Safer Transitions of Responsibility for Highly Automated Driving: Designing HMI for Transitions with Functional Safety in Mind

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***Abstract*—With highly automated driving on the horizon, and the wide adoption of functional safety standards for road vehicles, it is important for human-machine interface (HMI) designers to understand what this means in terms of their work. This article provides a very brief introduction to Automotive Safety Integrity Levels (ASILs), a key functional safety concept laid out in ISO 26262, and explores how they can impact HMI design in transitions of authority in highly automated driving. It also investigates interactions to avoid, namely *unfair transitions*, being *stuck in transition*, and *mode confusion*, and illustrates how to apply several guidelines to help design a safe transition.**

***Index Terms*—HMI, automated driving systems, transitions of authority, safety, ISO 26262.**

I. Introduction

The potential safety benefits that can be reaped from the marked increases in vehicle automation that is currently sweeping the market are undoubtedly significant, but it is important that the extra risks coming from potential failures of automation are kept to a minimum. More advanced functionality and intelligence implemented in the vehicle means that the relationship changes between the vehicle and its occupants, and the associated tasks, including a shift of the safety responsibility from the driver to functionality implemented in the vehicle. This not only increases the expectation on the automated vehicle, but leaves the driver less prepared in the case that they are required to take control [1]–[3].

This paper is the latest in a series of papers [4], [5], written as part of the ESPLANADE Project on automated driving and safety, which explores methods and approaches for combining functional safety and Human-Machine Interface (HMI) design to develop solutions for highly automated driving (SAE Level 4) [6]. In Level 4 automation, the Automated Driving System (ADS) may take over full responsibility for a safe behaviour in specific Operational Design Domains (ODDs). When inside of the specified ODDs, there is the possibility of human drivers taking back, or handing over, authority and responsibility for the vehicle from the ADS. And as of 2011, when the International Organisation of Standards released the first version of "ISO 26262: Road Vehicles - Functional Safety," [7] and it's introduction of Automotive Safety Integrity Levels (ASILs), which categorize the inherent risk, the expectations on functional safety in automotive product development have become more stringent.

By bridging the gap between functional safety principles and practices in HMI design, it will be possible to assess risks that would be found in a human/automation joint cognitive system such as highly automated driving, and design an appropriate system to reduce these risks, achieving safe transitions between the driver and the ADS for a Level 4-equipped vehicle.

While the previous papers in this series have endeavored to explain HMI perspectives to functional safety workers, this paper intends to help HMI experts and novices understand better how to incorporate functional safety in their work to produce solutions that satisfy both disciplines.

In the following paper we will endeavor to accomplish several key goals: Provide a light introduction to functional safety for designers by highlighting pertinent concepts from ISO 26262, translate these concepts into more HMI centric language, and, finally, discuss where and when HMI Designers might play a role in ensuring ISO 26262 compliance and safe interactions.

II. Functional Safety and HMI design

The standard ISO 26262 [7] sets expectations on functional safety within the automotive product development, and when arguing for a safe transition between ADS and human driving, HMI is a safety relevant factor to consider. This section provides information and discusses how functional safety and HMI design can affect another.

A. *ISO 26262 and factors affecting ASIL*

ISO 26262 defines functional safety as absence of unreasonable risk according to valid societal moral concepts, due to harm caused by malfunctioning behaviour of E/E systems [7]. The standard sets out a metric for safety, the Automotive

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Severity Score	Exposure Score	Controllability Score		
		C1	C2	C3
S1	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	A
	E4	QM	A	B
S2	E1	QM	QM	QM
	E2	QM	QM	A
	E3	QM	A	B
	E4	A	B	C
S3	E1	QM	QM	A
	E2	QM	A	B
	E3	A	B	C
	E4	B	C	D

Fig. 1. This **ASIL Matrix** shows us how Severity, Exposure, and Controllability combine to give specific ASIL scores

Safety Integrity Level (ASIL), which has 5 levels of increasing integrity. The levels range from QM, a quality management issue with nominal safety critical impact where the standard does not enforce additional requirements, up to D, which represents likely potential for severely life-threatening or fatal injury in the event of a malfunction. Level D requires the highest level of assurance that the dependent safety goals are sufficient and have been achieved (see Fig. 1). Between QM and D, there are three interval levels: A, B, and C. Each ASIL score is associated with the magnitude of integrity that elements must be designed and built for in order to avoid their failure, resulting in violation of the associated safety goal set for a system. These levels are assigned based on a composite score of three factors:

- Severity (**S**)
- Exposure (**E**)
- Controllability (**C**)

Severity (**S**) is a measure of the gravity, or seriousness, of potential injury in the case of failure, and ranges from S1, light and moderate injuries, up to S3, life-threatening injuries (survival uncertain) and fatal injuries. Exposure (**E**) is a measure of the relative expected frequency of exposure for each operational situation where a specific hazard may occur, and ranges from E1, very low probability of exposure to the situation, to E4, high probability of exposure. Controllability (**C**) is a measure of how easy or difficult it would be for the driver, or other persons involved, to control the situation, and ranges from C1, simply controllable by 99% of drivers, to C3, uncontrollable or difficult to control. In overly simplified terms, Severity is how bad the event may be, Exposure is how often it may happen, and Controllability is how avoidable the worst case scenario actually is.

