Packaging for Consumer Electronic Products; the Need for integrating Design and Engineering

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ABSTRACT

From the perspective of a multinational corporation producing durable consumer goods sustainable packaging is packaging that fulfils the right functionalities in the most efficient way. In order to achieve this, an integral design process is required. Such an integral approach to the design of packaging for CE goods would imply a process that takes into account all requirements, whether they are technical, financial, environmental or psychological in nature, and that also incorporates the relationship between the packed product and the packaging. In this paper this approach will be defined as packaging design engineering.

In business reality however, a split between packaging design and packaging engineering can be observed. Packaging engineering has to do with protection, and fulfilling the distribution functions. It is about the 3-D design, which is also referred to as structural packaging design. This is the expertise typically offered by packaging suppliers.

Packaging design on the other hand, has to do with the appearance of the packaging and is related to the marketing functions. Oftentimes packaging design will be limited to 2-D graphical aspects. It is typically the part of the total packaging concept that is supplied by external packaging design agencies.

The tools and methods of packaging engineering and packaging design differ substantially. This is a result of the fact that packaging engineering deals with materials and mechanical behavior, while packaging design deals with people.

In practice, one can observe that for a given product either the design aspects or the engineering aspects take preference, while the other receives less attention.

When striving for optimal packaging—either from an economical or from an environmental perspective—these two aspects will have to be balanced.

This paper will analyze the existing approaches in both packaging engineering and packaging design, and assess their strengths and weaknesses.

The data used originates from scientific literature, case studies of design projects and interviews with both employees from a major consumer electronics firm and employees from packaging supply companies.

Ways of improving the integration of the two fields will be proposed.

Keywords: distribution, marketing, design process, durable goods

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1. INTRODUCTION

Within the field of mass produced durable consumer goods the discipline of Industrial Design Engineering is often recognized. This is defined as an integral approach to the development of these products, incorporating engineering, aesthetics, ergonomics, environmental and business aspects (Roozenburg and Eekels, 1995; Buijs, 2003). Within the faculty of Industrial Design Engineering of Delft University of Technology, this is how students are taught to design new products. In the same manner one can image 'packaging design engineering' as: *a process that takes into account all requirements, whether they are technical, financial, environmental or psychological in nature, and that also incorporates the relationship between the packed product and the packaging.*

However, within the field of packaging for consumer durables, a split between packaging design and packaging engineering can be observed. Packaging engineering has to do with protection, and fulfilling the distribution functions. It is about the 3-D design, which is also referred to as structural packaging design. This is the expertise typically offered by packaging suppliers. This is also the aspect of packaging with which the members of IAPRI are most familiar. Packaging design on the other hand, has to do with the appearance of the packaging and is related to the marketing functions. Oftentimes packaging design will be limited to 2-D graphical aspects. It is typically the part of the total packaging concept that is supplied by external packaging design agencies. This split between packaging engineering and packaging design can also be observed within large CE companies, as for instance within Royal Philips Electronics, there is a department called Philips Packaging Development, which assists business units in developing the packaging from a distribution point of view. Simultaneously the Philips Design department developed a harmonization program for the graphical appearance of packaging (Marzano, 2005, p. 369).

The tools and methods of packaging engineering and packaging design differ substantially. This is a result of the fact that packaging engineering deals with materials and mechanical behavior, while packaging design deals with people. In practice, one can observe that for a given product either the design aspects or the engineering aspects take preference, while the other receives less attention.

2. PAPER OUTLINE & METHODOLOGY

This paper is part of a PhD project studying the potential of more sustainable packaging for durable consumer goods, and specifically consumer electronics (CE) products. Based on several environmental studies it was found that transportation of packed products is more significant than packaging materials. And due to the low density of packed consumer electronics, this means that volume reduction is an important design for sustainability strategy (Wever, Boks, Stevels, 2007; Wever, Boks, Marinelli, Stevels, 2007). This paper fits into the larger picture of the total research project, by studying how volume is determined in the packaging design process, and by identifying potential causes for sub-optimal design solutions.

Based on literature studies and observations of practices within packaging testing labs, packaging suppliers and consumer electronics companies the way of working in the field of packaging engineering and the field of packaging design will be described. Within each field it will be analyzed how solutions may be implemented that—though very logical for a multitude of reasons—may be sub-optimal from a minimum-volume perspective. Visited organizations were Huhtamakhi in Drachten (NL), Smurfit Kappa in Eindhoven (NL), Brødrene Hartmann in Lyngby (DK), Pira International in Leatherhead (UK), Philips Domestic Appliances in Drachten (NL) and Philips Consumer Electronics in Eindhoven (NL).

