



**Smart Containers and Sensors
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Introduction

90% of the world's goods are transported by sea, with 60% packed in containers.

In total, about \$14 trillion of the world's goods spend some time in a big metal box with about 130 million containers being used for sending out various shipments.

The traditional container is one that is visible only when docked at the ports and after being delivered to the consignee.

There is a black hole as the container travels the open ocean, where updates are few and far between

On average, the update of movement status changes, such as container shipment and unloading is at least 8 hours or longer behind actual container movement.



The Smart Container

- Any container can become a smart container.
- Either a standard marine container permanently equipped with electronics during manufacturing

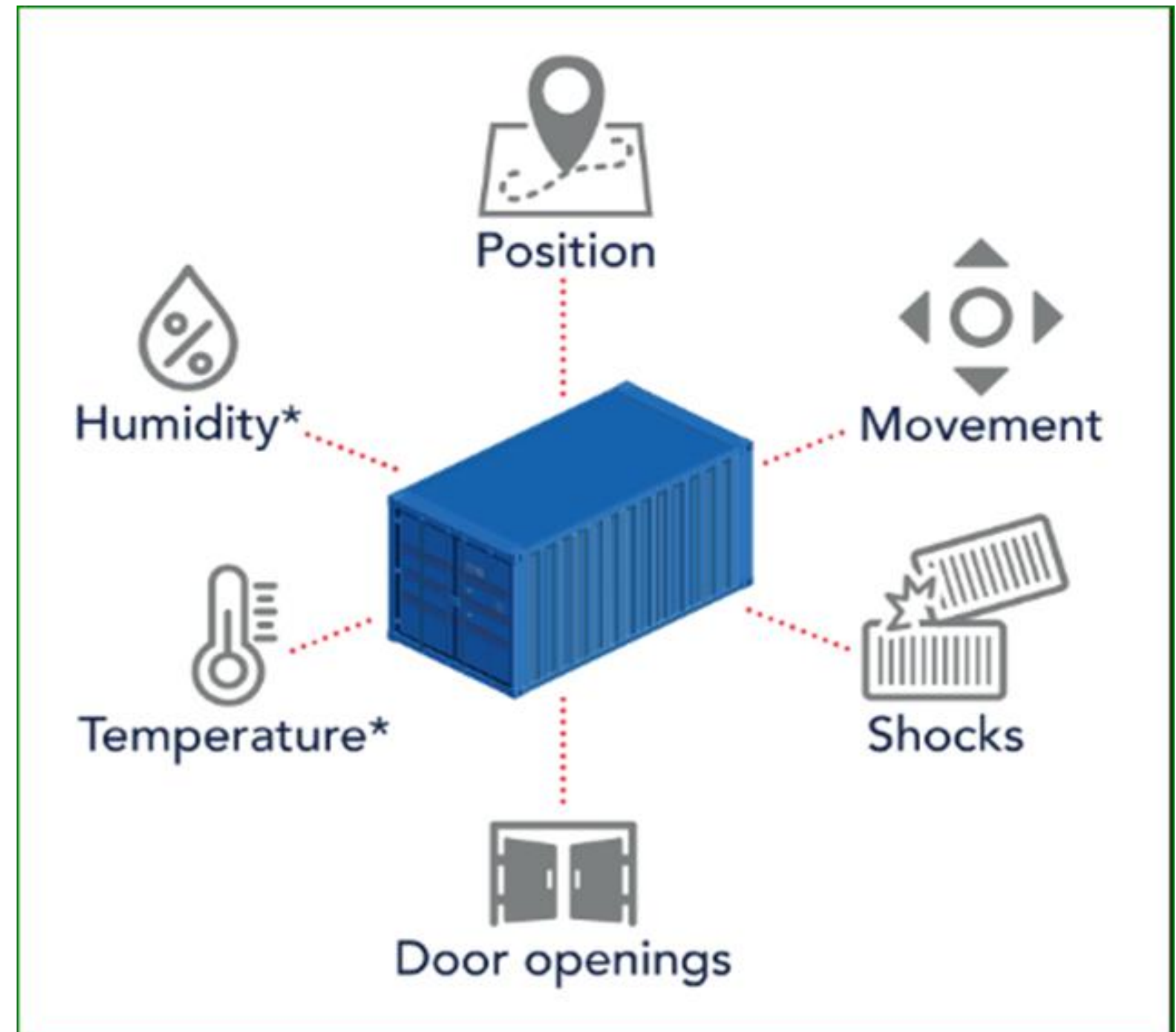
OR

- One that is retrofitted with independent removable IoT enabled devices with built in sensors that can be attached to any container.
- The devices can be used not only in marine containers but also to air cargo, pallets or trucks.



