

element14

TECH JOURNAL

TRANSPORT

TRANSPORTATION IN THE IOT WORLD



> THE CHALLENGES OF IIOT
PREDICTIVE MAINTENANCE

+ PLUS

- HEADS-UP DISPLAYS
- HOW TO MAKE A DRONE
- SMART FREIGHT

The Largest Online Community for Engineers

element14
COMMUNITY

Join for **FREE** at element14.com/community

CONNECT with a community of thousands of engineers and innovators from all over the world.

LEARN about the very latest in new technology from industry experts, suppliers, independent sources and user reviews.

CREATE and source your next electronics project with access to 24/7 community support to tackle tough project challenges.

INSPIRE and be inspired; build your next project and help others to create a better connected world.



Exclusive Features

- Design Challenge & Project14 Competitions
- element14 Presents Show Every Friday
- Design Center Technical Resources & Experts
- RoadTest New Products
- EAGLE, CircuitStudio & Other Design Software
- Essentials Learning Modules & Webinars

Popular Community Content

Business of Engineering – profiles on engineers from around the globe to case studies on successful startups.

Industrial Automation – follow discussions and get the latest information from top suppliers on what goes in to Industry 4.0.

Internet of Things (IoT) – join the conversation on nodes, gateways and the cloud - from selecting the right hardware to designing for safety and security.

Find out more @ element14.com

Join the conversation
Follow element14 on





Issue 13 2018

4 **Drone applications**
FROM DELIVERY AND SURVEILLANCE TO COMMUTING

14 **How to make a drone**
CONSTRUCTING YOUR OWN DRONE

20 **Visionary thinking**
VISION-BASED ADVANCED DRIVER-ASSISTANCE SYSTEMS

26 **From preventive to predictive maintenance**
HOW IIOT WILL TRANSFORM PLANT MAINTENANCE

30 **Automotive heads-up displays**
THE ROLE OF WINDSCREEN HEADS-UP DISPLAYS

40 **Transportation and the IoT**
THE TRANSPORTATION PROCESS IN THE IOT WORLD

EDITOR-IN-CHIEF CLIFF ORTMEYER
MANAGING EDITOR ANKUR TOMAR

element14

© Premier Farnell Corp 2018. All rights reserved. No portion of this publication, whether in whole or in part, can be reproduced without the express written consent of Premier Farnell Corp. All other registered and/or unregistered trademarks displayed in this publication constitute the intellectual property of their respective holders. Errors and omissions in the printing of this magazine shall not be the responsibility of Premier Farnell Corp. Premier Farnell Corp reserves the right to make such corrections as may be necessary to the prices contained herein.



Welcome

The automotive industry is on the verge to get a technology-driven reboot. Autonomous cars are a reality now and the move to flying cars promises to be an exciting and technology driven adventure. In this edition of element14 Tech Journal, read about the present state and future of drone technology from deliveries and surveillance to commuting. We look at the diversity of drone applications, onboard technologies, address national and international legislation and how drones can be scaled up to passenger transport, and the new set of challenges that this presents.

You'll also learn about the vision-based Advanced Driver-Assistance Systems (ADAS), the secret behind the ADAS sensing technologies to implement front, side and rear view cameras to detect objects such as traffic signs and pedestrians as well as track the vehicle's lane position. We also explore how the new vehicle safety legislation and demand for increased convenience is forcing ADAS technology to become a standard feature in high-end vehicles and increasingly an option in mainstream models.

Continue on to read more about how the windscreen Heads-Up Displays (HUD) have now become part of the automobile marketplace and its operating principle. And finally learn how IoT based smart control and monitoring capabilities can provide reliable and trackable global freight transportation for critical applications including perishable and high value goods.

We hope you enjoy this edition of *element14 Tech Journal* and welcome your comments and suggestions. Please feel free to drop us a note.

Cliff Ortmeier Editor, Tech Journal
Email: editor-TJ@element14.com

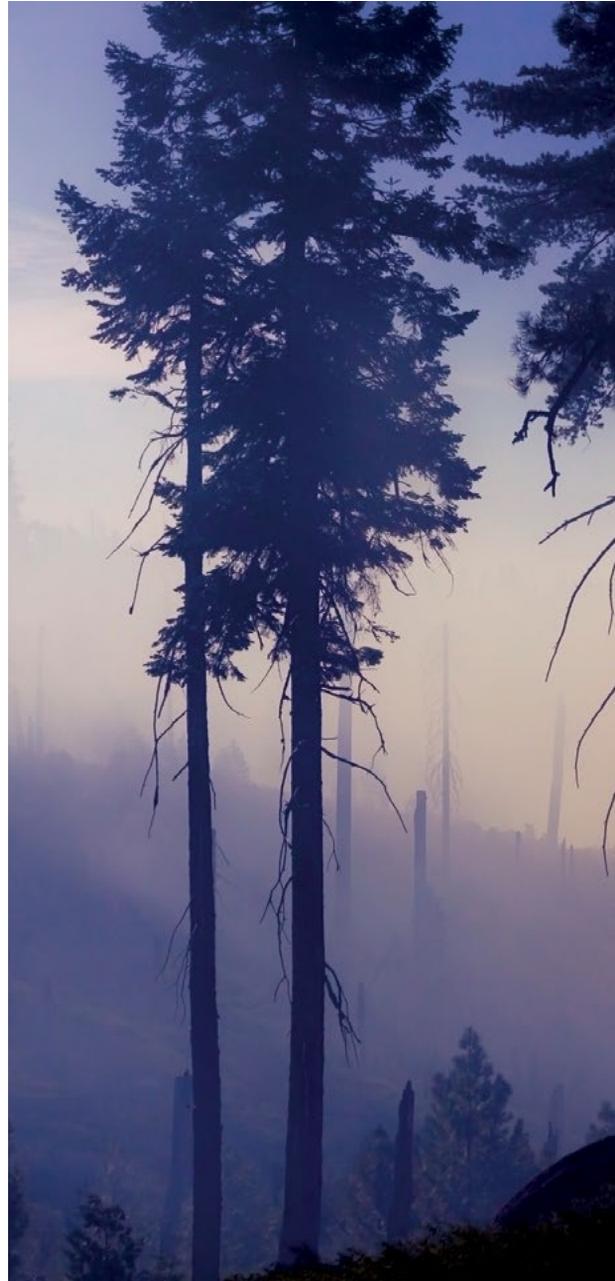


DRONES FROM DELIVERY AND SURVEILLANCE TO COMMUTING

In 1935, the DH.82 Queen Bee, a pilotless, radio-controlled variant of the de Havilland Tiger Moth, became available for use in training anti-aircraft gunners; its name is widely believed to explain why today's UAVs are often called 'drones'.

SINCE THOSE EARLY days, drones have not only found important military roles, but are also becoming increasingly powerful tools for government, commercial and consumer applications. While they are currently deployed for military, visual or cargo payload roles, Uber and other companies are planning to introduce drones designed for passenger transportation.

This article reviews present and future drone technology. We look at the diversity of applications where they're currently used, and discuss the onboard technologies that take them in to these. We also address national and international legislation that impacts drones. We then consider how drones can scale up to passenger transport, and the new set of challenges that this presents.



FIRE URGENCY ESTIMATOR IN GEOSYNCHRONOUS ORBIT (FUEGO): A DRONE WITH CAMERA TO DETECT AND INFORM ON FIRES EARLY



DRONE APPLICATIONS



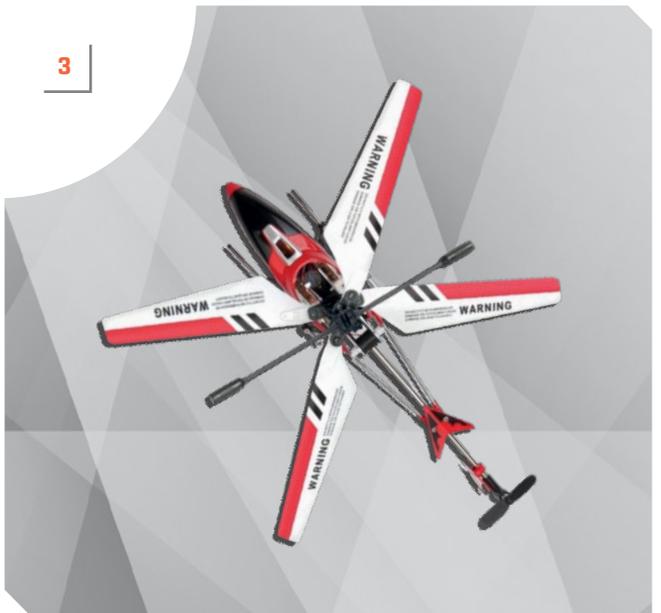
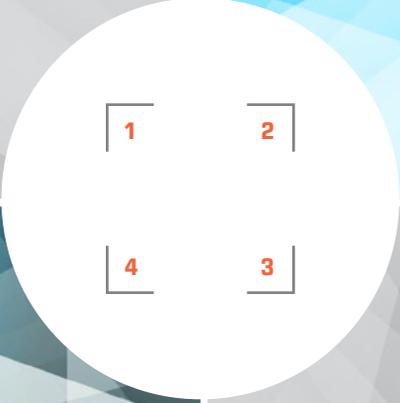
Drones can perform air operations that manned aviation finds difficult or impossible, and they provide evident economic savings and environmental benefits whilst reducing the risk to human life.

THEY ALREADY SUR-pass manned aircraft in endurance, range, safety and cost efficiency, but next-generation devices will widen the gap still further, adding greater stealth, sensory, payload, range, autonomous and communications capabilities. Drone sensor technology currently in development can map 2.7 million square miles in a single flight – nearly the area of the 48 contiguous US states.

With their growing capabilities, drones are being used in an ever-wider and more innovative range of applications, each with their own unique set of challenges. While some drones are versatile enough to fulfil many types of mission, most are more specialised, and designed for a single purpose.

TYPICAL APPLICATIONS

- Agriculture
- Airborne early warning
- Anti-submarine
- Cargo transport
- Communication relay
- Conservation
- Decoy
- Disaster recovery
- Environmental monitoring
- Fire fighting
- Intelligence
- Meteorology
- Mine detection and detonation
- Natural resources
- Personnel transport
- Photography
- Pipeline inspection
- Reconnaissance
- Remote sensing
- Search
- Surveillance
- Surveying
- Target designation
- Traffic
- Wildlife monitoring



■ DRONE APPLICATIONS

OPERATIONAL CONSIDERATIONS

Drones are available in many types of geometries, which can be broadly classified under three headings: **fixed wing, helicopter and multirotor.**

The choice of geometry, and the best way of assembling and equipping it, depend on the application. Here are some factors to consider when choosing a drone solution, as described in an article by CMEC, who are designers and manufacturers of batteries for electric UAVs.

DRONE TYPE COMPARISON

The relative merits of each drone type



01 MULTIROTOR DRONES

PROS

- › Accessibility
- › Ease of use
- › VTOL and hover flight
- › Good camera control
- › Can operate in a confined area

CONS

- › Short flight times
- › Small payload capacity

TYPICAL USE

- › Aerial photography
- › Video aerial inspection

Multirotor drones are an easy and cheap way of getting a small camera into the air for a short time. They allow good control over position and framing, making them perfect for aerial photography work. However, they have limited endurance and speed, making them unsuitable for aerial mapping, long endurance monitoring and long-distance inspection as needed for pipelines, roads, and power lines.

Although their technology is continually improving, multirotors are fundamentally inefficient and energy-hungry, as they must constantly fight gravity just to stay aloft. Current battery technology limits electric drones to around 20 – 30 minutes' flight time with a lightweight camera payload. Internal combustion (IC) engines aren't suitable, as they cannot handle the fast and high-precision throttle changes essential for stability.

02 FIXED-WING DRONES

PROS

- › Long endurance
- › Large area coverage
- › Fast flight speed

CONS

- › Launch and recovery needs a lot of space
- › no VTOL/hover
- › Harder to fly, more training needed
- › Expensive

TYPICAL USE

- › Aerial mapping
- › Pipeline and power line inspection

By contrast, fixed-wing drones, like aeroplanes, use their wings rather than vertical rotors for lift. Requiring energy only to move forward, they are far more fuel-efficient than multi-rotors. Additionally, these drones can use IC engines, so many can stay aloft for up to 16 hours. They can cover longer distances, map much larger areas, and loiter for extended periods monitoring their point of interest.

However, fixed wing drones also have downsides. Being unable to hover, they're unsuitable for aerial photography work. Launching and landing is more demanding, as they need a runway or catapult for take-off and a runway, parachute or net to land safely. Only the smallest fixed-wing drones are suitable for hand launch and 'belly landing' in an open field. These types are also higher-cost, and operating them is more difficult to learn.

03 SINGLE-ROTOR HELICOPTERS

PROS

- › VTOL and hover flight
- › Long endurance (with gas power)
- › Heavier payload capability

CONS

- › More dangerous
- › Harder to fly, more training needed
- › Expensive

TYPICAL USE

- › Aerial LIDAR laser scanning

Single-rotor helicopters are another option. While a multi-rotor drone has many rotors to keep it aloft, a helicopter has just one, plus a tail rotor to control its heading. Helicopters are more efficient than multi-rotors, and, for even better endurance, can use IC engines for propulsion. One rule of aerodynamics is that increasing size and reducing spin speed improves rotor blade efficiency; this is why a quad-copter is more efficient than an octo-copter, and special long-endurance quads have a large prop diameter. A single-rotor helicopter allows for very long blades which are more like a spinning wing than a propeller, giving great efficiency.

Single-rotor helicopters are ideal for hovering with a heavy payload such as an aerial LIDAR laser scanner, or for hovering combined with long endurance or fast forward flight. The downsides are their complexity, cost, vibration, and the danger of their large spinning blades, which represent a significant safety hazard. They can hover on the spot, making them easy to learn and manage, but they're not as stable or forgiving of bad landings as multirotors. Additionally, their mechanical complexity demands much maintenance and care.

04 FIXED-WING HYBRID VTOL

PROS

- › VTOL and long-endurance flight

CONS

- › Not perfect at either hovering or forward flight
- › Still in development

TYPICAL USE

- › Drone delivery

A new alternative, called fixed-wing hybrid VTOL, merges the benefits of fixed-wing flight with an ability to take off and land vertically, and hover. These concepts were tried out with manned aircraft in the 50s and 60s, but proved too complex and difficult to fly. However, they are now beginning to become feasible, with the arrival of modern autopilots, gyros and accelerometers. The autopilot can maintain stability, leaving the human pilot the easier task of guiding them around the sky.

DRONE LEGISLATION



Legislation as well as technology is a limiting factor on drone industry growth. Uncertainty weighs on innovation and commercial adoption, but anticipated regulatory clarity should unlock demand.

NASA IS LEADING A multibillion-dollar effort to develop a US airspace management system capable of safely coordinating manned and unmanned flight, while the Federal Aviation Administration (FAA) is expected to further ease restrictions that are keeping commercial

drones from reaching their full potential.

Current FAA regulations restrict drones from flying over 400 feet, and they must stay within their pilot's line of sight. Autonomous operation is not allowed. They cannot operate over people, and must be flown by someone with a remote pilot certificate.



