WISSENSCHAFTSRAT

Stellungnahme zu einer umfangreichen Forschungsinfrastruktur für die Grundlagenforschung: Tiefseeforschungsschiff (Nachfolge Forschungsschiff „Sonne“)

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Vorbemerkung

Das Bundesministerium für Bildung und Forschung (BMBF) hatte den Wissenschaftsrat im Jahr 2000 gebeten, zur Fortentwicklung und künftigen Struktur von Großgeräten der naturwissenschaftlichen Grundlagenforschung Stellung zu nehmen. Der Wissenschaftsrat hat am 12. Juli 2002 zu neun Großgeräten Stellung genommen und diese Stellungnahme mit weitergehenden Empfehlungen am 15. November 2002 verabschiedet.

Mit Schreiben vom 20. November 2007 hat das BMBF die Bitte an den Wissenschaftsrat gerichtet, zur Gesamtschiffsstrategie der deutschen Forschungsflotte eine von unabhängigen Experten getragene Stellungnahme zu erarbeiten. Zugleich hat das BMBF gebeten, aufgrund des dringlichen Ersatzbedarfs das Votum zur wissenschaftlich-technischen Ausstattung des geplanten Nachfolgeprojekts des Tiefseeforschungsschiffs „Sonne“ vorzuziehen. Die Begutachtungsunterlagen wurden dem Wissenschaftsrat im Oktober 2008 übermittelt. Er hat geprüft, ob die grundsätzlichen Voraussetzungen für die Aufnahme des Verfahrens, nämlich das Vorliegen eines Forschungsprogramms, eines technisches Realisierungskonzepts sowie einer Kostenschätzung, gegeben waren. Der Wissenschaftsrat hat im Anschluss an diese Vorprüfung die Arbeitsgruppe „Förderung von umfangreichen Forschungsinfrastrukturen für die Grundlagenforschung“ mit der wissenschaftlichen Bewertung und wissenschaftspolitischen Stellungnahme betraut.

Die Arbeitsgruppe hat die fachliche Begutachtung des Forschungsinfrastrukturprojekts an eine international besetzte Unterarbeitsgruppe delegiert, an der neun externe Sachverständige teilnahmen.[1] Die Unterarbeitsgruppe hat sich im Dezember während eines Vorortbesuchs am Zentrum für Marine Umweltwissenschaften (MARUM) an der Universität Bremen ein genaues Bild von dem Projekt gemacht und die wissenschaftliche Bewertung vorbereitet. Auf der Grundlage dieser fachlichen Begutachtung (wissenschaftlicher Bewertungsbericht) hat die Arbeitsgruppe die wissenschaftspolitische Stellungnahme vorbereitet (Näheres zum Verfahren vgl. A.I.).

Für die weitere Entwicklung der deutschen Forschungsflotte haben das Konsortium Deutsche Meeresforschung (KDM) und die Senatskommission für Ozeanographie der Deutschen Forschungsgemeinschaft (DFG) 2008 ein Strategiepapier vorgelegt:

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1 Von den externen Sachverständigen, die nicht Mitglied des Wissenschaftsrates sind, kamen zwei aus den Niederlanden, zwei aus Großbritannien, einer aus Frankreich, einer aus Norwegen, zwei aus den USA und einer aus Deutschland.

„Die deutsche Forschungsflotte – Anforderungen an die nächsten Dekaden“. Die Arbeitsgruppe wird sich im Anschluss an die Begutachtung des Nachfolgeprojektes für das Forschungsschiff (FS) „Sonne“ mit dieser Strategie auseinandersetzen und unter Berücksichtigung des europäischen und internationalen Kontexts eine wissenschaftspolitische Stellungnahme zur Entwicklung der deutschen Forschungsflotte erarbeiten. Der Ersatz des Forschungsschiffs „Sonne“ bis 2013 erschien allen Beteiligten so dringlich, dass der Wissenschaftsrat sich bereit erklärt hat, die Stellungnahme zum Nachfolgeprojekt der Sonne vorzuziehen. Die vorliegende Stellungnahme ist in vier Teile gegliedert. In einer Kurzfassung werden zunächst die Ergebnisse des Begutachtungsverfahrens dargestellt. In der dann folgenden Ausgangslage (Teil A) werden die methodischen und inhaltlichen Grundlagen des zweistufigen Bewertungsprozesses sowie der fachliche Kontext der bewerteten Forschungsinfrastruktur erläutert. In Teil B formuliert der Wissenschaftsrat sein abschließendes wissenschaftspolitisches Votum zum Nachfolgeprojekt des FS „Sonne“. Teil C enthält den wissenschaftlichen Bewertungsbericht der Unterarbeitsgruppe zum Nachfolgeprojekt „Sonne“. Dieser wird in der von der Unterarbeitsgruppe verabschiedeten englischen Originalfassung veröffentlicht.

In der Arbeitsgruppe und der Unterarbeitsgruppe haben auch Sachverständige mitgewirkt, die nicht Mitglieder des Wissenschaftsrates sind. Ihnen ist der Wissenschaftsrat zu besonderem Dank verpflichtet. Dank gilt auch den Mitgliedern des Zentrums für Marine Umweltwissenschaften (MARUM) der Universität Bremen für die freundliche Aufnahme und die konstruktiven Gespräche während des Vorortbesuchs der Unterarbeitsgruppe.

Der Wissenschaftsrat hat die Stellungnahme am 28. Mai 2009 in Saarbrücken verabschiedet.

Kurzfassung

Spätestens im Jahr 2013 endet die Dienstzeit des Forschungsschiffes „Sonne“ (Baujahr 1968), das bis dahin mehr als 40 Jahre für Forschungstätigkeiten hauptsächlich im Indischen und Pazifischen Ozean eingesetzt worden sein wird. Die „Sonne“ ist eines der sieben außerhalb der deutschen Küstengewässer einsetzbaren Forschungsschiffe für die marine Grundlagenforschung in Deutschland; nach ihrer Außerdienststellung wären die verbleibenden Schiffskapazitäten nicht ausreichend, die Erforschung des geographischen Raums und der Felder, in denen die „Sonne“ eingesetzt wird, adäquat fortzuführen. Ein gutachterlicher Bewertungsbericht hat die auf dem FS „Sonne“ entstandenen antragsbasierten Arbeiten in weiten Teilen als exzellent bewertet; diese Arbeiten haben maßgeblich zu neuen Erkenntnissen und Fortschritten in den Feldern Klimawandel, Marine Ressourcen, Tiefseebiodiversität sowie Geodynamik und Georisiken beigetragen.

Das geplante Tiefseeforschungsschiff schließt an die Arbeiten des FS „Sonne“ an, wobei die oben genannten Forschungsfelder ein sehr großes wissenschaftliches Potenzial aufweisen. Zwei gesellschaftlich relevante Themenkreise treten besonders hervor: (1) Der Klimawandel und das Eingreifen des Menschen in die Ökosysteme der Erde stellen große gesellschaftliche Herausforderungen dar, durch die es einen gesteigerten Bedarf an der Erforschung der Rolle der Ozeane im Klimasystem gibt. Der Nutzungszeitraum der Forschungsplattform wird in eine Zeit großer Klimaveränderungen fallen. Viele biogeochemische Prozesse, das Klima und die Ökosysteme der Erde können ohne weiteres Wissen über den indopazifischen Raum nicht im globalen Kontext verstanden werden. Zum Beispiel gibt es biologische, physikalische, chemische und geologische Formationen, die nur in diesen Gegenden auftreten oder dort eine spezifische Ausprägung aufzeigen. Zum zweiten (2) ist die Marine Ressourcenforschung zu nennen. Dies betrifft zum einen die Gashydrat-, Mineral- und Ölvorkommen. Zum anderen wecken die Mikroorganismen der Tiefsee große Erwartungen im Bereich der „blue technology“. Alle diese Ressourcen sind in weiten Teilen immer noch unerforscht und unerschlossen.

Den indopazifischen Ozean befahren vergleichsweise wenige europäische Forschungsschiffe. Aus Europa betreibt derzeit nur FS „Sonne“ in dieser Region ständig und regelmäßig Forschung. Auch das geplante Nachfolgeprojekt für das Tiefseeforschungsschiff „Sonne“ wird in der absehbaren Zukunft das einzige europäische For-

schungsschiff sein, das permanent den Indischen und Pazifischen Ozean befährt. Dadurch ist es die wichtigste Forschungsplattform für alle Forscher, die in den oben genannten Forschungsfeldern tätig sind. Sie ist nicht nur für die deutsche marine Grundlagenforschung wichtig, vielmehr ist sie europa- und weltweit ein Gewinn für die Meeresforschung.

Das Nachfolgeprojekt für das Forschungsschiff „Sonne“ ist als multidisziplinäres, technisch hoch avanciertes, global operierendes Tiefseeforschungsschiff konzipiert, das sich durch einen hohen Grad an Leistungsfähigkeit und Flexibilität auszeichnet. Diese Konzeption eröffnet eine Breite an technischen Nutzungs- und Einsatzmöglichkeiten, über die andere deutsche Forschungsschiffe in diesem hohen Maß nicht verfügen. In der technischen und technologischen Ausstattung und Ausrüstung geht das Nachfolgeschiff über die Möglichkeiten des FS „Sonne“ weit hinaus. Bei der Konstruktion des Schiffes werden die aktuellen technologischen Entwicklungen berücksichtigt, so dass seine technische Ausstattung es ermöglichen wird, die Anforderungen der nächsten Dekaden zu bewältigen. Das geplante Tiefseeforschungsschiff soll zudem so ausgestattet sein, dass es mit in anderen europäischen Ländern entwickelter Technologie und Equipment kompatibel ist.

Dem Bau des Nachfolgeprojekts „Sonne“ stehen keine grundsätzlichen Schwierigkeiten im Weg. Die benötigte Technik und die anvisierten Technologien sind verfügbar. Die große gesellschaftliche und wissenschaftliche Relevanz der oben genannten Forschungsgebiete, auf denen das Schiff tätig sein wird, steht außer Frage. Die Dringlichkeit des Baus ist angesichts der planmäßigen Außerdienststellung von FS „Sonne“ hoch.

Der Wissenschaftsrat ordnet das geplante Tiefseeforschungsschiff Nachfolgeprojekt „Sonne“ in die erste Kategorie der ohne Auflagen förderungswürdigen Forschungsinfrastrukturen ein.

A. Ausgangslage

Die vorliegende Stellungnahme beruht auf den Grundsätzen zum Verfahren und zur inhaltlichen Bewertung, die der Wissenschaftsrat in seinen „Stellungnahmen zu neun Großgeräten der naturwissenschaftlichen Grundlagenforschung und zur Weiterentwicklung der Investitionsplanung von Großgeräten“ aus dem Jahr 2002 erarbeitet hat. Diese Grundsätze hat der Wissenschaftsrat in der darauf aufbauenden „Stellungnahme zu zwei Großgeräten der naturwissenschaftlichen Grundlagenforschung: Freie-Elektronen-Laser für weiche Röntgenstrahlung (BESSY FEL) und eisbrechendes Forschungsbohrschiff (AURORA BOREALIS)“[2] weiterentwickelt. Dabei hat er deutlich gemacht, dass prinzipiell alle Disziplinen – einschließlich der Sozial- und Geisteswissenschaften – jeweils einen spezifischen Bedarf an Forschungsinfrastrukturmaßnahmen haben bzw. entwickeln werden.[3] Neben ‚klassische' Großgeräte wie Beschleuniger oder Teleskope treten nämlich andere Infrastrukturen wie Sammlungen, Archive, dezentral organisierte Datenbanken, Hochleistungskommunikations- und Rechnergitterverbund-Infrastrukturen (GEANT) etc. Der Wissenschaftsrat folgt damit in seinen Überlegungen der umfassenden Definition von Forschungsinfrastrukturen, wie sie das European Strategy Forum on Research Infrastructures (ESFRI) vorgeschlagen hat.[4] In Zukunft sollte daher von Forschungsinfrastrukturen gesprochen werden, nicht länger allein von Großgeräten. Daher wird, obwohl es sich bei dem begutachteten Projekt um ein ‚klassisches' Großgerät handeln wird, – entsprechend der europäischen und internationalen Nomenklatur – von einer „umfangreichen Forschungsinfrastruktur“[5] die Rede sein.

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2 Vgl. Wissenschaftsrat: Stellungnahme zu zwei Großgeräten der naturwissenschaftlichen Grundlagenforschung. Freie Elektronen-Laser für weiche Röntgenstrahlung (BESSY FEL) und eisbrechendes Forschungsbohrschiff (AURORA BOREALIS), in: Wissenschaftsrat: Empfehlungen und Stellungnahmen 2006, Band III, Köln 2007, S. 89-248.

3 Zur Entwicklung des Bedarfs an wissenschaftlicher Infrastruktur in den Geistes- und Sozialwissenschaften hat der Wissenschaftsrat im Januar 2008 die Arbeitsgruppe „Infrastruktur für sozial- und geisteswissenschaftliche Forschung“ eingesetzt. Die Vorlage des Entwurfs einer Stellungnahme im Wissenschaftsrat ist im Januar 2010 beabsichtigt.

4 Vgl. Wissenschaftsrat: Stellungnahme zu zwei Großgeräten der naturwissenschaftlichen Grundlagenforschung, a.a.O., S. 125.

5 Bei dieser Formulierung handelt es sich um die vom Wissenschaftsrat verwendete Übersetzung des Begriffs „large scale research infrastructures“. Vgl. Wissenschaftsrat: Stellungnahme zu zwei Großgeräten der naturwissenschaftlichen Grundlagenforschung, a.a.O.,S. 126.

A.I. Zum Verfahren der fachlichen Begutachtung und wissenschaftspolitischen Bewertung von umfangreichen Forschungsinfrastrukturen für die Grundlagenforschung

Die Begutachtung von Investitionsplänen für umfangreiche Forschungsinfrastrukturen für die Grundlagenforschung seitens des Wissenschaftsrates beruht auf drei Säulen:

1. auf den allgemeinen Leitlinien, die der Wissenschaftsrat in zehn „Thesen zur Bedeutung von Großgeräten für die naturwissenschaftliche Grundlagenforschung" formuliert hat;[6]
2. auf einer fachlichen Einzelbegutachtung (in englischer Sprache) durch eine international zusammengesetzte Expertengruppe (Unterarbeitsgruppe) (<u>wissenschaftlicher Bewertungsbericht</u>) sowie
3. auf einer <u>wissenschaftspolitischen Stellungnahme</u>, die von der Arbeitsgruppe des Wissenschaftsrates vorbereitet wird und die – neben den oben genannten zehn Thesen – den Stand des Forschungsgebietes, dessen nationale und internationale Förderung im Rahmen von Investitionen für Forschungsinfrastrukturen für die Grundlagenforschung sowie die Frage der Implementierung berücksichtigt.

In einem ersten Schritt bewertet eine international zusammengesetzte Unterarbeitsgruppe das Forschungsinfrastrukturprojekt unter folgenden fachwissenschaftlichen Kriterien:

- der Wahrscheinlichkeit fundamental neuer Erkenntnisse bzw. den Möglichkeiten entscheidender, nur mit der Infrastruktur erreichbarer wissenschaftlicher Fortschritte,
- der technischen Realisierbarkeit und dem technischen Innovationsgrad der Forschungsinfrastrukturmaßnahme,
- der wissenschaftlich-technischen Kompetenz der beteiligten Institutionen,
- der bereits vorhandenen oder zu erwartenden Akzeptanz der potenziellen Nutzer aus den betroffenen und angrenzenden Fachgebieten sowie

6 Vgl. Wissenschaftsrat: Stellungnahme zu neun Großgeräten der naturwissenschaftlichen Grundlagenforschung und zur Weiterentwicklung der Investitionsplanung von Großgeräten. Statement on Nine Large-Scale Facilities for Basic Scientific Research and on the Development of Investment Planning for Large-Scale Facilities, Köln 2003, S. 23ff. Da es sich in diesem Fall um ein Zitat handelt, wurde der Begriff „Großgerät" nicht geändert.

- der Erfüllung verschiedener für die Forschung bedeutsamer Ziele (Transfer, internationale Perspektiven, Nachwuchsförderung).[7]

Das Ergebnis der wissenschaftlichen Bewertung seitens der Unterarbeitsgruppe wird als ein eigenes Votum, das von der Arbeitsgruppe nicht mehr verändert werden kann, festgehalten und publiziert (wissenschaftlicher Bewertungsbericht, vgl. hier: Teil C). Mehrere Mitglieder der Unterarbeitsgruppe sind auch Mitglieder der Arbeitsgruppe. Diese personelle Verknüpfung unterstützt den Informationsfluss zwischen der Unterarbeitsgruppe und der Arbeitsgruppe. Aufbauend auf dem Bewertungsbericht bereitet die Arbeitsgruppe eine wissenschaftspolitische Stellungnahme vor. Folgende Kriterien liegen der wissenschaftspolitischen Stellungnahme zugrunde:[8]

1. *das wissenschaftliche Potenzial des Forschungsprogramms* (insbesondere die Langfristigkeit seiner Entwicklungsperspektiven, das Potenzial an Themenoffenheit beim Einsatz der Infrastruktur sowie die wissenschaftliche und technische Kompetenz der Einrichtungen einschließlich der möglichen Profilschärfung mit dem Betreiben einer Forschungsinfrastruktur),
2. *die Perspektive und Bedeutung der jeweiligen Forschungsgebiete* sowie die Bedeutung der Forschungsinfrastruktur für diese Gebiete,
3. *der Vergleich mit* bereits bestehenden oder in Planung befindlichen ähnlichen bzw. *konkurrierenden Initiativen*,
4. *der Reifegrad* des technischen Konzeptes und damit verbunden die mögliche zeitliche Realisierung des einzelnen Forschungsinfrastrukturprojekts bzw. die *Dringlichkeit ihrer Realisierung* (window of opportunity),
5. *die Erfüllung von wissenschafts- und technologiepolitischen Zielen*, wie sie der Wissenschaftsrat in den zehn „Thesen zur Bedeutung von Großgeräten“ formuliert hat.[9]

In den Thesen hat der Wissenschaftsrat die Relevanz von umfangreichen Forschungsinfrastrukturmaßnahmen der Grundlagenforschung für die wissenschaftliche und technische Entwicklung der Gesellschaft unterstrichen. Forschungsinfrastrukturen der hier betrachteten Dimension müssen mit langfristigen wissenschaftlichen Visionen verknüpft sein und <u>technisches Entwicklungs- und Innovationspotenzial</u>

7 Vgl. ebd., S. 26f.
8 Vgl. a.a.O., S. 27ff und S. 76f.
9 Vgl. a.a.O., S. 23-26.

bieten.[10] Ihr Einsatz erschließt vielfach erst ganz neue Forschungsgebiete. Angesichts der Bedeutung umfangreicher Forschungsinfrastrukturen der Grundlagenforschung für die Wissenschaft sollte es unabhängig von der jeweiligen institutionellen Trägerschaft selbstverständlich sein, dass universitäre und außeruniversitäre Forschungseinrichtungen bei der Konzeption, Planung und Nutzung solcher Infrastrukturen zusammenwirken. Zudem muss die Ausbildung des wissenschaftlichen Nachwuchses eine wesentliche Aufgabe der Betreiber und Nutzer einer solchen Forschungsinfrastruktur darstellen.

Im Folgenden werden zunächst der Stand und die Perspektiven des relevanten Forschungsgebietes (A.II.1.) sowie die bestehende Struktur und Finanzierung von Forschungsinfrastrukturmaßnahmen in der Meeres- und Polarforschung als Voraussetzung für die wissenschaftspolitische Stellungnahme zum Nachfolgeprojekt für die „Sonne" dargelegt (A.II.2.).

A.II. Stand und Perspektiven des einschlägigen Forschungsgebietes sowie dessen Förderung

II.1. Allgemeiner Stand der Forschung zum System Erde und seiner Dynamik

Die Umweltbedingungen auf der Erde unterliegen einem dynamischen Wandel, der zum einen durch natürliche Prozesse gesteuert wird. Zum anderen wird dieser Wandel in der jüngeren Vergangenheit aber zunehmend auch durch das Wirken des Menschen beeinflusst, beispielsweise durch die Inanspruchnahme biologischer und geologischer Ressourcen oder durch veränderte Formen und Intensitäten der Meer- und Landnutzung sowie die hiermit verbundenen Eingriffe in natürliche Stoffkreisläufe und Gleichgewichtszustände in Lebensräumen.

Die Erdsystemforschung zielt darauf ab, die komplexen Wechselwirkungen zwischen den Teilsystemen, die den Lebensraum Erde ausmachen – wie die feste Erde, der Ozean sowie die Atmosphäre und die Biosphäre –, zu erfassen und hierauf aufbauend ein integriertes und umfassendes Systemverständnis unseres Planeten zu ent-

10 Der Wissenschaftsrat hat sich dafür ausgesprochen, dass Deutschland – über die bestehenden Fälle hinaus – Standort multinationaler europäischer oder internationaler Forschungsinfrastrukturmaßnahmen wird und zumindest bei einigen von ihnen auch die wissenschaftliche Federführung übernimmt. Umfangreiche Forschungsinfrastrukturen müssen einen Kristallisationskern von nationalen und internationalen Forschungskollaborationen und Wissenschaftsnetzwerken darstellen. Aufgrund ihrer Dimension sollten sie in der Regel in europäischer und internationaler Trägerschaft angelegt sein und zugleich einer breiten europäischen und internationalen Nutzerschaft offen stehen. Duplizierungen auf nationaler und auch europäischer Ebene sollten verhindert werden, um eine effektive Nutzerauslastung der Forschungsinfrastruktur sicher zu stellen. Vgl.a.a.O., S. 25.

wickeln. Zentrale Beweggründe für diese Forschung sind die langfristige Erhaltung der Lebensgrundlage sowie die nachhaltige Nutzung der natürlichen Ressourcen.

Forschungen zum System Erde und seiner Dynamik sind somit von hoher wissenschaftlicher, gesellschaftlicher und wirtschaftlicher Relevanz. Gleichwohl bestehen noch große Lücken im Verständnis der komplexen Zusammenhänge zwischen den Teilsystemen der Erde. Für ein verbessertes Verständnis des Erdsystems und wissenschaftlich robuste Vorhersagen über die das System beeinflussenden Prozesse ist die Entwicklung und Implementierung adäquater Beobachtungssysteme, Analysemethoden und Modelle von zentraler Bedeutung.

Obwohl die Themen der Erdsystemforschung aufgrund ihres breiten Gegenstandsbereichs sehr vielfältig sind, lassen sich doch einige besondere Schwerpunkte identifizieren, die im Folgenden kurz skizziert werden. Die Erforschung der Ozeane spielt für alle diese Problembereiche eine herausragende Rolle. Zugleich zählen große ozeanische Kompartimente wie die eisbedeckten Gebiete, die Tiefsee und die Biosphäre in den Sedimenten der Ozeane zu den am wenigsten erforschten Bestandteilen des Systems Erde.

Ein solches zentrales – und bis heute unzureichend verstandenes – Thema ist die Veränderung des Klimas und ihre Konsequenzen. Hier steht insbesondere die Rolle klimaaktiver Gase – wie Kohlenstoffdioxid (CO_2) und Methan – im Mittelpunkt des Interesses. Dabei richten sich viele Forschungsaktivitäten auf den globalen Kohlenstoffkreislauf, der durch die Nutzung fossiler Brennstoffe stark beeinflusst wird. So werden die Aufnahme von CO_2 im Ozean und die Speicherkapazität an Land als Teile dieses Kreislaufs untersucht, um die zukünftige Entwicklung der CO_2-Konzentration in der Atmosphäre prognostizieren zu können. Klimamodulierend wirken außerdem der Wärme- und Stofftransport durch die globale Ozeanzirkulation. Für die Erstellung verlässlicher Klimamodelle und -voraussagen ist die Verfügbarkeit und Analyse von Daten über die Klimaentwicklung der jüngeren erdgeschichtlichen Vergangenheit von essenzieller Bedeutung. Da sich relevante Spuren von Umweltveränderungen in den Sedimenten der Meeresböden finden, wo sie über Jahrmillionen hinweg konserviert worden sind, müssen die Tiefseesedimente erschlossen werden, die als Paläoklimaarchiv dienen.

Ein weiterer Fokus der Forschung zum Erdsystem liegt auf der Analyse und Beurteilung von Umwelt- und Georisiken. Hier ist insbesondere die Bewegung der Lithosphärenplatten Gegenstand intensiver Forschungsarbeiten, da diese sowohl mit vulkanischer Aktivität als auch mit Erdbeben und Tsunamis verbunden ist. Die massiven Zerstörungen, die mit solchen Bewegungsprozessen einhergehen können, verdeutlichen die Notwendigkeit eines tieferen Verständnisses dieser Prozesse, um effektive Frühwarnsysteme entwickeln zu können.

