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BLUElink 2
Overview and milestone summary

Peter Craig *on behalf of the BLUElink team*

CAWCR Technical Report No. 074

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Enquiries should be addressed to:

Peter Craig
Centre for Australian Weather and Climate Research:
A partnership between the Bureau of Meteorology and CSIRO
GPO Box 1538, Hobart, Tas, 7001, Australia

peter.craig@csiro.au

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1. BLUELINK 2 OVERVIEW

1.1 Summary

BLUElink2 followed from the original BLUElink project. BLUElink2, which was completed in June 2010, delivered the following products of specific interest to the Royal Australian Navy:

1. A consolidated operational ocean-forecasting system (OceanMAPS) run by the Bureau of Meteorology;
2. A refined, automated ocean, atmosphere and wave forecasting system (ROAM), installed on a Navy computer enabling, in particular, better forecasts of radar and sonar performance;
3. An entirely new littoral-ocean forecasting system (LOMS), suitable for field use, providing prediction of wave and current conditions close to shore, to assist amphibious and diving operations.

1.2 Background

The BLUElink project is a partnership project between the Royal Australian Navy (RAN), CSIRO and the Bureau of Meteorology (BoM). The project was established in 2003 with two principal aims:

1. To create an operational oceanography capability at the BoM; and
2. To provide the Navy with modelling tools to improve their prediction of the performance of ocean sonar and atmospheric radar.

The original BLUElink project ran from July 2003 to June 2006. Its primary deliverables were software systems called OceanMAPS and ROAM, with the following functionality.

1.3 OceanMAPS

OceanMAPS is the operational system installed at BoM. It provides forecasts out to 7 days of ocean conditions (currents, temperature, salinity and sea-level) on a fixed grid with 10 km horizontal resolution in the Indo-Pacific region. The output is available in graphical form on a public website, or in digital form via OpenDAP. OceanMAPS is based on a global model called OFAM (Ocean Forecasting Australia Model), developed in BLUElink as an implementation of the Modular Ocean Model (MOM), an open-source code maintained by the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton University. OceanMAPS incorporates a data-assimilation scheme called BODAS (BLUElink Ocean Data Assimilation Scheme), that was implemented to assimilate satellite and in-situ ocean data. OceanMAPS is forced by surface winds, and heat and water fluxes from the Bureau's numerical weather prediction system. The operational status of OceanMAPS ensures that ocean forecasting is a continuous Bureau service.

BLUElink also produced a re-analysis called BRAN (BLUElink ReANalysis), that is an archive of OFAM output from 1992 (when satellite altimetry became available) until the present. BRAN was made available to the broader research community, both for validation and application.

1.4 ROAM

ROAM is the Relocatable Ocean-Atmosphere Model that was developed specifically for the Navy, to enable them to produce high-resolution (down to 2 km) forecasts of ocean and atmospheric conditions. These forecasts are provided to the Navy's TESS (Tactical Environmental Support System), that predicts acoustic propagation in both the atmosphere and ocean, for the assessment of radar and sonar performance. Prior to the development of ROAM, this prediction was based on climatology or, for the ocean, on single expendable-bathythermograph casts.

ROAM is based on the Colorado State University's atmospheric model code RAMS, and CSIRO's in-house ocean model code SHOC. ROAM is installed on a dedicated Navy computer cluster (called Salacia) located in CSIRO's High Performance Computing Centre at the BoM. ROAM takes direct feed of the forecast data from the Bureau's numerical weather prediction system, and from OceanMAPS. It is operated by Naval METOC officers from bases around Australia. The officers establish the model grid using a graphic interface, and then set the model running. ROAM performs the ocean and atmosphere model set up, and derives its initialisation and forcing from the large-scale Bureau models. The ROAM output data are supplied automatically to METOC officers.

OceanMAPS and ROAM were delivered as working, but not well-tested, systems at the end of the first BLUElink project.

1.5 BLUElink2

BLUElink2 was a follow-on project, spanning July 2007 to June 2010. From the Navy's perspective, the project was specifically aimed at testing and improvement of the OceanMAPS and ROAM systems. It also included a new development, the Littoral Ocean Modelling System (LOMS) aimed at predicting waves and currents on beaches to assist with amphibious operations.

1.6 OceanMAPS

The improvements in OceanMAPS during BLUElink2 were largely transparent to the Navy, but resulted in significantly enhanced performance. Specific upgrades were:

1 Higher vertical resolution (5 m rather than 10 m) near the ocean surface;
2 Introduction of river inputs around the Australian coastline;
3 Improvements in data-assimilation (BODAS), including the assimilation of sea-surface temperature from the AMSR-E satellite;
4 Forcing from the Bureau’s new numerical weather-prediction system ACCESS.

OceanMAPS forecasts were compared extensively against data during BLUElink2, including the following scenarios:

1. Warm and cold core eddies in the East Australian Current;
2. The Montara oil spill.

1.7 ROAM

Navy officers began using ROAM for Naval operations during BLUElink2. As a result they were able to provide direct feedback on its functionality. It was anticipated from the outset that improvements to ROAM would be based both on planned changes, and on feedback from the Navy.

The planned changes made to ROAM during BLUElink2 were:

1. Incorporation of the surface wave model SWAN, automatically nested in the Bureau's global AusWAVE model;
2. Incorporation of assimilation of sea-surface temperature to improve initial and boundary conditions;
3. Introduction of surface heat fluxes into the ocean model;
4. Improvement of the ocean vertical mixing;
5. Capacity for river inflows;
6. Upgraded user manual.

Changes made at the request of Navy users were often at the level of fine details of the user interface, but included:

1. Improved error and run-tracking messages;
2. Alternative output formats;
3. Higher vertical resolution in the atmospheric model (RAMS);
4. More versatility in specification for each of the 3 (meteorological, wave and ocean) models.

The ROAM architecture was significantly restructured during BLUElink2, to improve the efficiency and manageability of the system.

1.8 LOMS

LOMS is a laptop-based system for predicting nearshore waves and currents focussing on the surf zone. The LOMS concept is similar to that for ROAM, with Navy METOCs specifying the model grid (location and resolution) through a graphical interface. For LOMS, they also type in local wind and wave conditions taken, for example, from 6-hourly forecasts from the Bureau. LOMS then sets up and runs the models and provides 2-dimensional predictions of wave and current fields at very high resolution (order 10 m) for the duration of the forecasts (order 1 week).

Several model configurations were tested during the LOMS development. The model in the final version of LOMS is called XBeach, a littoral-zone model developed by Deltares (Delft

University), capable of prediction of nearshore waves, currents and morphology. Waves on beaches are typically observed to arrive in groups (or sets) and the XBeach model was chosen because, unlike other wave models, it includes wave groupiness. This groupiness plays an important role in forcing low frequency flows in the surf zone which in turn shape the nearshore morphology. The morphology module was not implemented in BLUElink2. XBeach is still under active development by Deltares, and upgrades were incorporated in LOMS as they became available.

