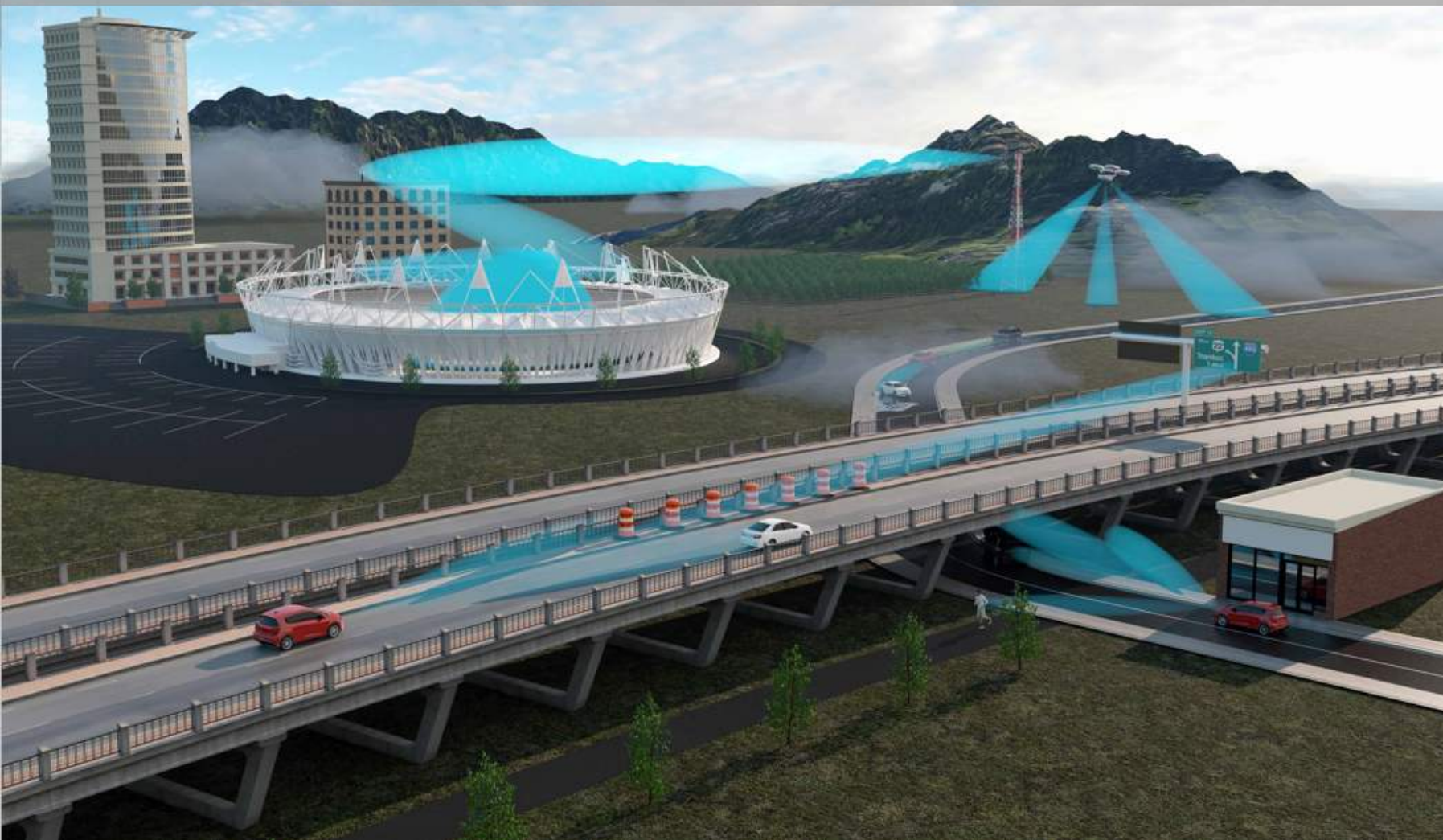




Future of Connected Autonomous Vehicles in Smart Cities



Maha Achour
Founder, CEO, CTO

maha@metawave.co

Outline

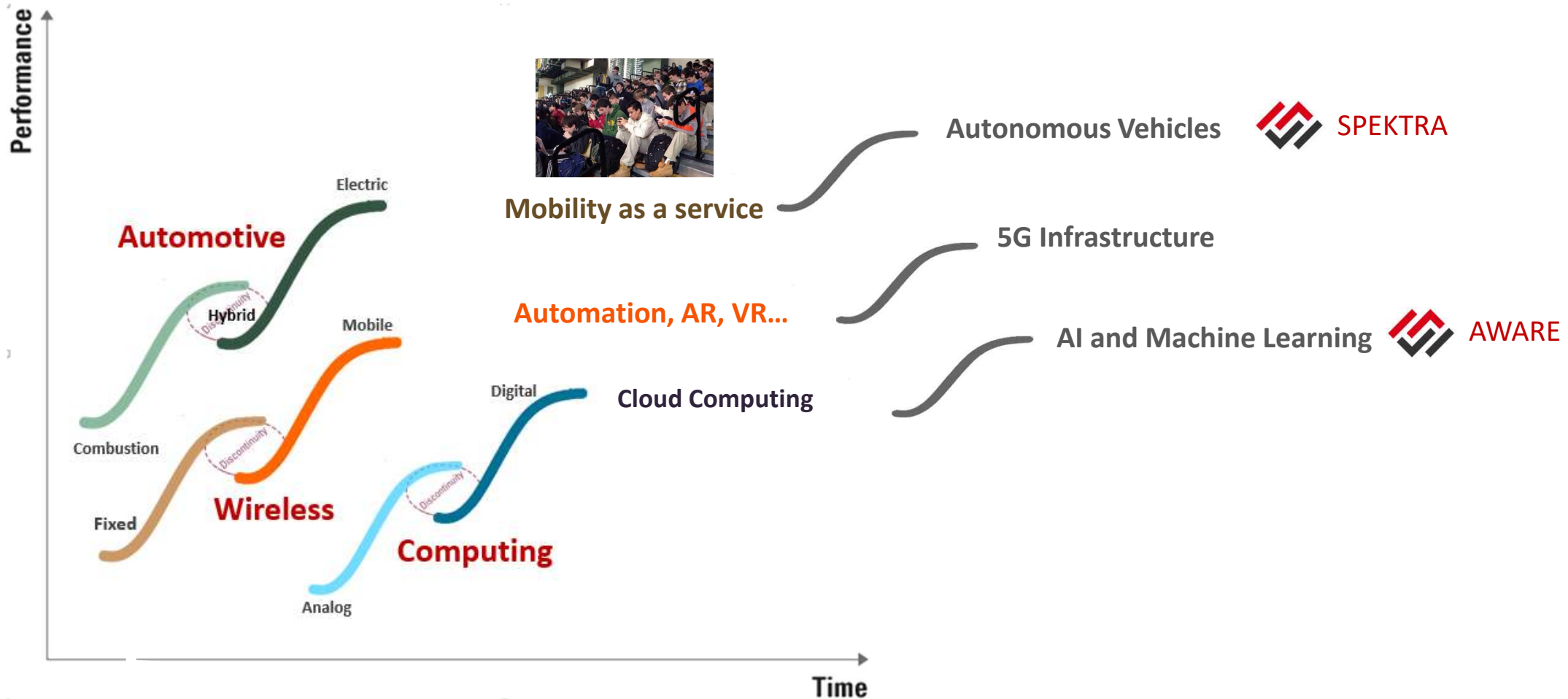
- › Automotive future is electrified, autonomous, shared, and connected
- › Role of 5G connectivity in mobility technology ecosystem
- › Connecting vehicles with transportation infrastructure (V2I)
- › Distributed edge compute versus centralized (V2X)
- › Seamless and transparent connectivity to riders during their journey
- › Next paradigm shifts: convergence between connectivity, mobility, and edge services/compute

Crossroad between e-Mobility and Connectivity

- Unlimited 5G capacity
- Secure, reliable, and low-latency connections
- Novel edge-services
- Mobility as a Service
- Delivery of Goods
- Autonomous Vehicles (AV)
- Ground and Air
- Consumer Experience
- Safety ratings



Riding Next Wave of Innovation and Disruption



ADAS/AV Safety Levels

- Driver-in-the-loop

OEM/Tier 1 must make sure driver can respond
Liability on Driver

- Driver-out-of-the-loop

Liability is on the OEM/Tier 1 and Mobility as
Service Provider

- L0 – L3 are all driver-in-the-loop



- L4 – L5 are driver-out-of-the-loop



SAE J3016™ LEVELS OF DRIVING AUTOMATION					
SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
