

# Developing Decision Support Tools for Offshore and Nearshore Marine Operations

**Matthew Zed – Snr Metocean Engineer**  
**Grant Elliott – Chief Metocean Meteorologist**

| July 2017



# Disclaimer and important notice



This presentation contains forward looking statements that are subject to risk factors associated with oil and gas businesses. It is believed that the expectations reflected in these statements are reasonable but they may be affected by a variety of variables and changes in underlying assumptions which could cause actual results or trends to differ materially, including but not limited to: price fluctuations, actual demand, currency fluctuations, drilling and production results, reserve estimates, loss of market, industry competition, environmental risks, physical risks, legislative, fiscal and regulatory developments, economic and financial market conditions in various countries and regions, political risks, project delay or advancement, approvals and cost estimates.

All references to dollars, cents or \$ in this presentation are to US currency, unless otherwise stated.

References to “Woodside” may be references to Woodside Petroleum Ltd. or its applicable subsidiaries.

Safety Moment

Introduction – Decision Support Tool Essentials

Being a Metocean Engineer at Woodside

Key Concerns for the Industry

Developing Decision Support Tools

Accurate vs. Effective Forecasting

Where We Are Now

[Case Study – Tropical Cyclone Dashboard Development Process](#)

Where are we Heading

# Safety Moment - El Faro

El Faro - A 700 foot liberty ship based in Jaxsonville was en-route to Puerto Rico

33 Crew on board

Vessel due to arrive in San Juan at 5:00pm Friday October 2<sup>nd</sup>

Vessel sailed into the path of Hurricane Joaquin

At 7:00am on Thursday the vessel, in the cusp of a category 4 Hurricane, the vessel lost power and began taking on water

Shortly after the vessel sank

None of the crew survived

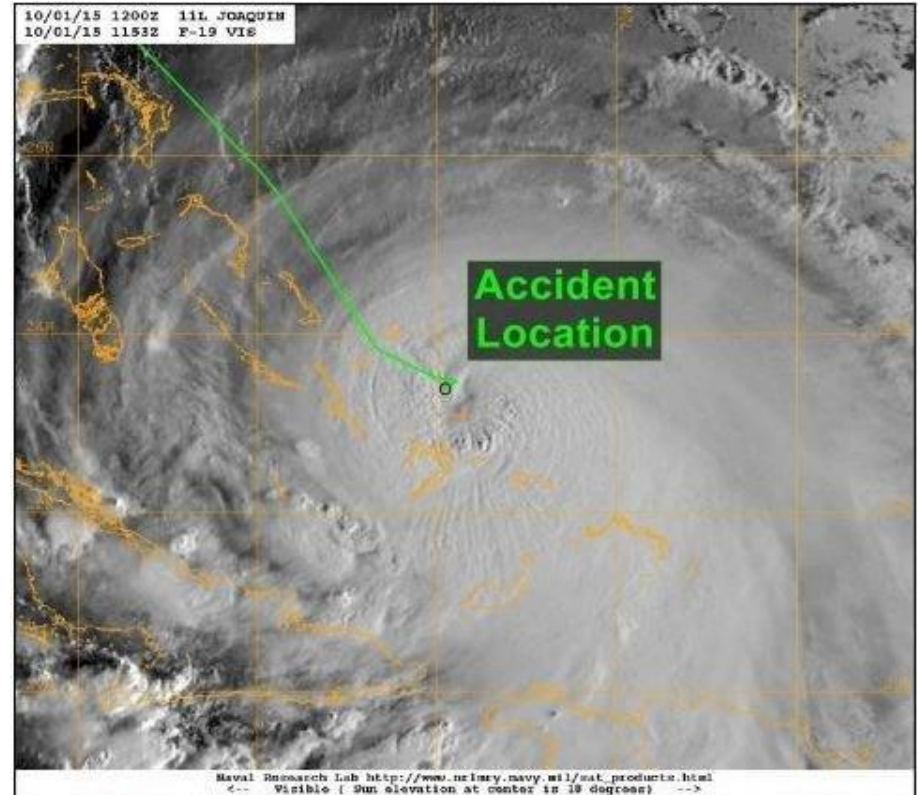
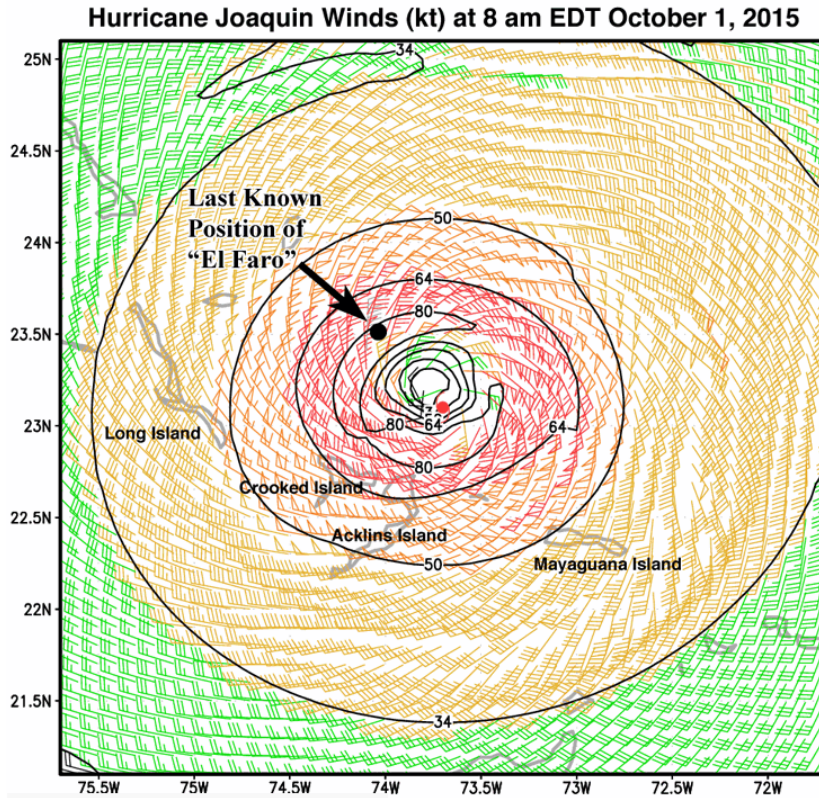




# Safety Moment - EL Faro



# Safety Moment - EL Faro



## \$7M lawsuit targets weather company for sinking of El Faro

Several insurance companies are suing a company that provides weather forecasting services, claiming one of the company's products is to blame for the sinking of the cargo ship El Faro.

The suit, filed in Florida federal court, alleges the Bon Voyage System version 7 (BVS 7), used by El Faro, "provided **delayed, inaccurate, and misleading information** the Vessel about the position of the storm and was a substantial factor in the Vessel sailing nearly directly into the eye of the hurricane."

Source: <http://wgme.com/news/i-team/7m-lawsuit-targets-weather-company-for-sinking-of-el-faro>

## NTSB Recommendations Aimed at Getting Better Weather Information to Mariners

The National Transportation Safety Board issued 10 safety recommendations aimed at **enhancing the availability** of weather information to mariners after it was revealed that critical tropical cyclone information issued by the NWS is not always available to mariners via well-established broadcast methods.

Further, factual data on the official forecasts for Hurricane Joaquin and other recent tropical cyclones suggest that a new emphasis on improving hurricane forecasts is warranted.

Source: <https://www.nts.gov/news/press-releases/Pages/pr20170629.aspx>

An effective decision support tool must:

- Provide timely information
- Provide effective information (multiple sources, accurately defines risk)
- Meet the needs and capabilities of the customer
- Be accessible to all key stakeholders
- Be reliable (consider failure modes?)
- Be auditable (enable interrogation by an expert)



