# Project Management Plan For IceCube 10 October 2001

## 1.0 Overview

IceCube is a neutrino telescope to be installed at the South Pole during Austral summers over approximately six years. The IceCube detector will be in a cubic kilometer of ice and consist of 4800 optical modules deployed on 80 vertical strings buried 1.4 to 2.4 km under the surface. IceCube will be brought into operation over the period of installation and used for scientific investigations, as the modules become available. The project is being designed, built, installed and used for research by an international collaboration. Funding institutions in the home countries of the collaborators provide funds for the construction of the detector and for research with the detector. The US National Science Foundation supplies funds for the design, development, fabrication, procurement, testing, drilling, and support for operations of the project at the South Pole. The University of Wisconsin-Madison with support from the National Science Foundation will, as the host institution, provide oversight and staffing for the execution of the project, as well as development of key components. The AMANDA project now in operation at the South Pole serves as a prototype of the improved and expanded IceCube project.

## 1.1 Scientific Goals.

IceCube will open unexplored wavelength bands for astronomy including the PeV ($10^{15}$ eV) energy region. Many parts of the universe are inaccessible with other types of cosmic rays: protons do not carry directional information because of their deflection by magnetic fields, neutrons decay before reaching the earth, and high-energy photons are absorbed. IceCube will answer such fundamental questions as whether the multi-TeV photons, originating in the Crab supernova remnant and near the super massive black holes of active galaxies (AGN's), are of hadronic or electromagnetic origin.

Data from Chandra X-ray satellite demonstrate that the "diffuse" extragalactic X-ray background (i.e. as observed with instruments of low angular resolution like IceCube) is mostly the accumulated radiation from all AGN sources. Models of the radiation producing processes in AGN's can provide a prediction of the "diffuse" flux of high-energy neutrinos. Figure 1-1 shows the results of a variety of such models and illustrates the discovery reach of IceCube. The broad, dark, steep spectrum is the atmospheric background.

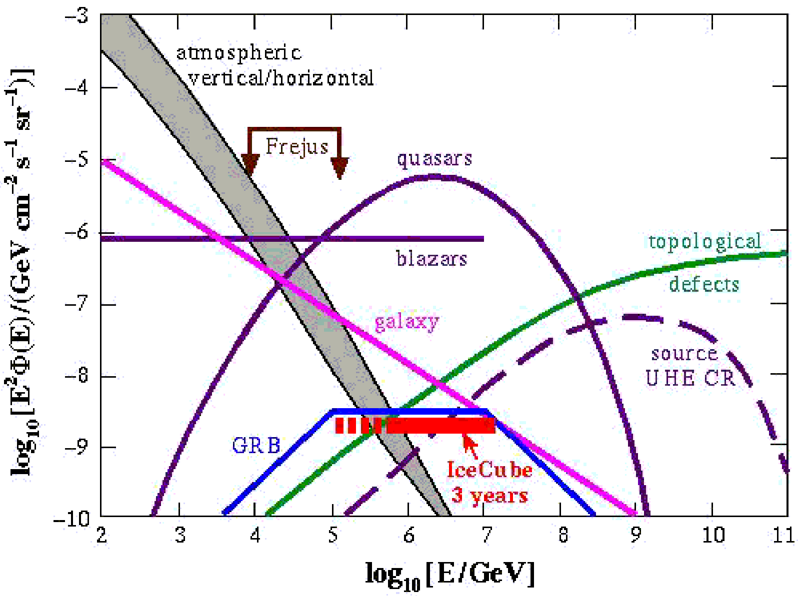


Figure 1-1. Diffuse neutrino flux vs. energy for various models of sources contributing to the diffuse background. The horizontal line in red indicates the IceCube sensitivity after three years.

IceCube also occupies a unique place in the multi-prong attack on the particle nature of dark matter, with unmatched sensitivity to cold dark matter particles approaching TeV masses. IceCube will be sensitive to supernova within our galaxy.

As a particle physics experiment with the capability to detect neutrinos with energies far above those produced at accelerators, IceCube will search for super-symmetric particles and the topological defects created in grand unified phase transitions in the early universe. The detection of cosmic neutrino beams would open the opportunity to study neutrino oscillations over Megaparsec baselines.

As history has demonstrated the opening of each new astronomical window has led to unexpected discoveries. Notwithstanding these exciting possibilities, the true potential of IceCube is discovery.

## 1.2 Technical Description

The IceCube neutrino telescope is a regularly spaced array of 4800 photomultiplier tubes buried between 1.4 and 2.4 km below the surface of the South Pole Ice. The array covers an area of about 1 square km as shown in Figure 1-2. The photomultipliers will record Cerenkov radiation from charged particle progenitors of neutrino interactions in the ice. Each photomultiplier is enclosed in a transparent pressure sphere, an optical module (DOM). The DOM also contains a digitally controlled high voltage supply to power the photomultiplier, an Analog Transient Wave Form Digitizer, and LED flashers. The configuration is shown schematically in Figure 1-3.

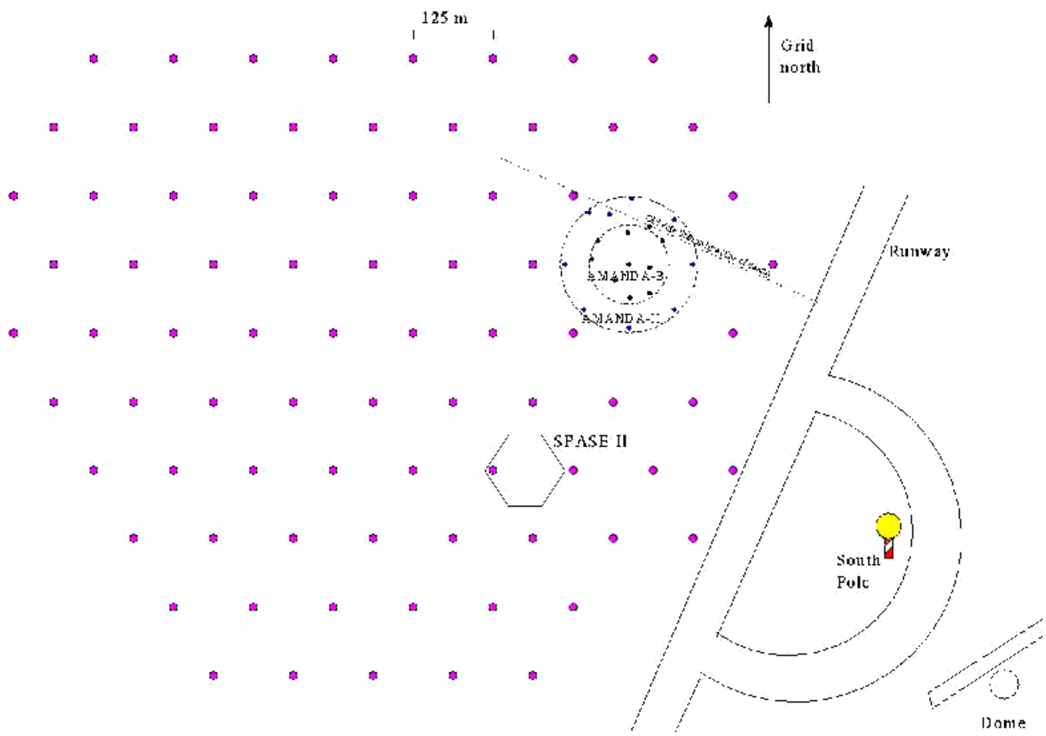


Figure 1-2. Site Plan for IceCube

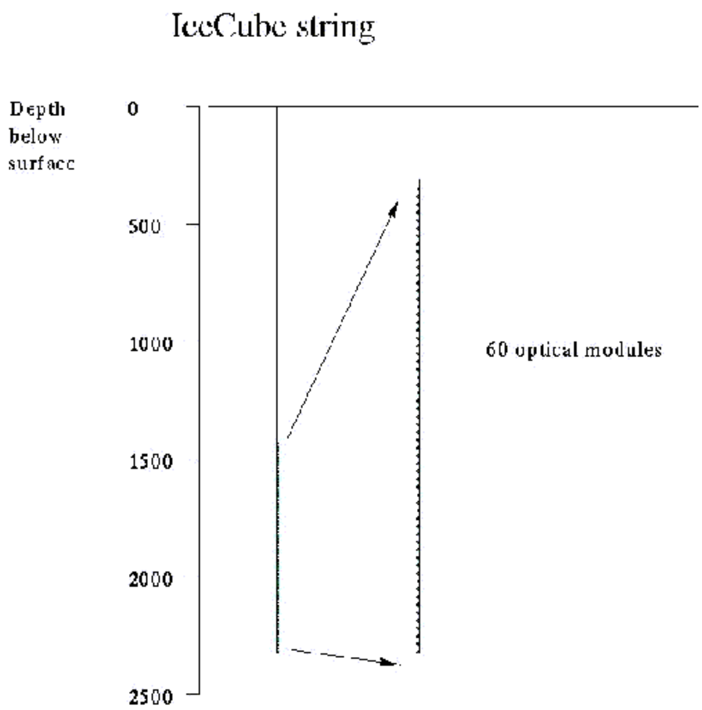


Figure 1-3.  Schematic IceCube Array

The Amanda array will be contained within the plan view projection of IceCube.  The Spase scintillator array on the surface is also over the IceCube detector.  The signals digitized in the Digital Optical modules are communicated to the surface via twisted pairs to the data acquisition and data analysis system at the surface.   Data is transmitted via satellite from the pole to data storage facilities accessible to the collaboration for its data analysis effort.

## 2.0 Organization and Responsibilities

The IceCube Project is an international project conducted by US and European institutions from several countries, and involving US and non-US funding agencies. The organization of the project is shown in Figure 2-1. It should be stressed that figure 2-1 does not represent a complete description of the organization of the IceCube project. A comprehensive account is given in the text of chapter 2 and in the IceCube Collaboration Governance document, Appendix 2.

