Supporting Driver Attention Holistically: Perspectives from the AHEAD Consortium

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Abstract: Since the current driver distraction guidelines were developed, the scientific understanding of glance behavior, attention threading, situation awareness, the role of driving context, and other related topics has advanced, based to a significant extent on naturalistic driving research. In addition, vehicle systems have progressed with new forms of external and internal sensing, increased computational capabilities, better screens, greater integration of multi-modal interfaces, driver monitoring, and driver feedback systems. A panel discussion will summarize relevant research and a new conceptual approach for addressing attention management through system design and driver support being developed by the Advanced Human Factors Evaluator for Automotive Demand (AHEAD) consortium. AHEAD is an MIT based, industry-academic pre-competitive collaborative entity, working to build on previous work, while developing an updated approach to driver vehicle interface design, validation, and testing that improves system usability while enabling a foundation for real-time driver attention support. The premise is to build upon existing work, introduce attention centric design, and in real-time assess whether drivers are paying sufficient attention for the current situation. The aim is to leverage technology to promote the rebuilding of situationally relevant knowledge and readiness to respond. This paper summarizes the foundations for the framework and select operational considerations.

1. Introduction

Current global driver-focus and driver distraction guidelines were developed based upon a rich understanding of drivers' interaction with traditional static and largely visual-manual driver vehicle interfaces (DVIs). At the time, the automobile industry and regulators were concerned with the expansion of tasks that could be undertaken while driving and their associated demand on the driver. System manufacturers were just beginning to explore multimodal interfaces and design approaches aimed at mitigating sustained demand. Portable devices (e.g., smartphones) and modern social media were largely yet to influence the connected experience.

While extensive collaborative research had been done (e.g., Angell et al., 2006), limited insight existed on the role of operational context on demand, the benefits and limitations of voice enabled and touchscreen interfaces, the importance of on-road glances, the capabilities of external perception, and the viability of in-cabin sensing to support driver readiness. Modern DVIs are largely multi-modal and disconnected (beyond navigation) from an awareness of the operating context, driver state, and an ability to adapt moment by moment to user needs. Systems have now been deployed with attentional cues designed to draw the eyes to the road (e.g., GM Super Cruise) by leveraging the human's instinctual attraction to motion effects in the periphery.

The Advanced Human Factors Evaluator for Automotive Demand (AHEAD) consortium is an MIT led global industry-academic effort presently consisting of Google, Honda, VW Group, JLR, and Touchstone Evaluations, working as a pre-competitive entity to develop a new conceptual approach for addressing attention management based on historical foundations and new science.

AHEAD's efforts consider the realities of portable electronic use, limitations of current guidelines, a vision towards better DVI design, updated assessment approaches, and a need for safer roads. A panel presentation and this paper builds on earlier work (e.g., Coughlin et al., 2011, Reimer, et al., 2016; Reimer et al., 2022), to share additional details on our vision for supporting driver attention holistically. The framework promotes attention- centric user interface design, the implementation of real-time approaches to rebuilding attention when required, and the use of countermeasures when driver behavior falls outside of acceptable tolerances.

2. Historical Development of Past Guidelines

For more than two decades, driver workload and driver distraction have been a subject of concern in the traffic safety arena. This concern began to deepen when electronic devices began to transform the tasks that drivers could undertake while driving. In 2000, NHTSA held an internet forum on the topic of driver distraction. This event triggered many different entities in the U.S. and abroad to act. A number of research programs were initiated with the goal of understanding driver distraction and various related issues. Formative policy discussions began taking place.

Much of the effort was on a "device-oriented" perspective and focused on assessing *the level and types of workload demands* that new vehicle subsystems placed on drivers – based on the notion that the demands on the driver should not be excessive.

While it was understood at that time that fully addressing distraction entailed issues of attention ***in addition to*** issues of workload – in the early 2000's the technology for attentional cuing and related attention-related countermeasures was far from ready for deployment. Therefore, to attempt to limit driver distraction, initial steps were made with a focus on driver workload. There was hope that at some future point it would become possible to also begin addressing issues of driver attention.

