

UNIVERSITY *of* WASHINGTON

# EXPLORING BATTERY DATA FROM KING COUNTRY METRO BUSES

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CHEM E 546 Final Presentation



# BACKGROUND

## King County Metro (KCM)

- > KCM operates the largest hybrid bus fleet in the country
- > Buses have a diesel-fueled generator that provides energy to a battery pack
- > Batteries power the electric motor and save energy from regenerative braking
- > As batteries age, performance declines and bus is flagged for maintenance
- > Replacement is triggered by the time spend below a cutoff voltage
  - Lots of unused data on actual State-of-Health of module being replaced
- > Modules are removed with significant storage capacity remaining
  - Inefficient, financially wasteful, and unkind to environment

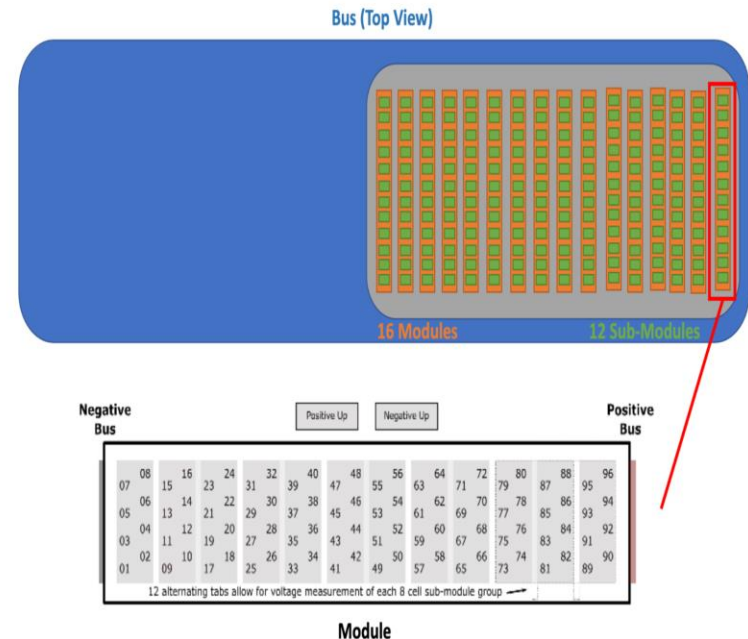


Source: The Seattle Times



# BATTERY PACK DESIGN

- > Each KCM hybrid bus contains a battery pack with approx. 12 KWh of battery storage in 16 modules
- > Each module has 12 submodules in series
- > Each submodule has 8  $\text{LiFePO}_4$  cells in parallel



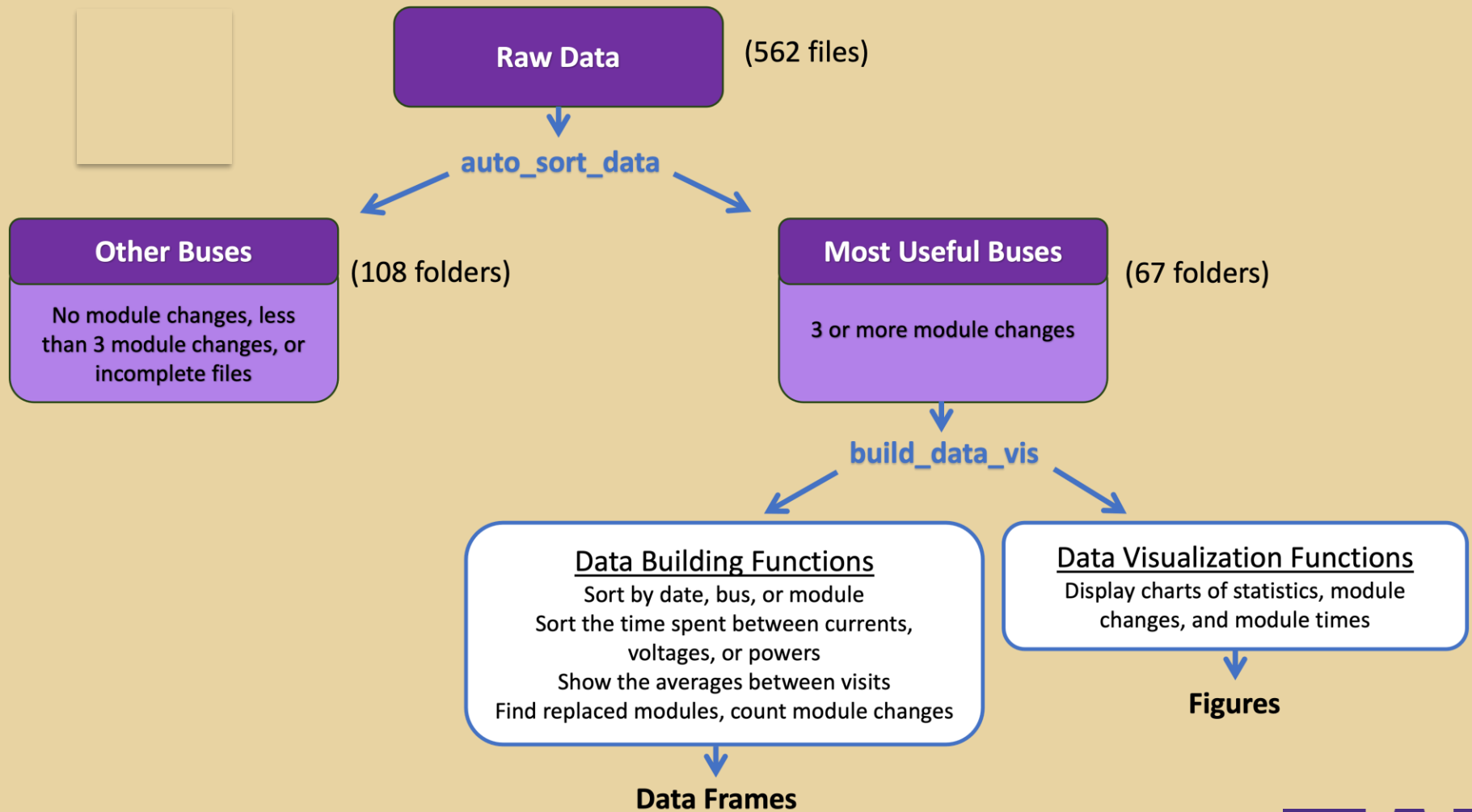
At maintenance visits, batteries replaced at submodule level

