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Sigfox: Building a Global IoT Network

We are connecting the real world to the data world through the creation of a global network. No one has ever done that before. It can change the world.

— Ludovic Le Moan, CEO and Co-founder, Sigfox

On an early morning of June 2018, Ludovic Le Moan, CEO and co-founder of Sigfox, rose to his feet and gazed out the window in his company's headquarters in Labège, southwestern France. "We should capitalize on the significant market opportunities which the new reality of IoT represents," he said as he overlooked the scenery of the Internet of Things (IoT) Valley—a vibrant space dedicated to supporting start-ups within the IoT field.[1] While the market of IoT was still at an early stage, it was growing fast, and Le Moan was excited by the endless opportunities it represented.

Founded in 2009, Sigfox was a global network that allowed large number of connected devices to send small amounts of data over long distances.[2] Described by Forbes as a "network for lightbulbs and toasters," it was not aimed at smartphones, but at the long-promised next wave of IoT devices.[3] When compared with other networks such as GSM, it offered the advantage that the data transmission was at a very low cost and only required little energy consumption.[4]

Since its inception, Sigfox had experienced impressive growth and was present in 50 countries as of 2018. With 3.7 million objects registered to its network so far, each paying as little as €1 for the service, Sigfox had just made €50 million in revenue in 2017, a 56% increase from the previous year. Although the firm wasn't profitable yet, Le Moan predicted that once its network would achieve true global scale, the business would ramp up quickly. However, the startup first had to overcome a number of fundamental challenges. Not only were new competitors emerging—from startups to telecom industry heavyweights, but the maturity of the market was also not as expected, as customers were still reluctant about replacing their traditional processes with IoT based solutions. The firm was finally under pressure as an initial public offering (IPO) was once again postponed.

In their last board meeting, Le Moan and his team had set an ambitious goal for the company: 1 billion objects connected to the Sigfox network by the end of 2023. To deliver on this vision, they had reflected on the many potential use cases which Sigfox could address with their technology and the new markets they could explore. With limited capital, they had eventually opted for a focused strategic

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approach and a particular niche: asset tracking. This sector represented a mature market, where Sigfox had the necessary capabilities to excel and make a name for itself.

Le Moan reflected on the consequential changes he needed to initiate in Sigfox's current structure to materialize this vision into results. How could he achieve the goal of 1 billion connections by 2023? Was it a wise strategic decision to focus on asset tracking? How could he scale the business to transition Sigfox into a leader in the complex IoT space? Le Moan stepped away from the window, sat down at the table, and looked at the notes spread out in front of him. "What should we do next?" he said, turning to his partner and Sigfox co-founder, Christophe Fourtet. The clock was ticking, and it was evident that the next years might prove decisive.

Company Background

Genesis of the Idea

At the root of all of this was Fourtet, a radiofrequency engineer who had spent years working at Motorola, an American telecommunications company. (See **Exhibit 1** for his biography.) Known by some as the "Mozart of radio technologies,"[5] Fourtet was captivated by an ultra-narrow band radio technology which submarines used to signal to each other during the First World War.[6]

When communicating over distances, which could expand to thousands of kilometers, the risk of interference with other messages in a transmission phase was very high which affected the quality of the output. To solve this challenge, it required transmitters which could narrow the band as a smaller spectrum would decrease the risk of interfering messages. Yet, this approach was technically challenging and required complex mechanical fine-tuning systems. When the cellular industry emerged in the 1960s, the focus shifted from narrowing the band as much as possible to, on the contrary, increasing the band as much as possible as this resulted in a larger capacity to provide mass connectivity. Despite the benefits, this obsession with broadening the band to enable transmissions of larger amounts of information had the drawback that it required more energy consumption. This was in contrast to the old techniques where messages in a transmission phase could travel long distances using little energy if they only contained information compressed to the essential.

Fourtet got increasingly intrigued by the idea of capitalizing on the century-old technology of low-bandwidth telecommunications for applications where the recipient only needed little information, for instance a status or a physical parameter such as a temperature. Present cellular networks (GSM, 3G, 4G, etc.) were often oversized and thus not adapted nor cost-efficient for such transmissions.[7] As Fourtet put it, "I wanted to combine the capabilities of the old radio technologies with the modern-day progress in the area of computing and signal processing to construct a digital interphase, which could receive transmissions in an accurate way despite the challenges of interference over long distances. I had an intuition that I could find markets for this technology, but I had no idea how to go about it. In 2008, I left Motorola to work full time on my research."

The Sigfox technology was derived from the idea that for a fixed amount of power, the range could expand with decreasing transmission rate. The connectivity infrastructure for this type of network required sensitive receivers, which Fourtet developed. He reflected on the challenges he endured when building the first antenna for this purpose, "At first, I had to identify the necessary building blocks. I spent three years browsing through publications and scouting the available components on the market to find the way for the first prototype. In addition, I had to construct specially-designed elements which was challenging from a technical standpoint."

Eventually, Fourtet was able to develop a patented technology and network which could ensure long-range and low-power transmissions without interference at a low cost. To enable this, it required fitted design choices. It was key that the volume of data contained in each transmission was held at the minimum in order to consume less energy and thus improve the battery life of the emitting devices.[8] The technology was also based on ultra-narrow band modulation which enabled long distance data links highly resilient to interference between a transmitter and a receiver.[9] Fourtet finally decided to operate in bands that didn't require any license, so he wouldn't have to pay any fee to operate the network and he could thus offer low-price connectivity.

In order to commercialize and monetize this business idea, Fourtet drove across the country to meet with industry experts and eventually came across Le Moan in 2009. With a background in software engineering, Le Moan had launched, managed, and sold several successful technology startups. The two men complemented each other well in experience and expertise and quickly decided to become partners. Le Moan recalled, "After our first meeting, I could not sleep for one month. The potential of the idea was incredible. It was like the Holy Grail! We could change the world. I spent six months verifying that there wasn't any gap between words and reality."

In 2010, Le Moan was appointed CEO and co-founder of Sigfox, while Fourtet became scientific director. As a next step, the company needed funding. However, raising the necessary capital proved challenging. As Fourtet put it, "At the beginning, people thought that we were nuts." Le Moan added, "Creating a global infrastructure dedicated to IoT objects sounded crazy. But we did it, because we believed in it." Initially, Le Moan secured a €2 million round of financing to develop the first prototype and to demonstrate the technology. (See **Exhibit 2** for details on funding rounds.) This money was deployed to address the use case in the advertising industry. Fourtet recalled:

> We installed our wireless equipment on billboards to monitor integral parts of the system. Once there was a deviation, the sensors detected it and triggered an alert. It would for instance activate if there were abnormalities in the system such as power failure leading to the interruption of the displayed images of the advertisement. This notification scheme could therefore raise awareness when material had to be changed in order to ensure a stable functionality of the billboard. Our solution had the advantage of pure simplicity. It was not intrusive in the sense that the equipment consisted of small sensors which were easy to mount. This was our very first success.

As the raised capital increased steadily, the next move was to deploy the network in France and then gradually expand abroad. The initial launch in 2014 in several French cities allowed the company to do further testing and improve performance before the network was deployed nationally. A successful deployment on the French market then allowed the rising company to demonstrate its technology and capabilities before scaling in new countries.

By November 2016, Sigfox closed a Series E funding of €150 million, which raised the capital to a total of €277 million. The company got funding from several key investors including U.S. cloud computing company Salesforce, French oil and gas firm Total, French businessman Henri Seydoux, French PE companies Alto Invest and Swen CP, as well as Saudi conglomerate Tamer Group.[10] Existing shareholders also announced that they were reinvesting in the company. While the company did not disclose its valuation, sources revealed that it was in the region of €600 million.[11] Sigfox increasingly started to gain foothold in the market and indicated plans to go public.[12]

Sigfox as of 2018

By 2018, the firm had a global network of 50 countries and aimed to reach 60 countries by the end of the year. Covering an area of 4.2 million km², Sigfox reached 949 million people worldwide and continued to grow by 30 million each month.[13] The number of active objects connected to the Sigfox network stood at 2.5 million in 2018, an increase of 65% compared to 2017. Sigfox wanted to connect 1 billion objects by 2023.[14] In its home market, France, 92% of the population was covered by the Sigfox connectivity grid in 2017. That same year, Sigfox managed to cover 25% of the U.S. population with its network.[15] The objective was to further increase the coverage in this market with a particular focus on Chicago, Seattle, Las Vegas, San Francisco, and the area from New York City to Boston.[16]

In 2017, revenues went up to €50 million.[17] The firm's payroll costs had increased significantly after a rise in staff numbers, from 200 to 400 employees, in less than two years.[18] In 2018, 250 employees were based in Labège and worked on the technology; 50 were in corporate functions in Paris; 80 were located in hubs abroad, such as Singapore, Dubai, or Brazil.

