



2017 Professional Development and Training Workshop

Reliable Non-Design, Code, Test, and Integration Cost Relationships

Software Track (SW03)

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- Introduction
- Data
- Generalized Methodology
- Program Management
- System Engineering
- Integrated Logistics
- System Integration
- Modeling and Simulation
- Training and Test Sites
- NDCTI vs DCTI Phasing
- Conclusion

- Non-Design, Code, Test, and Integration (NDCTI) costs can make up more than 50% of the total cost estimate
- NDCTI elements are typically estimating using cost relationships (CRs) derived by parametric methods as functions of DCTI cost
 - Increase in DCTI implies larger team, increased complexity, increased funding, increased contracting actions, all translating to increases in many NDCTI elements
- New CRs are needed on a routine basis to ensure models are consistent with current trends
- NDCTI costs are grouped into six major categories:
 - Project Management (PM)
 - System Engineering (SE)
 - Integrated Logistics Support (IL)
 - System Integration (SI)
 - Modeling and Simulation (MS)
 - Training and Test Sites (Sites)

- 12 years of data ending in 2016
- All data normalized to BY17\$s
- 3 completed projects, 1 project 75% complete
 - All results based on 3 completed projects unless otherwise noted
 - Fourth project presented anecdotally
- Software sizes range from 200k to 1.4M equivalent source lines of code (ESLOC)
- Field testing, which can have a wide variety of requirements, are not included in analysis
 - Cost estimates for field tests are based on unique test requirements for each test event

$$Factor = \frac{NDCTI \$}{DCTI \$}$$

- Insufficient data points for regression analysis
 - 2 degrees of freedom
- All means, standard deviation, and coefficient of variation (CV) based on three completed programs
- Fourth program assumptions
 - 100% DCTI completed in first 75% of program schedule
 - 85% of PM, SE, ILS cost incurred in first 75% of program schedule
 - SI, MS, Sites ETC minimally analyzed

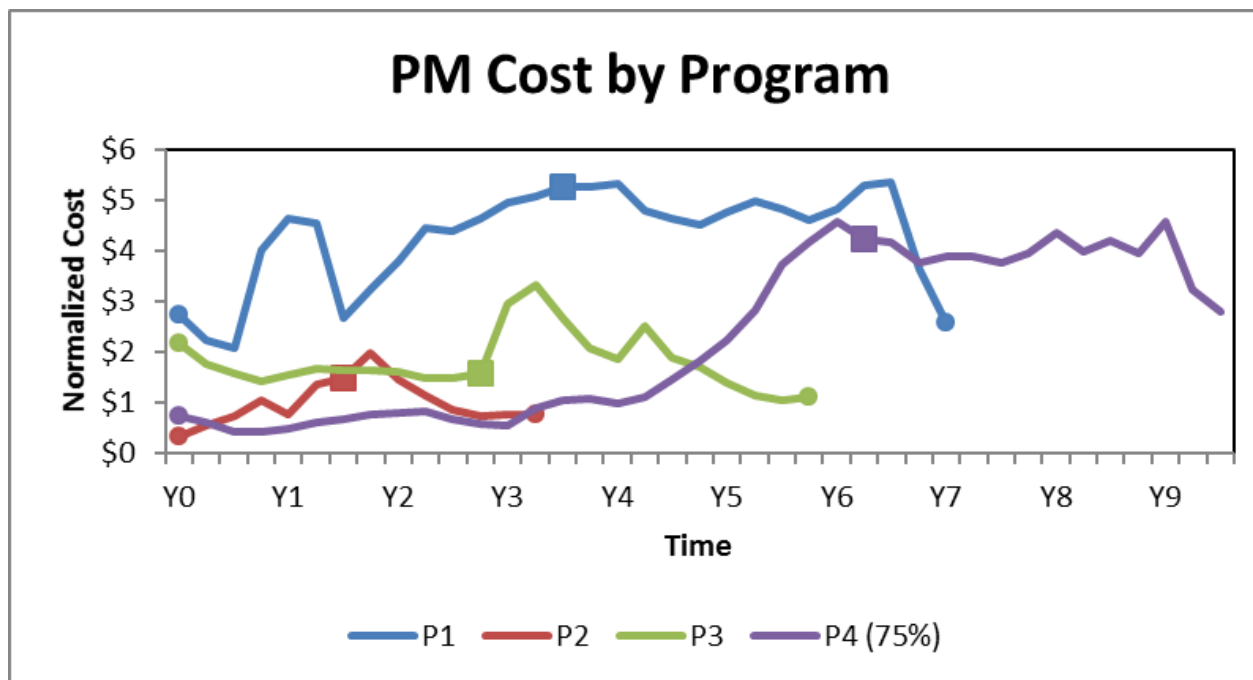
- PM Includes
 - business and financial management
 - quality assurance standards and adherence
 - data and configuration management
 - program planning
 - program evaluation

