GAMBLE Annual Report

EVRI-CT-2001-20009

Combining:
The 2nd Interim Management Report (D14)
&
The Mid Term Work Package Progress Report (D15)

March 2003

Period Covered: 1 Feb 2002 – 31 January 2003

Sections Included: 1-3

Project Home Page: http://www.altimetrie.net

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Distribution (Public Document):

1. A. Edwards (EESD programme, EC) - 2 Hard Copies
2. All Gamble Partners, by email
3. GAMBLE Steering Group (by email)
4. To be posted on GAMBLE web site (http://www.altimetrie.net)

Approved by:…… Dr P.D. Cotton ……...(Project Manager, SOS)

Approved by:…….(Quality control, SOS)
Date: .....

TABLE OF CONTENTS

SECTION 1: MANAGEMENT AND RESOURCE USAGE SUMMARY FOR THE REPORTING PERIOD AUGUST –JANUARY 2002

Global Altimeter Measurements by Leading Europeans (GAMBLE) is a Thematic Network supported by the Research and Technological Development Programme "Energy, Environment and Sustainable Development" within the Fifth Framework Programme. It has duration of 21 months and began on the 1st of February 2002.

There are 4 main contractors in GAMBLE, plus an additional 17 members. The Main contractors are:

Satellite Observing Systems, UK	(SOS)
Centre National d'Etudes Spatiales, FR	(CNES)
Delft University of Technology, NL	(DUT)
Istituto per lo Studio della Dinamica delle Grandi Masse, IT	(ISDGM)

1.1 Objectives of the reporting period

The tasks scheduled for months 7 - 12 of the project involved the work packages 2-6 and 10-11.

The primary objectives for this period were:

- To establish error budgets and altimeter measurement requirements (accuracy and sampling frequency) necessary to resolve key features in sea surface height and sea state. This to be achieved through workshops and communications with the widest possible community of users of altimeter data.
- To establish the key issues which present obstacles in meeting the measurement requirements identified above (specifically with regard to orbit tracking and orbit determination), and identify possible solutions to these.
- To make a preliminary identification of possible altimeter mission scenarios.
- To maintain an effective communication with the GAMBLE team and the larger European altimeter community, through the project web-site.

1.2 Progress according to the planned timetable

1.2.1 Scientific and Technical Progress Overview

Interim reports on user requirements for (altimeter based) sea surface height and sea state information were completed by July 2002 and November 2002 respectively. These reports and shorter summaries of the same, are available on the GAMBLE web site.

Workshops were held by **ISDGM** in Venice (for sea state) and by **DUT/CLS** in Delft (for Sea Surface Height) to further discuss these issues, and to identify users priorities for improvements to measurements of these parameters made by altimeters. Both meetings were informed by presentations from invited experts. Many of the presentations, and all meeting minutes, are available on the project web-site. Final reports on Sea Surface Height and Sea State error budgets

and feature detectability are under preparation. It is not anticipated that further material will be requested from partners for these reports.

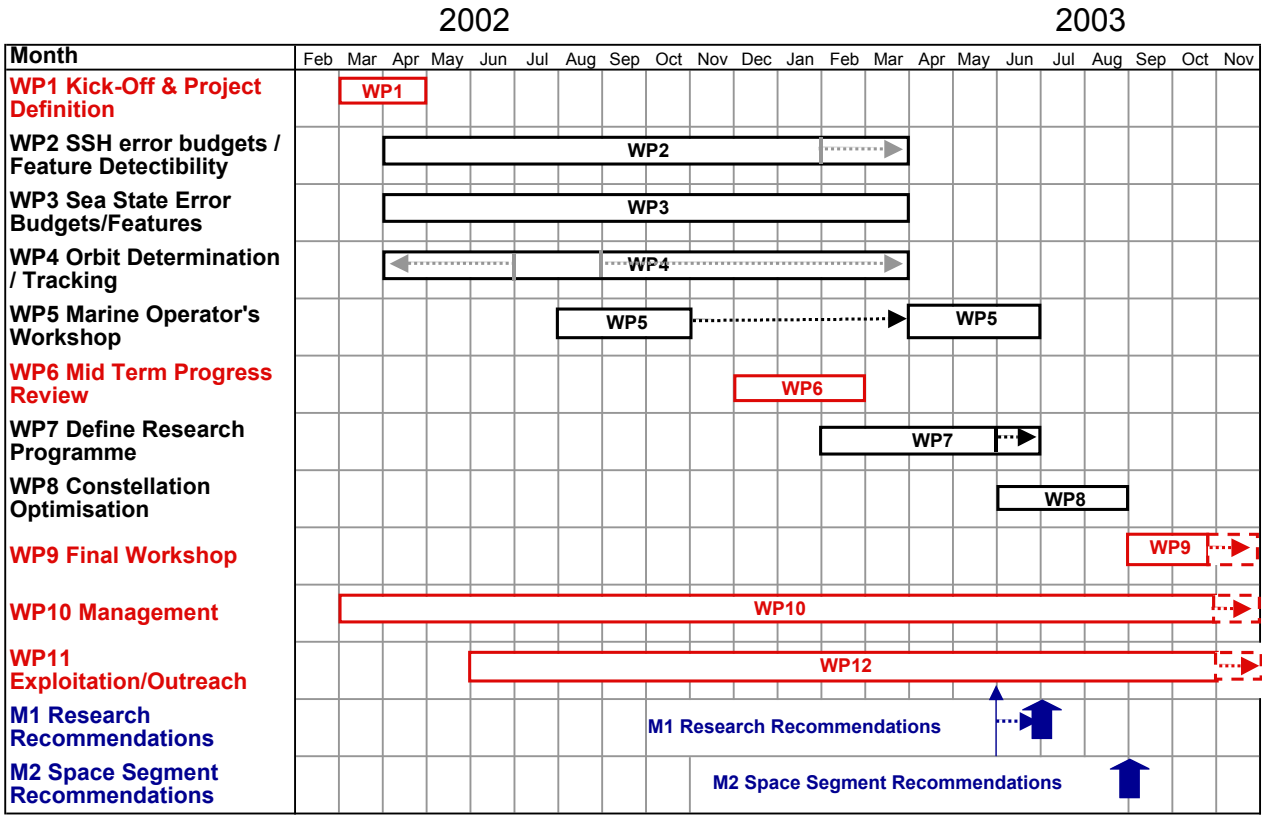
The GAMBLE network has also investigated the issues of orbit determination and satellite tracking. The timing of this work package was altered to April 2002-April 2003, as reported in the previous management report. At the workshop in Delft key issues were identified and discussed (e.g. how to ensure sufficiently accurate knowledge, what accuracy of orbit maintenance is required, what are the pros and cons of different altitude orbits,....) and the relative merits of different solutions discussed. Initial recommendations were provided in the interim report in November 2002.

The Operator's Workshop was not held as originally planned in Autumn 2002, because of the lack of a suitable venue/occasion. It was felt important to hold the workshop in cooperation with key members of the offshore operator's community, to maximise interest and input from this community. It is now planned to hold the workshop in cooperation with the MetOcean Committee of the International Association of Offshore Oil and Gas Producers (OGP), on May 19th at the Norwegian Petroleum Directorate in Stavanger, Norway. Further details will become available on the Gamble and OGP Met-Ocean Committee web-sites (the latter is to be found at http://www.ogp.org.uk/metocean/schedules.html). Initial discussions regarding the format and content of this workshop were held during the GAMBLE mid-term review meeting. A consequence of this delay is that it is also proposed to delay the end-date of WP7 (Defining a Research Programme) until June 2003 to allow input from this workshop.

