National Aeronautics and
Space Administration

2025 NASA

Battery Passivation – What NASA needs you to know

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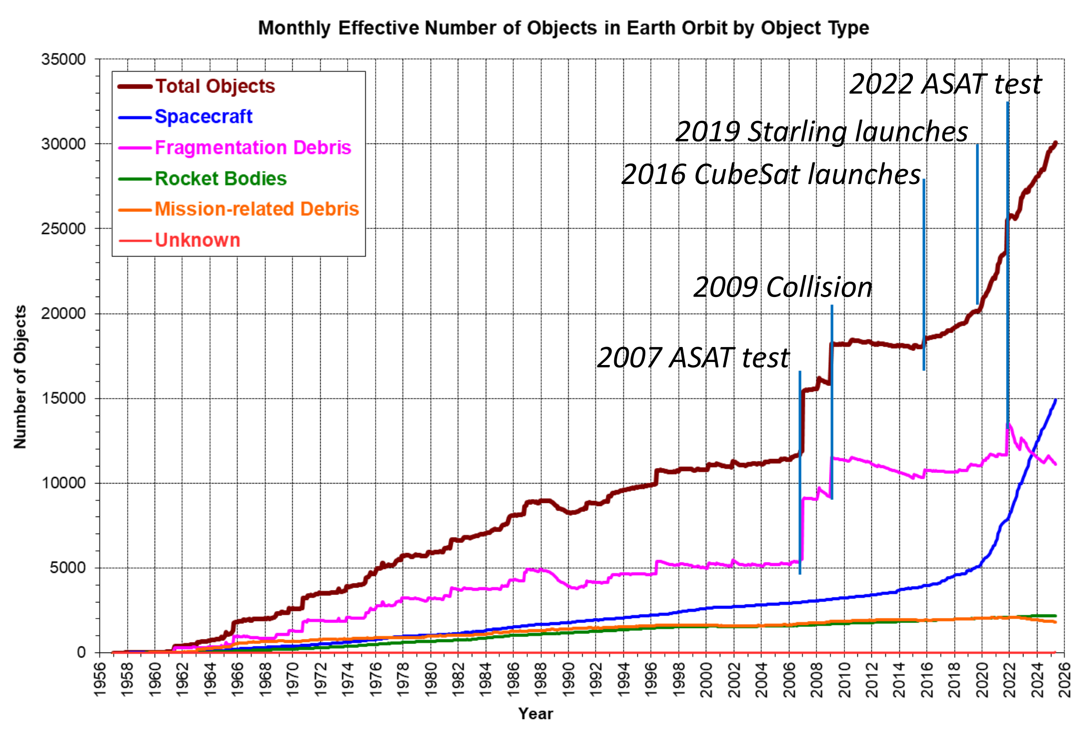
BLUF: NASA Battery Passivation

Goals of this talk:

- Identify and understand battery passivation techniques that can be implemented by NASA projects

