Strategic and Implementation Plan

Ice Drilling Program Office -
Ice Drilling Design and Operations

IDPO-IDDO

March 2016

Lead institution:
Dartmouth College

Sub-award Institutions:
University of New Hampshire
University of Wisconsin
Colorado School of Mines

Sponsor:
National Science Foundation

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Executive Summary

One of the most pressing environmental issues of our time is anticipating the climate changes resulting from our warming planet. In order to predict the future with confidence, we need a clear understanding of the past changes recorded in and under the climate archives of glaciers and the polar ice sheets. Detecting climate change in ice core records is a relatively new science that has evolved since the International Geophysical Year 1957 – 1958 (Langway, 2008). Ice core records have led to many important discoveries, for example the discovery that dramatic changes in climate can occur abruptly, in less than ten years (NRC, 2002). This discovery has revolutionized climate science and also has important impacts on policy; it established some of the key groundwork leading to the 2007 award of the Nobel Peace Prize to the IPCC for climate science. Members of the U.S. ice coring community have led the efforts for these and a multitude of other important findings in fields ranging from climate to life in extreme environments to geophysics. The societal need for accurate predictions of future sea level rise requires improved understanding of glacier and ice sheet dynamics. This involves probing glaciers and ice sheets by geophysical means, including poorly understood basal processes. Ice sheets themselves can serve as platforms for science for a wide range of discoveries, from astrophysics to biology in extreme environments. U.S. scientific productivity in these areas, including both knowledge generation and creation of the next generation of scientists, critically depends upon a mechanism for ensuring continuity and international cooperation in ice coring and ice drilling efforts, along with availability of appropriate drills, drilling expertise, and innovations in drilling technology. This plan outlines our approach to science and technology planning and coordination, one that relies on ice coring and drilling science communities' input for current and future planning, but that is coordinated nationally and internationally, conveyed to the public, and carried to fruition for NSF through the daily efforts of the Ice Drilling Program Office (IDPO) that works hand-in-hand with the Ice Drill Design and Operations group (IDDO).

There are six interrelated goals of IDPO-IDDO: 1) to provide community leadership in ice drilling research and development; 2) to identify new technology needs and plan for technology development; 3) to acquire new drilling technologies to support science objectives for new discoveries; 4) to provide the drills, equipment, and drilling expertise needed by the science; 5) to enhance communication and information exchange related to drilling science and technology, and 6) to establish activities in collaboration with the polar science and engineering community to contribute to the NSF strategic goals for desired societal outcomes.

Broader Impacts: The broader impacts of the Ice Drilling Program Office include the outcomes from IDPO leadership in the planning, coordination, and oversight necessary to form and execute continuously evolving ice drilling and science programs. The formation of ongoing, continuous programs will nurture the inclusion of students of a range of ages, races, and genders, will help to launch graduate students into promising careers in science, and will result in discoveries in climate and environment that are important to all citizens. Education and Outreach programs of IDPO will foster diversity through teaming with the American Meteorological Society for IDPO-led School of Ice, a residential experience that exposes a network of faculty from minority-serving institutions to the ice core lab, leading scientists, and their data. This will enable the faculty to provide their students in underserved institutions and community colleges with cutting-edge lessons and insight into inspiring careers in science and engineering. IDPO outreach efforts will sustain the pipeline of scientists and engineers by continuing to support activities and programs of the Association of Polar Early Career Scientists (APECS) and Ice Core Young Scientists (ICYS). IDPO outreach efforts will advance public literacy by humanizing the face of climate science by promoting interviews of science community members on main stream media and television.

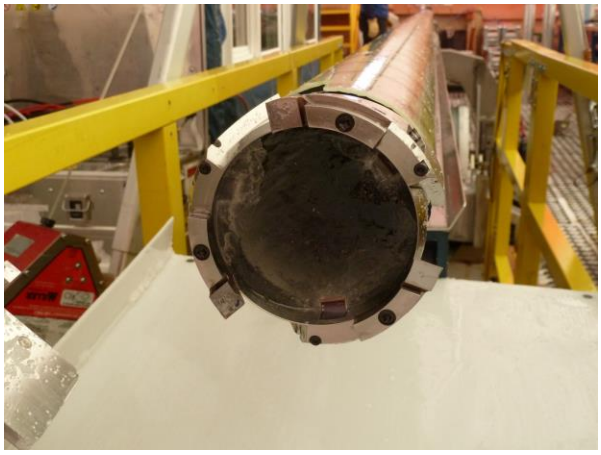
VISION

To enable scientific discoveries about changes in environment and climate, using evidence from glaciers and ice sheets, to inform environmental policy.

The bubbles visible in this piece from an Antarctic ice core contain carbon dioxide and other gases that were trapped in the ice when formed many thousands of years ago. Ice cores provide the only natural archive of ancient air. Credit: *Oregon State University*.

MISSION

To conduct integrated planning for the ice drilling science and technology communities and to provide drilling technology and operational support that will enable the community to advance the frontiers of science.



The last core is collected for the SPICE Core Project at the South Pole Station in 2015-2016 using IDDO's Intermediate Depth Drill (IDD). The two-year drilling effort was completed on January 23, 2016 at a final borehole depth of 1751 meters.

Situational Analysis

Strengths

- Experienced Principal Investigators (PIs) with leadership abilities
- PIs and staff of IDPO and IDDO have a long history of working well together
- Endorsements of senior members of the research community
- Close associations with U.S. and international science and technology communities
- National Science Foundation (NSF) support
- Strong Science Advisory Board (SAB)
- Experienced and knowledgeable Technical Advisory Board (TAB)
- Successful history of science-technology partnerships
- Good working relationships with researchers for both science and technology
- Existing equipment and infrastructure at the University of Wisconsin (UW)
- Engineering expertise in UW's Ice Drilling Design and Operations group (IDDO) and its parent Space Science and Engineering Center (SSEC)
- Cadre of experienced, knowledgeable drillers
- Strong commitment to quality and safety
- Project Management Institute (PMI) Certified Program Manager (PMP) with extensive science project management experience
- Disciplined Project and Risk Management system appropriate to the facility size and mission
- History of successful field support

Weaknesses

- Small staff size limits back-up capabilities in many position functions
- Some equipment is old and in need of upgrade or replacement; increasingly difficult to maintain the ever-growing fleet of drilling equipment under flat funding
- Very limited pool of experienced polar engineers from which to recruit staff
- Seasonal aspect of polar field work makes it difficult to retain experienced drill operators
- Limits on polar logistics makes it difficult to deploy additional drillers for training purposes; training is not easily accomplished outside of the polar regions

Opportunities

- Explore partnerships with other organizations, foundations and industry
- Explore collaborations with research groups not currently involved in community long-range planning
- Explore graduate student activity at Dartmouth, University of Wisconsin, University of New Hampshire, Colorado School of Mines, and other universities
- Robust programs will attract ice drilling engineers and technologists
- Augmentations to education and outreach from new proposals
- Structure enables us to proactively garner community support
- Enabling cross-cutting opportunities through other NSF programs

Threats

- Technologies not available that meet science objectives and also comply with environmental, logistical, and other constraints
- Misperceptions by the community
- Lack of research community consensus on priorities
- High cost and low availability of logistics and unpredictability of costs

- Unpredictability of annual NSF budgets and strong competition for NSF grants
- Field project dependence on polar support contractor's schedule performance
- Short timelines and large challenges
- Competing interests among subsets of the research community
- Loss of key drilling technology personnel
- Instability of the general economic environment

Goals and Associated Objectives

- To provide community leadership in ice drilling research and development
    - Develop U.S. Ice Drilling Program Long Range Science Plan (IDPO)
    - Develop Ice Drilling Design and Operations Long Range Drilling Technology Plan (IDPO-IDDO) in response to science plan
    - Develop IDPO-IDDO annual program plans for the coming year to implement the science and technology plans
    - Develop IDDO Project Portfolio Baseline and manage subawards from Dartmouth CA
    - Monitor continuous progress toward achievement of the goals and manage subawards to other institutions from the Dartmouth CA
    - Document IDPO and IDDO progress
- To identify new technology needs and plan for technology development
    - Identify future technology needs from the science community, and get prioritization from NSF on technology acquisition goals
    - Work with community members to seek additional resources for new technology development
- To acquire new drilling technology to support science objectives for new discoveries
    - Oversee production or acquisition of new technology
    - Develop and deploy new drill systems and related equipment needed by the science community
- To provide the drills, equipment, and drilling expertise needed by the science
    - Maintain inventory of high-quality drills and related equipment
    - Provide drilling and related support to funded NSF projects
- To enhance communication and information exchange related to drilling science and technology
    - Serve as a focal point for community input
    - Enhance information exchange with the community
- To establish activities in collaboration with the polar science and engineering community to contribute to the NSF strategic goals for desired societal outcomes
    - Establish and maintain an education & outreach program

Strategy

- Develop and maintain the U.S. Ice Drilling Program Long Range Science Plan (IDPO). Hold community planning activities and workshops. Seek SAB input and direction, be inclusive and also seek input from program managers. Provide opportunity for community comment on the draft before it is finalized.
- Develop and maintain the Ice Drilling Design and Operations Long Range Drilling Technology Plan (IDPO-IDDO) in response to the science plan. The drilling technology plan addresses the science needs articulated in the long-range science plan. Drilling

technologies include both new developments and those existing, in consideration of both costs and logistical needs. Seek technical advice from the IDDO Technical Advisory Board (TAB).

