RFID in Containerization

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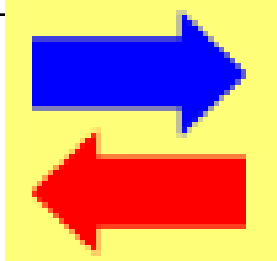
Objective of the presentation

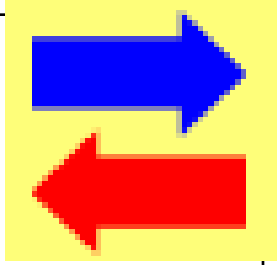


Central objective is to address the container security problem and investigate RFID-enabled solutions to confront it.

Suggestive references

- For a review of specific RFID Ocean Container Industry (OCI) applications, refer to Tsilingiris et al (2007a) & (2007b).
- Dahlman et al (2005) propose a comprehensive code of conduct towards container security.
- Lewis et al (2002) describe optimization techniques for efficient security approaches at ports.
- Stanford Study Group (2002) describes criteria for secure container systems, yet RFID is not discussed.

Introduction to RFID: Auto-ID technologies



RFID regards a system that transmits wirelessly the identity of an object using radio waves.

RFID belongs to Auto ID technologies (e.g., bar code, optical character readers, retinal scans, etc).

Auto-ID technologies have proved to reduce time and working resources needed and to increase data accuracy.

Despite their practical value, the fact that a person is needed to manually scan items is itself a constraint.

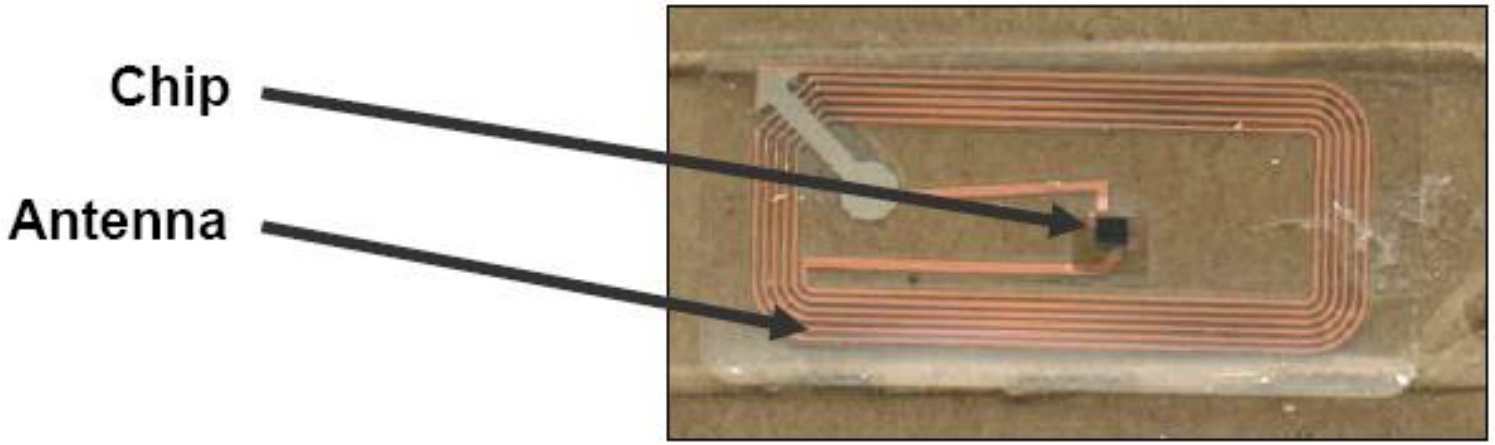
It is exactly this last part that RFID revolutionizes Auto-ID technologies.

Introduction to RFID: The RFID tag

A typical RFID tag has a microchip attached to a radio antenna mounted on a substrate.

Typical memory capacity of the chip is about 2 kb

Passive, low- (135 kHz) and high-frequency (13.56 MHz) tags usually comprise of a coiled antenna that couples with the coiled reader antenna to create a magnetic field.



