PRICE®

ICEAA 2019

BELL

Five Steps for Improving the Accuracy of Rough Order of Magnitude Estimates

Bell V-280 Valor Wing

Predictive Cost Analytics Case Study

Presented by:

Zachary Jasnoff and Ross Raburn

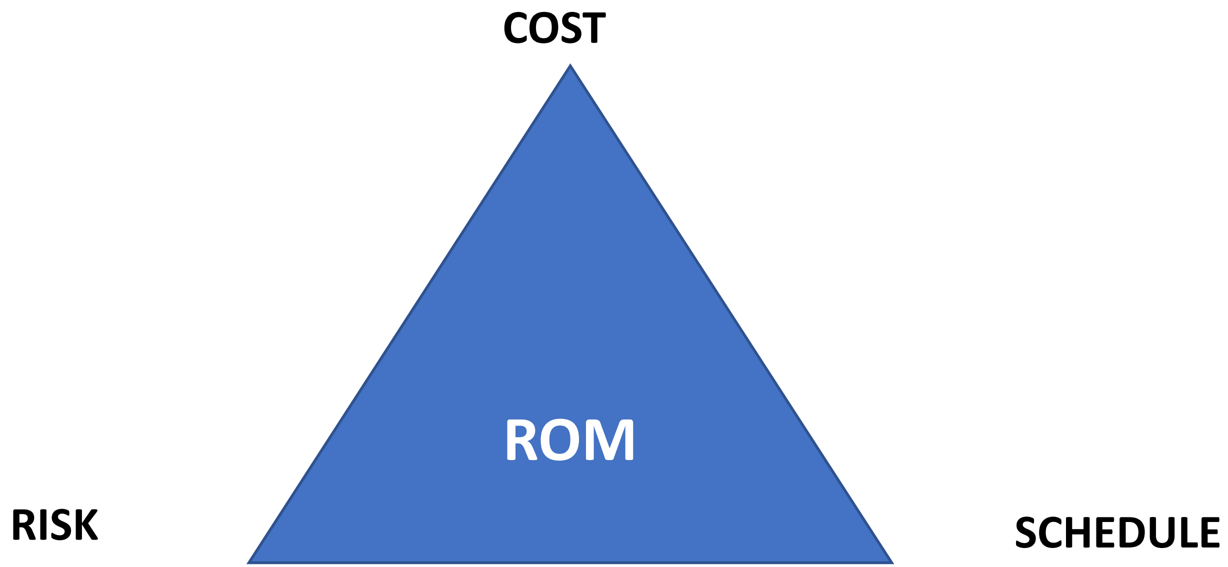
Estimate with Confidence™

Agenda

- What is a ROM?
- How are ROMS used?
- Precision vs. Accuracy in ROMs
- Characteristics of ROMS
- Challenges with ROM Estimating
- Asking the right questions for effective ROMS
- Case Study – V-280 Valor Wing – Predictive Cost Analytics
- Wrap Up / Conclusions

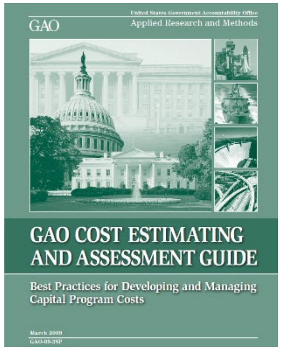
What is a ROM ?

- A “Rough Order of Magnitude” estimate answers the fundamental question of early project feasibility given a set budget. Often before much is known about the project details



- ROMS seek to evaluate and balance Cost / Schedule / Risk during early program phases

GAO view on ROM Estimating



GAO Cost Estimating and Assessment Guide - ROMS

Developed when a quick estimate is needed and few details are available.

Usually based on historical ratio information, it is typically developed to support what-if analyses and can be developed for a particular phase or portion of an estimate to the entire cost estimate, depending on available data.

It is helpful for examining differences in high-level alternatives to see which are the most feasible.

Because it is developed from limited data and a short time, a rough order of magnitude analysis should never be considered a budget-quality cost estimate

May be by a small group or one person; can be done in hours, days, or weeks; and may cover only a portion of the LCCE

How are ROMS Used?

