

# 711 HPW/HP Research, Analysis, and Consultation for UAS

5 May 2010



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**711<sup>th</sup> Human Performance Wing**

**Air Force Research Laboratory**



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**John Plaga & Hector Acosta**  
**711HPW/HP**  
**AFRL**



# Agenda



- **Structure of the 711<sup>th</sup> Human Performance Wing**
  - Human Performance Integration Directorate
- **Current HP Projects**
- **Predator/Reaper SPO Efforts**
- **HFE/HSI shortfalls**
- **Way forward**





# 711 HPW Top Level Organization



**Human  
Effectiveness  
Directorate  
(711 HPW/RH)**



**USAF School of Aerospace  
Medicine (USAFSAM)**



**Human Performance  
Integration  
Directorate  
(711 HPW/HP)**





# 711 HPW Mission



## 711 HPW/RH Mission

Leading the Air Force in  
Human-Centered Research

## 711 HPW/HP Mission

Advocate, facilitate and support the application  
of human systems integration principles to  
optimize operational capabilities.

## USAFSAM Mission

First-call consultants in Aerospace Medicine, we  
find solutions to operational needs of today and  
tomorrow and prepare new aeromedical experts  
for future global challenges





# Robust Human Systems Integration for the USAF



- RH Provide Cutting Edge Technology, Data, Methods
- USAFSAM Enhance Human Performance in Adverse Environments
- HP Integrator for 711<sup>th</sup> and Lead Implementation USAF-Wide

