European
Global Navigation
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GNSS IN IOT APPLICATIONS

Justyna Redelkiewicz Musial

Head of Sector LBS and IoT, European GNSS Agency

European GNSS Agency

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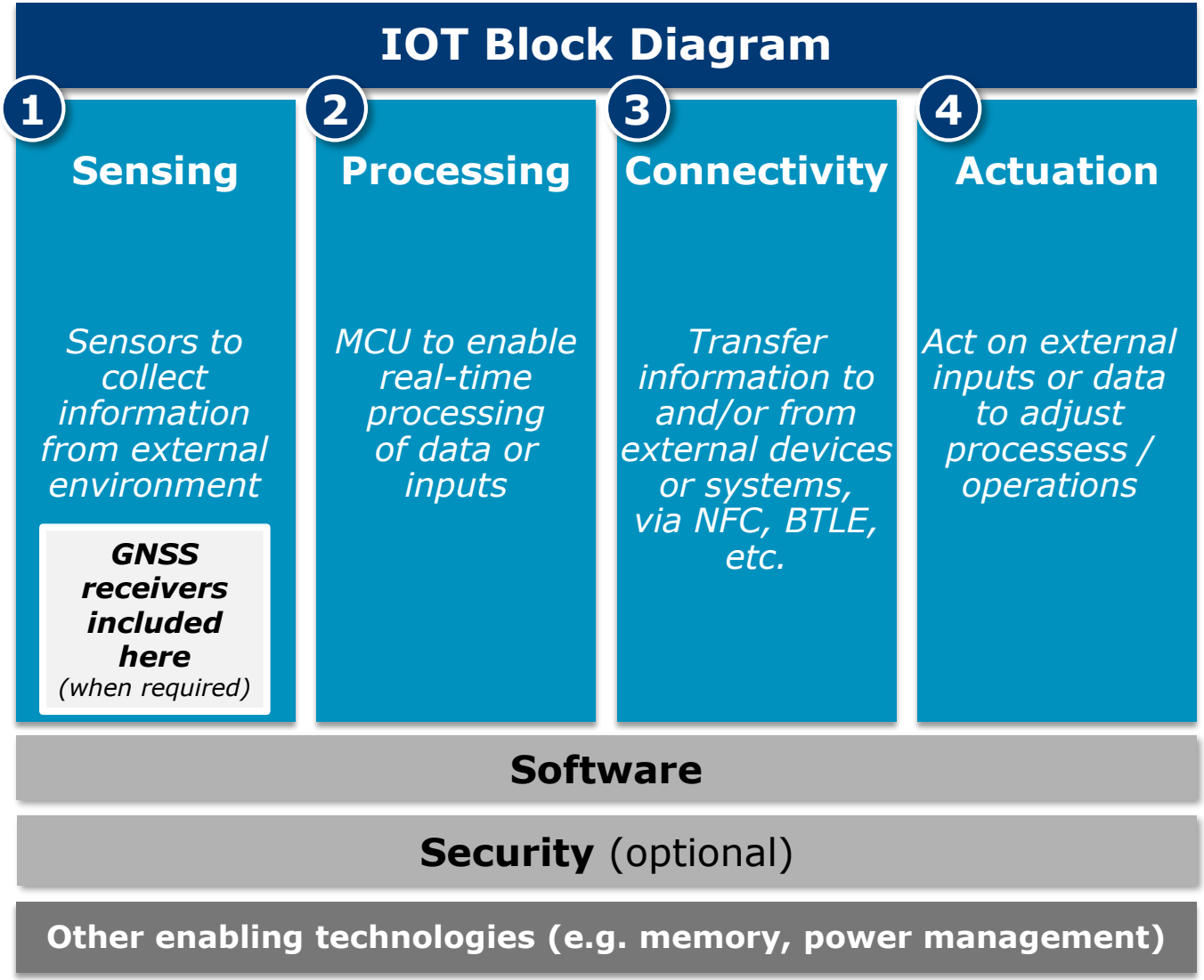
This presentation can be interpreted only together with the oral comments accompanying it

Internet of Things can be categorized into four building blocks where sensing is the enabler