RFID Tag Photograph (SAP, 2005)

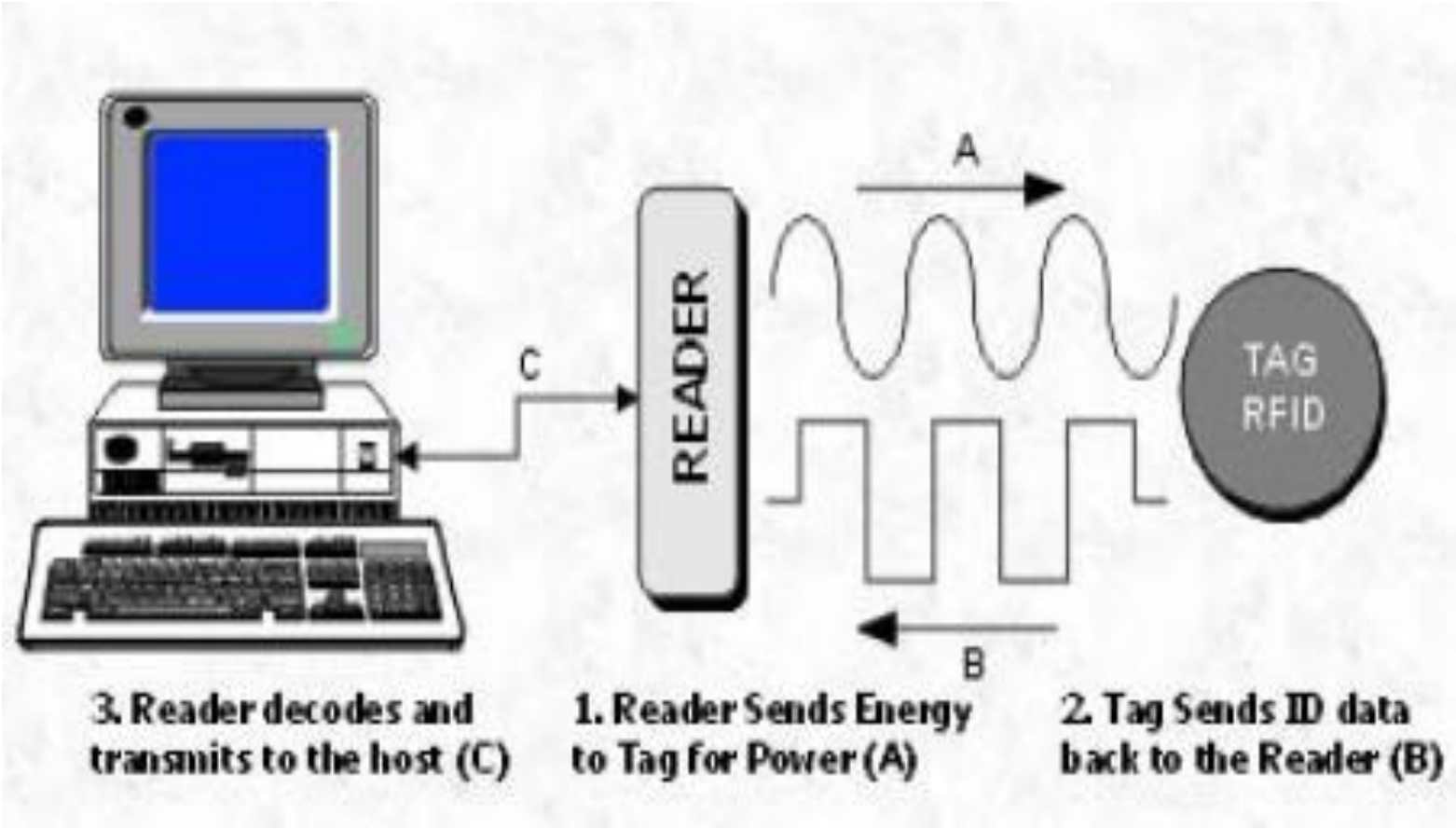
Introduction to RFID: The RFID reader

A typical reader has one or more antennas that emit radio waves and receive signals back from the tag.

