WHAT'S NEW?

H1 2019

EXECUTIVE LENS

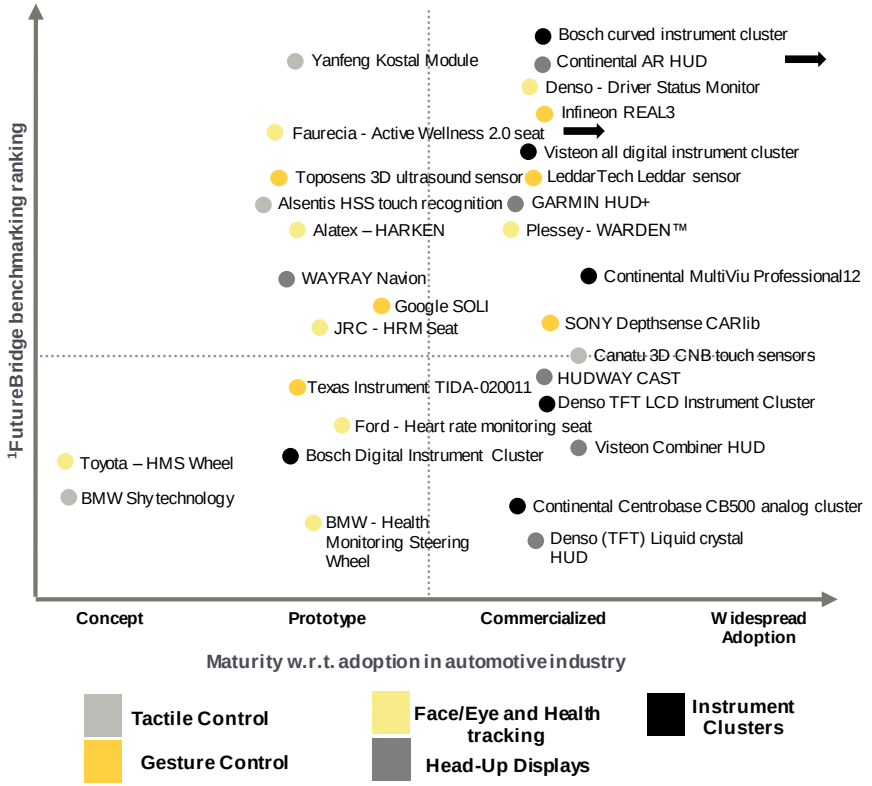
Summarized insights for Human Machine Interface w.r.t. trends in technology, market, and players

FutureBridge

State of the Trend

Technological advancements pave the way for 3D integration into displays. Systems are becoming more intuitive and predictive with the use of voice to enhance convenience

NEW



- Voice-enabled smart assistants for vehicle setting configuration, infotainment, convenience are finding their way to modern HMI, as demonstrated by our *H1'19 Development Tracker*. Learn about the supply chain *here*.
- Emotional intelligence in voice control can bring empathy to future HMI to unlock further personalization. Learn more in our webinar *''Empathetic, humanized vehicles''*.
- Gesture recognition is gaining momentum in HMI input. Read more about the development of the *Supply Chain in H1'19*.

Face / eye tracking → In H1'19, academic research concentrated on face/eye tracking demonstrating the need for passenger monitoring in modern HMI to advance to more efficient mitigation of driver distraction and secure driver availability in Level 3 automated driving. Read more in our *Academic research Highlights*

Displays → Displays are getting advanced with the integration of 3D projections as well as curved and flexible design that can be easily integrated on any surface of the interior to make it intuitive. Read more about Supply Chain in H1' 2019

Key Developments in past 6 months

Hyundai partners with Israeli medical AI startup MD Go for health monitoring after crash >>

Read more in our Q2 2019 Pulse

10th Jun 2019

5th Mar 2019: Nissan to choose TomTom to power its in-vehicle infotainment system >>

28th May 2019: BMW to introduce Curved Display on all its cars from 2021 >>

9th Jul 2019: Jaguar Land Rover developing AI-enabled mood-detection system >>

Y-axis: FutureBridge Benchmarking Ranking – Outcome of benchmarking analysis performed based on weightage based model. For more details, please check 'Benchmarking section' >>

Emerging trends

Advancements in Displays, Instrument clusters and collaborations for In-vehicle infotainment are the current areas of focus of various automakers, suppliers and startups.

Players incorporating and advancing In-Vehicle Infotainment

- **Renault**: Renault Samsung's QM6 mid-size SUV features AI-based Easy Link infotainment system, with voice-controlled audio and navigation features >>
- **Qt / LG Electronics**: Qt company partnered with LG Electronics for advanced In Vehicle Infotainment systems >>
- **Nissan / TomTom**: TomTom will supply its Maps, Traffic and Online Search to LEAF's new enhanced NissanConnect IV infotainment system >>

Voice controlled audio and navigation are becoming key features of modern In-Vehicle-Infotainment, hence developers are realizing the need and thus collaborating with suppliers to deliver new feature enhancements.

Read more in our Q1 2019 Pulse

Are flexible and curved displays the future of displays?

- **Bosch**: Bosch to put its curved instrument cluster in the 3rd generation VW Touareg >>
- **BMW**: Novares collaborated with Flexenable to integrate the Curved and glass free display in the Nova car 2 >>
- **Novares / FlexEnable**: BMW unveiled its iNEXT electric SUV with a large-size, fully-digital 'Curved Display >>

Carmakers want a display that can be easily manufactured in the desired size and shape. Suppliers, such as Marelli prepare for switchable viewing angles

Read more in our Q2 2019 Pulse

Vehicle Instrument clusters reach 3rd dimension to display critical feedback to drivers and passengers

- **Continental**: Continental collaborated with Leia to develop a 3D Lightfield Instrument Cluster with holographic effects >>
- **Visteon**: Visteon launched 3D instrument cluster that displays holographic objects in Peugeot 208 >>
- **Magneti Marelli**: Magneti Marelli showcased 3D instrument cluster at Auto Shanghai 2019 >>

3D instrument clusters can display more complex data in a more intuitive way and allow for an easier interaction with the driver.

