Case Study

AUTOMATED MANUAL TRANSMISSIONS

TRIAL SUMMARY			
The purpose of this trial was to assess the fuel efficiency benefits of Automated Manual Transmission (AMT) systems for heavy vehicle operation relative to conventional fully automatic transmission systems. The trial vehicles were urban tippers operating in the Greater Sydney region in New South Wales. The trial revealed that an AMT system can deliver significant fuel consumption benefits relative to a fully automatic transmission for tipper truck operation in Australia.	**Fuel benefit (L/100 km)**	**GHG benefit (g/km CO$_2$-e)**	**Economic benefit ($/100 km)**
	5.85 ⬆	157.8 ⬆	8.18 ⬆
	⬆performance better than conventional vehicle		

The *Green Truck Partnership* is designed to be a forum for the objective evaluation of the merits of clean vehicle technologies and fuels by heavy vehicle operators. This report discusses the results of an evaluation of the fuel efficiency performance of AMTs based on the findings of an in-service trial conducted in 2011.

1   AUTOMATED MANUAL TRANSMISSIONS

Providers of AMT systems suggest that these transmissions deliver driver convenience without the traditional fuel efficiency penalties associated with fully automatic transmissions.

AMT systems do not require clutch actuation or shifting by the driver – rather, gear shifting is controlled automatically and performed via an electric motor or hydraulic system.

This results in lower energy loss which, when coupled with lighter weight, is reported to deliverfuel efficiency savings compared with fully automatic transmissions.

Field trials completed under the umbrella of the United States Environmental Protection Agency SmartWay program have suggested efficiency benefits in the order of 7% over the life of the vehicle.

2   TRIAL OBJECTIVE

The purpose of this trial was to determine whether AMT systems would deliver similar fuel efficiency and GHG benefits within an Australian context.

3   METHODOLOGY

DATA COLLECTION

This trial involved comparing the fuel efficiency of vehicles fitted with AMTswith the fuel efficiency of equivalent vehicles fitted with a conventional fully automatic transmission.

The trial involved an in-field assessment of seven identically configured tipper trucks running similar routes in urban and outer urban Sydney.

Four trucks were fitted with the fully automatic transmission (i.e. baseline vehicles) and data was collected over a two-month period.

A further three vehicles (i.e. trial vehicles) were fitted with the AMT system,with data again being collected over a two-month period.

In order to ensure that the fuel consumption data collected for the trial vehicles was directly comparable with that of the baseline vehicles, all vehicles were fitted with data loggers. This approach allowed the collection of drive cycle descriptors for all vehicles so that any differences in vehicle operating cycle could be isolated.

Key drive cycle descriptors collected during the course of this trial were as follows.

- **FUEL ECONOMY**: daily fuel economy (km/L).

- **DISTANCE**: kilometres travelled.

- **IDLE TIME**: time spent at idle.

- **ENGINE LOAD**: percentage of time spent at a given engine load.

- **AVERAGE SPEED**: average speed (km/h).

- **STOPS**: number of stops per kilometre travelled.

The duty cycle descriptors for both the baseline vehicles and the trial vehicles were compared to ensure duty cycle consistency.

Fuel data obtained for periods demonstrating a high level of duty cycle consistency was then compared to quantify net fuel efficiency differences.

DATA ANALYSIS

Key descriptors considered in this analysis included average speed, drive fuel economy and engine load. This data was collected for both the trial vehicles and the baseline vehicles to ensure that the vehicles were being operated in a similar manner,and that subsequent comparison of fuel consumption data was valid. Data periods where the operation of the trial vehicles differed substantially from that of the baseline vehicles were excluded from the assessment. In this way, the study sought to eliminate any fuel consumption variances associated with differences in the individual operation of the trial vehicles.

Once the fuel consumption data sets for both the baseline vehicles (conventional automatic transmissions) and the trial vehicles (AMT systems) were validated, the fuel consumption data was then compared. The results of this comparison are presented in Section 4.

The data validation process involved comparison of the vehicle cycles of the trial vehicles and the baseline vehicles using two descriptors – engine load and average vehicle speed. Where these two descriptors were closely matched, it was concluded that both sets of vehicles were being operated in a similar manner.

Figure 1 shows that the engine load profiles of the baseline vehicles differed considerably from those of the trial vehicles. Vehicles fitted with fully automatic transmission systems spent 50% of operating time above 30% engine load, while the vehicles fitted with AMT spent less than 30% of operating time above this same threshold.

The difference in engine load profiles observed during this trial is most likely attributable to differences in the gear shifting regime adopted as a result of the different transmission systems (which was a key consideration in the conduct of this trial).

Consequently, it was necessary to consider vehicle average speed to determine whether this difference in engine load was due to the different transmission technologies or due to significant differences in the individual vehicle duty cycles. The resultant comparison reveals that both the trial vehicles and the baseline vehicles have very similar speed profiles (Figure 2).

Given this observation, it can be concluded that:

- the differences in engine load can largely be attributed to the different transmission systems;

- the similar speed profiles reveal that the vehicles were performing similar tasks and therefore direct comparison of fuel consumption data is valid.

4   RESULTS

Analysis of the trial data revealed that the average fuel consumption of the vehicles fitted with AMTs was 1.90 km/L. This is compared with an average fuel consumption of 1.71 km/L for the vehicles fitted with conventional fully automatic transmissions.

These results reveal that the AMT system delivered an 11% improvement in fuel efficiency relative to the fully automatic transmission vehicles in the trial application (i.e. urban tipper).

5   CONCLUSION

The trial results reveal that the AMT system delivered a fuel efficiency benefit in the order of 11%, compared with the fully automatic transmission.

