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IMMOVABLE OBJECTS v IRRESISTABLE FORCES

Nautical Institute, Hong Kong

May 2014

www.solis-marine.com

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PIANC is a non-profit organization bringing together international experts in the fields of sustainable, cost-effective infrastructure for ports, waterways and coastal areas.
www.pianc.org (membership from €95 per year)

Solis Marine Consultants provides independent expert advice on maritime and shipping incidents including navigation, collisions, salvage and fixed object damage.
www.solis-marine.com

Inshore Systems is a specialist provider of precision portable navigation and docking systems used by pilots and port operators.
www.inshoresystems.com

WORKING GROUP 145

TERMS OF REFERENCE

“The objective [is] to produce a report that provides data on actual recorded vessel approaches under a range of environmental conditions and provides clear guidelines to designers for the use of appropriate vessel design speeds. It is expected that the WG report will focus on larger ships [over 30,000 DWT] for which quantitative berthing velocity data can be obtained.”

KINETIC ENERGY

4 cars @ 38.6 tonne = 154.4 tonne

Head-on impact into station buffers

10 km/h = 2.8 m/s = 5.4 knots

Energy = $0.5 \times 154.4 \times 2.8^2$ = **605 kJ**

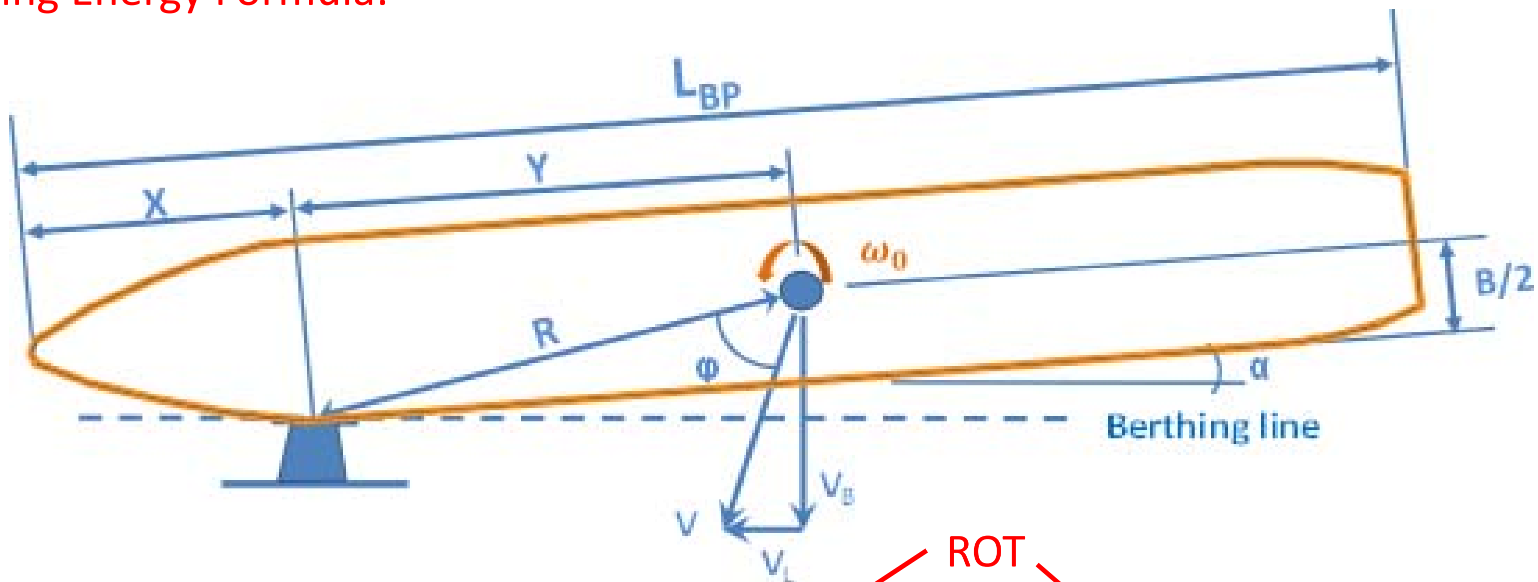
150,000 DWT bulker ≈ 174,000 tonne displ.

Quarterpoint impact on side fenders

0.2 knots = 0.1 m/s

Energy = $0.5 \times 174000 \times 0.1^2 \times 1.7 \times 0.5$ = **740 kJ**

Berthing Energy Formula:



ROT

$$E_N = \frac{0.5 \cdot M_D}{(K^2 + R^2)} \left[\left(V^2 \cdot (K^2 + R^2 \cdot \cos^2(\varphi)) \right) + (2 \cdot \omega \cdot V \cdot R \cdot K^2 \cdot \sin(\varphi)) + (\omega^2 \cdot K^2 \cdot R^2) \right] \cdot C_M \cdot C_C \cdot C_S$$

SOG & COG

CONSERVATION OF ENERGY

- **Kinetic**
- **Potential**

- Acoustic
- Thermal
- Electrical
- Chemical
- Electrochemical
- Electromagnetic
- Nuclear

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BERTHING TOO FAST?
UNSAFE BERTH?

