July 2001

JOIDES

Arctic Detailed Planning Group Report

A Letter from the DPG Chair

July 2001

I am pleased to submit this report to the Scientific Committee of the Ocean Drilling Program. Since last November, it has been my pleasure to work with some of the world's experts on Arctic operations, icebreakers, drilling, coring, and ice conditions. The team of people that was selected to this Detailed Planning Group provided an ideal balance of technical expertise and Arctic field experience that enabled us to fulfill the mandate assigned by the JOIDES Science Committee. Through the work of the Group members and with the help of Joint Oceanographic Institutions, we supplemented our own knowledge with that from other experts, including icebreaker captains, naval architects, weather and ice management experts, and Arctic drilling managers.

This extended group of experts has shared in the scientific excitement that ODP Proposal 533, to drill the Arctic's Lomonosov Ridge, promises to deliver. But more importantly, through our deliberations, we have also grown to share a vision that this expedition, at the top of the world, can be effectively and safely achieved using existing, well-proven equipment and ships. We agree that it is time to put aside the myth of the "challenge of the Arctic" and boldly undertake this mission for the benefit of science and society.

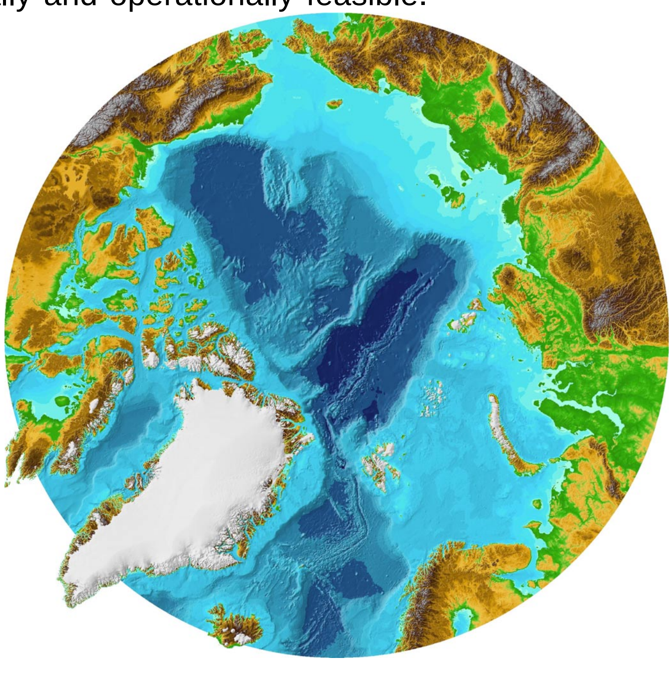
Jan Backman
Chair, JOIDES Arctic Detailed Planning Group

Executive Summary

Over the past few years, there has been increasing awareness that the Arctic Ocean plays a fundamental role in the global ocean-climate system. Yet there is a remarkable lack of the most rudimentary information about this ocean's geologic history. Ocean Drilling Program (ODP) Proposal 533, "Paleoceanographic and Tectonic Evolution of the Central Arctic Ocean", directly addresses this critical lack of information because it proposes direct sampling of seafloor rocks and sediments that have accumulated over the Cenozoic and which record the evolution of the Lomonosov Ridge and the Arctic environment. The scientific importance of this proposal was confirmed when it was ranked number one by SCICOM at their August, 2000 meeting. The proposal is one of only a few within ODP that calls for the use of platforms other than the *JOIDES Resolution* (JR) because the JR, which does not have an ice-reinforced hull, is incapable of entering the central Arctic Ocean.

To better define the operational, logistical, and cost elements of this science proposal, and to develop a project implementation plan, SCICOM constituted an Arctic Detailed Planning Group (DPG) in December 2000. The mandate of the DPG includes 15 specific tasks. These were discussed in two meetings (January 31 – February 1, 2001 in Stockholm and June 18-19, 2001 in Washington, DC) by the members of the DPG and through the advice and guidance of three external consultants secured through JOI.

We are pleased to report that all tasks in the mandate have been addressed and it is our expert opinion that given recent advances in science and technology, an expedition to the Arctic to accomplish the scientific goals of ODP Proposal 533 is logistically and operationally feasible.



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Introduction

The Working Group was charged by the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) to complete a series of tasks designed to describe the technical, financial and logistical aspects for completing JOIDES Proposal 533, a scientific drilling program in the central Arctic Ocean. The goal is to develop a project plan to conduct Proposal 533 as an Ocean Drilling Program (ODP) expedition, or "leg."

This report describes the work of the Group on a task-by-task basis. To complete the charge from JOIDES, the Group used its members' expertise, the advice of special consultants contracted by Joint Oceanographic Institutions Inc. (JOI) , and guidance from other external experts and advisors.

Task 1. Drilling:
Platforms, Rig and Equipment

Platforms

To function in the central Arctic Ocean, the DPG defined the following basic criteria:

1. A drilling platform must be "ice-class" to operate in the central Arctic Ocean (which does not mean that the platform must be able to break ice; it can be towed by, or steam behind, icebreaker(s)).
2. The platform must be equipped with a dynamic positioning (DP) system.
3. The platform must be equipped with a moonpool to enable drilling.

