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AEAi ASSOCIATION OF ENGINEERS, ARCHITECTS AND GRADUATES IN TECHNOLOGICAL SCIENCES IN ISRAEL

I-FEVS

Automotive Photonics Israel
16, February 2021, Virtual Event

Addressing low-cost sensing platforms for autonomous vehicles

Pietro Perlo, Interactive Fully Electrical Vehicles, I-FEVS Manufacturing, Haifa-Israel and La Loggia-Italy
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Abstract

Aiming at future sensing suites for affordable high performing fully autonomous vehicles, rather than using expensive and high computational demanding sensing suites based on a multitude of cameras, lidars and radars, we propose road-air-water vehicles to be equipped with “system-eyes”. The “system-eyes” like in every animal head are capable to rotate and are also capable to see in the infrared spectrum. Each eye has a pre-processing capability and is adapting to the illumination of the environment. Every couple of “system-eyes” has an associated local AI brain with adaptive learning and is connected to a low-cost central computational power unit that controls the actuators driving the vehicle.

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Organizer's suggested Outline

i. Description of your entity, its business/research, strength, and reputation --> Potential of success in collaborating with you and in marketing your products.
ii. The next goals & directions of development of your company --> It may stimulate others that have complementary capabilities, which are required in the direction of this development.
iii. Emphasize the feasibility of these directions of development & the market potential --> to increase the willingness to collaborate with you.
iv. The schedule and investment needed for the above developments --> Provides vital information for those interested in collaborating with you.
v. A concise summary of the main topics above --> for assimilation of the main points.
vi. Contact details and notice of when & where you are available for inquiries --> Strike while the iron is hot.

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Interactive Fully Electric Vehicles '**I-FEVS**'

- Set up in 2011 by Pietro Perlo, former Senior Director at Centro Ricerche Fiat
- Focused on Innovative Manufacturing Approaches of Safe, Efficient and Affordable Electric Vehicles
- Owner of **138 granted patents** covering all critical building blocks of electric vehicles
- Collaborating with over 150 R&D and World Leading Manufacturing Institutions
- Initiator of several EU projects related to Electric Mobility (9 on-going)

Business Model based on the collaboration with national entities and the production through microfactories

Current manufacturing in Italy, soon large scale manufacturing in other countries.

Strongly motivated to start a **Manufacturing Hub of Highly Innovative Electric Vehicles in Israel**

1.5T$

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I-FEVS: Towards low cost autonomous vehicles

Current vehicles 2020

Low cost L4 2024

EU project TELL Grant Agreement **824254**
EU project Multimoby Grant Agreement **101006953**.

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The need of a multifunctional sensing suite

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Sensor fusion solution to be used in future Poor Good Fair

	Camera	Radar	LiDAR	Ultrasonic	LiDAR+Radar +Camera
Object detection	Fair	Good	Good	Good	Good
Object classification	Good	Poor	Fair	Poor	Good
Distance estimation	Fair	Good	Good	Good	Good
Object edge precision	Good	Poor	Good	Good	Good
Lane tracking	Good	Poor	Poor	Poor	Good
Range of visibility	Fair	Good	Fair	Poor	Good
Funtionality in bad weather	Poor	Good	Fair	Good	Good
Funtionality in poor lighting	Fair	Good	Good	Good	Good
Availability for OEM deployment	YES	YES	2020/21	YES	

