Public Transport Authority & Main Roads WA

Fremantle Rail Bridge and Traffic Bridge Vessel Impact Protection Structures

Holistic Treatment of Fremantle Rail and Traffic Bridges

225387-REP-010

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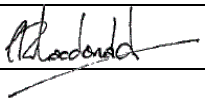
		Signature			
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Executive Summary

Arup was commissioned to consider the approaches taken to develop design solutions to improve protection from vessel impact to the Fremantle Rail and Traffic Bridges and determine if the approaches were equitable and defendable.

A staged approach for the improved protection works is proposed:

Stage 1 (to be implemented in the short term):

- Fremantle Traffic Bridge:
  - Construct frames adjacent to the Traffic Bridge navigation channel piers to provide increased capacity to withstand glancing impact.
- Fremantle Rail Bridge:
  - Construct five dolphins to the Port side of the Rail Bridge.
  - Implement an Early Warning System to indicate potential rail deflection in the event of an impact on the Rail Bridge.
- Waterway management:
  - Alterations to navigation channels and waterway management.
  - Enhance navigation aids (e.g. signage and lights) to increase safety, particularly when the southern channel is utilised by large vessels in both directions due to high tides.

Medium term solution (10 to 15 years):

- Fremantle Traffic Bridge:
  - Construct new Traffic Bridge.
  - Remove existing Traffic Bridge. (Extent of removal to be agreed).
- Fremantle Rail Bridge:
  - Reassess risk to upstream (city) side of Rail Bridge and consider additional protection measures.

Should the timeframe for the Traffic Bridge replacement be extended beyond 15 years a reassessment to increase head-on vessel impact protection to the Traffic Bridge should be made.

We consider this staged approach to impact risk reduction and mitigation is appropriate for the Fremantle Rail and Traffic Bridges. The approach to the development of the proposed designs is consistent between the bridges and each takes a holistic approach to the issue of impact protection. Although the two bridges cross the same waterway they are very different structures and support different modes of transport. Consequently the solutions proposed for the two bridges are different. Therefore, from a holistic solution point of view, we consider that the design solutions proposed are ‘equitable and defendable’.

1 Context

Fremantle Traffic Bridge and Rail Bridge have been in place for 75 and 50 years respectively. Due to their age and the continued development of design codes, neither is designed to current standards. This is the case with most existing structures of a reasonable age.

Previous reports indicate that both bridges are at risk of vessel impact and there are recorded incidents and evidence of impacts on both bridges. To date there is no evidence that these impacts have caused significant structural failure of bridge elements on either bridge structure. However, the Parmelia incident on the Rail Bridge in 2011 caused significant delay due to damage to the OLE structure. This damage had the potential to have a much more serious consequence had the bridge of the vessel hit the train that was passing at the time. As a result of this, Fremantle Port Authority took action to improve port processes and Public Transport Authority commissioned Arup to develop appropriate impact protection measures.

Fremantle Traffic Bridge is due to be replaced in the medium term (i.e. 10 to 15 years). The bridge fender system which was constructed in 1975 has suffered damage from frequent impacts but no major structural failure of bridge elements has occurred. Existing assessments indicate that the bridge has insufficient capacity to withstand a more significant impact. It is assumed that these issues would be mitigated in the design of a replacement bridge. In the interim period the bridge is at continued risk of a more significant impact. Main Roads WA commissioned Arup to develop a practical impact risk reduction strategy within the many constraints taking into account the planned bridge replacement and budget constraints.

