ASPECTS ON APPLYING OF FUNCTIONAL ANALYSIS METHOD TO PRODUCTS DESIGN AND ITS RELATIONSHIPS WITH OTHER VARIOUS DESIGN METHODS

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Abstract: Among all the stage of product life cycle, the design stage contributes significantly to the improvement of competitiveness, because it permits reduction of costs and often, shortening of the time necessary to get the products on the market.
The paper deals with some aspects related to Functional Analysis method used at products designing. It presents how Functional Analysis can improve your product development process, also the paper shows Functional Analysis relationships with other various design methods (Quality Function Deployment, the Kano Analysis etc.)

1. INTRODUCTION

The success of products on the market depends on how well they meet customer needs. The quality and reliability of a product are predominantly determined in the early phases of the development process. This design phase may determine more than 75% of products' lifecycle cost, and has therefore been widely recognized as the most vital phase of product development. In recent years have been proposed a lot of methods and tools for developing quality products, such as: Functional Analysis, Kano method, Quality Function Deployment, Failure Modes and Effects Analysis. Each of these methods solve different aspects of the product, as follows:

External Functional Analysis (of needs) develop techniques for establishing a technical specification for a product, as a basis for technical analysis and possibly for the value analysis.

Internal functional analysis, named technical analysis, develops tools to obtain the appropriate technical solutions to achieve the functions of product at the expected quality level, specified in the specification.

QFD is a customer-driven approach for processing new product developments in order to maximize customer satisfaction.

FMEA is a disciplined approach used to identify potential failures of a product and then determine the frequency and impact of the failure.

All these methods can be applied to existing products to improve their quality and the design of new products. They are based on the efficiency of work in team composed of specialists trained in different fields.

2. External Functional Analysis – characteristics

One of the most methods used in the design stage of new product is functional analysis. Functional Analysis is an approach whose goal is to express the need in terms of service functions expected and, ultimately, in terms of solutions [6]. Its aim is to reach a product which to satisfy the user's requirements. It is the base for the establishment of technical specifications.

The method of Functional Analysis, as was made by Miles, proposes a simple principle: to establish, first, functions that must fulfil a product and then to search the product to carry out these functions. In this way a solution can not be prosecuted or can

not be found without being reported to the functions that ensure the need to be done. A function is described as the action of a product or one of its constituent part, it is expressed only in terms of finality. The functions are classified into service functions and technical functions [3], [6].

The service functions are the functions expected from the product to meet the user needs. This functions make the value of a product. From a designer point of view, the service functions are divided into: principal functions which represent the purpose of the product's action, and constraints functions which represent the actions and/ or re-actions of the products towards different environmental elements, due to its presence in the system and in the environment.

Technical functions represents the internal functions of the product necessary to ensure the realization of the service functions.

