BUYING FOR THE RIGHT BATTLE: *DETERMINING DEFENSE ACQUISITION STRATEGIES*

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Summary

Research Questions

- What data reported in publicly released reports are significant predictors of program cycle time and schedule change?
- How do these predictors change with acquisition strategies?

Hypotheses

H1. Program cycle time may be predicted from programmatic resources and acquisition strategy decisions.

H2. Percent change in program cycle time may be predicted from programmatic structural changes

Significant factors for cycle time and percent change in cycle time

- Multivariate regressions (in backup)
- Statistically significant predictors
  - Program structural decisions
  - Factors that may be changeable during execution
  - External factors (may not be controllable)

Cycle time	*% change cycle time*
R&D Budget (+)	Procurement budget Change (+)
Software approach*: Agile, hybrid (-)	DoD 5000.02 (old) model **: 2,5,6 (+), 4 (-)
Joint (-) Depend on other MDAPs (+)	Service (relative to AF): Navy (+), Army, DoD (-)
Reuse existing DoD tech (-) Use commercial Tech (-)	Integration issues (-) # Critical Tech Elements (+)
Financial instability (+)	Financial instability (+) Restructure (+), NM breach (+)
** relative to Waterfall*	*** relative to model 1*

(+): more ~ longer cycle times
(-) : more ~ shorter cycle times

Program structural factors
Potentially changeable factors
External factors

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MDAP factor alignment with cycle time quartiles

Table V. Quartiles vs. regression factors – full dataset.

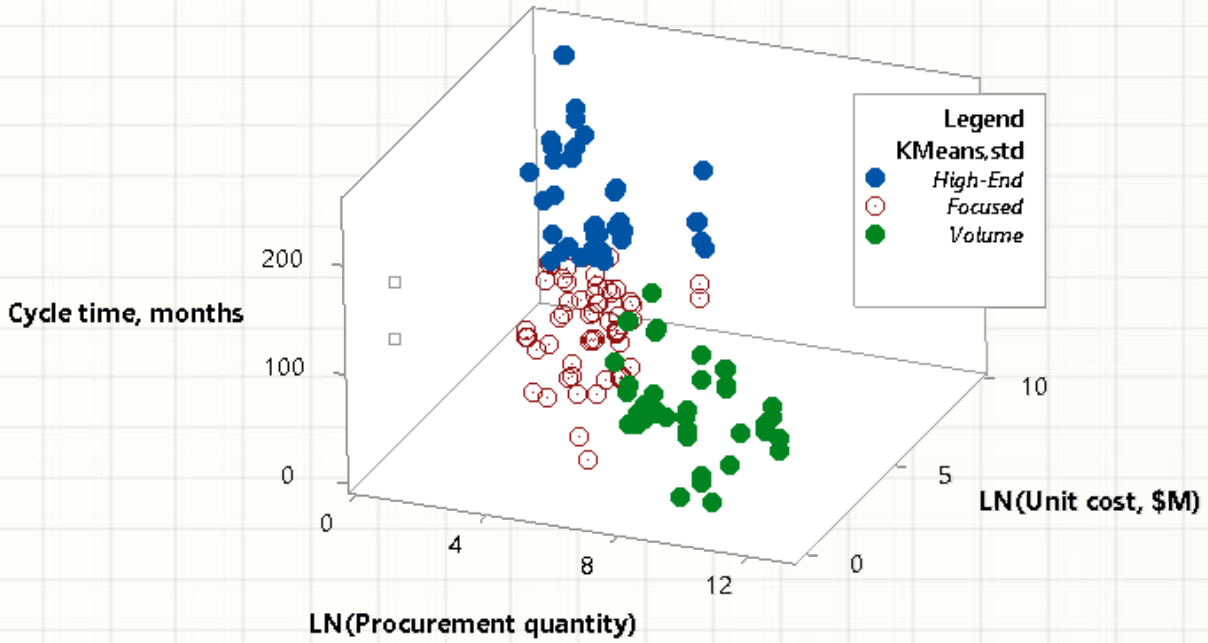
Factor		Q1	Q2	Q3	Q4	p-value[23]
SW development	Waterfall	17	15	20	26	0.001
	Agile	21	23	20	7	
	Hybrid/NA	5	0	2	6	
Joint	no	32	29	34	34	0.475
	yes	11	9	8	5	
Depends on other MDAP(s)	no	28	12	14	7	0.000
	yes	15	26	28	32	
Reuse DoD tech	no	12	19	13	15	0.176
	yes	31	19	29	24	
Commercial Tech use	no	21	21	31	35	0.000
	yes	22	17	11	4	
Financial instability	no	27	15	15	6	0.000
	yes	16	23	27	33	

