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GLOBAL PAPER REEL RFID (PapeRFID)

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WP6. The usability of standardised identification codes (EPC Gen 1 & 2, ISO 18006-c) in supply chains of paper reels and new possible work and business processes of paper reel cores

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VTT

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There are two options for using RFID tags and determining the memory content of the tag: either to choose the EPCglobal approach, which is mainly driven by the retail industry, or use the ISO approach. The basis of the paper reel identification system is the reel ID. At the moment, European mills are using CEPI code, news publishing industry IFRA code and US market NARI code. CEPI, IFRA and NARI codes can be written into the tag's EPC/UII memory block. All the reel information can be transferred via PapiNET. Forest Corporate information systems are already able to deal with reel information. Stevedoring companies and paper mills need systems changes. Solutions are needed for the following phases; How to integrate the tag into the core, chip resistance at winder, and how to write information on tag.

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Summary

The overall objective of PapeRFID research project is to develop a globally operable, reliable RFID tag antenna design for paper industry applications. This report summarises the work done and results from WP6. The goal of WP6 of the PapeRFID project is to study the usability of standardised identification codes (EPC Gen 1 & 2, ISO 18006-c) in supply chains of paper reels from mill to printing machine and new possible work and business processes of paper reel cores, especially integration of tag into the core.

There are two options for using RFID tags and determining the memory content of the tag: either to choose the EPCglobal approach, which is mainly driven by the retail industry, or use the ISO approach. In the EPC approach, a unique number is programmed in the EPC section, according to the EPC specifications. All other relevant information is on the internet, and can be retrieved through EPC specified processed. In the ISO approach, a Unique Item Identifier is programmed in the tag, and all information can be included in the tag memory. No additional data transfers with external parties are needed to retrieve the tag information

The basis of the paper reel identification system is the reel ID. At the moment, European mills are using CEPI code, news publishing industry IFRA code and US market NARI code. These codes have similarities but also differences. CEPI represents some 830 pulp, paper and board producing companies across Europe, and 1220 paper mills. Together they represent 28% of world production.

The air interface and memory structure of passive UHF tags is standardised in the ISO 18000-6 standard. This standard allows 3 air interfaces (A, B and C). The ISO 18000-6C standard is based on the EPC Gen 2 specifications. The memory available at passive UHF chips is continuously increasing. Today, memories with 512 bits of user memory exist, some newest have even 32 kbytes of memory. The ISO-18000-6C standard determines the chip memory to consist of four parts; tag ID, UII (Unique Item Identifier) memory, reserved memory and user memory.

CEPI, IFRA and NARI codes can be written into the tag's EPC/UII memory block. The CEPI code is aligned with the ISO-guidelines on Unique Item Identifiers, and hence would be the most straightforward to program into the tag's EPC/UII memory block. However, according to paper manufacturers, the CEPI code is difficult to "sell" to customers, and here is a danger that the customer demands own tag in the core. Another development is related to GS1, whose codes are in use in most applications. EPCglobal has recently started discussions with the paper industry on the implementation of EPC codes for the paper industry.

The moment of writing depends on what code is used. In case the tag is written after the winding (e.g. IFRA), another identification system is needed before the wrapping.

Different organizations are also developing codes. The same code question is true also in other industries such as electronics and metal industries.

All the reel information can be transferred via PapiNET. PapiNET currently defines RFID as a package identifier. PapiNET does not define the contents. PapiNET is commonly used between mills and big customers. Smaller ones are using web services, if any.

Forest Corporate information systems are already able to deal with reel information. Stevedoring companies and paper mills need changes in systems. The need and possibility to read reel information in the supply chain depends on the operator, the methods of operation and location. Automatic reading of RFID tags improves, according to interviews, efficiency and control of supply chains.

Corenso manufactures all StoraEnso’s and 60% of UPM's cores. As an example, in StoraEnso’s Anjalankoski mill there is only one core cutter for entire production (approximately 3000 rolls / day). Producers of StoraEnso’s core cutters are Raumaster and Corelink.

Solutions are needed for the following phases; how to integrate the tag into the core, chip resistance at winder, and how to write information on tag. Automated integration demands for the development of a "robot". This is not, according to Corelink, a challenging task. The real challenge is the fact that all mills are different.

It is possible to develop a label robot for PapeRFID tags. Technically it should not be especially demanding. Application of the tag should happen after the core cutter and before the winder. Also a hole for the chip is possible. At the moment there is no equipment ready. In the winder the joints have caused problems in pilots. All mill layouts are different and need an implementation project for the label robot.

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1. Introduction

The Finnish paper industry and research organizations have already for several years studied the possibility to use RFID (Radio Frequency Identification) for automatic paper reel identification. Since RFID does not require line of sight, identification, identification is independent of the orientation of the label towards the reader. When the tag is applied to the core of the reel, it also allows identification of partly used reels, and hence allows complete tracking from the start of manufacture until the end of use. RFID offers to make many processes more efficient, such as warehouse management and tracking. The increased possibility of identification offers also new prospects for logistic providers, and allows the paperless transfer of information between partners.

In order to guarantee wide take-up of RFID technology, which is beneficial for all partners in the supply chain (paper mill, logistic service providers, and final customer), standardization of the tag and its communication is required. If no standards are provided, it is possible that there will be different incompatible systems on the market, so that not all partners from the supply chain can benefit from the systems.

In paper industry paper and board reels have to be identified reliably throughout the supply chain from paper mill to the end user for example in printing companies. Passive ultra-high frequency (UHF) radio frequency identification (RFID) technology offers a possibility for automatic identification of paper and board reels. The first omni directional tag antenna, called C-tag antenna, for paper industry applications that can be read through paper and board with standardized RFID equipment (European standards, 2 W ERP) was developed in eSCID (Electronic Supply Chain Identification with Passive RFID) project. eSCID was a part of Electronics and Logistics (ELO) technology program of the Finnish Funding Agency for Technology and Innovation (Tekes).

