8. The Concept of Packaging Logistics in Aviation Cargo Transportation

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When we think of packaging, oftentimes consumer packaging is what first comes to mind. In reality however, packaging is used throughout the whole supply chain, way before a product reaches a consumer.

In a general sense, packaging is a means or a complex of tools that ensures the preservation of the quality of products in the process of their circulation, extension of the terms of their storage, protection against damage, pollution from the outside, including infection by microorganisms. The main function of packaging is the protection of packaged goods from unfavorable external conditions, as well as the prevention of the entry of particles of products or individual items into the environment, which reduces the quantitative losses of the goods themselves, as well as pollution of the environment.

The various functions of packaging are divided into primary, secondary and tertiary functions [3]:

8.1 PRIMARY FUNCIONT DIVIDED INTO THE FOLLOWING SUB-FUNCTIONS

8.1.1 Protective function. The protective function of packaging essentially involves protecting the contents from the environment and vice versa. The inward protective function is intended to ensure full retention of the utility value of the packaged goods. Packaging is thus intended to protect the goods from loss, damage and theft.

In addition, packaging must also be reliably able to withstand many different static and dynamic forces to which it is subjected during transport, handling and storage operations. Goods frequently also require protection from climatic conditions, such as temperature, humidity, precipitation and solar radiation, which may require „inward packaging measures“ in addition to any „outward packaging measures“.

The outward protection provided by packaging must prevent any environmental degradation of goods. This requirement is of particular significance in the transport of hazardous materials, with protection of human beings as primary importance. Packaging must furthermore, as far as possible, prevent any contamination, damage or other negative impact upon the environment and other goods.

The inward and outward protective function primarily places demands upon the strength, resistance and hermetic properties of transport packaging.

8.1.2 Storage function. Packaging materials and packaging containers required for producing packages must be stored in many different locations both before packaging of the goods and once the package contents have been used. Packaging must thus also fulfil a storage function.

8.1.3 Loading and transport function. Convenient goods handling entails designing transport packaging in such a manner that it may be held, lifted, moved, set down and stowed easily, efficiently and safely. Packaging thus has a crucial impact on the efficiency of transport, handling and storage of goods. Packaging should therefore be designed to be easily handled and to permit space-saving storage and stowage. The shape and strength of packages should be such that they may not only be stowed side by side leaving virtually no voids but may also be stowed safely one on top of the other.

The most efficient method of handling general cargo is to make up cargo units. Packaging should thus always facilitate the formation of cargo units; package dimensions and the masses to be accommodated should where possible be tailored to the dimensions and load-carrying capacity of standard pallets and containers.

Where handling is to be an entirely or partially manual, package must be easy to pick up and must be of a suitably low mass. Heavy goods must be accommodated in packages which are well suited to mechanical handling. Such items of cargo must be forklift-able and be provided with convenient load-bearing lifting points for the lifting gear, with the points being specially marked where necessary (handling marks).

The loading and transport function places requirements upon the external shape of the package, upon the mass of the goods accommodated inside and upon the convenient use of packaging aids. The strength of the package required for stowing goods on top of each other demonstrates the close relationship between the loading and transport function and the protective function.

8.2 SECONDARY FUNCTIONS DIVIDED INTO THE FOLLOWING SUB-FUNCTIONS

8.2.1 Sales function. The purpose of the sales function of a package is to enable or promote the sales process and to make it more efficient.

8.2.2 Promotional function. Promotional material placed on the packaging is intended to attract the potential purchaser's attention and to have a positive impact upon the purchasing decision. Promotional material on packaging plays a particularly important role on sales packaging as it is directly addressed to the consumer. This function is of subordinate significance in transport packaging. While product awareness is indeed generated along the transport chain, excessive promotion also increases the risk of theft.

8.2.3 Service function. Various items of information printed on packaging provide the consumer with details about the contents and use of the particular product. Examples are the nutritional details on yogurt pots or dosage information on medicines. The package may also perform a further function once the contents have been used (e.g. storage container, toy).