3. PACKAGING ENGINEERING

From an engineering point of view the purpose of the packaging is to ensure that the packed product reaches the consumer's home in the same condition as it left the factory, *i.e.* to protect it from the hazards of transportation. These hazards include shocks, vibrations, humidity, extreme temperatures, etc. Dominating in this aspect is the protection from shocks, as this is the most frequent cause of product transportation damage (McKinley, 1998, p. 51). Whether a packaging provides adequate protection depends on:

– Product fragility;
– The distribution environment;
– Packaging characteristics;

Each of these three factors will be discussed in more detail in the following sections. First the theory of how each aspect should be approached from an engineering perspective will be discussed. After that the actual day-to-day approach in the main stream consumer electronics business will be described.

3.1 PRODUCT FRAGILITY

Product fragility is the measure of the maximum shock a product can withstand, for instance when dropped. It is usually expressed in Gs, *i.e.* a number of times the gravitational constant. Product fragility can be tested in a laboratory setting. There is a standardized test available for this (ASTM D3332). Basically this test comes down to fastening a product to a test apparatus that administers a shock to the product. The product is checked for damage after each shock. Starting with small shocks, the level of shocks is increased until damage occurs. The last shock that did not cause damage is taken as the save level.

Whether damage occurs from a shock actually depends on two variables, the peak acceleration and the velocity change ΔV. If the velocity change is small enough no damage will occur no matter how high the peak acceleration. Above the critical velocity change the occurrence of damage depends on the peak acceleration. These two factors can be combined in a *Damage Boundary Curve* (DBC), a graph that has been the standard way of representing product fragility for several decades.

If the shock wave that is administered to the product has a block wave form the damage boundary curve has a horizontal bottom line. A block wave is the most severe shock possible. The resulting damage region envelopes all other possible wave forms. The actual wave for in the real world can have several shapes, but is never a block wave. Hence in using a block wave a certain safety measure is incorporated (Kipp, 2000).

The test prescribes just one product to be tested to determine the critical acceleration. Testing just one product means a statistical sample of one, which doesn't give a very reliable figure. This can be compensated by testing more products; however that raises the costs of products and lab time. Furthermore, the fragility of the product may differ for each orientation, thus requiring the product to be tested in multiple orientations (McKinley, 1998, p. 53; Brandenburg and Lee, 2001, p. 112-113). Another point of critique regarding DBCs is that by increasing the impact time after time fatigue may cause failure in the test product due to repeated low impacts, even though the test is based on the assumption that the final impact, by itself causes the failure. In other words the product is assumed to fail in a brittle way, while most products behave in a ductile way (G. Burgess, 1996; W.I. Kipp, 2000; M.P., Daum, 2004).

The process described above for determining the fragility of the product has one critical setback when applied to consumer electronics products. It assumes the product is finished before starting, or at least finalizing, the design of the packaging. Due to the dynamic nature of the market and the rapid prize erosion of consumer electronics (Minderhoud and Fraser, 2004) this is not a viable option, as time is money. The moment the first finished products come of the production line, they need to be packed and shipped to final customers. Hence concurrent engineering of product and packaging is essential. Fragility testing can only be performed on previous product models or on mockups. This does not give very accurate data, as mockups are never made with the same production tools as mass-produced consumer electronics are. Therefore the mechanical behavior of mockups and the final product is different.

3.2 THE DISTRIBUTION ENVIRONMENT

The second factor determining the proper condition of the packed product upon arrival is the level of shock that is expected during transportation. Shocks may occur during manual and mechanical handling, but also during transportation itself. For instance, coupling of rail carriages may produces significant horizontal impacts. In truck transport shocks may be direct (*e.g.* driving over a pothole) or indirect, when small irregularities in the road cause vibrations that build up in stacked packages. Due to resonating effects the top package may “jump” quite high, and impact the package below. In full-pallet shipments packages are usually tied together with bands or shrink-wrap. In less-than-full-truckload shipments (*e.g.* from distribution centers to retail outlets) this may not always be the case.