The potential drilling platforms that can fulfill, or that can be modified to fulfill, the above criteria were identified and include:

- Finnish icebreaker/drillship *Botnica* (96.7 m - www.fma.fi), built in 1998. *Botnica* is not built for breaking Arctic ice, but can operate in the Arctic Ocean if assisted by icebreaker(s). She is a DP vessel with a moonpool.
- Canadian-built drilling barge *Sea Sorceress* (114 m - www.caldive.com), built in 1983. The DP system requires evaluation to ensure that it could function in Arctic Ice. This platform was assessed by a marine architect (see JOI report, November 2000: "Alternate Platform Evaluation for ODP 533", Report 99019-01). A few other ice-classed Canadian barges exist: *Arctic Immerik Kamotik* (sister to the *Sea Sorceress), Arctic Tarsuit, Arctic Breaker,* and *Arctic Tuk.* To participate in an expedition to the Lomonosov Ridge, these platforms would require modifications, either installation of a moonpool or DP, in order to meet the basic criteria.

Because the *Botnica* meets all of the criteria without modification, the DPG ranked this platform highest. Lengkeek Vessel Engineering evaluated the *Botnica* for its suitability as a platform and provided a technical report to JOI. The *Botnica* has DNV icebreaker class 10; the vessel can enter the Arctic, but it cannot perform heavy icebreaking. Instead, it can work in the Arctic supported by heavy icebreakers.

Botnica is suitable for this purpose, but has two limitations that should be addressed: she has limited fuel capacity (approx. 30 days) and the moonpool must be modified to protect it from ice damage during transit.

Each of these identified limitations can be readily addressed and overcome. The *Oden* has enough fuel capacity to re-fuel the *Botnica* during the expedition and Lengkeek proposed a modification for the moonpool that is technically simple and costs $100K.

At the first meeting of the DPG, a third drilling platform option was considered. This option involved the use of the Swedish icebreaker *Oden*, with icebreaker support, as is the case with the other options. This option was evaluated in one of the contracted studies (Seacore Ltd.) and *Oden* was assessed to be ill-suited as a drilling vessel primarily because of the limited deck area for handling and storing drillpipe.

Consequently, in this final report, the DPG removed this option, *Oden,* as one of the potential drilling platforms.

Drill Rig and Equipment

Several different drill rigs and equipment (drill string, bottom hole assemblies, and sampling / logging tools) are available for installation on the preferred drilling platform. The DPG defined primary requirements for drilling equipment as capable of:

- being mobilized on the selected drilling platform;
- recovering continuous core in mud, and mudstone lithologies;
- sampling to a total depth of 1800 m (combined water depth and depth below seafloor);
- taking a core with a diameter that is no smaller than the current ODP size (ca 5.8 cm).

DPG members recognize the benefit of a drilling system that is capable of handling ODP drill string. This would enable deployment of ODP tools, specifically the advanced piston corer (APC), the extended core barrel (XCB), and possibly the rotary core barrel (RCB). These tools are the sampling tools of choice for paleoceanographic objectives such as the ones in Proposal 533. Given Arctic sea conditions, heave compensation may not be required.

External evaluation of these systems and their recommended configuration for each of the proposed drilling platform options was conducted by Seacore Ltd., under contract to JOI. Their results, a report to JOI delivered on June 18, 2001, were reviewed by the DPG and incorporated in the following description.

Drill systems evaluation

Seacore evaluated a range of drilling systems and found that the C100 and C200 rigs are suitable for either of the two drilling platforms. Of the two, the C200 is preferred because it:

- has greater load capacity (improved pipe length & pullout ability);
- is better able to structurally span the moonpool on either vessel;
- is larger, and thus, safer in terms of work area (sample and drill deck); and
- has an ease of bracing given its more rigid frame.

Thus, the DPG recommends the selection of the C200 system.

The C200 can by used with either the ODP-type drillstring (API 5” diameter) or aluminum drillstring. The advantages of the ODP drillstring are that ODP/TAMU may be able to supply this expedition with two full drillstrings. Furthermore, the drillstring is fully compatible with the coring tools the proponents recommend to meet the scientific objectives.

The advantage of aluminum drillstring is that, with some modification, its single bottom hole assembly (BHA) can accommodate a wider range of sampling tools than the ODP (BHA). In addition, the wider bore of the aluminum pipe would decrease wireline trip time, thus speeding up the operation

The DPG recommends selection of one of these two drillstring options (API or Aluminum) so that the APC, the XCB, and the RCB can be used to meet the paleoceanographic and tectonic objectives of Proposal 533.

Mobilization

The C200 is a containerized mobile drilling system which is deployed by following a simple mobilization and demobilization strategy. Mobilization time is estimated to be 4 to 5 days. As a containerized system, little is required in a port, other than a suitable berth and adequate cranes.

The berth needs to be on a hard standing quay with a suitable lay-down area to temporarily store the equipment to be installed; 400-600 m^2 is ideal. An ideal crane system is one that is capable of at least 25 tonnes capacity and a radius that will extend to the vessel’s moonpool. Dockyard welders will also be needed to secure the base of the rig to the ship and to install sea fastenings.

Shakedown

Seacore evaluated the need for testing the drill system and recommended that 1 to 2 days should be dedicated to seatrials for the drilling and sampling system. They proposed two options. One is to schedule trials immediately after expedition mobilization in a location proximal to port. The second option is to test the system on the selected platform, on an opportunity basis, one year or less before the expedition. Opportunities may arise where the combined vessel and drilling system could be used for another project. In this option, ODP would partner with the project to test the coring tools selected (APC, XCB, RCB) at an appropriate site near the location of the contracted work. For example, given other interests that have been expressed, it is possible that this system could be used in the North Atlantic (Rockall, Faroes, and West of Ireland) in 2002.

