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Cost Overruns and Their Precursors:

An Empirical Examination of Major DoD Acquisition Programs

International Cost Estimating and Analysis Association
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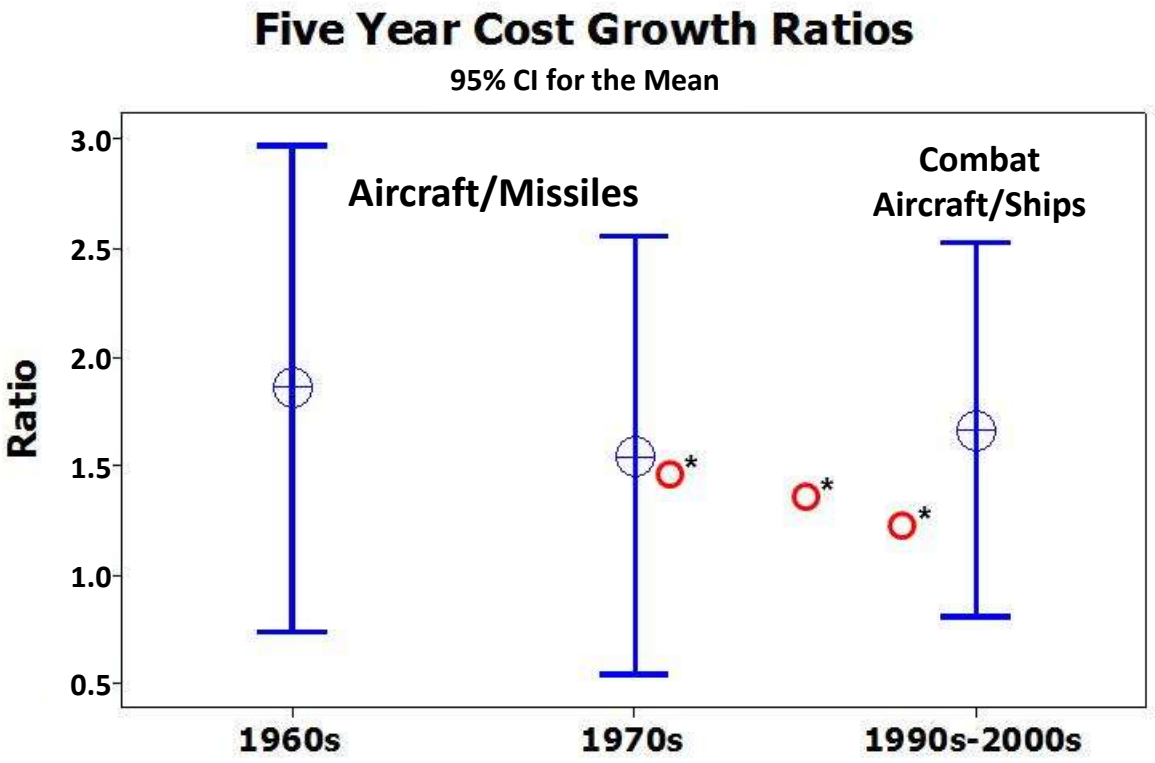
The Persistence of the Problem

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



`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

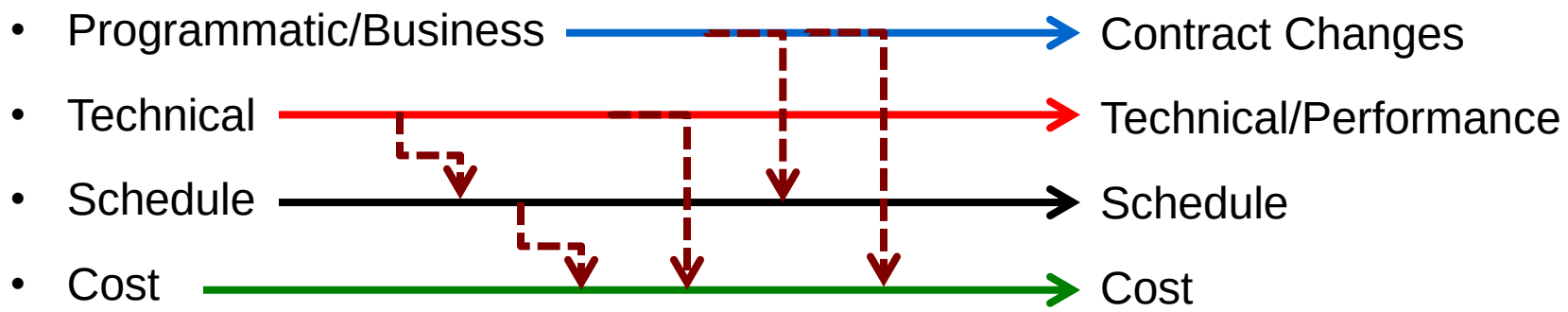
Previous Approaches to the Problem

- 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 ~ f (quantity purchased) (Dews et al. 1979)
  - IDA added
    Supply, labor shortages
    Concurrency
    Force majeur
    Cost growth ~ 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

