

DUNE ND I&I Assessment Report - 7/23/24

1. Charge

An internal review of the DUNE Near Detector installation plans was conducted during the first months of 2024. The main goal of this review was to evaluate the installation sequence, timeline and resources to ensure our estimates for ND installation are accurate. The details of the charge can be found [here](#). The review was held at FNAL on February 15-16, 2024 with Subject Matter Experts (SMEs) who have experience with the installation of similar underground detectors at FermiLab. The agenda and links to the presentation can be found [here](#). Recommendations from the subject matter experts were implemented during the months following the review.

The following sections summarize the outcome of this meeting, how the recommendations from the committee were incorporated in the Near Detector installation plans, and what action items remain to be incorporated.

2. Executive Summary

The committee provided extremely valuable feedback during each of the three presentations (a) [Overview](#), (b) [Installation sequence](#), (c) [Coordination Resources](#). This section provides a summary regarding three key questions addressed during this review.

- What was the overall strategy?

The key assumptions were:

- SAND and LHe Cryogenics are off-project and not included in this analysis.
- Detector commissioning and argon fill will be on operations.
- AUP is August 2028

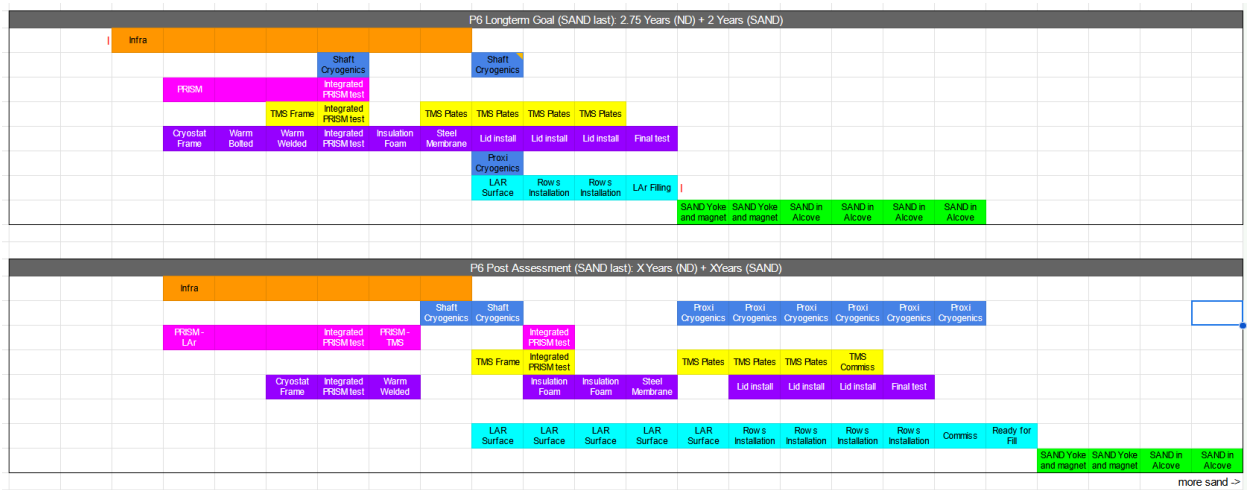
The main concept for the installation plan involves getting the PRISM system and support frames for each detector operational as soon as possible, and then using PRISM to shuffle the detectors into and out of the crane coverage area to alternate between heavy assembly using the crane for each of the detectors.

A major deliverable of the self assessment was the [ND Installation Sequence storyboard](#). This slide deck shows scale representations of each installation step in the context of the cavern and surface building floor plans. This allows us to showcase the space required for each installation activity, the space taken up by material staging, the space reserved for shaft or other stay clear zones, and the remaining space that could enable parallel activities off the critical path.

The SME team did not see any major issues with the installation plan and its major premise of the early commissioning of the PRISM system to move the partially assembled detectors and allow for parallel activities to take place. We took note of several topics to track as the installation planning progresses , and took several [actions](#) to investigate more pressing issues immediately.

- What have we implemented in the schedule, what was the effect on duration?

