Resource Loaded Schedule, costs and risks for the completion of the MICE project

1 Actions and recommendations

A full response to each action and recommendation made by the Resource Loaded Schedule Review (RLSR) Panel and the MICE Project Board (MPB) at the November 2014 review of the project is given in the "Response to Feedback" submitted in June 2015 [**?**]. The responses given in [**?**] stand. The project team would like to make the following additional comments in the light of the progress that has been made since the 19$^{\text{th}}$ January 2016 when the Response to Feedback was submitted.

Actions

1. **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.**
   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.

Recommendations

The updated project dashboard may be found at `http://micewww.pp.rl.ac.uk/dashboard/`.

2 Introduction

Since the last RLSR the project team have been working to:

- Develop a plan to recover the downstream spectrometer solenoid;
- Upgrade the quench detection and protection for both spectrometer solenoids such that they can be operated safely in the MICE Hall;
- Prove the cooling performance of the Hydrogen absorber ready for commissioning in the MICE Hall;
- Take forward the procurement of the remaining components of the cooling demonstration, including the extension of the partial return yoke (PRY) and the single-cavity modules;
- Execute the offline commissioning programme for the RF amplifiers at the Daresbury Laboratory (DL); and

- Take forward the design, procurement and preparations for the necessary infrastructure modifications required to mount the cooling demonstration.

The plan to recover the downstream spectrometer solenoid is being developed by the US team in consultation with the Project Manager and Project Office. The current best estimate has the downstream solenoid delivered to the MICE Hall, tested and ready for commissioning, by January 2018.

The MAP Director's downstream spectrometer solenoid recovery review [] was held at FNAL on the 3rd and 4th December 2015. Among the review panel's recommendations [], a draft version of which was released on 4th December, was the upgrade of the existing quench detection and protection systems for both the spectrometer solenoids before further operation of magnets at Step IV. A revised design was developed by FNAL and a plan to implement the required changes was produced by DL staff. The expected date for the start of commissioning is early May 2016 with a commissioned system ready for full magnet-string commissioning ready in June 2016.

In the interim period the experiment has begun the Step IV field-off scattering programme. Experimental running has been greatly streamlined with efficient start-up and many hours of systematic data-collection logged by a large number of shifters.

3 Schedule

3.1 Overview

After the failure of the downstream solenoid, it was decided to extend the operation of Step IV through to the end of 2016. This maximizes the data-taking opportunities at Step IV but does compromise the early installation of RF systems for the cooling demonstration due to restricted access to the MICE Hall. We are currently working to determine the best balance between data-taking and preparation for the cooling demonstration. This balance will necessarily be influenced heavily by future funding levels and any changes to the constructino schedule that result. The detailed planning will therefore be informed by the STFC Cost to Completion review of the MICE-UK project.

The recovery plan for downstream solenoid currently shows that the downstream solenoid will be available in the MICE hall by January 2018. This date is based on a schedule in which the make/buy decision is is made in June 2016. The recommendations of the MAP Director's downstream spectrometer solenoid recovery review [] have been fully considered in the recovery plan. Director-level discussions as well as meetings between the DOE and the STFC have been held to help resolve the issues that have been identified. The downstream solenoid is a US deliverable and as such the recovery of magnet remains a US responsibility. It is not yet clear whether the current funding situation provides sufficient resource to deliver and commission a replacement magnet in the MICE Hall.

The MICE-UK project has been asked to prepare three scenarios for the STFC Cost to Completion review to be held on Tuesday the 26th April 2016: flat cash, flat cash +10% and full cost. These three funding options have been prepared assuming a replacement for the downstream spectrometer solenoid is available in the MICE Hall on the schedule mentioned above.

The project was initially planned to a timetable using a full resource model, restricted only by the effort available to the project. This plan is presented as the "full-cost" option. The funding profile generated in the full cost option has a significant peak in resource, and therefore the funding required, in the second year (UK financial year 2017/18). The UK university part of the project is being judged against the requirements of the construction project, the need to exploit Step IV operation and the requirement to maintain the capability to commission, operate and analyse the cooling demonstration. The flat-cash-+10% and flat cash options hahve

Table 1: Headline milestone dates extracted from the schedule analysis of the three MICE-UK funding models requested by STFC for the cost-to-completion review. The table also shows the integrated cost to the UK under the three scenarios.

	Full Cost	**Flat Cash+10%**		**Flat Cash**	
	Date	**Date**	**Delay**	**Date**	**Delay**
SSD delivery date	Jan 18	Jan 18	0 Mths	Jan 18	0 Mths
Last date for Step IV	Dec 16	Dec 16	0 Mths	Dec 17	0 Mths
Cooling demo installation compete	Feb 18	Jun 18	4-5 Mths	Aug 18	6-7 Mths
Commissioning complete	July 18	Dec 18	4-5 Mths	Feb 19	6-7 Mths
Data taking ends	Jun 19	Oct 19	4-5 Mths	Dec 19	6-7 Mths
Analysis ends	Mar 20	Aug 20	4-5 Mths	Oct 20	6-7 Mths
Integrated cost	**£10.5M**	**£10.9M**		**£11.9M**	

been derived by delaying certain work packages while seeking to minimise the resulting delay the overall completion date. The integrated cost of the three scenarios is presneted in table **??**.

The tasks in both the UK and the US projects have been analysed and assigned one of five classifications from "High Level" risks (RISK1) to routine tasks which are considered to be risk free (RISK5). Tasks in the category RISK1 are assigned a remedial-work period of 16 weeks should the risk be realised. "Low Level" risks (RISK4) are assigned a period of 2 weeks. Milestones, or RISK5 tasks, are not assigned a risk-mitigation period beyond the 35% time contingency. Task end-dates including time contingency are used for critical-path analysis to produce the "baseline critical path". Task end-dates including remedial work periods are used to analyse the "including-risk critical path". The additional delay for this analysis is calculated by taking the product of the raw risk mitigation period and the estimated probability that the risk will be realised. The critical path is not required to pass through the same tasks in the two analyses. Headline dates extracted from the three UK funding scenarios and are listed in the table **??**.

The full-cost plan finishes fully 7 months ahead of the flat-cash option while the flat-cash-+10% scenario results in a 4- to 5-month delay. The flat-cash and flat-cash-+10% options make sacrifices in the RF programme to keep the length of the project within limits. These reductions do increase the risks in the RF project, though the risks remain manageable. Were the risks to teh RF project felt to be too large they could be mitigated at the cost of a further months delay and increased integrated cost.

The full-cost scenario results in a cooling-demonstration construction-end date of July 2018 with the recovery of spectrometer solenoid remaining on the critical path throughout.

Restricting funding to flat-cash +10% extends the construction phase to December 2018, a 4 month delay. The resource leveling required to meet this funding profile forces the delay of the installation of the second RF-power system in the MICE Hall by 10 months putting it on the critical path for the last 4 months of the construction project. The downstream spectrometer soleboid remains close to critical path throughout and were any of the risks associated with the recovery of magnet to be realized, it is likely to return to the critical path.

If funding is held at the current level, i.e. flat cash, further delay is incurred and construction of the cooling demonstration completes in February 2019. In this scenario it would be feasible to extend Step IV data-taking throughout 2017.

Table 2 above shows the interface points identified in the schedule analysis. The date at which a major item is required for installation is listed together with the date on which the schedule shows the item to be delivered to RAL. The Required date for each major component has been identified by a careful analysis of the installation schedule.

Table 2: Interface points identified in the MICE baseline-schedule analysis. The dates associated with the interface points at November 2014 are also shown.

	November 2014		April 2015		October 2015		March 2016	
	Delivered	**Required**	**Delivered**	**Required**	**Delivered**	**Required**	**Delivered**	**Required**
Step IV								
Liquid H2	09/02/15	04/03/15	15 May 15	19 May 15				Sept 16
Integration Complete	2 Jun 15	17 Mar 15	9 Jun 15	2 Jun 15	14 Aug 15			
Commissioning complete								Jun 16
Cooling demonstration								
RF system 1	18 May 16	1 Nov 16	16 Jun 16	23 Sept 16	9 May 16	15 Jul 16	14 Jul 16	Aug 17
RF system 2	18 May 16	1 Nov 16	16 Jun 16	23 Sept 16	7 Jun 16	12 Jan 17	11 Aug 16	Nov 17
South PRY	10 May 16	19 Dec 16	12 Apr 16	14 Dec 16	12 Apr 16	30 Nov 16	18 Jul 16	Feb 17
North PRY	10 May 16	10 Jan 17	12 Apr 16	10 Jan 17	12 Apr 16	23 Jan 17	18 Jul 16	Feb 17
Cooling demonstration complete	24 Mar 17		31 Mar 17		31 Jul 17			Jul 18

The effect of the failure of the M1 coil in the downstream solenoid has had the effect of removing many items from the critical path. The partiel-return-yoke components, though slightly delayed relative to the original plan, will now arrive at RAL many months before they are required and will be placed in dry, covered storage in Didcot. Similarly, because the RF project no longer lies on the critical path, the RF cavities have been allowed to slip in delivery by 2 months. Their arrival now meshes well with the availability of the RF power in the MICE Hall, though the extended running of Step IV has the potential to delay the completion of the RF-power system due to restricted Hall access during ISIS run periods.