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# Woodside Metocean Team



**Grant Elliott**  
Chief Metocean Meteorologist

3Yrs Woodside



**Matthew Zed**  
Senior Metocean Engineer

3Yrs Woodside



**Alessio Mariani**  
Metocean Engineer

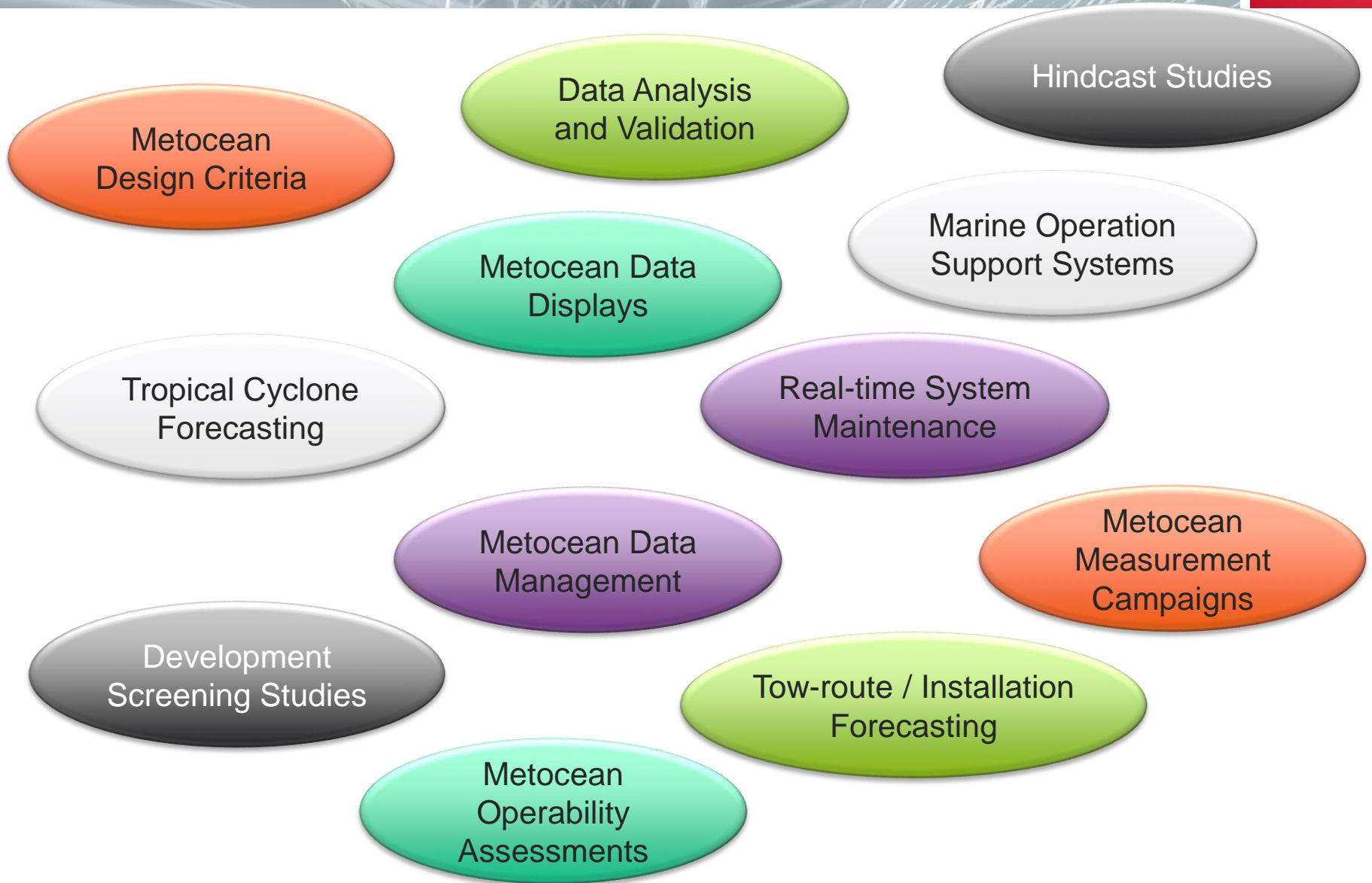
2Yrs Woodside



**Ron Hille**  
Senior Metocean Forecaster

Casual

# Focus areas for a Metocean Engineer at Woodside



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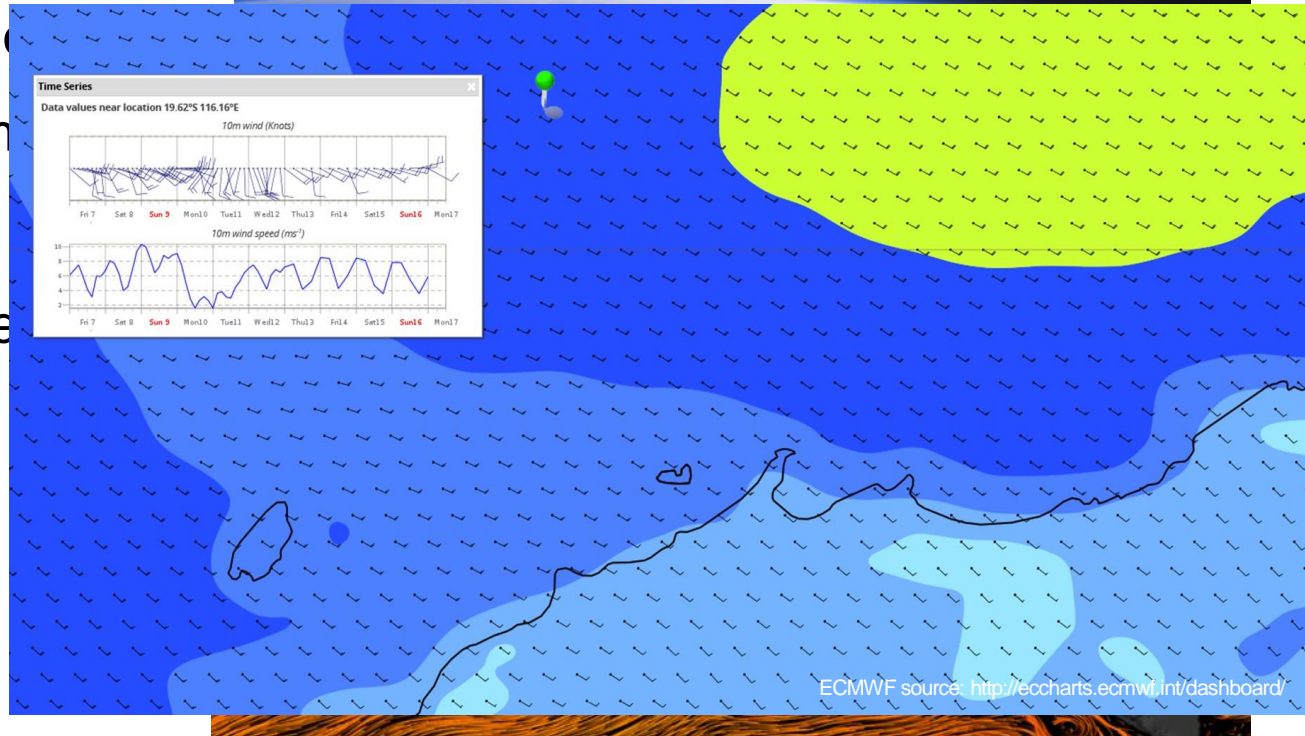
[Case Study – Tropical Cyclone Dashboard Development Process](#)

Where are we Heading



## Key Inclement Metocean Concerns

- Tropical Cyclones
- Squalls
- Persistent strong winds (non-TC)
- Excessive rainfall / ice
- Swells (large and small)
- Eddies
- Solitons / shelf currents



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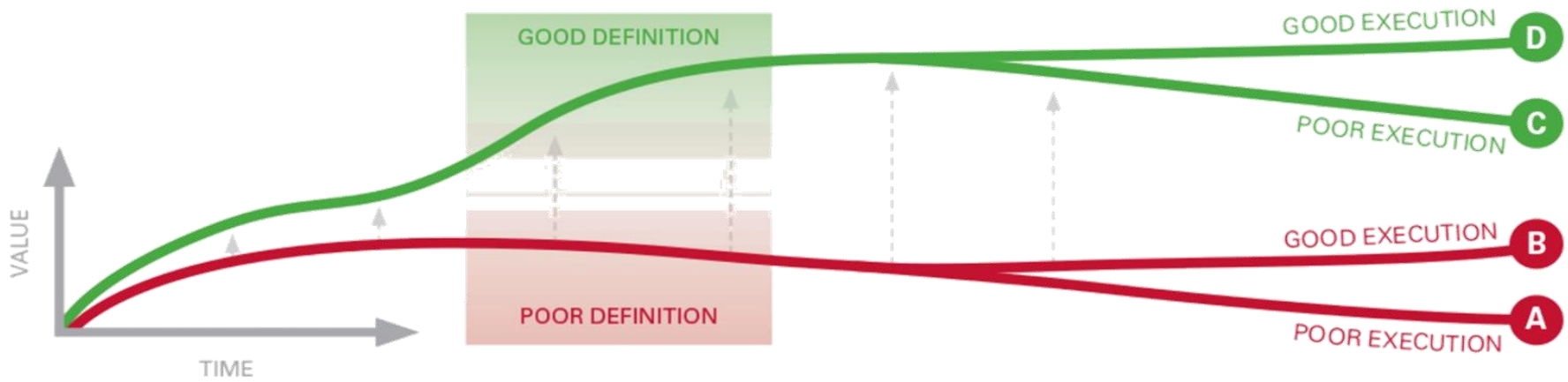
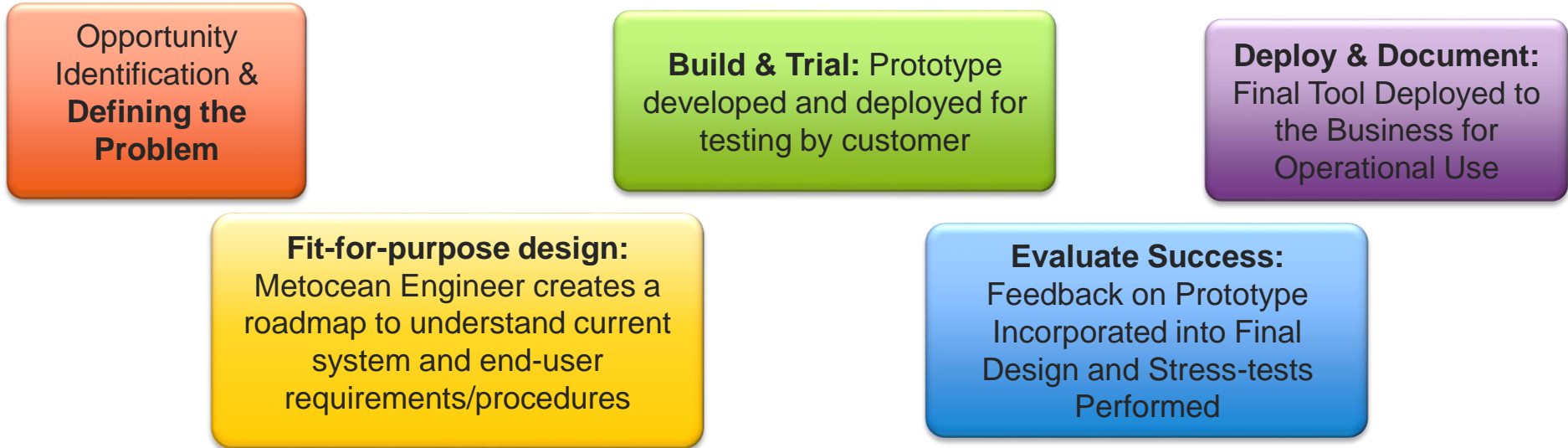
[Case Study – Tropical Cyclone Dashboard Development Process](#)

