Exploring cross-media concepts for future packaging – Challenges for the printing industry

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Abstract

Currently, packaging is one of the most significant application fields for the graphic arts industry. Recent studies and industry observations indicate that packaging is gaining even more importance for the graphic arts and print media industries since packaging, by its very nature, cannot be replaced by an electronic medium, but is a medium that requires printing.

However, packaging is currently the centre of an intensive research effort that is being carried out regarding new technologies that integrate digital data on a package. This has been fuelled by developments in electronics technology, materials and processes that have the potential to create packages that can carry digital - machine readable data, in particular new materials (such as printed polymers) and tagging applications (such as RFID and EAS systems) which are described as "intelligent", "smart" or "active" packaging.

This situation has given rise to several challenges. The first is to examine whether the application of the above mentioned technologies can leverage the cross-media concept in terms of the processing and distribution of information for packaging. Another challenge is to determine the degree of awareness of graphic arts companies concerned with print and packaging with regard to these new technologies and concepts. Further, to understand whether these companies would be interested in implementing and integrating these technologies in their packaging printing production processes.

This paper is based on a literature study of cross-media concepts and of new technology applications for packaging as well as on a survey based questionnaire with companies from the packaging printing sector. The outcomes of the study showed that the coexistence of printed and digital data on a package does not constitute a cross-media concept (at least not considering its traditional interpretation in the media landscape). The concept can be described more accurately with the term "hybrid package", where *both printed and electronic data coexist on physical substrate.* In addition the survey analysis revealed that the developments towards smart or intelligent packaging concepts are of great interest for packaging printing companies.

Keywords:

Cross-media concepts, information flow, smart and active packaging, packaging production workflows, printing technologies.

1. Introduction

Traditionally, packaging is a printed matter used for specific purposes, namely:

- to protect contents of the package, especially during transport packing and handling
- to identify the contents of the package
- to help sell the product, both by
    - providing information about the contents and their use,
    - and making use of aesthetics in form, shape and colour

These three purposes may use different types of packaging, an outer cardboard or plastic wrap binding, with printed information/data, and inner box with identification marks, and the individual product packaging that is aimed at the end user of the contents.

In its traditional form the information on the package relies upon a certain production workflow and certain types of information that need to be communicated between the producer, the retailer and the consumer. All the information required is produced and transferred to the packaging by means of traditional printing technologies.

However, recent developments and applications mean that not only human readable printed information, but also machine readable data needs to be incorporated in the packaging. Such data can be in the form of sounds, or smells, or other perceptions (for instance weight- some products such as fruit become lighter as they get older, and the juices inside them evaporate). These various perceptions and transformations or changes of conditions can be traced by sensors that compare the "printed" descriptions with the actual data from handling/scanning the package. A convergence of emerging technologies that rely on new materials (such as printed polymers) and tagging applications (such as RFID and EAS systems) are leading to new concepts of "intelligent", "smart" or "active" packaging.

The gradual application of these new technologies is leading to new norms for packaging where not only printed but also electronic (digital) data and information co-exist. The coexistence of printed and electronic data on a package, have led us to pose the question, of whether this development can be viewed as variation of the cross-media concept, and whether this is helpful.

Cross media is a concept found in the mass media landscape and most commonly refers to the idea of distributing the same message through different media channels. Many people understand cross-media publishing to be the ability to publish in both print and on the web without manual conversion effort. Because recipients behave differently and have different needs, the conversion cannot be automated with the electronic means available today. An increasing number of wireless devices with mutually incompatible data and screen formats make it even more difficult to achieve the objective "create once, publish everywhere" (COPE).

Having experienced the development of cross-media applications in the media sector, our interest was to see if this concept would be useful in regard to the information on packaging, particularly in the light of this information being digital. More specifically, we were interested in the flow of

information in relation with the printing processes that are traditionally applied for packaging printing. Related questions were to explore whether the production of new technologies enabled packaging will be affected (or significantly changed) thus creating the necessity for application of new design and production processes.

2. Background: The importance of packaging for the graphic arts industry

Packaging is about 2 % of the GNP in the developed countries. The volume of the packaging industry is about 345 million euros, and about one third of this is in Europe. As Juhola (Juhola, 2002) points out, packages will remain and their proportion will clearly increase in the Information Society. Increasing e-commerce will also serve to augment the number of packages. The packaging itself will carry more and more information, for consumer, for parcel tracking, becoming more and more an important communication media. Meanwhile, 50 % of the packages are food packages, indicating the importance of this industry for packaging.

Packaging is one of the most significant application fields for the graphic arts industry at present. Recent studies and industry observations indicate that packaging is gaining even more importance for the graphic arts and print media industries since packaging, by its very nature, cannot be replaced by an electronic medium, but is a medium that requires printing (Politis, 2005 (there is no reference for Politis 2005) In addition, data from the last DRUPA exhibition reveal that the vast majority of graphic arts manufacturers of prepress systems, printing and finishing equipment as well as producers of printing substrates and inks (DRUPA, 2004) Packaging printing constitutes probably the most important interest for the printing industry. All the main printing methods are being continuously developed for serving the specific characteristics of packaging printing. Tables 1 and 2 show the increasing rates of packaging production and the share among the principal packaging methods.

