Creating Infinite Possibilities.

SCTE
a subsidiary of CableLabs

A New Model for Power Plant and Health Estimation

Michael Nispel

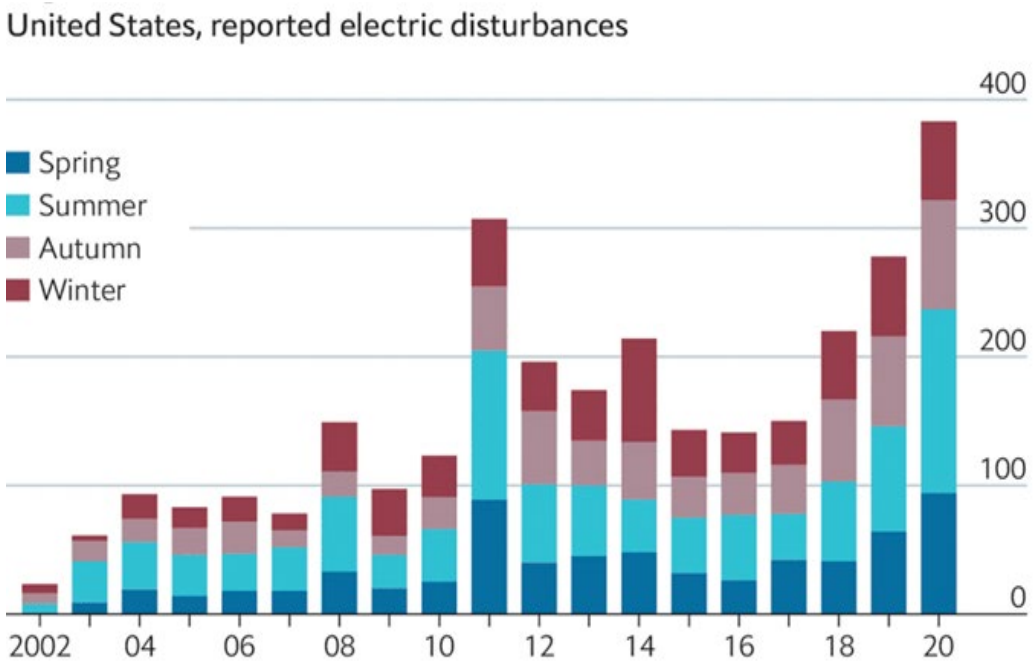
Senior Principal Engineer
Comcast Cable
Michael_Nispel@comcast.com

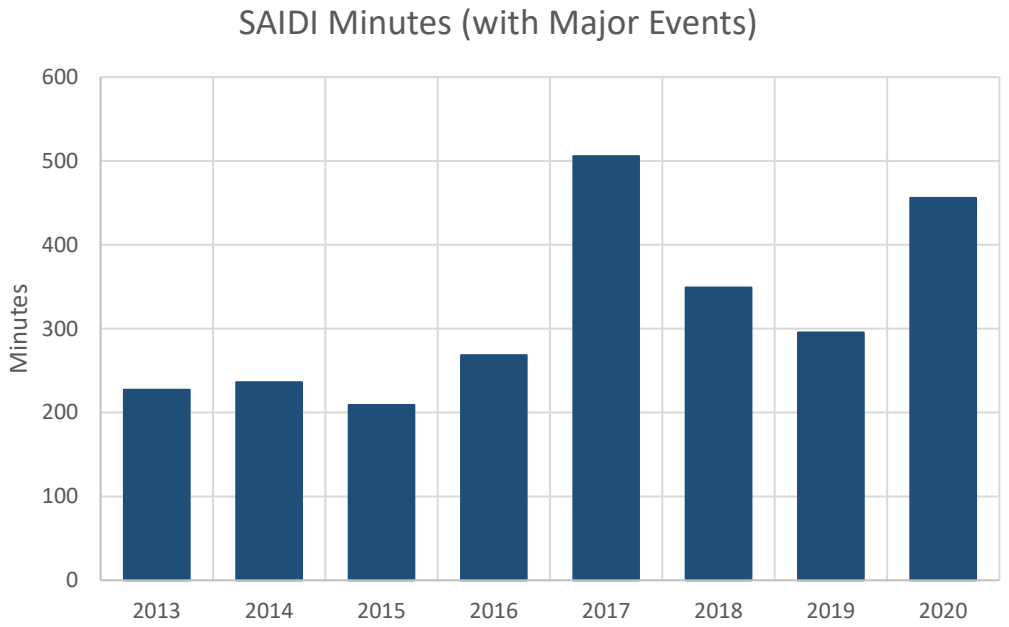
SCTE CABLE-TEC EXPO 22
SEPTEMBER 19-22 • PHILADELPHIA, PA

