DIGITIMES Research: Special Report, 2022

ICMS market and supply chain status

Introduction

DIGITIMES Research has observed that with the increasing usage of advanced driver-assistance systems (ADAS) and over-reliance on technology, drivers are more likely to be distracted while behind the wheel. The adoption of in-cabin monitoring systems (ICMS) for driver condition detection is found to reduce car accidents.

An ICMS includes two subsystems — a driver monitoring system (DMS) and an occupant monitoring system (OMS). Governments in Europe and America have instituted regulations and recommendations for ICMS while automakers each take a different approach to developing ICMS. This gives rise to growing demand for ICMS components and presents opportunities for Taiwan-based manufacturers to tap the market segment.

The US government considers ADAS + DMS a safe and reliable solution. EU mandates that all new cars be equipped with DMS. In-cabin monitoring is not something new. Some automakers proposed DMS as in-cabin monitoring solutions long ago, which however were not given much attention due to system cost considerations. It was not until there was a need for regulatory compliance and certification that more automakers followed suit and put forth solutions that later expanded to include OMS.

US automakers use cameras coupled with software and services to implement in-cabin monitoring. German automakers gradually transition from driver fatigue detection to smart services. Japanese automakers still focus on indirect ways to detect driver fatigue and attention out of privacy concerns. Korean automakers are among the few that use wearable devices for in-cabin monitoring.

An ICMS comprises several elements, including sensors, a computing unit and a user interface. Taiwan-based manufacturers have already penetrated the automotive supply chain, providing automotive cameras, image sensors and mmWave radars. They stand a good chance of receiving larger orders with rising demand going forward. With heightened system requirements, there will be a need to upgrade system core components such as chips, ECU and automotive computers. Taiwan-based manufacturers are well capable of providing products and services in this respect. User interface plays an instrumental role in user experience. Some Taiwan-based manufacturers develop smart cockpit solutions with built-in DMS.

DMS status

DMS is a viable solution to addressing the problem of driver distraction arising from over-reliance on ADAS.

ADAS is designed to give drivers added convenience and safety but drivers' over-reliance on technology breeds unsafe behavior. According to NHTSA, driver distraction is the main cause of auto accidents. As such, DMS that detects driver behavior coupled with ADAS is considered a safe and reliable solution.

NTSB also recommends DMS for SAE Level 2 semi-autonomous vehicles.

EU requires new cars to be equipped with DDAW systems.

EU research shows driver fatigue is a contributory factor in up to 20% of road collisions. Given this, the EU mandates that new vehicles be equipped with DDAW systems starting July 2022.

Euro NCAP crash-test safety standards also require DMS for a five-star rating starting in 2020.

Table 1: DMS current status
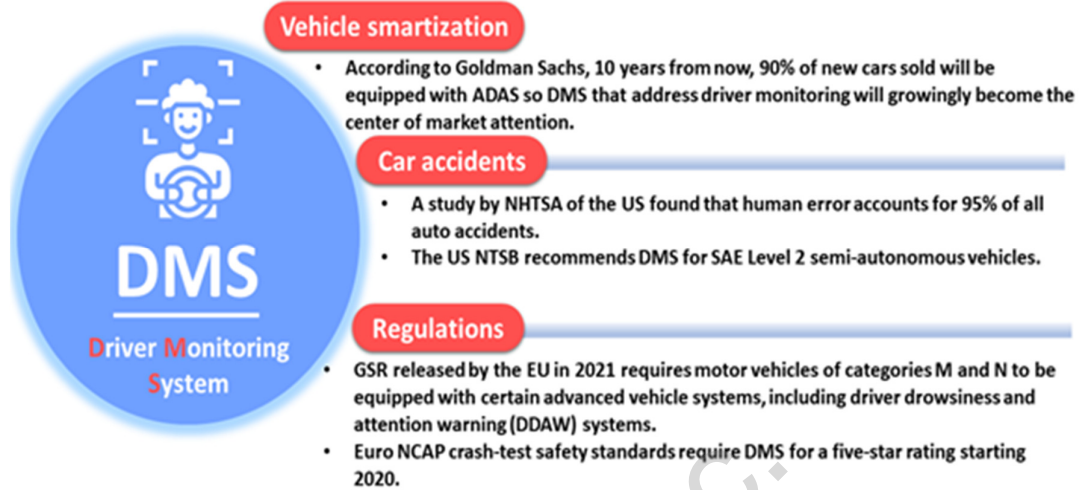
Source: ATIC, NCAP, NHTSA, NTSB, compiled by DIGITIMES Research, July 2022

DMS and OMS

In-cabin monitoring has expanded from focusing on DMS to including OMS.

