Earned Schedule: Utility in Major U.S. Air Force Acquisition Programs

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Overview

- The Issue
- Previous Research
- Definitions
- Methodology & The Five Tests
- Analysis & Results
- Conclusions & Recommendations
- Summary

The Issue

- Earned Value Management (EVM) is an effective tool for managing cost performance: but what are its merits in forecasting schedule?

- EVM measures schedule in terms of dollars, rather than in terms of time, and is ostensibly useless over the final 1/3 of a project.

- Earned Schedule (ES) developed to combat these EVM shortcomings, but does it translate to major defense acquisition programs?

The Issue

- Major Defense Acquisition Programs (MDAP) are consistently delivered over budget and schedule.
- Delayed delivery of programs leads to increased costs.
- Earned Schedule is a 10-year old concept, developed by Walt Lipke to give greater focus to schedule performance, but its application to defense acquisition programs has not been explored.

Research Questions

- **Three Research Questions:**
  - To what extent is Earned Schedule currently utilized in Air Force ACAT I acquisition programs?
  - Does Earned Schedule provide more accurate schedule predictions than traditional DoD methods?
  - Does Earned Schedule provide more timely schedule predictions than traditional DoD methods?

Previous Research

Previous Research

- **Earned Schedule In Practice**
  - **Henderson** - *"Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data"*
  - **Rujirayanyong** – *"A comparison of Three Completion Date Predicting Methods for Construction Projects"*
  - **Lipke** - *"Earned Schedule Application to Small Projects"*
  - **Tzaveas, Katsavounis, Kalfakakou** – *"Analysis of Project Performance of a Real Case Study and Assessment of Earned Value and Earned Schedule Techniques for the Prediction of Project Completion Date"*
  - **Vanhoucke and Vandevoorde** – *"Measuring the Accuracy of Earned Value/Earned Schedule Forecasting Predictors"*

Methodology & The Five Tests

Data Collection

- OUSD (AT&L) system: Defense Acquisition Management Information Retrieval (DAMIR)

- Contract Performance Report Format 1
  - Cumulative BCWS
  - Cumulative BCWP
  - SPI($)
  - SV($)

- ACAT I Programs from Aeronautical System Center

- Qualitative Data from Electronic System Center and Space & Missile Center

Selected Programs

List of Program Used for Analysis

Rockwell B-1B Lancer
Northrup Grumman B-2 Spirit
General Dynamics F-16 Fighting Falcon
McDonnell Douglas F-15 Eagle
Fairchild Republic A-10 Thunderbolt
Fairchild T-46
Boeing E-3 Sentry Airborne Warning and Control System
Boeing C-17 Globemaster III
General Dynamics/Grumman EF-111A Raven
AGM-131 Short Range Attack Missile II
AGM-86 Air Launch Cruise Missile
AGM-65 Maverick
Lockheed Martin C-130J Super Hercules Upgrade

Data

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Platform Name	# of Contracts	# of Data Points
B-1	14	233
B-2	2	19
F-16	4	51
F-15	8	115
A-10	5	135
E-3	2	50
T-46	2	25
C-17	11	226
EF-111	2	36
AGM-131 (SRAM)	1	17
AGM-86 (ALCM)	8	74
AGM-65	4	41
C-130J	1	65
Sum	64	1,087

Methodology

- Qualitative: Interview Program Offices to determine how schedule analysis is conducted, their familiarity with Earned Schedule, & the prevalence of Earned Schedule in their analyses.

- Quantitative: Is there a statistical difference between the SPI($) and SPI(t) values of EVM and ES? Use Paired-T Test to compare means of SPI($) and SPI(t).

- If so, run a series of five tests to determine which method provides for accurate and timely predictions of schedule overages.

The Five Tests

- **Test 1: Analysis of SPI(t) and SPI($) below .90 Over Time**

- Average SPI(t) and SPI($) value calculated at 6 different project completion points (20%, 40%, 50%, 60%, 80%, 90%)

- Addresses SPI($) inadequacies over the final third of a program.

The Five Tests

- **Test 2: Analysis of Frequency of SPI(t) and SPI($) values below .90**
- Calculate Completion Percentage where SPI value first dropped below .90.
- Calculate total number of data points below .90, when a program is determined to be “in trouble.”
- Addresses which method provides more timely schedule predictions.

The Five Tests

- **Test 3a: Analysis of Optimism and Accuracy in SPI(t) vs. SPI($) values**

- Calculate which SPI value for each data point is highest. Highest SPI is the most optimistic.

- Calculate at 6 different project completion points (20%, 40%, 50%, 60%, 80%, 90%) to see which method is more optimistic at certain points in a program.

- Addresses issue of schedule metrics being historically optimistic.

The Five Tests

- **Test 3b: Analysis of SPI(t) vs. SPI($) Points Closer to the Final Schedule Result**

- Calculate which SPI value is closest to the final schedule result.

- Calculate at 6 different project completion points (20%, 40%, 50%, 60%, 80%, 90%) to see which method is more accurate at certain points in a program.

- Addresses which method is more accurate.

The Five Tests

- **Test 4: Analysis of TSPI Values**

- Compare number of programs signaled as “in trouble” with TSPI values of 1.10, 1.05 and 1.01.

- Calculate at 6 different project completion points (20%, 40%, 50%, 60%, 80%, 90%) to see which TSPI value signals problems most accurately.

The Five Tests

- **Test 5: Analysis of SV(t) vs. SV($) Divergence Point**
- Calculate SV(t) and SV($) for each data point.
- Calculate divergence point for each program.

Application to the Critical Path

- **Application to the Critical Path**
  - "Deep-Dive" Analysis on C-130J Block 7.0 Upgrade

Analysis and Results

Analysis and Results

- **Qualitative Test**
  - Program offices use monthly EVM data and Integrated Master Schedule to perform monthly schedule analysis.
  - Most offices have heard of Earned Schedule.
  - 6/18 (33%) of program offices that responded use Earned Schedule in their analysis.
  - No programs use Earned Schedule as their *primary* schedule analysis tool; all used it as a secondary/cross-check to EVM.

