Applications of GIS for Coastal Rescue Response

David Burns (MACM)

Agenda

- Overview of New South Wales coastal rescue
- Risk mitigation
- Use of GIS for decision support
- Relevant data sources
- ArcGIS integration
- Sample results
- Future work

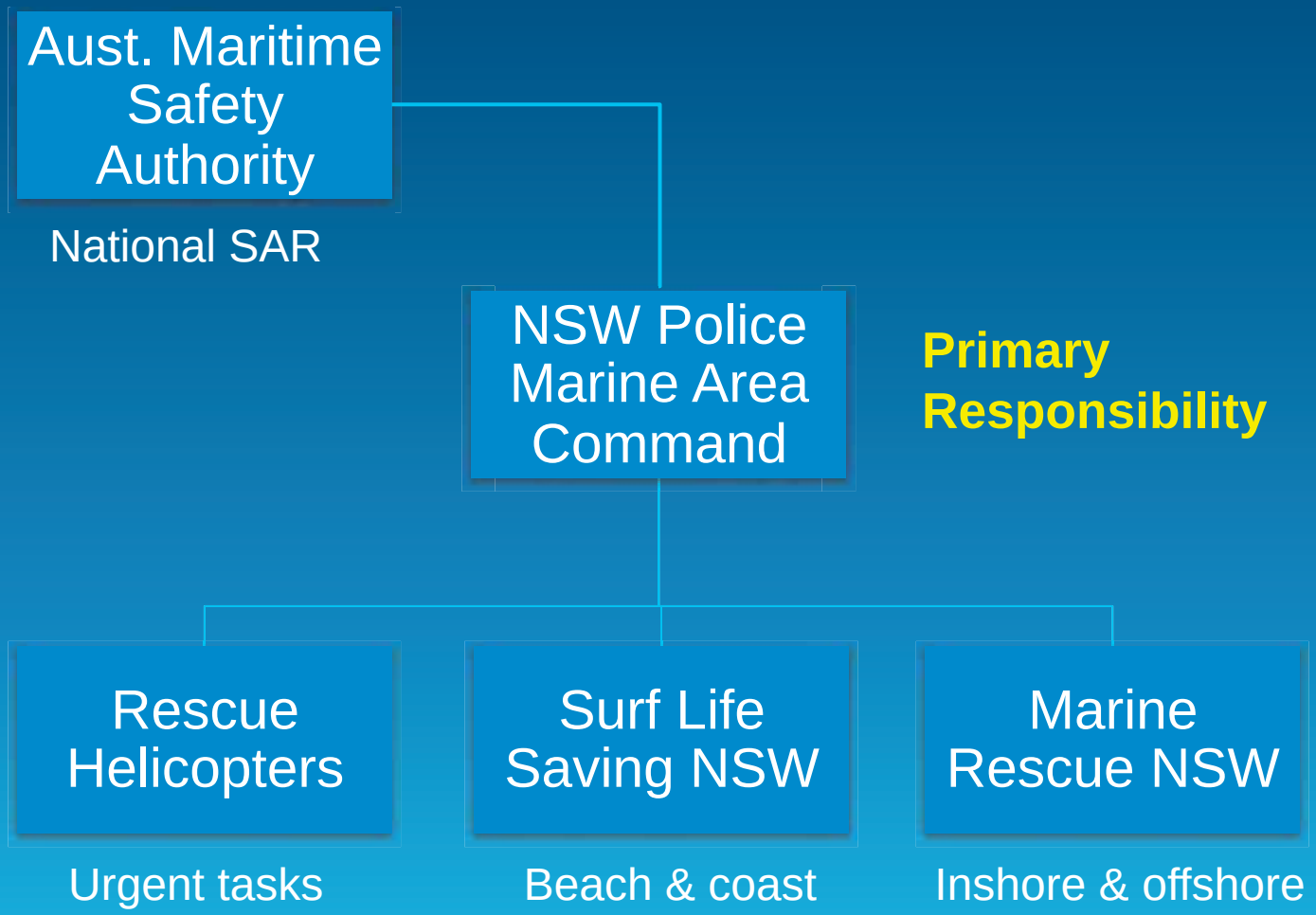
Project Background

- This project was completed as part of a Masters in Science & Technology at the University of New South Wales (Sydney, Australia) in 2013.
- Course supervisor: Associate Professor Dr Shawn Laffan

New South Wales – Did someone say *Boating*?