The mid-term review meeting was held by **SOC** in Southampton in January 2003. Representatives of the steering group and the **EC** attended and provided their opinion on progress and plans for the final year. Some initial suggestions of mission scenarios for further investigation under GAMBLE were discussed. The date and location for the remaining workshops was discussed. One possible scenario is to hold the Final Gamble meeting in cooperation with a meeting of the JASON Science Working Team, scheduled for November 2003. If this is to happen, it would require an extension of the GAMBLE project by 1 month - to the end of November 2003. This would also allow WP8 to be extended to hold a workshop, and finish, in September 2003 (currently it is timetabled to end in August 2003 – and difficulties are anticipated in gaining final comments and contributions during the summer period). A decision whether to ask for an extension will be made before the end of April 2003.

In addition the relevance of the current tandem Jason-1/TOPEX mission to the GAMBLE studies were noted. It was agreed that an appraisal of the benefits of such a mission would be highly relevant to GAMBLE. Thus it was agreed that **SOS** would request permission from the **EC** to issue a sub-contract (subject to a limit of €20K) to **CLS** to carry out such a study in support of GAMBLE. It is proposed to transfer the necessary funds from the budget allocated as a contingency for invited experts. This study will contribute to, and report, to WP8 (Constellation Optimisation).

1.2.2 Updated GANNT Chart (as of 31/01/03)



Notes:

- Changes in grey (WP2,3 & 4) indicate changes previously agreed and included in Project Definition V1 (01/05/02).
- Changes in black (WP5 & 7) indicate changes agreed at Mid Term Review and included in Project Definition V2 (20/01/03)
- Possible requests to change to end dates of WP9, 10 and 11 (in red) are yet to be confirmed.

1.2.3 Manpower Contributed to Date

1.2.3.1 4 main partners

	Effort to 31/01/03	*Planned to 31/01/03*	*Committed (for whole project)*	*Remainder (01/02/03 onwards)*
CO1 - SOS	4.4	5.50 (4.50)	9.25	4.85
CR2 - CNES	1.5	1.75	3.0	1.5
CR3 - DUT	4.0	3.50	6.5	2.5
CR4 – ISDGM	3.75	2.75 (2.0)	4.75	1.0
Sub Total	**13.65**	**13.5 (11.75)**	**23.5**	**9.85**

Figures for "planned" effort are initially given as written in the description of work, where affected by the delay of WP6 into year 2 revised figures are given in brackets

1.2.3.2 Other partners

	Effort to 31/01/03	*Planned to 31/01/03*	*Committed (for whole project)*	*Remainder (01/02/03 onwards)*
MB5 - SOC	2.0	3.25 (2.75)	6.0	4.0
MB6 - CLS	1.5	2.5 (2.0)	4.0	2.5
MB8 - UNEW	*1.5*	*1.5*	*2.0*	*0.5*
MB9 - ALCA	0.5	0.75	1.75	1.25
MB10 - CETP	0.3	0.75 (0.50)	2.0	1.70
MB11 - SHOM	*0.50*	*0.5 (0.25)*	*1.25*	*0.75*
MB12 – UJF	0.75	0.5	1.25	0.5
MB13 - LEGOS	*0.25*	*0.25*	*1.25*	*1.0*
MB14 - POL	0.05	0.25	0.75	0.70
MB15 - SSTL	0.5	0.25	1.0	0.5
MB16 – UVSQ (see MB10)	-	-	-	-
MB17 – LEGI (see MB12)	-	-	-	-
MB18 – INPG	0.0	0.0	0.0	0.0
MB19 - MPI	*1.0*	*1.0*	*1.0*	*0.0*
MB20 - ESSC	0.0	0.0	0.0	0.0
MB21 - NERSC	0.0	0.5 (0.25)	0.75	0.75
subtotal	**8.85**	**12.0 (10.25)**	**23.0**	**14.15**
TOTAL EFFORT TO DATE	**22.50**	**25.5 (22.0)**	**46.5**	**24.00**

Again, where they are affected by the delay of WP6 into year 2, the "planned" effort adjusted to allow for this is given in brackets. Figures in red are estimates, pending receipt of costs statements from members.

1.3 Milestones and Deliverables

No milestones were due in months 1-12
Deliverables status is given in the Table below:

Delive-rable No.	Deliverable Title	Delivery Date (Month)	Nature	Dissemination Level.	% cost (approx)	Status
1	Project Definition (V1) Project Definition (V2)	2	Re, Me	RE	8.2	✓ ~~ 1□ □ ✓ 10~13
2	Interim Report on SSH Error Budgets / Feature Detectability, for Tracking Workshop	5	Re	PU	4.3	✓ 31/07/ 02
3	Final Reports on Error Budgets / Feature Detectability	14	Re	PU	4.3	
4	Interim Report on sea-state error budget/Impact of GAMBLE in sea-state analysis and forecasting	5	Re	PU	4.1	✓ 31/07/ 02
5	Final Report on sea-state error budget/Impact of GAMBLE in sea-state analysis and forecasting	14	Re	PU	4.1	
6a	Interim Recommendations for Orbit Determination and Tracking	9	Re, Me	PU	3.4	✓ 28/11/ 02
6b	Final Recommendations for Orbit Determination and Tracking	14	Re, Me	PU	3.4	
7	Report on Marine Operator's Requirements	16	Re	PU	10.9	(delayed until 06/03)
8	Report on Error Budgets and Potential Solutions	12	Re, Me	PU	8.0	✓ 03/03
9 / ***M1***	Framework for Recommended Research Programme	16	Re, Me	PU	8.0	
10 / ***M2***	Orbit Recommendations	18	Re	PU	6.2	
11 / ***M2***	Satellite and payload specification recommendations	18	Re	PU	6.2	
12	Final Workshop report	20	Re	PU	7.0	
13	Interim Management Report	6	Re	PU	<1	✓ 31/07/ 02
14	Interim Management Report	12	Re	PU	<1	✓ 02/03 (this report)
15	Mid term Report	12	Re	PU	6.1	✓ 02/03 (this report)
16	Interim Management Report	18	Re	PU	<1	
17	Draft Final Report	19	Re	RE	5.8	
18	Final Report	21	Re	PU	7.0	
19	Website and exploitation report	21	Re	PU	3.0	

Note - Nature : Re – Report
Me – Methodology

Dissemination : RE – Restricted
PU – Public

Links to all project documents, including deliverables, are provided in the Appendix to this report.

1.4 Deviations from the Work Plan

1.4.1 Changes previously agreed and reported in Project Definition V1 (in May 2002)

N.B. Project Definition V1 was superceded by V2 in January 2003

WP2 Completion date extended from T0+12 to T0+14.
WP4 Duration of Work Package extended from two to twelve months. WP3 now runs from T0+2 to T0+14.

D2, D4. The due date for these deliverables was moved forward to month 5.
D3. Delayed to Month 14.
D6a Deliverable 6 divided into two,
Deliverable 6a due in Month 9 (November 2002)
D6b Deliverable 6b due in April 2003.
D8 Report on error budgets and potential solutions. Delayed to month 14 (April 2003) to allow input from final conclusions of WP2 and WP3.

1.4.2 Deviations from Project Definition V1.0 in months 1-12

Deliverable D2 (Interim Report on Sea Surface Height Error budgets and Feature Detectability) was not completed until November 2002 (Month 9), due to a delay in receiving contributions. It is not anticipated that there will be any follow-on delay to the subsequent full report (Deliverable D3).

The workshops for Sea Surface Height studies, and Orbit Determination and Tracking were merged to become a combined 2 day workshop at **DUT** in November 2002. This allowed orbit and tracking experts to respond immediately to queries regarding range accuracy requirements from the sea-surface height research community, and speeded up the dialogue. A particularly valuable outcome was the understanding that sufficiently accurate orbits (5cm radial accuracy) could be gained for microsatellite altimeter missions using dual cross-over analysis with orbits from a precisely controlled mission (e.g. JASON-1).

The Marine Operators' Workshop (WP5) was delayed until a suitable venue could be identified, to encourage the widest possible participation. The workshop will now be held in Stavanger on May 19th (see previous discussion in Section 1.2.1) and WP5 will run from April-June 2003.

