

DEVELOPING METHODS FOR ENGINEERING PROCESS METRICS CAPTURE AND ANALYSIS

“You can’t improve it if you don’t measure it”

NPS Acquisition Research Symposium, May 11 2022

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- **Problem: There is a deficit of data on the detailed execution of design acquisition processes**
 - Deep gathering of process metrics for large scale design efforts is not being done today
- Processes must be measured and analyzed in order to improve
- Digital engineering initiatives provides significant opportunities to gather and analyze acquisition process data
- Methods must be developed to mine data from the suite of digital engineering and manufacturing tools
- The engineering acquisition process should be instrumented, to capture data at sufficient granularity to provide actionable information
- Roadblocks:
 - Proprietary Nature of Data
 - Difficulties in data capture and categorization
 - Lack of emphasis by funding community

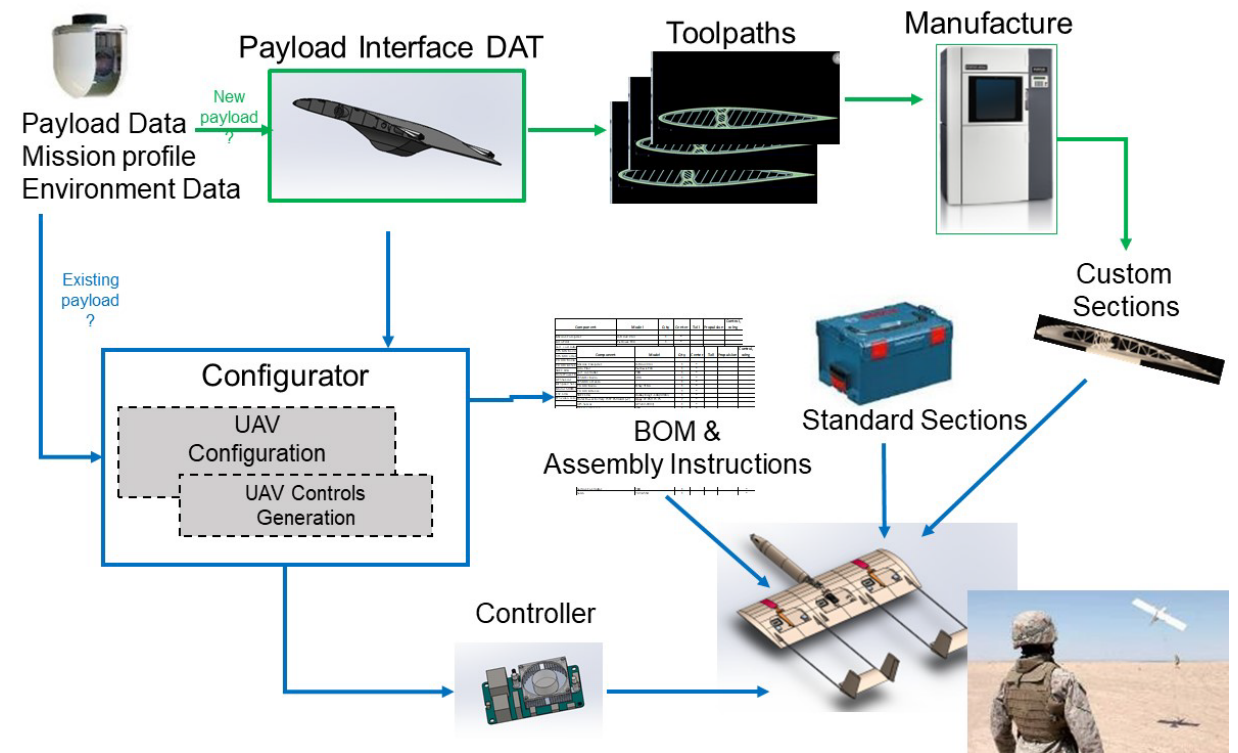
- ARL is a DOD designated University Affiliated Research Center (UARC)
- Conduct research, development, and systems engineering free from conflict of interest with industry
 - 100's of engineering design and development programs, varying in levels of complexity (i.e. UUVs, UAVs, Undersea weapons, Barge systems, Fuel Distribution systems etc)
 - Broad set of DE tools (requirements management databases, MBSE, CAD, engineering programming tools, product data and lifecycle management systems, and software management tools)
 - Core research in Systems Engineering (SE) and design methods for 20+ years
- UARC status provides a great opportunity develop data capture and analysis methods that can provide relevant information without revealing proprietary data