8.2.4 Guarantee function. By supplying an undamaged and unblemished package, the manufacturer guarantees that the details on the packaging correspond to the contents. The packaging is therefore the basis for branded goods, consumer protection and product liability. There are legislative requirements which demand that goods be clearly marked with details indicating their nature, composition, weight, quantity and storage life.

8.3 TERTIARY FUNCTIONS MEAN ADDITIONAL FUNCTIONS

The additional function in particular relates to the extent to which the packaging materials or packaging containers may be reused once the package contents have been used. The most significant example is the recycling of paper, paperboard and cardboard packaging as waste paper.

Much of packaging is used to protect the product during transport between manufacturers, distributors and retailers, called transport packaging [10]. Today, transport packaging also increasingly reaches consumers directly, as e-commerce business continues to grow and reshape the packaging value chain and the customer experience.

Transport packaging is a shipping unit that provides containment and protection to goods during handling, storage, and transportation. The term includes all industrial packaging and shipping containers for consumer products [4].

Transport packaging is designed to protect goods that are in transit, especially products that are shipped by trucks or trains. However, the supply chain often includes other modes of transport, including air transport. Therefore, transport packaging needs to be designed for both the local conditions and the export conditions if the goods are sent from one country to another. Here's why transport packaging is so important for aviation cargo transportation [9]:

1. makes transportation possible. It's an obvious point, but one well worth making. The right transport packaging makes it possible to get products out into the world. In the case of smaller products, packaging allows to deliver large quantities in a convenient way.
2. protects goods. Goods that are damaged upon arrival can cause major problems. Not only do lose the cost of the original item and shipping it in the first place, may also have to send replacements at additional cost. Broken or marked items can upset customers and retailers, souring relationships and giving company a bad reputation. Logistics packaging keeps all items safe, so they arrive at their destination in perfect condition.
3. conveys important information. There can be a lot of important information that distributors need to know about product. Transport packaging is the perfect place to display this information. A lot of different things can be printed on boxes. It could be something simple, like which way up the packages need to go, or that the contents are fragile. Company can also specify more detailed handling instructions, such as a particular temperature range products need to be stored at.
4. makes storage possible. Transport packaging makes all kinds of products easy to store. No matter what shape, or how fragile, the right packaging allows them to be stacked, placed onto pallets, or otherwise arranged for convenience.
5. helps sell products. If a company chooses retail ready packaging, its products can be displayed on the shelves in their own custom display. By choosing logistics packaging that features brand colours, product details, and other relevant sales information, company increase chances of catching the eye of its target market.

Transport packaging must provide sufficient damage prevention, optimize space utilization, and use sustainable materials with responsible end of life scenarios. Consider them in more detail [9]:

1. damage prevention. In aviation supply chain, every "touch point" increases risks of product damage and so packaging plays a central role in protecting a product. Damage to the product is the worst case scenario for aviation supply chain players and the environment. Replacing damaged products accounts for a much higher greenhouse gas output and resource usage than does packaging. Damage prevention also reduces unnecessary extra shipments due to returns and replacements. Working across the value chain to ensure damage prevention at these different levels helps bring products safely to market. Products can also be redesigned to minimize damage in aviation transport.
2. material efficiency. High importance placed on protection can lead to over-packing products, using unnecessary amounts of dunnage materials. More and more, end consumers see this waste first-hand through e-commerce packaging deliveries to their home. This can negatively impact company reputations, particularly when the material is not recyclable or reusable. Sustainable transport packages should aim to find that 'sweet spot' between protection and material reduction. To this end, companies must understand their damage rates and invest in continuous improvement and material optimization for their packaging.
3. volumetric efficiency. Lack of customizable boxing options can also lead to over-boxing and inefficient use of space where excess air is transported. Efficient box and container space that is lightweight allows for more products to be shipped in a single load, while reducing greenhouse gas emissions from unnecessary extra shipping and weight. It also further reduces packaging material usage. Open communication between brands, suppliers, manufacturers and distributors helps to facilitate this system wide optimization which also reduces costs of shipping.
4. sustainable material sourcing and end-of-life. While transport and optimization are central to sustainability considerations for transport packaging, it is also important to consider sourcing and end-of-life. Materials with favourable characteristics from the sourcing perspective are those that come from renewable and responsibly sourced resources or include recycled content. From an end of life perspective, favourable packaging are those that are reusable, recyclable (with access to collection and an end market), or compostable (where access to composting exists). Since transport packaging touches players across the aviation value chain, collaboration is critical in identifying best practices for materials and formats.