Omni directional reading of the paper reel tag is one of the fundamental requirements in applying RFID systems to paper industry. When reels are identified with a clamp truck-integrated RFID reader unit, the reel is clamped from arbitrary direction, and despite of that fact the reel has to be identified reliably. In addition, reading from any direction is a requirement also when the reels are identified at any other location in the paper reel supply chain, for example on a conveyor belt. In practice omni directional reading means that there is no need to turn the reel for desired identification orientation. The concept of omni directional reading is presented in Figure 1.

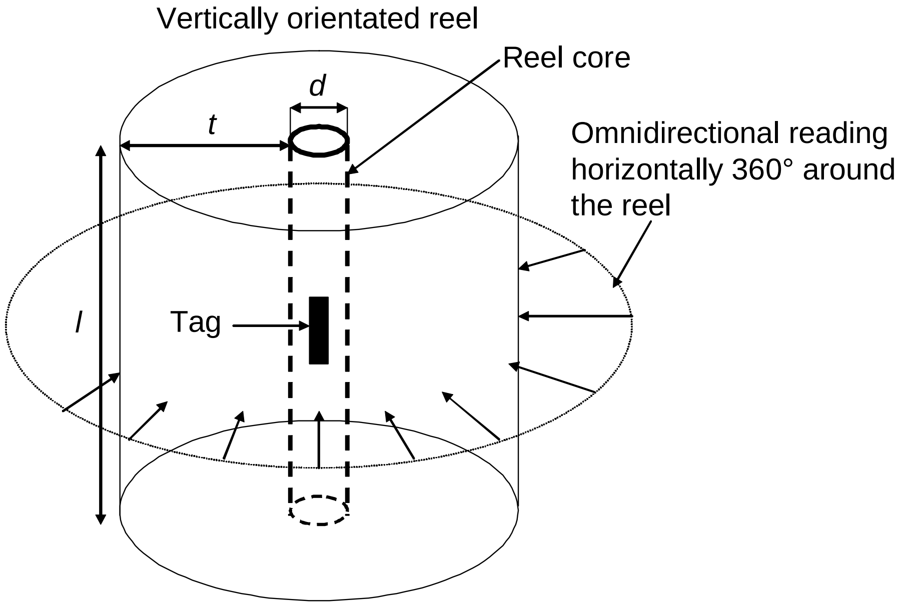

Figure 1. *The concept of omni directional reading.*

RFID of paper and board reels has been under research for over the past decade. However, previously sufficient read ranges, reliable identification or omni directional reading has not been achieved with standardized RFID equipment.

Nowadays when barcodes are used in paper reel identification, the identification number and other information about the reel disappear when the wrapping and the barcode are removed. However, many end users would like to identify the reels also after the wrapping is removed, for example when a half-used reel is taken into use again. Instead of a barcode, RFID systems use a tag as an identification carrier. A tag consists of a microchip and an antenna. The paper reel tag is attached on the outside surface of a reel core, after which paper or board is wrapped around the core. This way the tag is placed under the wrapped paper or board as shielded as possible, and it is identifiable throughout the whole life cycle of the reel from paper mill to the end user. This research concentrates on passive UHF spectrum RFID systems and passive tags. Passive tags do not have any internal source of energy to support the functioning: they get all the energy needed for functioning from the electromagnetic radiation emitted by the reader.

The reels have to be identified reliably in all the identification locations throughout the life cycle of the reel. Inside the paper mill the reels are identified for example when they move on a conveyor belt or are handled with reel handling machinery. Another important identification spot is a clamp truck. The reels would be identified with a clamp truck-integrated reader unit. RFID enables reliable identification of reels “from cradle to grave” in all the phases of manufacturing, transport and end usage.

The global aim in the standardization of RFID systems is to achieve one international RFID standard to ensure the compatibility of RFID systems around the world. This postulates studying the usability of these international standards in paper reel identification. In addition, the developed tag antenna design for paper industry applications has to be operable globally within the whole UHF RFID bandwidth. Global paper reel RFID means that the reels can be identified using the same tag equally in every continent (Europe, Americas, Asia, Australia) despite the differences in RFID centre frequencies and transmission power levels allowed.

Paper and board reel RFID also creates new processes concerning the supply and handling of the reel cores. The application of RFID in paper industry requires also automatised solutions for attaching the tag to the reel core.

2. Goals of WP6 and the PapeRFID project

This report summarizes the work done and results from WP6. The goal of WP6 of the PapeRFID project is to study the usability of standards and new business processes. This includes

- Usability of standardised identification codes (EPC Gen 1 & 2, ISO 18006-c) in supply chains of paper reels from mill to printing machine
  - Pallets, other units and products - interoperability with other developed identification systems
  - Integration with customers
  - Viewpoints of supply chain operators (ports, shipping lines etc)
- New possible work and business processes of paper reel cores
  - Integration of tag into the core

The overall objective of PapeRFID research project is to develop a globally operable, reliable RFID tag antenna design for paper industry applications:

- The basis of the research is that every reel that is handled has to be identified reliably with one passive UHF RFID tag.
- Read range from the centre of the reel will be at least 1500 mm despite the radius of the reel and paper or board quality. Currently the maximum diameter for board reels is 2100 mm. In this case, the sufficient read range measured from the board layer surface is 300 mm – 400 mm.
- Standardization of the tag antenna dimensioning: The goal is to develop a tag antenna that can be used with different paper qualities and reel core diameters.
- The tag has to be operable globally within the UHF RFID band from 865 MHz to 960 MHz (Europe, Americas, Asia, and Australia).
- Read/Write possibilities. The paper reel tag will be a Write Once Read Many-type tag
- The paper reel RFID tag will contain a fixed 14 character reel identification number.
- Recyclability of the tag materials and their effects on the reel core recycling process will be studied.
- The tag must endure the common environmental conditions in the paper reel supply chain
- The objective for the reading reliability is 99.99 % - 99.999 %
- The issues in industrial manufacturing of the paper reel tag will be studied.