3.2 Step IV

While Step IV installation was completed in July 2015, significant additional effort was required to commission the magnets and full commissioning was not achieved due to the failure of the downstream solenoid. Many issues associated with the magnet power-supplies, quench-protection and ground-fault-detection systems were solved in this period.

In December 2015 a failure of the semiconductor DC-contactor in the FuG power supply used to power the decay solenoid caused substantial damage to the power supply. The power supply was been returned to FuG in Germany where it was repaired using new output switches specified and procured by the Daresbury Laboratory (DL) Electrical Engineering Group. FuG agreed to absorb their own costs for the repair and returned the power supply to RAL on the week of the 22$^{\text{nd}}$ February 2016. The power supply was commissioned by DL staff during the week of the 29$^{\text{th}}$ February and is now fully operational.

The principal issues that must be addressed to complete the commissioning of Step IV are the reworking and commissioning of the quench-detection and quench-protection (QD/QP) systems for the spectrometer solenoids and the remediation of the issues identified in the cooldown of the liquid-hydrogen absorber. The QD/QP systems have been heavily revised after an in-depth failure-mode analysis following strong recommendations from the MAP Director's downstream spectrometer solenoid recovery review []. A new quench-protection strategy has been developed and a new design has been specified. Procurement is well advanced and a detailed installation plan has been developed. US and UK efforts have been dove-tailed and US staff will be fully involved in the commissioning of the new system. The QD/QP system is expected to be ready for commissioning by early May 2016.

Completion of the new QD/QP system will allow the MICE magnet channel to be operated.. Data taking will be prioritized to maximise the data return at minimum risk of further damage to the solenoids. To this end the downstream spectrometer solenoid will not be trained to operate at currents above those reached to date (a reduction in peak operating current of approximately 15%). Similarly the focus-coil modulel presently on the beamline (FC 1) will be fully trained before any combined magnet operations begin; the upstream spectrometer solenoid is already fully trained. This should minimize the probability of further quenches when the magnets are operated in together. In addition, careful consideration will be given to the decision on first operation of the remaining match coil 2 in the downstream solenoid.

Following the failure of the downstream solenoid, it was decided to extend the operation of Step IV until the end of 2016 to provide sufficient time for data-taking. The various cost-to-completion scenarios may allow further data-taking in early 2017 without compromise to the overall schedule.

At the last meeitng of the RLSR panel, the hydrogen system was fully operational and cool-down and vacuum tests prior to full safety approval for use with hydrogen were in progress. These tests identified two leaks, one from atmosphere into the insulating vacuum and one from the hydrogen system into the insulating vacuum. The system has now been taken off-line and moved to R9 to address these problems. The leaks have been traced to a faulty connector and one of the indium seals on the absorber windows, respectively. New connectors have been procured and the leaking indium seal has been re-designed. During operations in the MICE Hall it was not possible to cool the hydrogen-absorber vessel to the required temperature. Verification of absorber cooldown in the focus-coil module in R9 using helium is now a requirement before re-insertion of the module in the beam line. To this end, new vacuum end caps are in procurement and the timetable has the hydrogen system ready in the hall in time for the September 2016 ISIS User Cycle. There has been a change in Work Package Manager for the hydrogen system with V. Bayliss (RAL/TD) taking over from S. Watson. This transition has been managed by GLIMOS, A. Nichols (RAL/TD), maintaining the working relationship between MICE and ISIS.

3.3 Cooling demonstration

The downstream spectrometer solenoid (SSD) is a US deliverable and, therefore, the recovery of SSD remains a US responsibility. The final report of the MAP Director's downstream spectrometer solenoid recovery review panel [] was circulated on the 13^{th} January 2016. The report included many detailed recommendations, including the recommendation to:

- Improve the quench protection with quench heaters any new cold mass design;
- Make minimal changes to the cold-mass design, keeping only those required to guarantee stable operation;
- Investigate non-US commercial magnet-manufacturers as part of the solenoid-revovery excersice; and
- Continue to investigate and improve quench detection and quench protection before further Step IV running.

The panel also felt that the estimate of nine months for the procurement of a new cold mass was an under estimate.

At the MAP Director'sreview the MAP director presented initial magnet costings which exceeded his reserve fund. The exact amount by which the magnet cost exceeds the reserve held has varied as the costs have been refined, though it remains unclear whether the US team has sufficient funds to complete the SSD-recovery programme. Discussions are ongoing between the US and UK funding agencies with a view to resolving these issues.

The MAP Director has retained the magnet team at Brookhaven National Laboratory, led by Peter Wanderer, to lead the spectrometer solenoid recovery program. BNL has been charged to:

- Produce an updated magnet model pulling together all the existing data on the current magnet systems in the MICE Hall. Sources including LBNL and R. Preece (RAL/PPD) as well as MICE documentation were used to provide the input data; and
- Investigate the engineering of the cold mass structure, consider conductor margin and optimize coil packs.

Key dates over the next few months are:

- BNL initial package complete: mid-March 2016;
- Release drawings for tender to companies for full quotes: end March 2016;
- Quotes returned ready for evaluation by the project: mid-May; and
- Make or buy decision: mid-June 2016.

These dates give reasonable confidence that it is technically feasible to deliver a working magnet to the MICE Hall by January 2018. In parallel to the above, a number of magnet-fabrication companies have been approached. To date Tesla, Scientific Magnetics and Oxford Instruments in the UK have been approached as well as ASG in Italy. Indicative quotes have been received from Tesla and more firm budgetary quotes from ASG. In addition, magnet manufacturers in Japan and the US have been approached. One US spin-out company has bid for the cold mass and one Japanese company has submitted an indicative quote. All companies have been advised that further information will be provided once the drawing package from BNL has been evaluated by the project. We expect to be in a position to provide this data pack by mid-March 2016.

3.3.1 RF

The failure of the downstream solenoid has changed the project timetable to such an extent that the RF project has moved off the critical path. The conclusions of last year's RF review have now been superseded by events as the work profile of the RF-power-system project has become substantially less peaked.

The RF project plan has been extensively revised as a result of the RF September 2015 RF review [], increasing resources where required, identifying available ISIS and US resources and adding contingency to those parts of the programme identified as highest risk. The program was adjusted to accelerate the first RF-power system at the expense of the second as all off-line testing can be accomplished with one RF system. These features have been retained in the current plan and the first RF system will be available in the MICE Hall in late summer 2016 at the time that the RF cavities are being prepared.

The planned extention to Step IV running has the potential to delay the completion of RF-power-system commissioning in the MICE Hall. Full consideration will be given to all possible methods available to expedite the commissioning of the RF-power system. It may, for instance be possible to restrict data-taking to 2 shifts per day running from 4 pm to 8 am on weekdays and all day at the weekend, thus allowing DL staff to continue commissioning during normal working hours. Such a decision must be informed by the current status of the data-taking program and absorber availability and as such will be deferred until nearer the time. Such combined running/commissioning is facilitated by our new Duty Coordinator role. Recent experience shows that we are now capable of transitioning safely between running and commissioning and back to running with minimal start-up delay and little lost time.

The RF controls-and-monitoring system is now agreed and the process of assigning logical variable names to the controls list is in process. The strategy for linking the RF controls-and-monitoring to the experiment's EPICS-based system has been agreed and an independent "expert only" diagnostic system in NI is being developed. Key new staff have been deployed to bolster the linkage between the RF and the main experimental controls and monitoring.

