



X-47A

NORTHROP GRUMMAN





Test Pilot's Role in Flight Test of Unmanned Air Vehicles

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Abstract

With Increasing Emphasis on the Development of Unmanned Air Vehicles (UAV), the Test Pilot May Be Assigned to Perform Various Duties on the UAV Test Team. The Purpose of This Briefing Is to Highlight Some of the Tasks That May Be Assigned to a Test Pilot on a UAV Test Team. Information on Accomplishing These Tasks from Previous UAV Programs Are Presented. The Information Is Derived Primarily from the Author's Experience Performing Duties as Chase Pilot, Surrogate Aircraft Test Pilot, and Air Vehicle Operator on Various UAV Flight Test Programs.



AVO role for UAV Analogous to Test Pilot Role

- **AVO Role Defined in Early Design Decisions**
- **Command and Control Location**
- **AVO Display Requirements**
- **Surrogate Aircraft Flight Testing**
- **Chase Aircraft**
- **Contingency Planning**
- **Summary / Lessons Learned**



AVO Role Defined in Early UAV Design Decisions

- **Fully Autonomous UAV – Range Safety Role**
- **Autonomous Takeoff / Landing UAV**
 - **AVO Cannot Manually Takeoff / Land the UAV**
 - **AVO Involved in Decisions Related to Taxi and Takeoff Abort, Contingency Profiles, Waveoff, Destruct**
 - **Limited Capability to Control Flight Path – Manual Override Airspeed / Altitude / Bank Angle**
- **Manual Control of Takeoff / Flight Path / Landing**
 - **AVO Fully Responsible for Flight Path Control Through Remote Control Inputs**



Command and Control Locations

- **AVO in Cockpit of Chase Aircraft**
 - **Communication Issues**
 - **Removed from Engineering Decisions**
- **AVO in Remote Ground Based Location**
 - **Same Issues as Inflight Location**
- **AVO Co-Located with Engineering Decisions**
 - **Visual Response Supplements Net Communication**
 - **Advantageous to Co-Locate AVO with RSO**



Control Room Configuration

- **AVO Visual with Test Director / Test Conductor / Engineers to Supplement Net Communication**
- **AVO Share Displayed Information with RSO**
- **Radio Communication with Ground Crew / Chase Aircraft / Tower / Range Control**
- **External Camera View of UAV Highly Desired**
- **Forward Looking Camera from UAV Critical for Landing Decisions**



X-47A Control Room





X-47A AVO Station





AVO Command Display Requirements

- **AVO Command and Control Panel**
 - **AVO Selects and Executes Commands to Be Uplinked to UAV Using Hardwired Panel or Computer Display (More Flexible / Transportable)**
 - **Need Feedback That Uplinked Command Was Sent (Use of Color Change on Display Is Effective)**
 - **“Echo” Command Is Useful**
- **Use of “Mouse” to Select Commands on Display**
- **Limited Keyboard Entry (i.e., Altimeter Setting, ZFW, Go to WP, Mission Plan Number, etc.)**



Sample Command Display

Command and Control Panel

CCP DISPLAY

Flight Termination Display

Flight and Contingency Modes Display

AUTO WAVEOFF GO TO WP

Flight and Navigation Override Display

MANUAL

AIRSPEED ALTITUDE BANK
 TURN

Flight Test Inputs Display

DOUBLET SWEEP
SIDESLIP THROTTLE BODE

Systems Reset Display

ALTIMETER SET AIR DATA
BRAKES SRGPS GAIN

Start and Takeoff Display

ZFW FUEL

Socket Connection
 Connect
 Disconnect

Warnings, Cautions, and Advisories



AVO Systems Monitor Display Requirements

- **Vehicle Status Display**
 - **Monitor Current UAV Attitude, Flight Conditions, Basic System Status**
 - **Monitor Planned UAV Flight Conditions**
 - **Monitor Uplink and Downlink Status**
 - **Feedback That “Commands” Were Received**
 - **Distance to Go to Waypoints – Important**
 - **Telemetry Drop-Outs Are Really Irritating**
 - **Consider Backup Method to TM Downlink (i.e., Command Data Link – Limited Bandwidth)**



Sample Vehicle Status Display

Vehicle Status Display
⌵ ⌵ ⌵

MD : MMGC Initial Mode

DISARM ARM DEST

UPLINK: 0 1 **2** SEC: 0

DNLINK:

WPT: 9 FT: 0

CMD A/S:

KCAS: 15

MACH: 0.04

AOA: +2.0

G: +0.0

PLA: 5%

RPM HI: 0%

ITT: 530 ° C

EEC: OFF

Socket Connection

Connect

Disconnect

mag HDG: 346

LACC

8

0 0.0

-8

SRGPS: ON

NAV: INS

FOM: 0 NQ: 0

GSLOPE: +0.00

HAT: -2133 IDOT: V50 H50

AUTO WAVEOFF: ON

ALTIMETER SET: +0.00

CMD ALT

-4 MSL ALT

+0 FPM VVI

FIX : GAIN

INS : ADS

GO NOGO : IBIT

FUEL: 20 lbs

ZFW: 0 lbs

GND: ON

BRAKE: P A E

CMD BRK DECEL:

NWS

β

-10 0 10

Flight Controls

LIN	LEV	REV	RIN
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

BATT 1: 26.1 V	BUS 1: 40.0 A	HYD PRESS 1: 2989 PSI	AVMS 1 BIT STATUS: 5 A C 8
BATT 2: 25.9 V	BUS 2: 39.5 A	HYD PRESS 2: 2997 PSI	AVMS 2 BIT STATUS: 5 B B 1
UBATT: 23.4 V	UTIL: 106 A	EMER HYD: 0 PSI	HYD RES: 225 IN ³



Mission Situation Display (Range Map)

- **Presents “Gods Eye” View of UAV Position in Relation to Planned Mission Track / Waypoints**
 - **Shows Waypoints / Routes – Both Normal and Contingency Mission Plans**
 - **Need “Declutter” of Unused Route Segments**
 - **Need “Quick” Transition to Desired Segments**
 - **Center on UAV With Ability to Vary Map Size**
 - **Display of UAV “Track History” Is Very Useful**



Sample Mission Situation Display

MSD

Current Map Center
Latitude: 35.6835
Longitude: -117.6800

View Radius
25,000 nmi

Waypoint Display
Start: 1 Set
End: 31 All

Aircraft centered mode
 Off
 On

Socket Connection
 Connect
 Disconnect

Exit

Waypoint 22 — Waypoint 23 — Waypoint 26



Surrogate Aircraft Flight Testing

- **Manned Aircraft With “Some” UAV Systems Installed**
 - **Check RF Links (Command and Control / TM)**
 - **Check RF Links Used by UAV (GPS / Diff GPS)**
 - **Verify Navigation Software**
 - **AVO Range Familiarization Is by Product of Testing**
- **Aircraft Selection**
 - **Verifying UAV Track Guidance Is Primary Task**
 - **Replicate UAV Altitude and Airspeed Is Optional**
 - **Keep It Simple (Display Range Map / Route / UAV Position on Laptop in Aircraft Reduces Aircraft Mods)**



Surrogate Testing

- **Testing with Beech Barron Provides the Following:**
 - Data Link Range Limitations
 - Data Link Null Locations
 - Profile Link Reception
 - Quantitative NAV Performance
 - Integrated NAV / Mission Plan / Guidance / Control Verification





Chase Aircraft

- **Both Photo and Safety Chase Requirements**
- **Practice Airborne Pickup With Control Room**
- **Chase of Surrogate Aircraft Good Practice**
- **Consider High / Low Chase for “Agile” UAV**
- **Thorough Brief With Chase Pilot / AVO Required**
- **Chase-Control Room Comm Is Very Important**
 - **Photo Chase KIO Maneuver Must Be Preplanned**
 - **“T” Word (Terminate) Is Not to Be Used**



Contingency Planning

- **Develop Useable “What If” Procedures**
- **What Ifs Should Lead to Limited Preplanned Options:**
 - **Continue on Mission Plan (or Orbit / Alternate Route)**
 - **RTB (Following Planned Contingency Routing) Destruct (or Let It Crash)**
- **Ground Contingencies Are AVO Memory Items**
- **Defined No Fly Zone – Remaining Range Is OK to Fly**
- **Practice in Sim with All Engineer Stations Simulated**
 - **Develop Teamwork Attitude and Build**
 - **Confidence “Practice Like You Are Going to Play on Flight Day”**



First Flight/Lessons Learned

- **Plan Short Mission With Limited Objectives**
- **Follow Go / NoGo Criteria, FOLD, Test Cards**
- **Have Plenty of Fuel Onboard for Delays**
- **The “Real World” Contingency That Happens Will Not Be Anything You Planned**
- **Control Room Engineers Are Your Best WCA**
- **Remote “Flying” UAVs Requires Same Concentration and Test Discipline as Piloting Aircraft (but It Will Never Replace the “Real Thing”!)**



Video of first flight of Pegasus