Why: Changing space environment

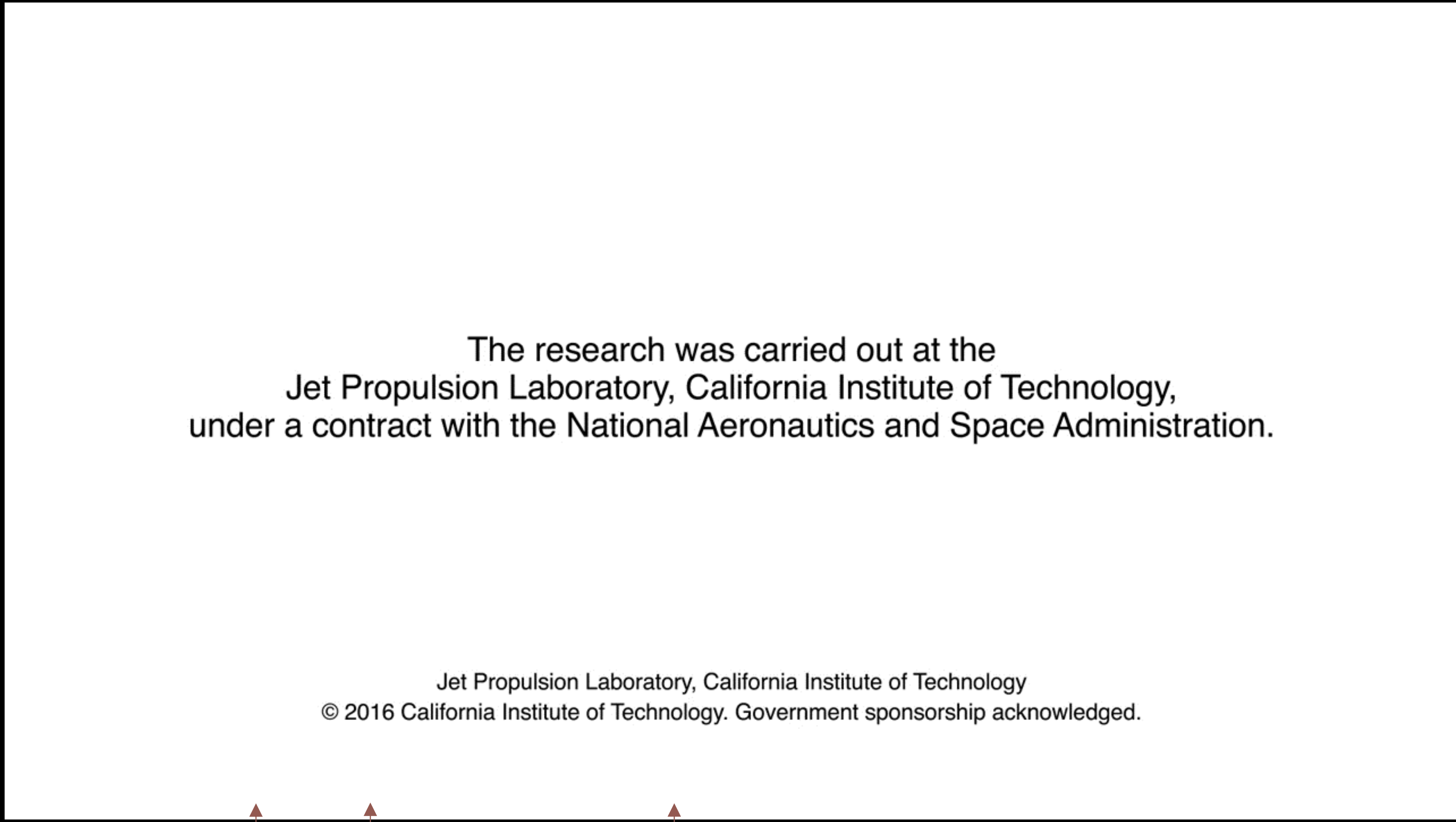
- National Space Policy to limit creation of new debris
  - NASA Technical Standard 8719.14c, based on Orbital Debris Mitigation Standard Practice (ODMSP) requires limiting creation of orbital debris during operations and after end of mission
- NASA is increasingly utilizing Commercial Spacecraft busses
  - Heterogenous implementation of battery passivation standards by commercial spacecraft



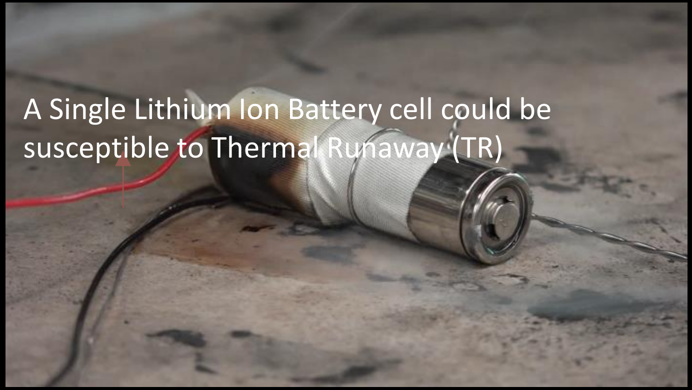
The population of LEO objects from the US Space Surveillance Network through June 2026. Two collisions, the FY-1C ASAT and Iridium 33/Cosmos 2251 collision caused large increases in debris in LEO.