Distinguish between inner and outer packaging [11]. Inner packaging is the primary container in which goods are placed at the place of production. Inner packaging includes packages, boxes, bottles, cases, cans, etc. Inner packs soften possible impacts during transportation, prevent ingress of moisture, dust, and odours. For tourist transfers, private hotels, hotels and clubs use the inner packaging.

Inner packaging is strengthened in the exterior with the help of packaging materials and, if necessary, spacers. Foil, shavings, sawdust, fibrous waste, cotton wool, foam rubber, and various types of paper – waxed, waterproof, wrapping, parchment, etc. – are used as packaging materials. To absorb shock and vibration loads that occur during transportation, shock absorbing pads from polyfoam, corrugated cardboard, wooden and plastic liners.

Outer packaging shall ensure the complete safety of inner packaging and cargo. The type of outer packaging is chosen in accordance with the physio-chemical properties of the cargo, the characteristics of the inner packaging and the conditions of transportation.

The most important sign of outer packaging is its rigidity. Commonly we can divide packaging into Rigid, Semi-rigid and Soft packaging.

Containers that do not lose their shape, during aviation transportation and storage, can withstand the pressure of the material packed in it, the top layer of the cargo, as well as the mechanical loads that occur during

transportation and handling operations, are tough or rigid packaging. This type includes metal, plastic and wooden packaging.

Advantages of rigid packaging:
- reliably protects products from mechanical influences (impacts, pressure, punctures) that arise during transportation and storage. We can put the goods on top of each other;
- some types of packaging – metal and glass – prevent the impact on the products of oxygen air, foreign flora, which reduces the risk of oxidative damage, as well as microbiological damage;
- metal packaging and bottles of dark glass protect the product from the action of sunlight, which accelerates the processes of oxidative damage.

Disadvantages of rigid packaging:
- high share and volume of packaging to mass and volume of goods (25-30%);
- high cost (purchase and operation price – repair, delivery of empty packaging).

Semi-rigid packaging is different from the rigid that is capable of deforming under load, but is sufficiently resistant to protect the load from damage. Semi-rigid packaging retains its shape while being empty, without being compressed. This package includes a large part of cardboard and wicker packaging.

Advantages of semi-rigid packaging:
- semi-rigid packaging differs from rigid, less mass and volume;
- empty packaging is easily composed or embedded in one another, which reduces the cost of transportation and storage;
- the cost of such packaging is much lower, because cheap materials, including those obtained by recycling of wood, are used;
- a semi-rigid packaging is used for goods which are relatively stable to mechanical influences, which ensures their safety.

Disadvantages of semi-rigid packaging:
- semi-rigid packaging is not mechanically stable during transportation and storage, it is necessary to create conditions that prevent significant mechanical action.

Soft packaging does not protect the cargo placed in it from mechanical impact and is used to create the best conditions for the aviation transportation of bulk cargo. Soft containers include bags, coolies, bast-plates, etc.

Advantages of soft packaging:
- low cost of purchasing, storing, transporting, returning, which makes it preferable to other types of packaging;
- separate types of soft packaging, in particular polymeric, are used for hermetic packaging by thermocycling;
- for products which are living biological objects, soft packaging of polymeric materials (polyethylene bags, liners) are used to create a modified gas environment.

