

Ratio Zero transmission

The clockwork CVT



Ratio Zero
transmission

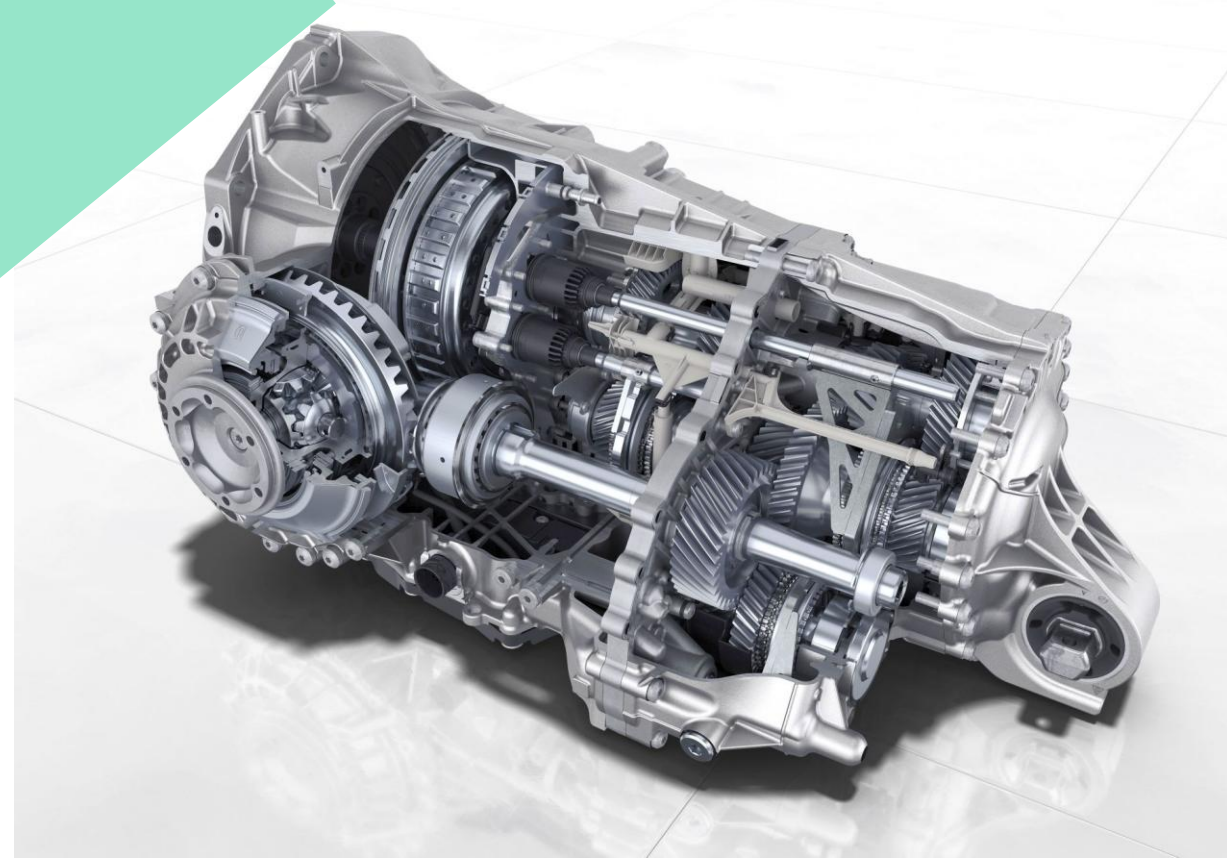
The context



We are all familiar with N-speed transmissions.

They are proven, well understood and very popular, especially in road vehicles but also in operating machines, tools and so on.

N-speed transmissions **are based on shape couplings** that exchange forces directly, normally involving gears, cogs, pinions, shafts, chains.



Regardless of their operating principle, they share the common feature of «discreteness», that is, **they can only work at fixed points (transmission ratios) and require a shifting to change ratio.** The shifting normally implies a suspension of the power flow and some degree of perturbation of the system.

To solve these issues, CVTs or **Continuously Variable Transmissions** have been proposed throughout the 21^o century.



They can change the transmission ratio continuously and do not require shifting, but **they usually involve some form of friction** to exchange forces.

Friction entails **a loss of efficiency and a substantial generation of heat**, which affects reliability and durability.

The impasse

Many attempts have been made to build CVTs based on shape couplings (gears/pinions/shafts/chains)

but with little success

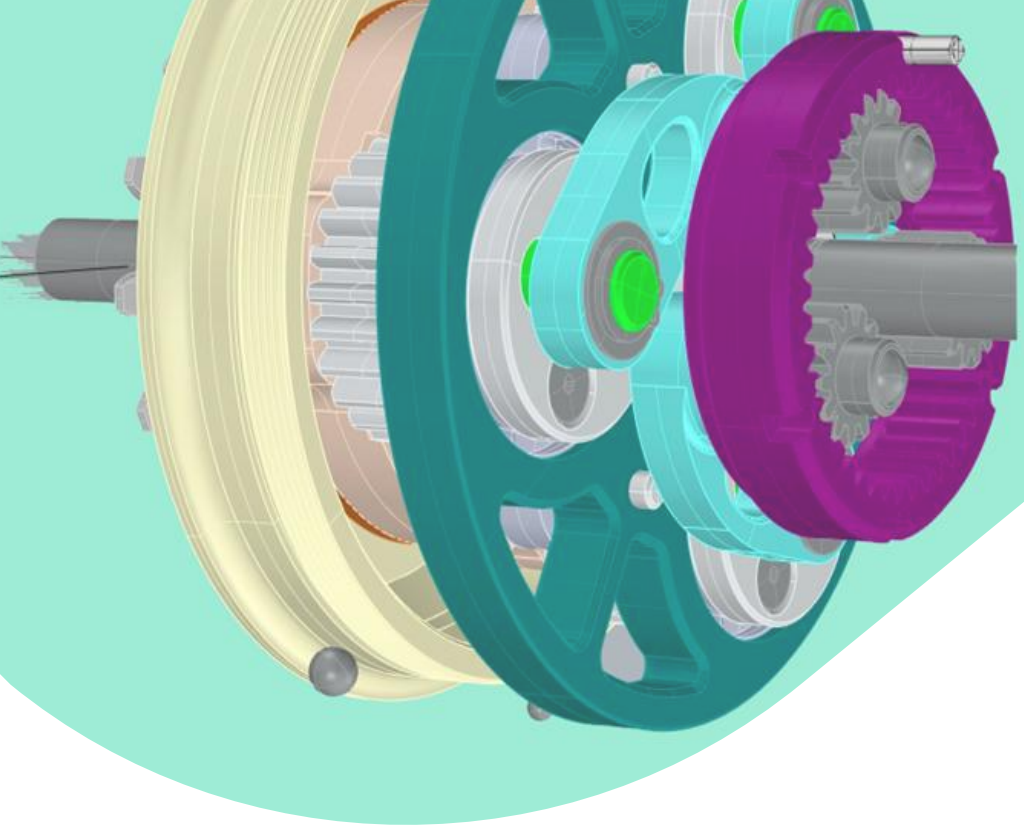
especially when costs are taken into account.

The breakthrough



In 2015, Mr Edyson Pavilcu started to devise a CVT based on shape coupling. He made several attempts with different kinematics.

In 2016, Mr Pavilcu had the breakthrough idea for a CVT based on a modified planetary system.



The breakthrough consisted in **splitting the rotation** in portions and using one satellite for each portion, turning it off in the other portions via a freewheel.

