Benchmarking SEER-H To the AH-64A Apache Rotorcraft

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Topics

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- System Definition
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- Summary

Purpose

- Promote parametric estimating within Boeing and the cost analysis community
- Adjust SEER-H for unique aspects of the Apache program
- Develop and document internal methods for parametric estimating

Methodology

- Select the appropriate system
- Specify a WBS
- Collect, validate and normalize historical data:
  - Cost
  - Quantity
  - Weight
  - Material composition
- Map weight and composition data into the WBS
- Build SEER-H Model Inputs:
  - Select SEER-H Knowledge Bases
  - Adjust default values when justified
  - Perform trial benchmark and reconcile differences with actual cost
  - Reconcile with actual costs and iterate if necessary
  - Measure benchmark accuracy in total and by cost element
- Document process and lessons learned

System Definition

•The Boeing AH-64A Apache is the Army's primary attack helicopter. It is a twin-engine, four bladed, multi-mission attack helicopter designed as a highly survivable and stable aerial weapons-delivery platform. The principal mission of the Apache is the destruction of high-value targets using the HELLFIRE missile, Hydra rockets, and the M230 chain gun.

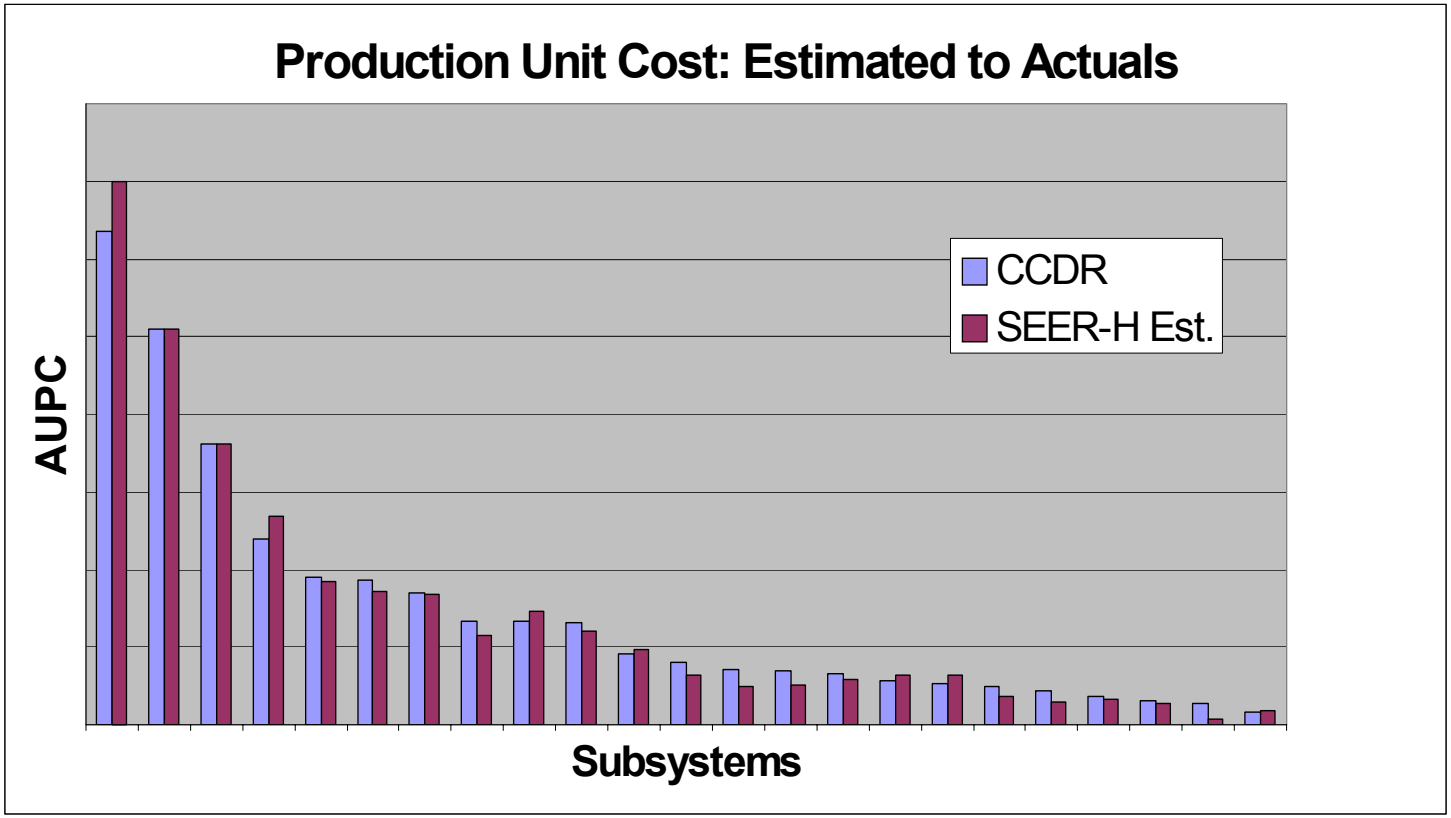
Ground Rules

- Retain underlying data of SEER-H
  - Minimize subjective inputs
  - Adjust SEER-H default values by exception with solid rationale
- Use analogy estimation when default knowledge bases were not applicable
- Production hardware costs include
  - Direct and indirect labor
  - Labor overhead
  - Raw material
  - Material overhead
  - Subcontractor and vendor costs for purchased parts
  - General and Administrative (G&A)
  - Other direct charges.
- Profit/fee, cost of money excluded from analysis

Sources of Data

- DD Form 1921, Contractor Cost Data Report (CCDR)
- Bill of Material
- Contract Work Breakdown Structure (CWBS)
- Weight Data from Mass Properties Accounting System (Mil-Std-1374A)

