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# New Effort and Schedule Estimation Models for Agile Processes in the US DoD

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Dr. Raymond Madachy  
Naval Postgraduate School  
[rjmadach@nps.edu](mailto:rjmadach@nps.edu)

Wilson Rosa  
Department of Homeland Security  
[wilson.rosa@hq.dhs.gov](mailto:wilson.rosa@hq.dhs.gov)

Bradford K. Clark  
Software Metrics, Inc.  
[brad@software-metrics.com](mailto:brad@software-metrics.com)



# Overview

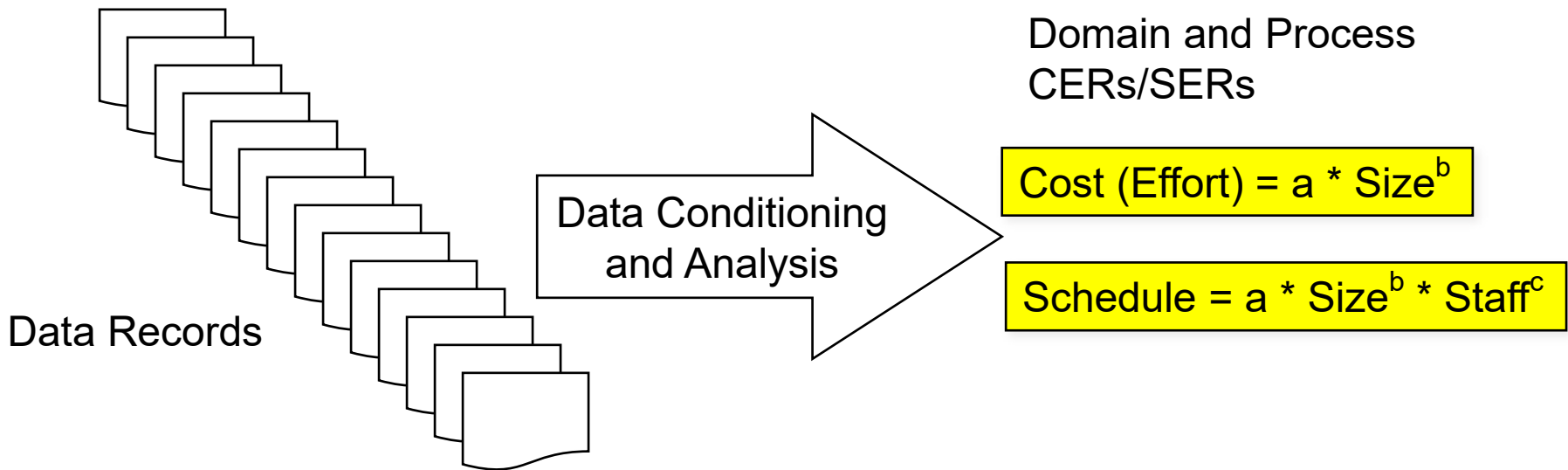
- Cost estimates for agile software projects are very critical at early stages to evaluate contract proposals and to establish initial program baseline budgets.
- The challenge is that common agile sizing measures such as story points, user stories or epics are not practical for early estimation as these are often reported after contract award in DoD.
- This study provides a set of parametric effort and schedule estimation models for agile projects using an early sizing measure based on data from recently completed agile projects in the DoD Cost Assessment Data Enterprise (CADE) repository [1].
- The results suggest that initial software requirements, defined as the sum of functions and external interfaces, is an effective sizing measure for early estimation of effort and schedule of agile projects. The models' accuracy improves when application domain groups and peak staff are added as inputs.

[1] W. Rosa, B. K. Clark, R. Madachy and B. Boehm, [Empirical Effort and Schedule Estimation Models for Agile Processes in the US DoD](#), in *IEEE Transactions on Software Engineering*, doi: 10.1109/TSE.2021.3080666, May 2021



# DoD Software Cost Research Objectives

- Goal is to make collected data useful to oversight and acquisition management
  - Segment data into different Application Domains, Operating Environments, and Software Processes
  - Analyze data for Cost Estimating Relationships (CER) and Schedule Estimating Relationships (SER)



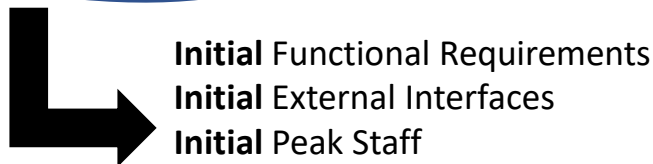
- Research questions relate to effectiveness of available cost model factors.