The torque is efficiently transferred through gears, freewheels and a four-bar mechanism, which re-construct the gear rotation with variable ratio.

In 2017, Mr Pavilcu built a proof of concept of this system, **an Infinitely Variable Transmission able to achieve $R_t = 0$.**

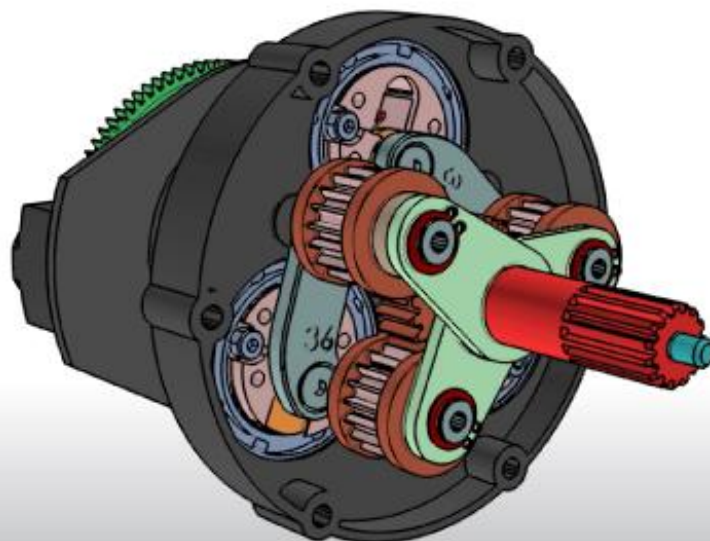
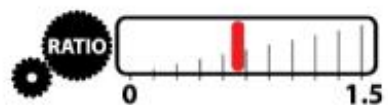
This meant possibly **ruling out any clutch system** on ICEs.

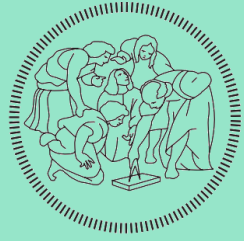
How it works



AlterEgo-Hardware s.r.l.

RatioRES®





POLITECNICO
MILANO 1863

In 2018, Mr Pavilcu joined forces with Alter Ego Hardware (AEH) Srl to develop the system, which was named «**Ratio Zero Transmission**»

- **The RZT was patented**, to a full extent in all the major Countries in the world
- A first geometrical and analytical study of the system was carried on at Politecnico di Milano (Milan Technical University)
- A **bicycle implementation** of the RZT (rear wheel hub) was built and tested.

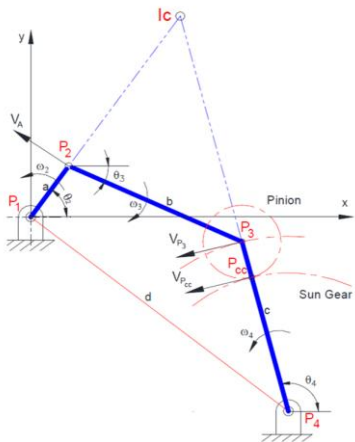
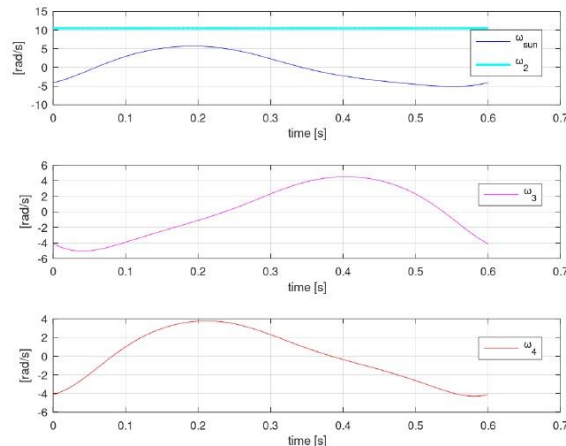
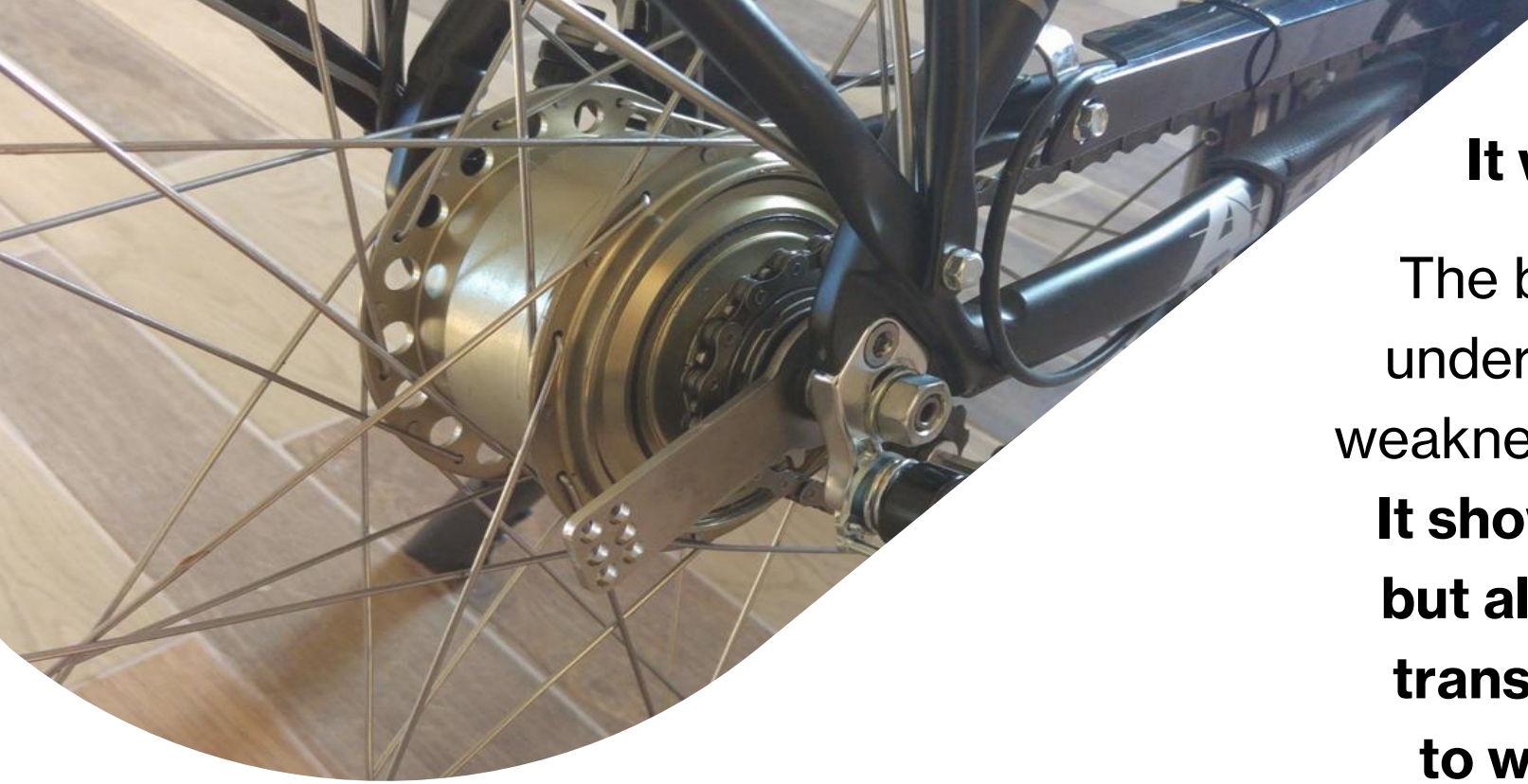


Figure 3–12. Diagram of instantaneous centre of rotation





It wasn't straightforward.

