CERN

EPC BIS Interface

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Introduction

- Several power converters throughout the accelerator complex are required to interface to the Beam Interlock System
- The power converter group is deploying the latest generation of Function Generator and Controller throughout the CERN complex
  - The consolidation road map foresees the entire PS proton chain using the FGC3 following LS2
  - Also the SPS NCODs will be replaced during LS2
  - LHC will use FGC2, FGC3 and FGClite hardware
    - Continues to interface to the BIS through PIC, WIC and FMCM systems

- All power converters will use FGC2, FGC3, FGClite or PLC platforms by LS3
  - Deprecate MIL1553 – G64 – GEREG platform
  - Deprecate MUGEF platform

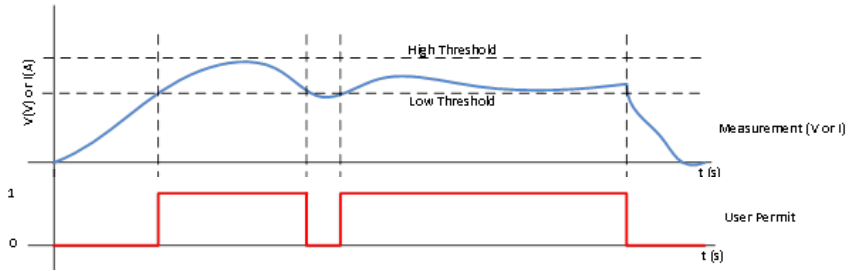
- PS and SPS complex will extensively use the FGC3 platform
  - Interfaces through the WIC for magnet protection and slower BIS functionality
  - Dedicated interface to the BIS for specific functions
  - We would like to standardise the power converter BIS interface

← Purpose of this presentation
See also EDMS 1744675

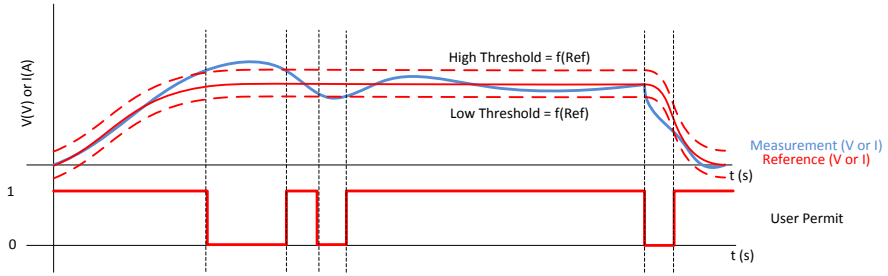
PC to BIS Requirements

- Functionality
  - When current (or sometimes voltage) is in a defined window, generate a beam permit signal to send to the BIS via a CIBU
  - In some instances a window around a complex function is required
  - The permit shall be continuously evaluated every 100us
  - Total reaction time between deviation and BIS reception = ~250us

- Outputs
  - Compatible with BIS CIBU
  - Shall allow up to 4 separate windows to be evaluated for a single power converter (applications requiring up to 3 outputs exist)



