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GPRS monitoring of air freight

Final report

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Photos: Brussels Airport Company, Aviapartner, Seabury, Onasset Intelligence, Biobest

Word of thanks to all participants from the supervising committee (Belgian Customs, BRUcargo Strategic Committee, Essenscia, IATA, Marsh, POM Vlaams-Brabant) for their willingness to share their insight and knowledge and of course, thanks to all participating companies without whose cooperation this project could not have been realised: Aviapartner, Biobest, Brussels Airlines, Brussels Airport Company , Ceva Logistics, DHL, Global Forwarding, Owens Corning, Scania Logistics, Sentipharm (MSD), Swissport and WFS.

GPRS monitoring of air freight

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Executive Summary

The demand for real-time monitoring of air freight

In May 2012 Flanders Institute for Logistics (VIL) initiated the 'GPRS monitoring of air freight' project in which eleven companies participated: Aviapartner, Biobest, Brussels Airlines, Brussels Airport Company, Ceva Logistics, DHL Global Forwarding, Owens Corning, Scania Logistics, Sentipharm (MSD), Swissport and WFS.


Brussels Airport Company

Belgium plays a prominent role in the pharmaceutical industry. In fact, time and temperature sensitive cargo forms a considerable part of goods transported by air. Vaccines are shipped throughout the world on a daily basis and must be delivered quickly and professionally to guarantee patients' health. Live animals such as useful insects are exported from Belgium to other continents to support the production of crops. Spare parts are transported on a daily basis to locations where there is an urgent need for components.

Air freight is the only mode of transport that guarantees delivery of goods to the other side of the world the following day. However, can location and storage requirements strictly be monitored for these time and temperature sensitive shipments?

Logistical stakeholders offer advanced track & trace systems allowing real-time monitoring of shipments for most transportation modes. These systems usually contain monitoring devices that make use of data transmission through the mobile network. Precisely these are an issue for air freight given that electronic devices need to be switched off during take-off and landing of an aircraft.

With the GPRS monitoring project, VIL aims to investigate the feasibility and applicability of systems that are authorised for air freight and allow real-time monitoring of location and storage conditions. VIL has tested several GPRS (General Packet Radio Service) / mobile-based systems in air freight shipments to ascertain whether with such systems transparency throughout the supply chain with reference to time, location and temperature could be improved. By means of quality measurements and practical tests, the applicability of GPRS monitoring to specific sectors was investigated.

The outcome is promising: several air freight tests reveal that GPRS-based systems promote a more proactive approach in the monitoring of time and temperature sensitive freight. Real-time information on location and condition contributes to the delivery of a high quality product as well as an excellent service to the customer. GPRS monitoring exactly satisfies those conditions.

In March 2013 the new Good Distribution Practice (GDP) guideline was published for the pharmaceutical sector. This updated version of the guideline establishes manufacturer and wholesale responsibility in order to assess the risks in the pharmaceutical supply chain.

Providing transparency in the supply chain is not only important from a regulatory perspective. Flanders possesses invaluable assets such as the pharmaceutical industry and biotech industry, spare parts and a great number of innovative companies specializing in life-sciences, science and sustainable development. Flanders should therefore not only make its mark in the field of production, but also in the service provided and the quality of products delivered by air freight. Brussels Airport is thus making all the necessary efforts to facilitate time and temperature sensitive air freight.

Introduction

Through air freight, goods can be delivered anywhere in the world the following day. As such, a unique service is rendered to sectors with time and temperature sensitive shipments. The short transit time guarantees quick delivery of goods, adding value to temperature sensitive cargo by limiting exposure to detrimental conditions.

The largest air freight volumes for export and import are industrial consumables, exotic fruit, machinery parts, technological products, and conditioned goods. In Flanders, interest for the GPRS monitoring project came particularly from the spare parts sector, the pharmaceutical (conditioned) sector and the live animals sector. Compared to others, the live animals sector transports smaller freight volumes. Nevertheless, it remains an important segment, especially for some fast-growing Belgian companies such as Biobest.

The pharmaceutical industry frequently uses air freight because the goods are extremely time and temperature sensitive. In terms of volume, more pharmaceutical goods are shipped by sea; however, typically individual air freight shipments have a significantly higher value than sea freight shipments. This also applies to live animals, spare parts and air cargo in general.

Europe plays a key role in the trade of pharmaceutical products. In 2012, Europe handled 34% of the world's total volume of pharmaceutical shipments.

The pharmaceutical industry is strongly represented in Belgium. In 2011, 149 pharmaceutical and 35 biotech companies, including the most prominent players in the sector, were located in Belgium.

The production value of the pharmaceutical industry was estimated at 7,713.83 million Euro in 2011, which is an increase of 13.1 % compared to 2010. This growth is greater than the total of the processing industry (+9.5%). The production of the pharmaceutical industry currently represents 19.9% of the production of the chemical sector and 5% of the production of the processing industries.

Belgium transports 5.4% of Europe's total air freight. 9.2% of Europe's pharmaceutical products are transported via Belgium.

Figures 3 and 4 clearly illustrate the importance of the pharmaceutical sector for Belgium and for air freight. Time and temperature sensitive shipments are crucial for the pharma-ceutical sector, spare parts and live animals.

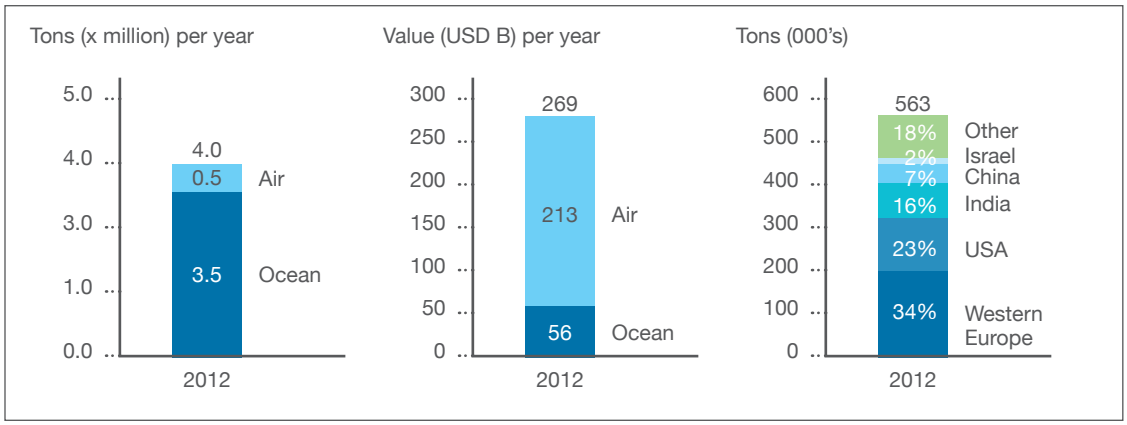
Figure 1 – Export and import of goods for Europe

Export and import commodities Europe	
Capital Equipment & Machinery	8%
Chemicals & Products	9%
Consumer Fashion Goods	5,7%
Consumer personal & household goods	5,5%
High Technology	12,8%
Land Vehicles & Parts	6,5%
Live Animals	0,2%
Machinery parts, Industrial consumables & Foods	18,3%
Raw Materials, Industrial consumables & Foods	20%
Secure or Special Handling	1%
Temperature or Climate Control	13%
Waste Products	0%
Pharmaceuticals	33%

Source: Seabury, Global Trade Database

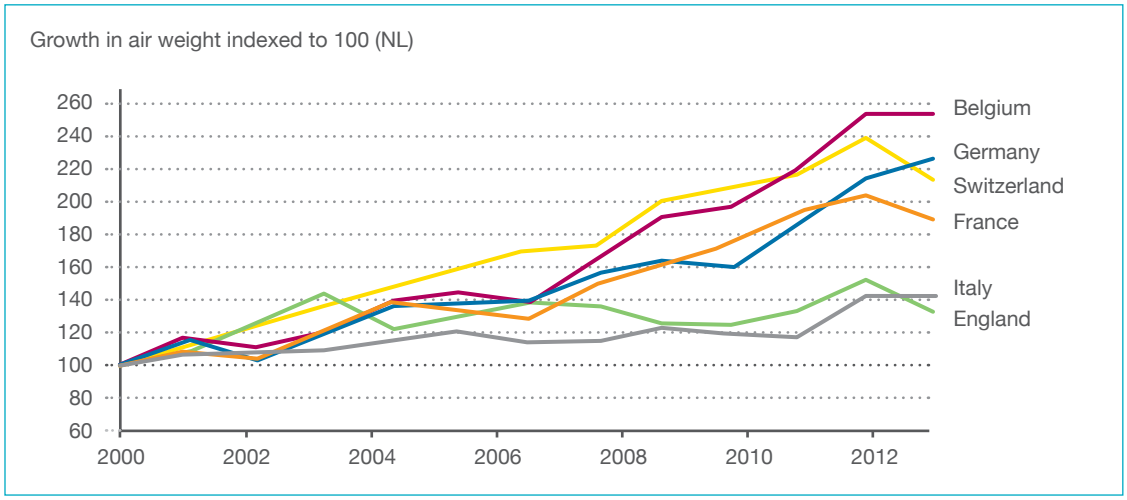
* Source: 2013, Pharma.be, Facts & figures Production.

Figure 2 – Volume and value of pharmaceuticals



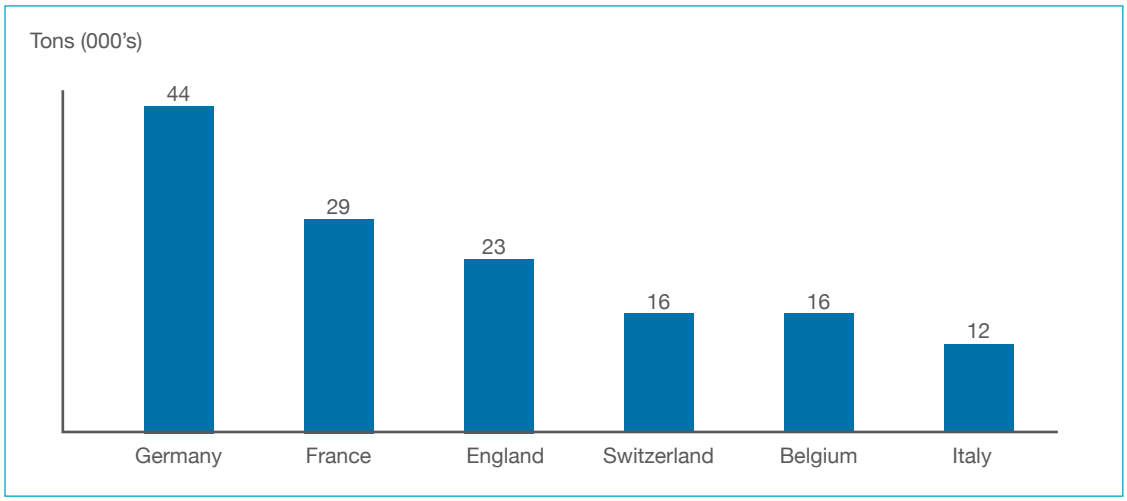
Source: Seabury, Global Trade Database

Figure 3 – Growth of pharmaceutical air freight export since 2000



Source: Seabury, Global Trade Database

Figure 4 – Total pharmaceutical air freight export 2012



Source: Seabury, Global Trade Database

> “Processes are crucial in order to attain conformity within the supply chain”

The air freight supply chain and its stakeholders

The air freight supply chain is very complex because each of the great number of stakeholders has an individual responsibility and makes different contributions, making the monitoring of status and storage conditions of shipments difficult to manage.