The type of approach taken in the early frameworks offered a number of practical advantages to manufacturers from the point of view of ***developing*** DVIs and their subsystems (by placing an emphasis on the *design of tasks and interface elements* that a manufacturer could influence and optimize through design and engineering). However, these approaches were also **highly constrained**. Specifically:

1. A secondary task was treated as **a single unit of analysis**, as an epoch of time **removed** from the larger continuum of driving – and **removed** from a consideration of varying concurrent demands of the driving task.

2. ***Fixed limits*** were placed on the "amount" of demand that a secondary task could impose on a driver during the slice-of-time that a single task took – and these limits were placed on each *individual type of demand* considered *separately* from all others (e.g., visual demand considered separately from auditory or cognitive demand).

3. The fixed **limits were *invariant* across driving scenarios and conditions** that themselves would typically vary in the amount of attention they required from drivers. Instead of testing across varying, representative driving scenarios, test methods assessed whether or not tasks interfered with driving in a *single standardized type of driving scenario* (which was a car-following scenario in a low-demand driving environment on a straight road). This was intended to reflect the type of setting that at the time had most often been associated with the conditions under which distraction-related crashes had been observed, based on a synthesis of the research reported by Bents (2000), Hendricks, Fell, & Freedman (2001), Stutts et al. (2001), and Wang, Knipling, and Goodman (1996).

4. These limits were rendered on a ***dimension-by-dimension basis*** (e.g., visual demand separately from other dimensions) – **and no means was typically provided for considering conjoint or interleaved demands of "multiple types"** on the driver by a task. Further, *no means for combining* results across tests or across resource dimensions into an overall measure of task load to obtain a holistic "big picture" of a task's effect on the driver and their driving performance was typically provided in the early frameworks. As a result, the early *frameworks had difficulty handling the evaluation of tasks that were complex and placed multiple types of demands on the driver* – e.g., multi-modal demands in rapid succession, or the intricate threading of task elements over time, or even the management of task elements and modalities concurrently. If multimodal tasks were evaluated in this early period, the existing methods required such tasks to be evaluated *multiple times* (each time using a different evaluation methodology for each type of resource demanded – e.g., glance measurement for visual demand, Detection Response Task for cognitive demand, etc.). *There were a few exceptions which provided an overall metric for performance as a function of any task load (whether on a single dimension or multiple dimensions) – for example, the lane change test (Mattes (2003), Mattes & Hallén (2009)), Burnett et al., (2013) and the box test (which is still under study – e.g., Morgenstern et al (2020)). However, these two methods have thus far been ancillary to the more common practice of evaluating tasks dimension-by-dimension.*

5. In addition, the early approaches to distraction focused solely on **preventing excessive demand on drivers** – *rather than* – **on supporting drivers as they try to optimize their level of attentiveness to driving**. These two objectives are very different. Achieving one of them (e.g., *ensuring that secondary task demand is not excessively high*) does not necessarily mean that the other will also be achieved (*i.e., that drivers will be effectively-supported in attending to the road when-and-where they need to be*).

Thus, the early frameworks typically did *not* consider whether drivers were attending to the road in an adequate manner (e.g., an adequate amount, at appropriate times, and with adequate levels of attentional arousal). This was largely because, at the time, the tools were not yet available for conducting naturalistic driving studies - and virtually no data were available regarding when drivers chose to initiate tasks (under what conditions of driving) – so questions about how drivers managed attention over time under natural conditions could simply not be examined.

6. Further, in the early frameworks, ***conditions of underload*** **were often not considered at all** (even though during states of underload, monotony, and boredom, drivers often *initiate* secondary tasks as a means of increasing and/or optimizing their levels of attentional arousal). Indeed, conditions of "increasing workload" were almost always assumed to be *undesirable* – and treated as such. Yet, published findings now suggest that when attentional arousal is low, performance can sometimes be improved with a heightening of arousal – and show that increases in task loads of certain types can improve overall performance.