Basic functionality



Window around a complex function

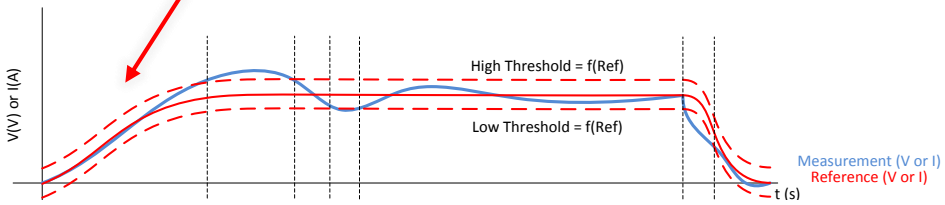
PC to BIS Requirements

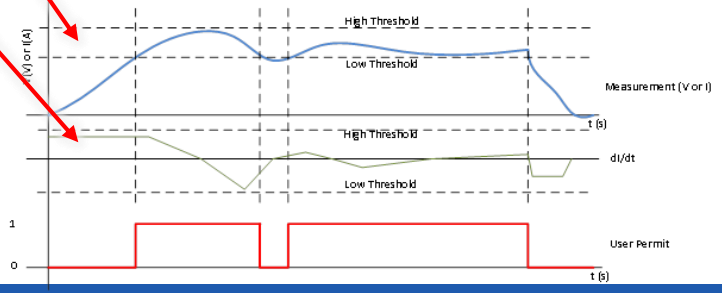
- Settings management
  - Interlock thresholds to be set and monitored periodically
    - In the LHC and SPS, concept of Machine Critical Settings (RBAC protected)
    - SPS requires different settings for each user
- Signal Concentration
  - It shall be possible to connect several power converters to a single CIBU
    - In particular the SPS uses the MUGEF architecture to concentrate up to 64 converters
  - *Not for detailed discussion today*
- Masking
  - In the event of a converter failing, or not participating for a given user permit, it should be possible to mask the permit
  - Software masking remotely by the operations team should be implemented on the converter (requires that converter controls are powered)

Implementation

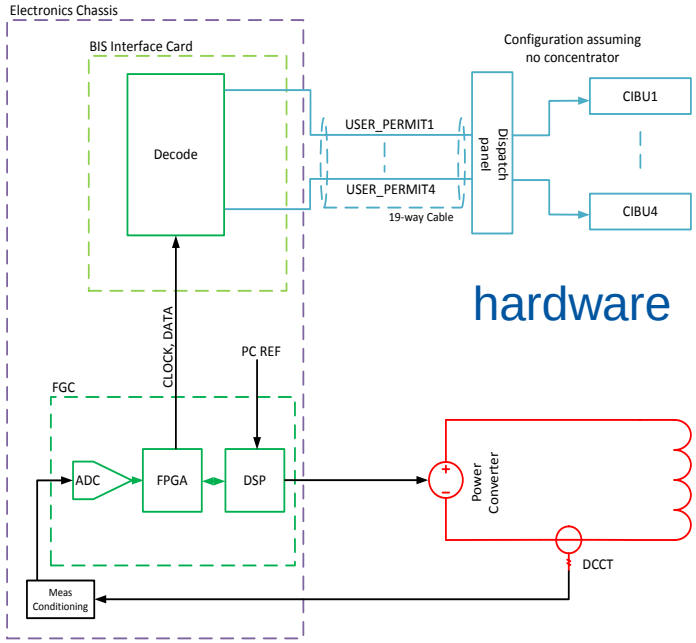
- Beam Permit calculation to be made by the FGC
  - Software based process (see next slide)

- Software approach allows more functionalities
  - Support for settings by USER and DESTINATION
    - USER 0 is always active (non ppm)
  - The result can be mapped onto any of the 4 hardware outputs
  - The result can be composed of an AND of several conditions
    - Fixed window evaluating the absolute value of current
    - Fixed window evaluating the absolute value of voltage
    - Fixed window evaluating the absolute value of dv/dt
    - Fixed window evaluating the absolute value of di/dt
    - Fixed window evaluating the difference between the reference function and the measured value
    - Power converter is NOT in the state ON

