MICE - Resource Loaded Schedule Review (RLSR) April 5th 2016: Panel Report

Professor Ian Robson

1 Introduction

The RLSR was held at the RAL on the above date. The recommendations and action from the previous review of Apr 2015 (Appendix 1) have been answered in the main (see below) but the repair to the spectrometer solenoid has now become critical for the future direction of the project. The charge to the Panel is provided in Appendix 2 and the RLSR Panel members are listed in Appendix 3. It should be noted that all members of the PB also participated in the RLSR session and subsequent discussion.

The MICE Spokesperson is to be congratulated on achieving increased international participation in the project. Progress on the project overall has been positive with steady advancement in the MICE Hall. However, the project has suffered a number of setbacks since the last meeting, and even though these have either been solved or are in the process of being solved, it serves as a reminder that the project is still not without risk in terms of cost and schedule. Further details of the progress of the work are provided in the MPB Report.

As usual the Panel investigated the staffing resources, the financial planning, the risk register and its use in the schedule planning for construction and commissioning. The resource requirements associated with the scientific output from the project (the hours of operational running and the lengths of the respective Steps IV and Cooling Demonstration) are covered by the Project Board as are the specific comments on the technical progress of the work.

The last RLSR report stated that the project had now reached a *critical* phase, and this has been confirmed by the implications from the spectrometer solenoid review and potential ways forward. This will form the basis for this Report; the details of the work involved will be covered in the MPB Report. The situation with respect to how to progress the solenoid repair (or replacement) is absolutely critical but the Panel found it difficult to come to definitive recommendations due to a lack of certainty in figures being presented, or not as the case may be. The degree of uncertainty in the project looking forward is high and the risk situation has probably progressed beyond red. Nevertheless, potential solutions are described, but the degree of risk associated with each is difficult to quantify at this point.

2. Response to Recommendations from the RLSR of Oct 2015

The responses to the four recommendations were, on the whole, well thought out and readily accepted by the RLSR Panel. However, two of the recommendations along with the responses are worth reproducing below as they directly affect the outcome from the RLSR meeting: ‘The Panel strongly recommends that the DoE offers some formal alleviation to the current hard schedule end-date and 9:6:3 funding profile. While this goes against the grain for top-level project management, the Panel is convinced that it is now necessary to relax these

boundaries/constraints to reduce on-going risk and maximise the probability of success for the MICE project to achieve its goals and hence maximise return for the funding agencies. *The project team notes the recommendation of the RLSR panel and will provide any necessary clarifications requested by the DOE. Subsequently, the guidance that the US effort has received from the US Department of Energy is that the ramp-down funding plan for the Muon Accelerator Program is fixed and that additional relief should not be expected. The US effort continues to work to identify options that will allow the collaboration to move forward with their experimental goals in the absence of further US support.'*

In short this sets the scene that the solution to the spectrometer solenoid repair has to fit within the parameters of the 18:9:3 ($M) financial envelope and that it must end in fiscal 17 (i.e. end of September 2017). Carry-over from previous years to beyond this date, however, is allowed to some extent although what the implications are for further MICE support are unclear.

The second recommendation was: 'The STFC and DoE need to jointly agree on the future funding for MICE over the next three months – this is the most important recommendation/action from the entire Review. *The project team notes the recommendation of the RLSR panel and will provide any necessary clarifications requested by the STFC and/or the DOE.'*

Progress on determining the future direction of the project due to the spectrometer solenoid repair have proceeded slower than the RLSR Panel has anticipated and so this recommendation has been overtaken by events but has now come to a point where a definitive decision of the future of the MICE is now required (see next section) as a matter of urgency.

Of the six actions, five have been satisfactorily answered and the sixth (extension of Step IV into 2016) has been overtaken by events.

3 Resource and Schedule from 'now to completion'

3.1 Step IV operation

Progress has been solid on Step IV running and preliminary data taking (commissioning) although there is still some way to go before all of the magnets are powered up together and the final data-taking stage is underway. The failure of the hydrogen system has caused a rethink of the plan and currently operating with the LiH absorber is the preferred option while the hydrogen system is repaired.

The failure of the decay solenoid power supply has been rectified, mostly at the expense of the manufacturer.

