



# GAMBLE

## Global Altimeter Measurements By Leading Europeans

A 21 month Thematic Network in Framework V

**PARTICIPANTS** - *Research and operational user communities.*

**COORDINATORS** - *SOS, CNES*

<http://www.altimetrie.net>





# Introduction

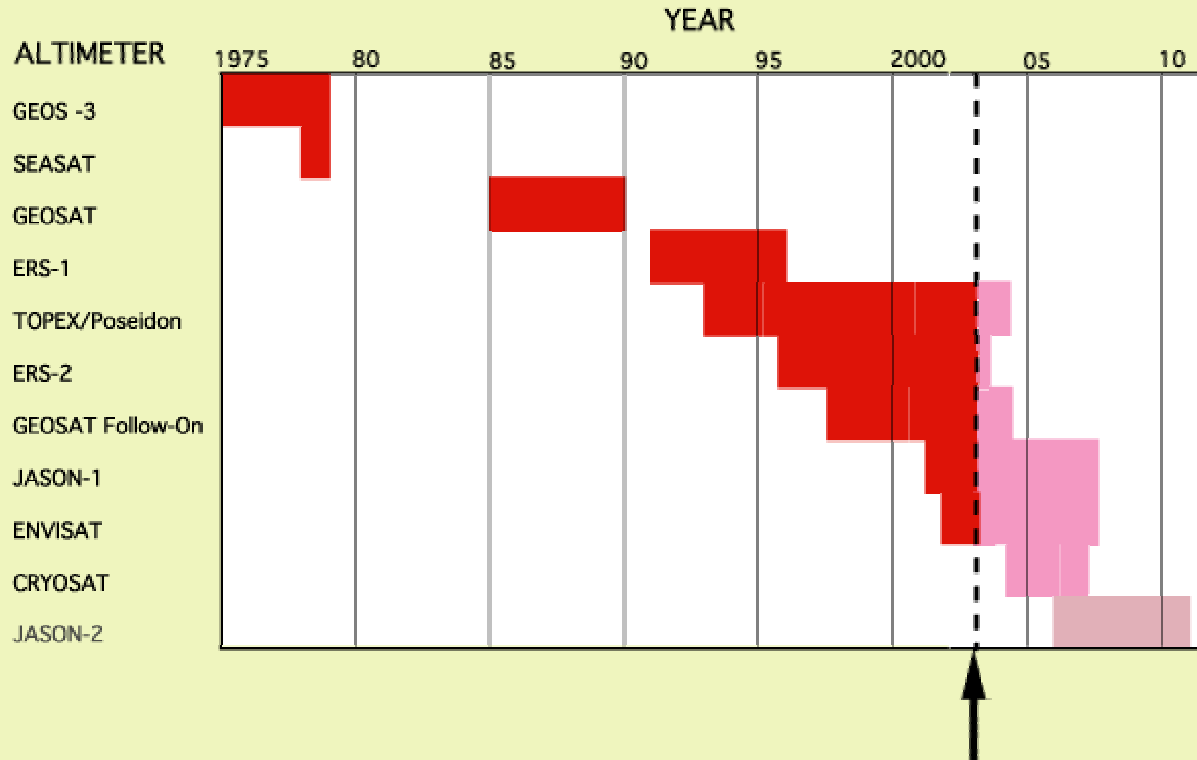
- GAMBLE - is an EC FP5 funded “Thematic Network” to look at future developments in satellite altimetry.
- Identify users' priorities for future improvements in information derived from satellite altimeters.
- What new developments in altimeter systems will best suit these requirements?
  - Recommendations for future research.
  - Recommendations for future missions.



# Altimeter Missions

## Past, Present and Future Satellite Altimeter Missions

Satellite altimetry, as a technology and a science, is now over 25 years old. The first satellite altimeter mission, GEOS3, became operational in 1975, and planned missions continue up to 2011. GAMBLE will help to co-ordinate the planning and exploitation of future altimeter missions.





# Who is involved in GAMBLE?

25 members are part of the original proposal  
(8 UK, 9 FR, 2 IT, 3 NL, 1 DE, 1NO, 1 Int.).

