Human factors aspects of navigation systems in support of Intelligent Speed Adaptation (ISA) functionality

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ABSTRACT:

This paper reports a study of the performance of in-vehicle navigation devices to assess speed-related functionality and the provision of speed information to drivers. There are currently no standards or assessments protocols for navigation devices that are complete and that are directly relevant to the assessment of commercially available Intelligent Speed Adaptation (ISA) devices. Human factors research is not conclusive about the best ways to convey speed limit information and speeding alerts to drivers, and a review of the literature indicated that there are some human-machine-interface methods that should be avoided in the driving task. Protocols for the assessment of navigation devices should avoid being design restrictive, but should discourage poor interface design concerning speed limit information and speeding alerts to drivers. A protocol was developed to evaluate in-vehicle navigation devices offering an ISA capability. The intended outcome from the use of this protocol is to assist consumers in decisions to purchase these devices. Four ISA devices currently available on the Australian market were tested on-road in a scenario incorporating freeway, commercial and residential environments, similar to how the devices would be commonly used. The results indicated that the protocol was very robust, being repeatable, relevant and objective, and can be used as the basis for the development and promulgation of a standard for the assessment of the safety of in-vehicle navigation devices with an ISA capability.

Introduction

Driving safety within the road transport system very much depends on individual drivers being aware of what is happening across many aspects of the road environment. Drivers must keep up with their speed, road positioning and vehicle separation relative to other drivers ahead, beside and behind them, and any other road users present at that moment. Drivers must monitor the status of their vehicle systems and attend to the operation of relevant and necessary vehicle controls. And drivers must recognise and respond to traffic control directives as indicated by signals, signage and pavement markings. These are just a few significant elements that are required: further volitional tasks can involve the use of internal environmental controls; use of entertainment controls; social engagement with passengers (if present); and the use of communications controls (see, e.g., Faulks, 2010; Faulks, Irwin & Morphett, 2010). This is challenging for the apportionment of a driver's attention and for the necessary, relevant and rapid decision making that is required for safe driving.

There is, however, a trend towards use of in-vehicle safety technologies reflects the increasing automation of vehicle performance and driver tasks, indicating that the human role of 'driver' is changing from vehicle controller to supervisor (Harvey, Stanton, Pickering, McDonald & Zheng, 2011). Many portable navigation devices (Sat Navs) and some smartphone applications purport to give advice to drivers about speed limits – a primary function – as well as assisting in wayfinding or navigation. In fact, a well-designed device with a widespread, accurate and up-to-date database of speed limits might well be considered a form of advisory intelligent speed assistance (ISA), as it will assist driver to comply with speed limits at all times.

Intelligent Speed Adaptation (ISA, also known as Intelligent Speed Assist), is any system that constantly monitors vehicle speed and the local speed limit on a road and implements an action when the vehicle is detected to be exceeding the speed limit (M. Paine, Paine & Faulks, 2009). The purpose of ISA is to assist the driver in keeping to the lawful speed limit at all times, particularly as they enter and pass through different speed 'zones'. This is particularly useful when drivers are in unfamiliar areas or when they transit areas where variable speed limits are used. Advisory ISA is any ISA system where the driver is warned via audible, visual or haptic alerts (or a combination of these) that the vehicle speed is in excess of the posted speed limit. In contrast, limiting ISA is any ISA system where the driving systems of the vehicle are controlled automatically to ensure that the vehicle's speed does not exceed the posted speed limit. A form of limiting ISA, known as supportive ISA, holds the vehicle to the posted speed limit but allows a driver to override the restriction temporarily. ISA systems typically alert a driver when a vehicle has entered a new speed zone, and may alert a driver when variable speed zones are in force (e.g., variable speed limits in school zones that apply at certain times of the day and only on certain days), and when temporary speed zones are imposed (such as speed limit changes in adverse weather or during traffic congestion, at accident scenes, or near roadworks).

In-vehicle device manufacturers are increasingly incorporating more and more functionality into navigation devices and smart phones. For example, there is a wide range of smartphones that include many technologies such as voice and data transceivers, GPS, Bluetooth, Wi-Fi, cameras, music, touchscreen interfaces, compasses, motion sensors, cameras, and storage cards. For many consumers, the inclusion of navigation functions that allow for turn-by-turn guidance services (see, e.g., Burnett, 2000a, 2000b), such as is provided by iPhones and Androids, are seen as a strong factor in the decision to purchase a GPS-equipped smartphone.

