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OGC Benefits of Indoor Location -
Use Case Survey of Lessons Learned and Expectations

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BENEFITS OF INDOOR LOCATION

USE CASE SURVEY OF LESSONS LEARNED AND EXPECTATIONS

VERSION 1 – MAY 2016

Editors: Giuseppe Conti (Trilogis Srl, Italy and Nively, France), Fabio Malabocchia (TIM, Italy), Ki-Joune Li (Pusan National University, South Korea), George Percivall (OGC, USA), Kirk Burroughs (Qualcomm, USA), Stuart Strickland (HP, USA).

Jointly edited by:

Indoor/outdoor LOCation and Asset management Through open gEodata

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1 Executive abstract

Indoor location technologies are enjoying and increasing market success. Technologies in the market have achieved maturity and have become a key driver for innovation and business activities in several value added scenarios, e.g. e-government services, eHealth, personal mobility, logistics, mobility, facility management, retail, to name but a few.

This paper collects the results of a survey on the benefits of indoor location, which was jointly prepared and launched by OGC – the Open Geospatial Consortium, InLocation Alliance and i-locate project at the beginning of 2016. Overall, 153 survey responses were received from 33 countries. Responses were categorized in two areas: Client Organizations and Technology suppliers.

The goal of the initiative was to acquire a broad view of the requirements and use cases emerging from the wider industrial and user community, beyond the memberships of the various organizations, in order to capture trends, challenges and opportunities, as well as trends and barriers to widespread use of indoor location technologies.

This paper does not represent a view of the membership involved in the different organizations; instead, it provides the opportunity to capture recommendations of relevance for the industrial and standardization community these organizations represent.

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4 Acronyms

API	Application Programming Interface
AR	Augmented reality
BIM	Building Information Model
CAGR	Compound Annual Growth Rate
CNIL	Commission Nationale de l'Informatique et des Libertés (French National Commission for IT and Freedom)
CPN	Centraal Planbureau (Netherlands Bureau for Economic Policy Analysis)
EC	European Commission
FM	Facility Management
GDF	Geographic Data Files
GML	Geography Markup Language
HTTP	Hypertext Transfer Protocol
ICT-PSP	The Information and Communication Technology Program of the European Commission
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEEE-ISTO	IEEE Industry Standards and Technology Organization
IFC	Industry Foundation Classes
ILA	InLocation Alliance
ISO	International Organization for Standardization
JOSM	Java OpenStreetMap editor
LBMA	Location Based Marketing Association
LBMA DACH	LBMA chapter Germany (D), Austria (A), Switzerland (CH)
LBS	Location Based Services
LED	Light-Emitting Diode
Li-Fi	Light Fidelity

MLS	Mobile Location Services
OASIS	Organization for the Advancement of Structured Information Standards
OGC	Open Geospatial Consortium
OMA	Open Mobile Alliance
OS	Operating System
OTT	Over-The-Top content
PS	Point-Of-Sale
RF	Radio Frequency
RF	Radio Frequency
RoI	Return on Investment
RSSI	Received Signal Strength Indication
RTT	Round-Trip Time
SAS	Sensor Alert Service
SOS	Sensor Observation Service
SUPL	Secure User Plane Location
TC	Technical Committee
TC211	Technical Committee on Geographic information/Geomatics
TCO	Total Cost of Ownership
TOC	Table of Contents
UAV	Unmanned Aerial Vehicle
VIM	Verbal Indoor Maps
VLC	Visible Light Communication
WFS	Web Feature Service
WMS	Web Map Service
WPS	Web Processing Service
XML	Extensible Markup Language

5 Introduction

We spend large share of our time indoors, be this at home, at work, while shopping or travelling, often in unfamiliar environments. Indoor Location Based Services (LBS) are not just an extension of outdoor location applications but they represent a true driver for innovation & business activities in several value added scenarios across a variety of domains such as e-government, eHealth, personal mobility, logistics, mobility, facility management, retail, etc. If compared to outdoor location services, the wide range of human activities that take place in indoor environments yield brand new use cases with unique requirements and challenges. These innovative use cases will affect most human activities by redefining our relationships with the indoor environment and our knowledge about the interactions and between businesses and their customers, companies and their employees and assets, and among each other.

According to recent market analysis[1] the market of indoor LBS will keep expanding at fast rate growing almost five-fold from 2014 to 2019, reaching $4,424.1 million at a Compound Annual Growth Rate (CAGR) of 36.5% [20].

This report collects results of a survey launched as a joint activity of ILA, OGC and I-locate, organizations with different missions, membership and approaches yet sharing the view that coordinating efforts in the domain of indoor location will have beneficial effects on market uptake of these technologies. The survey was launched at the beginning of 2016 and collected responses from 153 users from 33 countries.

The survey was envisaged to respond to the need to assess and report a state of the market by collecting and analyzing the “sentiment” of a large number people from companies operating from different perspectives and at different levels in this emerging field. In particular, the survey was aimed at surveying the benefits of indoor location and acquiring a broad view of the requirements and use cases emerging from the wider industrial and user community, beyond the memberships of the various organizations, in order to capture trends, challenges and opportunities, as well as trends and barriers to widespread use of indoor location technologies.

The success of the survey, in terms of number of respondents and of overall quality of the feedback received, has allowed the definition of a complete and clear landscape. The results will be distributed to the different memberships, helping promote future standards development at OGC and industrial development among members of ILA and made accessible also to all the interested readers from the institutional web sites.

[1] Source: MarketsandMarkets (Nov. 2014). Indoor Location Market by Solution (Tag-based, RF-based, Sensor-based), by Application (Indoor Maps & Navigation, Indoor Location-based Analytics, Tracking & Tracing, Monitoring & Emergency Management), by Service, by Vertical, & by Region - Global Forecast Up to 2019.

Lastly, over the course of the survey, we received the interest from the Location Based Marketing Association - LBMA (www.thelbma.com/), which promoted the initiative among their membership. We would like to thank LBMA for the valuable collaboration.

6 Rationale and background

At the end of 2015, the Open Geospatial Consortium (OGC) [15], the InLocation Alliance (ILA) [14] and the European Commission funded project i-locate [16], jointly decided to promote a survey on indoor location, to provide the three organizations with a current snapshot of the requirements of different stakeholders (within and beyond OGC and ILA members), so that the organizations will have an up-to-date overview of the market for indoor positioning.

At later stages of the survey, the survey received the attention of the Location Based Marketing Association - LBMA [13], an international group dedicated to fostering use of location based services among its members (retailers, agencies, advertisers, media buyers, software and services providers, and wireless companies). Following a sincere spirit of cooperation we decided to extend the survey and promote the initiative among their members.

6.1 The different communities involved

6.1.1 Open Geospatial Consortium - OGC

The Open Geospatial Consortium (OGC) [15] is an international industry consortium of over 519 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC® Standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.

6.1.2 InLocation Alliance - ILA

The InLocation Alliance (ILA) [14], a Federation Member program of the IEEE Industry Standards and Technology Organization (IEEE-ISTO), was formally established August 2012. ILA was founded by the mobile industry to accelerate the adoption of indoor position solutions that will enhance the mobile experience by opening up new opportunities for consumers and venue owners.

The overall vision is that consumers will benefit from personalized, contextual information and offers, as well as new services such as indoor navigation. Venue owners will benefit from increased customer satisfaction and enhanced information on customer behavior.

ILA has released and maintains a framework architecture for the development of indoor location based systems [19]. The relevant White Paper can be downloaded free of charge from the ILA website.

6.1.3 i-locate project

The project i-locate "Indoor/outdoor LOCation and Asset management Through open gEodata" [16] is a Pilot B type project funded by the European Commission through the ICT-PSP (Information and Communication Technology Program). Goals of the project were to create a public geoportal to collect, make discoverable and provide access to indoor geographical information of publicly accessible buildings as Open Data, as well as an open source "toolkit" for integrated hybrid (indoor-outdoor) LBS for location, tracking of asset and people as well as their routing based on open standard protocols. Toolkit is the first reference implementation of the OGC standard "IndoorGML".

6.1.4 General public

Last but not least, the survey was opened also to the general public, through an extensive web-based campaign (including institutional websites, LinkedIn groups etc.) and press releases. The goal was to capture feedback from experts, venue owners and other stakeholders, far beyond the scope of the "professional" communities beyond OGC, ILA and i-locate.

From the analysis of collected data, it is clear that most of the responders were from technology providers or product suppliers, followed by location service providers and, lastly, from client organizations (Fig. 1).

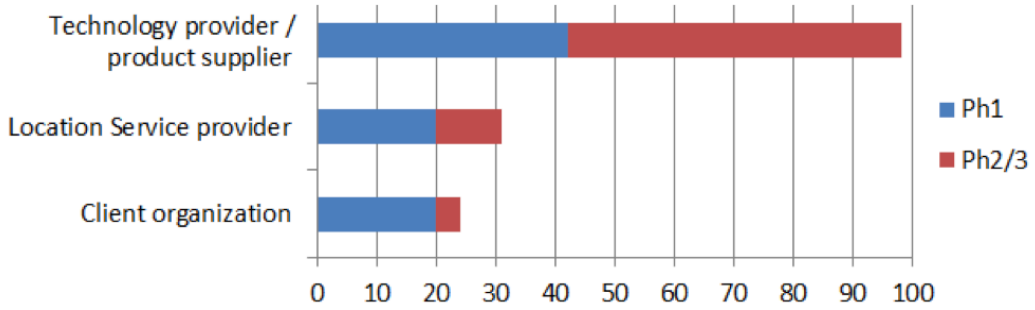

Fig. 1: An overview of the different macro-groups of respondents who contributed to the survey during the three phases, as detailed later in the following section.

6.2 The different phases of the survey

The survey was launched 10 January, closing on 22 February following three phases in which the link was distributed among different participating communities.

Initially the survey was shared only with members of the participating organizations, i.e. ILA, OGC and I-locate. During the second phase the survey was shared with a wider audience through press releases and the use of major specialized sites and magazines as well as through professionally oriented social networks.

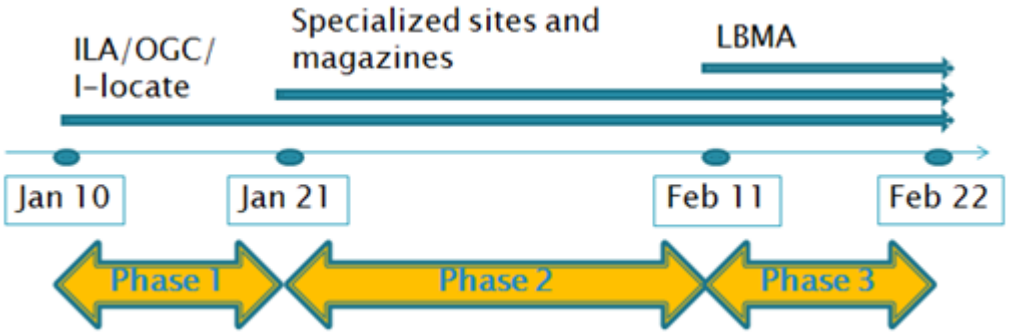

Fig. 2: An overview of the timing of the three different phases and the involvement of the different expert communities.

During the initial phase, interest in participating was received by the Location Based Marketing Association (LBMA) and a third phase was initiated for the February 12 through February 22 time period. In the first phase 82 submissions were received followed by 59 in the second phase and 12 in the third phase. Overall, 153 submissions were received from 33 countries. 44 submissions came from Italy alone, 32 from the United States and 10 from Spain.

7 Methodology of the survey

The schema of the survey is described in Fig. 3.

After a block of questions meant to acquire “general info” about the participants together with their expertise and role in the value chain, the survey separates the responders into two main legs: Client Organizations redirected towards the left leg and Technology suppliers towards the right leg.

Each box corresponds to a number of detailed questions, typically from two to five.

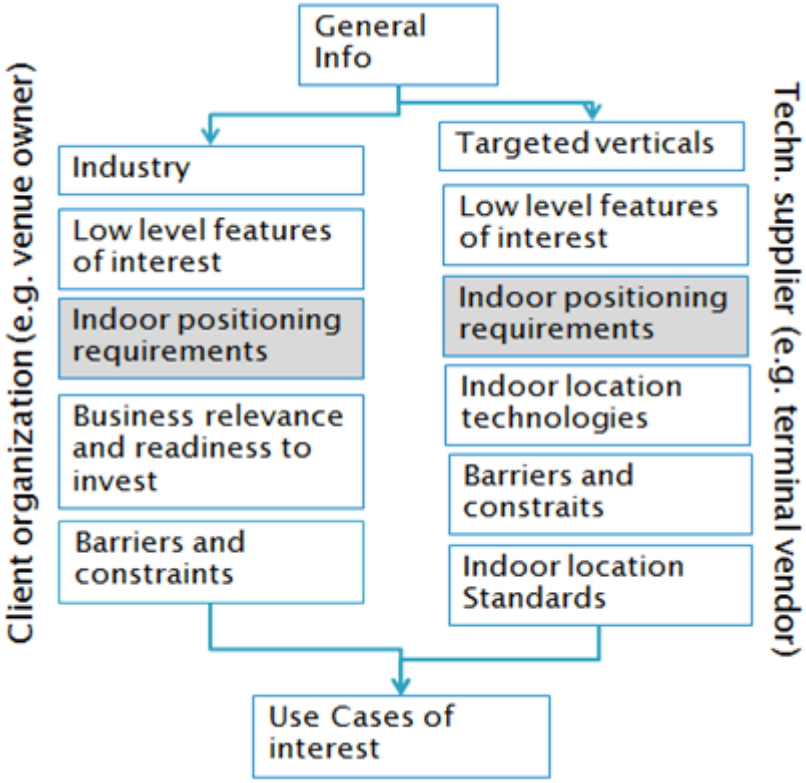

Fig. 3: Structure of the survey

Client organizations *such as venue owners or tenants* constitute an important category that is key to the entire indoor location value chain since they invest in both infrastructure and application development and require solutions that will integrate easily with current networks and vertical IT solutions already in place.

Facility managers represent another key group of client organizations. Often facility managers are proprietaries or have outsourcing contracts for the maintenance of real estates including security, surveillance and technical maintenance services related to heating, water pipes, lighting and similar infrastructure. The facility managers are technologically aware of new evolutions and use Building Information Models (BIMs)

including 3D models of the buildings for running the whole building lifecycle from design, construction and maintenance.

The main goal of surveying customer organizations was to understand their perceived benefits, barriers and readiness to invest. Further, the survey reported a perceived lack in the Indoor location standards. Finally some additional use cases were solicited. This was not the main aim of the survey: this additional question was proposed to elicit some use cases not covered in the previous questions and respondents were very collaborative, proposing new insights into applications.

Technology suppliers represented the vast majority of the respondents, as expected. When surveying this community the goal was to understand how they manage to deliver a complete business solution to client organizations. The picture is rather complex as multiple business roles are involved and their characterization is still evolving.

To avoid biases due to the order in which options are proposed to respondents, we extensively used the re-shuffling feature that allows proposing the identified options in a random sequence.

8 Analysis of the results

8.1 Participants

Most of the respondents were developers of indoor location systems. Approximately a quarter of the total answers came from users, whose point of view is fundamental to draw a better picture of this rapidly evolving market. Those classifying themselves as users came mostly from member organizations (30 out of 36 responses in this category were collected during the first phase of the survey). Developers outnumbered users in both phase 2 and 3.

In general, all respondents are directly involved in the indoor positioning market and are knowledgeable of the dynamics.

Finding 1. Software application developers represent the majority of the respondents, this confirms the fact that indoor positioning provides benefits to context based applications that have to be customized to the intended customers and adapted to the single venues.

The survey registered a good participation from Academia and R&D centers and this witnesses the fact that the technologies and solutions in this field are still in progress. Also the participation of a good number of consultants witnesses the fact that experts are needed to seize the solutions correctly.

Most of the respondents are technology suppliers, they outnumber both customers and service providers.

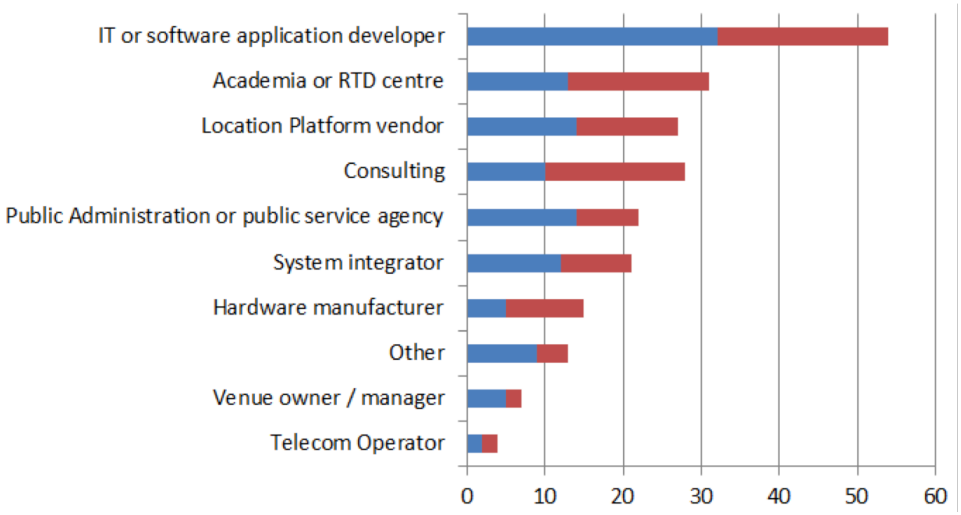

Fig. 4: The different respondent groups[2]

Client organizations appear to be increasingly interested to the monitoring of the building resources and how those resources are dynamically consumed to keep track and optimize resource allocation. This use case is increasingly present; complementing the more popular offline heath maps and analytics. Examples are the dynamic allocation of desks in a corporate building, meeting boxes in a convention center, or parking lots.

This leg of the survey was specifically meant to address the needs, requirements and readiness to invest of this population.

The **supplier leg** is also really variegated. Participants included representatives of all members of the value chain, from infrastructure and device developers, down to platforms and maps providers to consultants and system integrators.

The content of this document, although not reporting step by step each answer, is grounded on those answers and presents and comments the results given.

The analysis of results starts with a self-assessment phase. Respondents had to declare their experience, their industry of provenience and their roles in the value chain.

Then both communities were asked the technological features of interest directly referring to indoor positioning features. The proposed questions assume that the indoor positioning technology contributes to extend the high level features of vertical systems.

In Section 8.4 this report goes through the main requirements that can be technical, operational and normative with different levels of interest. That section is based on a large number of detailed open answers. Respondents were very collaborative and focused on a number of different complementary issues.

[2] Responses obtained from members organizations in the first phase are plotted in blue, the others in red.

The following sections will focus on the expected and perceived benefits as well as the barriers to entry. The aim is always to take a 3D image both from the eye of the suppliers and from the eye of the customers.

To correctly interpret the resulting picture, we have also to note that most of the respondents from customer organizations (e.g. hospitals) are from the IT department and are involved in the setup and maintenance of the service towards their internal users such as doctors, patients and nurses. Their technical knowledge is often remarkable and the resulting findings even more valuable.

8.2 Participating industry

If we consider the top three Customer Organization industries, there is a prevalence of health and care services. While this market is certainly one of the most promising, this bias reflects the composition of the participants to the i-locate project that focuses mainly on health care and public offices and administrations.

A similar bias is also reflected in the ranking of industries targeted by suppliers. Health care tops the preferences of the responding suppliers. Retail and Transportation confirm the interest already observed in 2015 when ILA published two white papers listing the use cases in these industries.

Customer Organizations	Industries targeted by the Supplier Organizations
1. Health, (Hospital and Clinics etc.) 2. Care services for aging people 3. Culture, entertainment and other public facilities	1. Health (hospital, clinics etc.) 2. Retail 3. Transportation and personal mobility

The rankings above reflect the current perception of where the low hanging fruits can be found. Even more importantly, respondents have reported current activities addressing more than 20 different industries, which witnesses the wide applicability of indoor positioning solutions. Other respondents openly declare their independence from the receiving industry: this is the case of players focusing on components and basic building blocks that can be found upper in the value chain.

Finding 2. Indoor positioning technologies appear to be applicable to a wide range of use cases in a wide range of industries

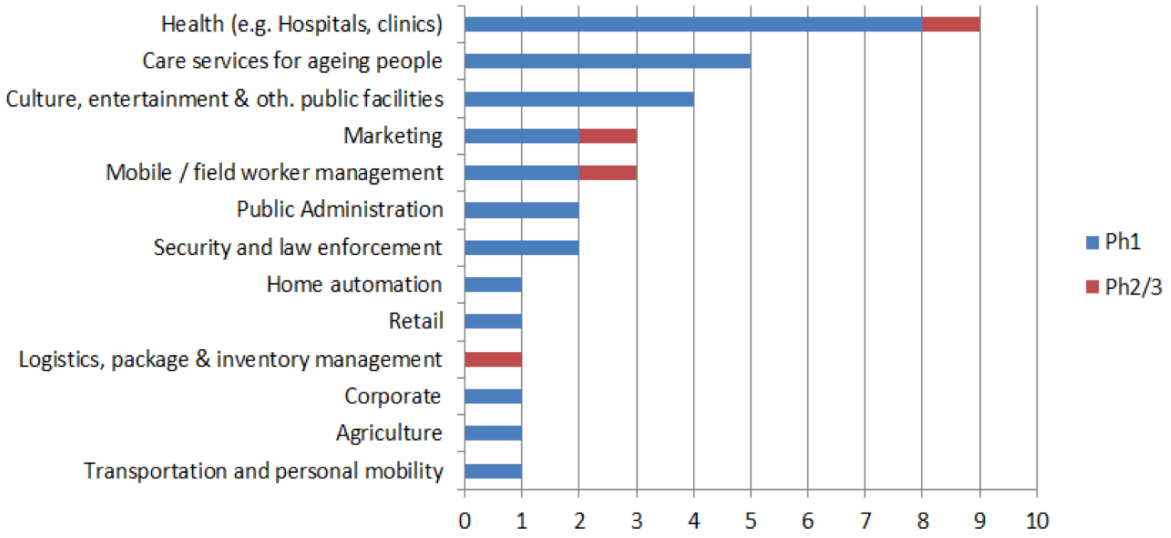

Fig. 5: Distribution, by domain, of responders of the first leg of the survey including client organizations

8.3 Low level features of interest

8.3.1 For location of people

Our survey reveals close alignment between consumers and suppliers of the features they prioritized in systems that locate and track people. The features identified in this category fall into two distinct groups: those where location information is determined in the visitor's device and those where location information is determined in the network environment. In the former category, both consumers and suppliers of location technologies reported a strong interest in navigation, guidance, and real-time positioning features required to enable way-finding and visitor engagement applications. In the latter category, both also showed similar levels of interest in analytics, geo-fencing, proximity detection, and other features related to establishing context-aware environments.

