FUNCTION ANALYSIS AND THE DESIGN OF NEW PRODUCTS: HOW TO DO IT RIGHT, THE FIRST TIME

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Mrs Parrot is an industrial engineer with 15 years of experience in manufacturing and consultation. She has accomplished many projects in optimization and computerization of operations as well as plant layouts and product-process improvement. Since 1990, Mrs Parrot is specialized in value engineering (VE), needs analysis and performance specifications. She has moderated many workshops resulting in the optimization of products, processes and construction projects, ranging from a few thousand to $30 million. She has been trained with SAVE and AFAV (Association Française pour l'Analyse de la Valeur) and is working on her CVS. She also has participated in the very recent creation of the Canadian Value Analysis Society.

Mr. Aglot graduated in Industrial Engineering from Montreal Ecole Polytechnique in 1983 and received a management certificate in 1987. He followed several courses and seminars in Value Engineering, Function Analysis, Reliability and Safety. Mr. Aglot worked for three years for the Société des Transports de la Communauté Urbaine de Montréal as an industrial engineering analyst. He joined the Bombardier Mass Transit Division in 1986 where he successively occupied the positions of RM&S supervisor, System engineering manager for a New Jersey Transit Push-Pull contract and now is the system engineering manager responsible for the engineering support activities: RM&S, technical documentation and drafting room.

ABSTRACT

This paper presents a successful implementation of function analysis on the design of new train and subway cars. The carbuilder has used the services of a consultant to transfer the function analysis methodology to his personnel. Some relevant examples are used to illustrate this process. They highlight hints to a successful implementation of the methodology as well as pitfalls to avoid. The paper reviews some criticism the methodology has received and then concludes with a brief outlook of the future prospects.

BOMBARDIER : an outlook

Bombardier was founded by Joseph-Armand Bombardier the inventor of the snowmobile (the famous SKI-DOO).

In the 1970's, with intense competition and a drop in market due to the energy crisis, the company in need of diversification took a big gamble: the city of Montreal needed about 400 new subway cars. Bombardier had the manufacturing capability but no expertise in this field. Bombardier then created the Mass Transit Division, bought the Montreal subway design from CIMT of France and entered this new market.

Expansion continued with manufacturing of Push-pull commuter cars based on an existing design (New Jersey, Boston, Philadelphia...) and culminated with the largest subway car order ever in North America: 825 cars in a single order for the New York Transit Authority. Since then, other major contracts include the Disney World Monorail, the EuroTunnel Shuttle , AMTRAK new Superliner cars as well as subway cars for New York, Boston, Toronto and Ankara.

Meanwhile, in the 1980's, the company expanded into the aeronautic field, first with the acquisition of Canadair and continued with the acquisition of Learjet Inc. (USA), Shorts Brothers PLC (Northern Ireland),and De Havilland (Canada).

The Mass Transit Division (now called TEG, the Transportation Equipment Group) early projects were based on the acquisition of existing service-proven designs of low complexity with few modifications. Their success came mainly from a very efficient manufacturing capability: the last of the 825 NYCTA subway cars was delivered one month before schedule.

With the growth of the group and the ever expanding market requirements, new and major challenges came to surface: several different contracts had to be designed and manufactured in parallel, customer required new and technically complex designs always with increased performance, schedules became tighter, lead times shorter and quality improvement became a concern (ISO-9001).

These factors put an increased pressure to improve the TEG design process, to have a direct positive impact on the product, and reduce its manufacturing schedule and costs: one of the goals was to reduce the number and the impact of product engineering changes during design and manufacturing through a better product definition and through a concurrent engineering approach.

To reach a better product definition, the Function Analysis methodology was selected and since such knowledge was not available in the organization, the help of a European consultant was needed.

The first attempts were made on two systems (HVAC and Doors) for the New Technology Test Train (R110-B) for the New York City Transit Authority. These systems were selected because they were completely designed and built by Bombardier (normally Bombardier specifies and integrates systems from sub-contractors)

This attempt was limited to major functions to be performed by the system and served only as a starter since no follow-up was made. This project, however, created awareness of the advantages and strength of the Function Analysis methodology. The next project (new commuter car for the Montreal-Two Mountains line) would use this Function Analysis approach more thoroughly and in-depth with the help of a Montreal based firm specializing in Value Engineering and Function Analysis : Valorex.

