FORMATION

The 7 Misconceptions of Mapping

Table of Contents

Introduction

Most of us use some kind of location technology everyday. We depend on it navigating to new places, finding good restaurants, shops or local services, using the most efficient public transport or even driving a better route avoiding traffic. It's so popular that today the majority of smartphones have hardware features enabling reliable positioning. And now the popularity of Location Based Services (LBS) in our personal life is also impacting professional applications. Businesses around the world are making their work more efficient by adopting positioning technologies. There are a lot of great examples of really smart solutions optimizing workflows, providing better customer experience, increasing safety measures or giving better process control in some sectors like logistics, aviation, etc.

However, most industry sectors have yet to fully leverage location based services. Part of the reason is that a lot of business takes place in environments that are either poorly mapped, indoors, or otherwise hard to navigate with off the shelf maps and positioning technology.

Indoor location based systems have been in the market for over ten years now but use cases for these are so far limited to very specific industry sectors like e.g. logistics. We believe that commoditization of technology and software stacks in this space is about to change this and that this will unlock new use cases and will enable everyone to benefit from this great technology.

When testing the waters with our early customers and pilots we noticed that people tend to have a set of pre-conceptions, expectations and assumptions about what that will mean for them based on their experience with consumer location based services.

This whitepaper explores this topic by challenging some of the common misconceptions you may experience and opening your eyes to the great potential of this technology . We believe location technology is going to be of great importance for businesses across essentially all sectors and are excited about helping you understand how you can integrate this into your business, improve the way you work, and mobilize your workforce.

A Word About Us

FORMATION is our productivity app that empowers front-line workers. The app is centered around an interactive map that allows workers to quick and easily find work materials and colleagues but also to manage tasks as well as meetings in their workplace. In addition, users can share location specific knowledge in the form of Points of Interest and interact with IoT devices on the map. The interactive map enables better situational awareness by making information around people, places and things more easily accessible to the frontline workers.

At its core it’s a location based service that works both indoors and outdoors. Hence, location technology is core to what we do.   From our experience in working with these technologies there are a few fallacies that we observed and would like to share with you.