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SIR ISAAC NEWTON (1642–1727)

First Law:

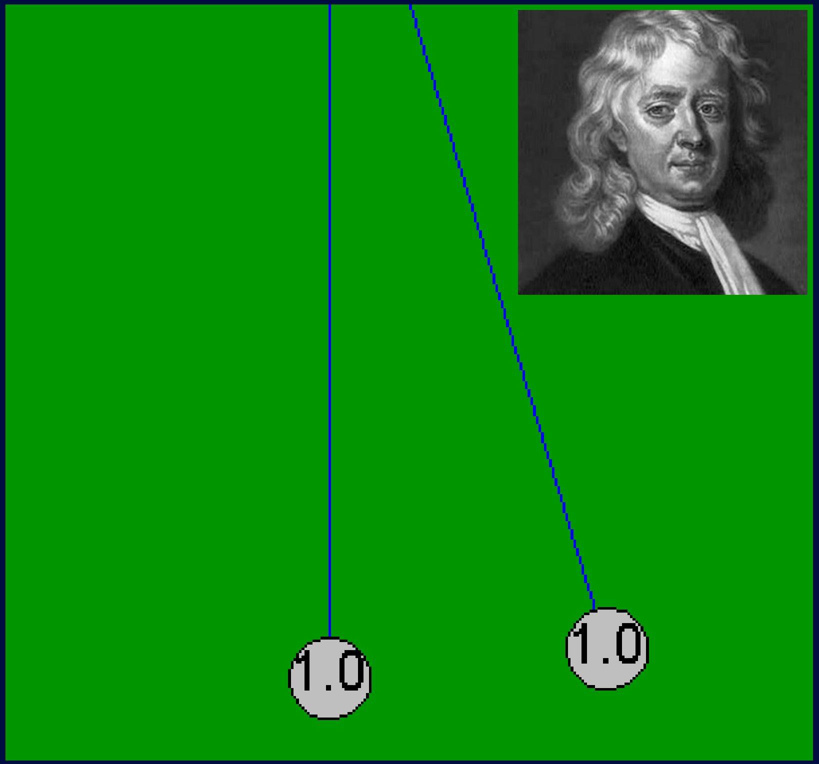
An object moves at a constant velocity, unless acted upon by an external force.

Second Law:

Acceleration (deceleration) is proportional to the force which acts on the object.

Third Law:

Every action has an equal and opposite reaction.



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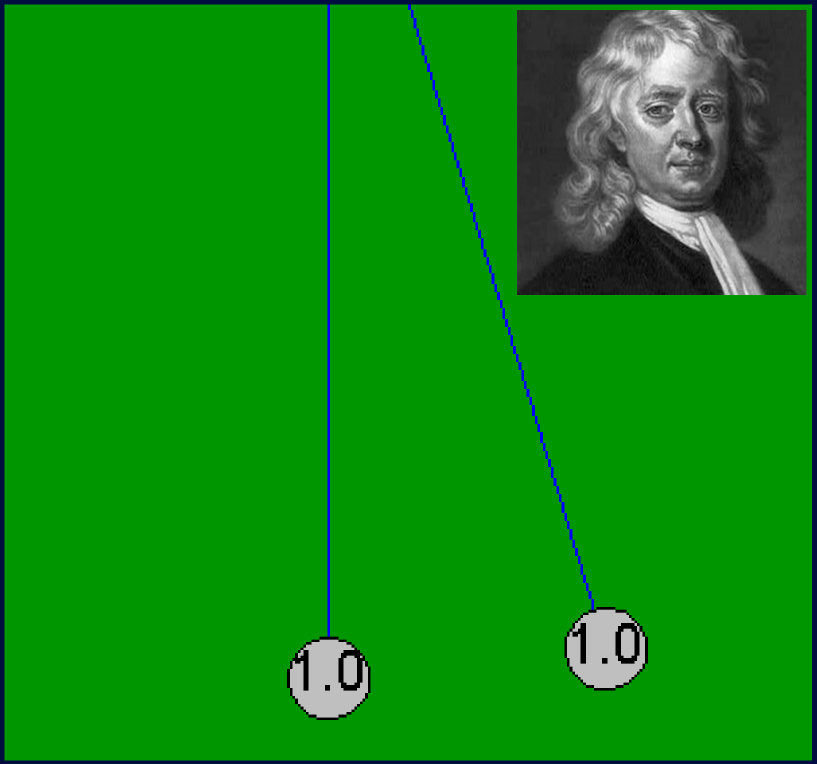

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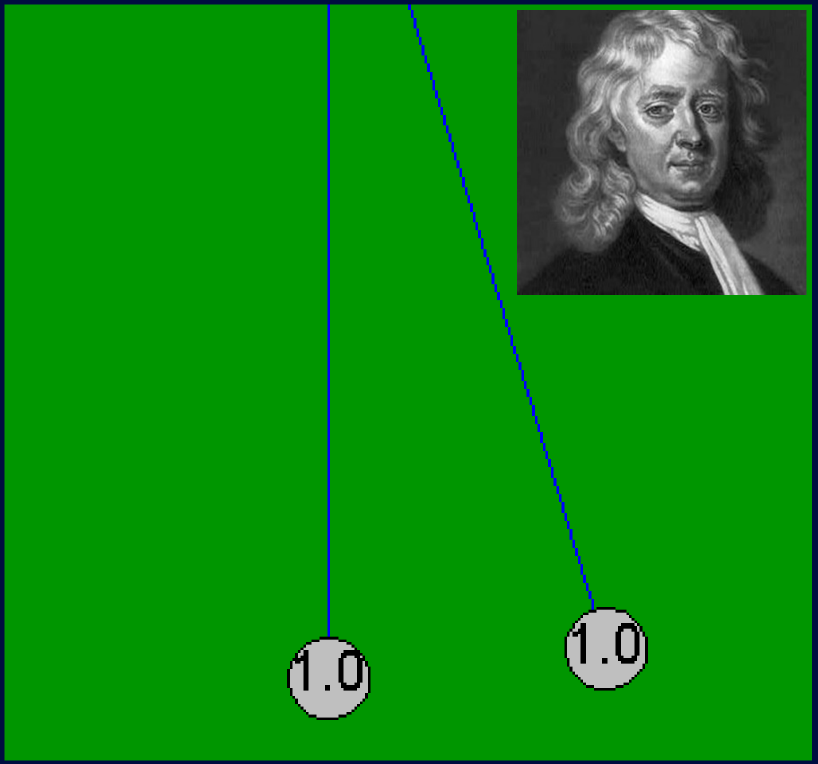

