Human Factors of UAVs Workshop 2007

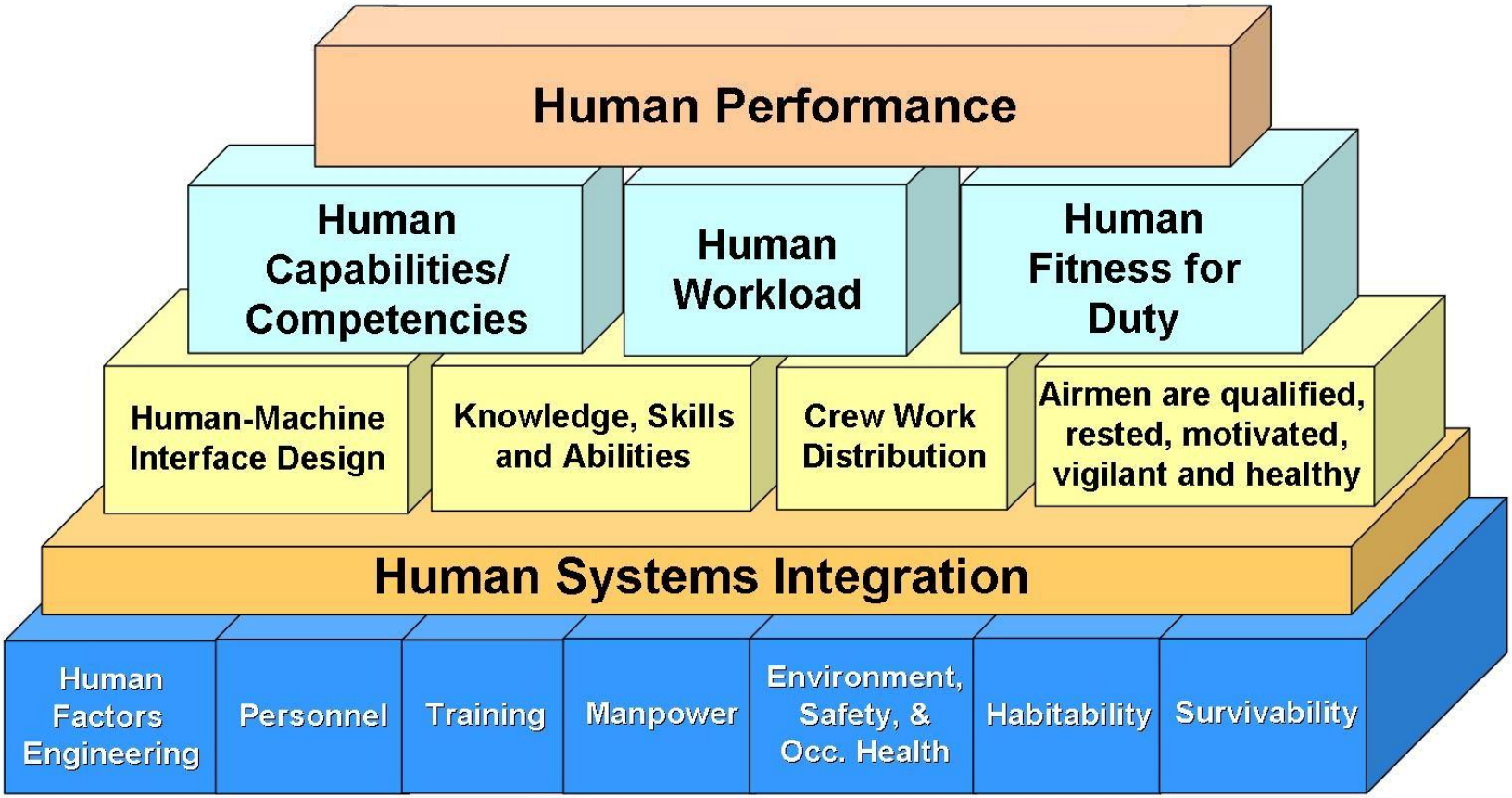
Birthplace, Home and Future of Aerospace Medicine

U.S. AIR FORCE

Development of Empirically-based Medical Standards for Unmanned Aircraft System (UAS) Pilots

Maj Anthony P. Tvaryanas
311 HSW/PER
(210) 536-4446
anthony.tvaryanas@brooks.af.mil

Human performance & HSI



HSI is the process model for human performance

To what standard should we certify our UAS pilots?