Technical Risk as a Precursor to Cost

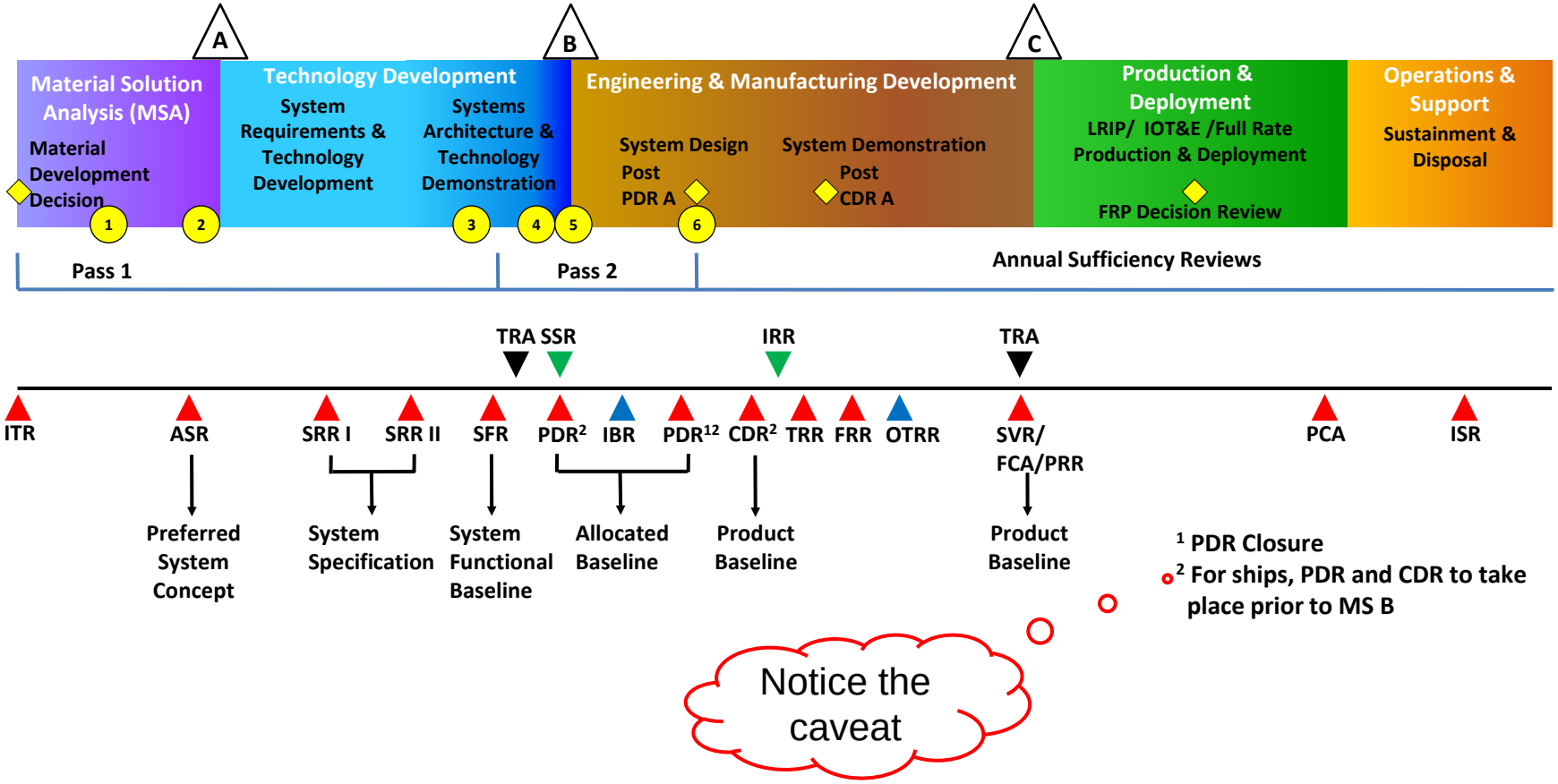
- There are no truly independent variables:



"All roads lead to Rome", and additional cost

Decisions, Decisions, Decisions…

Systems Engineering Technical Reviews



From: Naval Sea Systems Engineering Technical Review Handbook

Work scope and costs are tied to Milestone decisions

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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 <u>before</u> MS B for ships

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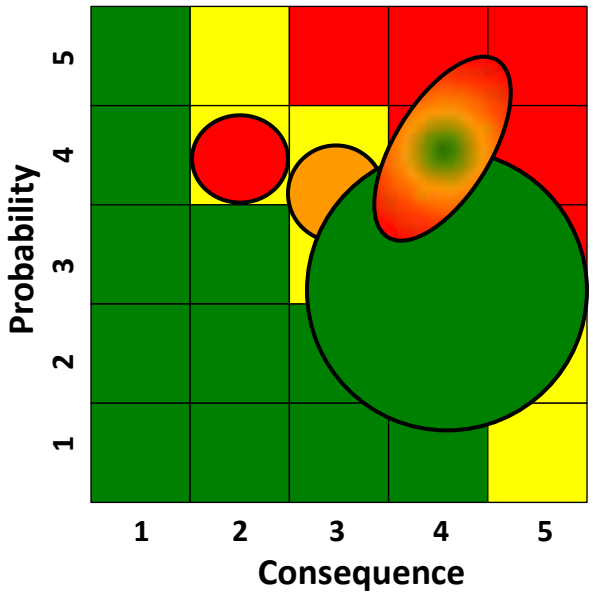
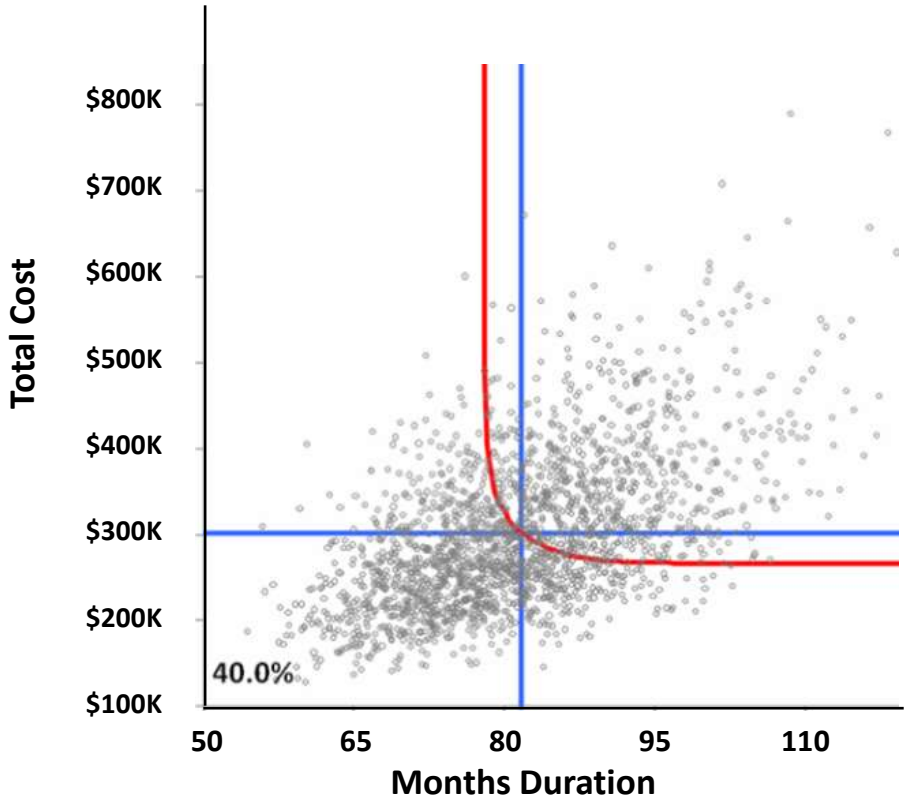
Knowing the Neighborhood