Große offene Fragen betreffen darüber hinaus die Biodiversität sowie die natürlichen Ressourcen der Meere und ihre mögliche Nutzung. Die Forschung zu diesem Thema befasst sich zum einen mit der Erforschung der Vielfalt bislang unbekannter mariner Lebewesen und ihrer Habitate sowie dem Wandel ihres Lebensraums in Folge von Klimaveränderungen und anthropogenen Einflüssen. Zum anderen geht es um die Erkundung des Rohstoffpotenzials des Meeresbodens. Von besonderem Interesse ist dabei die Nutzung von biologischen Ressourcen, insbesondere Mikroorganismen, beispielsweise in der Pharmazie. Mit Blick auf die Energieversorgung sind die Öl-, Erdgas- und Gashydratvorkommen von großer Bedeutung. Weiterhin sind Mineraliendepots wie Manganknollen zu nennen.

Für die Bearbeitung dieser Fragen sind der Einsatz und die Weiterentwicklung einer Reihe verschiedener umfangreicher Forschungsinfrastrukturen für die Grundlagenforschung notwendig. Hierzu gehören insbesondere Mehrzweck- und Polar-Forschungsschiffe, die für die Beobachtung und Beprobung des Meeres und des Meeresbodens auch mittels ferngesteuerter Roboter und autonomer Meßsysteme unerlässlich sind, aber auch Bohrplattformen sowie Forschungsflugzeuge und Satelliten zur kontinuierlichen und großräumigen Beobachtung globaler Prozesse. Eine zunehmende Bedeutung für die Erdsystemforschung kommt darüber hinaus Großrechnern für die Modellierung globaler Prozesse zu. Fortschritte in der Modellierung sind eng sowohl an die Leistungsfähigkeit solcher Rechner als auch an die Verfügbarkeit relevanter Beobachtungsdaten gekoppelt.

II.2. Zu Struktur und Finanzierung von umfangreichen Forschungsinfrastrukturen für die Grundlagenforschung

a) Ausgaben des Bundes für umfangreiche Forschungsinfrastrukturen für die Grundlagenforschung[11]

Im Jahr 2006 beliefen sich die FuE-Ausgaben des BMBF für Infrastrukturen der naturwissenschaftlichen Grundlagenforschung auf 782 Mio. Euro (Ist 2006). Dies entspricht einem Anteil von gut 14 % der FuE-Ausgaben des BMBF.[12] Davon werden in erster Linie Forschungsinfrastrukturen in Institutionen der Großforschung gefördert, insbesondere in den 15 Einrichtungen der Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGF). Zudem fließt ein Teil der Gelder in europäische Forschungseinrichtungen. So wird beispielsweise der 25,5 %ige Anteil an den Ausgaben der Europäischen Synchrotron-Strahlungsquelle (ESRF) in Grenoble den Ausgaben für Forschungsinfrastrukturen zugerechnet. 12 % der Mittel für umfangreiche Forschungsinfrastrukturen für die Grundlagenforschung stehen für die Projektförderung bereit, die vornehmlich Hochschulgruppen in Anspruch nehmen, die an Großgeräten arbeiten.

Bezogen auf das Gesamtbudget des BMBF stellt sich die Verteilung der Aufwendungen für Forschungsinfrastrukturen wie folgt dar:

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11 Basis der folgenden Tabellen sind die Ist-Zahlen aus dem Jahr 2006 des BMBF. Dabei ist anzumerken, dass das BMBF keinen eigenen Titel „Forschungsinfrastrukturen“ hat und die Investitionen in neue Anlagen nicht kontinuierlich erfolgen. Die einzelnen Forschungsinfrastrukturen werden aus dem Haushalt anhand der Mittel isoliert, die in die jeweiligen Fachtitel nach Bedarf eingestellt werden und in den Titeln der jeweiligen Institutionen enthalten sind.

12 Alle Angaben beziehen sich auf den Bereich „Großgeräte der Grundlagenforschung“ des BMBF. Darin sind nur Forschungsinfrastrukturen für naturwissenschaftliche Wissenschaftsbereiche enthalten. Förderungen von Großgeräten seitens der DFG oder auf dem Wege des Hochschulbauförderungsgesetzes (HBFG) werden hier nicht berücksichtigt.

Tabelle 1: Ausgaben des BMBF für umfangreiche Forschungsinfrastrukturen für die Grundlagenforschung im Jahr 2006 (Ist)

Förderform	in Mio. Euro	Anteil an der Forschungsinfrastrukturförderung	Anteil am Gesamtbudget des BMBF (reine FuE-Ausgaben)
Institutionelle Förderung	419	53 %	7,6 %
Beteiligung an Europäischen Forschungseinrichtungen (CERN, ESO, ESRF, ILL, ETW)	193	25 %	3,5 %
Projektförderung	94	12 %	1,7 %
Infrastrukturen aus dem Bereich „Erde und Umwelt“[13]	76	10 %	1,3 %
Gesamtförderung	782 (reine FuE-Ausgaben)	100 %	14,1 %

Quelle: BMBF, Bundesbericht Forschung 2006

b) Ausgaben des Bundes für umfangreiche Forschungsinfrastrukturen für die Grundlagenforschung in der Meeres- und Polarforschung

Die Meeres- und Polarforschung nutzt nationale, europäische und internationale Forschungsinfrastrukturen.[14] Forschungsschiffe werden bislang ausschließlich national betrieben, aber über den Austausch von Schiffszeiten international genutzt. Das Forschungsschiff „Sonne“ wie auch ihr Nachfolgeprojekt gehören zu den Forschungsschiffen der Klasse „Global“. Global operierende Forschungsschiffe sind länger als 65 m, befahren in der Regel alle Weltmeere, verfügen über große Windenkapazitäten von mehr als 6000 Metern und große Ladekapazitäten für wissenschaftliches Gerät (mehr als 100 Tonnen). Sie besitzen eine gute Lot- und Kommunikationstechnik und können länger als 40 Tage auf See verbringen (Standzeit).[15] Das Forschungsschiff „Sonne“ bzw. sein Nachfolgeprojekt ist eines der 11 derzeit vorgehaltenen global operierenden Forschungsschiffe in Europa. Diese machen rund ein Viertel der For-

13 Dies umfasst z.B. Forschungsschiffe, Forschungsflugzeuge, Klimarechner.

14 Die Ausgaben im Bereich der gesamten Erdsystemforschung werden in der in Vorbereitung befindlichen Stellungnahme zur Entwicklung des Forschungsinfrastrukturkomplexes der deutschen Forschungsflotte im europäischen und internationalen Kontext systematisch berücksichtigt werden.

15 Vgl. European Science Foundation (ESF). Marine Board: Position Paper 10. European Ocean Research Fleets. March 2007. Towards a Common Strategy and Enhances Use, ed. by The Ocean Research Fleets Working Group Report (OFWG) 2007. Das ESF spricht von Schiffen, die “currently operate on an at least multi-ocean scale” (S 14). Die von europäischer Seite vorgenommene Klassifikation ist kohärent mit der US-amerikanischen des University National Oceanographic Laboratory System (UNOLS) (ebd.).

schungsschiffskapazitäten in Europa aus. Allein große europäische Staaten wie Großbritannien, Frankreich, Italien, Spanien und Deutschland betreiben global operierende Schiffe.

Tabelle 2: Europäische Forschungsschiffe der Klasse „Global“

Land	Schiff	Indienstnahme	Haupteinsatzregion
Frankreich	Marion Dufresne	1995	stationiert im Indischen Ozean als Versorgungsschiff, operiert als Forschungsschiff weltweit
	Pourquoi pas?	2005	stationiert im Atlantik/Mittelmeer wegen Forschungstätigkeiten der Marine
	L'Atlante	1990	Atlantik/Mittelmeer, seltene Einsätze im Indischen und Pazifischen Ozean
Deutschland	Polarstern**	1982	Arktis und Antarktis
	Meteor	1986	stationiert im Atlantik, seltene Einsätze im Indischen Ozean
	M.S. Merian	2006	stationiert im Nordatlantik/Mittelmeer, auch Eisklasse
	Sonne (bis 2013)	1969	stationiert im Pazifik, seltene Einsätze im Indischen Ozean
Italien	Explora (bis 2009)	1973/2004*	Antarktis
Spanien	Hesperides**	1991/2004	Antarktis
Vereinigtes Königreich	James Clark Ross**	1991	Antarktis
	Discovery	1992	stationiert im Atlantik
	James Cook	2007	stationiert im Atlantik, seltene Einsätze im Pazifik

* Zeitpunkt der Generalüberholung
** Polarstern, James Clark Ross und Hesperides sind Eisbrecher und werden vorzugsweise in Polarregionen eingesetzt.
Quelle: Eigene Angaben und vgl. European Science Foundation (ESF). Marine Board: Position Paper 10. European Ocean Research Fleets. March 2007. Towards a Common Strategy and Enhances Use, ed. by The Ocean Research Fleets Working Group Report (OFWG) 2007, S. 39-42.

Aus dieser Übersicht wird deutlich, dass die „Sonne“ europaweit das einzige Schiff ist, das regelmäßig und auf Dauer im Indik und Pazifik operiert. Bisher wurden global operierende Forschungsschiffe von einem Land gebaut und betrieben. Über gemeinsame Projekte oder Schiffstauschprogramme wurden sie international genutzt. Im Fall des Nachfolgeforschungsschiffs für die „Sonne“ soll dieses Vorgehen beibehalten werden. Andere Projekte, wie das eines Europäischen eisbrechenden Forschungsbohrschiffs (AURORA BOREALIS), lassen sich aufgrund der deutlich höheren Kosten nicht länger national realisieren und verlangen multinationale Konsortien für Bau, Betrieb und Nutzung des Schiffes.[16]

Der Bau des neuen Tiefseeschiffes wird gemeinsam vom Bund und von den Küstenländern im Bau und Betrieb finanziert; der Betrieb wird vollständig vom Bund getra-

16 Vgl. Wissenschaftsrat: Stellungnahme zu zwei Großgeräten der naturwissenschaftlichen Grundlagenforschung, a.a.O.

gen. Er wird zu großen Teilen von der deutschen Meeres- und Polarforschungs-Community genutzt werden. Daher soll das Nachfolgeprojekt an dieser Stelle in den Kontext von Forschungsinfrastrukturen für die Meeres- und Polarforschung in Deutschland eingeordnet werden.

Tabelle 3: Vom Bund geförderte oder mit geförderte umfangreiche Forschungsinfrastrukturen für die Grundlagenforschung im Bereich der Meeres- und Polarforschung[17]

Gerät	Betreiber	Ungefähre Investitions-kosten in Mio. Euro*	Betriebs-kosten pro Jahr in Mio. Euro	Finanzierungsmodell (für die Investition)	Erläuterung zum Einsatz-gebiet
Forschungs-eisbrecher POLARSTERN	Stiftung AWI (Eigentümer der Schiffe: Bund)	97,34 (1982)	17,0	national (Bund: 100%)	Antarktis und Arktis
permanent be-mannte Station NEUMAYER		42 (2009)	4,1	national (Bund: 90 %, Län-der: 10%)	Antarktis (Kosten inkl. Fahrzeug-park)
Mittelgroßes Forschungsschiff HEINCKE**		16,4 (1990) Refit (2008/2009)	1,6	national (Bund: 100%)	Atlantik, Nord- und Ostsee
Forschungsschiff METEOR	Leitstelle Meteor/ Merian der Universität Hamburg (Eigentümer: Bund)	50,6 (1986)	11,2	national (Bund: 100%)	stationiert im Atlantik, sel-tene Einsätze im Indischen Ozean
Forschungsschiff SONNE	Projektträger Jülich am FZ Jülich (Eigen-tümer: Forschungs-reederei RF GmbH)	28,0*** (1991)	10,0	national (RF: 77,4%, Bund: 22,6%)	Pazifik und Indischer Ozean
Mittelgroßes Forschungsschiff ALKOR**	IfM-GEOMAR in Kiel (Eigentümer: SH)	16,9 (1990)	2,0	national (Bund: 90%, SH: 10%)	Ostsee, Nordsee
Forschungsschiff MERIAN	Leitstelle Meteor/ Merian der Universi-tät Hamburg (Eigentümer: MV)	56,2 (2006)	9,7	national (Bund: 75 %, MV: 12,5 %, HB: 2,5 %, HH: 5,0 %, SH: 5,0 %)	stationiert im Nordatlan-tik/Mittelmeer, auch Eisklas-se
Mittelgroßes Forschungsschiff POSEIDON	IfM-GEOMAR in Kiel (Eigentümer SH)	11,8 (1976)	2,4	National (Bund 90%, SH 10%)	Nordsee, Atlantik

* Die in Klammern geschriebenen Jahreszahlen geben den Investitionszeitpunkt wieder.
** Zum Pool der mittelgroßen Forschungsschiffe gehörig.
*** FS Sonne wurde 1969 als Heckfang- und Fabrikschiff gebaut. Erst beim Umbau des Schiffes 1991 wurden öffentliche Mittel in Höhe von 28 Mio. Euro eingesetzt.
Quelle: BMBF und Leitstelle Meteor/Merian (Universität Hamburg)

17 Investitionen kleiner als 15 Millionen Euro sind nicht berücksichtigt.

A.III. Darstellung des geplanten Tiefseeforschungsschiffs und seiner fachlichen Begutachtung

a) Kurzdarstellung des Forschungsinfrastrukturprojekts[18]

Der Nachfolger für das Forschungsschiff „Sonne“ ist als multidisziplinäres, technisch hoch avanciertes, global operierendes Tiefseeforschungsschiff konzipiert, mit dem international und interdisziplinär besetzte Expeditionen durchgeführt werden können. Sein Einsatzgebiet soll vor allem im Indischen und Pazifischen Ozean liegen. Nach Planung der Antragsteller soll der Schwerpunkt der Arbeit mit dem geplanten Tiefseeforschungsschiff in den ersten 5-10 Jahren auf der geologischen Erforschung des Meeresbodens liegen; das Schiff soll aber gleichzeitig so ausgestattet sein, dass auch die Forschungsfelder Meeresbiologie, -chemie und -physik abgedeckt werden können.

Die Forschung mit dem geplanten Tiefseeforschungsschiff wird insbesondere zwei gesellschaftlich relevante Themenkreise zum Gegenstand haben: Zum einen stellen der Klimawandel und das Eingreifen des Menschen in die Ökosysteme der Erde große gesellschaftliche Herausforderungen dar, durch die es einen gesteigerten Bedarf an der Erforschung der Rolle der Ozeane im Klimasystem gibt. Zum zweiten ist die Marine Ressourcenforschung zu nennen. Dies betrifft zum einen die Gashydrat-, Mineral- und Ölvorkommen. Zum anderen wecken die Mikroorganismen der Tiefsee große Erwartungen im Bereich der „blue technology“. Alle diese Ressourcen sind aber in weiten Teilen unerforscht und unerschlossen.

Den indopazifischen Ozean befahren vergleichsweise wenige Forschungsschiffe. Aus Europa betreibt derzeit nur FS „Sonne“ bzw. ihr Nachfolger in diesen Gegenden ständig und regelmäßig Forschung. Das Nachfolgeschiff soll an die Tätigkeiten des FS „Sonne“ anschließen und auf seine wissenschaftlichen Forschungsgebiete aufbauen. In der technischen und technologischen Ausstattung und Ausrüstung geht das Nachfolgeschiff entsprechend über die Möglichkeiten des FS „Sonne“ weit hinaus. Bei der Konstruktion des Schiffes werden die aktuellen technologischen Entwicklungen berücksichtigt, so dass seine technische Ausstattung es ermöglichen wird, die Anforderungen der nächsten Dekaden zu bewältigen. Besonderen Wert wird dabei auf die hohe Flexibilität gelegt, um verschiedenes schweres Gerät wie

18 Siehe ausführlicher Teil C.II. der Stellungnahme.

Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs) und das Meeresboden-Bohrgerät MeBo einschließlich neuartiger, künftig erst zu entwickelnder Instrumente einsetzen zu können.

Für den Bau des Forschungsschiffes sind 110 Mio. Euro veranschlagt. Die Finanzierung übernehmen das Bundesministerium für Bildung und Forschung (90 %) und die Länder Niedersachsen (5 %), Mecklenburg-Vorpommern, Schleswig-Holstein sowie die Städte Hamburg und Bremen (zusammen 5 %). Das Schiff soll im Jahr 2013 an die Wissenschaft übergeben werden.

b) Kurzdarstellung der Begutachtungsergebnisse der Unterarbeitsgruppe

Wahrscheinlichkeit fundamental neuer Erkenntnisse

Das geplante Tiefseeforschungsschiff baut auf die Arbeiten des FS „Sonne" auf, wobei große Teile der Forschungsfelder, in denen „Sonne" tätig ist, noch nicht erschlossen sind. Entsprechend werden maßgebliche neue Erkenntnisse und Fortschritte in den Feldern Klimawandel, Marine Ressourcen, Tiefseebiodiversität sowie Geodynamik und Georisken erwartet. Das Zirkulationsverhalten der Ozeane ist ein entscheidender Faktor im Klimasystem, während Veränderungen der Interaktion zwischen Ozean und Atmosphäre einen großen Einfluss auf die Entwicklung des globalen Klimas ausüben. Die dicht besiedelten Küstenregionen und die dort ansässige Industrie sind durch geologische Gefahren und Folgen des Klimawandels wie Erdbeben, Tsunamis und dem ansteigenden Meeresspiegel nachhaltig bedroht. Weiterhin sind die Mineralien-, Öl- und Gasvorkommen sowie die bislang weitgehend unbekannte Diversität von Habitaten und Tiefseelebewesen (darunter insbesondere Mikroben für die so genannte „blue technology") viel versprechende Forschungsgebiete, deren gesellschaftliche Bedeutung und wirtschaftlicher Nutzen überhaupt erst ausgelotet werden müssen.

Das enorme wissenschaftliche Potenzial des geplanten Forschungsschiffs liegt dabei insbesondere in den geographischen Räumen, deren Erforschung sich das Nachfolgeforschungsschiff widmen wird: Der Indische und mehr noch der Pazifische Ozean, welcher den größten Teil der Erdoberfläche bedeckt, besitzen Ökosysteme und dynamische Strukturen, die einzigartig sind oder dort eine spezifische Ausprägung aufweisen. Dazu gehören die schnell auseinanderdriftenden Rückensysteme und die in diesen Gegenden vorzufindende Biodiversität. Aus der integrierenden Perspektive der Erdsystemforschung können zudem globale biogeochemische Prozesse, das globale Klima und die Ökosysteme der Erde ohne weiteres Wissen über den indopazifischen Raum nicht verstanden werden. So sind die dort spezifischen Tiefenwasserbildungsprozesse und Funktionsweisen des Kohlenstoffkreislaufs zentral, um das Klimasystem in seiner Gesamtheit verstehen zu können.

Technische Realisierbarkeit und Innovationsgrad

Der Grad der technischen Realisierbarkeit ist hoch. Die Technik und Technologien, die für das geplante Schiff vorgesehen sind bzw. deren Implementierung anvisiert wird, sind entwickelt und vorhanden. Es müssen in erster Linie Entscheidungen getroffen und Priorisierungen vorgenommen werden, welches Equipment und welche Technik für das Schiff benötigt wird. Für die endgültige Festlegung des technischen Designs wird empfohlen, internationale Expertise durch die Mitglieder der OFEG in den Entscheidungsprozess einzubinden.

Das Schiff soll sich als multidisziplinär angelegte Forschungsplattform durch einen hohen Grad an Leistungsfähigkeit und Flexibilität auszeichnen. Bei der Konstruktion soll darauf geachtet werden, dass das Forschungsschiff luftblasen- und geräuscharm operiert, umweltfreundlich und nachhaltig konzipiert ist, über eine sehr gute Manövrierfähigkeit und die Möglichkeit, eine Position exakt zu halten (dynamic positioning system), verfügt. Es soll so ausgestattet werden, dass auch Technologien und Instrumente, die in anderen europäischen Ländern entwickelt wurden, auf dem Schiff installiert werden und zum Einsatz kommen können.

Relevanz und Bedeutung der Forschungsinfrastruktur für die potenziellen Nutzer

Das geplante Tiefseeforschungsschiff wird das einzige europäische Forschungsschiff sein, das permanent den Indischen und Pazifischen Ozean befährt. Dadurch ist es die wichtigste Forschungsplattform für alle europäischen Forscher, die in den oben genannten Forschungsfeldern tätig sind. Entsprechend ist das Nachfolgeschiff FS „Sonne" nicht nur für die deutsche marine Grundlagenforschung wichtig, vielmehr ist es ein Gewinn für die gesamte europäische Meeresforschung, wenn nach der endgültigen Außerdienststellung von FS „Sonne" 2013 ein Nachfolgeschiff bereitgestellt wird.

Die Notwendigkeit des Ersatzes für ein Tiefseeforschungsschiff ist von nationalen und internationalen Nutzergruppen ausdrücklich formuliert worden. Die Senatskommission für Ozeanographie der Deutschen Forschungsgemeinschaft und das Konsortium Deutsche Meeresforschung (KDM) haben dieses Gesuch in ihrer gemeinsamen Strategieschrift dargelegt, das Marine Board der European Science Foundation hat sich in seinem Position Paper 10 in gleicher Weise geäußert.

Erfüllung von bedeutsamen Zielen für die Forschung (Nachwuchsförderung und Transfer)

Das geplante Tiefseeforschungsschiff wird eine wichtige Rolle in der Graduiertenausbildung spielen. Es ist vorgesehen, dass im Durchschnitt 20-25 % der verfügbaren Plätze auf Expeditionen von graduierten Studierenden eingenommen werden können. Generell sind Forschungsschiffe für die Gemeinschaft der Meeresforscher ein wichtiges Mittel, um internationale Forscherkontakte herzustellen und zu pflegen.

Die Erforschung und Erschließung der Öl-, Gashydrat- und Mineralvorkommen sowie der Diversität der Mikroorganismen bergen ein hohes wirtschaftliches Potenzial und einen großen gesellschaftlichen Nutzen. Die Nutzbarmachung der marinen Ressourcen wird deshalb besonders empfohlen und sollte in Zukunft noch strategischer angegangen werden. Kooperationen mit der Industrie sollten verstärkt gesucht bzw. gepflegt werden.

FS „Sonne“ hat einen wichtigen Beitrag zur Vorbereitung von Bohrexpeditionen geleistet, indem es Voruntersuchungen im Rahmen des International Ocean Drilling Program (IODP) durchgeführt hat. Diese Vorstudien sind notwendige Voraussetzungen, um erfolgreich paläoozeanographische Forschung zu betreiben. Für die Fortsetzung dieser Forschungstätigkeit ist der Einsatz des geplanten Nachfolgeforschungsschiffs unbedingt notwendig.

Wissenschaftlich-technische Kompetenz der beteiligten Institutionen

Die auf dem FS „Sonne“ entstandenen Arbeiten sind in weiten Teilen als exzellent bewertet worden.[19] Die Antragsteller - die DFG-Senatskommission für Ozeanographie und das Konsortium Deutsche Meeresforschung - umfassen alle wichtigen uni-

19 Vgl. den Bericht der Gutachterkommission aus dem Jahr 2005, der durch den Projektträger Forschungszentrum Jülich für das BMBF in Auftrag gegeben wurde: Meeresforschung mit dem Forschungsschiff SONNE. Evaluation der Expeditionen SO 75-SO175 im Zeitraum 1991-2003, o.O: o.J.

versitären und außeruniversitären Forschungszentren der deutschen Meeresforschung, deren wissenschaftlich-technische Kompetenz und Qualität sich in verschiedenen, hoch kompetitiven Verfahren wie der Exzellenzinitiative des Bundes und der Länder gezeigt hat. [20] Das Bewilligungsverfahren für Forschungsprojekte, die auf dem geplanten Tiefseeforschungsschiff durchgeführt werden sollen, ist von der DFG-Senatskommission für Ozeanographie ebenfalls sehr kompetitiv angelegt worden, entsprechend werden nur wissenschaftlich erstrangige Vorhaben und Forscher gefördert.

20 Vgl. das Exzellenzcluster „Ozean der Zukunft" der Christian-Albrechts-Universität zu Kiel (CAU), des Leibniz-Instituts für Meereswissenschaften (IFM-GEOMAR), des Instituts für Weltwirtschaft (IfW) und der Muthesius Kunsthochschule sowie das Exzellenzcluster „Ozean im System Erde" und das Forschungszentrum „Ozeanränder", die am Zentrum für Marine Umweltwissenschaften (MARUM) der Universität Bremen angesiedelt sind.

B. Wissenschaftspolitische Stellungnahme

B.I. Abschließendes wissenschaftspolitisches Votum

Wissenschaftliches Potenzial des Forschungsprogramms

Der Nutzungszeitraum der Forschungsplattform wird in eine Zeit großer Klimaveränderungen fallen. Vor diesem Hintergrund ist es zu begrüßen, dass das geplante Tiefseeforschungsschiff als offen und flexibel angelegte Forschungsplattform konzipiert ist. Zum einen können damit langfristig wichtige und zugleich dringliche Fragen der Klimaforschung bearbeitet werden. Weiteres eminentes wissenschaftliches Entwicklungspotenzial für das Forschungsschiff liegt in den Bereichen Biodiversitäts- und Ökologieforschung. Neben der Erfassung der vorhandenen Biodiversität, die bei weitem nicht abgeschlossen ist, wird in den nächsten Dekaden die Beobachtung des klimainduzierten Wandels an Bedeutung gewinnen. Als Forschungsfelder mit einem besonders hohen wissenschaftlichen Erkenntnisgewinn sind neben den genannten die Gebiete Georisiken, Georessourcen und Geodynamik hervorzuheben.