## CURRENT GAMBLE PARTNERSHIP

	UK	France	EU, Italy, Germany, Netherlands, Norway
Research organisations	<ul style="list-style-type: none"> <li>- Southampton Oceanography Centre</li> <li>- University of Newcastle</li> <li>- Proudman Oceanographic Laboratory</li> <li>- Environmental Systems and Science Centre</li> </ul>	<ul style="list-style-type: none"> <li>- Centre Nationale d'Etudes Spatiales</li> <li>- Collecte Localisation Satellites</li> <li>- Centre Nationale de la Recherche Scientifique</li> <li>- Service Hydrographique et Oceanographique de la Marine</li> <li>- Universite Joseph Fourier</li> <li>- Institut national Polytechnic de Grenoble</li> <li>- Universite Versailles</li> </ul>	<ul style="list-style-type: none"> <li>- Istituto per lo Studio delli Dinamica della Grandi Masse</li> <li>- ENEA*, San Terenzo</li> <li>- Max Planck Institute of Technology</li> <li>- Delft University of Technology</li> <li>- Nansen Environmental and Remote Sensing Ctr.</li> </ul>
Commercial companies	<ul style="list-style-type: none"> <li>- Satellite Observing Systems</li> <li>- Surrey Satellite Technology Ltd.</li> <li>- Oceanroutes *</li> <li>- BP *</li> </ul>	<ul style="list-style-type: none"> <li>- Alcatel Space Industries</li> <li>- Meteo France*</li> </ul>	<ul style="list-style-type: none"> <li>- Shell*</li> <li>- Dockwise*</li> </ul>

*\* Member of Steering Committee*

“GAMBLE” is an open forum - we welcome contributions from all with an interest.  
We have now had contributions from ~40 different organisations.



# The GAMBLE Approach

## GAMBLE THEMES

- 1 - **Sea Surface Height** - *Error Budgets / Feature Detectability.*  
**CLS (Collecte Localisation Satellites, France)**
- 2 - **Sea State** - *Error Budgets / Feature Detectability.*  
**ISDGM, Italy**
- 3 - **Orbit Determination and Satellite Tracking.**  
**Delft University of Technology, Netherlands**
- 4 - **Marine Operations** - *Operator's workshop*  
**SOS, UK**
- 5 - **Research Recommendations**- *Use of combined data sets*  
**SOC, UK**
- 6 - **Constellation Optimisation** - *Payload, orbits, .....*  
**CNES, France**



## GAMBLE DELIVERABLES

1. The definition of a research programme  
- to make best use of data from present & future missions
2. Recommendations for the optimisation of future missions (orbits, tracking, payload).



# GAMBLE Workshops

- March 2002      **Kick-Off**
- Sept 2002      **Sea State Requirements Workshop**
- Nov 2002      **Sea Surface Height Requirements Workshop**
- Nov 2002      **Orbits and Tracking Workshop**
- May 2003      **Marine Operator's Workshop**  
(To provide recommendations from an operational prospective)
- Oct 2003      **Constellation Optimisation Workshop**  
(To provide recommendations for orbits and satellite payloads)
- Nov 2003      **Final Workshop**



# SSH Issues

## ***Sea Surface Topography for Ocean Circulation Studies***

2 (preferably 3) altimeters required for climate monitoring.

Higher sampling required to monitor mesoscale ( $< 100\text{km}$ ,  $< 10$  days).

Improved geoid (GRACE/GOCE) will allow determination of absolute circulation patterns.

## ***Sea Surface Height for Assimilation in Operational Modelling***

Currents biggest source of uncertainty for offshore operators.

Increased resolution of altimeter data would improve model accuracy

Improved accuracy for Near Real Time Orbits (DORIS tracking).

## ***Tides***

Higher spatial resolution needed for internal tides, coastal tides, tides near topography.

Coverage at higher latitudes ( $> 66^\circ$ ).

## ***Coastal Issues***

MUCH higher resolution ( $< 10\text{km}$ , 1 hr) required – cannot be achieved by altimeters alone.

Smaller footprint, agile trackers to improve along track resolution near coast.



# Sea State Requirements

- (Much) improved sampling in space and time required  
e.g. ~200km, 6 or 12 hourly.
- Near real time availability of data ( < 3 hours, ideally < 1 hour).
- Improved warning of storm surge events effecting vulnerable populations.
- Rogue waves - when and where can they occur?
- CO<sub>2</sub> climatologies, important for climate studies.
- Improved performance at coasts.
- Validation at high wave heights/wind speeds.
- Wave direction and wave period.



