The (development) life cycle for packaging and the relation to product design

Jos A. Oostendorp[1], Josselin M. Bode[2], Eric Lutters[2], Fred J.A.M. van Houten[2]
[1] Royal Grolsch N.V., Enschede, The Netherlands
[2] Laboratory of Design, Production & Management, Faculty of Engineering Technology
University of Twente, Enschede, The Netherlands

Abstract

The development cycle for packaging is not plainly comparable to the product development cycle, although obvious correlations exist. To facilitate the concurrent development of products and packaging, a framework for the packaging development cycle is employed. This framework allows for working methods that enable value-adding in packaging development. However, this requires a transition from using merely technical specifications to employing functional specifications in the aggregate packaging development chain. This transition is described, and the corresponding working methods are elaborated in more detail. Based on this, the synthesised development of product/packaging combinations comes within reach, as is shown based on a number of examples.

Keywords:

Packaging development, Product design, Functional specification, Design integration

1. INTRODUCTION

The primary functions of packaging are to protect the product inside, to make it possible to distribute the product and to inform stakeholders in the entire packaging chain about the product that is inside. Additionally, packaging should make our lives more safe (e.g. unbreakable), pleasant (e.g. user friendly) and healthier (e.g. biobased raw materials). Consequently, an important function of packaging is that it is fit for use.

Packaging development is more than “putting a box around a product”. This publication will give a broad overview of the development cycle of packaging in relation to the product and its design.

Packaging can be divided in a number of distinct levels; i.e. the primary packaging, which is in direct contact with the product, the secondary packaging, which is in fact the packaging for the primary packaging and the tertiary packaging, normally the transportation packaging.

Newly developed, or redesigned packaging materials are used through the entire packaging chain, from raw material, packaging supplier etc. to final disposal or recycling of the packaging. These materials may not cause quality concessions of the packaging, the product or the product/packaging combination. The main activities of the product designer and the packaging designer are to develop specifications that guarantee optimal quality of the product and the packaging. This implies that all agreed demands are fulfilled through the entire product/packaging chain. Quality assurance of the product and packaging is a separate topic in the specification, stating quality agreements between, for example, stakeholders in the packaging chain like packaging suppliers and packaging converters.

In many companies, it was –and still is– habitual to define packaging materials in terms of technical specifications. Documents are used in which for example a bottle is conscientiously described with figures, numbers, mechanical and chemical properties and drawings. A more elaborate goal in packaging development is the aim to develop functional specifications for packaging materials. These specifications describe the functionality of the packaging materials throughout the entire packaging chain, involving all stakeholders. This approach guarantees that all the available knowledge in the demand and supply chain is deployed to get the most applicable packaging.

In the following sections, the gradual transition from a technical to a more functional specification is described, based on an analysis of the traditional packaging development chain.

2. PACKAGING DESIGN LIFE CYCLE

Equivalent to the development cycle of products, the packaging development cycle also started to effectuate the integration of downstream processes like process planning, production planning and maintenance. This not only includes primary processes, but also covers aspects like life cycle analysis, cost estimation and other performance indicators.

Although distinctly correlated to the product development cycle, the packaging development cycle is not obviously comparable. It at least requires special attention. The life cycles of the product and the packaging can differ enormous. In some cases the packaging/product combination is only relevant until the beginning of the usage phase of the product. An example of this is the box used for transportation of bicycles. Adversely, a plastic bottle for sauces is used until the bottle is empty. When the packaging is designed for multi-usage, the life cycle of the packaging is even much longer than the life cycle of the product. This is for example the case for a refillable crate and bottle system.

Additionally, the ratio between the added value of the packaging and the added value of the product can be extremely dissimilar. Aiming at the optimal value for this ratio, an integrated approach for the development of product/packaging combinations is required. If an integrated method is applied in designing the product/packaging combination, the best agreeable solution for all the stakeholders in the product/packaging chain is achieved.

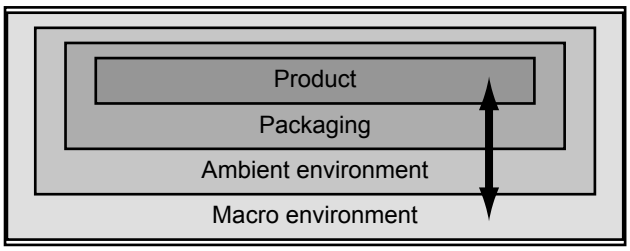

Figure 1: Interaction of the packaged product with the environment (based on [3]).

