PLANET CHANGE

Logistics:
Space data

Teacher manual

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Planet change is the short name of an EU Erasmus+ project aimed at VET teachers and their students. With small activities, the idea is to create awareness about sustainability and acquire 21st century skills. All this is done in a technical context, mostly from space technology.

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Contents:

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1. General information

Target group, age: 16-18Y / 18-20Y

European Qualifications Framework level: 1/2/3

Duration: 65 min

Materials:

- Satellite information sheets.
- Assignment 2 (per group):
  - The game 'From Space to doorstep', print out and cut out the gameplay sheet, board, orders, chance and action cards, satellite data cards, and logistic chains
  - One die, coins, m8 rings, beads, matchsticks or other objects that can function as credits (ca. 200 pieces)

Student background knowledge:

- basic knowledge of what logistics entails and what the constituent parts of a supply chain are.
- basic review of what kind of satellite data is available and how it aids in logistics.

Topic

Theme: Logistics

Keywords: Satellite data, space, supply chain, distribution, transport, logistics, warehouse, earth observation, weather, GPS, Galileo, GNSS, Meteosat, sustainability, pollution

Activity

Goals

The student will get better knowledge and training about:

1. The importance of satellite data in creating a sustainable logistic infrastructure:
   a. What is a supply chain and why it is important to make it more sustainable
   b. What kind of data satellite data is and how it impacts their personal life (e.g. google maps, weather reports, GPS, availability seats in trains, pollen reports, etc.)
   c. How satellite data can improve the efficiency and safety of the logistic infrastructure
2. How you can improve a fictional case of a company with satellite data. Students learn in which various ways satellite data impacts the logistics of a company while balancing the costs, risks and benefits.
3. How they could implement satellite data in their future profession.
4. How the abilities learned at school can help a future career in the space sector.

Summary of activity

Students first learn about the different components of supply chains, what kind of satellite data are available and how this data can make a supply chain more efficient, sustainable, less polluting, and safer towards its employees. During a board game they'll then revisit these concepts and learn about the benefits of such systems. The lesson concludes with a group discussion how satellite data can impact their school and their future profession.

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2. Introduction

What is logistics?

Logistics is more than just transportation from one place to another. It is a collective term for everything that is involved in organising, planning, controlling, and executing a flow of goods from the first to the last phase. A logistics employee may be responsible for picking orders, storing incoming goods, packaging goods, preparing goods for shipment, driving, loading and unloading freight traffic, and many administrative tasks that come with it. From the purchase of the raw materials to the moment the final product ends up at the customer's door. This entire process is also referred to as the 'logistics chain' or 'supply chain'. Below the most important links in this chain are described.

The products, raw materials or parts required for production, must be supplied from the supplier.
When the raw materials or products are delivered, the production process can begin. Within the production process there is also a flow of goods that must be managed. For example, forklift trucks can provide internal transport to and from the loading and unloading areas. Warehouse and stock management are also part of logistics. They deal with questions such as how to keep costs as low as possible while the stock is large enough to guarantee delivery to the consumer; which products are essential to have, and which products have a somewhat lower priority to keep in stock; and how to predict and anticipate supply shortages.

Distribution is the last step in the logistics chain. It covers the path the final product takes from warehouse to consumer or retailer. This also includes collection of orders and preparation of shipment to customers.

Transport connects all the steps mentioned above. Goods must be moved from one location to another during delivery, production, storage, and distribution. The way in which goods are transported is an important choice within logistics. Transport systems are major contributors to congestion, death and injuries from accidents, climate change, and resource exhaustion, public health problems due to air pollution and noise, and deterioration of ecosystems. Efforts in making transport more efficient is therefore one of the major ways to combat these environmental and safety problems while simultaneously increasing profits.

What is satellite data?

All around earth, satellites are moving in orbit collecting data. There are many satellites with different purposes. Some facilitate fast and reliable communication, others look at earth and its atmosphere, and others help your phone to know where you are (e.g. GPS/GNSS satellites). Together, satellites provide a wealth of information and can be used to form predictive models. This information includes where people or goods are, where and when they are expected to be, what the weather is and is going to be, how ocean currents flow, pollution levels, and road and traffic conditions. This information is valuable when operating a logistic chain.