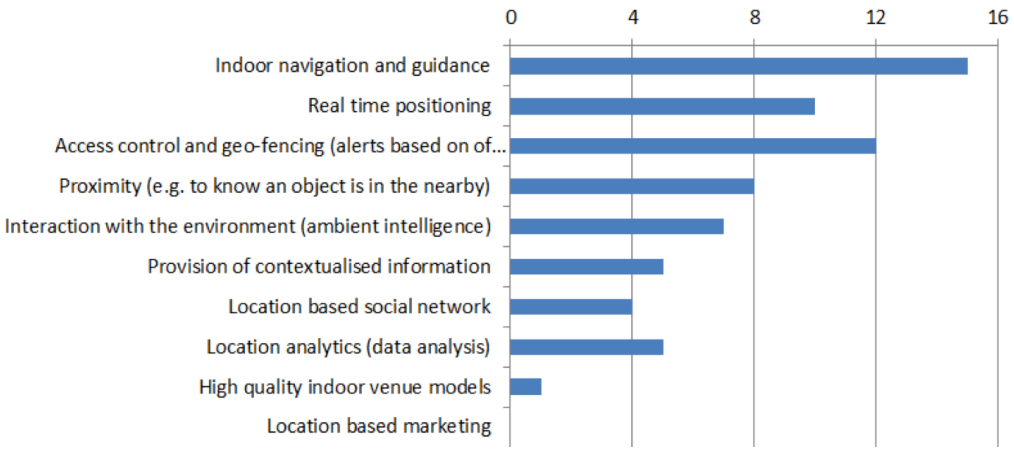

Fig. 6: Most important features for location of people (for client organizations)

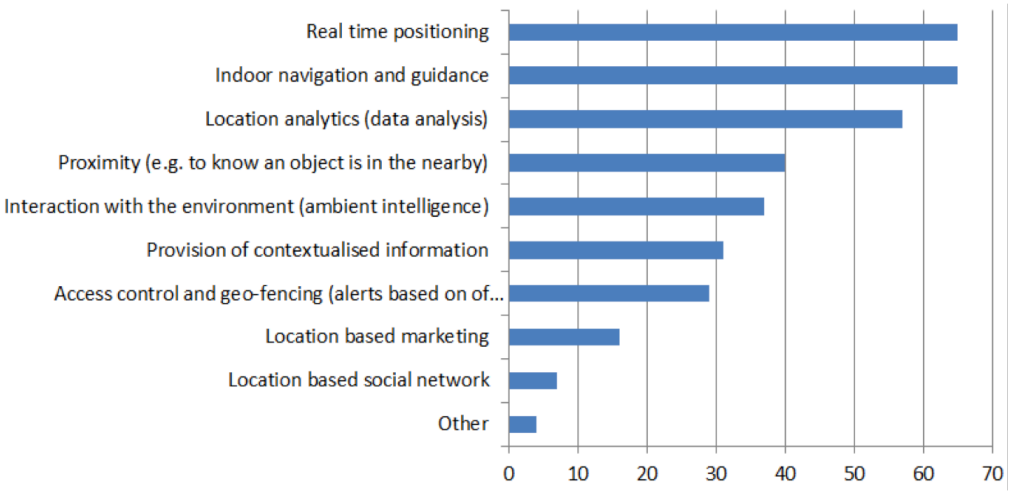

Fig. 7: Most important features for location of people (for suppliers)

While no direct indication of a preferred architecture can be seen in these responses, the widespread interest in enabling people to locate themselves and in enabling networks to locate them in the environment would tend to suggest a market favoring solutions capable of supporting both.

One area of apparent divergence is evident in location-based marketing. While identified as an application of interest by a significant number of suppliers, none of the customer organizations surveyed indicated this as a feature of interest.

8.3.2 For location of objects

As we turn to systems designed to locate and track objects, we continue to see alignment between customer organizations and suppliers, with asset tracking and real-time positioning a clear priority. In contrast to systems designed to locate people, analytics is apparently a lower priority for organizations interested in locating objects.

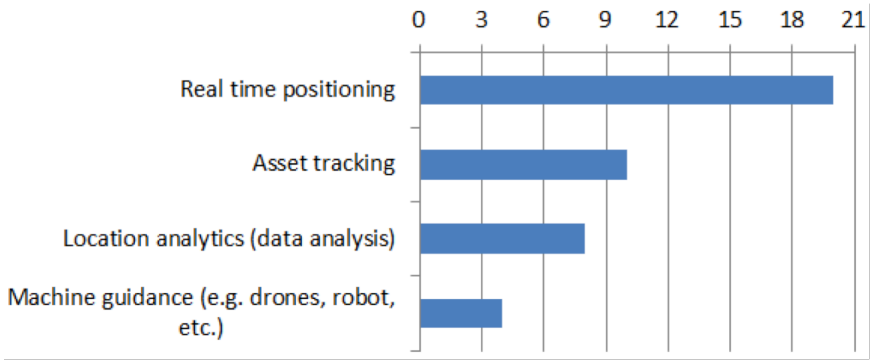

Fig. 8: Most important features for location of objects (for client organizations)

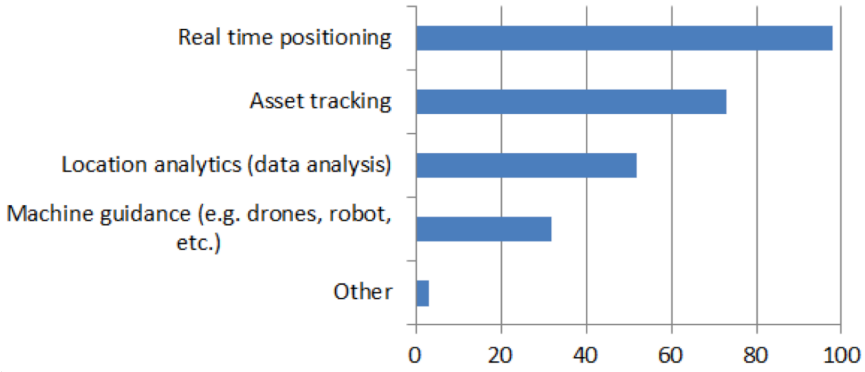

Fig. 9: Most important features for location of people (for client suppliers)

8.4 Indoor positioning requirements

Our survey asked specifically about accuracy requirements. As could be expected from the broad range of use cases, accuracy requirements also ranged from sub-meter to simple presence detection. The most frequent response from both consumers and suppliers indicated an expectation of 1-meter accuracy. It is unclear whether this represents a predominance of use cases that require this level of accuracy or the fact that this has been a long established target of the industry.

Finding 3. Given the typical relationship between cost and performance, it would appear that both suppliers and consumers believe there is a threshold of around 1 meter accuracy, below which costs rise and applications become more specialized.

Below we will consider responses relating to other performance parameters, such as latency, orientation, the ability to track legacy devices, power consumption (which would likely be a major consideration in battery-operated tags and beacons), the maximum number of simultaneously trackable devices, and the cost of deployment and maintenance.

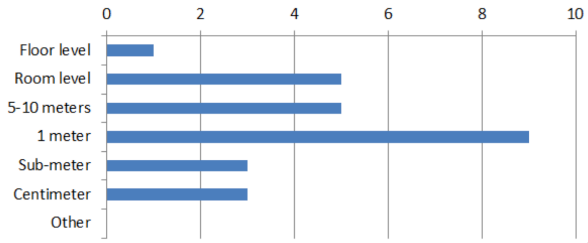

Fig. 10: Location accuracy (for client organizations)

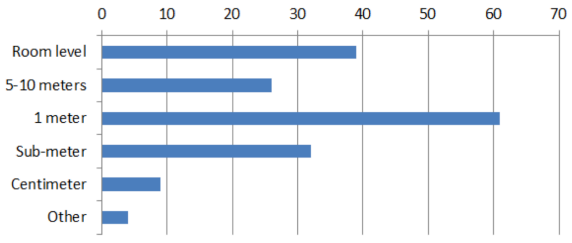

Fig. 11: Location accuracy (for suppliers)

The goal of section on “Indoor positioning requirements” was to capture any specific requirement related to indoor positioning, through additional feedback, in the form of free text, which could complement the input received within the previous sections, which instead were meant to collect structured feedback.

8.4.1 Client organizations

The results emerging from data collected during the first leg of the survey, which captured feedbacks from client organizations and venue owners, highlight two clear sets of requirements: 1) the need for **additional integration capabilities** and, 2) the need of **detecting user’s attitude or posture (i.e. leaning, laid down, facing direction).**

The former requirement is consistent with the clear need for interoperable solutions which also emerges in later sections of the questionnaire. This, in turn, is consistent with perceived lack of standardization, which has clearly emerged as one of the most relevant barriers preventing adoption of indoor location, as detailed in the sections on “barriers and constraints” to use of indoor location, further reinforcing the relevance of the aforementioned requirement.

Importance of having integrated and interoperable technologies has been extended to inclusion of tools beyond provision of mere indoor positioning or location features, to include, for instance, data analytics tools.

Finding 4. The survey highlights the need for interoperable frameworks and platforms capable to deliver value-added services by leveraging on indoor positioning technology as a commodity.

The second major requirement, that is to be able to **detect user’s attitude**, highlights the need for even more sophisticated technologies than those available today, clearly showing the high expectation around the domain of indoor positioning, in domains such as safety and monitoring, retail, personalized training, health and care.

***Additional note**. The responses have in particular highlighted the importance of being able to locate sub-body measurements in domains such as:*

- ***Safety and monitoring**, for instance in case of specialized applications engineered to ensure workers’ safety within dangerous working environments or in case of applications targeted to monitoring of old person (e.g. to identify if they have fallen down, etc.).*
- ***Retail**, to be able to analyze detailed purchasing behaviors (for instance if a customer has tried to lean down to pick an object on the lower shelf of a food store).*
- ***Personal training**, to analyze if trainees are doing the proper physical exercise as*

indicated by their personal trainer.

- ***Health and care**, where tracking of body limbs can be important for medical applications (e.g. diagnostic, post trauma rehabilitation, etc.). This very requirement has consistently emerged also in later section, where multiple users have responded explicitly highlighting use cases based on location of elderly people and analysis of their postures.*

However, it should be noted that such a very specific feedback may have been biased by response from the i-locate community, which addresses, to a significant extent, the healthcare market where this requirement is rather strong.

8.4.2 Suppliers

When analyzing the recommendations collected by the second leg of the survey, which has mostly captured feedback from technical suppliers, it becomes clear that a large set of different needs emerge, addressing several -often very technical- issues. Overall needs can be grouped in three main categories:

1. technical (location) requirements,
2. operational requirements,
3. data model and standardization requirements.

Technical requirements

The first technical requirements referred to the need for location technologies capable to detect proximity of all devices in the nearby area, be this connected or not, hence including development of systems capable to **collect information from passive devices**. With regard to connected devices, one of the most important requirements is **very low power consumption**. In case of network-centric location systems, the network should also be capable to **locate any device** within the area served by the wireless network with location response characterized by **low latency** (<500 ms) even with very high number of mobile devices connected to the network, therefore **ensuring high scalability**.

Finding 5. Suppliers need scalable and low-latency indoor location technologies capable to collect data from passive or very low power devices.

***Additional note**. It should be noted that some of these requirement partially conflict with current privacy and data security legal frameworks, as highlighted later in the document. In addition, the combination of these requirements is essentially consistent with results of a later section on barriers to use of indoor location systems which highlight, among other barriers, the limited accuracy, long latency and short battery life of many technologies used today.*

Further requisites for indoor positioning solution include seamless **integration with outdoor solutions** and concerted use of **multiple positioning technologies at once**. From a purely location technology standpoint, the survey has suggested wider adoption of emerging solutions based on **Visible Light Communication** (VLC), including, for instance, LED-based indoor location technologies.

Finding 6. To be able to make concerted use of multiple positioning technologies

at once.

Additional note*. It should be noted that, as from the previous requirement, this is consistent with results of a later section on barriers to use of indoor location systems, which have highlighted the difficulty to identify the right mix of technologies for each specific solution.*
Additionally, with regard to VLC-based solutions, their widespread use may also be influenced by emerging legal frameworks limiting RF-pollution, as detailed in later section discussing barriers to use of indoor location.

Operational requirements

Among operational requirements, **usability** has been regarded as of high priority. This regards both usability aspects related to end users as well as to those involved in the configuration and data preparation steps with particular regard to creation of indoor maps. With regards to the former, the survey has highlighted that current software interface data preparation are far too complex for non-expert use. Specific mention to use of **3D interfaces for data preparation and indoor mapping** (including creation of indoor paths) has been highlighted by the survey.

Additional note. It should be noted that some of the need for simple tools for creation of indoor maps and indoor connection graphs (e.g. as in the case of IndoorGML) may emerge from the i-locate community, which has attempted to provide a partial answer to improve user-friendliness during data creation phase with the development of a plugin for JOSM, the specialized software developed by the OpenStreetMap community, that has been extended to allow creation of indoor graphs based on IndoorGML standard. However, the final result is far for being usable by the general public in that it requests specific knowledge for using JOSM.

A similar requirement regarded the availability of indoor location **solutions available for all the platforms** in the market including, most notably, the various Operating Systems for desktop and mobile devices.

Finding 7. Indoor positioning solutions should be available on multi-platforms including desktop and mobile device operating systems.

Further requirements from an operational standpoint, included development of automatic procedures for **reduction of installation and setup costs**, which ultimately should be carried on by customers or venue owners (without requiring specific knowledge).

Finding 8. To develop tools for automatic system configuration of the location infrastructure.

A last requirement regarded the need to **create interfaces for IT and management systems**, in order to facilitate deployment and integration with existing infrastructures.

Data model and standardization requirements

Lastly, from the data structure and standardization point of view, the survey has clearly highlighted the need for tighter **integration of indoor location systems with BIM solutions**. With regards to feedback received by the OGC community, specific mention has been made to achieving integration of indoor location data, also in the context of transactional services, within a large range of OGC standards, as detailed in the concluding sections of the document.

A specific mention has been also made to achieving **integration of indoor location data with OASIS standards** in order to provide improved support to operators in mission critical environments, such as first responders in case of emergencies or military users.

Finding 9. To ensure wider support of indoor location data types and functions in OGC and OASIS standards

8.5 Barriers and constraints to use of indoor location

The section on “Barriers and constraints” was specifically targeted to collect, from respondents, perceived barriers and constraints to the use of indoor location solutions. Similarly to previous sections, the survey has allowed emphasizing differences between client organizations and suppliers.

8.5.1 Client organizations

When observing results collected from client organizations, it is clear that **privacy** emerges as the top concern. Privacy and data protection legislations have risen very high concerns, in particular in very sensitive domains such as health and care, (e.g. the person being tracked may not be able to provide explicit consent, hence requiring consent to collection of positioning data to be given by a proxy), and whenever this requires storing of positioning

data related to healthcare information (e.g. for monitoring purposes), which are typically subject to very strict legal requirements.

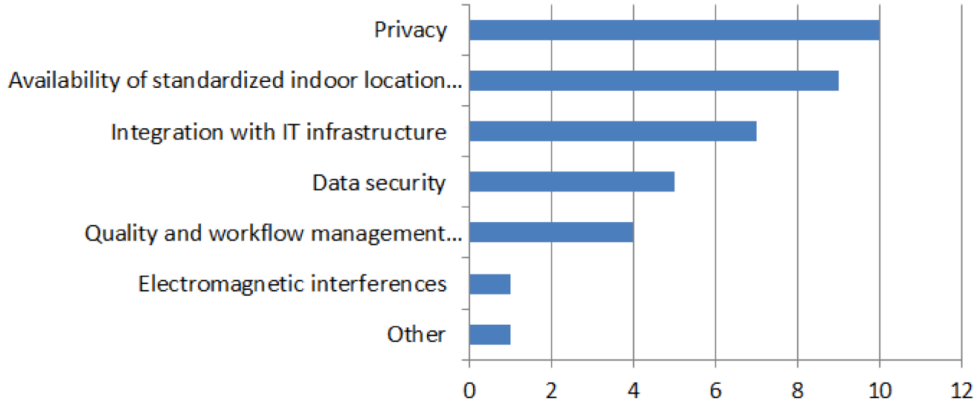

Fig. 12: Top barriers and constraints to use of indoor location for client organizations

Finding 10. Within client organizations, "privacy" is regarded as the most important barrier to indoor location.

***Additional note**. Within client organizations, "privacy" has also received the highest number of comments (as free text) within the section titled "do you know of any legal barrier to use of indoor location". This consistently reinforces the perception by client organizations of privacy being as the most important barriers to widespread use of indoor location, due to complexity of national and international legal frameworks.*

In fact, free text responses within section *titled "do you know of any legal barrier to use of indoor location"* have highlighted, besides the existence of international directives (e.g. from the European Commission), the potential impact of perhaps more restrictive legal frameworks at national levels. Responses have highlighted, for example, the importance of restrictive laws in countries such as the Netherlands, where CPB, the Netherlands Bureau for Economic Policy Analysis is requiring a verification charge of verifying that data are collected anonymously and deleted after 48 hours. Similar restrictive legislation has been reported in Luxembourg, where law forbids tracking workers, or in Italy, which has one of the most restrictive legal frameworks in terms of privacy and data protection.

***Additional note**. It is worth noting that all the comments related to privacy and data security issues have been provided by responders from European countries, clearly showing cultural and social differentiation with regards to perceived impact of data security and privacy, which makes people from European Countries far more sensitive to these*

issues if compared to those living in other geographical areas of the world.

Privacy requirement is particularly strong in Europe where an articulated international legal framework is in force including, but not limited to, the Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data [3], the Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data [4] and the Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 concerning the processing of personal data and the protection of privacy in the electronic communications sector (Directive on privacy and Electronic Communications) [5].

These results suggested the need for wider adoption of structured approaches to privacy protection in the context of location-based services (e.g. instance following design paradigms such as "privacy by design").

Most interestingly, the availability of **standardized indoor location technologies** has been perceived as the second strongest barrier. A detailed discussion on this issue is proposed in the following section, where the results received from the suppliers are discussed.

Finding 11. Within client organizations, standard products and services are seen as a means to reducing risks related to widespread adoption of a new technology and to ensuring integration with their IT infrastructure.

Further high-priority barriers include lack of **integration with IT infrastructures** (it should be noted that this requirement clearly emerged also in previous parts of the survey as detailed). The integration with IT infrastructure is perceived as important in order to be able to maximize benefits of location technologies. The integration anyway is often difficult to achieve and evaluate, especially when the suppliers offer standalone platforms.

Further barriers, albeit to lesser extent, have been selected by respondents including **data security**, **quality and workflow management tools**, and **electromagnetic interferences**.

When asked, within a dedicated section, to "describe your experience (if any) with barriers preventing adoption of indoor location", respondents reported the most relevant real-life examples highlighting existing barriers preventing use of indoor location.

In general terms, the results of this section can grouped into barriers related to: 1) **technical factors**, 2) **human factors** and 3) **business model aspects**, as follows. It is important to note the following items are prioritized as no specific metric had been given to the respondent to rank experience.

Among the barriers related to technical factors, the following have been highlighted:

- The presence of devices generating electromagnetic fields (e.g. photocopiers) may cause electromagnetic **interferences** (in case of indoor location systems based on electromagnetic technologies) which may affect accuracy. Experience of use of complementary location technologies has been reported to minimize overall inefficiency and/or inaccuracy.
- Lack of **standardized solutions**, with a specific mention of proprietary Wi-Fi based solutions.
- **Difficulty to rely on users owned devices**, most notably smartphones or tablets, due to large variety of products available. Depending on use cases this may make use of tag-based solution preferable.

Finding 12. Customer organizations are well aware that the indoor LBSs can be exploited only as a combination of different technologies cooperating.

A large number of barriers related to human or cultural factors including:

- **Motivation of the end user** to subscribe to indoor location services.
- **Reluctance and/or mistrust** by specific user groups, including most notably elderly people, to accept the use of indoor location technologies.

Finding 13. Other concerns among customer organizations refer to the level of engagement of people in using location-based services, therefore overcoming lack of motivation, reluctance or mistrust to technology.

The third group includes a range of barriers related to business model aspects, including:

- The **need for upfront investments** related to both data capturing and creation as well as infrastructural and hardware costs.
- **Final cost to the end users**.
- Not being able to select when to **opt-in or opt-out** from the service when in public spaces.
- Providing **indoor location services in private buildings, which are, open to public**, such as stations or airports.

***Additional note**. Most notably, in addition to the aforementioned barriers, a positive experience has been reported which included use of LBMA DACH code of conduct.*

***Additional note.** Looking at the answers to this section we notice that less than half of the respondents among customer's organizations has reported a barrier. Further that, none of the listed barriers has attracted a wide consensus. Those reporting barriers have*

described a wide variety of problems of different nature that suggests that this new technology simply requires solid commitment and project structure to obtain valuable benefits.

8.5.2 Suppliers

When analyzing responses from the supplier community, the results share the same top three concerns mentioned also by customers, although the priority among the top items changes. Results of the survey have clearly, and quite predictably, shown that the **lack of standard indoor positioning technologies** represents the single most important barrier to be addressed. It is interesting to note that lack of standardized technology is perceived by far as the most important barrier, generating twice as much the number of preferences from the second items (two with equal score) in the list, which is the **integration with IT infrastructures** and **privacy**.

Finding 14. Supplier organizations consider lack of standard indoor positioning technology as the most important barrier.

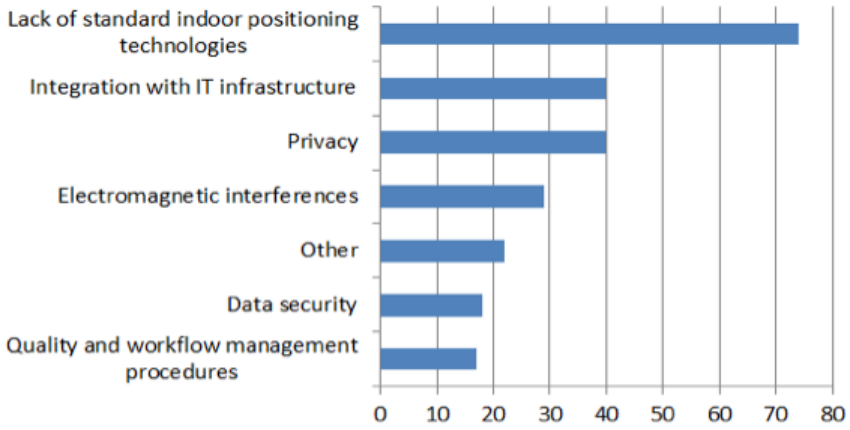

Fig. 13: Top barriers and constraints to use of indoor location for suppliers

Finding 15. Client and supplier organizations share the same top three barriers although with different priority.

One may argue that, while the former still emphasizes the importance of standards (in that the use of standards facilitates integration with IT infrastructures), the latter (i.e. “privacy”), shows a very different issue that, however, has received significant attention. Integration with IT organization is viewed as a barrier, possibly due to the rich variety of solutions that can be found in customer organizations.

In fact, it is worth noting that, similarly to what expressed by client organizations, privacy has been by far the topic that received the highest number of comments (as free text) within section *titled "Do you know of any legal barrier to use of indoor location?"* This clearly highlights that also the technical community considers legal implications related to privacy (and to a lesser extent, data security) as a very important barrier to the use of indoor location. Most notably, one of the respondents has highlighted the need to **make users aware of the impact of LBS on data privacy**.

Again, the extent to which privacy and data security are regarded as a barrier to indoor location becomes clear when analyzing the comments provided as free text. Very consistently with previous findings, respondents have highlighted how specific national legal frameworks (e.g. in France or Romania) may require technology to be adapted to comply with local regulations.

This may include specific requirements according to different business roles (e.g. telecommunication operators have different requirements from OTT providers), specific restriction to personal data storage (e.g. requirements by French CNIL, the National Commission for IT and Freedom) or obligation to ensure informed consent, in order to ensure people are aware of how personal data is being used and the associated privacy implications. Comments have highlighted how the data subject to legal frameworks and the concept itself of "personal information" may change from country to country (e.g. in Romania location is regarded as personal information by itself, even if non paired with any other personal information), making such legal barriers potentially very complex to handle by LBS providers.

