



**Model Series, Innovation and Technology Communications**

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**PRESS INFORMATION**

**TechDay piloted driving  
– The traffic jam pilot in the new Audi A8 –**

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Condensed information

## **The Audi AI traffic jam pilot in the new Audi A8**

**With the Audi AI traffic jam pilot, the brand with the four rings presents the world's first system that enables SAE level 3 conditional automation. The car can take over the task of driving in a traffic jam or slow moving highway traffic up to 60 km/h (37.3 mph). With traffic jam pilot engaged, drivers no longer need to continuously monitor the vehicle and the road. They must merely remain alert and capable of taking over the task of driving when the system prompts them to do so.**

The driver activates the traffic jam pilot with the AI button on the center console. On highways and multi-lane motorways with a physical barrier separating the two directions of traffic, the system takes over the driving task if the car is traveling at no more than 60 km/h (37.3 mph) in nose-to-tail traffic. The traffic jam pilot handles starting from a stop, accelerating, steering and braking in its lane. It can also handle demanding situations such as vehicles cutting in closely in front. The control signals required by the system for conditional automated driving are obtained from the central driver assistance controller (zFAS) and from a redundant data fusion in the radar control unit.

If the traffic jam pilot is activated, drivers can take their foot off the accelerator and their hands off the steering wheel. Drivers must remain alert and capable of taking over the task of driving when the system prompts them to do so. They no longer have to continuously monitor the car and can focus on another activity supported by the on-board infotainment system, depending on the legal situation in the respective country. The Audi virtual cockpit shows a stylized view of the car from the rear and blurred markings on the road that symbolize the motion and surroundings of the new A8. While traffic jam pilot is activated, a camera checks whether the driver is prepared to resume the task of steering if needed. It analyzes the position and movement of the head and eyes in order to generate anonymized data. If a driver's eyes remain closed for an extended period, for example, the system prompts the driver to resume the driving task. The prompt to take over is given in multiple stages. If the speed exceeds 60 km/h (37.3 mph) or the traffic begins to clear, the traffic jam pilot informs drivers they need resume driving themselves. If the driver ignores this prompt and the subsequent warnings, the A8 is braked until it stops completely in its lane.

Introduction of the Audi AI traffic jam pilot requires both clarity regarding the legal parameters for each individual country and specific adaptation and testing of the system. Moreover, varying worldwide homologation procedures and their deadlines must be observed. For these reasons, Audi will initiate series production of the traffic jam pilot in the new A8 incrementally, depending on the legal situation in the respective country.



The system in detail

## **Automated driving at a new level: the Audi AI traffic jam pilot**

The new A8 is the world's first production automobile to have been developed specially for Level 3 automated driving. The Audi AI traffic jam pilot takes charge of driving in slow-moving traffic at up to 60 km/h (37.3 mph) on highways and multi-lane roads where a physical barrier separates the two carriageways. Because traffic jam pilot is capable of handling the full driving task – acceleration, steering and braking – when certain conditions are met, drivers can take their hands off the steering wheel until the car requires manual driver control again. This takeover request occurs before the system nears the limits of its capabilities. Behind the traffic jam pilot are innovative technologies from Audi, including the new sensor set with a laser scanner and the central driver assistance controller (zFAS). The legal situation is decisive for the introduction of the system. In many countries the legal framework is not yet sufficient for this, so Audi will introduce traffic jam pilot into volume production of the A8 incrementally, as allowed.

### **The function**

Certain ambient conditions must be met for Audi AI traffic jam pilot to engage:

- The A8 is on a highway or a multi-lane road with barrier between oncoming lanes and a structure along the edge like guard rails.
- Slow-moving nose-to-tail traffic predominates in all neighboring lanes.
- The vehicle's own speed must not exceed 60 km/h (*37.3 mph*).
- No traffic lights or pedestrians may be present within the relevant viewing range of the vehicle's sensors.

If these conditions are met, the driver sees a visual cue that the system is available: first, the Audi AI button on the console of the center tunnel lights up in white. Next, a text message appears in the Audi virtual cockpit along with a pulsating white strip of light on its left and right edge. The AI icon in the digital instrument cluster also lights up in white.



Once the driver has activated the traffic jam pilot by pressing the AI button, it lights up in green. The Audi virtual cockpit shows a stylized view of the car from the rear and blurred markings on the road. The vehicle's own speed appears digitally and in the form of a band on the bottom edge of the digital instrument cluster. Green edge lighting and the green AI icon symbolize the function.



