Ship to Ship and Ship to Shore Interaction
Causes and Effects
Learning Objectives

• The principle behind interaction – Bernoulli

• Types of interaction – ship/ship & ship/shore

• Factors affecting interaction
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Types of Interaction

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<td>• Passing - Both Underway</td>
<td>• Bank Effect</td>
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<td>- One Ship Moored</td>
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<td>• Overtaking</td>
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<td>• Working in Proximity (e.g. ship &amp; tugs)</td>
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Consequences – Passing Vessel

Passing Ship

- 16 Sep 1990
- MOORED: Tanker U.S. JUPITER, cargo of gasoline; Bay City, Michigan
- 10,900 DWT; Length 116m.
- PASSING: BUFFALO; 17,500 DWT, Length 194m; Speed about 4.2 kts; Gap of about 18m.
- JUPITER had all but one mooring line break, the discharge hose broke and the resulting fire caused 1 death,
- 18 injuries, JUPITER was a total loss and the pier was damaged.

Source: M Live
Consequences – Squat

- 7 August 1992 – Martha’s Vineyard, off Rhode Island.
- QUEEN ELIZABETH II; Length 294m, Beam 32m. Speed; 25 Knots
- Series of gashes, cracks and dents along 400 feet of the hull!
- NTSB estimated squat of between 4.5 and 8 feet
- $20 Million USD
## Consequences – Subsequent Damage

<table>
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<th>More than just the cost of ship damage</th>
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<tr>
<td>• Damaged hull</td>
<td>£</td>
</tr>
<tr>
<td>• Broken lines (+ snapback personal injury risk)</td>
<td>£ (+ £££, USA ££££!)</td>
</tr>
<tr>
<td>• Vessel breakaway</td>
<td>£ - £££</td>
</tr>
<tr>
<td>• Damaged loading equipment</td>
<td>£ - ££</td>
</tr>
<tr>
<td>• Damaged fenders</td>
<td>£ - ££</td>
</tr>
<tr>
<td>• Damaged terminal structure</td>
<td>££</td>
</tr>
<tr>
<td>• Damaged gangway</td>
<td>£</td>
</tr>
<tr>
<td>• Environmental spill &amp; cleanup</td>
<td>££ - £££</td>
</tr>
<tr>
<td>• Loading delay</td>
<td>£ - ££</td>
</tr>
<tr>
<td>• Terminal Business Interruption</td>
<td>££££</td>
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Bernoulli’s Theorem

Conservation of Energy

Daniel Bernoulli, *Hydronamica* 1738

- Fluid or air
- Increased velocity
- Decreased pressure
Pressure Fields Around a Ship

<table>
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<th>Hydrodynamic Pressure</th>
<th>Open water v restricted water</th>
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Different pressure distribution in open water v restricted water, but a ship moving ahead will **always** generate a pressure field.
## Contributory Factor – Block Coefficient

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<th>Typical Factors</th>
<th>Block Coefficient</th>
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<td>ULCC tanker – 0.850</td>
<td></td>
</tr>
<tr>
<td>Container ship – 0.575</td>
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![Diagram of ship showing dimensions and block coefficient formula](image)

*Assume that the ship is carved from a box with a length L, breadth B, and depth D.*
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Interaction - Squat

Remember Bernoulli!

Shallow Water Squat

Fluid or air
Increased velocity
Decreased pressure
Interaction - Squat

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<th>Factors</th>
<th>Shallow Water Squat</th>
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Accelerated Flow Under the Keel = Reduced Pressure

Ship squats down (and can trim):

- Tankers & Bulkers trim by the bow
- Container/LNG trim by the stern
## Interaction - Squat

### Bernoulli

### How to calculate Squat

- Calculated values in ship tables
- Standard UKC based on experience - e.g., 10%
- Dynamic UK clearance systems that allow for heel of a vessel
Interaction - Squat

Signs of Squat

- Loss of steerage
- Loss of speed
- Vibration
- Increased turn diameter
- Wake breaking/rollers
Interaction - Squat

Not always a negative !!

ALLURE of the SEAS - 2010

Passing below Great Belts Bridge in Denmark

Went under the bridge at 22 knots (full speed) giving it another 30cms of squat

50 cm clearance !!!!
Interaction – Bank Effect

Pressure Wave & Bernoulli

Suction at Stern
Passing Ship Interaction – One Vessel Moored

**Main factors:**
- Speed & passing distance, UKC, berth type

**Other factors:**
- Hull shape, displacement of vessels

Source: W.of E P&I
Factors – Passing a Ship on a Berth

Forces affected by

Passing Vessel
- Hull type & size
- Draft & UKC
- Speed through water
- Passing distance (separation)
- Channel bathymetry

Moored Vessel
- Hull type & size
- Draft & UKC
- Mooring arrangement & equip.
- Line material (stretch)
- Line pre-tension
- Berth bathymetry

Reaction affected by

Graph showing Force increase (x factor) vs. Speed increase (x factor).
Passing Ship Interaction – Opposite Directions

Passing Ships

Bows then Sterns Pushed Apart
Passing Ship Interaction – Opposite Directions

Passing Ships – Texas Chicken Maneuver

Bows then Sterns Pushed Apart

Source: Port Revel, YouTube
Passing Ship Interaction – Overtaking

Passing Ships

Bows then Sterns Pushed Apart

Source: YouTube