The stakeholders within the air freight supply chain are shippers, forwarders, handling agents, airlines and consignees. Road transport accounts for an important part of the supply chain. However, as contractor of the shipper or forwarder, road transport is not included in this project.

An air freight supply chain is characterised by the adoption of defined processes (handling, live animals, dangerous goods, perishables). These are necessary in order to attain conformity within the supply chain, providing in turn support to the flow of goods.

The duties and responsibilities of each of the stakeholders and the related processes are briefly clarified below while discussing the air freight processes.

Time and temperature

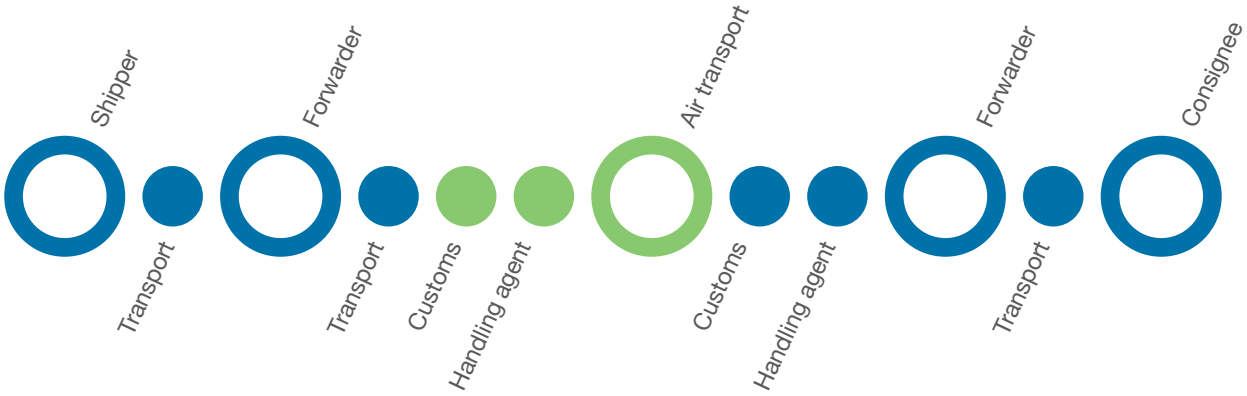
Time sensitive goods are goods requiring quick delivery at location. Temperature sensitive goods are goods requiring shipment and storage under controlled conditions. Time and temperature sensitive goods refer to the risk that goods are exposed to unfavourable conditions during transport and storage. The shorter the transit time of the shipment, the smaller the chance of long-term exposure to unfavourable conditions.

Transfer points, human errors or equipment failure can happen to make a conditioned chain ‘non-waterproof’. In order to guarantee a conditioned supply chain, a ‘waterproof’ system assuring the storage of goods at any time in a predefined condition and at a predefined temperature is required.

Time and temperature sensitive shipments are supported by clearly written processes in order to supervise the critical points and to take action when things are not going as planned.

Non-conditioned time sensitive goods (e.g. spare parts) have been included in the project given that this

Figure 5 – Air freight process and stakeholders’



Source: VIL

commodity constitutes an important part of air freight.

Monitoring of goods

Track & trace techniques and technology have long been used to monitor shipments and goods. Within track & trace, there are several hardware and software solutions providing access to:

- the location of the shipments
- the process flow
- the status or storage conditions of shipments.

The same applies to air freight. Loggers capture temperature data at product or shipment level, and track & trace software systems indicate location and/or process flow within the supply chain.

If a shipment becomes highly critical in terms of both time and temperature conditions, real-time monitoring should be done at any time, preferably at shipment level. This type of monitoring is available for most transport modes. For air freight however, there is a restriction in the use of electronic transmitting devices. Hence from the handling agent's premises, real-time monitoring becomes more difficult.

Shipments delivered to a handling agent are not allowed to have an active transmitting device. Owing to this restriction, monitoring as from delivery to a handling agent can thus only be done with the handling agent's system information, such as a bar code system. Whenever goods are not placed in a cooling chamber or whenever goods on the apron are exposed to unfavourable conditions, action is required. This can only be achieved through local infrastructure or by means of real-time monitoring.

Project scope

Market demand

Current trends in logistical monitoring set new requirements for monitoring systems relating to flexibility, infrastructure, data registration and integration, and real-time data transmission. A survey among shippers and forwarders showed that there is a need for transparency, independent from infrastructure and stakeholders, throughout all activities of the air freight supply chain.

The above-mentioned market demand sets the following technical requirements for the monitoring system:

- **Independence from local infrastructure**
  Monitoring of shipments should be done without local investments in hardware or software, which is not the case with a local RFID or Wi-Fi network.

- **Independence from stakeholders**
  Transparency in the monitoring process can only be attained if information is made available through the entire supply chain. Due to the great diversity of systems and data formats, acquiring supply chain data is not a simple task. Independent monitoring is only possible if the information is delivered by an independent service provider sharing the information with all parties concerned.

- **Throughout all activities in the supply chain**
  Besides independence from infrastructure and stakeholders, it is important that all activities in the supply chain remain visible. Activities lacking transparency trigger periods of risk, limiting intervention in case of problems.

- **Qualitative information**
  One obvious requirement stipulates that monitoring systems present qualitative information, enabling effective use by stakeholders in order to take immediate action or perform analysis.

Describing a market need is one thing, finding a practical solution in the context of air freight is another. Besides the imposed technical requirements, practical conditions have been put forward to come to a deployable solution:

- **Global deployment in air freight**
  The usage of electronic devices is strongly regulated in the aviation industry. The requirement to have electronic devices switched off during aircraft take-off and landing is generally adopted. Deploying monitoring systems for air freight requires the authorisation of the airline and should be applicable for all worldwide destinations.

- **Simplified customs formalities**
  Since import duties are applicable, goods above a specific value should be declared to customs. The same applies to monitoring devices. The frequent import and export of monitoring devices needs a general framework to optimise the efficiency of customs formalities.

> “There is a need for transparency, independent from infrastructure and stakeholders, throughout all activities of the air freight supply chain”

Brussels Airport Company

Real-time temperature-controlled supply chain monitoring

In 2011-2012, VIL carried out the 'Real-time monitoring of conditioned goods' project, aiming to chart the available technologies for real-time supply chain monitoring. At the same time, the need for monitoring systems, independent from infrastructure and stakeholders, had already been expressed.

During this project, GPRS-based monitoring systems were tested in American airspace given that authorisation for the use of some GPRS/GPS devices had already been granted in America. Compelling as the test results were, a subsequent project was bound to come.

Figure 6 provides an overview of the applicability of different technologies within various logistical applications, proving GPRS data transmission to be an interesting field of study for further in-depth analysis.

Practical testing

Practical supply chain deployment and applicability had been put forward as main objectives. Market demand needs to be translated into a functional deployable system requiring an assessment of the following aspects:

- What process support and integration is required?
- Which factors limit the use of the system?
- To what extent can system information be translated into an action?

Figure 6 – Applicability per logistical application

Technology Frequency	WSN 433 MHz	RFID 868 MHz	WSN 2.4 GHz	Wifi 2.4 GHz	GPRS 1.9 GHz	Satelliet
Applications						
Road transport trailer	+	+	+	+/-	++	++
Road transport boxes/pallet	++	+	+	+/-	++	++
Air freight boxes/pallet	-	+	-	+/-	++	-
Sea freight boxes/pallet	++	+	+	-	+/-	-
Sea freight container	++	-	+	-	++	++
Warehouse	+	+	++	+	+	+
Warehouse boxes/pallet	++	+	++	+	+	+/-
Transhipment boxes/pallet	++	+	+	+/-	++	++

Legend: ++ highly suitable, - less suitable

Source: 2012, VIL, Real-time monitoring of conditioned goods

- What is required to proceed to practical usage?
- What added value does the system offer? For which stakeholder?

Process analysis

In order to put the applicability and deployment of monitoring technology for aviation into practice, critical control points needed to be charted.

Critical control points are locations, steps or procedures where, by applying control activities, the aim is to reduce or avoid the chance and impact of a risk.

Through process analysis, it is possible to indicate where control by means of technology could add value to the monitoring of quality and efficiency within the supply chain.

This project's process analysis specifically focused on the airport's processes, from the handler's acceptance until aircraft loading. This choice is justified because of the urgent demand for monitoring at the airport.

Due to the maturity and market availability of standard monitoring systems, research into critical points at the level of shippers, forwarders and transporters was less relevant.

Quality of measuring values

In order to be useful, information should be detailed and accurate. Details convey to what extent a specific piece of information can be analysed.

Temperature measurement and localisation are two aspects that have been further investigated for the selected GPRS devices.

In order to chart the quality of localisation and temperature measurement, tests have been carried out at the three ground handling agents involved in the project. In their operations, GPRS devices were placed adjacent to calibrated temperature loggers at approximately seven points. The measurement setup was carried out at each handling agent during three days, registering values every ten minutes.

Packaging as limiting factor

In aviation, there are several ways to package shipments. Temperature sensitive goods are shipped in insulated material, whereas other products may be loaded in aluminium Unit Load Devices (ULD's). Packaging material can have a negative impact on radio waves used for GPRS data transmission and the reception of the GPS signal. Because of this, a test was included in the project to verify whether for some types of packaging specific constraints occur.

Data transmission is a significant aspect in guaranteeing real-time monitoring. Due to signal fluctuations on the mobile network, data transmission is sometimes hampered. The packaging test should indicate whether or not there is an impact on data transmission when using a common type of industrial packaging. The test did not take into account local fluctuations in the quality of the mobile network itself.

With a combination of factors however, such as during build-up of air freight pallets, container transport or storage in a cooling room, extra environmental circumstances may exert a greater constraint on the data transmission signal. Because of the large number of possible combinations, these were not included in the scope.

Use in air freight

The use of GPRS devices had to be put into practice during 'live' tests with air freight shipments. For time and temperature sensitive shipments, on the one hand the time aspect had to be taken into account, and on the other hand the registration of temperature and conditions. Air freight shipments accompanied by a GPRS device were tested on several lanes and the results were subsequently analysed. For temperature-controlled shipments, the focus lay on passive packaging at a temperature of +2 to +8 °C.

During the project, in order to chart visibility on the apron, an additional test was carried out at Brussels Airport during an airside transportation operation.

“Aviation regulations serve primarily to guarantee passenger safety”

Brussels Airport Company

Research

In the context of the project it was important to consult the applicable regulation for GPRS usage in air freight in the first place, for it could hold up progress of the practical tests. Additionally, all available devices and systems were scrutinised in order to make an accurate comparison between various technologies and suppliers.

During the research, various tests were carried out to assess the quality and applicability compared to the market’s needs.

Regulations

Aviation regulations serve primarily to guarantee passenger safety. Products or services of which usage information is limited are not authorised to be used in-flight. Every day, passengers take mobile phones and laptops on board an aircraft. Before take-off, the devices should be switched off, not only to avoid radio wave interference with critical aircraft equipment, but also to avoid passenger distraction during critical stages of the flight. The possibility of manually switching off the devices authorises their use on board.

In the course of the project, various sources were consulted to get a clear view on the regulations. The following four points provide a brief overview.

PED and interference

In modern aircraft, critical equipment is shielded from interference to such a degree that issues rarely occur, otherwise mobile phones would be banned. Due to the tremendous evolution of wireless communication products such as mobile phones, Wi-Fi, Bluetooth, Zigbee, etc., the aviation sector experienced difficulties in estimating the influence of all these devices on aircraft equipment.

Products or services of which usage information is limited are not authorised to be used in-flight.

