Luxoft
A DXC Technology Company

See it, hear it, feel it:

How driving assistants grab your attention

Part of the
'Automotive trends: Intelligent driving assistants'
white paper series

by **Barbara Metternich-Heider,** Strategic Development Manager, UXD Solutions
Andreas Mütsch, Senior Software Developer / Technical Writer

When you're in your car, you never drive alone: Modern cars are equipped with a variety of assistance systems whose feedback to the driver has soared over the years. While this feedback is meant to be helpful and can even save lives, creating pleasant and unobtrusive systems is a big challenge. In this white paper, we'll look at some well-established assistance systems to explore their different kinds of feedback.

Attention-seeking assistants

Over the past decades, more and more electronic helpers in the form of assistance systems have become our co-drivers. Today, modern cars are packed with digital assistants; while some of them work silently in the background, others fight for the attention of the driver.

To get the driver's attention, three main feedback methods are on offer: **Visual, acoustic and haptic.** In this white paper we discuss the advantages and disadvantages of each.

A brief history **of assistant systems**

Assistance systems in cars have a long history. Let's have a quick look at some major milestones.

Braking assistants

The early 1970's saw the appearance of the first assistant: The anti-lock braking system (ABS). It wasn't until 1985 that ABS became widely available however, with the Ford Scorpio being the first car shipped with it as a standard feature. The driver feedback when ABS interferes was — and still is — a pulsating brake pedal combined with a blinking light in the cluster display.

Soon more functions were added: Traction control system (TCS) and electronic stability control (ESC) extended the basic ABS in the late 1980's and early 1990's. With the appearance of adaptive cruise control (ACC) — an extension of the long-established simple cruise control — and automatic emergency braking (AEB), the new millennium brought more assistants with wider influence, as they now controlled vehicle speed during normal driving.

Getting to grips with the steering wheel

In the last decade, assistants also began to help with steering: Lane keeping assistance systems (LKAS), collision avoidance systems (CAS) and park assists are now able to take over the steering wheel in our cars and can override the throttle and brakes.

More information while driving

Let's not forget the various systems that provide additional information to the driver: For example, **an intelligent speed assistance (ISA) system** informs you when you exceed the speed limit; navigation systems tell you which route you should take; sign recognition supports you by displaying recognized street signs; and eco assistance suggests gear changes and environmental-friendly driving behavior. And this is just the beginning of the list.

Evolution of displays

While these systems have evolved, so have the displays in cars — the classic dashboard with a simple speedometer and some dedicated light bulbs used as indications for vital electric functions is long gone. Then, more advanced instrument panels — referred to as instrument clusters (ICs) — combined classic gauges with small dot matrix displays used to show a variety of information, warnings and errors depending on the current situation. The displays grew bigger and finally took over the presentation of the gauges, ending up with one big display behind the steering wheel or even pillar to pillar. But development doesn't stop here. **Current and future digital cockpits** combine several displays in the car for a fully immersive information and entertainment experience.

Ingredients for good system design

All these assistants in your car want to show and tell you information and give visual, acoustic or haptic feedback if they interfere. This presents system designers with a bunch of questions. The most important are:

- **Which feedback method to choose for a specific assistant?**

  Are there brand-, culture- or market-specific settings to be taken into account?

- **How to handle priority?**

  Which assistant comes first in a concurrent situation?

- **Should information be filtered to not overwhelm the driver?**

  If so, how to decide if certain specific information should be delivered to the driver or not?

The following chapters examine each of the three basic feedback principles. This will enable you to find the best answer to these questions for your specific task. In a later post we will show you an example implementation of a user experience (UX) design for the ISA use case.

See it: **Visual feedback**

The first option that comes to mind is to use optical feedback, as this is the most common type. With a modern digital cockpit, the possibilities for optical feedback are endless. The following options are the ones you will find in all modern cars.

Dedicated icons

For simple feedback, a single icon might be the solution. You can use it in different ways:

- On/off indication (e.g., “ESP off”, “A/C on”)
- Active indication (e.g., “High-beam active”, “ABS regulating”)
- Warning indication (e.g., “Low temperature outside”)
- Malfunction indication (e.g., “Oil pressure too low”)

The symbol can just light up, imitating light bulb indications that were used in ancient dashboards. Icons on displays can be made visible or they can change color. A periodical color change can simulate a blinking signal, for example indicator arrows or system malfunctions.

