AGL:
A UNIFIED POSITIONING AND NAVIGATION SYSTEM FOR INDOOR SPACES

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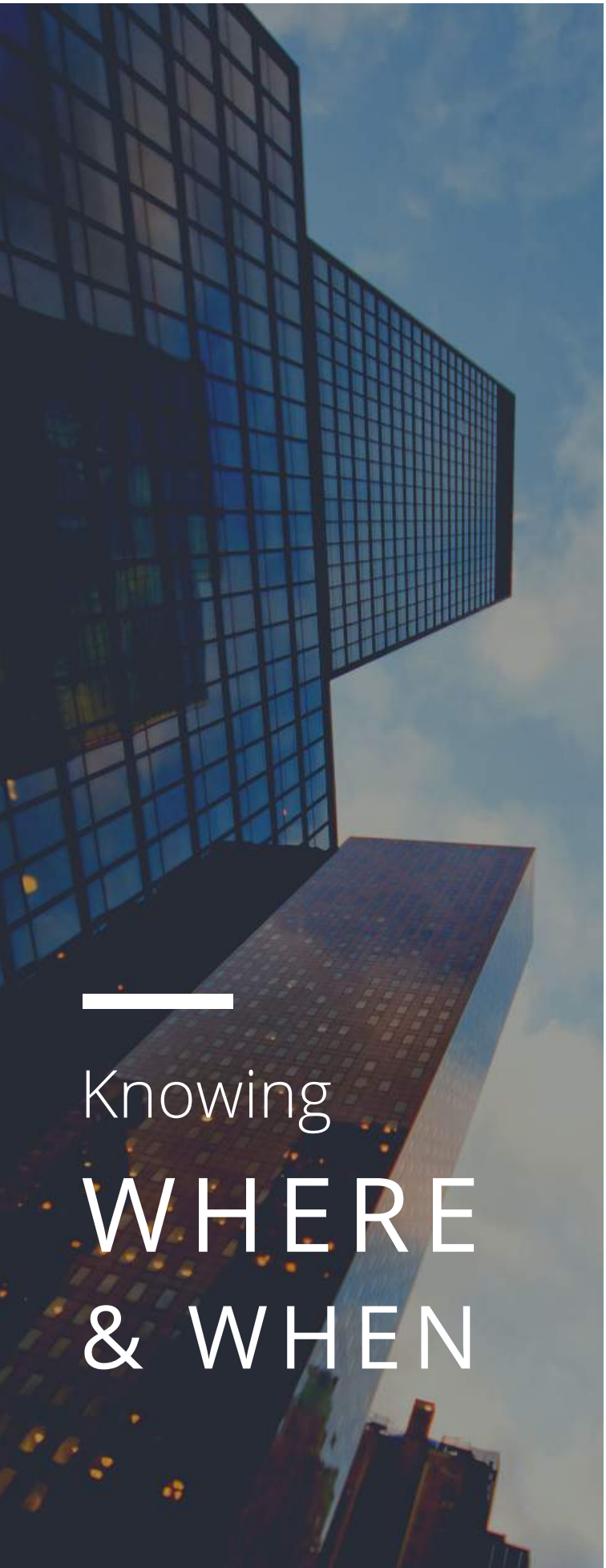

THE DAWN OF MANUALLY & AUTONOMOUSLY GUIDED ROBOTICS

Information on the location and timing of events, objects, and people has always been important. But recent technological trends have turned the acquiring, provisioning, and exploitation of this so called *spatio-temporal information* into the next frontier in scientific and technological progress, economic and social development, national security, and governance.

- The first big factor is the ubiquitous availability of cheap connectivity (especially wireless connectivity) and computing resources. Nowadays we can buy a wireless transceiver chip along with an application micro-controller for just a few euros.
- The second big factor is the huge potential of from the increasing availability of big data, through IoT enabled devices and widespread adoption of personal computing devices like smartphones. From a business point of view, the value of this data, can be tremendously increased if each data item has precise spatio-temporal information embedded. This is where location and timing information has the biggest potential to for impact across muitiple applications.
- The third big factor is the dawn of manually and autonomously guided robotics, especially in indoor environments, factory lines and mega warehouses; the frontier of the Industry 4.0 revolution. Real-time spatio-temporal information is not only needed for positioning and navigation of these devices, but also for situational awareness of these assets by management and control systems.

