

Unmanned Aerial Vehicle System Acquisition Cost Estimating Methodology

**Cost Research in Support of the
Deputy Assistant of the Army for
Cost and Economics
(DASA-CE)**

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Outline

- Objective
- Approach
- Database Development
- Methodology Development
- Summary

Objective

- Develop top-level performance-based UAV system acquisition cost estimating methodology
 - Applicable to broad range of UAV system classes
- Ensure methodology supports early Future Combat System (FCS) cost estimating
 - Must rely upon basic technical and programmatic inputs known to Army analysts today

Approach

- Collect, compile, and analyze cost/technical data from active and historical UAV programs
 - US Army, Navy & Marine Corps, Air Force, and Coast Guard
 - Subcontract support from Adroit Systems, Inc
 - UAV experts (planners, users, technologists)
 - Provide technical support to OSD
 - Deputy for the UAV Planning Task Force (Mr. Dyke Weatherington)
 - UAV Roadmap
- Develop statistically-based, top-level CERs for development and production hardware and support cost elements.
 - performance-based relationships
 - physical design-based relationships

Approach (cont.)

- “*Know your audience*” ...Our approach directly considers the users of our results
- Used the Army FCS Unit of Action Systems Book prepared by US Army Materiel Systems Analysis Activity (US AMSAA) to identify candidate explanatory variables
 - Only basic performance and weight goals are known
 - Detailed, lower level hardware specifications are still being scoped
- Our data collection and analysis recognizes the types of descriptive information available for cost estimating
 - Methodology does not depend upon detailed input parameters or not yet known
- Following slide provides table outlining FCS UAV quantitative measures

Approach (cont.)

Database of Army FCS UAV Objectives

Class	Block	Echelon	Platform Type	Gross Weight <i>lbs</i>	Payload Weight <i>lbs</i>	Operational Altitude <i>ft</i>	Endurance <i>hrs</i>	Range <i>km</i>	Cruise Speed <i>kph</i>	Maximum Speed <i>kph</i>	Transport	Payload (1)	Payload (2)
I	I	Platoon	VTOL	10	2	500	1	8	60	80	manportable	EO/IR (320x240)	
I	II	Platoon	VTOL	10	3	500	1.5	16	80	100	manportable	EO/IR (640x480)	LRF
II	I	Co/Plt	VTOL	160	40	1,000	2	16	80	100	3 per HMMWV	EO/IR (640x480)	Acoustic
II	II	Co/Plt	VTOL	160	40	1,000	5	30	100	140	3 per HMMWV	EO/IR (640x480)	Acoustic
III	I	Battalion	Fixed Wing	300	75	1K - 2K	6	40	140	200	4 per FMTV	EO/IR (640x480)	GMTI Radar
III	II	Battalion	deployable wings	300	75	1K - 2K	6	40	200 TBD		16 per box	EO/IR (640x480)	GMTI Radar
IV a	I	Brigade	VTOL	1,000	250	6,500	5	75	100	135		EO/MWIR	SAR/GMTI
IV a	II	Brigade	VTOL	4,000	250	6,500	5	75	150	200		EO/MWIR	SAR/GMTI
IV b	I	Brigade	Fixed Wing	4,000	400	10K-20K	24	150	200	300		EO/MWIR	SAR/GMTI
IV b	II	Brigade	Fixed Wing	4,000	400	10K-20K	24	150	200	300		EO/MWIR	SAR/GMTI

Database Development Organizations Contacted

Gov't Cost Agencies

DASA-CE
OSD CAIG
NCCA
AFCAA
MARCORSYSCOM
NAVAIR
IDA

Contractors

AeroVironment
BAI
Bell
Boeing
General Atomics
Northrop Grumman
...and Others

Gov't Program Offices

JTUAV Program Office
Shadow 200
Outrider
Hunter
Predator PO
Global Hawk PO
PMA-263
Fire Scout
Pioneer
Pointer
MRUAV
Eagle Eye demo
CL-327 demo
USCG Deepwater PO