In-cabin monitoring is nothing new. Some automakers began to incorporate DMS in their vehicles long ago, which however did not catch much attention due to system cost considerations. It was not until the burgeoning developments of ADAS starting in 2018, followed by regulatory compliance needs, shed light on DMS opportunities that more automakers and suppliers such as GM and Continental joined in the effort and proposed DMS solutions.

Over the past few years, there have been multiple cases of children being left unattended in vehicles, leading to deaths. Tesla introduced Cabin Overheat Protection in 2016 to address child safety in vehicles. Magna debuted a video-based rear seat monitoring system in 2018, which was used in Honda vehicles. It made Magna a pioneer in the OMS market and incidentally raised the bar on the sensing range of in-cabin monitoring solutions.

Euro NCAP announced that starting in 2022, it will award points for child presence detection, to increase global awareness of OMS.

Table 2: DMS and OMS development
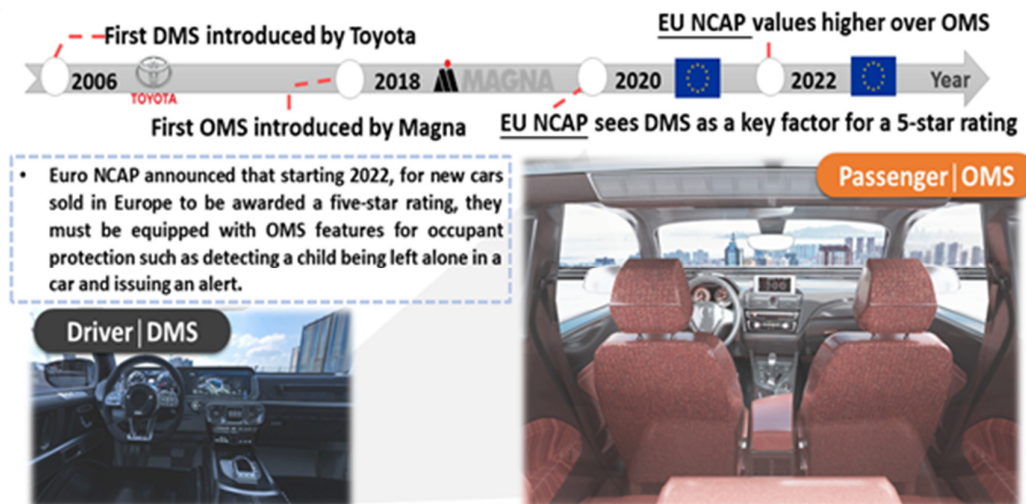
Source: Companies, EU NCAP, compiled by DIGITIMES Research, July 2022

Technology breakdown

Automaker solutions

The in-cabin monitoring solutions that the automakers adopt are mainly based on three types of technologies—machine vision, physiological indicators and telematics data. Automakers around the world each take a different approach to in-cabin monitoring.

American automakers primarily adopt vision-based monitoring systems with cameras. General Motors (GM) Super Cruise is available in several GM vehicles. Tesla activated Cabin Camera in a software update in 2021 to make sure drivers are paying attention to the road when they use Autopilot.

German automakers are transitioning from driver fatigue detection to intelligent behavior recognition technologies. Mercedes-Benz's 3D instrument cluster uses a camera and eye tracking to analyze driver behavior and intention.

Most Japanese automakers still make use of telematics data to monitor driver fatigue and attention as there are still passenger privacy concerns to put cameras in cars. Subaru and Toyota are among the few Japanese automakers that adopt camera-based DMS.

Aside from driver monitoring, Subaru's DMS also features face recognition, allowing it to identify who is in the driver's seat and automatically adjust the cabin environment according to his or her preferences.

Toyota's Advanced Drive enables autonomous driving on the highway while monitoring the driver's condition. It was first featured in Lexus LS and Mirai.

Hyundai Mobis developed M.Brain, a wearable brainwave detection device for driver monitoring. It is among the few in-cabin monitoring solutions that detect physiological indicators.

