Response to recommendations and questions from the MICE Project Board

MICE collaboration

MPB4 October 2012

1. ***Look further at the temperature margin on the Coupling Coils and make a decision as soon as possible on the copper-to-superconductor ratio for the production MICE coils, and buy sufficient conductor to make three coils.***

Following the Coupling Coil review of February 2012 and the MPB recommendations, the LBNL group considered three options:

A. Lowering the Cu/SC ratio (currently 4/1)
This increases risk. It would increase temperature margin but reduce transient stability and raise the hot spot temperature. Our experience with Cu/SC of 2/1 for potted magnets has not been good.
B. Lowering operating current
This was not considered to be an option at this point. As per the MICE proposal, the magnets have been designed to allow exploration of momenta as high as 240 MeV/c, which corresponds to an operating current of 210 A.
C. Redesign the coil
This option is considered extreme since it would significantly delay the project and we have no performance data on the coil that is nearly ready for testing. We would need to increase the amount of conductor significantly to increase the Cu/SC ratio to have much impact.

At the maximum required operating current of 210 A, the temperature margin along the load line is 1.3 K. Taking a more conservative approach and using the current sharing temperature, the margin is about 1 K. As a comparison, the temperature margin for the spectrometer solenoids, using the current sharing temperature as reference, is 1.2 K.

Taking into consideration all of the above, it was considered that making a change to the Cu/SC before having tested the current design seemed risky, so it was decided to leave the ratio at 4/1. Enough conductor has been purchased for 3 additional coils in addition to the existing test cold mass.

2. ***Wind three identical Coupling Coils, in order to have a spare coil.***

A coil winding review is scheduled in Beijing at the Qi Huan company on December 6, 2012. Initial tests on the test cold mass will be performed at Fermilab between now and February 2013 to understand the quality of fabrication. Assuming success of the review and of the initial tests, winding of 3 more coils will begin. The superconductor needed for these three coils is already at Fermilab. The test reports from Luvata are excellent with all SC meeting or exceeding spec. The piece lengths are very long and will result in the next coils having roughly ½ the number of splices that exist in the first coil. Samples from each spool will be retested at Fermilab before the SC is shppped to China.

3. ***Assemble an operational support plan that includes the resources required and types of resources needed for operation of MICE, both in the near term for Step 4 and also in the long term for Step 6, and present at the next MPB.***

The MICE Project is in the final constructional phase before embarking on the Step IV experimental program.

Much experience has been gained in running the experiment under the authority of the MICE Operations Manager (MOM), which is a rolling monthly appointment and whose main responsibilities are to meet the scientific objectives of the project and to accept delegated safety responsibility from the MICE Project Manager. So far experimental running has necessarily been mapped onto the ISIS six-week user runs and has only taken place during reasonably normal working hours and the technical scope has been to characterize the muon beam, to gain experience with detectors, conventional and superconducting beam line magnets, the personal protection system (PPS) and the normal range of project hardware.

As a somewhat independent exercise, a five-week system test for the MICE liquid hydrogen delivery system was successfully completed in August 2012. This activity was the first serious attempt to run continuously for twenty-four hour periods and gave valuable experience in the construction and operation of a shift plan. <u>It is an organisational and safety requirement of STFC, the hosts of MICE that suitably qualified experts are on the premises when hazardous operations are carried out.</u>

As MICE moves to Step IV of the project, the operational model needs to change and to be defined from there onwards. For Step IV specifically, the main requirements are listed below:

1. A full time resident MICE Operations Manager (r-MOM) will need to be appointed. This is essential, given the increasingly complex set of technical activities and associated risks. The post holder will need to fully conversant with STFC's safety and operational culture and must accept that they have to reside locally and to attend RAL during normal working hours. The post holder does not necessarily have to be an STFC employee and two possible candidates from within the project have been identified. This appointment carries delegated safety responsibility from the Project Manager.

2. The rolling monthly MOM appointment will continue, with largely unchanged duties, but the monthly MOM will be expected to be 'on-call'. It is expected that this post will carry the main load of the day to day experimental planning and running.

3. Experimental shifters will continue to be provided by the MICE Collaboration, arranged by MICE's shift co-ordinator, as this system has been proven to work well. The existing regime of Beamline On Call (BLOC) and Software OnCall (SOC) will continue. Experts for any particular subsystem, such as the target or decay solenoid are already identified

4. A minimum of three operational shifters need to be provided. They would provide the basis of the 24-hour coverage as outlined above and would need to be selected for the following expertise:

   - Cryogenic support: maintenance of magnet systems, management of cryogens and vacuum pumping rigs and instrumentation

   - Superconducting magnet diagnostics: cooling and powering expert, quench behaviour expert, will necessarily overlap with the above

   - Liquid hydrogen delivery: control engineering expertise, safety procedures

   - Conventional magnet systems, detectors and PPS systems

Although minimally three people are required, the number of trained people will be higher in order to meet the terms of the shift coverage within STFC's HR framework. This expertise is aligned more with 'engineering' than with physics and it is not clear that these people can be found within the project, but a possible solution might be fixed- term contract hire.

