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33rd ANNUAL GIRO CONVENTION

Hilton Vienna Hotel, Am Stadtpark

ELLA Working Party

Energy Large Loss Analysis Team Members

Franck Allaire
Stephen Burr
Justyn Harding
Tom Jowett (chair)

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Areas of Study

- Modelling Energy losses
- Wave damage vs Wind damage
- Rogue or Freak waves

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Modelling large losses

- Relied on Willis database – special data extract for this study
- 1985 to 2005
- Data is revalued using the IChemE rebuild index
- Threshold > $5m on a revalued basis

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Willis Database Background

- Idea conceived 1994
- Recognition of general lack of industry information
- Marine & aviation losses well reported but energy losses are not unless they are major and/or involve death or injury
- “This is a unique facility”

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The Database

- Only for losses of US$ 1,000,000 or more
- Information captured is from 1972 to date
- Mainly property related losses - does not include personal injury in isolation
- Losses are upstream and downstream, onshore and offshore
- Currently contains in excess of 6,800 records valued at over US$98,000,000,000 and is constantly updated
- All figures are 100% ground up except B.I.

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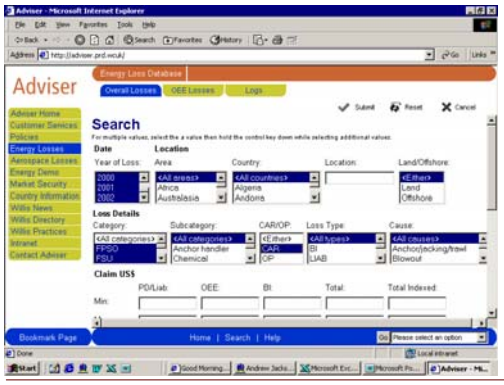
The Database - Types of Property

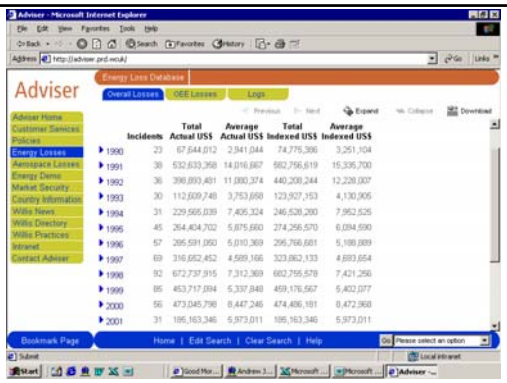
- **Offshore - Upstream**
  - Rigs
  - Platforms
  - Pipelines
  - Storage & offloading systems

- **Onshore - Downstream**
  - Refineries, petrochemical plants etc.
  - Loading terminals, tank farms
  - Power Stations
  - Gas plants, transmission stations

Types Of Report

- Summary: No. of incidents, agg. & avge. $
  - by year
  - by geographical area, country or location
  - by cause
  - by property type
  - by month (seasonal trends)
  - by cost bandwidths
  - by well depth
  - any combination of the above
- Listings of individual losses by date or value





The Willis Database

- At the moment it is not possible to extract claims data and model it as the working party has.
- For actuaries this makes the database harder to use
- But worth the effort

Modelling large losses

- Different fitting methods and curves available
- Data contains nat cat losses
- Data not developed for IBNR
- Not necessarily accurate or complete
- Understand your data & make your own selection

