CONS and HL-LHC day
Analysis of needs from TE-MPE

A. Siemko for TE/MPE

CONS and HL-LHC day 26.09.2017

CONS and HL-CONS approved requests
(for HL-CONS except spares)

Item n.	Description	Approved Budget [kCHF]	Funding (CONS/HL-CONS) %	Budget to be allocated in the years
1	Consolidation for DYPQ (yellow racks for protection of RQ circuits) EDMS 1702068, 1643365, 1749722	2850	100% CONS	2017 - 336 2018 - 1'166 2019 - 991 2020 - 350
2	600A Energy Extraction system replacement – R&D + first 2 prototypes EDMS to be published (Link to MPE-SB)	413	100% CONS	2017 - 263 2018 – 150 2019 - 125 2020 - 125
3	QDS electronics consolidation EDMS 1817314 Upgrade of the IPQ and IT protection units Upgrade of 600 A prot. units and current sensors Upgrade of quench loop controllers for main circuits R&D for didt sensors Upgrade of remote power cycle units Field-bus couplers	1600	100% CONS	2017 – 200* 2018 - 450* 2019 - 475* 2020 - 370* 2021 - 80*

* Spending profile to be updated in APT/CET still (total volume unchanged)

CONS and HL-CONS approved requests
(for HL-CONS except spares)

Item n.	Description	Approved Budget [kCHF]	Funding (CONS/HL-CONS) %	Budget to be allocated in the years
4	13 kA EE Systems - Controls Consolidation + spare switches and arc contacts EDMS 1761582	810	100% CONS	2017 - 100 2018 - 290 2019 - 220 2020 - 200
5	Monitoring and interlocking of conical joints for the 13kA warm leads (PROJOINT)	273	100% CONS	2018 - 113 2019 - 100 2020 - 60
6	Spare Diode stacks (provision of additional 30+10 spare diode stacks + wafers for full sector)	315	100% CONS	2017 - 235 2018 - 80
7	DQHDS lifetime studies (R&D for assessment of expected lifetime, lab infrastructure for lifetime tests)	250*	100% CONS	2017 - 100 2018 - 100 2019 - 50*

* 200kCHF already approved, 50kCHF request for 2019 pending approval

CONS and HL-CONS approved requests
(for HL-CONS except spares)

Item n.	Description	Approved Budget [kCHF]	Funding (CONS/HL-CONS) %	Budget to be allocated in the years
8	BIS v2 for LHC ring & Injection - second generation Beam Interlock System to meet dependability requirements, upgrade optical beam permit loops, address architectural improvements, and HL-LHC specific extensions EDMS 1728892	1457	100% CONS	2017 - 46 2018 - 53 2019 - 12 2020 - 47 2021 - 200 2022 - 500 2023 - 600
9	BIS v2 for SPS ring + TL - second generation Beam Interlock System to meet dependability requirements, upgrade optical beam permit loops, address architectural improvements, and HL-LHC specific extensions EDMS 1728892	1458	100% CONS	2017 - 45 2018 - 52 2019 - 13 2020 - 47 2021 - 200 2022 - 500 2023 - 600

CONS and HL-CONS approved requests
(for HL-CONS except spares)

Item n.	Description	Approved Budget [kCHF]	Funding (CONS/HL-CONS) %	Budget to be allocated in the years
10	WIC for PS – phase 1	280	100% CONS	2017 - 50 2018 - 80 2019 - 100 2020 - 50
11	WIC for TL Linac4 to PSB	115	100% CONS	2017 - 25 2018 – 40 2019 - 50
12	WIC for TL PSB to ISOLDE	150	100% CONS	2020 - 75 2021 – 75
13	WIC for TLs PSB to PS	150	100% CONS	2017 - 50 2018 – 50 2019 - 50
14	WIC for TT2 and nTOF	250	100% CONS	2017 – 60* 2018 – 97* 2019 – 88* 2020 - 5*

* Spending profile to be updated in APT/CET still (total volume unchanged)

CONS and HL-CONS requests pending approval or refused

Item n.	Description	Budget request [kCHF]	Budget to be allocated in the years	Pending	Refused
1	**600A Energy Extraction system** Replacement of all LHC 600A Energy Extraction systems due to the end of their lifetime	5600	2019-2024	100% Awaiting for the replacement strategy	0%
2	PIC v2 – development of a second generation Powering Interlock System to meet dependability requirements, address architectural improvements and extensions of the HL-LHC magnet protection EDMS 1586576	400	2020 - 80 2021 - 220 2022 - 100	100%	