3.4 Schedule to complete the project

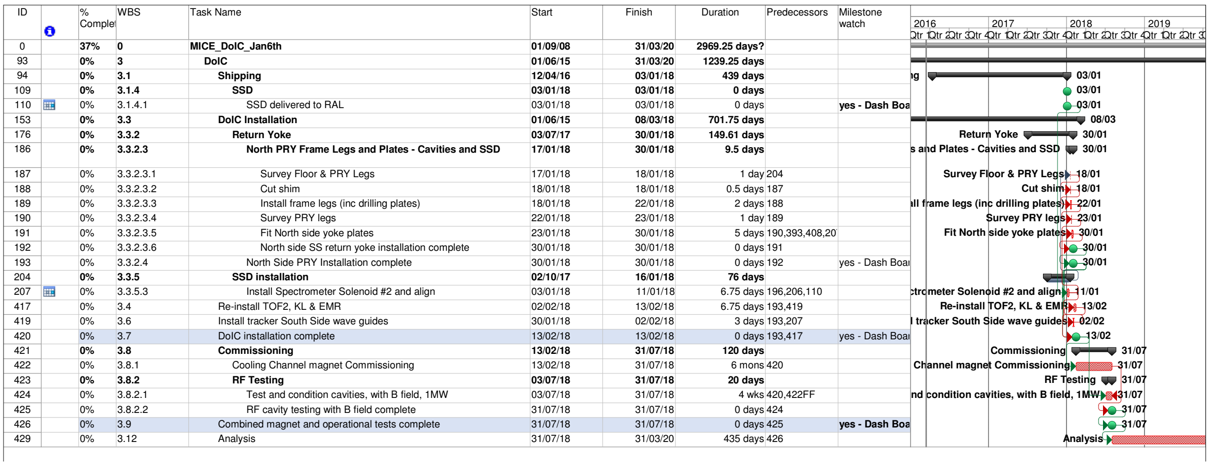
Three project plans have been developed corresponding to the STFC's request for input to the MICE-UK cost-to-competion review: "full cost"; "flat-cash $+10\%$"; and "flat cash". The timetable for the completion of the project in each of these scenarios will be summarised below.

3.4.1 MICE-UK full-cost scenario

Assumptions:

- Replacement downstream spectrometer solenoid available January 2018; and
- End of Step IV operations December 2016.

The MICE-UK full-cost scenario has been planned based on the original schedule developed during the re-baselining of the MICE cooling-demonstration program. Where appropriate the time estimates for certain tasks have been updated based on information developed during the commissioning of Step IV in the summer of 2015 and subsequent hall operations. We now have improved confidence in our time estimates for construction



ID	% Complete	WBS	Task Name	Start	Finish	Duration	Predecessors	Milestone watch
0	37%	0	MICE_DoIC_Jan6th	01/09/08	31/03/20	2969.25 days?		
93	0%	3	DoIC	01/06/15	31/03/20	1239.25 days		
94	0%	3.1	Shipping	12/04/16	03/01/18	439 days		
109	0%	3.1.4	SSD	03/01/18	03/01/18	0 days		
110	0%	3.1.4.1	SSD delivered to RAL	03/01/18	03/01/18	0 days		yes - Dash Boa
153	0%	3.3	DoIC Installation	01/06/15	08/03/18	701.75 days		
176	0%	3.3.2	Return Yoke	03/07/17	30/01/18	149.61 days		
186	0%	3.3.2.3	North PRY Frame Legs and Plates - Cavities and SSD	17/01/18	30/01/18	9.5 days		
187	0%	3.3.2.3.1	Survey Floor & PRY Legs	17/01/18	18/01/18	1 day	204	
188	0%	3.3.2.3.2	Cut shim	18/01/18	18/01/18	0.5 days	187	
189	0%	3.3.2.3.3	Install frame legs (inc drilling plates)	18/01/18	22/01/18	2 days	188	
190	0%	3.3.2.3.4	Survey PRY legs	22/01/18	23/01/18	1 day	189	
191	0%	3.3.2.3.5	Fit North side yoke plates	23/01/18	30/01/18	5 days	190,393,408,20	
192	0%	3.3.2.3.6	North side SS return yoke installation complete	30/01/18	30/01/18	0 days	191	
193	0%	3.3.2.4	North Side PRY Installation complete	30/01/18	30/01/18	0 days	192	yes - Dash Boa
204	0%	3.3.5	SSD installation	02/10/17	16/01/18	76 days		
207	0%	3.3.5.3	Install Spectrometer Solenoid #2 and align	03/01/18	11/01/18	6.75 days	196,206,110	
417	0%	3.4	Re-install TOF2, KL & EMR	02/02/18	13/02/18	6.75 days	193,419	
419	0%	3.6	Install tracker South Side wave guides	30/01/18	02/02/18	3 days	193,207	
420	0%	3.7	DoIC installation complete	13/02/18	13/02/18	0 days	193,417	yes - Dash Boa
421	0%	3.8	Commissioning	13/02/18	31/07/18	120 days		
422	0%	3.8.1	Cooling Channel magnet Commissioning	13/02/18	31/07/18	6 mons	420	
423	0%	3.8.2	RF Testing	03/07/18	31/07/18	20 days		
424	0%	3.8.2.1	Test and condition cavities, with B field, 1MW	03/07/18	31/07/18	4 wks	420,422FF	
425	0%	3.8.2.2	RF cavity testing with B field complete	31/07/18	31/07/18	0 days	424	
426	0%	3.9	Combined magnet and operational tests complete	31/07/18	31/07/18	0 days	425	yes - Dash Boa
429	0%	3.12	Analysis	31/07/18	31/03/20	435 days	426	

Figure 1: Waterfall chart for the completion of the cooling demonstration in the MICE-UK full-cost scenario.

Table 3: Key dates in the programme to complete of the cooling demonstration in the MICE-UK full-cost scenario.

	Milestone MICE-UK full-cost scenario
Step IV running ends	Dec 16
SSD Delivery	Jan 18
Cooling demonstration installation complete	Feb 18
Commissioning complete	Jul 18
Data Taking ends	Jun 19
Analysis ends	Mar 20

of the PRY and in-situ surveying in the MICE Hall as the team have developed experience in these areas. The waterfall chart for the Cooling Demonstration, full-cost option is detailed in figure 1.

The critical path for the completion of the cooling demonstration in the MICE-UK full-cost scenario is shown in figure 2. Previously, the RF was on the critical path for the majority of the cooling-demonstration construction period. This is no longer the case due to the work required to recover the downstream spectrometer solenoid. In addition, the work put in to advancing the RF-power project has borne fruit in the improved delivery of the RF power system to the MICE Hall. The RF plan is now considerably further advanced, the construction of the first amplifier system is now complete at the Daresbury laboratory and improved time estimates have been fed forward to the second amplifier program.

There remains some conflict between the extended Step IV running and installation of the RF system in the MICE Hall, but as the RF is no longer on the critical path this has a smaller impact. The relevant delivery dates for the RF cavities and RF power systems are:

- RF cavities delivered to RAL July and August 2016;
- RF system 1 delivered to RAL Sept 2016;
- RF system 1 commissioned Dec 2016;
- RF system 2 delivered July 2017; and
- RF system 2 commissioned End 2018.

Since the recovery of SSD is on the critical path for the duration of the project, risks associated with the

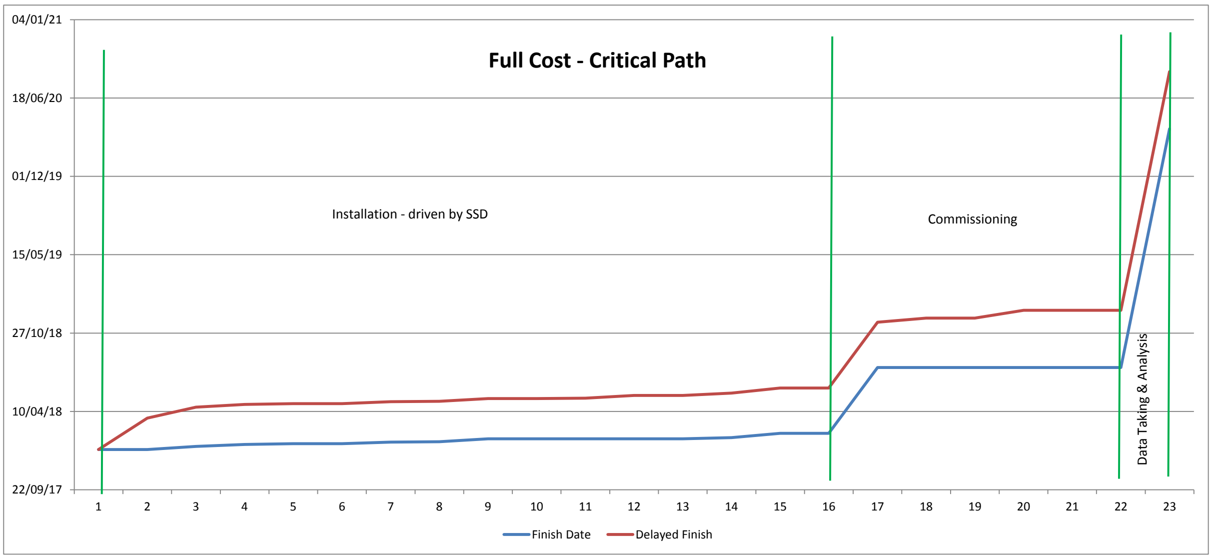


Figure 2: Critical path for the completion of the cooling demonstration in the MICE-UK full-cost scenario.

recovery of the spectrometer solenoid have the potential to delay the overall program. It would therefore be preferable to chose a low-risk recovery strategy. It is likely the recovery option chosen will be dictated by financial considerations and as such the chosen option may carry significant risks.