Where are we Heading

# Developing Decision Support Tools – The Process

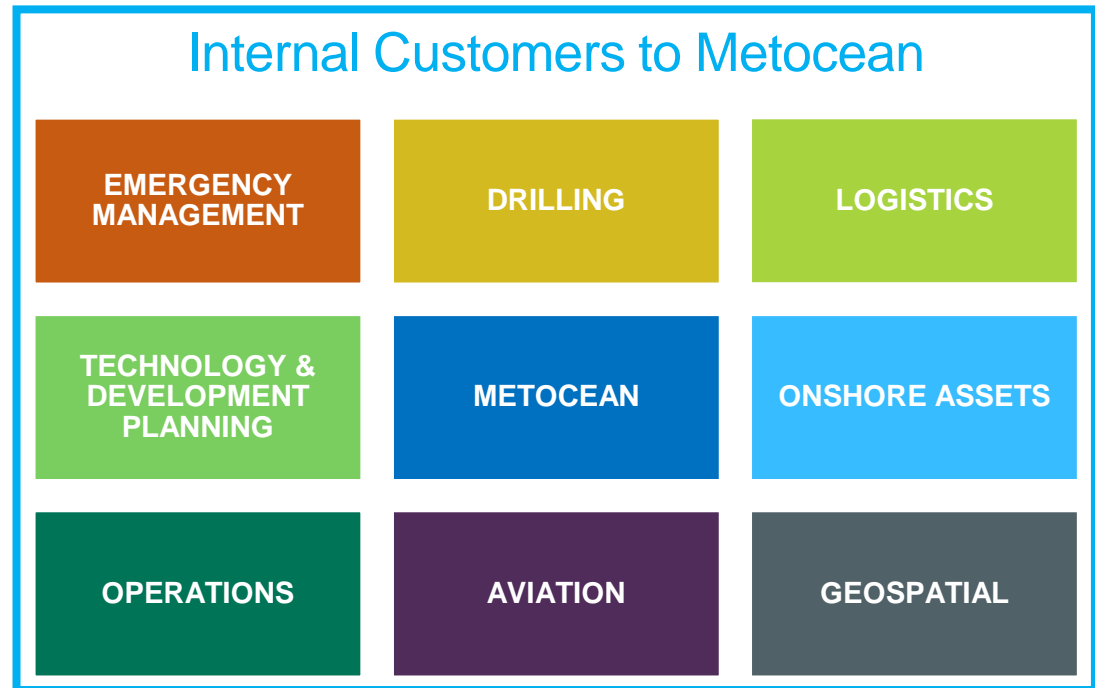


No Need to reinvent the Wheel > Utilise Woodside's Project Delivery Process



## Understanding The Customer:

1. Their metocean tolerances and response procedures
2. Accuracy requirements i.e. their acceptable level of uncertainty
3. Required forecast horizon
4. Communication Platforms
5. Expertise of the end-user





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# Accurate vs. Effective Forecasting

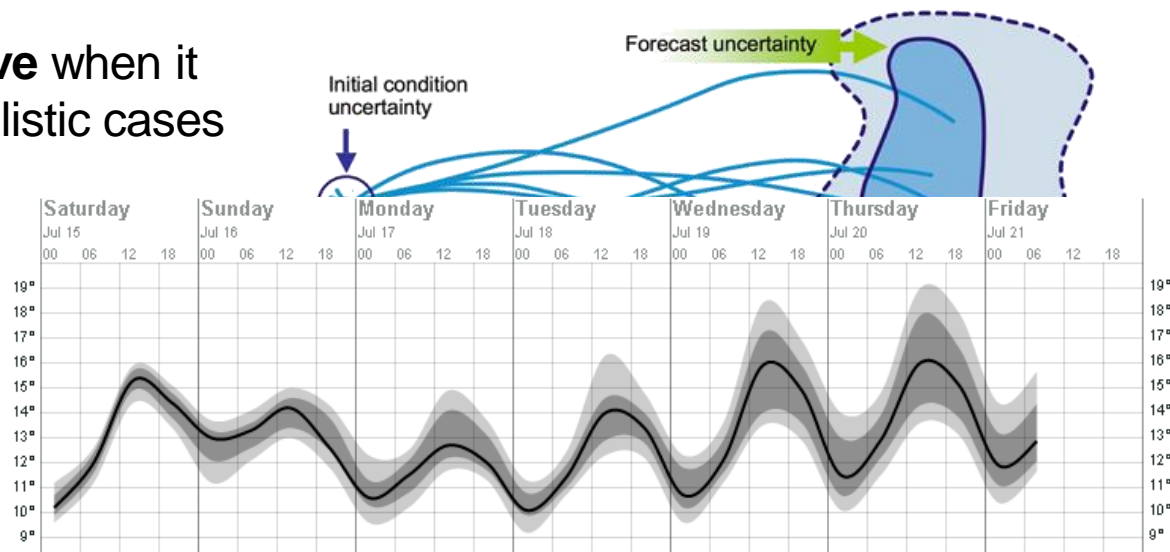
Many operators rely on deterministic guidance only i.e. forecast providing single most detailed estimate of future conditions (P50)

Integrity (**accuracy**) of the forecast is challenged when the outcome differs from the forecast > Forecaster tries to capture this with an uncertainty estimate

Uncertainty estimate generally based on past performance (forecast vs. actual) or climatology, which doesn't capture "physically" plausible future conditions from the current systems state

Forecast becomes **less effective** when it captures these physically unrealistic cases

**Solution =  
ensemble-based approach**



Source: <https://www.yr.no/place/Norway/Hordaland/Bergen/Bergen/long.html>

# Accurate vs. Effective Forecasting

Rather than using a single (deterministic) forecast run, forecasts make use of multiple ensemble forecasts which investigate the space of possible outcomes from a given initial state (nowcast).

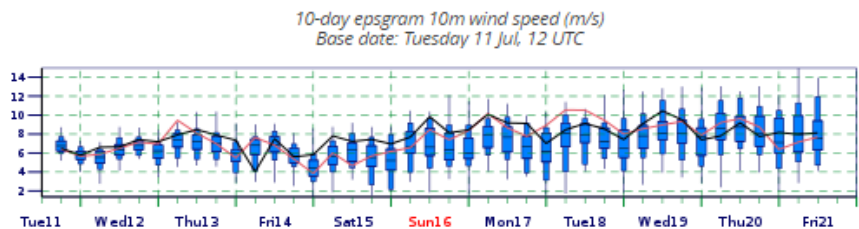
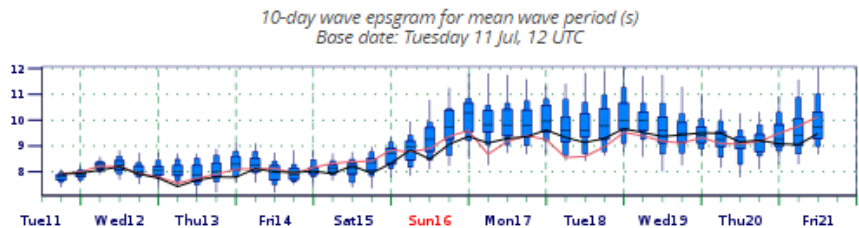
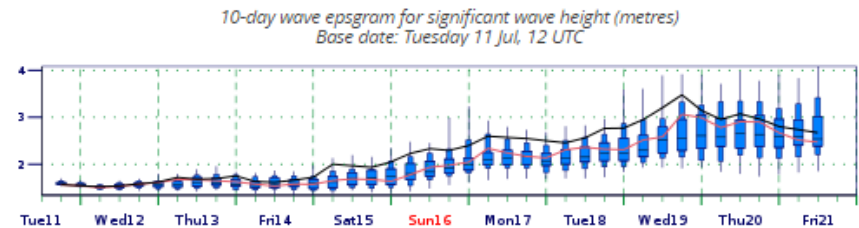
Ensemble spread is used to define the range of potential future conditions (hence quantify uncertainty based on current system state)

High spread = low confidence = less predictable future state

Low spread = high confidence = more predictable future state

**Customer can apply their risk acceptance to this spread**

(Generally expressed as % of ensemble exceedances above tolerance)



ECMWF source: <http://eccharts.ecmwf.int/dashboard/>

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Decision Support Tools Currently in Operation