Occupational medicine standards

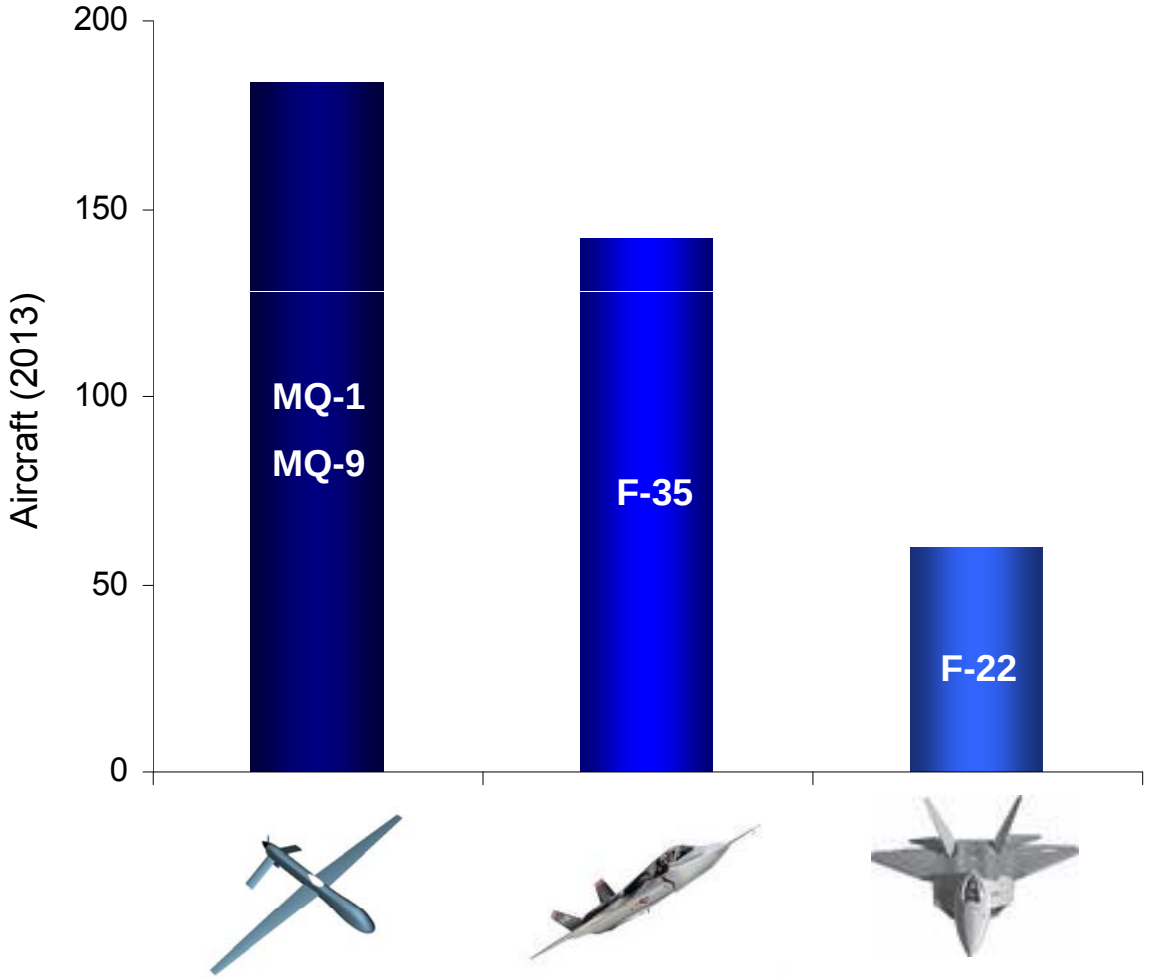
Task environment – determine job essential tasks