2022 Fall Technical Forum
SCTE • CABLELABS • NCTA

Utility Power (Un)Reliability

- Reliance on Battery Backup continues to grow in importance
- Predictive Runtime model was determined to be critical to network reliability





Source: Department of Energy OE417 – Annual Summary

Department of Energy EIA0861, Annual Report

‘One of the largest IOT databases in the world’

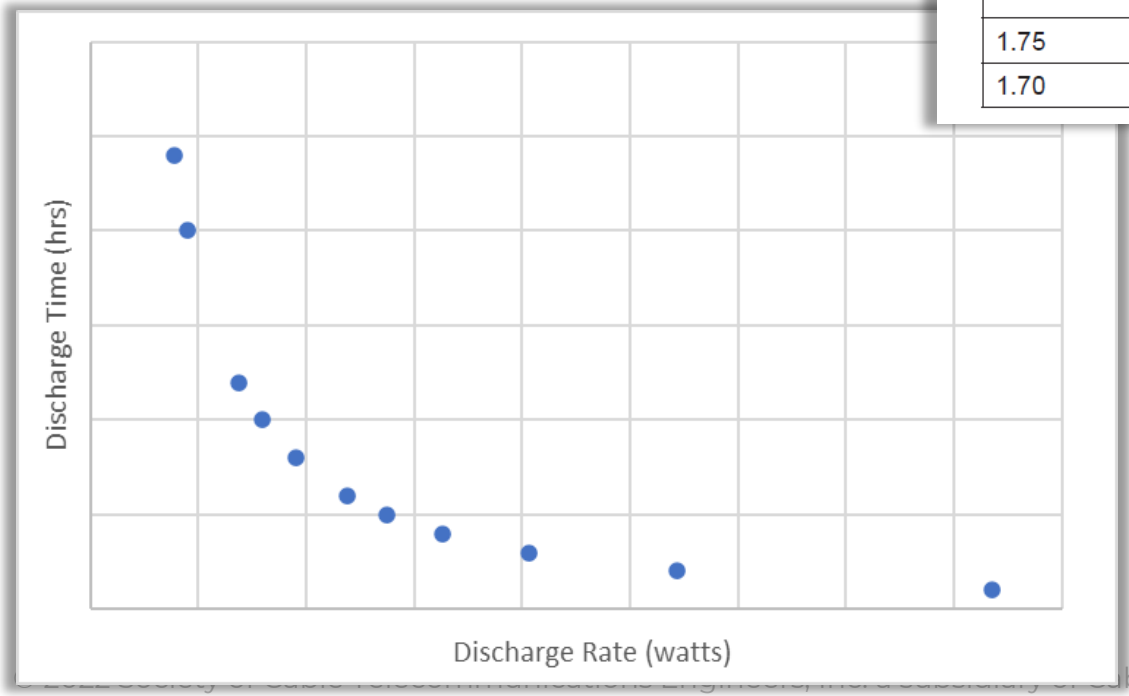
- Comcast has direct monitoring access to:
  - > 1,000,000 batteries installed in its network
  - >250,000 sites throughout the US
- Continuous monitoring is available and used for this study
  - Historical records of the status and all events
- Full information records of every battery
  - Manufacturer
  - Model
  - Quantity
  - Date of installation

All of this information was used to create a novel **Predictive OSP Battery Model**

Q: Can Battery Runtimes be Predicted?

