Accuracy Guidelines
for SBS Smart Batteries

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Smart Battery Systems Implementers Forum

PowerSmart, Inc.

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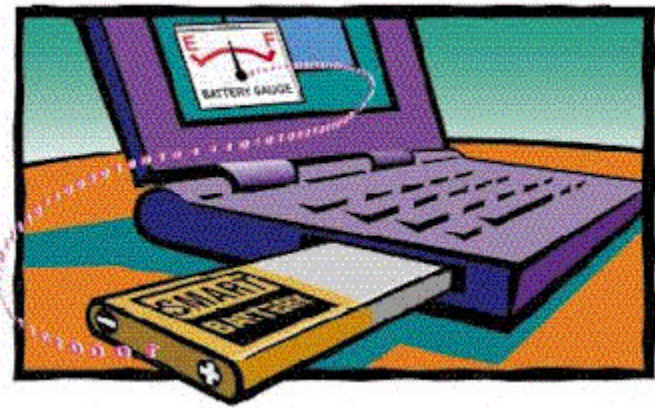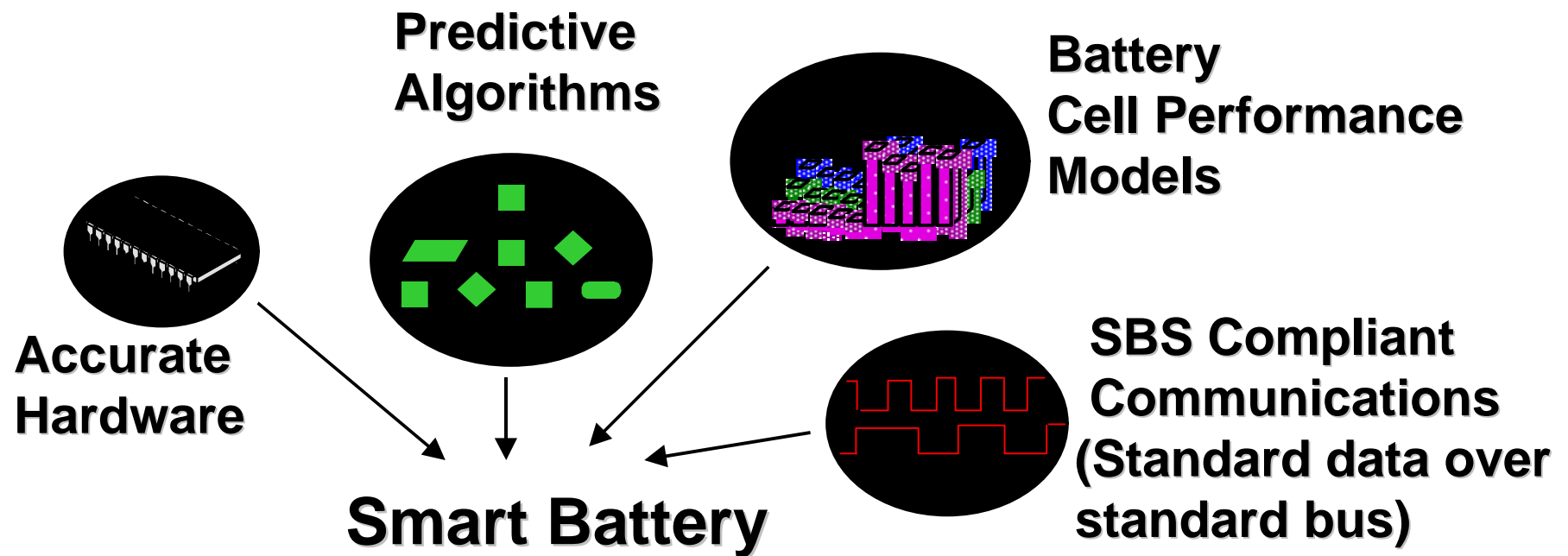
Agenda

- SBS Smart Batteries
- Accuracy in Smart Batteries
- SBS-IF Accuracy Guidelines
- Results - What Can be Expected
- Summary

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What is a Smart Battery ?

Predictive Algorithms

Battery Cell Performance Models

Accurate Hardware

SBS Compliant Communications (Standard data over standard bus)

Smart Battery

Multiple "Smart" Components Required

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Why Smart Batteries ?

- Enables longer operating times
- Prevent data loss and premature shut-down
- Chemistry independence
- Increased safety for Lithium chemistries
- More effective charging
- Provide useful information to user and OS