- Accommodation

Public safety – safety-sensitive jobs

- Risk for incapacitation/degraded performance

Changing human performance challenges

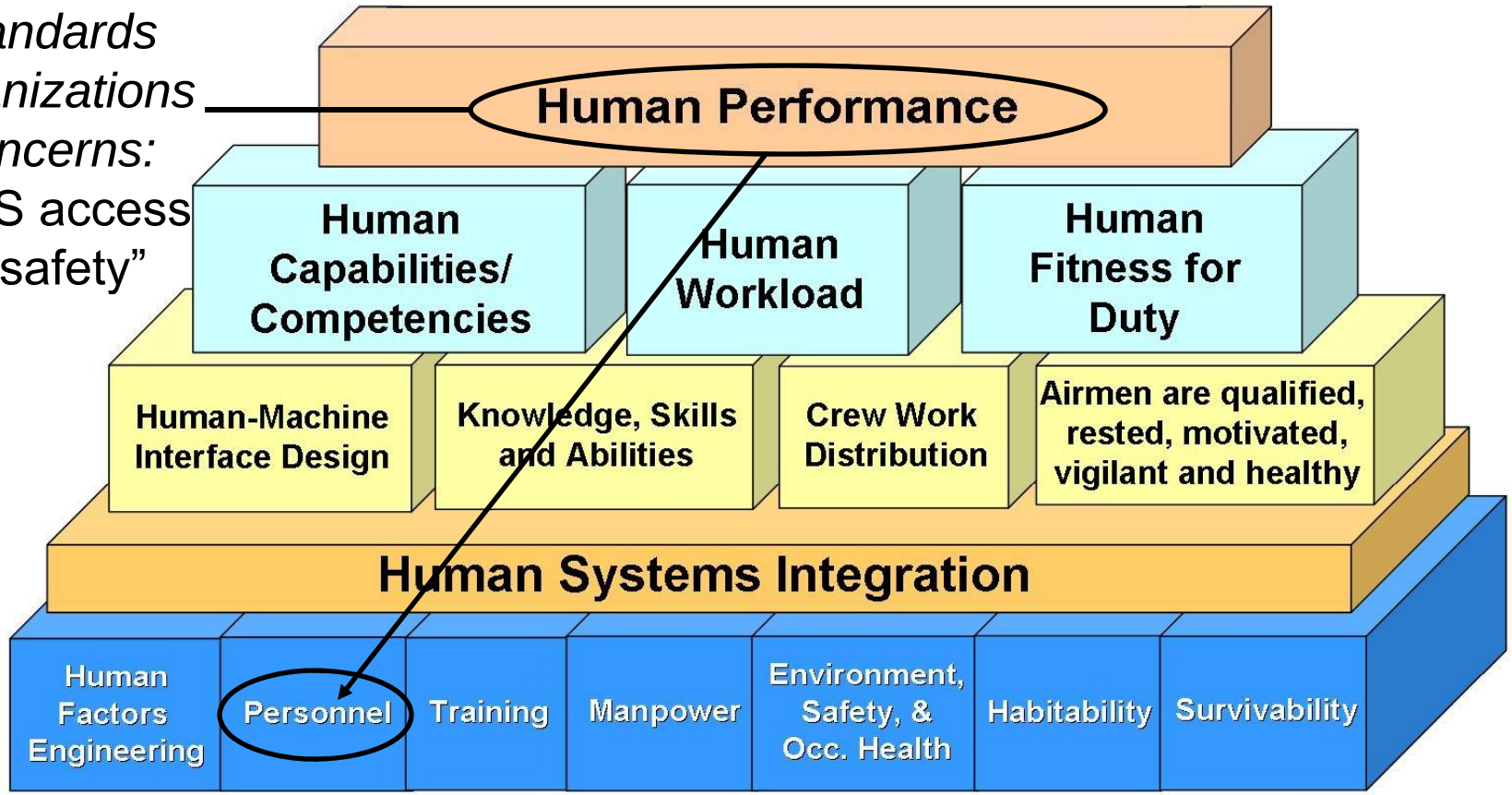


“The qualifications and status of remotely piloted vehicle operators are among the most controversial aspects of remotely piloted vehicle development… Opinions about who should be future…operators range anywhere from the man off the street to a highly qualified pilot with engineering background.”

-- Kiggans, 1975

Problem statement…

Regulatory & standards organizations concerns:
"NAS access & safety"



Certification standards

UAS-O aeromedical standards

FAA approach – make unmanned fit into manned aviation paradigm

- Certification criteria based on intent of flight (e.g., private, comm, airline)
- Doesn't address task environment

DoD approach – make unmanned fit into some other occupational grouping

- Certification criteria based on correlations (e.g., pilot, ATC, enlisted aircrew)
- Doesn't address task environment