Analysis and Results

- **Results of Significance Test**
  - Paired T-Test as Comparison of Means
  - T-Statistic: -8.6231
  - Degrees of Freedom: 1,086
  - P-Value: 2.27467 E -17

- **Reject the Null Hypothesis.**

- **There is a statistical difference between the Earned Value Management and Earned Schedule methods.**

Analysis and Results

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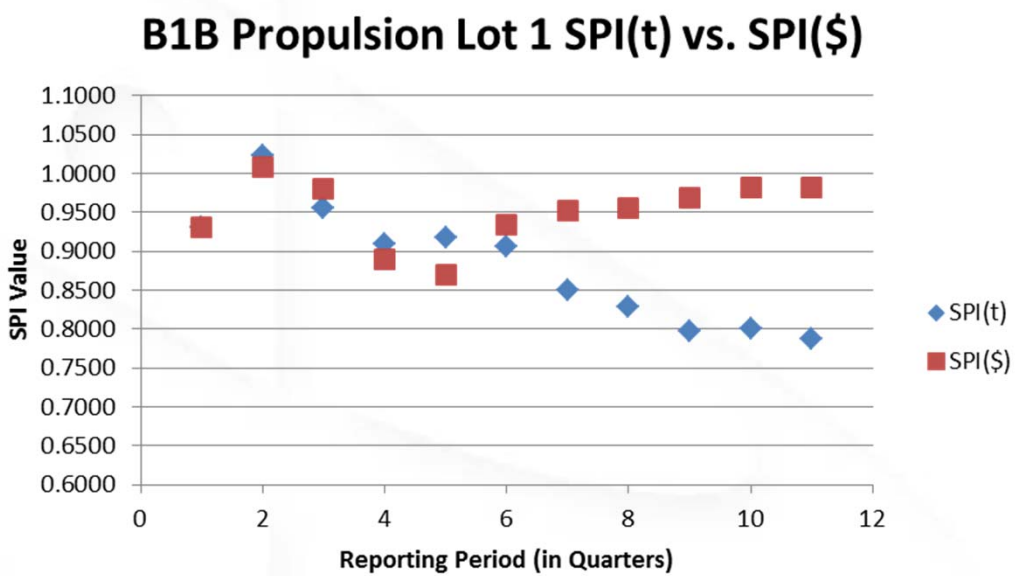
- **Test 1: Analysis of SPI(t) and SPI($) below .90 Over Time**
  - Typical Program: B-1B Propulsion Lot 1



Analysis and Results

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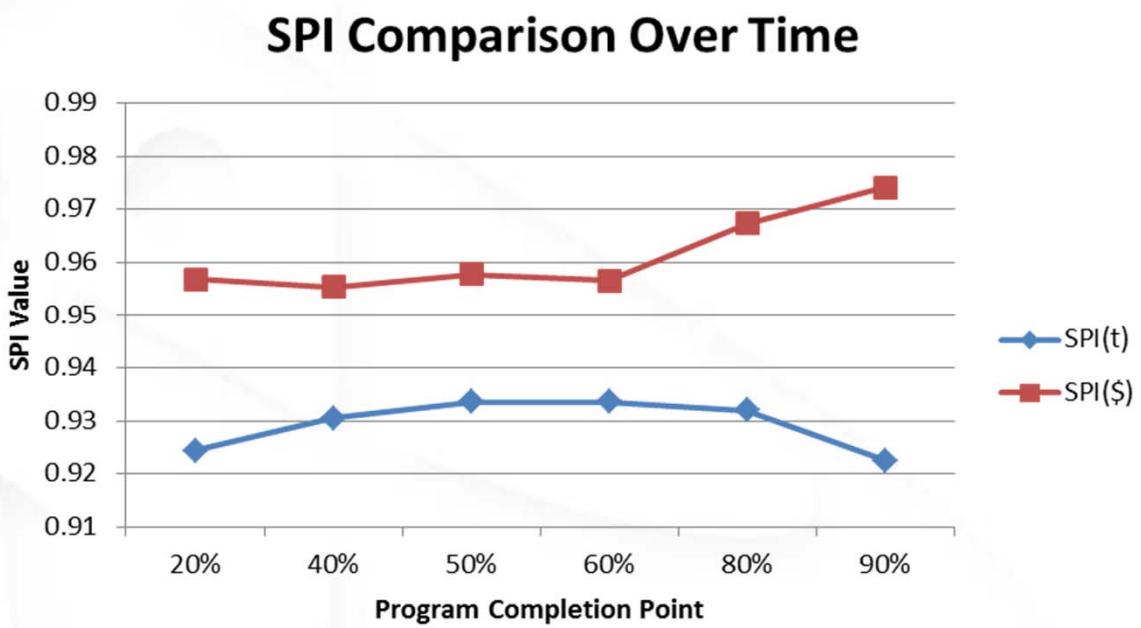
- **Test 1: Analysis of SPI(t) and SPI($) below .90 Over Time**
  - SPI Comparison Over Time



Analysis and Results

- **Test 2: Analysis of Frequency of SPI(t) and SPI($) values below .90**

	Percent Complete (Mean)	Programs with no SPI value below .90
Earned Schedule	29.89%	21
Earned Value Management	17.89%	30

Analysis and Results

- **Test 2: Analysis of Frequency of SPI(t) and SPI($) values below .90**

	Total Points < .90	Percentage of Overall Points
Earned Value Management	135	12.42
Earned Schedule	220	20.24

Analysis and Results

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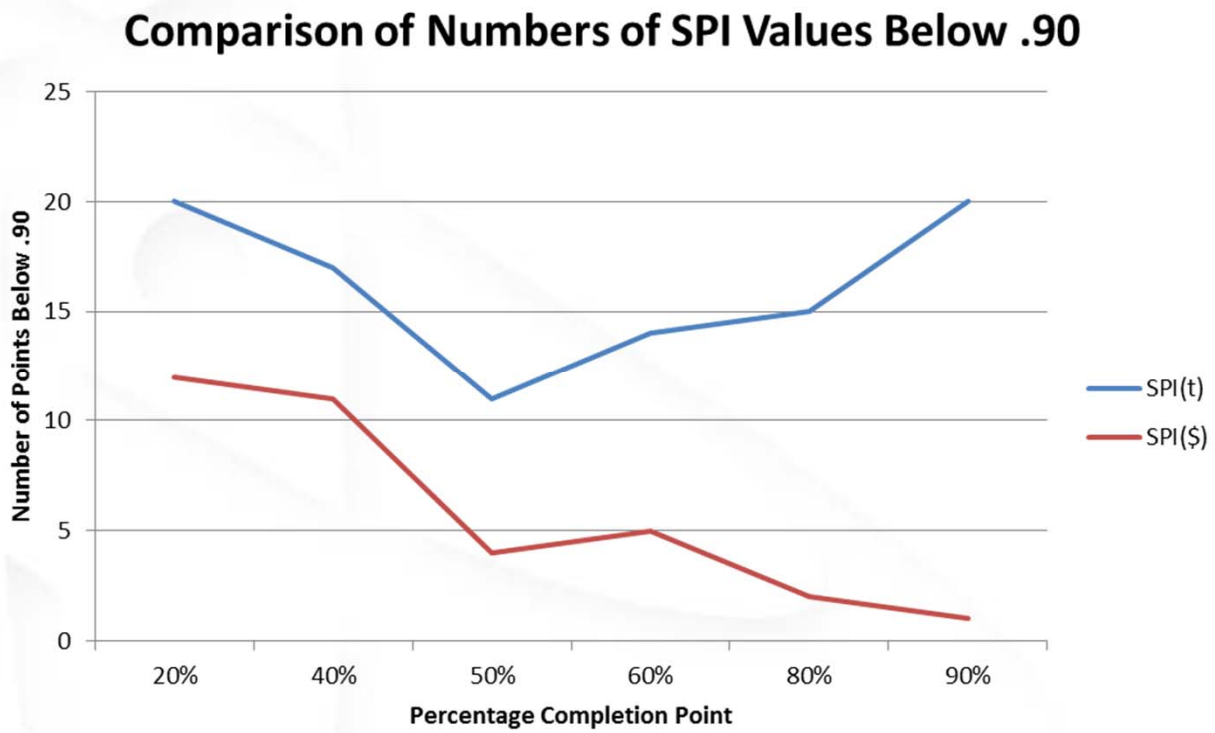