In February 2018, Le Moan publicly announced that he had rejected a €1 billion takeover offer by an undisclosed group.[19] He said, "We went through five rounds of fundraising. We have 28 investors. We are still in a position to reject a €1 billion takeover offer. But if someone tomorrow offers €2 billion to €3 billion, given our current financial structure, I think the firm would have to be sold."[20]

In 2018, Sigfox's mission was to "make things come alive." The startup had recently added marquee customers such as Swiss food and drink company Nestlé or European aerospace firm Airbus. Le Moan commented, "Up until a year ago, people were still asking whether Sigfox would succeed. We've signed some big names since. That's helped customers and investors get over those concerns." Sigfox was also hoping to make connected objects serve a greater purpose. The company had established a non-profit entity, the Sigfox Foundation, to design, develop, and test low-cost solutions for causes such as the protection of the planet, health, and living. The startup, for instance, started a rhino tracking experimentation in Africa, rolling out a Sigfox network in a wild area and prototyping a horn tracker that gave daily GPS information to local rangers.[21] Sigfox technologies were also used to monitor earthquakes in Mexico or to locate researchers in Antarctica.[22]

The Sigfox Technology

A Sigfox application followed three basic steps: 1) The *objects* transmitted their messages through the Sigfox network to a Sigfox base station. 2) The Sigfox *base station* then detected, demodulated, and reported the messages to the Sigfox cloud. 3) The Sigfox *cloud* finally pushed the messages to customer servers and IT platforms. (See **Exhibit 3** for an illustration of the Sigfox architecture.)

Objects (Devices)

Examples of objects using the Sigfox network included water and gas meters, smart garbage cans, temperature and humidity sensors, fire hydrant monitoring systems, pet trackers, home alarms, and many other applications that just needed to send small, infrequent bursts of data. (See **Exhibit 4** for additional examples of connected devices.)

Low Cost In most cases, these objects needed to be built around an ultra-low cost IoT Sigfox module in order for them to be used.[23] Prices for these modules started from just €1.68 for European, Middle East and African markets and €2.52 for American and Asian markets.[24] Not only were these

modules five times cheaper than the closest competing technologies,[25] but they were also royalty free to ensure the lowest possible cost. (See **Exhibit 5** for examples of a Sigfox module.)

These modules were designed, produced, tested, and distributed by Electronic Manufacturing Services (EMS) directly. As of June 2018, 31 EMS partners were listed on the Sigfox website. These manufacturers believed that by dropping some non-essential functionality, they could cut the cost of these wireless modules down to €0.15 in the near future—so cheap that it could even become part of disposable items. For example, in September 2017, Sigfox unveiled a prototype module contained in a hardcover envelope that triggered the sending of a text message when the envelope was opened.[26] (See **Exhibit 6** for an illustration of this wireless module embedded in a shipping envelope.) Sigfox was convinced that its partners could offer these types of services as early as 2018, offering a significant opportunity for industrial packing, logistics, and retail industries.[27]

In addition to the Sigfox module, Sigfox also provided a royalty-free protocol stack library to manage the channel access and to ensure interoperability between the device and the Sigfox network.[28] As Guillaume Larignon, operation technology director at Sigfox, explained, "The Sigfox technology relies on the idea that it has to be simple." As such, Sigfox solutions were plug–and-play. They didn't require any additional setup, parameters, configuration, or adjustment by the end user.

Long Range Sigfox used what was referred to as UNB (Ultra Narrow-Band) to transmit messages.[29] UNB enabled Sigfox to transmit data over a very narrow spectrum channel to achieve ultra-long distance. This typically allowed an average range of about 30-50 km in rural settings, and 3-10 km in urban conditions, where there were more obstructions and noise was greater.[30]

These transmissions used the Industrial Scientific and Medical (ISM) frequency bands, which were free to use without the need for a license.[31] The band used depended on the location: in Europe, for example, the band used was between 868 and 868.2 MHz; in the rest of the world, the band used was between 902 and 928 MHz with restrictions according to local regulations.[32] Since the band used by Sigfox was free, barriers to entry were low and companies were able to move from prototype to production very quickly.[33] However, the openness of the band came with a price.

Strict restrictions on transmit power and duty cycle (time spent transmitting) were in place to limit the interferences between devices, thus impacting how much and how often data could be transmitted.[34] In Europe, the regulation stated that Sigfox could occupy the band for 1% of the time. This translated into six 12-byte messages per hour or 140 messages per day per device.[35] A 12-byte payload was enough to transfer sensor data, the status of an event like an alert, GPS coordinates, or even application data.[36] However, this also implied that some projects were not currently meant to use the Sigfox technology, as they required high bandwidth and constant connection to the cloud.[37]

Using the public band also meant that the Sigfox technology had to be robust, even if the signal was jammed by another transmission or by environmental noise.[38] Given its very strong radio interference-protection capabilities, Sigfox was collaborating closely with Swedish company Securitas Direct to guarantee customers extra protection against GSM network outages and jamming attempts. With Sigfox as a backup, Securitas Direct could for example assure its customers that they would know if their home alarms went off, even if their telephone networks were not working.[39]

Low Power Finally, the reality was that small inexpensive objects used for IoT simply did not have enough power to communicate with large mobile networks.[40] This explained why Sigfox opted for a low power wide area network (LPWAN) technology.[41] This meant that the devices that were connected via the Sigfox network were operational for far longer: this could be as much as up to ten

years on a coin-cell battery. This was particularly important for devices such as water meters that could often be in highly inaccessible places to replace a battery frequently.[42]

Base Stations (Gateways)

Base stations were local Sigfox antennas, in charge of receiving messages from emitting devices and forwarding them to the Sigfox cloud. They were deployed in the field by local Sigfox Operators (SOs). As of June 2018, 33 SOs were listed on the Sigfox website.[43]

Base stations were composed of three major elements: an antenna, to receive messages over the air, usually deployed on high points or towers; a LNA or LNAC (low-noise amplifier) to amplify the signal and filter noise; and an access point, which understood the Sigfox messages and sent them to the Sigfox cloud. Once connected, these base stations became part of the Sigfox public network. They then started listening for all Sigfox messages sent by devices in the vicinity.[44]

The major utilization advantage of Sigfox was that an entire city could be covered by one single base station. In Belgium for example, a country with a total surface area of 30,500 km^2, the Sigfox network deployment covered the entire country with only seven base stations. As a comparison, there were over 11,700 mobile phone antennas in the country.[45] Similarly, reaching complete network coverage across France, a country with a total surface area of 643,800 km^2, required only about 2,500 Sigfox base stations, in comparison with 42,000 phone masts for the cellular network.[46]

In terms of costs, deploying the Sigfox network in France amounted to approximately €15 million. This amount included the costs of the base stations (about 50% of the total cost), the installation of those base stations, and the network running costs (e.g. site lease, maintenance, etc.). By contrast, the deployment of 4G in the country had an estimated cost of €1 billion to €3 billion per operator.[47]

The first Sigfox base stations were manufactured by Sigfox directly. However, to grow and scale, the founders decided to find an EMS and outsource this process. Olivier Martineau, CFO, explained, "This allowed us to decrease the costs of the base stations, but also to increase their quality. Their failure rate went from 20% initially to less than 1% today." (See **Exhibit 7** for illustrations.)

