Semi-Automation of Period Permit and Single Trip Permit Vehicle Bridge Assessments

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ABSTRACT

The volume of heavy vehicle permit applications has continued to increase at approximately 8% per annum in Western Australia, requiring more engineering assessment time and pressure to maintain agreed permit turnaround times.

To make the permit assessment process more efficient, Main Roads Western Australia (MRWA) has recently developed a Heavy Vehicles assessment module as part of its corporate, electronic Bridge Management System (BMS) to semi-automate the permit assessment process. Period permits and single trip permits for floats and platforms are now completed.

The completion of this application has halved load assessment time, ensured consistency in permit assessment, improved response to the transport industry and minimised risk for litigious situations. In addition, by storing all previous permits electronically within BMS, the full history of permit assessments enables quick and consistent assessment of comparable future permit applications.

This paper describes the approach adopted by MRWA to develop software that is used for all bridge load assessments for heavy vehicle period permits and single trip assessments. It also details the assessment methodology and shows the solutions adopted within BMS.

1. INTRODUCTION

In 2009 MRWA commenced the development of its own custom built BMS to ensure it would have a comprehensive corporate system that supported and facilitated all of the bridge management activities so they could be performed in a consistent, effective and efficient manner with all activities being transparent and based on reliable data.

The BMS has been developed in five modules – Program Management, Bridge Enquiry, Heavy Vehicles, Inspections, and Bridge Inventory. The Heavy Vehicles (HV) module of the BMS is the corporate working tool, developed to help with the assessment of heavy vehicle movement permits and bridge load rating management. It provides a number of key benefits, including:

- Elimination of repetitive work when assessing permits;
- Improvement in efficiency of the process of assessing permits;
- Collection and storage of information to provide information on previous assessments and performance of the network; and
- Promotion of consistency in the completion of bridge assessments.
The HV module sources bridge inventory data directly from the corporate Integrated Road Information System (IRIS) bridge database and semi-automates the permit assessment process for period permits and single trip permits for floats and platforms. The semi-automation of single trip permits for all other vehicle types is currently under development, and is planned to be completed this financial year.

This paper provides background on the types of permits, types of vehicles, the assessment philosophy and methodology, the scope of the BMS semi-automation, and provides two detailed examples for the semi-automation of platform vehicle single trip assessment and crane period permit for bridges on the WA road network.

2. WESTERN AUSTRALIAN AND MRWA’S HEAVY VEHICLE PERMIT SYSTEM

All types of travel permits for movement of over size and over mass vehicles on public roads within Western Australia (WA) are issued by the Heavy Vehicle Services (HVS) directorate of MRWA.

This is a point of differentiation between WA and other states of Australia, in that MRWA assesses the movement of vehicles on bridges on all public roads, regardless of bridge ownership.

Within MRWA, Structures Engineering (SE) branch is responsible for undertaking the detailed condition inspections to inform the assessment of the load rating for all bridges on public roads in the State, so as to be able to meet this permit assessment obligation.

3. PERIOD PERMITS

Period permits are issued for annual operation for Special Purpose Vehicles (SPVs, i.e. cranes, drill rigs, concrete pumping trucks etc.) and multi-combination 4-Tyre vehicles (standard width vehicles at vehicle standard regulation (VSR), concessional or full loads). These permits are usually issued for movement within nominated areas, often including the potential crossing of hundreds of bridges.

Period permits cannot be issued with additional bridge conditions to control vehicle movement or speed, so it becomes a yes or no decision for each requested bridge.

MRWA bridge engineers assess approximately 45 period permits each month. These permits are required to be assessed within a 2 week period.

4. SINGLE TRIP PERMITS

As the name suggests, single trip permits are issued for travel from origin to destination along a specified route on a once-off single trip basis. They are generally issued for the larger vehicles carrying indivisible loads (floats and platforms) but can be issued for any vehicle type, particularly where bridge capacity precludes the issue of a period or network permit.
MRWA bridge engineers assess approximately 25 single trip bridge permits each day. These permits are required to be assessed within a few hours of receiving the permit from HVS for a less than 24-hour total turnaround to the transport operator.