Supports 2004 SAB Report





# HP Mission Statement

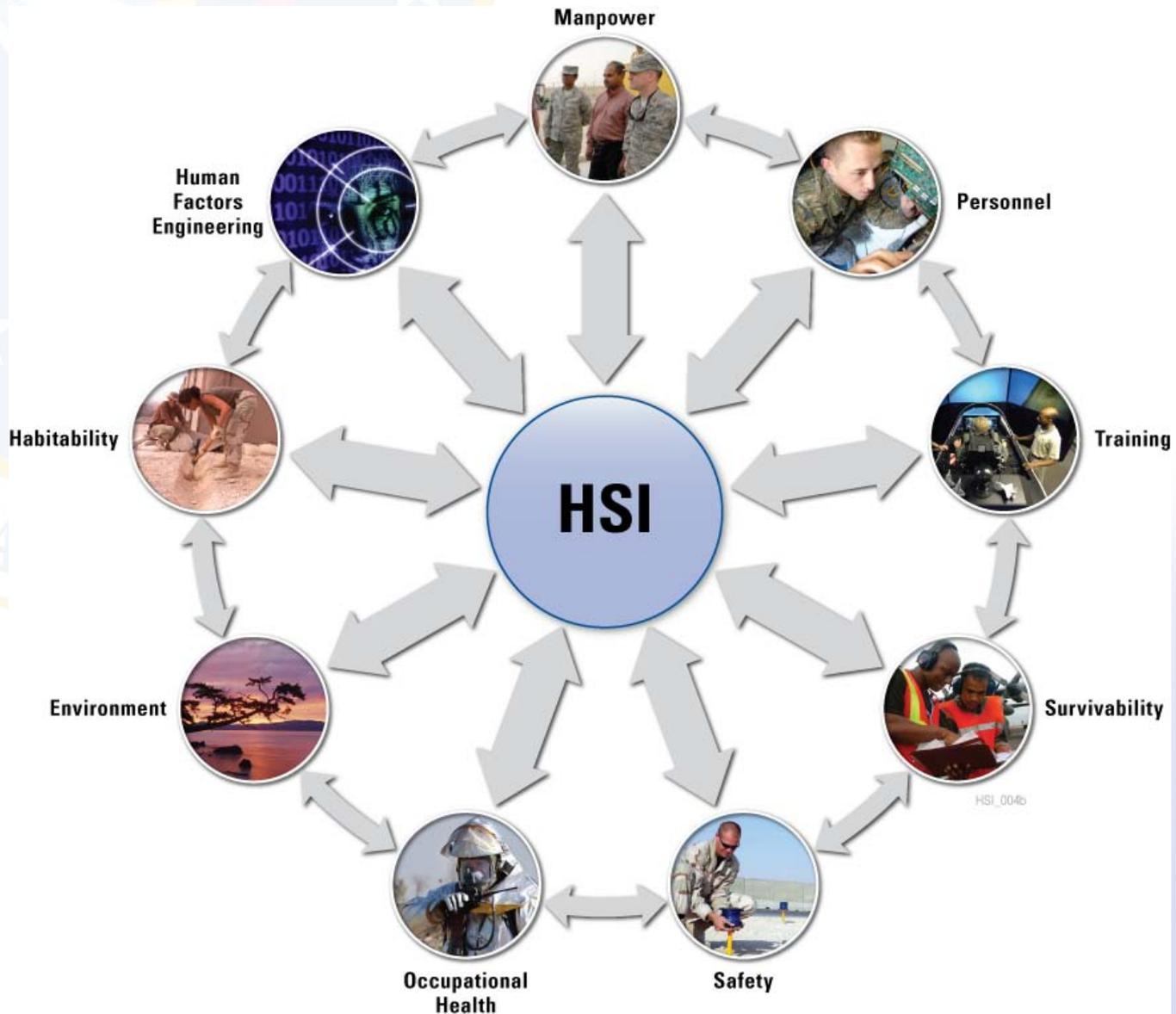


**Integrating Human Performance  
Sustainment, Optimization, and  
Enhancement through the application of  
operational knowledge and evidence-  
based Human Systems Integration**



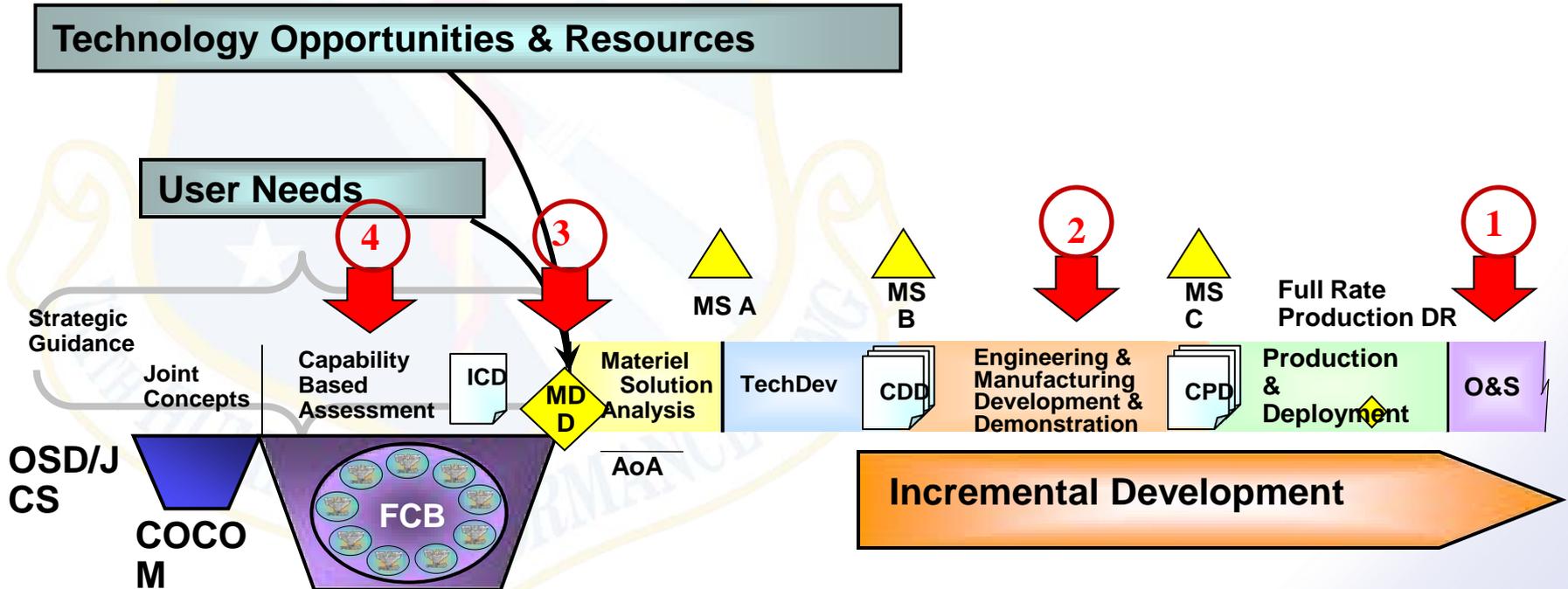


# The 9 HSI Domains





# HSI Insertion into the Acquisition Cycle: A "Big Picture" View



- 1** = Fix HSI problems after system is fielded
- 2** = HSI support before and during the system fielding
- 3** = Use HSI as a selection criteria/consideration (and cost)
- 4** = Make HSI part of the trade space to solve the gap/shortfall





