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Mobility Industry
Insights by
Michael L. Sena

THE DISPATCHER

IN THIS ISSUE

THE APRIL 2024 ISSUE IN BRIEF

LEO IS AN acronym for Low Earth Orbit, referring to satellites in that orbit. AGI are the initials for Artificial General Intelligence. Neither LEO or AGI have been developed specifically for vehicles, like ADAS (acronym for Advanced Driver Assistance System), or a key component of vehicle navigation, like GNSS (initials for Global Navigation Satellite Systems). However, they both will play important roles in the future of mobility, assuming, of course, that mobility follows along its current path. Neither technology is uncontroversial. Thousands of LEO satellites are being put into orbit, and astronomers are not happy. They are brighter than stars and making earth observations of the heavens increasingly difficult. Maybe that is exactly what the gods had in mind when they allowed humans to invent them. Maybe the same can be said about robots with human-level intelligence. "They think they're so smart. Maybe it's time to teach them a lesson." The Doomers are warning us that we are headed down the road to perdition, while the techno-optimists tell us they've got our backs and everything will be just fine when we eventually get to where we are going. "Trust me."

It's always the same old story with discussions about the eventual impacts of new technologies or new ways of doing things, like teaching kids. Grea't ideas, like those of education progressive John Dewey, turn out to be duds and we are compelled to return to how we did things before. Perhaps one day we'll forsake all forms of travel and non-personal communication, or maybe we won't.

My job is to help you have a little more information when you finally decide to pay your money and take your chances with one way or t'other.

THE DISPATCHER

Mobility Industry Insights by Michael L. Sena
April 2024 – Volume 11, Issue 6

Feature: Using LEO Satellites for Transport

The International Space Station is a Low Earth Orbit application

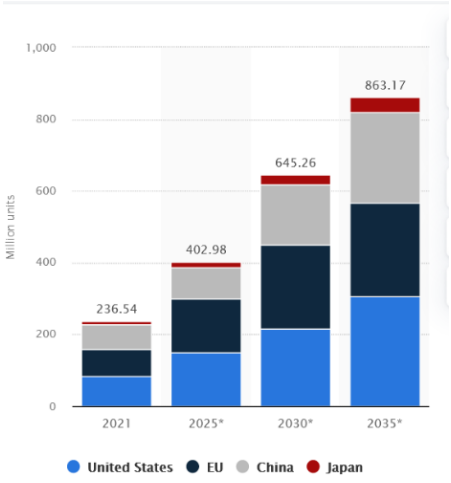
Feature Articles

Supplemental positioning and communications

IN THE EARLY morning of the 11th of JANUARY 2024, while it was still pitch dark during the night of a new moon, when the stars are at their brightest, I left Vadstena for a three-hour drive south to Göteborg. As I passed beyond the last streetlights at the edge of town and entered the black landscape, I saw a large, bright object in the southeastern sky. It appeared to be stationary, approximately 30 degrees above the horizon. It looked like a double cross and was visible for the next forty-five minutes until it was daylight, moving at about the same speed as my car. It was too large to be the International Space Station, although it had its shape. I have watched the ISS as a bright dot moving across the sky, 402 kilometers above the Earth. It travels quickly in its low earth orbit, five miles per second and orbiting earth every 90 minutes. Try as I might, I could not find any information about the mysterious object guiding me along my way on that cold January morning, but it started me thinking about the next frontier of vehicle communications: Low Earth Orbit (LEO) satellites.

Connected vehicles need constant connectivity

At the end of 2023, there were 1.475 billion vehicles in the world.[1] Of that total, approximately 20% were connected, meaning they had the hardware and software integrated into the vehicle to enable two-way communications of either voice or data or both, as shown in this chart by STATISTA (*Size of the global connected car fleet in 2021 with forecasts for 2025, 2030, and 2035 by region – 2024*).



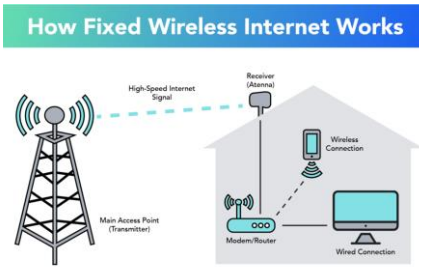
[1] https://hedgescompany.com/blog/2021/06/how-many-cars-are-there-in-the-world/

It is difficult to find exact statistics on the percentage of new cars and trucks being sold today that are fully connected, but all sources put it in the vicinity of around 60%. There appears to be agreement that by the end of this decade, all new vehicles will be sold with integrated communications, at least for data. Most will also have voice capabilities for emergency purposes (think *OnStar* and *EU eCall*). That means that approximately one-half of all vehicles on the roads, the combination of new and old, will be connected by 2035, with the vast majority of those being in three markets: the U.S., the EU, and China.

Constant connectivity requires ubiquitous coverage for high-speed Internet, known as 'broadband'. This has become essential for businesses and individuals, the latter finding it now essential to manage their daily lives—much to the dismay of the elderly and financially disadvantaged. Wireless broadband (i.e., to mobile devices) is becoming more important than fixed broadband.

Broadband Connectivity

There are three types of broadband connections: fixed; fixed wireless; and mobile wireless. Fixed broadband employs fiber optical cable trenched underground with last-mile connections made either aerially (usually from a telephone pole) or underground depending on the topography of the homes and businesses being served. Customer Premises Equipment (CPE) devices serve as the termination points. With fixed fiber, the CPEs are physically wired to the carrier network.



Fixed wireless access (FWA) provides broadband services through radio (wireless) links between a main radio access point (transmitter), such as a cell tower, and a stationary receiver, which is usually an antenna. The antenna is then connected to CPEs directly or via a Wi-Fi router. The wireless link operates on licensed spectrum over 4G/LTE and 5G networks.

Mobile wireless broadband is the term for wireless Internet access delivered through cellular towers to portable CPEs, like our Smartphones and connected vehicle devices. Wireless-carrier marketing uses the phrase "mobile broadband" as a synonym for mobile Internet access.

Fixed and fixed wireless broadband are generally cheaper, faster, and more reliable than mobile wireless connections. The trade-off with fixed and fixed wireless versus mobile broadband is that the

latter connections are stuck in one place. However, even though fixed wireless and mobile wireless have practical differences, they use basically the same technology. All wireless Internet uses radio waves to send data between transceivers and mobile devices (e.g., smartphones, laptops).[2]

Connectivity is not just a nice-to-have feature

Mobile wireless broadband service is absolutely essential for data communications to and from vehicles. Marketing service consulting companies, such as FROST & SULLIVAN and MCKINSEY, have pushed four principal hot buttons for why broadband connectivity is "redefining the world's driving experience", according to a WORLD ECONOMIC FORUM piece, *Why the future for cars is connected*:[3]

1. Improve safety with hazard alerts
2. Enhance the consumer experience with in-car infotainment
3. Reduce environmental impacts with better traffic flow management
4. Provide alternative revenue streams for vehicle manufacturers

These are all important vehicle features, both for customers and the vehicle manufacturers, and connectivity can help to enhance their performance, but connectivity is not their critical success factor. They miss the main reason why connectivity is essential and why it must be ubiquitous. Cars are being built with advanced driver assistance systems (ADAS) that require up-to-date road data to operate optimally for a safe driving experience. The on-board electronic horizon[4] must be as accurate as possible, and this requires constant refreshing. As more driving functions are automated, and as more of the hands-on driving tasks are moved to robotic systems, the need for absolute accuracy increases. Missing an update due to a coverage gap can prove to be fatal for the occupants of the vehicle.

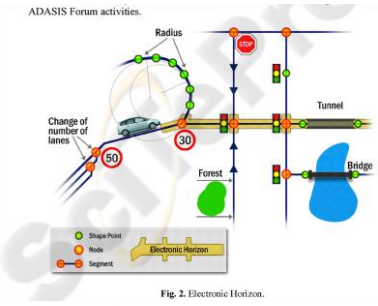


Fig. 2. Electronic Horizon.

Advanced Driver Assistance Systems Interface Specification (ADASIS) Electronic Horizon – ADASIS Forum

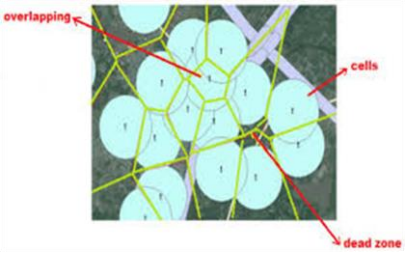
[2] https://spectrum.ieee.org/6-key-connectivity-requirements-of-autonomous-driving

[3] https://www.weforum.org/agenda/2021/07/why-the-future-for-cars-is-connected/

[4] The Electronic Horizon is a virtual sensor that provides information about the road ahead of a vehicle by extracting data from digital maps. The automotive industry has developed a standardized interface called ADASIS to access the Electronic Horizon.

The problem is that terrestrial telecommunications networks on their own are not suited for automotive applications. Note that I say, "on their own". Terrestrial telecommunications networks have been doing a great job so far "on their own", but they are not going to be able to take vehicle communications to the next level. Why not? First, the terrestrial telecommunications networks cannot guarantee that signals will be received everywhere. In the U.S. and EU, networks are built principally by the private sector, and installing fiber optic networks in rural areas has proven to be financially unfeasible. There are fewer potential subscribers in rural areas, and the challenges presented by topography often make the costs prohibitive. This means that in some places, there is no fixed broadband, fixed wireless broadband, or wireless broadband services.