If a new cold-mass is fabricated and integrated into the current cryostat, there will be risk to the program timetable throughout the integration process, there are many process-steps that have the potential to cause multi-month delays. Several "break points" will be apparent where significant reductions in risk occur, such as completion of "dunk" testing of the cold mass (essentially a dunk-test is a verification of the cold mass performance in a large liquid-helium volume prior to integration in a cryostat) and pressure testing of the cold mass vessel. However a high level of risk will still be present until the replacement magnet is fully trained and commissioned.

The spectrometer solenoid recovery program is not yet sufficiently developed to allow meaningful estimation of the impact on delivery of the realisation of these risks at this time. We have therefore planned on the basis that a replacement magnet is available in the MICE Hall on Jan 18.

3.4.2 MICE-UK flat-plus-$+10\%$ scenario

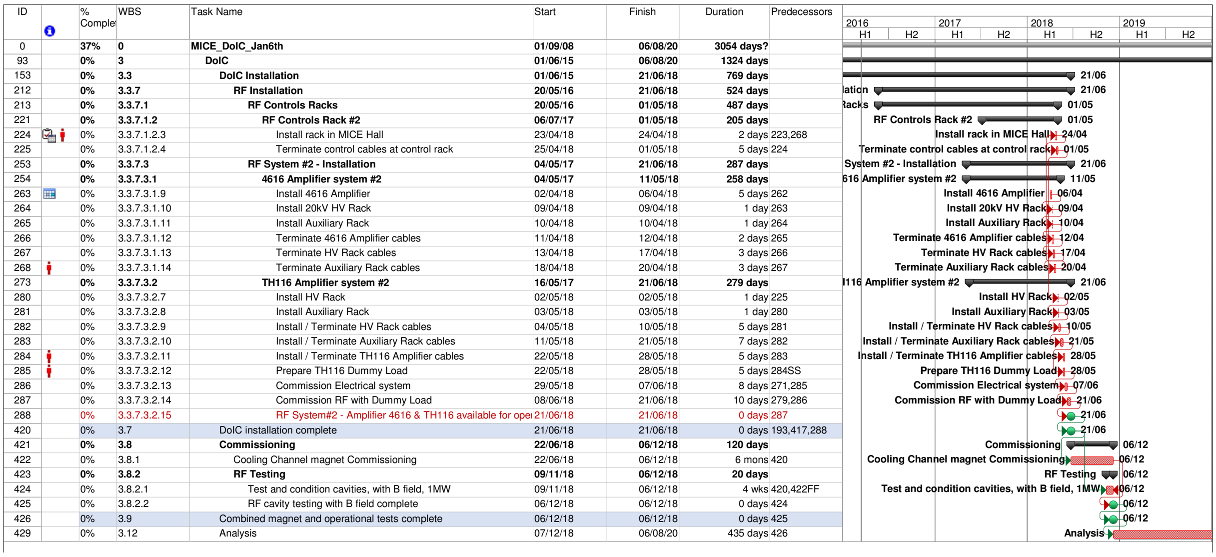
Assumptions

- SSD replacement is available in January 2018;
- End of Step IV operations December 2016 (it may be possible to extend operations into the first quarter of 2017, however, an end date of December 2016 is assumed); and
- RF-power system 2 is delayed 10 months relative to flat funding.

The waterfall chart for the completion of the cooling demonstration in the MICE-UK "flat-cash-$+10\%$" scenario is shown in figure 3 and the critical path is shown in figure 4. The key dates extracted from the schedule are shown in table 4.

The logical break points in the RF program are:

- Complete RF-system 2 build and test at DL and deliver to RAL mid July 17;



ID		% Complete	WBS	Task Name	Start	Finish	Duration	Predecessors
0		**37%**	**0**	**MICE_DoIC_Jan6th**	**01/09/08**	**06/08/20**	**3054 days?**	
93		**0%**	**3**	**DoIC**	**01/06/15**	**06/08/20**	**1324 days**	
153		**0%**	**3.3**	**DoIC Installation**	**01/06/15**	**21/06/18**	**769 days**	
212		**0%**	**3.3.7**	**RF Installation**	**20/05/16**	**21/06/18**	**524 days**	
213		**0%**	**3.3.7.1**	**RF Controls Racks**	**20/05/16**	**01/05/18**	**487 days**	
221		**0%**	**3.3.7.1.2**	**RF Controls Rack #2**	**06/07/17**	**01/05/18**	**205 days**	
224		0%	3.3.7.1.2.3	Install rack in MICE Hall	23/04/18	24/04/18	2 days	223,268
225		0%	3.3.7.1.2.4	Terminate control cables at control rack	25/04/18	01/05/18	5 days	224
253		**0%**	**3.3.7.3**	**RF System #2 - Installation**	**04/05/17**	**21/06/18**	**287 days**	
254		**0%**	**3.3.7.3.1**	**4616 Amplifier system #2**	**04/05/17**	**11/05/18**	**258 days**	
263		0%	3.3.7.3.1.9	Install 4616 Amplifier	02/04/18	06/04/18	5 days	262
264		0%	3.3.7.3.1.10	Install 20kV HV Rack	09/04/18	09/04/18	1 day	263
265		0%	3.3.7.3.1.11	Install Auxiliary Rack	10/04/18	10/04/18	1 day	264
266		0%	3.3.7.3.1.12	Terminate 4616 Amplifier cables	11/04/18	12/04/18	2 days	265
267		0%	3.3.7.3.1.13	Terminate HV Rack cables	13/04/18	17/04/18	3 days	266
268		0%	3.3.7.3.1.14	Terminate Auxiliary Rack cables	18/04/18	20/04/18	3 days	267
273		**0%**	**3.3.7.3.2**	**TH116 Amplifier system #2**	**16/05/17**	**21/06/18**	**279 days**	
280		0%	3.3.7.3.2.7	Install HV Rack	02/05/18	02/05/18	1 day	225
281		0%	3.3.7.3.2.8	Install Auxiliary Rack	03/05/18	03/05/18	1 day	280
282		0%	3.3.7.3.2.9	Install / Terminate HV Rack cables	04/05/18	10/05/18	5 days	281
283		0%	3.3.7.3.2.10	Install / Terminate Auxiliary Rack cables	11/05/18	21/05/18	7 days	282
284		0%	3.3.7.3.2.11	Install / Terminate TH116 Amplifier cables	22/05/18	28/05/18	5 days	283
285		0%	3.3.7.3.2.12	Prepare TH116 Dummy Load	22/05/18	28/05/18	5 days	284SS
286		0%	3.3.7.3.2.13	Commission Electrical system	29/05/18	07/06/18	8 days	271,285
287		0%	3.3.7.3.2.14	Commission RF with Dummy Load	08/06/18	21/06/18	10 days	279,286
288		0%	3.3.7.3.2.15	RF System#2 - Amplifier 4616 & TH116 available for oper	21/06/18	21/06/18	0 days	287
420		0%	3.7	DoIC installation complete	21/06/18	21/06/18	0 days	193,417,288
421		**0%**	**3.8**	**Commissioning**	**22/06/18**	**06/12/18**	**120 days**	
422		0%	3.8.1	Cooling Channel magnet Commissioning	22/06/18	06/12/18	6 mons	420
423		**0%**	**3.8.2**	**RF Testing**	**09/11/18**	**06/12/18**	**20 days**	
424		0%	3.8.2.1	Test and condition cavities, with B field, 1MW	09/11/18	06/12/18	4 wks	420,422FF
425		0%	3.8.2.2	RF cavity testing with B field complete	06/12/18	06/12/18	0 days	424
426		0%	3.9	Combined magnet and operational tests complete	06/12/18	06/12/18	0 days	425
429		0%	3.12	Analysis	07/12/18	06/08/20	435 days	426

Figure 3: Waterfall chart for the completion of the cooling demonstration in the MICE-UK flat-cash-+10% scenario.