- NSW coastline length = 2007 kilometres (1247 miles)
- 30+ major ports & harbours
- 445,000 licenced boat operators/skippers
- 217,000 registered vessels
- Some can’t get enough!

NSW Coastal Rescue – 30 second primer



NSW Marine Rescue – The Statistics

- Established in 2009
- 47 bases
- 75+ rescue vessels
- 2800+ members (99% volunteers)
- 3000+ assists/year
- 370,000+ radio calls/year

Marine Rescue NSW – Crew Training

- Sea Safety
- First Aid (resuscitation and advanced)
- Boat Handling (up to Coxswain)
- Navigation & Radar
- Communications (VHF & DSC)
- Routine exercises
- Accreditation to State Rescue Board standards
- But there is always the perennial question…

Crew Training – Is it ever enough?

- No matter what emergency personnel skills & experience are – there is always risk
- Water rescue can be risky as a result of weather & sea state, failures of equipment/communications, hypothermia, fatigue etc
- Offshore assists have inherently higher risks
- Challenge – how can we mitigate risk?

Risk Mitigation – Summary

- Training – base crew skills are important
- Experience – have a crew done a task before
- Process – formally assess crew readiness
- Equipment – engineering and redundancy
- Weather & sea-state – much harder

Risk Mitigation (continued)

- Weather & sea state can be predicted using forecasts (duh!)
- However many offshore assists require vessel deployment after a change in weather
- If we don’t consider both current and future weather we may deploy the wrong vessel from the wrong base which adds to response time and increases the risk to the rescue crew

Must be a better way

- Why are we here?
- The ESRI ArcGIS analysis tools are great for decision support
- All we need is some data!

Useful Inputs

- Coastline data
- Rescue base & vessel locations
- Rescue vessel characteristics
- Weather & sea state

NSW Coastline – Easy

- Primary Australian source of reference GIS datasets is Geoscience Australia (GA)
- Wide range of datasets available
- GEODATA COAST 100K 2004 was used for this analysis
- Polyline dataset

Marine Rescue NSW Base & Vessel Data – Easy

- Base locations – initial list had approximate locations only
- Accurate locations determined using Australian Hydrographic charts in conjunction with georeferencing to satellite imagery
- Vessel capabilities – derived from MRNSW data
- Vessels are categorised based on size and certification (eg Cat 2C vessels can only go up to 30 nautical miles offshore)

Weather Forecasts – Harder

- The primary Australian provider for weather is the national Bureau of Meteorology (BoM)
- Range of weather products including land and marine forecasts
- Sea state forecasts available
- Weather warnings available
- Coastal weather datasets available in XML

Weather Boundaries

- Regional coastal areas
- Forecasts & sea state data available for each area
- Weather areas reference points are used to build closed polygons – which can then be used for raster generation

Integration – Overview

- Live data import from BoM
- Raster (surface) creation
- Wind direction averaging
- Swell direction averaging
- Calculate significant wave height
- Run Path Distance & Cost Path Analysis
- Analyse results

Integration – Implementation

- Python for ArcGIS was used
- XML ~~unmangling~~ processing with Python module xml.etree.ElementTree allows easy integration of XML data
- Full data extraction required additional text parsing and tokenisation using regular expressions
- ArcGIS raster surfaces easily created and manipulated in Python

Integration – Tricky Bits #1 – Limitations of Data

- Wind & swell direction averaging
- The wind direction changes over time – we average the direction
- Accuracy limited by temporality of data
- Swell direction changes are similar but slower