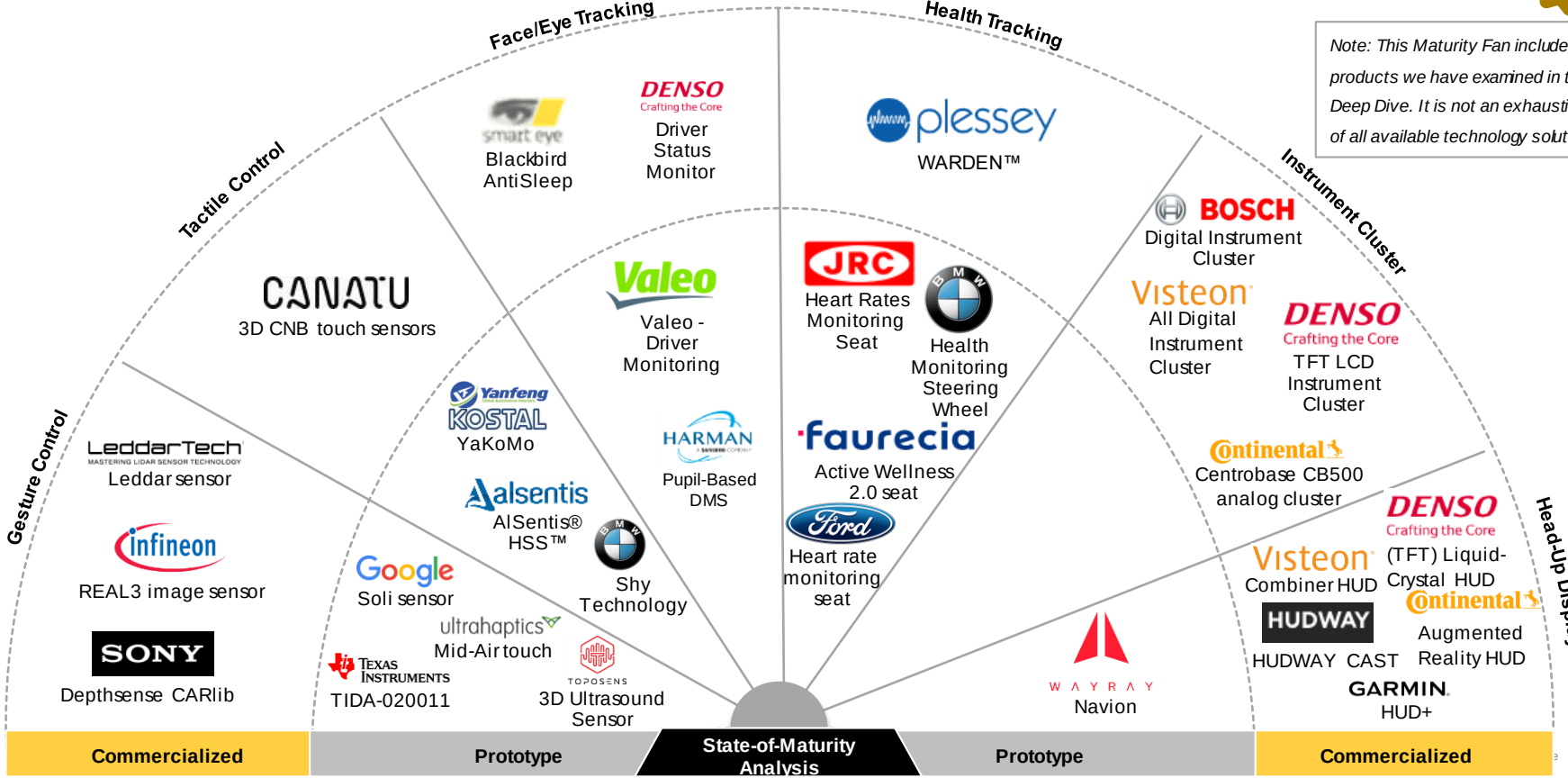
Read more in our Q2 2019 Pulse

Maturity Fan Diagram

3D and curved Instruments Clusters are making their appearance. AR HUDs are being introduced to the market

NEW

Note: This Maturity Fan includes all the products we have examined in this Deep Dive. It is not an exhaustive map of all available technology solutions

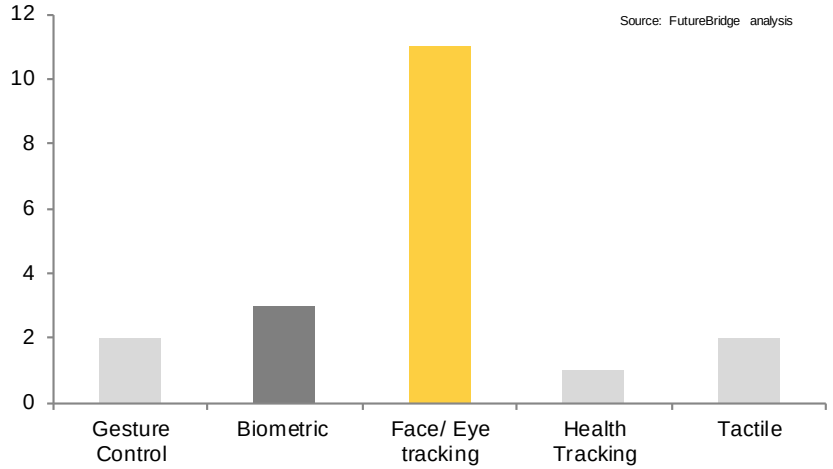


Highlights from Academic Research in H1'19 (1 of 2)

Academic research showed focus on face/eye tracking

NEW

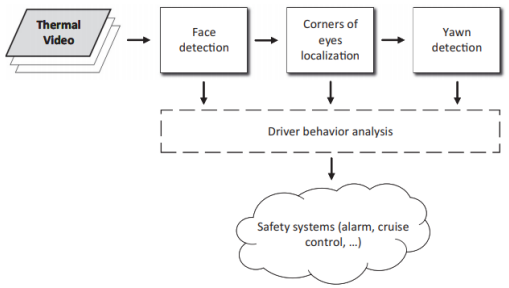
Research publications in H1'19



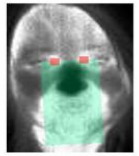
- Researchers are mainly focusing on face/eye tracking to reduce driver distraction, drowsiness, as well as measures to monitor the driver and modify interior environment.
- Gesture control, Biometric and Tactile have a potential to grow rapidly as the timelines for autonomous vehicle's deployment are approaching
- Health tracking will also gain momentum leveraging the shift towards health and wellbeing Unique Selling Points inside the cabin. Learn more in our webinar '*Cockpit of the future:2022*''.

