Highly Integrated Electrical Drive System

A3PS: Eco-Mobility 2025plus

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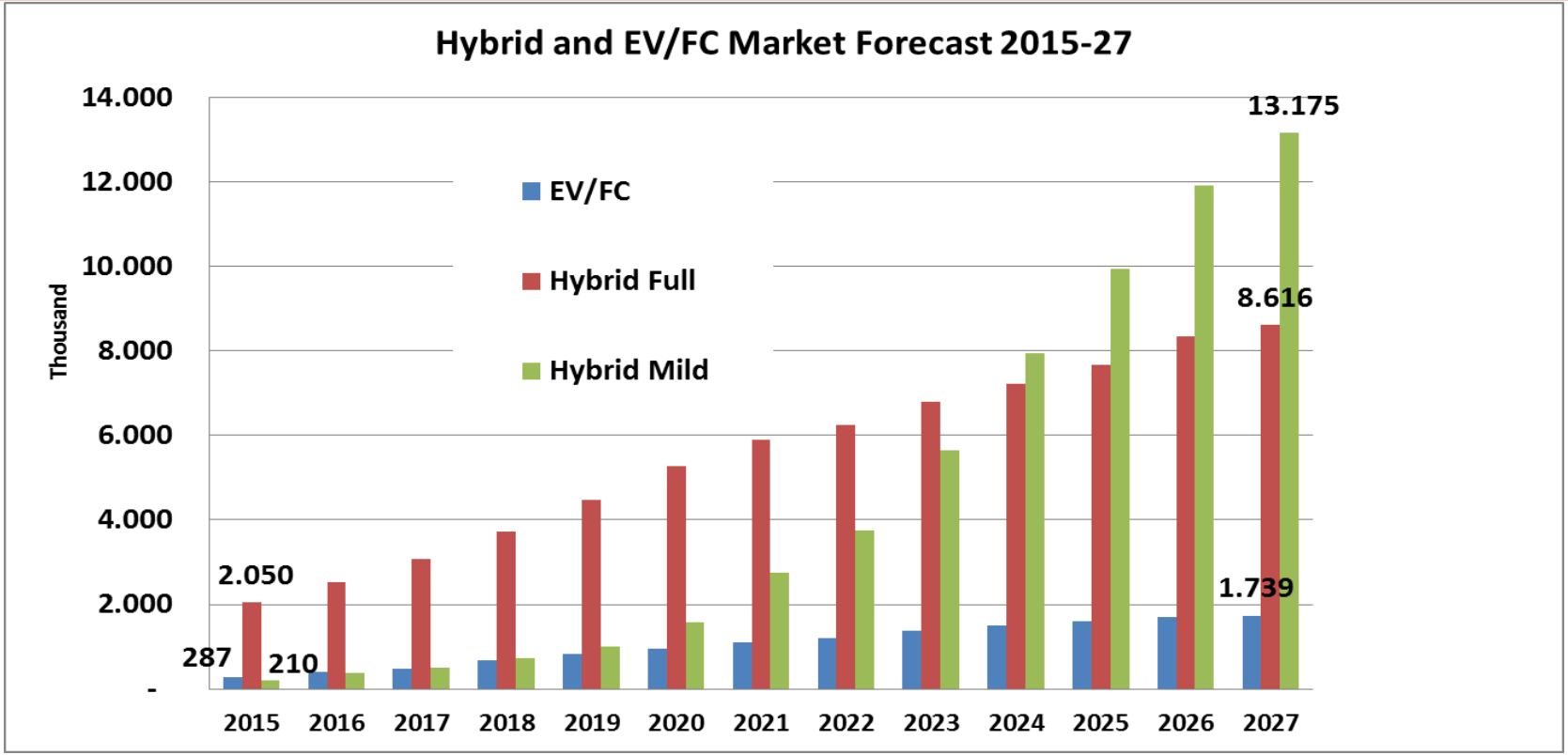
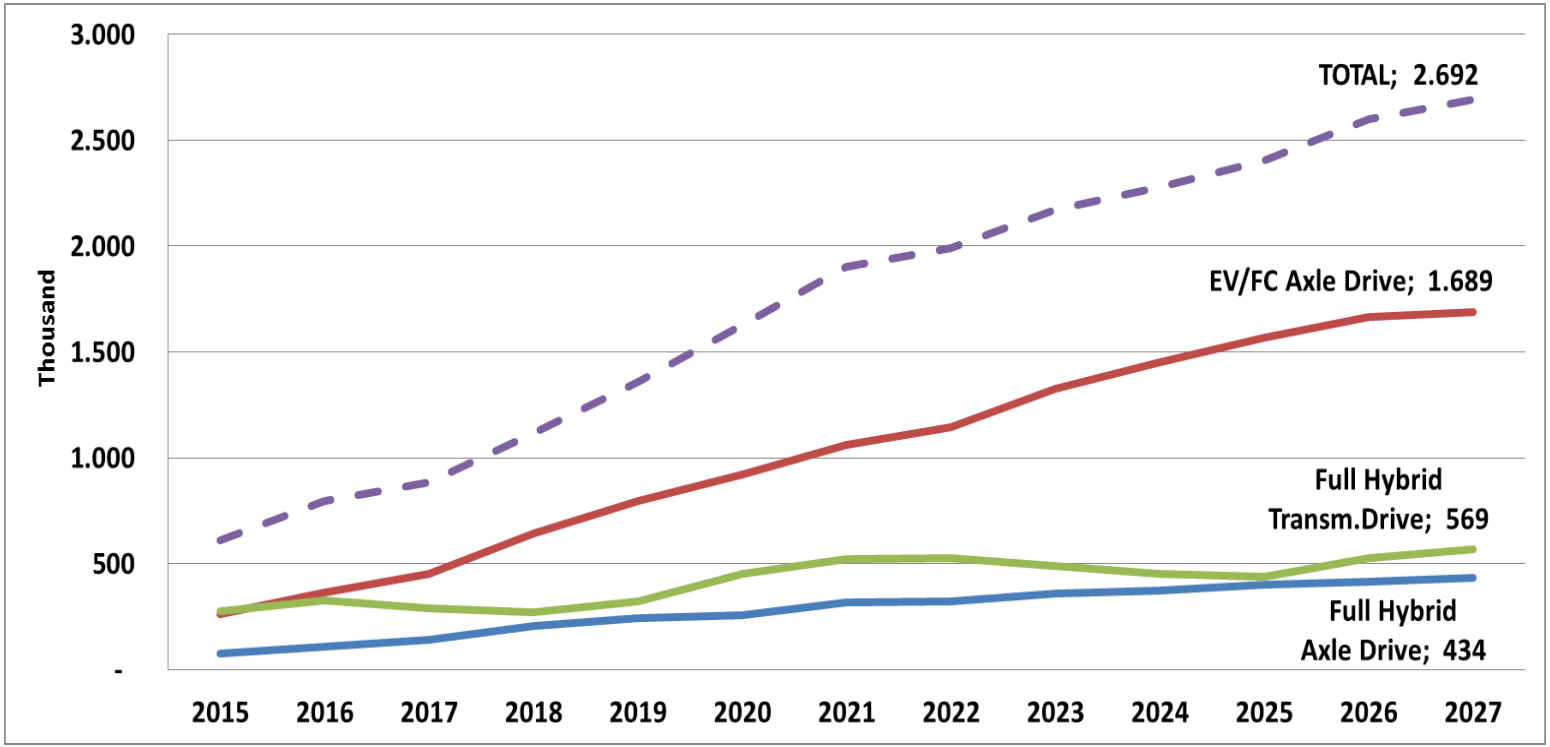
E-Propulsion Market