Table 3: ICMS systems adopted by major automakers worldwide

Region	Automaker	System name
US	GM	Super Cruise; Ultra Cruise
	Tesla	Active Safety Features (Cabin camera)
	Ford	Blue Cruise
Germany and Sweden	Volkswagen	IQ.Drive smart driving system
	Audi	zFAS
	BMW	I Drive
	Mercedes-Benz	Intelligent Drive
	Volvo	Driver Attention System (with additional camera installation)
Japan and South Korea	Subaru	Driver Monitoring System (DMS)
	Toyota	Advance Drive
	Mazda	Co-Pilot 1.0 & 2.0
	Honda	Driver Attention Monitor (DAM)
	Nissan	Driver Attention Alert (DAA)
	Hyundai	Driver Attention Warning (DAW) (Mobis brainwave sensing)

Source: Companies, compiled by DIGITIMES Research, July 2022

ICMS system details

An ICMS consists of several elements (modules), including a camera module (made up of a camera and an image sensor) for driver behavior sensing, a mmWave radar for whole-vehicle condition monitoring, a computing unit and other related in-vehicle equipment.

The camera module captures images in the vehicle. It should be able to capture high-resolution images even in poor lighting conditions so it mostly uses infrared (IR) cameras to detect driver behavior.

It may come with one or more cameras (for example, wide-angle cameras) that are often installed in front of the dashboard, on the steering column, on the left or right A-pillar, and/or on the digital rearview mirror. Locations that allow the camera to take a direct front-facing image of the driver create ideal results.

The mmWave radar enables in-depth sensing to compensate for the fact that the camera module may fail to capture clear images due to poor lighting. Coupled with the camera module, it can also expand the sensing area to significantly widen the field of view and enhance safety monitoring capabilities.

To enhance in-cabin safety, the user interface device is designed to notify or alert the driver and enforce safety practices.

As the system core, the computing unit processes the data collected by the sensors as well as related telematics information according to its built-in algorithm to determine drowsiness, attentiveness, distraction and other driver conditions and thereby work in conjunction with other in-vehicle equipment to perform effective safety monitoring.

Table 4: ICMS system components
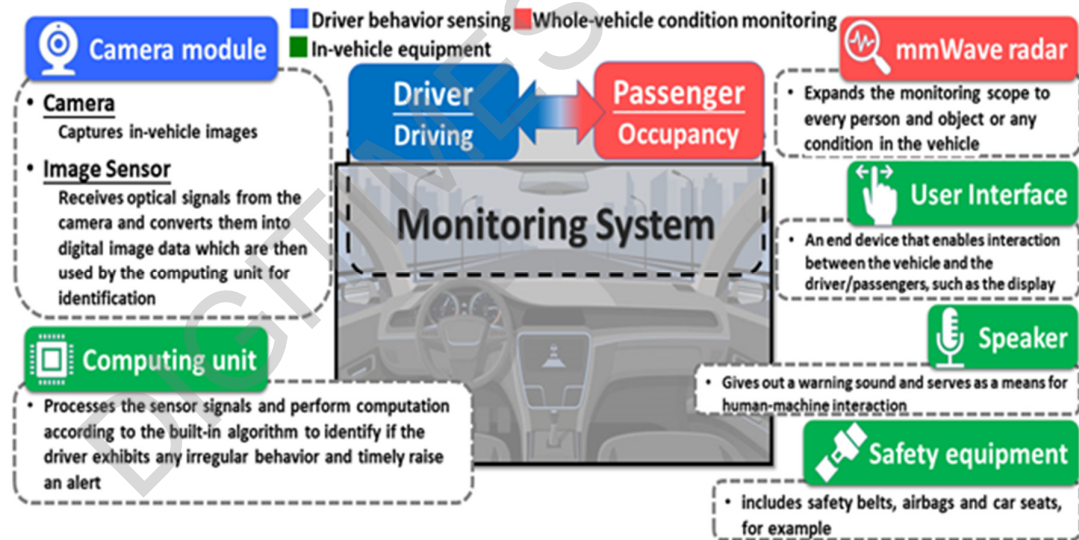
Source: DIGITIMES Research, July 2022

Supplier breakdown

Camera and image sensor

The demand for automotive cameras will be on the rise with the increasing use of machine vision technologies in ICMS. Asia Optical provides a spectrum of automotive cameras. Canon's automotive cameras are well received by Japanese manufacturers. Altek offers one-stop solutions addressing automotive camera needs.

Having made its way into the automotive camera supply chain for years, Asia Optical offers a complete portfolio of one-megapixel to 4K cameras while supplying IR and wide-angle cameras for ADAS and driver monitoring. It enjoys an established presence in the automotive component market.

