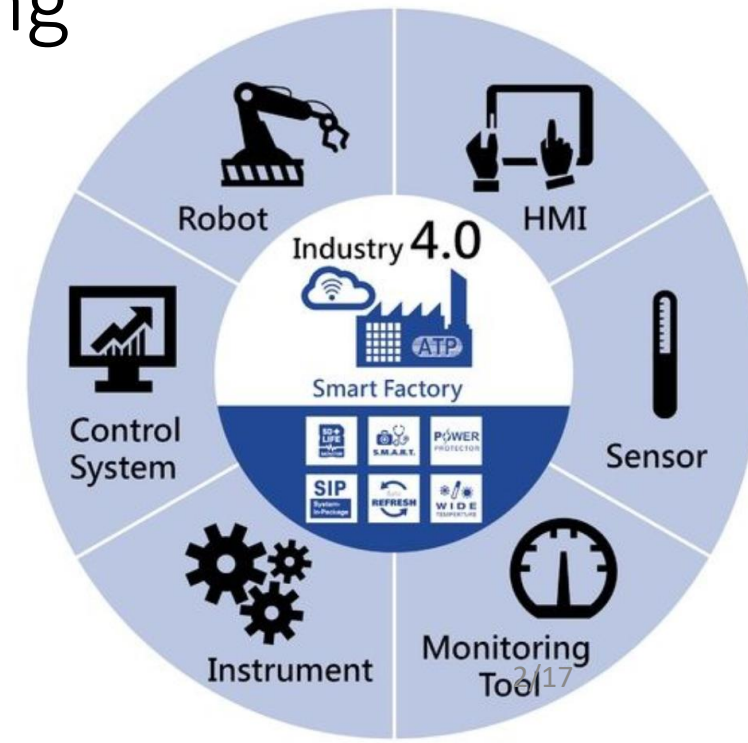


Sessione 3 – Esperienze di dottorato industriale

Nicolò Cavina - Università di Bologna

The product.... Highly Qualified Engineer in Automotive Engineering

“highly qualified personnel with multidisciplinary skills, able to direct the development and research, also in the industrial field, of **innovative vehicles**, creating a meeting point between **mechanical, industrial, electronics, telecommunications, controls, electrical, IT, logistics and civil engineering**”





The product....