It should be noted that the difference between each level for Exposure and Controllability is typically defined by orders of magnitude (x10 increase). Additionally, if any of these are level 0 (i.e. S0, E0, or C0), where there is no risk, then the ASIL will default to QM, as defined in Fig. 1. As you can see in this figure, lowering any of the Severity, Exposure, or Controllability scores will result in a lowered ASIL. In fact, for each level you lower one of these scores, you lower the ASIL by one level as well.

B. HMI and Controllability

Realistically, the impact that an HMI/Interface Design can have on Severity and Exposure is limited. However, Controllability can be impacted by a good HMI solution. Severity will usually be addressed by passive safety technology or lowering speed. Exposure will be lowered with e.g. better algorithms in automated driving technology which avoids potentially dangerous operational situations. But a good HMI solution can affect how likely a driver is able to adequately control a dangerous situation.

If an interaction design is executed well enough, the Controllability metric could end up being low enough that you could bring the ASIL level down. By creating an interaction that is easy to understand and allows for the user to simply execute the required action in a way that is intuitive enough to limit confusion, the ASIL will end up with a lower. Whether improving the understandability of the interaction is accomplished by finding a good metaphorical example as an inspiration (i.e. a certain handle or button), or if it is by finding a better way to communicate the critical information that a driver would need to handle the situation, if it is possible to lower a Controllability level from C3 (Difficult to control/ uncontrollable) to C1 (simply controllable), an ASIL D would lower to an ASIL B, or an ASIL C to a more acceptable ASIL A. If this magnitude of reduction is accomplished, then that makes the function easier to implement as lower ASIL requires less stringency in development and requires simpler safety mechanisms to safeguard against failure. Even better, if it is possible to implement multiple interactions that are simple, then we can continue lowering the stringency requirements with each

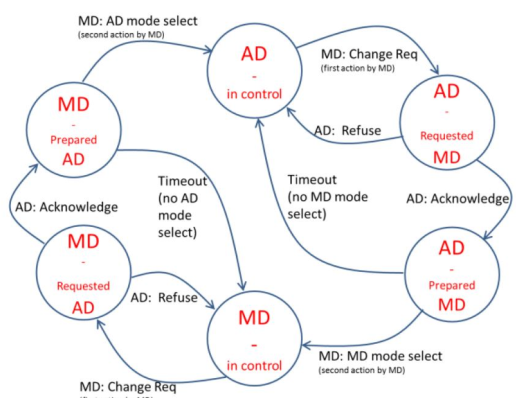

Fig. 2. Simple transition solution which would allow for quick and simple triggering for transitions of responsibility.

One example of how HMI and Controllability are related could be for a simple solution that the driver presses a button requesting that the automation system takes over control. However, as automated driving is slightly more complex

