Energy Efficiency Technologies

Innovation means invention implemented and taken to market
J.S. Brown,
Director Emeritus Xerox PARC

Actua S.r.l.

Company Overview

Torino, in July 2012

Actua S.r.l., Via Luigi Cavaglià 3, 10020 Cambiano (Torino), Italia
www.actuatech.eu - info@actuatech.eu

In short, Actua is looking to be a holding company for Energy Efficiency Technologies development and exploitation

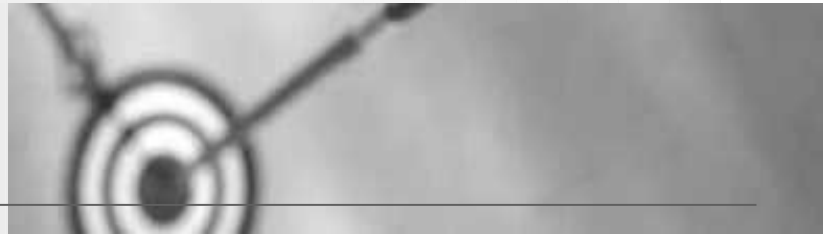
Actua S.r.l. – Origins, Mission, Competences

➔ Origins

Actua S.r.l. is a "technology atelier" for Energy Efficiency Technologies development based in Turin, Italy. A spin-off of Politecnico di Torino, Actua's founder and CEO is Stefano Carabelli.

➔ Mission

Actua focuses on innovation through prototyping and related tools for the industrial development of new mechatronic products in the transportation and renewable energies fields.



➔ Competences

Actua is a team of professionals with substantial year-long experience in Mechatronics and Systems integration. Actua is working with a network of selected companies and research centers.

Actua's managing team consists of professionals with a wide range of proven experience and fascination for innovative technologies

Managing Team & Location

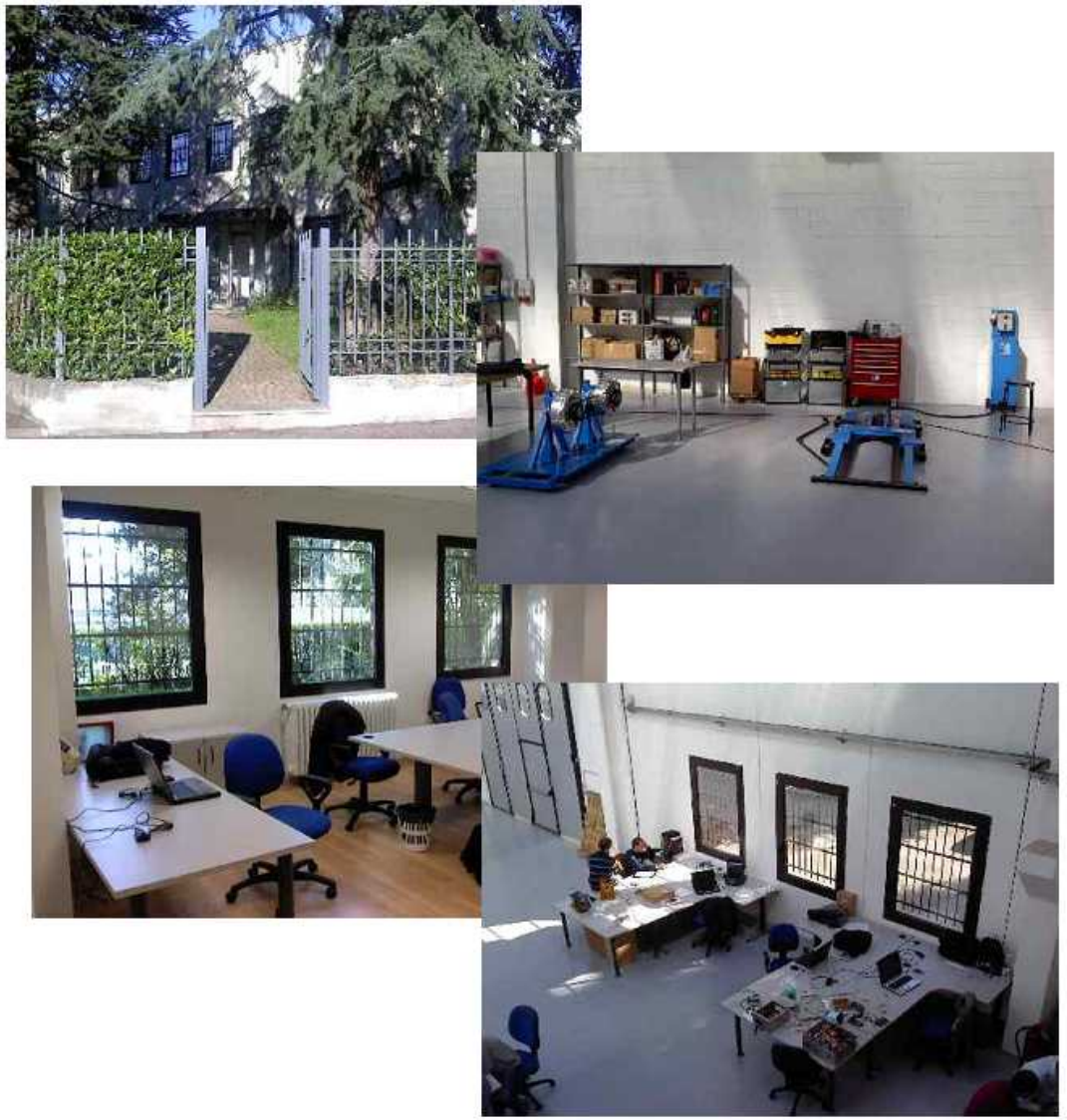
Stefano Carabelli
is Actua founder and CEO. Formerly Stefano was a senior lecturer of Automatic Control and Mechatronic Systems at Politecnico di Torino. Former director of the Mechatronics Lab that he co-founded in 1993, he is co-founder of Applied Mechatronics S.r.l. in 1999, co-founder and CEO of Actuation and Control Technologies S.r.l. in 2005 and TTW S.r.l. in 2007.

Giorgio Bocca
is an Actua stakeholder and responsible for Marketing and Commercial activities. Formerly he was Technical director of Klippan S.p.A. (safety belts), CEO of Breed (airbags), General Manager of Digitek (industrial electronics).

Fabio Cavalli
is responsible for the hybrid powertrain and electrical engineering of Actua. Fabio received the degree in Electrical Engineer and Ph.D. degree in Mechatronics at Politecnico di Torino in 2002 and 2007 respectively. He joined TTW S.r.l. and then Actua, in May 2007 and June 2009 respectively.

Pietro Macchi
is responsible for vehicle and rotor dynamics at Actua. He is also the project leader of Three Tilting Wheels vehicle. Pietro received the degree in Mechanical Engineer and Ph.D. degree in Mechatronics at Politecnico di Torino in 2002 and 2007 respectively. He joined TTW S.r.l. and then Actua, in May 2007 and June 2009 respectively.

Fabio Filippone
is responsible for ActuaTech line of products. Fabio received the degree in Electronic Engineer at Politecnico di Torino in 2004. He joined Actua S.r.l. in January 2006.

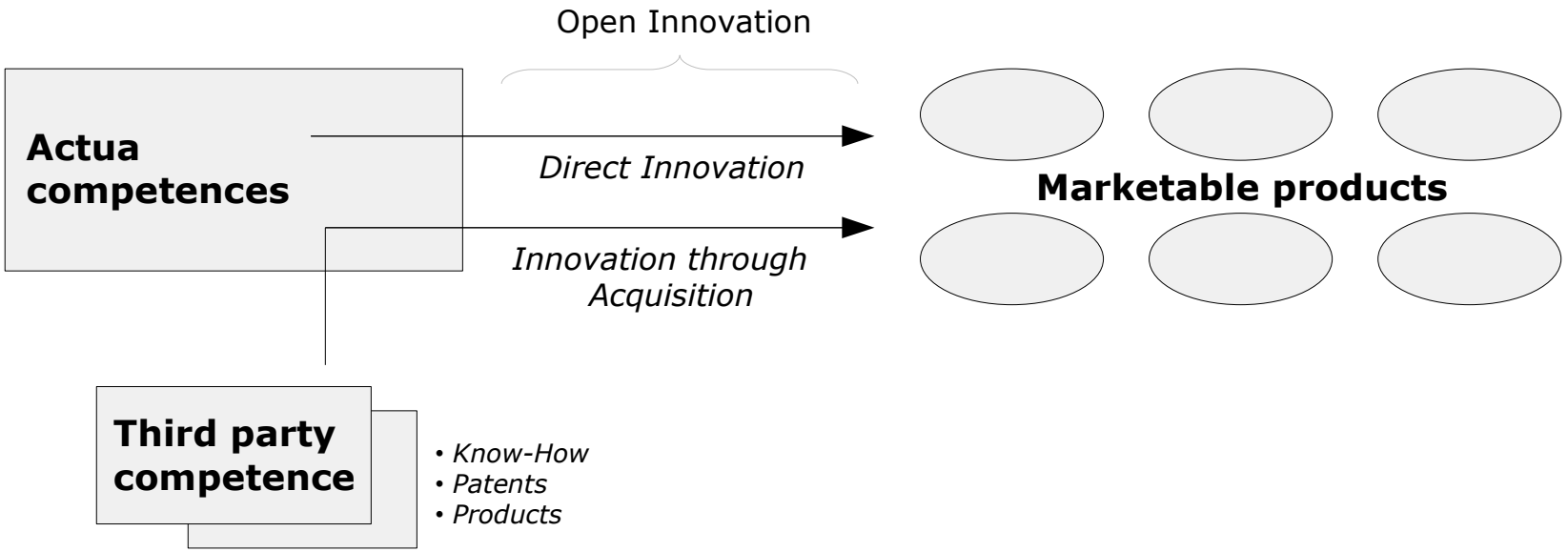


Actua is developing innovative products to be taken to the market

Innovation is invention implemented and...