Table 1 Basic packaging categories: Percentage of annual increase 2001-2005 in the USA. Source: Graphic arts marketing information service, USA 2004.

Basic Packaging Categories	Percentage of Annual Increase 2001-2005
Flexible Packaging	4,5%
Labels	4,5%
Corrugated - paperboard Packaging	3,5%
Paper – Board Boxes	2,5%

Table 2: Percentage of total printing market and basic segments of basic printing methods. Source: ERA (European Rotogravure Association e.V.), www.era.eu.org, April 2004.

TOTAL PRINTING MARKET AND BASIC SEGMENTS OF BASIC PRINTING METHODS.	**PERCENTAGE (%)**
Lithography Offset	40%
Flexography	30%
Rotogravure	22%
Other Printing Technologies	8%

Information on packaging today is almost exclusively from printing. Graphics, texts, images, instructions as well as advertising carried on packaging are nearly all made by traditional or digital printing technologies. Barcodes (EAN-code) serve the identification required for machine-readable data and various additional non-impact printing processes (such as ink-jet), create human-readable information on ready packages (e.g. the expiry date of a dairy product).

However, packaging is currently the centre of an intensive research effort that is being carried out regarding the types of information and flows of data that need to be used on a package. This has been fuelled by developments in electronics technology, materials and processes that have the potential to create packages that can carry machine readable data as well as information.

It is predicted that the application of the new technologies on packaging will affect not only printing but the whole design and production process. Those to be affected include designers, subcontractors, prepress, and printing departments of packaging producers

At the same time, it is possible to see these new types of packaging within the context of pervasive computing, Packages (i.e. package and content) can be considered as smart objects that communicate with one another and with other smart objects around them. Thus software frameworks from research areas like pervasive computing can be used to talk about packaging and the creation of entire smart environments, where objects describe themselves, are context aware, and can exchange data between them, as well as communicate over networks.(Siegemund & Krauer, 2004). The next section explores some of the new technologies that are being used in packaging and that make this scenario feasible.

3. New technologies for packaging: RFID, EAS and Printed Electronics

In the main, the new technologies refer to the machine readable data on packaging, that is, Radio Frequency Identification (RFID), Electronic article surveillance (EAS), and printed electronics. A brief description of the uses and operation of each is given below.

There are two descriptions on RFID (Rychee, 2005):

- The technology that is considered to be the next generation of barcodes. The RFID tag contains an antenna and a microchip. This technology was prompted by the need of the consumer product industry and large retail chains to update outdated and inefficient barcode systems. RFID technology can be used for supply chain distribution logistics, asset tracking, and inventory management.

- The use of small devices that can be electronically identified (and sometimes their data changed) at a distance without line of sight. Although radio is typically defined as 300 Hz to 300 MHz, in RFID the term even encompasses tags interrogated at 100 Hz and others at microwave frequencies (GHz). These devices are called tags and they may be used alone – contactless smart cards and car clickers are examples – or fitted to something in order to monitor its identity remotely. Sometimes RFID will employ tags that perform extra functions as well such as sensing what is happening or recording updated data remotely, for future remote interrogation.

EAS (electronic article surveillance) is akin to an antenna. It is a conductive electronic component that radiates and/ or receives electromagnetic energy usually in the radio frequency spectrum or thereabouts, an aerial on an RFID tag or interrogator, for example. All RFID interrogators have antennas as do most RFID tags. They are increasingly printed, usually with silver ink, the resolution and conductance required for adequate performance being more onerous the lower the frequency. Antennas for other uses are also sometimes printed. Ink makers are developing better silver inks that can be printed at high speed yet achieve adequate conductance in one pass. (Glyn et.al, 2005).

RFID tags come in a wide variety of physical forms dependent upon shapes sizes and protective housings. Animal tracking tags, inserted beneath the skin, can be as small as a pencil lead in diameter and ten millimetres in length. Tags can be screw-shaped to identify trees or wooden items, or credit-card shaped for use in access applications. The anti-theft hard plastic tags attached to merchandise in stores are also RFID tags, as are heavy-duty 120 by 100 by 50 millimetre rectangular transponders used to track inter-modal containers, or heavy machinery, trucks, and railroad cars for maintenance and tracking applications.

The tags are data carriers, and the data they contain invariably requires some organisation and additions, such as data identifiers and error detection bits, to satisfy recovery needs. The amount of data carried depends on the application and requires an appropriate tag to meet the need. Basically, tags may be used to carry Identifiers, in which a numeric or alphanumeric string is stored for identification purposes or as an access key to data stored elsewhere in a computer or information management system, or portable data files, in which information can be organised, for communication or as a means of initiating actions without recourse to, or in combination with, data stored elsewhere. (Harrop & Raghu, 2004).