Canon's camera modules are highly praised by Japanese manufacturers. Eyeing the development potential of ADAS + DMS, Canon plans to exert efforts toward the ICMS market.

To tap opportunities in automotive cameras and image processing, Altek is successfully transitioning from a camera OEM to an automotive electronics developer. On course to becoming a Taiwan-based camera supplier capable of both IC design and hardware manufacturing, Altek offers one-stop solutions integrating software and hardware.

According to a recent IC Insights report, the sales of CIS for automotive applications are set to grow at a CAGR of 33.8% from 2020 through 2025. PixArt Imaging is making aggressive efforts to penetrate the automotive supply chain. Tong Hsing plans to expand its capacity. SOI joins forces with Egis to expand its footprint in the automotive sector.

PixArt Imaging has forayed into the automotive CIS supply chain and has been delivering samples to automakers. It expects more orders from automakers going forward.

Tong Hsing is the world's third largest CIS assembler. Its top three customers represent 70% of the global CIS market. It is projected that a vehicle will use 4.4 CIS on average in 2025. Given the market opportunity, Tong Hsing has built new production lines on top of boosting the capacity of its existing facilities this year.

SOI plans to develop new automotive monitoring solutions leveraging the ISP technologies of iCatch, an Egis subsidiary.

Table 5: Automotive camera suppliers

Supplier	Status
Asia Optical	Cultivating the automotive camera market for years, Asia Optical made 42% of its revenue from optical devices in 2021 and has penetrated into the supply chain of European and American automakers.
Canon	Canon provides cameras for ICMS and ADAS. It signed an MOU with a tier-4 Japanese supplier to produce and market cameras for autonomous driving applications.
Altek	Altek manufactures automotive cameras. Its subsidiary Altek Semiconductor designs image signal processors (ISP), making the corporation one of the few Taiwan-based firms capable of offering hardware-software integrated solutions.

Source: Companies, compiled by DIGITIMES Research, July 2022

Table 6: Image sensor suppliers

Supplier	Status
PixArt Imaging	PixArt Imaging develops CMOS image sensors (CIS) and imaging IC solutions. Its Optical Finger Sensor (OFN) products are used in Hyundai's Genesis brand EV.
Tong Hsing	As the largest CIS assembler in Asia Pacific, Tong Hsing provides services to heavyweight customers including Sony, OmniVision and On Semiconductor (Onsemi). Onsemi is a CIS supplier to Tesla.
Silicon Optronics	SOI primarily supplies CIS for aftermarket parts (for example, reversing cameras) as well as DMS image sensors. It plans to develop dynamic vision sensors combining Egis' ISP technologies.

Source: Companies, compiled by DIGITIMES Research, July 2022

Chips, ECU and auto computer

A high refresh rate and low latency are a must for ICMS to deliver their safety monitoring benefits. That is why ICMS require high-speed signal transmission and high-performance image processing. Realtek offers high-performance network communication chips. iCatch specializes in image processors. Kneron's smart imaging chips are favored by automakers.

Positioned among the world's leading suppliers of automotive network communication chips, Realtek provides solutions that enable DMS + OMS to engage in high-speed network communication with low latency and thereby realize a diversity of network-enabled services.

iCatch has developed automotive-grade image processors that enable it to foray into the automotive supply chain. The jointly developed AI-based vision sensors with Prophesee target applications in ICMS.

Kneron demonstrated its self-developed chips for camera-based sensing and recognition in vehicles at a Mobility in Harmony (MIH) exhibition. It is also working with several manufacturers to co-develop smart driving and safety monitoring software and hardware solutions.

To keep up with heightening performance requirements, the control unit at the core of ICMS and the central computer integrated with the automotive electronics system must also upgrade. Pegatron stays committed to developing next-generation automotive computers. Quanta keeps strengthening ECU software and hardware technologies. Compal makes active efforts toward expanding its automotive electronics business.

Pegatron has been cultivating its automotive computer business for years and stands a good chance of snatching more orders in the automotive sector with Europe and America growingly considering ADAS + DMS a reliable solution. It will stay committed to developing next-generation automotive computers and smart in-cabin applications while actively recalibrating its global capacity planning and market positioning.

Aside from making efforts to penetrate the traditional automotive supply chain, Quanta also engages in collaborations with startup automakers to strengthen its ECU software and hardware capabilities. It is poised to skip tier-one automotive OEM and become a tier-one automotive supplier itself.