The reader antenna energy is read by the tag antenna and is utilized to power up the microchip, which changes the electrical load on the antenna and transmits back its own signal.

An UHF handheld RFID reader (www.mobilevillage.com)

Introduction to RFID: How RFID works



The fundamental operation of RFID (www.rollsoft.ro)

Introduction to RFID:
RFID components and costs

Component	Actual cost	Cost depends on
Passive tags[1]	20-40 cents (up to several USD for more sophisticated solutions).	• Frequency (e.g., HF is more expensive than UHF) • Memory size • Antenna design • Packaging around the transponder
Active tags	10-50 USD	• Battery size • Chip memory • Packaging
UHF readers	500-3,000 USD	• Dumb vs. intelligent readers • Single-frequency vs. multi-frequency readers
Middleware	Depends on application	Depends on application

[1] Companies should bear in mind the cost of testing passive tags.

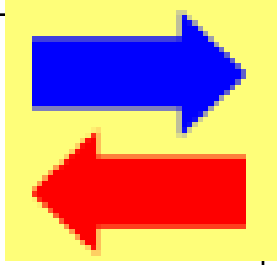
RFID components and costs

Introduction to RFID: RFID vs. Bar-code

System specifications	Barcode	RFID system
Data quantity	1-100b	2-64kb
Machine readability	Good	Good
People readability	Limited	Impossible
Influence of dirty/damp	Can lead to failure	None
Influence of covering	Can lead to failure	Moderate
Data carrier cost	Very low	Medium
Reading electronic cost	Low	Medium
Unauthorized copying/modification	Slight	Slight
Multiple reading	No	Yes
Reading speed	Relatively Low	Fast
Direct line of sight required	Yes	No
Maximum reading distance	Relatively short	Several times longer[1]
Simultaneous scanning	No	Yes
Reusable	No	Yes

[1] References report reading distances up to 80-90 meters.

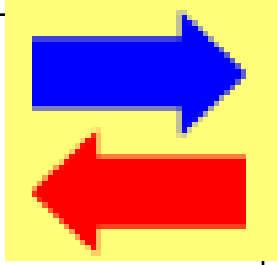
RFID vs. barcode



Drivers for RFID adoption in the OCI

- **Container Security (& Safety)** ← **We focus on this aspect.**
- Operational problems
- Legislation
- Technical reasons
- Other

Drivers for RFID adoption: Container security



Doubtlessly, container security has been the most influential driver for RFID OCI applications.

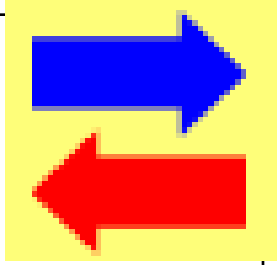
After 9/11, the millions of containers around the world are seen as gaping holes of vulnerability for terrorist attacks.

Threats:

A. Security
   - Smuggling of nuclear weapons, radiological dispersal devices, or conventional weapons
   - Nuclear and radioactive materials smuggling
   - Drugs smuggling
   - Smuggling of persons and stowaways
   - Contaminate containers with nuclear, radioactive, chemical or biological agents
   - Container boxes theft (piracy)
   - Containers contents theft (pilferage)

B. Safety
   - Damage to containers containing hazardous materials - explosion or leakage of hazardous materials
   - Damage to conventional containerized cargo caused by ordinary container transportation and handling operations and/or inspection

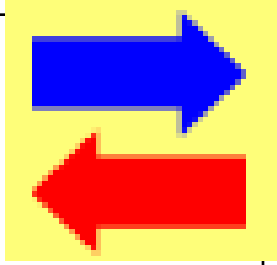
Drivers for RFID adoption: Operational problems