# Sea Surface Height and Sea State Requirements

- Main priority for both themes is improved sampling
  - For sea surface height to capture the meso-scale (~20km)
  - For sea state to revisit ocean regions more frequently to capture fast moving storms
- Greater accuracy not such a priority - so long as existing accuracy retained for at least 1 long term mission
- There are some potentially exciting new applications - pp CO<sub>2</sub> is one of the biggest unknowns in climate monitoring. Altimeter data offer a possible way to provide global gridded estimates.



# Orbits and tracking workshop

- Reviewed available technology.
- Much recent improvement in GPS capabilities.
- Note improvements expected (GRACE, GOCE).
- Contribution of cross-over reduction to improve orbits -
  - are precise orbits required for every mission?
- Orbit selection
  - High orbits permit more accurate orbits - but require more power for the altimeter.

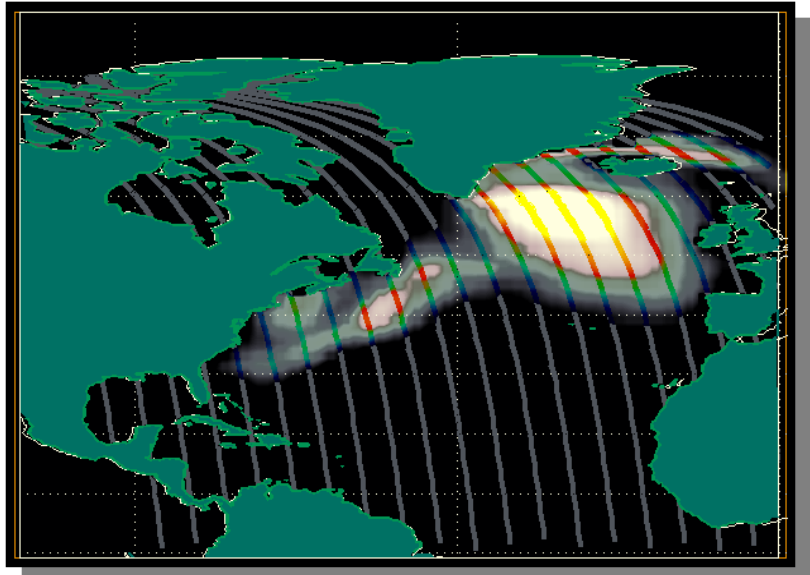
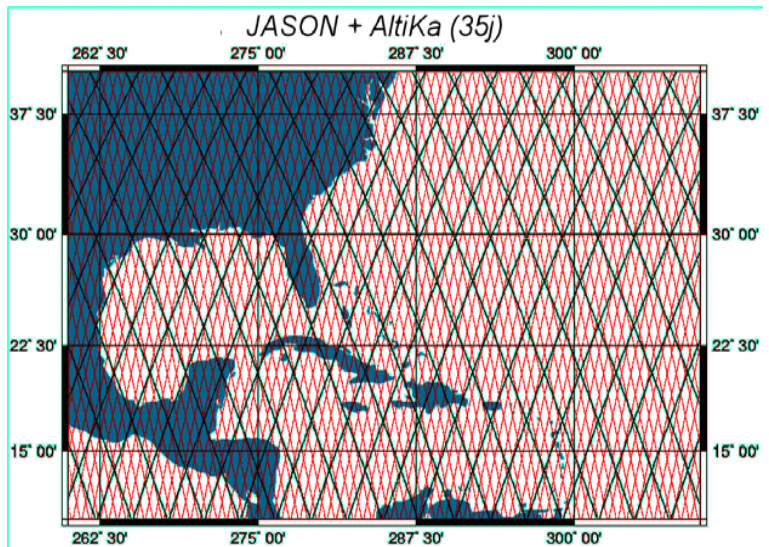
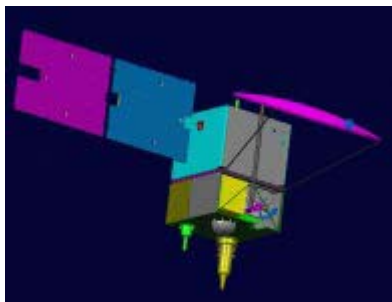