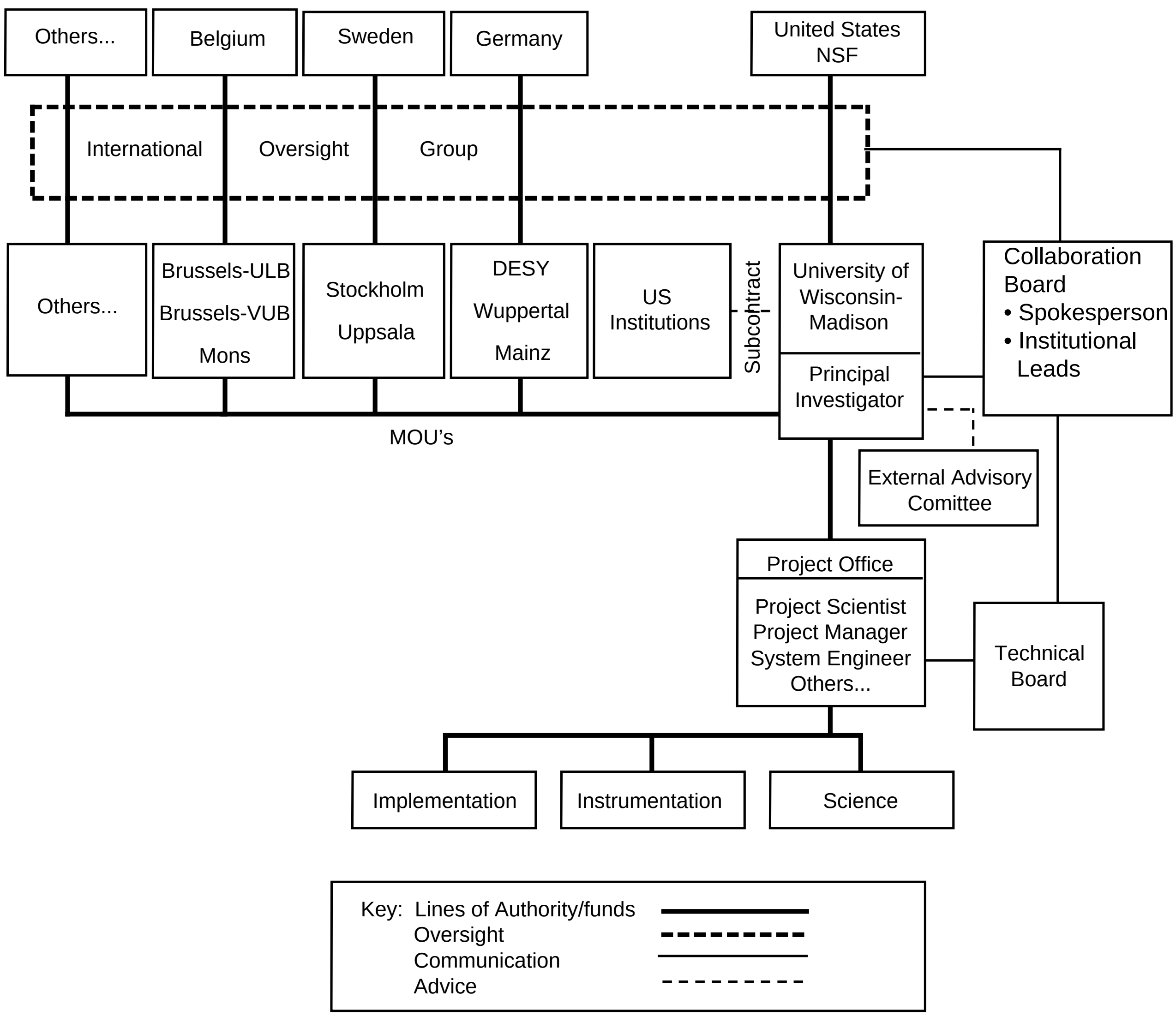


Figure 2-1. Organization of the IceCube Project

### 2.1 The Collaboration.

The collaboration now comprising the IceCube Project has sixteen universities (nine in the U.S. and seven in Europe), and two laboratory groups (one in the U.S., one in Europe). The US Collaborators are listed in Table 2-1 and the European Collaborators are listed in Table 2-2.

| The US Collaborators | |
|---|---|
| **Institution** | **Location** |
| University of Delaware, Bartol Research Institute | Newark, DE, USA |
| Clark-Atlanta University | Atlanta, GA, USA |
| Institute for Advanced Studies | Princeton, NJ, USA |
| Univ of California-Berkeley | Berkeley, CA, USA |
| Southern University | Baton Rouge, LA, USA |
| University of Pennsylvania | Philadelphia, PA, USA |
| University of Wisconsin-River Falls | River Falls, WI, USA |
| University of Wisconsin-Madison | Madison, WI, USA |
| University of Kansas | Lawrence, KS, |
| Lawrence Berkeley National Laboratory | Berkeley, CA, USA |
| University of Alabama | Tuscaloosa, AL |

Table 2-1**.** US organizations participating in IceCube Collaboration.

| European Collaborators | |
|---|---|
| **Institution** | **Location** |
| DESY-Zeuthen | Zeuthen, Germany |
| Uppsala University | Uppsala, Sweden |
| Stockholm University | Stockholm, Sweden |
| University of Wuppertal | Wuppertal, Germany |
| Vrije University | Brussels, Belgium |
| University of Mons-Hainaut | Mons, Belgium |
| University Libre of Bruxelles | Brussels, Belgium |
| Mainz University | Mainz, Germany |

Table 2-2**.** European organizations participating in IceCube Collaboration.

## 2.2. Funding Agencies.

The agencies are responsible for providing funding to the collaborating institutions for the IceCube Project. Through the IceCube International oversight Group, as described below, the funding agencies will provide general oversight, monitoring, and evaluation to help assure performance in accordance with the approved plans.

### 2.2.1. NSF/UW Cooperative Agreement.

The National Science Foundation (NSF) through a Cooperative Agreement with the University of Wisconsin-Madison will provide facilities at the South Pole Station. NSF will provide funds as set forth in the Cooperative Agreement for the US part of the effort, including other US institutions involved in the IceCube Project.

#### 2.2.1.1. Organization within NSF.

Within NSF the IceCube Program Manager is responsible for the scientific, technical, cost and schedule review and agency guidance. Review of progress and programmatic review of annual work plans is the responsibility of the IceCube Program Manager. Direct communication between the IceCube Program Manager and the IceCube Project is the method by which the review and guidance are accomplished. The IceCube Program Manager is the point of contact at NSF for coordination between the IceCube Project and the NSF for drilling operations and for support at the South Pole. IceCube personnel arrange services while at the South Pole through the Support Manager at the Pole.

The NSF Division of Grants and Agreements is responsible for Cooperative agreement matters between the NSF and the University of Wisconsin-Madison. Formal communications related to contracts and approvals required under the Cooperative Agreement are accomplished by the Division of Grants and Agreements and the Office of the Dean of the Graduate School - Research and Sponsored Programs working in close coordination with the SSEC Executive Director for Administration and the IceCube Project Office at the University of Wisconsin-Madison.

The organizational lines of communication between the NSF and the IceCube Project are shown in Figure 2-2.

**NSF/IceCube Project Lines of Communication**

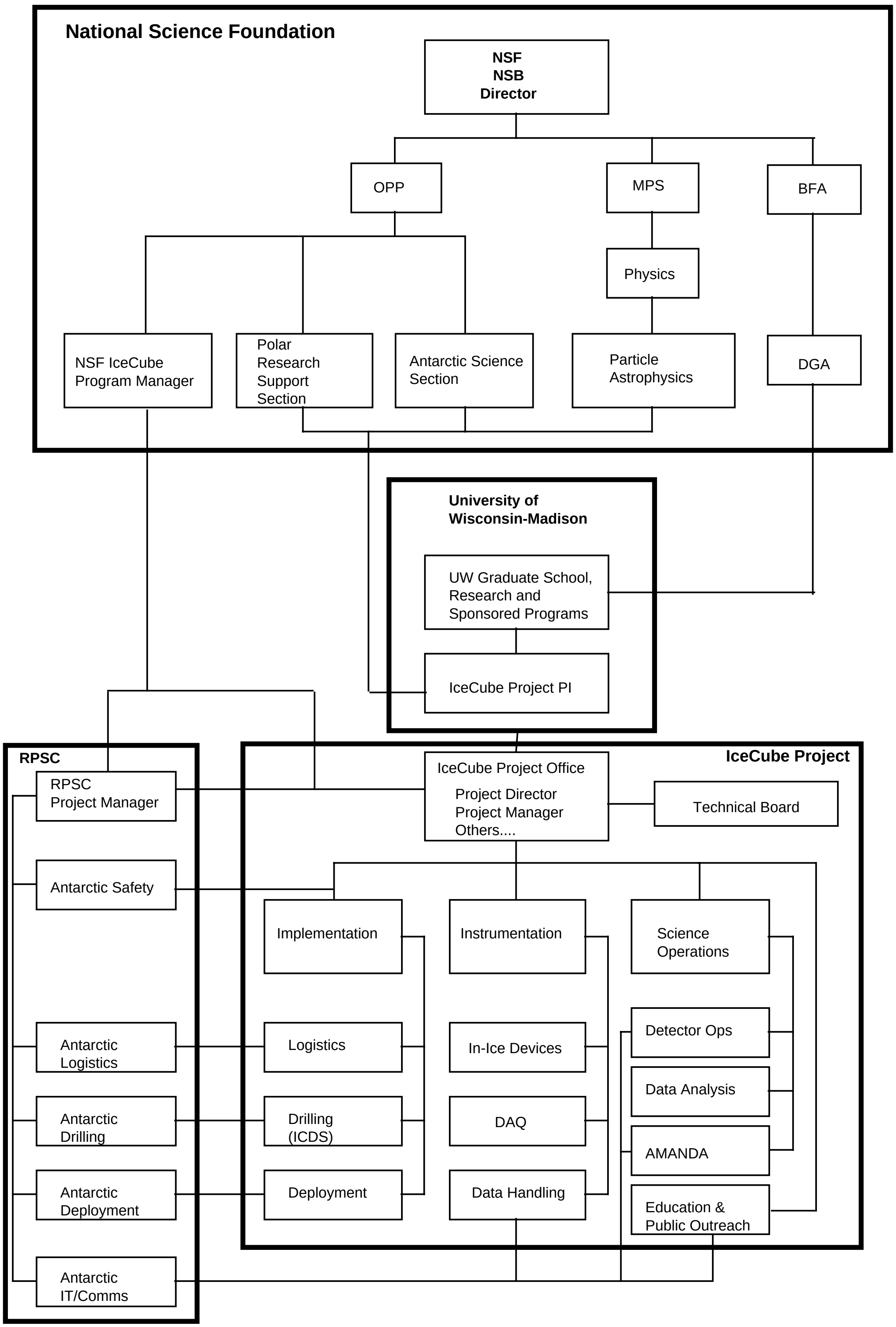


Figure 2-2 Lines of Communication between NSF and IceCube Project

2.3. IceCube International Oversight Group.

The IceCube International Oversight Group (IOG) will monitor all aspects of the IceCube Project. IOG will furthermore monitor the aspects of the project detailed in the Memoranda of Understanding between University of Wisconsin-Madison and each participating institution.

