

# Modeling Battery Manufacturing Complexity

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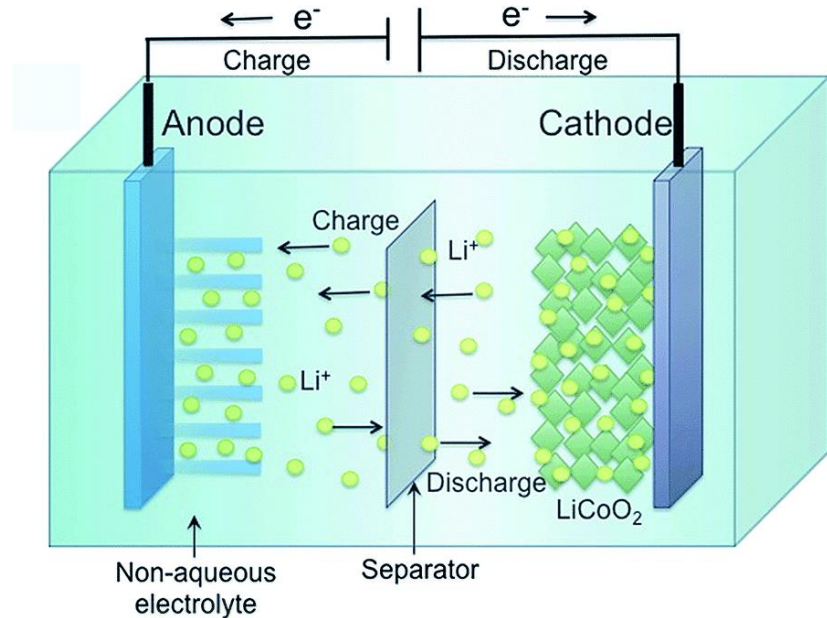


# Agenda

- Introduction
- Data Methodology
- Analysis & Results
- Summary of Findings
- Limitations & Future Research

# Introduction

- Interest and questions from agencies
- Purpose
- Basics of Battery
- Technologies
  - Conventional
  - Advanced





# Data Methodology (1 of 4)

- Data Sources: Battery characteristics and unit prices
  - Defense Logistics System
    - Over 15 million active and historical National Item Identification Numbers (NIIN) and Navy Item Control Numbers (NICN) and more than 100 million parts in the Federal Supply Catalog.
  - Defense Logistics Agency Internet Bid Board System
    - Search and view Request For Proposals (RFPs), Invitations For Bid (IFBs), Awards and other procurement information
  - Manufacturers' websites
    - Battery technical specifications
    - Product features and benefits
  - Government solicitations



# Data Methodology (2 of 4)

## ■ Input Data & Calibrate

- Weight of batteries
- Primary Op spec
- Dates based on contract
- Learning rates are based on power trend line to find the slope of quantity discount
- Calibrate Manufacturing Complexity for Structure (MCPLXS) to unit prices (Target Value)

The screenshot displays a software interface for cost item selection and calibration. It is divided into three main sections: 'Cost Item', 'Output Cost Selection', and 'Constraints'.

- Cost Item:** A dropdown menu is open, showing a list of cost items. The selected item is 'Manufacturing Complexity for Structure'. To the right, the 'Current Value' is displayed as 4.512067.
- Output Cost Selection:** A dropdown menu shows 'Saft 17677-000 (Ni-Cd)' as the selected 'Cost Object'. Below it, another dropdown menu for 'Cost Item' is open, with 'Estimated Cost' selected. To the right, the 'Current Value' is 6,881 and the 'Target Value' is 6,862.
- Constraints:** Two input fields are visible: 'Tolerance (%)' set to 0.500 and 'Maximum Iterations' set to 30.