Strategy

Actua is to stress existing **internal competences** into **marketable products** through **direct innovation** and **acquiring** new competences and technologies with best-in-class industrial and research partners



Strengths of Actua are its high-level of competences and clear vision of the market together with the capability to actract investments

… taken to market

High-level Competence

Actua has a team with year-long experience and fascination for innovative technologies, proven track record of technical development that is enhanced by a network with technical universities, and necessary protection of its technologies (patents, trademarks) to develop internally or with select partners technologies into products.

+ Vision of Market

Actua has a vision of the market and what products are offering opportunities in the future, the focus on "Energy Efficiency Technologies" is appropriately defined for transportation and renewable energies.

+ Access to Industrial and Financial Partners

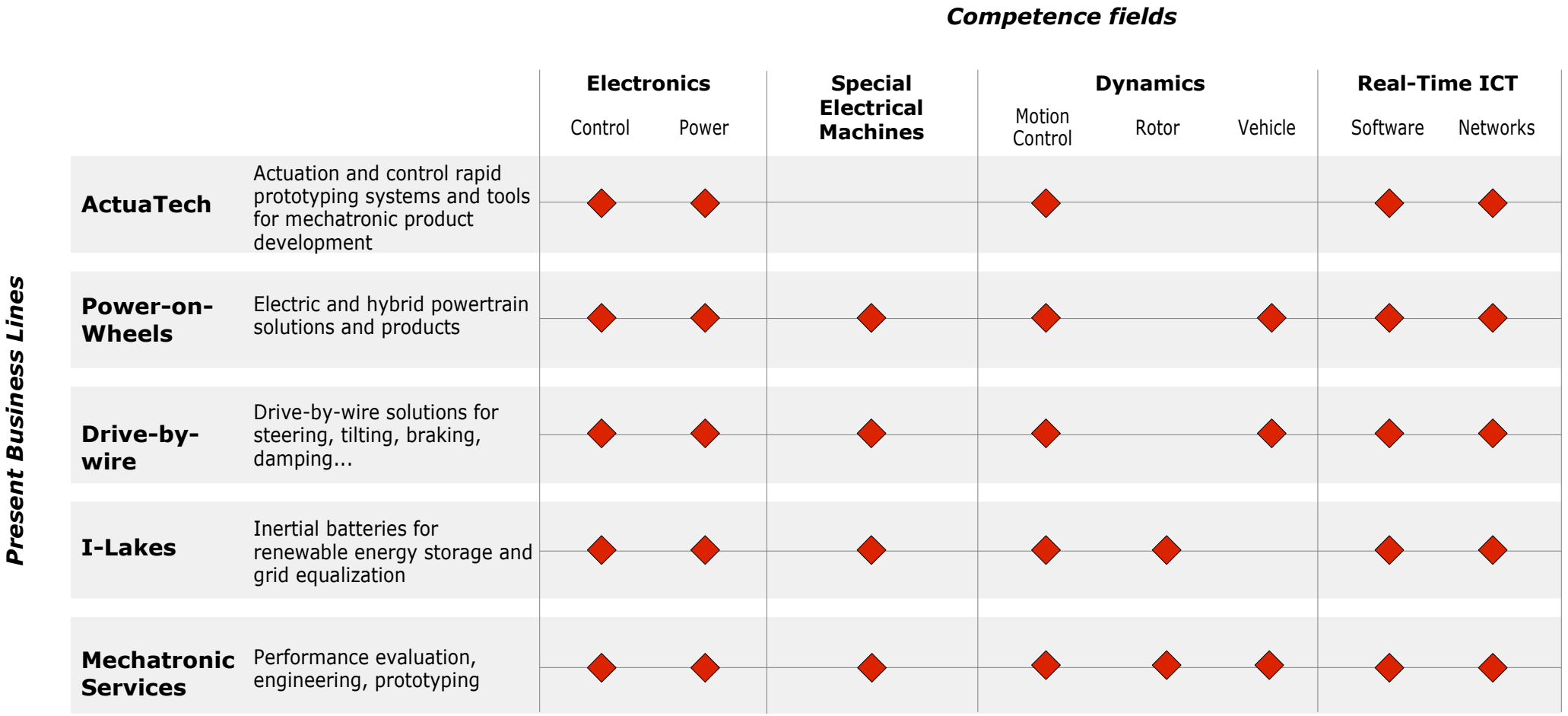
Actua aims to act as an advanced Research and Development center to accelerate industrial innovation as well as Technological Advisor for investments institutions to speed up selection and development of innovative products.

= Competitive Advantage

Actua has a sustainable competitive advantage in the technology sector by combining its development competences with its vision of the market, in order to develop marketable products that are ready to be commercialized together with its partners.

Actua leverages on its specific competences to create new energy efficiency products

ACTUA product lines and competence fields



Actua intellectual property spans from Open Source to world wide Patents (10 granted, 2 applied)

Actua patent portfolio

Narrow vehicles	Narrow vehicles	Narrow vehicles	Narrow vehicles	Narrow vehicles	Narrow vehicles
Suspension and drive tilting	**Pro link suspension**	**Redundant tilting**	**Tilting suspension - snowmobile**	**Hydraulic gearbox for tilting**	**Active Tilt and Steer**
The invention is relative to tilting suspension for vehicles with at least three wheels. The mechanical layout is innovative because it can be applied to driving wheels with electric motors inside. The spherical joints, the wishbones and the hubs have been designed to respect the mechanical constrains imposed by the electric motors on wheels	Starting from the architecture in the patents EP36339, a tilting suspension with pro-link system has been patented. This system allows to increase the suspension stiffness using only two springs avoiding additional device (bumpers) or high wheel displace	Electromechanical actuator to control the bank angle of a tilting vehicle during cornering to improve the vehicle safety. This system is constituted by two electric motors, two power electronic and two ECUs to avoid safety problems due to electric failures	The patent is relative to the application of a tilting suspension on a snowmobile to improve its drive feeling and safety. At high speed the introduction of the tilting suspension reduce the rollover risk during cornering. The vehicle can tilt as a motorcycle and its lateral dimensions can be reduced not compromising the vehicle stability	An electro-hydraulic actuator has been designed to control the tilt angle in tilting vehicles. This system is constituted by an electric motor, pump and hydraulic cylinders without valves. The force density of the hydraulic tilting actuator is higher than an electromechanical one	The patent is relative to architecture and control laws of a steer and tilt by-wire system for tilting vehicles. It is constituted by steer and tilting actuators which are driven by an ECU to minimize the load transfer during cornering.Respect traditional steer by wire systems, a mechanical link between the steer command and the wheels is maintained: this is a mechanical backup in case of electromechanical faults of the system
					PCTIT0900520
					Pending
EP1798080A1	EP1813450A1	EP1829719A	EP1798081A1	EP1870269A	
Request For Exam	Published	Granted	Granted	Granted	

Any wheeled vehicle	Any wheeled vehicle	Any wheeled vehicle	Any vehicle	Any vehicle	Any wheeled vehicle	Any electric / hybrid vehicle
Brake by cam&slide	**Corner brake&drive**	**Electronic differential**	**POF interconnection**	**Hydraulic gearbox for damper**	**Open Stator Hub Motor**	**PHEV Recharge**
Brake by wire system which uses electric motor, cam and slide is designed to solve friction and efficiency problems of traditional brake by wire system with ball screws and epicyclic trains. Moreover the introduced solution contains an innovative recover for the backlash between the brake pads	The patent is relative to a brake and drive system for a wheel for a local control of the positive (traction) and negative (braking) torque. This system can be applied to all vehicles allowing the independent control of each wheel improving the safety comfort and environmental characteristics	This system can be applied to vehicles with at least two wheels with electric traction on the same axle. It realizes the functions of a mechanical differential controlling the power absorbed by each electric motor and managing the power exchange between the wheels. Without driving shafts the vehicle consumption can be reduced	Innovative connection between ECUs and power electronics realized with POF (Plastic Optic Fiber) is designed. The POF connection allows to increase the bandwidth, the electromagnetic immunity, galvanic insulation and the fault tolerance. Considering .automotive ECUs nets the POF network can be used to realize a safe network	An electro-hydraulic actuator has been designed to control the damping coefficient of an automotive suspension. This system is constituted by an electric motor, pump and hydraulic cylinders without valves. The static damping coefficient can be changed using the electric motor as damper. This system can be used in active and semi-active suspension without involving valve control	An add-on system has been designed to transform normal production vehicles in hybrid vehicles. The invention comprises an open stator electric motor, a wheel and some mechanical parts which can be installed directly on an existing vehicle without modifications on suspensions or brake system	On-board electronics for the battery recharge of electric / hybrid vehicles with minimal o none addtional hardware with respect to existing traction power electronics
					PCT/IT2008/000712	PCT/IT200900164
					Pending	Pending
EP1798123A	EP1798092A1	EP1798093A1	EP1860821A1	EP1878598A1		
Granted	Granted	Granted	Granted	Published		

ActuaTech: Actuation and control rapid prototyping modules and tools for the development of mechatronic products

Decreasing time-to-market from rapid prototyping to series production

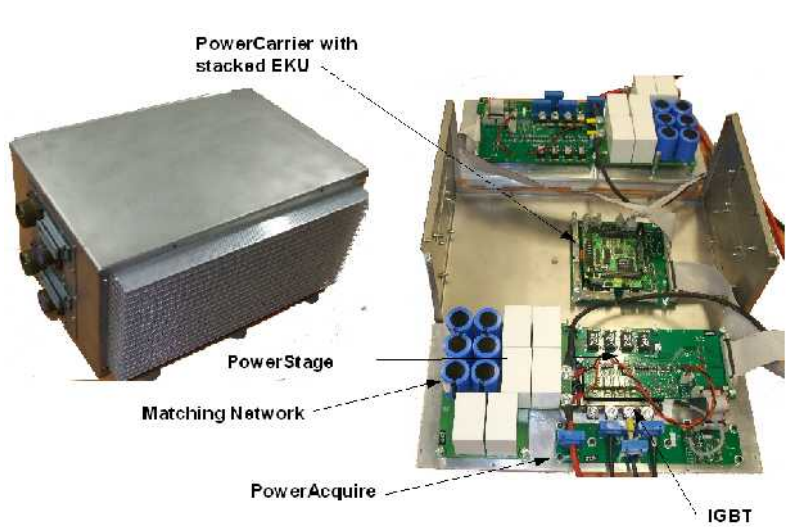
ActuaTech is a line of industrial rapid prototyping tools initially developed at Actua for its internal use and prototyping activity.