In-vehicle navigation systems are popular and many current models include features which assist drivers in keeping to the posted speed limit. Devices supporting in-vehicle navigation are after-market systems currently, but they are increasingly being incorporated into the new car market as OEM technology (Healy & Truong, 2009). While the primarily focus is to combine GPS tracking with an electronic map of the road network to advise a driver of the directions to take to travel a previously specified destination – referred to as wayfinding – the electronic maps provided also commonly include road and roadside features (points of interest, POI) such as school zones, railway crossings, fixed speed and red-light cameras, and also include speed limit information.

Sat Navs which integrate speed limit information or ISA have typically been designed such that the audio warnings are limited in duration, can be de-activated and that the speed limits can be shown visually only as a reminder to the driver. However, the evidence base for such design decisions is unclear. From a safety perspective, Healy and Truong (2009) have proposed that a number of functional features of ISA and an in-vehicle navigation device are desirable, including:

- ISA provides an audible warning if the vehicle exceeds the speed limit by 3 km/h or more for two seconds or longer;
- the speed threshold is adjustable to a maximum (say, 5 km/h);
- the audio warning is repeated, after a set interval, if speeding persists;
- the strength of the audio signal is adjustable but only down to a pre-set minimum;
- a visual indication of the current speed limit is available to the driver;
- GPS averaging for travel speed estimation should be accurate to within +/- 2km/h; and
- ISA is switched on for every re-start of the in-vehicle navigation device.

A challenge for road safety policy makers is to encourage the support of ISA systems as an element of speed limit compliance for in-vehicle navigation systems. That is, how can road safety policy makers encourage Sat Nav manufacturers, suppliers and marketers to build in and then promote ISA systems across their range of products? User expectations and acceptability need to be addressed (e.g., the speed information must be understandable, timely, and relevant) while ISA functionality requirements must also be met (e.g., the speed information is accurate both for the speed limit and the vehicle speed, the alerting signals must be unambiguous, etc.). There has been commercialisation of some ISA functionality into in-vehicle navigation devices in Australia (Faulks, Paine, Paine & Irwin, 2008), but there is a need for the development of a model for ISA functionality to be developed and promoted that is based on balancing safety outcomes with levels of acceptability. Indeed, there is a need for more empirical investigation to establish the framework for defining ISA functionality in Sat Navs as there is an absence of standards or agreed performance specifications for ISA devices (D. Paine, Paine, Faulks & Irwin, 2011). This means that there is a wide variation in the quality and effectiveness of devices on the market, making it difficult for consumers to differentiate the performance of various ISA-related products. Further, poorer performing devices could undermine the credibility of government ISA initiatives. There is a need to set requirements for functional performance (e.g., user interface, common features, critical specifications), on-road operational performance and quality of speed limit data (e.g., coverage, accuracy, up-to-datedness) for these systems. A program that evaluates and rates these devices based on the above requirements would encourage better performing devices and would allow consumers to make an informed choice when purchasing ISA products. Programs such as the Child Restraint Evaluation Program (CREP) and the Australasian New Car Assessment Program (ANCAP) are examples of road safety-based consumer rating systems that have successfully provided relevant safety information to consumers.

In this paper, we report a trial assessment of four ISA devices (currently available on the Australian market) against selected assessment criteria. The purposes of the trial assessment were to, first, demonstrate the feasibility of a scoring system developed to support a system to assess ISA functionality, and, second, identify practical issues that may arise during the conduct of such assessments. That is, the trial assessment did not attempt to provide a differentiation between ISA devices by showing that any device performed better or worse than any other. Rather, the aim of the trial assessments was to determine if the assessments were repeatable, relevant and objective.

Method

ISA devices: Four devices were assessed against twenty selected criteria. There were 3 Sat Nav based ISA products and one smartphone based ISA product: the OttoMobile (for iPhone); the Navman Ezy30; the Navig8r M35; and the TomTom GO. Devices were tested on-road in a scenario similar to how the devices would be commonly used. Functionality was observed in use and where necessary settings

where checked via the device menus. The devices were assessed separately and were all tested on the same day (during business hours, 8:00 a.m.-5:00 p.m.).

