

Status of AIAA S-144-2018 “American National Standard, Specification: Space Battery Cell, Large, Prismatic Format”

Brad Reed, Associate Fellow, AIAA

Sam Stuart, NSWC Crane

Jim Lee, Lockheed-Martin

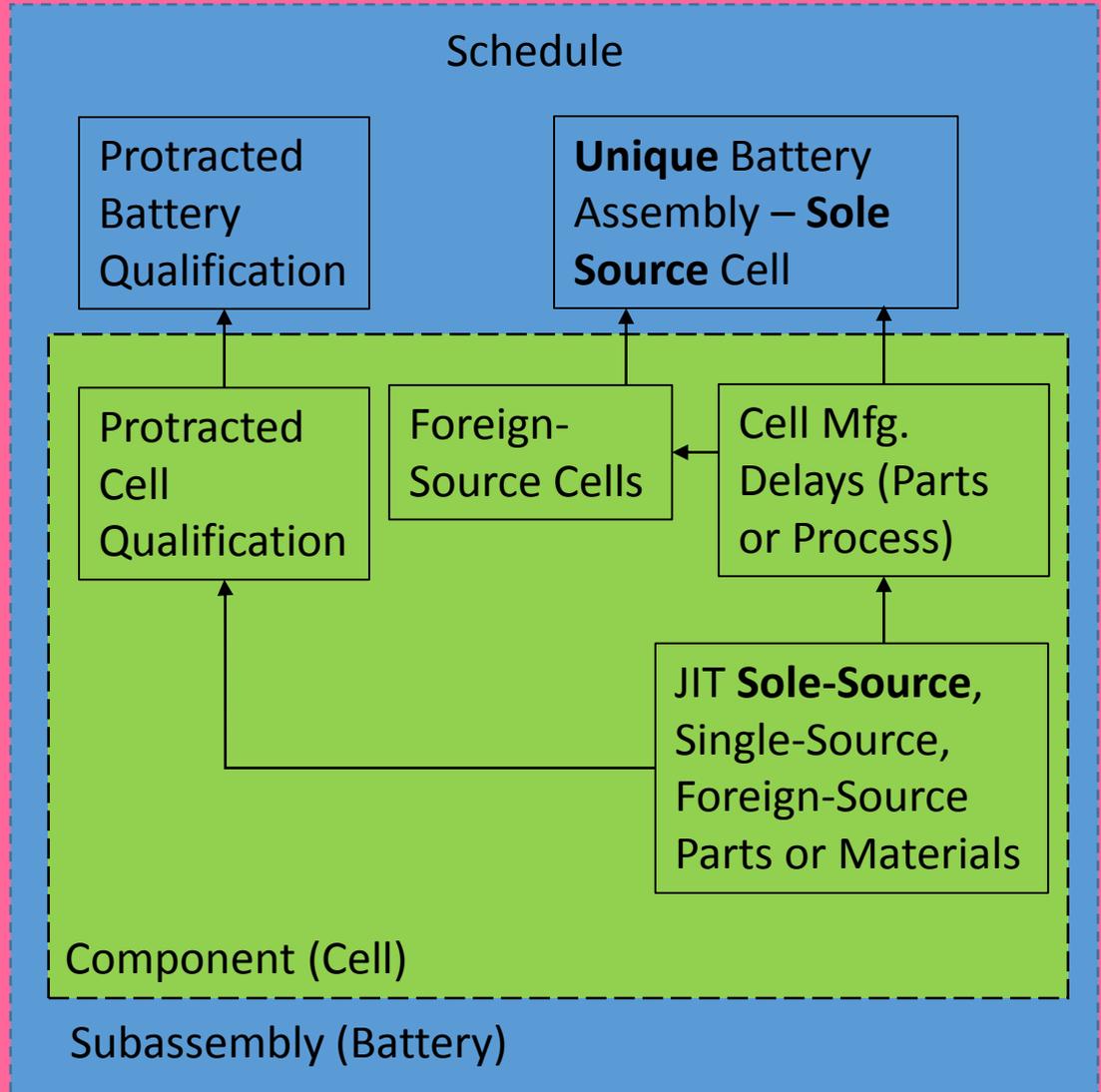
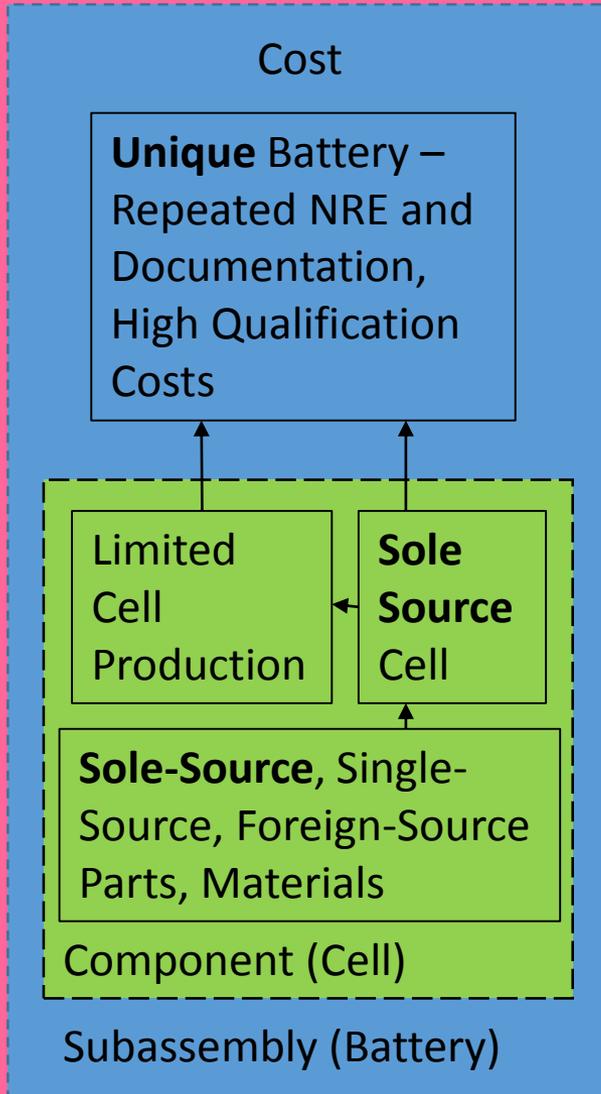
NASA Aerospace Battery Workshop, November 15, 2017