1.4.3 Proposed Changes in Months 13-21

The following further changes to the Work Programme (as defined in Project Definition V1.0) are proposed:

Approved Changes
WP5 Moved from Months 7 –9 to Months 12 –14
WP7 End date extended from Month 16 to Month 17 (to allow input from WP5)

D7 Delayed from Month 9 to Month 16
D9/M1 Delayed by one month from Month 16 to Month 17 (to incorporate input from D7)

These changes have been approved by the EC and are included in Project Definition V2.0.

Provisional Changes - To be confirmed

WP8, WP9 Depending on the venue decided on for the JASON Science Working Team (expected to take place in November 2003), it may be subsequently recommended that the final GAMBLE workshop is merged with this event. In that case a request would be made to the EC to extend GAMBLE by one month (to finish at the end of November 2003). The workshop and end of Work Package 8 would be delayed until Sept 2003. It is anticipated this would help to gain greater participation by avoiding the summer holiday period. Also the end of Work Package 9 (Final Workshop) would be extended until the end of November 2003.

WP2, WP8 In addition an opportunity for **CLS** to carry out a valuable study to assess the results of the JASON-TOPEX tandem mission has arisen (see above). The GAMBLE management team propose that a maximum of €20K is transferred from the "Invited-Experts" contingency budget so that **SOS** can issue a subcontract to **CLS** to carry out this study. This proposal waits approval from the **EC**. The budget implications are discussed below.

1.4.4 Impact of Proposed Changes

Timetable

The success of the GAMBLE Thematic Network relies on the input of acknowledged experts in satellite altimetry, over a period when there have been many calls on the time of these partners – following the launch of JASON-1 in December 2001 and of ENVISAT in March 2002. It has therefore been judged preferable to take a flexible attitude toward the GAMBLE timetable, and so maximise the contribution that experts are able to make, rather than to adhere rigidly to a pre-determined schedule.

The consequence so far has been a possible short delay, maximum 1 month, in the anticipated delivery of the final GAMBLE Milestones, but has allowed a significant contribution from experts with many calls on their time. The GAMBLE management team are grateful for the flexible attitude of the EC which has allowed this variation in the timetable.

Financial

Proposed CLS Study - "Invited Experts" Budget.

A budget has been allocated within GAMBLE to support the contribution of invited experts and the possible invitation of new members into the GAMBLE network. The original "invited experts" budget was €45000. To date, GAMBLE has held two workshops (plus a kick off and mid term review meeting), and invited 7 experts to contribute, at a total cost of €6218. Transfer of €20K out of this budget to support the CLS study would leave €18782. Three workshops remain in GAMBLE (Marine Operators workshop, Constellation Optimisation and Final Workshop). We anticipate that the remaining €18.78K could support workshop contributions from up to 5 experts from outside Europe (at up to €2K each), plus up to 9 from inside Europe (at €1K each).

We have noted that the Marine Operators' workshop will be held in conjunction with an OGP meeting. Thus OGP members will not be given financial support from GAMBLE. It is anticipated

that up to 5 non-members of OGP with particular relevant expertise may be invited to contribute to the workshop, and that their travel expenses would be covered (subject to normal EC rules).

Other Changes

None of the other proposed changes has financial implications.

1.5 Coordination

Coordination and information exchange between partners has been predominantly through e-mail. The web page of the project is operational and serves as a way of communication of results and exchange of documents between the partners.

1.5.1 Meetings

The following meetings were held during the last six-month reporting period:

	Meeting	Venue	Date
WP2	Sea Surface Height Feature Detection	Delft University of Technology	7-8 November 2002
WP3	Sea State Feature Detection	ISDGM, Venice	30 September 2002
WP4	Orbit Determination and Tracking	Delft University of Technology	7-8 November 2002
WP6	Mid Term Progress Review	Southampton Oceanography Centre	17 January 2003

Meetings are planned for 2003 as follows:

	Meeting	Venue	Date
WP5	Operators' Workshop	NPD, Stavanger, Norway	19 May 2003
WP8	Constellation Optimisation Workshop	CNES (to be confirmed)	September 2003 (to be confirmed)
WP9	Final Workshop	to be confirmed	November 2003 (to be confirmed)

1.5.2 Co-operation with other projects

The importance of establishing co-operative links with other programmes and projects is recognised, and these links have often been used to gain input to GAMBLE. The nature of these links is briefly outlined below:

- *GODAE (Global Ocean Data Assimilation Experiment)*
  Pierre-Yves le Traon of **CLS** is highly involved in GODAE.

- *NASA/NPOESS (National Polar-orbiting Operational Environmental Satellite System)*
  Yves Menard of **CNES** has well established lines of communication with NASA through the TOPEX and JASON programmes and provides a link to the US altimeter satellite community.

- *EUROGOOS*
  Trevor Guymer of **SOC** is a member of the EUROGOOS Space Panel.

- *European Space Agency*
  - ESTEC - Alcatel is currently conducting a study for ESA for reviewing the user needs in ocean and ice altimetry and for proposing and studying new altimeter concepts. **SOS, CNES**, and **CLS**, are contributing to this study
  - ESRIN –**CLS, CNES, SOC** and **SOS**, are all on the calibration and validation team for the altimeter on the ENVISAT. Most GAMBLE partners will be involved in research programmes using ENVISAT RA-2 data.

- *GMES (EC/ESA)*
  A number of GAMBLE partners (including **CLS** and **SOS**) are involved with ESA GMES programmes. It is expected that GAMBLE partners will be involved in bids for EC funding under GMES.

- *Offshore Operators*
  Representatives of Offshore Operators (Shell, BP, OceanRoutes) are on the GAMBLE Steering Group. The Marine Operators' workshop will provide further input from this sector.

- *WMO*
  Johannes Guddal (DNMI and WMO) presented at the WP3 workshop in Venice (Sept. 2002), and will be kept advised of developments within GAMBLE.

- *MaxWave*
  Johannes Guddal (DNMI) and Susanne Lehner (DLR) presented at the WP3 workshop in Venice (Sept. 2002).

- *EC Programmes - GAVDOS and IRIS.*
  SOS will establish contact with the Coordinators of the GAVDOS and IRIS projects.