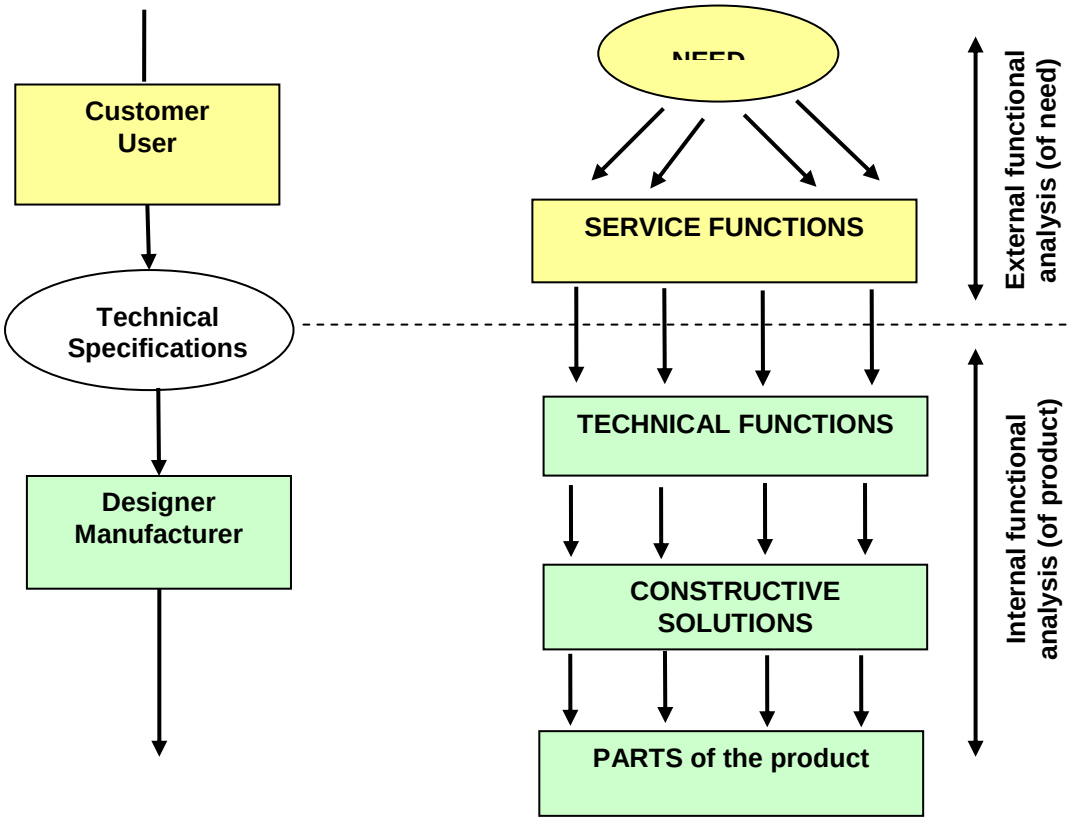

Figure 1. Functional Analysis

External Functional Analysis assumes the following steps [6]:

1. Identification the studied system and the life phase of it (definition of the subject);
2. Inventory of environmental elements of use;
3. Establish and formalization of functions;
4. Control the validity of the functions;
5. Characterization and hierarchy of functions.

The establish and formalization of function is carried out using the environmental elements method. This method uses a tool called "octopus diagram" or "interactions diagram" and is based on the proceedings of the product in the elements context with it is related, elements called "environmental factors", in various situations of life. The "interactions diagram" is a graph in which the product is represented in the centre of diagram by an oval, and the environmental elements are represented around the product,

also by the oval. The functions of the product resulting from its relationship with these environmental factors.

The service functions and constraints established for a product can be ordered by levels. On the first level is the principal function, which corresponding of the fundamental need. This function has a generic expression. It is supported by all other functions and constraints. All these functions are organized in a diagram named the functional tree diagram. After identifying the principal function will be placed on the two level the functions derived from the principal function and on the three position are placed the terminal functions derived from the functions situated on the second level. Functional tree diagram give a clear picture of the relationships that exist between functions.

3. Quality Function Deployment - QFD

Function analysis is also a primary tool for Quality Function Deployment, Requirements Engineering, and Value Engineering. The information obtained during the Functional Analysis is used to identify the product structure which reveals the technical parameters needed for the Quality Function Deployment process.

QFD provides a structured methodology for converting the “Voice of Customer” into design requirements guiding the product development process and improving the success rate for new product. It is a process that involves constructing one or a set of interlinked matrices, known as ‘‘quality tables.’’ The first of these matrices is called the ‘‘House of Quality’’ (HOQ). The HOQ matrix has two principal parts; the horizontal part, which contain information relevant to the customer, and the vertical part, which contains corresponding technical translation of their needs. The basic process underlying QFD resides in the centre of the matrix where the customer and technical parts intersect, providing an opportunity to examine each customer’s voice versus each technical requirement, for a detailed description of QFD formation process [1], [5].

4. Kano’s model- quality attributes and customer satisfaction

The quality of a product is evaluated by customers using several factors and dimensions. It is important to identify which product criteria or attributes create more satisfaction than others. The previous definitions for quality were linear and one-dimensional, figure 2.