- Develop annual program plans with associated documents for baseline actions, schedule, and budgets (Annual Baseline) that support the long range science and technology plans and NSF funding of field projects.
- Monitor performance against the annual baseline. IDPO manages subawards to IDDO at the University of Wisconsin, IDPO activities at the University of New Hampshire and IDPO activities at the Colorado School of Mines. IDPO monitors IDDO progress against an annual baseline plan and manages change control (reprioritization) when necessary. IDPO maintains an ongoing database for activities and achievements.
- Document and report IDPO and IDDO progress. Produce quarterly and annual reports for IDPO at Dartmouth and the NSF and monthly reports and weekly project status updates for IDPO. IDDO alerts IDPO to unexpected events to avoid surprises, and contributes information to make the reports accurate, concise, and useful for IDPO and the NSF. The University of New Hampshire and the Colorado School of Mines also report activities as required to Dartmouth. IDPO at Dartmouth manages and integrates sub-awardee progress, as well as its own, and reports this to the NSF.
- Work with scientists to identify future coring and drilling and related needs. Use community-produced documents and hold additional workshops as necessary to identify future needs in drilling technology.
- Seek additional resources for new technology development that will enable scientific discoveries. Assist community members with their proposals for new drilling technology. Build relationships with key individuals from industry, oil companies, foundations, etc. as appropriate for technology needed to support emerging science goals. Take action as opportunities arise.
- Develop or acquire relevant new technologies that have been identified in the Long Range Science Plan, including technologies identified in the Long Range Drilling Technology Plan.
- Develop and deploy new drills and related equipment for scientific research through the IDDO subaward and elsewhere if applicable.
- Maintain inventory of high quality drills and related equipment. Institutionalize drilling knowledge; maintain quality control on drill maintenance, plan ahead for upgrades and replacements. IDPO also reviews and approves an annual IDDO equipment inventory report to insure the terms of the cooperative agreement are met and the inventory is consistent with the equipment identified in Ice Drilling Design and Operations Long Range Drilling Technology Plan (IDPO-IDDO)
- Provide drilling and related support to funded NSF projects. Encourage Principal Investigators to seek advice and information and letters of support for proposals, get information on what the field conditions and circumstances and expectations are for the proposed project, and maintain good staff of experienced drillers. Provide updated language for solicitations to NSF, post table of drill commitments to the website and provide it to NSF, get feedback from Principal Investigators after the drilling.

- Serve as a focal point for community input. Promote cooperation between the IDPO and the community to make IDPO a pillar of the community through direct interaction with the scientists from across the community and the SAB, NSF, and other relationships.
- Enhance communication and information exchange with the community. Employ a multi-faceted approach: advertise and market to promote information exchange, use long-term existing relationships, website, interactions and community meetings, and distribute updates via electronic mailing list as well as one-on-one exchanges.
- To establish activities in collaboration with the polar science and engineering community to contribute to the NSF strategic goals for desired societal outcomes. IDPO established and maintains an education and outreach program on behalf of, and in collaboration with, the ice coring and drilling community to promote student and public understanding and awareness of the science and engineering.

The Blue Ice Drill deployed in Taylor Valley, Antarctica. The very popular system drills a 9.5-inch diameter core, primarily for onsite melting and gas analysis.

Actions and Responsibility

The actions, responsibilities, and schedule for each of the major goals and objectives are assigned as shown in the following chart.

Goals	Objectives	Major actions	Owner	Time frame
Provide community leadership in ice drilling research and development	Develop IDPO Long Range Science Plan	Maintain the SAB	Albert	Ongoing
		Acquire existing community plans	Albert	Ongoing
		Solicit community input	Albert	Ongoing
		Identify new technology needs	Albert, Twickler, Slawny	Ongoing
		Hold a meeting with the SAB to discuss elements of the plan	Albert	Annually
		Produce the draft science plan	Albert	Annually by May
		Obtain community, NSF, and IDDO comments on draft plan	Albert	Annually in May
		Produce the final plan	Albert	Annually in June
		Submit the plan to NSF	Albert	End of June annually
	Develop IDDO Long Range Drilling Technology Plan in response to Science Plan	Maintain the TAB	Mulligan	Ongoing
		Hold a meeting to discuss technologies relevant to the plan	Mulligan, Slawny	Annually
		Produce the draft plan	Slawny	Annually in June
		Obtain IDPO and NSF comments on plan	Albert, Slawny	Annually in June
		Produce the final plan and get IDPO approval	Slawny	End of June annually
		Approve and submit the plan to NSF	Albert	End of June annually
	Develop IDPO-IDDO Program Plan for the coming year	Confer with NSF to confirm funded science projects	Twickler	Ongoing as needed
		Define scope for IDDO projects	Albert, Stephanus, Slawny	Annually in spring
		Define and review IDDO project costs and schedules and gain IDPO approval	Stephanus, Slawny	Annually July through September
		Produce the IDPO-IDDO Annual Program Plan with input from others	Albert	Annually by August 30
		Submit the plan to NSF	Albert	Annually by August 31

Goals	Objectives	Major actions	Owner	Time frame
		Produce detailed baseline cost and schedule, integrated MS Project schedule, detailed MS Project schedule on significant development project(s), and gain IDPO approval	Slawny, Stephanus	Detailed baseline November 30
	Develop IDDO Project Portfolio Baseline for the coming year			
	Monitor progress and manage subawards from Dartmouth CA	Weekly written progress reports from IDDO to IDPO	Slawny	Weekly
		Weekly discussions	Stephanus & Slawny	Weekly
		Weekly IDPO-IDDO teleconferences for discussion & resolution of issues	Albert	Weekly
		Monthly project and summary OPPMs from IDDO to IDPO	Slawny	Monthly
		Quarterly written input from IDDO to IDPO	Slawny	Quarterly
		Quarterly written input from IDPO-UNH to IDPO-Dartmouth	Twickler	Quarterly
		Quarterly written input from IDPO-CSM to IDPO-Dartmouth	Eustes	Quarterly
		Manage subawards from Dartmouth CA	Stephanus	Ongoing
	Document IDPO and IDDO progress	Produce monthly OPPMs for IDPO	Slawny	Monthly
		Produce IDPO-IDDO Quarterly Reports on progress for IDPO and the NSF with input from others	Stephanus	Quarterly
		Produce IDPO-IDDO Annual Progress Reports for NSF, with input from others	Stephanus	Annually in September
		Maintain IDPO-IDDO Strategic & Implementation plan	Albert	Review annually; Update as needed
		Facilitate IDPO-IDDO group Teleconferences with NSF	Twickler	Monthly

Goals	Objectives	Major actions	Owner	Time frame
Work with the community to identify new technology needs, seek funding for new technology, oversee technology development	Determine the science need, technology requirement, and NSF prioritization for new technology development	Follow up on technology needs identified by research community members	Albert, Twickler, Slawny	Ongoing
		Work with community members and IDDO staff to produce IDPO Science Requirements for new technologies	Albert	Ongoing
		Respond to NSF advice on new technology development	Albert	Ongoing
	Seek additional resources for new technology development	Seek additional resources from NSF as appropriate	Albert	Ongoing
		Assist community members in response to calls for proposals as appropriate	Albert, Twickler, Souney, Slawny	As opportunities arise
		Seek additional resources from foundation & industry	Albert	Ongoing
	Produce or acquire new technology	Oversee production or acquisition of new technology from IDDO or other source	Albert, Stephanus	Ongoing
		Manage IDDO production of new technology or IDDO acquisition of existing technology	Slawny	Ongoing
Provide drilling technology and drilling operational support needed by science	Maintain inventory of drills and equipment	Maintain existing drills & equipment	Slawny	Ongoing
		Develop new drills and technology	Slawny	Ongoing
	Provide equipment and drillers to NSF-funded projects	Provide information and advice to PIs proposing research, and prepare cost estimates and support letters	Slawny	Ongoing
		Review and approve cost estimates and letters of support, and send final letters of support & cost to PIs	Albert	Ongoing

Goals	Objectives	Major actions	Owner	Time frame
		Provide equipment and operators to funded projects	Slawny	Ongoing
Enhance communication and information exchange related to ice coring and drilling science and technology	Serve as a focal point for community input	Reach out for community input through meetings, email, web page, & use community white papers in planning	Albert, Twickler	Ongoing
		Assist NSF with solicitation information	Albert	As requested by NSF
	Enhance information exchange with community	Establish and maintain the IDPO-IDDO Icedrill.org website	Souney	Ongoing
		Maintain electronic mailing list (*IceDrill.News*) so that community members can subscribe and unsubscribe, and produce quarterly newsletter (*IceBits*)	Souney	Quarterly
		Attend, give talks & get community input at community meetings (e.g. AGU, IPICS, WAIS-D, etc.)	Albert, Slawny	Ongoing
	Maintain and enhance the education and outreach program	Update existing and create new educational materials	Huffman	Ongoing
		Design and lead teacher workshops at national science education conferences	Huffman	Ongoing
		Maintain and enhance the educational outreach website	Huffman	Ongoing
		Develop and execute a media campaign	Huffman	Ongoing
		Deliver videoconferences and presentations in collaborations featuring community scientists, engineers and grad students	Huffman	Ongoing

Goals	Objectives	Major actions	Owner	Time frame
		Actively pursue collaborations and funding for high impact, enduring E&O products. Enhance diversity in the workforce through partnerships with minority serving institutions.	Huffman	Ongoing
		Create supplemental funding templates for scientists to use	Huffman	Ongoing

Metrics

* Long Range Science Plan
Addresses objective: Develop IDPO Long Range Science Plan
Measures*:* Input obtained from variety of stakeholders/contributors, specific enough to be useful for drilling technology plan, timely completion, useful for NSF and community planning

* Long Range Drilling Technology Plan
Addresses objective: Develop IDDO Long Range Drilling Technology Plan
Measures: Responsive to needs articulated in science plan, contains estimates of costs and schedules for technology development where possible, addresses the range of projects identified in the Long Range Science Plan commensurate with IDDO resources, timely completion.

* Quarterly and Annual Reports
Addresses objective: Document IDPO and IDDO progress
Measures: Complete, accurate, concise, timely, and well-received by NSF Program Managers

* Annual Inventory Listing and Audited Financial Statement
Addresses objective: Identify, report, and manage all government-owned equipment
Measures: Tag No., Location, Description Common Name, Model, Serial No, Condition, Department/Project, Ownership, Administrator, Acquisition Date, Acquisition Cost. Financial Statement includes Dartmouth College audited financial statement.

* Monthly and Weekly Reports
Addresses objective: Document IDDO progress for IDPO Management
Measures: Monthly OPPMs and weekly highlights of performance, outstanding issues, and concerns

* Support community proposals for new equipment funding
Addresses objective: Seek additional funding for new technology development in collaboration with the community
Measures: List proposals submitted and their outcomes

* Summary of drilling achievements and PI support
Addresses objective: Provide drilling and related support to funded NSF projects
Measures: Favorable PI feedback, timely project deliverables, projects on time and within budget

* Website, updates for community on electronic mailing list, quarterly newsletter, participation in community meetings
Addresses objective: Enhance information exchange with the community
Measures: Number of website hits, inquiries, and other feedback indicators

*Education and outreach activities
Addresses objective: Establish and maintain an education and outreach program
Measures: Response from audience, list of outreach activities conducted, number of participants reached, list of number of collaborative presentations given, teacher pre/post workshop content knowledge, web site statistics and enhancements.

