FLEXGALLEY – INNOVATIVE APPROACH FOR A MODULAR DESIGN OF 
AN AIRCRAFT-GALLEY

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OVERVIEW
For an improved in-flight service, the airlines need more 
and more individual cabin- and catering concepts. In this 
context, the aircraft galley is a decisive factor for the 
provided cabin service. From the perspective of the galley 
manufacturers, the product variety lead to high complexity 
and therefore high costs. This paper presents an 
approach, which develops a new product concept by using 
the design principle of modularity.

1. INTRODUCTION
Nowadays, for the airline passenger three basic factors 
are most important: The price of the ticket, the time 
schedule and the provided in-cabin service of the airline.

For providing and enhancing the service in the cabin, the 
interior components become more and more important. 
Due to the increasing market competition, the airlines 
furthermore need to differentiate from each other. 
Therefore individual cabin solutions are wanted, which 
offer possibilities for airline-specific design features and 
catering concepts. In this context, the galley is a decisive 
factor for a successful interior concept: On one hand, the 
galley is the central facility for any catering operations 
inside of the plane. On the other, the galley is a large and 
remarkable monument in the cabin, which represents the 
airline and its corporate design. So for improving either the 
cabin design or the catering concept, each the galley 
needs to be taken into account.

For the galley manufacturer, the requirements to design 
and product planning changed over the past years. Major 
previous selling points were: Airworthiness, load capable-
and lightweight design, reliability and design for 
maintenance. Whilst those requirements shifted to more or 
less standard specifications, nowadays new excitement 
factors come up: The airlines ask more and more for full 
customisable galleys. For satisfying these needs of the 
airlines, the current and even more the future galleys need 
to be very flexible and customisable. This customisation 
mostly affects the configuration and layout of the internal 
equipment in the galley. The customer wants to distinguish 
on own decision, which equipment should be contained 
and in which alignment. Additionally, custom design 
features or new types of technical equipment need to be 
implementable. For new catering concepts, the galleys 
need to be flexible and upgradable.

The current variety based on individual customer demands 
is covered mostly by adaption design and single-item 
production, which lead to complex processes for the galley 
manufacturer. In context of the project “FlexGalley”, a 
cooperation project by Hamburg University of Technology 
and the cabin interior manufacturer Mühlenberg Interiors 
GmbH & Co. KG, strategies for implementing a modular 
and flexible galley design are currently under 
development. This paper presents modularisation as a 
strategy for improving the product architecture of interior 
components, in particular galleys, with respect to design 
for variety.

2. THE AIRCRAFT GALLEY: A CUSTOMISED 
PRODUCT IN LOW NUMBER OF UNITS
In this chapter the product of the aircraft galley will be 
investigated. In particular, the variety situation will be 
analysed in order to develop a design concept in chapter 
4, which offers possibilities for a better variety handling 
and more flexibility for the customer. For simplification 
reasons, all examples will be represented in this paper by 
the widebody-galley type. In context of the project 
“FlexGalley”, there were other galley types, in particular for 
single aisle aircraft, investigated as well.

Figure 1 shows an image of a typical galley for widebody 
twin-aisle) cabins. This example is a G3 galley for an 
Airbus A330-200 aircraft. As shown, the given galley 
provides space for 4 trolleys, 8 standard units and further 
miscellaneous equipment.

FIG 1. Typical Widebody Galley G3
Given in Figure 2 is the placement of the galley monument. It is located in flight direction, centred in the front part of the cabin. The x-position (forward) of the galley is variable, according to the demands of the customer. The mechanical implementation of the flexible x-positioning of the galley is content of the project “FlexGalley” as well, but will not be issue of this paper.

The basic design parameter for this galley type is the number of provided trolley units. Commonly, 4, 5 or 6 trolley units can be installed. This parameter defines the type of the galley variant on first level, because it constrains the width of the monument. Following to the specification of the trolley number, further parameters specify the galley with respect to its internal design and equipment. Figure 3 exemplarily shows three variants of the 4-Trolley G3. As shown, three very different functional concepts are realised for the same type of galley. Every one of those galley types serves needs for different catering concepts.

Galley concept A purely provides stowage functions. A maximum number of 24 Standard Units can be installed into the upper compartment. Besides the mechanical attachments there are no media connections inside of the galley or to other systems.

