




Deliverable 2.3 Development and integration of the e-Axle subsystem

Primary Author	Giorgio Rossia
Lead Beneficiary	FPT
Deliverable Type ¹	Report
Dissemination Level ²	PU
Due Date	30.06.2020 (Month 18)
Pages	14
Version	3.1
Project Acronym	SYS2WHEEL
Project Title	Integrated components, systems and architectures for efficient adaption and conversion of commercial vehicle platforms to 3rd generation BEVs for future CO2-free city logistics
Project ID	824244
Project Coordinator	VIRTUAL VEHICLE Research Center (ViF) Bernhard Brandstätter (bernhard.brandstaetter@v2c2.at)
	<i>SYS2WHEEL has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824244. This document reflects the consortium's view the Agency and the Commission are not responsible for any use that may be made of the information it concerns.</i>

¹ Report (R), Prototype (P), Demonstrator (D), Other (O)

² Public (PU), Restricted to group (RE) or programme (PP), Consortium (CO)

Contributors

Name	Organisation
Lukas Kirzinger	AVL
Herbert Liebl	AVL
Preuss Markus	AVL
Luca Fabris	FPT
Luca Mantovani	IVECO

Formal Reviewers

Name	Organisation
Bernhard Brandstätter	ViF
Alois Steiner	ViF
Herbert Liebl	AVL
Giorgio Mantovani	IVECO

Version Log

Rev #	Date	Author / Company short	Description
0.1	03.08.2020	Giorgio Rossia/ FPT	Draft
0.2	06.08.2020	Giorgio Rossia/ FPT	Added 2.4 integration
			Update 2.4 tech data
1.1	21.08.2020	Bernhard Brandstätter	Workpackage approval
3.1	4. 11. 2020	Bernhard Brandstätter	Final changes after review

Table of Contents

- 1 Executive Summary 4
 - 1.1 Activities Done..... 5
 - 1.2 Activities To Do..... 5
- 2 E-Axle subsystem..... 6
 - 2.1 Modular approach..... 6
 - 2.2 E-Motor design..... 8
 - 2.3 E-Axle design 9
 - 2.4 E-Axle integration on vehicle..... 10
 - 2.5 E-Axle technical characteristics 11
- 3 Abbreviations and Definitions 12
- 4 List of figures 13
- 5 List of tables..... 14

1 Executive Summary

This deliverable is based on previous requirement engineering tasks reported in D1.1 and D1.2.

The deliverable D2.3 is the development of the e-Axle subsystem. One prototype will be assembled for integration into the demonstrator vehicle. One other prototype will be assembled as spare part and for testing. Design activities are focusing on the target vehicle (7t IVECO MCV) with modular approach in terms of components and line up application /extension

