Report

of the

ICNO Maintenance & Operation Mid-Term Review Panel

Performed for the
National Science Foundation

Conducted at University of Wisconsin, Madison, WI
April 29-30, 2024

June 11, 2024

Report of the NSF ICNO Maintenance & Operation Mid-Term Review Panel

April 29-30, 2024
University of Wisconsin, Madison, WI

Table of Contents

Appendices

Executive Summary

The midterm review of the IceCube Neutrino Observatory Management and Operations (M&O) Cooperative Agreement was carried out at the Wisconsin IceCube Particle Astrophysics Center (WIPAC) in Madison, Wisconsin on April 29 and the morning of April 30, 2024. One Panel member and several NSF staff members attended the meeting via Zoom. Members of the IceCube collaboration responsible for the M&O of IceCube made appropriate presentations to the Panel. This group represents approximately one third of the collaboration that now numbers over four hundred and twenty scientists and engineers. The main focus of the M&O is collecting the data from the detector located at the South Pole, analyzing and storing that data, improving the event trigger for reading out the data, carrying out the large simulation effort to understand the properties of the ice, maintaining the detector, interfacing with the Antarctic Science Support Contractor, publishing the scientific results from the data analysis, and finally managing the outreach activities to the broader community.

After listening to the presentations and meeting in executive session to discuss the progress of the collaboration, the Review Panel reached the following summary conclusions:

1. The science that IceCube has produced is excellent and the new directions in analysis promise even greater results. The observation of our galaxy with neutrinos was enabled by AI and the use of GPU's.

2. The IceCube collaboration, involving 59 institutions from 14 countries with more than 420 authors, is doing an excellent job of smoothly managing the maintenance and operations of the detector, the data analysis, and outreach while interfacing with the IceCube upgrade project.

3. Education and outreach activities of the collaboration are very well received and are doing an excellent job of attracting the next generation of scientists.

4. Coordinating and publishing the results of analysis of the data are very well managed and the data is being made widely available. The partially filtered data is in the 13 Petabyte region and continues to expand.

5. Robust M&O management at all levels are demonstrated by frequent telecoms, meetings on tech work by WBS, cross WBS coordination, and M&O Leadership.

6. The South Pole server upgrade is being deferred until after the IceCube Upgrade. This defers approximately $800k. We consider this a low technical risk.

7. We did not see money for M&O or upgrades to the electrical and HVAC system for IceCube Upgrade. We assume that there will be no significant upgrades needed to the building to accommodate the Ice Cube Upgrade. We have some obvious concerns about the lack of staff available at the Pole to properly manage and maintain all the equipment and software at a high reliability level that is sustainable in the long run.

8. As part of the change control system, IceCube will revert changes to the previous version until vetted by OPS. SMEs are available to help winter-overs. This results in high uptime due to test procedures, with all changes traceable providing stability with flexibility.

9. We discussed the average power consumption compared to forecasted power consumption after the upgrade of the Ice Top and Strings/associated computers. The replacement of all the DOMHubs

by FieldHubs would have a significant power saving that will offset this power increase but it is not funded.

10. The project spending has typically been 3 % to 4% below budget. Project year 4 had a 70 k$ overrun. Labor re-balance has reduced this. Causes are the 4% mandated COLA salary increase, labor turnover, and inflation impacts.

11. Deferred maintenance was reported in both hardware and software, both on-ice and in the North. We find this concerning and not sustainable in the long run.

a. The project and agency have chosen to adopt this path in order to complete the Upgrade.
b. We find this an acceptable path, but the next M&O proposal will have to address the back log of hardware and software issues.

12. Critical maintenance is not sustainable long-term.

13. Personnel rotations are key to support new science and train the next generation.

14. Overall Observation: The entire presentation to the Panel was very well prepared, and clear to understand. The project is well managed and very well planned out.

The Review Panel expects this to continue for the rest of the current Cooperative Agreement. IceCube continues to be a very important element of the Particle Astrophysics program.

Introduction

The physics progress made by the IceCube Collaboration has been tremendous in the last few years in the fields of both neutrino astrophysics and neutrino oscillation physics. IceCube is the world leading experiment in the field of neutrino astronomy. The discovery of a diffuse high-energy cosmic neutrino flux has been a big step in entering the era of multi-messenger astrophysics. The first compelling evidence of an identified source (TXS0506+056) was realized through a multi-messenger campaign. An additional nine sources have been identified in this manner using the improved Pass 2 data set. NGC 1068 has now been identified as an extra galactic neutrino point source using only IceCube data at the 2.9 sigma level. Within the M&O framework, more results of this kind are expected.

