Mark Messier for the NOvA Collaboration
Response to Reviewers' Questions
Operational Readiness Review, October 2014

[1] Please quantify the shift requirements per person. Compare to experiment's needs over the next year. Comment on how the needs and availability are expected to change beyond FY2015.

Shift quotas are assigned to NOvA institutions based on author counts at the time of biannual censuses of the collaboration. The assigned quota is currently 9.2 8-hour shifts per author per 6-month shift cycle which is sufficient to cover the 5 shifts per day (2+2+1:day:swing:night) we are running. Shifters currently have responsibility for operating the near detector, and two partitions of the far detector while near and far detector maintenance and retrofits continue. With a few individual exceptions, the shift schedule fills quickly and we have not had too much trouble getting full coverage.

In the next shift cycle starting in April 2015 maintenance and retrofits will be complete and shifters will only be responsible for monitoring detector operations on two partitions (one near, one far); we expect that we will be able to reduce shifts to 3 per day bringing the per author quota to 5.5 8-hour shifts per 6-month shift cycle where it is likely to stay for the duration of the experiment.

[2] The ORC you provided looks like the last in a series of ORCs. It's difficult for us to tell if all facets have been addressed. Can you provide a summary of the ORCs (or AD equivalent) performed and what each covered?

A complete list of Operational Readiness Clearances is posted here:

`http://www-nova.fnal.gov/review_2014/doe_cd4_rev_sept14.html`

[3] Can you please clarify the two 80%s in the term labelled "Accelerator x NuMI" in Mark's talk (cf. slide labeled "NOvA Proton Assumptions for FY15")? What is this accounting for? Is this just accelerator related downtimes? or is this also accounting for NOvA downtimes?

These two efficiencies are for the operational efficiency of the Main Injector accelerator complex and NuMI neutrino beam components (targets, horns, etc.). These do not account for any NOvA downtimes. Currently, NOvA operates the far detector with 95% efficiency and we expect that to rise to 99+% as we continue to streamline detector operations which would bring the detector uptime on par with, eg. the MINOS far detector.

[4] Can you please clarify what's the maximum number of ND bad channels you can tolerate before your physics sensitivity is significantly affected?

We have not done these simulations. Simulations of the far detector showed that we could tolerate as much at 5% bad channels and we expect the ND to be somewhat less tolerant of bad channels. Currently we have made one full pass on near detector maintenance which left 4% bad channels on the near detector. We will continue maintenance until we achieve fewer than 1% bad channels. There are ample APDs available to achieve this goal.

[5] Can you please provide a summary of the actions taken to respond to recommendations from the 2013 Operations Review?

The recommendations from the 2013 review with our responses follow:

I. The accelerator performance has important consequences for both the NOvA project KPPs and the NOvA collaboration's near term analysis plans. The AD should provide a realistic estimate of the number of POT at NuMI, as a function of time, for the coming year. The project should use this projection to refine estimates of KPP schedules. The collaboration should use this projection to refine estimates of physics sensitivity for the Neutrino-2014 conference.

This was done. Beam delivery during FY14 was generally quite good and the KPP dates were not adjusted. We were able to meet all the KPPs on time. At the time of the Neutrino conference, we were able to show first neutrino events, a timing peak at the far detector, and demonstrate the 40M:1 rejection against cosmic-rays required for operations on the surface.

II. The laboratory should work with NOvA and the rest of the NuMI program to develop a plan that gives MINOS+ and MINERvA the special horn runs they need in order to understand the ME production spectrum, and gives MINERvA the information they need to make a target decision.

Roughly 2 weeks of special runs were incorporated into the FY14 running while the NOvA far detector mass was still quite small minimizing the impact on out commissioning.

III. The project, together with the collaboration, should remain vigilant in maintaining the FD schedule.

The FD was completed on time and under budget with a successful CD4 signed in October 2014.

IV. The spokespersons should ensure that any change in run plans is communicated to the rest of the NuMI program.

Run plans are a topic of bi-weekly meetings with Program Planning; we do not expect to make any changes to the run plan in FY15.

V. The spokespersons should explore with the laboratory cost effective ways to establish the direct video link required for detector operations.

Fermilab has assumed responsibility for the ReadyTalk phone conference system used by the collaboration following ESNETs withdrawal of support for the system and we appreciate very much the continuation of this essential and convenient service.

[6] Can you please provide a list of potential Ph.D. theses over the coming year given the 2-3 e20 POT expected? Expand for out years based on realistic accelerator performance expectations.

Two PhDs on NOvA have already been completed:

1. Measurement of muon-neutrino charged-current cross-section with the NOvA near detector prototype
2. Measurement of the inclusive muon-neutrino charged-current cross-section with the NOvA near detector prototype

This year we expect 2 students to graduate based on their contributions to the first oscillations results in the electron neutrino and neutral current channels. We expect 4 students to graduate based on their contributions to the first results in the muon neutrino channels.

There are 3 PhD students working on non-oscillation physics topics who are near graduation studying supernova neutrino detection, magnetic monopole searches, and cosmic-ray air showers.

We expect based on experience on MINOS that the electron neutrino and muon neutrino oscillation results will be periodically topped up leading to as many 10 additional theses. Using MINOS as a guide, these theses would be distinguished by focus on different neutrino event topologies, applications of novel reconstruction and particle identification algorithms, different statistical approaches to the signal extraction, and varied treatment of the near-to-far spectrum extrapolation. Once first anti-neutrino data is available, it would be possible to make CPT tests of the neutrino oscillation parameters and searches for "non-standard" neutrino matter effects.

The near detector will be a large source of theses with topics including measurement of the muon neutrino charged-current quasi-elastic cross-section at 2 GeV, inclusive muon neutrino cross-section at 2 GeV, electron neutrino cross section at 2 GeV, measurement of neutrino-electron elastic scattering, neutral current pi-zero production, neutral current coherent scattering, inclusive charged-current pi-zero production, and measurements of dimuon (charm) production. Several exotic searches are possible with the near detector including searches for neutrino magnetic moment, and searches for dark-sector particles. All of these measurements would be repeated using a high statistics anti-neutrino data set.

Non-accelerator physics topics are the far detector include studies of atmospheric neutrinos using upward going muons and searches for neutrinos from dark matter WIMP annihilations.

Summing over the near and far detector, acceleration and non-accelerator physics topics, and neutrino and anti-neutrino data sets, I count about ~60 thesis topics. No doubt, the creativity of our collaborators will expand this list.

[7] Can you outline the calibration procedures in more detail.

The time, charge, and energy calibration procedures are outlined in this poster presented at the Neutrino 2014 conference by one of our students:

`http://nova-docdb.fnal.gov/cgi-bin/ShowDocument?docid=11325`