SOME ‘RECENT’ RESEARCH INTO SHIP BERTHING SPEEDS

1948 “The Heysham Jetty” ICE Paper 1948 by Prof. Arthur Lempriére Lancy Baker

1952 “Oil Loading and Cargo Handling Facilities at Mina Al-Ahmadi, Persian Gulf” ICE paper by McGowan, Harvey and Lowden

1952 “Some Designs for Flexible Fenders” ICE Maritime Paper by Donald Hamish Little

1953 International Navigation Congress in Rome Paper SII-Q2 Prof. Arthur Lempriére Lancy Baker

1963 “Berthing Forces of large tankers” 6th World Petroleum Congress, Frankfurt B.F.Saurin

1977 “Paper on Fender Design and Berthing Velocities” PIANC Leningrad Congress presented by Ir.J.U.Brolsma, Ir J.A.Hirs and Ir. J.M. Langeveld

BROLSMA (1977)

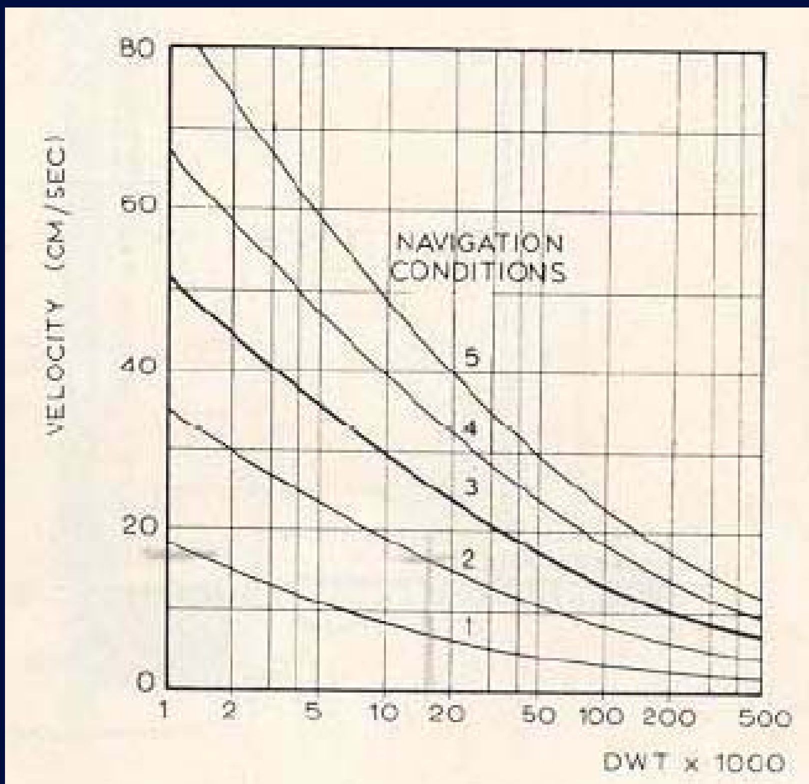

Fig. 11. — Design berthing velocity as function of navigation conditions and size of tanker (combination of results from Baker, Saurin and Brolsma).

Ships >200 metres long

150 tankers (95-285,000 DWT) Rotterdam

6 bulkers (150,000 DWT) in Rotterdam

15 container ships in Rotterdam

70 tankers in Lock Long (Scotland) – data collected in 1963 (Baker)

All locations defined as “Easy Exposed” (3)

Only tankers were statistically significant

Probability of exceeding values not defined

The same graph has been adopted (and distorted) in all subsequent port design codes like BS6349, EAU, PIANC 2002 etc.

THE WG145 STUDY

- ✓ PIANC WG145 formed in November 2010
- ✓ 2334 vessel berthings (most over 30,000 DWT)
- ✓ Container, bulk cargo, oil tanker, LNG carrier
- ✓ Docks, river berths and deep water terminals
- ✓ Sheltered and exposed locations
- ✓ Small and large tidal zones
- ✓ Small and large current effects
- ✓ 13 locations in Asia, Europe and North America
- ✓ Laser, microwave and DGPS/RTK docking aids

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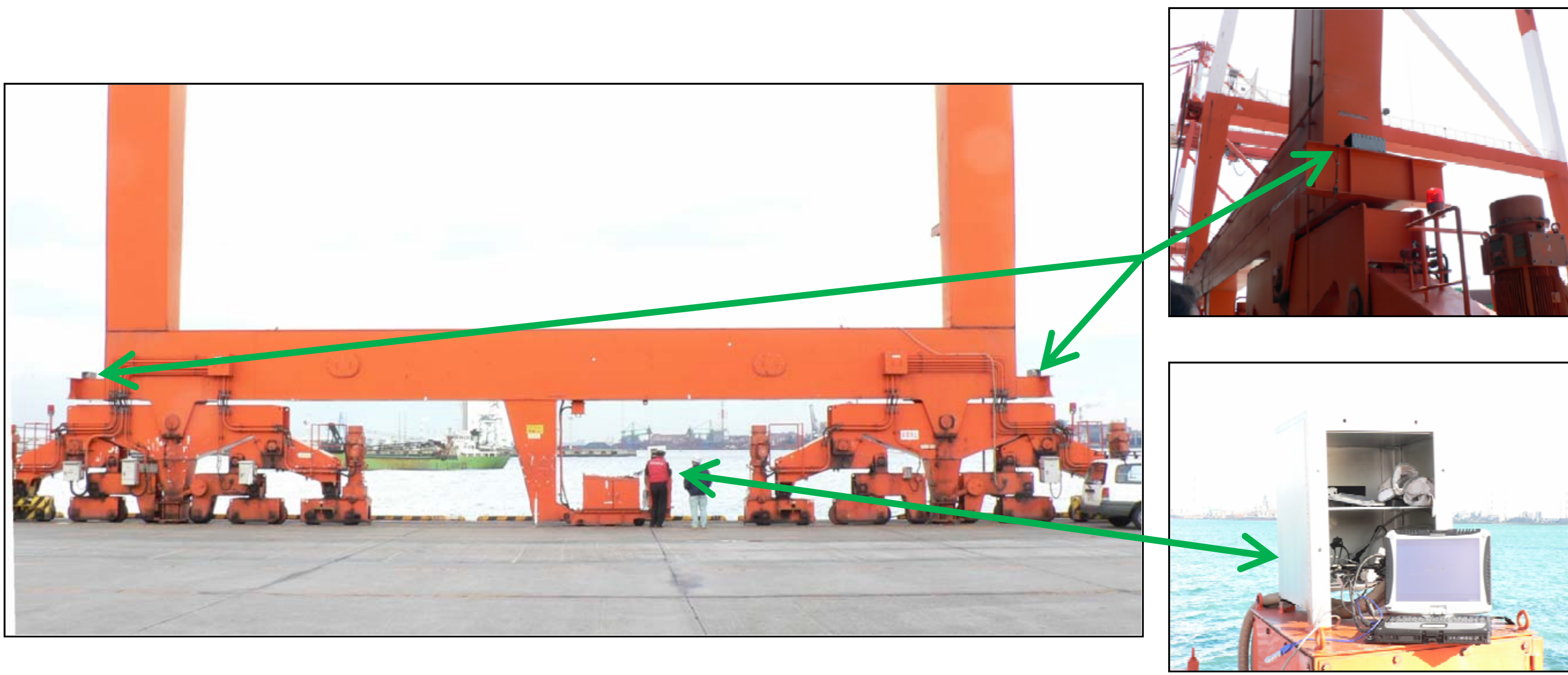
CRANE MOUNTED LASERS (MONITORING)