Note about Step IV programme:
The experimental programme for Step IV has not yet been defined in detail, but it is assumed that it will take place over one year, as described in the MPB report of March 2012. An estimated 4-6 weeks will be required at the beginning of the program to understand the behavior of the combined system of spectrometer solenoids and the focus coil, which will be running adjacent to each other for the first time. This operation will not require beam or 24-hour coverage, but will need the magnet expert to be on-call. When complete, the experimental work will start with an empty focus coil and progress to studying the liquid hydrogen then solid absorber configurations. For the Liquid Hydrogen running, the 24-hour plan needs to be in operation.

Note on Step V & VI
It will be a pre-requisite of running Step V that the operational procedure in general for the project has been developed properly before moving to Step V and Step VI. The technical and experimental requirements as outlined above will remain, but will need to be augmented by suitable RF experts, led by a full-time RF engineer. Presently this expertise is centred at Daresbury Laboratory, who are currently

interviewing for the RF engineer post, on the basis that the post holder will work full time at RAL when training is completed.

4. Make a single integrated resource loaded schedule for the production, assembly, installation and commissioning of all components, and present at the next MPB. Link this schedule with the available budget.

This important exercise has been performed in September-October 2012 for the first time. A dedicated schedule meeting was held on October 16 within the collaboration meeting MICE CM34 [1] in which the most important schedule drivers and risks were reviewed.

The full Microsoft project file can be found in [2]. The MICE schedule sketch as it was on June 2012 is shown in Figure 1. The new schedule is shown on Figure 2. Step IV run date is shifted by one year and step VI by two years. The analysis of the main delays is given below. The driving items remain construction and commissioning of the spectrometer solenoids for step IV and coupling coils for step VI, but the need to provide adequate magnetic shielding for the support equipment (power supplies, compressors, electronics, etc..) presently in the MICE hall would have added an incompressible element to the schedule if it had not been for the magnet delays.