It is important to highlight that the privacy issue has clearly emerged also within this section, where respondents were asked to describe their experience (if any) with barriers preventing adoption of indoor location, that can be categorized as follows:

- Difficulty to ensure implementation of privacy laws, which clearly relate with what had been highlighted in the previous sections.
- Need to provide information to reassure people to use location technologies.
- Need to support removal of personal data whenever the user does not opt in.

A second barrier, listed by respondents, included **Electromagnetic interferences** has been also perceived as the fourth most relevant barrier. This consistently matched the specific mention of radio pollution being a barrier to indoor location, which also emerged from additional comments provided by the respondents. In the latter section, a responder specifically mentioned their experience where they had been asked to favor non-radio-wave-based solutions in order to avoid increasing electromagnetic pollution.

***Additional note**. It is worth noting that the issue of electromagnetic interferences may be related to general perception as well as to emerging trends of legal frameworks limiting electromagnetic pollution. This is for instance the case of French law n. 2015-136 of 9/02/15 which forbids electromagnetic pollution from Radio Frequency (RF) emissions where there are children less than 3 years of age) as widespread adoption of such legal*

frameworks could impact on adoption of RF-based LBS.

Most notably, widespread adoption of similar legislations could determine an evolution of indoor location solutions towards non-RF technologies including computer vision, VLC and geo-magnetic technologies.

Data security has also been identified as further barrier to use of indoor location, followed then by **quality and workflow management procedures** and, lastly by a range of different minority items including **usability** of positioning services (indoors and outdoors), **lack of common frameworks** and **datasets** to evaluate the IPSs, lack of specific **services and business cases** relying on indoor location.

When asked to "Describe your experience (if any) with barriers preventing adoption of indoor location", the main barriers were highlighted: 1) lack of cross-platform solutions, 2) technology barriers and 3) business and financial factors.

With specific regard to the first item, the lack of **cross-OS APIs** to support app development is regarded as very important barrier, with a specific mention being made for specific lack of APIs for iOS systems.

Finding 16. Supplier clearly highlights the importance of developing cross-OS APIs.

The second set of barriers covered a range of different technological constraints preventing adoption of indoor location, including:

- The difficulty to identify the right mix of technologies for each specific solution.
- Need for solutions with better accuracy, shorter latency and longer battery life.
- Unpractical use of some tag-based solutions in some use cases (tags were reported as too big).
- Different accuracy achieved by different user devices when using mobile centric solutions.
- Instability of RSSI based methods.
- Difficult implementation and limited security.
- Need to develop software capable to handle the big data generated by indoor location systems.

Finding 17. The survey shows that that 90% of suppliers are working within a framework of hybrid location systems, while there is a non-negligible minority that is working at single technology approaches.

The third, and last, set of barriers instead highlighted business and financial constraints including:

- The difficulty to demonstrate Return on Investment - RoI and Total Cost of Ownership - TCO, an essential factor to justify investments, also through identification of the right technology mix.
- High investment costs as well as high investment/performance ratio.
- Lack of specific business cases, in particular for use of solutions leveraging on beacons and VLC.
- Lack of agreements between carriers to support LBS based on cellular networks.
- Lack of reliable eco-systems.
- Administrative issues related to Ambient Assisted Living applications of indoor location.

Finding 18. The top benefit expected by far is the improvement of the quality of services that not necessarily translates into improved revenues or improved savings. The real expected benefit is more intangible and can be described as better customer relation when users are customers, but they may well be employed, security personnel or maintenance personnel.

8.6 Use cases of interest

One of the final sections of the survey was meant to elicit a list of explicit use cases and scenarios of interest.

Besides receiving generic responses, such as “real-time positioning” or “indoor navigation and guidance”, the participants to the survey have identified a wealth of more specific use cases, across several industrial verticals. Many of the reported use cases are truly interesting, other are really innovative. Here is the list organized by industry:

Ambient intelligence:

- Proximity awareness
- Distance measurement between to objects / people (e.g. with I.R.)
- VLC: Use of street lights to distribute information

Assisted living and ageing people care:

- Retirement Complex, part of a large chain, with three tier living (for those who are able, and for those who need specialized or constant care) could employ indoor location services for engaging senior residents, providing health services, communication, and coordinating activities, as well as asset tracking and Operations/Administration.
- Analytics of the senior's indoor position in order to monitor daily activities as well as alterations in daily lifestyle
- Object finding, including medicines

- Be able to infer specific postures (e.g. standing, laying on the floor, etc.).

Building sites:

- Asset tracking

Education:

- Kids safety and behavior monitoring.

Justice:

- It is a common practice to put persons suspected of crimes under judicial control. This prevents them from leaving some premises, allowing them to continue their life at home and possibly also an office.

Corporate offices:

- Virtual reception of visitors and guidance to the intended destination.
- Occupational locating and monitoring of workers, duration of stay and moving patterns of people and objects at and between different facilities.

Facility management:

- Analytics: usage of spaces (buildings, floors or individual rooms) to develop a comprehensive spatial database of the indoor environment.
- Real time monitoring and allocation of resources.
- Monitoring the flow of people in indoor spaces
- Asset tracking
- Network resource management
- Security and authentication

Health care:

- Locating a patient room within a healthcare infrastructure.
- Tracking of assets: medical equipment

Retail:

- Location determination of people, lighting sensors are expected to provide the accuracy lacking with other technologies
- Locating a product within a retail space.
- Delivering targeted commercials and content
- Secure indoor location (position) of point-of-sale (POS) terminals and secure proximity of users making payments to that POS terminal.

Marketing:

- Location based marketing and advertising

Safety:

- Active Shooter: audio sensors that detect a gunshot can be used to detect the location of a potential active-shooter incident at public buildings (airports, train stations, public administration offices, etc.) using indoor mapping and locating the shooter's position in order to begin a threat assessment
- Imminent seismic forecasting through the analysis of sensors scattered in the environment.
- Personnel tracking

- Geo-fencing
- Guidance to emergency exits or to safe areas even when the illumination is not working or in presence of smoke.
- Disconnected soldier / firefighter / security agent in emergencies
- Real-time positioning of first responders in high-rise buildings.
- Usage of the device sensors to report the presence of smoke.
- Migrant centers monitoring. The current migrant crisis in Europe often puts refugees centers in difficulty monitoring the residents and ensuring safety and security. Location and geofencing can improve the safety, especially for women and children hosted in the centers.
- Positioning and collision avoidance of vehicles in underground mines

Industry:

- Localization of manufacturing assets
- Location of objects (e.g. vehicles) within indoor spaces for closed loop process control.

Tourism:

- Provide targeted content based on user location, his activity schedule and local context.
- Guidance in cruise ships.
- Search points of interest by category.
- Interaction with urban spaces like monuments.

Social networks:

- Allowing for a person within an indoor space to locate another person.

Security:

- Monitor people in properties (e.g. kids)

Transportation hubs:

- find the intended platform, gate or exit.
- find cash machine / change
- find local food / spirits shops
- Luggage transfer and monitoring
- Support to connecting travelers

Other:

- Support of people with disabilities
- Unmanned vehicles, moving robots and flying drones.
- Augmented reality to improve interface effectiveness
- Location of best exits for the intended direction.

This list reports the examples provided by the responders without adding anything, at least intentionally. In fact the answers were provided in free text whose interpretation was not always straightforward.

Finding 19. The wealth of use cases reported witnesses the huge benefits that

indoor positioning technologies are expected to deliver to a wide range of industries.

Finding 20. Different industries have different business goals and business processes in place supported by vertically oriented systems. Indoor location solutions have to be integrated in such systems and match different performance requirements (such as accuracy and availability) according to the requirements of the receiving systems.

***Additional note**. Also the building architecture is typical of the vertical industry. A typical factory plant is different from a hospital and from a school. This has an implication also on which signals of opportunity can be exploited and which kind of infrastructural investments may be needed to support the intended applications with the intended requirements.*

8.7 Business relevance and readiness to invest

The questions of this section aimed at assessing the expected benefits from the use of indoor location technologies, the perceived maturity and readiness to invest.

Finding 21. Prevailing expectations among Customer organizations are that indoor positioning benefits will mainly come from improved customer relations (through better service quality) and from improved business processes (mainly safety and security).

Therefore, venue owners should consider this investment as an enabler for upgrading current systems more than something that has to be justified in isolation. Consequently, the location enablers will have to be embedded into the IT systems of the enterprise to enhance and extend the capabilities of current services and business processes.

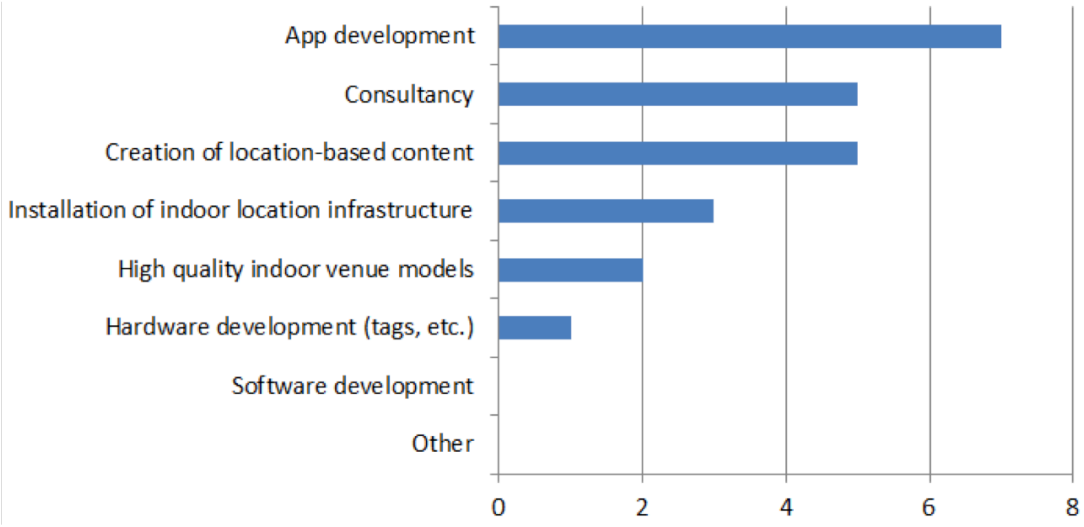

Fig. 14: Services of which respondents would be interested to benefit from

Most of the interviewed customers respond that their organizations are at least in an evaluation phase (not surprising since they responded to this questionnaire) but more importantly, they position the investments in the near future (Now). Only a few of them think that at least a couple of years are necessary to reach maturity. This means that current evaluations and pilots are providing results that justify further steps.

Integration of the indoor location enablers into current IT environments is not straightforward. To complete this process, customer organizations need external support from many actors contributing different competences. The most frequently cited are listed below:

- App developers to reach the customers and visitors on their mobile device
- Consultants to get oriented in this new arena
- Location based content providers to deliver the information that the improved customer relation will need.

Finding 22. Customer organizations need to be supported in the exploitation of indoor location based systems both in terms of consultancy to prepare the infrastructure and processes to support the new capabilities and in terms of software and content customization.

8.8 Targeted verticals

Most of the use cases listed above sound very general and are not targeting any specific verticals. However, features like navigation and geo-fencing, for instance, will support different user services and experiences when deployed in a retail context or to a hospital. This will affect the available budgets that can be invested, the requirements to be fulfilled

and the benefits expected from the different players of the value chain. This suggests that some industries will be more receptive than others, at least in the first evolutionary stages of this market.

Looking at the responses of customer organizations, we can notice that health care and ageing people houses represent the core business of nearly 40% of the respondents. Culture, entertainment and other public facilities also account for a remarkable number of respondents..

These findings are mainly due to the responses collected during the first phase (i.e. members of the ILA, OGC and I-locate communities) when 30 out of the 34 customer organizations submitted their responses. This result is clearly biased and it is expected that many of the respondents to this question came from the i-locate community. That said, it is clear that if the i-locate community grew and consolidated in this vertical, it is because this industry is eagerly awaiting solutions, and not only in Europe.

Looking at responses from the supplier side (see chart), health care is mirroring the previous results. Again, the bias highlighted above overestimates the importance of this field. The impression is that this is one of the top target industries anyway.

Second and third ranks responses from the supplier side are the retail and transportation industries. This result confirms the interest already highlighted by ILA with its white papers [11-12] covering the evolving trends of positioning in these two markets. These industries are perceived as the “low hanging” fruits, however, the respondents have clearly indicated that potential exploitations span across more than 20 different industries. That is to say that the stakeholders they represent do not see limitations intrinsic to the technologies and it is only a matter of prioritizing the efforts to target those industries where benefits and spending are expected to be higher.

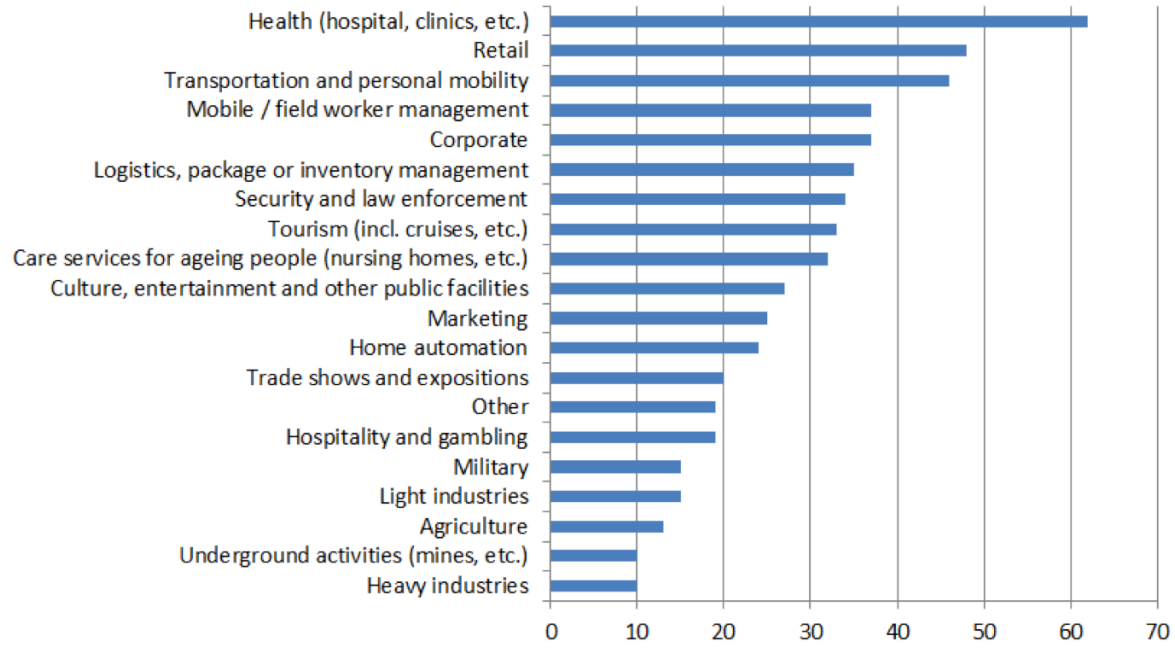

Fig. 15: Domains targeted by Technology suppliers (multiple answers were allowed)

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While most of the solutions being deployed appear to be vertical and adapted to the needs of a particular industry, nonetheless, there are also opportunities for players targeting venue owners with undifferentiated solutions addressing, for instance, security, safety and maintenance services. All these businesses are largely independent from the specific industry in which the client organization is active and possible adaptations are resolved as “service levels” to take into account that the security requirements of a bank are different from those of a retailer and the safety requirements in a Nursing Home are different from those applicable to a corporate HQ.

Other respondents offer solutions directly to people. Social networks and marketing agencies, for instance, adapt or specialize to target the end customers. In this case social networks cannot rely on the venue owner investments to increase accuracy but only on crowdsourcing, the device sensors and the signals of opportunity.

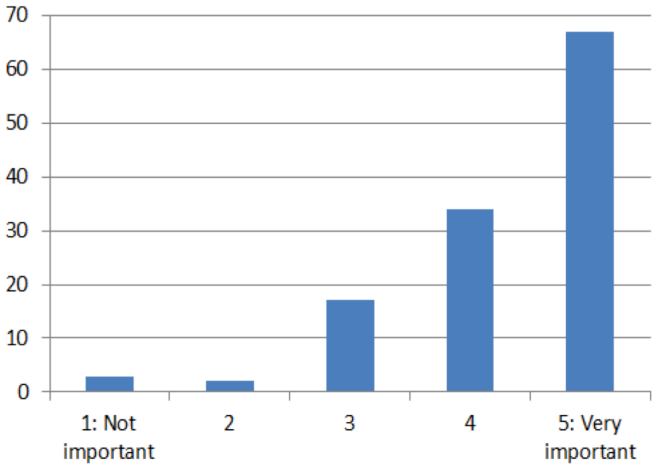


Fig. 16: Responses to the question "How important is interoperability to you or to your business?"

8.9 The role of standards

The last sections of the survey eventually addressed the perceived role of standards within the indoor location domain. Very interestingly, when asked how important interoperability is to their business, the absolute majority (54.5%) of respondents have declared that it is "very important", followed by an additional 27.6% of respondents regarding interoperability as "important". Perhaps equally interesting, only 2.4% of respondents have considered interoperability as "non-important".

Finding 23. Interoperability is regarded as extremely important to the business of the respondent.

When asking more specific questions about the perceived level of interoperability in the indoor location domain, the responses shows that the current level of interoperability is not perceived as adequate, with 32.8% of respondents considering is as not adequate and 19.8% considering it as "poor". Symmetrically only 7.8% and 2.6% of the respondents considered interoperability in the indoor location domain respectively "good" and "very good".

The analysis of response, also shows a very significant number of people, in fact the relative majority of them (37.1%), not being able to formulate a clear response.

Finding 24. The overall perception is that level of interoperability available today in the indoor location domain is not adequate.

***Additional note**. These figures are consistent with previous sections of this survey where lack of standards was reported among the most important barriers to development of indoor location solutions.*

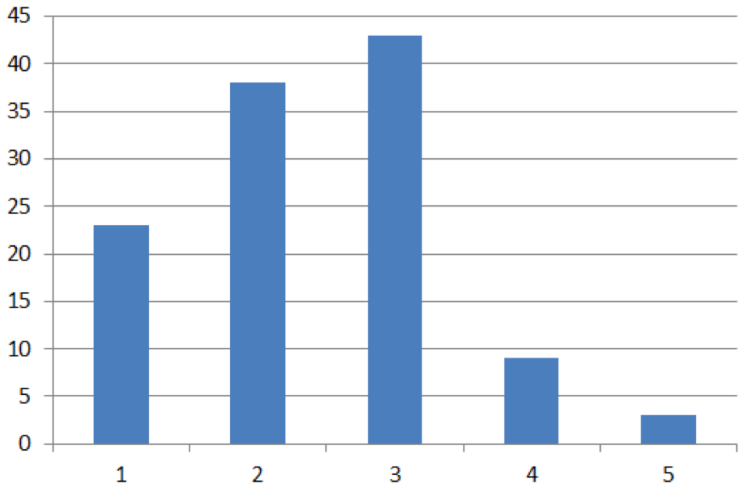


Fig. 17: The perceived level of interoperability available today in the indoor location domain (from 1 = poor to 5 = very good)

Previous results are further emphasized if analyzing the importance that has been given to interoperability in indoor location. In fact, the vast majority of respondents (52.5%) have declared that interoperability is “very important” to indoor location, followed by 33.3% of the respondents considering it “important” and with only 1.7% considering it negligible.

Finding 25. Responses from the survey clearly show that interoperability within indoor location domain as essential.

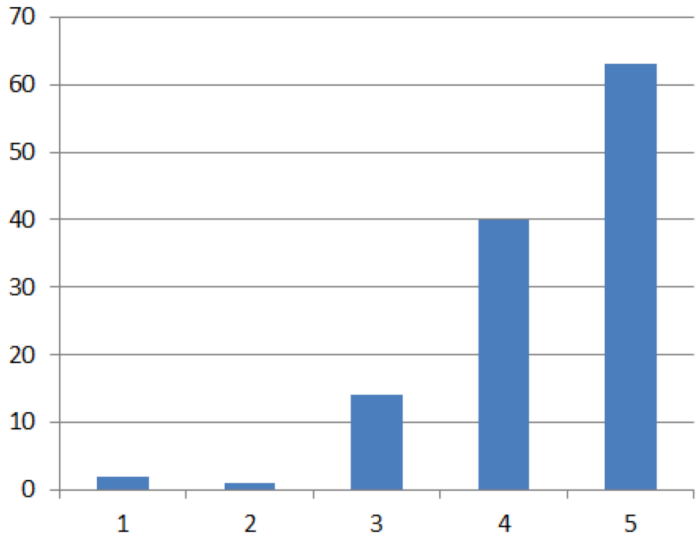


Fig. 18: The perceived level of importance of interoperability within the indoor location domain (from 1 = negligible to 5 = very important)

The following question aimed at assessing the familiarity of the sample with specific standards in the domain of indoor location. The three most popular standardization initiatives are, in order, OGC IndoorGML, OMA MLS and ISO/IEC 24730, with IndoorGML scoring three times more than the second.

***Additional note**. This result may have been biased by the large participation of members from the OGC and i-locate community, the latter being aware of i-locate being the first implementation of IndoorGML.*

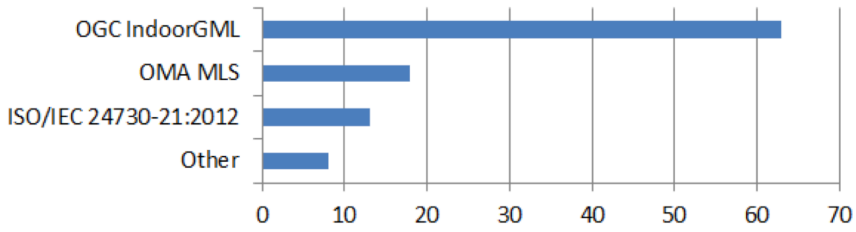


Fig. 19: The top most known standardization initiatives in the indoor location domain

When asked to list other relevant standards, the responses have included:

- ARTS
- none (2)
- cityGML (2)
- BIM
- IFC
- OGC OpenLS
- OGC Moving Objects

- GDF
- Wi-Fi Direct
- IEEE 802.11mc

The last, most technical question within this section of the survey, asked at which level interoperability, from low-level (hardware) to high-level (application), would be most beneficial. Results have been oriented towards the medium to high level as clearly illustrated in the chart below. This further highlights the fact that service-level and application-level interoperability (of highest importance for clients and suppliers) are perceived as most relevant.

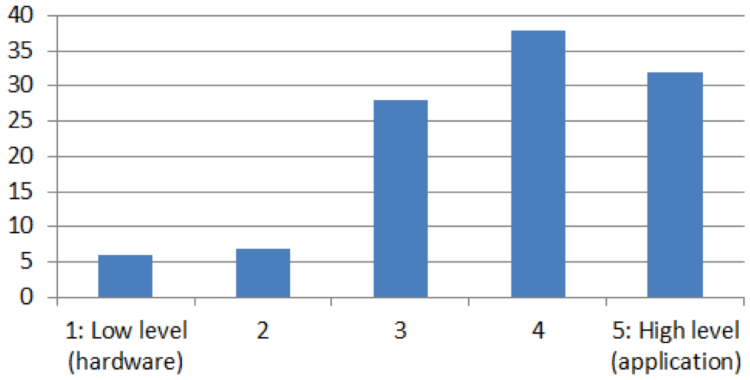


Fig. 20: Results of the question "At which level interoperability would be most beneficial?"