Data is available on the level of shock and vibration that can be expected in several different supply chains. For years a report written in the late 1970s was used as the main data source (Ostrem and Godshall, 1979). This report was actually a gathering of all previous studies, so the data in it was considerably older than the report. As both road conditions and truck suspension has since dramatically improved this data can be regarded as obsolete. Since the 1990s a serious movement has started to update the available data. Due to the fast array of different supply chains not all data has been updated yet. First focus has been on parcel shipments, e.g. UPS, DHL, Fed-Ex (e.g. Singh *et al.*, 2001; Singh *et al.*, 2004). Hence there may not always be data available on the actual supply chain a product will be going through.

The occurrence of a certain shock has a statistical likelihood. The more severe a shock the less likely it will be to occur. Brandenburg and Lee (2001, p. 106) provide a graph demonstrating the likelihood of a certain drop height related to the package weight. This is a generalized graph from a US source. The weight is relevant because it is related to the choice for manual or mechanical handling, with related lifting heights. If the most severe shock is taken as a reference for the package design, the result will be overpackaging most of the time. Hence packaging engineers have to decide upfront against which level of impact the product should be protected. This is dependent on the value of the packed product and the cost of additional packaging.

3.3 PACKAGING CHARACTERISTICS

If the impact at which the product fails during testing is lower than the shocks expected during transportation two options are open, either redesigning the product or protecting it with packaging. Even though redesigning the product can yield significant savings, as is demonstrated by Nielsen (1994) and Ten Klooster (2002) this approach is seldom taken due to time restrains and the costs related to changing product specific tools and the resulting delay of the market introduction. Nielsen (1994) describes a redesign of a very fragile computer component. Adding some material improved the robustness of the component considerably. The design change cost $1 per product, while the saving in packaging represented $10,80. Ten Klooster (2002, p. 25) gives an example of a photocopier made by Océ van der Grinten. Packaging designers examined the product to see from which transportation hazards it needed protection. They found that this were mainly vibrations exiting natural frequencies of components. By redesigning the components it became possible to transport 70% of the copiers without any packaging whatsoever.

To design a protective packaging in such a way that it will provide precisely the required amount of protection requires proper knowledge of the mechanical behavior of the packaging material. For some materials, such as expanded polystyrene foam, years of design experience has let to a proper understanding of the behavior of the material. Suppliers provide packaging engineers with graphs which allow detailed design of the cushions.
Of all cushioning materials, most data is available on the behavior of plastic foams. The type and amount of material for cushioning has received a lot of attention from environmentalists (even though for CE goods packaging volume is more essential as stated previously). From this perspective a move into cushioning made of renewable materials has been evident in the packaging design for consumer electronics for years now. Especially paper-based solutions, such as molded fiber, receive a lot of attention. Engineering in renewable, natural materials is more difficult than in plastic foams. There is less engineering experience with these materials, hence less is known of its mechanical behavior as a cushion. Furthermore natural-fiber based materials are not homogeneous, which makes their mechanical behavior less constant. Hence engineering an optimal cushion becomes more difficult. Staying with the example of molded fiber, the true understanding of the material behavior and the resulting design rules is evolving only slowly (Eagleton and Marcondes, 1994; Hoffman, 2000; Gurav *et al*, 2003, Wever and Twede, 2007).

3.4 PACKAGING EVALUATION

Once a design for a protective packaging has been made it can be tested to see whether it provides the protection required. In such a test a packed product is conditioned to a certain temperature and humidity and subsequently subjected to a series of drops and vibrations. The drop height(s) in these tests should be a representation of the actual distribution environment. However, most companies have at one time determined a test procedure, which is not revised afterwards, as long as no excessive damage occurs in the field.

Furthermore, once a packaging design passes the test, the usual approach is to accept the design. There hardly ever is an iteration back, to see whether the package would still pass the test with a little less material and/or volume. Reasons for omitting an optimization are a lack of time and the fact that a lot of cushioning materials used for mass-produced goods require dedicated tools that can not be easily changed. For most cushioning materials no reliable rapid-prototyping method is available.

The optimal packaging for consumer electronics products would allow for some damage. As described in section 3.2 designing a package for even the most unlikely drop would mean that the product is overprotected most of the time. This overprotection has a high economical and environmental cost, both directly through materials used and indirectly through less efficient transportation (Wever, Boks, Stevels, 2007). The cost of additional packaging should be balanced with the cost of expected damage.