Issues Due to Space Cell Production Delays

- Global
 - Space Program Cost Delays for All Countries/Governments/Organizations (\$B)
 - Human Cost of Delayed Asset Deployment
- Prime Contractor
 - Redesign, Re-Qualification, and Significant Schedule Impact (\$M) due to issues stemming from production delays of unique cell designs

Power Subsystem Impacts - Enterprise Perspective

Sole-Source Risks



Systems-Level Cost Issues for Large Space Batteries

- **Program Office Costs Due to Schedule Delays**
- **Prime Contractor Costs for Specialty Engineering**
- **Qualification Costs**
- **Sole-Source, Single-Source, and Foreign-Source Cost Risks**
- **Cell Manufacturer Costs: Less Throughput**

Commoditization: Standardizing Li-ion Cell Sizes for Large Missions (NASA, USAF, Commercial)

- State of Practice (Small Missions)
 - 18650: Approximately the size of a “AA” cell, up to 3.5 A-h capacity
 - 26650: Approximately the size of a “C” cell, up to 6 A-h capacity
- **Goal: Commercial off the Shelf (COTS) Cell for Large Missions: Approximately 6.8” x 3.2” x 2” with up to 75 A-h capacity**



COTS “Common Configuration” Cell

- Design initiated 15 years ago
- Implemented at multiple cell manufacturers
- Tested at USG and Prime Contractors
 - 4 variants of Li-ion chemistries
- Baselined for select future missions at four organizations