8.10 A sample of emerging use cases and scenario of interest

The use-cases and scenarios of interest collected from the respondents are classified into the following groups:

Navigation

1. Navigation to a place or to meet a buddy (moving destination).
2. Navigation of UAV or Robot: collision detection of UAV.
3. Navigation with reduced mobility or visual disability.

Tracking and Monitoring

1. Asset tracking.
2. Indoor facility management.
3. Monitoring visitors or aged persons for emergency services.
4. Geo-fencing.

Indoor analysis

1. Indoor context analysis.
2. Trajectory analysis: e.g. moving pattern analysis.
3. Sensor analysis: seismic sensors or gun shoot audio recognition.

Context based interaction

1. Context based content delivery (e.g. coupons or AR info in museum).
2. Dynamical resource management (e.g. parking lots or the nearest available meeting room).

Since they have different requirements and goals, we compared these use-cases from several viewpoints as the table below for better understanding;

	Point vs Trajectory	2D vs. 3D	Cell vs. Point	Accuracy Level*	Real Time	Additional Sensor
Simple Navigation	P	2D	C/P	B	Yes	None
UAV	P	3D	P	W	Yes	Camera**
Navigation - people with disabilities	P	2D	P	W	Yes	Camera and others
Asset Tracking	P/T	3D	C	R	Yes	None
Indoor FM	P	3D	C/P	W	Yes/No	None
Monitoring Visitors or Aged Persons	P	2D	C	R	Yes	Camera**
Geo-Fencing	P	2D	C	R	Yes	None
Indoor Context Analysis	P/T	2D	C/P	R	Yes/No	None
Trajectory Analysis	T	2D	C/P	R	No	None
Sensor Analysis	P	3D	P	W	Yes	Audio and others
Context based Content delivery	P/T	2D	C	R	Yes	Sensors for AR
Dynamical Resource Allocation	P	2D	P	P	Yes	Environmental sensors

* **W**all level: under 0.3m, **P**erson level: 0.3-1m, **B**ooth level: 1-3m, **R**oom level: 3-5m, **H**all level: over 5m

** Camera in this table does not mean camera sensors for indoor positioning but visual sensor for recognition such as behavior analysis or collision detection.

It is evident that all the use-cases and scenarios above require indoor maps but in different purposes. For example, the use-case for navigation normally needs indoor maps with navigation network, while asset management and monitoring require indoor maps for room deployment and semantic information such as classification of rooms (classroom, restroom, restaurants, etc.) is also necessary for indoor context analysis.

***Additional note**. An exemplary Use Case: Indoor navigation map for visually impaired*

people.

An experimental use-case of verbal indoor routing map service, called VIM (Verbal Indoor Maps) for visually impaired people has been developed by using TalkBack user-interface of smartphones with Android OS. Unlike ordinary indoor navigation and map services, specific requirements have been considered for this routing map service such as such as no additional devices except smartphones, accurate indoor positioning, verbal user-interface, environmental information, and walking pattern of visually impaired people. Even though it is an experimental service, there are several interesting points in this prototype service;

- *Braille block network in indoor space: a navigation network is constructed as an application schema IndoorGML where states and transitions in the network are defined by considering stop and walk signs of braille blocks and directions.*
- *Secondary indoor positioning by Wi-Fi: indoor positioning such as Wi-Fi-based indoor positioning serves as a secondary for example to confirm the current location.*
- *Verbal information attached to transitions: verbal navigation instruction such as "go straight 3 meters" is attached to each transition.*
- *Landmark information: the information about landmark features is also provided as additional instruction of transition.*
- *Definition of states and transitions: the movement and behavioral patterns of visually impaired people are analyzed for the definition of states and transitions of the network.*

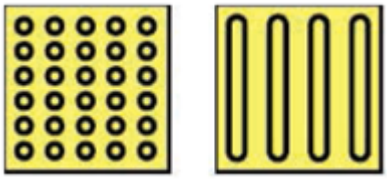


Fig. 21: Stop and Walk Signs of Braille Blocks

This service was implemented in a subway station in Seoul. More detail design and implementation are found in [18].

9 Findings from the survey

9.1 Overall findings

Although some of the responses of the survey may have partially biased by the different communities involved in the survey (OGC, ILA, i-locate), the results, as a whole provide a clear picture of the most important requirement emerging from the market.

In general terms, we can appreciate that there is a strong need for additional standardization efforts (de jure or de facto), while current level of interoperability is considered inadequate. In fact, lack of standard solutions is regarded by supplier as the most important barrier to overcome. At the same time, customer organizations have shown they are well aware that the indoor LBSs can be exploited only as a combination of different technologies symmetrically, 90% of suppliers has declared they are working within a framework of hybrid location systems).

Interoperability is regarded as an important driver to minimize costs and ensure lower TOC. The importance of interoperable solutions is particular important at higher logical level (i.e. at application level), in order to facilitate deployment of solutions leveraging on different hardware, different platforms (i.e. operating systems), devices (including different smartphones) and their integration within existing business and operational models.

From a software standpoint, future developments should focus on developing platforms that facilitate transparent use of multiple location technologies at once (therefore reducing risks from use of a single technology), delivering added value services that can be easily integrated with existing IT systems in order to leverage on indoor positioning technology as a commodity. Specific request for developments included standardized APIs (including real-time and cloud APIs) for deployment of cross-OS Apps, for device management, for privacy management, device discovery, position data exchange between devices and application server (SUPL - Secure User Plane Location), data translations and to access the location server, for testing (through test suites).

At data model level, interoperability should address several aspects, from common naming of indoor spaces, to data meaning, or shared data model for location (including RSSI & RTT) including easy interaction with BIM systems and with software that allow author indoor data in a user-friendly way.

From a hardware standpoint instead focus should be paid to development of low-latency indoor location technologies capable to collect data from passive or very low power device, and to the development of solution which are simply to deploy and configure, ideally allowing clients to install them autonomously (e.g. through self-configuration means).

The survey has also clearly depicted the most relevant barriers to widespread use of indoor location, the top three (privacy, lack of standardized solutions and limited integration with IT

infrastructures) being shared by both client and supplier organizations albeit with different priority. From the survey it clearly emerges that privacy could be regarded, as a whole, as the most critical barrier due to its social (in terms of user perception) and legal implications.

Specific communication actions targeted to making users aware of privacy implications should be deployed to reduce mistrust and reluctance to their use.

From a business standpoint, the survey has still highlighted lack of well-defined use cases as well as insufficient proof of true RoI. Most interestingly, client organization have declared that their top expected benefit is by far the improvement of the quality of services and that not necessarily improved revenues or savings.

9.2 Standardization-related findings

The emerging requirements highlight the importance of integrating indoor location data with other standards to maximize their use in scenarios such as facility mapping, asset tracking, design, operations & maintenance, statistical analytics. From data visualization point of view, these respondents have highlighted the need for integration with standards providing map visualization services, 3D portrayal, streaming web and mobile visualization.

Results of the survey, in particular within the sections collecting requirements of indoor location, have highlighted the need for ensuring better integration of indoor data within existing standards, including:

- CityGML, the OGC standard providing a “common information model and XML-based encoding for the representation, storage, and exchange of virtual 3D city and landscape models [...] realized as an open data model is implemented as an application schema for the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and the ISO TC211.” [7].
- WMS – Web Mapping Service, the OGC standard that “provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases” [8].
- WFS – Web Feature Service, the OGC standard that “offers direct fine-grained access to geographic information at the feature and feature property level” [9]).
- WPS – Web Processing Service, the OGC standard that “provides rules for standardizing how inputs and outputs (requests and responses) for geospatial processing services, such as polygon overlay.” [10].
- SOS - Sensor Observation Service, the OGC standard which “defines a Web service interface which allows querying observations, sensor metadata, as well as representations of observed features” [17].

***Additional note**. It is worth noting that, with specific regard to integration with CityGML, the existing IndoorGML standard by OGC already allows leveraging on CityGML to model 3D indoor spaces. In addition the Moving Feature has been also engineered to implicitly*

support representation of features moving within indoor spaces.

The survey has specifically mentioned how, integration of indoor location within the aforementioned standards, could be beneficial to support applications such as multi facility mapping, asset tracking, design, operations and maintenance, to name but a few. In more general terms integration of indoor location within mainstream OGC standards has been regarded as very important to improve map visualization services (including 2D and 3D portrayal), services for streaming data and for mobile visualization purposes, transaction services as well as for statistical analytics.

9.3 Industry-related findings

One first key issue to consider in future activities is the clear indication that the market is differentiating into a number of vertical industries. The location of people and assets is key to enable new opportunities to more effective and efficient operational processes. Venue owners will find motivations to invest in their infrastructure if and when they will be able to convert this new enabler into something meaningful with respect to their core business.

A reference architecture will have to be meaningful for all the players of the ecosystem from chip manufacturers to venue owners, including facility managers and external companies offering security or maintenance services.

Best practices are expected to emerge and consolidate from current wave of deployments that will impact on how indoor positioning features are going to be exploited, integrated and ultimately embedded into the IT systems of the venue owners.

From this point of view, the focus of standardization has to move to upper levels, where the lack of common approaches and best practices makes the exploitation process still prone to errors and expensive.

The InLocation Alliance (ILA) was founded by the mobile industry to accelerate the adoption of indoor position solutions that will enhance the mobile experience by opening up new opportunities for consumers and venue owners.

Requirements for standardization (de jure or de facto) are migrating upper in the stack where integration costs impact on the adoption decision of venue owners.

10 Conclusions

The overall feedback received from the survey has been very positive, with several explicit appreciations and encouragements for the initiative, showing how the domain addressed enjoys significant attention from often-enthusiastic industrial and user communities.

Among the many different items discussed within this report, certainly a few are worth a specific mention, due to their relevance and to the interest generated among the respondent.

The first is that a clear leading and proactive role must be taken by industry to offer solutions capable to provide high protection of personal data. In fact, privacy has emerged as the grand challenge to the success of indoor location technologies and legal frameworks related to privacy protection, especially in Europe, are regarded as the most prominent barriers to its widespread market uptake.

Most notably, a few very interesting use cases have emerged from the many received, most notably those related to facility management, which can be related to number of activities that will highly benefit from indoor positioning, and those related to location and support to specific user groups, such as elderly people, who could substantially benefit from indoor location while carrying on activities of daily life.

From a technology standpoint instead, possibly driven by increasingly sophisticated use cases, two requirements have emerged clearly: delivering good position accuracy and maximizing deployment of long lasting location infrastructures that can be used across a range of different applications. Results of the survey suggest that the increasing success enjoyed by beacons could pave the way to the creation of such a shared infrastructure.

Last, but certainly not least, the survey has clearly highlighted that interoperability is regarded as essential to the success of indoor (and outdoor) location solutions. The need for standards emerges clearly in terms of technologies, for promoting widespread use of standard solutions, as well as in terms of data formats (e.g. for management of indoor mapping data).

11 References

[1]	Elisa Morganti et al. (2014). The i-locate project deliverable "D1.1 Use cases description and Privacy Threat Vulnerability and Risk Analysis" (2014). Available online at: http://www.i-locate.eu/data/uploads/2015/07/D.1.1-UC-description-and-PTVRA-rev-2015-06-24.pdf
[2]	Paolo Guarda (2009). Data Protection, Information Privacy, and Security Measures: an essay on the European and the Italian Legal Frameworks. Available online at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1517449
[3]	Council of Europe (1981). Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data of the Council of Europe of 1 January 1981, Strasbourg. Available online at: http://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/108
[4]	Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Official Journal L 281 , 23/11/1995 P. 0031 – 0050. Available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:HTML
[5]	Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 concerning the processing of personal data and the protection of privacy in the electronic communications sector (Directive on privacy and electronic communications). Official Journal L 201 , 31/07/2002 P. 0037 – 0047. Available online at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0058:en:HTML
[6]	Project i-locate "Indoor/outdoor LOCation and Asset management Through open gEodata" co-funded by the ICT-PSP programme of the European Commission (Grant Agreement number: 621040). Available online at: www.i-locate.eu
[7]	CityGML. Official page. Available online at: http://www.citygml.org/
[8]	WMS - Web Map Service standard by OGC. Available online at: http://www.opengeospatial.org/standards/wms
[9]	WFS - Web Feature Service standard by OGC. Available online at: http://www.opengeospatial.org/standards/wfs

[10]	WPS - Web Processing Service standard by OGC. Available online at: http://www.opengeospatial.org/standards/wps
[11]	Indoor Location Based services in Retail and Marketing, ILA White Paper, September 2015. Available online at: http://inlocationalliance.org/2015/09/ila-use-case-white-paper-for-indoor-location-based-services-in-retail-and-marketing/
[12]	Indoor Location Based Services in Transportation Hubs, ILA White Paper, September 2015. Available online at: http://inlocationalliance.org/2015/09/ila-use-case-white-paper-for-indoor-location-based-services-in-transportation-hubs/
[13]	The Location Based Marketing Association (LBMA) homepage. Available online at: http://www.thelbma.com/
[14]	The InLocation Alliance (ILA) homepage. Available online at: http://inlocationalliance.org/
[15]	The Open Geospatial Consortium (OGC) homepage. Available online at: http://www.opengeospatial.org/
[16]	The project i-locate “Indoor/outdoor LOCation and Asset management Through open gEodata” homepage. Available online at: http://www.i-locate.eu/
[17]	SOS - Sensor Observation Service standard by OGC. Available online at: http://www.opengeospatial.org/standards/sos
[18]	Ryu, Hyeong-Gyu, Taehoon Kim, and Ki-Joune Li. "Indoor navigation map for visually impaired people." In Proceedings of the Sixth ACM SIGSPATIAL International Workshop on Indoor Spatial Awareness. ACM, 201 pp. 32-35.
[19]	ILA System Architecture Specifications. Available online at http://inlocationalliance.org/
[20]	MarketsAndMarkets (2015). Location Based Services (LBS) and Real-Time Location Systems (RTLS) Market by Location (Indoor & Outdoor), Technology (context-aware, UWB, BT/BLE, beacons, & A-GPS, and others), Software, Hardware, Services, and Application Areas - Global Forecast to 2020.

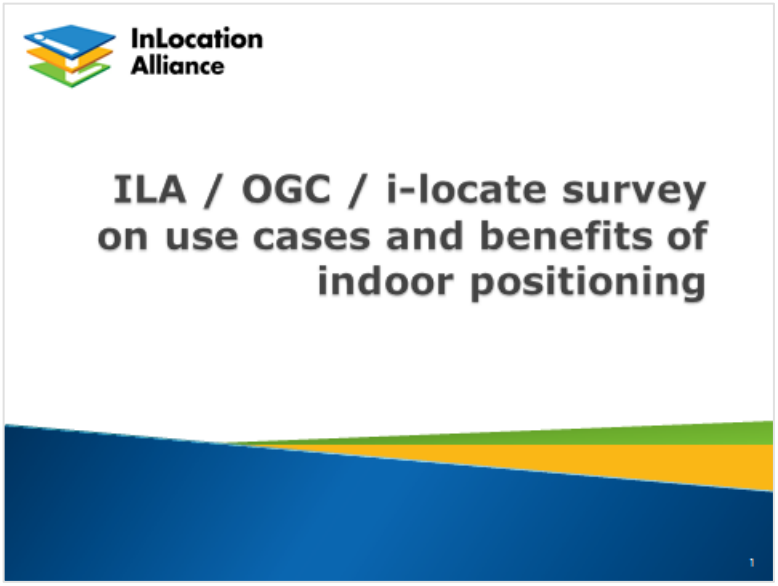
12 Annex 1: List of findings

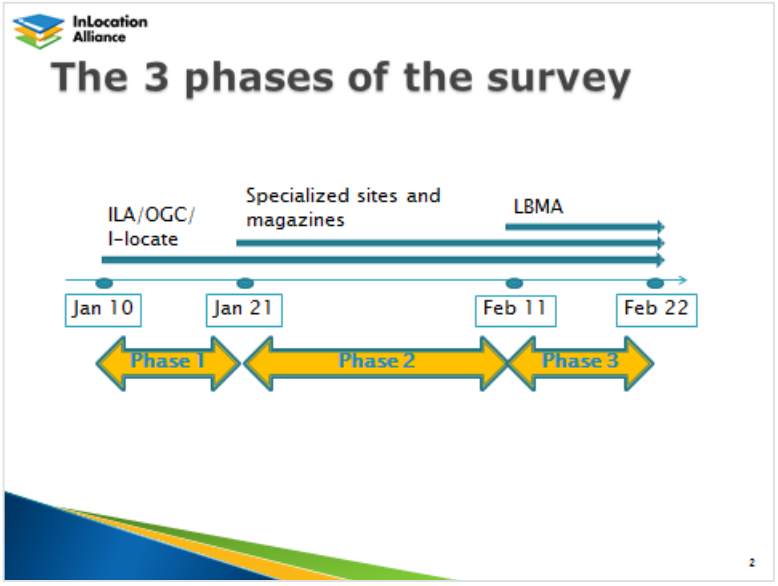
Finding 1. Software application developers represent the majority of the respondents, this confirms the fact that indoor positioning provides benefits to context based applications that have to be customized to the intended customers and adapted to the single venues. 17
Finding 2. Indoor positioning technologies appear to be applicable to a wide range of use cases in a wide range of industries 19
Finding 3. Given the typical relationship between cost and performance, it would appear that both suppliers and consumers believe there is a threshold of around 1 meter accuracy, below which costs rise and applications become more specialized. 22
Finding 4. The survey highlights the need for interoperable frameworks and platforms capable to deliver value-added services by leveraging on indoor positioning technology as a commodity. 23
Finding 5. Suppliers need scalable and low-latency indoor location technologies capable to collect data from passive or very low power devices. 25
Finding 6. To be able to make concerted use of multiple positioning technologies at once. 25
Finding 7. Indoor positioning solutions should be available on multi-platforms including desktop and mobile device operating systems. 26
Finding 8. To develop tools for automatic system configuration of the location infrastructure. 27
Finding 9. To ensure wider support of indoor location data types and functions in OGC and OASIS standards 27
Finding 10. Within client organizations, “privacy” is regarded as the most important barrier to indoor location. 28
Finding 11. Within client organizations, standard products and services are seen as a means to reducing risks related to widespread adoption of a new technology and to ensuring integration with their IT infrastructure. 29
Finding 12. Customer organizations are well aware that the indoor LBSs can be exploited only as a combination of different technologies cooperating. 30
Finding 13. Other concerns among customer organizations refer to the level of engagement of people in using location-based services, therefore overcoming lack of motivation, reluctance or mistrust to technology. 30
Finding 14. Supplier organizations consider lack of standard indoor positioning technology as the most important barrier. 31
Finding 15. Client and supplier organizations share the same top three barriers although with different priority. 31
Finding 16. Supplier clearly highlights the importance of developing cross-OS APIs. 33
Finding 17. The survey shows that that 90% of suppliers are working within a framework of hybrid location systems, while there is a non-negligible minority that is working at single technology approaches. 33
Finding 18. The top benefit expected by far is the improvement of the quality of services that not necessarily translates into improved revenues or improved savings. The real expected benefit is more intangible and can be described as better customer relation

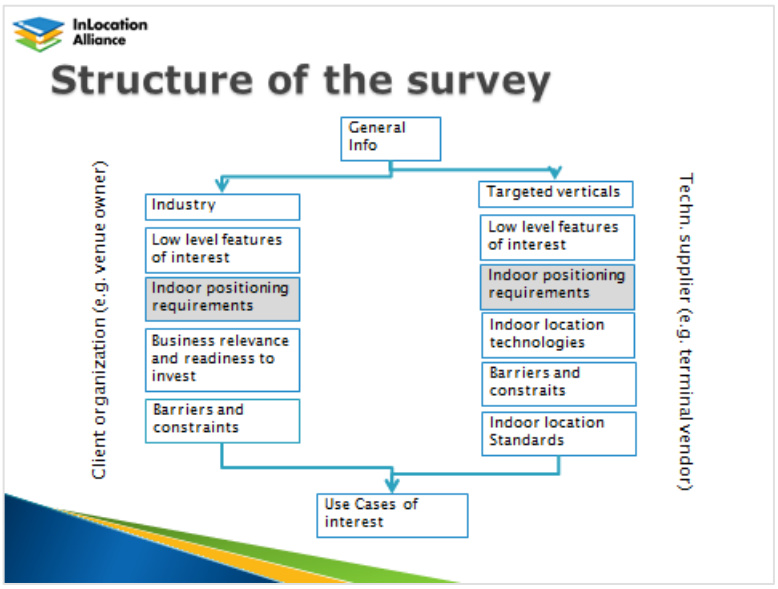
when users are customers, but they may well be employed, security personnel or maintenance personnel. 34
Finding 19. The wealth of use cases reported witnesses the huge benefits that indoor positioning technologies are expected to deliver to a wide range of industries. 36
Finding 20. Different industries have different business goals and business processes in place supported by vertically oriented systems. Indoor location solutions have to be integrated in such systems and match different performance requirements (such as accuracy and availability) according to the requirements of the receiving systems. 37
Finding 21. Prevailing expectations among Customer organizations are that indoor positioning benefits will mainly come from improved customer relations (through better service quality) and from improved business processes (mainly safety and security). 37
Finding 22. Customer organizations need to be supported in the exploitation of indoor location based systems both in terms of consultancy to prepare the infrastructure and processes to support the new capabilities and in terms of software and content customization. 38
Finding 23. Interoperability is regarded as extremely important to the business of the respondent. 41
Finding 24. The overall perception is that level of interoperability available today in the indoor location domain is not adequate. 41
Finding 25. Responses from the survey clearly show that interoperability within indoor location domain as essential. 42

