Jan Sudra, Carlo Valentine, Pele Berg, Zach Erickson

The CHUNNEL
Historical Purpose

- The Chunnel runs beneath the English Channel and connects Great Britain with France.

- Giving British citizens train access to the European continent and vice-versa.

- Transport passengers and freight cargo with greater convenience and efficiency.
Before the Tunnel

- Travel was very limited before the Chunnel was built
- Blimps – Unsafe and slow, could not sustain large demand of travelers
- Boats – Time consuming
- Ferries – Inconvenient, uncomfortable
- Airlines – Costly
Early Beginning

- The desire to link Britain and France dates back more than 200 years.

- 1880's: 1st attempts were made to channel through the earth, however due to technological inadequacies British government was forced to halt construction.

- It took 100 years for the idea to become a reality and in late 1984 the British and French governments reached an agreement to build the tunnel.
Construction period

Construction commencement

- UK government
- Treaty
- French government
- Inter-governmental commission
- Safety Authority
- Concession
- Maitre d’Oeuvre
- Shareholders
- Eurotunnel
  - Channel Tunnel Group Ltd / France Manche S.A.
  - Construction contract
  - Funding banks
  - Railway Usage Agreement
- Transmanche Link
  - Translink Joint Venture
  - G.I.E. Transmanche Construction
- Railways
The Tunnels

- 3 parallel tunnels (50.5 km each)
- 38 km undersea
- 3.2 underland (France)
- 9.3 underland (UK)
- One of the Seven Wonders of the Modern World

*Popular Mechanics,*
Construction

- Eleven tunnel boring machines
- Two rail tunnels
  - Diameter 7.6 m
- Service tunnel
  - Diameter 4.8 m
- Tunneling Sites
  - Shakespeare Cliff (UK)
  - Sangatte (France)
Tunneling Sites

- Shakespeare Cliff (England), Sangatte (France)

- As close to the ocean as possible
Economic Construction Challenges

- Time
  - Private investment
  - Importance of financial return

- Cost of $5 million a day
  - Far over budget

- Total $7 - $21 billion
  - £11 billion

- 80% cost overrun
Construction Challenges

- Water Inflow
  - Pressure
  - Leaks (weak ground conditions)
- Fires and equipment failure.
- Ten workers killed
  - 8 UK, 2 French
  - Tunneling accidents
- 60,000 jobs created
  - Added cost
  - Economic consequence
Geology

- Average: 45 Meters below seabed (150 feet)
- Majority Chalk marl stratum (layer).
- Chalk marl Properties
  - Impermeability
  - ease of excavation
Tunnel cross section

- A: Rail tunnels
- B: Service tunnel
- C: Linking Service tunnel from rail tunnels
- D: Piston relief duct (manage pressure from train movement)
The Need For Further Expansion?

- **First Profit of €1m (£890,000) Occurred in 2007**
  - Lon-Paris carrier: August 2004 vs. August 2003
    - Eurostar: 67.99% vs. 64.91%
    - Air France: 11.17% vs. 12.06%
    - British Airways: 11.78% vs. 13.59%
    - Bmi: 4.46% vs. 4.56%
    - Easyjet: 4.38% vs. 4.60%
    - Other: 0.23% vs. 0.28%
    - Total: 100%

- **First Dividend Paid in 2008**

- **Eurotunnel In Large Amounts of Debt**

- **No Need For Another Link, But A Need For More Users**
### Passengers transported...

<table>
<thead>
<tr>
<th>Year</th>
<th>by Eurostar (actual ticket sales)</th>
<th>by Eurotunnel Passenger Shuttles (estimated, millions)</th>
<th>Total (estimated, millions)</th>
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<tr>
<td>1994</td>
<td>~100,000</td>
<td>0.2</td>
<td>0.3</td>
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<td>2,920,309</td>
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<td>4,995,010</td>
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<td>1997</td>
<td>6,004,268</td>
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<td>2000</td>
<td>7,130,417</td>
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<td>2001</td>
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<td>6,602,817</td>
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<td>2008</td>
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<td>7.0</td>
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<tr>
<td>2009</td>
<td>9,220,233</td>
<td>6.9</td>
<td>16.1</td>
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</table>
Tunnel Problems