2.3.1. Membership.

The membership of the IOG will consist of one representative from each of the funding agencies, or their designated representatives, the Wisconsin Principal Investigator (PI) ex officio, the Project Director and Pproject Manager ex officio, and the Spokesperson ex-officio. A representative of the National Science Foundation will chair the IOG.

2.3.2. Functions.

2.3.2.1. Approve the Memoranda of Understanding between collaborating institutions and the University of Wisconsin-Madison.

2.3.2.2. Review and Monitor the status of financial and human resources. The chair of the IOG will forward reports and correspondence received from the University of Wisconsin-Madison to each agency.

2.3.2.3. Endorse the annual budgets for the project.

2.3.2.4. Approve in major changes to the project purpose or goals (defined in the section on Change Control).

2.3.2.5. Approve major changes to the total project cost.

2.3.3. Voting.

Decisions will be based on consensus. If no consensus can be reached decisions will be taken by vote and based on a majority of all voting members. Each representative has veto power over the use of the funds that are provided by the agency he/she represents.

2.4. The Host Institution.

The Host Institution for the IceCube project is the University of Wisconsin-Madison (UW).

2.4.1. UW is responsible for:

2.4.1.1. Appointing the key personnel of the IceCube Project Office such as the Project Scientist and the Project Manager, subject to concurrence of the IceCube collaboration board and the International Oversight Group, and the approval of the NSF as defined in the NSF/UW Cooperative Agreement.

2.4.1.2. Ensuring that the Project Office has adequate staff and support for the execution of the project.

2.4.1.3. Ensuring that an adequate structure is established for the purpose of monitoring the management and the progress of the project.

2.4.1.4. Ensuring that adequate and timely reporting is provided to the IceCube collaboration, to the NSF and to the International Oversight Group.

2.4.1.5. Providing funds to other US Collaborating Institution through subcontracts or Memoranda of Understanding (MOU's) let through the UW.

2.4.1.6. Establishing MOU's between the UW and each of the collaborating institutions. These MOU's will define the roles and responsibilities of the collaborating institutions.

2.4.2. University of Wisconsin-Madison Graduate School.

The lead executive officer of the UW is the Chancellor, who delegates responsibility for research activities to the Dean of the Graduate School. The Dean maintains oversight of the IceCube project. Additional channels for oversight come from the operation of IceCube within the Graduate School's Space Science and Engineering Center (SSEC) and its Antarctic Astronomy and Astrophysics Research Institute (A3RI). The Associate Dean, Physical Sciences, carries out ongoing informal contact with the PI on an ongoing basis.

2.4.2.1 Space Science and Engineering Center (SSEC).

SSEC is a multi-disciplinary research center, with an emphasis on instrument development and applications science. It has a dedicated staff that is made available to support PI-led projects, such as IceCube. By locating the IceCube Project Office within SSEC, the Project can draw on several key capabilities of SSEC, including its experience in purchasing for time-critical projects, personnel hiring, administrative services and technical/engineering capabilities. SSEC is organized by a Director, who is responsible for scientific policy and coordination, and a team of three Executive Directors who are responsible for the effective administration of Center resources to implement policy. While SSEC does not directly manage IceCube, it does provide oversight and support through a regular sequence of coordination and status reporting meetings.

2.4.2.2 Antarctic Astronomy and Astrophysics Research Institute ($A^3RI$)

IN 1999 the UW Graduate School formed the Antarctic Astronomy and Astrophysics Research Institute ($A^3RI$) within SSEC. $A^3RI$ is designed to foster and coordinate the Antarctic research programs at UW, including the AMANDA, IceCube and Ice Coring and

Drilling Services (ICDS) programs. Its Director is selected by the Graduate School. Since these projects have many features in common, including the need to operate in the Antarctic and to coordinate with the NSF Office of Polar Programs, an umbrella organization can identify common areas of concern and needs. $A^3$RI also provides the Graduate School with an opportunity to look at its Antarctic activities as a whole. The Dean of the Graduate School formed the $A^3$RI Advisory Council in 2001. It is charged with reviewing projects within $A^3$RI and providing written comments on their status to the Dean. The emphasis of the $A^3$RI Council is identifying management, financial, and organizational issues. The Council is selected by the Graduate School to include people with direct experience in the management of successful major research programs. The $A^3$RI Council will meet at least quarterly as the IceCube Project ramps up. Its Chair will review the monthly progress reports as a means to identify any difficulties in an early stage.

### 2.4.3. The IceCube Principal Investigator (PI).

The PI is responsible to the Dean of the Graduate School for the overall scientific and technical direction of the IceCube Project. Under terms of the proposed Cooperative Agreement with the NSF, the PI will be the head of the IceCube Project within the UW and will be the point of contact between the UW and NSF for official communications. The UW IceCube Project Office will be directed by the PI who will also communicate the scientific goals and objectives as established by the IceCube Collaboration. Within the collaboration, the PI will have authority over and responsibility for the disposition of funds awarded to the University of Wisconsin-Madison for the IceCube Project. The PI will be an ex-officio member of the Collaboration Board, the Technical Board, and Co-Spokesperson for the collaboration.

## 2.5. IceCube Collaboration Board (CB).

The IceCube Collaboration Board establishes the scientific goals and objectives of the IceCube Project. The CB approves all the major technical issues concerning IceCube. The Spokesperson is elected from among the members of the IceCube Collaboration and serves for a term of two years.

Collaboration Board membership and responsibility are described in detail in the IceCube Collaboration Governance document shown in Appendix 2.

## 2.6 IceCube Technical Board

The Technical Board is comprised of the Level 3 Subsystem managers, the PM, the Project Scientist, System Engineer, and the Level 2 coordinators. The technical board is chaired by the PM. The Technical board meets once per week by phone call to discuss project progress, problems, interfaces, potential changes, risk and risk mitigation strategies, and technical requirements. This group also forms the high level change control board as referenced in the change control process outlined in section 3 of the Project Management Plan.

## 2.7. The Project Office

Management of the IceCube Project will be carried out by a Project Office. The Project Office reports directly to the PI and thus to the Dean of the Graduate School. For administrative and logistical support purposes, the Project Office is located in $A^3RI$, which in turn is within the Graduate School's SSEC. Both $A^3RI$ and SSEC will help facilitate IceCube project operations where appropriate. The primary responsibilities of the IceCube Project Office are: ensuring the development and implementation of the project in a cost effective and timely manner with the goal of detecting neutrinos from astrophysical sources as described in the proposal, ensuring the ability of the project to meet the science requirements, ensuring the execution of IceCube construction, organizing and directing the project team, supervising the second-level managers, and preparing monthly, quarterly and annual reports to be forwarded to the IOG and NSF.  It will also exercise the management and budget control for the Project, and serves as the source of information for the NSF regarding budgetary, schedule, personnel, and logistical issues associated with the status of the Project.  Contractual matters are communicated to the NSF through the Dean's Office - Research and Sponsored Programs working in close coordination with the SSEC Executive Director for Administration.  Official programmatic issues are communicated to the NSF through the PI. Organization and reporting for the Project Office are shown in Figure 2 – 7.

### 2.7.1. Project Office Management

The senior members of the Project Office, the Project Director and the Project Manager, will work as a team to fulfill the responsibilities of the Office.  Both are given direction by the IceCube PI.  The Project Director is the head of the Project Office and has primary responsibility to ensure that the mission of the Project Office (para.2.7) is carried out. He/She is the Project Office point of contact with the NSF Program officer. The Project Manager is responsible for the organization and direction of the team constructing and supporting the project from inception through its initial operations.  The Project Office team also takes responsibility for accurately communicating the status of the project to the IceCube stakeholders, including  the IceCube IOG, the NSF, the UW Graduate .School, and SSEC. The Project Office will implement controls for the effective management of the Project within schedule and budget.

#### 2.7.1.1. Project Director

The Project Director has the authority and responsibility for carrying out the  IceCube Project  within the established technical, schedule, and cost baseline. He/she will be the senior scientist in the Project Office and will have responsibility within the Project Office for all matters requiring scientific judgment and experience and will provide scientific oversight of the construction effort to ensure that IceCube will meet its scientific requirements. The Project Director reports to the PI and also carries the responsibility for communication of scientific matters between the Project Office and wider collaboration, both through the PI and the CB, where he/she is the liaison to the Project.