The second problem with terrestrial networks is that there are always gaps in service even where the networks are completely built out. These are called 'dead zones'. Dead zones are areas with no cellular signals. They are locations that stand out of reach from the nearest signal towers and fail to deliver and receive passing radio waves from devices. Dead zones occur anywhere and everywhere. They exist in rural areas, cities, deserts, roadsides, and even between buildings and indoors. There are a few meters of white space between cell tower coverage, and signals can be blocked by tall buildings, tunnels, and sound walls along urban expressways. The further one travels from the most built-up areas, the more the coverage lapses increase. The easiest way to know if you've crossed into a dead zone is to check your cell phone signal strength. Or just look at the bars on your phone. No bars mean no signals.[5]



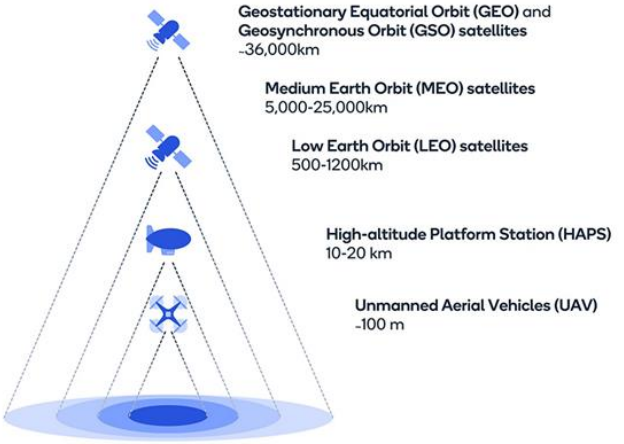
Adding another dimension to vehicle connectivity

It is for these reasons that there is increasing interest in Low Earth Orbit (LEO) satellites for vehicle-related mobile broadband service, both for data communications and for providing positioning in those cases where current GNSS (Global Navigation Satellite System), such as GPS and Galileo, which are Medium Earth Orbit, are not available.

5 (https://www.surecallboosters.ca/post/cellular-dead-zones-what-causes-them-and-how-to-fix-them).

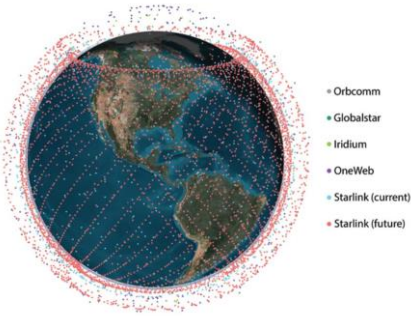
GEO, MEO, and LEO

According to BRITANNICA,[6] *Low Earth Orbit (LEO) is the region of space where satellites orbit closest to Earth's surface. There is no official definition of this region. The diagram to the right indicates the range is 500-1200 kilometers, but other sources extend it to between 160 and 1,600 km (about 100 and 1,000 miles) above Earth. Satellites do not orbit below 160 km because they are affected by atmospheric drag. The lowest orbiting satellite, the Japanese satellite* Tsubame,[7] *orbited at an altitude of 167.4 km. Satellites in LEO have orbital periods between 90 minutes and 2 hours. For the sake of comparison, most airplanes do not fly at altitudes more than 12 kilometers (7.2 miles). The International Space Station is in Low Earth Orbit, circling every 90 minutes 402 kilometers above the earth.*



GNSS satellites are in the Medium Earth Orbit (MEO) category, 20,000-25,000 kilometers above earth. Geostationary satellites (GEO) are in an orbit that can only be achieved at an altitude very close to 35,786 km (22,236 miles). At this height, the satellite is fixed over one longitude at the equator. The satellite appears motionless at a fixed position in the sky to ground observers. There are several hundred communication satellites and several meteorological satellites in GEO orbit.[8]

Some existing and future LEO satellite constellationsjljlkjljljjlj



Walter Ballheimer, CEO of satellite manufacturer REFLEX AEROSPACE, explains the main difference between LEO and GEO for communications: *"The low LEO orbit is suitable for very fast communication because of its low latencies of about 0.04 seconds, while the GEO orbit with approximately 0.5 seconds of latency is ideal for distributing the same content to many users."*

While cellular network latency averages 10 milliseconds (0.01 seconds), it does not provide the reliability needed for driverless vehicles to make safe decisions because cellular

[6] https://www.britannica.com/technology/low-Earth-orbit

[7] Super Low Altitude Test Satellite (SLATS) or Tsubame was a JAXA satellite intended to demonstrate operations in very low Earth orbit (VLEO, below 200 km), using ion engines to counteract aerodynamic drag from the Earth's atmosphere which is substantial at such lower orbital altitudes. It was launched on 23 December 2017, and decommissioned on 1 October 2019.

[8] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/geostationary-satellite

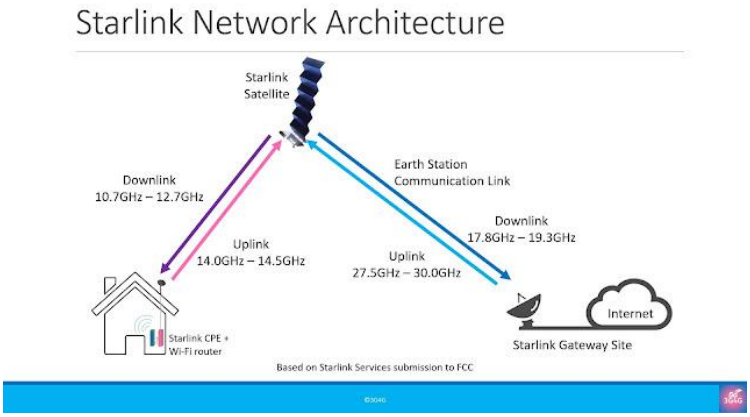
networks do not provide 100% coverage. Take, for example, the case of a self-driving vehicle in a highly urban setting surrounded by tall buildings that can disrupt cellular signals. As another example, consider rural areas where cellular connectivity is simply not available.

Single LEO satellites cannot generally be used for telecommunications since their constantly changing positions and fast speeds make them difficult to accurately track from the ground. In addition, relative closeness to the ground means that each satellite has a limited Field of View (FoV), so that many of them are needed for complete Earth coverage. That is why many LEO satellites are needed. Multiple LEO satellites can be used to create a network of linked satellites (illustrated in the diagram to the right) that work together to cover a large region of Earth's surface.

Multiple LEO Satellites in a Network

How LEO works for broadband connectivity

How LEO works for broadband connectivity can be illustrated with the example of the largest and probably best-known of the LEO satellite service providers, U.S.-based space company SPACEX.[9] By the end of 2023, SpaceX had put up 5,500 mass-produced small *Starlink* satellites in low Earth orbit. Nearly 12,000 satellites are planned to be deployed, with a possible later extension to 42,000. They were launched to bring the Internet to remote areas and deliver data to all types of land, sea, and air vehicles.[10] The satellites communicate with both designated ground stations, called Starlink Gateway Sites, and with user terminals, referred to as Customer Premises Equipment (CPE) operating in the networks that serve Embedded Subscriber Identity



[9] SpaceX, short for Space Exploration Technologies Corp., is headed by Elon Musk and has its headquarters in California. The company predominantly launches and manufactures spacecraft, but it also works extensively in satellite communications.

[10] In February 2022, two days after Russia's full-scale invasion, Ukraine requested American aerospace company SpaceX to activate their Starlink satellite internet service in the country to replace internet and communication networks degraded or destroyed during the war (BBC News, March 1, 2022). Initially, SpaceX provided and funded Starlink services to Ukraine largely on their own. As of June 2023 Starlink expenses for Ukraine are covered by the US Department of Defense through a contract with SpaceX (AP News, April 28, 2023).

Modules (eSIMs)[11]. They provide data rates of around 100 Mbits/second.[12] There are currently 150 Gateway Sites scattered around the world.

Starlink Customer Premises Equipment, stationary above and mobile below.

SPACEX's *Starlink* satellite constellation orbits about 550 km above the Earth, 148 kilometers higher than the International Space Station. The constellation of orbiting satellites provides far more complete coverage than terrestrial telecommunications, and their low orbit results in much lower latency than GEO or MEO. The latency associated with *Starlink* is around 20 milliseconds (0.02 seconds), compared to 250+ ms associated with geostationary broadband satellite solutions.

Current principal applications of LEO satellites

Today, most LEO technology is used for mobile communications in four general areas:

1. Remote industrial business – LEO communications enable services to remote areas that are too difficult or expensive to be covered by terrestrial systems. Oil and gas drilling, mining, forestry are heavy users of LEO communications.
2. Defense and government – LEO communications can be deployed easily and quickly, providing both voice and data services.
3. Emergency response – In cases where natural disasters destroy the terrestrial infrastructure, LEO communications can be established to provide emergency services. Search and rescue operations in remote areas are a natural use for LEO communications.
4. Recreation – LEO communications can provide services to any areas that are not covered by terrestrial communications, such as the ocean, large lakes, or remote forests.

LEO for navigation

An excellent article appeared in the November 29, 2021 issue of IG Inside GNSS titled ENTER LEO on the GNSS Stage, which describes both the advantages of using LEO for navigation, as well as the disadvantages.[13] LEO satellites possess desirable attributes for navigation. First, LEO satellites are around twenty times closer to Earth compared to GNSS

[11] An eSIM is a SIM card that stays inside your phone and can't be removed. It performs the same function as a traditional SIM card but has the potential to provide many additional functions.

