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Cost Overruns and Their Precursors:

An Empirical Examination of Major DoD Acquisition Programs

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The Persistence of the Problem

- Trends across the wider commodity list improved into the 1990's (Younssi)
- Aircraft remained relatively immune to improvement
- Graphic does not include outliers

Five Year Cost Growth Ratios

95% CI for the Mean

Commodity	1960s	1970s	1990s-2000s
Aircraft/Missiles	~1.9	~1.6	~1.3
Combat Aircraft/Ships	~1.7	~1.4	~1.3

'A million dollars here, and a million dollars there, and pretty soon, gentlemen, you're talking about real money.' Attributed to Senator E. Dirksen

* From Younossi, et al, using a wider group of commodities

Cost overruns remain a serious problem

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Previous Approaches to the Problem

- Cost and schedule overruns are not a new problem
- Previous work
 - Has tended to cast “cost overrun” as an amorphous lump, or
 - Investigators have dug deeper into the details of their specialties
- Previous papers and policy changes have failed to resolve the issue
 - RAND
 - Inadequate initial funding
 - Unexpected technical difficulties
 - Requirement changes
 - Estimating errors
 - Cost growth $\sim f$ (quantity purchased) (Dews et al. 1979)
 - IDA added
 - Supply, labor shortages
 - Concurrency
 - Force majeure
 - Cost growth $\sim f$ (median domain growth rates) (Asher and Maggelet 1984)
 - WSARA 2009, updates to DoDI 5000 series, lower level directives (P.L. 111-23)

Previous approaches have addressed symptoms of the basic question
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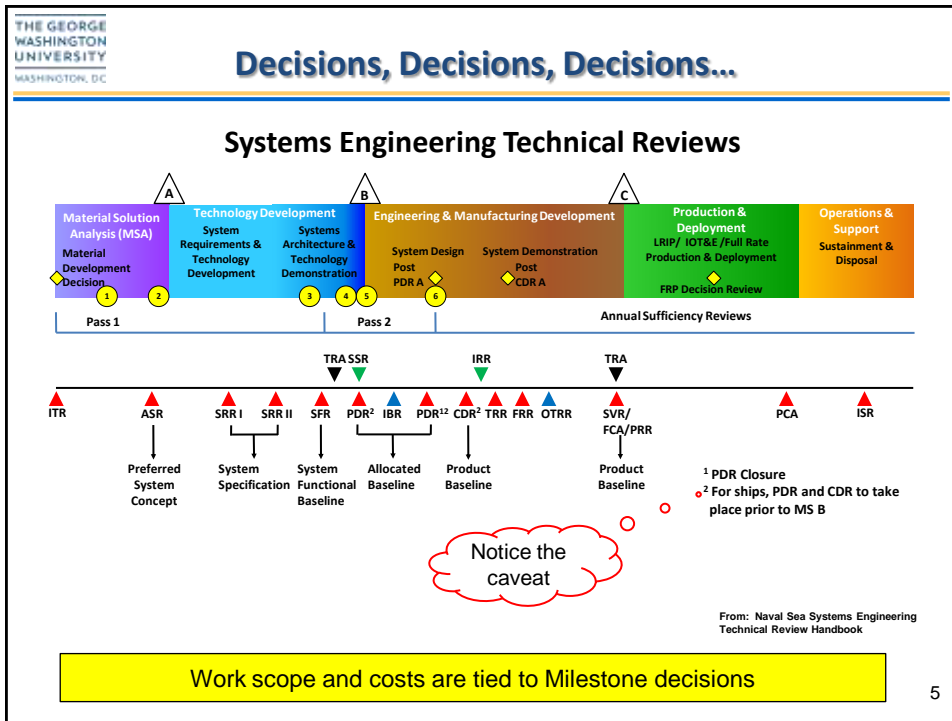
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Technical Risk as a Precursor to Cost

- There are no truly independent variables:

- Programmatic/Business → Contract Changes
- Technical → Technical/Performance
- Schedule → Schedule
- Cost → Cost

“All roads lead to Rome”, and additional cost
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The Cost Prediction Initialization Point

- It is important to note a significant normally unstated difference between the acquisition of ships and the acquisition of other customized purchases the Department of Defense makes
- We don't build prototype ships
 - Outcomes occasionally notwithstanding, the intent is that every ship built for the U.S. Navy will become an operational asset.
 - This affects the definition of "baseline cost", used later

Significant work scope and costs begin before MS B for ships

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Knowing the Neighborhood

- Metaphorically speaking, the more interesting destinations sometimes pass through or near some bad neighborhoods – creating risks
 - Cox paper
 - Does not show confidence levels
 - “Grade inflation”
 - Cannot show performance to plan

Risk “Cube” (Matrix)

Joint Confidence Level Scatterplot

(From: Rippe, Hogan, Elliot 2011) 7

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How Bad Can it Get?

