CRITICAL THINKING.
SOLUTIONS DELIVERED.

Ground Radar Expenditure Phasing Analysis

ICEAA – June 18 2103

Rick Garcia
MCR, LLC
360 N Sepulveda Blvd, Suite 2000
El Segundo, CA 90245
424.218.1631

Outline

- Problem Statement and Proposed Solution
- Data Identification Summary
- Data Normalization
- Analysis
- Results
- Way Ahead
- References

Problem Statement and Proposed Solution

- Need / Problem Statement
  - Independent Cost Estimate needed a methodology for recommending **a realistic expenditure and obligation phasing** in support of a POM input
  - Existing expenditure phasing models are generic to Department of Defense space or ground infrastructure programs (they are not ground radar specific)

- Proposed Solution
  - Develop a Ground Radar specific expenditure phasing model based explicitly on historical ground radar programs

Data Identification

- Compiled data and determined if it would be usable for this analysis

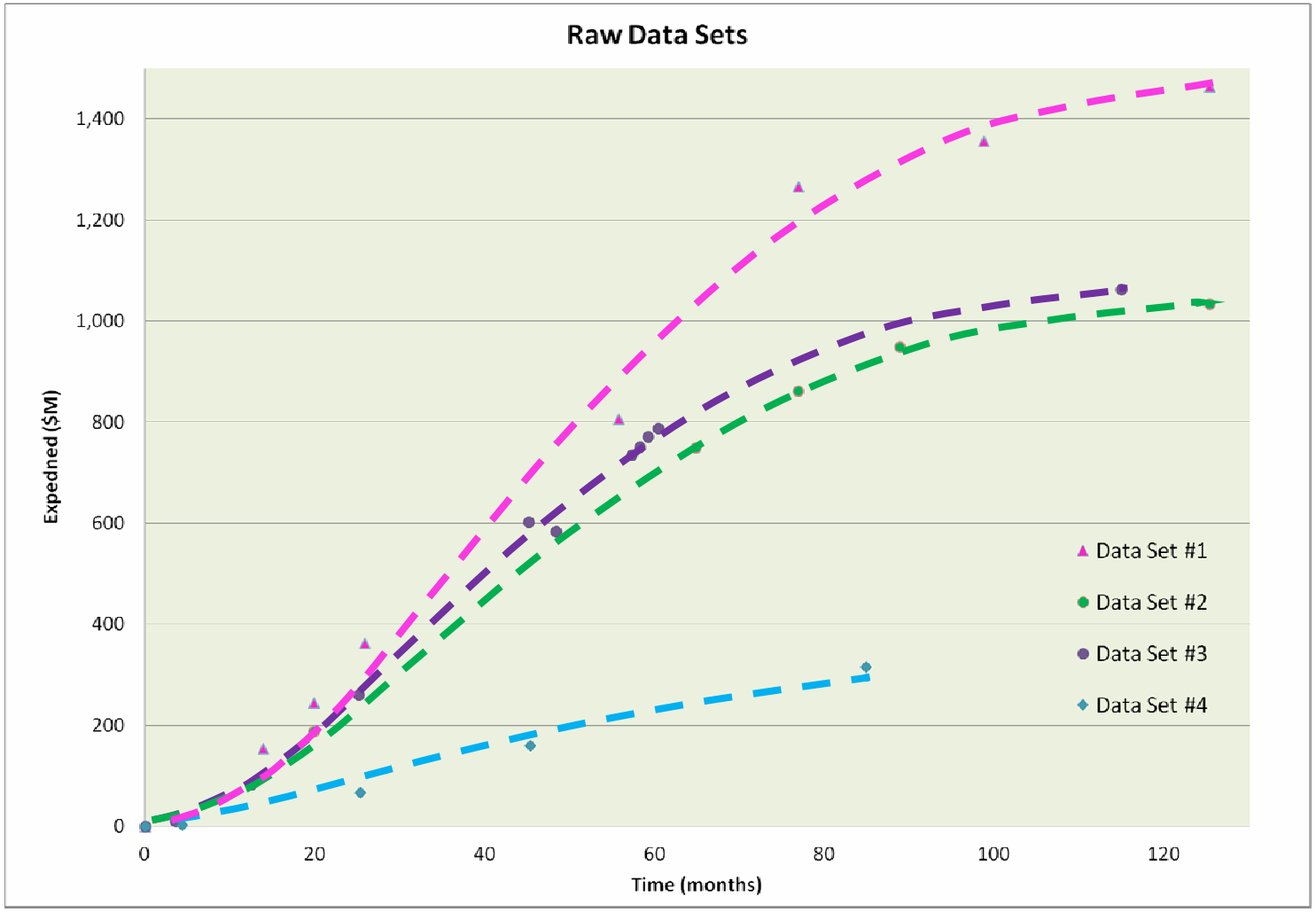
Data Sets	Data Points		Usable ? (Y/N)	Reason
	AFCAA DB	Phase		
Data Set #1	8	EMD	**Y**	EMD or D&V and time series.
Data Set #2	6	EMD	**Y**	EMD or D&V and time series.
Data Set #3	11	EMD	**Y**	EMD or D&V and time series.
Data Set #4	5	EMD	**Y**	EMD or D&V and time series.
Data Set #5	50	D&V	**Maybe**	Number of data points dominates analysis. Used to verify regression.
Data Set #6	64	D&V	**N**	Discrepency in timeline/quantity normalization.
Data Set #7	2	EMD	**N**	No time series.
Data Set #8	2	EMD	**N**	No time series.
Data Set #9	1	EMD	**N**	No time series.
Data Set #10	2	EMD	**N**	No time series.
Data Set #11	1	EMD	**N**	No time series.
Data Set #12	1	EMD	**N**	No time series.
Data Set #13	64	PROD	N	Production contract. Need D&V or EMD.
Data Set #14	2	PROD	N	Production contract. Need D&V or EMD. No time series.
Data Set #15	1	PROD	N	Production contract. Need D&V or EMD. No time series.
Data Set #16	1	PROD	N	Production contract. Need D&V or EMD. No time series.

