December 14, 2015

Final Report
MicroBooNE Operational Readiness Review

1. Introduction

The Fermilab Program Planning Office (Steve Geer, Pushpa Bhat) charged a committee to review the operational readiness of the MicroBooNE experiment in the fall of 2015. The charge is provided in Appendix A and the committee membership is provided in Appendix B. The review took place on November 23-24, 2015 and the agenda and the relevant materials are available from this URL, https://indico.fnal.gov/conferenceDisplay.py?confId=10744 (uboone). Following the last talk, the committee met to discuss first impressions, to formulate additional questions, and to make writing assignments. In the days following the review some additional material was provided in response to requests and questions from the committee.

This report describes the findings and recommendations of the committee based on the talks presented at the review, on the answers to the questions asked during the review, on the additional material provided in the days following the review, and on discussions among the committee members. Prior to the issuance of this Final Report, a draft version was shared with the spokespersons of the experiment in order to provide them with an opportunity to correct factual errors. The findings and recommendations enumerated represent the consensus opinion of the committee as a whole.

Each section below addresses one of the principal charge questions. The committee members whose primary responsibility it was it address this charge question are included in parentheses at the beginning of each section. The lead writer has their name starred (*). Each section includes "Findings", "Comments", and "Recommendations".

2. Charge question #1

(J. Cherwinka, N. Grossman*, V. O'Dell)

Is there a completed Experiment Operations Plan (EOP) document? The document should include (a) a description of operations tasks and how they will be covered, (b) ES&H activities and how they will be managed, (c) organization charts showing the management structure for the experiment and how it interfaces with the laboratory, (d) the model for data processing and analysis including the budget and

effort required, (e) a list of the identified resources available, and (f) a description of the roles and responsibilities of each institution together with a list of the support required by each institution from the funding agencies.

A preliminary EOP exists that includes some, but not all, of the elements requested in the charge.

2.1 Findings

- A preliminary EOP for the MicroBooNE experiment has been written (dated November 16, 2015) that describes the main operational tasks of the experiment.

- The EOP references the Technical Scope of Work (TSW) between the MicroBooNE experiment and the Fermilab Computing Sector for "Support of Computing". The TSW is dated January, 16, 2015.

- The experiment conducted a failure analysis and developed response procedures for all the major systems, including those related to the Liquid Argon test facility and cryogenics. The analysis and procedures were produced in consultation with all the relevant experts.

2.2 Comments

- A signature and revision page should be added. The relevant signatures should be collected once the EOP is completed.
- A description of the roles and responsibilities of each institution should be added.
- The collaboration has not quantified the personnel resources (ie. FTE) required for detector, cryogenics, and beamline maintenance and operations (M&O) and data processing and analysis needs in FY2016 or beyond or the personnel resources available to fill those needs. This list should include support expected from Fermilab.
- ESH&Q liaisons should be added to the MicroBooNE organization chart.
- The EOP section on safety should include ESH&Q activities and their management and any unusual hazards for MicroBooNE (e.g. ODH, lasers, HV) and their mitigation such as experiment specific training. A reference to the MicroBooNE SAD should be considered.
- The EOP states the M&O M&S needs as $220k/year M&O but does not include a clear list of what this covers and who will provide the funding.
- The spares list needs to include future spares needs and who is responsible for funding them. In many cases there is only one spare at present, and while this appears to be sufficient for FY16, it is not clear if that is sufficient longer term. The spares list does not include critical beamline spares such a

MicroBooNE horn and target. The spares list does not include cryogenic and purification items such as pumps and valves.
- The EOP does not include the support from the funding agencies required by each institution.

2.3 Recommendations

1. In cooperation with the relevant stakeholders complete the EOP and obtain the relevant sign-off signatures.
2. Consider whether additional formal agreements (e.g. TSW) with the other relevant divisions (e.g. ND, PPD) would be helpful.
3. Work with the laboratory and the collaboration to ensure adequate spares over the lifetime of the experiment.

3. Charge question # 2

(J. Cerwinka, D. Denisov*, O. Gutsche)

Has it been demonstrated that the detector is ready for physics-quality data taking? If not, what actions are required to make the detector ready? Is there a clear plan for monitoring the data quality and has the associated infrastructure been tested? If not, what actions are required to adequately monitor the data quality?