For positioning and timing information, many applications across a wide range of market segments rely on the Global Navigation Satellite System (GNSS) – commonly known as GPS. GPS is a truly global and scalable system. With the widespread availability and use of GPS enabled devices, pretty much every one of us recognizes the usefulness of this technology: being able to find our location and navigate through unknown places with relative ease. The technology underpins a vast majority of applications in our daily life and in a way, can be termed as an invisible utility very much like the internet, and it is hard to imagine life without it. For countries like the US and UK, a potential countrywide loss of GPS service is estimated to cost the economy more than $1.0bn per day.

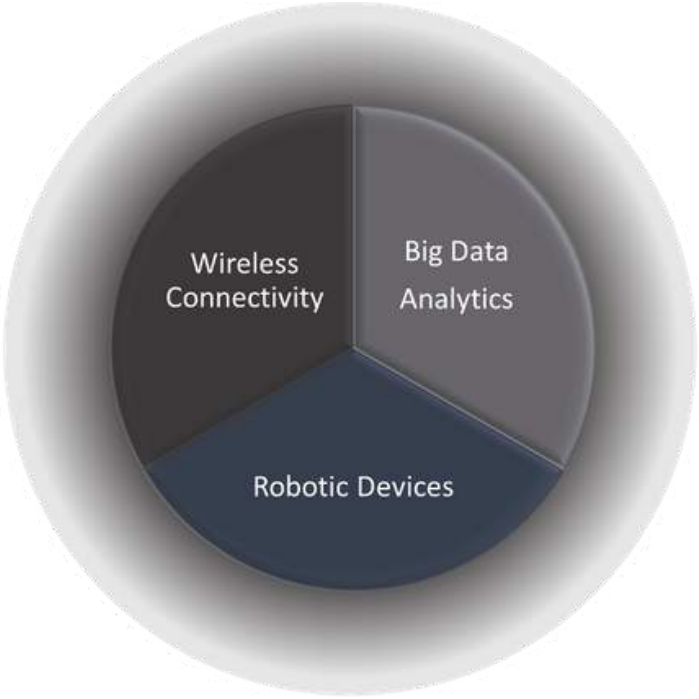

FIGURE 1: KEY TECHNOLOGY TRENDS THAT TURNED SPATIO-TEMPORAL INFORMATION SYSTEMS INTO THE NEXT FRONTIER.

When it comes to operation in covered spaces (e.g., inside airports & public venues, industrial environments, tunnels, and mines), this otherwise amazing system simply does not work. In indoor spaces, the coverage of GPS is not available and even if the signals are there, accuracy of 50m is inadequate to support indoor applications. This provides motivation to invest research efforts to develop and realise innovative solutions that can work in areas with no or intermittent GPS signals, and so extend and expand the economic and societal benefits of the GPS technology to the indoor environment.

The growth of solutions for indoor spaces is both driven by the demand from on application side, and often, interesting results from the technology side. When designing a positioning and navigation system, there are three key components: technology, algorithms, and applications, as shown in **Figure 2**.

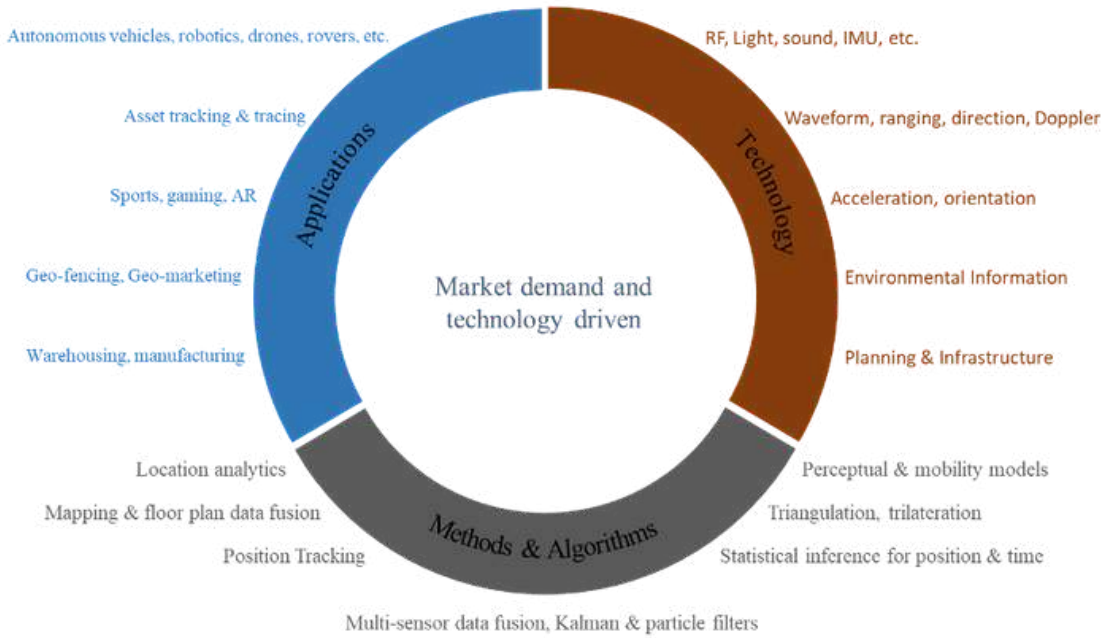

FIGURE 2: KEY COMPONENTS OF A POSITIONING AND NAVIGATION SYSTEM.