# Three Tier Approach



- Provide support for JCIDS requirements documents
- Develop process tools to aid HSI process
- Provide Capability Gap analysis
  - Operational deficiencies identified and rectified





VCSAF

**Air Staff**  
**Human Oversight/Advocate**  
**Human Performance      Human Systems Integration**

JCIDS, Policy, HSI

**MAJCOM HP Cells**

SE A5 SG  
 A3 Pilot-Physician  
 A1 A8 A9

Requirements, HSI Cap Gap

**Wing Level HP Teams**

Cap Gap

Cap Gap, Lessons Learned

**711<sup>th</sup> Human Performance Wing, AFMC**  
 Human Effectiveness Directorate  
 Human Performance Integration Directorate  
 USAF School of Aerospace Medicine

HSI

HSI

HSI

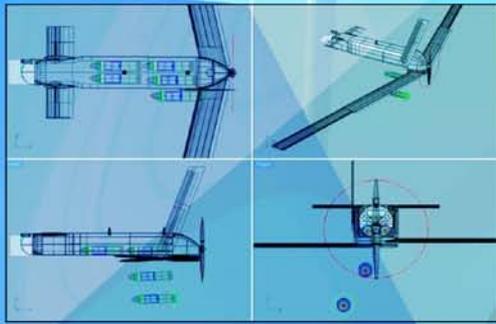
**Product Centers**  
 SMC  
 ESC  
 ASC  
 AAC

**Logistics Centers**  
 WR  
 OO  
 OC

**Test Centers**  
 AFOTEC  
 AFFTC  
 AFDTC

**Teaching      Research**  
**Consultation**





# Unmanned Aerial Systems





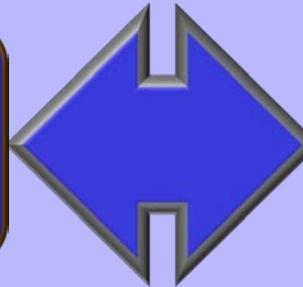
# BACKGROUND & SITREP



**The UAS  
Revolution**

**The HSI  
Revolution**

**Accelerated  
Responsiveness**



**Long Range  
S&T and  
Lifecycle HSI**

**HSI**



**Huge Demand  
for limited pool of  
Human Performance SMEs**





# BACKGROUND & SITREP

## USAF UAS Need/Requirements



- **Everybody is responding to UAS needs RIGHT NOW!**
  - OUSD UAS Task Force (ongoing)
  - AF/A2U (USAF UAS Flight Plan)
  - AFRL UAS IPT (ongoing)
  - AFRL MAV Team (initial workshop Aug 09)
  - 711 UAS Wing Team
  - Other government and Industry organizations
- **Concurrent planning at several levels can be synergistic, but also confusing**
  - UAS Integrator from Plans & Programs (711HPW/XP)
    - Mr. Dan Blaettler (210) 536-8262





# UAS Programs Supported



- **Global Hawk**
- **Predator**
- **Reaper**
- **Sentinel Hawk**
- **Human Systems Integration Support for the Unmanned Aerial Systems**
- **MQ-X**





# HP Research, Analysis, and Consultation – Workload Analysis



- **Task Analysis Taxonomy (c. 2001)**
- **Front End Analysis**
  - MQ-1 Sensor Operator (2006)
  - MQ-1 Pilot (2006)
  - MQ-1 Sensor Operator - MAC (2008)
- **IMPRINT Pro UAS workload modeling**
  - UAS maintenance model (MQ-1 and -9)
  - UAS MAC MQ-1 model
  - UAS MAC MQ-9 model
    - Includes mission coordinator





# Remotely Operated Vehicle Adaptable Tracking/Training System (ROVATTS)



- Provides an affordable PC-based simulation capability with a reconfigurable architecture
  - Allows development of air-, ground-, or sea-based Unmanned Aerial Systems (UAS) simulations
  - The Predator simulator provides a realistic environment to support United States Air Force (USAF) research, individual/team training, and mission rehearsal applications