controls

electronics

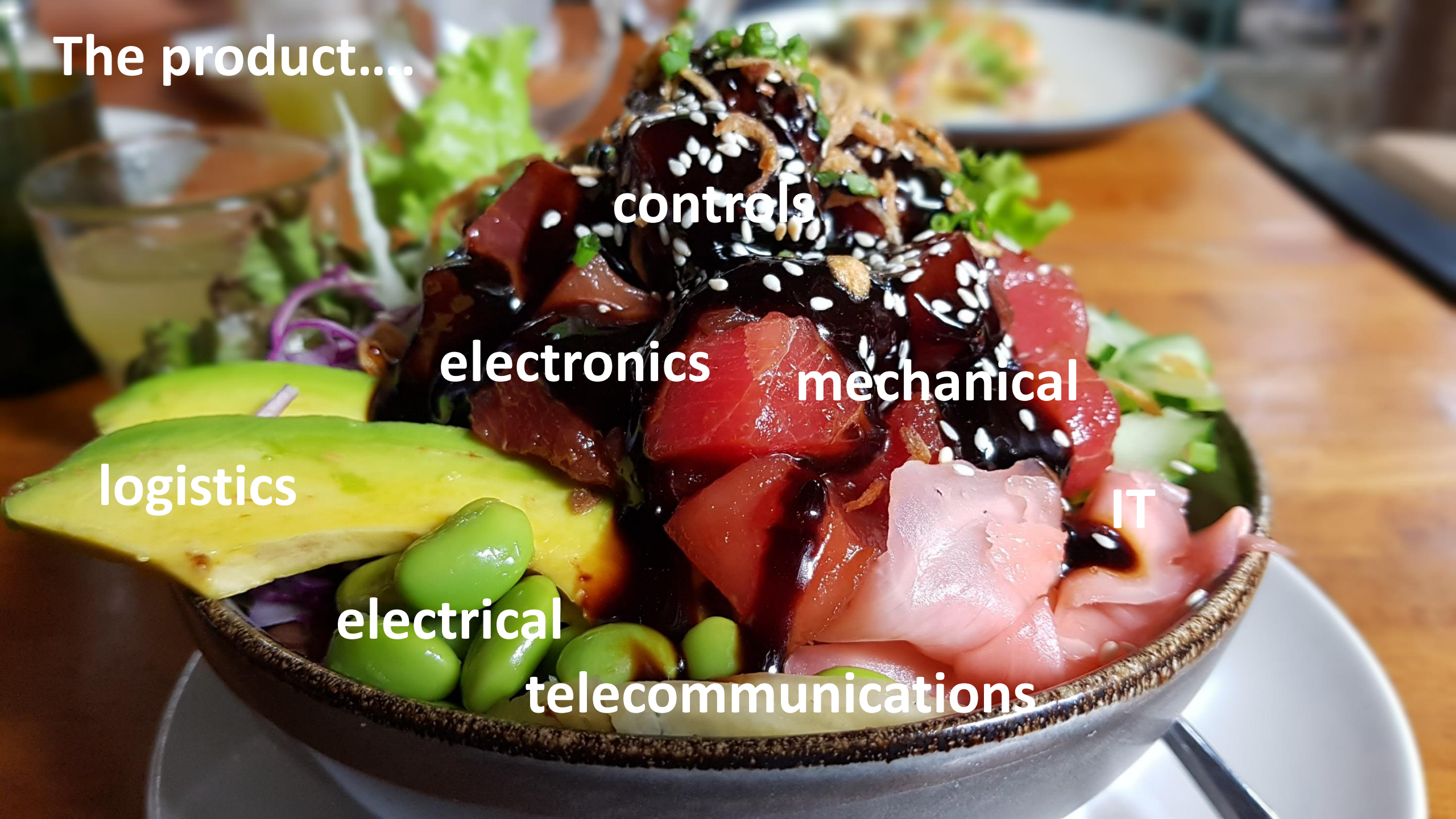
mechanical

logistics

IT

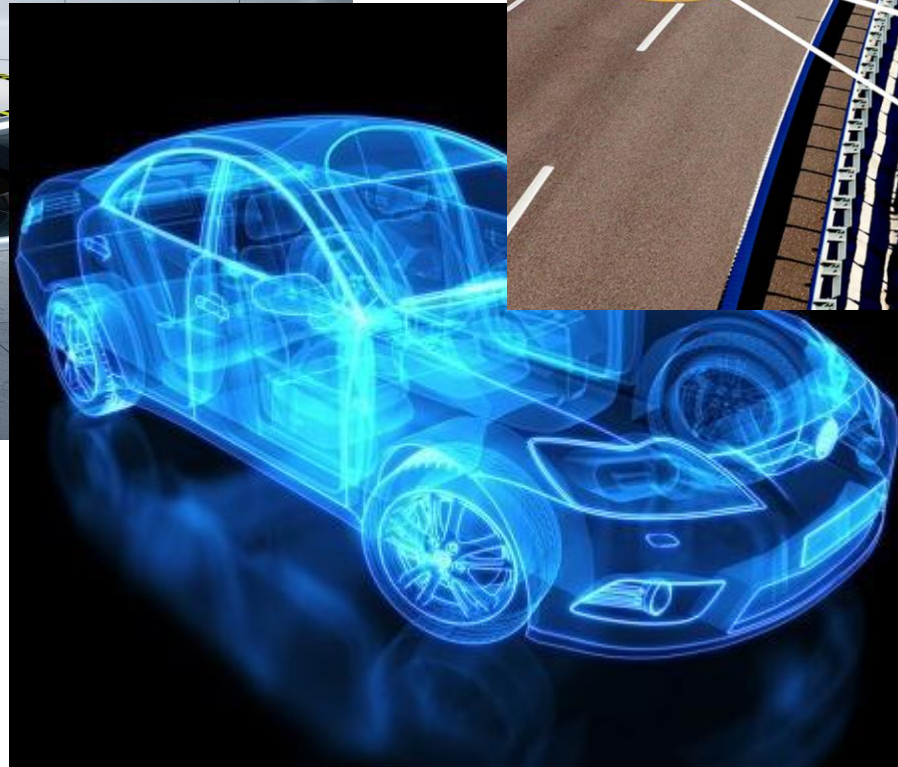
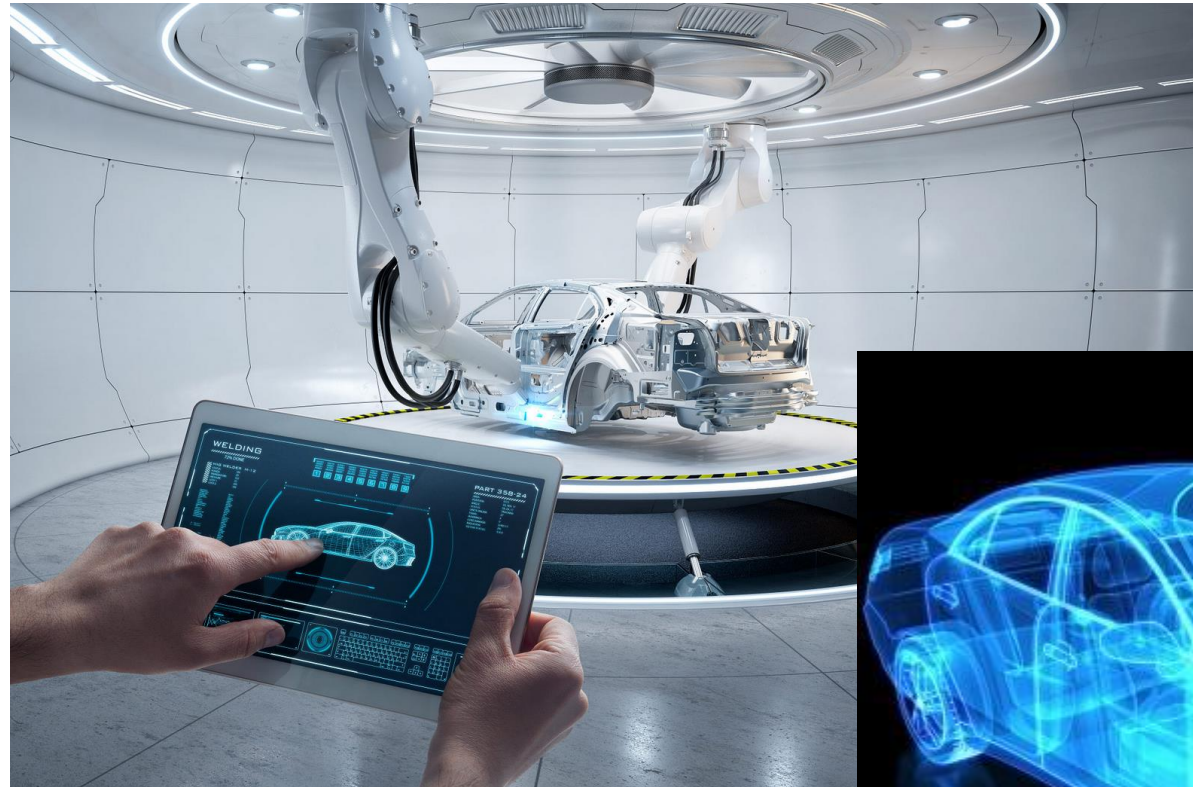
electrical