Thus, on the one hand, each of the six constraints itemized above could be seen as a shortcoming of the early distraction frameworks. **However, we see them differently. We see them as opportunities to advance the state of the art** as **many things have changed** since the first guidelines limiting distraction were formulated. Now, through naturalistic driving studies, **much more is understood about driver behavior** "in the wild." In addition, **technology has advanced** along several dimensions – and now offers the capability to adapt the user-interface, and to offer new types of support to drivers in real-time.

3. AHEAD's Scientific Contributions in Support of a Broader View of Glance Behavior & Attention

A major aspect of the AHEAD perspective is a shift in focus from the potentially narrow concept of distraction to a broader consideration of how a driver's attention is distributed over time. This approach asks whether the driver has been attending to the driving task, including the surrounding driving context, sufficiently to safely carry out the immediate task and maintain a level of situation awareness to anticipate and respond to changing events and demands as they emerge.

In terms of visual attention, this perspective considers not only 'distracting events' that take the driver's eyes off the road, but also whether the driver's pattern of glances back to the road are of sufficient duration to re-establish and maintain appropriate situation awareness. The concept of an 'attention buffer' was originally introduced by Kircher and Ahlstrom (2009). As adapted and extended by AHEAD, this view of attention argues that a driver's awareness of the details of the driving scene degrades as they look off-road such that not only does the risk of missing a critical event taking place on-road increase the longer one looks off-road, but maintenance of awareness of the details of the road scene degrade as well, leaving the driver less prepared to respond to events when they return their gaze to the road. Equally critical, this model of attention argues that it takes time once the driver looks back to the road to re-establish a comprehensive picture of the driving environment. Brief 'check' glances back to the road may or may not be of sufficient duration to detect a "bottom-up" stimulus such as brake lights coming on in a lead vehicle. Further, relatively long on-road glances are required in complex driving conditions to reacquire a level of awareness that allows a driver to anticipate emerging conflicts in the details of the road scene ("top-down" processing) and thus act to avoid conflicts before they become safety critical. Consequently, a more comprehensive assessment of attention needs to account for the pattern and duration of on-road glance behavior (and, ideally, the driving context).

AHEAD research has demonstrated that an attention algorithm that considers how a driver threads together both on and off-road glances can differentiate relative safety risks in naturalistic datasets that cannot be differentiated using just off-road glance metrics (e.g., Seaman, et al., 2017; Seppelt, Seaman, Lee, et al., 2017; Seppelt, et al., 2018). AHEAD efforts have explored refinements to the base rules of the initial buffer concept, particularly as regards the reestablishment of situation awareness through on-road glance characteristics as well as other features (e.g., Seppelt, Seaman, et al, 2017; Seaman, et al., 2021). These findings argue for both respecting prior work on the safety significance of off-road glance behavior and the importance of DVI design that considers on-road glance behavior in support of driver situation awareness.

In addition to the published work referenced above, AHEAD has explored the potential for further refinements in the study of on-road glance behaviour to detect divided attentional states such as those associated with high cognitive load or mind-wandering. While technical challenges are currently present (e.g., Wang et al., 2014; Ding et al., 2023), practical implementations are not necessarily far off and can easily be incorporated within the AHEAD framework.

4. Implications & Motivation for a New Framework Focused on Driver Attention Support

The availability of new technologies not only creates a need for human centred driver attention management methods, they also enable it. Moreover, system design may benefit from taking a functional approach to driver attention that focuses on a holistic (system-wide) view of the net impact of all sources of demand (primary and secondary, under all assistance levels, and the role of operating context) on safety. AHEAD sees this holistic approach focusing on driver attentional support to promote situation awareness across three interrelated concepts (first elaborated by Angell (2012) and adopted by AHEAD):

- Managing task workload within a zone of acceptability.
- Preventing interference with natural attention allocation strategies and preventing disruptions of the driver's attention functions.
- Supporting a driver's focus when capabilities are limited, they're having difficulty, or something unexpected occurs.

