Response to feedback from the Resource Loaded Schedule Review panel and the MICE Project Board

The project team welcomes the reports from the Resource Loaded Schedule Review panel and the MICE Project Board following their meetings in November 2014. This document provides the project team's response to each of the RLSR panel's and MPB's recommendations.

Four issues raised in the MPB report deserve particular attention:

1. *It should be noted that there are no spare magnets: the magnets should therefore be powered with the utmost care. If a coil fails we shall be out of business, so if the budget for the new baseline permits it would be useful to consider exercising the options and purchase a spare spectrometer cold mass and a spare focus coil cold mass.*

   The project team agrees that the commissioning of the magnetic channel must be carried out with the utmost care. With this in mind the training procedure is being reviewed in the preparation for the commissioning period.

   While it may be desirable for spare cold masses for the spectrometer solenoids and the focus coils to be manufactured, the project team believes it to be impractical. At present neither the UK nor the US has the resources required to launch such a procurement in parallel to completing Step IV and then preparing for and implementing the cooling-demonstration. Further, the project team considers the mitigation of other risks attendant on the Step IV and cooling-demonstration construction projects to be of higher priority. In addition, the lead time on a new cold mass for either the spectrometer solenoid or the focus coil is approximately 18 months. In the event of a failure, the spare cold mass would have to be integrated to produce a working magnet which would then have to be trained. The time constraints under which the project must now operate precludes this sequence of operations from concluding before the end of US fiscal year 2016. The project team therefore does not consider it feasible to launch the procurement of spare cold masses.

2. *The commissioning period appears to be well integrated with the ISIS running periods scheduled for 2015. The use of any available muons for detector tests and calibration will be essential in order to advance the commissioning schedule, even if this means taking data with an unfocused and unoptimised beam. The collaboration should act in 'data taking mode' in terms of shift organisation and the presence of collaborators at RAL, in order to use the opportunities for training and establishment of operational procedures.*

   Optimisation of the use of beam time to advance the detector commissioning in parallel to completing the installation of the PRY is a priority for the collaboration. The mock data-run that took place on the 21^{st} January 2015 was a success both in terms of the progress made in establishing the conditions for data taking and for the comprehensive list of issues that was generated. ISIS requested that the target be operated for an extended period on the 8^{th} March 2015 to allow the activation of the ISIS ring to be measured. The project team confirmed that closing the MICE Hall to allow data taking without field on the 8^{th} March, exploiting the "activation run", would not have a negative impact on the PRY installation schedule. Therefore, the collaboration laid plans to run the experiment to allow commissioning of the detectors with beam. However, on the 30^{th} January 2015 the project team learned that it had been decided to run ISIS at a maximum energy of 700 MeV for the first user run only. The decision was made because ISIS has too few spare dipoles to guarantee running at 800 MeV. This means that the activation study has to be postponed. The two shifts of data taking that were allocated to the activation study are still available for MICE operations. In view of the benefits that will accrue from commissioning the detectors

with beam, the project team continues to hold open the opportunity to take beam on the 8^{th} March 2015. The final decision to operate the experiment will be taken at the MICE collaboration meeting (9^{th} to 11^{th} February 2015 based on the anticipated delivery dates of the components of the PRY and a review of the PRY installation schedule.