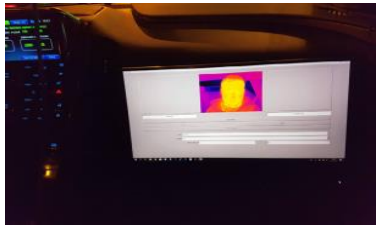
Driver's fatigue recognition based on yawn detection in thermal images

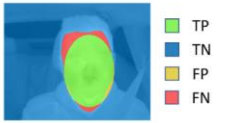
(Feb'19, Knapik, M., & Cyganek, B. Department of Electronics, AGH University of Science & Technology, Poland)



Overall architecture of possible driver drowsiness monitoring system







- The research article shows yawn detection using long range infrared imaging which is used to detect driver's fatigue and can warn on driver's drowsiness based on observations
- The face alignment is done by detection of eye corners then, yawns are detected based on the proposed yawning thermal model
- The system presents a viable alternative to systems based on other spectra and can operate in real car conditions without artificial source of radiation

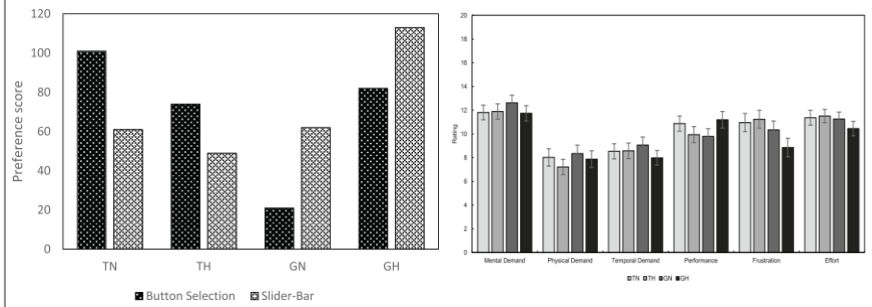
Highlights from Academic Research in H1'19 (1 of 2)

A research on novel method of gesture control and detecting emotions (fear) from facial thermography

NEW

Feel the noise: Mid-air ultrasound haptic as a novel human-vehicle interaction paradigm

(Jul'19, David R. Largea, Kyle Harringtona, Gary Burnetta, Orestis Georgiou; Human Factors Research Group, University of Nottingham, UK)

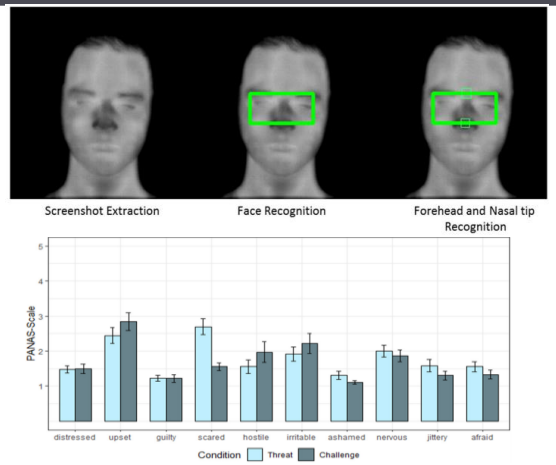


Preference scores (absolute values) for discrete button selection and continuous slider-bar tasks, where T = touch, G = Gesture, H = with haptics, and N = without (no) haptics.

- The study shows the potential of haptic enabled gestures in automotive domain
- Ultrasound combined with haptic can be used to guide the users in order to implement gestural interfaces and reduce visual interface
- Gestures were preferred by participants for continuous tasks when a traditional in-vehicle touchscreen was compared with a virtual mid-air gestural interface
- Results show that haptifying gestures with ultrasound was particularly effective in reducing visual demand (number of long glances and mean off-road glance time), and increasing performance (shortest interaction times, highest number of correct responses and least 'overshoots') associated with continuous tasks

Discriminating drivers' emotions through the dimension of power: Evidence from facial infrared thermography and peripheral physiological measurements

(Apr' 19, Meng Zhang, Klasl hme, Uwe Drewitz Institute of Transportation Systems, German Aerospace Center, Braunschweig, Germany)



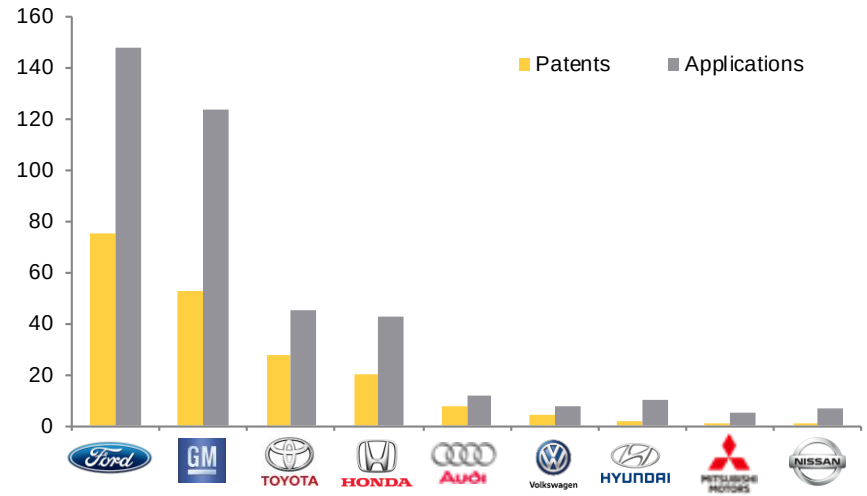
- The study investigates changes in body temperature as an indicator of emotional dimensions during driving using two emotions (fear or no fear) in the dimension of power (low power or high power)
- Infrared thermography video and automatic facial feature recognition were implemented to assess participants' facial temperature
- The forehead temperature is an indicator can help to measure drivers' fear and thus aid reliable in-vehicle emotion recognition