Financial Resources

The financial resources listed below reflect current conditions. Changing demands and opportunities may require revisions, especially in the IDDO budget, as we adapt to unforeseen events and evolving situations. Details of annual budgets are in the IDPO-IDDO Annual Program Plans.

Table 1. Resource allocation toward the goals ($1000)

	PY 2014		PY 2015		PY 2016		PY 2017		PY 2018		
Goal	IDPO	IDDO	IDPO	IDDO	IDPO	IDDO	IDPO	IDDO	IDPO	IDDO	Total
Planning & Oversight	574	0	550	0	549	0	547	0	564	0	2,784
New technology		1,570		1,091		1,103		1,637		1,641	7,042
Drilling operations		1,166		1,635		1,621	0	1,096	0	1,103	6,621
Communication	138	0	150	0	154	0	157	0	160	0	760
Total	712	2,736	701	2,726	703	2,725	704	2,733	725	2,744	17,207

Notes: Some total appear to have a slight rounding issue. This is due to the table showing numbers to the nearest thousand. The numbers reconcile when not displayed in thousands.

Detail for IDDO Budget: New Technology and Drilling Operations

IDDO Budget Component	PY 2014	PY 2015	PY 2016	PY 2017	PY 2018	Total
Ongoing Activities funded through the Core CA						
Program Management	620	588	610	614	618	3,050
Maintenance and Upgrade	375	450	592	295	292	2,004
Equipment Development	1,570	1,091	1,103	1,637	1,641	7,042
General Field Project Support	171	597	419	187	194	1,568
Subtotal – Ongoing Activities funded through the Core CA	**2,736**	**2,726**	**2,725**	**2,733**	**2,744**	**13,664**
Add-On Field Projects from Program Funds						
Antarctic Projects	164	144	418	TBD	TBD	726
Arctic Project	93	212	0	TBD	TBD	305
Division of Environmental Biology		4	0*	TBD	TBD	4
Antarctic Earth Sciences		25	0*	TBD	TBD	25
Antarctic Instrumentation		24	0*	TBD	TBD	24
2014 Herc delay additional travel costs		**16**				**16**
Total Budget	**2,993**	**3,151**	**3,143**	**2,733**	**2,744**	**14,764**

Notes: * Projects being supported in PY 2016, but funding was already received in PY 2015.
Amounts for PY 2014, PY 2015 and PY 2016 reflect the baseline at the time those annual Program Plans were submitted. Amounts for FFY 2017 and FFY 2018 reflect proposed budgets presented in the cooperative agreement. Additional projects may be added throughout the year as science proposals become funded.

A recently designed IDDO 3-Inch hand auger kit is packed for use by an investigator. The new model has begun replacing the aging PICO hand auger kits and is used in Alaska, Greenland and Antarctica. IDDO is also designing a new 4-Inch hand auger kit to replace other aging PICO equipment.

Managing the Strategic Plan

Mary Albert maintains the IDPO-IDDO Strategic and Implementation Plan, including annual updates with input from others in IDPO-IDDO.

IDPO-IDDO Succession Plans
The PIs for IDPO and IDDO are uniquely situated for collaboration. If the IDPO and IDDO PIs become incapacitated, the following provides guidance for NSF in handling the Cooperative Agreement with Dartmouth.

IDPO - If the Dartmouth PI for IDPO, Mary Albert, cannot fulfill her obligations for IDPO on a temporary basis, Blaise Stephanus should assume the role of the lead PI for IDPO. Albert is exploring the interest of PhD-level scientists involved in ice science at Dartmouth in becoming involved with IDPO, as a possible long-term replacement should the need arise. Either short-term or long-term replacements would need to be approved by NSF. If the PI for UNH, Mark Twickler cannot fill his obligations on a long-term basis, Joe Souney should assume the role of PI for UNH. If the PI for Colorado School of Mines, Alfred Eustes, cannot fulfill his obligations, then an assessment of that subaward will be made in discussion with NSF.

IDDO – There are four key functions in IDDO for which there need to be specific individuals assigned responsibility. Four different individuals currently fulfill these functions; these functions can be split in various ways among personnel, however, depending upon the specific talents of the personnel. These functions are described in Table 2.

Table 2. Key IDDO Functions

Key IDDO Function	Responsibilities	Qualifications	Person Currently Responsible	Plan for Succession
Principal Investigator	• Management of subaward between UW and Dartmouth • Planning and strategy development for IDDO • Oversight of operating tactics and IDDO projects • Organization of Technical Advisory Board	• Meets UW and SSEC criteria for PI • Acceptable to NSF • Knowledge/interest in ice drilling • Leadership skills	Mark Mulligan Principal Investigator	Exploring the interest of scientists involved in ice sciences becoming involved with IDDO.
Program Director	• Assisting with planning and strategy development • Day-to-day operations of IDDO; operating tactics • Overall direction/oversight of IDDO projects • Program administration • Management of support facilities (warehouse, shop, labs) • Reporting to IDPO and NSF • Management of IDDO staff and contractors	• Knowledge/experience/interest in ice drilling • Management knowledge and skills (including project, quality and safety) • Familiarity with technologies involved with ice drilling • Leadership skills • Business processes knowledge	Kristina Slawny – Program Director	Slawny succeeded Don Lebar as Program Director following his retirement in July 2014; at least one other individual in SSEC is well qualified.
Field Project Engineer	• Management of field projects • Training of field crews • Direction/oversight of the field support aspects of all IDDO projects	• Familiarity with logistics • Leadership skills including ability to work with diverse groups • Project management knowledge and skills • Safety orientation	Rory Holland– Field Project Support Engineer	At least one IDDO engineer is qualified to step into position, but would require additional training in project management (would be assisted by other personnel knowledgeable in project management until fully competent).
Maintenance Manager	• Oversight of maintenance and upgrade of IDDO equipment inventory • Management of IDDO maintenance/ fabrication shop • Planning maintenance of equipment	• Knowledge of ice drilling equipment – design and operation • Knowledge of fabrication, assembly and maintenance techniques/processes • Leadership & management skills • Safety orientation	Jay Johnson – Maintenance Manager	Young engineers have been assigned to work with Jay in the maintenance & upgrade of the equipment, resulting in on-the-job training which will make them qualified for the position.

Management Plans

1. Ice Drilling Program Office Management Plan

IDPO uses a management plan in order to accomplish its primary tasks; the plan continues to evolve over the course of the cooperative agreement in response to new needs and requirements. Elements of the plan are given here.

The primary tasks of the IDPO are to 1) provide community leadership in ice drilling research and development, including managing subawards to IDDO at the University of Wisconsin, IDPO at the University of New Hampshire, and industry liaison at the Colorado School of Mines; 2) to identify new technology needs and plan for technology development; 3) to acquire new drilling technologies to support science objectives for new discoveries; 4) to provide the drills, equipment, and drilling expertise needed by the science; 5) to enhance communication and information exchange related to drilling science and technology, and 6) to establish activities in collaboration with the polar science and engineering community to contribute to the NSF strategic goals for desired societal outcomes. Within the context of these tasks crosscutting activities such as leadership, outreach, reporting, planning and coordination take place.

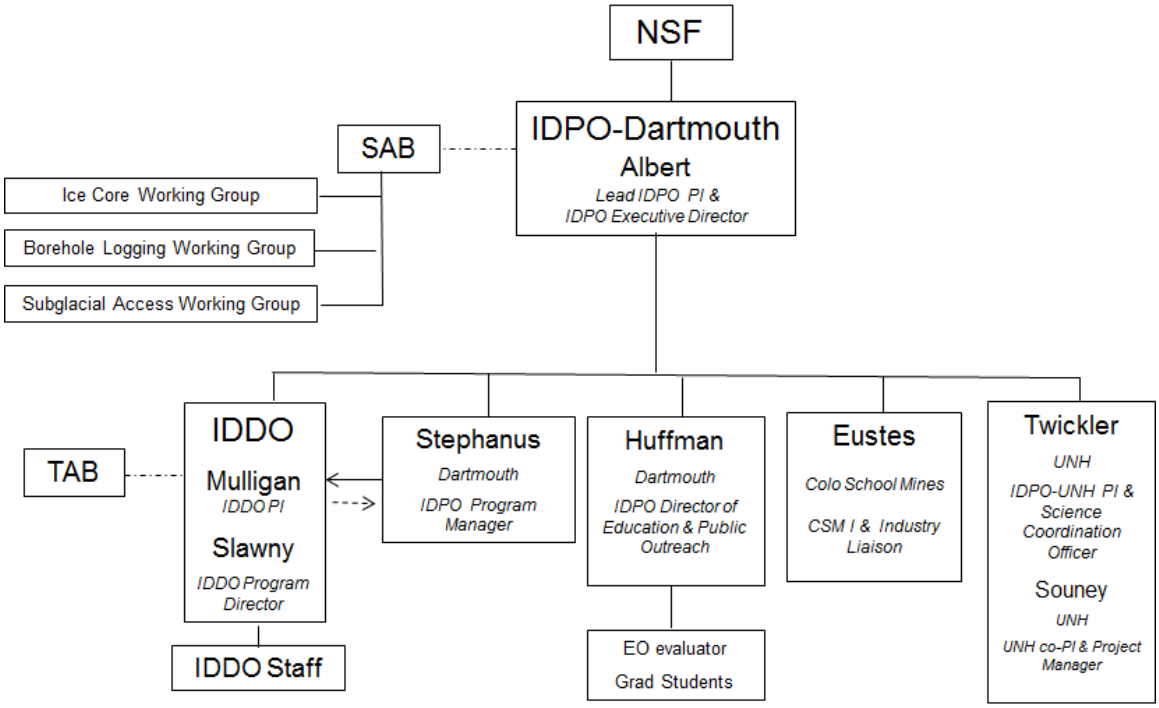


Figure 1. IDPO-IDDO Organization

1.1 Organization

The IDPO-IDDO enterprise consists of four collaborating universities comprising IDPO and IDDO (Figure 1). IDPO at Dartmouth manages subawards to three other institutions: IDPO activities at the University of New Hampshire, IDPO activities at the Colorado School of Mines and to IDDO activities at the University of Wisconsin.