A Sigfox base station was designed to receive up to 4 million messages per day. Many areas were served by three or more base stations.[48] (See **Exhibit 8** for a map of the Sigfox network.) Devices broadcasted each message three times on three different frequencies to ensure that the message went through. Sigfox was also a two-way communication service. Two-way stood for bidirectional or duplex, meaning that messages could be sent but also received by a connected device. This two-way communication system had the advantage that there was no need of physical intervention, should a device need an adjustment.[49] The Sigfox technology was, for instance, used for bicycle-sharing systems. When users walked up to a bike, entered a PIN, and pressed the 'unlock' button, a message was sent by the lock to the Sigfox cloud. The Sigfox cloud processed the information, communicated back to the lock, and released the bike.

Cloud (Internet)

In order to retrieve the messages emitted from a device, Sigfox developed a fully integrated cloud system. Apart from data processing, it also provided an interface for customers and Sigfox operators to directly manage their devices registered on the network. (See **Exhibit 9** for a diagram on the Sigfox backend.) The Sigfox cloud had two different interfaces in order to access its contained data. One consisted of a web portal which could be accessed through a classic Internet browser and the other option provided a direct link to the external servers of the customer or operator.[50] This connection

could be established in two ways according to whether the external recipient wanted to receive the detected message immediately or only upon request. The Sigfox cloud facilitated the way for customers and operators to perform operations on their registered devices. Depending on the connectivity type, the platform removed the necessity to connect continuously to the cloud to perform recurring operations such as callback[a] declarations, device management etc.[51]

Sigfox's Business Model and Portfolio

Infrastructure-As-A-Service for Sigfox Operators

As Sigfox didn't have the funds and capabilities to build, maintain, and operate a global network on its own, the company teamed up with third-party 'Sigfox Operators' (SOs). These SOs—often local mobile operators—agreed to install Sigfox's base stations on their existing towers, providing a fairly rapid coverage,[52] and were responsible for the network performance, maintenance, and daily operations. This partnership allowed Sigfox to rollout their network as fast and as broad as possible.[53]

In Europe, most SOs were entrepreneurial ventures. Emma Park, vice president Europe at Sigfox, explained, "When we searched for SOs a couple of years ago, Sigfox was perceived as much more of a risk. That's why in Europe, SOs tend to be small groups. But we also have big names: for example Engie in Belgium, T-Mobile in Czech Republic, Cellnex/Sunrise in Switzerland, or Arqiva in the UK."

Each SO went through a complex due diligence process, wherein a team of Sigfox representatives carefully examined every facet of their business to ensure that they would successfully rollout, sell the connectivity services, and drive the growth of Sigfox's IoT ecosystem in the country. Sigfox particularly assessed the SOs' go-to-market strategies, their technical skills, but also their fundraising capabilities. Park said, "It is a CAPEX intensive industry. At the beginning of the process, the SOs will need to raise money to buy and install the base stations. But they will also need money during the entire duration of the contract, especially if the market is slow to take off."

Once the distribution agreement was signed, the SOs had exclusive rights to deploy and operate the Sigfox network in a specific country. The contract included an expected coverage of 85% of the inhabitants within two years. Larger countries such as Brazil or the U.S. usually had more time to deploy. The contract also included a certain volume of connected devices based on certain expectations, generally one object per inhabitant within five to six years. Should an SO not reach the pre-defined contractual targets, Sigfox would assess their overall pipeline in order to determine its performance. In 2018, there was a dual SO situation in the UK, as Arqiva, the original SO, had failed to meet its agreements and had lost out on its exclusivity deal.

Sigfox provided guidance to the SOs, for example by helping them with storytelling to fuel fundraising, by giving them sales collateral, or even by physically going to customer meetings with them to negotiate contract details. Park explained, "Of course, it depends on their contacts, their networks, the various experiences of what they have done in their previous lives before becoming a SO. We have a bespoke approach per operator. For example, some SOs don't have hardware experience; so they need guidance with manufacturing devices. Others don't have expertise in one of our key verticals; so they need contacts within the industry." She added, "Each Sigfox country director has a go-to-market plan per SO. It starts from the SOs' strengths and weaknesses and where we need

[a] A callback was a custom http request containing the device(s) data, along with other variables, sent to a given server/platform. The callbacks were triggered when a new device message was received, when a location had been computed, or when a device communication loss had been detected for example.

to support them. Then we look at the market, the key verticals, the key customers, where we have got contacts, and where Sigfox needs to come in."

In return for its technology and network design, Sigfox claimed a 40% share on any service revenues that the SOs generated. In addition, the SOs paid Sigfox some equipment fees (€2,500 per base station), as well as upfront fees (for the access to the ecosystem and technology). Fees were standard worldwide. The upfront fee—generally a few million euros—differed according to the size of the country and the market's potential. Martineau commented, "The system is done in such a way that Sigfox is cash positive from day one." (See **Exhibit 10** for details on the business model.)

There were a few exceptions, however, when it came to network architecture. For example, Sigfox was managing its own network in countries like France, Germany, and the U.S. Martineau explained, "France was our home market. It was easier to do it ourselves. In Germany, this was due to competitive reasons. The local mobile operator didn't allow us to use its towers, so we had to deploy our own network. We cover about 50% of the country and aim for full coverage by the end of 2019. In the U.S., it was difficult to find a partner, and the costs to deploy a network are very high there."

Martineau summarized the pros and cons of this indirect business model, "The interesting thing for Sigfox is that we don't have to fund the CAPEX and the OPEX of the network. We get 40% of the revenues, so we can manage a lot of countries in parallel." The SO model also presented the advantage that an SO could leverage its local knowledge of the market to deploy the network successfully which facilitated Sigfox' entry into foreign markets. Since each SO possessed a unique knowledge of the local market conditions, they were also given some flexibility in terms of defining the customers, as the company management in the French headquarters lacked that familiarity.

On the other end, tensions over go-to-market strategies and client management could be a challenge. Franck Siegel, chief delivery officer, explained, "Sigfox is now implementing a global account program to support large customers across the world. If a client like Michelin, Marriott's or Hilton is unhappy, they may want to talk to Sigfox about it. Not the SO. How would the local operator feel over time as these clients interact more and more with Sigfox? We need to manage that very carefully." Martineau added, "The major drawback is also that we don't have full visibility on the pipeline. If the SO is not performing, there is nothing we can do. We can stimulate the local market, but we cannot sell anything on that market due to the exclusivity clause."

Network-As-A-Service and Data-As-A-Service for Customers

As of June 2018, the SOs offered three main services to their customers: connection (with Admiral Blue and Admiral Ivory); location (with Atlas); and cognition (with Monarch). These services were priced by SOs according to a Sigfox standard grid. While the structure of the grid (volume and level of service) was imposed by Sigfox, pricing could differ based on purchasing power and price levels across countries. (See **Exhibit 11** for an example of a Sigfox price grid.)

Network-As-A-Service (NaaS) NaaS included two offers: Admiral Blue and Admiral Ivory. "*Admiral Blue*" was the SOs' core solution for recurring connectivity. Consumers could either opt for a regular subscription (for a small amount of devices) or an enterprise subscription. The latter offered access to a larger set of options and a better price (for volume above 1,000 devices). There were two kinds of enterprise subscriptions: committed volumes or pay-as-you-grow. For committed volumes, customers paid the SO an initial one-time fee (to create a contract), an activation fee (to connect a device to the network for the first time), as well as a monthly subscription fee. The recurring charge usually ranged from €1 to €14 per year per device depending on the volume of devices and the number of

messages exchanged. Guérin Vong, pricing manager at Sigfox, explained the three types of billable elements:

> For example, if the subscription fee is €1 per year per device and you commit on a volume of 1,000 objects, you will pay upfront a part of the global price for creating the contract. This one-time fee will be equal to half the amount of your yearly subscription. In our example, you would pay €0.50 per device for your 1,000 objects, meaning a total amount of €500. For your commitment, you will access lower yearly subscription prices. You will then pay an activation fee to activate the devices for the first time in this contract. This fee is also equal to six months of subscription, so €0.50 per device. When your device renews its subscription inside the contract, you do not pay again for this activation. Finally, you will be charged a monthly subscription fee. The indicated price is a yearly price, but it is invoiced every month for each device (yearly cost divided by 12).