Longer Device Run-times

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Why Accuracy is Important

- Poor accuracy causes premature shut-downs
  - Data loss possible
  - False "low battery warnings" annoy users
  - Large 'guard-bands' of capacity waste battery
- Inaccuracy causes inefficient charging
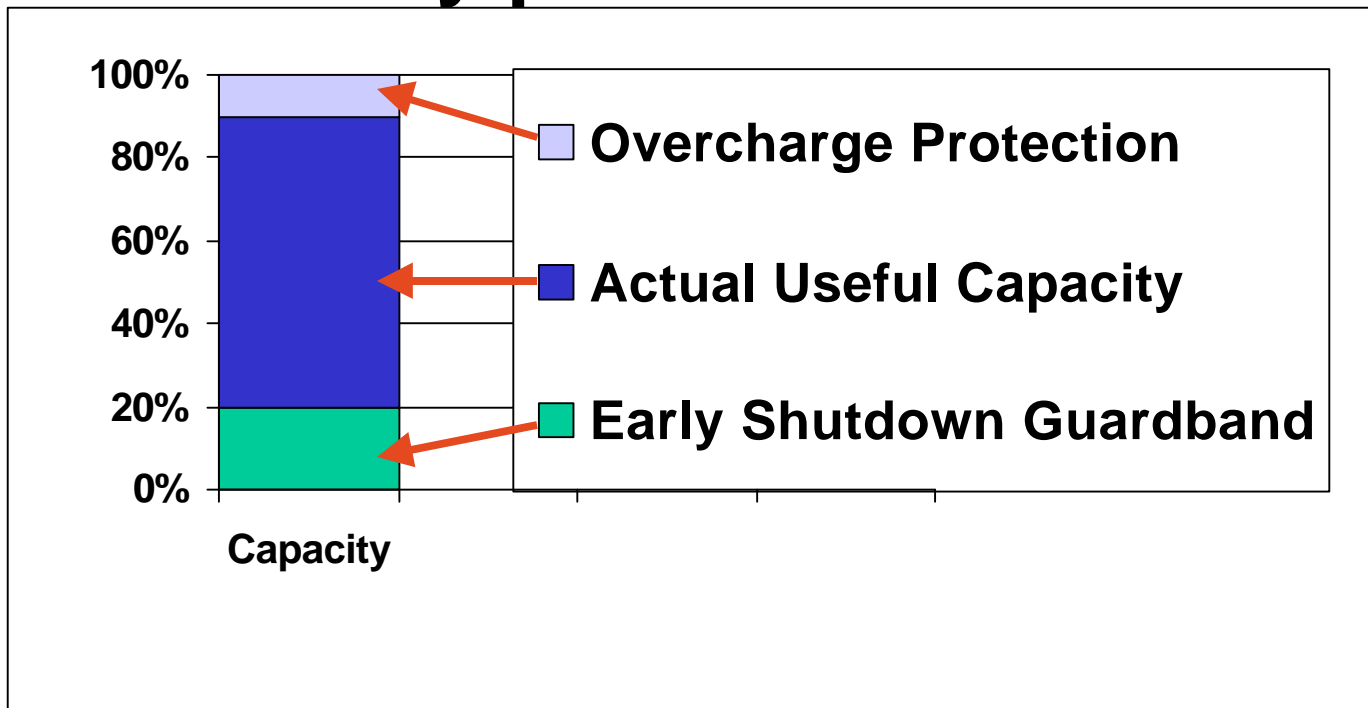- Low accuracy limits longer run-time benefits

Accuracy allows system to use "last drop" of energy

Why Accuracy is Important

- ● **Poor accuracy prevents full use of battery**

Only 70% of Rated Capacity may actually be used!

Benefits of Accuracy Tests

- Provide a level of accuracy that software can design to
  - OS can expect minimum conformance
- Improve reliability & repeatability
- Determine optimum charge & discharge thresholds
- Establish means to compare suppliers

Reliable & Accurate Battery Data for all Users

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SBS-IF Accuracy Guidelines

So, what to do about accuracy in Smart Batteries?

Introducing the _NEW_ Smart Battery Accuracy Testing Guidelines from the SBS-IF

Guidelines to Improve Accuracy Overall

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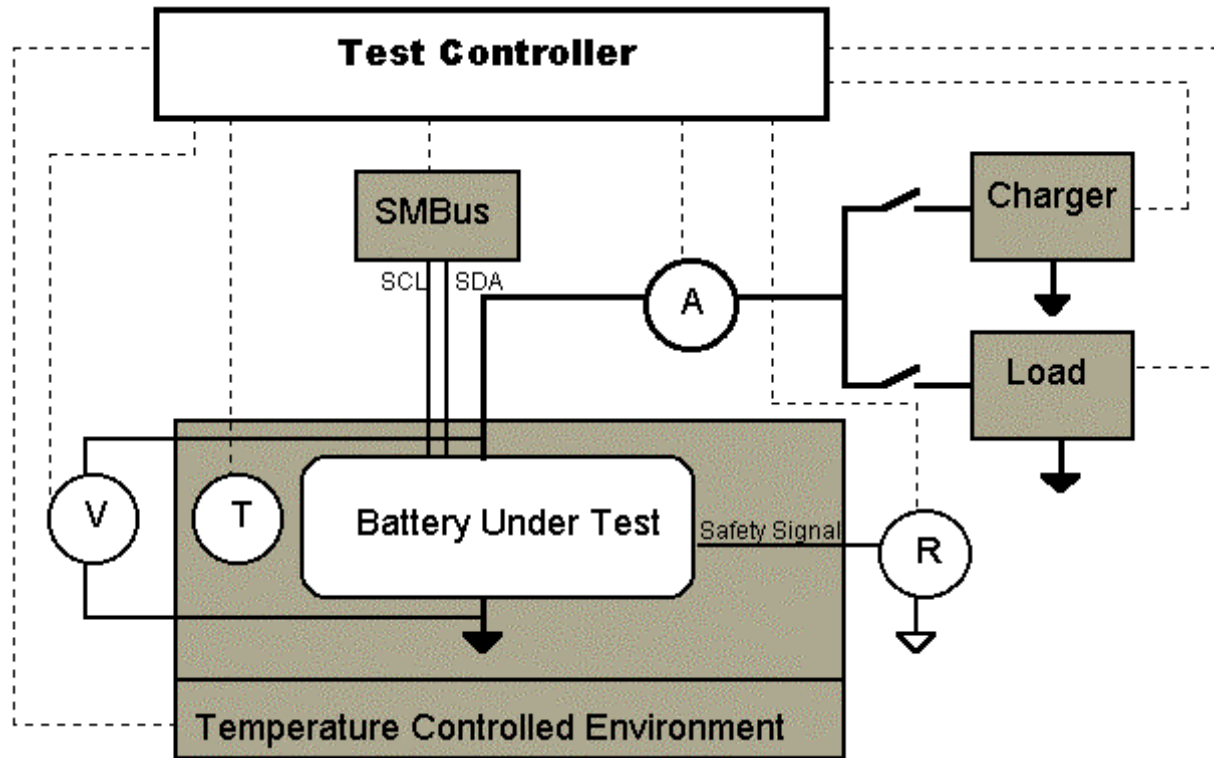
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Development History