In Europe, the European Aviation Safety Agency (EASA) has published an Opinion 01/2018 which includes a proposal for a new regulation for UAS operations, with three categories.

01 OPEN CATEGORY

'Open' category is a category of UAS operation that, considering the risks involved, does not require a prior authorisation by the competent authority nor a declaration by the UAS operator before the operation takes place;

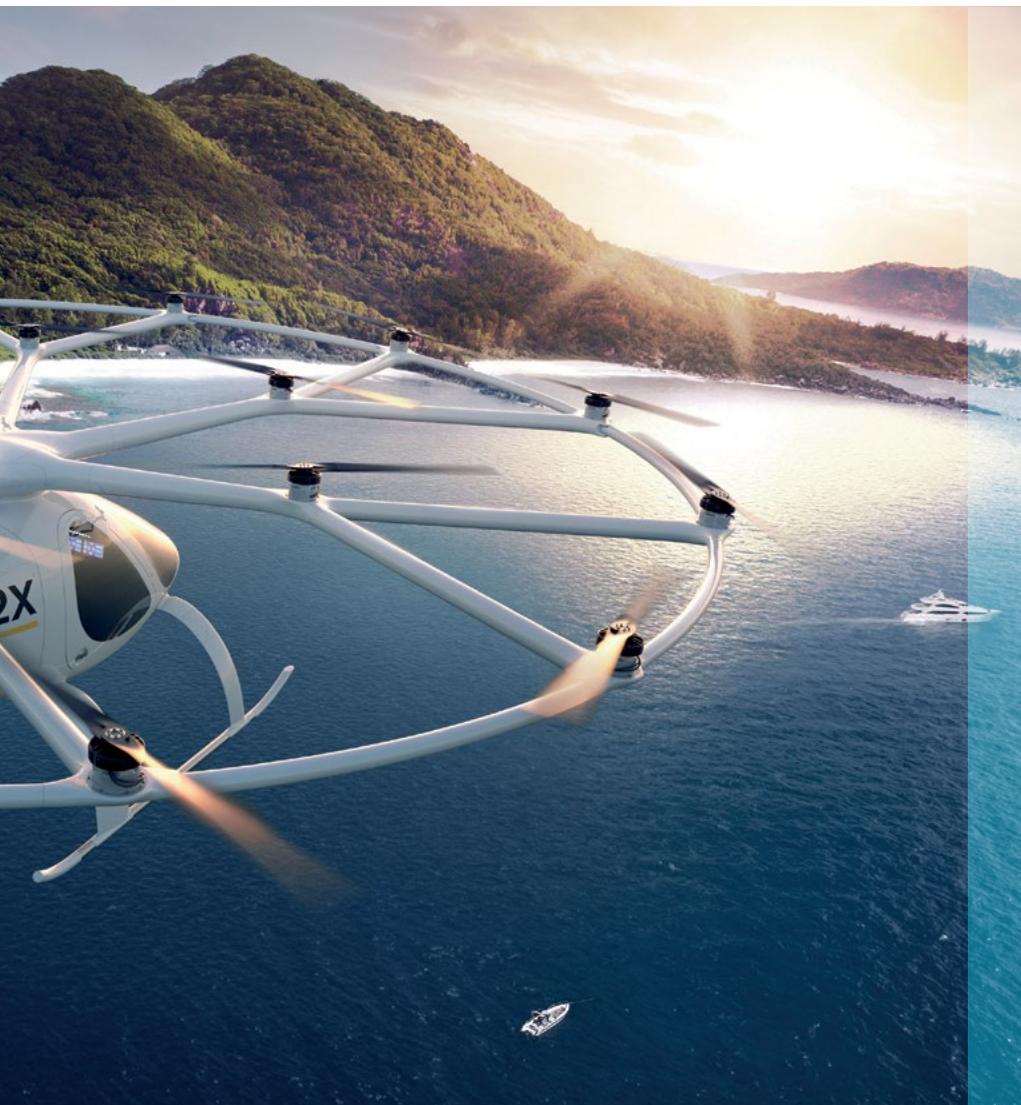
02 SPECIFIC CATEGORY

'Specific' category is a category of UAS operation that, considering the risks involved, requires an authorisation by the competent authority before the operation takes place, considering the mitigation measures identified in an operational risk assessment, except for certain standard scenarios where a declaration by the operator is sufficient or when the operator holds a light UAS operator certificate (LUC) with the appropriate privileges.

03 CERTIFIED CATEGORY

'Certified' category is a category of UA operation that, considering the risks involved, requires the certification of the UAS, a licensed remote pilot and an operator approved by the competent authority, in order to ensure an appropriate level of safety.

easa.europa.eu/document-library/opinions/opinion-012018



New UK Government laws, introduced in May 2018, are intended to tighten the safety of all drone flights. All drones are restricted from flying above 400 feet and within one kilometre of airport boundaries. Additionally, drone users have to register and take online safety tests to improve accountability.

EACH EUROPEAN country has its own aviation authority in addition to any applicable European legislation. In the UK, this role is fulfilled by the Civil Aviation Authority (CAA), whose aim is to ensure that all Unmanned Aircraft Systems (UAS) are fully and safely integrated into the UK's total aviation system.

The type and extent of CAA regulations imposed on a drone depend on the following parameters:

TYPE OF OPERATION

Within the Visual Line of Sight (VLOS) or beyond the Visual Line of Sight (BVLOS) of the person flying the aircraft.

PURPOSE OF FLIGHT

Recreational, Commercial or Private/Non-Commercial.

WEIGHT (MASS) CATEGORY

20 KG OR LESS Small Unmanned Aircraft

This class covers all types including traditional remotely controlled model aeroplanes, helicopters or gliders, as well as the increasingly popular multirotor 'drones' and remotely controlled 'toy' aircraft. They normally have a reduced level of regulation imposed on them which is aimed at being proportionate to the risk and complexity or their types of operation.

20–150 KG Light Unmanned Aircraft

This class covers the larger and potentially more complex types

of unmanned aircraft and large model aircraft. They are subject to all aspects of UK aviation law, although it is accepted that they will require to be exempted from many of the requirements.

OVER 150 KG Unmanned Aerial System

Unmanned aircraft within this class will normally be subjected to the same level of regulatory approval requirement as would be used for traditional manned aircraft. They will normally be certificated by the European Aviation Safety Agency (EASA).



TRANSPORT



COMMUTER & AIR TAXI PASSENGER DRONES

With progress in legislation and technologies, a \$100 billion market opportunity for the period 2016-2020 has been forecast for drones in military, payload and vision applications. However, many entrepreneurs and engineers around the world are pushing for a yet more exciting development; using drones for passenger transportation.



VOLOCOPTER PASSENGER DRONE

VOLOCOPTER

Volocopter, the drone's designer, hopes to have the taxis up and running within four years.

"Implementation would see you using your smartphone, having an app, and ordering a Volocopter to the next Voloport near you," said Chief Executive Florian Reuter. "The Volocopter would come and autonomously pick you up and take you to your destination."

volocopter.com

EHANG

A number of other companies, including Airbus and several of its subsidiaries, are researching self-flying drone technology.

Chinese company Ehang has launched their 184, which can carry a single passenger for up to 23 minutes on one battery charge, giving a flight radius of around 10 miles.

ehang.com

IN AND AROUND most large cities, ever-growing traffic volumes are making ground-based commuting and taxi transport an increasingly frustrating and time-consuming experience. Wouldn't it be great if we could relieve this with drones and their access to three-dimensional space?

To make this a viable and safe proposition requires considerable further development of drone

technology, legislation and infrastructure – but progress is being made, and detailed plans are being developed to overcome these challenges. In September 2017, Dubai conducted its first test of a drone taxi service that it hopes will become a viable transportation system in the city. The test comprised a two-seater, 18-rotor drone which completed a five-minute flight above a strip of sand on the Gulf coast.





UBER ELEVATE



Uber is developing plans, under an initiative they call 'Uber Elevate', to develop passenger drone technology and the infrastructure to support an air taxi drone service.

The concept is based on a network of small, electric aircraft that take off and land vertically (VTOL) that will enable rapid, reliable transportation between suburbs and cities, and, ultimately, within cities.

The VTOL aircraft could be complemented by an urban VTOL infrastructure of 'vertiports' based on the repurposed tops of parking garages, existing helipads, and even unused land surrounding highway interchanges. These vertiports would include multiple take-off and landing pads as well as charging facilities. The infrastructure could also contain single-aircraft 'vertistops' with minimal facilities.

Uber believes that in the long term, VTOLs will become an affordable form of mass daily transportation, even less expensive than car ownership. If VTOLs serve the on-demand urban transit case well, with quiet, fast, clean, efficient and safe transportation, then a path to high production volumes and associated lower per-unit costs may exist. This path can be helped, especially initially, with the ridesharing model and its amortisation of costs.

uber.com/elevate



UBER DRONE AND VERTIPORT

Success in this ambitious vision depends on effective co-operation between the key players within the VTOL ecosystem: regulators, vehicle designers, communities, cities, and network operators. Uber has identified that bringing on-demand urban air transportation to market depends on resolving the following critical challenges.

The Certification Process

BEFORE VTOLS CAN OPERATE in any country, they will need to comply with regulations from aviation authorities — namely the US Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) who regulate 50% and 30% of the world's aviation activity.

Air traffic control

URBAN AIRSPACE IS actually open for business today, and with ATC systems exactly as they are, a VTOL service could be launched and even scaled to possibly hundreds of vehicles. Under visual flight rules (VFR), pilots can fly independent of the ATC and when necessary, they can fly under instrument flight rules (IFR) leveraging existing ATC systems. A successful, optimized on-demand urban VTOL operation, however, will

necessitate a significantly higher frequency and air-space density of vehicles operating over metropolitan areas simultaneously. In order to handle this exponential increase in complexity, new ATC systems will be needed. Uber envisions low altitude operations being managed through a server request-like system that can deconflict the global traffic, while allowing UAVs and VTOLs to self-separate any potential local conflicts with VFR-like rules, even in inclement weather.

VTOL possibilities

NASA and the FAA recently spearheaded a series of On-Demand Mobility (ODM) workshops to bring the VTOL ecosystem together in identifying barriers to launching an on-demand VTOL service. Their findings aligned quite well with Uber's.



VEHICLE EFFICIENCY

Helicopter rotor flight is not as efficient as fixed-wing operation, due to wing lift efficiency. Efficiency must be improved to make VTOL aircraft commercially viable.

Vehicle performance

Vehicle performance relates to cruise speed and take-off and landing time, and system reliability is measured as time from request until pick-up. Robustness in varied weather conditions is also a concern, as bad weather could ground a large percentage of a vehicle fleet at arbitrary times.

Aircraft noise

Electric propulsion will be critical in achieving noise levels low enough

to be acceptable to any affected community.

Cost and affordability

Helicopters, the closest practical proxy to the proposed VTOL solutions, are too expensive and noisy for large-scale use in urban areas. Uber proposes simpler, quieter and more operationally efficient vehicle designs which leverage digital control rather than mechanical complexity. This could kickstart a virtuous cycle of economies of scale providing cost and price reduction.

Battery technology

Electric propulsion has many desirable characteristics that make it the preferable propulsion choice for the VTOL aircraft as discussed, and batteries are the obvious energy source. However, improvements in several key areas are needed to improve their viability; energy per unit weight, charge rate, cycle life, and cost per kWh. A collaboration between the US Department of Energy and university labs is focusing on lithium-metal solutions. There is also research into pulse chargers which could significantly reduce charging times.

Emissions

Electrically propelled vehicles have zero operational emissions. However, this still leaves concerns about how the electricity for recharging the VTOL batteries is generated; currently, this is still largely coal, natural gas and petroleum based.

Vertiport infrastructure

The greatest operational barrier to deploying a VTOL fleet in cities is a lack of sufficient locations to place landing pads that are readily accessible and can support charging stations. The Uber report discusses how infrastructure could be developed to overcome this problem.

Safety

Uber describes plans to ensure VTOLs are twice as safe (half the fatalities) as privately-operated cars.

Pilot training

Training to become a commercial pilot is demanding and time-consuming, and a shortage of qualified pilots is expected to curtail growth significantly. Pilot augmentation technology will significantly reduce pilot skill requirements, and this could lead to a commensurate reduction in training time.

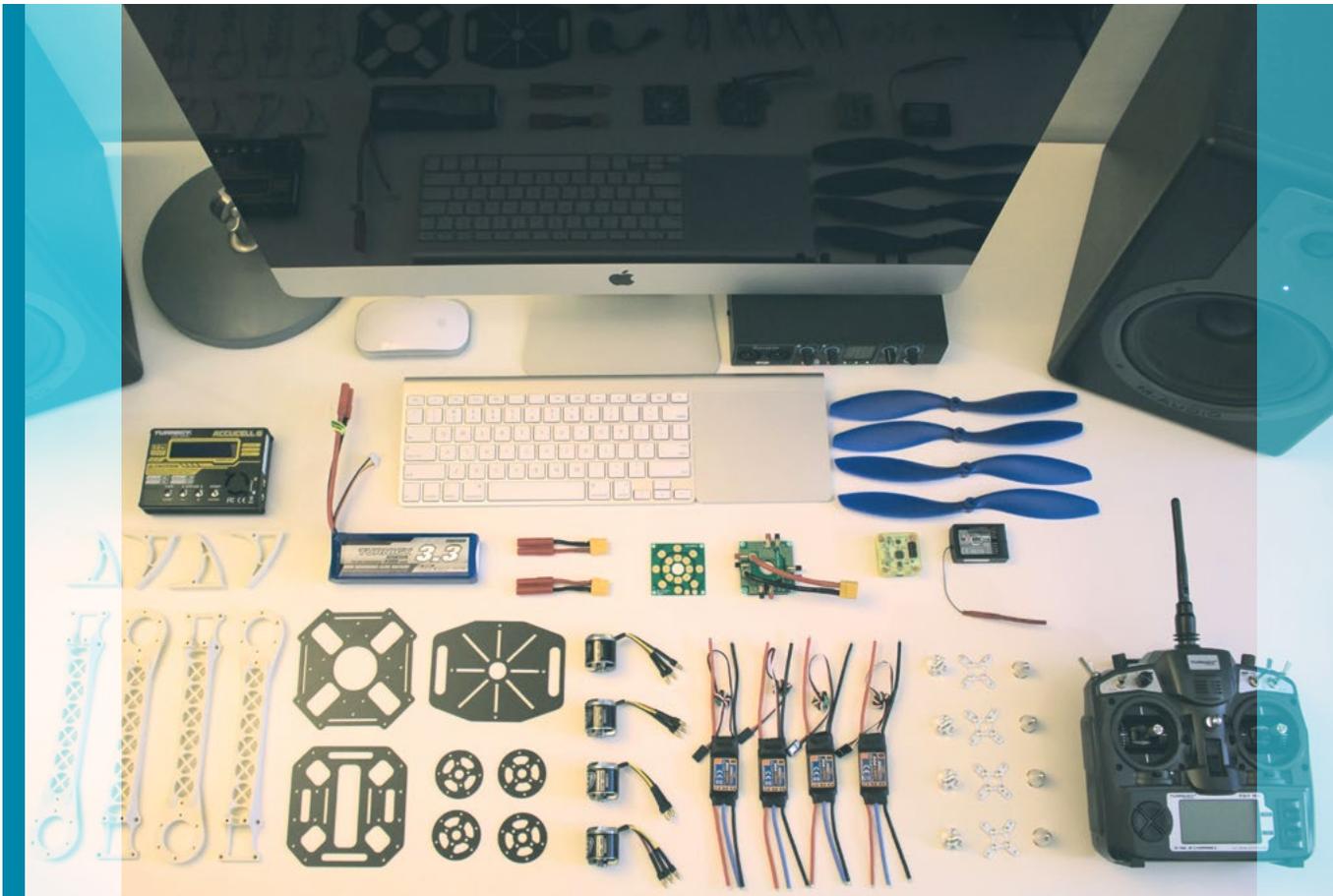




TUTORIAL

HOW TO MAKE A DRONE

If you're interested in constructing your own drone, Coleman Benson has prepared an 8-lesson tutorial explaining how to do so; this can be found on the RobotShop website. Here we present a summary of the topics covered. The tutorial starts with a Terminology reference list, including definitions of various UAV geometries.



robotshop.com/community/tutorials/series/how-to-make-a-drone-and-uav



THE FRAME

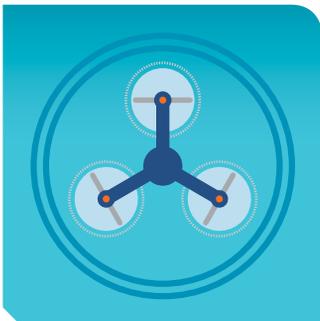


SCAN EAGLE CATAPULT

The first step in UAV construction is to choose the frame; this can be either assembled from a UAV frame kit, or entirely DIY. Geometry options include:

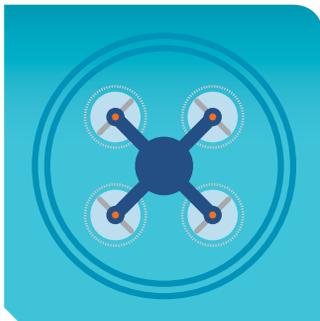
AIRCRAFT

For some applications, a fixed-wing design might be preferable to a multirotor approach. This tutorial compares the two design geometries.