Advanced monitoring

- In essence, a smart container is equipped with internet-connected devices and sensors that allow for advanced monitoring.
- Container monitoring devices and sensors encompass three general components:
 - Identification
 - Location
 - Physical parameter: temperature, humidity, vibration, door openings, movement.



Developing technologies making smart containers possible:

- Development of network technologies: From the analog-based 1G to the current 5G, wireless network technologies have gone through significant progress.
- Development & declining costs for sensor technology: Smart containers capture information via a wide range of sensors. Cheaper and smaller.
- The rise of the platform service market based on big data and cloud, where data from containers around the world can be analyzed within a few seconds, and a variety of information provided in a timely manner.
- Hence, key to the success of smart containers is the Internet of Things (IoT). This allows information about the container and its contents, which is gathered by the sensors to be transmitted to both the crew and remotely to the shipping line and owners of the container's contents.



<https://www.nytimes.com>

- Referring to the casualty of the *Ever Given* on the Suez Canal. *Digital Ship* magazine reported:
 - “the industry was divided into those who had full visibility of their containers - on the *Ever Given* or stuck in the queue of some 400 vessels – and those who didn’t. The owners of Smart Containers were able to track the location of their cargo as it idled or was rerouted around the Cape of Good Hope, a 5,500-mile diversion that takes seven or 10 days longer. Visibility that enabled information on ETA to be provided back to product owners.” Robert Koldys, VP Marketing and Business Development
- It is predicted that about 10% of container fleets around the world will be outfitted as Smart Containers by 2023 and possibly 25% by 2026 according to Drewry. The **smart container market** is estimated to grow from USD 2.6 billion in 2019 and projected to reach USD 5.7 billion by 2024.
- According to Drewry, factors driving this market growth is supply chain disruption and port congestion, which have highlighted the need for improved visibility of cargo to cope with longer and more volatile transit times.
- Demand seems to be strongest from smart reefer vendors, but not limited to reefers.
- Penetration with respect to dry containers is as little as 0.3%, but it is expected to increase.

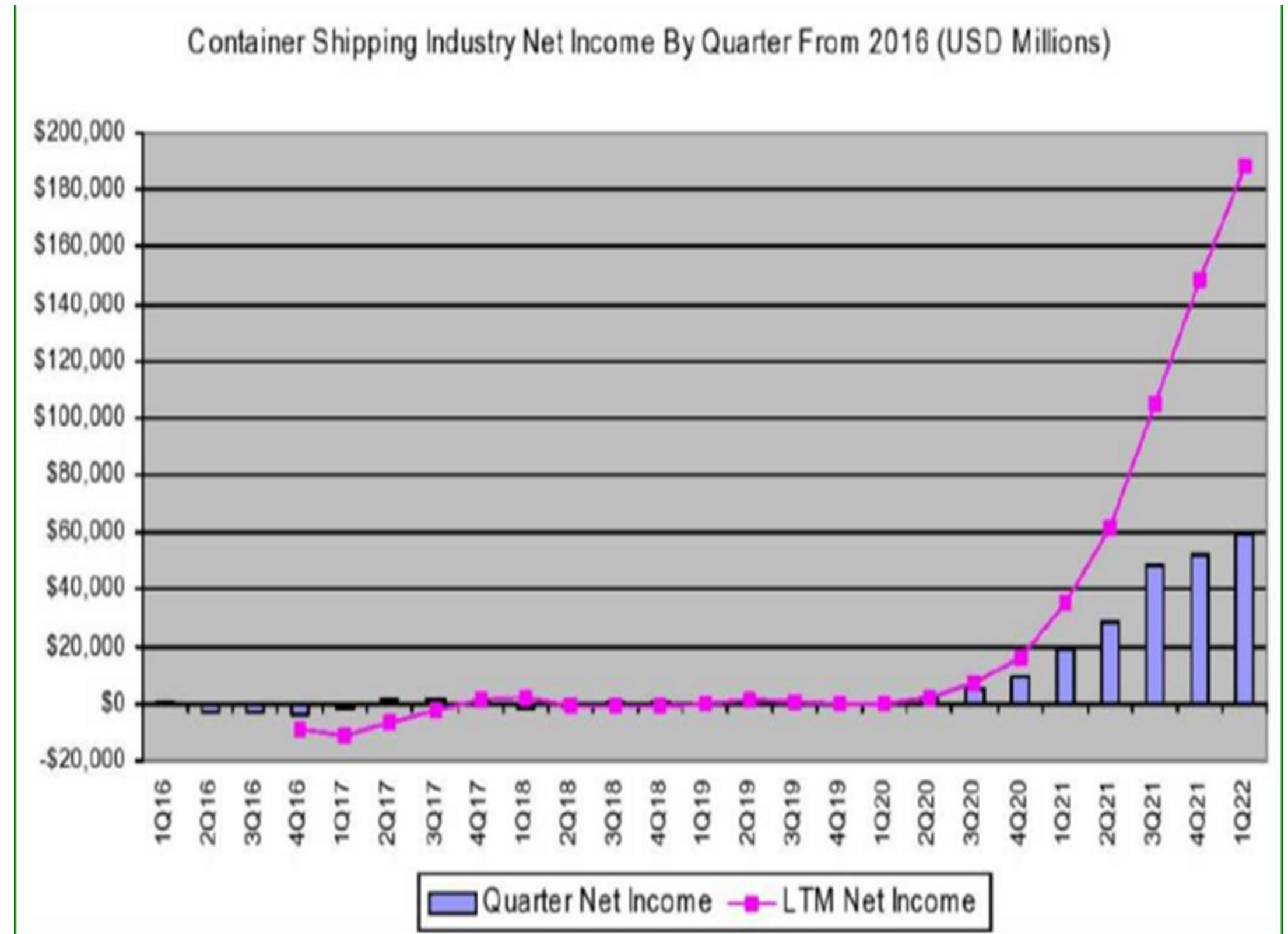
Container shipping industry net income.