5. ASSESSMENT PHILOSOPHY

The assessment philosophy used by MRWA for the different types of permits and vehicles complies with the requirements of Standards Australia Bridge Design Code\(^1\) or modified Code approaches as outlined in MRWA’s Bridge Branch Design Information Manual\(^2\).

In general terms, the assessment of requested vehicles for bridge transit is based on the load rating equation (refer Equation 14.2(2) in AS5100.7\(^1\)). This equation, noted below, is expressed for moment but comparable equations are also applicable for shear and reaction:

\[
\%\text{Rating} = \left( \frac{\phi M_U - (\gamma_G M_D + \gamma_{GS} M_{DS} + M_P + M_S + \gamma_T M_T)}{\gamma_L x (1+DLA)x M_L} \right) \tag{1}
\]

where:
- \(\phi\) = Capacity reduction factor
- \(M_U\) = Calculated ultimate moment capacity
- \(\gamma_G\) = Load factor for dead load
- \(M_D\) = Moment due to dead load
- \(\gamma_{GS}\) = Load factor for superimposed dead load
- \(M_{DS}\) = Moment due to superimposed dead load
- \(M_P\) = Moment due to parasitic effects of prestress
- \(M_S\) = Secondary moment due to differential settlement
- \(\gamma_T\) = Load factor for differential temperature
- \(M_T\) = Secondary moment due to differential temperature
- \(\gamma_L\) = Load factor for live load
- DLA = Dynamic Load Allowance
- \(M_L\) = Moment due to live load incorporating multiple lane modification factors or accompanying lane factors as appropriate

The bracketed numerator component represents the permanent effects (PE). This equation can then be simplified to:

\[
\%\text{Rating} = \left( \frac{\phi M_U - PE}{\gamma_L x (1+DLA)x M_L} \right) \tag{2}
\]

The assumption is then, that for a particular bridge at a given location (i.e. sag or hog) that, \((\phi M_U - PE)\) is a constant, and thus:

\[
\%\text{Rating} \times (\gamma_L x (1+DLA)x M_L) = \phi M_U - PE = Constant \tag{3}
\]

and

\[
\%\text{Rating}_1 \times (\gamma_{L1} x (1+DLA_1)x M_{L1}) = \%\text{Rating}_2 \times (\gamma_{L2} x (1+DLA_2)x M_{L2}) \tag{4}
\]

MRWA has developed a comprehensive IRIS database containing detailed location, geometry, condition and load rating information for all 2,500+ vehicular bridges on public roads for which it is responsible for issuing heavy vehicle permit access (including bridges owned by others). The detailed load rating information contains percentage rating values (\%Rating) for 12 standard MRWA defined Group 1 (standard width) and Group 2 (float and platform) rating vehicles, as well as T44/M1600 design vehicles. All ratings are based
on detailed assessments completed using appropriate structural analysis modelling in accordance with AS5100\(^1\).

By using a similar rating vehicle to the requested vehicle, Equation 4 can be further refined. Assuming that the vehicles have similar overall width of axles and thus similar transverse load distribution factors, and assuming the same movement conditions and thus the same DLA and \(\gamma_L\) factors for both vehicles, the equation is further simplified:

\[
\% \text{Rating}_1 \times M_{L1} = \% \text{Rating}_2 \times M_{L2}
\]  

(5)

Knowing \(\% \text{Rating}_1\) it is possible to then derive \(\% \text{Rating}_2\) by running a simple linebeam program to derive \(M_{L1}\) and \(M_{L2}\) (given the assumption of similar transverse distribution factors).

This is the assessment philosophy MRWA has adopted from inception of heavy vehicle permit assessments and for the development of its BMS.

If transverse ratings control the bridge load rating or if they are less than 100% then care needs to be taken as various programs for assessment or linebeam comparisons cannot accurately assess this transverse effect. The detailed bridge model should be used where possible.