There is a serious concern from the US-side that the spectrometer solenoid that failed is of a delicate nature and how long it will continue to operate cannot be guaranteed. The estimation is that it will not survive another warm-up/cool-down cycle, which will definitely impact on plans for different configurations for Step IV running.

Regarding the staff shortage identified by the September Commissioning Review and the last RLSR Panel Report, good progress has been made and the project is to be congratulated on this. Staff effort is no longer a driving force limiting progress.

The excellent work on the data taking and analysis software are described in the MPB Report.

3.2 The overall schedule and cost from now to the Cooling Demonstration

The US funding profile is very clear due to the outcome of the P5 Review and subsequent DOE statement (see section 2). However, for the UK as host lab, the project and costs are on-going until the end of the experiment and funding has yet to be formally secured for FY16-17 and beyond. There is a cost-to-completion review on Aril 26th 2016.

Assuming the conclusion of the experiment is the Cooling Demonstration, the project team were asked to provide three cost and schedule scenarios to the end of the project. These were: full resource cost; flat cash + 10%; flat cash. These produce the following for the Cooling Demonstration run slots and overall cost from FY16-17 to the end:

Full resource: run dates from July 2018-June 2019 and a cost-to-go of £11.4M

Flat cash +10%: run dates from Dec 2018-Oct 2019 and a cost-to-go of £10.9M

Flat cash: run dates from Feb 2019-Dec 2019 and a cost-to-go of £12M

All of these scenarios assume the new spectrometer solenoid is delivered to the MICE Hall in January 2018. This is on the critical path for the first two options and close to the critical path for the flat cash option. However, an immediate problem is that the latest US project plan for the solenoid repair injects a six month slip into this schedule. This is discussed further below.

The total UK cost of the project to completion on the flat cash scenario is £46.7M.

The UK OSC looked at the above costs two weeks ago and requested the project to look at further cost/risk reductions (descopes) and to produce a figure for the cost savings by stopping at STEP IV.

While the above are the best figures the project can derive based on what they know and assuming some risk contingency, there is caution in that the risks have not yet bottomed out and looking back it is clear that the risks in general have been underestimated.

A further risk has been realised in that the MAP Director, whose work has been hugely appreciated by the Panel, has moved on to another position and can only spend 25% of his time on MICE until the end of September 2016 and subsequently 15%. The impact of this has not been pursued given the other problems in section 3.3.

3.3 The Spectrometer Solenoid failure implications

Although it was stated earlier that the Panel had anticipated more progress on this aspect, nevertheless it is clear that the US project has put a lot of effort into the failure recovery options, the resulting costs and implications. The details of the technical aspects of the

recovery plans are reported in the MPB report while this report looks only at the top-level options and implications.

The December Solenoid Recovery Review in the US recommended firstly providing a new quench protection system. This has been taken on-board and is being manufactured for both spectrometer solenoids and will be installed in the MICE Hall in the next couple of months.

The Review also recommended providing a new cold mass and re-using the existing magnet/cryostat as the most cost-effective and speedy solution. This was initially costed by the MAP Director at ~$2.2M using assumptions of in-house (lab) work and using Fermilab labour rates (the cheapest of the US labs). The team were also recommended to consider an outside vendor for the work and to increase the schedule, which was believed to be too optimistic.

However, a re-appraisal of the recommendations by the US Project team in January came to the conclusion that the risks involved in the various paths had not been adequately taken into account with respect to the state of the current cryostat. Their conclusion was that continuing beyond Step IV with the current magnet/cryostat is 'very high risk', which, when pursued meant that at best a one in ten chance of it surviving a warm-up/cool-down. Therefore, any replacement of the cold mass must also include some refurbishment of the cryostat/magnet assembly. This meant that the only realistic options for continuing to the Cooling Demonstration were:

- Build a new cold mass and install in the current spectrometer assembly with adequate refurbishment
- Build a new cold mass and magnet assembly – in other words, replace the current spectrometer solenoid completely.
- Rebuild the existing cold mass and re-install in the current cryostat (with some refurbishment). This could be a back-up if there were problems with a new cold mass.