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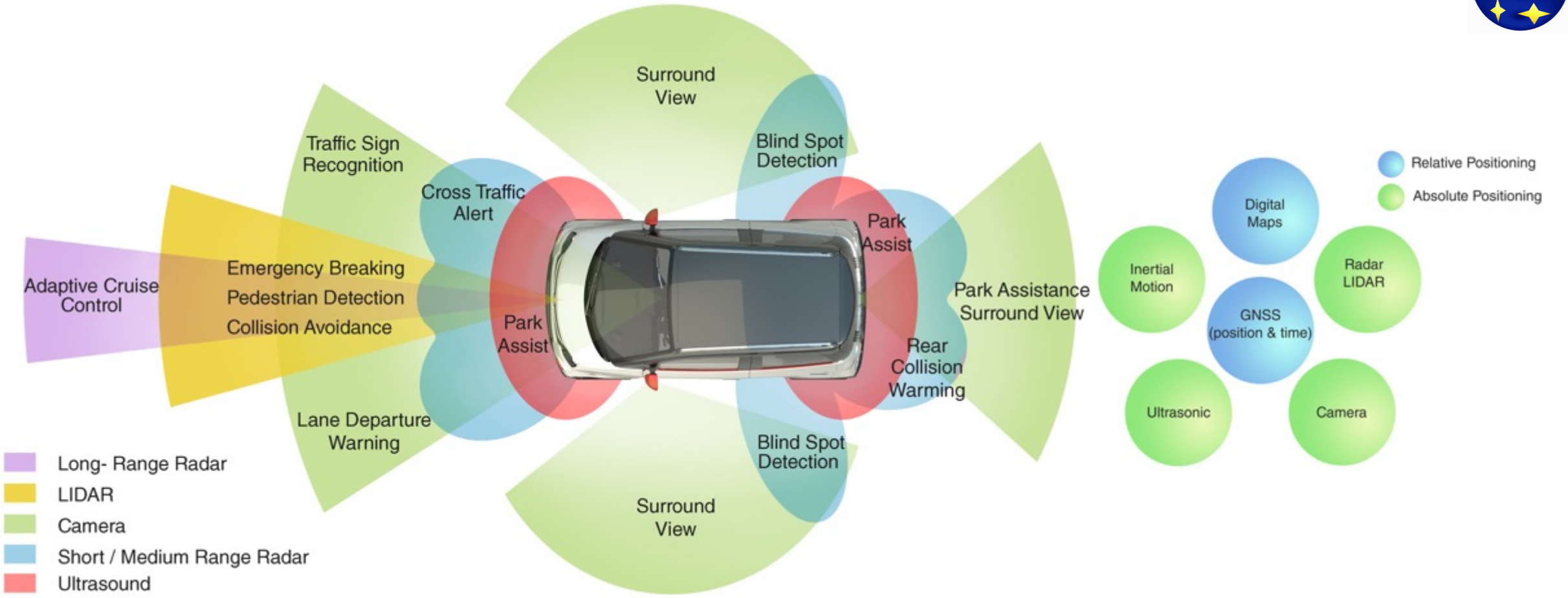
Typical sensor suite utilized in a level 4 AV: scaring level of complexity



- Lidars, Radars, Inertial Motion units IMUs, Ultrasonic US, are all relative.
- Cameras combined with maps can help Navigation in mapped areas at Level 3.
- Level 4 autonomy cannot be achieved without GNSS.

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Typical sensor suite utilized in a level 4 AV: scaring level of complexity

Most adopted approaches use sensing suite with Lidars, Radars…

Lidars and Radars follow the postulation of the **extramission theory** (rays of light emitted from the eyes) endorsed by Empedocles, Plato, Euclid, Galen.. originated in the fifth century BC and continued until Alhazen's modern explanation of vision in 965AC.
Sensing suites with 20 and more sensors are typical: complexity, high computation, cost,…

Need to introduce an alternative and 'more modern way of thinking' to:

- ❑ Reduced overall complexity,
- ❑ Reduced computational efforts,
- ❑ Increase performance,
- ❑ Reduce cost,
- ❑ Simplify installation.

