Technomics
Better Decisions Faster

Maintenance & Repair Reporting: Better Data and Advanced Analytics

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Authors

Paul Hardin

Paul Hardin is a Subject Matter Expert at Technomics with principal experience in methodology design and model development, including application of non-linear optimization techniques. He has over 25 years' experience leading independent cost estimates, conducting cost research initiatives and developing innovative cost estimating methods and visual data analysis tools.

Alex LoRusso

Alex LoRusso is an Associate at Technomics and graduate from Penn State University, where he studied Industrial Engineering. Since last July he has been working at Technomics in Arlington, Virginia in data analytics and supporting the development of estimates for naval programs. He hopes to grow his involvement in the cost estimating community through future efforts as an ICEAA member.

Tyler Staffin

Tyler Staffin is a Senior Associate at Technomics and Data Analytics graduate student. Since his graduation from Penn State University in 2018 (Mathematics), he has been working at Technomics in Arlington, Virginia in data analytics and cost estimating. He was introduced to the Cost community through EVM and data management, and has been involved in multiple ICEAA-related research efforts over the past two years.

Agenda

- Introduction
- M/R Reporting
- M/R Study Results
- Introduction to R
- What is Shiny?
- Dashboard Requirements
- Dataset Explanation
- M/R Dashboard Walkthrough
- Concluding Thoughts

Introduction

- Over the past few years, the Office of the Secretary of Defense (OSD) Cost Assessment and Program Evaluation (CAPE) has developed **additional data reporting requirements** to improve collection of sustainment cost data and related technical data from contractors with the intent of improved cost estimating capability
- One of these areas of improvement includes the **1921-M/R (Maintenance and Repair Parts) Report**
- Collection of M/R data for MDAPs is critical to improving cost management, cost reduction initiative investment and outcomes, and cost estimates of future programs
- In 2019, a Lessons-Learned Study (Army Shadow UAV Program) was performed to review (i.e., verify and validate) the actual data, identify and correct any data issues, and use data analytics to confirm the value of the reported data
- Various approaches were considered and led to the development of a dashboard prototype using **R Shiny**

M/R Reporting

- The -M/R is the Department of Defense (DoD) system for collecting actual maintenance event and repair part data as part of the Cost, Software, and Data Reporting (CSDR) System
- Total sustainment phase cost can represent **two-thirds or more** of the total life-cycle cost of a major defense acquisition program (MDAP)
- The -M/R provides critical information to program managers, systems engineers, and cost estimators to:
  - Review and evaluate maintenance event, LRU/DLR/repair part cost and failure data
  - Identify demand and cost drivers
  - Understand reasons for incurred cost and availability performance
  - Develop improved cost estimating techniques

M/R Reporting (cont.)

