TITAN
ADVANCED ENERGY SOLUTIONS

NAATBATT MEMBER UPDATE

February 2020

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Titan's ultrasound-based technology dramatically improves the economics and performance of Li-ion batteries by increasing their usable capacity and doubling their lifetime.

Titan also enables the 2nd life battery market, by providing fast, inexpensive, and reliable battery health assessments.

Titan AES Overview

BACKGROUND

- Co-founded in 2016 by two serial entrepreneurs and energy experts
- $12.2M in funding to date; series A was closed in July 2019 by Schneider Electric, EIC, and MassCEC
- Recipient of numerous awards including 2018 MassCEC Catalyst and AccelerateMass
- Strong customer traction among automotive OEM, energy storage & consumer electronics

TECHNOLOGY/PRODUCT

- **ionView™ –** Proprietary ultrasound technology that enhances current BMS performance through highly accurate SOH & SOC measurements while battery is in use
- **Scorpion™** – Fast and accurate battery diagnostics scanner that provides used EV batteries a second life
- Comprehensive and defensible IP portfolio – one patent issued and additional submitted

VALUE PROPOSITIONS

- 20% increase in battery usable capacity
- 2X increase in battery life (cycles)
- Safer and more reliable use of LiB through early outgassing detection, lithium plating, SEI growth observation.
- 5-sec used EV battery scan (vs. 8 - 20 hrs) with 99% accuracy
- QA/QC optimization for battery formation

MARKET OPPORTUNITY

- Titan's ionView platform can be integrated into existing Li-Ion BMSs globally, currently valued at $10B
- Li-Ion batteries sales surpass $25B annually growing at over 11% CAGR
- Titan is focused on four premium markets: Electric Vehicles; Smartphones; Energy Storage; 2nd Life EV Batteries/Recycling

BUSINESS MODELS

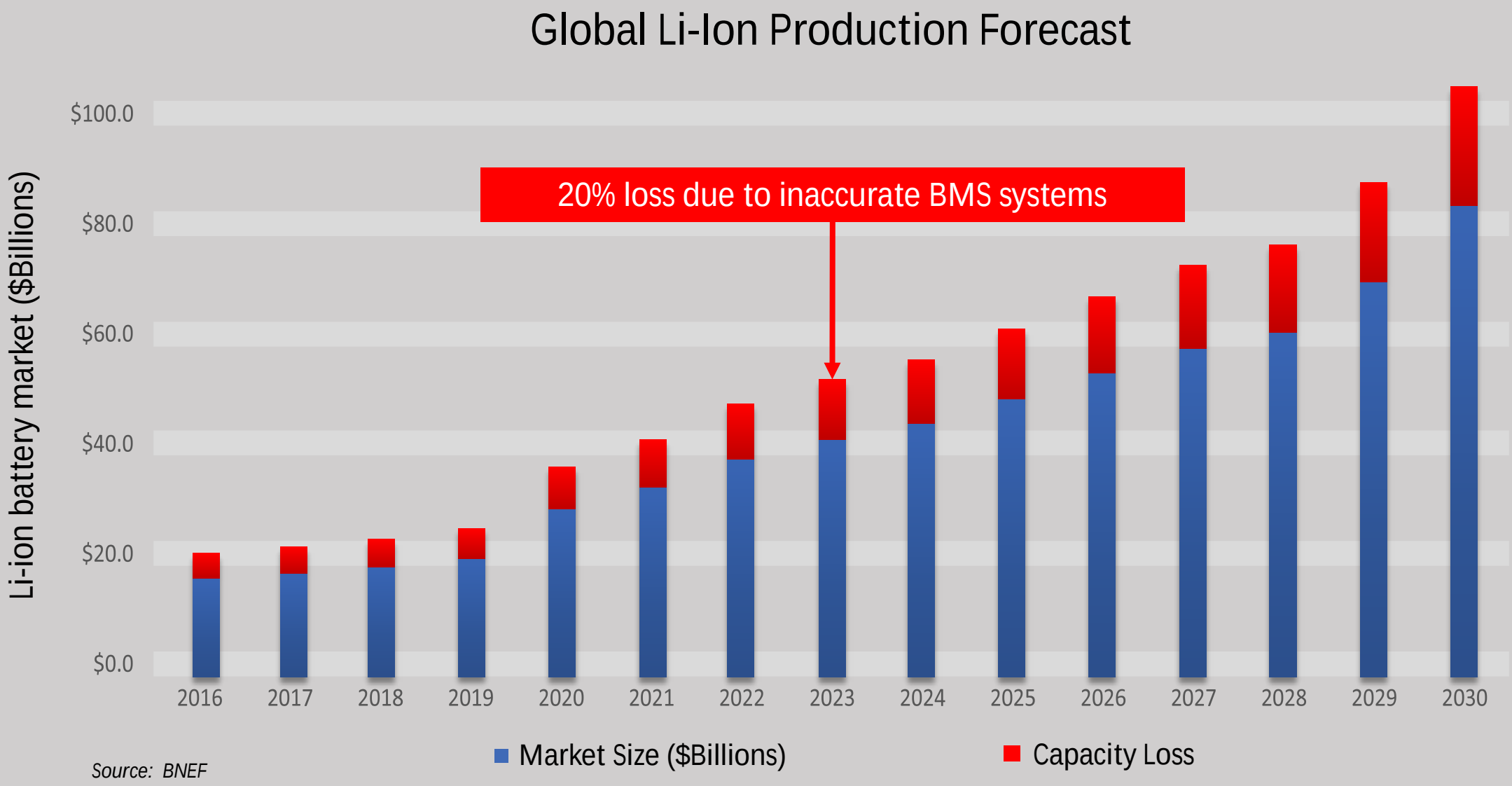
- ionView BMS technology:
  1. NRE project + licensing
  2. Design license to OEMs (consumer, EV, ESS)
- Scorpion: Scan-as-a-Service for used EV battery scan
- BMS sales with the universal ESS systems
- Battery performance global database, tbd

TEAM

- With over 13 prior start-ups and 6 successful exits, Titan leads with a strong core team
- 16-person team with multi-disciplinary experience and a mix of entrepreneurs, scientists, and engineers (EE, Product, SE)
- Strong advisory board and collaboration with Carnegie Mellon and UMASS-Lowell