- 3 systems purchased by RHA
- 3 systems purchased by NY ANG

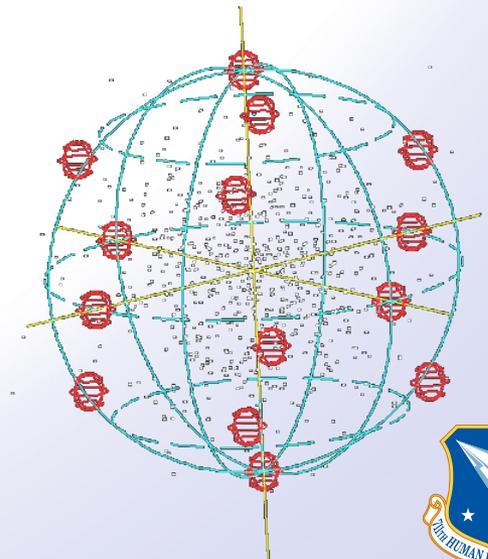




# Workstation Design Guidelines for Accommodations



- Approach developed 14 model points for Males and 14 model points for Females
- Down-selected to 8 suggested CASES for Predator by removing redundant model points
- The CASES selected are based on workstation design experience and evaluation and attempt to simplify the process
  - All of the model points should be reviewed to determine if any of them pose accommodation issues for specific designs
- 3 Principal Components are identified
  - PC 1 – Overall Size
  - PC 2 – Contrast of Torso Heights/Limb Lengths
  - PC 3 – Contrast of Torso Heights/Thigh Size





# 8 Suggested GCS CASES



## PREDATOR CASES: 99% Accommodation of 3 Principal Component Solution

Predator CASE NUMBER	Females (inches)				Males (inches)			
	1	2	3	4	5	6	7	8
Mathematical Model Point:	W1	W3	W6	W5	M6	M2	M4	M3
Thigh Clearance	4.8	5.6	5.7	6.4	7.0	5.6	7.4	6.0
Popliteal Height	13.3	16.2	15.0	14.0	17.5	19.0	20.2	17.4
Abdomen Depth	8.5	9.8	9.6	12.3	11.2	8.4	11.9	9.7
Buttock-Popliteal Length	15.7	19.6	17.5	18.5	20.0	20.1	22.1	18.1
Acromial Height, Sitting	20.2	19.9	24.8	21.4	21.1	23.7	26.6	26.5
Arm Length (Shoulder to Elbow)	10.5	12.8	11.8	11.5	13.6	14.3	15.3	13.0
Buttock-Knee Length	19.6	23.9	21.8	23.0	25.0	24.8	27.7	23.2
Elbow Height, Sitting	9.0	6.3	12.2	9.1	6.5	8.4	10.1	12.4
Eye Height, Sitting	27.2	27.5	32.2	28.4	29.1	32.3	35.3	34.7
Hip Breadth, Sitting	13.3	15.1	15.9	17.8	14.6	13.0	16.8	14.4
Knee Height, Sitting	17.1	20.7	19.5	19.0	22.3	23.2	25.5	21.8
Shoulder Breadth	15.0	16.3	16.8	17.5	19.5	17.4	21.2	18.8
Thigh Circumference Max Sitting	19.6	22.2	23.6	26.8	24.3	19.8	26.7	22.2
Thumb Tip Reach	25.3	29.8	28.1	27.9	32.5	33.2	36.2	31.2





# UAS Operator Selection/ Performance Improvement Study



- **Current: Build on existing research**
  - **selection & training effectiveness**
    - Assess applicants & provide medical & neuropsych recommendations
    - Collect and compare performance data
      - Traditional UAS crewmembers (cross-trained)
      - 1<sup>st</sup> Beta Test (Nov 08); 2<sup>nd</sup> Beta Test (Mar 09)
      - SUPT (Feb 09)
    - Define Mission Essential Competencies (Jun 09)
    - Assess IQT performance of various selection groups (Oct 09)
- **Way Ahead:**
  - Refine UAS operator selection tools (Jun 10)
  - Develop LVC applications for future training/assessment (Jul 10)