According to the McCown Container Results Observer report, the 11 global carriers that publish their results posted a \$59.3 billion net profit in the first quarter of 2022, a 300% improvement from the first quarter of 2021.

Container shipping Q1 2022 results beat out those of FANG (Facebook, Amazon, Netflix and Google – by 103%).

“Carriers are “flushed” with cash to invest” and see opportunities to improve the efficiency of their operations through the deployment of smart containers.”

Drewry.co.uk



Key Market Players

- Orbcomm (USA) - “Vessel connect” - Dry and reefer remote container monitoring
- Smart Containers Group AG (Switzerland) - manufacturer of temperature-controlled containers for pharmaceuticals and food products.
- Traxens (France) - Sensors and associated data platform (Traxens-BoxS+ and Tranxens Net)
- Arviem AG, (Switzerland) – Removable IoT devices with sensors
- Globe Tracker (Denmark) - Reefer container tracking devices and monitoring
- Nexiot AG (Switzerland) – Sensors/hardware IoT Cloud & big data for railcars, tank & intermodal containers
- Philips Connect Logistics (USA) – Tracking devices and platforms
- Robert Bosch Manufacturing Solutions (Germany) Reefer monitoring (temperature & ethylene sensors)
- Savi Technologies (Switzerland) – Smart containers/smart ports
- Loginno, Israel – Aiming to convert entire fleet of a shipping co. containers into smart containers
- Shenzhen CIMC Technology (China) – Smart container manufacturer

Market Strategies: Though product launches and developments, agreements, partnerships, collaborations, contracts, and joint ventures

Examples:

- China International Marine Containers (Group) Ltd. (CIMC), the largest manufacturer of freight containers in the world, holding over 40% market share globally, or over 750,000 TEUs (20-foot equivalents) and Savi Technology, a global leader in providing real-time solutions for the security and management of supply chain assets have established a strategic partnership to co-develop a new class of "smart and secure" shipping containers.
- Maersk, CMA CGM and Mediterranean Shipping Company MSC) are all share holders and customers of Traxens, a developer of 'smart' container monitoring and coordination systems.
- CMA CGM first invested in the start-up in 2012, MCS in 2016 and Maersk in 2019, with all three being committed to ordering 50,000 devices to deploy on their containers.

Other examples

- Hapag-Lloyd is using Danish visibility provider Globe Tracker to outfit its entire fleet of 100,000 reefer containers.
- Israeli technology provider Loginno is focused on creating CONTOPIA (Container Utopia) – a world where every shipping container is real-time IoT connected.
- In 2019, they led a global initiative to select one shipping company, whose entire container fleet would be digitalized. The selected winning company was Brazilian cabotage carrier Log-In-Logistica. Their entire fleet of containers was outfitted with their sensors.

Self-weighing technology

Concept:

Self-weighing technologies that can assist in getting accurate weight of the goods loaded into a container and transmitting the same information via an LDC screen that can be built into the container or printed out remotely.

Load cell technology has been tried and tested and could be adapted to the container industry.

The technology involves the use of load cells which are devices that convert pressure to force, into electric signal, which is then represented on a screen or print-out.

Israeli based Loginno has a granted patent for the scale-less measurement of the container's weight. No need for any external equipment.

They have also won a grant from the Israeli Innovation Authority to trial scale-less weight measurement for containers.



SOLAS Verified Gross Mass (VGM)
container weight measurement

Perhaps one could avoid...