Data Identification Summary

Data Sets	Data Points		Usable ? (Y/N)	Reason
	AFCAA DB	Phase		
Data Set #1	8	EMD	Y	EMD or D&V and time series.
Data Set #2	6	EMD	Y	EMD or D&V and time series.
Data Set #3	11	EMD	Y	EMD or D&V and time series.
Data Set #4	5	EMD	Y	EMD or D&V and time series.

- 30 Data points (Data Sets #1-#4) from four separate sets, were deemed useful for analysis
- A fifth complete data set of 50 data points was excluded from this direct analysis
  - If used in regression, it drives regression results
  - Data Set # 5 was used to test/verify analysis

Raw Data

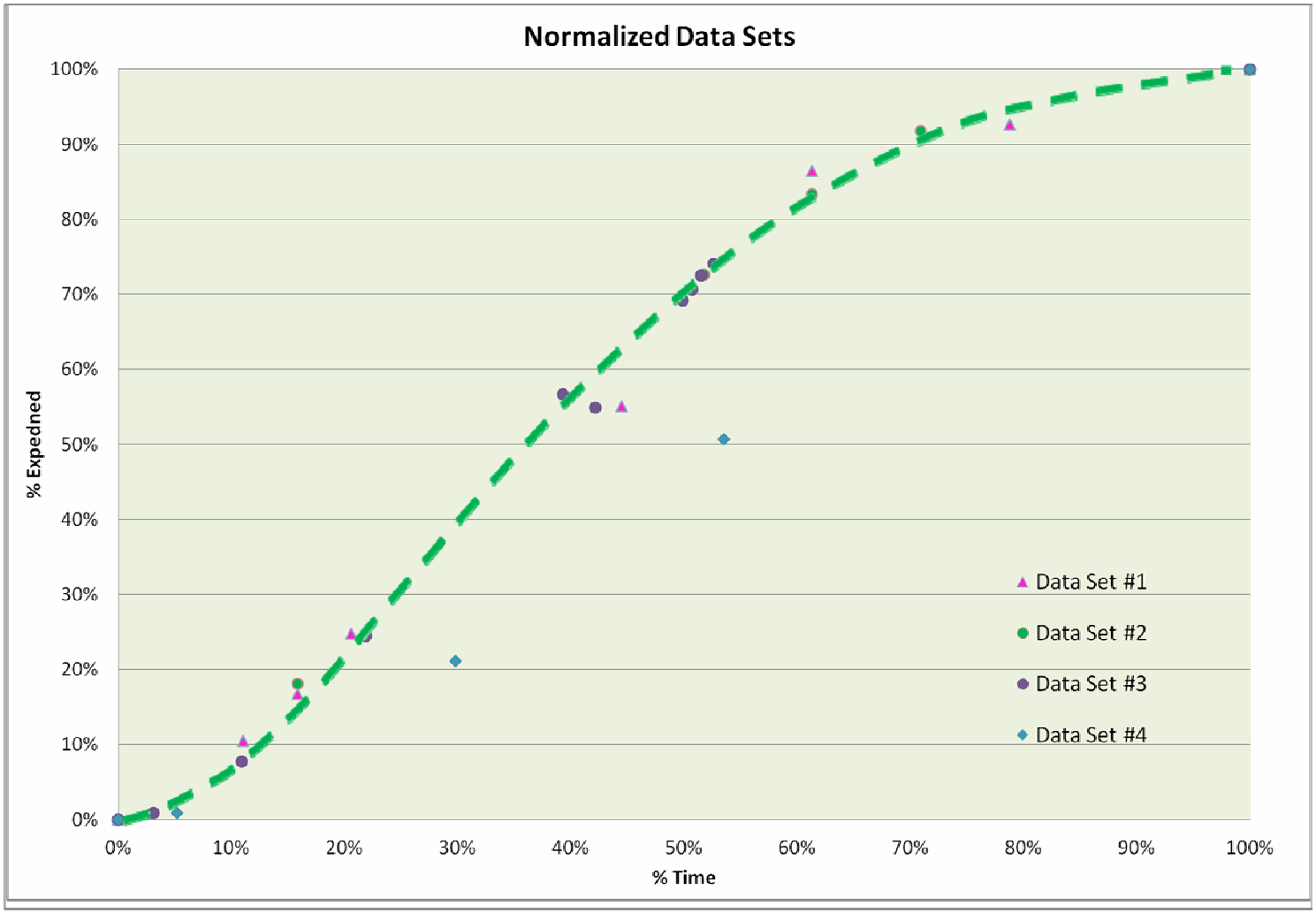


- Raw Data: Time (in months), Dollars (in $M)

Data Normalization

- For each data set, normalized all data sets to data pairs consisting of (% Time, % Expended):
  - Contract Award defined as Time = 0%
  - I&T complete PLUS 6 months defined as Time = 100%
    - Plus 6 months was to account for voucher/billing expenditure lag, not contractual efforts or activities
  - %Time=(Duration from Contract Award to Cost Report Period) divided by (Duration from Contract Award to I&T Complete + 6 months)
  - %Expended=(Cost Incurred to Report Date) divided by (Final Incurred Cost)