[12] https://www.zuken.com/us/blog/how-are-satellites-bringing-low-latency-internet-to-autonomous-vehicles/

[13] https://insidegnss.com/enter-leo-on-the-gnss-stage-navigation-with-starlink-satellites/

satellites that reside in medium-Earth orbit (MEO), making LEO satellites' received signals significantly more powerful than GNSS. Second, LEO satellites orbit the Earth at much faster rates compared to GNSS satellites, making LEO satellites' Doppler measurements attractive to exploit.[14] Third, LEO mega constellations will shower Earth with signals which are diverse in frequency, which will improve robustness to interference and cyberattacks. Fourth, LEO satellites will provide virtually a blanket of cover around the globe, yielding low geometric dilution of position (GDOP), which in turn gives more precise position estimates.

Multiple LEO Satellites in a Network

Doppler Effect

Doppler effect is the apparent difference between the frequency at which sound or light waves leave a source and that at which they reach an observer, caused by relative motion of the observer and the wave source. This phenomenon is used in astronomical measurements, in radar and modern navigation, and other applications. It was first described in 1842 by Austrian physicist Christian Doppler.[15]

Challenges of deployment and operation of LEO satellites

There are several challenges that must be addressed before LEO satellites can see wide deployment for positioning, navigation, and telecommunications. One of the first is cost. LEO satellites cost less to put into orbit, as less energy and smaller rockets are needed to launch them to their ultimate orbit. However, once in orbit, LEO satellites travel through a denser atmosphere than those at higher altitudes, and they require a more substantial power source to move at higher speeds and make any needed corrections to their low orbits. Over time these factors contribute to the deterioration of a LEO satellite's ability to correct its orbit, which gives a typical LEO satellite a lifespan of about 7 to 10 years. GEO satellites have a lifespan that is typically double that of LEOs. Note that when satellites go out of service, it is not because their electronics stop working, but because the satellite runs out of propellant.

14 https://insidegnss.com/enter-leo-on-the-gnss-stage-navigation-with-starlink-satellites/

15 https://www.britannica.com/science/Doppler-effect

Here are some of the factors that contribute to the high cost of LEO satellite deployment:

- Launch Costs: The cost of launching a single satellite into LEO can range from tens of millions to hundreds of millions of dollars, depending on the launch vehicle and other factors. To deploy a full constellation of LEO satellites, businesses must invest significant resources in launch services, which can be a major expense.
- Satellite Design and Manufacturing: LEO satellites must be designed and manufactured to withstand the harsh environment of space, including extreme temperatures, radiation, and microgravity. The cost of developing and building a satellite that meets these requirements can be significant, particularly for small businesses and startups.
- Ground Infrastructure: In addition to the satellites themselves, LEO constellations require significant ground infrastructure to support communication, data processing, and other functions. This includes ground stations, data centers, and other equipment, which can add to the overall cost of deployment.
- Maintenance and Upgrades: Once a LEO constellation is deployed, businesses must invest in ongoing maintenance and upgrades to ensure that the satellites remain operational and effective. This can include regular software updates, repairs and replacements for damaged hardware, and other maintenance activities, which can add to the overall cost of ownership.
- Regulatory compliance: The Radio Regulations treaty maintained by the INTERNATIONAL TELECOMMUNICATION UNION (ITU) ensures reliable satellite operation and, hence, space services in two key ways: firstly, by allocating radio frequencies to those services; and secondly, by coordinating the orbital positioning of different satellites. Article 5 of the treaty distributes radiofrequencies to space services.

Unlike GPS, Galileo, and other GNSSs, LEO satellites are not designed specifically for positioning, navigation, and timing (PNT). In the first place, they do not necessarily transmit their satellites' ephemerides,[16] and when they do it may be

[16] In astronomy and celestial navigation, an ephemeris is a book with tables that gives the trajectory of naturally occurring astronomical objects as well as artificial satellites in the sky, i.e., the position over time. Historically, positions were given as printed tables of values, given at regular intervals of date and time.

necessary to be granted special permission to use the data. As an alternative, the position and velocity of a satellite can be parametrized by its Keplerian elements, which can be found in so-called two-line element (TLE) files that are tracked and publicly published on a daily basis by the North American Aerospace Defense Command (NORAD). However, using these elements could introduce errors of on the order of kilometers because these elements are dynamic and deviate due to atmospheric drag, the Earth's oblateness, solar radiation, and other gravitational forces.

Another challenge to using LEO for PNT is that LEO satellites are not necessarily equipped with atomic clocks, nor are they tightly synchronized. Generally, the stability of LEO satellites' clocks and their synchronicity are unknown, whereas GNSS satellites' clocks errors are periodically transmitted to the receiver in the navigation message. Additionally, LEO satellites are owned and operated by private entities, while GPS, Galileo, GLONASS and BaiDou are owned and operated by national government authorities. Private companies may adopt proprietary transmission protocols which are not usable by non-subscribers. Also, they require specialized receivers that are capable of extracting the desired PNT data.[17]

Accentuating the positive, and eliminating the negative

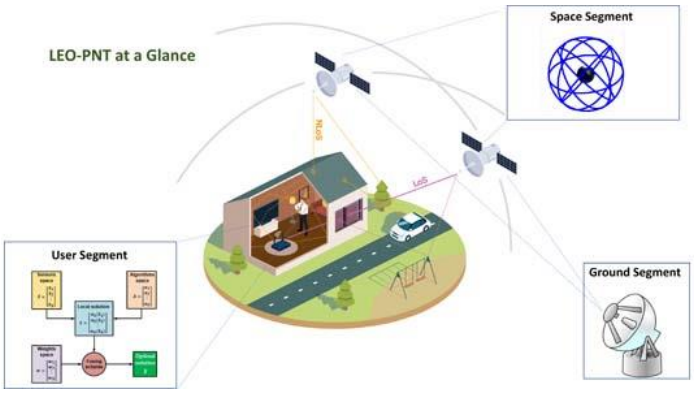
Any one of these challenges can be a show stopper for the faint of heart or the shallow of pocket, but the advantages may also be irresistible. There are two approaches being considered to address the shortcomings of LEO for navigation: 1) Tailor the transmission protocol of LEO to support navigation, which it does not do currently; and 2) Exploit the current transmitted signals for navigation in an "opportunistic" fashion. The first approach would be the simplest, allowing for single-purpose architectures and navigation algorithms. However, those who have been studying this problem believe a navigation-focused design would require a significant investment in satellite architecture and may even require a specific spectrum allocation. Since these systems are in the hands of private companies, there is no guarantees that the costs of services would be prohibitive.

[17] https://spj.science.org/doi/10.34133/space.0092

The second approach uses LEO signals of opportunity (SoO). There are no specific positioning signals transmitted. Calculating position is the responsibility of the receiver systems.

Integration of communications and navigation

Many of the groups working on using LEO satellites for PNT are concentrating on the second approach, integrating the best of terrestrial communications with 5G and 6G, and the advantages that LEO satellites can bring to improve coverage for navigation. The term which is used is ICAM for Integration of Communication and Navigation. The space segment is composed of a constellation of satellites transmitting radio frequency signals to users. The ground segment handles the management of the satellite system. It involves ground stations to perform the precise orbit determination, ephemeris computation, clock corrections estimation, and periodic updates of the satellite messages and other parameters. The user segment consists of radio frequency receivers and antennas that receive the PNT signals, process the measurements, and provide solutions.



For a complete and detailed description of PNT, see: https://ieeexplore.ieee.org/document/9840374.

Equipment requirements

The prerequisite for the new services is additional technology in the car, in particular for reception of data from space. Dish-shaped antennas of the kind used for stationary applications are out of the question for the car roof because of their size and shape. Instead, phased array antennas provide an option. They consist of many small antennas and special electronics that can consistently adjust the transmit-and-receive direction to the position of the satellites, thereby ensuring uninterrupted data reception. Phased array antennas are also completely flat and can be integrated into a sunroof.

Service domains for LEO satellites in navigation and positioning

A comprehensive list of services that have been judged to be suitable for using LEO satellite navigation and positioning services is provided in the Draft ISO TC/204 Standard

Preview for ITS-Mobility Integration: Role and functional model for mobility using LEO satellite system (ISO/DTR 17783.2).[18] In the introduction to the services section, the Draft states:

"LEO satellite systems may support ITS service implementations but should be assessed considering physical infrastructure needs and predicated on LEO offering improvements in safety or mobility over other communications technologies."

The document then goes on to list service applications for LEO within the ITS domain as including, but not limited to, the following:

- Critical safety information provision (Low latency in receiving service is key to implementation)
- Safety driving support
- Infrastructure planning
- Dynamic traffic management
- Traffic rule enforcement
- Dynamic map updates
- Emergency evacuation support

The Draft of ISO/DTR 17783.2 was prepared in August 2023, with voting on the Draft closing on the 26th of October 2023. It was registered for formal approval on the 22nd of December 2023. The document describes what the standards group views as a basic role and functional model for mobility services using LEO satellite systems. Its purpose is to provide a description of a concept for operations and the roles different actors would play in these operations. It defines a conceptual architecture between the actors involved, as shown in this figure. It also defines a mobility service use case summary, which is not available in the public Draft document, but may be obtained by organizations that have an ISO affiliation.

