Extending an Econophysics Value Model for Early Developmental Program Performance Prediction and Assessment

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Background

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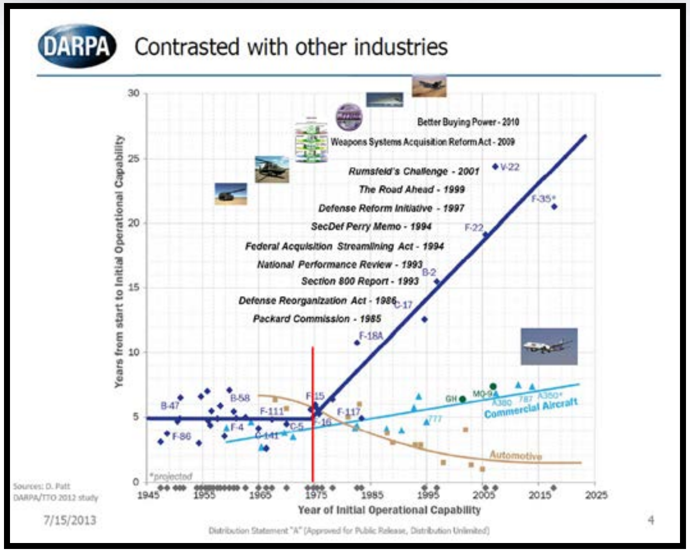

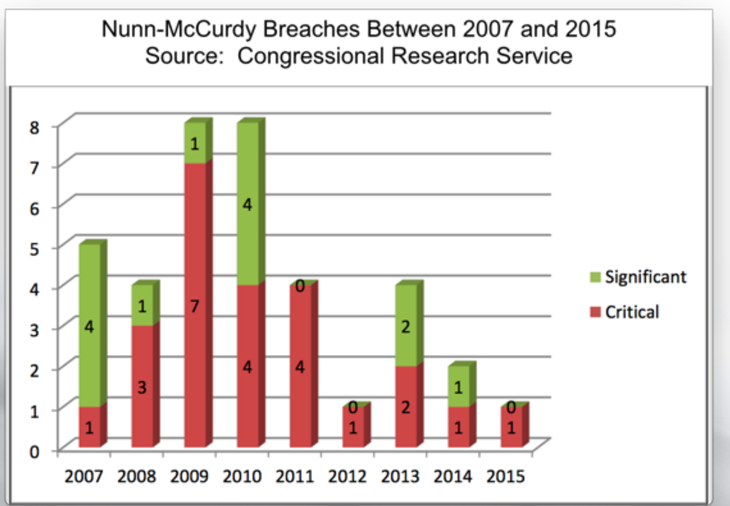

Are we Improving?

- Constrained budgets,
- Improved cost estimating (influenced by the Weapon System Acquisition Reform Act of 2009),
- Fewer new starts,
- The cancellation or curtailment in recent years of troubled programs,
- The impact of a generation of acquisition professionals who rose through the system under the Defense Acquisition Workforce Improvement Act
- The continuity and consistency of actions taken by the office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (AT&L).

Bottom Line Upfront

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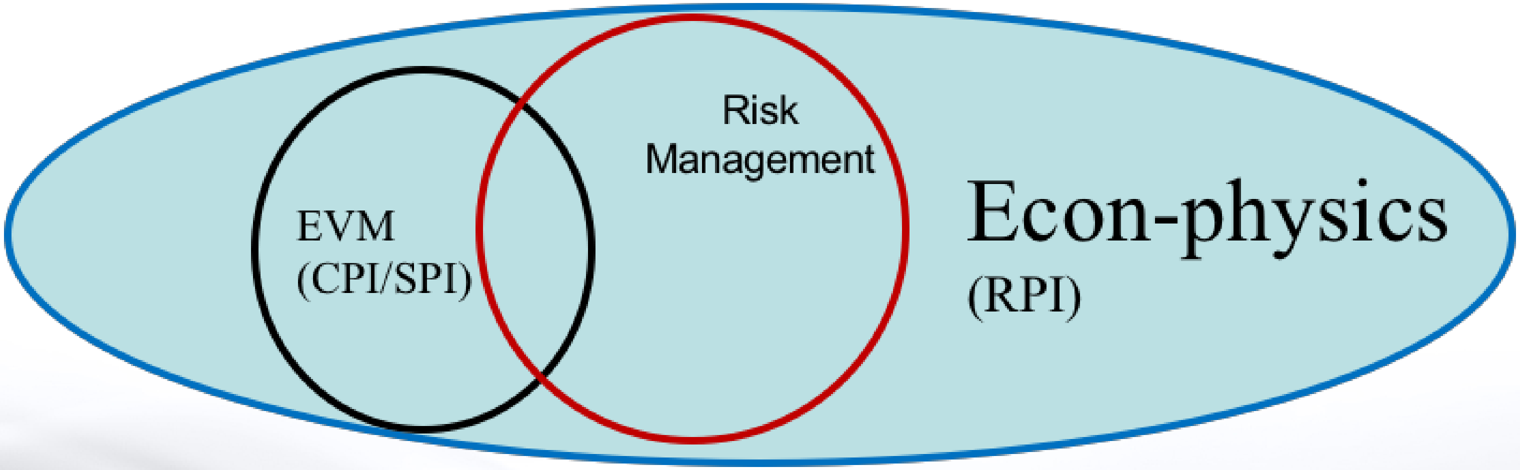
Extending econophysics value models and applying them to a typical program scenario provides a better understanding of Defense Programs allowing Program Managers to make more informed risk based decisions.