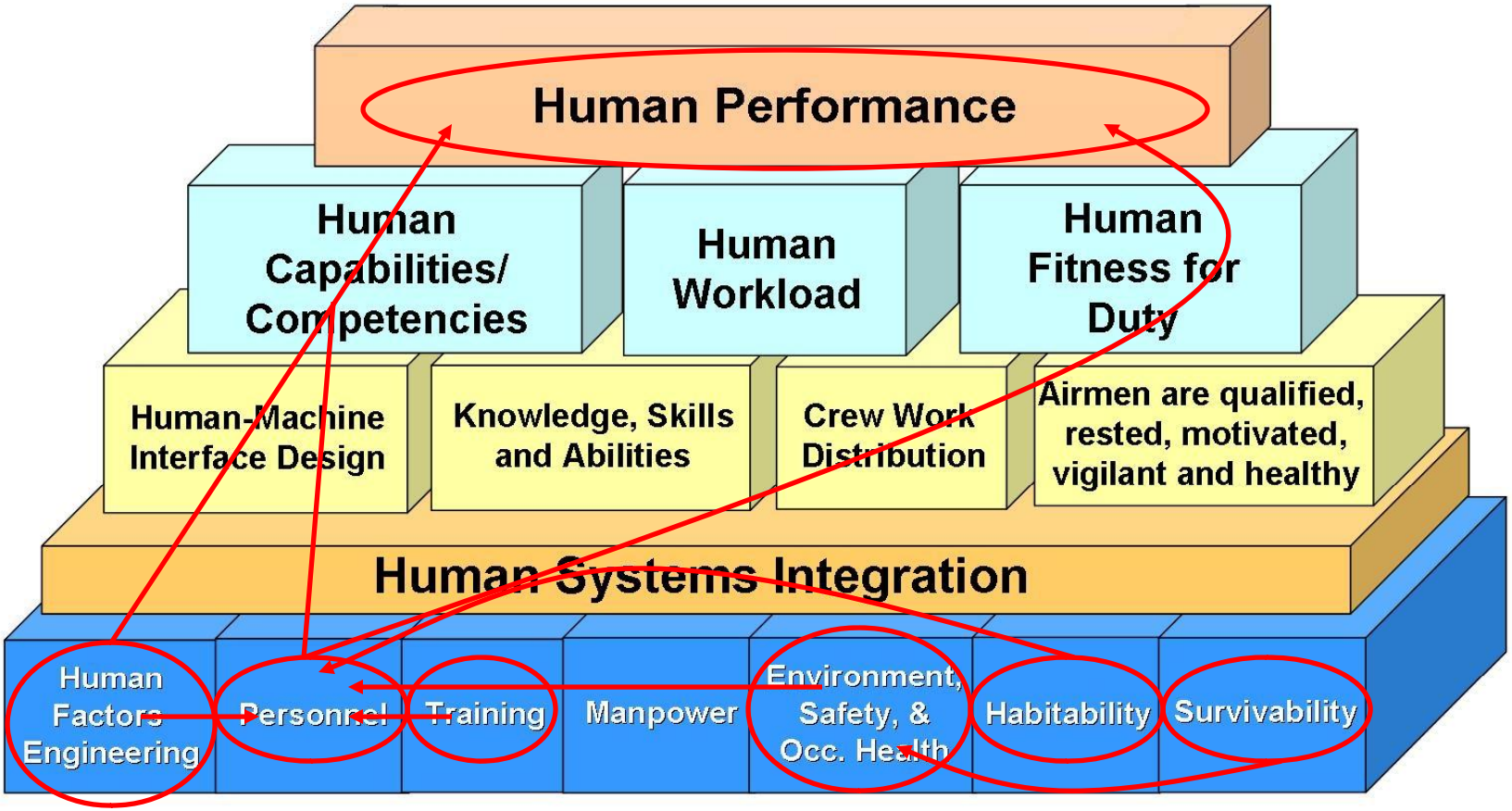
UAS-O task environment

TABLE 1. COMPARISON OF AEROSPACE MEDICINE HUMAN FACTORS CONCERNS FOR MANNED AIRCRAFT (MA) VERSUS REMOTELY PILOTED AIRCRAFT (RPA) CREWMEMBER PERFORMANCE.

Factors	MA	RPA†	Factors	MA	RPA†
Physical environment	+	+	Adverse physiological states	+	+
Vision restricted (clouds, ice, etc.)	+	+	Effects of G-forces	±	0
Noise & vibration	+	±	Prescribed drugs	+	+
Windblast	+	0	Sudden incapacitation	+	+
Thermal stress	+	±	Pre-existing illness or injury	+	+
Maneuvering forces	+	0	Physical fatigue	+	+
			Mental fatigue	+	+
Technological environment	+	+	Circadian desynchrony	+	+
Seating & restraints	+	0	Motion sickness	+	±
Instrumentation	+	+	Hypoxia & hypobarics	+	0
Visibility restrictions (e.g., FOV)	±	+	Visual adaptation	+	±
Controls & switches	+	+	Physical task oversaturation	+	+
Automation	+	+			
Personal equipment	+	0			

Tvaryanas AP. Human systems integration in remotely piloted aircraft operations. *Aviat Space Environ Med* 2006; 77(12):1278-1282.

Aeromedical certification HSI analysis



UAS-O aeromedical standards issues

Implement lessons learned from manned aviation → occupational standards decrease mishaps

Because the operator is not co-located with the aircraft in unmanned aviation, aircraft characteristics are not necessarily correlated with human performance (HP) concerns

- Control interface environment drives human performance issues
- Enormous variability in unmanned control interface environments compared to manned aviation

Because UAS are very heterogeneous, some HP requirements may be different, but there should be a consistent certification process

Everyone should be reasonable in UAS operator certification requirements

- If the UAS is intended to be cheap and expendable, then it obviously cannot be designed and built to the rigid standards required for routine flight in the NAS; operator certification requirements should likewise be less stringent

Putting the UAS spectrum into an occupational medicine context…

Task environment

ATC

Manned aviation

External pilot

Internal pilot

Multi-aircraft control

Putting the UAS spectrum into an occupational medicine context…

FQM 151 *Pointer*

Scan Eagle

Putting the UAS spectrum into an occupational medicine context…

Putting the UAS spectrum into an occupational medicine context…

Pilot

Sensor operator

MQ-1 *Predator* MAC GCS

1) Is there a universal set of aptitudes? No

2) Are there common task subsets? Yes

Task environment

Non-cockpit work station (heterogeneous task set)

Cockpit control station (homogeneous task set)

High-level supervisory control

ATC

Manned aviation

External pilot

Internal pilot

Multi-aircraft control

PROPOSED

Reasonable UAS-O certification levels

UAS control station	Airspace		
	National air space	Active restricted or combat zones	Expendable UAs in restricted or combat zones
High-level supervisory control	1	1	3
Cockpit control station (homogenous task set)	2	2	3
Non-cockpit work station (heterogeneous task set)	2	3	3

Doesn't exist

AF rated

AF non-rated

Level 1 – certify to standards equivalent to ATC tailored for UAS

Level 2 – certify to standards equivalent to manned systems tailored for UAS

Level 3 – certify to minimum aptitude requirements for the system

Risk approach derived from RCC 323-99, *Range Safety Criteria for Unmanned Air Vehicles*

PROPOSED

Establishing UAS-O performance thresholds

Levels 1 & 2:

Assertion: Certify operator to same reliability level as other system components

Predator airworthiness certification: Catastrophic failure rates no worse than 10^{-5} per flight hour

Assuming UAS operator has 8,760 potential flight hours/yr:

8.8% annual risk for incapacitating event

Is high-level automation a mitigating factor?

Level 3: ???