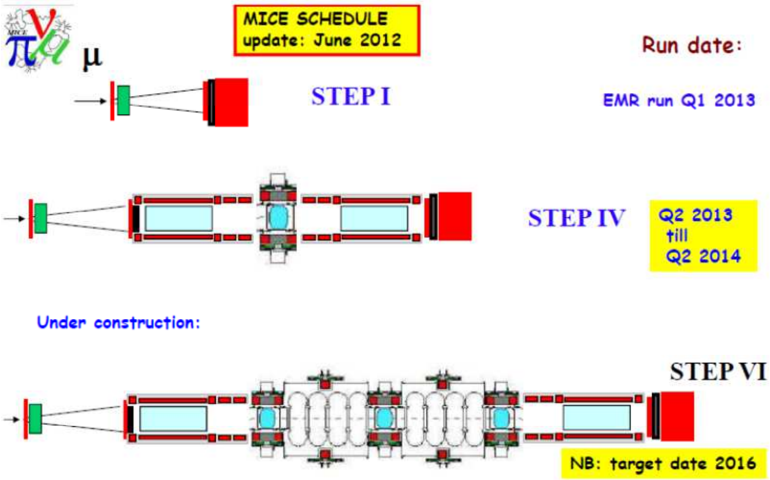

Figure 1 MICE schedule as of June 2012

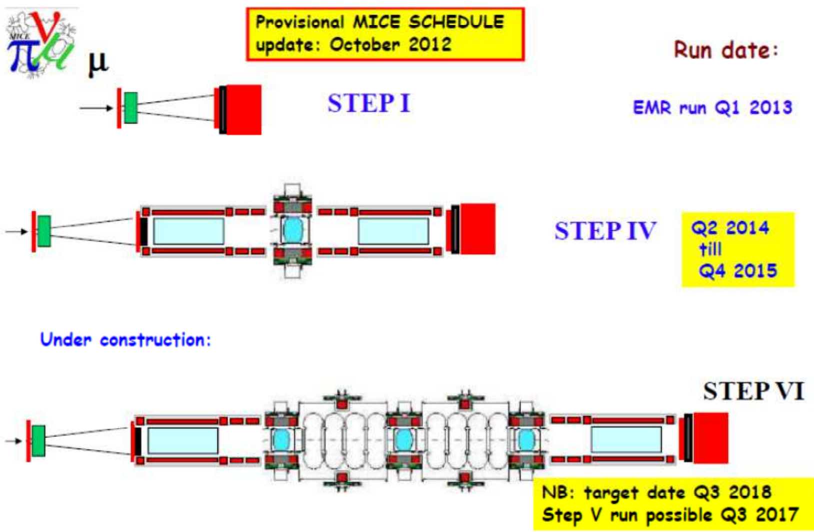

Figure 2 Provisional MICE schedule as of October 2012

Step IV delays: the spectrometer solenoids

At MPB3, the milestone tracking of the first spectrometer solenoid was excellent. The constant follow up of the project was greatly helped by the additional manpower resources assigned by LBNL and, alas only until June 2012, by the presence on site of a dedicated engineer from RAL (Roy Preece). The Control System prepared by the Daresbury Lab team was operational under supervision of Dr Hanlet from IIT. After some delays due to the shortage of Helium, the training of the magnet started on 13 June 2012. Training to 90% of the maximum operating current of 270A was achieved by 3 July but it was noted then that one of the HTS leads was open. It was found to be burned; probably the active protection system itself triggered a quench. Analysis of the data showed that the lead had displayed a higher than normal resistance all along (Figure 3)

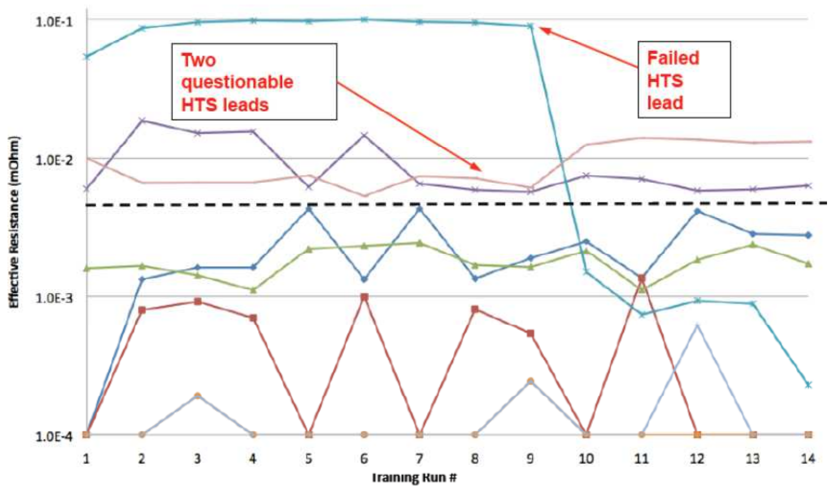

Figure 3 Resistance of the HTS leads.

After exchange of the lead, training restarted on 16 August and went smoothly all the way to a quench at 272 A on 17 September 2012. This is just above the nominal operating current. The test plan calls for ramping to the target currents (2% above operating), ramping back down to operating, and holding for a 24 hour period. However the heater system that maintains the pressure in the magnet vessel was not restarted and remained off for a long time; this was traced back to an incorrect operation of the control and alarm system (the alarm was not set to go off). Without the heater operating, the cold mass pressure dropped to 0.41 bar, and air leaked into the system through one of the relief valves, resulting in an ice blockage in the vent lines. This required warming up the magnet.

The events lead to the following schedule: after warm up, a two month period will be dedicated to review the operating system in detail, and ensure that its settings are adequate for safe operation of the magnet. Time will be taken to change the two questionable HTS leads. Training will then restart in January 2013. The magnet is then expected to retrain in 5 weeks, following which, a set of magnetic measurements will be performed. The magnet is expected to be packaged and ready to ship on the first week of May 2013. The second magnet will follow (hopefully without unexpected setback) with a delay of two months and be ready to ship on the first week of July 2013. While it was hoped to be able to ship the magnets by airfreight, this turns out to be prohibitively expensive and the present plan foresees a 2 months surface shipment.