$$\mu = 15.31\%$$
$$CV = 5.7\%$$

- Fourth project currently **13.14%** of DCTI; program 75% complete
 - PM costs continuing to accrue; DCTI complete
 - Estimated PM CR at completion: **15.46%**

Program Management Phasing

- Phasing Analysis
 - PM phasing shows long ramp up, some level of effort for a short duration (if at all), and steep drop at the end
 - Does not reflect markers of fixed, or level of effort, type cost



- SE comprises engineering oversight and support functions including:
 - system level coordination
 - planning and integration
 - special projects

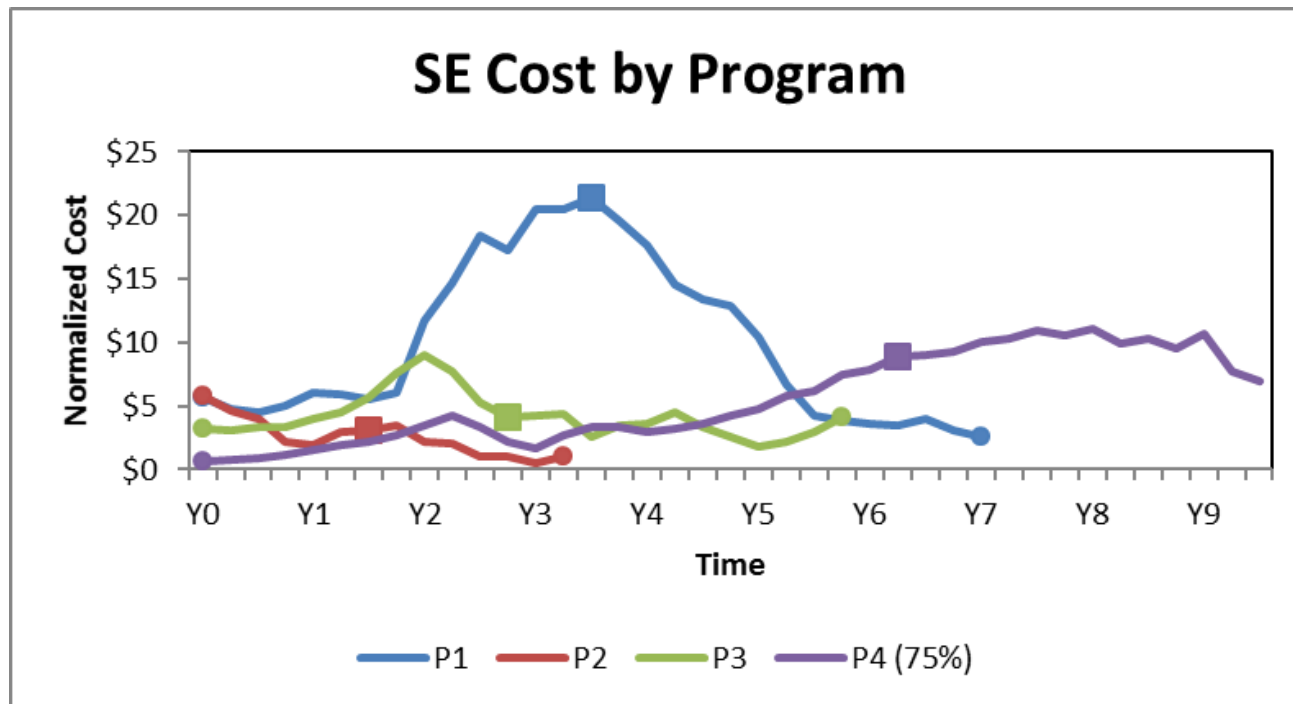
$$\mu = 36.48\%$$
$$CV = 8.0\%$$

- Fourth project currently **31.89%** of DCTI; program 75% complete
 - SE costs continuing to accrue; DCTI complete
 - Estimated SE CR at completion: **37.52%**