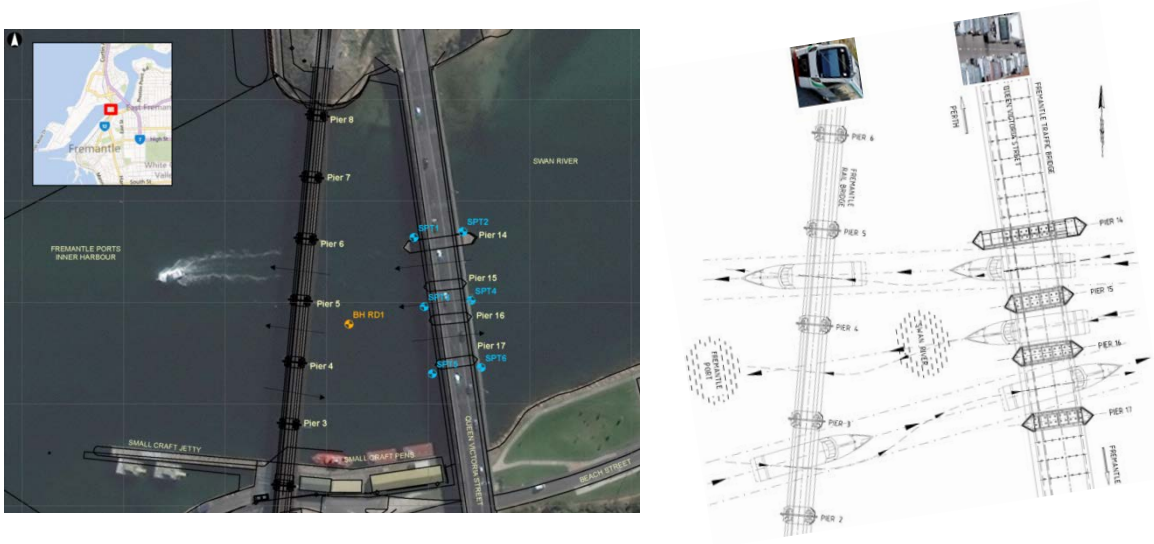

Figure 1: Location Plan.

2 Constraints and Solution Development

The bridges are located close to each other, with the Rail Bridge bordering the Port of Fremantle. The bridge piers do not align and the bridges cross a busy waterway. Each bridge is of a different span arrangement, structure and has different existing protection measures. They also carry different traffic and utilities resulting in different sensitivity to structural deflection. The layout of the bridges, navigation channels, surrounding area, and the availability of alternative routes means that the bridges are subject to different risks and results in different solutions being appropriate to each. It is assumed the impact risk to the Traffic Bridge will be mitigated when it is replaced in the medium term, while there are no current plans to replace the Rail Bridge.

Key stakeholders were consulted during the design development for each bridge to determine their key constraints and concerns. These were then assessed holistically to determine an appropriate solution. Solutions considered for each bridge included improvements to signage and navigational aids, operational changes, structural alterations to bridges, relocation of utilities, alterations to navigation channels, and additional protective structures such as piles, caissons, etc.

The approach taken to assessing risk and developing improvement strategies is the same for each bridge. However, as the bridges are different, the proposed solutions are also different.

3 Proposed Solution – Stage 1

The design and consultation process resulted in the following works being proposed to be constructed as soon as possible for each project:

- Fremantle Traffic Bridge:
  - Construct glancing protection frames adjacent to the Traffic Bridge navigation channels.
- Fremantle Rail Bridge:
  - Construct dolphins on key piers on the Port side of the Rail Bridge.
  - Implement an Early Warning System to indicate potential rail deflection in the event of an impact on the Rail Bridge.
- Waterway management:
  - Alterations to navigation channels and waterway management.
  - Enhance navigation aids (e.g. signage and lights) to increase safety, particularly when the southern channel is utilised by large vessels in both directions due to high tides.

This is shown diagrammatically in the figure below; new structural works are shown in red.