Mild Hybrids evolve exponentially

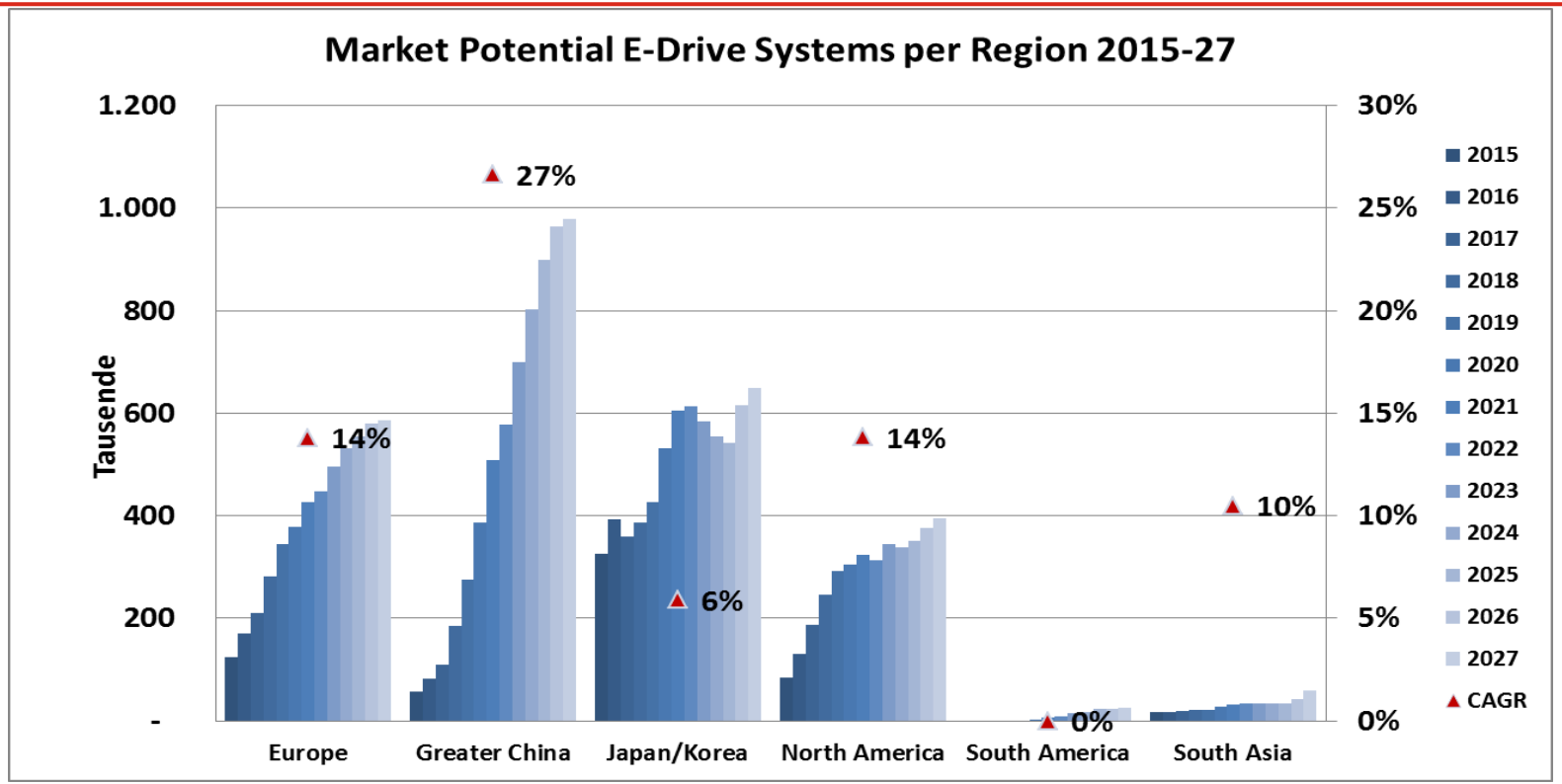
Source: IHS 03/2015

HV Market (EV and Full Hybrid)



HV electric drives evolve incrementally

HV Market (EV and Full Hybrid) - Region



China is the big market for e-drive systems

What is the motivation for electric axle drives?

