Modeling the Life Cycle Cost of Protecting US Commercial Aircraft

Presentation to:
75th MORS Symposium
Annapolis, MD
12-14 June 2007

By: Mr. Kurt Willstatter
Mr. Richard "Andy" Campbell
Summit Engineering Group
102 Paul Mellon Court, Suite 1
Waldorf, Maryland 20602
301-645-3535 (-3950 fax)
Kwillstatter@summit-group.com
Acampbell@summit-group.com
www.summit-group.com

Preface

- This briefing focuses on the Life Cycle Cost (LCC) estimate developed by Summit Engineering Group for the Counter-MANPADS (CM) Program managed by the Department of Homeland Security (DHS)
- The completeness and accuracy of the LCC estimate was a key requirement

The Risk of Any Specific Threat is NOT Addressed Here

Acronyms

- A/C = Aircraft
- CM = Counter-MANPADS & Countermeasures
- DHS = Department of Homeland Security
- DIRCM = Directed Infrared Countermeasures
- DT&E = Developmental Test and Evaluation
- ECP = Engineering Change Proposal
- LCC = Life Cycle Cost
- LOE = Level of Effort
- LRU = Line Replicable Unit
- MFHBF = Mean Flight Hours Between Failure
- NB = Narrow Body
- O&S = Operations and Support
- OEM = Original Equipment Manufacturer
- OGC = Other Government Costs
- OT&E = Operational Test and Evaluation
- P^3I = Pre-Planned Product Improvement
- PM = Program Management
- PMP = Prime Mission Product
- RDT&E = Research, Development, Test, and Evaluation
- SE = System Engineering
- ST&E = System Test and Evaluation
- STC = Supplemental Type Certificate
- T_1 = First Unit
- WB = Wide Body

Discussion Topics

- Background
- LCC Estimate
  - Goals
  - Risks
  - Risk Mitigation
- Key Assumptions
- LCC Estimate
  - Summary
  - RDT&E Phase
  - Production & Deployment Phase
  - Operations & Support (O&S) Phase
  - De-Modification & Disposal Phase
- Risk Insights
- Related Activities
- Questions

Background

- DHS Science and Technology (S&T) Directorate tasked with demonstrating the technical feasibility, assessing life cycle costs, and evaluating the effectiveness of protecting commercial aircraft against the threat of Man-Portable Air Defense Systems (MANPADS)
- Primarily focused on mature Directed Infrared Countermeasure (DIRCM) systems
  - Self-contained pod
  - Distributed installation
- Complex problem due to
  - Multitude of aircraft types (Wide-body vs. Narrow-body)
  - Varying flight profiles as a function of aircraft type
  - Multiple operating environments (Cargo vs. Passenger)
  - Potentially large lost revenue costs for installations that fall outside normal maintenance cycles

SUMMIT ENGINEERING GROUP

Aircraft Demographics

- Wide body (WB)
  - Multi-aisle
  - Longer flights at altitude
  - More passengers per aircraft
- Narrow body (NB)
  - Single-aisle
  - Shorter, more frequent flights
  - Fewer passengers per aircraft, but higher total passenger volume
- Cargo is ~1,000 of total

Aircraft	Type	Fleet Size*
777	WB	122
767	WB	334
747	WB	108
DC/MD10	WB	99
MD11	WB	74
A300	WB	140
A310	WB	64
A330	WB	29
A318/19	NB	279
A320/21	NB	368
717/727	NB	271
737	NB	1241
757	NB	617
DC8,9/MD80/90	NB	703
	Total**	**4,449**

* Circa 2005 ** Excludes ~1,600 regional jets

LCC Estimate Goals

- Comprehensive accounting of all foreseeable costs
- Explicitly address key LCC parameters
  - STCs and follow-on P3I/testing
  - Production rate tooling/test equipment (& for depot)
  - Investments to achieve reliability growth
  - CM system weight/drag impacts to fuel consumption
- Consistent approaches among vendors' LCC estimates so individual results could be leveraged
- Exercise LCC across various quantity profiles

The goal was an independent, vendor-neutral Cost Estimate at about the 70% confidence level

Civil Counter-MANPADS Cost Elements

- **Hardware (Production)**
  - **Aircraft Mod/Install** (Airframe, Power, Display, etc.)
  - **Counter-MANPADS** (Sensors, Processing, Negation H/W & S/W)
- **Other Cost Elements**
  - IA&T
  - SE/PM
  - Non-Recurring "Start up"
  - Gov't Furnished Equipment (GFE)
  - First Destination Transportation
  - Allowances for Change
  - Warranties

FLYAWAY COST

PLUS

- Data
- Peculiar Support Equipment
- Common Support Equipment
- Other Gov't Costs (OGC)