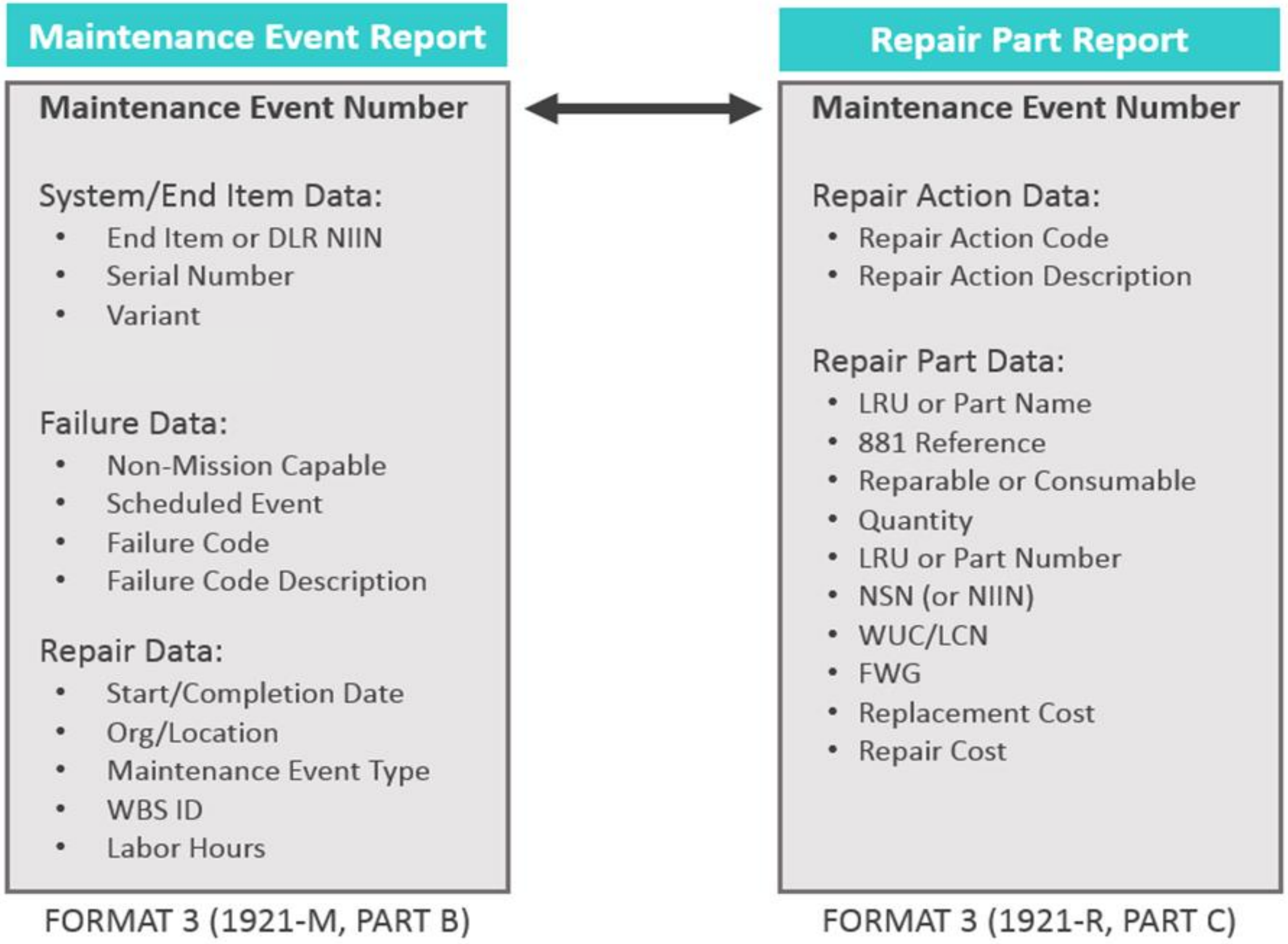
The -M/R consists of two separate reports:

Maintenance Event Report

- Collects information such as the specific system being repaired, location where the repair activity occurred, reason for failure, day failure was identified, and day repair activity was completed.

Repair Part Report

- Identifies LRUs, DLRs and/or repair parts associated with each maintenance event.



Maintenance Event Report

Maintenance Event Number

System/End Item Data:
- End Item or DLR NIIN
- Serial Number
- Variant

Failure Data:
- Non-Mission Capable
- Scheduled Event
- Failure Code
- Failure Code Description

Repair Data:
- Start/Completion Date
- Org/Location
- Maintenance Event Type
- WBS ID
- Labor Hours

FORMAT 3 (1921-M, PART B)

Repair Part Report

Maintenance Event Number

Repair Action Data:
- Repair Action Code
- Repair Action Description

Repair Part Data:
- LRU or Part Name
- 881 Reference
- Reparable or Consumable
- Quantity
- LRU or Part Number
- NSN (or NIIN)
- WUC/LCN
- FWG
- Replacement Cost
- Repair Cost