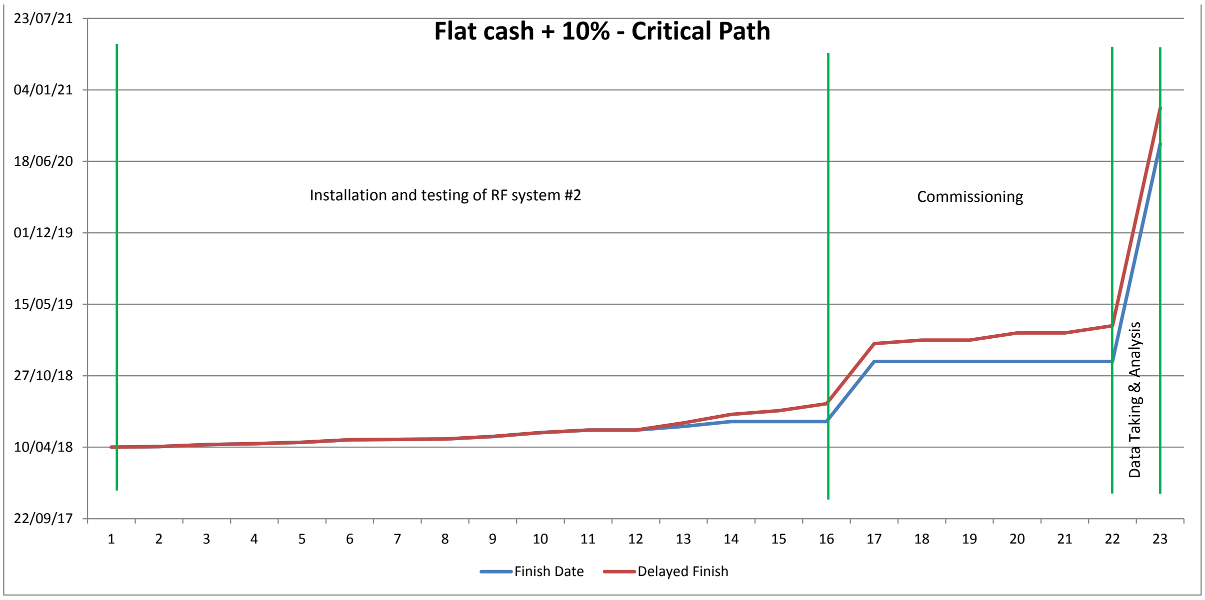


Figure 4: Critical path for the completion of the cooling demonstration in the MICE-UK flat-cash-+10%.

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Table 4: Key dates in the programme to complete of the cooling demonstration in the MICE-UK flat-cash-+10% scenario.

	Milestone		
	UK full-cost	**UK flat +10%**	**Delay**
Step IV running ends	Dec 16	Dec 16	
SSD Delivery	Jan 18	Jan 18	
Cooling demonstration installation complete	Feb 18	Jun 18	$\sim$ 4 Mths
Commissioning complete	Jul 18	Dec 18	$\sim$ 4 Mths
Data Taking ends	Jun 19	Oct 19	$\sim$ 4 Mths
Analysis ends	Mar 20	Aug 20	$\sim$ 4 Mths

- Delay installation of RF-system 2 until April 18 a delay of 10 months which results in a total project delay of 4 months. A shorter delay to RF-system 2 avoiding delay to the overall project is not sufficient to level the spend profile;
- Only test RF-system 2 into dummy loads, no full power test into a cavity before operation though the system design will have been fully de-bugged during the off-line cavity testing using RF-system 1; and
- No HPRF tests on the cooling channel before fully commissioning and operation.

The integrated project cost is increased over that of the full-cost scenario by $\sim$£300k.

The RF system in the full-cost scenario is no longer critical path. If the installation of the second RF in the MICE Hall is delayed by 9 to 10 months, it is still possible to carry out the risk-reducing off-line test of the RF cavities to the original plan using the RF system. This allows the peak in the cost of the programme in financial year 2017/18 to be reduced. A further reduction in the amount of pre-testing of the RF systems in the MICE Hall brings the cost profile level with only a 4 month delay in the completion of commissioning. This 4 month delay propagates through the remaining the data-taking and analysis sections of the project.

Whilst it is not desirable to bring the RF project back onto the critical path in this way, there are no other significant-cost parts of the program which can be delayed without impacting the completion date and/or adding risk in a more significant manner.

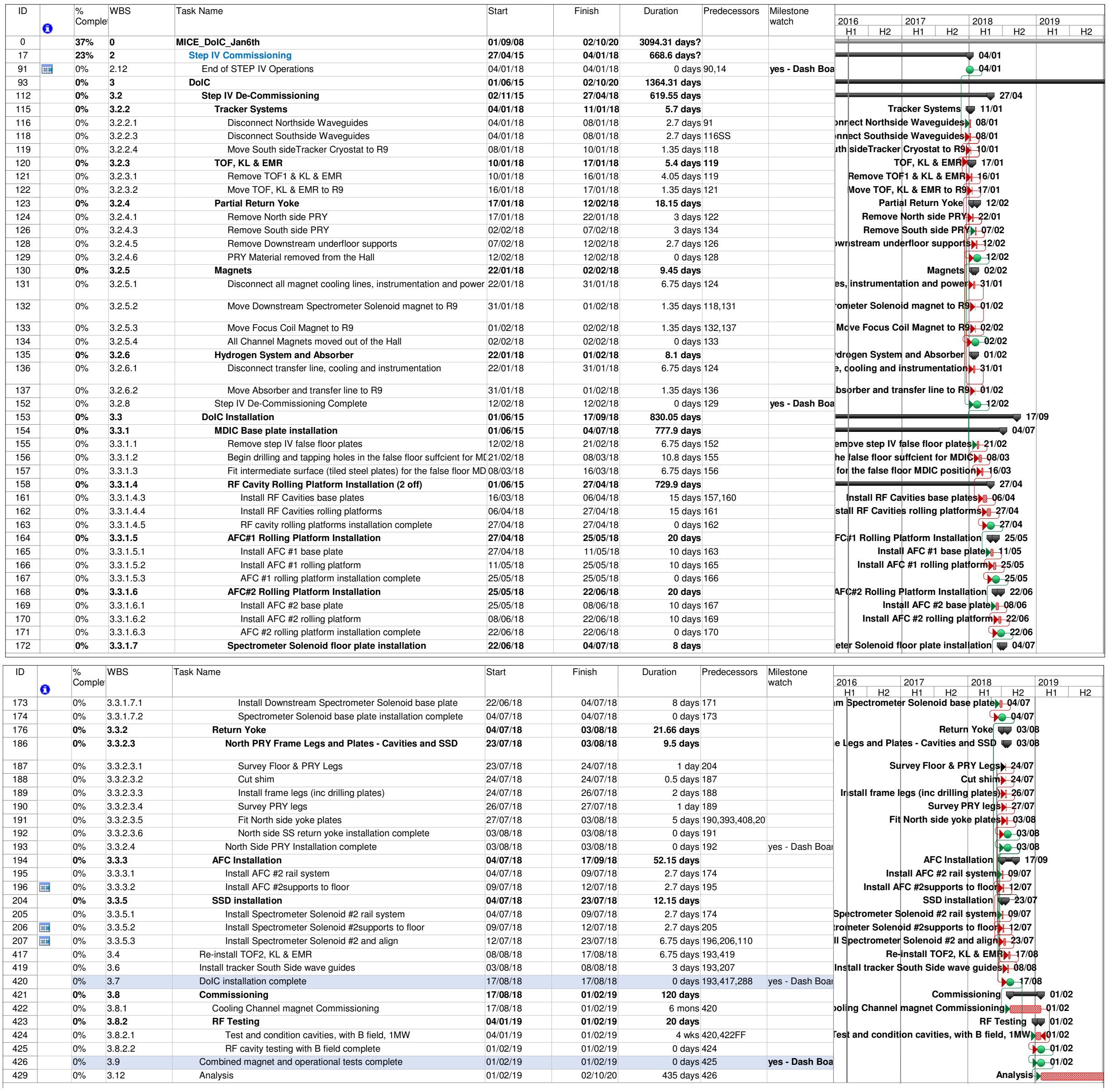
3.4.3 MICE-UK flat-cash scenario

Assumptions

- SSD replacement is available in January 2018;
- Step IV running continues, if required, to the end of 2017;
- RF-power system 2 delayed by 12 months to level funding;
- No HPRF tests on beam line only off-line; and
- RF-power system 2 only tested into dummy load before operation on beam-line.