**ROI: Reduced attrition, improved retention,  
increased performance = more time on target**



**Combined 711 HPW execution: USAFSAM/ACS, 711 HPW/HP, and 711 HPW/RHA)**



# Efforts with UAS Units



- **FAST/Flyawake fatigue analysis of UAS operators at Houston ANG**
  - Anticipate extending this to the other ANG units
- **Assisting USAFSAM with a large multi-base fatigue/stress survey of UAS operators**
- **Head/Eye tracking study in UAS GCS**
  - Incorporate SSEV model into IMPRINT
  - Pre-planning phase





# 703 AESG Vision & Mission



**MQ-1  
Predator**



## VISION

*Enabling kill chain dominance  
through decisive UAS solutions  
...on time, on cost*

## MISSION

*Arm the warfighter with timely UAS  
solutions through a high  
performance team executing  
acquisition excellence in all we do*



**MQ-9  
Reaper**



# HSI Efforts with the 703rd



- **Most efforts focused on Ground Control Station**
- **Most efforts relate to HFE domain**
- **Informal consultation as needed**
  - Crew station accommodations design
  - GCS Seat Redesign
  - Consultation on evaluation methods
- **Developing MOA with 703<sup>rd</sup> to formalize efforts**
  - Human Systems Integration Plan
  - Human Readiness Level activity list development
- **Grow beyond GCS & HFE**
  - Other HSI domains





# 703<sup>rd</sup> HFE Related Efforts



# Evolution Through Human Factors Engineering



Focused Human Factors Engineering and Usability Testing





# Evolution of Ground Control Stations



**ACTD Legacy**



**Block 15**



**Block 30  
(2010; shown with Phase 2 SW in 2012)**



**Block 50 Advanced Cockpit (2012)**





# GCS Production and Retrofit Current and Near Future



## Block 15 (Current)



## Block 30 (2011)

Improved Displays, Linux
Seat Replacement
DNET HW
Integrated Sensor Control Suite HW
HD/SAR Dissemination HW

CLAMP HW
PPDL Kit
Multi-port payload extender
STORM console, rudder pedals
Upgrade all computers to common config (710)





# Ground Control Station (GCS) Crewstation Seat Replacement



- **Description:**  
Replace CGS crewstation seat for both pilot and sensor operator. The seat was previously demonstrated under the Advanced Cockpit Increment 2 Program.

- **Purpose:**  
Increase the usability, comfort, and safety of the GCS crewstation seat. 99% of crew population is targeted. 245 seat kits will be delivered.

**SAMPLE**



## Program Schedule

Event	FY09	FY10	FY11	FY12	FY13	FY14	FY15
Contract Award		▲					
Usability Testing	Already been completed						
Acceptance Testing		▲▲					
Production Delivery			▲————▲				

**IOC: July 2010**

**FOC: 1QFY11**





# STORM: Safety, Technical, Operational, Reliability, and Maintenance



- **Description:**  
Replace the two legacy Command and Status screens with a console that contains one touch screen Command and Status, HOTAS, and keyboard.

- **Purpose:**  
Increase the usability and comfort by giving the pilot and sensor operator easier access to the Command and Status and HOTAS. Allows the other displays to be moved down.

## Program Schedule

Event	FY09	FY10	FY11	FY12	FY13	FY14	FY15
Contract Award		▲					
Usability Testing	Already been completed						
Acceptance Testing		▲▲					
Production Delivery			▲————▲				



**IOC: Oct 2010**

**FOC: 4QFY12**





# Rudder Petals



- **Description:**  
Replace pilot and sensor operator Rudder Petals with adjustable Rudder Petals.

- **Purpose:**  
Increase the usability and comfort of the GCS workstation. Helps to accommodate larger population of crew-members.

## Program Schedule

Event	FY09	FY10	FY11	FY12	FY13	FY14	FY15
Contract Award		▲					
Usability Testing	Already been completed						
Acceptance Testing		▲▲					
Production Delivery			▲————▲				

**IOC: Oct 2010**

**FOC: 40FY12**





# Upgrade HOTAS: Hands on Throttle and Stick and Stick



- **Description:**  
Throttle used for take-off and Landing.

- **Purpose:**  
Increase the pilots ability to fly the aircraft mainly during take-off and landing. Increase comfort and grip.



## Program Schedule

Event	FY09	FY10	FY11	FY12	FY13	FY14	FY15
Contract Award		▲					
Usability Testing	Already been completed						
Acceptance Testing		▲▲					
Production Delivery			▲	▲			

**IOC: Oct 2010**

**FOC: 40FY12**





# Ergonomic Display Assembly and Console (EDAC)



- **Description:**  
Frame with improved displays. Upgraded software architecture that is moving towards open systems architecture.