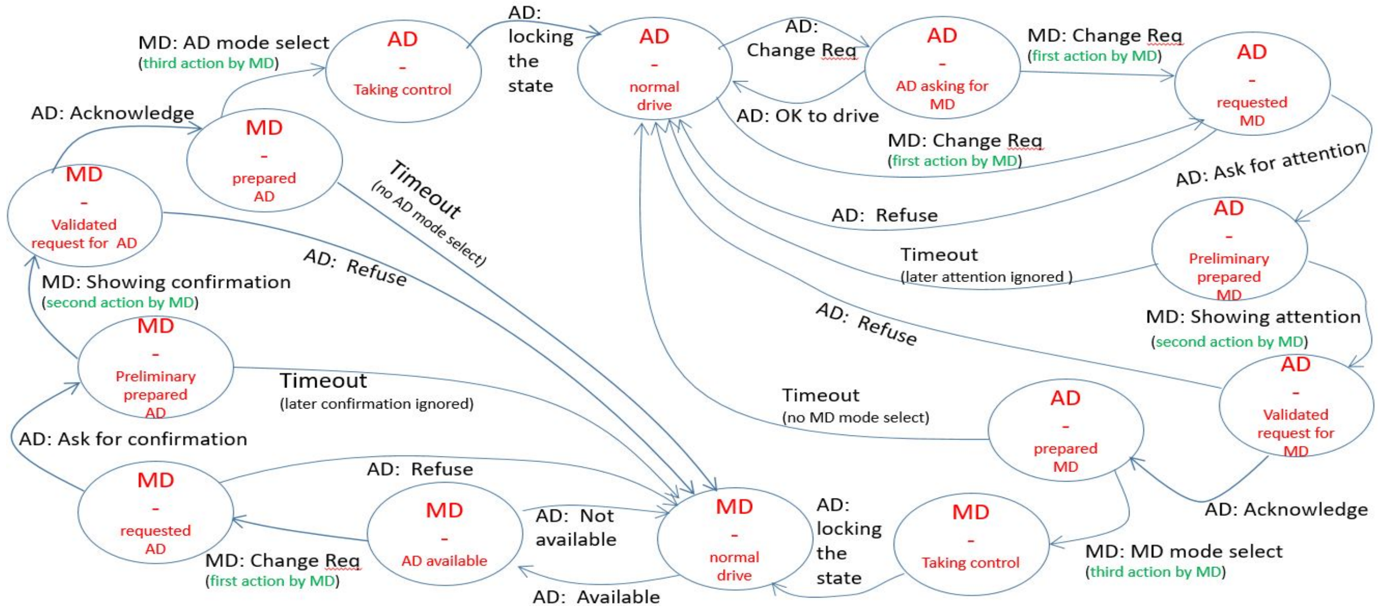

Fig. 3. Complex Solution: As mentioned in the text above, this is a a more complex transition protocol with more steps, and more fallback options.

than simply maintaining a drivers speed until deactivation, we have far more than simply activation and deactivation. With more complexity, there are multiple stages that can be identified in order to make sure that the transition of full responsibility of the car is as smooth and safe as possible, including speed, maneuvering, signalling, and responding to contextual situations appropriately. The driver should know when the automated driving system is available in the first place (within the ODD), be able to request the function, and know that the vehicle has taken over the driving task (see example protocol in Fig. 2). That would be the bare minimum to cover the transfer of authority. This bare minimum, however, is not going to be enough to ensure safety, there would need to be further steps involved.

A minimalistic and satisfactory HMI isn't the goal of functional safety. Making a situation less severe, less probable, or more controllable, is. With the addition of more steps, and having appropriate fallbacks at each step in case they fail to be completed, there is increased Controllability by reducing the chance that a fault in the interaction between the driver and the ADS goes through without being addressed by the driver. (see Fig. 3).

It is also possible through ISO 26262 to lower the necessary ASIL by introducing architectural independent redundancy of two or more functions that both address the same safety risk, a method known as *decomposition* [7]. In this case, successfully transferring full control and responsibility from the driver to the automated driving system or vise versa could be done through decomposition. The method could be perceived by the HMI designer as adding unnecessary complexity to the HMI. There are however examples where this is not the case, e.g. the two-hand control safety grip, where decomposition against one failure (unintentional activation of a chainsaw) is achieved through decomposition, while also securing that the operator's hands are in a safe position. Nevertheless, potential introduction of new functions due to decomposition needs to be considered if they affect HMI interaction patterns.

III. Interactions to Avoid

In SAE Level 4 when responsibility is transferred between the driver to the ADS, there are plenty of hazards, and ways that the interaction can go wrong. As mentioned above, there are several key moments in the interaction protocol (an example is shown in Fig. 4), where a fault can lead to the transition failing, and at each of these key moments there are different ways that interactions may fail. For the sake of expediency and efficiency, this section will focus on three larger classes of hazards as opposed to specific failures. These three types are hereafter referred to as *"unfair transition"*, *"stuck in transition"*, and *mode confusion"*, which can each cover a broader collection of more specific cases.

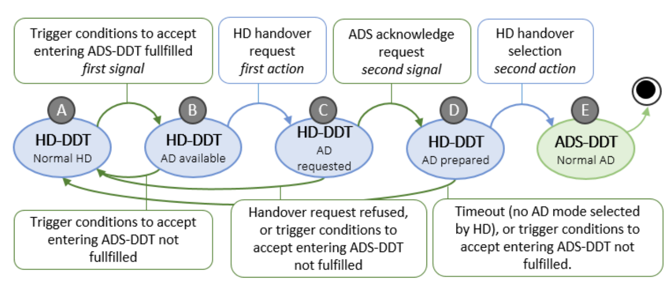

Fig. 4. An example of a transition protocol illustrating the each step in the protocol, and where failure or loss of control can occur

Before we go into finer detail, it is important to see how the protocol for authority transition presented in Figures 2 and 4 would look if everything goes according to plan. Fig. 5

displays a sequence diagram of how the exchange should go if it has multiple steps, ensuring some safety while not adding superfluous complexity. All of the interactions discussed further on are permutations of this transition protocol.