Angesichts dieses breiten Spektrums an Forschungsfeldern und Fragestellungen wird ausdrücklich unterstützt, dass das Nachfolgeschiff für „Sonne“ multidisziplinär genutzt und eingesetzt werden kann. Die Öffnung für ein breites Spektrum an Disziplinen, insbesondere die Klimaforschung, Ökologieforschung, das Forschungsfeld „life in extreme environments“ (chemolithotrophe Lebensgemeinschaften) und die „blue technology“ betreffend, wird begrüßt. Für das Gebiet Klimaforschung ist anzustreben, dass das Nachfolgeforschungsschiff über die Aktivitäten und die Ausstattungsgegebenheiten seines Vorgängers hinausgeht. Insbesondere im Bereich der Monsun- und El Niño-Forschung gibt es Desiderate, die mit dem geplanten Tiefseeforschungsschiff angegangen werden sollten.

Die wissenschaftliche und technische Kompetenz der Antrag stellenden Gremien, welche alle wichtigen universitären und außeruniversitären Einrichtungen der deutschen Meeresforschung umfassen, ist hoch. Der Evaluationsbericht zum Forschungsschiff „Sonne“[21] hat gezeigt, dass insbesondere die auf der Plattform durchgeführte antragsbasierte Forschung in weiten Teilen exzellent war und entsprechend die wissenschaftliche und technische Qualität der daran beteiligten Institutionen hoch zu veranschlagen ist. Die Arbeiten dieser Institutionen haben dazu beigetragen, dass

21 Vgl. den Bericht: Meeresforschung mit dem Forschungsschiff SONNE, a.a.O.

die Meeresforschung große Erfolge in der Exzellenzinitiative aufweisen konnte, wie an der Einrichtung der Exzellenzcluster „Ozean der Zukunft“ und „Ozean im System Erde“ sowie des DFG-Forschungszentrums „Ozeanränder“ abzulesen ist. Die an der Forschungstätigkeit des FS „Sonne“ und an dem Konzept für den Nachfolgebau beteiligten Einrichtungen haben außerdem eine bemerkenswerte Anzahl an Leibnizpreisträgern hervorgebracht.

Perspektive und Bedeutung der betroffenen Forschungsgebiete

Die oben beschriebenen Forschungsgebiete haben gesellschaftspolitisch eine hohe Relevanz und reflektieren zugleich wichtige anstehende Themen und Fragestellungen der Meeresforschung in den nächsten Jahrzehnten. Die Meeresforschung in Deutschland hat ein hohes Niveau und sie hat durch die Exzellenzinitiative einen zusätzlichen Schub erhalten. Im Zuge dessen entwickeln die beteiligten Institutionen neuartige, weltweit einzigartige Geräte und Technologien, die nur von Forschungsschiffen aus eingesetzt werden können. Um nach Außerdienststellung von FS „Sonne“ Forschung weiterhin auf diesem hohen Niveau fortsetzen zu können, ist die Forschungsplattform Nachfolgeforschungsschiff „Sonne“ deshalb unabdingbar.

Vergleich mit konkurrierenden Initiativen

Die geplante Forschungsplattform wird das einzige europäische Forschungsschiff sein, das dauerhaft im Pazifik stationiert ist und im indopazifischen Raum ständig genutzt werden kann. Für Langzeitstudien beispielsweise ist dieses Alleinstellungsmerkmal von großer Bedeutung.

Die Konzeption des Nachfolgeprojekts „Sonne“ als multidisziplinäres, technisch hoch avanciertes Tiefseeforschungsschiff eröffnet zudem eine Breite an technischen Nutzungs- und Einsatzmöglichkeiten, über die andere vergleichbare Forschungsschiffe in diesem hohen Maß nicht verfügen.

Reifegrad des technischen Konzepts und Dringlichkeit der Realisierung

Der Bau eines neuen Tiefseeforschungsschiffs angesichts der baldigen Außerdienststellung von FS „Sonne“ ist dringlich. Der Reifegrad des technischen Konzepts ist hoch. Der Wissenschaftsrat schließt sich in diesem Zusammenhang den Empfehlungen der Unterarbeitsgruppe an, die sich für die Optimierung des von den Antragstellern vorgelegten technischen Designs ausgesprochen hatte, um ein Schiff zu bauen, das möglichst geräuscharm ist, dessen Antrieb wenig Luftblasen produziert, das über ein gutes Dynamic Positioning System verfügt, einen geringen Energieverbrauch hat und sehr seegängig ist. Die Besonderheit des geplanten Forschungsschiffs in Bezug auf die technische und technologische Ausstattung wird in seinen breiten Nutzungsmöglichkeiten liegen. Der vorgesehene zeitliche Rahmen, innerhalb dessen das Projekt fertig gestellt sein soll, ist realistisch. Das Projekt sollte möglichst zeitnah realisiert werden.

Erfüllung von wissenschafts- und technologiepolitischen Zielen

Das Nachfolgeforschungsschiff „Sonne“ wird wie sein Vorgänger eine wichtige Rolle in der Nachwuchsförderung spielen. Da die geplante Forschungsplattform im Vergleich mit „Sonne“ über eine größere Anzahl an Plätzen verfügen soll und die Zahl der Tage, an denen das Schiff für Forschungszwecke bereitsteht, erhöht werden soll, wird die Bedeutung des Schiffes für die Nachwuchsförderung noch steigen.

Das oben skizzierte Forschungsprogramm macht deutlich, dass das geplante Tiefseeforschungsschiff in erster Linie der marinen Grundlagenforschung dienen soll. Daneben wird dem Nachfolgeprojekt „Sonne“ in der Erforschung von Rohstoffen eine wichtige Rolle zukommen, insbesondere in Bezug auf Gashydrate und Metallsulfide.

Das geplante Tiefseeforschungsschiff bedeutet eine Stärkung Deutschlands im europäischen Forschungsraum. Es wird als einziges europäisches Forschungsschiff, das regelmäßig den indopazifischen Ozean befährt, attraktiv für die internationale Forschergemeinschaft sein und einen Gewinn im Rahmen europäischer Schiffstauschabkommen darstellen. Zudem wird die Vernetzung europäischer Wissenschaftler gefördert. Das geplante Forschungsschiff wird technisch so ausgestattet sein, dass es mit in anderen europäischen Ländern entwickelter Technologie und Equipment kompatibel ist. In diesem Zusammenhang wird eine gute Integration in laufende Forschungsprogramme des indopazifischen Raums empfohlen und dazu ermutigt, sich am Aufbau von entsprechenden Forschungsprogrammen zu beteiligen sowie europäische und Übersee-Forschungskooperationen weiter auszubauen.

B.II. Votum zur Einordnung in Empfehlungskategorien

In seinen „Stellungnahmen zu neun Großgeräten der naturwissenschaftlichen Grundlagenforschung“ hat der Wissenschaftsrat drei Empfehlungskategorien benannt. Der ersten Kategorie werden Forschungsinfrastrukturinitiativen zugeordnet, die ohne Vorbehalt zu Förderung empfohlen werden. In die zweite Kategorie fallen Projekte, bei denen – trotz grundsätzlicher Befürwortung – noch Klärungsbedarf in bestimmten Fragen besteht. Kategorie III trifft auf Forschungsinfrastrukturinitiativen zu, zu denen der Wissenschaftsrat spezifische, auf das jeweilige Projekt bezogene Stellungnahmen vorlegt, da zum Zeitpunkt der Begutachtung auf der Basis der vorgelegten Materialien keine Förderempfehlung möglich ist.

Dem Bau des Tiefseeforschungsschiffs Nachfolgeprojekt „Sonne“ stehen keine grundsätzlichen Schwierigkeiten im Weg. Die benötigte Technik und die anvisierten Technologien sind verfügbar. Die große gesellschaftliche und wissenschaftliche Relevanz der oben dargestellten Forschungsgebiete, auf denen das Schiff tätig sein wird, steht außer Frage.

Bei dem Tiefseeforschungsschiff handelt es sich um eine Plattform für die marine Grundlagenforschung. Deshalb wird die Begutachtung der Forschungsanträge durch die DFG-Senatskommission für Ozeanographie, wodurch die Vergabe von Schiffszeiten nach dem Kriterium „wissenschaftliche Qualität“ erfolgt, ausdrücklich unterstützt. Die Nutzung des Schiffs für Ressortaufgaben von Bundesministerien ohne unmittelbaren Forschungscharakter (z.B. Bojenaussetzung) sollte auf das notwendige Minimum beschränkt und mit der DFG-Senatskommission abgestimmt werden.

Das Forschungsprogramm des Forschungsschiffs ist für die nächsten 5-10 Jahre prioritär auf den Indischen und Pazifischen Ozean festgelegt. Der Wissenschaftsrat empfiehlt, dass die variable und flexible Ausstattung des Tiefseeforschungsschiffs in seinen Einsatzmöglichkeiten optimal genutzt und das Einsatzgebiet sowie die Forschungsschwerpunkte des Schiffs nach 5-10 Jahren grundsätzlich überprüft und gegebenenfalls angepasst werden sollten. Dies entspräche auch dem integrierten Ansatz der Umwelt- und Geoforschung, bei welchem das gesamte Erdsystem betrachtet wird und welcher Forschungen zur Geosphäre, Hydrosphäre, Biosphäre und Atmosphäre einschließt.

Die Dringlichkeit des Baus ist angesichts der planmäßigen Außerdienststellung von FS „Sonne“ 2010 hoch.

Der Wissenschaftsrat ordnet das geplante Tiefseeforschungsschiff Nachfolgeprojekt „Sonne“ in die erste Kategorie der ohne Auflagen förderungswürdigen Forschungsinfrastrukturen ein.

C. Bewertungsbericht: Recommendations on a Deep Sea Research Vessel (Follow-Up Ship “Sonne”)

Drs. 8899-08
Köln, 21 January 2009

Recommendations on a Deep Sea Research Vessel (Follow-Up Ship “Sonne”)

Contents Page

Note:

This statement by a sub-panel of the steering committe “Large-scale Facilities for Fundamental Scientific Research” of the German Council of Science and Humanities concentrates on the scientific and technical review of the project for a successor to the research vessel “Sonne”. A separate report evaluates the project from an overall science policy perspective taking into account large scale facilities from different disciplines and embedding the project as part of the national as well as the European research area.

The following report is divided into two parts. The first (descriptive) part has been cleared with the submitters of the proposal, namely the German Federal Ministry of Science and Education, the German Research Foundation’s (DFG) Senate Commission on Oceanography and the German Marine Research Consortium (KDM) with respect to the correct representation of the facts. The second (evaluating) part contains the results of the assessment procedure from an expert point of view.

A. Introduction and Background

A.I. Proposed Facility

I.1. Fields of Research and Scientific Objectives

a) Research Programme

There are six fields of research identified for the proposed research vessel to contribute to. First (1), to this day the deep ocean is largely **terra incognita**. Deep ocean ecosystems cover 60 % of the earth, the inhabitants (especially the biodiversity of microbes but also fish etc.) and their extreme living conditions of temperature, pressure and food limitations are still widely unexplored. The Pacific Ocean in particular offers a wide diversity of unique habitats including high production areas, hadal trenches and the largest abyssal plains. In this field of study the physiological adaptation to these conditions and the fundamental search for the limits of life and the origin of life are addressed. What has lived in the oceans, what lives in the oceans, and what will live in the ocean are questions that outline this field of research in marine biodiversity but are largely left unanswered. Thus, there is a need for identification and classification of living beings as well as for the exploration of habitat distribution and community composition. They are intended to be investigated through *in situ* sampling, high resolution sonar systems, monitoring of acoustic tags by Autonomous Underwater Vehicles (AUVs), and video and photography.

Technologies deployed on the predecessor to the proposed facility, the research vessel “Sonne”, have addressed this kind of research by investigating biological and biogeochemical processes under *in situ* conditions. In this context, the exploration of the heterogeneous deep sea habitats and the identification of the diverse life forms, particularly of the microbial assemblages can be named. The study of the ocean’s biodiversity as outlined here also connects to the fields of fishery biology and ocean management and thus touches on environmental questions. It is the proposed facility’s objective to continue this kind of research and technology application.

Second (2)**,** tectonic activity, **the exchange of matter and energy** between the sediments (= earth crust) and the ocean interior is listed as another important field of study. As tectonic activity drives the exchange of matter and energy between the sediments either at subduction zons, active margins or ocean ridges, a major and yet to be quantified input of trace metals and other elements into the deep sea influences global ocean chemistry. In addition, the investigation of hot vents, cold seeps, mud volcanoes, mid ocean ridges and other active geostructures connects to resource research such as the exploitation of ore or hydrate from the deep ocean. There are geological formations and processes specific to the Pacific and Indian Oceans such as fast spreading ridges and numerous mid-ocean seamounts which can only be studied there.

Regarding (3) **marine resources,** methane hydrates appear as a promising field of study of their own. The discovery of methane hydrates at continental margins and subsea permafrost have raised questions about their advantageous and disadvantageous potential, respectively. The exploitation of hydrates as an energy source goes hand in hand with research done on the question whether gas hydrate reservoirs can be used as a deposit for carbon dioxide (CO_2). On the other hand, hydrate reservoirs are also held to be relevant in retaining the greenhouse gas methane. Their destabilization by changing environmental conditions might be a threat for the future climate and is subject of further research. Further marine resources to be studied are deep sea resources such as oil and gas, mineral deposits such as polymetallic nodules and manganese crusts, and the vast amounts of unknown microbes and genetic resources for research in biotechnology (“blue pharmacy”). Technologies such as seafloor mapping systems, positioning systems, AUVs and Remotely Operated Vehicles (ROVs) could be applied to identify and explore energy sources (gas hydrates), minerals and biological resources.

(4) **Biogeochemical processes**: As atmospheric CO_2 is transported into the deep ocean to a large degree through deep-water formation, the proposal submitters rate it of utmost importance for climate research (modelling) to obtain long-term data of the sinking of the surface waters to large depths in the ocean and of the mass transport by deep current systems. AUVs, moorings with mobile sensor packages, satellite-supported (Argos) buoys that drift and move up and down in the water column, transmission of data via satellite and new sensors are technologies mentioned in this context. Automatic observation stations deployed in the deep ocean provide data for physical oceanography and for chemical and biological (e.g. oxygen) studies.

In addition to the natural capacity of the ocean to store CO_2, the deliberate sequestration of CO_2 in the deep ocean could become another important process and, as a potential mitigation measure, represents a relevant field of study in climate research. Both, the deposition of CO_2 in submarine gas stores as well as iron fertilisation[22] or pumping of CO_2 enriched water into the deeper layers of the ocean have been discussed. Because of the demand of storage capacity for CO_2, this kind of research has also attracted interest of the industry. It is seen as an important field to study whether these measures are effective in removing CO_2, whether they have a negative impact on the system and what technology they may require.

The deep sea floor constitutes the largest archive for climate data stored in sedimentary deposits. The study of climate change relies strongly on these (5) **palaeoclimatic data**. Palaeooceanographic studies have focussed on high resolution sampling and on the development of new proxies to analyse the full range of natural variations of the oceanic environment on timescales beyond the observational record. Palaeooceanographic time series from deep sea sediments therefore enable the investigation of the role of the oceans in the earth's climate system over a wide range of timescales and allow testing and improving predictive models. Palaeoceanographic data can also be used to investigate whether processes in the oceans triggered rapid changes in the climate and/or possibly exhibit threshold behaviour critical processes.

The last field of research to name is that of (6) **geohazards**. Here, scientists look at plate tectonics through magnetic and seismic profiling and drilling programmes. In this field of study, the formation processes of new oceanic crusts by tectonic movements causing earthquakes and hydrothermal circulation as well as the history of oceanic basins are studied. A second field of investigation in this context is the subduction of the old crust into the mantle, potentially resulting in the generation of seismic events such as earthquakes, tsunamis and slumps.

Volcanic eruptions and sub-marine slumps on continental margins and island flanks can trigger effective tsunamis. As coastal zones are the most highly populated regions on the earth, they are endangered by such natural events originating in the deep ocean. Therefore, the detection of geohazards and the development of early warning systems are also objectives of this type of research.

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22 In compliance with international agreements: UN Convention on the Law of the Sea; Decision IX/16 of COP 9 on the Convention of Biological Diversity (May 2008); Resolution of London Convention/London Protocol (LC-LP.1 2008) on the Regulation of Ocean Fertilisation.

The ocean due to its long reaction time can be considered the “memory” of the climate system. Many aspects dealt with in the research fields outlined above can also be subsumed under the heading “the ocean’s role in climate change”. Their common denominator is the study of long-term climate developments through various disciplinary approaches. So, one approach consists of looking at consequences of human-induced disturbances that are due to influence the interaction between ocean, atmosphere, cryosphere and biosphere. A second approach would be the study of surface flow and deep water circulation, while a third way of study would comprise climate variations and consequences for the formation of monsoons and El Niño. The longest-term study of climatic change is conducted by geologists who investigate sediments to collect palaeooceanographic data. Last, looking at biogeochemical cycles reveals long-term climate change developments: the change of CO_2-transport, -storage and -uptake processes as well as the study of biological processes in the carbon cycle, driven by algae growth.

The submitters of the proposal see future research in these fields depending on research vessels with advanced equipment built for multi-disciplinary, global range, high-tech research. Such multi-purpose platforms would have to allow for handling deep submergence vehicles, long-term observatories, sea floor drilling rigs and other large sea-going infrastructure. Dynamic positioning and advanced seismic and sonar systems, improved crane and winch capacity, glass fibre cables for transmission of large data volumes, high environmental standards and reduced energy consumption would be the major developments to name in ship technology necessary for the advancement of marine science in the future.

b) Services to the scientific community

The research vessel is planned to have a flexible design for the deployment of a range of new large seagoing equipment that have become major tools for marine science during the last years and that are constantly upgraded or newly developed. Consequently, the ship is to accommodate not only the present tools, but to a very large degree also new technologies. Therefore, new requirements for navigation, station keeping, large deck space, special winches for heavy equipment, and cables for high data and energy transmission have been specified. According to the submitters, all of these technological requirements are basically available so that no major obstacles remain for the successful realisation of a research vessel. Since increased international exchange of large seagoing equipment will occur particularly within Europe, this aspect was also considered for the planning of the new research vessel. Thus, the planned vessel will provide its services to the national and international marine science community along the following lines:

- a platform with large deck space for handling and deploying large sea going equipment
- adequate crane and winch capacity for standard cables as well as optical and plasma cables to enable high data transmission, high energy transmission or deployment of very heavy loads
- advanced hydroacoustic systems for sea floor mapping and analysis of sub-bottom structures
- dynamic positioning, stabilisation during cruising and on station, heave compensation
- continuous recording of all environmental parameters and automatic input of controlled meteorological and oceanographic values into the global telecommunications system
- provision of flexible standard laboratories, sufficient cold labs, room for special laboratories in containers
- accommodation for an increased number of science-technology personnel on board due to the greater need for technicians and engineers for the deployment of large and special equipment.

The ship’s design is supposed to be flexible enough in order to accommodate various types of equipment and to deploy without further modification interoperable instruments from international partners. The participants can provide their own equipment and its adaptation to the ship’s system shall be ensured by a system’s operator. Data transmission between ship and shore will be improved compared to the present facilities on German ships and will help linking ship based measurements for online analysis of data in the home laboratories.

c) National and International Networks

The new research vessel is planned to be an essential tool in many large research programmes in Germany, such as the Clusters of Excellence “Future Ocean” in Kiel, “Integrated Climate System Analysis and Prediction” (CLISAP) in Hamburg and the

DFG Research Centre and Cluster of Excellence "The Ocean in the Earth System" in Bremen. The new research vessel is assumed to be involved in research projects funded within the DFG-programmes as well as research initiatives and large joint projects (Verbundprojekte) within the BMBF's Polar and Marine Science and Geotechnologies programmes.

In addition, research done on the new vessel is intended to be part of the 7th and 8th Framework Programmes of the European Union. Other important international networks, for which the planned research vessel is considered, are the "International Geosphere-Biosphere Programme" (IGBP), "World Climate Research Programme" (WCRP) including its sub-programme on "Climate Variability and Predictability" (CLIVAR), and "Census of Marine Life". The research vessel could provide pre-site surveys of drill sites for the "Integrated Ocean Drilling Programme" (IODP) and it could be involved in the observation of the ocean as part of the GEOSS (Global Earth Observation System of Systems) network. The new facility could be part of international networks in marine sciences including the Marine Board of the European Science Foundation or the world-wide "Partnership for Observation of the Global Oceans" (POGO).

Lastly, in Europe, exchange of ship capacities amongst the European partners (France, UK, Netherlands, Norway, Spain and Germany) is organized by the "Ocean Facilities Exchange Group" (OFEG). This cooperation aims at deploying European ships in the economically most effective way. The proposed vessel is designed to fit into the European research fleet by providing capacity for a globally operating ship and for deployment of sophisticated sea-going equipment for deep sea work.

I.2. Technology of/on the Proposed Research Vessel

The submitters have installed an expert committee ("Wissenschaftlich-Technischer Fachausschuss" [WTF] funded by the BMBF) with members from all relevant marine disciplines and international experts to identify and formulate the scientific-technical requirements of the new research vessel. International experts were also consulted. The committee consists of 26 members and is divided into the working groups (1) hydroacoustics and data, (2) laboratories and other rooms, (3) deck, lifting gear and winches.

The proposed research vessel is planned as a modern multi-purpose working platform for all marine research disciplines (physical and biological oceanography, marine geology, marine and atmospheric chemistry, marine geophysics and meteorology). It is supposed to cover similar scientific fields as RV “Sonne” and to operate world-wide with an emphasis on the Indian-Pacific realm.

The new ship is based on the RV “Sonne” experiences and planned along similar constructional lines as RV “Maria S. Merian”. It shall have the same major features as RV “Maria S. Merian”, but be moderately larger in order to accommodate more scientists and crew members as well as to fulfil the demands of a globally operating research vessel during the upcoming decades.

The new ship is laid out to have a very good manoeuvrability with dynamic positioning (DP) which will allow the ship to remain at the required position within a few meters, up 8 Bft wind from the side. According to the submitters, this is an essential requirement for the new generation of drilling equipment (MeBo) and ROVs. It will have very low noise and vibration levels, two stabilization systems, and a large working deck area. Altogether, it will have the minimum of necessary specific scientific equipment installed, including general laboratories and necessary connections for laboratory containers both on and below deck, lifting devices for the growing future needs of large sea-going equipment (e.g. ROVs and AUVs), and sheltered winches with several different cables and wires including glass-fibre cable and plasma rope. Furthermore, specific attention will be paid to achieving a highly energy-efficient and environment-friendly ship. An important aim is the reduction of fuel consumption to minimize running costs.

A research vessel of this design is only able to sample the upper sediment layers up to 30m depth with piston coring or up to 70 m depth with sea-floor drill rigs, such as MeBo. Therefore sampling of deeper layers is only possible with deep drilling facilities of special ships (e.g. JOIDES Resolution).

At the present time (October 2008) the technical design presented in the following is the general outline of the ship’s design, which will be further optimised and detailed.

a) Main features of the deep sea research vessel

A problem described by the proposal submitting bodies is the large demand of technical personnel on board for the servicing and deployment of the sophisticated equipment as this restricts the participation of scientists. Therefore, more space for housing of scientists (max. 40) and crew (max. 32 incl. physician) compared to RV "Sonne" is requested. This is a compromise between the demand for space and the maximum size of the ship. The ship will be run by a nautical crew, comprising officers, engineers, electronic engineers for technical support service for science, physician, sailors, stewards and cooks. The scientific crew is composed of scientists, technical crew (e.g. for equipment handling), lab technicians and students.

In comparison to "Maria S. Merian", another deck shall be added and the ship will be lengthened (Fig. 1). Within the front part as well as within the aft-part of the ship six meters (equivalent to 10 ribs) are planned to be added. The total length of the ship will thus be about 106 m. The width remains at 19.2 m. Only in the stern part will the width be enlarged by about 3 m (1.5 m on each side) to gain enough space for the A-frame. In contrast to RV "Maria S. Merian", the ship will not have ice class.