Applying ensemble-based forecasting for TC/Non-TC conditions

Tropical Cyclone Dashboard

Case Study – Tropical Cyclone Dashboard Development Process

ROWSv2

# Metocean Decision Support Tools at Woodside



## Environmental Monitoring System

- ROWS
- Moorin
- Facility
- Tropical
- Tropical
- Vessel

**Legend**

- NJEMS - Ngujima Yin FPSO
- NGEMS - Nghanhurra FPSO (Enfield)
- WEMS - Okha FPSO
- AEMS - Angel Platform
- PEM - Pluto Platform
- GEMS - Goodwyn Platform
- REMS - North Rankin Complex
- MEMS - Mooring Land and Environmental Monitoring
- Directional Waverider

### TROPICAL CYCLONE FORECAST

Forecast No. 1 for 15U  
Issue Time: 0925 Mon 06 Feb 2017 WST  
Next Issue: 2125 Mon 06 Feb 2017 WST

Discussion Prepared for Woodside  
Issued by Matt Boterhoven  
Contact Phone 08 9263 2205

**Tropical Low 15U large degree of uncertainty in the forecast**

Details at	0800 WST Mon 06 Feb 2017
Cyclone Name	15U
Severity Category	Below TC Intensity
Max Winds Forecast	15 gusting to 35 kn
Upper Bound Winds	20 gusting to 45 kn
Central Pressure	996 hPa
Recent Movement	W 16 kn
Location	16.3S 124.2E
Location Accuracy	Accurate within 90 nm
Radius to Gales	-

**Forecast Commentary**

The system has been located with surface observations but there is a low confidence in the analysis position as the system is still very weak. By Tuesday most models agree that the tropical low will be developing over waters north of the Pilbara. By Wednesday morning the system is likely to be located north of the Pilbara coast in a favourable environment for development. There is a large amount of uncertainty in the model guidance, both in system track and development. The system is likely to move west or southwest due to the mid-level steering flow associated with an upper high over based over the continent. Regardless of the development of the system, gales may be possible in eastern quadrants aided by the active monsoonal surge, and may extend onto the Pilbara coast between Pardoo and Cape Preston. Some guidance has the system crossing the coast near Port Hedland late Wednesday. In this scenario the system is unlikely to reach tropical cyclone intensity. During Thursday the system could be developing very close to the coast between Karratha and Exmouth. There is a chance that the system could reach tropical cyclone intensity. However, even if the system does not become a tropical cyclone, it is possible that gales could extend through the eastern quadrants and be felt over parts of the coast between Karratha and Exmouth. Some recent model guidance has the system crossing the coast in the Exmouth Gulf. The system is likely to be limited to a category 1 system, given the likely forecast speed and movement of the system. By Friday models generally agree on the system moving to the west of Carnarvon, and tracking southwestwards over open waters. Note: There is a large degree of uncertainty in the forecast as present.

Lead Time	Date/Time	Lat	Lon	Position Accuracy (nm)	Speed of Movement (knots)	Central Pressure (hpa)	Cat	Forecast Maximum Winds (knots)	Upper Bound (knots)	Gale Radii (nm)	NE	SE	SW	NW
+00hr	0800 Mon 06 Feb	16.3S	124.2E	90	16	996	L	15 gusting to 35	20 gusting to 45	-	-	-	-	
+06hr	1400 Mon 06 Feb	16.8S	123.4E	90	9	996	L	15 gusting to 45	25 gusting to 45	-	-	-	-	
+12hr	2000 Mon 06 Feb	17.2S	122.7E	90	8	994	L	20 gusting to 45	30 gusting to 45	-	-	-	-	
+18hr	0200 Tue 07 Feb	17.5S	121.7E	95	10	992	L	25 gusting to 45	30 gusting to 45	-	-	-	-	
+24hr	0800 Tue 07 Feb	17.7S	120.7E	100	10	990	L	25 gusting to 45	30 gusting to 45	-	-	-	-	
+30hr	1400 Tue 07 Feb	18.2S	119.9E	105	9	987	L	25 gusting to 45	30 gusting to 45	-	-	-	-	
+36hr	2000 Tue 07 Feb	18.7S	119.2E	105	8	987	L	25 gusting to 45	35 gusting to 50	-	-	-	-	
+42hr	0200 Wed 08 Feb	19.0S	118.6E	110	7	985	L	30 gusting to 45	40 gusting to 55	-	-	-	-	
+48hr	0800 Wed 08 Feb	19.3S	118.0E	115	6	983	L	35 gusting to 50	40 gusting to 55	130	130	130	130	
+60hr	2000 Wed 08 Feb	20.1S	116.9E	140	7	983	L	35 gusting to 50	45 gusting to 65	130	50	-	-	
+72hr	0800 Thu 09 Feb	21.6S	115.1E	165	11	980	I	40 gusting to 55	45 gusting to 65	100	50	-	70	
+84hr	2000 Thu 09 Feb	23.3S	113.2E	200	12	983	L	35 gusting to 50	40 gusting to 55	50	50	-	-	
+96hr	0800 Fri 10 Feb	24.6S	111.5E	280	10	983	L	35 gusting to 50	40 gusting to 55	-	130	130	-	
+108hr	2000 Fri 10 Feb	26.1S	110.8E	300	8	983	L	35 gusting to 50	40 gusting to 55	-	100	150	-	
+120hr	0800 Sat 11 Feb	27.4S	110.1E	340	7	987	L	35 gusting to 50	40 gusting to 55	150	150	150	150	

FOR ANY QUERIES OR ISSUES CONTACT  
CLICK HERE TO VIEW HISTORY

© 2013 RPS MetOcean Pty Ltd

# Where are We Now – Ensemble-based forecasting



Likelihood of exceedance of nominated threshold values (%)

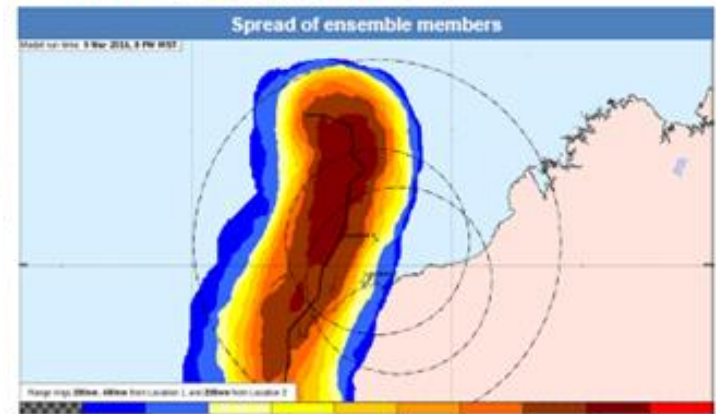
WST, 12 hour period starting	Tue 27 Jun 21:00	Wed 28 Jun 09:00	Wed 28 Jun 21:00	Thu 29 Jun 09:00	Thu 29 Jun 21:00	Fri 30 Jun 09:00	Fri 30 Jun 21:00	Sat 01 Jul 09:00	Sat 01 Jul 21:00	Sun 02 Jul 09:00	Sun 02 Jul 21:00	Mon 03 Jul 09:00	Mon 03 Jul 21:00	Tue 04 Jul 09:00
10m wind speed ≥25 kn	80	80	92	92	4	8	0	4	16	24	0	0	0	0
10m wind speed ≥35 kn	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Sig wave height ≥3.0 m	0	76	84	100	0	2	0	0	0	0	0	2	0	2
Sig wave height ≥5.0 m	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Key: Very Low Less than 5% Low 5% to less than 20% Moderate 20% to less than 50% High 50% or more

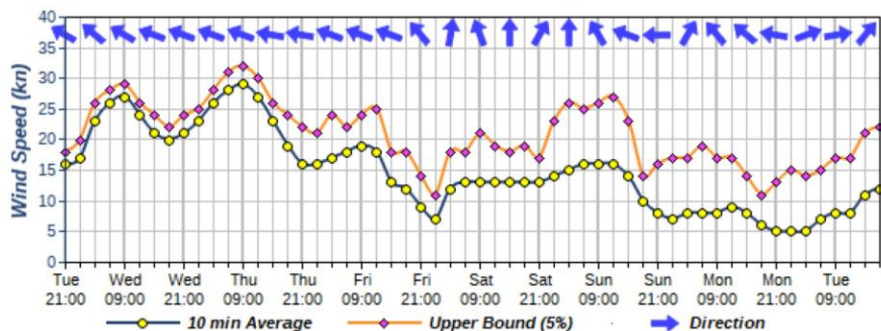
## Computer Model Tropical System Forecast

Issue Time: 0600 Thu 28 Nov 2013 WST Next issue: 1600 Thu 28 Nov 2013 WST

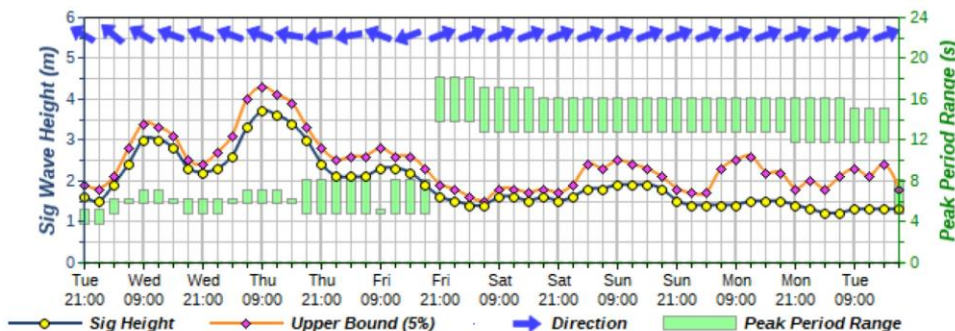
Contact Phone 08 9999 9999



10m wind speed



Total significant wave height



Graphics courtesy of Aust. Bureau of Meteorology

# Tropical Cyclone Dashboard



## TROPICAL CYCLONE DASHBOARD

BY CRITERIA	BY ASSET
<b>Gales (&gt; 34kn)</b>	

3 DAY HISTORY

◀	-72 hr	-60 hr	-48 hr	-36 hr	-24 hr	-12 hr	0 hr (Current)	▶
---	--------	--------	--------	--------	--------	--------	----------------	---

