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Acquiring Artificial Intelligence Systems:

Development Challenges, Implementation Risks, and Cost/Benefits Opportunities

Dr. Timothy Shives
Information Science Dept.
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Impact of the Growing Interest in AI: In Society and the DoD

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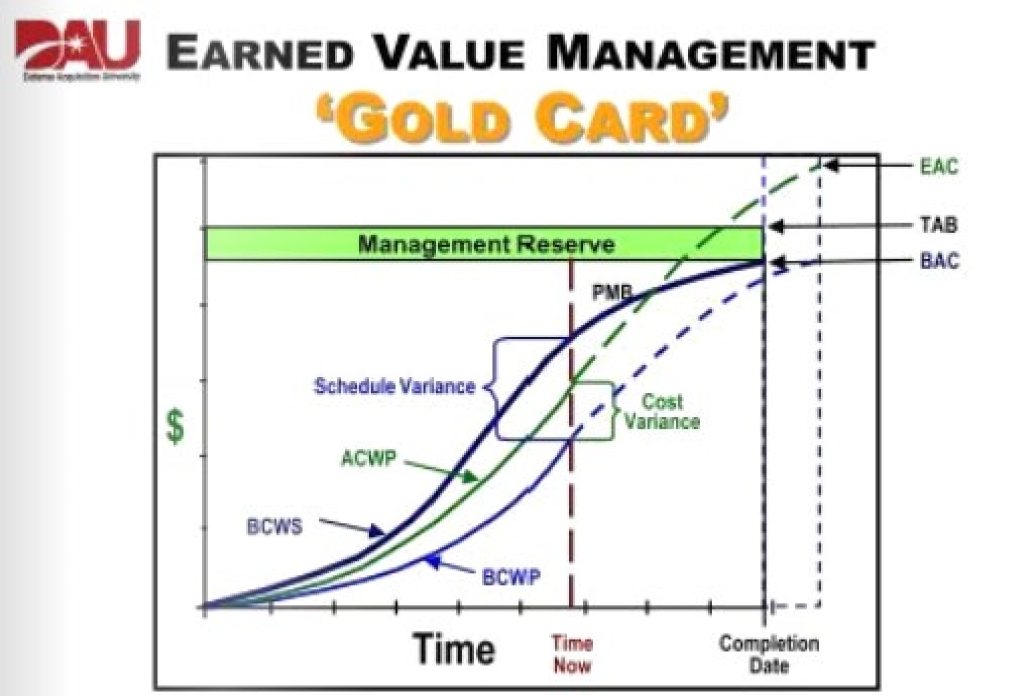
- Fielding of new and advanced technologies such as AI is a challenge for the DoD and all Federal Government.
- The current methodologies have proven unsuccessful in meeting the task of providing the requirements to the warfighter to face the challenges of the modern battlefield (Kendall, 2017).
- Recent case study on the two-decade process of developing biometrics.
  - "Effective military innovation can only occur through an integrated approach that takes into account the interdependent elements of technology development, acquisition planning, doctrinal design, and warfighting strategy" (Voelz, 2016, p. 180).
- Defense Science Board (2018) study on the DoD's Acquisition of software intensive programs
- Joint Artificial Intelligence Center (JAIC) as the coordinating focal point for the DoD
- 2020 CRS Report, "DOD may need to continue to adjust its Acquisition process to account for rapidly evolving technologies such as AI"
- 2019 RAND Report, the DoD should utilize and adapt acquisition approaches that are "appropriate for the technology"
- Current process management and control tools as used are ineffective
- PMs cannot respond to issues in a timely manner, delaying the delivery of promised capabilities to the services.
- This study examined how three methodologies, Earned Value Management (EVM), Knowledge Value Added (KVA), and Integrated Risk Management (IRM), can be used effectively to meet these development challenges and address risks to implementation.