- Like asking how low a particular stock price can go

NASDAQ Composite (^IXIC)

- Sound decisions can only be made with sound information

Quantity-Adjusted Cost (Actual Program)


Sound program and portfolio decisions require solid data, sound analysis

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The Cost Risk Box Canyon

- Markowitz “portfolio effect”
 - Risk is minimized through diversification
 - Requires that assets be truly independent
 - Presumes investors are rational
- DoD 7000.14R: recommends budgeting to the most probable cost
- DAPA Report 2006: recommended an 80% confidence level
- DTM 09-027 (5)(e): requires justification if the recommended confidence level is less than 80%
- Possible maximum values associated with violating these “most probable costs” is not part of anyone’s spreadsheet.



Official policy is at odds with program behavior and decision patterns

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Avoiding the Box Canyon

- Smart
 - Reminded us of the “flaw of averages”
 - Value at Risk: “the maximum loss not exceeded with a given probability”
 - Recommended lognormal v. normal distribution for lower risk
 - Conditional Tail Expectation
- “Conspiracy of hope” percentile funding is, unfortunately, built on faulty logic and does not work
- The way an aviator avoids becoming another “box canyon statistic” is by not flying into them

“Six months after winning a coveted \$35 billion aerial tanker contract, Boeing Co. announced last year that the first planes would cost \$1 billion more than promised during the contract’s competition. “ CQ WEEKLY – IN FOCUS, Jan. 21, 2012

Avoiding box canyons requires adopting different decision inputs

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Five Year Family Tendencies

Unlike previous approaches

- We limit ourselves to a five year “crystal ball”
 - Not claiming to see too far into the future
 - Consistent with the needs of the Five Year Defense Plan
- Add two more factors
 - Difficulty of the task to be performed
 - Funding dedicated to risk mitigation
- Different points of reference
- Obviously different outcome spectra

**Quantity-Adjusted Cost at Five-Year Point
Aircraft and Ships**

$$Cost_{IOC} = (\text{Median Cost Growth Factor})^y (Cost)_0$$

where y = years between program approval and IOC
0 = Program approval point

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Distribution of Five Year Cost Ratios

Different Outcomes Imply Different Input Details

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The Leading Edge of Technology

- Estimates for “modest” improvements are more accurate
- No penalty for under-estimating costs
- ~1970 marks the availability of greater computing power
 - Engine design
 - Reduced RCS
- Aircraft were divided into three groups
 - Pre-1970
 - Post 1970
 - Derivatives & special cases