What is Econophysics

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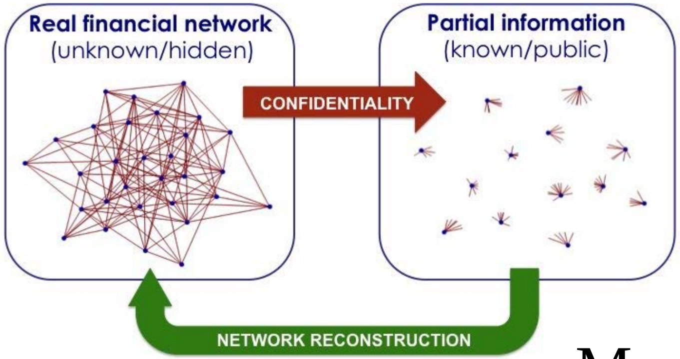
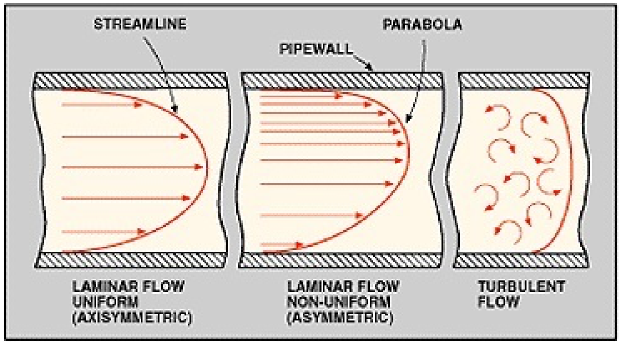
Econophysics is an interdisciplinary research field, applying theories and methods originally developed by physicists in order to solve problems in economics, usually those including uncertainty or stochastic processes and nonlinear dynamics.