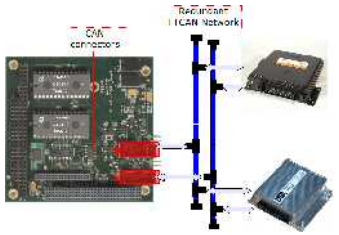
Integrating smoothfully hardware (both for signal and power electronics) and software (both for development and real-time operation) components ActuaTech products allows an efficient and effective development of mechatronic products, from industrial automation to robototics, from vehicle traction to drive-by-wire devices.

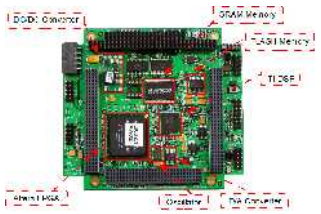
Hardware modules range from DSP & FPGA digital programmable platforms to power and energy units, to standard and deterministic networking.

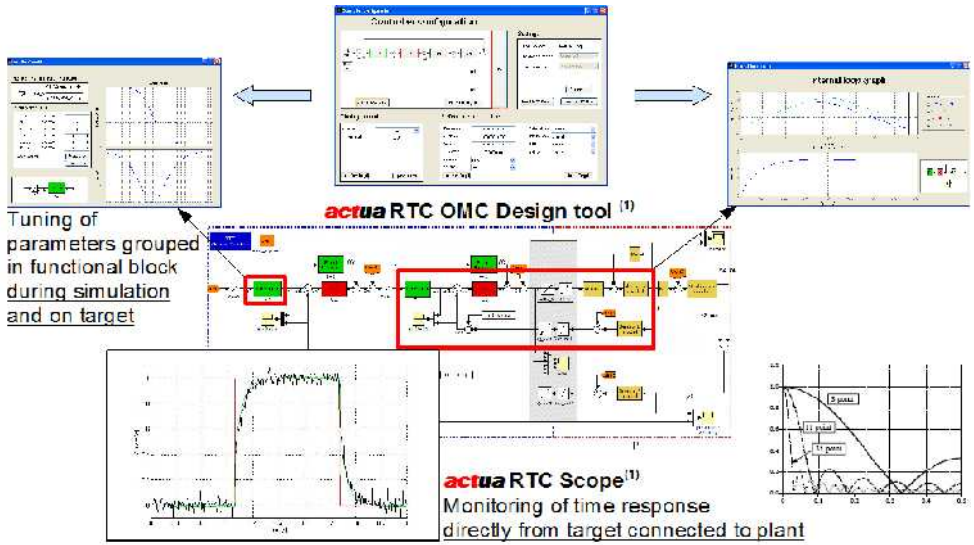
Software modules range from a hard real-time operating system to motion control and vehicle dynamics simulators, to a complete suite of real-time tuning, data logging and telemetry tools.

The main characteristic of ActuaTech tools is the constant aim at preserving what produced at the prototyping level in the industrial product both hardware and software, in particular for small and medium size series production.









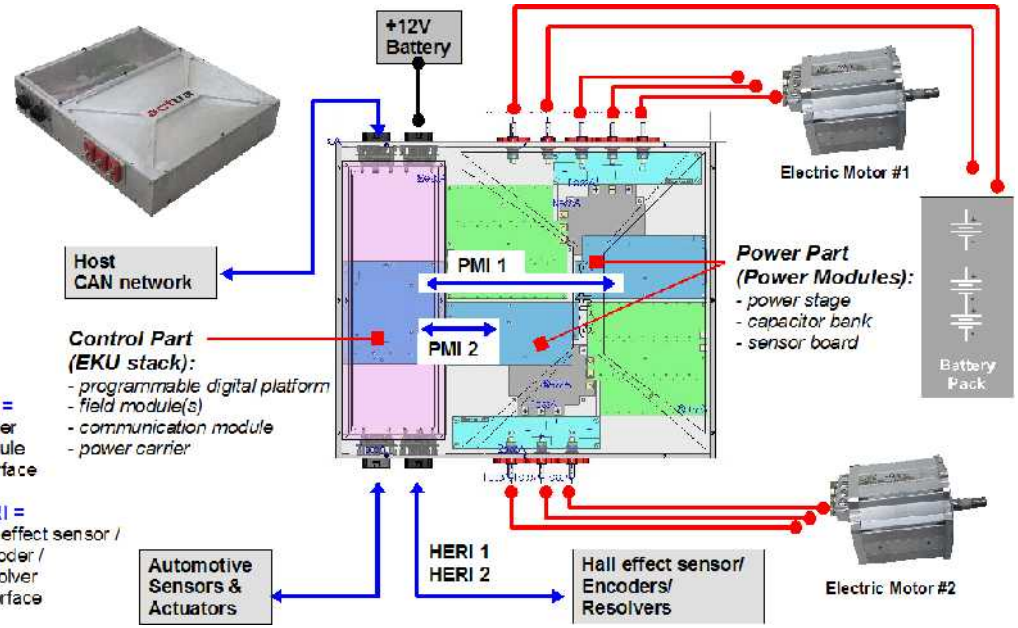
ActuaTech: Automotive Actuation Kontrol Unit

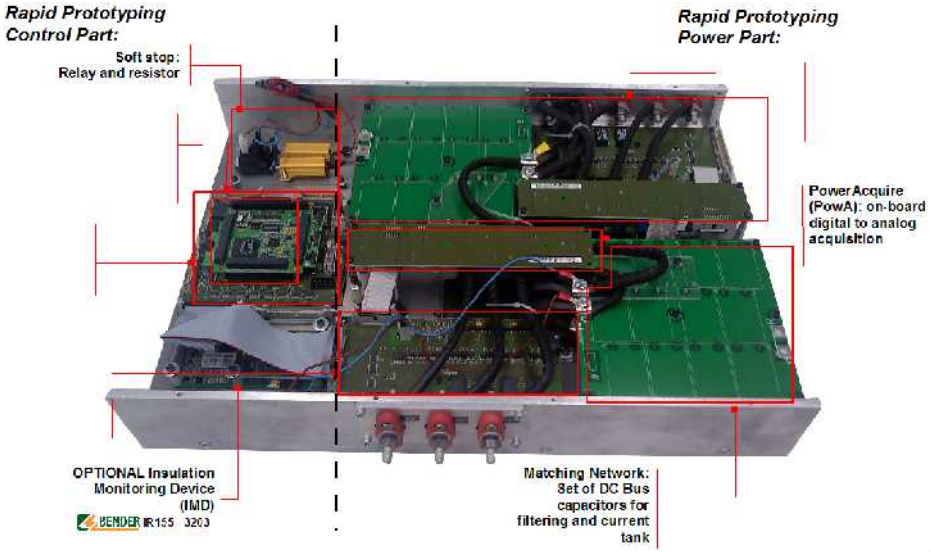
Integrated dual drive for hybrid/electric powertrains

Automotive AKU is a line of single and dual drive actuation control units for up to 380 V and scalable 75-150-300-600 A.

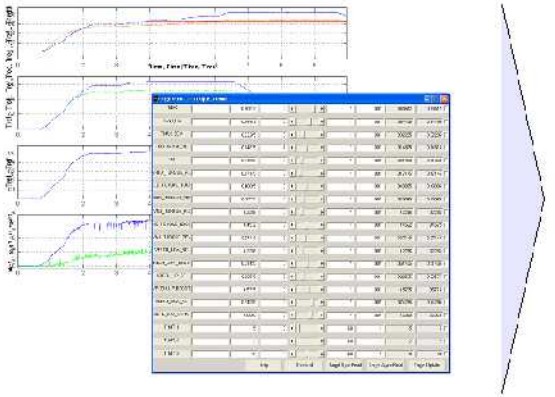
A DSP & FPGA based programmable platform implements a flexible and robust layered software architecture:

- a top layer for user defined applications,
- a middle layer with a Universal Direct Flux Vector Control for motor control,
- a bottom layer implementing a Hard Real-Time Operating System.

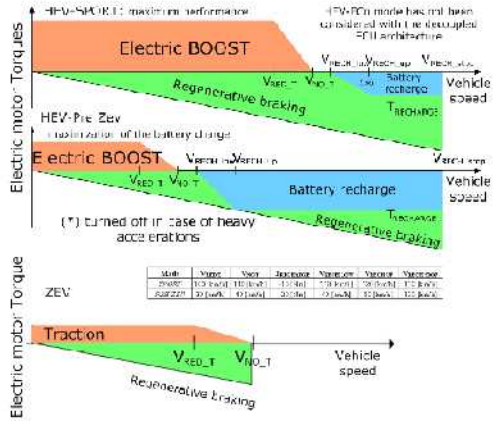




Actua's own software is used for parameter tuning



Drastically shorter Time to Market!



Power-on-Wheels: Electric & hybrid powertrain solutions

Add-on, replacement and new vehicle powertrain solutions

Power-on-Wheels solutions are ready-to-use modular products perfectly suited for on-vehicle prototyping of different electric or hybrid powertrain architectures.

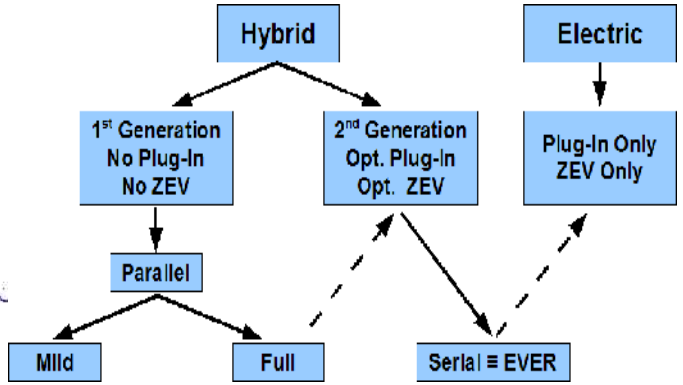
Vehicle electrification spans from pure electric vehicles to different kind of parallel hybrids to electric vehicle with extended range (serial hybrid).