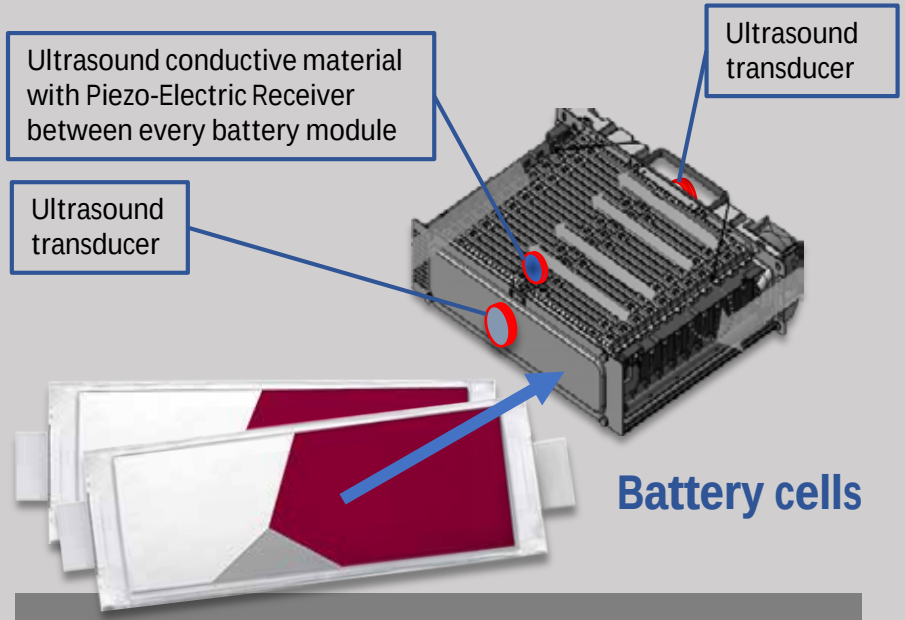
Billions of Batteries are Mismanaged Daily

To Illustrate the problem – $60B Loss in the Next 10 Years



Source: BNEF

Titan's Ultrasound 2L & BMS System



- **Control electronics augment or replace current BMS (Battery Management System)**
- **Titan proprietary algorithms process ultrasound signals providing accurate SoH and SoC for battery control**

State of Health (SoH): *usable capacity compared to original capacity*

Titan SoH: Real-time molecular scan, enabling direct determination of the actual SoH with **consistent 99% accuracy.**
System focuses on:

- The SSEI (secondary solid electrolyte interface) growth over time, which changes the mechanical structure of the anode
- Measuring SoH by monitoring structural changes via ultrasound

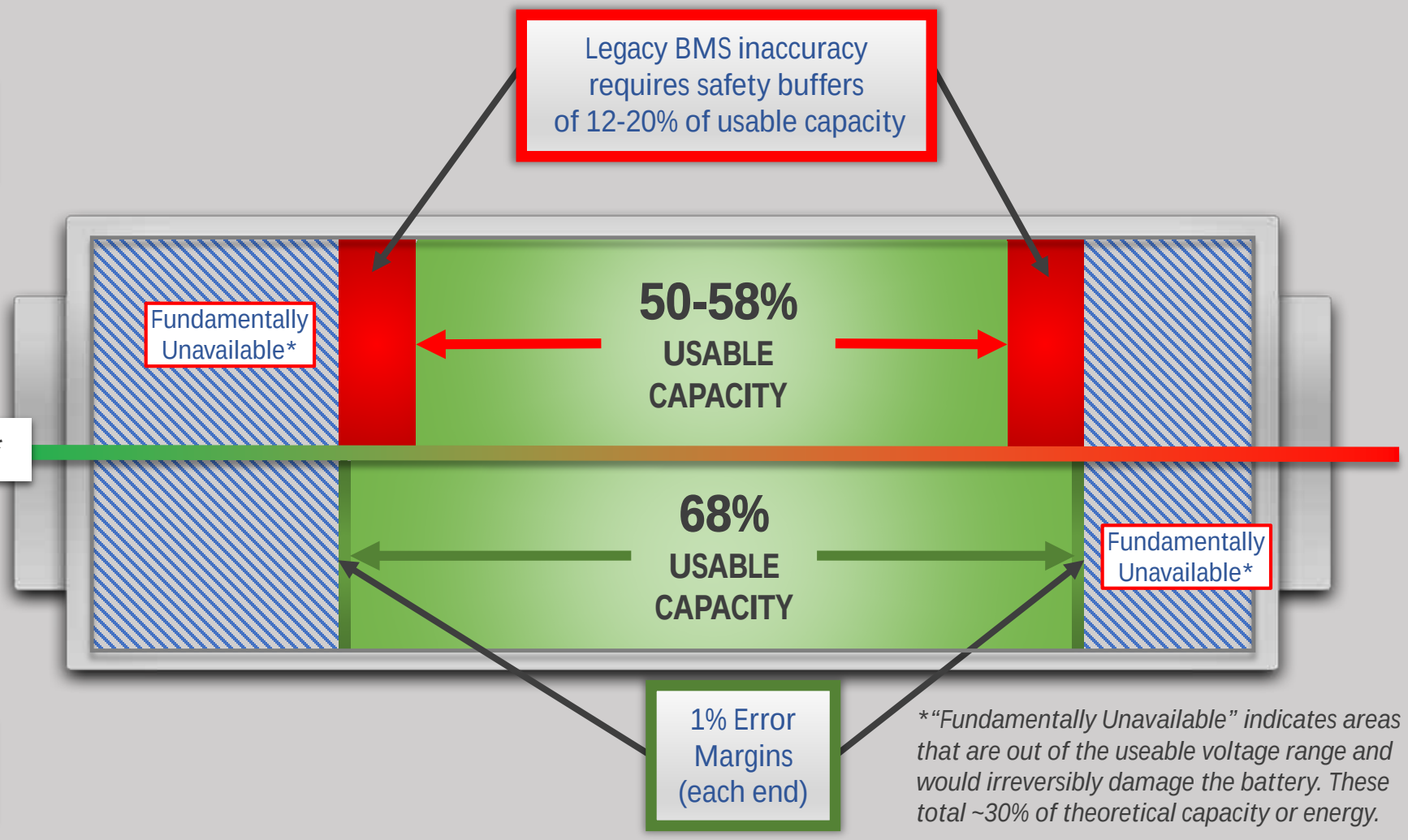
State of Charge (SoC): *remaining available capacity until charging is needed*

Titan SoC: Real-time scan with **consistent 99% accuracy.**
System focuses on:

- Battery charging (Lithium Ion intercalation) increases anode stiffness
- Measuring SoC by monitoring stiffness change via ultrasound

Titan Enables Significant Li-ion Usable Capacity Increase

Existing BMS



At Start of Battery Life**

*** SoH is well known at the start of battery life however, usage worsens SoH estimations, also impacting SoC calculations. Legacy BMS errors compound over time, requiring an even larger buffer.*

Titan

**“Fundamentally Unavailable” indicates areas that are out of the useable voltage range and would irreversibly damage the battery. These total ~30% of theoretical capacity or energy.*