telecommunications



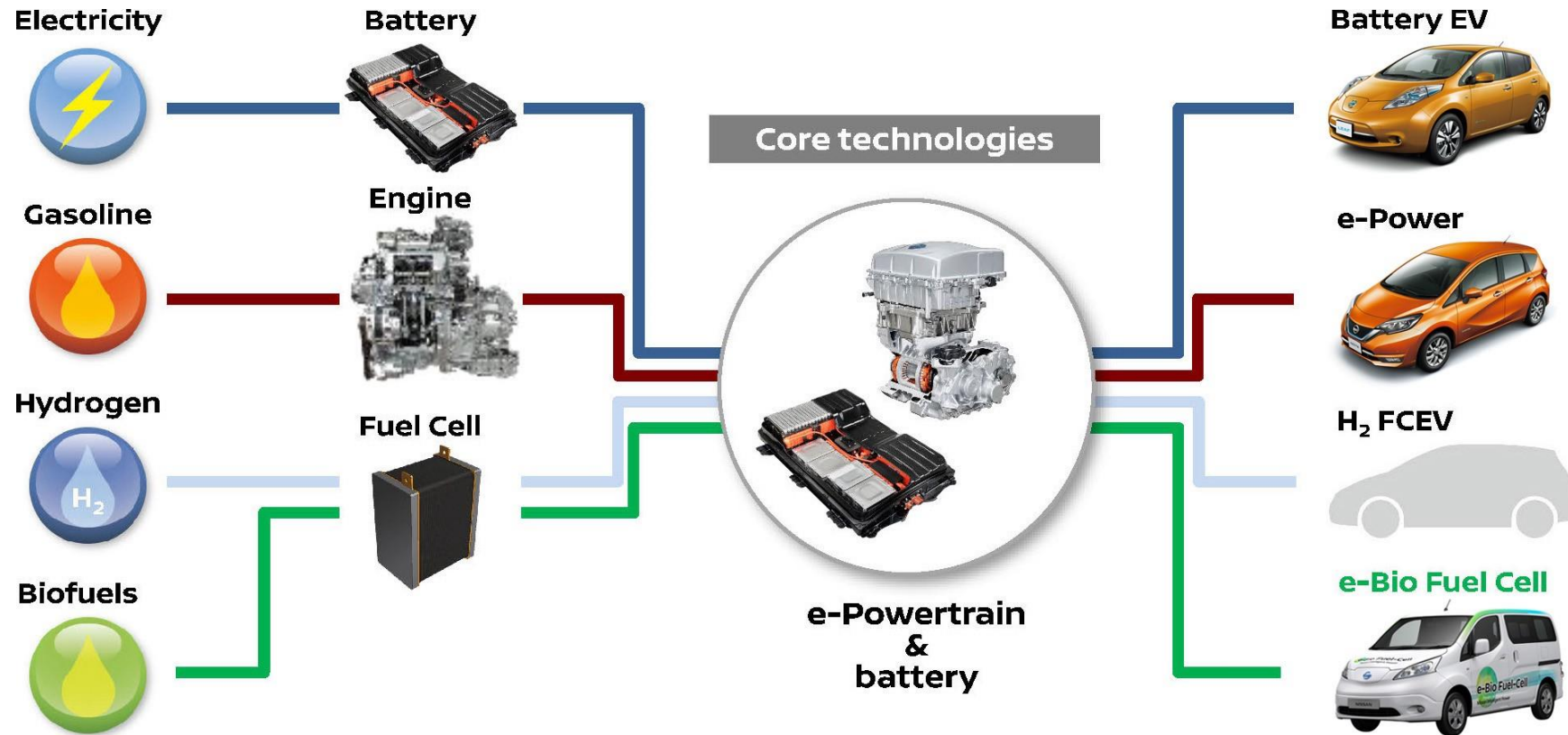
The package....

PhD Course in Automotive Engineering for Intelligent Mobility



The package....

PhD Course in Automotive Engineering for Intelligent Mobility



The package...

- Forte spinta dal basso per preparare i candidati (MUNER, UNIBO MOTORSPORT)
- Forte interazione con gli Atenei della Regione e con i partner industriali (MUNER+CONSORZIO ATENEI)
- Struttura in 3 curriculum
 - ...
 - ...
 - ...

The background of the image features a close-up, high-contrast photograph of red mechanical gears. The gears are highly polished, reflecting light in a way that creates bright highlights and deep shadows, emphasizing their metallic texture and complex geometry. The composition is dynamic, with the gears interlocking and creating a sense of motion and precision.

M

UN
ER

MOTORVEHICLE
UNIVERSITY OF
EMILIA-ROMAGNA

- What is MUNER

4 Italian universities that are synonymous with **advanced training** in association with the motor companies that represent the **excellence of Made in Italy** in the world and are historically rooted into the **Motor Valley (Emilia – Romagna)** and supported by the **Regional Government**

