Improving Port Safety through Geographic Information Systems (GIS)

John Riding
Andrew Rawson

28th May 2014
Contents – Geographical Information Systems

1. Who Marico are and what we do.
2. Explanation of the Emerging Capability and Benefits of GIS for Risk Assessment.
3. Practical Examples from around the Globe.
Marico Marine

- We operate out of Southampton UK and Wellington NZ. Operating since 1999, 15 Years Trading;
- Opened in New Zealand in 2004;
- Provide Development and Risk Management support in many Harbours worldwide;
- Navigational Risk Assessments for Decision Making;
- HAZMAN II Online Port and Harbour Risk Management Tool (Linked Incident Database);
- We are a marriage of salt water and science, employing master mariners, harbour masters, engineers and scientists.
What is GIS? Well it has a Definition!

- “A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information.” ESRI (2014).
The Problem GIS Solved

• Limitations of traditional risk assessment:
  ➢ Expert Judgement (traditional marine expertise is getting difficult to find);
  ➢ Incident Analysis; and
  ➢ Presentation of results in complex harbour systems.
The Case for Geographical Information Systems (GIS)

• GIS has been around now for quite some time but it has though become much more powerful;

• Synthesis (Connection) of multiple data sets;

• Provides a geographical visual interface;

• Powerfully informs and complements expert judgement with data driven analysis;

• Can supply clarity when the scale of a study area is large.
Geographic Approach

- Collect data;
- Store and Manage data;
- Analyse the data; and
- Present the data (Charts/Maps).
Case Studies
RIVER THAMES
CENTRAL LONDON
TRAFFIC STUDY
Traffic under London Bridge – 1 Hour
Traffic Density Profile
The Detail Supplied by Data is Key

Transits Per Day
0.1 - 4.0
4.1 - 8.0
8.1 - 12.0
12.1 - 16.0
16.1 - 20.0
20.1 - 24.0

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0.1 - 4.0
4.1 - 8.0
8.1 - 12.0
12.1 - 16.0
16.1 - 20.0
20.1 - 24.0
Vessel Encounter Assessments

- Dynamic safety buffer around vessels - “Domains”
- Count the number of vessel encounters at different times of day and number of exposed vessels.
Central London Traffic Study: Domain Model

Date: 14th July 2011 Time: 1100-1300 UTC (1200-1400 BST) Tidal State: HW-2 to HW

Study Time:
14/07/2011 10:59:51 to 14/07/2011 11:00:00

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26th – 30th May 2014, Bruges – Ghent, Belgium
Domain Encounter Results:

Date: 15th July 2011  Time: 1100-1300 UTC (1200-1400 BST)  Tidal State: HW-3 to HW-1

Lambeth Bridge to London Bridge (plot continues to east in inset)

Legend

Encounter Type - Shape
- Crossing
- Head On
- Overtaking

Encounter Speed - Size
- 0.5 to 2 Knots
- 3 to 4 Knots
- 5 to 6 Knots
- 7 to 10 Knots
- Over 11 Knots

Encounter Distance - Colour
- 0 to 5 Metres
- 5 to 10 Metres
- 10 to 20 Metres
- 20 to 30 Metres
- 30 to 40 Metres
- 40 to 50 Metres
- 50 to 60 Metres
- 60 to 79 Metres

Number of Encounters During All Study Periods.

<table>
<thead>
<tr>
<th>Encounters</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>Blue</td>
</tr>
<tr>
<td>2 - 4</td>
<td>Yellow</td>
</tr>
<tr>
<td>5 - 10</td>
<td>Green</td>
</tr>
<tr>
<td>11 - 14</td>
<td>Orange</td>
</tr>
<tr>
<td>15 - 18</td>
<td>Red</td>
</tr>
<tr>
<td>19 - 26</td>
<td>Red</td>
</tr>
</tbody>
</table>

Number of Domain Contraventions during each Study Period

- Study Periods (One Hour Duration)
- Power Trendline (correlation coefficient = 0.84)

Rawson et al. (2014), Journal of Navigation

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South West Pacific Hydrography Risk Assessment

• A Large Risk Assessment Programme in the SW Pacific using GIS to derive where Nautical Charts Should be improved.

• Methodology Developed similar to the IMO Formal Safety Assessment Methodology, with Hydrography needs Paramount.
Hydrographic Risk Assessment Methodology

FLOW CHART OF RISK ASSESSMENT METHODOLOGY FOR SW PACIFIC

STEP 1 - DATA GATHERING

- Task 1A: PREPARATORY STEP
  - Define scope of geographic areas being considered, regional or interlaced, define boundaries and constraints.