The waterfall chart for the completion of the cooling demonstration in the MICE-UK “flat-cash-+10%” scenario is shown in figure 5 and the critical path is shown in figure 6. The key dates extracted from the schedule are shown in table 5.

In order to achieve a flat cash spend profile, further significant delay to the RF program is required, increasing the total delay to the RF project one year. The effect of such a significant delay is that SSD moves off the critical path by a relatively small amount and the construction phase becomes the limiting step. This greatly increases the number of items appearing on the critical path.



ID		% Complete	WBS	Task Name	Start	Finish	Duration	Predecessors	Milestone watch
0		**37%**	**0**	**MICE_DoIC_Jan6th**	**01/09/08**	**02/10/20**	**3094.31 days?**		
17		**23%**	**2**	**Step IV Commissioning**	**27/04/15**	**04/01/18**	**668.6 days?**		
91		0%	2.12	End of STEP IV Operations	04/01/18	04/01/18	0 days	90,14	**yes - Dash Boa**
93		**0%**	**3**	**DoIC**	**01/06/15**	**02/10/20**	**1364.31 days**		
112		**0%**	**3.2**	**Step IV De-Commissioning**	**02/11/15**	**27/04/18**	**619.55 days**		
115		**0%**	**3.2.2**	**Tracker Systems**	**04/01/18**	**11/01/18**	**5.7 days**		
116		0%	3.2.2.1	Disconnect Northside Waveguides	04/01/18	08/01/18	2.7 days	91	
118		0%	3.2.2.3	Disconnect Southside Waveguides	04/01/18	08/01/18	2.7 days	116SS	
119		0%	3.2.2.4	Move South sideTracker Cryostat to R9	08/01/18	10/01/18	1.35 days	118	
120		**0%**	**3.2.3**	**TOF, KL & EMR**	**10/01/18**	**17/01/18**	**5.4 days**	**119**	
121		0%	3.2.3.1	Remove TOF1 & KL & EMR	10/01/18	16/01/18	4.05 days	119	
122		0%	3.2.3.2	Move TOF, KL & EMR to R9	16/01/18	17/01/18	1.35 days	121	
123		**0%**	**3.2.4**	**Partial Return Yoke**	**17/01/18**	**12/02/18**	**18.15 days**		
124		0%	3.2.4.1	Remove North side PRY	17/01/18	22/01/18	3 days	122	
126		0%	3.2.4.3	Remove South side PRY	02/02/18	07/02/18	3 days	134	
128		0%	3.2.4.5	Remove Downstream underfloor supports	07/02/18	12/02/18	2.7 days	126	
129		0%	3.2.4.6	PRY Material removed from the Hall	12/02/18	12/02/18	0 days	128	
130		**0%**	**3.2.5**	**Magnets**	**22/01/18**	**02/02/18**	**9.45 days**		
131		0%	3.2.5.1	Disconnect all magnet cooling lines, instrumentation and power	22/01/18	31/01/18	6.75 days	124	
132		0%	3.2.5.2	Move Downstream Spectrometer Solenoid magnet to R9	31/01/18	01/02/18	1.35 days	118,131	
133		0%	3.2.5.3	Move Focus Coil Magnet to R9	01/02/18	02/02/18	1.35 days	132,137	
134		0%	3.2.5.4	All Channel Magnets moved out of the Hall	02/02/18	02/02/18	0 days	133	
135		**0%**	**3.2.6**	**Hydrogen System and Absorber**	**22/01/18**	**01/02/18**	**8.1 days**		
136		0%	3.2.6.1	Disconnect transfer line, cooling and instrumentation	22/01/18	31/01/18	6.75 days	124	
137		0%	3.2.6.2	Move Absorber and transfer line to R9	31/01/18	01/02/18	1.35 days	136	
152		0%	3.2.8	Step IV De-Commissioning Complete	12/02/18	12/02/18	0 days	129	**yes - Dash Boa**
153		**0%**	**3.3**	**DoIC Installation**	**01/06/15**	**17/09/18**	**830.05 days**		
154		**0%**	**3.3.1**	**MDIC Base plate installation**	**01/06/15**	**04/07/18**	**777.9 days**		
155		0%	3.3.1.1	Remove step IV false floor plates	12/02/18	21/02/18	6.75 days	152	
156		0%	3.3.1.2	Begin drilling and tapping holes in the false floor suffcient for MI	21/02/18	08/03/18	10.8 days	155	
157		0%	3.3.1.3	Fit intermediate surface (tiled steel plates) for the false floor MD	08/03/18	16/03/18	6.75 days	156	
158		**0%**	**3.3.1.4**	**RF Cavity Rolling Platform Installation (2 off)**	**01/06/15**	**27/04/18**	**729.9 days**		
161		0%	3.3.1.4.3	Install RF Cavities base plates	16/03/18	06/04/18	15 days	157,160	
162		0%	3.3.1.4.4	Install RF Cavities rolling platforms	06/04/18	27/04/18	15 days	161	
163		0%	3.3.1.4.5	RF cavity rolling platforms installation complete	27/04/18	27/04/18	0 days	162	
164		**0%**	**3.3.1.5**	**AFC#1 Rolling Platform Installation**	**27/04/18**	**25/05/18**	**20 days**		
165		0%	3.3.1.5.1	Install AFC #1 base plate	27/04/18	11/05/18	10 days	163	
166		0%	3.3.1.5.2	Install AFC #1 rolling platform	11/05/18	25/05/18	10 days	165	
167		0%	3.3.1.5.3	AFC #1 rolling platform installation complete	25/05/18	25/05/18	0 days	166	
168		**0%**	**3.3.1.6**	**AFC#2 Rolling Platform Installation**	**25/05/18**	**22/06/18**	**20 days**		
169		0%	3.3.1.6.1	Install AFC #2 base plate	25/05/18	08/06/18	10 days	167	
170		0%	3.3.1.6.2	Install AFC #2 rolling platform	08/06/18	22/06/18	10 days	169	
171		0%	3.3.1.6.3	AFC #2 rolling platform installation complete	22/06/18	22/06/18	0 days	170	
172		**0%**	**3.3.1.7**	**Spectrometer Solenoid floor plate installation**	**22/06/18**	**04/07/18**	**8 days**		
173		0%	3.3.1.7.1	Install Downstream Spectrometer Solenoid base plate	22/06/18	04/07/18	8 days	171	
174		0%	3.3.1.7.2	Spectrometer Solenoid base plate installation complete	04/07/18	04/07/18	0 days	173	
176		**0%**	**3.3.2**	**Return Yoke**	**04/07/18**	**03/08/18**	**21.66 days**		
186		**0%**	**3.3.2.3**	**North PRY Frame Legs and Plates - Cavities and SSD**	**23/07/18**	**03/08/18**	**9.5 days**		
187		0%	3.3.2.3.1	Survey Floor & PRY Legs	23/07/18	24/07/18	1 day	204	
188		0%	3.3.2.3.2	Cut shim	24/07/18	24/07/18	0.5 days	187	
189		0%	3.3.2.3.3	Install frame legs (inc drilling plates)	24/07/18	26/07/18	2 days	188	
190		0%	3.3.2.3.4	Survey PRY legs	26/07/18	27/07/18	1 day	189	
191		0%	3.3.2.3.5	Fit North side yoke plates	27/07/18	03/08/18	5 days	190,393,408,20	
192		0%	3.3.2.3.6	North side SS return yoke installation complete	03/08/18	03/08/18	0 days	191	
193		0%	3.3.2.4	North Side PRY Installation complete	03/08/18	03/08/18	0 days	192	yes - Dash Boa
194		**0%**	**3.3.3**	**AFC Installation**	**04/07/18**	**17/09/18**	**52.15 days**		
195		0%	3.3.3.1	Install AFC #2 rail system	04/07/18	09/07/18	2.7 days	174	
196		0%	3.3.3.2	Install AFC #2supports to floor	09/07/18	12/07/18	2.7 days	195	
204		**0%**	**3.3.5**	**SSD installation**	**04/07/18**	**23/07/18**	**12.15 days**		
205		0%	3.3.5.1	Install Spectrometer Solenoid #2 rail system	04/07/18	09/07/18	2.7 days	174	
206		0%	3.3.5.2	Install Spectrometer Solenoid #2supports to floor	09/07/18	12/07/18	2.7 days	205	
207		0%	3.3.5.3	Install Spectrometer Solenoid #2 and align	12/07/18	23/07/18	6.75 days	196,206,110	
417		0%	3.4	Re-install TOF2, KL & EMR	08/08/18	17/08/18	6.75 days	193,419	
419		0%	3.6	Install tracker South Side wave guides	03/08/18	08/08/18	3 days	193,207	
420		0%	3.7	DoIC installation complete	17/08/18	17/08/18	0 days	193,417,288	yes - Dash Boa
421		**0%**	**3.8**	**Commissioning**	**17/08/18**	**01/02/19**	**120 days**		
422		0%	3.8.1	Cooling Channel magnet Commissioning	17/08/18	01/02/19	6 mons	420	
423		**0%**	**3.8.2**	**RF Testing**	**04/01/19**	**01/02/19**	**20 days**		
424		0%	3.8.2.1	Test and condition cavities, with B field, 1MW	04/01/19	01/02/19	4 wks	420,422FF	
425		0%	3.8.2.2	RF cavity testing with B field complete	01/02/19	01/02/19	0 days	424	
426		0%	3.9	Combined magnet and operational tests complete	01/02/19	01/02/19	0 days	425	**yes - Dash Boa**
429		0%	3.12	Analysis	01/02/19	02/10/20	435 days	426	