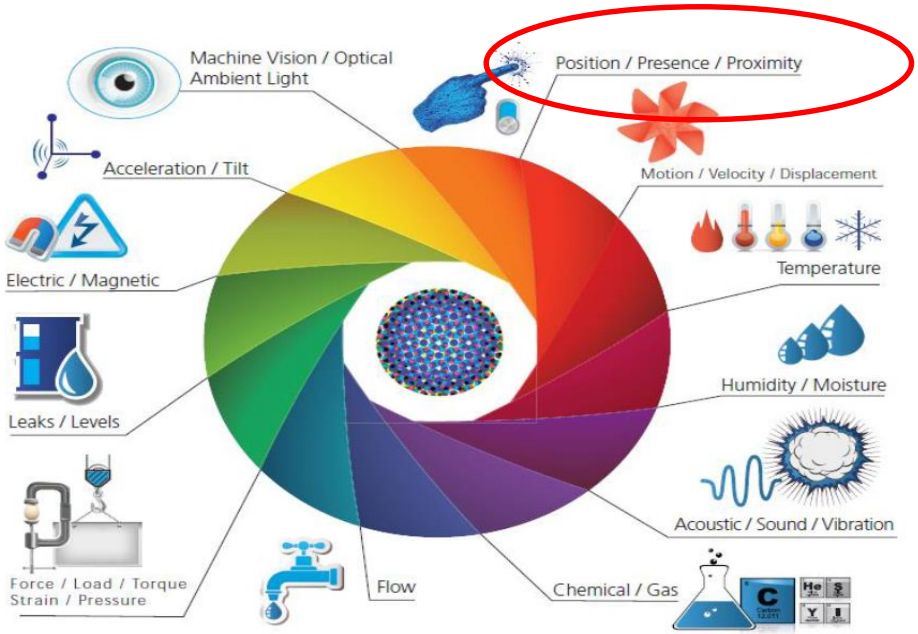
Source: Bain analysis, 2016

There is a large number of sensors enabling IoT, among which positioning sensors are key

Location information spans the area of identifying where IoT devices are in relation to their origins, destinations or other adjacent devices.

What is the value of sensors capturing identity, environmental data, and status among other things if the consumer of this data doesn't have the contextual location information to give this data some meaning?

Without sensors there's no IoT



Source: Harbour Research: "What exactly is the internet of things"

Several technologies can provide positioning capabilities relevant to locate “things”

Main absolute positioning technologies and accuracy

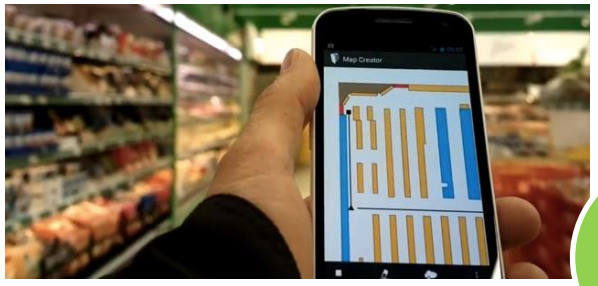
	Indoor	Outdoor	Accuracy
Network based	Cell-ID		200-5000m
	Cell Tower Triangulation		50-1000m
Handset based		GNSS	1 - 50m
Hybrid		A-GNSS	
Infrastructure based	Wi-Fi		3-10m /20-50m
	Bluetooth		3-10m
	UWB		20 cm-10 m
	RFID		<3m

- **Network based**: (Cell-ID, E-OTD, TDOA etc.) using the telecommunication networks
- **Handset based**: (GNSS) the handset itself is the primary means of positioning the user. The A-GNSS corresponds to a hybrid technology based on the GNSS but using the cellular network
- **Infrastructure based**: (Bluetooth, UWB, Wi-Fi or RFID) the position is computed by evaluating of the distance between the device and transmitters (for example a Bluetooth beacon or a Wi-FI router)

Internet of things is interlinked with new concepts where location is essential

Smart factories

Big data processing



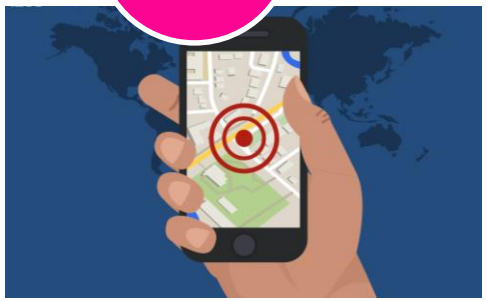
Ubiquitous positioning

Internet of Things

Smart cities

Tracking of objects and people

Autonomous vehicles and drones



IoT requires ubiquitous positioning to locate things everywhere

Ubiquitous positioning

Positioning and navigation play an increasingly important and pervasive role in our day to day lives enabling new applications in different fields.