This fuel saving corresponds to a 158 g CO_2-e/km GHG emissions reduction for the AMT technology compared with conventional fully automatic transmissions. Based on the average distance travelled during the trial period, the selection of AMTs over automatic transmissions has the potential to generate a GHG emissions reduction in the order of 9 tonnes CO_2-e per year per vehicle (i.e. urban tipper application).

Figure 1
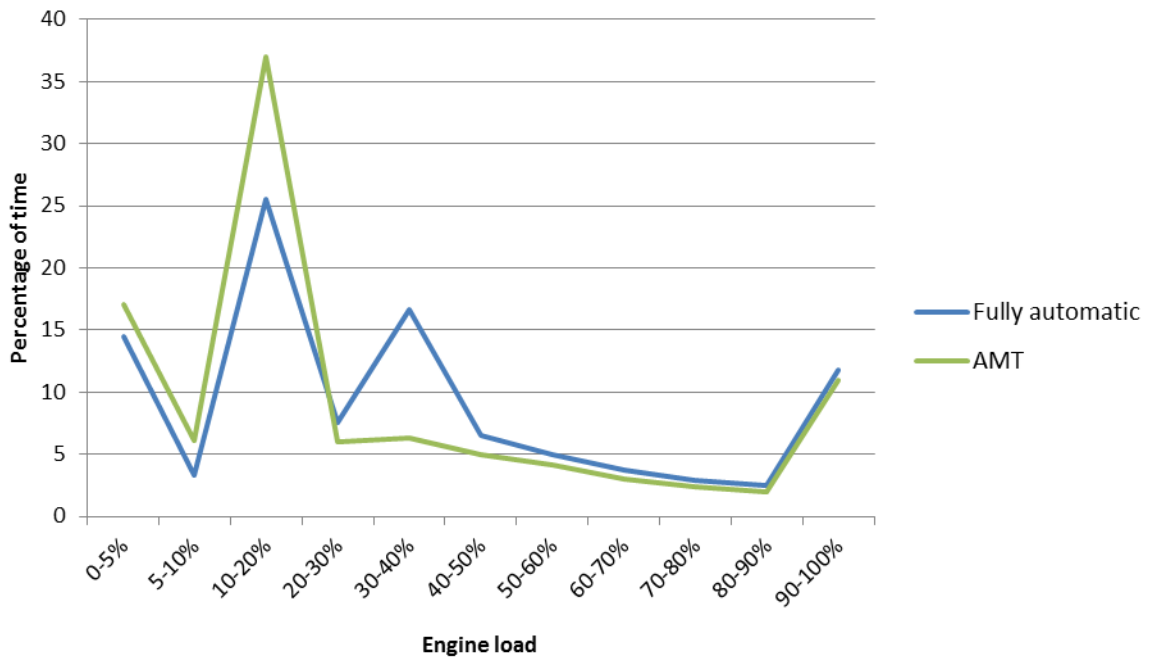**Comparison of vehicle engine load between transmission types**

Figure 2
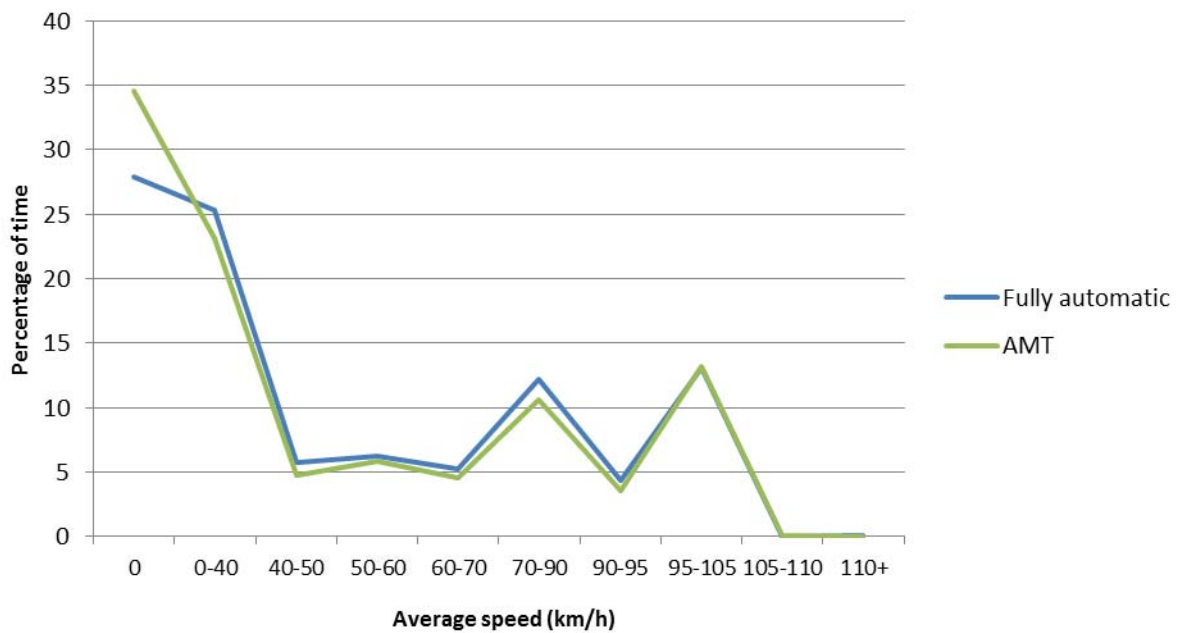**Comparison of vehicle average speed between transmission types**

Figure 3
Fully automatic and AMT transmission fuel efficiency results