- Produced in relatively short timeframes
- Useful in assessing programs in the early concept stages where little technical data is known , or data is rapidly changing.
- Estimated at a high level, but does not confuse precision with accuracy.
- Can be used to do rapid excursions, trades, what-if analysis
- Not considered sufficient for proposal quality or budgetary estimating.
- Useful in responding to RFIs, Bid/No Bid decisions.

Precision vs. Accuracy

- No estimate is "free from mistake or error"
  - Probability of achieving a given estimate is exactly zero! In other words, our cost estimates will always be exactly wrong!
- In cost estimating, accuracy is best thought of as achieving a given level of confidence based on the degree of inherent uncertainty in underlying parameters.
- A key decision early in an estimate is "appropriate" level of modeling of the Product Breakdown Structure.
  - Sets the stage for everything else including the "fidelity" of the estimate
  - Need to consider the ultimate outcome of the estimate.

What are the Characteristics of ROMs?

- **Level of Estimate:** Typically high level 2 or 4 of the WBS
- **Timeframe:** ROMs are produced within very short timelines using know , high level available data .
- **Assumptions:** May not be well defined or known but can cover the entire Lifecycle.
- **Fidelity:** Heavily informed and based on past project historical data combined with Subject Matter Experts opinion
- **Accuracy:** According to PMBOK® ROMs are typically have an uncertainty range of -50% to +50% .

What Estimating Techniques are used for ROMs?

ROM Estimating Technique	Strength	Weakness
Analogy*	Based on actual data Reasonably Quick Good Audit Trail	Subjective - Accuracy Depends on Similarity Blind to Cost Drivers
SME Opinion / Dephi *	Very quick to perform Leverages SME project knowledge	Subjective Does not take into account actual past performance
Parametric	Reasonably quick, mainly done via EXCEL	Simple Cost Estimating Relationships like $/lb fails to account for part count and design complexity.
Predictive Cost Analytics	Clear visibility to cost drivers. Quick to perform estimates. Rapidly analyzes past performance, fully informing the estimate. Estimates are data-driven taking into account performance / design complexity. Transparent audit trail tied to historical cost / performance data.	Can be limited by insufficient or inaccurate data / data collection . Requires organizational commitment to software tools and methodology.

Challenges with ROM Estimating

- More complex technical parameters are difficult to assess with simpler estimating techniques.
- Often required early in the program lifecycle where not much technical data is available, or only available at high level.
- Estimators given a very short time to produce the estimate, but results get "locked in".
- Difficult to assess the impact of schedule and risk – even if the estimate is in the ballpark.
- Methods such as "Analogy" , " Delphi:" or Expert Opinion fail to consider significant changes to technology and scope.

Five Steps for Improving the Accuracy of ROM Estimates – Asking the Right Questions

Audience: Who is the ultimate "consumer" of the estimate and requirements?

What: What is being estimated (entire program, **subsystem**, acquisition, LCC)?

Why? What is the "Question" asked and level of detail required ?.

Program phase?: At what level does the existing data and technical parameters exist?

Data? What is the depth and accuracy of historical costs / performance / technical data of similar programs.

Importance of not confusing precision with accuracy when producing a ROM estimate is critical!

Predictive Power for Effective ROM Estimates

- **Data Collection**– Based on past project experience, collect actual delivered cost data for all program phases.
- **Normalization / Benchmarking -** determine the key benchmark "cost drivers" used to inform future estimates. Benchmarks should be correlated to delivered technology.
- **Review program and technical data –** determine the key cost and schedule drivers. Assess the technology and align with benchmark data. Gather high level existing data.
- **Developed the ROM Product Estimating Structure –** match the level of the PBS to the level of known data.
- **Produce the first "point estimate"** – identify cost driver inputs, perform sensitivity analysis.
- **Prepare an uncertainty analysis** – determine the confidence level in the estimate.