- 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)

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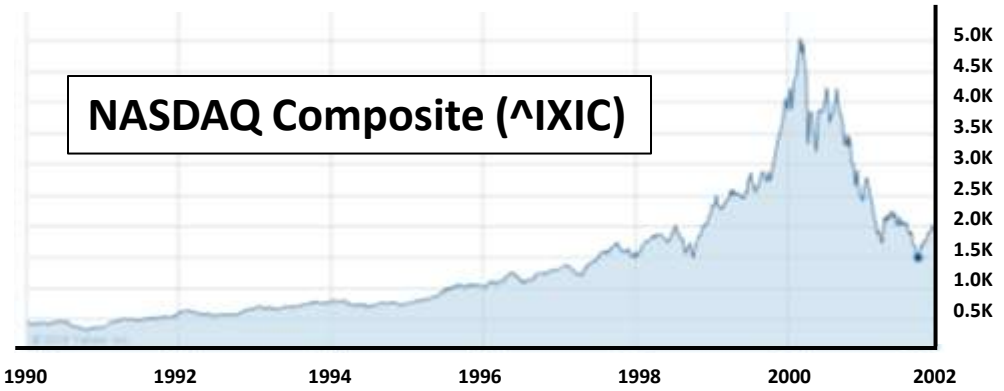
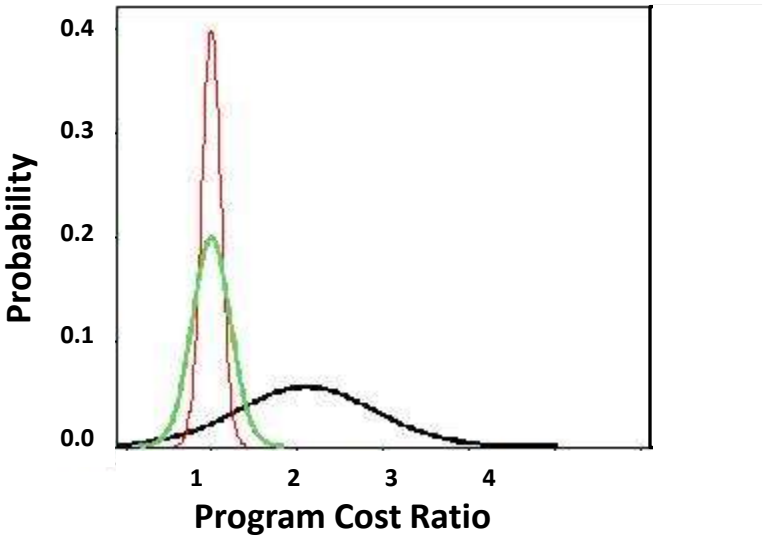
How Bad Can it Get?

- Like asking how low a particular stock price can go



- Sound decisions can only be made with sound information



Sound program and portfolio decisions require solid data, sound analysis

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. "