In some cases GNSS have made this a trivial problem. In others, for example indoors or near buildings, accurate positioning is still a considerable technical challenge.

Ubiquitous navigation requires an accurate and timely estimate of a user's position at all times, in all environments and across all modes of transport.

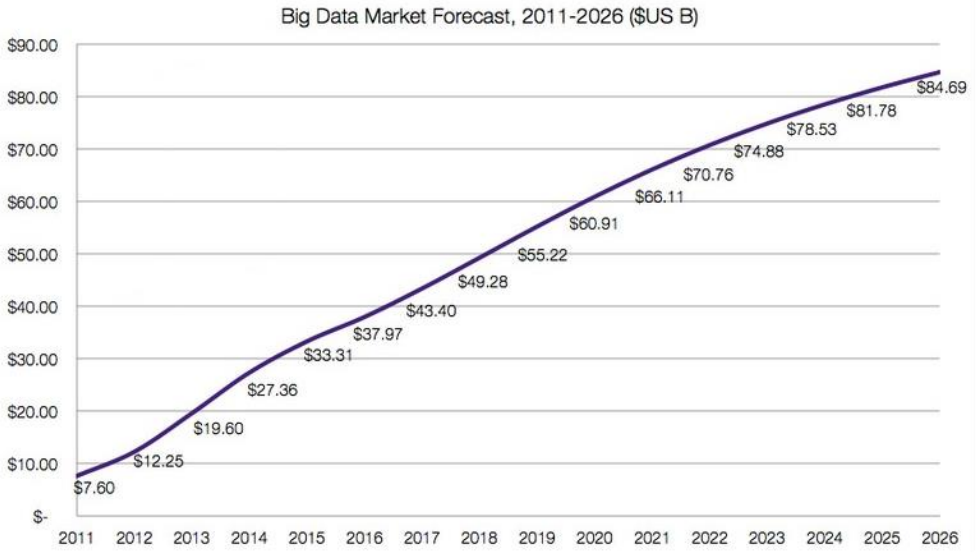
Examples of applications that will benefit from effective ubiquitous systems include:

- ✓ extending and completing the concept of augmented reality
- ✓ facilitating targeted advertising
- ✓ stock tracking
- ✓ airport navigation
- ✓ museum tours

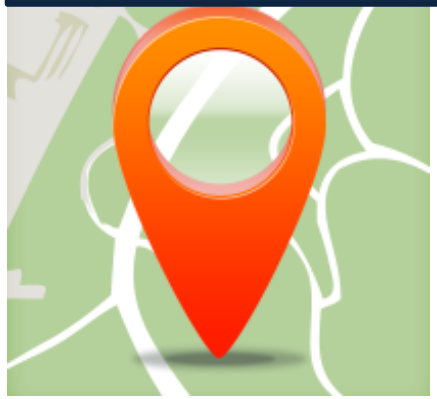
The management of big data is now possible, bringing new business opportunities

Big data processing

Wikibon projects the Big Data market will top $84B in 2026, growing at 17% Compound Annual Growth Rate (CAGR) for the forecast period 2011 to 2026



Positioning information are an important part of big data reality



The volume of mobile data and the speed at which it is created is only going to increase as both the global population and mobile device penetration rates rise, and the use of social media increases.

Mobile device data becomes particularly useful for analytics purposes when combined with positioning and outside data sources, such as weather data and economic data.

Example of Red Roof Inn shows how managing big data enables new LBS applications

Big data processing

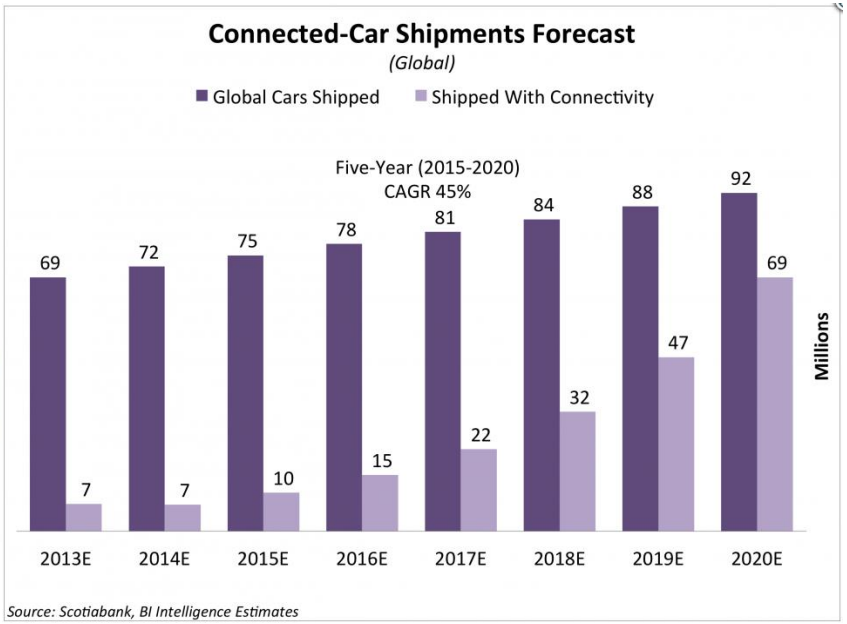
The company sourced freely available weather and flight cancellation information, organized by combinations of hotel and airport locations, and built an algorithm which factored weather severity, travel conditions, time of the day and cancellation rates by airport and airline among other variables.