The DPG recommends that, in implementing the DPG plan, ODP attempt to partner, on an opportunity basis, to test the drilling system on the selected vessel in advance of the Arctic expedition, perhaps in the North Atlantic. This would enable ample testing and would allow time between the test and the expedition for any required modifications.

Coring time estimates

Seacore analyzed the times to sample and log the sediment and rock intervals required to meet Proposal 533 science objectives. These times fit well within the planned program time and no modifications are required.

Other performance issues

Seacore did not find any major characteristics that would adversely affect the performance of the drilling system on either the *Sea Sorceress* or *Botnica*. However, they provided comparison comments on the two platforms. Because of the size and dimensions of *Botnica's* moonpool, Seacore preferred this platform. This preference is fully consistent with the DPG's priority of platforms.

Downhole logging

In addition to cores, logging data would help achieve the scientific objectives Logs will provide in-situ measurements of physical and chemical properties of the sediments on Lomonosov Ridge for correlation with seismic records and for use as a continuous paleoceanographic proxy record of climate and environmental change. Logging tools that measure natural gamma, porosity, density, resistivity, acoustic velocity, and magnetic susceptibility are desirable. All of these downhole logs are available from Schlumberger and have been used on the JR. The tools on the JR are combined into three tool "strings" each about 30 m in length and each requiring about 7 hours of wireline deployment for operations at the Lomonosov Ridge sites. Seacore determined that this system is compatible with the C100 and C200 rigs.

The DPG received recommendations from ODP's Logging Services Operator on two options to log Lomonosov Ridge: using the ODP Schlumberger tools and using the tools from another service provider. The other service provider options are included to demonstrate the range of options available for this project. Any logging service provider option requires the following components:

- sheave and a wireline logging cable at least 2000 m long
- logging container for data acquisition and analysis computers
- container laboratory and storage space
- logging tools and
- logging engineer.

The alternative option provides flexibility in terms of logging time and cost, but some service providers may have a limited suite of tool types compared with Schlumberger (Table 1). The DPG recommends that the logging services provider be selected by a bidding and negotiation process. This competitive process could either be incorporated into the drilling services contract or done separately through ODP Logging Services after the drilling contractor has been selected.

Table 1.
Logging Options for Lomonosov Ridge

	Schlumberger Slimhole Tools	Example Alternative Wireline "Compact" Tools
Tools	1.gamma/porosity/density/resi-stivity 2. FMS/sonic velocity	1.gamma/porosity/density/sonic 2.FMS-style tool (under development)
Type	Wireline	Wireline or Memory or Thru-bit
Time	23 hours	7 to 12 hours, depending on deployment and type
Cost	$363,000	ca. $200,000

(Please, see the update in the appendix "Arctic Logging Operations")

Task 2. Weather Window

Optimal ice conditions for icebreaker operations occur during August and early September. Therefore, it is recommended that the program begin during the first week of August (2003). The plan calls for leaving the pack ice 35 days later, in early or mid-September. Transit times to the rendez-vous point for starting the drilling leg at the ice edge will vary among platforms, depending on each of their respective mobilization ports.

The DPG envisions a 35-day operation within the pack ice, from the ice edge to the drill sites and back. The 35 days include a 5-day transit from the ice edge at ca 80°N to the key paleoceanographic sites located near 87°N, 25 days onsite, and 5 days transit back to open waters. Variations in regional ice conditions will determine the optimal location for entering the pack ice which can be anywhere between Svalbard and the Kara Sea, perhaps even the Laptev Sea. Drilling operations of 25 days is considered sufficient to achieve the major scientific objectives of Proposal 533.

Task 3. Icebreakers

During icebreaking, the prime objective is to transit as quickly as possible through a region with minimal fuel consumption and vessel damage. The strategy, therefore, is to avoid thick ice, follow leads, and identify (and avoid) ice environments that add to the likelihood of vessel damage and increase resistance to vessel passage. Vessels follow courses that may not be straight in order to minimize energy consumption and exposure to damage

This strategy, which will be followed while the vessels are in transit, is in stark contrast to ice management strategies that will be used when the vessels are configured for drilling operations. Ice management requires direct engagement of difficult ice in order to ensure that floes do not impact the stationary, drilling platform. The ice management vessels must follow the direction of ice movement to ensure that whatever ice approaches is reduced to a tolerable level for the drilling vessel.

These two types of operational strategies (ice transiting and ice management) have a significant bearing on the command structure of the operation, planning, fuel consumption, and crew fatigue.

The general strategy for ice management, while on station, calls for the largest vessel assigned to break ice to be positioned first, 3-4 km up drift. This distance would provide 2-3 hours of advance notice of ice conditions. This vessel would also break a wide enough swath to allow room for drift direction shifts.

The more maneuverable vessel(s) will work inside a 1.5 km radius to manage the ice, reduce it to small floe sizes, and maintain ice-free space around the drilling platform to allow ice to drift past.

Based on these strategies and the expert advice from the icebreaker captain and ice management experts (November 2000 meeting), as well as the discussions at the DPG, two different platform configuration options ("Arctic Armada") can meet the scientific objectives.