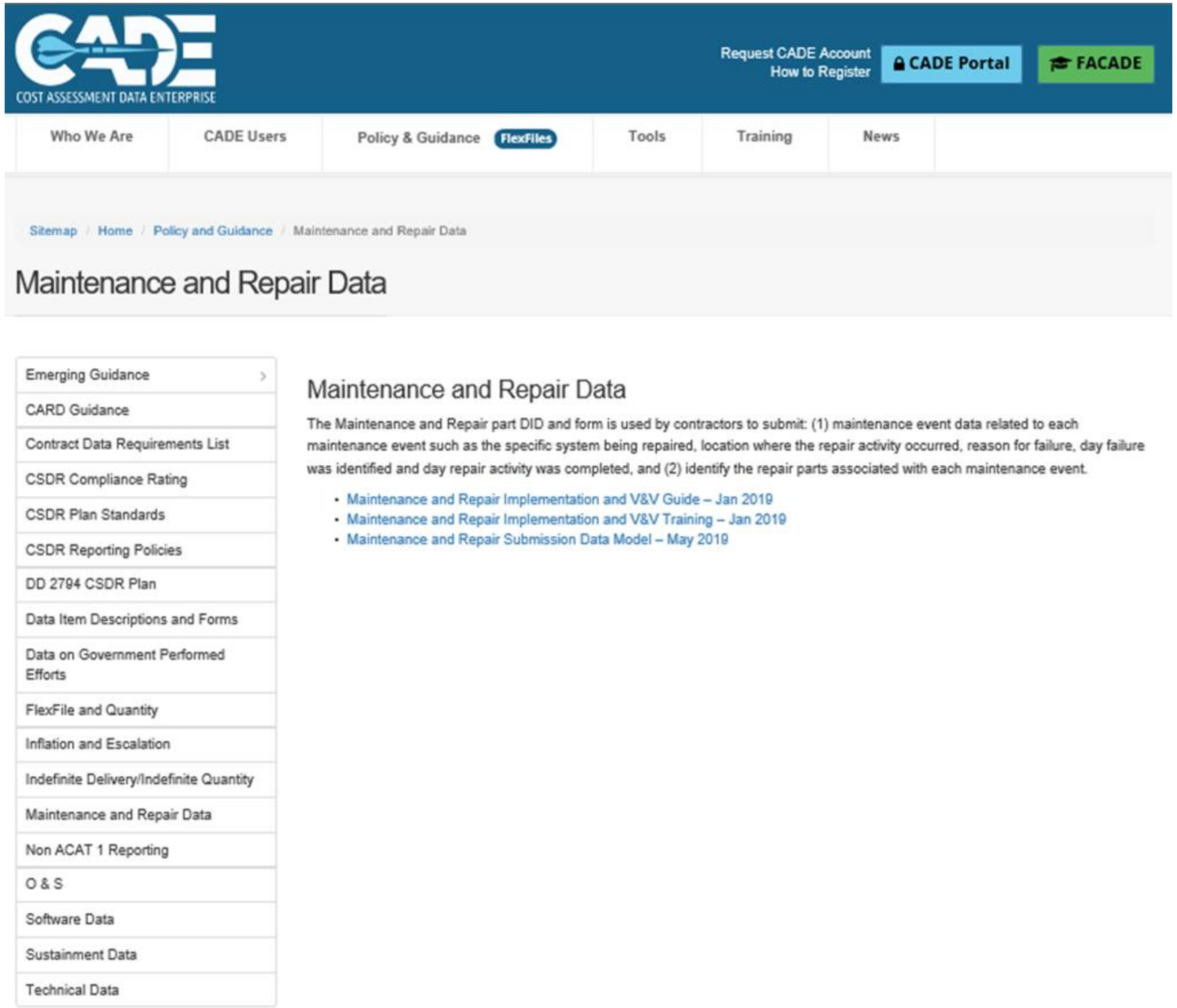
FORMAT 3 (1921-R, PART C)

M/R Study Results

- The **2019 MR Lessons-Learned Study** (Army Shadow UAV) was conducted to both validate and assess the value of actual reported data
- The study resulted in a number of **recommendations** for improving aspects of the data and the application of data analytics
- Value of M/R Data
  - Assess and better understand top drivers by cost or demand
  - Identify top reasons for failure (i.e., failure codes) for key Repair Parts
  - Determine trends in data to improve cost estimates and decision-making
  - Identify changes in cost and demand over time to determine problem areas and develop potential improvements and solutions
  - Capture critical maintenance management metrics such as:
    - Scheduled versus Unscheduled Activity
    - Hours per different maintenance event types
    - Days associated with events and/or repair parts
    - Current Replacement Cost of Repair Parts
    - Repair versus Replace Cost Ratios and Activity
    - Comparison of components to predicted reliabilities
    - Failures occurring faster than, or not as quickly as expected