Prime – Sub-award Organization and Responsibilities
As of November 1, 2013 the Ice Drilling Program Office of Dartmouth College engaged in a five-year Cooperative Agreement (CA) with the National Science Foundation for the "Ice Drilling Program Office." The CA is issued to Dartmouth College (prime) with tasks flowing through subawards from Dartmouth to IDDO at the University of Wisconsin, IDPO activities at the University of New Hampshire, and IDPO activities at the Colorado School of Mines.

IDPO at Dartmouth as the prime awardee has the responsibility of insuring proper guidance and oversight of its sub-awards in program performance and in complying with flow-down terms and conditions (per the 5-Year NSF Cooperative Agreement). In addition, Dartmouth has management responsibility over all sub-awards to insure that all parties meet the terms of Dartmouth's cooperative agreement with the NSF. Dartmouth will execute this charge through timely reporting, meetings both in person and remote, and (from time to time) auditing of the sub-recipients.

The Office of Management and Budget (OMB) Circular A-133 requires that recipients of Federal awards ensure that sub-recipients, who expend $500,000 or more per year, comply with the audit requirements in Circular A-133. IDDO at the University of Wisconsin annual budget exceeds $500,000 or more per year and therefore is subject to OMB Circular A-133. The University of New Hampshire and Colorado School of Mines are sub-recipients expending under $500,000 per year and not subject to OMB Circular A-133 but are subject to project management guidance generally accepted by the National Science Foundation and its Facilities.

1.1.1 Ice Drilling Program Office

The organization of the IDPO consists of staff from three collaborating universities Dartmouth, the University of New Hampshire (UNH), and the Colorado School of Mines. Dartmouth is the prime institution of the NSF Cooperative Agreement. Work of the IDPO is executed as appropriate between Dartmouth, UNH, and Colorado School of Mines as listed in the IDPO Subaward Management Plan (January 2016), and the three work together closely.

Decisions on major issues are made in a collaborative manner respecting the expertise of each of the parties. The PI for each of the subawards has responsibility for programmatic decision-making for their subaward and is the expert on their scope of work. They also assume responsibility for adherence to applicable federal program compliance responsibilities as they are using federal funds to carry out a program of the organization as compared to providing goods or services for a program of the pass-through entity.

The prime awardee (IDPO at Dartmouth) is responsible for assessing and managing to the terms of the cooperative agreement the sub-awardees' performance as well as compliance to the applicable pass-through regulations. This is defined in detail in the IDPO Subaward Management Plan (January 2016) Where practical, this will be made through consensus on matters designated major by any of the parties. Specific tasking (e.g. the production of a specific report or proposal, the development of content for the website, consultation with drilling technologists in the private

sector, etc.) will have an identified lead collaborator who has ultimate responsibility for the product with extensive input and review provided by the other collaborators.

Albert (IDPO Executive Director) facilitate coordination between IDPO collaborators, maintains the office for IDPO, and is the lead collaborator responsible for tasks primarily directed toward or involving the research, education, and engineering communities. Twickler (IDPO Science Coordination Officer) will be the lead collaborator for the website development, content, and major revisions over time, and for liaising with already-funded science projects that require IDPO-IDDO support. Eustes (IDPO Industry Liaison) conducts technology transfer activities between IDPO-IDDO and industry involved in drilling technologies. Table 3 shows the lead and contributing responsibilities for each of the IDPO collaborators.

Table 3. IDPO Roles and Responsibilities

Dartmouth (Albert – IDPO Executive Director)

- Manage IDPO Cooperative Agreement with NSF
- Direct the day-to-day operations of the Office of IDPO, maintain virtual conferencing capability, and foster effective collaboration between IDPO staff
- Lead generation and maintenance of IDPO Long Range Science Plan
- Participate in generation and maintenance of IDDO Long Range Drilling Technology Plan. With UNH, Colorado School of Mines and IDDO, ensure that the IDDO Long Range Drilling Technology Plan is consistent with the Long Range Science Plan.
- Lead for coordination with the IDPO Science Advisory Board and to ensure SAB participation in the IDDO TAB meeting
- Lead for assisting scientists in proposal development for new drilling technologies
- Lead for IDPO for information exchange and planning activities between US ice coring and drilling science and drilling communities and international groups (e.g. IPICS)
- Lead for development of Science Requirements for new drilling technology development projects, in collaboration with the science community and IDDO
- Participate in identifying potential industry partners, rationale for developing partnerships, and fostering collaboration with external entities for drilling technology development
- Lead for IDPO-IDDO educational outreach through the IDPO Director of Education & Public Outreach (Huffman)
- Contribute education and outreach content for IDPO website (Huffman)
- Lead preparation for and participation in NSF's annual review of IDPO

Dartmouth (Stephanus – IDPO Program Manager)

- Responsible for all reporting and budgeting requirements for Dartmouth and coordination of reporting and budgets with other IDPO subawards
- Lead for oversight of IDDO through subaward management, including providing approval and management where necessary of the annual baselines (cost, schedule, and scope) for the IDDO portfolio of projects in the planning, execution, and close-out stages of each IDDO Project. Desk and on-site reviews will be conducted to ensure compliance.
- Lead IDPO-IDDO quarterly reviews and write quarterly and annual reports, and review IDDO monthly reports and input to the quarterly reports
- Lead monitoring of the annual equipment inventory report and audits to ensure compliance with NSF government property requirements
- Participates in preparation for, and participation in, NSF's annual review of IDPO

University of New Hampshire (Twickler – IDPO Science Coordination Officer)

- Coordination between UNH and IDPO; responsible for all reporting and budgeting requirements for the UNH IDPO subaward
- Lead for establishing and maintaining the Icedrill.org website for IDPO and IDDO along with major revisions
- Contribute to generation and maintenance of the IDPO Long Range Science Plan
- Participate in generation and maintenance of IDDO Long Range Drilling Technology Plan
- Participate in oversight of IDDO, including review of details of IDDO earned value OPPM monthly reporting
- Contribute to IDPO-IDDO quarterly reviews and contribute to quarterly and annual IDPO-IDDO reports, and review IDDO weekly, monthly, and quarterly reporting
- Lead for acquiring PI project feedback to IDPO on IDDO drilling projects
- Participate in information exchange and planning activities between US ice core research and drilling community and international groups (e.g. IPICS). Participate in education and outreach activities.
- Contribute to assisting community members with proposal development for new drilling technologies
- Participate in preparation for, and participation in, NSF's annual review of IDPO

Colorado School of Mines (Eustes – Industry Liaison)

- Lead in identifying potential new industry or government partners, rationale for developing potential partnership, and identifying and communicating issues of technical interest between IDPO-IDDO and commercial drilling entities.
- Facilitate technology transfer between IDPO-IDDO and commercial drilling entities
- Assist in independent engineering assessments of IDDO (when requested by Albert).
- Participate in preparation for, and participation in, NSF's annual review of IDPO.

More details of roles and responsibilities are included in The IDPO Subaward Management Plan (January 2016) including each year's Annual Tasks and Deliverables Schedule.

1.1.2. IDPO Management of the Subaward to Ice Drilling Design and Operations

Key aspects of IDPO subaward management and direction of IDDO include the following.

1.1.2.1. Setting long term and annual direction:

The Annual IDPO-IDDO Program Plan and the IDDO Long Range Drilling Technology Plan provide the definition of IDDO activities to be monitored by IDPO. IDDO annually revises a comprehensive Long Range Drilling Technology Plan, based on the IDPO Long Range Science Plan and reviewed by IDPO, that includes goals, emphases, specific drilling projects that will be supported, drill allocation, and technology development activities, all to the extent they are known with timelines for IDPO-IDDO actions over the next decade. The IDDO Long Range Drilling Technology Plan is submitted to NSF by the end of June annually. The IDPO-IDDO Program Plan is created to provide goals and associated cost and schedule information for the upcoming fiscal year, created in accordance with NSF's prescribed budget levels for IDPO and IDDO. The Program Plan is submitted to NSF by the end of August of each year. The IDPO-IDDO Program Plan has specific, measurable products, timelines, and accompanying budgets, and it responds to the IDPO Long Range Science Plan and IDDO Long Range Drilling Technology Plan. The Program Plan and its

associated cost and schedule becomes the basis for the proposed annual budget submitted to the NSF and the detailed baseline planning which breaks those budgets and schedules into greater detail and adds earned value milestones. This detailed baseline planning process is completed at the end of the calendar year and is the basis from which the year's progress is measured.

1.1.2.2. Establishment of Science Requirements for new Technology: IDPO works with the science community and IDDO to develop IDPO Science Requirements for proposed new equipment. These requirements provide IDDO the basis for developing the concepts for equipment and processes needed to successfully complete planned scientific experiments. Once established, the science requirements provide a measure against which the designs and, ultimately, the equipment developed by IDDO can be gauged.

1.1.2.3. Oversight/Management: IDPO provides active oversight and subaward management of IDDO's execution of their portfolio of projects. The goals are to ensure sound project management practices are implemented that will provide early warning of issues that affect IDDO's technical, cost, and schedule commitments. Management occurs through baseline change request approval processes as well as the terms in Dartmouth's cooperative agreement. This oversight/management occurs during all stages of IDDO projects:

Initiation: IDPO oversees and manages the project proposal support process by reviewing and approving documents prepared by IDDO for prospective PIs and by monitoring and reporting the funding status of the proposals for which documents were prepared.

Planning: IDPO reviews and approves the cost and schedule baseline for each of IDDO's projects to ensure scope and schedules are responsive to the needs of the science community, and budgets are reasonable given scope and schedule. This includes review of the detailed cost and schedule workbooks for each IDDO Project. In addition an overall MS Project Schedule showing significant delivery and requirement milestones, detailed MS Project Schedules are also required for significant development project(s). This helps ensure realistic project baselines for cost, schedule and earned value so that performance can be measured in a discrete and accurate manner. The baseline review also reviews risks, milestones and any project assumptions that are significant to cost and/or schedule.

***Execution*:** IDPO monitors and oversees IDDO's execution of its projects by reviewing the weekly issues and concerns, monitoring the monthly progress documented in the OPPMs (one-page project manager) for each project and the total facility, and reviewing and approving the quarterly and annual report sections submitted by IDDO. The goal is to provide early warning of project performance, which will allow effective corrective action. IDPO also manages a formal change control process, developed in collaboration with IDDO, that fully identifies and controls any scope, schedule, and budget changes to IDDO's approved project baselines. In addition to the reporting actions, the IDPO Program Manager regularly conferences with IDDO on outstanding issues and concerns.