FORMATION

Misconception #1

Coordinates are Exact

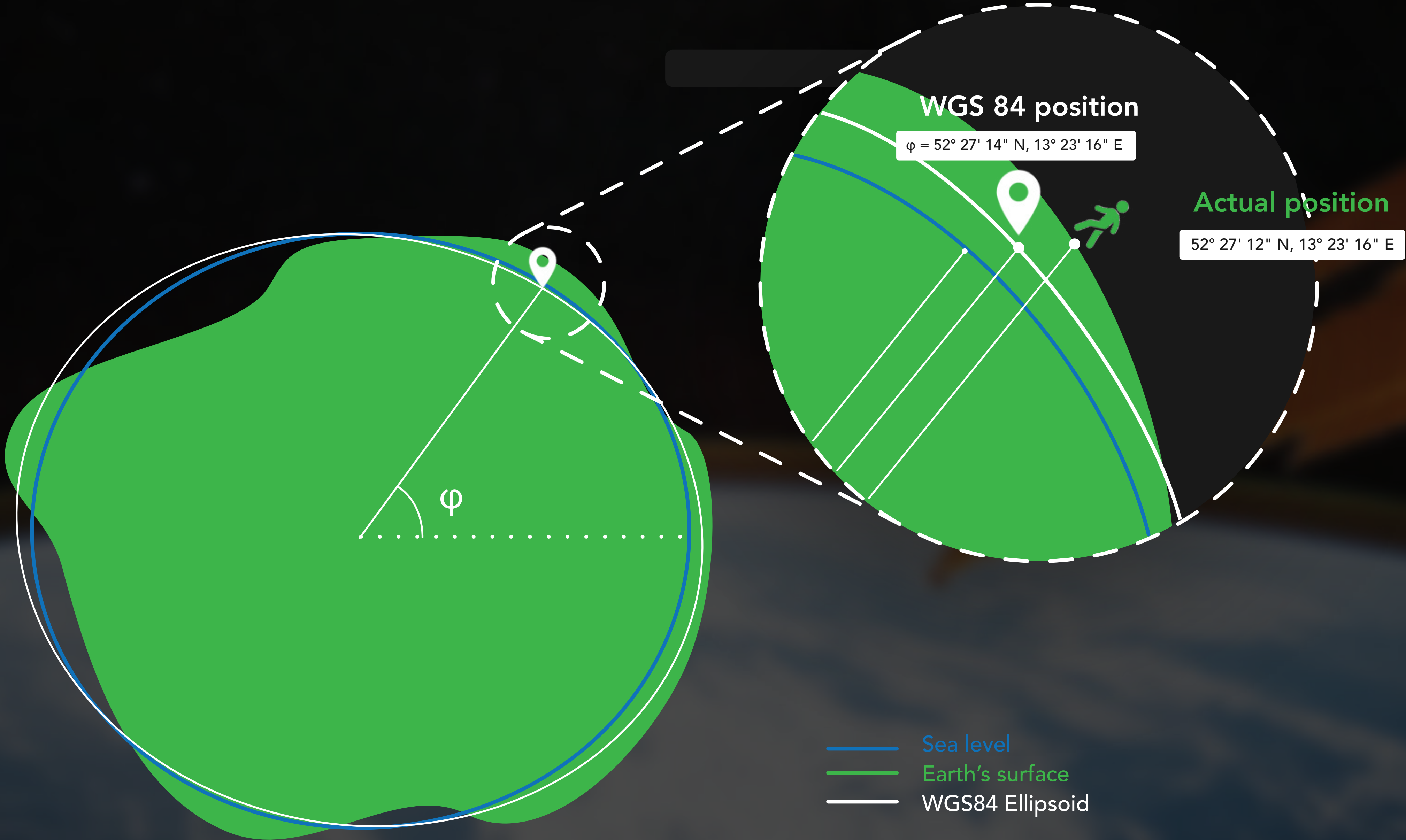
Most location based services use a coordinate system that has been standardized under the name WGS 84. WGS stands for the World Geodetic System and the number 84 refers to the year this standard was agreed on: 1984.

This standard defines the meaning of coordinates (latitude, longitude, and altitude) in terms of a mathematical model of the earth with many parameters. Degrees of latitude and longitude are relative to the equator and the meridian that runs through Greenwich and altitude is relative to sea level.

Where it gets hard is the notion that the earth is not a perfect sphere. The WGS standard solves this by modeling the earth as a slightly flattened spheroid. As a mathematical approximation this is good enough but obviously not perfect as things like mountains, hills and other geographic features add to this problem. Additionally, as climate scientists have been pointing out for a while, sea-level is not a constant either. So, there are issues related to the projection of coordinates on this model not being exactly the same as the real world. This complicates doing things like calculating distances, or agreeing where things are exactly.

Coordinates have a margin of error that depends on how they were measured, what the precision is of whatever reference point was used, and also when the measurement was performed. This is why WGS 84 is revised regularly.

Where it gets hard is the notion that the earth is not a perfect sphere. The WGS standard solves this by modeling the earth as a slightly flattened spheroid.