While it is clear that the detector is operating stably, the committee is unable to assess whether the detector is performing as required to meet the physics goal since the criteria were not clearly stated. There is well developed monitoring of low-level experimental parameters (e.g. voltages, currents, dead and noisy channels) and some higher-level parameters as well, most notably the argon purity. The committee did not see much monitoring of high-level physics quantities extracted from the beam data. These tools should continue to be developed.

3.1 Findings

- The experiment is running with about 97% collection efficiency during neutrino beam delivery.
- A readout rate of 5.7 Hz has been achieved for the full detector. Data integrity has been tested and found satisfactory.
- There exists a list of spares with the location for all major elements of the experiment.
- MicroBooNE monitors the beam parameters based on information provided by the accelerator division.
- The experiment conducted an internal “Commissioning Review” earlier this year in preparation for first beam.
- About 90% of the TPC readout channels are operating. The causes for the unresponsive channels are not yet documented. Preliminary studies show that the impact on detector performance is not significant.

3.2 Comments

- The experiment is to be congratulated for its rapid turn-on and high data collecting efficiency.
- A large amount of work has been done during beam-off commissioning of the experiment. This put the experiment in a strong position to rapidly detect neutrino events once beam was delivered. The majority of the beam-off commissioning tasks have been completed and the few remaining are in the final stages.
- High-level physics and detector goals are well developed, while the corresponding detector performance parameters, and their specifications required to reach the physics goals, are not yet quantified.
- More detailed studies are needed to understand the physics impact for the unresponsive TPC channels.
- The LAr community would benefit from an in-depth analysis of the causes for the lower than planned TPC HV, the unresponsive TPC channels, and the PMT noise rates.
- Existing monitoring tools provide in-depth monitoring of the main hardware parameters of detector elements, such as voltages, currents, status of the DAQ and off-line systems, etc., while few of the tools provide data-based information of high-level physics quantities, for example about efficiency of the charge collection.

3.3 Recommendations

4. Continue development of data-based monitoring tools to monitor all the parameters required to demonstrate physics-quality data collection.
5. Develop a list of the detector parameters required for high-quality data collection. Quantify specifications for these parameters to satisfy physics quality requirements.

4. Charge question #3

(M. Convery*, D. Denisov, J. Konigsberg)

Is there a well-understood run plan for FY16, consistent with accelerator schedule and performance? Have adequate resources from the laboratory and the collaboration been identified for an efficient and safe running of the experiment and for maintenance of the detector, and is it clear who is responsible for what?

A run plan exists for FY16, consistent with the accelerator schedule and performance. It appears that adequate resources have been identified in FY16 and it is clear who is responsible for what.

4.1 Findings

- MicroBooNE expects to receive 1-2 x 10^{20} POT in FY16, consistent with the accelerator schedule and performance.
- The run plan includes the implementation of a PMT-based trigger in early CY2016 that will significantly reduce the data-rate written to permanent storage.
- Resources have been identified in FY16, but the resources needed (FTE) were not presented.
- There are clear divisions of responsibility (AD, PPD, ND, SCD, Collaboration) for all the major elements of operation (beam, cryogenics, computing, shifts, etc.).
- There are no formal statements of institutional responsibility beyond FY16.

4.2 Comments

- The experiment presented a plan for implementing a PMT trigger that would significantly reduce the data rate. While completing the necessary studies, the experiment is encouraged to consider implementing a "soft" PMT trigger soon. This could substantially reduce the long-term load on data storage, reconstruction, and analysis.
- In about a year's time, consider re-evaluating the long-term sustainability of the staffing model for the Run Coordinator position taking into account the ability to consistently fill the position and to maintain a cohesive knowledge base.
- Consider utilizing a database to track Shift Training for the collaboration.

4.3 Recommendations

6. Complete the studies required to develop a PMT trigger that significantly reduces the data rate while maintaining reasonable sensitivity to the main physics goals of the experiment. Based on these studies implement the trigger as soon as reasonably possible.
7. Create a table which lists the personnel resources required to run the experiment. Compare to your available resources. Identify areas of potential shortfalls.
8. Consider establishing longer-term formal statements of institutional responsibilities to ensure continuity in the staffing and expertise for the essential operational tasks of the experiment.
9. Work with the collaboration to identify another Online expert.