We diagnosed the following operational symptoms:

- Port congestion in general
- **Congestion at truck gates**
- Unsatisfactory terminal productivity
- **Loading/unloading at the quay and at the port/rail infrastructure**
- **Inaccurate container identification** (incorrect reading and storage of this information)
- Inadequate and time-expensive container damage checks
- **Exceedingly time-consuming inspection procedures**
- **Information sharing among players is below expectations**
- Coordination issues

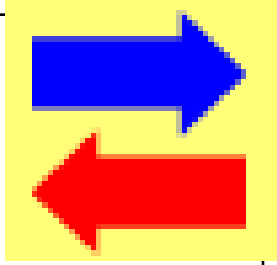
Drivers for RFID adoption: Legislation drivers



Certain initiatives and regulations foresaw the advent of RFID-enabled electronic seals (e-seals)

Many OCI practitioners think that RFID could help mitigate the side-effects of legislation on operations.

Even beyond the OCI cases that RFID utilization is mandatory, it is believed it can assist in regulatory adherence.



Drivers for RFID adoption: Legislative complexity

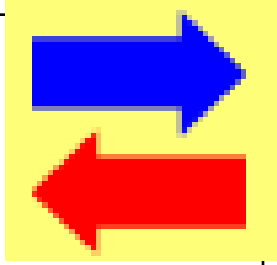
The market appears to be overregulated; there is an overlap of regulations and, yet, vulnerable gaps.

International Maritime Organization (IMO):

- International Ship and Port Facility Security Code
- International Convention for Safe Containers
- International Container Security Organisation
- Ship security alert system

EU:

- Regulation on Enhancing Supply Chain Security
- Directive on Enhancing Port Security (EC 2005/65)
- Regulation on Enhancing Ship and Port Facility Security (EC 725/2004)
- Green Paper on a European Program for Critical Infrastructure Protection (EC, 2005)

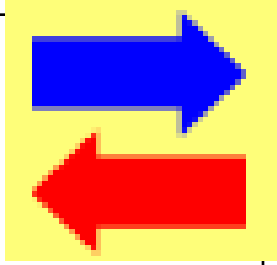


Drivers for RFID adoption: Legislative complexity (2)

USA:

- 24-Hour Advanced Manifest Rule
- 96-Hour Advance Notice of Arrival
- America's Waterway Watch
- Automatic Identification System
- Bioterrorism Act
- Cargo Handling Cooperative Program
- Container Security Initiative
- Customs-Trade Partnership against Terrorism
- Intelligence Fusion Centers
- Maritime Safety and Security Teams
- Maritime Transportation Security Act
- National Targeting Center
- Non-Intrusive Inspection Technology
- Operation Drydock
- Operation Port Shield
- Operation Safe Commerce
- Port security act of 2006
- Port Security Assessment Program
- Radiation, Chemical, and Biological Screening
- Seal Verification Program
- Security Boardings
- Security Committees Port Security Grants
- Smart and Secure Tradelanes
- Smart Box Initiative
- Transportation Workers Identity Card
- Trusted Shipper Program

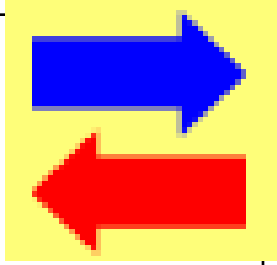
Drivers for RFID adoption: Technical drivers



Examples of technical drivers include:

- RFID reading rates improved (if implemented, tested & operated correctly, there is ~99.9% accuracy)
- Moreover, several interoperability bugs with ports computer systems have been resolved.
- International RFID-frequency standardization efforts are in progress (Technical Committee 104 "Freight Containers"/ Sub-Committee 4 "Identification and Communication")
- Electronic license plates (ISO 10374) as well as electronic seals (ISO 18185) are brought into the standardization bodies at ISO.

