: *“Be Predictable. Do no harm.”*

- One assigned Flight Level (FL 230), in Class A airspace.
- -Two-way radio communication and transponder.
- - Climbs/descents while in Edwards AFB airspace.
- File flight plan 72 hrs prior, fly 1 of 3 “standardized” routes.
- Demonstrated “Lost Link” ability: Return via same route.
- Emergency landing sites: Military only.
- Designate “set-down sites” (fields, lakebeds) if engine failed.
- MQ-9 demonstrated reliability/capability/systems redundancy

Keep-out zones

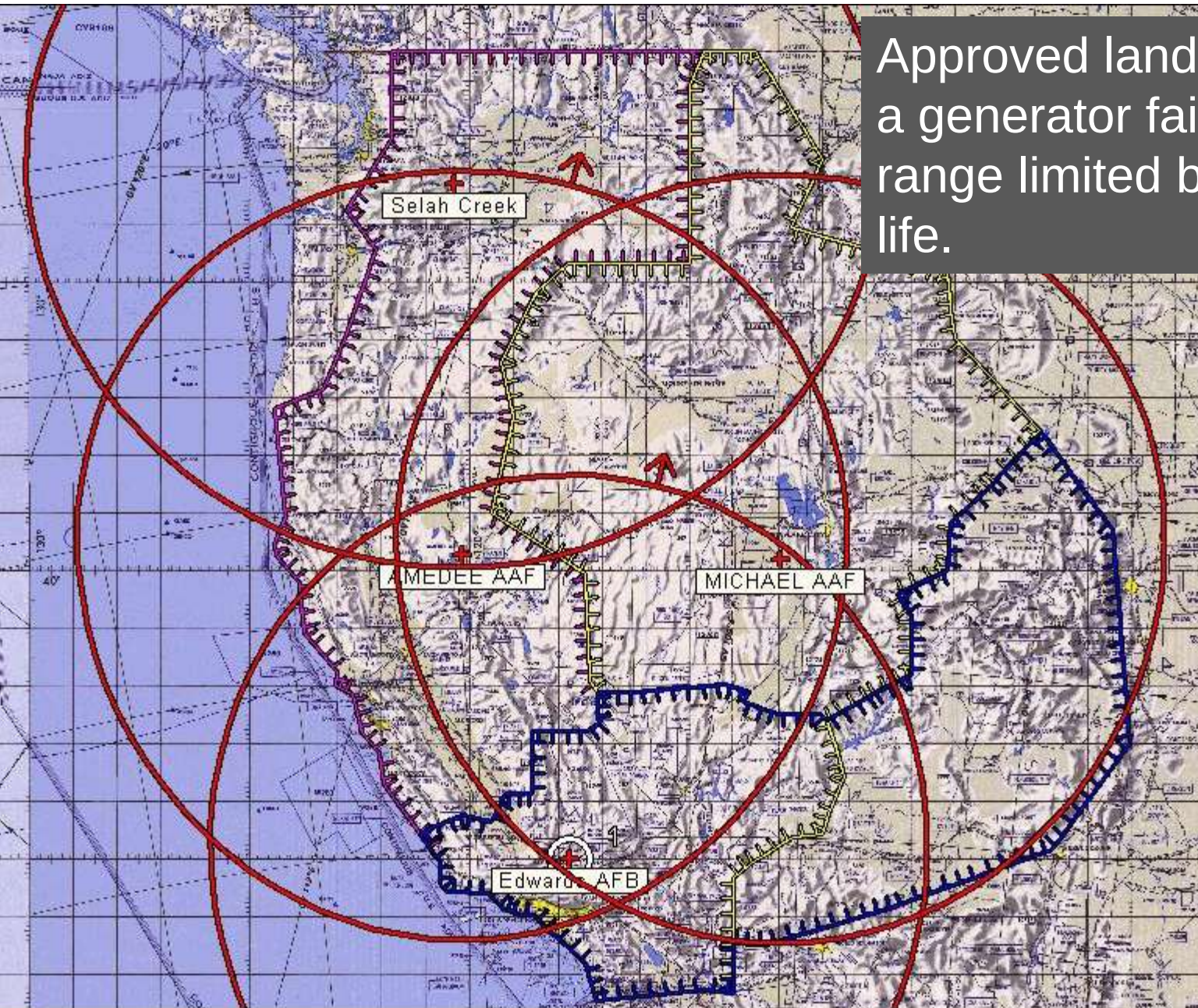


Pre-Approved Routes



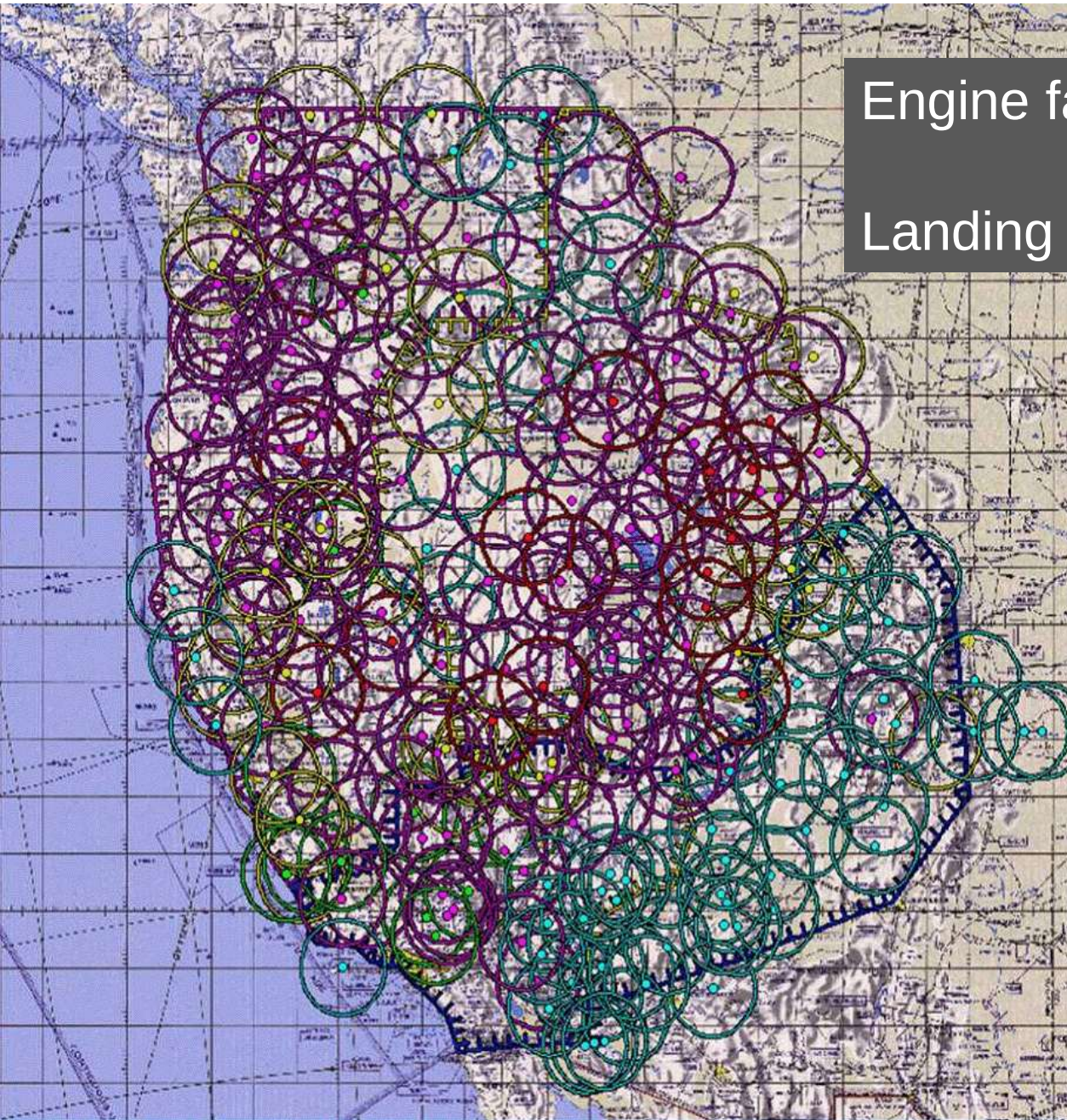
Actual flight route
negotiated in real-time
to acquire data over
fires.