While active, the Audi AI traffic jam pilot guides the new A8 within its own lane. The system manages starting from a stop, accelerating, steering and braking – the driver can relax. In this defined situation, the driver can take their foot off the accelerator and their hands off the steering wheel for longer periods and, in compliance with the applicable national regulations, can turn to other activities supported by the on-board infotainment system. In Germany, for example, drivers have the option of watching TV programs and DVDs on the 10.1-inch display in the center console and can use the Audi connect service to its fullest. They can turn their attention from the traffic and the car's steering to do things like answer their email, write text messages, tend their appointment calendar, read the news, or plan for their vacation.



Thanks to its extensive sensor sets, the traffic jam pilot masters even demanding situations like vehicles cutting in closely in front. If the system detects an obstacle in front of the car, the A8 will avoid it if there is enough room within its lane to do so. Otherwise, it brakes the car to a standstill.

The driving style of the traffic jam pilot is consistent and cooperative. During development of the system, special focus was placed on safety and comfort. Trials with numerous test subjects consistently led to the same result: people who use the traffic jam pilot quickly come to appreciate it. In traffic situations where driving is not much fun, it lets the driver relax and be chauffeured. No value is placed on hectic lane changes. In fact, the system is not even designed for that: as soon as the driver sets the turn signal, the traffic jam pilot responds by prompting the driver to take over. The on-board monitor turns off the picture and the infotainment system lowers the volume. The driver indicates taking over the driving task by grasping the steering wheel, for example, which is detected by a capacity sensor. The steering torque sensor, gas pedal and brake pedal likewise register activity.

#### **Ready to take over? Driver readiness detection**

The A8 is equipped with driver readiness detection. While the traffic jam pilot is activated, it checks whether the driver is ready to retake the wheel. The system uses the camera installed in the top of the instrument panel. It analyzes various criteria, including the position and movement of the head as well as monitoring the eyes. If the driver's eyes remain closed for a long period, for example, the system prompts the driver to prepare to resume driving. Activities not supported by on-board equipment, such as reading a newspaper, are generally not allowed. The camera's view of the driver's head becomes obstructed in this case, the system will prompt the driver to take over.

The technical indicators generated by the image analysis software are anonymized, do not allow the face of the driver to be reconstructed and cannot be matched with any individual person. The data is processed locally within the car. The camera's images are not saved and there is no automatic transmission of data to AUDI AG or other third parties.

#### **Three phases: the prompt to take over**

When the traffic jam pilot prompts the driver to take over the driving task, the driver has about 10 seconds to respond, depending on the situation. In phase 1, a red light pulsates on the edge of the Audi virtual cockpit, the AI icon in the digital instrument cluster and the LED on the Audi AI button also light up in red, and a subtle warning signal sounds.

If the driver ignores this first prompt, this is followed by phase 2 – the “acute” warning. The warning signal becomes more distinct, the audio volume is lowered, and the text “Traffic jam pilot: ending. Please resume full control of the vehicle!” appears in the Audi virtual cockpit. At the same time, the A8 slows down, gently at first and then with a jolt, and the driver feels the safety belt tighten slightly three times.



If the driver remains passive, due perhaps to a health issue, the final phase – emergency intervention – initiates. The warning signal becomes piercing, the safety belt is fully tightened. The A8 slows in its lane to a standstill and at the same time switches on the hazard lights. Once the sedan has come to a complete stop, the system activates the parking brake, shifts the tiptronic to its P setting, unlocks the doors, switches on the interior light, and then sends an emergency call via the mobile network if no response from the driver can be detected. This type of emergency stop in slow-moving traffic makes sense because it prevents the A8 from moving forward uncontrollably.

In trials with test subjects at Audi, most drivers responded during the first phase of the prompt to take over. The traffic jam pilot remains on standby until the driver switches it off with the Audi AI button. If the conditions are right for using it again, the system indicates its availability in the Audi virtual cockpit. The driver then merely needs to take their hands from the steering wheel to activate the traffic jam pilot.

While traffic jam pilot is activated, the speed of the Audi A8 is limited to 60 km/h (37.3 mph). If the traffic begins to clear and the vehicles ahead accelerate, the system remains active a few more seconds after a prompt to take over, until the driver has resumed driving.



