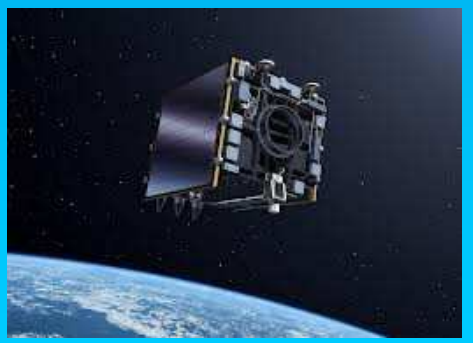
End-of-life battery passivation for PROBA platform



Peter Holsters
peter.holsters@qinetiq.be

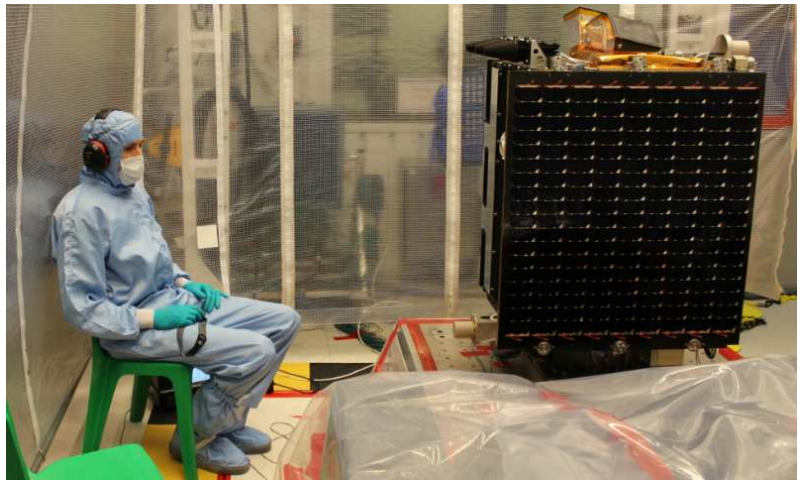
A presentation to:
Clean Sat Workshop

18 March 2015

QinetiQ

How will we spend the next 20 minutes?

1. **Introduction to PROBA and current passivation approach**
2. **Spacecraft passivation – guidelines and challenges**
3. **Method for battery passivation**
4. **Verification to requirements**
5. **Summary and conclusions**



1 INTRODUCTION – PROBA heritage

PROBA = PRoject for **O**n-**B**oard **A**utonomy

PROBA-1

PROBA-2

PROBA-3

PROBA-V

- Missions
  - In Orbit Demonstration
  - Earth Observation
  - Sun Observation
  - Formation Flying

1 INTRODUCTION - General PROBA features

1. Small, low cost mission

2. Maximum automation in flight and ground segment

3. Industrial turnkey project including space and ground segment HW and SW, launch and commissioning operations

4. Strong focus on AOCS performance

5. Design lifetime 5 years

   (>99% availability)

1 Passivation of current PROBA spacecraft

1. Make spacecraft passive at mission end
   - Clear all TC queues
   - Disable all FDIR eg for Tx activation
   - Also valid after reboot
   - All actions both on nom + red side

No possibility for passivation of electrical power sources

2 Spacecraft passivation - Guidelines and challenges

1. Guideline: ECSS-U-AS-10C (focus on passivation of electrical power sources)
   - On-boards energy sources: “permanently depleted” or “made safe”
   - Reliability of successful disposal: 90%
     - No disconnection
     - Made safe?
     - Afterwards?