3. TRADITIONAL PACKAGING DEVELOPMENT

The primary function of any package originally addressed containing the product, and protecting it from the ambient environment (see figure 1). On the one hand this can imply protecting the product against the environment, to enhance the products life time and conserve its content. On the other hand it can imply the protection of the environment against the packaged product (e.g. for harmful or toxic content). In either case, packaging provides possibilities to facilitate the transport of the packaged content [1] [2].

In current, everyday practice, packaging is usually developed from these primary functions, combined with a range of aspects that relate to the secondary functions of a package.

These secondary functions of packaging originate from all the stakeholders that have an interest in the packaging chain. Stakeholders in the packaging industry are firstly stakeholders in the packaging industry itself, but can also be found in the producing sector, the distribution and retailing industry, the government and among product users [3]. Looking at the wide range of stakeholders involved in the packaging chain gives insight in the range of interests, possibly requiring specific packaging functions or demands and constraints for the packaging. Consequently, the secondary functions of packaging address a wide range of fields like information and communication (also know as 'communicative artefacts' [2]), sales, marketing, distribution, design, etc. This entirety can be seen as the macro environment of the package. [3]

The overall functions of packaging can therefore be described in four stages:

Container function:

- Conserve: the packaging seals off the macro environment and is inert; it mechanically protects against pressure and shocks. Furthermore, it also protects against e.g. insects, thermal transfers, light, micro organisms and vandalism.
- Transport and storage: the modularisation of the package facilitates transport, storage and maintenance of the mechanical protection.

Information function:

- Identification: by means of explicit display, information to classify and trace the product/packaging is presented.
- Instruction: present information to prescribe the usage, lifetime, content etc.

Marketing function:

- Display: customer-oriented subjective communication is used to aim for retention; e.g. by displaying the logo on a strategic place.
- Attraction: product appeal is aimed at through the use of specific designs realise an "emotional" expressiveness of the packaging.

Utility function:

- Facilitating use: employ ergonomic design to include e.g. easy opening systems.
- Facilitating purchase: stimulating purchase through smart marketing tactics, like using an appealing design that e.g. facilitates domestic transport, strategic shelf placement and lowering the price of the packaging [1].

3.1 Stakeholders

The wide range of stakeholders involved in the packaging chain is usually the cause of the emergence of an abundance of strongly diverging and general packaging demands to satisfy the specific needs of these stakeholders. These demands may stem from the individual opinion of one stakeholder, but the origin more often lies in the fact that the interaction between the stakeholders and the packaging (development) is influenced by all kinds of rules, legislation, covenants and (industry dependent) trade agreements, –in short, the industrial and legal parameters [3]. Five main categories of these regulations can be distinguished (based on [4]), whilst different countries may ally with different organisations and standards:

- Administrative needs, e.g. regulations for the packaging of foods, medicines and dangerous substances. (e.g. FDA/BFR/CIVO-TNO)
- Requirements designed to protect the public, like Hazard Analysis of Critical Control Points (HACCP), safety and labour legislation.
- Protection of packaging design.
- Environmental protection (e.g. Essential demands in the European packaging legislation, LCA)
- Traceability and export

3.2 Technical specifications

As mentioned, the primary function of packaging is not merely protecting (combined with some additional functions) any more; it also comprises of adding value to the entire supply and demand chain [5]. This offers various advantages for producers and consumers. For example, the overall quality becomes higher, which has potential benefits like longer life times of packages and/or products and less waste disposal due to packaging etc.

To achieve this, the product and the packaging must be developed together. In doing this, the starting point must be the set of requirements that packages have to meet; this entirety is referred to as the technical specification, (figure 2). To obtain an adequate overview of everything involved in this technical specification, all involved stakeholders are taken into account, and also the entire packaging development chain is considered (figure 3).

Technical specifications are explicitly stated constraints; an example is the statement that the weight of a product together with its packaging may not exceed 15 kg. (e.g. because of labour legislation).