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PORTABLE LASERS

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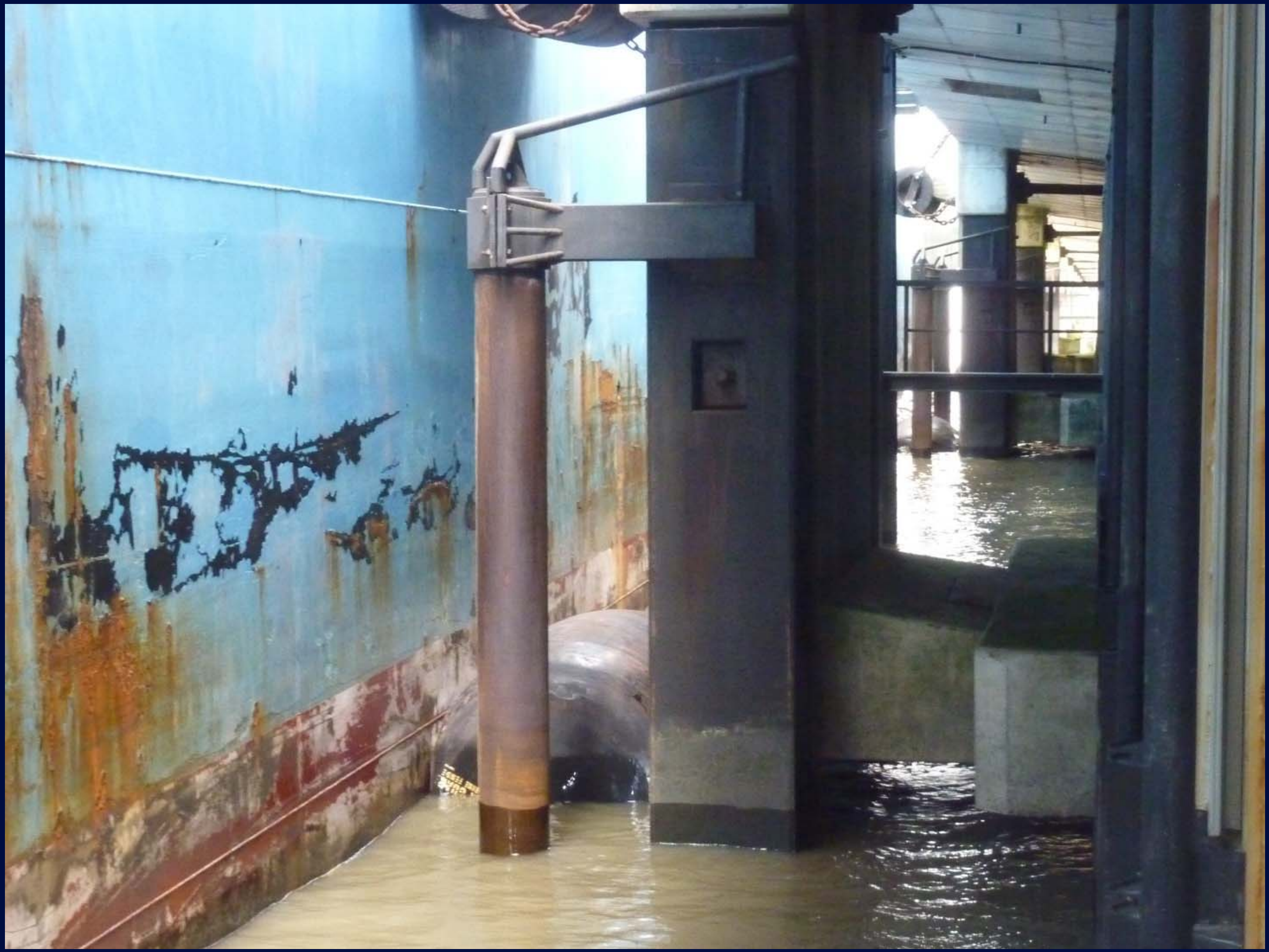
DOPPLER MICROWAVE (MONITORING)