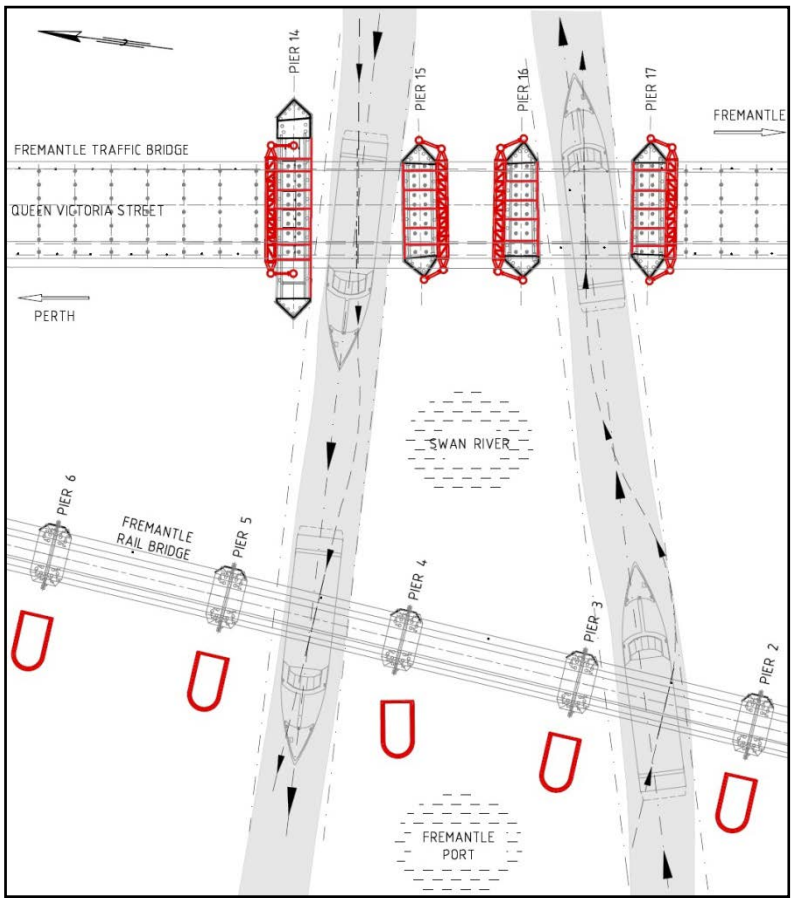

Figure 2: Proposed Solution – Stage 1.

4 Medium Term Solution

Fremantle Traffic Bridge is due to be replaced in the medium term (i.e. 10 to 15 years). Planned works are:

- Fremantle Traffic Bridge:
  - Construct new Traffic Bridge.
  - Remove existing Traffic Bridge. (Apart from 'heritage' section).
- Fremantle Rail Bridge:
  - Reassess risk to upstream (city) side of Rail Bridge and consider additional protection measures and channel alterations to suit new traffic bridge.