2. Challenge: how to avoid “the weakest link”?
   - Reliable
   - Controllable
   - Secure

2 Spacecraft passivation – impact

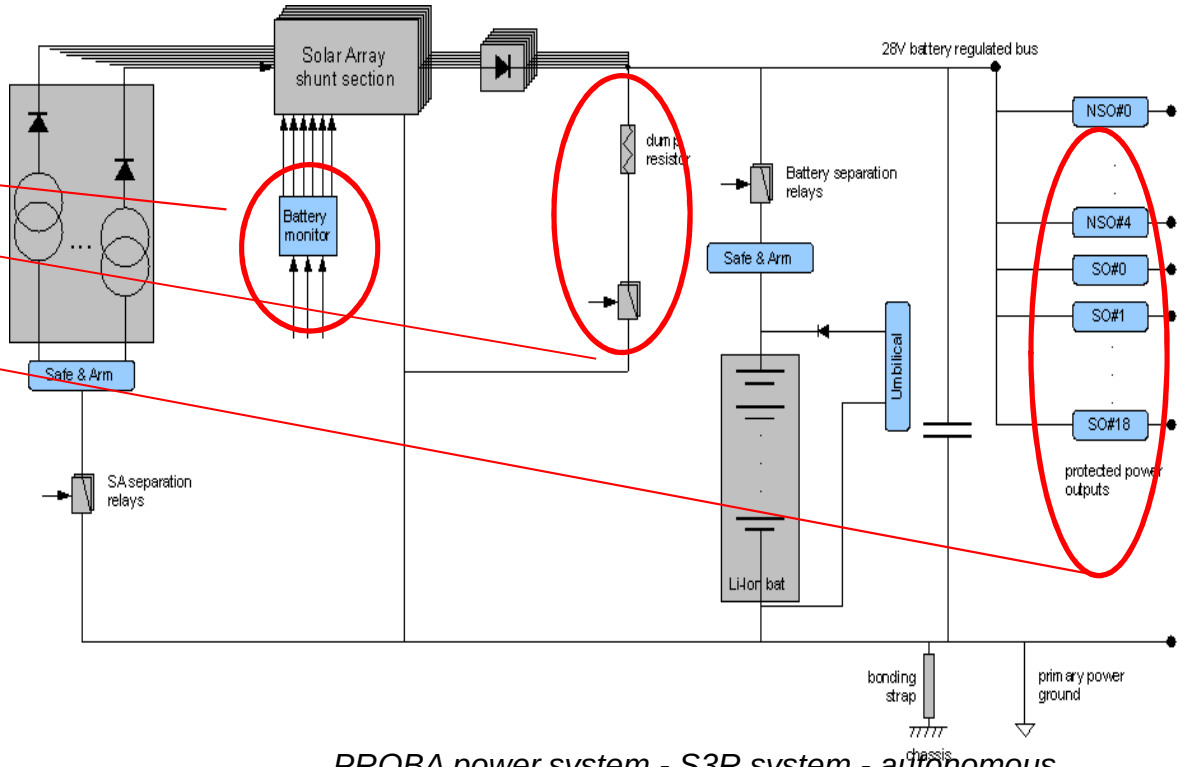
1. Current power system is designed for robustness
   - No SPF for loss of power bus
   - Power bus control independent from external control (e.g. OBC)
   - Battery EoC control is autonomous and 1-failure tolerant
   - Ultimate charge & discharge protection in HW, independent from any SW
   - Etc

Years of design heritage and FDIR makes it quasi impossible to “kill” the spacecraft.

And we would probably like to keep it that way…

3 Battery passivation – protection and features in place

1. Protections
   - Overvoltage:
     - Settable EoC
     - Dump if Vbat > EoC
   - Under voltage:
     - HW + SW
     - Essential & non-essential
2. Features
   - EoC level reset boot
   - Patchable SW levels