CONS and HL-CONS requests pending approval

Item n.	Description	Budget request [kCHF]	Budget to be allocated in the years	Pending	Refused
3	**WIC for North area**	900	2021-2023	100%	0%
4	**WIC for PS – phase 2**	280	2022-2023	100%	0%
5	**WIC for TT10**	250	2022-2024	100%	0%
6	WIC for SPS ring	600	2020 - 2022	100%	0%
7	BIS v2 for PS ring + TT2 + TT10	300	2017 - 2018	0%	100%*

* Currently refused as 'Out of scope'

LHC Quench Heater Power Supplies Consolidation

TE-MPE

September 2017

Introduction

- There are 36’000 electrolytic capacitors installed in the LHC heater power supplies that have been operative for the last 10 years
  - charged time estimated to around 50’000 hours
  - most of them discharged a dozen times on quench heaters
- Capacitors were qualified in collaboration with the Université Claude Bernard in Lyon (France) – collaboration established with this purpose and a PhD written on the subject – under the following assumptions:
  - *Chaque aimant est prévu pour subir environs 10 "quench" pendant sa durée de vie [5]. 2 tests de décharges des condensateurs seront effectués par année pour le diagnostic. Au total une moyenne par aimant de 50 décharges pendant les 20 années d’exploitation du LHC est donc prévue. Les alimentations doivent rester opérationnelles et les condensateurs chargés pendant toute cette période, c’est à dire pendant les 175000 heures de fonctionnement. Les alimentations seront exposées à des doses de rayonnement estimées entre 20Gy et 200Gy*

[5] CERN, “General parameters for equipment installed in the LHC”, LHC-PM-ES-0002-00 rev.1.1, Avril 1999.

Introduction

- The future of LHC with the approved HL-LHC years of operation and beyond makes imperative to find out the remaining lifetime of the capacitors and the definition of a strategy of replacement in due time. A study has been launched
  - This study will bring out first results not earlier than mid 2018
  - A similar study might have to be prepared for the thyristors within the heater power supplies – this is not yet decided when
- In general terms, there are two options for the consolidation of the DQHDS:
  - Replacement of the capacitors (and possibly other weak parts of the DQHDS)
  - Replacement of the whole DQHDS units

Remaining lifetime studies Tentative Schedule

Milestone	Description	Deadline
1	Roadmap and management plan	Oct 2017
2	Removal of ~ 60-100 capacitors from LHC	Dec 2017
3	First comparative measurements on both spares and aged capacitors (t0)	Jan 2018
4	Ageing tests (2500-3000 h) (t1)	Apr 2018
5	First estimation of remaining lifetime	May 2018
6a	Capacitor replacement plan if needed for LS2 – no indication today for this	May 2018
6b	Further ageing tests	Apr 2019
7	Final estimation of lifetime and capacitor replacement plan for LS3 if needed	May 2019

Cost estimates (I) – option a) Replacing capacitors

- We assume a replacement of capacitors or the whole DQHDS during LS3
- Assumed:
  - 150 CHF/ capacitor
  - 1500 CHF / person.week (based on PJAS + overheads)
  - 150 kCHF for capacitors qualification programme
  - Switching OFF and disconnection of HDS in eight sectors : 25 person.week
  - 30 minutes to replace the 6 capacitors in an HDS unit, 75 person.week of work
  - Units tested at CERN with final capacitors in 6 test benches, 0.25 h/unit, 35 person.week of work
  - Reconnection and switching ON of HDS in eight sectors after transport: 25 person.week

➔ Cost of capacitors: 5.4 MCHF + 540 kCHF (spares)

➔ Qualification programme: 150 kCHF

➔ Manpower: 240 kCHF + 30 kCHF (supervision)

➔ **TOTAL 6.36 MCHF**

➔ Not included costs: transport, storage, test benches, scraping of the old units according to environmental rules