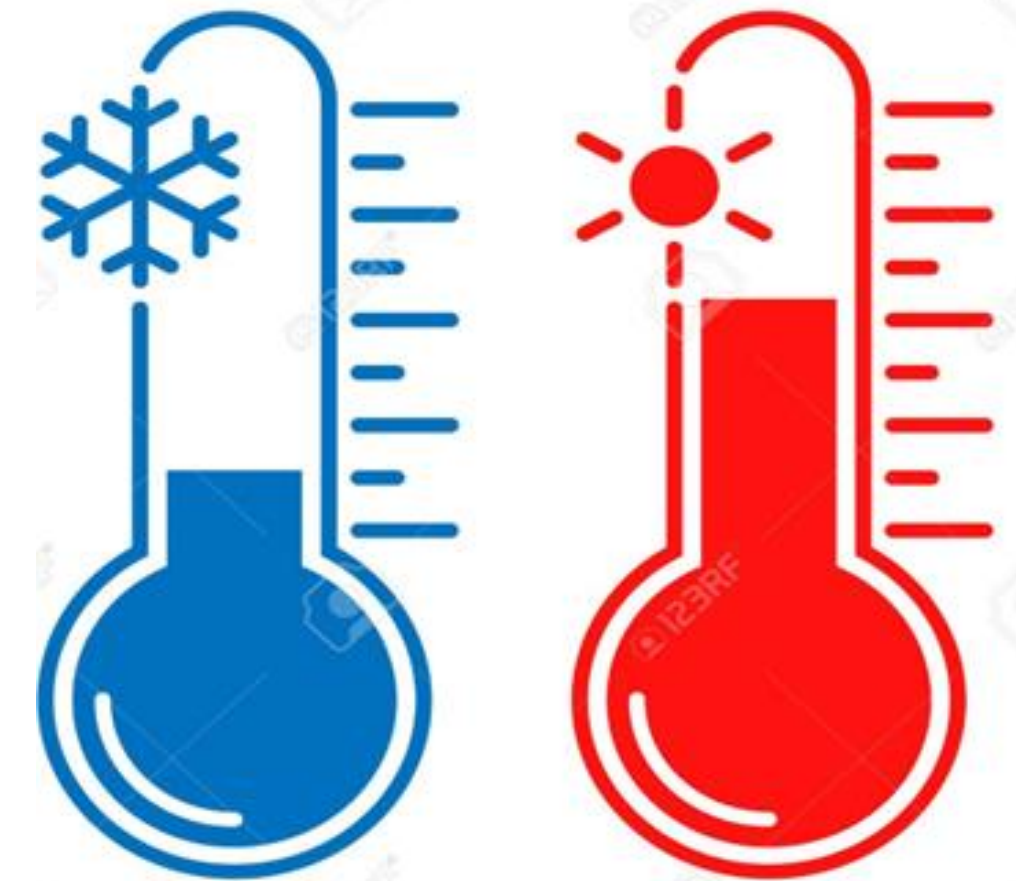
<https://www.shiplilly.com/>



Ref. Uwe Peter Scheider

Temperature sensors

- Traditional refrigerated containers are limited in that they only allowed operators to set temperature conditions inside containers at the start of transport, to maintain the quality of perishable goods (such as food or medication).
- Smart Containers improve upon this technology. Operators can track, remotely control and adjust the internal conditions as required.
- Remote or proactive monitoring enables the temperature to be adjusted in response to the fluctuations in the container's external environment. Critical in high value commodities like pharmaceuticals and fish.
- Eg: Globe Tracker (Hapag Lloyd)
“Hapag-Lloyd LIVE” will be gradually released for use of the entire reefer fleet” part of their “Strategy 2023”
-
- In case of high temperatures that could trigger a fire, an alarm is triggered to alert the crew so that immediate action can be taken.
- Time and place of the exception determines the responsible party.



Humidity Sensors

- Unexpected humidity change: An alert will be sent out in case the measured humidity goes above or below a predefined threshold.
- Measure and keep track of moist and humidity levels which may have serious impact on some cargoes.
- For example:
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 - Cardboard boxes could be compromised due to humidity and cause safety problems.
- In a controlled atmosphere container, an alert is sent if the amount of oxygen, carbon dioxide and nitrate is outside the acceptable range.
- Deck crew receive real-time event-based alerts on hand-held devices so they can take immediate action.
- Time and place of the exception determines the responsible party



Vibration/Movement Sensors

Acoustic sensors to detect unexpected container movement (footsteps) or theft in the container.

Fragile cargo shock vibration sensors that detect shock or vibration.

Traxens: Shock detention technology detects shocks on containers and assesses their severity through a “shock algorithm.”

An alert will be sent out in case a measured shock exceeds a predefined threshold

Time and place of the exception determines the responsible party



Door Openings

Unexpected door opening:

An alert will be sent out in case of door opening in an unexpected location.

No alert received means proof that doors were not opened during the trip.