The data storage capacities of tags vary. Data storage capacities up to 128 bits are sufficient to hold a serial or identification number together, possibly, with parity check bits. Such devices may be manufacturer or user programmable. Tags with data storage capacities up to 512 bits, are invariably user programmable, and suitable for accommodating identification and other specific data such as serial numbers, package content, key process instructions or possibly results of earlier interrogation/response transactions.

Tags characterised by data storage capacities of around 64 kilobits may be regarded as carriers for portable data files. With increased capacity the facility can also be provided for organising data into fields or pages that may be selectively interrogated during the reading process.

The more the data, the greater the need to calculate the Data Read Rate. The data transfer rate is essentially linked to carrier frequency. Generally speaking the higher the frequency, the higher the transfer rates. Reading or transferring the data requires a finite period of time, even if rated in milliseconds, and can be an important consideration in applications where a tag is passing swiftly through an interrogation or read zone.

There are also various data programming options. Depending upon the type of memory a tag has, the data carried may be ‘read-only’, ‘write once, read many’ (WORM) or ‘read/write’. Read-only

tags are most often low capacity devices programmed at source, usually with an identification number. WORM devices are user programmable devices. Read/write devices are also user-programmable but allow the user to change data stored in a tag. Portable programmers may be recognised that also allow in-field programming of the tag while attached to the item being identified or accompanied.

As noted by ID TechEx, once such a tag is included in packaging, many benefits of brand protection, tamper-evidence and supply chain management applications are available to the brand owner (Gen-Daniel & Brown, 2002).

In order to create these tags, and the communications between them, as well as with other devices, much of the circuity can actually be directly printed onto flexible plastic substrates. Printed electronics have a lot of potential in various industrial fields. With regard to packaging, printed electronics can be applied on various substrates for packaging, and the printed elements include circuits, antennas, power indicators, sensors, sensor indicators, batteries etc. Baumann and Weiss (2005). Central to these is the increasing importance of printing, although they caution that there increasing complexity and new skills to be acquired.

The use of these technologies allow for visions of the future such as Active communicative Packaging Systems. Such smart and intelligent systems can offer cost-effective solutions for new product concepts for traditional machine industries. These are defined by Juhola & Lindqist (2000) as intelligent logistics systems with active, communicative packaging for sensitive products. Such systems would be able to:

- continuously monitor or perceive their status and environment (awareness)
- react and adapt to environmental and operational conditions
- maintain optimal performance in varying circumstances, also in unexpected cases
- actively communicate with the user, the environment or other products and systems

Further, many of these properties can be seen as a result from long evolution in living organisms - in the future, machines are expected to imitate nature (biomimetics) and will be smart or intelligent, where a "smart" system is defined as one that adapts to expected situations in a predictable manner, and an "intelligent" system is able adapt to unexpected situations as well by reasoning and learning. (Juhola, 2002).

From the descriptions of the technologies and their capabilities, and the visions they afford, it is understandable that with these new technologies opening up so many new possibilities, there is a need for guidance in terms of concepts and models. Especially promising appear to be those from areas that have also been affected by new ways of doing things and by convergence between previously separate industries. One such concept is that of cross media, which is explained in the next section.

4. Cross media concepts for packaging

This paper set out to discover whether the integration of digital data and enabling technologies such as RFID and EAS along with printed electronics on packaging can make use of the concept of cross media. Cross-media refers to the ability to use the same content across multiple output media without having to reprocess the content at its origin. It may be considered as an integrated approach to managing documents for print and electronic versions of documents. Huusko (2001), defines publishing in multiple media or multimedia publishing as the process where the information is kept in one data source, for example a database, and published through different media, making use of

database and metadata technologies, XML, (eXtended Markup Language), XSL (eXtended StylesheetLanguage), and DTD (Document Type Definition). Cross media as a concept works well in current atmosphere of convergence. According to a study published by the German Federation of Printing and Media industries, print, publishing and Web run together and create new forms of communication, with media independent data handling, (BVDM, 1999).

So far, the cross-media concept is applied in particular to publishing, (GATF, 2000), (Comprint, 2002), (Politis, 2004) and its main characteristics are classified as follows:

- Application of new workflows based on the common processing of data for printed and electronic media.
- Development of asset and content management software.
- Increasing applications of new processing technologies for publishing based on XML
- Development of new standards and formats for production management and workflow in publishing such as Job ticket, CIP 4 initiative and JDF format, PPML (Politis 2004).

By extension, cross media concept are widely established in the media industry and account for numerous applications (Politis, 2002). Generally speaking, in terms of the graphic arts and media industry, cross-media applications are to be found in two main areas. Firstly in the area of publishing process, mainly applied as the guiding concepts for the management and workflow of data for various input and output media. A prominent output example is newspapers with their printed and electronic editions. Secondly, in the area of the application of specific technologies for multiple media (mainly the use of machinery and production systems and the application of software), compared to their traditional use oriented to only one media.