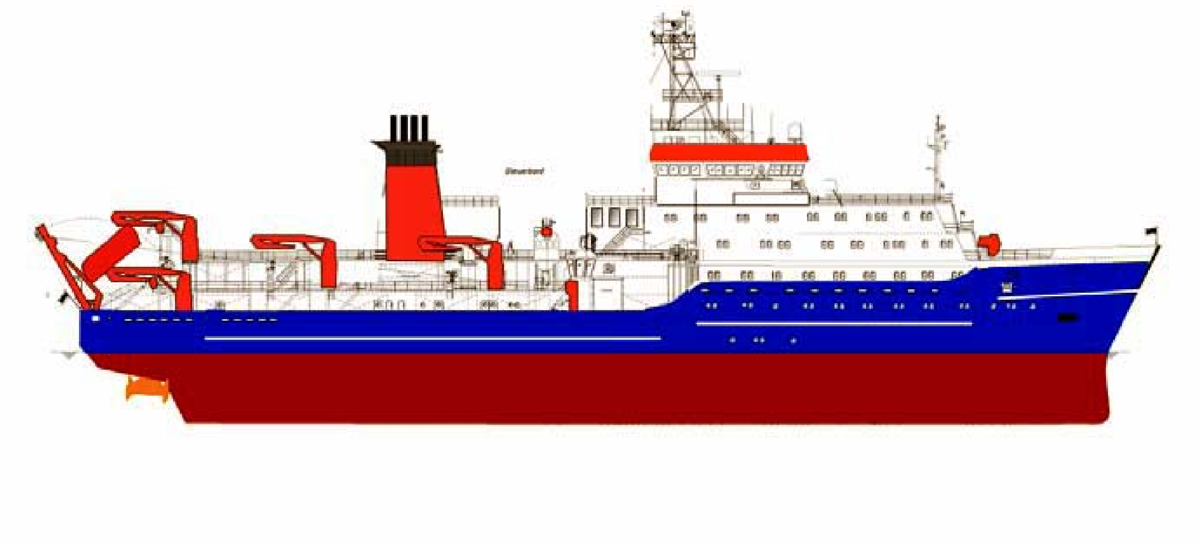

Fig.1: Side view of the new deep sea research vessel (length 106.8 m, width 19.2-22.2 m, Depth max. 7.5 m)

The line-plan drawn by The Hamburg Ship Model Basin (Hamburgische Schiffsbau Versuchsanstalt - HSVA) (see Annex 1) shows a ship expected to possess good seaworthiness and good manoeuvrability.

The design of the underwater ship hull is planned to be the same as that of RV "Maria S. Merian". The ship hull is designed to be approximately 10 m longer than that of "Maria S. Merian" in order to improve the handling characteristics. The hull shape aims at preventing transport of air-bubbles underneath the forward part of the hull where the sounders are installed. Altogether, the ship is optimized in terms of proper functioning of all hydro-acoustic systems.

Maximal speed will be in the range of 15 knots. A normal cruising speed of about 12 knots can be maintained with optimal performance of the diesel engines. This is expected to result in relatively low fuel consumption.

The duration of expeditions will be in the range of 50 days, depending on the distance covered. Fuel on board will support a cruising range of 7,500 nautic miles. The ship will be able to operate in waters with temperatures from 0°C to 35°C and air temperatures up to 40°C. On the forecastle deck there will be space for transferring goods by helicopter. Furthermore, capacity for scientific load will be in the range of 250 to 300 t. The ship will be able to maintain a "clean-ship" for 48 hours, during this time nothing except cooling water and exhaust gases are released from the ship.

The deep-sea research vessel can be functionally divided into three different parts: (1) the forward part provides crew and scientist accommodations, galley, pantry, food stores, dining room, mess, social rooms and recreation facilities; (2) in the middle part, which is considered to be least affected by stormy weather, mainly all scientific rooms are situated (laboratories, stores and winch room); (3) the aft part is occupied by machinery, workshops and stores for the ship's use. The bridge is situated atop the middle section with a good view not only ahead, but also onto the working deck and the starboard waterside. In Annex 5, a first draft of the general arrangement of all decks is presented.

Concerning environmental friendliness, technical advances in the fields of propulsion, stabilization, and positioning systems have become available mainly through offshore industries that lead to significant savings in fuel requirements and size of the crews. These developments are being considered in the design of the new ship. The propulsion system for energy efficient travel, good station keeping and low noise is still under consideration. The technological challenge consists in the assemblage of all components to a fully integrated system.

b) Technical Features and Data

Machinery/propulsion

The installation of the entire ship's machinery (diesel engines, alternators and pumps) will be in duplicate and strictly kept in two different machine rooms. So even with a "black-out" of half the system the ship will still be able to navigate safely into the next port. This precaution is above the existing regulations but seems reasonable for a safe navigation in a large region as the Indo-Pacific realm.

The main propulsion system will be diesel-electric, as on all modern research ships. A diesel-electric system with several engines assures low vibration as well as decreased noise levels within the ship and allows the possibility to run the diesel engine(s) at optimal conditions. The number of engines in operation at any given time can be adjusted according to the ship's demands from "high-energy"-cruising under bad weather conditions to "low-energy"-operation while working on station.

As the new ship will be longer and heavier compared to the RV "Maria S. Merian", it is supposed to have slightly more engine power. Total engine power, thus, will be in the range of about 6,400 kW.

The main aft drive on RV "Maria S. Merian" is provided by two Schottel POD-propulsion units with 2,050 kW each. The POD-propulsion systems installed on board RV "Maria S. Merian" were conceptualized as "scale down"-models of much larger (and proven reliable) propulsions. During the test period and the first months and years of service, these newly developed systems experienced severe initial problems. Cruises had to be cancelled and the ship had to be laid off for several months for repair. According to the submitters, these problems are solved now and the systems are running smoothly. Thus, the combination of the two POD-propulsion units with a bow-drive seems a workable solution for the planned research vessel. However, a definite decision on the future research vessel's propulsion system has not been made. Reliability, given the large distances in the Indo-Pacific realm, and availability of spare parts in these regions is a highly prioritized criterion in the design process and needs to be assured.

Additional considerations concerning the propulsion system are presented in the paragraph “noise-level” as the scientific requirements for a “very silent” ship cannot be fulfilled through POD-propulsion.

Energy efficiency

For the sake of the marine environment (to exhaust as few gases as possible) as well as for financial reasons in times of high fuel prices, it is regarded necessary to build a highly energy-efficient ship. Therefore, as much of the waste heat as possible is planned to be recycled, for example for air-conditioning.

Besides the regular ways of saving energy and using energy more efficiently, two other approaches are being considered within this project: (1) fuel-cells and (2) so-called “SkySails”.

(1) Fuel-cells burn hydrogen or normal diesel fuel more efficiently than normal combustion engines do. The disadvantages so far are their very high prices and a rather short life expectancy. But for very specific uses, they may provide the right solution. For example, to supply electric energy during harbour layovers or when no exhaust gases should be released in the environment when sensitive scientific sampling takes place. The role that fuel-cells of about 200 to 300 kW may play for the new deep-sea research vessel is, according to the submitters, currently under investigation.

(2) SkySails is the brand name for a wind propulsion system based on large towing kites which, for the first time, meets the requirements of German commercial shipping companies. SkySails quote that ship’s fuel costs can be reduced between 10 and 35 %. This may be beneficial for commercial vessels on long routes. For research vessels that do not have many long transects, it may be less appropriate. Nevertheless, it is being discussed and the submitters of the proposal consider it interesting and useful to fit the new deep-sea research vessel with such a system.

Noise level

Every ship is a source of noise within the marine environment. This man-made noise influences most of the higher marine animals. They may be disturbed and will react by fleeing from the noise or being attracted by it. These reactions prevent a “natural” behaviour and results in modification of assemblages of organisms around the ship, which should be avoided to enable undisturbed sampling. Therefore, the goal for a shipbuilder of research vessels should be to produce a vessel emitting as little noise as possible.

Maximal noise recommended for a fishery research vessel was defined by ICES (International Committee for the Exploration of the Sea).[23] At the moment only newer vessels fulfil it: the Norwegian RV “G.O. Sars”, the British RV “James Cook” and the German Fisheries RV “Solea”. For information purposes, the noise level of RV “Maria S. Merian“ and the ICES recommendation of maximal noise level are presented in Annex 2.

These strict recommendations cannot be met with a POD-System as it is only silent enough when it’s running low speed. Therefore, the propulsion systems of ships complying with the ICES recommendation consist of a diesel-electric system with AC or DC-propulsion motor(s), one or two shafts and one or two fixed propellers. For excellent manoeuvrability this configuration needs bow thrusters as well as stern thrusters. Both tend to interfere with common hydro-acoustic systems. The new multidisciplinary deep-sea research vessel is planned to be as silent as possible without great engineering and financial efforts. Therefore, a combined propulsion system consisting of approved and reliable parts is envisaged, with (1) small PODs (e.g., like RV “Maria S. Merian“) or Voith-Schneider propellers for effective station holding with dynamic positioning and for slow cruising, in conjunction with (2) fixed propellers for faster cruising on transects and between stations. According to the submitters, such a combined system and similar ones have already been realised on several ferries and on a megayacht. However, as pointed out above, the propulsion system is still under consideration and the attention to the noise level as defined by ICES will be part of the final decision.

Stabilization system

Normal commercial vessels travel at more or less constant speeds over long transects. To fulfill scientific needs, research vessels, in contrast, require variable ship speeds, from fast on transects to very slow motion on station during dynamic positioning, and all speeds in between. While stabilization of the ship’s movement during

23 See the paper „Underwater Noise of Research Vessels - Review and Recommendations“ (ICES, Cooperative Research Project No. 209).

cruising can be dampened by one system, stabilization during station-holding requires another one.

So far, two different stabilization systems are planned, which are expected to ensure as little ship motion as possible: (1) during cruising between stations a retractable fin stabilization system will provide a smooth ride and (2) on stations with no or only low ship speeds anti-rolling tanks will provide a stable ship.

Lifting devices

A-frame: At the stern an A-frame will be installed. It will handle large equipment of up to 35 t including wire (dynamic load). The A-frame will be suitable to handle all advanced ROVs, AUVs and MeBo drilling equipment. It will be possible to lower the A-frame onto the deck to change cables, wires and blocks easily. On top of the A-frame two auxiliary winches will be installed (SWL 5 t each which can be coupled) to enable mooring deployments and easy ROV as well as AUV handling. Inner height will be 10 m, inner width about 7.5 m and the range from 5 m behind stern to about 8 m inboard.

Large sliding beam: The large sliding beam (SWL 20 t) at the front area of the working deck will be employed primarily for heavy geological, physical and biological gear like sediment cores, landers, large nets and moorings. One feature of this sliding beam will be its usefulness as a crane. Maximal top height will be about 13 m and rotation will range from about 45° forward towards about 35° backward. It can be used to hoist containers into the ship’s hatch. A 12.5 t auxiliary winch on top will allow easy deployment of, e.g., mooring systems. The large sliding beam will reach from about 5 m inboard to about 4 m outboard.

Small sliding beam: A small sliding beam (SWL 7 t) or a similar device will be installed inside the hangar. It can be used for the deployment of CTDs with attached sampling-bottles (rosettes) as well as horizontal and vertical nets. The instruments can be deployed through a sliding door that can be closed with the sliding beam extended outside. Water and samples retrieved for, e.g. biogeochemical analyses can thus be handled inside the ship. A frame underneath the sliding beam will prevent swinging movements of the rosette. The small sliding beam will reach from about 5 m inboard to about 3 m outboard.

Cranes: Altogether four cranes with SWLs of 5 t to 7 t will be distributed over the working deck. Their working ranges overlap and allow normal transport of all scientific equipment from laboratories and stores towards the deck where they are needed. Even light laboratory containers as well as loaded containers can be handled. The ranges of two cranes on each side of the stern will extend to about 10 m over the sides for optimal handling of airgun arrays. Two more cranes with a SWL of 1.5 t each on the forecastle deck behind and in front of the deck house will be for handling ship's supplies and smaller scientific gear.

Scientific winches: There are few marine scientific disciplines (e.g. air chemistry), which do not depend on the use of winches. Their use is essential for any marine research and their capacities in terms of wire/conductor/glass-fibre/plastic cable as well as length and diameter determine the potential of any research vessel. The scientific winches will be:

- friction winch I with storage winch I for 12,000 m glass fibre-hybrid-cable of 18 mm Ø
- friction winch II with storage winch II for 12,000 m wire of 18 mm Ø and with storage winch III for 8,000 m plasma rope of 28 mm Ø
- cable winch I for 8,000 m one-conductor cable 11 mm Ø
- cable winch II for 8,000 m one-conductor cable 11 mm Ø
- serial winch for 8,000 m serial wire 8 mm Ø
- working winch, portable and situated on the upper deck below the big sliding beam, for 6,000 m wire 16 mm Ø
- capstan (portable) for use with A-frame as well as with large sliding beam
- 3 auxiliary winches on top of large sliding beam with 50 m wire 22 mm Ø
- 2 tow-winches for seismic needs
- small (portable) net winch for biological and fisheries sampling

Winder: One challenge of deep sea research is to deploy heavy equipment at the sea floor and provide energy and communication lines from the research vessels to the instrument. At depths of more than 4,000 m or, more correctly, at these wire-lengths, the weight of the wire (cable) alone limits the possible load. As a solution, the submitters advocate a "winder" that is regarded as a winch and situated directly under the upper beam of an A-frame. It wraps one or more cables and/or wires around a plasma rope during deployment. During recovery the cables and/or wires are unwound again. The system enables the use of power supply and signal transmission in conjunction with plasma ropes as a strength member.[24] The installation of such a system is considered to be very useful and is under discussion.

Heave compensation: “Heave compensation”-systems, which compensate for the movement between the ship and the scientific load, are important for safe deployments in rough seas. These systems for loads up to 20 t are, however, not commercially available. For RV “Maria S. Merian” a new system was developed that now, after initial engineering problems, can be tested in the field. If these tests are successful, the submitters envisage a similar device for the large sliding beam of the deep sea research vessel.

Other lifting gear: If necessary, in the scientific store room as well as in the hangar, crane crabs will serve as transport means for all heavy scientific equipment such as huge cable reels, sediment cores or large sampling bottles. Within the ship, an elevator will be able to carry Euro-pallets from the scientific store room (store deck) to the laboratories and scientific rooms (main deck). Underneath the planned free-fall lifeboats there will be a crane to assure full function of this part of the working deck, even when covered.

Working deck

As the working deck is supposed to be the main outdoor working space of the ship, scientific instruments such as lander systems and/or mooring systems could be prepared here. Supply containers could be stored and samples from, e.g. benthic trawls be sorted. According to the submitters of the proposal one of the most important purposes will be the provision of space and all necessary supplies (energy, sanitary, communication) for a number of special containers (supply, winches and electronics) for the deployment of ROVs, AUVs and deep coring devices (e.g. MeBo). The reason for this is that most of them need a specific configuration for an optimal functioning of the whole system. The large working deck is intended to have a wooden surface that allows safe and non-slip handling of all sensitive scientific gear. The space below the large sliding beam should be able to be heated to avoid freezing in cold weather. Altogether about ten 20’ containers should be stored along or across the deck with the possibility of a top layer doubling the container space. Besides the container grid, an

[24] See http://www.deeptek.co.uk/video.html.

extra grid of screw-sockets (M24) will serve as fastening devices for boxes and scientific gear. The ship's rail is planned to have several sliding doors as well as removable parts.

Container space

The space on the working deck, the upper decks, the forecastle deck, the wheelhouse top deck, inside the hangar and the scientific store (planned to accommodate up to 50 containers) is to provide many possibilities to organize the scientific work on board. Altogether, it would enable to connect 9 laboratory containers to the water system (fresh water (w/c), seawater, clean seawater, power supply (230 and 400 V), data distribution system and communication system. There would be space and supplies for up to 7 containers inside the ship (hangar and scientific store) and a sheltered space for 2 laboratory containers on the aft part of the working deck with direct access from the ship's interior. An isotope container is intended to be part of the ship and a position on a high deck is to provide for a container to release meteorological radiosondes.

Specific scientific equipment

The deep-sea research vessel is designed as a ship for multi-disciplinary use with an emphasis on geosciences. Therefore, some specific permanent scientific equipment is intended to be provided for as follows:

- Airgun array: at the starboard and the port side airgun arrays are situated. They can be disassembled and stored in a container. For geophysical and seismic research a compressor will provide up to 30 m^3/min of compressed air. In order to obtain higher power additional compressor containers that provide a similar amount of air can be combined with the ships compressor. Together with both aft cranes the total width of airgun equipment can be over 40 m.
- Coring devices: equipment to handle cores of maximal 24 m length, tubes as well as box cores of 300 x 300 mm diameter will be provided.
- Two hydrographic wells: inside the hangar two wells (clear width 1.2 m x 1.2 m) for installation of scientific equipment below the ship's hull, e.g., water sampling during cruises or additional hydro-acoustic systems will be installed.
- "Flying cable system": the so called "flying cable system" will allow installation of cables and/or hoses throughout the entire ship (clear width 100 mm x 150 mm).

- Two working boats, one of them a fast rubber boat, will be onboard for various scientific uses.

Hydro-acoustic systems

Various echo sounding systems are meant to be installed permanently; the exact instruments are still under consideration:

- multibeam echo sounder for deep waters
- multibeam echo sounder for shallow waters
- sub-bottom profiler
- Acoustic Doppler Current Profiler (ADCP), (2 different frequencies)
- USBL (Ultra-short baseline, e.g. Posidonia) for tracking of underwater vehicles
- hydro-acoustic centre with postprocessing

I.3. Societal and Economic Impact of the Planned Research Vessel

The proposed research infrastructure is regarded a major step towards a better understanding of a largely unknown part of the planet, the deep ocean. A significant part of the worldwide progress in this context - deep-sea processes, resources and deep-sea life that is - during the last years has been promoted by technological developments to monitor processes in the water column, at the sea floor or in the sediments (e.g. for the oceanography: ADCP, drifters, Argo floats, AUV, etc., for geology: ocean bottom hydrophone (OBH), ocean bottom seismograph (OBS), instrumentation of boreholes by pressure, temperature and chemical sensors, ROV, bathymetric swath mapping, parametric echosounder, drilling equipment).

Additional benefits for society are expected to arise from several other research fields carried out on the new ship.

Georisks are directly relevant for coastal settlements. The “German Indonesian Tsunami Early Warning System” (GITEWS) presently developed by German scientists might serve as an example of direct relevance of deep sea research for society.

Deep sea resources including both, the detection of such resources and the monitoring of environmental risks associated with exploitation, are a topic of economic and social interest to many nations. Deep sea resources encompass not only mineral resources but also biological resources (blue biotechnology). The resources of the oceans are increasingly used for the supply of energy and minerals. Especially the oil and gas industries produce already more than 30 % of their production from offshore reservoirs. This proportion is believed to increase as the rapidly developing deep-water technology is opening the access to even deeper resources. As onshore mineral ore deposits are more and more depleted, the deep sea mineral deposits like manganese nodules, manganese crusts and hydrothermal deposits move into the focus of the mining industry. Industrial prospection of submarine hydrothermal deposits has been initiated. The exploration of gas hydrates as a potential energy resource has been a topic of RV “Sonne”-expeditions. The economic potential of gas hydrates is of special interest for the oil and gas offshore industries. Basic knowledge and exploration techniques are also investigated within the BMBF-BMWi (Federal Ministry of Economics and Technology)-project SUGAR (Submarine gas hydrate deposits: exploration, exploitation and transport) and the BMWi-supported, mainly industry-based action “Go Subsea” (to develop marine technology) with the ISUP project (Integrated System for Underwater Production of Oil and Gas).

Sequestration of CO_2 in deep geological formations is another issue of increased interest and is investigated in science-industry projects. The improved knowledge of the role of the deep sea processes in climate regulation including CO_2 uptake and of the effects of ocean acidification on sensitive species in the deep ocean (such as cold water corals) will be a central issue in the next assessment of the “Intergovernment Panel of Climate Change” (IPCC).

The sector of ship-building and construction, marine technology and engineering as well as off-shore exploration industry will also benefit from the development and construction of a state-of-the-art multi-purpose deep sea research vessel. Cooperation between science and industry is fostered through the national Maritime Conferences that are well established to provide linkages between government, industry and science. They are also instrumental in the definition of the strategies and the political framework. At the last conference in December 2006 the marine technology was specifically named as a strategic technology to promote science-driven development.

Some examples for technological improvements achieved in the German scientific community which have resulted in spin-offs or might do so in the future are: Lander (IFM-GEOMAR), 3D magnetometer (patented) (BGR), heatflow probe (work in progress) (BGR), heatflow meter (University Bremen), deep-tow seismic fish (IFM-

GEOMAR), sea-floor drill rig MeBo (MARUM), penetrometer (just started) (MARUM), Parasound improvement (University Bremen), magnetotelluric method improvement (IFM-GEOMAR, MARUM and BGR), autoclave coring technology (IFM-GEOMAR and BGR). In addition, new ideas are and will be generated by the geoscientific community to improve the very high-resolution imaging of the subseafloor (e.g.: 3D imaging and tomography of the subsurface structure), which will be developed in co-operation with an industrial partner (ATLAS Hydroacustic, Bremen).

Some of these prototypic developments are expected to be useful for survey companies and the offshore oil and gas industries, where the new technologies will be refined. The improved instrumentation can then be re-employed by a broader scientific community, and thereby closing the cycle from science to industry back to scientific users.

The BMWi has installed a long-term funded project for the marine technology to evaluate the existing capacities, to identify promising technological projects and finally to support excellent ones. The marine Masterplan of Schleswig-Holstein aims at the same direction and Lower Saxony is preparing a similar programme.

The new research vessel is expected to provide 340 ship days per year for scientific research on behalf of the BMBF. Scientific use has priority over all other possibilities of use. If opportunities for use by industrial companies should arise, these will be regulated in line with the conditions for approval of projects receiving BMBF funds. Other than research project cooperations, no industry collaborations are intended.

A.II. Users of the Research Facility

II.1. Marine Science

The following disciplines carry out sampling and experimentation at sea and are thus dependent upon ship time: marine geology, marine biology, chemical oceanography, physical oceanography, atmospheric chemistry, meteorology. The first four mentioned disciplines that include many subdisciplines are expected to make most extensive use of the facility (e.g. marine biology includes microbiology, biodiversity, physiology; marine geology and chemical oceanography include biogeochemistry etc.). Maritime technology is also regarded important in using ships for testing new instruments.

According to the submitters, the user groups are not restricted to Northern German research institutions and universities renowned for their maritime research, but they are also located in many universities throughout Germany. The maritime scientific community in Germany alone counts about 2200 persons, and a majority joins research cruises. The community is certainly large enough to make full use of the new ship. Its predecessor RV "Sonne" was constantly over-booked.

It is expected that the ship will be in operation year round with about one month interruption for service in a ship yard. Each cruise is subdivided into several legs of 4 - 8 weeks duration, thus 6 to 12 cruise legs can be carried out in one year. This means that about 240 to maximally 480 scientists from Germany, Europe and overseas will participate each year in cruises on the new deep sea research vessel.

II.2. Availability and Storage of Research Data

Multidisciplinary seminars and workshops are carried out after the cruises in order to present the results and to promote joint analysis of the data. Ship-born data are made available via open access data bases such as WDC MARE (World Data Center for Marine Environmental Sciences). Scientific results are disseminated via international peer reviewed journals and international conferences, and by various means and multimedia to the public, including "open ship" days.

Twice a year a German online-newsletter is published.[25] There, the regional areas planned for future cruises are explained. Twice a year there is the possibility to submit cruise proposals. In many cases projects are carried out in cooperation between universities and research institutions and with international partners.

Metadata of the cruises have to be provided to the Bundesamt für Seeschifffahrt und Hydrographie (BSH) in Hamburg shortly after the cruise. Here most of the oceanography data are stored in the German Oceanographic Data Centre (DOD). For a wide range of published and quality checked marine data the PANGAEA data information system of the World Data Centre MARE of AWI/MARUM provides long term data storage and open access via internet. Scientists are requested to place their data in these data banks. In order to improve the data delivery the Senate Commission for Oceanography plans to issue a Code of Conduct for data policies that is part of every cruise grant.

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[25] See http://www.fz-juelich.de/ptj/ forschungsschiffe/SONNE-rundbrief.

II.3. Scientific Education

RV “Sonne” is rated important by the submitters of the proposal for at sea training of students and young scientists as well as technical staff. On each cruise several students are participating as scientific support staff (HiWis). The students are involved in the regular scientific work and thereby receive an excellent training on the job. These cruise participations are usually accepted as training units with ECTS points. On average, one doctoral thesis was produced per cruise on RV “Sonne”; an entire series of academic appointments of young scientists with shipboard experience has followed, and several scientific RV “Sonne” chief scientists have been awarded the Leibniz Prize, Germany’s most highly endowed science prize. On the international level, some cruises served as capacity building in connection with collaborative research with the Peoples Republic of China, Indonesia and others. This training activity is primarily oriented towards students, but indirectly serves the development of well trained personnel also for the private sector.

Depending on the discipline, fields of future employment for young scientists in science could include geological subjects, oceanography, marine or atmospheric chemistry, meteorology or biology. In the private sector, chances for employment would be in geophysics and in the oil and gas industries. Further career options can be found in the blue biotechnology sector, in maritime technology, meteorological services, but also in environmental monitoring and related jobs. Some of the students have also become science journalists and used cruises as a platform to transfer scientific knowledge and information on marine science methods to the public.

II.4. Public Relations

The Federal Government and the *Länder* agreed to organize a pupils’ competition to find a name for the vessel, which will also be flanked by related PR measures. Other means to generally address the public about the research vessel include multimedia and “open ship” days.

Future research results will be brought to the media by the respective institutions (this was done in regard to the other German RVs “Meteor” and “Polarstern”), or the results are requested by the media and are presented to the broad public in an easy-to-understand manner. Media reports on topics of marine research and the earth system generate a broad public interest.

The wider scientific community is supposed to be informed about the development of the new research ship via the newspaper of the Deutsche Gesellschaft für Meeresforschung and via announcements of the European Science Foundation's Marine Board. Press releases and a brochure describing the new facility will be widely distributed. A specific web-page will be installed for general information and to apply for ship time.