Arctic Armada Option A

The highest ranked and preferred option consists of three vessels: the *Botnica* as the drilling platform with two supporting icebreakers, a 75,000 hp Russian nuclear icebreaker (NIB – there are several to select from) and one hunter icebreaker (HIB, there are several to choose from including the *Oden* (24,500 hp, which will be provided by Sweden) and the Canadian *Terry Fox*).

Arctic Armada Option B

This is the second ranked Armada option, comprised of four vessels: the *Sea Sorceress* as the drilling platform with three supporting icebreakers, a Russian NIB, the *Oden* (provided by Sweden), and the *Terry Fox*, a quick, highly maneuverable ship capable of breaking and moving smaller floes. The *Terry Fox* would remain close to the drilling platform to protect the vessel from any impact by bergy bits. This added support for this option is needed because the *Sea Sorceress* does not have a powerful propulsion system that can aid the DP when small ice (bergy bits) hit the barge. The *Terry Fox* is ideally suited for this because it was built for this type of work in the Beaufort Sea and inshore Newfoundland, protecting non-ice class ships from impacts by bergy bits.

Task 4. Ice forecast

Ice forecasting is important to select general transit routes. However, the transiting phase, through the pack ice, is less difficult than the drilling phase, when dynamic positioning of the drilling vessel must be maintained continuously. Therefore during drilling, ice forecasting is essential for making decisions on the relative positions of the vessels ahead of the drilling platform, for deciding optimal icebreaking modes, and for long-term forecasting of the predominant heading of ice movement.

The ice forecasting is also used as input in established operating limits. For example, such limits will need to be set for the:

- maximum floe size ice thickness and ice concentration allowable for the DP vessel; and
- minimum width of the channel that must be maintained open around the DP vessel.

During Beaufort Sea drilling operations, Canadian Marine Drilling (CANMAR), Gulf Canada Ltd. and Imperial Oil Ltd. developed techniques for "managing" ice for their summer and winter drilling operations. These techniques became known as "ice management systems" (Clark, K., et al., eds., 1997: *Breaking Ice with Finesse, Oil & Gas Exploration in the Canadian Arctic.* The Arctic Institute of North America, University of Calgary).

These systems are built upon a combination of ice monitoring techniques and icebreaking methods (break or deflect). The systems include techniques for surveying both regional and local ice conditions. Air photos (satellites and airplane) and radar (SAR - developed by CANMAR in cooperation with the Canadian Centre for Remote Sensing) comprise the basis for regional ice reconnaissance.

Ice management requires precise and reliable ice monitoring systems that include access to satellite imagery (RADARSAT), airborne Synthetic Aperture Radar (SAR), helicopter reconnaissance visual observations (local ice conditions), and weather forecasting. The ice monitoring information is used to develop the icebreaking and management operations on a daily basis (e.g., distances from the drill platform, headings for all vessels, whether to break ice or move it away).

On behalf of the DPG, JOI contracted the Swedish Polar Secretariat to recommend a weather and ice monitoring plan and determine the cost of such a plan. This group, in turn, engaged other experts from Russia (AARI, INTAARI, and Northern Sea Route Administration); Finland (Finnish Maritime Administration), and the Swedish Maritime Administration. The completed plan was delivered to JOI on June 18, 2001.

The ice forecasting plan is based on recommendations for planning the expedition, transiting to drill sites, and drilling operations. The most critical component, during drilling operations, requires three different proposed forecasting systems for weather, ice-drift, and ice type/thickness predictions. These three forecasts are needed to make decisions:

- to select the region and site to drill;
- to decide the time to start drilling; and
- during drilling, to decide if and when emergency pull-out is required.

Site selection and initiating drilling

The forecasting system will be used to identify, at a minimum, a 48-hour window at one of the proposed sites where ice conditions are favourable. Once this has been done, a 3-day forecast for the site will be prepared for wind direction and speed and the distribution of high and low pressure systems. GPS transmitting units will be placed on ice floes in the site region in a grid pattern to begin collection of real time ice drift, direction and speed measurements. Ice reconnaissance helicopter flights will locate any giant floes or icebergs in the region.

Drilling operations

During drilling operations, data are needed to guide decisions about the position and operation of the NIB and the HIB. Forecasting during this time will include real time GPS ice drift; plots of ice floe type and thickness drawn from helicopter reconnaissance; and weather forecasts. These data will also be used to provide enough advance warning of large floes to pull out of the well and wait on ice conditions.

Task 5. Communications

The DPG recommends that a communication plan be established similar, if not identical to the ODP. This plan includes the following reports that are the responsibility of the co-chief scientists, the drilling superintendent and the staff scientist:

- preparation of a daily drilling summary by the operations manager onboard the drilling platform,
- preparation of a daily ice management summary and forecast,
- preparation of a weekly science summary by the co-chief scientists.

These reports should be sent to ODP/JOI, ODP/TAMU, ODP/LDEO, and the JOIDES Office daily or weekly (depending on the report) using Maritex transmission. All vessels are equipped for this transmission type.

Communication among the Armanda will be based on standard HF radio transmission.

NASA recently used their Tracking and Data Relay Satellite for data exchange with a team of government researchers using six satellites that flew over the North Pole as they worked on the ice in 1999. The DPG recommends that ODP investigate and, if appropriate, request this type of communication for the drilling period in 2003. This would provide full, continuous email and internet communication for the leg.

In addition to routine reports, this program's vessels would follow their respective emergency communication plans and strategies in the event of an accident. Each of the vessels recommended here already has plans in place that meet this requirement and have been approved by their national standard associations and external auditors (e.g., Lloyd's Registry).