Trial Assessment Routes: Two test routes were used (one in Sydney, one in Melbourne). The only maps available for the OttoMobile application were limited to the Melbourne metropolitan area; all other devices were tested on the Sydney route. The route selected for Melbourne began at Melbourne airport and headed southeast along the Tullarmarine Freeway, then east along the Western Ring Road until finally heading northbound along the Hume Highway/Sydney Road until Campbellfield. The same route (in reverse) was followed during a return trip. The route comprised mainly of motorway sections. A test route in Sydney was selected that passed through several speed zones (with speed increases and decreases at zone change points), including school zones and zoned high pedestrian areas. The route included urban, suburban and motorway road types. The test route started at the intersection of Miller Street and Pacific Highway in North Sydney, heading northbound along Miller Street until the southbound entry ramp to the Warringah Freeway, at Cammeray thence southbound along the Warringah Freeway until the Alfred Street exit at Neutral Bay, then along High Street, Kirribilli, returning to the staring point at North Sydney. The route was repeated as necessary to enable testing of each device individually.

Trial assessment criteria: The criteria were taken from D. Paine et al. (2011), who proposed a comprehensive list of minimum functional specifications, critical features and minimum performance standards for Sat Navs claiming ISA functionality. As shown in Appendix A to this paper, these criteria are categorised in terms of: Feature Performance; Hardware Performance; Ease of Use/Human Factors; and, Mapping Performance (Coverage, Accuracy and Update Utility). The assessments were rated: Good, Acceptable, Marginal; and Poor. For selection of the trial assessment criteria the following principles were followed:

- Criteria were selected to include assessment of key parameters identified by D. Paine et al. (2011) but with consideration of the ease and repeatability of testing (noting that the purpose of the trial assessments was to demonstrate the feasibility of the test method and had certain limitations).
- Assessments where environmental conditions could significantly affect results were avoided.
- Criteria were not necessarily chosen to provide differentiation between devices (i.e., criteria were not selected to show that any device performs better or worse than any other and were not designed to highlight or penalise any particular feature).

Twenty criteria were selected for the trial assessment (see Table 1). Devices scored 3 points for a Good result, 2 points for an Acceptable result, 1 point for a Marginal result and 0 points for Poor. If an item could not be assessed the device was awarded a default score of 3. All points awarded were summed to provide a final score for each device.

In D. Paine et al.'s (2011) list of minimum functional specifications, critical features and minimum performance standards for Sat Navs claiming ISA functionality, the proposed assessment methodology requires devices to pass all criteria in order to move on to further assessment components. In the trial analysis reported here, devices that failed to pass any of these criteria still underwent the full trial assessment, as the purpose was to evaluate the assessment method and this was best served by assessing devices against all selected trial criteria. Furthermore, no weighting was applied to any criteria (although this is recommended within the proposed assessment methodology).

Table 1 Trial Assessment Criteria

Criteria Description	Good	Acceptable	Marginal	Poor
Must include school zones	Includes school zones	NA	NA	Does not includes school zones
Must display current time	Displays current time	NA	NA	Does not display current time
Displays vehicle speed	Displays vehicle speed	NA	NA	Does not display vehicle speed
Displays current speed limit	Displays current speed limit	NA	NA	Does not display current speed limit
Displays correct speed limit for school zones when zone is active	Displays correct speed limit for school zones when zone is active	NA	NA	Does not display correct speed limit for school zones when zone is active
Provides driver with alert (audible/visual/ haptic or combination) when speed limit is exceeded	Provides driver with alert when speed limit exceeded	NA	NA	Does not provide driver with alert when speed limit exceeded
School zones enabled as default	School zones enabled as default	NA	NA	School zones not enabled as default
Audible Alert volume	Easy to hear alerts over loud vehicle/traffic noise on default setting	Alerts sometimes difficult to hear over loud vehicle/traffic noise on default setting	Alerts sometimes difficult to hear over normal vehicle/traffic noise on default setting	Constantly difficult to hear alerts over normal vehicle/traffic noise on default setting
Redundant/back up location system	System has back up location system that requires no infrastructure	System has back up location system that requires infrastructure	System has no back up location system	