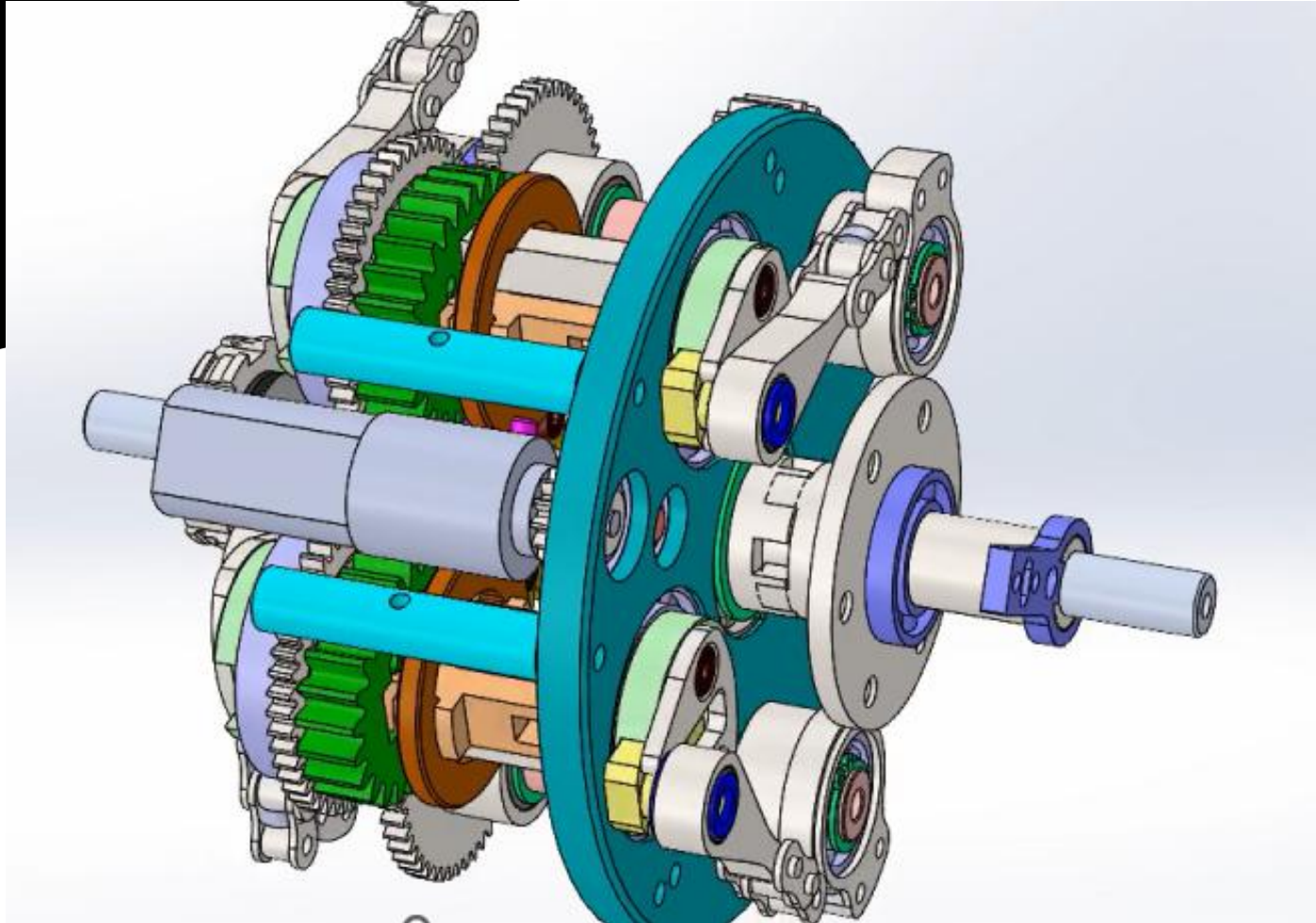
The bicycle prototype helped in understanding the strengths and weaknesses in a real-life application.

It showed a good gearing range, but also a cyclic variation of the transmission ratio; and it failed to withstand decent torques.

Partly because of the Covid-19 downfalls, it took years to solve the issues.

In the process the team produced several improvements, a digital twin of the system and gained a complete understanding of its mechanical properties of the system. **This led in turn to new concepts and to a second patent.**

The second patent (2024)

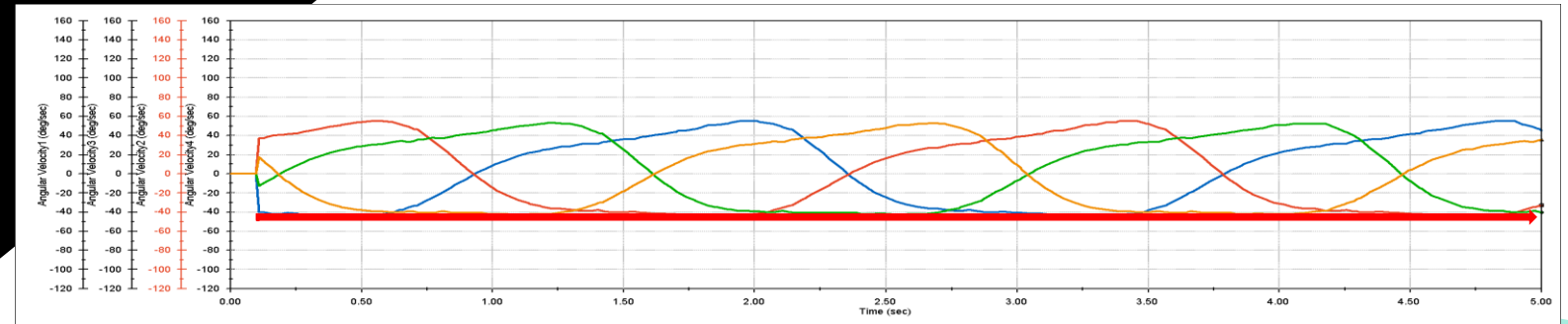
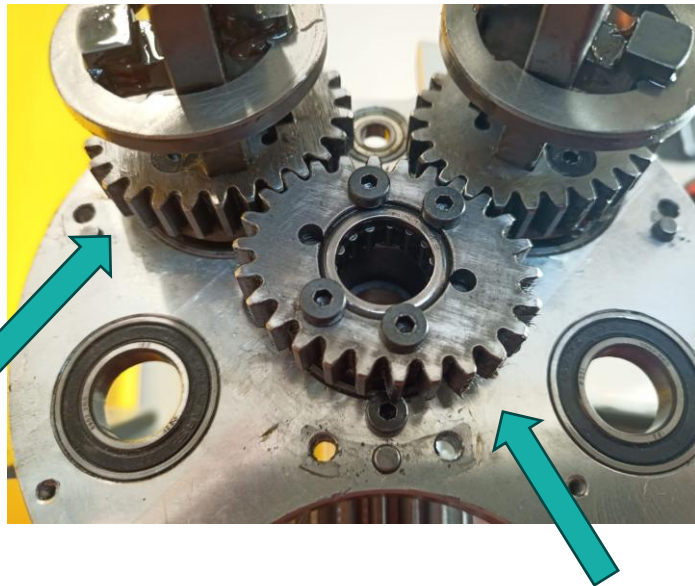


The second patent (2024)