In a similar vein, cross-media publishing is an emerging concept in the production-process of print and electronic media, whose main features can be seen one or combinations of the descriptions below:

- As workflow production applications for the publishing process.
- As the common processing of data for publishing of print and electronic media.
- As the application of production tools and new software applications (such as XML editors).
- As the establishment of production workflow systems (such as JDF – the Job-definition format) applied from pre-press to finishing for the print media, combining production and management processes.
- As the reorientation of existing production systems, processes and tools (scanning, image processing, color management, proofing) into common production environments for print and electronic media.
- As content management of any sort, e.g. format and multimedia (any combination of text, images, graphics, sound and video) (Politis 2002).

With this in mind, the question now arises “Are the production workflows of publishing (as a cross-media concept) and the new packaging production workflow comparable?” According to Baumann and Weiss, (2005), the packaging production workflow, with the integration of printed electronics, tags or antennas is structured in the following way:

- Design and print antennas (with semiconductor ink)

- Print (texts, images, graphics, colour printing).
- Put a chip (at the necessary point).
- Lamination.
- Folding / transformation / transfer / distribution

This workflow can be further specified as follows, with an example of the integration of an antenna on a package:

Antenna for interaction with computer system

- short to high run length
- image and text information [to be recognized by the eye] (in conventional printing)
- Pasting of Silicon Chips or Plastic Circuitry
- Finishing

Writing / Reading (Supply Chain Management System [PC]/(radio frequency) (Baumann and Weiss, 2005)

This packaging workflow can be compared to a cross media workflow, using the model suggested by Kipphan (2001), which combines print, electronic media and multimedia documents with workflow and transmission media for customer use, as illustrated in Figure 1:

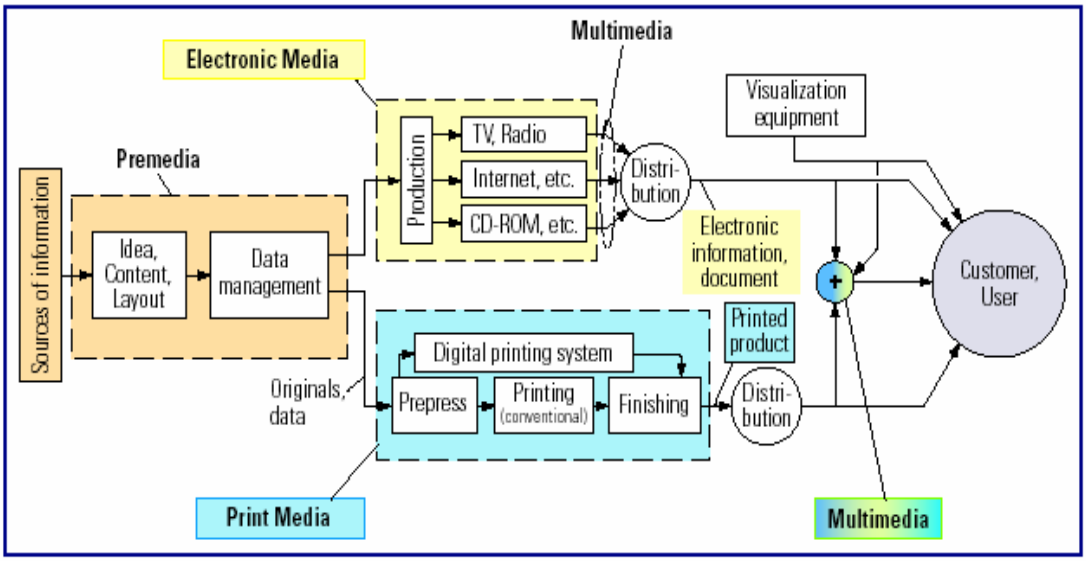

Figure 1: Cross Media Workflow (Kipphan 2001)

In its simplest form it consists of common processes of information which can be processed together and then it can be transferred to various media (print and electronic. Such a concept is applied for newspapers production both in electronic and printed form (Politis and Halonen, 2002).

By contrast however, the packaging production workflow however, still remains a print media production workflow. What is added, is the integration of electronic data via a wide range of new technologies and applications in the form of tags, antennas, and printed electronics (circuits, microchips) (Harrop & Raghu, 2004). By contrast cross media concepts constitute either the

processing and management of content to be produced jointly *before* the definition of the output (print or electronic), or new technical developments in production workflow for media. However, packaging, even in its new form – with the integration of digital data one or the other way – is still a printed medium, carrying information on a substrate. With new technologies it becomes a digital data carrier, but is not akin to having one source of data, to be output to different media.

In order to understand better what the industry thought about these issues, we made a survey of printing packing industries in Greece. The next section describes the survey and its results.