# PROJECT HISTORY

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- > Raw data was last acquired from KCM in 2019
- > Data from multiple buses and multiple visits including time battery pack spent at discrete intervals of:
  - Voltage
  - Current
  - Power
  - Temperature
  - Cell Balancer (on/off)
- > Previous capstone project created python packages to clean and organize this raw data





# CURRENT CHALLENGES

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## Inherited Python Packages

- > **Missing code, lack of documentation, outdated environment**
- > **Cannot clean any newly acquired data**
- > **Cannot put cleaned data into data frames, needed for analysis and higher-level learning**

## Conflicting Interests

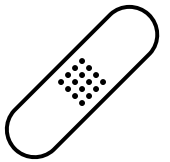
- > **Desire to create viable, reusable & sexy software**
- > **Desire to see results from statistical/machine learning by end of Spring**



# PLAN GOING FORWARD

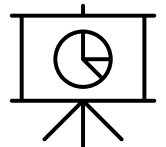
## Package Repair

- > **Retrospectively apply documentation to inherited code**
- > **Line-by-line recreation of auto sort and data build packages**



## High-Tailing to Results

- > **Take previously cleaned data and get it into data frames now**
- > **Run a Principal Component Analysis (PCA)**
- > **Further data exploration & model training**



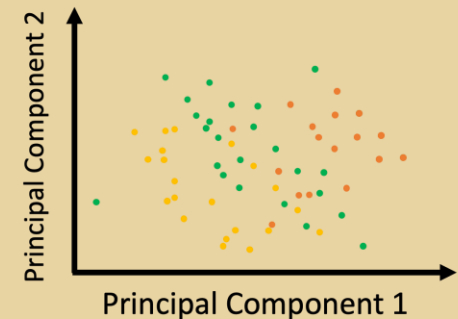
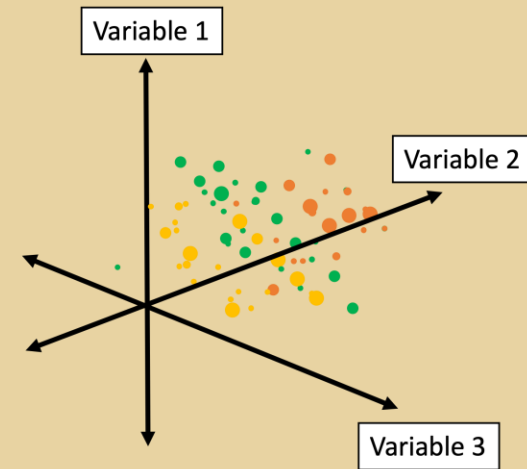
# FUTURE WORK

## Principal Component Analysis

- > **Dimensionality reduction technique that uses unsupervised machine learning**
- > **Transforms high-dimensional data into new subgroups that describe greater variance with less dimensionality**

## Why PCA?

- > **Good preliminary ML method**
- > **Help select important features that affect battery life**
- > **Compare all bus data to "most useful" bus data**





# Thank You!



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