PROPOSED

Level 2 UAS-O aeromedical standards

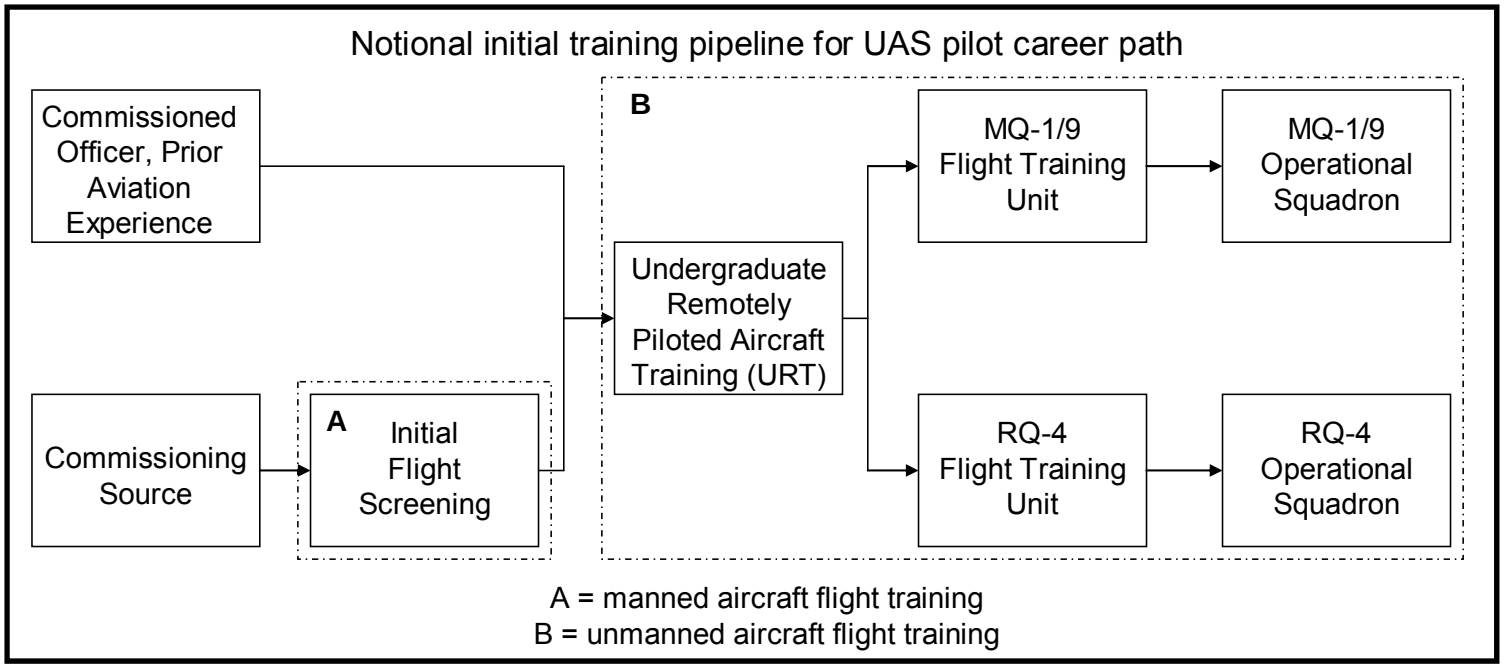
PROPOSED

Level 2 UAS-O aeromedical standards

HSW-BR-TR-2006-0004

Purpose:

AF/A3OT inquiry on appropriate medical standards for proposed UAS pilot career field (abandoned)



PROPOSED

Level 2 UAS-O aeromedical standards

Methods:

New Performance Planning Front End Analysis (NPP FEA) → tool for analyzing new jobs because of introduction of new technology

- Major accomplishments → associated tasks

USAFSAM/FEP expert panel → standards developed through consensus of panel members based on:

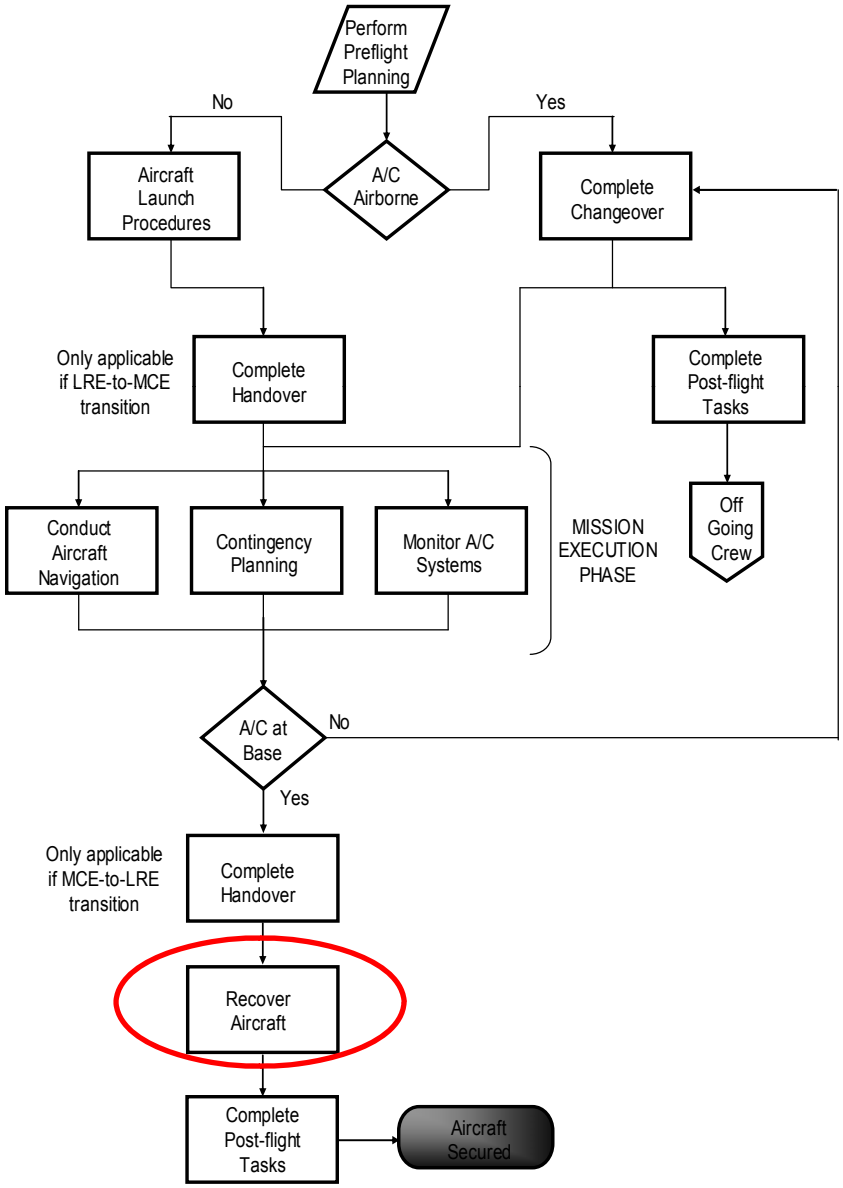
- Physical demands of GCS task environment
- Likelihood of medical condition to predispose to sudden incapacitation
- Likelihood of medical condition to cause undue distraction and /or degrade performance