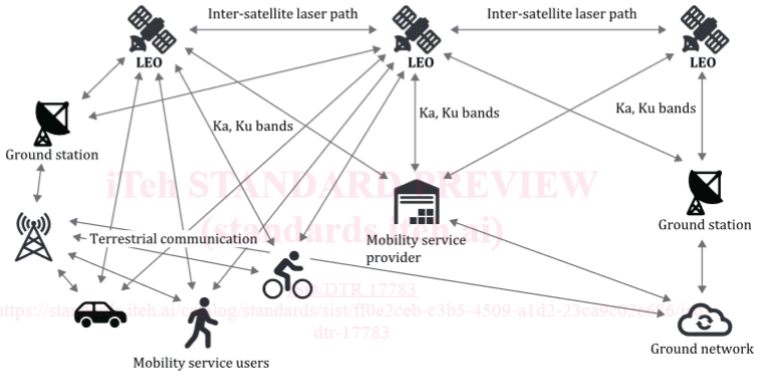


Figure 1 — LEO satellite system use example

[18] https://cdn.standards.iteh.ai/samples/85050/e9f975eb5b474bd79a765890c0b09f94/ISO-DTR-17783.pdf

The document does not include any references to in-vehicle control systems, which are out of scope for standardization by ISO TC/204. Also, its scope is limited to mobility services using physical and digital infrastructure.

In the mobility system use example shown in the diagram, mobility service users are connected to service providers through satellites or private 5G/6G communications through ground network infrastructure or directly to the satellites. It leaves open the possibility for the use of wireless local access networks as well as DSRC 802.11p in the transport sector.

Are companies investing in ICAM/PMT?

Although STARLINK and TESLA are part of Elon Musk's constellation of businesses, there are currently no firm statements made by either company or Musk about using STARLINK for supplemental positioning and navigation in *Tesla* vehicles. Musk did confirm in 2022 that there would be a future Starlink-based phone service in Tesla vehicles in cooperation with T-Mobile. Supposedly, it will be available some time in 2024.

Another LEO satellite launcher with automotive connections is GEESPACE, which is part of the *GEELY TECHNOLOGY GROUP* within ZHEJIANG GEELY HOLDING GROUP (majority owner of VOLVO CARS, POLESTAR, GEELY AUTOMOTIVE, ZEEKR, among others). Following the launch of nine satellites June 2022, GEESPACE launched another eleven satellites in early 2024 "to improve the Chinese car maker's integrated terrestrial and space smart travel ecosystem". *The Geely Galaxy E8*, which is planned to be launched in January 2024, will be equipped with the company's self-developed satellite communication functionality. In October of 2023, Zeekr, showed its *K001 FR* model that was also equipped with satellite communication able to achieve two-way satellite messaging and two-way satellite calls.[19] GEELY has said that it plans to complete the launching and networking of 72 LEO satellites by 2025 that will have the functionality to enable GEELY vehicles to achieve global positioning capabilities without blind

[19] https://www.chinamoneynetwork.com/2023/12/28/geely-to-launch-11-satellites-in-early-2024-aiming-for-a-72-satellite-network-by-2025

spots. I have found nothing indicating how Geely intends to do this.

At present, it looks like the only automotive companies that are saying anything about their LEO plans are focusing on <- the 'T' portion of the PNT triad: telecommunications. It is probably just as well because there is a significant number of standards work that still needs to be started, not to mention eventually completed.

ITU will have the last word

The INTERNATIONAL TELECOMMUNICATION (no 's') UNION is specialized agency within the UNITED NATIONS for information and communication technologies (ICTs). The Organization is made up of a membership of 193 Member States and more than a thousand companies, universities, and international and regional organizations. Its headquarters are in Geneva, Switzerland, and with regional offices on every continent. It was founded in 1865 as the International Telegraph Union and became part of the UN in 1947.

The ITU is responsible for assigning satellite orbits and develops worldwide telecommunications technical standards. Its remit covers broadband Internet, optical communications, wireless technologies, aeronautical and maritime navigation, radio astronomy, satellite-based meteorology, TV broadcasting, amateur radio, and next-generation networks. In 2019, at its World Radio Communications Conference-19 (WRC-19), it approved and adopted new rules for LEO satellite activities.[20] The new rules provide a regulatory framework for ensuring that ITU's Master International Frequency Register reflects the actual deployment of non-geostationary satellite orbits (NGSO). The rules are intended to define more flexible timelines and objective criteria for deployment and aims at striking a balance between the prevention of spectrum warehousing, the proper functioning of coordination mechanisms, and the operational requirements related to the deployment of NGSO systems.

[20] ITU adopts new regulations for LEO satellites | Advanced Television (advanced-television.com)

Dispatch Central

The topics covered in Dispatch Central are newsworthy, but I leave it to others to deliver them "as they break". I give them a little time to settle in, and try to provide an analysis of their impact.

Toyota's Toyoda on BEVs' sales prospects

THERE ARE CERTAIN people to whom I pay special attention. Akio Toyoda is one of them. He is currently the Chairman of TOYOTA MOTOR CORPORATION and served as the company's president and CEO between 2009 and 2023. He is also the grandson of the company's founder, Kiichiro Toyoda. He has a pseudonym which he uses when he suits up as a race car driver: Morizo Kinoshita.

In late January this year, Akio Toyoda was quoted in a TOYOTA publication saying he predicted that battery electric vehicles will reach only a 30% share of the total global market of automobile sales. He did not qualify that statement with a year when this 30% would be reached. He simply said that the total market will settle down with BEV, hybrid, hydrogen fuel cell, and fuel-burning cars, and BEVs will comprise 30% of the total. "Customers—not regulations or politics—should make that decision," he said. "With a billion people in the world living without electricity, limiting their choices and ability to travel by making expensive cars isn't the answer," he added.

Words of wisdom spoken by someone with experience.

Toyota developing CO_2 extraction tech

IS TOYOTA BECOMING the BELL Labs of the 21st century? It is searching for answers to how humans can continue to be mobile without affecting the habitability of Planet Earth. TOYOTA is working on a carbon-negative vehicle design which sucks CO_2 out of the atmosphere while it uses hydrogen as an energy carrier to power the vehicle's engine. It took me a while to understand what TOYOTA was actually doing. The *CO_2 extractor* uses the movement of the vehicle and the heat of the engine to perform its work, but the *CO_2 extractor* has nothing to do with powering the vehicle.

The idea is to have these carbon capture devices on board vehicles which pull CO_2 out of the atmosphere while the vehicles are moving and convert the CO_2 to a form that is disposable. The system consists of two principal parts: filters that trap CO_2 from the air that is sucked into the vehicle as it moves; and a receptacle with fluid that absorbs and stores the CO_2 from the filters.

Does it work? Yes, to as degree. An average petrol engine vehicle pumps out about 8,887 grams of CO_2 for every gallon (4.55 liters) of petrol burned. TOYOTA's current *CO_2 extractor* design is pulling around 5% of that amount out of the atmosphere during a RAV4 hybrid vehicle's 100-kilometer trip that would use around 4.5 liters of petrol. Then there is the issue of disposal, which is (figuratively) still up in the air. But, how about an A+ for attempting to do something, rather than just plugging in and dropping out.

Polestar's winding path

IT'S A SOAP OPERA. That's what the POLESTAR story feels like, a daily dose of drama played out on Internet social media. In the February 2024 issue of The Dispatcher, I wrote that POLESTAR is an example of a brand that should never have been released from the the VOLVO CARS stable. Li Shufu, the man behind GEELY, made POLESTAR a separate company, did a SPAC IPO, and gave VOLVO half the responsibility for funding it. It should have remained a sub-brand of VOLVO, adding to VOLVO's revenue and managed as part of VOLVO, rather than building its own expensive headquarters, having its own administrative staff, operating like a separate company, and losing a lot of money in the process.

The soap opera, Coronation Street, premiered in December 1960 on British television. It is still running. It holds the GUINNESS WORLD RECORD for being the longest running soap opera. It will be 64 years this coming December. It centres on the lives of the residents of Coronation Street in fictional the town of Weatherfield, near Manchester.

Instead of doing the right thing, Li decided that GEELY would take over VOLVO's ownership share. Everything in the POLESTAR vehicles was developed by VOLVO, from the exterior design to the telematics system. POLESTAR should be to VOLVO like *LEXUS* is to TOYOTA. Now, VOLVO gets zero value from what it has put into the brand. Like VOLVO's ICE engine technology, it is being transferred to GEELY, lock, stock and barrel. Sooner or later, VOLVO will disappear into the Hangzhou mist, GEELY's headquarters city.

Carbon offsets

IF MARTIN LUTHER were alive today, he would surely be protesting against carbon offsets. He opposed the Catholic Church's practice of selling indulgences. They were sold in the 16th century as an extra insurance, over and above the absolution a faithful Catholic received after saying his or her confession to an ordained priest. An indulgence reduced the amount of time a person would have to spend in purgatory[21] if he or she died with venial sins. Dying with an unconfessed mortal sin means a ticket straight to hell, of course. The amount of time spent in purgatory depends on how much purging of the soul is needed, but according to Church teaching at the time, the duration could be shortened if the person bought some get-out-of-purgatory cards in the form of indulgences. Luther believed salvation is a gift God gives to those who have faith which could not be bought or somehow earned with good deeds. His belief earned him excommunication, and the rest (i.e., the Reformation) is, as they say, history.