What can go wrong?

Video: Robosimian Robot (notice reignition)



Video: 18650 Thermal Runaway



Batteries in TR can ignite and reignite. In case above 96 pouch batteries 2kWh energy, not configured to protect for overcharging

https://www.youtube.com/watch?v=hm18s-NYLZU https://www.washingtonpost.com/travel/2025/03/28/air-france-lost-cellphone/

The Washington Post
Democracy Dies in Darkness

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Why a plane turned around when a passenger lost a phone midflight

Airlines are cracking down on the use of lithium batteries after fires forced evacuations and destroyed planes.

March 28, 2025

5 min | 200

An Air France plane that took off from Paris Orly Airport on March 21 was forced to return about two hours later. (Julien de Rosa/AFP/Getty Images)

By Hannah Sampson

An Air France flight to the Caribbean returned to Paris last week after a passenger could not locate their cellphone, taking the "precautionary measure" to avoid a safety hazard if the unattended phone overheated. It was the airline's second Caribbean-bound flight to turn around because of a phone since early February as the aviation industry grapples with the risk of fires sparked by lithium batteries.

https://onemileatatime.com/news/air-france-777-diverts-missing-cell-phone/

ONE MILE AT A TIME

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Air France 777 Diverts To Paris Over Missing Cell Phone

Ben Schlappig | Published: March 21, 2025 | Updated: April 26, 2025 | 25

25

A long haul Air France flight diverted after a passenger misplaced their cell phone. You read that right.

In this post:

- Air France flight returns to Paris over misplaced cell phone
- The airline industry is a tough business, eh?
- Bottom line

Air France flight returns to Paris over misplaced cell phone

This incident happened today (March 21, 2025), and involves Air France flight AF750, scheduled to fly

Minimizing debris generation from accidental explosions: US Govt Orbital Debris Mitigation Standard Practice (ODMSP) and NASA Technical Standard 8719.14C

	During Operation	After Mission End
ODMSP	ODMSP, Obj 2-1. ***Limiting the risk to other space systems from accidental explosions and associated orbital debris during mission operations***	ODMSP, Obj 2-2 ***Limiting the risk to other space systems from accidental explosions and associated orbital debris after completion of mission operations***
NASA Technical Standard 8719.14c	NS 8719.14C, Req. 4.4-1. ***Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon***	NS 8719.14C, Req. 4.4-2. ***Design for passivation after completion of mission operations while in orbit about Earth, or the Moon***

Minimizing debris generation from accidental explosions: US Govt Orbital Debris Mitigation Standard Practice (ODMSP) and NASA Technical Standard 8719.14C

	During Operation	After Mission End
ODMSP	ODMSP, Obj 2-1. ***Limiting the risk to other space systems from accidental explosions and associated orbital debris during mission operations*****:** In developing the design of a spacecraft or upper stage, each program should demonstrate, via commonly accepted engineering and probability assessment methods, that the integrated probability of debris-generating explosions for all credible failure modes of each spacecraft and upper stage (excluding small particle impacts) is less than 0.001 (1 in 1,000) during deployment and mission operations	ODMSP, Obj 2-2 ***Limiting the risk to other space systems from accidental explosions and associated orbital debris after completion of mission operations:*** All on-board sources of stored energy of a spacecraft or upper stage should be **depleted** or **safed** when they are no longer required for mission operations or postmission disposal. Depletion should occur as soon as such an operation does not pose an unacceptable risk to the payload. Propellant depletion burns and compressed gas releases should be designed to minimize the probability of subsequent accidental collision and to minimize the impact of a subsequent accidental explosion.
NASA Technical Standard 8719.14c	NS 8719.14C, Req. 4.4-1. ***Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon*****:** For each spacecraft and launch vehicle orbital stage employed for a mission (i.e., every individual free-flying structural object), the program or project shall demonstrate, via failure mode and effects analyses, probabilistic risk assessments, or other appropriate analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts).	NS 8719.14C, Req. 4.4-2. ***Design for passivation after completion of mission operations while in orbit about Earth, or the Moon*****:** Design of all spacecraft and launch vehicle orbital stages shall include the ability and a plan to either 1) deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or postmission disposal or 2) control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft. The design of depletion burns and ventings should minimize the probability of accidental collision with tracked objects in space.