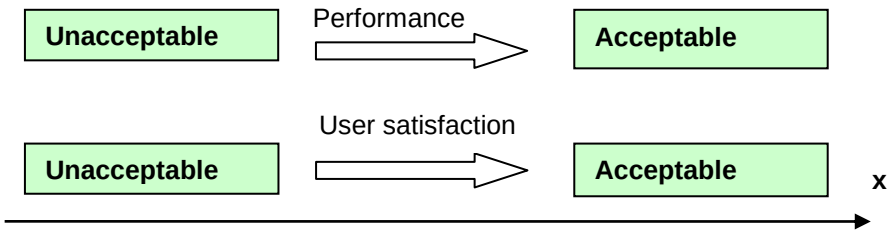

Figure 2. One-dimensional quality

At the end of 70’s, Dr. Noriaki Kano from Tokyo’s Rika University developed a two - dimensional model to illustrate the different relationship between customer satisfaction and product criterion performance. Kano integrated quality a two-dimensional model by taking in account two dimensions: the way in which the product or service behave, indicated on the X- axis, and user/customer degree of satisfaction, indicated on the Y- axis, figure 3 [4].

The Kano model has been applied not only to new product development but also to new service creation.

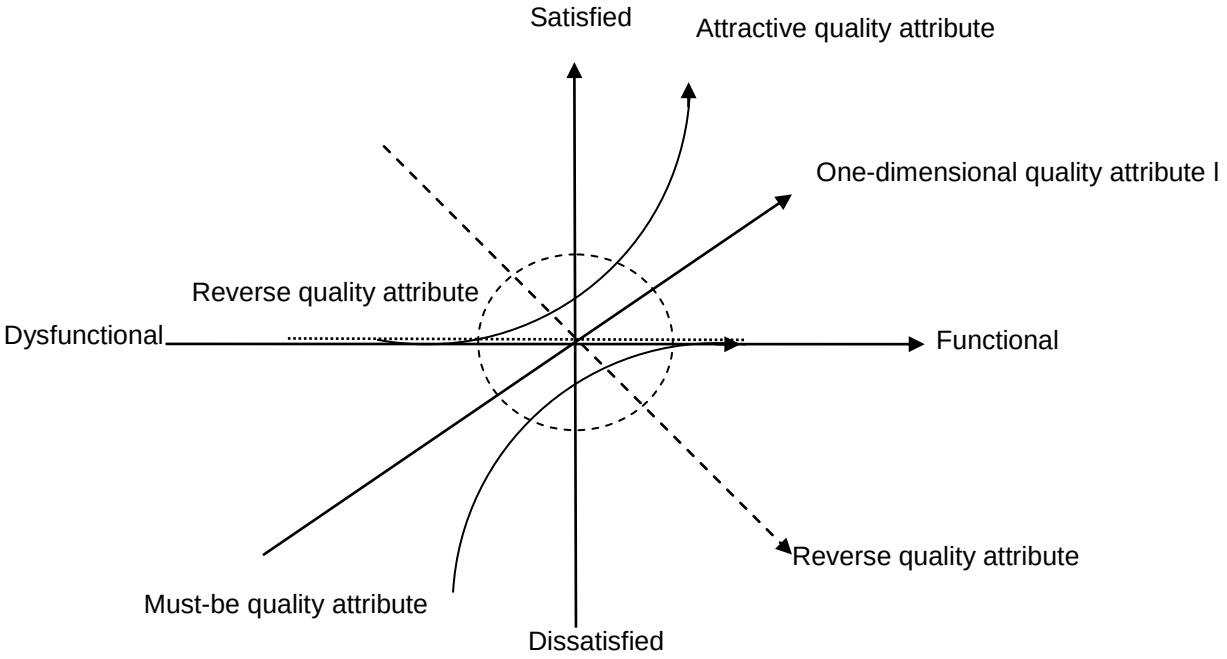

Figure 3. Kano's two-dimensional quality model and five types of quality element

The Kano's model divides product or service features into five distinct categories: must-be or basic quality attribute, performance (one-dimensional) quality attribute, excitement (attractive) quality attribute, indifferent quality attribute and reverse quality attribute, as shown in figure 3 [2], [5]. Each category respectively affects customer satisfaction in a different way.