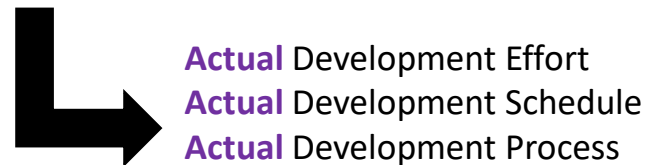
# DoD Acquisition Software Cost and Schedule Primary Data Collection Instrument

- ▶ The Software Resource Data Report (SRDR) is a standardized mechanism to collect objective and measurable data on programs
- ▶ Required for software development contracts over \$20M USD
- ▶ Includes fields for **agile processes and metrics reporting**

Submitted after contract start



Submitted after contract end

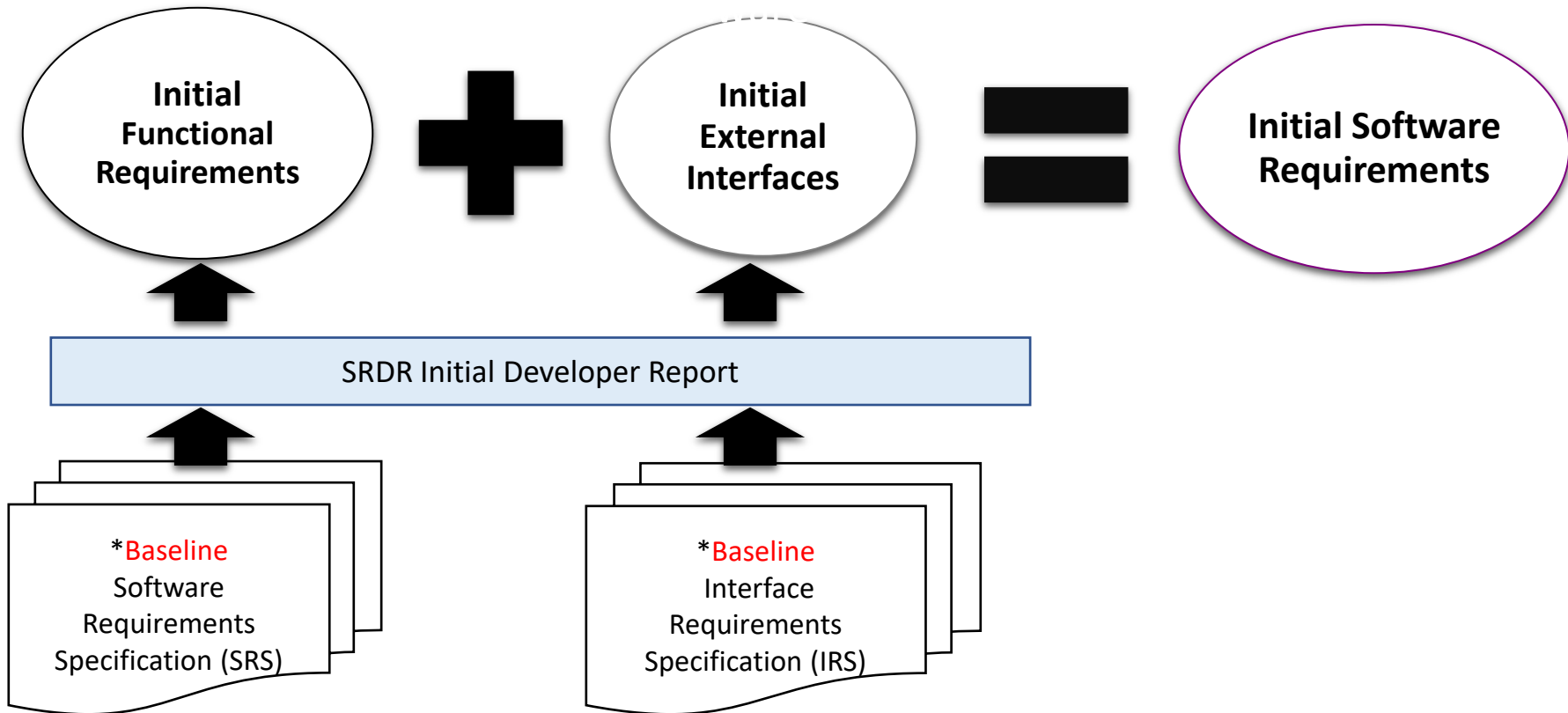


Questionnaire: [https://cade.osd.mil/Content/cade/files/cskr/guidance/DI-MGMT-82035A\\_SRDR%20Report.pdf](https://cade.osd.mil/Content/cade/files/cskr/guidance/DI-MGMT-82035A_SRDR%20Report.pdf)

Form: [https://cade.osd.mil/content/cade/files/cskr/dids/current/dd3026-1\\_2019.XLSX](https://cade.osd.mil/content/cade/files/cskr/dids/current/dd3026-1_2019.XLSX)



# Agile Software Sizing Measure



\* Baseline SRS and IRS are typically developed by the government before contract award  