Disadvantages of soft packaging:
- it does not adequately protect the product from external mechanical damage;
- it has the lowest reliability of protection from impact of environmental, therefore, it applies only for a certain list of goods.

Packaging has a significant impact on the efficiency and effectiveness of supply chains, where improvements can be achieved through the adaptation and development of the concept of packaging logistics [7]. In order to enable these improvements, models are needed that facilitate evaluations along the aviation supply chain and show the activities involved in the packaging logistics process.

There is no doubt that packaging has a significant impact on the efficiency of aviation logistics systems, as well as on the processes of production, distribution, storage and processing throughout the supply chain. However, many packaging dependent costs in the logistical system are frequently ignored by packaging designers. Packaging specifications directly influence the time required for loading and unloading operations which ultimately affects supply chain time and due date performance (delivery) to the customer. Examples of the relationship between packaging and aviation logistical activities are shown in table 1.

Table 1. The impact of packaging on aviation logistics activity [based on 6,7]

Logistics activity	Decisions for improving packaging	Impact on logistics activity	Comments
Transportation	Increased package information.	Decreases shipment delays.	Increased package information decreases tracking of lost shipments.
	Increased package protection.	Decreases damage and theft in transit.	At the same time, this leads to an increase in packaging weight and transportation costs.
	Increased standardization.	Decreases handling costs, vehicle waiting time for loading and unloading.	Increased standardization increases modal choices for shipper and decreases need for specialized transport equipment.
Inventory	Increased product protection.	Decreases theft, damage, insurance. Increases product availability.	At the same time, this increases product value and carrying costs.
Warehousing	Increased package information.	Decreases order filling time, labour cost.	–
	Increased product protection.	Increases cube utilization (stacking).	At the same time, it decreases cube utilization by increasing the size of the product dimensions.
	Increased standardization.	Decreases material handling equipment costs.	–
Communications	Increased package information.	Decreases other communications about the product.	For example, telephone calls to track down lost shipments.

The concept of packaging logistics in aviation cargo transportation focuses on the synergies achieved by integrating packaging and logistics systems with the potential to increase the efficiency and effectiveness of the aviation supply chain, through the improvement of both packaging and logistics related activities. One way to achieve this is to concentrate on packaging development that benefits packaging related activities in the logistical system, often called logistical packaging [7].

A framework for evaluating packaging concepts, with emphasis on a wider systems view, where interrelated logistics, marketing and environmental aspects are addressed is therefore needed. Overview of different packaging functions is presented in Fig. 1.

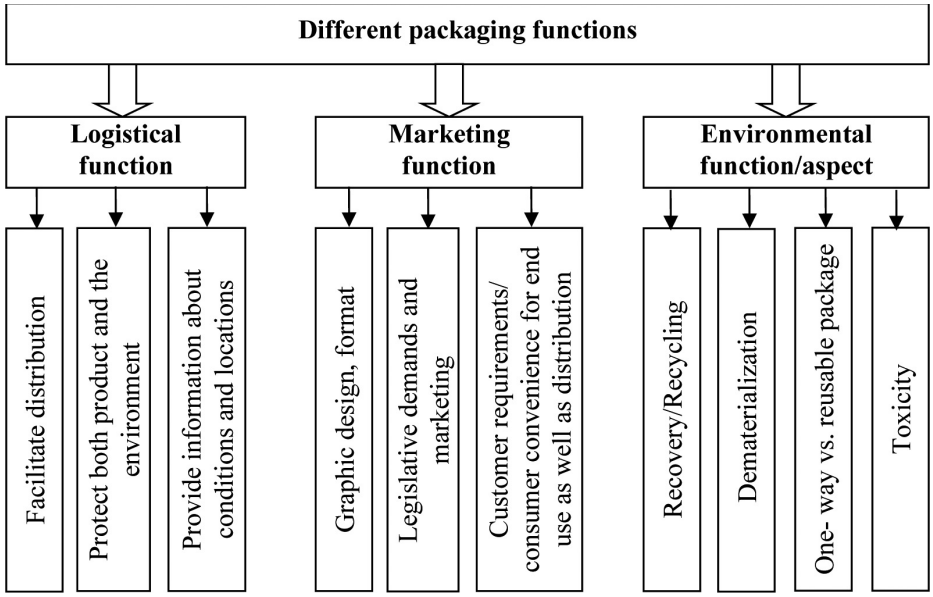

Fig. 1. Overview of different packaging functions [based on 5, 7]