No clear regulation exists on the use of electronic transmitting equipment, making this a source of ambiguity for GPRS devices in air freight.

In the case of portable electronic devices (PEDs), specific types and models need to be found suitable for a specific type and model of aircraft. Only an airline can make a statement on the impact of a specific type of electronic device used on their fleet.

Passengers carrying a PED are requested to switch off their devices before take-off and landing. In the cargo hold, manual manipulation of the devices is not possible, thus requiring that the data transmission function be switched off automatically at least before take-off and landing, and in most cases during the entire flight.

Fixed aircraft component

In aviation, components and devices connected to the aircraft frame are differentiated from components and devices travelling along with cargo or passengers. Elements connected to the aircraft frame, for instance a smoke

detector in a cargo hold, need to have passed a comprehensive test procedure before being added to the aircraft. PEDs and track & trace devices accompanying cargo or travelling along with a passenger, are not considered components of the aircraft. Regulating bodies within the aviation industry, EASA (European Aerospace Safety Agency) and FAA (Federal Aviation Authority), issue rules related directly to aviation, specifically for elements connected to the aircraft frame. Since PEDs are not considered components of an aircraft frame, directives for these devices have been enacted by EASA.

Directives for non-fixed components

For both EASA and FAA, cargo handling falls under the responsibility of the airline. The same applies to PEDs. Recently, regulation EU No 965/2012 was issued for commercial flights in which the usage of PEDs is clarified.

As a complement to this, EASA enacted directives describing in detail the operator's responsibility concerning PEDs (cfr. "EASA Acceptable Means of Compliance and Guidance Material to PART-CAT"). These directives state that the usage of PEDs is and remains the responsibility of the airline, which must grant authorisation for each type of PED.

FAA has provided some PED suppliers with a 'No Technical Objection' (NTO) status indicating that there is no objection against the usage of PEDs. An NTO does not negate the fact that the airline remains responsible.

Initiatives

Due to increased PED usage and on forwarders' request, various initiatives have been taken to provide more clarity in the use of PEDs by passengers and in cargo.

- FAA PED ARC – Advisory and Rulemaking Committee. A report from this committee is expected by the end of July 2013.
- IATA Time and temperature monitoring devices. A workgroup writing a recommendation about the usage of PEDs.

Technical framework

Technology selection

Given the stated requirements and market demand, the decision within the project was to work exclusively with devices based on GPRS data transmission.

Figure 7 briefly compares commonly used devices for the monitoring of the temperature-controlled supply chain. The table shows that GPRS devices are the only devices not requiring local infrastructure to transmit real-time information.

- **Data logger:** Common product in cooling rooms, for example in a truck.
- **USB logger:** For the moment, the most frequently used product for temperature registration.
- **RFID logger:** Automatic identification of shipments and temperature logging, though market penetration is till limited.

As of 2013, there are four suppliers (three American and one European) of GPRS-based monitoring devices with authorisation for usage by some airlines. The two most popular are 'Onasset Sentry 400 Flightsafe' and 'Moog-Crossbow ILC2000'. In terms of functionality, most of these devices are similar, have an automatic switch-off mechanism and can be used for the monitoring of air freight.

Onasset Sentry Flightsafe

Moog-Crossbow ILC2000

Vilant Tracker

Overview of authorised GPRS-monitoring devices

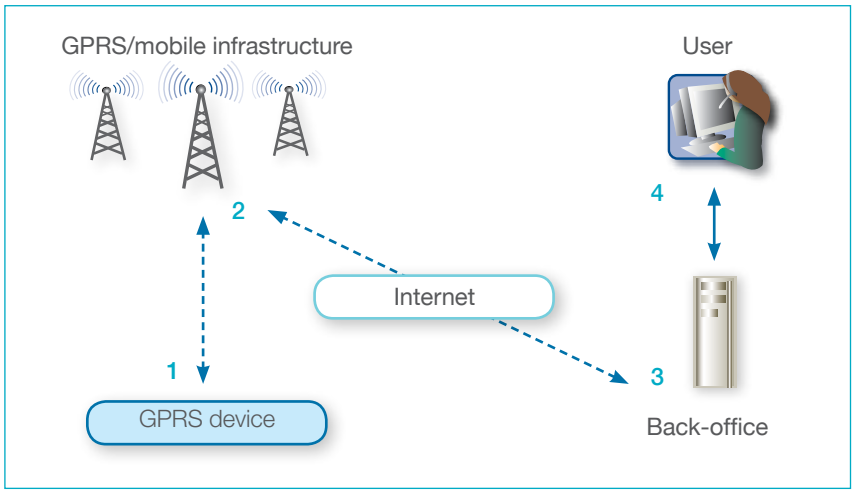
Figure 7 – Comparison of logger systems

	Data logger	USB logger	RFID logger	GPRS logger
Temperature measurement	x	x	x	x
Localisation			(x)	x
Registration	x	x	(x)	(x)
Display	x	(x)	(x)	(x)
Alarm on display		(x)		(x)
Performance				
Flexibility *	(x)	(x)	(x)	x
No infrastructure*				x
Data integration*			x	x
Real-time			(x)	x

Source: VIL

Legend: x available for all devices, (x) not available for all devices
*Flexibility – parameters adjustable in the device
*No infrastructure – Does not concern local infrastructure for measurements and read-outs
*Data integration – Automatic, non-manual integration in a software system

Figure 8 – GPRS/mobile communication pad



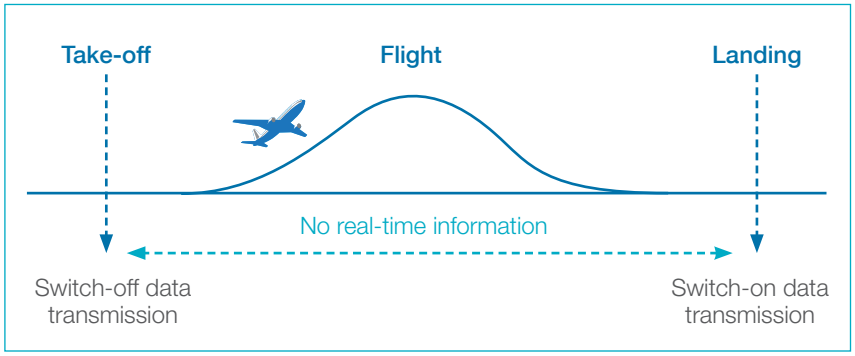
Source: VIL

Figure 9 – Basic properties of GPRS monitoring devices

Property	Requirement
Data transmission	GSM quad-band cellular network
Localisation	GPS and/or cell-ID
Sensor measurement	Temperature, Light
Battery capacity	At least 4 days
Authorisation for air freight	Airline, FAA, EASA
Dimension/weight	< 20 cm, < 500 gram
Software system	Presentation • Sensor data • Location data • Configuration and alarms

Source: VIL

Figure 10 – Switch-off mechanism



Source: VIL

GPRS data transmission

GPRS data transmission is in fact an extension of the existing mobile network, enabling efficient wireless data transfer via internet to the end user. GPRS is one of the available standards for data transmission through the mobile network. Every modern mobile phone has GPRS, EDGE or 3G, indicating the speed at which data can be transmitted.

The only requirement for data transmission through GPRS is a SIM card, provided by a telecom supplier. The telecom suppliers in turn have agreements to guarantee global, international communication.

The cost of this communication is to a high degree dependent on the quantity of data being transmitted, which for monitoring devices is limited.

Data transmission through the mobile network offers independence from local infrastructures, making it an interesting communication medium for random monitoring of shipments.

System requirements

There are several requirements that can affect the selection of a supplier. Depending on the total transit time of the air freight supply chain, the type of product and monitoring terms, various requirements can be imposed on a system. The following have been put forward in this project:

Switch-off mechanism

The authorisation of devices for use in air freight is to a certain extent linked to the possibility of switching off the data transmission function before the flight. The working principle is patented* and runs for most devices on three sensors: a radio signal present at the airport, acceleration and difference in air pressure. An algorithm triggers the ruling based on

* Onasset Intelligence patent US 7791455 B1

these three measurements, switching the system on or off and blocking data transmission during the flight. As a result, the device ensures that flight systems are not disturbed by interference. This principle is used for both take-off and landing.

An important aspect is the fact that the communication is switched off a couple of minutes before take-off and only switched on again a couple of minutes after landing, thus limiting access to real-time data for a period of time. The sensor registration however keeps running continuously.

Temperature controlled shipment with GPRS/GPS-device on parking lot

Localisation

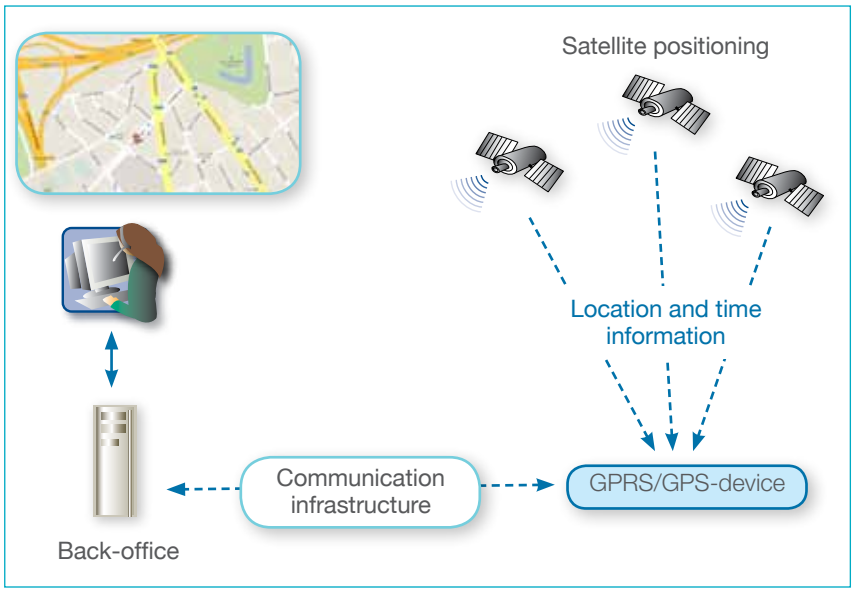
Localisation conveys the geographical position of an object at a specific moment. This can be done in several ways, the most familiar being via satellite, also known as Global Positioning System (GPS). In addition to satellites, a position can also be determined within a mobile infrastructure, which happens by means of Cell-ID or triangulation. Another indirect method links process information with relevant geographical data.

Global Positioning System

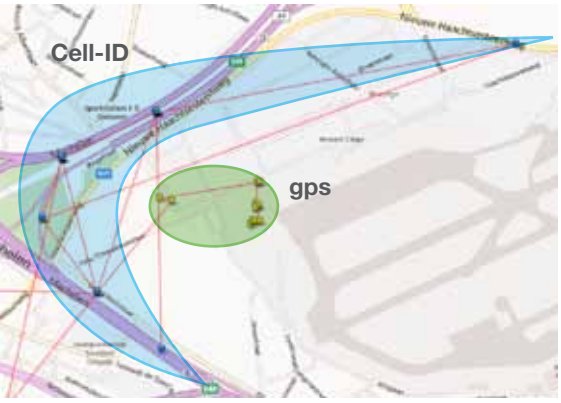
The measuring principle of GPS is based on the distance between satellite and receiver and knowing the exact location of the satellite. The distance between satellite and receiver is deducted from the transit time of radio waves.

In ideal circumstances, GPS can be accurate to within less than 10 metres. This precision depends on the operational circumstances in which the signal is measured. GPS functions at its best outdoors and will be less accurate or not functional indoors.