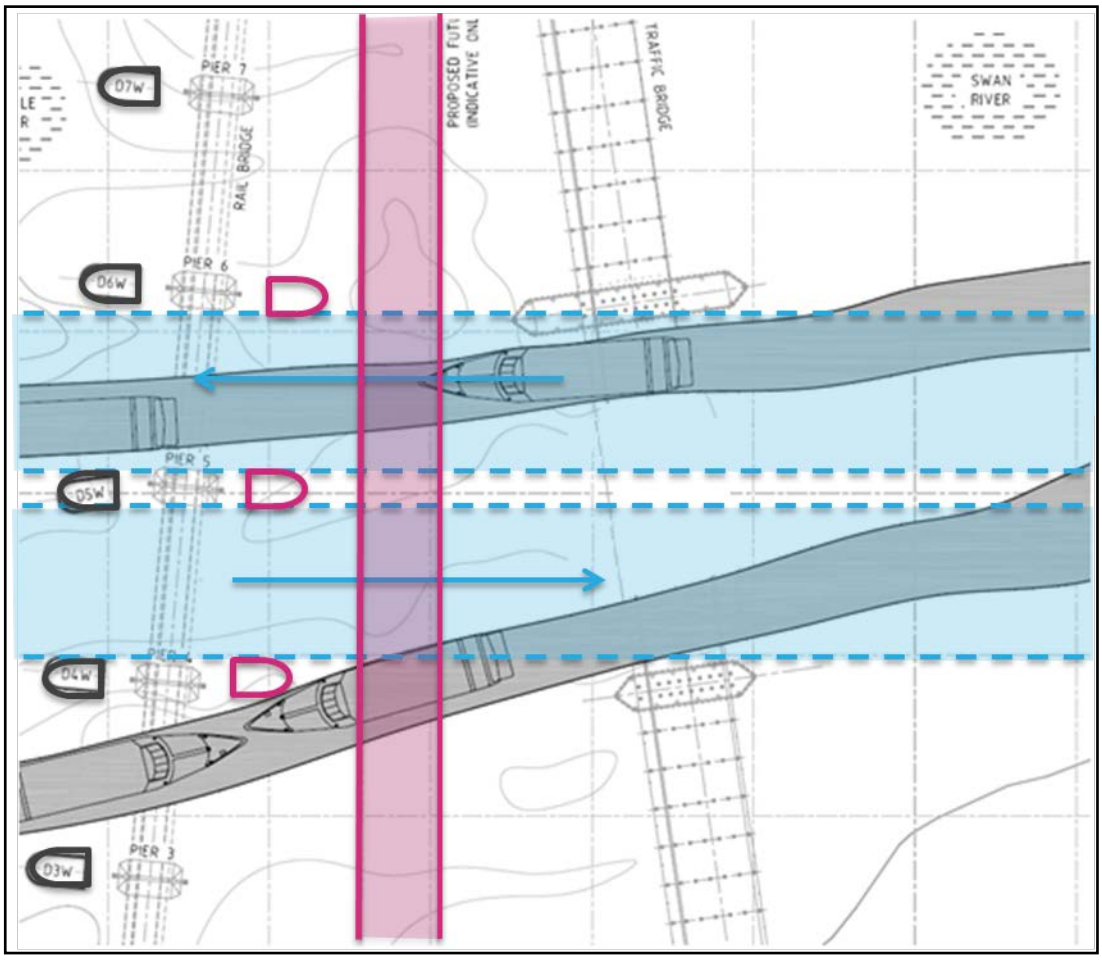

Figure 3: Potential Medium Term Solution.

Should the timeframe for the Traffic Bridge replacement be extended beyond 15 years a reassessment to increase head-on vessel impact protection to the Traffic Bridge should be made.

5 Impact Risk Improvement Summary

A risk assessment in accordance with Main Roads WA Risk Management Process was carried out to determine the improvement to risk developed for each structure using the same procedure.

Risk assessment is by nature a subjective process, carried out by key stakeholders and so consistency is assessed more transparently by repeating the Rail Bridge risk assessment using Main Roads WA procedure.

The following tables present the risk matrix and likelihood and consequence rankings used in the risk assessment process.

LIKELIHOOD

1 – Rare, 2 – Unlikely, 3 – Moderate, 4 – Likely, 5 – Almost Certain

Consequences	1	2	3	4	5
5 – Catastrophic	H	H	H	VH	VH
4 – Major	M	H	H	H	VH
3 – Moderate	M	M	M	H	H
2 – Minor	L	L	M	H	H
1 – Insignificant	L	L	L	M	M

LEVEL	DESCRIPTOR	FREQUENCY
1	Rare	Less than once in 20 years
2	Unlikely	At least once in 10 years
3	Moderate	At least once in 3 years
4	Likely	At least once per 1 year
5	Almost certain	More than once per year

Risk Rankings	
VH	Very High (Unacceptable)
H	High (Urgent Action)
M	Moderate (Management Controls)
L	Low (Specify Actions & Monitor)

Figure 4: Main Roads WA Risk assessment key.

The figures below summarise the vessel impact risks to the Rail and Traffic Bridges at three stages:

Figure 5 summarises vessel impact risks to the Rail and Traffic Bridges in their current configuration. This indicates that the current risks are high and require action.

Figure 6 shows that significant improvement is made at Stage 1 for the most likely vessel impact events where protection measures do not adversely impact on other elements.

Figure 7 shows the improvement in the medium term achievable through replacement of the Traffic Bridge. (When the Traffic Bridge is replaced, additional protection measures to the Rail Bridge should be reassessed and provided as required).