- More electric power in HEVs
  - Fuel economy & reducing emissions
  - Driver‘s pleasure:
    - Acceleration
    - Top speed (higher continuous power)

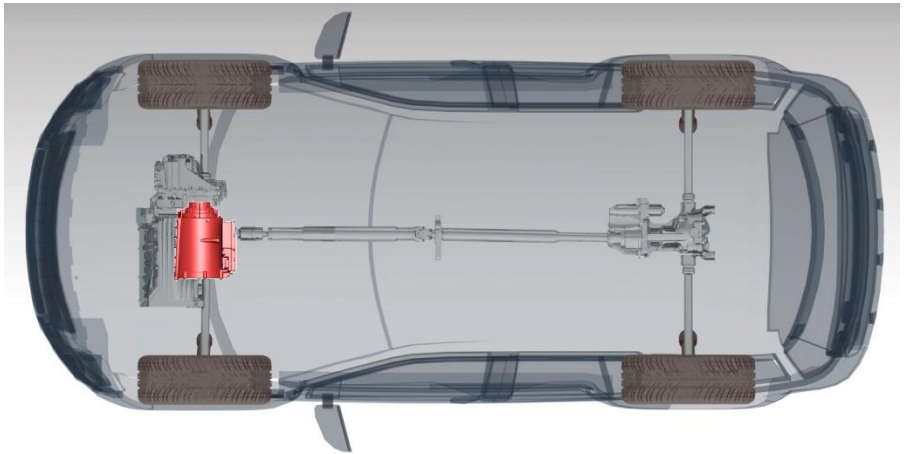
Draw back:

Higher costs

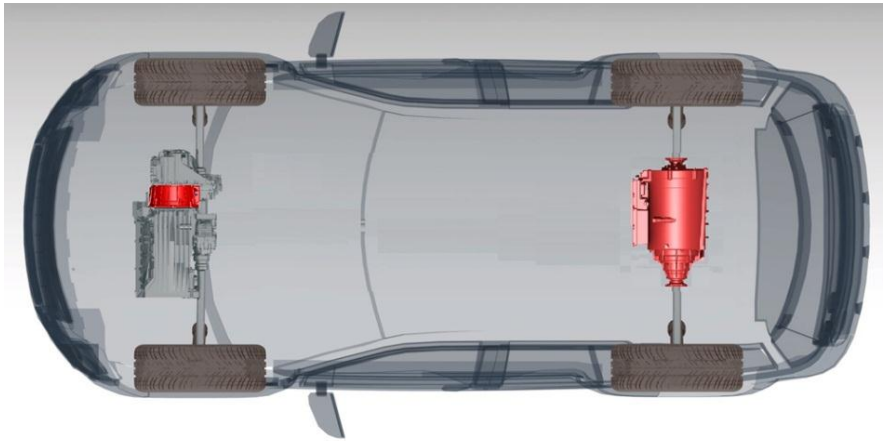
- Higher functionality of HEVs
  - AWD (comfort & safety)
  - Power distribution to both axles
  - Weight balance

There are good reasons for pursuing e-axle drives

PHEV (Plug-In Hybrid Electric Vehicle) with AWD



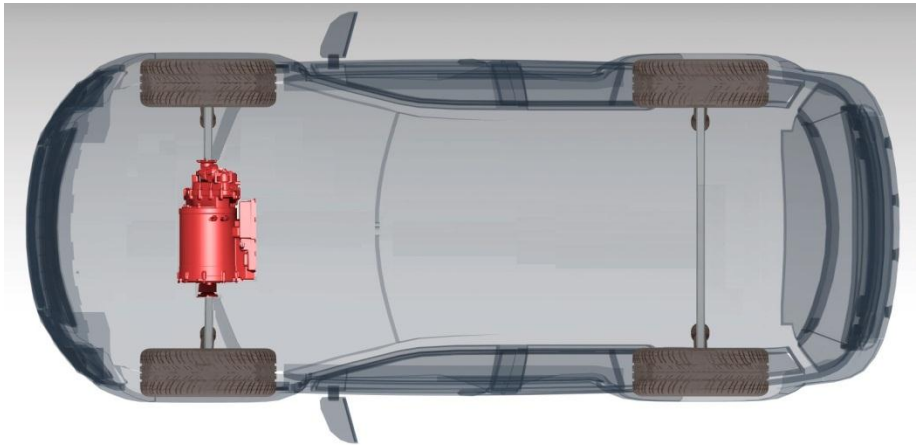
Single electric drive supports ICE on the conventional power train to both axles