The MAP Director then undertook a more detailed study in preparation for a procurement process. This process maintained Fermilab labour rates, included improved scheduling assumptions and opened an initial dialogue with potential vendors for first-cut cost estimates. The timescale for this route is that the technical documentation for procurement would be ready by the end of April and that tenders would be sent out with replies by mid-June. This would lead to a make/buy decision in August and with a procurement start to be taken in October. However, the cost estimate for this route comes to $2.5M. This exceeds the available US funds by order $800k.

In parallel the project undertook an intensive piece of work (using two independent consultants) into the failure reasons for the existing Wang design. This unearthed a number of insights into design deficiencies of the current solenoid and provided design improvements to ensure any replacement system would not have the same problems. This will be built into the technical documentation set and represents excellent work.

However, returning to the financial implications, after intensive questioning it appears that there is *no solution* whereby a US-led procurement process for the spectrometer repair can be funded. Given this fact alone, the recommendation from the RLSR would be to stop at STEP IV, to immediately halt all work for the Cooling Demonstration and then to consider the most optimum running time for STEP IV to maximise the scientific return on investment.

But, as is always the case with the MICE project, there is another possible option. The above problem was predicated on the repair being a US-led procurement activity. This brings problems, as well as being unaffordable. Very recently there has been a suggestion for the US to transfer a sum of money to another agency (e.g. STFC as the only option on the table), who would then take responsibility for the procurement, installation and commissioning of the new system. This is a very new possibility and there has not been enough time to work through precise costs and timescales, but RAL Technology have been pursuing this option and have thought through the potential steps to the procurement process. Their presentation gave what many of the Panel felt to be optimistic timescales but to be fair these figures were provided at very short notice. To be prudent the Panel recommends that it is hardly likely that the US timescale could be bettered (and a number of the Panel felt that it could be notably longer going through a UK and SBS procurement process).

Some rough estimates have been received from a magnet company in Italy; these are without VAT and contingency. When these are added, the figure comes close to the lower end of the US estimates, but, it must be stressed that until firm quotes are available from industry, these are only estimates, which could be notably adrift from a quotation. Hence, whether there is enough headroom for the UK to be able to proceed within the US-to-be-provided sum is currently very unclear and presents another uncertainty and potential risk. However, as most magnet vendors are located in Europe, follow-up from the UK would be less costly than from the US, and the recent recruitment by RAL of an experienced magnet engineer is a positive element.

In fact the true situation will only be clear when potential vendors come back with firm quotes for the work in terms of cost and delivery schedule. This point is anticipated to be at least six months downstream from now, i.e. October at the very earliest. Should these quotes exceed the US-provided cash then the recommendation would be as above, terminate at STEP IV and stop all work on the Cooling Demonstration immediately. This extra six months would lead to a potential UK nugatory spend of ~£0.5M assuming that all work on the Cooling Demonstration continued (e.g. the RF at DL and the work in the MICE Hall). Mitigating this financial risk could be undertaken by pausing the RF and Hall work, but this would just move the problem elsewhere in STFC with an unfunded set of staff for the period.

There is a further concern about the schedule as currently the Solenoid is essentially on the critical path and the US solenoid repair schedule already appears to have injected a delay of six months into the schedules produced by the UK team. Whether a UK-led procurement could lead to a schedule recovery of six months is at best uncertain at the current time. There is definitely potential scope for the Cooling Demonstration data-taking to slip into 2020.

A further complication and additional risk is that ISIS is currently planning a major shutdown of about a year either in 2019 or 2020 for the upgrade of Target Station 1 target and replacement of one of the Linac components. Either of these would pose a risk for MICE and potentially negotiating this to 2021 might need to be an option for STFC to consider.

To be in a position for the STFC to make a well informed decision as to how to proceed the following information needs to be known.

1. The amount and timeframe of transfer of US cash to the UK
2. The degree of risk and cost that STFC is prepared to take in proceeding from STEP IV to the Cooling Demonstration (physics data versus financial investment)
3. Confidence that the UK can satisfactorily take over ownership of the solenoid repair procurement
4. The vendor quotes for the solenoid repair – probably not available until October at the earliest
5. Confidence in the vendor quotes for the repair (cost, performance and schedule)
6. Knowledge of the ISIS shutdown or ability to negotiate this timeframe so there is no impact on the MICE Cooling Demonstration
7. Confidence in the project schedule and cost-to-go for the Cooling Demonstration (degree of risk)

Therefore, the decision for the UK is now clear.