If consumers picked a "pay as you grow" subscription and didn't commit on a volume, they wouldn't have to pay anything upfront; they would only pay the activation and subscription fees.

As the current pricing was complicated and consisted of many variables, company management was in the process of readjusting it based on customer feedback. Sigfox contemplated whether to apply more standardized conditions and reduce the number of fees in order to simplify the pricing.

The second offer, "*Admiral Ivory*", launched by Sigfox in early 2018, was a transactional offer for disposable assets and one-time IoT applications, such as trackers for small letters and parcels. That simple service worked with modules that were not very sophisticated and that didn't send more than a couple of messages. This pay-as-you-go service could cost as little as €0.10 per device.[54]

Data-As-A-Service (DaaS) Beyond connectivity services, the SOs also had access to a wide range of data that could be exploited in the long run. The "*Atlas*"suite, previously known as Sigfox Geolocation, was a location service for Sigfox devices, which didn't have a GPS module and used the network information to calculate a device's approximate location. The service was sold on its low cost and low energy consumption and was charged as a percentage of the monthly subscription fee. For better accuracy, Sigfox recently introduced a geolocation service that combined the Sigfox network with Wi-Fi hotspots from Dutch mapping company Here.[55]

"*Monarch*" was finally a new radio-band recognition service, which let a Sigfox device transmitter switch between unlicensed bands if it changed country. Designed for use in logistics, transportation, or supply chain, the service allowed an asset to hop between a European 868 MHz band into a US 915Mhz band for example, without needing to be prompted by the system.[56] The Sigfox price structure was adjusted if objects moved across borders in a way that was similar to international roaming charges in mobile telecommunication networks. Day-by-day the local communication price was applied. This was creating a certain complexity as the price differed country by country and the range factor could be two (potentially more). The second complexity came from the country price indicated in the local currency. As a result, consumers were subject to money variation risks.[57]

Solution Enablement for Partners

Sigfox was not only interacting with SOs and customers. The startup was part of an entire value chain, from chipset manufacturers, device makers, to module manufacturers and IoT platform providers. Sigfox was working hand in hand with these partners to develop the ecosystem and to accelerate the adoption of IoT-enabled devices worldwide. Laetitia Jay, chief marketing officer, said,

"We provide know-how and tools. We deliver libraries to make devices Sigfox compatible. We offer certifications to ensure that device makers implement our technology correctly."

WND—Sigfox's Deployment in Latin America

The network operator WND was responsible for deploying and managing Sigfox's connectivity grid in Latin America and the U.K.[58] The company initially contacted Sigfox regarding the possibility of concluding a distribution agreement. Following the sign-off, the deployment of the network began in Mexico, Colombia, and Brazil respectively in 2016. According to the terms of the standard contract, WND set up the base stations and led the commercial efforts to sell the connectivity to third parties such as device makers, integrators, and cloud developers who were then responsible for initiating the sales process to the final customer requesting an IoT based solution. Therefore, an important part of WND's launch strategy was to evangelize the technology and identify relevant and capable partners.

On the Latin American markets, the use cases were concentrated on four verticals: security, logistics, agriculture, and utilities. Examples included the installation of devices on gas tanks which were mainly located on inaccessible rooftops. After a completed transmission, owners could access the data on a mobile app which enabled them to monitor their consumption levels and detect leaks.

Another important use case was in the security sector. Daniel Guevara, CEO of WND Mexico, explained, "Security concerns are prevalent in Mexico City. The Sigfox technology has a particularity which is important for alarm systems as a transmitted signal cannot easily be jammed by thieves. Thanks to this specificity, a stolen vehicle can be located and retrieved with precise GPS coordinates." He added, "We are also working on a security project with the police regarding the placement of buttons in restaurants to address robbery concerns. Once a button is pushed by the personnel or customers, it identifies the nearest police officer who can intervene."

In order to build Sigfox's business on the Latin American market, it required a coordinated strategic framework. In the last years, WND had adopted a narrowed focus on the chosen verticals in order to use its resources on applications with a proven success and scalability. Guevara reflected on the challenges he endured when deploying the network on the Latin American markets. He noted,

> The pricing model of Sigfox is currently under review as it is too difficult to grasp which can prevent us from acquiring customers. Another challenge relates to shifting the business towards selling IoT services as a whole: when a customer requests an IoT solution, we want our partners to do the integration, acquire the necessary devices, and thus be the data providers. Every time a new use case is introduced, they need to think about selling data. We have an entity called the IoT House which serves as a platform to give direction on this.

As of July 2018, the company had managed to cover 60% of the population in Mexico. The costs of complete coverage of the country amounted to €5 million which included an installation of 2,500 base stations. The rollout was expected to be completed in 2019. "Our goal is to massify the connectivity," Guevara noted. By 2020, he expected 5 million devices to be connected to the network in Mexico.

The Emerging Market of the Internet of Things

Sigfox' decision to venture into the connected devices industry was based on the founders' fascination with the disruptive technology and the endless opportunities which it enabled. Possible IoT applications could be beneficial in important economic settings including health, education,

agriculture, transportation, manufacturing, electric grids, and many more.[59] The technique allowed for the collection of data generated by IoT devices which could be aggregated, analyzed, and acted upon.[60] As a result, it could drive major alterations in the way traditional processes were conducted and, thus, be a catalyst for innovation and research.[61]

Even though the market was young and in the process of materializing itself, analysts noted that the advent of IoT "represented the next step in convergence between information communication technologies and the economy on an unprecedented scale."[62] According to a report by McKinsey & Company, the potential economic impact—including consumer surplus—of IoT applications could generate between €3.5 trillion to €10 trillion per year in economic value.[63] By 2025, the value of this impact was estimated to be equivalent to approximately 11% of the world economy.[64]

Companies also started to realize the full value creation of IoT. Analysts estimated that firms would be spending €250 billion a year on IoT in 2020 with half of that spending coming from the manufacturing, transport, and utility industries. Another study concluded that the adoption of the technology would cause firms to raise connectivity expenditures by 15% annually up until 2022.[65]

Naturally, Sigfox was not the only one to pursue the emerging market of IoT. The firm started feeling pressure as it was facing competition from both entrenched telecom players and new entrants, who were looking to gain foothold on the growing market. According to Le Moan, the vision of creating a worldwide network represented a threat to established telecom companies. He explained:

> When we launched, the bet of building a global network seemed too big and as a small French startup we were not perceived as a threat. When we started scaling and demonstrated our technology and its capabilities, traditional telecom players wanted to squeeze us out of the market by saying that our technology did not work. It damaged our credibility which was harmful to our fundraising. This changed when we started signing bigger contracts which helped us to excel and position ourselves on the market.

By 2018, many competing market entrants had emerged (see **Exhibit 12** for an overview of competing technologies). Founded in 2015, the LoRa Alliance, an open, non-profit technology association devoted to the promotion and standardization of LPWAN technologies, was presented as Sigfox's main competitor.[66] The Alliance relied on a patented technology developed by French startup Cycleo, which was later acquired by U.S. semiconductor supplier Semtech.[67] The group was seeking to implement the LoRaWAN protocol as a global standard for IoT LPWAN connectivity.[68]

While the technology differed from the one of Sigfox, the group also targeted mobile network operators and thus represented direct competition.[69] In France, major telecom companies such as Orange and Bouygues Telecom were members of the LoRa Alliance and had started using the technology in the development of their IoT business.[70] Although LoRa had certain similarities with Sigfox's technology, Fourtet did not perceive them as a competitor per se. He commented, "LoRa and Sigfox are derived from the same idea: to establish long range and low energy radio links for message transfers. Therefore, it is inevitable that our solutions have similarities. However, in my opinion, LoRa's technology is more adapted to industry applications in an isolated space, whereas the Sigfox signal can travel the world. This is one of the main differences."