Figure 11 – GPS infrastructure



Source: VIL



GPS versus Cell-ID accuracy

Cell-ID and triangulation
In most cases, GSM/GPRS devices transmit data via the nearest mast of the telecom infrastructure. Cell-ID is a technique that uses the geographical coordinates of a mast to determine a position.

A GSM/GPRS message contains routing information about the usage of telecom infrastructure and about the mast via which the data was transmitted. Accordingly, the geographical location of a transmitted message can be determined within the telecom infrastructure. Although it lacks accuracy, this mode of localisation is nevertheless solid enough to determine a position in a specific region at any time.

A derived version of the Cell-ID technique is triangulation based on various Cell-IDs. Through calculation of information received from at least three masts, a more accurate location can be determined. This method is more

Figure 12 – Comparison of localisation techniques

Technique	Advantages	Disadvantages
Satellite (GPS)	Highly accurate	Dependent on location Need for GPS module
Cell-ID	No GPS module required (cost-effective)	Limited accuracy Dependent on telecom supplier
Triangulation	No GPS module required (cost-effective)	Dependent on telecom supplier
Process-based	Highly accurate	High degree of integration required

Source: VIL

Figure 13 – Most commonly used sensors

Sensor	Application	Requirement in air freight
Temperature	Temperature excursions	Temperature sensitive shipments
Light	Monitoring opening of shipment	Safety monitoring of shipment
Motion	Tuning of data transmission to motion of shipment	Switch-off mechanism for data transmission
Air pressure	Air pressure measurement of air freight	Switch-off mechanism for data transmission

Source: VIL

accurate than Cell-ID, although highly dependent on information received from telecom suppliers.

Process-based localisation

Each defined process in the supply chain is linked to a specific location. According to GS1, location is defined through a specific Global Location Number (GLN), a unique number linking a location to a geographical coordinate. The registration of a process can be linked to a geographical GLN – a coordinate indicating the location of an object, for instance a warehouse.

Sensor measuring values

Sensors are designed to convert information about ambient conditions into digital information, which is especially important for temperature sensitive shipments, requiring temperature registration throughout the supply chain.

Common monitoring sensors include temperature, light, acceleration/shock/motion, humidity, pressure and air pressure. Sensor selection depends on what needs to be monitored. For this project, temperature, light, motion and air pressure sensors were used.

System configuration

GPRS-recorded data should be supported by software solutions that process, record and visualise the information. Additionally, the software also needs to guarantee configuration and control of the GPRS devices.

A detailed explanation of all requirements falls beyond the scope of this project. However, in order to give a clear framework, some aspects are briefly described below.

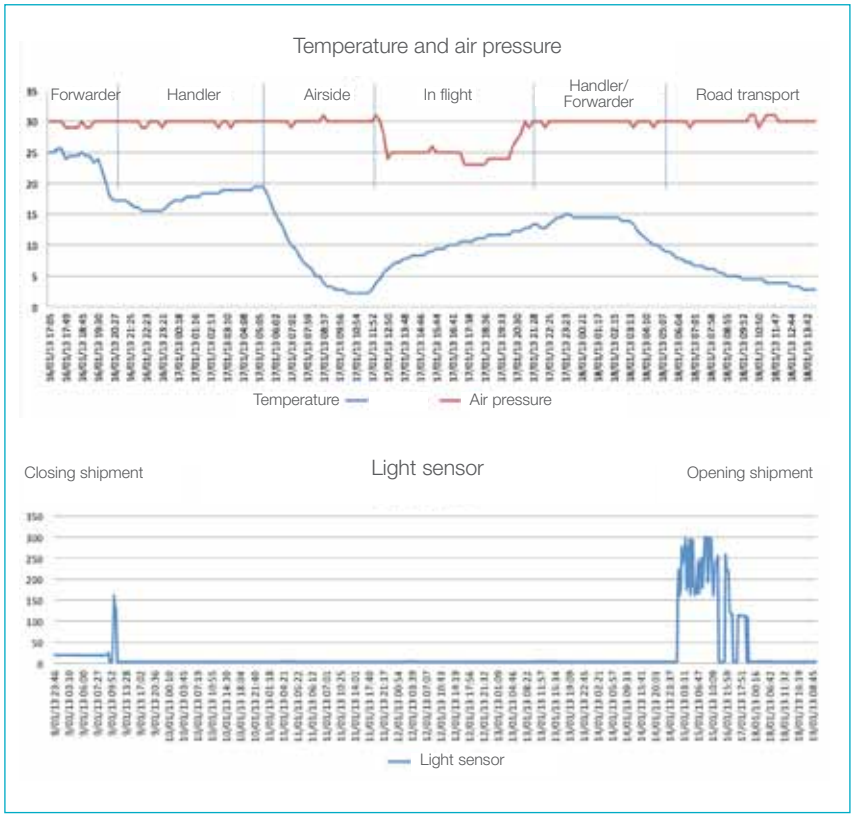
Presentation of information

Presentation or visualisation of information should enable the user to quickly assess the status of the shipment. For instance, a temperature chart provides information about the temperature over a specific time span. A temperature excursion should visualise the temperature limits and how long they are exceeded.

A good presentation of real-time monitoring information contains at least the following aspects:

- **Geographical data**, represented on a map;
- **Timeline**, presented in a graph or table for a specific period;
- **Event interaction**, enabling quick access to important data, such as temperature excursions and locations.

Figure 14 – Display of temperature and light



Bron: VIL

Configuration and interface
GPRS systems require the following important aspects for configuration and control:

- **Data transmission interval**

The data transmission interval is the duration between each data transmission from the GPRS device to the software. The shorter the time span, the shorter the battery life. The longer the time span, the longer it takes to receive an update about the shipment.

- **Rules and alerts**

The system's software links GPRS information processing to rules, enabling configuration of values triggering alerts.

- A rule is an equation based on a quality or business requirement. For example, if the temperature surpasses 20°C, an event needs to be triggered.
- An action or alert indicates how to respond to an event. For example: send an e-mail every 15 minutes to person X and Y at every temperature event.
- A list of contacts provides all relevant contact information.

- **Location and geofences**

A geofence is a digital boundary, which can be used in the software to mark out zones. An alert can be configured for entry or exit of a geofence.

- **Shipment configuration**

Submitting information concerning the shipment does not contribute to the functionality of a tracking system, but it does provide a framework and simplifies data processing. Shipment details may include the parties concerned, flight number, mode of transport, contact information of logistical service providers, etc.

Exchange of information
Supply chain transparency is based on a smooth exchange of information between stakeholders. Typically, users get access to an online platform where information can be consulted. Additionally, there is a possibility to communicate through e-mail and text message.

Further integration with corporate applications usually involves machine-to-machine data transmission, whereby information is directly extracted from the track & trace database of the GPRS manufacturer.

Operational results

Measurement results

During the project tests were carried out to verify the quality of measuring, packaging constraints and accuracy of localisation.

Quality of measuring values

- **Temperature**

A maximum deviation was detected of 1.7°C for non-calibrated devices. Most values deviated from +1°C to -1°C. The suppliers can calibrate the devices if the measurement quality does not meet the monitoring standards. Calibrated devices guarantee a precision of <0.5°C. This accuracy is a highly

important requirement. In a vast area or space, temperature measurements will be more prone to fluctuations than measurements in a sealed package of a shipment. For measurement of ambient factors however, a calibrated device is not always required.

- **Measurement speed**

Thermal inertia is the responsiveness of a material to temperature fluctuations. Considerable inertia was detected with the GPRS devices. When extreme fluctuations occur, it is advisable to use an external temperature probe.

- **Localisation**

Taking into account operational aspects as limiting factors, a deviation of 150 metres was established for localisation. This accuracy was attained with GPS localisation but not with Cell-ID.

Brussels Airport's handling agents were subjected to tests to determine which operational activities could guarantee localisation to within 150 metres.

Overall, GPS localisation is only feasible when a shipment is placed:

- outdoors, or in an area having an open outdoor connection, such as a shed;
- in an area having a thin-panelled roof with windows.

In other areas such as cooling rooms, roller beds, and concrete and steel constructions, localisation was only possible with Cell-ID, although with a deviation of more than 500 metres.

Packaging as a limiting factor

Tested from a cooling room, a signal could be transmitted from all packages, proving that packaging is not a limiting factor for data transmission. However, operational circumstances such as the cooling room and areas with steel construction combined with the packages, can affect data transmission.

The table below (figure 15) provides qualitative measuring values of the various types of packaging. These are:

- Very good, from -50 to -60 dBm
- Good, from -60 to -85 dBm
- Average, from -85 to -90 dBm
- Bad, less than -90 dBm

Overview of tested types of packaging

Envirotainer

Softbox – Pallet Shipper

Sofrigam box

4-layered Temax blanket

Figure 15 – Data transmission test from packages

Packaging	Quality of the signal
No packaging	Very good
Envirotainer	Good
Sofrigam	Good to average
Softbox	Good
Temax	Average to bad

Source: VIL

GPRS tracking, tracing and monitoring of air freight

To illustrate the use of GPRS in air freight, screenshots of road transport, the airport cargo zone, the supply chain, and some graphs have been included in this report, showing the practical options for tracking, tracing and monitoring.

During the project test lanes were carried out from Brussels Airport to Washington - Dulles International Airport and Atlanta International Airport. Only flights to America were used, since no authorisation was granted for usage on European and Asian airlines.

Road transport

The maps show the monitoring of road transport from Antwerp to BRUcargo and from Atlanta to Charlotte (US). The details are dependent on the time of reporting and the duration of the road transport. The Antwerp – BRUcargo itinerary takes about 30 minutes. With a report every 15 minutes, only one position is indicated on this route. The Atlanta – Charlotte (US) itinerary takes approximately 3 hours. For this route multiple positions are indicated on the map.

Antwerp – Brussels 30 minutes

Atlanta – Charlotte 3 hours

Source: Onasset Intelligence – Vision platform

Airport cargo zone

Registrations show the monitoring at Brussels Airport's cargo zone, BRUcargo. As a partial result of a test lane, a shipment could clearly be localised using GPS. The shipment left the forwarding agent (DHL Global Forwarding), and was located with intermediate stops at handling agents Swissport and Aviapartner before being offloaded at WFS. The shipment was then positioned for airside pick-up and subsequently moved to planeside for loading.

Source: Onasset Intelligence – Vision platform

Apron zone Brussels Airport

The registrations represent the monitoring of the apron at Brussels Airport. The test was carried out by tracking a GPRS-equipped towing tractor on the apron. The tractor and thus the shipment could accurately be monitored.

Source: Onasset Intelligence – Vision platform

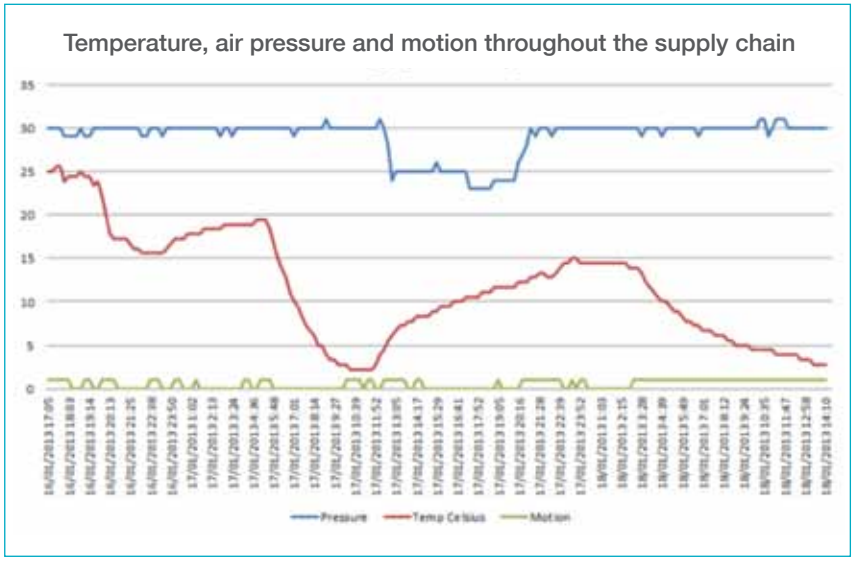
Integral air freight supply chain

The map represents the monitoring of an integral air freight supply chain. During the flight no coordinates were recorded.