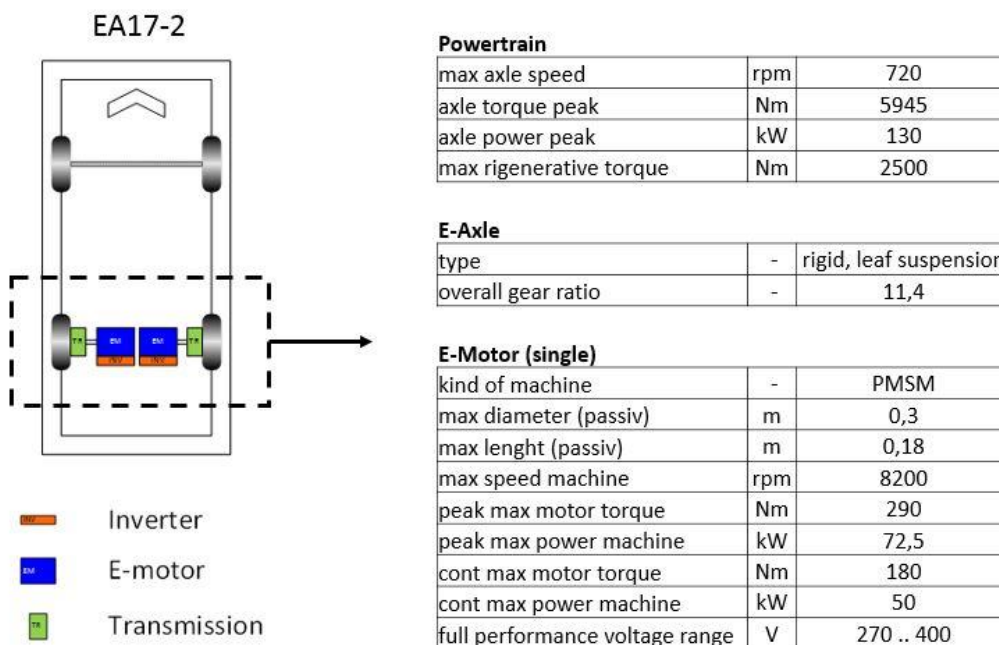


Figure 1 E-Axle requirement from WP1 activities

1.1 Activities Done

- E-Axle design activities:
 - AVL completed the design of the e-Motor active parts to integrate them into the e-Axle assembly
 - IVECO supported vehicle installation preliminary analysis
 - SYS2WHEEL consortium supports FPT to select the best choices for the e-axle
 - FPT coordinated all activities to freeze the e-Axle design
- E-Axle prototype activities:
 - AVL started procurements for active parts and housing of e-Motors
 - FPT started procurements for gears, gearbox housings, wheel end components
 - Supplier sourcing for parts is complete

1.2 Activities To Do

- E-Axle design activities:
 - AVL IVECO FPT teamwork for integration of e-Axle assembled on vehicle
- E-Axle prototype activities:
 - AVL FPT E-Axle parts procurements
 - AVL FPT E-Axle build-up prototypes
 - FPT fatigue test for structural parts of E-Axle to guarantee safety and durability on demo vehicle

During COVID-19 emergency FPT activities stopped under Italy national lockdown, because of that the deliverable D2.3 is delayed by three months, a recovery planning shared with SYS2WHEEL partners does not foresee consequences on final result.

2 E-Axle subsystem

E-Axle architecture EA 17-2 selected and evaluated in the requirements engineering workpackage by AVL FPT and IVECO will be integrated into the demonstrator vehicle:

- Architecture EA 17-2 main characteristics
 - rigid axle³ for 2WD vehicle leaf suspension (mechanical or pneumatic)
 - e-Motor, gearbox, wheel, all in axis
 - two e-motors, gearboxes and inverters, no differential
 - fixed ratio 11.4
- E-Axle Design guidelines
 - e-Motor fully integrated into E-Axle structure
 - modular approach for all components
 - attention to cost and efficiency

2.1 Modular approach

The modular approach is accomplished by interchangeability of 3 master components

- E-Motors assembly
 - output power can easily be changed according to the vehicle request by active parts axial length increasing or decreasing
 - integrated cooling and sensing makes the e-Motor group independent
- Gearboxes
 - the housing of the gearboxes is the mechanical structure connection from electric motors to wheel-end; the best solution is make it in two parts, one complex that contains all gears and one simply tube with length in according to vehicle wheel distance
 - 11.4 ratio is an excellent compromise for working well with both high speed and high torque motors
 - In accordance with the vehicle mission and torque request it is possible to increase gears strength simply by improvement of gears materials and technology (shot peening)
- Wheel - ends
 - is interchangeable in accordance with customer request
 - for the 7t IVECO MCV wheel-ends are carried over from current production

³ rigid axle is not a requirement, it is the only viable solution within Sys2Wheel constraints; non structural e-axle will be the preferred solution for electric LCV and MCV

- use of hub reduction wheel – end makes it possible to extend applicability of SYS2WHEEL e-Axle also for heavy duty application (front steering agriculture tractor)