Either:

1. Decide now to terminate MICE at STEP IV, maximise the scientific return from this experiment by extended running and immediately cancel all work on the Cooling Demonstration. This would save of order £10-11M of the cost-to-completion based on the flat-cash allocation assumption from FY16-17 onwards.

Or:

2. Proceed in principle to the Cooling Demonstration with STFC assuming the risk of taking on-board the spectrometer solenoid recovery procurement process and in six months or so:
    a. Either, continue to the Cooling Demonstration as essentially a UK-only project, which would see data-taking in 2019/20 and with a cost-to completion of a further £12M minimum (giving a total project cost of £47M).
    b. Or, stop all work on the Cooling Demonstration and terminate at STEP IV as in bullet 1.

4 Recommendations and Actions

Actions

1 The US to confirm formally that with a US-led procurement there is no way forward to a satisfactory spectrometer solenoid repair within the financial framework set by the DOE.

2 The US needs to inform the STFC how much funding and when it is prepared to transfer to them (see below)

3 The STFC needs to determine whether it is prepared to take on the responsibility of the procurement for the spectrometer solenoid repair and to wait and see the outcome of the initial UK procurement process (expected by October 2016 at the earliest), or, whether to terminate MICE at STEP IV and to stop all work immediately on the Cooling Demonstration.

4 If the STFC decides to proceed with the solenoid procurement, the US must inform the project of the support it can give, from any remaining funds in the MICE/MAP budget.

Appendix 1: Recommendations and Actions from the RLSR of Oct 2015

Recommendations

1. The project is recommended to go ahead and procure the LiH secondary discs as soon as possible using prepayment and accruals (advice can be obtained from STFC on this procedure).

Preparations are underway to begin the procurement of the LiH discs that will form the secondary absorbers. The purchasing route has been identified and the necessary permissions for advanced commitment of resources are being sought. Once a satisfactory quote has been received, the order will be placed.

2. The Panel strongly recommends that the DoE offers some formal alleviation to the current hard schedule end-date and 9:6:3 funding profile. While this goes against the grain for top-level project management, the Panel is convinced that it is now necessary to relax these boundaries/constraints to reduce ongoing risk and maximise the probability of success for the MICE project to achieve its goals and hence maximise return for the funding agencies.

The project team notes the recommendation of the RLSR panel and will provide any necessary clarifications requested by the DOE. Subsequently, the guidance that the US effort has received from the US Department of Energy is that the ramp-down funding plan for the Muon Accelerator Program is fixed and that additional relief should not be expected. The US effort continues to work to identify options that will allow the collaboration to move forward with their experimental goals in the absence of further US support.

3. The US Project Director should not undertake a fully resource-loaded schedule for the second Solenoid Review but rather investigate more than one option that provides a 'good-enough' solution and subsequently spend time working on the resource-loaded impacts in detail to report to the funding agencies in ~January.

A fully resource-loaded schedule for the MAP Director's Spectrometer Solenoid Recovery Review [1] was not developed. Nonetheless, a detailed work plan was presented in order to assess the full range of issues and interactions critical to the repair. The primary focus entering the review was a detailed examination of the risks associated with each of the repair options identified and a plan was proposed at the review, with preliminary schedule and cost estimates, to achieve a successful repair in the shortest possible time and within the budget constraints of the project-held contingency reserves of the US effort. The review committee endorsed a path towards construction of a new cold mass for the downstream spectrometer solenoid. The committee also provided input on the expertise required to execute the repair, recommended approaches to the repair, as well as providing comments on the achievable schedule. Given the complexity of the repair, a validated resource-loaded schedule, which is ready for preliminary review, is unlikely to be available until sometime in the February-March 2016, with a final version expected by April 2016

4. The STFC and DoE need to jointly agree on the future funding for MICE over the next three months – this is the most important recommendation/action from the entire Review.