1.5.3 Participants' information:

N°	Institution/Organisation	Street name & number	Post Code	Town/City	Country	Title	Family Name	First Name	Phone N°	Fax N°	E-Mail
CO 1	Satellite Observing Systems (SOS)	15 Church Street	GU7 1EL	Godalming	UK	Dr Dr	Allan Cotton	Tom David	+44 (0)1483 421213	+44 (01483 428691	tom@satobsys.co.uk d.cotton@satobsys.co.uk
CR 2	Centre National des Etudes Spatiales (CNES)	18 Ave Ed. Belin	31401	Toulouse	F	Mr Mr	Menard Vincent	Yves Patrick	+33 (0)5 61 27 48 72	+33 (0)5 61 28 25 95	yves.menard@cnes.fr Patrick.Vincent@cnes.fr
CR 3	Delft University of Technology (DUT)	Kluyverweg 1	2600 GB	Delft	NL	Prof ir	Boudewijn	Ambrosius	+31 15 278 5173	+31 155 278 5322	b.a.c.ambrosius@ir.tudelft.nl
CR 4	Istituto per lo Studio della Dinamica delle Grandi Masse (ISDGM)	San Polo 1364	30125	Venice	IT	Dr	Cavaleri	Luigi	+39 041 5216810	+39 041 2602340	gigi@isdgm.ve.cnr.it
MB 5	Southampton Oceanography Centre/James Rennell Division (SOC)	Waterfront Campus, European Way	SO14 3ZH	Southampton	UK	Mr	Challenor	Peter	+44 (0)23 805 96413	+39 (0)23 8059 6400	pc@soc.soton.ac.uk
MB 6	Collecte Localisation Satellites Space Oceanography Division (CLS)	8-10 rue Hermes	31526	Ramonville St Agne	F	Dr	Le Traon	Pierre-Yves	+33 5 61 39 47 58	+33 5 61 39 37 82	letraon@cls.fr
MB 8	Univ. Newcastle (UNEW)	Dept. of Geomatics	NE1 7RU	Newcastle upon Tyne	UK	Prof	Moore	Philip	+44 (0)191 222 5040	+44 (0)191 222 8691	philip.moore@ncl.ac.uk
MB 9	ALCATEL Space Industries (ASPI)	26, avenue JF. Champollion	31037	Toulouse	F	Mr	Phalippou	Laurent	+33 5 34 35 60 02	+33 5 34 35 59 94	laurent.phalippou@space.alcatel.fr
MB10	Centre d'Etudes des Environnements Terrestre et Planetaires (CETP)	10-12 Avenue de l'Europe	78140	Velizy	F	Dr	Hauser	Daniele	+33 1 39 25 48 52	+33 1 39 25 48 72	hauser@cetp.ipsl.fr
MB11	Service Hydrographique et Oceanographique de la Marine (SHOM)	14, avenue Edouard Belin	31401	Toulouse	F	Mr	Bahurel	Pierre	+33 5 61 33 29 14	+33 5 61 33 29 16	pierre.bahurel@cnes.fr
MB12	Universite Joseph Fourier (UJF)	1025 rue de la Piscine	38041	Grenoble	F	Dr	Verron	Jacques	+33 4 76 82 50 18	+33 4 76 82 52 71	jacques.verron@hmg.inpg.fr
MB13	Laboratoires d'Etudes en Geophysique et Oceanographie Spatiale (LEGOS)	18 avenue Edouard Belin	31401	Toulouse	F	Dr	Le Provost	Christian	+33 5 61 33 29 23	+33 5 61 25 32 05	christian.le-provost@cnes.fr
MB14	Proudman Oceanographic Laboratory (POL)	Bidston Observatory, Bidston	CH43 7RA	Birkenhead	UK	Dr	Woodworth	Philip	+44 (0)151 653 8633	+44 (0)151 653 6269	plw@pol.ac.uk
MB15	Surrey Satellite Technology Ltd. (SSTL)	Surrey Space Centre	GU2 7XH	Guildford	UK	Dr	Da Silva Curiel	Alex	+44 (0)1483 879278	+44 (0)1483 879503	a.da-silva-curiel@sstl.co.uk
MB16	Universite Versailles St Quentin (CETP)	10-12 Avenue de l'Europe	78140	Velizy	F	Dr	Hauser	Daniele	+33 1 39 25 48 52	+33 1 39 25 48 72	hauser@cetp.ipsl.fr
MB17	Laboratoire des Ecoulements Geophysicques et Industriels (LEGI)	1025 rue de la Piscine	38041	Grenoble	F	Dr	Verron	Jacques	+33 4 76 82 50 18	+33 4 76 82 52 71	jacques.verron@hmg.inpg.fr
MB18	Institut National Polytechnique de Grenoble (INPG)	1025 rue de la Piscine	38041	Grenoble	F	Dr	Verron	Jacques	+33 4 76 82 50 18	+33 4 76 82 52 71	jacques.verron@hmg.inpg.fr
MB19	Max-Planck-Institut fuer Meteorologie (MPG)	Bundestrasse 55	20146	Hamburg	D	Dr	Mueller	Detlev	+49 40 41173 306	+49 40 41173 298	detlev.mueller@dkrz.de
MB 20	Environmental Systems Science Centre/The University of Reading (UREADES)	3 Earley Gate	RG6 6AL	Reading	UK	Prof	Haines	Keith	+44 (0)118 931 8742	+44(0)118 931 6413	kh@mail.nerc.essc.ac.uk
MB 21	Nansen Environmental and Remote Sensing Centre (NERSC)	Edvard Griegsvei 3a	5059	Bergen	NO	Prof.Dr	Johannessen	Johnny	+47 55 297288	+47 55 200050	johnny.johannessen@nrsc.no

1.6 Difficulties Encountered

There was a delay from some partners in submitting the cost statements for the first 6-month period (01/02/02-31/07/02). One cost statement from this period remains outstanding.

Costs statements for the 2nd 6 month period (01/08/02-31/01/03) have been requested from all partners and members, and at the time of writing are being gathered together at **CNES** and **SOS.**

No other co-ordination difficulties have been encountered

SECTION 2: EXECUTIVE SUMMARY, RELATED TO REPORTING PERIOD (12 MONTHS)

Contract n°	EVR1 – CT - 2001 – 20009	Reporting period:	1/2/2002 – 31/1/2003
Title	Global Altimeter Measurements By Leading Europeans		

Objectives:

- To establish error budgets and altimeter measurement requirements (accuracy and sampling frequency) necessary to resolve key features in sea surface height and sea state. This to be achieved through workshops and communications with the widest possible community of users of altimeter data.
- To establish the key issues which present obstacles in meeting the measurement requirements identified above (specifically with regard to orbit tracking and orbit determination), and identify possible solutions to these.
- To make a preliminary identification of possible altimeter mission scenarios.
- To maintain an effective communication with the GAMBLE team and the larger European altimeter community, through the project web-site.

Scientific achievements:

Progress has been achieved along three scientific/technical themes:

Theme1: Sea Surface Height Error Budgets and Feature Detectability

The aims of this work package are to identify the major issues of interest in applications of altimeter measurements of sea surface height, and to establish what improvements are required over the next 5-10 years, in terms of measurements from satellite altimeters. This work package is led by CLS (Collecte Localisation Satellites, France).

Contributions on a wide range of applications relevant to this theme have been gathered from the European altimeter community. A workshop (joint with Theme 3) was held at Delft University of Technology on 7-8th November 2002, to gather further contributions and discuss how the various requirements could be addressed. These contributions have been synthesised into an interim report (21 pages), available at:
http://www.altimetrie.net/docs/GAMBLE_interimreport_theme1_021121.pdf

Theme 2: Sea State Error Budgets and Feature Detectability

The aims of this is work package are to identify the major issues in applications of altimeter measurements of sea state (wave measurements and wind speed), and to establish requirements over the next 5-10 years. This work package is led by ISDGM (Istituto per lo Studio della Dinamica delle Grandi Massi, Italy).

Contributions on a wide range of applications relevant from this theme have been gathered from the European altimeter community. A workshop was held at ISDGM, Venice, on 30th September 2002, to gather further contributions and discuss how the various requirements could be addressed. An interim report (27 pages) has been compiled from these contributions. This report is available online at:
http:// www.altimetrie.net/docs/GAMBLE_interimreport_theme2_020711.doc

Theme 3: Orbit Determination and Satellite Tracking

Accurate determination and control of the satellite's position in space are essential if useful measurements of the sea surface are to be provided by a satellite borne radar altimeter. The aims of this work package are to identify the techniques by which this control and knowledge can be achieved to a satisfactory accuracy for a number of candidate satellite systems. This work package is led by DUT (Delft University of Technology, The Netherlands).

Contributions have been gathered from experts within the European altimeter community. A workshop (joint with Theme 1) was held at Delft University of Technology on 7-8th November 2002, to discuss how satisfactory orbit determination and tracking could be achieved for various satellite scenarios. These contributions have been synthesised into an interim report (20 pages), available online at:
http:// www.altimetrie.net/docs/GAMBLE_interimreport_theme3.pdf

Socio-economic relevance and policy implications:
The GAMBLE project brings together the skills within the European space industry - in space engineering, in satellite tracking, signal processing, and data interpretation - while benefiting from advice from a broad 'user' community drawn from both academic research and daily marine operations. The aim is to design future ocean space systems in Europe that respond directly to the needs of a wider community than at present.

Over the last decade Europe has been particularly active in the use of satellites to measure ocean surface conditions. ESA's first EO satellites, ERS-1 and ERS-2, are equipped with sensors primarily designed for ocean monitoring, and Topex/Poseidon is a joint venture between France and the USA. The European space industry has developed precise, all-weather radars that measure surface currents, waveheights and wind speed. A more recent development in Europe has seen the emergence of very small satellites (nanosats and microsats) which in a number of missions have already demonstrated their ability to carry special-purpose sensors.