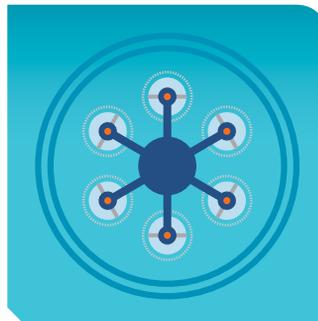
TRICOPTER

Three arms each with one motor.



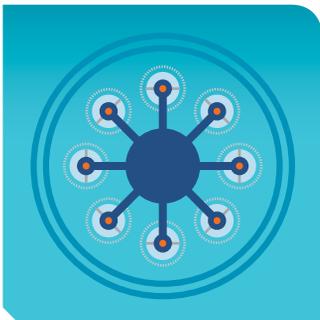
QUADCOPTER

Four arms each with one motor.



HEXACOPTER

Six arms each with one motor.



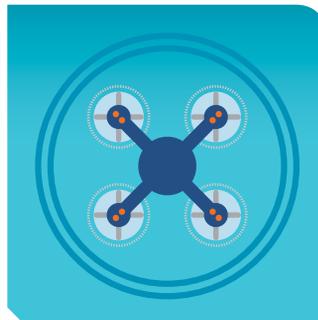
OCTOCOPTER

Eight arms each with one motor.



Y6

Three arms, each with two motors, one top and one bottom. Note that all propellers project thrust downwards.



X8

Like a Y6, but with four arms, each with two motors.

SIZE RANGE

Size must also be decided. For hobbyists, the best size range for versatility and value is between 350 mm and 700 mm, as a measurement of the diameter of the largest circle that intersects all of the motors. Decisions between construction materials – wood, foam, plastic, aluminium and others – must also be made. Other considerations include:

Gimbal

For mounting and stabilising cameras.

Payload

The extra weight must be accounted for, and the load must be secured against shifting in flight.

Landing gear

Mounting



PROPULSION

A complete propulsion system includes motors, propellers, electronic speed controllers and a battery. Almost all small multi-rotor drones / UAVs are electric, with almost none being gas-powered.

● Motor

Brushless DC motors are used extensively in the hobby RC industry for products ranging from helicopters and aeroplanes to the drive system in RC cars and boats. Smaller UAVs (usually the size of the palm of your hand) tend to use small brushed motors because of the lower price and simpler two-wire controller. Key parameters for motors include KV ratings (rotation speed for a given voltage) and thrust in Kg, Lb or N.

● Propeller

Propeller parameters include number and diameter of blades, pitch, angle of attack, efficiency and thrust, rotation (clockwise or anti-clockwise), material, folding, mounting, prop savers and guards, and balancing.

● ESC

An Electronic Speed Controller (ESC) controls the speed and direction of a motor. The ESC must be able to handle the maximum current which the motor might consume, and provide it at the right voltage.

● Battery

Most batteries are lithium polymer (LiPo), or possibly lithium-manganese or another lithium variant. LiPo offers high capacity with low weight, together with high discharge rates. However, they are of comparatively higher cost, and have some safety issues.

■ DRONE MOTOR TYPES



INRUNNER



BRUSHLESS DC



DC 'PANCAKE' TYPE



FLIGHT CONTROLLER



A flight controller for a multi-rotor UAV is an integrated circuit normally made up of a microprocessor, sensors and input/output pins.

OUT OF THE BOX, A FLIGHT controller does not magically know your specific UAV type or configuration, so you need to set certain parameters in software, and once complete, that configuration is then uploaded to the board.



STMicroelectronics

STEVAL-FCU001V1 Evaluation Board

PART# 2818311

The STEVAL-FCU001V1 Evaluation Board is a complete flight controller unit evaluation board for toy drones, featuring flight sensors and Bluetooth. It is designed to support quadcopter drone designers. A complete sample FW project allows the designer to begin flying small and medium size quadcopters.

Multicopter UAV flight controllers will be connected to the sensors listed below, or a subset of them.

● Magnetometer

An electronic magnetic compass measures the earth's magnetic field and uses it to determine the drone's compass direction (with respect to magnetic north). This sensor is almost always present if the system has GPS input.

● Pressure/barometer

Provides accurate reading of UAV height.

● GPS

Uses the signals sent by satellites in orbit around the earth to determine the UAV's specific geographic location.

● Distance sensors

Measures distance from the ground – or a hill, mountain or building – to minimise risk of hitting a target. Distance sensors use Lidar, laser or ultrasonic technology.

● Accelerometer

Measures acceleration in up to three axes and helps maintain UAV stability.

● Gyroscope

Measures the rate of angular change in up to three angular axes.

● IMU

An Inertia measurement unit (IMU) is a small board which contains both an accelerometer and gyroscope. It may contain additional sensors such as a three-axis magnetometer.

REMOTE CONTROL



A remote control (RC) transmitter and receiver is needed to allow an operator to control the drone. The (usually) hand-held transmitter has at least four channels, comprising:

Pitch

Which translates to forward/backward motion.

Elevation

Closer to or farther away from the ground.

Yaw

Rotating clockwise or counter-clockwise.

Roll

To strafe left and right.

Additional channels

Additional channels can include:

- Arming / disarming the motors
- Gimbal controls: pan up/down, rotate clockwise / counter-clockwise, zoom
- Change flight modes: acrobatic mode, stable mode etc.
- Activate / deploy a payload, parachute, buzzer or other device
- Any number of other uses

ASSEMBLY

This tutorial contains practical information, and mistakes to avoid, when assembling the frame, motors, ESCs, propellers, battery, charger, power distribution, flight controller and communications device.

Get it all working together

Setting up and configuring the assembled components.

FIRST PERSON VIEW & LONG RANGE

THIS TUTORIAL INTRODUCES the concepts of First Person View (FPV) and long-range control. FPV currently involves mounting a video camera on the drone which sends video in real time to the pilot. FPV systems can work with 3D/VR head mounted displays from Oculus Rift, Samsung, Gear, Morpheus and other manufacturers.



Sentera

Double 4K Inspection Sensor

Rugged, high throughput sensor for agricultural infrastructure inspection applications. Both cameras are capable of capturing high-megapixel colour stills, near-infrared (NIR), normalized difference vegetation index (NDVI) data, and 4K video.

SUMMARY & CONCLUSION



This article has introduced the concepts of UAV operation and construction, and looked at their existing and potential applications.

THIS HAS INCLUDED A CLOSER INVESTIGATION of the exciting and somewhat, but not entirely, futuristic possibilities and challenges of manned UAVs. We finish with a summarised listing of all the factors relating to UAVs and their flight. It has been beyond the scope of this article to cover all these in depth, but the listing should serve as a basis for further research. It's based on an article titled 'Drone Technology' written by Ian Burns of ATIP Law.

atintellectualproperty.com/drone-technology

AIRFRAMES AND STRUCTURE

- Endurance
- Launch and recovery
- Manoeuvrability
- On-board systems
- Operating altitude
- Operating environment
- Range
- Scale effects
- Stability
- Stealth
- Transportation and storage

CONSTRUCTION METHODS

PROPULSION SYSTEMS

- Control
- Endurance
- Maintenance
- Monitoring
- Size and weight

POWER SYSTEMS

STEALTH

- Electromagnetic emissions
- Infrared
- Radar
- Sound
- Visible

LAUNCH AND RECOVERY SYSTEMS

COMMUNICATION SYSTEMS

CONTROL SYSTEMS

- Acceleration and vibration tolerant
- Interference
- Moisture
- Power conditions
- Temperature range and thermal cycles

COLLISION AVOIDANCE

- Communicating with air traffic control, other aircraft and ground stations
- Sensing other traffic
- Determining potential collisions
- Taking evasive action

DATA

- Acquisition
- Processing
- Storage
- Transmission

SENSORS

TRANSPORTATION AND STORAGE

TESTING

SUPPORT

- Diagnostics
- Mission planning
- Recharging
- Refuelling
- Repair and maintenance
- Training
- Security

NXP SBC-S32V234 VISION AND SENSOR FUSION EVALUATION BOARD From MicroSys Electronics GmbH



- Evaluation and production platform for safe, compute-intensive vision processing applications
- miriac® MPX-S32V234 module – NXP S32V234 quad-core automotive microprocessor based on Arm® Cortex®-A53, power regulator
- CRX-S32V234 carrier board – camera, Ethernet, CAN and LIN connectors, SD card slot
- Free-of-charge NXP S32 Design Studio for Vision IDE with ISP and APEX graph tools; Vision SDK with object detection and tracking software demos
- Linux Board Support Package
- \$649 suggested resale

nxp.com/SBC-S32V234



NXP and the NXP logo are trademarks of NXP B.V. All other product or service names are the property of their respective owners. © 2018 NXP B.V.



VISIONARY THINKING

Vision-based Advanced Driver-Assistance Systems (ADAS) are now a firmly established automotive technology, however, complex image processing, vision algorithm development and power dissipation restrictions present challenges for traditional embedded design. To achieve the functionality, performance and safety levels required for broad mass market adoption, new hardware and software approaches are needed.

BY NXP SEMICONDUCTORS



DRIVEN BY NEW vehicle safety legislation and demand for increased convenience, ADAS technology is now a standard feature in high-end vehicles and increasingly an option in mainstream models. Today, driver assist functions include blind spot detection, park assist, adaptive cruise control and automatic emergency braking. Beyond these are varying levels of self-driving capability extending up to fully autonomous systems that can safely operate the vehicle in all conditions without driver monitoring or intervention.



While many ADAS systems fuse data from multiple sensor technologies (camera, radar, LiDAR etc), vision is increasingly likely to act as the mainstream solution for single sensor implementations. These feature front, side and rear view cameras for detecting traffic signs, objects, pedestrians and tracking the vehicle's lane position.

AN EXTRA INTERNAL camera may be included for driver monitoring purposes. The complex and dynamic nature of even a relatively quiet road environment requires an embedded platform with advanced computation and video processing features to continuously capture, condition and classify rich data streams

from high resolution sensors in all weather and lighting conditions. Having acquired this the system must then perform image stitching to create a detailed, real-time map of the vehicle's surroundings. Sophisticated machine learning and environmental modeling algorithms are then applied to determine the most appropriate response and commands sent to the

actuating ECUs to accelerate, brake and/or steer the vehicle as required. The inherent safety-critical nature of the application requires that the hardware achieves a level of reliability beyond that of traditional automotive systems. Likewise, it must include ISO26262 compliant functional safety mechanisms to prevent, detect and mitigate any system failures that may occur. Finally, a robust security layer is required to protect proprietary and third-party application software and, in the case of an externally connected vehicle, to prevent system intrusion that could compromise vehicle safety or allow illegal access to proprietary driver data.

In single and multi-camera vision systems the sequence of generated images (video) contains an extremely large

amount of pixel data which arrives at the microprocessor in raw format via a high speed MIPI-CSI interface, or in encoded format – JPEG or H.264 – via Ethernet.

The complexity of modern vision algorithms and the need to instantly derive useful information from the incoming data stream, presents a significant challenge for standard microprocessor architectures – how to perform the optical flow analysis at a sufficiently high frame rate without dissipating a huge amount of power (heat). The solution is a heterogeneous approach at System-on-Chip (SoC) level where specialized image processors, CPUs and a graphics processing unit (GPU) are assigned specific tasks and hardware acceleration is used extensively.