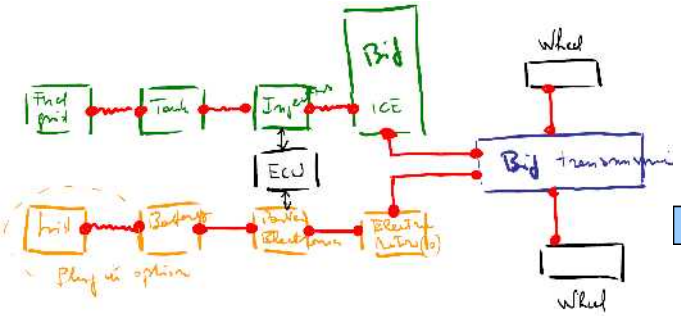
Vehicle electrification allow the distribution of traction to more axles or even corners to use torque control for unmatched handling performances.

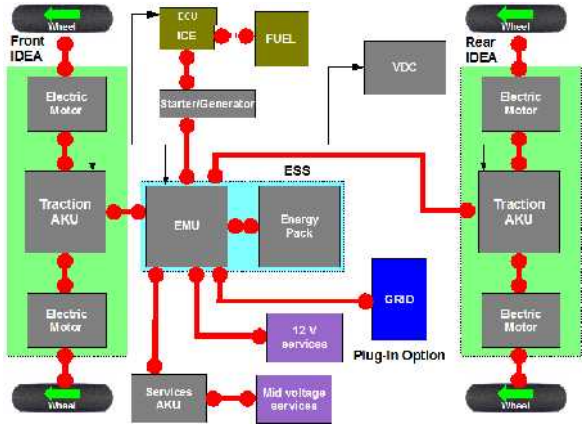
Power-on-Wheels solutions cover from add-on components to standard powertrain to its replacement, to new electric or hybrid powertrain.

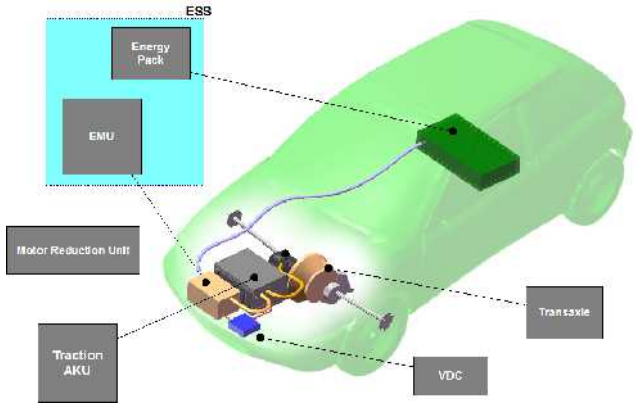
Power-on-Wheels power and energy handling are implemented compliant to current legal regulations and ready for omologation.

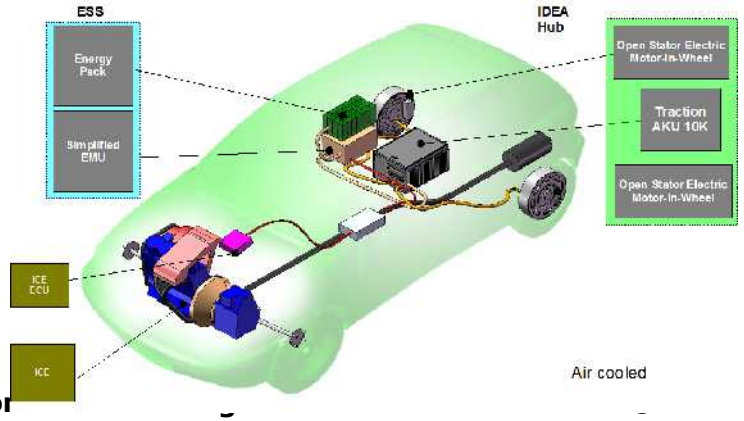
A comprehensive development environment allows the high level definition of the vehicle mission with the required powertrian components, from concept to vehicle prototyping.











actua Actuation and Co

Power-on-Wheels: Motor-in-Wheel

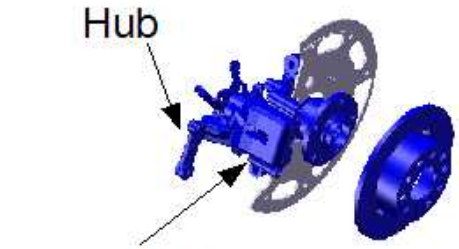
Open stator electric motor to integrate disc brake caliper

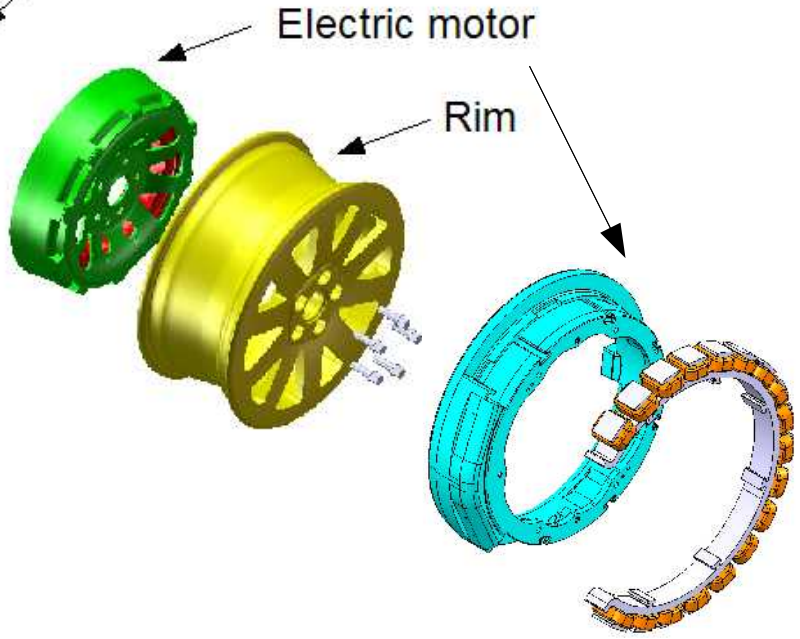
Open stator motor-in-wheel is a patented solution that allows to integrated a disc brake caliper with a permanet magnet direct drive motor to completely fill the volume inside the wheel rim.

The motor-in-wheel is well suited for aftermarket retrofit or end-of-line add-on to transform standard into mild (parallel) hybrid vehicle. For this application, the system is completed by a high power battery and an air cooled power electronics to be located in the spare wheel room.

Actua motor-in-wheels are also a very interesting solution for usage on very compact urban vehicles or scooters freeing all the chassis space and implementing a native integral traction.

Actua motor-in-wheel is designed to adapt to a wide range of suspension and wheel mounting to provide maximum power and torque up to 10 kW and 350 Nn per wheel.





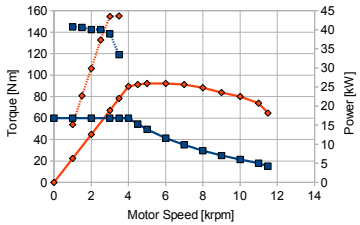
Power-on-Wheels: Transaxle

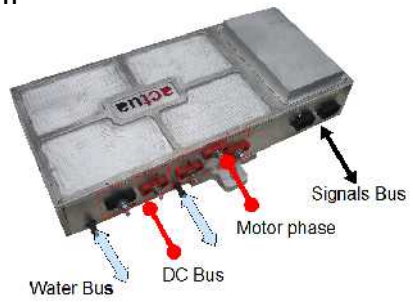
High performance modulare traction for automotive applications

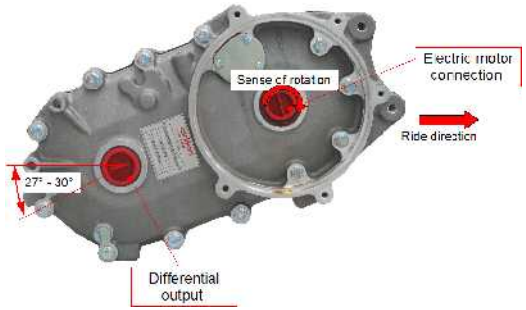
Power-on-Wheels transaxle integrates a differential/reduction gearbox with different high performance electric motors (with or without permanent magnets) specifically designed for automotive applications (high overload current and wide constant power speed range).

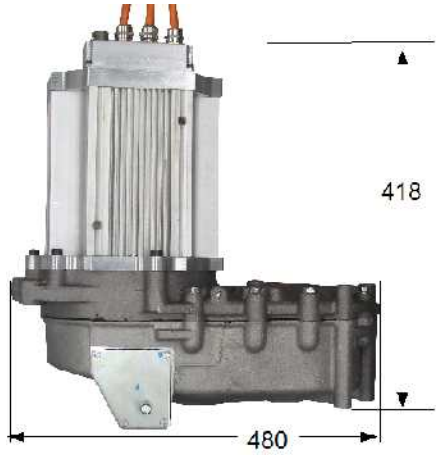
The solution is characterized by a high component modularity to cover a wide range of power needs: from 4 to 16 kW with air cooling or from 20 to 100 kW with water cooling.