Loginno is working in the development of a 'Cyber Seal' certificate to replace a container's physical seal with a software certificate in partnership with Lloyd's Register



Location and altitude sensors

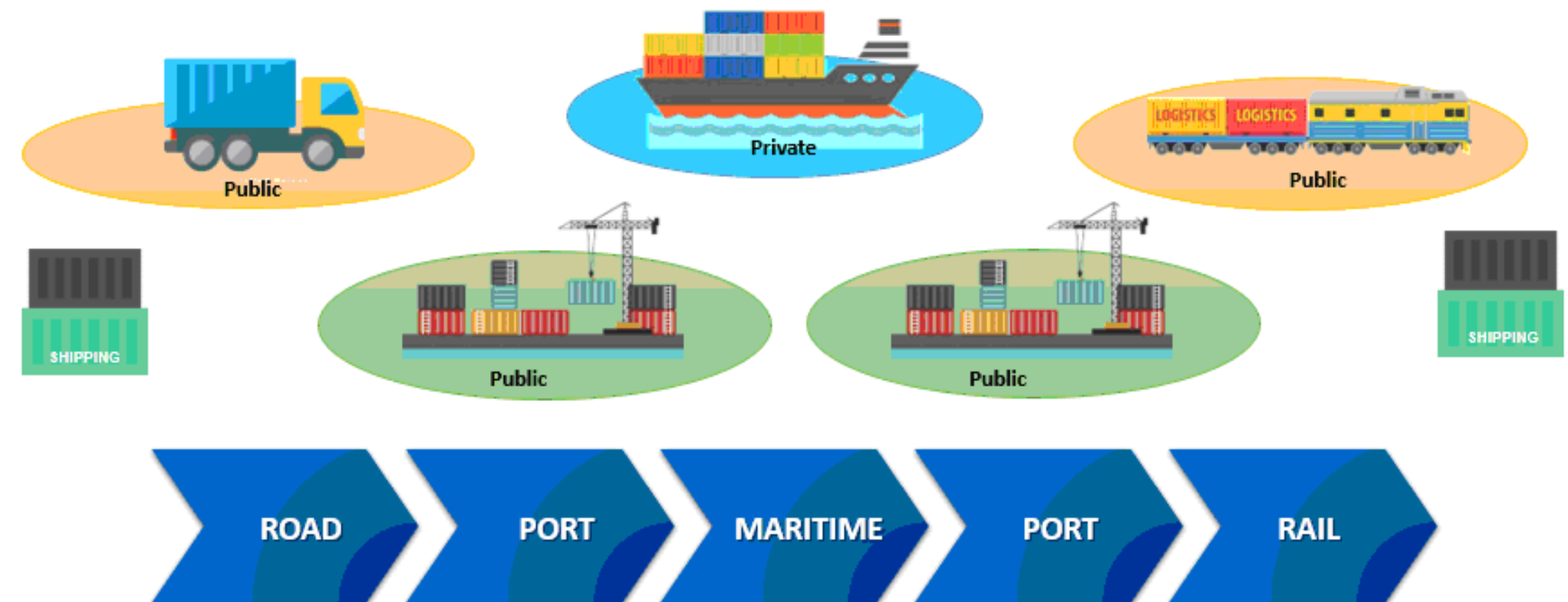
- GPS to satellite or GSM container tracking:
- Satellite traditionally the connectivity tool of choice for the shipping industry.
 - Expensive but always-on
- GPS sensors rely on satellites to deliver placement information.
- Real-time location and predictive ETA based on shipment location
- Cloud based: An all-internal monitor that communicates with the cloud.



Digital transformation: Public and Private Mobile Network

- While the containers are being moved around on land, they are connected via public mobile operator networks (e.g. AT&T, Rogers)
- Also, when the vessel is in port or when hugging the coast 40km/25 miles out to sea.
- While the smart containers travel the open ocean, there is no public mobile network. Some shipping routes can be 20+ days.
- What is required is a private mobile network to allow for continuous monitoring during the ocean sailing.
- Private refers to a private mobile network on the shipping vessel, which connects to the smart containers locally and then enables data to be available to centralized resources.