Method One: Earned Value Management
"The Traditional Way"



VARIANCES Favorable is Positive, Unfavorable is Negative

Cost Variance	CV	= BCWP – ACWP	CV % = (CV / BCWP) *100
Schedule Variance	SV	= BCWP – BCWS	SV % = (SV / BCWS) *100
Variance at Completion	VAC	= BAC – EAC	

OVERALL STATUS

% Schedule = $(BCWS_{CUM}$ / BAC) * 100

% Complete = $(BCWP_{CUM}$ / BAC) * 100

% Spent = $(ACWP_{CUM}$ / BAC) * 100

DoD TRIPWIRE METRICS

TW Cost Efficiency CPI = BCWP / ACWP Favorable is > 1.0, Unfavorable is < 1.0

TW Schedule Efficiency SPI = BCWP / BCWS Favorable is > 1.0, Unfavorable is < 1.0

TW **BASELINE EXECUTION INDEX (BEI)** = A Schedule Metric

BEI = Tasks with Actual Finish Date / (# of Baseline Tasks Scheduled to Finish Prior to Status Date + Tasks Missing Baseline Start or Finish Date)

TW **CRITICAL PATH LENGTH INDEX (CPLI)** = A Schedule Metric

CPLI = (CP Length $_{\text{(Time Now To Contract End)}}$ + Total Float $_{\text{(To Contract End Baseline Finish)}}$) / CP Length

Hit / Miss = Month's Tasks Completed ON or AHEAD / Month's Tasks Scheduled to Complete

ESTIMATE AT COMPLETION (EAC) = Actuals to Date + [(Remaining Work)/(Performance Factor)]

EAC_{CPI} = $ACWP_{CUM}$ + [(BAC – $BCWP_{CUM}$) / CPI_{CUM}]

= BAC / CPI_{CUM}

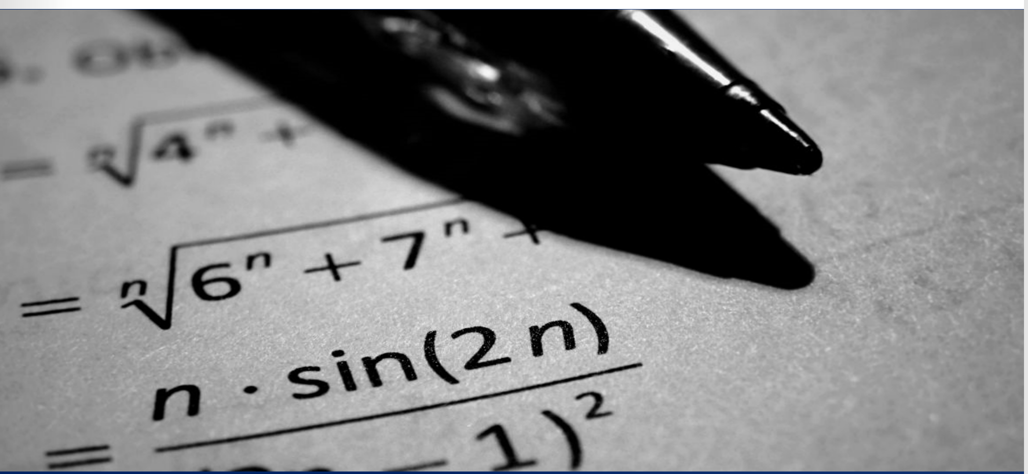
$EAC_{Composite}$ = $ACWP_{CUM}$ + [(BAC – $BCWP_{CUM}$) / (CPI_{CUM} * SPI_{CUM})]

§ **TO COMPLETE PERFORMANCE INDEX (TCPI)**

$TCPI_{EAC}$ = Work Remaining / Cost Remaining = (BAC – $BCWP_{CUM}$) / (EAC – $ACWP_{CUM}$)

To Determine a Contract Level TCPI or EAC; You May Replace BAC with TAB

§ To Determine the TCPI $_{\text{BAC or LRE}}$ Replace EAC with BAC or LRE



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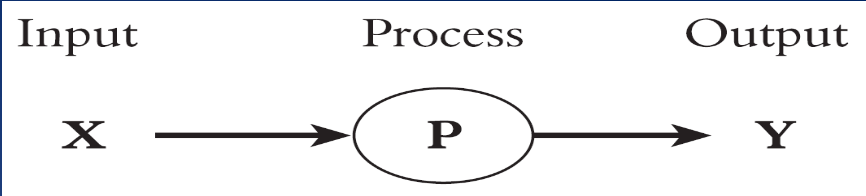
Method Two: Knowledge Value Added "Provides Common Units of Value"



$$P(X) = Y$$

Fundamental assumptions:

1. If X = Y no value has been added.

2. "value" ∝ "change"

3. "change" can be measured by the amount of knowledge required to make change.