Galley B provides three ovens and compartments for stowage. In this galley, an E-Panel is necessary for providing switches and fuses for the ovens.

Galley C offers various functions such as bun warmer, espresso makers or water heater. Due to the use of many electrical devices in Galley C, the switch- and fuse panel has a larger width than the one in galley B. Therefore less Standard Units can be installed into the upper part.

The trolleys in the lower galley compartment can be cooled using the two alternative concepts “air-through” or “air-over”. The schematic diagrams of the two concepts are given in figure 4. Using the air-through concept, the cooled air is blown into the trolleys using a supply ducting. The cold air circulates inside the trolley and cools its content. Using the “air-over” concept, the air circulates around the trolleys. Since content of the trolleys has no direct contact to the cooling air in this concept, it offers an increased hygienic standard. A sealing lip is integrated to avoid a direct air flow from the supply ducting to the return ducting.

As shown in figure 3, the galleys have a very high variety compared to each other. In particular for small galley manufacturers, who are the system suppliers for the airlines and aircraft manufacturers, it is common use that one galley variant is only produced one time.

Further below, the variety of the given three G3-Galleys will be shown graphically for explaining the consequences of the variety (cf. [1]). For visualising the variety, it is meaningful to use the tool of the variant tree. The variant tree will be used as a basis, but for a further investigation...
the different geometrical areas of the product will be added to the tree-visualisation. This is useful, because certain product areas have configurations which are independent from each other. According to this, the variant tree of the galley is given in figure 5. Compared to the visualisation type of the component structure, which only gives components, assemblies and variants, the current visualisation considers more parameters. The assignment of variant parameters to certain product areas is helpful to identify re-usable configuration packages for new products and gives a better overview.

The difference between variant components and alternatives can be shown as well: Alternatives are different solutions to the same technical problem. Examples for this are the different cooling concepts.

Figure 5 shows already at its low resolution, that on one hand the variety is high, but on the other several elements are shared between the variants. Many other galley variants, which are not shown in this paper, combine elements of these three shown designs.

Even though certain elements are shared between the galley variants, it is still hard to create larger carry over parts, which could ease the engineering- and production processes. When a new galley variant is created, the layout of the galley changes more or less. Due to the integral design of the product, a design change rapidly affects more and more component groups. If the customer orders a new product, usually the engineering process is started new to realise the product either as adaption design or as new design. The engineering processes then often creates further internal variety, because technical details have slight changes. These changes then lead in sum to a high variant product, even though the external variety of the product may be not that high.

3. MODULARIZATION AS A DESIGN STRATEGY FOR CABIN MONUMENTS

The design strategy of modularisation in general offers many benefits. By a different combination of few basic modules a high variety for the final product can be realised [2]. Simultaneously, modularisation can support specific development aims [3]. These development aims, which may be targeted additional to design for variety, can be for example: design for maintenance, design for recycling, design for upgrading. Additionally, design for manufacturing becomes more and more important for decreasing production costs and lead time. Due to a reduced vertical range of manufacturing, often many suppliers need to be integrated in development and production processes. Modularity can support this integration.

Figure 6 schematically shows reasons for modularisation. It is differentiated between modularisation for variants and single-modularity. Single-modularity supports the fulfilment of specific development aims.
FIG 6. Reasons for modularity

In literature, there is no consistent definition of modularity. Two properties are highly important for modular design (cf. [4]):

- The final product needs to be separable into physical component groups
- The component groups need to be combinable such that they can create different product configurations.

As one can see in the shown galley examples, component modules are already in use. The variant tree in figure 5 shows, that some elements are used in share by all three products. Anyhow, in this case the use of component modules is not helpful in terms of modularity for the final product. If the configuration of component modules is changed, typically the structural layout of the galley changes as well, which leads to the need for a new design. The structural design of the shown galleys does not fulfill the demand of modularity for physical separability.

Analogical this design concept can be found in other aircraft interior components, which again each share components in their variants but show no modularity for the final product. Therefore it is important to differentiate between component modules and assembly modules, figure 7.

If a modularisation for the whole product is wanted, the component modules (e.g. ovens) need to be considered as parts. Due to different interfaces and geometry requirements, they cannot lead to modularity for the whole product.