3. Description of the activity

Part 1: Classroom discussion; in which way can satellite data improve logistics? [30 min]

Begin the class with some basic information about satellites. You may expand on how long satellites have been around, what types of satellites we have orbiting, and what kind of sensors they have. Importantly, give the students some examples of what kind of data is available from satellites or because of satellites. A few common examples of these are the GNSS satellite systems, the monitoring of road and traffic conditions, fast and reliable communication, warning systems, real-time weather data and predictions, and pollution monitoring.

a. Have a classroom discussion in what way satellite data is currently influencing the students' lives. You could make a word web out of their answers. Optionally, you can use online tools (e.g. lessonup.com or kahoot.com) to let the students answer the question. Report back to them some of their common observations. If necessary, point out some other ways in which satellite data is impacting their lives.

Introduce or remind the students what logistics are and what a supply chain is. Shortly explain which important components can be identified in the supply chain [supplier, warehouse management, distribution centres, transport, packing, orders, vendors, consumers]. Write down these components on the black board.

> Logistics is the process of planning and executing the efficient transportation and storage of goods from the point of origin to the point of consumption.
>
> A supply chain includes every step that is involved in getting a finished product or service to the customer. The steps may include sourcing raw materials, moving them to production, then transporting the finished products to a distribution centre or retail store where they may be delivered to the consumer. The entities involved in the supply chain include producers, vendors, warehouses, transportation companies, distribution centres, and retailers.

b. Divide the classroom into groups of 4. Give each group a different satellite data information sheet. THe sheet depicts information on what this particular sensor can do or what the satellite's ability is. For example, Galileo GNNS system with an accuracy of 20 centimetres or Meteosat's weather forecast predictions. Let the students discuss within their group how their satellite data can specifically improve the supply chain (e.g., in terms of efficiency, safety, sustainability, less pollution, healthier workspace, etc.). Ask them to be specific where in the supply chain this is a benefit and challenge them to provide a concrete example how such data would be used. Let the students write down their main finding/conclusion, including a concrete example. Discuss the answers with the class.

Part 2: Play the 'from space to doorstep' game [30 min]

In this activity students will play the board game 'from space to doorstep'. During this game they operate their own logistic chain, earning credits getting orders from supplier to consumer. Acquiring satellite data along the way makes their logistic chain more efficient, sustainable and safer, thereby potentially saving the company money. However, this requires investments. Will these investments eventually prove themselves to be beneficial? During the game students learn how satellite data can help make a company's logistics more profitable, efficient, sustainable, and safer for its employees.

Let the students set up the board according to the instructions and play the game. Indicate the time every 5 to 10 minutes.

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Part 3: Reflection [10 min]

Conclude the activity with a classroom discussion about how satellite data could improve some aspect of their school (e.g., school cafeteria, administration, commuting to school, scheduling, etc.). Can they be more efficient, sustainable and/or safer? How would they use satellite data in their future profession?

Part 4 (optional): A possible future of working with satellite data

A logistics employee is responsible for picking orders, storing incoming goods, packaging goods, preparing goods for shipment, driving, loading and unloading freight traffic and many administrative tasks that come with it. As we've seen from the examples in the game, satellite data can greatly affect the smooth workings of the supply chain.

Part 5 (optional): Excursion

Options: Visit a logistic company which employs satellite data in order to run their operation smoothly.

4. Annexes:

Examples of satellite data in logistics

Suppliers

A supplier trades in products they produce, by for example growing or mining them, or assemble the products themselves by combining raw materials. Suppliers such as farmers can use satellite data to see if their land is dry and needs to be irrigated, or what the best moment is to seed, plant, or harvest. Farm equipment can autonomously do their work directed by GPS or equivalent, and livestock farmers can track their herds. Other suppliers of raw materials, such as mining companies, can use satellite data to analyse earth's surface at hard to reach or remote locations.