Additional rear axle drives appear typically in P2/P4 architectures

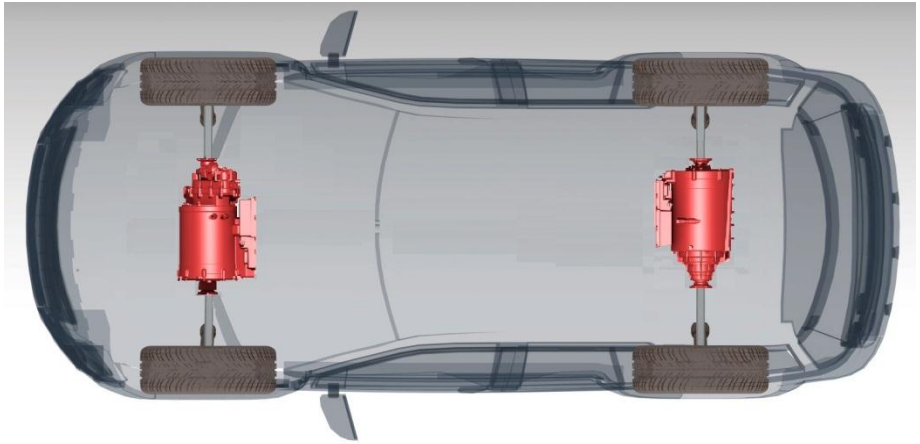
Proceeding variants of HEV will be based on e-axle drives

BEV (Battery Electric Vehicle)



Typical example

Voltage nom. 360Vdc
Battery Capacity 25kWh
E-Motor 120kW



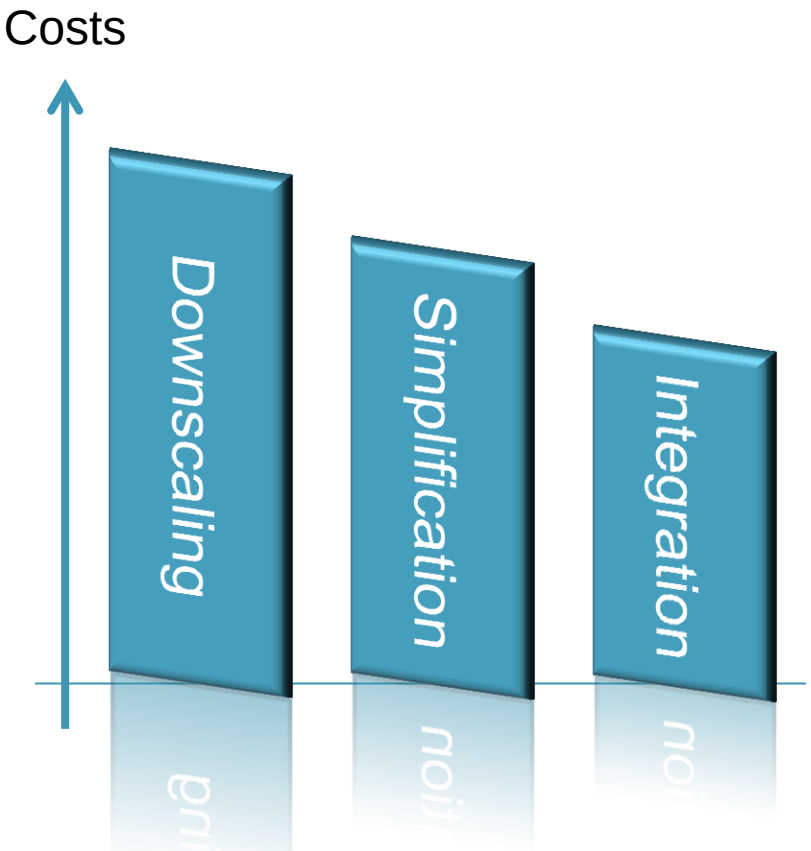
Typical example

Voltage nom. 600Vdc
Battery Capacity 100kWh
E-Motor 2x 120kW

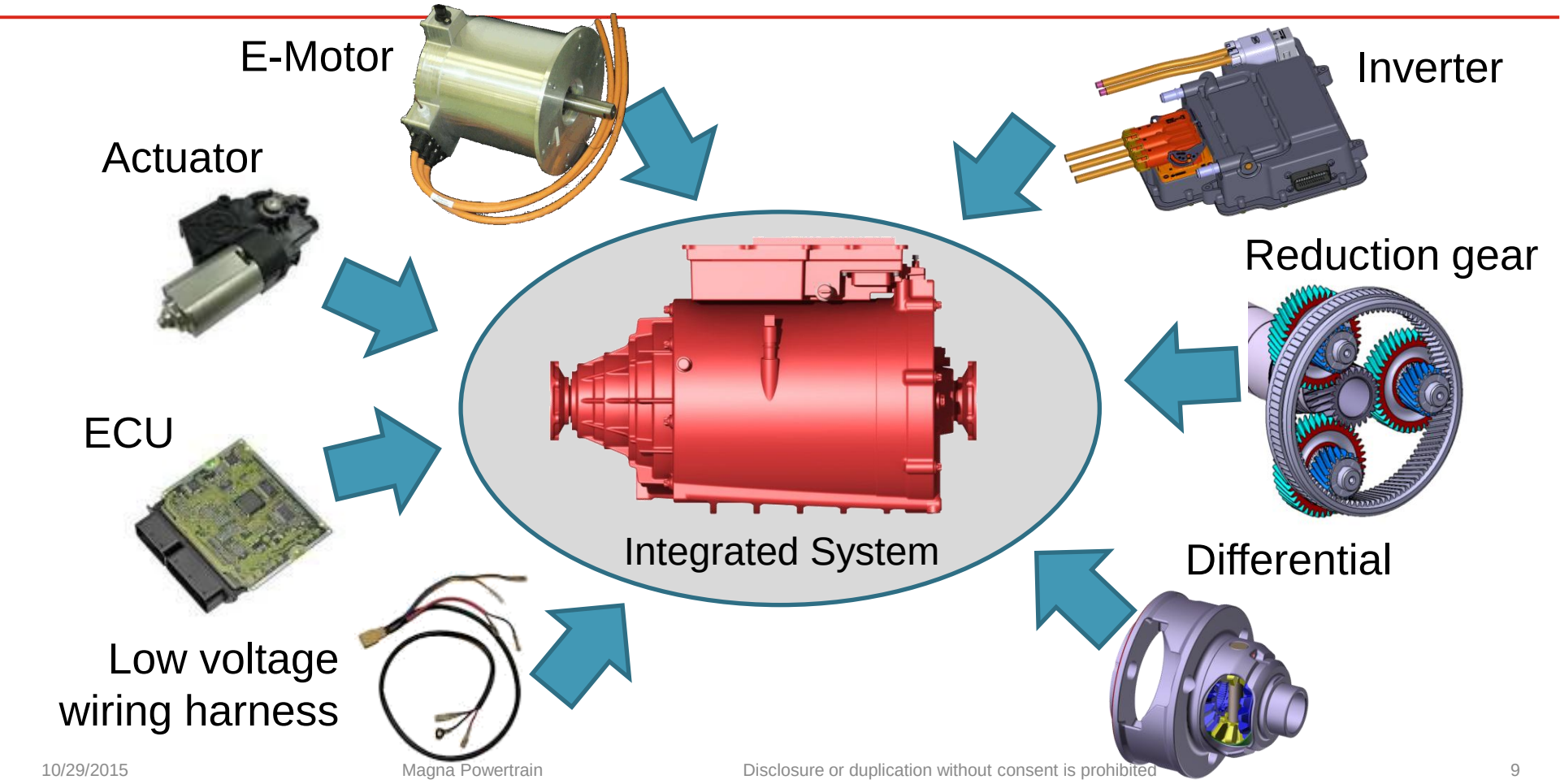
Electric axle drives have big potential in future markets:
BEV and FCEV are based on e-axle drives