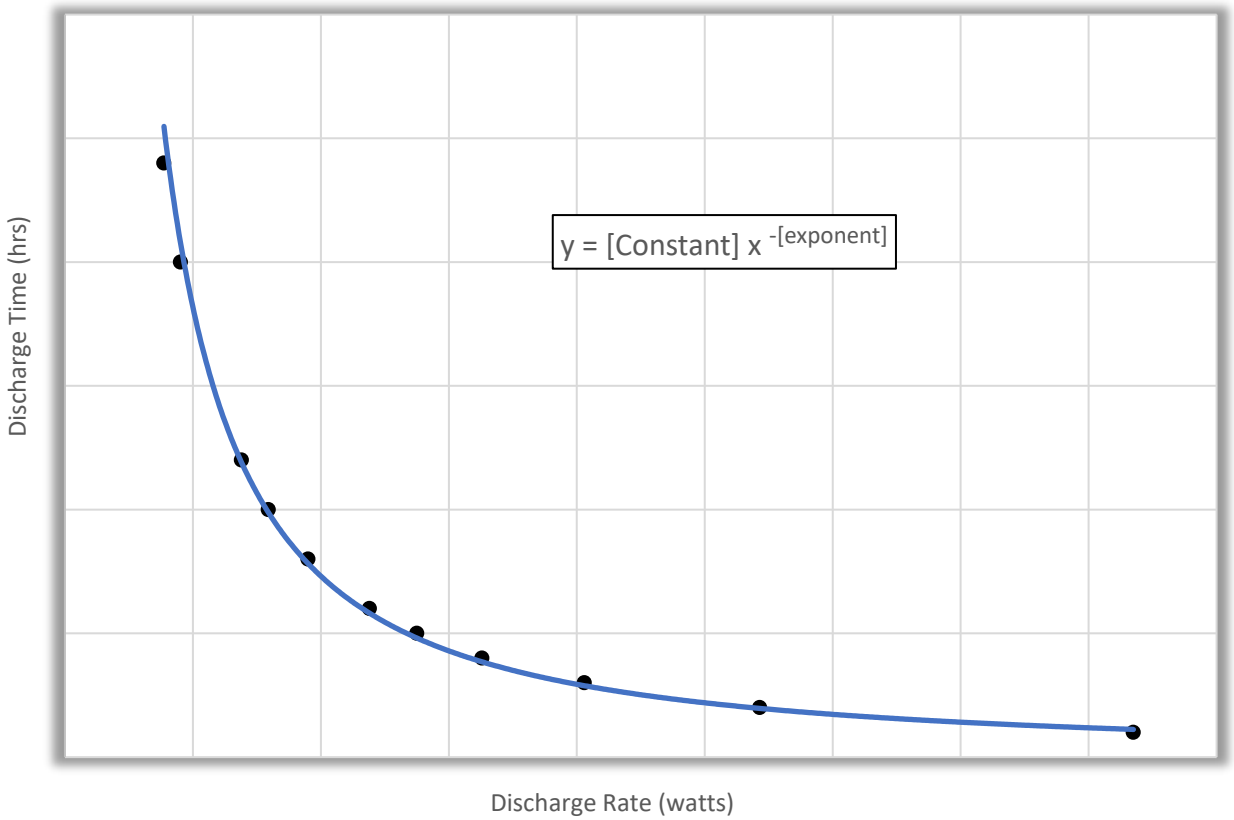
Manufacturer's Performance Data is limited