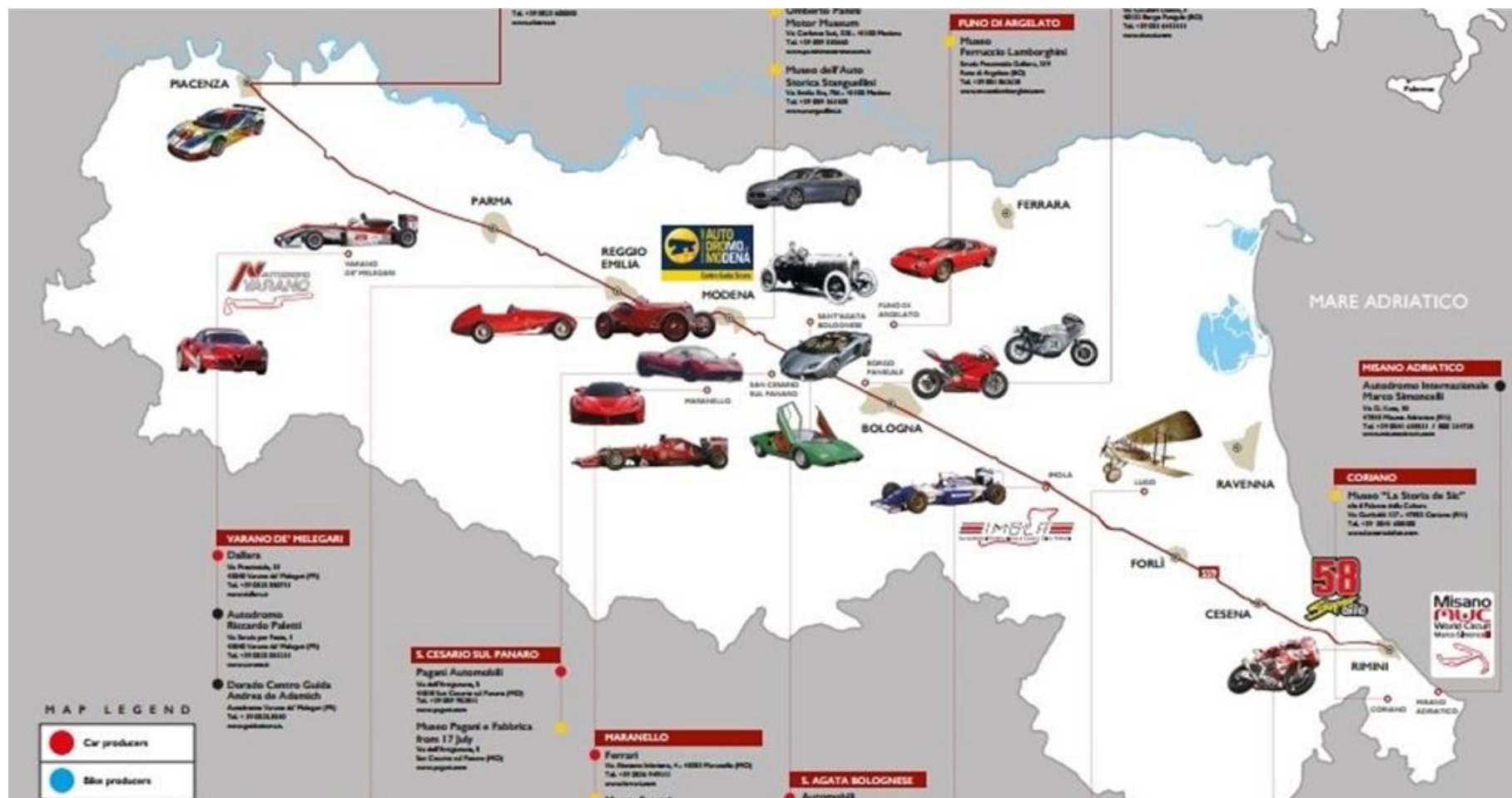


- Emilia-Romagna KEY FACTS

- **World Top Super Car Companies:** Ferrari, Maserati, Lamborghini, Ducati, Dallara, Pagani together with top Suppliers (Magnetit Marelli, Bosch, etc.)
- **Skills:** High Concentration of Mechanical Engineers
- **Innovation:** Mechatronics, Self-Driving cars, Electric
- **4,000 Quality Suppliers, Startups,** Aftermarket Companies
- **Trade Fairs:** Motorshow and Autopromotec
- **Museums:** Ferrari Museum, Ducati Collection, historical cars
- **Motor Valley** Tourism



- **Total Value Added:** € 146 BLNS (13% Of Italian GNP)
- **Export:** 56% In the Mechanic & Automotive Sector
- **40.000 Manufacturing Companies**
- **Human Capital:** the oldest University in the world (Bologna, 1081) and the most advanced infant education system in the world (Reggio Emilia School)
- **Emilia-Romagna Motor Valley World Class Cluster**



- International Master Degrees:

- **Advanced Automotive Engineering (AAE) → LM-33**

A maximum of **150 students** are admitted each year:
120 for Advanced Automotive Engineering and
30 for Advanced Automotive Electronic Engineering

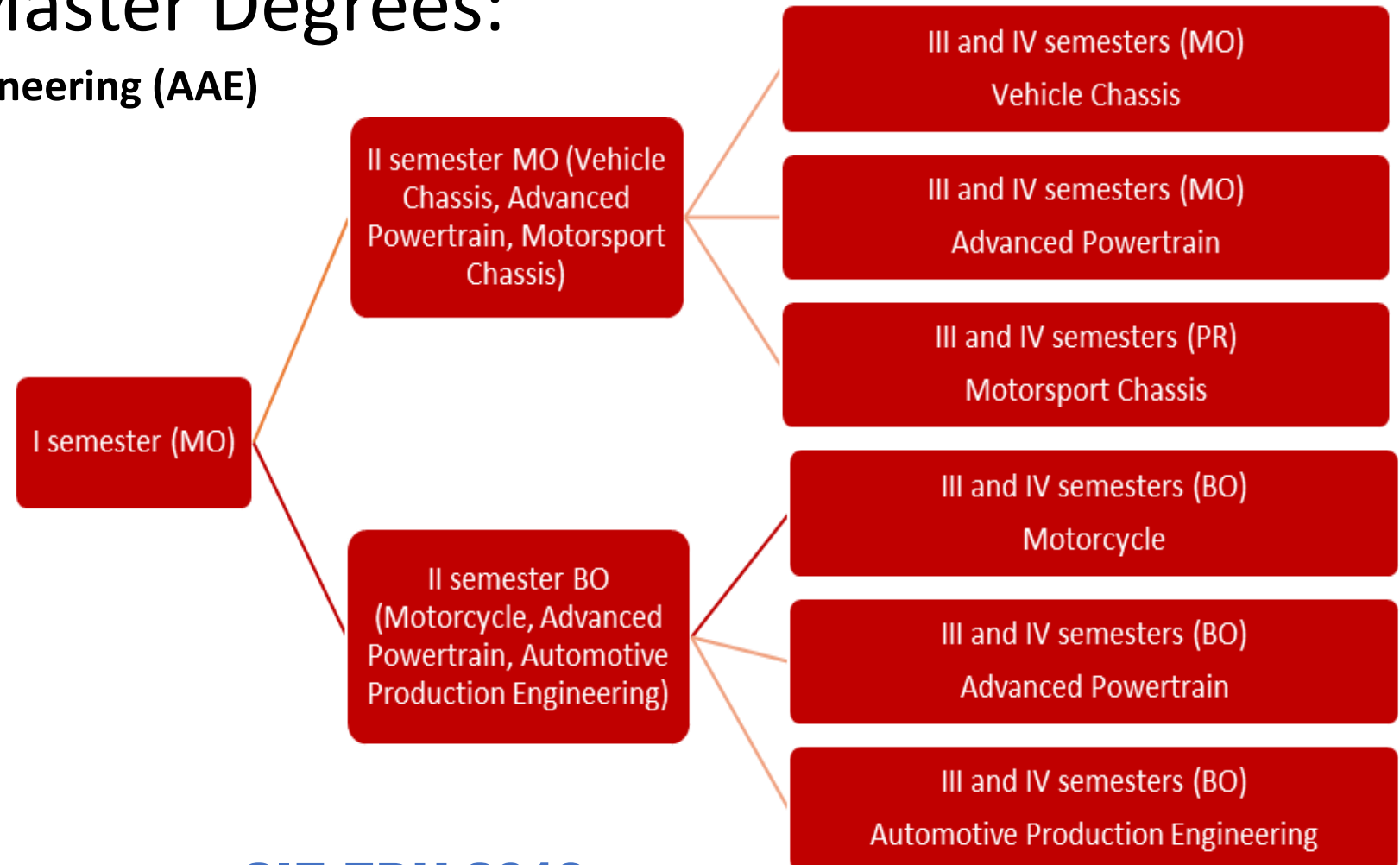
- **Advanced Automotive Electronic Engineering (AAEE) → LM-29**

- Pillars:

- Academy/Industry **co-teaching**
- **Selection of professors** by an inter-university Steering Committee
- **Learning by doing** through activities in university and industrial labs, special projects (Formula SAE, Moto Student) and Mandatory internships and thesis based on a **project working** approach



- International Master Degrees:
- Advanced Automotive Engineering (AAE)



The package...