Close-out: IDPO provides oversight of IDDO close-out activities to ensure lessons learned are documented and those lessons are applied to continuously improve the management and execution of future projects. Specifically, IDPO interacts with IDDO on an ongoing basis to exchange information and to maintain awareness of IDDO's progress on its projects and to ensure the terms of Dartmouth's cooperative agreement are met. IDDO is responsible for updating IDPO on activities, challenges, and opportunities that materially affect the scope, schedule, and budget baseline for each IDDO Project. IDDO produces a weekly update of all its projects, which is provided to IDPO to facilitate

IDPO's monitoring of project progress. IDPO and IDDO teleconference on a weekly basis to discuss the IDDO update, to plan future joint activities, and to exchange information of interest. IDDO provides a monthly report on project status utilizing earned value metrics and financial data to IDPO, which IDPO reviews and discusses with IDDO. IDPO and IDDO collaborate on measures needed to correct any problems arising in the scope, schedule or budget of the projects. IDPO reviews reports from IDDO review of conceptual designs for new equipment developed by IDDO to ensure that the equipment will meet the science requirements developed in collaboration with IDDO and the science community while addressing other constraints such as those related to safety, the environment, and logistics. IDPO may hold additional design reviews that include input from a broader range of technical experts and appropriate scientists as needed. These reviews can address the various aspects/approaches that arise during the detailed design process.

1.1.2.1. Facilitating feedback from PIs and assisting with corrective actions: IDPO solicits feedback from PIs after the conclusion of each field season that IDDO provides operational support in the form of equipment, personnel, or both. The responses to the questionnaires sent to the PIs are shared with IDDO, and IPDO and IDDO collaborate in identifying areas needing improvement and in planning actions that will lead to improvements in support of projects. IDPO and IDDO, when necessary, follow up with PIs to obtain a better understanding of their feedback (good and bad). IDPO monitors IDDO's execution of the identified improvement activities.

1.1.2.2. Facilitating interaction with science community and assisting with resources: IDPO is the principal contact between the science community and IDPO-IDDO and as such facilitates the interaction of IDDO personnel with scientists contemplating projects needing new equipment developed. IDPO facilitates this interaction by leading development of the science requirements for drilling technologies, sponsoring meetings that help the engineers at IDDO and the scientists to better understand the proposed experiments and the limits of technologies. IDPO identifies scientists interested in the development of science requirements for new equipment to be developed, and IDPO leads in the development of the science requirements including participation of IDDO, the scientists, and other experts as appropriate.

1.1.2.3. IDPO Reporting**:** IDPO-Dartmouth submits quarterly reports to NSF utilizing significant IDDO (and other sub-award) programmatic data submitted to Dartmouth per the agreed sub-award deadlines. The quarterly reports present highlights of the IDPO-IDDO operation for the quarter including status of the various projects and other activities, clear identification and early warning of performance issues (and potential performance issues), identification of any risks to the successful completion of the planned activities of IDPO-IDDO and planned mitigation measures (corrective actions). The quarterly reports also provide an update of project performance in terms of earned value (EV) measures. The Annual Report of IDPO-IDDO replaces the Fourth Quarter Report and is a similar to the quarterly reports in content except that it covers the operations for the entire fiscal year. IDPO at Dartmouth receives monthly OPPMs from IDDO at the University of Wisconsin to help it in its effort to manage and assess IDDO progress in execution of its baseline. Issues arising from this reporting may be used in the monthly telecommunication conference call with the NSF but no formal report is submitted.

1.1.3. IDPO-IDDO Scope

There are six interrelated goals of IDPO-IDDO: 1) to provide community leadership in ice drilling research and development; 2) to identify new technology needs and plan for technology development; 3) to acquire new drilling technologies to support science objectives for new discoveries; 4) to provide the drills, equipment, and drilling expertise needed by the science; 5) to enhance communication and information exchange related to drilling science and technology, and 6) to establish activities in collaboration with the polar science and engineering community to contribute to the NSF strategic goals for desired societal outcomes. The process for the IDPO-IDDO annual cycle including interactions with IDDO, NSF, the Science Advisory Board (SAB) and the community is shown in Figure 2.

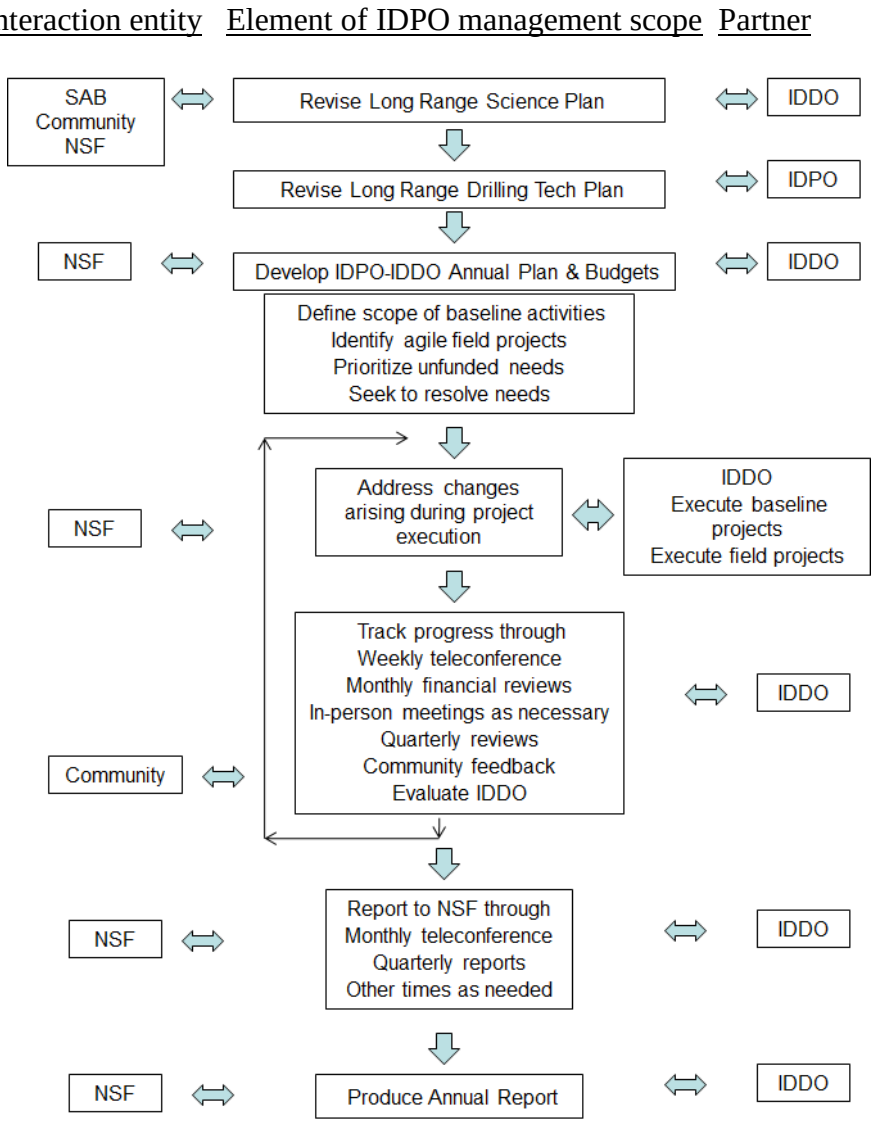


Figure 2. IDPO-IDDO Annual Process Cycle

Descriptions of the six elements of the scope of IDPO are as follows.

I. ***To provide community leadership in ice drilling research and development.*** Working closely with the IDPO Science Advisory Board, IDPO will produce and update yearly a Long Range Science Plan that articulates near-term and long-term research goals, timelines, and associated technology requirements of the ice drilling research community. The plan will include long-term goals to the extent that they are known and will provide most detail and timelines on the upcoming several years. Topics will also include discussion of possible implementation constraints imposed by time, environmental considerations, and the plan and will include both logistically large and small endeavors that involve ice coring and drilling. IDPO provides direction and subaward management to IDDO for drilling support and drill development activities. IDPO provides both strategic and implementation direction, oversight, and management of the IDDO subaward through:
    a. Setting long term and annual direction through formation of the IDPO-IDDO Annual Program Plan and review and approval of the IDDO Long Range Drilling Technology Plan
    b. Managing the subaward to IDDO and overseeing IDDO activities
    c. Collaborating with IDDO in defining improvements to IDDO's equipment and processes as the result of feedback from PIs, and
    d. Facilitating interactions between IDDO and the science community and assisting in procuring resources not readily available to IDDO

II. ***To identify new technology needs and plan for technology development***: Strategies for identifying new technology needs and pursuing their development include:
    a. An annual consultation with NSF on upcoming requirements for funded and unfunded proposals submitted to them for consideration
    b. Review of currently active or proposed activities to extract new technology requirements (e.g. subglacial sampling, replicate coring)
    c. Scenario building with the Science Advisory Board to identify long-term possibilities, including discussion of input from interactions with other research community-based groups and individuals, and articulating these needs in the Long Range Science Plan
    d. Acquisition of planning/implementation documents generated by appropriate scientific groups, committees, or organizations (e.g. ICWG, IPICS, Scientific Committee on Antarctic Research (SCAR)) and soliciting input from the research community at large by email using the IDPO electronic mailing list (*IceDrill.News*)
    e. Development of strategies for new technology development, including consultation with drilling programs in the private sector, other universities, and federal agencies external to the ice drilling community that are developing or contemplating developing applicable new drilling technology
    f. Maintaining awareness of new ice drilling technologies developed elsewhere through consultation with international ice drilling and borehole technology entities
    g. As scientific needs for new technologies are identified, IDPO will generate the science requirements in collaboration with IDDO and the proposing community members and will work with community members to seek resources through proposals, partnerships, and collaborations as appropriate to develop the required technologies.

III. ***To acquire new drilling technology to support science objectives for new discoveries***
   a. Purchase or develop, and deploy new drill systems and related equipment needed by the science community (IDDO).

IV. ***To provide the drills, equipment, and drilling expertise needed by the science***
   a. Maintain an inventory of high-quality drills and related equipment, and provide drilling and related support to funded NSF projects (IDDO).