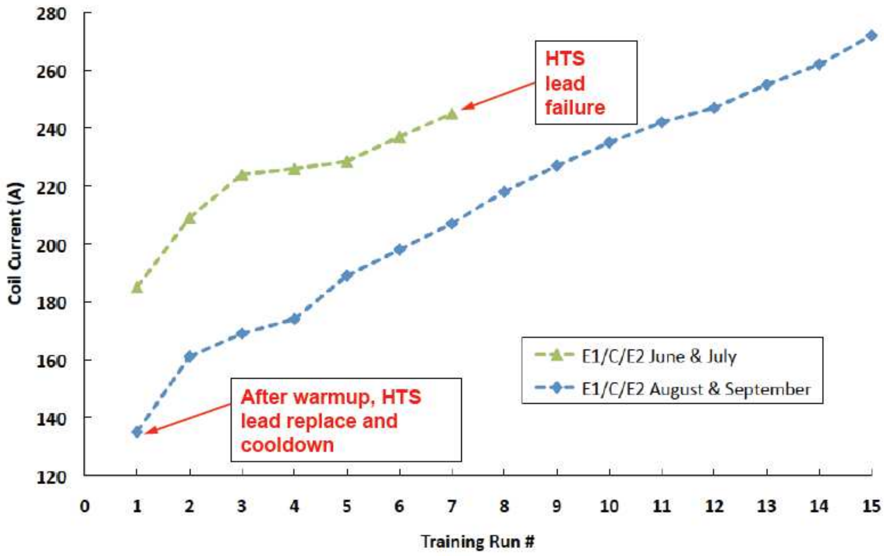

Figure 4 Training history of the spectrometer solenoid 1, which achieved the maximum operating current.

At RAL the magnets will be installed in situ in the MICE hall one after the other to allow for precision magnetic measurements by the CERN team. Bringing each magnet to full operation is assumed to take 5 weeks. An additional 5 weeks are counted for possible need to retrain the magnets once they are all installed in the hall in step IV configuration. The system should then be ready for step IV data taking by June 2014.

The breakdown of delays with respect to the previous (MPB3) schedule is as follows:

+ 4 months for warmups and retrainings of SS1 following the mishaps.
+ 2 months for full implementation of controls, monitoring and alarms
+ 2 months for shipping
+ 3x5 weeks for re-training the magnets at RAL

Which totals up to 12 months.

The following comments were made
-- because the operating system was not complete the two corrector coils were run at the same current as the main solenoid, while their nominal excitation is lower (241A and 227A respectively, while the main solenoid operates at 272A). It so happens that these coils triggered all but one training quenches. Implementing the trim power supply and its control system should save a substantial number of the – Helium and time expensive – quenches.
-- Shipping the two magnets together accounts properly for the fact that the already thin LBNL team cannot be at the same time training a magnet at LBNL and commissioning another one at RAL. Advancing the first magnet shipment by 2 months may allow some of the shipping time to be recovered. This will be considered taking into consideration the level of progress of the second magnet and the readiness of the hall at RAL.
-- the in-situ magnetic measurements at RAL slow down the schedule considerably (6 weeks each). We are considering if enough information can be assembled from magnetic measurement in situ of the AFCs (to evaluate the impact of the iron masses in the hall) combined with precision magnetic measurements of the spectrometer solenoids at LBNL. Again this will be considered according to progress in the training of the solenoid at LBNL.
-- on the negative side, any incident in the training of SS2 would lead to an additional delay of 8-10 weeks.

It is concluded that the best estimate of starting step IV at this point is June 2014, with an uncertainty of ±4 months.

Assuming a start in June 2014, the step IV running is cut in two parts, one ISIS user run before and four ISIS user runs after the long ISIS shut down August 2014-February 2015.

STEP VI delays: the coupling coils

The coupling coil schedule governs the delivery schedule of step VI. The present schedule of the coupling coil fabrication (extracted from the main MICE schedule) is shown in Figure 5. The baseline plan foresees three coupling magnets to be built, one for the MUCOOL (test of RF in magnetic field) at Fermilab MTA, and two more for MICE.

Name	Start	Finish
CC Test stand ORC received	Wed 8/29/12	Wed 8/29/1
CC Test stand operational	Wed 1/23/13	Wed 1/23/13
CC Coil #1 at Fermilab	Mon 11/12/12	Mon 11/12/12
Signoff for Further Coil Winding at QiHuan	Wed 2/20/13	Wed 2/20/13
CC Coil #1 Test Complete	Mon 3/25/13	Mon 3/25/13
QiHuan completes CC Coil #2	Thu 6/13/13	Thu 6/13/13
CC Coil #2 Cold Mass Ready for Use	Wed 2/26/14	Wed 2/26/14
QiHuan completes CC Coil #3	Mon 10/7/13	Mon 10/7/13
CC Coil #3 Cold Mass Ready for Use	Thu 6/19/14	Thu 6/19/14
QiHuan completes CC Coil #4	Wed 2/5/14	Wed 2/5/14
CC Coil #4 Cold Mass Ready for Use	Mon 10/13/14	Mon 10/13/14
Release Package for Shield and Cooling Circuit Parts Fab	Thu 5/23/13	Thu 5/23/13
Release Package for MLI Blanket Order (for all cryostats)	Thu 1/31/13	Thu 1/31/13
Take Delivery of MLI Blankets	Thu 5/23/13	Thu 5/23/13
1st Cryostat Assembly Ready for Shipment to FNAL	Wed 2/19/14	Wed 2/19/14
1st. Cryostat Assembly ready for Cold Mass Integration	Wed 3/12/14	Wed 3/12/14
CCM Prototype Operational	Wed 5/6/15	Wed 5/6/15
CCM Prototype Ready to be moved to MTA	Wed 5/6/15	Wed 5/6/15
Optional: RFCC Prototype Ready to Ship to RAL	Thu 12/8/16	Thu 12/8/16
Optional: MICE RFCC Prototype arrives at RAL	Fri 2/17/17	Fri 2/17/17
2nd. Cryostat Assembly ready for Cold Mass Integration	Fri 6/5/15	Fri 6/5/15
CCM#1 Operational	Tue 9/13/16	Tue 9/13/16
RFCC#1 Ready to Ship to RAL	Tue 10/25/16	Tue 10/25/16
MICE RFCC#1 arrives at RAL	Wed 1/4/17	Wed 1/4/17
3rd. Cryostat Assembly ready for Cold Mass Integration	Fri 6/3/16	Fri 6/3/16
CCM#2 Operational	Thu 9/14/17	Thu 9/14/17
RFCC#2 Ready to Ship to RAL	Thu 10/26/17	Thu 10/26/17
MICE RFCC#2 arrives at RAL	Fri 1/5/18	Fri 1/5/18