Driver Attention Support is about helping drivers supply sufficient attention for the current driving situation. This can be accomplished through a combination of system design to mitigate workload and protect attention, as well as real-time adaptions that are now increasingly feasible to help ensure that the attention a driver supplies meets or exceeds the attention the driving task requires at a given time, so that drivers are well positioned to respond to developing events. As noted, technical developments have increased capabilities to estimate relative required attention using data on:

- Driving task demands - assessed using vehicle and infrastructure sensors (e.g., speed, map data of congestion/design, camera/radar/ lidar, user-generated content, weather data, and traffic signal SPaT).
- ADAS capabilities - accounting for effectiveness in supporting driving, and reducing crash risk, assessed using FOT studies and safety benefit estimates.
- Driver capabilities - information (e.g., a parental control identifying a novice driver or other historical data) indicating an attention challenged driver.

AHEAD proposes that a new model for DVI design and evaluation be considered that promotes an attention-centric approach. In cases where required attention and supplied attention are unknown, a case can be made for defaulting to current distraction guidelines. However, when the required attention and/or supplied attention can be estimated, extensions to the current guidelines are developed to enable adaptable DVIs that, in real-time, support rebuilding attention as required. Furthermore, countermeasures may be used when driver behavior falls outside of acceptable tolerances (e.g., texting using a personal electronic device). Core interrelated topics are discussed in the following sections.

4.1 Attention-Centric Driver Vehicle Interface Design

One of the most important factors associated with task completion in the vehicle is how well the system is designed in the first place. Following a human-centred approach to design and trying to find the most appropriate interfaces within the context of use is fundamental to achieving a simple and satisfying experience for all vehicle users. The focus on how a driver uses their attention in relation to the demand generated within the driving context is the basis for the AHEAD design approach, and hence signifies a change in direction from existing guidelines that tend to shy away from specific recommendations around interface design.

AHEAD recommends that as an industry we focus more on: simplification of content (Rosenholtz, et al., 2011), avoiding attention-based traps (*i.e., visual search*, Scott, 1993), and using appropriate multi-modal methods of interaction (Schnelle-Walka & Radomski, 2019). Design must be based on empirical findings, as often theory or rationale-based assumptions do not translate to the actual real-world user behavior. Therefore, it is critical to test and compare solutions, in context, to understand how they impact attentional behavior.

Content simplification starts with understanding the fundamentals of task design at a system level to make sure that achieving important functional goals are simple and short in duration. For example, surfacing frequently used tasks, or allowing users to configure favourite options to appear more prominently. In the display design process, it is valuable to assess how much content it contains and how deep the structures go, and then reassess how much of the functionality is absolutely necessary.

Avoiding attention-based traps starts with the understanding that humans will search for visual information that matches their goal (Wolf & Horowitz, 2017). Therefore, content heavy information displays may naturally lead to long periods of visual search and increased glance durations, thus increasing the chances of supplied attention being compromised. The combination of different interfaces and task types lead to tasks that take longer (*such as typing*) or have no clear end point (*scrolling lists, deep menus*) are examples of interface strategies that can lead to attention-based traps (Large, et al., 2019). Equally, there are also examples of design approaches that automatically trigger glances back to the road, such as contextual cueing (Chun, 2000). Another form of an attention-based trap is when messages are presented at inopportune times. A mis-timed glance during a demanding situation could lead to a misbalance of attention. As discussed later in the countermeasures section, building in mechanisms to schedule feedback at appropriate times is an important attention-centric strategy.