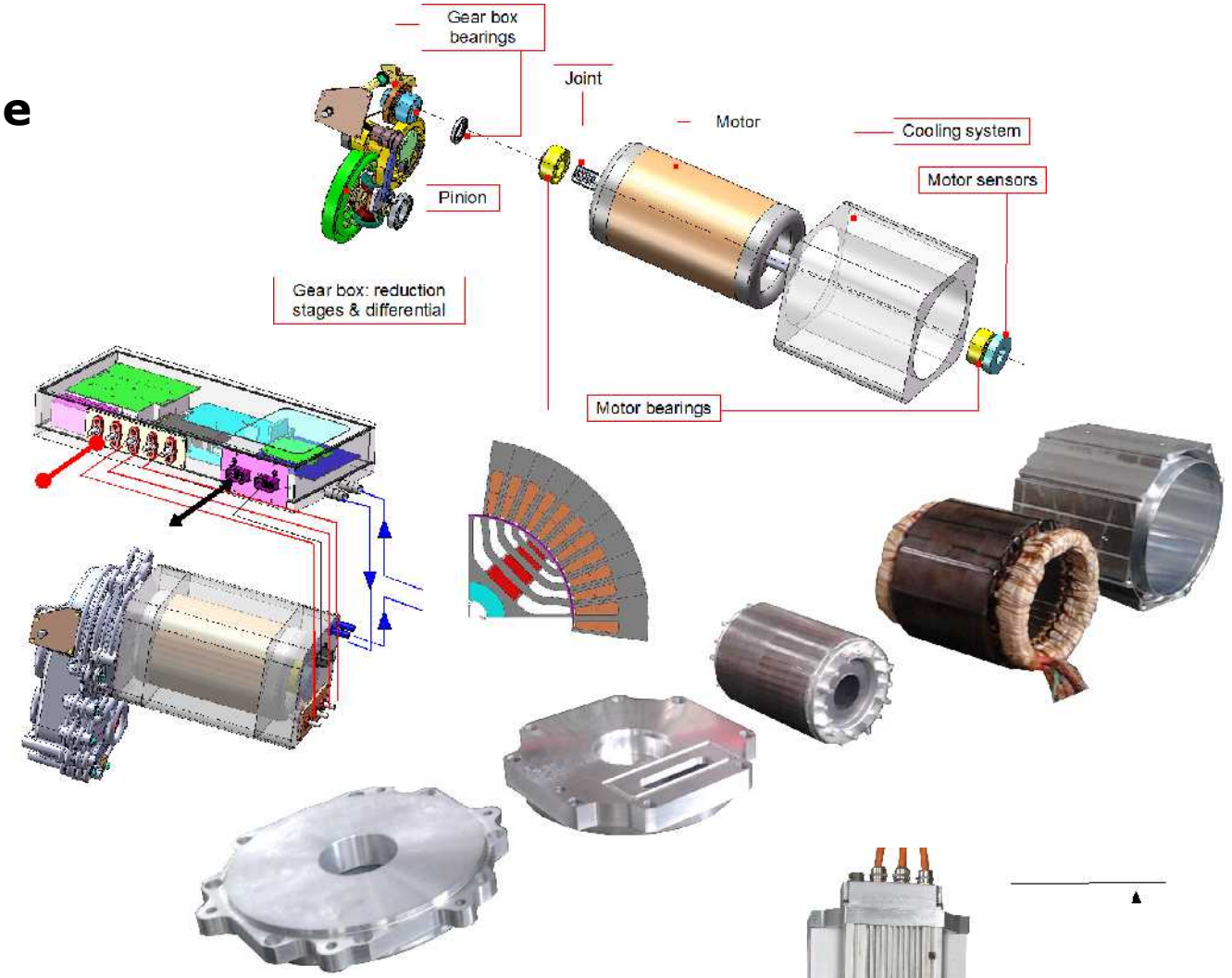
Power and control electronics are integrated into a dual drive Actuation Control Unit that runs a proprietary universal direct flux vector control with a number of fault tolerance and fail-safeness features.











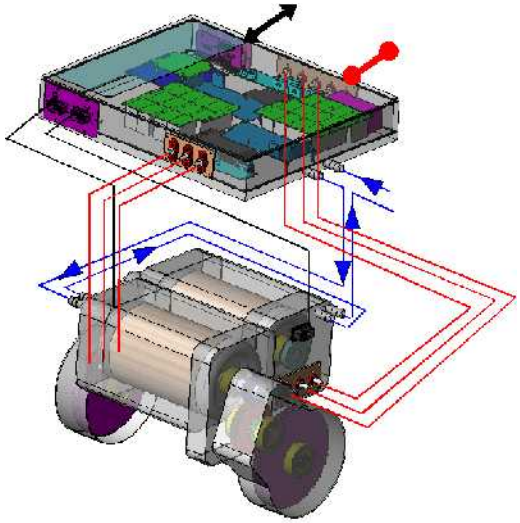
Power-on-Wheels: IDEA

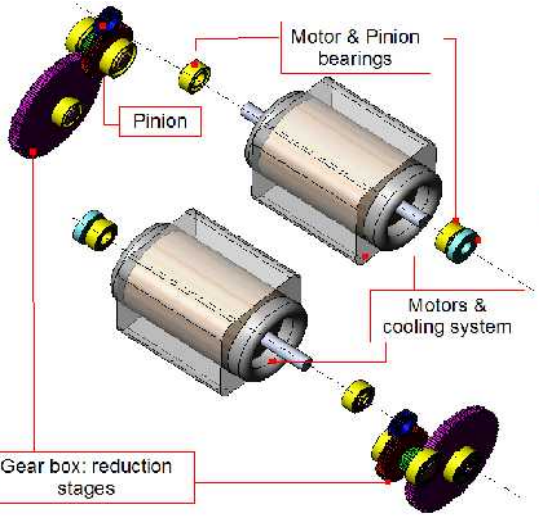
Integrated Differential Electrical Axle

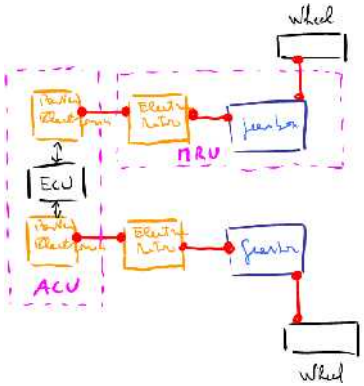
Power-on-Wheels *Integrated Differential Electrical Axle* – IDEA, implements an almost ideal active differential to apply separately the torque to each wheel.

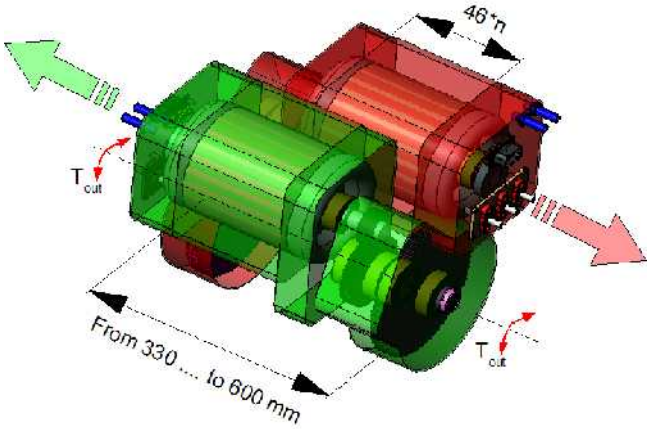
IDEA may be used for full electric as well as hybrid sport vehicles to achieve the highest vehicle handling by means of *torque vectoring* techniques.

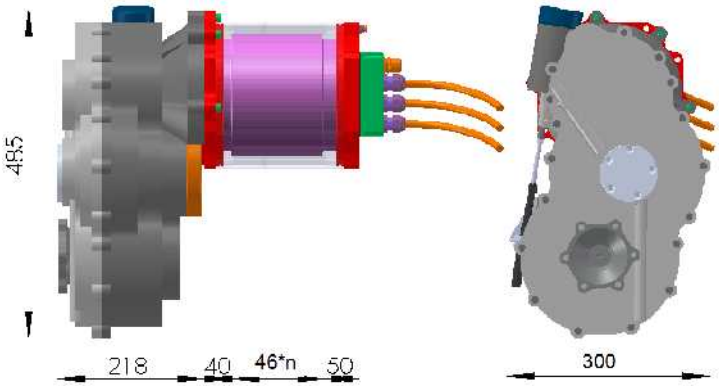
In combination with an electrified and robotized internal combustion engine transmission, IDEA allows the implementation of a permanent integral traction with the highest performances.











Power-on-Wheels: Energy Storage System

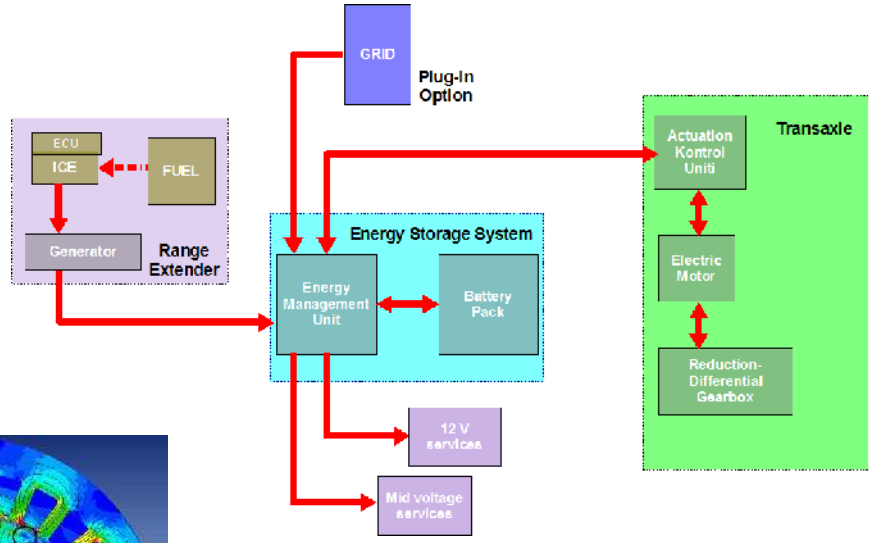
Not only batteries…

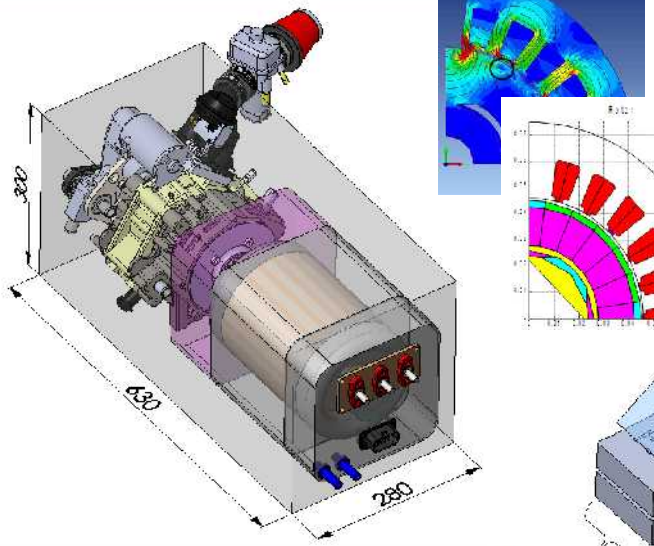
Power-on-Wheels *energy storage system* integrates third party battery packs with a proprietary Energy Management Unit to handle the energy flow to traction and auxiliaries as well as from of a range extender.