SYSTEM COST

PLUS

- Initial Spares

PROCUREMENT COST

PLUS

- **RDT&E**
  - Design Engineering
  - Software
  - Prototypes
  - System Test & Evaluation
  - SE/PM
  - Other
  - OGCs
- **FAA Certification**
- **Facility Construction**

PROGRAM ACQUISITION COST

PLUS

- **Operations & Support (O&S)**
  - Mission Personnel
  - Unit Level Consumption
  - Intermediate Maintenance
  - Depot Maintenance
  - Contractor Support
  - Sustaining Support
  - Indirect Support
- **Disposal**

LIFE CYCLE COST (LCC)

PLUS

- Expendables during Airline Operations
- Unique Counter-MANPADS Operational Architecture
- Replacement for Attrition
- Mission Support
- Return to Peacetime Status
- Other

TOTAL OWNERSHIP COST (TOC)

LCC Estimate Risks

- Inaccurate assumptions
- Vendor optimism
  - Initial system reliability and reliability growth
  - Learning curves
  - Flight duration across various aircraft types
- Uncertain policies
  - Export controls
  - Ground notification requirements
  - Alarm response
- Deployment timeframe

LCC Estimate Risk Mitigation

Summit Engineering Group role was to …

- Develop comprehensive Cost Ground Rules and Assumptions
  - Promulgated and updated at each major program milestone
- Interface with major air carriers to discuss and socialize program assumptions
- Conduct intensive research into US commercial flight demographics
- Interface with vendors on developing detailed Manufacturing Rate Assessments

–Illustrative–

Key Assumptions

- Quantity of CM Systems and Aircraft Modified
- Production start & initial deployment in FY08
- 20-year service life
- 2-level maintenance (Airport and OEM/Depot)
- Flights demographics
  - 350 Days per Year
  - Narrow body (NB), ~5 flights/ day, ~2.3 hours/ flight
  - Wide body (WB), ~2 flights/ day, ~6.8 hours/ flight
- $2.00/gallon (BY03) applied to CM system induced fuel consumption
- >525 A-kit installs/ year could a ‘special visit’ penalty

–Illustrative–

LCC Estimate – Summary

LCC Phase	% of Total Cost
1. RDT&E	1.5%
2. Production & Deployment	23.4%
3. O&S	73.9%
4. De-Mod & Disposal	1.1%
Total	100.0%

Large Cost Drivers (2. Production & Deployment; 3. O&S)

- RDT&E – FY08 to FY18
- Production & Deployment – FY08 to FY17
- O&S – FY08 to FY34
- De-mod & Disposal – FY27 to FY35

–Illustrative–

LCC Estimate – RDT&E Phase

WBS Element	Phase%	LCC%
1.1 PMP	17.4%	0.3%
1.2 A/C Integr	0.0%	0.0%
1.3 Grd Sys Imp	0.0%	0.0%
1.4 ST&E	56.2%	0.8%
1.5 SE/PM	14.9%	0.2%
1.6 Support	1.1%	0.0%
1.7 Data	1.1%	0.0%
1.8 ECP	4.5%	0.1%
1.9 OGC	4.8%	0.1%
Total	100.0%	1.5%

- 73.6% of Total RDT&E $ is for PMP and ST&E (shaded areas)
- Prime Mission Product (PMP)
  - ~LOE/Yr for Block Design Upgrades
- System Test & Evaluation (ST&E)
  - Periodic DT&E/OT&E to Support PMP block upgrades
    - LOE/Test Cycle & Test Materials
  - New/Amendment STCs each vendor
    - X quantity New STC
    - Y quantity Amendment STC

Strongest Influences or Highest Risk
- **PMP – Extent of future design updates**
- **ST&E – # and Extent of STCs**

SUMMIT ENGINEERING GROUP

–Illustrative–

LCC Estimate – Production/Deployment Phase

WBS Element	Phase%	LCC%
2.1 PMP	61.8%	14.5%
2.2 A/C Integr	3.6%	0.8%
2.3 Grd Sys Imp	0.0%	0.0%
2.4 ST&E	0.0%	0.0%
2.5 SE/PM	8.3%	2.0%
2.6 Supportability	20.3%	4.7%
2.7 Data	1.2%	0.3%
2.8 ECP	1.9%	0.4%
2.9 OGC	2.9%	0.7%
Total	100.0%	23.4%

- **85.7% of Production/Deployment $ is for PMP, A/C Integration and Supportability** (shaded areas)
- **Prime Mission Product (PMP)**
  - Detailed T_1 (Labor/Mat'l) and Learning Curve across Each LRU
- **Aircraft (A/C) Integration**
  - Assumed no Learning for Modification/Install Labor based on numerous organizations performing them across time
- **Supportability**
  - Manufacturing Rate Assessment: Special Tooling/Prod Rate SE/Repair Station SE
  - Annual Quantity drives demand