So "value"∝ "change" ∝"amount of knowledge required to make the change"

Steps	Learning Time	Process Description	Binary Query Method
One	Identify core process and its subprocesses.		
Two	Establish common units and level of complexity to measure learning time.	Describe the products in terms of the instructions required to reproduce them and select unit of process description.	Create a set of binary yes or no questions such that all possible outputs are represented as a sequence of yes or no answers.
Three	Calculate learning time to execute each subprocess.	Calculate number of process description words, pages in manual, and lines of computer code pertaining to each subprocess.	Calculate length of sequence of yes or no answers for each subprocess.
Four	Designate sampling time period long enough to capture a representative sample of the core processes final product or service output.		
Five	Multiply the learning time for each subprocess by the number of times the subprocess executes during the sample period.	Multiply the number of process words used to describe each sub process by the number of times the subprocess executes during sample period.	Multiply the length of the yes or no string for each sub process by the number of times the subprocess executes during sample period.
Six	Calculate cost to execute knowledge (learning time and process instructions) to determine process costs.		
Seven	Calculate ROK and ROP and interpret the results.		

As-Is Process

Process Description	Total Knowledge	Expenses ($)	ROK
Open SR	4320.00	$ 1,663.70	260%
Induction	87360.00	$ 3,327.39	2625%
Order Parts	10080.00	$ 332.74	3029%
Supply Opens Parts Requisition	20160.00	$ 1,663.70	1212%
Receive Part	41040.00	$ 1,996.43	2056%
Perform Maintenance	109920.00	$ 13,309.57	826%
Final Inspection	87360.00	$ 3,327.39	2625%
Totals	**360240.00**	**$ 25,620.91**	**1406%**

To-Be Process

Process Description	Total LT (Hrs)	Expenses ($)	ROK	ROK w/ Acq Costs
Open SR/Induction/OrderParts	101760.00	$ 3,992.87	2549%	2398%
Supply Opens Parts Requisition	20160.00	$ 1,663.70	1212%	1053%
Receive Part	41040.00	$ 1,996.43	2056%	1827%
Perform Maintenance	109920.00	$ 13,309.57	826%	811%
Final Inspection	87360.00	$ 3,327.39	2625%	2442%
Totals	**360240.00**	**$ 24,289.96**	**1483%**	**1468%**

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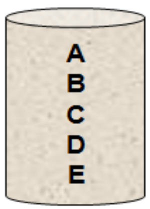
Method Three: Integrated Risk Management
"Forecasts Risks"

Integrated Risk Management Process

1 List of projects and strategies to evaluate

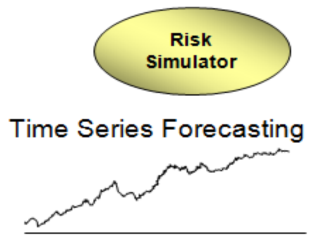
RISK IDENTIFICATION



Start with a list of projects or strategies to be evaluated… these projects have already been through qualitative screening

2 Base case projections for each project

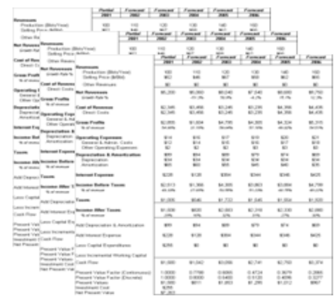
RISK PREDICTION



…with the assistance of time-series forecasting, future outcomes can be predicted…

3 Develop static financial models

RISK MODELING

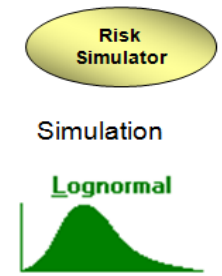


Traditional analysis stops here!

…the user generates a traditional series of static base case financial (discounted cash flow) models for each project…

4 Dynamic Monte Carlo simulation

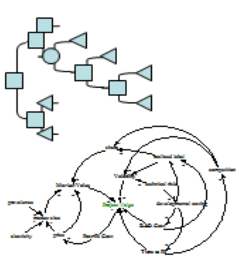
RISK ANALYSIS



…Monte Carlo simulation is added to the analysis and the financial model outputs become inputs into the real options analysis…

5 Framing Real Options

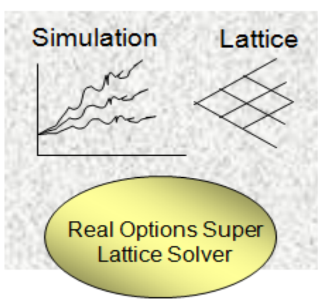
RISK MITIGATION



…the relevant projects are chosen for real options analysis and the project or portfolio real options are framed…

