

Ratio Zero transmission

The clockwork CVT



Ratio Zero
transmission

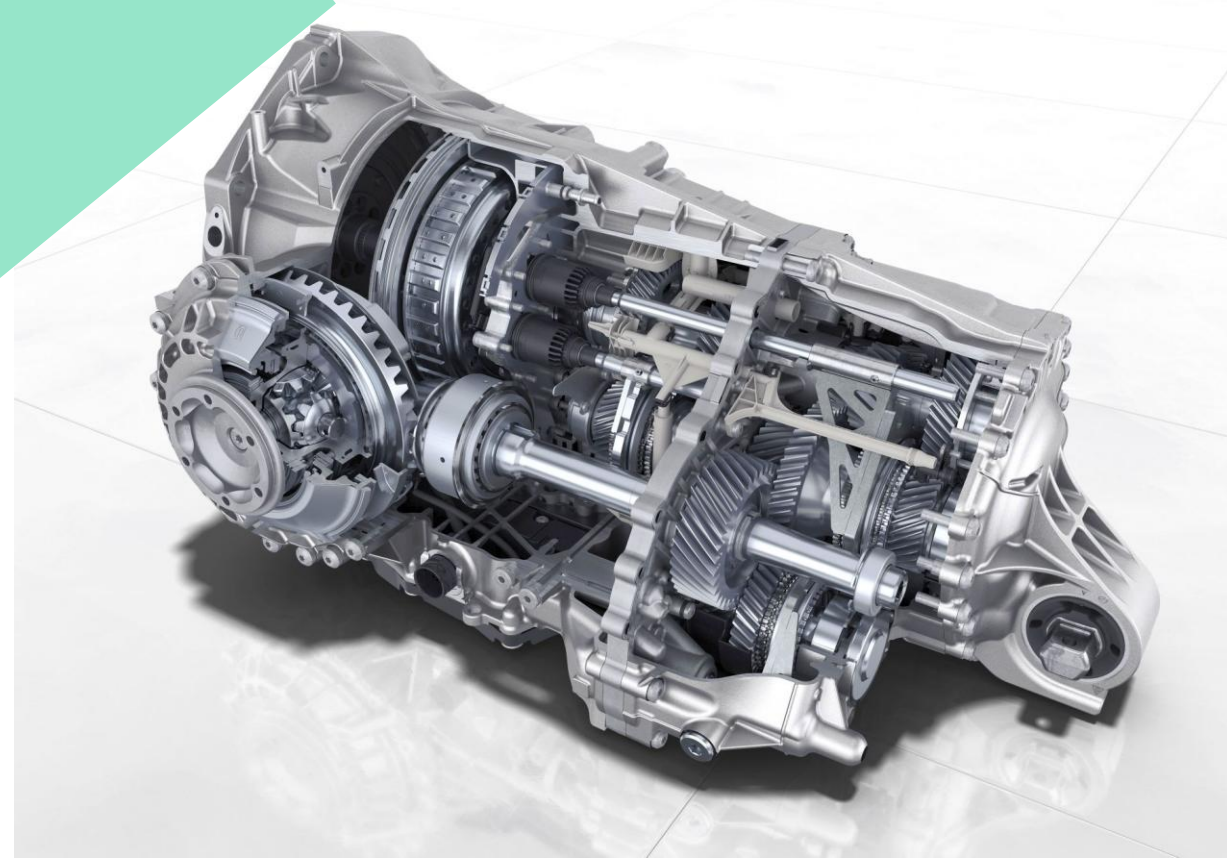
The context



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

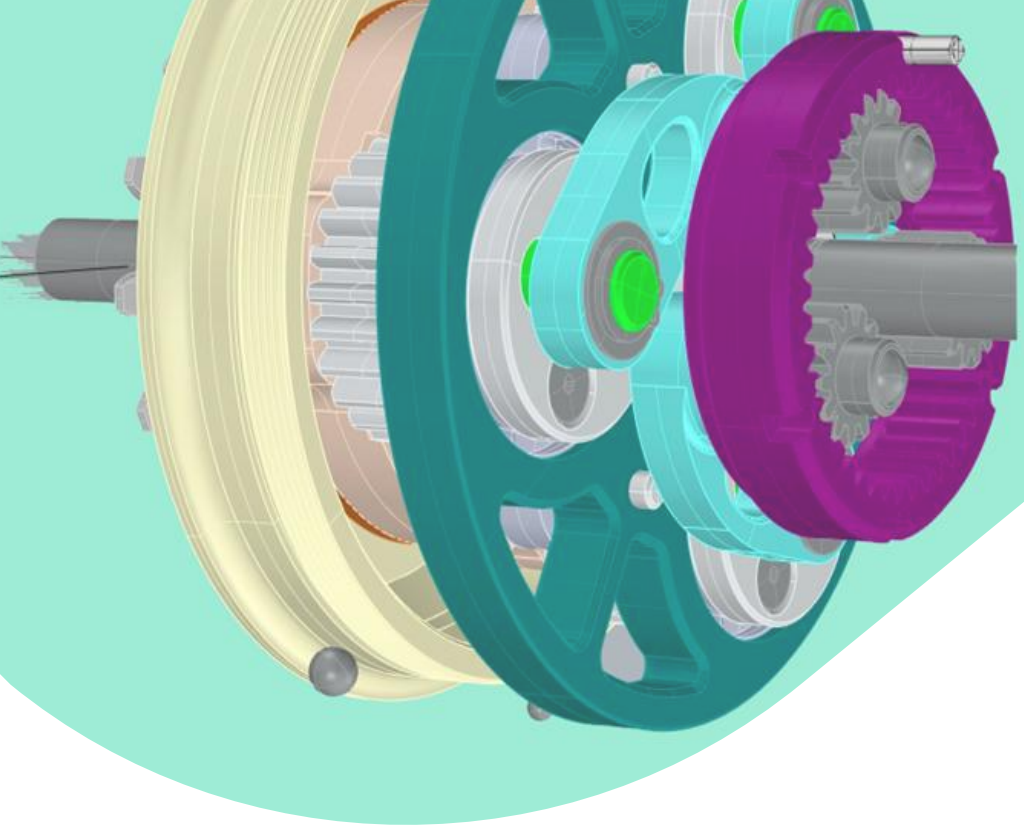
especially when costs are taken into account.