Raw Data => Normalized Data



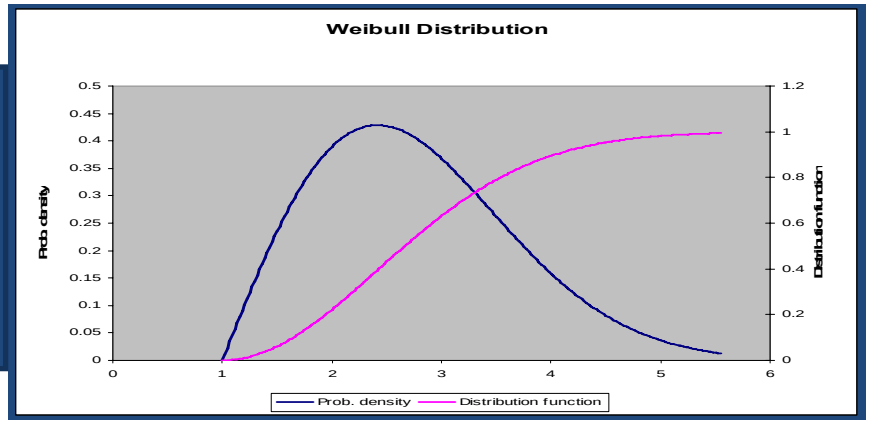
- Normalized Data: % Time, % Expended

Analysis - 2-Parameter Weibull Curve

- Weibull Distribution
  - Is a generalization of the Rayleigh distribution
    - Rayleigh Distribution is a continuous probability distribution used in probability theory and statistics
  - Standard Excel function
    - Used in the field of life data analysis because of its flexibility, it can approximate the behavior of other statistical distributions
    - **α (alpha) and β (beta)**
    - **Previous analysis has shown DoD data fits with Weibull distributions due to the Weibull's malleability allowed by is additional parameters**
      - Burgess 2004, Porter 2001, Unger 2001