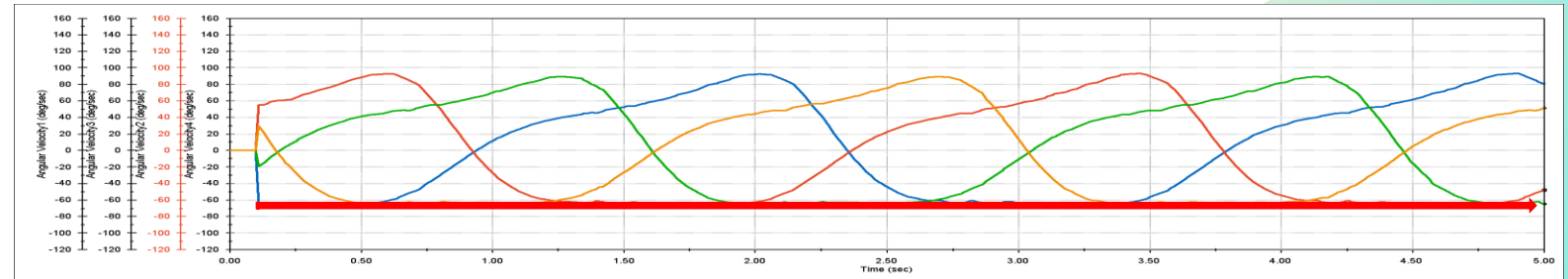
Improves on the original in several ways:

- constant velocity (homokinetic)
- better pedal feel
- faster ratio variation

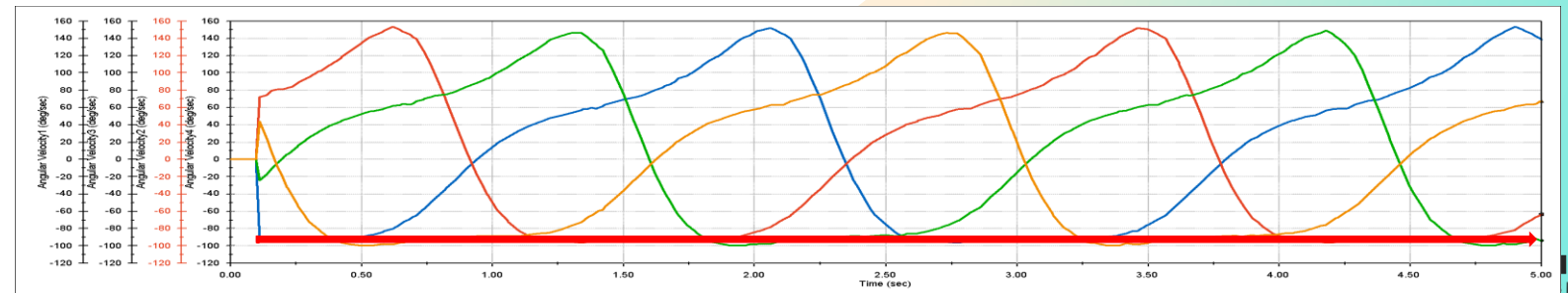
The use of a pair of **elliptical gears** allows for leveling off the ratio oscillations at any speed.



Lowest ratio

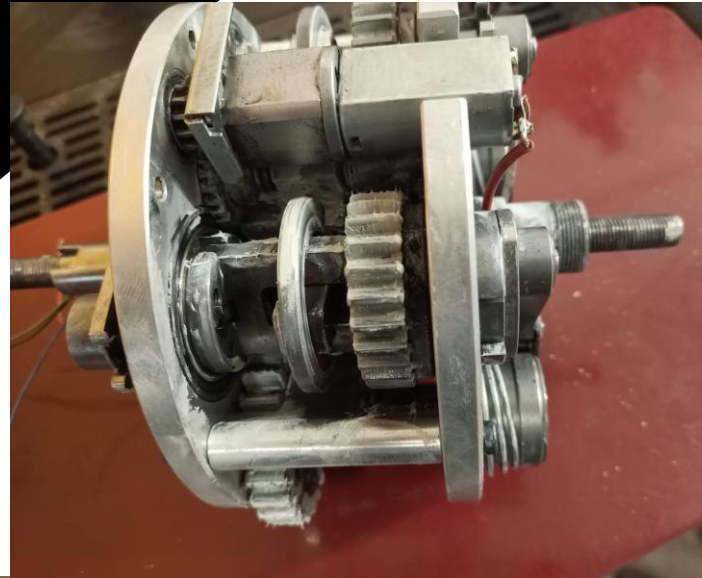


Intermediate ratio



Highest ratio

The second patent (2024)



A new system for actuating the sled and a new 12V motor allows for faster variation of the ratio.

The use of **short chains** instead of a rigid link in a section of the four-bar link allows for a smoother transition between the satellites.



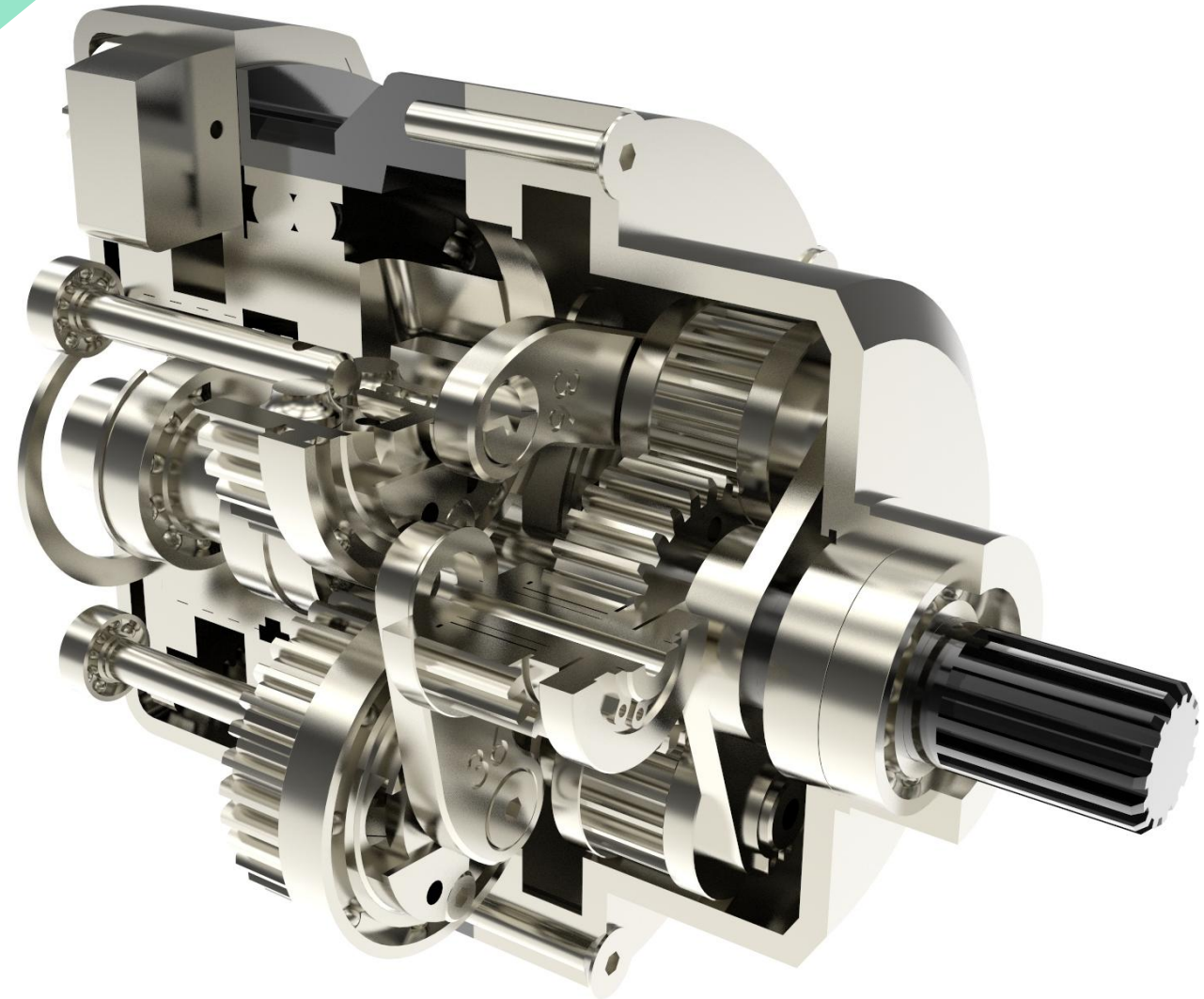
Where we are

The RZT is currently at TRL = 5, as the technology is being validated in a relevant environment (use case = bicycle)