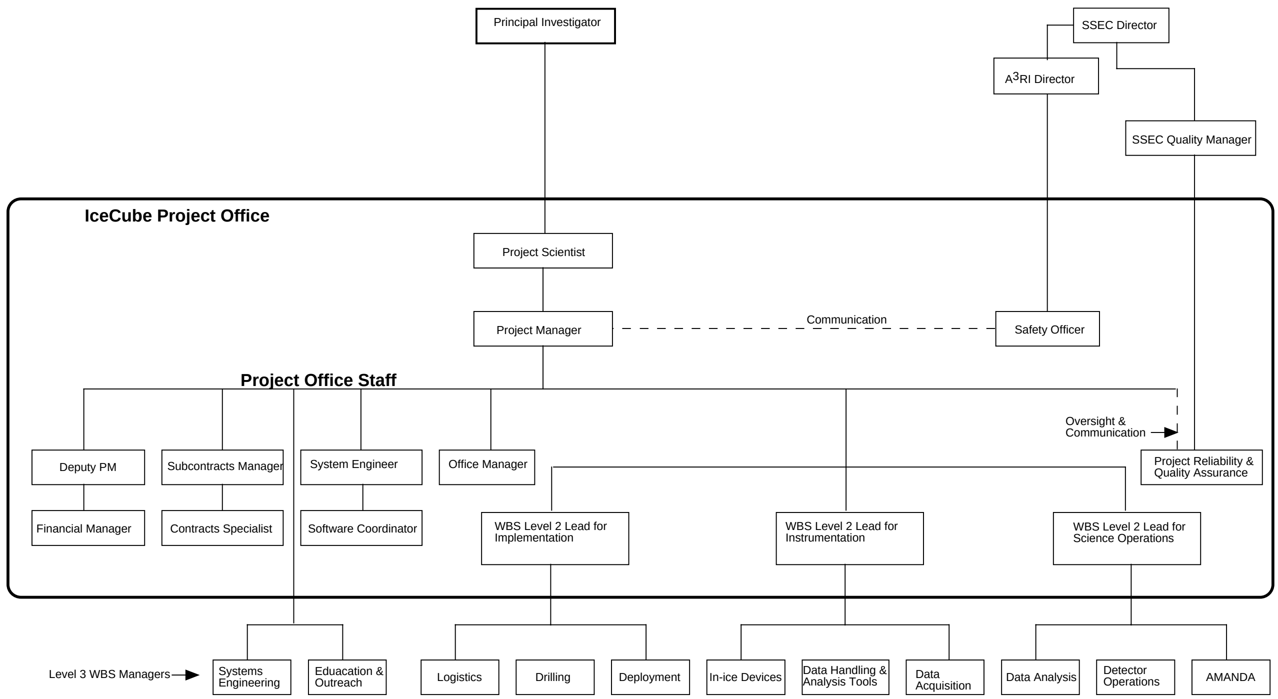


Figure 2-7 Project Office Organization and Reporting Scheme

### 2.7.1.2. Project Manager.

The PM reports to the Project Director and is responsible for the day-to-day management of the IceCube Project and those aspects of the Project office associated with construction. The PM serves as the deputy to the Project Director. The Deputy Project Manager assists the PM in his duties. The PM has the responsibility and authority for organizing and directing the IceCube team. The PM supervises the design and execution of IceCube, including development of schedules with well-defined milestones against which progress can be measured, resource loaded work breakdown structures, task management, cost and management control schemes, and reporting mechanisms. The Project Manager authorizes construction staff appointments, budget expenditures, contracts, and other allocations of resources within the baseline estimates for construction including those defined by MOU's. The Project Manager communicates the status of the construction project to stakeholders via timely written and oral reports.

## 2.7.2. Project Office Staff

### 2.7.2.1 Systems Engineer

The IceCube system engineer has primary responsibility for all system level issues. It is critical in this process to view all elements of the IceCube project as a system and properly allocate requirements and design approaches across the entire system. Early in the design process the system engineer will be primarily concerned with top level requirements flow-down and precisely how the system will operate once in operation so that design decisions are made with system considerations in mind. The other key role that the systems engineer has is in the development of interfaces between subsystems. As such, the system engineer will be working continuously with subsystem managers to ensure that interfaces are properly defined and that technical issues affecting more than one subsystem are resolved efficiently and effectively. The approval of the Systems Engineer is required before proceeding with construction of major subsystems, on interface control documents, and before accepting subsystems. She/he works with the Project Scientist to monitor scientific performance of IceCube as it is being built. The Systems Engineer is part of the Construction team, and reports to the Project Manager.

#### 2.7.2.2 Deputy Project Manager

The Deputy Project Manager assists the Project Manager in managing Project activities. He/she acts of behalf of the Project Manager in his absence. The Deputy PM has responsibility for the development of budgets and schedules for the project. This is accomplished by working with the PM, the financial manager, and the Level 2 and 3 leads in planning the IceCube construction activity. He/she reports to the Project Manager.

#### 2.7.2.3 Financial Manager

The Financial Manager works with the Deputy Project Manager and the SSEC Executive Director for Administration to follow the receipt, allocation, and expenditure of funds, develop budgets, and produce financial reports. He/she is responsible for the implementation of proper business practices and controls in the Project Office, and for the relationship between the Project and administrative support units within SSEC. The Financial Manager reports to the Deputy Project Manager.

#### 2.7.2.8 Software Coordinator

The Software Coordinator is responsible for maintaining a uniform approach to the development of all software within the Project. This includes the maintenance of interfaces between software elements, and communication from/to the software developers and the project management team. This position is not responsible for budget and schedule issues associated with the software effort, but does work with the Level 3 managers and the project office to develop plans and procedures. The Software Coordinator is a system engineering function and reports to the project System Engineer.

#### 2.7.2.9 Subcontracts Manager

The Subcontracts Manager will principally be responsible for monitoring progress at partner institutions and major suppliers. He/She will also be responsible for the development of plans and procedures in the event that problems develop at a subcontract location. The Subcontracts Manager works with the Contracts Specialist to develop subcontracts including statements of work, schedules, and budgets for each subcontract. The Subcontract Manager reports to the Project Manager.

2.7.2.10 Contracts Specialist

The Contracts Specialist is responsible for drafting of subcontracts and subsequent modifications with all US partner institutions and major suppliers. The Contracts Specialist works with the SSEC Executive Director for Administration and reports to the IceCube Subcontracts Manager.

2.7.2.7 Office Manager

The Project Office Manager will be responsible for project office operations. This includes personal schedules, travel, document preparation, budget preparation, and inter-office communication. The Office Manager reports to the Project Manager.

2.7.2.8 Reliability and Quality Assurance Manager

The R&QA manager is responsible for insuring that IceCube will operate effectively over the design lifetime of 7 years following the completion of IceCube construction. This person will visit sites where components are being built, review contracts and testing procedures, and has approval authority for insuring that appropriate quality and reliability standards are met. The R&QA manager reports formally to the Project Manager for matters affecting the IceCube Project. The SSEC quality assurance manager provides oversight for IceCube quality assurance matters. This structure provides the IceCube R&QA Manager with a mechanism to resolve conflicts or problems between the project and the policies of SSEC and A3RI.

2.7.2.9 Safety Officer

The Safety Officer is responsible for all aspects of compliance with federal, state, and local laws and regulations pertaining to environmental, safety, and health matters. The Safety Officer develops the plans, documentation, and surveillance necessary to comply with these laws and regulations. The IceCube Safety Officer will ensure that IceCube safety documentation meets the requirements of RPSC safety plans. This will include frequent communication with the RPSC Safety office including the exchange of formal documents for comment. The Safety Officer reports formally to the A3RI Director, and to the Project Manager as it pertains to IceCube project matters.

2.7.2.10 WBS Level 2 Leads

The Level 2 Leads have the authority and responsibility to manage all the activities within the WBS element. The Level 2 Coordinators report to the Project Manager. The Level 2 Leads will work in close coordination with both the Project Director and Project Manager. Level 2 Leads will have control over and responsibility for the allocated budget to the WBS element, schedule matters, work assignments to institutions and management of interface matters between institutions and specific WBS tasks. Level 3 Leads report to the Level 2 Lead. The Level 2 Leads also serve as a communication link to the IceCube Collaboration as they will reside principally at their home institutions, spending modest time at the Project Office at UW – Madison. The Science Operations Coordinator has the additional role of communicating with the IceCube Collaboration Board.

## 2.8 Memorandums of Understanding

Memoranda of Understanding (MOU) will establish the basis of working relationships between the host institution, the University of Wisconsin-Madison, and the members of the IceCube collaboration. These are being drafted and negotiated by the IceCube Project Office for formal approval by the International Oversight Group. These agreements will provide the general descriptions of mutually agreed upon tasks to be performed by the collaboration member. Detailed descriptions of the work to be performed, the schedules the cost, and deliverables will be included in a Statement of Work developed by the collaboration member and approved by the host institution. The Statement of Work will be an exhibit of the MOU. The MOU will be reviewed along with progress each year, as part of the yearly financial planning cycle and the Statement of work will be modified as required.

The US members of the IceCube collaboration will subcontract to the University of Wisconsin-Madison. The subcontract will be established by means of a proposal to UW that contains a statement of work, technical requirements, specification where appropriate, schedule, and cost of elements to be provided. A subcontract manager from the IceCube project office will monitor progress and be the point of contact for contractual matters between the project office and collaboration institutions. The subcontract manager reports to the PM.

# 3.0 Management

The IceCube Project requires project management that can deal with a compound/complex project that is distributed across three continents and funded by several governments. The project is compound in the number of tasks, the number of independent contributors and the number of years that it spans. It is complex in that it must be designed to explore the edges of scientific knowledge, without knowing what discoveries it will make. The inhospitable environment at the South Pole adds complexity to the logistics, deployment and maintenance of IceCube.

IceCube Project Management understands the issues and risks associated with the project and has developed plans and procedures to handle its unique requirements. Working with the Collaboration partners, we have devised a management structure that deals with the issues and concerns of all of the stakeholders. While many of the project management tools are common, enhancements such as Internet-based status updates and reporting will allow the Project Office to obtain and maintain project status in near real-time and be able to respond to developing problems in a timely manner.

## 3.1 Cost and Schedule Control

The Ice Cube Project Office develops, maintains and uses a consistent set of cost and schedule baselines for the development, implementation and commissioning of the Ice Cube Neutrino Observatory. These baselines use the IceCube Work Breakdown Structure as the basis for planning. Schedules for the construction of IceCube are the responsibility of the Project Manager, while those associated with scientific operation are the responsibility of the Project Scientist. A web-based Project Management System provides the mechanism to report progress against these baselines and to create summary reports for the stakeholders. This information will be supplemented with data obtained from a variety of other sources, including management teleconferences, financial reports, placement of orders and/or subcontracts, and site visits. The schedules will include well-defined milestones against which progress of major tasks will be judged.

### 3.1.1 Objectives

The following objectives will be used to guide the management of the Ice Cube project:

- To plan and schedule all activities necessary to meet the scientific, technical and project objectives with minimum risk;
- To routinely monitor and report the cost and schedule status;
- To use the WBS structure for measuring the cost of the work performed against the cost of the work scheduled and the web-based Project Management System for comparing actual schedule against planned schedule. These tools are used to identify potential cost and schedule problems that require corrective action.
- To keep the stakeholders informed about the status of the project.