Developers will report the initial functional and external interface requirements in the SRDR Initial Developer Report



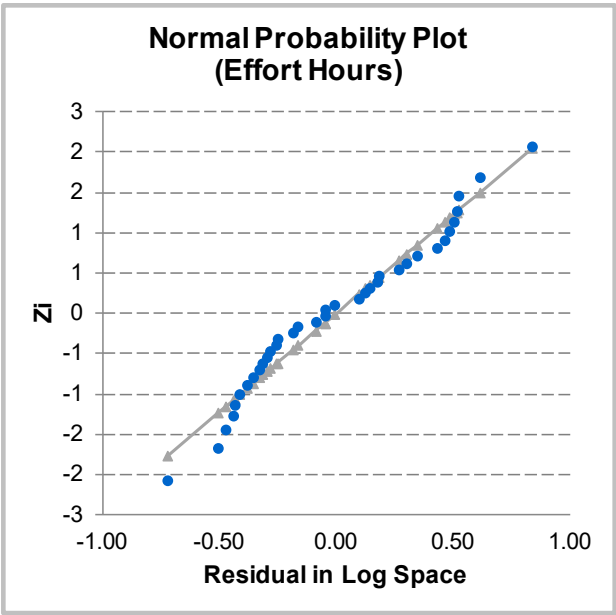
# Effort Model with Three Variables

Model	Equation Form	N	R <sup>2</sup>	R <sup>2</sup> (adj)	R <sup>2</sup> (pred)	MMRE
3	$E = 173 \times \text{REQ}^{0.539} \times \text{Staff}^{0.463} (2.3^{D1}) \times (3.7^{D2}) \times (3.9^{D3})$	36	89%	87%	84%	34%

E = Final Effort (in Hours) at contract completion  
 REQ = Initial Functional Requirements + Initial External Interfaces  
 Staff = Initial Peak Staff at contract start

- D1** = 1 if Automated Information System, 0 otherwise
- D2** = 1 if Engineering, 0 otherwise
- D3** = 1 if Real-Time Embedded, 0 otherwise

Term	T-Statistic	P-value	VIF
Intercept	12.7	0.0000	
REQ	8.6	0.0000	1.7
Staff	5.2	0.0000	1.8
<b>D1</b>	3.3	0.0025	2.6
<b>D2</b>	4.9	0.0000	2.7
<b>D3</b>	5.5	0.0000	2.9



- Effort Model shows the best fit and highest accuracy when all three variables are added
- Useful for assessing contract cost proposals