Public and Private Mobile Network



<https://www.starsolutions.com>

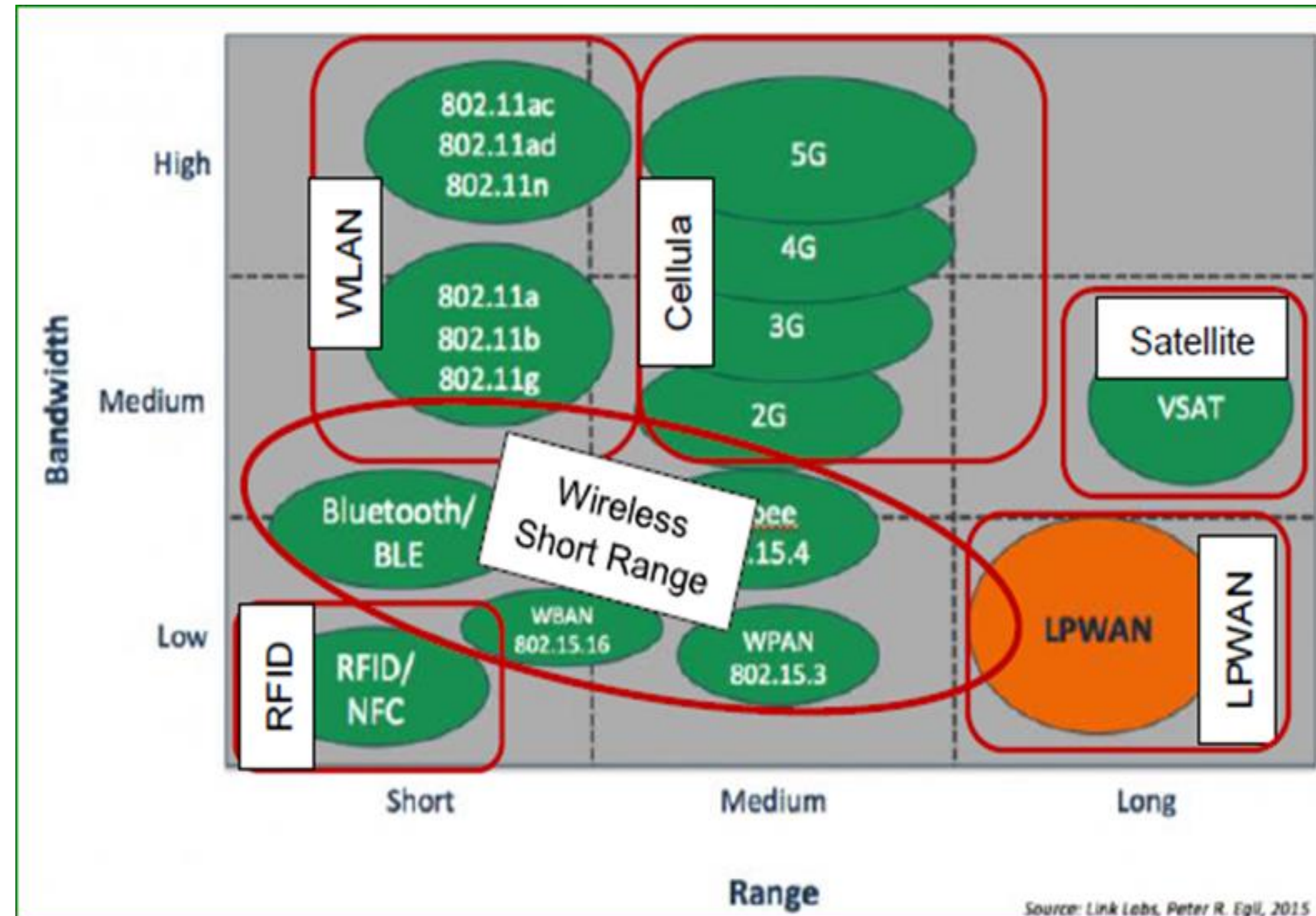
Wireless sensors: LoRa/LoRaWan

Traxens, Globe Tracker and Semetch use LPWAN (Low power wide-area network). The sensors used are low power long range (LoRa), which work on batteries able to transmit via open radio frequency onto gateways between 1 to 10 km away. Data that is transmitted to the gateway (radio masts) is then connected to the internet (ship's server).

Devices consume little amount of power and transmit info over a long distance. License free.

Traxens uses Tri-band frequencies (433MHz, 868MHz, 920MHz). The device is equipped with GPS, which will only be used if the mesh network is not functioning.

A mesh network was specifically designed to function in metallic and humid environments and communication reaches the deepest levels of the biggest container vessels.