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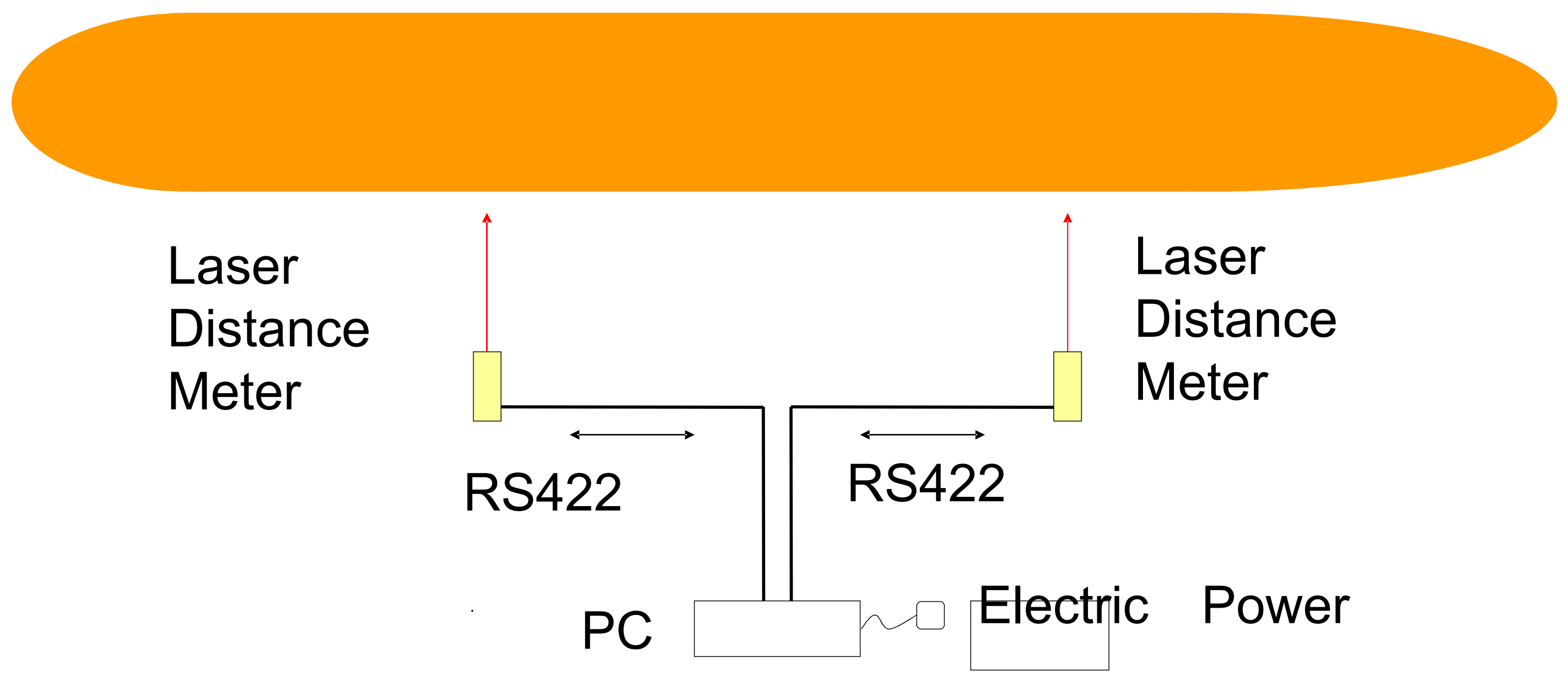
FIXED LASER BERTHING AID


Laser
Distance
Meter
Laser
Distance
Meter
RS422
RS422
PC
Electric Power

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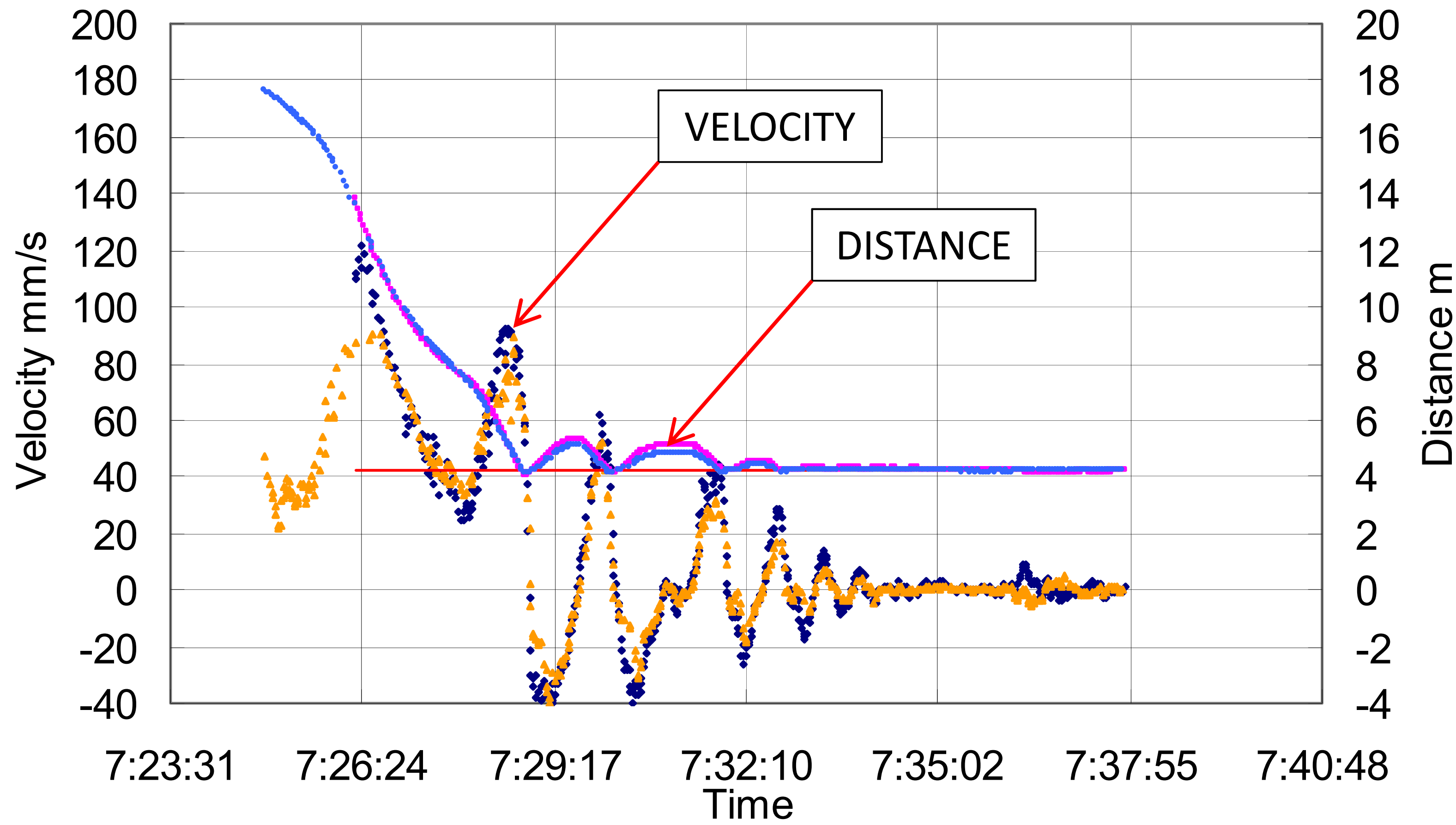