Finally, using **appropriate multi-modal methods** of interaction can help users complete challenging tasks. The difference between good or bad performance is usually good or bad design. For example, determining when visual-manual interaction is necessary and needed as opposed to other modalities is very important. The balance between physical and digital control execution is particularly sensitive. The digital space offers huge variety and flexibility but also significantly increases the potential for bad design. Consider how voice can help or be used proactively rather than letting a user decide which way they want to interact. Utilizing AI methods, can the vehicle itself predict the user's goal and proactively offer the most attention centric way to interact?

Making an optimized design decision amongst a catalogue of potential solutions is part of the challenge. A lot of work, research, and empirical evidence is still required to understand how to support driver attention naturally and, hence, industry should focus on consistent, repeatable interaction methods that target a reduction of visual demand in its entirety.

4.2 Required and Supplied Attention

The goal is to build upon previous work and leverage new technologies and research in constructing a driver attention framework that helps support driver focus. As such, given the proliferation of information technology and embedded sensors, it is increasingly feasible to estimate the required attention of the driving task that is used a priori to inform design assumptions and/or on a moment-to-moment basis in to inform adaptive systems. Supplied attention by the driver is a function of the visual attention to the road, cognitive attention to the road, and manual control of the vehicle. Supplied attention over time is critical for building and maintaining a model of the driving situation (see Section 3). Supplied attention can be estimated in various ways based on driver behavior, such as using taps on the display, in-vehicle cameras, and perhaps even voice interaction. Similar to required attention, supplied attention could be estimated a priori (for design) or in real-time to dynamically estimate or forecast the driver's state.

AHEAD sees significant potential in the development of adaptive DVI's within a framework of driver attention support that compares required attention versus supplied attention for a task (Figure 1). If required attention is greater than supplied attention, a countermeasure is needed to increase supplied attention. Countermeasures can also be leveraged when driver behavior, a factor often outside of the control of vehicle designers and manufacturers, falls outside of an acceptable tolerance level. Such situations can occur from internal sources (e.g., choice to use a personal electronic device) or from external sources (e.g., digital billboards, Belyusar et al., 2016). This framework is extendable to both sides of the Yerkes-Dodson curve (Coughlin et al., 2012) to appropriately consider both overload and underload.

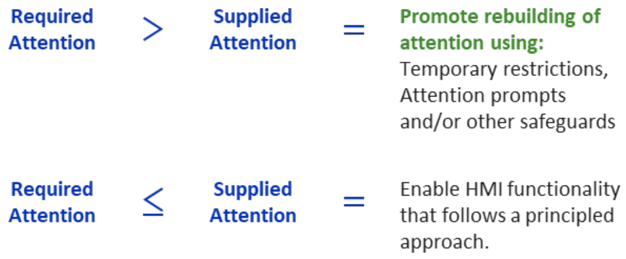

Fig. 1. Comparing required and supplied attention.

The framework is explicitly designed to scale across a variety of passenger vehicles equipped with an assortment of sensors and technologies. In this context, required and suppled attention can be inferred to inform different levels of model sensitivity using a range of indirect (e.g., taps) and direct measures (e.g. eye glance data) and driver behaviors. Case studies, shown in Table 1 in Appendix A, demonstrate the scalability of the framework.

4.3 Countermeasures

A countermeasure can be defined as an active intervention to realign attention. In the case where supplied visual attention is not sufficient to meet attention required, the aim of an attentional countermeasure is to get the driver looking back at the road. There are three general types of such countermeasures: Adapt, Feedback, and Block.