Results:

NPP-FEAs → pilot tasks and workflow

PROPOSED

Generic high-level UAS pilot workflow



PROPOSED

KSA sample – recover aircraft

Recover aircraft	Time required (hrs): 0.1-0.75	
Knowledge	Skills	Aptitudes
(1) Aerodynamics and principles of flight relating to an unmanned aircraft's flight characteristics and performance in normal and abnormal regimes; (2) Principles and functions of unmanned aircraft systems and powerplants; (3) Procedures for operating the instruments, equipment, and imbedded software programs in the make and model of GCS used to control the unmanned aircraft, including operation of LOS or satellite datalinks and recognition of datalink integrity; (4) Aircraft weight and balance, use of charts, graphs, tables, formulas, and computations, and their effect on aircraft performance; (5) Use of aeronautical charts; (6) Procedures for operating within the National Airspace System under VFR, IFR, or both; (7) Air traffic control system and radio communication procedures, including appropriate phraseology; (8) GPS fix-to-fix navigation and GLS approaches; (9) Recognition of critical weather situations, and the procurement and use of aeronautical weather reports and forecasts; (10) Safe and efficient operation of unmanned aircraft, including methods of collision avoidance; (11) Aeronautical decision making and judgment; (12) Human factors; and (13) Crew resource management to include crew communication and coordination.	(1) Comply with air traffic control clearances and procedures; (2) Navigation; (3) Proficiency in monitoring or performing maneuvers and procedures as required for the make and model of GCS used to control the unmanned aircraft: (i) Maneuvers by reference to sensor imagery (optical or infrared), instruments, or both; (ii) Airport traffic patterns, to include area arrival, entry into the traffic pattern, and approach; (iii) GLS approaches to the landing area; (iii) Approaches to the landing area with simulated engine malfunctions; (iv) Landings, including normal and cross-wind; (iv) Go-arounds; (v) Taxi or surface operations; (vi) Special operations, to include night, cold, and hot weather recoveries; (4) Complete appropriate checklists; (5) Emergency procedures and equipment malfunctions; and (6) Recognize datalink loss and take appropriate action. .	(1) Input-output (i) Oral comprehension (ii) Written comprehension (iii) Oral expression (2) Sensory (i) Visual (a) Near vision (b) Far vision* (c) Visual color perception (ii) Auditory (a) General hearing (b) Auditory attention (3) Perception (i) Conceptual (a) Problem sensitivity (b) Selective attention (c) Spatial orientation (4) Motor (i) Fine motor (a) Control precision* (b) Rate control* (c) Finger dexterity (d) Manual dexterity