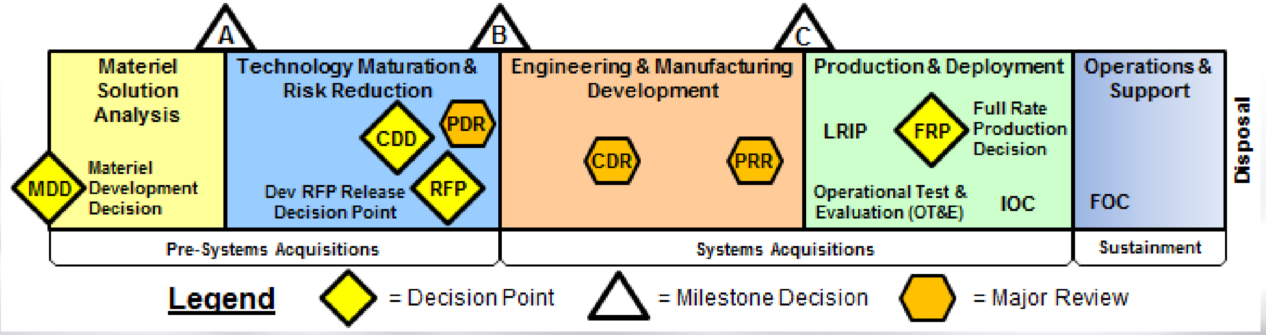


Network Ties

Managing Turbulence



Turbulence Modeling



Program Complexity

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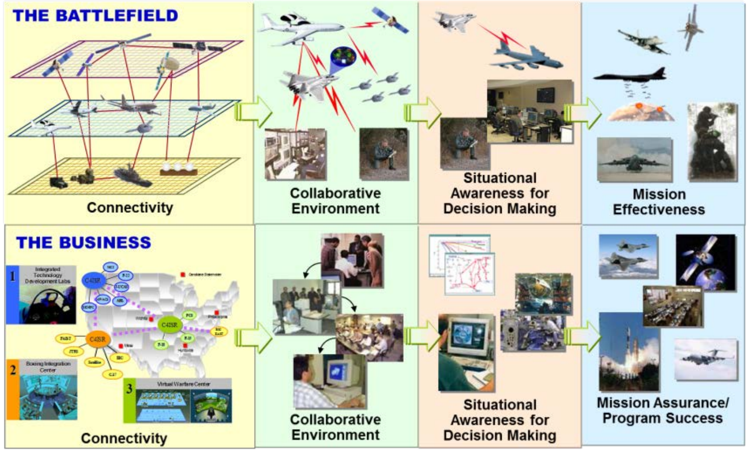

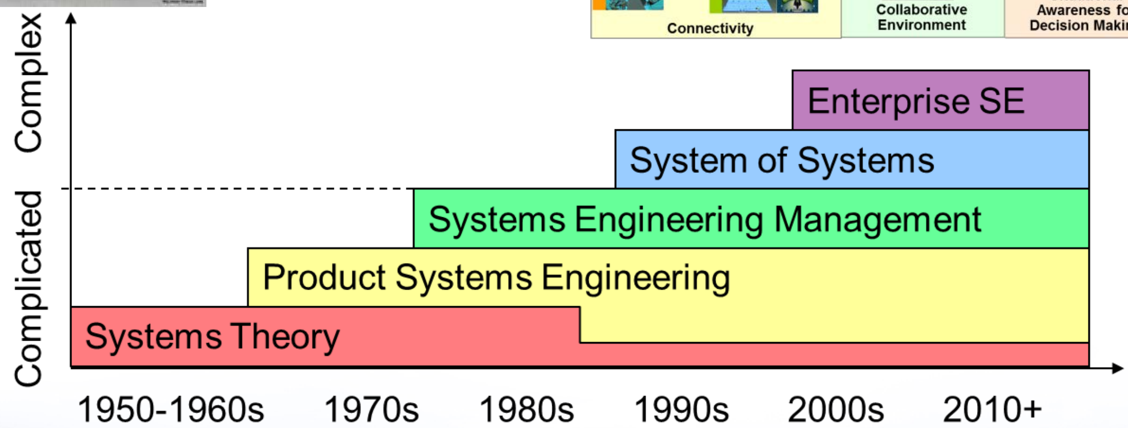

Increasing complexity of programs requires more sophisticated management and control and prediction techniques

Complex Programs

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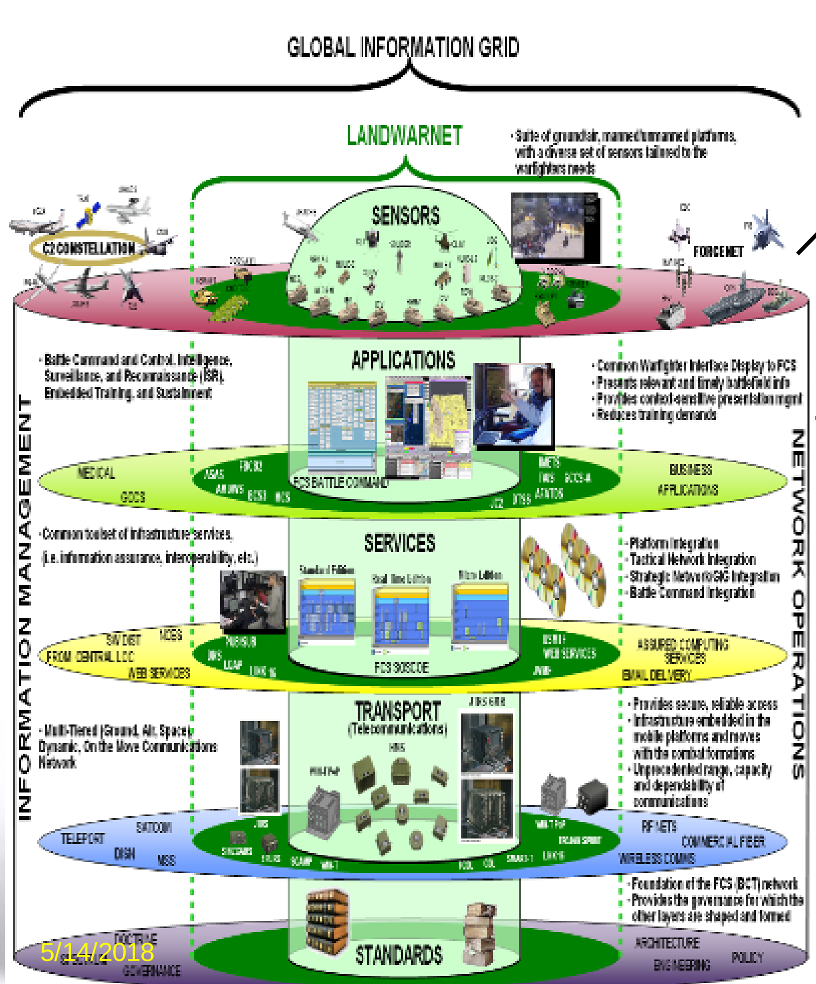
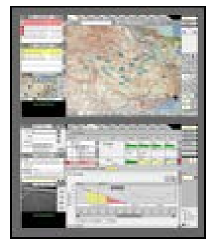
FCS(BCT) Network