Figure 5: Waterfall chart for the completion of the cooling demonstration in the MICE-UK flat-cash scenario.

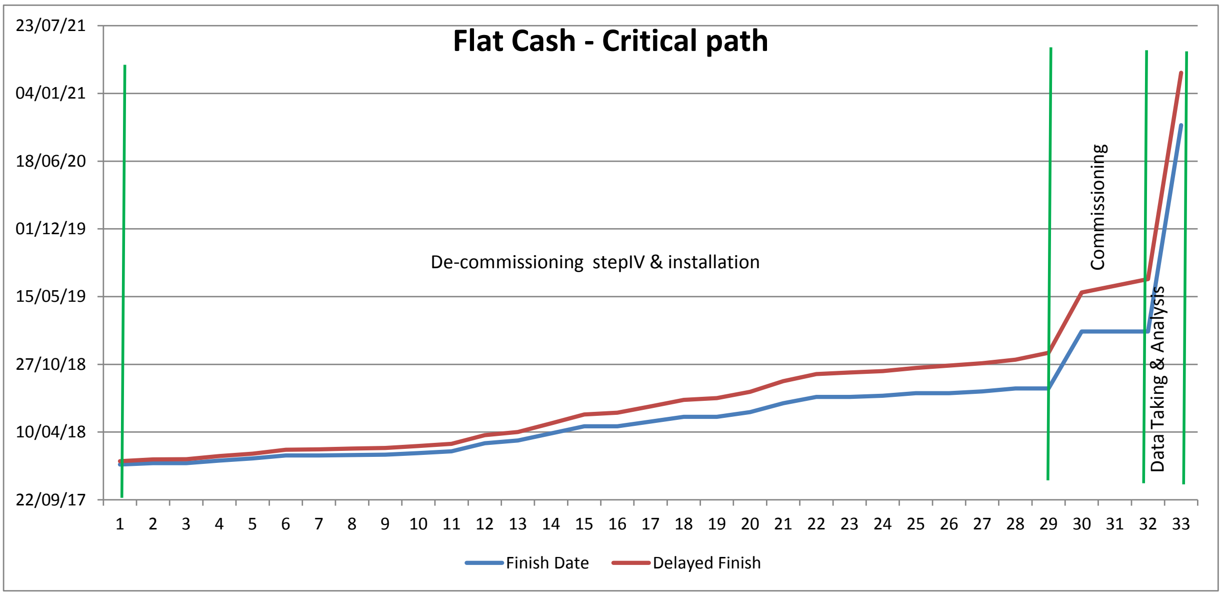


Figure 6: Critical path for the completion of the cooling demonstration in the MICE-UK flat-cash scenario.

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Table 5: Key dates in the programme to complete of the cooling demonstration in the MICE-UK flat-cash scenario.

	Milestone			
	UK full-cost	**UK flat +10%**	**UK flat**	**Delay** (w.r.t. full cost)
Step IV running ends	Dec 16	Dec 16	Dec 17	
SSD Delivery	Jan 18	Jan 18	Dec 16	
Cooling demonstration installation complete	Feb 18	Jun 18	Dec 16	$\sim$ 6 Mths
Commissioning complete	Jul 18	Dec 18	Dec 16	$\sim$ 6 Mths
Data Taking ends	Jun 19	Oct 19	Dec 16	$\sim$ 6 Mths
Analysis ends	Mar 20	Aug 20	Dec 16	$\sim$ 6 Mths

The delay has the benefit that Step IV could continue to operate should there be the requirement, the additional time available amounts to one year. If Step IV was run until the end of 2017 there is a significant probability that there will be a delay to the delivery of SSD if the cold ne mass is replaced in the existing cryostat. Internal measurements are required from the existing SSD cryostat to minimize the risk of incorrect dimensioning in the SSD recovery plan, therefore SSD must be de-commissioned and dis-assembled before a replacement cold-mass can be finalized. Obviously, if a full magnet is procured this requirement becomes redundant. A small amount of delay to SSD can be tolerated in this plan, as SSD lies off the critical path, but it may be wise to limit the duration of Step IV to remove the risk of delay in the integration of the cold-mass in the cryostat in view of the risk profile likely to exist in the SSD-recovery plan. The required Step IV termination date can be determined once detail on the SSD-recovery plan becomes available. The integrated cost in a flat cash scenario increases over the full cost by a large amount (approximately £1.25M) as a result of the delay and the additional resourced required later in the program to complete the works.

4 Cost

The construction project is broken down into work-packages for which the UK is responsible and work packages for which the US is responsible. The financial reports presented below reflect these lines of responsibility. The UK and US budget summary is presented figure 3. For both the UK and the US, the budgets include support for the experimental collaboration. The cost of ISIS Operations Group staff effort supporting MICE operations is also included in the UK budget projections. The figures do not take account of income that arises from the Common Fund and a number of European Commission awards. Risk mitigation has been included in the figures.

A great deal of effort has been directed toward reducing the risk to the RF deployment and commissioning project. This has produced an uplift of required resource so cost accordingly (see section 3.3).

5 Risk

The top level risks identified within the tasks that make up the UK contributions to the project risk register are presented in table 6.

Since the last report to the RLSR the principal risks to the UK sub-projects remain unchanged with the exceptions noted below.

MICE 9. Senior management of the MAP collaboration / MICE-US changes.

This risk is realised in the movement of the MAP director Mark Palmer from FNAL to a new post at BNL.

MICE 17. Failure of a Spectrometer Solenoid Magnet.

This risk is realised in the failure of M1 in SSD. The plan for recovery of SSD is as yet not fully defined. Alternative lattice parameters have been determined and continue to be developed to allow measurements in Step IV. It is not considered likely that this mitigation strategy can be extended to the cooling demonstration and a repair or alternate configuration will be required.

MICE 17.1. Failure of Upstream Spectrometer Solenoid Magnet.

SSU carries many of the same design weaknesses as SSD. Enhanced QD/QP is required for protection and has been developed. Installation is currently in progress, parts have been procured and delivered, the current schedule has commissioning starting in early May 2016.

MICE 18. Inability to procure Lithium Hydride for secondary absorbers.

The lithium hydride secondary absorbers can only be sourced from Y12 in the US. The purchase stalled

Table 6: Top-level risks in the MICE-UK construction project.