FIG 7. Component- and assembly modules

For designing a cabin monument modular it is necessary to create assembly modules, which contain the component modules / parts and are combinable. Using this strategy in combination with standardised interfaces, it is possible to take the mentioned benefits of modularity for the whole product.

The use of assembly modules shows high potential for interior monuments with respect to the prior explained advantages of modularity in general. As far as the interfaces are standardised and the modules show combinability to each other, more flexibility for the customer and the use of economy of scale for the manufacturer can be activated. Pre-assembled modules can be manufactured and stored, which eases manufacturing- and assembly processes. Additionally, airlines have the possibility to change the modules of their galleys in the maintenance phases. This, for example, gives the opportunity to adapt the catering concept for seasonal requirements. More flexibility can be offered in case of leasing- or charter operations.

The modular system gives advantages for the engineering department of the galley manufacturer as well, because the design teams can be divided into segments according to the modular structure. This eases the engineering- and management processes. Even if areas of a monument are ordered by the customer as individual design, the engineering process still is limited to the affected module only.

4. THE MODULAR GALLEY STRUCTURE

This chapter describes an approach for applying the advantages of modularity, which were described in chapter 3, to the product of the 4-trolley widebody galley prior explained in chapter 2.

For conceptual visualisation, the tool of the Module-Interface-Graph (MIG) will be used [5]. The MIG roughly shows the package of the single modules with their components and interfaces. Prior to the module definition, the variety of the product needs to be analysed. In the performed project, the number of modules was defined to three, because due to the high individuality of the products a separation into further modules offered no advantages. Figure 8 shows the Module-Interface-Graph (MIG) for an exemplary galley, based on the state of the art design.

FIG 8. Module-Interface-Graph (MIG)

This physical separation of the galley into three structural modules offers the possibility of sharing modules in variants, which leads to quicker and therefore cheaper engineering- and manufacturing processes. If, for example, a new variant of the centre-module needs to be
designed, upper- and lower module can be re-used. Anyhow, standardised interfaces are essentially needed, which in case need to be oversized.

Modularity in general tends to cause higher weight by additional interfaces. Therefore, in the product the overall weight needs to be balanced. This can be achieved by using existing structural interfaces, such as panel-inserts, as module interfaces. Furthermore, the principle of integration of functions can be used for creating integral structures inside of the modules [6] [7].

Figure 9 exemplarily shows the change of the MIG into a 3D-visualisation. In this case, the next development step would be the design of the standardised interfaces for realising mechanical and media connections.

![State of the art Modular product](image)

**FIG 9. 3D-Visualisation of the modularisation**

The shown structure now can be used for designing a modular product system. For this purpose, the past ordered variants need to be analysed for creating a catalogue, from which a future customer can assemble his individual system. Figure 10 shows the possibilities of such a modular product system. On one hand, individual customer demands still can be served by adding a custom module. On the other, the general use of standard modules offers the mentioned benefits for flexibility in use (customer) and the production line (manufacturer). Most existing galley variants can be covered by the presented product system, which consists of three variants each of upper- and lower module. The centre module shows a higher variety and represents by its variants the customisability of the system.

An important focus for the engineering design is the dimensioning of the standardised interfaces. These interfaces need to offer always compatible geometry and connection system. Additionally, the interfaces need to be lightweight and should not hinder the assembly / disassembly process. For a lightweight optimisation, structural elements can be replaced by space frames. The use of easy assembly connectors is decisive for providing the aimed flexibility for the airlines, especially for providing change of a galley module during the utilisation phase of the plane.

5. CONCLUSION

This paper describes a concept for modular design of an aircraft galley in example of the 4-trolley widebody G3. Based on the state of the art design and an analysis of the product variants, a design was developed which allows the use of standardised and pre-manufactured modules. This gives advantages to both the customers (airlines) and the galley manufacturers: the customer can assemble his individual product system from a predefined catalogue and has furthermore the possibility to order custom modules. Additionally, he can change the galley layout in the utilisation phase of the plane. For the galley manufacturer the production processes can be eased significantly, because modules can be pre-manufactured and the engineering efforts are reduced. An important factor for the mechanical design is the use of standardised and light weight interfaces, which allow easy assembly / disassembly. For further realisation, feasible solutions are currently under development in context of the project “FlexGalley”.

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![Catalogue of standardised modules](image)

**FIG 10. Modular system of the G3**
6. REFERENCES