High-resolution bathymetry is critical for accurate prediction of nearshore dynamics. LOMS includes a default low-resolution bathymetry (Geoscience Australia 250m resolution data) that enables the model to run. However, it includes the capacity for in-the-field insertion of bathymetry derived from sources such as dive surveys or LADS (laser airborne depth sounder) surveys. Currently the lack of high resolution bathymetry is a serious limitation on the accuracy of LOMS predictions.

The development of LOMS was supported by a nearshore field program conducted at Hillarys and Secret Harbour in Western Australia. The field program was based on a shore-based x-band radar, for measuring the surface wave field, and in-water acoustic meters for currents and surface height. The program provided data against which model predictions could be assessed. A focus was the growth and decay of the wave field during the strong summer sea-breeze cycle on the WA coast, and the low frequency (period T>30s) response to wave groupiness.

A working version of LOMS, complemented by a user manual, was presented to the Navy at the end of BLUElink2. As with ROAM, it was anticipated that LOMS would be refined in response to user requirements as the Navy developed familiarity with the system. The nearshore circulation is very sensitive to spatial and temporal changes in bathymetry and, as with large-scale ocean simulation, we expect that accurate prediction in the littoral zone will only be possible if data-assimilation is implemented. Data capture, in particular high resolution bathymetrty, and subsequent assimilation techniques are in only early stages of development for the littoral zone.

1.9 Other BLUElink2 developments

In addition to the development of OceanMAPS (including BODAS), ROAM and LOMS, other research and development in BLUElink2 was not delivered directly to the Navy, but either enhanced background products, or was aimed at longer-term operational improvements. The milestones and outcomes are summarised in the following table, and include:

1. *OFAM development*: background research on the global model to support OceanMAPS, including experimentation with vertical resolution, turbulence algorithms and tidal forcing;
2. *NWP (numerical weather prediction) fluxes*: comparison of sea-surface flux estimates from NWP routines with measurements from the international meteorological buoy network;
3. *BRAN (BLUElink reanalysis*: reruns of BRAN with upgraded versions of OFAM, together with analysis against data, as a test of OFAM (and OceanMAPS) accuracy;
4. *Air-sea interaction*: testing against buoy data of sea-surface flux formulations incorporating sea-state; testing of near-surface flux formulations in 1-D and 3-D models against data collected under tropical cyclones;

5. *Regional ocean data assimilation*: extension of the applicability of the BLUElink data-assimilation scheme (BODAS) from the global model to limited-area and relocatable models; development of BODAS as a design tool for observational systems;
6. *SST data products and analysis*: delivery of operational "skin" SST in native (satellite) data format ("L2"), and trial of operational delivery of L2 sub-skin ("foundation") SST and gridded ("L4") SST.
7. *Coastal wave forecasting*: replacement of the Bureau wave-forecasting with a new system ("AusWAVE") based on the model WaveWatch3, valid across the continental shelf.

2. BLUELINK 2 MILESTONE SUMMARY

P1 – Global Ocean Forecasting Milestone Summary **Peter Oke & Gary Brassington**				
Date	Milestone	Test	Milestone Achieved	Brief Comments
P1.1 – OFAM Developments – David Griffin				
Jun 2007	Climatological river discharge dataset based on GRDC established and implemented into OFAM.	Database available for all BLUElink partners.	Complete	A dataset based on seasonally varying climatological river discharge has been established.River discharge into OFAM has been implemented and tested in a series of 1-year runs. Results can be seen at www.marine.csiro.au/~mansbrid/omas/river_runoff/river_runoff_study.html. River discharge implemented in BRAN2.1.
	Progress towards implementation of the improved vertical coordinate and mixed layer schemes.	Results presented to S&TC.	Complete	Finalised in June 2008 milestone.
	Documentation complete.	Documentation available on BLUElink website and presented to S&TC.	Complete	BRAN: www.cmar.csiro.au/staff/oke/BRAN.htm. River discharge: www.marine.csiro.au/~mansbrid/omas/river_runoff/river_runoff_study.html. A manuscript describing BODAS and BRAN1.5 has been submitted to Ocean Modelling: Oke , P. R., G. B. Brassington, D. A. Griffin and A. Schiller (2007): The Bluelink Ocean Data Assimilation System (BODAS), submitted to *Ocean Modelling*.

Jun 2008	Improved version of OFAM developed and available for BRAN and OceanMAPS trial system.	Model components and executables made available to P1.4 and P1.5.**	Complete	Further improvements to continue toward the June 09 S&TC.
	Improved vertical coordinate.	Model components and executables made available to P1.4 and P1.5.++	Complete	The improved vertical co-ordinate system has been adopted.
	River discharge.		Complete	Seasonal river fluxes have been included in OFAM and were used for BRAN1.5 and BRAN2.1. Time vary river fluxes are being run already and data is being input into a real-time db.
	Explicit tidal forcing.		Complete	Done with MOM4p0d and will be done with MOM4p1.
	Modules for different mixed layer schemes embedded in MOM4 and tested. Agreement on upgrades to OFAM.	Results from a series of short test runs in MOM4 presented to the S&TC. Decision on upgrades made by S&TC.	Complete	A series of sensitivity experiments using three different mixing schemes (Chen, KPP and K-epsilon) has been completed. No scheme was significantly better than the others and as such it has been decided to stay with the Chen scheme as it is the most efficient computationally.
Jun 2009	Documentation complete.	Documentation available to P1.5 for operational trials.	Complete	Several papers documenting OFAM, BODAS and BRAN have been published: Oke, P. R., G. B. Brassington, D. A. Griffin and A. Schiller, 2008: The Bluelink Ocean Data Assimilation System (BODAS), *Ocean Modelling,* 21, 46-70, doi:10.1016/j.ocemod. 2007.11.002.

				Schiller, A., P. R. Oke, G. B. Brassington, M. Entel, R. Fiedler, D. A. Griffin, and J. V. Mansbridge, 2008: Eddy-resolving ocean circulation in the Asian-Australian region inferred from an ocean reanalysis effort. *Progress in Oceanography,* 76, 334-365.
	Latest version of OFAM developed and available for OceanMAPS trial system.	Model components and executables made available to P1.5. **	Complete	OFAM2.0 has been built and several multi-year test runs performed. Structural improvements over OFAM1 are: 1. more accurate bathymetry in the coastal seas, 2. better vertical resolution (e.g. 5m instead of 10m in top 30m), 3. parameterized tidal mixing and bottom drag 4. climatological rivers 5. based on new MOM code 6. surface fluxes of heat and precipitation are pre-balanced to prevent long-term drift. 7. fine spatial resolution over a larger domain (0.1 degree global, except north of 50N) OFAM2 configuration was finalised on 4 August 2009 (after the first successful one-year run was complete) and made available to BoM. In Dec 2009, the model (ported to the NCI),

				resulting (13Tb) data set, and derived products (ensemble, monthly means, etc) were all finished and available (by OPENDAP).
Jun 2010	Support BMRC during operational trials.	Operational trials complete.	Complete	OFAM2 and MOM4p1 have been transferred to CAWCR-Bureau and implemented onto the new supercomputer (solar). OFAM2 spinup6p8 has been transferred to CAWCR-Bureau for further analysis. The first version of the OFAM3 grid has been generated, with 1/10 degree resolution between 75 N and S. The topography we are using is Geosciences Australia (2009) for the region around Australia, and GEBCO (2008) elsewhere.
P1.2 - BODAS Developments **– Peter Oke & Gary Brassington**				
Jun 2007	Improved version of BODAS that enables the assimilation of SST and incorporates improved error statistics is available.	BODAS components and executables made available to P1.4 and P1.5. BRAN successfully completed. Results presented at S&TC meetings.	Complete	1. A capability for the assimilation of SST has been implemented and in BODAS and tested in BRAN1.5. 2. Improved error statistics have been incorporated into BODAS and tested in BRAN1.5.
Jun 2008	Improved version of BODAS complete.	Results presented at S&TC meetings. BODAS components and executables are being used	Complete	Various improvements have been made over the last year.