φ
WGS 84 position
φ = 52° 27' 14" N, 13° 23' 16" E
Actual position
52° 27' 12" N, 13° 23' 16" E
Sea level
Earth's surface
WGS84 Ellipsoid

Misconception #2

Coordinates are Absolute

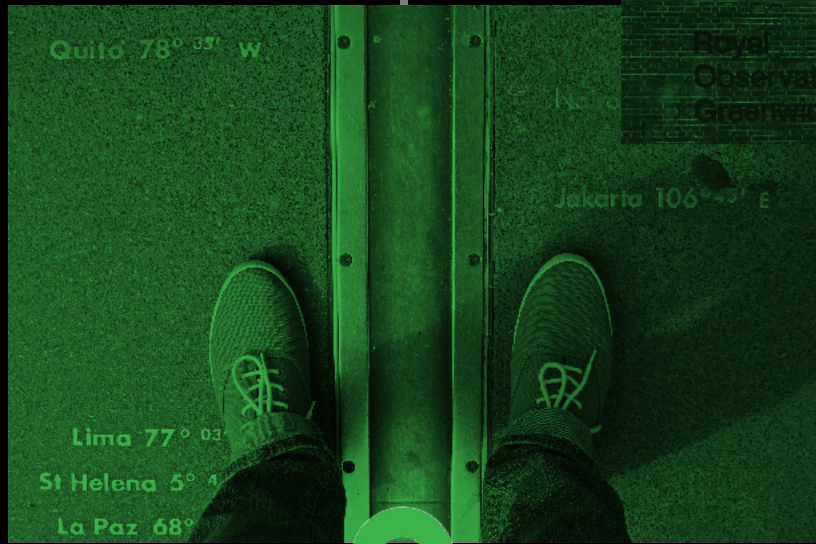
But it's worse: Stuff moves around on our planet Earth! For example, Greenwich which is the place we use to indicate 0 degrees longitude has moved by about 100 meters since it was first used for this purpose[1]. Normal tectonic movement causes continents (including the Eurasian continent) to move at a slow pace relative to other continents. In some places (like the UK) by centimeters per year. Some things move away from each other, some things move closer to each other. Sometimes this happens suddenly (during an earthquake).

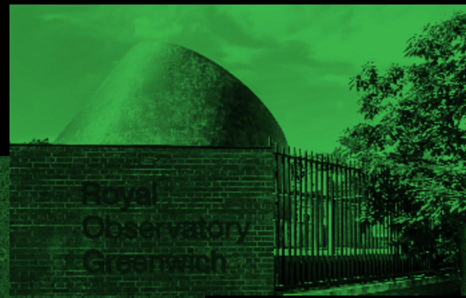
Greenwich which is the place we use to indicate 0 degrees longitude has moved by about 100 meters since it was first used for this purpose[1].

When we associate coordinates with for example a point of interest like the Eiffel tower, our house, or a moving car, we are assuming that these coordinates are absolute and unchangeable. But in fact what we are doing is identifying our position relative to the equator and the meridian at a particular point in time. We typically don't store that time and the notion of how much error builds up in our datasets as things move around over time. In any case, the coordinates we store in data sets are approximations with an undocument level of accuracy.

Finally, the entire solar system is traveling through the universe; so our coordinates are relative to a system that is moving around 200 km/second relative to the rest of the Milky way. Which of course moves as well.

1 http://www.thegreenwichmeridian.org/tgm/articles.php?article=7





Greenwhich Royal Observatory
in 1884

51°28′40.8"N ***0°0′00"W***

100m

Greenwhich Royal Observatory
Today (2020)