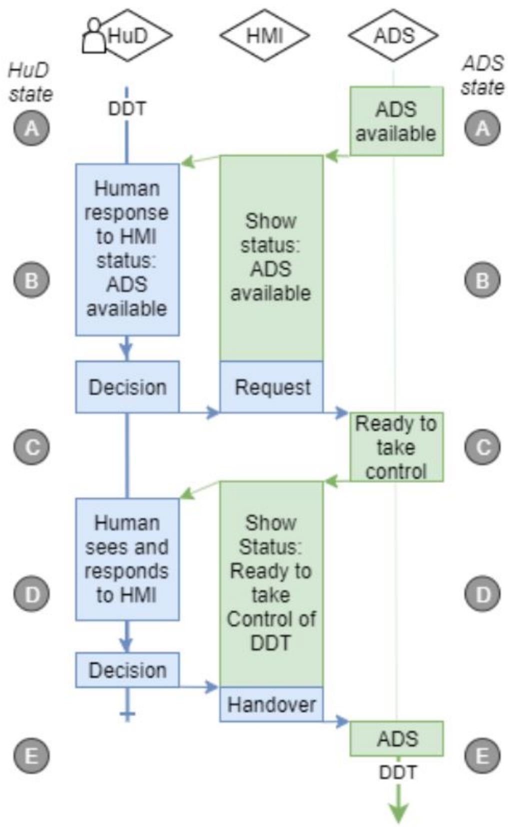

Fig. 5. A successfully executed transition protocol where a Human Driver (HuD) requests that the ADS take responsibility for the Dynamic Driving Task (DDT).
(Note: HuD and ADS States refer to the Transition Protocol image, Fig. 4)

A. Unfair Transition

In *unfair transition*, the party receiving authority and responsibility for the driving task (either the human driver or the automated driving system) will be unable to smoothly continue or complete the tactical plan that has already been initiated. When transferring responsibility between human and automated driving at an inopportune moment, such as in the middle of a maneuver, or when the other party is otherwise engaged, it is not logical to assume that the receiving party will have the same understanding of the situation, or have the same plan for resolving said situation.

Unfair transition could stem from the fact that ADS and human drivers will process contextual information in fundamentally different ways. An ADS would create an awareness and take decisions from e.g. a continuous detailed 360 degree monitoring system of various sensors, and potentially communicate with other vehicles (V2V) or infrastructure (V2X). In contrast, a human uses completely different input and cognitive functions to create a situation awareness as basis for decision making and actions. These two variations on awareness are not always in agreement, and if they are not in agreement when a transition moment occurs, then there is high risk for unfair transition.

This first failure type finds its source in mismatched comprehension of the situation. For example, if an ADS starts undertaking a maneuver based on its understanding of the world, and the human driver takes control because they feel the maneuver is erroneous based on their world model, then you have a situation where the human may not know all the factors, and thus be unable to smoothly complete a safe maneuver.

A second, more widely discussed way for unfair transitions to occur is when either the Human Driver (HuD in Fig. 6) or the ADS is out of the loop. This can be either due to driver distraction and inattention, or it could be when the ADS is not in an appropriate ODD. In either case, one party is not even appropriately primed to receive a transition of authority. One example of this, as shown in Fig. 6, would be the driver activating ADS functionality as the vehicle is leaving a valid ODD, meaning it is unprepared to complete the tactical plan that has already been initiated.