In neutrino oscillation physics, the latest results obtained by the IceCube, mostly based on the exploitation of their DeepCore data, have placed IceCube among the most competitive experiments. The IceCube results are consistent with worldwide measurements that are obtained with very different systematics. The imminent unblinding of a sample of 210,000 neutrino events which include 6900 tau events will further improve the systematics and reduce the uncertainty in the measurement precision. This is a clear goal of the collaboration through the INCO Upgrade proposal.

The recent improvements in the event reconstruction based on recalibration and a refined understanding of the ice properties have yielded better direction and energy estimates for the neutrino candidates. This overall effort will continue to be pursued as part of the M&O program.

ICNO Scientific and Technical Management

Findings

The science from IceCube is excellent and is focused primarily in three areas: Neutrino astronomy with cosmic neutrinos verified using muon neutrinos coming through the earth, starting neutrinos in the detector, and tau neutrinos, along with a Glashow event. Multi-messenger astronomy is underway with the coincidence between high energy gamma rays seen with Fermi and MAGIC and IceCube and the subsequent observation with optical telescopes. Neutrino physics from 5 PeV to 5 GeV (with the upgrade project) with oscillation measurements at higher energy, tau appearance, and potential determination of the neutrino mass ordering is being expanded by IceCube.

The DOM survival rate remains above 98% after more than ten years of running with about one failure per year during the last five years. During the past year the detector uptime has been better than 98%. The PMT gain has also been very stable with a timing resolution for bright events of 1 nsec and for single photoelectrons 5 nsec FWHM and is limited by the PMT. Each PMT has now been calibrated individually.

Characterization of the ice is carried out using the LED calibration system in the DOMs continues to be improved. Azimuthal variation is observed in the scattering with a smaller variation in the direction of the ice flow. These data also indicate that the ice layers are tilted and not planar. There are systematic uncertainties due to the cable position and the new ice formed by the refreeze. A few DOMs have a tilt of 25 degrees with most of the others having a

tilt of less than 4 degrees.

Observation of a 5.9 PeV neutrino is of special interest and now indicates the likely observation of the Glashow Resonance.

The observation of our galaxy with neutrinos is an indication of the of power of new analysis techniques enabled by a combination of machine learning and the use of GPUs.

The IceCube Collaboration now numbers around 420 people and 59 institutions. The M&O portion numbers about 120 people and is managed by the Director of Operation through a series of Memoranda of Understanding. The in-kind contributions to the data handling, the data analysis, the detector calibrations and the characterization of the ice by the rest of the collaboration are substantial.

Education and Public Outreach programs continue to be a high priority of the Collaboration. It uses the South Pole as the land, environment and the science for inclusion in masterclasses, comic books, and upward bound material. It includes the whole family via the Grandparents University. By having IceCube scientists teaching in these classes who had been students in similar classes provides intergenerational connections.

Comment

Based on the expertise of the Collaboration and the recently published results, the Panel finds that the scientific goals are very good and are very likely to be achieved. One area that could use increased help is in computing, especially in software development to take advantage of GPU resources that are available to the collaboration.

Recommendation

Pay particular attention to make sure that there is sufficient expertise in software development to take advantage of the GPU computing resources available to the collaboration.

ICNO Operations

Findings

The South Pole experimental apparatus is now a mature system that continues to undergo slow evolution. Likewise, the northern compute platforms and software stacks are mature systems and undergoing slow evolution. Evolution is necessary as equipment ages and new computational methods become available. Examples are moving to Goggle Workspaces and looking for ways to move away from the VMWare stack along with the adoption of Github. Additionally, the aim of evolving the Madison compute cluster towards a data serving farm and away from providing analysis computational power aligns with the current trends in large scale computing.

Deferred maintenance on both hardware and software by the M&O team, both on-ice and in the North has been chosen as the path to be able to complete the Upgrade within the current budget profile. While it is an acceptable path currently, it is not sustainable and will have to be addressed in the next M&O proposal.

Comments

The work on calibrations by the M&O group is exceptional and they are working on options for moving some of the work being done on the Madison compute cluster and opportunistic grid computations. Currently these are expensive but with large scale compute farms coming on-line, the costs may be affordable.

Interfaces between the M&O group and the collaboration are very good with the re-engagement providing in-kind contributions to the software after the covid slowdown. This is especially evident in the buy-in on common software tools and frameworks. The collaboration is driving the adoption in machine learning with the M&O group working on balancing the needs for GPU additional capability. The desire for improved science analyses has pushed the M&O group to make these improvements.