ADAS

Sensing Technologies



01 CAMERA

FEATURES

- › Data rate 30/60/120 MB/sec
- › Range 3-100m
- › Field of View (FOV) +/- 50°
- › Resolution sensor/optics/ distance dependent

ADVANTAGES

- › Cost
- › Colour and pattern recognition
- › Lateral accuracy
- › Information rich, semantics

LIMITATIONS

- › Lighting/weather dependant
- › Multiple cameras required for reliable 3-D information
- › Image interpretation challenging

02 RADAR

FEATURES

- › Data rate 500 kB/sec
- › Range 30-70m / 70-200m
- › FOV 5° V, 60° H

ADVANTAGES

- › Not affected by low visibility
- › Longitudinal accuracy
- › Range, fast signal return speed

LIMITATIONS

- › Difficult to identify non metals
- › No texture or colour information
- › Lateral measurement accuracy

03 LIDAR

FEATURES

- › 600K 3D/2D pts/sec (2.5 GB/sec)
- › Range up to 100-200m
- › FOV up to 360° H, 0-30° V

ADVANTAGES

- › 3-D mapping (surround & road)
- › Not dependent on ambient lighting
- › Robust against interference

LIMITATIONS

- › Cost
- › Object detection in hot conditions
- › Limited surface texture/colour info

04 ULTRASOUND

FEATURES

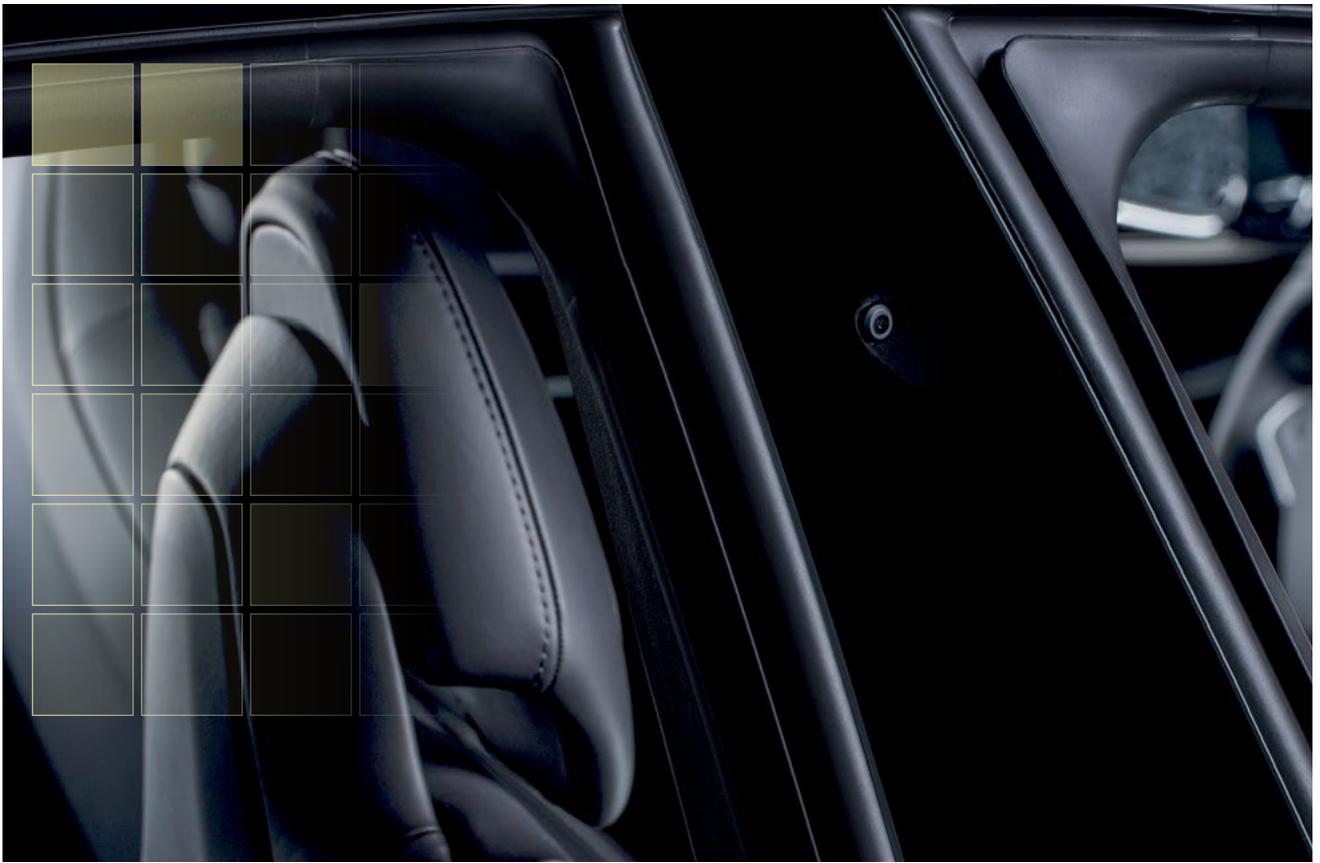
- › Data rate a few kB/s
- › Range 1 – 3 meters

ADVANTAGES

- › Cost

LIMITATIONS

- › Range
- › Speed
- › Resolution

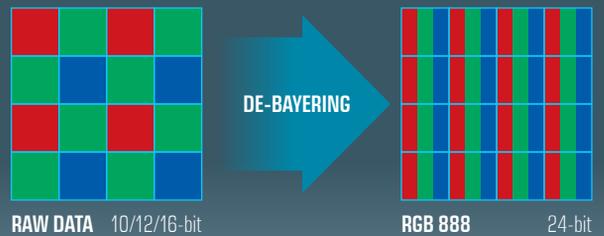


The majority of CMOS image sensors use a Colour Filter Array (CFA) to capture colour information. A Bayer filter mosaic, often referred to as an RGGCB, is a common one and consists of a 50% green, 25% red and 25% blue filter pattern arranged on a square grid of photosensors.

IN ADDITION TO HIGH resolution and fast frame rate, many sensors offer multi exposure capability and analogue/digital gain control for delicate tuning of image quality. This is particularly useful when image degradation occurs due to low contrast, sun glare and other challenging lighting conditions. On its own, sensor pre-processing of the unrefined pixel data is insufficient for most ADAS applications and hence further image conditioning (filtering, noise

removal, etc.) is required using a dedicated Image Signal Processor (ISP). The ISP's role is essentially to convert raw sensor data into a more useful format for subsequent processing within the vision pipeline. A typical example is converting a Bayer pattern image to a more commonly used data format such as RGB or YUV. The ISP also performs multiple other tasks to enhance image quality e.g. High Dynamic Range (HDR) conversion, white balancing and tone mapping. These

IMAGE DE-BAYERING



functions are generally hardware accelerated to offload image related tasks from the main core. ISPs can be implemented in the image sensor, in the main microprocessor or in a companion chip. Using a microprocessor-integrated configuration allows use of lower cost cameras and avoids the cost and board size impact of adding an external IC. The design effort is also simplified as the processor vendor provides the ISP development tool and support package.

After the initial image pre-processing comes the massive parallel acceleration of the vision algorithm and then the high-performance computation and decision-making stage. The use of a parallel processing pipeline maximizes computing efficiency while preserving all-important memory bandwidth. In contrast, performing this with an infotainment type processor that relies on a large Graphics Processing Unit (GPU) is generally considered expensive and bandwidth inefficient.

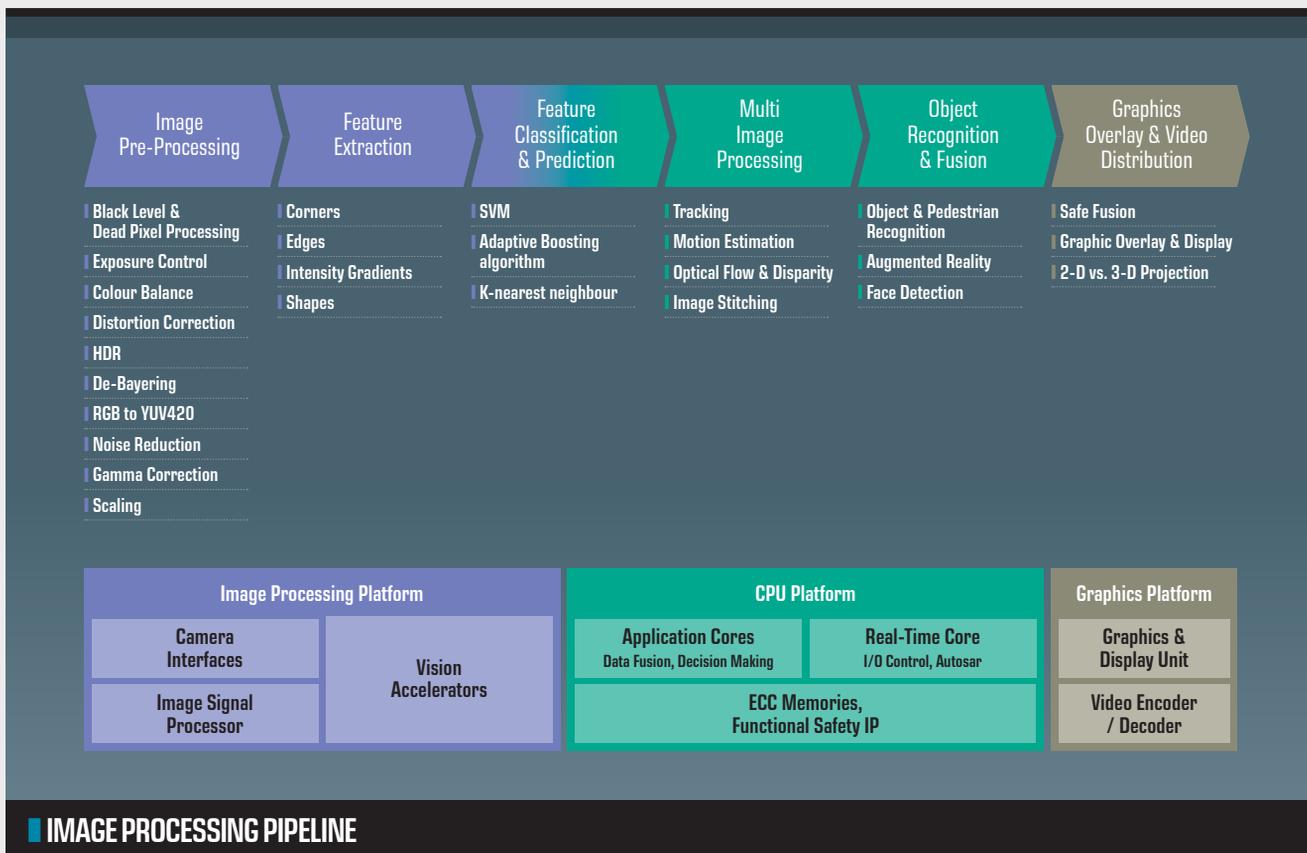


IMAGE PROCESSING PIPELINE

Once the desired image format and quality has been achieved features are extracted and classified, however, using the CPU or GPU to perform this adversely impacts processing bandwidth, memory resources and power consumption.

AS THESE FUNCTIONS consist of multiple repetitive tasks – convolution and filtering on neighboring pixels – an alternative approach is to divide them into smaller blocks where they can be managed by several computational units simultaneously. The preferred solution is a dedicated vision accelerator with large parallel processing engines each with local memory. An example of this is the programmable APEX image cognition processor two of which are included on NXP’s S32V234 Vision processor. Each APEX processor contains two Array Processing Units (APUs) with

32 computational units – 128 in total – for vector and scalar processing. Extensive DMA engines streamline internal and external data operations and a sequencer offloads the main CPU from vision related scheduling tasks allowing it to attend to safety-critical operations. With the growing trend towards neural networks for object classification, Single Instruction Multiple Data (SIMD) based vision accelerators are also ideal for deploying deep neural networks on the target.

The automotive qualified S32V234 processor combines the advanced image processing, computation and safety features required for modern vision platforms. A total of

eight cameras can be supported via two MIPI-CSI interfaces with four more JPEG or H.264 pre-encoded video streams managed via a Gigabit Ethernet interface. The programmable on-chip ISP is compatible with all image sensor types and can support up to four 1-megapixel raw data streams at approximately 30 frames per second with a wide range of image conditioning functions. Four 1GHz Arm Cortex-A53 cores with NEON SIMD engines provide approximately 10,000 DMIPS of computing power for running Linux or other safety-certified operating systems and managing the application. For low-level time-critical tasks, I/O control and AUTOSAR OS management an Arm Cortex-M4 core is also provided. Supplementing these is a Vivante GC3000 GPU capable of 50 GFLOPS at 600MHz for handling the image stitching, spatial conversion and 3-D space modeling functions for constructing the surround view model of the

vehicle. Communication peripherals include PCI Express, CAN FD and FlexRay for connecting to other system components and ECU networks within the vehicle.

Security requirements are met by a SHE-compliant Cryptographic Security Engine (CSE) that provides secure key storage, AES-128 encryption/decryption support and secure boot functionality. A secure RAM block within the ISP allows third party ISP firmware providers to encrypt their kernel software after delivery to the vehicle OEM or ADAS system integrator. ISO26262 functional safety elements cover a range of on-chip IP: ECC on RAM and DDR memories, Built-in Self-Test for logic and memories, and a Fault Collection and Control Unit (FCCU) that supervises all functional safety blocks including clock, temperature and voltage monitors. Together these maintain minimal safe system operation under partial failure conditions in ASIL-B rated applications.

Image Processing Platform

Dual Camera Interfaces	Image Cognition Proc.	
2 x MIPI CSI2	Image Cognition Proc.	
2 x Parallel 16-bit	L-mem	L-mem
Image Signal Processing	32 CU	32 CU
HDR, Color Conversion, Tone Mapping	Sequencer	DMA
	APEX2CL	

CPU Platform

ARM® Cortex-A53		ARM® Cortex-A53	
ARM® Cortex-A53		ARM® Cortex-A53	
32 KB I-cache, I-Cache, 2 way	32 KB D-cache, D-Cache, 4 way	32 KB I-cache, I-Cache, 2 way	32 KB D-cache, D-Cache, 4 way
ARM® NEON		ARM® NEON	
Cortex-M4	SCU	L2 Cache-512 KB + ECC	

Vision Platform

Gfx & Display
3D GPU
DCU 18/24 bits RGB
Video Codec H.264
8-12 bits Encoder
8-12 bit Decoder, JPEG/H.264

Internal Memory	Security	Fabric	
4 MB RAM with ECC	CSE + Flashless	ARM® AMBA AXI3/ACE Interconnect 128-bit with MPU	
Ext. Memory I/F	Connectivity		
DDR Ctrl + ECC	2 x CAN-FD 64 Msg	Dual Ch. FlexRay™ 128 MSG.	Gigabit Ethernet Control
DDR Quad SPI	5 Gbit/s PCIe® 1 lane	2 x LinFlex Ctrl & 3 x I ² C	4 x dSPI (4 cs)
External Memory (optional)	2 x eTimers	2 x SAR ADC 12 bits 1 Ms/s	1 x SD-HC
LP-DDR2/DDR3		Zipwire®	

System Control and Support
FCCU and M/L BIST
T-Sensor
CRC Computing
Safe DMA
DEBUG and Trace Unit

NXP S32V234 BLOCK DIAGRAM

THE S32V234 HARDWARE development platform is based on the SBC-S32V234 single board computer. This system-on-module from MicroSys Electronics contains a miriac MPX-S32V234 module with the processor, external memories and power management components. A compatible carrier module with camera, Ethernet, CAN and LIN connectors supports four serialized cameras via MIPI-CSI connectors when used with the MAX9286S32V234 deserializer board. The enclosed SD card is pre-installed with a generic Linux board support package based which can be customized for the application. NXP's free of charge S32 Design Studio for Vision IDE is the main software development platform and comes with a production grade Vision Software Development Kit (SDK) with ADAS tracking and detection examples, and an ISP Graph tool. Inside the SDK is AEPX-CV, a highly optimized and flexible software library



for developing computer vision algorithms for use with the APEX accelerator. Algorithms cover basic image processing kernels for arithmetic, color conversion, interpolation and image filtering; and advanced feature detection, transformation and tracking. The ISP graph tool provides an intuitive drag and drop GUI for configuring the image pipeline components and automatically generates the source code saving significant development effort and cost.



NXP also offers a Vision Toolbox for MATLAB that runs on top of the SDK and supports the simulation and deployment of computer vision and sensor fusion designs in a model-based design environment. Developers can also use Open-CV libraries and a range of third party software and tools to implement their vision algorithms.

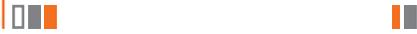


NXP

S32V234 Vision Processor

PART# 2850289

The SBC-S32V234 is a low-cost evaluation system and development platform supporting the S32V234 family. This family of products is designed for high-performance, safe computation-intensive applications such as automotive front vision, surround vision and sensor fusion.