Power (Watts)											
End Voltage	15min	30min	45min	1hr	2hr	3hr	4hr	5hr	8hr	10hr	20hr
1.85	312.2	206	156.9	127.9	75.4	54.2	42.5	35.1	23.1	18.9	9.9
1.80	331	215.4	163.1	132.4	77.5	55.5	43.5	35.9	23.7	19.4	10.2
1.75	347.6	223.6	168.3	136.2	79.2	56.7	44.4	36.6	24.2	19.8	10.5
1.70	361.7	230.3	172.6	139.2	80.6	57.5	45	37.1	24.5	20.1	10.7



- Data is for new batteries
- Data is typically for 77° F

Modification of Peukert's Law



Steps

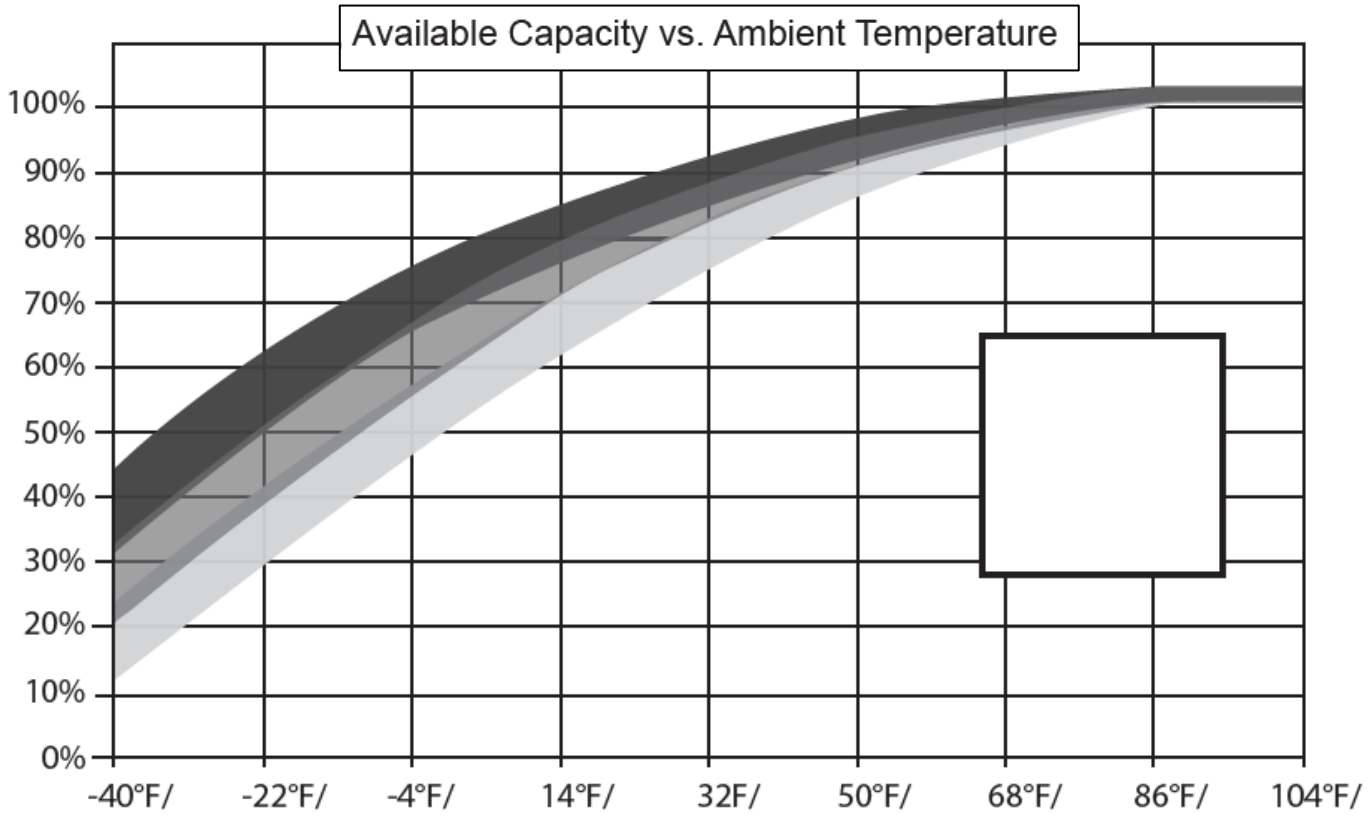
- Curve fit discharge data
- Obtain load on the batteries (not directly measured by the power supply)
  - Output voltage
  - Output current
  - Inverter efficiency