However, the cost of damage is not only that of a broken product, but also potential reputation damage if the broken product ends up in the hands of a consumer. Because of this OEMs are wary of accepting a substantial damage rate. Furthermore OEMs do not always collect data on distribution damage. Usually they work with reports from retailers regarding broken products, a statistic called ‘field call rate’. However, this number is not the same as the percentage of distribution damage, as it also includes:

- Manufacturing errors, *i.e.* broken products leaving the factory;
- People returning products they could not get to operate, but which are functioning according to specifications (Den Ouden, 2006);
- People returning products that did not deliver the expected functionality, but which are functioning according to specifications (Den Ouden, 2006);
- Damage occurring after unpacking, that is claimed by the consumer to be caused by original distribution;
- Retailers claiming damage in order to get rid of unsold old product numbers;

Furthermore the data may exclude distribution damage for which the consumer did not take the trouble of returning to the store (although it may have caused reputation damage). Products reported broken are often not returned to the manufacturer as costs of recollecting the product and determining the cause far exceed product value.

Field call rate only relates to damage either noticed at the retailer or at the consumer’s home, so after the product leaves the control of the OEM. Damage that is noticed during the part of the supply chain that is under the control of the OEM only results in financial damage related to the lost product or to the lowered outlet price. Damage making a product unsalable at full price may be related to the product itself or to the packaging as several retailers refuse packages that show too much wear and tear.

3.5 CONCLUSION REGARDING PACKAGING ENGINEERING

Packaging engineering is a field of expertise reasonably well developed. Due to constrains regarding time-to-market, forcing concurrent engineering, packaging engineers oftentimes have to work with data less precise than what they would like. Not every new product can be tested for its fragility prior to the packaging design, data on distribution environment may be outdated or related to different geographical regions, and understanding of the behavior of packaging material may be limited. Besides time constrains, the cost of tooling often prevents an optimization phase in the design after an acceptable packaging design has been found. Optimization is possible, based on damage reports from the field, but this information is often contaminated with other types of damage, as collecting data on true distribution damage is deemed too expensive.

The packaging engineering approach differs strongly from the methodologies proposed by Buijs (2003) and by Roozenburg and Eekels (1995), as both the generation of multiple alternatives as the potential for multiple iterations is limited.

4. PACKAGING DESIGN

From a packaging design point of view, the purpose of the packaging is to help sell the product. To do this several functions come into play, whose importance may differ from product to product. These functions can be:

- Attracting attention
- Communicating Unique Selling Points (USPs)
- Communicating brand image
- Appealing
- Proofing newness (*e.g.* for hygienic products such as electric toothbrushes)
- Preventing theft (making small valuable items harder to hide under a coat)

The last function is an example of a retailer requirement. The retailing of CE goods is evolving into self-service environment, in which packed products are displayed on the shelf. Hence theft prevention has become a relevant function of the packaging. For further discussion of the changes in retailing of CE goods, please see Wever (et al, 2008). Oftentimes manufacturers will hire outside agencies for this design work. The designs are produced by creative people that often have developed their own design process, as will be apperent from the case descriptions in the following section.

4.1 CASE STUDIES IN LITERATURE

Many books are published that show examples of 'great packaging design'. Some of these books also show or discuss part of the development process that let to these designs. Below a overview is given of case studies related to consumer electronic products found in such publications, in order to illustrate how the packaging design process—which is focused on the marketing aspects of the packaging—works in business reality.

CASE A: HALFORD CYCLE COMPUTER

Cliff (1999, p. 16-21) describes a packaging development project for Halfords cycle computers. The project focused on the graphical aspects of the packaging. The process followed is in reasonable concurrence with the Delft Innovation Model.
External design consultants were hired. They started with an exploration of the current market, studying how competitors positioned themselves. About the design brief Cliff states (p. 17): *"The strategic importance of giving customers enough product information and the long-term need to upgrade customer perception of Halfords' own-brand cycle accessories became the core elements"*. This demonstrates the strong marketing focus of the project. From the start the designers wanted a cardboard box instead of a blister pack.
The designers started generating ideas in the form of very rough sketches. Many alternatives were generated, after which a selection was made of three avenues to explore further. These were detailed and presented to the customer, after which the artwork phase was started for final detailing.