Database Development

UAV Cost Data Collected

	Platform	Contractor Cost Rept.	Contractor Acct Rec's	Historical Budget	Contract	Program Documents	Proposal	Cost Study	Open Sources	Estimates
Primary	Dragon Eye		X		X	X			X	X
	Fire Scout		X			X			X	
	Global Hawk	X				X		X	X	X
	Hunter	X				X			X	X
	Outrider	X	X			X			X	X
	Pioneer			X	X		X		X	
	Predator	X		X		X			X	
	Pointer								X	
	Shadow 200	X		X		X				X
Secondary	Camcopter 5.1								X	
	Compass Cope	X	X			X				
	Desert Hawk					X			X	
	Eagle Eye	X			X	X				X
	SkyEye			X	X			X		
	Ugglan Owl								X	
Other	Amber I			X	X			X	X	
	Aquila	X						X	X	X
	Cypher II				X				X	
	MR UAV	X			X	X				X
	Vigilante								X	X

Database Development

UAV WBS } CES

1	UAV SYSTEM
1.1	AIR VEHICLE
1.1.1	AIR VEHICLE OTHER
1.1.2	I&A AIR VEHICLE
1.1.3	AIRFRAME
1.1.4	PROPULSION
1.1.5	AVIONICS
1.1.5.1	COMMUNICATION / IDENTIFICATION
1.1.5.1.1	1-UHF
1.1.5.1.2	2-Ku
1.1.5.1.3	3-na
1.1.5.1.4	OTHER COMM/ID
1.1.5.2	NAVIGATION/GUIDANCE
1.1.5.3	OTHER AVIONICS
1.1.6	AUXILIARY EQUIPMENT
1.2	PAYLOAD
1.2.1	1-EO/IR
1.2.2	2-SAR
1.2.3	3-OTHER PAYLOAD
1.3	NONRECURRING ENGINEERING-AIR (NRE-A)
1.4	CONTAINER
1.5	GROUND SEGMENT
1.5.1	GROUND CONTROL STATION (GCS)
1.5.2	GROUND DATA TERMINAL (GDT)
1.5.3	LAUNCH & RECOVERY EQUIPMENT
1.5.3.1	LAUNCH EQUIPMENT
1.5.3.2	RECOVERY EQUIPMENT
1.5.3.3	OTHER LRE
1.5.4	OTHER GROUND
1.5.5	NONRECURRING ENGINEERING-GROUND (NRE-G)
1.6	TEST & EVALUATION
1.7	SEPM
1.8	DATA
1.9	TRAINING
1.10	SUPPORT EQUIPMENT
1.11	SPARES
1.12	TOOLING
1.13	OTHER SUPPORT

- *No UAV standard WBS*
- *Cost reporting reflected at varied WBS/CES configurations*
- *Limited data at lower levels required us to grouping*

UAV SYSTEM
HARDWARE
AIR HARDWARE
RECURRING
AIR VEHICLE
SENSOR
NONRECURRING
GROUND HARDWARE
RECURRING
NONRECURRING
TEST & EVALUATION
SE/PM, TRAINING, DATA, OTHER SUPPORT
CONTAINER
SPARES

Methodology Development Overview

- Developed 3 performance-based CERs
 - Air Vehicle
 - Sensor
 - Ground System & Equipment
- Developed 3 weight-based CERs
 - Air Vehicle
 - Sensor
 - Ground System & Equipment
- Developed 3 additional CERs
 - Test & Evaluation
 - SE/PM plus
 - Containers
- Developed 6 additional factors
 - NonRec Air Hardware, Development
 - NonRec Air Hardware, Procurement
 - NonRec Ground Hardware, Development
 - NonRec Ground Hardware, Procurement
 - Spares, Development
 - Spares, Procurement