Expected battery runtime can be determined from the operating data

Temperature Effect

Generally: higher temperatures improve runtimes

lower temperatures reduce runtimes



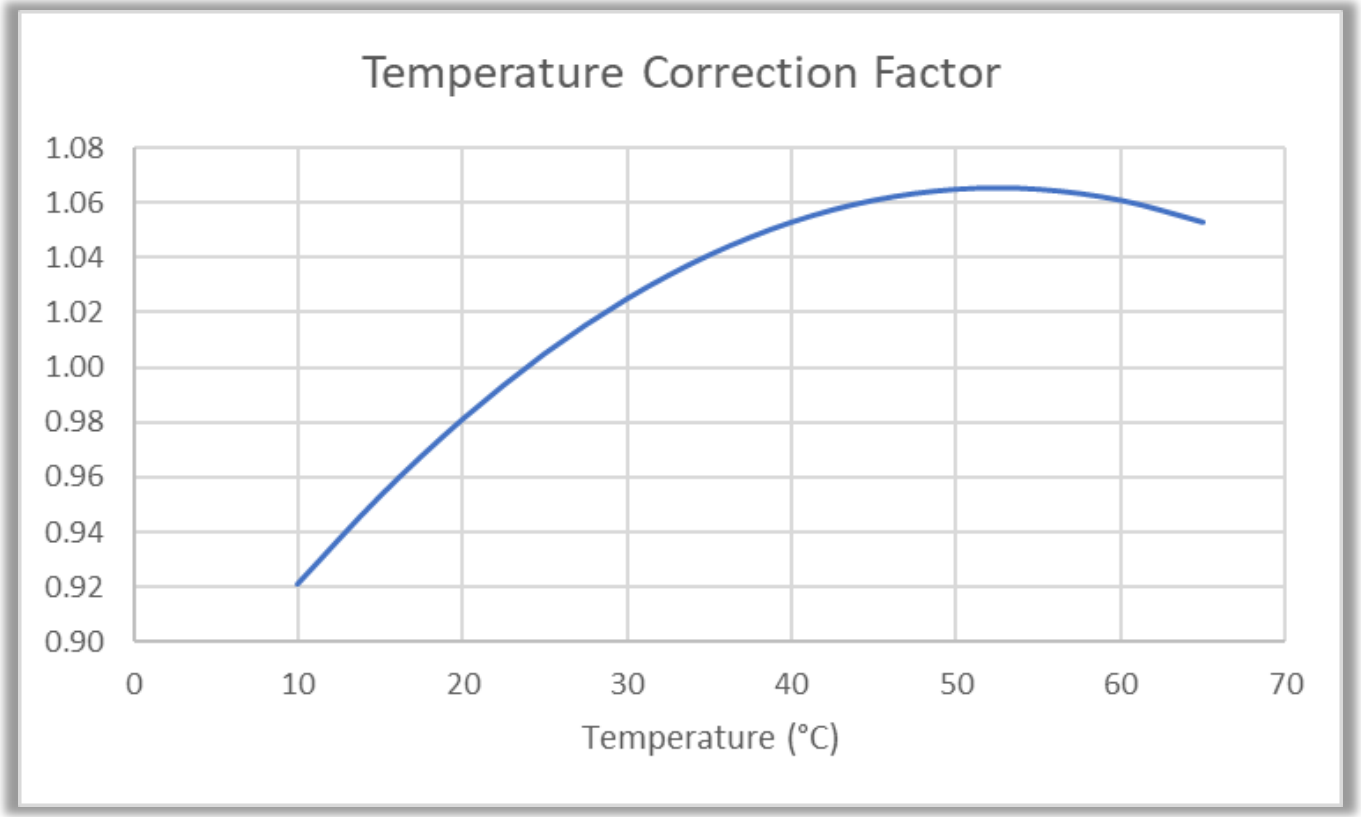
Not accurate enough to be useful

Design dependent

- Arhennius +
- Two-phase reaction
- Double layer capacitor
- Convective/liquid effect