		by P1.4 and P1.5.		
	Forecast / sensitivity experiments complete.	Results presented at S&TC meetings and manuscript in preparation.	Complete	A series of sensitivity experiments have been performed.
Jun 2009	Documentation complete.	Documentation available to P1.5 for operational trials.	Complete	BODAS has been documented (see P1.1 comments). Developments of BODAS continue, including: 1. more flexibility for super-obbing, 2. improvements to load balancing (for efficient use of computing resources), 3. assimilation of AVHRR SST, more assimilation diagnostics.
Jun 2010	Final forecast/ sensitivity experiments complete.	Results presented at S&TC meetings and manuscript in preparation.	Complete	The BoM and CSIRO version of BODAS has been consolidated and tested on the NCI machine. The latest version of the code has been transferred to BoM for operational trials, and is being used for BRAN3. Several improvements were incorporated into the latest version of BODAS including: 1. MPI version of inverter (Freeman); 2. MPI version of ensemble read and manipulation (Fiedler); 3. Assimilation of NAVO SST (Andreu-Burillo); and 4. Improvements to

				super-obing, data processing, and improved treatment of observation errors (Oke). The latest version has been uploaded to the CAWCR-Bureau SVN code repository and preliminary configuration and testing is in progress. An improved version of BODAS has been developed and tested extensively under Bluelink-3, the follow on to Bluelink-2.
P1.3 – NWP fluxes – Eric Schulz				
Jun 2007	Wind Stress curl verification completed and performed routinely.	Report available. (Notice of change in operational system issued.) This milestone has been change to the wording below: Running routinely and available externally.	Complete	Gridded 1x1deg daily mean winds are being sourced from COAPS. A prototype system to verify GASP and LAPS-375 is running routinely and generates plots to internal BMRC web. There will be further ongoing work to enhance this verification system.
Jun 2008	Documentation of surface flux accuracy and bias completed.	Report available.	Complete	Report will be presented at the July 08 S&TC.
Jun 2009	Surface flux verification performed routinely.	Notice of change in operational system issued.	Complete	This milestone was completed in late 2010, although I note that it ended up being a "routinely operated system", rather than operational.
Jun 2010	Final testing and documentation completed.	Documentation completed and presented to S&TC.	Complete	The milestone was met. The verification was tested, and documentation provided showing flux verification

				for NWP system upgrades (GASP to ACCESS-G).
P1.4 – BRAN – Peter Oke				
Jun 2007	BRAN experiment with improved BLUElink versions of OFAM and BODAS complete.	Results presented at S&TC meeting; and available to all BLUElink partners.	Complete	1. We have completed BRAN1.5 (1/2003-6/2006), evaluated it thoroughly, written and submitted a manuscript describing it to Ocean Modelling: Oke , P. R., G. B. Brassington, D. A. Griffin and A. Schiller (2007): The Bluelink Ocean Data Assimilation System (BODAS), submitted to Ocean Modelling. 2. We have completed BRAN2.1 (10/1992-12/2006). The performance of BRAN2.1 is similar to BRAN1.5. An evaluation of BRAN2.1 is ongoing. 3. A series of sensitivity experiments, designed to assess the “best” way to couple BODAS and OFAM has been conducted. Results identified significant improvements.
	Preliminary evaluation of BRAN complete.	Results presented at S&TC meeting; and available to all BLUElink partners; feedback provided to P1.1, P1.2 and P1.5.	Complete	1. A manuscript describing BODAS and BRAN1.5 has been submitted, see above. 2. A manuscript describing a case study of extreme events in the Tasman Sea, based

				on BRAN, is in preparations.
Jun 2008	Analysis of the latest BRAN experiment complete.	Documentation provided to all BLUElink partners; feedback provided to P1.1 and P1.2.	Complete	1. Analysis of the latest BRAN experiments is complete. 2. A manuscript describing and evaluating BODAS and BRAN1.5 is in press: Oke, P. R., G. B. Brassington, D. A. Griffin and A. Schiller, 2007: The BLUElink Ocean Data Assimilation System (BODAS), Ocean Modelling, doi:10.1016/j.ocemod.2007.11.002. 3. A manuscript describing the circulation around Australia in BRAN2.1 is in press: Schiller, A., P. R. Oke, G. B. Brassington, M. Entel, R. Fiedler, D. A. Griffin, and J. Mansbridge, 2006: Eddy-resolving ocean circulation in the Asian-Australian region inferred from an ocean reanalysis effort. Progress in Oceanography, in press.
Jun 2009	BRAN experiment with new OFAM and BODAS components complete.	Results presented at S&TC meeting; and available to all BLUElink partners.	Complete	Several short interim BRAN runs (using BODAS2 but OFAM1 rather than OFAM2) have been complete but BRAN3 is delayed because OFAM2 was delayed.

	Preliminary evaluation of BRAN complete.	Results presented at S&TC meeting; and available to all BLUElink partners; feedback provided to P1.1, P1.2 and P1.5.	Complete	Evaluations of BRAN1.5,,2.1, 2.2 and 2.3 are complete and drove the prioritisation of upgrades to OFAM1.. Evaluation of BRAN3 will commence once it is completed.
Jun 2010	Analysis of the BRAN experiment complete.	Documentation provided to all BLUElink partners.	Complete	The period for BRAN3 is 1/2005-12/2009. We are using the latest version of BODAS together with OFAM2. In addition to the changes included in the latest version of BODAS (see above), other changes include the adoption of the adaptive nudging initialisation scheme (Sandery and Brassington), changes to the assimilation cycle (updates every 4-days to match OceanMAPS), and longer data windows. Tests of the revised version of BODAS include the performance of BRAN3 - an 18-year reanalysis. Results from BRAN3 have been analysed and published in the peer-reviewed literature. The reference follows: Oke, P. R., P. Sakov, M. L. Cahill, J. R. Dunn, R. Fiedler, D. A. Griffin, J. V. Mansbridge, K. R. Ridgway, A. Schiller, 2012: Towards a dynamically balanced eddy-resolving ocean reanalysis: BRAN3, Ocean Modelling, 67, 52-70,10.1016/j.ocemod.2013.03.008.