Source: Onasset Intelligence – Vision platform

Monitoring

The graph represents the sensor values for temperature (red), air pressure (blue) and motion (green). During the flight reduced air pressure was observed. Although there was no data transmission, sensor values were continuously registered. The sensor monitoring function was not switched off during the flight, charting data throughout the entire supply chain.



Source: VIL

> “In order to determine the applicability of monitoring to air freight, blind spots need to be identified”

Blind spots – data transmission
Time and temperature sensitive goods require continuous monitoring, preferably real-time. In order to determine the applicability of monitoring for air freight, blind spots need to be identified. A blind spot is a period for which no real-time information is available. During that time, the information is saved for transmission later on.

Data transmission is a requirement for the transfer of real-time information. This is not possible under certain circumstances, for example due to network interference or road transport while in a tunnel. Transport through air requires data transmission to be switched off during the flight.

For use in air freight, the GPRS data transmission function needs to be switched off before take-off and switched on after landing. During the project the following times were registered:

- Switched off 5 to 15 minutes before take-off
- Switched on 20 to 45 minutes after landing

Gaps – information
Blind spots do not necessarily imply gaps in the information received. Gaps involve periods for which no data is available. During a blind spot, data cannot be transmitted in real-time but are saved and transmitted at a later stage when the connection is restored. An information gap refers to a period for which no information is available, neither in real-time nor after a blind spot.

Sensor data are continuously registered (at intervals) and can be retrieved after a blind spot. During a blind spot, localisation is only possible through satellite positioning. During flight location registration is completely switched off out of safety precautions. As a result, localisation can under certain circumstances contain gaps.

Figure 16 maps the blind spots and gaps in an air freight supply chain, reflecting the principle of blind spots in relation to stakeholders.

Air freight process
During the project, partners were asked to make an assessment of the critical points in the airport’s cargo zone. Through process analysis, those critical points were mapped to determine which GPRS devices are adequate for monitoring, taking into account the type of monitoring and additional tools such as bar code or process control systems in order to make the supply chain entirely ‘waterproof’.

Shippers’ goods are either stored temporarily at a forwarder, who provides all the necessary facilities, or delivered directly to a handling agent. The process analysis mainly focused on the handling agent’s processes.

Figure 17 shows the different stakeholders in the air freight supply chain. The green section indicates the scope of this project.

Aviapartner, Pharmahub

Figure 16 – Real-time information and blind spots

	Shipper	Forwarder	Handler	Airline	Consignee
Location	Real-time	Real-time	Real-time	N/A	Real-time
Sensor	Real-time	Real-time	Real-time	Post flight	Real-time

Source: VIL

Figure 17 – Air freight process and stakeholders

Source: VIL

Handling processes

Within the handling agents' processes, which are performed both landside and airside, critical points have been identified. Airside activities are only authorised for persons and companies screened and accepted by the Belgian Civil Aviation Authorities (BCAA). Additionally, the airport grants a licence for airside business activities. At Brussels Airport, Aviapartner and Swissport operate both landside and airside, whereas WFS only operates landside.

Since WFS has no licence to run activities airside, the goods need to be passed on to either Aviapartner or Swissport for aircraft loading.

Figure 18 illustrates the activities for both landside and airside. Each of these activities has been further examined, mainly for temperature sensitive freight. Condition control systems provide information about ambient factors whereas process control systems supply monitoring information of processes. The combination of both systems is crucial in order to provide correct information about the shipment's status.

Shipments need to be stored and handled according to the information on the airway bill. Failing to do so could result in loss of quality, which should be prevented by taking the right actions at the right time.

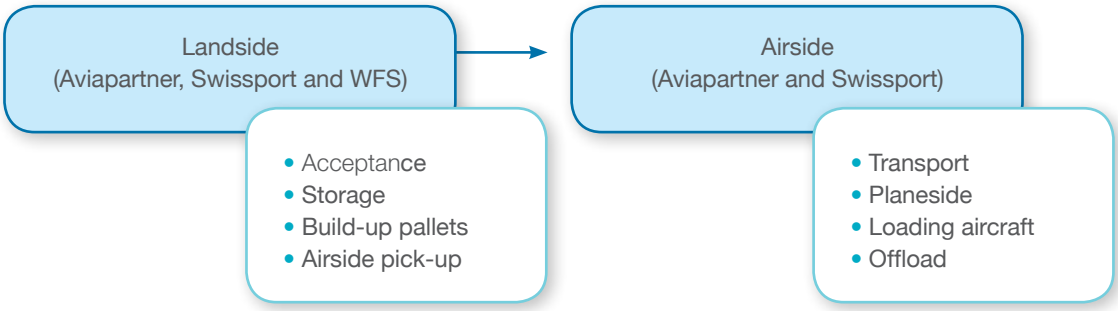
Figure 19 outlines all stages in the airside and landside processes and indicates where information about ambient conditions is required. Some processes take place under controlled circumstances such as during storage and build-up, others are exposed to external conditions such as during airside pick-up and while planeside. For each of these stages a manageable monitoring solution needs to be found.

Figure 20 clarifies the different handling stages. The table essentially establishes that if shipments are stored under incorrect conditions, both timing and ambient factors need to be registered.

Detailed monitoring

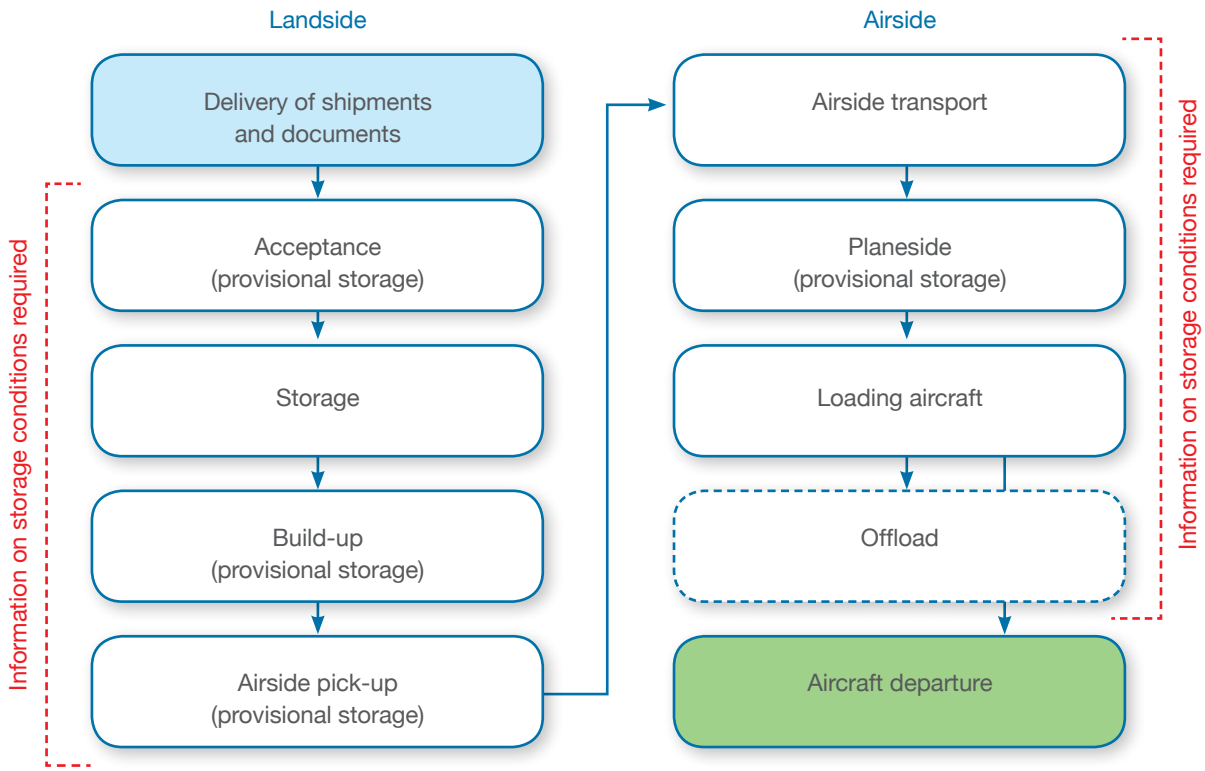
For monitoring at the process level, for example for a shipment that has just been taken from the cooling room, information about the various process stages has to be available. In order to assess GPRS usage for process monitoring, it is necessary to verify whether a GPRS system can deliver data that could be relevant to a process. GPRS monitoring offers the supply chain information about location status and temperature conditions of shipments. For process monitoring and process integration, information transmitted from GPRS monitoring systems should be considered as an added value and not as a replacement for existing process systems such as bar code and others.

Figure 18 – Landside and airside handling process



Source: VIL

Figure 19 – Block diagram of handling processes



Source: VIL

Figure 20 – Description of handling processes

Activity	Nature of critical point
Acceptance	**Process:** Shipments are delivered to the handler, where the goods are physically and administratively checked before being stored at the right location. **Critical point:** Limited capacity of the acceptance zone.
Storage	**Process:** Shipments are stored according to booking and airway bill information. **Critical point:** Manual storage and verification of actual storage.
Pallet build-up	**Process:** Build-up of pallets is done in a dedicated area and is time-consuming. **Critical point:** Pallet build-up is not always performed in a cooling room and is not registered.
Airside pick-up	**Process:** After build-up, shipments are positioned for transport to the apron. Depending on the available space, shipments are placed indoors or outdoors. **Critical point:** Conditions of time sensitive shipments should be monitored.
Airside transport	**Process:** Shipments are transported on airside to the aircraft. **Critical point:** Possibility of lengthy exposure to external conditions, depending on the duration of transport.
Planeside	**Process:** Shipments are placed next to the aircraft before loading. **Critical point:** Exposure to external conditions.
Offload	**Process:** Exceptionally, at the very last minute, shipments are refused on board an aircraft. The shipments are placed on the apron and must be collected by the handler. **Critical point:** Exposure to external conditions.

Source: VIL

Brussels Airport Company

‘effectiveness of control’ x ‘chance of occurrence’ x ‘impact on shipment / product’ = risk

Risk analysis

A risk analysis is to a certain extent an addition to the process analysis. The main difference is that process analysis provides an indication of critical points whereas risk analysis clarifies the importance of each individual point.

A risk analysis was carried out from shipment acceptance by the handler to shipment departure by aircraft. The risk analysis specifically focused on temperature sensitive shipments in passive packages of +2 to +8°C and +15 to +25°C.

The risk analysis used a standard methodology, quantifying a risk based on following equation:
‘effectiveness of control’ x ‘chance of occurrence’ x ‘impact on shipment / product’ = risk

Eleven critical points were defined for which a risk score was assigned using both the current AS IS situation and the situation where GPRS is used. However, risk scores assigned through GPRS were rather based on a theoretical approach given that not all risks could be assigned with a value during the test lanes.

Figure 21 lists the most relevant ones. The column ‘High risk’ indicates the critical points in a temperature sensitive supply chain. The last column indicates the situations where GPRS is most useful. These were determined by identifying the outcome of real-time monitoring on each of the critical points regarding risk reduction.