- SBS Accuracy Guidelines Developed by Key Industry Participants
  - Battery cell suppliers
  - Smart Battery electronics suppliers
  - OEMs
- For the Benefit of All
  - Part of the Smart Battery System Specifications (SBS)

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Example Test Setup

- ## No custom hardware needed

Setup can be built with off-the-shelf equipment

What to Test

- ● Capacity Tests
  - – Compares Smart Reported Capacity to Actual
  - – Full & Partial Cycling with Simulated Waveforms
    - > High and low rates simulate real-world applications
    - > Pulsed and steady-state conditions with varied temps

- ● Measurement Accuracy Tests
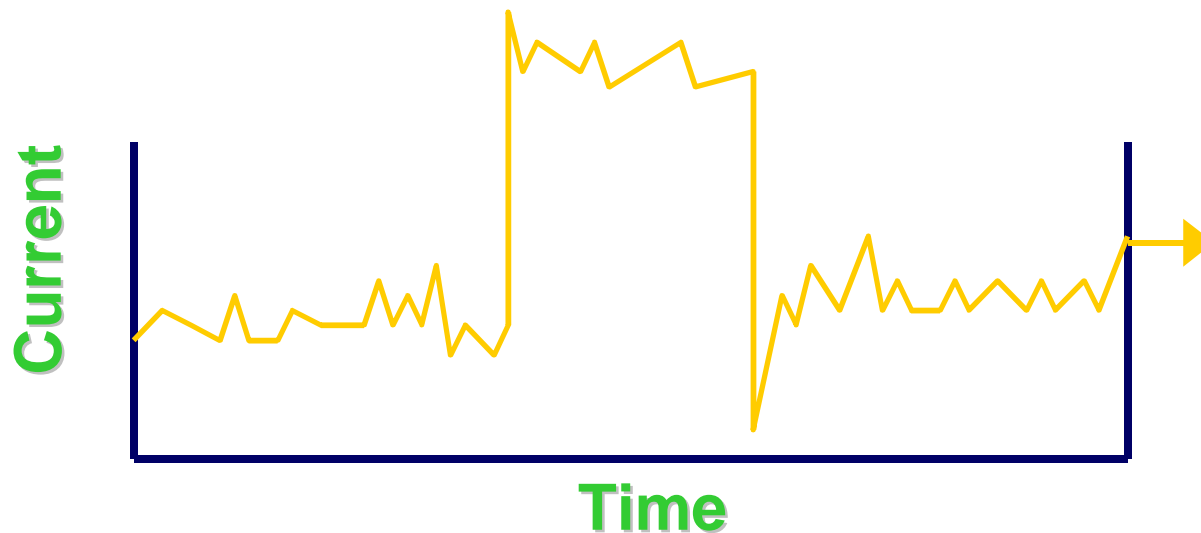 - – Absolute measurement accuracy (V, I, T)

Multiple Tests for Varied Requirements

Laptop Load Profile
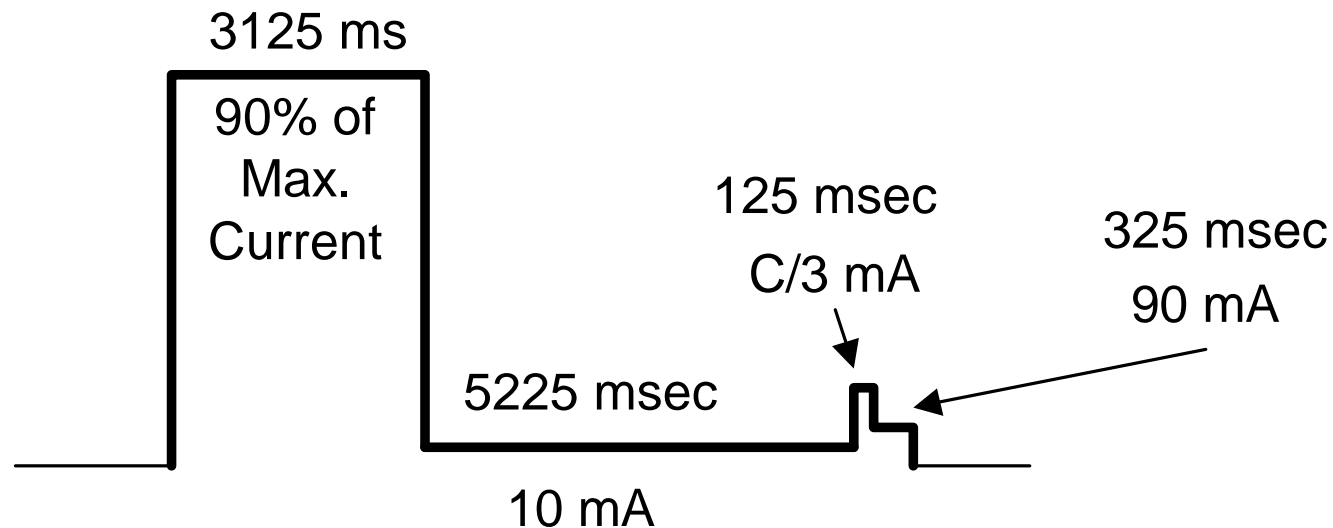
- **Typical Laptop Waveform (Current vs. Time)**