RF TECHNOLOGY HAS POTENTIAL TO BRIDGE THE GAP IN COVERAGE AND ACCURACY

It is possible to design a positioning and navigation system based on many different technologies, like radiofrequency (RF), optical, acoustics, inertial measurement units, or a combination.

- ·Inertial measurement unit (IMU) based solutions are proliferating due to the widespread adoption of personal computing devices that have built-in IMU. The well-known drift problem of this technology limits the accuracy and autonomy that can be achieved with this type of solution. They are really only effective when used in combination with other types of technologies.
- ·Sound-based solutions provide limited range, accuracy, and update rate (e.g., due to order of magnitude difference in speed of sound and RF signals).
- ·Light-based (visible and non-visible) solutions can provide accuracy down to a millimeter range but are bulky and relatively expensive offering limited economies of scale. They need optical line-of-sight (LoS) and work well in highly structured environments. Positioning and navigation with light-based solutions involves intensive computations (e.g., image processing with machine learning algorithms) that are battery power hungry rendering these solutions relatively expensive.
- ·GNSS is an example of an RF system on a large, global scale . RF technology offers potential to bridge this gap in coverage and accuracy at a fraction of the cost of expensive LIDAR and advanced machine vision-based solutions. RF LoS is required instead of optical LoS, where the latter is a clearly restrictive condition.

	IMU-Based	Sound-Based	Light-Based	RF-Based
Position Accuracy Range	m-range	cm-range	mm-range	cm-rage
Area Coverage	High	Low	High	High
Error Drift Issue	High	-	-	-
Timing Information	No	Yes	No	Yes
Infrastructure	No	Yes	No	Yes
Environmental Structure Dependence	-	-	High	-
Resources Demand on End-device	Low	Low	High	Low
Benefit of Economies of scale	Low	High	Low	High

FIGURE 3: COMPARISON OF MOST RELEVANT TECHNOLOGIES.

Figure 3 compares typical solutions for indoor spaces under the four most relevant technology categories. As such different technological solutions are not mutually exclusive, and can be deployed in complementary way, fusing information from multiple systems on opportunistic basis whenever and wherever available such that the joint hybrid system is more robust, more accurate, and more reliable.

In the RF category, RFID technology and the common consumer wireless access technology standards, WiFi and Bluetooth Low Energy (BLE), are widely leveraged in developing solutions for positioning of objects and people in the indoor spaces. More recently, solutions based on the ultra-wideband (UWB) technology are gaining increasing traction in the indoor positioning and location services market. **Figure 4** compares key characteristics of these four RF technologies.

	RFID	WiFi	BLE	UWB
Position Accuracy Range	Proximity detection	15 m	3 – 10 m	10 – 50 cm
Area Coverage	<= 1 m	< 150 m	< 75 m	< 150 m
Battery Life	-	Medium	High	Medium
Cost	Very low	Medium	Low	High

FIGURE 4: COMPARISON OF POPULAR RF TECHNOLOGIES FOR INDOOR POSITIONING APPLICATIONS

When it comes to building alternatives to the GPS system, no one-size (solution, technology, system) will fit the needs of all operational environments. A more practical and plausible approach is to develop specialised autonomous systems that work well for a particular environment or a set of environments but make the application interface standardised and cross-compatible, such that the information from multiple systems can be easily fused together on an opportunistic basis, whenever and wherever available, to build a unified system, that is more intelligent, more accurate and more reliable.

This concept is illustrated in **Figure 5**. While developing the AGL system, Agilica adopted this approach. We focused on the indoor segment and built a unified positioning system and methods for both asset tracking and navigation applications, while making the application interface compatible with the GPS system - the result: the ability to enable seamless transition of GPS applications between indoor-outdoor environments. The AGL solution is based on UWB wireless access technology and offers positioning accuracy down to 10 cm.