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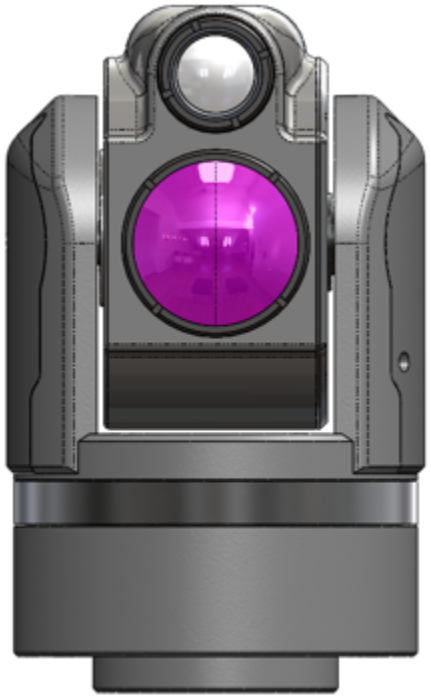
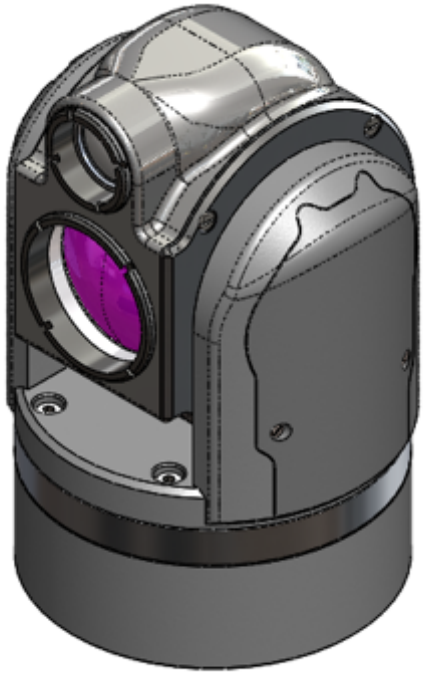
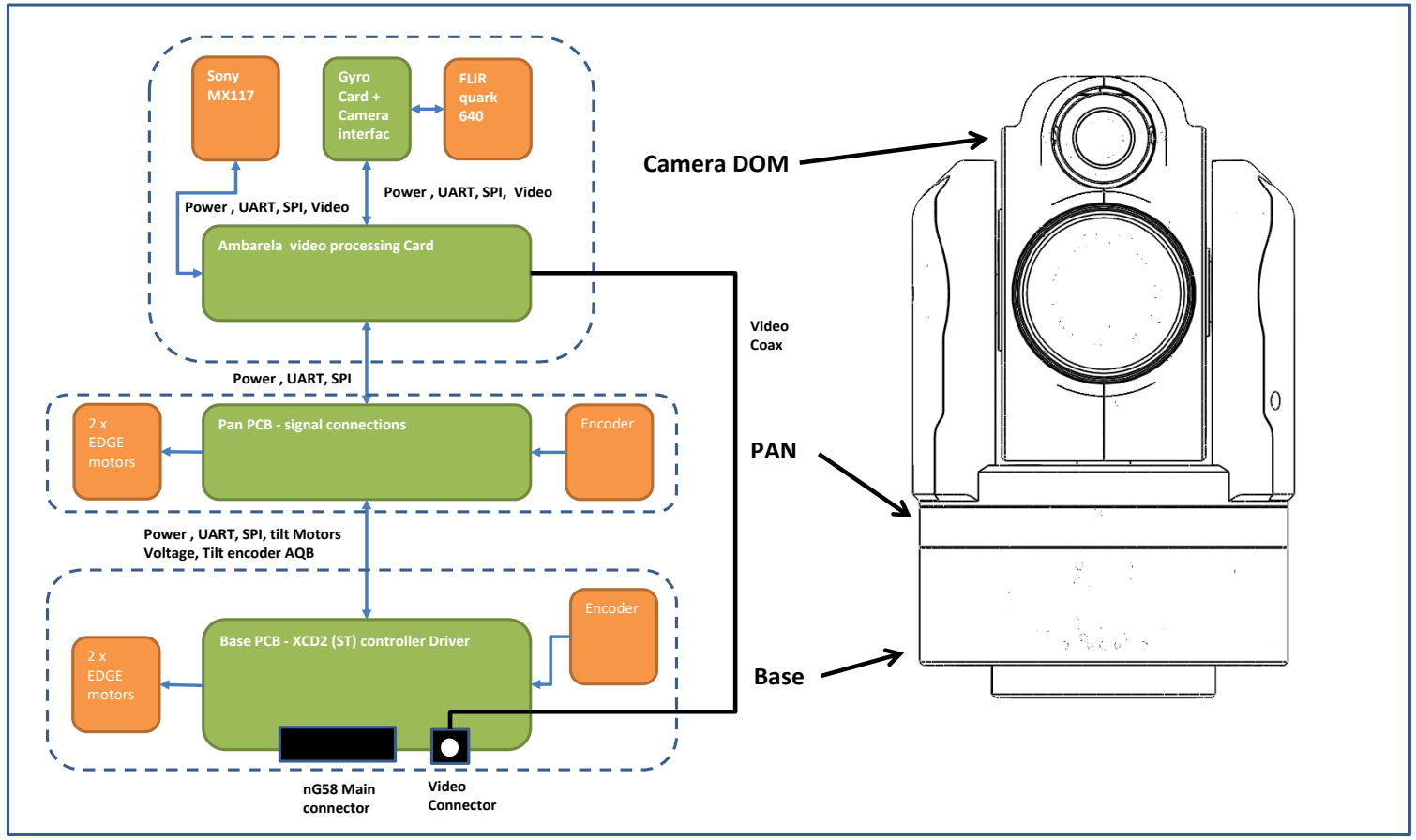
The Velox Alternative