V. ***To enhance communication and information exchange related to drilling science and technology***
   a. Strategies for enhancing communication and information exchange will include:
   b. The IDPO icedrill.org website – which will serve as a resource to the science community, the drilling community, and the interested general public
   c. Contact with and/or attendance at appropriate scientific or technical meetings for the primary purpose of information gathering
   d. Presentations by IDPO and IDDO personnel at scientific and/or technical meetings and at outreach activities
   e. Acquisition of science planning/implementation documents generated by appropriate scientific groups, committees, or organizations (e.g. IPICS, SCAR)
   f. Articles in appropriate publications (e.g. AGU-EOS, Industry journals)
   g. Participation in outreach programs and development of materials as resources permit.
   h. Generation of electronic IDPO-IDDO updates that are sent to the IceDrill.News electronic mailing list, and publication of the quarterly newsletter (*Ice Bits*)
   i. Responsibility for the execution of communication and information exchange will be shared among the collaborators as identified in Section

VI. To establish activities in collaboration with the polar science and engineering community to contribute to the NSF strategic goals for desired societal outcomes.
   a. Foster diversity through teaming with the American Meteorological Society
   b. Sustain the pipeline of scientists and engineers by continuing to support activities and programs of the Association of Early Polar Career Scientists, and Ice Core Young Scientists
   c. Advance public literacy by humanizing the face of climate science by promoting interviews of science community members on mainstream media and television.

1.1.4. Role of external collaborators, advisory board and review committees

As the funding agency, NSF sets performance requirements for IDPO. Close consultation with NSF is needed in order for IDPO to identify the scope of emerging new science requirements for both funded and as-yet unfunded activities.

IDPO collaborates with established ice core science and drilling planning entities through consultation and joint planning (e.g. ICWG, IPICS). Articulations of emerging needs are also solicited from the broader principal investigator population through the IDPO website as a mechanism for ensuring an inclusive approach to information gathering. Planning documents from community groups and input from individuals and small groups are factored into the development of the IDPO Long Range Science Plan and into planning for seeking funding for new technologies that will be required to meet future science needs.

The IDPO convenes a Science Advisory Board (SAB) for the purpose of forming and updating the IDDO Long Range Science Plan that addresses multiple aspects of ice coring and drilling science and technology – emerging frontiers, sustaining capabilities, maintaining relevance, innovative technologies, fostering the next generation of ice core scientists and engineers – to name a few. This plan is revised and extended annually and will drive the IDDO Long Range Drilling Technology Plan (and its annual updates) for IDDO and proposal writing efforts to seek funding for the development of required new technologies. At least one member of the SAB is from the international community. The SAB will ensure that their membership will rotate to represent the spectrum of research areas dependent on ice coring and drilling, and the SAB will solicit nominations for membership from the broader research community. Every effort will be made to provide cross-communication between the SAB and TAB advisory groups, through virtual participation in meetings to the extent possible. IDDO will participate in the SAB in an ex officio capacity, and IDPO will participate in the IDDO-TAB in an ex officio capacity.

IDPO will be provided an evaluation by NSF. In years two, four, and five, a virtual site visit will be convened to review the progress of IDPO-IDDO. On or about March 15th in year three of this cooperative agreement, an external review panel will conduct a site visit at Dartmouth to review IDPO-IDDO progress on activities described in this plan.

1.1.5. Deliverables

Deliverables identified in the original proposal or required by the cooperative agreement are scheduled in detail at the beginning of each year. Each year's schedule includes interim due dates for Dartmouth, Wisconsin, New Hampshire, and Colorado School of Mines planning. Information on the past years' execution will be used to improve subsequent due date schedules.

1.1.6. Schedule

Scheduling is a part of each IDDO project's detailed planning workbook. MS Project is utilized in an integrated project schedule that coordinates drill deliveries with field project need dates. In addition IDPO can require a detailed MS Project schedule(s) for significant development projects. .The scheduling objectives are to identify significant schedule activities, durations, and predecessor and successor relationships. The schedules also are a tool to assess significant resource constraint and limitation issues. IDPO will review the schedules for their ability to provide early warning of significant issues. Critical path analysis also is used to determine optimal resource allocation and remaining float on significant development projects.

1.1.7. Costs

Budgeted costs and the tracking of spending against such budgets will be maintained in IDDO's excel based cost workbooks. These workbooks provide detailed planning information for each project and include the OPPM (One Page Project Manager) reporting tool. Estimates of resources spent, earned value, identified risks, and cost assumptions are all included in each project's cost workbook. IDDO will periodically reconcile its spending estimates to the university accounting records. Program costs will be individually monitored to determine if expenditures track the anticipated payout rates and to provide a basis for comparison between anticipated costs and actual costs for out-year cost projections. Reviews of total costs for the overall IDPO organization will be conducted to ensure cost control and overall financial accountability.

2.0 Ice Drilling Design and Operations

Introduction

The primary purpose of IDDO is to provide ice drilling support to the US scientific community. Consistent with the goals of IDPO, IDDO will focus on these specific program goals:

1. Provide drilling and drilling related support for NSF projects in the Arctic and the Antarctic and on lower latitude ice caps and glaciers
2. In collaboration with IDPO and the scientific community, identify technology needs and maintain the IDDO Long Range Drilling Technology Plan consistent with the IDPO Long Range Science Plan
3. Using the IDDO Long Range Drilling Technology Plan as its basis, collaborate with IDPO in developing annual Project Plans that focus on the IDDO activities necessary to support the short and long-term ice drilling support needs of the scientific community
4. Develop or procure new equipment needed for support of the scientific community
5. Maintain existing equipment
6. Provide appropriate storage areas to preserve the existing and future equipment inventory
7. Execute all projects in a safe manner
8. Work to ensure that activities are designed to minimize impact on the environment
9. Continuously improve operations including development of new ice drilling equipment and equipment operation using feedback from the users of IDDO ice drilling services and through post-project reviews
10. Ensure an appropriate level of program management and support of IDDO activities and reporting of IDDO activities to IDPO.

The activities of IDDO designed to achieve the goals articulated in the CA fall into five broad categories: support of scientific field projects, existing equipment maintenance and upgrade, new equipment development, program management/support, and collaboration with IDPO.

1. Scientific Field Project Support – The ultimate function of IDDO is to provide equipment and personnel for ice drilling activities in support of science projects in the field. Field project support begins with the preparation of the drilling equipment prior to its shipment to the field and extends through the routine repair of the equipment when it is returned. Usually, but not always, field support entails providing one or more drillers for the field work. This function also includes developing Letter of Suppot/Scope of Work (LOS/SOW) documents for IDPO review and approval, which assist investigators in the development of their proposals for research projects involving ice drilling and coring.
2. Equipment Maintenance and Upgrade – Having the appropriate ice drills and related equipment available for science projects is a major aspect of IDDO's responsibilities. Maintenance activities generally involve repairing and replacing existing components of a drill system with similar components with the aim of restoring the equipment to its original functionality. Upgrades to the equipment can enhance or extend performance of the equipment or to replace components that are obsolete.
3. Equipment Development – As the scope of the scientific investigation broadens, new drilling and related equipment is needed for the experiments. When the SAB determines there is a need for equipment not currently in IDDO inventory, IDDO will purchase or develop that equipment. The development activity generally consists of design, fabrication, and testing of equipment not previously available for ice drilling.
4. Program Management and Support – Program Management and Support includes providing the day-to-day direction of the IDDO staff and all those activities that

support the day-to-day activities and administration of IDDO including planning, personnel management, quality, safety and environmental planning and development of policies and procedures, etc.

5. Collaboration with the Ice Drilling Program Office – IDDO will collaborate with IDPO in fulfilling its responsibilities of providing support to the scientific community and in meeting the requirements of the IDDO subaward. IDDO and IDPO collaborate extensively in future planning activities such as the development of the Long Range Plans and the Annual Program Plan, and IDDO cooperates as well in IDPO monitoring and reporting activities during execution of the planned projects. IDDO also collaborates in developing processes that allow IDPO-IDDO to plan and execute its projects.

Ice Drilling Design and Operations Management Plan

The management of IDDO is more fully described in the IDDO Program Management Plan (SSEC Document 8501-0010).

2.1. Organization and Staffing

IDDO is a unit of the University of Wisconsin Space Science and Engineering Center (SSEC). IDDO is staffed by professionals led by Mark Mulligan the PI and Program Director Kristina Slawny. Primary support personnel includethe Field Project Support Engineer, Rory Holland, and the Maintenance Manager, Jay Johnson. The core staff consists of project managers and engineers who are full-time employees of SSEC in IDDO. SSEC provides additional personnel on a part-time basis for quality and safety processes and IDDO utilizes the administrative services provided by SSEC. The core staff is supplemented by engineering personnel from within the University, including SSEC and other departments, and by contract to those outside the university as dictated by specific project needs. Drillers are hired as part-time University employees on a seasonal basis as necessary. The responsibilities of IDDO staff are shown in Table 5 and the organization in Figure 3.