M/R Study Results

- For more information visit OSD CADE: https://cade.osd.mil/policy/maintandrepair


CADE
COST ASSESSMENT DATA ENTERPRISE
Request CADE Account
How to Register
CADE Portal
FACADE
Who We Are
CADE Users
Policy & Guidance
FlexFiles
Tools
Training
News
Sitemap / Home / Policy and Guidance / Maintenance and Repair Data
Emerging Guidance
CARD Guidance
Contract Data Requirements List
CSDR Compliance Rating
CSDR Plan Standards
CSDR Reporting Policies
DD 2794 CSDR Plan
Data Item Descriptions and Forms
Data on Government Performed Efforts
FlexFile and Quantity
Inflation and Escalation
Indefinite Delivery/Indefinite Quantity
Maintenance and Repair Data
Non ACAT 1 Reporting
O & S
Software Data
Sustainment Data
Technical Data

Maintenance and Repair Data

Maintenance and Repair Data

The Maintenance and Repair part DID and form is used by contractors to submit: (1) maintenance event data related to each maintenance event such as the specific system being repaired, location where the repair activity occurred, reason for failure, day failure was identified and day repair activity was completed, and (2) identify the repair parts associated with each maintenance event.

- Maintenance and Repair Implementation and V&V Guide – Jan 2019
- Maintenance and Repair Implementation and V&V Training – Jan 2019
- Maintenance and Repair Submission Data Model – May 2019

Introduction to R

- When working and analyzing large quantities of data, R is a highly suitable option
- R is a free, functionally-oriented language and integrated platform developed for **statistical computing**, **data manipulation**, and **advanced graphical display**[1]
- The R platform consists of a variety of specialized packages with a nearly unlimited supply of documentation/examples online
- The RStudio Integrated Development Environment (IDE) is a software application that simplifies working with the language
- In addition to creating the IDE, RStudio also develops a number of well-maintained packages, including `shiny` and the `tidyverse` package family

[1] https://www.r-project.org/about.html

Image: https://rstudio.com/

“Shiny allows you to take your work in R and expose it via a web browser so that **anyone can use it**. Shiny makes you look awesome by making it **easy** to produce polished **web apps** with a minimum amount of pain[2].”

– Hadley Wickham, Chief Scientist at RStudio

[2] http://www.mastering-shiny.org

What is Shiny?

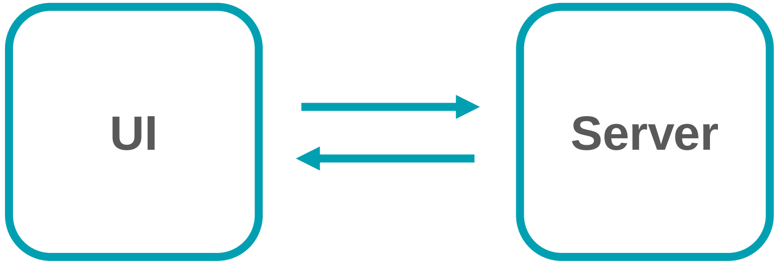
- Built by RStudio, the `shiny` package provides an **easy** way to build dynamic, **interactive dashboards** in R
- Shiny applications are "directories containing a user-interface definition, a server script, and any additional data, scripts, or other resources required to support the application[3]."
- The package enables users to construct dashboards **without** requiring knowledge of full-stack web development
- Shiny dashboards are **fully customizable**, and provide users with deeper insight into their data with a **simple interface**
- Each dashboard consists of two main components: **User Interface (UI)** and **Server**

[3] https://rstudio.github.io/shiny/tutorial

What is Shiny? (cont.)

User Interface (UI)

- The portion of code where user-facing controls are established
- May consist of inputs (i.e. drop-down lists, buttons, sliders, fields, etc.), panels, sidebars, and other visual components
- Most of what is seen on the screen is controlled by the defined structure of the UI.