Data Capture Example: UAVs

- ARL instrumented the design, development and test efforts of a 3D printed UAV on 2 full product cycles
- Project Objective: mission definition to operations in weeks

- Data Tracked and Analyzed

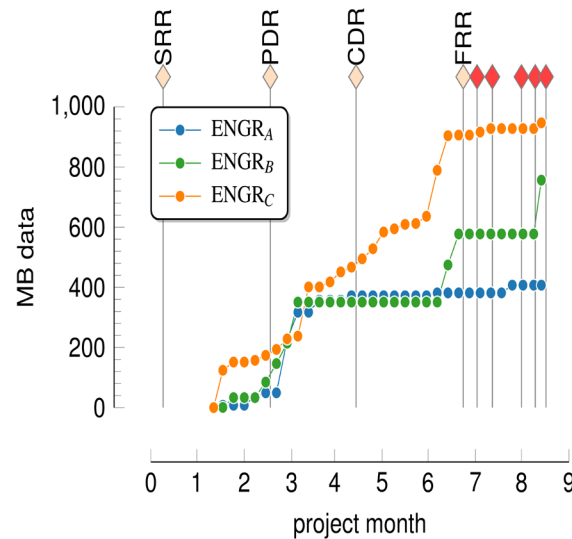
- Engineering hours per skill set
- Design and Test milestones
- Build and Material Cost
- Digital Footprint history



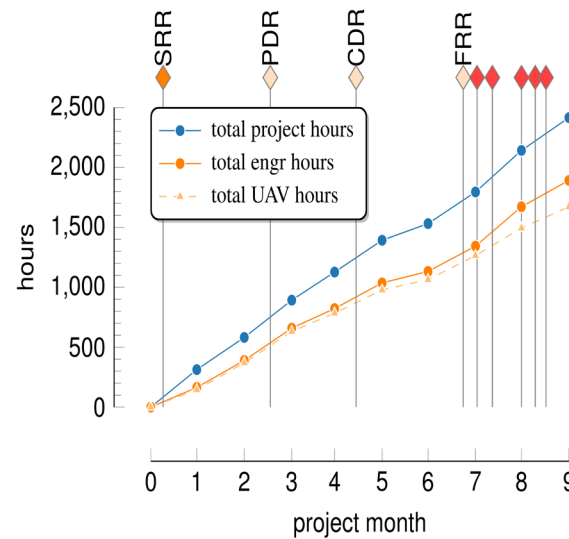
Data Capture Example: UAVs

• Results

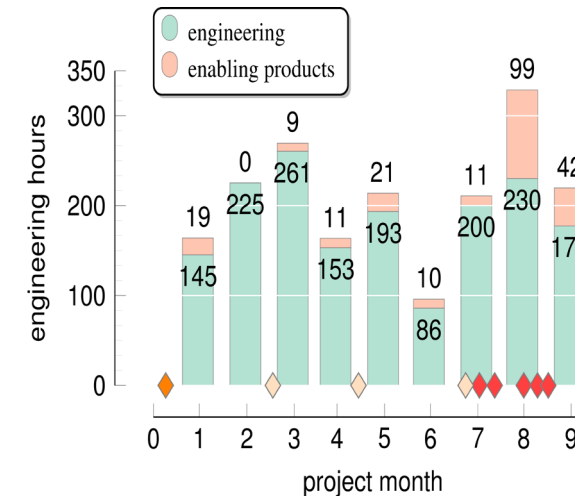
- Developed relationships between team performance and design iterations
- Identified influence on rapid prototyping methods on overall schedule
- Gained insight into process for data mining design and build process systems



(a) cumulative digital data generated by engineers (summed weekly)