Internal flow of goods

Within the production process different materials and goods need to come together to be assembled. For instance, forklifts unload goods from the supplier, store them and bring these into the production process. Within warehouses, automated self-driving forklifts greatly improve the efficiency of this internal flow of goods, plus increases the safety of the workspace. Often these automated forklifts are in constant connection with satellites, sending information about their position, load, battery life and overall functioning.

Warehouse management

Warehouse management and the internal flow of goods are closely connected. The materials for production are stored in warehouses, but also the finished products ready for further distribution towards vendor, retailers, other distribution centres or directly to the customer. Warehouse management ensures supplies are kept in stock so production can continue, but also balances the stock of finished products with the amount of orders. Too much inventory might be costly. For instance, a warehouse has only limited space. To be able to manage a warehouse, the managing party needs to know what orders to expect, know when supplies are on their way and know where each item is in the warehouse. With the help of satellite data, inventory and supply can be tracked. Even weather forecasts may be used to predict costs and availability of supply, or even demand of products. Within warehouses robots can unpack and pack pellets.

Distribution

Distribution is the overall management that oversees the movement of goods from their development to the point of sale. It also includes collection of orders and preparation of shipment to customers. A distribution centre prepares orders to be collected, packed and sent off to customers. In large distribution centres much of this work has been automated by robots guided by systems that include a satellite. Also the management of when, which and by which route shipments are sent off is a task for distribution management. They choose smart routes that minimise transport milage while still providing fast deliveries using the data.

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Transport

Transport is the factor that connects all the previously mentioned aspects of logistics. It is what most people think of when they think about logistics. Transport systems are the most polluting aspect of logistics and where the most environmental gains can be made. Transport systems are major contributors to traffic jams, accidents, climate change, resource exhaustion, public health problems due to air pollution and noise, and deterioration of ecosystems. Efforts in making transport more efficient is therefore one of the major ways to combat these environmental and safety problems while simultaneously increasing profits. Currently, satellites are being used to track ships, trains, freight trucks, delivery trucks, cars and even individual (sea)containers. Information about the vehicles fuel level or battery life, how long a driver has been driving and where they can best have a rest stop is send through satellites. Active road and traffic monitoring avoids trucks being in congestion, saving time and fuel, or avoids dangerous routes. Likewise, weather predictions and monitoring may avert truckers getting into dangerous and time consuming (road) situations. Pollution monitoring may be used to avoid workers being exposed to too many harmful substances.

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Types of satellites

Satellites can have different or even multiple functions. First of all, there are communication satellites which provide a fast and reliable way to communicate over vast distances and on places where other means of communication are not possible. Constellations of satellites can work together to form a global navigation satellite system (GNSS), such as Galileo or GPS. Such systems are the reason your phone, cars, trucks, drones, ships know its location. Other satellites observe earth with a variety of different sensors.

The most common satellites sensors are optical sensors. Like common camera's, they gather light that we can perceive and light in the nearby infrared range called "near infrared" as well. Optical sensors only see reflected light. Therefore, they cannot observe anything on a dark night or under clouds. The image an optical sensor produces can be black-and-white (panchromatic). Here it just looks for the presence of light. Other sensors can also produce coloured (multispectral) images. These are made by stacking images captured by different wavelength bands. When we take one picture with only red light, one with only green light, and one with only blue light, and we superimpose them on each other. Then, we get an image like how we see the world around us. Unlike our eyes, multispectral sensors are often sensitive for many more bands of wavelength than just red, green and blue. Many multispectral sensors also see much farther into the infrared side of the light spectrum than us humans can. Different objects have different colours because their material reflect sunlight with different wavelengths at different intensities. By analysing the properties of reflected light we can distinguish the materials that make up the surface of earth. Looking down on earth using our eyes, we would distinguish vegetation, water and deserts because they reflect light with different wavelengths at different intensities. However, with multispectral sensors we could identify types of plants as each type of plant reflects a slightly different form of wave. We can even see a difference in vegetation density and between healthy and unhealthy plants.