Bell V-280 Valor Wing

Predictive Cost Analytics

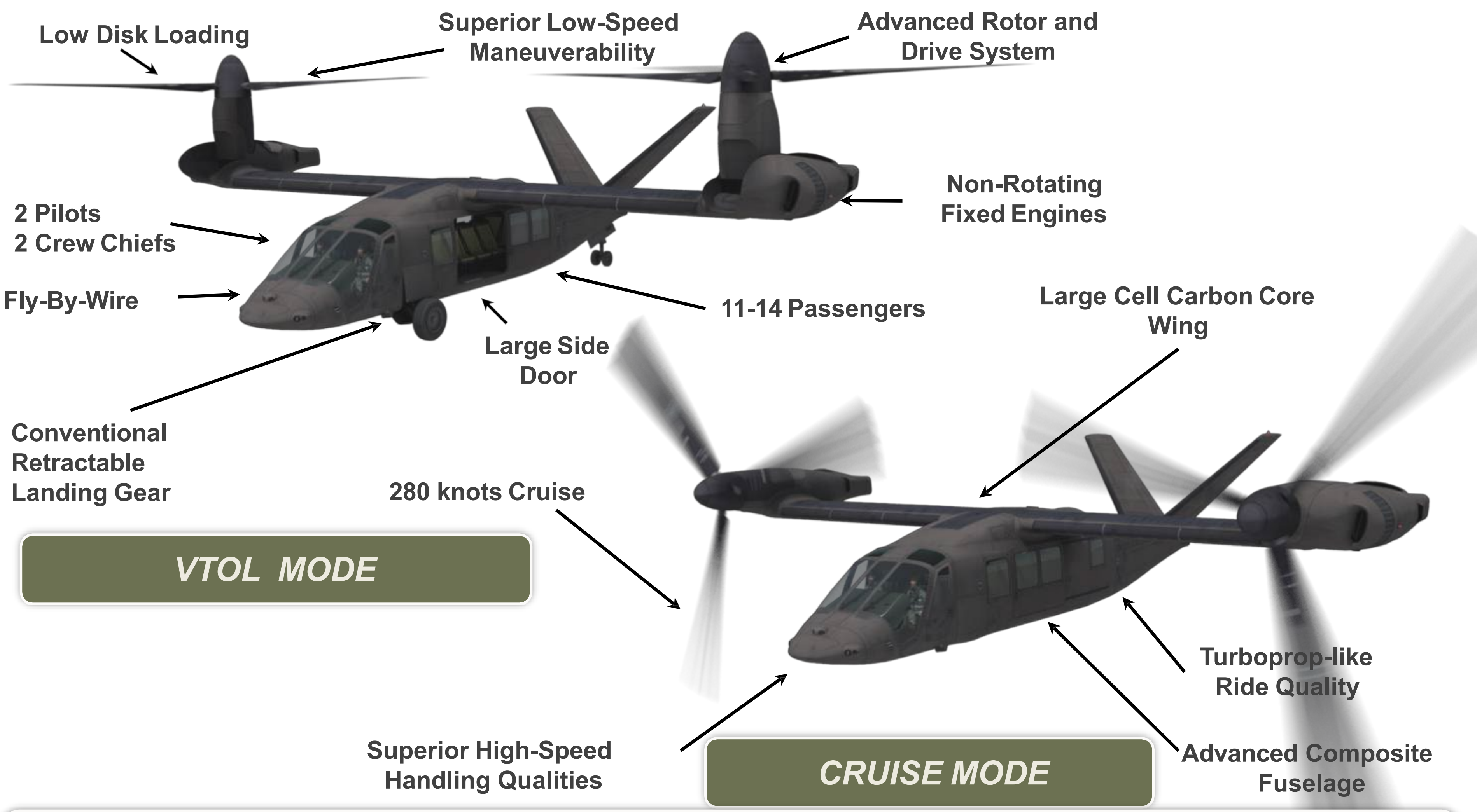
Case Study

ROM PCA Case Study : Bell V-280 Valor Wing

Question	Response
Who?	Bell V-280 Valor - Wing Design IPT
What?	Subsystem ROM Cost Estimate - Predictive Cost Analytics
Questions Asked?	How do part count and design complexity reductions affect ROM cost estimates at the aircraft system level?
Program Phase	Development
Depth/Accuracy of historical data	Based upon 50+ years of Bell tiltrotor design, flight test, and manufacturing experience
Product Breakdown Structure	PCA modeled to the detailed elements (wing spars, ribs, and skins)