Battery Passivation workshop at JSC

- ~50 Attendees: OSMA, SMD, STMD, ODPO, NESC, FCC, USSF, ARC, GSFC, JPL, JSC, KSC, Industry partners.
- Hybrid format

This gathering aimed to clarify passivation requirements, improve understanding of relevant technologies, and establish consistent interpretation and implementation of passivation procedures across NASA missions and commercial partners.

Workshop Takeaways – 1 of 3

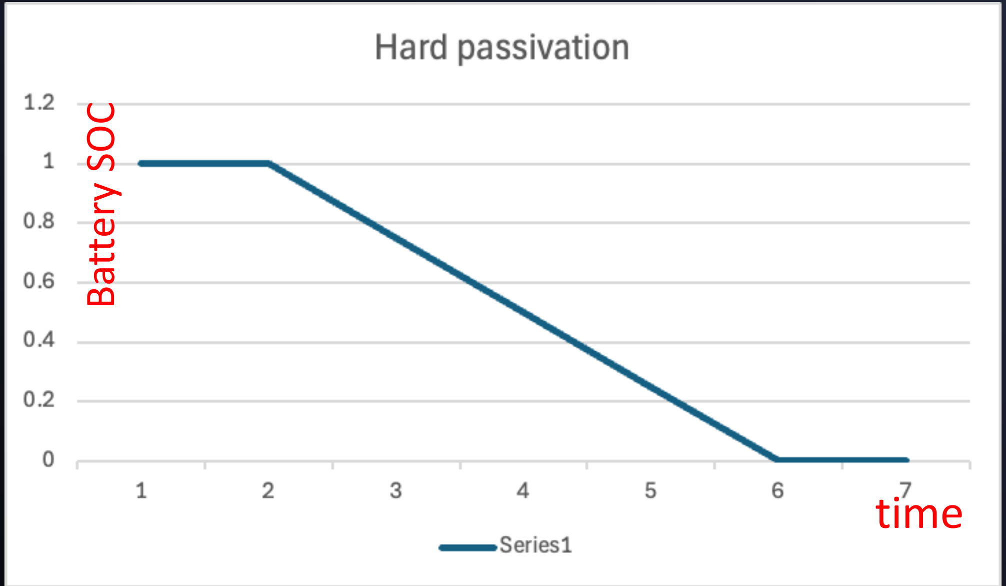
Battery Passivation is a critical process in spacecraft design to deplete stored energy in batteries at the end of mission life to mitigate the risk of orbital debris creation. The following strategies and considerations have been identified to comply to requirements:

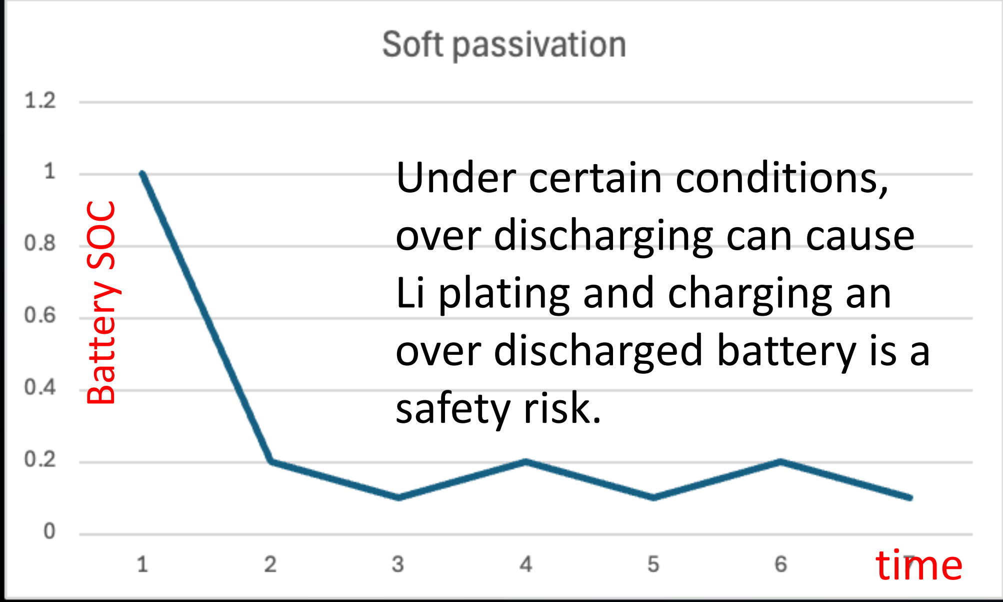
1. DEPLETE STORED BATTERY ENERGY: *disconnect battery from charging circuit*
2. OTHER METHODS: *Containment*
3. SCENARIOS WHERE PASSIVATION MAY BE UNNECESSARY:
   a. *If spacecraft is in operation until demise*
   b. *If it can be proven that the batteries will not generate orbital debris*

Over discharging can cause Li plating and charging an over discharged battery is a safety risk.

Deplete Stored Battery Energy

1. DEPLETE STORED BATTERY ENERGY:
    a. *Hard Passivation*
    b. *Soft Passivation*
2. OTHER METHODS: *Containment*
3. SCENARIOS WHERE PASSIVATION MAY BE UNNECESSARY:
    a. *Operate until demise*
    b. *Non-debris generating batteries*