Technology Trend

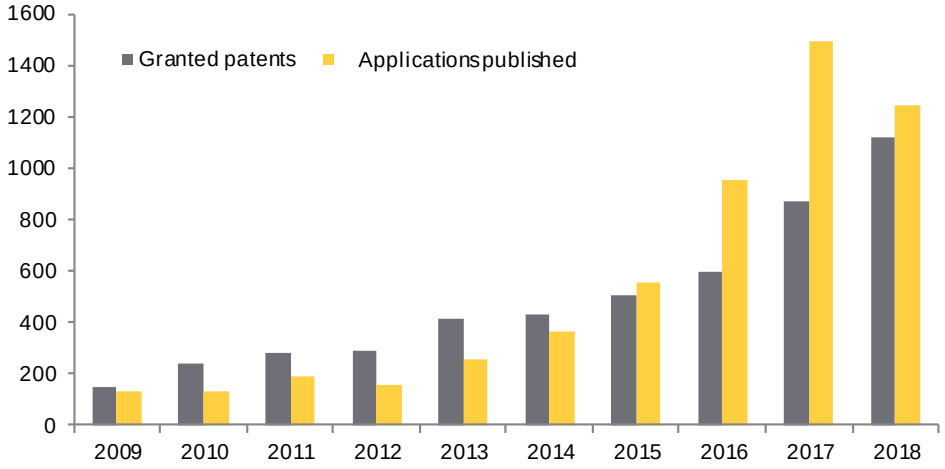
Biometric recognition is experiencing increased development as automakers see more potential towards safety and well-being rather than just unlocking the car

NEW

Patents and patent applications assigned to auto manufacturers



Total number of patents granted and applications published in 2008-18



Key Developments in past 6 months

24 Jan 2019

SMK and CAARESYS collaborate for biometric sensor for heart rate, respiration rate, and heart rate variability detection >>

9 Jul 2019

Jaguar Land Rover is developing facial recognition technology that can evaluate driver's mood and alter cabin settings >>

16 Jul 2019

Hyundai has announced the development of Driver State Warning System with biometric facial recognition >>

11 Jul 2019

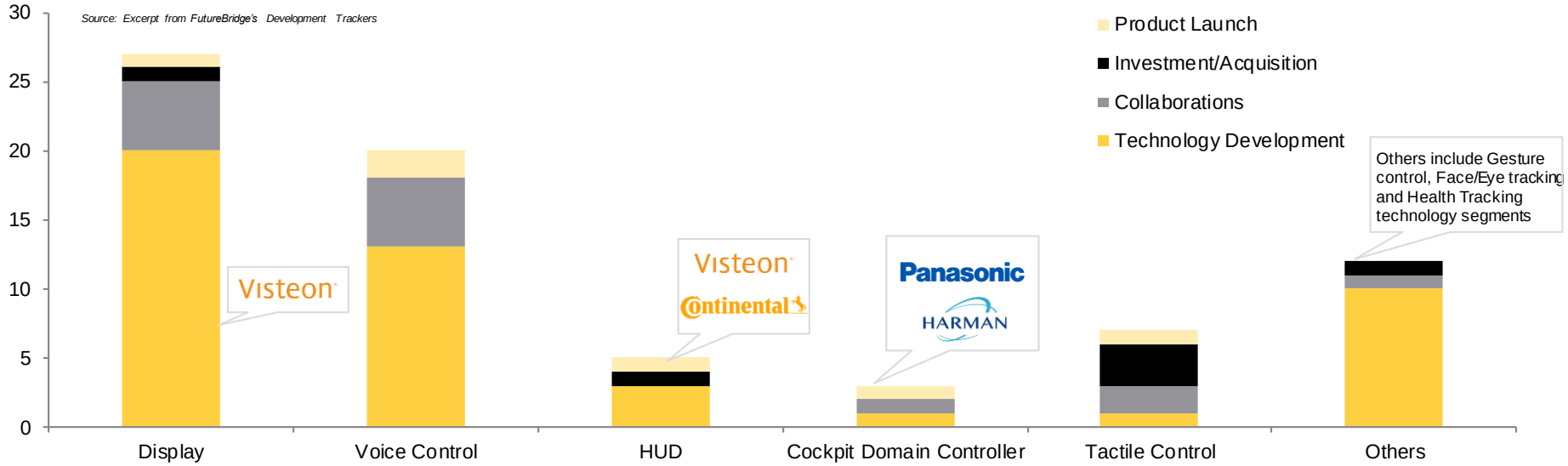
Bentley unveiled its concept car EXP 100GT with adaptable seats >>

Source>> Norton Rose Fulbright law firm

H1'19 HMI developments summary

NEW

Technology Developments in displays, such as product/prototype launches, key announcements, incremental technology developments, dominated HMI output activities, followed by voice on the input side



- The technological advancements in the display technologies like providing a 3D display, curved and flexible ones are leading to integration of more functions in display applications like warning, controlling functions and infotainment (navigation, audio, maps) in the same display
- Virtual personal assistants, which are able to recognize voice commands, are expanding from consumer electronics to modern ve hicle interior. This allows and easy access to car functions while also reducing driver distraction when driving.
- There has been an effort to reduce the mechanical knobs and switches to reduce weight and complexity with the help of tactile control technologies. Also the distraction risks posed for drivers by using current generation touchscreens while driving, throw the spotlight on touchless HMI as an additional interaction mode.