PapeRFID will also include a preliminary study on clamp truck integrable RFID reader units. The results of this research project will be verified with large-scale testing in industrial environment.

3. Project executing

Tampere University of Technology Rauma Research Unit was the responsible executive organization of the PapeRFID project focusing on all the tasks related to development of the tag antenna design. Technical Research Centre of Finland (VTT) Logistics Unit was responsible of defined work packages focusing on the usability of RFID standards in paper reel RFID and developing new business processes for tag attaching to the reel cores. The duration of the project was from September 1, 2006 to April 30, 2009.

In 2006 studies focused in the manufacturing and use of cores in the forest industry. In addition, the contents of EPC standard and different types of information architectures were studied.

In 2007, the handling and transfer of reel information in the supply chain was studied (Metso as manufacturer of handling equipment in paper mills, Stora Enso and M-Real as producers of paper, Raumastevedoring and Steveco as handling operators and Sanomala as an end customer). Also possibilities how to integrate the tag in the core were studied. EPC chip memory structure, EPC and ISO standards of business processes, and various codes (especially currently used CEPI reel number) were clarified.

In 2008 the work focused on the use of different identifier codes at various supply chain stages.

Co-operation was launched with the CEPI (Confederation of European Paper Industries) to ensure the compatibility of used codes. Data transfer was discussed with the PAPINET (global forest industry data standard).

VTT has participated in the management meetings 18.8.2006, 29.11.2006, 18.4.2007, 20.9.2007, 12.12.2007, 12.3.2008, 26.1.2009 and 26.5.2009 (Permala and / or Scholliers) and Workshop-days 27.9.2006 (Permala, Scholliers) and 11.12.2007(Scholliers).

In addition, Permala has participated in the project planning meetings and to the pilots in Sanomala and UPM mill. PowerID introduced their products to the project team at VTT 18.4.2007. Co-operation meeting with CEPI was arranged in 26 February 2008.

The results of the project have been included in a paper presented at the ITS World Congress 2008 in New York and will be included in a paper accepted for ITS World Congress 2009 in Stockholm.

At VTT the project manager was Chief Research Scientist Antti Permala. Dr Johan Scholliers has participated in the study. Project management team consisted of the following persons: Jouko Aumasalo / Jari Ovaskainen Raflatac / UPM Oyj, Jaakko Tuomainen / Vesa Sarkkinen Stora Enso Oyj, Antti Laukkanen M-Real Oyj, Arttu Lehto / Petri Viinikkala Rauma Stevedoring Oy, Ahti Turkia Steveco Oy, Hannu HeinoNordicID Oy, Kari Terho MetsoPaper Oy, Peter Merin Auramo Oy (chair of the

group), Jari Ovaskainen UPM-Raflatac Oy, Johanna Blom Sanoma Oy, Heidi Lindroth / Jukka Lohivuo Tekes, Lauri Sydänheimo / Leena Ukkonen TTY Rauma unit (secretariat), Antti Permala / Johan Scholliers VTT.

The project was financed by participating companies, Finnish Funding Agency for Technology and Innovation (Tekes) and VTT.

4. Core and tags

4.1 Production

Corenso produces all cores of StoraEnso and 60% of UPM cores. Strength classes of cores are Eco4 – Eco8. The strength of core depends on the strength of core board and thickness of board. Part of raw material of board can be recycled material which can contain "glossy" particles. Some characteristics of cores:

- Thickness of wall is 10 – 15 mm; e.g. 15 mm core contains 32 laps of 0.5–0.6 mm thick board
- On the surface there is thinner band (0.3 mm)
- Clueing is done with water glass, also other clues are in use
- Sizes 3´and 6´and bigger 9´and 12´
- Core tube has the width of winder
- Humidity of core is 13–15% in production and 8-9 % after drying which is the same as humidity of paper
- Drying takes about one week
- Bar widths are 3050–9500 mm (in Loviisa) / - 9550 mm (in Rauma)
- Accuracy of bar length is +/- 2 mm, in cuts +/- 1 mm

Orders and deliveries of cores are done every week. Outer diameter has to be precise as the mill can use different bars in same trim. [1]

4.2 Paper mill

Core handling was studied in Anjalankoski paper mill[2]. There is only one core cutter in Anjalankoski mill for the whole production (about 3000 reels per day). There are 4 winders, a fifth is coming. Cores are ordered according to the width of winders and cut one by one. Today the reel end label is clued by hand, in future this is done with an ink-jet printer. Automation of core cutting is planned. Core cutter manufacturers of StoraEnso are Raumaster and Corelink companies. Winder bases on king roll or seat principle. The reel pressure of a winder is big and it takes a long time before the winding process starts. The high reel pressure may damage the tag. Some specifications:

- Winder widths are 8.60 and 5.50 m.
- Main size of cores is 76.2 mm, other sizes in use are 71 and 79 mm (inner diameter). Outer diameter is always 102.2 mm.

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[1] Source Corenso Maarit Vilhunen 22.9.2006

[2] Stora-Enso Jussi Kääpä 25.9.2006

Figure 2. *Automated core cutter*[3].

4.3 Core cutter producer

The Core Link Company, a producer of core cutter equipment was interviewed[4] to survey the cutter development and possibilities to integrate RFID technology. Usually there is one automated cutter per mill and one manual cutter as backup and for rewind. Core Link is a big supplier in Finland. The target group for automation is about 250 mills globally. The number of cores can vary between 2 to 40 per winder. The cut plan comes from the mill system.

Recycled material in cores cause problems (ends are not round). In joints Core Link uses male / female grooves and glue (returned from the mill). In North-America often metal caps are used at the end of the core.