A.III. Project Management, Location, Costs, Funding and Schedules

III.1. Project Management

a) Management of Construction

The "Wissenschaftlich-Technischer Fachausschuss" (WTF) drew up the following recommendations based on "Maria S. Merian"-experiences concerning actors and responsibilities to be involved in the construction of a follow-up ship:

The contract-awarding authority of the ship project is the BMBF. The BMBF guarantees legal counselling by paying a law firm which is experienced in procurement procedures; it also guarantees commercial counselling by a consultant who is experienced in ship construction. What is more, the BMBF will commission external controlling and be responsible for public relations. Consequently, the owner of the ship will be the Federal Government (BMBF) which transfers possession of the ship to the coastal *Land* in which the port of registry is located.

The scientific and technical planning is conducted by the WTF together with international experts. The large European marine research institutions (NERC, UK; IFREMER, France; IMR, Norway; NIOZ, The Netherlands) that operate modern research vessels are intended to be invited in order to discuss the general arrangements and the scientific-technical requirements in view of the existing barter agreement and possible requirements from their sides. Also, it is planned to present, discuss and optimise the results achieved during the annual meetings of the "European Research Vessel Operators" (ERVO) and the "International Research Ship Operators" (ISOM). Here, experts from institutes from all over the world gather to exchange their experiences with existing and planned research vessel fleets.

The scientific targets and the designated technology that have been defined in an initial phase will be further developed by the Federal Waterways Engineering and

Research Institute (BAW) to a comprehensive technical design. Persons with relevant experience in the different fields (science, technology, administration and legislation) should - as a result from experiences with “Maria S. Merian” – be involved to a greater extent in the follow-up project, this includes, in particular, the BAW with its know-how in the construction of special ships. The BAW is assigned a larger role in construction planning, description and supervision of the project.

In this context, the combined call for construction and ship management of the follow-up ship “Sonne” will take place through a negotiated procedure, which has meanwhile been included in the public procurement law, with a preceding competition for potential participants. After the call and the submittal of proposals, negotiations with the bidders are planned to be taken up and the further agenda of the project is set. In spite of the high workload of the shipyards, the bidders are asked to ensure that this project can reach the construction phase as soon as possible. Stricter penalties for contract violation are intended to be included in the contracts for construction and ship management. This also results from some negative experiences with “Maria S. Merian”. These contracts should, in particular, provide for a replacement provision of research vessels during the guarantee period in case longer repairs become necessary.

Quality control to assure deadlines and project schedule will be awarded by the BMBF to a company with relevant experience in the field of controlling of large-scale projects. Regarding project management, the financing authorities of the Federal Government and the Länder act within the framework of their working group meetings. That means that they have installed a “contract implementation group“ consisting of representatives of the BMBF as contract-awarding authority, of Lower Saxony as host Land, of the scientific community, of the field of law, FZJ, PTJ, etc. If necessary, the shipyard/ship management consortium will be included. A contract working group will deal with the progress of the project and also monitors the consortium of shipyard and ship management agency. This procedure has proven to be useful during the construction of the most recent research vessel “Maria S. Merian”.

The commercial department of Jülich Research Centre (FZJ), one of the biggest research centres in Germany that is experienced in the management of large contracts, should be the contract awarding agency. Project management agency Jülich (PTJ), which is also in the FZJ’s portfolio, will be commissioned to take over the financial administration of the project. The BMBF and the FZJ agree that the FZJ, through its purchasing department, will act as the authority awarding the contract in accordance with the public procurement law for the call for the construction and management of the deep sea research vessel. (At that time, the extension of the existing charter contract for the use of RV "Sonne" until the time when successor vessel goes into operation was agreed.)

Jülich project management agency (PTJ) is intended to be in charge of the financial administration. The coastal *Länder*, which contribute to the funding, will participate in the project within the framework of the Bund-Länder Working Group German Research Fleet (BLAG) under the chairmanship of the BMBF.

During the call and the construction and testing phase, the project will be moni-tored by a "contract implementation group" which consists of representatives of the BMBF as contract-awarding authority, of Lower Saxony as host *Land*, the scientific community, the law counsellors, FZJ, PTJ, etc. This group is the contractors' coordinating body under the chairmanship of the BMBF and advisory board acting on behalf of this working group. If necessary, the shipyard/ship management consortium will be included.

b) Post-Construction and Operation Phase, Ship Management and Expeditions

After delivery of the vessel to the scientific community, ship management and controlling is assigned to Hamburg University that plans to handle the new vessel similar to RVs "Meteor" and "Maria S. Merian".

The planning of expeditions will continue to be managed by the Jülich project management agency in cooperation with the DFG and the ship management and control centre at Hamburg University. An independent evaluation of ship time is planned to be conducted by PTJ. The operational aspects of the approved ship time proposals are the task of the operations control centre at Hamburg University in coordination with the ship management agency. The ship management agency is responsible for the expeditions under nautical aspects in coordination with the respective scientific head of expedition.

c) Operation Phase, Handling of Research Proposals

Open calls for submission of proposals to participate in a cruise are issued via e-mail. According to the submitters the e-mails are distributed to more than 60 institutes and facilities in Germany that are involved in marine science (see Annex 6).The proposals are evaluated by a review board (Senate Commission for Oceanography of the German Research Foundation). The criteria for the evaluation are scientific excellence, potential for technical innovation, multi-disciplinarity and involvement in the scientific programs of the BMBF, DFG or EU. The evaluators are also checking the budget and give comments on the feasibility of the proposed work program for the cruise. Only highly rated proposals are allowed access to the cruise. Less than 35 % of the proposals applying for “Sonne”-cruises have been granted ship time for research. The submitters assume that a larger number of excellent proposals can be granted ship time on the follow-up ship as it will provide larger capacities.

During the cruise, a weekly report is sent from the ship. Two months after the cruise a cruise report has to be delivered. The submitters of the proposal expect publications from the cruises to appear in well established scientific papers with an evaluation procedure. The chief scientist is expected to deliver all scientific publications based on observations made during the cruise within the next two years to a data base. In regular intervals workshops are arranged where the results of the research are presented. The evaluation panel is also present to assess the output of the projects. These Status Seminars have become well established for RV “Sonne” cruises as a form of reporting, but are not meant to replace the scientific evaluation of projects.

Since it is a German research vessel, priority will be given to German science organizations for work on the vessel. However, the ship will also be available to scientists from other countries through the European Barter Agreement[26] and joint international projects.

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[26] Barter agreements regulate the exchange of research vessel cruise times among partners. The “Ocean Facilities Exchange Group“ for example, is a cooperation between Germany, France, the UK, Norway, the Netherlands and Spain to facilitate the exchange of major marine equipment and ships without the need to charter or exchange money.

III.2. Location

The financing agencies of the Federal Government and the *Länder* have agreed on Lower Saxony as the host Land for the future research vessel. Lower Saxony has chosen Wilhelmshaven as port of registry for the vessel.

III.3. Costs

Costs have been calculated on the basis of the increase in prices in vessel construction and raw materials for “Maria S. Merian” by the Federal Waterways Engineering and Research Institute (BAW) as of September 2008. Eventually, the cost calculations of the bidding consortia will show what costs are to be expected.

a) Costs for vessel contruction

Total costs for vessel construction amount to an estimated € 110 million. € 99 million will be paid by the BMBF, the federal states Lower Saxony, Bremen, Hamburg, Mecklenburg West-Pomerania and Schleswig-Holstein will split € 11 million. The chart below lists the BMBF share broken down for the years 2008-2013.[27]

Investments	2008	2009	2010	2011	2012	2013	Total Costs (mio €)
Sonne II	0.3	1.0	27.0	33.0	28.0	9.7	99.0

Fig. 2: Ship building investment for the follow-up ship “Sonne” in the next years

The annual costs, however, are said to be only available from the calculation of shipyard and ship management agency after the call. Likewise, further specifications of different cost shares will result only after the call and the conclusion of negotiations for the vessel construction between contractor and consortium.

At this time, cost budgeting for the construction is available from a 2002 proposal by Kröger Werft for the construction of “Maria S. Merian” and allows for

1) commissioned additional services and adjustments of services/costs during construction,

2) preliminary assumptions such as maintaining the main dimensions and maintaining the basic concept,

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[27] See for an overview of all German middle and long-term ship building investments in the next years Annex 3.

3) taking into account the annual rate of inflation (2 % p.a.), (does not include the steep increase in prices in 2004/2005), no Polar Code for the new ship in contrast to RV “Maria S. Merian”, further technical changes, such as 2nd rescue satellite, larger scientific winches, larger aft gallows, no ventilation behind casing, reduced insulation, additional deck.

4) a construction reserve of about 3.8 %.

On the basis of these plans and assumptions the following prices were calculated (2007 prices):

price (net) 65,550,000.00 €

price (gross) 78,000,000.00 € (with 19 % VAT)

Based on the specific current market situation in ship building, including the supply industry, future estimates for 2008 must include an additional 20 % price increase due to the shipbuilding boom of 2004/ 2005 and the related price development and an annual inflation rate of 3 % for 2008.

This results in the following subtotal (2008 prices):

price (net) 81,000,000.00 €

price (gross) 96,500,000.00 € (with 19 % VAT)

Additional cost-effective modifications must be taken into account as revealed by a first rough examination of the latest technical requirements. Important in this context are a the planned increase in vessel length, the planned construction of two heave compensation devices and the enlargement of technological equipment, e.g., cranes, winches, etc. In total, these changes are estimated at about 11,500,000.00 € (net). The costs of possible application of fuel cell technology, etc. have not been taken into account.

This results in a total budgeted price (2008 prices)

price (net) 92,500,000.00 €

price (gross) 110,000,000.00 € (with 19% VAT)

The costs incurred by the construction of a new vessel are usually broken down according to assembly groups (assembly groups 0-9, see Figure 3). As already explained, current cost budgeting is based on comparison with the construction of RV “Maria S. Merian”, the known technical modifications and enlargements and current parameters, since a detailed calculation by assembly groups is not possible for the time being and therefore not available. However, a rough breakdown of the costs of the main assembly groups is possible, also based on existing, representative key figures from past evaluation of the results of calls (research vessel section).

Based on a total amount of 110,000,000.00 € (100 %), the following rough breakdown can be given:

Assembly group	Designation	Share in %	Value in €
0	General (e.g., model tests, construction, delivery documentation, …)	10	11,000,000
1	Hull with superstructure	15	16,500,000
2, 3 and 4	Fixed Equipment, ship outfit and corrosion protection	30	33,000,000
5, 6, 7, 8 and 9	Ship propulsion, ship operation equipment, electrical system, communication equipment, fixtures	45	49,500,000

Fig. 3: Cost estimates follow-up “Sonne”

The cost estimate takes into account the most recent economic developments in both the maritime and the supply industry, which have resulted in considerable increases in costs in past procurements. For future developments, in particular further increases but also reductions are possible. The calculated purchase price is therefore considered to be the correct budgeted price from today’s perspective.

b) Costs for R&D after Construction and During Operation of RV

The expenditure calculation for scientific projects on the research vessel (without charter costs) was done by summing up the approved project costs for 2004-2008 at

RV “Sonne” which amounted to € 6.6 million. This sum was correlated with the charter days used by the BMBF during this period. The result made it a daily rate for science of about € 5,700. These numbers are difficult to compare, however, as RV “Sonne” is owned by a private company and its charter rate includes capital service.

This daily rate is taken as the basis for calculating R&D expenditure for the new research vessel. If the amount is multiplied with the planned expedition time of 340 days p.a. (remaining time is shipyard time), annual expenditures of about € 2.3 million result for scientific projects. Since price increases can be expected in particular in the field of travel and transport and due to high operation costs of modern equipment, at least € 2.5-2.7 million must be estimated for the new vessel (see Annex 4). The scientific and technological staff costs are about 50 – 65 % of this amount (on average).

c) Charter Costs after Construction and During Operation of RV

An extrapolation was made on the basis of current operating costs for RV “Sonne” of € 29,300/day and extra charges of € 6,000 (which were found to be insufficient over the past few months of 2008 due to rising fuel costs). The submitters expect that the diesel-electric propulsion system taken into consideration for the follow-up research vessel will eventually contribute to reducing energy expenses. Compared to current propulsion systems, aggregates from the 1970s and 1980s are 10 – 15 % less efficient. Moreover, fuel cells and a sky sails are considered as further options to decrease fuel consumption.

The operating costs 2009 for RV “Sonne” will be about € 38,000/day. The final energy savings of the new ship cannot be assessed at this stage, but running costs will be around if not less than this daily expenditure for operation of the ship.

Hence, total operating costs are expected to amount to € 13.9 million p.a. The calculation of operating costs for a full-year operation of the vessel (365 days) (including shipyard time) is based on the current costs for RV “Sonne”. However, a price increase of 1-1.5 % p.a. must be expected. The estimation of the rate of increase is based on increases over the past five years.

Capital costs need not be calculated since this vessel is financed by the Federal Government and the *Länder* without raising funds on the capital market.

The costs have been calculated on the basis of the increase in prices in vessel construction and raw materials for RV “Maria S. Merian” by the Federal Waterways Engineering and Research Institute (BAW) as of September 2008. Eventually, the cost calculations of the bidding consortia will show the actual realistic costs.

III.4. Funding

a) RV Construction

The Federal Government and the German coastal *Länder* have agreed to finance the construction of the vessel with a split of 90 %:10 % Federal Government:*Länder*. Lower Saxony as the ship’s host state has agreed to pay 50 % of the 10 %-*Länder*-share; Bremen, Hamburg, Mecklenburg West-Pomerania and Schleswig-Holstein will equally split the other half. An involvement of other funding agencies from industry or abroad is not envisaged.

The submitters postpone the final design of the vessel after the public bid and the negotiations with the bidder consortium. The negotiations are supposed to define the timeframe to implement and construct the research ship. Legal regulations (in case of breaking contracts, penalties for delays etc.) will therefore be included in the contracts in the form of penalty clauses. A technical or financial risk analysis is envisaged only after the contract awarding negotiations.

If the new research vessel cannot be commissioned on time, RV “Sonne” can continue to operate under the current conditions (charter of at least 250 days p.a.).

b) RV Operation

The BMBF is committed to fund up to 100 % the costs of operating the vessel.

The participation in the cruises of national and cooperating international scientists is free of charge, but the scientific groups have to secure the finances for their own research.

III.5. Schedules

a) Planning and Construction

Depending on the vote of the Wissenschaftsrat, a public bid to plan and construct the new deep sea research vessel has been launched in December 2008. In mid or fall 2009, concluding the specifications for the call which must be agreed by science, technology and lawyers, is expected. As the call is subject to legal periods, the contract can be awarded as long as 2010. Sorting through the offers, negotiations with the different bidders and the final decision-making by a bidding consortium are taken into account as factors determining the progress of the project. The commissioning of the vessel is planned for 2012.

A Europe-wide call will be issued that combines construction and ship management. The aim is to conclude a contract which includes the construction of the new deep sea research vessel and the management of the ship for a prolonged period (about 10 years). Therefore consortia of shipyards and ship management agencies will be addressed by this call. Throughout its lifetime the research vessel will be run by ship management agencies. The contract will be put out for tender internationally in regular intervals to obtain the best offer. External services may be contracted for standard measurements (e.g. FILAX Company for routine oceanographic data).

Apart from building and managing the ship, business cooperation with oil industry or pharmaceutical industry can be envisaged for seismic data or provision of samples from specific habitats.

b) Expedition Schedule

The new vessel is planned to operate 340 days p.a (including transit and port days). The remaining days would be needed for shipyard time. The submitters of the proposal have come up with this schedule through long-standing experience with RV “Sonne” in the Pacific and Indian Oceans. Modifications of the new vessel’s operation mode are not planned. The number of pure transit days is declared to depend on the one hand on the area of operation of the vessel, mainly the Pacific Ocean and the rim areas (181.34 million km^2) and the Indian Ocean, and on the other hand on the distance between the different areas of operation. In addition, the employment of a research vessel is subject to regional seasons and weather conditions. Lastly, the scheduling of expeditions is determined by the integration into ongoing BMBF-projects and into the framework of international scientific and technological cooperations.

The most economical expedition planning is required to reduce pure transit routes to a minimum, taking into account that some researcher groups are actually interested in continuous measuring data over long transit routes. The 70 transit days p.a. given in the evaluation report of RV “Sonne” also include the necessary access routes to the ports and to/from areas of operation which are necessary for all research vessels and cannot be reduced. The optimal expedition coordination for all users is determined by the ship management agency in coordination with the operations control centre on the basis of approved expedition proposals.

B. Statement and Recommendations

Climate change and human-induced pressures on the Earth's ecosystems are great societal challenges that pose eminent questions to research in marine science and call for an increasing need to study the role of the ocean in the climate system. In addition, the oceans hold resources (minerals, oil and natural gases) that wait to be exploited in a sustainable manner. There is an enormous and largely unknown diversity of habitats and species in the deep sea with potential relevance for the "blue technology" left to be explored.

The least well-explored oceans are the Indian and Pacific Oceans. In particular, there are biological, physical, chemical and geological formations that are unique to the Pacific Ocean and can only be studied there. Many of the Earth's biogeochemical processes, its climate and ecosystems cannot properly be understood without knowledge about the Indian and Pacific Oceans.

Only relatively few modern and well-equipped research vessels operate regularly in the Pacific and Indian Oceans at all. In fact, Europe-wide, RV "Sonne" and its future replacement is and will be, respectively, the only research ships dedicated to the investigation of these areas. Thus, it is of utmost importance for German and European marine science that a research vessel continues to cover future research needs in these geographical areas after RV "Sonne" retires in 2010. In this regard, a vessel replacement would follow up on the excellent work done on RV "Sonne" so far. However, recent technological advancements and innovations require the vessel replacement to meet certain design requirements so it remains state-of-the-art in the decades to come. So, there is a high need for a new deep sea research vessel that will contribute to fundamentally new insights about the Indo-Pacific realm and is technically designed and technologically equipped so it meets the criteria of technical capability and flexibility necessary for a multi-disciplinary ship of the Global class.

B.I. Fields of Research

The fields in which current RV "Sonne" is active have only started to be explored and will continue providing excellent research opportunities. Thus, major progress in these fields is expected in the future. Moreover, the study of the Indo-Pacific Ocean offers a wide array of unique scientific issues which have not been studied so far. Thus, it is important to follow up on the scientific tasks of RV "Sonne". A replacement research vessel promises to contribute to new insights most prominently in the following fields:

a) Climate Change

Investigating the chemical composition of the oceans' water masses and their (geo)physical behaviour on a long-term basis is absolutely essential to understand past and future climate behaviour. The properties of ocean waters are tightly connected to atmosphere circulation processes which in turn have been subject to human-induced disturbances such as greenhouse gas- and nitrogen-emissions. The way the ocean chemistry changes due to human activity, and the way the oceans respond to changes in their chemical composition may result in climate variations such as monsoonal rainfalls, El Niño or biogeochemical consequences such as changes in algae growth. Regarding physical oceanography, understanding the exchange between the surface and deep ocean water masses for which the Pacific and Indian Oceans both play critical roles, is important for understanding the oceans' role in heat storage and thus as a moderating force within the climate system. However, our current knowledge of both water-atmosphere-interaction and deep water formation and exchange processes, the latter especially with reference to the deep ocean, is still rather limited.

In addition to accurate measurements of current oceanographic parameters, reliable knowledge about climate history is also needed to predict and align future climate developments. The deep-sea floor constitutes the largest archive for climate information that is stored in sedimentary deposits. Palaeoceanographic time series from deep-sea sediments enable the investigation of the role of the oceans in the Earth's climate system over a wide range of timescales and allow for testing and improving predictive models needed to understand climate change.

Among the major results of the research done on RV "Sonne" are the study of oxygen minimum zones in the Northwest Indian Ocean; palaeooceanographic studies that enlightened the dynamics of the Asian monsoon system and the response of the El-Niño-Southern Oscillation during past climate changes; and biogeochemical studies looking at the oceanic uptake of anthropogenic CO_2. This research provides an excellent base but only serves as a starting point for future studies necessary to understand the role of the ocean in climate change on a local as well as a global scale.

b) Deep Sea Resources

There are unexplored deep sea resources that wait to be developed and exploited eventually, in a sustainable manner, especially in the Pacific Ocean. Among them are methane hydrates which constitute a field of research that has been extensively pursued by RV "Sonne". As early as the 1970s, German marine science started to investigate the potential of energy resources by drilling various deep water frontier regions around the globe, the South Atlantic off Argentina, the Costa Rica margin and Nankai Trough, to name a few. Currently, the energy content of gas hydrates is deemed to be much larger than that of all known gas and oil reserves (about 3,000 petagrams carbon). Yet in order to assess the volume and potential of submarine gas hydrates a much better resource estimate is needed. It is important to mention in this context that research done on RV "Sonne" has resulted in developing an approach that involves the storage of CO_2 and the simultaneous recovery of methane gas in gas hydrate deposits below the seafloor. Thus, methane hydrates have the potential of being a carbon neutral energy source that could gain more significance as an energy provider in a long term perspective. This kind of research needs further development. More generally, further work is needed to better understand the generation and trapping of hydrocarbons within large sedimentary basins through the application of 3D modelling and geophysical tomography.

Exploitation of marine resources is however not restricted to methane hydrates. Additional promising marine resources include polymetallic nodules rich in nickel, copper and cobalt as well as the large biodiversity of micro-organisms to be explored for biotechnological use and the so-called "blue technology". These fields have only been started to be explored and their medical and technological potential is yet to be measured.

c) Deep Ocean Biodiversity

Much of the life in the deep ocean has remained unknown to this day. As an example, the Pacific Ocean covers nearly 50 % of the Earth's water surface and it can be assumed that it hosts over 50 % of the Earth's biodiversity. Also, the Pacific hosts the widest range of habitat diversity. At least 50 % of all animals and probably as much as 99 % of all microorganisms found in marine samples (both water column and seafloor samples) today are new to science and need classification and investigation. To date 230,000 marine species have been described with an estimated 10-100 million waiting to be specified. Hydrothermal vents which can be described as life oases in the deep sea, are among the most productive communities on the planet as primary production can be fueled by chemosynthesis and the biomass there is dominated by animals living in symbiosis with chemosynthetic bacteria. As less than 10 % of the deep ocean ridges have been investigated so far, many more different types of chemosynthetic habitats and their biogeography are yet to be discovered. The Pacific Ocean is particularly important as it is the oldest ocean and so holds important keys to the ancestry of vent and seep animals and their evolution. In this regard, deep sea biodiversity and biogeography research is also strongly connected to marine resource research. The micro-organisms to be identified and classified are expected to display novel biosynthetic pathways (as they exist under extreme conditions of pressure, temperature and food limitation) and thus promise large biotechnological and pharmaceutical benefits.

d) Geodynamics and Georisks

Georisks associated with subduction zones have been subject of study during various geoscientific expeditions and programmes of German institutions. Geographic foci included the Pacific subduction zone offshore Oregon, off Central America, in the Northwest Pacific Ocean, along the margins of Peru and Chile and the Indian Ocean offshore Indonesia. These studies showed that seismic activity is regionally highly variable.

As a result and based on these studies, the German initiative GITEWS (German-Indonesian Tsunami Early Warning System) has been launched in the Indian Ocean off Sumatra and Java following the Sumatra tsunami of 2004 with the aim of mitigating the effects of earthquake-generated tsunamis in the future. The installation of the early warning system relied on intensive geoscientific investigation of the Indonesian subduction zone in order to select optimal sites for deep sea monitoring stations, as well as the application of new sensors and transmitting technology. It is valuable and desirable that long-term observation be implemented in order to monitor creep movements, internal structure and fluid composition of the fault zone to aid better understanding of geohazards of this kind.

Besides earthquake monitoring, the study of the global dynamics of the lithosphere ("plate tectonics") has been established through magnetic and seismic profiling and the scientific drilling programme (ODP/IODP). RV "Sonne" has contributed extensively to these programmes, mainly by providing pre-site surveys.

Finally, past and present RV "Sonne" research activities concentrated on active processes of magmatic intrusions, including the origin of large igneous provinces (LIPs), the spatial and temporal variation of the magma chambers and volcanic eruptions beneath mid-ocean ridges, the tectonic movements and related earthquakes, and the role of ultra-fast and very slow seafloor spreading in changing the hydrothermal circulation. Continuing this type of research on formation processes of new oceanic crust will allow a more comprehensive view of the complex interactions of tectonics and magmatism of spreading centres.

It should be added in this context that the early history of oceanic basins is not well understood either. The sedimentary record of this early period lie within many of the basins along the passive margins of continents but are now deeply buried at the foot of the present continental slopes. These regions form an unexplored area where large hydrocarbon reservoirs are expected. Some of the gas generated at depth might migrate upwards in much younger sediments where it is trapped in gas hydrates.