Analysis and Results

- **Test 3a: Analysis of Optimism and Accuracy in SPI(t) vs. SPI($) values**

	Number of Occurrences	Percentage of Overall (%)
Earned Value Management	646	59.43
Earned Schedule	381	35.05
EVM = ES	60	5.52

Analysis and Results

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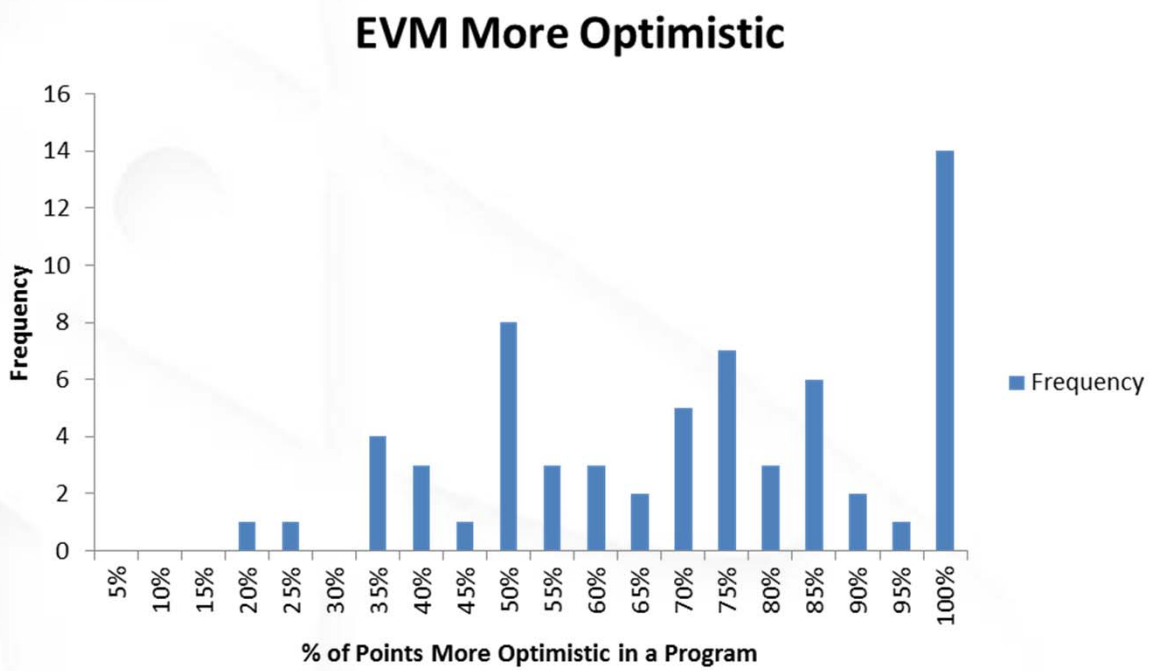

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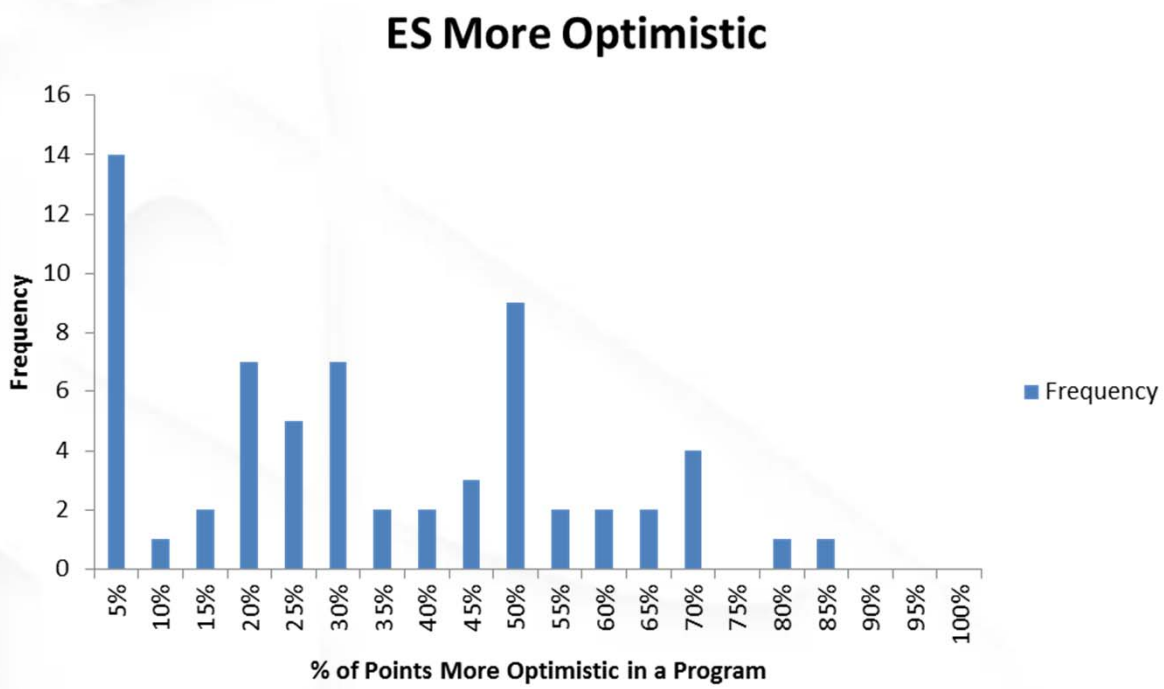