It has already reached a transmission range of 550% and has no obvious limitations in torque (provided its elements are well dimensioned)

The pluses 1

Efficiency



TRANSMISSION TYPE	EFFICIENCY
Manual (geared)	95~97%
Torque converter	80~86%
CVT belt	70~86%
CVT toroidal	87~93%
Ratio Zero (estimated)	95%

The pluses **2**

**Shiftless &
Clutchless
(motorbike)**



**A completely new
pedaling experience
(e-bike)**



The pluses

3

High range



TRANSMISSION TYPE	RANGE
Bike derailleur, 1x12	550%
Car epicyclic MT, 6 gears	530%
CVT belt	400%
CVT toroidal	350%
Ratio Zero	550% (∞)

The pluses

4

**High torque:
Use cases**

E-bike

Scooters and
Maxi-Scooters

Wind Turbines

Farm Tractors

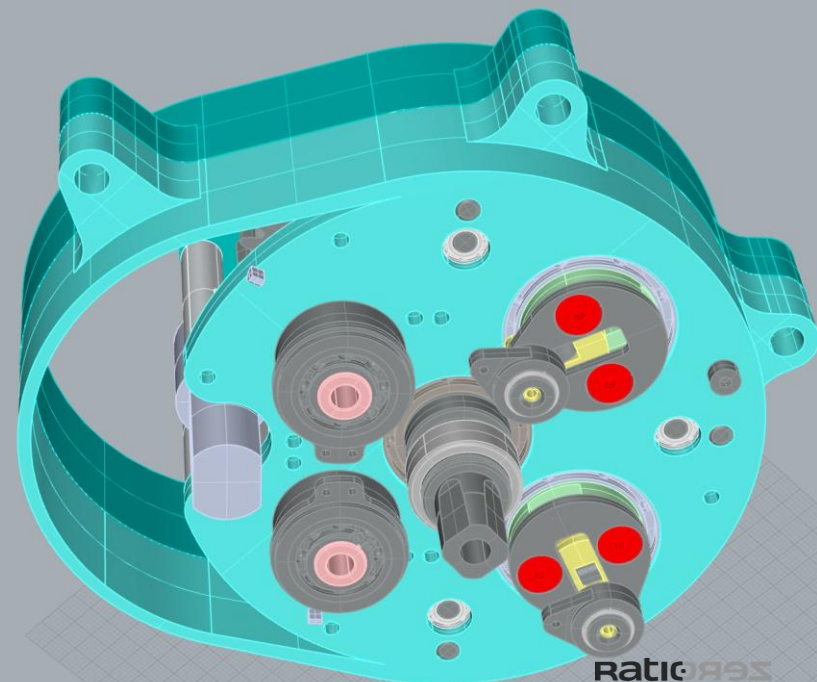
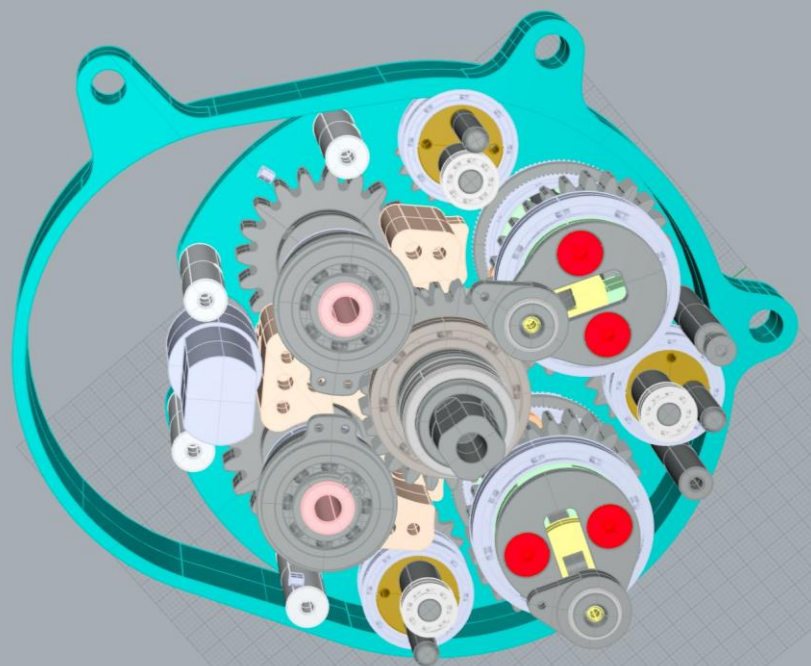
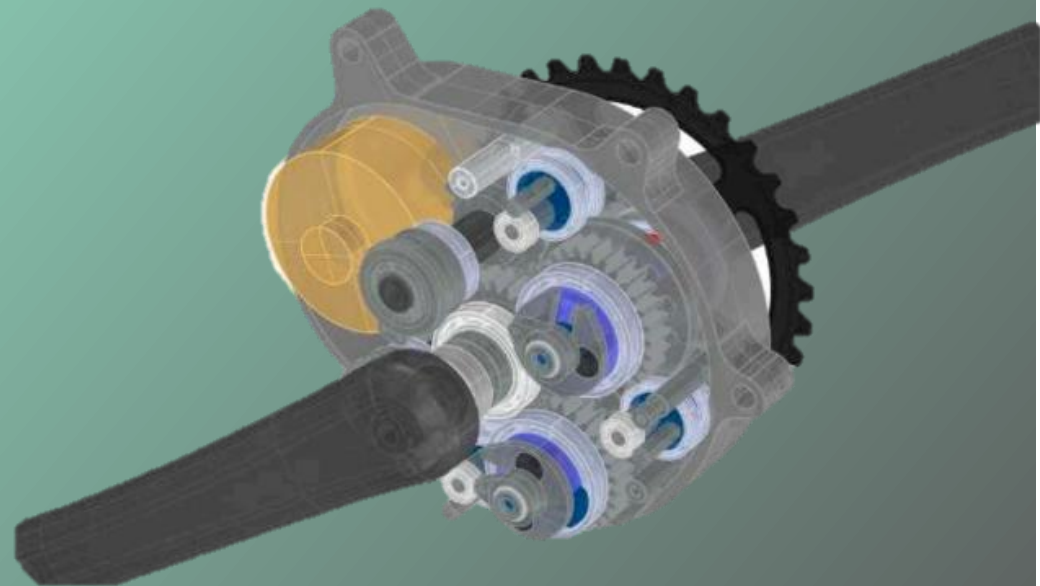
The pluses

5

Integration

Example:

E-bike central hub motor



Overview: Benefits



Assets:

Two patents (a very strong, foundational one and a «refinement» patent)

Working prototype on e-bike

Thorough understanding of the system & complete working designs for further applications



Competitive advantages:

Efficiency: **10% more energy efficient** than any other CVT on the market; cheaper to build than robotized standard multi-gear gearboxes

Can handle high torques, suitable also for heavy industry applications

Range: infinite gear ratios, more range than any gearbox (including CVTs) applicable on motor vehicles (**560%** and more)

Durability: no fast wear parts (eg: trapezoidal belt in classic scooter CVTs), no regular maintenance required

Simplicity and ease of installation: more **compact and light** design compared to other gearboxes

Integration: can be easily integrated with electric motors (eg: electric scooters, ebikes, etc.)