Criteria Description	Good	Acceptable	Marginal	Poor
School zones - correct time/day of operation	Enables school zones at correct school time only on school days and differentiates school zones from other speed zones audibly	Enables school zones at correct school time only on school days	Enables school zones at correct school time OR only on school days but (but not both)	School zones enabled permanently (irrespective of time of day or date) or does not differentiate school zones audibly from other speed zones
Electronic variable signs	Detects variable zones and informs driver of default speed	NA	Detects variable zones but does not inform driver of default speed limit	Does not detect variable zones
New speed zone alert	Audible alert distinguishable from other alerts and visual alert	Audible alert not distinguishable from other alerts (select if only one type of alert)	Visual alert only	No alert
Default application	ISA is default (or only) application on the device (select for smartphone ISA applications where ISA is enabled as default for the application)	ISA is not default but can be selected in one simple action (no need to refer to instructions) except for smartphones (see 'Good')	ISA is not default but can be selected in two simple actions (no need to refer to instructions)	ISA is not default and is selected in more than two steps or steps are not simple (need to refer to instructions)
Alerts are enabled as default	Alerts are enabled as default	NA	NA	Alerts are not enabled as default
Default tolerance of alerts	0km/h tolerance as default	1km/h tolerance as default	2km/h tolerance as default	>2km/h tolerance as default
Minimum alert tolerance	0km/h	1km/h	2km/h t	>2km/h t
Maximum alert tolerance	2km/h	5km/h	10km/h	>10km/h

Criteria Description	Good	Acceptable	Marginal	Poor
Unit can only fit into limited number of vehicle models	Device cane likely be fitted to all models of vehicle	Device can likely be fitted to most models of vehicle with some exceptions	Device can be fitted to limited models of vehicle (greater than 50 current models)	Device can be fitted to limited models of vehicle less than 50 current models)
School zones cannot be disabled	School zones cannot be disabled	NA	NA	School zones can be disabled
Driver interaction required	Driver does not need to interact with device at all during use	Driver may need to interact with device, single touch, ISA functions still run	Driver may need to interact with device, single touch, ISA functions temporarily disabled	Driver may need to interact with device, multiple touch

Results and discussion

Table 2 shows the results of the trial assessments. Note that for the purpose of the assessments it is not necessary to compare the devices scores in detail (trial assessment criteria only represent a partial list of the proposed assessment criteria shown in Appendix A, and it if the full list of proposed criteria were applied the scores could vary significantly).

Subject to the limitations of the trial assessments, it is evident that there is variation between the selected devices. In several criteria there are substantial differences between devices and there is scope for improvement for devices. This demonstrates that the method has the potential to encourage manufacturers to improve Sat Navs claiming ISA functionality.

No Sat Nav device claiming ISA functionality obtained the maximum/minimum (or close to maximum/minimum) score, which demonstrates that the range of criteria are relevant. Furthermore, in many criteria where a device has achieves less than a 'Good' result, another device has achieved a 'Good' result (or at least a better result), which suggests that improvement in these areas is technically possible. In a practical sense, the assessments appeared repeatable, relevant and objective.

There are currently no standards or assessments protocols that are complete and are directly relevant to the assessment of ISA devices. Any product functionality assessment system developed to assist consumers will therefore need to develop its own standards and protocols. Human factors research is not conclusive about the best ways to convey speed limit information and speeding alerts to drivers. However, there are clearly some human-machine-interface methods that should be avoided, particularly in terms of poor interface design concerning speed limit information and speeding alerts to drivers.

