KLION | Automotive & Industrial

How to enable Software-Defined Off-Highway Vehicles

KYUNGWOO

The automotive industry is undergoing a paradigm shift, with an increasing number of vehicle functions and features being driven by software technology.

Building on a solid hardware foundation, software technology enhances innovation through its flexibility, connectivity, and upgradability.

How can we leverage this trend to advance off-highway vehicle development?

Introduction

The Software-Defined Vehicle (SDV) initiative is revolutionizing the **planning, design, development, deployment, and maintenance of automobiles.** This transition is being accelerated by electrification and increasingly stringent safety regulations. Modern vehicles are now fundamentally reliant on advanced software technology.

Although off-highway vehicles remain predominantly hardware-centric, this doesn't mean they can't benefit from the automotive industry's shift towards software-driven innovation. In fact, the hardware-focused nature of mobile machines presents significant opportunities to integrate advanced software technology, thereby **accelerating innovation, improving efficiency, and enhancing safety.**

In this whitepaper, Kyungwoo presents a unique approach to enable more software-driven off-highway machinery development and operation in a flexible and cost-effective manner covering following topics:

- ✓ **Why is SDV the hottest topic in the automotive industry?**
- ✓ **Does this trend make sense for off-highway vehicle development?**
- ✓ **Why is the adoption of this critical trend so slow in the off-highway vehicles industry.**
- ✓ **What are some ideas to overcome the obstacles.**
- ✓ **How would this re-shape the industry?**

What is SDV and why does it matter?

"A Software-Defined Vehicle is any vehicle that manages its operations, adds functionality, and enables new features primarily or entirely through software." – Blackberry QNX

ABCD of SDV Characteristics

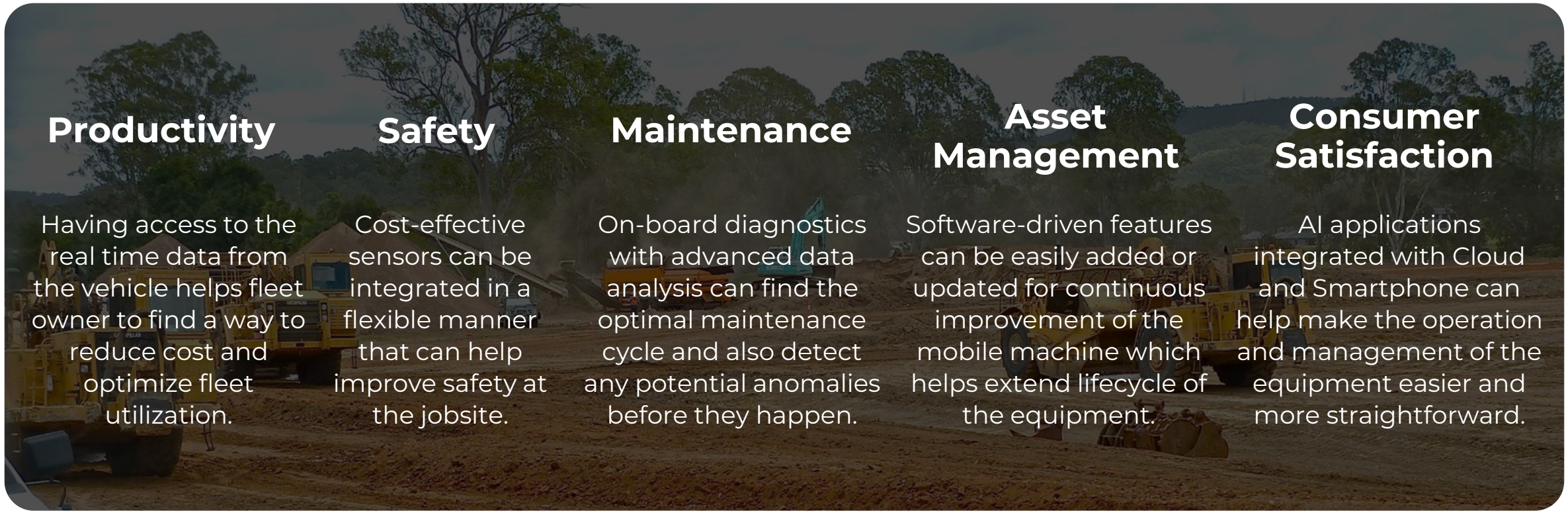
Abstraction	SW is decoupled from HW implementation as much as possible
Blended	Vehicle functions are consolidated or distributed with maximum flexibility
Connected	System is connected to the cloud for SW update over-the-air as well as data acquisition and analysis
Digitalized	Vehicle features are digitalized to accelerate development, validation and update

SDV Benefits

- ✓ Fast innovation cycles
- ✓ Increased reusability and cost-saving
- ✓ New services and business models
- ✓ Improved life-cycle management
- ✓ Higher level of safety and security

How does it help Off-highway vehicles?