The overall duration of the Near Detector Installation is about 3 years and 9 months (as of 7/23/24). The graphics below show the previous and new 30,000ft view. The key difference is that the Shaft Cryogenics (blue block) and TMS (yellow blocks) used to be entirely in parallel with the Cryostat activities (purple block). We can now see the interruptions in the Cryostat activities to facilitate these activities. This schedule is longer but much more robust (less risks of cascade delays).



- What major changes, if any, were implemented to the resources

The main change is with respect to the distribution of the Level of effort. It now includes a top and bottom floor coordinator, and additional designer support to

maintain the as built CAD model. Lead, Installation, and manufacturing engineer hours are slightly reduced. The total hours of LOE for management and coordination remains stable (~45,000 hours).

After the review, we merged installation activities that were scattered across multiple WBS. All the activities are now regrouped within the I&I WBS. This approach was strongly endorsed by the SMEs. The total hours for labor for riggers and technicians also remains stable (~55,000 hours)

3. Charge questions

Working with Fermilab SMEs, we ask that you please complete an initial assessment of our near detector installation plans by considering similar installations that have already taken place at Fermilab. This is an important input to determining CD milestones and the end date for the BNF/DUNE-US Near Detector Subproject. Specifically, we ask that you please address the following:

3.1 Timeline

- Starting point is Fabrice's 30,000 foot installation summary

The 30,000 foot installation was presented to the SME. The new 30,000 ft view shows the alternance of activities between TMS and ND-LAR which enables parallel activities, and provides flexibility to adjust the schedule in case one of the detector installations gets delayed (if one detector gets delayed, we can continue installation on the other one).

- Is the duration allocated for the installation of each sub-system reasonable?

We walked through the detailed installation sequence, and the estimates were considered reasonable, based on previous experiments installed at FermiLab. The duration of specific activities was increased to account for efficiency (see answer to next questions).

- What is the most optimal installation sequence, paying close attention to activities which can and cannot be done in parallel. How much can we serialize?

The SME appreciated the careful considerations of parallel activities as shown in the storyboard. The recommended to consider a gantry for installation of TMS components outside of the crane coverage.

- Please explicitly call out any activities that will require 100% (solo) occupancy of the hall because of crane usage needs or otherwise.

The most restrictive activity is the installation of cryogenics piping in the shaft. We pointed out that we are currently not planning any other rigging activity during that time, but we might identify opportunities for optimization later on. The reviewers appreciated this approach. We also pointed out that at any given time, rigging activities will only be performed on one or the other detector, which was also endorsed by the reviewers.

- Have we properly accounted for the time needed for safety reviews and ORCs?

The reviewers emphasized the importance of accounting for the planning of ORC, prioritizing activities that require ORC, and sufficient duration to perform ORC. The commissioning and testing of ND-LAr as shown in the 30,000ft view illustrate how those recommendations are taken into account.

- Have we clearly defined the boundary between the end of project-supported installation activities and the start of commissioning for each subsystem? How do we validate the installation?

The hand off points were described to the reviewers. The details remain to be formally captured within the systems engineering documentation (Requirements, Verification, etc...)

- Does the overall efficiency of work seem reasonable? Please consider both surface and underground activities.

The installation duration was increased for several activities to more accurately account for the efficiency of underground activities. For instance we used to plan for one TMS plan a day, and we are now planning for 1.5 days per TMS plan (50% increase).

SMEs suggested that Bathrooms may be required in the cavern, in addition to the higher comfort models suggested for the surface building.

- What is our total estimated duration of near detector installation underground?

It is now 3 years and 9 months. See additional details in the executive summary section.

There are two main bodies of work that have not yet been fully integrated into the installation schedule logic, and which may have an effect on the duration: cryogenics installation and electrical utility installation. During this assessment we identified the tasks that we expect will be performed on the critical task chain and to integrate them into the P6 schedule logic, but there are still other activities in each WBS that haven't been fully captured in the installation schedule.

- Please identify any impacts the installation sequencing may have on possible design features (re: safety, tooling, motorized vs. manual PRISM movement).

The key element remains the operability of the PRISM system. A non functioning PRISM system will directly impact the installation plan and duration. The TMS gantry proposed by the SME is being considered as a mitigation plan.