The project team notes the recommendation of the RLSR panel and will provide any necessary clarifications requested by the STFC and/or the DOE.

Actions

1. The STFC needs to communicate concerns about potential transferred risks to the US project side prior to the second Solenoid Review

The project team notes the action and is ready to clarify issues identified by the STFC or its partners in the course of the communication referred to. Done by STFC

2. The STFC needs to be made aware of the consequences of the flat-cash funding profile on the schedule of the project (action on the RLSR Chair)

The project team notes the action and is ready to provide clarifications as required to the chair of the RLSR panel as required. Done, by Panel Chair

3. The Project Spokesperson is actioned to approach other agencies involved in MICE to determine if appropriate resource for construction and commissioning could be injected into the project – especially in the RF area.

Progress in recruiting additional personnel has been made since the last meeting of the RLSR panel: Three Chinese scientists have been recruited into the project.Two magnet experts (M. Wang and W. Yao) from IHEP will come to the Rutherford Appleton Laboratory (RA Where possible the visits of the two magnet experts will be arranged such that there is a period of overlap when both experts are on site. An accelerator physicist (W. Liu) from CSNS will make a number of visits to RAL, each of three to four months duration. Efforts continue to identify suitably-qualified RF experts who may be available to contribute to MICE. Discussions with E. Jensen, leader of the CERN RF Group, culminated in a meeting on the 6th January 2016 between members of the CERN RF Group, MICE and ISIS. The CERN RF Group is being called upon to ensure the smooth operation of the CERN accelerator complex and to carry out the accelerator-facility consolidation plan. Despite these pressures, the MICE request was discussed in a manner that was positive and supportive. It was agreed that a personnel-exchange mechanism would be set up. In the first instance MICE personnel will go to CERN to work alongside the Linac 2 and 3 commissioning and operations teams when the proton-accelerator complex is restarted in February 2016. In this way, the UK personnel would gain valuable experience and the CERN teams would be strengthened for the period the UK personnel are on site. The experience gained by the UK personnel will be directly applicable to the commissioning and operation of the MICE systems. The personal and institutional relationships that will develop will also provide valuable lines of communication and support for MICE in the commissioning and operations phases. An addendum to existing MOU and collaborative agreements is required to allow the personnel exchange to take place. K. Long and J. Thomason will draft such an addendum. The recruitment of a PhD student at NIKHEF is underway. The student's programme would be split equally between work on MICE and work on the Deep Underground Neutrino Experiment in the USA. The successful candidate will be spend some time on long-term attachment to RAL.L) for periods of up to four months per year. The first visit will start at the end of February 2016.
Added: In our Response to Feedback we noted the progress made in recruiting valuable additional contributions from China and NIKHEF and the positive discussion of a personnel agreement between MICE, ISIS and the RF Group at CERN. Since the document was submitted, interest in MICE has been expressed by the Ulsan National Institute of Science and Technology (UNIST, Ulsan, South Korea) and the Centre for Axion and Precision Physics (CAPP, Daejon, South Korea). Both institutes have valuable expertise in RF systems and RF instrumentation. A letter from the MICE Spokesman to the Korean PI in support of a proposal for the resources to allow UNIST and perhaps CAPP to

participate in the experiment was provided. It is anticipated that there will be Korean particpation in the MICE collaboration meeting that will be held at LBNL in July 2016. This will allow further discussion of possible Korean involvement in the experiment with a view to the formal presentation of proposal to join the collaboration at the October 2016 collaboration meeting that will take place at RAL.

4. The collaboration must be fully informed of input to and outputs from the second Solenoid Review

The collaboration was engaged in the preparations for the MAP Director's Spectrometer Solenoid Recovery Review [1] and was represented across the relevant areas of expertise at the review itself. Following the review the collaboration received copies of both the interim [2] and final reports.

5. The output from the second Solenoid Review must be fed into the Beam Dynamics review of early December

The beam dynamics review will be held on the 14th and 15th January 2016 at RAL [3]. Links to the recent reviews of the project were provided to the reviewers. The draft report on the solenoid-recovery review was provided as part of this material.