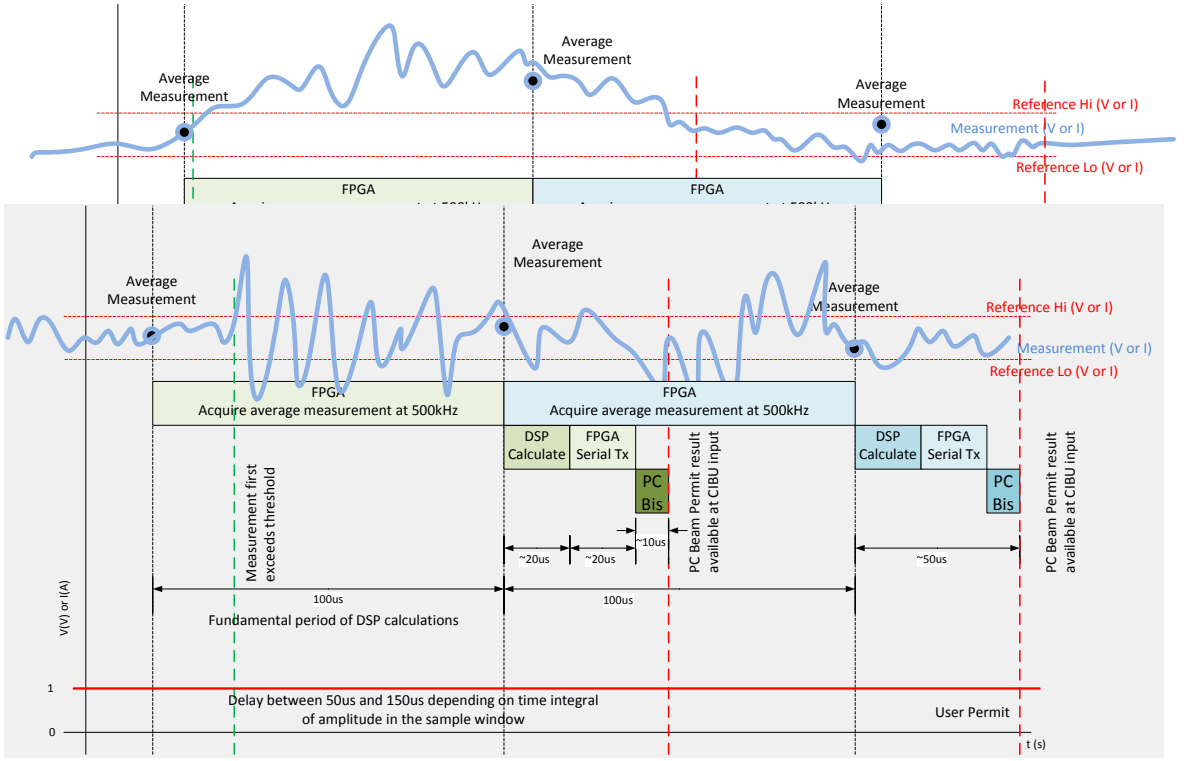




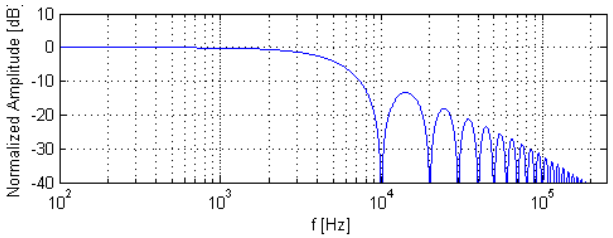
Implementation



hardware



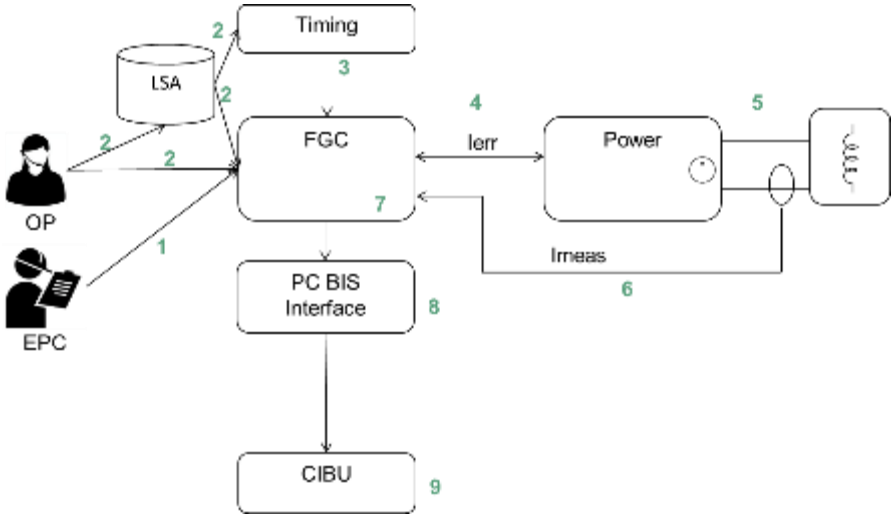
software



measurement filter

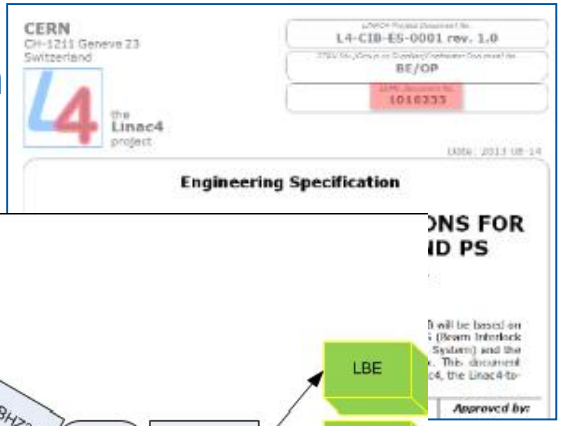
Integrity

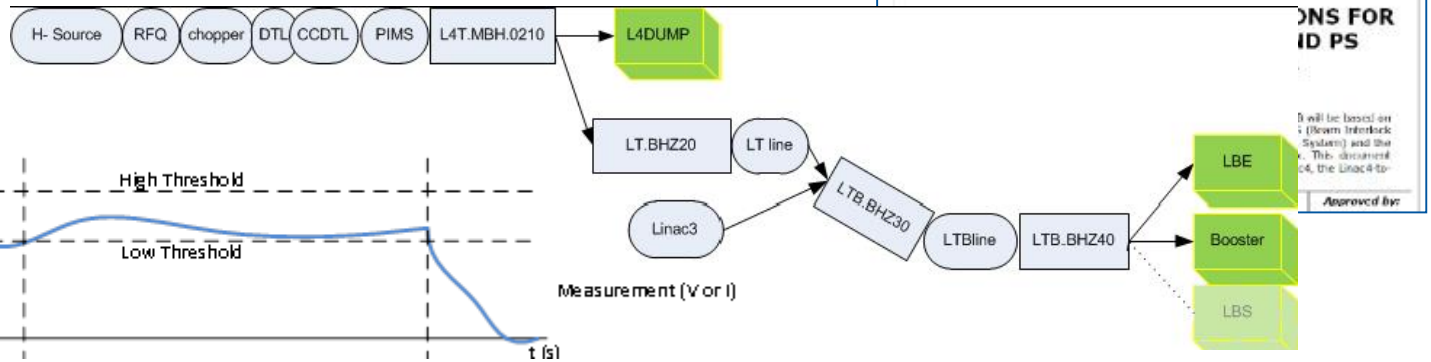
- A lot of systems required to deliver permit
  - Should only consider system valid following a check with safe beam
  - Regular checking and validation is necessary for a reliable system