51°28'40.8"N ***0°00'05.2"E***

0°

0°00′05.2″

Misconception #3

Coordinates are 2-dimensional

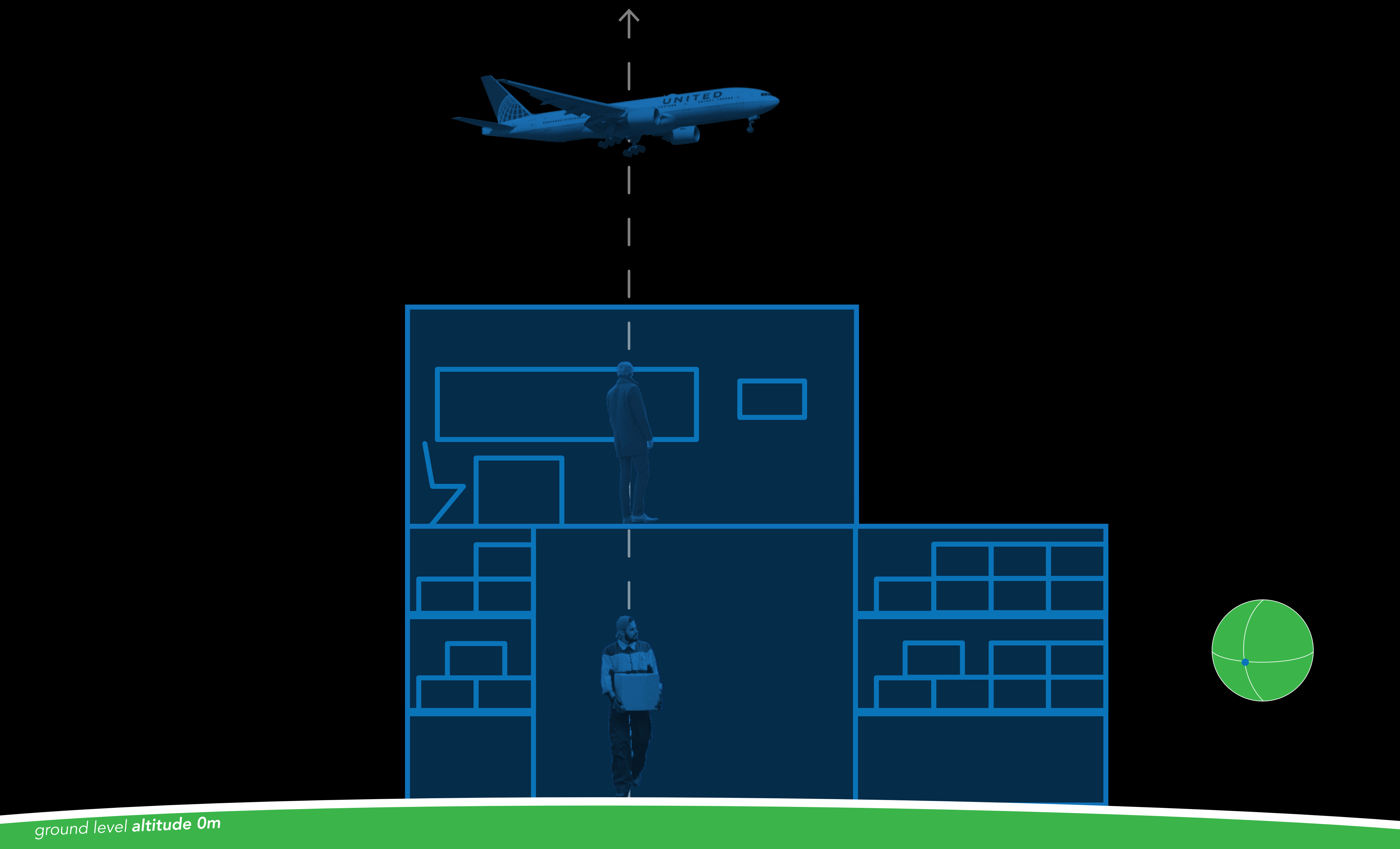
Mostly, outdoors we don't care about the z part of our coordinate (altitude) because we spend most of our time at ground level. Of course when we go inside a building, this changes and the z component becomes very important as we tend to have multiple floors beyond the ground floor. So, coordinates for location based systems are 3 dimensional.

Or they should be at least. In reality, most Geographic Information Systems (GIS) don't store the altitude at all, even if it is available. Most outdoor positioning systems are not very good at telling you your altitude accurately and will have margins of errors that are only acceptable if you are flying an airplane but not if you are moving around in a building.

Planes also use calibrated altimeters that work using a configurable air-pressure at ground level. These altimeters are actually intentionally biased to be wrong by a few tens to hundreds meters at higher altitudes because it is better to be over flying than underflying a mountain or building.