- Task 1B: HAZARD IDENTIFICATION
  - Stakeholder Identification
  - Stakeholder Questionnaire, Grouping and Consultation
  - Visit locations collected ship movement data (SOLAS and local from ports, agents or officials, obtain satellite or local AIS data ship information attached)

- Task 1C:經濟 information about each area; GDP, growth volumes, tourism activity

STEP 2 - RISK ASSESSMENT

- Task 2A: RISK CRITERIA
  - Traffic Analysis (Satellite Derived AIS Data) and locally acquired information

- Task 2B: GIS RISK MODEL
  - GIS Assessment of Traffic Frequency by Type and Size
  - Identify Navigational Safety Hazards, Define Likelihood Criteria
  - Evaluate environmental and cultural impact and significance of area, define consequence criterion

STEP 3 - Economic Analysis

- Decision from Pacific Island Country with the support of regional charting authorities to define nature and scope of chart improvement surveys

STEP 4 - Publish and distribute Risk Assessment results
SW Pacific Scope

- Study area is 6,100 km wide and 3,200 km high.
- Approx. Total area is 16.3 million square km.
- Approx. Total area completed is 3.1 million square km (19%).
- The European Union could fit in 4 times, and the total area is equivalent to 75% of Europe’s landmass.
- Even Australia could fit in twice.
Scale of the Charting Problem
Study Area Compared with Europe
Traffic Coverage
GIS Risk Terrain Modelling (RTM)

- The GIS approach allows many layers of data to be presented to decision makers;

- Common Likelihood & Consequence risk factors for each area result in 29 Different GIS Layers, including shipping traffic from AIS;

- A Risk Matrix sets the risk criteria for calculations on each layer;

- Other Layers are Environmentally Important Locations, Culturally Valuable locations and Areas of Economic Activity;

- Shipping Traffic (International and Domestic) is the key underlying layer - no ships no risk.
Risk Model Variables

Causation Risk Factors
- Bottom type
- Navigationally complexity
- Chart quality - CATZOC
- Aids to navigation
- Depth – bathymetry

Consequence Risk Factors
- Coral Reefs
- Mangroves
- Breeding grounds
- Protected sites
- Key infrastructure - ports
Vanuatu Results

All Traffic
Vanuatu Results
Risk Output

Vanuatu

Results
Risk Output

<table>
<thead>
<tr>
<th>Province</th>
<th>Area</th>
<th>Comparative Risk Level</th>
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<tbody>
<tr>
<td>VANUATU</td>
<td>Espiritu Santo, Luganville and approaches</td>
<td>Significant</td>
</tr>
<tr>
<td>MALAMPA</td>
<td>Malo, east coast</td>
<td>Significant</td>
</tr>
<tr>
<td>SHIJA</td>
<td>Esp. north-west corner</td>
<td>Significant</td>
</tr>
<tr>
<td>SHIJA</td>
<td>Esp. west coast</td>
<td>Significant</td>
</tr>
<tr>
<td>SHIJA</td>
<td>Esp. Port Vila and villages</td>
<td>Significant</td>
</tr>
<tr>
<td>TORBA</td>
<td>Vaha Lava, Soia</td>
<td>Highlighted</td>
</tr>
<tr>
<td>VANUATU</td>
<td>Espiritu Santo, west coast</td>
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<tr>
<td>MALAMPA</td>
<td>Sea area between Espiritu, Esp. and Ambry</td>
<td>Highlighted</td>
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<tr>
<td>SHIJA</td>
<td>South of Mateva island</td>
<td>Highlighted</td>
</tr>
<tr>
<td>SHIJA</td>
<td>Esp. north-west coast</td>
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<tr>
<td>TAFE</td>
<td>Tamboi, Lémalal</td>
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<tr>
<td>TAFE</td>
<td>Ambry (Mystery Island)</td>
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<tr>
<td>TORBA</td>
<td>Buka Reef and Misc🇷 substantive, Long Bay</td>
<td>Moderate</td>
</tr>
<tr>
<td>PENAMA</td>
<td>Penecost, Waqa Bay</td>
<td>Moderate</td>
</tr>
<tr>
<td>SHIJA</td>
<td>Esp. Upinui Bay and Post Luganville</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Vanuatu Zoom - Efaté
Tonga Cruise Ships

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Tonga Zoom
Nuku’akofa

28th May 2014

MARICO MARINE

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Cooks
Result
Track
Density
Cooks
Results
Add a Financial Layer......

Plot of +Ve Cost Benefit

For Charting Update
Summary

- Risk assessments become much more powerful when they can access multiple data sources;
- GIS can improve risk assessments using data driven scientific analysis;
- GIS can readily communicate complex results.
Thanks for Listening!

John Riding
Andrew Rawson

28th May 2014