Flying Unmanned Aircraft: A Pilot’s Perspective

“It’s not un piloted…”

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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
A LEGACY OF UAV RESEARCH at NASA DRYDEN
More Uninhabited Vehicles
MQ-1 Predator - A

48 ft wingspan
2500 lb

MQ-9 Reaper/ Predator - B

66 ft wingspan
10,500 lb

Altitude: 45,000 ft.
Endurance: 24 hours
NASA MQ-9 *Ikhana*

*Ikhana* = Native American Choctaw word for...

“Intelligence”
“Learning”
“Awareness”
Initial power-up, fueling, engine start, and local area flying

C-Band Line-of-sight antennas
Ground Control Station

Over The Horizon
Long Range Link
Ku-band SatCom
Two Pilot Control Stations
The Control Room is in the cockpit!
- Conversations
- Phones Ring
- People come and go
Two Cameras
1. Daylight Color
2. B&W IR
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

• WW II: Progression from Bi-Planes to Jets
• 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 pilot-vehicle interface design.
• Some UAV mishaps are attributed to this (root cause).
The nightmare of poor interface design
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.
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
Digital Information … in Analog Format

UAS Tabular Display
Use of the Tactile sense

Different shapes of actuators enable the pilot to direct attention elsewhere...while activating systems. Multi-tasking
Systems Display Screens...all digital...no analog. Keyboard Controls...all switches are shaped identically.

Cumbersome embedded menus

Visual Attention is diverted to the keyboard for systems actuation.
Flap Handle- note the shape.

Engine controls – sensitivity is an issue.
Rudder Pedals and Brakes…no sensory feedback (other than visual)
Q: How do I TURN ON the Fuel Heaters?

Example of control / display issues
Example of Display and Control Issues

IFF Transponder
“IDENT” Task

1. Remove right hand from control stick
2. Move curser 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
Prototype Advance GCS are in Development
But...by which standards? Company proprietary...
RQ-4
Global Hawk

Length: 44 ft
Wing: 116 ft.
GWT: 30,000 lb

Altitude: 65,000 ft.
Endurance: 30 hours
Global Hawk
Operations Center
Q: What’s a “pilot”?
Q: What’s a UAS pilot?
Defining “Pilot” : Recognizing a changing paradigm
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”….

• Pilot is “Remotely” connected to the controls, systems management, monitor autonomous operations.

• In some cases, motor skills have little/no relevance.
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 SHOULD 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.
NASA Proposal:
A Collaborative R&D Effort
with DOD, DHS, and FAA

Objective is integration and routine access to
NextGen ATM System
and National Airspace System

- Separation Assurance/Sense & Avoid
- Systems Verification/Validation
- Frequency Spectrum Management
  - Human-Machine Integration
Pilot Vehicle Interface Issues

- UAS Pilot/Operator
  - Loss of senses
    - Audition
    - Vestibular Cues
    - Olfactory
    - Monocular vision & reduced FOV (e.g., 30 degrees)
- Long duration missions ...complacency, boredom
- Crew handovers
- No standard requirements/training
  - USAF - rated pilots
  - Army - specially trained soldiers
  - Raven operators - one week of training
Pilot Vehicle Interface Issues

- **Ground Stations**
  - Lack of standardization
  - Lack of application of 70+ years manned cockpit experience
  - Huge disparity in level of automation & proposed use of NAS
    - Raven, Predator, Shadow, Global Hawk
  - Rush to service
    - Advanced Concepts Technology Demonstrations
    - Engineering displays became operational
      - Improved GCS efforts are underway
  - Proprietary
  - Generally not built with eye toward NAS
- **UAS specific issues**
  - Delays
  - Loss of link
  - Contingency operations
  - Link strength/Type
  - Data-link Frequency Use
  - Vehicle Speed/maneuverability (pilots and ATC)
Western States Fire Mission

[NASA logo]
[Forest Service]
[National Interagency Fire Center]
[California Department of Forestry & Fire Protection]
[Federal Aviation Administration]

[Image of drone: Ikhana NASA 870]
[General Atomics Aeronautical Systems logo]

[Boise, Idaho]
Where do you put Limited Resources? …and keep them Safe!
Yellowstone Fires from ER-2
Representative Imagery (From ER-2)

Visible (TM 3-2-1)
Infrared (TM 6-7-5)

Castaic Fire, CA (8/26/96)
(25 Meter Resolution; 65,000 ft AGL)
FAA Provisions

- 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.
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
~1350 nmi route
~9 hours
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......Questions?