6. **DETAILED EXAMPLE 1: ASSESSING PLATFORM VEHICLE SINGLE TRIP PERMITS**

Platforms represent the larger mass single trip permit vehicles and equate to approximately 45% of all single trip permit assessments requiring specific engineering assessment. These vehicles and the single trip permit assessment of these vehicles is a focus of this paper, but the same assessment philosophy and similar approach within BMS is adopted for the single trip assessment of other vehicle types.

Multiple axle platforms permit up to 18t per axle under supervision with 8-tyres per axle, up to 27t per axle under supervision with 12-tyres per axle (3-file), and up to 36t per axle under supervision with 16-tyres per axle (4-file). They vary significantly in their overall width of axles, from 3.0m to 4.5m for 8-tyres and from 6.2m to 7.5m for 16-tyres.

As laden platform vehicles can only travel using single trip permits, these vehicles can be controlled with additional bridge supervision conditions (e.g. central movement on the bridge at 10km/h with video supervision) if required to limit the effects on the bridges.
Given the large number of requests for platform vehicles with similar configurations, MRWA’s SE bridge engineers have developed a ‘Platform Table’ to assist in the individual assessment of platform vehicles of defined various spacings and overall width of axles, for the more common transport routes. This is a guiding tool only and SE must approve the movement of all laden platform vehicle single trip permits.

The Platform Table summarises the rating for standard vehicles with a prime mover (single steer) and platform (6 to 16 axles) with axle spacings of either 1.55m or 1.80m at no supervision (NS) and supervision (S) limits for different overall widths of axles. The majority of NS and S values are controlled by generic lower-bound NS and S limits set by HVS (GLLHVS and GLLPLAT) to protect the State’s assets and are not generally controlled by the bridge capacity.

If the bridge being assessed is covered by the Platform Table but the vehicle differs, the difference in vehicle needs to be assessed by the MRWA bridge engineer. The difference may be insignificant, for example, if the spacing difference is only in the prime mover or if the spacing difference is only small. However, if the spacing change is considered significant or if a dolly is present in the requested vehicle, then full structural assessment is warranted.

The general assessment steps are represented diagrammatically in the flow chart in Figure 2.
Receive permit from HVS

Is vehicle as per Platform Table?

Define vehicle differences

Detailed analysis required?

Y

Does bridge have a timber deck?

N

Full capacity?

Y

Bridge in Metro Region?

N

Assign condition based on HLR – NS or Overloaded only

N

Assign condition based on HLR – NS or Overloaded only – or GLLPLAT or GLLHVS for dolly

Bridge in Metro Region?

Y

Assign condition based on HLR – NS, S or Overloaded

N

Assign condition based on HLR – NS, S or Overloaded – or GLLPLAT or GLLHVS for dolly

Relevant G2 and HLP ratings available?

N

Assign condition based on HLR or GLLPLAT or GLLHVS for dolly and consider if HLR might be unconservative

Y

Assign condition based on linebeam comparison or GLLPLAT or GLLHVS for dolly

Interrogate Results (Works & Conditions, Previous Permits)

Finalise, adding/amending conditions as required

* Full Capacity refers to minimum ratings of at least 18t tandem-axle, 27t tri-axle, 36t quad/484quad-axle and 100% T44.
* MRWA’s G2 vehicles have overall width of axles/tyres per axle of 3.0m/8, 3.7m/8, 4.81m/12, 6.22m/16 for comparison to similar width vehicles.*
* HLR" refers to the Heavy Load Routing software program used for the assessment of vehicle crossing bridge structures.

**Figure 2 – Single Trip Assessment Steps for Platforms**
The Single Trip Permits screens of the HV module include a streamlined process for the single trip permit assessment of bridges by:

- Directly interrogating IRIS for bridge data;
- Retrieving previous single trip permits for similar vehicles and routes from stored history;
- Identifying changes to bridge ratings;
- Semi-automating the assessment process to improve efficiency and consistency of results;
- Providing seamless integration with the structural analysis software (Heavy Load Route (HLR\(^3\)) Analysis System) and MRWA’s permit system (RAVS);
- Allowing the user to review and amend assessment results;
- Automatically assigning additional bridge supervision conditions; and
- Automatically saving the details of the deficient bridges and assessment records for use in future single trip permit assessments.