Costs are key – How can costs be limited?

1. **Downscaling**
   - Lower performance
   - Lower voltage: 48V
2. **Simplification**
   - Established parts
   - Platform elements
3. **Integration**
   - Share common parts
   - Compact weight
   - Optimized package
   - Reduce number of connectors
   - Reduce wiring harness
   - Optimize EMC characteristics

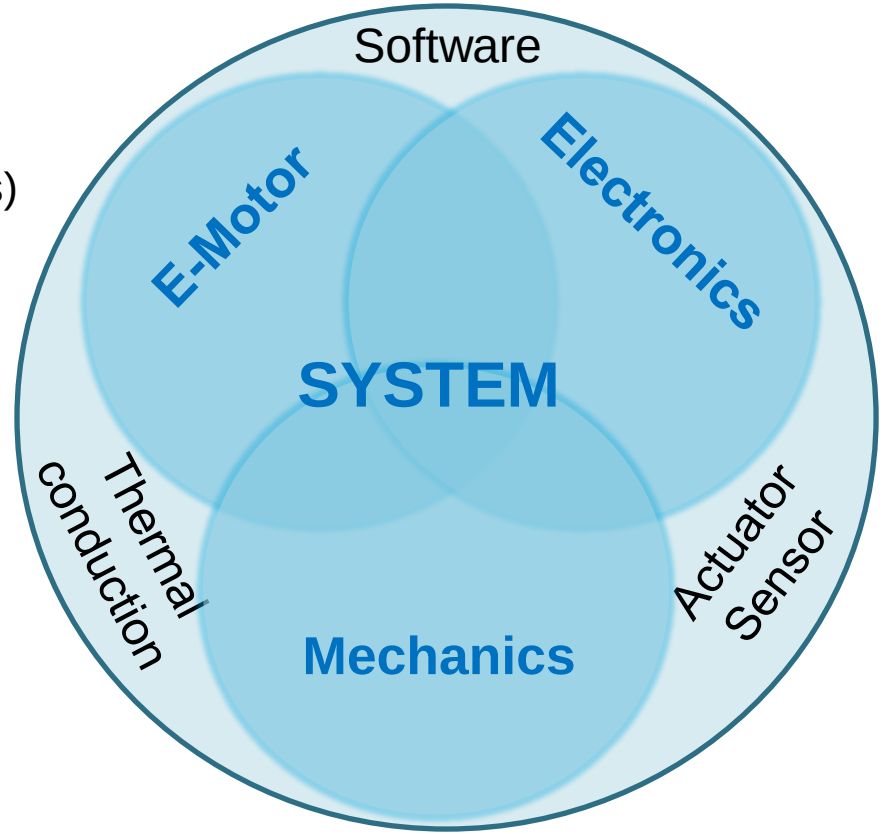


What does integration mean?