In summary, while a single icon only takes a small space on the dashboard and many symbols are well-known (battery, ESP, snowflake) or, even better, standardized (e.g., “On/Off” ISO 2575), there is a danger of turning the dashboard into a ‘Christmas tree’ without offering a real benefit. It’s true that the whole functionality of a car can be presented with a myriad of icons, but as the number of icons increases, the presented information overwhelms the driver and vital information can be missed. Icons may also be misinterpreted or not recognized. Finally, an icon may not suffice: Additional numbers or texts are sometimes necessary, often in different lengths.

Textual indications

Warnings and errors might need a little extra explanation. This leads to our second visual option — the display of texts. Error messages and warnings, especially as pop-ups, are common use-cases. Infotainment and navigation heavily depend on the display of texts for lists and menu options of all kinds.

Texts may be more expressive and not as ambiguous or cryptic as single icons, but they use more space. Users also need more time and mental capacity to read them. Long texts might distract the driver and a translation might be needed for foreign markets.

Shared icons

Some carmakers display more than one icon in the same position on a screen. With shared icons you can save space on the dashboard, but you lose the familiarity of icon position. For example, in the same display position a car might indicate 'lane assist intervention' while driving and 'active automatic brake' when standing still — this leads to driver confusion.

Dedicated areas

A part of the display that is reserved for one functionality is ideal for elements that the user expects to always be available, like the speedometer or the charge level. You can allow the user to rearrange those elements with personalization of the display, but this adds to the (already numerous) settings.

With dedicated areas you can create a classic look by imitating classical dashboard elements. Sophisticated graphical elements like gauges can display whole sets of information at once. There's even the possibility of using size according to importance of information. For example, the speedometer can be shown with a larger gauge than the oil temperature. However, graphical elements use up precious space and may distract the driver if used for secondary information. For example, do you really need to be informed about the cross acceleration all the time?

Shared areas

A shared area is a good alternative to the dedicated area. Information can be swapped when needed. This way, the look-and-feel of the dashboard can be maintained and secondary information can be hidden temporarily, thus saving space. On the other hand, switching the elements can make the display look restless and noisy and therefore distracting. Changing the information too often distracts the driver.

Pop-ups

Displays in cluster instruments allow the use of pop-ups for urgent messages and information. Users are already familiar with the concept of pop-up messages from their phones and home computers. Warnings and error messages that require immediate actions are best presented as pop-ups, but be careful not to overdo it. Also, avoid shadowing out vital information like current speed, etc.

Common issues of optical feedback

Distraction

Bear in mind that for all optical feedback, drivers have to take their eyes off the road to look at the display. This may not be true for head-up displays (HUDs), but HUDs interfere with the outer-world vision. Information presented in HUDs has to be handled in a way so that the driver can still see the road ahead and recognize the real-world traffic situation.

The challenge is to offer the driver enough information without producing a visual and mental overload.

Priority handling

As soon as more than one element shares some space on the display, the question of priority arises. If two things should be shown at the same time, which one wins? Only priority handling can decide this. Thus, well-designed priority handling is essential for modern digital cockpits. Ideally, the priority handling is defined during the requirements phase, so that it can be tested and refined along with the development of the system.

Hear it: **Acoustic feedback**

The second feedback option is also long-established and well known: Audible feedback (referred to in the ISA regulation and hereafter as 'acoustic feedback').

For decades, drivers got acoustic feedback mainly from indicators, with their characteristic clicking sound. This acoustic feedback was incidentally produced when the first flashing indicator was introduced on a Buick in 1938. The sound originated from the mechanical bend and re-bounce of a bimetallic spring that was used to open and close the electric current for the flashing light. Nowadays the clicking sound is electronically generated and the sound is played using a small loudspeaker inside the dashboard or via the car's sound system.

The use of loudspeakers in the car opened up a whole new world of acoustic feedback. Now we can use any kind of sound including spoken announcements.