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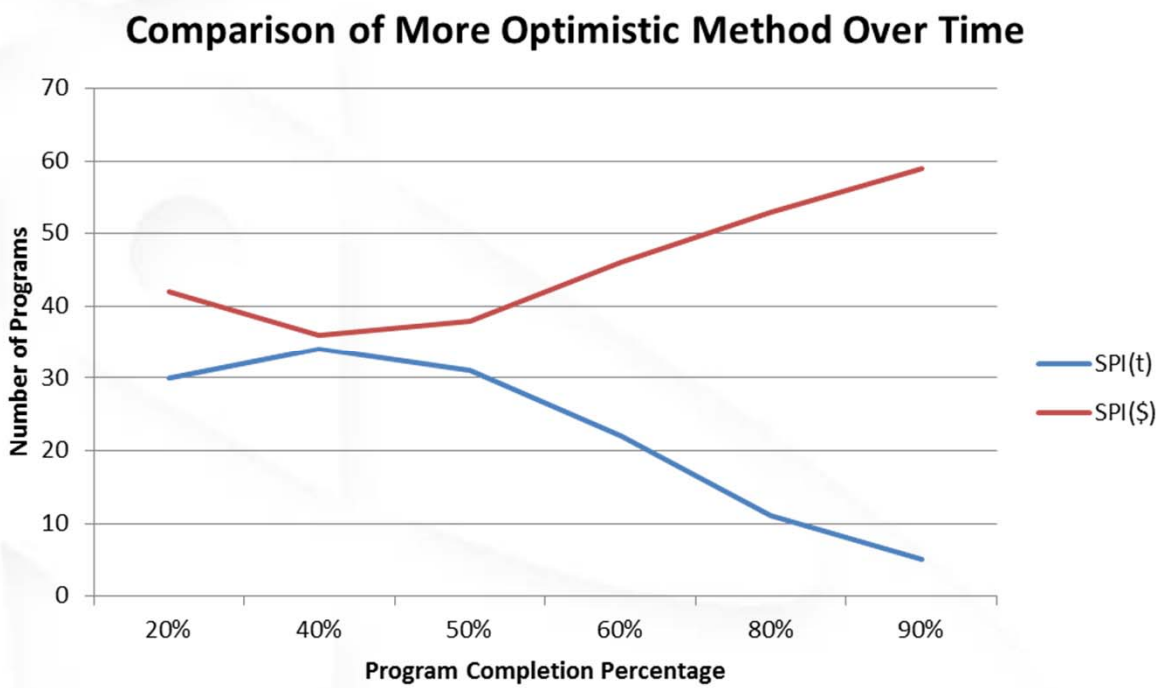

Analysis and Results

- **Test 3b: Analysis of SPI(t) vs. SPI($) Points Closer to the Final Schedule Result**

	Number of Occurrences	Percentage of Overall Occurrences (%)
Earned Value Management	403	37.07
Earned Schedule	624	57.41
EVM = ES	60	5.52

Analysis and Results

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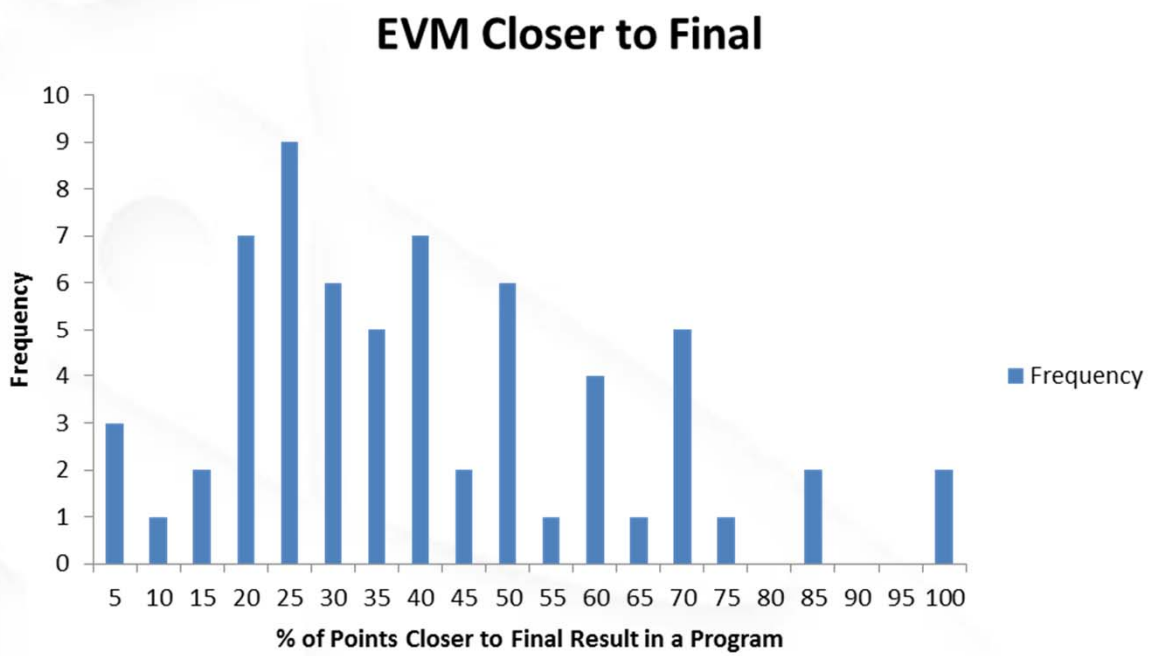
- **Test 3b: Analysis of SPI(t) vs. SPI($) Points Closer to the Final Schedule Result**