- In the SPS the MCS application assists with the management of the settings
  - Could this be complemented by the SIS, particularly in the PS complex?

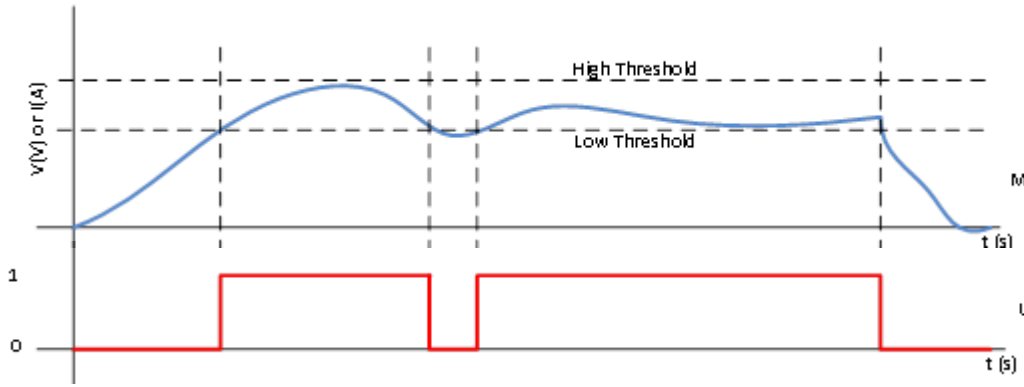


Case study: L4 Bending Converters

- Requirement outlined in EDMS 1016233
- Proposed FGC implementation meets requirements
  - Up to 2 windows required (eg AQN LT and AQN L4Z)
  - Software thresholds will require periodic monitoring
- Do not need to manage multiple USERs
  - Could use the ‘USER 0’ settings, which will be non-ppm