Indoors, people either use beacons to tell floors apart or relative measurements. Some systems we've worked with don't provide the z axis at all and instead provide a floor level. While this is fine for some use-cases, it is not for things like logistics where there may be several shelf levels that need to be identified within a floor. This requires a z-axis with cm level accuracy.

In reality, most GIS systems don't store the altitude at all, even if it is available.


ground level altitude 0m

Misconception #4

Knowing Where Things are Means Knowing the Coordinates

A simple rhetorical question: do you know your current coordinates and to what level of accuracy? The answer in all likelihood is either going to be no; or some of our more expert readers might know their current latitude and longitude (52 and 13 in my case). I just told you my whereabouts with a precision of a bit over 100km.

Of course the next question is what does that mean. In my case that means I'm in Berlin: coordinates are a means to an end to find out where we are in more meaningful terms.

I know my way around this town pretty well but I never think of it in terms of coordinates. Instead I think in terms of streets, neighborhoods, and landmarks, and where things are relative to those. Inside a building, I refer to floor levels, building sections, room numbers (or names) to find my way. Coordinates are useless to us humans for this purpose.

I know my way around this town pretty well but I never think of it in terms of coordinates. [...] Coordinates are useless to us humans.


You know where the new burger restaurant is?
Yes. It’s in 52° 27' 18.05"N, 13° 23' 6.68"E.
Great, thanks!
THE ROLLING STONES 50

Misconception #5

Maps are Proportional

Maps tell us where things are in the real world. They do that by projecting things like roads, country borders, rivers, etc. on a 2D plane. As we just learned, the earth is not flat and also not completely round. Yet most world maps you have ever seen are flat.

The one that you probably are familiar with uses something called the Mercator projection. You might have some notions of the relative size of certain countries relative to each other. However, the Mercator projection is highly misleading and ends up making things at extreme southern and northern latitudes much larger than they are in real life. E.g. Greenland looks huge on a map; almost as big as Africa. Yet it comfortably fits inside the borders of Africa. And you can squeeze in the US and Europe along with it and still have some space left.

[...] the Mercator projection is highly misleading and ends up making things at extreme southern and northern latitudes much larger than they are in real life.

Planet Earth

Mercator Projection

Misconception #6

Maps are Precise

Most good outdoor maps are accurate to around a few meters or so. If you zoom in all the way on Google maps, you get to a scale where 1" on a big laptop screen corresponds to about 5m. This suggests a level of accuracy that may be better than it really is. Mapping the world is expensive and used to be a job done by land surveyors figuring out where things are relative to other things. In parts of the world where accuracy matters a lot, more effort is spent on this. In other parts of the world less effort is spent.

Aerial photography has made things easier of course but high resolution photos tend to have a precision measured in meters per pixel for satellite imagery and maybe a few tens of centimeters for aerial photography. Of course you have to account for things like lens distortion, parallax, etc. And you have to know the vantage point from which the photo is taken as well; for which you'd typically use something inaccurate like GPS.

In short, maps from different vendors don't always align. Additionally some features on maps like roads and building outlines are not necessarily matching their real world contours. Mostly map makers do their best to correct for all this but different map makers might make different choices. Maps are ultimately an abstraction and simplification.

In short, maps from different vendors don't always align. [...] Maps are ultimately an abstraction and simplification.