- Electrical Failures
- Natural Disasters
- Immigration
- Fires
Electrical Failures

- Four Major Electrical Failures
- No Major Injuries Were Caused
- Two Of The Four Failures Were Caused By Ice And Snow
February 19, 1996

- Approximately 1,000 passengers were trapped inside the Channel Tunnel travelling towards France.
- Snow and ice melted inside the circuit boards.
August 3, 2007

- Electrical Failure Trapped Passengers Inside The Tunnel
- Failure Lasted Approximately 6 Hours
December 18, 2009

- 2,000 passengers trapped overnight
- Fluffy snow went through the winterization shield
- Emergency train was dispatched to pull train out
- Passengers were evacuated from inside the tunnel
Eyjafjallajökull Eruption

Caused Travel Disruptions For 6 Days In April 2010

Ash Cloud Crippled European Air Transportation

Increased Demand On Alternative Links

Millions Stranded For Days
Immigrants and Asylum Seekers

- Many illegal immigrants utilize the Channel to enter Britain.
- By 1997, the problem increased.
- Approximately 12 people have died.
- Costs approximately 5 million Euro per month.
Eurostar/Channel Tunnel Fires

- 3 Major Fires Occurred On The Route
- All Took Place On the Heavy Goods Vehicle (HGV)
- Two Of the Three Fires Were Inside
November 18, 1996

- HGV caught fire
- 7 miles outside French exit
- Burned for 5 hours
- Took 6 months and more than $300 million to repair
- 46 Meters Of The Tunnel Was Damaged
Alternate modes of Transportation
Air Transportation

- London, Heathrow to Paris, Orly
- Companies: British Air, Air France, Lufthansa
- Flight Cost
  - Weekday: $81 to $120
  - Weekend: $95 to $150
- Car Rental: $50 per day
- Time: 1:15 minutes
Passenger & Car Ferry

- Dover to Calais
- Companies: Sea France, P&O Ferry
- Cost:
  - W/ Car: 35€ to 75€
  - W/O Car: 6€
- Time: 1:25 minutes
The Model

- Simple three path, three link O/D network
  - Where each path = link
## Estimated Costs/ Demands

<table>
<thead>
<tr>
<th>O/D (London-Paris)</th>
<th>Plane Cost</th>
<th>Train Cost</th>
<th>Ferry Cost</th>
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<tbody>
<tr>
<td>Plane Ticket</td>
<td>$120</td>
<td>Train Ticket</td>
<td>$180</td>
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<tr>
<td>To and From Airport</td>
<td>$70</td>
<td>To and From Station</td>
<td>$30</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$190</td>
<td>Total Cost</td>
<td>$210</td>
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</tbody>
</table>

| Time to airport  | 30         | Time to Station | 15         | Time to Dock | 80          |
| Time to airport  | 90         | Station wait time | 20        | Station wait time | 40          |
| Time to airport  | 75         | Movement time  | 145        | Movement time | 85          |
| Time to airport  | 45         | Leave time     | 15         | Leave time   | 170         |
| Time to airport  | 240        | Total time     | 195        | Total time   | 375         |

| Stress Factor (1-10) | 9          | Stress Factor (1-10) | 4          | Stress Factor (1-10) | 6          |

<table>
<thead>
<tr>
<th>Demand</th>
<th>19721</th>
<th>Demand</th>
<th>12000</th>
<th>Demand</th>
<th>13640</th>
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<tbody>
<tr>
<td>Air Bus 321 seats</td>
<td>185</td>
<td>Train seats</td>
<td>1600</td>
<td>Ferry seats</td>
<td>550</td>
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<tr>
<td>Average flights per day</td>
<td>164</td>
<td>Average trains per day</td>
<td>15</td>
<td>Average ferries per day</td>
<td>31</td>
</tr>
<tr>
<td>Fill percent</td>
<td>65%</td>
<td>Fill percent</td>
<td>50%</td>
<td>Fill percent</td>
<td>80%</td>
</tr>
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