The change control, quality control, and validation of the change process, along with the evidence of its widespread use is impressive.

Recommendation

The deferred maintenance of both the software and hardware must be addressed in the next M&O funding proposal to insure the sustainability of the IceCube science program.

ICNO Project Administrative Management

Findings

The funds that support IceCube M&O come from the NSF M&O Core, the 5-year award that mostly covers Core M&O tasks, travel, M&S and service agreements for UW and the eight U.S. sub-awardee institutions and contribution to the M&O Common Fund. NSF Base Grants for analysis support the M&O activities done by U.S. graduate students and postdocs. U.S. Institutional In-Kind mostly covers M&O activities done by faculty members, different fellowships and university funded activities. The fourth source is Europe and Asia Pacific In-Kind institutional contributions from non-U.S. collaborators that includes labor and travel and their contribution to the M&O Common Fund.

The M&O Core tasks are the technical tasks required for the continuing efficient operation of the detector and it associated data acquisition, transmission, analysis and archiving systems. These consist of South Pole overwinter personnel, computer system administration, software engineering to improve the performance of production code, and running simulation production.

M&O Sub-awards are monitored through a combination of WIPAC and the University of Wisconsin Research and Sponsored Programs office.

Scope of Work and M&O responsibilities within the collaboration are updated twice a year through MoUs. In-Kind resources are coordinated by the IceCube Coordination Committee (ICC).

IceCube has three advisory panels. The Software and Computing Advisory Panel advises the IceCube Spokesperson and Director of Operations on online computing, online and offline data processing, offline computing facilities and simulation and analysis support. Written reports follow each meeting (9 members). The Science Advisory Panel provides advice to the Collaboration and management on the scientific and data analysis program (7 members). The International Oversight and Finance Group (IOFG) International Panel provides oversight and financial coordination among the international funding agencies that supported the IceCube MREFC: USA, Germany, Sweden, and Belgium. The members review the decisions made on Common Fund payments and expenditures, the MoU scope of work between ICNO and collaborating institutions, concurrence on M&O plans, funding issues and coordination, and future facility expansion planning and coordination.

The IceCube upgrade to install seven new strings in the central core of IceCube is moving forward after the delay caused by covid. The schedule compresses drilling all seven holes and installing the strings into a single season.

Comments

The University and Wisconsin IceCube Particle Astrophysics Center (WIPAC) administrative structures appear to be working well. The oversight of the collaboration is being carried out in an effective manner and the reporting to the NSF appears to be well done. The Education and Outreach activities are doing very well with a broad spectrum of activities and appear to be well received by the general population. The three advisory panels also appear to be working well. Overall, the administrative structure is working well.

Robust M&O management appears at all levels and is demonstrated by frequent telecoms, meetings on tech work by WBS, cross WBS coordination, and M&O Leadership. There does not appear to be money for M&O or upgrades to electrical and HVAC system for the IceCube Upgrade along with any significant upgrades needed on the building to accommodate the upgrade.

The Panel has obvious concern about the lack of staffing available at the South Pole to properly manage and maintain all equipment and software at a high reliability level that is sustainable in the long run.

Recommendation

None

ICNO Program Organizational Structure

Findings

There are six elements in the M&O WBS at level two. They are:

WBS 2.1: Program Coordination
B. Riedel (UW) Chair
L. Mercier Resource coordination
TFT Coordination: N. Whitehorn
Real Time Oversight Committee: M. Santander
WBS 2.2: Detector Operations -Weekly ops calls
WBS 2.3: Computing: Daily standups, bi-weekly sprints
WBS 2.4: Data Processing and Simulation: Bi-weekly calls
WBS 2.5: Software: Bi-weekly Software Calls
WBS 2.6: Calibration: Weekly calibration calls

These are financed by roughly a third each from the NSF M&O Core, NSF Base grants along with U.S. Institutional In-kind, and European and Asia Pacific In-kind.

In-kind resource management is carried out with twice a year up-dates to the MoU statements of work. The ICC chair, the Software Coordinator, and the Computing Coordinator work with institutional PIs to match labor with collaboration needs that include:

Basic requirement for detector monitoring shifts
Software-simulation/reconstruction algorithms, general analysis tools, strike team
Calibration
Occasional detector maintenance
Distributed computing resources

The bridge between the Collaboration and the M&O activity is the ICC. It manages the scientific needs of the collaboration by assigning high-priority tasks to the in-kind labor from the MoUs, the software strike team, and the coordination of the next pass of the data analysis. The ICC also coordinates the in-kind resource pledges like assigning labor to high priority tasks or the software strike team, and the distributed computing resources. Management is carried out by a combination of scheduled teleconferences and meetings when needed.