- Networked Sensors
- Commonality



Battle Command



- Common Warfighter Interface
- Rapid Visualization of the Fight
- Shared Information/Planning/Execution
- Embedded Training and Logistics

SOSCOE

- Role Based Access
- Information Assurance
- Interoperability

JTRS GMR

JTRS HMS

- Network-enabled BCS
- Timeliness of Information to Squad Level in seconds
- Units "Self-synchronize" as they re-establish Network connectivity

JTRS AMF

WIN-T JC4ISR

ICS

The Problem

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The Department of Defense manages programs using static cost estimates limiting the program manager from making value based decisions based on volatility.

Return on Investment = (Value – Cost)/Cost

Meaningless

DoD ROI = (0 – Cost)/Cost = -1

Managing complex programs is a RISK based process that needs to allow the program manager to manage within a threshold of Return on Investment that balances cost, schedule, and performance

Econophysics will allow the program manager to integrate a revenue metric into the decision making process, providing a pathway for assessing program execution return on investment

Return on Investment

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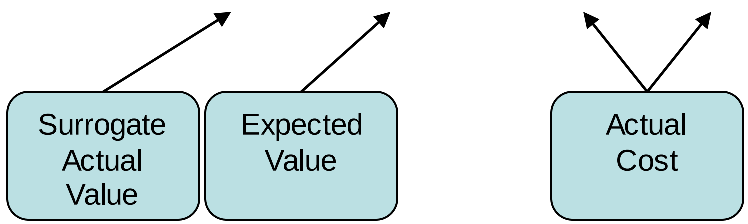
CPI = BCWP/ACWP (Cost Performance Index)

SPI = BCWP/BCWS (Schedule Performance Index)

BCWP – Budgeted cost of work performed
ACWP – Actual cost of work performed
BCWS – Budgeted cost of work scheduled (Performance Measurement Baseline; Desired Value expressed in Cost)

RPI = [(PV)(BCWS)-ACWP]/ACWP (s-ROI Performance Index)*



RPI Provides More Insight into Turbulent Region of a Program and Gives the Program Manager More Options

*Typically measured every 30 days

Proto-value (surrogate revenue)

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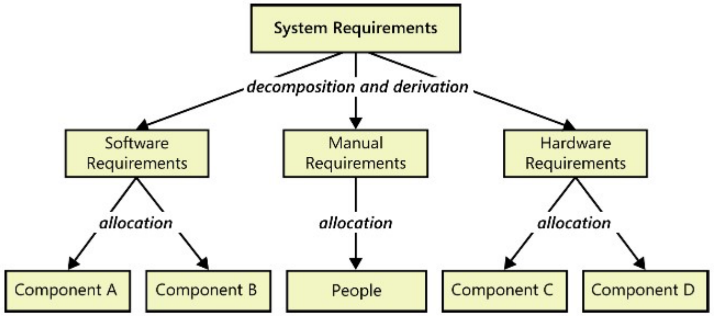
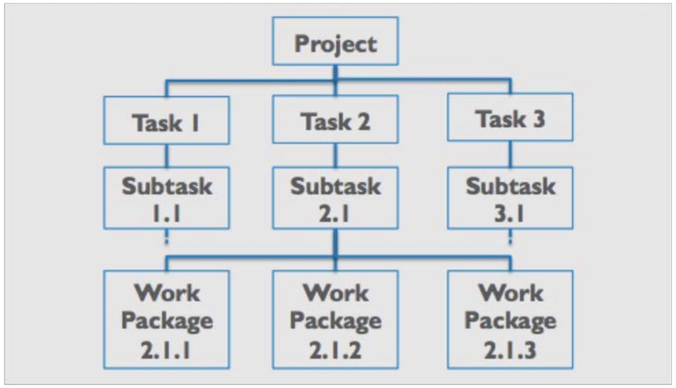
$$PV_i = (R_{qi} * P_{si})(m_i * N_i)$$