Key Industry developments H1 2019

Major developments as per their impact in HMI domain on supply chain

Investments/Acquitions

Novares acquires minority stake in Actronika for smart surfaces in vehicles >>

Novares invests in Quad Industries to develop intuitive user interfaces for automotive interiors >>

Bridgestone acquires TomTom Telematics and TomTom to focus on map making platform >>

Affectiva raises $26m in funding led by Aptiv PLC to fast-track human perception AI in automotive >>

Product Launches

Blue Link connectivity technology in India >>

Elektrobit HMI infotainment system >>

3D landscape operating concept based on haptic feedback >>

Technology for the intelligent digital cockpit to demonstrate its Smartcore andDriveCore™ autonomous driving controller >>

Silicone optical bonding materials for displays >>

VIVID in-vehicle infotainment system >>

Technology advancements

Develops compact head-up display (HUD) which modifies the projection distance for sports car >>

Nuance's Dragon Drive platform powers Geely's GKUI digital cockpit system >>

AI to understand driver state of mind while driving >>

Develops intelligent glass control to control the shading of glass >>

Device that can recognize human emotions which can be integrated with voice assistants in vehicle >>

Integrate ACCESS' Twine for Car solution in-car infotainment >>

Collaborations/Partnership

DTS Connected Radio platform in vehicles >>

Face detection for vehicle security >>

Touch feedback technology for in-vehicle touchscreens >>

Developed 'Natural 3D Lightfield Instrument Cluster' >>

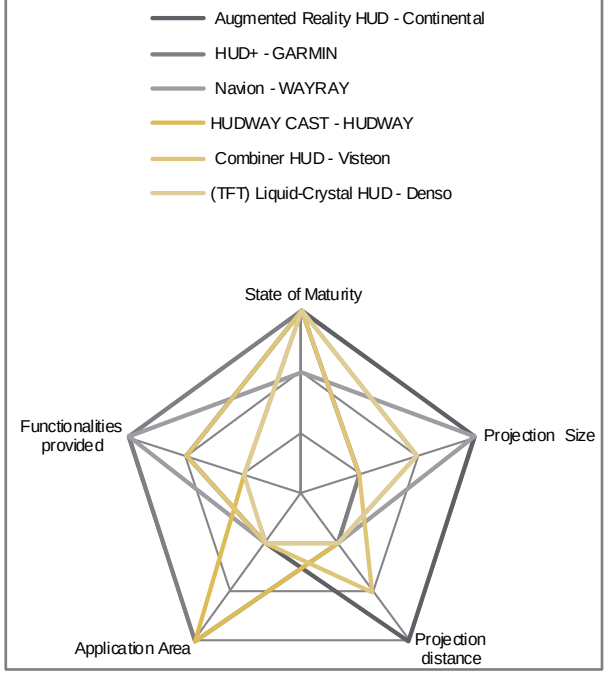
Technology Benchmarking Summary (1 of 2)

Key Takeaways

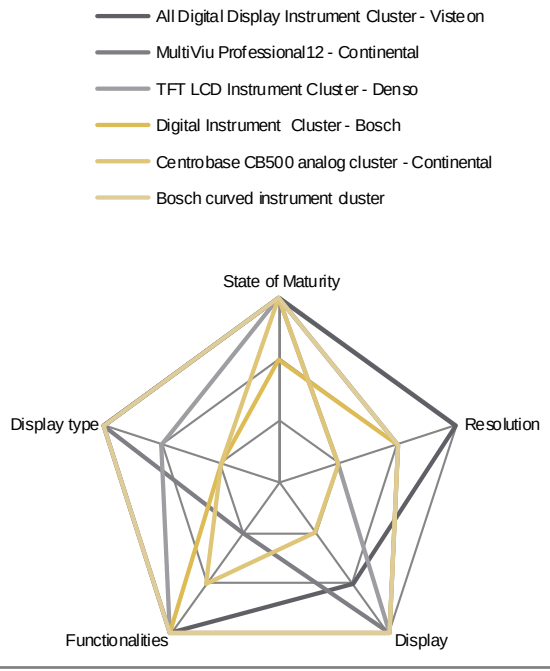
Compared to analog ones, digital clusters score higher in our benchmarking due to the integration of different functionalities like displaying navigation, audio, vehicle information etc.

Out of the 6 HUDs we benchmarked, 5 have already been commercialized. HUDs that can project at a long distance and can project images with high contrast even in the sunlight perform better in our scoring.

Head-up Displays



Instrument Cluster



Source: FutureBridge benchmarking

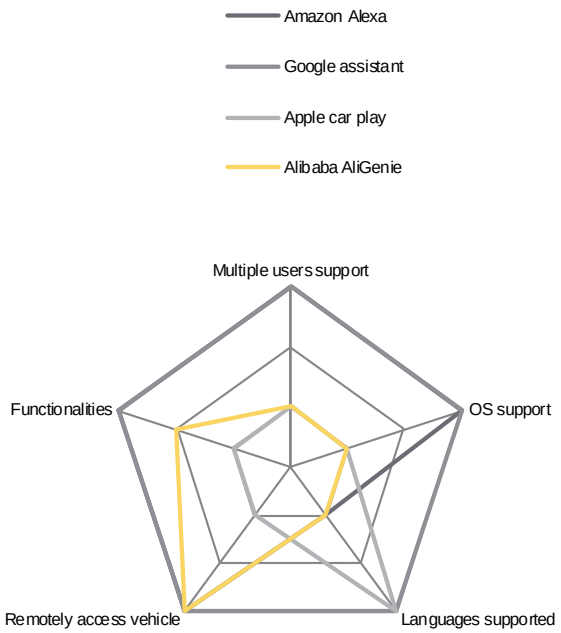
Technology Benchmarking Summary (2 of 2)