Budget comparisons: PY-1 3.6% under budget, PY-2 3.7% under budget, PY-3 cumulative -70 k$ (Final). The causes of this increase are the 4% mandated COLA salary increase, labor turnover, and inflation impacts. This could have been higher, but a labor re-balance reduced the impact. Note that Penn State had original PY3 funds of $96,850, but current funds showed $0 due to Penn State being late on invoicing. The South Pole server upgrade was deferred till after the IceCube detector upgrade is complete. It defers approximately 800 k$ and has low technical risk.

Comment

The organizational structure appears to be working well with costs being managed. The U of W has taken over IceCube networking so that they didn't have to fill the vacancy when a staff member leaves. The collaboration provides help when new science directions appear, to carry out the analysis. Simulation of the ice properties and detector response are more challenging in finding the staff and computing resources to carry them out. Currently they are able simulate one year of live time in one year so they are breaking even. They are able to attract students to become expert in GPU computing and developing the software to use them. The main problem is that each supercomputer is different and requires learning new techniques to use them.

Recommendations

1. Continue to explore increased efficiencies and additional funding sources to manage the escalation of costs during the remaining two years of the current M&O contract.

2. The Collaboration should begin now to put together the proposal for the next five-year M&O support award.

ICNO Management

Findings

The management of the M&O activities can be summarized as follows:

At NPX: Changes are tested before they are implemented using scaled down ICL hardware, software, full string of DOM mainboards, and replay ability.

PSL: Use full length cable for communication testing, and walk-in freezers for cold testing.

All hardware and software is tested at PSL with upgrades at Pole staged over two years, old hardware stays at Pole over the winter.

All hardware changes are recorded in the logbook.

All source code is under revision control, bugs are tracked, changes discussed on telecoms, and discussed in IceCube Live.

IceCube will revert changes to the previous version until they vetted by OPS.

SMEs are available for help to winter-overs.

Comment

Following these test procedures has resulted in a high uptime with all changes traceable, stable, and providing flexibility.

Recommendation

None

ICNO Coordination with NSF and Antarctic Support Contractor & S.P. Logistics

Potential Issues

1. What is the average power consumption compared to forecasted power consumption after upgrade of Ice Top and Strings/associated computers. Has this been coordinated with ASC and do they have the capacity, especially considering other potential additional power needs by other science at Pole?

2. Personnel rotations are key to support new science and train the next generation. What is the plan to fix this problem?

3. Deferred maintenance especially of critical infrastructure is not sustainable long-term. What is the plan to fix the problem?

Recommendation

Develop plans to insure adequate personnel rotation and proper maintenance of critical infrastructure.

ICNO Upgrade Integration

Findings

The ICNO upgrade project consists of installing seven additional strings near the center of the present IceCube array. Each string will have two types of optical modules, the original mDOMs and D-Eggs that look both up and down that are supplied by the Japanese collaborators. In addition to the optical modules there will be an array of camera and light sources to better characterize the ice. There will also be some deep instrumentation that includes radio transmitters and receivers and other instruments to further characterize the ice.

Interfaces to the existing IceCube readout systems and data storage systems are also included along with upgrades to the existing systems.

The installation is planned over three seasons with the first season successfully just completed with all goals achieved. By rearranging tasks, the three to four week delay in getting materials to Pole was mitigated. The IceCube population was 11 during this last season. The coming season has a planned population of 21 and will be commissioning and testing all of the equipment needed to drill and install the seven strings during the final season. The population is planned to be 46 during this last season.

Comment

Arrival of all needed equipment in a timely manner will be key to the successful installation of the seven strings during these last two seasons. Logistics challenges due to the lack of heavy wheeled transport aircraft being able to land at McMurdo from December to the end of January are a real concern.

Recommendation

None

Overall Observation: The entire presentation to the panel was very well prepared, and clear to understand. The project is well managed and very well planned out.