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.



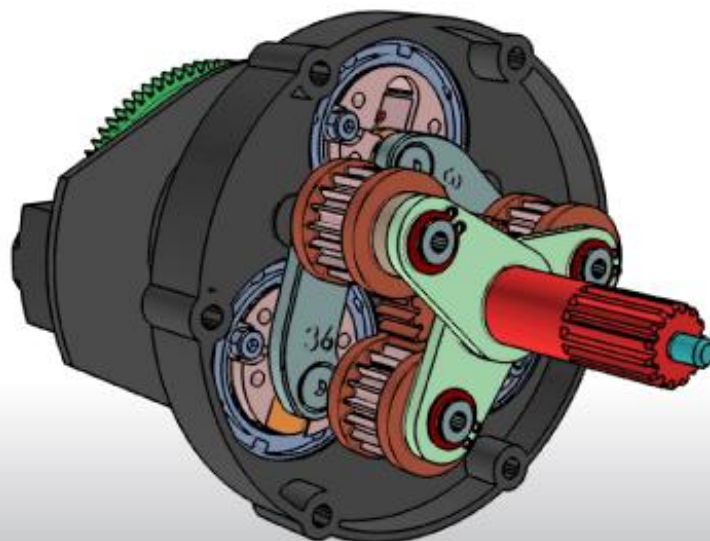
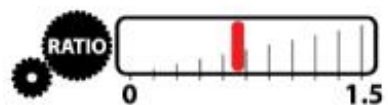
The breakthrough consisted in **splitting the rotation** in portions and using one satellite for each portion, turning it off in the other portions via a freewheel.

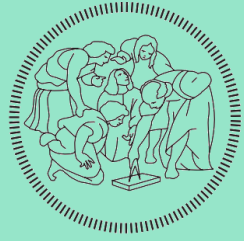
The torque is efficiently transferred through gears, freewheels and a four-bar mechanism, which re-construct the gear rotation with variable ratio.

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





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.

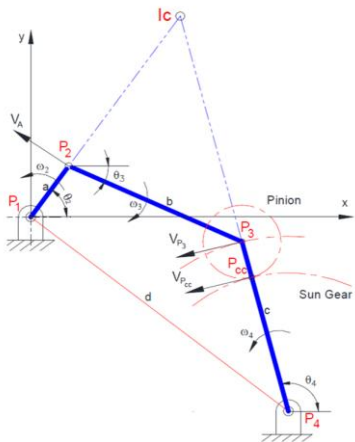
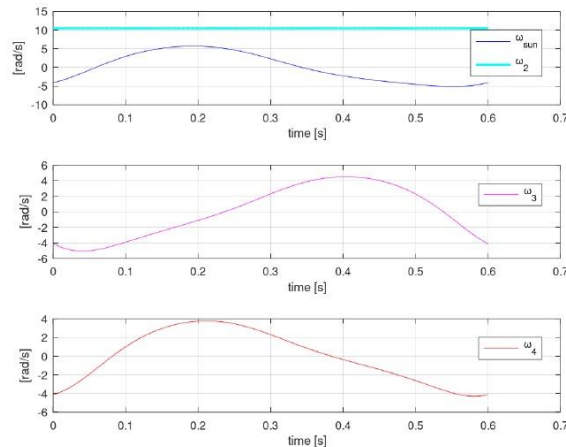
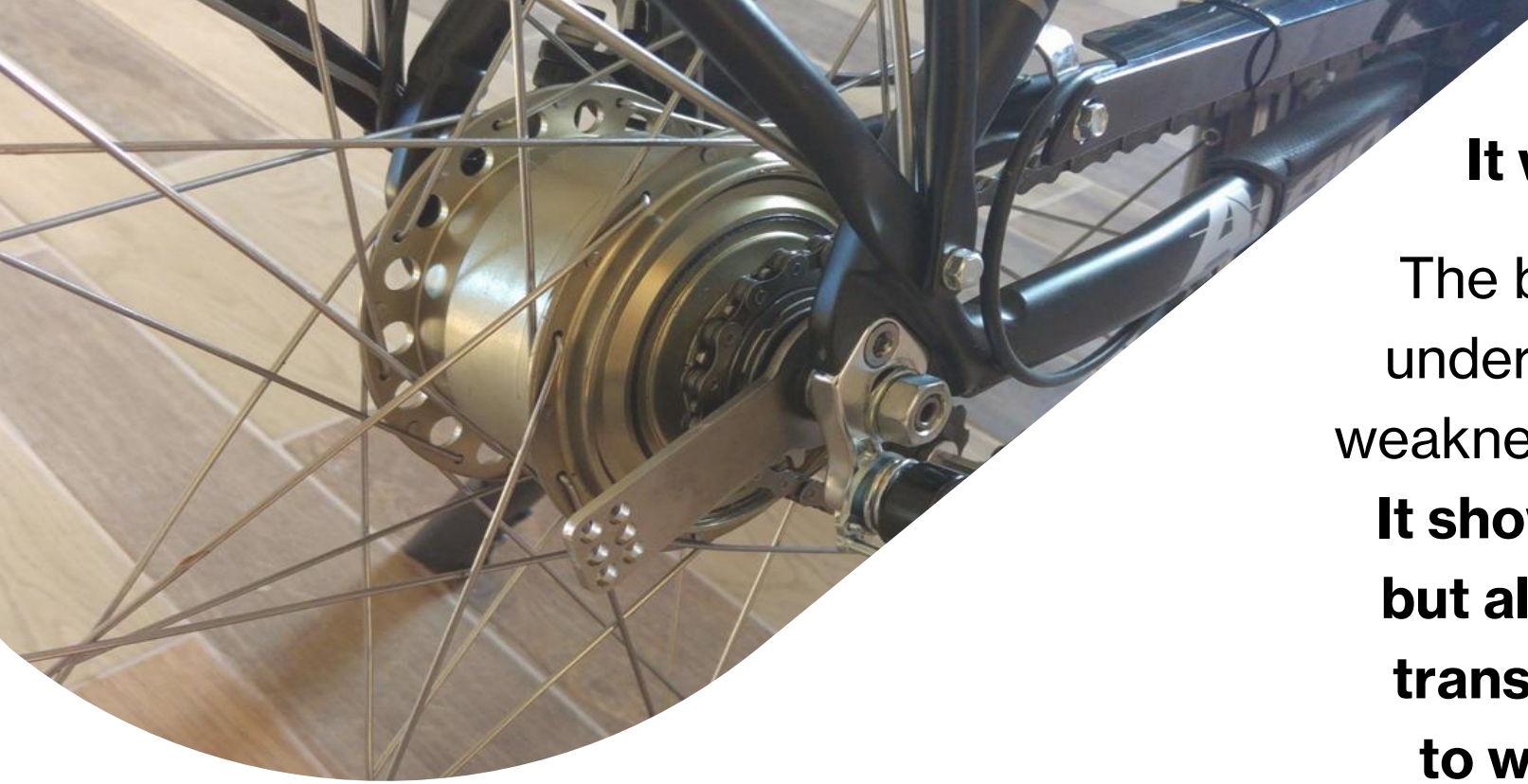