Server

- The part of the application that enables R to accept given user input and generate a conditional response or output
- This can include generating plots, updating drop-down lists, exporting files, running scripts, connecting to databases, and much more
- Anything that can be performed in R can be executed on the server-side

Dashboard Requirements

1. Navigate from high-level to low-level information
2. Visuals should have near-limitless customization
3. Visuals render dynamically and show varying levels of detail based on user inputs
4. User input functions are easy to use
5. All visuals must be interactive
6. Dashboard must be dynamic without sacrificing speed

Dataset Explanation

Variant

FWG

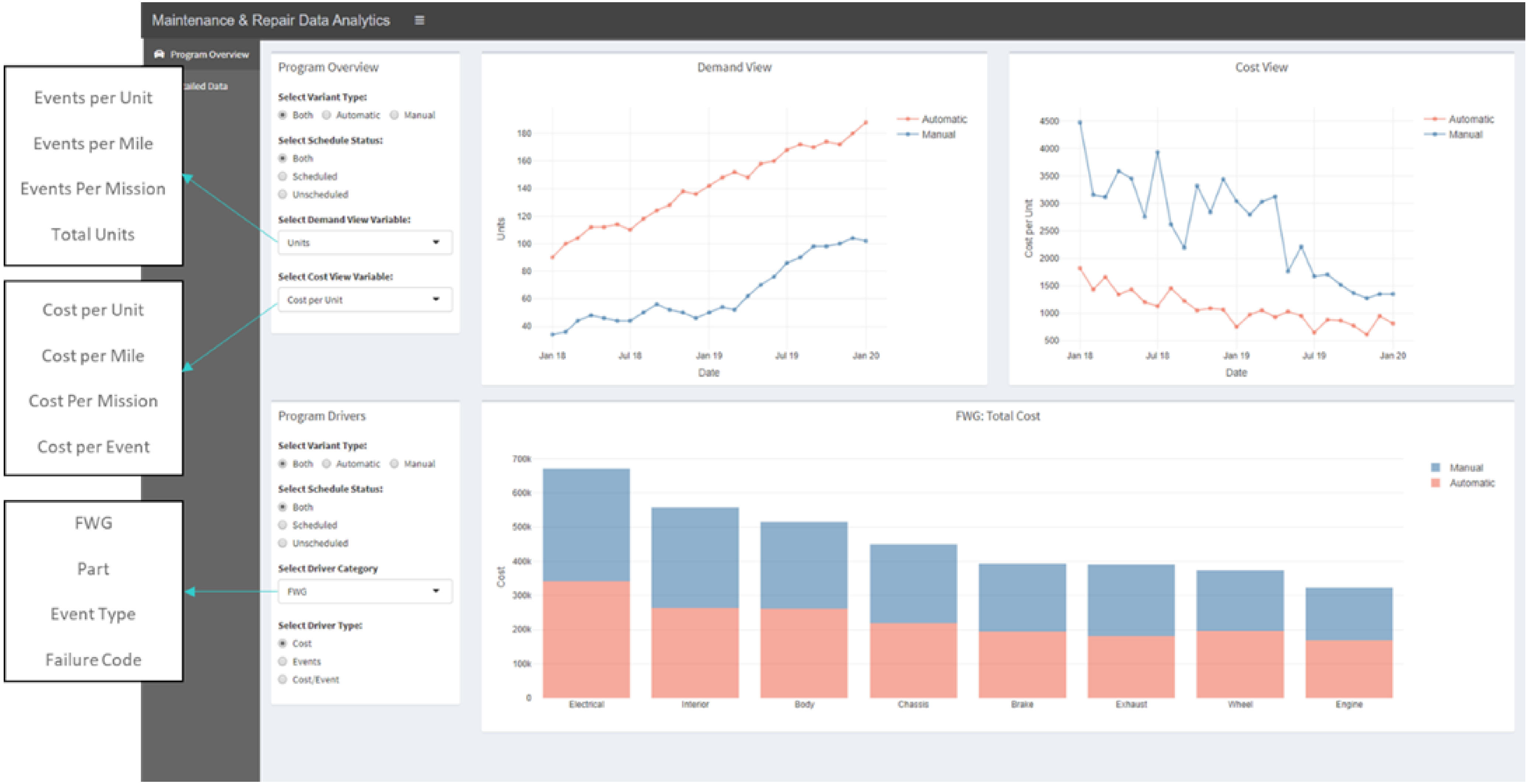
Part Name

Event Type

Failure Code

Schedule Status

M/R Dashboard Walkthrough – Part I



Events per Unit

Events per Mile

Events Per Mission

Total Units

Cost per Unit

Cost per Mile

Cost Per Mission

Cost per Event

FWG

Part

Event Type

Failure Code

Maintenance & Repair Data Analytics

Program Overview

Select Variant Type: ● Both ○ Automatic ○ Manual

Select Schedule Status: ● Both ○ Scheduled ○ Unscheduled

Select Demand View Variable: Units

Select Cost View Variable: Cost per Unit

Program Drivers

Select Variant Type: ● Both ○ Automatic ○ Manual

Select Schedule Status: ● Both ○ Scheduled ○ Unscheduled

Select Driver Category: FWG

Select Driver Type: ● Cost ○ Events ○ Cost/Event

≡
Program Overview
ailed Data
Demand View
Units
40
60
80
100
120
140
160
180
Jan 18
Jul 18
Jan 19
Jul 19
Jan 20
Date
Automatic
Manual
Cost View
Cost per Unit
500
1000
1500
2000
2500
3000
3500
4000
4500
Jan 18
Jul 18
Jan 19
Jul 19
Jan 20
Date
Automatic
Manual
FWG: Total Cost
Cost
0
100k
200k
300k
400k
500k
600k
700k
Electrical
Interior
Body
Chassis
Brake
Exhaust
Wheel
Engine
Manual
Automatic