<p>You <u>are</u> driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering</p>			<p>You <u>are not</u> driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”</p>		
<p>You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety</p>			<p>When the feature requests, you must drive</p>	<p>These automated driving features will not require you to take over driving</p>	

What does the human in the driver's seat have to do?

The EV factor and Power Consumption

- Waymo and CRUISE use more sensors
- L2 vs future Robo-taxi L4
- ADAS architectures will evolve with advanced imaging radars capabilities
- Today is all about safety, tomorrow will be about power consumption and lower pricing..

	Camera	Long Range RADAR (typically 77GHz)	Short & Mid Range RADAR (typically 24GHz)	Ultrasonics (48 kHz)	LIDAR CMOS < 1µm	LIDAR SWIR > 1µm
Object detection	●	●	●	●	●	●
Object classification	●	●	●	●	●	●
Environment analysis	●	●	●	● (near)	●	●
Distance estimation	●	●	●	● (near)	●	●
Speed measurement	●	●	●	●	●	●
Object edge precision	●	●	●	●	●	●
Lane tracking	●	●	●	●	●	●
Range of visibility	●	●	●	●	●	●
Operation in bad weather	●	●	●	●	●	●
Operation in poor light conditions	●	●	●	●	●	●
Operation in dark	●	●	●	●	●	●

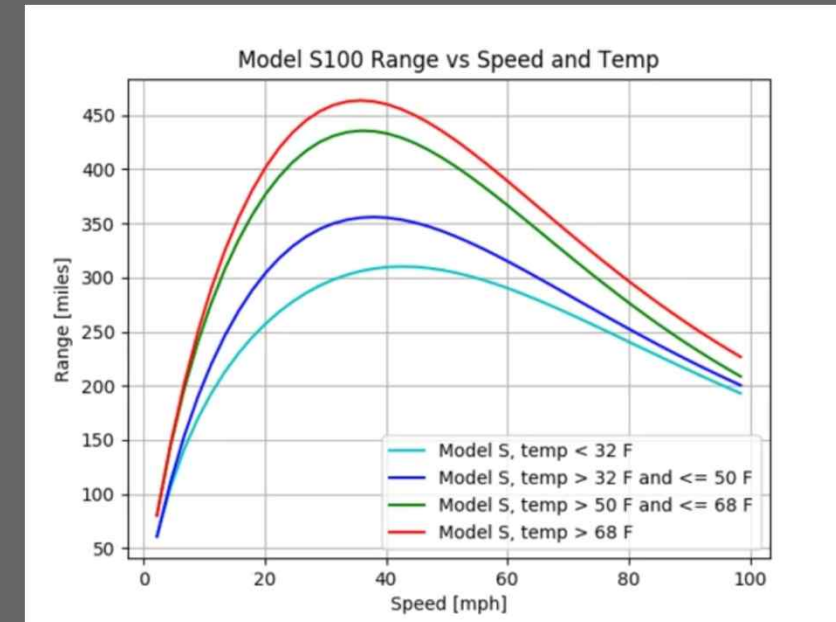
	Cameras	LIDAR	RADAR
Tesla	8	0	1
Waymo	8	3	4
GM/Cruise	16	5	21

