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Application of USGS ShakeCast for Rapid Post-Earthquake Assessment of Critical Infrastructure Facilities in Western Australia

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Abstract

The National Earthquake Alerts Centre (NEAC) at Geoscience Australia (GA) operationally provides alerts on earthquake events in the region which include Shakemap. This paper describes a pilot project in the NEAC to provide added information to these alert products to give indications to key asset owners of potential damage. The United States Geological Survey (USGS) ShakeCast is an example of such a system that uses USGS Shakemap and provides near-real-time post-earthquake impact and inspection metrics for critical infrastructure facilities following an event. This enables asset owners and infrastructure operators to prioritise damage inspections. Geoscience Australia is undertaking a project entitled “Risk Assessment and Mitigation Study for Earthquakes in the Yilgarn” (RAMSEY) in collaboration with the Global Earthquake Model Foundation (GEM) and five Western Australian government partners. The key focus of the project was to understand critical infrastructure system risk with geographically dispersed assets in the Wheatbelt Region of southwestern Western Australia, inland from Perth. One key issue raised by project partners is the need to effectively prioritise inspection resources following an earthquake where there are many assets exposed to strong shaking. As a response to this need, the USGS ShakeCast application has been operationalised in the NEAC as a pilot for the RAMSEY partners using the vulnerability knowledge developed through the project on bridges. In this paper, the input requirements for the system and the products provided are described in the context of a real event. Furthermore, the benefits and limitations of the system are discussed along with feedback from the partners on utility in informing the potential development of a broader capability.

Keywords: earthquake risk, infrastructure, impact, inspection priority, bridges

1 Introduction

Geoscience Australia is undertaking a project entitled “Risk Assessment and Mitigation Study for Earthquakes in the Yilgarn (RAMSEY)” in collaboration with the Global Earthquake Model Foundation (GEM), Department of Fire & Emergency Services (DFES), Main Roads, Western Power, Water Corporation, Arc Infrastructure, Department of Planning, Lands and Heritage (DPLH), and Western Australia Country Health Service (WACHS). A key aspect of the project is to understand critical infrastructure system risk, particularly with geographically dispersed elements, in the Yilgarn region.

One key issue raised by project partners is the need to effectively prioritise inspection resources following an earthquake where there are many assets exposed to strong shaking. As a response to this need, the United States Geological Survey (USGS) ShakeCast application has been operationalised in the National Earthquake Alerts Centre (NEAC) at Geoscience Australia (GA) as a pilot for the RAMSEY partners using the vulnerability knowledge developed through the project on bridges. In this paper the input requirements for the system and the products provided are described in the context of a real event. Furthermore, the benefits and limitations of the system are discussed along with feedback from the partners on utility in informing the potential development of a broader capability.

2 National Earthquake Alerts Centre

The National Earthquake Alerts Centre (NEAC) at Geoscience Australia (GA) is a 24/7 near-real-time earthquake monitoring, detection, analysis and alerting service. It is a partner with the Bureau of Meteorology (BoM) in the Joint Australian Tsunami Warning Centre (JATWC). As part of its role, the NEAC integrates observed events into a curated Australian earthquake catalogue (https://earthquakes.ga.gov.au). This is a fundamental input into Australian earthquake bedrock hazard assessments, such as the recently released NSHA23 (Allen et al., 2023). The time-critical earthquake information it provides includes ShakeMap (Wald et al., 1999) that is progressively refined:

- ShakeMap initial publication (10-20 minutes after the earthquake).
- ShakeMap updated at 60 minutes, 2 hours, and 4 hours.
- Final ShakeMap typically released in the next business day.

Significantly the final products are adjusted to align with 1,000s of felt reports now received by NEAC after a major event (e.g., Allen et al., 2019; Pejić and Allen, 2024).

3 USGS ShakeCast

The ShakeCast is an openly available near-real-time post-earthquake information management system developed by USGS (Wald et al., 2017). The system has been widely used by infrastructure operators. For instance, ten US State Department of Transportation (DOT) have partnered and deployed the ShakeCast to better identify which facilities are most likely impacted by an earthquake (Turner et al., 2018).

The system sends automatic notification with the information of inspection priorities based on damage estimates using the fragility model and ShakeMap ground motion parameters. In the current version of the ShakeCast, fragility models for HAZUS bridge types are implemented.

4 Input requirement

Because the fragility models for the HAZUS bridge classes (FEMA, 2022) are already implemented in the ShakeCast, the assignment of each bridge in the study region to the corresponding HAZUS bridge class was only required. HAZUS bridge class was determined based on structural characteristics such as seismic design and number of spans. Table 1 sets out the required bridge attributes for the HAZUS bridge class assignment.