Tests Designed for Typical Applications

Example Load Waveform

- **Waveform simulates laptop discharge current**

3125 ms

90% of Max. Current

125 msec

C/3 mA

325 msec

90 mA

5225 msec

10 mA

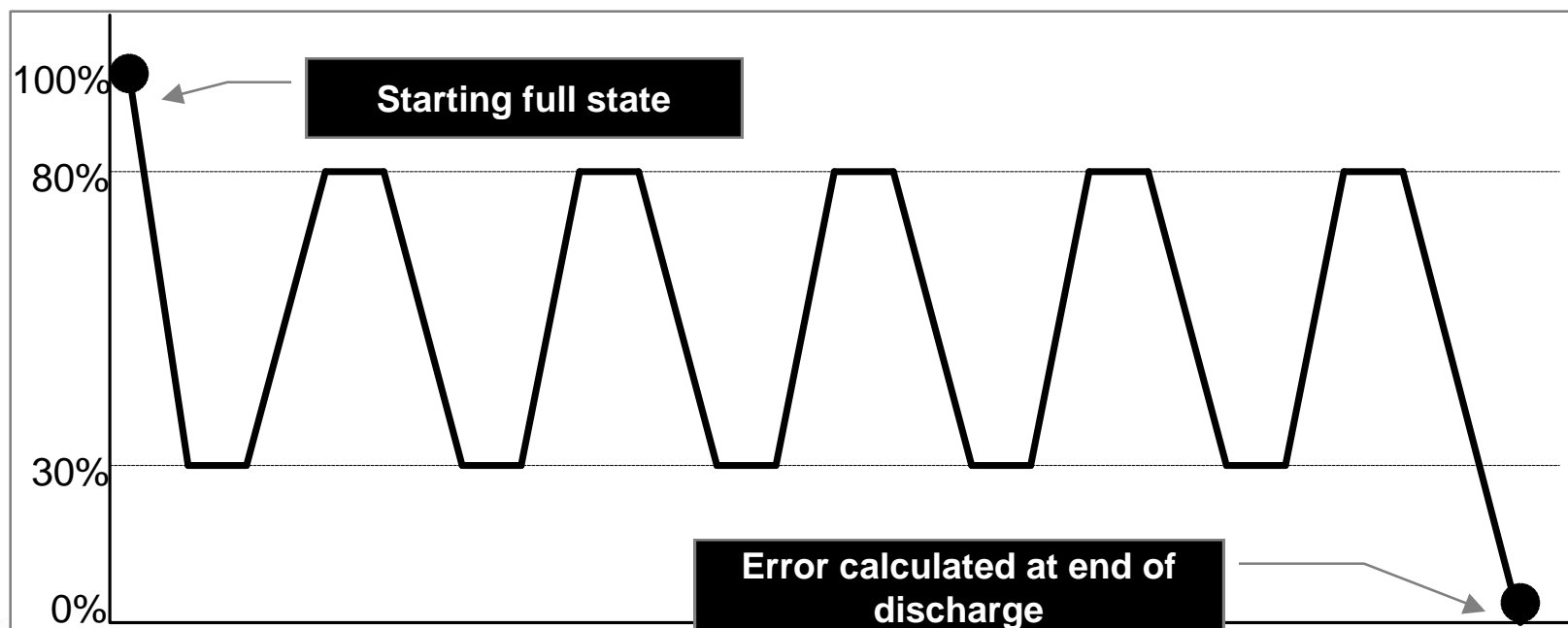**Real-World Application Tests**

Example Cycling Test

- **Simulates typical usage pattern**
  - Partial use (not full, not empty) illustrates error