Key Takeaways

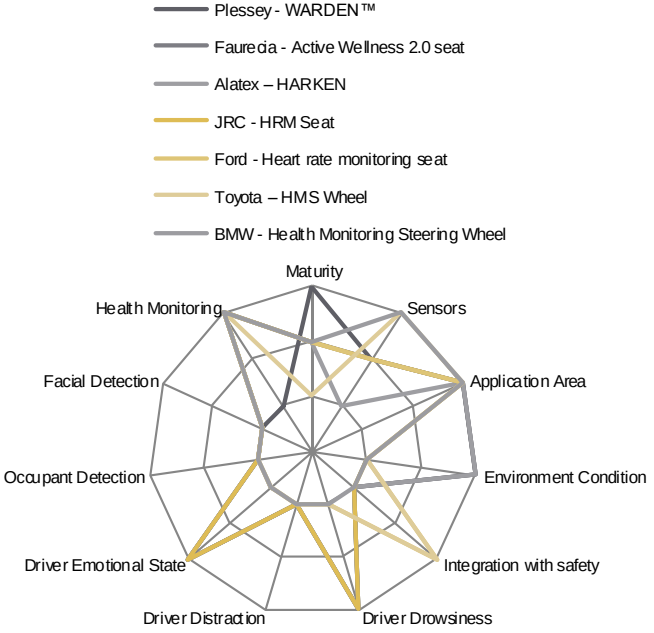
We see increased adoption of voice assistants as all the platforms in our benchmarking have been commercially available. We expect the functionalities of assistant to increase to provide personalization and convenience.

Health Tracking integrated with safety systems will be used widely as driver safety remains a prime focus. Carmakers are working on remote vehicle access.

Independent voice platform



Health Tracking



Source: FutureBridge benchmarking

Supply Chain for Voice Control technology

Apple Car play can be seen widely adopted by OEMs followed by Amazon

NEW

Suppliers	Apple Car Play	Alexa	Dragon Drive	Houndify platform	Android automotive and assistant	Tmall Genie
OEMs	A3, A4, A5, A6, A7, Q2, Q5, Q7, Q8, R8, and TT models	Toyota Avalon, Toyota Corolla Hatchback, Toyota Sienna, Toyota RAV4, Toyota 4Runner Toyota Camry	Audi	Mercedes-Benz	Volvo	BMW
	Accord, Civic, CR-V, Fit, Pilot, Ridgeline, and Odyssey models	AUDI E-Tron electric SUV	BMW	Hyundai	Hyundai	
	2 Series, 3 Series, 4 Series, 5 series, 6 Series, 7 Series, i3, X1, X2 X3, X4, X5, and X6 models	BMW X2 BMW X3 Mini	MG	Honda		
	A-Class,B-Class, CLA-Class, CLS-Class, E-Class, GLA-Class, GLE-Class, GLS-Class, and SL-Class models		Toyota	PSA Groupe		
	Mirage, Mirage G4, Outlander models		Geely			
	Altima, GT-R, Kicks, Leaf, Rogue, Maxima, and Murano models					
	Azera, Sonata, Elantra, Tucson, Veloster, IONIQ, Kona, Santa Fe, Santa Fe Sport					
	Focus, Fusion, Taurus, Transit, Transit Connect, and Mustang					
	ES, LC, LS, RC, AND UX MODELS					
	Avalon, Corolla Hatchback, C-HR, and RAV4					
	Atlas, Beetle, CC, SportWagen, Passat, Tiguan, Jetta models					
	S60, S90, V60, V90, XC40, XC60, and XC90 models					

Future Outlook

Suppliers are planning to bring emotional intelligence in their voice assistants:

- Amazon to integrate emotional intelligence in Alexa (Filed a patent for the same)
- Affectiva and Nuance collaborate to bring emotional intelligence for its AI assistant

BMW and Alexa are working together to integrate visual responses to Alexa which will be able to display additional graphs and facts when wanted

Supply Chain for Automotive Displays

With the arrival of curved/flexible displays & 3D instrument clusters, developments in the area of displays have increased