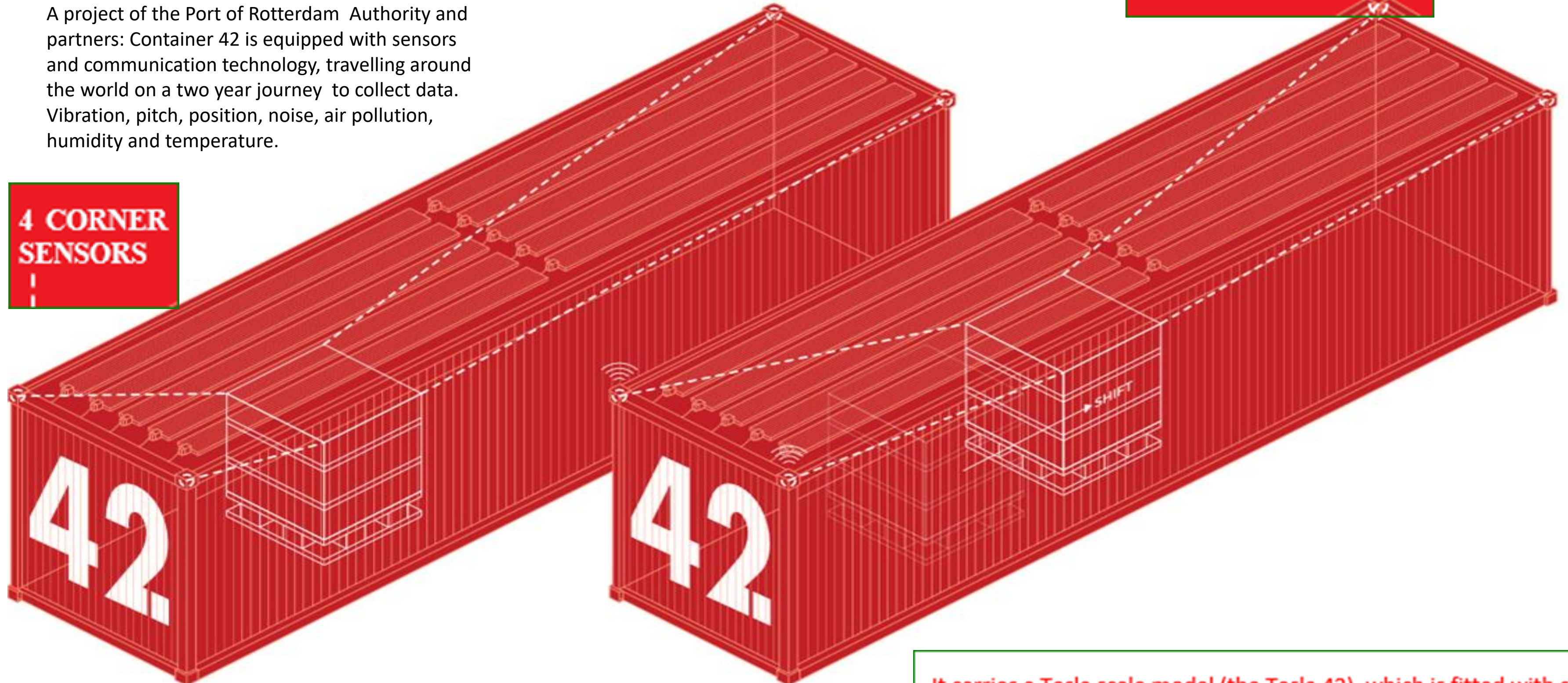


Smart container 42

A project of the Port of Rotterdam Authority and partners: Container 42 is equipped with sensors and communication technology, travelling around the world on a two year journey to collect data. Vibration, pitch, position, noise, air pollution, humidity and temperature.

4 CORNER
SENSORS

ALERT:
CARGO SHIFTED



It carries a Tesla scale model (the Tesla 42), which is fitted with sensors that measure whether the vehicle moves around inside Container 42 during transport; and if so, why.

Geo Fencing

Geozone entry/exit: When a smart container enters into the premises of a depot (geo-fence) this event can be reported/recorded.

Container 42 is fitted with an advanced high-end Smart lock. With the help of geofencing, it is even possible to open the lock only at set locations (such as at customs).



Batteries

- Smart shipping containers can be self-powered by solar panels on their exterior and have batteries to enable energy to be stored.
- Container 42: The roof of the container is mounted with HyET Solar Powerfoil which provides power to the battery system that powers the sensors.
- It ensures a steady supply of power during transit, allowing the batteries to be continually charged and maintain power supply to in-container systems
- The container has lead crystal batteries from Betta Batteries that use a crystallized electrolyte.
- Provides the safety of gel batteries, price of a lead-acid batteries and performance of Lithium batteries.



Hyetsolar.com

Challenges

Containers are made of steel and can be stacked deep down at the bottom of a pile, making communications a challenge.

Difficulties for electronic signals to escape from a metal cage.

Breakdowns in communications between the sensors and the networks that relay their information to data repositories.

If an antenna is needed to be placed outside the box, the antennas can be damaged or removed.

Containers spend a lot of time on the ocean far away from any cell towers.

Length of battery life.

Reverse Logistics – on removable IoT devices

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Cybercrime

Cybercrime: Smart Containers generate data and communicate with authorities through a satellite-based or internet-based system.