All data taken from open sources

Computing power has made significant improvements possible

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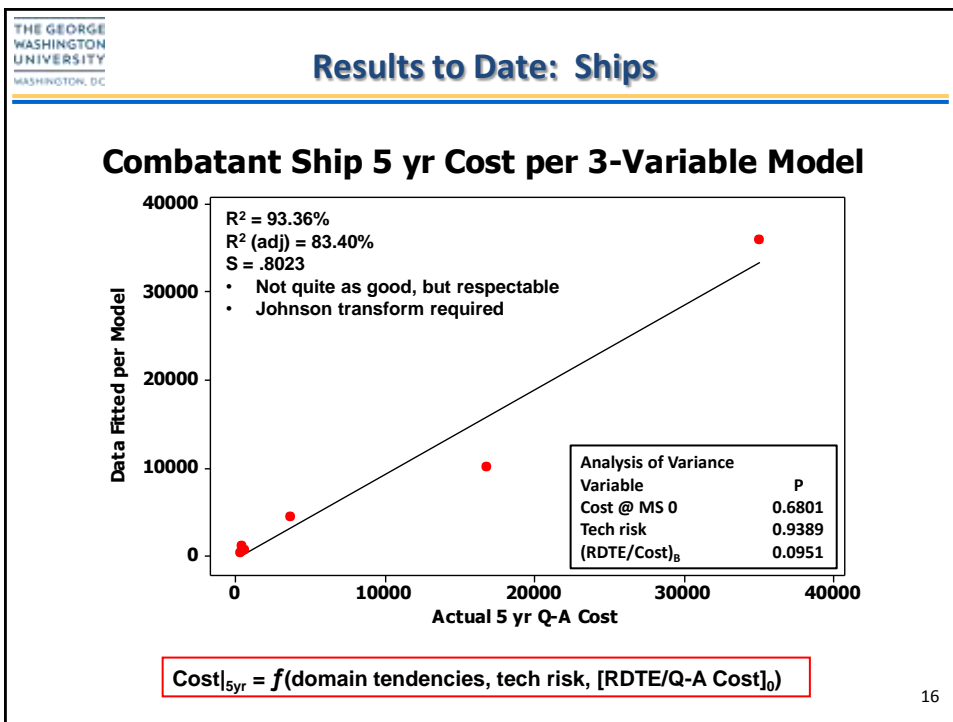
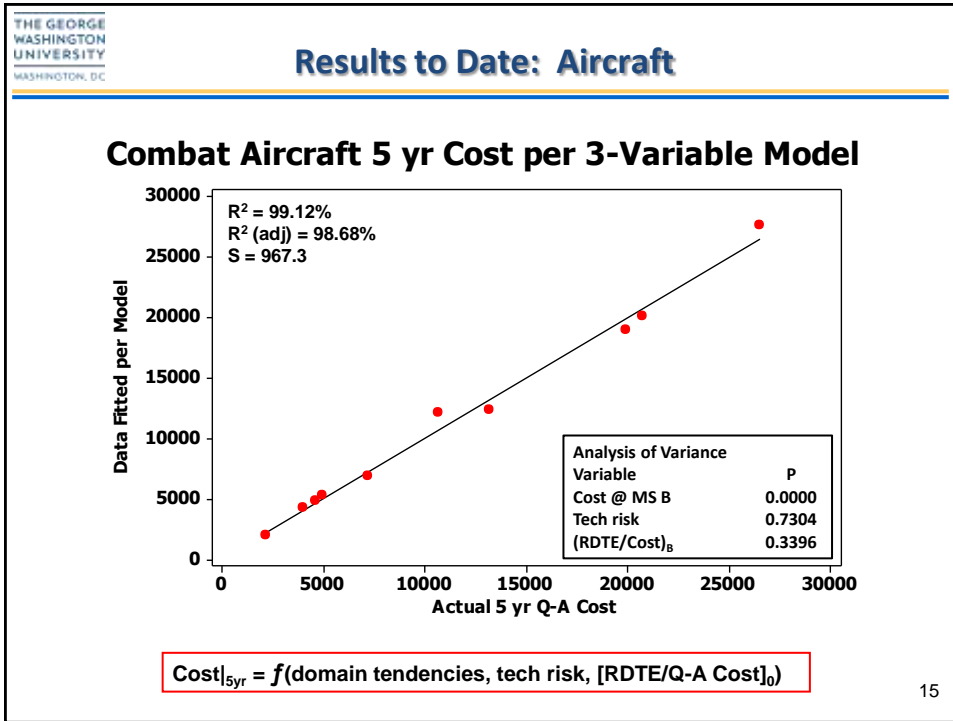
The Leading Edge of Technology