Adapt countermeasures modify the interface's system behavior. For example, adapting, de-cluttering or simplifying displayed information (Chew, et al., 2021), moving drivers to an appropriate interaction modality for the task (*i.e., voice instead of visual-manual*), adjusting or supressing driver feedback at inopportune times (Wright, et al., 2017; Caber, et al., 2023) (and/or suppressing low priority interrupts sent to the driver by subsystems) or even modifying the ADAS system settings to be more sensitive for periods of high demand. **Feedback** countermeasures are active feedback that the vehicle interface uses to nudge the driver to look back at the road. They may also include real-time coaching or brief forms of ‘help’ or instruction given at carefully selected teachable moments. One example, a real-time prompt that indicates a glance to the road is necessary. Cues could be visual, auditory, haptic, kinaesthetic (*vehicle movement*), pre-attentive or active coaching (*spoken*). Alternatively, the vehicle interface could provide direct and active notification / feedback of threats on the road if a specific threat is of concern. Finally, there is **Blocking** where either dynamically, or permanently, functions are blocked because the situation is too demanding (Leipnitz, et al., 2022). This could take the form of actively stopping a task in progress if the current driving situation requires more attention. Another example would be when the required attention level is such that preventing access to certain tasks, because of the demand that task would place on the driver, could prevent a potential issue.

Countermeasures could and should be used in an escalating fashion if enough foresight can be gained into how quickly the situation could change. Alternatively, if an initial feedback intervention doesn’t achieve an increase in supplied attention, then more salient feedback should be triggered. All countermeasures need to be designed carefully, and using a human centred design process to ensure that there is robust evidence that they work to increase supplied attention in an operational environment and do not simply prolong tasks, , nor cause frustration of the driver, nor are too easily ignored.

5. Clarification of Scope & Limitations

AHEAD’s work to date explicitly acknowledges several **limitations**. Legal requirements need to be maintained until or unless modified. There are a set of in-vehicle activities whose type, nature, and/or demands lie beyond what many feel should be socially acceptable while driving (e.g., watching video). While what is socially acceptable and legally required may evolve over time, it’s recognized that in some global markets legally required lockouts need to be respected.

This framework does not identify a specific set of demand limits for what may be considered socially acceptable tasks. OEMs may consider benchmarking this approach to traditional (e.g., radio tuning) or other tasks to ensure that demand considerations meet their organizational philosophies and regulatory commitments. Whatever route is taken, it is important to make sure that limits are credible, evidence-based, and representative of real-world driving.

With regard to scope, one important clarification relates to the use of automated or partially automated driving features by a driver. With the approach described here, the level of assisted or partially automated driving is **viewed as an input into the situationally appropriate attention equation**. In this context, the current framework does not argue that drivers should or should not be provided any additional liberties to engage in secondary tasks under any type of assisted or partially automated driving.

L3 systems dramatically shift the relationship between the driver and vehicle. The framework recognizes that if L3 driving systems are engaged, drivers may be permitted to engage in activities that are not optimized for the driving situation. Future extensions to the framework could encompass elements of L3 operation but, for now, have been considered out of scope.

6. Conclusion

While there is still much to be learned about driver behavior with secondary tasks, many of the historical limitations that framed early driver demand guidelines can now be reasonably addressed. This is an **opportune time to build upon the foundations** of prior work and harness new findings and capabilities **to focus on more effective ways** of designing DVIs and related systems to support drivers and mitigate issues such as portable electronic device use.

AHEAD aims to promote these perspectives as an alternate path or approach (not necessarily a replacement) for current guidelines for DVI design, validation, and testing. The premise is to build upon new insights in attention-centric design to, in real-time, assess whether drivers are paying sufficient attention for the current situation and, if not, leveraging technology to support the rebuilding of attention. Where needed, countermeasures can also provide attention triggered failsafe actions.

This framework moves the language of DVI assessment beyond previous efforts to consider: The role of spatial and temporal characteristics of a task; a framework in which demand can be optimized across all dimensions, i.e., visual, auditory, haptic, vocal, manual, etc., by taking into consideration the relative cost and benefit interactions of various input, output and processing modalities, and interactions between secondary tasks and the broader operating environment. As such, assessment moves from focusing narrowly on distraction to a broader consideration of driver attention support and safe operation that emphasises mechanisms that promote rebuilding situation awareness which can:

- Reduce exposure (Seppelt et al., 2018) to unfolding conflicts
- Foster less surprise (Meyer et al, 2022)
- Encourage more measured responses (Seppelt et al., 2017)
- Improve driver readiness
- Result in fewer crashes (Seaman et al., 2017; Seaman 2021) when exposed to a conflict

The development of this work will continue to evolve through the integration of input from interested parties. Efforts to date are explicitly neutral regarding the need for new or updated policy or industry guidelines. We hope that by sharing our work, relevant global organizations can leverage it in their research and that this effort will encourage a broader discussion of next generation driver focus principles and lead to safer, more satisfying travel on the world’s roadways.