As shown in the table, an incorrect booking entails the highest risk for a shipment on landside. This increased risk can be attributed to the fact that during shipping the booking is not verified. The ensuing impact of a wrong booking is especially unfavourable for the shipment.

On airside, shipments are exposed to external conditions, which, in case of extreme weather conditions such as freezing temperatures, can have a negative impact on the shipments. For this reason airside activities are perceived as being high-risk.

In the column 'GPRS useful', added value is shown for monitoring of shipments on landside, specifically in the warehouse. For example, for a shipment that has been stored incorrectly in the warehouse, the handler can easily be informed through GPRS and take action for appropriate storage of the shipment.

On airside, the usage of GPRS especially helps to improve control and reduce impact on the shipments. The analysis shows the device's effectiveness when shipments are positioned or picked up at planeside. During airside transport however, GPRS alerts are less effective. Due to operational and practical reasons, bringing shipments under controlled storage conditions seems to be more difficult.

Customs

Shippers and forwarders ship goods on a daily basis and use loggers for data registration during transport. These loggers are usually 'one-way' loggers valued at less than 22 Euro, which are exempted from custom clearance.

If a shipment's total intrinsic value does not exceed the 22-Euro mark, a complete exemption of VAT and import rights is granted.*

In order to simplify the use of data loggers for temporary import and export, a system was set up in cooperation with Belgian customs. A company can register a pool of logger devices to which unique numbers are attributed. These numbers will appear on a list at customs that the company can refer to during import or export. As a result, no import rights nor VAT have to be paid.

Every company can use this system for simplifying shipments with reusable data loggers, such as GPRS devices.

Figure 21 – High-level conclusion risk mapping

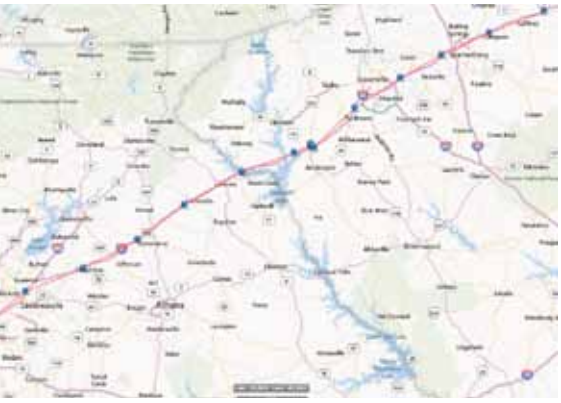
Activity	Risk	High Risk	GPRS useful
Trucking	1. Shipment not delivered at correct temperature		
Handler landside	**Risks due to:**		
	2. Incorrect label		Yes
	3. Incorrect booking	Yes	Yes
	4. Human error, incorrect storage		Yes
	5. Pallet build-up		
Handler airside	**Risks due to:**		
	6. Location airside pick-up	Yes	Yes
	7. Apron transport	Yes	
	8. Planeside positioning	Yes	Yes
	9. Offload	Yes	Yes

Source: VIL

* Source: Belgian Customs - Administration of Customs and Duties

Lessons Learned

Road transport GPS



Road transport Cell-ID

GPS time sensitive shipment

Cell-ID time sensitive shipment

Source: Onasset Intelligence – Vision platform

Location accuracy

To what extent is accuracy of localisation important?

As mentioned before, GPS conveys more accurate location information than Cell-ID does. Most GPRS devices offer both localisation methods, although for cost reduction purposes devices operating solely on Cell-ID or triangulation are also being developed. Choosing one method over the other mainly depends on the situation and the monitoring objective. It is therefore important to determine the situation in which information accuracy is expected:

- Monitoring of long-distance road transport
- Arrival time of shipment at the right airport
- Monitoring of time sensitive shipments

The screenshots on this page illustrate the above-mentioned scenarios.

Operations or quality

What are the registration objectives?

A distinction has to be made between service quality and product quality. For temperature controlled shipments, insulated packaging is used to guarantee temperature stability of the content. External conditions such as outside temperatures affect the condition of the internal packaging. Exposure to excessive heat or cold will gradually change the temperature within the packaging. In this context, which measurement is more relevant? The internal or external temperature? Is information about product stability the GPRS monitoring objective, or is it information about when ambient factors become critical?

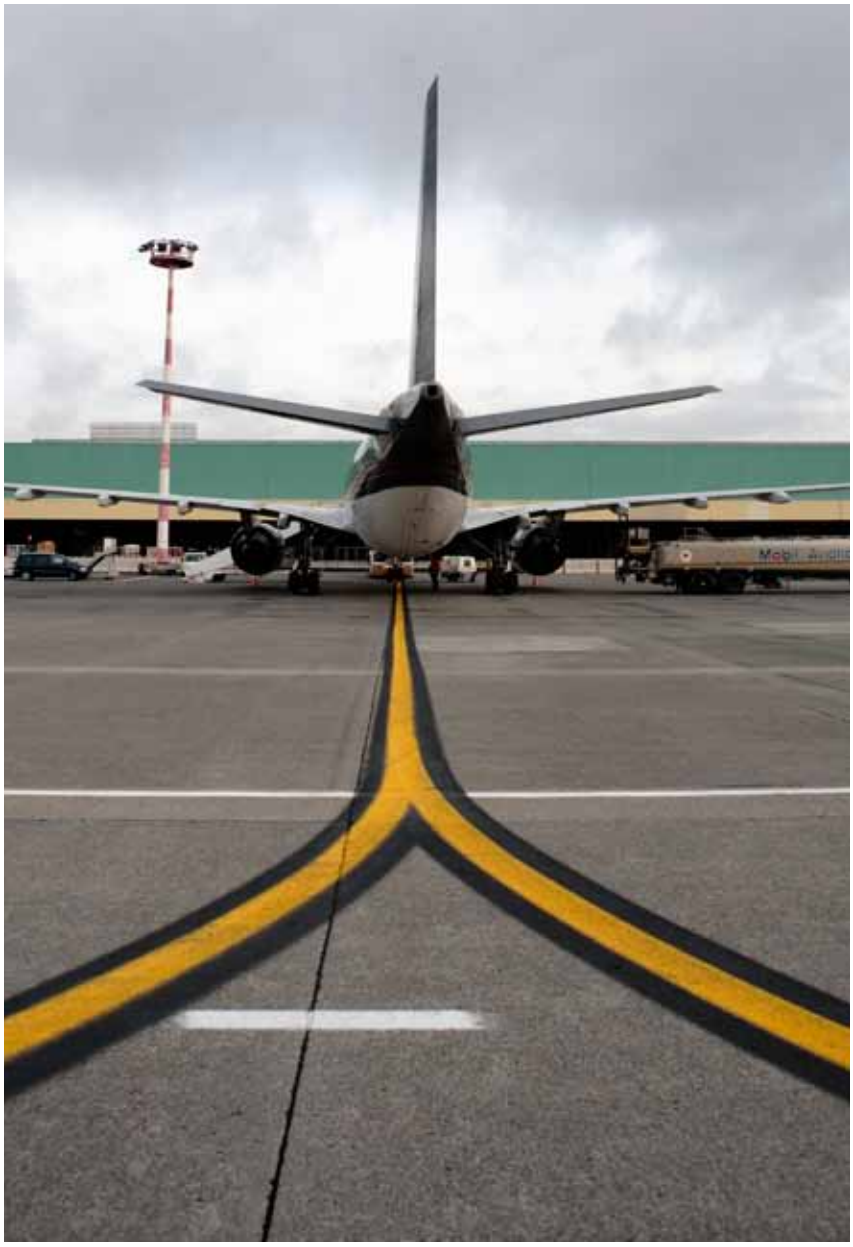
Important to mention is that with a GPRS device both the internal and external temperature can be measured, albeit with a second sensor connected via a cable-connected probe. By introducing GPRS monitoring, each stakeholder can be informed preventively about inconsistencies. Transmitted data for example, can reveal under which ambient conditions a shipment has been stored. The monitoring system thus enables users to take action to guarantee appropriate storage of the shipment if necessary.

A GPRS device can be used as a preventive tool complementary to a USB logger. The registered data of the USB logger can be used when inconsistencies have occurred.

Supply chain cooperation

How can cooperation in the supply chain be improved?

Cooperation in the supply chain is all about communication and agreements. Both are interconnected. Agreements between stakeholders are outlined in Service Level Agreements (SLAs) and Standard Operating Procedures



(SOPs). Ideally, these agreements should be conform to procedures in order to sustain the global supply chain. In air freight, such conformity is regulated and warranted by publications such as IATA's Airport Handling Manual, Perishable Cargo Regulations, Dangerous Goods Regulations, Live Animals, etc.

In addition to the agreements, it is crucial to maintain efficient communication with the stakeholders using the right tools. Communication between stakeholders evolves from mutual commercial agreements. The shipper has an agreement with the forwarder, the forwarder with the airline. As a result, the forwarder communicates with the airline about the status of a shipment, and not directly with the handler.

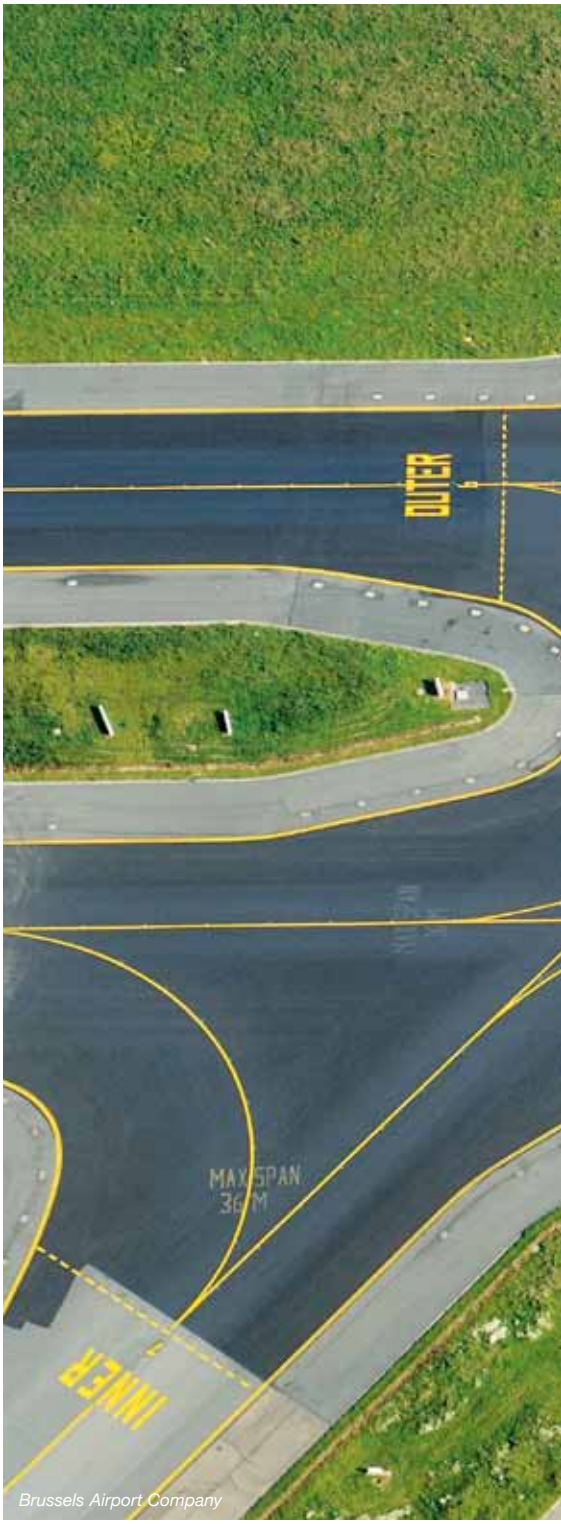
With GPRS monitoring, communication is independent from infrastructure, providing all parties concerned with automatic updates of shipments, such as temperature deviations. An indirect communication channel thus arises between for instance a forwarder and a handler. The handler can directly take all necessary actions without having to communicate with the forwarder.