It is possible to develop a label robot for PapeRFID tags. Technically it should not be especially demanding. Application of the tag should happen after the core cutter and before the winder. Also a hole for the chip is possible. At the moment there is no equipment ready. In the winder the joints have caused problems in pilots. All mill layouts are different and need an implementation project for the label robot.

There is also pressure from other competing RFID projects (Sonoco, Power ID). These projects are driven by mills, not necessarily on company level. Anjala, Imatra and Simpele are good sites for identification of mill needs.

4.4 Tag integration into the core

The maximum allowable thickness of the antenna and chip is 0.1 – 0.2 mm. In case there is roughness on the core, this has still influence after 30mm of paper has been wrapped. It is possible that a hole is needed in the core for the chip.

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[3] http://www.corelink.se/Page.asp?PageNumber=18

[4] Corelink J Jensen 8.10.2008

Core cutter is the place where the tag should be installed. Integration with existing core cutters needs analysis of existing types and integration possibilities. In new core cutters integration of tag installation is needed. In case the installation is manual, there will be one work phase more. Pre-cutted cores are also a possibility.

When the tag should be written and what to do if the writing is not successful? Possibilities are

- Before installing on the core
- On core cutter after installing the tag
- After winding; the write distance is approximately one half of the reading distance.

The first identification is needed when the reel is measured and weighted after winding. The need of all existing labels and manual markings should also be evaluated. The second reading is needed after the packaging when the reel is going into storage and loading.

4.5 Conclusions on tag and core integration

Corenso manufactures all StoraEnso’s and 60% of UPM's cores. As an example, in StoraEnso’s Anjalankoski mill there is only one core cutter for entire production (approximately 3000 rolls / day). Producers of StoraEnso’s core cutters are Raumaster and Corelink.

Solutions are needed for the following phases; how to integrate the tag into the core, chip resistance at winder, and how to write information on tag. Automated integration demands for the development of a "robot". This is not, according to Corelink, a challenging task. The real challenge is the fact that all mills are different.

If no changes are made to the core, the chip "rises" from the surface of the core. This problem has to be solved e.g. with a hole in the core. The high pressure caused by the winder damaged tags during earlier tests at the Imatra mill.

Potential places for the installation of the tag:

- Core production (on surface or under the surface board or even more deep in core)
- In core cutting
  - in core production
  - in every mill
  - in centralised unit
- At winder
  - by hand
  - automated
  - on core
  - on paper

When will the tag be written – before winding or after? The answer depends on the code to be written. Production phases should be automated, no manual procedures should be added.

5. Data content and transfer

5.1 Two approaches: ISO and EPCglobal

There are two options for using RFID tags and determining the memory content of the tag: either to choose the EPCglobal approach, which is mainly driven by the retail industry, or use the ISO approach.

EPC

EPCglobal is developing industry-driven standards for EPC (Electronic Product Code). Standards cover the tag content and interfaces and the exchange of EPC related information over the network.

In the EPC approach, a unique number is programmed in the EPC section, according to the EPC specifications. Current codes, which can be programmed, include SSCC (Serial Shipment Container Code) and SGTIN (Serialised GTIN – Global Trade Identification Number). All other relevant information is retrieved through EPC specified processes (Figure 3). Electronic Product Code Information Services (EPCIS) is an EPCglobal standard for a data communication interface to securely share product movement information between trading partners. Product information may be delivered by RFID or e.g. barcode or active RFID tag. EPCIS defines interfaces for capturing data and querying data.

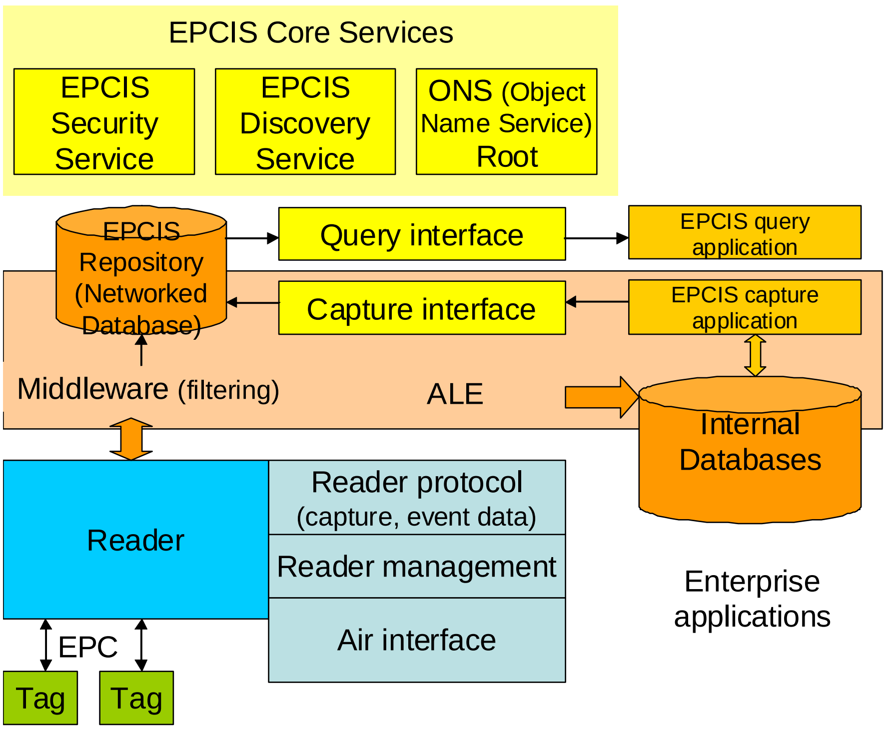

Figure 3: *Exchange of data using EPC services*

The advantage of the EPC code system would be that paper reels will be part of the global numbering system, maintained by GS1 organisation. This is already the standard for the pallets in many branches such as retail, defence and health care.