THE CONSULTANT

Valorex is a small VE firm affiliated to a major Montreal engineering firm called Soprin (300+ employees). Founded in 1986, it started with workshops in VE for water treatment plants. It has now evolved to a major VE firm in Eastern Canada with over 100 workshops in various fields such as industrial products, processes, construction projects, management information systems, etc.

Valorex has implemented a new gradual approach to VE with its clients by using the function analysis very early in their process to help them accurately design their product, right from the start.

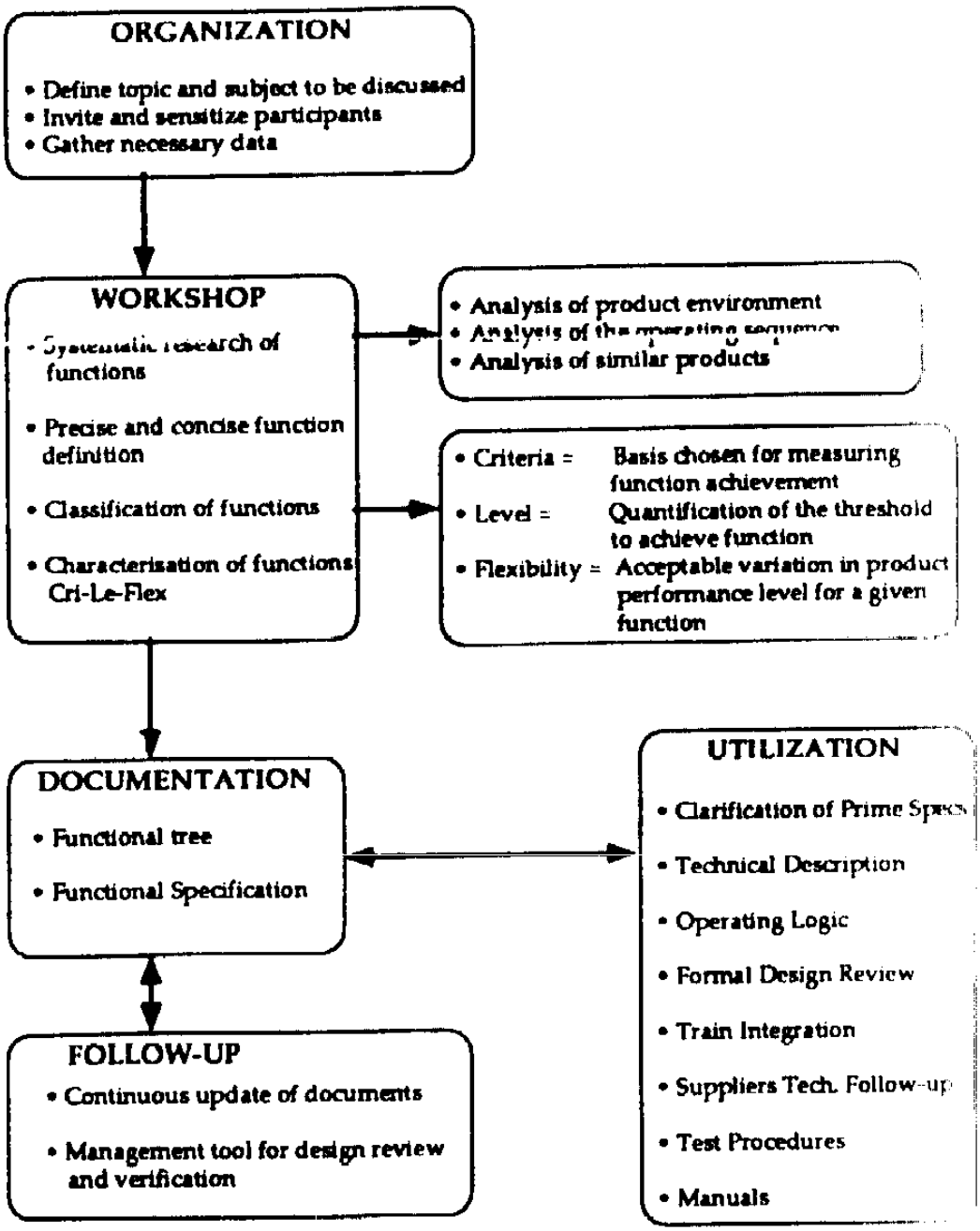
Valorex's philosophy is to provide its clients with a profitable quality service in VE, function analysis, quality management and training in the aforementioned disciplines.