The LoRa technology presented the advantage of being an open network. Any company could create its own network and use the technology by the means of an antenna connected to the Internet and a base station emitting on a 868 MHz bandwidth.[71] The price setting for the network access depended on the provider.[72] While the ecosystem itself was open, Semtech was the only company which was licensed to produce radios that would work on the LoRa network to transmit the data.[73]

Another competitor to Sigfox's technology was LTE-M.[74] The technology enabled battery-run IoT based devices to connect to a 4G network without the use of a gateway.[75] It had the additional advantage that the required network was already there in the sense that the present infrastructure of LTE base stations only required a minor upgrade to be compatible with the technology.[76] Despite the value proposition of the LTE-M structure, it had the restriction that it required specially designed devices with embedded chips that only two startups, Altair and Sequans, manufactured at the time.[77]

Sigfox also faced competition from the emerging cellular rival NB-IoT (Narrow Band Internet of Things) which was backed by many of the largest mobile operators and equipment makers.[78] The technology was a product derived from the conclusions of a working group established by the third Generation Partnership Project (3GPP), a collaborative project dedicated to developing specifications for cellular telecommunications network technologies, in order to combine the technical capabilities of the major telecom companies Huawei, Nokia, Ericsson, and Intel.[79] As the technology was backed by some of the largest telecom infrastructure manufacturers, it had the advantage that it could be deployed over already existing networks.[80] In 2018, Huawei estimated that there would be more than 150 million NB-IoT connections by the end of the year.[81] Vodafone was also advocating the technology and had successfully deployed commercial networks in Australia, Ireland, the Netherlands, Spain, South Africa (through Vodacom), and Turkey in early 2018.[82]

The American company Ingenu, which engaged in building a network entirely dedicated to provide LPWA connectivity for machines, was also viewed as a competitor to Sigfox.[83] In the course of seven years, the company had managed to deploy a total of 35 networks around the world with a strong local presence in the U.S.[84] Industry experts estimated that an Ingenu access point had the abilities to cover the equivalent of 70 Sigfox antennas over a cellular network.[85] Fourtet recognized that the market was becoming increasingly crowded with heightened competition; however, he thought that there was still space enough for everyone, "The market of IoT is still in a developing phase, thus the discussion around competition is not yet relevant. Furthermore, I do not believe that there will be only one technology as a standard reference in the future. The market of IoT is so vast that we will need multiple technologies to address the varieties of potential future applications."

Use Cases

Sigfox was able to address a large variety of use cases with their technology concentrating on nine verticals: supply chain and logistics, manufacturing, smart cities, utilities and energy, smart building, retail, agriculture, home and lifestyle, as well as insurance.[86] (See **Exhibit 13** for detailed examples of Sigfox use cases.) Le Moan considered the decision to focus on asset tracking to be one of the most important strategic imperatives in order for Sigfox to move forward and excel on the IoT market.

Tracking of assets could bring significant value to the global supply chain and logistics sector. (See **Exhibit 14** for more details.) The technology enabled trackers to transmit data on the location and conditions of goods as they travelled from the warehouse until the final destination by land, sea, and air. For instance, the trackers could address shipping market participants' challenges of monitoring intercontinental sea-freight flows.[87]

The startup collaborated with a host of companies to launch new products and applications. On average, a sales cycle lasted between 8-18 months. Recent examples of Sigfox's collaborations included the launch of a luggage tracker with French luxury retail firm Louis Vuitton. Exclusively available for the brand's Horizon luggage range, the tracker allowed passengers to track their checked luggage in major airports even when crossing borders.[88] The ability to track an asset internationally was thanks to the Sigfox Monarch technology which could transmit data through radio frequencies in airports

worldwide.[89] The tracker was listed at €250, including a three-year Sigfox subscription, in addition to the cost of the bag which was in the range of €2,650 and €2,900.[90]

Sigfox had also entered into collaboration with the European aerospace firm Airbus who wanted to use IoT-enabled solutions to improve its supply chain, which was interlinked with more than 8,000 suppliers, in order to map items and show its specific status. The trackers had successfully contributed to solving Airbus' global asset tracking challenge as they provided alerts regarding status, improved transport cycle times, and reduced the number of lost items. The company planned to implement a solution for data collection when it conducted flight tests to assess the overall performance of each flight. For this purpose, the Sigfox sensors were mounted to the aircraft during the test to monitor and record various aspects such as the temperature of the components, humidity, vibration, and shocks. This allowed crucial data to be collected and analyzed afterwards.[91]

Another important milestone for Sigfox was the conclusion of a deal with French tire manufacturer Michelin, in collaboration with the international consulting firm Argon Consulting, on tracking of international sea-freight flows. The service enabled customers and suppliers of Michelin to track their sea container shipments as mounted sensors could report back data on the real-time geolocation. As a device was designed to recognize and adapt to local radiofrequencies, the technology allowed for tracking on a global scale. The implementation of the solution took few months and had successfully improved the supply chain of Michelin.[92]

As French global satellite operator Eutelsat was among Sigfox's backers, there were ongoing discussions about IoT from satellites to increase the coverage in very remote areas such as deserts and the sea. Raoul Mallart, chief technology officer, explained:

> It doesn't make business sense to put Sigfox antennas everywhere because it becomes too expensive, and there are some areas where there are very few objects to connect. Nevertheless if you could have global coverage of these wide spaces through satellite, it could be interesting. There is an economic equation to solve between how many satellites you need to launch, the cost of the satellite, and how many base stations on the ground. Working with the satellite companies can help solve these equations.[93]

Le Moan added, "I think two to three years from now, we will be able to cover the entire world with our base stations and some potential satellites. With this global coverage, we will be able to track any physical assets broadcasting their position. Do you know that Argos transmitters which are currently used to track long distance movements of boats or oceanic species are hugely expensive? Imagine how disruptive this would be if we can replace these transmitters with a €1 Sigfox device…"

Mapping the Way Forward

The Dream of a New IoT Reality

Le Moan had big visions for the future of Sigfox. He dreamt of a fully interconnected world, and the thought of how Sigfox could play a vital role in this new reality was so exciting to him that it could keep him awake at night. With his entrepreneurial spirit, his mind was continuously wandering on the vast amount of use cases which Sigfox was capable of addressing with its innovative technology. The thoughts were browsing in his head, and he shared the various ideas with his management team, who were excited about contributing to the startup's intriguing journey to change the world by enabling IoT technologies.

Le Moan was fully determined to foster the use of IoT technologies in order to make his company succeed. He knew that Sigfox had the potential to become a leader as its technology was truly disruptive. In an increasingly interconnected world, he dreamt of deploying a truly global connectivity network. To make the most out of a global connectivity interface, he was also playing with the idea of integrating a "social Wi-Fi network" in the structure. While the planning of its execution was still in progress, the idea evolved around enabling customers to share their Internet subscriptions with other users on the platform. This sharing scheme would allow participants to connect to the global network even when crossing borders without paying extra roaming fees as a travelling participant would be able to use the shared connectivity of another user.

Le Moan also had other applications in mind. According to him, integrating IoT technologies could transform online retailing in the sense that a manufacturer could simply attach a device to the goods intended for sale. With this approach, the offered item would automatically be displayed and made available for purchase with the simple gesture of activating a device. Le Moan was convinced about the transformative potential of Sigfox's technology, and he travelled the world tirelessly to talk to investors, secure new clients, identify new partners, and spread the knowledge of IoT and its many capabilities in order to promote his company.

To overcome the current obstacles and conquer the complex IoT market, Le Moan had launched several initiatives in collaboration with his management team. Pressure was increasing as he had to deliver the desired results fast in order to achieve his goal of becoming profitable by the end of 2018 as a precursor to launch a successful initial public offering (IPO) in the coming year.

From Startup to Scale-Up

Marketing-Led Growth Le Moan perceived a focused marketing approach as critical to sustain a consistent growth path. The scaling of the company had prompted the need of a dedicated marketing section capable of acquiring more customers by enhancing the perception and brand value of the company. Jay recalled, "When I joined, Sigfox was a startup that had invented a new technology, a new positioning, and a new market. But as it was growing, it needed a structure to scale. A structure to define what our key markets were, where Sigfox's technology and proposition fit, and what our value proposition was all about. My first action was to understand what had been done and then to clarify our portfolio of offerings."