3.3 Formalised development chain

Looking at the overall packaging development chain leads to a viewpoint that intuitively diverges from a common product development cycle. This also engenders a distinct set of requirements for every stage of the development chain. A number of primary stages in the packaging development chain of packaging is displayed in figure 3. The types of constraints that emerge from a certain stage of the development chain are strongly dependent on the product under consideration. Obviously this stresses the

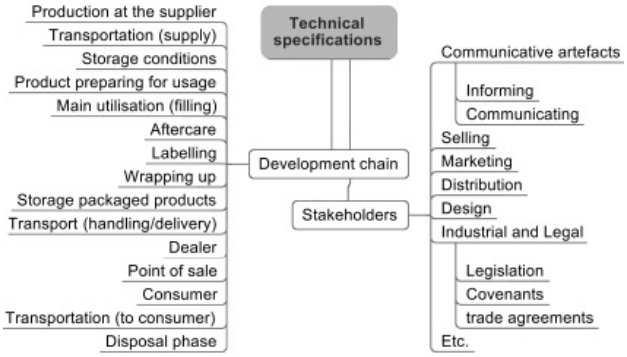

Figure 2: Origin of technical specifications.

importance of an integrated approach for the collective product/packaging development. A number of examples drawn from different stages clearly show the variety in packaging specifications:

- Transportation; Increasing demands are imposed on the traceability of expensive products (e.g. electronic equipment), to prevent theft, but also to improve the verifiability of the logistics of products.
- Storage conditions; Required storage characteristics can be extremely different; e.g. from one week to a year, from inside to outside, (un)sealed, etc.
- Packaging preparation before usage; Some types of packaging require preparation; e.g. cleaning before filling in the case of multi-usage, or pre-shaping of the packaging in the case of disposables for food.
- Labelling; Due to the increased accessibility of foreign markets, the variety of required labels increases.
- Point of sale; Products are sometimes packaged in blisters to prevent theft. Blisters are difficult to open –by design; they also frequently have excessive dimensions to prevent (too) easy handling of the product/packaging combination (figure 4).
- Consumer; In the huge variety of customers in a market, important distinctions can often be made; for example between primary customers (like parents paying for a toy, and assessing quality, suitability and safety), and secondary customers (like children expressing the 'need' for the product, but not worried about e.g. the toxicity of the materials used).

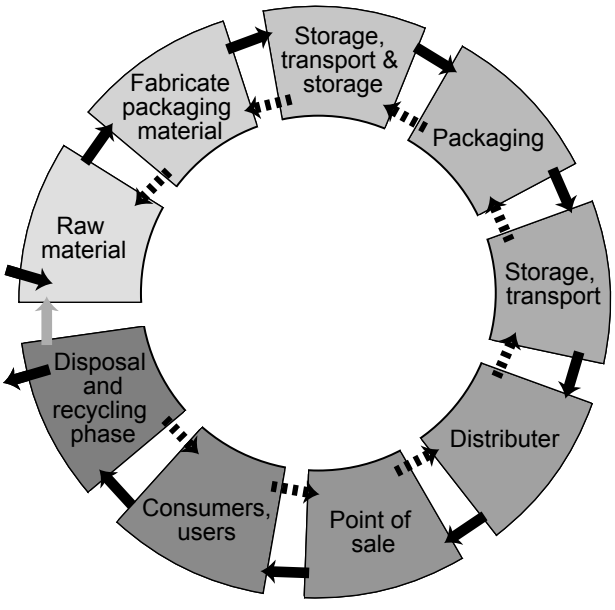

Figure 3: The packaging development aspect chain.

Figure 4: Blister package.

- Disposal phase; Some packaging types can be reused (like glass bottles), others can be recycled (like cardboard boxes) and others will be treated as waste.

As depicted in figure 3, the packaging development chain is a sequential chain. This is one of the main reasons for the technical specifications to become a static entirety of constraints that packaging development must adhere to. The technical specifications therefore decay into a kind of checklist merely listing important issues that must be taken along in the design process.

However, the use of such checklists does –by default– not lead to product/packaging combinations with added value, because these technical specifications merely give the minimal requirements a packaging must comply with.

What is really needed in the development process, is a type of constraints that enables guidance of the combined product/packaging development cycle in such a manner that real added value can be achieved. These constraint have to be embedded in a certain 'solution space'. Such a solution space represents the freedom of actions for the developers, within the circumscriptions derived from the technical specifications.