A simple scheme clarifies the modularity of e-Axle component

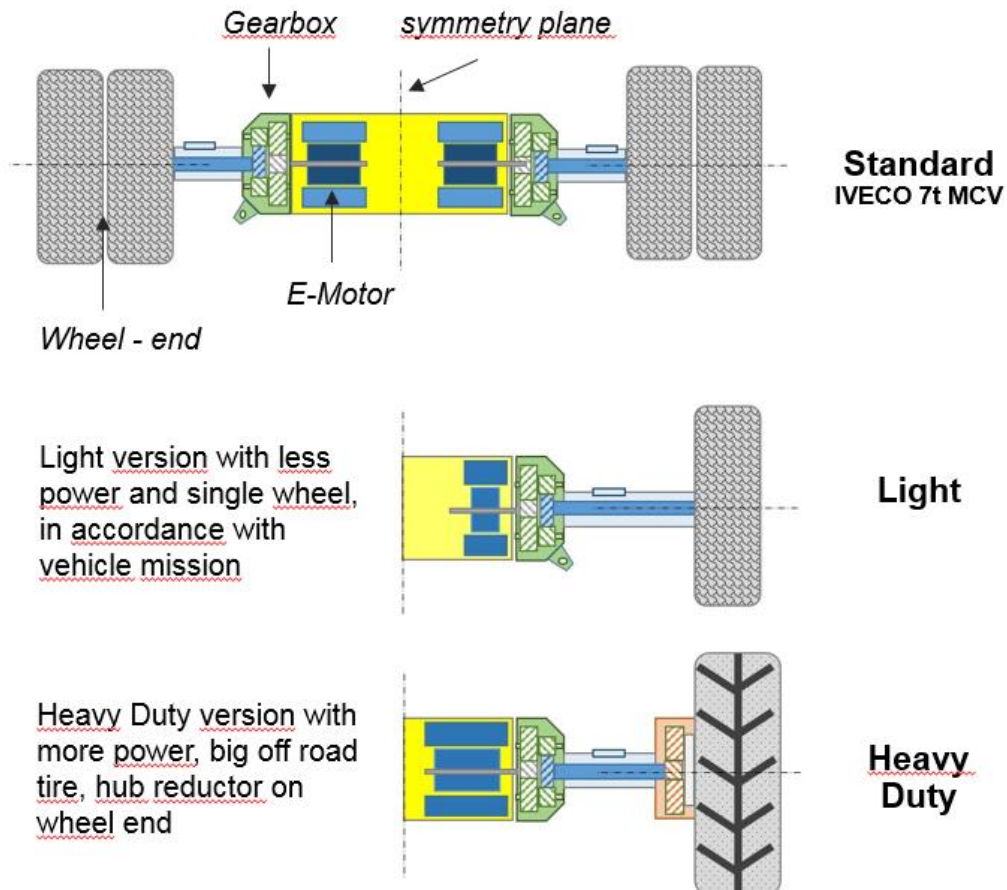


Figure 2 E-Axle modular design approach

2.2 E-Motor design

AVL is the e-Motor specialist that has developed the machine for e-Axle. Following the modularity mainstream the e-Motor is dimensioned as a standalone unit, it has a separate main housing and bearing shields that have also structural function for complete e-Axle.

E-Motor is accurately designed by AVL to have max efficiency at low cost. One of the best characteristics of the e-Motor is the coolant system features with stator parts immersed completely in the coolant flow. An innovative plastic tube between rotor and stator regions guarantees the sealing of the system.