With its big data insights, and recognition that travellers will be using mobile devices for this use case, the company used LBA mobile campaigns to deliver targeted mobile ads to stranded travellers and make it easy for them to book a nearby hotel achieving a 10% business increase.

Source: http://www.crmsearch.com/retail-big-data.php

New technologies are transforming the automotive sector

Autonomous vehicles and drones



A McKinsey interview finds that 13 percent of **buyers are no longer considering a new vehicle without Internet access**, and more than a quarter already prioritize connectivity over engine power and fuel efficiency.

Yet while drivers are eager for the benefits of car connectivity, they also express **concerns** :

- worry about digital safety and data privacy
- limited willingness to pay for car connectivity features

Source: McKinsey: “What’s driving the connected car”

GNSS will play a key role in most of the connected car applications

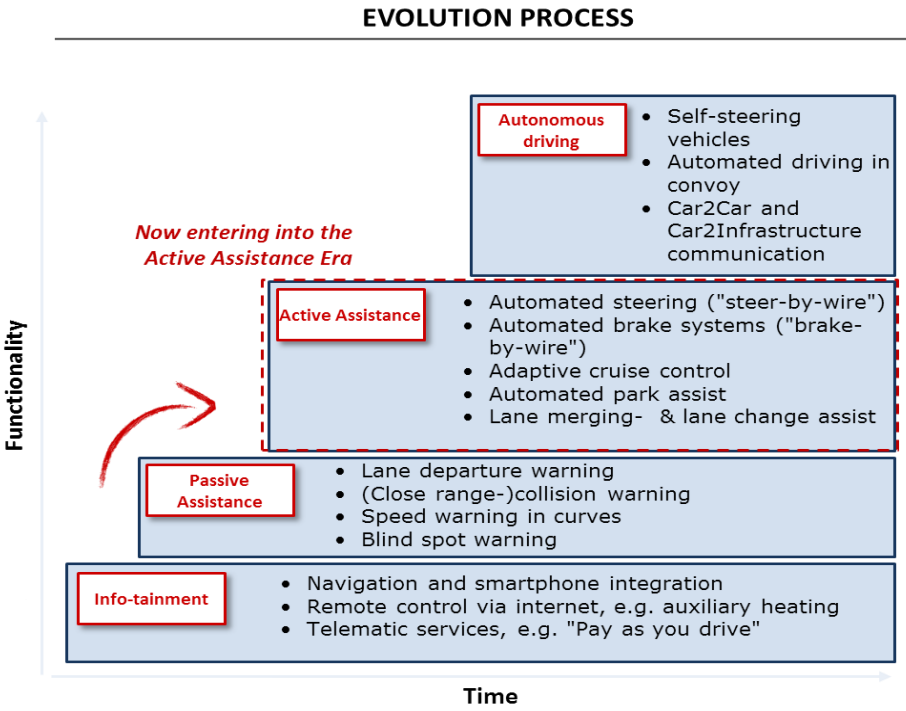
Autonomous vehicles and drones

Connected cars are likely to include the following capabilities:

- ✓ Integration with home networks*
- ✓ Data exchange with insurers, manufacturers and third parties*
- ✓ Diagnostics and vehicle health reports
- ✓ Improved navigation and positioning*
- ✓ In-vehicle WiFi hotspot
- ✓ Payment integration*
- ✓ Streaming of music and Video on Demand
- ✓ Localised information and advertising*
- ✓ Police warnings and location*
- ✓ Car-to-car gaming
- ✓ Real time traffic and incident alerts*
- ✓ Assisted and automated driving*