Appendix A. Charge to the Review Panel

IceCube Neutrino Observatory Maintenance & Operation (M&O) Mid-Term Panel Review (V242133)
April 29-30, 2024

April 4, 2024

TO: Panel Members

The IceCube Neutrino Observatory (ICNO) is a major scientific facility sponsored by the NSF and operated by the University of Wisconsin in Madison under the Cooperative Agreement with NSF. The current award for the maintenance and operations (M&O) of this facility is OPP-2042807 to cover a period of 60 month from April 1, 2021 to March 31, 2026. The ICNO enables research in ground-based neutrino astrophysics by the U.S. and international scientific communities.

The IceCube Collaboration is an international effort of over 350 scientists (currently involving 59 institutions from 14 countries; https://icecube.wisc.edu/collaboration/) conducting scientific analyses of data collected by ICNO. In addition, members of the Collaboration contribute to the overall M&O enterprise by performing service work needed to operate the Observatory and preparing data for scientific analyses. Some institutions provide "in-kind" computing and database infrastructure and services to facilitate the work of the Collaboration. This approach creates a mechanism for collaborating scientists and institutions to support the work needed to make ICNO data graded as scientifically valid, as well as providing to students and postdocs unique realistic experience in operating a major research astrophysical facility.

This mid-term external review of the ICNO/M&O award is recommended by the Cooperative Agreement to cover, at a minimum, project management, cost and performance objectives, and scientific and technical performance to inform NSF's decision on potential pathways for the support of the ICNO/M&O activities through 2026 and beyond.

The Charge

The ICNO Mid-Term Review Panel should examine the existing balance of activities to support the ICNO maintenance and operations. The primary goal of this review, and of any resulting adjustments to the M&O activities, is to ensure that investments in the IceCube-related science and respective facility's support are properly aligned, both as now and in the future, within the project's goals and objectives as well as with research priorities of the U.S. and international particle astrophysics community.

The review will assess the budget and management activities encompassing the ICNO's maintenance and operations from April 2011 through March 2024 and consider the costs of continuing the ICNO observing capabilities funded through March 2026. The Panel may also assess the current needs and future developments of the ICNO capabilities.

As identified in the attached copy of the ICNO/M&O Cooperative Agreement, the following elements are considered for the Panel's review and recommendations:

ICNO Scientific and Technical Management:

1. a) ICNO Science Overview, Collaboration, Education & Outreach
2. b) ICNO Systems Architecture (IceCube and IceTop, triggering and filtering)
3. c) Data management (preprocessing, local & remote computing requirements, data transfer from the South Pole to U. Wisconsin)
4. d) Data quality, simulation and reconstruction tools

5. e) Data analysis coordination and publications
6. f) Technical progress (hardware data collection systems at the South Pole and U. Wisconsin)
7. g) Field support & logistics, hardware upgrades, and R&D effort for the IceTop replacements
8. h) Expected integration (during the 2025–2026 field season) of the IceCube Upgrade's 7 new strings into the ICNO main data collection system.

The Panel should consider the effects of its recommendations on the future landscape of the U.S. and international particle astrophysics communities. The recommended M&O support and its potential changes should be viable and lead to a vigorous and sustainable scientific research program.

Finally, the elements of recommended support for ICNO should be prioritized in sufficient detail to enable NSF to make subsequent appropriate adjustments in response to variations in the available Federal and non-Federal funding.

NSF Cognizant Program Officers:

Dr. Vladimir Papitashvili
Program Director
Antarctic Astrophysics & Geospace Sciences
GEO/Office of Polar Program
Phone: (703) 292-7425
E-mail: vpapita@nsf.gov

Dr. James Whitmore
Program Director
Particle Astrophysics
MPS/Division of Physics
Phone: (703) 292-8908
E-mail: jwhitmor@nsf.gov

CA Cognizant Officer:

Ms. Kristin Spencer
Grant & Agreement Specialist
NSF/DACS
Phone: 703-292-4585
E-mail: kspencer@nsf.gov

LFO Liaison:

Dr. Florence Rabanal Large Facilities Advisor
NSF/Large Facilities Office
Phone: 703-292-8808
E-mail: frabanal@nsf.gov

Panel Support Contact:

Ms. Desiree Marshall
Program Specialist
Office of Polar Programs
Phone: 703-292-7433
E-mail:demarsha@nsf.gov

Intentionally blank

Appendix B. Review Panel Members

Prof. Donald Hartill Emeritus (Chair)
Cornell University, Ithaca, NY
E-mail: dlh13@cornell.edu
Phone: 607-227-6958
https://physics.cornell.edu/donald-hartill
NSF ID: WW0117731