3. *The plan is very similar to that traditionally used by small particle physics experiments, and appears well founded. The decision as to whether to run MICE 24/7 or 16/5 rests solely upon the availability and commitment of collaborators to take shifts. Given the investment into the experiment over many years, and the stringent limits on available ISIS beam time, we support, in the strongest terms, the collaboration coming to grips with this issue and ensuring round-the clock exploitation of the experiment.*
   The project team and the collaboration agrees that full exploitation of the available running time calls for "24/7" running. The shift-allocation tool has been prepared and released to the group leaders through the MICE Collaboration Board. The discussion of staffing MICE operations will be an important topic for the Collaboration Board when it meets at the February 2015 MICE collaboration meeting.
4. *The success of the MICE experiment depends upon the maximisation of operational efficiency, meaning (a) taking the largest quantity of measurements, and (b) ensuring the highest quality of those measurements. Although it was not clear from the supplied reports, the collaboration assured the board that a comprehensive system of online data quality monitoring tools would be in place to allow rapid feedback on data quality to shifters. However, it was reported that full reconstruction of data was likely to take 24 hours, apparently due to relatively straightforward dataflow bottlenecks related to the use of Grid computing.*
   Two kinds of online tools exist for monitoring the performance of the detector hardware and software. One for monitoring the quality of the data at the data-acquisition level to provide feedback on the performance of the detector hardware. "Data quality flags" from each system will be stored in the configurations database for all systems. This is being enhanced and the documentation for shifters is being improved. The second tool—online reconstruction—has been implemented for all detectors with the exception of the EMR, which is presently being added.
   In production data-taking mode, reconstruction will be performed on the GRID within 24 hours of the data being recorded. In order to perform this "batch" reconstruction the data transfer to permanent storage is being automated. The automated transfer and batch processing will be tested with mock data prior to Step IV data taking to ensure that there are no bottlenecks.

Resource Loaded Schedule Review

The project team's response to the actions and recommendations made by the RLSR panel follow.

Recommendations

1. **The project must ensure that results from the Step IV data-taking are obtained as soon as possible in order to support the UK application to STFC for remaining funding for the completion of the project.**
   The project team is taking several steps to ensure efficient data taking and extraction of results. The critical activity is the careful planning of interleaved construction and commissioning activities until the PRY installation is complete, followed by careful planning of interleaved magnet commissioning and instrumentation shakedown activities.
   The first mock-data run, which took place on the 21^{st} January 2015, was a success and highlighted a number of areas for continued development. It has been agreed between the operations and construction teams (through the MEMO and MIPO) that the opportunity to run MICE in the ISIS run-up on the 8^{th} March 2015 will exploited to take beam into the Hall so that a first attempt to take data with the Step IV

instrumentation can be made. The operations team is now planning the programme of work needed to prepare for data taking on the 8^{th} March 2015. This programme will include a second mock-data run in the second half of February 2015.

In parallel, the analysis teams are undertaking a programme of analysis against Monte Carlo data sets to prepare for the arrival of real data.

2. **The STFC Programmes Directorate should give a firm undertaking that the additional funding (£180k) required for FY15/16 will be made available as a release of centrally held contingency. Failure to provide this will have a negative impact on the Step IV and Cooling Demonstration schedules.**

   The project team notes the RLSR panel's recommendation and awaits direction from the Science Programmes Directorate.

3. **The commissioning/controls/software schedules/milestones should be included in the top-level project schedule with appropriate milestones included in the milestone (waterfall) charts.**

   The commissioning, software and controls milestones are incorporated in to the top-level project plan and are included in the waterfall plot in the first bi-monthly progress report [1].

4. **The project is requested to inform the MPB of the update of the Dashboard on a bimonthly basis so that members can remain informed of progress between meetings.**

   The first bi-monthly update of the project Dashboard may be found at `http://micewww.pp.rl.ac.uk/dashboard/`. A brief update on progress may be found in [1].

Actions

1. **If necessary, the project must work with STFC Programmes Directorate to ensure that the required RF staff at Daresbury Laboratory (ASTeC and Technology Department) will be made available on the timescale needed to meet the critical milestone for the MICE Cooling Demonstration. This action should not be delayed so that if the staff are not available, there is adequate time to seek an alternative solution.**

   Following the November review, K. Long contacted S. Smith, Director ASTEC and Head of Daresbury Laboratory, to discuss the needs of the MICE programme and to transmit the panel's concerns. S. Smith recognised the importance attached to the timely delivery of the RF-power systems for MICE such that the critical cooling-demonstration milestone could be met. Further, she agreed that the work on the MICE RF systems would be given appropriate priority. In order to plan the allocation of effort effectively, S. Smith undertook to initiate a review of the commitments of the DL (ASTEC and TD) staff. The project team will maintain the close contact that they presently enjoy with the DL teams and with senior management at DL to ensure appropriate allocation of staff effort or early indication of pressures such that appropriate mitigating actions can be taken.