Classification of the losses

Fire/lightning/explosion	1					Fire/lightning/explosion	1
Flood	2	←	ONSHORE			Flood	2
Heavy weather	2		Fire	1		Heavy weather	2
Windstorm	2		Natural Hazard - W/S	2		Windstorm	2
Earthquake	3		Natural Hazard - Other	3		Earthquake	3
Ice/snow/freeze	3		Blowout	4		Ice/snow/freeze	3
Subsidence/landslide	3		Other	5		Subsidence/landslide	3
Blowout	4		Design/workmanship	6		Blowout	4
Anchor/jacking/trawl	5		Mechanical failure	7		Anchor/jacking/trawl	5
Capsize	5		Blank	8		Capsize	5
Collapse	5		Blank	9		Collapse	5
Contamination	5		Collision / Impact	10		Contamination	5
Corrosion	5		[unknown]	11		Corrosion	5
Drive off	5					Drive off	5
Grounding	5					Grounding	5
Leg punch through	5					Misc	5
Misc	5					Misc	5
Misc	5		OFFSHORE	→		Piling operations	5
Piling operations	5		Fire	1		Riot	5
Pipelaying/trenching	5		Natural Hazard - W/S	2		Stuck drill stem	5
Riot	5		Natural Hazard - Other	3		Supply interruption	5
Stuck drill stem	5		Blowout	4		Terrorism	5
Supply interruption	5		Other	5		Theft	5
Terrorism	5		Design/workmanship	6		Design/workmanship	6
Theft	5		Mechanical failure	7		Mechanical failure	7
Design/workmanship	6		Pipelaying/trenching	8		Pipelaying/trenching	8
Mechanical failure	7		Leg punch through	9		Leg punch through	9
Collision	10		Collision / Impact	10		Collision	10
Impact	10		[unknown]	11		Impact	10
[unknown]	11					[unknown]	11

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Summary Tables 1

Count of claims spilt by cause and category

	L.Other	L.Plant	L.Ref	L.Wells	O.Other	O.Platf	O.Wells	Total
Blowout	22	0	0	200	41	11	187	461
Cat.Other	2	43	30	2	3	2	3	85
Cat.Wind	3	51	23	1	106	179	10	373
Design	3	18	9	0	66	131	5	232
Fire	5	335	249	4	27	34	0	654
Impact	0	7	5	1	17	33	3	66
Leg	0	0	0	0	17	0	0	17
Mech	2	61	16	2	28	21	6	136
Other	1	21	5	3	23	55	7	115
Trench	0	0	0	0	1	31	0	32
Unknown	4	39	26	2	43	71	4	189
Total	42	575	363	215	372	568	225	2,360

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Summary Tables 2

Amount of claims spilt by cause and category ($m)

	L.Other	L.Plant	L.Ref	L.Wells	O.Other	O.Platf	O.Wells	Total
Blowout	411	0	0	2,414	2,219	927	3,598	9,570
Cat.Other	38	1,358	1,180	21	36	18	90	2,741
Cat.Wind	67	2,199	1,454	5	2,848	10,896	213	17,681
Design	39	252	253	0	872	2,856	170	4,442
Fire	92	14,325	8,079	126	923	2,837	0	26,382
Impact	0	91	89	10	188	597	25	999
Leg	0	0	0	0	258	0	0	258
Mech	14	910	248	23	508	404	125	2,233
Other	25	959	93	22	455	1,733	104	3,392
Trench	0	0	0	0	9	432	0	441
Unknown	82	983	496	17	652	887	34	3,152
Total	769	21,075	11,893	2,638	8,969	21,588	4,359	71,291

- Fire is the largest claim category with 37% of the loss cost
- Cat wind losses amount for 25% of all energy losses in the WDb ($17.7bn / $71bn)

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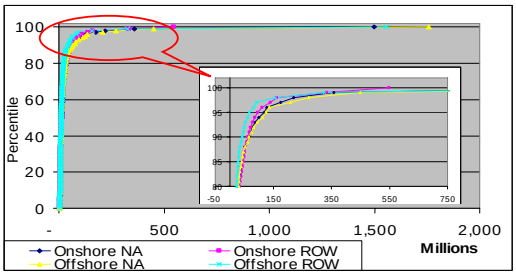
Plot of revalued observed data



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Curve Fits to some of the data

- There is enough data to fit curves for some of the classifications
- No single distribution fitted all the data
- Which index to use when revaluing old claims is always an issue
- Fitting to the tail of the distribution is subjective

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Offshore Platform - Wave v Wind

1. Offshore Platform Windstorm Losses
2. 2005 Hurricanes
3. Offshore structures design
4. Freak Waves
5. Cat models
6. Conclusion

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Offshore Platform Windstorm Losses

	Percentage
	50
	13
	13
	23
	100

- Windstorm is the main peril for offshore platform (50% of losses)

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2005 Hurricanes - Wind damage

- Built in 1996, Shell Mars Tension Leg Platform was designed to withstand waves of 71ft (22m) and winds of 140mph (62m/s)
- The Helmerich & Payne 201 derrick was lost, during Katrina, with major damage to the rig floor and substructure.