Results

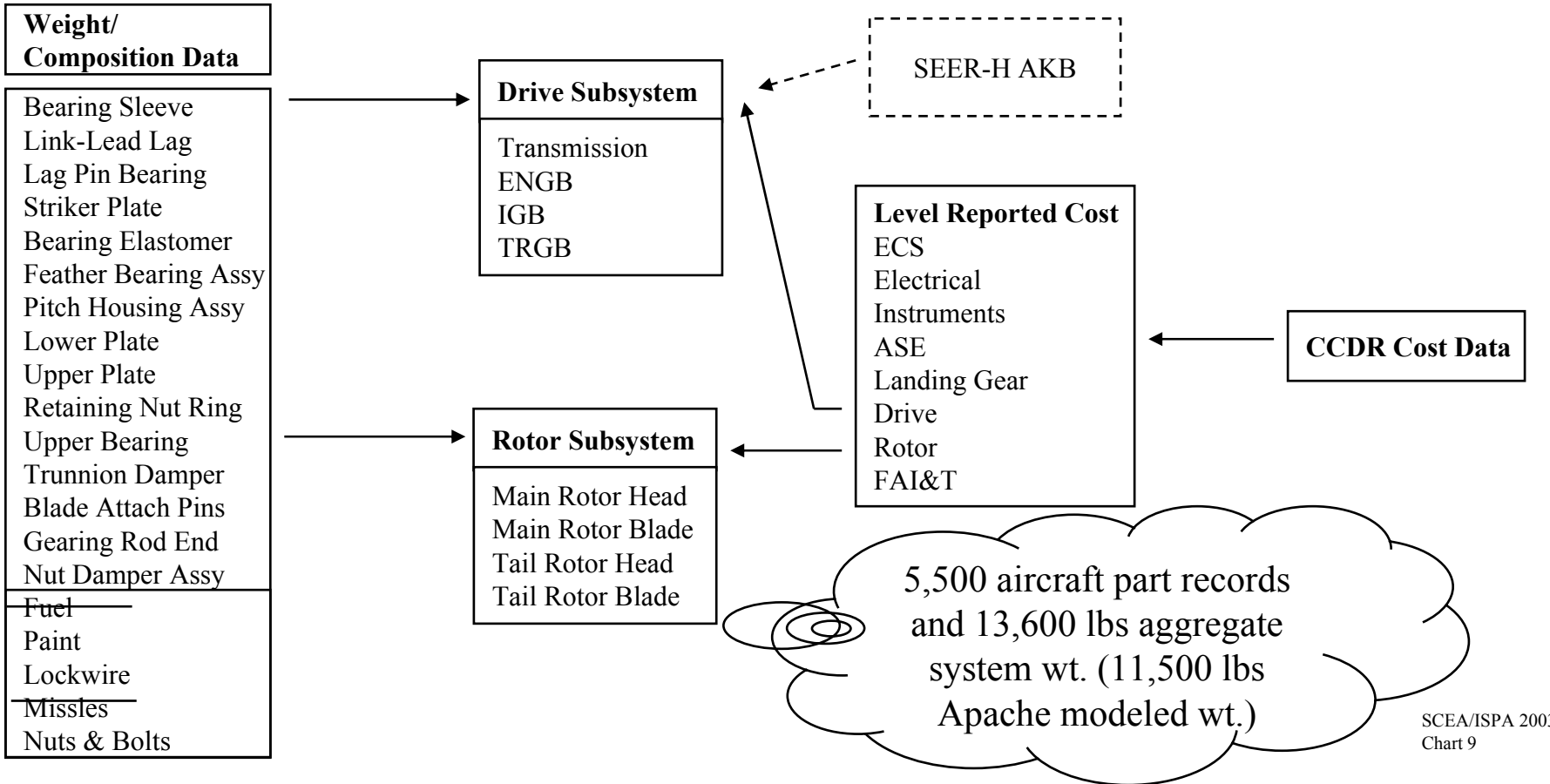


75 percent of the estimates produced at the CCDR roll-up levels were within 20 percent.

96 percent were within 35 percent.

Lessons Learned

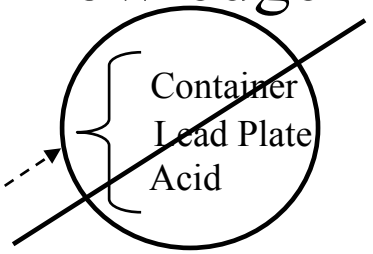