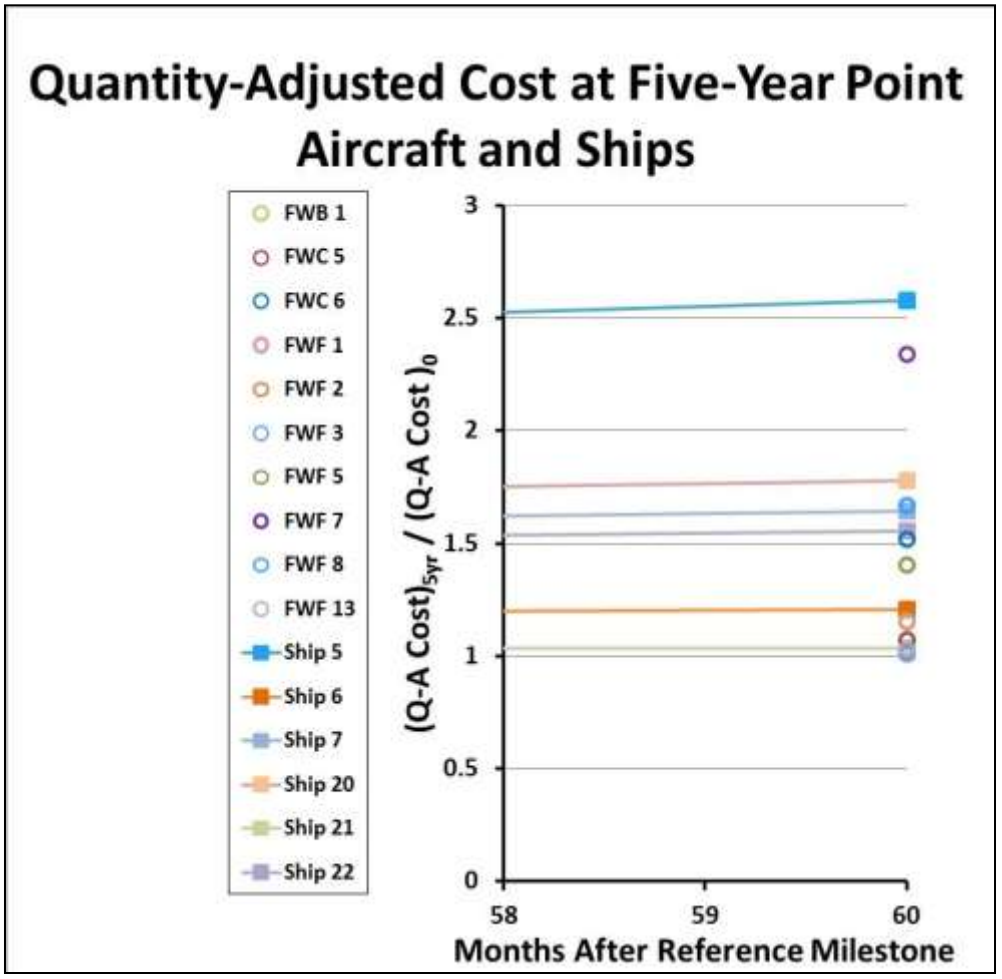
CQ WEEKLY – IN FOCUS, Jan. 21, 2012

Avoiding box canyons requires adopting different decision inputs

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



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

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

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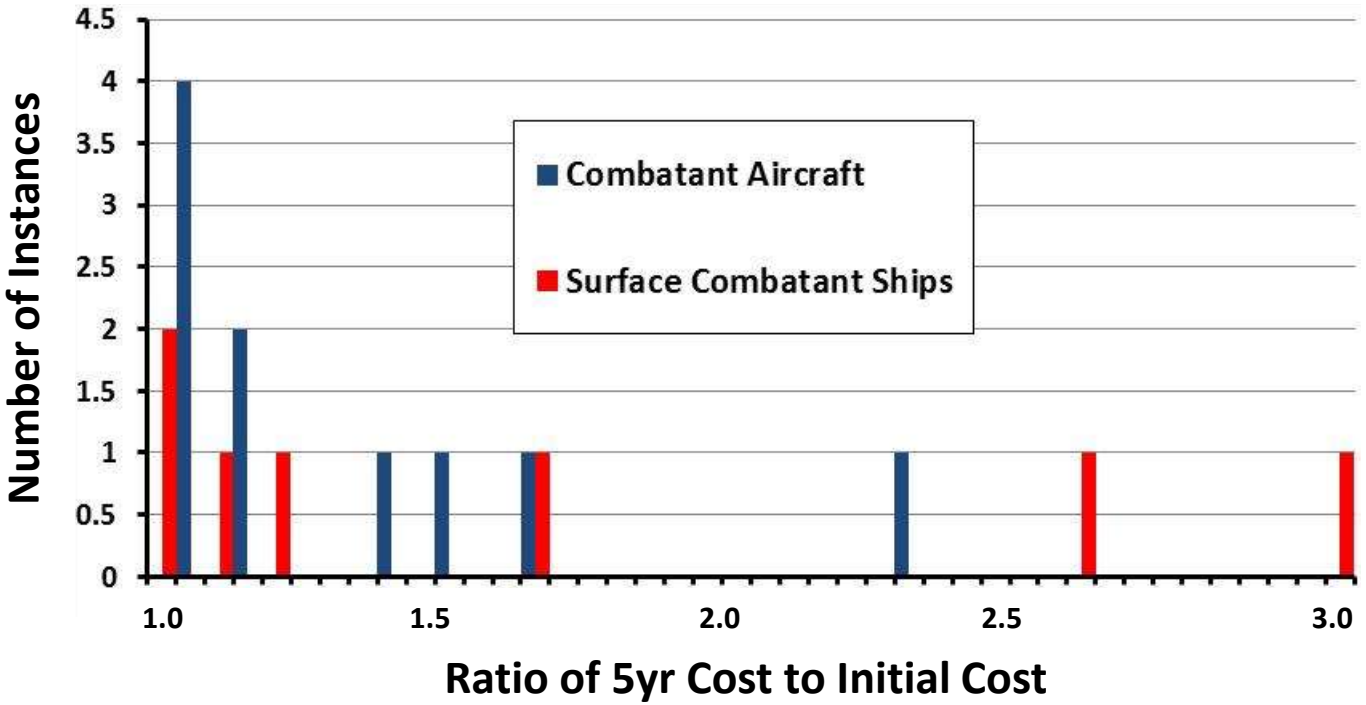
Distribution of Five Year Cost Ratios