Table 2 Trial Assessment Results

Criteria Description	DEVICES			
	OttoMate (iPhone)	Navman Ezy30	Speed Alert M35	TomTom GO
Must include school zones				
Must display current time				
Displays vehicle speed				
Displays current speed limit				
Displays correct speed limit for school zones when zone is active				
Provides driver with alert (audible/visual/haptic or combination) when speed limit is exceeded				
School zones enabled as default				
Audible Alert volume				
Redundant/back up location system				
School zones - correct time/day of operation				
Electronic variable signs				
New speed zone alert				
Default application				
Alerts are enabled as default				
Default tolerance of alerts				
Minimum alert tolerance				
Maximum alert tolerance				
Unit can only fit into limited number of vehicle models				
School zones cannot be disabled				
Driver interaction required				
Overall score (max possible score 60, min possible score 0)	47	41	50	25

Key to results

Good
Acceptable
Marginal
Poor
Not Assessed

Given the wide range in ISA performance for products on the market a staged assessment process would be the most efficient use of resources – that is, the more complex criteria would only be assessed if the device first passed agreed critical functional and performance requirements.

Based on Australian and overseas crash studies it is estimated that a good advisory ISA system will save 11% of fatal crashes, 8.3% of serious injury crashes, 7.4% of minor injury crashes and 4.5% of other (property) crashes. This represents societal costs of $91.16 per registered vehicle per year, using BITRE estimates of the costs of road crashes (D. Paine et al., 2011).

It is noted that ISA devices are intended to inform the driver about the current speed limit applicable in the road segment being travelled and the speed of the vehicle being driven. As such, some driver distraction is unavoidable. There is currently insufficient published research to base assessments on whether driver distraction is too high for any of the systems being assessed, and no systematic assessment procedure is available.

Conclusion

Research evidence from around the world shows that speed management, particularly compliance with posted speed limits, will provide an immediate and substantial improvement in safety outcomes, as well as other community benefits. ISA technology has been recognised as an effective way to reduce speeding by providing drivers with on-board information about speed limits and alerting them if these speed limits are exceeded. Numerous successful trials of ISA have been undertaken (Paine et al., 2009), and more than a dozen commercial ISA products are now available in Australia (Faulks, et al., 2008). Australia, in fact, is a world leader in this area, with the entire national road system mapped for GPS and speed zoning. Australia commercialised ISA technologies (both Advisory ISA, and Limiting ISA) in the mid-2000s, and Advisory ISA devices are now well entrenched in the Australian marketplace (M. Paine, Paine, Griffiths & Germanos, 2007). Despite this, there remains a tendency to continue to regard ISA as a technology that is not yet ready to enter the marketplace (M. Paine, Healy, Passmore, Truong & Faulks, 2008).

A key part of the Australian National Road Safety Strategy 2001-2010 was to bring about "continuing reductions in the number of people killed and injured on the nation's roads, and to increase effort in areas that are likely to see rapid gains" (AISAI 2009). The Australian Transport Council (2011) similarly provides a strong endorsement of ISA in the recent National Road Safety Strategy 2011-2020. As a consequence, it is likely that all Australian states and territories will be interested in ISA technologies. They may be keen to participate in a consumer-oriented rating program that assesses the functionality of ISA devices already available in the marketplace.

Based on the exploratory analysis reported here, it is concluded that it is feasible to set up a consumer program that reports on the usability and functionality of ISA devices being marketed as Sat Nav or smartphone apps claiming ISA functionality. Such a program has the potential to be a highly cost-effective countermeasure to address one of the critical areas of road safety: the management of vehicle speeds and the promotion of safe speed choices by drivers.

Consumer-related stakeholders could be targeted as an element of an effective marketing program to publicise the results of testing and rating ISA devices. For example, the Australian Consumers Association could be encouraged, in any reviews of Sat Nav devices or ISA devices, to advise consumers to check the ISA ratings and to publish or refer consumers to relevant data and web links (a

similar strategy has been effective in the area of child occupant restraints, where the Australian Consumers Association's Choice magazine publishes reviews of child restraints and refers readers to the CREP ratings (Suratno, Job, Leavy, Brown, Paine, Magedara, Kelly, Griffiths, Haley & Case, 2008). As well, a ratings system could be effective in the promotion of work-related road safety, both in vehicle fleet management (Faulks, 2012) and for individual commuters (Faulks & Irwin, 2002).