- Substantial effort was required to map weight and composition data to costs from the CCDR.



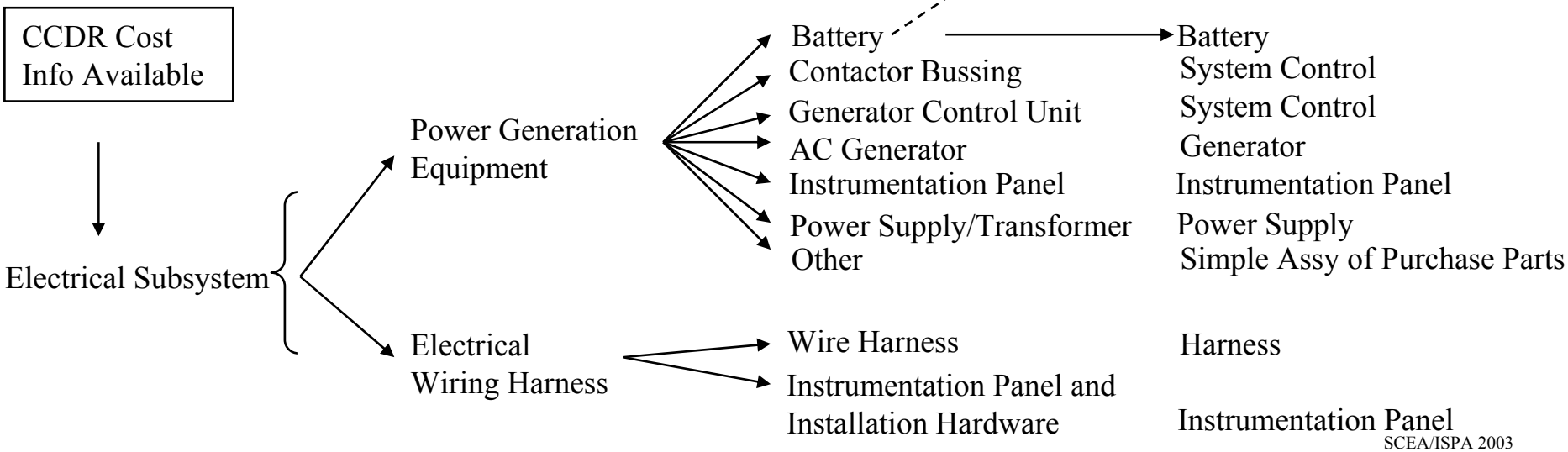
Lessons Learned (Cont.)

- The system was subdivided into subassemblies that could be represented by SEER-H knowledge bases.