Misconception #7

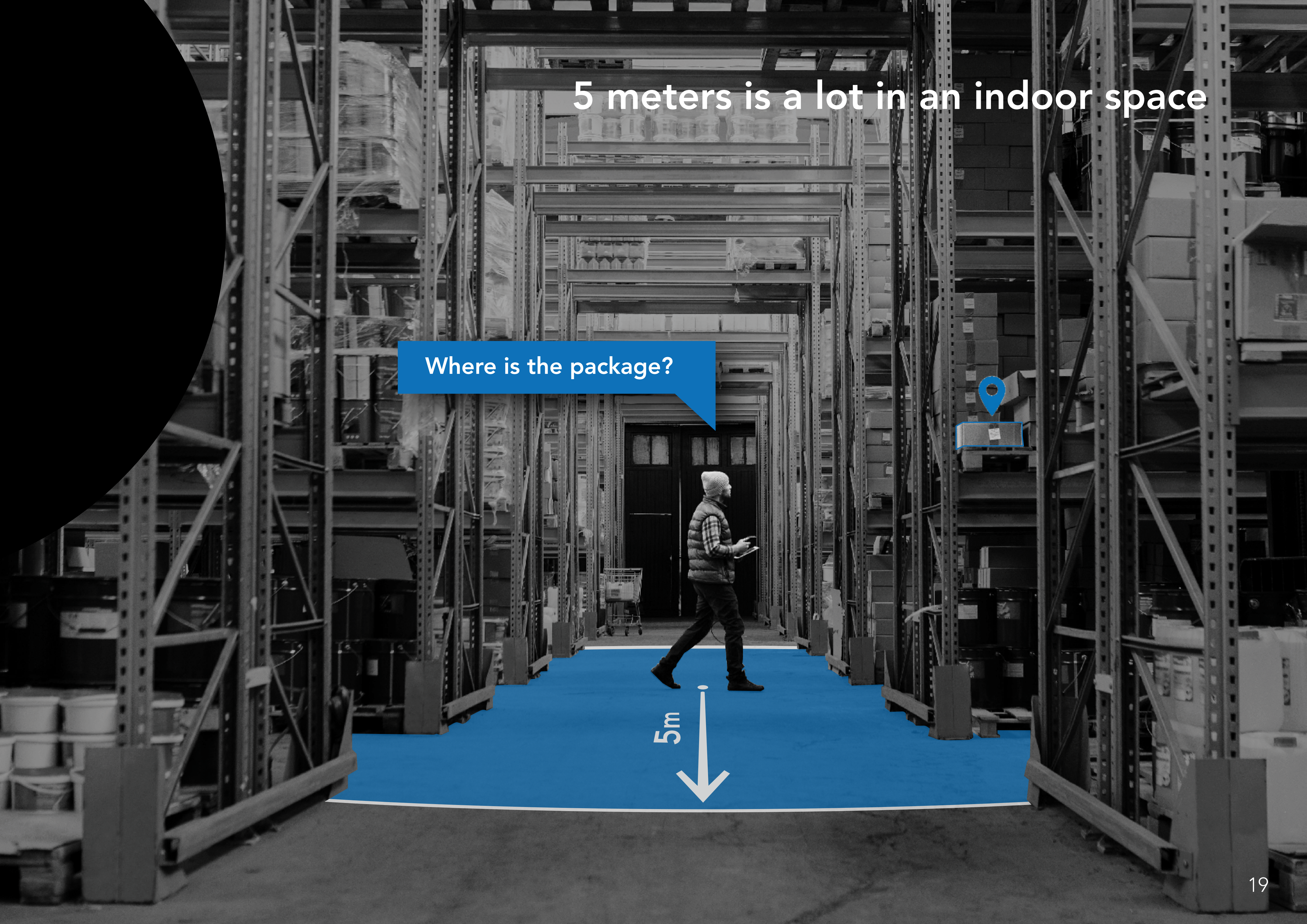
WGS 84 is a Suitable Way to Record Indoor Location

The reason the above is not a huge problem is that historically we weren’t very good at figuring out our coordinates. We figured out measuring latitude pretty early but determining longitude has been challenging for a very long time. Up to 200 years ago the kings and rulers of various empires and countries commonly issued rewards for finding the longitude. Up to 300 years ago anything close to even a single degree of accuracy was pure science fiction as it required things that simply did not exist (like accurate clocks). Doing so was of course key to not getting lost when e.g. crossing the Atlantic or Pacific and had great strategic value.