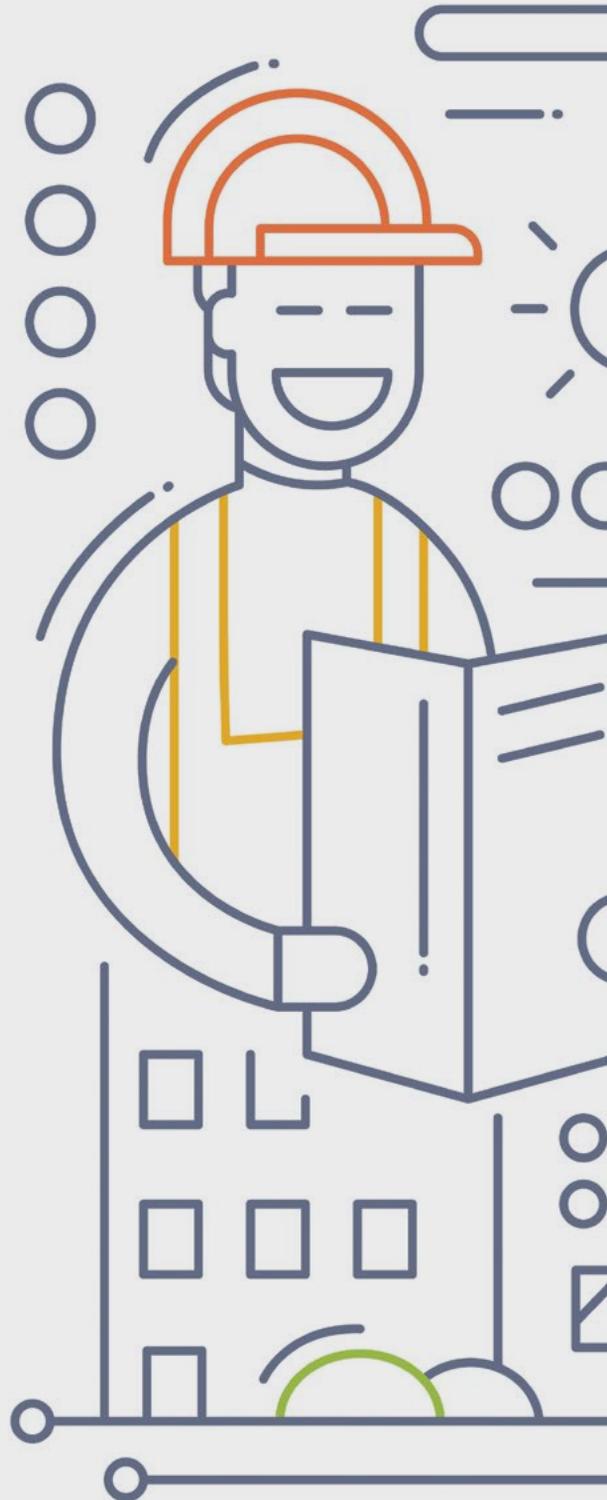


THE IIOT WILL HAVE A TRANSFORMATIVE IMPACT ON PLANT MAINTENANCE

Profound changes lie ahead as the IIoT drives the shift from reactive to predictive maintenance

PLANT MAINTENANCE has often been a source of untimely, expensive and unplanned equipment downtime. Preventive maintenance, managed by a computerized maintenance management system, has been a much better alternative to reactive, "breakdown" maintenance, but has not always

been the cure to failures and production downtime. A solution that's on the horizon, which promises to combat the high cost of plant maintenance, is predictive maintenance, a radically new form of maintenance that is enabled through implementation of the Industrial Internet of Things (IIoT) systems at manufacturing facilities.





FROM PREVENTIVE TO PREDICTIVE MAINTENANCE

There are many differences of opinion in the manufacturing industry with regard to the value of the Industrial Internet of Things.

THE ON-GOING DEBATE on the value of IIoT has frequently reduced the problem to corporate buy-in and capital investment, yet often overlooks its usefulness in the area of plant maintenance, which can amount to about 20% of operating expenses and between 4% to 7% percent of gross revenues for large organizations, according to the consulting firm Accenture. Without a doubt preventive maintenance has improved equipment life cycles and controlled the rising slope of capital costs. But the value of IIoT is multi-faceted; in the context of plant maintenance, it has the ability to take maintenance to a new level – well beyond a preventive style of regularly scheduled maintenance to an innovative, condition-based maintenance that is predictive in nature.

This move to predictive maintenance is expected to occur in the very near future as thousands of machine-based sensors feed data to industrial control systems in order to provide real-time information about both operational status and rule-based equipment conditions. Predictive maintenance is expected to significantly reduce unplanned downtime and eliminate many instances of catastrophic failures – those untimely accidents waiting to happen that kill productivity targets.

But the promise of predictive maintenance can only be realized with the full scale adoption of the IIoT. Featuring more complex hardware and software as well as many I/O sensor networks, the IIoT poses a wholly new set of implementation challenges.





THE CHALLENGES OF IMPLEMENTING IIOT

Security, interoperability and connectivity are often cited as the three major obstacles to implementing IIoT.

A LACK OF SECURITY for critical infrastructure is a risk to operational performance. A lack of standardized protocols for industrial networks can pose significant limitations on how to get gear from different vendors “talking” to one another. Since industrial processes operate in real time, the need for time sensitive, low latency and high reliability networks that connect massive wireless I/O to the controller is another important challenge that cannot be underestimated.

Beyond the considerations of data security, interoperability and connectivity is the I/O itself. One fact of life (and wireless sensor network maintenance) is that the life

expectancy of sensors is uneven. As machine-level devices, IIoT sensors endure a significant amount of environmental exposure and stress that isn’t experienced by data processing equipment housed or co-located in an environmentally controlled data center. And sensor networks used in the IIoT will be huge – 20,000 to 50,000 at large facilities.

The maintenance of such a large I/O would likely be unmanageable without making communication down to the sensor visible – a critical need for the success of the IIoT. This is why the IO-Link standard is so important to implementing the IIoT and achieving the holy grail of plant maintenance – predictive maintenance.



MAINTAINING A LARGE I/O DEMANDS SENSOR COMMUNICATION

Maintaining a large I/O starts with making communication down to the sensor visible.

THIS IS ONE OF THE goals behind the IO-Link International Standard (IEC 61131-9). What is IO-Link? In brief, it is the first I/O technology for communicating with sensors and actuators to be adopted as an international standard (IEC 61131-9). Technically speaking, it is a fieldbus and vendor-independent communication standard.

Since IO-Link compliant devices can provide information about their status, they can be deployed to help reduce downtime because they can notify plant operators of faulty components in real time. As a result, the frequency of sudden failures can be drastically reduced.

IO-Link allows consistent communication between sensors/actuators and the

controller by providing access to all process data, diagnostic data, and device information so corrective maintenance as well as the scheduling of preventive maintenance can be optimized. IO-Link can minimize the risks of catastrophic failures and reduce the efforts needed for troubleshooting equipment problems.

With IO-Link, the last yard between the sensor/actuator to the fieldbus or controller becomes communication-enabled. The parameters for the actuators and sensors can be stored in the controller and automatically transferred when the unit is replaced. It allows the detection of wiring cable disconnections and errors.

IO-Link can also help improve system commissioning and changeover efficiency by checking identifications in batches. This is especially useful when I/O checks for any of the thousands of sensors installed on a production line must be performed.

What do you think about IIOT and the move to predictive maintenance?

Share your thoughts on our IIOT Community hub.

➤ element14.com/community/groups/internet-of-things

IO LINK HELPS REALIZE THE PROMISE OF IIOT

The importance of the IIoT to the continued success of the manufacturing industry is no longer in the experimental arena.

The majority of manufacturers are already at some stage of investment in IIoT technology. But the broad scale adoption of IIoT and the benefits it promises to offer, from predictive maintenance to high productivity and ROI, will depend on the engineering of a coordinated set of solutions, of which, IO-Link compliant devices will play a key role at the sensor/actuator level.



OMRON'S IO-LINK COMPLIANT PRODUCTS CAN MAKE SENSOR PROCESS AND DIAGNOSTIC DATA, AS WELL AS DEVICE INFORMATION VISIBLE IN ORDER TO HELP REDUCE MAINTENANCE DOWNTIMES, ELIMINATE FREQUENT AND SUDDEN FAILURES, AND IMPROVE THE EFFICIENCY OF PRODUCTION CHANGEOVERS.



WINDSCREEN HEADS-UP DISPLAYS

The IoT, with its data-gathering, analysis and communications capabilities, has enormous potential to entertain us, inform us and keep us safe throughout our car journeys. However, how do we access and interact with this information safely and legally while we're preoccupied by driving?

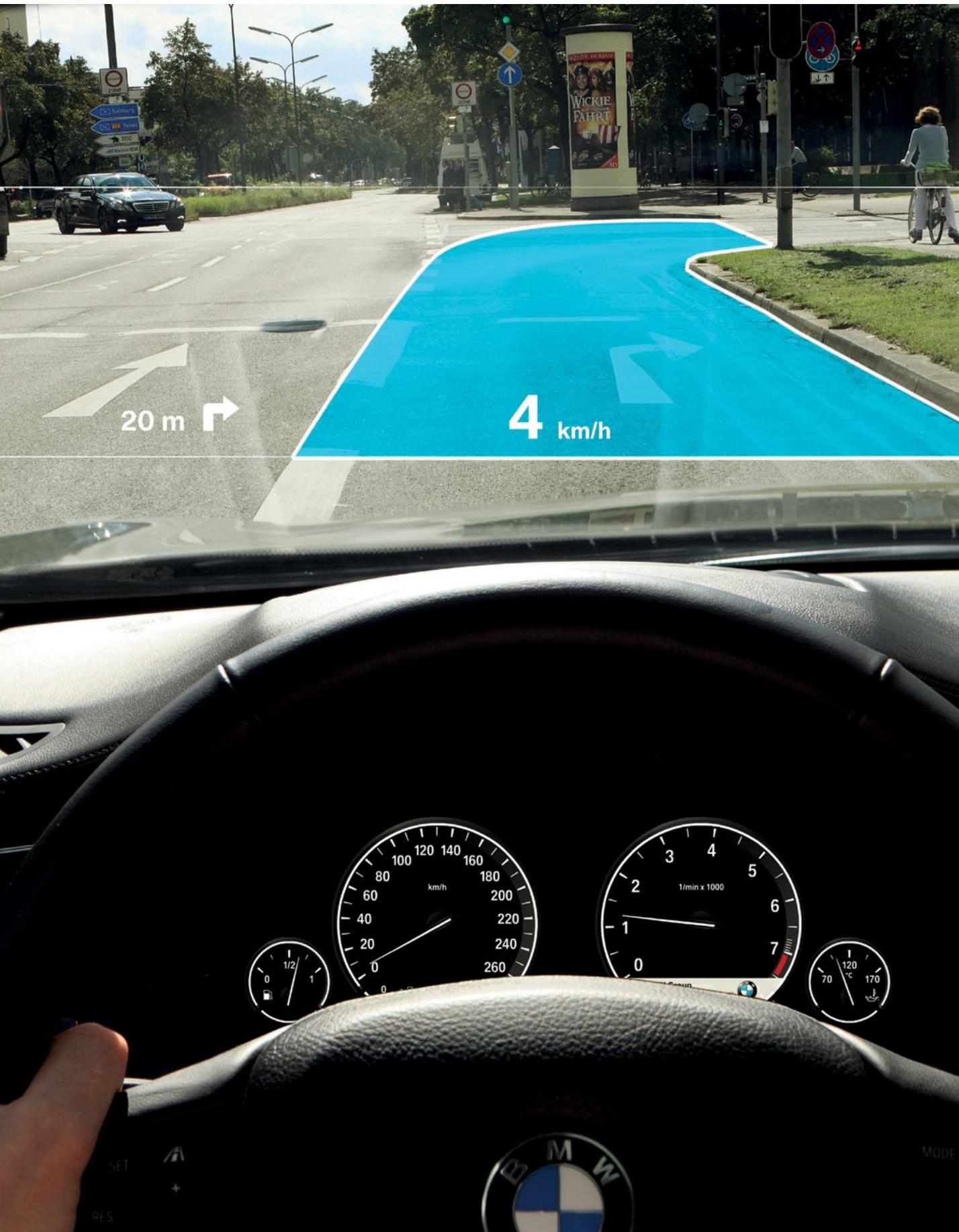
MOBILE PHONES and satnav systems are obvious conduits for such information, but users risk both accidents and prosecution if they use them while driving. Even changing channels on a radio can incur penalties if it leads to careless driving or an accident. One solution now being introduced by car manufacturers and aftermarket suppliers is the head-up (or heads-up) display, or HUD. An HUD is any transparent display that presents data without requiring users to look away from their usual viewpoints. HUDs were originally developed to allow pilots to view information with

the head positioned 'up' and looking forward, instead of looking down at lower instruments. Another advantage is that the pilot's eyes do not need to refocus to view outside after looking at the closer instruments.

The first military HUDs were extensions of pippers or PIP (Predicted Impact Point) markers. These displayed a probable point of impact or location for a bomb, missile or bullet. As technology advanced, displays expanded to include ballistic variables such as aircraft velocity, target velocity, target elevation, distance to target, drag and gravity forces on the projectile and others.

In the 1970s, HUD deployment extended to commercial as well as military aircraft, and in 1988, the Oldsmobile Cutlass Supreme became the first production car with a heads-up display. Since then, other car manufacturers have also adopted the technology on their sports or luxury vehicles. The first European automaker to offer an HUD interface was BMW. Aftermarket HUD systems also exist; these project the display onto a glass combiner mounted above or below the windscreen.





20 m

4 km/h



HEADS-UP DISPLAY

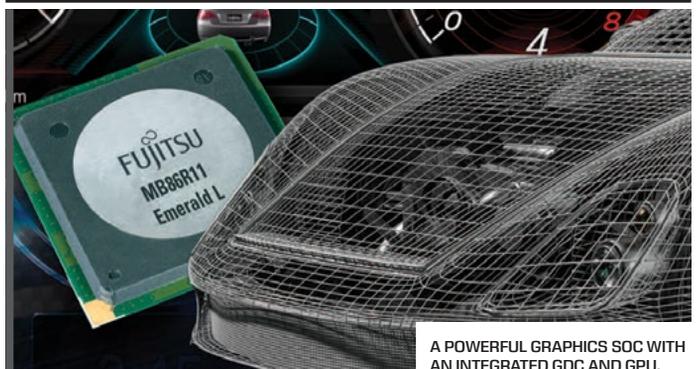
OPERATING PRINCIPLE

A Heads-Up Display system usually comprises a combiner, a projector unit and a video generation computer.

THE COMBINER IS THE SURFACE ONTO which the data is projected and is located directly in front of the pilot or driver. A combiner can be implemented by special treatment of the windscreen glass. It can take either a concave or flat shape and has a special coating (most commonly, phosphor) which reflects the monochromatic light from the projector unit, while allowing all the other wavelengths of light to go through. This creates a fluorescent or phosphorescent image of high visibility that overlaps the driver's real view.

Combiners also manage the function of setting the distance of the HUD's virtual image. In test situations, a projected HUD which appears near the nose of the vehicle is said to result in the most rapid response times and best situational awareness on the part of the driver, as well as facilitating better driving quality.