3.2 Resources

- Does the level of costed resources in support of near detector installation seems reasonable given how similar installations have occurred at Fermilab? Please also consider what we are considering for uncosted labor.

Response: We have reviewed the uncosted labor assumptions for installation during this assessment. Only the TMS and ND-LAr TPC installations will rely on uncosted labor.

- ND-LAr has significant uncosted labor in the installation plan, particularly for electronics checkouts
- TMS has a lower uncosted labor estimate, and this must be revised

The process of formally capturing the uncosted labor remains to be addressed with the consortia.

- Are we double counting any installation resources held in I&I and at the detector subsystem level?

The SME team did not identify issues (overlap or double counting) with our resource estimates for the installation activities. The main issues they identified were instead with the availability of resources to meet the needs of ND, particularly the rigging and electrician resources.

- Competition with beamline for installation resources: welders, electricians, rigging team.
- Riggers generally work a 4-10 schedule, and this not captured in our current plans
- Electricians can be hard to hire, and scheduling for work can be challenging.
 - Contracting process is time consuming
 - Small number of vendors willing to perform work at FNAL
 - Competition for resources between FNAL projects.
 - A new FNAL process for Indefinite Duration Indefinite Quantity (IDIQ) contracts may be replacing the old Time and Materials model, and allow for more flexibility in electrician contracting.

The SME team suggested that we increase our LOE allotment for onsite installation coordination. Additional LOE resources recommended to manage work in both cavern and surface. Floor managers are needed for each of the cavern and the surface work. This recommendation is now implemented.

With respect to power Distribution

- Review of labor estimates against P6 for duration accuracy.
- Electrician contracting concerns
 - Similar concerns to the scheduling of external labor for cryogenics work.
 - Electricians in particular are becoming hard to find for work at FNAL. Some vendors choose not to work at FNAL due to the strict safety regulations.

They emphasized that external contractors can be difficult to schedule with the installation. We have engaged in discussion with our EE team to the concerns raised by the SME.

- Please review assumptions about on-project equipment rental versus existing resources at Fermilab. Are there any resources we are including on-project that would instead be provided by the host lab?

We presented the list of equipment captured on our basis of estimates. The SME indicated that some of this equipment may already be available at FermiLab. We are in communication with the SME to follow up and adjust the BOE accordingly.

In addition the SMEs mentioned/asked:

- A counterbalanced lifting beam is proposed for installing cryogenic equipment on the mezzanines, and such a beam has been used before on Icarus.
- 50A limits on lithium batteries may affect rental equipment choices/availability.
- Safety features (eye washing station, PPE etc...) - who provides which elements?

3.3 Prior Reviews

- Please review and comment on the recommendations from the ND I&I Cost.

The following recommendations were made following the May 2022 cost review:

(i) “The project should review if uncosted labor assumptions have been fully captured in the schedule and be prepared to present and defend those estimates at the CD-1 RR. The risk registry should capture risks where that labor might fall short and/or opportunities where more in-kind contributions may be possible.”

Response (copied from previous section): We have reviewed the uncosted labor assumptions for installation during this assessment. Only the TMS and ND-LAr TPC installations will rely on uncosted labor.

- ND-LAr has significant uncosted labor in the installation plan, particularly for electronics checkouts.
- TMS has a lower uncosted labor estimate.

(ii) The project should review if the effort captured in the overall I&I WBS and in the sub-detector areas has any gaps or double-counting prior to the CD-1 RR. Particularly in the engineering and the rigging estimates considering the total number engineers and riggers that can really be working simultaneously on I&I in the ND facility at any given time.

Response: We have reviewed our labor estimates and verified that rigging labor was not double counted in the I&I and Sub-system WBSes. Since this review the installation schedule has been combined, with all I&I and Sub-system labor now combined into a single WBS for activities that occur after AUP. To retain the resolution of rigging vs mechanical technician hours, we've coded the rigging activities with personnel from the FNAL rigging team.

(iii) The project should work with FNAL alignment to refine I&I alignment estimates prior to the CD-1 RR.

Response: We've received input from the SMEs regarding the size of the alignment/metrology team at FNAL which we can use to update our labor estimates, but we have not yet invested much time in detailing out the metrology activities.