- **Purpose:**  
Increase the ergonomics, usability, comfort, and safety of the GCS. Optimize reach to touch-screens. Move towards open systems architecture and maximized commonality.



## Program Schedule

TASK	2010				2011				2012				2013				2014			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Phase 2 Block 50																				
MQ-1 Block 50 Prototype	[Contract Execution]																			
Block 50 GMod Phase 2 Final Dev	[Contract Execution]																			
Block 50 GMod Phase 2 Retrofit - LRIP																				
Block 50 GMod Phase 2 Retrofit - Full Rate Bse																				

◆ Milestones      [Blue Bar] Contract Execution

**IOC: TBD**

**FOC: N/A**

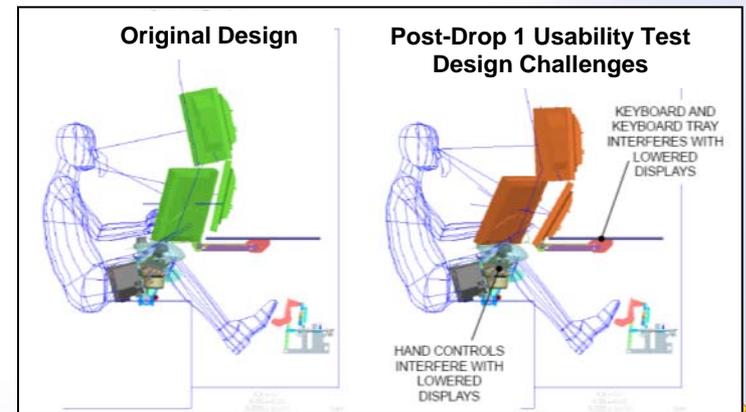
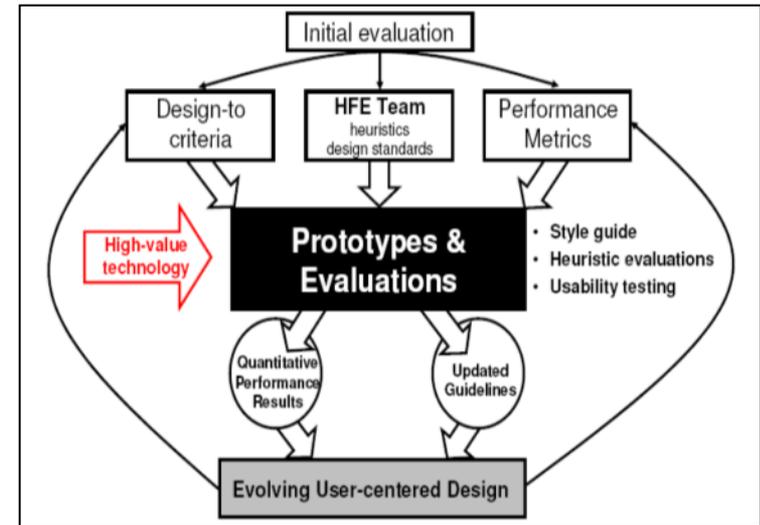




# Usability Assessments



- **Task scenarios/vignettes**
  - Daily use – common tasks
  - Necessary use – infrequent but critical tasks
- **Cognitive walkthroughs with users**
  - Utilize scenarios, vignettes, prototype
- **Target assessment of high-value technology**
- **Two formal assessments completed**
  - Significant feedback obtained



Usability Test Questions	EDAC Workstation Mean
9 Pilots asked during formal usability process (1-5; the higher the number the more comfortable)	
Overall, how would you describe the ENTIRE workstation environment?	<b>4.78</b>





# Multi-Aircraft Control (MAC)



- **Description:**  
Allow one pilot to fly multiple aircraft during different types of operations, including transit ops, benign ops, and dynamic ops.

- **Purpose:**  
Decrease the number of personnel needed to meet the CAPs requirements.