B.II. The Proposed Facility

II.1. Scientific Programme

The scientific case for the new deep sea research vessel is extremely strong given the intended geographical area of operation (the Indo-Pacific Ocean) in combination with the technical features and technological facilities envisaged for the ship. Fields to profit most from the new research vessel will be disciplines involving seafloor studies such as biology and geology, but water column studies and ecosystem research are also expected to be largely expanded. Many habitats are so far only marginally studied and vulnerable to ocean acidification (which threatens the calcifying biological species), such as seamounts, fast spreading ridges, hadal trenches and the world's largest abyssal plains that are unique to the Pacific Ocean. A large amount and variety of deep sea living creatures wait to be explored. Mineral deposits could be exploited in the future. In addition, the large igneous provinces and hydrothermal vents of the Pacific have remained largely underexplored so far. Active subduction zones, that are associated with geo-risks such as tsunamis, are promising and highly relevant research fields. The Southern Pacific because of its remoteness is especially undersampled for all disciplines, geology (palaeooceanography in particular), biology, chemistry (e.g. atmospheric trace gases) and meteorology. Studies in these fields are expected to add exciting new results to research concerning climate change, marine resources and the ocean as terra incognita.

The ship will be a platform from which new and highly advanced instruments will be deployed which allow for great research opportunities in these fields in greater detail because of higher resolution than previously possible. Further as the Southern Pacific in particular is a remote region with relatively little (commercial) traffic, it is recommended to implement autonomously working systems that collect time series data and report back via satellite. It is considered a strength that the new deep sea research vessel can be located in the Pacific Ocean on a long-term basis. Due to the submitters' commitment to keep the research vessel in operation there for at least 10 years, instruments and technology allow for time series studies that were previously unattainable.

The Southern Pacific is a particularly interesting subject for climate science because it is the oceanic region in the world that is expected to be least subject to change: the wind systems there are stable, for example. What is more, the climate system in this region differs from that of the Northern hemisphere and its specificities and characteristics need to be known in order to understand the system as a whole. El Niño and the southern oscillation, for example, have an impact on the entire climate system. The role of the Pacific in its relation to the other oceans is also a point in case for biogeography as the Pacific is a center of speciation from which the Atlantic has been and is still being invaded. At last, as parts of the Southern Pacific are home to the largest marine desert, they are a potential target for iron fertilization experiments to study the limited biological productivity of the region due to lack of natural iron supply.

Main results from research done on RV “Sonne” included methane hydrate surveys and insights into oxygen minimum zones in the Northwest Indian Ocean. Oxygen minimum zones will increase with climate change and therefore remain important subjects of study. For future research, it is recommended that methane hydrate research is continued in combination with geophysics since many of the basins along the passive margins of continents form an unexplored area where large hydrocarbon reservoirs are likely to exist.

II.2. Technology

The submitters' idea to construct a multi-disciplinary, technologically advanced research ship with a highly capable and flexible design is strongly supported. Even though the ship is dedicated to deep sea research, especially for investigating the deep sea floor, it will also be well-equipped for other disciplines and able to do chemical, physical and biological work as well as geological work. While it is anticipated that 80-90 % of the ship's time over its first 5-10 years of operation will be for seafloor research, 10-20 % of its efforts will probably focus on water column research. Moreover, the ship is designed for 30-40 years of operational life time, and one should take into account that it might at some time in the future be shifted to other disciplinary uses as well. Thus, it is strongly supported that the ship is designed as a modern, fuel-efficient all-round vessel. In fact, the versatility and flexibility of the future research vessel will be one of its major strengths. Therefore, a lot of thought needs to be given to ensure that the new vessel has the best hull design possible – especially as about 20 % of its time will be for transit steaming, to and from locations and ports.

Generally, the feasibility of the technical features envisaged for follow-up "Sonne" and the technology is high. No major hurdles need to be overcome as good tools and equipment already exist (good propulsion systems, for example, that wait to be chosen). Rather, decisions need to be made on what technology is wanted for which scientific task, and technical features and technology need to be combined in a way so they meet the demands of a research vessel with low noise, low air bubble production, appropriate dynamic positioning system, low energy consumption, and excellent sea-keeping abilities. It is recommended that construction priorities are adjusted to and follow the scientific priorities of the ship and, for that matter that the WTF prioritizes construction and technology needs (see also B.III.1.).

It is vital that the ship will be able to serve as a host for all kinds of instruments and equipment developed in European countries except for manned submersibles such as "Nautile". This is an important point to stress because the RV "Sonne"-replacement will be the only European research vessel regularly operating and thus tackling the main scientific objectives in the area of the Pacific and Indian Ocean. Thus, it is recommended that interoperability with European gear (ROV, AUV, towed vehicles, especially) is ascertained in the construction process and that the research vessel will be practically able to carry and employ European equipment.

The ship's design needs to emphasize low noise (ICES 209 must be respected), low air bubble production, appropriate dynamic positioning system, low energy consumption, environment-friendliness, and excellent sea-keeping abilities. Executing these optimization criteria would result, first, in a modern and efficient hull design to improve transit speed and reduce fuel consumption. It is suggested in this context to compare hull designs and to perform hull model tests to validate the projected hull's adaptation to real Pacific sea conditions, possible storms and long passage times in the Pacific and Indian Oceans. It would further result in a modern engine and propulsion system that reduces noise and air bubble production. This is important as a large number of air bubbles limits scientific hydro-acoustical equipment efficiency. Vibrations also disturb working conditions for sensitive instruments and personnel. Diverse propulsion configurations, the "classical" propellers on shafts plus thrusters versus PODs or Voith Schneider propellers, have their advantages and disadvantages concerning air bubble production and noise reduction and need to be compared carefully. Excellent station keeping, including dynamic positioning, navigation and instruments is needed as well as a clean ship (as is already standard with all recently built research ships in Germany and abroad) meeting all environmental criteria of sustainability and energy efficiency. The definition of a typical year with a dispatch in percentage of passage time, percentage of station works, percentage of *en route* works could be helpful to optimize number and power of diesel engines, and so optimize future fuel consumption. Sufficient space needs to be granted for a large number of scientists and technical crew necessary to operate the complex underwater equipment. Last, it is agreed that no moon pool is necessary for the new deep sea research vessel as a sliding beam that can be pulled out sideways is planned which will suffice for the deployment and recovery of heavy equipment.

For the overall optimization of research vessel, it is strongly advised to consult vessel designs and achieved performances from other nations and the industry. Non-German institutes, in particular OFEG members should be consulted for preliminary usage possibilities concerning technical features and technology. A more formal and complete consultation of IFREMER, NERC, and other research and multipurpose ship operators and designers might be helpful in order to supply the German experts with the results obtained while constructing RVs “James Cook”, “G.O. Sars”, and “Pourquoi pas?”. RVs “James Cook” and “Pourquoi pas?” in particular could serve as “model” RVs since both are large vessels (around 100 m long), dedicated to multi-disciplinary deep sea research and propulsed by two propellers and thrusters. Both are also fitted with DP.

Concerning the scientific needs underlying the technical features and technology, besides geologists, active sea-going water column scientists and meteorologists should be incorporated to the Wissenschaftlich-Technische Fachausschuss (WFT) (see also B.III.1 for this point). As the BAW has not taken up its design task yet and the presented design based on “Maria S. Merian” serves only as an orientation, it is appreciated that the real and eventual design of the new vessel stays fully open.

The versatility and flexibility concept includes diverse tools of which implementation is strongly recommended:

- anticipated frequent ROV operations require dynamic positioning and the possibility of deploying ROVs alternatively over the stern or over the side,
- large-heave compensation crane (for heavy over-the-side operations such as the drill MeBo), as is fitted on several multi-purpose new Norwegian vessels[28], and the possibility to carry winches and cable that allow operations below 6,000 m,
- a proper working deck surface (wide and open) to guarantee operation of interoperable heavy gear. In this context, the positioning of the life boats planned for the new research vessel should make sure that enough working space is available, especially with regard to the heavy ROV systems and geophysics needs,
- for water column sampling a proper sized A-frame and/or sliding beam that is able to turn and located amidship directly behind the hangar is recommended. This is essential for good CTD (ConductivityTemperatureDepth)-rosette operations also in heavy seas. There is a development of large CTD-rosettes with larger volume (30 liters instead of traditional 10 liters) of the 24 samplers mounted on the rosette. Moreover, midship operations can go on longer in bad weather and heavy seas, such that an extra A-frame also allows continued operations for

28 See e.g. “Acergy Viking“ as a model.

other gear (except very heavy gear) that normally (at more pleasant weather and sea state) is run from the A-frame at the stern,

- the aft-deck should be laid out to allow the deployment of multi-channel seismic reflection profiling equipment. Options for multi-streamer seismics should not, however, dominate the ship's design. Full-blown 3D-seismics are not recommended as an option for a multi-purpose research vessel. If they are needed, specialized industrial vessel operators should be consulted,

- sufficient laboratory space inside the ship including a sufficient number of labs with fume hoods. In compliance with the flexible design of the ship large labs equipped with mobile separations are preferred. The need for in board or containerized clean laboratory space has to be assessed. Stability of the electrical current supply in the labs must be ensured as thermostated stable temperature (e.g. cold rooms for biological rate studies at natural deep water temperature of e.g. 2 to 4 degree C) and a laboratory with very stable temperature is required for accurate measurement of the increasing CO_2 (DIC) in ocean waters. In addition, the position of the labs should preferably be located in the canter of the ship where the ride will be smoothest. Thus, very stable low noise and stable electric supply in a laboratory in the middle of the ship at a fairly low deck is recommended. This would be suitable for microscopy, very sensitive electronic analyser systems, etc.,

- underway sampling facilities, including so-called ferry boxes for automated measurements and sampling of surface waters when the ship is underway. More and more research vessels do automated underway measurements and sampling. Autonomous pCO_2 instruments are run automatically and data is submitted to a globally connected database. This is done at all cruises, i.e. also on cruises which have very different major research objectives. More recommendable data collection facilities include underway aerosol sampling for dust input into the oceans and automatic air sampling in flasks for accurate analyses afterwards of greenhouse gases, O_2, etc. (to assess global CO_2 budgets),

- e-access. Real-time internet is necessary in order to improve ship-to-shore transmission allowing scientists to receive data stored ashore or on-shore technicians to calibrate instruments,

- a plan for water- and air-inlets. The design of the ship should envisage suitable continuous intakes for surface seawater, air and tubing etc. into a dedicated underway laboratory room which holds the automatic instruments.

In terms of future enlargement and upgrading of the vessel, the flexible design of the ship is highly appreciated. In this context, the flexibility to launch diverse underwater systems is increased by the intended possibility to deploy them from the (starboard) side the way it is done normally by industrial operators.

The ship hull and scientific equipment will need a major refit after 10-15 years of operation as planned by the submitters of the proposal.

II.3. Societal and Economical Impact of the Planned Research Vessel

Data and research results from cruises with the new RV will in general be shared within the scientific community. There will be open access to data through databases. However, compliance with data sharing policies by RV “Sonne” users has not been satisfactory in all previous cases. In this context, it is appreciated that the DFG-Senate Commission for Oceanography plans to issue a Code of Conduct for data policies. In order to ensure compliance with these policies, users who do not submit their data in accordance with the Code of Conduct should be considered for sanction. Thus far, funding agencies (e.g. EU) that have strict requirements in themselves for data delivery to a central (and open-access) database have only had mixed success because they had limited means of enforcement. Here, it is recommended that in addition it would be a good idea that ship operators should impose data delivery requirements on the cruise participants and make sure that data repositories are used. The IODP can be regarded as an example for good sample, data and obligation policies.

There are some cooperations with industry and data will be shared with industry on a case-by-case basis. It is highly recommended that industry cooperations will be pursued more systematically than they have been in the past. There are starting points. For example, the BGR, one of the follow-up research vessel’s users holds the German exploration license for polymetallic nodules in the Central Pacific Ocean for a period of 15 years covering an area of 75,000 km^2. This license would be an excellent starting point for contracts with the (German and international) industry. German companies could go in first and exploit these areas after the BGR has done the explorative work. In particular, by operating a “Sonne”-replacement in the Pacific, Germany maintains its claims with the International Seabed Authority, thereby opening up a strategic option for German industry.

Options for transfer and application of scientific knowledge and expertise are not restricted to polymetallic nodules. Methane hydrates are another field of interest to both industry and society. Marine biology might provide similar options for cooperations with industry. The study of microbes and genes might offer vast benefits for biotechnology and the so-called “blue pharmacy”. Thus, it is highly recommended to intensify transfer and cooperation in these topical areas. It is also recommended to develop a general knowledge transfer plan that includes a more strategic approach and guidelines to data sharing with commercial partners.

The “Sonne” replacement will be part of various European marine science cooperations such as the OFEG barter agreements. It is expected that these ventures will not only contribute to an efficient use of the European research vessel fleets but also to an increase of international knowledge and expertise exchange.

II.4. Users of the Facility

It is highly advantageous for German marine science to have a new deep sea research ship as an important strategic resource for European research under the OFEG barter agreement. With the planned increase of ship time from 240 to 340 days per year, the exchange of ship time could also be increased. This would lead to an increase in the collection of points in the European barter ship agreements. It is suggested in this context to obtain preliminary figures from five other OFEG members stating their potential usage of follow-up “Sonne” during its first years of existence.

Existing arrangements for access to the German marine science fleet are well established and should be followed and continued. International scientists have access through bartering as well as direct academic collaboration. The unique position of the new research vessel in the Pacific makes it an European asset that needs to be open to cooperations. The recommended expansion of the range of scientific disciplines plus expansion of barter will optimize the effective use of the vessel.

RV “Sonne” has played a significant role in the collection of site survey data that has enabled ODP and IODP drilling programs. It is anticipated that the replacement of RV “Sonne” will continue to play a major role in the pre-drilling surveys especially through the collection of seismic reflection data. As seismic surveys consume a considerable amount of ship time, it is highly advisable that other kinds of simultaneous *en route* tasks are considered in order to optimize ship use. Carrying out underway measurements of surface waters and the atmosphere will easily enhance the total scientific output of the research vessel. Ferry boxes and underway pCO_2 measurements were already mentioned above. Moreover, there is ample good experience with alongside towing from starboard amidship of a very small torpedo at shallow (3 m) depth for ultraclean sampling of surface waters for trace elements. This can be done while at the same time instruments (e.g. for seismics) are towed from the stern.

At present, the research vessel is designed for 40 scientists and 32 crew members (including technicians and physician). It is recommended, however, to reconsider building only single cabins because the option that some or several cabins are suitable for double occupancies would allow more scientists (and crew members) to participate in cruises (up to 42-44). The overall lay-out of the ship permitting, it would give the ship more flexibility if in some cruises single occupancy of all cabins and in other cruises double occupancy of one or more cabins could be chosen. This flexibility would improve the usage of the ship and would create opportunities for meeting the increasing demand for technical assistance and/or interdisciplinary cooperation in future scientific cooperations. It could also increase the number of students being able to come on board.

Flexible double occupancy is not only an option for the long research cruises but also for occasional relatively short cruises (e.g. only 3-7 days) or when in transit for education purposes. Most notably, the major operational regions South Pacific and Indian Oceans are adjoined with several developing nations, and education and training will help “capacity building” there which makes the ship a true ambassador of Germany. Conversely, fundamental science in developing collaborative programs will be supported, or simply the access for research within Exclusive Economic Zones of adjoining (developing) nations will be permitted.

II.5. Scientific Education

The vessel will provide excellent education opportunities for graduate students. Taking the figures from RV “Sonne”, it can be estimated that 20-25 % of the berths on an average cruise will be available for graduate students. Graduate students also participate in the transit lines and do excellent hard work when in 24-hour-operations work is done in shifts. Thus, they practically learn their future tasks at sea. During transit times, floating university programs could be conducted on board of RV “Sonne” replacement. Undergraduate education usually takes place on regional vessels (30 % of the space available there goes to undergraduate training). In general, research vessels are a means in the marine science community to create international contacts and continuing the invitation of students from other European countries is strongly encouraged.

B.III. Project Management, Costs, Funding and Schedule

III.1. Project Management

The combined call for construction and operation of the planned research vessel is recommended as construction and operation would lie in one hand and are not separated. It is expected that common construction and operation management will assure better handling and operation once the vessel is in use. Given the fact that the combined call will increase the probability that shipyard and operator will be from the same region, efforts should be undertaken to ensure that international expertise concerning RV construction is taken into account.

During the design and construction phases, quality assurance for the project management and the installation of a consortium to watch over the procedure is required. Also, a risk analysis should be performed for the entire project as soon as possible.

Thus far, the proposal for the deep sea research vessel’s follow-up has been largely centered on excellent research of (multidisciplinary) seafloor science. It is recommended, however, that water column and atmospheric research becomes more prominent in the concept for the research vessel. Thus, it is recommended that the design team (WTF) of the ship includes leading and experienced sea-going water column and atmospheric scientists: at minimum one person each for physical, biological and chemical oceanography and meteorology. The views of these people should be visible in the research objectives as well as the technical design of the ship. This is an important point to stress because it would make cruises dedicated to sea-floor research more efficient and optimize the future RV as a research platform. The same recommendation is given in regard to the technical realization of the research vessel: International technical experts should be added to the Wissenschaftlich-Technischer Fachausschuss (WTF) (see also B.II.2.).

Operation and cruise coordination of the new deep sea research vessel by Leitstelle Merian/Meteor in Hamburg is highly supported to foster operational liaisons with other German Global class RVs, namely “Meteor” and “Maria S. Merian”. For the time of operation, it is also strongly recommended that the cruise schedule is coordinated with RVs “James Cook” and “Pourquoi pas?” as both work on similar scientific tasks as the “Sonne”-replacement will (even though the geographical areas of operation are different. So, in terms of coordinating similar scientific tasks one can think of simultanous or parallel measurements to obtain comparable data or to reduce transit times because one ship is already in the area where data are needed from, anyway, and the other ship could save the journey to go there.

It is appreciated that the DFG-Senate Commission which already evaluates the scientific proposals for cruises on RVs “Meteor” and “Maria S. Merian” will apply the same procedure on expeditions with the “Sonne”-replacement.

III.2. Costs, Funding and Schedule

The proposal provides fair and reasonable figures for building and running costs. As the global investment costs seem to be a maximum, however, scientific and technical priorities have to be properly ranked by WTF. In addition, precise figures will be known only when the contract with the shipyard is signed. Thus, no current financial risk analysis is available and cost budgeting for the RV “Sonne” replacement relies on an extrapolation from the construction costs of RV “Maria S. Merian” (see A.III.3.a) on this).

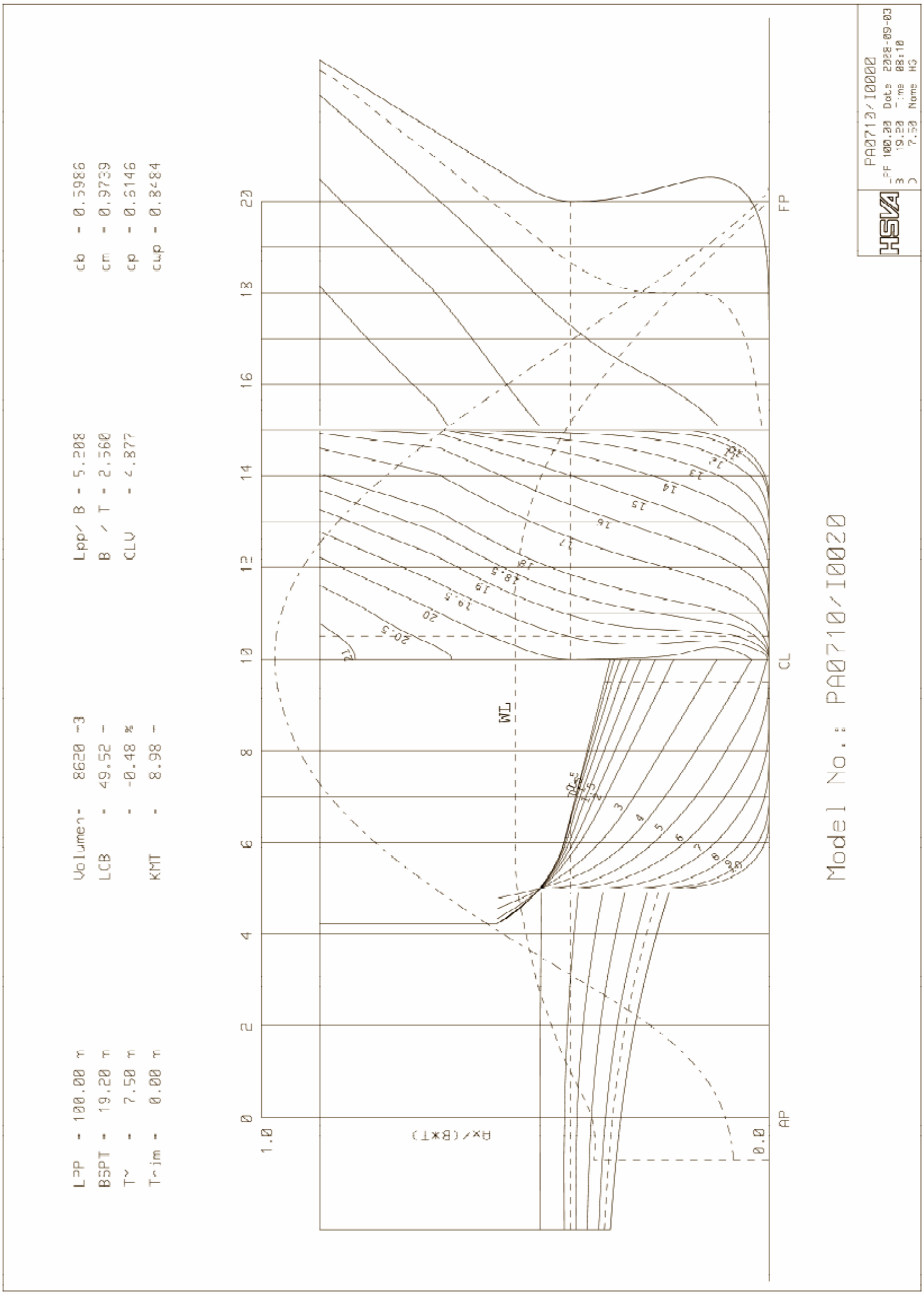
It is recommended that running cost estimates (with an explicit reference to the relevant fuel price) be optimized by the consortium that builds and operates the ship. Energy costs should be reported separately in order to make it easier to calculate the consequences of rising energy costs. For environmental reasons, however, special attention should be paid to the fuel quality (as the anticipated fuel will be diesel oil and not heavy fuel oil).

It is appreciated that 110 Mio. Euro funding for construction are secured from BMBF (90 %) and Länder (10 %).[29] The subsequent operation of the vessel is funded fully by BMBF. Thus, the research vessel is ready for funding based on the assumption that optimization and improvement of the vessel design has highest immediate priority upon funding. As no financial risk analysis is available at present that would include cost increases, for financial reasons the WTF should be asked to prioritize the construction and technology needs (see also B.II.2. for this point).

The construction of the follow-up research vessel is considered to be urgent as RV "Sonne" is scheduled to go out of service in 2010 and its operation will be extended only on a year-by-year basis. Thus, it is important that no time gap occurs between RV "Sonne" and its successor. In view of the facts that (1) the technical feasibility of the project is very high, (2) the funding is secured in the budget and (3) enough time is granted to make adequate and proper technical and technology choices, the time frame laid out by the BMBF to build the ship ensures this and seems, overall, adequate (see Annex 7 for the proposed schedule).

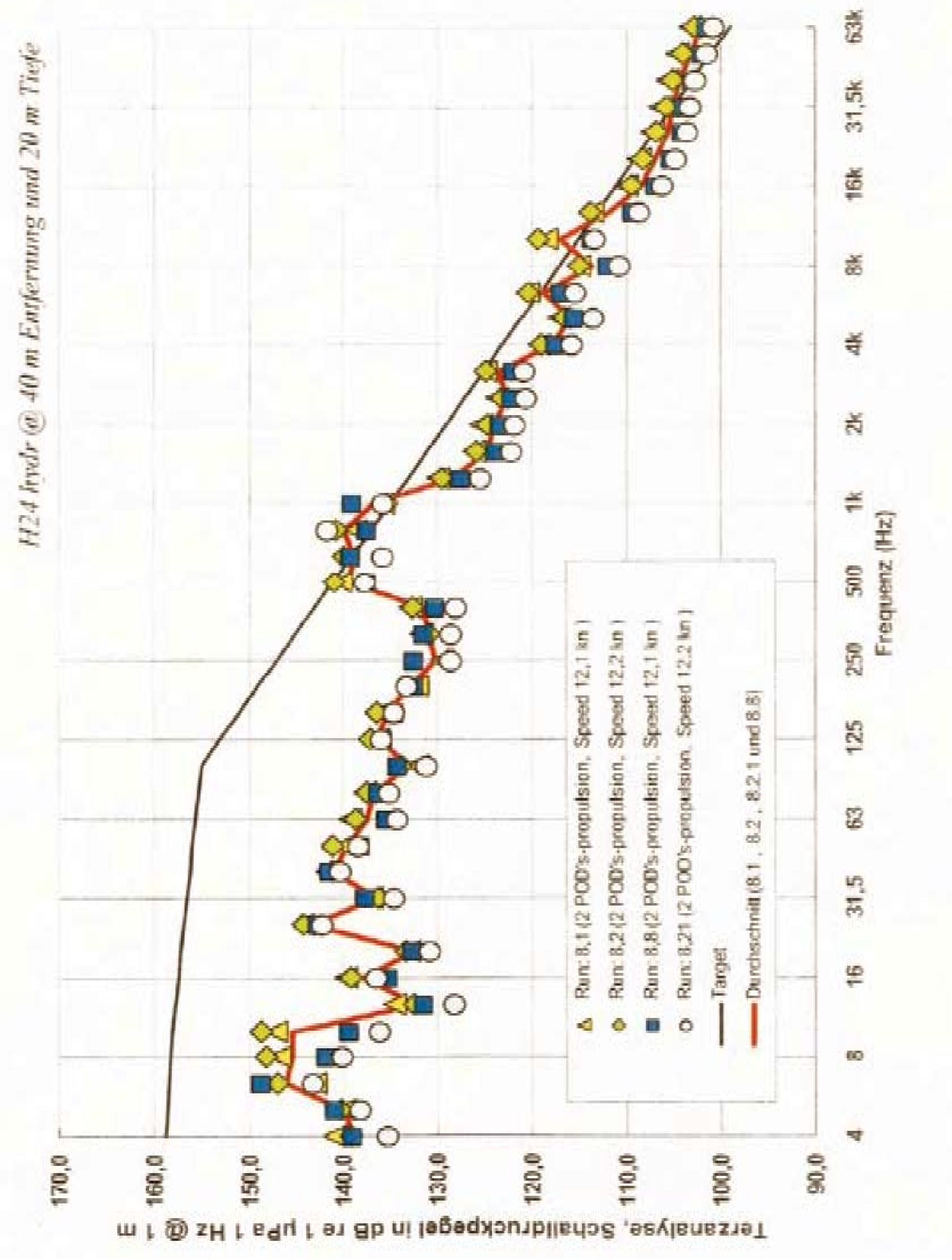
[29] On December 18th, 2008, the Federal Ministry of Education and Research (BMBF), the *Länder* Lower Saxony, Mecklenburg-West Pomerania, Schleswig-Holstein and the Cities of Bremen and Hamburg signed the administrative agreement on the construction and operation of the RV "Sonne" replacement.