- **UNIBO MOTORSPORT → Learning by doing in ambito internazionale e sportivo, con focus su automotive**
 - >130 studenti (LT + LM) coinvolti ogni anno (80% Ingegneria, 20% tra Economia, Scienze della Comunicazione, Statistica, Informatica, ...)
 - Progetti in corso: Formula Student Combustion + Moto Student Electric + Formula Student Electric
 - **Partner industriali elemento chiave per la sostenibilità del progetto**



SIE-EDU 2019



The package...

PhD Course in Automotive Engineering for Intelligent Mobility



– Struttura Inter-Ateneo

- STIPULA DI CONVENZIONE PER CONSORZIO TRA UNIBO, UNIPR e UNIMORE (9 BORSE PER PARTIRE)
- COLLEGIO MISTO (25 MEMBRI → 13 + 8 + 4)
- COORDINATORE E SEDE AMMINISTRATIVA UNIBO
- POSSIBILITA' DI BANDIRE POSTI/BORSE SU CURRICULUM e TEMATICHE SPECIFICHE
- CORSO DI DOTTORATO IN COLLABORAZIONE CON IMPRESE ITALIANE O STRANIERE CHE SVOLGANO ATTIVITÀ DI R&D
- GESTIONE AMMINISTRATIVA DINAMICA e SNELLA



SSD
ING-IND/08
ING-IND/08
ING-IND/14
ING-IND/16
ING-IND/15
ING-IND/17
ING-IND/13
ING-INF/01
ING-INF/03
ING-IND/32
ING-INF/04
ICAR/04
INF/01
ING-IND/15
ING-INF/01
ING-IND/08
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ING-IND/32
ING-INF/02
ING-INF/05
ING-IND/10
ING-IND/22

The package... PhD Course in Automotive Engineering for Intelligent Mobility

- Struttura in 3 curriculum

1. Vehicle Design, Manufacturing and Systems Integration

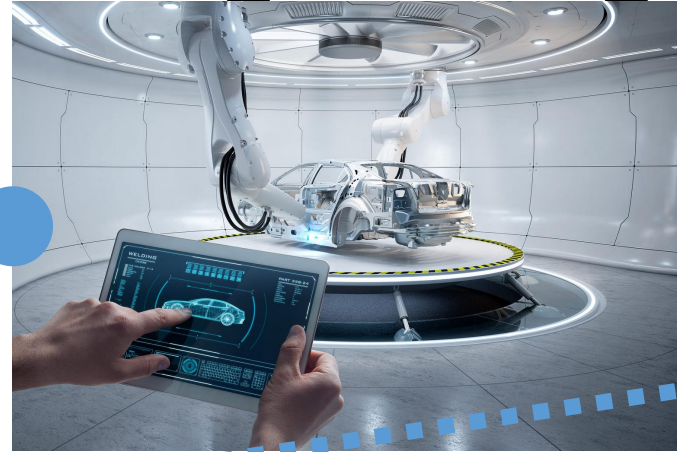
Industry 4.0 and Advanced Manufacturing Technologies
Supply Chain Management
Industrial Automation and Robotics
Big Data and Cloud Computing for Manufacturing
Materials, Lighting Technology and Design Methods for improving Efficiency and Safety of Vehicles
Vehicle Lifecycle Assessment. Circular Economy: Vehicle refurbish, re-use of Vehicle Parts.

2. Energy Systems, Powertrains, Vehicle Performance

Electrification and Power Electronics
Electric, Hybrid and ICE-based Powertrains
Advanced Combustion and Aftertreatment Systems
Batteries and Energy Storage Systems
Vehicle Energy Management and Energy Optimization
Vehicle Dynamics and Control

3. Vehicle Informatics and Connectivity

Vehicle Human Machine Interface and Infotainment systems
Gamification for improving Driver Behavior
Vehicular Networks, Vehicular Sensors and Big Data for Mobility
Automatic and Autonomous Drive
Connectivity for V2I- Vehicle to Infrastructure, V2V – Vehicle to Vehicle and V2G – Vehicle to Smart Grid interfacing
Data Analytics and Advanced Prediction Models



The marketing...

The marketing...



The marketing... results!

- Progetto partito in settembre 2017
- Presentazione scheda di attivazione pro ANVUR in marzo 2018
- 9 borse come base di partenza, di cui **5 finanziate dagli Atenei**
- Uscita bando 10 aprile 2018, con **14 posti finanziati** (+ 4 senza borsa)
- Chiusura bando 30 giugno 2018, con **23 posti finanziati (+4 = 27)**

The marketing... results!

- **26 posti finanziati, di cui:**
 - 5 messi a disposizione dagli Atenei
 - 3 finanziati dai Dipartimenti su fondi di ricerca
 - 3 finanziati dalla Regione (fondi POR-FSE)
 - **15 finanziati da partner industriali**
(Lamborghini, Ferrari, FEV, Samputensili, Alma Automotive, Vislab, Dallara, ...)

The marketing... results!

- **26 posti finanziati... esempi di tematiche:**

- Azionamenti multi-fase per trazione elettrica ad elevata affidabilità
- Sistemi di comunicazione radio per applicazioni automotive
- Big data analytics per la diagnostica predittiva e proattiva di sistemi batteria di auto elettriche
- Antenne Automotive per Connettività V2X
- Guida Autonoma
- Algoritmi di controllo per azionamenti elettrici di tipo unificato applicati alla trazione elettrica
- Utilizzo di tecniche di realtà virtuale acustica e visiva in campo motoristico ed automobilistico

The marketing... results!