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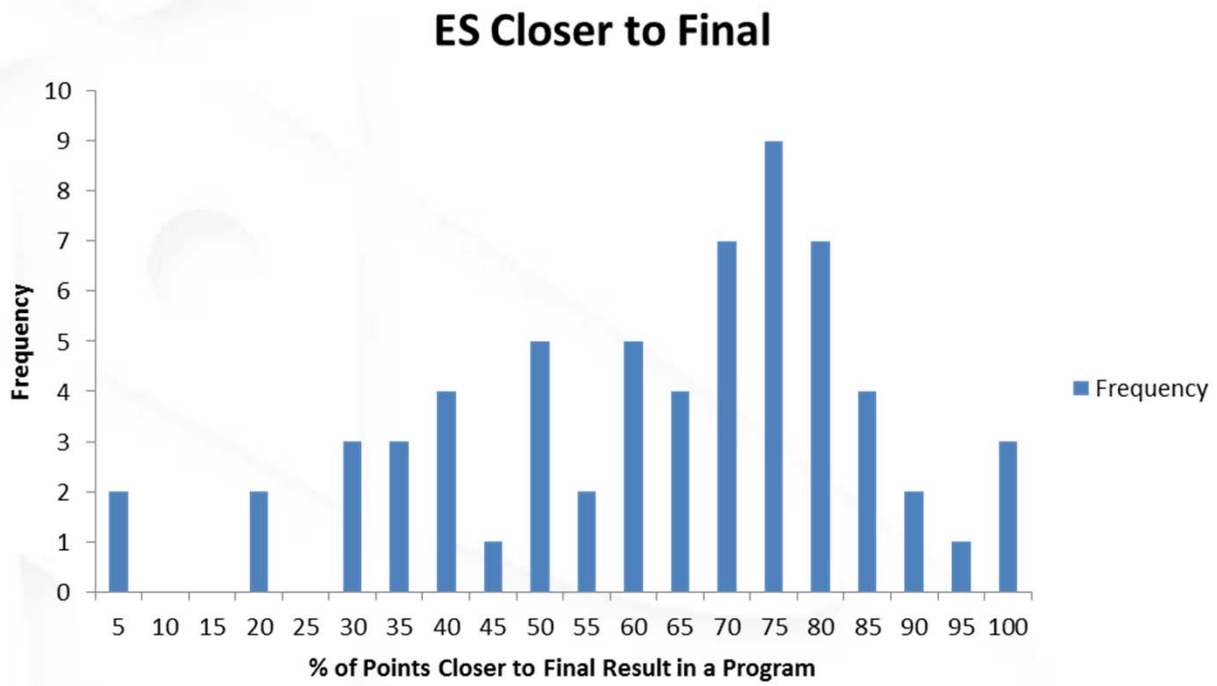

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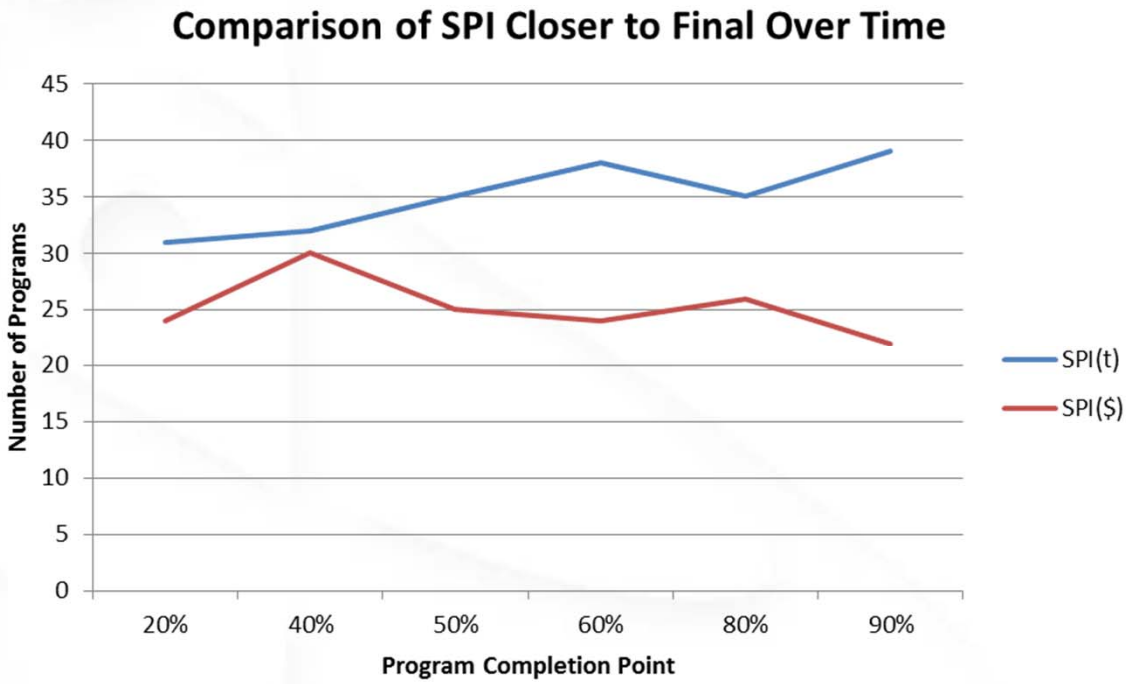

Analysis and Results

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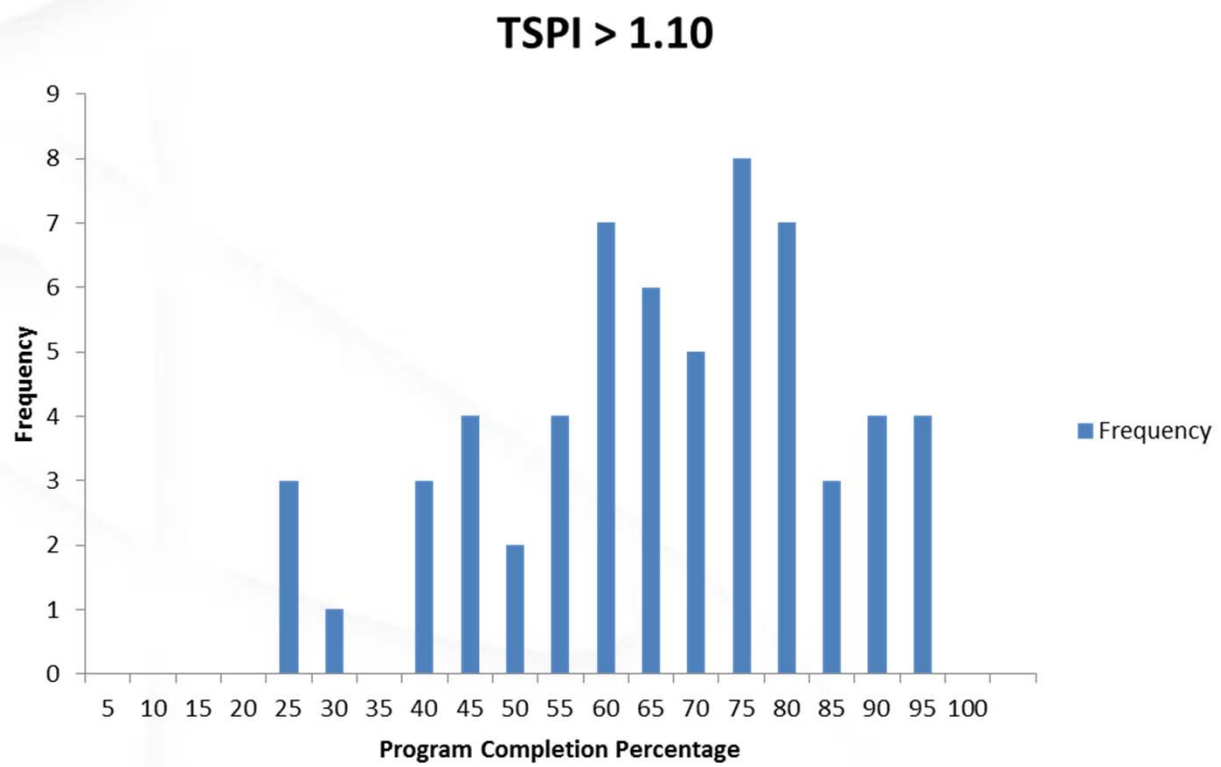
- **Test 4: Analysis of TSPI Values**