<https://www.eetindia.co.in/adas-best-ways-to-make-vehicles-see/>

The EV factor and Power Consumption

EV Car range is impacted by:

- Operating speed
- Outside temperature
- Driver in or out of the loop
- Tesla Model S range is reduced by 30% with Auto Pilot
- AI software stack can optimize EV range in L4



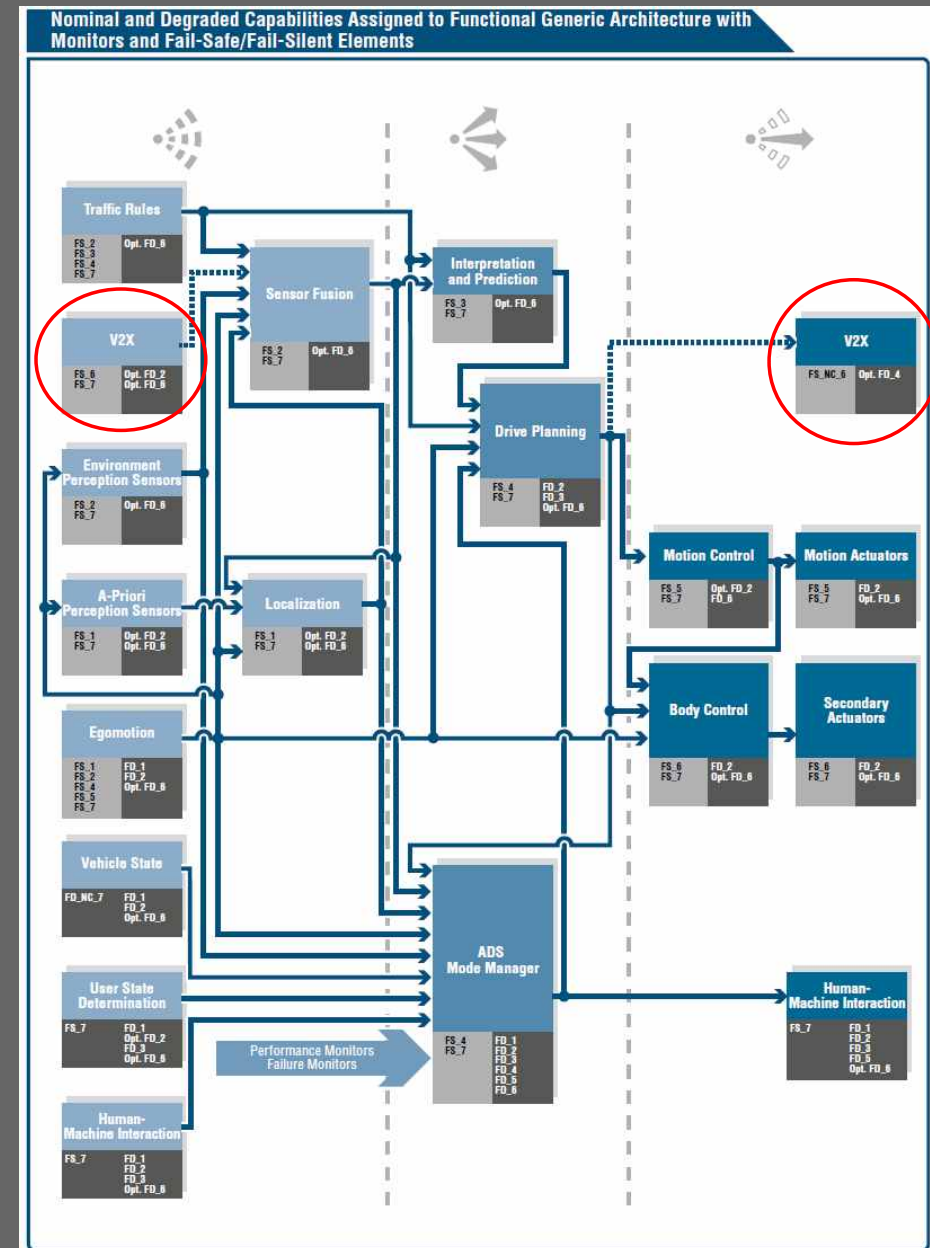
Connected Cars and Smart Roads

Open Loop Operation

- Example of open and closed loop system
- Dotted V2X lines are for Open Loop operation
- Human-machine interface is for Driver in the Loop