## **The technology**

### **Comprehensively connected: the sensors in the new Audi A8**

The basic requirement for use of the traffic jam pilot in the Audi A8 is the highly detailed collection of data about the environment surrounding the car. The flagship car accomplishes this with a new complete set of sensors:

- twelve ultrasonic sensors on the front, sides and rear,
- four 360 degree cameras on the front, rear and exterior mirrors,
- one front camera on the top edge of the windscreen,
- four mid-range radar sensors at the vehicle's corners,
- one long-range radar sensor on the front,
- one laser scanner on the front,
- driver observation camera in the top of the instrument panel.

### **High-tech data center: the central driver assistance controller (zFAS)**

Data from the laser scanner and all other systems are combined in the central driver assistance controller known as zFAS. The roughly tablet-sized computer continuously monitors the signals to create an image of the car's surroundings. In sum, the control unit has more power than all of the systems in the previous model of the A8. The sensor data is read into the "fusion" layer in the zFAS unit and combined into a sophisticated environment model. To further increase safety during piloted driving, Audi has given the system a redundant design that uses a second data fusion taking place in the control unit of the long-range radar. Data from the other sensors is also processed here.

## **The legal situation**

Introduction of the Audi AI traffic jam pilot requires both clarity regarding the legal parameters for each country and specific adaptation and testing of the system. Moreover, varying worldwide homologation procedures and their deadlines must be observed. For these reasons, Audi will initiate series production of the traffic jam pilot in the new A8 incrementally.

### **A question of responsibility: the levels of automation**

In the classification of automated driving, the responsible bodies in Europe and the United States – for example, the German Federal Highway Research Institute and the SAE Institute – have agreed on six levels.



- **Level 0 – No Automation:** The driver is continuously responsible for longitudinal and lateral control.
- **Level 1 – Driver Assistance:** The system is able to take over either continual longitudinal or lateral control of the vehicle. The driver is supported by the system but remains responsible. The driver must be ready to take over the driving task immediately when needed. An example of a level 1 system of this type at Audi is the adaptive cruise control (ACC) system.
- **Level 2 – Partial Automation:** In certain situations, the driver can delegate continuous combined longitudinal and lateral control of the vehicle to the system but retains the monitoring and overriding function at all times. The driver therefore always maintains responsibility. An example is the traffic jam assist from Audi. It assumes the tasks of braking and accelerating the car in slow-moving traffic up to 65 km/h (40.4 mph), and also takes charge of steering on better roads.
- **Level 3 – Conditional Automation:** The driver no longer has to continuously monitor and can carry out other activities supported by on-board equipment. The system autonomously recognizes its own limits – that is, the point at which the ambient conditions no longer match the range of functions of the system. In these cases, the vehicle prompts the driver several seconds in advance to take over the task of driving. The new traffic jam pilot from Audi fulfills these criteria.
- **Level 4 – High Automation:** Systems with Level 4 function do not require drivers to assist or take over the driving but their function is limited to a specific area – such as on highways or in a parking garage. In these situations, the driver can completely transfer the task of driving to the system. The driver only needs to resume the task when the car leaves the area defined for fully automated driving. Future scenarios such as robot taxis in city centers are another example of such a system. They take over all driving tasks within a restricted speed range and on a limited route.
- **Level 5 – Full Automation:** The car assumes complete longitudinal and lateral control. Level 5 systems do not need help from the driver in any situation.



### **The legal parameters: registration laws and regulations**

The introduction of the traffic jam pilot is subject to varying legal parameters worldwide. Many legislators are currently dealing with the issue. They want to create regulations for automated and autonomous systems or appropriately adapt existing provisions. This applies both to laws governing approvals and to regulatory laws regarding conduct. The former govern the technical requirements for the piloted system the car manufacturer must fulfill in order to obtain approval of the system in a particular country. Regulatory laws regarding conduct or road traffic laws, on the other hand, govern the use of the system by the driver and the driver's conduct on public roads.

The required conditions for approving the traffic jam pilot are currently being revised in many countries around the world. Audi expects to obtain the required authorizations for the use of the traffic jam pilot successively and for individual countries.

Lawmakers are also actively working on road traffic laws and support the introduction of automated driving functions. The government in Germany, for instance, modified the regulations in late June 2017 to allow driving cars with conditional and fully automated functions "within the designated parameters for use." Audi hopes that other countries will follow in the next few months.