Beeps, buzzes and clicks

The cheapest solution to providing acoustic feedback was to integrate a small piezoelectric speaker into the dashboard. These little devices are able to produce simple sounds in various frequencies — they're ideal for generating the clicks of an indicator, acting as keypress sounds or as alarm beeps. They're widely used in clocks, phones and other technical devices.

Piezoelectric buzzers are cheap, small, robust and easy to operate. Because of their poor sound quality, they are mainly used for simple tones. A drawback is that their poor sound suggests cheap overall product quality.

Simple sound effects like these are often used to support the pop-up of a warning or error message.

High-quality sounds

Using the sound system of the car with its superior sound quality is the better option for acoustic feedback. Specially composed high-quality sounds create a brand-specific acoustic experience. However, using the sound system that is meant primarily for the infotainment system requires the integration of the system sounds into the source management of the infotainment. Having the car as an additional sound source makes the system design more complicated.

It's true that there are no extra hardware costs if a sound system is already fitted, but the integration of the car as an additional sound source creates extra development costs. Due to their better sound quality and dynamics, they are often used to generate a brand-specific acoustic feeling.

Spoken announcements

When the integration into the infotainment source management is established, the next logical step is to use spoken announcements instead of simple sounds. This way, the message is presented in a clear and concise way. However, don't underestimate the effort it takes to support messages in different languages. Translated versions of all the system messages have to be prepared and selected according to the language the user has chosen in the settings, even when it's changed during runtime. Using a text-to-speech engine may reduce development costs, but it often comes at the cost of reduced speech quality and the feeling of an inferior product quality. Sampled texts from professional speakers sound more natural — the acceptance of such systems is higher.

Systems that use spoken announcements can be greatly improved when keeping one recommendation in mind: Offer specific instructions to the driver. The driver should not only be informed about a certain situation (e.g., "It is +1° C outside", "The oil pressure is low"), but also get a hint of what this means and what he should do now (e.g., "Drive carefully, danger of black ice!", "Stop the car and call for assistance!"). Taking this into account will add value for the user.

Spoken announcements are a double-edged sword as they can be used to provide precise feedback; and they are highly accepted by users as they already know them from digital assistants on phones and smart speakers, but there are drawbacks; translations are necessary and language switching takes time. Moreover, long texts block the audio channel for a long time and spoken announcements bring more development efforts — announcements need to be precise, clear and understandable.

Common issues with acoustic feedback

Orientation reaction

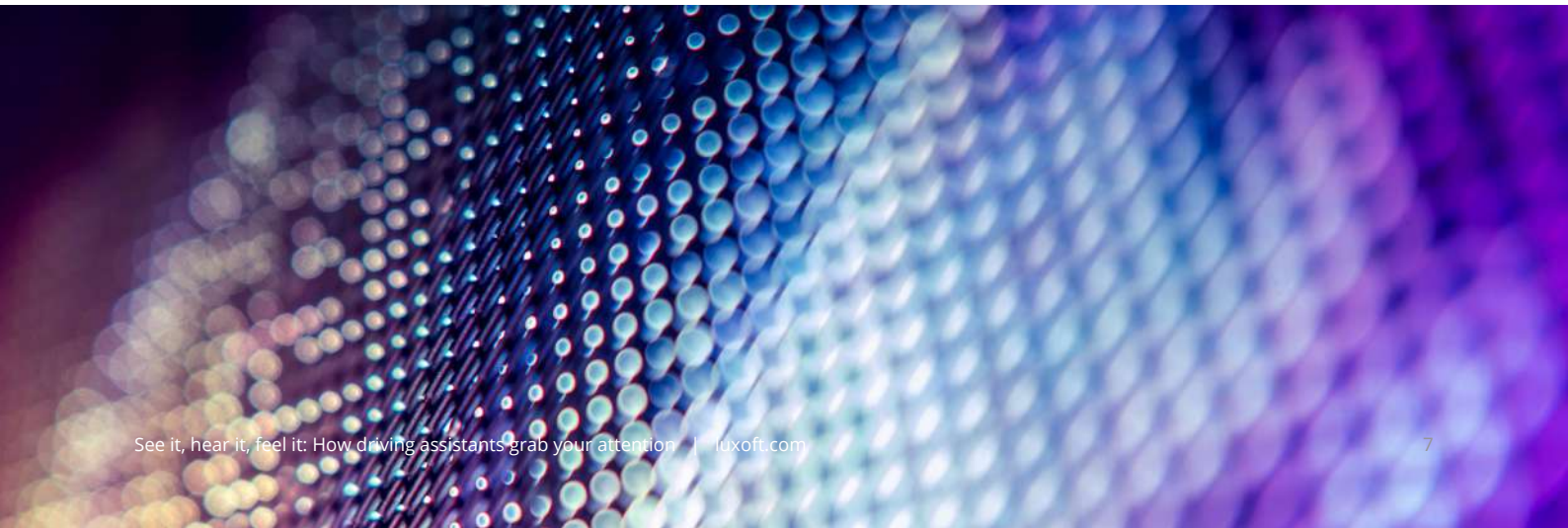
Sounds and other acoustic feedback trigger a psychological reaction known as 'orienting response'. This means that when drivers hear a sound, their attention is drawn to the sound — and therefore away from what they were concentrating on before. This might lead to situations where drivers are not in full control of their vehicles anymore. The effect can be minimized with careful creation of the sounds and spoken announcements. For example, a soothing intro sound before an announcement produces less distraction than a sudden yell from the loudspeakers. Systems can also reflect the urgency of a message by adapting the speaker volume accordingly (e.g., by presenting low-priority information in another voice and with a lower volume than critical warnings).