System Engineering Phasing

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- Phasing Analysis:
 - Shows markers consistent with variable cost phasing
 - Ramp up, peak, and ramp down more consistent with DCTI phasing



- IL includes:
 - oversight and coordination of IL requirements and processes
 - management of supply chain and spares
 - development of technical manuals
 - training support

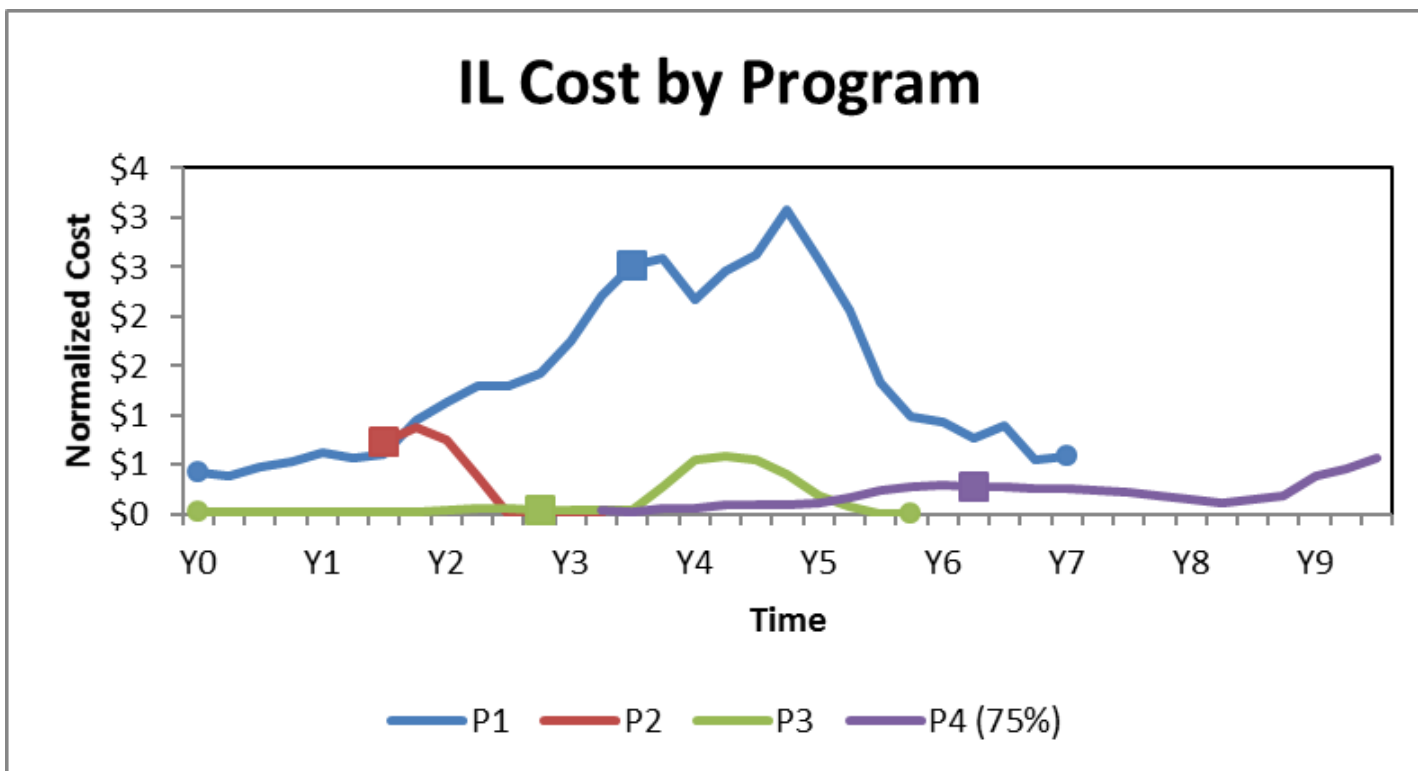
$$\mu = 2.85\%$$
$$CV = 62.2\%$$

- Fourth project currently **0.77%** of DCTI; program 75% complete
 - IL costs continuing to accrue; DCTI complete
 - Estimated IL CR at completion: **0.91%**
- Evaluation of CV
 - IL is very small portion of total cost
 - Assuming NDCTI represents 50% of total cost, ILS error likely represents error in estimate between 0.5% and 2%