P1.5 - OceanMAPS - Gary Brassington				
Jun 2007	Assessment of operational ocean forecasts Case study evaluation.	Results of performance of OceanMAPS presented at S&TC meetings; specific actions recommended.	Complete	1. A chart discussion group has been established to review the ocean forecast products routinely 2. Ocean events have been catalogued on an internal Bureau wiki page for case study evaluation. 3. Further analysis has been performed on, anomalous warm eddies off Eden, the EAC separation through a vortex merger and cold eddy of Sydney (Oke). 4. OceanMAPS performance metrics have been established. 5. GODAE intercomparisons activites ongoing: 6. GODAE metric implementation 7. NCODA-HYCOM case study comparison 8. GODAE OPeNDAP server AMSR-E has been fast-tracked into OceanMAPSv1.0b in response to anomalous warm eddies of Eden and BRAN1.5 results.

Jun 2008	Operational trials of enhanced OceanMAPS upgrade completed. Case study evaluation.	Results of operational trials presented at S&TC meetings. Complete	Complete	Case study evaluations have been documented within papers in several scientific journals and also are routinely discussed in the Bureau's monthly chart discussions.
Dec 2008	Enhanced OceanMAPS upgrade.	Notice issued.	Complete	Implementation of Jason-2, upgrade to BODAS, observing system processing, flux regridder code. Clear performance improvements obtained. Trials of the initialisation procedure and u,v initialisation were inconclusive and withheld. This is the focus of further research for the next system. BODAS has been implemented onto linux cluster servers and tested using the SUN compilers. The code has been optimised using MPI and several bug fixes. Flux regridder has been optimised and work on the UM flux products.
Jun 2009	Assessment of operational ocean forecasts.	Results of performance of OceanMAPS presented at S&TC meetings; specific actions recommended.	Complete	The BoM monthly Oceanographic Chart Discussions and AMOS Bulletin communications provide routine assessment of the operational system. GODAE intercomparisons providing a benchmark for comparing the operational system with the international systems. Performance of the system is documented in the following

				GODAE symposium articles: Hurlburt, H. E., G. B. Brassington, Y. Drillet, M. Kamachi, M. Benkiran, R. Bourdalle-Badie, E. P. Chassignet, G. A. Jacobs, O. Le Galloudec, J.-M. Lellouche, E. J. Metzger, P. R. Oke, T. F. Pugh, A. Schiller, O. M. Smedsted, B. Tranchant, H. Tsujino, N. Usui and A. J. Wallcraft, 2009: High resolution global and basin-scale ocean analyses and forecasts, Oceanography, 22(3), 110-127. Dombrowsky, E., L. Bertino, G. B. Brassington, E. P. Chassignet, F. Davidson, H. E. Hurlburt, M. Kamachi, T. Lee, M. J. Martin, S. Mei and M. Tonani, 2009: GODAE systems in operation, Oceanography, 22(3), 80-95. Hernandez, F., L. Bertino, G. B. Brassington, E. Chassignet, J. Cummings, F. Davidson, M. Drevillon, G. Garric, M. Kamachi, J.-M. Lellouche, R. Mahdon, M. J. Martin, A. Ratsimandresey and C. Regnier, 2009: Validation and intercomparison studies within GODAE, Oceanography, 22(3), 128-143. Davidson, F., A. Allen, G. B. Brassington, O. Breivik, P. Daniel, M. Kamachi, S. Sato, B. King, F. Lefevre, M. Sutton and H. Kaneko, 2009: Application of GODAE ocean current forecasts to search and rescue and ship routing, Oceanography, 22(3), 176-181. Two articles are in prep for the South East Indian Ocean and South West Pacific. One article was published: Oke, P. R., G. B. Brassington, J. Cummings, M. Martin and F. Hernandez, 2012: GODAE inter-comparisons in the Tasman and Coral Seas, J. Operational

				Oceanography, 5(2), 11-24. The results for the south east Indian Ocean were presented at an international conference: 9th International Conference on Southern Hemisphere Meteorology and Oceanography, Melbourne, February, 2009: Brassington, Oke, Mansbridge, Pugh and Freeman: BLUElink ocean forecast intercomparison. Detailed report available on performance of coastal sea level. (see reference below). Participating in the incomparison of Automatic QC processing being coordinated by Jim Cummings, later documented in an OceanObs'09 article and continues to be independently evaluated: Cummings, J. A., G. Brassington, R. Keeley, M. Martin, and T. Carval, 2010: GODAE ocean data quality control intercomparison project. Proceedings, Ocean Obs '09, Venice, Italy. 5 pp. in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 1),* Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D. E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.pp.08.
Jun 2010	Operational trials of OceanMAPS system upgrade completed.	Results of operational trials presented at S&TC meetings.	Complete	Porting of OceanMAPSv1.0c is complete and available for operational swap to new supercomputer. The NMOC operational compliance testing with Oracle/SUN failed in May and has therefore been restarted and scheduled for early June for completion. GHRSST L2P data formats were introduced for NOAA series AVHRR through Navoceano and

				AMSR-E microwave. These global datasets resulted in a reduction of RMSE relative to RAMSSA of 0.6 to 0.5. The introduction of this into operations was documented: Andreu-Burillo, I., G. B. Brassington, P. R. Oke and H. Beggs, 2009: Including a new data stream in BLUElink ocean data assimilation, Australian Meteorological and Oceanographic Journal, 59, 77-86. Configuration of BODAS2.0 was finalised based on a 144-member stationary ensemble and ported to the Bureau environment as a prelude to first BRT trials. A key element of the new configuration was the implementation of a daily forecast cycle. The BRT hindcast cycle was based on a uniform four-day analysis cycle instead of the 3 day/4day cycle of version 1. The daily forecast was then based on four cycles. OceanMAPSv2.0 completed a 12 month hindcast from which the performance was extensively documented: Brassington, G. B., J. Freeman, X. Huang, T. Pugh, P. R. Oke, P. A. Sandery, A. Taylor, I. Andreu-Burillo, A. Schiller, D. A. Griffin, R. Fiedler, J. Mansbridge, H. Beggs and C. M. Spillman, 2012: Ocean Model, Analysis and Prediction System (OceanMAPS): version 2, CAWCR Technical Report No. 052, pp110. (http://www.cawcr.gov.au/publications/technicalreports/CTR_052.pdf). The system was also described in a book chapter for the summer school: Brassington, G. B., 2011: System

				design for operational ocean forecasting, In: A. Schiller and G. B. Brassington, Operational Oceanography in the 21st Century, doi 10.1007/978-94-007-0332-2_18, *Springer Science+Business Media B. V.* 2011, pp441-486. A report comparing OceanMAPS coastal sea level with non-tidal sea level from the national tide gauge network has been revised in final form for publication as a CAWCR report. Taylor, A., G. B. Brassington and J. Nader, 2010: Assessment of BLUElink OceanMAPSv1.0b against coastal tide gauges, CAWCR Technical Report No. 030, pp86 (http://www.cawcr.gov.au/publications/technicalreports/CTR_030.pdf). Montara Oil Spill - BLUElink performance being reviewed in detail with APASA. The performance of BLUElink closely corresponded to the periods it was found to be performing best compared with NCOM and GSLA. The performance was reported in a conference presentation: AGU Ocean Sciences, Portland Oregon, 22-26 February 2010, Brassington and King: Ocean nowcasting and forecasting for the Montara oil spill. The impacts on observing systems requirements for ocean forecasting from oil spills were documented in an OceanObs'09 publication: Brassington, G. B., A. Hines, E. Dombrowsky, S. Ishizaki, F. Bub, M. Ignaszewski, 2010: "Short To Medium-Range Ocean Forecasts: Delivery And Observational Requirements" in *Proceedings of OceanObs'09:*