Acoustic overload

It's easy to overdo it with sounds. Adding more and more audible information soon leads to an acoustic overload, in the case of acoustic feedback, less is more.

Priority handling

As with the visual feedback, priority must be handled if two or more sources want to use the audio channel at the same time.



Feel it: **Haptic feedback**

Haptic feedback is only possible with equipment that is in direct or indirect contact with the driver. The obvious options for direct contact are the pedals, the steering wheel and the seat.

Pedals

The first haptic feedback was merely a necessity; when ABS actively controls the pressure in the brake system, the driver feels the pressure-changes as a pulsating in the brake pedal.

With the arrival of new assistants, the pedals' behavior was also deliberately altered to give additional feedback. The pedals can alert the driver with a single stronger pulse, or the accelerator can be made stiffer to warn about speed limits.

Pedals are a long-established feedback channel (ABS), but they provide only limited possibilities of feedback. They may also be misinterpreted as mechanical malfunction.

Steering wheel

The steering wheel is also a common object to deliver haptic feedback. Lane assists often indicate optimal steering by making the steering harder to one side and lighter to the other. Collision avoidance systems sometimes alert the driver by adding a strong shaking to the steering wheel.

The steering wheel is logically connected to steering, making it ideal for driving feedback like lane keeping. But there is also the possibility that steering wheel feedback might be misinterpreted as mechanical malfunction.

Seat

The biggest object that is in contact with the driver is the driving seat. Some seats already come equipped with heating and massage functions. Why not use that for haptic feedback? The problem is that the seat isn't intuitively connected to a driving function. Instead, it typically only reflects road conditions, like bumps or holes. Its main purpose is to provide a comfortable and ergonomic seating position. Automakers who use seats for haptic feedback have to create the connection to driving functions in the driver's mind. Teaching of some sort is needed to create this connection.