The Single Trip Permits screens represent the working area for the SE bridge engineers to manage and assess single trip permits.

### 6.1 Single Trip Permit List General Screen

The opening screen of the Single Trip Permits section lists all outstanding single trip permits (for all vehicle types). The user can also tick the box to “Show completed permits and assessments only” to report the history of single trips completed using BMS.

All data is automatically retrieved from HVS’s RAVS permit database. The transport operator requests a permit from HVS and all details are then entered into RAVS. BMS extracts the relevant information from RAVS to enable bridge assessment of the single trip permit.

The Single Trip Permits screenshot (for completed permits) is shown in Figure 3.

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**Figure 3 – BMS Single Trip Permits Screenshot**
To begin the bridge assessment of a single trip permit, the user simply clicks on the BMS Permit Number hyperlink.

After opening a single trip permit the user is presented with eight standard screens – Permit Details, Route Details, Vehicle Details, Previous Permits, Selected Bridges Report, Assessment, Summary Report and Finalise. These screens are viewed as a series of tabs, located across the top of the screen to enable the user to easily go from one to another. The screens are ordered in the typical work sequence to input, review, assess and finalise the results of the single trip assessment. The content of each of these screens and the general workflow are detailed in the following sections.

6.2 Single Trip Permit Details Screen

All basic data for the permit including permit number, permit type, transport company, and date the permit is received, are automatically retrieved from HVS’s RAVS database but the user has the option to amend the permit type (if required) before starting the assessment of this permit.

6.3 Single Trip Route Details Screen

The route data is automatically retrieved from HVS’s RAVS permit database but the user has the option to amend the route (if required). The routes are built using IRIS road names and intersection data to ensure that there are no gaps in the requested outgoing or return route.

The Single Trip Route Details Screen is shown in Figure 4.

**Figure 4 – BMS Single Trip Route Details Screen**
Taking into account the direction of travel, BMS determines the bridges that are crossed and thus need assessment, for the selected route details. The user can opt to view a report with the list of bridges, their rating values and other specific attributes as well as display the route on a map with the bridges to be crossed highlighted to the user.

The map for the above example route is shown in Figure 5 as the red coloured route, and shows all bridges to be crossed.

Figure 5 – BMS Route Details Map
6.4 Single Trip Vehicle Details Screen

The vehicle data is automatically retrieved from HVS’s RAVS permit database and cannot be amended. The vehicle data is summarised and displayed for easy reference to the user.

The Single Trip Vehicle Details Screen is shown in Figure 6.

![Figure 6 – BMS Single Trip Vehicle Details Screen](image)

6.5 Single Trip Previous Permits Screen

BMS automatically retrieves previous single trip permit assessments for similar vehicles and routes from stored history. A permit is deemed ‘similar’ if the difference in bridge list (i.e. the bridges crossed by the requested vehicle) is less than ten, the vehicle is of the same type with the same number of axles and tyres per axle, with axle masses within 2%, spacings within 5% and overall width of axles within 3%.

It may be that the current single trip permit is identical to a previous permit and no further assessment is required. At the least, the similar previous permit will give some history of the conditions applied and any restrictions imposed, promoting consistency in bridge assessments.

6.6 Single Trip Selected Bridges Report Screen

This screen displays all the bridges on the selected route(s) and their rating values and other specific attributes. In some instances, for an experienced engineer, this information will be sufficient for finalisation of the permit without completing a full assessment. For less experienced engineers, this report provides a good check for assessment results.
6.7 Single Trip Assessment Screen

This screen displays a summary of the information from the preceding screens and determines the information to be used in the semi-automated BMS bridge assessment. Any differences in vehicle dimensions from the standard Platform Table vehicles are highlighted to the user, for judgement by the engineer as to whether these are significant or not for this particular single trip permit vehicle.