The projector unit uses one of three types of light emitting sources to project the image, namely a Cathode Ray Tube, light emitting diode, or liquid crystal display. In the early days of HUDs this was accomplished through refraction, but modern HUDs use reflection for improved readability.



A POWERFUL GRAPHICS SOC WITH AN INTEGRATED GDC AND GPU.

HEADS-UP DISPLAY

ELECTRONICS

The projection system's quality and functionality, while clearly essential to developing HUD technology, depends on increasingly integrated and powerful electronics to process and deliver the data it needs.

HIGH-PROFILE EXAM - ples of these include graphics and CPU chips such as Texas Instruments' Jacinto family of infotainment processors which enhance digital car interior integration, and Fujitsu's MB86R11 Emerald-L 2D/3D graphics System-on-a-Chip (SoC).

The Jacinto 6 Ex, for example, offers two embedded vision engines (EVEs) for simultaneous informational Advanced Driver Assistance Systems (ADAS) and infotainment functionalities without compromising the performance of

either system. Informational ADAS describes capabilities such as object and pedestrian detection, augmented reality navigation and driver identification leveraging cameras both inside and outside the car to enhance the driving experience without actively controlling the vehicle. These capabilities can be used in the centre stack, programmable cluster and head's-up display systems.

Fujitsu's MB86R11 Emerald-L is a powerful graphics SoC with an integrated GDC and GPU. Designed for high-end embedded graphical



THE AUTOMOTIVE PRODUCT GUIDE

A useful document on this subject, called the Automotive Product Guide, has been prepared by Maxim and is available on Farnell's website. The Guide provides specifications and design information for devices used in HUD systems as well as infotainment, navigation, driver assistance, lighting and other in-car applications. Products include automotive-qualified

step-down regulators, buck converters, PMICs for car batteries, USB protectors and wide operating range regulators. Other supporting products such as Class D amplifiers, LVDS and GMSL serial links, video decoders, GPS, GLONASS, Compass, and Galileo Front-Ends, thermocouple open/short monitors and other functions are also included.

➔ farnell.com/datasheets/2079899.pdf

applications in the automotive market, the MB86R11 Emerald-L manages cluster, centre information displays, navigation and in-car multimedia graphics applications.

The Emerald-L SoC comprises a 400MHz ARM Cortex A9 processor and a powerful, custom-built graphics core capable of cutting-edge 3D and 2D graphics. The device supports Fujitsu's 360° WrapAround Video Imaging Technology. A Visibility Enhancement feature performs adjacent pixel comparison to reproduce

images with natural colours and great detail. A flexible Signature Unit offers automotive system developers a powerful way to verify data integrity and enhance safety.

However, for these big chips and their peripherals to function reliably in a vehicle's electrically challenging environment, the power distribution system must be carefully managed; the right power must be delivered where it's needed, while noise and spikes are efficiently filtered out.

ONGOING ENHANCEMENTS TO THE HUD COMPONENTS

Continued development in several technologies is allowing manufacturers to introduce increasingly sophisticated upgrades to these basic HUD concepts.

THE MOST CAPABLE HUDs – such as Jaguar's Urban Windscreen, described below – will be based on the entire windscreen becoming smart glass; this can display both text and images, in colour, and possibly in 3-D. These need large, yet high-resolution images.

Such images, with a larger field of view, higher contrast and an extended range of reproducible colours could be generated by blue and green semiconductor laser diodes developed by Japanese semiconductor supplier Nichia Corp. These diodes, according to Nichia, are designed specifically for automotive HUDs. The company says that they also offer improved brightness, colour reproducibility, contrast ratio, viewing angle and power efficiency compared with LEDs.

The systems will also need cameras that can monitor the driver's head position so that the projector can align the images with the real objectives it is augmenting. Additionally,

it must be driven by an extremely fast processor to deliver images with latency as close to zero as possible. This would make it easier to paint arrows and lines on the road ahead, making navigation more intuitive. Virtual highway signs could also be created. As a safety feature, the system could also paint virtual brake lights on a car in front if it was decelerating sharply without showing its own brake lights – for example, if it was using regenerative braking.

Improvements to how drivers interact with the HUD are also possible. Gesture-based control of functions like sun blinds, rear screen wipers and air conditioning could be achieved through sensors. Drivers could wave at these rather than having to search for buttons on the dash.

Further development would always be possible; the HUD can be regarded as an intelligent projector waiting to run new applications and upgrades as they become available.

DISPLAYS



THE ROLE OF HUDS



To a greater or lesser extent, HUDs have now become part of the automobile market place; solutions are available both from car manufacturers, and aftermarket suppliers. But what role do they fulfill, and what is the extent of their functionality?

At the most general level, HUDs contribute to driver wellbeing. To be more specific, we can break this down into several components:

Improving safety by assisting drivers in adverse driving conditions.

Improving safety by increasing drivers' situation awareness related both to their vehicle performance, and what's happening on the road they're using.

Reducing stress by efficiently presented satnav information.

Reducing stress by advising on traffic conditions, local parking possibilities and nearby availability of fuel.

Enriching the travelling experience with information on nearby restaurants, other entertainment opportunities and special offers.

Providing entertainment in the form of radio channels, podcasts or music.

Allowing hands-free communications – staying connected.



THIS EVER INCREAS-
ing functionality is
being/will be matched
by better methods of
interaction, all aimed at
minimizing distraction
from driving. These

include voice commands
via Google Voice and
other channels, mobile
phone integration, and
gesture control.

Car HUDs were originally
simple, limited-function
devices designed to
increase safety and
situation awareness.
Driving in low visibility,
for example, is a major
cause of accidents in both
first-world and developing
countries. Low visibility is
caused by rain, fog, heavy
snow or darkness, and
is exacerbated by poor
street lighting. According
to the World Health
Organization (WHO), 350
people worldwide die every
day due to low visibility
conditions while driving.

**HUD DISPLAYS
CAN MITIGATE
TRAFFIC ACCIDENTS
RELATED TO
POOR VISIBILITY**

The WHO also refers to further studies
from around the world that report on traffic
accidents related to poor visibility:

In the state of Victoria, Australia, poor visibility was a factor in 65% of crashes between cars and motorized two-wheelers, and the sole cause in 21% of them.

European research found that one third of pedestrian casualties had difficulty seeing the vehicle that had struck them, while two fifths of drivers had difficulty seeing the pedestrian.

Nearly 5% of severe truck crashes in Germany can be traced back to poor nighttime visibility of the truck or its trailer.

A large proportion of pedestrian and cyclist collisions in low-income countries occur around dusk, dawn or at night, possibly because of poor visibility. However, research in this area is limited.

Motorized two-wheelers, because of their size and shape, are harder to see than other motor vehicles and are poorly visible, even during the daytime. For example, most motorcycle crashes in Malaysia occur during daylight hours.

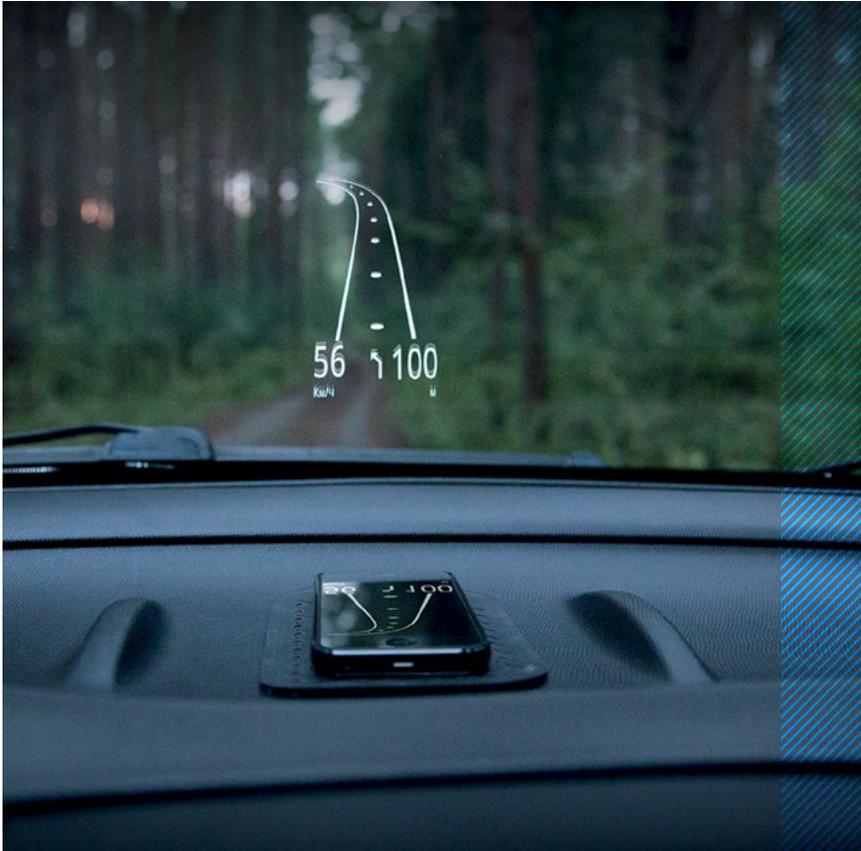
HUD displays can mitigate these problems while allowing drivers to focus on the road, without being distracted by audio commands or complicated maps and symbols. However, HUDs have been continuously evolving, and will continue to do so, for four reasons:

Driving conditions are becoming more challenging, with greater traffic density, more competition for parking spaces, more complex road signage, and more time pressure.

Improvements in display, communications, computing, software and IoT technologies are providing opportunities to develop more advanced HUD platforms to meet these evolving requirements and expectations.

Users' expectations, fuelled by their experience with mobile phones, tablets and other IoT devices, are raised.

The HUD is designed as an integrated component of the car's electronic systems.



Next, we give examples of how this evolving demand is being met now, and will be met in the future, by solutions being offered or proposed by various car manufacturers and aftermarket HUD suppliers.

■ A SIMPLE SOLUTION

HUDWAY

HUDWAY OFFERS A SOLUTION which is based simply on a mobile phone app, available for Android or Apple. No special hardware is needed, it works by placing the phone on the car dashboard.

HUDWAY displays current vehicle speed, distance to the next sharp curve, and where it is best to slow down. All dangerous turns are displayed in red, and prior marks on the road help to visually measure

the distance. Distance between each mark is equal to 50 metres (or 200 feet). This heads-up information is supplemented with voice assistance. Although an Internet connection is required when setting up the route, it is not necessary during navigation, as the app works from the information pre-loaded into the phone.

➤ hudwayglass.com

The potential for HUDs is growing continuously, driven by advances in computing, image capture and display, communications, and the increasing availability of cloud-based information pertaining to navigation, safety, and other useful or entertaining information.





MORE FUTURISTIC HUDS

JAGUAR LAND ROVER URBAN WINDSCREEN

One vision of the HUD future is offered by Jaguar Land Rover (JLR), with their 'Urban Windscreen' technology concept, announced in December 2014.

IT IS SO-CALLED BE-cause, instead of confining itself to the relatively small area typical of current HUDs, it uses video projection to turn a normally static windscreen into a virtual moving image display. For example, it can project the image of a ghost car onto the screen; this appears to be driving in front of your vehicle, so that you can follow it as it leads you to your destination. This is more intuitive and easier to use than traditional satnav audio and video instructions that can leave you unsure of whether you should actually be turning at this exit or the next one.

The screen will also integrate displays of useful information, such as prices at the nearest petrol station, or availability of parking spaces in a convenient car park.

While doing so, the technology will make effective use of the windscreen's real estate. When cameras on the front of the car spot an obstacle such as a pedestrian or cyclist, the HUD draws a red square around it. If you drive past a point of interest, a floating info box will appear to provide more data – the restaurant's rating, or other items as above.

Dr Wolfgang Epple, Director of Research and Technology, said of the tech "Driving on city streets can be a stressful experience, but imagine being able to drive across town without having to look at road signs, or be distracted trying to locate a parking space.

Another aspect of this JLR technology is the ability to provide safe 360° vision and eliminate blind spots. Screens can be embedded in the car's A, B and C pillars. (A pillars

hold either side of the windscreen in place; B pillars start where the driver and passenger-side windows end as you look backward along the length of the car. C pillars hold the sides of the car's rear window in place.)

The pillar screens are fed from cameras in each blind spot location. When the driver signals a turn, then moves his head to make the manoeuvre, the relevant screen will immediately display a moving image of what's behind it. These screens, together with the windscreen HUD, make up 360° vision, and should make urban and motorway driving much easier and safer.

Dr Epple explains that the tech is designed to improve visibility and give drivers the right information at the right time. He comments: "If we can keep the driver's eyes on the road ahead and present information in a non-distracting way, we can help them make better decisions in the most demanding and congested driving environments." It's not yet possible to buy cars with this technology, but some commentators expect to see it in Jaguars and Land Rovers by 2020.

landrover.com



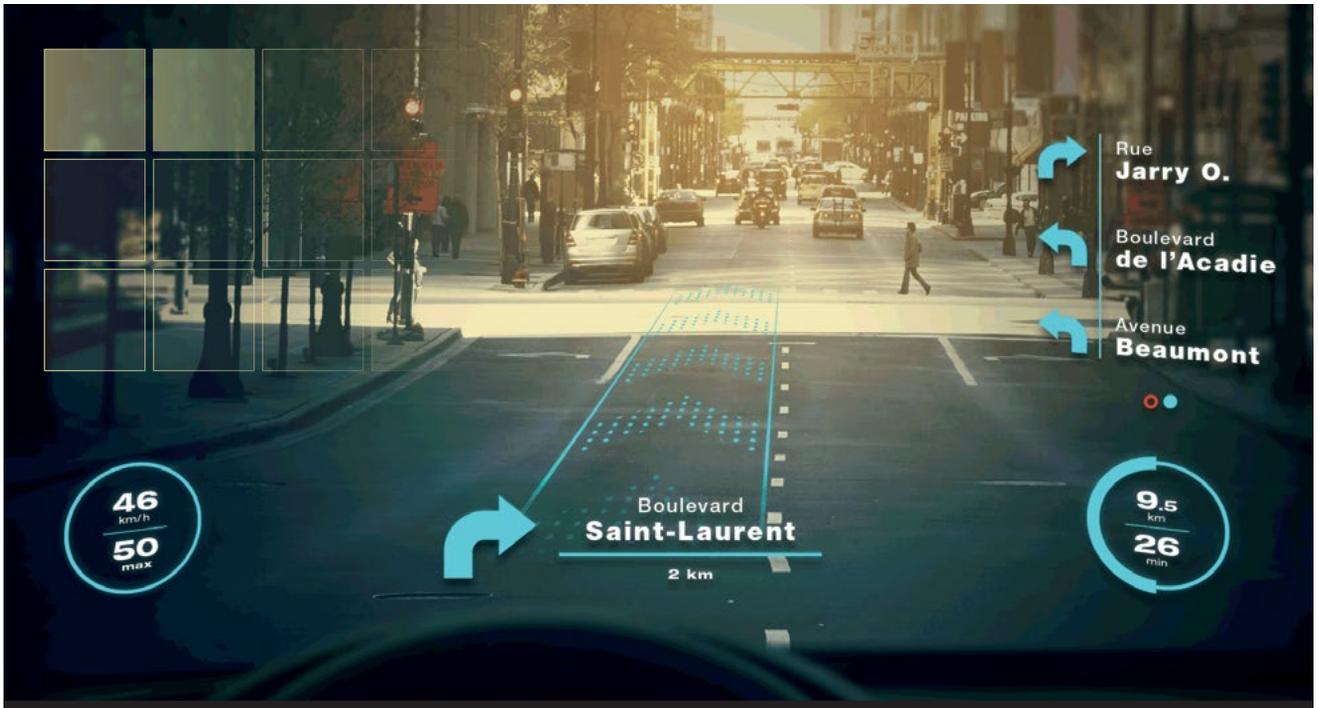
CARROBOT HUD AUTO ACCESSORY

By contrast to the Urban Windscreen, the Carrobot auto accessory is an aftermarket product, but a very powerful one.