Asset:	Risk Criteria:	07 Tue				08 Wed				09 Thu				10 Fri				11 Sat				12 Sun			
		0-6	6-12	12-18	18-24	0-6	6-12	12-18	18-24	0-6	6-12	12-18	18-24	0-6	6-12	12-18	18-24	0-6	6-12	12-18	18-24	0-6	6-12	12-18	18-24
OKHA	Gales (> 34kn)			16	53	61	67	80	65	35	10	2													
NRC	Gales (> 34kn)			8	45	51	59	71	65	43	14	2													
GWA	Gales (> 34kn)			8	45	51	59	71	65	43	14	2													
KGP	Gales (> 34kn)			10	20	49	65	80	65	47	14	2													
NY	Gales (> 34kn)						2	25	51	65	53	33	12	4											
NG	Gales (> 34kn)						2	25	51	65	53	33	12	4											

LEGEND	
<span style="background-color: #008000; width: 15px; height: 10px; display: inline-block;"></span>	No Risk 0%
<span style="background-color: #90EE90; width: 15px; height: 10px; display: inline-block;"></span>	Very Low 1% - 5%
<span style="background-color: #FFD700; width: 15px; height: 10px; display: inline-block;"></span>	Low 5% - 20%
<span style="background-color: #FF4500; width: 15px; height: 10px; display: inline-block;"></span>	Moderate 20% - 50%
<span style="background-color: #FF0000; width: 15px; height: 10px; display: inline-block;"></span>	High 50% - 100%
<span style="background-color: #FFDAB9; width: 15px; height: 10px; display: inline-block;"></span>	Morning (0:00 - 12:00)
<span style="background-color: #ADD8E6; width: 15px; height: 10px; display: inline-block;"></span>	Afternoon/Night (12:00 - 24:00)

**REMEMBER:**

**WE ARE HERE FOR THE LONG TERM. WE LOOK AFTER EACH OTHER, OUR COMMUNITIES AND THE ENVIRONMENT. WE KEEP EACH OTHER SAFE.**

DATA PROVIDED BY THE BUREAU OF METEOROLOGY, DERIVED FROM 51 ENSEMBLE ECMWF MODEL RUNS. [CLICK HERE FOR MORE INFORMATION.](#)

FOR ANY QUERIES OR ISSUES CONTACT \_\_\_\_\_

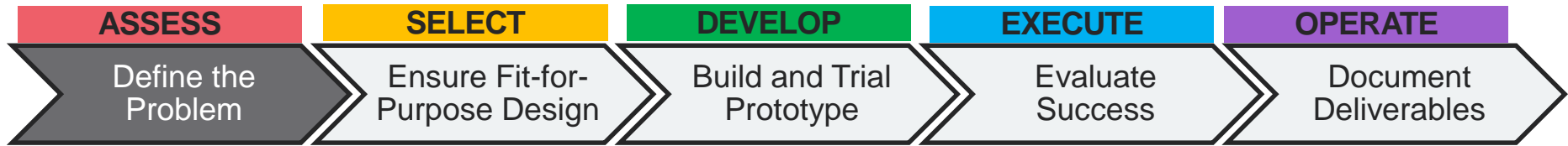
[CLICK HERE TO VIEW HISTORY](#)

Last Issued:	Model Base Time:
21/12/2016 06:00 WST	20/12/2016 18:00 WST
<a href="#">Get PDF</a>	
<a href="#">View History</a>	

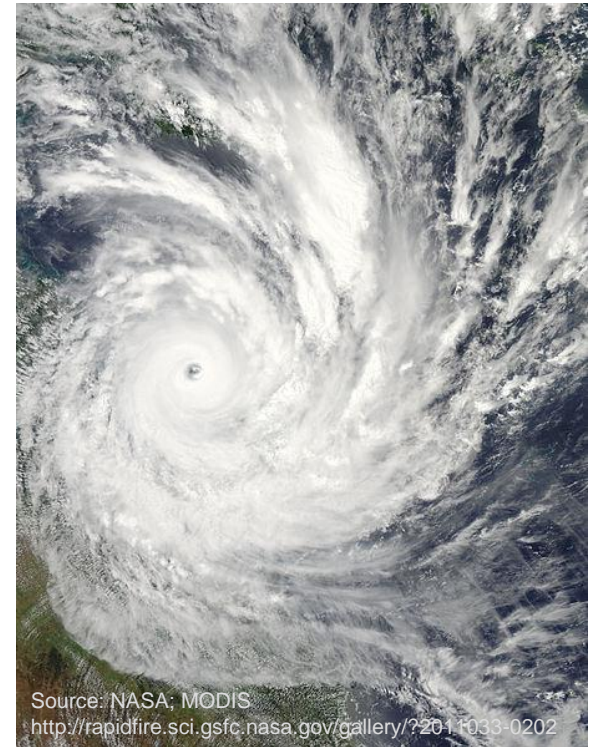
Let's look at the Tool Development Process as it was applied to this scenario ...

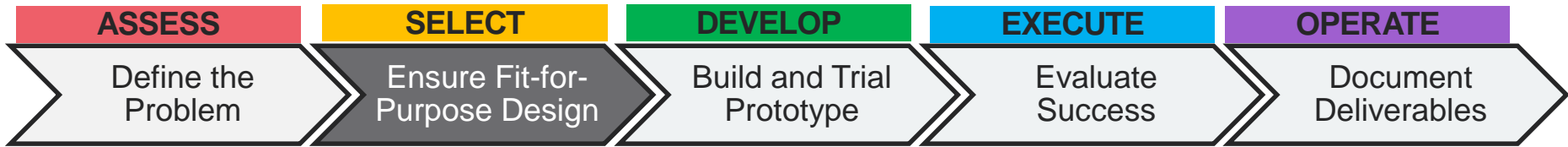


# Tropical Cyclone Dashboard – Problem Definition



*Design a tool that can be used to report on tropical cyclone risk to assets in the North West Shelf and effectively inform Woodside decision makers.*





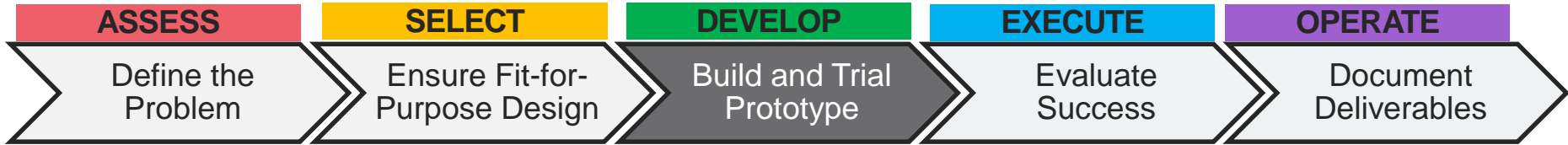
- Identify & interview key stakeholders
- Collect requirements & additional information
- Manage Scope

## A Collaborative Approach





# Tropical Cyclone Dashboard – Prototype Development



- Prototype trialled by a select user-group
- Preliminary output distributed to key stakeholders under test conditions
- Feedback sought and recorded

## TROPICAL CYCLONE DASHBOARD

BY CRITERIA	BY ASSET	
Gales (> 34kn)		▼

Asset:	Risk Criteria:	06 Mon			
		0-6	6-12	12-18	18-24
OKHA	Gales (> 34kn)				2
NRC	Gales (> 34kn)				
GWA	Gales (> 34kn)				
KGP	Gales (> 34kn)				2
NY	Gales (> 34kn)				
NG	Gales (> 34kn)				

BY CRITERIA	BY ASSET	
OKHA		▼

Asset:	Risk Criteria:	06 Mon			
		0-6	6-12	12-18	18-24
OKHA	Gales (> 34kn)				2
OKHA	Hurricane (> 64kn)				
OKHA	Waves (> 3m)			2	6
OKHA	Waves (> 5m)				









# Tropical Cyclone Dashboard – Evaluation



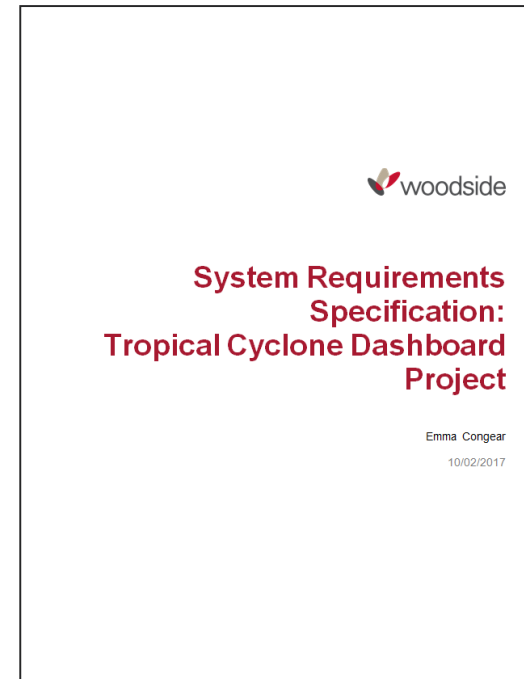
“For me the value in the simply tabular format is that it **quickly** and **concisely communicates** the range of outcomes we should plan for when run against a number of criteria (for example 3, 5, 7m waves) or against a single criteria which may be a trigger point for disconnect, down man, shutdown etc. It addresses what can be a tendency to be somewhat blinkered when reviewing deterministic forecast tools” – Woodside Operator