Note that the impact risk ratings given are for the bridge elements that are affected by the protection works only, i.e. the protected bridge piers. No improvement in risk rating is obtained for unprotected elements. Pier protection measures are designed for typical vessels at a credible maximum speed and direction of impact. These have been developed based on vessels currently using the waterway.

The figures below are colour-coded corresponding to the risk ranking table in Figure 4.

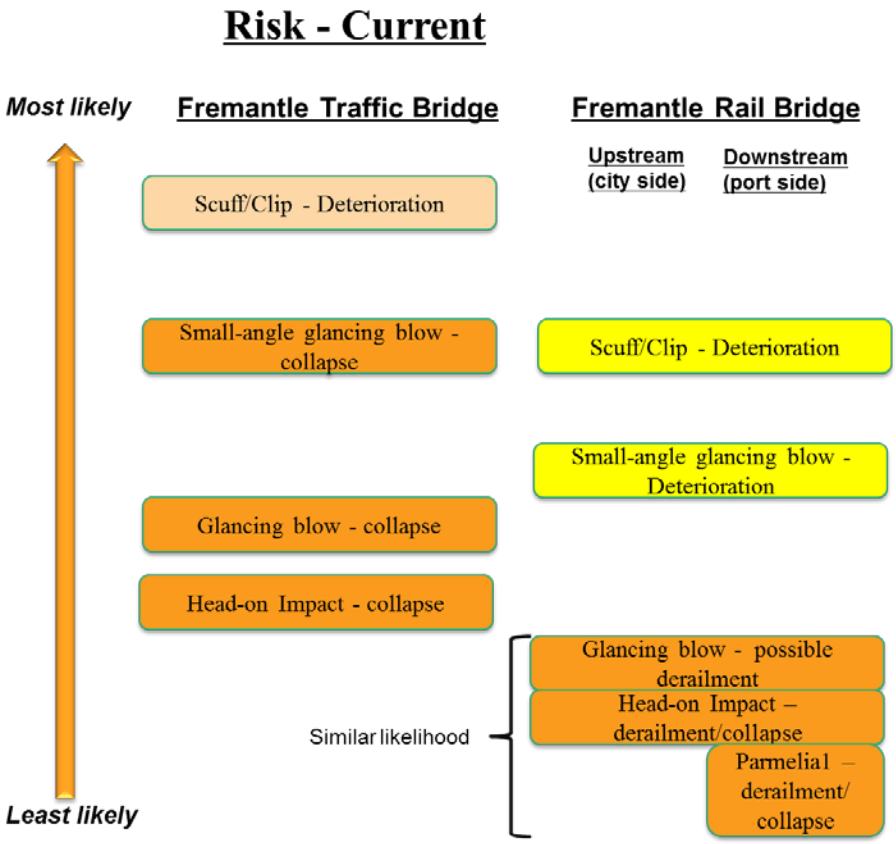

Figure 5: Summary of vessel impact risks to Rail and Traffic Bridges in current configuration.