Their second-generation device can be considered as a personal assistant including HUD functionality rather than simply as a HUD; with AI capability, it integrates many functions and technologies. It acts as a central platform to integrate all the driver's smart devices. Its features include:

- High-resolution display
- Smart voice interaction
- Project mobile phone apps to windscreen
- Fatigue and distraction detection and warnings
- Smart navigation
- Mobile app
- Wireless connectivity

carrobot.com



element14.com/community/videos/24360/1/preparing-for-demo-day-with-hudlog-startupbootcamp-iot

EXAMPLE

AN HUD STARTUP



HUDLOG'S OBJECTIVE IS TO PROVIDE A VISUAL DRIVING ASSISTANT THAT OPTIMISES PRESENTATION OF ESSENTIAL INFORMATION WITHOUT DISTRACTING THE DRIVER.

Farnell, as a partner in an organisation called Startupbootcamp IoT, is providing support to an HUD startup company called HUDlog.

STARTUPBOOTCAMP IoT's aim is to make the journey of building a connected hardware startup clearer, shorter and more successful for entrepreneurs. This is done through a three-month acceleration programme run once a year in London. The program gives up to 10 startups access to a global network of business mentors, hardware professionals, corporate partners, potential customers and investors.

HUDlog's approach is to offer a solution designed for commercial fleets, based on their Atlas One aftermarket HUD. They pitch this to fleet operators by promoting Atlas

One's commercial benefits; they claim collisions reduced by 30%, fuel savings of up to £670 per year, per van, and insurance savings of up to 15%.

Technically, Atlas One provides a harsh driving indicator, a speed limit indicator to promote fuel savings and prevent speeding fines, and turn-by-turn navigation. This only displays essential directions, with no extra visual clutter. The HUD connects directly to the mobile network, eliminating the need for mobile phones and allowing fleet managers to retain control.

startupbootcamp.org/hudlog

FROM HUDS TO AUGMENTED REALITY AND DRIVERLESS VEHICLES

With Ford announcing mass-production of driverless cars for 2021, and driverless truck convoys already a reality, issues such as automated safety, navigation and infotainment, including all the functions described in this article, become ever more critical.

CAR AND AFTER-market manufacturers gathering in forums like CES 2017 in Las Vegas are talking in terms of Augmented Reality to reflect increasingly sophisticated and integrated systems that include the HUD as a key component.

Augmented reality systems and HUDs will provide stepping stones on the route to driverless vehicles. For example, driving in today's environment can be improved by better and more precise mapping functions – but this high-quality mapping will be essential to the success of driverless vehicles.

Similarly, driverless cars will be dependent on large arrays of sensors that ensure safety by collecting data on other nearby vehicles, cyclists, pedestrians, signage and other items; and this data is already being used in AR systems and HUDs.

It's also possible that it could be used for deep learning to provide better insight into the current situation, and how to react. Additionally, cloud-based services could gather big data from large fleets of cars to improve understanding of the big picture for issues such as traffic flow.

corporate.ford.com/innovation/autonomous-2021.html



AN OPPORTUNITY FOR DEVELOPERS

HUDs represent an expanding market with opportunities for car system developers. However, developing an OEM solution requires talent with specialised skillsets and domain experience. In taking on an HUD development project, an OEM and/or automotive supplier may encounter the following pain points:

Investments in R&D and technology

Increased time-to-market and losing out on competitive advantage

EMBITEL TECHNOLOGIES

Embitel Technologies, a company whose expertise includes embedded design services, cloud, mobility and IoT solutions for automotive, smart home and smart factories, has developed a reference design for a car HUD system that they claim can reduce time for developing advanced features and customisation from an average 2½ years to six months, with an associated reduction in development costs.

embitel.com

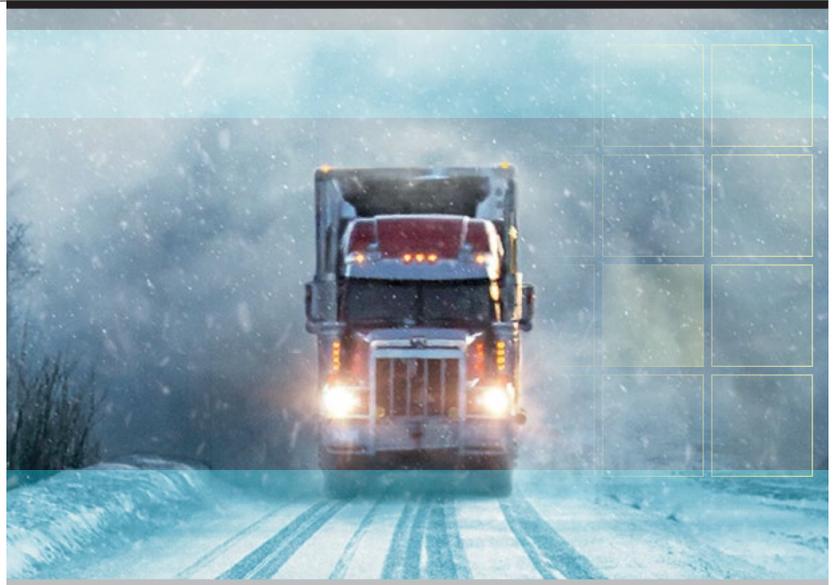
CONCLUSIONS

This article has shown how HUD displays have evolved from standalone devices of limited functionality to sophisticated components of vehicles' overall electronic communications and management systems.

THE TREND NOW

is to use the entire windscreen as a projection area, to open the display options as widely as possible. HUDlog's contribution to the debate is interesting, as they quantify the commercial benefits of using HUDs.

While fulfilling an increasingly valuable role currently, HUDs are ultimately set to become redundant, or least change their role towards infotainment rather than safety and navigation functions, as vehicles become self-driven.



THE TRANSPORTATION PROCESS IN THE IOT WORLD

Out in the Alaskan wilderness, IoT technologies are ensuring the safe passage of goods and services along one of the harshest stretches of highway in the United States. The Alaska Department of Transportation and Public Services has used Cisco solutions to manage highly secure radio, channel and media resources, co-ordinate dispatching, and provide network connectivity for the roadways.



THE IMPLEMENTATION allows fast response to emergency situations, improved safety, and significantly more efficient equipment management and maintenance. While this is an extreme environment, the IoT is playing an increasingly significant role in transportation systems of all types – rail, sea and air as well as road – around the world. These advances are allowing the transportation industries to keep pace with their manufacturing customers; other articles on the IoT Hub have shown how productivity, competitiveness and granularity of choice in factories and warehouses is being boosted by the evolving sensor, networking and cloud technologies comprising the IoT.

So, if advanced manufacturing needs the support of advanced transportation, how is the transportation industry rising to the challenge? What are the components of a transportation system, how can they be modified by the IoT, and where will the benefits arise? Below, we explore these questions and their answers.

If we focus on road transportation systems, we can be more specific about the challenges and potential benefits

– both of which are huge, as last year the US trucking industry generated \$676b, compared with Apple, Amazon and Google's combined revenue of \$442b. Issues confronting this large industry include a shortage of drivers, increasing costs of downtime due to breakdown or accidents, theft of vehicles or loads, operational efficiency, and growing demands for real-time information about freight status; not only its geographical location, but also details about exactly which items a shipment contains. Additionally, if the shipment comprises perishable food or pharmaceutical goods, early information about any refrigeration or other environmental control problems is required, so that they can be fixed before valuable and possibly irreplaceable stock is destroyed.

These problems become more complex for large and international shipping operations, as these are fragmented and involve many different carriers, warehouses and vehicles along the route. Accordingly, after looking at the issues named above, we review the challenges of a large or international operation, and a possible IoT-based solution.



RIO TINTO OPERATES AUTOMATED FLEETS SINCE 2008

COPYRIGHT - 2018 RIO TINTO

TRUCK DRIVING AUTOMATION



Some of these issues could be resolved through increased truck driving automation; augmenting drivers or eventually eliminating the need for them entirely. Although the cost of using automation to achieve smart trucking would be high, it would likely be economic compared to drivers' annual wages.

IN ANY CASE, WHILE the reality of highways populated with self-driving vehicles may be somewhat futuristic, there are already some limited applications. Mining conglomerate Rio

Tinto has been operating automated fleets of massive trucks since 2008 in a remote region of Western Australia, reducing loading and hauling costs by roughly 13%. Required breaks, absenteeism, shift change

costs and meal logistics are eliminated, while removing people from the mine environment increases safety.

Truck convoys provide another opportunity for autonomous driving. The lead truck driver retains control of all steering functions and sets the pace. Drivers in the following trucks provide no steering, acceleration or braking control, and technically may not be needed once the convoy is underway. The system reduces accident rates and can reduce fuel consumption by about 15%. Road space is better utilised, and carbon emissions are cut.

One successfully tested convoy was led by a Volvo truck in Barcelona, Spain. The driver provided steering functions for the four following vehicles. The journey towards full automation will progress through intermediate steps; experimentation is already under way.

Autonomous driving could

reduce the number of trucking-related accidents, which can cost hundreds of thousands of dollars per incident, or even millions if a fatality is involved. It could also help with the shortage of truck drivers; The American Trucking Association has estimated that the US faced a 48,000 shortfall in drivers in 2015, growing to possibly 175,000 in 2024.

While increasing automation of the driving function could bring benefits as described, there's plenty that the IoT can achieve by detecting, gathering, analysing and alerting users to events in vehicles at any level of automation. Increasingly, trucks are fitted with sensors monitoring engine behaviour, driver behaviour, load status and truck location. Many different systems integrators are using data from these sensors, together with cloud-based analytics, to generate actionable information for fleet operators.



NEXT-GENERATION TRACK AND TRACE

In 2012, FreightWatch recorded 946 cargo theft incidents in America, and 689 in Europe; activities that cost shippers billions of dollars each year in inventory delays as well as stolen goods costs.



Similarly, DHL offers a couple of SmartSensor products

SMARTSENSOR RFID

SmartSensor RFID is a UHF RFID passive device that measures temperatures during transportation. Its data can be analysed retrospectively through DHL's web portal anywhere in the world and at any time. It fulfils pharmaceutical regulations EU GMP Annex 11, US 21 CFR Part 11 and EU GDP.

SMARTSENSOR GSM

SmartSensor GSM measures temperature, humidity, shock and light data (door opening), and identifies location during transportation. It uploads its data over the GSM mobile phone network to DHL's web portal for near real-time data analysis.

➔ dhl.com/smartsensor

BlackBerry Radar is one system that operators can use to combat this

BLACKBERRY RADAR

Delivers near real-time on the location of trailers and containers to a portal which can be viewed anywhere, on any smartphone, tablet or computer.

Notifies warehouse staff of impending arrival so they can plan accordingly.

Based on an asset tracking device that's easily installed on a trailer.

Security is assured as all transmitted data is encrypted, and all devices and cloud endpoints are authenticated.

Identify where assets are, how they're being used, identify and prevent opportunities for theft and drains on efficiency.

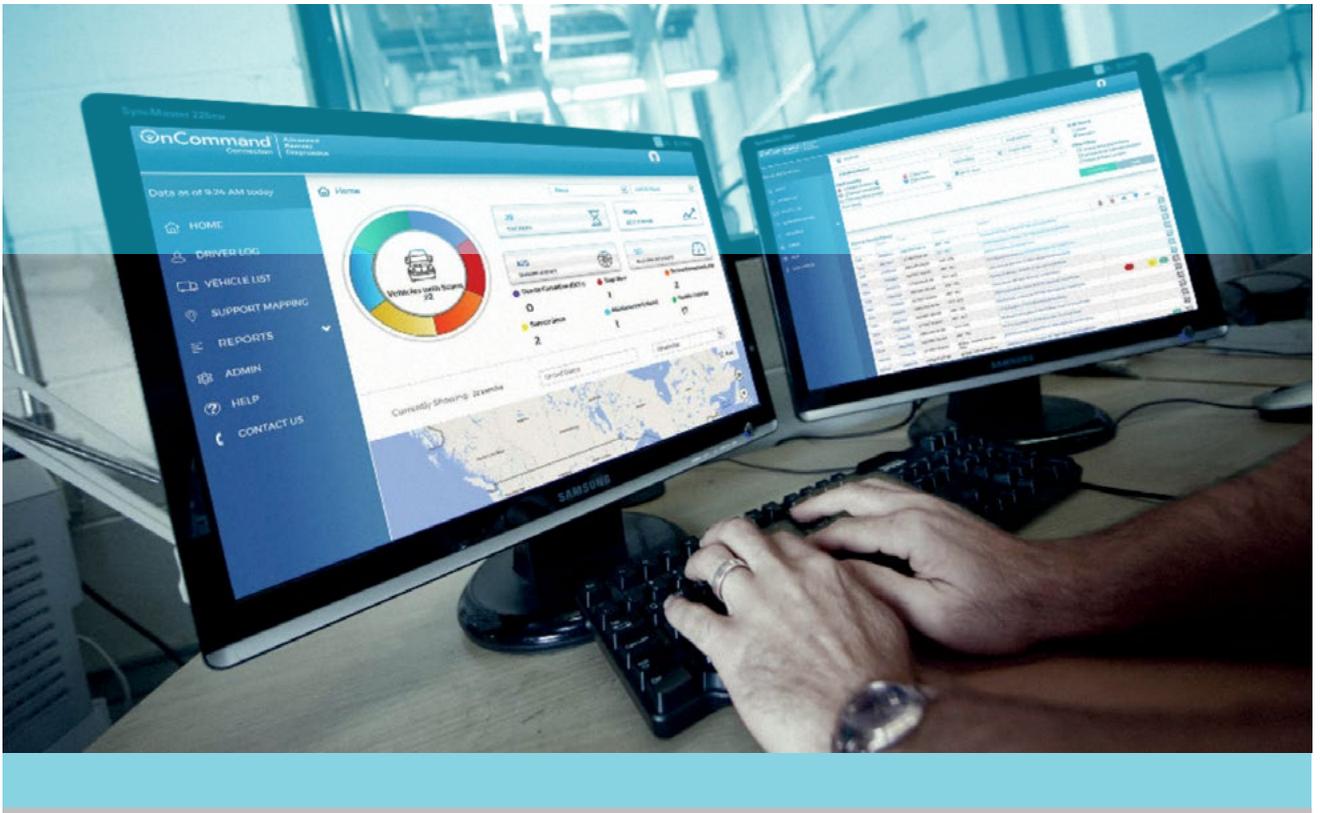
No need for costly IT infrastructure as the system is cloud-based.