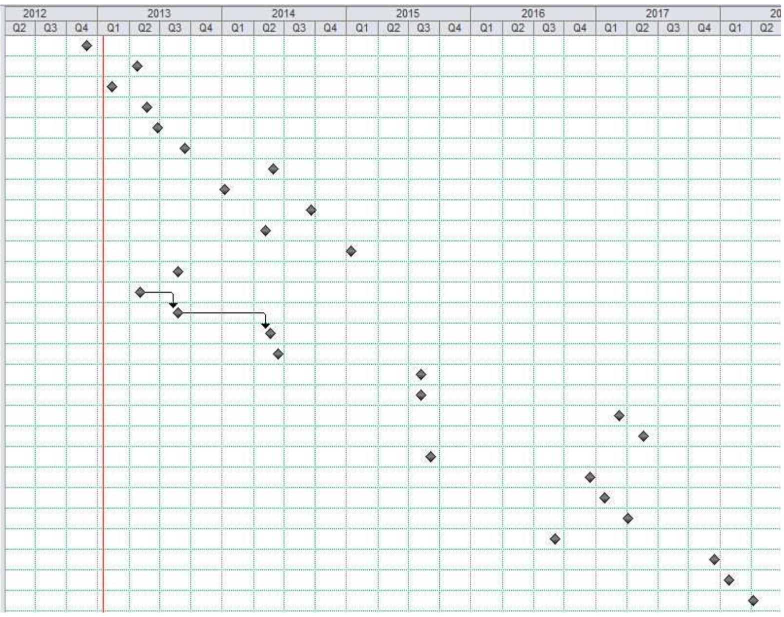

Figure 5 MICE coupling coil schedule. The horizontal axis is US reference (October 2012 is US Q1-2013)

The fabrication process is as follows: the first CC cold mass fabricated at Qi Huan (China), has arrived at LBNL in September 2011, and has been prepared since (instrumentation, quench protection, cooling circuit) with a number of difficulties. Meanwhile a large effort was made at Fermilab to prepare a Solenoid Test Facility (STF) based on a large dewar obtained from Florida. The cold mass is expected to be shipped in November 2012 and then tested in the STF. A winding review will take place on 6 December 2012 at Qi Huan. Assuming a positive review and that the first tests of the cold mass are favorable, 3 more cold masses will be wound at Qi Huan. Meanwhile the drawings for the cryostat will be completed and released for fabrication at LBNL by Q2 2013. The construction of the cryostat is expected to take 9 months, followed by 15 months at Fermilab for assembly of the cold mass in the cryostat and the full integration of the magnet. The first magnet will thus be ready for use in MUCOOL in summer 2015 (at that time MICE will still be running step IV). The MUCOOL measurements are expected to extend over 18 months.

The fabrication of the next two Coupling Coils for MICE assumes the same fabrication times for cryostat assembly in one place and magnet integration in the other. This leads to completion of the first Coupling Coil in Q3 2016, followed by assembly and shipping of the RFCC #1, arriving at RAL in January 2017. It is estimated that the full installation and operational tests (including the significant test of running a full 4-cavities RF module in magnetic field) of the RFCC at RAL takes between 6 months and one year. The second RFCC arrives in January 2018, leading to starting MICE Step VI running with beam in the second half of 2018.

Analysis of the longer time estimate with respect to MPB3 is as follows:
-- the test of the first cold mass has been delayed by 6 months.
-- the preparation of fabrication drawings for the cryostats is almost one year later.
-- the construction time for the cryostats is longer (9 months instead of 6)
-- the integration time is also longer (15 months instead of 12)

Certainly the limitation in engineer manpower is the main cause of the first two time schedule shifts. Given that the additional length of cryostat construction and magnet integration is cumulative, the total construction time estimate is extended by two years.