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PORTABLE PILOTING UNIT (PPU)

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LNG CARRIER BERTHING VIDEO (4')

www.youtube.com/inshoresystems

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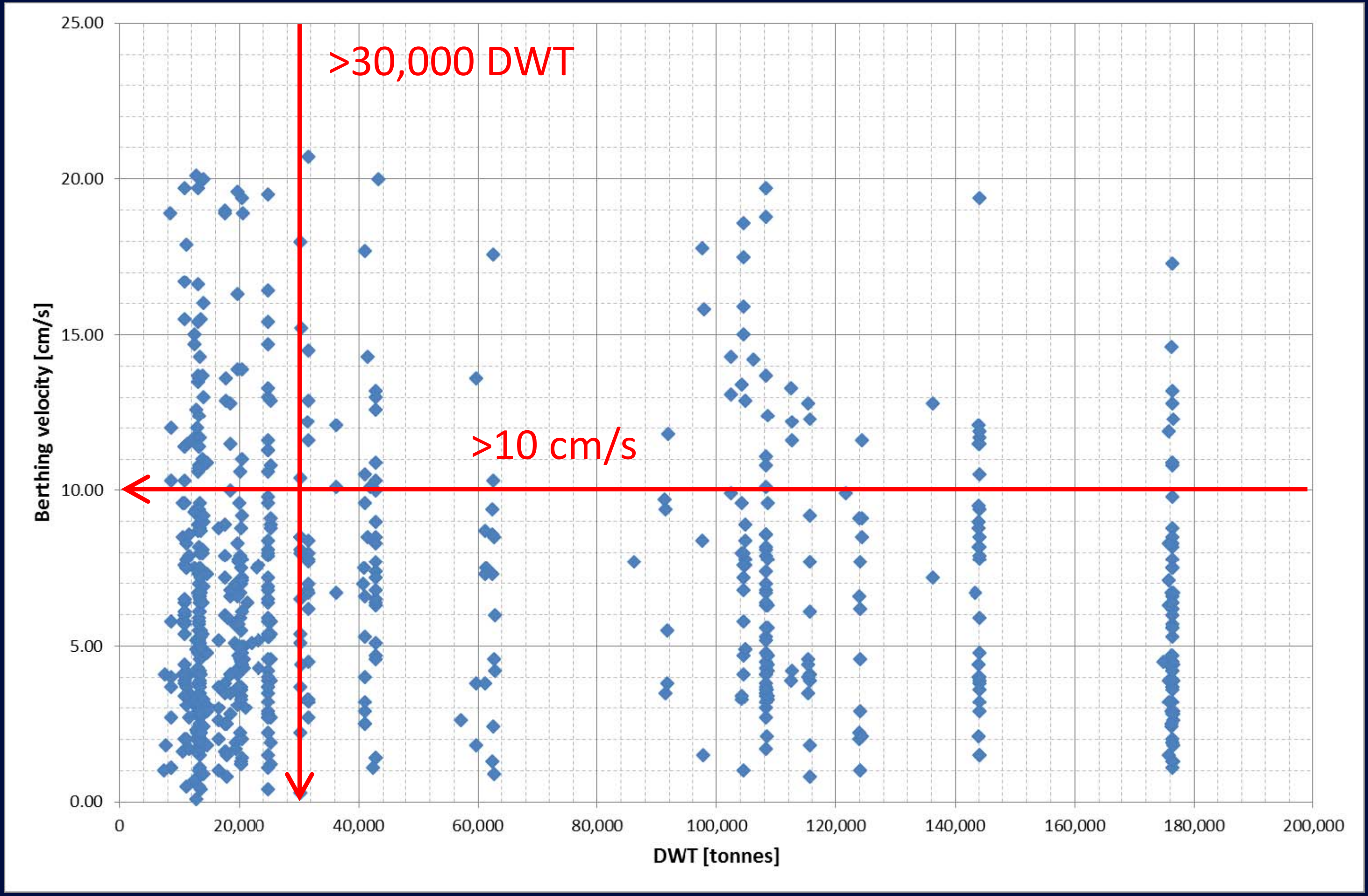
PERFORMANCE