* GNSS supported

Autonomous Driving is the final step of a long automation process



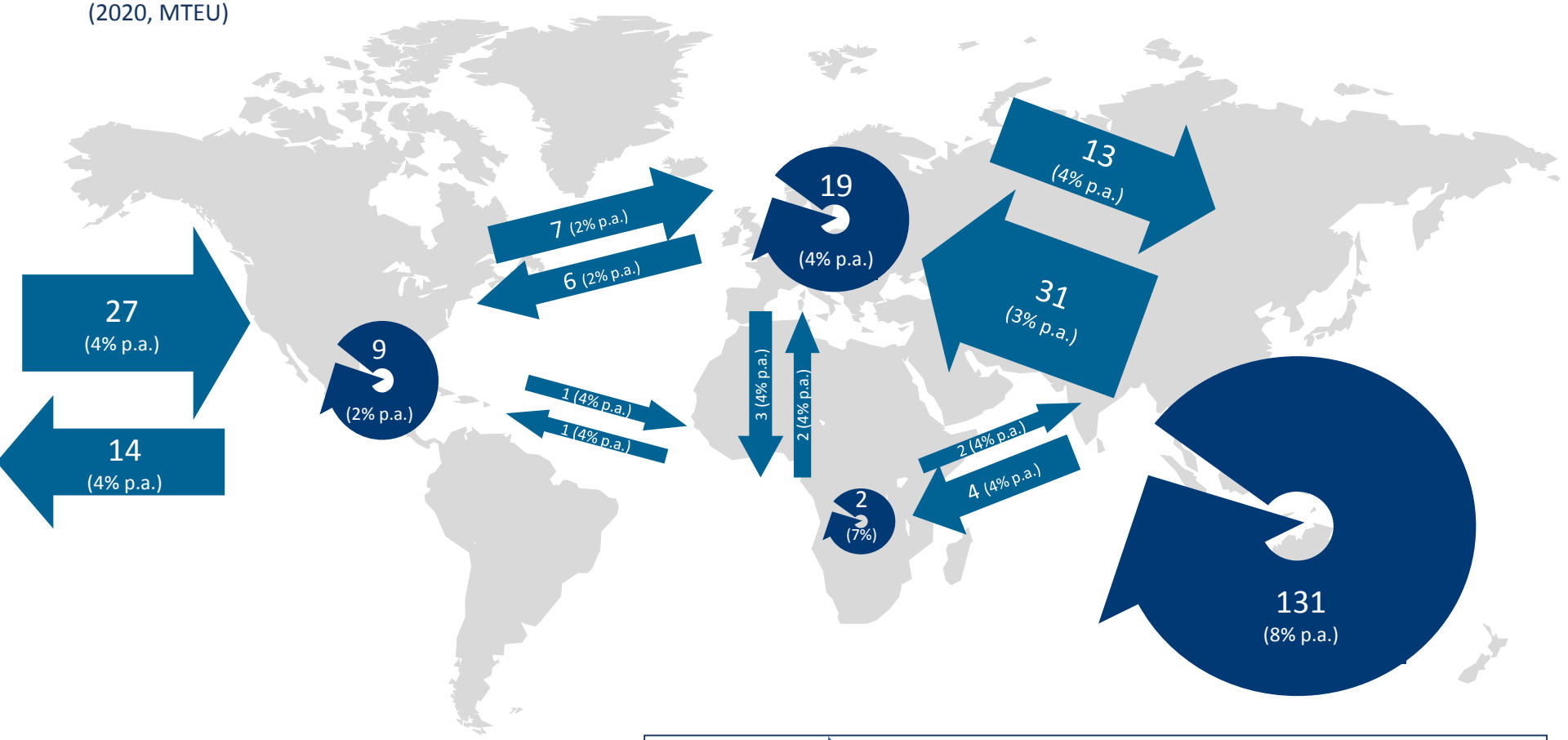
Autonomous vehicles are capable of sensing its environment and navigating without human input.

Autonomous cars exist today mainly as prototypes and demonstration systems.

Intermodal transport growth is driven by containerization of commercial exchanges

Tracking of objects and people

Containers traffic evolution by trade lane
(2020, MTEU)



Note: Including transhipment and empty containers
Source: Drewry 2009; Bain analysis

Example: Traxens using GNSS-based solution for on-the-route positioning

Tracking of objects and people

TRAXENS, container monitoring devices

Traxens has developed a specific low-energy technology for devices allowing them to be energy autonomous for the active life of a container.