Purchasing carbon offset certificates is also a way of avoiding punishment for sins, and a way to purge one's conscience. Let's say you are the owner of a electricity generation plant that burns coal. We'll call you the 'sinner'. You want to keep on burning coal, and you don't want to spend the zillions of dollars it would take to put in CO_2 scrubbing equipment. Your government says it is going to shut down your operation unless you either stop burning coal, install the scrubbing equipment, or offset the CO_2 you produce by paying someone else, an 'offsetter', to do something that either removes the equivalent amount of CO_2 out of the atmosphere that you emit during a given period of time, or stops doing something it is doing to emit the same amount of CO_2. The offsetter could shut down its own coal-burning plant and build a wind farm or solar cell park to produce electricity for its customers, or it could plant a forest of trees, or it

[21] Purgatory is a place or state of punishment wherein according to Roman Catholic doctrine the souls of those who die in God's grace may make satisfaction for past sins and so become fit for heaven. The word is derived from the Latin *purgare*, "to make clean, to purify. It is a place of final purification before a soul reaches the gates of Heaven. (https://www.merriam-webster.com/dictionary/purgatory)

could not cut down thousands of acres of rain forest which it was planning on doing.

If every sinner had to find its own CO_2 offseter, there would be lots of toing and froing all over the place to locate partners and negotiate deals. The sinner just wants to have a piece of paper that proves to his government that he has bought a certain number of CO_2 emission credits so he can keep on burning carbon-based fuel. (If you would like, substitute 'she' for 'he'.) Surely, there are potential offsetters dotted around the Planet who would be willing to make a deal if the money was right, muses the sinner. The problem is locating them. What happens when buyers and sellers want to meet, but can't easily locate each other? Matchmakers miraculously appear. In the case of carbon offsets, matchmakers match those who want to buy credits with those who are willing to provide the offsets.

CO_2 has therefore become a commodity, like tulips or pork bellies or get-out-of-purgatory-early credits. Naturally, the buyers of the carbon offsets want to pay as little as possible for each gram of CO_2 they will continue to emit, and the sellers of the offsets want to receive as much as possible for the same amount of CO_2 they will remove or save. The broker in the middle wants to take as much of the difference as possible. He's not running a charity, after all.

This approach to addressing climate change raises many questions. Who sets the prices for the buyers and sellers, and how are they set? Who verifies the veracity of the programs for removing or not emitting CO_2, and how are the verifications performed? Do the timelines of the emitters and the offsetters match one another?

It all smells very fishy to me. WALT DISNEY CORP. claims that since 2009, it has paid a matchmaker, CLIMATE SOLUTIONS, enough money to buy carbon offsets that are the equivalent of removing 900,000 cars from the roads, which is almost all the cars are on the roads today. In a 2023 article in *THE NEW YORKER*, staff reporter Heidi Blake wrote an article titled *The Great Cash-For-Carbon Hustle: Offsetting has been hailed as a fix for runaway emissions and climate change – but the market's largest firm* (SOUTH POLE) *sold millions of credits for carbon*

reductions that weren't real.[22] The story of SOUTH POLE related by Blake is a sobering tale of what is going on in the multi-billion dollar "profit for purpose" business. It is worth reading.

Selling indulgences was basically a benign practice. The buyers were paying for peace of mind, and the sellers (i.e., the Roman Catholic Church) was then, and still is, in the peace of mind business. There was no way to prove that what was paid for (i.e., spending less time in purgatory, which is a place that for non-believers doesn't exist—nor do heaven or hell, for that matter—but that's not really the point) actually worked. It's different with selling carbon offsets. The buyers of the credits are paying for the privilege of being labelled 'non-sinners'. They receive the non-sinner label when they pay for the credit. The sellers of the services behind those credits should be duty bound to deliver every gram of CO_2 represented by the credit. The folks in Papau New Guinea who are assured by the UNFCCC that all the purchased carbon credits will mean that their islands will not be under water by 2035 are not going to be happy if it turns out that the carbon credit sellers lied.

Who stops on red?

ONE DAY IN early March, I was in Stockholm to perform several errands. I spent the day walking around various parts of the city. During my walk, I came to many signaled crosswalks, each time waiting for the walk sign. On one or two occasions, someone else also waited. Everyone else ignored the *Don't Walk* sign and sauntered or hustled across, sometimes even causing cars that had the right-of-way to stop. My rough calculation was that 95% of pedestrians on this particular day were jaywalkers. The official percentage for Sweden, published by the SWEDEN AUTOMOBILE ASSOCIATION, M SVERIGE, is 13%. The M SVERIGE report was compiled from 12,000 observations in nine medium-sized cities, not including Stockholm and Göteborg.

The report states that 9% of cyclists, 3% of motorcyclists, 2% of private passenger cars, and 1% of taxis also did not stop at red lights but cruised on through. My own observations

22 https://www.newyorker.com/magazine/2023/10/23/the-great-cash-for-carbon-hustle

would put the figure for offending cyclists at 99%, and for electric scooters at 100%. While driving in Stockholm just a few days ago, I observed one car ignoring a red light completely, and another driver turning intentionally into a one-way street, ignoring toots, and forcing his way past cars trying to block his way.

It is not surprising that people flout the traffic laws, even those laws that are intended to ensure the safety of both pedestrians and drivers alike. There are no police on the streets of Sweden to enforce the laws. In the name of personal freedom, we hesitate to put up cameras to record red light runners and jaywalkers, although we have no qualms about snapping photos of speeders on the highways and byways. Eventually, societies are going to have to decide whether to make its laws either obligatory or optional for all. Right now, at least in Sweden, there are different cadres of folks, the self-anointed privileged, who believe (yes, actually believe!) that certain laws do not apply to them. For them, stopping at red lights or crossing only when the light says Walk are for the small people.

Oops! Apple did it again

IS THIS THE last time we are going to hear that APPLE has stopped developing its own car? Would anyone like to offer odds? During the years I have been writing in these pages, APPLE has engaged in and disengaged from *AppleCar* at least three times during the last ten of them. It started its *Titan Project* in 2014, scaled it back in 2017, then gave it a big re-start boost in 2021, only to close it down in February 2024. Is this now really the end?

In the 15 March 2015 issue of *THE DISPATCHER*, I wrote a piece titled *What is Apples's Core*? Whether APPLE was going to enter the automotive manufacturing business was still not completely confirmed by the company. It was still in the "maybe we will; maybe we won't" stage. I wrote: *"Average profit margins for automakers are around 5%. GM's is 2.53% on sales of $155 billion. Apple's profit margin is 24.16% on sales of $183 billion. I believe that for* APPLE *to enter the automotive manufacturing, sales and repair business, it will have to completely change its very successful business model.* APPLE *has a cash hoard ($178 billion at the time) because of this model, which involves creating a virtuous link between information that it can deliver to*

devices that it designs, has manufactured, and sells. The interlocking value chains for devices and content complement each other."

I ended the article with the following suggestion: "To figure out what APPLE is doing, look at its business model." Well, APPLE did finally confirm it was going to design and sell a car in 2015. It took the company almost ten years for someone at APPLE to finally do their homework, to look at the company's business model, and decide whether an *AppleCar* is a good fit. APPLE has now, finally(?) come to the same conclusion I did nine years ago: It is not. One more thing: This has nothing to do with whether the car would drive itself or how its motors would be powered. A car is not a phone, a watch, a laptop, or an app. Get over it and get on with it.

Pay attention to the throw-away phrases

ALTHOUGH ELON MUSK has recently been nudged out of his position as the richest man in the world by Jeff "The Body Builder" Bezos, and out of his position as the number one geek in the news by Jensen "Take the Risk" Huang, he stays topical with periodic interviews when he is at his pesky best (worst?), or by being discussed in business articles, often in *THE ECONOMIST*. Musk took up a few days of airtime during and following his interview in mid-March with Don Lemon for Lemon's new pod show (called The Don Lemon Show). Lemon did what ended up getting him fired from CNN, which is to harass the person he is interviewing. Musk did not like Lemon's line of questioning and told him so on air. "His (referring to Lemon) approach was basically just CNN, but on social media, which doesn't work, as evidenced by the fact that CNN is dying." So, he dissed both Lemon and CNN at one blow.

I wonder how he will get back at *THE ECONOMIST*. In the March 16th issue, Schumpeter, writing about companies deciding now not to register their companies in Delaware, where currently two-thirds of the Fortune 500's largest firms by revenue are registered, said Musk is contemplating deregistering TESLA in Delaware and re-registering it in Nevada. He wrote: "Some aggrieved tycoons, such as X's troll-in-chief, Elon Musk, are helping to make the anti-Delaware case for them." I hope Patrick Foulis, the man behind Schumpeter, isn't counting on getting an interview with the 'troll-in-chief' anytime in the future.

Crew Comments

A view on the place of natural gas as an energy carrier

In the March 2024 issue of *THE DISPATCHER*, in *Musings*, I asked: *What else can we put into our tanks*. In the February 2024 issue, the lead article was also principally about why electric vehicles are not the only answer to climate change. Fred Dryer offered comments on both articles and suggested that an article on the future benefits of natural gas would be a useful and important addition to the conversation. His expert views are provided below. Footnotes in the piece are provided as end notes.

Frederick L. Dryer, Ph.D. was engaged in combustion research at PRINCETON UNIVERSITY for more than 50 years, serving on the Professional Research Staff from 1971 - 1981, joined the tenured faculty in the Mechanical and Aerospace Engineering in 1981, and became Professor Emeritus in 2013. Fred joined the UNIVERSITY OF SOUTH CAROLINA as an Educational Foundation Distinguished Research Professor in Mechanical Engineering in October 2016. He is actively engaged in experimental and computational research on topics relevant to optimizing the fuels/energy conversion interface for ground-based power generation/transportation, aircraft applications, and chemical propulsion.