- **26 posti finanziati... esempi di tematiche:**

- Controllo cooperativo per la gestione del traffico stradale
- Modellazione matematica di veicoli ibridi elettrici
- Soluzioni e tecnologie per l'incremento dell'efficienza di propulsori ibridi, e sviluppo di strategie di controllo predittive
- Modellazione, controllo e sperimentazione di motori a combustione interna per la minimizzazione del consumo e delle emissioni inquinanti
- Studio, sviluppo ed applicazione di metodi computer-based per l'integrazione di aspetti funzionali ed estetici nel settore Automotive

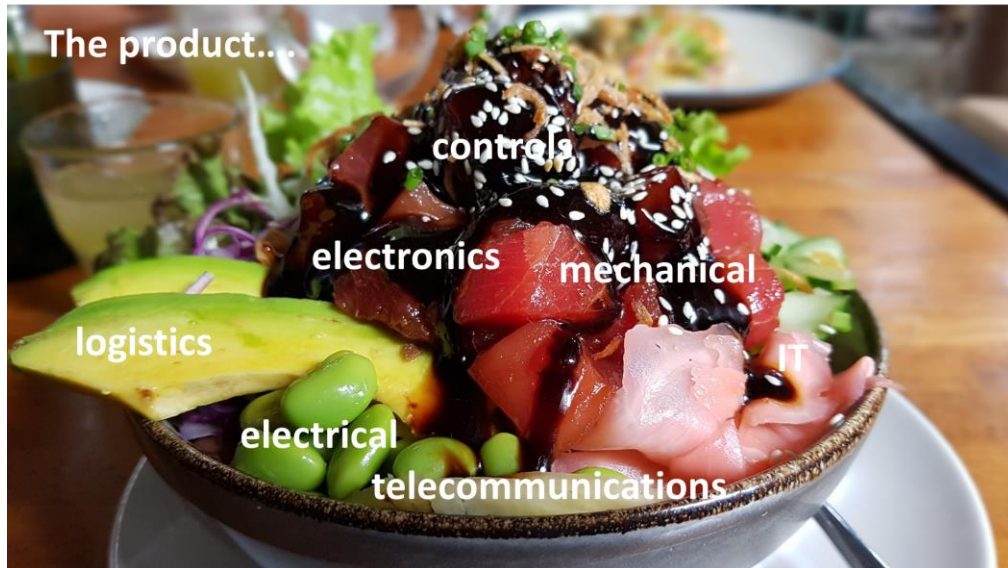
The marketing... results!

- 26 posti finanziati... esempi di tematiche:

- Analisi e sviluppo di soluzioni per la formazione della miscela in motori GDI ad alta potenza specifica tramite simulazione CFD
- Sistemi di combustione innovativi per la riduzione dei consumi e delle emissioni inquinanti
- Collegamenti e componenti innovativi per applicazioni in ambito automotive
- Modellazione avanzata CAD basata su voxel per simulazioni FSI nella progettazione di strutture automotive
- Modello Analitico di Giunti Ibridi Metallo-Compositi
- Advanced Manufacturing Technology for Gear Cutting Tools

The product....

”highly qualified personnel with multidisciplinary skills, able to direct the development and research, also in the industrial field, of innovative vehicles, creating a meeting point in the third level of education between mechanical, industrial, electronics, telecommunications, controls, electrical, IT, logistics and civil engineering”



GaN Inverter

Why?

- No reverse recovery → higher switching frequency → smaller capacitors
- Wide bandgap semiconductor → higher electric field → higher power density

Relatively new technology, low current devices available, paralleling needed...

Challenges:

- Devices are extremely small in difficult packages
- Need for high current, low parasitics, thermally efficient assembly
- Large number of devices in parallel to be switched on all simultaneously.

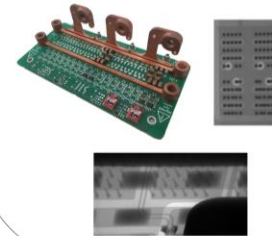
GaN Mosfet



4.6 x 2.6 x 0.7mm
7kW Peak Power
500+ KHz Switching

Assembly:

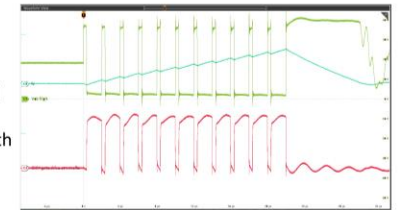
Optimized reflow process has been developed allowing both heavy copper busbars and mosfets to be soldered in the same process. Mosfets are soldered using Pb-Free paste (OM-338PT Melting point: 220°C) while busbars are soldered using SnPb paste (F381 Melting point: 189°C). This prevents mosfets from falling from the board while soldering the busbars. X-Ray analysis of the soldered parts show no damages or short circuits using this technique.



Switching test

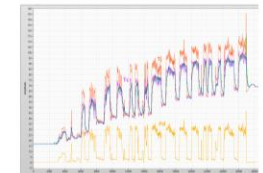
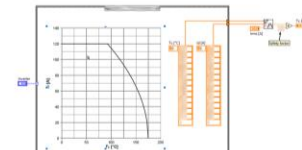
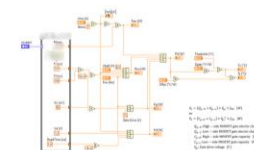
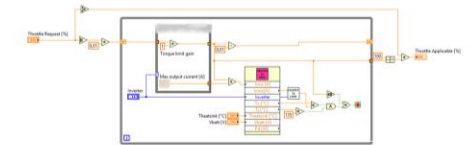
40A, 48V, 500KHz
400ns ON-Time
Two devices in parallel

