



DFM Conceptual Design Review: Outcome and Recommendations from the Review Panel

Review Panel:

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(Scientific Secretary)*



Introduction

- The Review Panel was mandated with the following:

Scope:

“Review the conceptual design of the DFM with the purpose of validating maturity and confirm readiness for starting detailed design”.

Mandate:

- 1) Review the functional specification and confirm their completeness in terms of cryogenic, mechanical and electrical requirements;
- 2) Review the functionality of the design concept wrt cryogenic design and operational aspects, mechanical design and interfaces – including the lambda plate;
- 3) Review the proposed integration and installation plan in the LHC machine and the compatibility of the DFM location wrt the tunnel environment (including preliminary plan for maintenance and repair interventions during operation);
- 4) Review cryogenic requirements for safety aspects and compatibility of safety equipment with tunnel environment;
- 5) Review plan for detailed design development;
- 6) Review schedule for prototype production, including strategy for intermediate validation.

Introduction

Review Committee: S. Atieh, G. Ferlin, M. Modena (chair), F. Rodriguez Mateos.

(A special thanks to M. Mendes for his clear and careful annotation of all comments&questions and help in the reviewing).

Proposed Program of presentations (Indico: <https://indico.cern.ch/event/821879/>):

- *Welcome: Luca Bottura (CERN)*
- *DFM in WP6a: Dr Amalia Ballarino (CERN)*
- *DFM Functional specification, Speaker: Yann Leclercq (CERN)*
- *DFM Conceptual Design, including integration and interfaces in the tunnel: Yann Leclercq (CERN)*
- *DFM Safety aspects, Speakers: Thomas Otto (CERN), Vittorio Parma (CERN)*
- *Production Plan, Speaker: Yann Leclercq (CERN)*

Outcome and recommendations

General remarks:

- The DFM procurement strategy and plans and the differences in comparison to the DFX procurement were clarified to the Panel.
- We understood that, despite the different advancement of the 2 projects (DFM design and procurement will follow on the time-scale the DFX one), the plan is to have the two procurement proposal approved as part of the “UK-2 Agreement” at the next Finance Committee (FC) of September 2019.
- Given the still conceptual status of the DFM design and also looking at the procurement plan (for both DFM and DFX), it would be in theory feasible to present the proposal to the FC of December 2019 instead of September. This would allow arriving at the FC with a more advanced, sound, and validated DFM design and integration. *Evidently these remarks do not consider any eventually existing managerial consideration that would push for the presentation to the September FC.*
- Due to the relative less complexity of the DFM respect to the DFX and to the fact that a very similar DFM distribution box was successfully tested in the “DDFX” demonstrator at SM18 in 2018, WP6a proposes to skip a (Global) System Test phase after the procurement of the 1st unit (pre-series and future spare).

Outcome and recommendations

General remarks (cont.):

- The knowledge on the DFM concept and details by the SOTON colleagues is less comparing to the DFX. This is also due to the fact that for the DFM, SOTON will be not responsible of and will not develop the Conceptual design as done for the DFX. SOTON will be responsible for the procurement (based on design and drawings “for procurement” developed and provided by CERN) of five DFM units (1 pre-series and 4 series).
- Anyway, looking at the experience with the DFX conceptual and detailed design, the Panel support the proposal of WP6a to have a part-time presence of SOTON colleagues at CERN during the finalization of the DFM Conceptual Design. The collaboration should discuss and agreed on this aspect.

Outcome and recommendations

Referring to the six Review Mandate specifications, the preliminary Review conclusions are here reported:

1. “Review the functional specification and confirm their completeness in terms of cryogenic, mechanical and electrical requirements”:

- The functional specification draft presented seems clear and seems to contain all the expected interfaces. Similar boundary conditions and constraints like for the DFX exist.
- **→ RECOMMENDATION N.1:** Similarly as reported for the DFX, pursue on the *finalization* of the reference documents (Functional Interface and Technical specifications), *interacting with ALL interfaces (WP9, WP15, WP3, HSE, etc.)* in order to have these documents *fully checked and approved BEFORE* the FC of September.

Outcome and recommendations

2. “Review the functionality of the design concept wrt cryogenic design and operational aspects, mechanical design and interfaces – including the lambda plate”:

- The powering scheme of the DFM is simpler with respect to the DFX one (10 cables versus 19).
- Despite the DFM design being composed by two distinct modules, the cryogenic and mechanic design presented seem also simpler with respect to the DFX one. The functionalities of GHe generation (for the DSHM cooling) and LHe bath for the MgB2/NbTi splices are separated. The DFM configuration is very similar to the one tested in the DDFX in SM18.

→ **RECOMMENDATION N.2:** *Even though the cryogenic functional scheme is clear and quite advanced, there are still parts to be completed (**jumper and interlink**) and **some questions** were raised mainly about aspects and details linked with the transitory phases and operation (not exhaustive list, please refer also to the “Contribution Review” section):*

- *The thermal gradient in the DSHM during cool-down is a critical working aspect, GHe will arrive from the 2 main DFM vessels. It is recommended to carefully analyse this aspect and **implement all the needed instrumentation (e.g. temperature sensors)** to correctly control the cool-down phase.*

Outcome and recommendations

- In a similar way, the presence of an 8-m “interlink” between DFM and D2 magnet working in superfluid Helium (object formally in the scope of WP3, but mechanically and cryogenically interfacing the DFM design), *needs a study and integration of temperature sensors* for the cooling down and filling operation.
- As reported for the DFX, it is needed *a decision on the redundancy of the LHe heaters* (electrical and by heat exchanger).
- The *specificities of the 4 installation sites* for the DFMs (with different geometries of the Tunnel, height of the beam and QXL) will most probably bring to minor differences in the design of the DFMs or at least in their integration. This aspect is critical and needs a careful study.
- Some mechanical/assembly aspects bring to common recommendation as for the DFX: *LHe inlet pipe design, O-ring procurement, IFS and redundancy of instrumentation wiring*, etc.