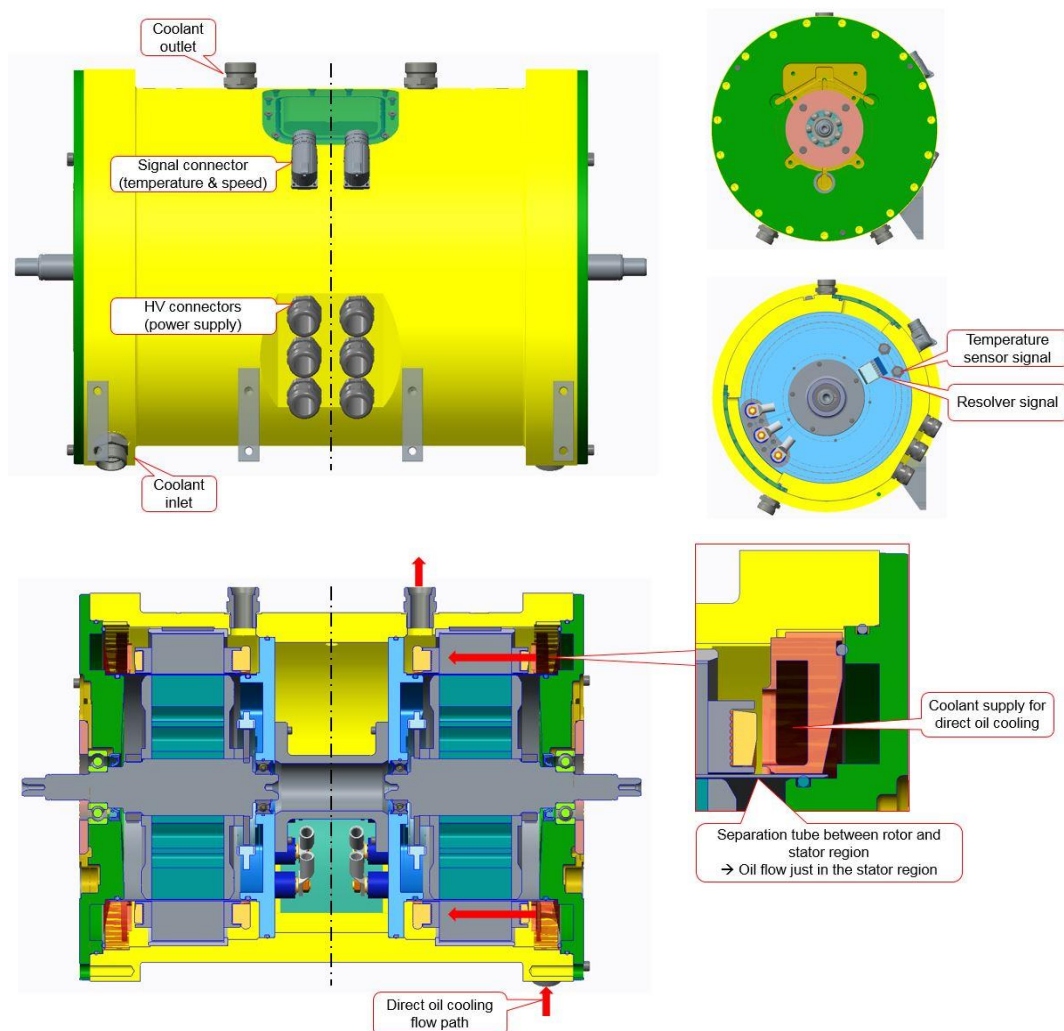


Figure 3 E-Motor design by AVL

2.3 E-Axle design

FPT is the mechanical transmissions specialist that has developed the gearbox and structural parts for e-Axle. The gearbox layout applied on SYS2WHEEL e-Axle is the most promising solution considering cost, efficiency, durability at high speed and high torque mission. This is a dual stage gearbox that split the power on three axis equally disposed around the input and output shaft and guarantee a typical in axis compact solution. Those particular features and designs are protected by patent applications registered in the Italian and European Patent Offices.