Drivers for RFID adoption: Supply chain drivers



We factor in the trend that ocean container carriers are transforming themselves from sea transport providers to total door-to-door supply chain providers.

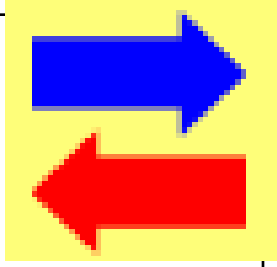
The potential impact from mass RFID usage in SC commerce is enormous.

Supply chain visibility, assisted by RFID, could transform nowadays *push* system to a *pull* one.

Today, companies plan and execute based on forecasts.

The vision is that goods are pulled through the supply chain based on real-time demand.

RFID readers placed on shelves, on the backroom, on warehouses, on manufacturer facilities and so forth would monitor how many products are being sold and the products' inventories.



RFID in the OCI: Why bother?

Answer:

We judge, and it has been proven in real small-scale applications, that RFID-enabled solutions can alleviate security problems and align with existing and forthcoming security regulations without adverse side-effects and subject to reasonable cost.

"How" this is accomplished is discussed in the slides that follow.

Generic comments on the status of real RFID applications in the OCI towards container security

1. Commercial projects dominate over academic ones.

2. The EU lags far behind the USA as regards RFID utilization to promote maritime security.

3. The central motivation for RFID use in OCI is mainly security and not operational excellence.

4. RFID does not only revolutionize technology employed, but also serves for business processes re-engineering.

5. Intermodal port-rail RFID-enabled applications are scarce.

RFID applications: RFID-enabled e-seals

The standard e-seal is an attachment device fixed to (or integrated into) the mechanical seal that secures the door of the container.

E-Seal consists of a metal locking bolt with a plastic case that holds the RFID tag linked to a sensor.

Mechanical seal

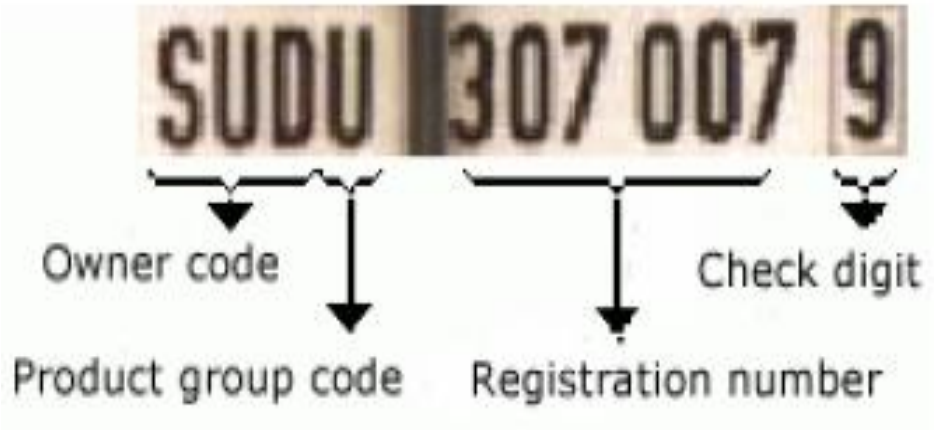
www.tenacent.co.za

E-seal

www.ops.fhwa.dot.gov

RFID applications: Container identification

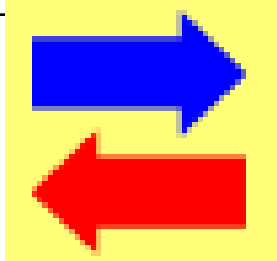
Container identification regards the correct reading (and correct storage of this information) of the markings that associate with the container ID.



nerhandbuch.de

- Often intermodal containers have multiple ID numbers.
- Even if the container ID number is unique, the personnel often stores inaccurately this information.