5. Survey

In order to extract results regarding whether and how the previously mentioned technologies and developments on packaging affect the packaging printers, we decided to carry out questionnaire based interviews with Greek companies specialising in this field. A questionnaire was developed for this purpose, structured in order to receive answers to fundamental issues concerning the objectives of the study. The selection of the companies was based on the type of packaging printing according to the main printing substrate and the printing process applied, as follows:

- Packaging printing of paper and board - production of folding boxes (Offset sheet-fed printing and die-cutting of boxes)
- Packaging printing of rolls of flexible substrates production (Gravure and flexography printing)
- Label printing production – production self-adhesive labels (Narrow web printing with letterpress and flexography)

According to data derived from industry analyses (ICAP, 2004), packaging printers in Greece are mainly small to medium companies employing 30 to 50 employees on average. There is a constant demand for packaging printing. Paper and carton packages, flexible polymeric and aluminum foil packages, carton boxes, labels, plastic and metal packages are constantly on the increase.

There are about 30 printing plants for printing exclusively flexible packaging items, with the application of rotogravure and flexographic printing and about 40 companies specializing in the printing and processing of cartons and boxes. With regard to label production, there are around 15 medium-sized companies and about 20 small ones, employing narrow-web printing machines (with flexo and letterpress printing units).

The aim of the survey was to gain information from the majority of medium-sized packaging and printing Greek companies. Questionnaires were been sent out to 40 companies, divided as follows:

- 15 questionnaires sent to of paper and board - packaging printing companies (offset printing).
- 15 questionnaires sent to Packaging printing of rolls of production (rotogravure and flexography packaging printing companies (printing of flexible substrates) and
- 10 questionnaires sent to label printing companies

In Table 3 the questionnaires sent out and the answers received are presented:

Table 3: Type of packaging printing companies interviewed, questionnaires sent out and answers received

	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production. (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
Number of medium-sized Greek companies specialized in packaging printing (approx. number)	30	25	15
Companies where the questionnaire has been sent out	15	15	10
Questionnaires received	9	8	6

In total, 25 companies responded, a response rate of 62.5%, which was sufficient to enable us to make an analysis. It is worth noting that is that the number of 70 companies in the first row, represents over 95% of packaging printing production in Greece (excluding printers of corrugated board) (ICAP, 2004).

5.1. Objectives of the questionnaire

The questionnaire is designed to getting feedback on the degree of awareness of the graphic arts companies oriented in packaging printing, as to the new technologies to be applied in packaging (RFID -EAS - printed electronic circuits, antennas and generally, smart and interactive packaging applications). It was also designed to obtain information about whether these companies are interested in implementing and integrating these technologies in their packaging printing production process.

The questionnaire has the following structure: The first section consisted of two questions to establish the main activity of the company and the printing method(s) incorporated in the company.

Question 3 deals with the degree of awareness of the companies regarding new technologies that are applicable on packaging Question 4 follows up on this querying the importance for receiving information and further knowledge about these technologies.

Question 5 briefly explains the characteristics of RFID and EAS– both employ special inks for printing of antennas, laminating technologies for the integration of microchips and according to manufacturers, they can be printed by all available main printing methods, and asks the respondents to judge which approach is best for fitting in with their production processes.

The aim of this question was to understand whether companies would prefer to receive antennas or microchips already-printed by a third party, or whether they would aim to proceed with investments for full integration of printing and production of antennas, microchips, etc. One of the responses to this question was also to wait and get further informed before making decisions.

Question 6 is aimed at those companies who want to invest in know-how, and asks them about the time frame for this. Question 7 addresses the issue of the implementation of the new technologies in the existing production workflow, whereas question 8 asks for feedback on the importance of these

new technologies to be applied in the companies' production process, taking under consideration that these are capable of conveying data for the production process as well as quality control, stock regulation, etc.

Finally, question 9 is addressing the willingness of the companies (their owners and/or managers) to receive training, take part in seminars and generally develop their know-how on the new technologies to be applied on packaging, regardless of their intention on investing on such new applications.

The results of the survey are next discussed. The questionnaire itself and a summary of the results obtained are presented in Appendices 1 and 2.

5.2. Survey results - answers from the questionnaire

The findings from the interviews and the answers to the questionnaires received from the 25 Greek packaging printing companies, were as follows:

With reference to the range of the main business activity of the companies interviewed,

- 9 companies are involved in paper and board packaging printing,
- 8 companies are producing flexible packaging materials, employing rotogravure and flexographic printing machines
- 6 companies are printing and processing labels.
- 3 of the companies that use rotogravure and flexographic machines print also aluminum foils.

Concerning the degree of awareness of the companies as it regards the new technologies that are applicable on packaging (question 3), not a single company reported that is fully aware and informed on the new key technologies for packaging.

- 7 out of 25 companies reported that are sufficiently informed (28 %),
- 12 that are relatively informed (48%),
- whereas 6 of the companies reported that are not well informed (24%).

With regards to the companies that are relatively or not properly informed (that is; 18 out of 25 companies), the majority responded that would like to be informed immediately about the new technologies for packaging (question 4).

