



5th Western Australian State

# COASTAL CONFERENCE 2009

*Whose Coast Is It?  
adapting for the future*

8C:

Before and After  
the Storm:  
11.55am–12.25pm  
Friday 9th  
October 2009  
Pleiades Room

## Technologies for the Assessment and Prediction of Coastal Hazards

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### Abstract

Reducing risks to life and property in the coastal environment requires monitoring of conditions to enhance our understanding of coastal processes and their associated hazards. CoastalCOMS is developing technologies that will provide hazard indices and risk profiles for Australian beaches. This will build on previous assessments of Australian beaches by incorporating short-term changes to hazard ratings based on prevailing and forecast environmental conditions. Long-term monitoring of physical coastal processes provides the basis for the development of predictive models of our coastal environment. With a continuous data collection program in place, there is also the opportunity to provide real-time information to authorities charged with the duty of care of coastal users and management of coastal infrastructure. CoastalCOMS, Coastalwatch, Surf Lifesaving Australia, Surf Lifesaving Queensland and Griffith University are working on the development of assessment tools which integrate data collection and numerical methods to enable short-term forecasting of coastal processes which impact upon coastal users. The techniques being integrated include live video image capture, artificial neural networks and shape detection algorithms.

### Key points

- Real time coastal hazard assessment.
- Technology development that integrates live video capture, artificial neural networks and shape detection algorithms.
- Surf hazard monitoring partnership with Surf Life Saving Western Australia.

## Introduction

CoastalCOMS P/L in conjunction with Coastalwatch P/L, Griffith University, Surf Life Saving Queensland (SLSQ) and Surf Life Saving Australia (SLSA) received funding from the Queensland State government Smart State Innovation program in 2008 with the objective of developing a dynamic hazard rating for beaches.

There are a number of factors that contribute to beach hazards including, breaking wave heights, intensity and power of the breaking waves (wave dynamics), the state of the beach (morphology and bathymetry) including rip formation and the number of people and surf craft using the beach

This project is developing the technology for a live real time assessment tool that will provide a risk profile and hazard/safety index for beaches around Australia. Current tools that are available to surf lifesavers are based on static measurements conducted on data collected over ten years ago. Successful outcomes will result in more accurate risk profiling of beaches, better resource management by Surf Life Saving and local government, and more importantly the prevention of unnecessary injury or death on our beaches.

The result of this project will be a real time assessment tool that will analyse beaches for both environmental and usage factors, and provide surf lifesavers and councils with the necessary information to provide appropriate personnel and resources to minimise risk for the beach going public.

## Research Methodologies

The research program was divided into three preliminary phases with a final phase of the development of a real time hazard assessment.

### Phase 1: Beach Morphodynamics

There are a number of tasks focussing on the beach morphodynamics, wave condition and environmental forcing parameters. Of critical importance is the definition of the beach state transitions and the development of a beach state index which will prescribe the dynamic variations in a particular beach safety rating.

A significant task is to establish a correspondence between the accepted beach state models (Short, 2006; Short and Woodroffe, 2009) and the observed conditions obtained from video imaging. Images have been classed according to both cross-shore and longshore morphological and hydrodynamic features. These features include the number of bars present, dominant wave process, surf zone shape and longshore variation in surf zone topography. Wave height has been found to be a controlling factor in determining the surf zone type that develops, along with wind and wave direction. Rapid change in wind and wave conditions have been identified and tested as possible triggers for beach state transitions and formation of transient (flash) rips. A further task in this phase has been the integration of Environment Protection Authority (EPA) wave rider data and the modelling of wave transformation in shallow water using the global wave model WW3 and SWAN software.

With the real-time capture of video images and other dynamic information beach condition snapshots have been produced. Neural network analysis is also used to analyse beach state. The resulting information is correlated with beach safety data obtained from surf lifesavers in order to identify significant short-term changes in beach conditions.

The main output is a short time scale transition predictive model, presenting a picture of typical beach conditions and their changes over time. Relating these descriptions to the morphodynamic beach state model also further enhances the predictive assessment tool "training". As an outcome of this work a beach condition trend index can be produced, which will take a set beach state as a starting point, then examine a range of simulation scenarios of beach and wind/wave/tide conditions thereby creating a matrix of predicted states and conditions.

### Phase 2: Automated techniques

A second group of tasks has focused on the development of the algorithms for the neural network analysis and the automation of the hazard rating system.

A number of key techniques have been developed and investigated to facilitate the automation of the CoastSAFE Beach Hazard and Risk Assessment tool:

- Automated shoreline detection and measurement.
- Wave height processing and forecasting (ANNA).
- Automatic people counting.
- Life guard data logger device.