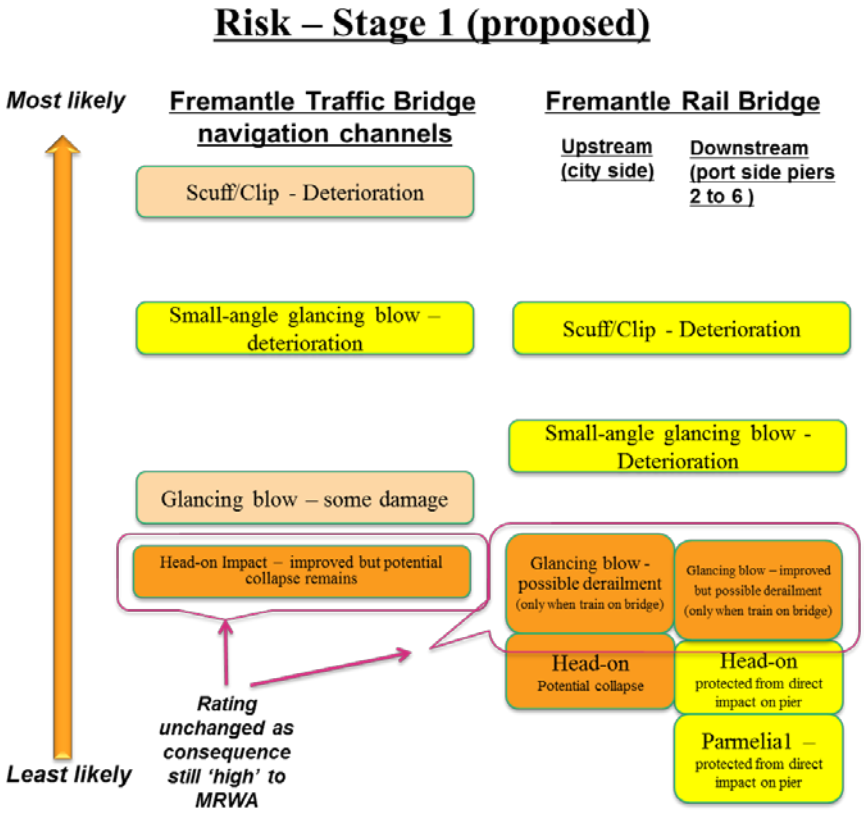

Figure 6: Vessel impact risk improvement summary – Stage 1 (proposed).

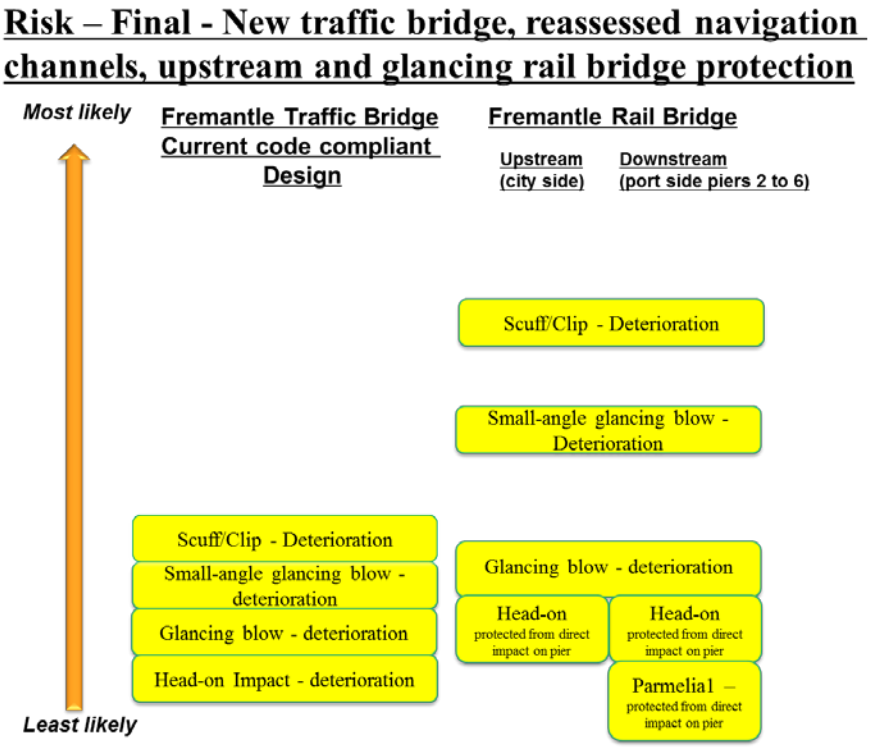

Figure 7: Vessel impact risk improvement summary – Medium term (proposed).

6 Conclusion

We were requested to assess the consistency of the proposed pier protection at both Rail and Traffic Bridges. The development of the projects and revised programme for the replacement of the Traffic Bridge has resulted in a staged approach being taken. This staged approach to vessel impact risk reduction and mitigation is appropriate for the Fremantle Rail and Traffic Bridges given the constraints to each bridge and the plan for replacement of the Traffic Bridge in the medium term. Therefore, from a holistic solution point of view, we consider that the design solutions proposed are ‘equitable and defendable’.