7. Acknowledgments

The authors wish to acknowledge Bobbie Seppelt, Dan Clifton, Code Grebe, Christian Lorenz, Shani Jayant, Elizabeth Wykes, and Pnina Gershon, who all contributed to the development of this work.

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Appendix A

In this framework, each case builds upon the previous one; we begin with rudimentary, indirect measures of driver attention and driving context and progress toward direct measures of glances and behaviors. It is important to note that framework implementation is not necessarily a linear process, manufacturers do not have to begin at Case 1 and they can skip cases if it better aligns with their organization's goals and philosophies for driver assistance.

Changes between cases are bolded so you can easily see what parameters are added.

- Starting with Case 1: we leverage fixed parameters for required attention, like the NHTSA/DFT guidelines, however, we incorporate measures of supplied attention by using interactions with the in-vehicle infotainment system.
- In Case 2 we leverage limited vehicle sensing data such as speed and steering angle to obtain information about the driving environment, while continuing to use IVIS interactions as the supplied attention metric.
- Case 3 is applicable to vehicles with additional sensing capabilities, such as radar, which provides even more information about the driving environment.
- Case 4 keeps the same parameters for required attention, but adds indirect measures of supplied attention, such as steering entropy.
- Case 5 adds moment to moment driving risks to the required attention assessment – this can include longitudinal conflicts, lateral conflicts, lane departures, and more.
- Case 6 adds in direct driver monitoring measures – that could include driver glance metrics such as eyes off road time or glances to specific areas of interest.
- Case 7 adds in parameters of behavioral modelling – going beyond glance metrics and incorporating measures of driver behavior and workload such as non-driving related tasks, drowsiness, and fatigue.

As this set of cases shows, this is a scalable solution, which allows this framework to be applied across wide range of vehicles without mandating any additional technologies.

Table 1. Driver Attention Support Framework Case Studies

Case	Key Factors for Required Attention	Key Factors for Supplied Attention
Case 1: Leveraging supplied attention alone	Fixed	Using interactions with in-vehicle information systems (IVIS)
Case 2: Context dependent levels of required attention	**Using limited vehicle sensing (e.g., current speed, steering angle)**	Using interactions with IVIS
Case 3: Enhanced context dependent levels of required attention	**Using additional vehicle sensing (e.g., current speed, steering angle, ACC/TTC)**	Using interactions with IVIS
Case 4: Enhanced assessment of supplied attention using indirect measures of supplied attention	Using vehicle sensing (e.g., current speed, steering angle, ACC/TTC)	Using interaction with IVIS and **supplemented/supported by indirect measures of driver attention (e.g., steering entropy)**
Case 5: Extending to moment-to-moment driving risks	Using vehicle sensing (e.g., current speed, steering angle, ACC/TTC) and **moment-to-moment driving risks**	Using interaction with IVIS and supplemented/supported by indirect measures of driver attention (e.g., steering entropy)
Case 6: Incorporating direct measurement of driver attention	Using vehicle sensing (e.g., current speed, steering angle, ACC/TTC) and moment-to-moment driving risks	Using interactions with IVIS **and direct driver attention monitoring**
Case 7: Driver state monitoring outputs as supplied attention modifiers	Using vehicle sensing (e.g., current speed, steering angle, ACC/TTC) and moment-to-moment driving risks	Using interactions with IVIS, direct driver attention monitoring and **other behavior monitoring**