M/R Dashboard Walkthrough – Part II

FWG

Part

Event Type

Failure Code

Events

Unscheduled %

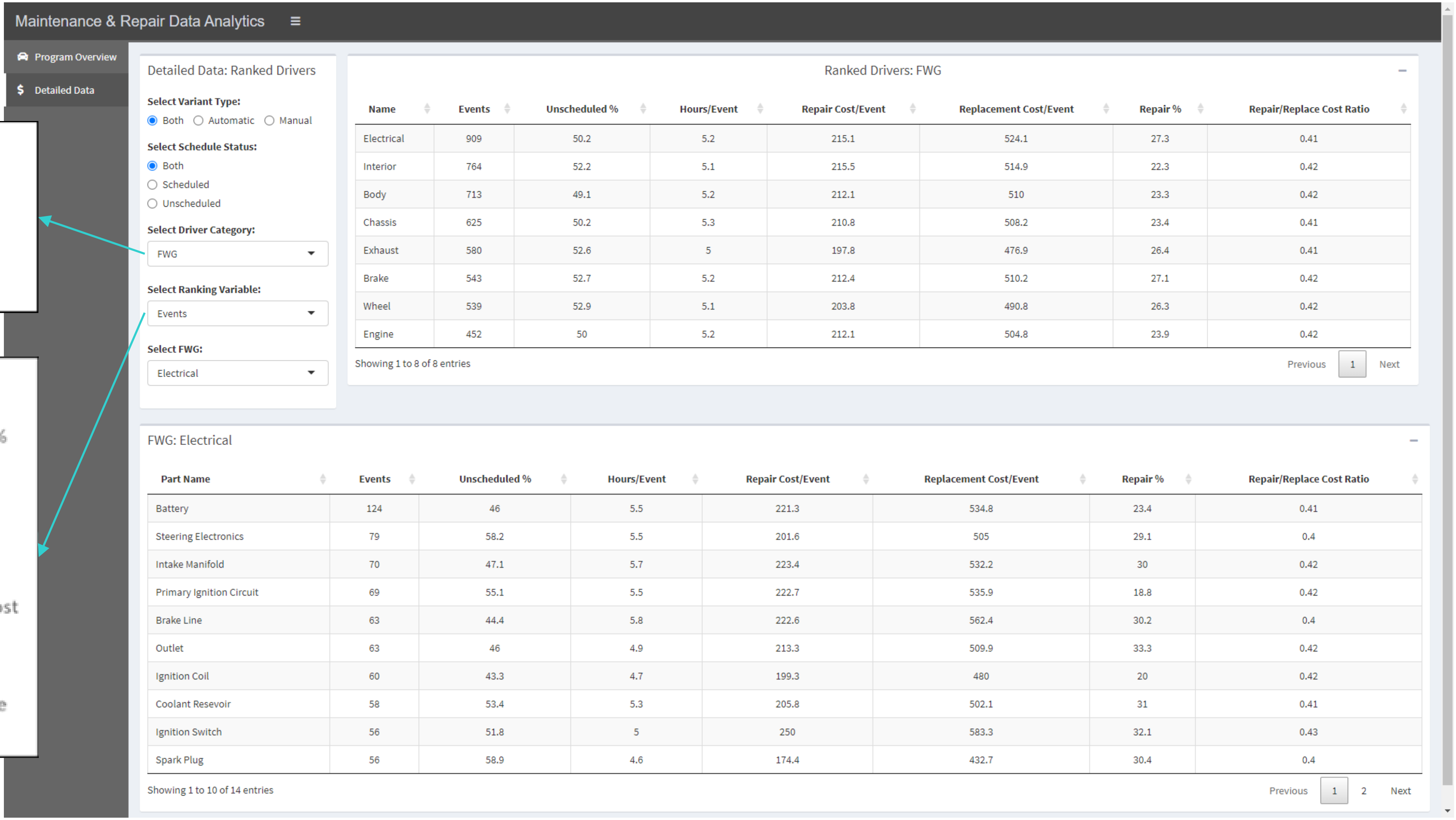
Hours/Event

Mean Repair Cost/Event

Replacement Cost

Repair %

Repair/Replace Cost Ratio



Detailed Data: Ranked Drivers

Select Variant Type:
● Both ○ Automatic ○ Manual

Select Schedule Status:
● Both
○ Scheduled
○ Unscheduled

Select Driver Category: FWG

Select Ranking Variable: Events

Select FWG: Electrical

Ranked Drivers: FWG

Name	Events	Unscheduled %	Hours/Event	Repair Cost/Event	Replacement Cost/Event	Repair %	Repair/Replace Cost Ratio
Electrical	909	50.2	5.2	215.1	524.1	27.3	0.41
Interior	764	52.2	5.1	215.5	514.9	22.3	0.42
Body	713	49.1	5.2	212.1	510	23.3	0.42
Chassis	625	50.2	5.3	210.8	508.2	23.4	0.41
Exhaust	580	52.6	5	197.8	476.9	26.4	0.41
Brake	543	52.7	5.2	212.4	510.2	27.1	0.42
Wheel	539	52.9	5.1	203.8	490.8	26.3	0.42
Engine	452	50	5.2	212.1	504.8	23.9	0.42