Integrated Logistics Phasing

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- Phasing Analysis:
 - Variable costs with no common spend pattern
 - Possibly includes “on-demand” or schedule based services or products



- SI includes:
 - System level requirements
 - multi-element integration and test
 - test plans and procedures
 - integration oversight

$$\mu = 20.91\%$$
$$CV = 91.9\%$$

- Evaluation of CV:
 - DCTI cost is not a very good basis of estimate for SI cost
 - High productivity reduces DCTI cost, but likely has no impact on the effort to integrate the various elements into a single program

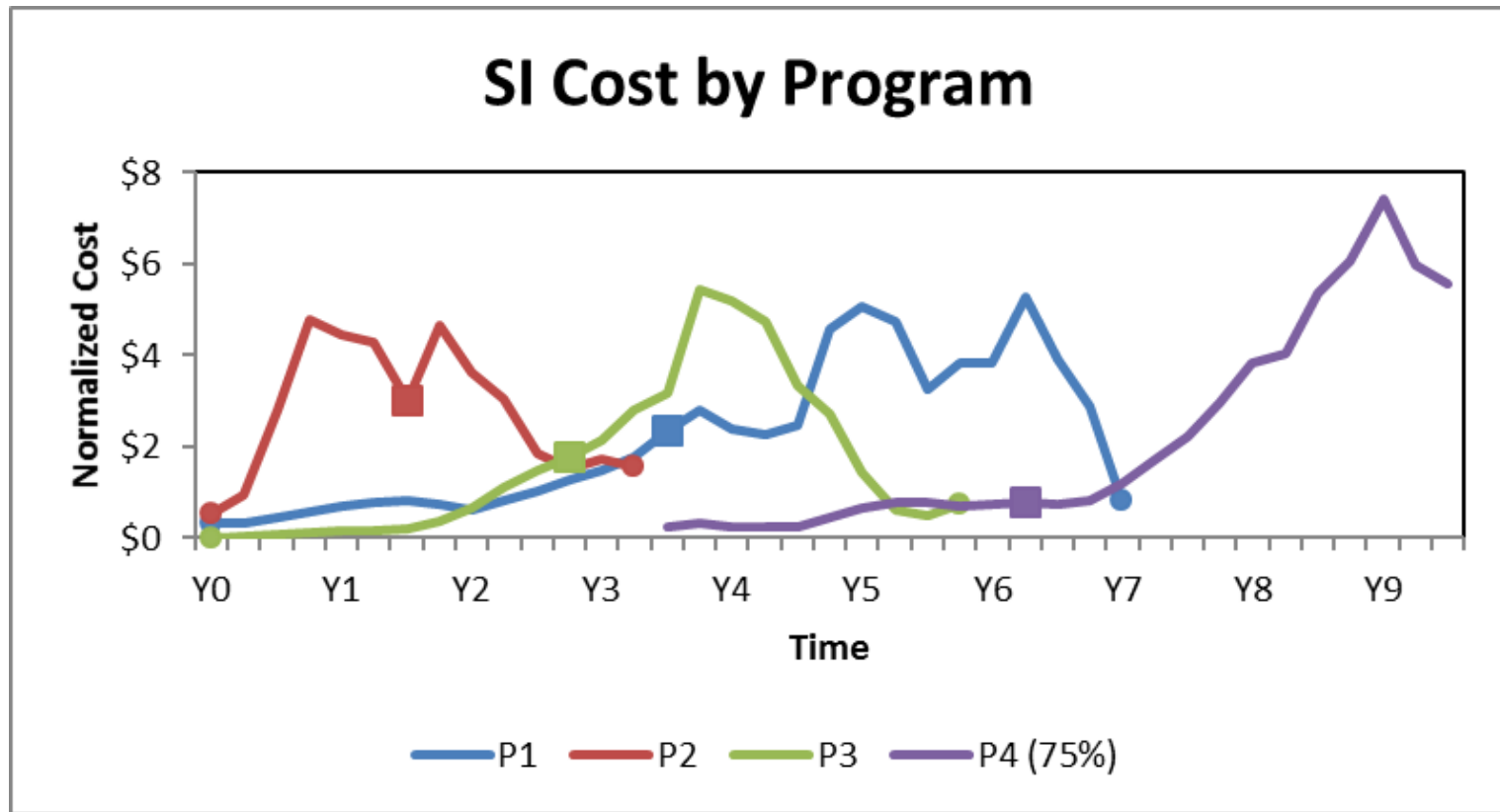
- SI measured as a function of ESLOC
 - Removes DCTI productivity from the equation
 - Large ESLOC may relate to large integration efforts