(b) project and tasking hours accumulated per month



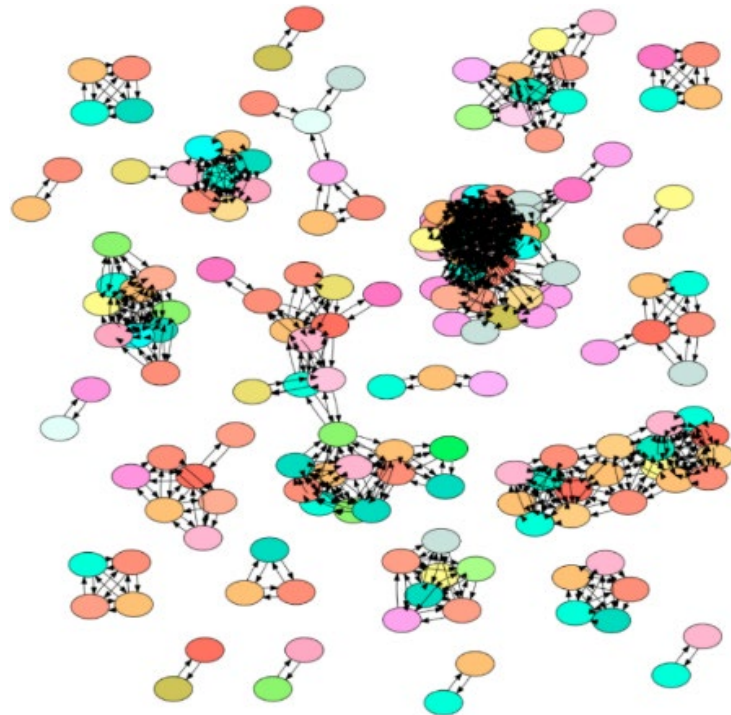
(c) engineering and enabling technology hours at the start of each month

Data Capture Example : Ship Systems

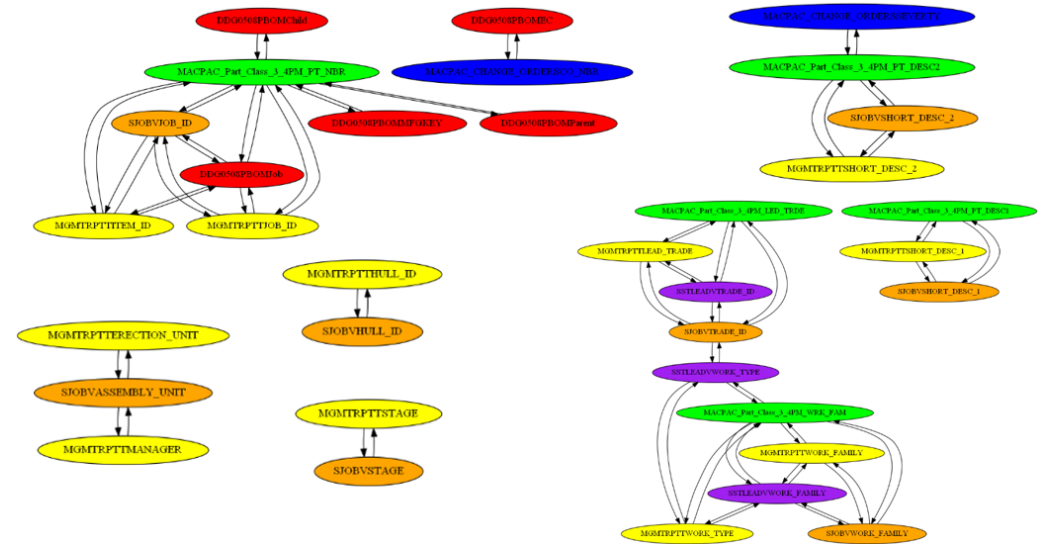
- Research Effort: Data capture and analytics in the shipbuilding industry through the Institute for Manufacturing and Sustainment Technologies (IMAST)
- Focused on Production Bill of Material (PBOM) data from a major shipbuilder
- Created a configurable web-based AI software application to enable rapid, robust and accurate error discovery
- Data mining and mapping efforts were challenging
 - Data represented among many tables in a database
 - Investigating more than one table in isolation that required valid connections between the tables to be mapped
 - data in the database is highly connected, but not all of the connections are useful

Data Capture Example : Ship Systems

- Results:
 - Implementation of the PBOM Quality Assurance (PQA) software with embedded AI/ML that achieved a 90% detection rate of complex errors
 - Gained insight into process for data mining design and build process systems
 - Developed automated database mapping software that can be used across domains



Original data Connections



Data Connection Map with advanced mapping algorithms



- Reducing defense acquisition cycle times has been a cornerstone goal of DOD initiatives
- A crucial part of implementation success is showing improvement (reduced cost or schedules) from previous practice

“You can’t improve it if you don’t measure it”

- New research projects are necessary to support acquisition process instrumentation and improvement
 - Automated data collection methods across complex data repositories
 - Data analysis to identify statistical relationships and patterns (where can we improve?)
 - Provide methods and data analysis results to acquisition professionals and others
 - Begin efforts with dedicated researchers (UARCs, FDRC, DOD Labs) and then transition to industry and DOD acquisition programs
- Discover areas for acquisition improvements based on analysis of data on current and historical programs