The main disadvantage is that it may require EPCglobal membership, so there is a cost to maintaining the codes. The CEPI number has to be incorporated in one of the existing EPC types, or the use of a new type has to be discussed with EPCglobal.

Also there are phases in the paper supply chain where there is no access to the internet or to other network. This means that there can not be solutions where some information is retrieved online from the IT system. The operations must base on advance information or visual codes.

ISO

In the ISO approach, a Unique Item Identifier is programmed in the tag, and all information can be included in the tag memory. No additional data transfers with external parties are needed to retrieve the tag information.

The Unique Item Identifier is the ISO equivalent to EPC code. It includes three components (**Table 1**):

- an issuing agency. ISO and CEN have engaged NNI to administer the registration of organisations as Issuing Agencies. Both CEPI or GS1 are registered.
- a company identifier issued by the issuing agency
- a serial number assigned by the company.

Table 1: *Unique Item Identifier structure (example implementation of HIBCC, the health industry organisation)*

	Description	Example
DI	Data Identifier	25S (Serial Number is contained in the data, ANS MH 10.8.2)
IAC	Issuing Agency Code	LH (HIBCC).
Labeler	company code	company code issued by the Issuing Agency
Data		e.g. Serial Number The labeler must ensure that the data coded is unambigous within their company

The identifier is independent from technology, and can be implemented as bar code, 2D-code, RFID or human readable text.

5.2 Codes in use in the paper industry

The basis of the paper reel identification system is the reel ID. At the moment, European mills are using CEPI code, news publishing industry IFRA code and US market NARI code.

5.2.1 CEPI Code - UIB

CEPI represents, through its 17 member countries (15 European Union members plus Norway and Switzerland) some 830 pulp, paper and board producing companies across Europe, ranging from small and medium sized companies to multi-nationals, and 1220 paper mills. Together they represent 28% of world production. Finland is represented in CEPI by The Finnish Forest Industries Federation. CEPI has also relations to other similar international organisations such as The International Council of Forest and paper associations (ICFPA see http://www.icfpa.org/).

The PapeRFID project contacted CEPI, in order to find a standardized solution, and to guarantee that partners all over Europe can benefit from the RFID technology. CEPI does not have a Working Group dedicated to RFID or unit identification. According to CEPI, the RFID solution - whatever it is - should use the CEPI Unit Identification System.

The CEPI Paper Packaging Coordination Group should be informed about this issue and might the right body to consider this subject as it gathers all the representatives from the paper packaging chain.

The CEPI code is a packaging ID. In case there are two reels in the same package, each reel has a unique CEPI code and the package either a third one or the other of the package. The CEPI code consists of a 4 digit mill code and a 10 digit identifier (**Figure 4**):

1	*8*	*0*	*9*	*4*	*4*	*3*	*7*	*2*	*1*
10 Digit identifier *unstructured – format to be agreed by trading partners*									

3	*8*	*1*	*5*
4 digit Mill code *number given by CEPI*			

Figure 4. *Structure of the CEPI UIB code*

Most reels made in Finland contain the CEPI code in bar code format. This is also called the transport code. CEPI manages only the last four digits of the 14-digit code. Each CEPI member mill in Europe and some mills in other continents have a unique CEPI identifier.

Every mill can have own system for the first 10 digits in the CEPI code. Some examples: in StoraEnso Varkaus mill the code contains machine number, check digit, a sequential number of 7 digits and the last digit of the year. In UPM a code may consist of 1 digit for the year, 1 for the machine, 2 for the week, 3 for the tambour, 2 for the setoff tambour and position of the reel and 1 for check. In case 9 digits is not enough for the 1 digit machine code, capital letters are used (A, B, C …).

A part of the CEPI codes, which do not include reel specific information, can be written in advance in the tag. The codes which contain reel specific information, e.g. the position of the reel, can be written only after the reel is wound. If the tag has to be written before the winding, many mills have to change their CEPI coding system.

5.2.2 IFRA-Code

The IFRA code is a 16 digit code, consisting of the following elements shown in **Figure 5.**

2 3 5 5 2 5 1 2	**0 7 3 2**	**1**	**2**	**7 2**
Digits 1-8	Digits 9-12	13	14	15-16
	reel weight			

Figure 5. *IFRA-code*

- Digits 1-8
  - Digit 1 paper machine no
  - Digit 2-3 week of manufacture
  - Digit 4-8:
    - Scandinavia: 5-digit serial number
    - Central Europe:
      - 3 digit tambour number
      - set & position in tambour
- Digit 9-12: reel weight
- Digit 13: copacking /manuf. code
- Digit 14: grammar & quality
- Digit 15& 16 manufacturer code

The code hence includes reel weight, which is only known after reel manufacture. IFRA is developing its code contents. IFRA has the opinion that the reel ID and the data should be separated. The reel ID could be handled with a clearly defined identification system like the CEPI reel identifier. The current IFRA code has the problem that codes are reused. This causes problems in IT systems. There can be two reels with the same code.

5.2.3 NARI (North American Roll Identifier)

US NARI customer codes include 13 digits; company, mill, machine, year, month, day, jumbo, set and position, according to North American Paper Roll Identifier standard (**Figure 6**).