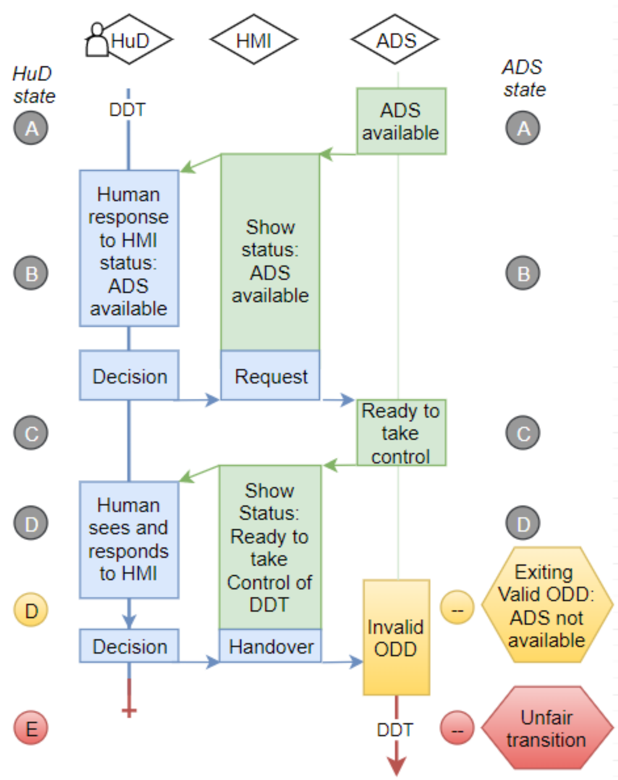

Fig. 6. Unfair Transition where the ADS is no longer in a valid ODD, thus unable to take responsibility to the DDT.
(Note: HuD and ADS States refer to the Transition Protocol image found in Fig. 4)

The latter example is far simpler, and would be easier to tackle in the short term with intuitive Input/Output devices and interfaces, but the end result for both the mismatched world model situation and the 'out of ODD' situation is that the party that is receiving responsibility for the DDT in this transition is ill-equipped to complete the maneuver safely. This makes the moments immediately following the transition incredibly dangerous, and presents an alarming safety risk.

The transition of control is precarious enough in optimal stable driving conditions, but adding a dynamic maneuver to the equation exacerbates the situation tremendously. For both of the situations mentioned, there can be an HMI solution that affects the Controllability of the situation.

B. Stuck in Transition

An interaction is *stuck in transition* if either party is unsuccessful in executing their role during a transition. When one party fails in their role in the handover of responsibility for the driving task, be it taking back or handing over authority, or when there is a lack of clear feedback indicating that further action may be required to complete the transition, we risk being stuck in transition.

First off, enforcing the acceptance and relinquishing of authority in a timely manner is hard to avoid. Compelling someone to take action is not a task that is easily accomplished. There are ways that an interface can request with more insistence, but the simple fact is, in any protocol, there needs to be a fallback in case action is not taken. The solvable evolution of this situation is making sure that the appropriate feedback is in place to cajole the party to carry out a request, whether the feedback is warnings or confirmations.

Expanding on the issue of unclear feedback, if an ADS fails to inform the driver that it has taken responsibility and is acting on the vehicle, but fails to let the driver know, then we could be dealing with a situation where there may be incongruous inputs to the vehicle. It is possible that this could go on for quite some time before it is realized, leading to a minor situation becoming quite critical with both the human driver and ADS providing contradictory input to the vehicle. In ASIL terms, if the *stuck in transition* state persists for an extended period of time, the Severity (S) score for the moment when a response is required may well increase, and the Controllability (C) of the situation at this moment has decreased dramatically as , the likelihood of a driver being able to avoid the worst outcome is much higher now. As the likelihood of this state lasting an extended time is quite low, you will also see a lower Exposure (E) score, but not enough to offset the increases in both Severity and Controllability scores.

With the subsequent increases in Severity and Controllability scores, it is very possible that this will result in a higher ASIL rating.

The end result is that a transition remains incomplete or unresolved (see Fig. 7), as the required steps to ensure that the hand-off is complete were not accomplished. The two examples can illustrate some ways a transition might become stuck, but it is worth noting that this can also be caused by an *unfair transition*, faulty interactions, or distractions. One of the more critical outcomes is that it can lead to *mode confusion*, where the initiating party being left monitoring for a confirmation that will never come. In any of these outcomes, there is a risk that the driving skills of the responsible party will be less than optimal as they have incomplete control over the situation.

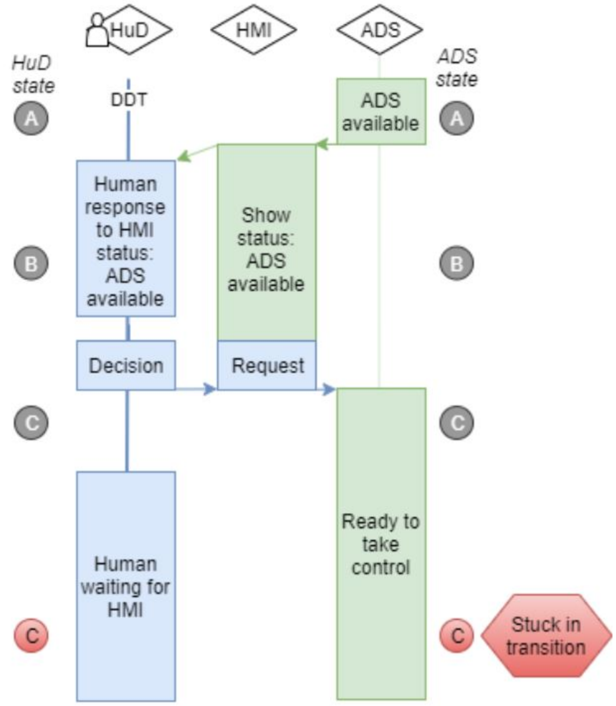

Fig. 7. Stuck In Transition where neither the ADS nor the Human Driver (HuD) has taken responsibility for the DDT as they are both waiting for feedback from the other.
(Note: HuD and ADS States refer to the Transition Protocol image found in Fig. 4)