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



Engine failure glide range

Landing sites



Four Tech Demonstration Missions





Edwards AFB

~1350 nmi route
~9 hours

Ranch, Buckweed

Grass Valley, Slide

Los Angeles

Riverside

Anaheim

Santiago

Santa Ana

Long Beach

Rice

Poomacha

Ammo

Witch

Harris

Image NASA San Diego

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Pointer 33°51'09.31" N 117°19'07.50" W elev 664 m

Streaming ||||| 100%

Eye alt 374.54

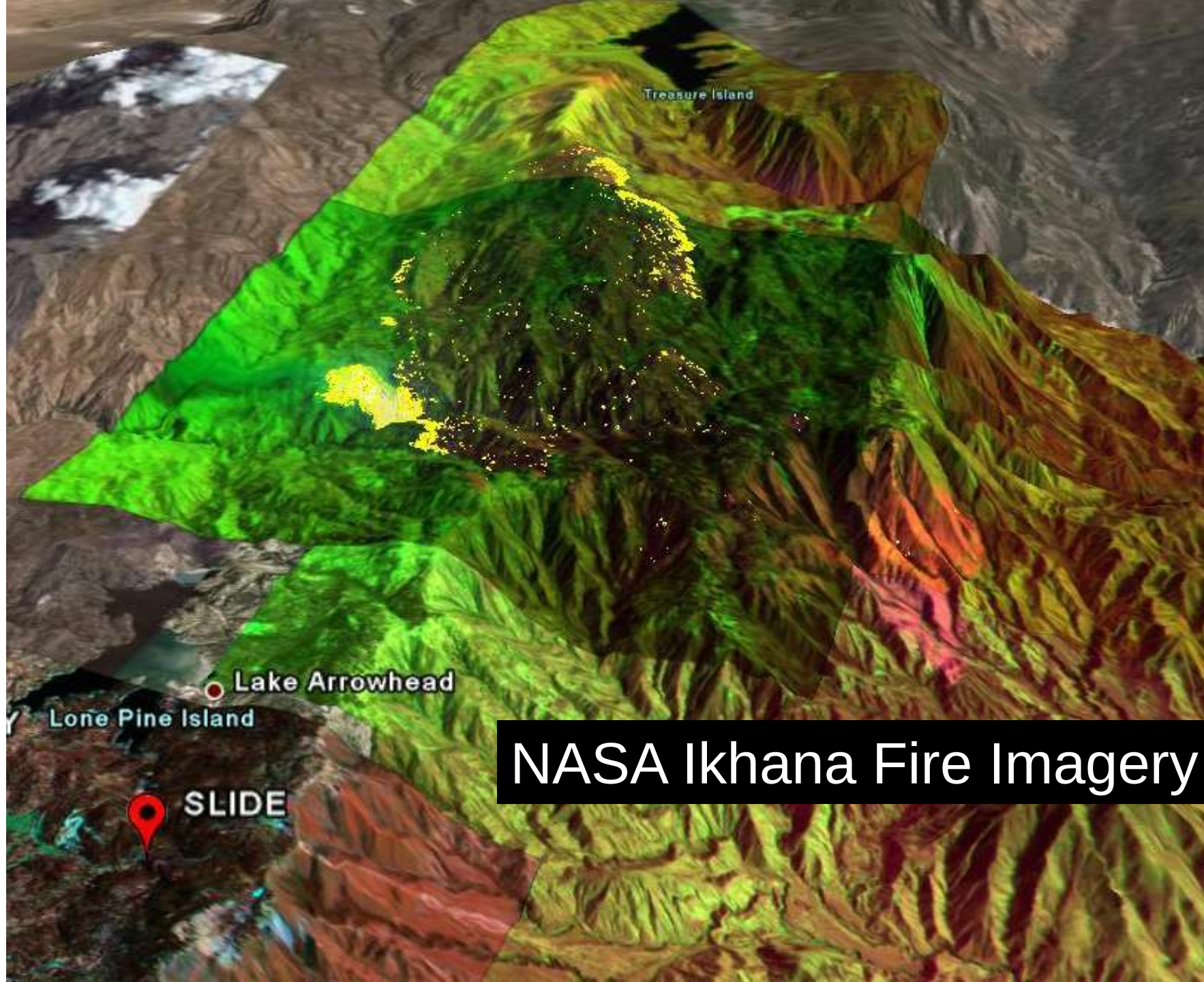


The end product:

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

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





NASA Ikhana Fire Imagery

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:

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

Thanks for listening.