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APPENDIX A – Assessment Criteria

A1. Feature Performance

Table A.1 Feature Performance

Category	Criteria Description	Criteria			
		Good (3)	**Acceptable (2)**	**Marginal (1)**	**Poor (0)**
Feature/ software performance	School zones	Enables school zones at correct school time only on school days and differentiates school zones from other speed zones audibly	Enables school zones at correct school time only on school days	Enables school zones at correct school time OR only on school days but (but not both)	School zones enabled permanently (irrespective of time of day or date) or does not differentiate school zones audibly from other speed zones
Feature/ software performance	Default tolerance of audible alerts	0km/h tolerance as default	1km/h tolerance as default	2km/h tolerance as default	>2km/h tolerance as default
Feature/ software performance	Minimum audible alert tolerance	0km/h	1km/h	2km/h t	>2km/h t
Feature/ software performance	Maximum audible alert tolerance	2km/h	5km/h	10km/h	>10km/h
Feature/ software performance	Default tolerance of visual alerts	0km/h tolerance as default	1km/h tolerance as default	2km/h tolerance as default	>2km/h tolerance as default
Feature/ software performance	Minimum visual alert tolerance	0km/h	1km/h	2km/h t	>2km/h t
Feature/ software performance	Maximum visual alert tolerance	2km/h	5km/h	10km/h	>10km/h
Feature/ software performance	Default tolerance of haptic alerts	0km/h tolerance as default	1km/h tolerance as default	2km/h tolerance as default	>2km/h tolerance as default
Feature/ software performance	Minimum haptic alert tolerance	0km/h	1km/h	2km/h t	>2km/h t
Feature/ software performance	Maximum haptic alert tolerance	2km/h	5km/h	10km/h	>10km/h
Feature/ software performance	Vehicle outside of map coverage	Audible and visual, clearly conveyed to the driver, notification remains while vehicle is out of map coverage	Audible and visual, discretely conveyed to the driver, notification remains while vehicle is out of map coverage	Audible and visual, discretely conveyed to the driver, notification does not remain while vehicle is out of map coverage	No audible notification
Feature/ software performance	Roadworks	Detects roadworks zones and informs driver of currently set (temporary) speed limit	Detects roadworks zones but does not inform driver of temporary speed limit	Does not detect roadworks zones	
Feature/ software performance	Electronic variable signs	Detects variable zones and informs driver of currently set (temporary) speed limit	Detects variable zones and informs driver of default speed limit	Detects variable zones but does not inform driver of default speed limit	Does not detect variable zones

Category	Criteria Description	Criteria			
Feature/ software performance	New speed zone alert	Audible notification distinguishable from audible alerts and other audio	Audible notification not distinguishable from other audio (select if only one type of alert)	Visual alert only	No alert
Feature/ software performance	Other system features	ISA functionality not overriden/obscured , interrupted, interfered with by other system features (partially or fully)		Other features temporarily override/obscure , interrupt, interfere with or ISA functionality (partially or fully)	Other features override/obscure, interrupt, interfere with or ISA functionality driver interaction required to return to ISA functionality
Feature/ software performance	Audio mute	Alerts can not be muted (select if no audible alerts) at all	Alerts can be muted only at start up but can be unmuted with single step at any time	Alerts can be muted only when vehicle is stationary but can be unmuted with single step at any time	Alerts can be muted when vehicle is in motion and can be unmuted with single step at any time
Feature/ software performance	Volume control	Volume can not be decreased	Volume can only be decreased at startup	Volume can be decreased when vehicle is not in motion	Volume can be decreased when vehicle is in motion
Feature/ software performance	Separate volume	ISA volume setting separate to other volume settings		ISA volume setting not separate to other volume settings	
Feature/ software performance	Overrides other in vehicle audio	ISA audible alerts override vehicle stereo (e.g., radio, CD, MP3) connected phone, OEM entertainment and OEM navigation audio	ISA audible alerts override vehicle stereo (e.g., radio, CD, MP3) connected phone, and OEM entertainment audio but not OEM navigation audio	ISA audible alerts override vehicle stereo (e.g., radio, CD, MP3) but not phone or OEM entertainment audio. ISA audible alerts do not override OEM navigation audio	ISA audible alerts do not override vehicle stereo (e.g., radio, CD, MP3).
Feature/ software performance	Overrides other audio from device	ISA audible alerts override other audio from device, e.g., music, video, phone, navigation)			ISA audible alerts override other audio from device e.g., music, video, phone, navigation)
School zones can not be disabled	School zones can not be disabled			School zones can be disabled	