4. FUNCTIONAL SPECIFICATIONS

This description of solution spaces indicates that it is indeed not enough to have an adequate overview of the constraints and checklists that apply to either the product or the packaging under consideration. The answer to the design problem has to be found in the solution space, with the 'dimensions' established by the technical specifications.

However, within this solution space, there is neither indication nor initiative to steer the development process in a certain direction. This control of the development cycle can either stem from (traditional) design methods, or from depicting the character of the solution as a target for the development process. The latter can be achieved by scenario based design.

In scenario based design, techniques are used that apply scenarios to bring products, environments and their interactions into harmony. Here, scenarios are explicit descriptions of hypothetical events concerning a product during a certain phase of its life cycle.

Independent of the working method chosen for the design process, a number of aspects will emerge that play a distinct role in the development cycle, by either assessing, valuing or directing the present, intermediate representation of the design. Obviously, there is a clear distinction between these aspects and the functional requirements.

As such, these aspects can be referred to as functional requirements, thus stressing the fact that a design not only needs certain criteria to adhere to, but also has a set of 'goal functions' to drive its development.

In regarding product development, it is clear what the role of functional requirements is; however, for packaging development, the impact is less distinct. This is obvious, as for packaging the set of 'traditional' functions that could be influenced by functional requirements is limited to the primary functions as mentioned in section 3.

However, in presuming that functional specifications can not only be formulated for either a product or its packaging, but also for the product/packaging combination, this situation might change considerably.

4.1 Functional specification for product/packaging combinations

A functional specification is a tool to address the functionality of packaging materials throughout the entire packaging chain. Until now, it usually is a combination of all the technical and quality aspects of a packaging (the technical specification) and the functional aspects of the packaging/product combination.

Ideally however, a functional specification purely includes the functional aspects; the technical specification is only attached as a derivative thereof, outlining the solution space. This also indicates the main goal of using functional specifications: all stakeholders are now conjointly aware of the functional aspects throughout the entire packaging chain. All technical solutions must accordingly fit into this set of functional specs.

The use of functional specifications can aid in reducing costs, because the quality of the resulting packaging/ product combination can be improved. Quality costs can be divided in four major categories:

- Prevention costs
  (e.g. making the functional specs)
- Inspection costs
  (e.g. check on quality of the process or product)
- Internal costs
  (e.g. packaging failures in a filling line)
- External costs
  (e.g. a product recall from the market)

The more complete the functional specification is, the less quality costs a company will face in the other three categories. On the one hand this goes without saying, as everything that is anticipated will probably not cause unexpected costs. On the other hand, costs in the other three categories are lower, because all stakeholders were involved in the process; therefore they are partly responsible for the quality of the final specification as well as for the final product/packaging combination.

In this manner, a much more integrated development cycle for product/packaging combinations is devised. This, among others, implies that functional specifications can only be changed if all relevant stakeholders approve of the changes. Obviously, the process of determining and maintaining these functional specifications must facilitate (instead of hamper) the development process, and should definitely not lead to chain reactions in communication [6].

The functional specification enables the accomplishment of the expected quality of the product/packaging combination (protection, legislation etc.) and establishes the quality of the packaging material in the different phases (distribution, opening etc.) of the packaging chain (see also figure 3).

Functional Packaging Specification

Type : Non-returnable exportpallet
Date : 06 jan 2006
Supplier : "the Palletmaker"
Articlenumber : xxxxyy

General Description:
Non-returnable pallet for transporting cartons with steel containers containing product *bbbb* all over the world.

Quality of the packaging (to ensure product-quality):
- pallets according to purchase conditions;
- pallets according to international legislation;
- pallets do not injure or harm people involved in producing and using the pallets throughout the whole packaging chain;
- pallets must assure the quality of the cartons and the content of the steelcontainers during transportation and stocking;
- pallets must be suitable for normal use for all stakeholders in the packaging chain.

Use of pallets in the packaging chain:
- pallets must be produced according to the specifications;
- pallets must keep their properties during transportation, stocking and use in the entire lifecycle of the pallet packaging chain;
- pallets should be recycled according to international environmental legislations.

Annexes:
- list of requirements;
- quality assurance aspects like critical faults;
- drawings and other technical specifications;
- packaging issues.

Changes of this document are only valid
if approved by all stakeholders

Authorization by supplier and owner of the pallet

Figure 5: Simplified example of functional specification.