100%

Starting full state

80%

30%

Error calculated at end of
discharge

0%

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Example Results

- **Large 'guard-band' accuracy error example**

Battery at 'Empty' before actual capacity depleted
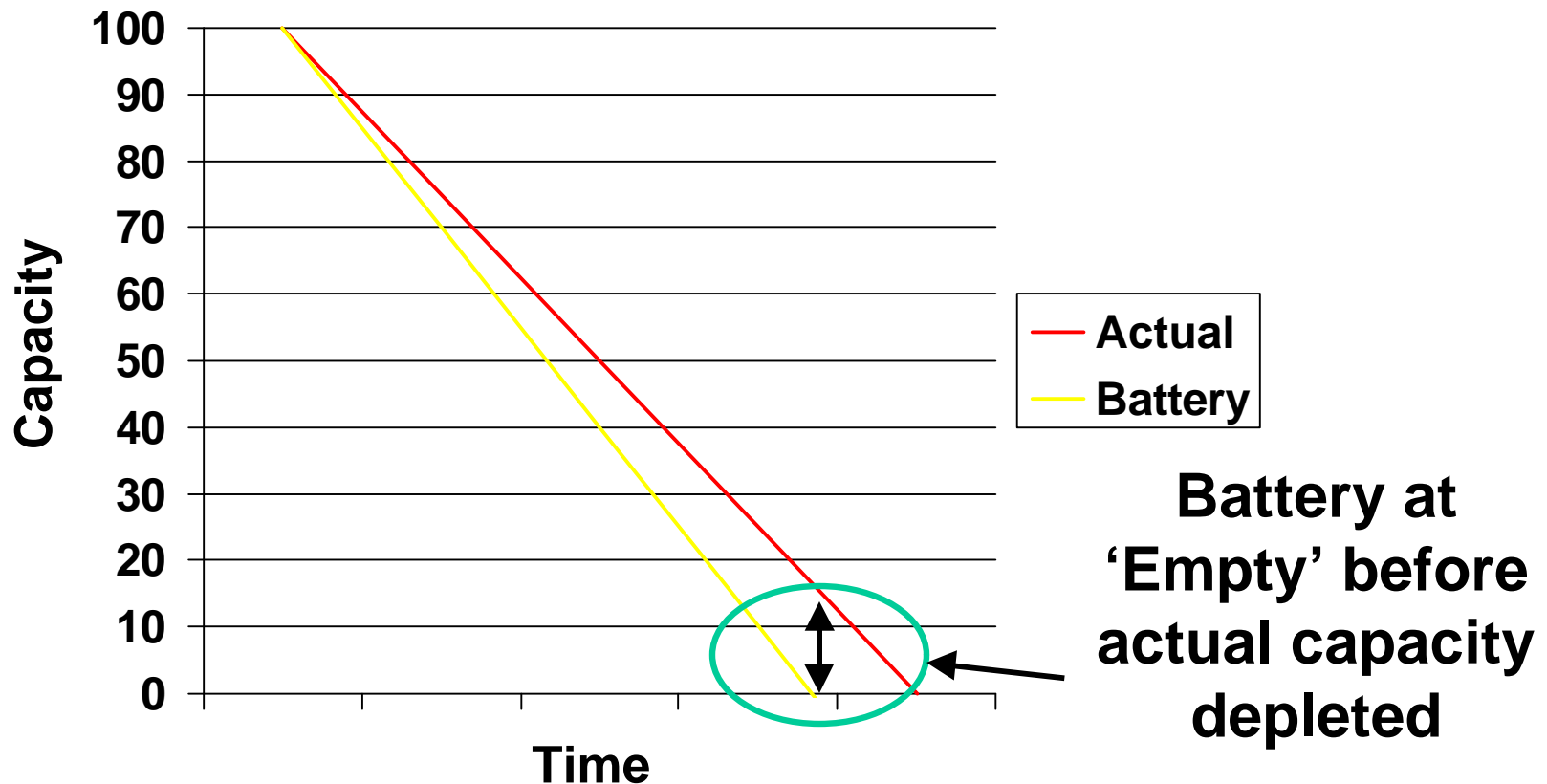
'One Number' Result Report: 15% error