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2005 Hurricanes - Wind damage

Article on WorldOil.com

- Wind damage refers to rigs getting blown off platforms or the damage to topsides facilities, as occurred on Shell's Mars platform after Katrina.
- "When I look at all of it, I think our current standards are good. However, I think that some people have gotten sloppy in their operations. The tie-downs, for instance, weren't good enough." Ken Arnold Senior Executive Vice President at AMEC Paragon, one of the industry's most respected experts

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2005 Hurricanes - Wave damage ?

- Built in 2001 - Chevron Typhoon TLP floating upside-down after Rita.
- "Its failure is of great concern to us," said Chevron's senior facilities engineering advisor. "We're studying what happened right now, but there's no clear-cut smoking gun. It's a huge disappointment."

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2005 Hurricanes - Wave damage

Article on WorldOil.com

- Operators have lost platforms in these storms, because wave heights were greater than engineers would have expected, and that is the puzzlement.
- Arnold suggests the following contributing factors:
  - limited understanding of wave crest elevation
    - "rogue waves" within a storm
    - model error for deep water
  - lower security loading
    - better modelling of stresses lead to a less cautious attitude
    - economical pressure pushed for more tight designs

Should these wave heights have been unexpected when there is so much information in the public domain? We summarise a little on the next few slides.

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Offshore structures design - ISO 19901

Table C.21: Indicative extreme values - GOM Area II and III for water depths greater than 300m. ISO/FDIS 19901-1:2005(E) - GOM, 2005-04-01

	Return period		
	10	50	100
Wind			
10 minute mean wind speed (m/s)	28.4	40.9	46.9
3 s gust wind speed (m/s)	35.6	51.3	57.8
Waves			
Maximum wave height (m) (Hmax)	15	22.8	25.8
Significant wave height (m) (Hs)	8.5	12.9	14.6
Spectral peak period (s)	12.3	14.3	14.9
Hmax/Hs	1.76	1.77	1.77

Normal practice is to load the 100 year return period characteristics using a multiplicative factor of 1.3

The design is then considered to be able to withstand sea conditions for 10,000 year return period

Article on WorldOil.com:

- American Petroleum Institute's reaction post Katrina & Rita: design should be able to withstand winds with a one-hour average of 115mph (35m/s) and wave heights of 70 feet (21m)
- Some experts say this corresponds to little more than a category 3 hurricane
- Since 2004, hurricanes Ivan, Dennis, Katrina and Rita have all generated one-minute sustained winds of more than 140mph (63m/s)

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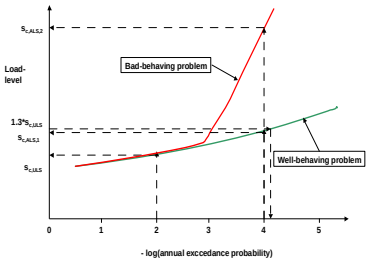
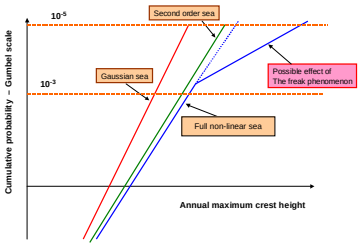
Freak Waves – Non Observed Sea States



In a badly behaving problem, a 1.3 load factor does not protect at the 10,000 year return period any longer

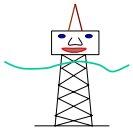
Freak Waves – Non Observed Sea States

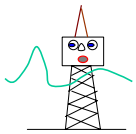


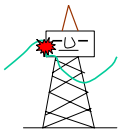
Occurrence of freak waves is dramatically increasing in non-linear sea states

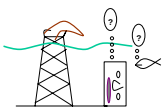
Freak Waves – Problem?

Freak waves will mainly represent a problem if their crest hits a structural element which is not designed for wave loads









Freak Waves - Camille & the New Year Wave

- "The analysis of data from the North Sea and Gulf of Mexico indicates that the difference between the characteristics of the individual freak waves do not seem to be significant, although the Camille waves tend to have a lower ratio of maximum crest to significant wave height."
- "However these conclusions must be considered with care as the length of records and the number of abnormal waves considered is not very large."