Figure 3-12. Diagram of instantaneous centre of rotation





It wasn't straightforward.

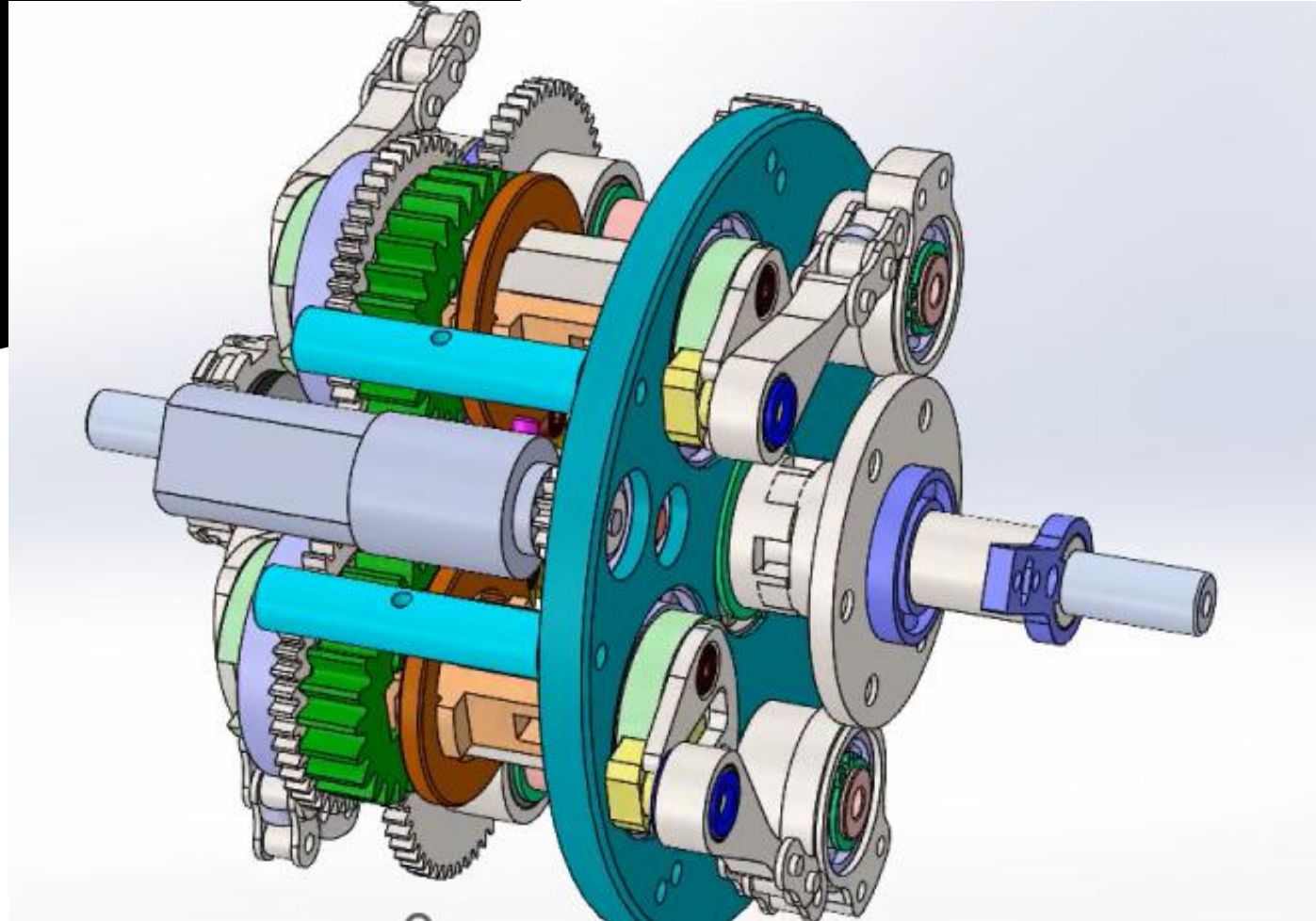
The bicycle prototype helped in understanding the strengths and weaknesses in a real-life application.

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)