Probability of obtaining a specified requirement



Likelihood of completing a specified capability

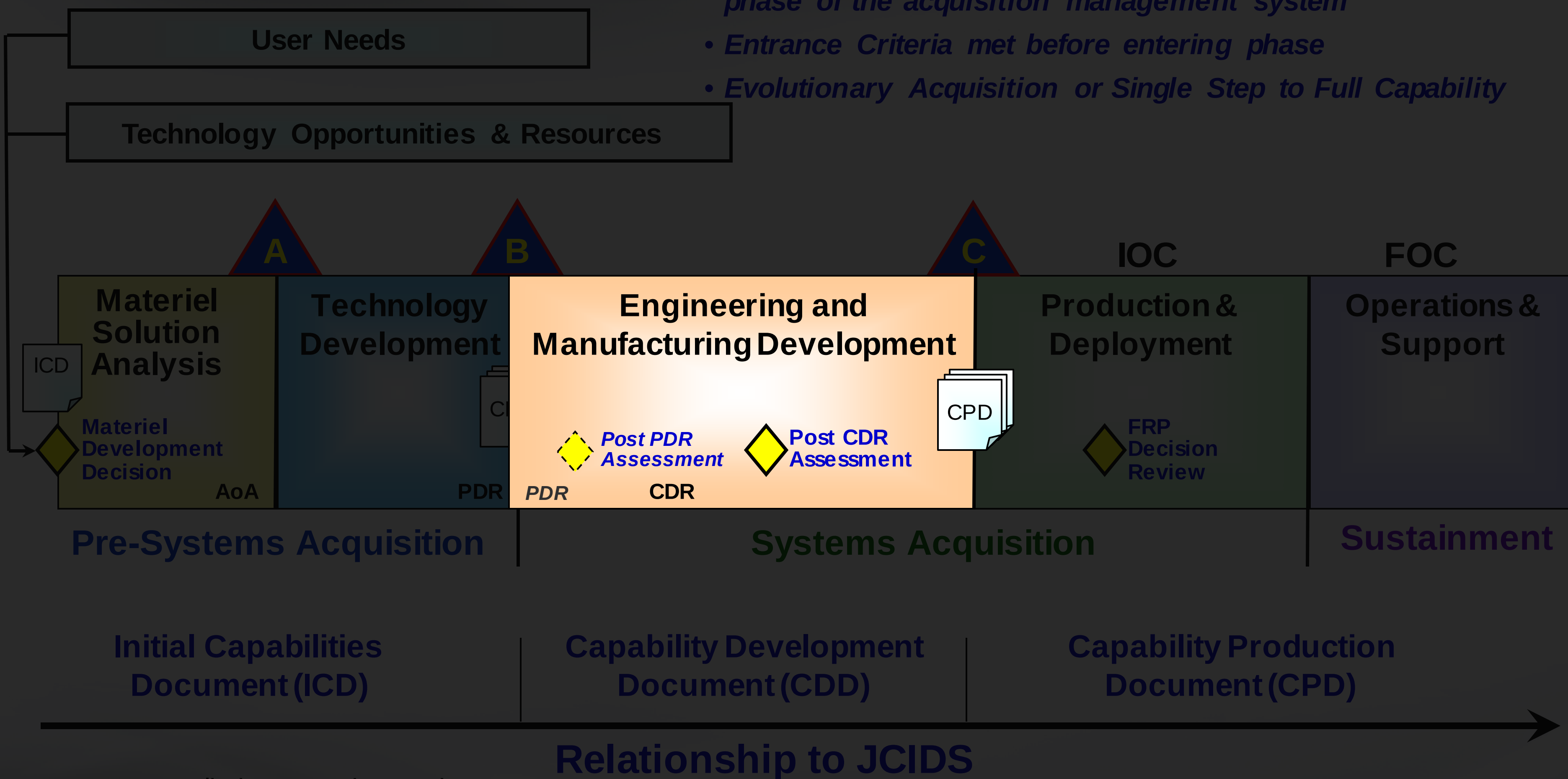
$$\text{Total } PV_{in} = \text{sum}(PV)\Big|_i^n$$

mass {m} –refers to the attraction between program requirements and the customer .