The plan should remain flexible in order to incorporate the latest technological developments. Many ships are going to the Arctic in the next two seasons and will be working on improvements to the various communication devices. Therefore, this proposed plan should be revised to include newly tested and proven systems. There is also a new Canadian Standards Association standard (S475) that includes multiple vessel operations where one central individual is responsible for management of the flotilla and therefore all associated communications. A final communication plan should be developed utilizing this new standard.

Task 6. Contingencies

There are two types of contingencies to consider: scientific and operational. The ability to achieve the scientific objectives will depend, to some extent, on the severity of the ice conditions.

The proponents have developed an ideal plan to address this type of need for contingency by including alternate regions for meeting the scientific objectives. The alternate sites are distributed over a 360 nm long and 40 nm wide stretch along the crest of the Lomonosov Ridge. In the event the primary sites have conditions too severe for operations, it is highly likely that one of the other regions, being located up to 360 nm away, will have better ice conditions.

Operational contingency plans need to be prepared in order to minimize the impact which unforeseen events might have on the whole operation. One can envisage a number of scenarios, for example:

- loss of drill string;
- engine breakdown to an icebreaker;
- serious fire onboard a vessel; and
- serious injury, illness or loss of life.

Protection against some of these scenarios can be achieved by ensuring that adequate quantities of spares and self-maintenance capabilities are available. For example, a drill string of up to 1800 m in length is needed for successful operations. At least two complete drill strings should be carried in case one is dropped or damaged.

The fact that drilling on the Lomonosov Ridge is a multi-vessel operation adds a significant degree of protection against the risks that a vessel may suffer (fire, flooding, etc.). For this program, there will always be vessels nearby to provide assistance. The breakdown of a single icebreaker could bring the operation to a halt by preventing ice management. To minimize this risk, the DPG has proposed only proven, well-maintained, reliable icebreakers for this program.

In terms of medical emergencies, all of the proposed icebreakers, except the *Sea Sorceress*, have medical personnel and hospital facilities on board (*Oden* and *Botnica* carry medical doctors for high Arctic expeditions).

The plan should include an explanation of the medical emergency evacuation plans for transfer of personnel to hospital in 24 hours. The Northern Sea Route Administration holds this responsibility for the NIBs and they incur the costs including those for the large, long range helicopters.

A detailed communication plan must be provided that explains all possible emergency strategies that will be followed. It is recommended that a standard Health, Safety and Environment (HSE) plan that is normally used for multiple vessels in the offshore oil industry be developed. In these plans, a Bridge document is used to define the roles of each vessel and brings them together under one plan.

Task 7. Liability

There are two general types of civil liability that must be addressed for all types of operations:

- loss of life and personal injury; and
- property claims, such as damage to ships, property, or harbour works.

In addition, specific to marine operations, the International Maritime Organization (IMO) recently established a global liability and compensation regime for spills of oil, when carried as fuel in ship's bunkers.

Protection against liability or indemnification is typically carried by ship owners in two forms: (1) establishment of standards and procedures that ensure a high level of performance to reduce risk; and (2) by insurance. Vessels owned by some nation states (e.g., Canada) do not carry insurance because the nation agrees to indemnify without relying on insurance companies.

Once the final vessel selection is made for the Arctic Armada, each of the individual vessel insurance plans should be reviewed to ensure they have adequate limits on liability. Also, the collective or "global" multi-ship program, as defined in a Bridge Document, should be reviewed from a liability perspective to define any additional insurance or HSE procedure guideline requirements.

In summary, the Program's liability protection should be developed under the direction of a project manager by:

- definition of each partner or vessel owner's risk and their coverage;
- definition of any global risk and required coverage;
- definition of any vessel interface risk and required coverage;
- evaluation of any 3rd party risk and recommended coverage, if required; and
- specification of the Program's operational and environmental guidelines, following industry and government standards (HSE Documents – see Task 8).

Task 8. Environmental impact

The proposed program is in international waters, thus no national environmental regulations apply. However, the Arctic is recognized as a sensitive region of the world and, thus, stringent pollution protection procedures must be followed.

An Environmental Impact Statement (EIS) should be incorporated into the charter party agreement. It is suggested that this program follow the new draft IMO guidelines for Arctic operations. We should also look at the very stringent Antarctic rules to ensure that we follow a strict precautionary approach.

Because ODP is a US-led program, an EIS must be filed with the National Environmental Protection Agency (NEPA). The ODP currently has an EIS on file, but this does not include operations in the Arctic Ocean. This EIS must be modified for the Arctic and submitted to NEPA for approval. Modifications to this ODP EIS should utilize three existing documents:

- new IMO Guidelines for Arctic ship operations;

- Antarctic environmental guidelines for marine operations; and
- The Swedish Polar Secretariat's EIS for *Oden*.

This EIS will establish the environmental component of the program's HSE guidelines. Once established, these guidelines must be included in all commercial agreements. Insurance providers (and governments, if they indemnify) will also require assurance regarding compliance of these guidelines. This assurance is normally achieved by 3rd party surveys and audits (e.g. ABS or Lloyd's Registry) to ensure that all parties (ship owners, contractors) are compliant with the agreements.

Task 9. To be ODP or not to be ODP?

The advantages of conducting Proposal 533 within a scientific ocean drilling program outweigh any possible disadvantages. The science of Proposal 533 is currently the highest ranked within ODP and the proposal was written within the ODP framework to optimize the scientific return.