Dr. James Annis (ICNO science and technology)
Fermi National Accelerator Laboratory, Batavia, IL
E-mail: annis@fnal.gov
Phone: 630-840-5181
http://computing.fnal.gov/james-annis/
NSF ID: ZY0872290

Mr. Richard S. Armstrong (ICNO infrastructure and management)
RSA Engineering Inc. AK
E-mail: darmstrong@rsa-ak.com
Phone: 650-926-3388
https:/rsa-ak.com/
NSF ID: ZG0854223

Appendix C. Agenda

AGENDA

IceCube Neutrino Observatory Maintenance & Operations Mid-Term Panel Review

222 West Washington Avenue, Suite 500, Madison, WI 53703

https://wipac.wisc.edu/about/contact
Event registration for in-person participation: link

WIPAC logistics contact: Alexandra Fleagle **Monday, April 29, 2024** (Time CDT)
08:00 – 08:15 Coffee/tea, snacks
08:15 – 08:30 Introductions, panel overview, logistics **(Don Hartill & William Wester)**
08:30 – 10:00 ICNO Science and Technical Management (Don Hartill)

a) Science Overview (20+5 min) – **Francis Halzen**

b) IceCube Collaboration (20+5 min) – **Ignacio Taboada**

c) Education & Outreach (15+5 min) – **James Madsen**

d) Analysis coordination and publications (15+5 min) – **Naoko Kurahashi Neilson**

10:00 – 10:20 Coffee/tea break

10:20 – 12:20 ICNO Operations (Jim Annis)

a) ICNO systems architecture – IceCube and IceTop, data flow, triggering and filtering (10+5 min) – **John Kelley**

b) Detector performance and on-site maintenance — hardware, data acquisition and monitoring, upgrades incl. surface detectors, IceACT, and ARA (20+5 min) – **Matt Kauer**

c) Data management (hardware & software, local & remote computing) (15+5 min) -–

Benedikt Riedel

d) Simulation, offline data processing, and data releases (15+5) – **Juan Carlos Díaz-Vélez**

e) Detector calibration — ongoing improvements and plans for the IceCube Upgrade (15+5 min) – **Dawn Williams**

f) Software and multi-messenger real-time operations (15+5 min) – **Erik Blaufuss**

12:20 – 13:10 Lunch Break

13:10 – 14:30 ICNO Project Administrative Management (Richard Armstrong)

a) ICNO Advisory Bodies: International Oversight and Finance Group, Science Advisory Committee, Software & Computing Advisory Panel (10+5 min) – **Albrecht Karle**

b) Project organizational structure, financial status, and U.S. and in-kind contributions (20+5 min) – **John Kelley / Laura Mercier**

c) Change Management – software, detector configuration, data processing (15+5 min) – **Erik Blaufuss / John Kelley**

d) Coordination with NSF and Antarctic Support Contractor, and South Pole logistics (15+5 min) – **Matt Kauer**

14:30 – 14:50 Coffee/tea break
14:50 – 16:00 ICNO Upgrade Integration

a) IceCube Upgrade progress – Field Season 1 results and preparation for Field Season 2 (20+5 min) – **Vivian O'Dell**

b) Integration of the IceCube Upgrade's seven new strings into the ICNO data acquisition system (20+5 min) – **Jim Braun**

c) Towards unified IceCube and IceCube Upgrade Operations (15+5 min) **– John Kelley**

16:00 – 17:00 Executive Session (discussion, wrap-up, homework assignments) Panel & NSF

17:00 – 17:40 Meeting with Project for homework assignments **17:40 Adjourn**

19:00 – 21:00 Dinner (Sardine, 617 Williamson St., reservation under Kelley)

Tuesday, April 30, 2024 (Time CDT)

08:00 – 08:30 Coffee/tea and snacks

08:30 – 10:30 Response from Project to homework assignments

10:30 – 11:30 Executive Session (work on the panel's summary)

11:30 – 12:30. Q & A and concluding discussion with the Project.

12:30 – 13:00 Lunch

13:00 Adjourn

Teleconference Information

Topic: INCO M&O meeting
Description: Maintenance & Operations Mid-Term Panel Review
Time: April 29-30, 8:00 AM Central Daylight Time (U.S. and Canada
Join ZoomGov Meeting
https://nsf.zoomgov.com/j/1601884851?pwd=MzBBTDhTYjhPTUgzaDgyMlFENW5ZQT09 Meeting ID: 160 188 4851

Passcode: 202609

DocuShare directory with presentations and other materials:

https://docushare.icecube.wisc.edu/dsweb/View/Collection-16957