BOMBARDIER - VALOREX PARTNERSHIP

After a few meetings it was clear that Bombardier and Valorex had the same values, philosophies and point of view concerning the projects to come. It was easy to establish what kind of partnership could be expected. It looked like this:

CONSULTANT	Trainer
	Support to the trainees
	Take charge of overload
	Evaluate Trainers
METHODOLOGY	Function analysis
	Classroom training
	Live pilot projects
	American and European Methodologies
INVOLVEMENT	Trainer = Back-up
	Trainees = Facilitators when at ease
	Design team receives basic training
OBJECTIVES	Meet customer needs on first try
	Identify all necessary functions
	Eliminate unnecessary functions
	Encourage Innovation in design

Figure 1 - FUNCTION ANALYSIS PROCESS



ACTION PLAN OF FIRST PROJECT: MONTREAL- TWO MOUNTAINS COMMUTER TRAIN

The first contract studied using this process (shown in Figure 1) was the Montreal - Two Mountains commuter train. Even before the contract was signed many actions took place: First, two facilitators were chosen, among the reliability engineering group. They went through a theoretical training on function analysis. Then an awareness session was held with all the managers involved with this project and with the attendees that were already identified.

Workshops were organized: they involved many specialists, the two facilitators in training and the Valorex facilitator. The

logistics of it all was a challenge by itself.

Who will attend these meetings was not an easy question to answer. First, the proper persons with the appropriate level of expertise, the availability for a few days in a row and an innovative attitude had to be chosen. Management had to be truly supportive to make sure the previous point was done quickly.

The workshop schedules were distributed well in advance for everybody to be available and plan around the meetings.

The workshops finally started! During the first workshops, function analysis knowledge was transferred from the Valorex facilitator to the facilitators on training along with general facilitating skills and group interaction psychology.

After each workshop, the experts of the systems to be studied were called in a smaller meeting to draw the functional tree of their system using FAST methodology . This helped cover all the functions and structure the functional specifications document .

All the information discussed during the workshops was documented directly on computer for faster release and update. Each department involved received its copy within a few days (or a few weeks for the first ones!) They were all structured the same way for ease of adaptation by the users.

The results and benefits of the function analysis were not readily obvious or quantifiable, but the greatest impact was that the complete project team got together and not only understood the requirements the same way but also knew about each others constraints.

These meetings, in which every basic assumption was questioned, allowed clarification of grey areas in the specification, helped interfacing with the customer and vendors and finally led to better program management.

Today, the first carshell is completed with no engineering changes and the interface with the customer went without major crisis due to the adequate and timely product definition.

TORONTO T1 SUBWAY CAR

The next contract signed consisted in providing the Toronto Transit Commission with a new design of cars, inspired by their actual fleet but with an accent put on reliability of the systems. The action plan drawn up consisted of:

- Use the same function analysis methodology and aim at the same basic objectives;
- Use the same facilitators, of course;
- Start function analysis from scratch because there was not enough evidence that the previous project could be of some use since there were few similarities between the two cars (this proved to be untrue later on...);
- Use these function analysis workshops to integrate the new Bombardier employees to the older ones: indeed, Bombardier had just taken over the Thunder Bay (Ont.) facilities from UTDC. Thus, the teams involved consisted of personnel from the various departments of:
  - the Montreal office
  - the Thunder Bay plant,
- Make sure, during the workshops, that the company culture would even out, that the newcomers would adopt the new values presented to them, that they would also learn Bombardier procedures, that knowledge would be transferred both ways since they had a strong manufacturing background especially with the product involved. Of course, all this had to be done and still obtain the function analysis of the new product. Quite a challenge.

ANKARA SUBWAY CARS

The third project signed was the design of subway cars for the new turnkey project of the fully automatic Ankara subway in Turkey.

Here a new process was considered: it planned on using the previous function analysis to identify the functions to perform. The workshops would concentrate on confirming the relevance of the previously identified functions and would then make sure the criteria, levels and flexibilities would be updated to the present client requirements.

This new set of workshops would also be used to train a third facilitator, the demand for them being increased.