## Program Schedule

**Legacy MAC prototype fielded (8001)**

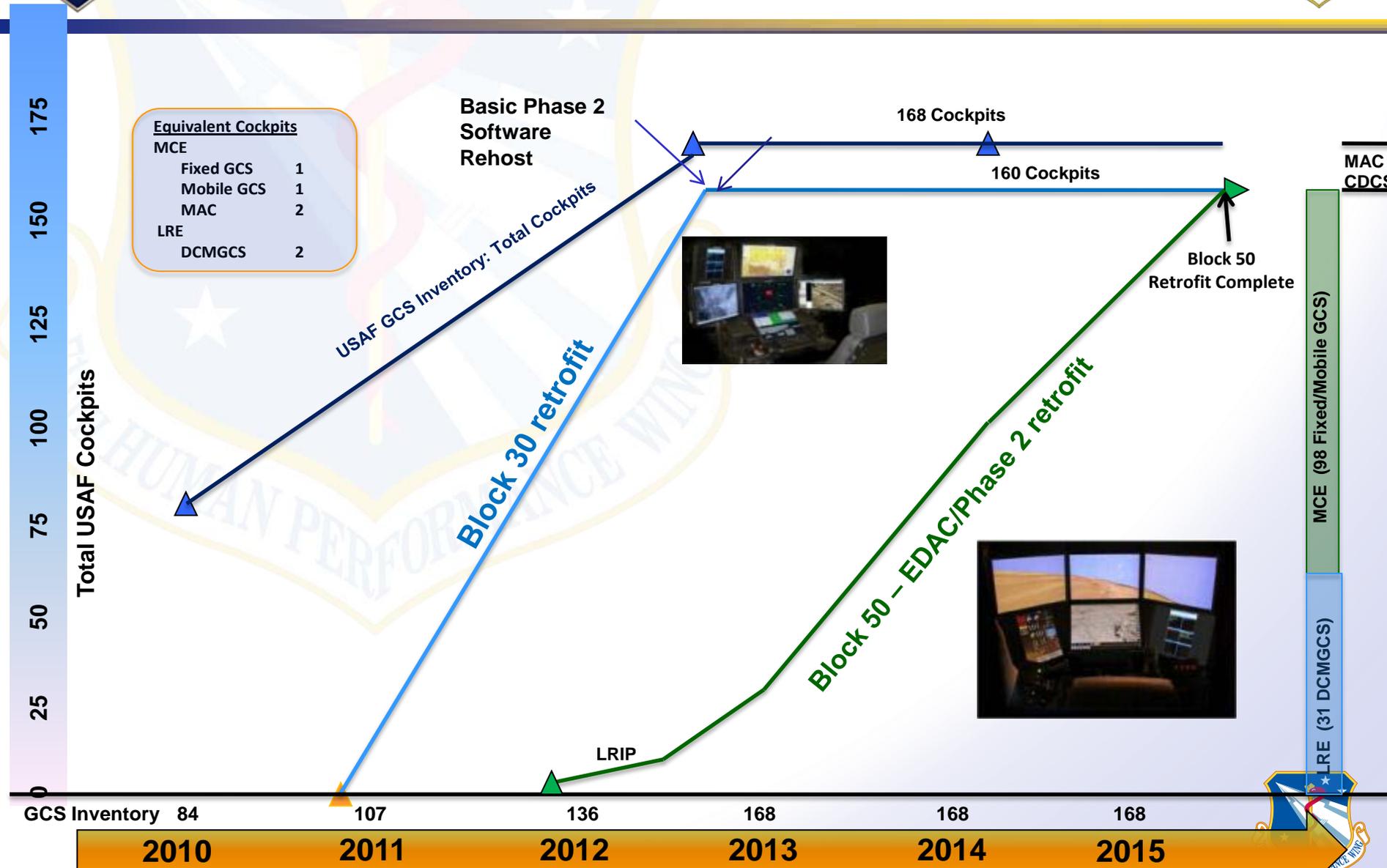
- Intended as Tactical Mission Manager & Benign ISR Manager
- MQ-1 only
- Quick-reaction capability; 9 months

**Updated Legacy MAC in development (8002)**

- Field Aug 2010; minor updates
- MQ-1 only



# GCS Modernization Roadmap





# Training Simulator (PMATS)



- **Training is vital to improving warfighter effectiveness**
- **Efforts to improve concurrency working**
- **Every new capability requires training upgrade**
  - Must institutionalize into core program processes
  - ROMs, schedules, software development practices
- **703 AESG will continue to manage system-wide priorities with user community**
- **Continuous improvement required to reduce PMATS impacts**
  - Process and technical
  - Monthly 703d/677th/GA-ASI/L3 tag up