6. The case for extending the data-taking for Step IV into ISIS run 2016/2 must be very carefully considered in terms of the risk to the overall schedule to completion (and thus increased cost) and this must be presented to the next RLSR/PMB.

The MAP Director's MICE spectrometer solenoid recovery review that was held at FNAL on the 3rd and 4th December 2015 [1] concluded that the most optimistic timetable for recovery of the damaged downstream spectrometer solenoid will not provide a working replacement before the end of 2017 [2]. The committee also gave a strong recommendation that the collaboration maximise the return on the Step IV programme. This advice sits well with feedback from the UK Oversight Committee which made similar recommendations concerning the exploitation of Step IV. Analysis of the cost impact of the extended schedule has been started with initial estimates for the cost of the project for construction timescales extending into 2018 having been produced. A full re-costing exercise is underway the results of which will be presented to the RLSR panel and the MPB at its next meeting.

Appendix 2: The Charge

This review will again be split, with the Resource Loaded Schedule Review (RLSR) aspect being covered in the first part of the meeting, followed by sessions with a technical focus. As at previous meetings members of the panel will remain the same throughout to avoid unnecessary repetition. The outcome of the RLSR and MICE Project Board (MPB) will be reported to the MICE Funding Agency Committee (FAC) meeting that will take place in the afternoon of 6 April and will be chaired by John Womersley. A written report will also be submitted to Grahame Blair and John Womersley.

The events with the downstream spectrometer solenoid have had a major impact on the experiment. Understanding the recovery route and the implications that this has on the schedule and costs will be important in this meeting as will understanding the risks to all aspects of the project and its stakeholders.

The main focus of this meeting is to;

1. Confirm the goals and criteria for scientific/technical success,
2. define technical issues to be solved for,
    a. Superconducting magnets
    b. Balance of systems
3. consider the revised schedule taking account the DOE and STFC integrated funding profiles,
4. advise the funding agencies on clear go/no-go decision points associated with the spectrometer solenoid recovery plan,
5. consider whether the goals can be achieved in light of currently available information.

The RLSR section will concentrate on the human, financial and technical resources that are required to achieve the key milestones, and for completion of the MICE program within the known funding profiles (i.e. the US profile for the 3 fiscal years starting in 2015 of $9M, $6M $3M, flat cash at £3M/year in the UK and the continued contributions of the funding agencies supporting the non-UK, non-US members of the collaboration).

The panel will want to consider the implications of a resource limited approach, and to understand fully the assumptions being made by the project and the experimental collaboration, as well as their assessment of the potential schedule delays.

The collaboration is asked to;

1. Present in the RLSR section of the meeting a revised schedule that takes account of the spectrometer solenoid issues and in doing so to;
    a. Examine DOE and STFC integrated funding profiles.
        i. Consider realistic time lines and end dates
        ii. Acknowledge and define the uncertainties associated with different recovery routes and the decision points
    b. Define available specific human resources needed.
        i. UK Side
        ii. US Side

    The scientific aspects of the project should not be included at this stage and the focus should be on setting out clearly the current status of the resources (staff/cash), schedule and risks to achieve Step IV and to demonstrate ionisation cooling. This should identify, with the resources available,
        i. progress against the established key milestones,
        ii. the remaining risk factors as well as any newly identified risks, and
        iii. the most likely schedule and subsequent cost when these risks are fully incorporated.

The panel is asked to;

1. Advise on the implications of the current slippage in terms of cost and to the science goals.
2. Highlight the outstanding risks and comment on their management and cost analysis, taking into account the progress to date.
3. Monitor integrated project management performance, where appropriate.
4. Comment on whether the goals can be achieved.
5. Comment on the scientific output to date.
6. Outline the steps and timescale needed to put in place a recovery plan for the spectrometer solenoid.

The Collaboration should respond to the relevant recommendations from the last meeting, which are included in Appendix 1, and update as appropriate its previous response.

Appendix 3: The RLSR Panel

Professor Ian Robson	STFC (Chair)
Dr Steve Peggs	Brookhaven National Lab
Mr Ron Prwivo	Brookhaven National Lab
Dr Tom Taylor	CERN
<u>In attendance</u>	
Mrs Charlotte Jamieson	STFC
Dr Bruce Strauss	DoE