The GPS network only went up in the eighties and only provides accuracy to about 5 meters (at best). 5 meters is a lot in a building! Besides, as described above, things move and it’s all relative anyway. And it wasn’t until about 10-15 years ago that phones with GPS became common.

Outdoors this mostly does not matter and an accuracy of a few meters is considered pretty good. When we go indoors, we need far better accuracy. Often we are interested in sub meter accuracy or even sub centimeter accuracy. Architects tend to be precise about things like thicknesses of walls and their placement, dimensions of features like doors and windows, etc. WGS 84 simply does not provide us this level of precision. And even if it would, most information and maps simply aren’t that accurate. You can still use WGS 84 coordinates but they are effectively relative to some known origin (e.g. a building corner).

Outdoors this mostly does not matter and an accuracy of a few meters is considered pretty good. When we go indoors, we need far better accuracy.


5 meters is a lot in an indoor space
Where is the package?
5m

What Does This Mean for Indoor Services Like FORMATION?

We work with several partners to determine position. They all measure their performance in meters; or in some cases centimeters. Some SDKs we've worked with even provide WGS 84 coordinates along with a floor level. Others provide relative coordinates to some anchor with a known coordinate. FORMATION uses geo-referenced maps that we overlay on e.g. Google Maps. This does of course pose some challenges for us.

How do we deal with differences between different map-providers?

E.g. Here Maps, Google Maps, and Apple Maps all have detailed maps with building outlines. However, we have found 2-3 meter variations when geo-referencing indoor maps with one and calibrating our positions with the other. Important for us is to make those maps not break the illusion that the outdoor map is accurate (misconception #6) or that the coordinate for our anchor is precise (misconception#1). But this means that our coordinates and maps are necessarily relative to these inaccurate things. Having a cross device, cross map provider consistent experience for our users is challenging and mostly boils down to ensuring we either make the same errors everywhere consistently or apply corrections to "correct" for the various errors and deviations. In any case, our users don't actually know their coordinates to any meaningful level of precision (misconception #4). What matters is that we help them make sense of the world around them.

Next generation positioning systems based on e.g. ultra wide band, the Galileo high accuracy profile, etc. promise us centimeter accuracy.

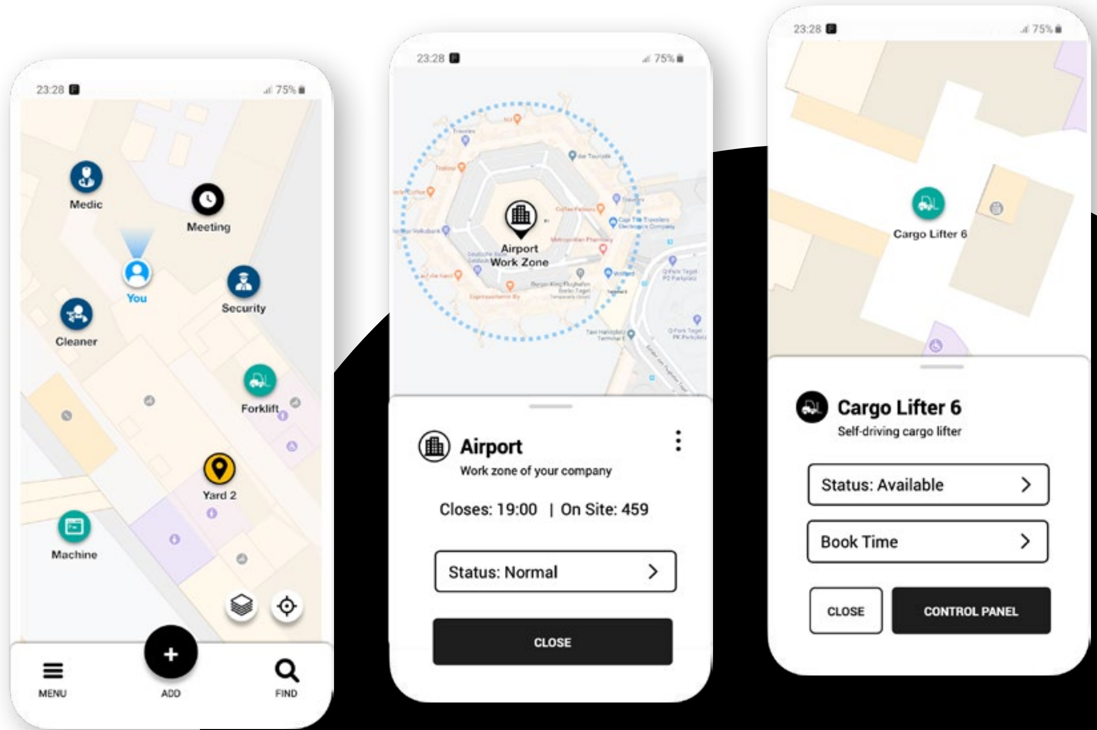
But what does that mean when the coordinate system is WGS 84, our maps are far less accurate (misconception #6), and our model of what this planet looks like is a mathematical approximation (misconception #1)? To address this we need to work with relative coordinates coming out of e.g. ultra wide band based positioning technologies and map those to correctly georeferenced maps and data sets with a correction that is appropriate for the given map provider and other data. This preserves the illusion that the indoor map is accurate.

