BRIDGE ALTERNATIVES
BRIEFING NOTE to compare the single-span and 3-tower bridge options
November 2005

Context

The preferred route for the new crossing of the River Mersey estuary features a four-span cable stayed structure over the central 1000 metre section supported from three towers within the tidal estuary (see Figure 1 and 2).

To reduce the hydrodynamic impacts on the tidal estuary, a single-span bridge has also been considered for the same route. To achieve this, the bridge would require a clear span of 1000m (no towers within the tidal river). A solution could be found by selecting a suspension/cable-stayed hybrid (see Figure 3 and 4).

This briefing note aims to compare and contrast these two bridge types based on economic, environmental and navigational criteria.
Figure 1 - Plan on 3-tower bridge

Figure 2 - Elevation on 3-tower bridge
Discussion

The preferred scheme (Route 3A) requires a bridge 2.4km long across the estuary. This comprises approach viaducts approximately 600m long over the north bank and 800m over the south. Both are curved in plan. The central 1000m would be over the tidal river.
The preferred bridge solution is cable-stayed with 4 spans supported from 3 towers (see Figure 2). This bridge type is relatively simple to build, hence it is considered to be the most economical for this length of crossing.

To reduce the hydrodynamic impacts on the estuary (no towers situated within the tidal estuary), a single span of 1000m would be required. This would be possible by suspension bridge or cable-stayed. The advantage of the latter structure is that is relatively simple to build and is economic. A 1000m span would place the Mersey Gateway at the top end of cable-stayed bridge spans - but examples of longer spans do exist with Stone cutters (currently under construction in Hong Kong) and others in China. However the towers for such a bridge have to rise to 200m above deck level putting the tower tops at an elevation of approximately 240m AOD. The new bridge would fall within the airspace of Liverpool John Lennon Airport which restricts any structures to 174m AOD. Thus a 1000m span cable-stayed structure is not an option.

A suspension bridge, however, only requires towers approximately 125m high above deck level - i.e. top of tower approximately 165m AOD. This does not intrude into Liverpool John Lennon Airport airspace, so would be acceptable. The disadvantage of pure suspension bridges is their flexibility (making them unsuitable for rail traffic) and their cost. They tend to be rather slow to build since construction is entirely sequential in process and has limited construction fronts.

An alternative is a hybrid structure illustrated in Figure 4. This combines a suspension bridge with a cable stayed bridge. The end lengths of the main span would be cable stayed and only the central 500m or so would be pure suspension bridge. The result is shorter towers (approximately 130m tall - 160 to 170m AOD) and multiple working fronts (units can be added to cantilevers progressing from either tower while deck units are being lifted in the centre). Examples of such a bridge form have been suggested (e.g. Stonscutters in Hong Kong) but not yet built for a span of 1000m. Smaller historic examples do exist i.e. Albert Bridge, London (1873), Brooklyn Bridge, NY (1883).

The curved approach spans limit the opportunity to anchor the back stays to the towers in the deck. Independent anchor blocks would need to be formed within the salt-marshes on each bank. To develop the necessary capacity to withstand the large anchorage forces will require massive concrete monoliths approximately 20m by 40m in plan area. These would be hollow concrete structures incorporating stressing galleries for the back stay cables, and would need to develop the necessary ground reaction to prevent them sliding towards the river.

The cost of a long-span structure has been estimated at approximately £150 million for the tidal river crossing compared with £75.6 million for the 3-towers alternative. The overall effect on scheme costs is indicated in the table below.

The impact on the tidal river would be reduced by crossing using a single span bridge, although not entirely eliminated since there would be a need for some works within the river to provide the base for the tower of the new bridge. However, the destruction of salt-marsh would be extensive with a significant area being lost due to the requirement of the anchor blocks.

Mersey Gateway - Briefing Note to compare single span and 3 tower options for Preferred Route November 2005
Comparison between the 3-tower and single-span bridge option

A simple comparison between the preferred 3-tower bridge and the alternative single-span bridge gives the following results:

<table>
<thead>
<tr>
<th>Cost(^{(1)})</th>
<th>Route 3A 3-tower bridge</th>
<th>Route 3A Single-span bridge</th>
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<tbody>
<tr>
<td>£260 million</td>
<td>£335 million</td>
<td></td>
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**Environmental Impact**

River hydrodynamics:
- a. Length of bridge over tidal water: 1000m vs. 1000m
- b. No of piers in tidal water: 3No vs. 0
- c. Permanent loss (operation): 250m\(^2\) vs. 0m\(^2\)
- d. Temporary loss (construction): 2120m\(^2\) vs. 0m\(^2\)

Natural habitat\(^{(2)}\):
- a. Permanent loss (operation): 518m\(^2\) vs. 4555m\(^2\)
- b. Temporary loss (construction): 3000m\(^2\) vs. 13120m\(^2\)

**Notes:**
1. Based upon the capital cost of the works plus land excluding risk and optimism bias
2. Natural Habitat is taken to be the salt marshes

**Conclusions**

It can be seen that a hybrid single-span bridge would fail to offer a sensible economical alternative to the 3-tower bridge.

Although the single-span bridge would have less impact on the hydrodynamics of the tidal estuary than the 3-tower bridge, it would have a significantly greater impact on the natural habitat. Overall it does not perform better than the preferred option in terms of environmental impacts.

The 3-tower bridge for Route 3A remains the preferred option.