The five different of quality attributes proposed by Kano are explained as follows, table 1 :

Quality attribute	**Signification**
Must-be or basic quality attribute	It is taken for granted when this element is sufficient and will not result in more satisfaction, but insufficiency of this element results in non-satisfaction.
Performance (One-dimensional) quality attribute	If this element is sufficient, customers feel satisfactory. Insufficiency of this element results in non-satisfaction.
Excitement (Attractive) quality attribute	When this element is sufficient, customers feel satisfactory, but still acceptable if it is not sufficient.
Indifferent quality attribute	This element will not result in satisfaction or not, whether it is sufficient or not.
Reverse quality attribute	Non-satisfaction comes when it is insufficient and on the contrary satisfaction comes when it is sufficient

Table 1. Quality attributes proposed by Kano

A simple way of identifying different Kano categories is to use a Kano questionnaire. In this questionnaire, customers indicate if they feel satisfied or dissatisfied with a given

situation. First, a situation supposes the quality (criterion) is present or sufficient. The customer must choose one of the following answers to express his feelings [2]:

a. Satisfied;
b. It should be that way;
c. I am indifferent;
d. I can live with it;
e. Dissatisfied.

A second situation assumes the quality is absent or insufficient. Again, the customer must choose one of the above-mentioned feeling responses. By combining the two answers in the Kano evaluation table, table 2, the product criterion can be identified as attractive, must- be, one-dimensional, indifference or reversal.

Product criteria/attributes		Insufficiency				
		Satisfied	It should be that way	I am indifferent	I can live with it	Dissatisfied
Sufficiency	Satisfied	Q	A	A	A	O
	It should be that way	R	I	I	I	M
	I am indifferent	R	I	I	I	M
	I can live with it	R	I	I	I	M
	Dissatisfied	R	R	R	R	Q

A-attractive, O- one-dimensional, M – must-be, I – indifference, R-reversal, Q – questionable.

Table 2. Kano evaluation table

5. Case study –Functional Analysis for "camera tripod" product

In this paper, in order to applied the functional analysis method was selected the "camera tripod" product. In the first phase were established the environmental elements of the product for the usage stage. The environmental elements of the product are: user, terrain, subject photographed, cover, cleaning agent, camera, figure 4. The research of the functions is carried out by studying the connection between the product with its environmental elements.