	DEVELOPMENT PHASE	PROCUREMENT PHASE
UAV SYSTEM	sum	sum
HARDWARE	sum	sum
AIR HARDWARE	sum	sum
RECURRING	sum	sum
AIR VEHICLE	✓ Performance-based ✓ Weight-based	✓ Performance-based ✓ Weight-based
SENSOR	✓ Performance-based ✓ Weight-based	
NONRECURRING	✓	✓
GROUND HARDWARE	sum	sum
RECURRING	✓ Performance-based ✓ Weight-based	
NONRECURRING	✓	✓
TEST & EVALUATION	✓	✓
SE/PM, TRAINING, DATA, OTHER	✓	✓
CONTAINER	✓	
SPARES	✓	✓

Methodology Development

Explanatory Variables Considered

Performance Drivers

- Range/Radius of Action
- **Operational Ceiling**
- Speed
- **Endurance**
- Weather Rating
- Coverage Area
- LOS Operations (1,0)
- Hostility Rating
- Carrier Suitability
- Strike Capability
- Datalink Bandwidth
- Stabilization of Payload
- **Sensor Resolution**
- Launch/Recovery-Modes
- **Base of Operations**

Other Drivers

- Competition
- **Prototype Quantity**
- Development Schedule Duration
- Number of Flight tests
- **Production Quantity**
- **Production Rate**
- Commonality
- Legacy
- COTS
- **Payload Weight**
- **Aircraft Weight**

Note: Statistically Significant Drivers in Bold

Methodology Development

Air Vehicle, Performance-based CER

UAV T1R1 (FY03\$K) =

$$118.75 * (\text{Endurance} * \text{Payload_Wt.})^{0.587} * e^{-0.010(\text{FF_Year}-1900)} * e^{-0.921(\text{Prod } 1/0)}$$

T Statistics: (7.8) (40.2) (-1.6) (-10.8)

Statistics adjR² = 99.4%

s = 0.149 (+16.1%, -13.9%)

(13 Data Points) (9 Degrees of Freedom)

Where:

UAV T1R1 = Theoretical first unit cost of UAV air vehicle hardware normalized for learning (95% slope) and rate (95% slope), via unit theory. In FY03 \$K.

Endurance = UAV air vehicle endurance in flight hours

Payload_Wt. = Weight of total payload in pounds. Total payload includes all equipment other than the equipment that is necessary to fly and excludes fuel and weapons.