These smart devices can decide what information is needed and when to make the best use of energy by only communicating when necessary and by sharing the duty of power transmissions with other neighbouring devices.

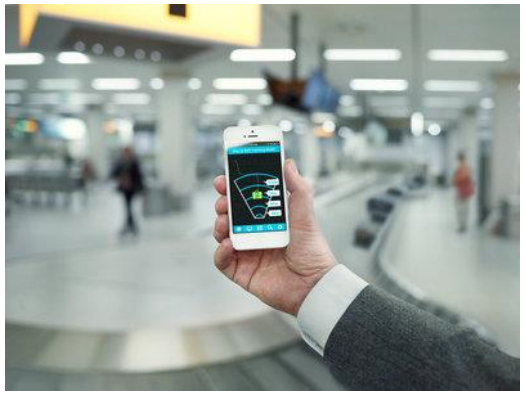
All the data gathered by the devices is available for customers through a dedicated platform service.

Containers are the optimal target for GNSS in a multimodal perspective since they are widely adopted and their capacity is high enough to invest in a GNSS-based device.

GNSS is complemented by other sensors for relative positioning on the vessel or truck.

Example: Connected suitcase, “eTrack” responds to sophisticated user needs

Tracking of objects and people



- Air France KLM developed and experimented “eTrack”, a GNSS enabled device that enable **tracking & tracing** of luggage
- Based on M2M technologies, this device together with the “eTrack” app allows the owner of the luggage to know where his/her luggage currently is
- **Benefits include**: faster bag drop process, improved airline/ airport efficiency, reduced stress for travellers, improved customer experience (personalization)

Geofencing further enhances the concept of positioning

Tracking of objects and people

Geofencing is a technology that defines a virtual boundary around a real-world geographical area. In doing so, a radius of interest is established that can trigger an action in a geo-enabled phone or other portable electronic device.

Use	Example
Fleet management	When a truck driver breaks from his route, the dispatcher receives an alert
Human resource management	An employee smart card will send an alert to security if an employee attempts to enter an unauthorized area
Compliance management	Network logs record geo-fence crossings to document the proper use of devices and their compliance with established rules
Marketing (Location-Based Advertising)	A restaurant can trigger a text message with the day's specials to an opt-in customer when the customer enters a defined geographical area
Asset management	An RFID tag on a pallet can send an alert if the pallet is removed from the warehouse without authorization
Law enforcement	An ankle bracelet can alert authorities if an individual under house arrest leaves the premises

Example: Wearable devices for kids already provide location-tracking capabilities

Tracking of objects and people

Not all kids are ready for smartphones

Doki Technologies has launched a new smartwatch for kids called the dokiWatch that combines video calling, voice calling, messaging, and location-tracking capabilities in one device.

Location capabilities include:

Smart Locator

The system enables tracking of a child's location using a combination of GNSS, GSM and WiFi technology

AlertArea

The watch can send notifications when the child enters or leaves a defined location (geofencing)

Urban population growth drives the need for Smart Cities

Smart cities

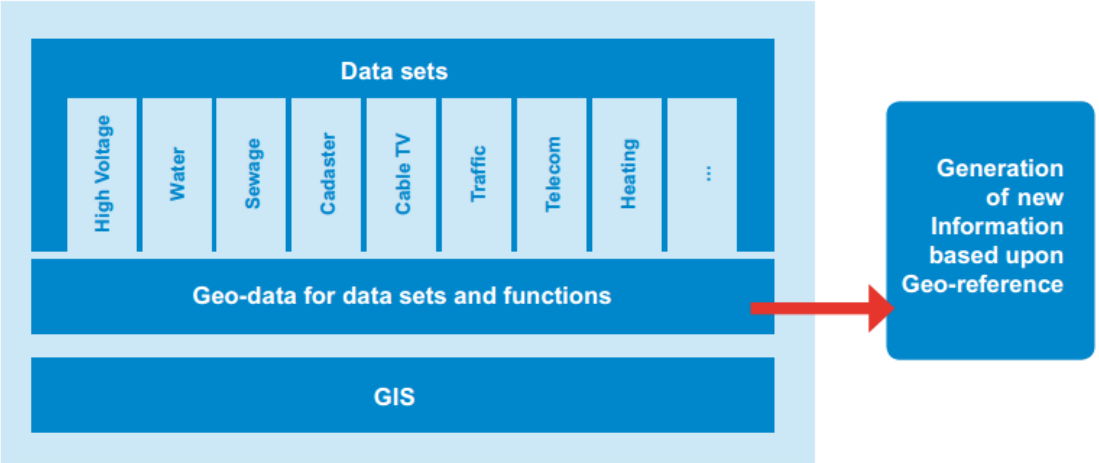
A **smart city** uses digital technologies to enhance quality and performance of urban services, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens.