SEAMLESS TRANSITION: GPS OUTDOORS TO AGL INDOORS - POSITIONING & NAVIGATION

Our research shows that the currently available alternatives in the market for indoor spaces are mostly for positioning and tracking of assets and are incompatible with existing on-board GPS based navigation systems and there is lack of confidence regarding the scalability and flexibility of those solutions, especially in terms of the number of end-user devices that can operate simultaneously in an area, their position update rate, and spatial area coverage.

The **AGL** solution from **Agilica** is targeted to fill this gap by providing a unified positioning system and methods, and spatio-temporal analytics platform to provide a unified digital picture of the assets and their movement pattern.

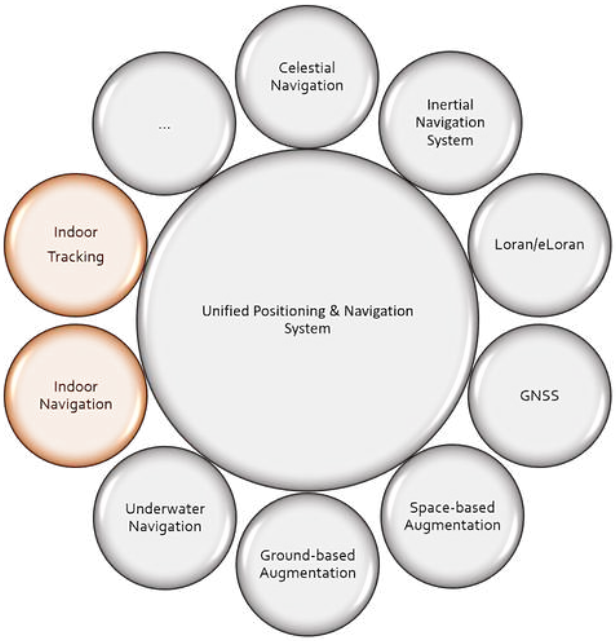

FIGURE 5: CONCEPT OF UNIFIED POSITIONING AND NAVIGATION SYSTEM.

With AGL we are extending and expanding the positioning and navigation services to the indoor spaces by providing the end-user a flexible and scalable infrastructure that can easily be adapted to the changing needs and scale of the inside space. The AGL system supports both asset tracking and navigation applications simultaneously and offers user interface compatible with GPS, enabling easy integration with existing applications. **Figure 6** illustrates the architecture of the AGL system which comprises a set of anchor nodes that constitute the AGL network infrastructure simultaneously supporting both the navigation tags and asset tracking tags.

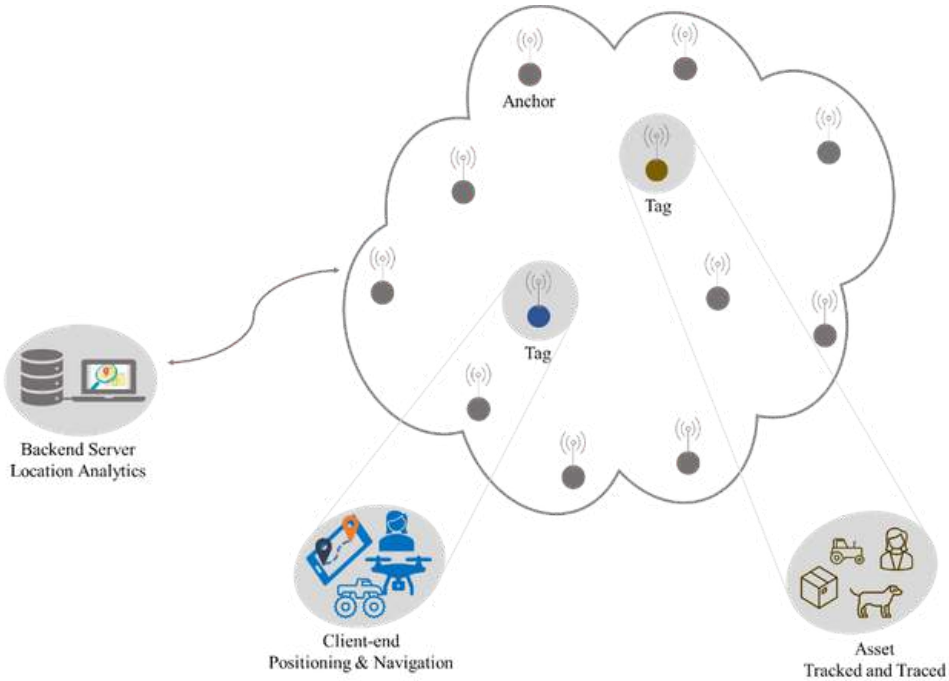

FIGURE 6: AGL SYSTEM ARCHITECTURE.