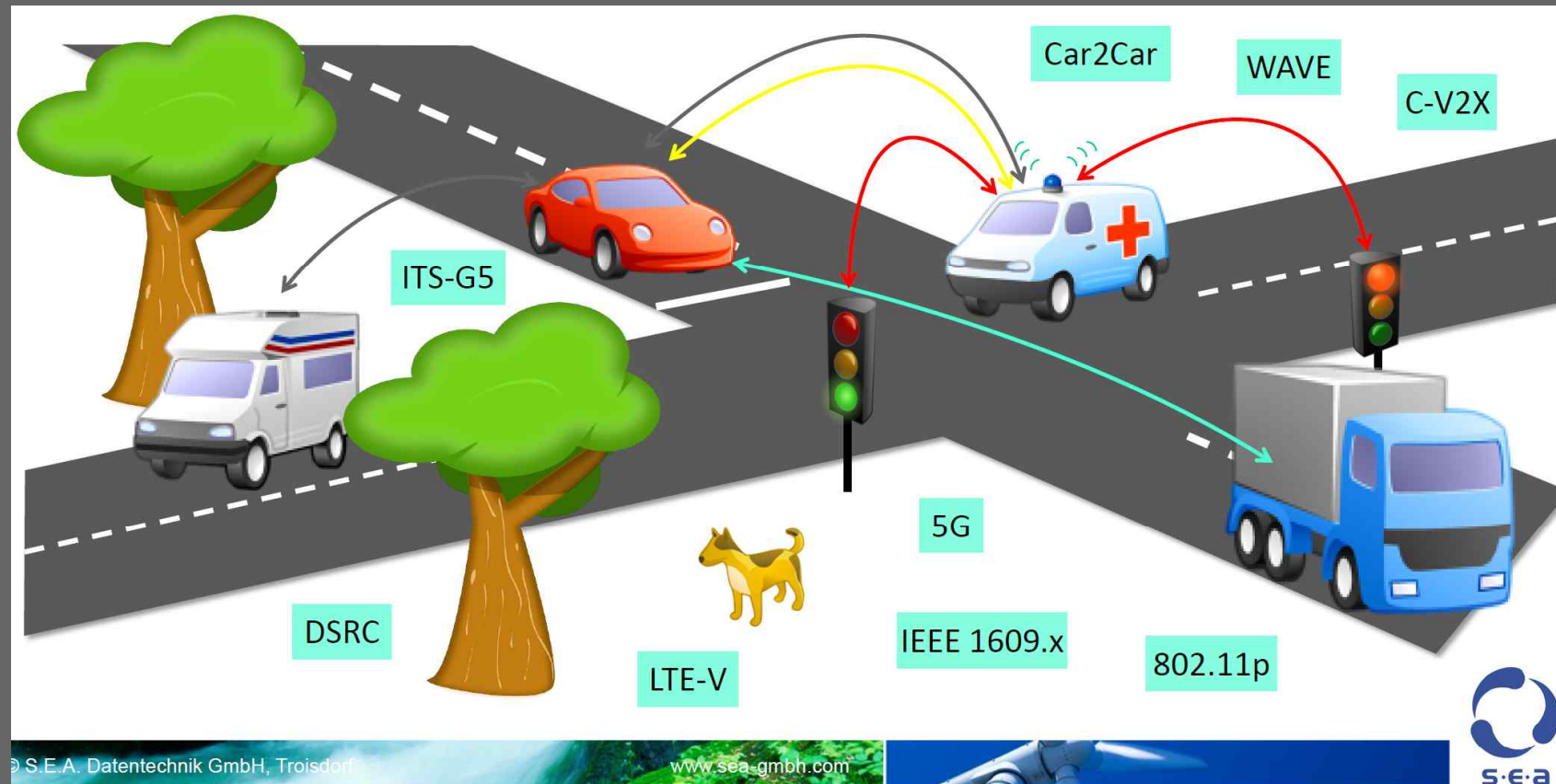
Term	Definition
HARDWARE-IN-THE-CLOSED-LOOP (HIL)	Target software is executed on target hardware, whereas the hardware outputs influence the hardware inputs.
HARDWARE REPROCESSING (OPEN LOOP)	Target software is executed on target hardware, whereas the hardware outputs do not influence the hardware inputs

<https://www.apiv.com/.../safety-first-for-automated-driving-apiv-white-paper.pdf>



Connected Cars and Smart Roads Open Loop Operation

- No security breach
- ADAS
- V2X
- V2V
- V2I

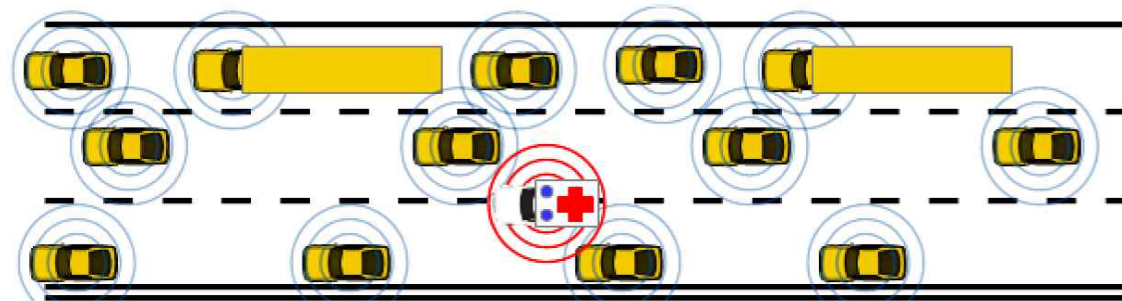


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www.sea-gmbh.com

Connected Cars and Smart Roads Open Loop Operation

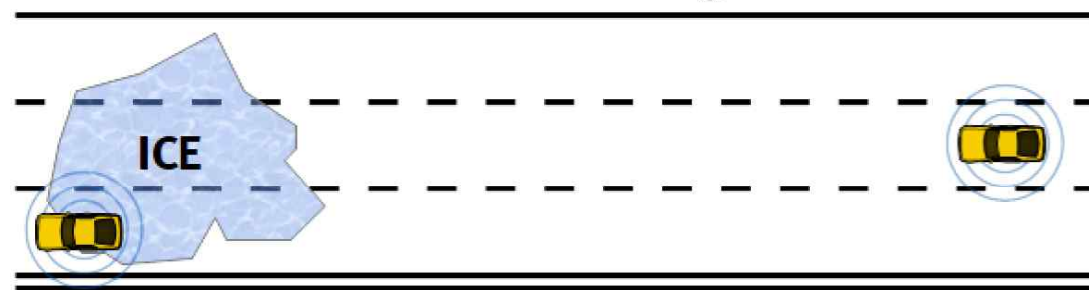
Priority/Emergency
Vehicles



Road Side Unit

Road Hazard Warning
(centralized/
decentralized)

Message types:
Road Condition (e.g. Ice)
Accident Ahead
In-Vehicle Signage
Roadway Weather
etc...