Common issues of haptic feedback

Guidance and acceptance

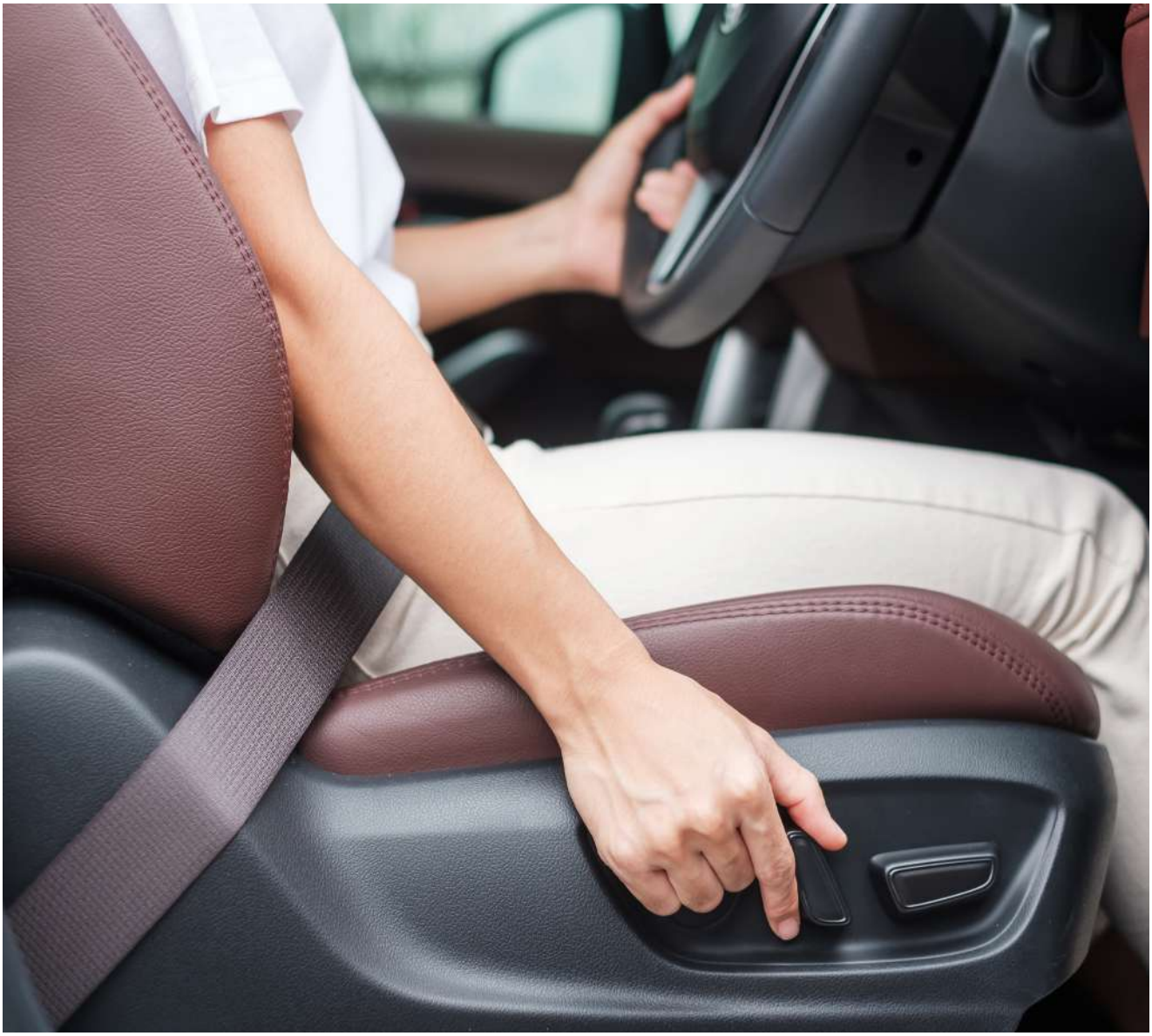
Drivers rapidly got used to the pulsating pedal of ABS. However, other haptic feedback methods, which are all relatively new, require a learning curve.

Ambiguous signals

Without guidance, haptic feedback easily becomes ambiguous. What does a sudden vibration in the steering wheel mean? Is it a hint from the lane assist, a warning from the speed assistance or a tire puncture?

Another issue is that the connection between the feedback and the situation is often not self-explanatory. For example, ISA might vibrate the seat to indicate that the speed is too high, but the seat is not directly connected to speed. Inexperienced drivers might not understand this kind of feedback. If ISA increases resistance on the accelerator pedal, users might interpret this as a mechanical malfunction.

Automakers should clearly communicate all the haptic feedback types they use.



Choose wisely: **Why UX design matters**

With all these kinds of feedback, we come back to one of the design questions: Which feedback method to choose for a specific assistant? Different designers find different answers for different users.

But before we choose a specific feedback method or even combine them, we have to examine another point — the risk of distracting drivers instead of assisting them.

Assistance or distraction?

How much attention-seeking is acceptable and when does it turn into distraction?