*Dependent of GCS control input/output devices

PROPOSED

Level 2 UAS-O aeromedical standards

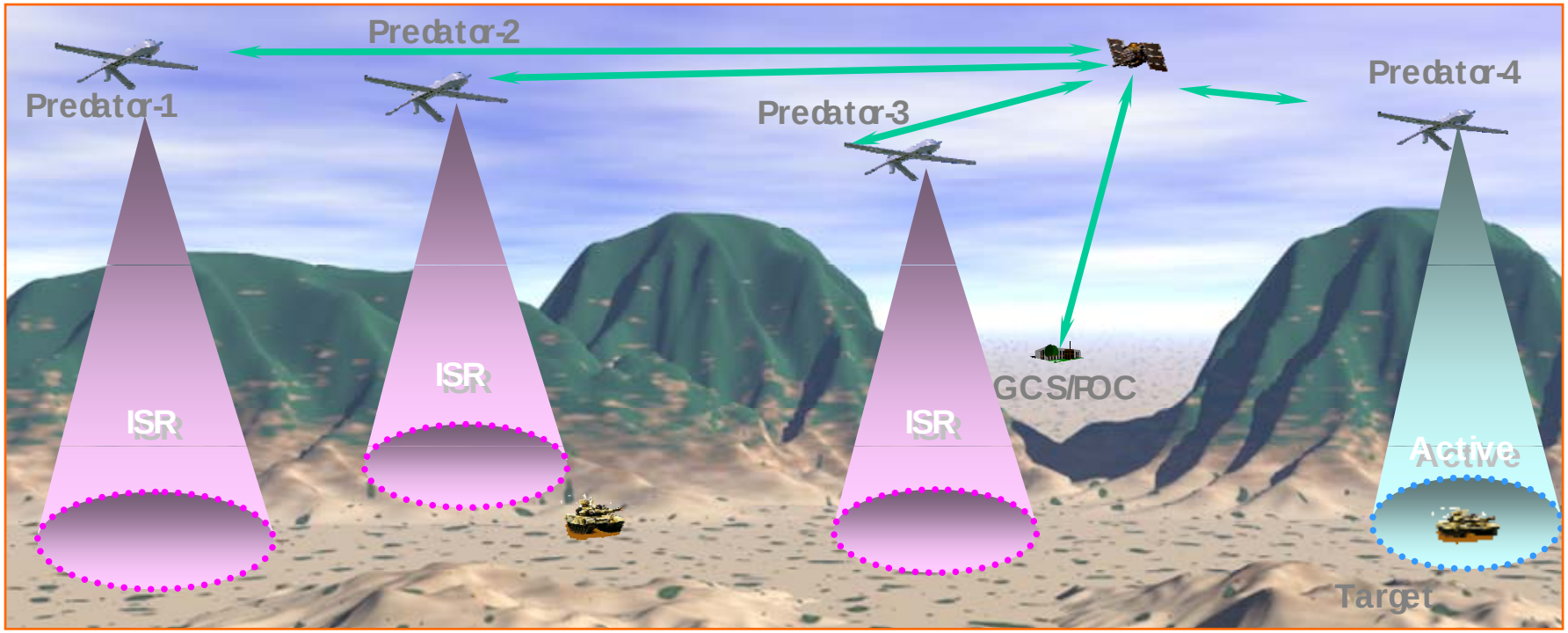
Results:

1. Job essential tasks of UAS pilot ≈ manned pilots, but work environments fundamentally differ

2. Work environment of ground-based controller (GBC) ≈ UAS pilot, but job essential tasks fundamentally differ
   - Performance decrements more concerning for UAS pilot *vs.* GBC (layers of defense)

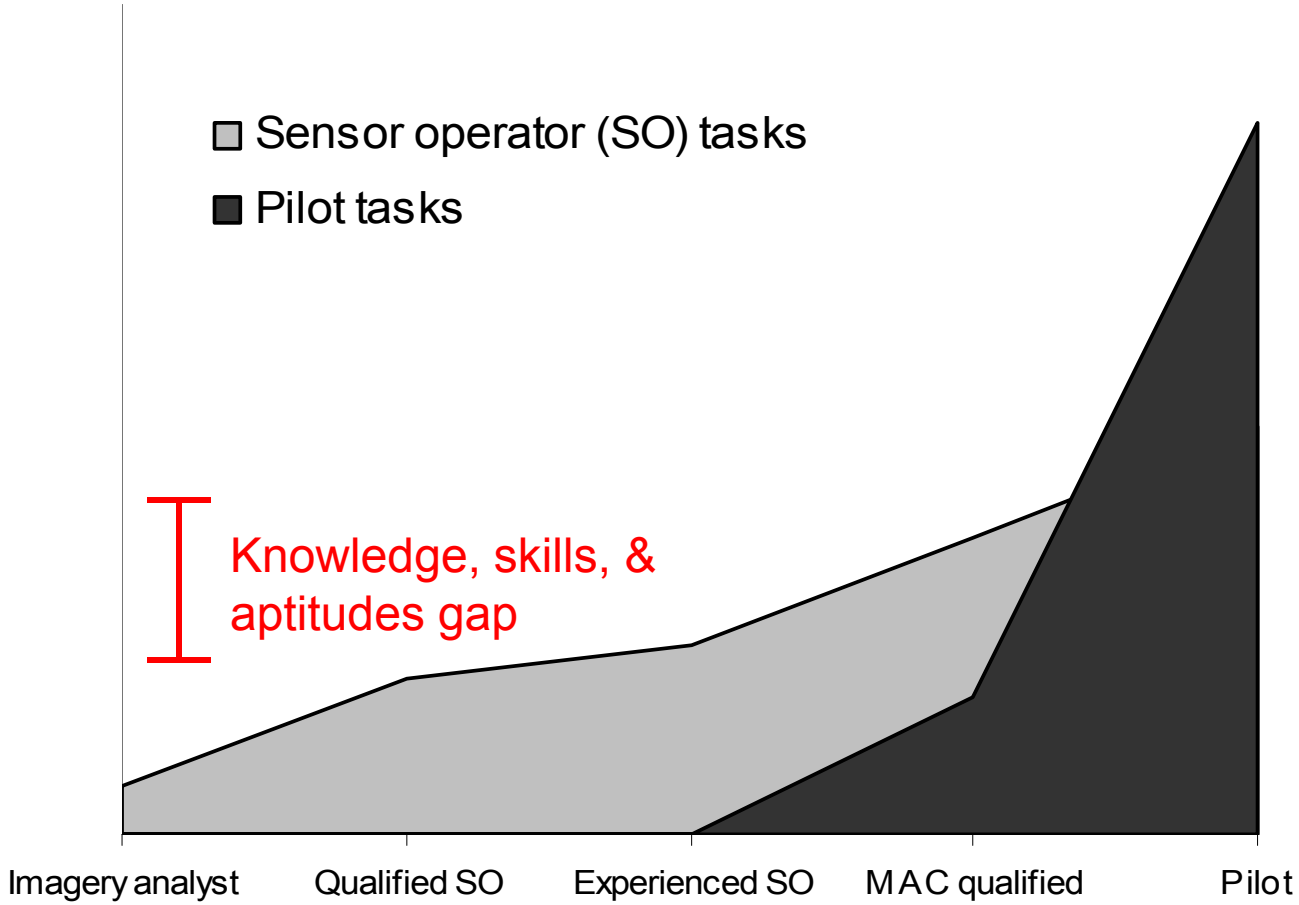
3. Relative to GBC standards, recommended UAS pilots standards emphasized:
   - Visual
   - Cardiac
   - Neurologic
   - Psychiatric