5. SYNTHESIS OF PRODUCT AND PACKAGING DEVELOPMENT

From the previous sections it is clear that in many cases, additional added value can be generated by the synthesised design and engineering of products and packaging development trajectories. In this, the functional specification of product/packaging combinations plays an important role. This has already become habitual for product development, but has to be introduced for the development of packaging. Over the last decades, comparable situations have been encountered for the integration of downstream product-related aspects like process planning, production planning, life cycle analysis, etc. Invariably, an ostensible dissimilarity in interests seems to present a barrier for an adequate integration. However, in recognising that all these downstream processes are actually contributive to the product development cycle, the product design itself becomes a reference point for all processes involved [6].

Unfortunately, the situation for packaging development is completely different, as -in striving for added value- the development cycle for packaging cannot be considered to be a downstream process in product development. This is obvious, as in combined product/packaging development, the mutual influence between product and packaging is bidirectional. As a simple example; in reconverting to colourless transparent glass for a bottle for beverages, the content may require special raw materials to prevent the product from degeneration under the influence of light.

This example stresses the coherency between products and their packaging. Compared to product development, this liaison -at first sight- resembles how components interrelate to the parent assembly, and other components that are part thereof. In continuing this line of thought, the

development cycle for a product/packaging combination can then be compared to the cycle for assemblies, constituted of geometric entities. In this, it is immaterial if the product stems from the food or the non-food sector.

This approach does justice to the equal share of the product and the packaging in the entire result; moreover, existing design models can then be used to govern the combined development. However, there might be a number of reflections to prevent from an all too imprudent adoption of this comparison.

Firstly, product/packaging combinations may seem to have a more explicit differentiation between the parts than is the case for components and sub-assemblies in an assembly. However, in looking at e.g. a desk-jet printer, the cartridges have an analogous relation to the printer body.

Secondly, the life cycles of the product and its packaging can differ, which may seem illogical for an assembly. Again, the example of the printer heads shows that such differences can indeed exist.

Thirdly, products and packaging can be argued to stem from different domains. In other words, they need different expertise, processes, knowledge and information from different contexts during their development. This argument holds, as long as a comparison to sheer geometric assemblies is made. In considering that a vastly increasing number of products encompass geometry, as well as electronics and software, product developments cycles already are accustomed to deal with multiple domains. This does not necessarily imply that inviolable working methods for the development of such products exists, it merely affirms that developing a product/packaging combination indeed shows strong correspondence to the development of multiple-domain assemblies.

This, from a completely different viewpoint, also values the importance of functional specifications for packaging. In straight terms; if the packaging is a part of the overall assembled product, how can it's demeanour be specified without functional specifications, as used for other components and sub-assemblies?

Consequently, working methods for developing product/packaging combinations can directly be borrowed from product development, as long as these working methods are valid for assemblies, and can appreciate the existence of multiple domains. As is the case for the integration of e.g. electronics and geometry in a product, the design method and working methods have to be capable of adjusting to unforeseeable details. Again, it is not assumed that these conditions are already solved for e.g. geometry, electronics and software; it merely implies that for product/packaging combinations, no -a priori- upheaval in design methods is required. The main precondition is that developers understand and value the denotation and possible added value of the synthesis of product/packaging development.

6. CASE STUDIES AND EXAMPLES

6.1 Grolsch returnable swingtop bottle; polypropylene knob

Since 1897, Grolsch Premium Lager is bottled in so called returnable swingtopbottles with a swingtopclosure made of a ceramic knob, stainless steel wire and a thermoplastic seal (figure 6). Based on technical specifications, the ceramic knob was improved many times; e.g. as concerns material properties, printing and tolerances of the dimensions. After starting to work with functional specifications for packaging, other and better solutions for the swingtopknob

Figure 6: Grolsch swingtop.

were developed. In 2002, the brewery introduced the returnable two-colour polypropylene swingtobknob in the returnable market. Compared to the ceramic knob, the polypropylene knob shows improvements as concerns a.o. the oxygen- and carbondioxide permeability, the shelf live of the knob after 60 cycles, the recycling of the knob and the assembling of the complete closure. Additionally, due to better tolerancing of all dimensions of the knob, the efficiency of the swingtop-assembling machine and the swingtop closing improved considerably.