Xx under-represented in quartile
Xx over-represented in quartile
p-value is for likelihood ratio

- Divided cycle time distribution into quartiles
  - Significant p-value < 0.05
- Shorter cycle times (Q1 or Q2) related to
  - Hybrid or agile software development approach
  - Use of commercial technology
- Longer cycle times (Q4) related to
  - Financial (budget) instability
  - Depending on other MDAPs

Programs have different functional objectives

- Quantity, cost, schedule, performance?
  - Lots of ways to categorize strategies
- We used functional objectives
  - Cost, Quantity, Schedule, performance
  - Clustered on Procurement quantity, unit cost, cycle time
  - Assumed performance
- 3 strategies:
  - High- End (Max performance)
  - Focused (balanced objectives)
  - Volume (Max volume)



An example MDAP classification-K-Means
(Based on 2007-2018 MDAP data)

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How cycle time factors change with strategies

High-End	*Focused*	*Volume*
R&D Budget (+)	R&D Budget (+)	~~R&D Budget (+)~~
Software approach*: Agile, ~~hybrid (-)~~	~~Software approach*: Agile, , hybrid (-)~~	Software approach*: Agile, hybrid (-)
~~Joint (-)~~ Depend on other MDAPs (+)	~~Joint (-)~~ ~~Depend on other MDAPs (+)~~	Joint (-) ~~Depend on other MDAPs (+)~~
Reuse existing DoD tech (-) ~~Use commercial Tech (-)~~	~~Reuse existing DoD tech (-)~~ Use commercial Tech (-)	~~Reuse existing DoD tech (-)~~ Use commercial Tech (-)
~~Financial instability (+)~~	Financial instability (+)	~~Financial instability (+)~~
• *relative to Waterfall*	Box-Cox transform, λ=0.5	Box-Cox transform, λ=0.5, one outlier removed

~~XXX~~ = not significant

How % change cycle time factors change with strategies

High-End	*Focused*	*Volume*
Procurement Budget Change (+)	Procurement Budget Change (+)	~~Procurement Budget Change (+)~~
~~DoD 5000.02 (old) model **: 2,5,6 (+), 4 (-)~~	~~DoD 5000.02 (old) model **: 2,5,6 (+), 4 (-)~~	~~DoD 5000.02 (old) model **: 2,5,6 (+), 4 (-)~~
Service ~~(relative to AF):~~ Navy (+), ~~Army, DoD (-)~~	Service (relative to AF): Navy (+), Army, DoD (-)	Service (relative to AF): Navy (-), Army, DoD (-)
~~Integration issues (-)~~ ~~# Critical Tech Elements (+)~~	~~Integration issues (-)~~ # Critical Tech Elements (+)	~~Integration issues (-)~~ # Critical Tech Elements (+)
~~Financial instability (+)~~ Restructure (+), ~~NM breach (+)~~	Financial instability (+) ~~Restructure (+), NM breach (+)~~	Financial instability (+) ~~Restructure (+), NM breach (+)~~
Two outliers removed		

~~XXX~~ = not significant

Conclusions

- Program cycle time ~ research and development budget (+)
  - Shorter cycle times ~use of commercial or reuse existing in-service technology
  - Longer cycle times ~ dependency on other programs and financial (budgetary) instability
- Cycle times ~ initial strategy decisions
  - Some can be changed in execution
  - Some are imposed on the program
- Acquisition strategies can be grouped by objectives (High-End, Focused or Volume)
  - Each strategy group has different factors ~ reducing cycle time