V-280 Valor

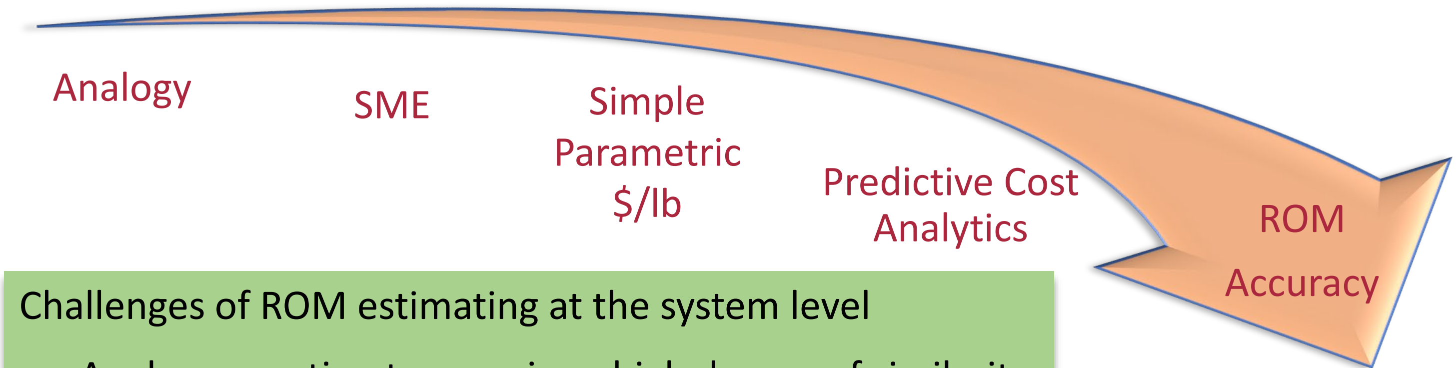
Bell V-280 Valor – Future Vertical Lift



V-280 air combat vehicle technology provides warfighters strategic options, operational reach, and tactical agility and overmatch at the point of decision

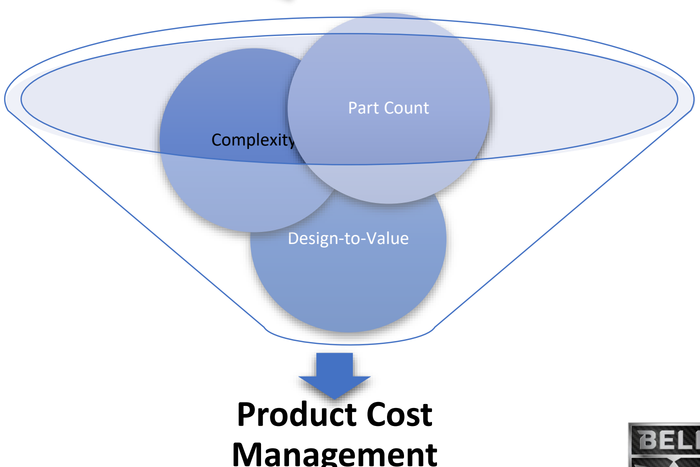
Bell V-280 Valor
ROM Estimating at the Aircraft System Level

Challenge: Given two systems of similar size, weight, and function…
How do part count and design complexity affect the ROM estimate?