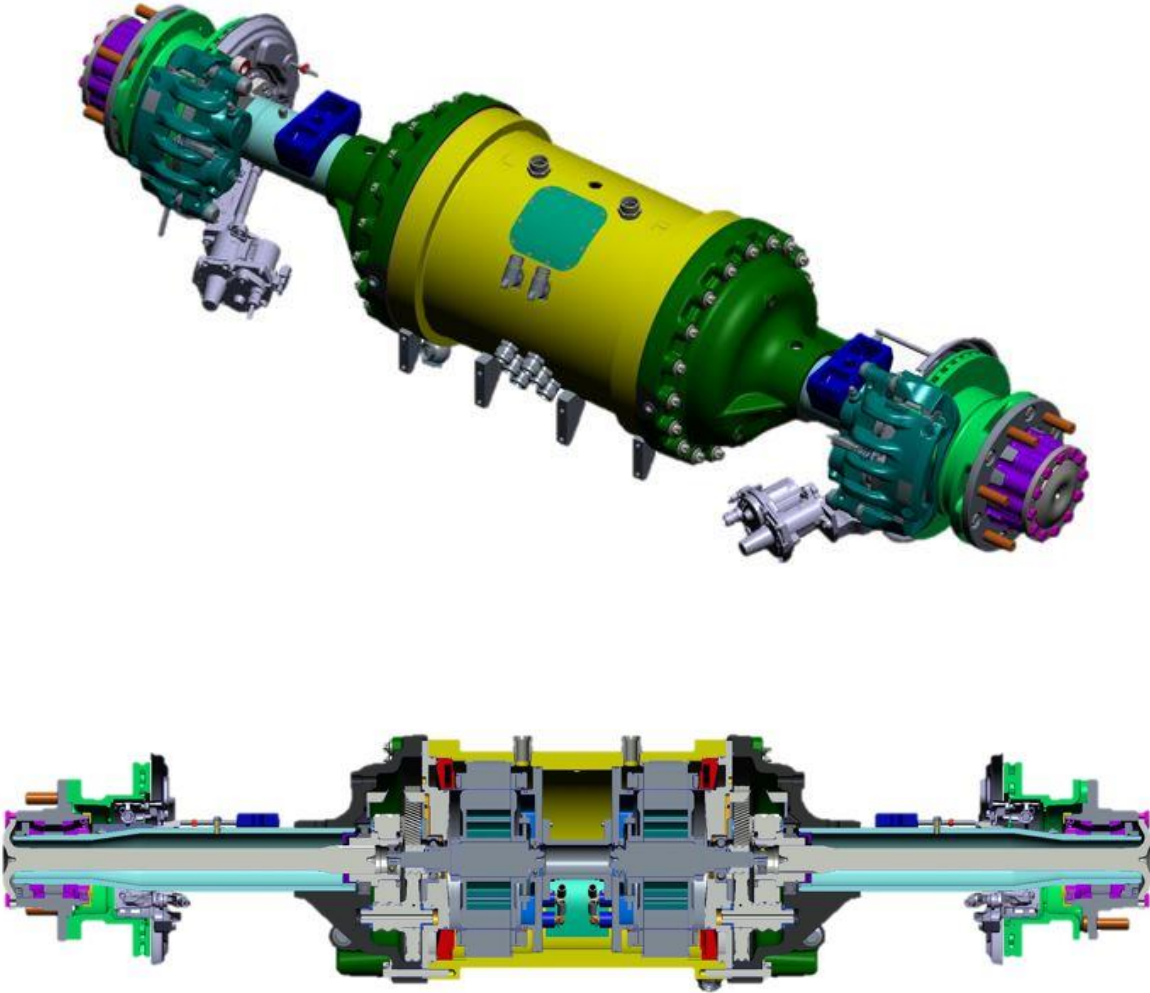


Figure 4 : E-Axle design by FPT

The E-Axle is fully designed and virtually verified by FPT to perform at best way the mission of 7t IVECO MCV.

Structural analysis for safety and durability are on line current production criteria and mechanical efficiency is better due the simplicity of transmission layout (cylindrical gears instead of hypoid). Of course, the best quality of SYS2WHEEL e-Axle are compactness and lightness in comparison a traditional center drive e-Driveline.

2.4 E-Axle integration on vehicle

The E-Axle is designed for assembly into the 7t IVECO MCV chassis with minor modifications. The E-Axle system uses current production suspension, pneumatic or mechanical, with the only repositioning of shock absorber cross member frame.