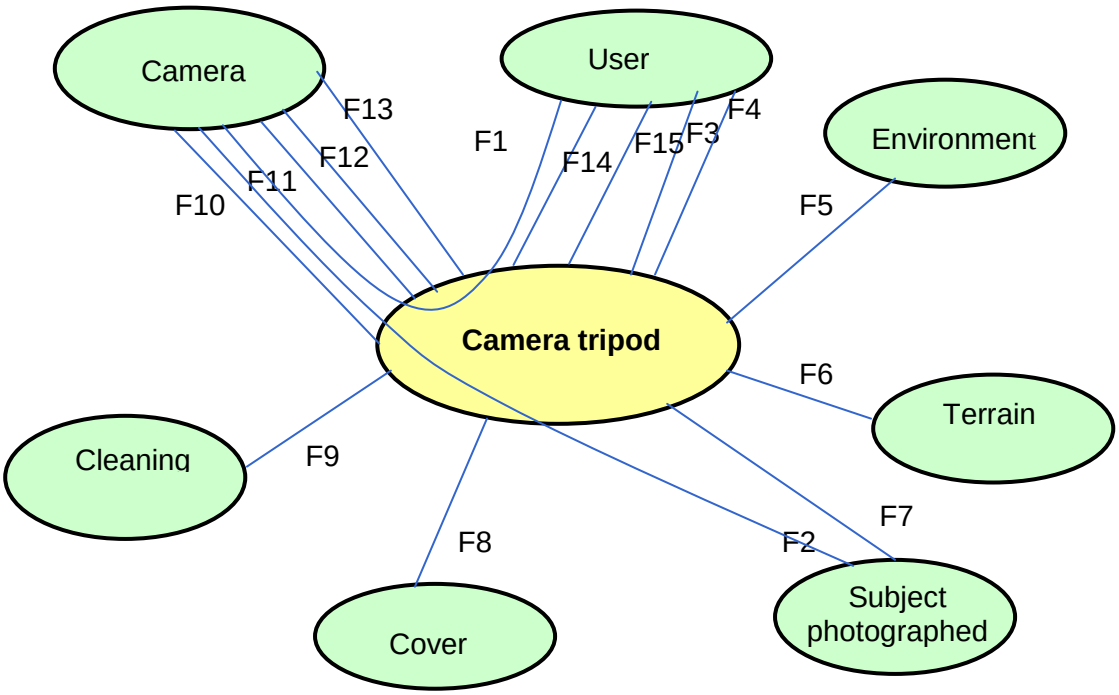

Figure 4. The environments and the service functions of the product "camera tripod"

The service functions of the product are presented in the table 3. This functions are classified taking in account the three methods:

1. The function type: service, technical and constraint;
2. The Kano analysis: basic, performance, excitement, indifferent, reverse;
3. The classification method proposed by AFNOR: the standard AFNOR proposed classification the functions in order of importance. Levels of classification are the following: indispensable, important, interesting, accessory.

No.	Functions	Classification methods		
		Type	Kano	AFNOR
F1	To allow to user the possibility to install a camera	service	basic	indispensable
F2	To allow the camera orientation to the subject in order to photograph	service	basic	indispensable
F3	To be handy	constraint	performance	important
F4	To be light	constraint	performance	interesting
F5	To resist to the environment's actions	constraint	performance	important
F6	To be adapted for any type of ground	constraint	constraint	indispensable
F7	Do not disturb the subject area	constraint	constraint	important
F8	To occupy a small space	constraint	constraint	interesting
F9	To resist to the corrosive action of a cleaning agent	constraint	constraint	interesting
F10	To ensure a stable position to the camera	constraint	basic	indispensable
F11	To allow the translation movement of the camera after X, Y, Z	constraint	basic	indispensable
F12	To allow rotations around the X, Y, Z	constraint	basic	indispensable
F13	To allow the connection with the camera	constraint	constraint	indispensable
F14	To be aesthetically	constraint	performance	accessory
F15	To be ergonomic	constraint	performance	important

Table 3. Functions of the product "tripod camera"

When the functions of the product were identified, one can then construct functional tree diagram. The functional tree diagram for our product is shown in the figure 5.

The principal function "to allow the camera orientation to the subject in order to photograph" is situated on the first level of functional tree diagram. The functions situated on the second level respond to the question "how" the product will be able to achieve the principal function. On the three position are placed the terminal functions derived from the functions situated on the second level. The function F16, "Give the user the ability to handle with a certain precision on the X,Y,Z" is considered a technical function.