### 3.1.2 Responsibilities.

The Project Manager is responsible for the completion of IceCube construction on schedule and within budget, while meeting the science requirements set by the Collaboration Board and the PI, and verified by the Project Scientist. The Project Office will work with SSEC to implement automated cost and schedule tracking, analysis, and reports. This facility will include monthly comparisons of resource use in comparison to plan as a means to monitor progress and expenditure rates. Password protected web postings of summary reports will provide managers outside of the UW with the means to follow the overall progress of the project.

The Project Office is responsible for seeing that tasks are properly executed. If difficulties emerge, it has the authority to take appropriate action to rectify the situation through the use of its technical, financial, and management resources. In cases where a solution is not found in a timely way, the Project Office will transmit its concern to the Principal Investigator and also contact the relevant oversight group in writing, presenting the nature and impact of the concern. This will be the Dean of the Graduate School for issues under control of the host institution. The chair of the International Oversight Group will be contacted for difficulties involving the international or national partners. These groups have the authority to change the nature of the relationship between any party and the IceCube Project and will act to ameliorate the problem, including suspension of the relevant MOU if no solution is found.

Each of the WBS Level 2 functional areas has a coordinator who is technically knowledgeable about his area and understands the issues involved in successfully completing the Level 3 tasks grouped in his area. The Coordinator ensures that communications among the Level 3 Managers are open and that issues involving the interfaces or dependencies among the tasks are resolved. They are also responsive to the management issues of the Project Manager and provide a conduit between the Level 3 Managers and the Project Office. They provide a single point of contact for information required by the Project Manager, Project Scientist, or Principal Investigator. Their job is to facilitate information flow between the Project Office and the Level 3 Managers and to reduce the risks involved in the distributed task structure. Level 2 coordinators will meet with Project Management weekly.

Managers are assigned to WBS Level 3 tasks. Level 3 Managers are responsible for the financial, schedule and technical performance of the tasks they are assigned. They implement risk management procedures in accordance with the Risk Management Program Plan and mitigate the risks associated with their tasks. They report to the Level 2 Coordinator on a continuous basis and participate in weekly telephone conference calls with other Level 3 Managers as scheduled by the Project Manager. They will provide formal written status reports and financial/resource expenditure summaries to the Project Manager on a monthly basis.

Level 3 Managers shall take immediate actions to correct any task that is falling behind schedule, consuming more resources than planned or encountering unforeseen difficulties. If the impact of a problem on the project is greater than a Severity Level 1 in the Change Control Matrix, then the Level 3 Manager shall require approval at the appropriate management level shown in Table 3-1. The Level 3 Managers are responsible for continuously estimating what remains to be done, iterating the schedule, budget, and requirements for an optimum balance and communicating the results to all concerned.

### 3.1.3 Approach.

Level 2 Coordinators are responsible for providing communications among the Level 3 Managers about issues that span the responsibilities of any one Level 3 Manager. Level 2 Coordinators also provide an early warning mechanism for potential risks or problems. They are cognizant of the requirements of the group of Level 3 Tasks under them and act as the Project Office’s advisor on technical and schedule issues.

Weekly conference calls among the Project Manager and the Level 2 Coordinators are used to report progress or problems and to keep all parties informed and involved in current IceCube Project issues.

Monthly status reports provide the cost, schedule and technical progress on each task. The monthly status reports are entered into the Project Management System via the Internet. After reviewing the inputs for consistency and accuracy, the Project Management System will be updated and reports will be available on the Internet based on username/password protection and the role of the user. In addition to remote entry of information, the Project Office will obtain information from presentations at major reviews and from site visits. Site visits by members of the Project Office staff will be made at least annually to institutions carrying out significant tasks and will also be used to monitor progress of contracts.

A series of formal reviews will be conducted for the system and each major subsystem including a Subsystem Requirements Review, a Preliminary Design Review, a Critical Design Review and an Acceptance Review. The content and format of these reviews will be determined by the System Engineer and are detailed in the Engineering Management Plan.

When cost or schedule problems arise, the Project Manager, or his designee, will investigate and work with the cognizant Level 3 Manager or subcontractor to correct the problem within the resources currently allocated for the task. If current resources are not sufficient, it may be necessary to reduce the scope of the task, change the scope of another task to free up resources, apply contingency funds, or take any other action deemed appropriate under the circumstances. The Project Scientist will decide whether the proposed change represents a change in scope. Any problem that exceeds a Severity Level of 2 will require escalation to the appropriate management level. If any of these actions result in changes to the configuration baseline, then these changes will be proposed and reviewed in accordance with the Ice Cube Configuration Management Plan.

#### 3.1.4 Agency and Institutional Directives.

In the event that, in the view of the Project Office, NSF, UW, or any other collaboration members offer direction that significantly alters the scope, cost or schedule of planned activities; the Principal Investigator shall notify the NSF and the International Oversight Group, in writing, of the cost and schedule impact of such alterations. Any significant changes in scope require approval of the NSF Grants and Agreements officer or the equivalent officer of the International Collaboration Group, if the changes impact the expenditure of their resources.

### 3.2 Subcontract Management

#### 3.2.1 Objectives

It is the objective of the IceCube Project to build the IceCube Observatory in a timely fashion at the lowest cost. To accomplish this objective each participating US Institution and commercial vendor has a subcontract(s) with the host institution, the University of Wisconsin-Madison, that defines the cost, schedule and performance requirements for the work to be performed.

The Project Office Subcontract Manager, supported by IceCube scientists and engineers as required, supervises these contracted efforts.

### 3.2.2 Responsibilities

The IceCube Project Manager is responsible for ensuring that all aspects of the subcontracts are planned and managed successfully. He is assisted by a Subcontracts Manager who is responsible for the technical management of the subcontracts. Subcontracts will also be a focus area for the Financial Manager, who will assist the Project Manager, together with the SSEC Executive Director for Administration and the UW's Research and Sponsored Programs Office of the Graduate School, in setting up subcontracts and in identifying those subcontracts that require NSF approval. The Project Manager ensures that such approval and/or concurrence has been received prior to executing legally binding contracts. He also appoints the appropriate technical staff to be responsible for the technical management of the subcontracts.

Each of the major subcontracts is managed by a cognizant Manager (WBS Level 3). The Manager is responsible to the cognizant WBS Level 2 Coordinator for the day to day subcontract activities that require project attention. The Manager will provide the technical direction and oversight of the subcontract through regularly scheduled communication and on-site visits as required. The Project Office Subcontract Manager and the IceCube Contract Officer support the Manager. They will prepare and facilitate contract documentation and analyze cost and schedule data as appropriate. When cost or schedule problems arise, the Project Manager, cognizant Level 2 Coordinator and cognizant Manager, together with appropriate subcontractor personnel, will work together to resolve the problem. The cognizant Manager reports subcontract status at weekly Project Control Meetings and budget, schedule and resource status through monthly status reports.

### 3.2.3 Approach

Major IceCube subcontracts will be issued using selected contracting methods (Firm Fixed Price, Cost Reimbursable Contracts, etc.) appropriate for each contract. Subcontract terms incorporate applicable flow-down requirements from the Cooperative Agreement, the IceCube Science Requirements Document and the Engineering Requirements Document. Sub-contract terms provide for technical direction, progress payments based upon measurable performance milestones, and require delivery of data required to manage the contract. This data includes detailed technical status, cost experience, and cost-to-complete estimates. This information allows the detection of potential problems and the implementation of early corrective action through technical directives.

Subcontract specifications and/or Statements of Work appropriate for the subcontracted effort provide the necessary detail description of the tasks to be accomplished by the subcontractor. Subcontractors are selected based upon their responsiveness to Request for Proposal (RFP) requirements, relevant technical expertise, and financial capability to accept the risks of the method of contracting. The cognizant Manager participates in regularly scheduled meetings at the subcontractor's facility to monitor technical progress and ensure that decisions are made in a timely manner. While technical and quality control responsibility are delegated to the cognizant manager and institution, the IceCube Project Office maintains oversight by: 1) review and approval of subcontractor plans and procedures, 2) contractually required formal design reviews, and 3) inspection of work in progress.

## 3.3 Office of Polar Programs

The NSF Office of Polar Programs performs the construction, maintenance and operation of the facilities at the South Pole. The IceCube Project Office will establish a cooperative agreement with the Office of Polar Programs to perform these tasks.

## 3.4 Configuration Management

Configuration Management of the IceCube Project requires an approach that allows the tasks to be performed by a distributed network of collaborators and at the same time provides the necessary controls to ensure that the system configuration is maintained. The Project Office establishes the requirements for the IceCube Configuration Management and those requirements flow down to the organizations performing the actual tasks through MOU's and/or Statements of Work. Configuration requirements will be reviewed and approved by the Project Scientist, Program Manager and Systems Engineer in all cases. It is the responsibility of each organization to use its existing Configuration Management System or institute one that complies with the IceCube Configuration Management requirements. Conformance to configuration management plans will be monitored by the Deputy Program Manager and the R&QA Manager. Key management documents and their respective approval authority are shown in Table 3-4.

| **Document** | **Originator** | **Management Approval** | **Quality Assurance** | **Science Approval** |
|---|---|---|---|---|
| Science Requirements | Project Director | Project Manager | IQAM | Collaboration Board |
| Engineering Requirements | System Engineer | Project Manager | IQAM | Project Director |
| Project Management Plan | Project Manager | __ | IQAM | PI/PS |
| Quality | IQAM | Project | __ | Project |

| | | | | |
|---|---|---|---|---|
| Management System Plan | | Manager | | Director |
| System Engineering Management Plan | System Engineer | Project Manager | IQAM | Project Director |
| Risk Management Plan | System Engineer | Project Manager | IQAM | Project Director |
| Safety Plan | Safety Manager | Project Manager | IQAM | Project Director |
| Preliminary Design Document | Project Science Coordinator | Information Only | Information Only | Information Only |
| Technical Design Document | Project Director | Project Manager | IQAM | Collaboration Board |

**Table 3-4** Key Management Documents and Approvals

### 3.4.1 Configuration Management Plan

A Configuration Management Plan (CMP) shall be developed by the Reliability and Quality Assurance Manager, in close consultation with each work team, that insures the schedule, budget and performance impact of changes to the Ice Cube Project are tracked and recorded. This CMP provides: 1) a mechanism for the identification of changes, 2) a process to manage the change, 3) a method to verify the proper implementation, 4) reports to notify the change to others who have an interest, and 5) records of the change for historical reference.