CASE B: TELFORT PAK&BEL

Koopmans (2001, p.234-241) describes the development process of the Pak&Bel (Grab&Call) brand for Telfort cell phones. This took place in 1998 when three new providers received licenses to operate on the Dutch market. Telfort was already active in the market for regular phones, and therefore it had an advantage over the other new entrants. Its main challenge lay in making the right marketing decisions.
At that time there were no established pack shapes or market requirements in this young market. Cell phones were perceived by the general public as complicated and something for business people. Telfort wanted to emphasize simplicity. It had to be extremely easy to start using a cell phone. Therefore they needed to position themselves as a retail brand.
Again external design agencies were hired for the design work. They started their work by a field study in the supermarket, as the quintessential place for simple, every-day-like products

and packages. Here the idea came about to use the structural design of milk cartons. This design was perfect to communicate the Telfort message of Grab&Call simplicity.
Due to the dynamic nature of the market, the goal of attracting normal consumers to the cell phone market was reached in half a year. Increasingly consumers wanted more advanced phones, with additional functionality. From and advantage, the simplicity concept turned into a disadvantage, and an upgrade was needed. A metal cookie jar was introduced with a high-end Ericson phone.
Later on a second generation milk carton was introduced, now consisting of a rectangular carton within a transparent PET milk carton, which allowed a clear view of the cell phone itself.
This process shows that the structural design was fully based on marketing ideas, and not on physical distribution considerations.

CASE C: BOSTON ACOUSTICS CAR AUDIO SPEAKER SYSTEMS

Cliff (1999, p.86-89) describes packaging development project for Boston Acoustics car speakers. Again this project is focusing on the graphical/ marketing aspects of the packaging, and again an external design agency is hired to do the job. Crocker, the head of the agency, describes his way of working as: *"We're hunters and gatherers. We create a scrapbook for each project, and we throw everything in there, idioms, metaphors, sometimes pictures photocopied from old books, or drawings of random thoughts." … "Generally, Crocker will show a client four or five directions, each one visualized as a three-quarter view of the pack."* Again aspects of the Delft Innovation Model with several consecutive diverging and converging steps can be recognized.

CASE D: NIKON COMPACT CAMERA

Cliff (1999, p.150-155) also covers two packaging design projects at Nikon, for a newly introduced low-end camera and for a range of more expensive cameras. The project was executed by an external design agency, which focused strongly on marketing issues, such as retailer demands, retail audits identifying competitor design styles and analyzing the Nikon brand identity. Although they came up with structural design for both projects, the designers were focused strongly on the marketing aspects. For instance, the selection of the type of cushioning material was based on the appearance related to the product, and not primarily on its cushioning characteristics.

CASE E: PACKAGING FOR THE DISCOVERY CHANNEL LABEL

Fishel (2003, p.86-89) describes a packaging project for Discovery Channel. Discovery Channel puts its name on a wide variety of products, ranging from headphones to tool sets to popcorn dishes to DVDs and to kids' science products (*e.g.* microscope, metal detector). All these products are produced and packed by third party manufacturers. Also target group wise there is a wide spread with kids' products, adult products and products specifically aimed at either men or women. Furthermore there was the complicating factor of sub-brands such as Animal Planet. The products are sold in a variety of retail outlets ranging from high-end specialty stores to large retail outlets.
An external design agency was hired to develop a design guide for the packaging of all these products, which eventually consisted of several color palettes, typefaces and patterns were prescribed.
Again this project focuses exclusively at the marketing aspects of the packaging.

CASE F: REMINGTON ELECTRIC SHAVER

Cliff (1999, p.188-191) follows the development process of the new packaging for a range of electric shavers by Remington. There were three different models to be packed. An additional challenge being that Remington had no basis for claiming superiority of wet shaving or competitor brands. The external agency followed a process of mood boards leading to 3 concepts. The size of all the packs was unified because of a marketing choice to emphasize the connection between the different shavers.

These case studies demonstrate that many packaging design project have a strong focus on the marketing functions of the packaging. Projects are oftentimes executed by design agencies that have little expertise on packaging engineering. It is relatively common for the marketing functions to directly determine the structural design and volume of the package (*e.g.* Telfort Pak&Bel and the Remington Shaver).