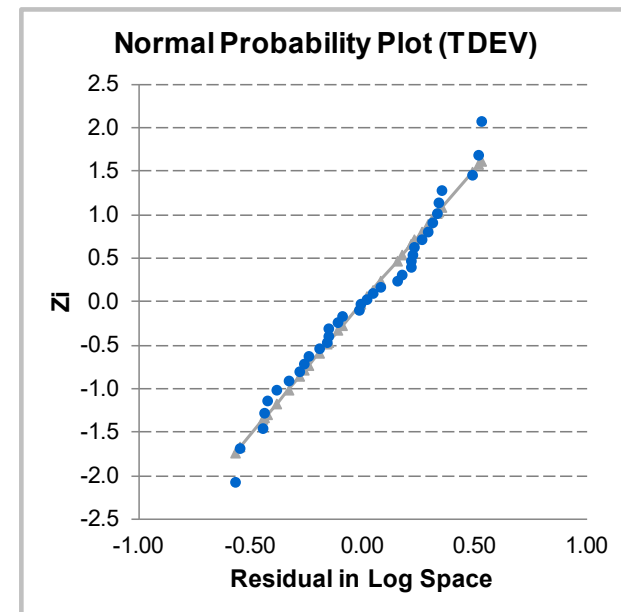
# Schedule Model with Three Variables

Model	Equation Form	N	R <sup>2</sup>	R <sup>2</sup> (adj)	R <sup>2</sup> (pred)	MMRE
2	$TDEV = 1.7 \times REQ^{0.34} \times Staff^{0.19} (2.3^{D1}) \times (3.0^{D2}) \times (4.5^{D3})$	36	75%	70%	63%	27%

TDEV = Final Schedule (in Months) at contract completion  
 REQ = Initial Functional Requirements + Initial External Interfaces  
 Staff = Initial Peak Staff at contract start

- D1** = 1 if Automated Information System, 0 otherwise
- D2** = 1 if Engineering, 0 otherwise
- D3** = 1 if Real-Time Embedded, 0 otherwise

Term	T-Statistic	P-value	VIF
Intercept	1.7	0.0986	
REQ	6.9	0.0000	1.7
Staff	-2.6	0.0135	1.8
<b>D1</b>	4.2	0.0002	2.6
<b>D2</b>	5.1	0.0000	2.7
<b>D3</b>	7.5	0.0000	2.9



- Schedule Model shows better fit and higher accuracy when all three variables are added
- Useful for assessing realism of cost proposals



# Example: Radar Display Manager

- Initial Requirements: 207 + External Interface Requirements: 23
- Total Requirements: 230
- Estimated Peak Staffing: 16
- Real-Time Embedded (RTE) super domain
  
- Effort Model (3):  
 $Effort\ Hours = 173.2 \times REQ^{0.539} \times Staff^{0.463} \times 2.3^{D1} \times 3.7^{D2} \times 3.9^{D3}$ 
  - D3 represents the RTE super domain and its value will be 1 (one)
  - D1 (AIS) and D2 (ENG) will be 0 (zero)
- Estimated Effort Hours = 45,595
- Schedule Model (6):  
 $TDEV = 1.74 \times REQ^{0.345} \times Staff^{-0.189} \times 2.3^{D1} \times 3.0^{D2} \times 4.5^{D3}$ 
  - D3 represents the RTE super domain, its value will be 1 (one)
  - D1 and D2 will be 0 (zero) resulting in the 2.3 and 3.0 values not being used
- Estimated TDEV = 30 months
- Development will take 45,595 person hours and 30 months to complete
  - An average of 1,520 hours per month





# Online Tool

- Web-based tool implementation under development at [http://softwarecost.org/tools/DoD\\_agile/](http://softwarecost.org/tools/DoD_agile/)

### DoD Agile Software Process Cost and Schedule Estimation

This tool estimates cost for DoD agile software processes from Equation 2 in Reference [1].

Requirements:

Superdomain:  AIS  Real-Time

**Results**  
Effort = 53056 Person-Hours

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**Reference**  
[1] W. Rosa, B. K. Clark, R. Madachy and B. Boehm, *Empirical Effort and Schedule Estimation Models for Agile Processes in the US DoD*, in IEEE Transactions on Software Engineering, doi: 10.1109/TSE.2021.3080666.

Tool created by Ray Madachy at the Naval Postgraduate School. For more information contact him at [rjmadach@nps.edu](mailto:rjmadach@nps.edu).



# Conclusions

- The results indicate that initial software requirements, defined as the sum of functional plus external interface requirements, ***as opposed to final***, is an effective sizing measure for early estimation of effort and schedule of DoD agile projects.
- The models' accuracy improves when application domain groups and peak staff are added as inputs.
- These models can be used for building independent government cost estimates to crosscheck request for proposals.
- DoD contractors should consider adding peak staff along with initial software requirements (as defined in this study) and super domain as inputs when building effort and schedule models for their agile project cost proposal.