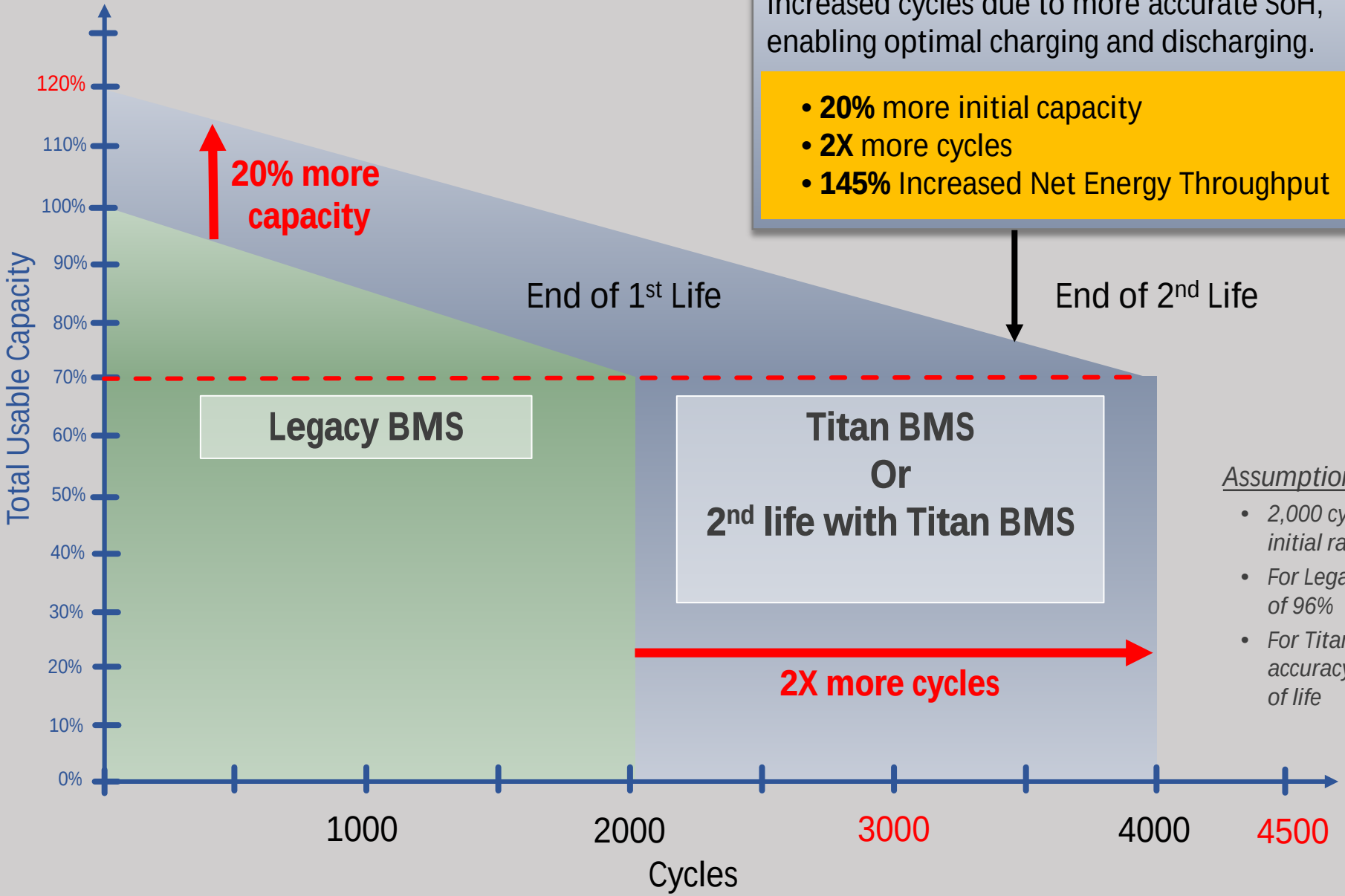
Titan’s 2nd Life product transforms the economics of energy storage by giving retired batteries from Electric Vehicles (EV) a second life in stationary storage solutions (schools, hospitals, etc).

An expensive, lengthy and remote process is now fast, accurate and in-situ.

Titan Delivers Extended Battery Lifetime and Increased Usable Capacity

Increased cycles due to more accurate SoH, enabling optimal charging and discharging.

- **20%** more initial capacity
- **2X** more cycles
- **145%** Increased Net Energy Throughput

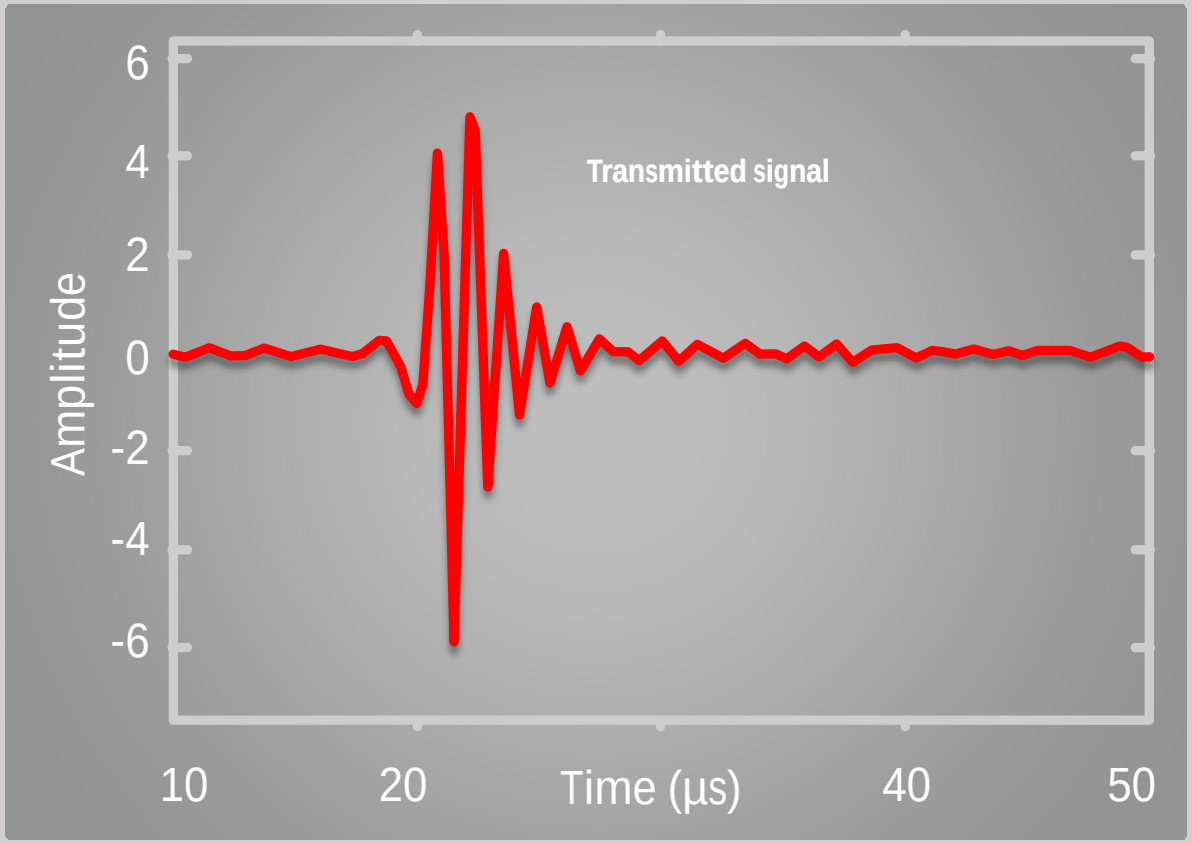


Assumptions:

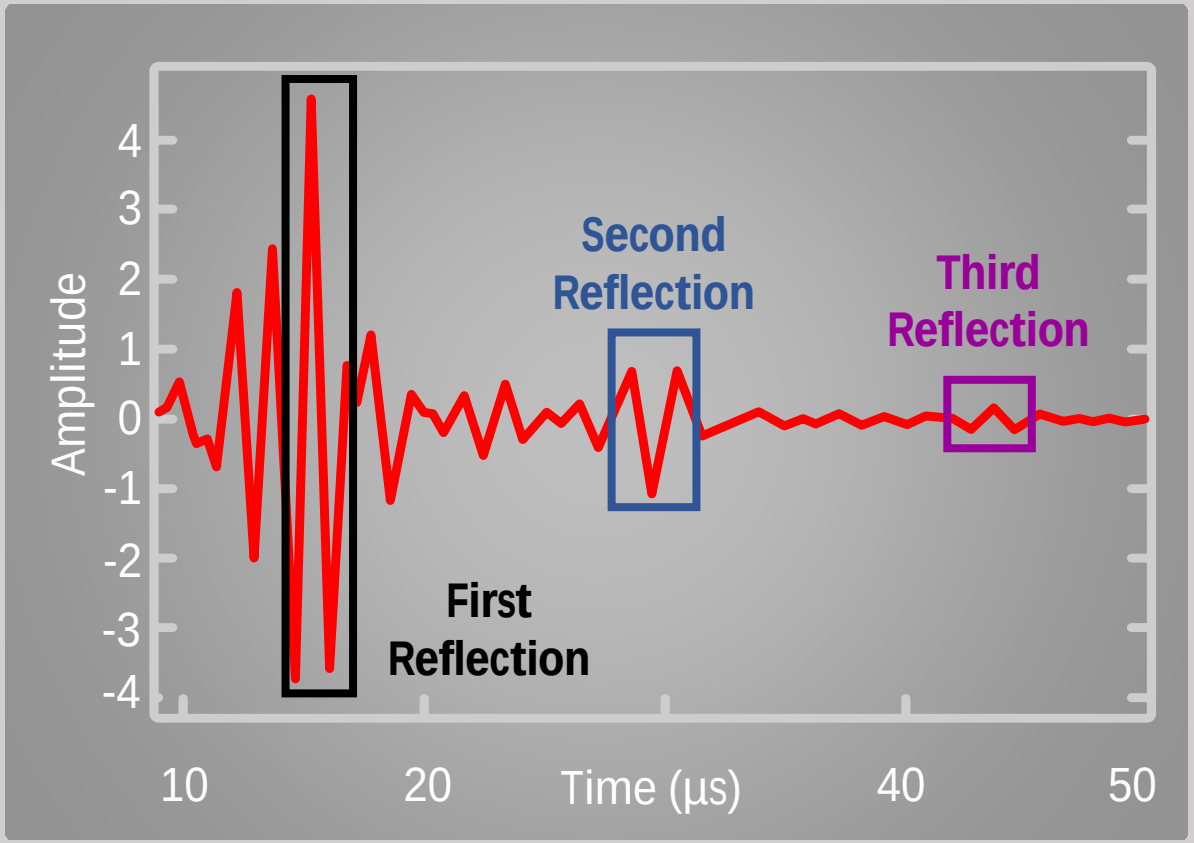
- *2,000 cycles at 80% DoD as an avg. life to 70% of initial rated capacity*
- *For Legacy BMS, we use best in class BMS accuracy of 96%*
- *For Titan (EOL1) we use BMS accuracy of +/- 1% accuracy to reduce existing BMS buffers at start/end of life*