There exist some possibilities of regaining time (6-9 months), and resources, by using the MUCOOL magnet as MICE coupling coil #2. This possibility relies on the assumption that this magnet satisfies the requirement of being operated on cryo-coolers, and that the MUCOOL program is so successful that it will become unnecessary to extend it beyond 18 months of operation. Another possibility to be pursued is that the full integration task for the MICE magnets is performed by a new collaborating partner – discussion has started with the CERN ATLAS magnet group, but it is too soon to assert that an agreement can be found that would be satisfactory for all parties.

Please make use of the "single integrated resource loaded schedule" of recommendation 4 (wherever possible), to respond to the following questions:
A) Define the "project success" scope for MICE. Describe an alternative "off-ramp" definition of success at Stage V, as well as a punch list of potential achievements at Step VI.

Facilities based on muon storage rings have been advocated for several physics applications of great interest with discovery potential:

A. nuSTORM: 10^{11} μ/s storage ring: (<1%) ν_e ν_μ $\bar{\nu}_e$ $\bar{\nu}_\mu$ x-sections and $\nu_{sterile}$ search
B. neutrino factory: 10^{14} μ/s storage ring for precision study of neutrino oscillations, CP violation, unitarity and broad search for sterile neutrinos.
C. Precision muon collider: Higgs factory studies of H(125), H/A system (if there) ultra-precise measurements of any new particles in 50-1000 GeV range
D. High energy muon collider: the most powerful machine so far envisaged to search the high energy frontier

The key to high intensity muon beams is that the high intensity muons beams are generated and prepared in a powerful magnetic 'bottle', from the target solenoid all the way to the last stages of cooling. This magnetic 'bottle' consists of continuous magnetic field lines generated by a string of axial coils and solenoids.

MICE is such a magnetic 'bottle', from the diffuser to the end of the experiment. Cooling is the aim of the experiment but the lessons learned extend beyond that, since the design of the phase rotation and transfer lines of the neutrino factory and muon collider operate under the same principles. MICE is designed to test the concepts in stages with important results at each step. There are three main steps in the program:

1. The MICE step IV program will provide a number of important physics and methodological results:
-- Liquid hydrogen absorber realisation and safe routine operation
-- engineering test of beamline made of several magnetically connected components
-- understanding of propagation of (imperfect) beam through the magnetic bottle
-- complete particle detector system; calibrations of emittance measurement to $\pm 10^{-3}$
-- measurement of 6D emittance change (observation of normalized emittance cooling)
-- validation of simulation codes
-- limited possibility to test the longitudinal cooling with the wedge absorbers
-- correlated precision measurements of multiple scattering and energy loss straggling.
These measurements will constitute a textbook contribution to experimental particle physics, and will be essential for reliable simulation of the performance of neutrino factory and muon collider.

2. The MUCOOL program at Fermilab will provide demonstration of the combined magnet and RF hardware that are required for a realistic cooling channel. This requires successful construction of a coupling coil magnet and operation of at least one 201 MHz RF cavity in a configuration that replicates a cooling channel geometry. The U.S. effort presently has a major emphasis on preparing a prototype coupling coil magnet which can be tested with a 201 MHz RF

cavity in the MuCool Test Area at Fermilab. Upon successful completion of that test, it is anticipated that production hardware can be completed for the MICE beamline.

3. MICE Step VI provides
-- an essential reality-check of the operation of a channel with all magnetic couplings in place.
-- a full cooling cell allowing all optics configurations: flip, non-flip etc…
-- the possibility of exact replenishment of energy
-- significant and measurable longitudinal heating
-- precise measurement of equilibrium emittance of various configurations
-- detailed and precise verification of simulation codes

The relative risks (and associated expenses) of step VI wrt Step V have been considered minor in view of the delay involved in actually implementing and running step V (18 months delay to step VI). We have thus agreed that the baseline option is to skip step V and go directly to the implementation of step VI. The greater experimental flexibility of the Step VI configuration, which enables a much richer experimental program for the first deployed ionization cooling channel, is a strong argument in favor of making Step VI the overall project goal. MPB supported this policy in the conclusions of MPB3.

Step V could represent an acceptable intermediate step if it proves impossible to reach Step VI for some unforeseen difficulty. It is less complete because it does not have all magnetic couplings and does not provide as much optics flexibility or cooling lever arm. Both the baseline and the accelerated magnet production schedule proposed by the U.S. program have completion dates for tests of the prototype coupling coil magnet with an RF cavity, and acceptance tests for the first "production" magnet, which will take place within a few months of each other. Thus there appears to be a reasonable path to proceed directly to Step VI that is intrinsic to the present plan, as well as a clear decision point where the availability and quality of the two coupling coil units could be evaluated. In the event of a problem with the R&D program towards the RFCC demonstration, we expect that there would be a clear decision point that would enable an informed choice on whether to take the "off-ramp" to Step V or to continue on to Step VI.

