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”.

![Image of NASA Ikhana UAS MQ-9 Reaper](image-url)
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, 30º 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
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)

Radio Controlled
Visual Line-of-sight

Remotely Piloted Unmanned Aircraft System

Piloted (manned) Aircraft

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 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
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 than 10 minutes.
Infrared Data and GPS locations are merged with 3-D Google Earth map/image.
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