Integration – Tricky Bits #2 – Use Mathematics

- **Significant Wave Height**

$$SignificantWaveHeight = \sqrt{SeaHeight^2 + SwellHeight^2}$$

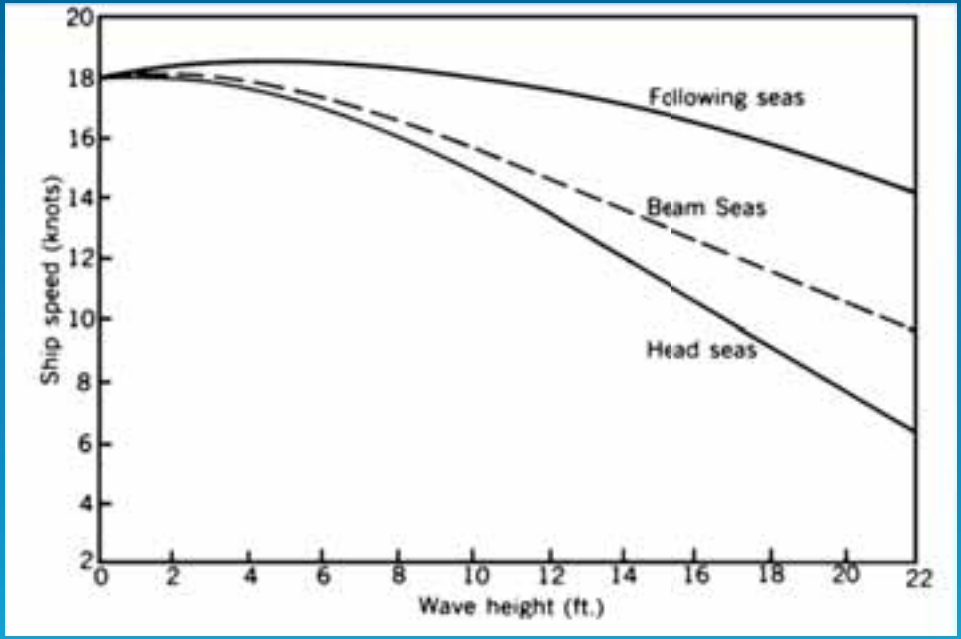
- **Above formula valid if the difference in direction between sea & swell is less than 30 degrees, otherwise**

$$SignificantWaveHeight = Max(SeaHeight, SwellHeight)$$

- **Easy to implement in Python**

Integration – Tricky Bits #3 – Model Accuracy

- **Vessel Performance varies according to path of vessel through a given sea and is not linear**



Bowditch 2002

Integration – Tricky Bits #3 – Model Accuracy (cont.)