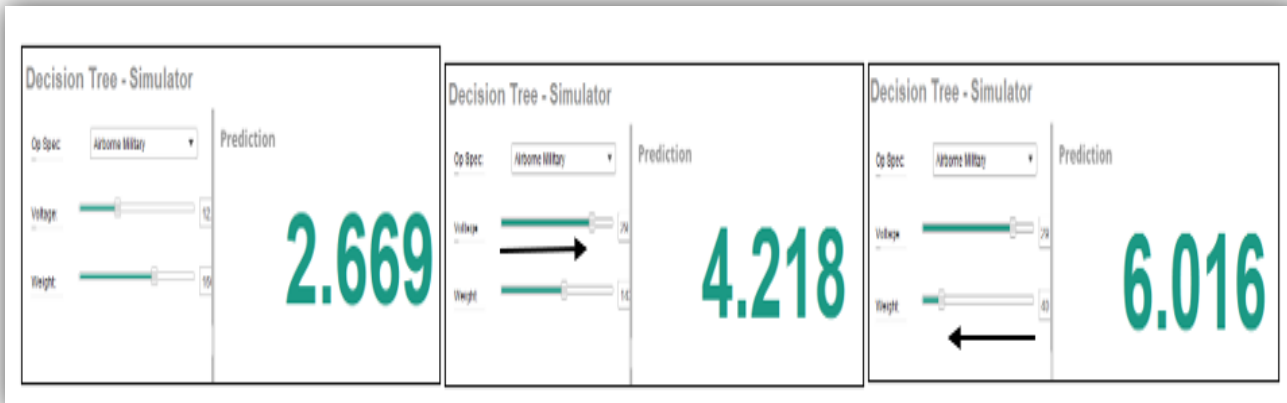


## Data Methodology (3 of 4)

- Included the following attributes to look at dependencies for MCPLXS:
  - Voltage
  - Weight
  - Capacity
  - Battery types (categorized by chemistry)
  - Rechargeable or non-rechargeable
  - Manufacturer

# Data Methodology (4 of 4)

- Ran multiple simulations in RapidMiner
  - Preferred model: Decision Tree based on relative error
  - Voltage increases = MCPLXS increases
  - Weight decreases = MCPLXS increases





# Analysis

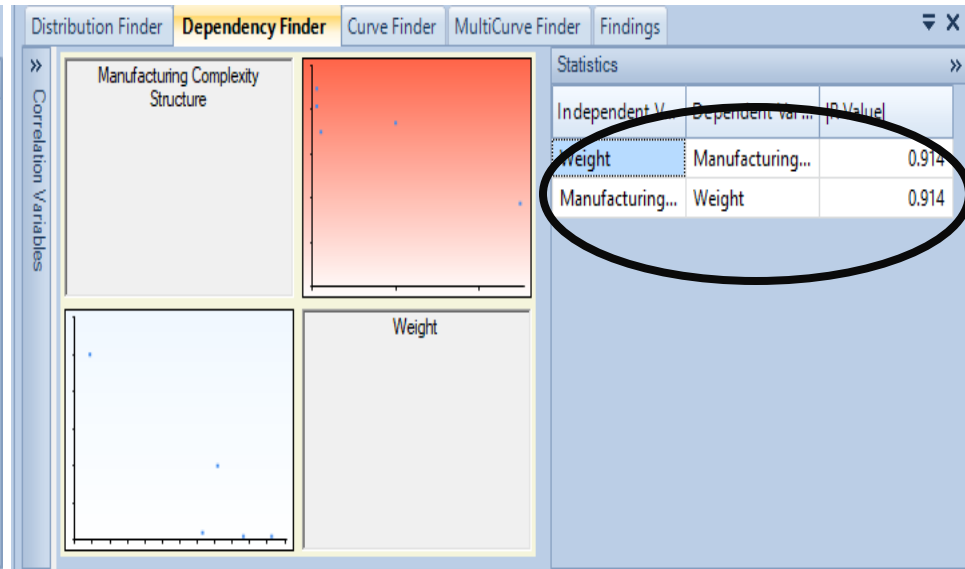
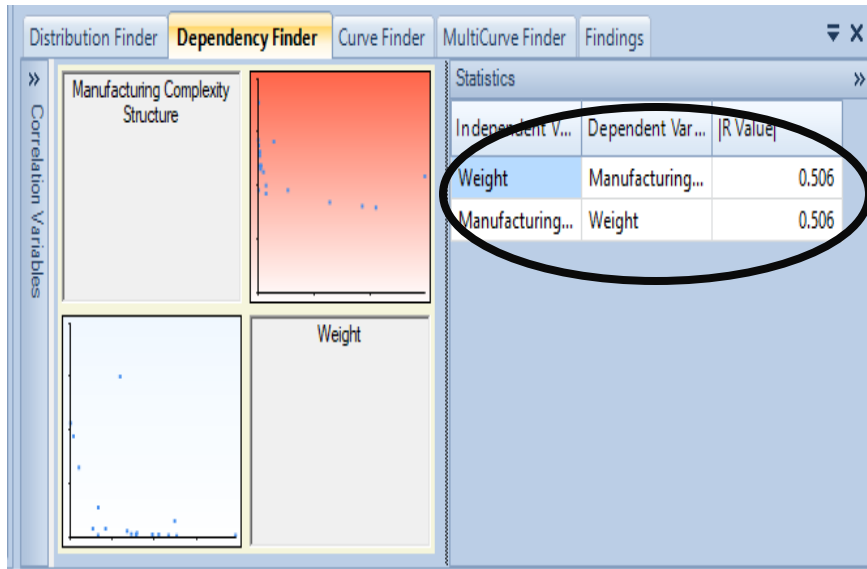
## ■ Dependency Finder in TrueFindings