Table 5 IDDO Staff Responsibilities

Principal Investigator (Mark Mulligan)

- Management of IDDO subaward from Dartmouth
- Ensuring compliance with University of Wisconsin regulations for research and sponsored projects
- Representation of IDDO within SSEC and the University of Wisconsin
- Representation of IDDO at science and drilling technology meetings
- Development of the overall goals and strategies of IDDO in collaboration with IDPO
- Representation of IDDO and SSEC in the IDPO-IDDO collaborative effort for ice drilling
- Organization of the IDDO Technical Advisory Board (TAB) meeting

Program Director (Kristina Slawny)

- Planning and strategy development
- Procurement of needed resources
- Direction of the day-to-day activities of IDDO including administrative activities and direction and oversight of the IDDO staff
- Development of the tactics IDDO employs to meet its strategic goals

- Together with the IDDO staff, definition of the deliverables, schedules, budgets, and reporting methods associated with IDDO projects in collaboration with IDPO
- Management of IDDO support facilities including the warehouse, shop, and labs
- Definition of the processes and procedures needed for IDDO operations and oversight of their development and implementation
- Assistance, as necessary, with the management and execution of specific projects

Field Project Support Engineer (Rory Holland)

- Serving as primary point of contact with PIs of field projects, drillers, and logistical support organizations
- Planning and coordination of field projects
- Primary management of field support projects
- Development of schedules and budgets for assigned IDDO projects
- Selection and oversight of personnel for the crews for field projects
- Development, as necessary, of processes and procedures, particularly those involving field projects
- Preparation of support documents for prospective PIs' proposals
- Coordination and management of the reporting of field projects
- Assisting, as necessary, with the execution of specific projects

Maintenance Manager

- Oversight of the maintenance and upgrade of equipment in IDDO inventory
- Management of the IDDO maintenance/fabrication shop
- Design, fabrication, and testing of new ice drilling equipment as assigned
- Assisting, as necessary, with the execution of specific projects
- Assisting with the preparation of cost estimates and schedules for projects

Project Coordinator

- Assisting Field Project Support Engineer in coordinating field projects with PIs, drillers, and logistics providers
- Assisting with the preparation of reports
- Assisting with the management of the IDDO warehouse

Project Managers

- Planning and coordination of development and maintenance and upgrade projects
- Primary management of development and maintenance and upgrade projects
- Development of schedules and budgets for assigned IDDO projects
- Assisting with the preparation of support documents for prospective PIs' proposals
- Coordination and management of the reporting of development and maintenance and upgrade projects
- Assisting, as necessary, with the execution of specific projects

Engineers

- Design new drill systems and related equipment
- Fabrication and assembly of equipment
- Testing equipment, including the writing of test plans and test reports
- Maintenance of equipment as necessary
- Designing and implementing upgrades to existing equipment

- Assisting in the development of IDDO processes and procedures, particularly equipment operation and maintenance
- Assisting in scheduling and budgeting for projects
- Serving on field crews as appropriate

Drillers

- Operating drilling and related equipment
- Reporting on field activities
- Assisting in the maintenance of the equipment
- Providing input into the design of new equipment and the upgrading of existing equipment

The IDDO utilizes the concept of a matrix organization in which projects are executed by teams led by a project manager and staffed with IDDO personnel, other UW personnel, and contractor personnel. The IDDO staff is small so that each member, including management, will usually be assigned to more than one project and may play different, sometimes multiple, roles in those projects, e.g., mechanical engineer for one project and project manager for another. Figure 3 graphically depicts the IDDO matrix organization.

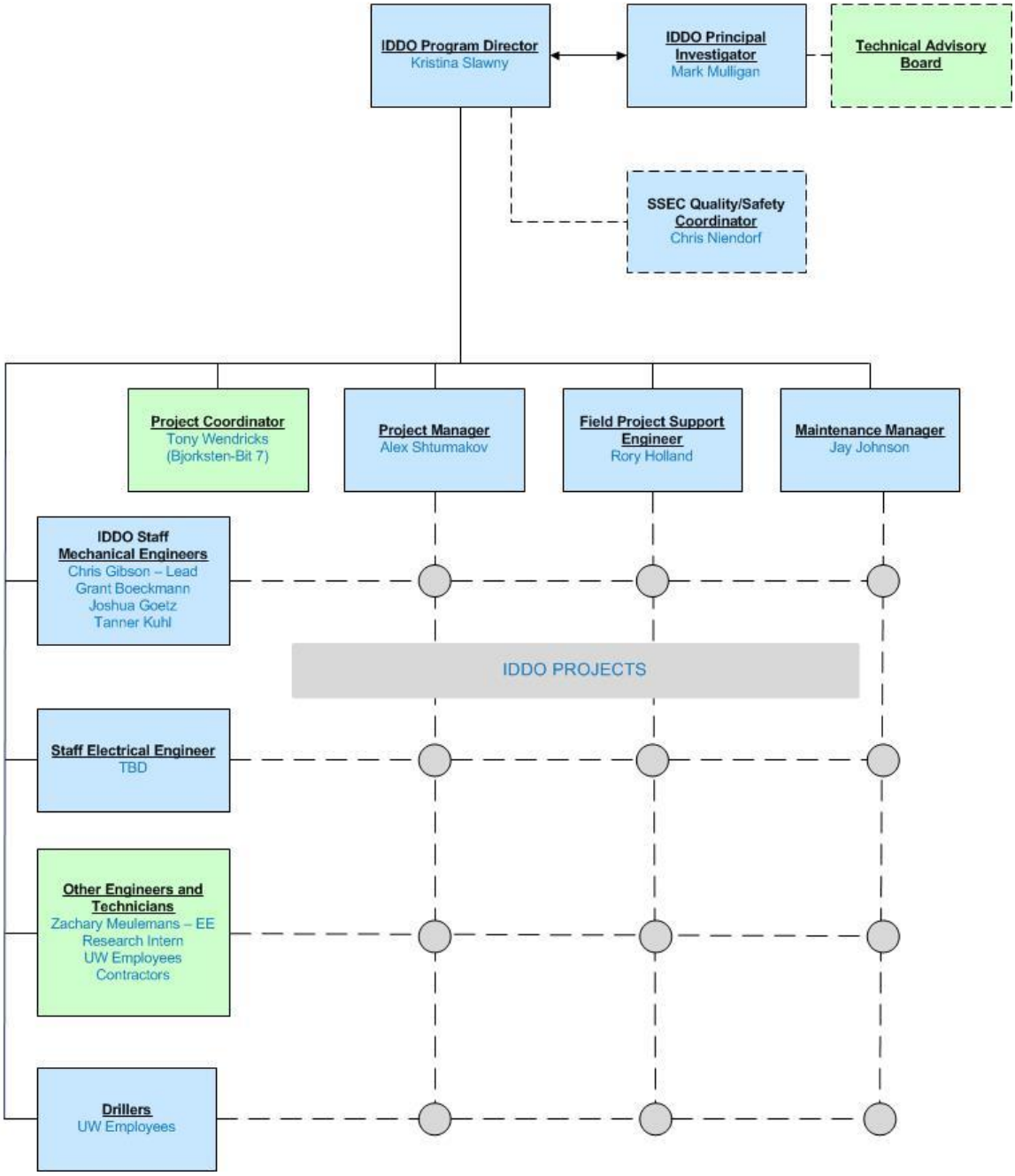


Figure 3. IDDO Organization

2.2. Program Planning

IDDO collaborates with IDPO to generate and annually revise the comprehensive IDDO Long Range Drilling Technology Plan (see section 1.1.2.1, above) based on the IDPO Long Range Science Plan for which IDDO provides input. IDPO, through its liaising with the science community and NSF Division of Polar Programs (PLR), provides insight into the science projects

likely to be supported by PLR and other organizations and longer term equipment needs of the science community. IDDO prepares estimates of resources and time required for potential projects and provides advice to IDPO on prioritization of technology projects. For the Annual Program Plan, IDDO prepares project plans including scope, schedules, budgets, risks, etc. for IDPO review and approval. These are done in a manner to facilitate the use of Earned Value metrics on each of the projects and provide early warning of any project performance issues. The baseline schedules and the associated budgets provide a detailed plan for monitoring and controlling the performance on the projects.

2.3. Project Management

The IDPO-IDDO team implements proven project management techniques for all projects in IDDO's Project Portfolio. Project management techniques are implemented to fit the size and complexity of the individual projects. For smaller, more "routine" projects, more general plans and procedures with addenda to address project specific issues are used. Larger and medium projects, especially larger equipment development efforts such as the development of the Agile Sub-Ice Geological Drill, require more rigorous control techniques to address the more complex issues faced.

The Baseline planning process involves planning detailed scope, cost, and schedule estimates. Taken together, these form a detailed baseline that can later be used for the measurement of performance for each project in the IDDO Portfolio. These detailed baselines are the tools that IDDO uses to monitor and control project activities and that allow IDPO to monitor project progress and manage the IDDO subaward during the execution phase of each project.

1. Scope – Defining a detailed scope of work for each IDDO project is critical to effective project management. Detailed scope management defines the boundaries of the project, its objectives, requirements, constraints, assumptions, risks, and acceptance criteria. IDDO develops a detailed scope-of-work for each project which is reviewed by IDPO. Changes to scope are monitored and controlled through a change management process developed collaboratively by IDPO and IDDO.

2. Schedule – Scheduling of the annual IDDO activities is a critical and challenging issue. MS Project is used to integrate IDDO's maintenance and upgrade and development project deliveries with the field project need dates. Scheduling is a part of each IDDO project's detailed plan. Large and complex projects include significant schedule activities, durations, and predecessor and successor relationships. IDPO will collaborate with IDDO to ensure that schedules provide information needed for IDDO's management of the project and IDPO's oversight of IDDO and its management of the subaward.

Detailed monitoring of schedule performance is a difficult task due to the large and varying nature of IDDO activities and the relatively small crew utilized in support of those activities. At the beginning of the annual planning cycle, a high level schedule is created for each project, which is outlined in the Annual Program Plan. After approval of the Plan by the NSF program officer, IDDO generates a detailed plan for each project. These plans assume certain equipment and personnel availability and equipment condition that are the best estimates at the time the detailed plans are created. These plans are implemented into the detailed baseline schedule and cost estimates.

As the year progresses, actual equipment and personnel availability and equipment condition are better known and create variances from the original baseline plan

assumptions. These variances are analyzed and significant variances are reported and explained. In some cases significant variances can cause a change to the scope, schedule, or budget for a project. These changes are formally recognized and approved (as appropriate) through the IDPO-IDDO Change Management Process. Proper management of these changes is key to providing an early warning of potential schedule and cost problems.

Both IDPO and IDDO realize the detailed schedule management is critically important and continue to closely monitor schedule changes throughout each year. Proper management of schedule detail and planning assumptions are part of the "art of project management" which need to be closely tied to the detailed project execution. The lessons learned each year in detailed schedule creation and management will allow a continuous improvement in subsequent annual project baselines.

3. Cost – Control of costs is one of the primary functions of project management and begins with a good baseline cost estimate for the project. In order to timely monitor and control the financial aspects of its projects, IDDO has developed with the cooperation of the SSEC Accounting Department a system that records costs as they are accrued, i.e., as funds are committed, rather than when they are disbursed. These accrued costs are periodically reconciled with the ledgers of SSEC for IDDO projects thereby allowing project costs to be updated with actual disbursements and allowing the accounting records to be verified and corrected as necessary.

Costs estimates are also dependent on the assumptions made in the baseline schedule estimates. As described in the prior narrative on schedule, the identification and refinement of the detailed schedule and cost assumptions throughout the year are key to controlling costs. Early warnings of cost and schedule issues are key management goals because they allow for more effective corrective actions.

Corrective actions are taken as necessary and to the extent possible to prevent project costs from exceeding budget while delivering the product or services outlined in the scope of work.