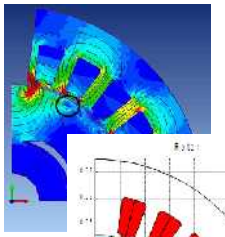
The Energy Management Unit includes all the high voltage safety components (emergency and inertial switches, isolation check, soft start, etc) and voltage regulations (control back-up battery, legacy 12/24 V, middle voltage auxliaries) into a single system box.

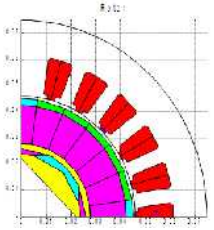
Moreover the Energy Management Unit may directly drive the range extender eletrogenerator as well as the combustion engine injectors in accord with the vehicle state-of-charge.

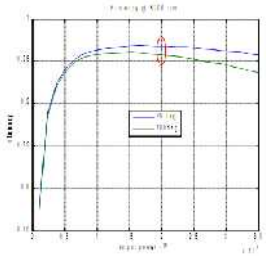
A special designed permanent magnet electric generator has been design to minimize losses and maximize efficiency of energy generation. The electric motor acts also as combustion engine starter and transition manager to minimize toxic and greenhouse responsible emissions.

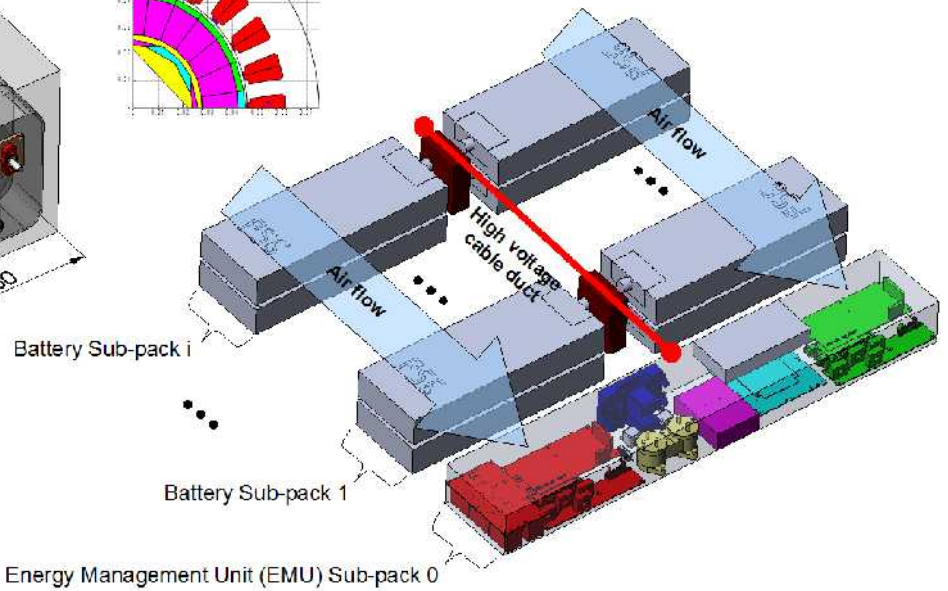












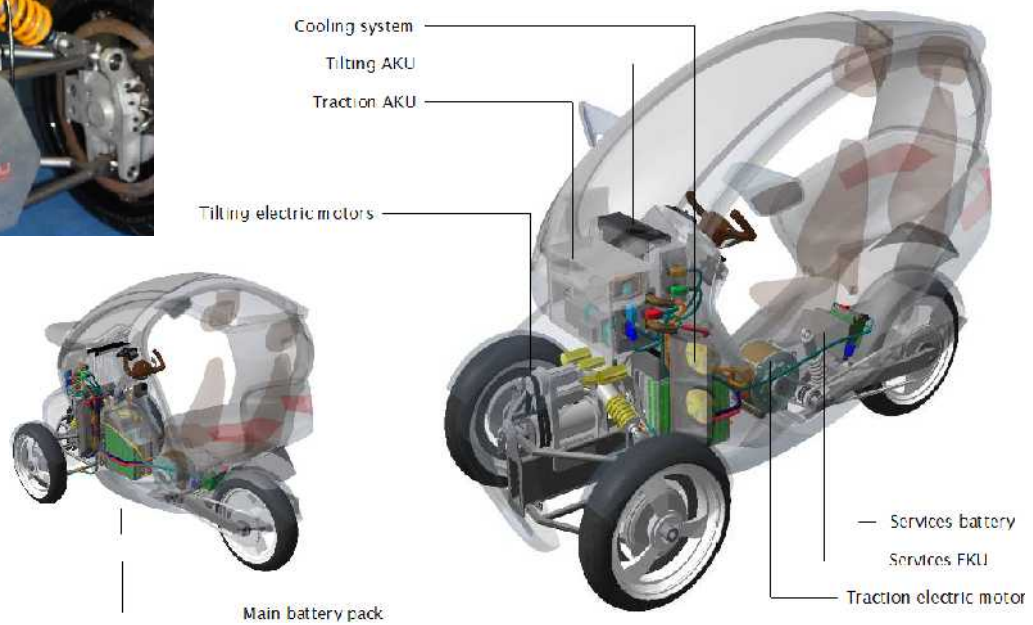
Drive-by-Wire: active tilt & steer for narrow vehicles

A new driving feeling: fly the road

Actua Active Tilt & Steer is a patented solution integrated with a dedicated suspension geometry to give a narrow vehicle che capability to turn like a bike whiel it driven like a car.

- Tilting actuator tilts the vehicle into the curve (load transfer 70% max).
- Power steering does not add any torque to steering column. Wheels are dynamically decoupled from steering tool and no lateral force is generated by tires side slip angle.
- Tilting actuator maintains the desired roll angle (no load transfer is generated by tilting actuator action).
- Power steering applies a torque on steering column. Lateral forces generated by tires side slip angle increase vehicle performance reducing curve radius.

A Three Tilting Wheels vehicle has been developed with hybrid powertrain to participate to the Automotive X Prize in 2009 and with electric powertrain for Shanghai Automotive fair in 2011.



Drive-by-Wire: cam brake, electrohydraulic damper, robotized gearbox

Making the most of "more electric" vehicles

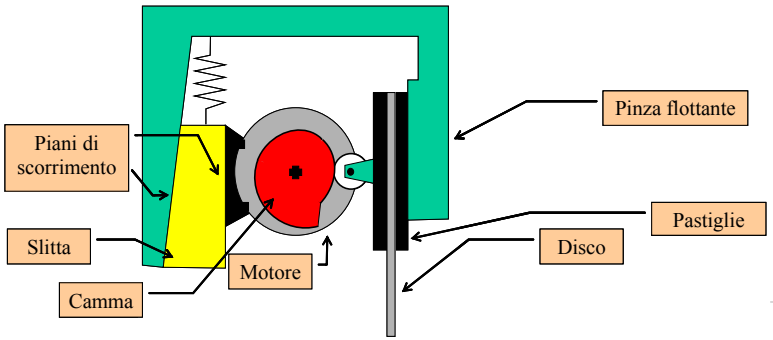
Mechatronics solutions range from drive-by-wire brakes, dampers, tilt & steer, to robotized gear-and-clutch.

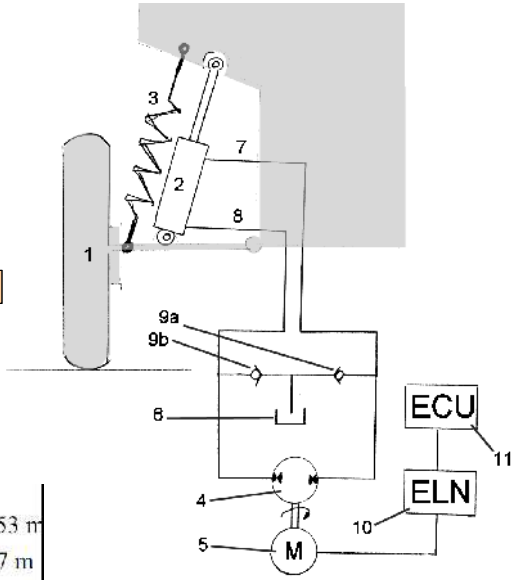
Drive-by-wire solutions are well known and extensively used in aeronautics and are increasingly adopted on other vehicles. In particular, off-road vehicles begin to make extensive usage of drive-by-wire technology.

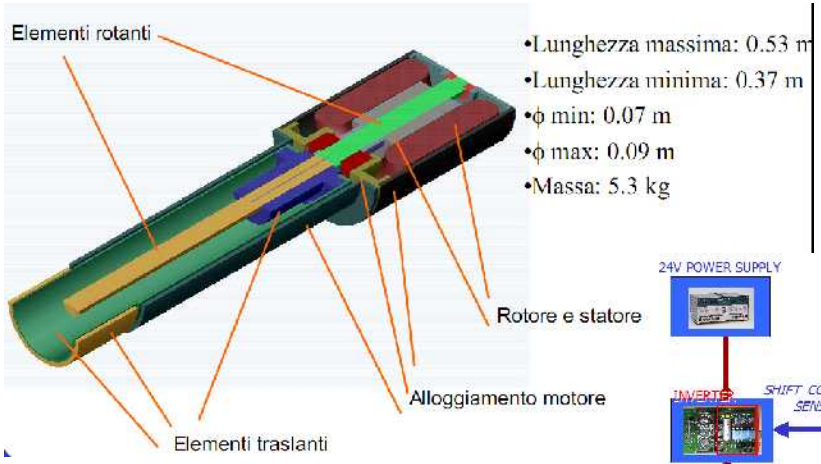
The usage of real-time deterministic networks together with redundant electric motors and power electronics enable full fail safeness and fault tolerance.