Significantly, the implementation of the pilot capability was broader than the RAMSEY study region as it included the road bridges in the Perth Metro studied as part of a previous project (Edwards et al., 2021). In total, 733 bridges located in Perth and the Yilgarn in a corridor extending out towards Kalgoorlie were selected and their structural characteristics were compiled for the HAZUS bridge class assignment (Edwards et al., 2021). The spatial distribution of the selected bridges is shown in Figure 1.

Table 1. Bridge attributes for HAZUS bridge classification

Attribute	Description
LID	Unique identifier
LONGITUDE	Longitude of the bridge location
LATITUDE	Latitude of the bridge location
VINTAGE	Construction year
LENGTH	Overall length (m)
SPANS	Number of spans
LONGEST_SPAN	Longest span length (m)
SKEW_ANGLE	Skew angle (deg)
PIER_TYPE	Type of vertical support structure
PRIMARY_FUNCTION	Usage
CONTINUITY	Deck continuity
PRIMARY_MATERIAL	Bridge primary material
DECK_TYPE	Deck structure type

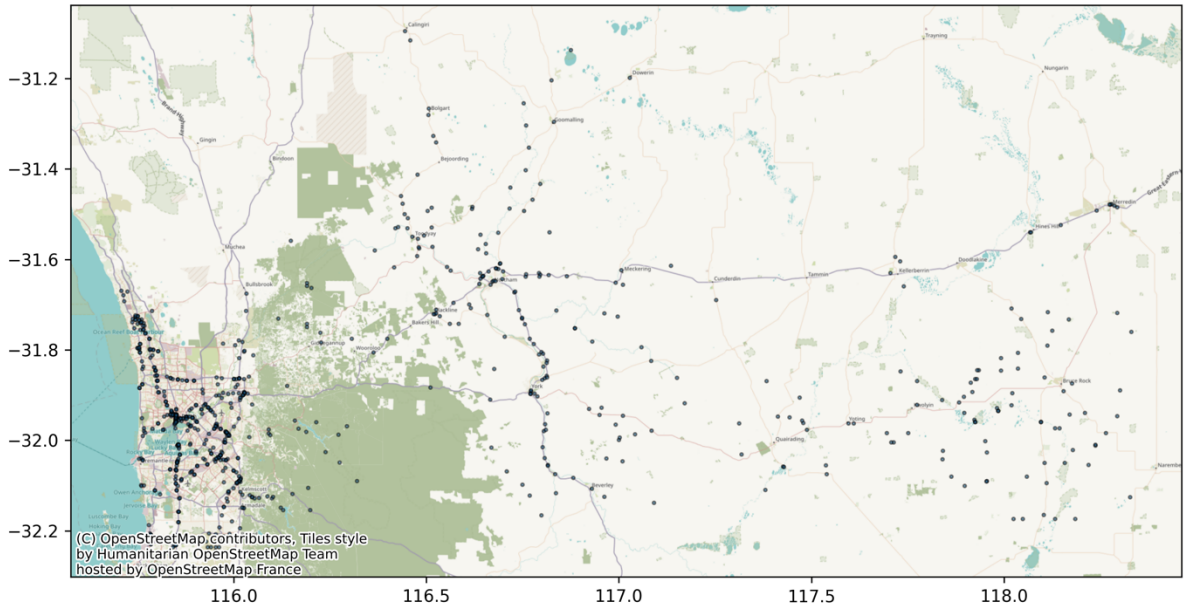


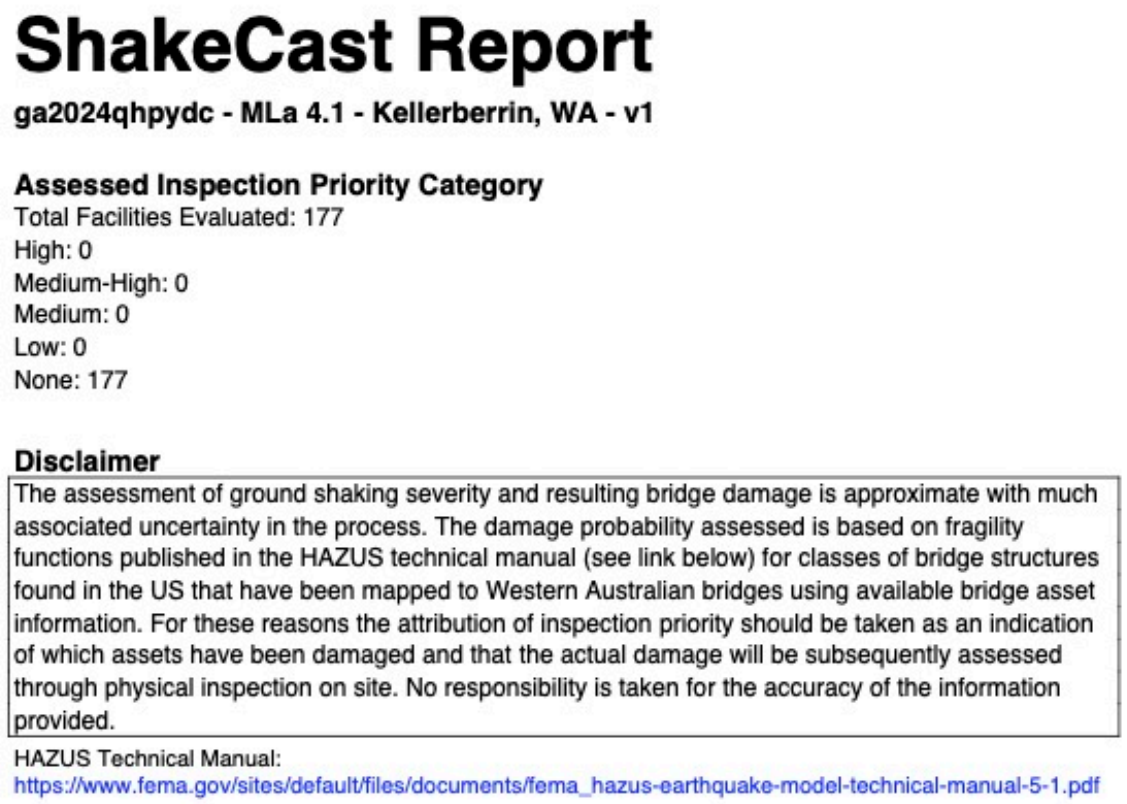
Figure 1. Spatial distribution of the road bridges (marked in black dots) in the ShakeCast pilot