Europe is well-placed to implement a system of fast sampling using a constellation of comparatively inexpensive, dedicated small sats to work in conjunction with the 'premium' research platforms Envisat and JASON (successor to Topex/Poseidon). Such an initiative would place Europe in pole position providing an innovative new technology - the first major EO breakthrough in over 2 decades. The benefits to the space industry would be matched by the socio-economic benefits to Europe providing a leading role in monitoring global climate change. From an operational standpoint the seas, which are presently used to transport over 90% of goods in and out of Europe, remain hazardous and claim many thousands of lives each year, as well as causing substantial damage and delay to ships. Last year, marine insurance losses in weather-related incidents totalled $2.5 billion.

It becomes imperative to focus the expertise that resides in European institutes and attempt to identify the cost/benefits of different mixes of small satellites in improving the effectiveness of the larger, solitary missions. The benefits to science stem from sampling the ocean's surface at a rate more nearly in tune with observed rates of change. The behaviour of the ocean and the way it transports energy across the globe is one of the most important factors in determining climate change. Yet, at present, it is seriously under-sampled.

The issues addressed by GAMBLE - understanding processes governing global currents, improving short term predictions of sea state and currents, enhancing global observing systems – form the backbone of the first scientific challenge identified in a recent report by the European Science Foundation's Marine Board ("Towards a European Marine Research Area", European Science Foundation, Marine Board, December 2000, http://www.esf.org/marineboard). In addition this report calls for the development of infrastructure to support operational oceanography from satellites, and an improvement in co-ordination of space based activities to provide an enhancement of complementarity and competitiveness.

GAMBLE offers the opportunity to make better use of satellites by combining programmes in a way that has never before been attempted. GAMBLE addresses 3 fundamental parts of EC marine policy – increased safety at sea, increased efficiency, and increased awareness of global environmental changes.

Conclusions:
The Final Reports addressing the GAMBLE Scientific Themes of Sea Surface Height and Sea State Error Budgets and Feature Detectability, and Orbit Determination and satellite tracking are close to completion. Key issues with implications for future missions and instrumentation have been identified. Possible solutions to questions in the area of orbits and tracking have been established. The GAMBLE team is now in a position to move into the second year, in which possible future mission configurations and research programmes will be discussed in greater detail.

Keywords: Satellite altimetry, currents, sea state

Publications (cumulative list)

Peer Reviewed Articles:

Authors / Editors	Date	Title	Event	Type[1]
T.D. Allan and E..R. Ash	16-18 October 2001 Published 15 January 2003	The Gamble Project: A fresh approach to satellite remote sensing of the sea. Phil. Trans. Roy Soc., Mathematical, Physical and Engineering Sciences. Vol 361, No 1802.	"Science and applications of the space environment: New results and interdisciplinary connections". The Royal Society of London	Presentation and Proceedings
Aouf L., J-M. Lefèvre, and D. Hauser	May 2002	Assimilation of synthetic SWIMSAT directional wave spectra in the wave model WAM,	ISOPE Conference, Tokyo	Presentation and Proceedings

Non refereed literature:

Authors / Editors	Date	Title	Event	Type
T. D. Allan	3-6 December 2002	The Future Role of Satellite Altimetry	3rd Eurogoos Conference Building the European Capacity in Operational Oceanography Athens, Greece.	Presentation and Proceedings
P.D. Cotton	26 November 2002	GAMBLE – The future role of Satellite altimeters	British Association of Remote Sensing Companies, The Linnean Society	Presentation
Aouf L., J-M. Lefèvre, and D. Hauser	May 2003	Optimization of the assimilation scheme of directional wave spectra in wave model WAM: Application to real ASAR-ENVISAT wave spectra	Abstract submitted to ISOPE Conference, Hawaii	Presentation

[1] Type: Abstract, Newsletter, Oral Presentation, Paper, Poster, Proceedings, Report, Thesis

SECTION 3: DETAILED REPORT ORGANIZED BY WORK PACKAGE

FOR THE REPORTING PERIOD FEBRUARY 2002 – JANUARY 2003

(Work has not started on WP 7, 8 and 9 and so there are no sections for these work packages)

3.1 Work Package 1 – Kick-Off / Project Definition (led by CNES)

3.1.1 Objectives

The main purpose of this work package was to generate the Project Definition, to provide the work plan for the rest of the duration of GAMBLE. It was also important to co-ordinate the GAMBLE timetable with that of the satellite missions under consideration, to ensure that recommendations from GAMBLE are made in a timely fashion.

Secondary aims were to set dates and venues for the GAMBLE workshops, to establish the working groups which will address the various scientific and technical themes, and to define the remit of the Steering Group.

This Work Package Started in February 2002, and was brought to a close in April 2002 with the delivery of the Project Definition (Deliverable D1)

3.1.2 Methodology and scientific achievements

The adopted methodology was:
Convene a workshop at which the GAMBLE team will:

- Define the best approach to apprehend the whole problem
- Define the best approach to simulate the combined missions of the future
- Identify resources
- Assign responsibilities

Establish a series of topic specific expert review groups

The Kick-off meeting was held at the offices of LEGOS (Laboratoire d'Études en Géophysique et Océanographie Spatiale) Toulouse, France, on 21 March 2002. Minutes have been generated and distributed. At the Kick-Off meeting all participants agreed to the suggested Work Programme, subject to revisions which were included in the Project Definition subsequently generated.

SOS, CNES, DUT, ISDGM, SOC, CLS, ALCATEL, LEGOS, SETP, LEGI all attended the Kick-Off meeting and contributed to this work package. **ESA/ESTEC** were also represented.

3.1.3 Socio-Economic relevance and policy implications

No extra socio-economic or policy issues arose out of this work package.

3.1.4 Discussion and Conclusion

WP1 ran according to the Description of Work, with no outstanding issues. The project Definition established the programme of work for the 1st year of GAMBLE. The Project Kick-Off established a constructive and co-operative tone which has since characterised the GAMBLE thematic network.

3.1.5 Plans and Objectives for the next period

The work package is completed. No further work is intended or required.

3.2 Work Package 2 – Sea Surface Height Error Budgets and Feature Detectability (Led by CLS)

3.2.1 Objectives

The objectives of this work package were to summarize works that have been carried out to provide recommendations for future missions on:

- Sampling requirements for SSH (and surface current) measurements.
- SSH error budget (orbit, noise, corrections, repetitivity, geoid).
- Merging methodologies.

Work Package 2 runs from Month 2 to Month 14 (April 2002 to April 2003).

3.2.2 Methodology and scientific achievements

The main activities of this work package have been the presentation and discussion of recent research involving the use of combined data from different altimeter missions with relation to applications (scientific and operational) of ocean sea surface height measurements. These discussions reviewed and built on the work presented at such meetings as JASON Science Working Team, and the High Resolution Ocean Topography meeting held at the University of Maryland in March 2001.

Aspects discussed included:

- Simulation of new altimeter missions/concepts.
- Theoretical analyses of sea level and velocity mapping capabilities of existing multiple altimeter missions.
- Analysis of the Wide Swath Ocean Altimeter system and constellations of 3/4 satellites (Alti-Ka, Wittex) – High Resolution Ocean Topography report.
- Analysis of the potential contribution of GPS reflected signals.
- Merging of existing missions (TOPEX/Poseidon, ERS, Geosat Follow On, Jason and ENVISAT).

In addition contributions were taken from Gamble partners on data assimilation (**LEGI, SHOM, NERSC** and **MPI**), feature detection (**SOC**), and coastal regions (**POL, LEGOS**).

The Interim Report D2 was completed in November 2002. A joint WP2/WP4 workshop was held at DUT, Delft, The Netherlands, on 7-8 November 2002. Presentations made at that meeting are available at the GAMBLE web-site.