Challenges of ROM estimating at the system level

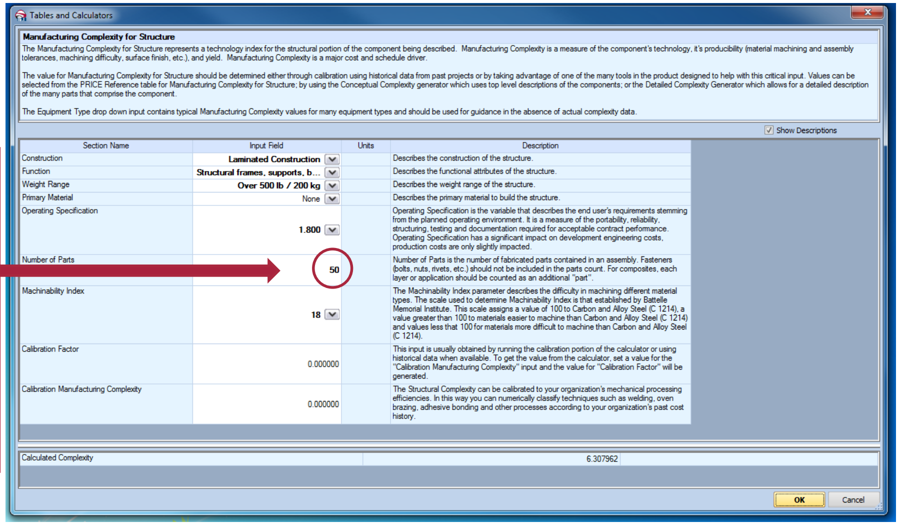
- Analogous estimates require a high degree of similarity
- Subject Matter Experts are limited and often biased
- Simple parametric Cost Estimate Relationships (CER) fail to consider part count and design complexity
- Predictive Cost Analytics (PCA) account for these cost drivers and improves ROM accuracy



Bell Legacy Tiltrotor Wing Historical Data

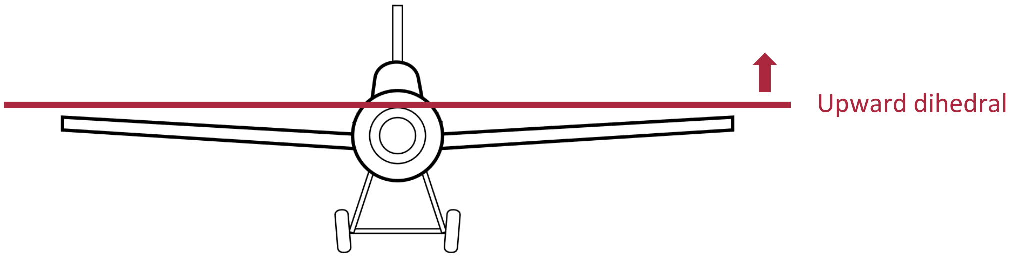
Baseline Assembly Analysis

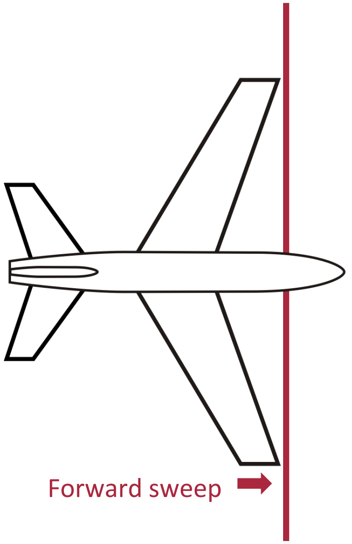
Legacy Tiltrotor Wing Design	Complexity Factor
• Wing Spars – 50 detail parts	6.31
• Wing Ribs – 500 detail parts	6.92
• Wing Skins – 6,000 parts	7.32



- Average Unit Production Cost = 100% (normalized baseline)

Note: Detail part counts are representative values (not actual)