	Application Knowledge Bases	
	Mechanical	Electrical
High Level	3	6
Lower Level	95	30

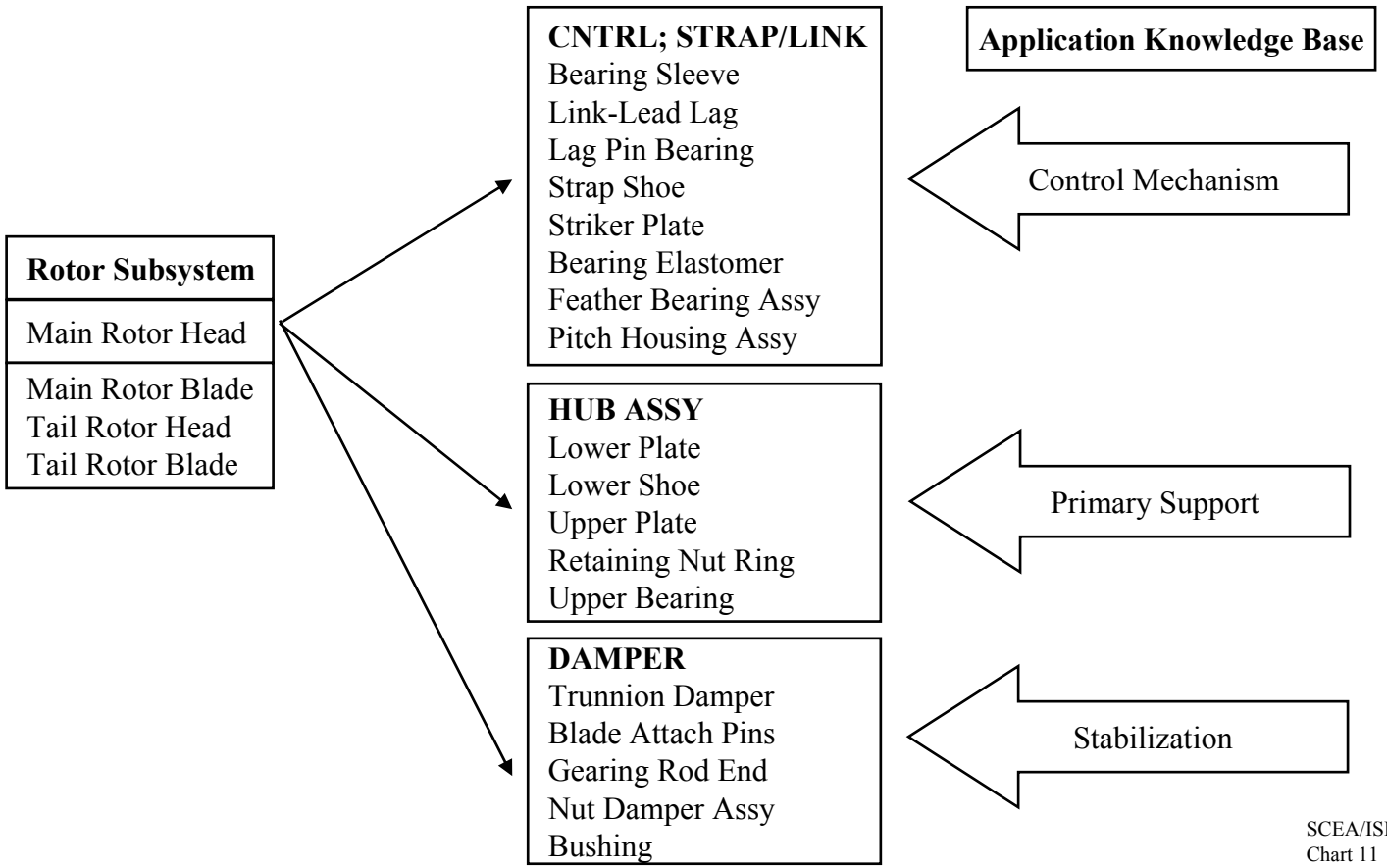


Application Knowledge Base



Lessons Learned (Cont.)

- Subdivided subassemblies (cont)



Lessons Learned (Cont.)

- WBS levels 5 & 6 were the focus of the benchmarking; caution was necessary at higher and lower levels.