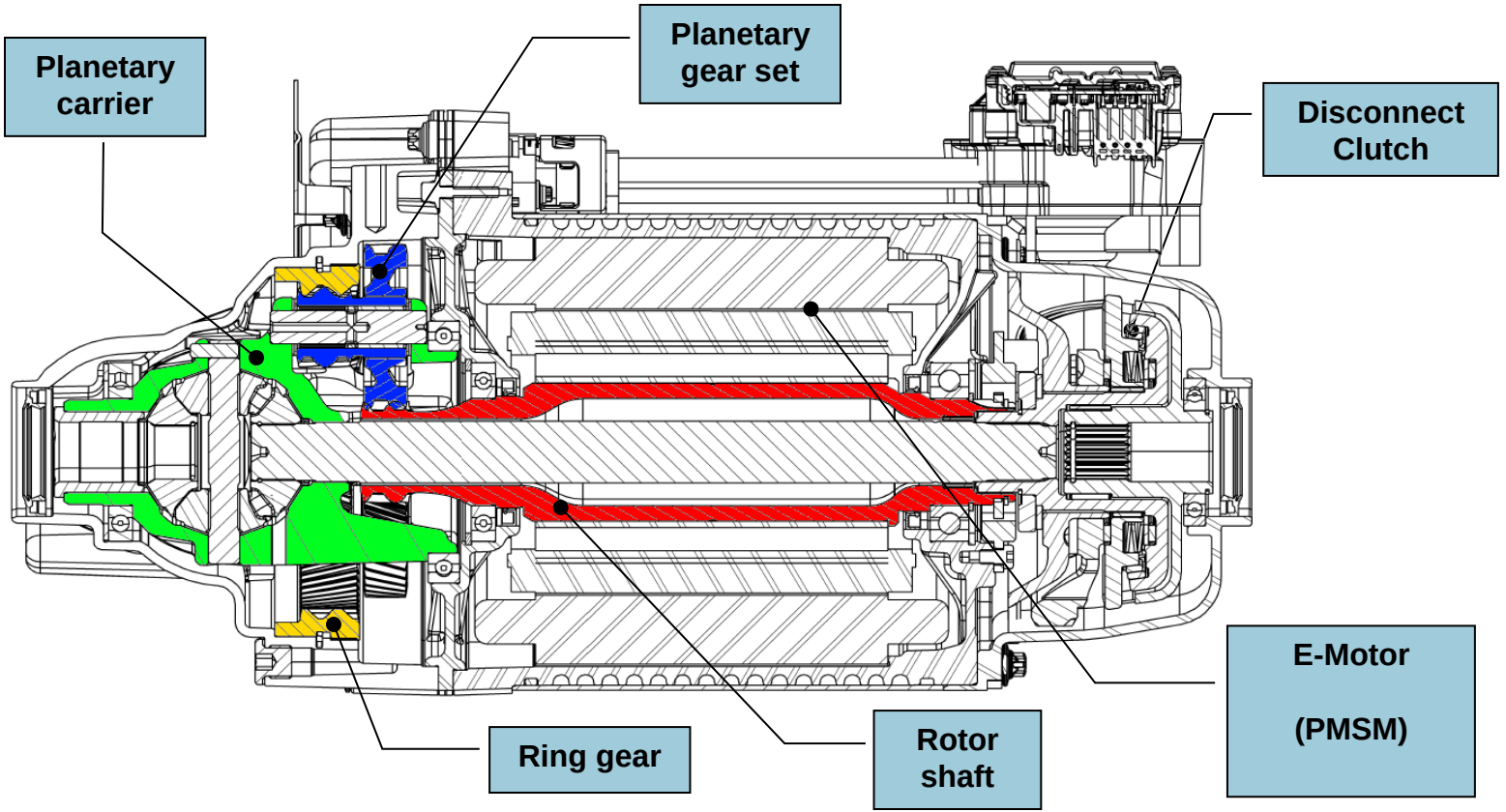


Advantages of integration?

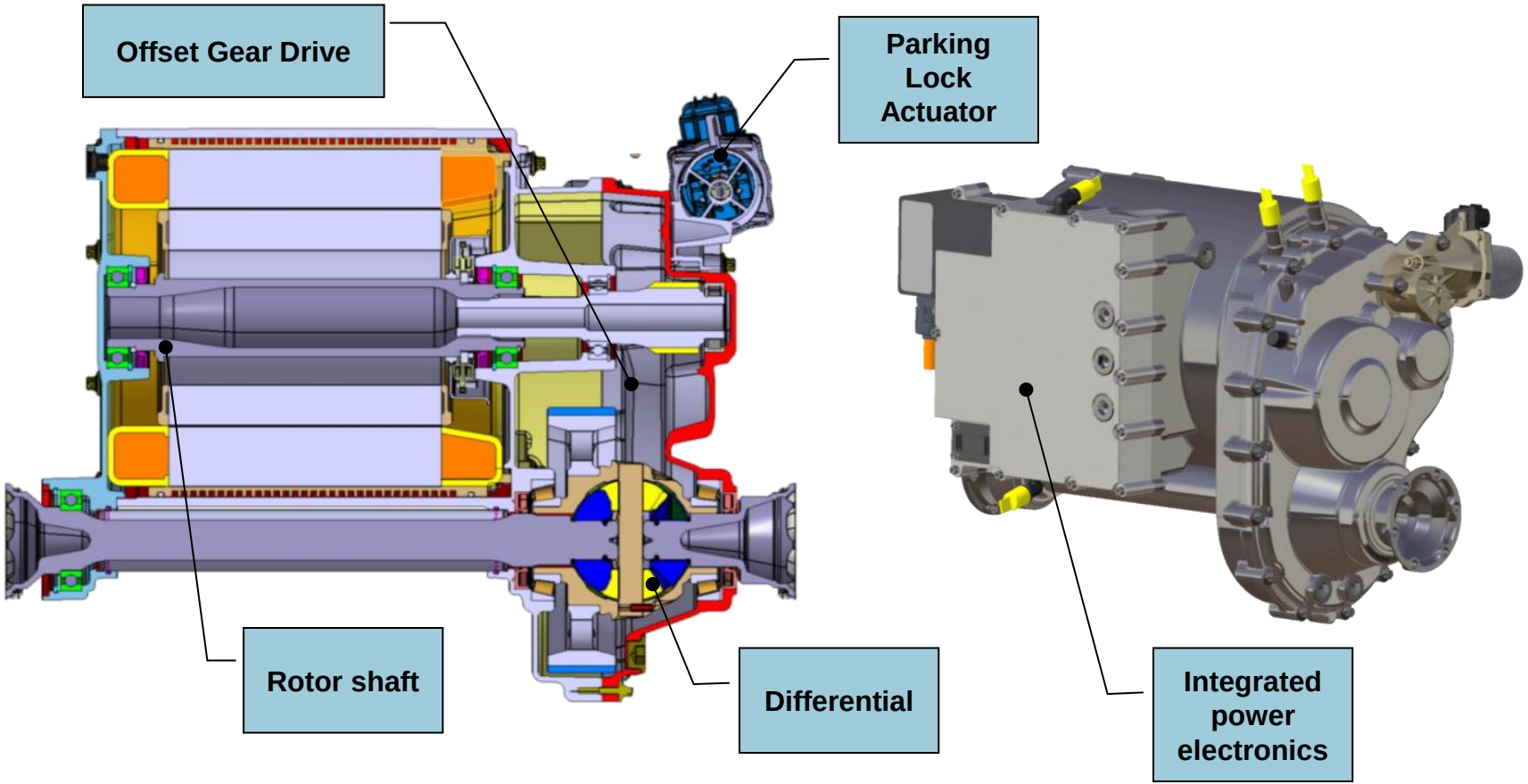
- Number of parts can be reduced
- Number of interfaces can be reduced
  - Number of electrical connectors
  - Number of cooling connections (water spigots)
- Weight optimized by common parts
  - Housing, thermal plate, sealings
- Optimize package volume
  - Less parts, internal connections
- Simplify system integration
  - Plug-and-Play at the vehicle integration
- Enhance quality
  - One system supplier
- Cover safety topics
  - Interaction of system elements
  - Reduce costs if based on standard elements