### 3.4.2 Approach

A top-level project requirements document, the IceCube Science Requirements Document, shall be developed during the first three months of the program by the science team working with the Project Scientist. The Project Scientist takes responsibility for ensuring that IceCube as built will meet the science requirements. The IceCube Systems Engineer will work with the Project Scientist to develop the Engineering Requirements Document, ERD, based on the Science Requirements Document. Once these documents are completed and approved by the Collaboration Board, they will become the Ice Cube Requirements Baseline. This approval will establish the "functional baseline" for the IceCube Project.

The systems engineer will lead the definition of lower level system and subsystem requirements. A requirements matrix will be used to identify where the requirement is satisfied in the system. All hardware and software elements of the IceCube system will then be defined in subsystem specifications.

At the appropriate point in the program for each subsystem, after the Preliminary Design Review (PDR) these specifications will be placed under configuration control. This will be accomplished in consultation with the R&QA Manager who will present it as a formal document to the Project Office management team for final acceptance. This forms the "designed to" baseline for the subsystem. Subsequent changes are made by means of formally controlled Engineering Change Orders (ECO's) process. The ECO process will assure proper review by all affected project elements.

At the Critical Design Review (CDR), the "build to or code to" baseline is established and is placed under formal change control. Later, after the subsystem is created, the "as built" baseline is established and will also be controlled by the ECO process.

Updated documentation will be made available to all affected parties. A version control system ensures that the latest version of any project document is accessible to all users. The details of this process will be described in the Configuration Management Plan.

### 3.4.3 Change Control

Change is inevitable in the development process and managing these changes is necessary throughout the IceCube Project lifecycle. These changes will be managed at two levels, the Project Management level and the Collaborating Institution level. Changes have been assigned "severity levels" based on the magnitude of their impact on budget, schedule and technical performance as shown in Table 3-1.

The Project Management level addresses changes that have been assigned a severity level of two or greater. The Collaborating Institution level addresses issues of severity level one and changes to its "configuration items." The details of the change management process are described in the Configuration Management Plan and in the Configuration Management Plans of the collaborating institutions.

In general, the Project Office will be responsible for maintaining Configuration Management of the "Level 1" documents, for example, the IceCube Science Requirements Document, the Engineering Requirements Document, the System Design Document plus other system level documents. The institutions performing tasks at WBS Level 3 and below will be responsible for maintaining the configurations of their own configuration items.

#### 3.4.3.1 Institution Level Change Control.

The Collaborating Institutions are responsible for managing the change process at their respective institution. Each institution will be responsible for developing a Configuration Management Plan that satisfies the requirements of the IceCube Configuration Management Plan. In addition, each institution is given the authority to make changes that are considered to be a Severity Level One. The Project Manager will be informed of all changes so that the possible impact of the change on other parts of the project can be assessed.

3.4.3.2 Project Management Level Change Control.

Changes to the baseline technical requirements, schedule, and budget at severity level 2 will follow a change control process overseen by the Project Manager. At severity level 3 and above, a technical board composed of subsystem managers, the Level 2 Coordinators and others designated by the Project Manager will function as the Change Control Board (CCB). The Project Manager chairs the CCB. The Principal Investigator is also a member of the CCB to ensure that the scientific requirements of the project are met. At severity level 4 the change process requires approval of the Collaboration Board. Changes in the scientific objectives, total cost, or completion date are considered Severity Level 5 and require endorsement by the NSF and the International Oversight Group.

3.4.3.2.1 Severity Level 2.

The Project Manager can approve a change that affects the Task 3 Schedule by more than one month but less than three months and/or involves more than $50K in expenses.

3.4.3.2.2 Severity Level 3.

If the change involves a change of more than 3 months schedule and/or $250K, then the Change Control Board and the Principal Investigator must make the decision. Changes at this level will normally affect more than one Level 3 Task and will have impact on deployment.

3.4.3.2.3 Severity Level 4.

In the case where the proposed change affects the schedule by more than 6 months, represents a major technical design change, or results in a major change in scope for the IceCube Collaboration, then the Principal Investigator and the Collaboration Board, would be required to decide on the merits of the proposed change.

3.4.3.2.4 Severity Level 5.

If during the course of the IceCube Implementation, new scientific goal(s) are developed or existing scientific goal(s) are dropped that result in a change in scope for the IceCube Project, the resulting change would have to be proposed by the Principal Investigator or the Spokesperson for the Collaboration Board and approved by the Principal Investigator, the Collaboration Board and the International Oversight Group and their respective funding agencies.

**Change Control Matrix**

| Proposed Change | Subsystem Manager (Level 3) | Project Manager /Project Director | Change Control Board | Principal Investigator | IceCube Collaboration Board | International Oversight Group | Severity Level |
|---|---|---|---|---|---|---|---|
| Level 3 Task change < $50K | X | | | | | | 1 |
| Level 3 Task schedule change <1 month | X | | | | | | |
| Technical Change affects only Level 3 Task | X | | | | | | |
| Level 3 Task schedule change < 3 months | X | X | | | | | 2 |
| Level 3 Task change > $50K | X | X | | | | | |
| System change > $250K | X | X | X | X | | | 3 |
| System schedule change > 3 months | X | X | X | X | | | |
| Project schedule change > 6 months | X | X | X | X | X | | 4 |
| Baseline design or scientific scope change | X | X | X | X | X | | |
| Scientific objectives total cost or Completion date | | | | X | X | X | 5 |

**Table 3-1 Approvals Required for Changes in Project.**

### 3.4.4 Configuration Management Accounting

The purpose of configuration accounting is:

- To maintain an up to date list of all project baseline documents;
- To maintain the current status of all changes;
- To provide access to all documents under configuration control.

The Project Office maintains a Document Control Center that maintain copies of all controlled documents and their current revision status. Project personnel will be able to obtain copies electronically from the Document Control Center.

The Ice Cube technical baseline will be maintained throughout the project. Site visits will be made to enhance communication about the requirements and progress of systems as they are being designed and built. Audits may be performed to ensure that the system "as built" reflects the system "as designed" and that the system meets the requirements of the Ice Cube System Baseline.

### 3.5 Risk Management

Risk is defined as the possibility of loss or injury or the failure to achieve program goals. In the IceCube Project, risk will be classified as programmatic, technical, cost, schedule, and supportability.

Risk Management is the sum of all proactive management-directed activities within a program that are intended to acceptably accommodate the possibility of failures in elements of the program. It is the continuous process of: 1) planning, 2) identifying, 3) analyzing and 4) mitigating and tracking risk. Risk management can not be separated from good project management and, as a result, will be an integral tool for managing the IceCube Project. The Project Manger is responsible for ensuring that risk management is implemented and mechanisms exist for its application throughout the IceCube Project lifecycle. The basic risk management philosophy of the IceCube Project is that everyone is responsible for identifying risks and that once identified, someone will be responsible for managing the risk. In order to integrate Risk Management activities into the Project Management activities, a Risk Management Program Plan will be developed by the Project Office.

#### 3.5.1 Risk Management Plan.

The Risk Management Program Plan will identify the project's overall risk policy and objectives. It will define responsibilities, resources, schedules and milestones for risk management as it applies to the IceCube Project. The methodologies, processes and tools that will be used for risk identification and characterization, risk analysis, and risk mitigation and tracking will be identified. It will also define the role of risk management in reliability analysis, reviews, and status reporting. Documentation required for each risk management product and action will identified so that a history of decisions can be maintained.

## 3.6 Quality Assurance

IceCube project management will implement a quality plan meeting the requirements of ANSI/ISO/ASQC Q9001-2000 (ISO 9000). The UW Space Science and Engineering Center (SSEC) is in the process of implementing a Quality Management System (QMS) meeting the requirements of ISO 9000 and eventual registration.

The ISO 9000 standard is process based using a “plan, do, check, act” model. The plan begins with identification of the processes necessary to control quality. The definition and documentation of those processes are done to the extent required to achieve the desired results. The QMS emphasizes the process of continuous improvement via internal audits, corrective and preventive action, and management review. The system is based on the heritage of assurance programs meeting NASA requirements for spacecraft instrument development projects that SSEC has implemented within a university based research and development organization. In general, the quality aspects of the project are designed and built-in from the beginning, rather than “tested in” after the fact. This approach makes quality assurance part of the management and engineering process thereby increasing efficiency, improving results, and minimizing errors.

### 3.6.1 Scope.

The IceCube Quality Plan will define the overall project policy, the processes to be controlled and how they interact, and the procedures to be used.

The details of the plan will resemble plans appropriate for spacecraft instrumentation because IceCube must operate reliably in a remote and harsh environment, is a large and complex system, once deployed cannot be returned for repair, and represents a major investment. The quality plan must therefore be rigorous and fully integrated in the management and development process.

The plan will include, but not be limited to, addressing the following areas: the overall scope of the Quality Plan, the standards (ISO 9000, etc) it is designed to meet; the control of documents; the quality organization; the control of customer and supplier documentation; the procurement controls; the management review process; the design and development processes including design reviews and design documents required by phase; the reliability guidelines; the assembly standards; the traceability requirements; the inspection and test standards; and non-conformance control;

### 3.6.2. Key Quality Documents

Several key documents will be used to define the IceCube Quality Plan. The American National Standard ANSI/ISO/ASA Q9001-2000 (and referenced documents) defines the standards we are intending to meet. The SSEC Quality Management System (QMS) Plan (in development) describes the UW-Madison SSEC Quality Management System policies and procedures. The IceCube Quality Plan will describe how the SSEC QMS will be applied to meet the needs of the IceCube project. Supporting Procedures, Specifications, and Instructions will be created specifically for IceCube.

## 3.7 Environmental, Safety and Health Protection

This section describes the policies being established to ensure that Environmental, Safety and Health Protection (ES&H) considerations are adequately addressed within the IceCube project activities. ES&H is a line management responsibility represented by the ES&H Officer who has dual reporting responsibilities to the Project Manager and the Director of A3RI.