# How can we improve altimeters?

- Increase Sampling Frequency
  - Swath Measurements.
  - Constellations of micro-satellites.
  - Use GPS reflections
- Increase Along Track Resolution
  - Ka-band.
  - Use doppler spectrum.
- Across track slope
  - Parallel altimeter tracks (e.g. Bi-static altimeters - “WITTEX” )
  - Synthetic aperture altimeter
  - Swath altimeter
- More wave information (direction/period)
  - Real aperture radar, SAR
  - Rotating asymmetric altimeter beam
- Air-Sea Fluxes (wind stress, rain, gas transfer velocities)
  - Dual Frequency measurements



# Microsatellite Constellation?

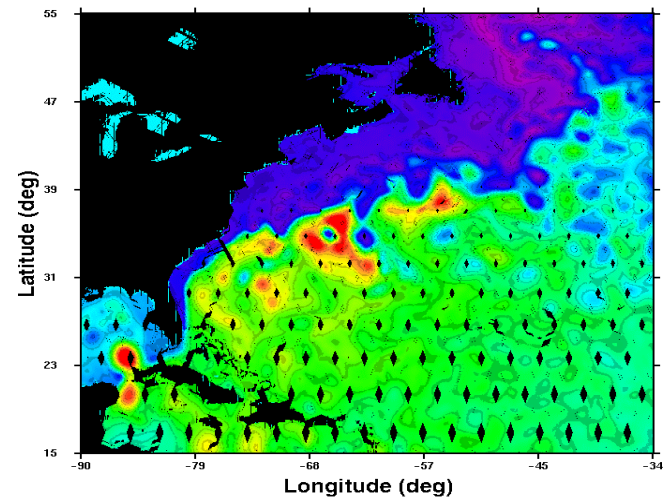
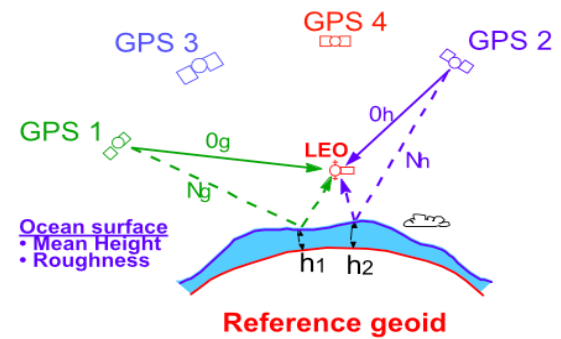
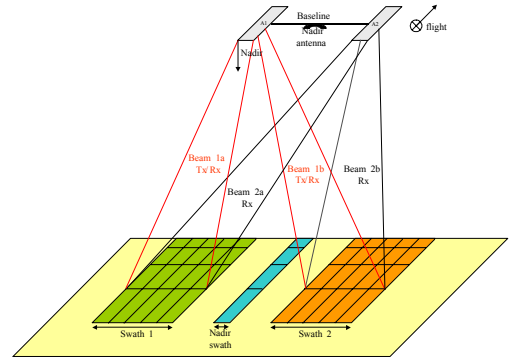


AlitKa - monitoring mesoscale variability  
 Jason + 3 Alitka on ENVISAT type orbit (35d),  
 ~10 d coverage

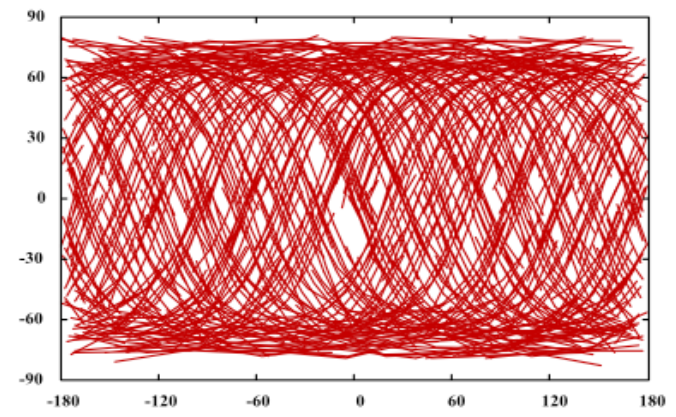
GANDER - Real time global monitoring of  
 sea state. 6 hours sampling from 10  
 GANDER microsats