RFID applications: Container identification (2)

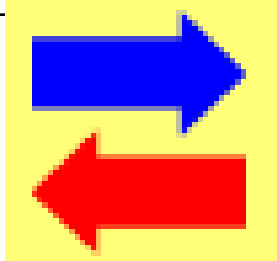


- With the RFID technology, the ID of the container can be stored on the RFID tag according to the ISO standards automatically leaving no room for wrong ID recordings.

- RFID container IDs cannot be forged.

- On the implementation side, readers placed on cranes, vehicles and other equipment enable the automatic recording of each container ID as it is offloaded and transported within the terminal.

RFID applications: Staff identification



Staff IDs via RFID identification cards

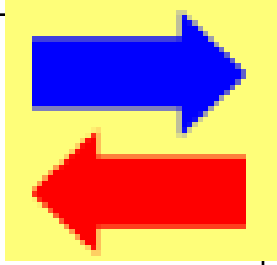
These cards can store information like holder data (name, photograph) and data related to the job function.

In unmanned areas, the RFID tag could be used as an entry card (e.g., via Closed Circuit TV).

In manned areas, other personnel may be relieved of burden as the RFID badge can contain clearances or permissions.

Using the RFID badges as stored value cards, enabling the employees to make certain purchases, could catalyze employee acceptance.

RFID applications: Vehicle access, control, and tracking



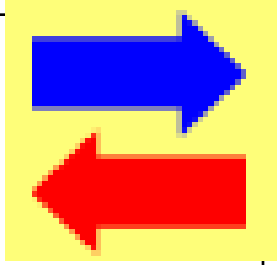
RFID tags can be adduced to equipment like straddle carriers, tractors, chasses, etc, in order to locate the equipment used.

On the implementation side, RFID tags can be attached (or buried) at certain places of a container yard.

The tags can be read by RFID readers placed on vehicles, thus, signaling the location of equipment.

The information can be communicated to the offices via wireless LAN, which is already commonplace in modern container terminals.

RFID applications: Vehicle access, control, and tracking (2)



Moreover, RFID could be used for equipment access.

Synergies could be developed with RFID employee badges to check that the right driver is driving the right vehicle.

RFID tags applied to personnel badges and vehicles can secure the correct usage of equipment (e.g., RFID tags could lock/unlock the equipment).

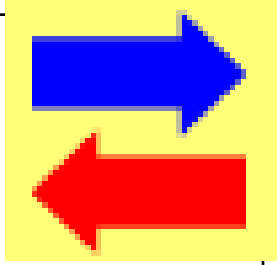
Furthermore, readers placed at access points of intermodal nodes can validate entry and exit to/from a port.

RFID applications: Activity monitoring

Apart from locating and tracking personnel and equipment, RFID can promote the monitoring of activities in a real-time fashion.

This can assist managers in the better supervision and execution of activities.

RFID applications: Synergies with sensors

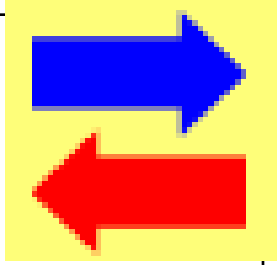


The sensors could measure certain attributes of interest and the RFID technology could store these values.

Each time the RFID container tag enters the field of an RFID reader, the values of these attributes will automatically be transmitted to the IT system of the respective stakeholder(s).

In turn, based on non-typical values of any of these attributes, the IT system could right away identify "suspect" containers and, indeed, rank the "potential hazard" of these containers according to the deviation of their attributes' values from the acceptable ones.

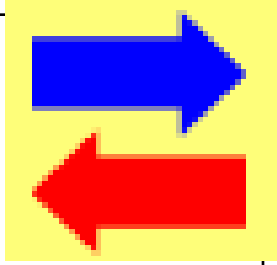
RFID applications: Synergies with sensors (2)



The sensors could measure certain attributes of interest like:

- *Humidity*
- *Light*
- *Temperature*
- *Air pressure*
- *Vibration*
- *Sound*
- *Chemical agents*
- *Position*
- *Motion*

RFID applications: Synergies with data mining



RFID can be the modus to automatically collect container transport information.