Another important way to look at earth is with radar. Synthetic Aperture Radar (SAR) first emits microwaves. The microwaves then reflect back off the Earth's surface and are received by the sensor. Although radar sensors don't have the high resolution as optical sensors, they do have other qualities. SAR sensors are not affected by sunlight conditions because they observe the reflection of radio waves they emit themselves. Therefore they always capture images under the same condition, day or night. This makes them more suitable to detect changes in images of the same area captured at different times. Moreover, they can see through clouds since radio waves penetrate clouds. Different SAR sensors can emit and receive different wavelengths of microwaves. Different materials reflect this light differently. For example, long wavelengths penetrate foliage and branches of trees, thus letting us see the ground. Whereas shorter microwaves are reflected by foliage and grass. Moreover, SAR sensors can also play with differences in the polarization of emitted and reflected light. That is the direction of the waveform. We won't go into the details but different materials respond differently to different polarised light, so they look different in satellite imagery.

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Examples of how satellite data can be used to benefit a supply chain

Weather predictions

- can inform suppliers like farmers when to irrigate, plant and harvest. (supply)
- can warn about unsafe routes. For instance, weather predictions can be used to identify areas of flooding or other hazardous conditions such as slippery bridges and roads that could put drivers and cargo at risk. (transport)
- can save energy consumption. For instance, by decreasing stocks of refrigerated goods when warm weather is predicted. (warehouse management)
- can predict traffic. For instance, more people will commute by car vs. cycling or walking when the weather is bad. (transport)
- can forecast demands of certain weather dependent products. For instance, a sunny weather forecast may predict increased demand for sunscreen at retailers. (supply, internal flow of goods, warehouse management, distribution)

Traffic monitoring

- can be used to identify and analyse road networks, identify traffic patterns and potential hazards such as traffic congestion, construction, accidents, and monitor the condition of roads and bridges. This information can be used to plan routes, identify potential bottlenecks, avoid hazards and delays, and determine the best times to travel. (distribution, transport)

GNSS (Galileo & GPS)

- helps in tracking the internal flow of goods, for instance warehouse robots (internal flow of goods, transport)
- tracks the location of a company's vehicles and monitors their performance such that fleet operations can be optimised and costs are reduced. (transport)
- can accurately forecast arrival time of supplies (supply)
- enables the potential use of self-driving cars or trucks, as well as autonomous robots in warehouses and distribution centres. (distribution, transport, internal flow of goods)
- can monitor the security of transportation and logistics operations. By tracking the movement of its fleet, a company can identify areas where theft or other security risks may be present. This can help companies take the necessary steps to protect their cargo and ensure the safety of their drivers. (Supply, internal flow of goods, transport)
- ensures hazardous materials are tracked and handled with the utmost care. (*Supply, internal flow of goods, transport*)

Pollution monitoring

- can impact an employee's health. For instance, to avoid smog during certain hours of certain polluted regions or routes.
- companies can use satellite imagery to monitor air and water quality, as well as land use and land cover. This information can be used to plan routes that minimise environmental impacts.
- Monitoring water currents
- By using this data shipping can be made more efficient and sustainable
- Related to weather predictions, finding safer shipping routes.

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Information for the teachers

It is also possible to let the students continue the game for a longer time to ensure that students have the chance to complete multiple orders.

The satellite information sheets can be found below.