To streamline the marketing efforts and use it as an enabler for further growth, it was essential to map the main markets and identify the key problems which Sigfox could solve in order to highlight the true value proposition of the technology and attract customers. Jay explained that assessing market trends, supporting the sales forces, and categorizing potential partners in each country were ongoing efforts to achieve success.

Shaping the Ecosystem To accelerate the development of the IoT market, which was still at a rather early stage, Le Moan also decided to set up a new adoption and evangelization department within the firm. As a result of that decision, Sigfox established partnerships with universities, incubators, and start-ups in the IoT sector in order to provide the necessary technical training and go-to-market strategies to succeed in the market.

The objective was to foster a strong ecosystem of IoT specialists and to ensure a widespread knowledge of the technology in order to pave the way for the future. Nicolas Lesconnec, head of technology adoption, explained, "The decision to create our department was informed by the lack of maturity of the IoT market. We intervene in order to encourage a larger segment to enter the IoT funnel

by establishing educational programs and partnerships. Our vision is to stimulate a strong ecosystem so that we can shape the direction and development of the IoT market."

What to Do Next?

So many thoughts whirled in Le Moan's mind. What was the best way to deliver short-term on the new strategy agreed to at the latest board meeting? He poured himself a cup of coffee and settled back to chat. "Will these latest initiatives be enough to accelerate the development of the market and bring the company to the next stage?" he asked, almost to himself. "It's difficult at this stage to know for sure, but we know we will succeed," Fourtet replied.

As the two men were considering the different options for Sigfox going forward, they thought about what else could be done to develop their company and reach the target of 1 billion connections by 2023. They could consider a different business model. Focus on a different industry. Pick different types of Sigfox Operators. Lower the prices of Sigfox modules. Shape the ecosystem even further. There were undoubtedly other options too that had not even been considered.

They knew that they had to come to a decision on the path to take if they wanted to remain independent in the long run. What should they recommend? What direction should they take?

Exhibit 1 Biographies (as of 2018)

Ludovic Le Moan, CEO and co-founder, Sigfox

Le Moan co-founded Sigfox and was its CEO since December 2010. He started his career in scientific and business positions prior to taking over the management of Cogrami Group (1,500 people). In 2000, at the age of 38, he decided to become an entrepreneur and founded two successive companies: Anyware Technologies (in the M2M sector) and Goojet, later renamed Scoop.it (content marketing software). Le Moan was an engineer and graduated from ENSIMAG (group Polytechnique Grenoble).

Christophe Fourtet, co-founder, Sigfox

Fourtet founded Sigfox in 2009 and served as its scientific director. He spent his entire career in the electromagnetic and radio-frequency business units of blue chip companies (DGA, SAGEM, Motorola, Freescale). Among other achievements, he contributed to creating the HW cellular group (that created the Motorola cellular phone). His extensive expertise enabled him to bridge the gap between technology and high volume manufacturing product. Since 2003, Fourtet became an ANR expert. Passionate about radiofrequency, his expertise was acknowledged worldwide. Fourtet was an engineer and graduated from INSA (Lyon) in Electrical and Telecommunications Sciences, and held a Postdoc in Electromagnetism.

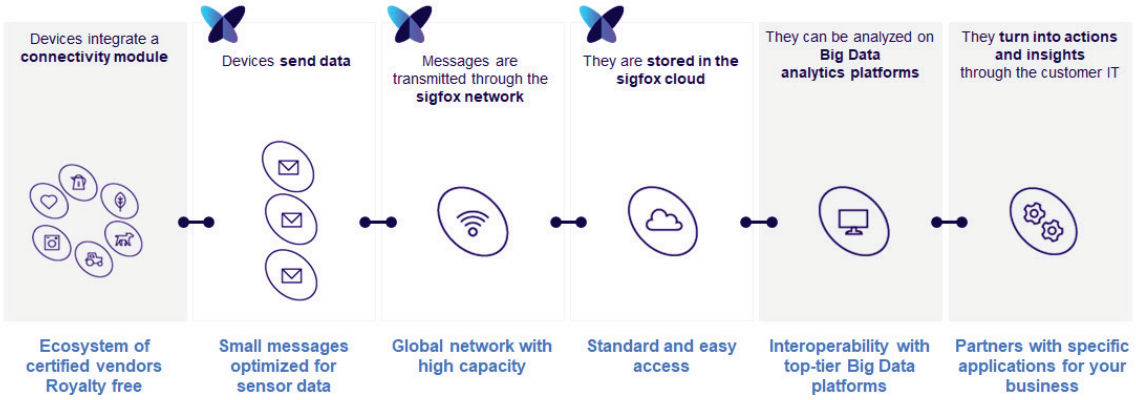
Source: Company documents.

Exhibit 2 Sigfox Funding Rounds (in euros, as of 2018)

Date	Transaction	No. of Investors	Money Raised
5/24/2017	Private Equity Round	1	N/A
11/18/2016	Series E	12	150,000,000
2/11/2015	Series D	10	100,000,000
3/28/2014	Series C	6	15,000,000
11/11/2012	Series B	4	10,000,000
10/1/2011	Series A	1	2,000,000

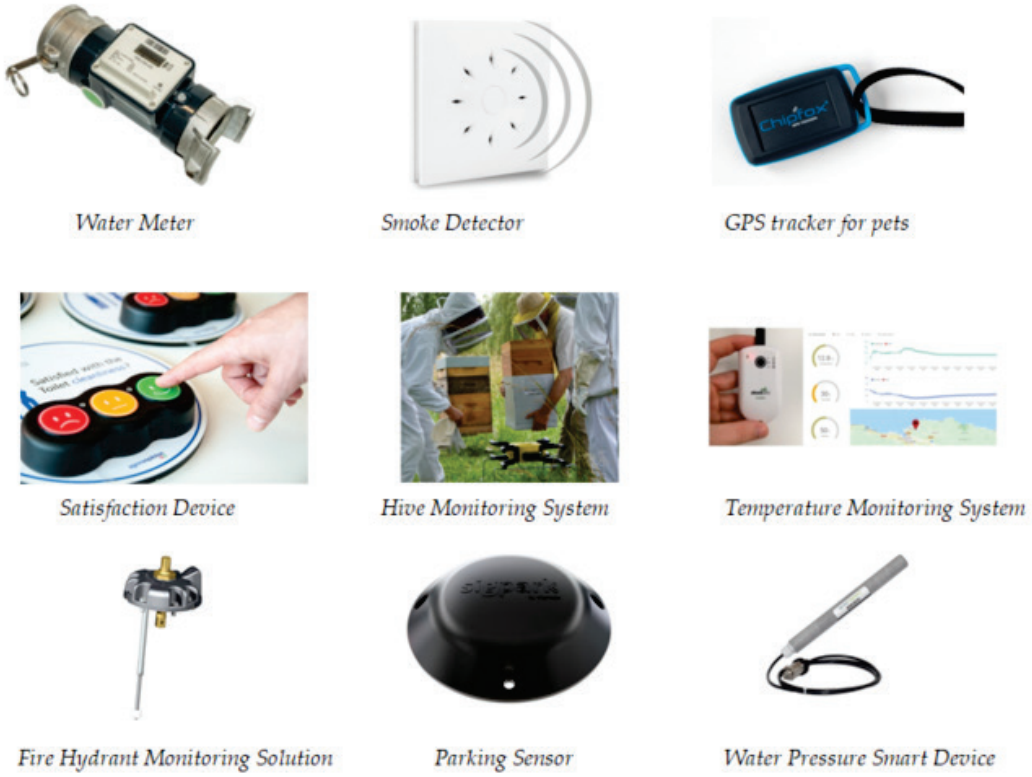
Source: Crunchbase, "Sigfox Funding Rounds," Crunchbase Website, https://www.crunchbase.com/organization/sigfox/funding_rounds/funding_rounds_list, accessed June 2018.