Satisfying logistics and marketing requirements means optimizing and harmonization the dimensions package size, mass products in it, and other parameters.

Logistics requires optimization of the size of the consumer and transport containers, so that the container accommodates 94-100% of the area of the pallet, the dimensions (mm) of which are determined by the international standard: 1200*1000, 1200*800, 1000*800.

From the standpoint of marketing requirements, packaging and labelling should serve informative functions, promote the creation of consumer preferences and also serve as advertising.

We can distinguish client-oriented packaging (that is convenient to a customer, beautiful, is additional advertising products and so on) and logistic package (that ensures product safety, easy storage on pallets, and convenience in selection). In addition, packaging should be multiple boxes, which should be multiple standard pallets. During the creation of packaging for a new product, it is necessary to consider all these parameters, which is possible only in case of participation in the development of both marketers and logistics.

There are three "levels" of packaging that are commonly recognized [5, 7, [10]]. Not every shipment utilizes multiple levels of packaging and in some cases, one packaging level provides the function of multiple levels.

1. Primary Packaging contains the product. It provides protection and containment, but is not necessarily suitable for transport. This is most typically what consumers see when they purchase a product and it serves as a marketing tool as well as protection.
2. Secondary Packaging contains one or more primary packages for use during transport. Secondary packaging aids in containment, handling, unitization and damage prevention. In some cases, such as online retail, this is also the packaging used to ship directly to consumers. Common types of secondary packages include bags and boxes. Boxes include single-use or reusable shipping boxes, which can be stackable, collapsible, foldable, or unstable. Bags can be multiwall bags or envelopes or bulk sacks. Crates, drums and barrels, and specialty containers for unique products can also be put in this category.

This packaging sometimes includes interior dunnage that reduces friction and contact between the primary packs during transport, providing additional protection. Dunnage can take many forms, including air cells, airbags, expanded or other foams, paper systems, suspension films, or product separators.

3. Tertiary Packaging is used to group secondary packaging together to aid handling, unitization, transportation and damage prevention to products. Tertiary packaging is the traditional transport packaging used to move bulk items to distribution and retail outlets. Oftentimes, tertiary packaging provides the function of flat unit load support in transport. Common types include pallets and skids, most commonly made of wood or plastic. These can be single use or reusable. Slip sheets are also used for this purpose, which are typically kraft or corrugated paper with lips that fold up to hold secondary packs in place. For lighter loads, trays can be used, which also come in a range of materials and forms.

Often Tertiary packaging also uses exterior dunnage to reduce friction between units and support load stabilization during transport. This dunnage typically includes stretch wrap, metal or plastic strapping, protective reusable covers, edging placed on the outside of units, or air pillows or other cushions placed in between secondary units.

These definitions should be used together with the consideration of packaging as a system, with hierarchical levels. See Fig. 2 [7]. This approach highlights the natural interaction between the different levels of packaging and facilitates an understanding of their interdependence. It can therefore be argued, in a systems fashion, that the performance of the packaging system is affected by the performance of each level and the interactions between these levels.

The packaging system has to fulfil demands from a number of dependent areas and customers, which makes it hard to isolate relationships and functions in a cause and effect manner. In order to understand the impact of the packaging system on the supply chain, it is necessary to investigate and analyse the activities related to packaging at the operational level. The interactions between packaging, aviation logistics and marketing are especially important because of the compromises that often have to be made when choosing a packaging concept. When considering aviation logistics and marketing issues, the balance between product differentiation and standardization is vital. Compromises between differentiated and standardized packaging affect the choice of the right type of packaging for the product.