	SHIP SYSTEM	LASER FIXED	LASER PORTABLE	MICROWAVE	PPU DGPS	PPU RTK
Position	±1m? DGPS	Not measured	Not measured	Not measured	±30cm	±1cm
Heading	1° ±0.5°	1° ±0.5°	1° ±0.5°	1° ±0.5°	0.05° ±0.01°	0.05° ±0.01°
Rate of Turn	1°/min (10°/min threshold)	Not measured	Not measured	Not measured	0.5°/min	0.5°/min
Speed over ground	2 cm/s 0.1 knot	1 cm/s	1 cm/s	1 cm/s	2.5 cm/s 0.05 knot	1 cm/s 0.02 knot
Distance off berth	Not measured	300m ±1cm	200m ±1cm	25m ±5cm	Unlimited ±30cm	Unlimited ±1cm
Display	ECDIS, other?	Jetty display Control room	Local laptop	Control room	Laptop/tablet Optional remote	Laptop/tablet Optional remote
Operating time	Always on	On demand	10 hours	On demand	>15 hours	>15 hours
Set-up time	Not applicable	5 mins	20 mins	5 mins	2-3 mins (from arrival on bridge)	2-3 mins (from arrival on bridge)
Operation	Anywhere DGPS dependent	Dedicated berth	Anywhere	Dedicated berth	Anywhere SBAS, MF-beacon	Anywhere RTK Base Station
AIS Receiver	Yes	No	No	No	Yes	Yes
Replay facility	Via VTS logs	Depends on software	Depends on software	No	Standard	Standard
Weight	N/A	N/A	30kg ++	N/A	3kg min (depends on spec)	3kg min (depends on spec)
Cost (USD)	?	>$100k	$40–60k	A lot..!	$10–30k	$30–40k

SAMPLE DATA
CONTAINER BERTH



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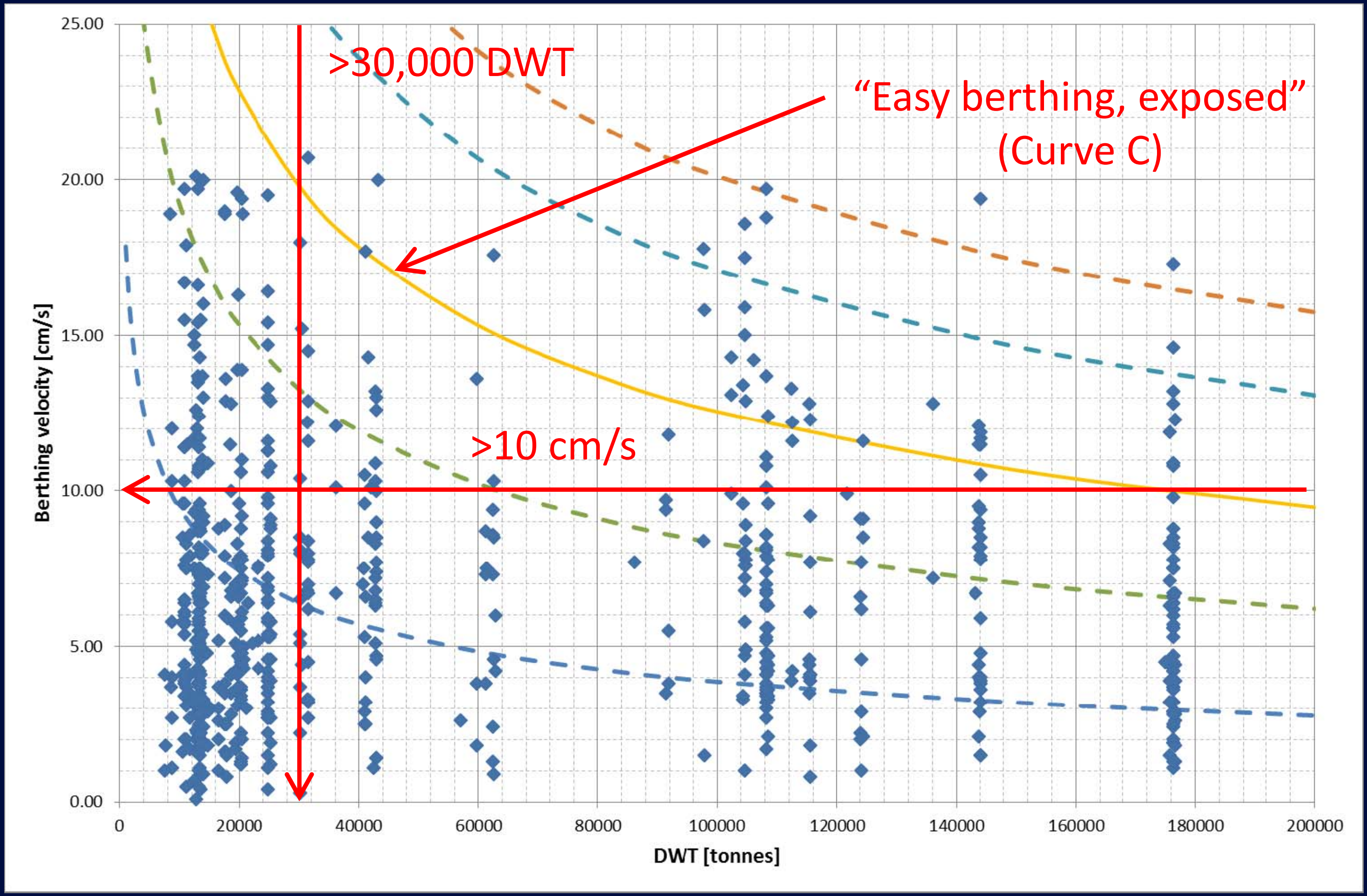