### 3.7.1 Objectives

The IceCube ES&H program has the following specific objectives:

- to prevent personnel injury or loss of life during all phases of the IceCube project;
- to prevent any environmental contamination during the construction, test or operation of IceCube;
- to prevent damage to equipment caused by accidents during all phases of the project; and
- to comply with all federal, state and local laws, rules and regulations.

### 3.7.2 Responsibilities

The IceCube ES&H program is the responsibility of the Project Manager. The Project Manager has responsibility to insure that the IceCube project members identify specific ES&H issues and risks, and establish appropriate safeguards and procedures for addressing those risks. To accomplish the detailed ES&H planning, documentation and surveillance, an IceCube ES&H Officer will be appointed. The ES&H Officer shall be responsible for all ES&H program activities and report to the Project Manager on matters pertaining to the ES&H program.

Industrial contractors will perform a major portion of the IceCube project. These contractors will implement their own ES&H policies and procedures, which will be subject to review and audit by the ES&H Officer and the IceCube project staff. The project will be supported in its oversight function as needed, by employing the available expertise of UW's Occupational Safety Office.

### 3.7.3 Environmental Protection

The IceCube project shall follow standards and practices which fully support the NSF environmental protection policies and requirements. The project will initiate activities necessary to ensure compliance with the Resource Conservation and Recovery Act (RCRA) and the National Environmental Policy Act (NEPA).

### 3.7.4 Safety and Health Protection

UW has an established Safety Office, responsible for the Institute's overall safety and health program, and the IceCube management will implement the applicable health and safety program elements as outlined in the UW Safety Manual. The specific areas which will be addressed are hazards and safety requirements related to the construction of the facility, and the installation and operation of the detector system. For work performed at other collaboration partners facilities, the safety and health protection measures adopted by their respective organizations will similarly apply.

The following order of precedence for resolving safety issues has been established by the IceCube Project:

Design for Minimum Risk: The primary means for mitigation of risk shall be to eliminate the hazard through design.
Incorporate Safety Devices: Fixed, automatic or other protective devices shall be used in conjunction with the design features to attain an acceptable level of risk. Provisions shall be made for periodic functional checks as applicable.
Provide Warning Devices: When neither design nor safety items can effectively eliminate or reduce hazards, devices shall be used to detect the condition, and to produce an adequate warning to alert personnel of a hazard. Devices may include audible or visual alarms, permanent signs or movable placards.
Procedures and Training: Where it is impractical to substantially eliminate or reduce the hazard or where the condition of the hazard indicates additional emphasis, special operating procedures and training shall be used.

### 3.7.5 Employee Training

IceCube project employees will be provided with procedures, training and information to ensure their safety. Briefings and presentations will be made to managers and supervisors to communicate ES&H policies and procedures.

### 3.7.6 Contractors and Visitors

Contractors and visitors to the IceCube operational sites will be informed of ES&H rules and procedures applicable to the specific area. Hosts will be responsible for the safety of visitors.

### 3.7.7 Documentation

The IceCube Project shall provide hazard assessments, safety analyses and evaluations as required. Specific procedures and training documents will be prepared and released.

### 3.7.8 Governmental Code Requirements.

The IceCube Project, including its contractors, will comply with applicable US Federal Codes, laws and regulations, industrial codes and state rules, regulations and codes. The ES&H Officer, together with the Project Manager, will be responsible for clarifying compliance requirements and the resolution of safety issues.

## 3.8 Institutional Roles and Responsibilities.

A matrix that relates the WBS tasks to the Roles and Responsibilities of each collaboration partner is attached as Appendix 1.

## 3.9 Work Breakdown Structure

IceCube WBS Structure

Revision Date: 6/21/00

- 1 Project Support
  - 1.1 Management
    - 1.1.1 Project Manager / Deputy Project Manager
      - 1.1.1.1 Project Planning
      - 1.1.1.2 Subsystem Management
      - 1.1.1.3 Reserve Management
      - 1.1.1.4 Progress Reports
      - 1.1.1.5 Risk Management
      - 1.1.1.6 Project Tracking
      - 1.1.1.7 Statement of Works / Memorandum of Understanding
    - 1.1.2 Financial
      - 1.1.2.1 Cost & Schedule Updates
      - 1.1.2.2 Monthly Reports
      - 1.1.2.3 Budget Replanning
    - 1.1.3 Subcontracts
      - 1.1.3.1 Monitoring
      - 1.1.3.2 Subcontract Planning
      - 1.1.3.3 Site Visits
    - 1.1.4 Reviews
      - 1.1.4.1 Yearly Reviews
      - 1.1.4.2 External Advisory Committee
      - 1.1.4.3 Design Reviews
      - 1.1.4.4 Collaboration Meetings
    - 1.1.5 Reliability & Quality Assurance
      - 1.1.5.1 Quality Assurance Plan
      - 1.1.5.2 Coordination
      - 1.1.5.3 Procedures / Configuration Control
      - 1.1.5.4 Monitoring

- 1.2 Systems Engineering
  - 1.2.1 Specifications and Requirements
    - 1.2.1.1 Drill System
    - 1.2.1.2 Optical Modules
    - 1.2.1.3 Cables & Strings
    - 1.2.1.4 Data Acquisition
    - 1.2.1.5 Data Handling
  - 1.2.2 Interface Control Documents
    - 1.2.2.1 Data Acquisition / Data Handling
    - 1.2.2.2 Data Handling / Uplink
  - 1.2.3 Risk Assessment
    - 1.2.3.1 Planning
    - 1.2.3.2 Assessment
    - 1.2.3.3 Monitoring
  - 1.2.4 Engineering Support
    - 1.2.4.1 Electrical Engineering
    - 1.2.4.2 Mechanical Engineering
    - 1.2.4.3 Software Support
- 1.3 Education and Public Outreach
  - 1.3.1 Coordination
  - 1.3.2 High School Teacher Training
    - 1.3.2.1 Teaching
    - 1.3.2.2 Develop Curricular Material
  - 1.3.3 Summer Enrichment Program
  - 1.3.4 Curricular & Class Module Development
    - 1.3.4.1 UW Dissemination
    - 1.3.4.2 Teachers in Antarctica
    - 1.3.4.3 UCB Dissemination
    - 1.3.4.4 Southern University
  - 1.3.5 Evaluation

2 Implementation

- 2.1 Logistics
  - 2.1.1 Logistics Liaison
    - 2.1.1.1 Personnel
    - 2.1.1.2 Cargo
    - 2.1.1.3 Lab & Communication
- 2.2 Drilling
  - 2.2.1 Planning
    - 2.2.1.1 Staffing
    - 2.2.1.2 Equipment
    - 2.2.1.3 Component Testing
    - 2.2.1.4 "Inventory, Inspection, & Repair"
  - 2.2.2 Drill Upgrades
    - 2.2.2.1 Wotan Development
    - 2.2.2.2 Production Drill
  - 2.2.3 Drill Verification Seasons

2.2.3.1 "Drill Season 1, FY-04"
2.2.3.2 "Drill Season 2, FY-05"
2.2.4 Production Drilling
2.2.4.1 "Drill Season 3, FY-06"
2.2.4.2 "Drill Season 4, FY-07"
2.2.4.3 "Drill Season 5, FY-08"
2.2.4.4 "Drill Season 6, FY-09"
2.2.4.5 "Drill Season 7, FY-10"
2.3 Deployment
2.3.1 Planning
2.3.1.1 "Planning, staffing and preparation (UW)"
2.3.1.2 Coordination (South Pole)
2.3.2 Optical Module & String Preparation
2.3.2.1 OM quality tests
2.3.2.2 Cable preparation
2.3.2.3 Site preparation
2.3.3 Deployment
2.3.3.1 Mount 60 Optical Modules on String
2.3.3.2 Cable drag
2.3.3.3 Final Checkout & Handoff to DAQ
3 Instrumentation
3.1 In-Ice Devices
3.1.1 Optical Modules
3.1.1.1 Optical Module Technical Design
3.1.1.2 Optical Module Main PCB Technical Design
3.1.1.3 Procurement
3.1.1.4 Integration & Production Planning
3.1.1.5 Optical Module Production
3.1.1.6 Optical Module Main PCB Production
3.1.1.7 Quality Assurance and Calibration
3.1.2 Cables
3.1.2.1 Electrical & Fiber Cables
3.1.2.2 Specification
3.1.2.3 Quality Assurance
3.1.3 Calibration Devices
3.1.3.1 Design & Build Light Sources
3.1.3.2 Design & Build IceTop
3.1.3.3 Pressure & Temperature Sensors
3.2 Data Acquisition
3.2.1 Design
3.2.1.1 System Architecture
3.2.1.2 System Design
3.2.1.3 Front End Engineering & Prototyping
3.2.1.4 Trigger Subsystem
3.2.1.5 Event Builder Subsystem
3.2.1.6 Power & Slow Controls

- 3.2.1.7 Calibration & Monitoring
- 3.2.1.8 Post-Deployment Commissioning

3.2.2 Software
- 3.2.2.1 System Architecture
- 3.2.2.2 Experimental Control
- 3.2.2.3 String Control
- 3.2.2.4 Trigger Subsystem
- 3.2.2.5 Event Builder Subsystem
- 3.2.2.6 "Data Quality Assurance, Calibration, & Monitoring"

3.2.3 System Test
- 3.2.3.1 Design
- 3.2.3.2 Fabrication
- 3.2.3.3 Test & Evaluation

3.2.4 Fabrication
- 3.2.4.1 Purchasing & Warehousing
- 3.2.4.2 Fee Board Production
- 3.2.4.3 Fee Board Quality Assurance
- 3.2.4.4 "Crates, Racks, & Power Supplies"
- 3.2.4.5 Commissioning / On-site Installation

3.3 Data Handling

3.3.1 Management
- 3.3.1.1 Data Handling Coordinator
- 3.3.1.2 Data Handling Manager
- 3.3.1.3 Software Architecture

3.3.2 Analysis Tools
- 3.3.2.1 Data Model
- 3.3.2.2 Database Design
- 3.3.2.3 Calibration Database Librarian
- 3.3.2.4 Simulation
- 3.3.2.5 Track Reconstruction
- 3.3.2.6 Energy Reconstruction Librarian
- 3.3.2.7 Cascade Reconstruction Librarian
- 3.3.2.8 Visualization Tools
- 3.3.2.9 Monitor Tools