				Sustained Ocean Observations and Information for Society (Vol. 1), Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D. E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.pp.08. Preliminary results interpreting the four-cycle system as a time-lagged ensemble were presented at an international conference: IUGG, Melbourne, 28 June - 7th July, 2011, Brassington, Pugh, Sandery and Freeman: Time-lagged ensemble ocean forecasting.
	OceanMAPS system upgrade.	Notice issued.	Complete	

P2 – Coupled Relocatable and Limited Area Modelling **Peter Craig & Eric Schulz**				
P2.1 – Coupled Limited Area Model (CLAM) development – Paul Sandery				
	Extension of the BLUElink coupled ocean-atmosphere model with AusWAM completed.	Results in annual report.	Completed in Dec 2008	Preliminary evaluation of AusWAM code for coupling occurred. Further progress was on hold for completion of BLUElink P2.2.4 and diverting resources to fast-track implementation of AMSR-E in P1.6 (see above). Coupling of AusWAM was limited to TCLAPS and AusWAM for Gulf of Mexico experiments. TCLAP-AusWAM code prepared and available.
Jun 2007	MOM implemented on NW domain.	'Handover' of code to P2.2.	Complete	A modified version of MOM has been implemented on the NWS domain that was used for ROAM testing. This version has the full GOTM suite of vertical mixing options and improved open-boundary specification. The mom4p1 open boundary code has undergone extensive re-writing, improvement, bug-fixing and testing, by Mike Herzfeld and Martin Schmidt. Documentation has been produced for the mom4p1 User's Manual. The code is in a finalized state suitable for inclusion in a mom4p1 version release. Its availability to P2.2 is subject to official release of mom4p1 by GFDL. 1. A regional version of MOM4p0d has been implemented for the Australian tropical region and configured to initialise with BRAN2.1 or OceanMAPS restarts. Case studies have been performed for TC Ingrid and TC Larry to evaluate ocean response. 2. OASIS2.5 has been configured with TCLAPSv5

				with a toy ocean and MOM4p0d with a toy atmosphere. A MOM4p0d-OASIS2.5-TCLAPSv5 coupled system is being pursued.
Dec 2008	Development of a coupled ocean-wave-atmosphere model based on ACCESS model components completed.	Results in BMRC tech report. Handover of code to P2.2 and P2.6.	Not Completed	A coupled ocean-atmosphere model based on ACCESS-TC OASUS4 and MOM4P1 was developed and research trials were carried out with TC test cases. This was delayed due to technical problems but the milestone was met after December 2008. Evidence of the development of this system having being completed and used to advance coupled short range TC prediction can be found in Sandery, P.A. and O'Kane, T.J. (2013), Coupled initialization in an ocean-atmosphere tropical cyclone prediction system. Q.J.R. Meteorol. Soc.doi.10.1002/qj.2117 WWIII is currently under development and not available for implementation into CLAM. This aspect of system is now been considered for BL3.
Jun 2009	Implementation of new air-sea interaction algorithms completed.	'Handover' of code to P2.6.	Complete	Inertial coupling method implemented and experiments completed Tuning of this algorithm will continue in the operational trials of P2.6.

P2.2 - Air-Sea Interaction – Peter Craig & Eric Schulz				
Jun 2007	Identification of wind-wave-current datasets.	Data obtained and usage agreements arranged from external parties if required. (This data is not for commercial use).	Complete	Through Metocean Engineers, we have obtained data sets from Woodside, Inpex and BHP Billiton. Gulf of Mexico wind-wave datasets from NDBC buoys have been investigated.
	Assessment of wave-atmosphere parameterisation in limited-fetch conditions.	Algorithm available. Results described in progress reports.	Complete	Progress report was submitted to the S&TC and accepted as satisfying the milestones.
	Implementation of 1-d ocean mixing model.	Model results and SST interpretation in progress report.	Complete	The GOTM model has been implemented and shown to reproduce the Schiller and Godfrey diurnal mixed-layer results. The model is now being used to assess mixing under tropical cyclones.
Jun 2008	Evaluation of impact of ocean heat-flux on atmosphere in TC conditions.	Results in progress report and/or draft manuscript prepared.	Complete	Wiki page available with results.
	Preliminary Wave-atmosphere algorithms prepared for ocean-wave-atmosphere coupled experiments.	Algorithms and test case available.	Complete	Report presented at the July 08 S&TC.
	Preliminary assessment of ocean turbulence closure schemes under TC conditions.	Results in progress report with comment on implementation in coupled TC modelling.	Complete	The model (SHOC) is being tested against data principally from TC Bobby. Most attention thus far has focused on open boundary conditions, also of relevance to ROAM. Report presented to July 08 S&TC meeting.

Jun 2009	Assessment of impact of waves in wave-atmosphere coupling.	Results in progress report and/or draft manuscript prepared.	Complete	Progress report submitted to the S&TC and accepted as satisfying those milestones.
	Further 3-d implementation and evaluation of upper ocean mixing schemes, incorporating breaking waves.	Recommendations on turbulence closure for regional and TC modelling (including ROAM & CLAM-TC).	Complete	Comparison of model with data focused on TC Bobby, for which CSIRO has in-situ data. The k-ε closure scheme gave the best results. Breaking waves affect surface currents, but are not discerned by deeper measurements from CSIRO moorings.
Jun 2010	Implementation of algorithms describing full interaction of severe winds and waves.	Case studies run and reported.	Discontinued	Work has ceased on this task due to the discontinuation of WAM/TCLAPS at the BoM. Report provided.
	Consideration of 1-d mixing algorithms for use with OFAM in SST interpretation.	Algorithms developed, if feasible.	Discontinued	Milestone was not considered relevant.