The fuel system is a system made up of many other smaller systems. SEER-H Knowledge Bases should be used to estimate only the analogous system they describe.

The main transmission assembly however can be treated at the WBS level 5. Nonetheless, things such as bearings, gears, nuts, and bolts are not specifically treated.

WBS 5	WBS 6	Application Knowledge Base
Fuel System		Do not apply knowledge base
	Armor	Secondary Structure
	Fuel Cells	Tankage
	Pumps, Manifolds, Hoses, Valves	Fluid System
	Instrumentation Panels	Instrumentation Panel
	Inerting Unit	Fluid System
Transmission		Drive Mechanism
	Bearings	Do not apply knowledge base
	Gears	Do not apply knowledge base

Lessons Learned (Cont.)

- Weight data for similar components were grouped into estimating elements that mirror SEER-H knowledge bases.

Component	Where to Put	Application Knowledge Base
Valves Tubes Manifolds Pumps Hoses Vents	Sum weights and normalize with appropriate unit weight and quantity	Fluid System
Nuts, Bolts, Paint, & insulation	With next higher assembly	Appropriate Application knowledge base for next higher assembly

Lessons Learned (Cont.)

- Adjustment was necessary to include system level integration cost:
  - Apache A-series system level well within industry average range.
  - System level integration was not adequately captured
  - Integration complexity input appeared to work well at capturing the integration efforts at WBS level 4 and below.
- Recommendation
  - Use historical integration rates to specify overall aircraft level integration.

Lessons Learned (Cont.)

- Unique labor rates improved the cost distribution among the individual elements.

Subs-Tier	Example	Contractor Specific rate
1st	G.E., Boeing, Lockheed	$$
2nd	H.R. Textron, Parker Hannifin, Purdy	$$
3rd	Mom & Pop Shops	$$

•Use labor rates that are current to the contract period.

•Provides improved cost distribution, but did not significantly improve overall cost estimate.

Lessons Learned (Cont.)

- CCDR labor and material differed from SEER-H estimates due to outsourcing and interdivisional work.
  - Problem area: CCDR data for the Fuselage (Not SEER-H related)
  - Successfully isolated and removed labor cost in the material portion of the CCDR data
  - Aliening Labor Hours critical to benchmark process
- Differences in CCDR material costs were reconciled outside of SEER-H.
  - Labor dollars/hours were removed from the material category to the labor category.
    - Material cost = Associated weight * ($/lbs depending on material composition)
    - Labor dollars = Total cost – material dollars (estimated)

Lessons Learned (Cont.)

- The SEER-H electronic weight conversion algorithm saved time but required care for sophisticated, expensive and heavy/dense electronic components.
  - Weight information ready available for algorithm use.
  - Use directly for smaller/less complex electronic components.
  - Or, breakdown larger components into smaller sub-elements.
    - For example: FCR to CPU, power supply, exciter, etc.
    - Mimics similar process as mechanical components to AKB level

Lessons Learned (Cont.)

- Wrap rates reduced uncertainty in material costs with a high proportion of purchased parts, particularly in the area of the airframe/fuselage.
  - Preferred estimating the material by using Wrap Rates
    - SEER-H default: 4% or $14.41/lbs for raw material
    - Examined Apache A-Series: $/lbs raw material, including composites/graphite
    - Examined $/lbs for raw bar stock

Lessons Learned (Cont.)

- Default learning curves were adjusted by exception and only when justified by substantial historical data.
  - SEER-H Defaults:
    - Mechanical – 90 % LC
    - Electrical – 88 % LC
  - Boeing Mesa prefers to use default Learning Curves:
    - Primarily final assembly and system integration
    - Numerous/generic subcontractors – aggregate should be nominal
  - Important to adjust for prior production and ship-set quantity

Conclusions

- Calibration/benchmark methods in the SEER-H manual were more effective when supplemented with lessons learned.
- Benchmarking effort was considered highly successful, meaningful and worthwhile experience.
- Experience and knowledge gained were essential to improving parametric estimating capability at Boeing Mesa.
- Benchmarking a complete weapon system was time consuming and involved a significant amount of engineering support.
- Additional benchmark testing is advisable to increase modeling confidence.

The Future

- Submit detailed research paper for publication
- Continue benchmark testing
- Promote internal use of SEER-H
  - Crosscheck of engineering estimates
  - Initial estimates for new programs