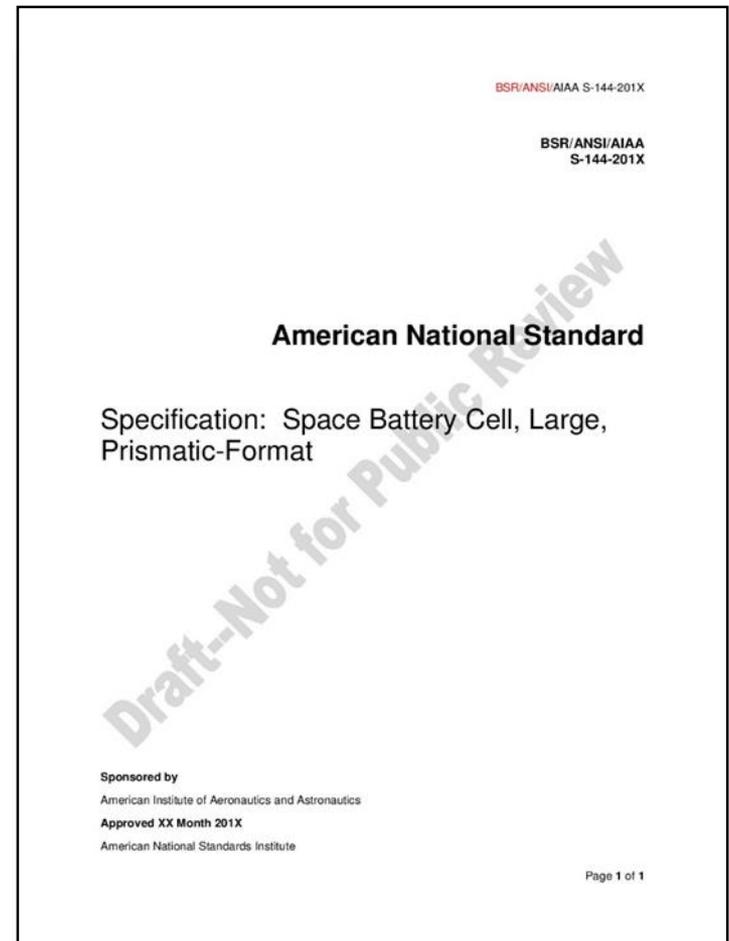


History

- April 2016: DLA Study indicated problems within the Prime Contractor/Battery/Cell supply chain
 - Study organizers encouraged by government, prime contractors, and cell manufacturers to help find solution
 - Design implementation of “common component” cell with standard outer cell dimensions is noted for 75 A-h cells
- May 2016: Seed document written for AIAA S-144-201X
- June 2016: Editing of AIAA S-144-201X performed by steering committee
- July 2016: Editing of AIAA S-144-201X performed by larger working group
- August 2016: Working group implements 8 of 9 pages of Aerospace Corporation/USAF proposed changes in document
- September 22, 2016: First meeting of AIAA Committee to edit AIAA S-144-201X
- September 2016 – Present: Editing of AIAA S-144-2018

AIAA Li-ion Space Cell Commoditization Committee on Standards (CoS): AIAA S-144-2018

- AIAA CoS Includes **41 Organizations**
 - Government Customers
 - Prime Contractors
 - Battery Assemblers
 - Cell Manufacturers
 - Range Safety (East and West)
- **Standardize** cell design (approximately 6.5"x3"x2") produced by multiple cell vendors
- Issue: **Stockpiles** of heritage NCA, LCO and MCMB will be **exhausted in 2-3 years**
- Solution: **Test programs on four (4) Li-ion chemistry variants through two organizations using S-144-201X:** domestic NCA/MCMB, domestic LCO/MCMB, Vector, and "ZeroVolt"
- **Tailorable standard** to enable quicker new technology introduction
- AIAA S-144-201X modified to industry standard operating procedure



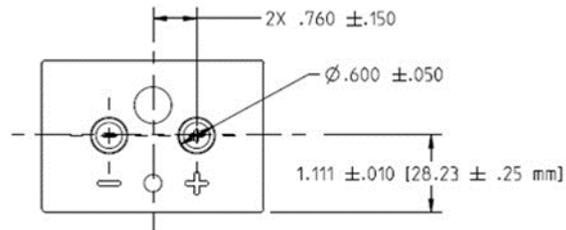
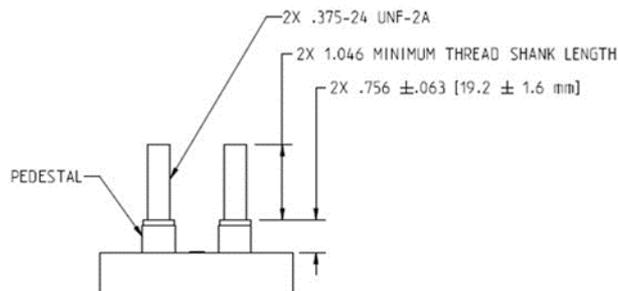
AIAA CoS Participants

- Government
 - USAF Space and Missile Systems Center – AEHF, SBIRS, GPS, Launch Wing, Chief Engineer’s Office, Advanced Development (Science)
 - NASA – Glenn (ISS), Goddard (Space Science), Johnson (Planetary Missions), Marshall (Launch Vehicle)
 - NSWC Crane
 - Defense Logistics Agency
 - OGA
- Prime Contractors
 - Ball, Boeing, Firefly, Lockheed-Martin, Northrop-Grumman, Orbital/ATK, Space Systems Loral, SpaceX, United Launch Alliance
- Battery Assemblers
 - ABSL
- Cell Manufacturers
 - EaglePicher, GS Yuasa, EnerSys (Quallion), Saft, EaglePicher Yardney Division
- Range Safety
 - USAF Kennedy (45th), NASA Kennedy, USAF Vandenburg (30th), NASA Wallops
- FFRDCs, Consultants
 - Aerospace Corporation, Teledyne, Jet Propulsion Laboratory, Salim, Airbin, Voltaiq
- Academic
 - Kyushu Institute of Technology, Texas A&M

COTS Cell

- 15-year-old “Standard” Cell Design
- Produced by Saft, EaglePicher, and Energys (Quallion)

Dimension	Nominal Measurement	Tolerance
Length	171.9 mm (6.768")	± 1.0 mm (.039")
Width	80.95 mm (3.187")	± .5 0 mm (.019")
Thickness	56.45 mm (2")	± .50 mm (.019")
Terminal Height Above Top of Cell	Up to 55.75 mm (2.222")	N/A
Fill Tube Height above Top of Cell	Up to 15.7 mm (.618")	N/A