### **Data logging: liability in an accident**

In the case of an accident in automated driving mode, it must be determined who was carrying out the task of driving when the accident occurred – the driver or the system. In Germany, for example, the car insurance company is initially liable to the other party in the accident. In the second step, the insurance company would then – as it is the case today – hold the manufacturer liable, provided that a product defect of the car, or of the system, led to the damage.

In an A8 with Audi AI traffic jam pilot, the data memory for automated driving (DAF) documents who is performing the driving task. When the traffic jam pilot is activated, this legally mandated data logger registers the handover between the driver and car as well as the prompts to take over. As required by law, the information is stored in the memory for six months. The DAF parallelly records various indicators from situations in which contact with other vehicles almost or actually occurs, or in which certain acceleration thresholds are exceeded. An event of this type can include an airbag deployment or automatic emergency braking, for example. The indicators are continuously recorded in the control unit. These do not permit the identification of persons or vehicles, such as faces or license plates. When the ignition is switched off, the data is deleted.



In the case of a collision, the DAF permanently saves the data packet from the last few seconds prior to the accident. The following criteria are stored here:

- Driver interaction (e.g. braking by the driver or steering angle)
- Status of the traffic jam pilot function (e.g. “traffic jam pilot was activated”)
- Vehicle dynamics (e.g. longitudinal and lateral acceleration)
- Environment (e.g. sensor information)
- When the traffic jam pilot is activated: readiness of the driver to take over (e.g. “the anonymized input data of the camera indicate that the driver was ready to take over”)

Data packets of an accident that have already been saved cannot be overwritten but those of automatic emergency braking can. If existing memory capacities are full and another accident or another event that triggers data recording occurs, the oldest data packet that can be overwritten is always replaced by the new data packet.

Processing and storage of the information described above is carried out locally in the car. There is no automatic transmission to AUDI AG or another third party, such as through the Cloud. Control over the data lies with the owner or driver. AUDI AG has no access to it.



Interview

## **A conversation with traffic jam researcher Prof. Michael Schreckenberg**

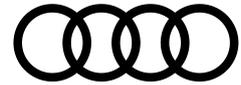
Michael Schreckenberg, professor at the University of Duisburg-Essen, is one of Germany's most highly respected traffic researchers. His area of expertise is the modeling, simulation and optimization of transport systems in large networks, especially in road transport. The Nagel-Schreckenberg model, which he formulated in 1992 with his colleague Kai Nagel, explained for the first time the "traffic jam out of nowhere."

***Prof. Schreckenberg, in 2016 the German automobile club ADAC counted 1.3 million kilometers (807,783 mi) of traffic jams. How much economic damage resulted from this and what does the international situation look like?***

*Michael Schreckenberg: If we consider only the sum of the earnings that drivers missed out on due to traffic jams, it adds up to at least EUR 14 billion in Germany. A four kilometer (2.5 mi) traffic jam over three hours on a two-lane highway causes an estimated EUR 100,000 in economic damage. In an international context, the costs for lost time are lower in many countries, but this is then correlated with the cost of living.*

***What were the most common causes of traffic jams?***

*Michael Schreckenberg: In Germany, obstructions caused by road construction increased significantly in 2016, particularly due to bridge rehabilitation measures that had been put off for a long time. Construction sites caused traffic congestion in 20 percent of the cases; accidents were the cause in 15 percent. About 13 percent of the jams were caused by human error and 2 percent were caused by weather events like storms, heavy rain and fog. The biggest share, however, – about 50 percent – can be traced to exceeding the capacity of the road. The causes are also interlinked, of course. The data in the United States are comparable, whereas traffic jams occur much more frequently due to overloading road capacities in China. The same applies to Brazil. In the capital city of Sao Paulo, the biggest traffic jam of all time – 344 kilometers (213.8 mi) long – occurred a few days before the opening match of the FIFA World Cup on May 23, 2014.*



***How does the “traffic jam out of nowhere” form?***

*Michael Schreckenberg: In our model we showed that chance plays a part in every traffic jam. There are numerous disrupting factors, most of which result from human error. Time and again, individual persons trigger the jams. This is often the case when drivers in heavy traffic brake more sharply than the car in front of them because they didn't maintain enough distance.*

*Another factor is lane changes in a jam that has already formed. This also triggers new waves of congestion that the drivers who cause them do not even notice. Drivers are much more likely to notice cars that are passing them than they are to notice the cars they themselves have passed. After all, they constantly see the former in front of them in a jam. And for this reason, many people think they are in the wrong lane. In reality, changing lanes does not save any time. The average speed in a traffic jam is 10 km/h (6.2 mph), regardless of the lane.*