Example Results

- ## Inaccuracy causes pre-mature shut-down

Inaccurate Battery 'thinks' it has more capacity than it actually does.
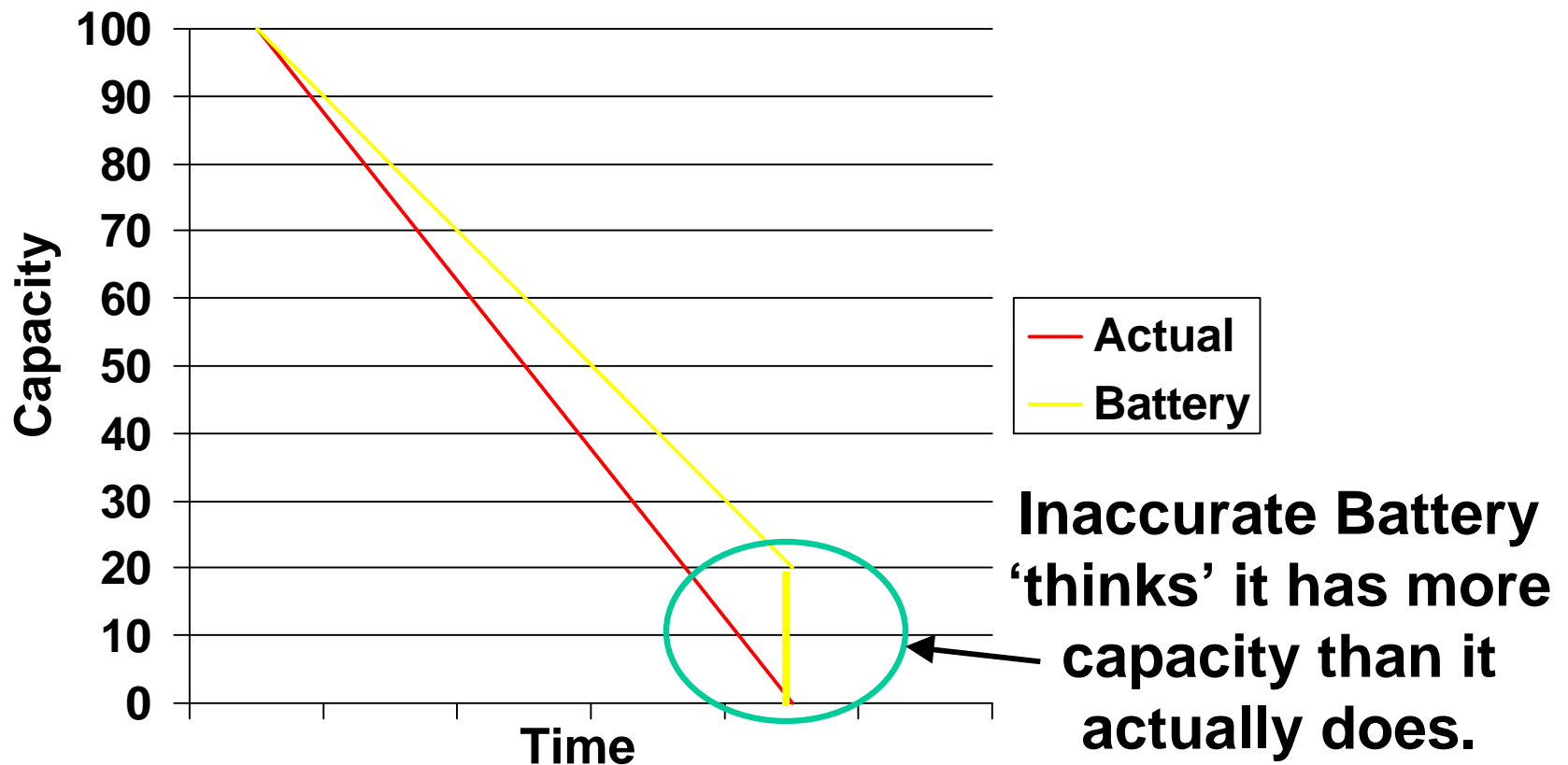
'One Number' Result Report: 20% error

Example Results

- ## Actual Results: Full Cycling Tests

SBS-IF Accuracy Test 1A - Capacity Estimation

	1	2	3
■ Test System	3360.1855	3375.41678	3368.72493
■ Smart Battery	3405	3424	3382
□ Error (%)	1.316138032	1.418902453	0.392521289

Discharge - Charge - Discharge
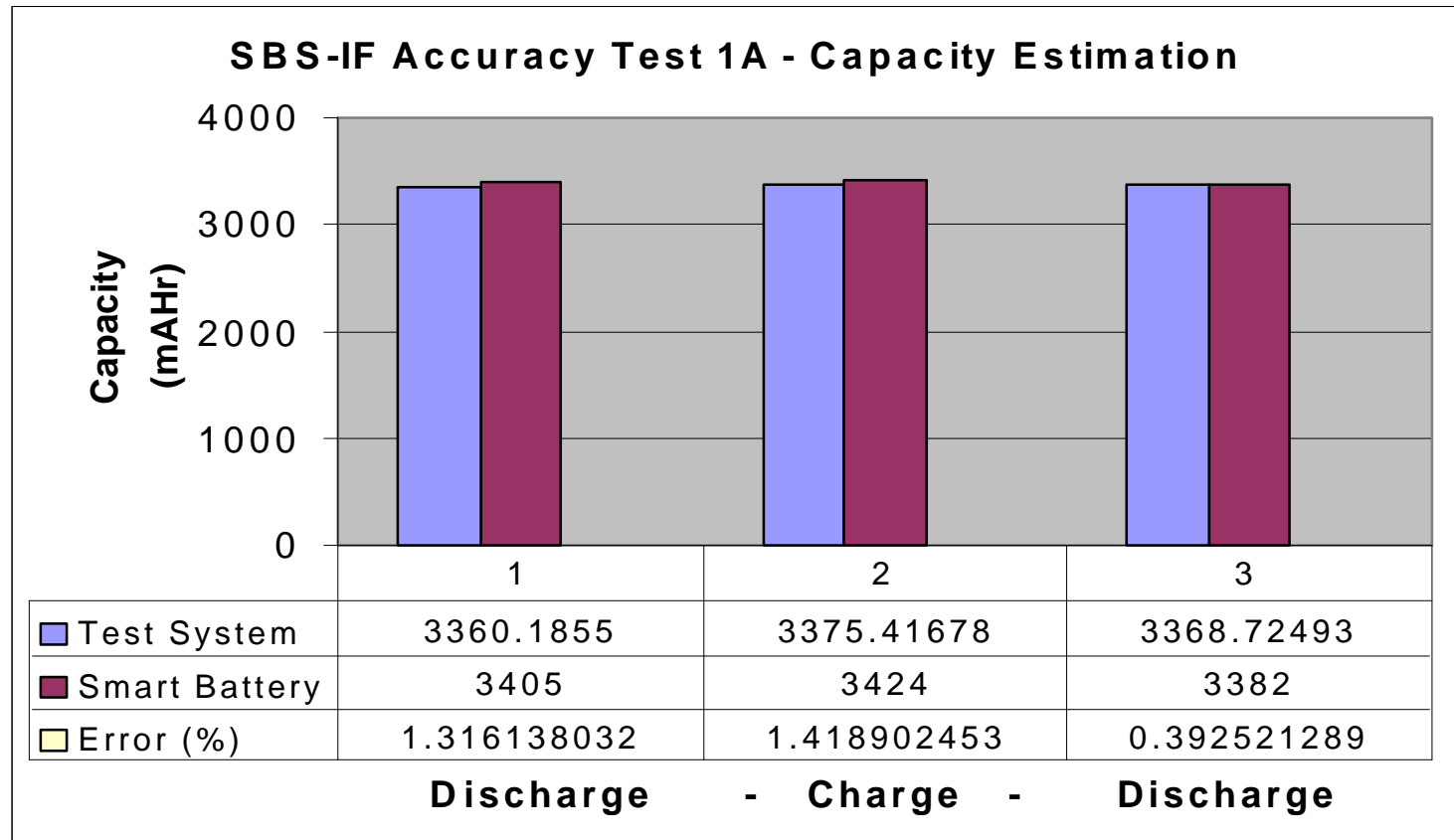
High Accuracy is Possible!