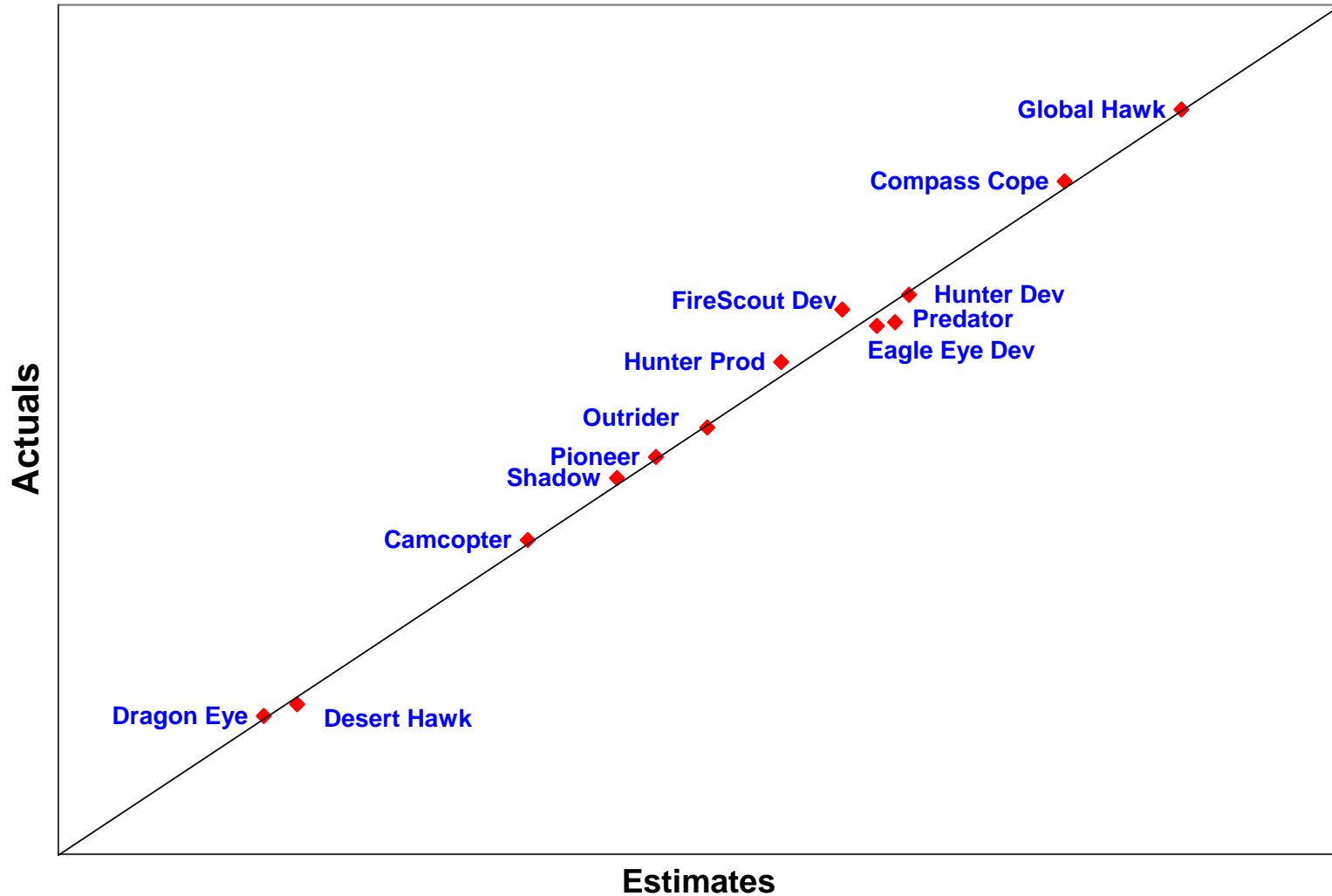
FF_Year = Year of first flight

Prod 1/0 = 1 if air vehicle is a production unit.

= 0 if air vehicle is a development or demonstration unit.