# Preparing for the Next Cyclone Season



- Document dashboard design
- Record stakeholder feedback
- Obtain final approval from Operations Lead and SMEs
- Operationalise system on real-time infrastructure



Applying ensemble-based forecasting for TC/Non-TC conditions

Tropical Cyclone Dashboard

Case Study – Tropical Cyclone Dashboard Development Process

**ROWSv2**

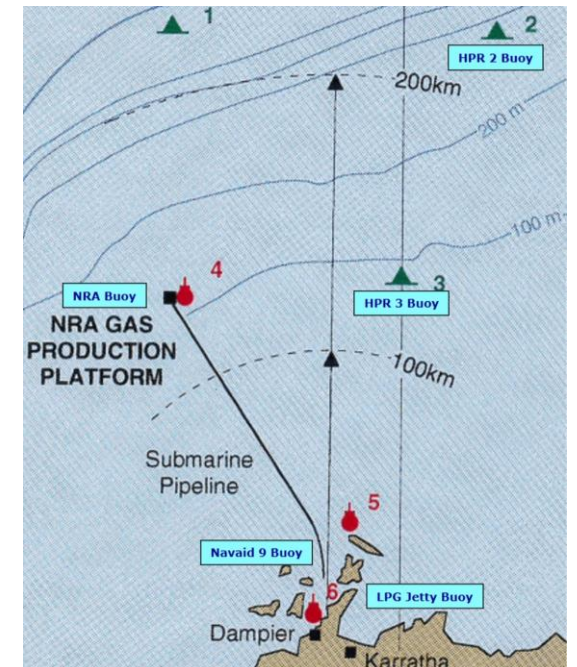
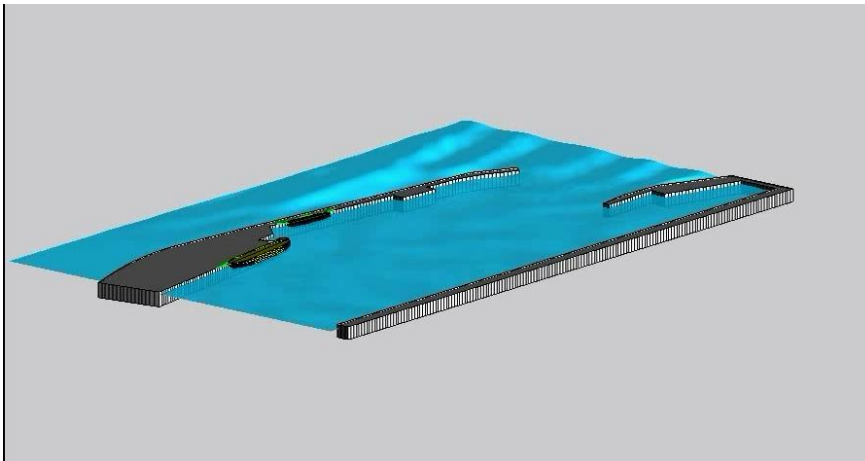
## Swell Forecasting across NW Shelf

Woodside ROWS employed by KGP Marine Operations since late 1980's

System effective during certain Tropical Cyclone conditions, however, accuracy in capturing critical swells limited due to lack of available measurements upstream

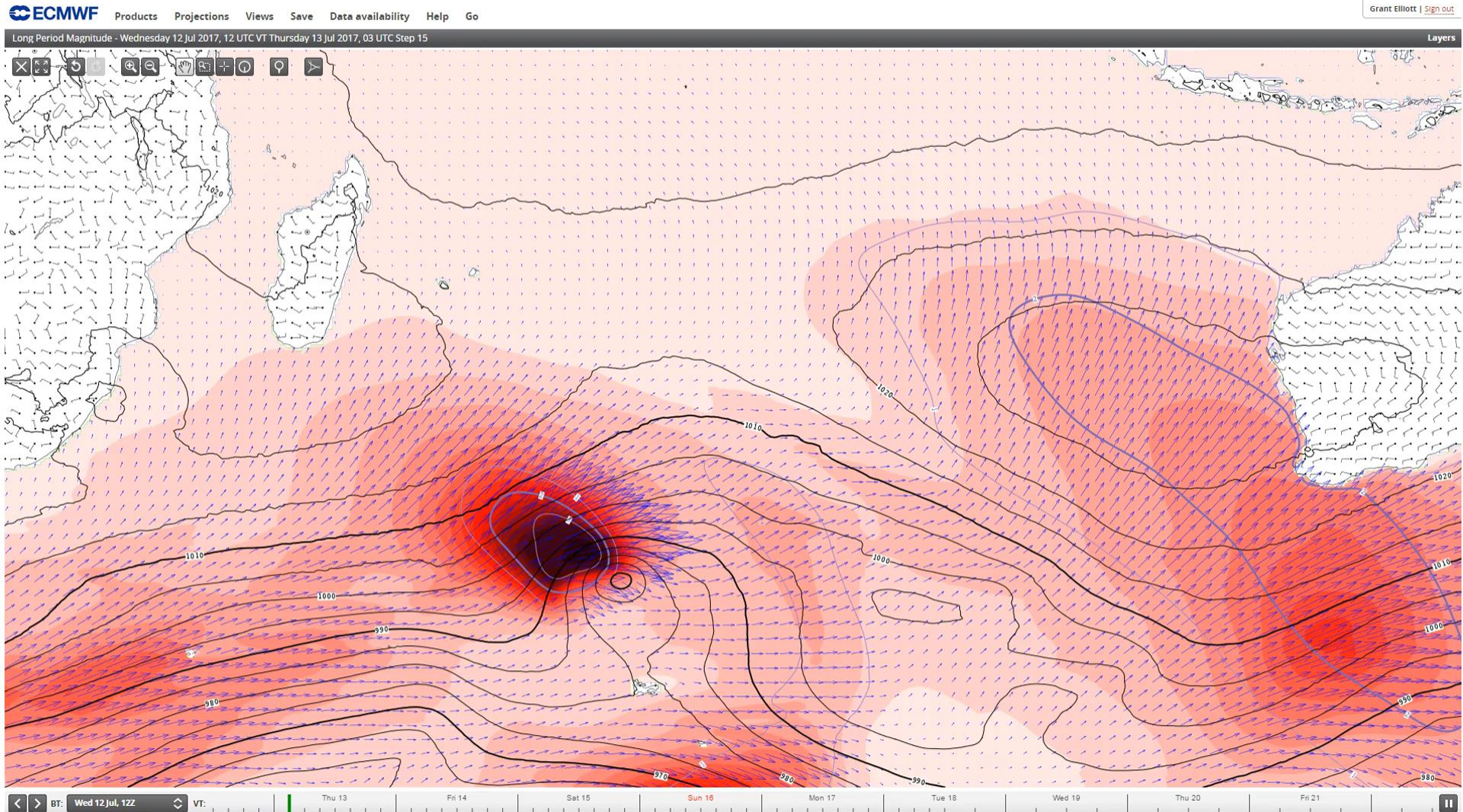
Large southern ocean swells responsible for mooring line failures at KGP Berths **AND** critical parameter during sensitive offshore operations (topside and pipe installation, landing BOP's etc.)