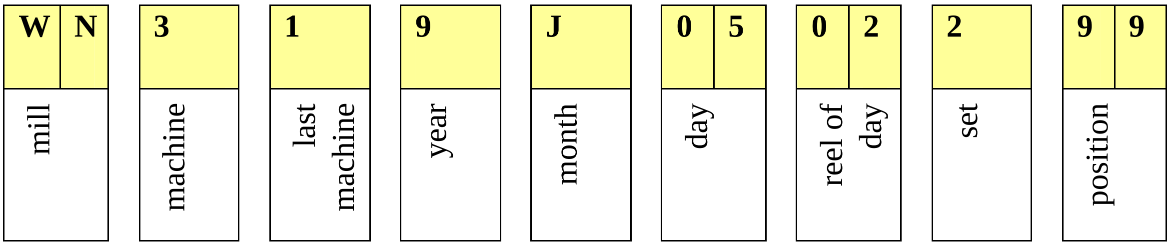

Figure 6*: Example of NARI-code (http://www.wlinpco.com/documents/NARI_roll_numbers_color.pdf)*

The new North American Roll Identifier provides a unique number on each roll of paper manufactured in the U.S., Canada, and Mexico, and the one that follows a uniform format from one mill to the next. This specification, developed by a GCA-led joint paper/publishing/printing industry committee improves on the former roll identifier by offering a standard format and extending the time span of the unique number from two to ten years. The basis was the former TAPPI roll identifier. The standard offers guidelines for implementing the new roll identifier in the industry.

If the code does contain more information than a serial number, this information can be used for statistics. According to experiences of UPM in US, the reel number with reel information gives the printing houses good source for statistical data.

All the necessary customer information is also printed in the naked end of the reel so that the customer can read the codes after the wrap has been removed.

5.2.4 Comparison of CEPI, IFRA and NARI codes

Figure 7 gives the comparison of data content of different codes. These codes have similarities but also differences. Critical is the reel weight which can be written into the tag after the weighing station.

CEPI	IFRA	NARI
Mill code (4 digits)	Paper machine no	Mill code
10 digit serial number (may be running number or have meaning dependent on mill)	Week	Machine nr
	Serial nr or tambour nr	Last machine
	Set & position in tambour	Year
	reel weight	Month
	Copacking /manuf. Code	Day
	Grammage & quality	Reel of day
	Manufacturer code	Set
		Position

Figure 7. *Comparison of the data content of CEPI, IFRA and NARI codes.*

5.2.5 Additional codes

EAN

The structure of EAN codes is:

- EAN-14 V 123 456789012 C
- EAN-13 0 123 456789012 C
- EAN-8 0 000 001234567 C
  - **V:** Logistic Variant assigned by the manufacturer (trade items)
  - **C:** The last digit serves to check that those preceding have been correctly captured. It is always calculated using the previous digits.

Printing houses

Printing houses are certainly willing to write own data in the tag as they today attach own reel labels.

5.3 ISO 18000-6c tags

The air interface and memory structure of passive UHF tags is standardised in the ISO 18000-6 standard. This standard allows 3 air interfaces (A, B and C). The ISO 18000-6C standard is based on the EPC Gen 2 specifications.

The memory available at passive UHF chips is continuously increasing. The first UHF EPC Gen2 chips had only 96 bits of memory. During the project, chips with a higher amount of memory became available, such as the Philips NXP G2LM chip, which was announced in September 2007 and provides 240 bits of user memory, and the G2XM chip which offers 512 bits of user memory. In February 2009 the start-up Tego announced their passive UHF tag which has 32 kbytes of memory.

The ISO-18000-6C standard determines the chip memory to consist of four parts.

1. **TID (Tag ID**) memory (min. 32 bits). This memory part is permanent and programmed by the chip manufacturer. The size of the memory is minimum 32 bits, and in this case the Tag ID is not unique. Some chip versions also provide (unique) 64 bit Tag IDs.
   - 8-bit ISO/IEC 15963 allocation class identifier (bit 0-7)
   - 12-bit tag mask-designer identifier (bit 8-19)
   - 12-bit tag model number (bit 20-31)
   - Opt. tag- and vendor-specific data (e.g. tag serial number)

2. **UII (Unique Item Identifier) memory** (also called EPC memory)
   - For EPC-tags: EPC code (e.g. SSCC, SGTIN)
   - For ISO-tags: structure:
     - Issuing Agency Code (IAC),
     - Company Identification (CIN),
     - Serial Number (SN)
   - The size of the memory is typically 96 bit, but can also be 495 bit
   - The memory structure is in more detail:
     - CRC-16 at bit 0-15
     - Protocol-Control bits (bit 16-31)
       - UII length field (bit 16-20)
       - bit 21: user memory used (0: no user memory, 1 user memory)
       - bit 22: PC extension indicator bit
       - NSI (Numbering System Identifier) (bits 23-31)
         - bit 23: 0 for EPC header; 1 for AFI
         - bit 24-31
           - AFI (Application Family Identifier) - ISO/IEC 15961 (draft version). The AFIs should be managed by a specific Registration Authority, as determined in ISO 15961-2.
           - AFI for product/product package: B1h
           - AFI for transport unit: B2h
           - AFI for RTI intended for non-retail: B3h
           - zero for EPC
     - code starting at bit 32:
       - EPC code (including EPC header)
       - UII (Unique Identification Number).
     - memory is filled with zeros.

3. **Reserved memory**
   - kill password (bit 0-31) [if not exist, treated as zero]

- access password (bit 32-63) [if not exist, treated as zero]

4. **User memory** allows user-specific data storage. The user memory is formatted in compliance with the ISO 15961 and 15962 RFID data protocols

Table 2 gives an overview of products from chip producers (status at end of 2007).