NANO's Velox: 58 mm, 190 gram, 70µRad angular stabilization, Vis and IR







Complementarity foreseen in: **IR sensors and in edge AI**

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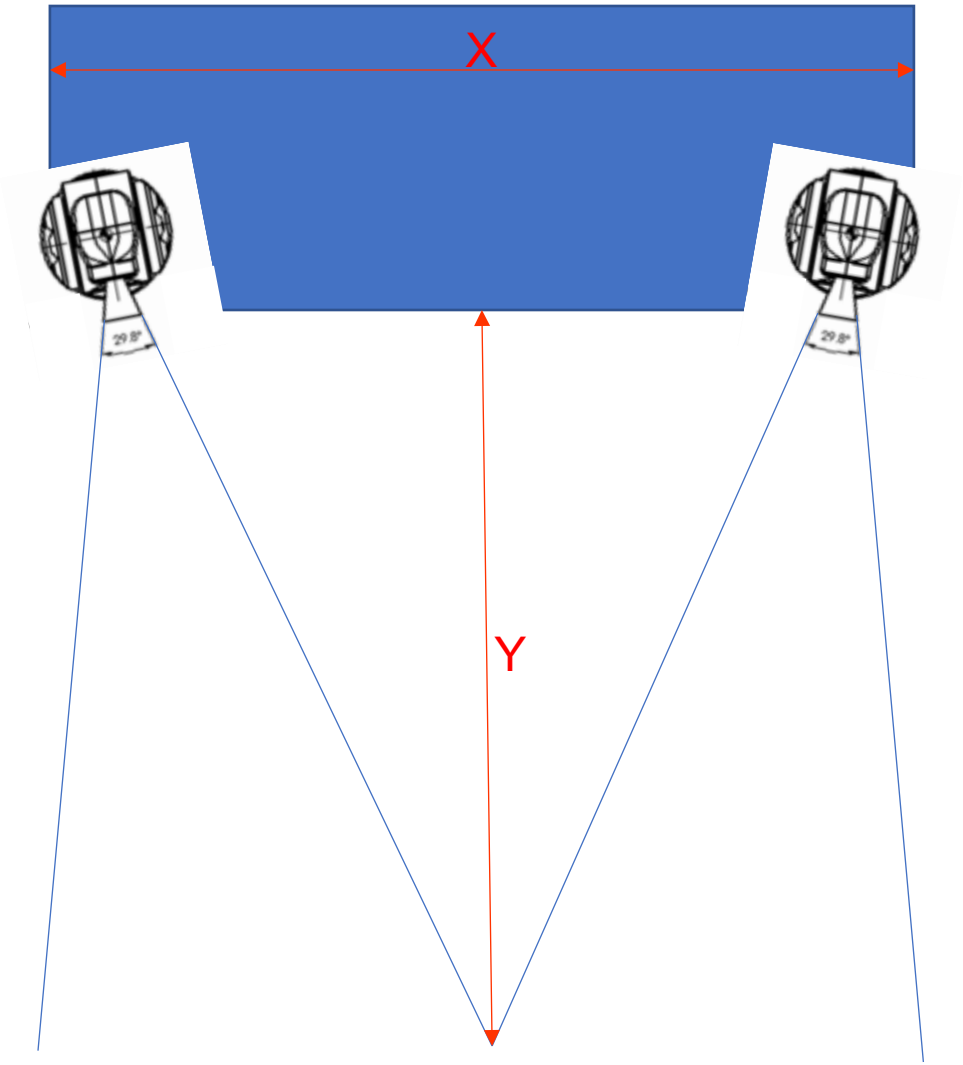
Gimbal Product spec (Current proven gimbal)