5 Implementation of ShakeCast at NEAC

The ShakeCast system for the bridge assets was successfully launched in June, 2024 by the National Earthquake Alerts Centre (NEAC) at Geoscience Australia (GA). In the current setting, notification is sent for every earthquake in southeastern WA with a local magnitude of M_L 3.5 or greater. The automatically generated reports provide information on the earthquake event, the severity of shaking, and an indicative prioritisation of which bridges may be a high priority for inspection. The reporting identifies each bridge asset with the same unique identifier attributed by the asset manager, in this case the WA Department of Main Roads.

The first ShakeCast report was generated after the M_L 4.1 event near Wyalkatchem, WA occurred on 18 August 2024 (https://earthquakes.ga.gov.au/event/ga2024qhpydc). An email was sent to the registered email list of project partners, with three attached files: shakecast_impact.geojson, shakecast_impact.csv, and BRIDGES_impact.pdf. The *geojson* file enables the impact assessment to be viewed in a geographic information system environment for visualisation of the severity and locations of the impacts. Given the low ground motion intensity of this event, damage to bridge asset was not expected. The first page of the report is shown in Figure 2.

As the disclaimer stated in the report, the assessed ground motion intensity and resulting damage came with uncertainty due to the limitation of ShakeMap and fragility models implemented in the system.



ShakeCast Report

ga2024qhpydc - MLa 4.1 - Kellerberrin, WA - v1

Assessed Inspection Priority Category

Total Facilities Evaluated: 177
High: 0
Medium-High: 0
Medium: 0
Low: 0
None: 177

Disclaimer

The assessment of ground shaking severity and resulting bridge damage is approximate with much associated uncertainty in the process. The damage probability assessed is based on fragility functions published in the HAZUS technical manual (see link below) for classes of bridge structures found in the US that have been mapped to Western Australian bridges using available bridge asset information. For these reasons the attribution of inspection priority should be taken as an indication of which assets have been damaged and that the actual damage will be subsequently assessed through physical inspection on site. No responsibility is taken for the accuracy of the information provided.

HAZUS Technical Manual:
https://www.fema.gov/sites/default/files/documents/fema_hazus-earthquake-model-technical-manual-5-1.pdf

Figure 2. ShakeCast report for the bridges after the event of M_L 4.1 near Wyalkatchem, WA

6 Future Expansion of the Trial

The RAMSEY project partner groups include Western Power and WACHS. The previous project focussed on the Perth Metro and included over thirty of Perth's hospitals and key electrical substations. As an initial expansion of this pilot, the terminal stations and substations in the Yilgarn study region and the Perth Metro (approximately 90 in total) will be included using earthquake vulnerabilities developed through both projects. Western Power will provide asset attributes to enable the mapping of Australian specific vulnerabilities to each. The inclusion of over 30 health facilities as a health sector expansion is also being explored. Finally, information sharing arrangements with Arc Infrastructure, the state rail operator, is being negotiated to enable rail bridges to be included as a fourth infrastructure sector.

7 Summary

The NEAC at GA successfully has launched the USGS ShakeCast for bridges in Perth and surrounding areas including Yilgarn, WA, which provides near-real-time post-earthquake impact and inspection metrics for critical infrastructure facilities following an event. This system will enable asset owners and infrastructure operators to prioritise damage inspections.

8 References

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