$$f(x) = (1-e^{-(\alpha x^{\beta})})$$

$$Expenditures(t) = (1-e^{-(\alpha t^{\beta})})$$

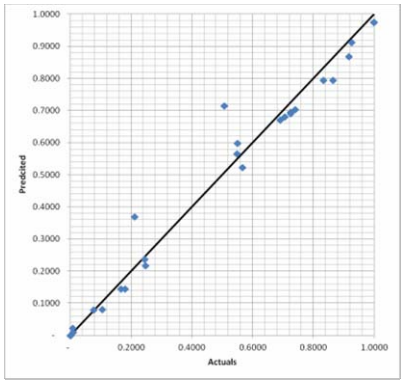


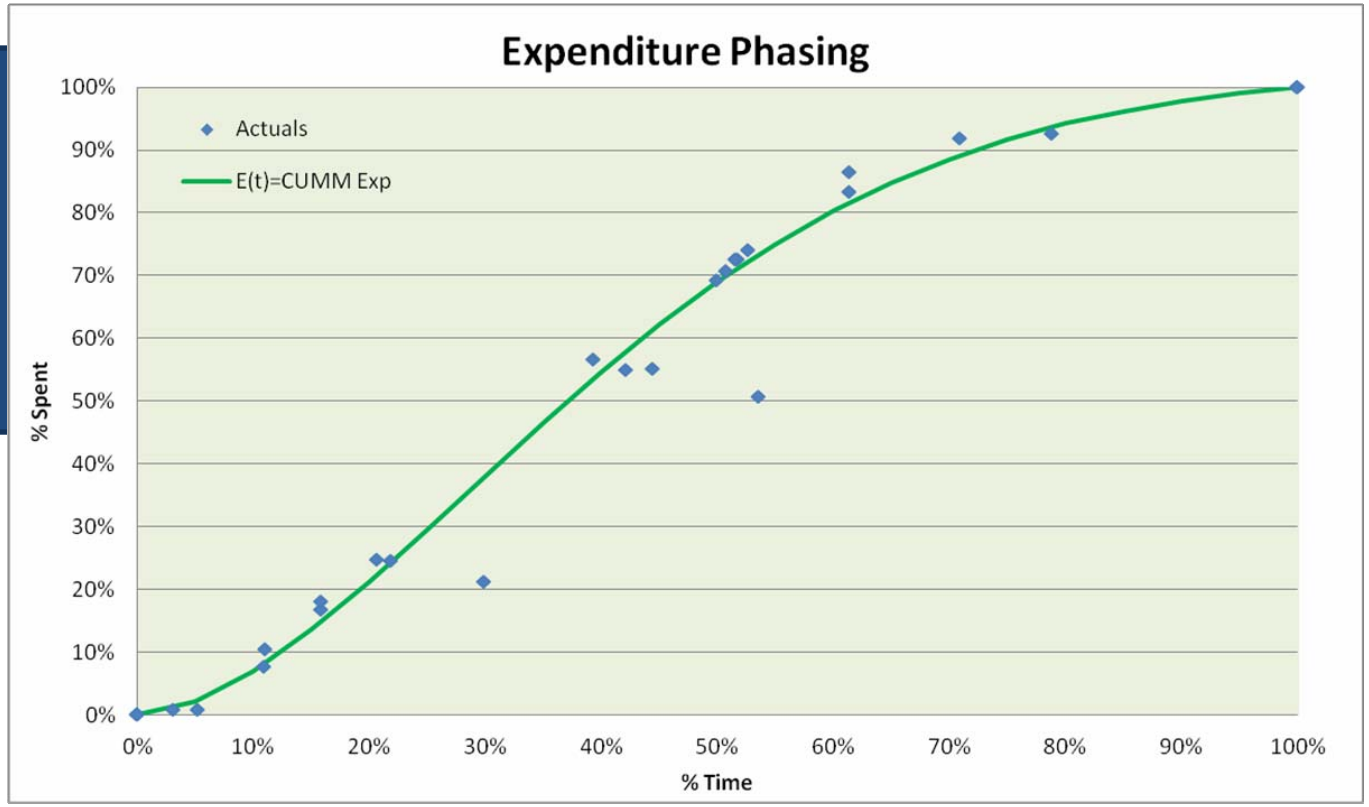
Analysis Results

$$E(t) = (1-e^{-(\alpha t^{\beta})})$$

with β=1.7143, α=3.6586

N = 30
R^2 = 97.8%
Std Error = 17.95%
Bias = 0%

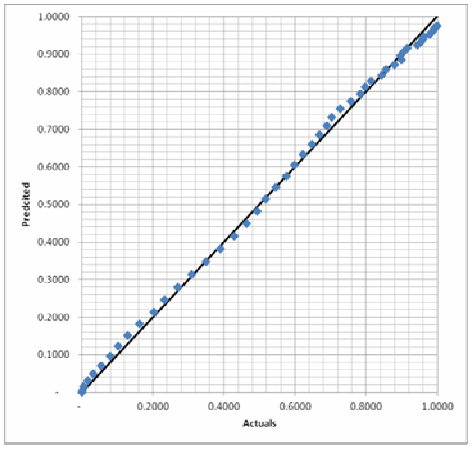


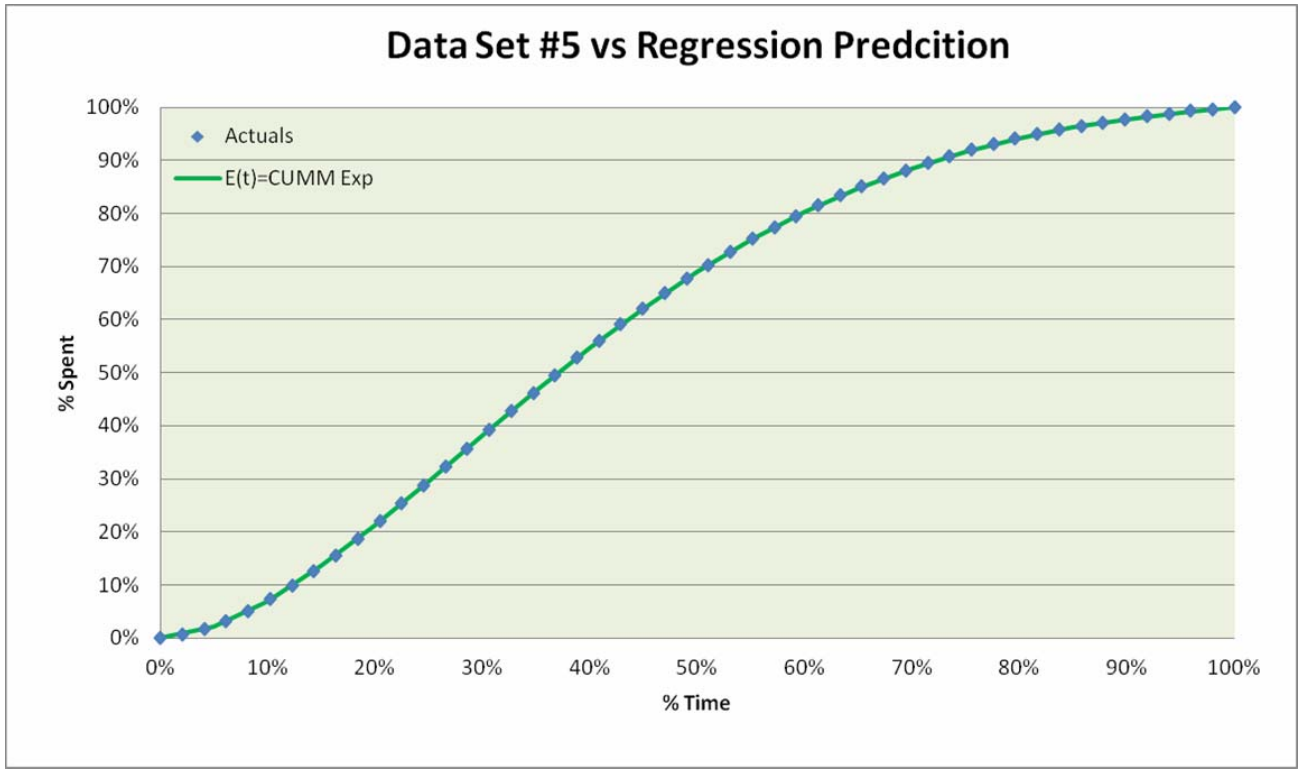


- ZMPE equation based on all 30 data points (4 data sets)