The following question 5 explained briefly the characteristics of RFID and EAS Furthermore, the question asked which is the best approach they envisage with regard to the integration of the new technologies in their production process, namely whether they will receive the already-printed antennas or microchips from a third party, or whether they will proceed with investments for full integration of printing and producing antennas, microchips, etc.,

The answers to this question were quite diverse:

- 5 out of the 25 companies (20%) stated that they would prefer to cooperate with a subcontractor, to receive the already-printed antennas and integrate them in the surface of the packaging that they print.

- On the other hand, the majority of companies (11 out of 25, - 44%) reported that they intend to proceed with investments and development of know-how for full integration of printing and producing antennas, microchips, etc., in their own production process.

- A further significant number of companies (7 out of 25 or 28%), stated that they would prefer to wait to be informed more properly on the specifications, production characteristics, the processes of integration, etc. at this stage.

- Finally, 2 companies both oriented on flexible substrates printing, answered that they do not know - they have not yet decided how they will proceed on this subject.

With reference to the issue whether the companies should invest in the know-how and equipment of the new technologies and, when they foresee this happening, not a single company reported that this could happen within the next 6 or 12 months. Rather:

- 9 companies (36%) answered that they could proceed in 2 years time, whereas

- the majority (11 out of 25 or 44%) will be waiting to be informed further before they proceed in any investment.

- and 5 companies replied that they do not know yet whether they will go on with investments (question 6).

Regarding the importance of substitution of the linear barcode (EAN barcode) in packaging by new technologies (eg RFID), all 25 companies replied that this is a very interesting or interesting enough development (question 7).

Furthermore, with regards to the issue of the implementation of the new technologies in the existing production workflow and the importance of these new technologies to be applied in the production process of the companies and conveying data for the production process as well, quality control, stock regulation, etc. (question 8),

- 13 out of 25 companies (52%) replied that this is a “very important” issue for their production process and

- 7 companies (28%) that it is an “important enough” issue.

- For the remaining 5 companies (20%) this is a “rather important” issue.

Finally, replying to the final question addressing the willingness of the companies (their owners and/or managers) to receive training, take part in seminars and generally develop their know-how on the new technologies to be applied on packaging, regardless of their intention on investing on such new applications (question 9),

- 17 companies (68%) declared that they are ready for immediate participation and the rest

- 8 companies responded that they are rather ready for such activities (32%).

5.3. Survey analysis

Broadly speaking, the findings from the interviews and the answers to the questionnaires received from the 25 Greek packaging printing companies, show quite a strong degree of interest in new technologies and understanding of the importance they will have on future packaging production.

Offset printers (producing paper and board packaging) are slightly more aware on new technologies

in comparison with the other two categories of packaging printing companies.

Companies are only relatively aware of the applicability of the new technologies to packaging. This means that they need to be more informed and this is expressed very clearly by the majority of the companies.

The remarkable differences reported on the subject of the approach that companies should follow regarding the integration of the new technologies in their production process and the steps they should follow, can be related with the degree of awareness and possibly on their different market orientation and production segmentation.

However, the willingness of the majority of the companies to proceed with investments and development of know-how for full integration of printing and producing antennas, microchips, etc. in their own production process shows that companies want to stay ahead in their business and production activities with everything that is new. In addition, a significant number of companies that stated that they prefer to wait to be informed more properly on the specifications, production characteristics, integration processes, etc. reveal that more information is required. This finding is further supported as not a single company intends to proceed in any investment in the next 2 years, with a significant number reporting that they might start investments after 2 years time and some companies (20%), to report that they do not know yet whether they will go on with investments .

As companies are familiar with the printing and processing of barcodes they all rate the ability of new technologies to replace or substitute this machine-readable element as very interesting and important development. The same exists for the implementation of the new technologies in the existing production workflow and the importance of these new technologies to be applied in the production process of the companies.

It is also considered important that owners and/or managers of the companies are willing to receive training, take part in seminars and generally develop their know-how on the new technologies to be applied on packaging, regardless of their intention on investing on such new applications.

A final conclusion regarding the survey with the 25 companies is that the “wait and see” behaviour together with the willingness of the majority of the companies to proceed with investments on these new technologies are the trends dominating the responses of the packaging printing sector in Greece. This holds for all types of companies. And companies have similar opinions regarding both their willingness to participate in training and to increase their degree of awareness about the new technologies.

6. Discussion – Cross-media for packaging?

The work undertaken here shows that the key technologies to be applied in packaging seem to affect considerably – or it is expected that they will affect considerably - the design, production and printing of packages. This is expected to happen with various interventions in the traditional production workflow. This means that packaging printing companies (including designers, pre-press and finishing) as well as graphic arts equipment manufacturers need to o consider the changes in the design and production process.

However, comparing the analysis of the characteristics of cross-media applications and the production workflow in packaging, we come to the conclusion that cross-media is not a concept that can be applied directly yet on packaging. This is firstly because cross-media in one of its interpretations is considered as a process for production of print and electronic media. Secondly, as regards the production workflow, cross-media constitutes a concept where common data are

processed together until the output media is defined, whereas what we are looking at here is packaging production combined with the integration of print and digital information.