Booking procedures

What needs to be considered before using a GPRS device in a shipment?

Booking procedures refer to specific requirements for both air freight bookings and for GPRS usage in a shipment.

- **Booking procedures** are specific to each airline. Owing to the rather novel nature of the device, the booking procedure still lacks some clarity. A special handling code needs to be indicated and on the airway bill, a unique serial number of the GPRS device needs to be mentioned. The booking procedures can differ depending on the airline and GPRS device.
- **Lithium Ion Battery Sticker (LIB).** Depending on the battery capacity of the device and the number of cells, the shipment needs to have an indication that it contains lithium. The requirements can be found in the IATA guideline 'Packaging Instructions for Dangerous Goods', PI967*, for lithium-ion batteries.
- **FCC form 740** is a document required for the import of goods to the US to indicate that the goods conform with the Federal Communications Commission (FCC) requirements. The equivalent for Europe is the CE label. A device having an FCC identification code has no problems entering the US. The document only needs to be included in the shipment the first time.



Brussels Airport Company

Complementary to identification and monitoring technology

Is GPRS monitoring sufficient for integral process monitoring?

GPRS monitoring should not be considered a technology that could replace other track & trace systems. GPRS is not suitable for detailed process monitoring.

Figure 22 provides recommendations for the application of specific technologies.

- **Data loggers and RF loggers** register storage conditions at product level (e.g. USB loggers) or conduct continuous logging activities (e.g. in a cooling room). There are also RF loggers / RFID (e.g. BAP tags) providing registration of goods as well as identification of goods. A separate category for this kind of technology has been added.
- **Bar code and RFID** are technologies used for the identification of shipments in relation to a process. Both technologies give information about a shipment's location within a process.
- **GPRS loggers** are complementary to the above-mentioned technologies. Shipments are registered and information about the process flow is conveyed, which is indirectly linked to the detail oriented processes.

Operational usage

Which elements need to be considered in practice?

The following elements are important for the use of the GPRS hardware and software system:

- **Visual indication.** Estimating the shipment's status enables the user to take action if necessary. A visual

Figure 22 – Application of identification and monitoring technology

Hardware technology	Application
Data logger (manual read-out) RF loggers (Wi-Fi, Zigbee, …)	• Registration of ambient conditions at product level • Registration of storage conditions
Bar code label RFID tag	• Identification of shipments • Low-level indication of progress in the processes
GPRS loggers	• Registration of conditions at product and / or shipment level • High-level indication of process flow

Source: VIL

* IATA Dangerous goods, packing instructions

indication on the GPRS device about temperature, battery power, etc. is an extra tool for rapid problem-solving at location.

- **Recharge.** Battery powered systems need to be regularly charged. For this reason, a battery charger needs to be available at locations where a recharge is required. The use of a charger with a universal plug is preferred over a plug requiring a specific connector. In case the GPRS device should be further used, a charger would have to be sent to the next destination.
- **Thermal inertia.** Thermal inertia is the responsiveness of a material to temperature fluctuations. Through the charging process, thermal heat is released, affecting the ongoing temperature measurement. In order to avoid this, recharge of the device needs to be completed at least one hour before usage.
- **Shape factor.** The smaller and lighter the device, the easier it is to integrate it in the shipment. One of the tested devices was 0,8 cm thick and was as big as a credit card, fitting perfectly in the shipment.
- **Pool management.** A GPRS device can be monitored as long as it is activated. In order to respond to a situation with a dead battery, it is important to have an organised management system for GPRS devices.

Value Proposition

In order to assess a type of technology, it is important to determine the following three aspects within an objective:

- **Technical feasibility**
  Is the preconceived objective technically feasible? Does the market provide products that can respond to the specific requirements of the business case?
- **Economic feasibility**
  Does the technology provide affordable solutions?
- **Added value**
  What added value does the solution provide? What are the gains and costs?

The assessment of the above-mentioned aspects is specific for each business case and can thus only be explained generically for this report.

Technical feasibility

The market offers GPRS monitoring devices authorised for use in the aviation sector which can be employed for:

- **Temperature registration** at product and shipment level throughout the entire supply chain;
- **Localisation** throughout all activities in the supply chain, where accuracy depends on operational constraints (e.g. cooling room, packaging, etc.);
- **Time indication** for monitoring throughout the processes at location level;
- **Communication** within the supply chain.

GPRS monitoring is not, or is to a lesser degree, suitable as:

- an internal process monitoring tool, providing information about the different process stages;
- a global monitoring tool, since there is still a limited number of airlines worldwide that have given authorisation;
- a tool for temperature registration to be used for product stability data. Thermal inertia slows down the measurement. A probe is thus recommended.

Economic feasibility

The TCO (total cost of ownership) of GPRS was included in order to make an estimation of the economic advantages of the project. Two business models were developed to evaluate the adoption of GPRS monitoring. The first via the purchase of hardware, the second via a Product as a Service (PaaS).

PaaS involves a monthly cost which includes use of hardware, communication and web application. Although the recurrent cost is high, there is more freedom and flexibility with the adoption of GPRS devices. If the company chooses to purchase the devices, the following costs apply:

- **Purchase of hardware**
  Depending on the purchase quantity, the purchase of the hardware involves a one-time investment cost of 150 to 400 Euro per device. Training for usage of the web application is sometimes charged at the first order.

- **Monthly communication cost**
  Most suppliers offer a service package in which the monthly communication cost along with the usage of the web application is included.

Note: Quantity rebate for both purchase and communication is possible. The prices in the table of figure 23 show the most common minimum and maximum prices.

- **Operational costs**
  Shipments provided with a monitoring device involve manual manipulations which should be considered.

- **Return of devices**
  The return of GPRS devices to the shipper involves a cost that should be taken into account. Cost reduction can be obtained by assembling all devices at one particular location and returning them in one package.

Cost example

The table below shows a cost model of 50 shipments per year, for which 5 GPRS devices are purchased at a cost of 300 Euro per device. The transit time of a shipment indicates how long

it takes before a shipment returns to the shipper. The transit time also affects the number of devices required.

The operational handling of adding a GPRS device to a shipment was allocated as a cost, since it involves an extra service. This service is charged at 25 Euro per hour and lasts 30 minutes.

Calculation of Product as a Service (PaaS)
The PaaS cost is based on the service charge per shipment. In the calculation a cost of 170 Euro per service was considered.

Figure 23 – Cost model for GPRS monitoring usage

Cost factor	Price
Purchase GPRS device	150 to 400 Euro
Monthly communication	15 to 45 Euro/month/device
Product as a Service (PaaS)	70 to 200 Euro/month
Return of devices	60 Euro (per shipment)

Case parameters	Quantity	Price
Purchase GPRS devices	5	300 Euro/device
Monthly communication cost	5	5 x 25 Euro/month
One-time purchase cost		
(web application, training, SIM cards etc.)	1	3,800 Euro
Number of shipments / boxes per year	50	
Transit time of return	8 days	
Number of devices assembled for return	1	
Insurance per device	20%	25 Euro/device

Purchase hardware	Investment	Annual costs (Euro)
GPRS devices	1,500	125 (insurance)
Web application and communication	3,800	1,500
Manual handling and return	0	625 + 3,000
Total	5,300	5,250

Product as a Service	Investment	Annual costs (Euro)
GPRS devices	0	8,500
Web application and communication	0	0
Manual handling and return	0	625 + 3,000
Total	0	12,125

Source: VIL

“The shipper is responsible for the delivery of product quality to the customer”

Aviapartner, Pharmahub

Conclusion
The choice of either purchase or PaaS depends on the frequency the devices are used. The calculation shows that the recurrent cost of GPRS purchase is relatively low. For PaaS in contrast, the recurrent costs are much higher based on the same cost model. The focus of PaaS also lies more on sporadic use of the device rather than continuous use.

No gains were included in the calculation for the reason that individual shipments of pharmaceuticals, live animals and spare parts have such a high value in air freight that the cost of GPRS monitoring is justified.

To make a comparison, the loss of a shipment, decrease in quality and late delivery is much more expensive than the annual TOC of all GPRS devices together in this calculation.

Added value

Shipper
The shipper is responsible for the delivery of product quality to the customer. Upon mutual agreement, part of this responsibility will be assigned to the forwarder, although according to the latest GDP guidelines,

it is the responsibility of the shipper to take a risk assessment approach towards all supply chain activities and stakeholders.

Controlling the rendered service is thus the shipper's responsibility. GPRS devices allow the shipper to control and audit:

- **new lanes or qualification of existing lanes for new products.** Before time and temperature sensitive goods are shipped via a new itinerary, an assessment needs to be made of whether the new route is suitable for the goods and whether it meets the service requirements. A GPRS device assists in validating a lane for time and temperature conditions, without having to take measures at location throughout the supply chain.

The guidelines of 7 March 2013 on Good Distribution Practice of Medicinal Products for Human Use (2013/C 68/01) holds the shipper responsible for making a risk assessment of all aspects in the supply chain.

- **the service quality of stakeholders on a regular basis.** GPRS devices can be employed at any random time without the need to inform the stakeholders. Through the airway bill, other stakeholders are notified about the addition of GPRS to the shipment, although in practice little attention will be paid throughout the supply chain.

- **the protection of shipments.** High-value shipments require continuous monitoring. The extra cost of a GPRS device is negligible for such shipments.

Forwarder

The forwarder has an organisational and coordinating role in the supply chain, steering the stakeholders in order to get the goods at the final destination. This role translates into a responsibility towards the shipper and the consignee to guarantee the integrity of the supply chain and provide access to all relevant information. This information serves as support for the processes and process flows in the supply chain as well as a continuous controlling tool for stakeholders and suppliers.