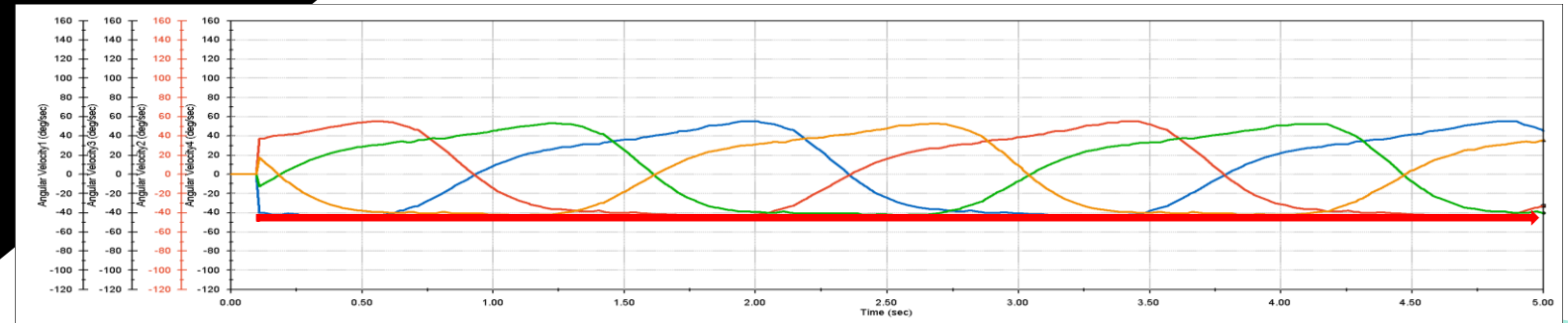
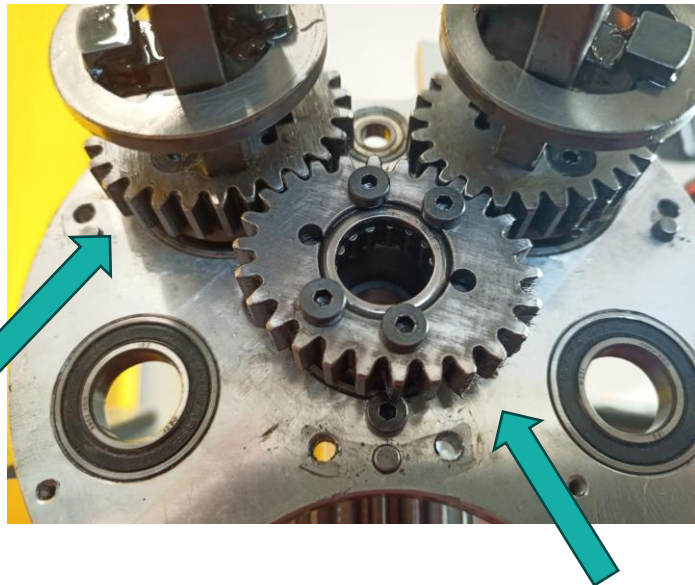


The second patent (2024)

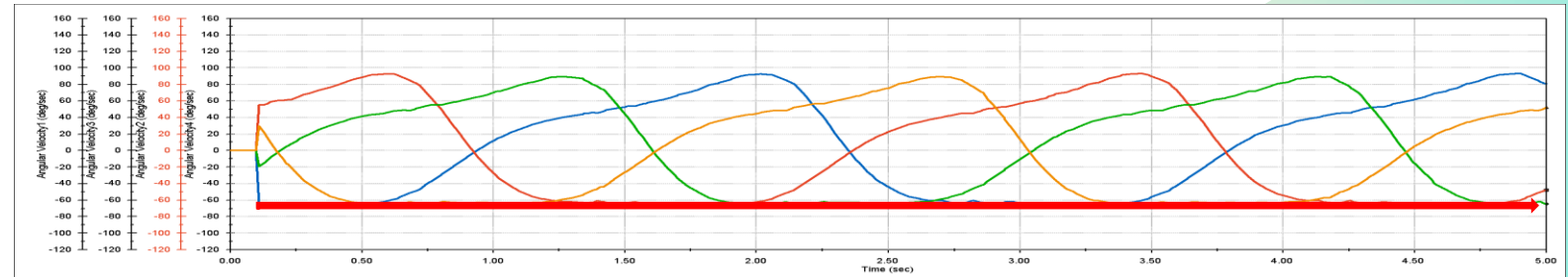
Improves on the original in several ways:

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

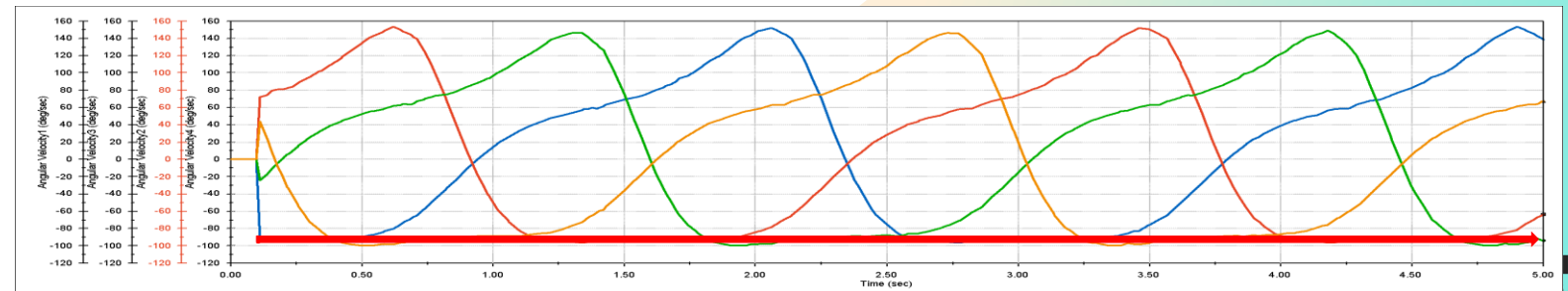
The use of a pair of **elliptical gears** allows for leveling off the ratio oscillations at any speed.



Lowest ratio

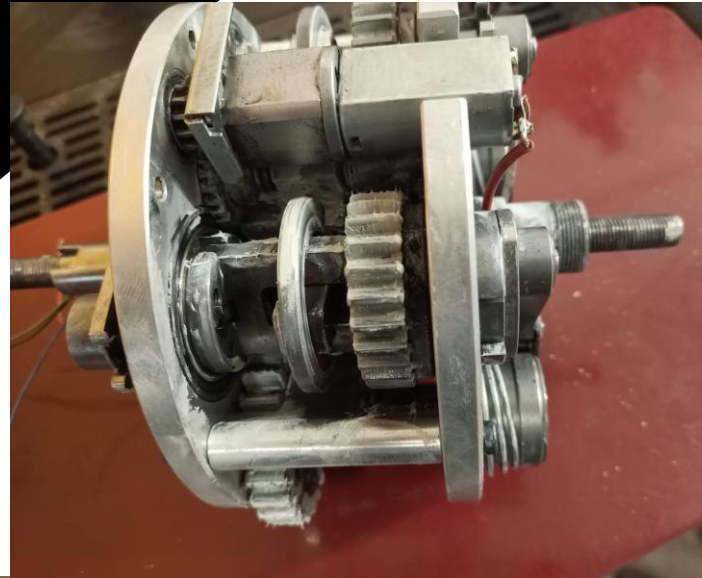


Intermediate ratio



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.