While off-highway vehicles are different from on-highway passenger cars or commercial vehicles, we're also facing challenges that can be addressed by adopting ideas from the rest of the automotive industry:



Productivity

Having access to the real time data from the vehicle helps fleet owner to find a way to reduce cost and optimize fleet utilization.

Safety

Cost-effective sensors can be integrated in a flexible manner that can help improve safety at the jobsite.

Maintenance

On-board diagnostics with advanced data analysis can find the optimal maintenance cycle and also detect any potential anomalies before they happen.

Asset Management

Software-driven features can be easily added or updated for continuous improvement of the mobile machine which helps extend lifecycle of the equipment.

Consumer Satisfaction

AI applications integrated with Cloud and Smartphone can help make the operation and management of the equipment easier and more straightforward.

What’s blocking the adoption of SDoV strategy?

Even though we understand and agree to the benefits of more software driven innovation for off-highway vehicle development and operation, there are some difficulties slowing down the adoption.

Software Defined Vehicle technology for on-highway vehicles are well known and under deployment already with decent level of maturity. However, the business dynamics are different for smaller volume, purpose-build off-highway vehicles:

Market Volume

Off-highway vehicle market is estimated to be around 5 million units sold a year versus 90+ million units in the on-highway vehicles market. Combined with diversity of vehicles, technology companies may not see the economy of scale.

Cost of Adoption

SDV requires significant initial investment in terms of architecting the best approach, modernizing E/E system, building cloud infrastructure and securing resources to design and develop all of this. There is a long term cost saving but many companies may have difficulties in justifying the initial investment.

Use Cases

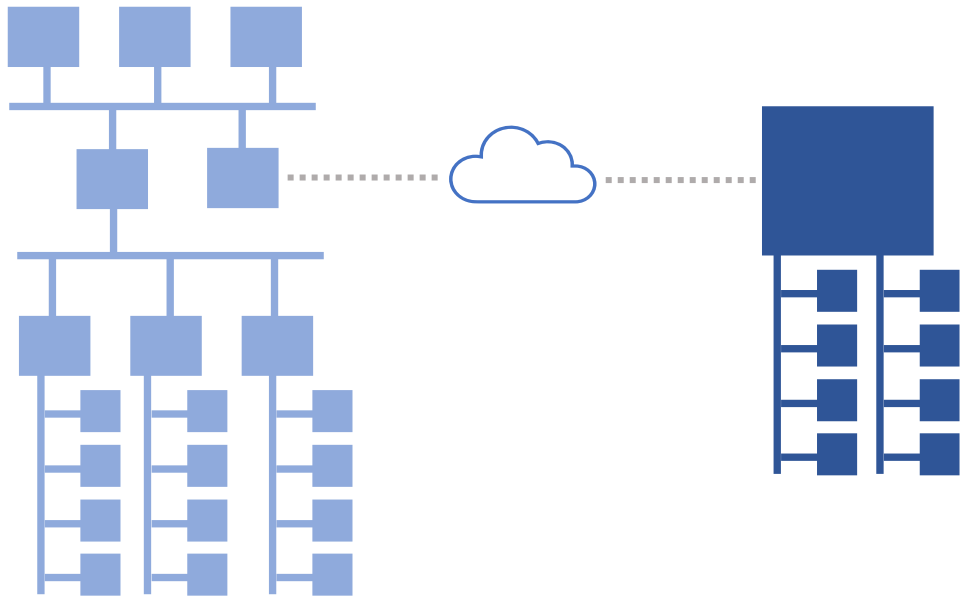
There are a few critical drivers for SDV for the passenger cars and commercial trucks including ADAS and Infotainment system as well as regulatory requirements for SW update over-the-air. Off-highway vehicles still need to define use cases that justify the investment and effort.

What is the right approach for SDoV?

The modern E/E system for on-highway cars are very complicated as it has to deal with 50 to 100 ECUs. It has a number of high performance computes (ADAS, Infotainment, etc) connected to a gateway over high speed Ethernet bus that also connects multiple domain controllers (powertrain, chassis, body) that have downstream ECUs, sensors and actuators over CAN bus. There's a separate Telematics Control Unit to provide 4G/5G cellular network access.

While there's a good reason for this complicated E/E architecture for the rest of the automotive industry, it's not realistic approach for off-highway equipment that deals with much smaller number of ECUs.

Instead, having a **single high performance compute** that consolidates multiple functions including **gateway, internet** access and even **AI applications** make more sense. Given the fact that all the critical ECUs are connected to the digital instrument cluster for off-highway vehicles, it makes the ideal candidate for the role by aggregating CAN traffic, display & analyze the information and provide cloud connectivity.