Backup

Cycle time factors change as systems mature

Significant factors:

- R&D Budget, ($ millions)
- Joint program
- Uses Commercial technology
- GAO-reported % Δ in unit cost since program start (100% change= 1.0, and can be negative)
- GAO-reported unit cost LN ($ millions)
- *P*rocurement quantities % Δ since program start 100% change= 1.0, (this value can be negative)
- Reported external issues for PM)

(+): more ~ longer cycle times
(-) : more ~ shorter cycle times

GAO: Tech (KP1)and design (KP2) **NOT mature**	GAO: BOTH Tech (KP1)and design (KP2) **mature**
R&D budget (+)	R&D budget (+) Joint (-)
Commercial tech (-)	
Unit cost (+) Unit cost change (+)	Procurement quantity % Δ (-)
	Other PM issues (+)
R-sq(pred)~ 52%	*R-sq(pred)~ 59%*

Procurement quantity becomes significant to cycle time model as technology matures

Program structural factors
Potentially changeable factors
External factors

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Cycle time and schedule change regression models

Cycle.Mo = -10.2 + 18.98*LN.RD.M + SW.Gp + Joint + DEPEND + Reuse + COML + Fin_Uns

Where

- LN.RD.M is the natural log of the MDAP research and development budget in millions;
- SW.Gp = -27.38 for Agile, -24.2 for hybrid or N/A, 0 for waterfall approaches;
- Joint = -15.02 if MDAP is designated as Joint, else 0;
- DEPEND = 16.1 if MDAP depends on another MDAP, else 0;
- Reuse = -19.42 if in-service technology is re-used, else 0;
- COML = -23.99 if MDAP uses commercial technology to deliver capability; else 0; and
- Fin_Uns = 26.79 if more than 10% change in funding since program start, else 0

Cy.Mo.PCT = -0.0955 + 0.01979*P.M.PCT + 0.02706*CTES + Fin_Uns + ACQ_P + SVC + Restr + INTEG + NM

Where

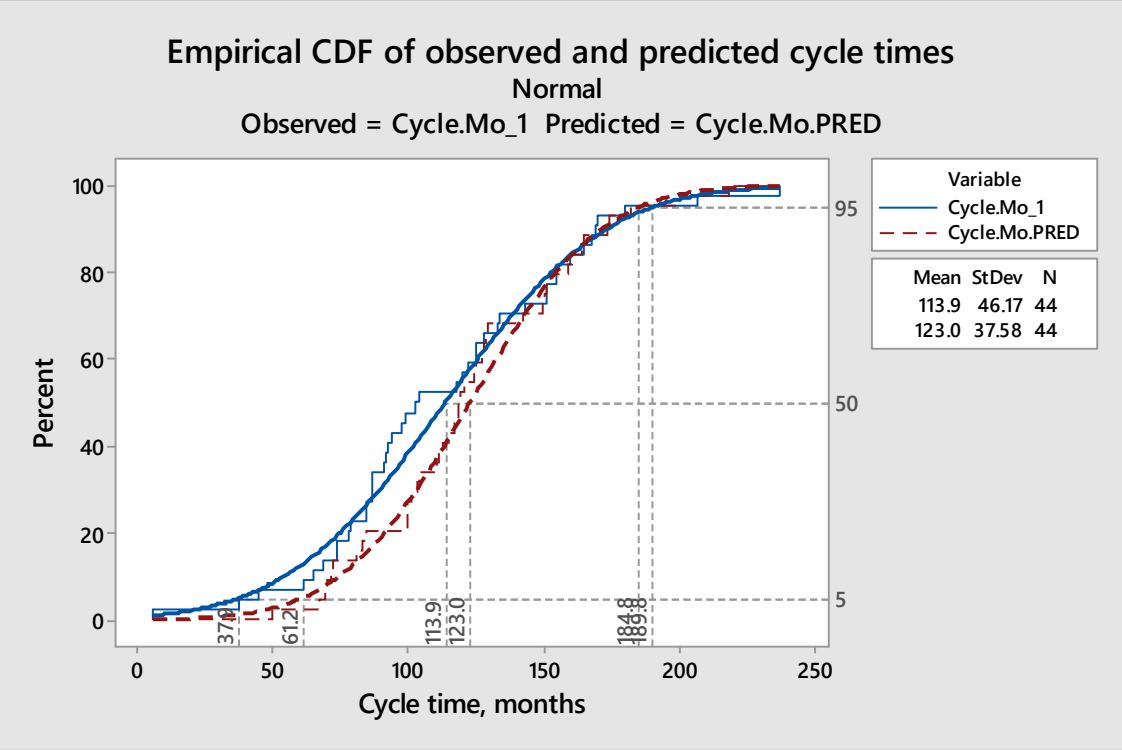
- PM.PCT = percent change in procurement budgets since program start;
- CTES = number of Critical Technology Elements identified by GAO reporting
- Fin_Uns = 0.1230 if budgets change by more than 10 percent, else 0;
- ACQ_P = 0.3184 if model 2, - 0.023 if model 4, 0.0110 if model 5, or 0.0429 if model 6;
- SVC = 0.0 if AF, - 0.0765 if Army - 0.0218 if DoD, 0.1741 if Navy;
- Restr = 0.1301 if restructured, else 0;
- INTEG = - 0.1007 if there are system integration issues found during testing, else 0; and
- NM = 0.1258 if MDAP has a Nunn-McCurdy breach, else 0.