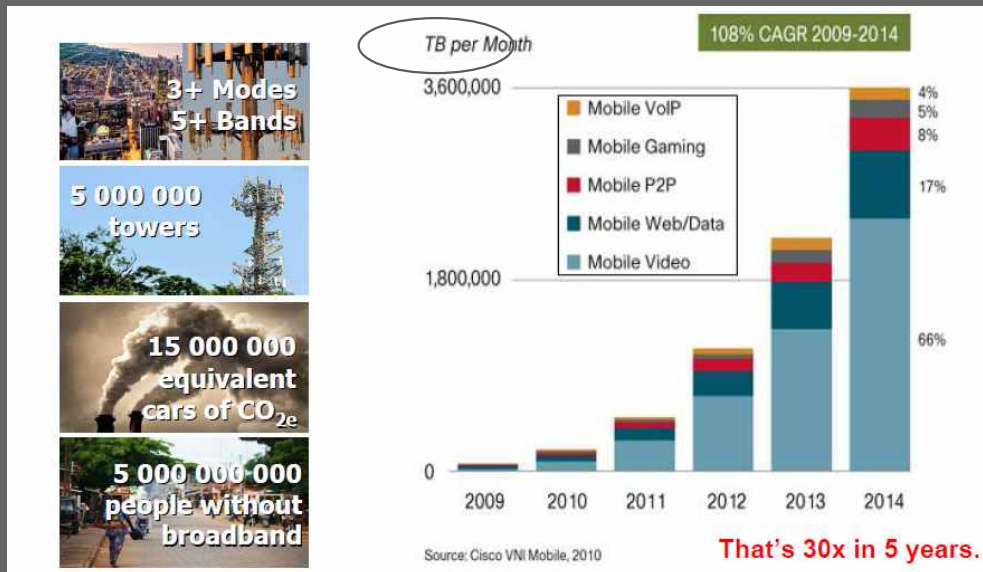


Road Sensor Station

- 5G Network Security
- 5G High Capacity
- 5G Low Latency

Global Warming Factor

Cisco VNI Mobile 2010



Not Counting Data Centers !

Cisco VNI Mobile 2015

Global IP Traffic by Local Access Technology

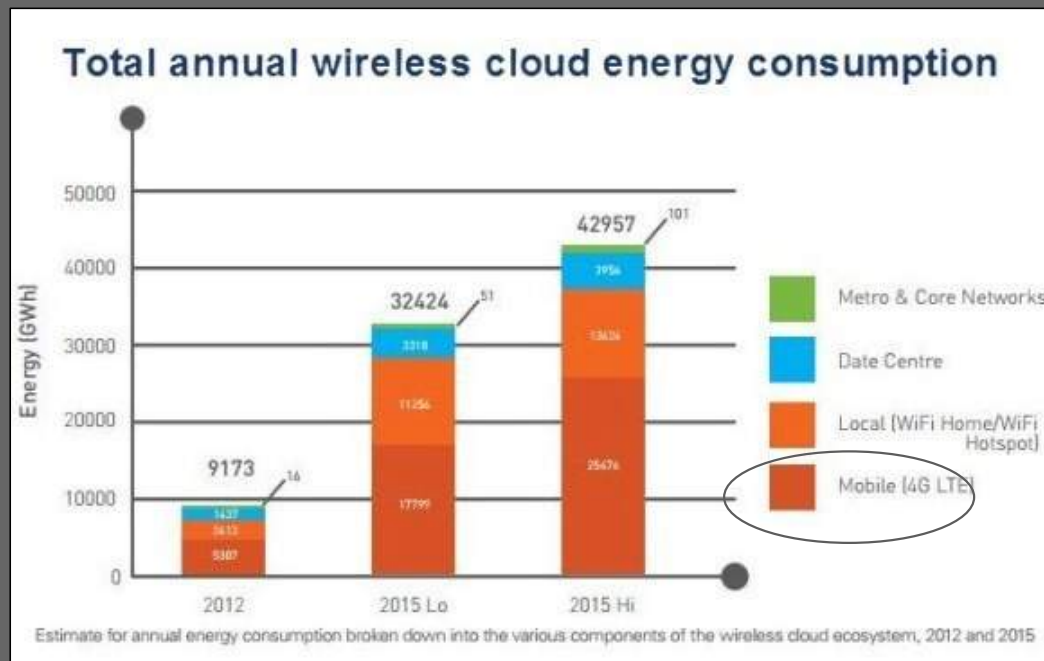
By 2019, Two-Thirds of Total IP Traffic Will Be Wireless*



1 Exabyte = 1,000,000 Terabyte (TB)

Wireless Networks Ecosystem

- Mobile Networks consumes most of energy
- 5G densification is 1,000x that of 4G LTE
- How can 5G infrastructure energy consumption be reduced?



Mobile Data Volume – 5G vs. 4G

10
—
TERABYTES / S /
SQ. KM²

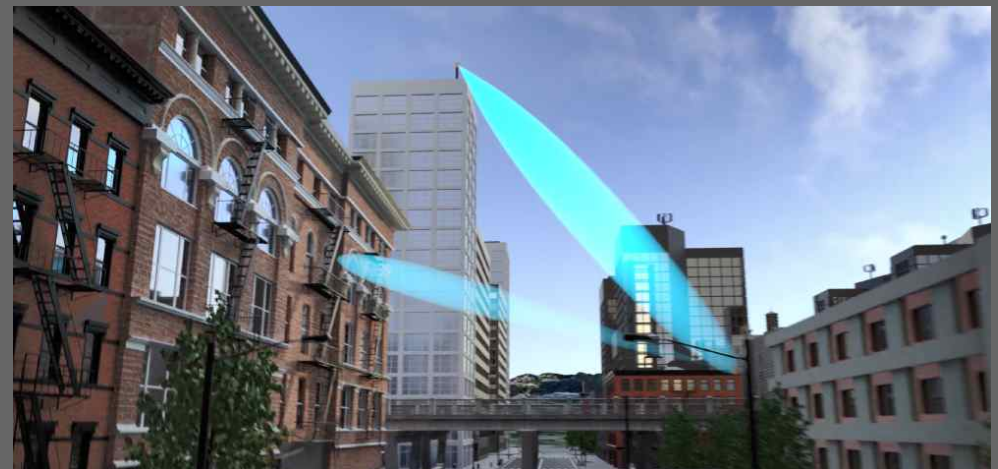
5G

1/100
—
TERABYTES / S /
SQ. KM²

4G

Metawave 5G Solutions

- ✓ Increasing Speed & Bandwidth
- ✓ Eliminating Indoor & Outdoor Dead zones
- ✓ Low Cost & Low Power Consumption
- ✓ Lightweight, Infrastructure-Light
- ✓ Enhanced Signal Amplification





