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
- 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

Nellis AFB Ranges
Edwards AFB / R-2515
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 and 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
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)

Radio Controlled
Visual Line-of-sight

What do these people have in common?

Video Gamer

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.

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”

• 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
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

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
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:

• “...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.