Exhibit 3 Sigfox Architecture (as of 2018)



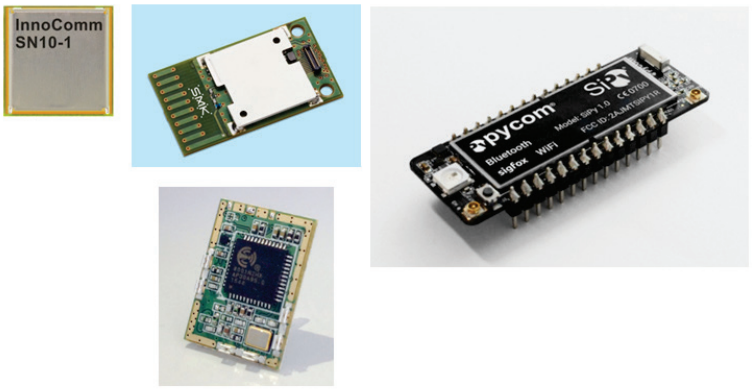
Source: Company documents.

Exhibit 4 Devices Using the Sigfox Technology (as of 2018)



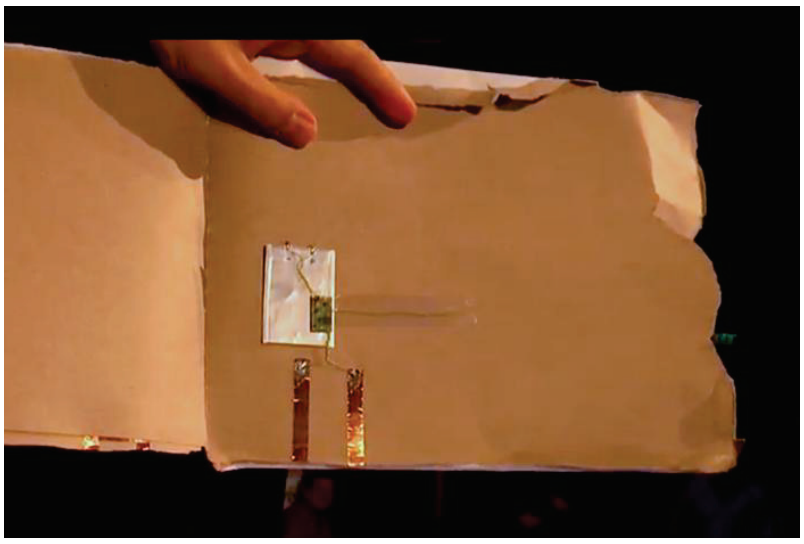
Source: Company documents.

Exhibit 5 Examples of Sigfox Modules (as of 2018)



Source: Company documents.

Exhibit 6 Low-Cost Wireless Sigfox Module Embedded in a Shipping Envelope (2017)

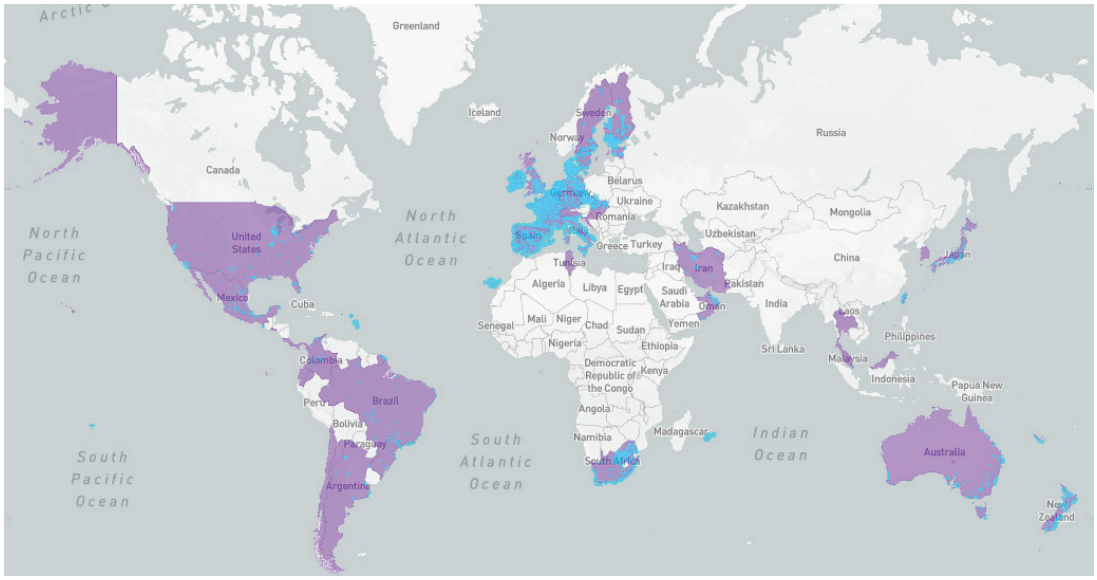


Source: Company documents.

Exhibit 7 Illustration of a Sigfox Base Station (as of 2018)

Source: Frontier BV, "Case Study: Aerea," Frontier BV Website, https://frontierbv.nl/case-studies-en/aerea-sigfox-en/?lang=en, accessed October 2018.

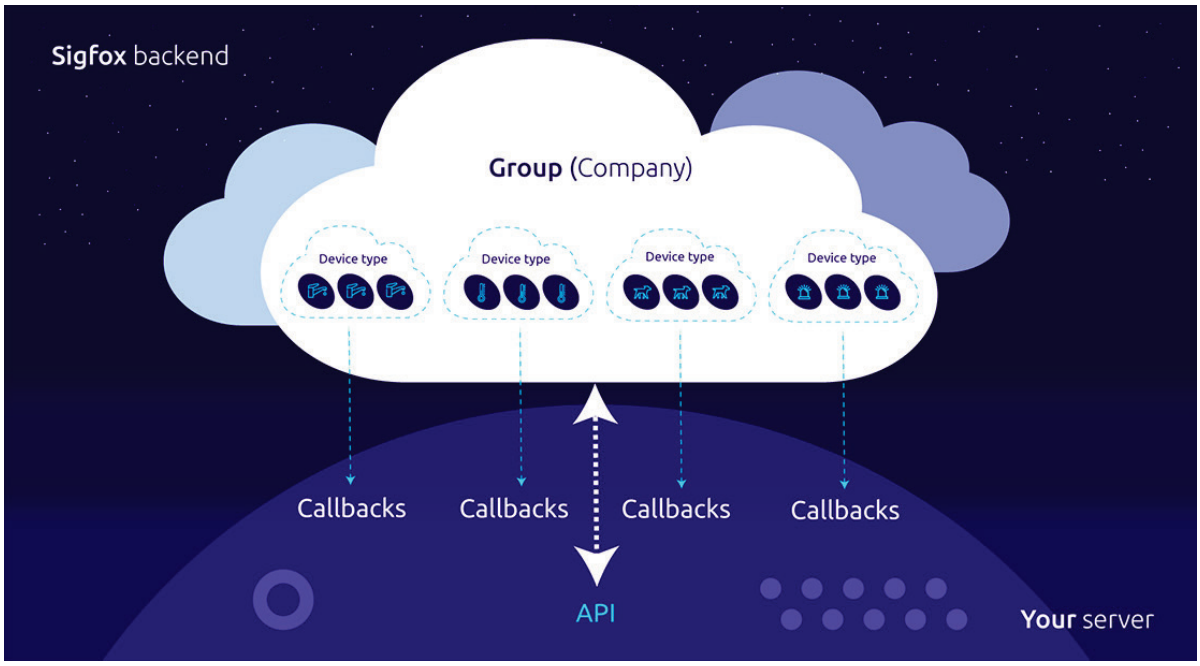
Exhibit 8 Map of the Sigfox Network (as of 2018)



Source: Company documents.