Solutions: AIAA S-144-2018, “Specification, Space Battery Cell, Large Format”

- Reduce Program Office Costs Due to Schedule Delays
 - **Provide COTS drop-in alternatives from multiple manufacturers**
- Minimize Prime Contractor Costs for Specialty Engineering
 - **Make batteries modular and scalable, reducing the need for changes in mission-specific battery design assembly, documentation, and requalification**
- Reduce Costs of Qualification
 - **Standardize qualification and acceptance tests based on international requirements**
- Reduce Sole-Source, Single-Source, and Foreign-Source Cost Risks to Production
 - **Encourage dual-source parts to reduce sole-source, single-source, and foreign-source risks**
- Reduce Cell Manufacturer Costs: Commoditization
 - **Standardize Qualification and Acceptance reports and reporting formats, improving customer awareness of alternatives for new missions**
 - **Require manufacturer transparency to resolve any issues that affect parts, materials, and processes, or form, fit, and function**
 - **Establish one standardized cell in the 50-75 A-h range for large missions, developing an economy of scale for cell manufacturers**

CoS Addressing Ongoing Industry Issues: USDOT/UN 38.3 Discrepancy

- **Identified in CoS discussions with UN and USDOT representatives**
- **United Nations** - Recommendations on the Transport of Dangerous Goods: Model Regulations, Volume I, Nineteenth revised edition. Within this document, in the Annex: Model Regulations on the Transport of Dangerous Goods, on page 317, Part 3, Chapter 3.3 - Special Provisions Applicable to Certain Articles or Substances, Section 310, it states "The testing requirements in the Manual of Tests and Criteria, part III sub-section 38.3 **do not apply to production runs consisting of not more than 100 cell and batteries**, or to pre-production prototypes of cells and batteries when these prototypes are transported for testing when packaged in accordance with packing instruction P910 of 4.1.4.1'.
- **United States** - CFR 49(B)(I)(C)173(E)173.185 Code of Federal Regulations Title 49: Transportation, Subtitle B, Chapter I, Subchapter C, Part 173, Subpart E, §173.185 Lithium cells and batteries. "**Low production runs (i.e., annual production runs consisting of not more than 100 lithium cells or batteries)**, or prototype lithium cells or batteries, including equipment transported for purposes of testing, are excepted from the testing and record keeping requirements of paragraph (a) of this section" (https://www.ecfr.gov/cgi-bin/textidx?SID=06ea53b061b2298779c2de648e10986b&mc=true&node=se49.2.173_1185&rgn=div8)
- Two problems highlighted by difference between UN and US language (5/12/17):
- **"Cells" and "batteries of cells" are different - which standard should be followed?**
- **What is the standard - annual production runs, runs from a single production lot, or production runs of a single product?**

CoS Addressing Ongoing Industry Issues: AFSPCMAN 91-710 Practice/Procedure Discrepancy

- Discrepancy between AFSPCMAN 91-710 State of Practice and existing procedure for Range Safety
 - AFSPCMAN last updated in 2004
 - The 2004 version applied to Ni-H chemistries, but not necessarily the emerging Li-ion chemistry
 - Interim changes to range safety procedures based on Li-ion experience have been compiled and are practiced at both Vandenburg and Kennedy, however
 - **The interim changes have not been incorporated in AFSPCMAN 91-710**
 - **Through CoS discussion, range safety state of practice is incorporated in AIAA S-144-2018**
 - USAF safety professionals at Air Force Space Command have been informed that practice is different than the current codified procedure

CoS Addressing Ongoing Industry Issues: Standard Reviews

- First draft of AIAA S-136-201X has been released for public review
 - Issues with discrepancies between existing standards
 - Issues with cost increases
 - Issues with schedule increases
- Final Draft of AIAA S-144-2018 to be released shortly
- How can you help?
 - Review AIAA S-144-2018 and/or AIAA S-136-201X with comments that help practical implementation of standards
 - Contact Brad Reed for further information

Summary

- AIAA Li-ion Space Cell Commoditization Committee on Standards addressing:
 - Program Office Costs Due to Schedule Delays
 - Prime Contractor Costs for Specialty Engineering: No Large Standardized Cells
 - Costs of Qualification
 - Sole-Source, Single-Source, and Foreign-Source Cost Risks to Production
 - Cell Manufacturer Costs: Commoditization
 - UN 38.3, USDOT, and AFSPCMAN 91-710 Discrepancies
- AIAA S-144-2018 Currently Being Edited
- Four variants of Li-ion chemistries being tested to AIAA S-144-2018
- **S-144 Standard to be Published in 2018 – need help with review**
- **S-136 Standard CURRENTLY in public review period – last chance to register comments**