Zero gear: can reach a “**zero**” **gear ratio** (decoupling) **without the need of a clutch**, therefore possibly requiring less components and controls compared to standard gearboxes and many CVTs

A completely new experience of riding/driving

Overview: Competitors



Application overview	Epicyclic gearbox	Sequential gearbox	Belt CVT	Sphere-cone type	Cassette-type	Torque converter	RatioZero
Car	●	●	●	●	●	●	●
Powered Two Wheeler	●	●	●	●	●	●	●
E-bike	●	●	●	●	●	●	●
Bicycle	●	●	●	●	●	●	●
Wind Turbine	●	●	●	●	●	●	●
Machine Tools	●	●	●	●	●	●	●
E-mobility	●	●	●	●	●	●	●

Competitors offering comparable innovative CVTs:

Technical wish list	Epicyclic gearbox	Sequential gearbox	Belt CVT	Sphere-cone type	Cassette-type	Torque converter	RatioZero
High efficiency	●	●	●	●	●	●	●
Clean (boxed)	●	●	●	●	●	●	●
Low noise	●	●	●	●	●	●	●
Stepless	●	●	●	●	●	●	●
Smooth feeling	●	●	●	●	●	●	●
Low maintenance	●	●	●	●	●	●	●
High durability	●	●	●	●	●	●	●
Easy automation & control	●	●	●	●	●	●	●

The TEAM

We are the **team that makes the difference** with leading world experts in the fields of:

- drivetrain engineering
- automation engineering
- mechanical and systems engineering
- Management and business development
- Management and business development
- Journalism



Edyson Pavilcu
Mechanical and Automation
Engineer with 10 years
experience gearbox design



Alexander Hohenegger
Team Manager, developed patents
and businesses for the past 20 years



Christian Cavaciuti
Car/Motorbike Technical
Journalist, Mechanical
Engineer and Author

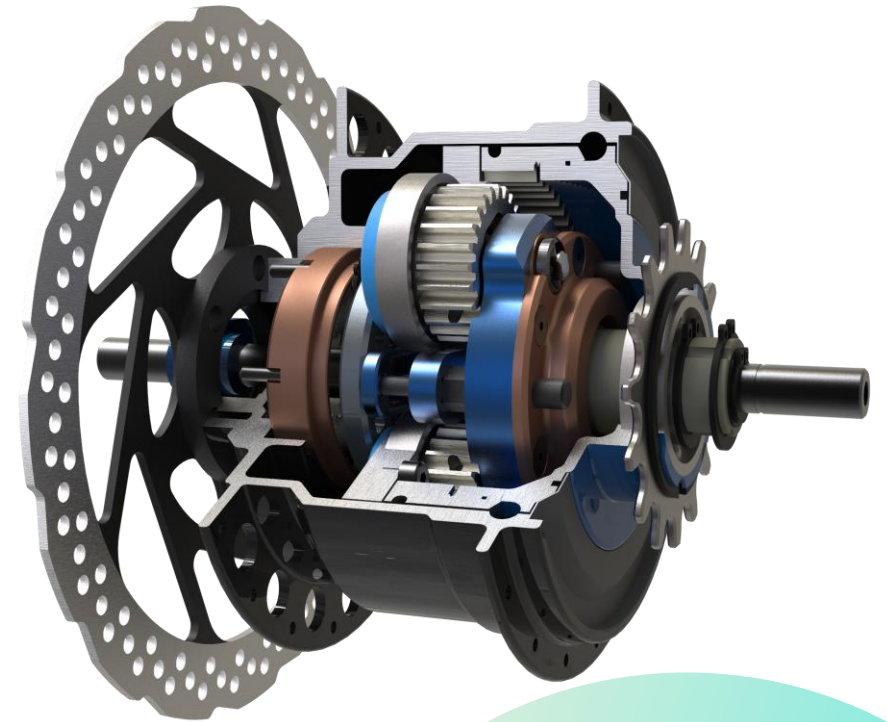


Guglielmo Amorelli
Mechanical and Systems
Engineer with 10 years
experience in Formula 1



Rosario Aliperti
Electronics and Software
Engineer with 8 years
experience in electric
motors and controls

Synopsis [TRL = 5]



DONE	TO DO
Idea of the system	Addressing the last issues: ripple, noise
Patenting	Downsizing (e-bikes), Upsizing (industrial)
Proof of concept	Complete FEA/FMEA of the system
Modeling/Characterization/Digital Twin	Sign partnership with OEM
Engineering: targets of torque/range	Industrialization
Fully working prototype installed on e-bike	Launch and marketing

TAM: Total CVT (Continuously Variable Transmission) market size



Wind turbine gearbox (as of 2023) **\$22.7 B**, CAGR 8.08% (Fortune Business Insights Report ID: FBI101355)

Passenger cars and commercial vehicles (as of 2023) **\$22.1 B**, CAGR 4.9% (IMARC Report ID: SR112024A1197)

Bicycle transmission (as of 2022) **\$0.36 B**, CAGR 12.8% (Market Research Future Report ID: MRFR/AM/21612-HCR)

Marine current turbine gearbox (as of 2023) **\$6.8 B**, CAGR >5% (Global Market Insights Report ID: GMI9775)