Negligible overshoot with
minimal capacitor
requirement



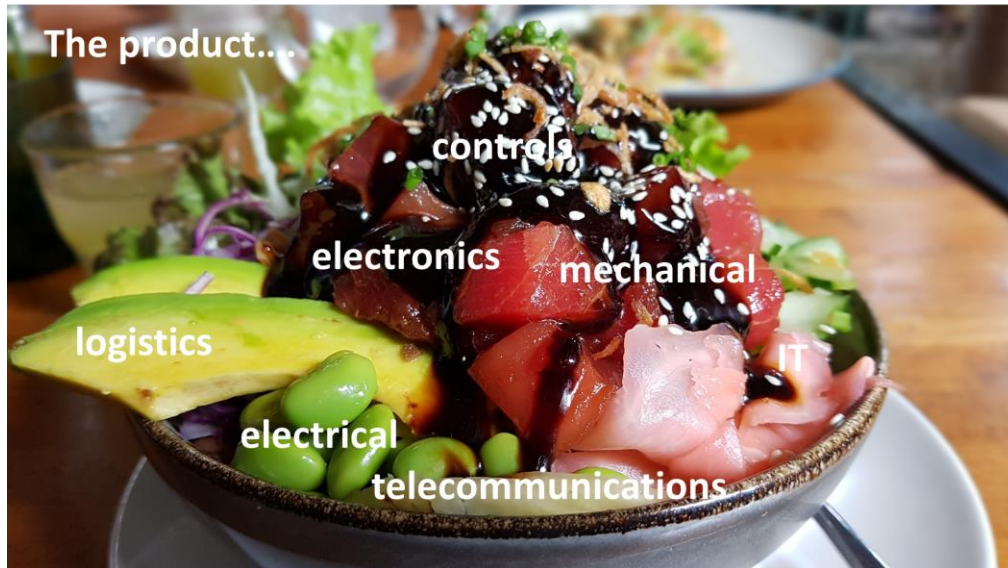
Power MOSFET Junction temperature estimation

- In order to keep the mosfet within it's Safe Operating Area the torque request is clipped by successive approximations to allow the junction temperature stay below a limit value
- A model of the entire system thermal behaviour has been developed in Labview and it is running in a real time ECU



The product....

- Studente di Ingegneria elettronica (LM)
- Esperienza in Formula Student come Responsabile di Reparto
- 2 anni in Mercedes F1 (UK)
- Rientrato per iscriversi al Dottorato, con forte connessione al team Unibo Motorsport e a spin-off Unibo
- **Sintesi competenze elettroniche, elettriche e meccaniche**



GaN Inverter

Why?

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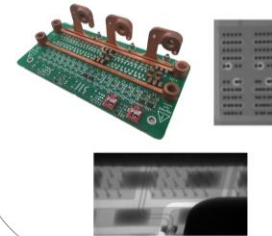
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500+ KHz Switching

Assembly:

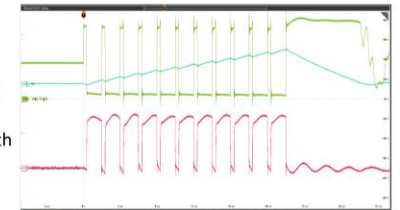
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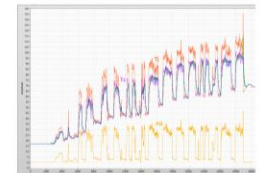
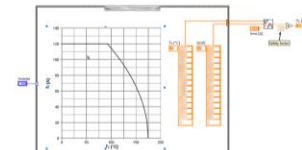
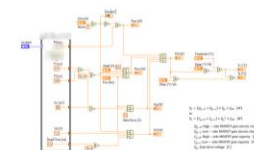
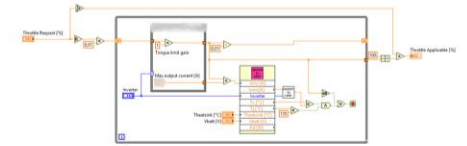
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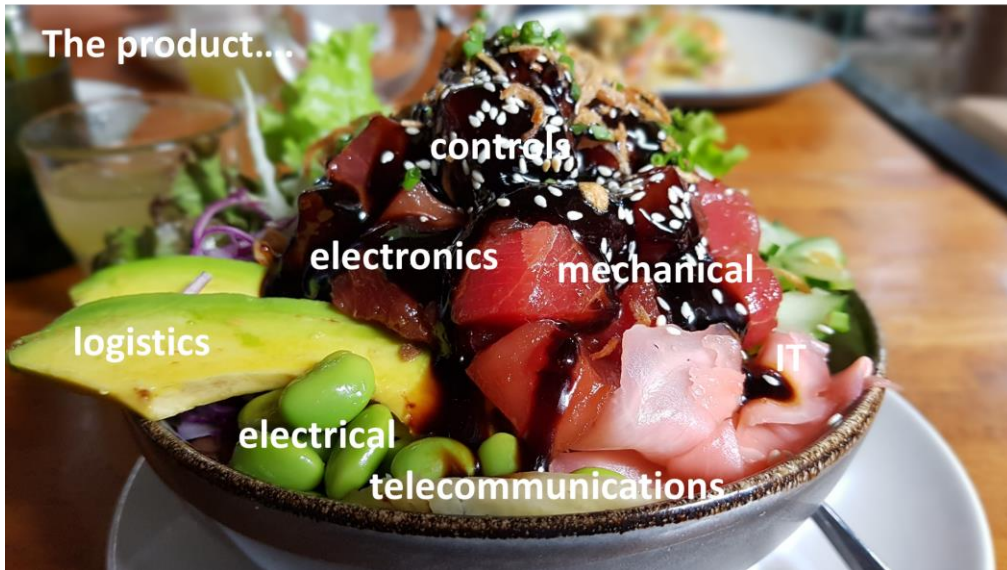
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- A model of the entire system thermal behaviour has been developed in Labview and it is running in a real time ECU



The risks and cons....

- Attività in collaborazione con partner industriale, ma attività di ricerca full-time e non “produttiva”
- Gestione **prodotti della ricerca** e periodo all'estero
- Assorbimento presso partner prima della fine del percorso



The package.... specific contents

DOTTORATO INDUSTRIALE IN SENSO STRETTO

- RIFERIMENTI da REGOLAMENTO

- corsi di dottorato industriale, che prevedano la possibilità di **destinare una quota dei posti disponibili ai dipendenti di imprese impegnati in attività di elevata qualificazione** e/o che rispettino ulteriori requisiti previsti dalla normativa vigente. I dipendenti sopra citati sono ammessi alla frequenza dei corsi di dottorato a seguito della partecipazione al bando di concorso di cui all'art. 8 e del superamento delle prove di selezione di cui all'art. 9. **La convenzione deve specificare la ripartizione dell'impegno complessivo del dipendente.**

- OPPORTUNITA' E CRITICITA'

- Molto attraente per i partner industriali (no logiche di scambio!)
- Complesso monitorare e mantenere su una linea scientifica/di innovazione e ricerca
- Aspetto legato ai prodotti della ricerca (pubblicazioni, brevetti, ...)
- Aspetto legato al periodo all'estero