Cost estimates (II) – Option b) Replacing full units

- We assume a replacement of the full quantity of units (6000) during LS3
- Assumed:
  - 5000 CHF / whole DQHDS unit
  - 1500 CHF / person.week (based on PJAS + overheads)
  - 200 kCHF for components qualification programme
  - HDS fully tested at manufacturers' premises
  - Full quantity of capacitors sent to CERN – better control of storage and conditioning
  - Functional tests at CERN in 6 test benches, 0.5 h/unit: 50 person.week
  - Switching OFF and disconnection of old HDS in eight sectors : 25 person.week
  - Reconnection and switching ON of new HDS in eight sectors after transport: 25 person.week

➔ 6000 DQHDS units: ~ 30 MCHF + 1.5 MCHF (spares)

➔ Manpower : ~150 kCHF

➔ Components' qualification programme: 200 kCHF

➔ **TOTAL: 31.85 MCHF**

➔ Not included costs: transport, storage, test benches, scraping of the old units according to environmental rules

Consolidation of HDS
Planning and budget profile

Item n.	Description Upgrade of 6000 Quench Heater Power Supplies	Budget request [MCHF]	Budget to be allocated in years (from-to)	Priority (1-3) 1 top 3 low
Option a)	Replacement of 36000 capacitors	6.36	2021-2024	
Option b)	Replacement of 6000 complete units	31.85	2021-2024	

- Tentative budget profile:
  - 150 kCHF/200 kCHF allotted to qualification studies and tests during the tendering phase (2021)
  - Profiling contracts (first guess): 20% in 2022; 60% in 2023; 20% in 2024 + manpower LS3 in 2024

Consolidation of HDS - Preliminary discussion

- So far there is no indication of any new systematic component degradation/failure (ON/OFF switches were replaced in the past)
  - There are around 300 DQHDS spares (231 in Prevessin, 72 in the tunnel); there are no individual spares of components (with the exception of capacitors ~200)
- Postponing the HDS upgrade/replacement from LS3 to LS4 would mean really stretching on the lifetime of components
- HL-LHC will need anyhow new HDS for LS3 in the several hundred units and the R&D synergies between the two projects will be substantial
- Budget is the clear advantage of replacing only the capacitors (24 MCHF saving) – but this replacement might be only a partial remedy (to be further analyzed)
- If the results of the presently launched studies give hints of any major issue (e.g. corrosion of electrodes), a decision should be then anticipated

Consolidation of LHC Quench Detection Systems (nQPS)

TE-MPE

September 2017

QDS Consolidation – nQPS systems

- nQPS systems (436 protection crates) comprise the aperture symmetric quench detection systems for the MB and MQ magnets, the bus-bar splice protection systems and the earth voltage feelers for the main circuits
  - Installed in 2009 the maximum expected useful lifetime is 20 years, i.e. up to LS4
  - The radiation tolerance of the installed system being sufficient for all locations up to LS3, there might be problems in half cells 8 through 12 around IP1 and IP5 after the HL-LHC upgrade during LS3
    - Consolidation could focus on the most vulnerable parts, i.e. the splice protection systems only or consider a full upgrade of the concerned 20 units
  - The technology for the upgrade can be based on the universal quench detection systems (uQDS) currently being developed for the HL-LHC upgrade
    - Estimated cost per nQPS crate is 5000 CHF
  - Additional required functionality like an increased number of earth voltage feelers or an upgrade of the data acquisition systems still needs to be defined

QDS Consolidation – resources for the upgrade of nQPS systems

Item	Material	FTE	Internal & external contributions
R&D	50 kCHF	0.5 x FTE (STAFF), 1 x FTE (FELL or VIA or FTEC)	TE-MPE-MS, TE-MPE-PE
LS3 (20 + 2 spare units)	110 kCHF	0.5 x FTE (STAFF), 1 x FTE (TTE)	TE-MPE-EM, TE-MPE-MS, BE-CO, BE-ICS
LS4 (416 + 8 spare units)	2120 kCHF	1 x FTE (STAFF), 2 x FTE (TTE)	TE-MPE-EM, TE-MPE-MS, BE-CO, BE-ICS
TOTAL	**2280 kCHF**	**2 x FTE (STAFF), 1 x FTE (FELL), 3 x FTE (TTE)**	

Consolidation of LHC Post Mortem System

TE-MPE

September 2017

Consolidation of Post Mortem System

Due to a growing number of use-cases (IQC, XPOC, SPS quality checks, Powering analysis) and the increasing data volumes from all user systems, the current architecture has reached its limits of capacity and scalability. In view of the continuous upgrades projects throughout the injector complex and the LHC, the current system needs to be replaced by a new, performant and truly scalable architecture to assure the reliable storage and analysis of accelerator transient data recordings for the HL-LHC era.