Required expansion of system to capture swell propagation across the NW Shelf





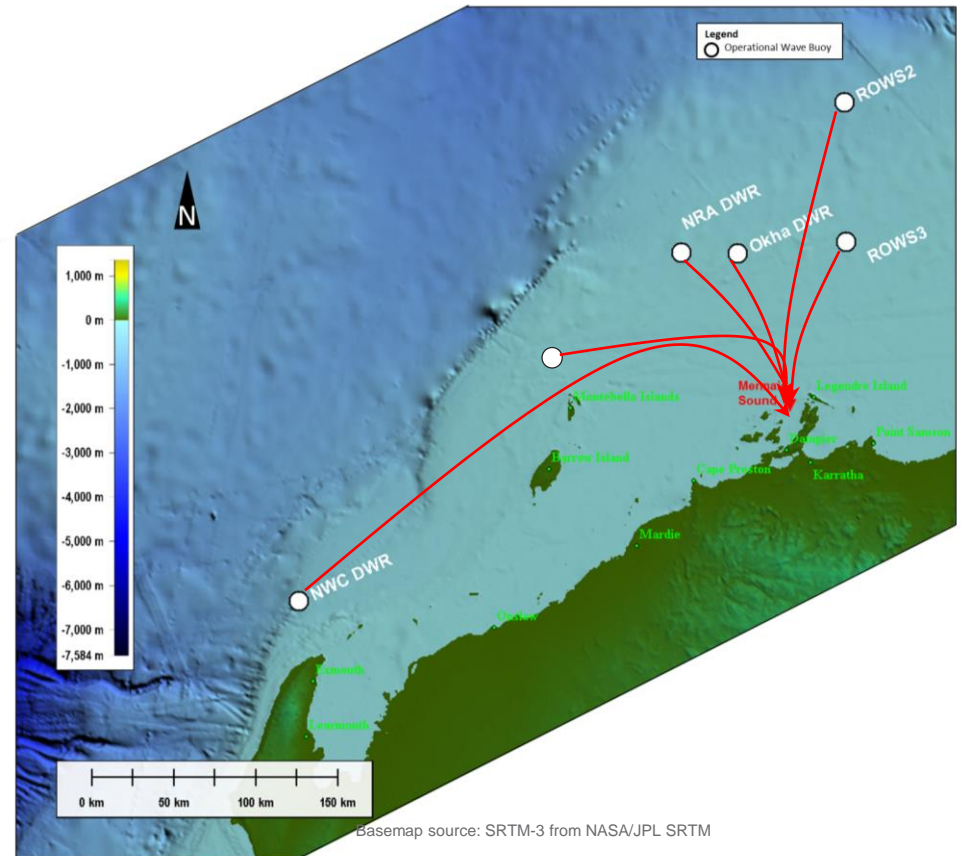
# Swell Source for NW Shelf



**GOOD (CURRENT)** – Offshore wave transformation for early Tropical Cyclone swell warning for KGP Maine Operations

**BETTER (2016 Update)** – Expansion of tool to incorporate southern ocean swell and improved berth operability curves

**BEST (2017 Update)** – Increase forecast locations, improved reliability through cost-effective redundancy and expansion of tool to provide swell forewarning for multiple locations on the NW Shelf





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Where are we Heading



Digital forecast displays with user-group optimisation

Motion-based forecasts and heading optimisation

# Digital Forecast Displays – User-based Optimisation



North Rankin, WNRC FORECASTS

FORECASTS OBSERVATIONS ALERTS

July 13 2017 7:00 AM

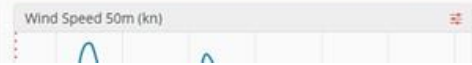
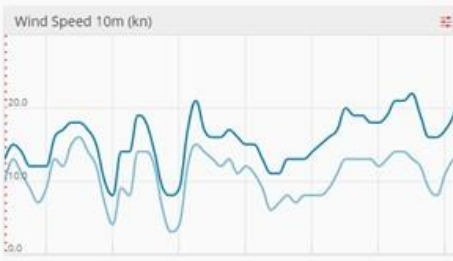
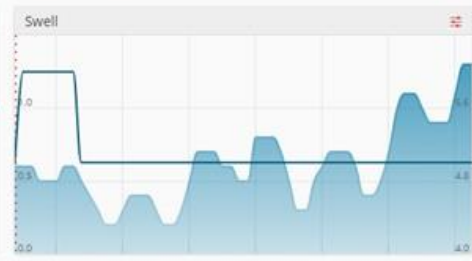
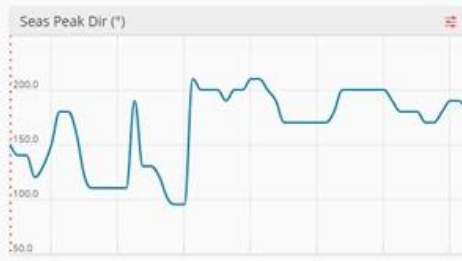
E/SE morning surges expected on Thursday through Sunday, reaching to between 12-18kts.

With a high pressure system building over central WA expect a surge in E'ly winds each morning expected over the next few days, likely to be between 12-18kts.

Winds may ease from early next week as another significant cold front impacts the southwest corner of the state, eroding the E'ly gradient over the Pilbara and offshore waters. A moderate long-period swell is forecast to move up the west coast peaking at your location later on Friday and early Saturday morning, although significant wave heights will remain below 2.0m. The next long period swell pulse onsets on Sunday and peaks on Tuesday.



**Confidence:** High  
**Precis:** Sunny. VIS 0600-1800WST: 10km+.  
**SST:** 25  
**Sunrise:** 06:50  
**Sunset:** 17:52  
**Wind Wave AM:** Mean winds 2/10 knots-br>Total waves 0.7-0.8 m  
**Wind Wave PM:** Mean winds 7/13 knots-br>Total waves 1.1-1.2 m



Filter... x

Data

Data Query.

Forecasts

Return Site list

Inventory

Return forecast fields for a Site.

## Forecast API

Documentation for accessing forecast data

0.3.0

### Data

#### Data - Data Query.

0.2.0

**GET**

```
/api/forecasts/data
```

Usage examples:

```
curl -X GET -H "Authorization: <TOKEN String>" "http://<Site Address:Port number>/api/forecasts/data?site=WORN&field=%s"
curl -X GET -H "Authorization: <TOKEN String>" "http://<Site Address:Port number>/api/forecasts/data?site=WORN&field=%s"
curl -X GET -H "Authorization: <TOKEN String>" "http://<Site Address:Port number>/api/forecasts/data?site=WORN&field=%s"
```

#### Header

Field	Description
Authorization	Basic Access Authentication token.

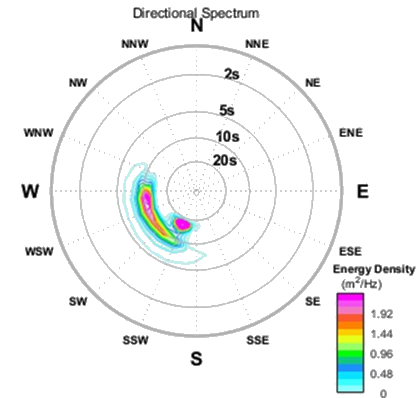
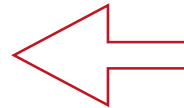
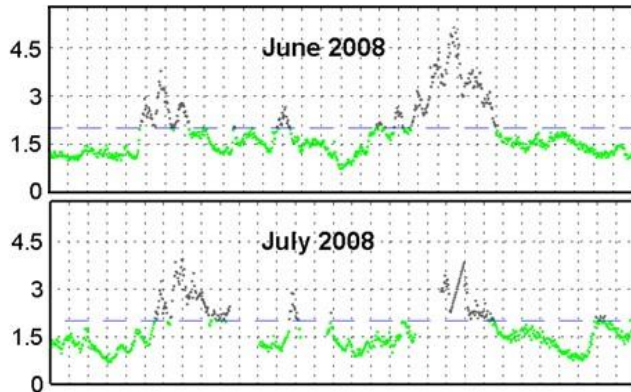
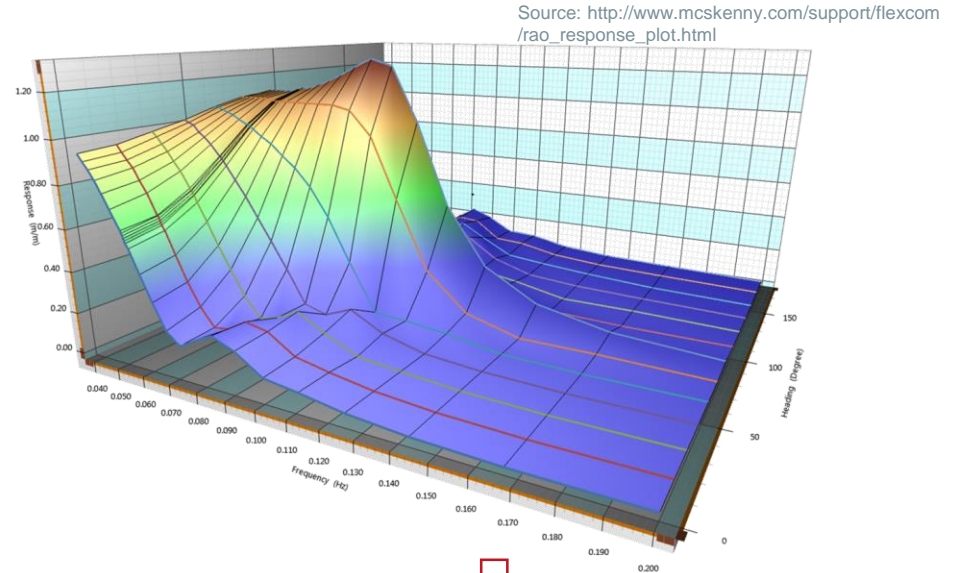
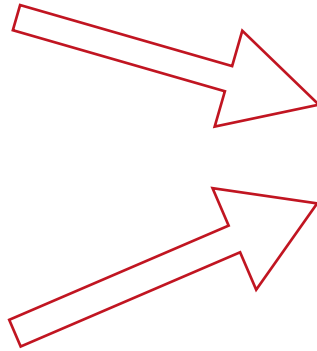
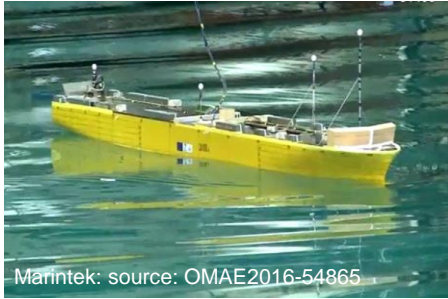
#### Parameter