C. Mode Confusion

With *mode confusion*, when the two parties fail to maintain a stable and shared understanding or agreement about who is currently in charge, there is a significant risk for two dangerous situations:

1) both parties end up trying to control the vehicle, **O**R
2) neither party is in control.

Both *unfair transition* and being *stuck in transition* can ultimately result in this situation, and they can also be triggered by this situation, depending on the sequence of events. It is possibly the most critical of the situations. This issue is also entirely rooted in Controllability, because in either case the end result is that the vehicle has no designated pilot, and thus no control. The consequent arrangements (both in control or no-one in control) leave the vehicle in a state where, in a critical situation, it is lacking adequate input, or receiving contradictory inputs, both of which can lead to a critical safety risk.

In one instance, the precipitating issue is an unfair transition, as discussed earlier. The human driver is not paying adequate attention, or there is a system failure and the driver thinks the ADS has taken responsibility when it hasn't (see Fig. 8). Regardless of whether the deactivation is caused by a vehicle side failure or the driver initiating the change without processing everything entirely, the resulting situation is that neither the driver nor the ADS is taking control of the vehicle.

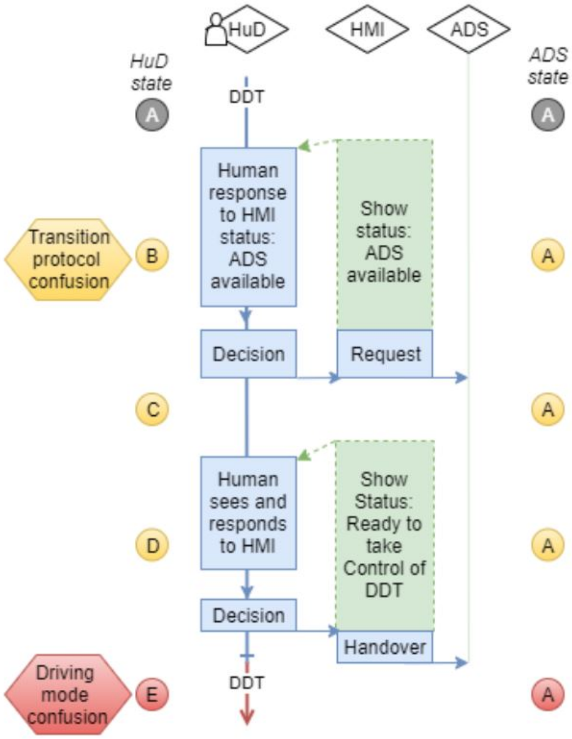

Fig. 8. Mode Confusion where the Human Driver (HuD) is expecting the ADS to have responsibility when it was never prepared to do so. (Note: HuD and ADS States refer to the Transition Protocol image in Fig. 4)

Another instance is precipitated by being stuck in transition. The driver thinks they have retaken control from the vehicle, when in fact, they have not. While this situation is less problematic as there is technically still a party in control of the vehicle, and thus would result in a lower ASIL score, it is still an interaction to be avoided. This could still be a quite critical situation depending on how the driver reacts. If the driver attempts to take control from the ADS once they realize they are not actually in control and the HMI or the protocol do not allow for quick easy resumption of control.

One interesting compounding element to the risk is that the state of mode confusion could potentially last for some time before it is realized and corrected, as mentioned above. While this affords a larger window for identifying the issue and communicating it to the driver, it also means that when a safety critical situation does arise, the driver may not be able to fully comprehend what is happening, attributing the control of the DDT to the automation system.

When it is necessary for a driver to respond in a timely manner, such as when regaining control from an autonomous driving system, the situation can become quite critical if there has been mode confusion for any significant amount of time, which may lead to an marked increase in ASIL level. It's also worth noting that even in conditions where driver's are prompted to be wary of mode confusion, it can take a significant amount of time to respond [8], and when it does happen, mode confusion would only make this more critical. Regardless of how mode confusion might get triggered, or what events precipitate it, once we hit this critical time threshold, we are going to be looking at high Severity scores with very little Controllability. In fact, there is very little that can be done in these critical situations, which is why HMI designers should work effectively with functional safety experts to assure safe transitions and ensure adequate Controllability in the lead up events to prevent this situation from ever coming to pass.