Analysis Results – Testing results

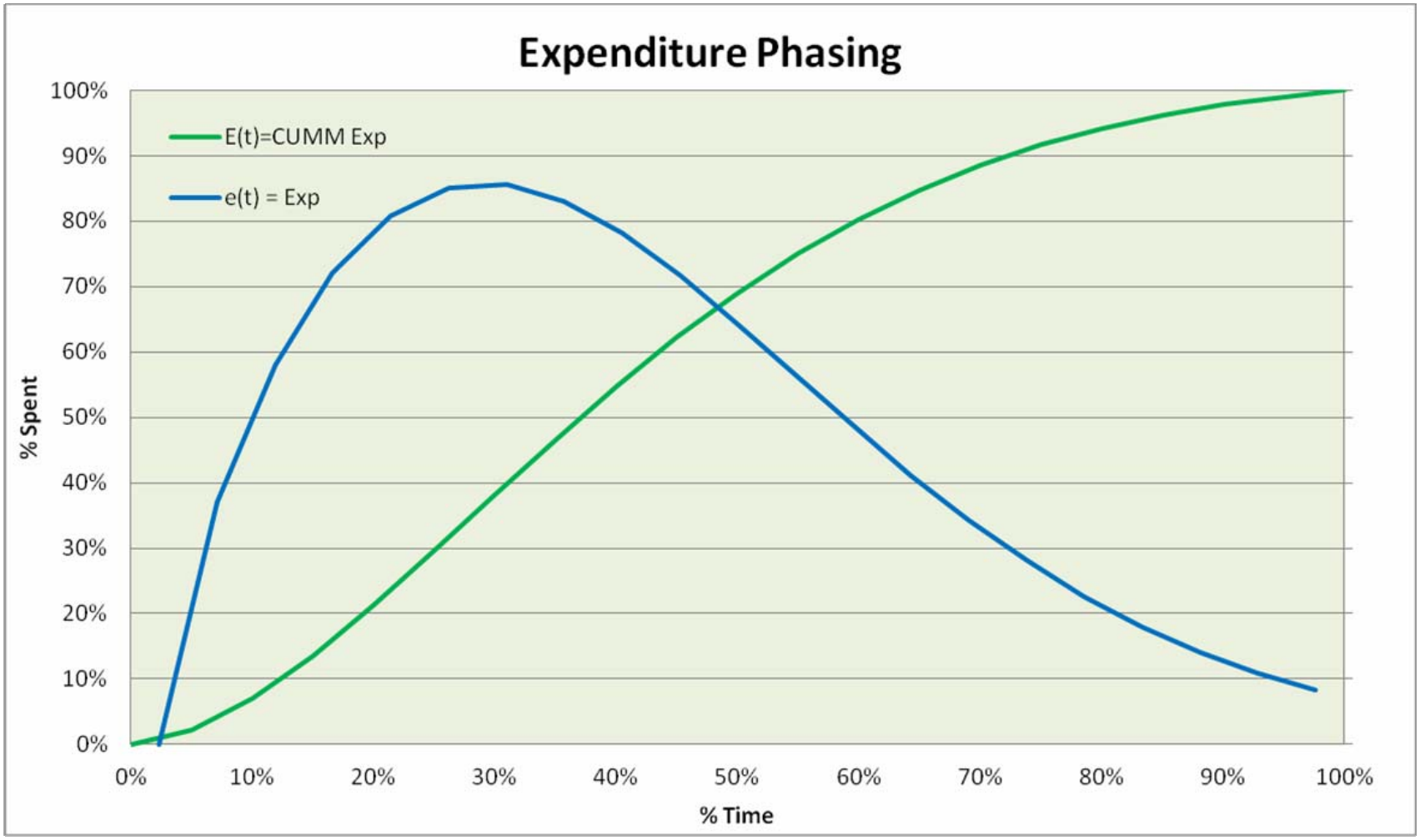
Data Set # 5
Predicted Vs Actuals
R^2 = 99.85%





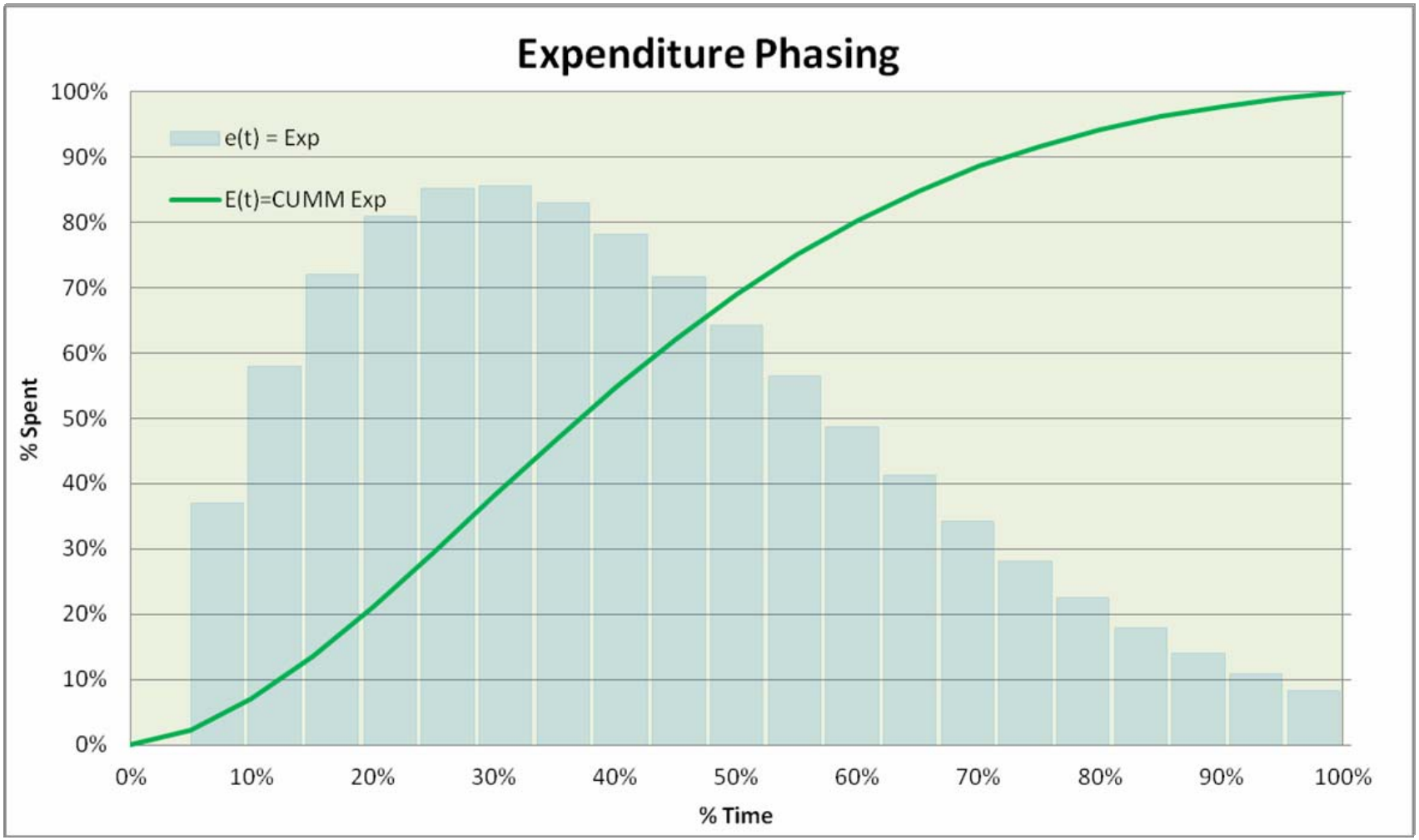
- Regression equation compared to another program's actuals (Data Set #5)
- Data Set #5 was not used in the original regression analysis