ID	Risk Description	Potential impact on project	Risk score			Ownership	Proposed Action	Post-action risk score			Comment / Conclusion	Cost of mitigation		Likely retirement of requirement			
			L	I	LxI			L	I	LxI		Staff years	Non-staff (£k)		Year	Q	Category
MICE 3	Magnetic field effecting operation of electrical equipment relating to the continued operation of the cooling channel magnet systems and detectors.	Inability to operate the cooling channel	5	5	25	MICE - UK / MAP	Installation of a partial return yoke has mitigated the major risk. Movement of the control and power supply equipment to a dedicated room outside of the magnetic field.	1	4	4	Much work has been completed and provision of additional rack room has enabled the majority of the sensitive equipment to be moved away from the hall. The PRY has not yet been installed and so has not been tested, the residual risk still applies. Significant investment from UK and US to mitigate risk has been expended. Non staff risk persists in the event of additional material being required.	0.2	100	End of Cooling Demo commissioning - may 2018	2018	2	Technical
MICE 4	Extended period of re-training for the lattice of magnets for Step IV - SS1/AFC/SS2.	Timescales for the training period, cost of the amount of LHe required to carry out the training the availability of the Lhe. Expert personnel required to be available for magnet operations over a protracted period of time.	4	5	20	MICE-UK / MAP	Discussions with BOC (or supplier) to agree delivery timescales and availability during heavy use periods. Magnet integration task force to define commissioning method to keep schedule and cost to a minimum.	4	4	16	Each re-cool and fill of the Spectrometer Solenoid can take upto 500l LHe, AFC remebers it's training. Each full lattice quench could cost in the region of £7K. Initial investigations with BOC show that the predicted amount of LHe will be available during the commissioning period.	1	100	End step IV commissioning - June 2016	2016	2	Technical
MICE 8	Resourcing issues from the STFC and national labs	inability to complete significant sections of work on agreed time or cost scales.	4	5	20	MICE - UK / MAP	Realised. Escalation of the issue to the STFC and DOE.	2	4	8	Project scope has changed leading to a different labour profile required to complete the project.	2		Impacts Step IV and all other steps. March 2018	2018	1	Resource
MICE 9	Senior management of the MAP collaboration / MICE-US changes.	Leadership and direction of the construction team unfocused.	4	5	20	MAP	Discussion with senior MAP and MICE management	1	4	4	SSD repair TBA and funded. Oversight to completion required.			End of Cooling Demo June 2019	2019	2	Resource
MICE 10	Late delivery of the PRY and / or Cavities for Cooling Demo after advanced scheduling.	Standing army cost for period after hall preparations are complete and receipt of the PRY materials / Cavities	3	5	15	MICE-UK / MAP	Interaction with the MICE-US construction team.	1	5	5	Cost will need to be borne as releasing and then re-forming the team will be difficult with an unknown timescale. From the MAP schedule analysis the PRY and RF Modules will arrive well in advance of the requirement	£90k / Month		End of Cooling Demo construction march 2017	2017	1	Technical
MICE 11	US budget limits magnet manufacture, commissioning and delivery	Halting project installation and subsequent data taking. Loss of key personnel from the project. Inability to continue with full cooling program.	4	5	20	MAP	Discussion with senior STFC management and DOE management	2	4	8	DOE has assigned a budget profile of 6 / 3 for this and the next US financial years.			Impacts Step IV and Cooling Demo commissioning may 2017	2017	2	Financial
MICE 12	RF Power systems are not available for cavity testing	The critical path items following the RF system installation will extend in time. Testing of the cavities with and without B field. Commissioning of the channel and gaining data for the final step	4	5	20	MICE UK	Discussions with UK senior management to gain sufficient staff to carry out the work required on the RF systems and controls. Additional technical staff from collaborating institutes for installation work.	2	4	8	Successful completion of the RF power system installation will result in delays leading to the US collaborators being unable to contribute to the data taking period for Cooling Demo. Further interaction with STFC senior management to gain sufficient staffing for RF completion.	2	75	End of Cooling Demo commisioning may 2017	2017	2	Technical
MICE 14	Loss of key project and operational staff	Continuation of the funding to allow re-newal of University contracts	3	5	15	MICE UK	Discussions with The STFC senoir staff. Preparation of funding profiles, plans and staffing to completion of the Cooling Demo	1	5	5	Much of the key aspects of the operation of the Step IV stage of the project are carried out by University staff. Gaining replaceable resource from the national labs would be difficult	10	50 (LTA / Travel)	Novemeber 2015	2015	4	Resource
MICE 15	Restricted entry to the UK for key project and operational staff	Visa and invitation burocratic difficulites procluding non-EU engineers and scientific staff from entering the UK to carry out work at the STFC RAL.	3	5	15	MCIE UK	Arragements with the imigration department of the SBS and highlight / escelating difficulties to the STFC senoir staff	2	5	10	Much of the key aspects of the operation of the Step IV stage of the project are carried out by University staff. Gaining replaceable resource from the national labs would be difficult	10	50 (LTA / Travel)	End of the Cooling Demo march 2018	2018	1	Resource
MICE 16	Failure of a Focus Coil Magnet	Internal cold mass or associated equipment deep within the assembly. LTS leads.	3	5	15	MICE UK	Follow all specific operational aspects as defined by the experts for the superconducting magnet	2	5	10	Transportation, dis-assembly, investigation, fix and reassembly would be extreamly costly and extensive with regard to schedule. A spare magnet would be out of the reach of the project. A repair intervention would be 12 months including testing and commissioning and manufacture of new magnet system, test and commission around 2 years.	3	500	End of the Cooling Demo march 2018	2018	1	Technical
MICE 17	Failure of a Spectrometer Solenoid Magnet	Internal cold mass or associated equipment deep within the assembly. LTS leads.	3	5	15	MAP	Realised SSD.	3	5	15	The plan for the recovery of the functionality of SSD is as yet undefined.	3	500	End of the Cooling Demo march 2018	2018	1	Technical
MICE 17.1	Failure of Upstream Spectrometer Solenoid Magnet	Internal cold mass or associated equipment deep within the assembly. LTS leads.	4	5	20	MAP	New quench protection system	2	5	10	Has the same design issues as SSD	3	500	End of the Cooling Demo march 2018	2018	1	Technical
MICE 18	Inability to procure Lithium Hydride for secondary absorbers	Reduction in scientific output and resulting cooling effect.	3	5	15	MICE-UK / MAP	Following the MPB Oct 15, new avenues to advance the procurement have been identified. Currently awaiting updated quote from vendor. Financial instruments in place to complete purchase this year.	1	5	5	The design for the placement of the secondary absorber at the radiation shutter placement is complete. The changes to the design of the Helium window 'Top hat' will be small.	0.2	30	June 2016	2016	2	Financial
MICE 19	Failure of M2 in SSU.	Reduction in scientific output and resulting cooling effect.	3	4	12	MICE-UK / MAP	Maximise data collection before running M2.	2	4	8	Consider completing data set for one absorber.	0.2	30	December 16.	2016	4	Technical
MICE 20	Failure of Helium space feedthrough in SSU.	Reduction in scientific output and resulting cooling effect.	3	4	12	MICE-UK / MAP	Limit number of quenches	2	4	8		0.2	30	December 16.	2016	4	Technical
MICE 21	Cannot agree program and budget	Only go to stepIV	3	5	15	MICE-UK / MAP	Work to agreed solution with partners - funding agencies	1	5	5	Programme funding issue	0.2	30	December 16.	2016	4	Financial
MICE 22	SSD delivery on schedule, quality & cost	Delays to programme and/or poor compromised data	4	5	20	MAP	Discussion with senior MAP and MICE management	2	4	8	SSD repair TBA and funded. Oversight to completion required.			End of Cooling Demo June 2019	2019	2	Financial

for some time due to an unresponsive contact in Y12, this problem now appears to be resolved though a close watch will be kept on progress and delivery.

MICE 19. Failure of M2 in SSU.

The current plan does not allow for the upgrade of SSU, as SSU carries many of the same design weaknesses as SSD it must be considered a high risk that SSU suffers a similar failure to SSD. While the current understanding of the failure of SSD indicates that the mode of operation and specific weaknesses in the fabrication process had a dominant influence on the failure mechanism, SSU must be protected as fully as possible before further operation of any coils. The new QD/QP system has been designed to ensure the fullest possible protection is provided to SSU and SSD, however there are weaknesses in the internal quench protection components which cannot be rectified without a rebuild and will therefore remain until the end of the cooling demonstration.

MICE 20. Failure of Helium space feedthrough in SSU.

See MICE 19 above. The failure in SSD may have damaged the feedthrough from the helium volume to the vacuum insulation space. Whilst there is every indication that the current condition of the feedthrough will allow operation, there is no guarantee that an event in SSU will produce a similar result. The new QD/QP system will provide enhanced protection against such a failure, but the risk cannot be discounted.

MICE 21. Cannot agree program and budget.

The SSD recovery plan is not yet fully defined though a clear timetable has been defined to reach an informed decision. US-UK discussions continue but limited US funds make technical support for any replacement magnet in the UK difficult. Limited UK appetite to absorb risk transferred from the US program makes an agreed program a significant challenge. Discussions between US and UK funding agencies continue.

MICE 22. SSD delivery on schedule, quality and cost.

Limitations in the US budget currently appear not to allow one of the lower risk recovery options: a commercial procurement from a well established magnet expert company. A sequential program with delivery of a tested cold mass followed by integration carries significant risk for a longer period. The current US plan finds significant funding profile advantages in a US lab based procurement for the cold mass.