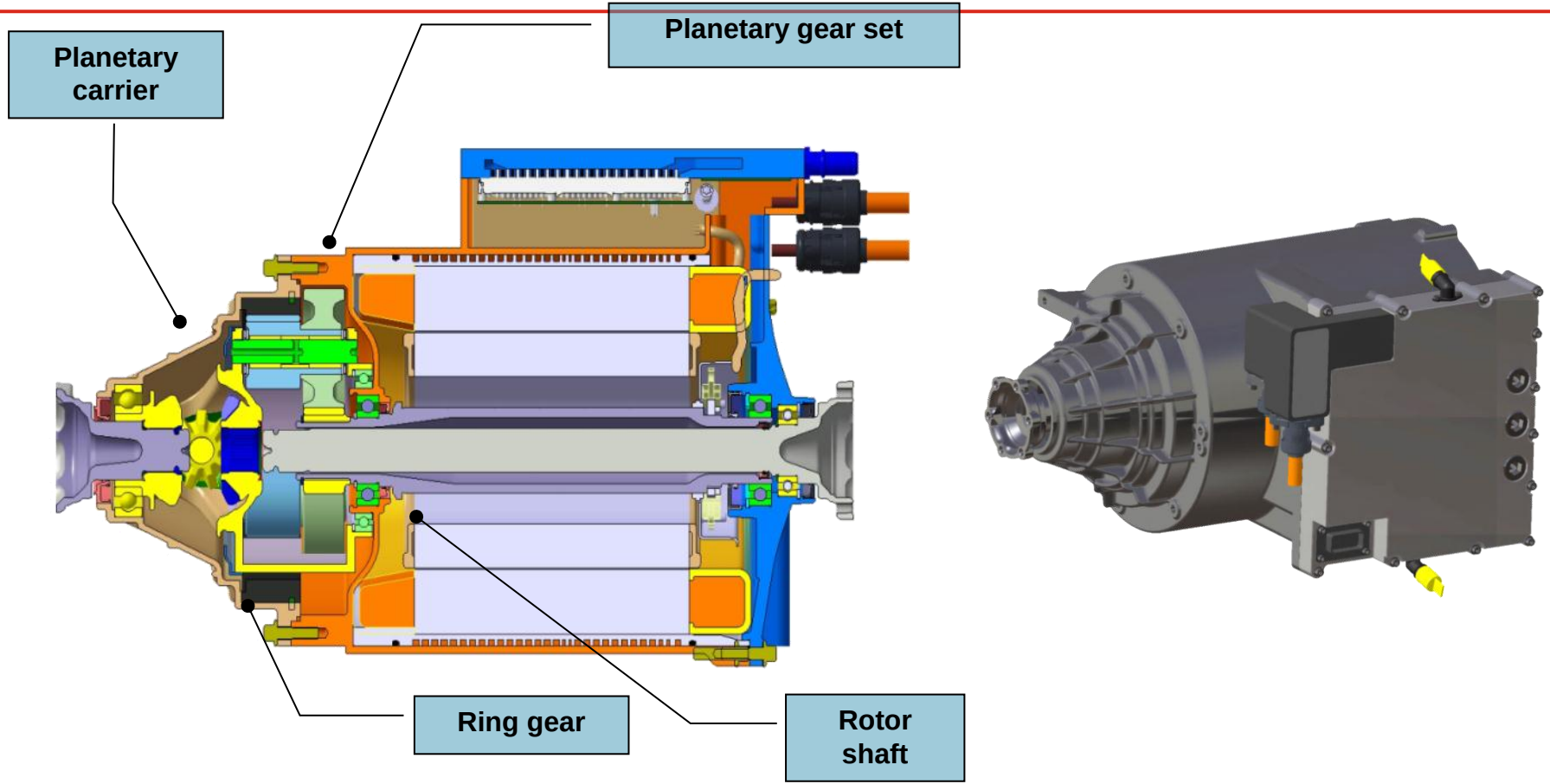
First approach: E-Motor integrated into Gearbox