So, a new schedule was prepared and it was made clear that, once again , the workshops would provide an integration ground for the recently taken over facilities of UTDC in Kingston (Ont.) as previously done. The personnel involved in the workshops would consist of people from:

- Montreal office;
- Kingston office;
- Thunder Bay plant;
- La Pocatiere plant. (Four locations many miles apart!)

This way of using a previous function analysis done for a very similar product proved to be very effective but also a little tedious. Care had to be taken not to forget anything by trusting the previous analysis too much. Actually, this exercise helped clarify the Toronto analysis by finding better ways of expressing the functions. The document was updated accordingly.

These are two major projects, still in early design phases where there are yet no apparent initial quantifiable benefits except the fast integration of the Kingston system engineering and the Thunder Bay production engineering groups within the Bombardier system.

The main practical advantage lied in the early detection of risky areas and the definition of the best strategy to meet the requirements under the difficult contractual conditions.

SUPERLINER COMMUNICATION SYSTEM

Function analysis was used and extended for another smaller but better defined project: the AMTRAK Superliner II cars communication system. Between the original Superliner equipment manufacturer and a new supplier there was a significant cost difference. While there was a chance to improve the product with state-of-the-art technology, the major risk was that the new supplier did not have a product meeting AMTRAK requirements and that he could not keep up with the very tight schedules.

This Function analysis, the first to be entirely led by our newly trained facilitators, allowed in a very short time to clearly understand and specify to the new supplier the precise functions expected from the communication system.

In fact, this analysis forced our engineers to get very accurate data on actual system performance and operation. These functions were then simulated on a computer model which allowed step-by-step following of the design progress and to redirect the new supplier into the right track before it was too late while validating the system's global functionality and sensibility to failures. This model allowed validation of all conditions and operating modes and ensured that the electrical schematics would actually allow the system to perform as intended.

Due to the smaller size of the project, the benefits of the method were obvious sooner: not only did the design meet the requirements on the first try, the schedules were respected and the FAI (first article inspection) was successfully passed including a functional test of the system, but most important, this was done with a major cost reduction.

INITIAL COMMENTS CONCERNING THE METHODOLOGY

This new methodology and major changes in the way design and engineering were performed was not an immediate success and several criticisms were raised:

- the approach was seen as time-consuming and involving too many participants at an early time in the project.
- It was perceived as costly, useless and it prevented designers from starting designing right away. "We have short schedules, therefore no time to waste in meetings! Lets start working! Turn on the Autocads!"
- This important initial effort did not seem to have immediate

gains while staff were removed from crisis zones in other projects to attend the workshops. "Lets put out this fire, we'll address the next project if (when) there will be problems! "

- Quantitative results and benefits are not obvious and cannot be calculated in detail since there is no comparison: the impact cannot be directly linked to the method. "Yes, it was a success; it would still have been without the function analysis."

- The evolution of a corporate culture and process is slow and difficult since everyone tends to value experience and past successes. "We have done 600 cars this way and it has worked, we don't need anything new!"

