Unmanned Aircraft: A Pilot’s Perspective

“It’s not un-piloted…”

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Presented to the
Aviation Technical Education Council
Annual Symposium, Orlando, FL
April 2011

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

• NASA Dryden Intro
• UAS Overview
• NASA MQ-9 Predator-B
• Pilot – Vehicle Interface Design
• Defining “Pilot” in the UAS world
• Western States Fire Mission
• Role of Technicians in UAS world
NASA Dryden Aircraft Fleet
Edwards Air Force Base, California

Aeronautics

Airborne Science
A LEGACY OF UAV RESEARCH at NASA DRYDEN
More Uninhabited Vehicles
YRO-4A Global Hawk

- 65,000ft
- 30 hrs
- Autonomous (mouse-driven)
- Unique GCS / Sim
- Stand-alone Sim
DROID
Dryden Remotely Operated Integrated Drone

UAS Pre-Trainer
Small UAS Research
Camera view
Autopilot

DROID Ground Control Station
External Safety pilot
Split Screen: Camera / GPS moving map
Mobile
X-48 Blended Wing Body
Ximango TG-14 Motor Glider

110 Kts
5 hours endurance

UAS Surrogate platform
Autopilot
Safety Pilot(s) in/on the Loop
Safety chase UAS
Low cost ops
NASA MQ-9 *Ikhana*

*Ikhana* = Native American Choctaw word for…

“Intelligence”

“Learning”

“Awareness”
MQ-1 Predator -A

MQ-9 Reaper/ Predator-B
Initial power-up, fueling, engine start, and local area flying.
MQ-9 Ground Control Station (GCS)

Two Pilot Stations
Ground Control Station:

People talk
Phones ring
People come and go
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!
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
Example of Display and Control Issues

IFF Transponder
“IDENT” Task

1. Remove right 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*
Use of the Tactile sense

Different shapes of actuators enable the pilot to direct attention elsewhere...while activating systems. Multi-tasking
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 (GHOC)
NASA Global Hawk “cockpit”

“Flown” by keyboard and mouse
Global Hawk Operational Capability
Four Mission Regions, with Arcs of Constant On-Station Times
Q: What’s a “pilot”?
19th Century Pilot.
• Riverboat Captain
• Skills: River navigation, rudder control, soundings, shovel coal, supervisor…

Samuel Clemens and his Pilot’s Certificate
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.

**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.
Where do you put Limited Resources?

...and keep them Safe!
Visible Light….vs…Infrared Image
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
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 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.”
The Crew Chiefs and Mechanics for Unmanned Aircraft Systems have unique knowledge and skills beyond traditional concepts.
The Crew Chief / Mechanic requires traditional airframe & powerplant skills and knowledge.

They also work closely with the scientists and engineers in the process of integrating payloads, sensors, and specialized instrumentation.
The “system” is more than an airplane
Provides situational awareness of people, equipment, and vehicle movement near aircraft.

My eyes and ears, that I depend on for safety.
External Power Interface Panel

The Crew Chief also starts the engine from this panel.
The Avionics Technician is also the “Flight Engineer”, behind the pilot.
What about long-duration missions?

Multiple crews

Fatigue
Boredom
Complacency

Shift work = “day sleepers”

Technicians’ skills and knowledge will also require expertise in these disciplines.
Considerations for the Technicians of Unmanned Systems

Must still know about nuts and bolts, **AND also about electrons and cyberspace**…

- Communication networks
- Multiple data-links
- Software load, upgrade, and verification
- Frequency management

Some are also a flight-required crew member.

**CRM:** Crew Resource Management

“Eyes and ears” for the pilot who has lost normal situational awareness.
Q: Robots or Humans?

“Intelligence, utility, and endurance”

...vs...

”judgment, innovation, and adaptability”
A: Both, as required
Unmanned Systems...
For the boring, and dangerous, jobs

• Combat
• Border Patrol
• Science
• Disaster assessment
  – Hurricanes
  – Floods
  – Volcanoes
  – Nuclear incidents
Thanks for listening.