Next generation of electric axle drives



Next generation of electric axle drives – more compact



Complexity of integrated systems

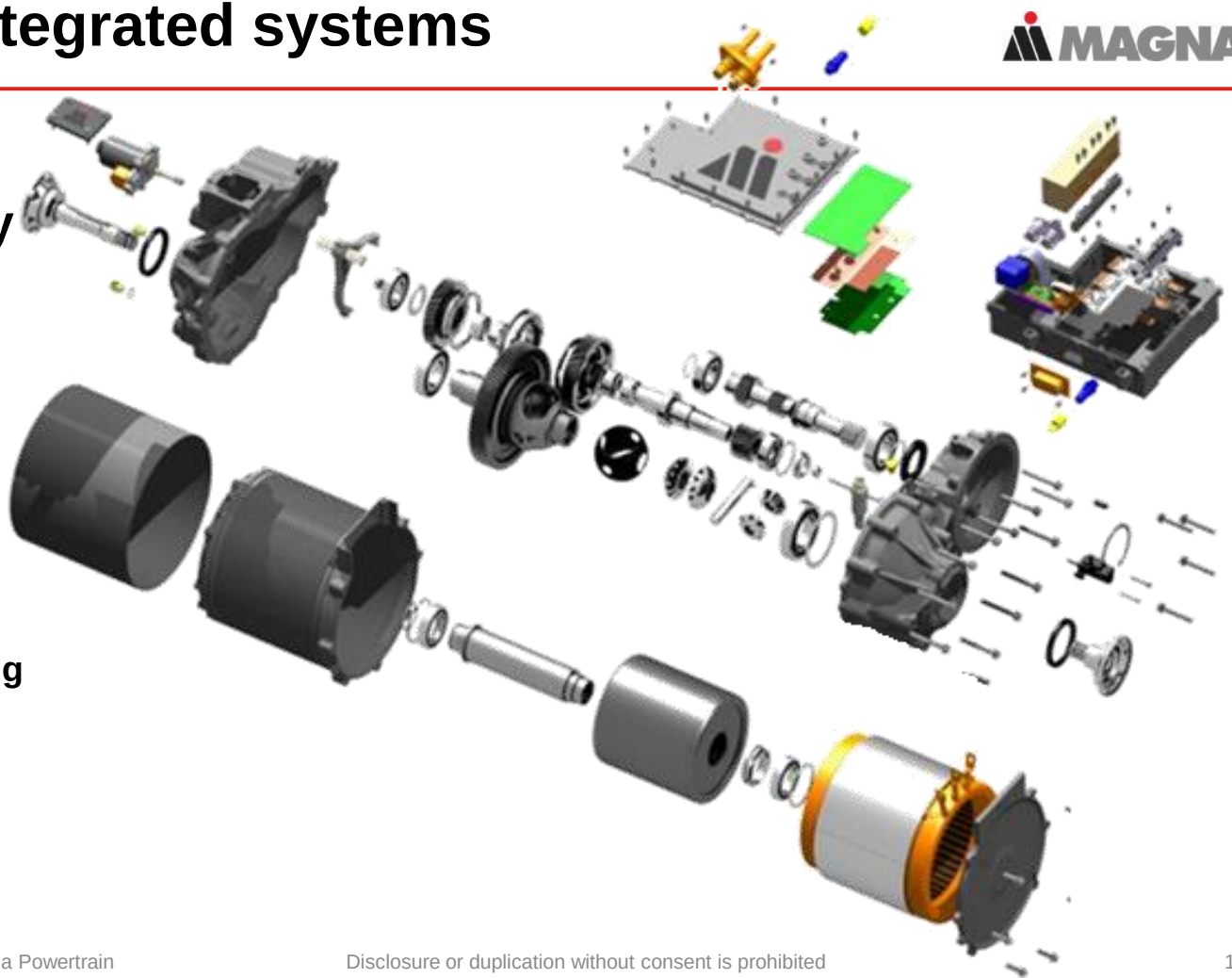
Big challenge for automotive industry

System contains

- Electronics
- Mechanics
- Hydraulics
- Software

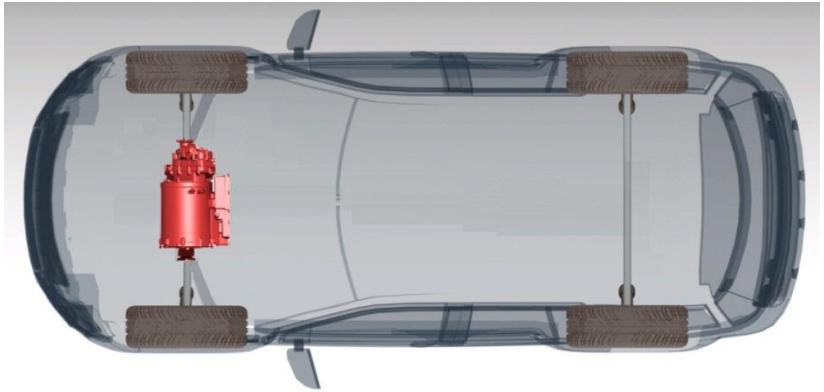
Engineering & Manufacturing

- Resources
- Communications
- Expenditures



Concluding theses

- Electric axles will be the main powertrain in future
  - ✓ **Simple**
  - ✓ **Effective**
  - ✓ **Smart**



- Costs are key for pushing electric drives towards larger volumes
  - – Beside the battery the entire drivetrain has to be cost effective
- High level integration is a general way for evolving technology
  - – Each automotive module does also experience proceeding integration


DRIVING **EXCELLENCE.**
INSPIRING **INNOVATION.**