Parameter	Parameter	Day Camera	IR Camera
Camera	Type	SONY 4024x3036, 1.55µm	LWIR 640x480 17µm
	HFOV/VFOV/iFOV	29º/22º to 4.8°/3.7° (x6 zoom) 129µrad	18°/14° 0.5mrad
Performance	Field of Regard	Tilt: +110° to -30° Pan : ± 175° / optional nx360	
	Encoder Resolution	43 µrad (optional 21µrad)	
	Stabilization Error	80 µrad rms @ 100ms, dist. 1.5rad/sec, 1-15Hz, θ<0.25rad	
	Gyro bias	< 5°/min	
	Angular Velocity	150°/sec	
	Sensors	Temp; 2 axis gyro, encoder (angle)	
Communication & Video	Communication	RS232 (RS422 optional) / SPI (future)	
	Video	FHD	640x480 Digital
Dimensions	Diameter	58 mm	
	Height	91 mm	
	Weight:	190 gr	
Electronics	Operating voltage	Nominal 7.8 VDC , range 7.5-28V	
	Power consumption	5.5-6.5W Typ , Max 10W	
	Electronic circuit	Nanomotion XCD2	
Environment	Audible Noise	MIL STD 810 Level 2, undetected from 10m,	
	Shock	20g, 5ms	
	Vibrations	5grms 20-2000Hz	
	Operational Temp	-10 °C to 40 °C	
Standards	Sealing	Sealing-IP64	
	Standards	MIL-STD- 810, MIL-STD-461C	

Gimbals on Vehicle top view



- Present: With ~30º FOV and gimbals slightly turned toward the center: X ≈ Y
- While for 3D the gimbals intuitively should be bore-sighted, due to the high angular accuracy the 3D information can be retrieved also when looking inwards
- Panorama function and optimized lens FOV can cover near and far objects

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Overall sensing capabilities achievable by using a suite of miniature NANO gimbals

NANO sensing Suite based on NanoPop Gimbals	Level of performance Poor, Good, Fair, Excellent	Comments
Object detection	Good	Human recognition at 900m
Object classification	Good	Human classification at 400m
Distance estimation	Good	Using parallax
Object edge precision	Good	
Lane tracking	Good image quality	Further image processing required combination with the dynamic optical Tag to be implemented
Range of visibility	Good	Dual thermal and day sensor
Functionality in bad weather	Fair	Current gimbals are not sealed.
Functionality under poor lighting	Good	With thermal sensor
GPS functionality	Fair, offers redundancy to the conventional GPS	Needs to be combined to the on-board IMU and based on algorithms relying on the Optical Flow.
Protection against cyber attacks	Good	Passive. On host level
Robustness	Good	Qualified according to mil specs
Complexity of integration into vehicle	Good	
Required computational complexity to reach level 4	Good	Passive system, open for DL and other MV algorithms.
Overall cost	Fair	To be addressed as part of the commercialization roadmap. Saving cost installations also with respect to L1-L2-L3 ADAS functionalities.