MICE Project Board

Superconducting magnets

1. **Investigate how and where the cavity power couplers can be tested at full RF power at the earliest convenience, in order to mitigate any project risks. A power coupler test bench could be considered.**

   So far, four couplers have been tested in the MuCool Test Area (MTA) to power levels approaching twice that which will be needed in MICE. The current pre-production set is being readied to test in magnetic field and it is anticipated that results will be available in February 2015. With these couplers the cavity was driven to ~ 14 MV/m (to be compared to the MICE specification of 10.3 MV/m). Small design modifications will be incorporated into the final set of six couplers (four for use on MICE and two spares).

A new coupler-test-module conceptual design has been developed. However, presently the resources require to complete the design and to fabricate the test module are not available. In lieu of this, the intention is to install one set of the production RF-power couplers in the Single Cavity Test System in the MTA. The test will take the couplers to the full MICE power specification and beyond, if the couplers can accommodate the full power available from the MTA 201 MHz power source. The time required to remove and install couplers and, given the manpower resources we currently have available in the MTA, will not allow us to test all of the three sets of production couplers. We therefore rely on the assumption that a single, qualifying test of the first production coupler set will be sufficient.

2. **Ensure that the required resources will be in place for the operation of the LH2 absorber during Step IV running, for example in the form of a more robust MICE liquid hydrogen team.**
   A requirement of the hydrogen safety case is that only the expert team interacts with the system while it is running. Presently the three members of the expert team are:
   - S. Watson (TD, RAL), LH2 Project Engineer;
   - P. Warburton (TD, DL), Control Engineering; and
   - M. Courthold (TD, RAL), Cryogenic engineer.

   The team has been augmented by a fourth member, M. Tucker (PPD, RAL, cryogenic engineer) who has extensive experience in cryogenic, vacuum and control engineering. All of the team members are part-time on the MICE LH2 project but arrangements have been made with their managements to protect their MICE commitments when necessary. With the above addition, the strength of the team is considered adequate to deliver the hydrogen system for, and to operate, Step IV. Another significant mitigating factor is that the revised cooling-demonstration configuration does not require an additional hydrogen system. In addition, the MICE LH2 Working Group contains two expert members from the ISIS Hydrogen Group. Though the ISIS experts cannot involve themselves directly in MICE at present, they have been, and will continue to be available to provide guidance and advice.
3. **Prepare for an accurate comparison of the LH2 and LiH absorber efficiencies during Step IV.**
   An accurate comparison of the performance of LH2 and LiH absorbers requires that sufficient, high-quality data is taken with each absorber. This will be possible if the installation proceeds on schedule, the commissioning and operations activity are well planned and efficient and if the absorber exchange can be carried out smoothly. The Project Manager, supported by the MIPO, is actively engaged in ensuring the success of the first and third of the above conditions while the Spokesman, supported by the MEMO and the full MICE collaboration, is working to ensure that the commissioning and operations activities are as efficient as possible.
4. **Maintain good progress in the control systems in order to provide adequate readiness for the start of Step IV commissioning.**
   Intermediate milestones have been established to help gauge progress and the requisite tasks have been identified. The first milestone was the mock data run of 21st January 2015 in which the full MICE Muon Beam (MMB) and detector controls were to be fully integrated into RunControl. As the date approached it became evident that both systems would not be complete in time, so the detector integration was postponed since the detectors can be operated as stand-alone devices. Stand-alone operation was sufficient to meet the objectives of the mock data run.
   For the MMB, the required tasks were the completion of the Input/Output Controller (IOC), the MMB state machine (SM), and its integration into RunControl (RC). Each part ran successfully. Several minor short comings were identified which are now being addressed. A weakness in RC was also identified which made it too rigid to recover from failures of individual modules; a solution has been identified and is now being implemented.
   The next milestone is on the 1st March 2015 when the MMB and detectors are to be fully integrated into

RC. The most challenging tasks here will be the completion of the EMR controls and the integration of the tracker controls.