Outcome and recommendations

3) *“Review the proposed integration and installation plan in the LHC machine and the compatibility of the DFM location wrt the tunnel environment (including preliminary plan for maintenance and repair interventions during operation)”*:

- For this part, only preliminary and conceptual assembly sequences were presented.
- The integration of the DFM modules: above the D2, connected to the DSHM on one side and to the interlink to D2 magnet on the other side, will be a complex operation also from equipment transport point of view.
- The DFM design contains a “20 degree elbow” element (where it will be connected with the DSHM).
- This inter-connection operation will include a critical “pivoting operation” of the “20 degree elbow” element.
- Safe manipulation of the DSHM and its connection will be an essential aspect to be mastered during this operation.

Outcome and recommendations

→ **RECOMMENDATION N.3:** it will be critical in the next development design phase a *tight collaboration* with other WPs (WP9, WP15, HSE, Transports and other LHC Services,) in order to develop a design and *tooling fully compatible* with the neighbour equipment, different sites constraints, installation and maintenance sequences.

- *Specificities* of the different installation sites must be included.
- The “*interlink*” design (at least conceptual) is necessary to finalize the DFM detail design and assembly sequence in the tunnel (the rigidity and the “interlink” assembly sequence *could impact* on the one of the DFM).
- As for the DFX we remind and aware that the radioprotection aspects make any intervention (apart from the first installation) critical for **ALARA** considerations.
- The *maintenance* and *reparation plans* must take into account these aspects too.
- More *detailed sequences* for these operations are expected at the DDR review.

Outcome and recommendations

4). “Review cryogenic requirements for safety aspects and compatibility of safety equipment with tunnel environment”:

- The presentations covered only the cryogenic safety aspects. The design of the DFM was presented highlighting the most important aspects (operating, design and test pressures, fulfilment of PED requirements, and a 1st Risk assessment evaluation).

→ **RECOMMENDATION N.4:** *the DFM design and its technical documentation has to coherently address the point of the design standard applied (PED) and consequent requirements all along the procurement, assembly and testing phases.*

- *The exact role of HSE should be identified and clarified.*
- *The integration of burst disk, rated valve and relief plates must be done together WP15 and HSE.*

Outcome and recommendations

5). “Review plan for detailed design development”:

- The design of the DFM will be done by CERN in collaboration with SOTON.
- When the design is completed, CERN will produce the manufacturing drawings which will then be used by SOTON for the procurement.
- A Detailed Design Review is planned to be hold soon, (probably around November 2019)
- → **RECOMMENDATION N.5:** *following the presentations, the DFM design plan doesn't show today critical aspects but design is still at initial phase.*
- *A **DDR Review** is planned and WP6a envisages also to have in a due time a **Production Readiness Review (PRR)**. The panel support this plan.*
- *Very important in the incoming detailed design phase is to address all the important aspects like:*
 - *Design done considering the **accessibility for execution, test and eventual reparation** of all critical welds in a “HL-LHC Tunnel configuration” (including necessary mock-up and tooling design and qualification).*

Outcome and recommendations

→ RECOMMENDATION N.5 (cont.):

- Investigate the *minimisation of the LHe volumes* in the DFM that would be effective from several points of view. Evaluate if this reduction of volume could be implemented in the design of the busbars supports.
- The *specificities* of each *installation* site (IP1 and 5, R and L side) must be carefully analysed with the help of WP15 in order to check their eventual impact on the final DFM design.

6). “Review schedule for prototype production, including strategy for intermediate validation”:

The pre-series unit of the DFM should be ready by **March 2021** (thus one year after DFX). The complete series of DFM should be ready by **March 2023**.

→ RECOMMENDATION N.6:

- Being the design still at the conceptual phase, a lot of aspects/activities on-going or planned need to be carefully implemented. The *responsibility of CERN and SOTON must be clearly stated* and coherently reflected in the technical and procurement documentation.

Outcome and recommendations

Those aspects should be fully clarified and presented at the DDR review. e.g.:

- - Development and completion of *detailed design* and all *Technical Specification* (by CERN)
- - Detailed *list of supply* (with delivery dates) (by CERN)
- - *Responsibility for minor tooling procurement* shared between SOTON and CERN as well a complete and sound QA/QC plan (by CERN/SOTON)
- - Preparation of *Procurement Documentation* (technical, QA/QC, follow-up, test plan required, etc.) (by CERN/SOTON)
- - *Final acceptance test* (at CERN and by CERN)
- - *It is not planned to perform a DFM System Test*. Looking at the presented plan it seems that there will be eventually time to plan it. *For a so critical component, WP6a should reconsider better this opportunity.*

- → **RECOMMENDATION N.7:** *The strategy and policy for the DFM spares procurement (with the eventual “site specificities”) and spare assembly sequence in the Tunnel should be defined and presented at the DDR review.*