Different Outcomes Imply Different Input Details

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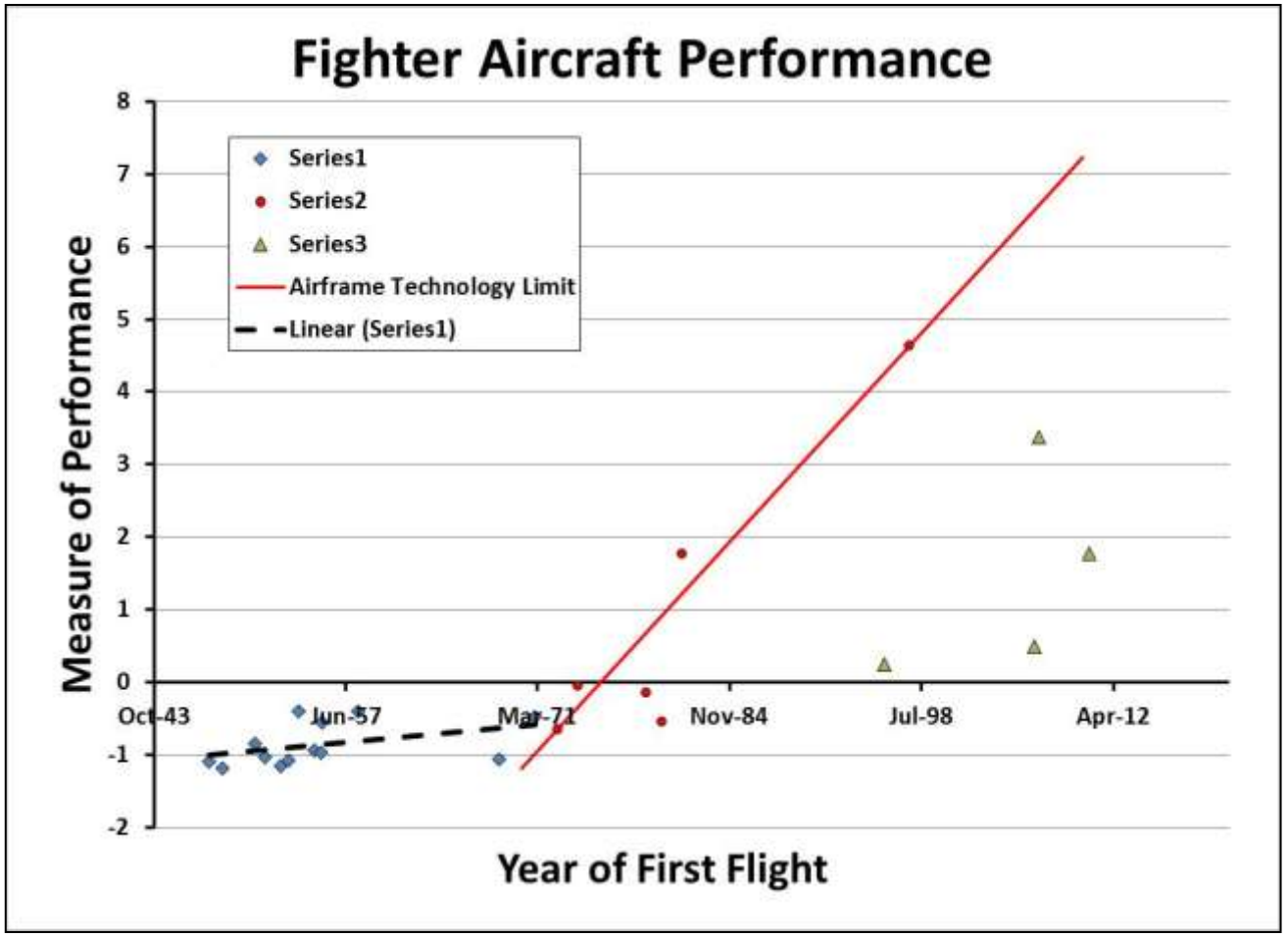
The Leading Edge of Technology

- 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

- ~1970 marks the availability of greater computing power
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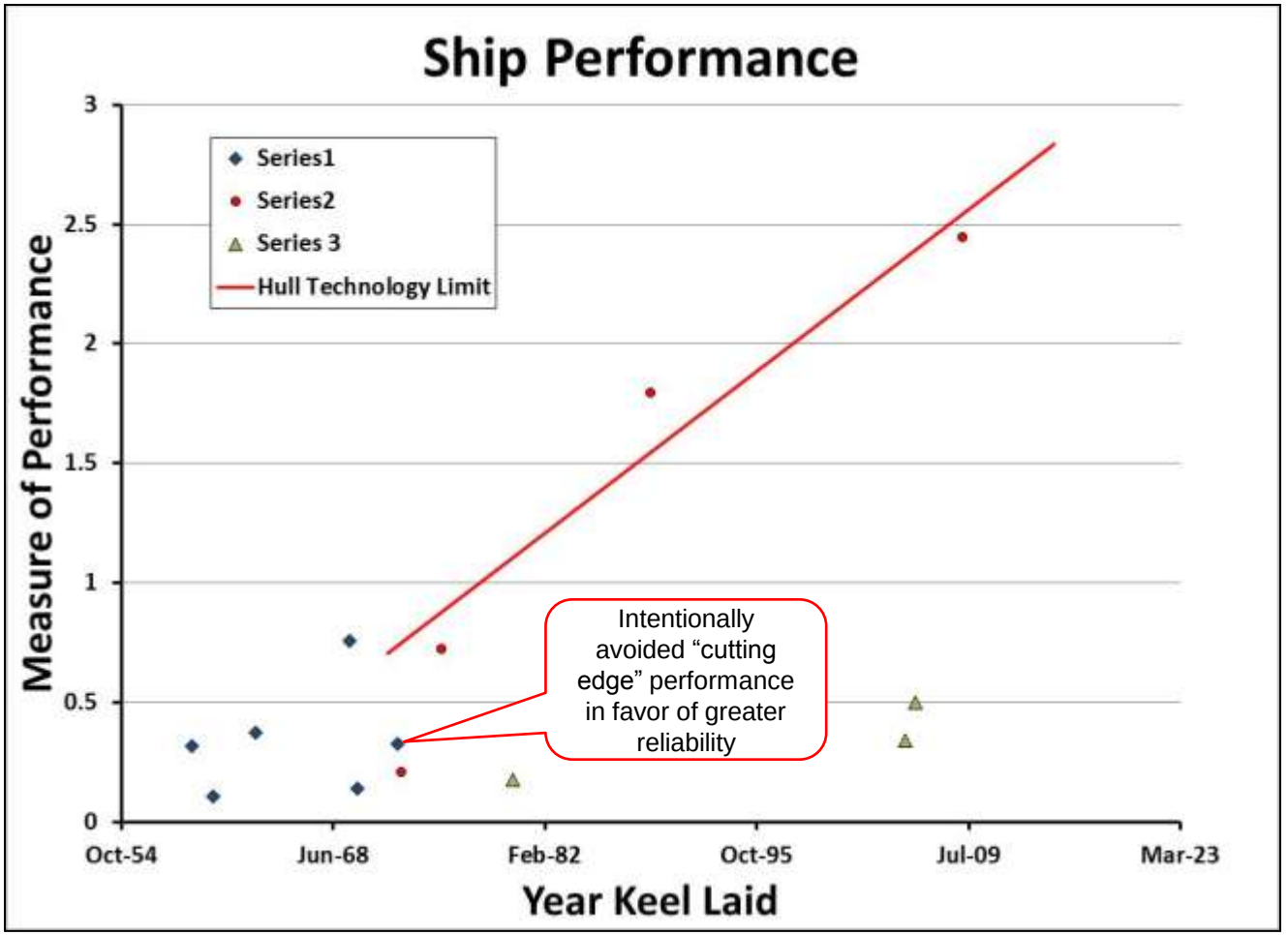
- Ships were divided into three groups
  - Pre-1970
  - Post 1970
  - Derivatives

