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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
Dryden Aircraft Operations Facility, Palmdale
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.
MQ-9 Ground Control Station (GCS)

Two Pilot Stations
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 30º 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

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
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)

What do these people have in common?

Video Gamer

Radio Controlled
Visual Line-of-sight

Remotely
Piloted
Unmanned
Aircraft
System

Piloted
(manned)
Aircraft
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

• 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”

• 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!

- 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
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.
Four Tech Demonstration Missions

1st Fire Mission
8/16/07
9.5 hours
1400 nmi

2nd Fire Mission
8/29/07
16.1 hours
2500 nmi

3rd Fire Mission
9/7/07
20 hours
3200 nmi

4th Fire Mission
9/27/07
10 hours
1800 nmi
Edwards AFB
Grass Valley, Slide
~1350 nmi route
~9 hours
Ranch, Buckweed
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.

Zaca Fire
Santa Barbara, 2007
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.