Lab tests

$$TCF(°C) = -8E-05 * (°C)^2 + 0.0084 * (°C) + 0.8452$$



Calendar and Cycle Aging

$$AF(yr) = -(1 - Aging\ Constant) * yr/7 + 1$$

End-of-Life: 80% of initial capacity

Design Life: 5 or 10 years

Service Life: 5-x or 10-y

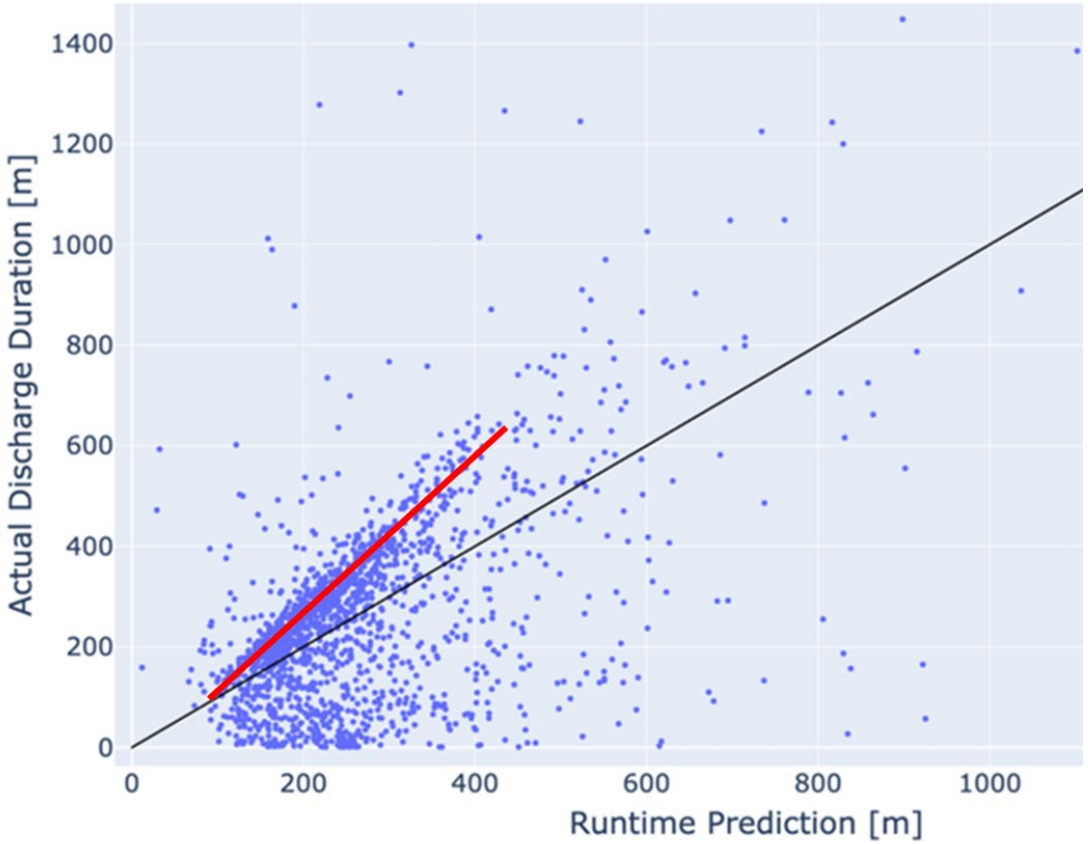
x, y depends on various factors (temp, power quality, cycles, more…)