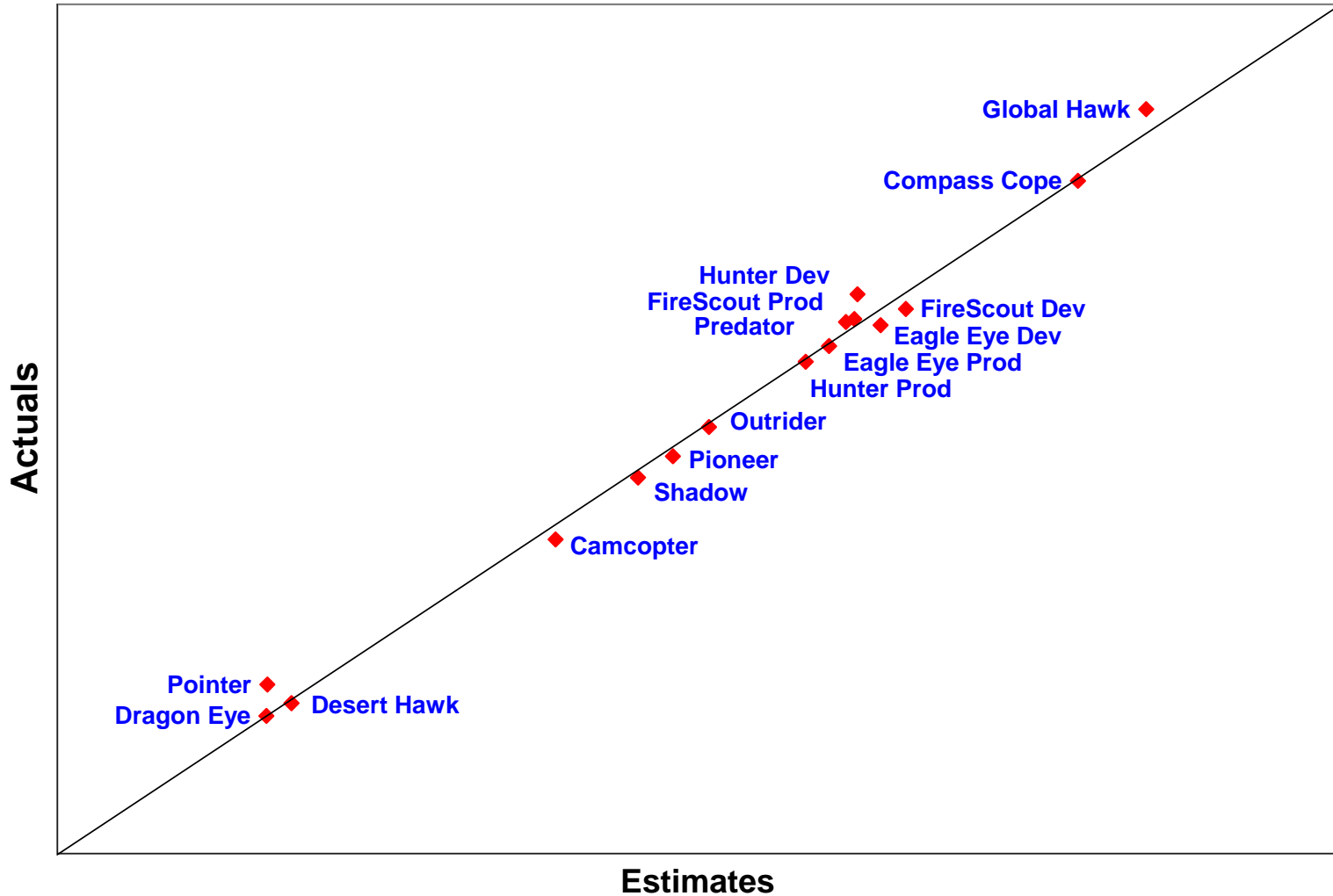
UAV Air Vehicle, Performance-based CER

Actuals VS Estimates

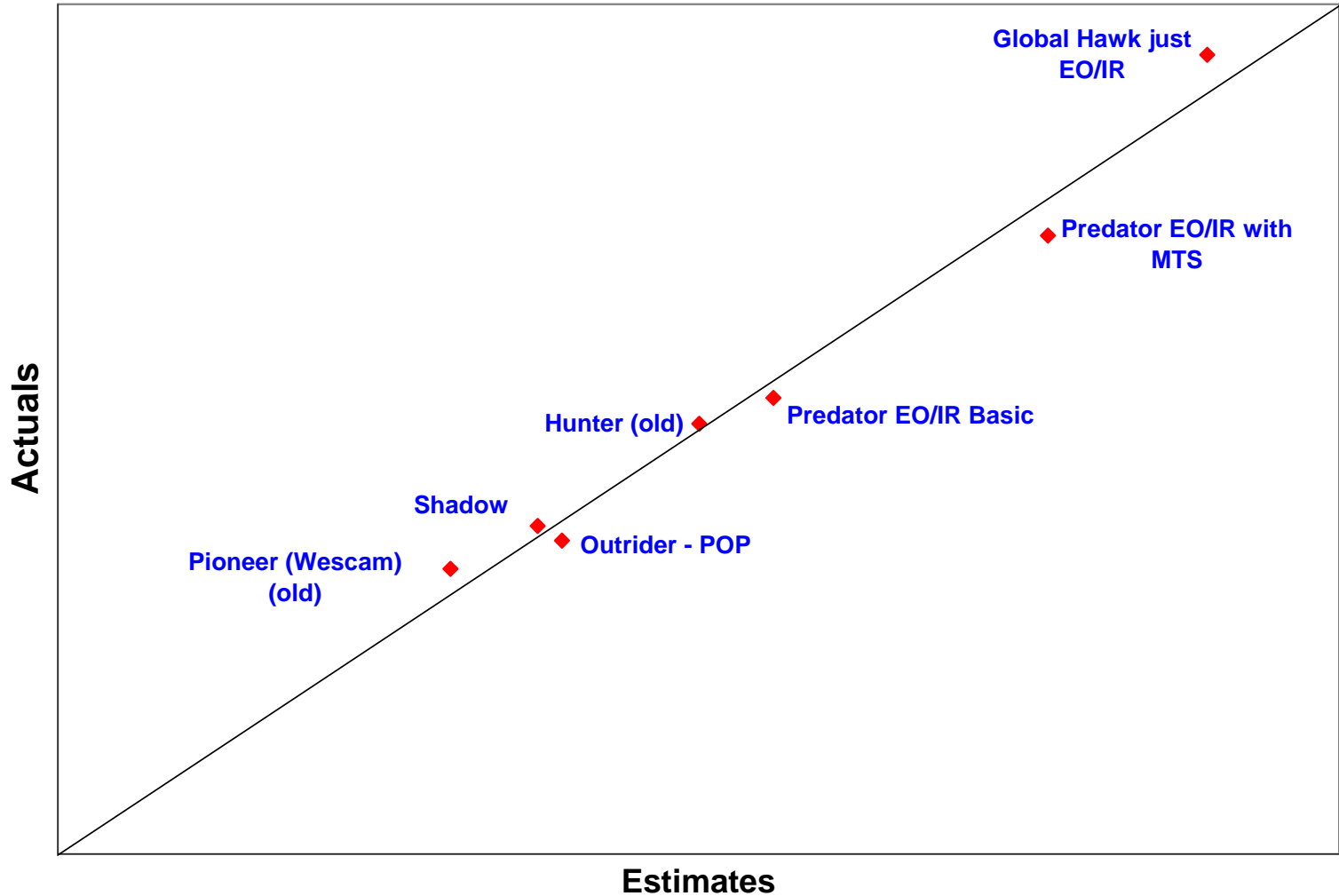


Air Vehicle, Weight-based CER

Actuals VS Estimates



Payload EO/IR Sensor, Performance-based CER Actuals VS Estimates



Methodology Development

Ground System and Equipment, Performance-based CER

Ground System and Equipment AUC (FY03\$K) =

$$433.4 * (\text{Range})^{0.507} * e^{0.398(\text{Mobile Base, Tactical})} * e^{-3.480 (\text{Man Packable})}$$

T Statistics: (7.6) (4.2) (1.3) (-5.1)

Statistics: adjR² = 98.5%

s = 0.31 (+36.3%, -26.7%)

(10 Data Points) (6 Degrees of Freedom)

Where:

Ground System and Equip. = Average unit cost of all ground systems and equipment required to control, disseminate data, and support a system of UAVs and payloads. Ground equipment includes, but is not limited to: GCS, GDT, launch and recovery equipment, portable control equipment, transport vehicles, shelters, maintenance equipment, and other support equipment. In FY03 \$K.

Range = The max distance, in nautical miles, between the ground equipment and its air vehicle for a typical mission. (Note: 1 nm = 1.852 km)