IV. Ensuring Safe Transitions

While the aim of this paper is not to provide the reader with prepackaged solutions, it is still beneficial to provide some ground level recommendations. There are certain things that will, at a minimum, help to ensure a safe transition of control between manual driver and the ADS. In order to do that, transfer of responsibility for the Dynamic Driving Task (DDT) should only occur if the following conditions are fulfilled at the very least:

1) Both the driver and the ADS must consent to, accept, and communicate their acceptance of, the transfer to avoid unfair transitions
2) The recipient (driver or ADS) must be capable of safe operation in the current DDT to avoid unfair transitions
3) The non-responsible party (driver or ADS) must not affect vehicle motion outside the constraints set by the DDT-responsible party (ADS or driver) to minimize the chance of Mode Confusion
4) Transition sequence shall not affect the capability of the responsible party (driver or ADS) to drive safely thus avoiding a stuck in transition situation where neither party has control.

The first two points above introduce a procedure for handover to minimize the chance of unfair transitions. This means that the current responsible (driver or ADS) stays responsible until there is an agreement for a handover to a capable recipient. This also implies that both the driver and the ADS need to explicitly agree, and confirm, via HMI, that a transition is possible and fair to perform. Furthermore, it implies that both the driver and the ADS are aware of what has been agreed. Thus limiting the possible need for the driver or the ADS to forcibly override the other, as they have clearly agreed on a course of action. If done properly, this will also help to avoid confusion, as any failures to agree on which party is control and bears responsibility for the vehicle would lead to a fallback returning control to the party in charge before the request was initiated.

Mode confusion, as mentioned in the third point, can be addressed by combining the safe handover procedure described above with mechanisms that handle interference from the part which is not in charge, i.e., override. Regardless of whether the driver or the ADS is responsible, inhibiting the influence of the non-responsible party can ensure clear division indicating which party is, in fact, in charge of the vehicles actions.

The fourth point addressing stuck in transition can be handled similarly to the third point, in which a mechanism that clearly defines who is in charge at a given moment should be able to avoid the situation where an incomplete transition leads to an erroneous and high risk state.

If these can be covered, then there will be at least some basic assurance that the interactions to avoid have been addressed in an effort to make the transition safer.

A. How to handle specific situations

As the focus here is trying to understand how to ensure safety, doing the bare minimum is hardly an acceptable stopping point for the discussion. There are some other generic HMI solutions that should be at least considered.

When reviewing unfair transitions for an example of how these conditions might be fulfilled in a practical sense, the potential role of the HMI designer in helping to find a safe solution that meets the safety goals set out by functional safety procedures would likely be to help develop something that includes:

- confirming action between the driver and the ADS (i.e. a button press, a telltale) is required in order to avoid initiating this transition in the first place (exposure) **O**R
- if this transition has already begun, there is a way for the receiving party to delay or decline the transition until the current maneuver is finished (Controllability) **O**R
- there is a way for the receiving party to be informed enough about the maneuver before the transition, or during the early moments of the transition, so that they can complete the maneuver as the other party intended (Controllability)

With each of these options, a step has been added to the handover protocol, which would effectively result in creating a redundancy or introducing an element that can help avoid an unfair transition. The additional step(s) would have an element, such as a software or hardware component, with an associated ASIL value, which would consequently lower the likelihood of faulty assignment of responsibility for the driving task. The idea here is that instead of having a single point of failure, there are multiple points where failure can occur, and that if only one of the multiple points have failed, the system can still be considered as safe.

If more than just one of these options were put into place, we could see how if any of the chosen safeguards were to fail, there would still be multiple fallback procedures in place to make sure that the transition did not fail entirely, thus assuring that each step is of lower consequence, earning a lower ASIL.

These are the kinds of procedures and logic an HMI designer will need to adopt, or at least understand, in order to ensure that there is successful comprehension, and implementation, guaranteeing functional safety.

V. Discussion

As mentioned before, the main goal of this paper is not to supply the reader with a battery of predetermined solutions. It is meant to introduce the reader to some of the functional safety concepts that they will be encountering in their work when ISO 26262 compliance needs to be considered.

There are plenty of articles and sources that the reader can explore further. The Adaptive Project [9] has produced an interesting document providing a Human Factors Recommendations catalogue that covers some of the key moments outlined in this paper such as Automation Availability, Status, Change in Automation Function, and Accidental De/Activation. The earlier papers from this series [4], [5] also present more solutions, albeit from a more functional safety stance.