Metawave is providing enhanced speed, bandwidth and connectivity through low cost, infrastructure-light deployments

Capabilities for Increased 5G Coverage:



High-Performance Passive Reflector

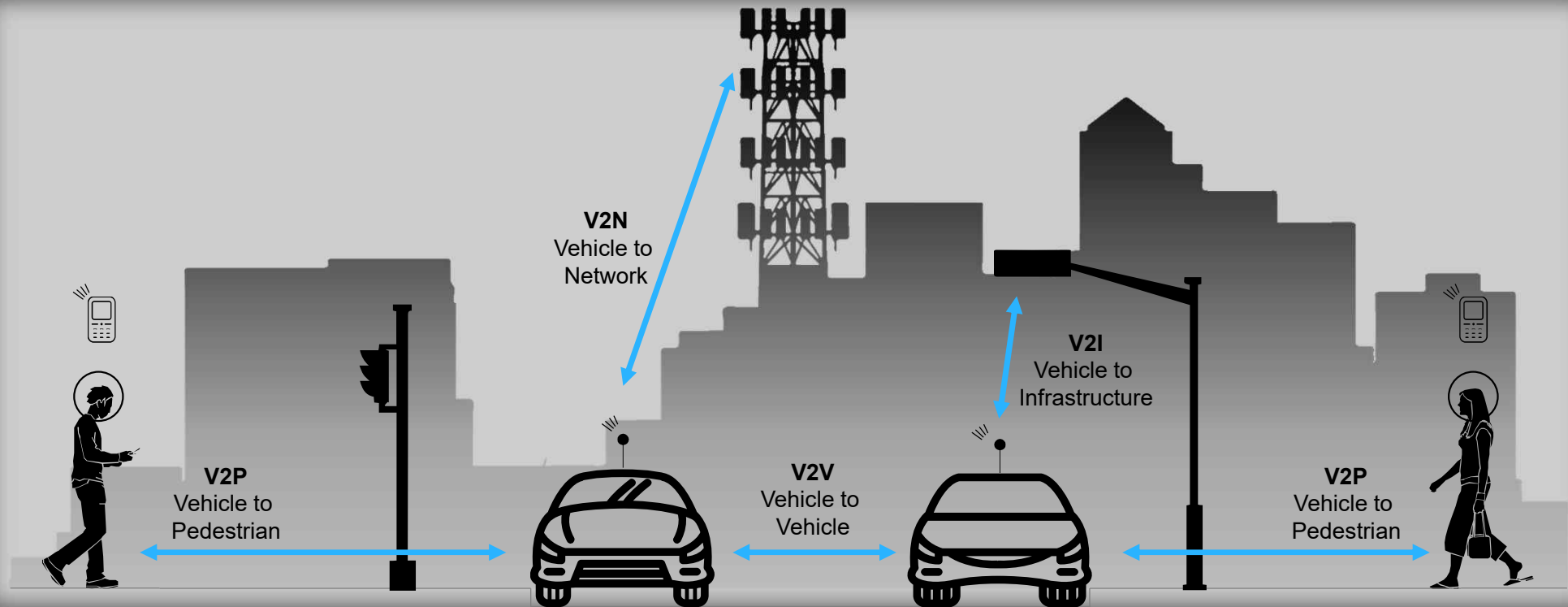
50m+ increased range



High-Performance Active Analog Repeater

250m+ increased range

5G Driving Massive New Opportunities Across Telecom Landscape



5G Offers New Use Cases



5G Lower Latency Applications Will Need Edge Cloud



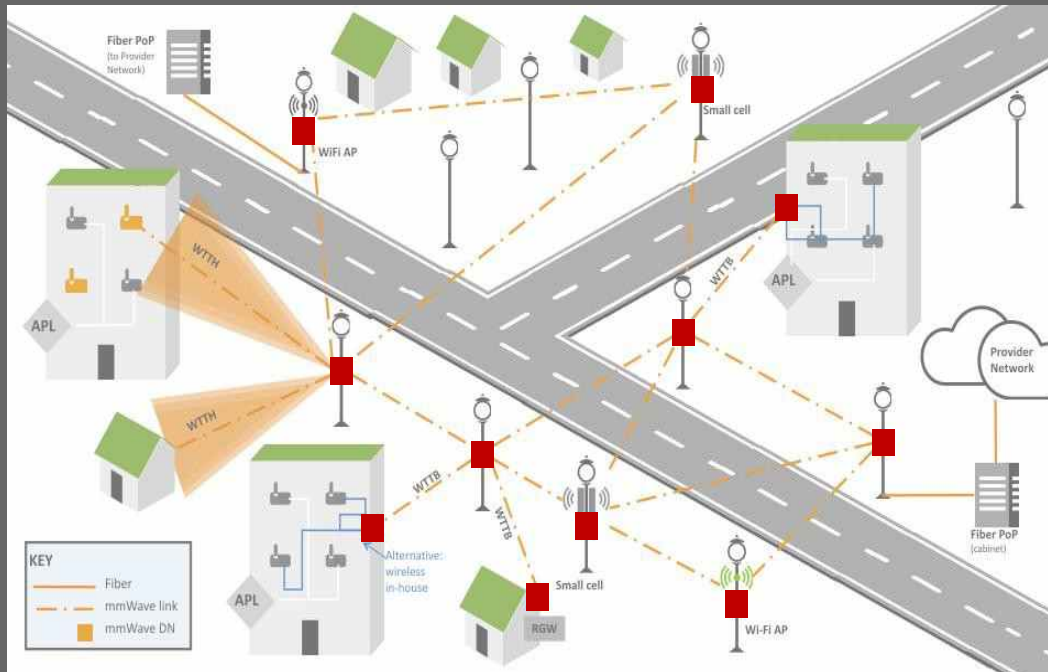
Move Toward Small Cells



Enabling Open Radio Access Network (RAN)