mass = f[TRL, Risk, Budget, Threat….]dt

Scope and Context of Research

- *The Materiel Development Decision precedes entry into any phase of the acquisition management system*
- *Entrance Criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*



PDR: Preliminary Design Review
CDR: Critical Design Review
FRP: Full Rate Production

IOC: Initial Operational Capability
FOC: Full Operational Capability

Typical Program Behavior

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Month	Cost Est/ Mo	BCWS	BCWP/mo	BCWP	ACWP/mo	ACWP	R	Ps	PF	PV per Month	Cum PV	RPI	CPI	SPI
1	10	10	10	10	10	10	10	0.9	10	90	90	8.9	1	1
2	10	20	10	20	10	20	10	0.9	10	90	180	8.9	1	1
3	10	30	10	30	10	30	10	0.9	10	90	270	8.9	1	1
4	10	40	10	40	10	40	10	0.9	10	90	360	8.9	1	1
5	10	50	10	50	10	50	10	0.9	10	90	450	8.9	1	1
6	10	60	10	60	10	60	10	0.9	10	90	540	8.9	1	1
7	10	70	10	70	10	70	10	0.9	10	90	630	8.9	1	1
8	10	80	10	80	10	80	10	0.9	10	90	720	8.9	1	1
9	10	90	10	90	10	90	10	0.9	10	90	810	8.9	1	1
10	10	100	10	100	10	100	10	0.9	10	90	900	8.9	1	1
11	10	110	10	110	10	110	10	0.9	10	90	990	8.9	1	1
12	10	120	10	120	10	120	10	0.9	10	90	1080	8.9	1	1
13	10	130	10	130	10	130	10	0.9	10	90	1170	8.9	1	1
14	10	140	10	140	10	140	10	0.9	10	90	1260	8.9	1	1
15	10	150	10	150	10	150	10	0.9	10	90	1350	8.9	1	1
16	10	160	10	160	10	160	10	0.9	10	90	1440	8.9	1	1
17	10	170	10	170	10	170	10	0.9	10	90	1530	8.9	1	1
18	10	180	10	180	10	180	10	0.9	10	90	1620	8.9	1	1
19	10	190	10	190	10	190	10	0.9	8	72	1692	7.1	1	1
20	10	200	10	200	10	200	10	0.8	8	64	1756	6.3	1	1
21	10	210	10	210	10	210	10	0.8	8	64	1820	6.3	1	1
22	10	220	10	220	11	221	10	0.8	8	64	1884	5.7181818	0.909	1
23	10	230	10	230	11	232	10	0.8	8	64	1948	5.7181818	0.909	1
24	10	240	9	239	11	243	10	0.7	8	56	2004	4.9909091	0.818	0.9
25	10	250	9	248	11	254	10	0.7	7	49	2053	4.3545455	0.818	0.9
26	10	260	9	257	12	266	10	0.7	7	49	2102	3.9833333	0.75	0.9
27	10	270	8	265	12	278	10	0.7	7	49	2151	3.9833333	0.667	0.8
28	10	280	8	273	12	290	10	0.7	7	49	2200	3.9833333	0.667	0.8
29	10	290	8	281	12	302	10	0.7	7	49	2249	3.9833333	0.667	0.8
30	10	300	8	289	14	316	10	0.7	7	49	2298	3.4	0.571	0.8
31	10	310	7	296	14	330	10	0.7	7	49	2347	3.4	0.5	0.7
32	10	320	7	303	14	344	10	0.6	7	42	2389	2.9	0.5	0.7
33	10	330	7	310	14	358	10	0.6	7	42	2431	2.9	0.5	0.7
34	10	340	7	317	15	373	10	0.6	7	42	2473	2.7	0.467	0.7
35	10	350	7	324	15	388	10	0.6	7	42	2515	2.7	0.467	0.7
36	10	360	7	331	15	403	10	0.5	6	30	2545	1.9	0.467	0.7

1. Potential Field, PF = (m*N) begins to decline due to declining N
2. Mass (m) – begins to decline due to reduced confidence in meeting requirements, R
3. P_s begins to decline