Issues discussed at the workshop included:

- Overview of new altimeter concepts (JASON-2, Wide Swath Altimetry, Cryosat, Alti-Ka, GANDER) **CNES, ALCATEL, SOS, Ohio State University.**
- Simulations of the contribution of present and future missions (**LEGI, LEGOS, SOC**).
- Refined requirements for sea level measurements, open ocean features, tidal features, and coastal features (particularly addressing sampling issues) – **CLS, LEGOS.**

- Requirements for Sea Surface Height Measurement Errors (general issues, orbits considerations, and issues related to measurements from microsatellite platforms) - **CLS, CNES, SOC, SOS, DUT.**

An outline of proposed recommendations was presented to the Workshop, these were:

Future Missions

Minimum requirement:

- Continue the Jason series for long-term, precise altimeter system.
- Fly a post-ENVISAT mission to continue the T/P+ERS (Jason-1+ENVISAT) configuration after 2006 => Alti-Ka is a good candidate and demonstrator for a future constellation system (GANDER).

"More ambitious" requirement

- Fly a three satellite constellation (interleaved Jason tracks or ENVISAT with a 35/3 repeat period) (in addition to the Jason series) that will provide a very significant improvement for SSH operational applications and will "pave the way" for GANDER.

It was also suggested that a demonstration of WSOA on board Jason-2 is required before considering swath techniques for future operational systems (post 2010).

SSH Errors

- Radiometer and ionospheric corrections (Ka or dual) are needed. Should be revisited if this becomes a critical issue.
- Orbit error should be below 2 cm rms in real time for the Jason series (goal). This can be relaxed for the other missions (if tracking system is an issue).
- Orbit should be maintained in a +/-1 km band. Can be relaxed if along ERS or T/P tracks.

3.2.3 Socio-Economic relevance and policy implications

The material gathered for this work package concerns many direct and indirect applications which have direct relevance to social, economic and policy considerations.

Planned activities by participants include the setting-up (already well under way) of operational ocean models to provide near real time information on ocean surface topography (including surface currents, locations of oceanographic features such as fronts) to offshore operations, fisheries, and climate prediction centres.

The long-term programme of global sea level monitoring has a central role in establishing the scientific background for discussions on how to monitor, respond to, and manage, climate change.

3.2.4 Discussion and Conclusion

This work package brought together experts on applications of altimeter sea surface height data, enabled a discussion of the latest research and reviews, and a discussion of the implications of the characteristics of various proposed future missions. Progress on the work package is on schedule, and a final report is due by April 2003.

GAMBLE has enabled a look beyond the immediate short term, and the timescale of GODAE (2003-2005), into a wider range of possible missions in the time scale 2005-2010 and beyond.

3.2.5 Plans and Objectives for the next period

It is not intended to gather in any further inputs from GAMBLE partners (apart from reviewing versions of the final work package report). The remaining activity is to organise the material that has already been gathered and update the interim report to provide the final Work Package report containing recommendations for measurement requirements (including sampling regimes). This report is due in April 2003

The GAMBLE management team are recommending that CLS are assigned an extra task to investigate the added sampling capabilities of the TP - Jason tandem mission. This work would feed into Work Package 8 (Constellation Optimisation). The report from this study could form an addendum to the WP2 final report.

3.3 Work Package 3 – Sea State Height Error Budgets and Feature Detectability (Led by ISDGM)

3.3.1 Objectives

The objectives of this work package were to bring in expert opinion and hold discussions to provide recommendations for future missions on :

- Sampling requirements for sea state: wave parameters including significant wave height, wave period and direction; ocean surface wind speed; and other air sea flux parameters including rain rate, air sea gas transfer velocity and wind stress.
- Accuracy and reliability requirements for these parameters.
- Studies that may be necessary to ensure that best use is made of altimeter sea state data.

Work Package 3 runs from Month 2 to Month 14 (April 2002 to April 2003).

3.3.2 Methodology and scientific achievements

The general approach to this work package was to review and assess state of the art knowledge from most recent workshops and literature. Written contributions and workshop presentations have been offered by members of the GAMBLE team, and also from external experts. A workshop was held at ISDGM, Venice, Italy, on 30 September 2002.

Contributions from GAMBLE partners included:
ALCATEL – An overview of recent and proposed developments in altimeter instrumentation.
CETP – Presentation of the SWIMSAT mission proposal and of results from a simulation of assimilation of wave spectra information into a global wave model.
CNES – Presentation of the JASON missions, and results from studies into Ka band altimetry.
ISDGM – Discussion of applications of sea state data in coastal applications and in the Mediterranean Sea.
SOC – Presentation of recent studies at SOC, including wave climate variability, investigations to develop new altimeter algorithms for wind speed and wave period.
SOS – Presentation of requirements for sea state data from the operational offshore user community (near real time and climatology).

Contributions from invited experts included:
CICESE (Mexico) **-** Presented a view of the requirements for satellite derived sea state data from countries without the resources to support large integrated monitoring systems.
ECMWF - Results from studies of assimilating significant wave height data into global wave models (estimates of error in altimeter, buoy and model measurements, the benefits to forecast accuracy of assimilating data from more than one altimeter mission), sea state bias theory.
Météo France – The results of studies in comparing performance of different wave models, and comparing the affect of assimilating altimeter significant wave height data, and wave spectra data (as would be available from SWIMSAT).
DNMI – Presented a view from JCOMM, emphasising the importance of improving the forecasting of extreme events which affect vulnerable coastal populations.
DLR – Presented early results from the MAXWAVE project, which is investigating occurrence of very high “Rogue” waves.

UKMO – Provided a statement indicating that a key problem in wave modelling was the accurate representation of the generation and propagation of swell.

From the various contributions a number of preliminary recommendations were agreed.

From the perspective of users (research and commercial) priorities are:

- Improved sampling in space and time (uniformly distributed, so far as is possible)
- Availability of wave directional and wave period information – also separate wind sea and swell parameters (height, period and direction), wave steepness and joint distributions (e.g. of wave height / period, Hmax/Hs).
- Better combination of ocean / coastal monitoring resources (satellite, in-situ, models) to provide improved warning of severe events with high impacts on vulnerable populations.
- Implementation of a (new) wind speed algorithm valid for higher wind speeds.
- Validation of measurements at higher wave heights and wind speeds.
- Improved performance at coasts (higher along track resolution, quicker gain of ocean surface when the track comes from land to sea).
- Near real time availability of data (< 3 hours) .
- Joint climatologies of altimeter and SAR data - e.g. groupiness, expected maximum wave heights, crest length.
- Climatologies of air-sea fluxes (momentum, heat, gas, freshwater) are important for climate studies. Dual frequency altimeters offer the possibility for direct measurements of surface wind stress, and air-sea gas transfer velocities.

Possible directions for further research include:

- Simulations with wave models to investigate the impact of a system combining SWIMSAT and Altimeters on a global scale wave model.
- A combined study with SAR wave mode and altimeter (and optical?) data to map characteristics and occurrences of possible rogue waves.
- Investigate validity of altimeter wave height measurements for significant wave heights above 10m.
- Develop and test new wind speed algorithms for high wind speeds.
- Further testing and development of altimeter wave period algorithms.
- Test validity of altimeter derived estimates of air sea gas transfer velocity and if appropriate generate climatologies.
- Provide an objective assessment of the relative benefits to wave modelling of improving the sampling of the wind field or improving the sampling of the wave field.
- Analysis of the waveform shape (averaged if necessary) could provide estimates of: Kurtosis/skewness, pdf of surface elevation.
- Develop algorithms to estimate wave steepness, of use to offshore operators and for better estimates of sea state bias.
- Cryosat altimeter data over the ocean should be requested, to allow:
  Analysis of phase information from Cryosat altimeter.
  Analysis of returns from altimeter “sub-cells”, possible from ISAR mode of Cryosat.

3.3.3 Socio-Economic relevance and policy implications

The accurate forecasting of sea state affects the safety and economic viability commercial offshore operations. Environmental consequences of accidents in offshore operations can also be severe. Coastal populations are vulnerable to storm surges and high waves. The improved prediction of such severe conditions could thus have a wide impact.