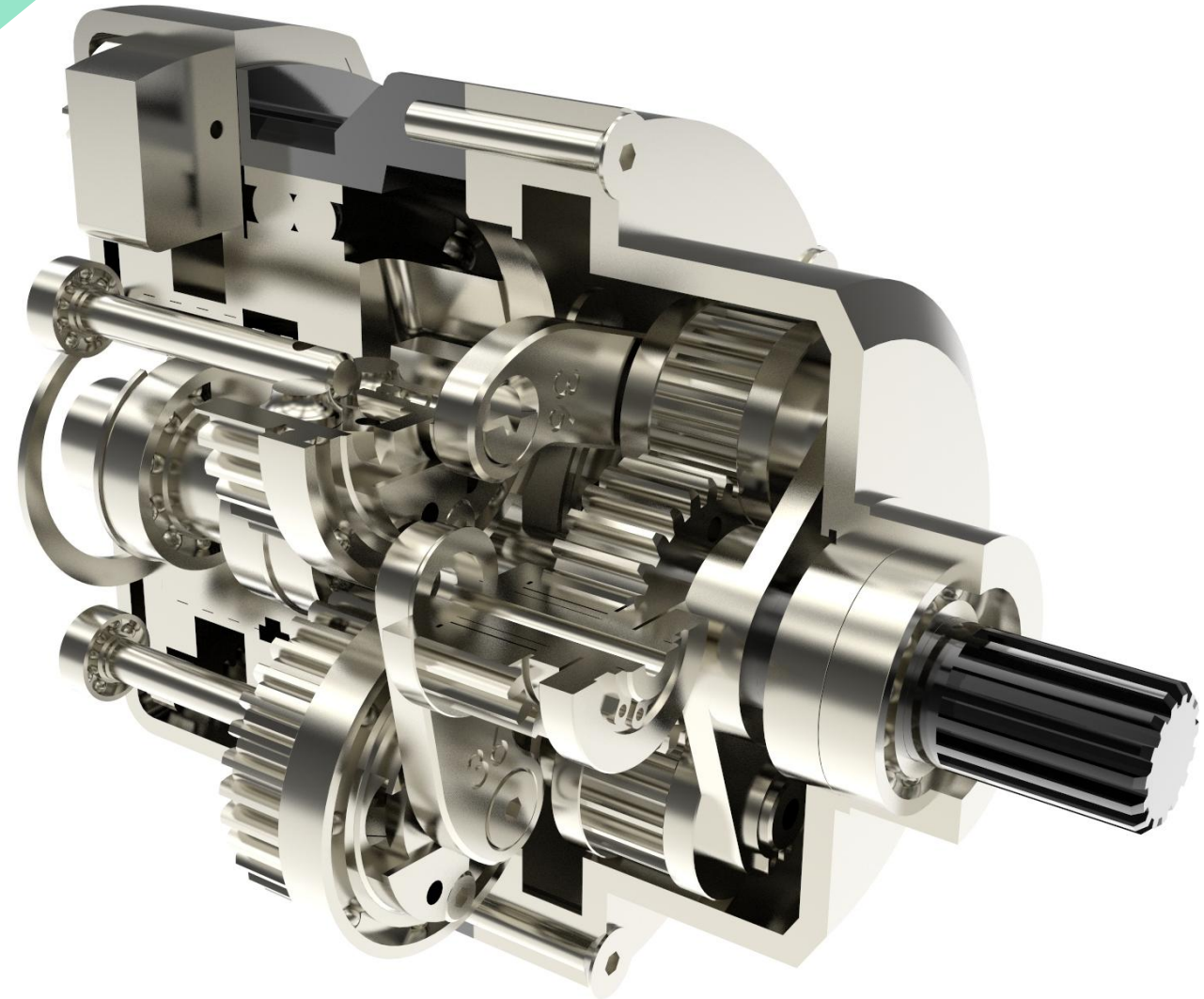
Where we are

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

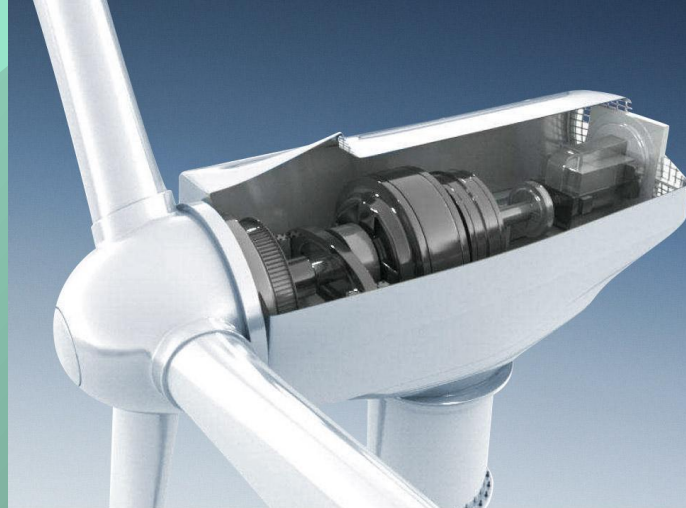


TRANSMISSION TYPE	RANGE
Bike derailleur, 1x12	550%
Car epicyclic MT, 6 gears	530%
CVT belt	400%
CVT toroidal	350%
Ratio Zero	550% (∞)