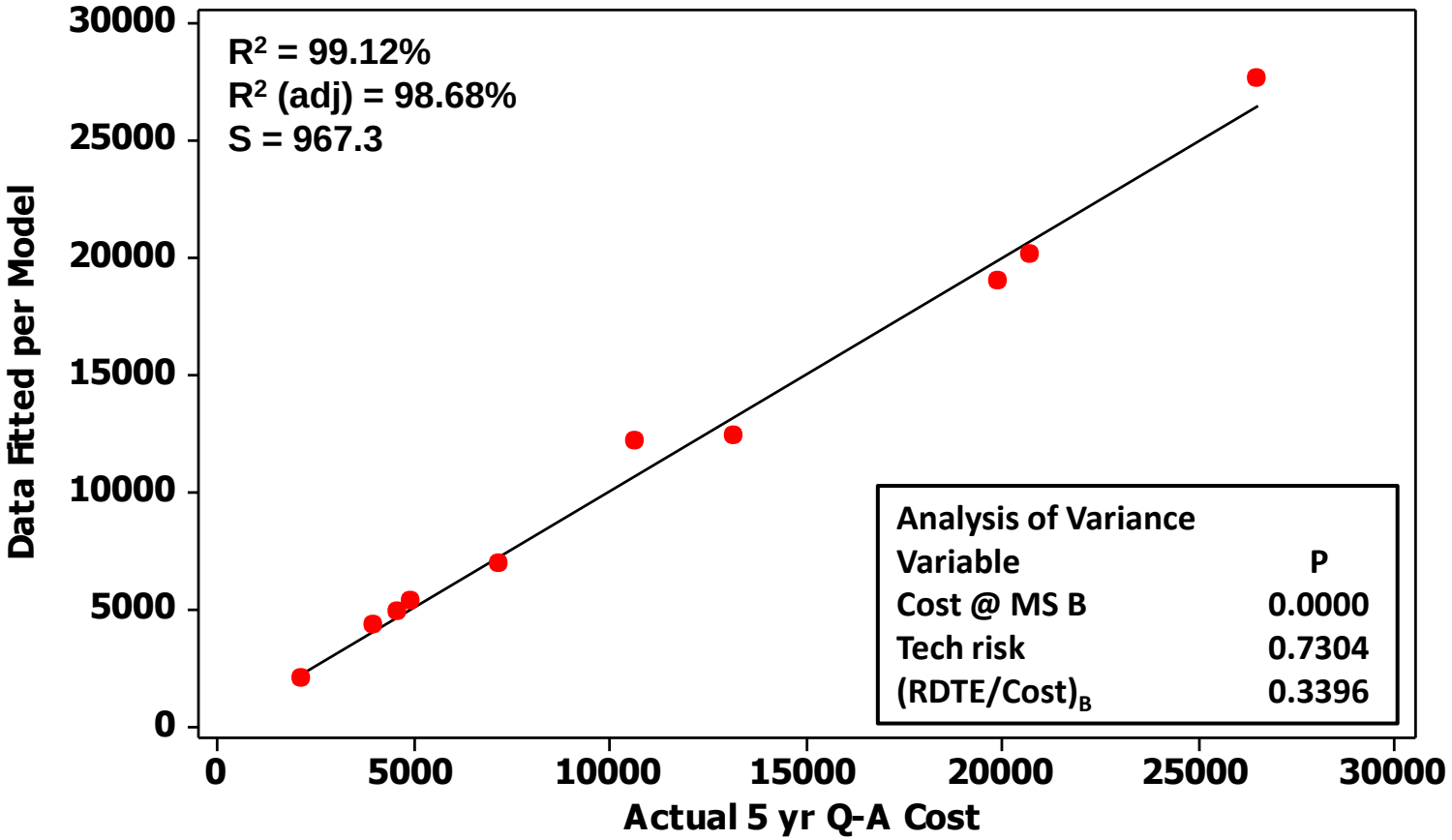


All data taken from open sources

Some progress was being made before significant computing improvement

Results to Date: Aircraft

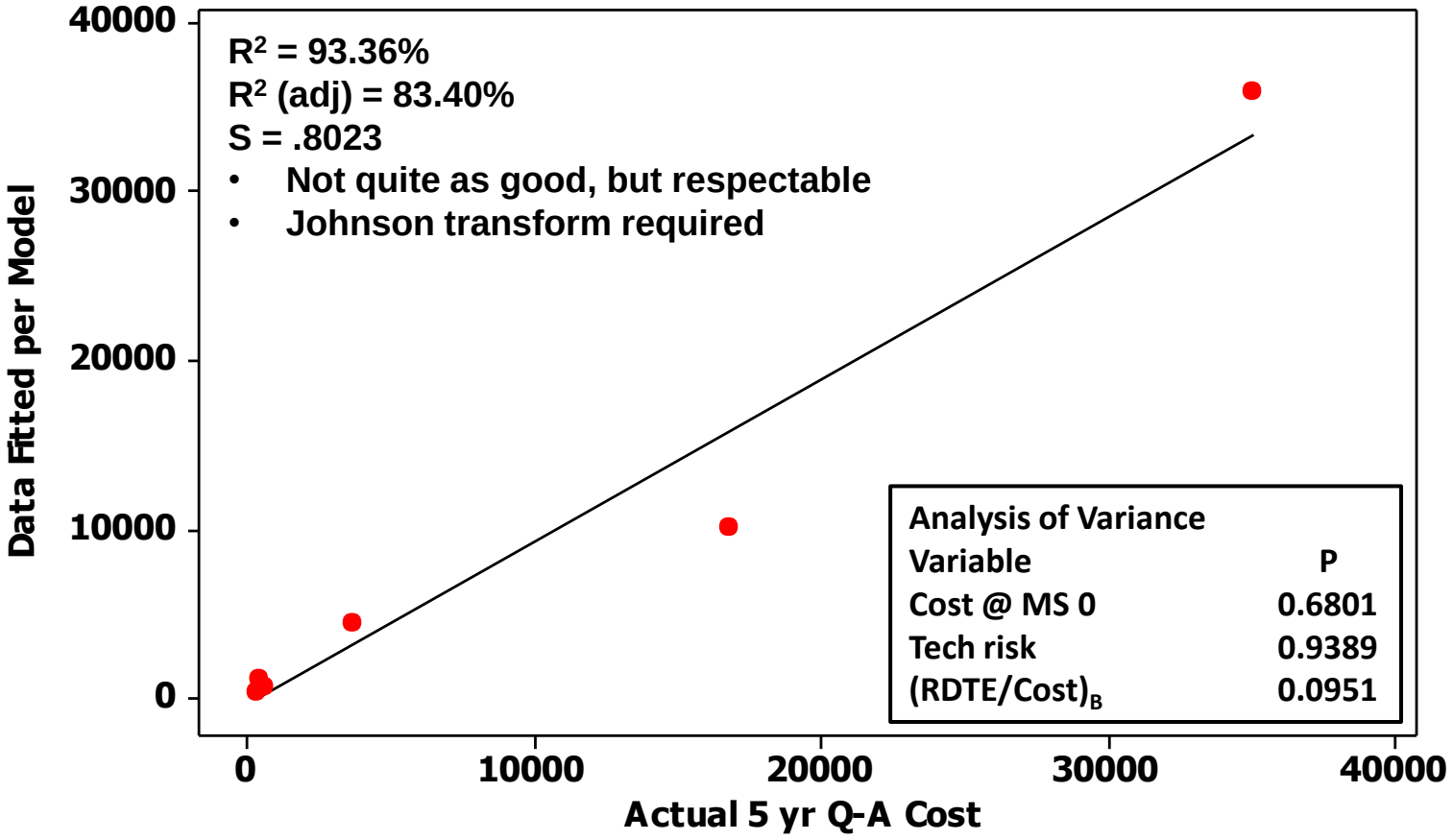
Combat Aircraft 5 yr Cost per 3-Variable Model



$Cost|_{5yr} = f(\text{domain tendencies, tech risk, } [\text{RDTE/Q-A Cost}]_0)$