Compal's customers in the automotive sector are primarily based in Europe so it stands to benefit from the EU's mandate in the ECU market. From Cal-Comp, a member of the same conglomerate, Compal acquired a factory in Indiana in 2021, where a cluster of Japanese and American automakers' factories are also located. The deal is expected to help Compal expand its automotive electronics business. New orders are coming in starting in 2022. The contribution to its revenue will begin to manifest in 2025.

Table 7: Auto chip suppliers

Supplier	Status
Realtek	Providing network communication chips for automotive applications, Realtek has secured orders from multiple global automakers. Its AI camera chips featuring low power consumption and network connection have a chance of being adopted in DMS.
iCatch	iCatch partners with APPRO to co-develop intelligent imaging applications that have the potential of being used in DMS for image recognition.
Kneron	Kneron provides its self-developed chips to Toyota's main supplier Kenwood while working with several renowned automakers to explore face recognition, DMS and other applications.

Source: Companies, compiled by DIGITIMES Research, July 2022

Table 8: ECU and auto computer suppliers

Supplier	Status
Pegatron	Pegatron offers center console computers for EVs. ICMS requirements have indirectly driven the need to upgrade automotive computers.
Quanta	Quanta collaborated with European and Japanese autonomous driving startups on strengthening ECU and computing platform technologies. Aside from autonomous driving systems, it also provides ICMS control units.
Compal	Mercedes-Benz and BMW are the main automaker customers of Compal. EU's ICMS mandate opens an opportunity for Compal in the ECU market.

Source: Companies, compiled by DIGITIMES Research, July 2022

mmWave radar and ICMS solutions

Integrating software services, Cubtek has developed solutions for detecting and analyzing object conditions. TungThih has secured leadership in the automotive radar market.

As Taiwan's iconic supplier of mmWave radars, Cubtek offers a complete radar product portfolio and plans to foray into the automotive sector.

Its imaging radar developed in collaboration with an automotive IC design firm is capable of high-precision detection and object identification. It has a promising outlook for being adopted in ICMS.

Its self-developed radar named "The one" is an everything-in-one solution combining multiple warning systems. Featuring compelling cost advantages, it stands a good chance of replacing other automotive sensors.

TungThih, Asia's largest reversing radar supplier, enjoys leadership in the aftermarket and is poised to tap the growing ICMS market.

The user interface in an ICMS plays a crucial role in determining user experience. AUO and Innolux have prepared mature automotive display solutions. Giantplus endeavors toward customized products for automotive applications.

AUO's multi-screen cockpit solution provides a diversity of smart services. The display is embedded with a camera module for driver recognition to thereby automatically adjust the cabin settings according to the driver's preferences. The solution enables additional refreshing features on top of safety functions.

Innolux has introduced an integrated cockpit display system that highlights safety on the road. Targeting the smart cockpit market, Innolux supplies to automakers throughout Europe, America and China. It is in a position to grab more orders with government regulations driving market demand.

Giantplus' automotive product portfolio primarily includes displays for instrument panels and center consoles. It has been directly supplying products to European, American, Japanese and Korean automakers. As opposed to ICMS with large displays that come with high system costs, Giantplus stands a good chance if targeting the affordable vehicle segment and making efforts toward products with a high level of customization.

Table 9: mmWave radar suppliers

Supplier	Status
Cubtek	The three EV models developed under the MIH open platform all use Cubtek's radar. It has also penetrated into the radar supply chain for commercial vehicles in China. Its bio-detection radar detects human physiological signals in the vehicle so it can be used for in-cabin monitoring in the future.
TungThih	TungThih is the world's third largest reversing radar supplier, providing products to automakers throughout Europe, America and China. Its automated parking system has expanded into Tesla's supply chain. It has plans to strengthen its in-cabin offerings going forward.

Source: Companies, compiled by DIGITIMES Research, July 2022

Table 10: ICMS solution suppliers

Supplier	Status
AUO	AUO offers a smart cockpit solution targeting both the driver and the passenger. A camera module is integrated with the display for user recognition. The solution has good potential of being used in ICMS in the future.
Innolux	Innolux has introduced an integrated cockpit display system that highlights safety on the road. The IR camera facing the driver can track the driver's line of sight and raise an alert on the display.
Giantplus	Giantplus provides mid- and small-size instrument panels for automotive and industrial applications. They have a good chance of being adopted in in-cabin solutions targeting affordable vehicles in the future.

Source: Companies, compiled by DIGITIMES Research, July 2022