Historically, there has been massive pressure to replace the use of coal- and petroleum-derived fuels with "cleaner" natural gas. More recently, concern about the global warming potential of methane, the source-to-use emissions, and "slip" emissions from natural gas combustion processes have caused many to propose limiting natural gas use as an energy carrier and source of hydrogen production.[1] Even low emission rates of methane to the atmosphere from source-to-use are proposed to result in global warming potential greater than for source-to-Rankine cycle, steam-based power generation using coal.

But eliminating the use of natural gas as an energy carrier in the next few decades, if ever, is a catastrophic response in terms of economics, social impacts (e.g., advancing living standards), or expeditiously transitioning the immense, complex energy sector to renewables and nuclear power. Natural gas should remain an important contributor to the energy sector and as a source of hydrogen. Replacing natural gas with hydrogen as the preferred energy carrier, especially over the near-term transition, is fraught with

technical, political, and economic barriers, and will have limited or no impact on rapidly addressing climate concerns. Hydrogen production by water splitting (not just electrolytic, but catalytic) to produce ammonia as a commercial/industrial energy carrier, or hydrocarbon energy carriers that yield lower methane emissions from current applications, are amongst the preferable alternatives to hydrogen itself. Achieving energy densities per unit volume for hydrogen equivalent to those of hydrocarbon liquids requires very high storage pressures or cryogenic liquefaction. Infrastructural impacts for distributing high energy density per unit volume hydrogen are immense, even if "green" hydrogen could be produced economically using renewable/nuclear energy.[2]

The concerns about fugitive (e.g. equipment distribution/transfer leaks) and combustion device unburned hydrocarbon ("methane slip") emissions associated with utilizing natural gas are definitely important, even as the marine commercial industry embarks replacing petroleum-derived fuels with liquefied natural gas (LNG). Methanol is an alternative to LNG and yields far less slip emissions of methane, but its energy density per unit volume is only about 1/3 that of today's hydrocarbon liquids. Mitigating fugitive methane emissions from source-to-use and pursuing emerging technologies to oxidize methane slip emissions are preferable approaches to eliminating the use of natural gas for power generation and heating.

Replacing coal steam power generation by natural gas is an inferior route forward to reduce power sector carbon emissions. Combustion-driven, Rankine cycle steam generation has thermal efficiency typically near 40%. Alternatively, natural gas combined cycle gas turbine power generation (already in the field) has demonstrated efficiencies greater than 60%. Unlike earlier gas turbine "peaking systems",[3] *the range of unit capacities available for natural gas integrated gasification combined cycle (IGCC)*[4] *and their very rapid start-up times to full capacity (even with limited turn down of individual units), assist in renewable power integration into the grid.*

In summary, technologies that are already in the field using natural gas can be further improved to meet energy needs over the coming decades, while also addressing concerns over atmospheric methane concentrations. Emerging technologies that produce hydrogen and char[5] *from natural gas in the longer term could provide economically desirable products as well as carbon sequestration in a more desirable form that* CO_2 *itself.*

Notes:

1. *The generic term "Natural gas" is applied to the material obtained from wells, and used in power generation, transportation, and residential heating, but its composition differs from the point of recovery to end use. Dependent on the geographical and geological properties of the well source, the gas may contain variation amounts (vol%) of low molecular weight alkanes along with the contaminants noted below. Typically, methane (CH_4), is the principal hydrocarbon species present.*

Well-head Natural Gas

C1 – Methane (CH_4), C2 – Ethane (C_2H_6), Propane (C_3H_8), Butanes (C_4H_{10}); C5+ (higher alkanes (C_nH_{2n+2})

	Canada	Kansas	Texas
C1	77.1	73.0	65.8
C2	6.6	6.3	3.8
C3	3.1	3.7	1.7
C4s	2.0	1.4	0.8
C5s+	3.0	0.6	0.5
H_2S	3.3	0.0	0.0
CO_2	1.7	0.0	0.0
N_2	3.2	14.7	25.6
He	0.0	0.5	1.8

Typical non-hydrocarbon species found are Hydrogen Sulfide (H2S), Carbon Dioxide (CO2), Nitrogen (N2), Helium (He), water (H2O), and other trace species. Most of the non-alkane species and those larger than C4 are typically removed to yield "pipeline quality" natural gas,

Major Components	Minimum Mol%	Maximum Mol%
Methane	75	None
Ethane	None	10
Propane	None	5
Butanes	None	2
Pentanes and heavier	None	0.5
Nitrogen and other inerts	None	3
Carbon dioxide	None	2-3
Total diluent gases	None	4-5

Trace Components:

- **Hydrogen sulfide: 0.25-0.3 g/100 scf (6-7 mg/m^3)**
- **Total sulfur: 5-20 g/100 scf (115-460 mg/m^3)**
- **Water Vapor: 4.0-7.0 lb/MM scf (60-110 mg/m^3)**
- **Oxygen: 1.0%**

Other Characteristics:

- **Heating calculated (gross, saturated): 950-1,150 Btu/scf (35,400-42,800 kJ/m^3)**
- **Liquids: Free of liquid water and hydrocarbons at delivery temperature and pressure.**
- **Solids: Free of particulates in amounts deleterious to transmission and utilization equipment.**

Pipeline quality, "sweetened" y natural gas is distributed through many miles of transmission pipelines at 500-1400 (some to 2000) pounds per square inch pressure (psig), requiring re-compression stations along the pipeline systems Local distribution pressures are typically low (<60 psig), while within residences, the utilization pressure is generally less than 4 psig (http://naturalgas.org/natural-gas/transport/).

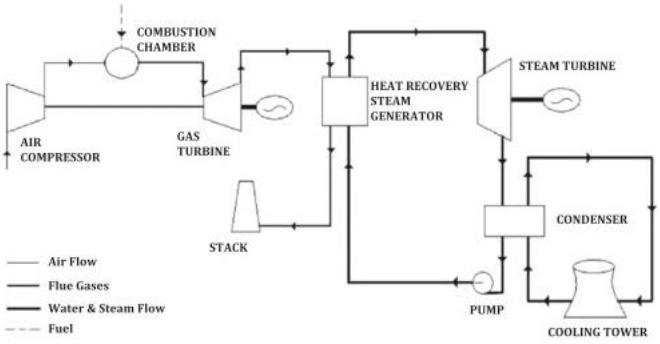
Compressed natural gas (CNG) used in vehicles is required to be composed of at least 93% methane and is typically stored onboard in transportation applications at ~3800 psig. Liquified natural gas (LNG) is cryogenically condensed natural gas at ~ -162 C with a maximum transport pressure above the liquid held to below 25 kPA (4 psig). To keep the remaining LNG in liquid state, the material required vaporizing a portion of the storage. The required off-gas can be recompressed, but can also be used as as a gaseous fuel for energy conversion systems.

In ALL cases, the major constituent of natural gas is methane (CH4). As a hydrocarbon the oxidation kinetics of methane are such as to make it difficult to oxidize in comparison to the higher alkanes, and in the combustion of natural gas will be the major species present in unburned hydrocarbon emissions.

2. *Natural gas pipeline system materials are not compatible with hydrogen, and so higher-pressure pipeline systems would need to be installed to accommodate wide utilization of hydrogen for power generation and residential applications. Cryogenic distribution of hydrogen for transportation will require multiple tankers to transport hydrogen to cryogenic storage locations.*

3. *(https://www.enelnorthamerica.com/insights/blogs/what-is-a-peaking-power-plant) Power generation requires means to provide "base load" generation, along with means to vary the generation on a time scale sufficient to supply load variations 24/7. It may take anywhere from 8 hours to several days for natural gas or coal fired Rankine systems to come to full steady state generation, with little or no "turn down" capability. And renewables also are not capable of operating 24/7, generally they are less than 30 % of their generation "capacity" , i.e. power produced/name plate power generation rating (boilers, turbines are more like 90%). "Peaking" gas turbines have been available for decades, operating on oil or gas, but generally with efficiencies less than 30%. They are able to be put on line quickly to full power, but as such are not useable for generating other than peaking needs, and are expensive to operate.*

On the other hand NEW natural gas, combined cycle gas turbine systems can function for peaking (start up times of perhaps 20 to thirty minutes to full power), have generating capacities approaching those of Rankine cycle systems (~500 megawatts largest ones, several smaller sizes too down to perhaps 50 megawatts), with perhaps 20-30% turndown without sacrificing full power thermal efficiency), and are over 60% efficient! The peaking turbine installations can be replaced by combined cycle units.



4. *IGCC -integrated gasification combined cycle (IGCC) is a technology using a high pressure gasifier to turn coal and other carbon based fuels into pressurized gas – synthesis gas (syngas).*

5. *Natural gas char: Char is the solid material that remains after light gases (e.g. coal gas) and tar have been driven out or released from a carbonaceous material during the initial stage of combustion, which is known as carbonization, charring, devolatilization or pyrolysis. (https://en.wikipedia.org/wiki/Char_(chemistry)*

Musings of a Dispatcher: Opposing AI Thoughts

When it comes to AI, who can you trust?

IT'S NOT LIKELY that *THE NEW YORKER* magazine comes to mind when we need a source for the latest thinking on science and technology. However, sometimes those publications that show up in our mailboxes every week or month surprise us. That's why I try to find the time to read them.