Annex 1: Line-plan drawn by The Hamburg Ship Model Basin (Hamburgische Schiffsbau Versuchsanstalt – HSVA)



Annex 2: Noise Level of RV "MARIA S. MERIAN" and the ICES Recommendation of Maximal Noise Level

Abbildung 3.4: Unterwasser Schalldruckpegel Maria S. Merian
Dynamische Vermessung , Run 8.1, 8.2, 8.2.1 und 8.8 Pod antrieb 12 kn



Annex 3: Middle and Long-term Ship Building Investments in the next years

BMBF/725/Alberts

08.12.2008

Anl. 2

„Schiffsbauten kommender Jahre"

(vorr. Ausgaben für Bau und Betrieb - Abteilung 7)

- SONNE II — 99 Mio. € (90% von ca.110 Mio. €)
- POSEIDON II — 60 Mio. € (75% von ca. 80 Mio. €)
- POLARSTERN II — ca. 450 Mio. € (Vollfinanzierung BMBF)
- AURORA BOREALIS — ca. 189 Mio. € (30% deutscher Anteil)
- METEOR — ca. 130 Mio. € (Vollfinanzierung BMBF)
- FS ALKOR, FS HEINCKE — Ersatzbauten ab 2020

	MiFriFi					Langfristplanung							
Investitionen	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018ff.***	***Gesamt***	***Bemerkungen***
SONNE II	0,3	1,0	27,0	33,0	28,0	9,7	-	-	-	-	-	99,0	99 Mio. € Bundesanteil. M-Entscheidung liegt vor. 6/09 europaweite Ausschreibung
POSEIDON II	-	-	1,0	15,0	25,0	15,0	4,0	-	-	-	-	60,0	60 Mio. € Bundesanteil
POLARSTERN II	-	-	-	-	40,0	115,0	140,0	120,0	35,0	-	-	450,0	Vergleich Neubau (30 Jahre Betrieb vs. 15 Jahre Refit) in Bearbeitung
AURORA BOREALIS	1,7	-	-	-	-	0	0	0	0	0	0	1,7	Keine Etatreife; Feasibility-/ESFRI-Studie abwarten, Entscheidung frühestens 2012
METEOR	-	-	-	-	-	-	-	-	-	5,0	125,0	130,0	Wissenschaftlicher Bedarf begründet durch DFG/KdM-Papier
Gesamt	***2,0***	***1,0***	***28,0***	***48,0***	***93,0***	***139,7***	***144,0***	***120,0***	***35,0***	***5,0***	***125,0***	***740,7***	

Betrieb	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***Gesamt***	***Bemerkungen***
SONNE I	9,0	9,5	10,0	10,5	11,0	6,0	-	-	-	-	-	56,0	Chartervertrag bis in 2013 verlängert für 250 Tage p.a.
SONNE II	-	-	0,2	0,5	0,8	6,0	13,0	13,5	13,5	14,0	14,0	75,5	Bis in 2013 Baubelehrung, danach Betriebskosten für 365 Tage p.a.
POSEIDON I + II	-	-	-	-	-	-	-	-	-	-	-	-	Betriebskosten institutionell durch WGL
POLARSTERN I + II	-	-	-	-	-	-	-	-	-	-	-	-	Betriebskosten institutionell durch HGF
AURORA BOREALIS	-	-	-	-	-	-	-	--	-	-	-	-	Zweischiffsbetrieb zwingend, 40 Mio. € p.a., davon 1/3 dt. Anteil. Betriebskosten institutionell
METEOR	-	-	-	-	-	-	-	-	-	-	-	-	Betriebskostenteilung BMBF 30%, DFG 70%
Gesamt	***9,0***	***9,5***	***10,2***	***11,0***	***11,8***	***12,0***	***13,0***	***13,5***	***13,5***	***14,0***	***14,0***	***131,5***	

Annex 4: R&D, Construction and Operation Costs

Table 1

a) R&D and construction of SONNE II

	Total Staff (FTE)	Capital Costs	Staff Costs	Total Costs
Costs for R&D	ca. 20-25	n/a*	2.5-2.7 mio €	2.5-2.7 mio €
Costs for Construction	n/a	n/a	n/a	110 mio €
Total (R&D + Construction)				112.5-112.7 mio €

n/a = not applicable

b) operation of SONNE II

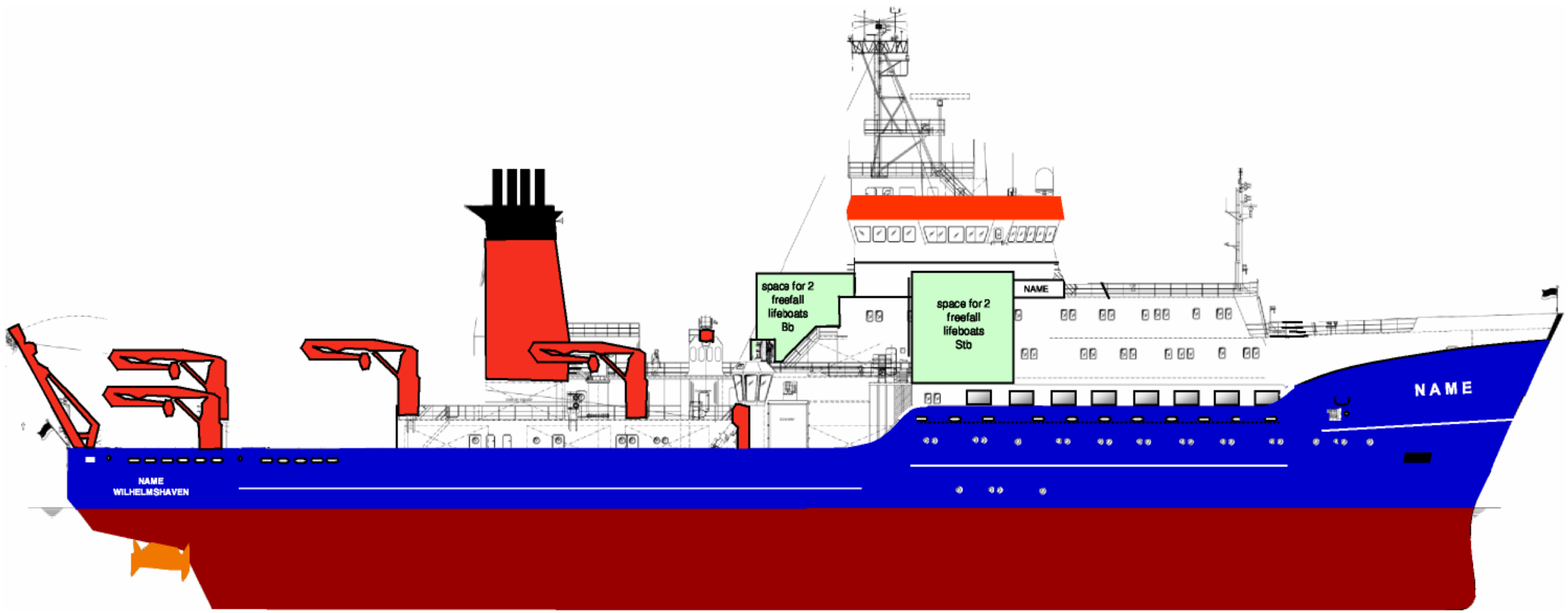
	Total Staff (FTE)	Capital Costs	Staff Costs	Total Costs
Estimated annual operation costs	n/a	n/a	n/a	13.5 mio €

** based on 37, 000 € per day and 365 days per year

The distribution of total costs by year (2009-2012), in particular the distribution of construction costs, will be defined with regard to the actual needs.

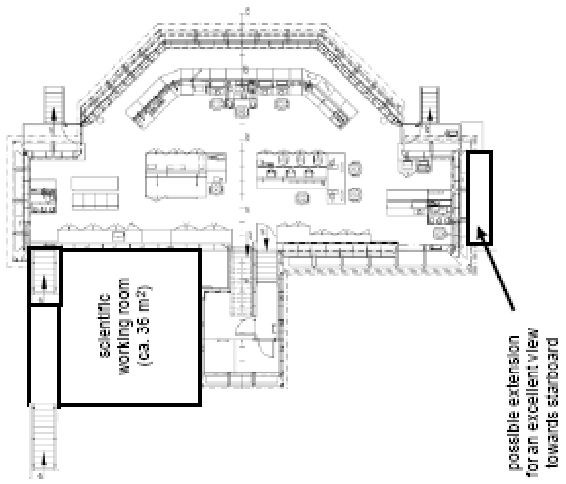
Annex 5: General Arrangement Deep Sea Research Vessel

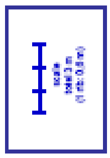
Deep-Sea Research Vessel **general arrangement – preliminary draft** K. von Bröckel + H. Dobinsky + WTF state: October 2008	The presented draft is based on the general arrangement of MARIA S. MERIAN. Changes made are: - an additional deck for cabins - front and aft part extended for 6 m (10 ribs) each to create space for machinery - siedewards extension of aft part for a bigger working deck - two freefall lifeboats on starbord and port side - galley, mess and social rooms on 1. deck with panorama view - cabins for scientists on store deck The draft offers accomodation for 32 crew members in single cabins and for 40 scientists in 6 double and 28 single cabins.



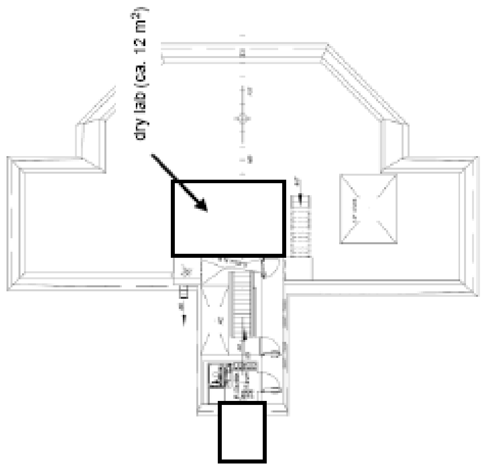
Deep-Sea RV preliminary draft
Wheele house top + bridge deck