4. PV shows significant reduction
5. RPI shows significant reduction

6. ACWP reports showing initial increasing cost are published
7. CPI shows first significant reduction
8. SPI shows first significant reduction

$$PV = (R*P_s)(m*N) = ([R*(1-r)])(m*N)$$

$$RPI = [(PV)(BCWS)-ACWP]/ACWP$$

Program Lifecycle Evolution

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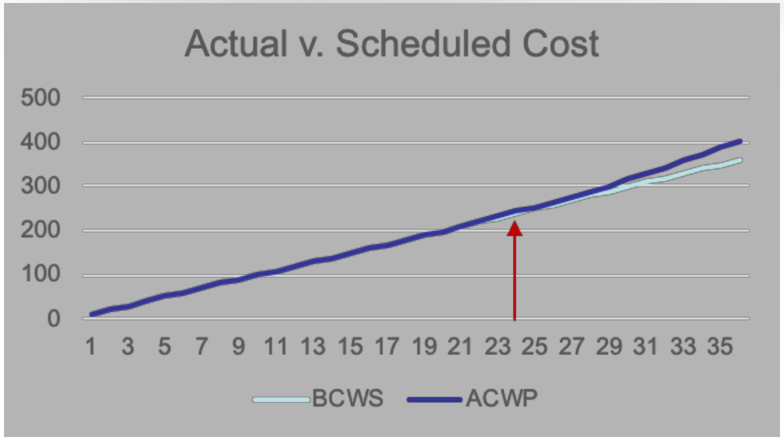