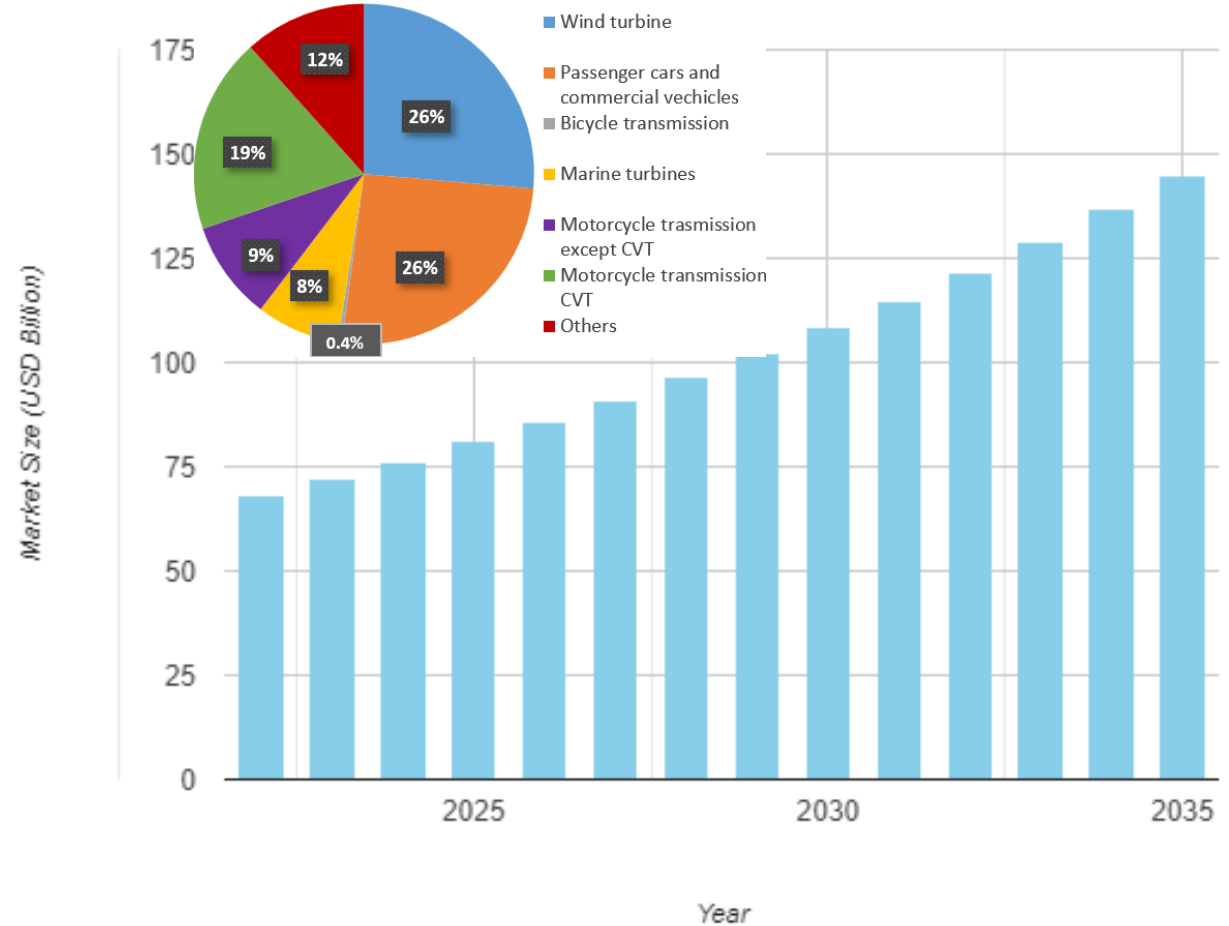
Motorcycle transmission (as of 2022) **\$24.1 B**, CAGR 3.46%, (Market Research Future Report ID MRFR/E&P/2424 4-HCR)

of which CVTs represent roughly 2/3rd (hence **\$16 B**) and growing (Fortune Business Insights Report ID: FBI101893)

Other potential applications include industrial gearboxes, etc.)

Total CVT market size in 2022/2023 ≈ \$68 B to \$100 B with avg CAGR ≈ 6%

CVT Market Growth (2022-2035) - CAGR 6%



SAM: Initial Target sectors and geographical areas



IN THE FIRST PERIOD OF GROWTH AND TECHNOLOGY DEVELOPMENT RATIOZERO'S TARGET SECTORS INCLUDE THE BICYCLE, THE MOTORCYCLE CVT MARKET (**\$16 B**) AND THE WIND TURBINE GEARBOX MARKET (**\$22.7 B**).



SIMILARLY, THE TARGET GEOGRAPHICAL AREAS ARE THOSE WHERE A PREMIUM AND MORE EFFICIENT CVT SYSTEM IS REQUIRED, THEREFORE RATIOZERO WILL AT FIRST CONCENTRATE ON WESTERN AND DEVELOPED MARKETS (EUROPE, USA, JAPAN, AUSTRALIA, ETC.), ROUGHLY **16%** OF THE WORLD POPULATION.

INITIAL RATIOZERO CVT SAM: \$6.2 B

SOM: Startup obtainable market

As a first project, RatioZero aims to concentrate on the **motorbike/scooter CVT market**

Discussions are ongoing with market leading motorbike **OEM manufacturers**, both in **Italy and Japan**

With a fully working prototype on a motorbike/scooter Ratiozero can produce or sell the technology (patent) to one leading manufacturer in each of the areas mentioned in the SAM

The 2 interested manufacturers alone have > 30% market share in the SAM target geographical areas

Therefore, even ignoring future discussions with large manufacturers, the initial Serviceable Obtainable Market (SOM) is **\$1.86 B**



TAM \$68 B



SAM \$6.2 B



**SOM
\$1.86 B**

Business model



1. Co-develop the technology with large manufacturing companies (OEMs), interested in building and selling the product

→ **consulting/engineering** income starting from year
+ **royalties** once the product hits the market (expected 2 years)

2. License the patent without co-development → annual fees income starting from year 1

3. In-house develop, produce at scale and sell the technology → income from the sale of the finished product: 1 year development + 1 year setting up the production and distribution + 1 year to increase sales volume (income to start at the end of year 2)

Business model for co-development and royalties



1 year for development + 1 year for full-scale distribution in Italy



Operating profits: >\$1M in year 3



New motorcycles/scooters sold in Italy every year: 337k in 2023 (Confindustria Ancma data)



Forecast: >\$7M revenue and >6.5M Operating Profits by the end of 2029

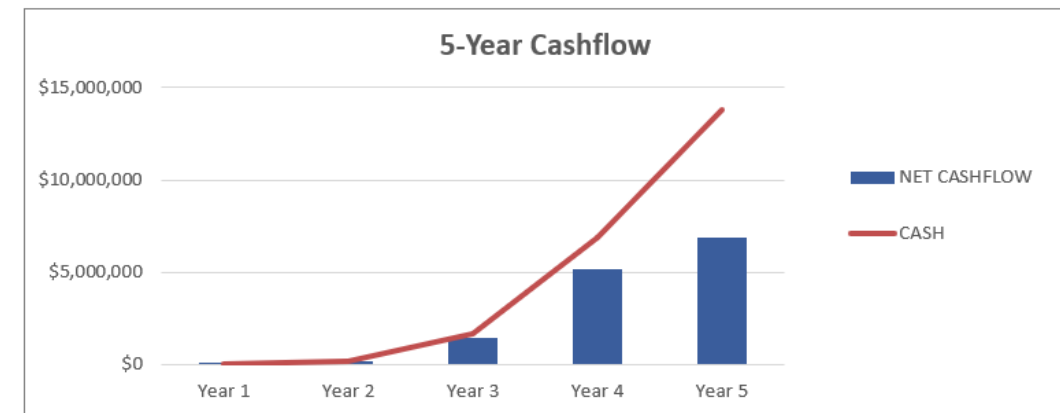
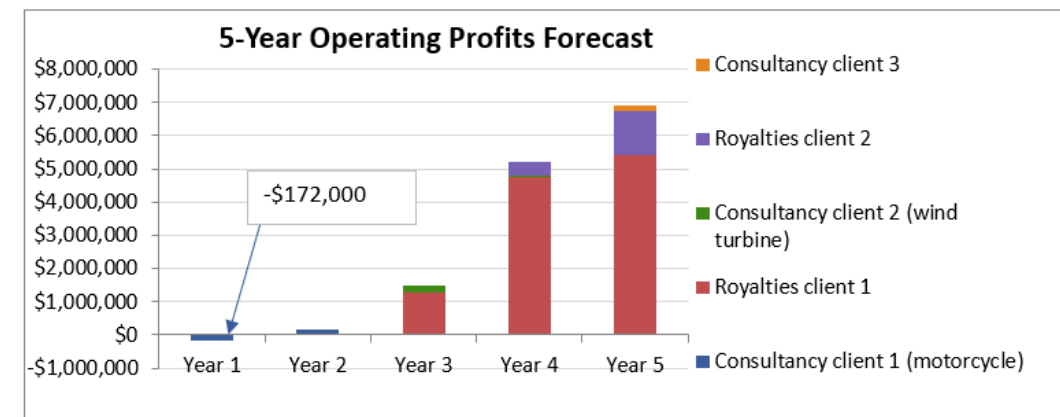
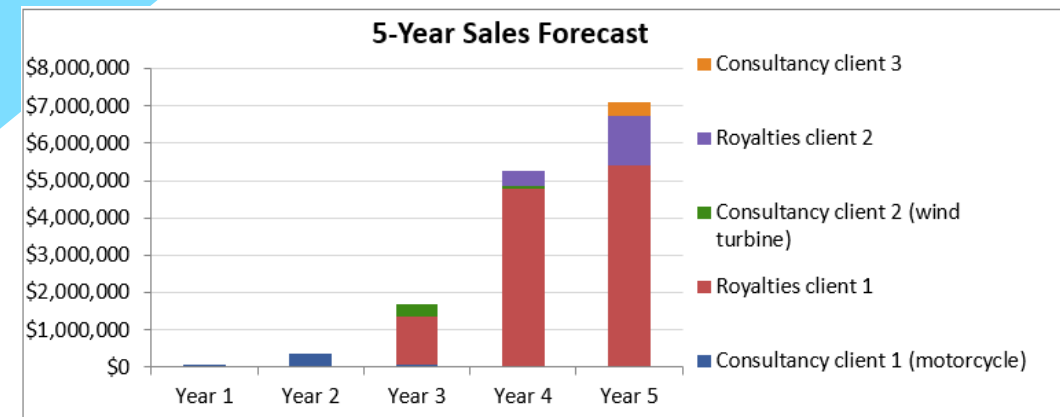