***What does the anatomy of a jam due to network overload look like?***

*Michael Schreckenberg: Jams due to network overload consistently form at the same points – at interchanges, at connection points and at inclines. Traffic congests and slows down here. When a car stops, a backup wave forms. The fatal thing is that these areas act like pumps and create one wave after another.*

***And then when you finally drive out of a wave like that ...***

*Michael Schreckenberg: ... then it can get really dangerous since many drivers feel like they've been released and lose concentration. And then they often drive directly into the end of the next backup wave.*

***Do you differentiate between different types of drivers in a jam?***

*Michael Schreckenberg: The decisive difference lies between commuters and holiday traffic. Commuters know their route well, they want to get to work and they tend to behave cooperatively. In holiday traffic, on the other hand, people are stressed out and are driving through areas they are unfamiliar with, and the tendency for frustration and aggression is greater. A special feeling of togetherness often emerges in a traffic jam, however – if nobody is able to move forward, we're all equal. As soon as someone gets in a car, they change. They behave differently than they do in their usual private lives. 15 to 20 percent of all traffic jams are avoidable. They are the direct result of the human ego.*



***This is precisely where the traffic jam pilot from Audi comes in. Can it ease the situation?***

*Michael Schreckenberg: I am convinced it can. Automated systems like the traffic jam pilot help minimize the human factor. It is important that customers gain trust in the system. We Germans are generally quite skeptical of new technologies and it is therefore important to proceed incrementally and continue developing trust in each stage. In the United States and especially in China, people are much more open to new technologies. A Chinese customer would get into a conditional automated car without hesitation.*

***How will traffic on German autobahns change in the next few years?***

*Michael Schreckenberg: Transport by truck has grown by more than 2 percent annually for the past 15 years. And that will continue as long as the economy is doing well. Germany is a transit country in which most goods are transported by road. One truck wears down a road as much as 60,000 cars. Because of this, and because of the high need for repair, the construction site situation will become more complicated. This makes it all the more important for cars to use the remaining space efficiently and to move intelligently – with systems like the traffic jam pilot as well as in a tight network with each other and with other people using the roads.*

***What can drivers already do today? What are five tips you have for proper conduct on the highway?***

*Michael Schreckenberg: Be cooperative and let others pass by. Create proper merging formations and emergency lanes. Always keep an eye on traffic behind you as well. Leave enough space behind you when you cut back into the right lane after passing. Also, take frequent breaks because stressed-out drivers are inefficient and aggressive.*

***And the five mistakes you should avoid?***

*Michael Schreckenberg: Avoid constant lane changes. When you hectically steer into gaps, you often cause the next backup wave. Do not drive onto the highway too slowly. Do not constantly accelerate and then brake. Drive at a consistent pace and stay relaxed. Do not try to make up time lost in a traffic jam – this will make your driving risky and reckless.*



Facts and figures

## **More than 1.3 million kilometers (807,783 mi): traffic jam report for Germany in 2016**

The traffic jam situation on Germany's highways worsened further in 2016. The main causes for this were the numerous construction sites and bottlenecks. This was the finding of the ADAC's Traffic Jam Report for 2016. In comparison to 2015, the number of jams as well as the jam hours and kilometers measured increased by a full 20 percent.

- Number of jams: 694,000, of which 349,000 were on highways
- Number of jam kilometers: 1,378,000 (856,250 mi), of which 806,000 (500,825 mi) were on highways
- Number of jam hours: 418,757
- German states with the most jam kilometers:
  - North Rhine-Westphalia (28 percent, 388,382 km [241,329. mi])
  - Bavaria (21 percent, 293,718 km [182,508 mi])
  - Baden-Württemberg (13 percent, 181,791 km [112,960 mi]).
- Highways with the most jams:
  - A3 (Oberhausen – Cologne/Frankfurt – Würzburg)
  - A8 (Stuttgart – Karlsruhe)
  - A1 (Cologne – Euskirchen)
- Months with the most jams (ranked by frequency):
  - September
  - July
  - August
- Weekdays with the most jams: Friday (average: about 5,000 km [3,106.9 mi])
- Day with the most jams: September 30, 2016 (about 11,200 km [6,959.4 mi])

Source: ADAC e.V.