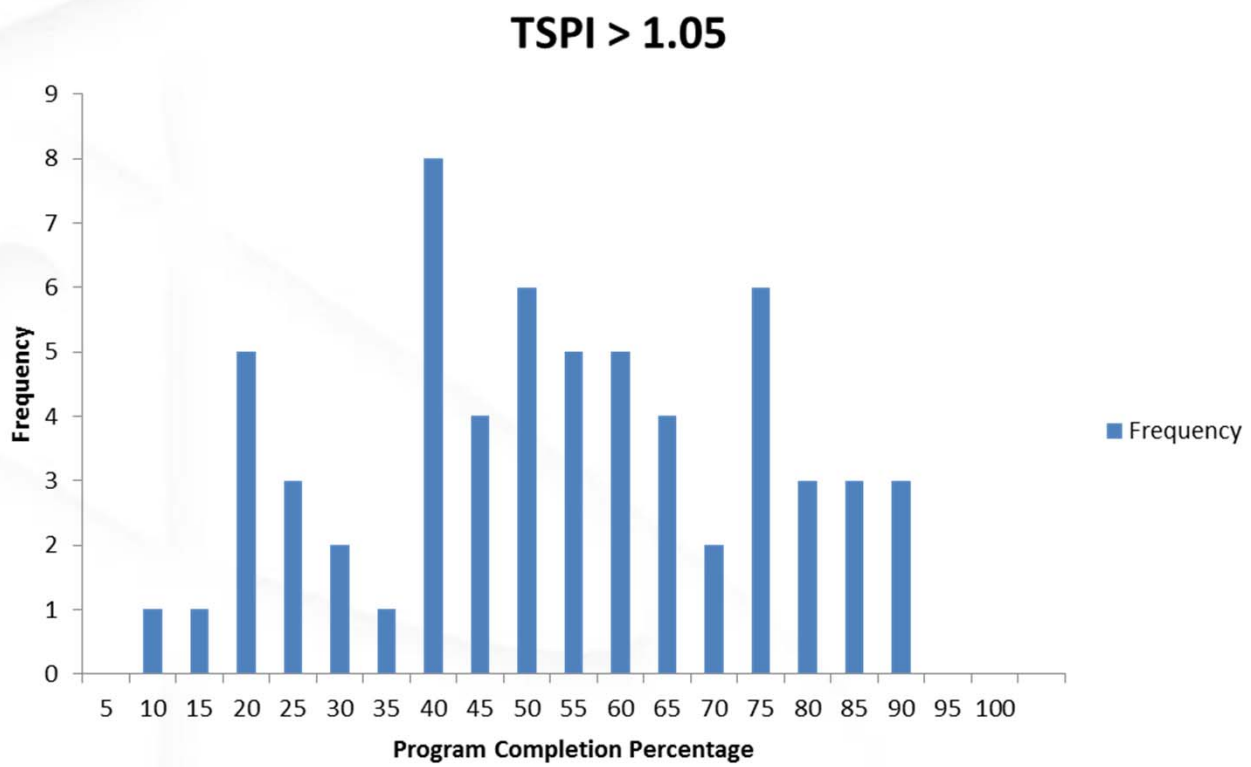
Mean: 64.22%



Analysis and Results

- **Test 4: Analysis of TSPI Values**

Mean: 50.81%



Analysis and Results

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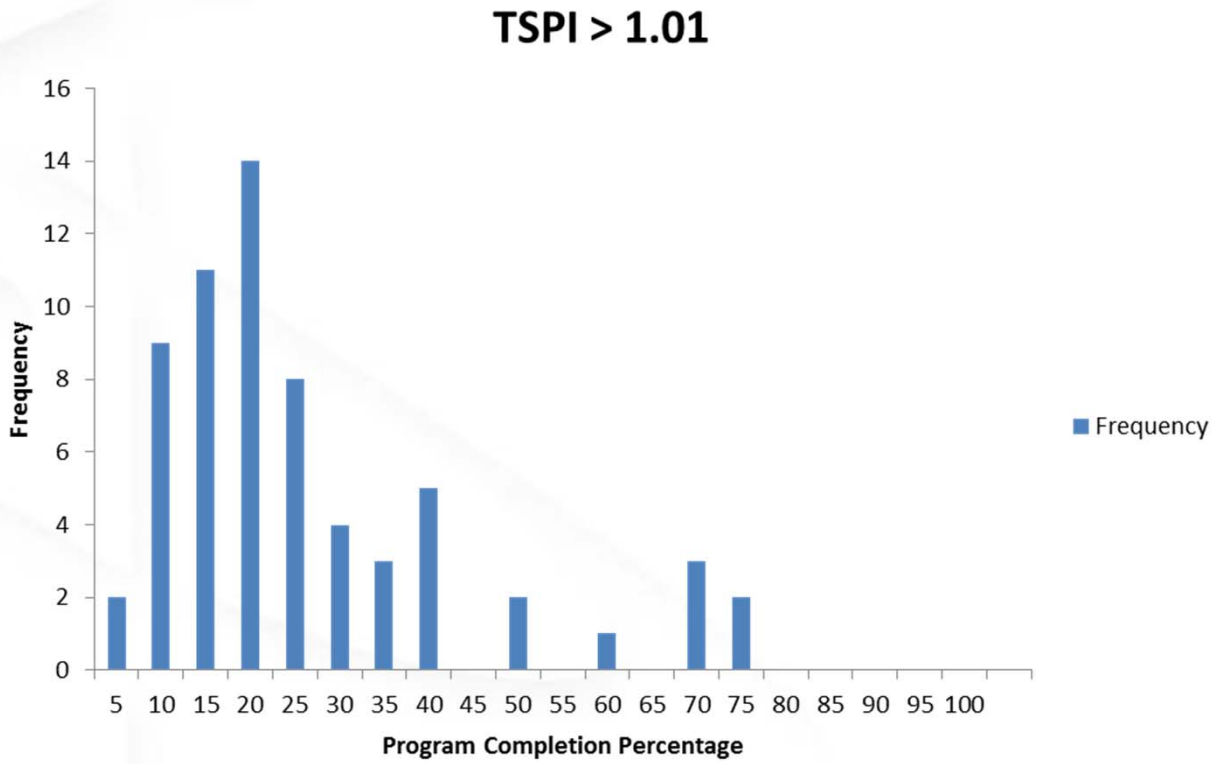
- **Test 4: Analysis of TSPI Values**