$$SI = f(ESLOC)$$

- Findings
 - To avoid potential disclosure of proprietary information, results of SI as a function of ESLOC cannot be shown
 - Two of three completed programs have very similar \$ / ESLOC cost
 - Incomplete program on track to be similar to the two programs with similar \$ / ESLOC ratios
- Other considerations:
 - Possible SI could be analyzed in groups based on similar technical specifications

System Integration Phasing

- Phasing Analysis
 - SI phasing displays ramp up/ramp down with peaks and valleys
 - More cost in the second half than the first half

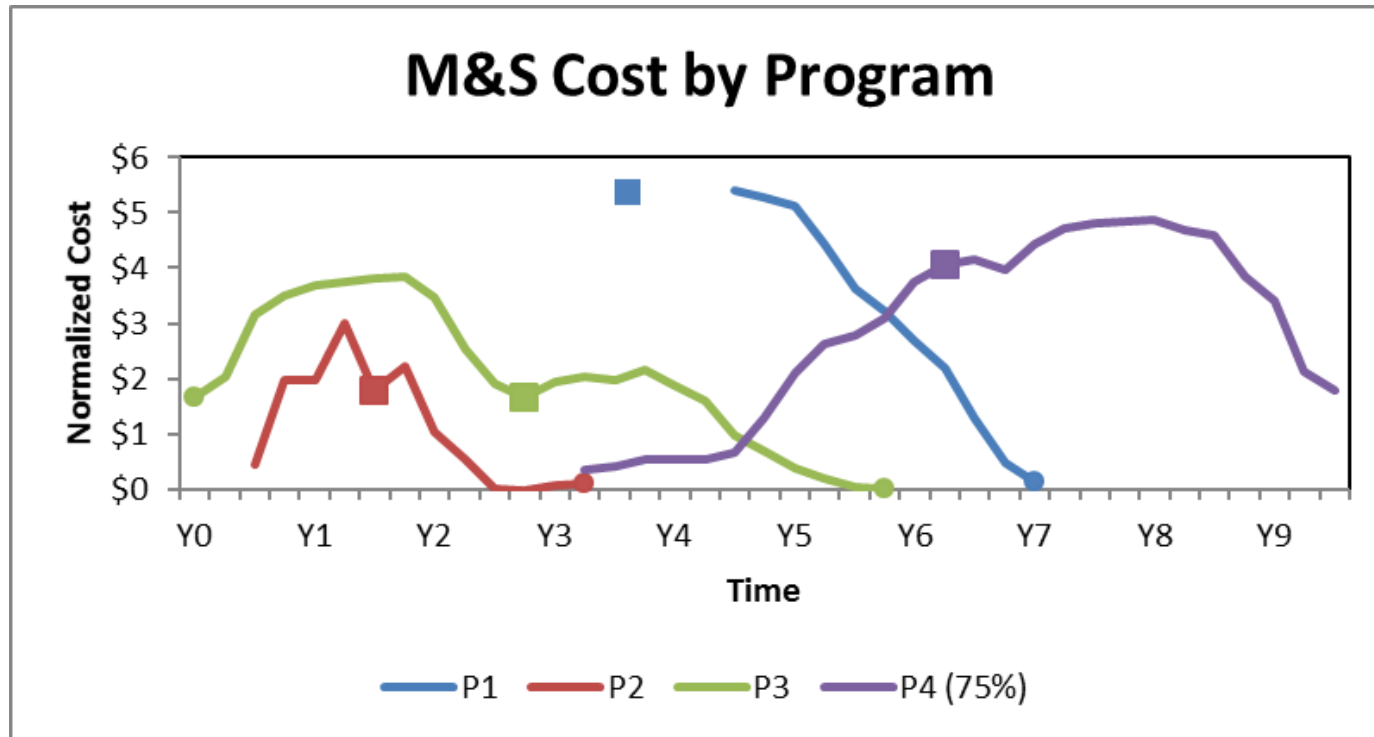


- M&S comprises the effort to develop simulated environments within which a computer program can be tested

$$\mu = 11.83\%$$
$$CV = 59.3\%$$

- Fourth project currently **11.08%** of DCTI; program 75% complete
- Evaluation of CV