5. Charge question #4

(O. Gutsche*, J. Konigsberg, R. Plunkett)

Are there robust plans for data processing and data analysis? Have adequate resources from the laboratory and the collaboration been identified for data analysis to meet these goals?

MicroBooNE is in good technical shape to perform all needed processing and analysis tasks. The presented software development, production, processing, and analysis plan leading up to the July neutrino conference is aggressive but achievable. The plan is consistent with the computing resource envelope established through the SC Portfolio Management (SC PMT) process. Since the plan requires that many activities occur in parallel, the availability of experts is a concern.

5.1 Findings

- The MicroBooNE collaboration is well setup technically and organizationally to carry out data processing, MC production, and data analysis activities.
    - Workload management is based on SCD supported tools (Jobsub) augmented by a widely used script toolkit (larbatch) and a custom MicroBooNE-specific state machine solution (PUBS).
    - Data Management is based on SCD supported tools SAM and ifdh as well as FNAL-FTS.
    - The software is based on the Art framework and the community LArSoft reconstruction software, both supported by SCD. In addition, MicroBooNE is using the LarLite toolkit for fast-turnaround development tasks.
    - Analysis is predominantly done using centrally produced ntuples, which can be registered in SAM. All users of the collaboration have access to tutorials or documentation to facilitate analysis and access to data.
    - MicroBooNE covered all major tasks related to processing and analysis with effort documented in their organization chart.
- Resource needs are covered through the SC PMT process and reflect the needs of MicroBooNE.
- Currently the experiment is writing “open trigger” data at a very high rate.
- The experiment presented a timeline leading up to the neutrino conference in July 2016 detailing the needs for software development, MC production, data and MC re-processing and analysis and data study tasks.

5.2 Comments

- MicroBooNE’s LarLite toolkit is being merged with LArSoft and changes are being made to enable efficient usage of both. MicroBooNE commented that the integration process is progressing well.

- MicroBooNE is currently working on improving the metadata setup for datasets in SAM to fully utilize it as the collaboration's means of discovering data besides wiki pages.
- A concern is the availability of experts to carry out all tasks outlined in the plan leading up to the neutrino conference in July 2016.
- Software validation is technically set up but currently suffers from not enough disk space. The plan is to start systematic software validation when sufficient disk space is available.
- The overall problem of triggering the detector affects the offline processing by increasing the need for every sort of resource, with particular loads on the I/O bandwidth as well as the disk and tape storage requests. The trigger issue needs to be addressed promptly, including intermediate solutions that could partially reduce the data rate.

5.3 Recommendations

10. Produce a concrete plan for the long-term support and maintenance of PUBS, including the personnel and technical resources required.

6. Charge question #5

(M. Convery, V. O'Dell*)

Are there clear goals set for reporting and publishing the results from the experiment in a timely fashion?

Yes, there are clear goals for reporting and publishing. The collaboration is targeting first physics results for a July 2016 neutrino conference.

6.1 Findings

- MicroBooNE has a focused plan for data analysis and is actively working on the tools and calibrations needed to realize its first analysis.
- The first analysis, the ν_μ CC inclusive cross section, has been performed entirely with MC. This will be carried over to data, targeting a result for the Neutrino 2016 conference.
- A collaboration process for approving results exists and has been exercised with MC and "first event" public results.
- MicroBooNE has published 13 papers during detector construction.

6.2 Comments

- Studying the low-energy excess will be a long and difficult analysis. It is important that MicroBooNE continue to attract strong postdocs and graduate students that can carry the analysis through to completion.

6.3 Recommendations

11. In the short term, continue to study the detector performance and its impact on physics analysis. In the long term, ensure that analyses are adequately resourced.

7. Charge question #6

(D. Glenzinski, N. Grossman, R. Plunkett*)

Does the committee recommend further actions to ensure full exploitation of the MicroBooNE program?