- Beach state processing.
- Dynamic risk indication.

**Automatic shoreline detection** is an important component of the CoastSAFE Alive Beach Risk Assessment system. Apart from providing essential measurements and information pertaining to the shoreline's location, it serves as a base step for other components of the system. The process for shoreline detection entails image processing techniques such as noise removal and hue calculation for detecting the variation between the sand and the sea. This is followed with further processing for smoothing the line and detecting the shoreline using such techniques as a Median Filter and the Sobel Operator respectively.

Another important parameter is the measurement of nearshore **wave height**. In order to estimate nearshore wave height, artificial neural network technology (termed ANNA) is used to successfully generate this information from the global deep-water wave model output known as NOAA. The system is trained using recorded video that is geo-referenced and processed using cross pixel density analysis to calculate the breaking wave height.

**Automatic people detection and counting** is achieved through a number of image processing techniques including noise removal, segmentation of people objects from the scene and subsequently validating their shape based on the extraction of salient information from the object and performing automated classification. The output from the algorithm may be processed to provide the number of persons on the beach at a given time. This information is important for providing data to help predict future beach needs.

Aside from counting people, and analysing beach usage, automated detection of beach objects may also be extended to the process of tracking for the purpose of behaviour detection. This information may be used to determine the location of persons on the beach and then monitoring their behaviour with respect to potentially hazardous situations near the water. Algorithms to model people behaviour as they approach the shoreline and subsequently enter the sea may be used to provide alerts and incident feedback to the appropriate authorities.

Objective discrimination of beach state is an important component of computational systems for monitoring the nearshore zone. The CoastSAFE Alive Beach Risk Assessment tool will implement two alternative representations of variability in cross-shore surface reflectance. Both approaches represent the variability of pixel intensities over time, as opposed to a simple image averaging technique. This has provided an effective way of providing objective classification of beach state in terms of Wright and Short's model (Short, 2006). Estimation of these parameters from locally mounted cameras is preferred to relying on large-scale meteorological and oceanographic models.

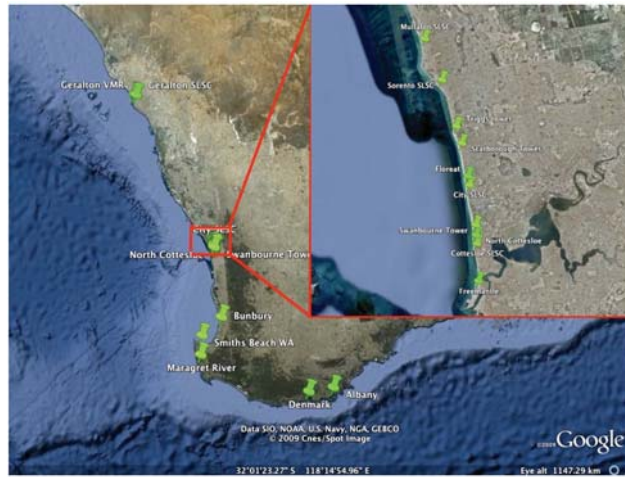
Following the development of the individual components, output from each will be fused to provide an accurate risk rating of a particular beach site. The combined information will generate an appropriate dataset to implement a dynamic predictive model for indicating and reporting risk at beach sites.

### **Phase 3: System component development—software and hardware**

A third group of tasks has focused on data acquisition, camera control, data networks, data storage and information dissemination. Coastalwatch has developed a Turn Key solution that allows a unique system to acquire, process and distribute information from a camera site.

To date, Coastalwatch has been able to develop specific software that allows for a camera to be individually controlled in order to collect information on a particular coastline. The impact of this tool is that cameras can be distributed across large geographic areas, as well as those that are distant from the control centre. This means that the control and command of a widely distributed camera network would be possible with minimal replication of hardware, software and personnel. The implementation of this tool means that CCTV surveillance and data acquisition would no longer be limited by geographical constraints including remote locations and widely distributed systems.