Over 90% of the transport of goods in and out of Europe is by sea. Despite the increased resolution of computerised models for forecasting sea state, and despite the progress made in communication systems, storms at sea still take their toll in lives, damage and delays. Some 150 ships of over 500 tonnes are lost every year; the marine insurance industry pays out $2.5 billion, and 24,000 lives are lost. Weather forecasts may be reliable for most of the time but the development of the storms which do the damage is difficult to follow with pinpoint accuracy by conventional means.

A combination of a constellation of small satellites carrying wave/wind measuring altimeters together with the observations of JASON-1, and Envisat, and those of the proposed SWIMSAT wave measuring radar, could provide a density of observations which has been lacking in the past. The EU policy addressed in this part is an increase in marine safety which has been a recurring theme for many years, especially in DG VII.

3.3.4 Discussion and Conclusion

This work package brought together experts on applications of altimeter sea state data, enabled a discussion of the latest research and reviews, and a discussion of the implications of the characteristics of various proposed future missions. Progress on the work package is on schedule, and a final report is due by April 2003.

A summary of requirements for altimeter sea state measurements has been assembled and an initial view of how well these requirements may be met by various mission options has been formed.

3.3.5 Plans and Objectives for the next period

An interim work package report was completed and circulated in July 2002. A draft final work package report has been prepared and is presently under review. A final version will be completed by April 2003.

3.4 Work Package 4 – Orbit Determination and Tracking (Led by DUT)

3.4.1 Objectives

The main objective of Work Package 4 is to provide recommendations for optimum orbits, orbit maintenance and satellite tracking and orbit error budgets that may be expected for various proposed satellite altimeter missions.

Work Package 4 runs from Month 2 to Month 14 (April 2002 to April 2003).

3.4.2 Methodology and scientific achievements

The approach to this work package was to review and assess state of the art knowledge from most recent workshops and literature. Written contributions and workshop presentations have been offered by members of the GAMBLE team, and also from external experts. A workshop (joint with GAMBLE WP2) was held at DUT, Delft, The Netherlands, on 7-8 November 2002.

Contributions from GAMBLE partners included:
DUT – Orbit solutions, precise orbit determination, satellite laser ranging, gravity field modelling.
CLS – Gravity field modelling.
CNES – The DORIS satellite orbit determination system.
SSTL – GNSS/GPS micro-satellite applications.
U Newcastle – Precise orbit determination, cross over orbit reduction.
SOS – Sea state and GANDER microsatellite issues.

Contributions from invited experts included:
Technical University of Munich – GPS Orbit Determination.
Ohio State University – Orbit Choices and Orbit Issues.

A number of issues have been addressed by the work package:

Orbit Choice
In order to obtain multi-decadal time-series of altimetry data over the same ground tracks, the orbit choices of both TOPEX/Poseidon/Jason and ERS-1/ ERS-2/Envisat must be adopted for their follow-on missions.

Solar activity will be at a minimum in its 11-year period around 2006. Still, if GRACE models have eliminated the gravity-induced radial orbit error, drag perturbations will likely remain a large error source at lower altitudes. The choice of a high altitude orbit is recommended.

Tracking Systems
Future high-accuracy altimeter satellites should carry either a GPS/Galileo or DORIS receiver for high-accuracy, near continuous tracking.

In addition, a laser retro reflector is required for several purposes: for additional high-accuracy tracking, for validation of the radiometric tracking, for calibration of the altimetric range, and as a fail-safe backup tracking device.

The TOPEX/Poseidon and Jason missions have proven that each of the three available tracking devices (SLR, DORIS and GPS) adds unique valuable information to the computed orbits and to the improvement of force and measurement models. It is therefore recommended to take this combination into consideration for the follow-on missions of Jason and Envisat as well.

General Issues
When real-time orbits are required, the DORIS/DIODE system is a flight-proven technology. Onboard orbit determination at the same precision using GPS is more difficult, because of the need for auxiliary information. However, this might also become possible in the near future.

In the design of new satellites, often a large solar array will be required in order to generate sufficient power. Also, mass must often be minimized in order to reduce launch costs. Despite this, it is still advisable to take the area to mass ratio into account during the design of altimetry satellites. A low area to mass ratio can greatly improve dynamic orbit determination, because of the lower sensitivity to surface forces.

GANDER specific issues
A high-precision tracking system for GANDER only needs to be considered if its altimeter instrument is upgraded for making sea-height measurements. Otherwise, the use of NORAD elements might be sufficient.

If sea-height measurements will be part of the GANDER products, it might be possible to use crossovers with a reference-class mission such as Jason, in order to generate GANDER orbits. These orbits will likely be accurate enough to study meso-scale ocean signals. However, because crossovers only contain information in the radial direction, another means of tracking will be required to fix the orbit in the along-track and cross-track directions.

3.4.3 Socio-economic relevance and policy implication

The orbit and tracking issues discussed in this work package have largely indirect relevance to socio-economic and policy issues, through the applications of sea surface height (and to a lesser extent) sea state data. One relevant policy issue is the need to maintain a global network of satellite laser ranging stations to support accurate orbit tracking – of particular importance to satellite altimetry.

3.4.4 Discussion and conclusion

Several recommendations for the planning of future altimeter missions can be made using the details on tracking systems and precise orbit determination presented in the interim report. Some of these recommendations might conflict with each other, or with restrictions on costs, mass, etc. In these cases, further discussion could be required, both inside or outside the framework of GAMBLE.

3.4.5 Plans and Objectives for the next period

An interim work package report was completed and circulated in July 2002. A draft final work package report has been prepared and is presently under review. A final version will be completed by April 2003.

3.5 Work Package 5 – Marine Operators' Workshop

As noted in earlier sections, the start of this work package has been delayed until April 2003. This work package will now run from April – June 2003, and will be based around a workshop to be held in co-operation with the MetOcean Committee of the International Association of Offshore Oil and Gas Producers (OGP). This workshop will be held in Stavanger, Norway, on May 19th 2003.

Offshore operators are working to specifications that become more challenging year by year. These specifications can relate to operational activities, e.g. the need to operate within precise sea state limits, or for advance knowledge of "weather windows", or they can form part of the design procedure (operational planning or vessel design). It is a priority of Gamble to consider input from offshore operators, so that the requirements for future missions are driven as much by the needs (on account of commercial, safety or environmental considerations) of offshore operators as they are by those of the scientific community. Thus the workshop will allow operators to communicate their priorities, and to engage the GAMBLE partners in a dialogue as to the best way that these requirements can be satisfied.

The work package will aim to:

- Determine more precisely requirements from offshore operators for near real-time information on sea state and current regime.
- Establish with what accuracy currents and severe sea-state information may be detected and delivered to ships at sea within a specified time-frame.

3.6 Work Package 6 – Mid Term Progress

3.6.1 Objectives

The main purposes of this work package are twofold: To review progress over the first year of GAMBLE, and, in the light of this review (and of other developments external to GAMBLE), to reassess, and if necessary, redefine the programme for the second year. The Steering Group will play a central role in this activity. The second purpose is to produce the report (D8) on Error Budgets which will feed into Work Packages 7 and 8.

The management committee will consider if other organisations outside GAMBLE could contribute to GAMBLE in its second year, and whether it is able to offer financial support to any of these organisations.

Work Package 6 runs from Month 10 to Month 12 (December 2002 to February 2003).

3.6.2 Methodology and scientific achievements

The progress of GAMBLE at mid-term was reviewed at a workshop held at SOC, on 17th January 2003. This workshop was attended by **SOC, CLS, CNES, DUT, ISDGM**, and **SOS**. In addition 4 members of the Steering Group (C. Grant, T. Guymer, C. Shaw and J. Thompson) attended, other members of the steering group were given the opportunity to submit written comments, based on a overall progress reports written by SOS, and the interim work package reports for Work Packages 2, 3 and 4. Alan Edwards, of the EC also attended this meeting.