Specifically, the advantages, in terms of science, include: the paleoceanographic methods developed within ODP are the best in the world for successfully recovering a complete sediment record, the science operations infrastructure within the ODP can efficiently deliver the science objectives as well as publish these results, and the experience of the ODP staff to plan and conduct paleoceanographic legs cannot be duplicated.

Conducting this program within ODP also has advantages for ODP itself. In ODP's Long Range Plan, both Arctic research and the use of other platforms are goals that are highlighted. By conducting Proposal 533 within the Program, ODP demonstrates that it can deliver the majority of its goals set out in the Long Range Plan. This demonstration is beneficial for all nations to justify new funding in the next program, IODP. At a recent science planning workshop for IODP (e.g., COMPLEX and APLACON), the Arctic and alternate platforms were again highlighted as essential. The Proposal 533 expedition, if conducted within ODP, will provide the Program with knowledge and experience for conducting mission-specific research in the Arctic and elsewhere that will be essential to a successful IODP.

Task 10. Labs & Data

Laboratory environments for Arctic drilling will be highly dependent on the platform chosen for drilling and coring operations. Laboratory needs could span the range from simply packaging the cores up for off-loading at the end of the cruise to a shipboard environment with analytical capabilities similar to those on the *JOIDES Resolution*. Three laboratory scenarios are outlined below. They range from an environment that considers only the most essential laboratory functions to one in which cores are split on the platform. All scenarios assume that no pre-built integral laboratory space is available on platform.

Essential Laboratory Functions

At a minimum, basic core storage and safety (hydrocarbon) monitoring is essential. In this scenario, cores would be monitored for hydrocarbons and then properly marked/stabilized/packaged, stored in a climate-controlled container, and transported to a shore-based repository/laboratory at the end of the leg. Three containers would be required on the drill platform, including a containerized laboratory with Gas Chromatographs (and, potentially, Rock Eval and CNS units), a container for core marking/stabilization/packaging and one (at least) for core storage. All containers would require climate control, including the core-storage container(s).

Additional Laboratory Functions

Given the efforts put toward the planning and implementation of this leg and the high scientific interest of this first major drilling effort in the Arctic, a larger suite of laboratory facilities should be considered if space is available. In addition to basic (essential) safety and curation functions, additional facilities (containers) for whole-core physical property work (multi-sensor track), basic micropaleontological age dating, and deep-biosphere analyses could be added.

Split-core Laboratory Functions

The next incremental consideration is that of splitting the cores on the platform (or at least one hole from each site). This scenario incorporates the laboratory needs of the previous two scenarios (core curation/storage, hydrocarbon monitoring, whole-core multi-sensor analyses, micropaleontological age dating, and deep biosphere analyses) plus needs for core splitting and core description containers. Core description involves macroscopic and microscopic descriptions, digital line-scan photography, and split-core spectral imaging at a minimum. Some of the required equipment could be housed in the same container as the whole-core multi-sensor track. Additional chemical/biological and physical property analyses (containers) could be considered on a space availability basis.

Other considerations

Considering the need for the modular nature of laboratories in an alternate platform environment, the technical laboratories will most likely be supplied (or leased) by interested investigators. ODP-TAMU simply does not have the duplicate whole-core and split-core equipment readily available for use on alternate platforms. Most, if not all, of the modular equipment/laboratories outlined above (including core splitters) exist at institutions around the world and have been used on research vessels for years. This equipment usually has its own (very capable) data-capture systems. A standard output format can be specified so the data can be uploaded into the JANUS database at the end of the leg. Commercial (off the shelf) or readily available applications (e.g., that used by the Hawaii Drilling Project) could be utilized for core descriptions. These packages have the basic information needed for graphical and text-based core descriptions and have a variety of output formats.

Flexibility is the *key* consideration. To the extent possible, all laboratories should be modular, utilizing standard 20-ft shipping containers. This approach would minimize preparations on the platform and mobilization costs.

Task 11. Costs

The DPG received cost estimates from operators of all of the platforms. DPG members experienced in managing mission-specific programs prepared the other costs, based on recent experience in the Arctic and elsewhere. For cost estimates that had a range, based on this experience, the highest cost estimate was selected and used. The DPG incorporated the cost submitted in the contracted studies.

Table 2
Arctic Armada A Costs

Costs	Explanation of costs
4580000	Botnica, Oden, NIB day rate total
945000	Drilling system
440600	Project managers
400000	Laboratory equipment
350000	Seatrial & shakedown
363000	Downhole logging
306540	Sub-managers
230000	Environmental & ice management
160000	Other drilling & BHA's
150000	Helicopter service
125000	Container purchase
120000	Coring tools
100000	Moonpool modification
90000	Expedition supplies
68250	Technicalstaff
50000	Container shipping
50000	Travel to/from port
50000	Global program insurance
15000	Planning meetings
5000	Port call expenses
8,598,390	**Total**

The grand total estimated cost for Arctic Armada option A is approximately $8.6M. Of this total, about $2M can be considered to be "normal" ODP science operational costs, $0.9M will be contributed by Sweden as the cost of *Oden,* and some costs will likely be contributed by individual scientists and labs lending laboratory and containers to the expedition. Table 3 summarizes these contributions and the resulting net total cost is: $5.3M.