 - DCTI may not be a good BOE for MS
 - MS effort involves developing a synthetic environment within which the primary program can be operated and tested
 - Likely requires ESLOC inputs and unique DCTI type calculations

- Phasing Analysis
 - The effort to development simulated environments within which a computer program can be tested
 - No obvious common pattern
 - May require unique phasing based on program requirements

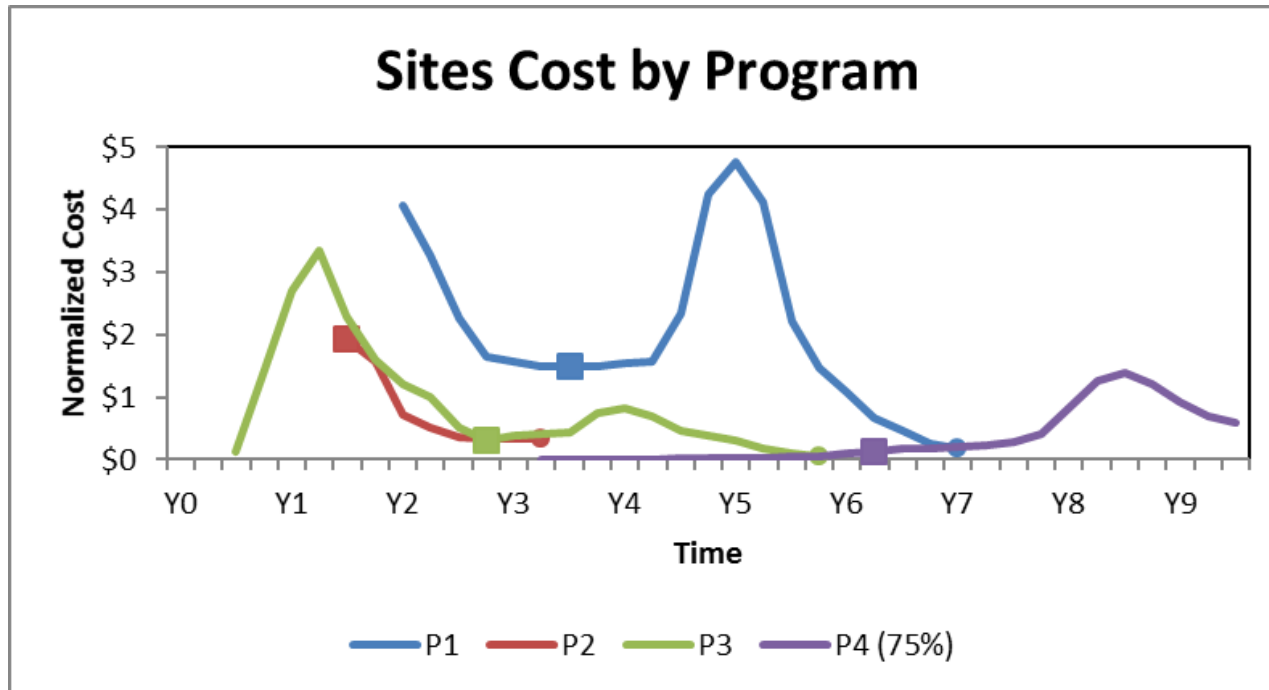


- Sites comprises the effort to integrate, install, and test the designed system at both training and test site facilities

$$\mu = 6.32\%$$
$$CV = 19.49\%$$

- Fourth project currently **1.29%** of DCTI; program 75% complete
 - Sites costs typically incurred near the end of the program
 - Expect fourth project final Sites cost to be in line with completed projects