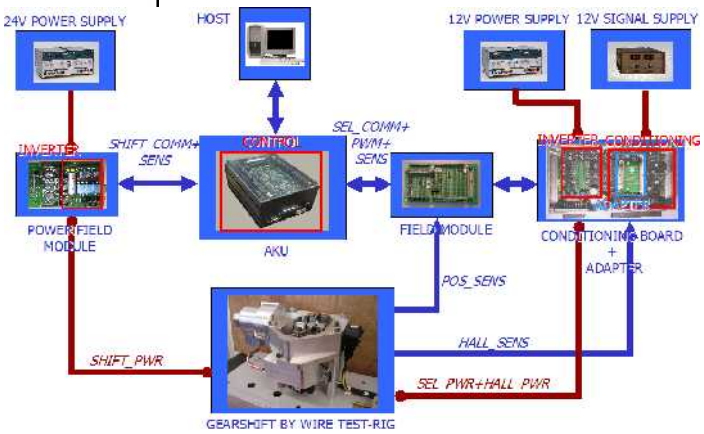
The progressive electrification of vehicle traction with the availability of on-vehicle higher voltages allows an easier adoption of electrical driven actuations and drive-by-wire control.

Actua *patented solutions* like open stator motor-in-wheel, brake-by-wire system by cam and slide, active tilt & steer, active differential are example of innovative mechatronic drive-by-wire products.









I-Lakes: inertial batteries for renewable energy storage and equalization

Wind blows in gusts, sun is shadowed by clouds...

Actua I-Lakes is a stationary energy storage system based on mechatronic instead of chemical technology. (The name comes from the similar usage of alpine lakes as potential energy storage.)

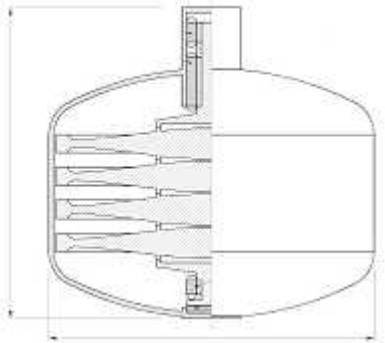
The energy is inertially stored in rotating flywheels that are accelerated by an electric motor during the charging phase and that are decelerated by the same motor (working as an electro generator) during the discharging phase.

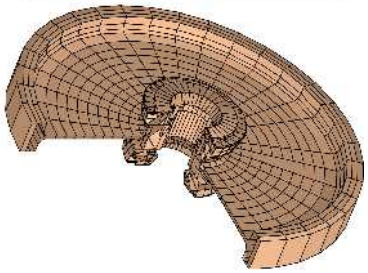
In order to minimize the energy losses due to friction the flywheel rotor is suspended by means of no contact magnet bearing and sealed in vacuum.

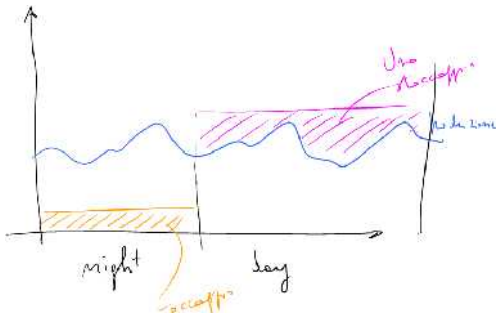
The energy density of inertial batteries is relatively poor compared to chemical batteries but its power density is very high with no possible damage and an infinite number of deep discharge cycles.

Together with storage capacity, inertial batteries provides a very effective power equalization in small renewable energy sources, both for on-site usage and grid injection.

1 small Alpine Lake ≅ **A handful of Soccer Fields**
(with flywheels installed underneath)







Mechatronic Services: performance evaluation, engineering and prototyping

From concept to industrial prototype

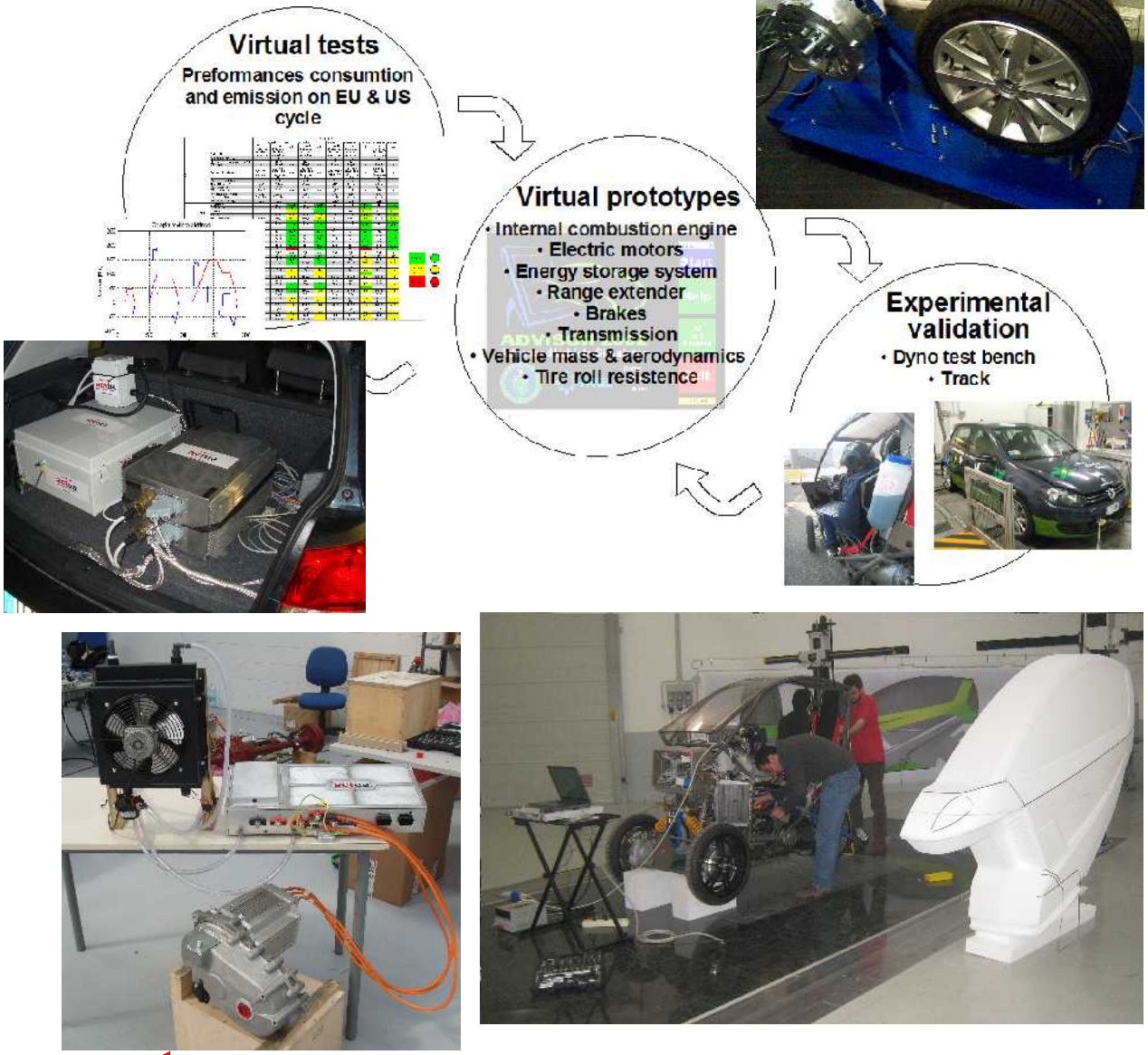
Actua Mechatronic Services span from product development to on-vehicle powertrain prototyping.

Actua rapid prototyping system are fully integrated with simulation environment in order to move smoothfully from virtual to real tests using a true model based design approach.

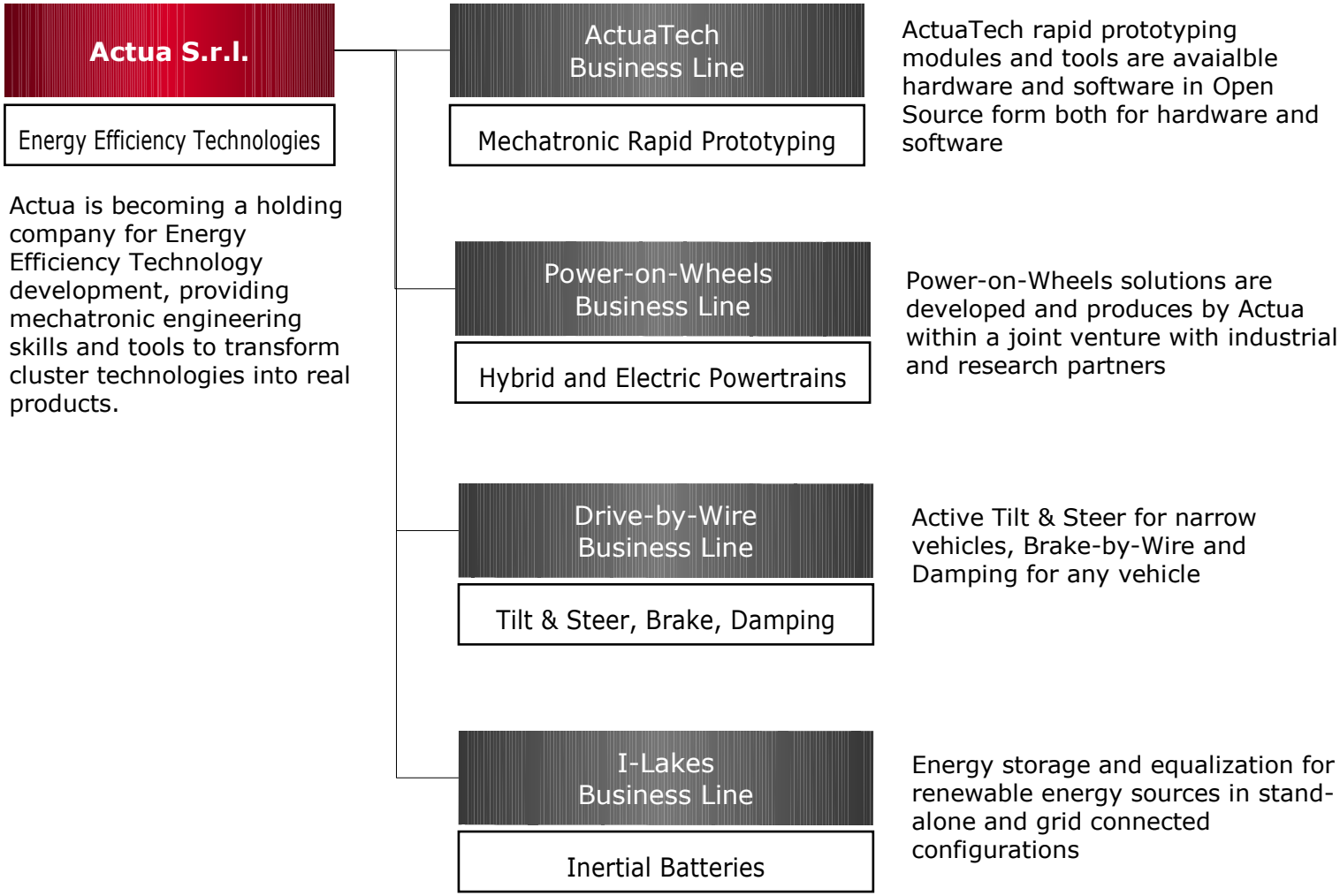
Actua rapid prototyping technology is aimed at the development of an industrial prototype, i.e. a functional prototype fully whose main components can be moved to small series or pre-series productions.