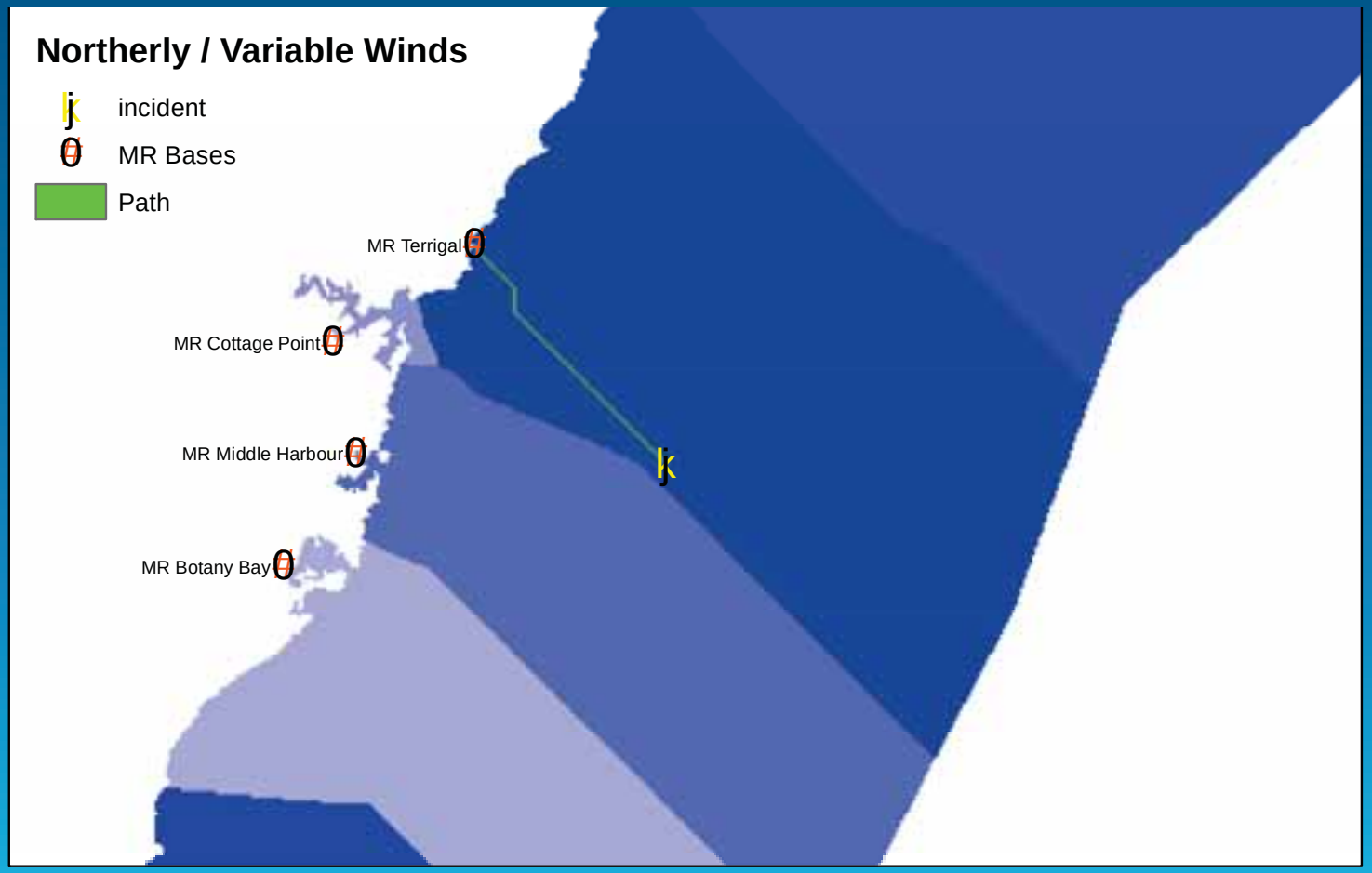
- Smaller vessels have different handling characteristics – need to avoid head seas (water over front of vessel) & following seas (risk of broaching)
- Combining the performance chart with above requirements yielded a hybrid set of vessel cost factors.
- NB Cost factors will require further validation for different vessel types (eg monohull versus catamaran)
- Estimated vessel cost factors loaded into custom modifier table prior to Path Distance analysis

Results

- **Model accuracy was analysed for a number of scenarios using both real and simulated weather & sea conditions**

Results – Sample #1

Results – Sample #2



Limitations

- **Model limitations** – Eg Some rescue vessels do not always have fast offshore access in some weather conditions (eg. river bar crossing)
- **Additional data** – incorporate sea current data (2-3 knots)
- Incorporate vessel windage modelling
- Always more to do – modelling should always be considered to be iterative

Future Work

- Use new BoM high resolution (0.1°) forecast data (which became available as this project was nearly completed!)
- Improved forecast data temporality (based on enhanced BoM forecast models)
- Improved vessel performance modelling (would require substantial work)
- Real time vessel tracking (using marine AIS – Automatic Identification System)
- Translation of Cost Path to navigational waypoints & communications to rescue vessel(s)

That’s All!

Thankyou!