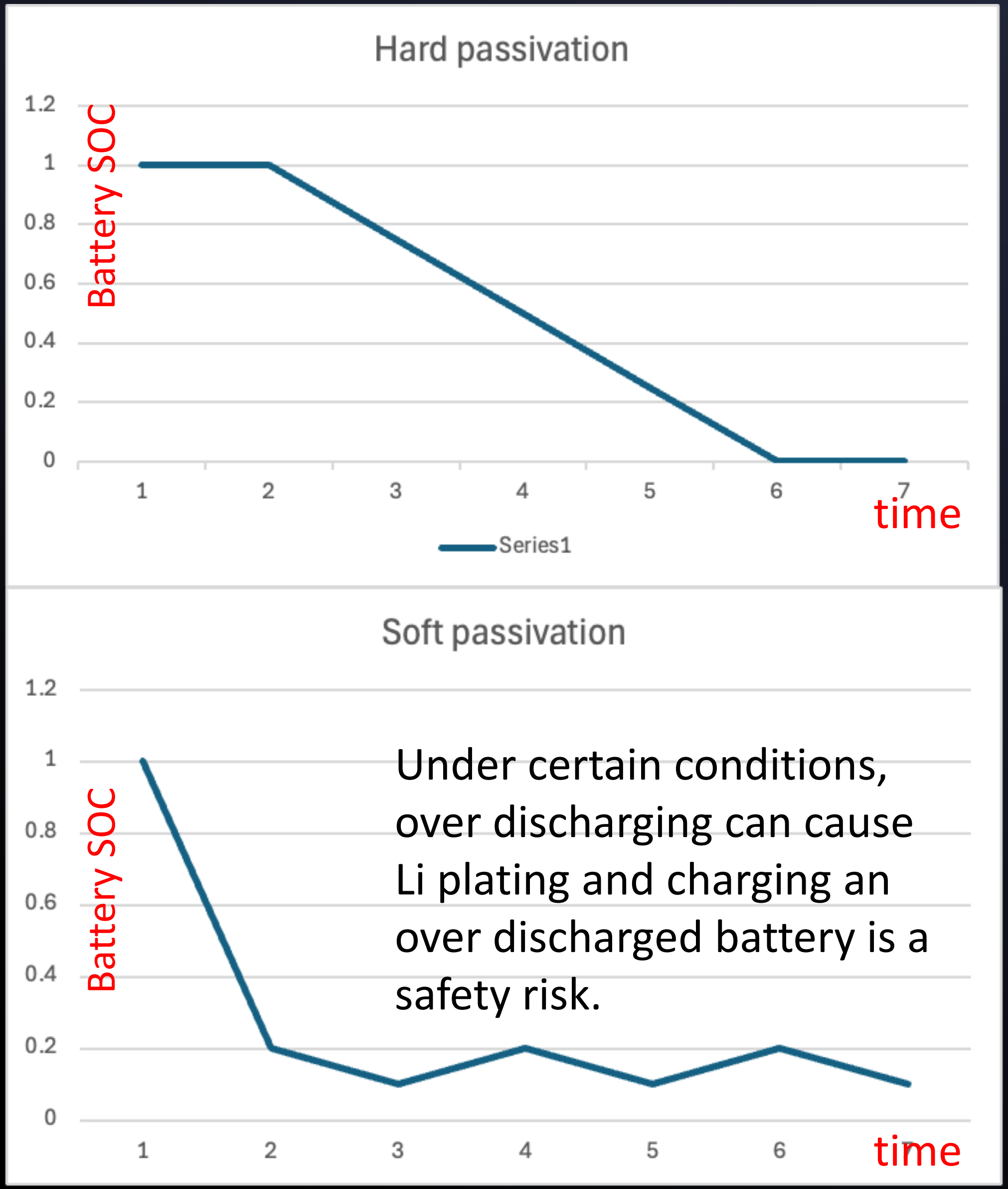




Cartoon of battery state of charge (SOC) for hard and soft passivation

Containment

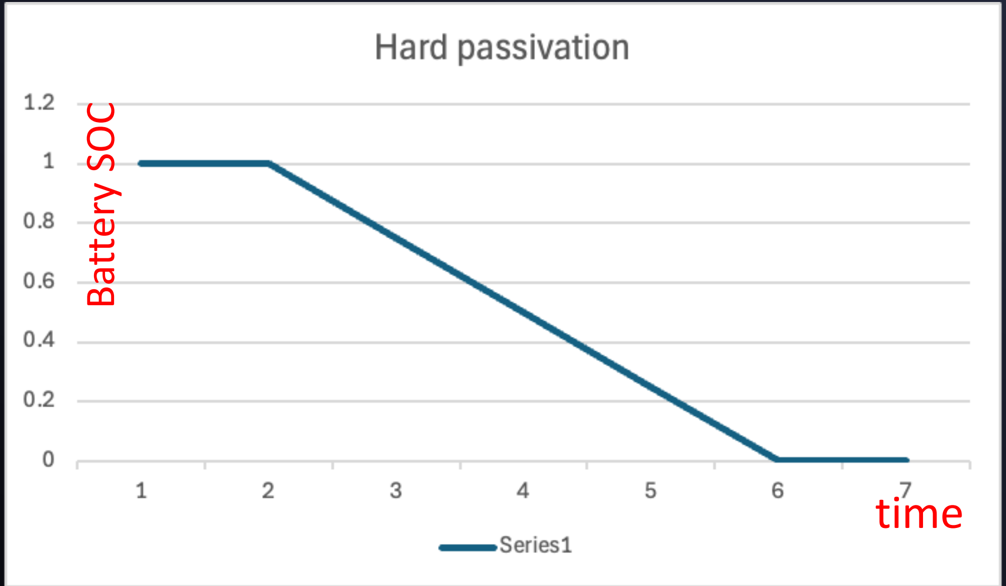
1. DEPLETE STORED BATTERY ENERGY:
    a. Hard Passivation
    b. Soft Passivation
2. OTHER METHODS: *Containment*
    a. Containment could effectively prevent release of orbital debris (defined as particles greater than 1mm) at the Battery's anticipated end of life state.
3. SCENARIOS WHERE PASSIVATION MAY BE UNNECESSARY:
    a. Operate until demise
    b. Non-debris generating batteries