The pluses

4

High torque:
Use cases



Ratiores
transmission

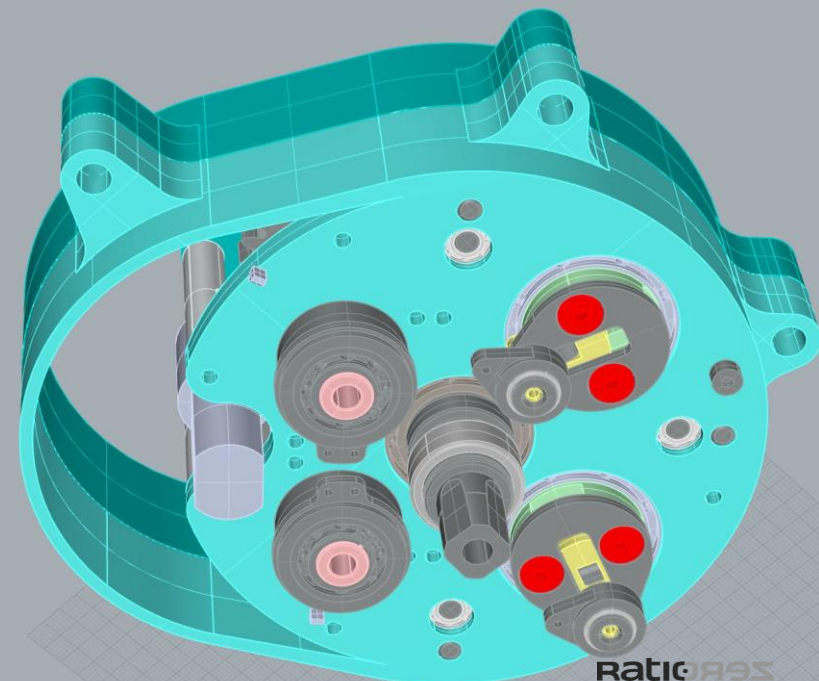
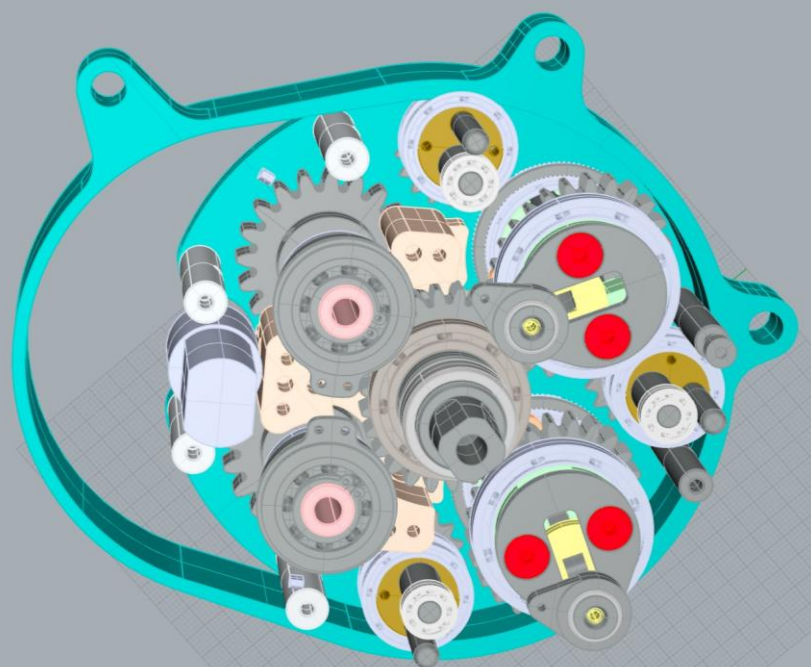
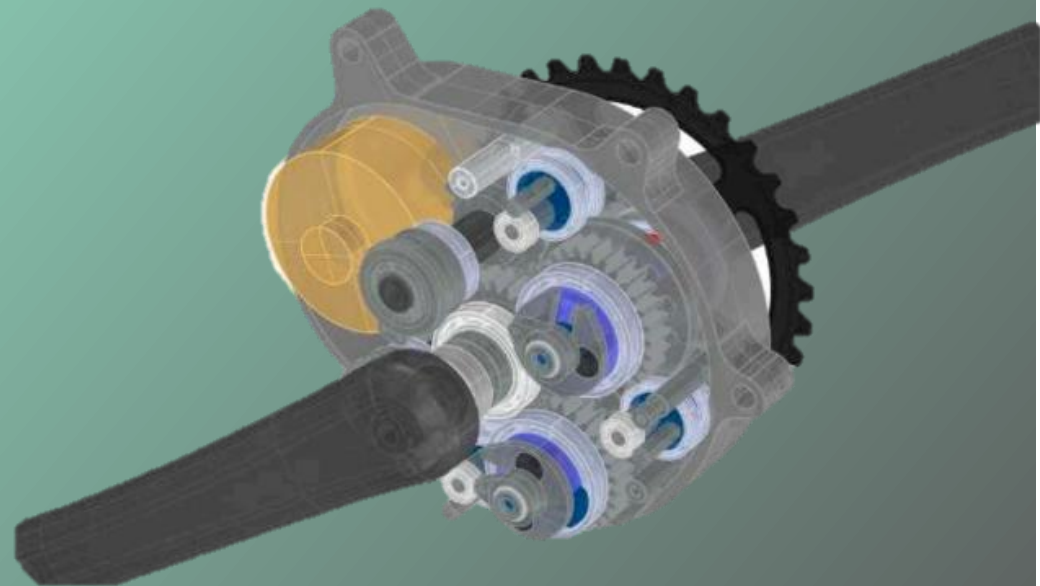
The pluses

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

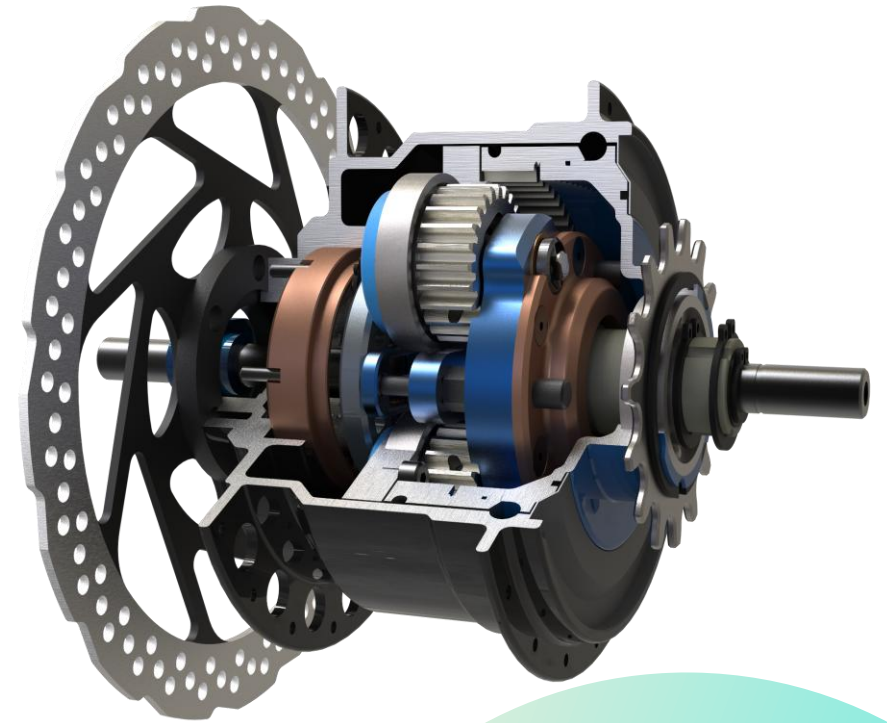


Guglielmo Amorelli
Mechanical and Systems
Engineer with 10 years
experience in Formula 1