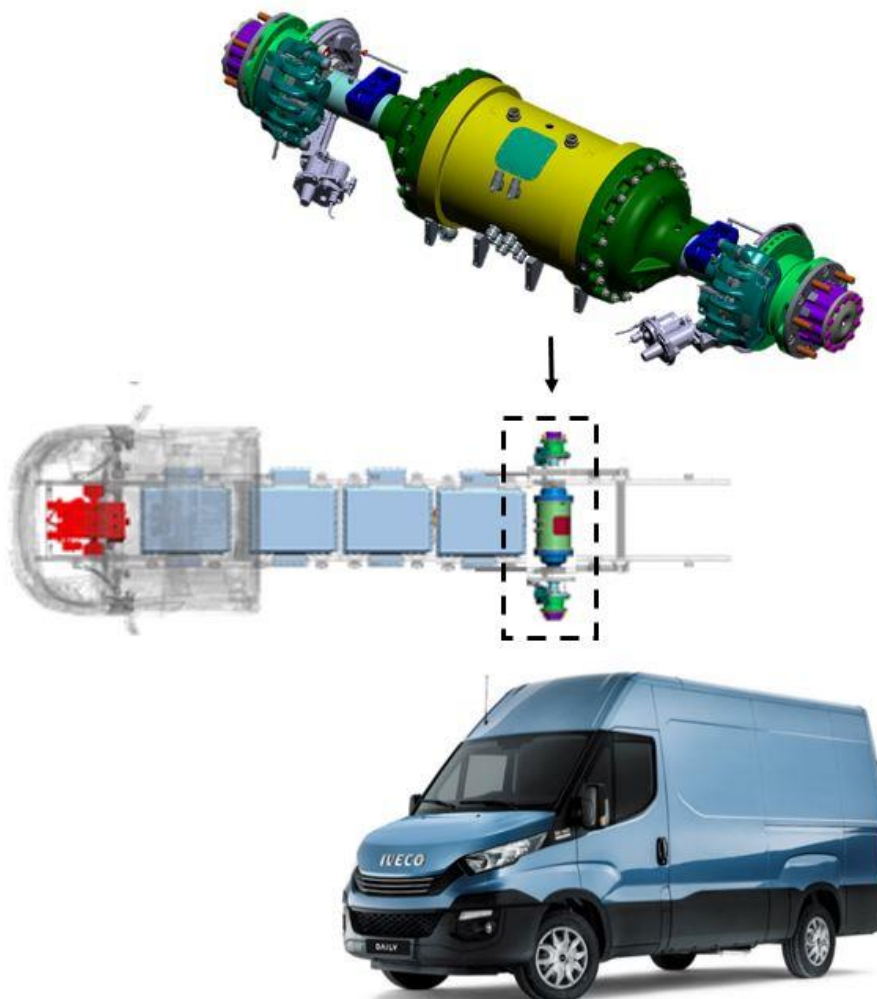


Figure 5 : E-Axle integration on vehicle

2.5 E-Axle technical characteristics

Table 1 :E-Axle technical characteristics

max vehicle speed	Km/h	100
dynamic tire radius	m	0,37
max axle speed	rpm	720
axle torque peak	Nm	5945
axle torque countinuous	Nm	376
axle power peak	kW	130
axle power countinuous	kW	90
max rigenerative torque	Nm	2500
suspension type	-	rigid, leaf suspension
overall gear ratio	-	11,4

3 Abbreviations and Definitions

Table 2: Abbreviation

Abbreviation	Long title
GVW	Gross Vehicle Weight
E-Axle	Electric driven axle
E-Motor	Electric motor
E-axle	Electric driven axle
EM	Electric motor
INV	Inverter
TR	Transmission

4 List of figures

Figure 1 E-Axle requirement from WP1 activities 4

Figure 2 E-Axle modular design approach..... 7

Figure 3 E-Motor design by AVL..... 8

Figure 4 : E-Axle design by FPT 9

Figure 5 : E-Axle integration on vehicle..... 10

5 List of tables

Table 1 :E-Axle technical characteristics 11

Table 2: Abbreviation 12