As Fig. 3 shows, the packaging system is considered as one of other logistical sub-systems as the transport system, inventory management system, order-processing system and warehousing system.

Packaging logistics in aviation cargo transportation focuses on the packaging system, considers the relationship between the two systems of packaging and logistics and aims to increase efficiency and effectiveness in the combined system, optimally from the point of origin to the point of consumption and subsequent reuse / recovery or disposal.

According to [7], packaging logistics should be considered as an integrated approach, where both systems of packaging and logistics interact, complement and adapt to each other. The total potential of improvement should be larger if an integrated approach was adopted.

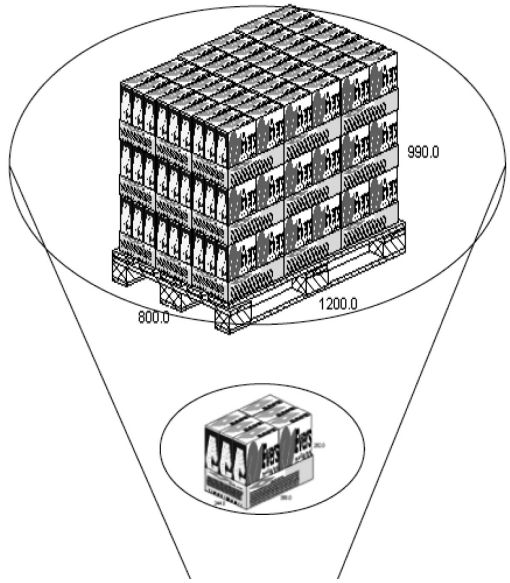

Fig. 2. The levels of the packaging system [7, p. 7]

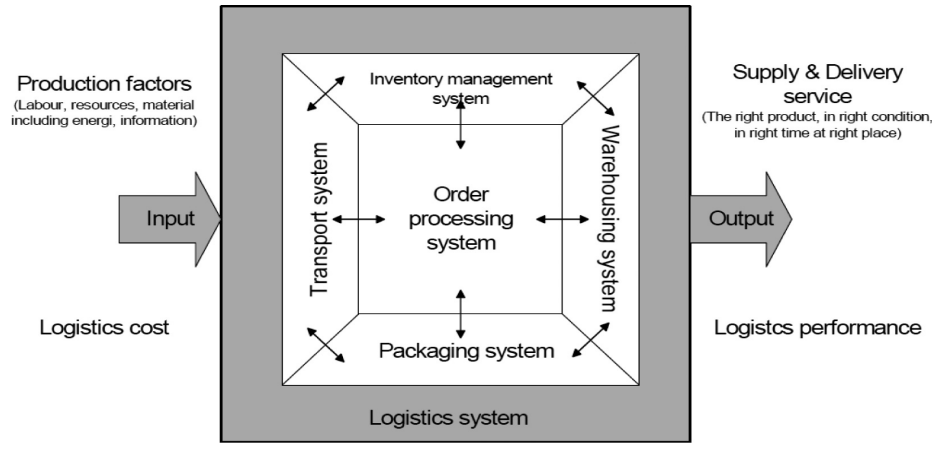

Fig. 3. The logistical system and its components, freely translated [7, p. 8]

Thus, we can argue that logistical packaging in aviation cargo transportation affects the cost of each logistical activity, and has a significant impact on the performance of aviation logistical systems. Transport and storage costs directly depend on the size and density of the packages. Handling cost depends on unit loading techniques. Inventory control depends on the accuracy of manual or automatic identification systems. Customer service depends on the protection of as well as the cost of unpacking and disposal of packaging materials. In addition, the characteristics of the logistics system determine the requirements and costs of packaging. An integrated logistics approach to packaging can provide significant logistics value.

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