Integrated 5G Solutions Present Large Market Opportunity

*The Value Potential of the Internet of Things:
9 settings culminate in a \$3.9T-\$11.1T annual impact by 2025*



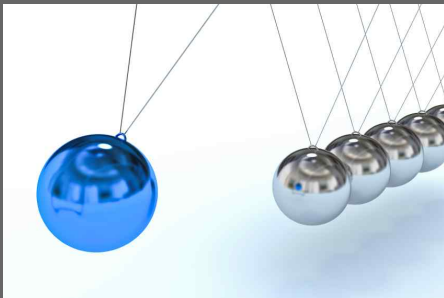
Integrated Metawave Technology ■



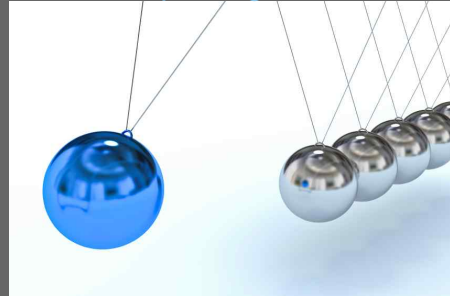
Enterprise vs Consumer 5G

- 2G cellular networks were about **VOICE** services
- 3G cellular networks were about **DATA** services
- 4G cellular networks were about **APPS** services
- 5G cellular networks were about **real-time EDGE** services

2G, 3G, 4G RoI from Consumer
because of WiFi

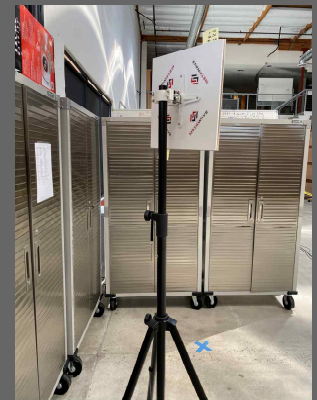


Initial 5G RoI from Enterprise
replacing WiFi



Metawave Passive KLONE Reflectors

- 24 to 60 GHz frequency bands
- Zero power without wiring
- 50m range extension
- Zero delay with friendlier to factory users
- Lowest CAPEX with increased coverage
- Ease of planning and Installation
- Zero OPEX with Universal Designs
- Measured gain 15-30 dB



Active TURBO-2 Repeaters

- Small and Macro cell backhaul
- Remote access for configuration and monitoring during installation
- Extremely low delay < 5 nsec
- Easy installation and no required OPEX
- 250m+ range extension with adjustable up to 100+ dB gain
- Dynamically configuring antennas to lock on strongest signal strength by steering the beam



Metawave's 5G / Telecom Go-to-Market Strategy

Target 5G infrastructure vendors complemented by limited direct sales

- Sell / license KLONE & TURBO to 5G infrastructure vendors
- Passive relays based on meta-structures for outdoor and indoor network integration
- Urban network planning and support
- Indoor network planning and support