This is not to say, that in a future view, information will be authored and then processed separately as print and web, so that someone can read the package, as well as see the same information on a web page that may be displayed on a screen incorporated into white appliances, or part of the supermarket shelving. This is a form of cross media regarding information flow. Already scanners that read product information from packaging and display it elsewhere (or speak it aloud for those who cannot read) are at the end of their research phase ready to go into production.

For the present, we can say that electronic information will be integrated, designed and printed, following in many cases the same process as for printed data. What will be new are the systems to be established to produce tags, antennas etc. and that will be integrated in the existing workflow of packaging. As a conclusion, the future packaging will be a <hybrid information carrier> with both printed and electronic data.

7. Conclusions and Further Research

The research reported in this paper is based both on the study of literature as well as on a survey with graphic arts companies. The literature used for this study concerned research and analyses from the fields of cross-media concepts and applications within the media landscape as well as literature study on smart, intelligent and active packaging concepts. Various recourses have been investigated, including key technologies for application to packaging.

The final conclusion is that such developments in packaging are not helped presently by the cross-media concept. Packaging will continue to be printed on a substrate (paper, board, polymer aluminum or on a multilayer substrate), with new types of information carriers to be embedded in and/or on packaging, especially printed electronics, antennas, circuits, etc.

As a result, packaging – the substrate- which will continue to be printed and processed as usual, is changing, with regard to the types and structure of information to be presented. It becomes a physical carrier of both printed and electronic information and as such it could be termed a “hybrid information carrier”.

The survey with companies revealed that packaging printing companies in Greece are willing to proceed with investments. However, they first want to be more informed and be in a better position to understand the potential of future packaging.

Further research is required in order to define further the information types and flow within packaging production as well as the range of information defined as electronic data. It is perhaps here that the cross media concept will prove more useful. In any case, it would be useful to explore the development of a model for gaining a better understanding of the complex processing and output of information from the package producer to the end-consumer that can be used by the packaging sector.

From a practical point of view, studies of the transformation required from the traditional design and production processes of packaging to the new production workflows are needed to help the packaging printing sector to better cope with new applications to be implemented in packaging production, including printed electronics.

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Appendix 1.

SMART PACKAGING - INTEGRATION OF DIGITAL DATA ON PACKAGING THROUGH PRINTING TECHNOLOGIES

Questionnaire for the integration of printed electronics and digital data in the existing production process of packaging printing.

Dear colleagues,

To the extend of our activity in the scientific research of innovative advancements that are expected to influence the industry of graphic arts, we are currently working on the field of new developments in packaging and in particular on the integration of printed electronics and digital data on packages through the packaging printing production process.

Within our study, we will present a paper in the international conference of the IARIGAI (International Association of Research Organisations for the Printing, Information and Communication Industries), that will be held in Finland during September 2005. The theme of our scientific paper is: "Exploring cross-media concepts for future packaging – Challenges for the printing industry"

Our study is dedicated on new possibilities that new technologies, such as Printed Electronics, RFID (Radio Frequency Identification) and EAS (Electronic article surveillance) offer to packaging. More specifically, we have processed a questionnaire containing questions aiming in exploring the degree of awareness of the graphic arts companies oriented in packaging printing, with these technologies. In addition, we would like to examine weather the companies are interested in implementing and integrating these technologies in their production process of packaging printing. Therefore, we would like to request your kind contribution, by spending a while of your time, to answer the questions that follow.

You can send the questionnaire to the fax number 210 4904500 or the e-mail address: politisresearch@techlink.gr or nomic@aegean.gr, up to the 6th of July 2005.

On behalf of the research team,

Dr. Anastasios E. Politis and Spyridon Nomicos, M.Sc.

P.S. The data that you will be filling in will be kept confidential. These will be processed in total to derive scientific results that will be presented in the scientific conference.

Questionnaire for the integration of printed electronics and digital data in the existing production process of packaging printing.

Question 1:
Which is your main business activity?
(You can check more than one answers)
Paper and board packaging packaging printing
Production of self-adhesive labels (narrow web flexo and letterpress printing)
Production of flexible packaging materials
Corrugated board packaging production
Printing production of aluminum foils for packaging
Other, please specify

Question 2:
Which of the following printing methods does your business incorporate?
(You can check more than one answers)

Gravure
Flexography
Offset-lithography
Silk screen printing
Digital printing
Narrow web flexo and letterpress printing
Other, please specify

Question 3:
To what extent you are informed on the new technologies that are applicable on packaging (e.g. RFID - Radio Frequency Identification, EAS - Electronic article surveillance applications, printed electronic circuits, antennas and generally smart and interactive packaging applications)?
I am fully informed
I have sufficient information
I am relatively informed
I am not well informed
I am not informed at all

Question 4:
In case you are not properly informed, do you think that it is necessary to be informed:
Yes, immediately, Rather yes, Rather not, No