A.2 Hardware Performance

Table A.2 Hardware Performance

Category	Criteria Description	Criteria			
		Good (3)	**Acceptable (2)**	**Marginal (1)**	**Poor (0)**
Hardware performance	System start up (warm)	Start up <5 seconds	Start up <10 seconds	Start up <20 seconds	Start up >20 seconds
Hardware performance	System start up (cold)	Start up <15 seconds	Start up <20 seconds	Start up <30 seconds	Start up >40 seconds
Hardware performance	GPS fix	<5 seconds	<10 seconds	<15 seconds	> 20 seconds
Hardware performance	Last position	System remembers last position and uses as start up position	System does not remember last position (on shutdown)		
Hardware performance	System performance in no GPS region	Audio and Visual indication that system has no GPS reception, Visual indication persists while GPS unavailable	Visual only indication that system has no GPS reception, persists while GPS unavailable	Visual indication that system has no GPS reception, does not persist while GPS unavailable	
Hardware performance	Power usage when off	System uses <0.02 amps when off	System uses <0.2 amps when off	System uses <0.5 amps when off	System uses >0.5 amps when off
Hardware performance	Speed zone detection	Immediate (or just prior)	<1 second	<2 seconds	>2 seconds
Hardware performance	Variable screen intensity	Auto dimming/brightening to match light conditions	User adjustable via single step	User adjustable via multiple steps	Not adjustable
Hardware performance	Equipment requirements	Device is supplied with all equipment required for use	User must source equipment to position device within vehicle separately	User must source equipment for vehicle speed/position derivation separately	User must source equipment to enable alerts separately (unless system already provides at least one alert method as standard)
Hardware performance	Install requirements	Device does not require installation (can be positioned anywhere within occupant cabin)	Requires simple installation	Requires install instructions but no specialist knowledge, skills or tools	Install only by specialist installer (user recommended not to carry out install) or specialist knowledge, skills or tools required or install requires modifications to the vehicle
Hardware performance	Additional software required	Device supplied with all software required pre-installed. No other software install/set up required.	Device supplied with all software required pre-installed. Other (supporting) software install/set up required (e.g., download utility for updates on PC), and all supporting software supplied at point of sale.		Device not supplied with all software required. Software readily available from Website or CD (or other medium).

Category	Criteria Description	Criteria			
		Good (3)	**Acceptable (2)**	**Marginal (1)**	**Poor (0)**
Hardware performance	Redundant/back up location system	System has back up location system that requires no infrastructure	System has back up location system that requires infrastructure	System has no back up location system	

A.3 Ease of Use/Human Factors

Table A.3 Ease of Use/Human Factors

Category	Criteria Description	Criteria			
		Good (3)	**Acceptable (2)**	**Marginal (1)**	**Poor (0)**
EOU	Default application	ISA is the default (or only) application on the device	ISA is not default but can be selected in one simple action (no need to refer to instructions)	ISA is not default but can be selected in two simple actions (no need to refer to instructions)	ISA is not default and is selected in more than two steps or steps are not simple (need to refer to instructions)
EOU	Alerts are enabled as default	All alerts (audible, visual and haptic) are on as default	Alerts not on as default but can be enabled with one simple action (no need to refer to instructions)	Alerts not on as default but can be enabled with two simple actions (no need to refer to instructions)	Alerts not on as default but can be enabled with more than two actions or actions are not simple (need to refer to instructions)
EOU	Unit can only fit into limited number of vehicle models	Device can likely be fitted to all models of vehicle	Device can likely be fitted to most models of vehicle with some exceptions	Device can be fitted to limited models of vehicle (greater than 50 current models)	Device can be fitted to limited models of vehicle less than 50 current models)
EOU	Driver interaction	Driver does not need to interact with device at all during use	Driver may need to interact with device, single touch, ISA functions still run	Driver may need to interact with device, single touch, ISA functions temporarily do not run	Driver may need to interact with device, multiple touch
EOU	Turning on device	Device turns on automatically on ignition and ISA loads automatically	Simple, single touch switch to turn on which is easy to find (no need to refer to instructions).	Switch not easy to find (need to refer to instructions).	Multiple steps required to turn on device and load ISA
EOU	Turning off device	System turns off Automatically	Simple, single touch switch to turn off which is easy to find (no need to refer to instructions).	Switch not easy to find (need to refer to instructions).	Multiple steps required to turn off
HF	Icon size	>30% screen size or >25mm minimum dimension (whichever is	>20% screen size or >20mm minimum dimension (whichever is	>10% screen size or >15mm minimum dimension (whichever is	<10% screen size or <10mm minimum dimension (whichever is