It is useful to look at the MICE success in terms of the MICE legacy: at the end of the program, MICE will have achieved the first demonstration of ionization cooling and tested essential concepts for production of intense muon beams. It will have generated experience and know-how, bridging, sometimes painfully, a significant gap between the neutrino factory and muon collider dreams and reality. This will set future developments on firmer ground.

Once Step VI is complete a powerful **Cooling Test Facility** will have been developed with
-- a high quality muon beam
-- 8MW of 200 MHz RF power
-- 23MV of acceleration
-- infrastructure for 70 litres of liquid Hydrogen absorbers
-- instrumentation for precision 6D emittance measurements
-- a number of available magnets and associated infrastructure
-- a number of people and an international collaboration who have made (most of) the mistakes

All of this will constitute a formidable asset that could be used for e.g. a 6D cooling experiment

Define the required timeliness of MICE results in co-ordination with "external" muon activities, including (but not only) the MAP R&D phase.

US view: The U.S. Muon Accelerator Program presently has defined a Feasibility Assessment Phase, which occurs in two parts:

1. Feasibility Assessment Phase I, which will span U.S. Fiscal Years 13-15 (October 1, 2012 – September 30, 2015), and which will focus on completing critical technology R&D (eg, RF in magnetic fields) required for a neutrino factory and/or muon collider design and clearly identifying baseline technology and design choices for each of the major accelerator sub-systems required to support these facilities.
2. Feasibility Assessment Phase II, which will span U.S. Fiscal Years 16-18 (October 1, 2015 – September 30, 2018), and which will focus on completing advanced technology demonstrations (eg, 6D cooling cell technology demonstration), detailed performance evaluations of the baseline designs for each accelerator sub-system, and preparing a technical feasibility assessment for the neutrino factory and muon collider designs.

The U.S. program views the availability of MICE Step IV results, tests of MICE RF cavity operation in magnetic fields, and construction of a prototype MICE Coupling Coil magnet as high priority deliverables for Phase I of the feasibility assessment. Commissioning of the first cooling channel by the conclusion of Phase II in late 2018 will be a critical contribution to the overall feasibility assessment for a future neutrino factory or muon collider. It would be advantageous if a more aggressive MICE schedule could be achieved, but that appears completely unrealistic if the funding profiles remain as anticipated.

It should be pointed out that significant technical risk remains inherent in the program, which is reliant on the successful development of novel and challenging magnets and reliable operation of RF cavities in magnetic fields. It remains unclear to the US MAP management whether these risks can be successfully dealt with on the above timescale in a flat-flat funding scenario. While a joint US-UK schedule has been prepared that is consistent with the required deliverable timescales, without suitable allowance for R&D contingencies, a major surprise in the ongoing technology development effort could easily result in further delays on the scale of a year or more. The only way for these contingencies to be properly mitigated is for the project to carry out a more detailed assessment of risk mitigation plans and for the funding agencies to provide sufficient funding to implement them. *Such a contingency event would almost certainly require funds exceeding a flat-flat profile in the US and/or UK to avoid further significant delays to the experimental program and to remain consistent with the 6-year feasibility assessment plan in the US!* A fully integrated and tightly coordinated project plan along with sufficient funding to mitigate the technical risks represents the only way to ensure a timely conclusion of the experiment.

European view: the MICE experiment was mentioned by several speakers at the Krakow workshop on the European Strategy for Particle Physics (ESPP2012), as an important expected and necessary achievement within the years of application of the strategy (2012-2018). The EUROnu consortium, regrouping members from all around Europe including CERN, with full support of the European community working with accelerator-based neutrino beams have defined the priorities for the 6 years to come:

“The European Strategy for Particle Physics must therefore provide for European participation in the programme required for a Neutrino Factory proposal to be **prepared in time for the next update of the European Strategy.**

This programme must encompass:

-- The completion of the necessary hardware and system R&D **including the MICE experiment;**

-- The experimental demonstration that stored muons can serve a first-rate neutrino programme with the percent precision measurement of the $\nu_{e,\mu}$ N and $\bar{\nu}_{e,\mu}$ N scattering cross sections and the search for sterile neutrinos using the nuSTORM experiment ;

-- All relevant design work, including consideration of the implementation of the facility at CERN”

Given the importance of the experiment there is no real ‘deadline’ for its execution, the case for the high energy collider or neutrino factory will not vanish. However, it is important for its successful realization that the program advances well and does not suffer from excessive dilution in time: lengthening of the experiment leads to evaporation of competent people (completion of PhD theses, end of post-doc positions, promotion or retirement, etc…) and the need to continuously regenerate competence. This is inefficient and costly, and increases the risks.