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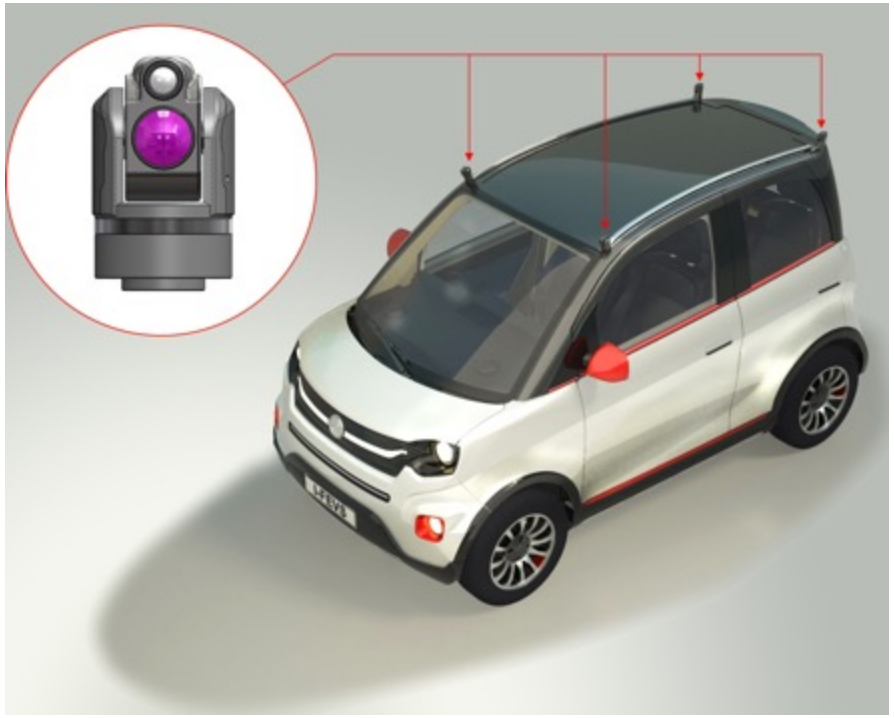
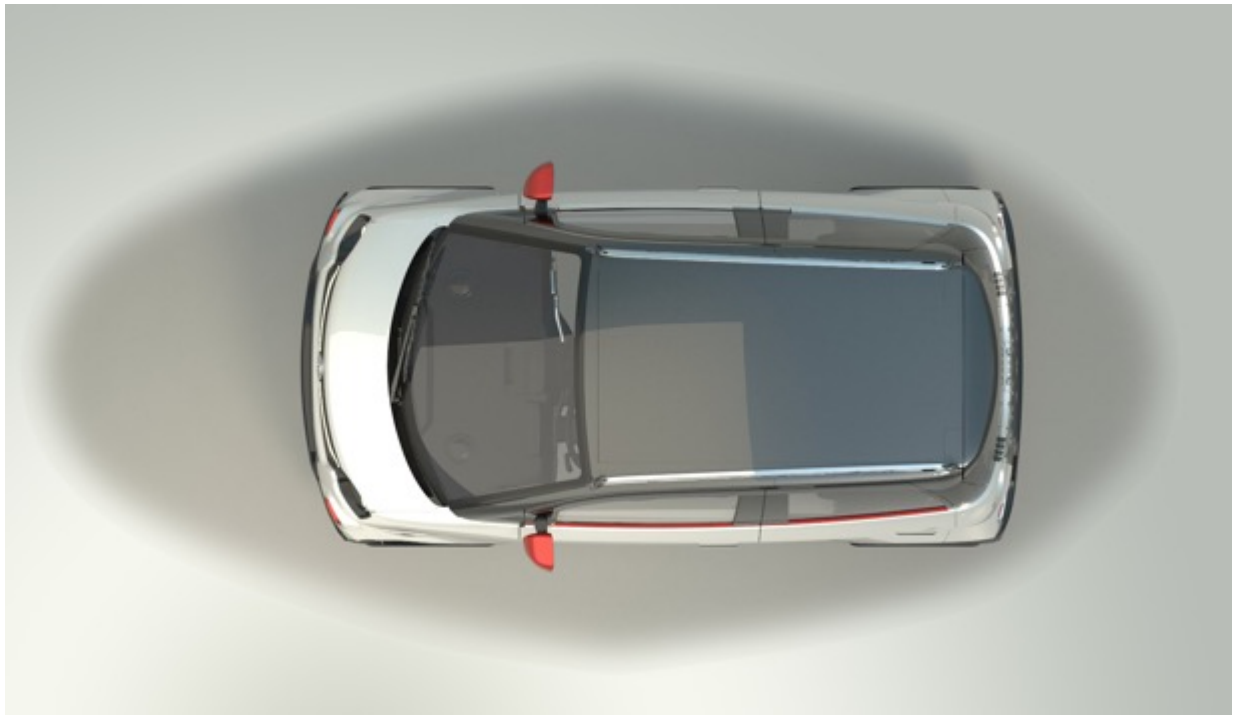
I-FEVS AVs: Typical sensing suite based on four gimbals with minimal footprint of invisibility gimbals

A specific in the cabin installation of the gimbals is possible.