Applying the Analysis Results to the ICE



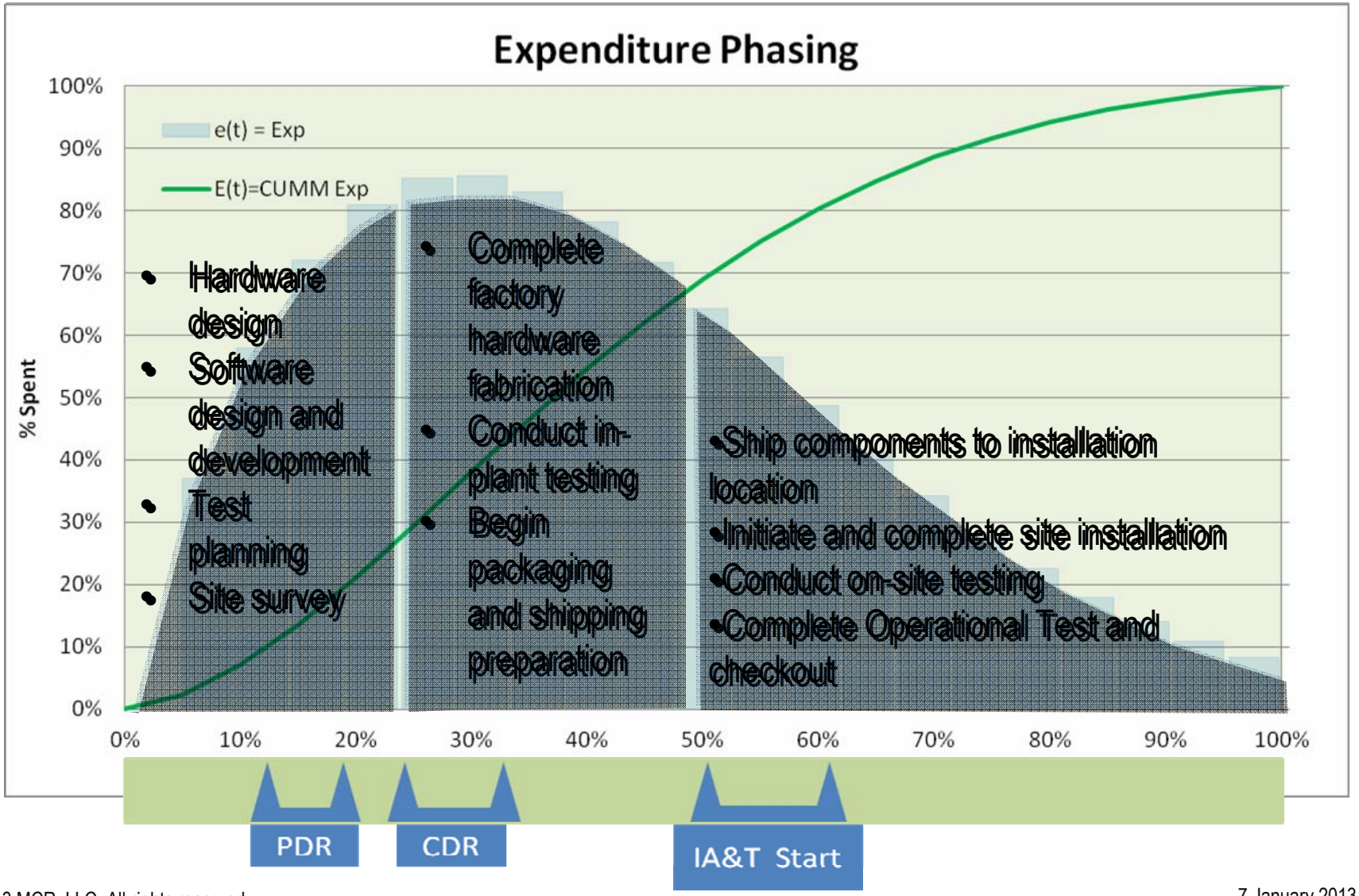
- How do the results support the required activities?