NEW

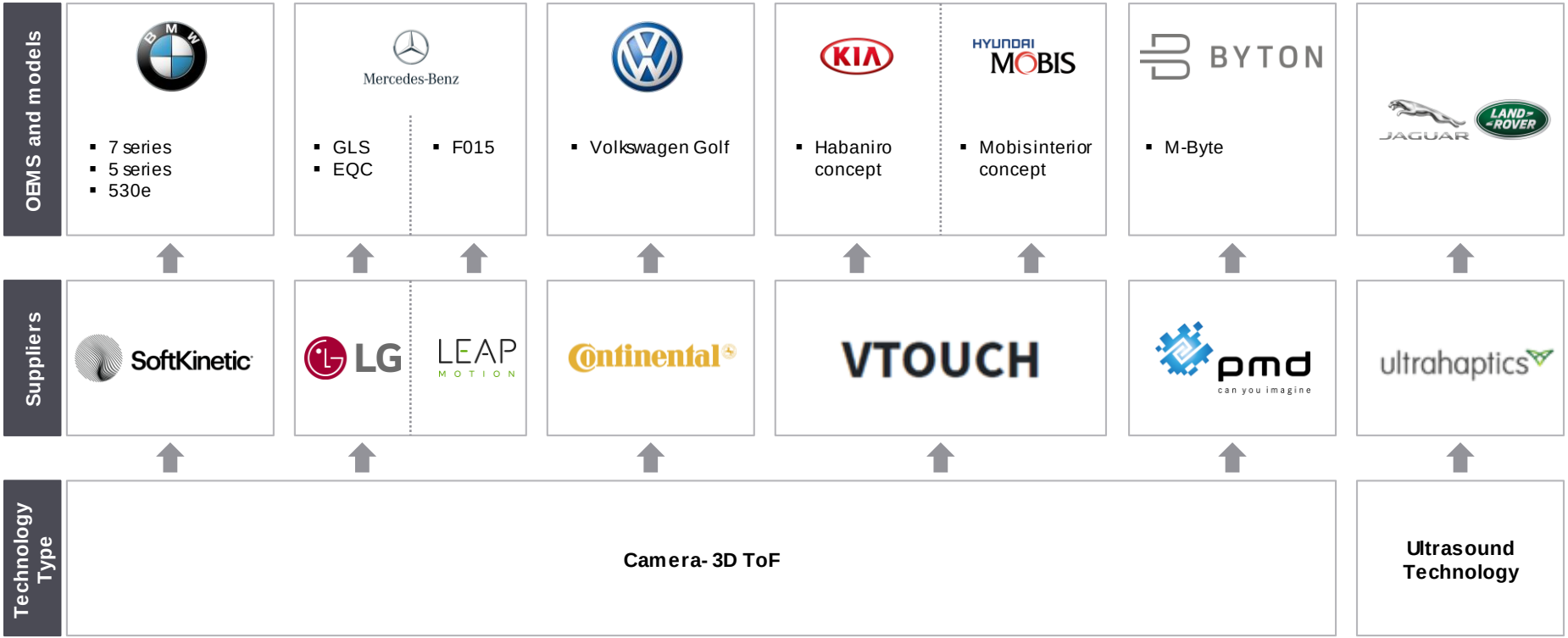
	OEMs	Suppliers	Model	Technology type
Curved/ Flexible Displays	Volkswagen	BOSCH	Touareg	12.3 inch curved instrument cluster
	Land Rover	Panasonic	Velar	Curved Central Console
	Yanfeng	FlexEnable	XiM17	Flexible OLCD
	Audi	SAMSUNG	E-tron	7-inch OLED display
Displays	TOYOTA	Panasonic	Lexus ES	Display
	TESLA	FOXCONN	Model 3	Center information display
	Audi	ALPINE	A4L, A6L	Liquid crystal display
	TOYOTA	DENSO	LS 500	Center display
	Aston Martin	Valeo	Vanquish	Display
	Audi	BHTC	A6	Center information display
	Mercedes-Benz	LG	E Class, S Class	OLED Display
Instrument Cluster Displays	PSA Groupe	Visteon	Peugeot-Citroën DS 3	All Digital Instrument Cluster
	BMW	BOSCH	BMW i8	Digital Instrument Cluster
	Volkswagen	BOSCH	Volkswagen Touareg	Curved Instrument Cluster
	TOYOTA	DENSO	2017 Camry	TFT LCD Instrument Cluster
	HONDA	NIPPON SEIKI CO.,LTD.	CR-Z	Light-emitting type
	Mitsubishi Motors	NIPPON SEIKI CO.,LTD.	Mitsubishi Outlander	Digital & Analog combination type
	Ford	Delphi Technologies	Ford Mustang	OLED Display

** Not exhaustive list of players*

Supply Chain for Gesture Control technology

Major Players focus on cameras for gesture control but ultrasound is also considered an emerging technology

NEW

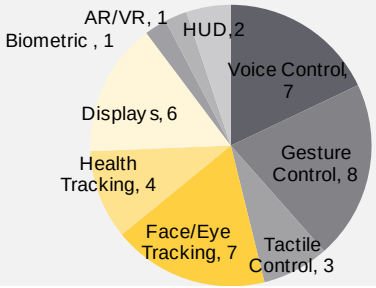


** Not exhaustive list of players*

Startup Summary in H1'19

Of the 39 startups we monitor, 20% are working on Gesture control. USA leads as innovation hub, followed by Germany

Startups in HMI by technology



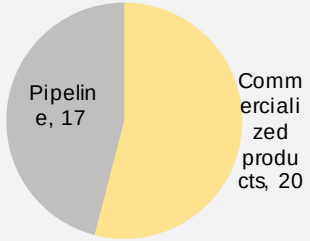
Some key startups active in H1 2019

actronika → Haptic technology for haptic feedback

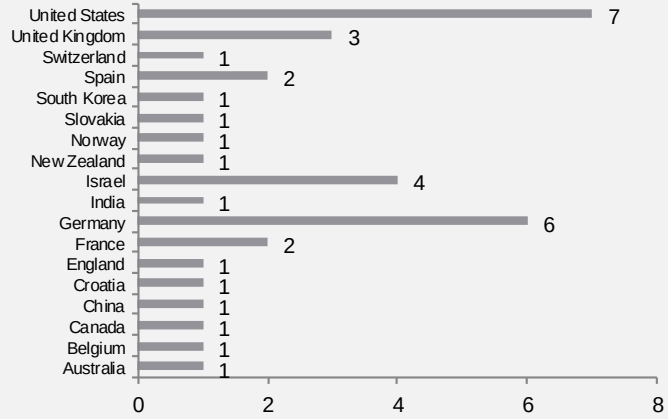
QUAD industries → Printed flexible electronics

FlexEnable Truly flexible electronics → Flexible displays

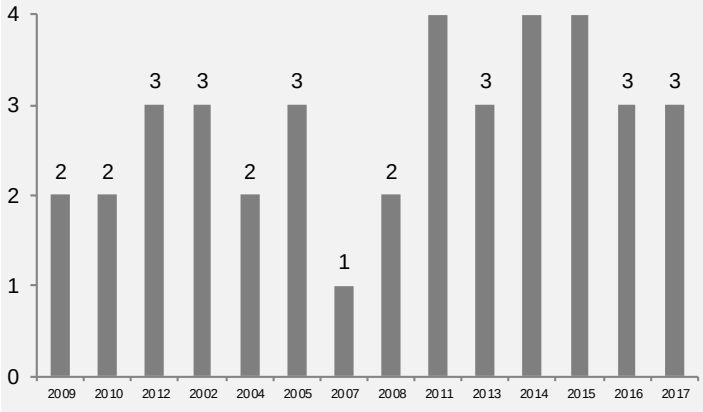
Startups with commercialized products



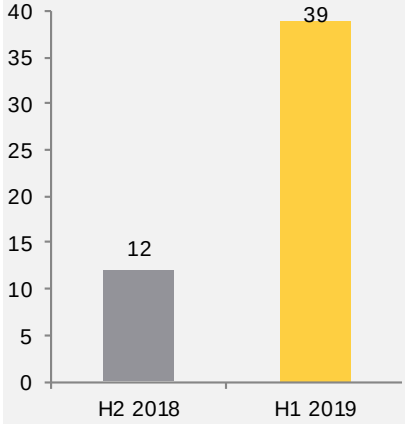
Startups by geography



Startup incorporation



Number of Startups Tracked



Product Launches in Human Machine Interface Technologies

Major players, such as Ford and BMW develop China-specific offerings to cater to the market which has high potential