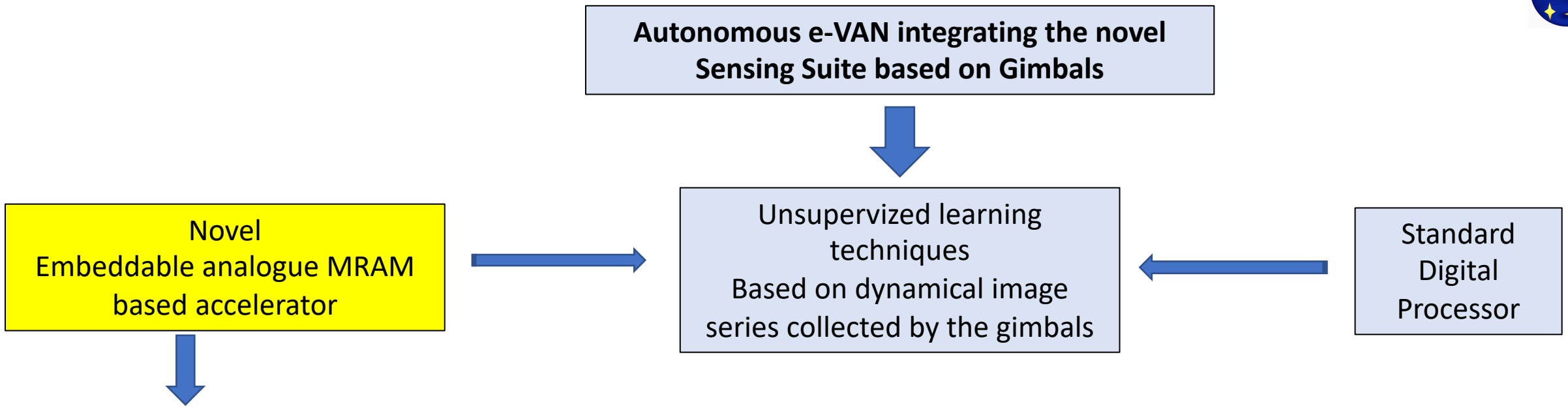




Motivation to adopt gimbals

Reduced overall complexity. Reduced computational efforts, high performance, lower cost, easy of installation.
The “system-eyes” like in every animal head are capable to rotate and are also capable to see in the infrared spectrum. Each eye has a pre-processing capability and is adapting to the illumination of the environment. Every couple of “system-eyes” has an associated local AI brain with adaptive learning and is connected to a low-cost central computational power unit that controls the actuators driving the vehicle.

Simplicity is the last sophistication: Leonardo da Vinci



Most of AI computing is *matrix multiplication* (time-consuming operation)
To get the best AI acceleration, we propose to use a mix of

- **binary neural networks (BNNs)** – simpler matrix multiplication
- **in-memory computing based on STT-MRAM** – performs matrix multiplications in analog way with the speed of electric current

That allows us to speed up calculations by an order of Flops and reduce energy consumption

Results:

1) embeddable MRAM-based AI accelerator chip design

2) testing a real MRAM crossbar with proprietary BNN algorithms

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Market potential/size

Various types of Lidars, Radars and multicameras systems operating in the VIS or IR bands will be offered to vehicle manufacturers as Plug and Use systems at rather affordable prices. The expectation is that there will not be a single winning technology but several possibile architectures competing on cost/performance. First ready to use systems are expected to enter the market from 2025 and widespread by 2030.

Road Vehicles: >30% L4 Autonomous 2030, mainstream 2040

Drones and PAVs: 2021-2030 decade of big change, robot taxi **1.5T$ by 2040** (Source Morgan Stanley). The Virginia-based Teal Group consulting firm predicts a total of $203 billion to be spent on drones over this decade.

Wheeled and Legged Indoor - outdoor Robots: most optimistic forecasts probably underestimating the reality.

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Summary

- Novel approach to Autonomous vehicles adopting a high performing low-cost sensing suite based on gimbals.
- Universal embeddable MRAM based AI processor: '10000 times faster than Intel i7'.
- Radical novel approach to Manufacturing of High performing and affordable urban electric vehicles
- Starting in Israel a manufacturing innovation hub for all type of future mobility. 50 vehicles a day starting production from 2022 aiming at becoming the producer of reference in the mediterranean area.
- High strategic value for Israel because of
  - The proposed high tech
  - The impact on CO_2 reduction
  - The impact on employment and local supply chain.

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THANK YOU

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