Assumptions: 1% (3.4k) of the Italian market reached in the 2nd year; 5% (16.9k) in the 3rd year



The business plan does not consider additional income that may result from:

- patent licensing in other sectors
- in-house development, production and distribution of Ratiozero for other applications (eg: e-bikes and cargo bikes)



Funding Requirements

Initial funding required for:

1. The development of a fully working prototype installed on a 530cc Yamaha Tmax scooter (\$150k)
2. R&D department for a year (\$200k)
3. Budget for fairs and events contributing to Ratiozero's exposure to OEM motorcycle manufacturers (\$150k)

Project development and start-up total costs = \$500k

Funding campaign target = \$500k

Any overfunding will be used to speed up the development and reach the business plan targets in a shorter time period

Exit strategy

Ratiozero aims to sell the business and technology to an OEM manufacturer within 5 years: investors should realise an exit by selling ownership through strategic acquisition.

- **Current pre-money valuation = \$7M**
 - **5-years expected valuation according to BP= \$80M**
- **11x multiplier**

Examples of related technology successful crowdfunding campaigns



Equity

LEKTRO

Lektro s.r.l. è una società che produce e-bike di alta qualità con motori all'avanguardia e che grazie alla sua leggerezza, integrazione e personalizzazione possiede i fattori per distinguersi in un mercato sempre più affollato di prodotti

CAMPAGNE	INVESTITI	INVESTITORI
1	€ 250.000	181

DETTAGLI SOCIETÀ



Equity

ARCO FC

Arco FC è la startup innovativa che ha sviluppato e brevettato delle speciali batterie per veicoli elettrici che garantiscono un'autonomia fino a 1000 km con una ricarica di soli 3 minuti. Arco, grazie alla tecnologia ad alta performance (Fuels Cells che hanno un +15% di efficienza energetica rispetto ai migliori sistemi, ad un 20% del costo in meno), rappresenta un operatore appetibile per grandi gruppi interessati al settore dell'idrogeno (come Amazon, Bosch, e Cummins)

CAMPAGNE	INVESTITI	INVESTITORI
2	€ 3.087.657	1093

DETTAGLI SOCIETÀ



Chiusa 15/10/2018 **FUNDED**

Totale raccolto
199.984 €

Goal min 149,03k €

Goal max 596,11k €

Attesa Inv. Professionale

90 investitori 133% Goal min

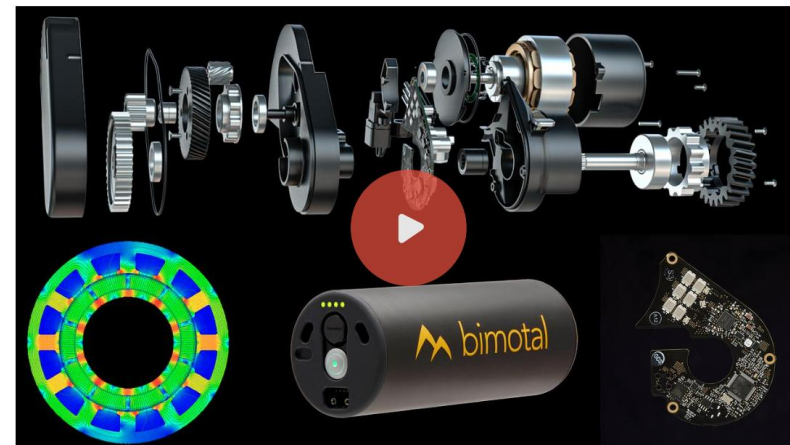
Ordine minimo 499,77 €

Pre-Money 4,40Min €

BIMOTAL INC.

Condividi

Powering electric vehicles with better motors, batteries, electronics, and software



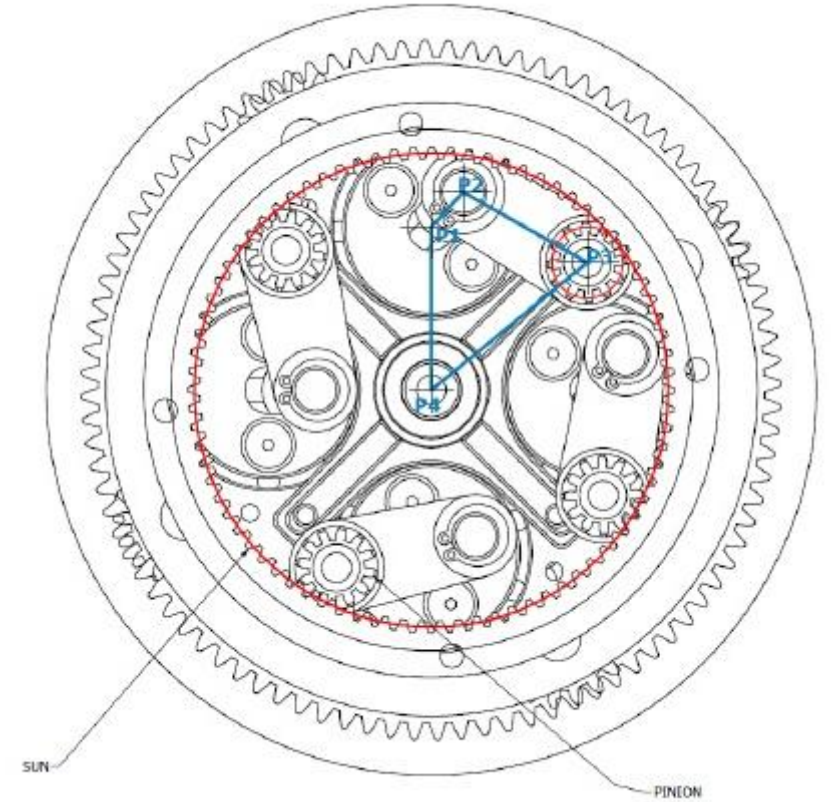
Ultimo finanziamento
gennaio 2024

512.150 \$
raised from 223 investors

SEGUI

**“If only I had known,
I should have become
a watchmaker.”**

Albert Einstein



RATIO99S
transmission

**Test ride our
RZT-equipped bikes
yourself!**

More info:

www.ratiozero.com



Ratio Zero
Transmission