6 Options analytics, simulation, optimization

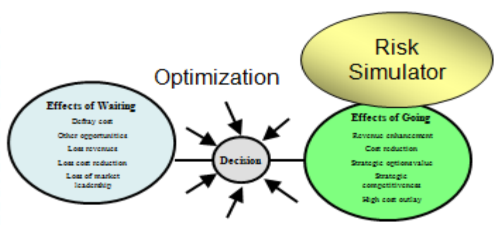
RISK HEDGING



…real options analytics are calculated through binomial lattices and closed-form partial-differential models with simulation…

7 Portfolio optimization and asset allocation

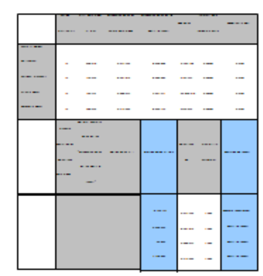
RISK DIVERSIFICATION



…stochastic optimization is the next optional step if multiple projects exist that require efficient asset allocation given some budgetary constraints… useful for strategic portfolio management…

8 Reports presentation and update analysis

RISK MANAGEMENT



…create reports, make decisions, and do it all again iteratively over time…

Comparison of Methods for Project Analytics

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- Choosing a methodology depends on the nature of the project
- EVM only needs the management team to track the cost and schedule of the project compared to the baseline as there is no goal alignment with the organization
  - If the software is not complex or consists of known processes, EVM sufficiently monitors its progress
  - Integrating software and hardware is also complicated with EVM
  - EVM is more efficient when used to manage the physical creation of systems or infrastructure

- KVA only needs the analyst and process owner, as the subject matter expert, to determine the value of a process's output, supporting the need to align the project with an organization's productivity goals
  - KVA can provide an objective, ratio-scale measure of value and cost for each core process and its subprocesses within any IS system
  - Using the two measurements, managers can then analyze productivity ratios information, such as ROK and ROI, to determine the efficiency of a process compared to the resources used to achieve the output

- IRM requires organizational leadership, portfolio and project managers, and the analyst to determine how a project fits within an organization's portfolio, the uncertainties in the project estimates, and potential strategic options
  - IRM provides a prediction of a project's likely performance, which allows managers to build in flexibility via real options at the appropriate locations within the project
  - IRM quantifies risks and forecast performance probabilities for measures of the potential success for programs and components of programs using historical and contemporaneous data

- Combining the KVA results with IRM allows managers to iterate the value of the system , risks and uncertainties, while also providing strategic real options analysis of alternatives through Monte Carlo simulation and other techniques. Can also be combined with EVM

Combinations of EVM, KVA, IRM

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- EVM remains the only program management methodology for all DoD acquisition programs
- However, there are significant limitations when using EVM for AI acquisitions, the major weakness being that it was not designed for managing AI acquisitions that follow a very iterative pathway.
    - Organic AI acquisitions require a given level of flexibility to deal with the unknowns that arise during the development process.
    - EVM does not provide a common unit of value metric to enable standard productivity metrics, such as ROI.
    - If an AI acquisition program is trending toward cost and schedule overruns, but the resulting value added of the modifications to the original requirements provides disproportionate increases in value, EVM is not designed to recognize this increase in value.
- To remedy the shortcomings of EVM in AI acquisitions, the methodology can be combined with KVA and IRM
    - Example use case is during the requirements phase of EVM by ensuring that a given AI acquisition is aligned with organizational strategy and that a baseline process model has been developed for establishing current performance before acquisition of the supporting AI.
    - A future process model (IRM) that estimates the value added (KVA) of the incorporation of the AI can also set expectations that can be measured against the baseline model (EVM) after the AI has been acquired.
    - IRM can also be used to forecast the value of strategic real options flexibility that an acquired AI may provide so that leadership can select the options that best fit their desired goals for the AI in defense core processes.

Summary

- The growth of interest in AI is on the rise.
- The DoD Acquisition community is not optimally postured for effectively assessing the performance in the development of their AI programs.
- While EVM remains the only program management methodology required by the U.S. government for all DoD acquisition programs with a contract value exceeding $20 million, PMs can augment EVM with other methodologies such as KVA and IRM.
- If you have any Questions/Comments, please use the chat box or we can discuss after the final presentation.

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