First estimate: Straight line degradation – 80% capacity at end-of-life

7 year life selected to encompass all climates

Peukert + Temperature + Aging

Predicted Runtimes vs Actual Runtimes

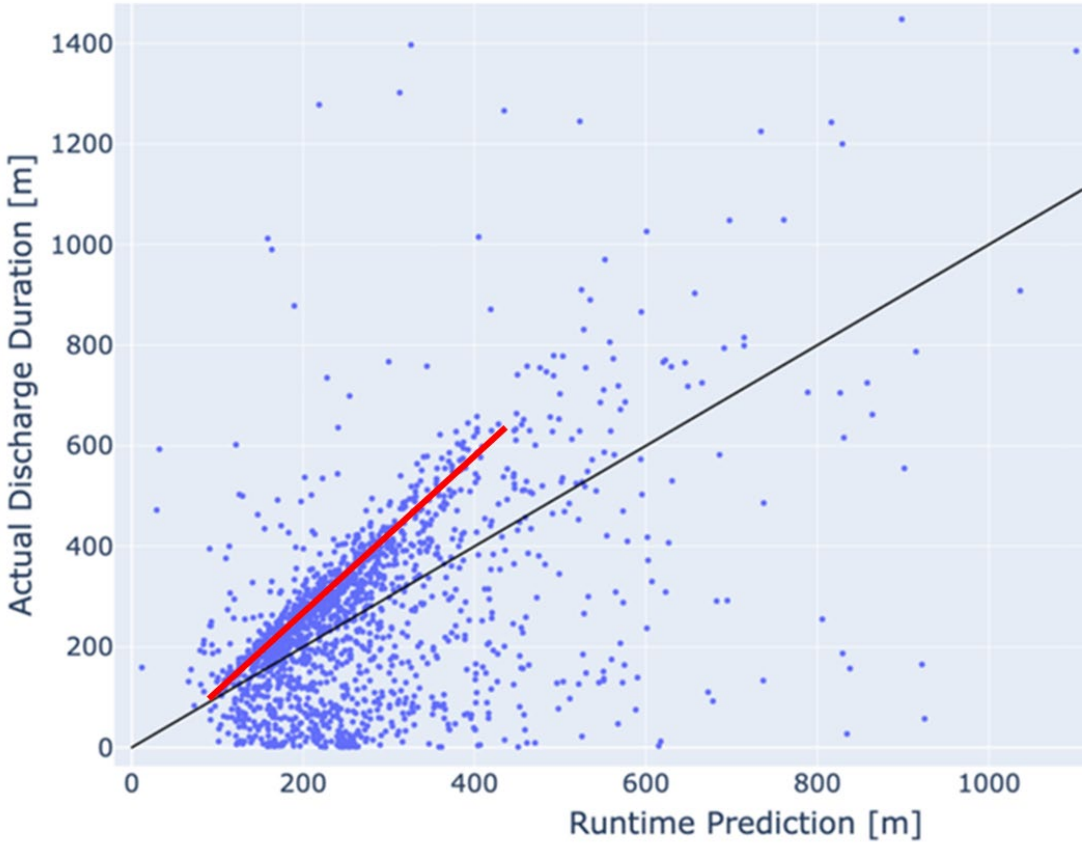


A perfect prediction would be the black 45° line

Preliminary observations:

- *Extremely encouraging*
- A distinct correlation can be seen in the data
- The 'error' increases with longer runtimes
- Most deviations are lower than the 45° line
  - Actual runtimes are less than predicted

Use of machine learning/artificial intelligence



- Investigate the reason for the shift
  - Internal ohmic heating
  - Error in manufacturer's battery data
  - Battery aging
- Develop a cycle aging factor
- Account for state-of-charge
  - Prior discharge/charge cycle
- Filter out defects
  - Hardware/cables/connections
  - Prematurely failed batteries in a string

Creating Infinite Possibilities.

Thank You!

Michael Nispel

Senior Principal Engineer
Comcast Cable
Michael_Nispel@comcast.com