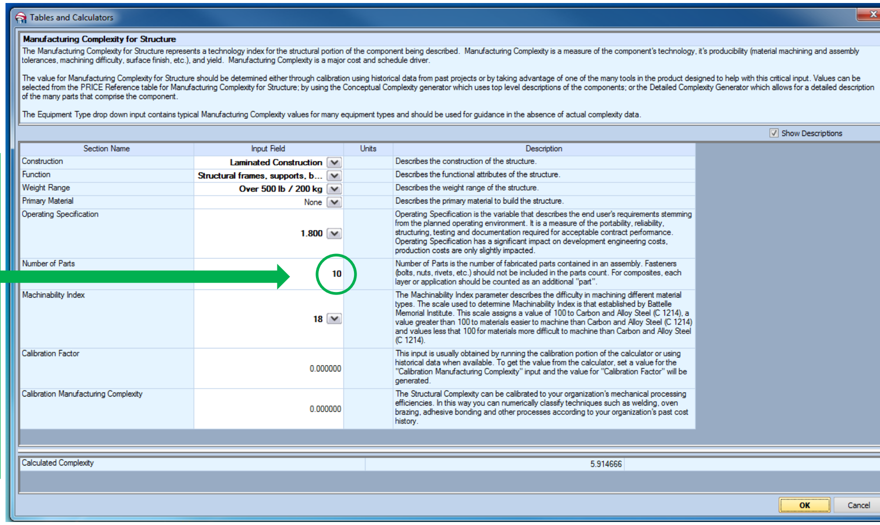


Bell V-280 Valor Wing

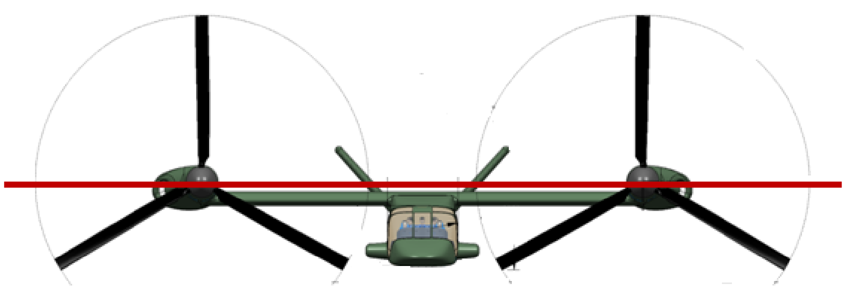
Predictive Cost Analysis

V-280 Wing Design	Complexity Factor
• Wing Spars – 10 detail parts	5.91
• Wing Ribs – 100 detail parts	6.49
• Wing Skins – 1,500 parts	6.93

- Average Unit Production Cost = 43%



Note: Detail part counts are representative values (not actual)