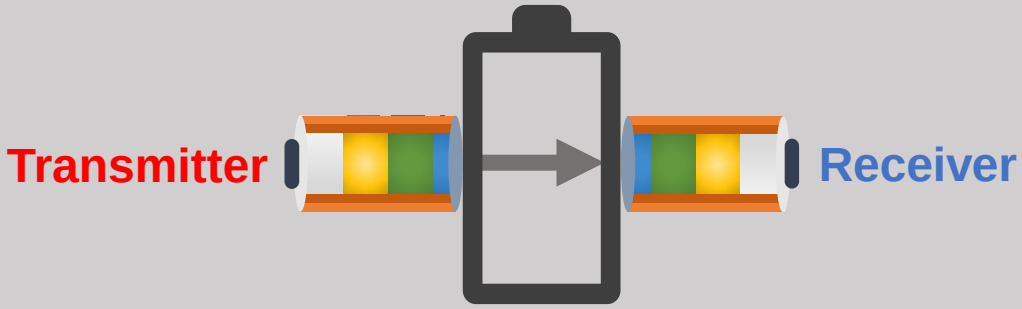
How Ultrasonic Data Looks

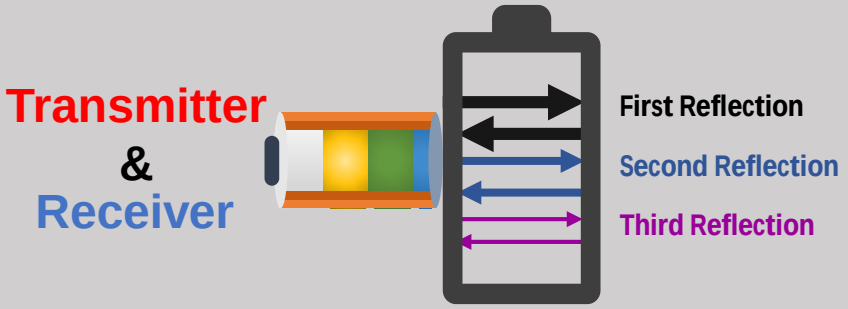
Transmission



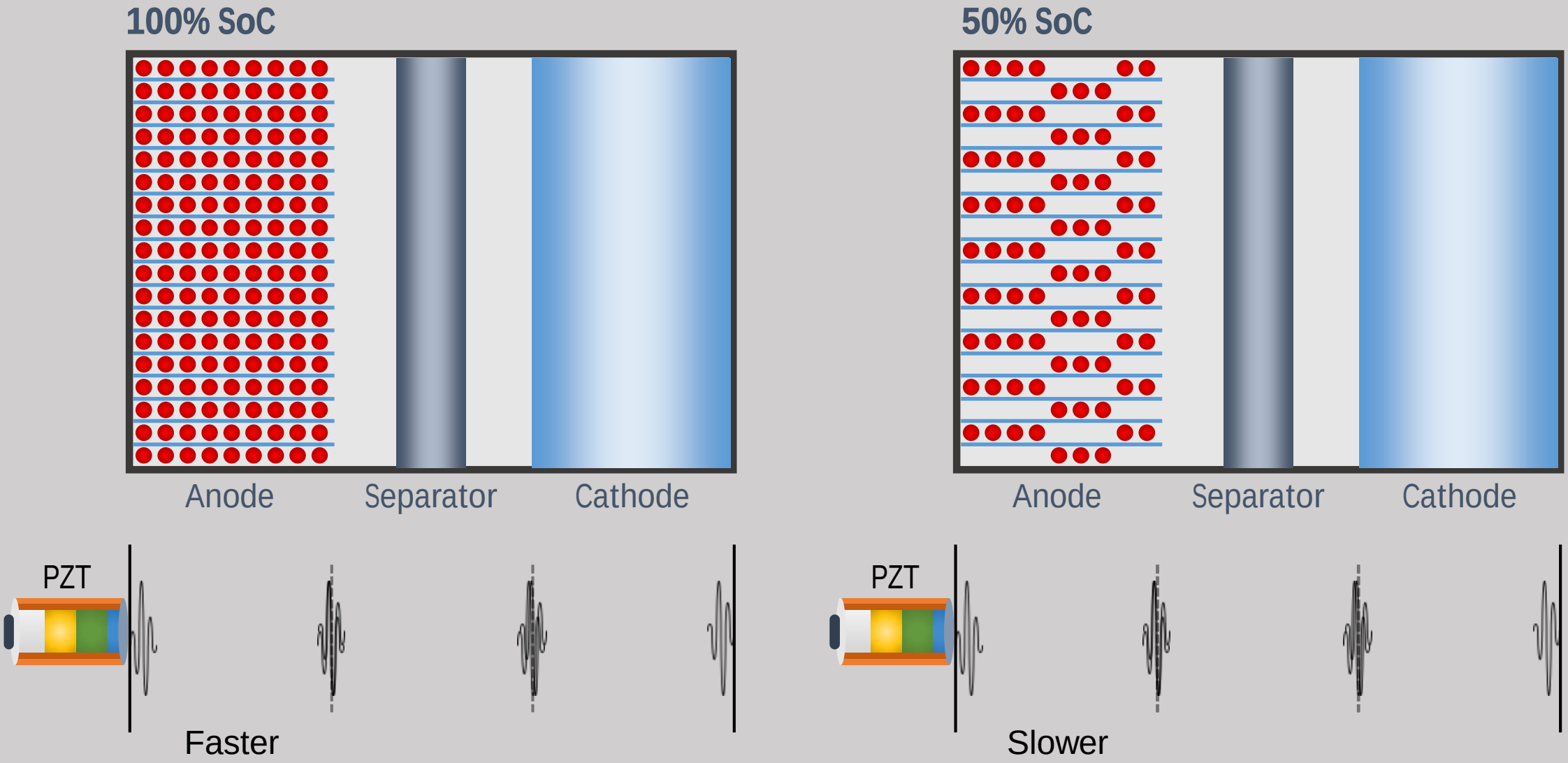
Reflection







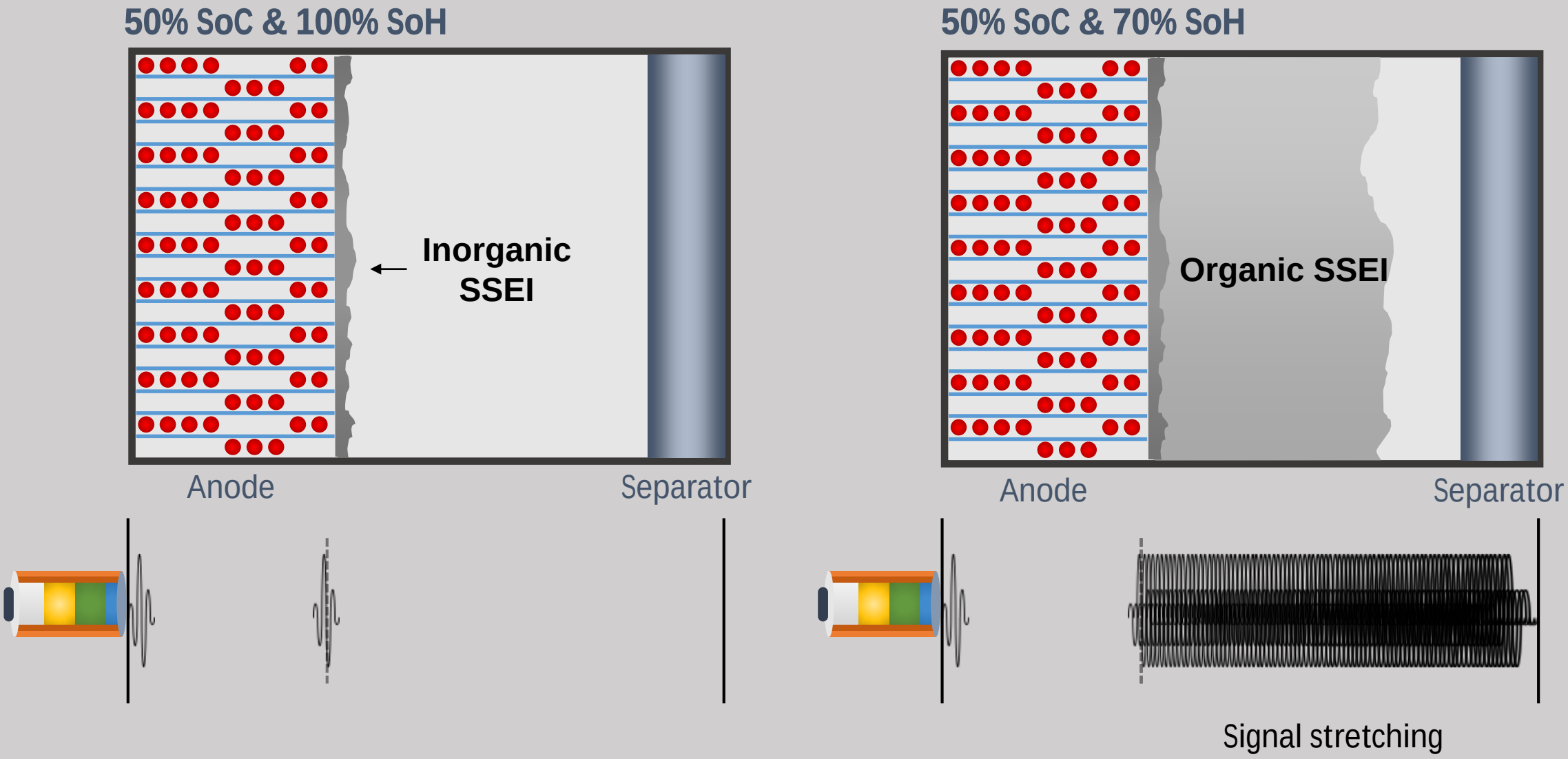
How Ultrasonic SoC (state of charge) Physics Works