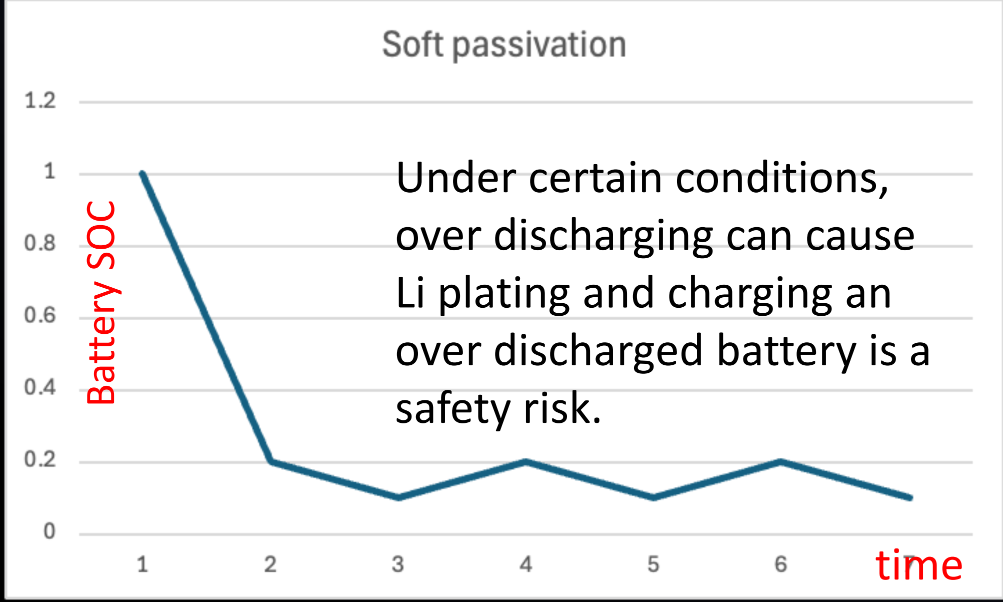


Cartoon of battery state of charge (SOC) for hard and soft passivation

Deplete Stored Battery Energy

1. DEPLETE STORED BATTERY ENERGY:
    a. Hard Passivation
    b. Soft Passivation
2. OTHER METHODS: Containment
3. SCENARIOS WHERE PASSIVATION MAY BE UNNECESSARY:
    a. Operate until demise
        i. Operation until demise could be a method to meet the non-orbital debris requirement
        ii. This method cannot be used as a means to skirt the post-mission deorbit lifetime requirement
    b. Non-debris generating batteries
        i. Further testing will be required





Cartoon of battery state of charge (SOC) for hard and soft passivation

Workshop Takeaways – 2 of 3

- Stakeholders have mistaken perception of battery safety and operations.
- The workshop dispelled many preconceived notions.
- Need for all stakeholders to be aware of Orbital Debris Assessment Report requirements and its due dates

Workshop Takeaways – 3 of 3

Passivation efforts should focus on

1. Bus families and especially those with the potential for high launch rate, high on orbit count
2. Tests to see if battery thermal runaway would be non-debris generating or if it can be contained readily for CubeSats with small batteries
3. Ground and flight demonstration of battery abuse prevention on mission (e.g. layers of overcharge protection) and passivation routines for larger batteries where debris generating potential is not readily avoidable

Next Steps

- Further educate community on ODAR applicability to all missions
- Develop guidelines for acceptable passivation methods
- Establish follow-up working groups to address remaining concerns
- If applicable, update relevant NASA documentation and media communications to align with passivation implementation and guidelines to define acceptable risk levels

Next steps aim to enhance understanding, standardize procedures, and improve safety measures related to spacecraft battery passivation across NASA missions and commercial partnerships

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Questions?