Two articles appeared in *THE NEW YORKER* at the end of November and early December that did more to inform my thinking about artificial general intelligence (AGI) than most of what I have read in the more technically focused press. The first article is titled *Metamorphosis: The godfather of A.I. thinks it's actually intelligent – and that scares him*.[23] It is an interview with Geoffrey Hinton, a computer scientist and University of Toronto professor specializing in neural networks who sold his three-person company to Google for $44 million in 2013. The second article is titled *The Chosen Chip: How Nvidia is powering the A.I. revolution*, which is an interview with Jensen Huang, founder and CEO of NVIDIA.[24]

These articles epitomize the two sides of the artificial general intelligence (AGI) conundrum, which is: Will AGI help us or hurt us? By "us", I mean humanity. The articles do not distinguish between artificial intelligence and artificial general intelligence, but Hinton does explicitly, and Huang does implicitly. Artificial intelligence (AI) leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind. It is what we have today in systems that are trained and focused to perform specific tasks, such as recognizing a deer crossing a road. AGI is the hypothetical ability of an intelligent agent to understand and learn any intellectual task that a human can learn. It possesses the ability to analyze a situation on its own and take a calculative decision without being programmed in advance.

[23] *THE NEW YORKER*, November 20, 2023.

[24] *THE NEW YORKER*, December 4, 2023.

Heads it's bad; tails it's good

In March 2023, 33,708 business and academic leaders signed an open letter that called for a "moratorium on the development of the most powerful artificial intelligence systems". The initiative was led by Max Tegmark, MIT professor and co-founder and President of THE FUTURE OF LIFE INSTITUTE. Tegmark's 2017 book, Life 3.0: Being Human in the Age of Artificial Intelligence, was full of warnings about the negative potential for systems with "human-competitive intelligence".[25] Below is the open letter in full. It is worth reading.

AI systems with human-competitive intelligence can pose profound risks to society and humanity, as shown by extensive research and acknowledged by top AI labs. As stated in the widely endorsed Asilomar AI Principles,[26] Advanced AI[27] could represent a profound change in the history of life on Earth and should be planned for and managed with commensurate care and resources. Unfortunately, this level of planning and management is not happening, even though recent months have seen AI labs locked in an out-of-control race to develop and deploy ever more powerful digital minds that no one – not even their creators – can understand, predict, or reliably control.

Contemporary AI systems are now becoming human-competitive at general tasks, and we must ask ourselves: Should we let machines flood our information channels with propaganda and untruth? Should we automate away all the jobs, including the fulfilling ones? Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete, and replace us? Should we risk loss of control of our civilization? Such decisions must not be delegated to unelected tech leaders. Powerful AI systems should be developed only once we are confident that their effects will be positive and their risks will be manageable. This confidence must be well justified and increase with the magnitude of a system's potential effects. OpenAI's recent statement regarding artificial general intelligence, states that "At some point, it may be important to get independent review before starting to train future systems, and for the most advanced efforts to agree to limit the rate of growth of compute used for creating new models." We agree. That point is now.

Therefore, we call on all AI labs to immediately pause for at least 6 months the training of AI systems more powerful than GPT-4. This

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[25] See *THE DISPATCHER, FEBRUARY 2018, No Humanless-Drive without AGI*

[26] The *Asilomar AI Principles*, coordinated by FUTURE OF LIFE INSTITUTE and developed at the Beneficial AI 2017 conference, are a set of AI governance principles.

[27] "Advanced", "powerful" and "highly-capable" AI refer to Artificial General Intelligence (AGI).

pause should be public and verifiable and include all key actors. If such a pause cannot be enacted quickly, governments should step in and institute a moratorium.

AI labs and independent experts should use this pause to jointly develop and implement a set of shared safety protocols for advanced AI design and development that are rigorously audited and overseen by independent outside experts. These protocols should ensure that systems adhering to them are safe beyond a reasonable doubt. This does not mean a pause on AI development in general, merely a stepping back from the dangerous race to ever-larger unpredictable black-box models with emergent capabilities.

AI research and development should be refocused on making today's powerful, state-of-the-art systems more accurate, safe, interpretable, transparent, robust, aligned, trustworthy, and loyal.

In parallel, AI developers must work with policymakers to dramatically accelerate development of robust AI governance systems. These should at a minimum include: new and capable regulatory authorities dedicated to AI; oversight and tracking of highly capable AI systems and large pools of computational capability; provenance and watermarking systems to help distinguish real from synthetic and to track model leaks; a robust auditing and certification ecosystem; liability for AI-caused harm; robust public funding for technical AI safety research; and well-resourced institutions for coping with the dramatic economic and political disruptions (especially to democracy) that AI will cause.

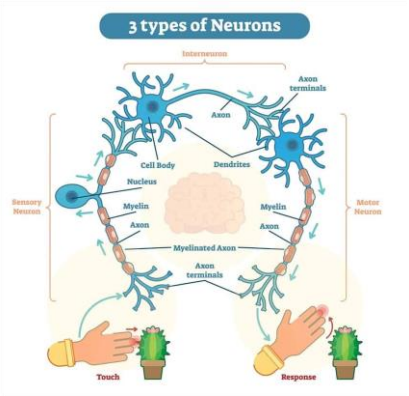
Humanity can enjoy a flourishing future with AI. Having succeeded in creating powerful AI systems, we can now enjoy an "AI summer" in which we reap the rewards, engineer these systems for the clear benefit of all, and give society a chance to adapt. Society has hit pause on other technologies with potentially catastrophic effects on society. We can do so here. Let's enjoy a long AI summer, not rush unprepared into a fall.

Elon Musk signed the letter. He was among the initial funders of THE FUTURE OF LIFE INSTITUTE. Sam Altman, CEO of OPENAI (responsible for ChatGPT), did not, and neither did Geoffrey Hinton. "If you take the existential risk seriously, as I now do, it might be quite sensible to just stop developing these things any further," Hinton said in *THE NEW YORKER* article. "But I think it is completely naive to think that would happen. I don't know of any solution to stop these things," he continued. "I don't think we're going to stop developing them because they're so useful."[28]

[28] https://www.forbes.com/sites/craigsmith/2023/05/04/geoff-hinton-ais-most-famous-researcher-warns-of-existential-threat/

In *THE NEW YORKER* interview, Hinton was asked: "Why don't we just unplug it? Is that a totally unreasonable question?"

He responded: "It's not unreasonable to say, We'd be better off without this—it's not worth it, just as we might have been better off without fossil fuels. We'd have been far more primitive, but it may not have been worth the risk. But it's not going to happen. Because of the way society is. And because of the competition between different nations. If the U.N. really worked, possibly something like that could stop it. AI is just so useful. It has the potential to do good. China's not going to stop developing it."



Hinton is a cognitive psychologist, known mostly for his work on artificial neural networks, a subset of AGI. Neural networks were inspired by the way neurons are connected in the brain. Artificial neural networks weren't successful at first. They didn't get past the third grade. But Hinton (who is now 76, a good age) kept at it, "tinkering, building bigger neural nets structured in ingenious ways. He imagined new ways of training them…He thought of himself as participating in a project that might come to fruition a century in the future, after he died".[29]

Then, about ten years ago, according to Hinton, things began to change. Mainly, computers got a whole lot faster, and neural nets, using more data that was becoming available on the Internet, started actually doing things. Hinton's contribuition, and the reason Google acquired his company, DDNRESEARCH (which consisted of Hinton and his two collaborators/graduate students, Alex Krizhevsky and Ilya Sutskever) was that they had developed an eight-layer neural network program they named *AlexNet* which could identify images on *ImageNet*.[30] *AlexNet* outperformed the next most accurate image identification program by more than 40%. It was through Deep Learning, one of the subsets of

[29] *THE NEW YORKER*, November 20, 2023.

[30] *ImageNet* is an image database organized according to the *WordNet* hierarchy (currently only the nouns), in which each node of the hierarchy is depicted by hundreds and thousands of images. The project has been instrumental in advancing computer vision and deep learning research. The data is available for free to researchers for non-commercial use.

AGI and a technology which Hinton helped to pioneer, that these improvements were made.

Who would choose not to know how knowing works

Hinton now believes his life's work is responsible for the "existential threat that technology might pose to the harm of our species". He believes the intelligence displayed by AGI systems transcends their artificial origins. This is the reason for the title of the article, *Metamorphosis*. It (an AGI machine) starts out as one thing, and becomes something else, like a butterfly. "Although neural nets like OPEN AI's GPT models are brainlike in that they involve billions of artificial neurons, they're actually profoundly different from biological brains. They do not think the way we do." But their level of "understanding" astonished Hinton, and he felt that they represented a new era in AGI. "They force us to ask if our kind of thinking is the only kind of thinking that counts," he muses.

It's too late to put the genie back in the bottle, and Hinton does not regret the work he has done because so much good can come of it. Nevertheless, he left Google so that he could be free to communicate his concerns about the dangers of AGI. He believes that AGI is truly intelligent, and he expects that it will contribute to many fields. When the article writer asked him, "So what should we do?" Hinton responded: "I don't know." That was an honest answer, and he gave a topical (for those of us reading *THE DISPATCHER*) reason to why it is so difficult. "It would be great if this were like climate change, where someone could say, 'Look, we either have to stop burning carbon or we have to find an effective way to remove carbon dioxide from the atmosphere. There, you know what the solution looks like.' Here, it's not like that."

On the flip side of the AGI coin

It might be worthwhile to know how many people did not sign the FLI letter. Jensen Huang was among those non-signers. *The Chosen Chip* article's author baited Huang with an analogy to extract his reasoning for not supporting the calls for caution. "Some economists have observed that the Industrial Revolution led to a relative decline in the global population of horses and have wondered if AI (meaning AGI) might do the same to humans. Huang quipped: "Horses have limited career options. For example, horses can't type."