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)

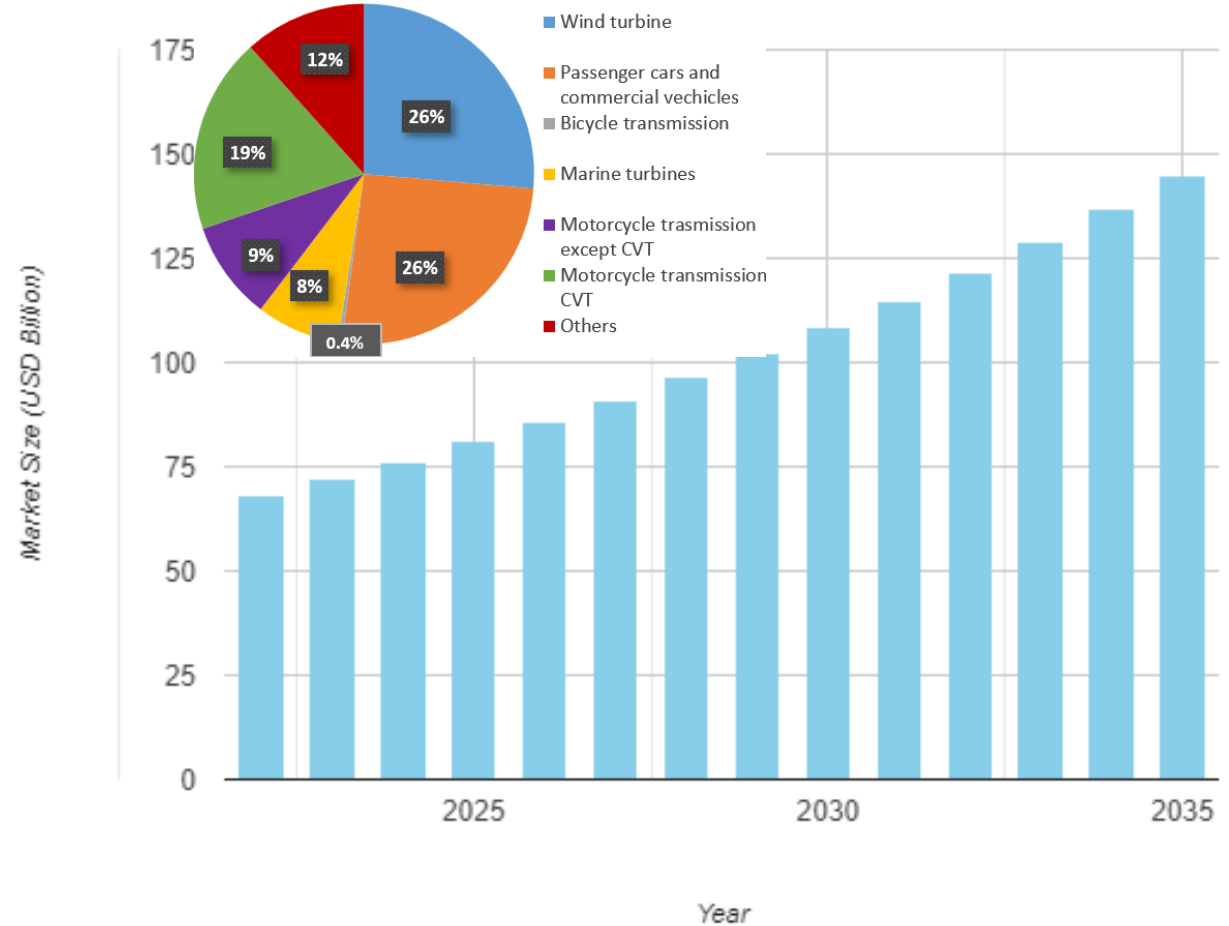
of which CVTs represent roughly 2/3rd (hence **\$16 B**) and growing (Fortune Business Insights Report ID: FBI101893)