Given the present schedule, it would be highly beneficial and we believe eventually economical, to apply well placed resources to absolutely reduce the risk of further extension of the schedule. The visit of one additional, dedicated, engineer from RAL at LBNL has been a blatant example: during his one-year stay at LBNL, and only then, the milestone tracking has been highly successful.

Define a realistic flat-funding cost scenario, within the single integrated plan. Define a realistic end date for Step VI based on flat-funding. Define a date on which Step V would be achieved, if it were not to be skipped. Discuss the possibilities of additional sources of future funding that would affect the "scope and timeliness" issues.

As previously discussed the flat funding scenarios in place among the MICE collaborators, (US and UK but also INFN and Geneva) leads to the running dates of Figure 2, with step V conceivably running in 2017 instead of 2018. Additional funding to enable more rapid development of the coupling coils in the US and to enable a more aggressive deployment schedule in the UK, would greatly enhance the likelihood that Step V or VI experimental results could appear on the 2018 timescale. MAP would strongly support a plan that aims for this goal.

In order to increase the resources available to the experiment it is absolutely essential that the project does not reduce itself to a US-UK collaboration. We have been in contact with the CERN ATLAS team who has supervised and commissioned a large system of coupled coils, the ATLAS barrel and endcap toroids. This would enrich the collaboration both in terms of the potential financial and manpower contribution but also in terms of experience. The exact terms of the collaboration need to be defined and discussed in agreement between MAP or DOE and the CERN management.

Identify and quantify the main risks associated with the integrated plan

1. Manpower issues

There is a great danger of attrition of the project – lengthening makes project at risk for several reasons

-- lose expertise of people moving on

-- have to re-learn and this leads to a) time loss and b) mistakes

-- lose enthusiasm of volunteer institutes (University groups and interested lab people).

Application of appropriate and well targeted influx of manpower would be highly beneficial and we believe economical in the long run.

2. controls monitoring, alarms (C&M) as an acute example of point 1, C&M constitutes in many places the last protection against damaging very expensive MICE equipment and causing major setbacks and delays.

➔ each component of MICE should have one clearly identified person responsible for controls, monitoring and alarms (and not only for providing the hardware for it). At this moment the responsibility rests on one person only for the whole of MICE.

3. MICE magnet system The transition from single magnets to full magnet system may be painful and associated with a number of 'glitches' and quenches. We have added 5 weeks for retraining of the magnets, but we are anxious to see whether it happens at each time we have to change the magnetic configuration, such as (and in particular) the change from flip to non-flip mode

4. Magnetic field mitigation

-- Following the study of a MICE internal group we have found that much equipment foreseen to be in the MICE hall would not operate properly because of the stray fields of the magnets. We have launched two studies to find a satisfactory solution. The baseline for step IV, called global shielding (GS) to relocate the sensitive equipment along the west hall (downstream of MICE) or behind the north shielding wall (where the RF should eventually go). There is a risk to overlook some equipment that would turn out to be critical.

- There is a promising study of a ‘return yoke’ (a.k.a. local shielding LS) solution that will be necessary for step VI in any case. However it is not engineered yet and could lead to significant expenses.

-- a recommended solution would be to obtain from ISIS access to the ‘ plant room’ next to the MICE hall.

5. Helium availability

The design of the magnet witout recuperation system makes us vulnerable to helium shortage. The lack of Helium led to some time loss for the spectrometer solenoid. Enough helium has been secured for the commissioning of the AFC. We intend to check with CERN and other ‘friends’ for availability of Helium if needed.

6. RF project:

-- T116 availability remains a threat

-- expertise in the high power part of the amplifiers is scarce. It is important to establish a network of relations with ISIS and CERN to allow for occasional consultancy

-- RF in magnetic field is not a solved problem and could still cause a bad surprise either in the cavities themselves or in the couplers etc…

→ mitigation, operation of MICE RF cavity in the fringe field of MTA magnet and MUCOOL testing program starting in Q4 2015

7. Lack of staff on project for operations, as discussed earlier particularly with requisite accelerator operations experience for operation of the cooling channel, magnets and RF cavities. The operation-dedicated staff is at this moment not funded.

REFERENCES

[1] MICE CM34 https://indico.cern.ch/conferenceDisplay.py?confId=208246 where more information can be obtained from the various aspects of the experiment.

[2] MICE project file. http://dpnc.unige.ch/users/blondel/MICE/MPB/MPB-2012-10-31/Top_Level_MICE_Installation_v19_stepIV_data_run_12mths.mpp