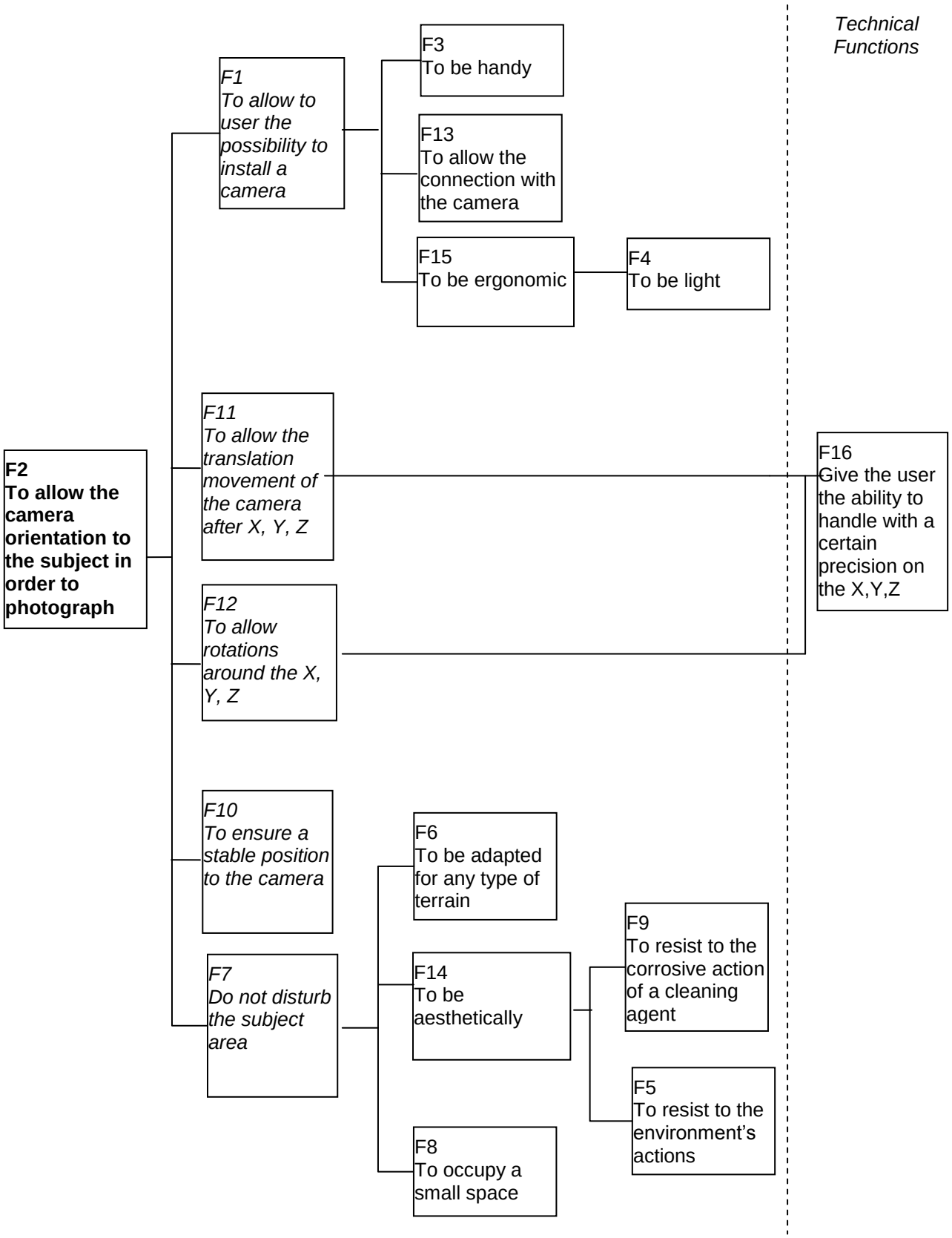

Figure 5. Functional tree diagram of the product "tripod camera"

6. Conclusions

The paper shows the Functional Analysis method and its relationships with other methods used in the design, in order to propose a useful methodology in the design process. To put into practice the methods and the methodology presented, it was analysed the "camera tripod" product. Functional Analysis method has been used in establishing the product functions. In their characterization have contributed the Kano and AFNOR methods, and after the classification of functions was realised the functional tree diagram of the product. The tools presented are simple, the analysis is done quickly, and input on the design process is high because the much problems are clarified in the early stage of the process.
The methodology presented in paper provides to designers the possibility to better meet the customer desires, leading to the development of products conforming with the real needs of clients.

References

1. Almannai, B., Greenough, R., Kay J., A decision support tool based on QFD and FMEA for the selection of manufacturing automation technologies. Robotics and Computer-Integrated Manufacturing, Vol. 24, No.4., 2008, pp. 501–507.
2. Chen,C.-C., Chuang, M.-C., Integrating the Kano model into a robust design approach to enhance customer satisfaction with product design. International Journal of Production Economics 114, 2008, pp. 667–681.
3. Garo, O., Analyse Fonctionnelle. Editons UTMB, Belfort, 2001.
4. Kano, K.H., Hinterhuber, H.H., Bailon, F., Sauerwein, E., How to delight your customers. Journal of Product and Brand Management 5 (2), 1984, pp. 6–17.
5. Lee Y.-C., Sheu L.-C., Tsou Y.-G., Quality function deployment implementation based on Fuzzy Kano model: An application in PLM system. Computers & Industrial Engineering, Vol. 55, 2008, pp.48–63.
6. Ungureanu, I., Analiză funcţională, Editura Universităţii din Piteşti, 2007. ISBN: 978-973-690-667-1.