The SMs for the control of the spectrometer and focus-coil magnets were well advanced during the training and commissioning of the magnets. Completing these SMs will allow for easy integration of the magnet control into RC. This milestone is set for the 30^{th} March 2015, so that, should the schedule allow for early commissioning of the magnets, their control systems will be ready.

Further milestones are contained in the project plan referred to under our response to RLSR recommendation 3.

Data acquisition, simulation and reconstruction

5. **Investigate as a matter of urgency technical means to optimise the trigger efficiency for 'good' muons, and remove dataflow bottlenecks before the Step IV run.**

   To increase the trigger efficiency for "good" muons the physics team is examining ways in which the downstream instrumentation (TOF2, KL and EMR) may be included in the trigger logic so as to maximise the good-muon efficiency without introducing biases in the physics results. In parallel the trigger simulation used to estimate the good-muon rate is being reviewed and the use of collimators in D1 and D2 to improve the pion and muon momentum selection is being considered.

   The principal "dataflow bottleneck" is the dead-time introduced reading out the analogue data from the AFE-IIt. The tracker- and central-DAQ teams are collaborating on the development of a plan by which the on-board discriminators are used to determine which tracker channels are hit. Implementation of the AFE-IIt discriminator readout would allow the analogue pipelines to be removed from the readout stream. Firmware upgrades are required to implement the discriminator readout. In addition, extensive calibration and testing is required to ensure that thresholds, pedestals and gains are set such that inefficiencies are not introduced. The strategy that has been adopted is to devise and document the steps required to implement the discriminator readout. This plan will be rolled out once the tracker readout that is presently implemented (i.e. the readout of the analogue pipelines) has been commissioned.

6. **Plan and execute a blind 'physics analysis challenge' in order to ensure the readiness of the whole collaboration for data analysis, early in 2015.**

   A physics-analysis challenge was already in progress prior to the MICE Project Board meeting in November 2014. Initial analysis of the data had already been performed and the full analysis of the data is ongoing. Lessons learnt in this exercise will be taken into account in planning a subsequent blind-analysis challenge.

7. **Ensure optimisation of the beamline settings in order to preserve matching at the entrance of the ionization channel and potentially increase the number of 'good' muons, during the Step IV run.**

   The optics of the MICE Muon Beam (MMB) was extensively studied at Step I and satisfactory settings were obtained that allowed the various beams required by the MICE programme to be delivered. A re-evaluation of the optics and beam dynamics of the MMB is underway in preparation for Step IV in order to optimise the beam including matching from the spectrometer solenoid into the cooling cell. This investigation includes detailed study of the diffuser taking into account changes in the configuration of the apparatus implemented since Step I. The ideal beam needs to have a small betatron function, matched to the periodic value dictated by the uniform field, the $\alpha = 0$ condition needs to be met at the centre of the spectrometer solenoids and the input beam emittance required needs to obtained using the diffuser. A revised model of the optics has been developed that allows beam-line settings that minimise mismatches to be investigated. Monte Carlo simulations are ongoing to check the validity of the model and, simultaneously, to maximise the transmission. Performance of the beam-line settings will be investigated experimentally during commissioning as soon as the beam is available and, if possible, during the Spring ISIS run.

8. **Include a set of measurements in a configuration with large beta functions in Step IV data taking, in order to validate the muon tracking tools for trajectories with large displacements passing through nonlinear magnetic fields, and to explore the size of the cooling system apertures.**
   A series of large beta function measurements is planned for the Step IV commissioning period. Time has also been set aside for the special runs required for the study of systematic effects. A set of large beta-function measurements will be included in the Step IV data taking.
9. **Finish documentation of the technical software and systems of the experiment before the Step IV commissioning and data-taking run.**
   A documentation review is on-going. Documentation of the software, and operational procedures, for each of the main technical systems is available and is being updated with the intent that a revised set of documents outlining the schematics, operations and emergency procedures will be available in time for the 8^{th} March 2015 run.