Current risk analysis does not factor container route details at a global level, like the loading/unloading ports and transshipment hubs.

Data mining techniques could be used to spot suspicious movements.

Thus, non-typical container itineraries or uncharacteristic collective behavior of groups of containers, which could not be targeted before, are likely to be timely noticed.

Recap: Route legs w&w/o RFID

Route leg	Without RFID	With RFID
Ship approaches port of discharge	No check or information exchange regarding the status of containers	Readers placed at strategic port points automatically collect information before unloading begins
Container is unloaded at the quay	Cont ID, seal, and damage check are all performed manually	Automatic check leaving no room for wrong storage of information or forgery
Within Port	Limited	Monitoring of employees, equipment, activities, and containers
Port gates	Cont ID, seal, and damage check are all done manually	Automatic check leaving no room for wrong storage of information or forgery
En-route	Limited	Readers placed at strategic points along the route check the status of containers

RFID perspectives in the OCI: Encouraging factors

The following factors fuel our cautious optimism regarding the perspectives of RFID in the OCI:

- The OCI is going well
- RFID perspectives beyond the OCI are not bad

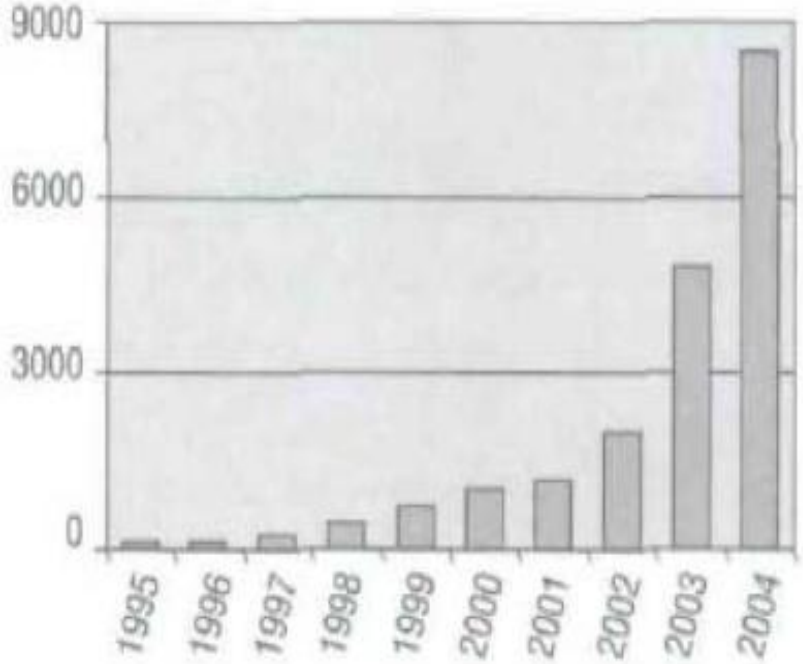
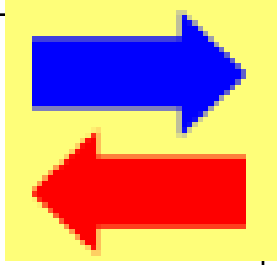
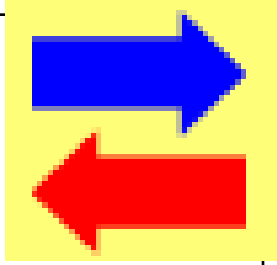


Figure 9. Number of RFID publications (Source: Sheffi, 2004)

RFID perspectives in the OCI: Encouraging factors (2)



- **The as-yet RFID in OCI projects are successful**
- **Reliability of RFID and related technologies is increasing (and bugs are getting resolved).**
- **The increasing need for container security.**
- **Operational excellence, which is so far overlooked, will be forwarded in the next years as competition in the OCI is intense.**
- **Another positive indication is the increased use of the internet.**
- **The cost of tags to the cost of the containers and of their contents ratio is rather low.**
- **The new generation of planners (more IT literate)**



Paths for RFID adoption

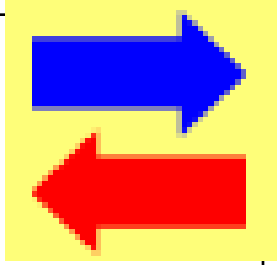
The RFID adoption path in the OCI has its pioneers/leaders and followers.

