GAMBLE at Arles

17th November 2003

http://www.altimetrie.net

GENERAL CONCLUSIONS

Coverage

- **The PRECISION of the altimeters flying today is adequate for the measurement of:-**
  - i. **Sea Surface Height anomalies (SSH)**
  - ii. **Sea State (wave height and wind speed)**

- **It is the COVERAGE afforded by single missions such as ENVISAT and JASON that is inadequate for tracking:-**
  - i. **Energy-carrying mesoscale eddies**
  - ii. **Storm centres**

Delivery

The 2 communities of users have different requirements

- **SSH measurements are predominantly for ocean climate studies. No real need for fast delivery.**

However

- **Marine operations also benefit from statistical analysis of multi-year archives that predict monthly average and extreme conditions.**

For sea-state the situation is the opposite, i.e.

- **Observations must be delivered quickly to units at sea and to forecasting centres.**

However

- **Archives of a changing wave climate reveal inter-annual trends that reflect global change mechanisms of considerable interest to climatologists.**

INNOVATION *v* WELL-ESTABLISHED TECHNOLOGY

In Europe there is no operational oceanographic agency.

It is the remit of space agencies to pursue innovative technology NOT to conduct operational missions.

Future sensors or methodologies that reach beyond the simple radar altimeter presently include:

- **Wide Swath Ocean Altimeter (WSOA/OSTM)**
- **SWIMSAT**
- **WITTEX (Doppler)**
- **GPS reflectometry**

There is, however, a strong argument, supported by both the ocean climate and the marine operational communities, for increased sampling using existing technology.

For a comparatively modest injection of cash the benefits to each user community would be substantial.

Let us condense our main findings for the short-term, medium-term and long-term into minimum requirements and what would be needed to bring about a real improvement in response to the GMES objectives.

SHORT-TERM (2004 - 2007)

	SSH	Sea-State	Increased Cost Estimate
Minimum	▪ Retain Topex/Poseidon, JASON, ENVISAT ▪ Retain POD facilities including laser tracking ▪ Retain 'fast-delivery (FD)' mode (MERCATOR, FOAM, Operational Oceanography)	▪ Retain Topex/Poseidon, JASON, ENVISAT ▪ Retain FD facility ▪ Make ENVISAT FD data freely available to all	NIL
Comment	o Retains the status quo with precise tracking support	o Insufficient coverage for improved forecasts	

SHORT-TERM (2004 - 2007) *cont.*

	SSH	Sea-State	Increased Cost Estimate
Improved	▪ All of the above plus funding approval for 1 - 2 microsats carrying altimeters, equipped with laser retroreflectors and with a FD mode	*Ditto*	1 microsat + altimeter €10m
Comment	o Could initiate plans to deliver improved products for more 'operational oceanography' o Investigate the effectiveness of using precise altimeters to calibrate free flyers.	o Would lead to an increase in the daily number of observations of sea-state to quantify: i) Improvement to forecast models ii) Feasibility of direct transmissions to units at sea	2 microsats + altimeter €16m

MEDIUM-TERM (2007 - 2011)

	SSH	Sea-State	Increased Cost Estimate
Minimum	▪ JASON-2 launched supported by a continuing of JASON-1 (?) ▪ JASON-2 carries WSOA/OSTM ▪ No Envisat replacement	*Ditto*	Funding for JASON-2 and for WSOA/OSTM are already committed
Comment	o This scenario presents the possible danger of relying on only one altimeter mission already known to be inadequate for both SSH and Sea-State monitoring.	o WSOA/OSTM, even if successful for SSH measurements will NOT measure surface wind or wave height	

MEDIUM-TERM (2007 - 2011) *cont.*

	SSH	Sea-State	Increased Cost Estimate
Improved	▪ All of the above plus 1 - 2 GANDER micros.	▪ SWIMSAT mission approved and development of prototype started.	?
Comment	o A total of 3 or possibly 4 platforms, one with WSOA/OSTM, would allow an 'operational oceanography' service to develop based on improved models. o Planning could proceed towards a mini-constellation of 2 premier + 4 micros.	o If it is seen that 2 GANDER-type microsats + JASON-1/2 provides a marked improvement to sea-state monitoring, a good case may be made to commission a further 2 micros. There may then be enough market potential to attract private investment.	

LONG-TERM (> 2011)

	SSH	Sea-State	Increased Cost Estimate
Minimum	▪ JASON-2 + WSOA/OSTM ▪ JASON-1 (?) ▪ 2 free-flying GANDERs	*Ditto*	
Comment	o This combination will ensure good spatial resolution for SSH but if JASON-1 is terminated the 2 GANDERs depend on JASON-2 for SSH. Good spatial resolution if WSOA/OSTM performs to spec.	o A constellation of 5-6 spacecraft each with a 'fast-delivery' capability will:- a) Produce more accurate forecasts; b) Deliver an instant graphic presentation of prevailing sea-state to units at sea; c) But will still fall short of an operational system.	

LONG-TERM (> 2011) *cont.*

	SSH	Sea-State	Increased Cost Estimate
Improved	▪ The above configuration plus 2 other GANDER-type micros.	▪ SWIMSAT mission approved and development of prototype started	?
Comment	o The thrust behind flying 4 micros is the need for improved NRT coverage for Sea-State. But 'operational oceanography' would also be strengthened by such a configuration.	o Inclusion of Swimsat to provide additional information on sea surface wave spectra. Such an array of 6 conventional sea-state monitoring platforms plus 2 microsats could act to attract private investment.	

SUMMARY

- The performance of satellite-borne radar altimeters has probably contributed more to our understanding of global ocean processes than any other single satellite sensor.
- The last thing that any environmental change programme such as GMES should think of is cutting back on altimeter programmes. They need to be sustained and enhanced.
- Sampling by a solitary satellite has been shown to be inadequate to match the rate of change of both surface currents AND sea-state. By one means or another the sampling must be increased.

SUMMARY *(cont.)*

The solution to this problem can be approached in one of several ways:-

- **Adapt well-proven technology to sample more frequently by means of simple and comparatively inexpensive arrays of small altimeter-carrying satellites (the GANDER approach).**
- **Develop new sensors that generate a wider swath (WSOA/OSTM, Swimsat etc.).**
- **Make more effective use of combining the observations from present and planned altimeter missions (Topex/Poseidon, JASON, GFO, Envisat) and in 2 years time, Cryosat.**

SUMMARY *(cont.)*

We have consulted widely within GAMBLE. Over 60 organisations drawn from the marine industries (shipping and offshore), satellite tracking centres, value-added industry, wave climate research, ocean modellers, meteorological forecasting centres, manufacturers of satellites and sensors, and representatives of space agencies have attended our 6 Workshops.

Together we have discussed the requirements and the capabilities of these separate communities - and attempted to accommodate them in our recommendations.

SUMMARY *(cont.)*

In the final analysis we have had to recognise the interplay between several competing factors:-

- **The desire to be innovative within realistic funding envelopes**
- **The separate user communities of the different products derived from the same altimeter signal**
- **The search for new knowledge of ocean processes that must also address the daily needs of marine operations**
- **The resolve that public spending on environmental monitoring should lead eventually to a partnership with the private sector**

In GAMBLE we have attempted to construct a roadmap that would lead as many as possible to within sight of their final destination.

We hope it will not be lost.