Figure 1: Current Coastalwatch camera sites in Western Australia

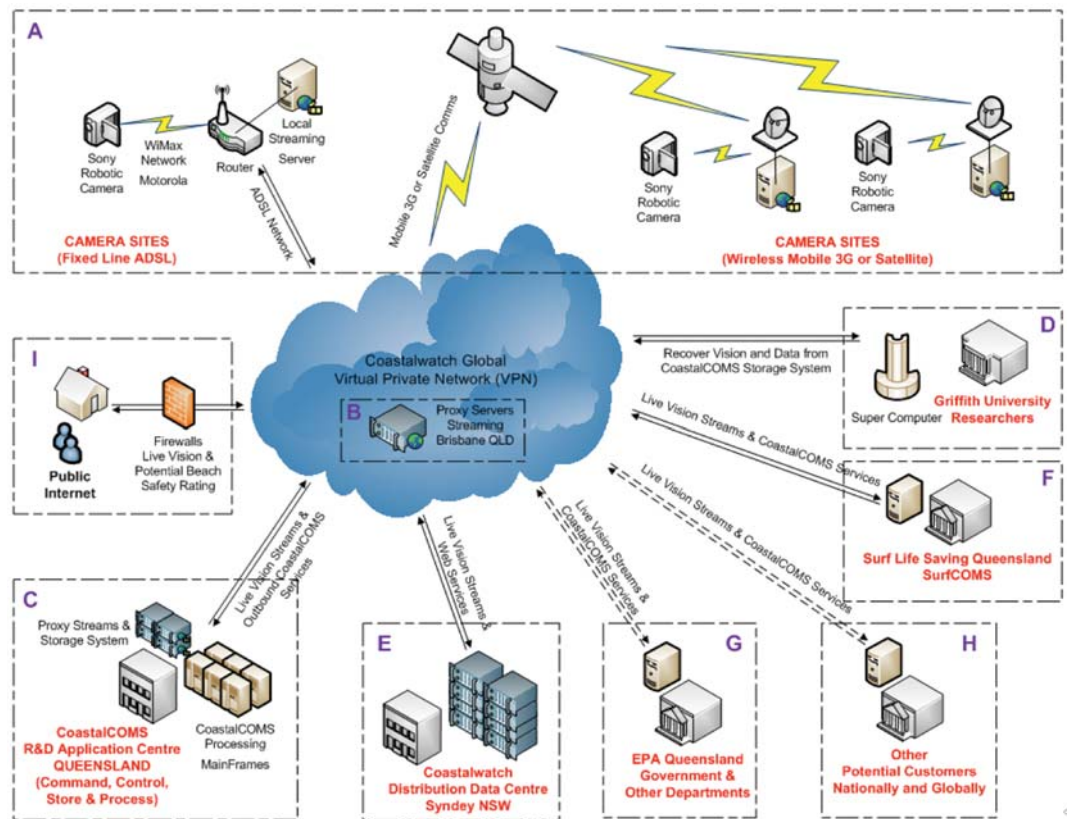


Source: Google Earth and Coastalwatch

The importance of the tool that will be developed in the CoastSAFE Alive project is both the capacity for surveillance of a wide location of cameras on one VPN network and the data acquisition from cameras located at a 140 different camera locations in a wide geographical network.

Figure 2 illustrates the key areas required to collect, store, process and distribute the data collected.

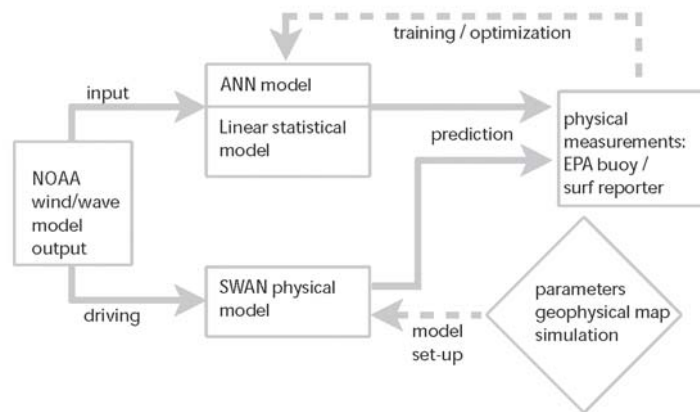
Figure 2: The integrated CoastalCOMS and Coastalwatch processing system.



### Final Phase: Dynamic Hazard and Risk Assessment

Following the development of the individual components the output from each has been integrated to provide an accurate risk rating of a particular beach site. The combined information results in a dynamic predictive model for assessing and reporting risk at beach sites (Figure 3).

**Figure 3: Integration of system components for risk assessment**



(Browne *et al.*, 2005)

## Take Home Message

The beauty and amenity of Australia's beaches are well recognised both in Australia and internationally. This project offers outcomes of national importance through the development of a real time and forecast beach risk assessment tool. There are direct economic benefits to Western Australia through enhanced safety for beach users and the mitigation of instances of death by drowning which may have negative effects on tourism. The provision of enhanced monitoring facilities also informs coastal authorities about the health of the beach system and will assist in the longer term monitoring and planning for climate change impacts.

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