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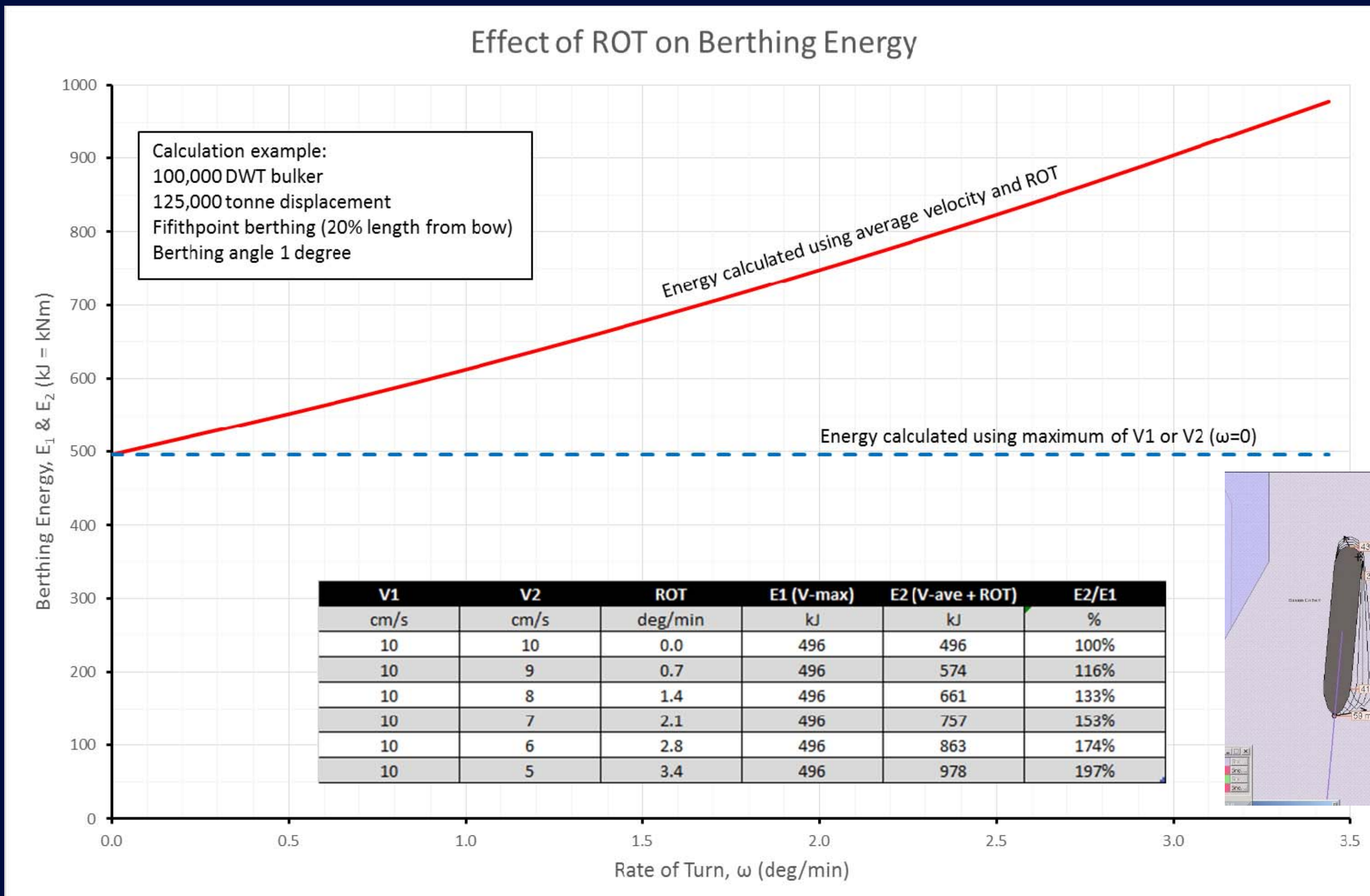
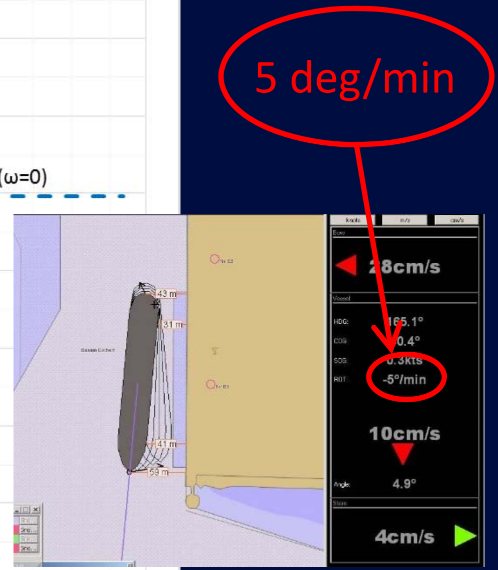
ROT – A HIDDEN HAZARD?



V1	V2	ROT	E1 (V-max)	E2 (V-ave + ROT)	E2/E1
cm/s	cm/s	deg/min	kJ	kJ	%
10	10	0.0	496	496	100%
10	9	0.7	496	574	116%
10	8	1.4	496	661	133%
10	7	2.1	496	757	153%
10	6	2.8	496	863	174%
10	5	3.4	496	978	197%



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WG145 FINDINGS

EFFECTS ON BERTHING SPEED
× Ship size – no clear effect
× Port layout – no clear effect
× Open or closed structures – no clear effect
× Newer facilities – no clear effect
× Pilot experience – no clear effect
× Type/size/age of fenders – no clear effect
× Size/type/number of tugs– no clear effect
✓ Under keel clearance
✓ Strong currents (V_B larger but consistent)
✓ Routine use of berthing aids & PPUs
✓ Known operating limits
✓ Rate of turn common where measured

WG145 RECOMMENDATIONS

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Use ‘reliability design’ methods (99% CL)
Tell users the operating limits
Reduce target speeds (<design speed)
Monitor & log berthing speeds
Review the berthing process regularly
Consider all changes that affect the berth
Ensure designs include real safety margins
Appropriate training (simulators, mentors)
Use numerical modelling of berths
Identify hazards, probabilities & consequences
Allow for degradation during the service life
Witnessed fender testing
Adopt ‘guaranteed performance’ for fenders

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"A port will not be safe unless, in the relevant period of time, a particular ship can reach it, use it and return from it without, in the absence of some abnormal occurrence, being exposed to danger which cannot be avoided by good navigation and seamanship"

(Eastern City) [1958]

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BUT IN THE END…

“Energy and persistence conquer all things”

Benjamin Franklin (1706-1790)

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Copies of this presentation are available from:

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We can also present this or an adapted version to colleagues at your office – let me know