● **Lithium ion**

Higher SoC increases the wave speed due to a stiffer anode

How Ultrasonic SoH (state of health) Physics Works

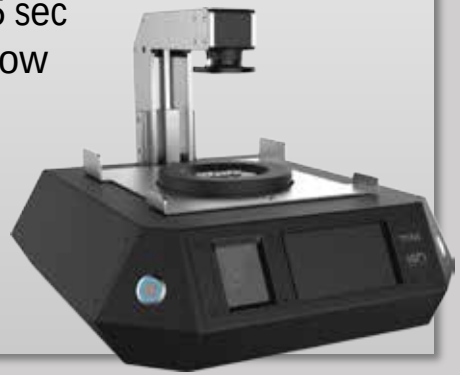


Growth of the SSEI, due to usage, leads to changes in wave property characteristics

Titan Target Markets and Business Models

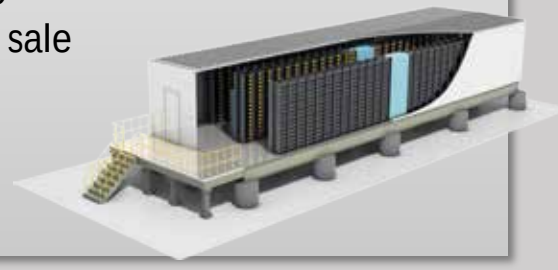
A 2nd LIFE EV BATTERIES

- **APPROACH:** Provide Titan machine to recyclers, auto service centers for rapid state of health scans, Scan as a Service (SaaS).
- **VALUE PROP:** SoH/SoC scans in <5 sec vs. current 8h+ , portable unit for low cost battery diagnostics.
- **REVENUE MODEL:** Pay per scan



B STATIONARY ENERGY STORAGE

- **APPROACH:** Partner with Schneider Electric to develop universal energy storage system (UESS) which can use new and 2nd life batteries
- **VALUE PROP:** Ability to utilize 2nd life batteries (20% cost of new) with full functionality.
- **REVENUE MODEL**: license or sale of BMS



C CONSUMER ELECTRONICS

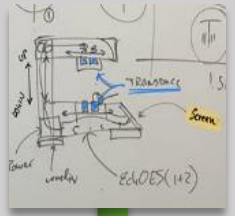
- **APPROACH:** Licensing/support model with one of the top three premium smartphone and laptop companies
- **VALUE PROP:** Increase safety and longevity while increasing overall capacity
- **REVENUE MODEL:** license per device

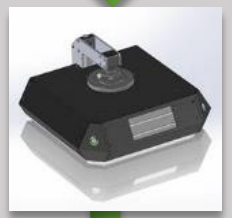
D ELECTRIC VEHICLES

- **APPROACH:** BMS licensing/support to global EV OEMs through tier one supplier / integrator
- **VALUE PROP:** Over $2,600 lower battery costs per vehicle or 20%+ increased range
- **REVENUE MODEL:** license per car

2L Scorpion: 2nd Life Battery Diagnostics System, Concept to Market in < 12 months

Concept (August '19)



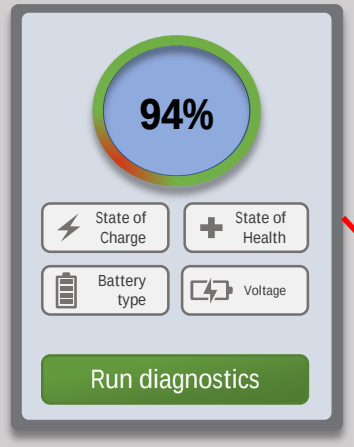


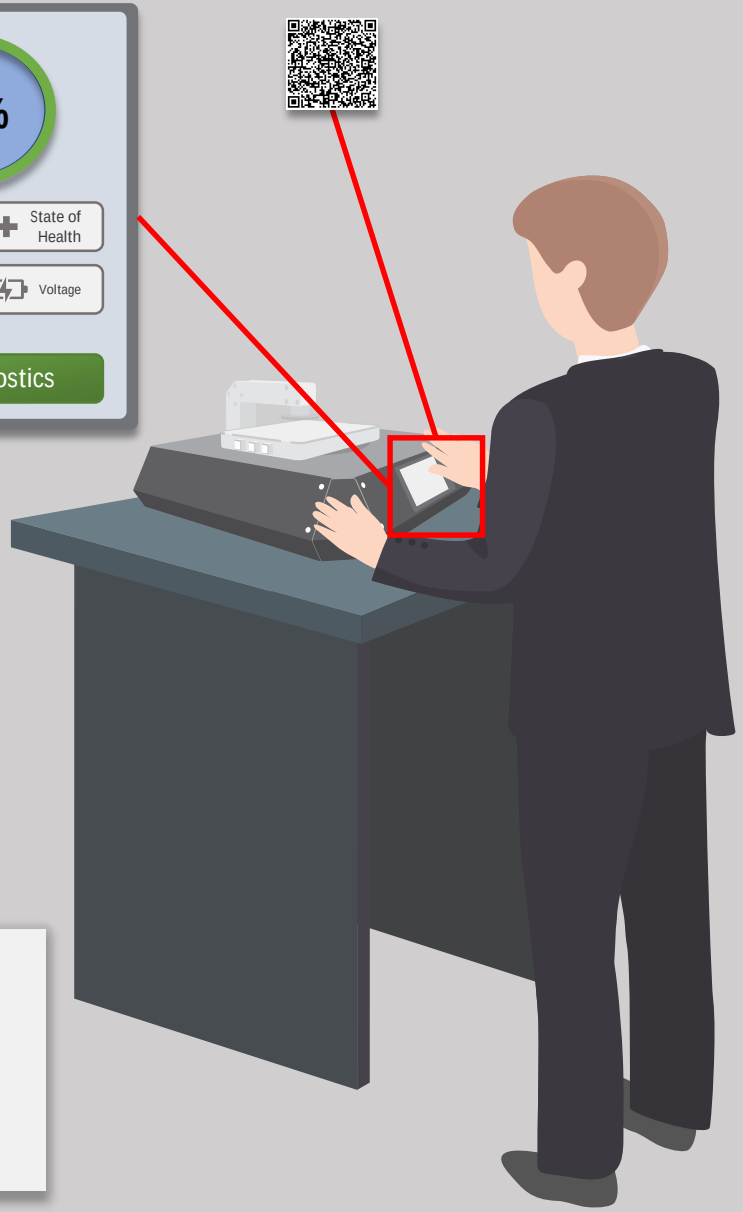
KEY FEATURES:

- Fast testing <1 second
- Accuracy at 99% (SoH/SoC)
- Battery connection not required
- Low Cost Unit
- Enables Scan as a Service Model (SaaS)
- Connected to Cloud for SaaS model
- Ready for Market end of Q2 2020

Scorpion Prototype
(November '19)

Gen 1 Scorpion
(March '20)





2L Scorpion dramatically shifts the economics of energy storage by cost-effectively performing battery diagnostics and giving used EV batteries a second life in stationary storage solutions (ESS-residential, commercial).

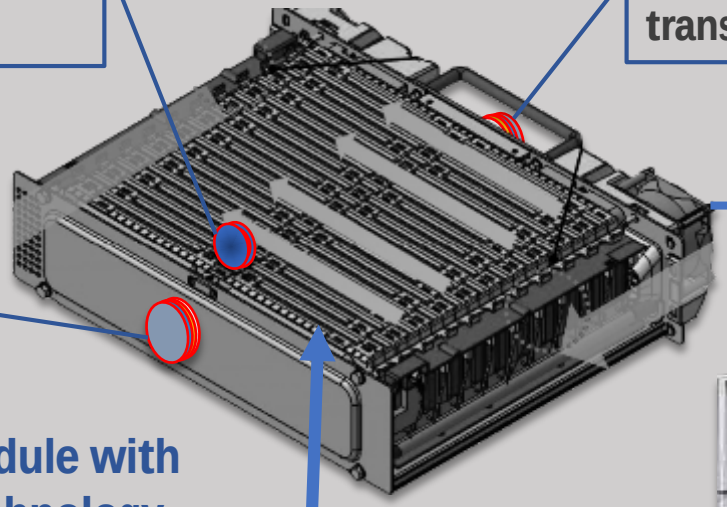
An expensive, lengthy, and remote process is now fast, accurate, and in-situ.

Energy Storage System, Architecture and Solution

Ultrasound conductive material with Piezo-Electric PVd/ PMUT Reciever between every battery module

Piezo ultrasound transducer

Piezo ultrasound transducer



Battery module with ionView technology

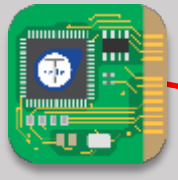
Battery cells

Battery container

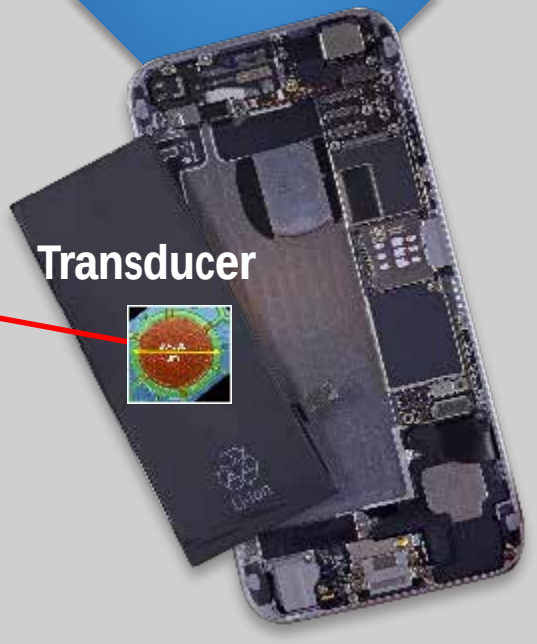
Battery rack

Consumer Electronics – 4 hours of additional battery life

PMIC EchOES board



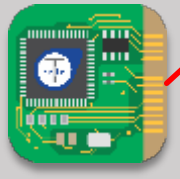
Transducer

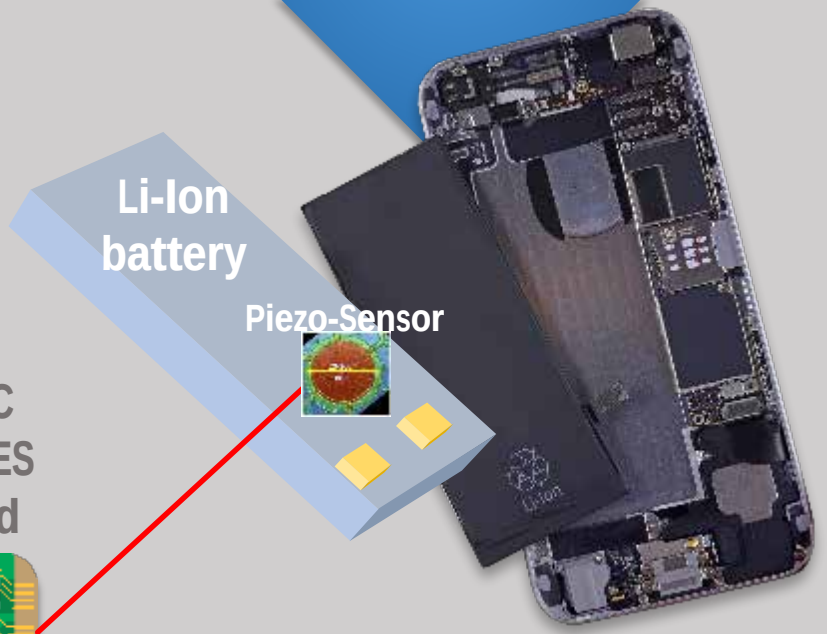


Li-Ion battery

Piezo-Sensor

PMIC EchOES board





Electric Vehicles – Titan Value Proposition (case study)

Production and Quality:

Q/A inspection of new batteries before being used in new cars (at factory)

Advanced BMS:

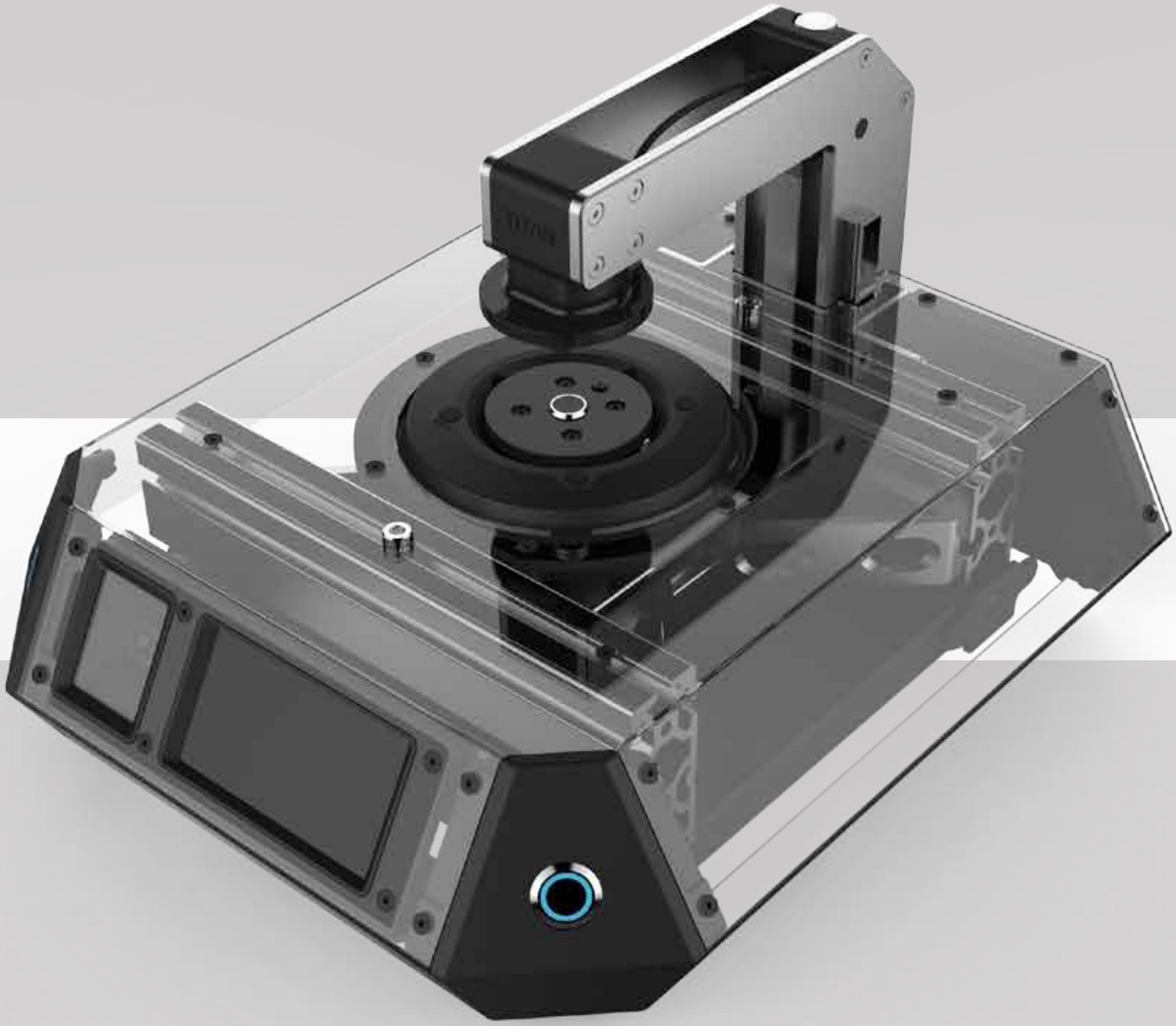
1. Increases overall capacity 20% - 30% with better accuracy and control, which translates in:
   a) Increased overall range vehicle with the same battery pack
   b) Reduce the battery pack which will translate into reduction of weight, space, and **cost**
2. Real-time high accuracy SoH obtains 2X on longevity of car batteries.
3. High accuracy SoH/SoC eliminates range anxiety, thus increasing customer satisfaction.

Automotive Maintenance Program Application:

1. Battery inspection at the annual maintenance check up (non-intrusive test), reducing inspection time from three days to several hours.
2. Fast sorting and evaluating battery modules for replacement purposes, increasing customer satisfaction.
3. Certified pre-owned test procedure, to evaluate remaining capacity and health of the battery.

2nd Life of EV Batteries:

1. Evaluating of battery pack/modules at dealership upon end-of-1st-life to be shipped to EPS
2. Track and trace of batteries from new car to end of life including recycling.



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ADVANCED ENERGY SOLUTIONS

Titan AES Team

Founders

Shawn Murphy
CEO | CTO

Entrepreneurial executive leader with 25 years of bottom-line driven experience. Shawn was the CEO of multiple successful start-ups, the head of Space Science & Technology at Draper Laboratory, and the founder of Shell TechWorks, Shell Innovation Center. His career spans multiple industries: Energy Systems (O&G and Renewables), Aerospace, Defense, IT Security, Semiconductor, and Consumer Electronics.

Sean O'Day
CCO | Pres

Seasoned serial entrepreneur who has been solving the challenge of deploying cost-effective solutions for Renewable Energy Generation combined with Grid Scale Energy Storage (GSES) to meet global energy demands. Most recently served as the Director of the Future Solutions Division of Sonnedix a global solar IPP. Deep expertise in grid scale energy storage, and utility scale solar

Titan Team

Steve Africk PhD.
Principal Scientist

Nemanya Sedoglavic PhD.
Head of Product Development

Jeff Kowalski PhD.
Head of Algorithms and Battery Scientist

Zoran Djordjevic PhD.
Sr. Data Scientist

Dan Ledger MS.
Embedded Systems Engineer

Erik Soule
Product Architect

Zoran Coric MS.
Head of Hardware Development

Khoi Cao MS.
Embedded Systems Engineer

Todd Jensen BS.
Research Engineer

Michelle Quigley JD.
Director of People Success

Eli Battis BA.
IT Systems Administrator

Maya Shen MS
Machine Learning Engineer

Titan AES – Directors and Advisory Board

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Shawn Murphy
Chairman

Sean O'Day
Secretary

Scott Pearson
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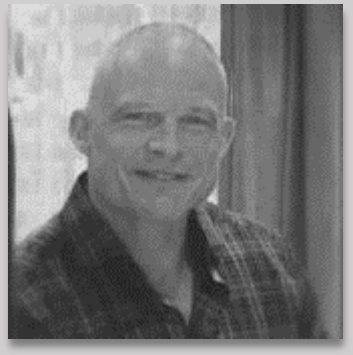
Jean-Luc Meyer
SVP Business Development
Schneider Electric

Ben Stanzl
Managing Director
Energy Innovation Capital

Advisory Board

Jay Whitacre
Professor of Material Science & Engineering, Carnegie Mellon University



Bart Riley
CEO & Founder of Metalenz.

Ryan Wartena
President & Director of Product at Geli

Anna Carolina Tortora
Head of Innovation Strategy at National Grid, UK

Daniel Erasmus
The Digital Thinking Network & CEO of NewsConsole

Jose Gutierrez
Executive Director of Hardware Engineering at Bently Nevada, Inc.