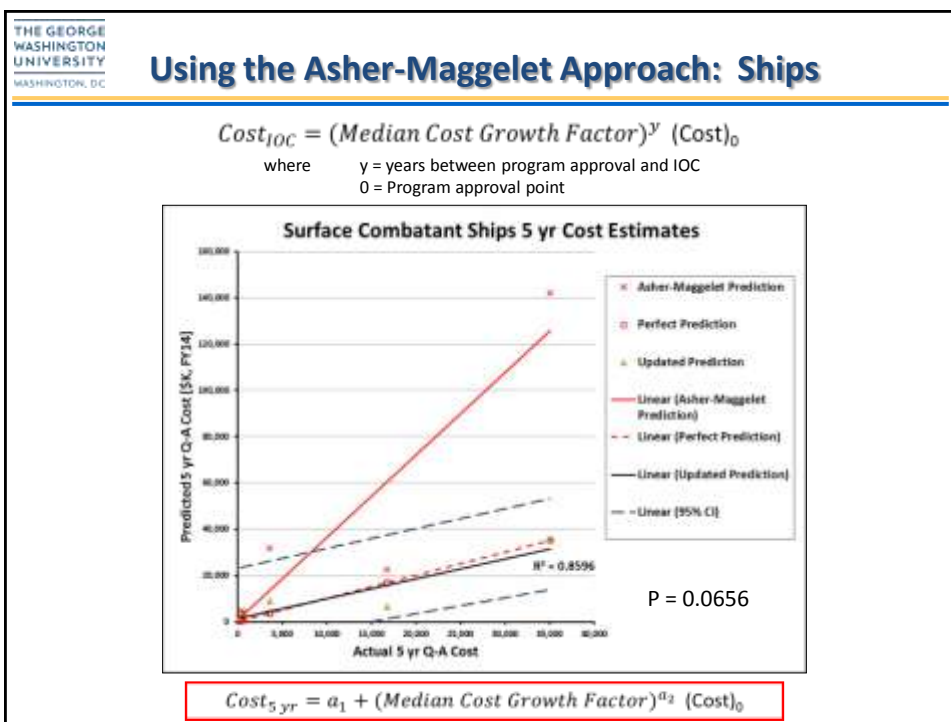
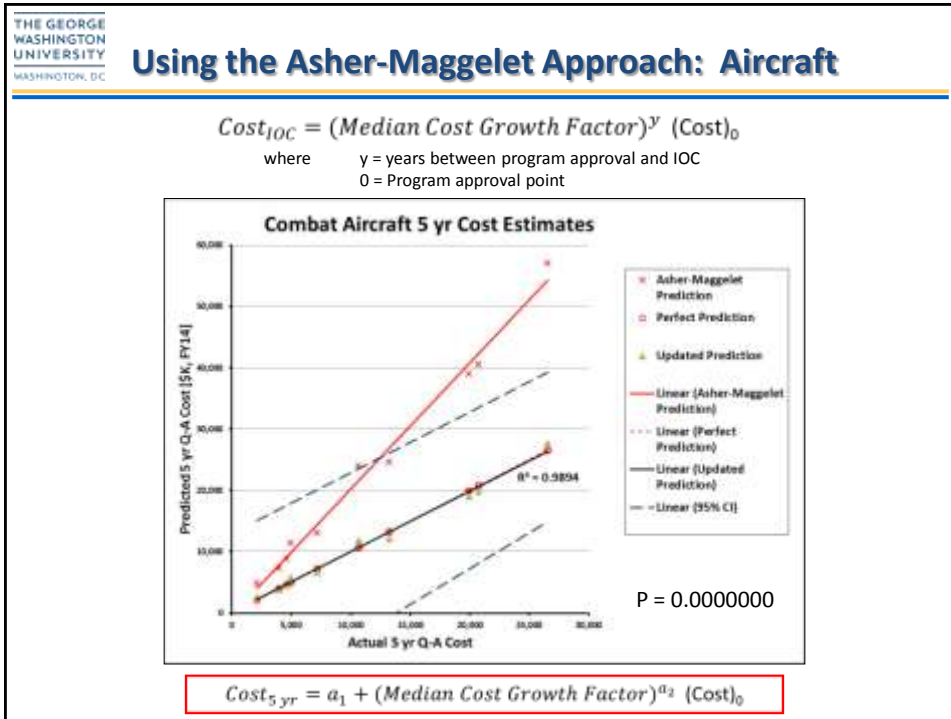
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Some progress was being made before significant computing improvement

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Contract Implications

- “There ain’t no such thing as a free lunch.” (TANSTAAFL)
- Robert Heinlein
 - Risk doesn’t go away just because the contractor is forced to assume it
 - The contractor has to make a profit in order to stay in business
 - Contractor’s answer is to calculate the six-sigma probabilities and be very, very stubborn – especially when he is the only available supplier
- Can we use this new method to have more complete discussions about risk and the need to establish more accurate costs?

DoD’s Monopsonic Status Skews Negotiations

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Portfolio Implications

- Upper management needs to balance the entire portfolio, especially if future budgets are reduced as many people have postulated
- No one likes surprises
- DoD cannot afford egg on its face – every service and program will suffer
- Intended to augment, not replace current methods
- Portfolio and “Grand Portfolio” views of available budgets
 - Provides a higher level comparison to other programs in the same domain
 - Allows a head start on resolving problems
- Where next?
 - The two examples presented here were chosen because of the authors’ familiarity with the end products.
 - Similar relationships can be derived for other product lines

The Proposed Approach May Provide Lower Portfolio Risk

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Thank You

Questions?

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