# Wide Swath / GPS reflections



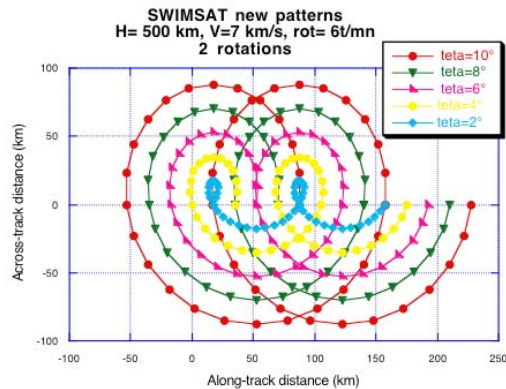
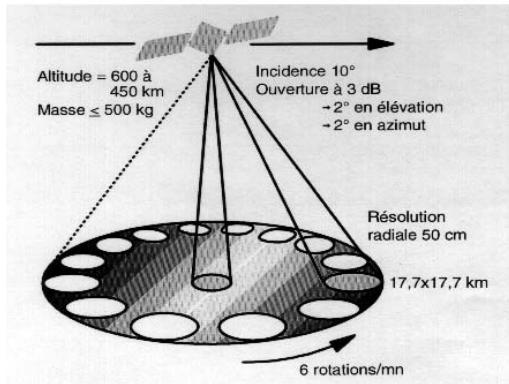
Wide-Swath altimeter, Topex Orbit, fixed yaw coverage, 10 day coverage



GPS reflection.  
1d coverage from single receiver at 400km BUT to get ~cm accuracy need to average over ~10 days (25 km<sup>2</sup> grid)