Altitude is important indoors and tends to be the most ignored and least accurate bit of information you get out of e.g. GPS.

Most buildings are less tall than the typical margin of error. Therefore, other signals like WIFI, bluetooth, beacons, earth magnetic fingerprinting, barometric pressure, etc. are used to determine floor levels. Within those floors of course we still have about 3 meters of space (more in factories) that are mostly unaccounted for because indoor maps are 2D (misconception #3) and tend to have their elevation specified in terms of floor level rather than meters.

Maps and coordinates are important but our users tend to think in terms of floors, sections, rooms, etc. (misconception #4).

Translating raw coordinates to these is key. Just like you specify where you live using an address, you would specify where you have your meeting using a symbolic name. Putting these on a map (geo coding) or telling you where you are (reverse geo-coding) are just as important indoors as outdoors; or arguably even more important.



It’s All Relative

Mapping and positioning are not an exact science and a means to an end for us. Mostly we are providing information services that make use of knowing where people, things, and places are. We can tell you the where part of course but it’s not what we are about primarily. In fact, we mostly rely on off the shelf, 3rd party solutions for this. Instead, we provide productivity tools that make use of this information.

The important takeaway here is that coordinates are relative to each other, to things like the meridian, or to landmarks that are assumed to not move around. Especially indoors, this tends to create issues. Buildings are relative to the building outlines or satellite imagery provided by your map provider. These are in turn stretched and aligned to their maps. While of course they do their best to keep things accurate, this creates big enough errors that we have to worry about this for indoor positioning. When going from meter level accuracy positioning to centimeter level accuracy positioning, this becomes more important as most existing data out there is simply not that accurate.

The 7 Misconceptions of Mapping

a white paper from FORMATION GmbH

About the Author

Jilles van Gurp - Chief Technology Officer FORMATION GmbH

With 24 years of IT experience, including 15 in Location Tech, Jilles is one of the leading experts in the business. He was a researcher at Nokia Center in Helsinki, where he worked on indoor location based software, IOT and topics related to intelligent spaces. Jilles also worked as a senior engineer in Nokia's Maps division in Berlin. He holds a PhD from the University of Groningen (2003) and joined FORMATION in 2020 as CTO to elevate the utilization of positioning technology in work environments.

Illustrations and cover: **Mercedes Alves**

Contact us

www.tryformation.com
info@tryformation.com