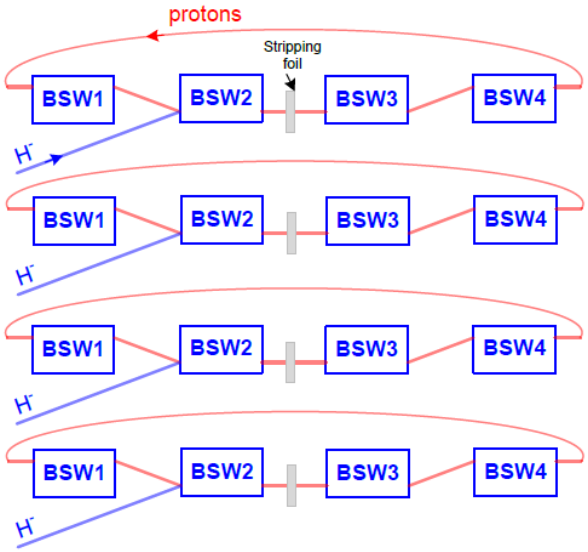




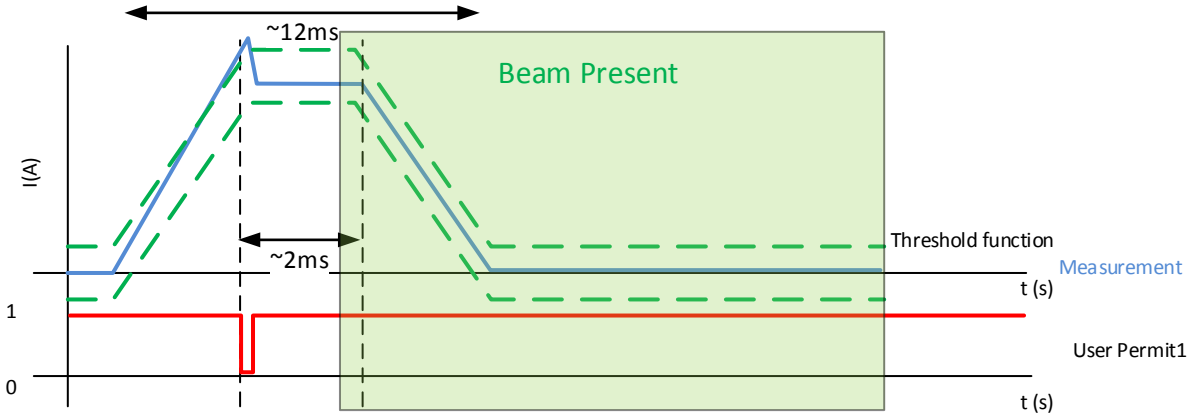
Case study: L4-PSB BSW Converters

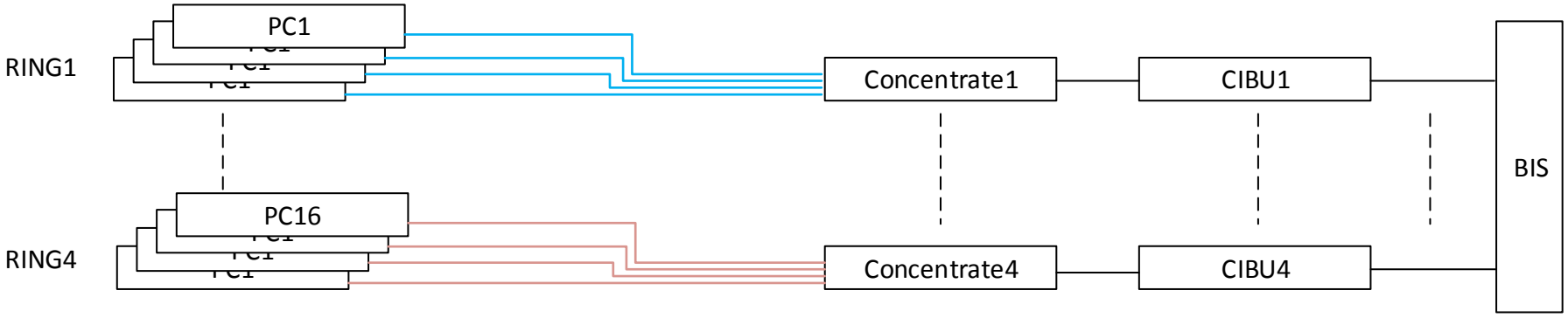
- Also mentioned in EDMS 1016233 (definitive requirements tbc)
- Demanding application - merge fast signals from 16 converters