The user can choose a partial or full assessment. A partial assessment assumes that the Platform Table values are appropriate. A full assessment undertakes full comparative assessment – comparing the load effects of the requested vehicle to the allowable rating values using the rating values for a similar width vehicle, or using HLR analysis if no relevant detailed ratings are available. BMS uses the assessment philosophy outlined in Section 5. The determination of the relevant rating vehicle, the type of assessment and the generic lower limit values are all automatically determined and reported in BMS.

6.8 Single Trip Summary Report Screen

Following successful assessment, the summary report screen is populated with the results for each bridge on the route. A bridge is either assessed using 'HLR' (if no relevant MRWA Group 2 (float or platform)/HLP rating vehicles exist) or 'linebeam' with a comparative approach as per the assessment philosophy outlined in Section 5.

By default, only those bridges with movement or weight restrictions are shown on the summary report screen. The user can also tick the box to “Show all structures” to report the results for all bridges.

From this screen, the user can also easily upload the load rating summary information, any special conditions, outstanding critical repairs, or upcoming bridgeworks that may affect the bridge assessment.

The user has the ability to override the condition and provide comments before the final condition is assigned in BMS. The associated special movement condition or bridge video supervision condition (if applicable) is automatically determined in BMS (‘BVS Code’ in the screen example below).

The Single Trip Summary Report Screen is shown in Figure 7.
Following completion of all conditions in the summary report screen, the finalise screen is used to automatically save the details of any deficient bridges and save the full assessment records for use in future single trip permit assessments.

Further, these assessment results are automatically and seamlessly sent back to HVS through their RAVS permit system to enable collation with additional permit conditions prior to issue of the permit to the transport operator.

7. **DETAILED EXAMPLE 2: ASSESSING CRANE PERIOD PERMITS**

Cranes permit up to 12t per axle on 20” (500mm) tyres. They are generally close to 3.0m width on ground and can move within a marked lane. All special purpose vehicles are weighed when licensed and there is reduced risk of overloading.

As cranes are generally lighter vehicles, they normally operate using period permits.
Given the large number of requests for crane permits, MRWA has some common crane configurations covered under the network access permit system, whereby some crane period permits can be self-assessed by the transport operator for predefined vehicle configurations operating on restricted networks. Only those cranes that are not covered by these network access permits need specific engineering assessment and are assessed and recorded in BMS.

The general assessment steps are represented diagrammatically in the flow chart in Figure 9.

* HLR\(^3\) refers to the Heavy Load Routing software program used for the assessment of vehicle crossing bridge structures.
The Period Permits screens of the HV module include a streamlined process for the period permit assessment of bridges by:

- Directly interrogating IRIS for bridge data;
- Retrieving previous period permit assessments for similar vehicles and routes from stored history;
- Identifying changes to bridge ratings;
- Semi-automating the assessment process to improve efficiency and consistency of results;
- Providing seamless integration with the structural analysis software (Heavy Load Route (HLR°) Analysis System);
- Allowing the user to review and amend assessment results;
- Preparing memos of assessment outcomes, with documented approval provided to HVS; and
- Automatically saving the details of the deficient bridges and assessment records for use in future period permit assessments.

The Period Permits screens represent the working area for the SE bridge engineers to manage and assess period permits.

### 7.1 Period Permit List General Screen

The opening screen of the Period Permits section lists all outstanding period permits. The user can also tick the box to “Show completed permits” to report the history of period permits completed using BMS.

At this stage of development, all data is manually entered but there are plans to automatically retrieve this data in the future from HVS’s RAVS permit database. The Period Permits List screenshot is shown in Figure 10.

**Figure 10 – BMS Period Permits List Screenshot**
To begin the bridge assessment of a period permit, the user simply clicks on the BMS Permit Number hyperlink.

After opening a period permit the user is presented with nine standard screens – Permit Details, Route Details, Vehicle Details, Previous Permits, Selected Bridges Report, Single Trip Check, HLR Assessment, Summary Report and Memo. These screens are viewed as a series of tabs, located across the top of the screen to enable the user to easily go from one to another. The screens are ordered in the typical work sequence to input, review, assess and finalise the results of the period permit assessment.