Total Budget request	300 kCHF	Budget to be allocated in years (from-to)	2018-2020
Material budget request	50 kCHF (proto & operational storage)	Personnel available [y/n] in addition to personnel budget request	y (MPE staff)
Personnel budget request (M2P budget for MPAs and fellows)	250 kCHF		

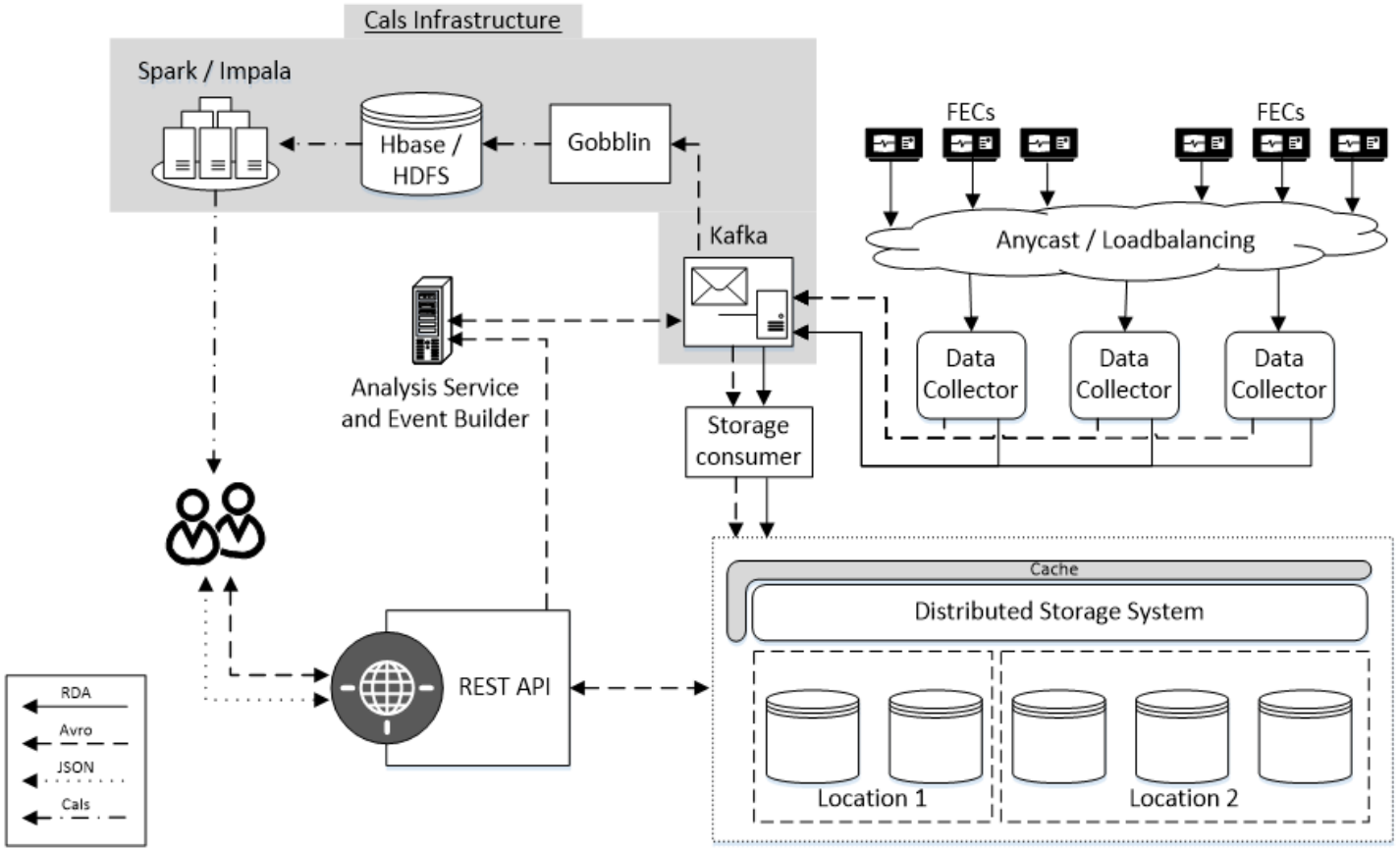
Consequences of suppression of request

Potential non-readiness of new infrastructure, requiring LS2 restart with present infrastructure.