Field	Type	Description
site	String	String identifying sitecode
field	String	Measurement field url encoded JSON Object String Array, where each array element is a string. Requires at least one string in JSON array.
s	String	Start-time string (ISO 8601 date YYYY-MM-DD) or (date shorthand syntax [-]?[d]*[WwDdMm])
e	<b>optional</b> Object	End-time string (ISO 8601 date YYYY-MM-DD) (date shorthand syntax [-]?[d]*[WwDdMm])

#### Success 200

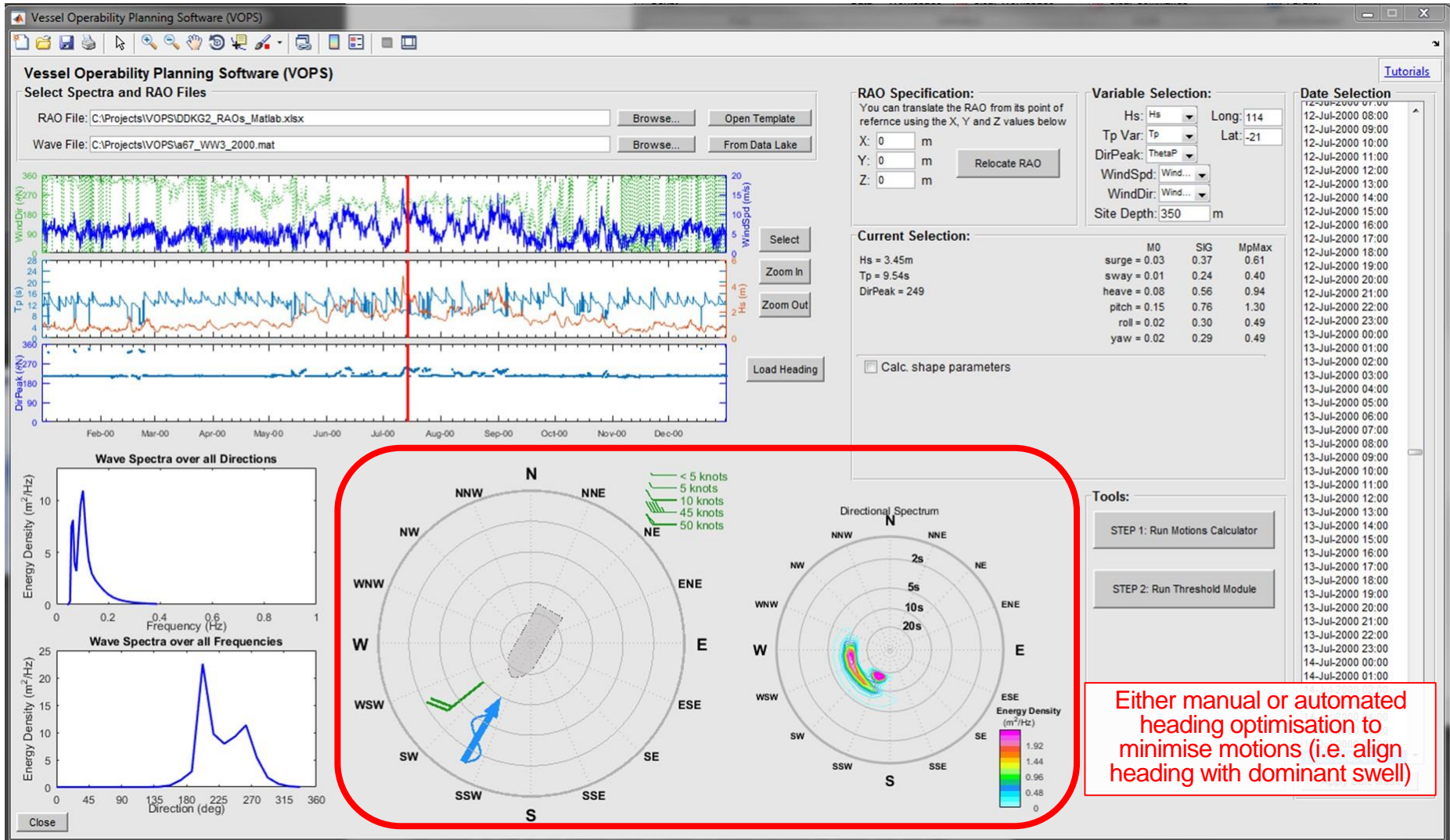
Field	Type	Description
-------	------	-------------

# Motion Operability Module – Simple Theory





# Motion Operability Module – User Interface



# Motion Operability Module – Campaign Planning



## Weather Window – Sustained 36hr period below limits shown

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Heave 1.5m	49%	57%	52%	51%	46%	45%	44%	37%	42%	51%	50%	59%	58%
Heave 2.0m	61%	68%	65%	64%	56%	59%	55%	50%	55%	60%	62%	70%	68%
Heave 2.5m	66%	69%	69%	69%	60%	64%	61%	57%	60%	65%	67%	75%	72%
Heave 3.0m	67%	70%	71%	70%	62%	67%	62%	58%	62%	67%	69%	77%	73%
Heave 3.5m	68%	70%	71%	70%	63%	67%	63%	59%	62%	67%	69%	77%	73%
Heave 4.0m	68%	70%	71%	70%	63%	67%	63%	59%	62%	67%	69%	77%	73%



Global forecast model resolution (temporal and spatial) improvements

How does this help?

# Global forecast model resolution improvements

Continual improvements to model resolution (ECMWF, CFS, BLUElink, HYCOM etc) is enabling smaller scale features to be captured

Deterministic atmospheric forecasts approaching resolutions where parametric nesting of Tropical Cyclone wind fields is no longer required

Deterministic circulation models now capturing eddy formation and dissipation at much greater accuracy

Deterministic wave models resolving more bathymetric features = capturing shoaling processes at a finer scale

> Ensemble solutions will eventually follow

**So what new opportunities does this present for the offshore O&G industry?**



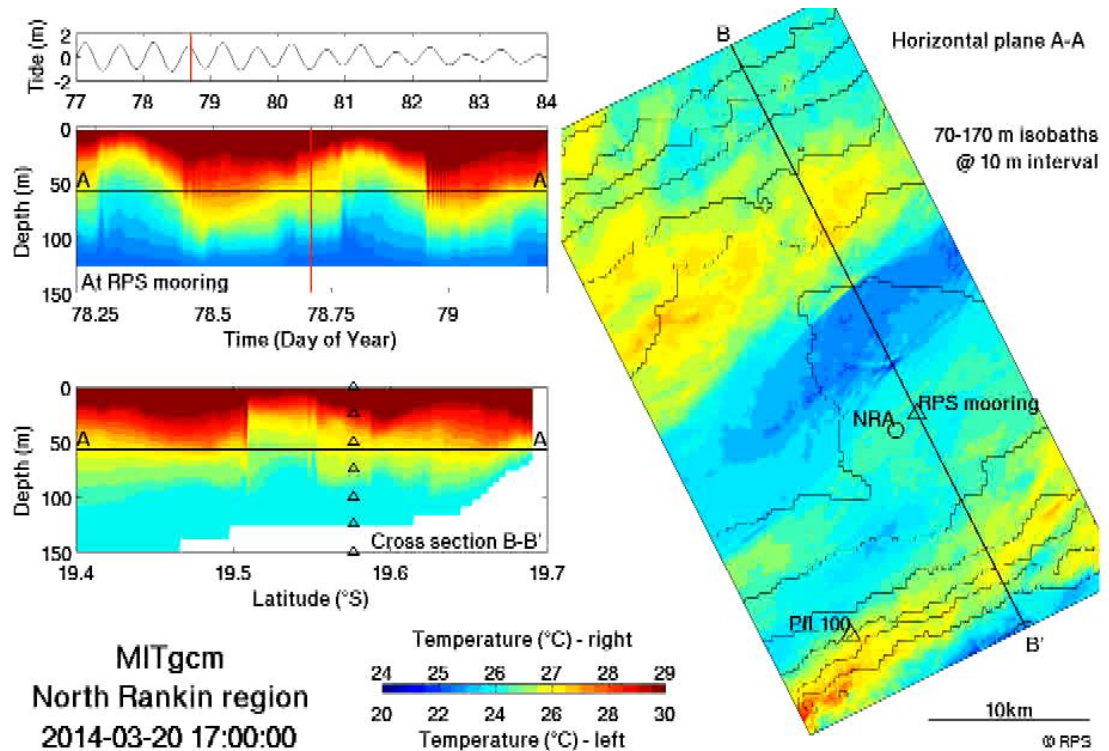
MPAS-O: Ringler, T., Petersen, M., Higdon, R. L., Jacobsen, D., Jones, P. W., & Maltrud, M. (2013). Ocean Modelling. *Ocean Modelling*, 69(C), 211–232. doi:10.1016/j.ocemod.2013.04.010 (pdf) source: <https://mpas-dev.github.io/ocean/ocean.html>

# One thought... Soliton Forecasting

Emerging circulation models with tidal forcing (OzROMS, OCEANmaps-ROMS) enabling internal tide to be forecasted out to ~7 days

Understanding the generation mechanisms enables favourable conditions for formation to be identified in forecasts

Could enable potential forewarning such events



Animation courtesy of K. Shimizu & S. Buchan  
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An effective decision support tool must:

- Provide timely information
- Provide effective information (multiple sources, accurately defines risk)
- Meet the needs and capabilities of the customer
- Be accessible to all key stakeholders
- Be reliable (consider failure modes?)
- Be auditable (enable interrogation by an expert)