Applying the Analysis Results to the ICE

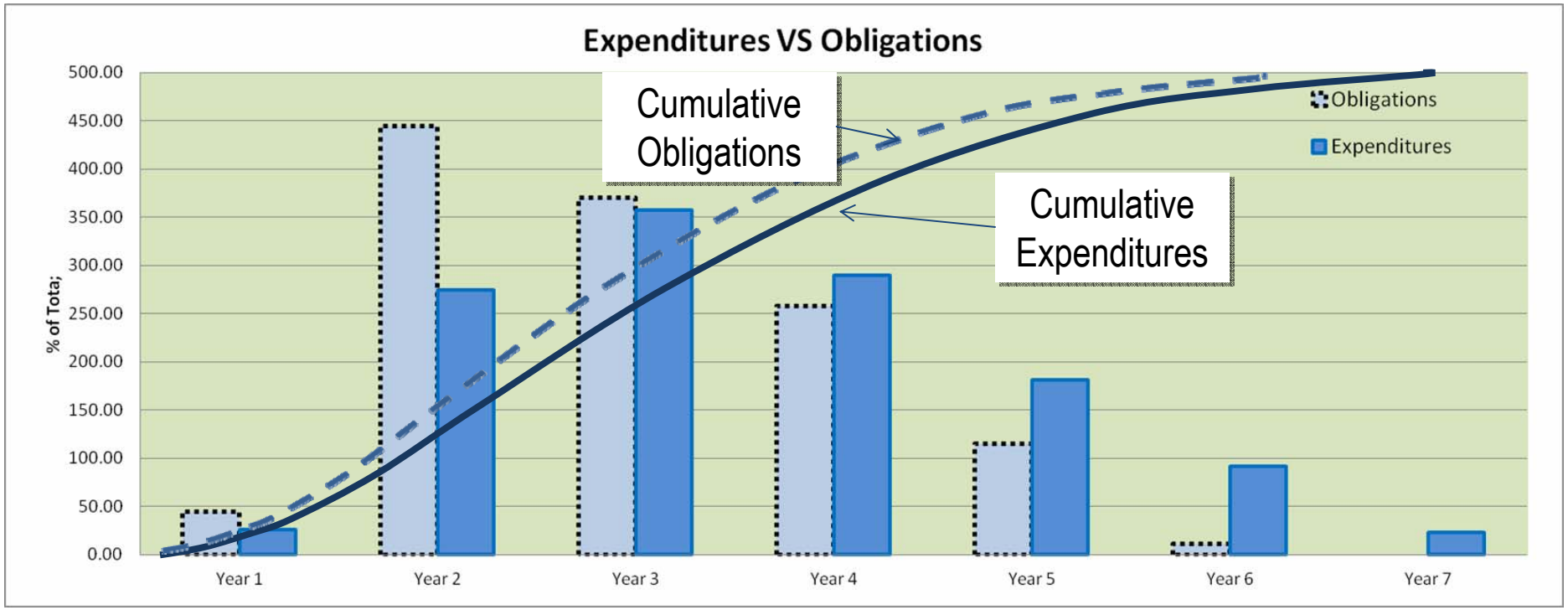


- How do the results support the required activities?

Applying the Analysis Results to the ICE



Convert the Expenditure Profile to an Obligation profile



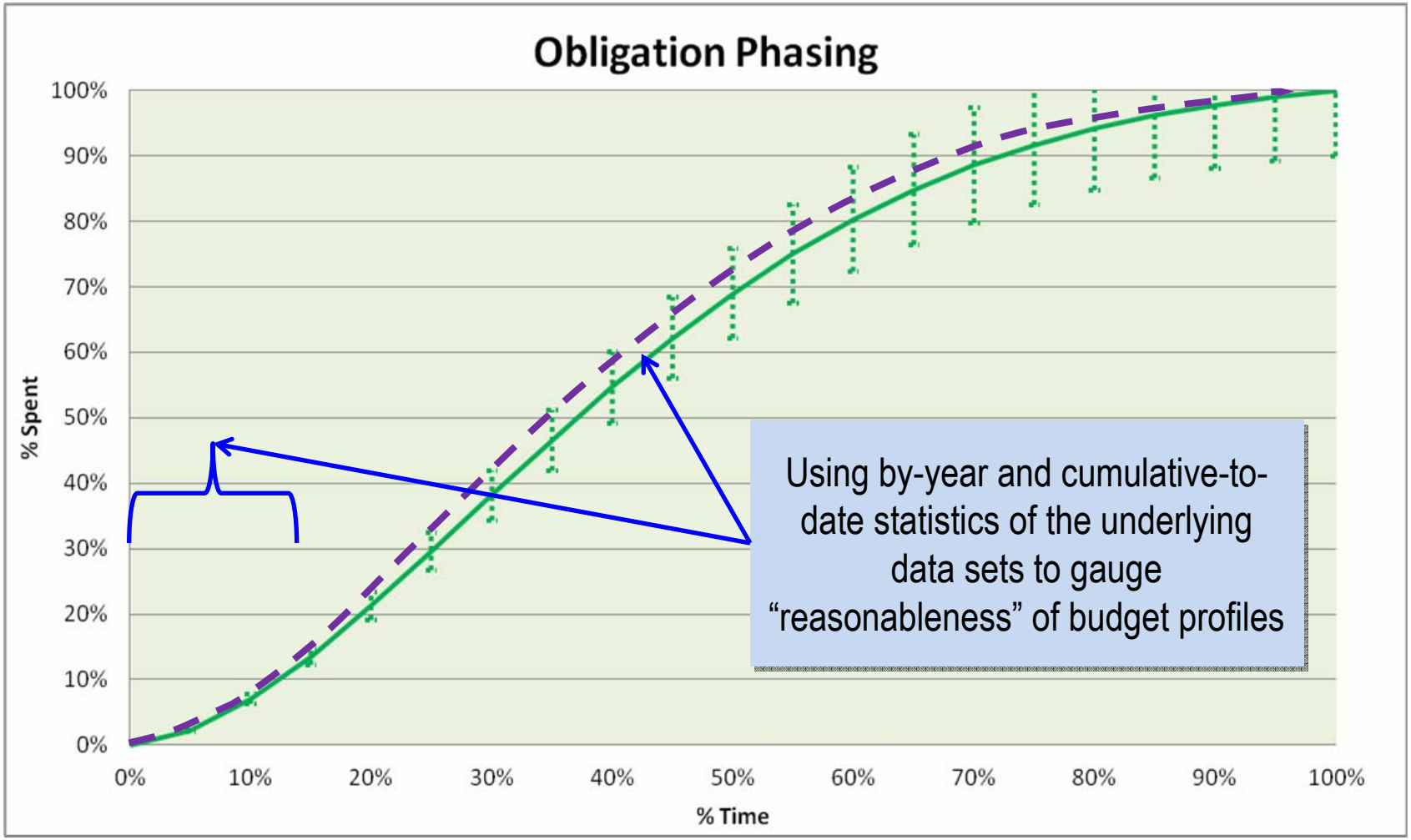
- Expenditure profiles **are not** budget profiles
- Convert the cost profile to a budget profile appropriately