Results to Date: Ships

Combatant Ship 5 yr Cost per 3-Variable Model

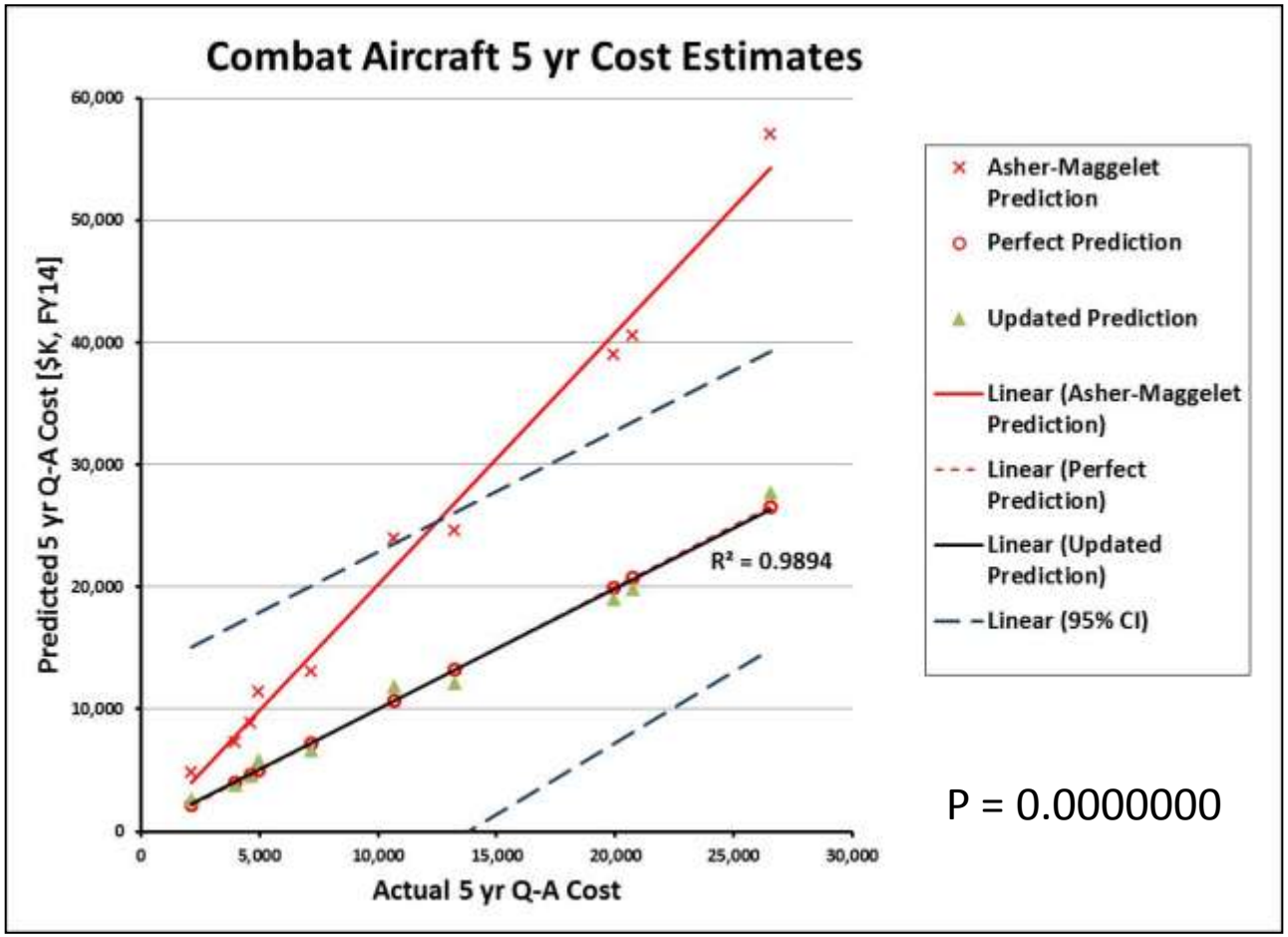


$Cost|_{5yr} = f$(domain tendencies, tech risk, $[RDTE/Q\text{-}A\ Cost]_0$)

Using the Asher-Maggelet Approach: Aircraft

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

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



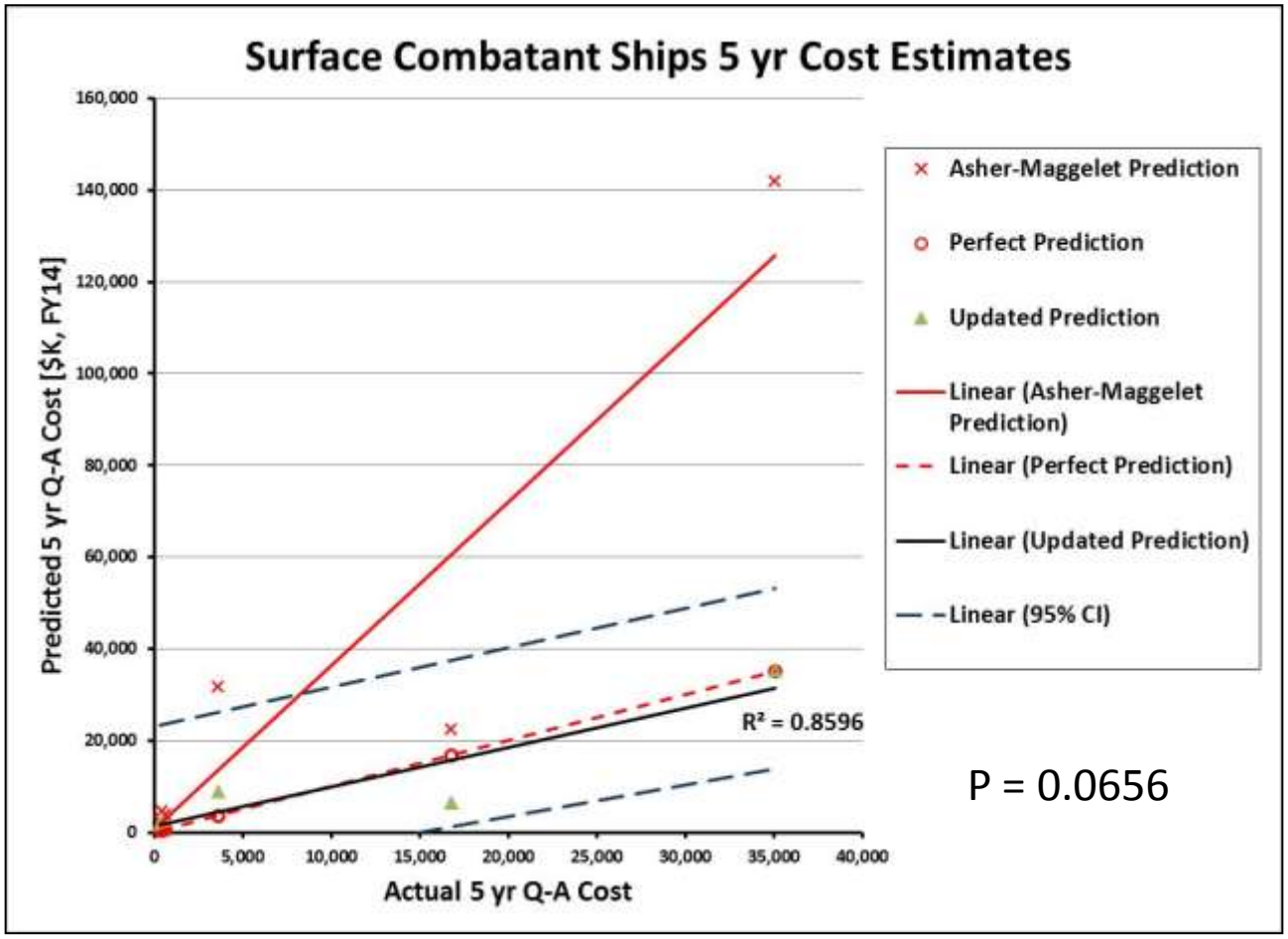
P = 0.0000000

$$Cost_{5\ yr} = a_1 + (Median\ Cost\ Growth\ Factor)^{a_2}\ (\text{Cost})_0$$

Using the Asher-Maggelet Approach: Ships

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

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



P = 0.0656

$$Cost_{5\ yr} = a_1 + (Median\ Cost\ Growth\ Factor)^{a_2}\ (\text{Cost})_0$$

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 Monopsic Status Skews Negotiations

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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