Mean: 24.24%



Analysis and Results

- **Test 4: Analysis of TSPI Values**

	20%	40%	50%	60%	80%	90%
TSPI > 1.01	35	46	51	51	62	57
TSPI > 1.05	9	21	31	40	53	55
TSPI > 1.10	3	9	14	25	45	51

Analysis and Results

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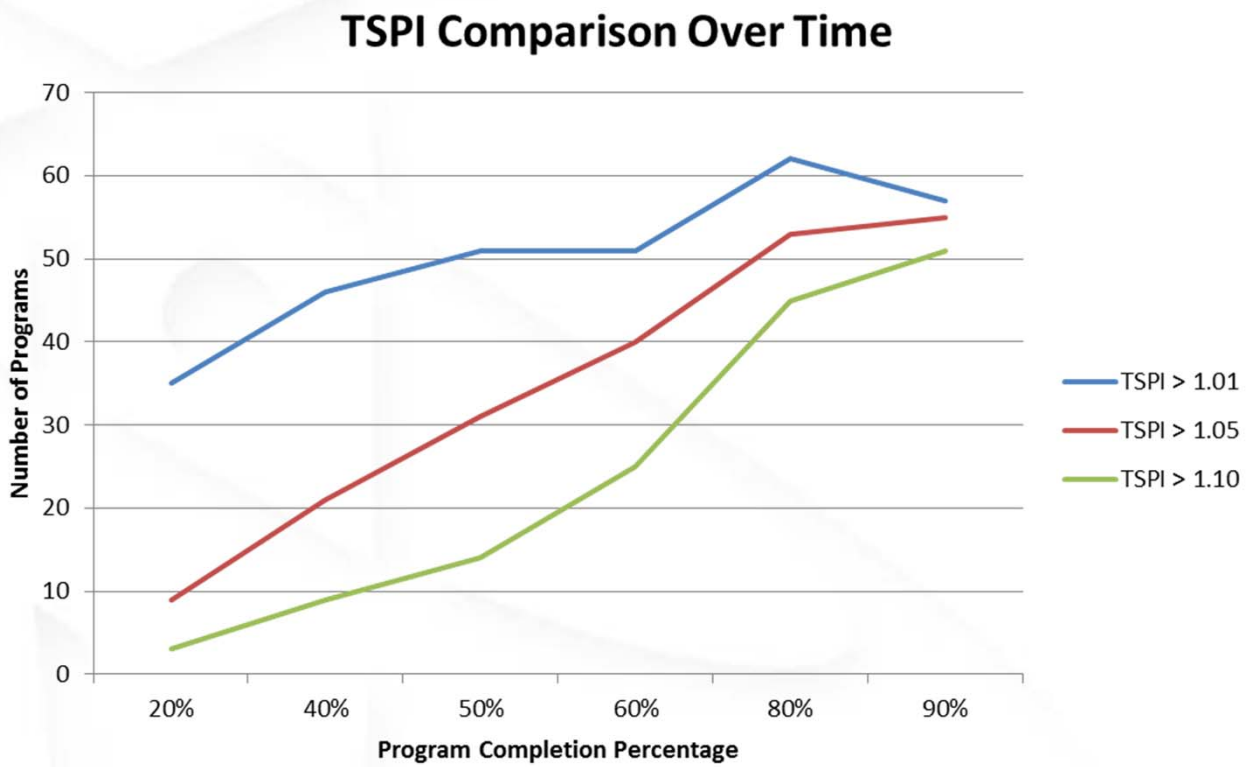

Analysis and Results

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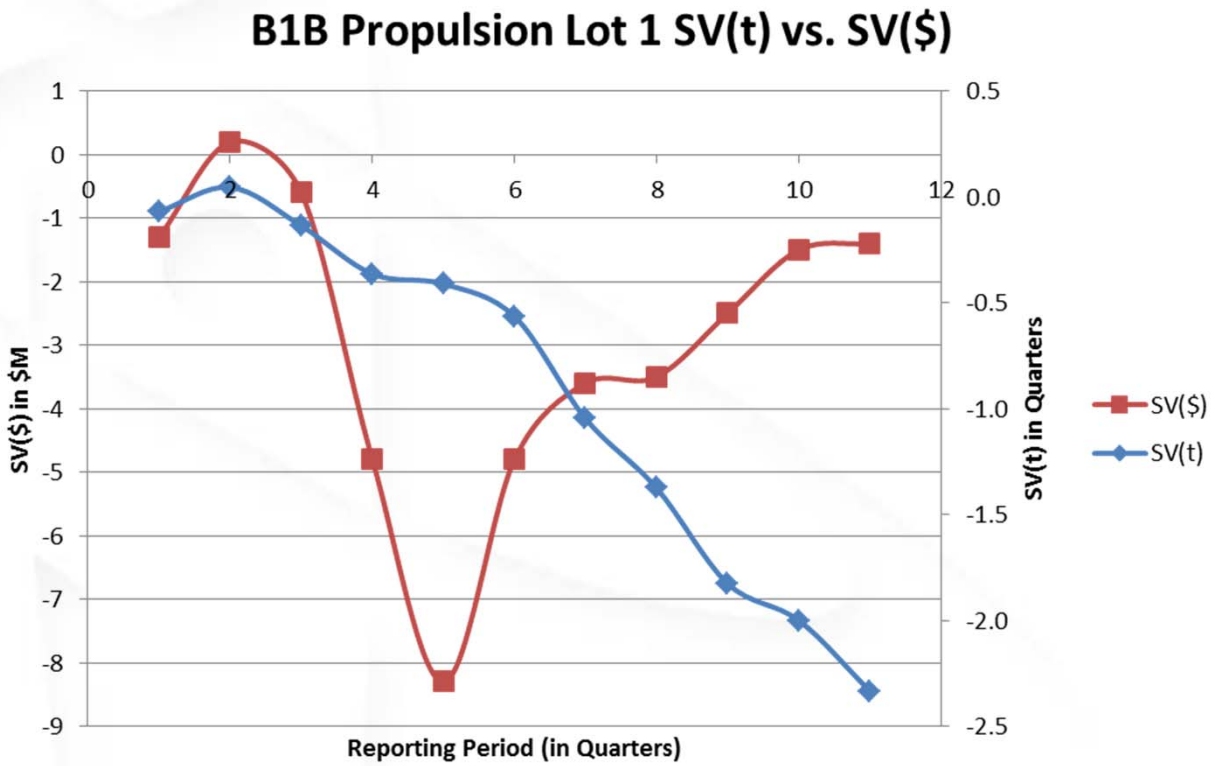
- **Test 5: Analysis of SV(t) vs. SV($) Divergence Point**
  - Typical Program: B-1B Propulsion Lot 1