P2.3 – Regional Ocean Data Assimilation – Peter Oke & Isabel Andreu-Burillo				
Jun 2007	Develop a prototype system for ocean data assimilation in a limited area model.	Prototype system available for incorporation into the ROAM control system and CLAM-TC; preliminary results presented to S&TC.	Complete	1. Tests have been successfully performed applying BODAS to the ocean component of ROAM. This includes a strategy for updating the ocean state and boundary conditions in a consistent way. Examples will be presented at the S&TC meeting. 2. Scripts and executables made available to Uwe Rosebrock upon request. 3. Preliminary evaluation of BODAS for CLAM has begun. First steps are evaluation of OFAM statistics in the Coral Sea.
Jun 2008	Develop and assess the "relocatability" of the data assimilation system.	Successful tests of SHOC with data assimilation with a number of different applications. Results presented to the S&TC.	Complete	BODAS is now coupled to ROAM and, for any new domain that ROAM creates, BODAS can generate the analysis and prepare the data files. There will be a comprehensive analysis on the impact of assimilation in the near future but the current performance seems reasonable. This work is directly translatable to the next milestone (CLAM).
Dec 2008 (was Jun 2008)	Ensemble strategies evaluated for CLAM.	Results presented to S&TC.	Complete	BODAS has been implemented in a regional configuration for both ROAM and CLAM. The stationary ensemble will be adopted for CLAM and ROAM applications. Availability of observations and the target region (ahead of the TC) indicate this strategy will provide improvements.
Jun 2009	Test the performance of data assimilation in a suite of limited area applications of MOM.	Successful tests of ROAM and CLAM-TC with data assimilation with a number of different applications.	Complete	BODAS has been successfully adapted to, and tested with, SHOC. Incorporation of BODAS into the ROAM control system is complete and ready for testing by the Navy. A regional version of BODAS

		Results presented to the S&TC.		has been implemented to be interfaced with CLAM. Preliminary tests for TC Billy and TC Hamish cases show an improvement of the analysis over the forecast as expected. Different forecast-analysis cycles are being carried out and assessed.
Jun 2010	Address the question of "what observing system is needed to constrain a shelf-scale ocean model".	Results from a series of observing system simulation experiments presented to S&TC.	Complete	Some Observing System Simulation Experiments were presented to the S&TC earlier and the work is now published. Since then we have commenced work on using altimetry over the continental shelf, since this is the only global data set, apart from SST, that actually exists. Results were presented to the 2nd Coastal Altimetry Workshop (Rome), and highlighted the importance of being able to de-tide the altimetry more accurately than is possible using global tidal models.
	Operational CLAM-TC with data assimilation.	Notice issues.	Complete	BODAS has been implemented into a regional version, relocatable to different areas. Tests involved OceanMAPS-type forecast-analysis cycles interfacing BODAS-regional with the Limited Area Model. Assimilation was performed with (a) AMSR-E data only, (b) NAVOCEANO data only, AMSR-E + NAVOCEANO (c) with and (d) without altimetry data. Assimilation improved the SST representation. The Regional-BODAS is not currently operational.
P2.4 – SST data products and analyses – Helen Beggs				
Jun 2007	Collection of existing real-time SST data sets (satellite L2 and in situ) completed.	Reported in progress reports.	Complete	1. Helen Beggs has been collecting currently available GHRSST-PP L2P data sets and assessing their suitability for use in the BL-II SST analysis systems. Prepared web document at http://www.bom.gov.au/bmrc

				/ocean/BLUElink/SST/SST_Data_Streams_Summary-BLII.html summarising details on each data stream currently being used for the BLUElink SST analysis system and potential new data streams. This document has been presented 2. GAC AVHRR SST L2P files from NAVOCEANO now being routinely downloaded by Operations and will shortly be tested for ingestion into RAMSSA analysis system. 3. MODIS 4 km resolution composite SST files are being assessed for use in the RAMSSA system and OceanMAPS. 4. MTSAT-1R SST: The new Satellite Specialist - Oceanography (Dr Leon Majewski) commenced 1 June in SpBOS and is making rapid progress on the operational implementation of NOAA's MTSAT-1R SST processing system at the Bureau. Real-time MTSAT-1R SST files are currently available in McIDAS AREA format and shortly will be available in the BLUElink-preferred netCDF format. 5. HRPT AVHRR SST: Leon is working with Helen on improving the local processing of the HRPT AVHRR SST data. The IMOS AVHRR SST scientific programmer position has been filled by Dr Justin

				Freeman who commenced in SpBOS on 8 Oct.
Jun 2008	Collection of reprocessed delayed-mode L2 SST data sets completed.	Data sets available for testing – notice issued.	Complete	The GHRSST-PP L2 SST data sets required for TWP-ICE studies have been downloaded and evaluated. MTSAT-1R L2P SST reprocessed data sets are available on request from SpBOS. Accuracy of MTSAT-1R SST is being evaluated by Bureau. Statistics from match-ups between MTSAT-1R skin SST and buoy bulk SST is available from the Bureau's internal web page at http://dave.bom.gov.au/trac/apps/wiki/SSES. Issues with raw counts to radiances calibration still need to be resolved in collaboration with NOAA and JMA.
	Determination of technique to take account of diurnal warming effects on satellite-derived SST estimates.	Report available.	Complete	Current RAMSSA method of filtering for suspected diurnal warming events was evaluated in BMRC Research Report RR130. The University of Edinburgh diurnal variation model based on SEVIRI data has been compared with current RAMSSA diurnal warming mitigation method and results presented at 9th GHRSST-PP Science Team Meeting.
	Trial real-time global foundation SST L2 data products and L4 analyses available.*	Notice issued.	Complete	Global GAC AVHRR and AMSR-E GHRSST-PP L2P files are now ingested into the Bureau and used in test GAMSSA and operational RAMSSA. Level 2 foundation SST is available in GAMSSA UARCH output files. The Global Australian Multi-Sensor SST Analysis (GAMSSA) L4 files are being routinely produced by NMOC on Gale and are being assessed for ACCESS.
Jun 2009 (was swapped from Jun 2008)	Operational implementation of new real-time regional foundation SST L2 data products	Notice of change in operational system issued.	Complete	As part of the operational RAMSSA SST analysis system BoM produces a daily file of QC'd, super-obbed, foundation SST L2 data, available on RTDS. Test files back to 1 Oct

	and L4 analyses.*			2006 are archived on SAM. RAMSSA v1.2 L4 analysis (with bug fixes and incorporating NAVOCEANO GAC AVHRR SST L2P data) became operational 10 June 2008. An operational bulletin was issued in June 2007. Operational RAMSSA v1.1 has been documented in an external paper (currently in internal review, see http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/Bureau_HR_Regional_SST_Analysis_v19.doc). RAMSSA v1.3 became operational on 9 April 2009 incorporating NAVOCEANO land mask resulting in significant improvements to coastlines. RAMSSA has been updated to use operational ACCESS-R winds in place of LAPS winds and is currently undergoing testing prior to operational implementation.
Jun 2009	Trial real-time regional skin SST L2 data products and L4 analyses available.	Notice issued.	Complete	The Bureau's OEB is routinely generating MTSAT-1R v1.0 hourly skin SST L2P files. These files are available back to June 2006 but the SST suffers from raw counts to radiance mis-calibration creating diurnally varying biases and RMSE of 0.5K (night) and 0.8K (day) compared with buoys (for Dec 2008). JMA has informed Anthony Rea they are unable to recalibrate MTSAT-1R radiances. OEB expects to upgrade to the new version of NOAA's MTSAT-1R processing code by Apr 2010 and release new operational MTSAT-1R v2.0 skin SST L2P and L3U files by Jun 2010 (for June 2010 milestone). New system should reduce RMSE and possibly diurnal bias. RAMSSA_skin hourly, 1/12 degree, skin SST analysis files (incorporating ACCESS-R surface winds) for 1 Oct 2008 to