6.2 Packed endive:

A noticeable example of a new product/packaging solution is a new packaging for endive. In the development phase of the packaging, all stakeholders in the whole demand and supply chain were explicitly involved. This enhanced the brand/value proposition and shopping experience for the end consumer in terms of product presentation, best-before-end date, ease of shopping and use of the product.

To keep endive heads longer fresh, they are cooled before they are packaged. Quality Growers Holland introduced PP film with extremely fine perforations as packaging material (see figure 7). This results in a natural reduction of oxygen inside the packaging and an increase in the level of CO_2; thus the product stays fresh and crisp much longer. Because green, brown or reddish discoloration is greatly reduced, losses are reduced as well. When unpacked and exposed to light, endive will turn green within just a few hours. When stored properly (i.e. dark and refrigerated at 4 to 5 ˚C), the new packaging preserves the quality of the endive heads for weeks. This quality is not influenced by several days of storage in display cases. Moreover, the packages can be printed with e.g. recipes, storage and preparation tips, production information and –also important– bar codes and production codes (for tracking and tracing). The products are stored hygienically, and consumers no longer have to dig around to find the nicest looking heads. Obviously, all these advantages mean a much better presentation, accompanied by a much higher turnover.

Figure 7: Packed endive.

Figure 8: Soluble packaging.

6.3 Sun tablets with biodegradable soluble packaging for use in a dishwasher

In 2004, Unilever's brand Sun introduced a biodegradable, soluble packaging for dishwasher tablets. The new packaging is a hydrofilm™ soluble wrapper, that contains detergent, salt, rinse-aid and glass protection technology (see figure 8). The end-consumer does not have to unwrap the tablet, avoiding direct contact with the tablet, which gives more convenience.

This type of product/packaging combination is an example of the synthesis between the product and the packaging. In fact, the packaging has become part of the product. Combining the basic functions of the packaging (protect, transport, inform) and re-defining the functions of the product packaging combination made it possible to change the (technical) design of the old wrapper.

6.4 Digital camera

Nowadays, digital cameras and camcorders are designed as high-tech electronic consumer products. The design process of the packaging is usually considered as a necessary evil to pack the camera and some attributes into a carton box. By starting to develop the camera and the packaging simultaneously from the beginning of the design process and to describe the possible functions of the product and the packaging throughout the whole product/packaging chain, new solutions for the product/packaging combination will find their ways to consumers. Examples may include a packaging that is also a docking station for the camera, a recharge unit for the batteries or even a display to show the movies and photos.

Here, the digital camera is just an example. An improved approach, using functional specifications can aid in developing more sustainable designs for many product/packaging combinations.

6.5 Koopmans Shaker Pancake mix

About a year ago, the so-called Koopmans shaker was introduced on the Dutch market. This new product/packaging combination assists in conveniently baking pancakes (see figure 9).

When bought, the packaging only contains a small amount of powder (filling amount around 10-15% of the packaging volume). When preparation the mix for the pancake, milk is added into to the new packaging; the required amount of milk is indicated on the packaging by means of a line. After shaking the powder and the milk for a while, the product can directly be poured in a pan.

Figure 9: Koopmans Shaker.

During the packaging development process it is very important to investigate the product-packaging combination in terms of composition, sticking at the inside layer of the shaker, shelf life, contamination, migration, etc. and make sure that the pancake-powder mixes well after putting the milk in the bottle. Integral development of the product and the packaging, using functional specifications, is necessary to achieve the optimal solution for this new product-packaging combination throughout the whole product-packaging chain.

7. CONCLUDING REMARKS

Using only technical specifications will not provide the added value that adequate packaging development can bring. For packaging, the result of the design process can be stated in functional packaging specifications. These specifications become useful tools in decreasing quality costs. Additionally, the functional packaging specification is a tool for redesigning new packages using input from all stakeholders in the packaging chain. Inclusion of all these stakeholders is not straightforward nor obvious; it will take considerable efforts to get all of them acquainted with the new approach. Thus, the working methods to realise the synthesis in product/packaging development have to be carefully introduced; also the context that encloses the working domain requires considerable attention.

The given examples indicate the validity of the approach; the corresponding working methods will be belaboured in more detail to arrive at a generic model. This model will be implemented and assessed in industrial practice.

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