Table 3
Arctic Armada A Net Cost

Grand Total	8598390
Total Science Ops	2050390
Sweden Contribution	900000
Other Contribution	325000
Net Total	5,323,000

Table 4
Arctic Armada B Costs

Costs	Explanation of costs
5550000	Sea Sorceress, Oden, NIB , Terry Fox rates
945000	Drilling system
440600	Project managers
400000	Laboratory equipment
350000	Seatrial & shakedown
363000	Downhole logging
306540	Sub-managers
230000	Environmental & ice management
160000	Other drilling & BHA's
150000	Helicopter service
125000	Container purchase
120000	Coring tools
90000	Expedition supplies
68250	Technical staff
50000	Travel to/from port
50000	Global program insurance
15000	Planning meetings
5000	Port call expenses
9360390	**Total**

Table 5
Arctic Armada B Net Cost

Grand Total	9360390
Total Science Ops	2050390
Sweden Contribution	900000
Other Contribution	325000
Net Total	6085000

Task 12. External funding

There are two types of external funding sources that would require different strategies to seek support. These are external funding within the framework of ODP and external funding completely separate from ODP.

Because of the clear advantage of completing this science within ODP, it is important to identify "external" funding that could be achieved within the ODP framework. There are four options for external funding within an ODP framework: (1) seek "in-kind" vessel support similar to the contribution from Sweden; (2) use innovative management, i.e. exchange the *JOIDES Resolution* with the *Botnica* because DSND, Ltd. operates *Botnica* and owns 50% of the *JOIDES Resolution*; (3) the third-tier subcontract within the ODP with Offshore Drilling Ltd. could be terminated early and another contact established with DSND Ltd. to supply the drilling platform for Proposal 533; and (4) request more funding through the ODP Council at a cost of approximately $3M for the US and $750k for each of the full members (less if associate members contribute).

For truly external funding, the proposal would have to be submitted to the national science funding agencies of the

proponents (Sweden, United States, Norway, Germany, Canada and Denmark). A "membership" fee from each of the national agencies should be established and it is recommended that the proponents set up "rules" for scientific participation similar to the current ODP. A Memorandum of Understanding would be needed to cooperate and get access to ODP drilling tools and potentially other support services.
The major issues that accompany this approach are (1) the funding agencies are the same as those that now fund ODP and some may have the view that "they already paid at the office"; and (2) the timing schedule is tight for getting funds in time to take advantage of the Swedish contribution in 2003.

Task 13. Limiting factors

The two factors that control the program's ability to complete the scientific objectives are not different from any other ODP leg. These two factors are (1) limiting the funds that are made available for the equipment and facilities needed to complete the science, and (2) the weather conditions that can restrict drilling operations. For the special case of Proposal 533, budgets are needed for a special platform. However, the DPG has provided recommendations that address this factor (see Task 12). In terms of weather, the limiting factor in the central Arctic Ocean is the sea ice conditions. The proposed location is one of the most favourable in the Arctic Ocean in terms of ice thickness (typically first and second year ice). Also, the DPG has recommended vessel support and alternate sites to ensure that this factor is a very low risk.

The DPG emphasizes that modern science and technology has brought Arctic operations into the realm of normal marine operations. Nowadays, scientific programs are conducted from surface ships in the Arctic pack ice each field season, and several trips taking tourists to the North Pole also occur each summer. During the discussion, it was noted that "it's time to dispel the myth that Arctic operations are an insurmountable challenge."

Task 14. Project management

The management requirements for Proposal 533 are similar to those of other ODP legs with the addition of ice management expertise.

As in the ODP, there should be an overall project manager who oversees the planning of the program and begins efforts, on a full time basis, 2 years prior to leg implementation. This person should have Arctic experience, and a good knowledge of drilling management. This person would work closely with the co-chiefs and ODP contractors and be responsible for: developing the RFP's and/or contracts for vessels and services; working with ODP managers to schedule and coordinate their services; developing an HSE plan; overseeing (through contract) the development of an insurance plan once the vessels have been selected; preparing the EIS; coordinating and running necessary planning meetings; and providing routine reports to JOI, JOIDES, NSF, the selected subcontractors and the ODP contractors on all planning activities.