3.3.3 On-line System
- 3.3.3.1 On-line System Management
- 3.3.3.2 On-line Processing
- 3.3.3.3 Data Archive & Transfers

3.3.4 Off-line System
- 3.3.4.1 Off-line System Management
- 3.3.4.2 Off-line Integration / Automation
- 3.3.4.3 Data Distribution Tools

4 Science Operations

4.1 Detector Operations

4.1.1 Detector Monitoring & Maintenance
- 4.1.1.1 Slow Controls
- 4.1.1.2 Monitor Detector Performance
- 4.1.1.3 Monitor Data Quality
- 4.1.1.4 Winterovers

4.1.2 Calibrations
- 4.1.2.1 PMT Gain
- 4.1.2.2 Timing
- 4.1.2.3 Geometry
- 4.1.2.4 Ice Properties
- 4.1.2.5 IceTop

4.2 Data Analysis

4.2.1 Data Analysis Management
- 4.2.1.1 Data Analysis Coordinators
- 4.2.1.2 Working Group Coordinators
- 4.2.1.3 Editors for Publication

4.2.2 Calibration
- 4.2.2.1 Calibration Database Design
- 4.2.2.2 Detector Geometry Calibration
- 4.2.2.3 PMT Time Calibration
- 4.2.2.4 PMT Gain & Efficiency
- 4.2.2.5 Ice Properties

4.2.3 Simulation Working Group
- 4.2.3.1 Generate Signal & Background Events
- 4.2.3.2 Tune Detector Simulation Parameters

4.2.4 Reconstruction Working Group
- 4.2.4.1 Single Muon Tracks
- 4.2.4.2 Multi-Muon Bundles
- 4.2.4.3 Cascades
- 4.2.4.4 Taus
- 4.2.4.5 Contained Events

4.2.5 Working Group 1
- 4.2.5.1 Atmospheric Muons
- 4.2.5.2 IceTop

4.2.6 Working Group 2
- 4.2.6.1 Atmospheric Neutrinos
- 4.2.6.2 Neutrino Oscillations
- 4.2.6.3 WIMPs

4.2.7 Working Group 3
- 4.2.7.2 Point Sources
- 4.2.7.3 GRB
- 4.2.7.4 Relativistic Monopoles

4.2.8 Working Group 4
- 4.2.8.1 Isolated Cascades
- 4.2.8.2 Electron Neutrinos
- 4.2.8.3 Neutral Current Events

## 5.0 **Cost and Staffing**

### 5.1 Cost Estimate

The total cost estimate for the IceCube Project is $209,246 million dollars. This estimate includes $41.7 million dollars contributed by the European Collaboration partners reducing the cost to be funded by the NSF to $167.6 million dollars. These estimates include contingency and inflation using OMB inflation rates. This does not include the cost of PRSS logistics support.

### 5.2 Funding Profile

The funding profile by Fiscal Year is shown in Table 5-1.

| | FY02 | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Total Cost | 23,913 | 30,042 | 35,402 | 32,770 | 25,009 | 23,014 | 15,116 | 13,642 | 10,338 | 209,246 |
| European Contributions | 3,301 | 5,711 | 6,733 | 6,663 | 5,515 | 4,982 | 3,245 | 3,034 | 2,496 | 41,679 |
| NSF Cost | 20,612 | 24,331 | 28,669 | 26,107 | 19,494 | 18,032 | 11,871 | 10,608 | 7,842 | 167,567 |

Table 5-1 Funding Profile by Fiscal Year in $1,000's of dollars including contingency and inflation

### 5.3 Contingency

Due to the risks inherent in the construction of IceCube, provisions for contingency funding have been using the following formula:

*Contingency (in %)* $= W_t R_t + W_c R_c + R_d + R_s$

Where,
$R_t$ = Technical Risk Score (1-10; 15)
$R_d$ = Design Risk Score (1-10; 15)
$R_c$ = Cost Risk Score (1-10; 15)
$R_s$ = Schedule Risk Score (1-8)
$W_t$ = Technical weighting factor (1, 2, 3 or 4)
$W_c$ = Cost Weighting Factor (1 or 2)

Applying this approach to the lowest level WBS items results in the contingencies shown in Table 5-2.

| | FY02 | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Contingency | $ 4,271 | $ 4,692 | $ 4,937 | $ 4,132 | $ 2,892 | $ 2,537 | $1,084 | $ 872 | $ 561 | $ 25,978 |

Table 5-2 Contingency budget for IceCube in 1000's dollars not including inflation.

Further contingency for the project is in a funded schedule reserve year, Fiscal Year 10, $7.84M. Total contingency for the project is then $33.82M.

## 5.4 Staffing

The staffing profile for the IceCube Project by Fiscal Year is shown in Table 5-3.

| | FY02 | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| FTE's | 98 | 123 | 145 | 143 | 127 | 119 | 110 | 102 | 82 | 1,641.1 |

Table 5-3 Full time Equivalents by Fiscal Year

## 6.0 **Schedule {See A3RI web site URL http://www.ssec.wisc.edu/A3RI/icecube/internal/Top_Level_skd.pdf for current schedule}**

## 6.1 Development Schedule

## 6.2 Construction Schedule

## 7.0 Reporting

## 7.1 Reports to NSF and International Oversight Group

### 7.1.1 Monthly Progress Reports

A monthly progress report will be prepared and submitted to the NSF. The report will include financial, schedule and technical status and will highlight any spending of Contingency Funding in excess of $100K. Changes in schedule of over three months will be discussed with a planned recovery plan. The monthly report will also include progress versus any major schedule milestones that happen to fall in that month.

### 7.1.2 Quarterly Progress Reports

Three IceCube Project Quarterly Reports shall be prepared and submitted to NSF and the IOG for the first three-quarters of each fiscal year. This report is prepared in accordance with the Cooperative Agreement and "shall consist of a summary of work accomplished during the reporting period. The quarterly report will include major scientific and technical accomplishments, an assessment of current status against scheduled status, a review of current or anticipated problem areas and corrective actions, and a status of action items affecting IceCube/NSF/IOG responsibilities. This report shall also include management information such as changes in personnel, a financial status report and other financial information including actual or anticipated underruns or overruns, and any other action requiring NSF/IOG notification."

The financial information in the Quarterly Report will include a summary (to WBS level 3) of actual obligations compared to the baseline estimated costs and graphs showing actual obligations (to WBS level 2) versus time compared with the planned obligation profile. A narrative discussion of construction and R&D progress will be provided and referenced to the baseline schedule. The Report will include a description of all Change Control actions for key milestones or contingency usage, and any changes in the annual acquisition plan.

### 7.1.3 Annual Report

An Annual Report will be prepared and submitted to NSF and the IOG, in lieu of a fourth Quarter Report, containing: "1) a summary of overall progress, including results to date, and a comparison of actual accomplishments with the proposed goals of the period; 2) Indication of any current problems or favorable or unusual developments; and 3) a summary of work to be performed during the succeeding year; and any other pertinent information." Financial and schedule status information similar to that given in the Quarterly Report will be included in the Annual Report.

### 7.1.4 Annual Work Plan

Prior to the development of the Annual Work Plan, the IceCube Project will conduct planning meeting(s) with the NSF Office of Polar Programs and their support contractor to review the IceCube requirements. Each year on October 1, the IceCube Project shall negotiate and submit an annual Work Plan and a funding request to the NSF. This Plan shall discuss and compare the scientific and program achievements with the planned goals in the currently approved Work Plan. It will summarize the proposed goals for construction, R&D, science and collaborative programs for the next program year. Significant staffing changes, estimated costs, and schedules for the next year will be presented for each level 3 WBS item and compared with the current IceCube cost/schedule baseline. Any changes to the IceCube organization will be described. Additional changes to the current Project Management Plan will be discussed. The Annual Work Plan shall provide the IceCube annual calendar that includes proposed dates for IOG and advisory committee meetings, scientific workshops and reviews. The

Plan shall include, for procurements greater than $100K in value an acquisition plan including the proposed date of submission to NSF and the type of procurement.

The annual plan will also identify changes to the IceCube cost, schedule and technical baseline. Changes exceeding $250K and schedule changes of over 90 days will described along with planned corrective actions for approval by the NSF/IOG. If these changes modify the existing Program Management Plan, the Program Management Plan will be updated in accordance with the Configuration Management Plan.

## 7.2 Meetings and Reviews

### 7.2.1 Internal Meetings

The IceCube Project Office will conduct several different types of meetings to assess the progress of the project. Since the IceCube Project involves many collaboration partners in the US and Europe, Weekly Project management meetings will be held primarily by conference call to determine the current status of all tasks. Focus will be on what has been accomplished to plan, what are the next important milestones and what are the anticipated or existing problems. Corrective actions will be developed and their progress will be reviewed the following week(s). Configuration Control Board meetings will be conducted as required to review and approve change requests. Preliminary and Critical Design Reviews will be conducted on the system design and each of the subsystems to determine that they meet the requirements of the IceCube Science and Engineering Requirements. Communications with the UW SSEC and A3RI will be promoted by weekly coordination meetings; every month one meeting will be devoted to reviewing the draft of the NSF monthly report.

### 7.2.2 IceCube Collaboration Group Meetings

IceCube Collaboration Group meetings will be held at least twice a year. One meeting will be in Europe and one will be in the United States. Progress and status reports of the IceCube Project will be presented to the entire collaboration. These meetings will also serve as a forum for the presentation of scientific results by collaboration members. Official Collaboration Board meetings will be conducted at these meetings.

### 7.2.3 IceCube Advisory Committee Meetings

The External Advisory Committee will meet annually to review performance and progress of the IceCube Project. Members of the IceCube Project science, engineering, and management teams will give short briefings. The External Advisory Committee will provide a summary report to the Collaboration Board and PI with recommendations, suggested plan of action, and general observations after conclusion of the meeting.

### 7.2.4 IceCube International Oversight Group Meetings

The International Oversight Group will meet annually to approve MOU's or changes to MOU's and to review the current status of the IceCube project.  The IOG reviews and endorses the Annual Work Plan including budget, schedule and technical objectives.