				present available for testing. Peter Steinle (NWP Data Assimilation Group) has requested these skin analyses for testing with the ACCESS-R data assimilation system. Both MTSAT-1R skin SST product and regional skin SST analysis documented in the Australian report to the 10th GHRSST Science Team Meeting at http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/GHRSST10/GHRSST10_Meeting-Australian_Report_Beggs.pdf .
Jun 2010	Operational implementation of real-time regional skin SST L2 data products.	Notice of change in operational system issued.	Complete	OEB has released an operational, regional, real-time HRPT AVHRR L2P skin SST product from NOAA-18 and NOAA-19 satellites. Notice of new product release documented in Report from Australia to the 11th GHRSST Science Team Meeting at http://www.ghrsst.org/documents.htm?parent=674. By Sep 2010 RT and reprocessed hourly, MTSAT-1R skin SST L3U (gridded) files back to Jun 2006 should also be available publicly from both IMOS and Bureau's OPeNDAP servers. Leon Majewski (OEB) is working on implementing NOAA's Version 3 MTSAT-1R processing code, incorporating the NOAA physical retrieval method. Andy Harris and Jon Mittaz (NOAA) visited BoM 10-21 May 2010 to assist. Version 1 MTSAT-1R SST L2P files have all ready been made available on Bureau systems but it is expected that v3 products will be more accurate, hence the delay in releasing MTSAT-1R SST products publicly.
	Final testing and documentation completed.	Documentation completed and presented to S&TC.	Complete	Paper on operational RAMSSA submitted to Australian Met Ocean Journal. Extended Abstract and poster written for 5th WMO DA Workshop on experimental skin SST analyses. Extended abstract written for

				GHRSST User Symposium on new HRPT AVHRR SST products (see http://imos.org.au/srsdoc.html). More detailed technical documentation of the new HRPT AVHRR SST system is planned for 2010. Recent developments in MTSAT-1R skin SST, HRPT AVHRR SST, RAMSSA, GAMSSA, RAMSSA_skin and GAMSSA_skin products documented in Report from Australia to 11th GHRSST Science Team Meeting at http://www.ghrsst.org/documents.htm?parent=674. From 4 Dec 2009 operational RAMSSA and GAMSSA use ACCESS-R and ACCESS-G winds. Operational RAMSSA and GAMSSA have been ported successfully to Solar.
P2.5 – Relocatable Ocean-Atmosphere Model (ROAM) - Uwe Rosebrock				
Jun 2007	Assessment of model-coupling software (OASIS or ACCESS coupler).	Decision on uptake.	Complete	Assessment by Russ Fiedler indicates that OASIS is not appropriate (for speed and simplicity reasons) for ROAM. This means that future changes to the coupling in ROAM will be coded in.
	Incorporation of SWAN model into ROAM architecture.	Upgraded version of ROAM delivered to RAN.	Complete	Modification of the user-interface for selection of the SWAN domain together with the definition of the input grid is implemented. Options to couple SWAN with the atmospheric model have been added, the workspace environment as been setup, and additional data has been sourced and added to the Data Management Framework.
	Design of non-automated version of ROAM.	This Milestone is not part of the Navy's requirements.	Complete	This is an internal CSIRO exercise, and is conducted according to need. To date, functionality has been added to ROAM to enable direct access to output disc area as well as the presentation of additional information.
	Responses to RAN enquiries	Delivery as requested.	Complete	Numerous interface modifications have been made

	(ongoing).			and problems solved. These include (but are not limited to): fixing of memory leakage and file handle problems; improved run status tracking; implementation of a more robust runtime environment; improvements to the data output registration to the DMF; registration of model output with the RCF; improved reporting on model run failures, the server has been equipped to maintain previous user settings at a rebuild of the environment. OFAM region now displayed on graphical interface; improved use of Salacia (RAN server) with computing resources and priority queues implemented; run description displayed on run specification summary; administration manual released; user manual released and subsequently updated; functional test manual produced.
Jun 2008	Modifications to ROAM for data streams (XBT and SST) for data assimilation.	Reported in progress reports.	Complete	Results reported at July 08 S&TC meeting.
	Implementation of model coupler.		Changed	Evaluation of the coupler indicated that it was too cumbersome for incorporation.
	Preliminary coding for research version (non-automated) of ROAM.		Complete	Major modification has been incorporated in code, reported at July 08 S&TC meeting.
Jun 2009	Modifications to incorporate data assimilation into ROAM.	Reported in progress reports. Test version available to RAN.	Complete	ROAM architecture has been modified to incorporate BODAS, and the new system is ready for Navy testing.
	Improvement of surface flux representations as advised by P2.2.		Complete	Advice from P2.2 is that we should continue to use our present (Large and Pond) formulation.

	Further coding of non-automated versions of ROAM.		Ongoing	A new communication framework has been implemented in ROAM to improve its versatility. ROAM is also being modified to allow hindcasts based on BRAN and a meteorological reanalysis.
	Further ROAM modifications requested by Navy.		Complete	ROAM now provides 3 output formats: standard net CDF, simple netCDF for Thales, and GIS. It also has an option to supply similarly formatted output from LAPS and OceanMAPS. The ocean model in now has a stand-alone mode. Different near-surface levels have been introduced into RAMS.
	Ongoing ROAM maintenance.		Complete	Upgrades introduced into ROAM in 2008/9 include: better obc's; empirical surface heat flux; disconnect of atmos, wave and hydro model grids.
Jun 2010	Finalised surface flux representation.	Delivered in ROAM to RAN.	Complete	RAMS heat fluxes have been corrected and implemented in ROAM. At present the default is no surface heat flux. RAN has requested that flux options (none, RAMS or bulk) be included in GUI. This will be done in BL3.
	Incorporation of freshwater fluxes from OFAM development.	Delivered in ROAM to RAN.	Complete	ROAM is ready to receive freshwater fluxes. When the climatology is implemented in OceanMAPS, the flux file will be fed to the ROAM data server. This will happen early in BL3.
	Final incarnation of ROAM2 for RAN.	Installed on RAN machine. Documentation delivered.	Complete	The ROAM software has been updated to the latest tested version, including the deployment of the SWAN and BODAS models and the documentation has been modified accordingly. Ongoing support has been provided where necessary.
	Working version of non-automated ROAM.	Made available to Divisional modellers for trial.	Complete	System is installed.
P2.6 – Coupled Tropical Cyclone Prediction System (CLAM-TC) - Paul Sandery				
Jun 2007	Configure prototype	CLAM-TC prototype	Complete (Dec 2007)	A prototype configuration was completed based on