3.4 Possible Opportunities (bonus question)

- Are there any obvious installation-related activities that should be considered to be performed above ground so as to increase ease of installation underground?

We are collaborating with the TMS team on bundling options for the TMS planes. We will also pre-assemble multiple LAr rows before installation.

- Please identify any components that exceed the capacity of the 15 ton surface crane. Is there an optimization to be had between increasing the capacity of the surface crane versus having to rent an external crane?

Crane Capacity - the surface crane 15 ton capacity is low compared to other cranes around the FNAL campus.

- Undersized cranes which then need to be upsized at greater cost are a recurring issue at FNAL (2x Icarus, SBN)
- Facility lead of detector design is a factor

Based on these recommendations, we requested an upgrade of the surface crane to 40T.

Surface and Cavern Crane Hook Limit Overlap

- The cavern crane hook limit does not extend past the centerline of the shaft.
- The surface crane hook cannot approach the edges of the shaft due to the cabling from the hook to the drums.

We followed up with NSCF to obtain the required information. We completed drawings that indicate that we do have sufficient overlap between the two crane coverage.

- What worries you? What are the largest risks in the installation plan? Are there any gaps in the current plan?

The SME asked the following questions which we are addressing with the TMS team:

- How big are the TMS magnet power supplies?
- Will they require water cooling?
- Do they need to be mounted in a stationary mezzanine?

4. Actions and Resolutions

- ~~Revisit surface building crane capacity~~
 - **Status 7/23:** Quote for increased crane capacity pending from NSCF.
 - **Status 11/5:** Surface crane capacity increase submitted: **BCR NSCF_0004**
- ~~Revisit cavern crane coverage of shaft centerline~~
 - **Status 7/23:** I&I performed an evaluation of the [crane overlap](#) and didn't see a potential issue. The analysis has been shared with the ND team for additional review, no issues have yet been identified.
- Send list of lifting fixtures to Dave, Tom, and see what items are available at FNAL
 - **Status 7/23:** Spreadsheet shared week of 4/29
 - **Status 11/5:** Dave Pushka provided a list of equipment available at FNAL, but before ND takes these costs off the BOE, we need to ensure we have agreements in place to reserve them
- Revisit bathroom budget
 - Do we need bathrooms in the cavern? Standard porta potties underground.
 - **Status 7/23:**
 - I&I prepared a budgetary estimate for EXTERNAL bathroom based on feedback from Peter Wilson, but this hasn't yet been implemented in the BOE. A BCR is being drafted to present the cost of higher quality surface bathrooms for approval.
 - We can base an estimate on cavern porta potties on the quote originally generated for the surface, assuming transport from the cavern to the surface weekly would be on project.
 - **Status 11/5:** Improved bathroom facilities at the surface and other amenities for workers **BCR ND 1061**
- TMS current and power supply size
 - Location: should they be stationary, or can they move with TMS?
 - **Status 7/23:** TMS does not yet have a power supply selected. We will revisit this when TMS has selected their power supply.
- Revisit LOE roles and budget
 - **Status 7/23:** Implemented: the LOE recommendations from the SMEs were implemented via **BCR ND 1049** in April.





Important note: 7/23/24 marks the end date of the installation assessment period. Additional actions implemented after this date will be summarized at the next I&I review (date and format to be decided).

5. References

Materials presented at the review:

1. [Overview](#)
2. [Installation sequence](#)
3. [Coordination Resources](#).

Other materials:

-  2024 - Cavern and Surface - ND Integrated Installation Sequence
-  I&I 30000 ft
-  Feb 15, 2024 | LBNF/DUNE Near Detector Installation Assessment
- [ND Surface and Cavern Crane Overlap Analysis](#)
-  TS002 - ND Bathrooms

BCRs Released:

- [ND_1040](#) - Update of installation activities and durations to reflect the most current installation plan.
- [ND_1048](#) - Rearranging the schedule so that all installation activities are contained in the I&I WBS.
- [ND_1049](#) - Update of I&I LOE based on SME feedback.
- [ND_1061](#) - Personnel Amenities/Personal Protective Equipment
- [NSCF_0004](#) - Capacity update of the ND Surface Crane