4.2 EVALUATION TOOLS FOR PACKAGING DESIGN

As the goal of marketing is to sell products, and many packaging designs are based on marketing functions, determining the performance of these designs becomes relevant. The effectiveness of a design can not be calculated. It can however be tested. There are several tools available to test the marketing performance of pack designs, mainly coming from FMCG, and each focusing on different aspects of the performance (for a discussion see Wever, Boks, Stevels, 2006, Wever, De Vries, *et al*, 2007):

– Focus groups
  'Focus groups' is a research method consisting of a group interview with carefully selected participants from the products' target group. Focus groups have traditionally been widely used as a packaging design research methodology. It has been applied both at the start of design projects as market research and for evaluation of final designs, i.e. a form of disaster check.
  A weak point of focus groups is that it does not resemble real purchase situations very well as people do not deliberate about a product for an hour, before buying it or not, at least not with fast moving consumer goods. Hence it may be a reasonable research method for durable consumer goods, where often consumers take more time to reach a purchase decision. As stressed by Gold (2004) it is very important to at least place packaging designs next to competitor products, to improve the realism of the setting. Nevertheless, the focus groups approach does not give a numerical output; information about the packaging is generated but performance is not quantified.
– Eye-tracking
  Other methods do allow for measuring. One of these is eye-tracking. The basic idea of the test is to use equipment which is attached to a participants head to measure where (s)he is looking. When performing this test with a section of store-shelves, one can test how many consumers look at a certain package, how long, how often and in what order (Swope, 1981).
– Tachistoscopy (T-scope)
  Another test allowing a certain level of quantification is the Tachistoscope (T-scope). This is a method in which a participant is shown flashes of a product. Starting at for instance 1/100th of a second, exposures are incrementally increased to for instance 2 seconds. After each exposure the participants is questioned about what he saw. Hence average time scores can be obtained needed for aspects like brand recognition, product type identification and noticing special product features (Swope, 1981; Morich, 1981). Where eye-tracking determines where we look, the T-scope focuses on what we have actually seen.
  Hence T-scope is a useful tool in cases where product recognition is of the highest importance, such as medicines which may have to be used quickly in an emergency (Anon., 1993). T-scope testing has also been applied as a scientific research tool, for instance to research the effects of latency of the brain, i.e. whether placement of copy and illustration of the left or right of a package made a difference (Rettie and Brewer, 2000). Major disadvantage of this method is that its setting is very different from actual shopping environments.
– Semantic differential
  This is a method in which participants are asked to score designs on scales between two extremes, i.e. modern versus old fashioned or beautiful versus ugly (Schoormans and De Bont, 1995). In comparison to eye-tracking and T-scope, Semantic differential will measure how people feel about a package.

To some extent these tools are indeed applied in business practice. For instance, the harmonization program for Philips packaging was tested using laser eye-tracking and in depth interviews (Marzano, p.371). However, as testing takes time and time-to-market is essential in the CE business, testing that was scheduled within a specific packaging project is oftentimes skipped in the end.

4.3 CONCLUSION REGARDING PACKAGING DESIGN

Packaging design, as opposed to packaging engineering, is related to marketing functions, as is therefore focused on the appearance of the packaging. It is more of an art than a science. One sees many different creative design processes being applied. However, aspects such as the basic design cycle of analyze-synthesize-simulate-evaluate can often be recognized, as can repetitive divergence and convergence steps.

5. DISCUSSION AND CONCLUSIONS

As discussed in section 1 volume reduction is a top priority in making more sustainable packaging designs for CE products. As this paper has shown the volume of a package can be a result of distribution related packaging functions, as well as the result of marketing related functionalities. Which type of functionality is dominant differs from product to product (It should be noted here that the dominant factor in determining the volume of the packaging is not necessarily the same as the dominant factor determining the total design. For instance, the packaging volume for a large television set may be purely the result of distribution related functions, while marketing related functions will determine the required level of finishing, *i.e.* the quality and elaborateness of the printing).

Each type of functionality comes with its own design process, usually executed by different people. In most cases one of the types of functionalities seems to dominate the packaging development process.

Due to time-to-market restrains and limitations in the available data, the result of packaging engineering is not necessarily optimal. In the reality of the CE market one often has to work with estimated data regarding product fragility and the hazards of a particular distribution system. Even after shipping the feedback data is not clear enough to get a detailed picture of the pack performance. Furthermore the fact that tooling for mass-produced cushions is expensive, and there are no reliable rapid prototyping methods available for many cushioning materials, one often has to accept a satisfying solution, instead of searching for an optimal one.

The same time-to-market restrains limit the testing of the effectiveness of individual pack designs from a marketing perspective. Several tests are available, but they can be quite time consuming, and are therefore oftentimes skipped in the end of a development process. A quick-and-dirty methodology could help here, but it is not currently available.

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