The content of each of these screens and the general workflow are similar to those for the single trip permits, refer Section 6 for details. Only the screens with major differences will be outlined in the following sections.

7.2 Period Permit Route Details Screen

On this screen the user enters the route details to enable extraction of all bridges that may be crossed under the use of the requested period permit vehicle. The Period Permit Route Details Screen is shown in Figure 11.

![Figure 11 – BMS Period Permit Route Details Screen](image-url)
The main difference for period permits is the selection of the route by area (region and/or local government area) as opposed to a defined route from origin to destination.

BMS determines the bridges that are crossed and thus need assessment, for the selected route details.

7.3 **Period Permit Assessment Screen**

This screen displays a summary of the information from the preceding screens and determines the information to be used in the semi-automated BMS bridge assessment.

BMS performs an analysis of the permit using the Heavy Load Route Analysis System (HLR\(^3\)) program, comparing the requested crane to the HLR recorded T44 rating values for each bridge. BMS uses the assessment philosophy outlined in Section 5.

7.4 **Period Permit Memo Screen**

The final step in the period permit assessment process and the last tab in BMS for each period permit is for the creation of the standard memo, approval and reporting back to HVS.

![Figure 12 – BMS Period Permit Memo Screen](image)

A standard memo is created by BMS from the vehicle and route input data, and incorporates the outcomes of the assessment. Once this memo has been approved it is automatically and seamlessly sent back to HVS to enable collation with any additional permit conditions prior to issue of the permit to the transport operator.
8. BENEFITS AND OUTCOMES

The completion of the BMS period permit application and single trip permit application for floats and platforms has halved load assessment time, ensured consistency in permit assessment, improved response to the transport industry and minimised risk for litigious situations. In addition, by storing all previous permits electronically within BMS, the full history of permit assessments enables quick and consistent assessment of comparable future permit applications.

The seamless integration with HVS for permit documentation and issue to the transport industry has provided improved business process linkages and removes human error in the transfer of data between load assessment outputs and permit conditions that are applied to the transport operator’s permit.

Period permit assessment and single trip permit assessment within MRWA SE previously required 2 engineers full time. It is anticipated that with the completed BMS single trip permits (still to implement semi-automation for special purpose vehicles, 4-tyre and mixed vehicles) MRWA will only require 1 engineer for this work. This equates to significant savings and refocus of a valuable full time resource for other asset management tasks.

9. CONCLUSIONS

Despite the economic downturn, MRWA continues to issue approximately 18,000 single trip permits every year, an 8% increase per annum, with approximately 25 each day requiring specialist bridge engineering input for assessment. In addition, specialist bridge engineering input is required for the assessment of approximately 550 period permits every year. The industry and political pressure to maintain agreed permit turnaround times and the increase in requested permit loads prompted MRWA to develop custom built BMS software capable of structural assessment of these vehicles. The assessment process adopts long-serving and Australian Standard Bridge Design Code supported philosophies, interrogating detailed load rating data for various overall width of axles to compare to the effects of each requested vehicle.

Detailed statistics are readily available from within BMS to report on the total number of period permits and single trip permits completed within a period of time, the number approved, not approved or those that required further input, and the average time taken to complete the permits.

The completion of this semi-automated process has halved load assessment time, ensured consistency in permit assessment, improved response to the transport industry and enables the full history of permit assessments to be available for quick and consistent assessment of comparable future permit applications.

The significant savings has permitted refocus of a valuable engineering resource for other asset management tasks.
MRWA has commenced development to complete the single trip assessment within BMS enabling semi-automation of 4-tyre per axle vehicle, special purpose vehicle and mixed vehicle bridge assessments. This will complete the heavy vehicle semi-automation of period permit and single trip permit vehicle bridge assessments within BMS.

10. REFERENCES


3. Heavy Load Route Analysis System (HLR) program, Transport SA.

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