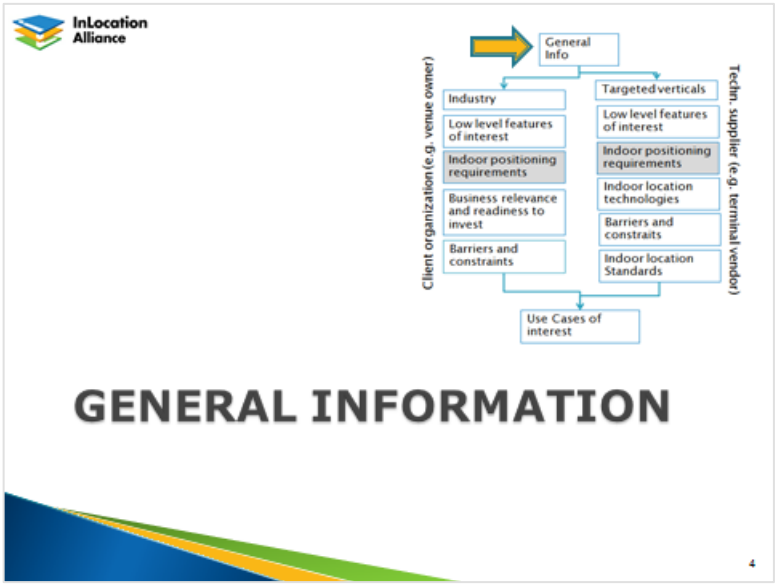
13 Annex 2: copy of the survey

14 Annex 3: main figures extracted from the survey






InLocation Alliance
Structure of the survey
General Info
Client organization (e.g. venue owner)
Industry
Low level features of interest
Indoor positioning requirements
Business relevance and readiness to invest
Barriers and constraints
Targeted verticals
Low level features of interest
Indoor positioning requirements
Indoor location technologies
Barriers and constraits
Indoor location Standards
Techn. supplier (e.g. terminal vendor)
Use Cases of interest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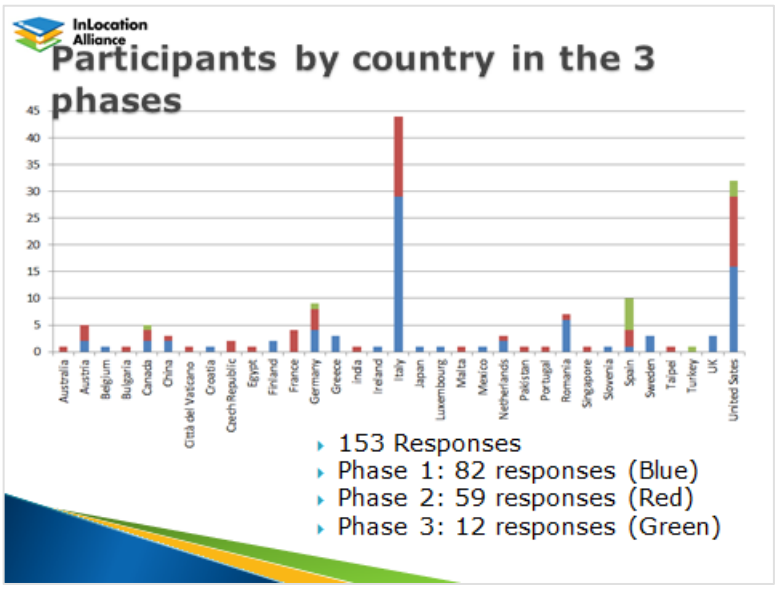
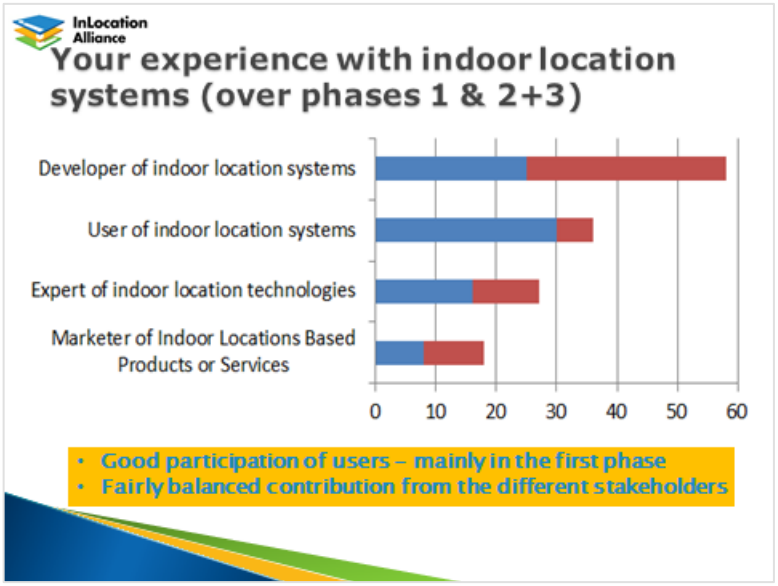
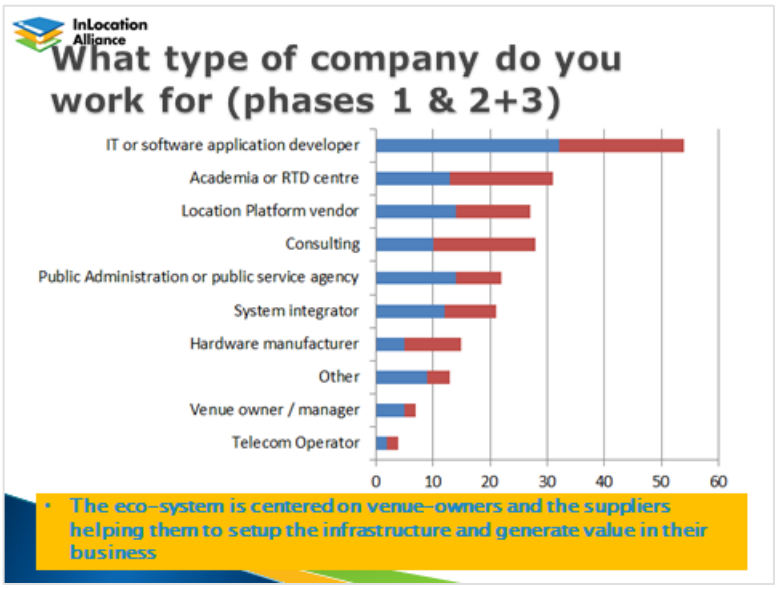
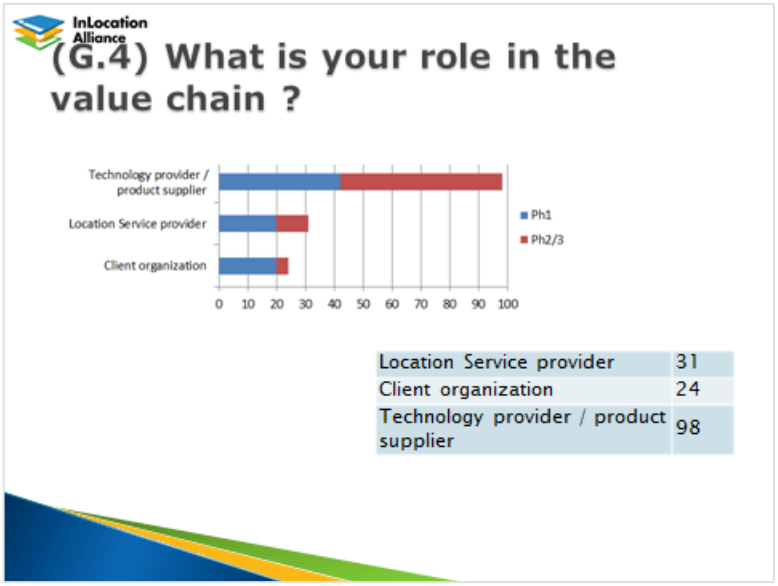
GENERAL INFORMATION
4


InLocation Alliance
Participants by country in the 3 phases
45
40
35
30
25
20
15
10
5
0
Australia
Austria
Belgium
Bulgaria
Canada
China
Città del Vaticano
Croatia
Czech Republic
Egypt
Finland
France
Germany
Greece
India
Ireland
Italy
Japan
Luxembourg
Malta
Mexico
Netherlands
Pakistan
Portugal
Romania
Singapore
Slovenia
Spain
Sweden
Taipei
Turkey
UK
United Sates
153 Responses
Phase 1: 82 responses (Blue)
Phase 2: 59 responses (Red)
Phase 3: 12 responses (Green)


InLocation Alliance
Your experience with indoor location systems (over phases 1 & 2+3)
Developer of indoor location systems
User of indoor location systems
Expert of indoor location technologies
Marketer of Indoor Locations Based Products or Services
0
10
20
30
40
50
60
Good participation of users – mainly in the first phase
Fairly balanced contribution from the different stakeholders


What type of company do you work for (phases 1 & 2+3)
IT or software application developer
Academia or RTD centre
Location Platform vendor
Consulting
Public Administration or public service agency
System integrator
Hardware manufacturer
Other
Venue owner / manager
Telecom Operator
0 10 20 30 40 50 60
The eco-system is centered on venue-owners and the suppliers helping them to setup the infrastructure and generate value in their business


(G.4) What is your role in the value chain ?
Technology provider / product supplier
Location Service provider
Client organization
Ph1
Ph2/3
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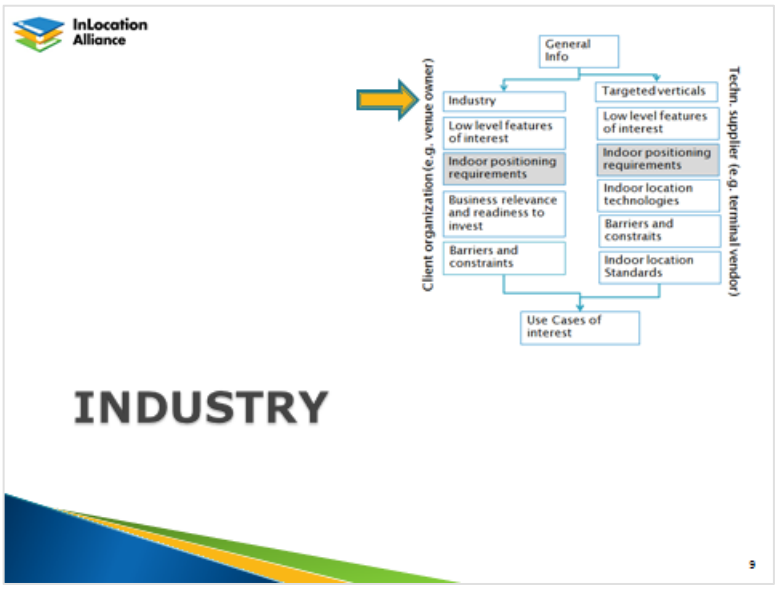
Client organization 24
Technology provider / product supplier 98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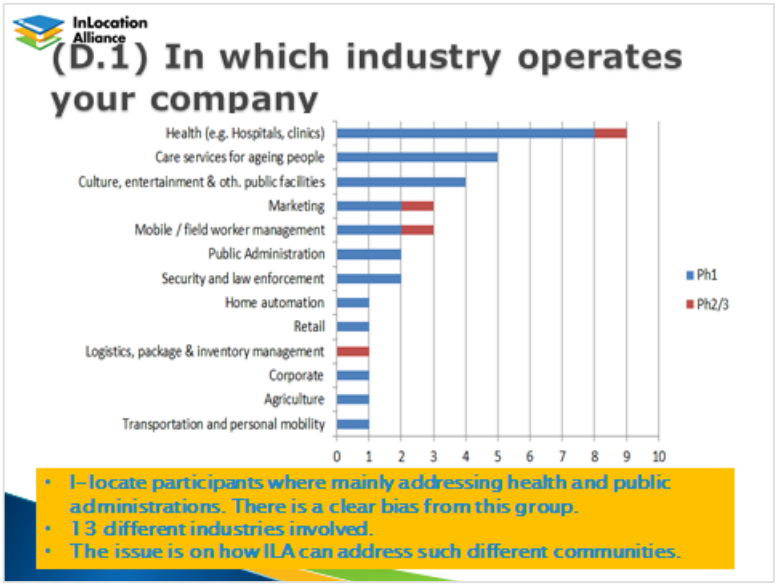
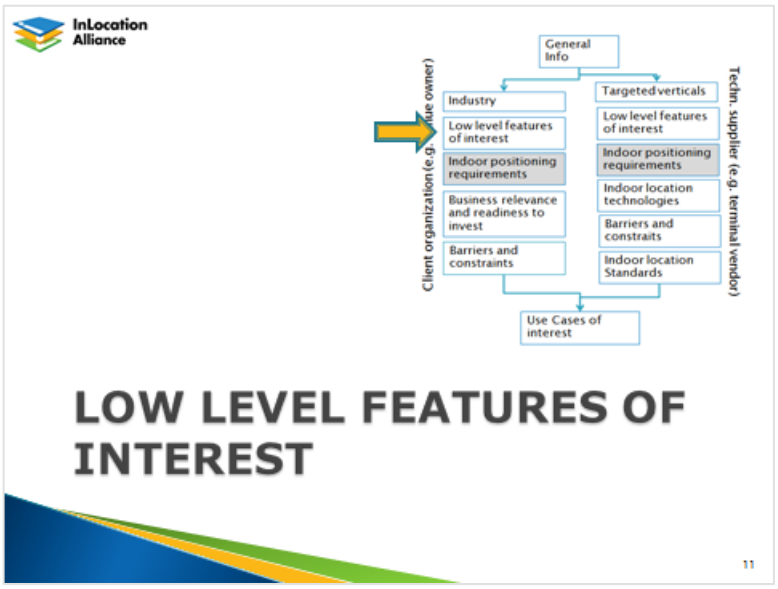
Low level features of interest
Indoor positioning requirements
Business relevance and readiness to invest
Barriers and constraints
Techn. supplier (e.g. terminal vendor)
Targeted verticals
Low level features of interest
Indoor positioning requirements
Indoor location technologies
Barriers and constraits
Indoor location Standards
Use Cases of interest
INDUSTRY
9


InLocation Alliance
(D.1) In which industry operates your company
Health (e.g. Hospitals, clinics)
Care services for ageing people
Culture, entertainment & oth. public facilities
Marketing
Mobile / field worker management
Public Administration
Security and law enforcement
Home automation
Retail
Logistics, package & inventory management
Corporate
Agriculture
Transportation and personal mobility
0 1 2 3 4 5 6 7 8 9 10
Ph1
Ph2/3
• I-locate participants where mainly addressing health and public administrations. There is a clear bias from this group.
• 13 different industries involved.
• The issue is on how ILA can address such different communities.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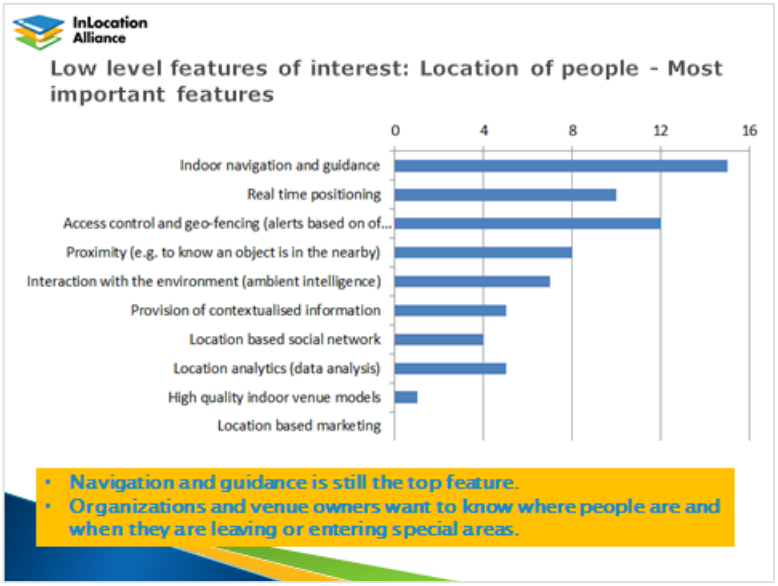
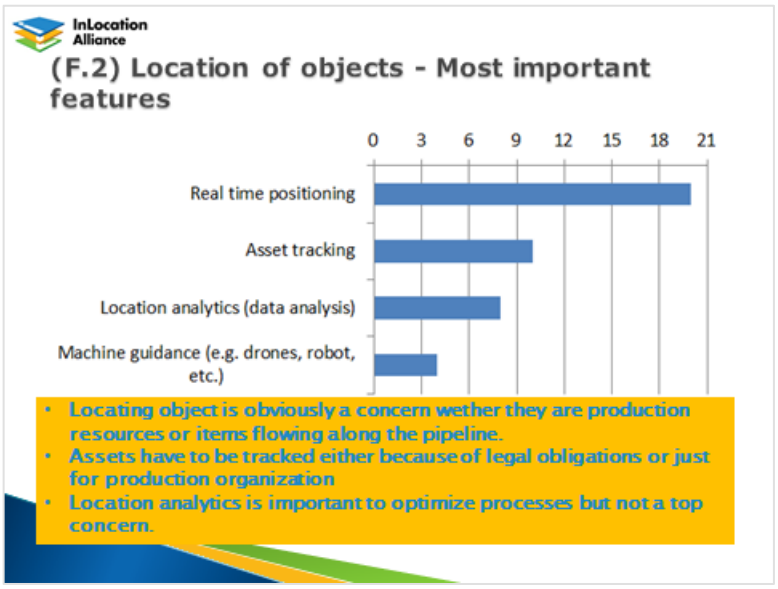
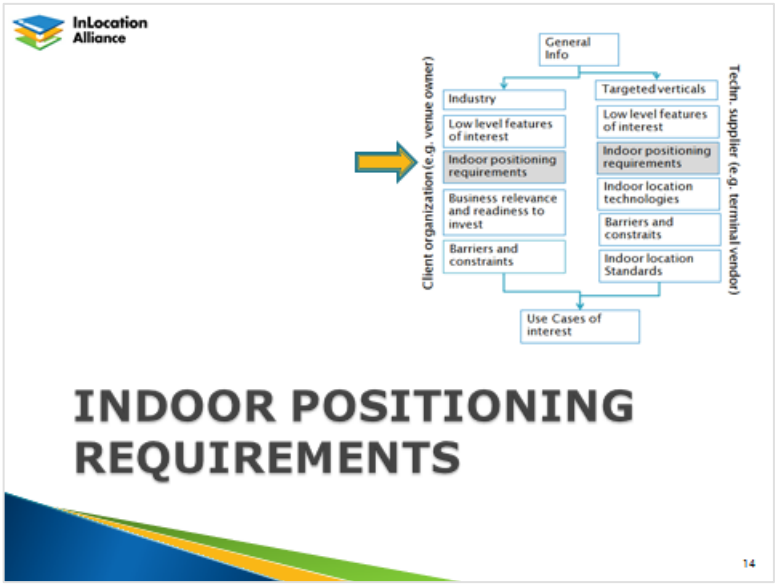
Use Cases of interest
LOW LEVEL FEATURES OF INTEREST
11


InLocation Alliance
Low level features of interest: Location of people - Most important features
0
4
8
12
16
Indoor navigation and guidance
Real time positioning
Access control and geo-fencing (alerts based on of...
Proximity (e.g. to know an object is in the nearby)
Interaction with the environment (ambient intelligence)
Provision of contextualised information
Location based social network
Location analytics (data analysis)
High quality indoor venue models
Location based marketing
Navigation and guidance is still the top feature.
Organizations and venue owners want to know where people are and when they are leaving or entering special areas.


InLocation Alliance
(F.2) Location of objects - Most important features
0
3
6
9
12
15
18
21
Real time positioning
Asset tracking
Location analytics (data analysis)
Machine guidance (e.g. drones, robot, etc.)
• Locating object is obviously a concern wether they are production resources or items flowing along the pipeline.
• Assets have to be tracked either because of legal obligations or just for production organization
• Location analytics is important to optimize processes but not a top concern.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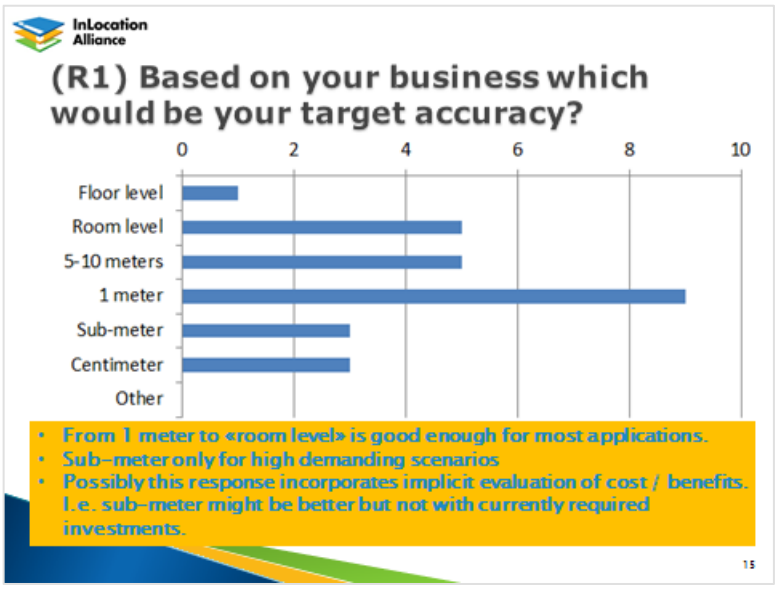
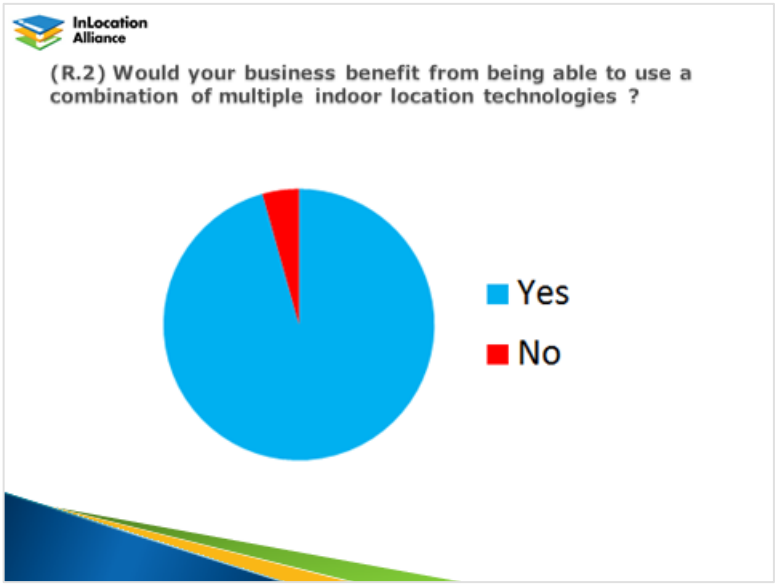
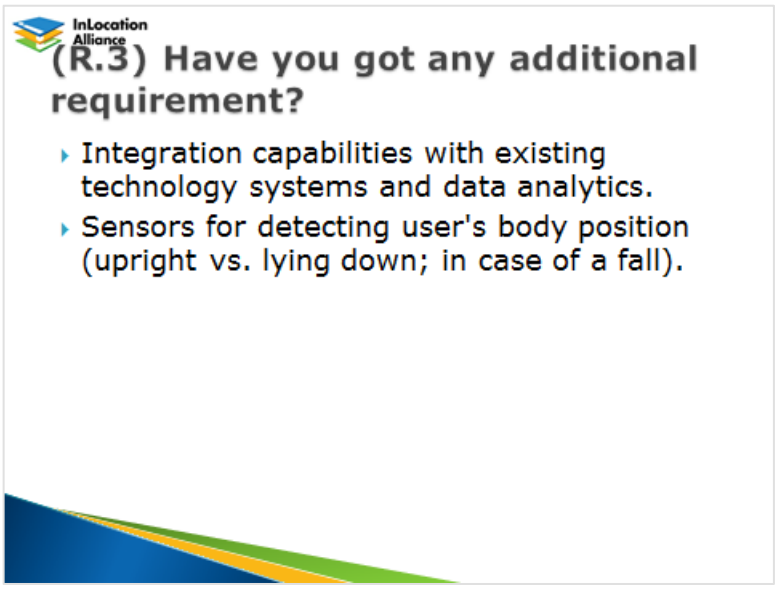
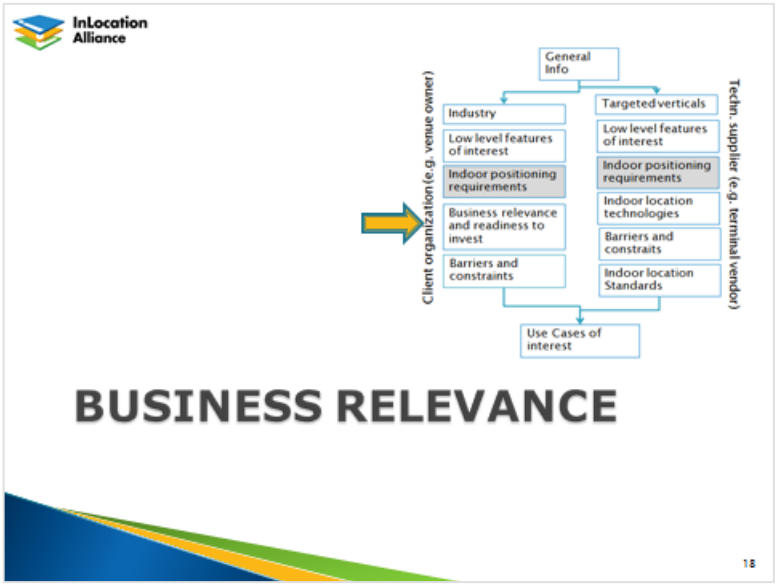
INDOOR POSITIONING REQUIREMENTS
14