If T_i = TOA in the i^{th} year of the program, E_i = the estimated expenditures for the i^{th} year, and s_i = outlay pattern for the i^{th} year, then the systems of linear equations is defined by

$$TOA_i = (E_i - s_2T_{i-1} - s_3T_{i-2} - \cdots - s_jT_{i-j+1}) / s_1$$

  - Reference Burgess, Erik "Time–Phasing Methods and Metrics," 2004

Using This Analysis to Support Budget Drills



- Use the results to provide budget drill feedback

Summary

- Successfully collected historical expenditure data
- Successfully normalized historical expenditure data
- Converted the expenditure profile to an obligation profile; applied it against a completed cost and schedule estimate and provided the result as the **recommended budget profile**
- Used the underlying expenditure data to gauge "reasonableness" of alternate budget profiles
  - Is the alternate budget/obligation profile consistent with historical expenditure profile?

Questions?

References

- Lee, David A., Hogue, Michael R., and Gallagher, Mark A. “Determining a Budget Profile from a R&D Cost Estimate,” DoD Coast Analysis Symposium, 1993.
- Burgess, Erik “Time–Phasing Methods and Metrics,” 37th DoD CAS, 2004, pp. 9, 27-31
- Norden, Peter V. “Useful Tools for Project Management,” Management of Production, M.K. Starr, Editor. Penguin, Baltimore, Maryland, 1970.
- Watkins, Harry. “An Application of Rayleigh Curve Theory to Contract Cost Estimation and Control,” Master’s Thesis, Naval Postgraduate School, Monterey, California, March, 1982.
- Abernathy, T. “An Application of the Rayleigh Distribution to Contract Cost Data.” Master’s Thesis, Naval Postgraduate School, Monterey, California, 1984.
- Lee, David A., Hogue, Michael R., and Gallagher, Mark A. “Determining a Budget Profile from a R&D Cost Estimate,” DoD Coast Analysis Symposium, 1993.
- Office of the Undersecretary of Defense (Comptroller) (USD(C)). “National Defense Budget Estimates for FY 2011: ‘Green Book’.” September 2012.
- Gallagher, Mark A., and Lee, David A. “Final-Cost Estimates for Research and Development Programs Conditioned on Realized Costs,” Military Operations Research, V2 N2, 1996.
- NRO Cost Group, “Converting Time Phased Costs to Time Phased Budgets”, 2002.
- Garcia, Rick “Cost Estimate to Budget Conversion v3”, 2010
- Office of the Undersecretary of Defense (Comptroller) (USD(C)). "Department of Defense Financial Management Regulation, DoD 7000.14-R," Volume 1. 27 December 2008.

BACKUP

Why Use a Rayleigh or Weibull Model?

- Why is a Rayleigh Model Used?
  - 1963: Peter Norden (IBM) showed that R&D projects followed well defined Rayleigh curved shapes in relating manpower to duration
  - 1978: Lawrence Putnam (GEC) applied the Rayleigh model to software development projects
  - 1980's: Harry Watkins (1982) and Thomas Abernathy (1984) concluded that the Rayleigh model fit Defense acquisition expenditure data well
  - 1993: David Lee, Michael Hogue and Hoffman confirmed a Rayleigh model fit to a variety of defense acquisition programs' expenditure data
  - 1993: David Lee, Michael Hogue and Mark Gallagher identify that cost profiles need to be converted to budget profiles
  - 1996-2010: As detailed below, several studies and authors confirm that a Rayleigh 60/50 curve is a good representative "standard" expenditure model if an analogy or specific model is NOT available

1995 ESC study of 69 AF programs resulted in an average of 64% spent at 50% time*

1996 D Lee and M Gallagher study found 60% spent at 50% time*

Study of 14 single-satellite contracts resulted in an average of 59% spent at 50% time*

* Direct excerpts from "Time–Phasing Methods and Metrics," Erik Burgess, 37th DoD CAS, 2004

CRITICAL THINKING.
SOLUTIONS DELIVERED.