It was apparently the revelation that OPENAI's *ChatGPT* was trained on an NVIDIA supercomputer that caused one of the largest single-day gains in stock market history. It was on the 25th of May 2023 when NVIDIA's market value increased by around $200 billion. Huang had told his board a few months earlier that NVIDIA had sold similar computers to the one used on *ChatGPT* to fifty of America's one hundred largest companies. Overnight, NVIDIA was worth more than WALMART and EXXON-MOBIL combined.

Jensen Huang is convincing

Jensen Huang is not an academic. He is not a serial Silicon Valley entrepreneur. He is a businessman. He started his company thirty years ago at the age of thirty with two colleagues over breakfast at a Denny's restaurant in San Jose, California. They were employees of different computer companies at the time. He took the CEO job at the company's founding and has never given it up. His goal was to stay in business. Their product was graphics processing units (GPUs). In 2013, he bet the business on artificial intelligence. The bet paid off—BIG TIME!

GPUs, a category of computing which NVIDIA claims it invented (so they could be a category leader, said Huang), are the alternative to CPUs, or central processing units. CPUs solve mathematical problems one at a time. GPUs break complex mathematical tasks into small calculations and process them all at once. It's called parallel computing. In 2004, NVIDIA began to develop its supercomputing platform called *CUDA* (*Compute Unified Device Architecture*). It was not a hit until a researcher named Geoffrey Hinton wrote to Huang and asked him for some free samples of their super *GeForce* cards, which Huang refused to provide. That was around 2012. Hinton's student and business partner, Alex Krizhevsky, scrounged enough money to buy two of NVIDIA's *GeForce* cards, and used them to train a visual-recognition neural network, and the rest is history, both for NVIDIA and Hinton's startup.

This could be the start of something big

In 2016, NVIDIA delivered its first dedicated AI supercomputer, the DGX-1. The recipient was a research group at OPENAI. It is said that Huang delivered the computer himself, and the then-chairman of OPENAI, Elon Musk, opened the package with a box cutter. Since then, NVIDIA cannot

build DGXs fast enough to meet demand. One of its biggest customers is none other than Elon Musk's TESLA. In July 2023, Musk said that his company was using so much NVIDIA hardware to power its self-driving training systems that NVIDIA could not keep up with its demand. He discussed TESLA's "massive need for high-powered NVIDIA chips" during TESLA's Q2 earnings call. "We're using a lot of NVIDIA hardware," Musk said during the earnings call. "We'll actually take NVIDIA hardware as fast as NVIDIA will deliver it to us. Tremendous respect for Jensen and NVIDIA. They've done an incredible job."

Huang has been fielding an increasing number of questions these days about the risks of AGI. His responses are sanguine, confidently optimistic:

"There's the doomsday AIs—the AI that somehow jumped out of the computer and consumes tons and tons of information and learns all by itself, reshaping its attitude and sensibility, and starts making decisions on its own, including pressing buttons of all kinds," Huang said, pantomiming pressing buttons in the air. "No AI should be able to learn without a human in the loop."

Someone wondered if someday soon an AI might become self-aware. "In order for you to be a creature, you have to be conscious," answers Huang. "You have to have some knowledge of self, right? I don't know where that could happen."

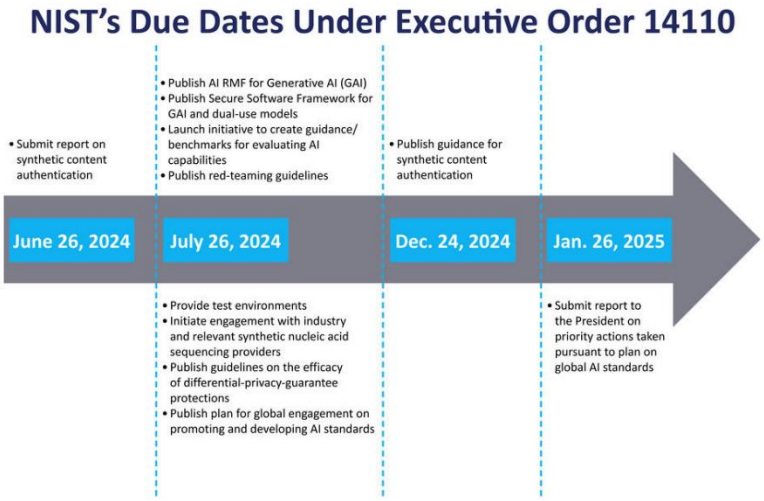
"Deep learning is a method," says Huang. "It's a new way of developing software. I know how it works, so there's nothing there. It's no different than how microwaves work. All it's doing is processing data. There are so many other things to worry about."

Who can you trust: Someone who is building the machines to train the AI agents, who says don't worry; or someone who is building the software to do the training, who says you better be worried? Is artificial general intelligence the ultimate forbidden fruit, or is it a wonder drug, like penicillin or the polio vaccine? Shall we put our faith in politicians to decide this for us, and if not, who will? No one has the answers to any of these questions. All of us need to engage. It would be useful to have some guidelines we could follow.

The serpent said to Adam and Eve that eating the apple, the forbidden fruit, would make them wise, like God.

The U.S. and EU take different paths to regulate AGI

On the 20th of October 2023, President Biden issued *Executive Order 14110 on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. Its purpose is to "build U.S. capacity to evaluate and mitigate the risks of artificial intelligence systems to ensure safety, security, and trust, while promoting an innovative, competitive AI ecosystem that supports workers and protects consumers. The Executive Order instructs the *National Institute of Standards and Technology (NIST)*, an office within the U.S. DEPARTMENT OF COMMERCE, to take the lead in establishing a plan for global engagement on promoting and developing AI standards.[31] Once the NIST has completed its plan, and it has been subjected to public review and internal analysis, the next steps will be defined.



Never let a good vacuum go to waste

That should be the official motto of the *EUROPEAN COMMISSION*. Its *modus operandi* is to be first to occupy the standards-setting space on the chessboard to try to control the board. It was successful with that gambit when it established the *General Data Protection Regulation (GDPR)* so that now, whenever we do a search, we have to click through half a dozen questions to avoid having the entire cookie shop downloaded onto our computers. On the 13th of March 2024, it was announced with the commensurate amount of fanfare (meaning excessively big) that the EU was first with a law that will regulate AI.

The only problem with this statement is that, as usual, the headlines ignore the fact that the still-proposed "Act" has not been officially passed. It was proposed, according to EU procedures, by the *EUROPEAN COMMISSION*. It was voted on by the *EU PARLIAMENT* on the 13th of March, and passed by a vote of 523 in favor, 46 against, and 49 abstentions. It now

[31] Executive Order on Safe, Secure, and Trustworthy Artificial Intelligence | NIST

must be reviewed by lawyers/linguists for correctness of language, then it needs to be reviewed as part of the "corrigendum" procedure to ensure that it meets all the legal requirements, and then it must be formally approved by the *EUROPEAN COUNCIL* comprised of the heads of state of the 27 EU member countries, the President of the *COUNCIL*, and the President of the *EUROPEAN COMMISSION*. Then, and only then, is it official. But we can pardon everyone for thinking that once something is presented by the *EU COMMISSION*, it is a done deal because that is most often the case. The *COUNCIL* is expected to vote on it in May.[32]

To dream the impossible dream

The EU's AI Act, when passed, will establish a European AI office which will be responsible for coordinating compliance, implementation, and enforcement of the Act's rules.[33] The EU was determined to be first out of the box with binding rules so that its rules would become the de facto standard for the rest of the world. It wants to be the go-to AI regulator, just like it believes it is the go-to privacy regulator. What really happens next with artificial general intelligence, what the AI Act is attempting to control, will not be determined in Brussels no matter how much Brussels wishes to make it so. It will not be determined in Washington, DC or in Beijing either. It will be determined by companies developing the applications, and the consumers who will use it; how much the former can get away with and how much the latter will tolerate.

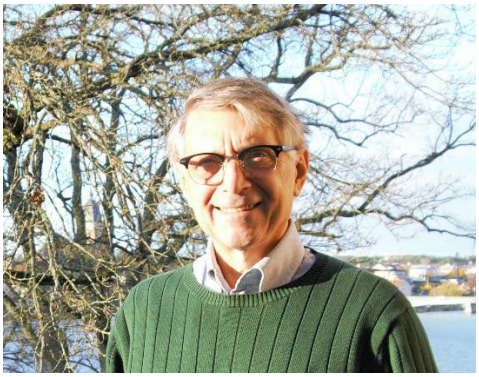
[32] Europe one step away from landmark AI rules after lawmakers' vote | Reuters

[33] https://www.technologyreview.com/2023/12/11/1084942/five-things-you-need-to-know-about-the-eus-new-ai-act/

About Michael L. Sena

Through my writing, speaking and client work, I have attempted to bring clarity to an often opaque world of highly automated and connected vehicles. I have not just studied the technologies and analyzed the services. I have developed and implemented them, and have worked to shape visions and followed through to delivering them. What drives me—why do what I do—is my desire to move the industry forward: to see accident statistics fall because of safety improvements related to advanced driver assistance systems; to see congestion on all roads reduced because of better traffic information and improved route selection; to see global emissions from transport eliminated because of designing the most fuel efficient vehicles.

This newsletter touches on the principal themes of the industry, highlighting what, how, and why developments are occurring so that you can develop your own strategies for the future. Most importantly, I put vehicles into their context. It's not just roads; it's communities, large and small. Vehicles are tools, and people use these tools to make their lives and the lives of their family members easier, more enjoyable and safer. Businesses and services use these tools to deliver what people need. Transport is intertwined with the environment in which it operates, and the two must be developed in concert.



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