Consequences of delay of request

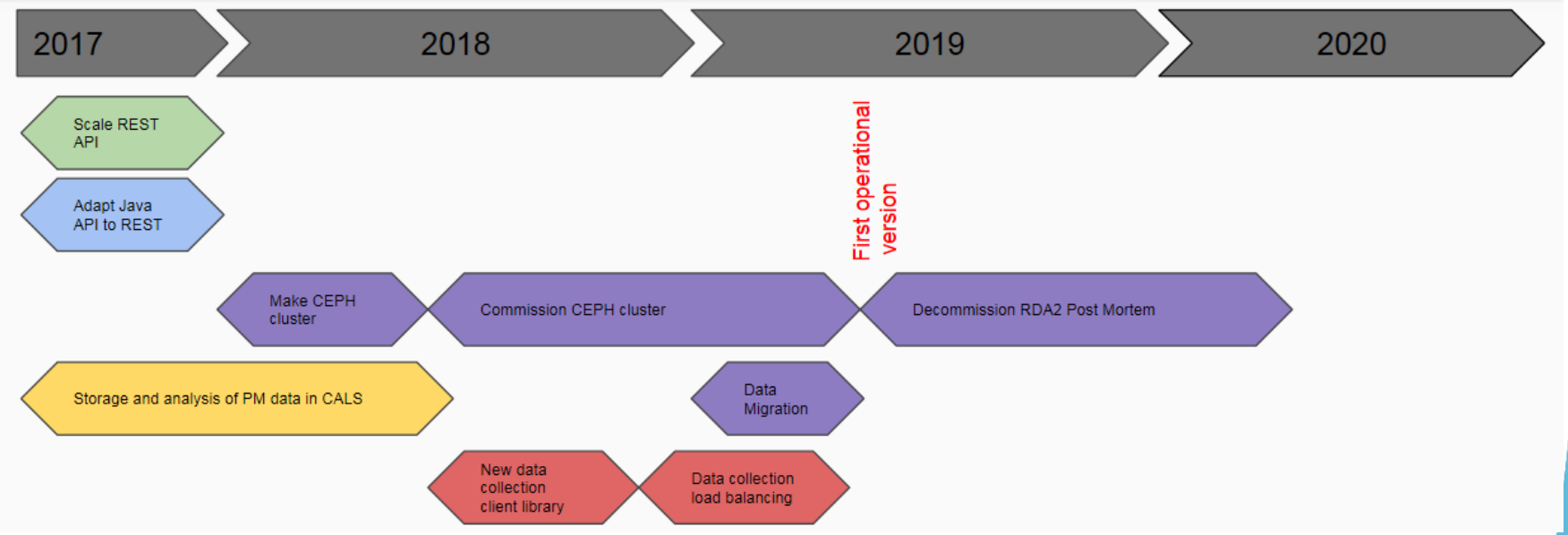
Potentially delayed availability of the new infrastructure, which in turn would delay the start of IST and commission tests post LS2

ITEM: Post Mortem Consolidation



- Current working hypothesis is full integration of PM consolidation with NXCALS
  - Strong coupling/collaboration with BE-CO and facilitated access to CALS/PM data for users
  - PM CEPH cluster to guarantee 'real-time' use cases for PM

ITEM: Post Mortem Consolidation - Roadmap



Consolidation items not submitted yet (undergoing internal evaluation)

Item n.	Description Upgrade of 6000 Quench Heater Power Supplies	Budget request [MCHF]	Budget to be allocated in years (from-to)	Priority (1-3) 1 top 3 low
1	Consolidation of Safe Machine Parameters System (SMP v2.0)	?	2020-2024	
2	Consolidation of Fast Magnet Current Monitoring System (FMCM v2.0	?	2020-2024	
3	Consolidation of Current Leads Heating System (heating controllers)	?	?	