InLocation Alliance
(R1) Based on your business which would be your target accuracy?
0
2
4
6
8
10
Floor level
Room level
5-10 meters
1 meter
Sub-meter
Centimeter
Other
From 1 meter to «room level» is good enough for most applications.
Sub-meter only for high demanding scenarios
Possibly this response incorporates implicit evaluation of cost / benefits. I.e. sub-meter might be better but not with currently required investments.
15


InLocation Alliance
(R.2) Would your business benefit from being able to use a combination of multiple indoor location technologies ?
Yes
No


InLocation Alliance
(R.3) Have you got any additional requirement?
Integration capabilities with existing technology systems and data analytics.
Sensors for detecting user's body position (upright vs. lying down; in case of a fall).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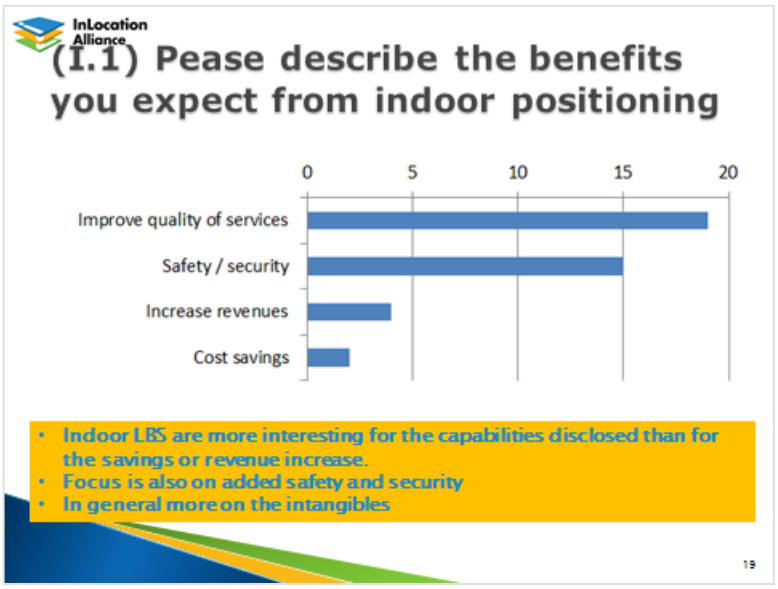
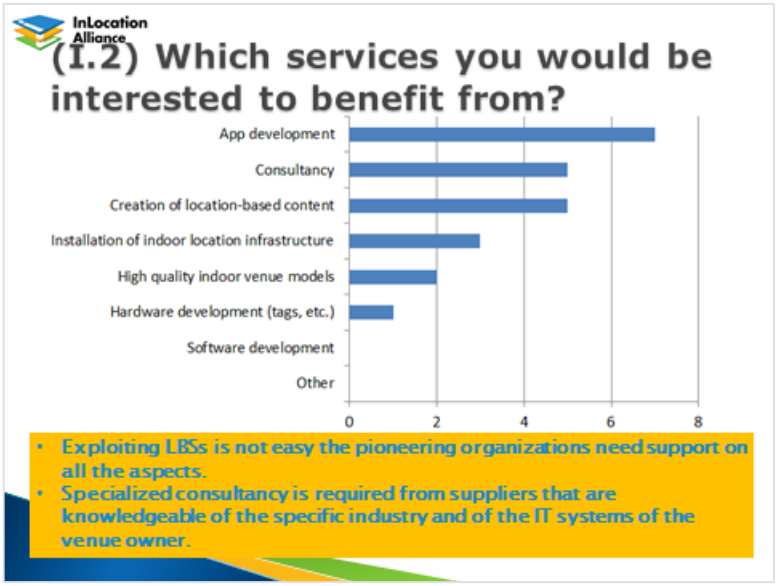
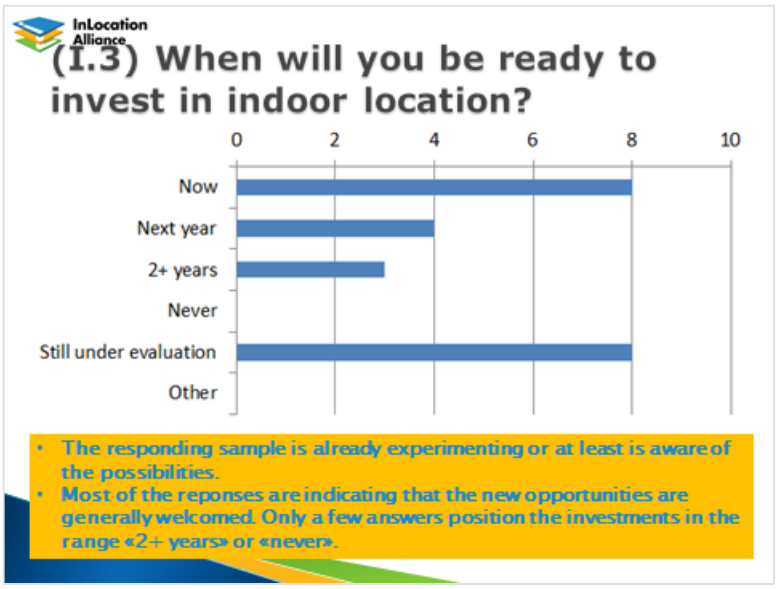
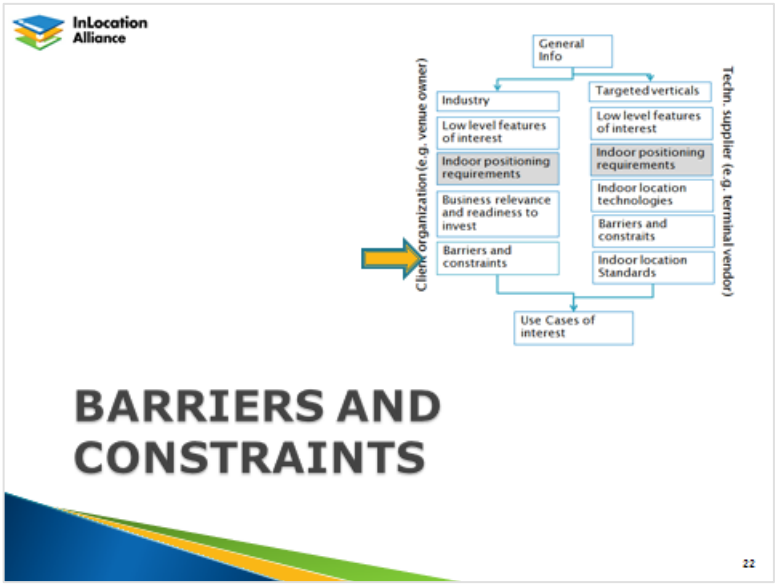
BUSINESS RELEVANCE
18


InLocation Alliance
(I.1) Pease describe the benefits you expect from indoor positioning
0
5
10
15
20
Improve quality of services
Safety / security
Increase revenues
Cost savings
• Indoor LBS are more interesting for the capabilities disclosed than for the savings or revenue increase.
• Focus is also on added safety and security
• In general more on the intangibles
19


InLocation Alliance
(I.2) Which services you would be interested to benefit from?
App development
Consultancy
Creation of location-based content
Installation of indoor location infrastructure
High quality indoor venue models
Hardware development (tags, etc.)
Software development
Other
0
2
4
6
8
• Exploiting LBSs is not easy the pioneering organizations need support on all the aspects.
• Specialized consultancy is required from suppliers that are knowledgeable of the specific industry and of the IT systems of the venue owner.


InLocation Alliance
(I.3) When will you be ready to invest in indoor location?
0
2
4
6
8
10
Now
Next year
2+ years
Never
Still under evaluation
Other
The responding sample is already experimenting or at least is aware of the possibilities.
Most of the reponses are indicating that the new opportunities are generally welcomed. Only a few answers position the investments in the range «2+ years» or «never».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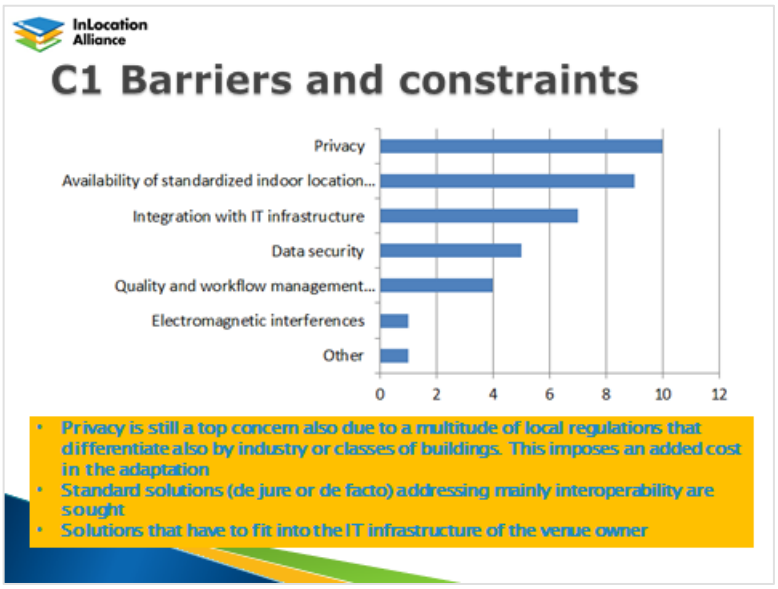
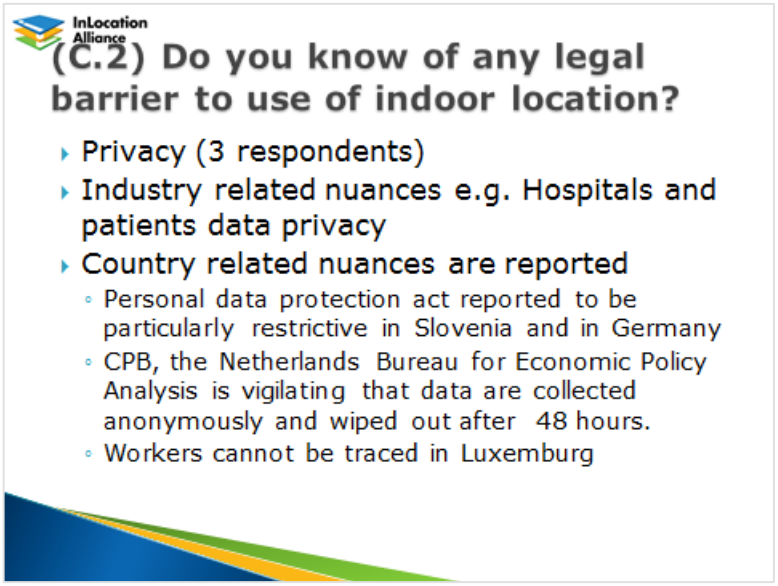
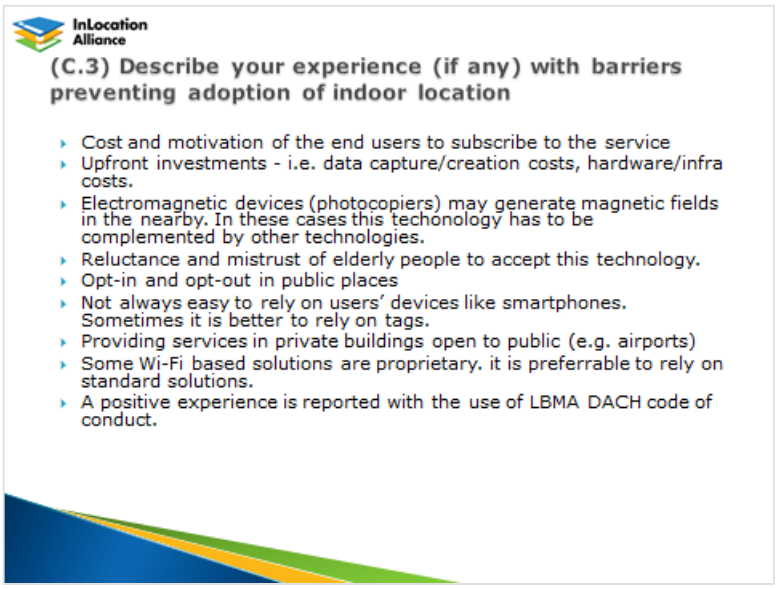
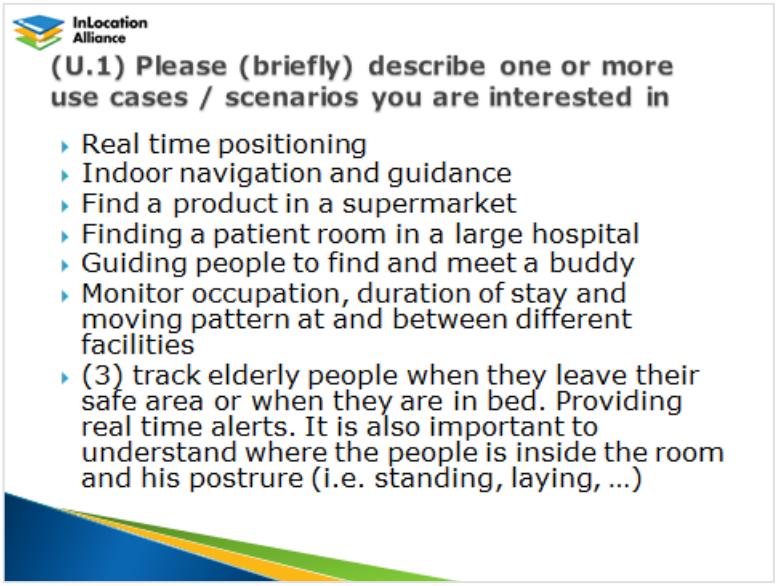
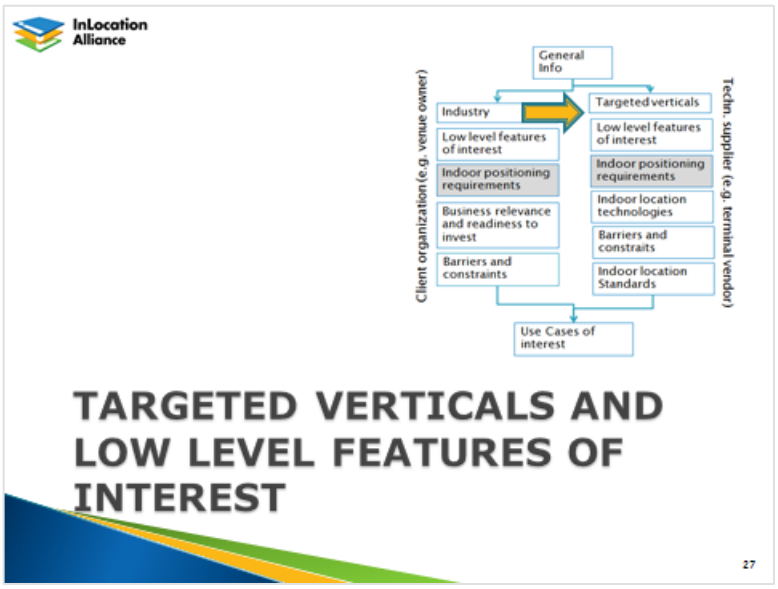
Use Cases of interest
BARRIERS AND CONSTRAINTS
22


InLocation Alliance
C1 Barriers and constraints
Privacy
Availability of standardized indoor location...
Integration with IT infrastructure
Data security
Quality and workflow management...
Electromagnetic interferences
Other
0
2
4
6
8
10
12
Privacy is still a top concern also due to a multitude of local regulations that differentiate also by industry or classes of buildings. This imposes an added cost in the adaptation
Standard solutions (de jure or de facto) addressing mainly interoperability are sought
Solutions that have to fit into the IT infrastructure of the venue owner


InLocation Alliance
(C.2) Do you know of any legal barrier to use of indoor location?
Privacy (3 respondents)
Industry related nuances e.g. Hospitals and patients data privacy
Country related nuances are reported
Personal data protection act reported to be particularly restrictive in Slovenia and in Germany
CPB, the Netherlands Bureau for Economic Policy Analysis is vigilating that data are collected anonymously and wiped out after 48 hours.
Workers cannot be traced in Luxemburg


InLocation Alliance
(C.3) Describe your experience (if any) with barriers preventing adoption of indoor location
Cost and motivation of the end users to subscribe to the service
Upfront investments - i.e. data capture/creation costs, hardware/infra costs.
Electromagnetic devices (photocopiers) may generate magnetic fields in the nearby. In these cases this techonology has to be complemented by other technologies.
Reluctance and mistrust of elderly people to accept this technology.
Opt-in and opt-out in public places
Not always easy to rely on users' devices like smartphones. Sometimes it is better to rely on tags.
Providing services in private buildings open to public (e.g. airports)
Some Wi-Fi based solutions are proprietary. it is preferrable to rely on standard solutions.
A positive experience is reported with the use of LBMA DACH code of conduct.


InLocation Alliance
(U.1) Please (briefly) describe one or more use cases / scenarios you are interested in
Real time positioning
Indoor navigation and guidance
Find a product in a supermarket
Finding a patient room in a large hospital
Guiding people to find and meet a buddy
Monitor occupation, duration of stay and moving pattern at and between different facilities
(3) track elderly people when they leave their safe area or when they are in bed. Providing real time alerts. It is also important to understand where the people is inside the room and his postrure (i.e. standing, laying, ...)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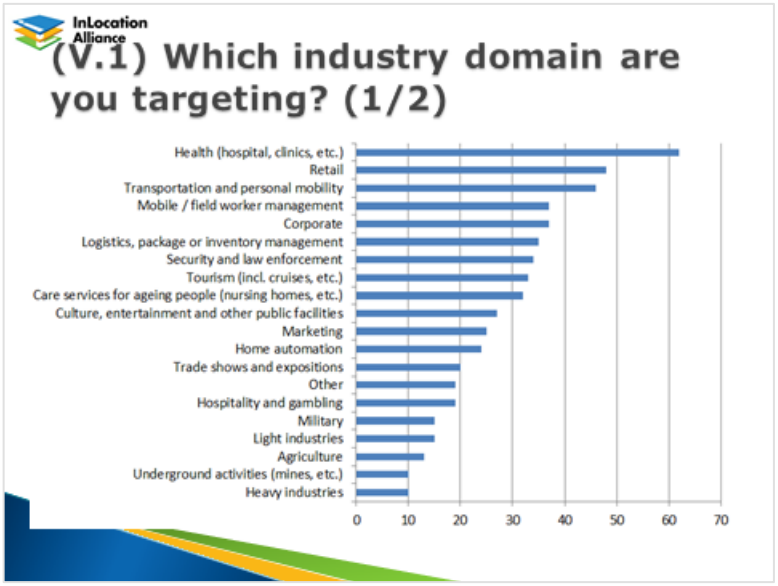
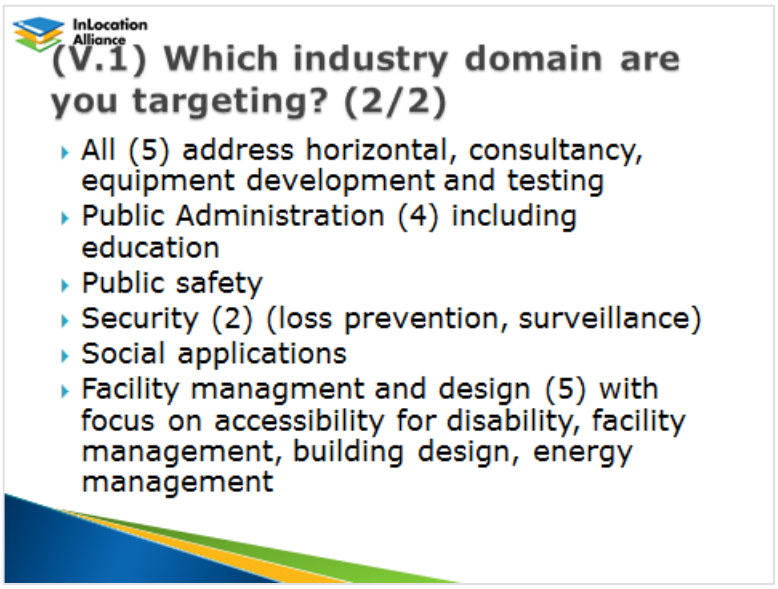
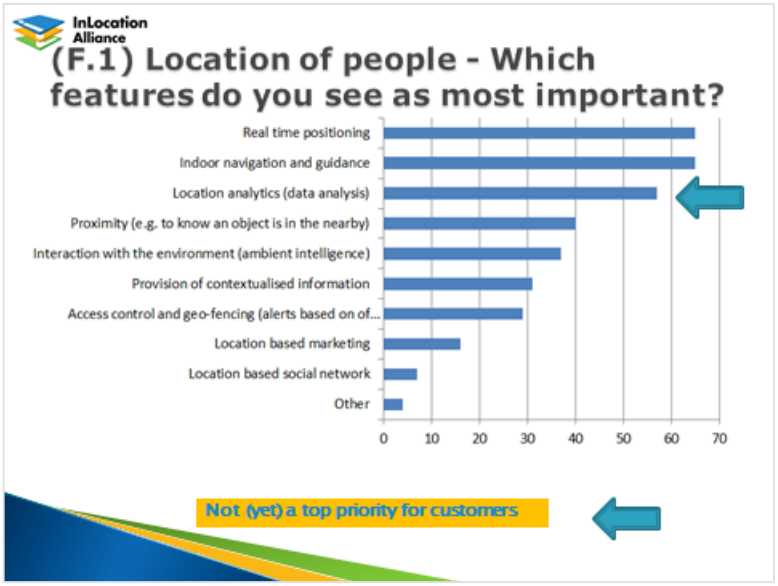
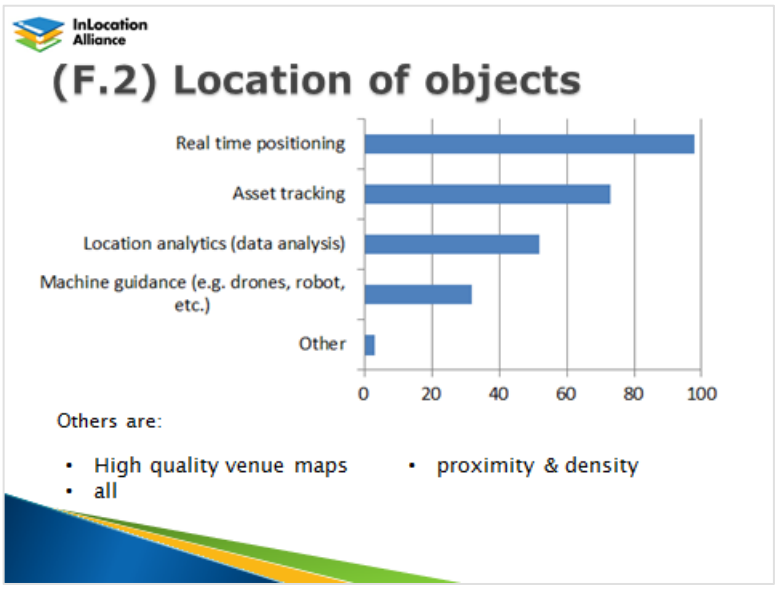
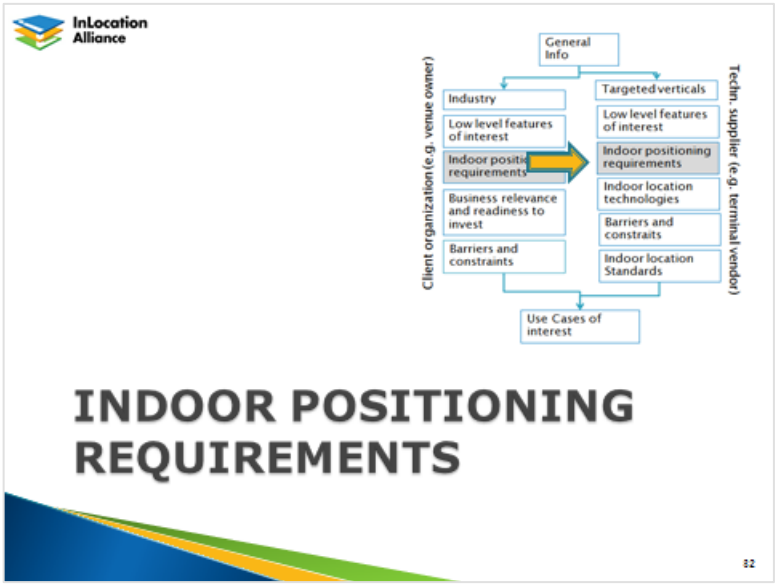
TARGETED VERTICALS AND LOW LEVEL FEATURES OF INTEREST
27