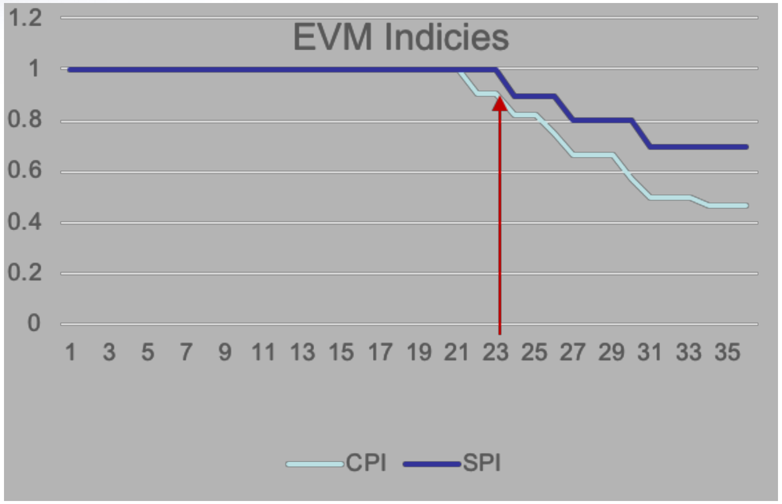

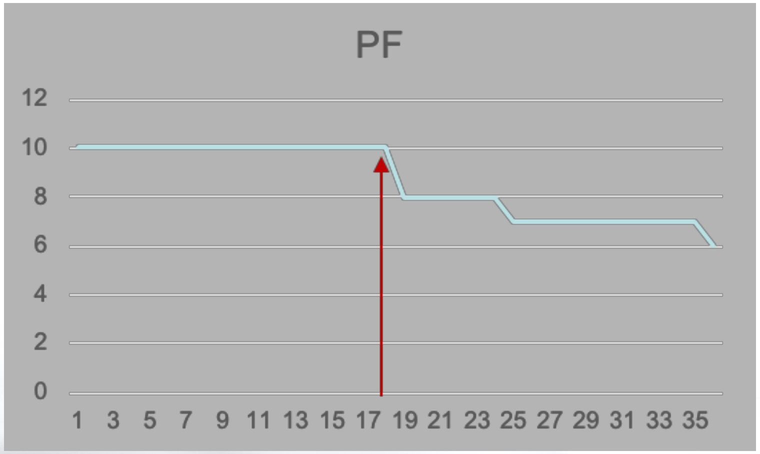

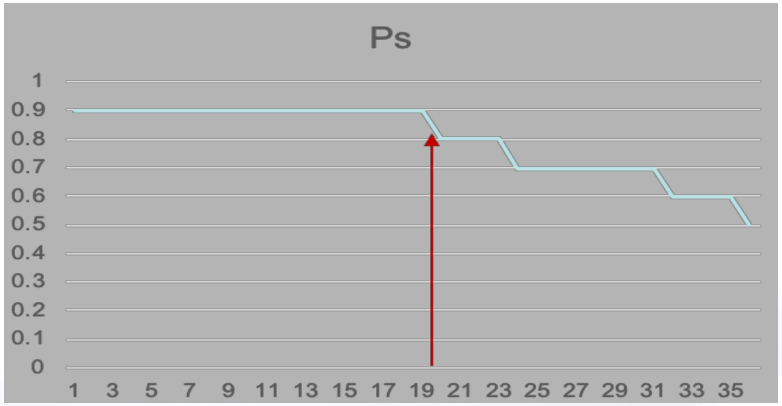

$$PV_i = PP_i*PF_i = (R*P_s)(m*N) = ([R_i*(1-r_i)])(m_i*N_i)$$

Program Lifecycle Evolution

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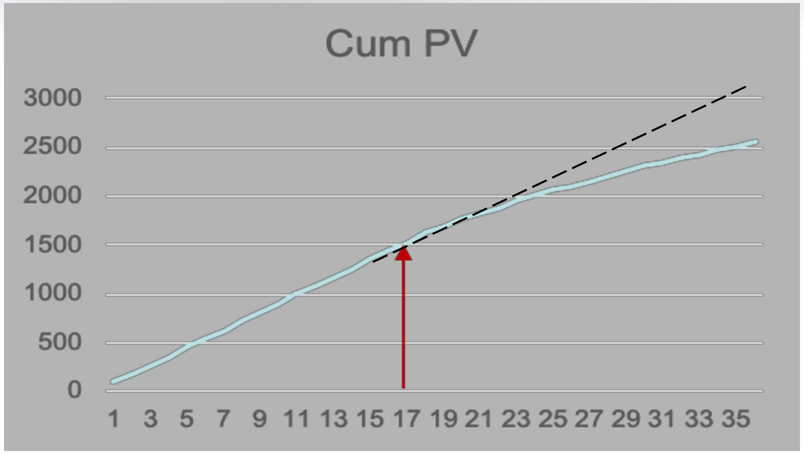

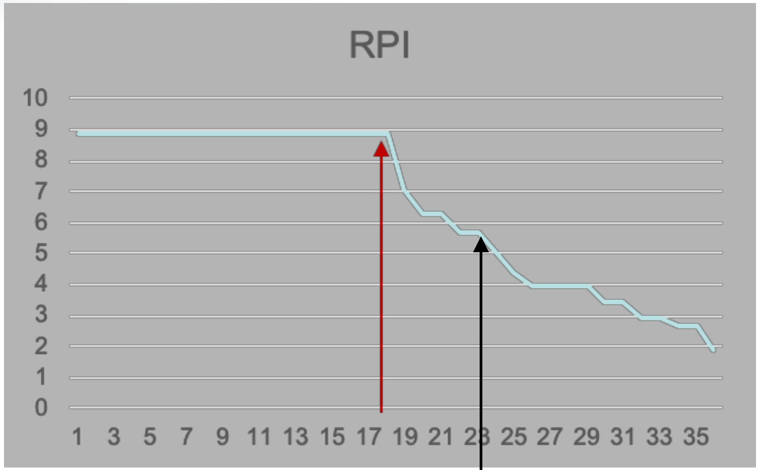

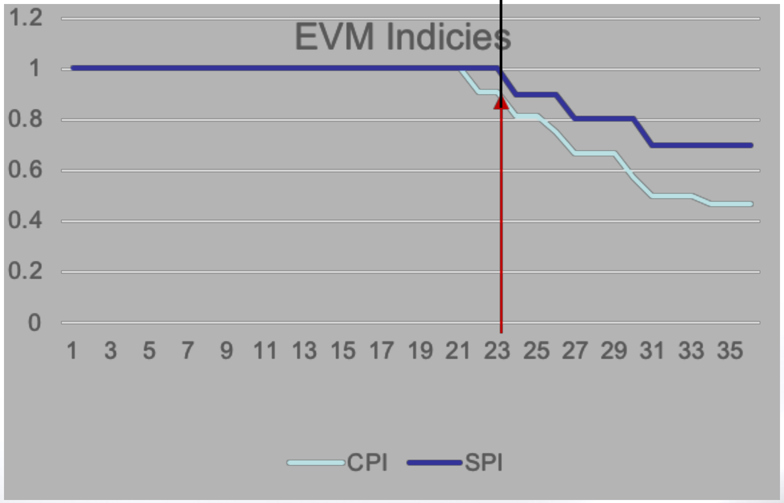

RPI shows program performance issues
Earlier in the life cycle

What's Next

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- Establish derivatives that describe mass and Probability of success
  - **mass = f[TRL, Risk, Budget, Threat….]dt**
  - **P_s = f(cost, schedule, TRL, Volatility (β)…)dt**
- Develop a measure of Beta that accurately describes the transition region at which programs begin to become turbulent.
- Integrate Beta into Protovalue to capture ancillary variables that effect mass and probability of success
- Code the model and conduct regressive analysis with program data and simulation to validate and converge the predictive nature of the theory.
- Predict and Explain!