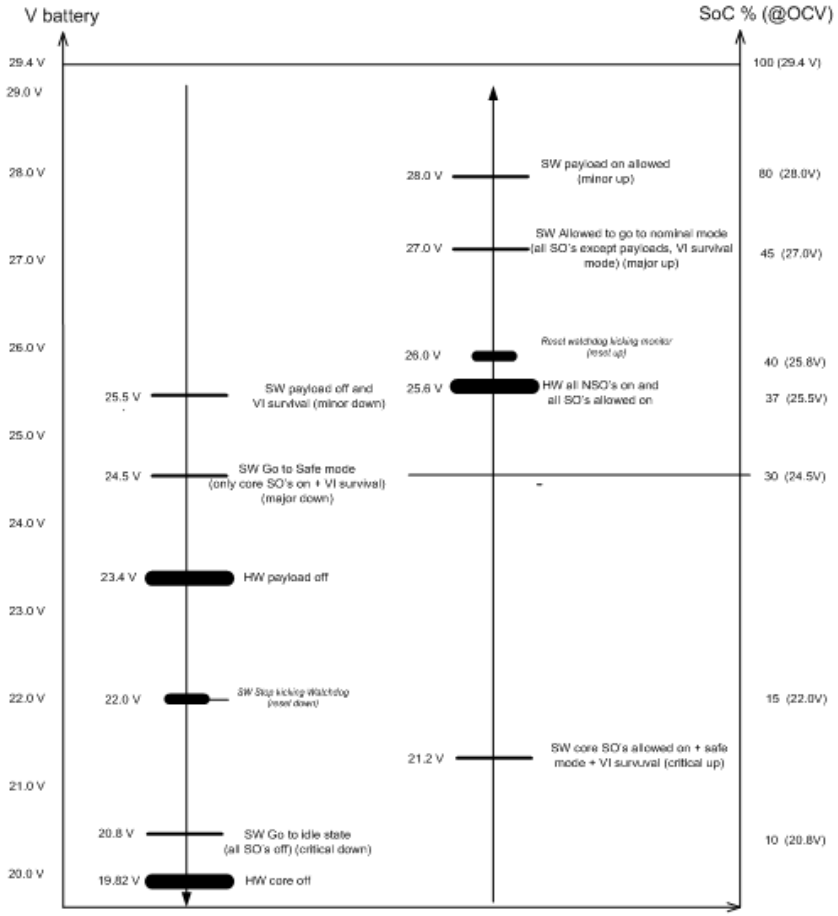


PROBA power system - S3R system - autonomous

3 Battery passivation – proposed method

1. Additional steps
   - Design - Implement “low” EoC
   - OPS - SW patch – default is low EoC level

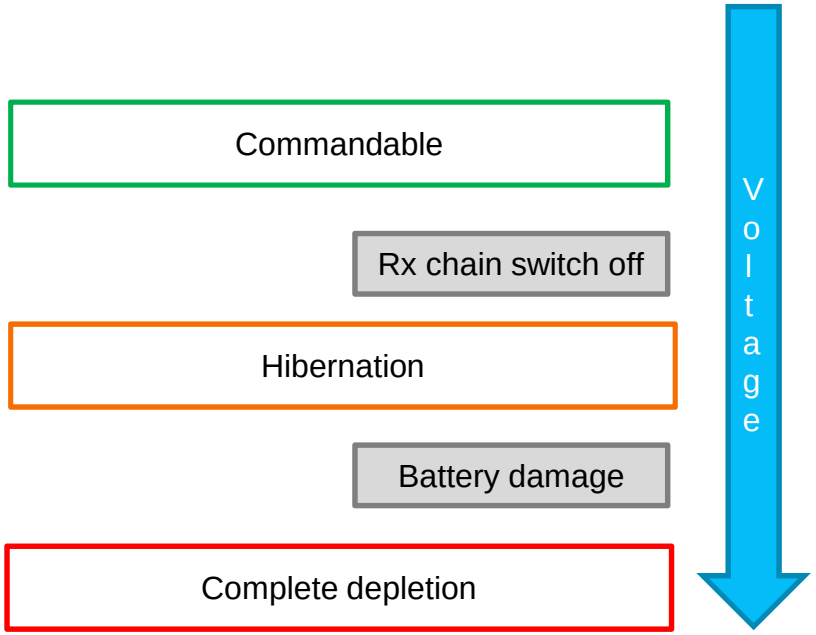
2. What after reboot?
   - Depletion
   - Nominal FDIR disables loads & AOCS
   - Stabilise at new EoC level



3 Battery passivation – which EoC level?

1. Minimum SoC for battery to be safe?
   - Internal battery protections
   - <10% of total capacity (on-ground storage level)

2. Different “end states”, depending on battery size, undervoltage & EoC levels
   - Commandable
   - Hibernation
   - Complete depletion



4 Verification to requirements

1. Robustness of original system
   - No SPF disconnecting battery
   - “ARM” barrier; SW patch on nominal & redundant:

2. Passivation itself
   - No critical “kill-switch” action;
   - Existing hardware/functionality
   - Controllable (step-by-step) and measurable
   - Protected and secure

4 Verification to requirements

3. Post – passivation: free of SPF
   - Very basic & reliable HW
   - EoC itself is majority voting

4. Other
   - Battery thermal control remains
   - Reverting possible

5 Summary and conclusion

1. “Simple” method for battery passivation
   - Compatible with existing hardware
   - Needs conscious initiation
   - Process takes several orbits - step by step
   - Protection against unintended operation

2. Assumes battery SoC (~ 5 – 10%) is safe
   - Complete depletion if EoC < damage threshold

3. First implementation in PROBA-3 spacecraft

4. Automation need and method to be assessed

Thank you !

QinetiQ Space nv

www.QinetiQ.be