Category	Criteria Description	Criteria			
		Good (3)	**Acceptable (2)**	**Marginal (1)**	**Poor (0)**
		greater)	greater)	greater)	greater)
HF	Alert type	Any two of audible, visual, haptic	Audible only	Visual only	
HF	Audible alert type	Spoken information	High pitch alarm AND > 3Hz	Low pitch alarm or < 3 Hz	Tone (or no audible alert)
HF	Alert information	Alert includes information on current speed limit, vehicle speed and type of speed zone	Alert includes information on only two of current speed limit, vehicle speed and type of speed zone	Alert includes information on only one of current speed limit, vehicle speed and type of speed zone	
HF	Alert reoccurrence	Alert continuous while speed limit is exceeded	Alert reoccurs less than every 10 seconds	Alert reoccurs less than every 20 seconds	Alert reoccurs only once speed has dropped to limit or >30 seconds
HF	Alert variation	Alerts increases in volume, frequency or pitch depending on how far over the speed limit		Alerts do not increase in volume, frequency or pitch	
HF	Alert distinction	Different types of alert are distinct from one another and clearly distinguished by the driver	Different types of alert are distinct from one another but are similar so that the driver may not perceive the distinction	Different types of alert are not distinct from one another	
HF	Alert start	Immediately (no delay, no speed buffer/tolerance)	<2km/h and within 2 seconds	<3km/h and within 3 seconds	>3km/h and/or >3 seconds
HF	Mounting position	Multiple mounting locations available, does not affect driver's view	Single mounting option available does not affect driver's view	Multiple mounting locations available, some affect driver's view slightly	Single mounting option available affect's driver's view slightly
HF	Obstructing driver’s field of view	ISA device is in direct field of view of driver	Driver does not need to move head (only eyes) to fully view ISA visual alerts clearly	Driver needs to move head slightly to fully view ISA visual alerts clearly (select if no visual alerts)	Driver needs to move head greatly to fully view ISA visual alerts clearly (select if no visual alerts)

A.4 Mapping Performance (Coverage, Accuracy and Update Utility)

Table A.4 Mapping Performance (Coverage, Accuracy and Update Utility)

Category	**Criteria Description**	**Criteria**			
		Good (3)	**Acceptable (2)**	**Marginal (1)**	**Poor (0)**
Update Utility	Update method	Automatically updates	User must initiate updates, but possible from device	User must initiate updates separate to device (e.g., by internet, phone or mail) with time between order placement and update arrival less than 2 hours.	User must initiate updates separate to device (e.g., by internet, phone or mail) with time between order placement and update arrival greater than 2 hours.
Update Utility	Update Format	Wireless	Direct connection to computer (e.g., USB)	CD, SD card or other physical media	
Update Utility	Update frequency	At least monthly	Every 2 months	Quarterly	Greater than quarterly
Update Utility	Update notification	Users automatically updated (via device) when updates are available	Users automatically updated via other method (e.g., SMS, email) when updates are available	User can check website to see if updates are available (includes information on when last update was made)	User is unable to determine when new updates are available or provider recommends that the user updates every 3 months or more (without knowing if any changes have actually been made to the dataset)
Coverage	Coverage	80% or greater coverage of Australian roads (by kilometre).	80% coverage or greater of roads (by kilometre) for all capital cities and major highways	80% coverage or greater of roads (by kilometre) for specific state only	Specific cities or less than 150km radius coverage
Accuracy	Accuracy of speed zone values	99% accuracy or higher (by kilometre)	95% accuracy or higher (by kilometre)	90% accuracy or higher (by kilometre)	85% accuracy or higher (by kilometre)