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

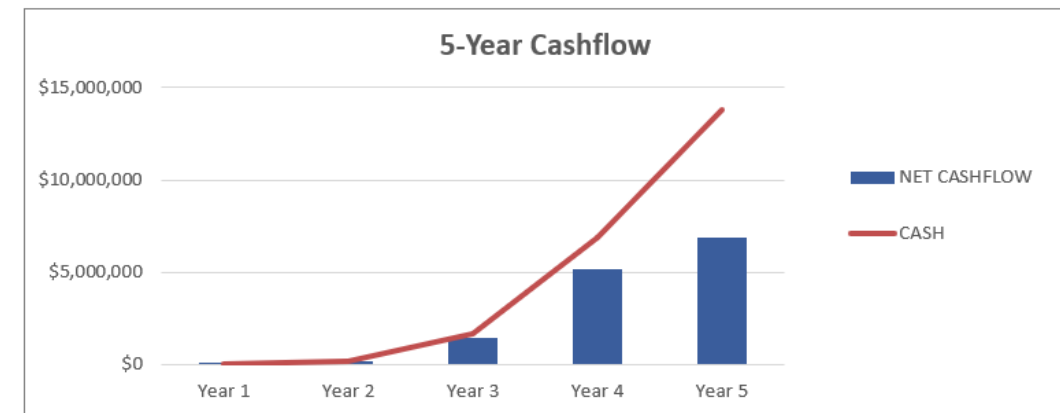
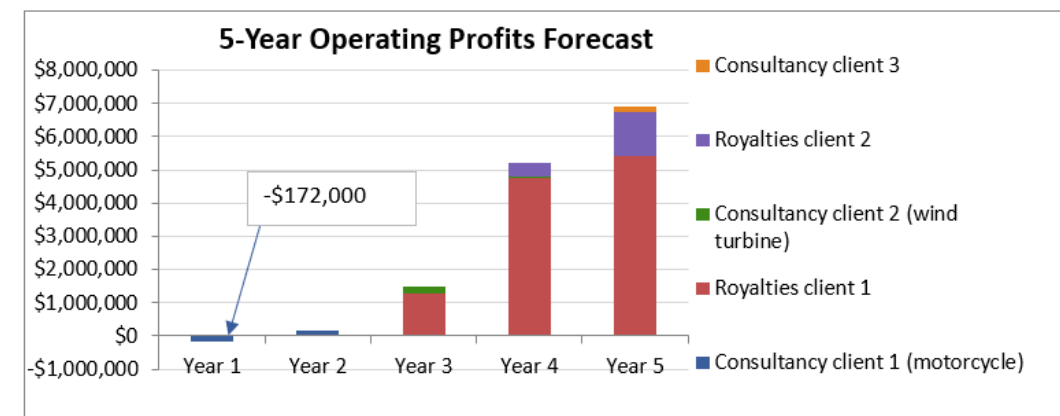
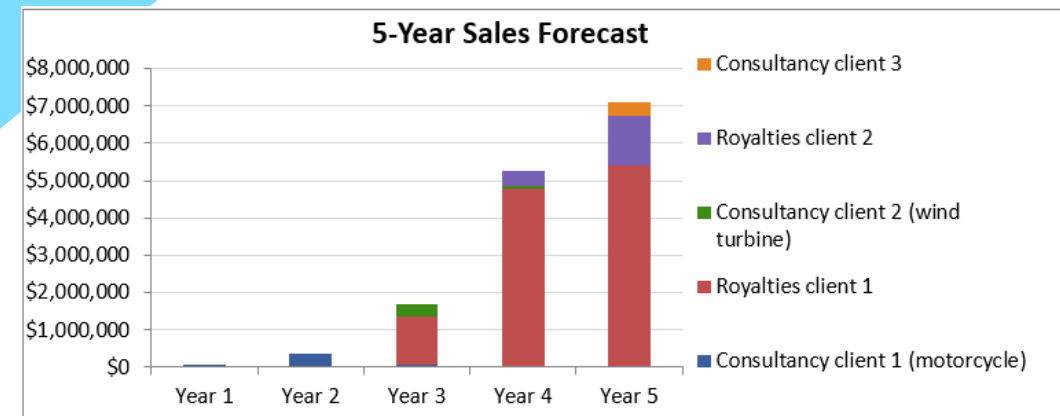


Assumptions: 1% (3.4k) of the Italian market reached in the 2nd year; 5% (16.9k) in the 3rd year



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

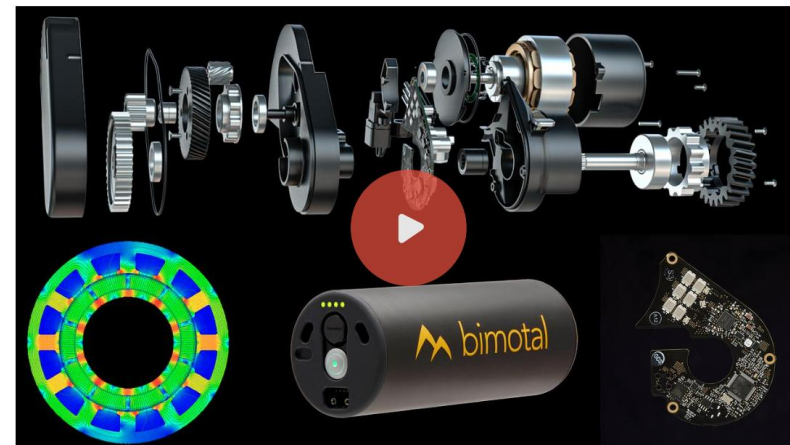
Ordine minimo 499,77 €

Pre-Money 4,40Min €

BIMOTAL INC.

Condividi

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



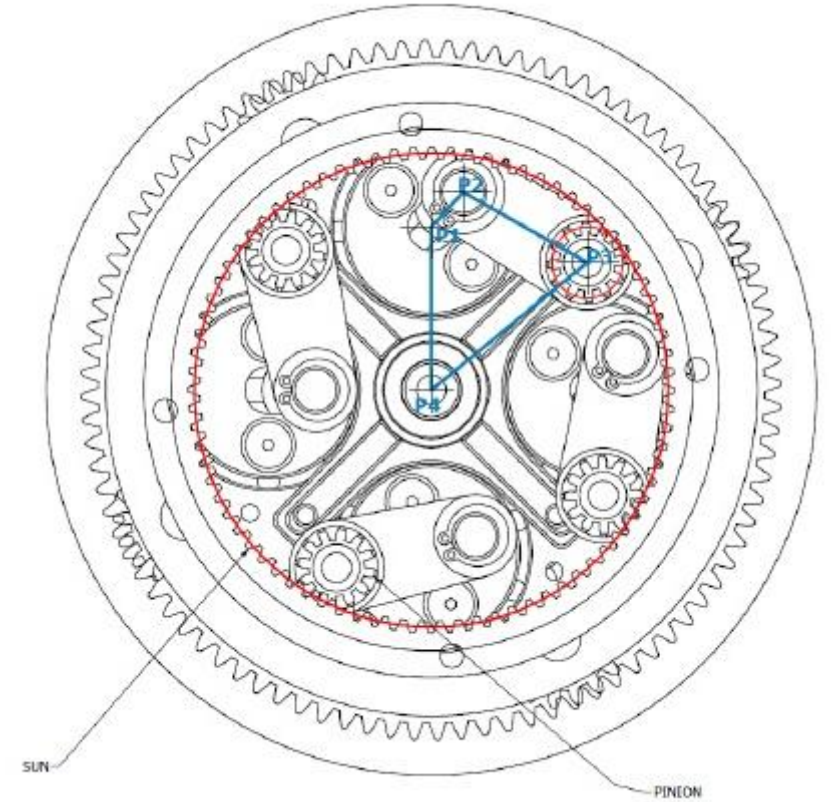
Ultimo finanziamento
gennaio 2024

512.150 \$
raised from 223 investors

SEGUI

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

Albert Einstein



RATIO99
transmission

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RZT-equipped bikes
yourself!**

More info:

www.ratiozero.com



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