Large ocean container carriers, which also possess the majority of the container boxes, along with the biggest container terminals are the pioneers.

Small-to-medium-sized carriers, terminals, and inland transport operators will follow.

We suggest that now is the right time for an ocean company to invest in RFID.

Paths for RFID adoption: Process re-engineering & emerging technologies



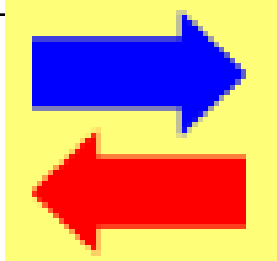
The RFID adoption path should not restrict itself to substituting other technologies.

It is important that processes are *re-engineered* in order to match the particularities of RFID.

RFID technology cannot work alone.

It should be adopted in coordination with other modern, emerging technologies.

Paths for RFID adoption: Industry adoption schemes



Lessons from other industries utilizing RFID.

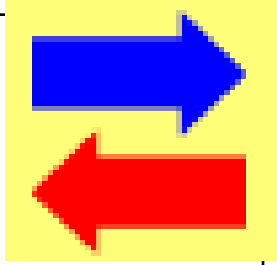
***Solo*: This path takes place when many organizations invest in the technology, but the benefits are exploited by a single company.**

***Single-to-many*: In this case, key investments are made by one partner but benefits accrue to many stakeholders.**

***Partnership*: In this path, both the investment in the technology and the benefits are collective.**

***Closed Loop*: In this path, a single company invests in RFID and harvests its benefits.**

Challenges in RFID adoption

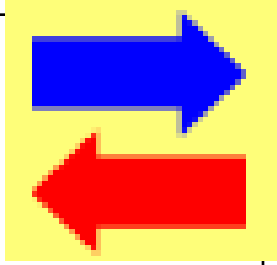


Risk aversion of ocean stakeholders: As was to be expected, initially the players were very skeptical of RFID.

Standardization: Progress in global RFID standards is taking place, but a *modus vivendi* has not been reached yet.

Differences in business processes: Our study unveiled (regarding big vs. medium-to-small EU ports) significant differences in the respective business processes.

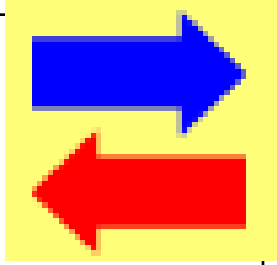
Information issues: The *modus operandi* of the ocean industry is not accustomed to the concepts of information sharing and collaborative optimization of processes.



RFID in the OCI: Conclusions

1. The main drivers for RFID in the OCI are security and operational excellence.
2. Some significant relevant RFID projects have been identified.
3. Most of them are real projects rather than academic ones.
4. Application areas are mainly:
    a. container identification;
    b. e-seals;
    c. staff identification,
    d. vehicle access control, and tracking;
    e. activity monitoring;
    f. data collection; and
    g. regulatory adherence.
5. For several factors, RFID perspectives in the OCI appear relatively rosy.

RFID in the OCI: Directions for further research



In such a thriving and continuously evolving environment there could be many research topics abreast of the industry needs.

Potential topics can be traced in the open challenges described in the challenges section, such as standardization and information issues.

One could conduct a cost-benefit analysis of RFID vs. satellite systems (among a plethora of alternatives) for container applications.

Another interesting topic of research is the generic system architecture designed to confront maritime security and, specifically, terrorism.

Acknowledgements

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Thank you for your attention!

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www.martrans.org