Office Buildings



Stadiums



Airports



Malls



Outdoor Dead Zones



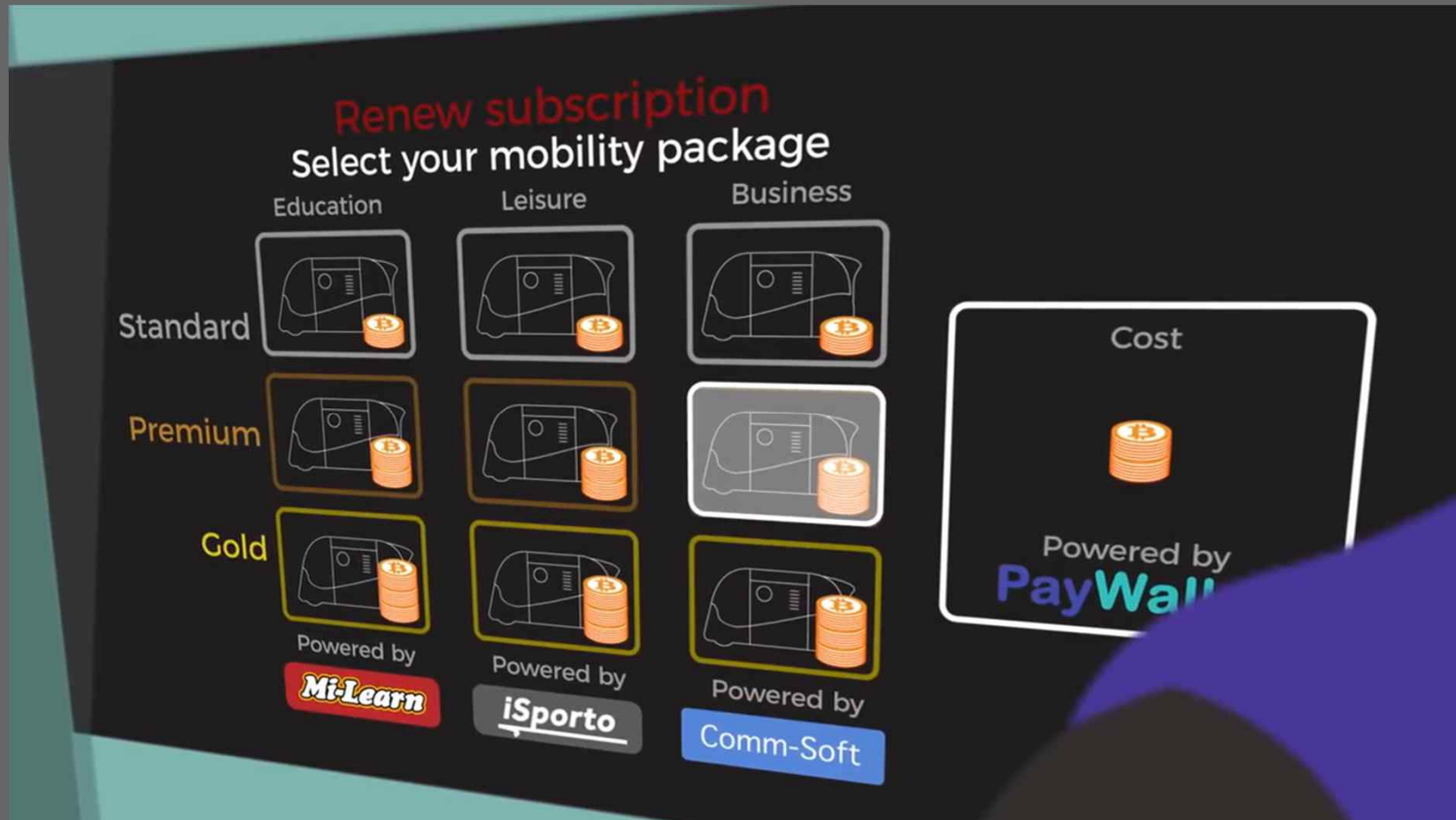
Around the Corner



Non-line-of-sight Backhaul

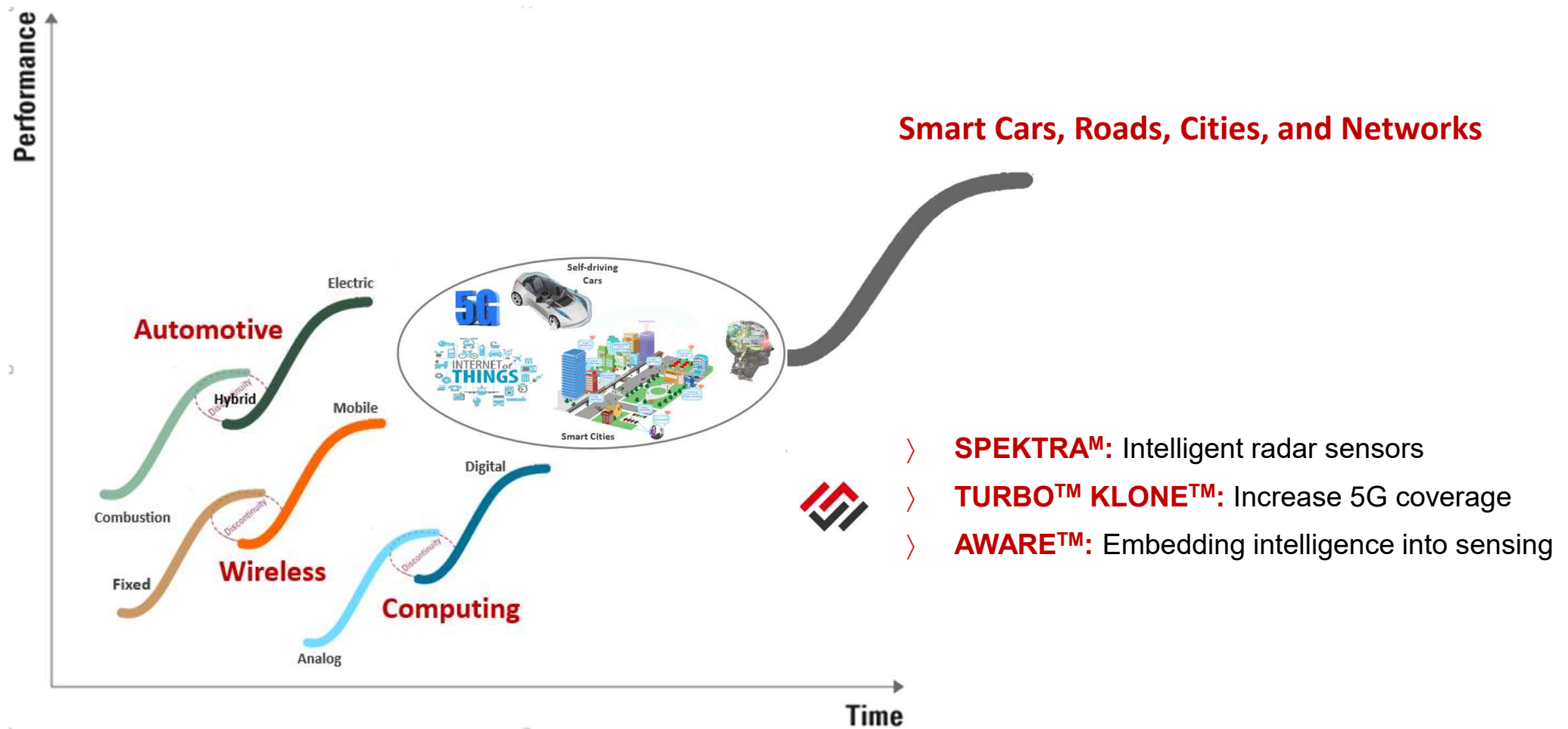
	Metawave Licensing KLONE Design to Partners -> Final Customer		Direct Sales and Support	
	Metawave	Partner	Metawave	Customer
Site Planning		✓		✓
Scanning for 3D Maps		✓	✓	✓
E&M Modeling		✓	✓	
KLONE Design Selection		✓	✓	✓
New KLONE Design	✓		✓	
Manufacture, Assembly & Testing		✓	✓	
Installation		✓		✓

Mobility 2030: Beyond transportation (KPMG)



<https://www.youtube.com/watch?v=4B7mZFU2sB4>

Next Paradigm Shift



Thank You