Analysis and Results

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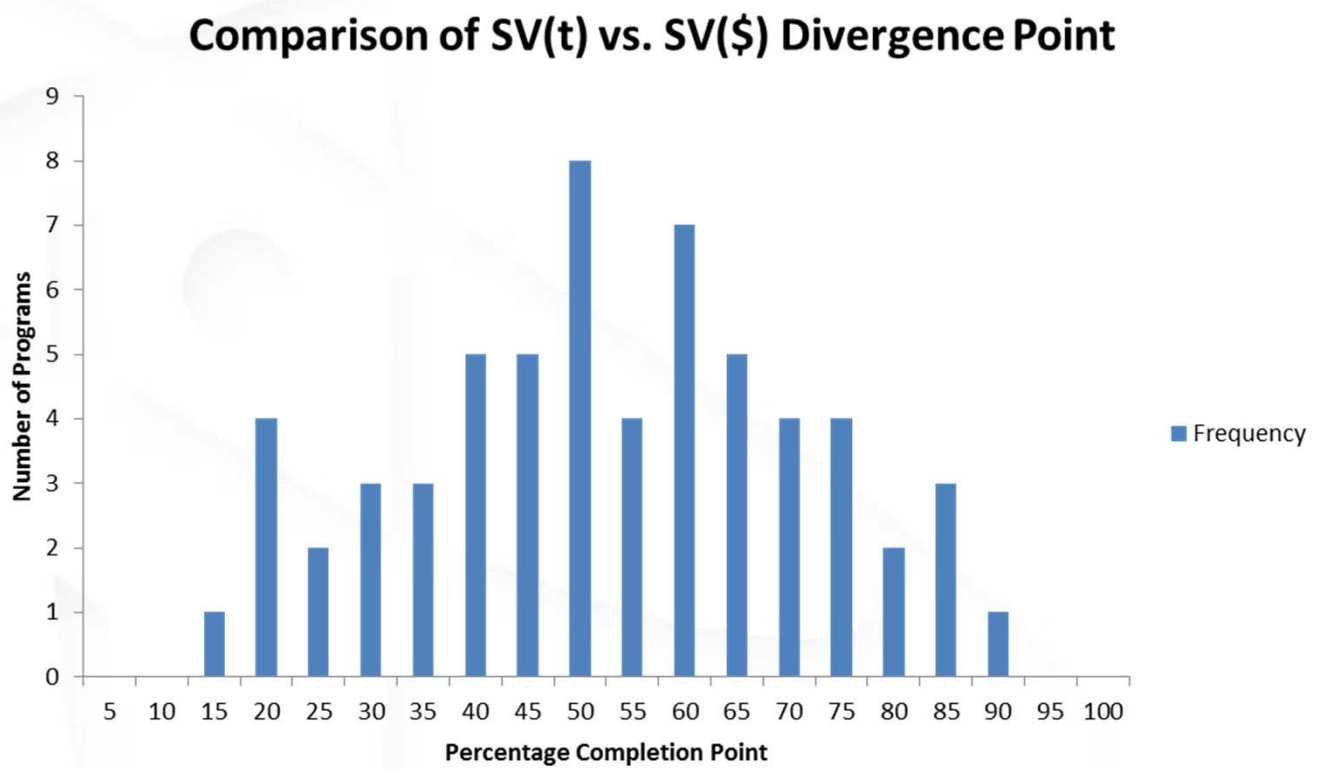

Analysis and Results

- **Critical Path Method**
  - Disconnect between how EVM data collected and Critical Path data used by Program Office.
  - EV data collected at WBS Level 3 vs. Critical Path data collected deeper (i.e. WBS Level 7).
  - Doesn't suggest ES doesn't apply to Critical Path Method, but conclusive research needs more detailed EVM data.

Research Questions Answered

- **To what extent is Earned Schedule currently utilized in Air Force ACAT I acquisition programs?**
  - Only 1/3 of program offices that we spoke with use Earned Schedule in any capacity, and those who do use it exclusively as a secondary/cross-check tool.

Research Questions Answered

- **Does Earned Schedule provide more accurate schedule predictions than traditional DoD methods?**

  - Yes. Earned Schedule provides more accurate schedule predictions than Earned Value Management. It is more frequently the method that delivers closer to the final schedule result, is often the more pessimistic/realistic measure, and more frequently detects problems in programs that eventually are late in their delivery.

Research Questions Answered

- **Does Earned Schedule provide more timely schedule predictions than traditional DoD methods?**
  - Yes. On average, in the programs where EVM detected a problem, it did so earlier than ES. However, ES detected problems with greater frequency, and the detection occurred with greater consistency earlier in the programs.

Conclusion

- Earned Schedule is a relatively new phenomenon, previous not studied with respect to Air Force ACAT I programs.

- The benefits to the implementation of Earned Schedule, outlined in the literature of Walt Lipke, Kym Henderson, and others, manifested themselves when applied to this research.

- Earned Schedule provides valuable information regarding schedule performance analogous with Earned Value's ability to manage a program's cost performance.

Significance of Research

- Highlights the inadequacies of Earned Value Management as a schedule performance tool on ACAT I Programs.
- Outlines the advantages to implementation of Earned Schedule.
- Details what useful information Earned Schedule offers program managers, and how it can better equip them to make decisions with substantial financial implications.
  - ES is more accurate & timely than EVM

Recommendation for Action

- Implement Earned Schedule as, at least, a secondary tool for schedule analysis.
- Incorporate TSPI as a tracked metric, using TSPI > 1.01 as a trigger for change on a program.
- Expand research into how Earned Schedule applies to the critical path.

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Air Force Institute of Technology

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- U.S. Air Force's graduate school for engineering and management
- Defense-focused technical graduate/continuing education and research
- Cost Analysis graduate program is the only one of its kind in the United States

Contact Information

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Questions

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