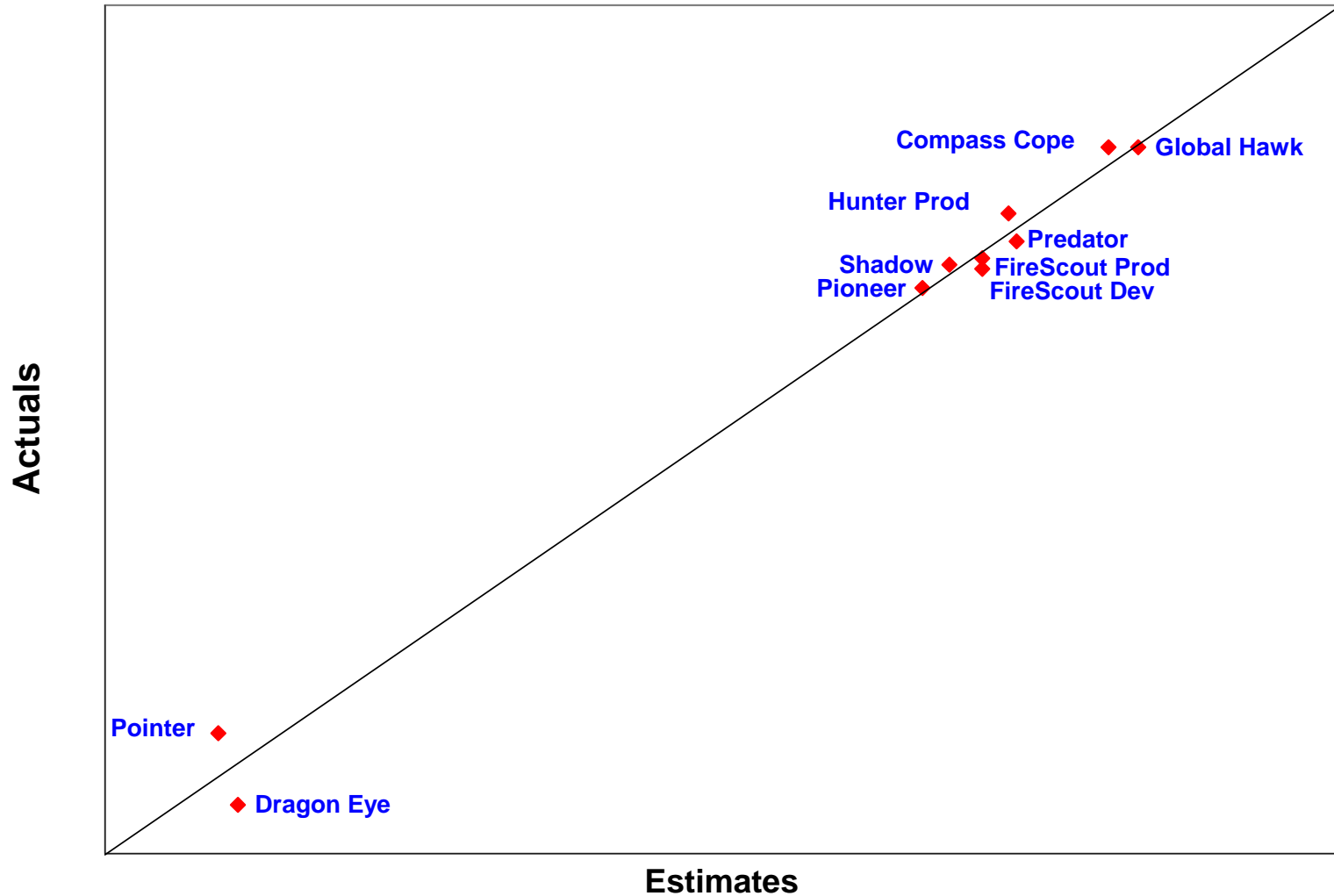
Mobile Base, Tactical = 1 if the ground system and equipment is designed to support a UAV system that is mobile and self sufficient; and transports and launches its air vehicles in the battlefield for tactical operations. This is common in Army systems and some Marine systems.

= 0 if the ground equipment is not.