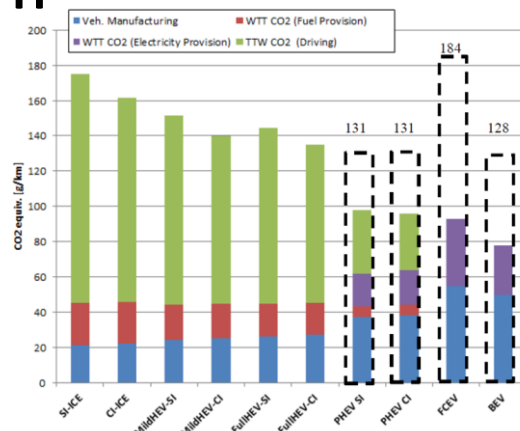
→ strumento delicato, da utilizzarsi solo se sussistono certe condizioni (abitudine del partner a rapporti con Università, inserimento in R&D del Dottorando e dimensioni dell'azienda, chiarezza prima e durante il percorso, possibilità di monitoraggio continuo, ...)

The package.... specific contents

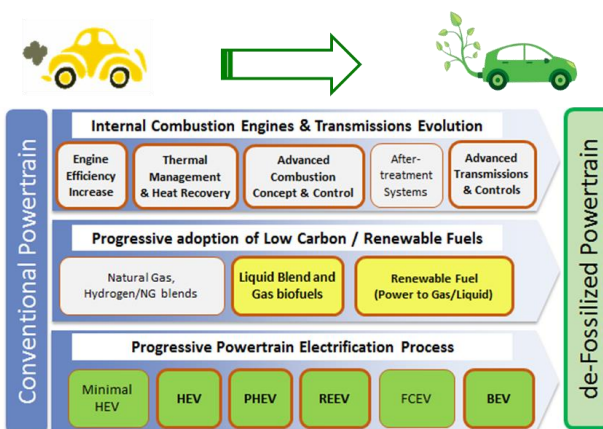
DOTTORATO INDUSTRIALE IN SENSO STRETTO

- BEST PRACTICE EXAMPLE

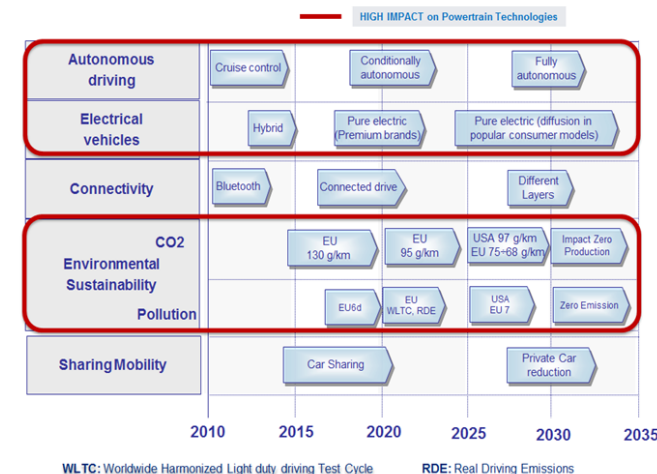
- Dipendente di Magneti Marelli, responsabile R&D Powertrain
- Da più di 20 anni collaborazioni di ricerca con Unibo e altri Atenei
- Dottorato su «**Powertrain Architectures and Technologies for New Emission and Fuel Consumption Standards**»... *The evaluation of powertrain solutions has to take into account at the same time the end-user's requirements and the sustainability constraints, that should be evaluated in terms of Life Cycle.*
- > 20 PUBBLICAZIONI INTERNAZIONALI IN 3 ANNI (DI CUI 5 SULLA PIU' IMPORTANTE RIVISTA IN AMBITO AUTOMOTIVE/POWERTRAIN)
- 2 BREVETTI



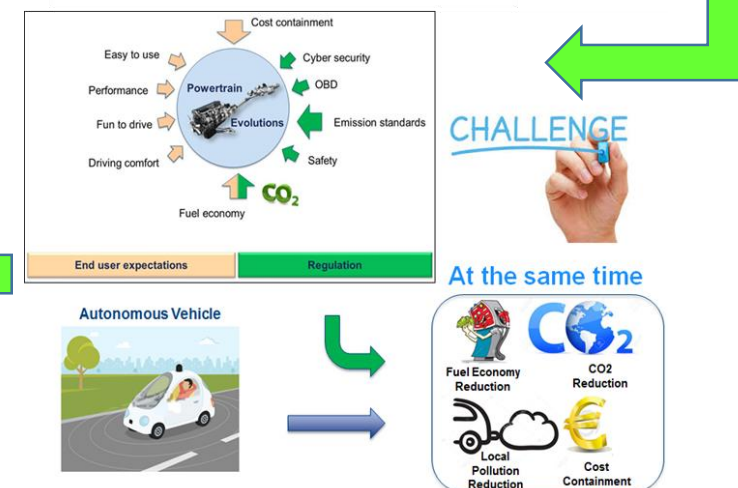
04/03/20



Automotive technology macro-trends



Powertrain design challenges



The package.... specific contents

DOTTORATO INDUSTRIALE IN SENSO STRETTO

- BEST PRACTICE EXAMPLE

- **FAILURES**

- Diverse situazioni in cui il percorso è stato interrotto prima del suo completamento (meglio se al primo/secondo anno...), a causa di:
 - Cambiamento di posizione all'interno dell'azienda (o di azienda!)
 - Difficoltà nel realizzare pubblicazioni e mantenere impegno full-time su ricerca/innovazione

**→ ESTREMA ATTENZIONE NELL'ATTIVARE CONVENZIONI DI
DOTTORATO INDUSTRIALE, CON «FILTRI» MOLTO SELETTIVI**

35° ciclo... ultimi aggiornamenti

- **Base di partenza pre-bando con 14 posti finanziati, di cui:**
 - 5 messi a disposizione dagli Atenei
 - 5 finanziati dai Dipartimenti su fondi di ricerca
 - **4 finanziati da partner industriali (Vislab, Dallara, McLaren, FEV)**

Sessione 3 – Esperienze di dottorato industriale

GRAZIE PER L'ATTENZIONE...
... DOMANDE?

Nicolò Cavina – Alma Mater Studiorum Università di Bologna