Showing 1 to 8 of 8 entries

Previous 1 Next

FWG: Electrical

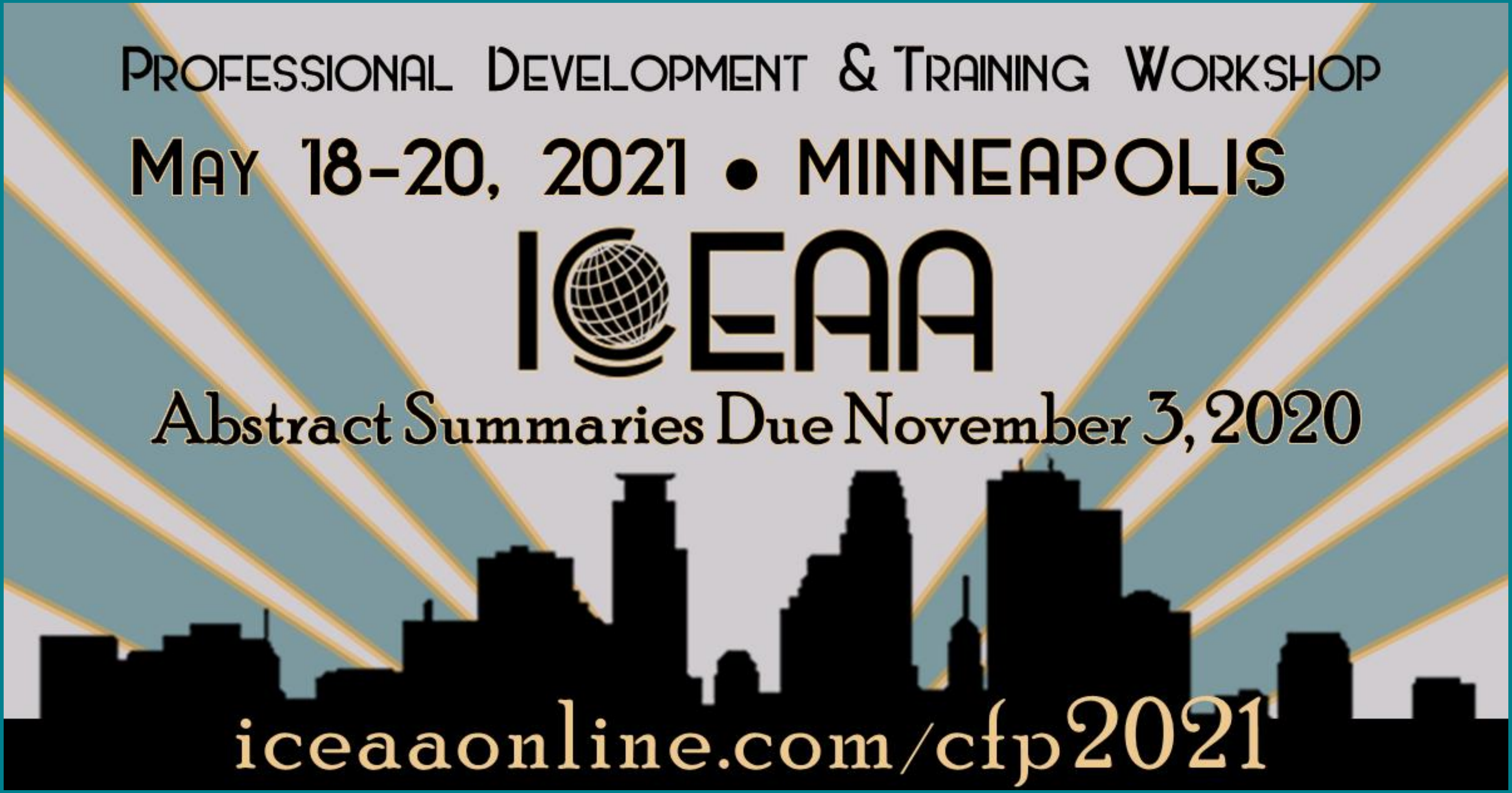
Part Name	Events	Unscheduled %	Hours/Event	Repair Cost/Event	Replacement Cost/Event	Repair %	Repair/Replace Cost Ratio
Battery	124	46	5.5	221.3	534.8	23.4	0.41
Steering Electronics	79	58.2	5.5	201.6	505	29.1	0.4
Intake Manifold	70	47.1	5.7	223.4	532.2	30	0.42
Primary Ignition Circuit	69	55.1	5.5	222.7	535.9	18.8	0.42
Brake Line	63	44.4	5.8	222.6	562.4	30.2	0.4
Outlet	63	46	4.9	213.3	509.9	33.3	0.42
Ignition Coil	60	43.3	4.7	199.3	480	20	0.42
Coolant Resevoir	58	53.4	5.3	205.8	502.1	31	0.41
Ignition Switch	56	51.8	5	250	583.3	32.1	0.43
Spark Plug	56	58.9	4.6	174.4	432.7	30.4	0.4

Showing 1 to 10 of 14 entries

Previous 1 2 Next

Concluding Thoughts

- **Collection** of M/R data is **vital** to improving cost management, cost reduction initiative investment and outcomes, and cost estimates of future programs
- **Understanding** maintenance-related cost drivers well enough to pose the ‘right’ questions is **critical** to estimating, managing, and reducing costs
- Using latest technology to develop improved data analytics environments enable program managers, systems engineers, cost estimators, and managers to **effectively exploit** and **analyze** M/R data or any data
    - And provides a more efficient way to V&V data
- Collecting contractor maintenance and repair-related data and advancing data analytics capabilities are **essential** for improving our cost community capability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Questions?

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