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Results - What Can be Expected
Example Results

- ## Actual Results: Partial Cycling, Pulsed Load

Total Error < 0.9%

Capacity

Error

PS331 Reported Capacity & Error

Legend: REM-CAP (red), Error (blue)

X-axis: Time (0 – 3500)
Left Y-axis: mAhr (0 – 6000)
Right Y-axis: -0.80% – 1.00%

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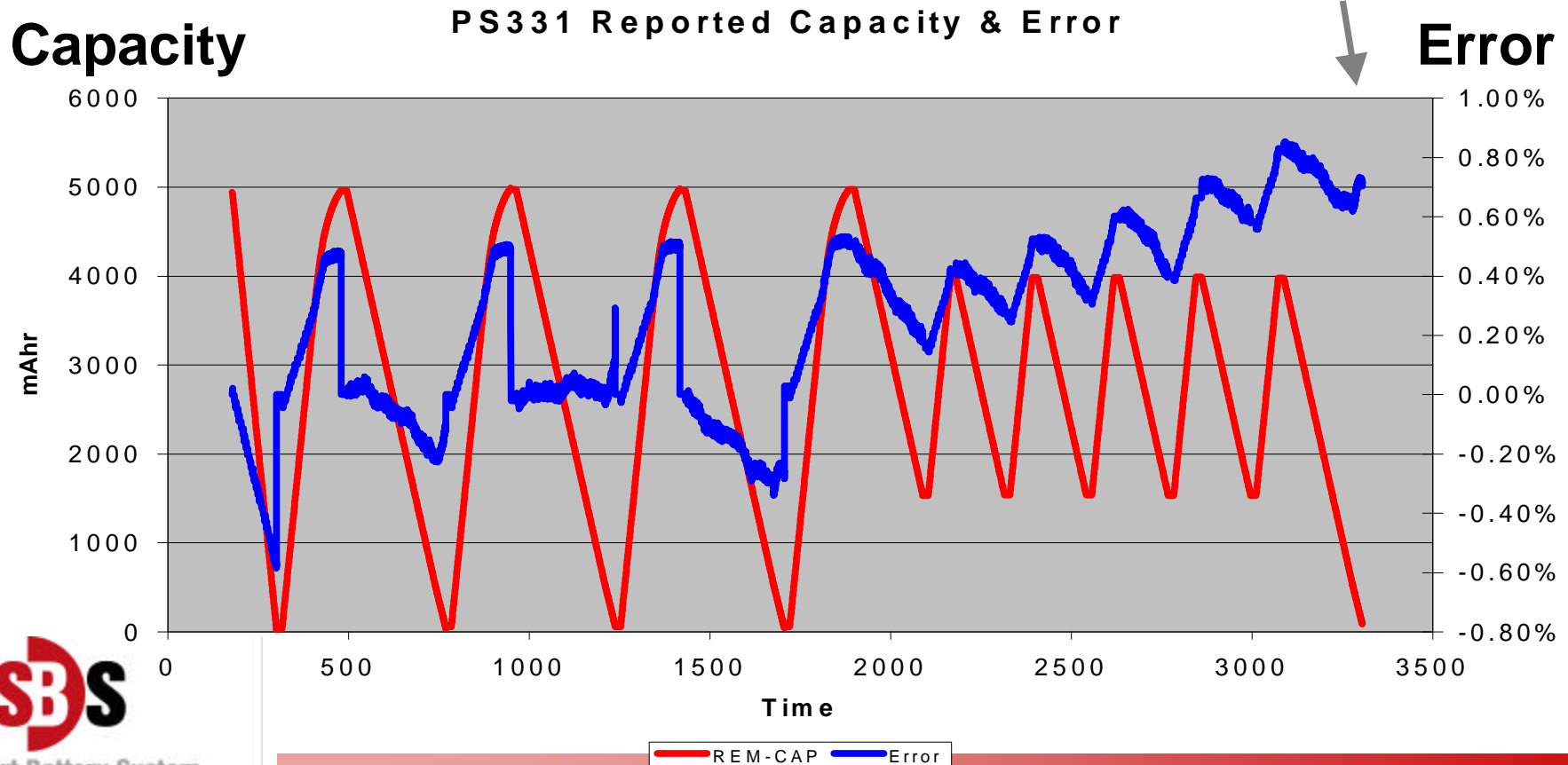
Results - What Can Be Expected
Example Results