InLocation Alliance
(V.1) Which industry domain are you targeting? (1/2)
Health (hospital, clinics, etc.)
Retail
Transportation and personal mobility
Mobile / field worker management
Corporate
Logistics, package or inventory management
Security and law enforcement
Tourism (incl. cruises, etc.)
Care services for ageing people (nursing homes, etc.)
Culture, entertainment and other public facilities
Marketing
Home automation
Trade shows and expositions
Other
Hospitality and gambling
Military
Light industries
Agriculture
Underground activities (mines, etc.)
Heavy industries
0
10
20
30
40
50
60
70


InLocation Alliance
(V.1) Which industry domain are you targeting? (2/2)
All (5) address horizontal, consultancy, equipment development and testing
Public Administration (4) including education
Public safety
Security (2) (loss prevention, surveillance)
Social applications
Facility managment and design (5) with focus on accessibility for disability, facility management, building design, energy management


InLocation Alliance
(F.1) Location of people - Which features do you see as most important?
Real time positioning
Indoor navigation and guidance
Location analytics (data analysis)
Proximity (e.g. to know an object is in the nearby)
Interaction with the environment (ambient intelligence)
Provision of contextualised information
Access control and geo-fencing (alerts based on of...
Location based marketing
Location based social network
Other
0
10
20
30
40
50
60
70
Not (yet) a top priority for customers


InLocation Alliance
(F.2) Location of objects
Real time positioning
Asset tracking
Location analytics (data analysis)
Machine guidance (e.g. drones, robot, etc.)
Other
0
20
40
60
80
100
Others are:
• High quality venue maps
• all
• proximity & density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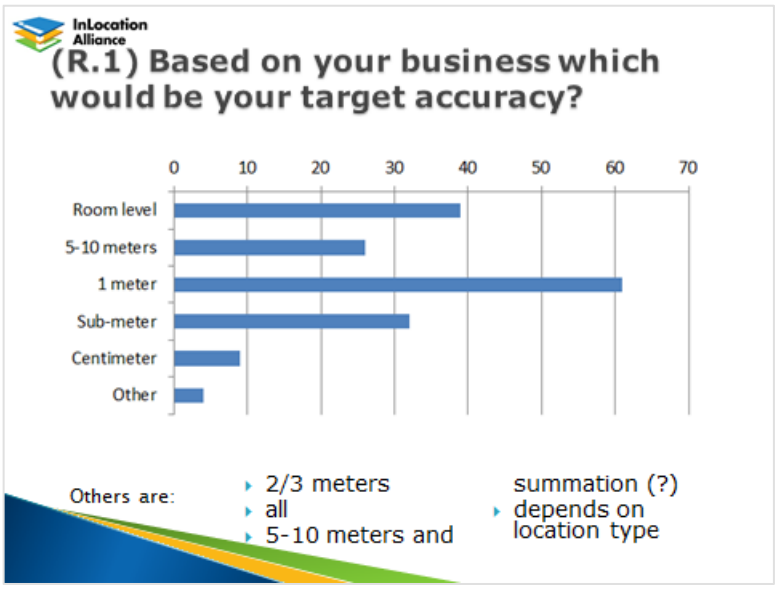
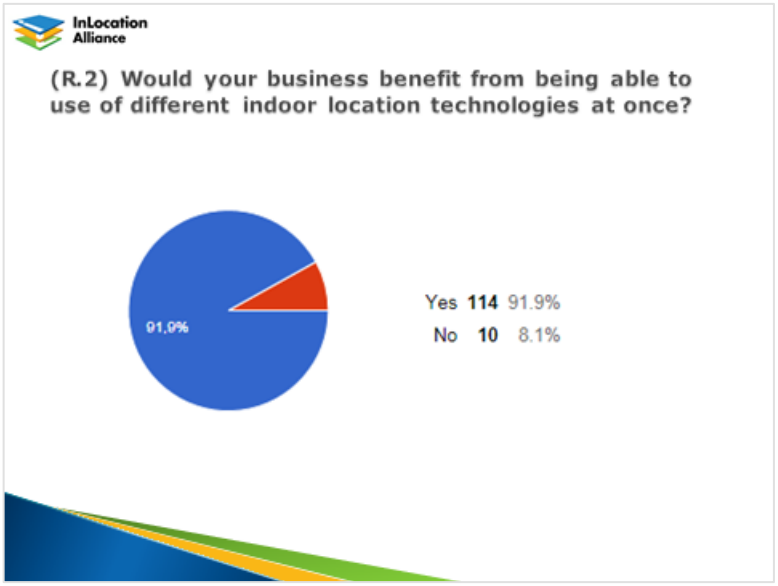
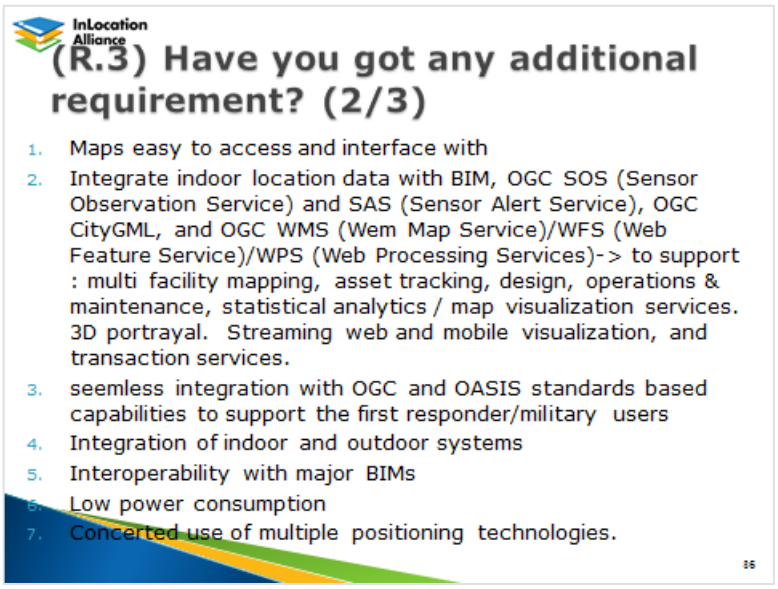
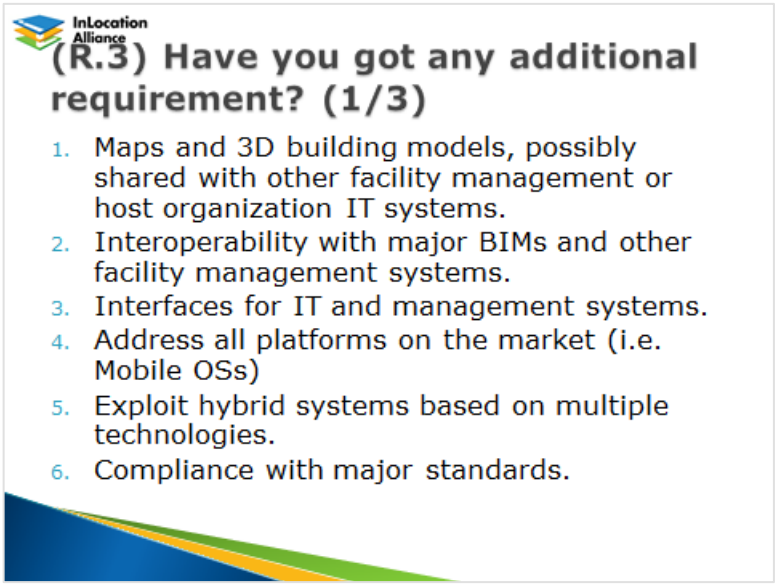
INDOOR POSITIONING REQUIREMENTS
82


InLocation Alliance
(R.1) Based on your business which would be your target accuracy?
0
10
20
30
40
50
60
70
Room level
5-10 meters
1 meter
Sub-meter
Centimeter
Other
Others are:
2/3 meters
all
5-10 meters and summation (?)
depends on location type


InLocation Alliance
(R.2) Would your business benefit from being able to use of different indoor location technologies at once?
91,9%
Yes 114 91.9%
No 10 8.1%

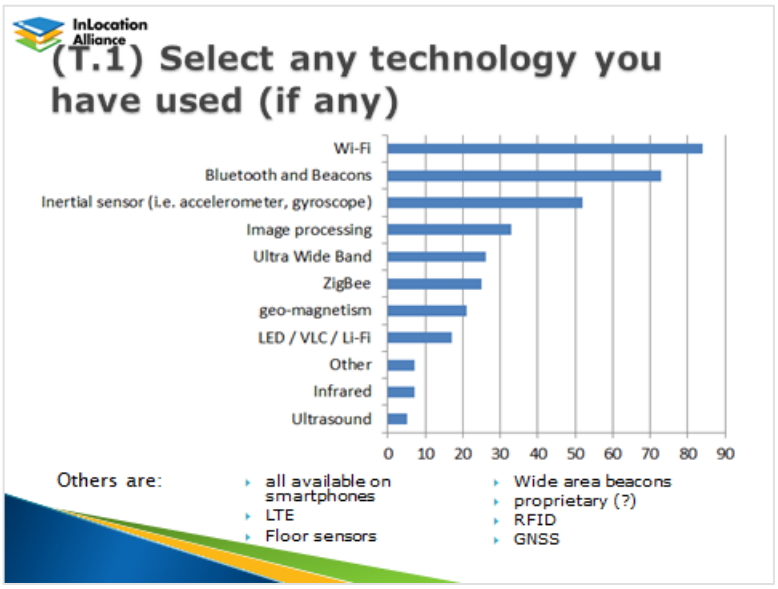

InLocation Alliance
(R.3) Have you got any additional requirement? (2/3)
1. Maps easy to access and interface with
2. Integrate indoor location data with BIM, OGC SOS (Sensor Observation Service) and SAS (Sensor Alert Service), OGC CityGML, and OGC WMS (Wem Map Service)/WFS (Web Feature Service)/WPS (Web Processing Services)-> to support : multi facility mapping, asset tracking, design, operations & maintenance, statistical analytics / map visualization services. 3D portrayal. Streaming web and mobile visualization, and transaction services.
3. seemless integration with OGC and OASIS standards based capabilities to support the first responder/military users
4. Integration of indoor and outdoor systems
5. Interoperability with major BIMs
6. Low power consumption
7. Concerted use of multiple positioning technologies.
86

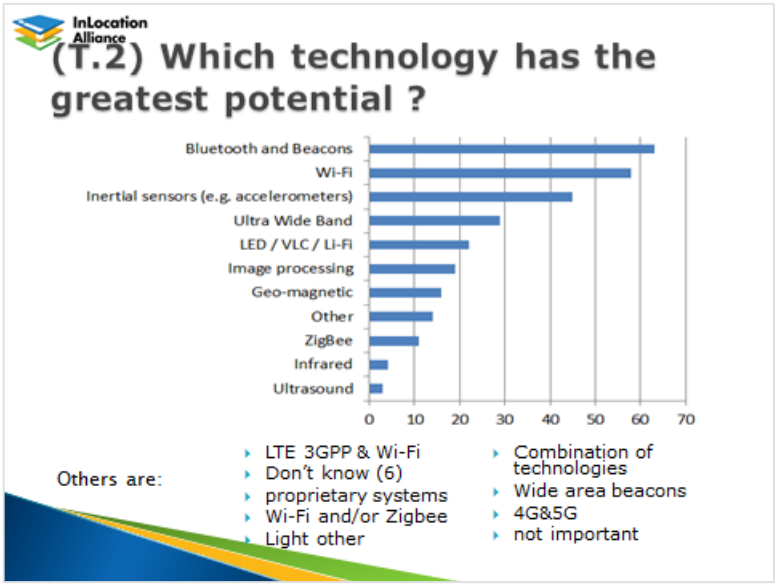

InLocation Alliance
(R.3) Have you got any additional requirement? (1/3)
1. Maps and 3D building models, possibly shared with other facility management or host organization IT systems.
2. Interoperability with major BIMs and other facility management systems.
3. Interfaces for IT and management systems.
4. Address all platforms on the market (i.e. Mobile OSs)
5. Exploit hybrid systems based on multiple technologies.
6. Compliance with major standards.

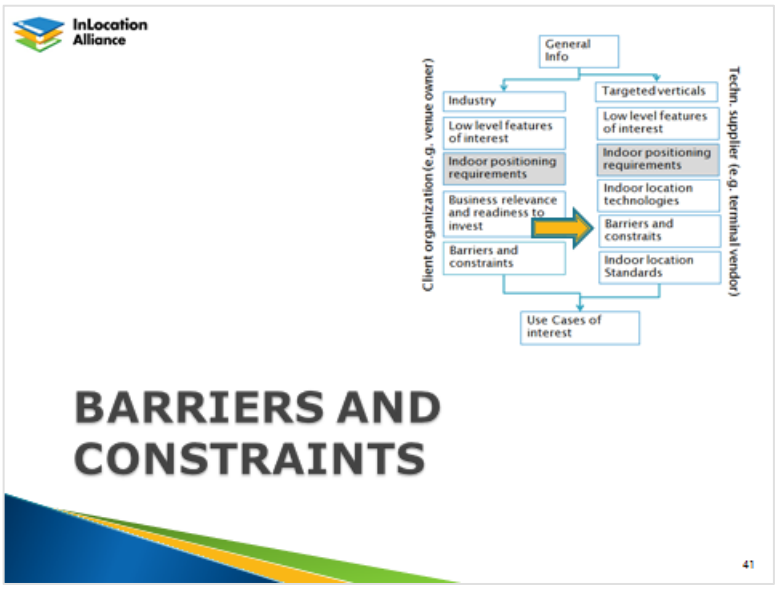
(R.3) Have you got any additional requirement? (3/3)

1. Location requests should be initiated and responses terminated in the wireless network. The network-based location system should be able to locate any active mobile device within the area served by the wireless network. Location responses should be low latency (<500ms). Simultaneous tracking of all associated mobile devices should not impact the overall performance of the wireless network.
2. user requirements win over accuracy
3. Possibility to exploit VLC and Li-Fi Technology
4. Location tracking for closed loop process control

INDOOR LOCATION TECHNOLOGIES


InLocation Alliance
(T.1) Select any technology you have used (if any)
Wi-Fi
Bluetooth and Beacons
Inertial sensor (i.e. accelerometer, gyroscope)
Image processing
Ultra Wide Band
ZigBee
geo-magnetism
LED / VLC / Li-Fi
Other
Infrared
Ultrasound
0 10 20 30 40 50 60 70 80 90
Others are:
all available on smartphones
LTE
Floor sensors
Wide area beacons
proprietary (?)
RFID
GNSS


InLocation Alliance
(T.2) Which technology has the greatest potential ?
Bluetooth and Beacons
Wi-Fi
Inertial sensors (e.g. accelerometers)
Ultra Wide Band
LED / VLC / Li-Fi
Image processing
Geo-magnetic
Other
ZigBee
Infrared
Ultrasound
0 10 20 30 40 50 60 70
Others are:
LTE 3GPP & Wi-Fi
Don't know (6)
proprietary systems
Wi-Fi and/or Zigbee
Light other
Combination of technologies
Wide area beacons
4G&5G
not important


InLocation Alliance
General Info
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Business relevance and readiness to invest
Barriers and constraints
Use Cases of interest
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Targeted verticals
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Indoor location technologies
Barriers and constraits
Indoor location Standards
BARRIERS AND CONSTRAINTS
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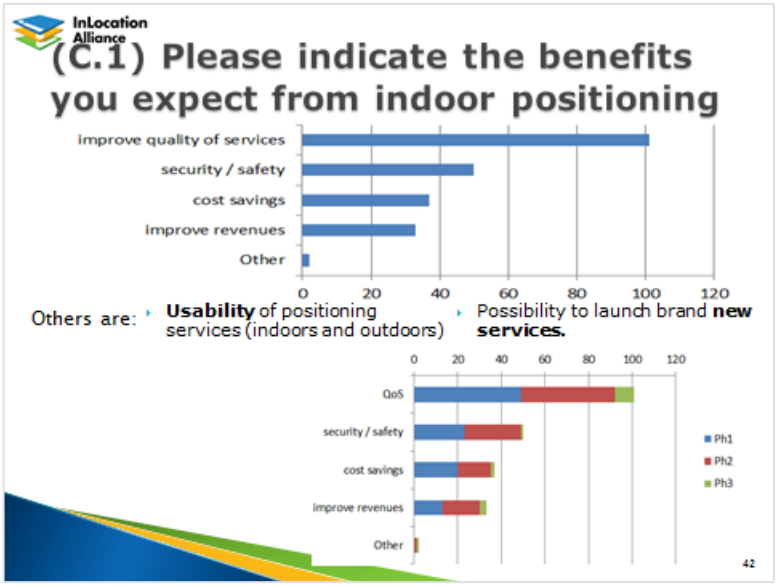
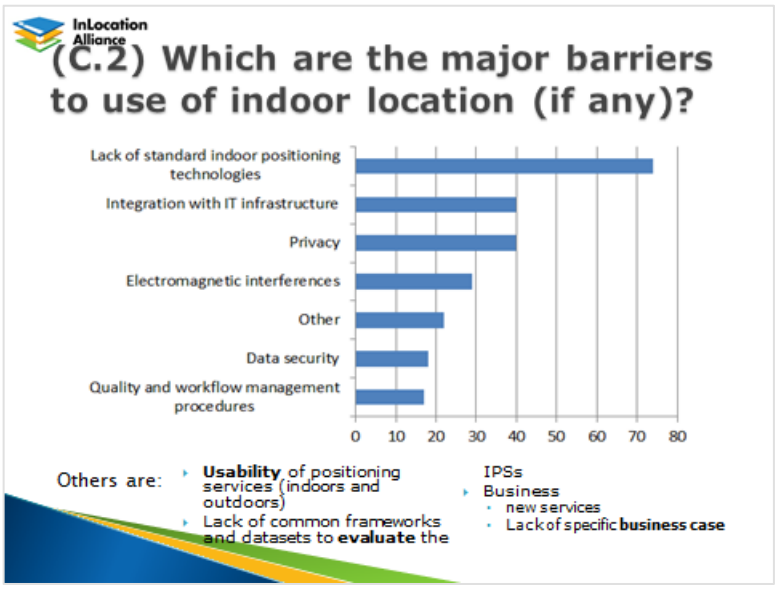
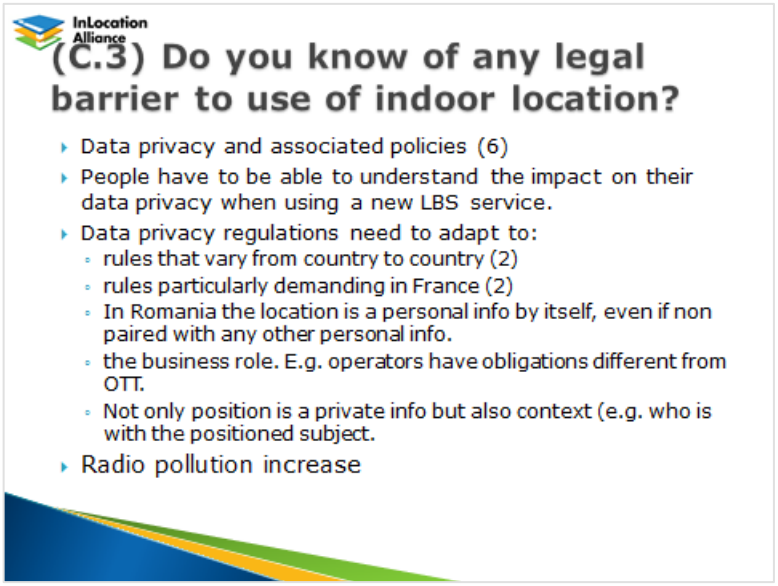
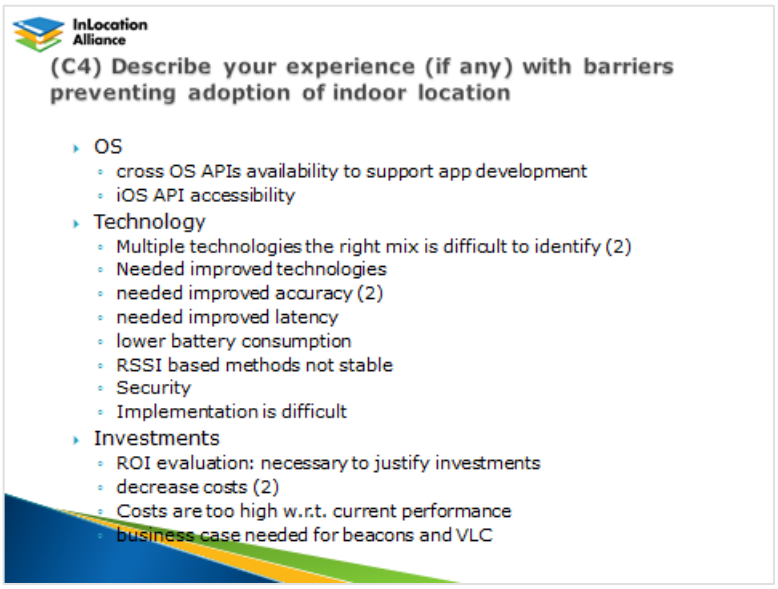
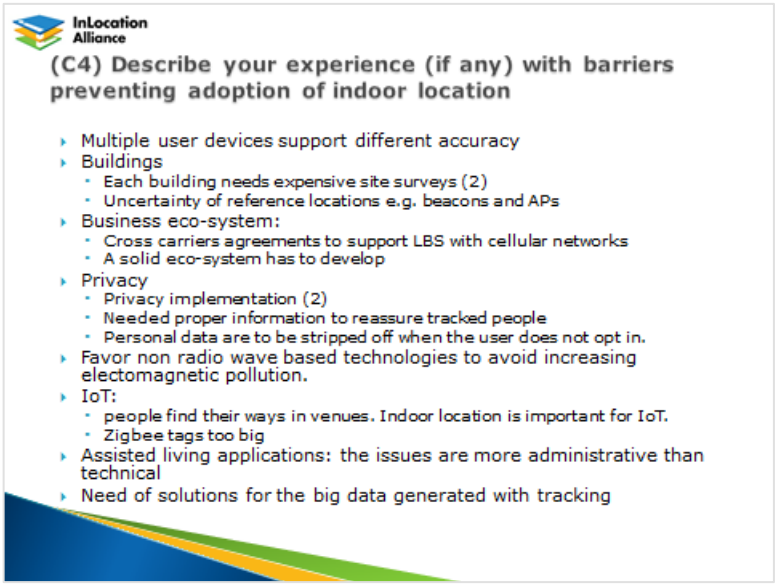