Future certification controversies



MAC & “pilot extenders”

Notional summary of Predator pilot and sensor operator (SO) task analyses…



Nagy JE, Guenther L, Muse K, et al. *USAF UAS performance analyses: Predator sensor operator front end analysis report.* Wright-Patterson AFB, OH: Survivability/Vulnerability Information Analysis Center (SURVIAC); 2006 Jun.

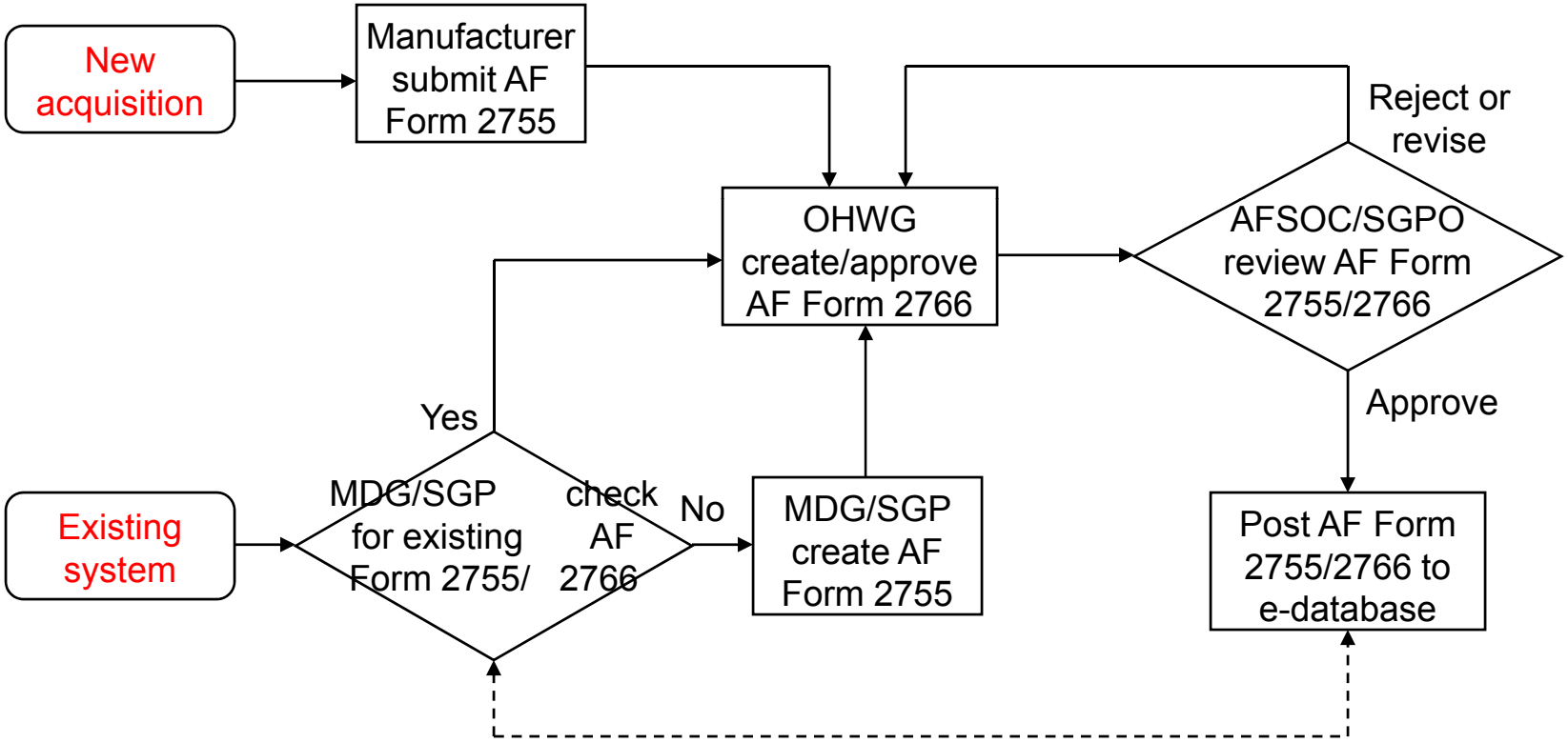
Questions

PROPOSED

Level 3 UAS–O aeromedical standards

PROPOSED

Level 3 UAS–O aeromedical standards



PROPOSED

UAS-O aeromedical certification process

Certification level	Level 1	Level 2	Level 3
Standards OPR	AF/SGOP	AF/SGOP	AFSOC/SGOP
Standards development	ASWG	ASWG	OHWG
Standards documentation	AFI 48-123	AFI 48-123	AF Form 2766
Medical recommendation	AF Form 1042	AF Form 1042	AF Form 422
Waiver authority	MAJCOM	MAJCOM	MDG/SGP
PCM	FSO	FSO	PCO