Commissioning, operations and data analysis

10. **Establish and implement the practical safety and operational steps required to operate the MICE detectors and take data alongside magnet commissioning, between now and the start of Step IV data taking.**
    The primary barrier between the experimental hazards and personnel is the PPS (Personnel Protection System) coupled with a pre-operation search procedure. The system allows controlled access for nominated experts, such as those required during a magnet or detector commissioning run; this system has already worked very well. The methodology of the PPS is mature and the system has been used in practice successfully in Step I data taking and in several pre-running commissioning exercises such as the TIARA RF project and the liquid-hydrogen system test. All users, experts and shifters, must undergo PPS training before they are qualified as part of the MICE operations team.
    Practical steps, such as the control of ferro-magnetic tools and equipment, need to be taken and a system has already been developed for use in R9 while the FC was being commissioned: a responsible person is nominated who has to "sign in" and "sign out" tools and equipment. Polycarbonate safety boots will be required and the magnetic safety part of the visitor induction training will be emphasised. An airport-style metal detector has also been installed. An STFC safety code exists, controlling aspects of stray magnetic fields; it can be found here:
    - `http://www.stfc.ac.uk/SHE/Codes/STFC/SC39_static+magnetic+fields/35607.aspx`

    As far as reasonably practicable, the MICE installation and operations plans comply with this code; in addition, MICE was visited by Public Health England in 2014 under the terms of the above legislation and no major actions were noted. A comprehensive ODH alarm system is being installed now, paying particular attention to confined spaces where gaseous nitrogen could collect during magnet pre-cooling. This system will be commissioned and certificated as a pre-requisite for Step IV running.
    The hazards connected with running the MICE instrumentation are limited to trip hazards and an awareness of high voltage, both of which are covered as necessary by barriers, signs and user training.
    It is to be understood that only the expert team (see above) will be interacting with the liquid hydrogen system. This team is necessarily familiar with and extensively trained in the particular hazards connected with the hydrogen. During commissioning, their access will be controlled by the PPS system.
11. **Take all necessary steps to ensure 24/7 exploitation of the experiment during all commissioning and data taking runs.**
    The 24/7 exploitation of the experiment rests on the availability of sufficient personnel to man three, eight-hour shifts per day. The MICE Collaboration Board has agreed the shift policy which provides that each MICE author is eligible to take shifts and defines the algorithm by which shift quotas will be

assigned to each of the collaborating institutes. To establish the number of personnel in the shift pool the shift-allocation tool ("CHEESE") has been rolled out. The institute contact persons have been asked to complete the data-base entry for their institute before the start of the next collaboration meeting (CM41) in February 2015. The headcount will be used to define the running pattern and shift-allocation policy for discussion at the Collaboration Board at CM41.

In parallel, efforts are ongoing to raise the resources necessary to deliver the personnel required for 24/7 running. Since the last round of reviews a proposal to the European Commission for an Initial Training Network has been submitted. In addition, a proposal to support exploitation of the experiment will be submitted to the NSF early in February 2015.

12. **Optimise the offline computing production plan in order to allow sufficient real-time track reconstruction and data analysis, to provide the most rapid possible feedback to shift crews and experts on experimental performance in Step IV.**

    The automation of data transfer from the MICE control room to permanent tape storage is being implemented. This will enable us to perform batch reconstruction immediately on the RAL Tier 1 cluster to make the reconstructed data available for further analysis. This procedure will be tested during the run on the 8^{the} March 2015. In addition, the online reconstruction tools are being enhanced to provide real-time feedback on the quality of reconstruction from all detectors.

References

[1] The MICE International Project Board, "MICE bimonthly project update ♯1." `http://micewww.pp.rl.ac.uk/documents/121`, 2015.