InLocation Alliance
(C.1) Please indicate the benefits you expect from indoor positioning
improve quality of services
security / safety
cost savings
improve revenues
Other
0
20
40
60
80
100
120
Others are:
Usability of positioning services (indoors and outdoors)
Possibility to launch brand new services.
QoS
security / safety
cost savings
improve revenues
Other
Ph1
Ph2
Ph3
42


InLocation Alliance
(C.2) Which are the major barriers to use of indoor location (if any)?
Lack of standard indoor positioning technologies
Integration with IT infrastructure
Privacy
Electromagnetic interferences
Other
Data security
Quality and workflow management procedures
0 10 20 30 40 50 60 70 80
Others are:
Usability of positioning services (indoors and outdoors)
Lack of common frameworks and datasets to evaluate the IPSs
Business
new services
Lack of specific business case


InLocation Alliance
(C.3) Do you know of any legal barrier to use of indoor location?
Data privacy and associated policies (6)
People have to be able to understand the impact on their data privacy when using a new LBS service.
Data privacy regulations need to adapt to:
rules that vary from country to country (2)
rules particularly demanding in France (2)
In Romania the location is a personal info by itself, even if non paired with any other personal info.
the business role. E.g. operators have obligations different from OTT.
Not only position is a private info but also context (e.g. who is with the positioned subject.
Radio pollution increase


InLocation Alliance
(C4) Describe your experience (if any) with barriers preventing adoption of indoor location
OS
cross OS APIs availability to support app development
iOS API accessibility
Technology
Multiple technologies the right mix is difficult to identify (2)
Needed improved technologies
needed improved accuracy (2)
needed improved latency
lower battery consumption
RSSI based methods not stable
Security
Implementation is difficult
Investments
ROI evaluation: necessary to justify investments
decrease costs (2)
Costs are too high w.r.t. current performance
business case needed for beacons and VLC


InLocation Alliance
(C4) Describe your experience (if any) with barriers preventing adoption of indoor location
Multiple user devices support different accuracy
Buildings
Each building needs expensive site surveys (2)
Uncertainty of reference locations e.g. beacons and APs
Business eco-system:
Cross carriers agreements to support LBS with cellular networks
A solid eco-system has to develop
Privacy
Privacy implementation (2)
Needed proper information to reassure tracked people
Personal data are to be stripped off when the user does not opt in.
Favor non radio wave based technologies to avoid increasing electomagnetic pollution.
IoT:
people find their ways in venues. Indoor location is important for IoT.
Zigbee tags too big
Assisted living applications: the issues are more administrative than technical
Need of solutions for the big data generated with tracking

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INDOOR LOCATION STANDARDS
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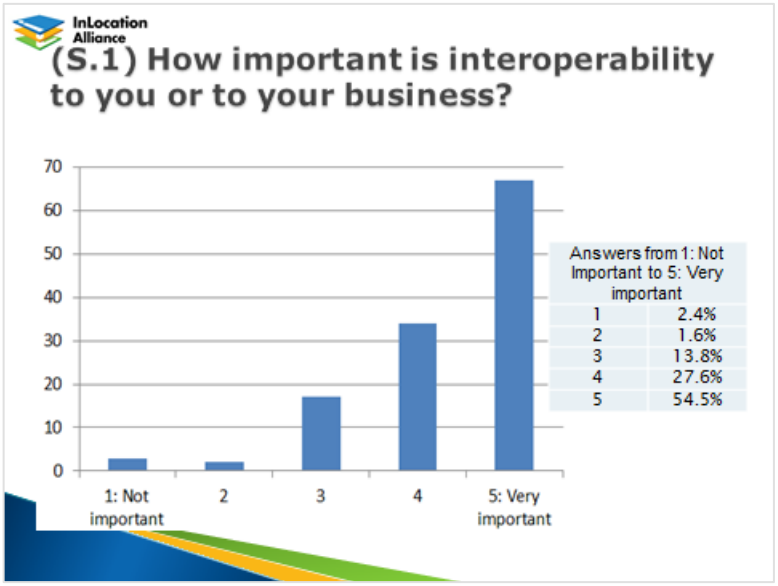
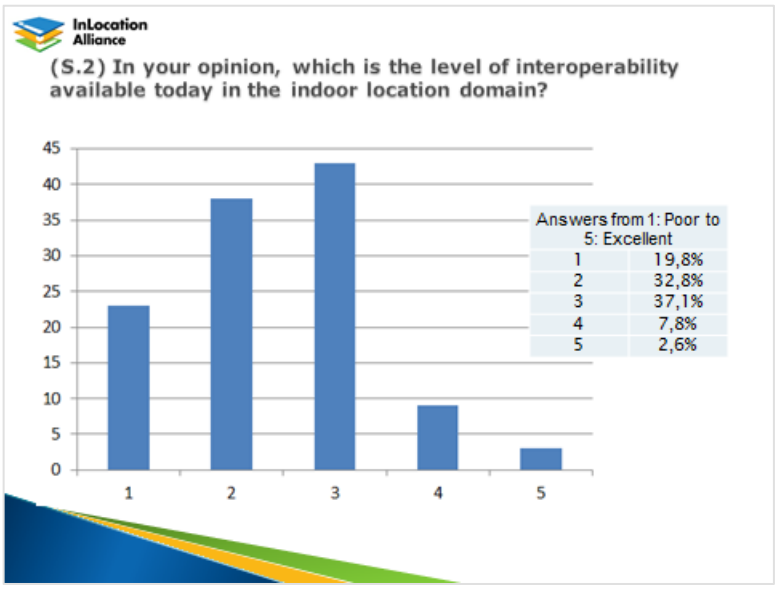
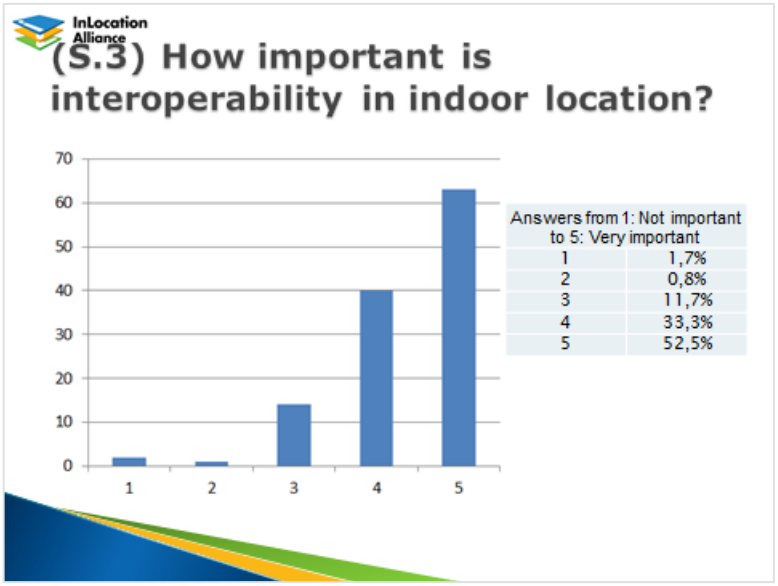
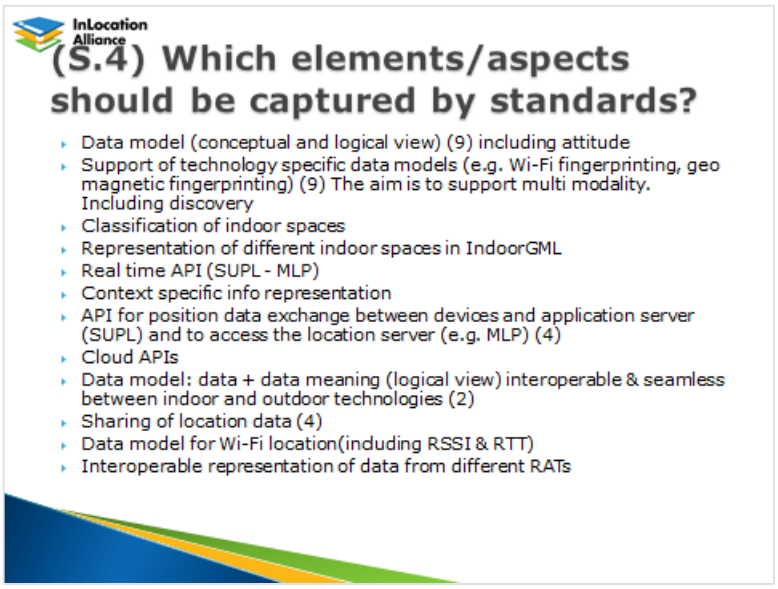
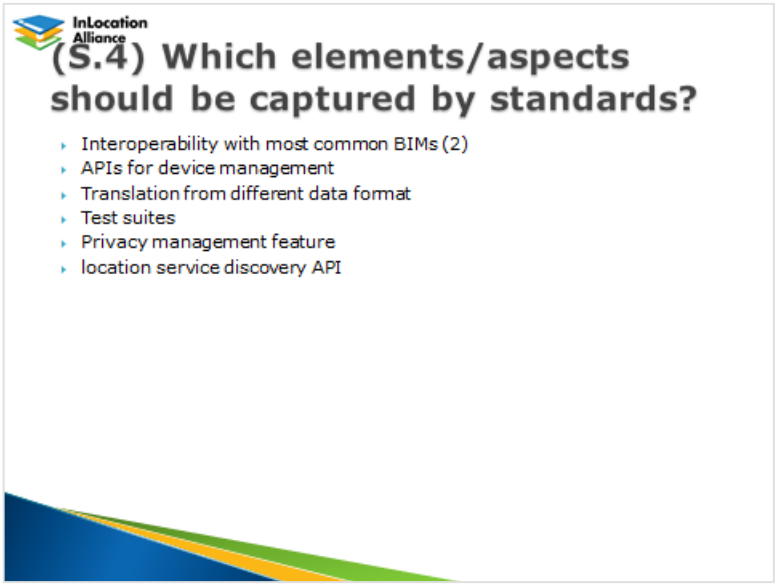
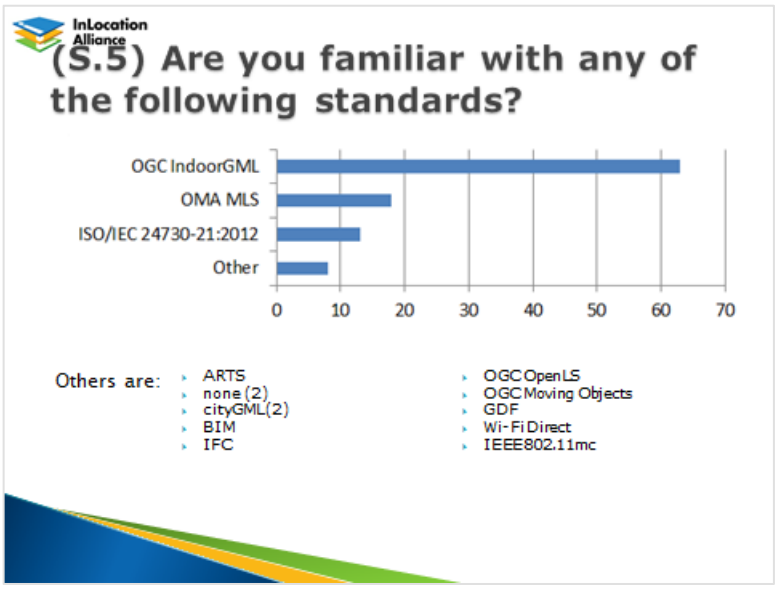

InLocation Alliance
(S.1) How important is interoperability to you or to your business?
70
60
50
40
30
20
10
0
1: Not important
2
3
4
5: Very important
Answers from 1: Not Important to 5: Very important
1 2.4%
2 1.6%
3 13.8%
4 27.6%
5 54.5%

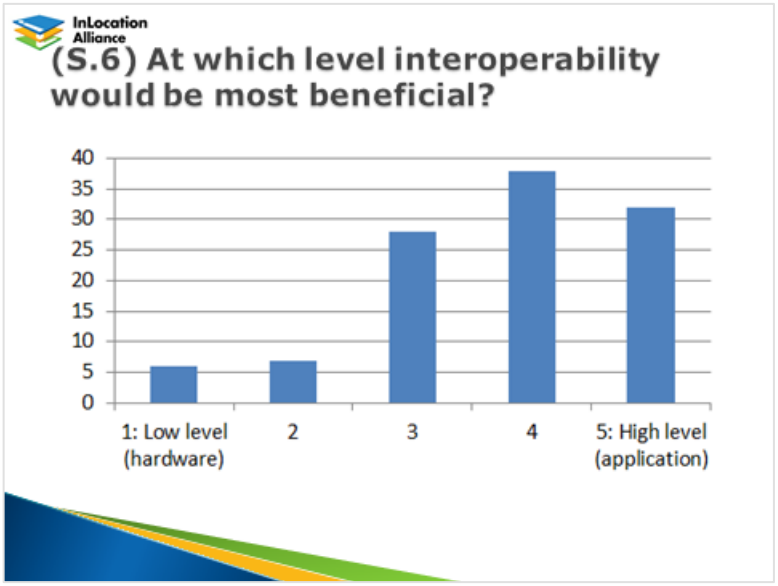

InLocation Alliance
(S.2) In your opinion, which is the level of interoperability available today in the indoor location domain?
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Answers from 1: Poor to 5: Excellent
1 19,8%
2 32,8%
3 37,1%
4 7,8%
5 2,6%

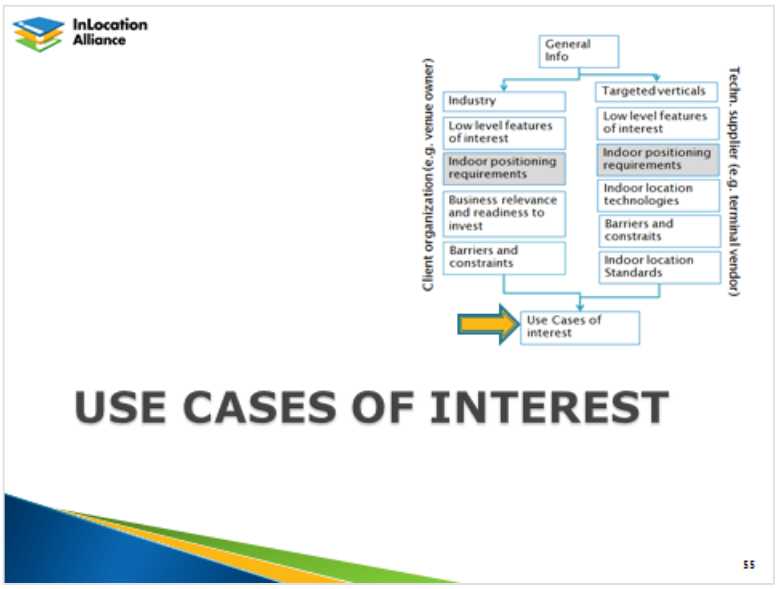

InLocation Alliance
(S.3) How important is interoperability in indoor location?
70
60
50
40
30
20
10
0
1
2
3
4
5
Answers from 1: Not important to 5: Very important
1 1,7%
2 0,8%
3 11,7%
4 33,3%
5 52,5%


InLocation Alliance
(S.4) Which elements/aspects should be captured by standards?
Data model (conceptual and logical view) (9) including attitude
Support of technology specific data models (e.g. Wi-Fi fingerprinting, geo magnetic fingerprinting) (9) The aim is to support multi modality. Including discovery
Classification of indoor spaces
Representation of different indoor spaces in IndoorGML
Real time API (SUPL - MLP)
Context specific info representation
API for position data exchange between devices and application server (SUPL) and to access the location server (e.g. MLP) (4)
Cloud APIs
Data model: data + data meaning (logical view) interoperable & seamless between indoor and outdoor technologies (2)
Sharing of location data (4)
Data model for Wi-Fi location(including RSSI & RTT)
Interoperable representation of data from different RATs


InLocation Alliance
(S.4) Which elements/aspects should be captured by standards?
Interoperability with most common BIMs (2)
APIs for device management
Translation from different data format
Test suites
Privacy management feature
location service discovery API


InLocation Alliance
(S.5) Are you familiar with any of the following standards?
OGC IndoorGML
OMA MLS
ISO/IEC 24730-21:2012
Other
0
10
20
30
40
50
60
70
Others are:
ARTS
none (2)
cityGML(2)
BIM
IFC
OGC OpenLS
OGC Moving Objects
GDF
Wi-Fi Direct
IEEE802.11mc


InLocation Alliance
(S.6) At which level interoperability would be most beneficial?
40
35
30
25
20
15
10
5
0
1: Low level (hardware)
2
3
4
5: High level (application)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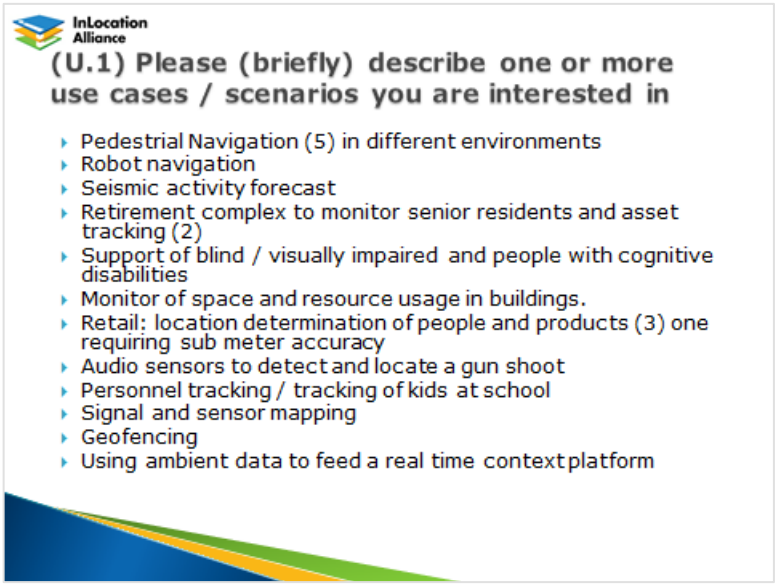
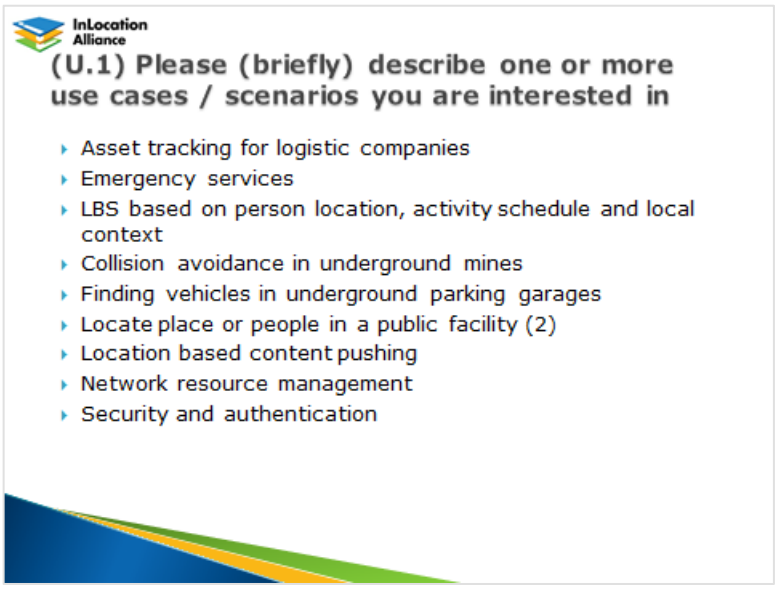
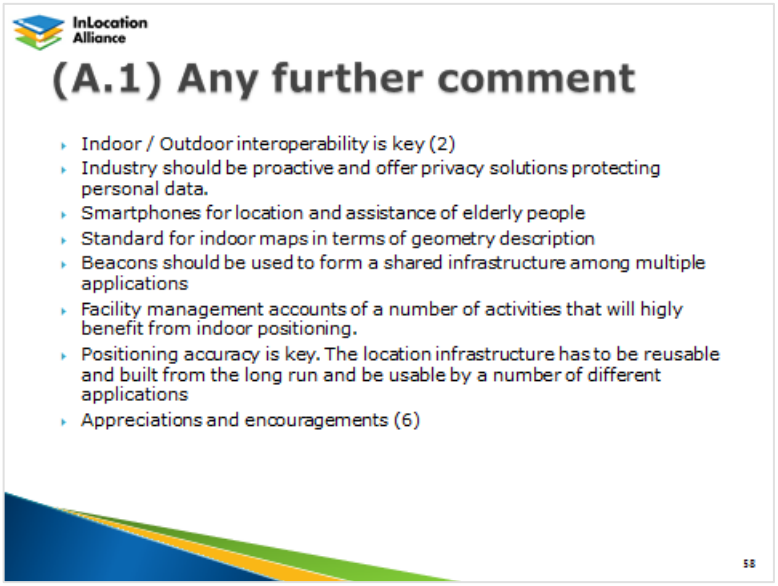
USE CASES OF INTEREST
55


InLocation Alliance
(U.1) Please (briefly) describe one or more use cases / scenarios you are interested in
Pedestrial Navigation (5) in different environments
Robot navigation
Seismic activity forecast
Retirement complex to monitor senior residents and asset tracking (2)
Support of blind / visually impaired and people with cognitive disabilities
Monitor of space and resource usage in buildings.
Retail: location determination of people and products (3) one requiring sub meter accuracy
Audio sensors to detect and locate a gun shoot
Personnel tracking / tracking of kids at school
Signal and sensor mapping
Geofencing
Using ambient data to feed a real time context platform


InLocation Alliance
(U.1) Please (briefly) describe one or more use cases / scenarios you are interested in
Asset tracking for logistic companies
Emergency services
LBS based on person location, activity schedule and local context
Collision avoidance in underground mines
Finding vehicles in underground parking garages
Locate place or people in a public facility (2)
Location based content pushing
Network resource management
Security and authentication


InLocation Alliance
(A.1) Any further comment
Indoor / Outdoor interoperability is key (2)
Industry should be proactive and offer privacy solutions protecting personal data.
Smartphones for location and assistance of elderly people
Standard for indoor maps in terms of geometry description
Beacons should be used to form a shared infrastructure among multiple applications
Facility management accounts of a number of activities that will higly benefit from indoor positioning.
Positioning accuracy is key. The location infrastructure has to be reusable and built from the long run and be usable by a number of different applications
Appreciations and encouragements (6)
58