Straight & level

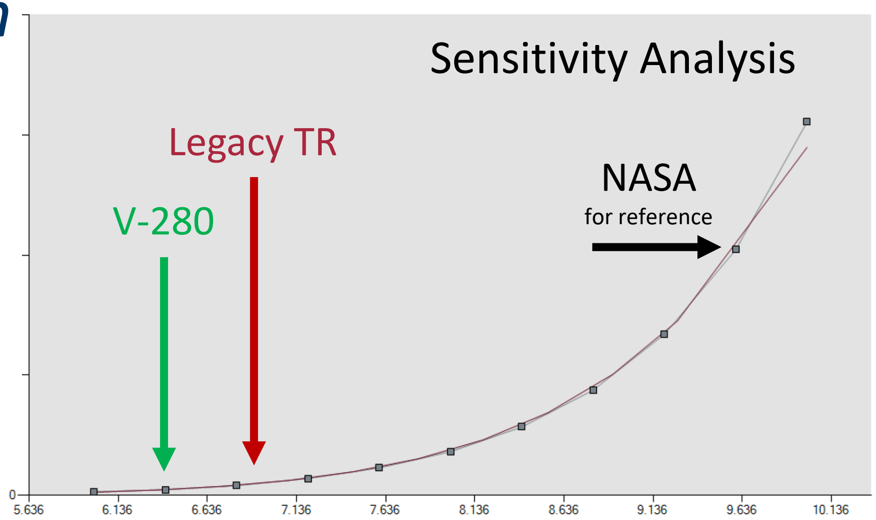
No forward sweep

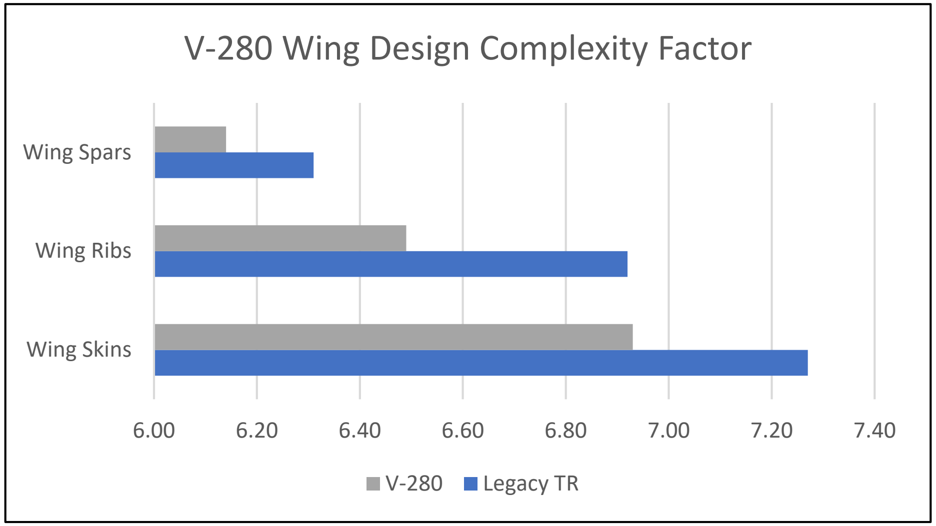
To demonstrate PCA estimating capabilities, the V-280 wing structural weight was inflated in this case study to match the Legacy Tiltrotor wing weight. Setting these weights equal allows us to isolate the affect of part count and design complexity reductions on the average production unit cost estimate.

Bell V-280 Valor vs. Legacy Tiltrotor Wing

Complexity Factor Comparison

Wing Design	V-280	Legacy TR
• Wing Spars	5.91	6.31
• Wing Ribs	6.49	6.92
• Wing Skins	6.93	7.32





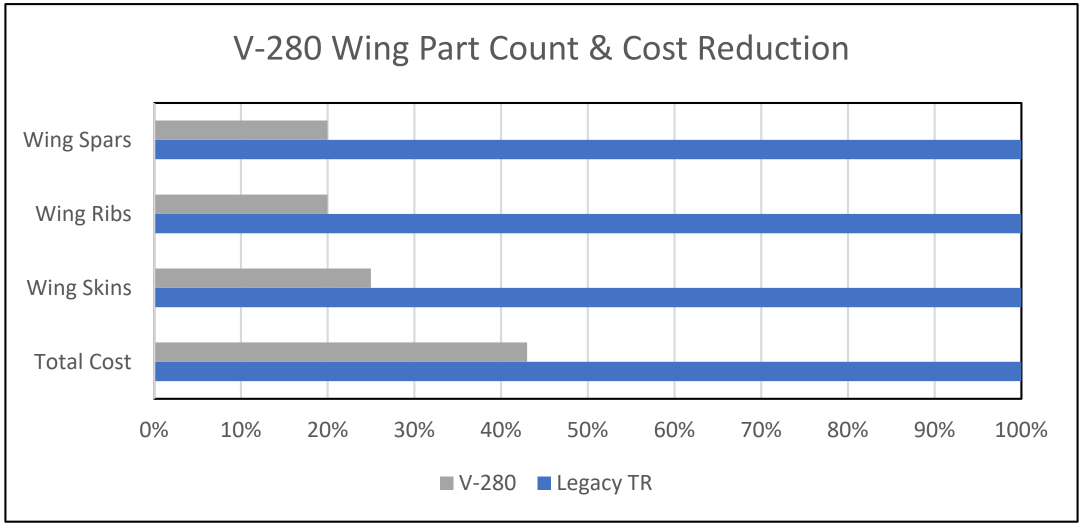
Bell V-280 Valor PCA Opportunity

Part Count & Complexity Reduction

Case Study Outcome

- Wing assembly total part count reduction of approximately 70%
- Projected total labor hour reduction of 57%
- Projected development tool cost reduction of 50%
- Projected total assembly cost reduction of greater than 50%

Note: Detail part counts are representative values (not actual)



Bell V-280 Valor

- Life cycle affordability
- Revolutionary capability
- Reduced acquisition risk

https://vimeo.com/307065235

For additional information on Bell's V-280 Valor Wing affordability effort, please check out Vertical Flight Society, "Affordable Design and Manufacturing of the V-280 Wing"
Authors: Ryan Decker, Andrew Baines, Dave Carlson, James Kooiman, Keith Stanney, and Doug Wolfe
https://vtol.org/store/product/affordable-design-and-manufacturing-of-the-v280-wing-12100.cfm

Utilizing Product Cost Management to exceed Customer affordability expectations