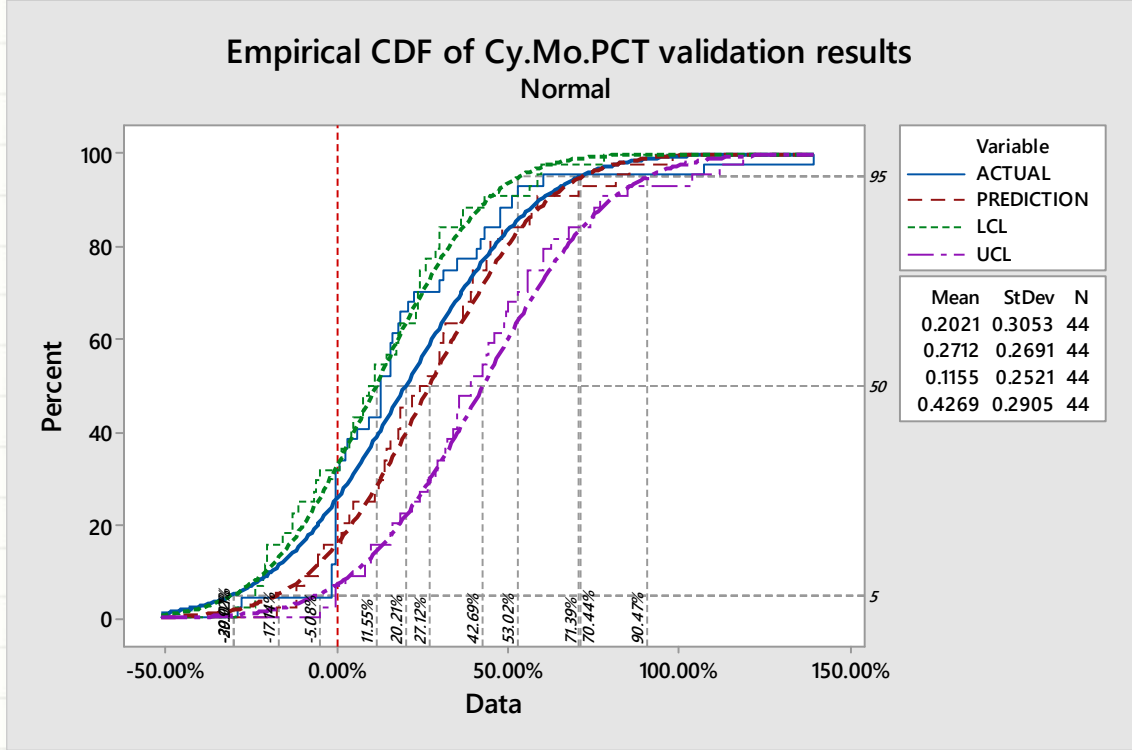
Research hypotheses supported

Models validated using withheld (44/162) samples

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)
30.8136	65.29%	62.74%	125493	57.91%

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)
0.233575	70.65%	66.99%	7.87371	59.28%





RMSE is 25.4 months

RMSE is 2.1 percent

Significant cycle time (Cycle.Mo) predictors – new capability

GAO assessed *neither* technology or design as mature (00)

Cycle.Mo = 92.6 + 0.001097*RD.M + 17.46*UC.M.PCT + 5.12*LN.UC.M + COML

Where

- *RD.M* is the MDAP research and development budget in millions;
- *UC.M.PCT* is the GAO-reported percent change in unit cost since program start (100% change= 1.0, and can be negative);
- *LN.UC.M* = the transformed GAO-reported unit cost in millions; and
- *COML* = **-24.43** if MDAP uses commercial technology to deliver capability; else 0

GAO assessed *both* technology or design as mature (11)

Cycle.Mo = 91.08 + 0.003143*RD.M **- 58.2*** P_no.PCT + Joint + PM.oth

Where

- *RD.M* = MDAP research and development budget in millions;
- *P_no.PCT* = percent change in procurement quantities since program start
- 100% change= 1.0, (this value can be negative)
- *Joint* = **-86.3** if MDAP is designated as Joint, else 0;
- *PM.oth* = **26.74** if MDAP has outside program office direction on program execution, else 0.

Model	Ref ()	S	R-sq	R-sq(adj)	R-sq(pred)
Trained	(1)	30.81	65.29%	62.74%	57.91%
00	(3)	33.30	58.98%	56.05%	52.46%
11	(4)	31.32	66.10%	66.76%	58.94%

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Factors change as systems mature

Significant factors:

- R&D Budget, ($ millions) (RD.M)