- ## Actual Results: Current Measurements

Error (%)

Current Measurement Accuracy

High Accuracy over Temperature

Current
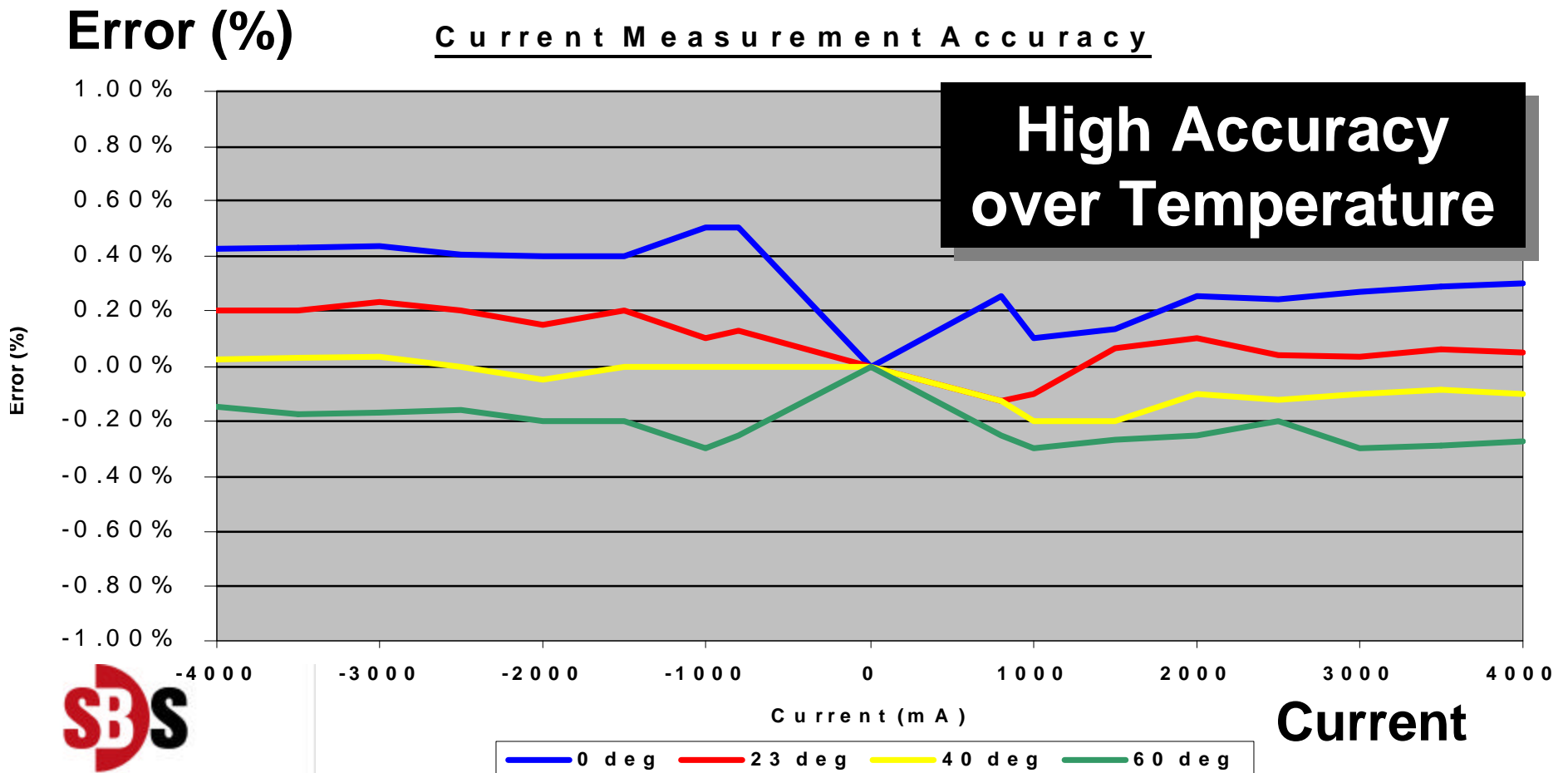
Summary

- SBS-IF promotes better power management
- Smart Batteries enable longer run-times
- Accurate Batteries add to safer operation
- Inaccurate Batteries may not use all capacity
- Accuracy Tests simulate real-world needs
- Testing is easy and straight-forward
- Highly accurate (1%) Smart Batteries do exist
- Ask <u>your</u> Smart Battery suppliers for test data

Insist on the <u>Most Accurate</u> Smart Batteries

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For More Information...

- SBS Accuracy Guidelines available at:
  - www.sbs-if.org
  - Member Review: NOW
  - Public Release: Soon

- Join the Smart Battery System Implementers Forum (SBS-IF)

- SBS Members - Join the Battery WG
  - Battery Working Group Chairman -
    - Dan Friel, PowerSmart
    - Send email to: "DFriel@PowerSmart.com" or "Battery@SBS-Forum.org"