There are several use cases in the indoor space where both types of applications are present at the same time. **Figure 7** illustrates a typical use-case in a warehouse where AGL is enabling positioning and tracking of a set of assets while simultaneously providing positioning and navigation services to a set of human and robotic users. Similar needs exist in manufacturing plants and other industrial environments where manually and autonomously guided mobile robotic devices are being introduced on the factory floor; with the Industry 4.0 revolution there is a renewed emphasis on finding and removing process inefficiencies and building digital twins of the physical infrastructure, processes, assets, and people; and location-based analytics are spurring processes automation on an unprecedented scale. There are several other use cases in a wide variety of other verticles like shopping malls, tradeshows, hospitals, healthcare facilities, airports and other public venues where there is a need for positioning and navigation services and location-based services for human and other assets.

FIGURE 7: A TYPICAL USE-CASE WHERE THE AGL SYSTEM IS ENABLING POSITIONING & TRACKING ASSETS WHILE SIMULTANEOUSLY PROVIDING POSITIONING & NAVIGATION SERVICES HUMAN AND ROBOTIC USERS.

Figure 8 below, illustrates the AGL ecosystem map from the end-users perspective. Currently available solutions have scalability, flexibility, and compatibility issues which the AGL system addresses by offering a unified positioning system and methods, and a user interface compatible with the GPS. Simply put, AGL offers a solution to deliver the best, whether it is autonomous drones, asset tracking or location analytics, you as the end-user will always find exactly what you need and when you need it.

EXACTLY WHAT YOU NEED, WHEN YOU NEED IT

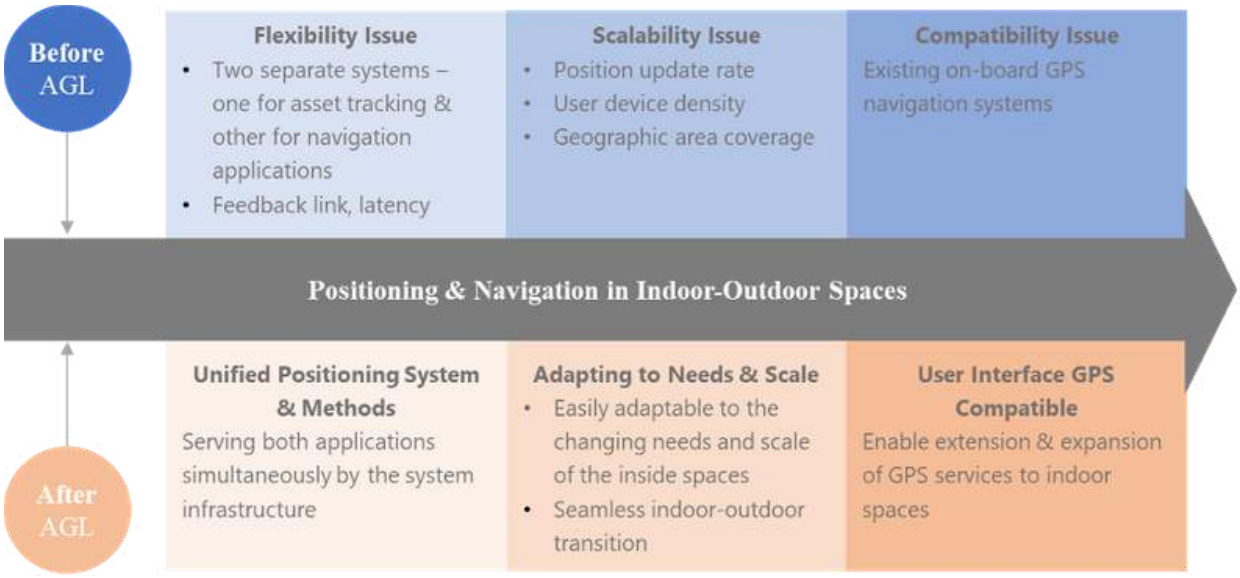

FIGURE 8: THE AGL ECOSYSTEM MAP

We protect this competitive positioning with barriers enabled by patented technology, solid knowledge and knowhow, unique skills and background within the R&D domain in the defense industry.
More information on the AGL solution is available at our website **www.agilica.be**

Contact us to explore the possibilities:

- Real-time location visualisation & analytics
- Geotagging, geofencing and heatmaps of indoor mobile assets
- Indoor navigation for autonomous vehicles and robotics
- Smart Supply Chain & Automated Intralogistics
- Automated Indoor Farming / Hydroponics
- GPS systems testing indoors - robotics, automotive etc.
- Subterannean tracking and worker safety - mining, railway etc.
- Indoor Drone landing systems