bridge deck

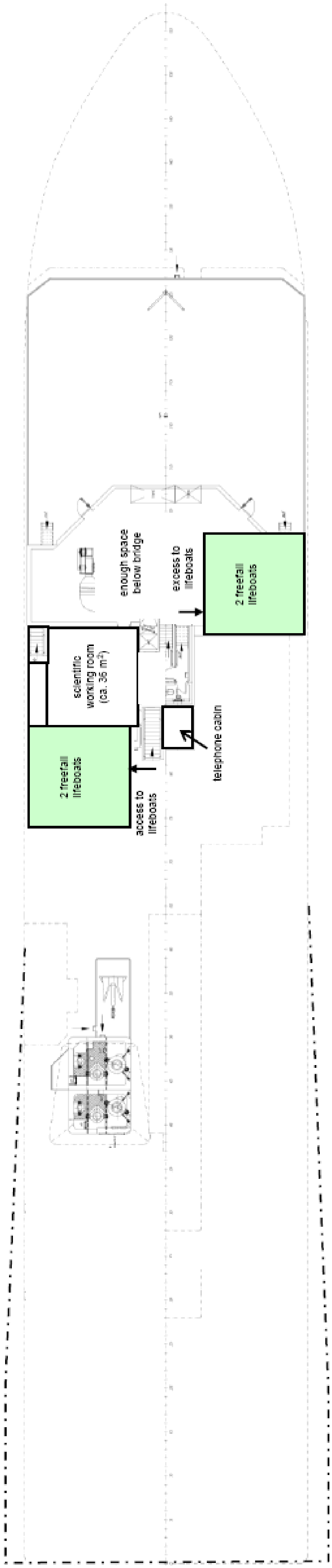




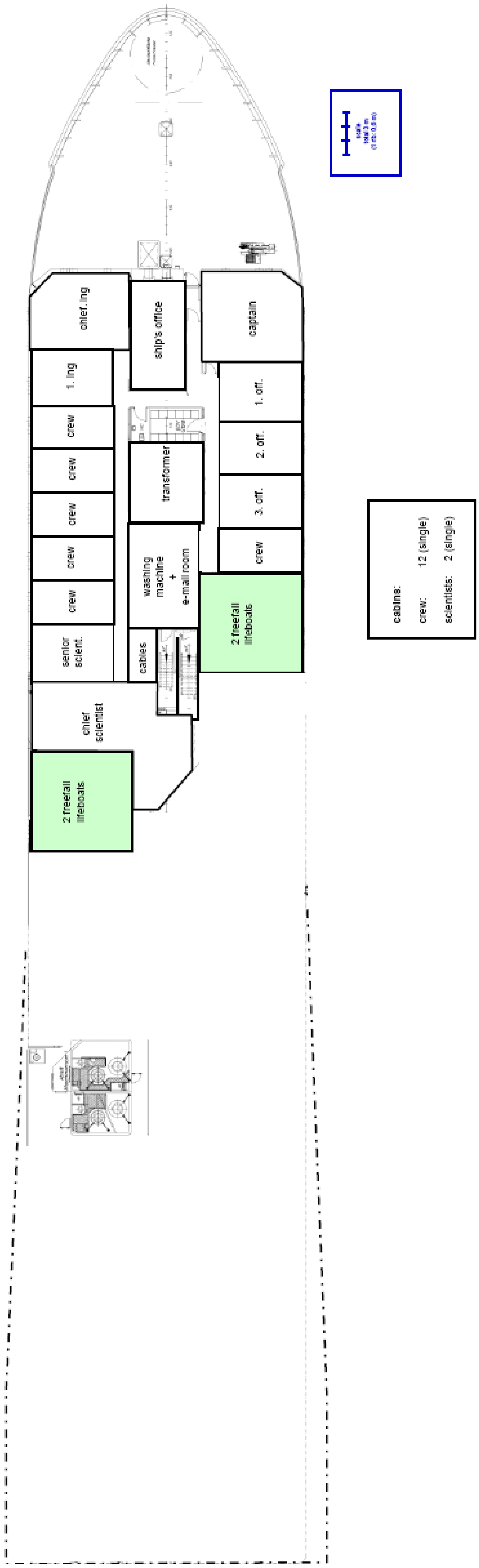
wheele house top



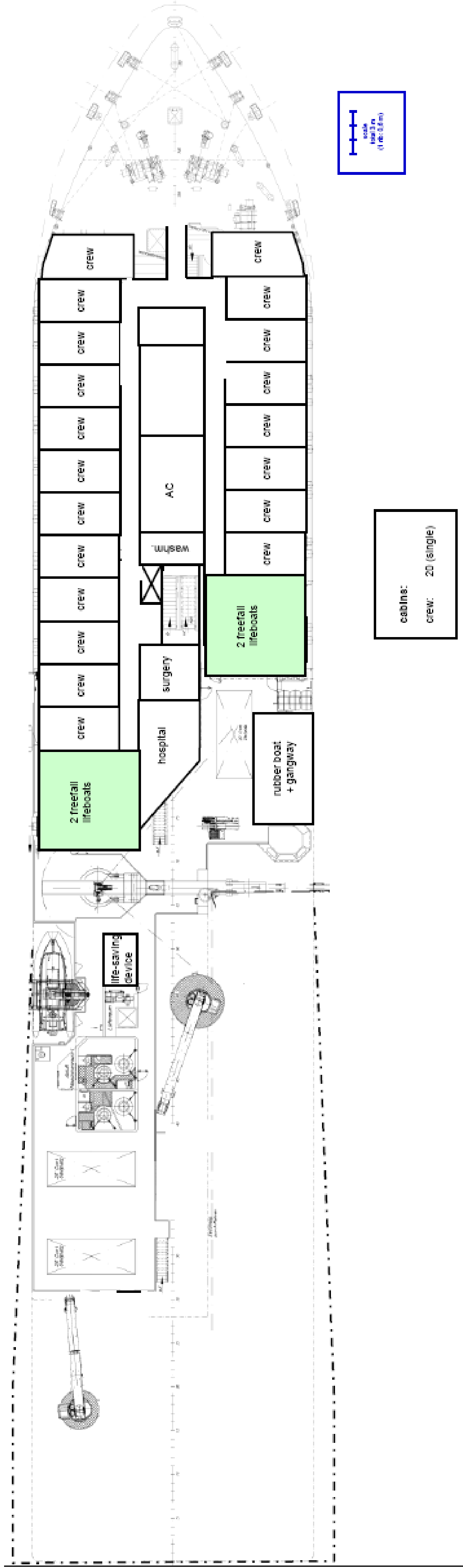
Deep-Sea RV preliminary draft
4. deck



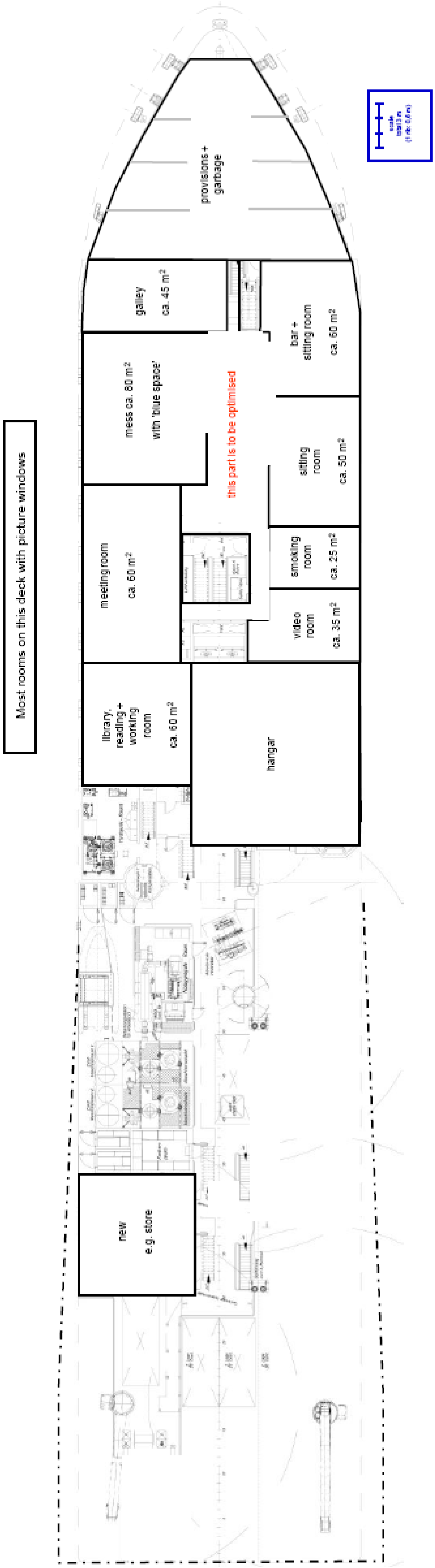
Deep-Sea RV preliminary draft
3.deck



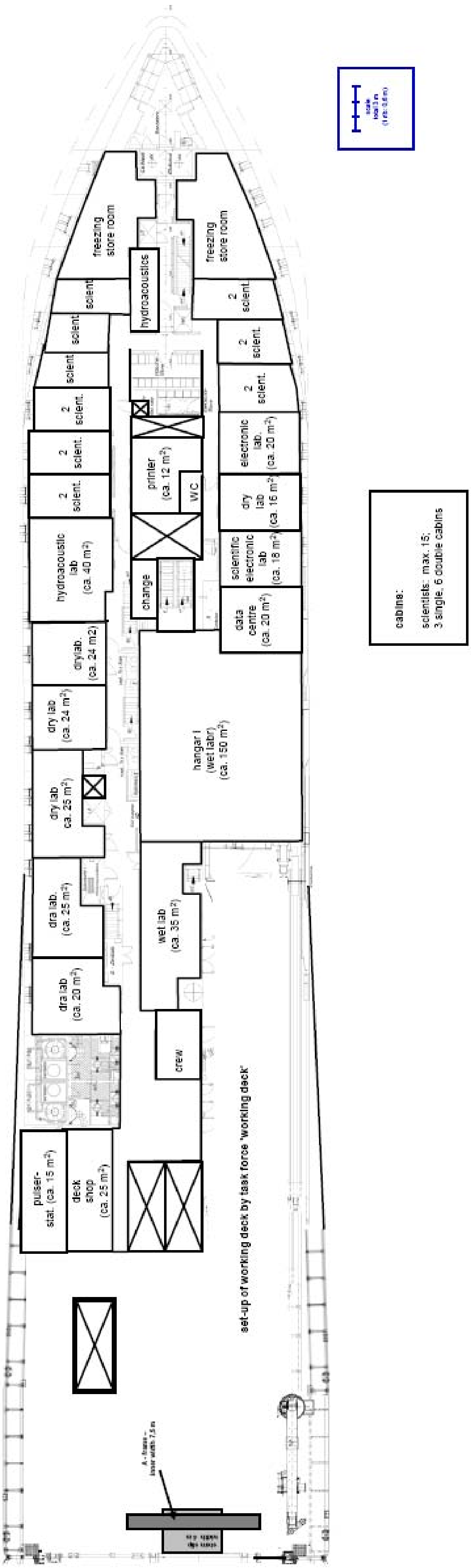
Deep-Sea RV preliminary draft
2. deck



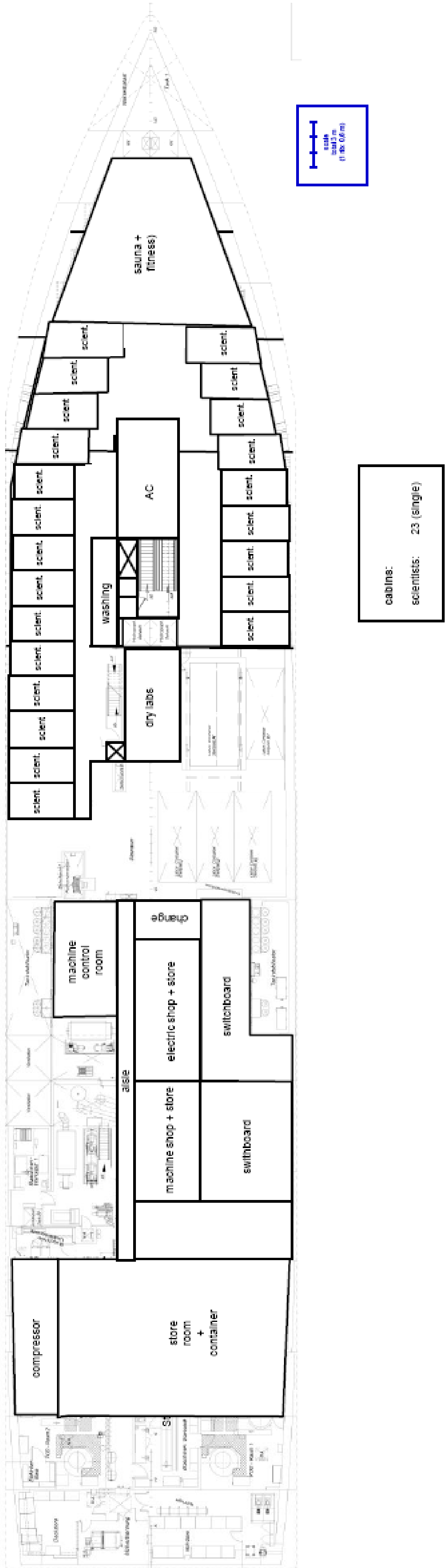
Deep-Sea RV preliminary draft
1. deck



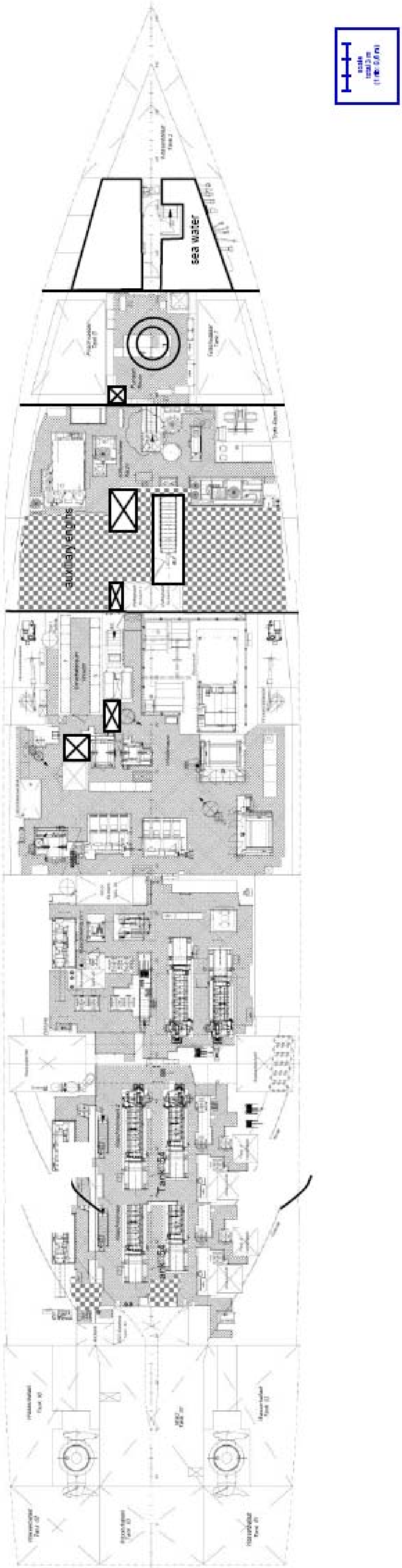
Deep-Sea RV preliminary draft
main deck



Deep-Sea RV preliminary draft
store deck



Deep-Sea RV preliminary draft
machine deck



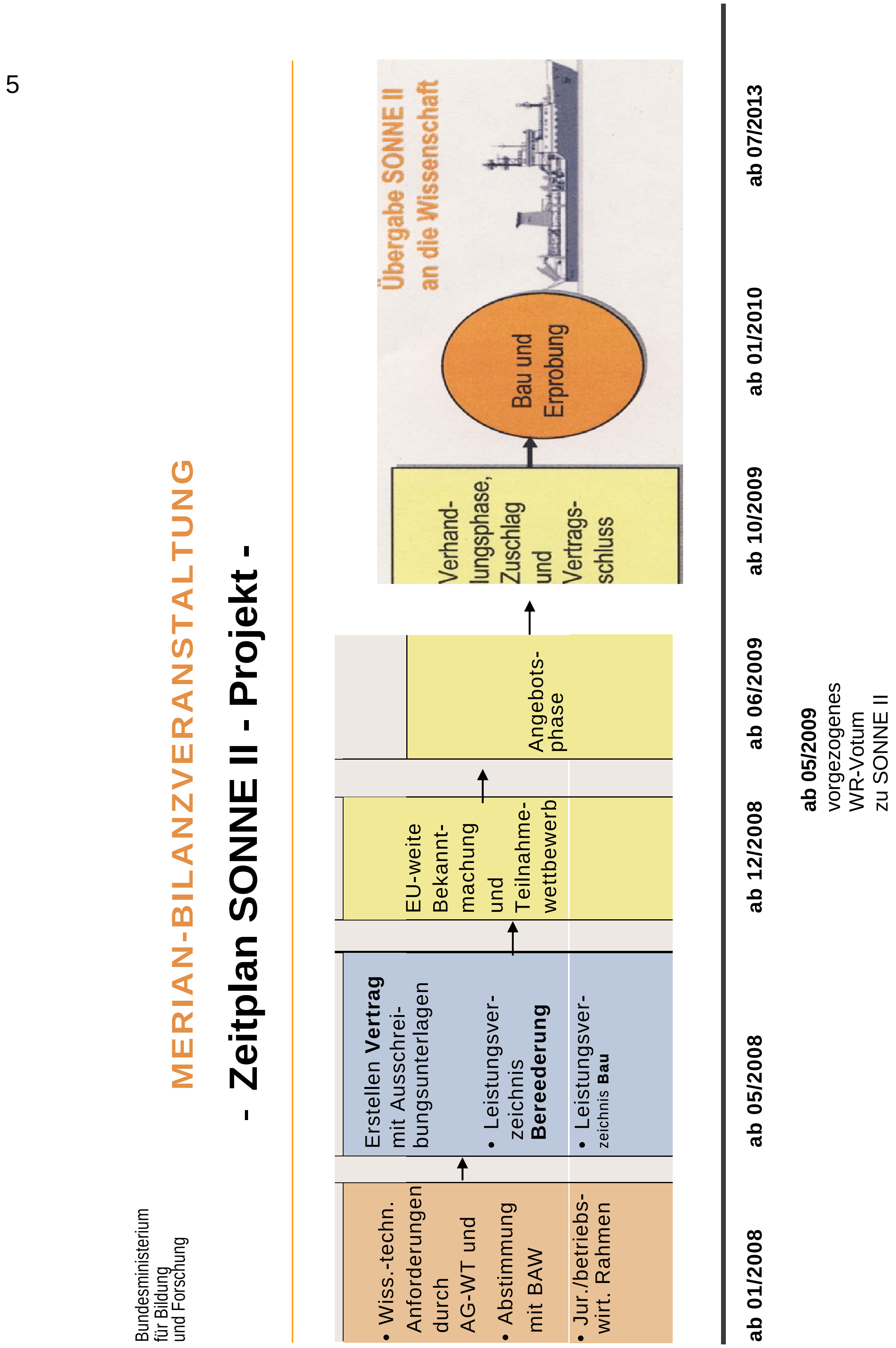
Annex 6: Verteiler “Sonne Rundbrief” Stand Dez. 2008

	Ort	Einrichtung
1.	Aachen	Geologisches Institut der RWTH Aachen
2.	Berlin	FU Berlin, FB Biologie
3.	Berlin	FU Berlin, Institut für Geologie, Geophysik & Geoinformatik
4.	Berlin	TU Berlin, Geologisches Institut
5.	Berlin	Konsortium Deutsche Meeresforschung (KDM)
6.	Berlin	Museum für Naturkunde der Humboldt-Universität zu Berlin
7.	Bochum	Universität Bochum, Institut für Geologie
8.	Bonn	Universität Bonn, Institut für Geologie
9.	Bonn	Deutsche Forschungsgemeinschaft
10.	Bonn	Universität Bonn, Meteorologisches Institut
11.	Bremen	Universität Bremen, MARUM (Zentrum für Marine Umweltwissenschaften)
12.	Bremen	Universität Bremen, Fachbereich Geowissenschaften
13.	Bremen	Zentrum für Marine Tropenökologie
14.	Bremen	Max-Planck-Institut für Marine Mikrobiologie
15.	Bremen	Jacobs University Bremen
16.	Bremerhaven	Alfred-Wegener-Institut für Polar- und Meeresforschung (AWI)
17.	Büsum	Forschungs- und Technologiezentrum Westküste (FTZ)
18.	Clausthal-Zellerfeld	TU Clausthal, Geologisches Institut
19.	Darmstadt	Universität Darmstadt, Geologisch-Paläontologisches Institut
20.	Erlangen	Universität Erlangen, Geologisches Institut
21.	Flintbek	Landesamt für Natur und Umwelt, Abt. Geologie/Boden
22.	Frankfurt	Universität Frankfurt, Geologisches Institut
23.	Frankfurt	Universität Frankfurt, Institut für Meteorologie und Geophysik
24.	Freiberg	Geologisches Institut der Bergakademie Freiberg
25.	Freiberg	TU Bergakademie Freiberg, Inst. f. Mineralogie, Geochemie
26.	Geesthacht	GKSS Forschungszentrum Geesthacht

27.	Göttingen	Universität Göttingen, Geologisches Institut
28.	Greifswald	Universität Greifswald, Sektion Geolog. Wissenschaften
29.	Halle	Universität Halle, Geologisches Institut
30.	Hamburg	Bundesforschungsanstalt für Fischerei
31.	Hamburg	Universität Hamburg, Institut für Biogeochemie u. Meereschemie
32.	Hamburg	Leitstelle METEOR, Institut für Meereskunde
33.	Hamburg	Universität Hamburg, Mineralogisch-Petrographisches Institut
34.	Hamburg	Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e. K.
35.	Hamburg	Universität Hamburg, Zoologisches Institut
36.	Hamburg	Bundesamt für Seeschifffahrt und Hydrographie (BSH)
37.	Hamburg	Max-Planck-Institut für Meteorologie (MPI-M)
38.	Hannover	Universität Hannover, Geologisch-Paläontologisches Institut
39.	Hannover	Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
40.	Hannover	GGA – Institut
41.	Hannover	Niedersächsisches Landesamt für Bodenforschung
42.	Heidelberg	Universität Heidelberg, Institut f. Umweltphysik
43.	Helgoland	Biologische Anstalt Helgoland, Forschungsstelle des Alfred- Wegener-Instituts für Polar- und Meeresforschung (AWI)
44.	Helmstedt	GeoJournal Chefredaktion
45.	Kiel	Forschungsanstalt der Bundeswehr für Wasserschall u. Geophysik
46.	Kiel	Leibniz-Institut für Meereswissenschaften IfM-GEOMAR
47.	Kiel	Universität Kiel, Institut für Geowissenschaften
48.	Köln	Universität Köln, Geologisches Institut
49.	Krefeld	Geologisches Landesamt, Nordrhein-Westfalen
50.	Leipzig	Universität Leipzig, Fakultät für Physik und Geowissenschaften
51.	Mainz	Universität Mainz, Institut für Geowissenschaften
52.	Marburg	Universität Marburg, Fachbereich Geowissenschaften, Geologisches Institut

	Ort	Einrichtung
53.	München	Ludwig-Maximilian-Universität München, GeoBio Centre
54.	München	Technische Universität München, Lehrstuhl für Geologie
55.	Münster	Geologisch-Paläontologisches Institut der Westf.-Wilhelms-Universität
56.	Oldenburg	Universität Oldenburg, Institut f. Chemie u. Biologie d. Meeres (ICBM)
57.	Potsdam	Deutsches GeoForschungsZentrum (GFZ)
58.	Rostock	Universität Rostock, Fachbereich Biologie / Meeresbiologie
59.	Rostock	Institut für Ostseeforschung (IOW)
60.	Tübingen	Universität Tübingen, Institut für Geowissenschaften
61.	Wilhelmshaven	Senckenberg am Meer
62.	Würzburg	Universität Würzburg, Geologisches Institut

Annex 7: Schedule "Sonne II"-Project



D. Anhänge

D.I. Abkürzungsverzeichnis der Gesamtstellungnahme

ADCP	Acoustic Doppler Current Profiler
AUV	Autonomous Underwater Vehicle
AWI	Alfred-Wegener-Institute for Polar and Marine Research, Bremerhaven
BAW	Bundesanstalt für Wasserbau (Federal Waterways Engineering and Research Institute)
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe Hannover (Federal Institute for Geosciences and Natural Resources)
BMBF	Bundesministerium für Bildung und Wissenschaft (Federal Ministry of Education and Research)
BMWi	Bundesministerium für Wissenschaft und Technologie (Federal Ministry of Economics and Technology)
CTD-Rosette	ConductivityTemperatureDepth-rosette
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
FS	Forschungsschiff
FZJ	Forschungszentrum Jülich
HSVA	Hamburgische Schiffsbau Versuchsanstalt (Hamburg Ship Model Basin)
ICES	International Council for the Exploration of the Sea
IFM-GEOMAR	Leibniz Institute of Marine Sciences, Kiel
IFREMER	Institut Français de Recherche pour l'Exploration de la Mer

JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
KDM	Konsortium Deutsche Meeresforschung (German Marine Research Consortium)
MARUM	Zentrum für Marine Umweltwissenschaften, Universität Bremen (Center for Marine Environmental Sciences)
MeBo	Meeresboden-Bohrgerät
NERC	National Environment Research Council
PTJ	Projektträger Jülich (Jülich Project Management Agency)
OFEG	Ocean Facilities Exchange Group
ODP/IODP	Ocean Drilling Program/International Ocean Drilling Program
ROV	Remotely Operated Vehicle
RV	Research Vessel
WDC MARE	World Data Center for Marine Environmental Sciences
WTF	Wissenschaftlich-Technischer Fachausschuss (Scientific-Technical Expert Committee)

D.II. Vom Wissenschaftsrat im Auftrag des BMBF begutachtete Großgeräte (Stand 2009 nach WR-Begutachtungen 2002[30] und 2006[31])

Gerät	Standort	Investitions-kosten	Betriebskosten pro Jahr in Mio. Euro	Finanzierungs-modelle	Realisierungsstand
Gruppe 1					
HLD	FZ Rossendorf/ IFW (Dresden)	24,5	3,7	national (Bund: 50%)	in Betrieb seit 2007
HALO	DLR (Oberpfaffenho-fen)	69,7	3,8	national (Bund: 70%, Rest HFG u. MPG)	in Betrieb ab 2009
Gruppe 2					
TESLA)*	DESY (Hamburg)	3450,0	135,0	international	vom Bund Deutsch-land nicht als Standort vorgeschlagen
European XFEL (früher: TESLAX-FEL) Startversi-on)**		850,0	64,0	international (Bund: 60%)	im Bau seit Ende 2008
FAIR Startversi-on)***	GSI (Darmstadt)	940,0	118,0	international (Bund: 65%, Hessen: 10%, Rest: internatio-nal)	MoU über gemeinsa-me Vorbereitung
AURORA BOREA-LIS	AWI (Bremerha-ven)	635	32,5	europäisch/ international	Zweite Begutachtung im WR 2006
Soft X-Ray FEL	BESSY (Berlin), jetzt HZB	222,3	12,4	national	Zweite Begutachtung im WR 2006 Projekt von der Ein-richtung aufgegeben, Beteiligung an FLASH II bei DESY (geplant)
Gruppe 3					
ESS	Standortinteresse in Schweden (Lund), Spanien (Bilbao) und Un-garn (Debrecen)	1300,0	110,0	europäisch	Bisher keine Stand-ortentscheidung; Bund unterstützt derzeit keinen dt. Vorschlag
Hochfeldmagnet HFM	HZB, früher HMI	21,0	3	national	im Bau

Quelle: Einrichtungen und BMBF

)* TESLA wird zugunsten des International Linear Collider (ILC), der gemeinsam von Einrichtungen aus Amerika, Asien und Europa als globales Projekt vorbereitet wird, nicht weiter verfolgt. Dabei wird die von der TESLA-Kollaboration unter Führung von DESY entwickelte supraleitende Beschleunigertechnologie eingesetzt. Die potenziellen Geldgeber kooperieren in FALC (Funding Agencies for Large Colliders).

)** Bei FAIR wird nicht von Anfang an die Vollversion realisiert, sondern eine so genannte Startversion.

)*** Beim XFEL wird nicht von Anfang an die Vollversion realisiert, sondern eine so genannte Startversion.

30 Vgl. Wissenschaftsrat: Stellungnahme zu zwei Großgeräten, a.a.O.

31 Vgl. Wissenschaftsrat: Stellungnahme zu neun Großgeräten, a.a.O., S. 23ff. Da es sich in diesem Fall um ein Zitat handelt, wurde der Begriff „Großgerät“ nicht geändert.

D.III. Questionnaire

Foreword

The purpose of this questionnaire is to provide the sub-panel of the German Council of Science and Humanities' working group on large-scale facilities for fundamental scientific research with key information on the proposed large-scale facility. Supplementary information or documents in addition to the answers to the questionnaire and the requested documents may be provided. Please keep the responses brief and concise.

The reporting period covers the last five years (2003 up to and including 2008); all facts and figures provided should be those that were current on 1 January 2008. All financial data should be given in Euros (€).

Any further questions, particularly those concerning the technology and operation of the large-scale facility, will be dealt with in more detail during a visit by the sub-panel to the premises.

NB

Throughout this questionnaire, the term "field of research" refers to the field(s) of research in which the large-scale facility is or will be used.

Please send 40 printed copies of your responses and additional documents, each in a file, to the head office of the German Council of Science and Humanities by 10 November 2008. If possible, please also send your responses and additional documents in electronic form (barkhaus@wissenschaftsrat.de or rueve@wissenschaftsrat.de).

A. Executive summary

Please provide a brief summary of the proposed facility (scientific vision, strategic importance, scientific objectives, max. two pages).

B. Field(s) of research and technology

B.1 How has the field/have the fields of research developed over the last ten years, nationally and internationally? Which changes do you expect until the facility would become fully operational? (approx. 3-4 pages)

B.2 How do you assess Germany's position in this/these field(s) of research? Please specify Germany's position within the European research area and also put it in perspective to overseas marine research. Are there any specific qualitative or structural strengths or deficits relevant to Germany's competitiveness?

B.3 Which technological innovations is the project based on? Are there major R&D tasks that remain to be completed before the facility can be realised? Do these include potential obstacles to its successful realisation?

B.4 Which different technologies exist for obtaining analogous, related, or supplementary information? How have these developed over the past few years, nationally and internationally? How will they develop until the facility would become fully operational? In this context please address the question how the implementation of highly specialized equipment (deep sea laboratories, -observatories, ROVs and AUVs) affects the approach of multi-disciplinary research and expeditions?

B.5 Please discuss to what extent different technologies are alternative, complementary, and/or mutually dependent. Will the success and the strategic importance of the proposed facility be influenced, positively or negatively, by expected or possible developments in other technologies?

C. The facility

C.1 Scientific objectives, services, and technology of the facility

C.1.1 Please outline the research programme for the facility.

C.1.2 Describe the need for the new research vessel in the context of the German marine research fleet, the European research fleet and in relation to other infrastructures used in research fields mentioned above.

C.1.3 What range of services is the facility meant to offer scientists? How do these services differ from those of existing or projected other facilities?

C.1.4 What are the facility's main strengths and weaknesses? From a scientific or technological point of view, what does it leave to be desired? To what stage has the planning of the facility proceeded?

Concerning environmental friendliness, what precautions and measures (technics, fuel consumption, carbon balance etc.) are planned to be taken?

What kind of ship propulsion do you take into consideration? Please discuss your choice in regard to the noise level (acoustics) as well as financial investments and running costs involved.

How do you plan to design the ship hull? Please provide the report of the “Hamburgische Schiffsbau Versuchsanstalt (HSVA)”, if possible.

C.1.5 What options are there for enlarging / upgrading the facility at some later date? Do these imply specific requirements at the present stage?

C.2 Impact of the facility on the science system and on the economy

C.2.1 What impact will the expected research results have on scientific, technological and social developments?

C.2.2 In what way is implementation of the facility likely to benefit Germany / to benefit the EU as a centre of scientific activity and excellence? Please outline alternative infrastructure options (plans for new facilities or expansion / upgrading of existing facilities) should the facility not be implemented.

C.2.3 Are there analogous projects (in Germany / in the EU / overseas)? If so, are these mutually exclusive or additional? How do you assess overlaps?

C.2.4 Which business sectors and which key technologies could particularly benefit from the results and the development of the facility? Are appropriate transfer mechanisms projected for this purpose?

C.2.5 Are spin-offs expected to arise from this project, and if so, how will they be supported?

C.2.6 According to your estimates, to what extent will regional, national and international businesses participate in the project by way of contracts awarded for planning and construction services as well as for services relating to further operation of the facility?

D. Institutions participating in the project

D.1 Please list the institutions participating in the project and outline their contribution and specific competence.

D.2 What experience do you have in planning and operating large-scale facilities? How is the construction of the research vessel planned and coordinated?

D.3 Please describe the national and international networks and programmes into which the facility is to be incorporated.

D.4 Describe the research results of the past years achieved with the precursor vessel “Sonne” either a) at the collaborating institutions or b) worldwide which were most important for implementation of the facility.

D.5 How many members of staff will be required for the appropriate use and operation of the facility (please differentiate by levels of qualification)?

D.6 What costs have been incurred so far for preliminary development work etc. for the facility, and how have these been financed? How much external funding (not including budgetary funds) has been obtained for this purpose by the proposing institutions (or their co-operation partners) in the last five years (broken down into funding from the Federal Government, regional government, the DFG, the EU, business and industry, and other sources)? Please specify the fields in which this funding was used.

E. Users

E.1 Which disciplines stand to benefit from or are dependent on use of the facility for research purposes, and to what extent (main interested parties)? How can the different needs of diverse user groups be reconciled? How do you ensure knowledge exchange between the research fields, particularly the fields geohazard and marine ressources?

E.2 What is the expected extent of use (numbers and origin of users, duration and extent of use)? How have potential users been taken into account in the planning for the facility? (Please document user meetings.)

E.3 Is the scientific community large enough to make an adequate and sustained use of the facility?

How will the research be funded and how will the procedure of grant giving be organized (selection of proposals, financial administration etc.)?

What amount of user support is needed (operational costs, personnel, supplies, fuel, development and upgrades of the facility)?

E.4 How will access to the facility be organised for external scientists?

E.5 How do you ensure access to the collected data for the scientific community? How do you provide for a data archive?

E.6 What role has the research vessel “Sonne” played in training and furthering the future generation of scientists (both guided and independent scientific work, seminars, postgraduate studies, etc.)? How will “Sonne’s” successor do so?

E.7 In which fields of work and research can future scientists be employed following successful qualification?

E.8 How will the plans for the facility and the future research results be presented to the general public?

E.9 To what extent do you expect the facility to be used by private-sector companies?

E.10 How do you rate the third-party-income to be obtained from cooperations with the industry?

F. Project management, location, costs and schedules

F.1 Project management

F.1.1 How is the progress of the project planned, managed and documented? Please describe your quality assurance procedures.

F.1.2 How is budget responsibility organised structurally and in terms of personnel?

F.1.3 Has an advisory board been established, or are there plans to do so? If so, please specify its functions and name its members.

F.1.4 What evaluations of the facility (assessment of concepts, preliminary work, etc.) have been carried out by external assessors in the last five years? What were the results and what was the impact? How and by whom were the groups of evaluation named? (see also G.3)

F.1.5 Who will have organisational responsibility for maintaining permanent operation of the facility?

F.2 Location

F.2.1 Which are the specific requirements for a potential location for the facility?

F.2.2 What would be the consequences for a) the research institutions currently involved in the project and b) for the national research institutions working in your field of research if the facility (or a similar facility) was not implemented in Germany?

F.3 Costs

F.3.1 Please detail the expected R&D, construction, and total costs, and the expected annual operation costs, each broken down into capital and personnel costs (table 1, cf. Appendix). Which of these components are the most expensive ones? How do you assess the long-term cost impact, and on what criteria is your assessment based?

F.3.2 How do you rate the status of the table of costs and how up-to-date is it?

F.3.3 Please give estimates of total costs for R&D and construction by year if the project proceeds as intended (table 2). Differentiate by costs for civil engineering, core facility, and experiments.

F.3.4 How are the overall costs for the facility intended to be financed? Are there plans to involve foreign partners in the financing, and to what extent would this be realistic? What mechanism is used for apportioning overall costs (or parts thereof) to any foreign partners involved? Are there plans to involve industry? If so, what will be the modalities, and what kind of services will be provided?

F.3.5 What financial consequences do you expect if the project was to fall behind schedule? Is there a technical and financial global risk analysis concerning the design of the new vessel available? If so, please provide one.

F.4 Schedule

F.4.1 What is the schedule for implementation of the facility? What are the critical milestones of the schedule? Please provide the necessary details concerning planning, construction, time of commissioning, and periods of use.

F.4.2 Specify the annual period of use for the facility and the total period of operation including / without any modifications to the facility. Please address the problem of costly transit days involved in operating a research vessel. How do you provide for an optimized coordinated use between all users of the facility?

G. Additional information

The institutions involved are requested to provide, if applicable, the following additional documents in triplicate:

G.1 List of graphics of the general arrangement drawings presented in your Annex 7 (p. 76 ff) in a larger scale as yet provided.

G.2 List of publications (publications in renowned scientific journals, collections, monographs, textbooks) of the leading scientists involved in the project;

G.3 Documentation of the evaluations carried out with regard to the facility (assessment of concepts, preliminary work, etc.) by external experts in the last five years.

Appendix: Sample tables

R&D, Construction, and Operation Costs (table 1)

Please state all costs in million Euros (mio €).

a) R&D and construction

	Total Staff (FTE)	Capital Costs	Staff Costs	Total Costs
Costs for R&D				
Costs for Construction				
Total (R&D + Construction)				

b) operation

	Total Staff (FTE)	Capital Costs	Staff Costs	Total Costs
Estimated annual operation costs				

Total costs for R&D and construction by year (table 2)

Please state all costs in million Euros (mio €), for each year of the construction period.

Do not include operation costs. Total costs in this table, bottom right cell, equal total costs (R&D + construction) in table 1 a), bottom right cell.

	2009	2010	2011	2012	...	Total Costs
Costs for R&D						
Costs for Construction						
Total (costs by year)						