- Proposed FGC implementation will meet requirements
  - Threshold on reference function
  - Software thresholds will require periodic monitoring
- Do not need to manage multiple USERs
  - Could use the ‘USER 0’ settings, which will be non-ppm



Case study: L4-PSB BSW Converters





Case study: SPS FEI

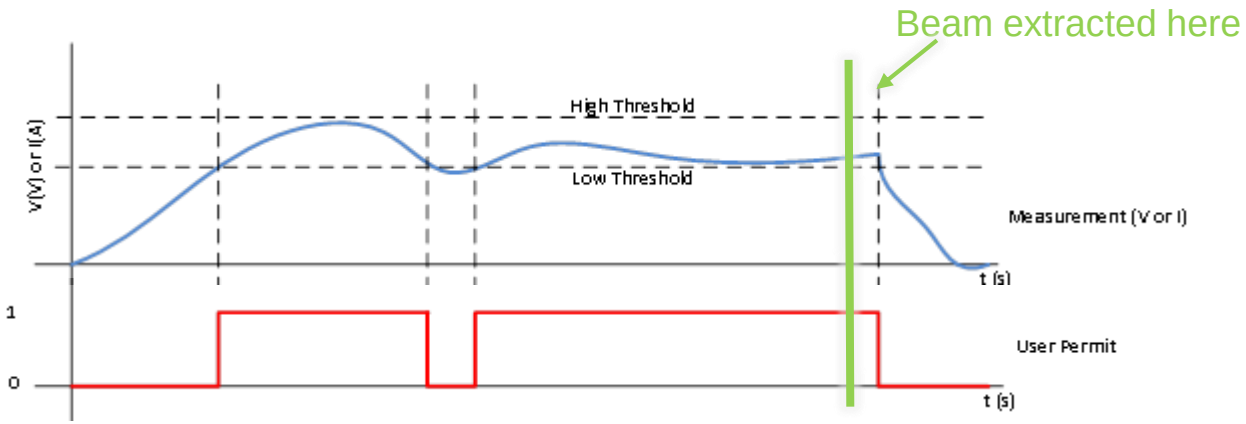
- FEI requirements
  - FEI Functional specification: LHC-CI-ES-0002-10-00 (particularly chapter 7.3)
  - FEI List of interlocked channels: LHC-CIB-ES-0003-10-00
  - MCS Functional specification: LHC-CI-ES-0003-10-00
- Features of the existing implementation
  - Software implementation
  - Different interlocks required depending on cycle type
  - Can generate Dump events or Permit events
  - Result is calculated at several distinct points of the supercycle
  - Each building has an interface to the BIS, generated from the mugef server
  - The mugef server allows up to 64 converters to participate to the interlock
  - 193 power converters interface to the BIS
    - 93 are NCODS installed in 4 buildings

Will become continuous

Replace with FGC3 converters during LS2

Case study: SPS FEI

- FEI signal would be implemented with a flat-top threshold value
  - Continually evaluated (not triggered by timing event)
  - Thresholds would be managed from MCS (as today)
    - A different set of thresholds for each user, although users are typically grouped by activity (eg LHC, North, Awake, etc)
    - Would need to communicate with the FGC3 (eg Class_61)



Conclusion

- A new Power Converter Beam Permit functionality has been proposed
  - Power Converter Beam Permit will be calculated using the FGC software
  - A common implementation across the accelerator complex
- To assure adequate integrity
  - Operations have responsibility for the power converter Beam Permit settings
  - Regular checking of the power converter settings using an appropriate tool is recommended
    - Extend Machine Critical Settings (MCS) beyond the SPS and LHC?
    - Investigate using the SIS for monitoring?
  - Validation of the permit functionality using a safe beam intensity should be part of a startup routine
- Some outstanding details to be defined for the concentration of signals
  - Requirement in the SPS, desirable elsewhere
- Development of the new power converter beam permit platform will start soon (significant software effort, modest hardware effort)
  - Deployment during LS2

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