Strongest Influences or Highest Risk

- **PMP – Assumed learning curve**
- **A/C Integration & Supportability – System deployment qty/rate**

–Illustrative–

LCC Estimate – Operations & Support Phase

WBS Element	Phase%	LCC%
3.1 Mission Per	3.2%	2.4%
3.2 UL Consmp	56.1%	41.4%
3.3 I/M Maint	16.1%	11.9%
3.4 Depot Maint	8.9%	6.6%
3.5 Ktr Support	3.5%	2.6%
3.6 Sustain Spt	8.8%	6.5%
3.7 Indirect Spt	1.4%	1.0%
3.8 ECP	0.5%	0.4%
3.9 OGC	1.5%	1.1%
Total	100.0%	73.9%

- 81.1% of Total O&S $ is for Unit Level Consumption, Inter. Maint. and Depot Maint. (shaded areas)
- Unit Level (UL) Consumption
  - CM System induced Weight/Drag Impacts on Fuel Use across Aircraft Types (done for every discrete aircraft type) *Ex of how risk/uncertainty reduced*
- Intermediate Maintenance (I/M)
  - Unscheduled Repairs—due to MFHBF/year across each LRU—times $/Repair
- Depot Maintenance
  - Periodic CM System Tech Refresh

<u>Strongest Influences or Highest Risk</u>

- **Unit Level Consumption – Assumed fuel cost, induced drag**
- **Maintenance – System reliability**

SUMMIT ENGINEERING GROUP

–Illustrative–

LCC Estimate – De-Mod/Disposal Phase

WBS Element	Phase%	LCC%
4.1 De-Mod	72.2%	0.8%
4.2 Disposal	27.8%	0.3%
Total	100.0%	1.1%

- De-Modification
  - Final removal of the Aircraft Modifications (e.g., A-kit)
    - 100% of original install time
  - Final removal of CM Equipment (e.g., B-kit)
    - 50% of original install time
- Disposal
  - All disposal costs of A-kit and B-kit material

Strongest Influences or Highest Risk

- **De-Modification – % of labor effort from original installation**

–Illustrative–

LCC Estimate – Sensitivities

Attribute	+ / - %	Low	LCC	High
$/STC (New/Amend)	20	0.998	1.000	1.002
CM System T_1	15	0.952	1.000	1.048
CM System Learning Curve	5	0.852	1.000	1.255
Fuel ($/gal)	25	0.903	1.000	1.097
Fleet Drag (%)	20	0.941	1.000	1.059
Installed Weight (lbs)	10	0.991	1.000	1.009
Initial Reliability (MFHBF, WB/NB)	25	0.970	1.000	1.050
Order Quantity (For Illustrative Case)	5	0.958	1.000	1.040

- Costs normalized to 'Base Case'
- Sensitivities are shown as being independent of each other
  - Correlations could result in significantly different impacts (e.g., an increase in fuel cost coupled with higher than projected drag effects)

Risk Insights

- Highest Estimating Risk
  - System Deployment Quantity and Rate
  - Fuel Cost
  - System Reliability
  - Learning Curves
- Other 'Influences'
  - NRE Cost for Each Aircraft Type
  - Technology Refresh Costs
  - Installation Weight (unless talking Regional Jets)
  - First Unit Cost (e.g., T_1)

Related Activities

- Deployment decision influenced by probability of threat and applicable cost/benefit analyses
- USC CREATE has done groundbreaking work on the economic impacts of a MANPADS attack
  - Avoiding the economic impact is a benefit
- Ongoing threat assessments are crucial to evaluating the likelihood of a MANPADS attack
- Metrics for quantifying the level of protection afforded by a given deployment alternative
  - More than just number of planes, number of flights, and/or number of passengers

Questions?

Presenter Biographies

- Mr. Kurt Willstatter
  - Sr. Principal at Summit Engineering Group
  - Certified Cost Estimator/Cost Analyst (SCEA)
  - BA Biology (Texas A&M)
  - MS Operations Research (Naval Post Graduate School)
  - 15+ years of systems engineering, modeling & simulation, cost estimation experience
  - 20 years of Navy operations and systems engineering
- Mr. Richard "Andy" Campbell
  - Associate at Summit Engineering Group
  - Certified Cost Estimator/Cost Analyst (SCEA)
  - BS Mathematics, BA Economics (Rhodes College)
  - 4+ years of cost estimation, program analysis/management, and effectiveness modeling experience