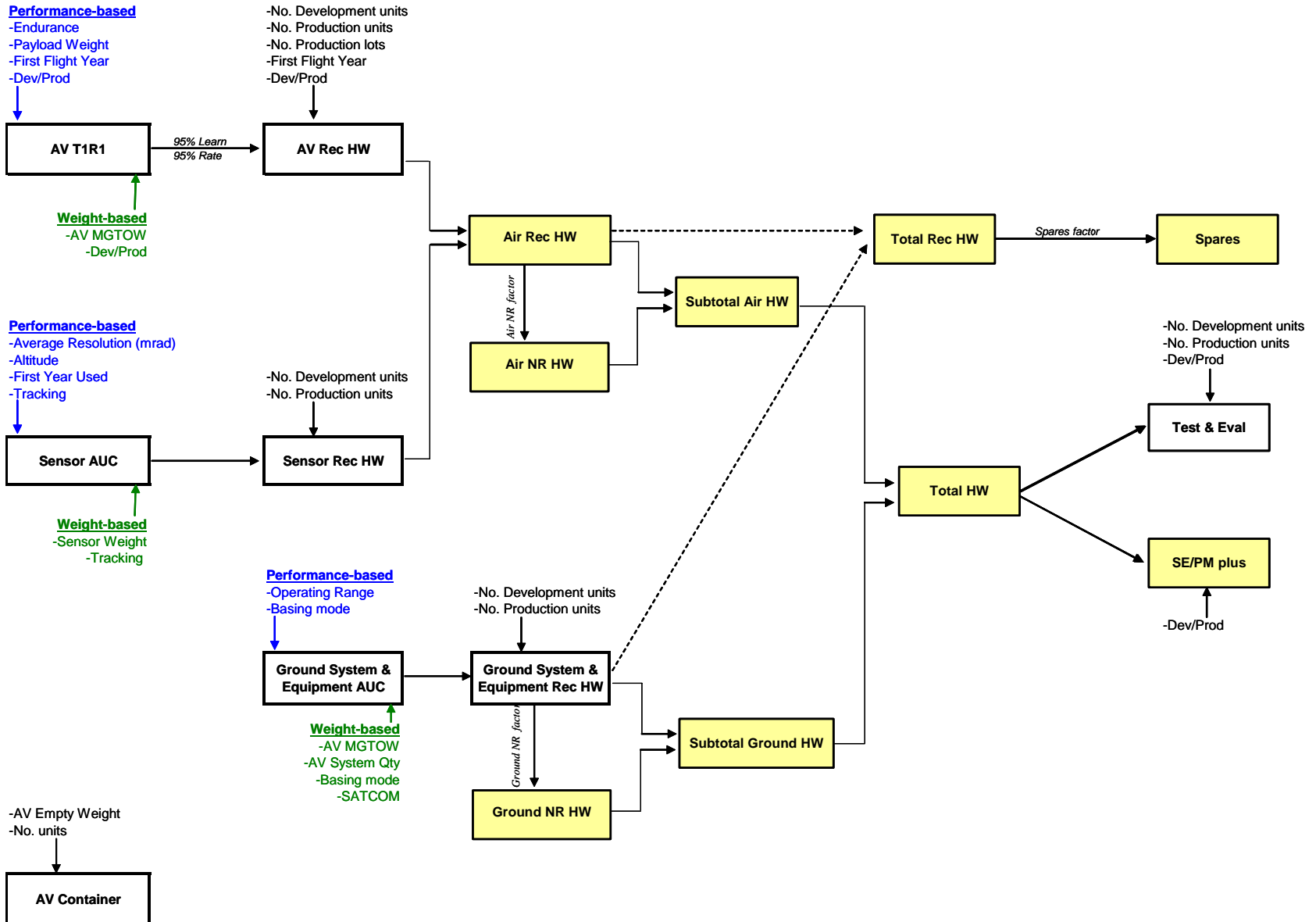
Man Packable = 1 if the ground system and equipment's corresponding air vehicles can be hand carried.

= 0 if not.

Ground System and Equipment, Performance-based CER Actuals VS Estimates



Methodology Development Cost Model Flow Chart



Summary

- Developed an integrated set of top-level parametric and non-parametric estimating methodologies that will support FCS UAV cost analysis
- Developed cost and technical database covering
 - 20 UAV systems
 - Development and/or production cost
- DASA-CE POCs
 - Mr. David Henningsen (703) 601-4163
 - Mr. Dale Penner (703) 601-4177