# The Multiple Aircraft Control (MAC) Challenge



## 1 MIND, 1 MISSION (SINGLE AIRCRAFT CONTROL)

### DESCRIPTION

- Pilot and sensor operator prosecute dynamic targets

**1 Pilot 1 SO  
1 UAV: Full Msn**



- 1 Pilot, 1 UAV (current MQ-9)
- 1 Pilot performs

### ASSUMPTIONS

- High threat environment
- Supervisory control
- Dynamic targets
- Weapon effects
- Collaboration with other UAVs (air and ground)
- Retention of

## TRANSIT MANAGER (MAM)



Does this (Mission Control Element) MC

### DESCRIPTION

- Operator who controls multiple UA to/from base and op area

**1 Operator  
n UAVs: Enroute Only**

## BENIGN OPS MANAGER

- 1 Pilot, nUA, nSO (current MAC)
- 1 Pilot-mind, multiple missions

### DESCRIPTION

- Pilot controls multiple UA assigned to static/benign ISR tasks

**1 Operator  
n UAVs: Benign Ops**

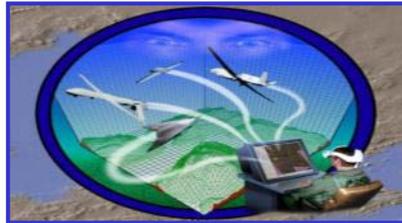
### ASSUMPTIONS

- Air superiority/airspace control
- High-level coordination
- MAM responsible for navigation
- Fused SA
- Multiple UAs
- Globally distributed management

### ASSUMPTIONS

- Air superiority/benign environment
- Sensor priority (vs other UAs)
- Adjustable autonomy ('pilot extender')
- Pilot responsible for navigation, & coordination of UA potentially assigned different missions
- GDMM for agile human-machine goes dynamic

## X-CS: 1 MIND, MULTIPLE MISSIONS (MULTIPLE AIRCRAFT CONTROL)



### ASSUMPTIONS

- Selectively autonomous UAS capable of intelligent collaborative engagement ('man-on-the-loop')
- Some level of swarm capability
- 'Play-book' engagements
- GDMM
- Automated target recognition

### DESCRIPTION

- Network of UAS operators, each immersed in virtual reality controlling multiple aircraft with varying capabilities (hypersonic, sub-sonic mix etc) in the prosecution of multiple targets in geographically dispersed areas

### RISKS/HSI UNKNOWNNS

- Human capabilities/limitations wrt control of multiple autonomous systems
- State of technology for immersive environments and human-computer interaction
- Ethico-legal issues of autonomous weapons systems

**1 Operator  
n UAVs:  
Full Mission with Dynamic Ops**





# MAC Issues



- **What will pilot reduction rate can REALLY be achieved?**
  - What areas of mission profile allow MAC?
  - Optimization of RPAs versus pilots
  - Handoff issues – time to get SA
- **What effect will this have on the MPT issues**
  - Greater skill levels for MAC operation
    - Longer training, fewer available applicants
  - Greater stress, lower retention
- **Technologies required for effective MAC**
  - Automation





# Conclusions



- **The UAS challenge is being addressed, has many planners and is resource-limited**
- **Must continue to identify R&D and other support efforts relating to UAS**
  - **Keep abreast of ongoing UAS work**
    - **Avoid duplication**
    - **Develop collaborations**
    - **Create symbiotic efforts**
  - **Extract necessary information that can be used for Acquisitions**
    - **Design Guidelines**
    - **Evaluation Criteria**





# HP UAS Related Publications



- **U.S. Military Unmanned Aerial Vehicle Mishaps: Assessment of the Role of Human Factors Using Human Factors Analysis and Classification System (HFACS), HSW-PE-BR-TR-2005-0001**
- **Effects of Shift Work and Sustained Operations: Operator Performance in Remotely Piloted Aircraft (OP-REPAIR), HSW-PE-BR-TR-2006-0001**
- **The Development of Empirically based Medical Standards for Large and Weaponized Unmanned Aircraft System Pilots, HSW-PE-BR-TR-2006-0004**
- **Human Factors Considerations in Migration of Unmanned Aircraft System (UAS) Operator Control, HSW-PE-BR-TR-2006-0002**

<http://www.wpafb.af.mil/afri/711hpw/hpi.asp>





# Questions?

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