- GAO-reported % Δ in unit cost since program start (100% change= 1.0, and can be negative) (UC.M.PCT)
- GAO-reported unit cost LN ($ millions) (LN.UC.M)
- Uses Commercial technology (COML)
- *P*rocurement quantities % Δ since program start (P_no.PCT) 100% change= 1.0, (this value can be negative)
- Joint program (Joint)
- Reported external issues for PM (PM.oth)

GAO: Tech (KP1)and design (KP2) **NOT mature**	GAO: BOTH Tech (KP1)and design (KP2) **mature**
R&D budget (+0.001)	R&D budget (+0.003)
Unit cost (+5) Unit cost change (+17.5)	Procurement quantity % Δ (-58 for 100% change)
Commercial tech (-24)	Joint (-86)
	Other PM issues (+24)
R-sq(pred)~ 52%	*R-sq(pred)~ 59%*

Procurement quantity becomes more important than unit cost

Streamlining and tailoring

- Strategy formulation drives future options for reducing cycle time
  - How do you get a product into use faster?
- In execution, Streamlining or tailoring
  - Typically means reducing requirements
  - Shifting to something that works

- ***Most streamlining (program tailoring) actions occurred during program development***
- Statistically correlated with
  - Commercial technology
  - Prototyping
  - Interoperability
  - Restructuring

Examples of streamlining during execution

- Eliminating redundant systems engineering and program management support,
- Adopting commercial manufacturing processes,
- Shifting to incremental product delivery,
- Working with contractors to reduce overhead costs,
- Tailoring certification processes,
- Improvements via contractor-government teaming (capability sharing),
- Aligning specific system upgrades to incremental production delivery blocks