Table 2. *Chip characteristics.*

		EPC memory	TAG ID	user memory
Philips NXP	UCODE EPC G2	96	64	224
Impinj	Monza	96	32	0
	Monza/ID	96	64	0
	Monaco/64	96	32	64
TIRIS	RI-UHF-00001-01	96	32	0
	RI-UHF11111-01	96	32	0
	RI-UHG-STRAP-08	96	32	0
ST-microelectronics	XRAG2	304	64	
		176	64	128

5.4 Assessment of the implementation of paper reel codes with ISO 18000-6C tags

5.4.1 Memory use

CEPI code

The CEPI code corresponds to the UII requirements:

- Issuing Agency: code PA: 2 char
- Company Identifier: Mill code: 4 digit
- Serial number: 10 digit identifier

Need for memory for the CEPI code:

- IAC: 2 char (””): 16 bits (ASCII)
- Mill code: 4 digits > 14 bits
- Serial nr: 10 digits > 34 bits

- Sum :
  - Optimised (Mill code and serial number stored as integers in binary form): 64 bits
  - 1 digit = 4 bits: 16+14*4=72 bit
  - All in ASCII: 16 bytes = 128bits

IFRA code

Content	Min. number of bits (binary integer)
Digits 1-8	
• Digit 1 paper machine no	4 bit
• Digit 2-3 week of manufacture	6 bit (max. value 52)
• Digit 4-8:	18 bit
• Scandinavia: 5-digit serial number	17 bit
• Central Europe:	10 bit+4 bit + 4 bit
• 3 digit tambour number	
• set & position in tambour	
Digit 9-12: reel weight	14 bit
Digit 13: co packing /manuf. code	4 bit
Digit 14: grammar & quality	4 bit
Digit 15& 16 manufacturer code	7 bit
Sum	57 bits

- Sum :
    - Optimised (integers in binary form): 57 bits
    - 1 digit = 4 bits: 4 bit * 16 = 64 bit
    - All in ASCII: 16 bytes = 128bits

NARI code:

- Mill code: 2 characters: 16 bits (ASCII)
- rest: 10 digits + month code; if programmed as 4 bits: 4 bit *11 = 44 bits
- total: 60 bits

In summary, CEPI, IFRA and NARI codes can be written into the tag's EPC/UII memory block. The CEPI code is aligned with the ISO-guidelines on Unique Item Identifiers, and hence would be the most straightforward to program into the tag's EPC/UII memory block.

However, according to paper manufacturers, the CEPI code is difficult to "sell" to customers, and there is there is a danger that the customer demands own tag in the core.

Another development is related to GS1, whose codes are in use in most applications. EPCglobal has recently started discussions with the paper industry on the implementation of EPC codes for the paper industry.

5.4.2 Moment of writing

If the code is completely known before manufacturing of the reel, the tag can be pre-programmed before application. If not, then the tag should be written after manufacturing. The writing distance is essentially shorter than the reading distance (about half of the reading range). CEPI codes may, depending on the mill, include data which is only available after manufacturing. IFRA and NARI contain data such as weight or position, which are not known beforehand.

Tests are needed in order to find out the writing range and right writer antenna solution. Also the chip model has influence on read/write distance. PaperRFID project tests showed that writing through the reel is possible.

One question is how the CEPI code and the reel information are attached in the database. In case the tag is written before winding, the code can be read in wrapping phase. The diameter and weight are measured in packaging phase. Width comes from winding machine. In case the tag is written before winding, it can replace the bar code labels used at the core end. In this case the mill IT system gives the CEPI code before winding and the code can be read after the winding, before the packaging. If the CEPI code is given at the packaging phase, the core bar code labels are still needed.

The codes or the information may change during the chain. E.g. in case the reel is re-wound, the IFRA weight information is not right. Some mills reuse old cores. How the tags are managed in these cases? Also tags may be re-wound. In re-winding the code can be re-written into new tag

Regarding writing of data, security issues have to be taken into account. Writing has to be secured with password. It is possible to lock the data written to the UII part of the tag permanently, and to leave the user memory for the customer to write whatever they want to include in the tag with access password.

5.5 Transfer of RFID data between partners

5.5.1 PAPINET[5]

PapiNet is an XML standard developed by and for the paper & forest industry to facilitate exchange of business documents between business partners in XML format. PapiNet has evolved to a global standard for the paper & forest industry since September 2000. Co-operation with North America was initiated & started with Idealliance (GCA at the time) and American Forest and Paper Association (AF&PA). The standard has created documentation for about 40 messages. [6]

All the reel information can be transferred via PapiNET. PapiNET currently defines RFID as a package identifier. PapiNET does not define the contents. PapiNET is commonly used between mills and big customers. Smaller ones are using web services, if any.

The identification references, attached to a package as RFID, can already today be transfered in PapiNet messages. This is one identification of a package among others (CEPI, EAN, internal references, etc) and it will not affect messaging in a specific way. Changes have to be done in information systems. An open question is can PapiNet agree to recommend standard(s) for RFID usage in the future?

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[5] Bengt Wentus 26.2.2008

[6] www.papinet.org

5.5.2 Case StoraEnso – Sanomala

A practical example of the current ways of exchanging information between the mill and customer is the case StoraEnso – Sanomala, a Finnish printing house. Data is transferred via email. The message is based on PapiNet DeliveryMessageV2R10. Message is defined in StoraEnso Fenix in-house system. The content of this message is:

- Header - Waybill ID
- Mill code
- Mill name
- Record – weight, length, units, waybill ID
- IFRA code.

5.5.3 RFID architectures

The information from the readers has to be transmitted and integrated in the company's own information system (e.g. ERP system). All big IT providers have developed solutions and software for the managing of RFID readers and data.

EPCglobal does not only specify the data content and air interface, but has also standards developed for the communication of data between the different partners in the supply chain.

6. Identification processes in paper supply chain

This chapter gives some viewpoints of the different stakeholders in the paper supply chain. The outcome bases on interviews of project management group members. Figure 8 gives a simplified structure of the paper supply chain.