In addition, earned value metrics are used to assist in monitoring and reporting IDDO project status. Earned value techniques are valuable as they give a better definition of true progress and their proper use will allow earlier and better identification of potential problems and more effective corrective actions.

2.4. *Scientific Field Projects Support* – IDDO supports science projects requiring ice drilling equipment and drillers. Projects are conducted in a manner consistent with processes outlined in the IDDO Field Project Support Procedure (SSEC Document 8501-0002) and in the IDDO Field Project Safety Plan (SSEC Document 8501-0008). The Field Project Support Engineer has primary responsibility for field project support activities and will, in most cases, act as project manager for the projects. Activities involved in the support of field projects include:

1. Proposal Support – Prospective PIs complete a Field Project Support Requirements form obtained online or through IDPO or IDDO. This document provides a description of the project being proposed and allows IDPO-IDDO to determine whether the project can be supported, the resources needed (equipment and field personnel), a realistic schedule for the project and the estimated cost of IDDO's support of the project. A Letter of Suppot/Scope of Work (LOS/SOW) document is provided to

IDPO which is reviewed and sent to the proposer. The document is then included as Supplemental Information in the PI's proposal.

2. Project Requirements – Once the proposal has been funded by NSF, IDPO-IDDO will collaborate with the PI to refine, as necessary, the scope of the support needed. The refined scope and resulting cost and schedule estimates will be reviewed by IDPO-IDDO and included in the next Annual Program Plan, or, if necessary, submitted as a request for supplemental funding from NSF.

3. Project Plan – The Field Project Support Engineer will prepare a project plan as detailed in the IDDO Field Project Support Procedure with the assistance of the Lead Driller (if selected) for the project. Larger projects (e.g., ASIG) may warrant a more detailed project management plan, safety plan, etc.

4. Field Activities – If the project requires IDDO to provide field personnel, the Field Project Support Engineer, in consultation with the Program Director, will select and engage personnel (IDDO staff or part-time/temporary UW employees) to perform the field work as outlined. The Field Project Support Engineer will arrange for any training deemed necessary for the field crew. The Lead Driller is responsible for the completion of the drilling as directed by the PI or his/her field representative as long as it does not, in the Lead Driller's judgment, endanger personnel or equipment or increase IDDO costs of the project without the approval of IDPO-IDDO management. The Lead Driller has the authority and responsibility to make decisions regarding the operation of IDDO equipment in the field.

5. End-of-Season Reports – The Lead Driller is responsible for providing IDDO management with a report on the conduct of the field project including any problems encountered with equipment, procedures, or personnel. The Lead Driller will also provide any driller's logs associated with the project. IDDO may also conduct a project debriefing of the Lead Driller or the entire crew, as the Field Project Support Engineer deems appropriate; notes of the debriefing will be made. IDDO will submit these reports to IDPO; they may be posted in a controlled access portion of the IDPO-IDDO website.

6. Science PI Evaluation of Field Support – IDPO will request the PI or his/her representative complete an evaluation of the support received on his/her project. This feedback will be used by IDDO to improve the support it provides; IDPO will monitor IDDO's activities to ensure the implementation of improvements planned.

7. Equipment Repairs – IDDO personnel, including the drilling personnel, will evaluate the condition of the equipment and recommend repairs and upgrades to the equipment. As part of the field project, IDDO will make routine repairs to the equipment (e.g., sharpening or replacement of cutters); major maintenance will be scheduled and budgeted as a Maintenance and Upgrade project.

2.5. Equipment Maintenance and Upgrade – Repairs and modifications to equipment to improve performance or to replace aging or obsolete components are considered as system maintenance and upgrade projects and will be overseen by the Maintenance Manager. IDDO has established projects for each existing drill system although not all projects will be active in a particular program year. Procedures are being developed for each type of drill maintained in inventory (e.g., the 10-cm (4-Inch) Drills) and the drills are to be maintained in accordance with those

procedures. Records of maintenance activities are maintained in order to ascertain that equipment is being repaired and kept in serviceable condition. The records also provide valuable information for planning purposes.

2.6. Development Projects – Development projects are those that usually entail the design, fabrication, assembly, and testing of a new ice drilling system. These projects rely on the adaptation of an existing technology to ice drilling or the development of entirely new technologies. Project Managers are assigned on a case-by-case basis. Facets of the IDDO development projects include:

1. Science Requirements – IDDO collaborates with IDPO and the scientific community in developing the science requirements, i.e., the performance features of the drill system needed to meet the needs of the science experiments. IDPO initiates the development of the science requirements and works closely with interested scientists in developing the requirements; IDDO assists IDPO in their development by providing input into the technical and cost feasibility of meeting the requirements. The process is often iterative and may be associated with the development of conceptual designs for the systems. Once the science requirements are finalized (subject to some mutually agreed upon modification as development proceeds), they become the basis for the design of the system and provide a gauge by which the success of the development can be measured. The science requirements for a project are treated as a controlled document by IDDO and IDPO.

2. Engineering Requirements – High-level engineering specifications are developed by IDDO from the science requirements; they translate the science requirements into quantifiable parameters that define the physical characteristics of the equipment. IDDO engineering personnel develop the engineering requirements for a system; they are treated as a controlled document by IDDO. Inasmuch as there could be multiple sets of engineering requirements derived from the science requirements, the engineering requirements could be expected to change over the course of the development of the conceptual design and to a much lesser extent over the course of the detailed design.

3. Conceptual Design – IDDO develops an overarching design of the system that will meet the engineering requirements and the underlying science requirements for the equipment. It includes the technologies to be used and their relation to one another. IDDO, in developing the concept, will also estimate the cost and the schedule for development of the equipment. The conceptual design and the associated engineering requirements will be reviewed by disinterested non-IDDO reviewers with technical expertise to determine if the concept is technically and financially sound, and the scheduling feasible. The concept will be modified in response to the review and submitted to IDPO for review and for inclusion in the Annual Program Plan for the appropriate fiscal years; IDPO will consider the proposed concept in the updating of the Long Range Science Plan and IDDO will incorporate the development of the system in the update of the Long Range Drilling Technology Plan. IDDO will treat the conceptual design as a controlled document.

4. Detailed Design – Once the conceptual design of the drill system has been approved and funded for development, IDDO will complete all necessary analyses (e.g., failure modes and effects analyses, finite element analyses), fabrication and assembly drawings, material and component specifications, etc. necessary to the manufacture of the system. The design will be validated through the review process as provided in the project

management plan and verified, to the extent possible, through testing of prototypes. Drawings, analyses, software documentation, specifications, etc. are treated by IDDO as controlled documents.

5. Fabrication and Assembly – Once the detailed design is complete, fabrication/purchase and assembly of components and subsystems is undertaken. IDDO checks to ensure that components and subsystems meet the specifications developed. Once the system is assembled, IDDO may conduct a pre-test review to verify the system is complete and capable of meeting the science requirements. Test plans are also reviewed. Generally, at least one disinterested, qualified person not on the IDDO staff would be included on the review panel. The results of the review, which includes the reviewers comments, suggestions, etc. and the project teams responses to those, are treated as an IDDO controlled document and will be provided to IDPO.

6. Field Testing – When possible, equipment will be tested under field conditions similar to those expected when it is used for actual science projects. Test plans are developed to verify that the equipment will meet the engineering requirements and consequently the science requirements. Test plans will be developed prior to the testing or deployment of the equipment; these along with a report on the test results will be treated by IDDO as controlled documents and provided to IDPO. Since new technologies are being tested, it can be expected that changes will need to be made in the design of the equipment before it is ready for deployment for science projects. These changes will be made in a manner consistent with the SSEC Change Control Procedure.

7. Pre-Deployment Review – Once changes resulting from the testing are completed and the system is ready for deployment, IDDO will conduct a review to ensure that the equipment is ready for use. The review panel will check that all design changes and fabrication corrections found necessary in testing have been made and that all operating and maintenance procedures are complete and reflective of the final configuration of the equipment. IDPO will normally be involved in this review. Results from the review will be summarized and treated as a controlled document.

2.7. Equipment Inventory Management

SSEC and IDDO provide warehouse space for the storage and maintenance of ice drilling and related equipment. SSEC and IDDO utilize the inventory control system in place at the University of Wisconsin to track IDDO inventory. The Project Coordinator, under the direction of the Program Director, manages the inventory and the warehouse operation. SSEC will provide IDPO with a report of all IDDO inventory on an annual basis that is compliant with the terms of the NSF-Dartmouth Cooperative Agreement which flows down to SSEC/IDDO. IDPO will oversee and approve this process as it applies to the terms of the cooperative agreement.

2.9. Safety

Safety is of primary concern to IDDO and SSEC, which has adopted center-wide project safety and personnel safety plans along with a risk management plan. ICDS, IDDO's predecessor, developed a safety plan specifically addressing the safety in its particular operations. IDDO continues to update and use these plans and procedures as well as develop new ones as needed to ensure that its projects are conducted in a safe manner and that the equipment it designs and fabricates presents no undue hazards to personnel.

2.10. Quality

IDDO uses experience to improve continuously and systematically the services it provides the science community. IDDO has updated and uses a questionnaire developed initially by ICDS to solicit and document feedback from investigators concerning its performance in supporting field projects with the goal of improving its service on field projects; IDPO formally solicits the feedback from the investigators and provides the feedback to IDDO; IDDO in turn develops plans to correct any problems noted or to incorporate permanently any particularly positive aspects in the conduct of its projects. IDPO monitors IDDO's implementation of those plans. IDDO also makes use of the end-of-season project reports prepared by the lead driller on field support projects to improve both its services and its drilling equipment. IDDO makes use of drilling reports and logs to establish baselines for drilling performance parameters such as core quality (ICDS established a core quality rating system that it implemented for use on coring projects) and then to measure improvements in those parameters resulting from equipment and technique improvements. IDDO uses post-project reviews for development projects to improve the design, fabrication and testing processes for new equipment. Finally, IDDO works with IDPO to obtain feedback on its services through advisory and working groups.

2.11. Reporting

IDDO prepares and sends reports to IDPO and participates in a weekly teleconference with IDPO to ensure that IDPO has information to oversee IDDO's execution of projects, and to manage the IDDO subaward, IDDO collaborates with IDPO in the preparation of various reports to the NSF as required by the IDPO Cooperative Agreement.

References

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