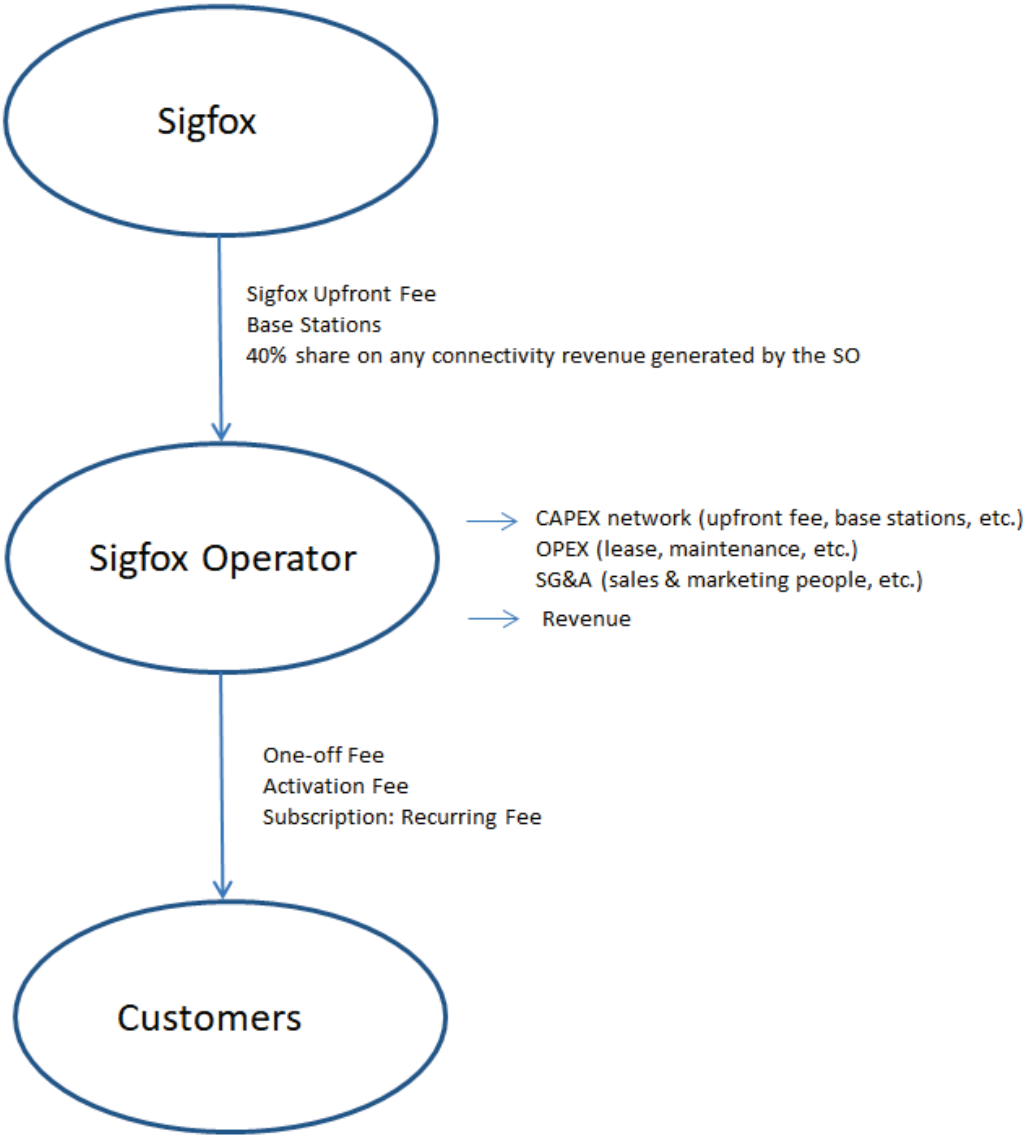
Note: Light blue: live coverage; Purple: countries under roll-out.

Exhibit 9 Sigfox Backend System (as of 2018)



Source: Company documents.

Exhibit 10 Sigfox's Business Model (as of 2018)



Source: Created by casewriter based on company documents.

Exhibit 11 Example of Price per Device per Year According to Volume and Level of Service (as of 2018)

LEVEL OF SERVICE / Number of messages per day	VOLUME: Number of devices — 1,000	1,000-10,000	10,000-100,000
1 -10	€7		
10 - 140			€1

Source: Company documents.

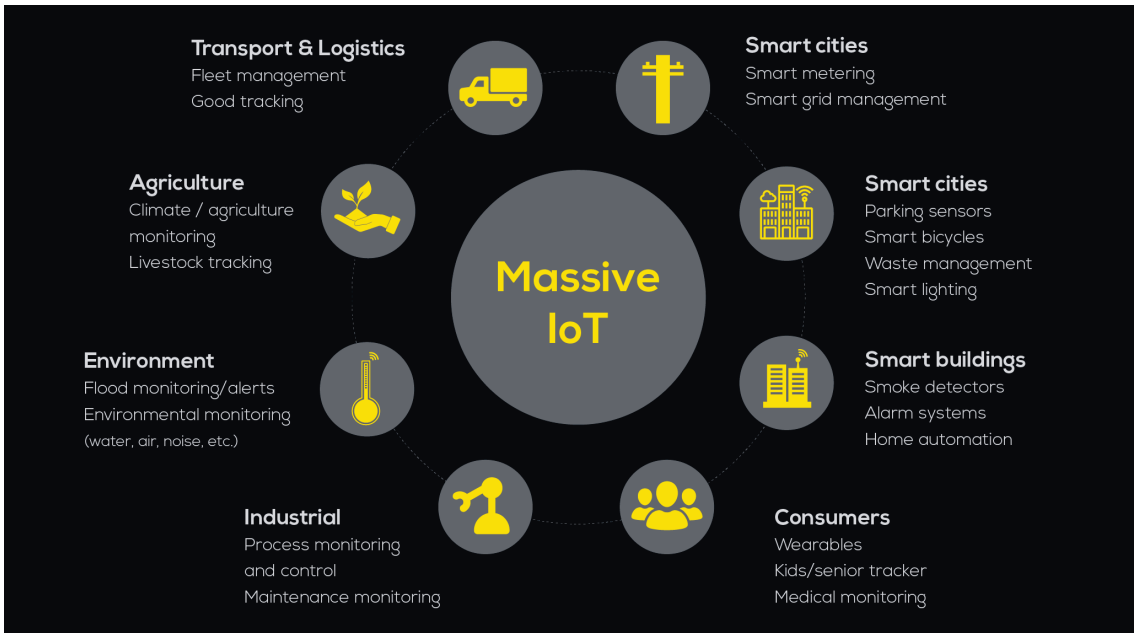
Note: For a European network, limited to 140 messages per day. The structure of the grid (volume and level of service) was imposed by Sigfox. The prices were adjusted based on price levels in the country.

Exhibit 12 LPWA IoT Connectivity Overview (as of 2018)

	Sigfox	LoRa	LTE-M	NB-IoT	Ingenu
Battery life	>10 years	>10 years	>10 years	>10 years	>10 years
Channel bandwidth	100Hz	125, 250, and 500kHz	1.4MHz	180kHz	1MHz
Range (km)	Urban: 3-10 Rural: 30-50	Urban: 2-5 Rural: 15	Urban: 2-5	Urban: 1-5 Rural: 10-15	Urban: 1-3 Rural: 25-50
Spectrum	Unlicensed	Unlicensed	Licensed	Licensed	Unlicensed
Type	Non-cellular	Non-cellular	Non-cellular	Non-cellular	Non-cellular

Source: Created by casewriter based on Anton Kulichenko, "Top 7 technologies for IoT connectivity 2017," June 28, 2017, post on blog "Flespi," https://flespi.com/blog/top-7-technologies-for-iot-connectivity-2017; Nokia, "LTE-M—Optimizing LTE for the Internet of Things—White Paper," p. 7, https://novotech.com/docs/default-source/default-document-library/lte-m-optimizing-lte-for-the-internet-of-things.pdf?sfvrsn=0; and Michael Alba and Juliver Ramirez, "The Guide to Low-Power Wide Area Networks," *Engineering.com,* April 30, 2018, https://www.engineering.com/IOT/ArticleID/16869/The-Guide-to-Low-Power-Wide-Area-Networks.aspx, accessed March 2019.

Exhibit 13 Examples of Sigfox Use Cases (as of 2018)



Source: Company documents.

Exhibit 14 Sigfox Use Cases in the Supply Chain and Logistics Sector (as of 2018)

Source: Company documents.

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