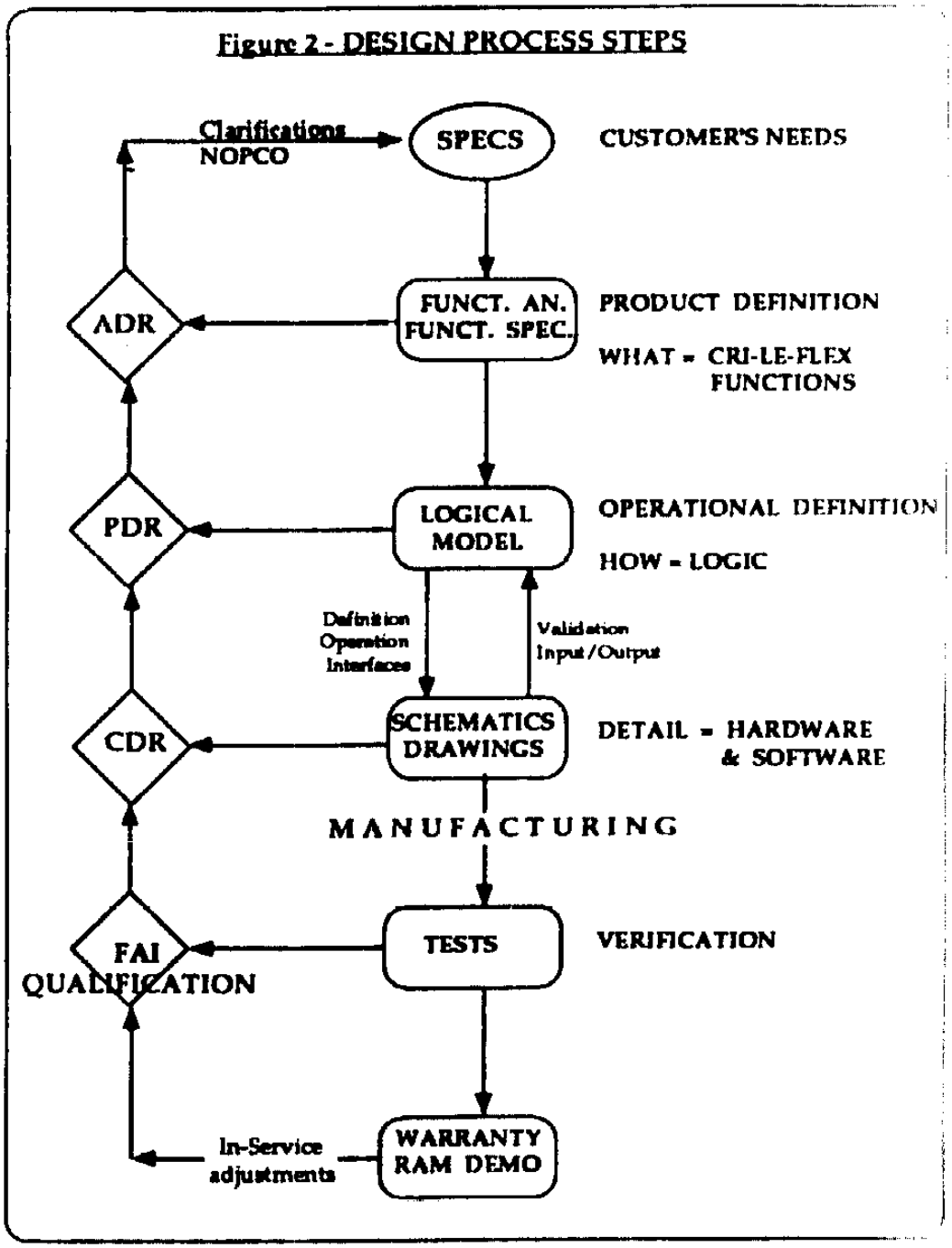
- The initial Function analysis effort is more profitable during contract negotiations and proposal stages. However this can be wasted if the contract is not signed, which leads to harsher criticism.

But finally, after a year in the process, everybody realizes these criticisms have no true meaning: the benefits are there to see.

WHAT WILL THE FUTURE LOOK LIKE NOW?

Bombardier has now the challenge to ensure function analyses are made systematically on each project. Since all were proven effective and very useful, the methodology is now accepted by most managers, but some of the setbacks are still strong enough to make this process still fragile. Work has to be done to get the process to be fully accepted and bring it to perfection.

This design process, as illustrated in figure 2, is still new and has not yet been completely assimilated by our corporate culture.



The following points will have to be worked on and improved to ensure that the previously mentioned benefits (no engineering changes, early detection of risky areas, better definition of client's requirements, respect of schedules and first article inspection passed at first try) will remain and be the basis for further improvement :

- consolidate the Function analysis approach with a formal design procedure (do the right thing)

- improve documentation of the Function analysis results and ensure it is updated. Ensure its systematic implementation to warrant that all and only the defined system functions are included in the design. (design exactly what is needed; no more, no less) by thorough and formal design reviews.

- standardize a thorough operational logic analysis following the Function Analysis by simulation or modeling prior to actual detailed design

- develop and implement a VE approach after the product definition phase in order to systematically design the most cost efficient solution (do it the best way).

CONCLUSION

The recent positive and encouraging results are reducing the criticisms and the function analysis program has gained corporate recognition. As indicated, it allows a better program management and better interface with the customer in understanding their needs. It also facilitates inter-department communication and coordination towards the same goal.

The next step would be to perform VE: obviously, once the function analysis is done, its fine for the design engineers to boot their computers and work on the design that will fulfill all these functions.