The market is driven by factors such as non-regulated expansion of cities and urbanization, growth in the construction sector, the widespread adoption of green technology and the stress on cost efficiency in electricity production and distribution.

Sectors that have been developing smart city technology include:

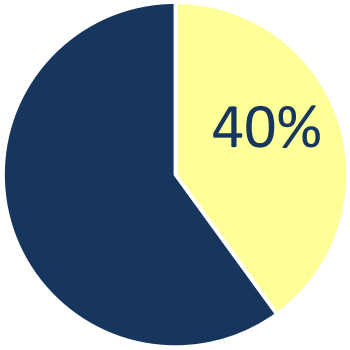
- ✓ Government services
- ✓ Transport and traffic management
- ✓ Energy management
- ✓ Health care
- ✓ Water and waste management

Geospatial data and geographic information systems (GISs) are essential components for building smart cities in a basic way that maps the physical world into virtual environment as a referencing framework.



Example: GNSS enhances street light system performance

Smart cities



Lighting can account for up to 40% of a city's energy consumption.

Cities and other agencies operating large grids of street lights are looking for ever more efficient ways of operating them

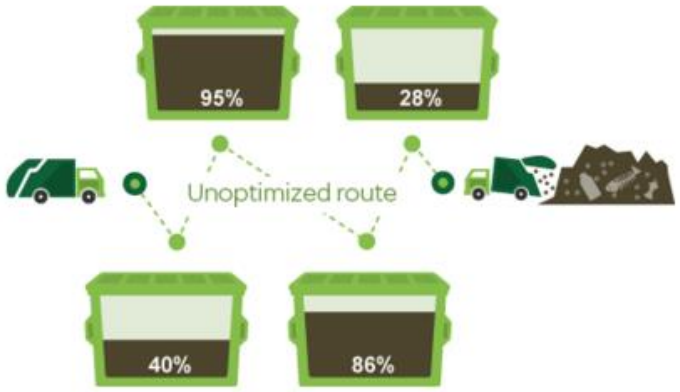
Operation of each lamp could be remotely monitored and controlled to **maximize energy efficiency** and to determine when maintenance is required.

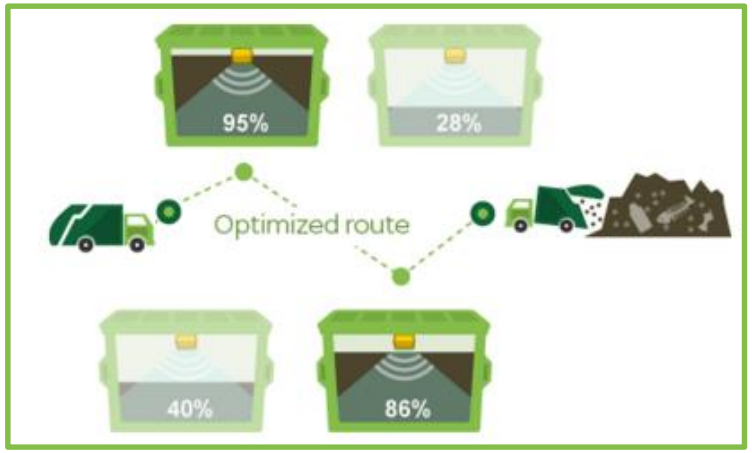
In this solution, each streetlight is equipped with a low cost GNSS receiver and connected to mesh radio network which relays its data to a Cloud Gate Gateway device for review and analysis in a centralized location.

In this way defective lamps communicate their status in real-time and can be precisely located for replacement.

Example: GNSS based Smart Waste Management system optimises routes

Smart cities





Until now the collection of waste and recyclables has been done using fixed schedules where containers are collected every day or every week, regardless if they are full or not.

New generation garbage containers transmit signals to indicate that they are almost full and should be emptied.

Via the mobile communications network, the signals with location information are sent to a central software application used by the waste management company.

This information is taken as a basis to plan the best route for waste collection—garbage trucks travel only to those containers that actually need to be emptied.

Smart Factory solutions provide real-time operational awareness, flexible control and data-driven insights

Smart factories

Example: Geo-fencing enabled autonomous logistics at Ingolstadt

To make sure components arrive punctually at the factory at just the right time for the most efficient assembly, Audi uses geo-fencing technology.