In particular the vehicle specific software developed in the prototyping phase is used on the final product moving from tuning to diagnostic capabilities.

Actua mechatronic services are part of the Power-on-Wheels solutions remote and on-site assistance as well as general engineering for any electric or hybrid architecture and third party technology.



Actua company structure and partnerships



oerlikon graziano

CIMA

LANDIRENZO

MOOG

A number of industrial partnerships including co-design and co-business agreements allows Actua to shift smoothly from prototyping to industrial production

Actua is part of a consortium to provide complete vehicle solutions

Tecnocad progetti S.p.A.

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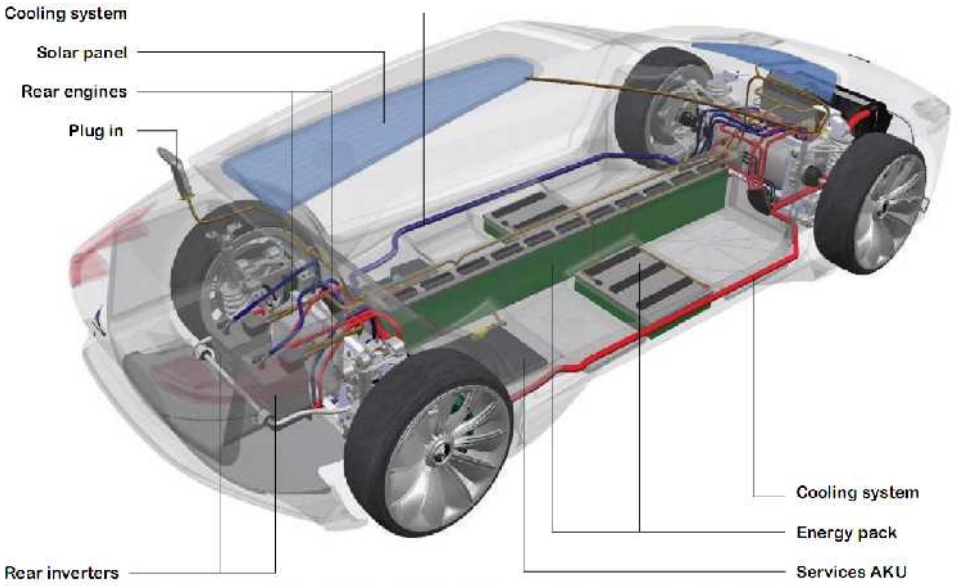
actua
Actuation and Control Technologies

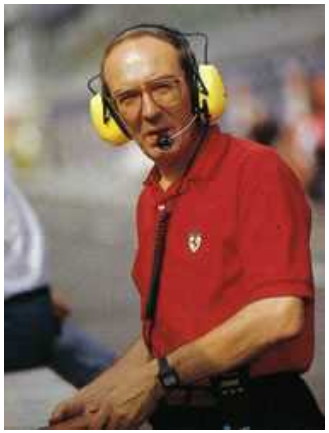
Actua with Icona @ Shanghai 2011

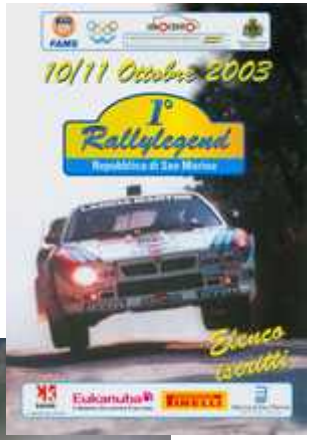


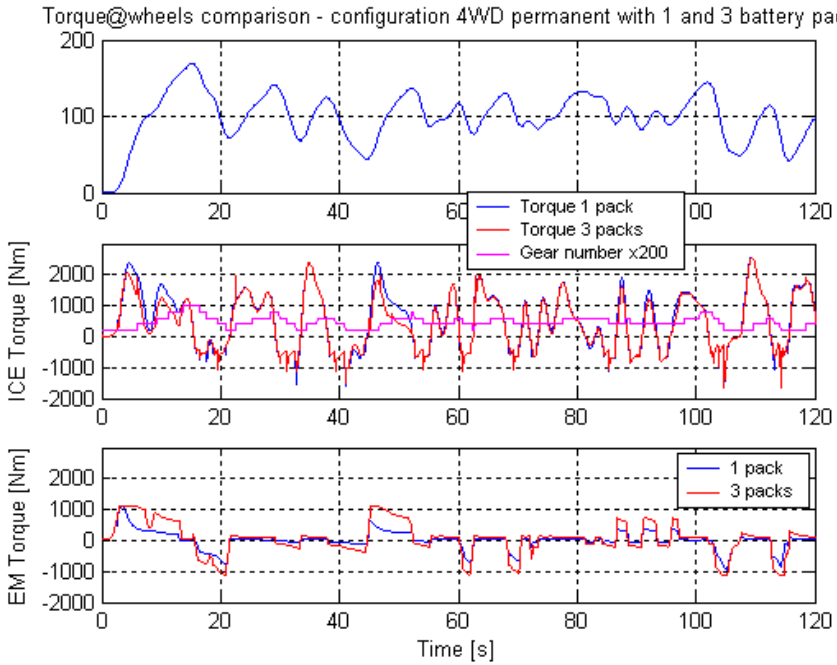
Actua with Oerlikon and RGM @ Rally Legend 2012

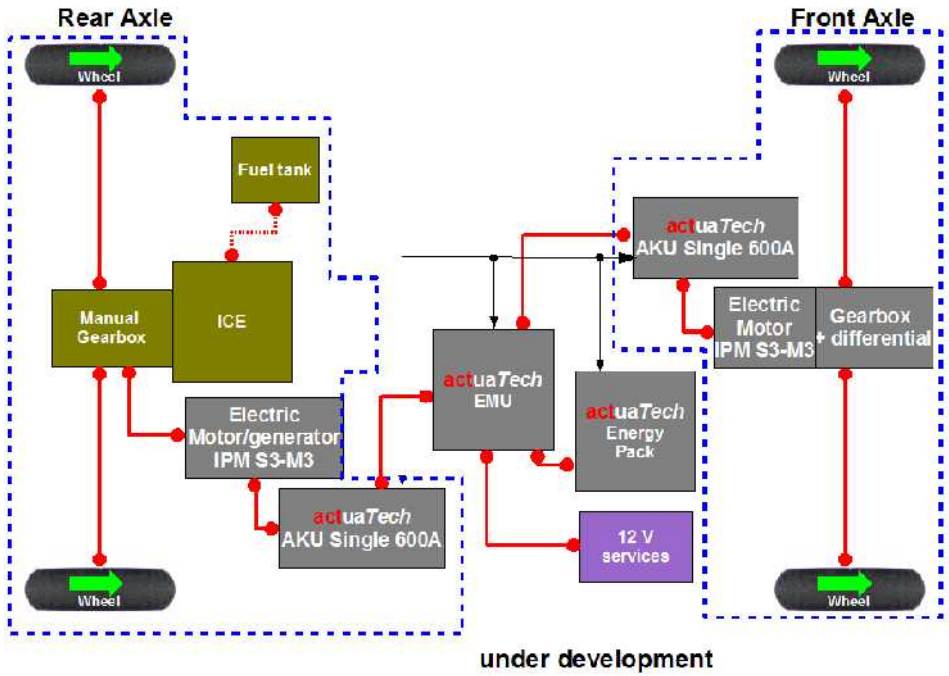
Legendary World Champion Lancia 037 again on the road with Actua, Oerlikon-Graziano, RGM and Volta Racing to provide a parallel hybrid solution for a permanent integral traction.

The front electrical transaxle is coupled to the combustion engine by means of an Energy Management Unit to control the energy/power flows between front traction, battery and rear electric motor/generator.









Actua with PoliTo Team @ RAC Brighton-London 2012

Royal Automotive Club is sponsoring an ecorace from Brighton to London to show the capabilities of hybrid and electric vehicles.

Togheter with extreme vehicles to partecipate to the Shell Eco-marathon, Team H2PolitO of Politecnico di Torino has designed an innovative light vehicle that will be powered by Actua.

For Actua, with Oerlikon-Graziano and RGM, a chance to show Power-on-Wheels powertrain full line of components for Electric Vehicles with Extended Range – EVER.