Detect when truck crosses user-defined geofence or when a trailer door has opened or closed.

Other systems can also improve security by monitoring door sensors, establishing reliable two-way communications and panic buttons, and help prevent hijacking by detecting GPS and GSM signal jammer activity. GPS information can also be used to track stolen vehicles.

Monitors temperature, humidity and cargo presence to check for problems that could threaten cargo integrity.

➔ blackberry.com/radar



MOVING FROM PREVENTIVE TO PREDICTIVE MAINTENANCE

As well as monitoring freight movements and conditions, the IoT is helping fleet operators improve truck uptime by using predictive rather than preventative maintenance. Manufacturer International Truck has launched a program called OnCommand Connection that exploits Big Data and IoT technologies to minimise disruption to truck services.

Every IT truck built since Summer 2015 has a telematics option which plugs into the engine and reads data from other components in the truck system

Monitors engine speed, truck speed, coolant temperature, brake wear and other variables.

Data collected at 15 to 60 second intervals, and transmitted over cellular networks to (mostly) an Amazon Web Services repository for access by IT and their customers.

The data is then loaded into a Hadoop cluster for analysis using machine learning algorithms written in Python, R and SAS.

Analytic results help TI improve their own internal testing mechanisms and engage customers on predictive maintenance activities.

The Hadoop cluster is expected to exceed 1 petabyte of data, supporting over 200,000 trucks.

Can predict how different truck configurations and part combinations – of which there are about 20,000 possibilities – react with one another in the real world, and generate alerts if these predictions and sensor inputs indicate a latent fault.

Predictive maintenance reduces downtime, important as each truck day off the road can cost up to \$1000 in lost revenue.

oncommandconnection.com



LOOKING AFTER THE DRIVERS AND ENSURING REGULATORY COMPLIANCE

Drivers can be considered as components of a truck's system, just like the engine, brakes and load. As such, they and the operators can equally benefit from monitoring, feedback and recommendations for improvement.

Dispatchers can remotely monitor real-time fuel efficiency; do drivers brake or accelerate too hard?

Recommend optimum speed for a route.

Track driver routes, time spent loading and unloading

Manage hours of service compliance.

A system can become smarter as it gains feedback, and better able to advise on road conditions, loading docks, weather conditions and any other factors that could impact a delivery schedule.

Electronic Logging Devices (ELDs); The Federal Motor Carrier Safety Administrator (FMCSA), responsible for regulating and providing safety oversight of commercial motor vehicles, mandates that US truck drivers must use an ELD. This collects information related to location, date, time, vehicle and driver ID, engine power status, vehicle motion status, miles driven, and engine operation hours.

ELDS can be paired with smartphones to store and back up collected information, facilitating organised and systematic data collection.

Regulatory compliance is assured with accurate hours of service (HOS) and vehicle maintenance data recording.

Drivers have been found to like these devices, as they eliminate hours of time completing paper logbooks to comply with hours of service regulations. ELD evidence can also exonerate drivers in the event of a disputed incident.

It is also possible to use ELD data to model driver fatigue risk. Predictive modelling technology uses thousands of data points to build a true picture of a driver's behaviour and present an opportunity for remediation.



USING CONNECTED FREIGHT TECHNOLOGY TO PROVIDE A RELIABLE AND VISIBLE GLOBAL SHIPPING SOLUTION

International and other large-scale freight shipping operations can involve transit through many different operators, vehicles and waystations.

PLENTY OF OPPORTUNITIES for error arise if humans in the field fail to behave as expected, for example, putting a parcel into the wrong truck after scanning it. The centralised system no longer has an accurate view of what's really happening. This is exacerbated as the freight is probably travelling through a complex, fragmented mesh of waypoints or warehouses owned by different service providers along the route.

Traditional track and trace implementations have attempted to improve this scenario with more efficient systems, but IoT technology is now enabling a newer and entirely better approach. Intel, for example, has developed a global system based on making freight smart. This is based on smart sensors attached to each box or item that can feed data back to a central or Cloud resource through mobile gateways on the vehicle, or fixed gateways inside way points.

Freight stakeholders gain a single, coherent view of freight status as it moves through the system.

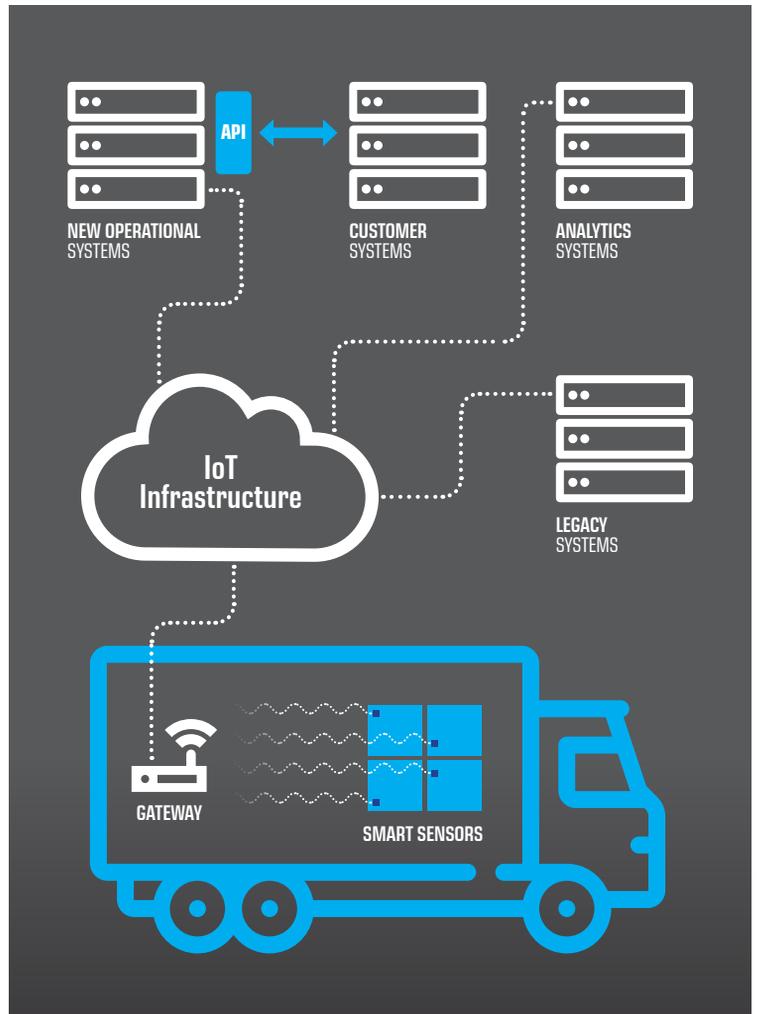
Real-time shipping information can be fed to both existing systems and new big data analytics systems, giving customers access to shipping information during transit.

Temperature sensors and accelerometers allow customers to monitor freight conditions, and take corrective action if necessary. This may mean changing the shipping container environment, or re-routing the freight to another destination.

The data collected can also facilitate longer-term visibility and planning.

INTEL'S SMART FREIGHT SYSTEM

The Intel IoT Platform is a reference architecture for connecting freight sensor tracking technology to gateways that communicate with a customer's legacy data analytics and management system via an API firewall. It comprises the following components:



Smart sensors

Sensors with integrated processor, memory and wireless communications functions, attached to packages

Configurator

Cloud application that interfaces with customer apps to create configuration parameters for each load, including parameter adjustments.

State reconciliation engine

Cloud application that manages consistency between gateways and abstractions residing in customers' operational systems: shipments, loads and waypoints.

Gateways

Mobile, battery-powered devices that accompany transit loads, and fixed waypoint versions associated with packages that have been received and/or are yet to be shipped. Managed by an application specifically designed to accept and provision against shipment parameters, including operating system and applicable packages for security, manageability and local analytics.

Clearinghouse

Cloud application managing communications between gateways and customer applications – legacy, logistics and operational; inbound periodic events and out-of-cycle events that are received here for exchange with customer systems; outbound state changes and method invocations are received by clearinghouse for transmission to gateways.

Software development kits

Software development kits (SDKs) are tools provided for customers building new operational systems to ensure forward compatibility with gateway, clearinghouse, configurator and state reconciliation engine feature enhancements.



MERCEDES-BENZ VISION
URBANETIC CARGO MODULE

CONCLUSION

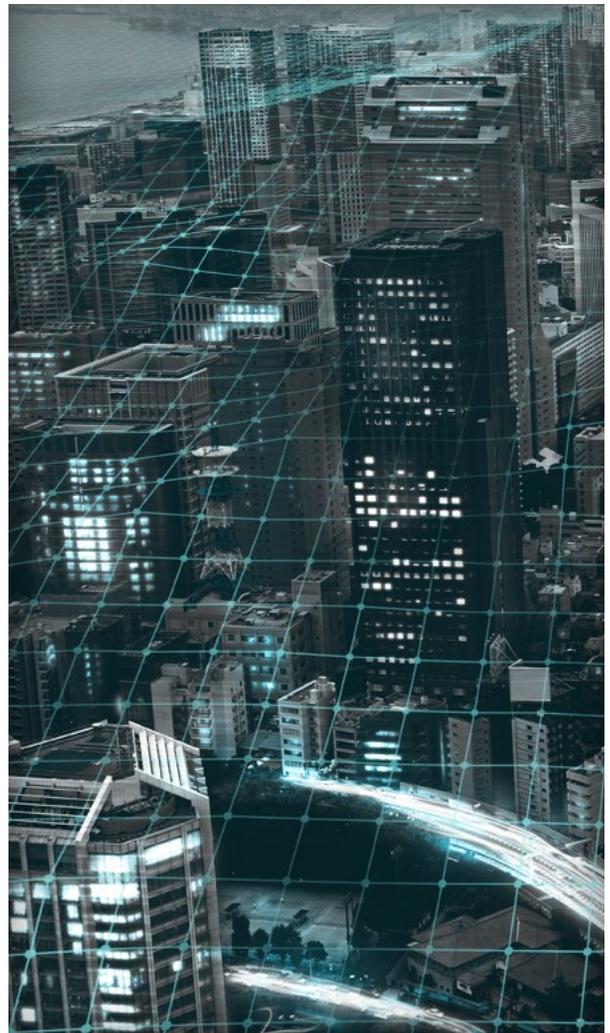
Freight transportation, especially when perishable goods are involved, can be complex and difficult to manage; adverse events can affect drivers, vehicles and freight.

IN THIS ARTICLE WE have seen how the IoT's control and monitoring capabilities can alleviate these issues. A roadmap to automated and even entirely driverless vehicles has been established, and in some implementations, these have already become a reality. The drivers also see benefit from being able to maintain compliance more easily and with less paperwork.

Using IoT networks of low cost, rugged wireless sensors and mobile gateways, tracking freight also becomes easier and more reliable. Sensor-enabled freight items can talk to central control stations;

operators can see, in real time, where the freight is and the conditions it is experiencing, rather than relying on indirect, delayed and possibly incorrect information from scanners and manual data entry devices.

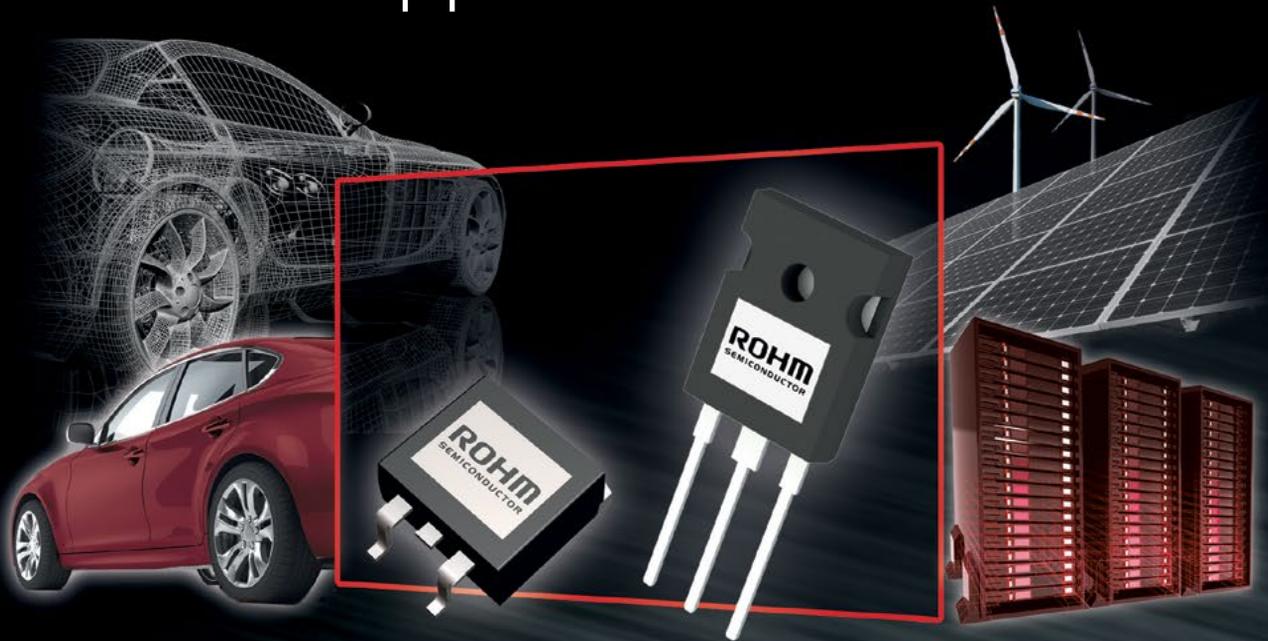
The benefits of exploiting IoT technology in this way are numerous. Costs arising from wasted fuel, truck downtime, driver issues and spoiled freight can be avoided, while profits can be improved by diverting freight to alternative destinations if market opportunities present themselves while shipments are en route.



**SMALLER
STRONGER
FASTER**

ROHM
SEMICONDUCTOR

IGBTs for Automotive and Industrial Applications



■ RGS Series (Automotive)

- Package: TO-247N
- BV_{CES} : 650V, 1200V
- Short circuit withstand time: 8-10 μ s
- Low switching noise
- Built-in fast & soft recovery diode
- AEC-Q101 qualified

■ RGP Series (Ignition)

- Package: TO-252 (DPAK), TO-263S (D2PAK)
- BV_{CES} : 360-560V
- Low saturation voltage typ. 1.6V
- Avalanche energy 250-500 mJ ($T_j=25^\circ\text{C}$)
- Built-in ESD protection diode for gate
- Built-in resistor between gate and emitter (opt.)
- AEC-Q101 qualified

■ RGTV / RGW Series (Industrial)

- High speed switching
- Quick turn-off with less transient oscillation
- Built-in fast & soft recovery diode
- Light punch through & thin wafer technologies
- Package: TO-247N & isolated TO-3PFM
- RGTV: $V_{CES} = 650\text{V} / I_c = 30, 50, 80\text{A}^*$
- RGW: $V_{CES} = 650\text{V} / I_c = 30, 40, 50\text{A}^*$
- Low saturation voltage typ. 1.5V ($T_j=25^\circ\text{C}$)
- Short circuit withstand time 2 μ s (RGTV)

* $T_j=100^\circ\text{C}$

SIGN UP

ROHM
e-Newsletter



www.rohm.com