- Find a relationship where MCPLXS is the Dependent Variable
- Filter attributes and select variables
- R-value: ranking of the linear correlation of independent to dependent variables



# Analysis

## ■ Dependency Finder: Filtered by Op Spec then Battery Type





# Analysis

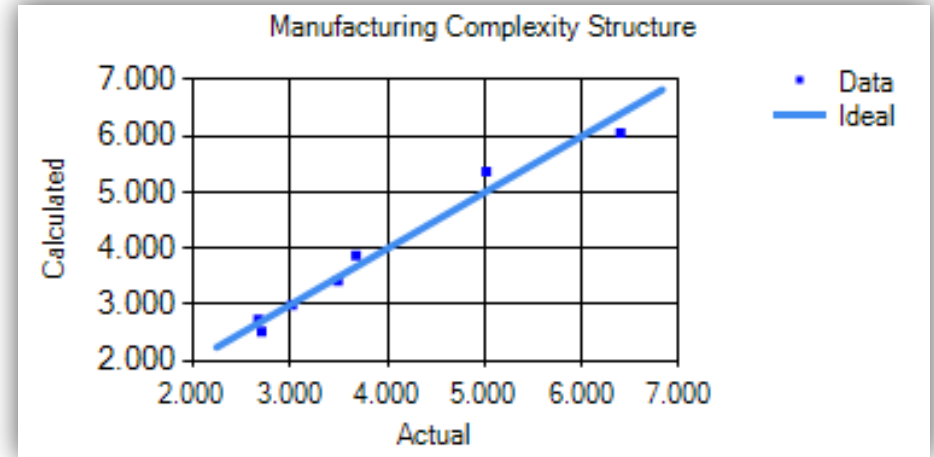
## ■ Multicurve Finder in TrueFindings

- Analyze scatter plots to find relationships and trends
- Predictions are more complex than just the single predicted value
- Predictions include a margin of error and calculate statistics to a 95 percent significance level
- Regression Statistics
  - R-Squared
  - Adjusted R-Squared

# Results

## ■ Scatterplot for Lead Acid batteries for Airborne Military

- R-Square: 0.971
- Adjusted R-Square: 0.957
- Produce prediction formulas



- $MCPLXS = 0.126 * [Voltage] - 0.029 * [Weight] + 3.204$

# Summary of Findings

- Battery database
  - approximately 975 datapoints across 114 individually identifiable part numbers
- Data repository serves as a useful resource for users to reach back to calibrated manufacturing complexities
  - Multiple attributes
  - Numerous operating environments
- Types of batteries have a strong relationship to MCPLXS

# Limitations and Future Research

- Insight into Manufacturers' rates
    - assumptions were made to utilize set values for overhead, general and administrative, and fee or profit
  - Amount of labor and automation built into manufacturing process
  - Expand this study by increasing the scope of data collection and fill-in the gaps of battery characteristics
- \* The success of validity for CERs will depend on accumulating more data from other sources



# Questions?