	CLAM-TC.	version available.		Mom4p0d-OASIS2.5-TCLAPSv5. A MOM4p0d regional configuration was established based on BRAN2.1/ OceanMAPSv1.0b initial conditions, closed boundaries and boundary relaxation. OASIS2.5 was configured for TCLAPS5-toy ocean and MOM4p0d-toy atmosphere. A full coupled system was completed TC Ingrid and TC Larry were used as case studies. Synthetic TC vortex specification was developed. A heat content climatology was established.
Jun 2008	Coupled TC experiments.	Report on the impact of ocean-atmosphere coupling on skill.	Complete	Evaluation of coupling signal is being diagnosed through 1-way case and the correlation of heat content and TC intensity has also been assessed.
	Experimental coupled TC forecasts.	Report on TC forecasts.	Complete	Restricted to one-way experiments only
Jun 2009	Full prototype CLAM-TC implemented.	CLAM-TC available.	Complete	The prototype CLAM-TC system based on ACCESS-TC was implemented into Bureau systems.
Jun 2010	Operational trials of CLAM-TC completed.	S&TC report.	Complete	Implementation as operational system was deemed to be not appropriate because trials demonstrated a persistent bias in ACCESS-TC towards under estimating TC intensity, which was only made worse by ocean coupling. This was beyond the control of the Bluelink team.
	Analysis and documentation of CLAM-TC.	Notice issued.	Complete	Documentation for CLAM research system is published in Monthly Weather Review in Sandery, Brassington, Pugh and Craig, 2010: Impacts of ocean-atmosphere coupling on tropical cyclone intensity change in the Australian

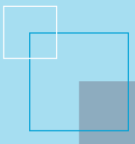
				region. Notice not issued because system will not go operational, as noted above.
P3 – Near-shore Wave Forecasting **Peter Craig & Diana Greenslade**				
P3.1 - Near-shore Wave measurement – Graham Symonds				
Jun 2007	Purchase radar and associated hardware.	Radar delivered to Floreat Marine Labs.	Complete	
	Setup and test radar.	Test data available and reported.	Complete	Radar installed at Watermans and initial tests completed. Security installed and noise issues addressed.
	Implementation and development of data acquisition software.	Test data available and reported.	Complete	Proprietary software is installed and in use.
Jun 2008	Field data collection – inner shelf.	Data available and reported.	Complete	This field work was delayed due to a conflict with WAMSI node 1 field program. Contardo, S., G. Symonds and N. Mortimer, 2010. BLUElink II Workpackage P3 Inner Shelf and Nearshore Field Programs, CAWCR Tech. Rep., No. 28, 34pp.
	Implementation and development of wave analysis software.	Wave analyses reported.	Complete	Matlab software developed for (1) 3D fft analysis of radar data; (2) cross-spectral analysis; (3) water depth determination. Reported to July 08 S&TC
	Comparison of radar derived wave measurements with in-situ observations.	Comparison described in progress report and/or draft manuscript.	Complete	Delayed due to the delay in commencing the field work. However, data from the WAMSI field program, in particular directional wave data from outside the reef line, may be used for preliminary comparisons.

Jun 2009	Field data collection – near-shore.	Data available and reported.	Complete	Field program at Secret Harbour, south of Perth, completed February 9-28, 2009. Contardo, S., G. Symonds and N. Mortimer, 2010. BLUElink II Workpackage P3 Inner Shelf and Nearshore Field Programs, CAWCR Tech. Rep., No. 28, 34pp.
	Continued development of analysis software.	Wave analyses reported.	Complete	Time averaged radar images from Secret Harbour were analysed to monitor morphological change during the course of the measurement program. Results from radar and in situ measurements were presented at the S&TC meeting in July. Development of software will continue beyond this milestone.
	Inter-comparison of in situ measurements, radar derived wave data and model predictions (P3.2 and P3.3).	Comparison described in progress report and/or draft manuscript.	Complete	Observations at Secret Harbour were obtained through successive sea breeze cycles. These data provide a unique opportunity to model wave growth and decay, and the acceleration and deceleration of wave driven alongshore currents. Model-data comparisons reported at the July S&TC. A manuscript is planned, but not written.
Jun 2010	Inter-comparison of near-shore in situ measurements with model predictions (P3.3).	Comparison reported. Model selected for P3.3.	Complete	XBeach has been implemented in LOMS. Intercomparison of observations and model output at Secret Harbour is complete and was reported at July S&TC.
P3.2 - Coastal Wave forecasting – Diana Greenslade				
Jun 2007	BC decision made.	BC's available in R/T to ROAM-W.	Complete	The Bureau started delivering the files from Regional and

				Aus_meso WAM to the OpenDAP server on 10 July. In addition, for ROAM-W, these files are also being delivered to the HPCCC "Navy transfer disk".
Jun 2008	Decision on configuration made.	Documentation available.	Complete	"SWAN" replaced by "WW3".
	Forecast skill evaluated.		Complete	"SWAN" replaced by "WW3".
Dec2009	Operational implementation if justified.	Operations bulletin issued.	Complete	WW3 now operational on solar under ACCESS.
	Documentation complete.	Research Report.	Complete	Draft Research report complete.
P3.3 - Littoral (Wave-breaking)zone models – Jim Gunson				
Jun 2007	Review of available near-shore hydrodynamic models.	Review provided in annual report.	Complete	
Dec 2008 (was Jun 2007)	Model implementation and testing.	Preliminary model results reported.	Complete	Following the assessment of a number of models we have decided to use the Curvecirc/RefDif modules in the Nearshore Community Model (NearCom) modelling package.
2008	Preliminary model specs provided for interface development.	Documentation provided for P3.4.	Complete	
Jun 2009	Inter-comparison of in situ measurements, radar derived	Comparison reported in progress report and draft	Complete	Curvecirc/RefDif has been set up for the Secret Harbour site and the model

	wave data (P3.1) and model predictions .	manuscript.		performance is being assessed against the observations. Results will be reported at the July S&TC meeting.
	Model specs provided for interface development (P3.4).	Documentation provided to P3.4.	Complete	Model specs have been provided to P3.4, primarily through a worked-up example of LOMS implementation at Secret Harbour.
Jun 2010	Inter-comparison of near-shore in situ measurements (P3.1) with model predictions.	Comparison reported in final report and manuscript .	Complete	Symonds, G., Liejun Zhong and Nick A. Mortimer, 2011. Effects of wave exposure on circulation in a temperate reef environment, *J Geophys. Res.*,116, C09010, doi:10.1029/2010JC006658.
P3.4 – Littoral-zone software system - Uwe Rosebrock				
Jun 2007	Detailed user specification.	User specification agreed with RAN.	Complete	
	Detailed design document.	Design document provided to RAN.	Complete	Draft design document completed after the user specifications agreed by Navy.
Jun 2008	Initial prototype system.	Demonstrate prototype to RAN.	Complete	The graphic interface prototype has been supplied to the Navy and the S&TC as a voiced-

				over computer animation.
	Detailed design document.	Design document provided to RAN.	Complete	The design document is now complete and available. It should be noted that this document is primarily an internal document for the software engineers.
Jun 2009	Fully functional prototype system.	Demonstrate refined prototype to RAN and make available for evaluation and feedback.	Complete	The functional LOMS prototype demonstrated at the July S&TC.
	Specification of minimum software and hardware requirements.	Software and hardware requirements agreed with RAN.	Complete	The system will require a top-of-range laptop.
	Draft user manual.	User manual provided to RAN.	Complete	Supplied to Navy.
Jun 2010	System testing, installation and delivery.	Final software, user manual and training provided to the RAN.	Complete	X-beach has been incorporated in LOMS code. The LOMS software was supplied to RAN for user testing in July 2010, acceptance testing in August and then in final form with minor enhancements in November 2010. A training course was given in October 2010 at the Nowra base.



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