More than 70,000 transport containers have to be delivered to the plant every single day and arrive at the right time to keep production running smoothly.

- Every time one of the long-haul truck approaches the Ingolstadt factory, the “Quick Check-In” app activates when it is 50km away, and informs the plant that goods are approaching
- The app sends its GNSS coordinates, as well as information about the load to the Ingolstadt logistics centre
- Another checkpoint occurs when its 20km away, comparing the ordered materials with what is present on the truck
- Finally, as the truck comes within 3km of the plant, the goods are switched from “in-transit” to “in-factory” and it becomes a part of the plant’s internal logistics processes
- Without having to check in at the truck control room, the driver can directly follow the navigational instructions from his smartphone to bring his load to one of the 60 off-loading points at the plant

In spite of all its possibilities, the GNSS use has some limitations

A — Size

- GNSS module miniaturization helps **reducing the size of IoT devices**, widening the areas of potential applications where size is a constraint

B — Cost

- GNSS module cost reduction contributes to **lower total IoT device cost** eventually increasing adoption in current and new area of application (e.g. substitute RFID tags)

C — Power Consumption

- Reduction of GNSS module power consumption can **help increasing device overall autonomy** with direct benefits in terms of application/service adoption

D — Indoor/ outdoor availability

- Ubiquitous indoor/outdoor positioning is **one of the critical limits of current IoT location based service/applications**

E — Performances

- The improvement in positioning performances (e.g. accuracy, TTFF, etc.) would **directly imply an increase in service quality** in many types of apps/services

F — Robustness to attacks

- System vulnerability **is receiving an increasing attention** from the IoT user community

R&D in progress to overcome these limitations

Galileo is delivering improved performances, tackling some of the limitations

Multi-constellation

•Galileo in combination with other GNSS provides improved **accuracy, availability** and allows for a **faster time-to-first-fix***

Galileo OS Authentication

• Galileo is expected to be the only GNSS providing Open Service authentication, data encryption solutions allowing PSAP to be **the most confident about the distress person location**

Multipath Resistant

•The strength of Galileo signal, together with an advanced code modulations, makes Galileo **better mitigating multipath effects** (especially in E5, but also E1)**

Data-less signal of Galileo

• Using the data-less signal with a 100ms length for the secondary code, Galileo allows for an **enhanced indoor penetration, improved performances in urban canyon, better performances in noise measurements and improved sensitivity in A-GNSS mode**

Enhancement of currently offered services

Development of new value-added services

*Source: "Experimental Results for the Multipath Performance of Galileo Signals Transmitted by GIOVE-A Satellite", Andrew Simsky, DavidMertens, Jean-Marie Sleewaegen, Martin Hollreiser, and Massimo Crisci, Septentrio, ESA, 2008

**Source: "Estimating the Time-To-First-Fix for GNSS Signals Theory and Simulation Results"' *Marco Anghileri, Matteo Paonni, Stefan Wallner, José-Ángel Ávila-Rodríguez, Bernd Eissfeller, Institute of Geodesy and Navigation, University FAF Munich, Germany'*

Funded by the Fundamental Elements programme, the development of low-end receiver core technology will target IoT applications

With the objective to support the European industry to enter and consolidate market share in the emerging mass market applications **enabled by IoT**, GSA has issued in Q1 2016, a call for proposals for the development of low-end receiver core technology.

The foreseen outcome of the project is an evolution of consumer singles frequency chipsets meeting the requirements of new highly specialised applications, including:

- Power consumption optimisation
- Reduced size and weight
- Interference detection and mitigation
- Multipath mitigation
- Use of signals of opportunity
- Carrier phase tracking for smartphone
- Use of augmentation sensors and data fusion

GSA

Fundamental Elements

Horizon 2020 Applications in Satellite Navigation – Galileo – 2017 Call Is Published!

http://ec.europa.eu/research/participants/portal/

A budget of € 9 mln will be allocated to EGNSS for applications in mass market

Proposals should aim at developing new innovative applications, with commercial impact and a clear market uptake perspective.

The following areas have been identified as especially promising for further EGNSS applications development:

- ✓ Mobility as a service and Smart Cities
- ✓ Internet of things
- ✓ Commercial and social LBS

GSA special prize for Geo IoT World Awards 2016 aims to promote innovation

UBIGNSS solution for GNSS in tracking apps

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THANK YOU

justyna.redelkiewicz@gsa.europa.eu