Question 5:
EAS and RFID technologies have a lot in common – both employ special inks for printing of antennas, laminating technologies for the integration of microchips and (as manufacturers claim) they can be printed by all available main printing methods. Which do you think is the best approach for your production process:

A. To receive the already-printed antennas or microchips from a third manufacturer - subcontractor and integrate them in the surface of the packaging that you print.
B. To proceed with investments and development of know-how for full integration of printing and producing antennas, microchips, etc. in your own production process.
C. You will be waiting to be informed more properly on the specifications, production characteristics, the processes of integration, etc. at this stage
D. You are not interested in this activity
E. Do not know
F. Other, please specify

Question No 6:
In case you believe that you should invest in the know-how and equipment of the new technologies in your own production, do you foresee this happening:
Immediately (within 6 months)
In 12 months
In 2 years
I will be expecting to be informed further before I proceed in any investment
I do not intend to
I do not know
Other, please specify…..

Question 7:
The implementation of the new technologies (eg RFID), is possible to derive in substitution of the lineate barcode (EAN barcode) in packaging. How interesting do you think this application is in your business to the degree that it will amend your current workflow production?
Very interesting
Interesting enough
Rather interesting
Not interesting at all

Question 8:
The new technologies are capable of conveying data for the production process as well, quality control, stock regulation, etc. How important do you think is such an application on your production process?
Very Important
Important enough

Rather important
Not at all important

Question 9:
Regardless of your intention on investing on the new applications of smart packaging, do you think you should receive training, take part in seminars and generally develop your know-how on these subjects?

Yes, immediately, Rather yes, Rather not, No

Thank you for your valuable contribution in our research.

Appendix 2.

Questionnaire for the integration of printed electronics and digital data in the existing production process of packaging printing.

Answers to the questions

Question 1:
Which is your main business activity?
(You can check more than one answers)
Paper and board packaging packaging printing 9
Production of self-adhesive labels (narrow web flexo and letterpress printing) 6
Production of flexible packaging materials 7
Corrugated board packaging production -
Printing production of aluminum foils for packaging 3
Other, please specify

Question 2:
Which of the following printing methods does your business incorporate?
(You can check more than one answers)
Gravure…….5
Flexography……..8
Offset-lithography……10
Silk screen printing -
Digital printing……2
Other, please specify…..
Narrow web flexo and letterpress printing ……6

Question 3:
To what extent you are informed on the new technologies that are applicable on packaging (e.g. RFID - Radio Frequency Identification, EAS - Electronic article surveillance applications, printed electronic circuits, antennas and generally smart and interactive packaging applications)?

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
I am fully informed			
I have sufficient information	4	3	
I am relatively informed	6	3	3
I am not well informed		6	
I am not informed at all			

Question 4:

In case you are not properly informed, do you think that it is necessary to be informed:

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
Yes immediately	4	6	2
Rather yes	3	3	
Rather not			
No			

Question 5:

EAS and RFID technologies have a lot in common – both employ special inks for printing of antennas, laminating technologies for the integration of microchips and (as manufacturers claim) they can be printed by all available main printing methods. Which do you think is the best approach for your production process?

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
A. To receive the already-printed antennas or microchips from a third manufacturere - subcontractor and integrate them in the surface of the packaging that you print.	3		2
B. To proceed with investments and development of know-how for full integration of printing and producing antennas, microchips, etc. in your own production process.	5	5	1
C. You will be waiting to be informed more properly on the specifications, production characteristics, the processes of integration, etc. at this stage	2	5	
D. You will be waiting to be informed more properly on the specifications, production characteristics, the processes of integration, etc. at this stage			
E. Do not know		2	
F. Other, please specify			

Question 6:
In case you believe that you should invest in the know-how and equipment of the new technologies in your own production, do you foresee this happening:

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
Within 6 months			
In one year			
In two years	4	5	
I will be waiting to be informed further before I proceed in any investment	4	4	3
I do not intend to make any investment			
I do not know	2	3	

Question 7:
The implementation of the new technologies (eg RFID), is possible to derive in substitution of the linear barcode (EAN barcode) in packaging. How interesting do you think this application is in your business to the degree that it will amend your current workflow production?

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
Very interesting	4	6	
Interesting enough	6	6	3
Rather interesting			
Not interesting at all			

Question 8:
The new technologies are capable of conveying data for the production process as well, quality control, stock regulation, etc. How important do you think is such an application on your production process?

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
Very Important	4	6	3
Important enough	4	3	
Rather important	2	3	
Not important at all			

Question 9:
Regardless of your intention on investing on the new applications of smart packaging, do you think you should receive training, take part in seminars and generally develop your know-how on these subjects?

Classification of companies questioned and interviewed	Paper-Board Printing – Production of folding boxes (Offset sheet-fed printing)	Flexible packaging substrates production (Gravure and flexography printing)	Label printing production (Narrow web printing with letterpress and flexography)
Yes, immediately	6	9	2
Rather yes	4	3	1
Rather not			
No, not at all			