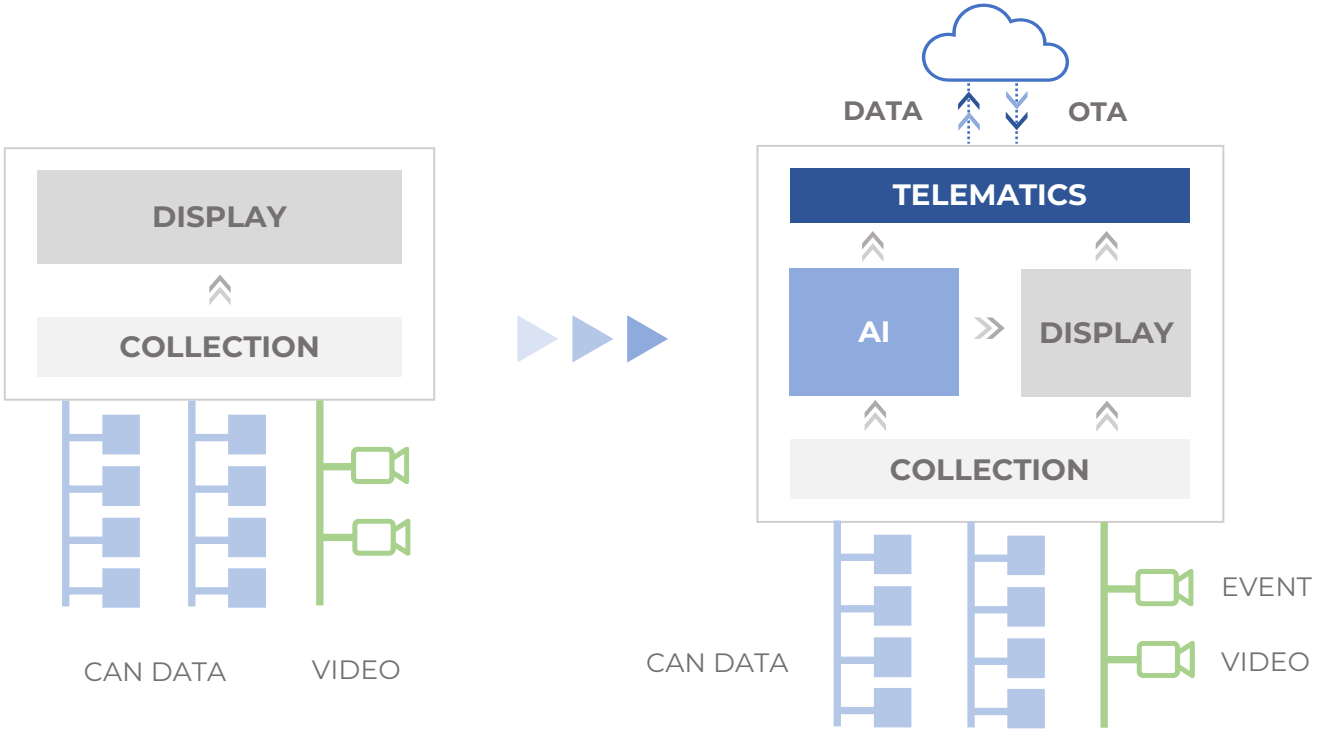


On-Highway E/E System

Off-Highway E/E System

AI-Connected Digital Cluster

All the modern off-highway vehicles are equipped with some sort of digital cluster display as Human Machine Interface (HMI.) Because it handles the touch screen and various control signals, it makes a good candidate as the central computer with cloud connectivity to implement software defined off-highway vehicle design.



Legacy Off-Highway Cluster System vs. AI-Connected Off-Highway Cluster System

How will this re-shape off-highway equipment industry?

Taking advantage of multi-core application processor in the digital cluster enables not only more sophisticated and flexible HMI but also gateway functionality for cloud connectivity and advanced applications such as AI-based object detection for improved worksite safety for mobile machines.

Telematics

Accessing real-time diagnostics data helps fleet managers optimize vehicle maintenance cycle and improve uptime. This can be done through on-board modem or smartphone tethering.

OTA Update

As the vehicles are more digitalized, the role of SW becomes more critical, hence updating SW over-the-air enables improving existing functions or adding new features.

Safety

High performance compute enables consolidating more sensor inputs to improve situational awareness and take proactive actions to prevent accidents

Digital Twin

OEMs can build virtual representation of the physical vehicle and enable fast feedback loop to compare the real world performance with specification and to improve design.

Prognostics

Collecting various vehicle parameters in a flexible manner helps build optimized prediction model to enable preventive maintenance and minimize unexpected downtime.

Edge AI

Instead of using another ECU for camera-based object detection or edge AI computing, the integrated high performance digital cluster can provide new brain power for advanced AI applications.

Conclusion

Digitalizing more vehicle functions and features open up a great opportunity for **more flexible, agile and future-proof design** of off-highway vehicles. Most of the technological innovation in modern automotive industry relies heavily on **advanced software architecture** that's connected to the **cloud services.**

Off-highway vehicles are different from passenger cars but we can still take advantage of the lessons learned and innovative technologies from the automotive industry to **improve productivity** with real time data activation and to **enhance safety** with more intelligent sensors.

There is a pragmatic approach to accelerate the adoption of the **Software Defined Off-Highway strategy.**

Do you want to Transform your off-highway vehicle into Software-Defined Vehicle?

Visit https://klion-alpha.kyungwoo.com to explore more.

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