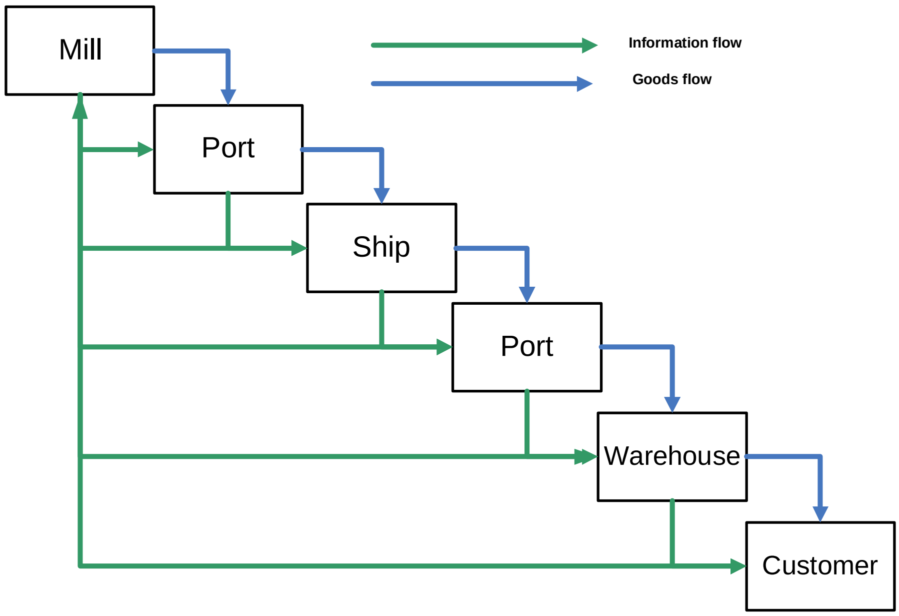

Figure 8. *Paper reel supply chain*

6.1 Paper mills

Identification of reels at paper mill:

- Customer order number is given to the customer (also mill order number exists)
- Mills give the Unit Identifier Barcode (UIB) to each reel after winding (in packaging order)
- Customer codes are printed in the label; Customer order, IFRA in printing paper branch, etc (Figure 9).
- In case UIB is in the tag, links between order, UIBs and other used customer codes are needed

Different types of ERP systems are used; SAP at M-Real and FENIX at StoraEnso. Forest company/mill can follow the movements of reels via IT system, based on reel numbers. Some questions still exist:

- How UIB is combined to orders and transferred automatically in the supply chain?
- All bookings should be done electronically

- Receipt from customer delivery is missing today.

Figure 9. *An example of paper reel label.*

6.2 Stevedoring

Mostly used information is the order number and the number of reels.

- When one order is unloaded on same storage square or on cassette/flat, industrial truck driver gives the receipt when the work is done. In case the whole order is unloaded in the same square no tallying is done
- When the order splits in several storage places, reel identification is needed
- Also in some cases reel numbers are identified (e.g. loading into a container)
- UIB is not readable when
  - The number is on back side
  - When the reel is high up in the pile
- All mills can not provide reel numbers. A part of waybills include reel numbers
- Part of the reels have belt bar codes

Stevedore is doing manual tallying on loading of a vessel. Loading information is sent to mill, shipping company/vessel and destination port. Question for RFID applications:

- Can the reels from sea cassette be read simultaneously? Tests at Rauma port showed that this is possible.

- Hand held readers are used today in containerization of pallets. Can handheld RFID-readers be used? At least the reading distance sets limitations.

IT departments of stevedoring companies see RFID as a monster. The current IT systems do not have all reel numbers which means that the ERP system must be modified. Outsourcing the activities might change the division of work between parties, also transport company can control the trucking operations.

6.3 Customer

Focus on track & trace is increasing. Handling automation is a driver for automated identification. Today, project member Sanomala uses IFRA codes. The problem with IFRA codes is that in case all parameters are equal, several same codes may exist.

6.4 Motivation for the use of RFID

In a port, one single reel is handled 3-10 times and in average 4-5 times. The interviewed people saw a lot of benefits in automated identification:

- No mistakes, better checks of the operations
- More effective operations
  - better time usage - no search for information
  - work flow will change in case all reels are tagged, less stages in operations
- Less human resources in tallying
- Less damages; automated pressing force information available for clamp handling
- Handling instructions; Reel can tell what to do. Today, you have to know the order number
- In case a clamp truck can read ID, all reels are read in unloading and loading

Forest Corporate information systems are already able to deal with reel information. Stevedoring companies and paper mills need changes for systems. The need and possibility to read reel information in the supply chain depends on the operator, the methods of operation and location. Automatic reading of RFID tags improves according to interviews, efficiency and control of supply chains.

7. Conclusions

The forest industries do not have a global coding system (such as trade with EAN). There are at least three different types of codes in use; CEPI, IFRA (news publishing industry) and NARI (U.S. market).

The PapeRFID project has worked with the idea that CEPI code will be used as reel ID. When the PapeRFID project plan was written, the EPC chips contained only 96 bits memory. Today, chips may also contain user memory up till 512 bits. In addition to CEPI code, user memory enables technically customer information to be written in a chip memory. Data security aspects must also been taken into account.

The use of different codes for RFID is restricted by the fact that some of the reel information is available earliest at the packing stage. Almost all IFRA code information can be written before the winding in the tag. The only information which must be written after the winding is the reel weight. Same applies to the NARI code. In case IFRA is changing the code into ID type code, the printing problem is solved.

Different organizations are also developing codes. The same code question is true also in other industries such as electronics and metal industries.

In case the user memory is used, it should also be harmonised and not to leave it open for users.

There is also a competition situation between different RFID projects:

- Sonoco-Ipico project; integration of tag inside the core[7]
- News International project; Active tags in returnable cores with 4 suppliers; UPM Shotton, Norske Skog, SE Hylte, Holmen
- Power ID Project; Battery-Assisted, Passive (BAP) RFID technology. Labels are applied on the outside of the core, between the core and the paper, providing read ranges of up to 8 meters[8].

One way forward is that the information systems and the technologies used are not linked. The system should allow the transition from semi-passive tags into passive tags.

Now when the technology exists, piloting and implementation projects are needed in order to find solutions for paper handling chains.

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[7] http://www.ipico.com/index.cfm?id=5897

[8] http://www.power-id.com/

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