Therefore, there is a risk that data collected could be hacked or altered due to cybercrime. Institutions should ensure their systems are robust to mitigate the risk of cybersecurity breaches



[https://robbreport.com/motors/marine/how-to-keep-yacht-safe-from-hacking-seas-2834436,](https://robbreport.com/motors/marine/how-to-keep-yacht-safe-from-hacking-seas-2834436/)

Data Ownership

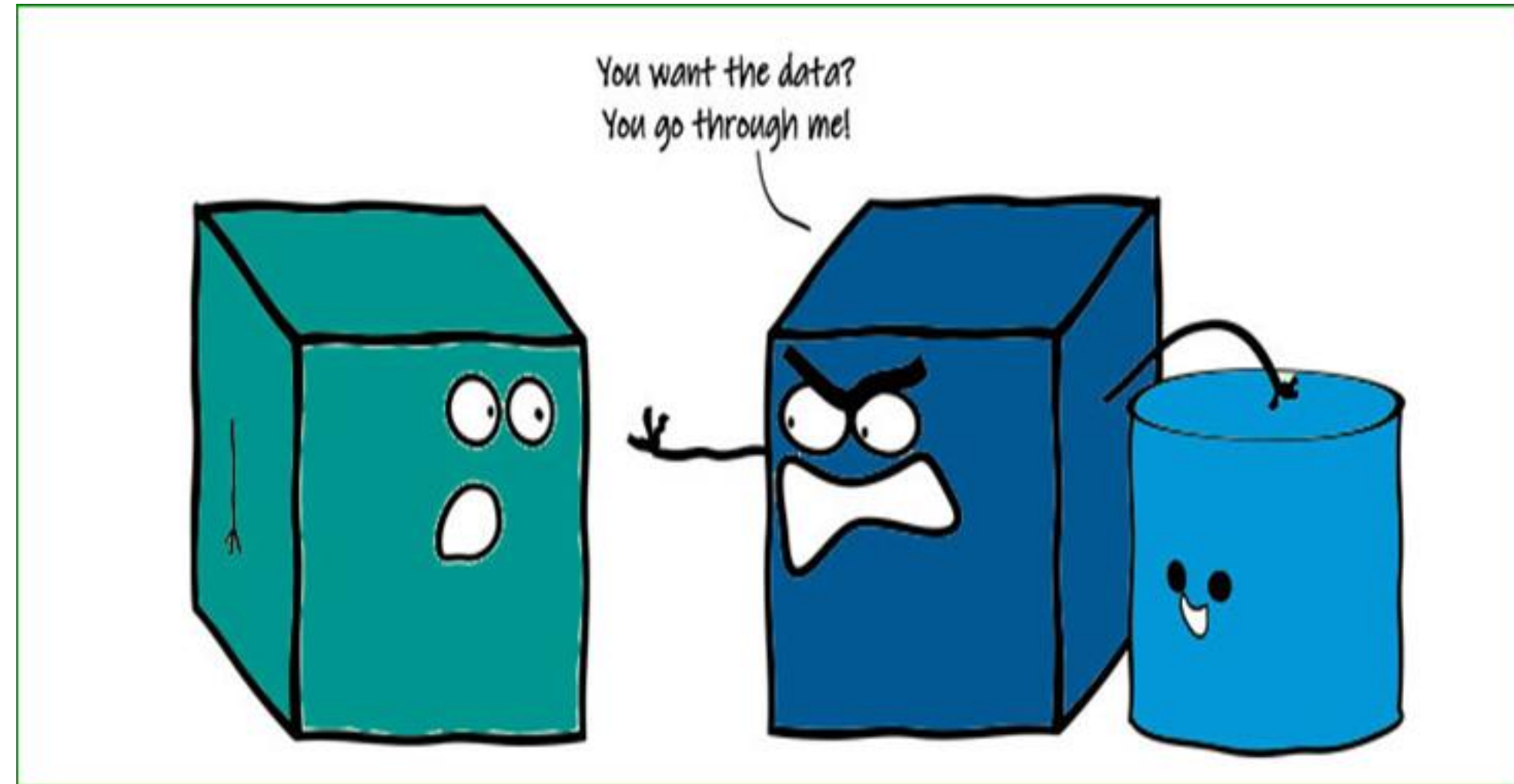
Who owns the smart containers?

Who owns the data from smart containers?

The shipping line or carrier?

Is the data easily available to shippers?

Smart device enabled monitoring data is independently owned by cargo interests or shippers. These devices are removable and can be attached to any container.



STANDARDIZATION

- With numerous sensor providers in the market, there is a need for data standards, on the assumption that shippers, third party logistics providers, container lines and port entities could be juggling data from multiple providers.
- In October 2019, The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) in collaboration with providers of container sensor devices (Marseille-based Traxens, Denmark-based Globe Tracker, Switzerland-based Nexiot, Marine Traffic, FedEx and GS1) published standards for “smart container data exchange” a new set of standards to help make the data generated by its devices more interoperable with other devices and systems that process the data.

Conclusion

Doing away with the black hole of information!