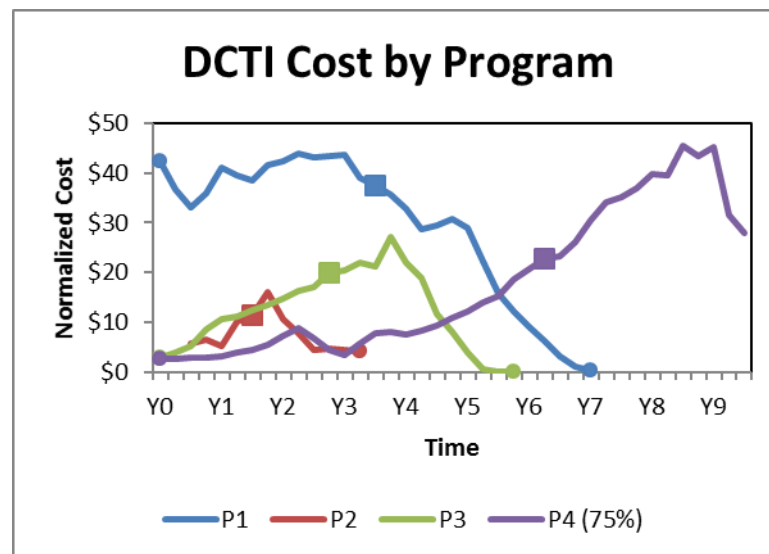
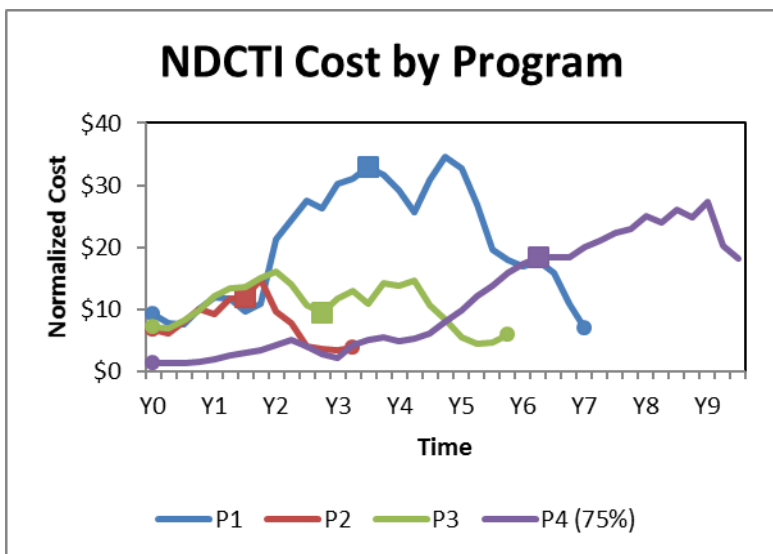
- Phasing Analysis:
 - Sites cost phasing shows peaks and valleys
 - Schedule based phasing best approach



NDCTI vs DCTI Phasing

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- More likely variable and/or schedule based phasing than fixed, or level of effort, type phasing
- As a composite, NDCTI cost tracks closely to DCTI cost
- Variable cost phasing may be due to corporate strategy to develop functional teams



Conclusion

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- Five of six NDCTI CRs recommended for general use
- SI requires additional analysis
- Cost phasing shows variable patterns rather than fixed, or level of effort, type phasing
- Larger data set would likely improve results

| | Mean | St. Dev. | CV |
|-------------------------|--------|----------|-------|
| Program Management | 15.31% | 0.87% | 5.7% |
| System Engineering | 36.48% | 2.91% | 8.0% |
| Integrated Logistics | 2.85% | 1.77% | 62.2% |
| Modeling and Simulation | 11.83% | 7.02% | 59.3% |
| System Integration* | 20.91% | 19.21% | 91.9% |
| Training and Test Sites | 6.32% | 1.23% | 19.4% |

*Not a recommended cost relationship

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