Another important point that needs to be mentioned is that some of the things that most HMI designers are trained to value highly (i.e. minimalistic design) are not inherently valued by functional safety. Aesthetics and user satisfaction are not the concern of safety. ISO 9241 outlines three main factors for usability: efficiency, effectiveness, and satisfaction [10], [11]. So both functional safety and HMI design share common ground on efficiency and effectiveness, but there will likely be lack of alignment on satisfaction. Fig. 9 visualizes how efficiency, effectiveness, satisfaction, and safety all overlap, and ideal solutions will be found in the sweet spot in the center. Functional safety experts will gravitate towards safety, and HMI design will always pull towards satisfaction, but it is important to always seek that sweet spot, which will often be quite difficult to find.

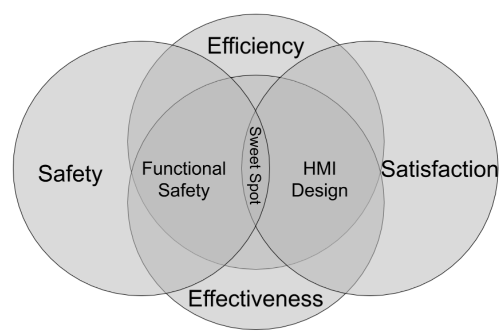

Fig. 9. Areas of Concern

VI. Conclusion

Now that the reader has gained more insight to functional safety, it will be easier to find that sweet spot that creates a safe and enjoyable transition for human drivers when interacting with Automated Driving Systems. In writing this abridged practical introduction to designing safer interactions in line with ISO 26262, the aim is to give HMI designers a dialogue tool set for communicating with functional safety experts, making communication between the two easier, and making progress towards safe solutions more efficient. The key takeaways are:

- functional safety will play a significant role in any HMI designs dealing with transitions of Level 4 Automation in cars moving forward.
- There are some basics to functional safety that the reader is now armed with to help make communication easier in the future.
- It should be clearer how to create an HMI design or protocol that will be acceptable to functional safety experts.
- It should be easier to identify when and where compromise can be made to produce the best, and safest, solution.

By bridging the gap between these two disciplines, it will be easier to correctly identify all the components of safety critical events and produce effective interactions, achieving safe transitions between the driver and the ADS for a Level 4-equipped vehicle.

References

[1] C. Martinie, P. Palanque, and M. Ragosta, "Some issues with interaction design and implementation in the context of autonomous interactive critical systems." in *In Workshop on End-user Interactions with Intelligent and Autonomous Systems*, ACM SIGCHI Conference on Human Factors in Computing Systems, May 2012.

[2] E. Palmer, "Oops, it didn't arm-a case study of two automation surprises." in *In Proceedings of the Eighth International Symposium on Aviation Psychology*, 1995, pp. pp. 227–232.

[3] L. Bainbridge, "Ironies of automation." in *In Analysis, design and evaluation of man–machine systems*. Pergamon, 1983, pp. pp. 129–135.

[4] R. Johansson, J. Nilsson, and M. Kaalhus, "Safe transitions of responsibility in highly automated driving." *The Ninth International Conference on Dependability (DEPEND 2016)*, 2016.

[5] R. Johansson, J. Nilsson, and A. Larsson, "Safe transitions between a driver and an automated driving system," *International Journal on Advances in Systems and Measurements*, vol. 10, no. 3-4, 2017.

[6] SAE, "SAE J3016:201806 - SURFACE VEHICLE RECOMMENDED PRACTICE - Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles," 2018.

[7] ISO, "ISO 26262:2018 Road vehicles – Functional safety," 2018.

[8] A. Eriksson and N. A. Stanton, "Takeover time in highly automated vehicles: noncritical transitions to and from manual control." *Human Factors*, vol. 59, no. 4, pp. 689–705, 2017.

[9] J. Kelsch, M. Dziennus, A. Schieben, N. Schömig, K. Wiedemann, N. Merat, T. Louw, R. Madigan, G. Kountouriotis, M. L. A. abd Mikael Söderman, and E. Johansson, "Deliverable d3.3 // final functional human factors recommendations," 2017. [Online]. Available: http://www.adaptive-ip.eu/index.php/deliverables_papers.html

[10] ISO, "ISO 9241-11:1998 Ergonomic Requirements for office work with visual display terminals (VDTs) – Part 11:Guidance on Usability," 1998.

[11] C. Fayollas, C. Martinie, P. Palanque, Y. Deleris, J.-C. Fabre, and D. Navarre, "An approach for assessing the impact of dependability on usability: application to interactive cockpits." *2014 Tenth European Dependable Computing Conference*, pp. pp. 198–209, 2014.