A draft Mid Term Report has been produced and circulated. This report summarises mid-term conclusions with regard to:

- Altimeter measurement requirements/error budgets for resolution of features in sea surface height and sea state.
- The issues requiring technical solutions/developments that are raised through these requirements.
- An assessment of the solutions that are potentially available.

This report is based on work carried out under GAMBLE work packages 2, 3 and 4. It does not repeat detailed information presented in other GAMBLE documents, so readers are referred to the WP2, WP3 and WP4 interim and final reports for greater detail and reference material.

The main points within the report are summarised below:

- *Range corrections* – Further studies are required to investigate errors associated with using modelled wet troposphere corrections. The use of modelled ionospheric corrections has proved a satisfactory solution for single frequency altimeters.
- *Orbit tracking* – Dual satellite cross-overs can be used to generate satisfactory precise orbits (5 cm radial accuracy). If real time orbits are required, DORIS seems a good option.

- *Orbit Choice* – There are conflicting requirements between higher altitude giving more accurate orbits, but also requiring more power from the altimeter.
- *Wave direction, Wave spectra, Separate wind sea / swell measurements* – Requires specific wave measuring instrumentation – most probably on a specific wave measuring mission.
- *Wave period, Wave/wind measurements under severe conditions* – New / improved algorithms should be developed.
- *Improving Sampling* – What are relative benefits of different techniques by which sampling can be improved (swath measurements, constellations of microsatellites). Further simulations are required to identify preferred sampling regimes for different applications.
- *Maturity of Technologies* - On what time scale will GPS reflectometry provide a practical measuring capability.

Technical solutions exist to address many of the issues raised. Some solutions are relatively straight forward and could be easily applied, for instance the use of dual satellite cross-overs to improve orbit accuracy. To satisfy other requirements may be more difficult and may incur significant costs or perhaps even require specialised missions.

It is intended to submit the final version of the Mid Term Progress report to the EC before the end of February 2003.

3.6.3 Socio-economic relevance and policy implication

The socio-economic and policy issues addressed by GAMBLE have been discussed in sections 3.2-3.5 above. This work package does not of itself have relevance to issues beyond those already identified.

3.6.4 Discussion and conclusion

The Mid Term Report on Error Budgets and feature detectability has identified issues that must be addressed to allow an informed decision on the best configuration/combination of satellite altimeter missions to meet user requirements.

Many of these issues will be further addressed within GAMBLE. WP7 will identify recommended themes for further research, WP8 will assess the relative benefits of a number of possible mission scenarios, with a view to identifying satellite combinations preferred for specified mission aims.

3.6.5 Plans and Objectives for the next period

This work package will close with the acceptance of the Mid Term Report, Deliverable D8.

3.7 Work Package 10 – Management and Reporting

3.7.1 Objectives

Management of GAMBLE thematic network and reporting to European Commission.

3.7.2 Methodology

- Appoint Project Manager, and establish GAMBLE website and exchange forum.
- Provide Interim Management reports at T0+6 , 12 and 18 months.
- Provide Mid-term and Final reports of Work Packages to the Commission.
- Provide reports to Steering Group, and convene Steering Group meetings which will provide guidance to GAMBLE project managers.
- Provide cost statements at T0+6, T0+12 months.

3.7.3 Socio-economic relevance and policy implication

The socio-economic and policy issues addressed by GAMBLE have been discussed in sections 3.2-3.5 above. This work package does not of itself have relevance to issues beyond those already identified.

3.7.4 Discussion and conclusion

This annual report of itself provides an overview of progress of the GAMBLE coordinator, **SOS**, in meeting the management and reporting requirements. SOS has been ably supported in this work package by **CNES** in particular, and all the other members of the GAMBLE management team (**SOC, ISDGM, DUT, CLS**), and the GAMBLE Steering Group.

Changes to the programme timetable have been discussed above, but the overall programme remains on schedule, and no major problems have been experienced.

3.7.5 Plans and Objectives for the next period

To continue management of GAMBLE thematic network according to the latest GAMBLE Project Definition (V2.0), in particular:

- Provide Interim Management report at T0+ 18 months.
- Provide outstanding Mid-term and Final reports of Work Packages to the Commission.
- Provide reports to Steering Group, and convene Steering Group meetings which will provide guidance to GAMBLE project managers.
- Provide cost statements at T0+18 and T0+21 months.

3.8 Work Package 11 – Exploitation / Outreach

3.8.1 Objectives

To ensure that the widest possible group of interested parties are aware of the GAMBLE network, to enable this community to contribute to discussions and gain access to the recommendations and reports.

3.8.2 Methodology and scientific achievements

It is important to ensure that the GAMBLE network involves all members of the European altimeter and ocean using community who can make a valid contribution. It is also important that the co-ordination activity initiated by GAMBLE will continue beyond the initial 21-month phase for which Framework V support is available. Thus the activities in this work package have included:

- Ensuring that all relevant organisations (research institutes, space agencies, offshore operators, funding bodies) are informed of GAMBLE recommendations.
- Establishing a GAMBLE web site which will contain all reports and documentation, and which will be open to view for the wider community. The web site will feature an open feedback option, so that all interested parties can keep up to date with progress and contribute to the ongoing GAMBLE network discussions.
- Establishing an information network through which future satellite plans can be disseminated and discussed.

To this end links have been established with other projects as described in Section 1.5, and presentations have been made by **SOS** to relevant bodies as described in Section 2. The GAMBLE web site (http://www.altimetrie.net) is maintained and operated by **DUT.** This web site contains links to a wealth of up to date information, and project specific documentation.

3.8.3 Socio-economic relevance and policy implication

The socio-economic and policy issues addressed by GAMBLE have been discussed in sections 3.2-3.5 above. This work package does not of itself have relevance to issues beyond those already identified.

3.8.4 Plans and Objectives for the next period

The GAMBLE team must as a whole continue to encourage contributions from the wider community who have interests in information developed from applications of altimeter data. In the second year of GAMBLE attention must turn on how to support and maintain the outreach activities beyond the end of EC funding in November 2003.

APPENDIX

Links to Project Deliverables and other documentation on the GAMBLE web-site:
(http://www.altimetrie.net/documents.shtml)

Deliverables and Reports

GAMBLE Description of Work (http://www.altimetrie.net/docs/GAMBLE_dow.pdf)

GAMBLE Project Definition V 2.0 (January 2003) (D1)
(http://www.altimetrie.net/docs/GAMBLE_projdef.pdf)

Interim Report on Sea Surface Height Error Budgets and Feature Detectability (D2)
(http://www.altimetrie.net/docs /GAMBLE_interimreport_theme1_021121.pdf)

Summary Report on Sea Surface Height Error Budgets and Feature Detectability
(http://www.altimetrie.net/docs/GAMBLE_mtr_WP2_summary.pdf)

Interim Report on Sea State Error Budgets and Feature Detectability (D4)
(http://www.altimetrie.net/docs/GAMBLE_ interimreport_theme2_020711.pdf)

Summary Report on Sea State Error Budgets and Feature Detectability
(http://www.altimetrie.net/docs/GAMBLE_mtr_WP3_summary.pdf)

Interim Report on Orbit Determination and Satellite Tracking (D6a)
(http://www.altimetrie.net/docs/GAMBLE_interimreport_theme3.pdf)

Summary Report on Orbit Determination and Satellite Tracking
(http://www.altimetrie.net/docs/GAMBLE_mtr_WP4_summary.pdf)

Meeting/Workshop Minutes

Kick-Off Meeting (http://www.altimetrie.net/docs/GAMBLE_kickoff_minutes.pdf)

Sea State Workshop (http://www.altimetrie.net/docs/GAMBLE_venice_minutes.pdf)

Joint Sea Surface Height / Orbit and Tracking Workshop
(http://www.altimetrie.net/docs/GAMBLE_delft_minutes.pdf)