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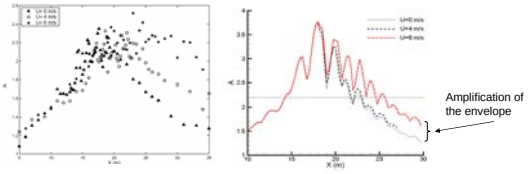
Freak Waves – Experimental Relationship with Wind Speed



A = Max wave height / Reference wave height

"Both experimental and numerical results are in quite qualitative agreement. It is shown experimentally and numerically that the effect of the wind is twofold: (i) it increases slightly the amplification of the envelope of the short group containing the rogue wave and more importantly (ii) it increases the time of existence of this group."

www.icms.org.uk/meetings/2005/roguewaves/presentations/Kharif.pdf

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Freak Waves – So what?

- Platforms not designed for wave impact at the freak wave height
- Damage function of cat models only relies on wind speed.
- Waves are a significant factor too
- Especially if wave heights do not behave in a linear way.
- Increasing property damage and uncertainty

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Cat Models

- Onshore models
  - Emphasis on wind speed
- Offshore models
  - Wave wind relationship based on average?
  - Or based on linear wave model?
  - Or (more likely) an implicit relationship assumed
  - Damageability function ignores impact of freak waves?
  - Calibration, GOM suggests high level of uncertainty?
- Underestimation of the severity of extreme events?
- Possible adjustments factors?
- Actuaries need to take more account of the uncertainty?

Concluding thoughts

- Discussion with M&E engineers suggest a 80% Wind 20% Wave split rule of thumb
  - But this is not data tested and we think is a post Andrew statistic
- Recent hurricanes and scientific research on freak waves suggest that their occurrence in rough sea conditions have been underestimated
- Offshore platform design criteria may not be as safe as had been assumed
- Do Cat models make enough allowance for freak waves in extreme conditions?
  - Does the damage function allow for enough variability?
- Pricing actuaries take care

Appendix

Wind vs Wave References

WorldOil.com article on US GOM structures standards
http://www.worldoil.com/MAGAZINE/MAGAZINE_DETAIL.asp?ART_ID=2716

Sverre Haver (Statoil, Norway) - " Freak Waves - A Suggested Definition and Possible Consequences for Marine Structures "
www.ifremer.fr/web-com/stw2004/rw/presentations/haver.ppt
www.ifremer.fr/web-com/stw2004/rw/fullpapers/haver.pdf

C. Guedes Soares, and E.M. Antão (IST, Portugal) - " Comparison of the characteristics of abnormal waves on the North Sea and Gulf of Mexico "
www.ifremer.fr/web-com/stw2004/rw/fullpapers/guedes2.pdf

Wind speed and Rogue Wave: www.icms.org.uk/meetings/2005/roguewaves/presentations/Kharif.pdf

Searching for rogue waves with Radar: http://www.esa.int/esaCP/SEMOKQL26WD_index_0.html

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ella.wikispaces.com ……..look it up
Data Sources

Willis Data **http://www.willis.com/Adviser.aspx**

OPL Data **http://www.oilpubs.com/wofdq**

My Giro 2005 workshop handouts **Gulf of Mexico offshore energy**

IFREMER Rogue Waves 2004 Seminar **http://www.ifremer.fr/web-com/stw2004/rw/**

OGP International Association of Oil & Gas Producers **http://www.ogp.org.uk/**
» Metocean Committee (Design and operation of offshore installations) **http://info.ogp.org.uk/metocean/**
» ISO 19901-1 **http://www.galbraithconsulting.co.uk/iso/19901-1/ISO_19901-1_FDIS_SUBMITTED_2.pdf**

RMS GOM Offshore Model
» Web page **www.rms.com/Catastrophe/Models/OffshorePlatform.asp**
» Flyer **www.rms.com/Publications/OPR.pdf**
» Analysis of Katrina **www.rms.com/Publications/KatrinaReport_LessonsandImplications.pdf**

Blowout statistics
» **http://www.sintef.no/content/page1____4649.aspx**
» **www.hse.gov.uk/research/otopdf/2000/oto00091.pdf**
» **www.hse.gov.uk/research/rrpdf/rr095.pdf**

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