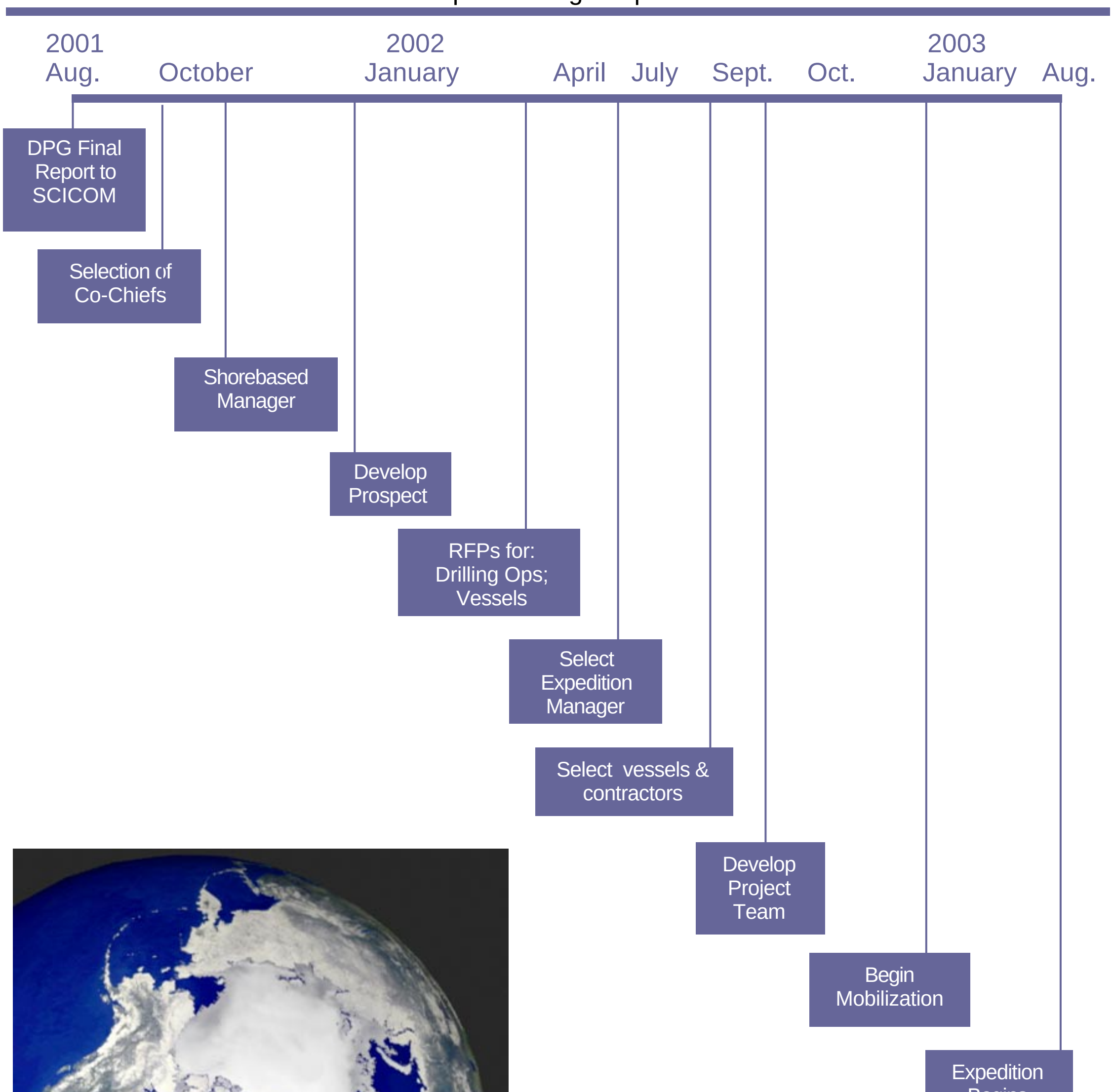
In addition, this planning effort should be supplemented, starting 8 months prior to the beginning of the leg, by contracting the lead expedition managers: a drilling/coring operations manager (this position could be an existing ODP engineer), a science operations manager (this position could be an existing ODP staff scientist), and an ice and vessel manager to oversee subcontractors.

During the expedition, the selected ice and vessel manager would be the head of the expedition in the field and all other field managers would work under his/her direction. The person selected for this position should have Arctic operational management and multi-vessel drilling expertise. This manager would develop the reporting structure for all field operations. The DPG discussed example management structures, but the selected expedition leader should be allowed the flexibility to develop the best possible field management team and structure.

Task 15. Timeline

The DPG developed a schedule to implement Proposal 533 within ODP (Fig. 1). The major milestones are: a dedicated manager, starting in October 2001; request for bids for vessels and services in spring, 2002; the selection of the expedition manager in April 2002; and vessel selection by September 2002.

Figure 1
Timeline for Implementing Proposal 533 in ODP



ARCTIC LOGGING OPERATIONS

As stated in the DPG Report, log data would help achieve the scientific objectives of the cruise. Logs will provide in-situ measurements of physical and chemical properties of the sediments on Lomonosov Ridge for correlation with seismic records and for use as a continuous paleoceanographic proxy record of climate and environmental change. Logging tools that measure natural gamma, porosity, density, resistivity, acoustic velocity, and magnetic susceptibility are desirable. Any logging service provider option requires the following components:

- ♦ Sheave and a wireline logging cable at least 2000 m long
- ♦ Logging container for data acquisition and analysis computers
- ♦ Container laboratory and storage space
- ♦ Logging tools and engineer

A request for preliminary quotations has been issued to several potential providers by ODP Logging Services. A formal request for quotations will be needed when the leg is scheduled.

A table outlining the various options is presented below. Option A includes a full suite of ODP-style oilfield tools, Option B is a reduced set of ODP-style oilfield tools, and Option C is a reduced set of tools operating in memory mode only. Geotechnical tools are also available but are not recommended for the Arctic environment.

Service	Option A	Option B	Option C
Natural Gamma	√	√	√
Spectral Gamma	√	—	—
Density	√	√	√
Porosity	√	√	√
Sonic	√	√	√
Resistivity	√	√	√
FMS-type imaging	√	—	—
Susceptibility	√	—	—
Real-Time Logging	√	√	—
Pipe Back Off and Severing*	√	√	√
Robust Oilfield-Style Tools	√	√	√
Estimated Leasing Costs	$244,000	$220,000	$210,000
Mobilization, Insurance & Other Costs	$73,000	$55,000	$55,000
Estimated Shored-based Costs	$58,500	$58,500	$58,500
Total Estimated Costs	$375,500	$333,500	$323,500

* Costs not included