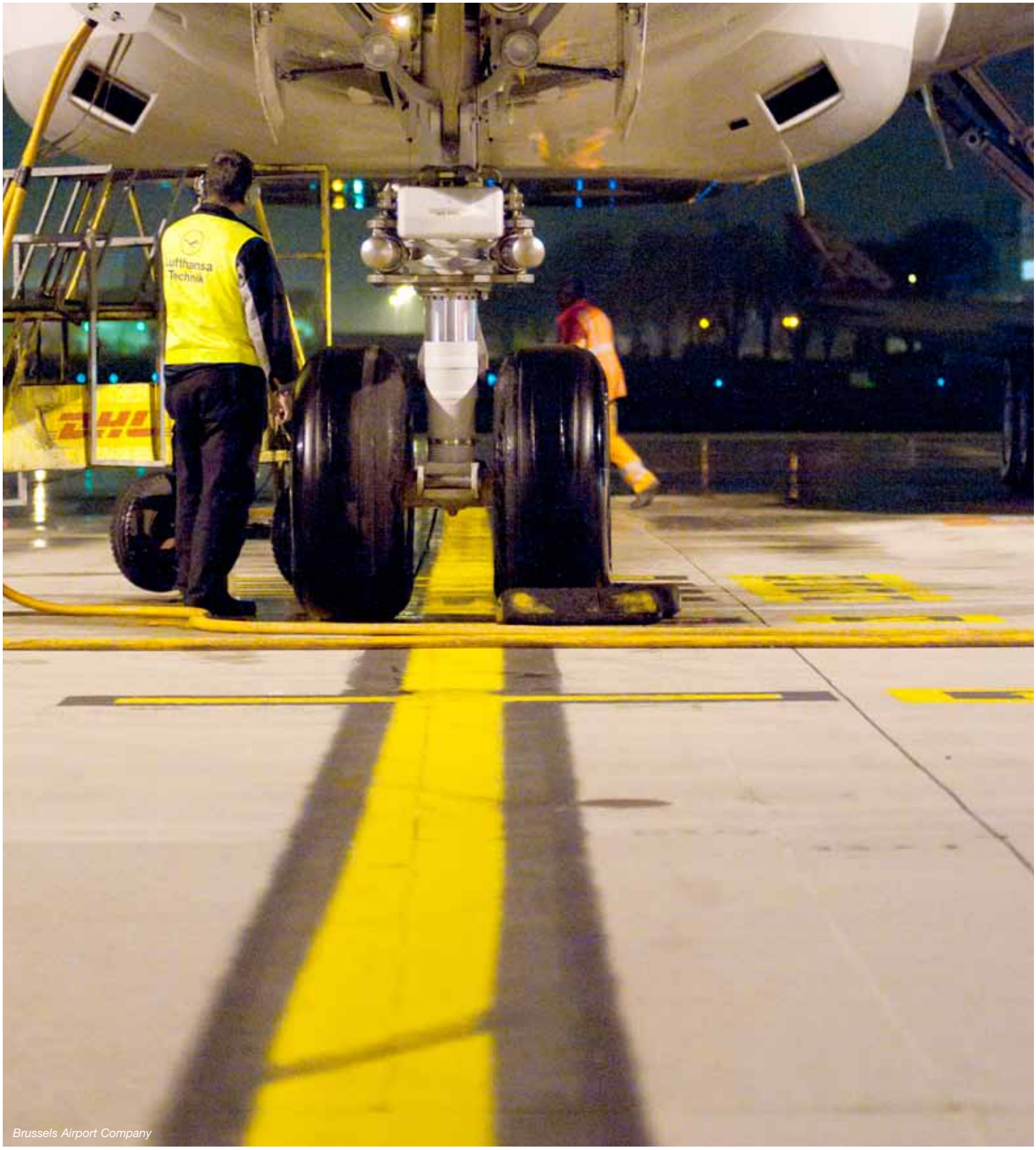
As communication tool, GPRS devices assist the forwarder in:

- **creating transparency throughout the supply chain**, providing access to information about the progress as well as the status of the shipment. This is especially useful during delays, where clients can

Figure 24 – Approach of the controlled supply chain by pharmaceutical shipper

Action plan	Value of GPRS
Product property • Stability data and tests	
Transport properties • Various distribution routes • Risk assessment and mitigation plan • Various transport modes	Tool for storage condition measurements as input for risk measurement
Shipment properties • Packaging • Monitoring devices • Required training • Start of logistical and communication processes	Tool when real-time monitoring is required

Source: VIL



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receive the most up-to-date information about shipments.

Transfers from one airline to another are usually avoided for temperature sensitive shipments. GPRS does not provide a direct solution for this, but ensures that bottlenecks are exposed.

- **acting proactively and reactively.** The processing of information about the location and storage condition of a shipment gives the forwarder the possibility to be alerted whenever inconsistencies requiring immediate action occur.

  The Standard Operating Procedures (SOPs) comprise procedures for specific actions within the supply chain that need to be respected. SOPs need to be adjusted according to experience.

- **stimulating supply chain cooperation.** The GPRS software system enables involvement of the stakeholders in the information flow. The appropriate contact persons can be notified of emerging problems. The logistical service provider can initially assess and solve the problem independently. If not, the forwarder will take the necessary action.

  The Standard Operating Procedures (SOPs) includes contact information of the people relevant for a particular action in the supply chain.

- **risk management.** To a forwarder, it is important to monitor and reduce risk, mainly in order to promote the quality of the rendered service.

Handler

The handler's expertise and specialty convey to a great extent the possibilities of an airport. The handler has to correctly manage the confluence of different types of shipments, such as spare parts, high-tech products, perishables, live animals and pharmaceuticals.

On the one hand, the handler's facilities portray its operational possibilities. For example, without a cooling room shipments cannot be stored at a temperature of -20°C. On the other hand, transparency in the handler's operations can to a great extent be attained through process control, which entails verifying the registration of consecutive process stages. With this kind of control, the handler can prove that the shipments have been handled accordingly.

GPRS monitoring is not a process monitoring tool, but an addition to this kind of system. The following points indicate the added value of GPRS monitoring information for handlers.

- **Pre-notification of shipment delivery.** A shipment with a GPRS system can by localised within a specific distance from the handler by means of a geofence. Handlers should verify the documents accompanying the shipment, which can hamper the transit of the goods at the moment of acceptance. By integrating pre-notification in GPRS systems, the handler is notified of the shipment's arrival.

- **Cooled shipment at delivery.** A handler should verify whether cooled shipments have indeed been delivered at the right temperature. With GPRS systems, a report can be issued or an indication can be given on whether the shipment has been kept in adequate ambient conditions. Upon delivery at the handler, the parties concerned can be notified of possible inconsistencies.

  The IATA time and temperature checklist is a list verified by the handler upon acceptance of delivered goods. The checklist also has a field indicating whether the shipment has been received in cooled conditions.

- **Internal monitoring of storage conditions.** One of the handler's responsibilities is to guarantee the quality of the shipments, both in the warehouse and on the apron. Monitoring in the warehouse will happen through control of the processes. The most critical point for a handler is the apron, where shelter is limited. Through GPRS, a handler can be notified of shipments stored in conditions exceeding their tolerance level.

- **Monitoring of logistical resources.** With GPRS / GPS monitoring, logistical resources such as towing tractors and dollies can be monitored for location, status and storage conditions. Through this monitoring, increased efficiency and risk management can be attained on the apron. Eligible GPRS / GPS devices used for these purposes are not loaded into an aircraft and do not need airline authorisation.


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Airline

Time and temperature sensitive shipments require a certain service quality from all stakeholders. Airlines can differentiate themselves in terms of the delivered service of a specific type of shipment – either time or temperature sensitive – and the number of destinations they offer.

To an airline, a handler is a contractor, responsible for the handling and monitoring of goods prior to aircraft loading. From this perspective, the same added value applies for an airline as mentioned for the handler, namely, acceptance of the right shipments and monitoring of handling activities.

GPRS devices enabling real-time monitoring throughout all supply chain activities, except during a flight, provide both the aviation sector and the market with a tool that stimulates supply chain cooperation in proactive problem-solving.

- **Proof-of-service.** An airline granting authorisation for use of GPRS monitoring devices provides access to their own services, which should positively affect the market's perception towards the airline. Transit points are critical points for an air freight shipment. Through GPRS monitoring, goods can be monitored while located at a given transit point.

- **New service offers.** GPRS offers an increased degree of transparency, communication and cooperation. For some sectors, new services can be offered.

  For example, a service can be offered for continuous monitoring of pets or other live animals. The emotional nature of transporting live animals by air freight could convince the owners to choose an airline which provides the possibility to monitor the animals via pc or smartphone.

- **Risk management.** To an airline, risk management is crucial in order to provide a high service level and maintain a solid customer portfolio.

- **Monitoring of logistical resources.** Location, status and storage conditions can be monitored by equipping logistical resources such as ULDs with GPRS / GPS trackers.

An airline determines independently whether to authorise a GPRS device in air freight. It can either authorise the use of a device or offer the service on its own.

In line with the service rendered for ULDs, a service can also be offered for GPRS devices. ULDs are the property of airlines and are in theory part of the aircraft frame. An airline offers the use of ULDs to parties who in return, pay a price. At the end of the supply chain, these ULDs are given to other parties via a pooling system. Similar to ULDs, an airline could thus also provide a service for the usage of GPRS devices.

Airport

Risk reduction, efficiency and service continuity are the most important criteria for choosing an airport. Shippers and forwarders base their choice on the following aspects:

1. The presence of direct and frequent routes from the airport to destinations of choice;
2. Quality and expertise for a specific type of commodity or sector (pharmaceuticals, perishables, etc.);
3. Facility and service costs at the airport.

An airport should guarantee an optimal inflow of goods for export and outflow of imported goods. Additionally for some sectors, such as the sector for time and temperature sensitive freight, direct flights to final destination should be offered.

Offering service and expertise for time and temperature sensitive goods requires qualified personnel, who are responsible for monitoring the quality of shipments. An airport can in this context facilitate by offering on-site

training from which all parties at the airport can benefit.

Shippers and forwarders conduct a risk analysis to assess the suitability of an airport. From this perspective, an airport can provide added value by promoting and supporting the use of process monitoring and track & trace tools at the airport.

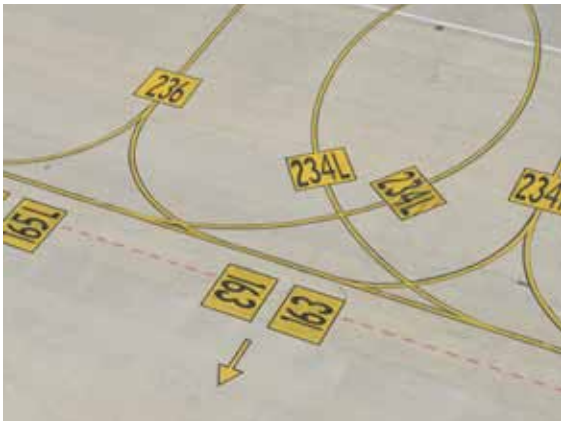
Process monitoring and track & trace tools are inextricably linked to process registration and indicate where bottlenecks may occur in the supply chain. If used correctly, these tools can increase service quality and consequently attract more cargo. The airport should position itself as a concerned and neutral party in order to extract relevant and useful information from track & trace systems and integrate this in a risk analysis throughout all operations on the airport and accordingly, act as facilitator between the stakeholders.

Such risk analysis should give the airport insight for future improvements regarding:

- Provisional storage capacity for time and temperature sensitive shipments;
- Transit time reduction for shipments;
- Airside facilities offered for temperature sensitive shipments.

By promoting and facilitating risk management, airports hold the key to a 'waterproof' solution for time and temperature sensitive shipments.

Conclusion



With this project, VIL shows that GPRS monitoring for air freight is technically feasible, economically justifiable and offers considerable added value for the pharmaceutical sector, live animals and spare parts.

Technically feasible: monitoring of location and storage condition throughout the air freight supply chain is feasible with GPRS monitoring.

Economically justifiable: There is a market for GPRS devices, both for continuous usage and sporadic usage (Product as a Service). The individual value of shipments is much greater than the TOC of GPRS monitoring devices.

Added value: The company's business case should indicate which model is recommended, either purchase or PaaS. The added value of applying GPRS monitoring mainly lies in the transparency of shipment monitoring through all the different stages in the supply chain, contributing to new or improved services. Transparency offers both providers and users of GPRS monitoring a tool for controlling and improving risk and efficiency.

Before employment of GPRS monitoring though, the following points should be considered:

- GPRS monitoring is not a system suitable for detailed monitoring of process stages. Other systems are applied for this purpose such as bar code, RFID or other.
- Employing GPRS monitoring on aviation routes depends on the airline's authorisation, which involves a lengthy procedure and great effort. It is also the airline's responsibility to initiate the authorisation process.

Simplified customs formalities help to encourage the use of GPRS devices in air freight as a tool for reducing risk in the air freight supply chain and for innovating and improving the service quality. With GPRS, we are entering a new era of air freight monitoring.

With thanks to our participants

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