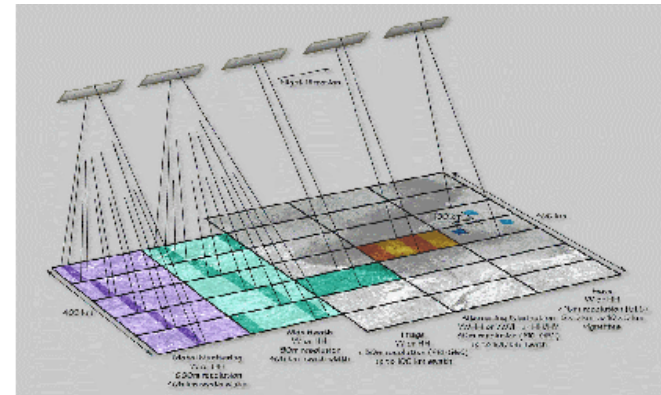


# Wave Measuring Radar



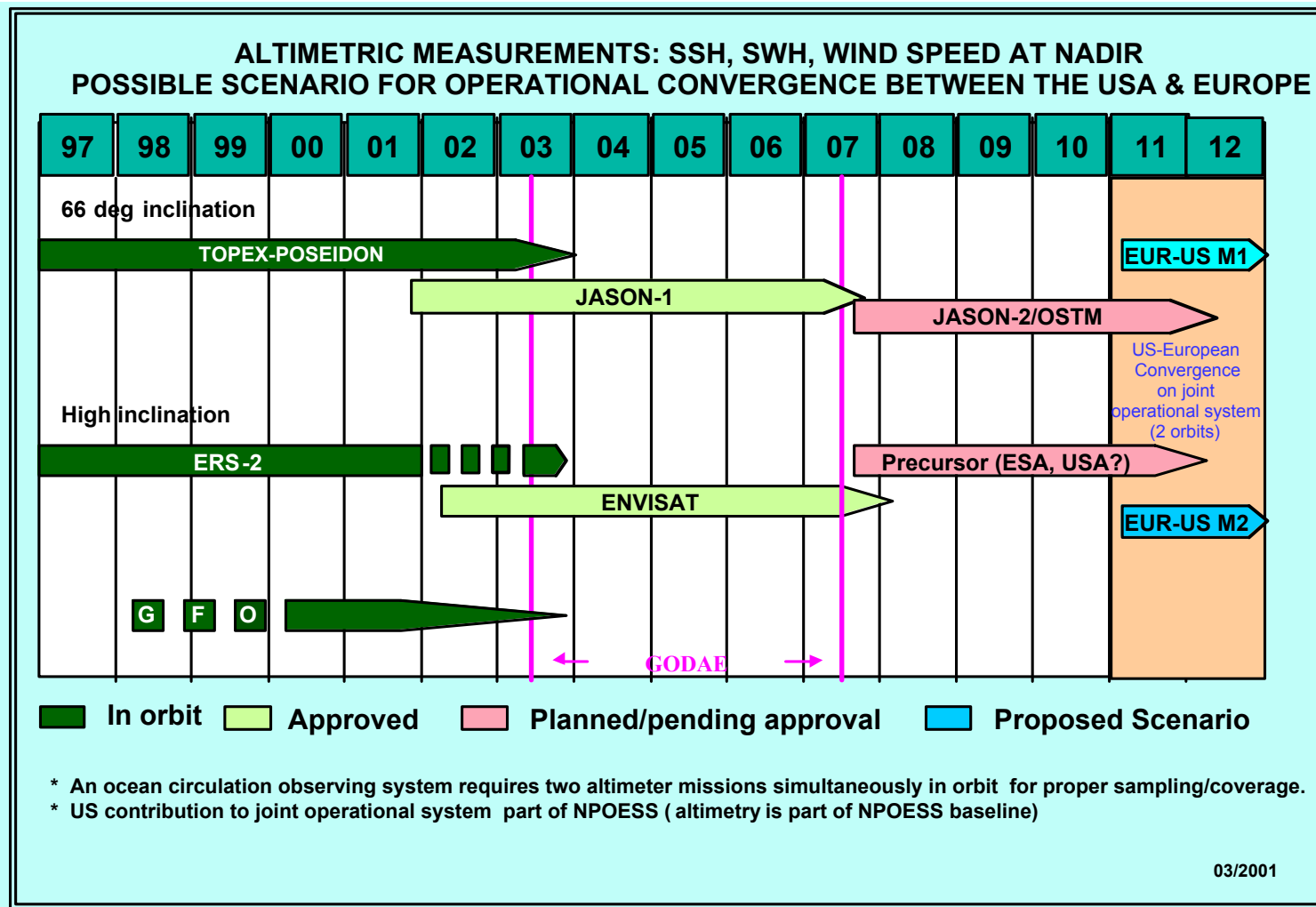
SWIMSAT - Real Aperture Wave Measuring Radar  
Full directional spectrum, 50 x 50 km cells  
Global coverage in 8 day cycle

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.



Advance Synthetic Aperture Radar - wave mode. 5 x 5 km vignettes, 100 km spacing  
Wave spectra - lower wavelength cut-off

# Altimeter Missions





# Research Programmes

What programmes are recommended to:

Make best use of present data sets (TP, JASON, GFO, ENVISAT) to meet user needs?

To provide information necessary to provide solid basis for decisions on future missions?



# Recommendations for future missions

Recommend an optimized convergent strategy for SSH and sea-state objectives, based on careful assessment of user requirements

The short-term future (2004-2007)

The mid-term future (2007-2011)

Recommendation for a mission to complement JASON-2/OSTM.

The long term situation (2011 and beyond)

2 altimeter missions are presently planned for this period.

Are there high priorities for supplementary missions?



# What are the Future Priorities?

- **Maintain Continuity**
  - GOOS, Sea Level,.....
- **Improve Global Sampling**
  - Monitor mesoscale features.
  - Genuine real time global monitoring.
- **Improved Accuracy**
  - Higher sensitivity to important signals.
- **Higher Resolution**
  - Better coverage of coastal phenomena.
- **Improved Near Real Time Data Provision**
  - Operational Applications - Improved Geiod -> better NRT orbits.



# Today's Presentations

- Session 1 - The GAMBLE project and the outlook for altimetry
- Session 2 - Requirements for altimeter data in ocean dynamics
- Session 3 - Requirements for altimeter data in sea state, by offshore industry, and for inland hydrology applications
- Session 4 - Future altimeter systems - Recommendations and Summary



# What Now?

- How to advance the recommendations?
- Research requirements
  - EU framework programmes.
  - GMES?
  - Other collaborations.
- Mission Requirements
  - ESA, EU (note ESA/EU space policy), EUMETSAT?
  - National opportunities.
  - Intercontinental co-operation (with US, and others)
- And Gamble?
  - Continue web site / email list as forum for news and discussions?



European Commission

□ WHITE PAPER

## **Space:** a new European frontier for an expanding Union



An action plan for implementing  
the European Space policy