Yes, complete and document studies for the benefit of the liquid argon community, particularly concerning the PMT noise, the TPC HV issues, and the unresponsive TPC channels. This appears to already be part of the plan.

7.1 Findings

- The experiment has established a Technical Coordination group to study the benefits and costs of added detector and facility enhancements.

7.2 Comments

- The experiment is approaching the PMT, HV, and unresponsive channel issues in a thorough and systematic fashion. They seem to have struck a good balance between investigating the problems for the benefit of future LAr development and achieving stable operations that will enable physics results.

7.3 Recommendations

Once the relevant studies have concluded:

12. Produce a full and documented response to the PMT noise issues.
13. Produce a full and documented response to the drift high voltage issues.
14. Produce a full and documented response to the causes of the unresponsive TPC channels.

8. Summary

The MicroBooNE experiment was reviewed for its data-taking and analysis operations readiness. The review committee was provided with a set of MicroBooNE documents relevant to addressing the charge questions. The MicroBooNE collaboration also made a full day's worth of presentations to the review committee. The committee was grateful for all the collaboration's effort to provide the required input.

The committee wishes first to congratulate MicroBooNE on the successful commissioning campaign and on their rapid start-up with beam. The committee was impressed with the level of professionalism and enthusiasm evident in the operations of the experiment and in the presentations and discussions during the review . The committee applauds MicroBooNE's ability to produce, so quickly once beam was delivered, first results demonstrating they have observed neutrinos.

The committee identified no show stoppers. While a significant amount of work remains, MicroBooNE is well organized and appears to have the resources it needs to produce high-quality physics in the coming year and beyond. The committee has provided above a list of 14 recommendations that are meant to mitigate the most significant remaining operational risks. The committee suggests that the MicroBooNE collaboration provide regular progress reports at the Experiment Management Group meetings.

Appendix A – Charge

September 4 , 2015

MicroBooNE Experiment Operational Readiness Review

October 13-14, 2015

CHARGE

The MicroBooNE experiment has completed the commissioning of its detector and is beginning operations with the Booster neutrino beam. The primary goal of the MicroBooNE experiment is to address the anomalous excess of events at low energy observed by the MiniBooNE experiment. In addition, MicroBooNE will also make cross section measurements of neutrino-Argon interactions, and contribute to the development of Liquid Argon detector technology useful for future neutrino physics experiments. We would like the committee to review the preparations for running, plans for maintenance & operations of the detectors, and data taking and analysis, including the current status of the detector, the status of the online and offline software, and the run plan.

In particular:

1. Is there a completed Experiment Operations Plan (EOP) document? The document should include (a) a description of operations tasks and how they will be covered, (b) ES&H activities and how they will be managed, (c) organization charts showing the management structure for the experiment and how it interfaces with the laboratory, (d) the model for data processing and analysis including the budget and effort required, (e) a list of the identified resources available, and (f) a description of the roles and responsibilities of each institution together with a list of the support required by each institution from the funding agencies.

2. Has it been demonstrated that the detector is ready for physics-quality data taking? If not, what actions are required to make the detector ready? Is there a clear plan for monitoring the data quality and has the associated infrastructure been tested? If not, what actions are required to adequately monitor the data quality?

3. Is there a well-understood run plan for FY16, consistent with accelerator schedule and performance? Have adequate resources from the laboratory and the collaboration been identified for an efficient and safe running of the experiment and for maintenance of the detector, and is it clear who is responsible for what?

4. Are there robust plans for data processing and data analysis? Have adequate resources from the laboratory and the collaboration been identified for data analysis to meet these goals?

5. Are there clear goals set for reporting and publishing the results from the experiment in a timely fashion?

6. Does the committee recommend further actions to ensure full exploitation of the MicroBooNE program?

We request a brief written closeout report from the committee addressing these questions by December 17, 2015.

Appendix B – Committee Membership

Jeff Cherwinka (U. Wisconsin)
Mary Convery (Fermilab)
Dmitri Denisov (Fermilab)
Doug Glenzinski (Fermilab – Chair)
Nancy Grossman (Argonne)
Oliver Gutsche (Fermilab)
Jaco Konigsberg (U. Florida)
Vivian O'Dell (Fermilab)
Rob Plunkett (Fermilab)