Attentive and fit drivers typically show a reaction time of no more than 1 second. Any distraction extends this reaction time. If this happens, the reactions path (i.e., the distance travelled during the reaction time) also rises significantly. For example, a prolonged reaction time of 3 seconds instead of 1 second while traveling at a speed of 50 km/h leads to a reaction path of 45 meters instead of 15 meters: An additional 2 seconds (or 30 meters), in which the driver is not able to react or intervene accordingly. During this time, drivers might not notice an obstacle or other road users at all. This may lead to dangerous situations or even accidents.

Distraction and inattention are estimated to be the cause of 5–25% of all traffic accidents. Therefore, it is our duty to create driving assistant solutions that reduce distraction to an absolute minimum for safer driving.

Of course, there are other factors that cause distraction and prolong reaction times, like using a mobile phone, (emotional) talks with passengers, being under the influence of alcohol and drugs or just being tired; even more reasons to drive down distraction caused by intelligent driving assistants, especially in software-defined vehicles.

Learning types

People who learn visually easily adapt to optical feedback, while people who prefer learning by hearing might be repelled by an overuse of optical feedback. If a system can overcome these obstacles by offering different ways of access, for example by combining optical and acoustic feedback, the acceptance will be significantly higher.

Age groups

Targeting a specific age group may also have an influence on the selection of feedback methods. Whereas younger generations — having grown up using smartphones — are used to multichannel input, older generations might need some time to get used to it. Additionally, the senses change over time.

Preventing confusion: **The power of standards**

With all the new possibilities, we can see a trend where each brand invents its own set of haptic feedback. A vibrating steering wheel in car A might warn about a collision, whereas in car B it might simply be a hint that the driver is about to drive too fast. So, when changing the car or using a rental car, the familiar sensory perceptions suddenly mean something completely different.

A way to reduce ambiguity is to combine two feedback methods. E.g., combining a vibration of the steering wheel with a blinking icon gives drivers an optical explanation and a reason behind what they feel.

However, using two feedback methods for one feedback increases sensory input and thus increases the risk of turning assistance into distraction. Using single, standardized feedback is much safer.

Therefore, the automotive industry should continue defining international standards to reduce driver distraction and confusion. In the past this was already possible: In every modern car the pedal order is clutch, brake, accelerator. Try to drive a 1920's Ford Model T with its clutch, reverse and brake pedal and you know immediately how important standards can be.

At Luxoft, we have recognized the importance to engage here. We actively participate in the **DIN** and **ISO** working groups defining the upcoming national and international standards. Luxoft is also member of the **Association for Standardization of Automation and Measuring Systems** (ASAM e. V.). Engagements that help us shape automotive standards and the software-defined vehicles of the future.

Next, **UX design in action**

We've seen that the possibilities of providing user feedback are endless. A common understanding of the best practices is needed. This will avoid end-user confusion when changing the car and increase the chances of user acceptance of digital assistants for safer mobility.

In another part of our series, we will have a closer look at a potential UX solution for ISA systems and how to provide feedback to the user considering the corresponding regulations.

Do you want to create a good user experience that is in line with regulations?

Our experts are happy to support you.

Get in touch.

About **the authors**

Barbara Metternich-Heider
Strategic Development Manager, UXD Solutions
linkedin.com/in/barbara-metternich-heider

Barbara is a solutions architect for User Experience at Luxoft. She's responsible for the strategic development of UXD in the Automotive line of business. Before coming to Luxoft, she worked for other renowned suppliers and Tier 1s in the automotive sector. Her expertise helps clients all over the world provide a user experience that adds value. Barbara holds a diploma in psychology and has filed patents in Europe and the US.

Andreas Mütsch
Senior Software Developer / Technical Writer
linkedin.com/in/andreas-muetsch

Andreas is a technical writer and former software developer at Luxoft. As part of the solutions team, he's responsible for the accuracy and reliability of technical articles and documentation. As a software developer, he helped to bring several generations of in-car infotainment systems to market. Andreas studied applied physics with a focus on opto-electronics and digital data processing. He's also an award-winning author of several books.

About Luxoft

Luxoft, a DXC Technology Company delivers digital advantage for software-defined organizations, leveraging domain knowledge and software engineering capabilities. We use our industry-specific expertise and extensive partnership network to engineer innovative products and services that generate value and shape the future of industries.

For more information, please visit **luxoft.com**