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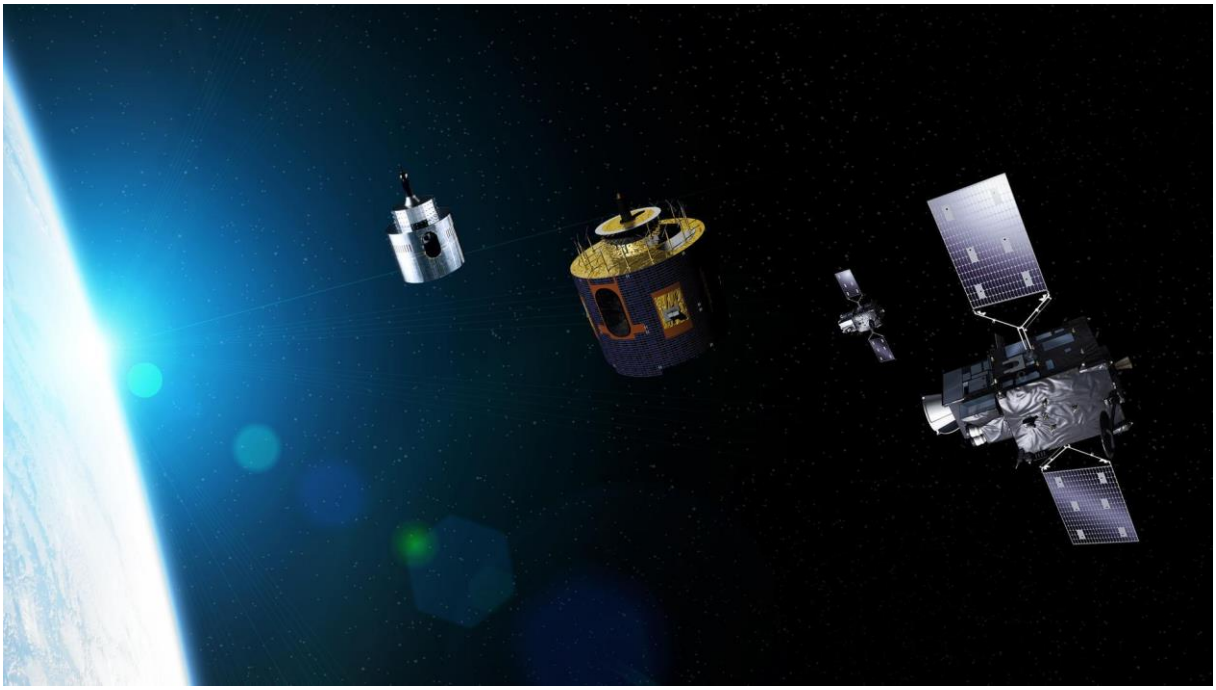
Meteosat satellite system

Meteosat satellites have been providing crucial data for weather forecasting since 1977. As to date, Meteosat-9, -10 and -11 are in a geostationary orbit over Europe and Africa, and the Indian Ocean. This means the satellites appear to 'hang' still at about 36.000 km above earth. This makes it possible to make a full disc image of Europe and Africa every 15 minutes and rapid scan imagery over Europe, every five minutes. These images are crucial for spotting fast developing weather events. This means we can predict storms a few hours ahead and we can save lives and property. Meteosat's data is also used to improve weather prediction models, and for climate monitoring.

Meteosat Third Generation Imager-1 (MTG-I1) is the first of a new generation of satellites providing crucial insights for the early detection and prediction of fast-developing severe storms, weather forecasting and climate monitoring.



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GALILEO satellite system

When Galileo, Europe's own global satellite navigation system, is fully operational, there will be 24 satellites plus spares in Medium Earth Orbit (MEO) at an altitude of 23 222 kilometres.

Eight active satellites will occupy each of three orbital planes inclined at an angle of 56° to the equator. The satellites will be spread evenly around each plane and will take about 14 hours to orbit the Earth. Two further satellites in each plane will be a spare; on stand-by should any operational satellite fail.

Planners and engineers at ESA had good reasons for choosing such a structure for the Galileo constellation. There is a very high probability (more than 90%) that anyone anywhere in the world will always be in sight of at least four satellites and hence will be able to determine their position from the ranging signals broadcast by the satellites.

The inclination of the orbits was chosen to ensure good coverage of polar latitudes, which are poorly served by the US GPS system. From most locations, six to eight satellites will always be visible, allowing positions to be determined very accurately – to within a few centimetres. Even in high rise cities, there will be a good chance that a road user will have sufficient satellites overhead for taking a position, especially as the Galileo system is interoperable with the US system of 24 GPS satellites. When all the satellites are in space on these three orbital planes, Galileo will be fully operational, providing its services to a wide variety of users throughout the world.