NEW

Jan 2019

Panasonic

Jan 2019: Panasonic Automotive Announces Launch of SPYDR 2.0 with HUD integration >>

Feb 2019

PERATECH

Feb 2019: Peratech has launched its QTC®-based EDGE force-sensing solution suitable for automotive application >>

Mar 2019

TomTom Elektrobit

Mar 2019: TomTom and Elektrobit introduced first HD map horizon for automated driving >>

Apr 2019

Ford

Apr 2019: Ford launched SYNC+ infotainment system in **China** >>

Apr 2019

Weather Telematics

Apr 2019: Weather Telematics launched road safety alert platform >>

May 2019

BMW

May 2019: BMW M develops new display and control system for its vehicles >>

Jun 2019

TELENAV

Jun 2019: Telenav launches VIVID in-vehicle infotainment system >>

Jun 2019

Dow

Jun 2019: Dow launches silicone optical bonding materials for displays >>

2019 (end)

BMW

2019 (end): BMW to launch Alibaba's intelligent voice assistant "Tmall Genie" in **China** >>

2019 (end)

BYTON

pmd

2020: Byton M-byte with pmd technologies' gesture control to available in **China**, **US** and **Europe** from 2020 >>

2020

SoundHound

PSA GROUPE

2020: SoundHound Inc. and Groupe PSA Partner to Integrate Embedded, Voice AI Into Groupe PSA vehicles in **Europe** from 2020 >>

2020

Google

VOLVO

2020: Google's android Automotive OS on the Volvo's Polestar 2 EV >>

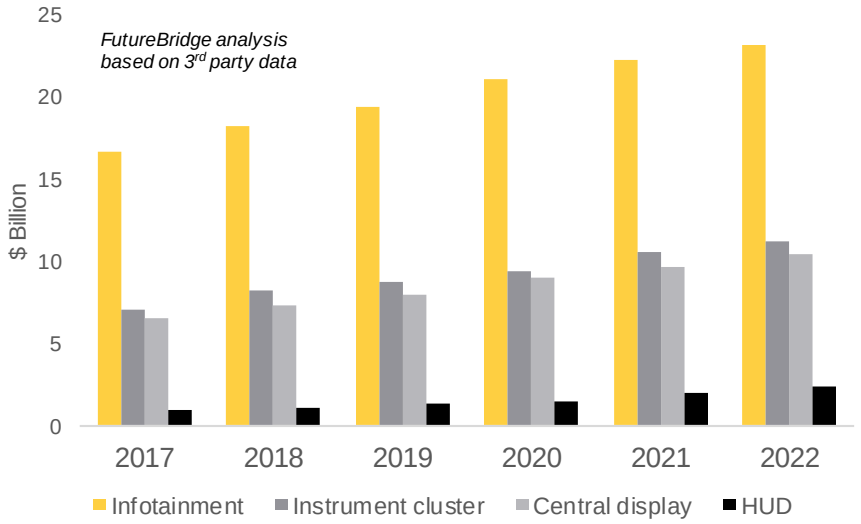
Source: Industry Developments

HMI Forecast

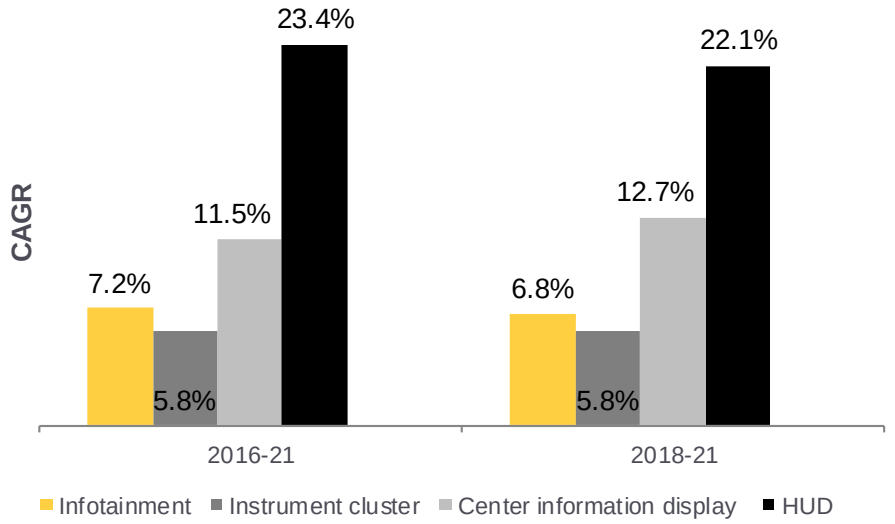
Digital instrument clusters, HUDs to go mainstream while display functions increase to support the cockpit of future

NEW

Market Projections on HMI technology segmentation



Revenue growth of HMI technologies between 2016-21 & 2018-21 (CAGR)



We expect that revenues from In-car displays, which include Instrument clusters, central displays and HUDs, will grow with CAGR 10.1% between 2019 and 2022 to reach $24 billion from $18bn. We see demand across all the technology segmentation to provide the fully-digital, multi-display, interactive cockpit of the future customers demand. Specifically, the shift to higher levels of autonomy pushes for driver monitoring cameras to support transition control while digital, HD clusters enhance the customer experience in autonomous mode. Gesture and haptic feedback go mainstream.

We see HUDs, a niche market today, as the technology segmentation growing faster in the period 2018 to 2021 (CAGE 22.1%) as features become mainstream. Within instrument clusters, we assess that digital clusters will achieve the highest growth in terms of global revenues, with CAGR 11.9% between 2018-22, from 2.3 to $3.6bn. However, analog-digital clusters will still hold the highest market share.

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