Intelligent system for assisting decisions in advanced product and process planning and design

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ABSTRACT

The current planning and advanced design systems of the products and processes require a higher complexity and this necessitates more than a single designer to accomplish it. **The collaboration and teamwork** represent the optimal way by which all the activities linked to the decision process can be realized. The current decision-assistance systems are designed to improve the efficiency and the effectiveness of the decision-takers by facilitating the information exchange, the way the information is accessed and used, the diminution of the specific deficiencies related with the design activities, the key-presence of some members, the social pressure, the inhibition of expression and so on. The IDDesign project presented in this paper aims at **improving the decision** occurring in product and process advanced planning and design, from identifying customer requirements, product / process planning, to prototype validation and production. It is our purpose to use modern tools that are related to intelligent decision support systems, and integrate them in process / product planning in order to reduce or eliminate the existing deficiencies, such as the geographical distribution of meeting participants, the subjectivism, and the dominant characters of some members, the social pressure, and the restraint.

KEYWORDS: Design, APQP, Collaborative Decisions, FMEA

SHORT BIOGRAPHICAL NOTES.

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Constantin Oprean was born in Spring, Alba County, Romania, in 1948. He graduated as an engineer in mechanical engineering in 1971, gained his doctorate in industrial engineering in 1985 at the Polytechnic University Bucharest. He went to become a professor in 1978 and a PhD adviser in 1985 at *Lucian Blaga* University of Sibiu (LBUS), Sibiu, Romania, after accomplishing experience as an engineer in the industrial production field between 1971 and 1978. In 1992, Prof. Oprean was promoted to Vice-Rector for Quality Management and Scientific Research at the LBUS. In 2004 he was elected as Rector of the Lucian Blaga University of Sibiu. Prof. Oprean is a recognized specialist in the fields of quality management, university management, strategic management and technological transfer. Prof Constantin Oprean is a member of the editorial advisory boards of many international journals, and he has written over 24 books/handbooks and published 276 scientific papers, 82 of them being presented at international conferences. He is the author of 24 inventions and has coordinated over 50 scientific research projects at the national and international levels.

1.Introduction and general framework

Globalization tends to produce a new industrial revolution conducting to production, product and services distribution without precedent. All countries and economical regions, even the emerging ones are affected, the competition becoming very harsh. There is a powerful development of knowledge based economies, with radical effect on markets, society and technology. This determines a new approach on production, based on high added value and knowledge involvement at all levels.

The *European Technology Platform on Future Manufacturing Technologies* for 2020 (www.manufuture.org), referred to within *Europa Report of the high level group*, must restructure its related industry by taking over the new business models that might induce a new understanding of products and services functions. There is a proposition for remodeling the industrial processes in order to introduce new models of knowledge management and manufacturing technologies, to move from a cost based competition to a value added one. Similar approaches are to e found also in the EpoSS platform (http://www.smart-systems-integration.org/public).

In the past years, the Romanian economy has undergone major changes, being oriented on "loan" based production, implying a reduced contribution of know how. A lot of Romanian organizations have given up product planning, the project coming from the customer or being bought from specialized institutes in exchange for large sums of money. There are very few foreign companies coming to Romania that have also planning, research and development departments; the majority have oriented towards production, due to the law labor costs; their expected migration will leave an empty space that will be hard to fill.

Considering the international challenges, and the Romanian economic and research area realities, the Romanian research strategy for 2007 – 2013 defines the following strategic objectives: knowledge creation, **increase in Romanian economy competitiveness, and increase in social welfare.** These are the lines based on which the National Plan for Research, Development and Innovation II was set up, and the Partnership Programme has as a **general objective**: *increase in RD competitiveness through stimulation of partnerships in leading areas, translated in innovative* ***technologies, products and services*** *for solving complex problems and creating implementation mechanisms*.

The current planning and advanced design systems of the products and processes require a higher complexity and this necessitates more than a single designer to accomplish it. **The collaboration and teamwork** represent the optimal way by which all the activities linked to the decision process can be realized. The current decision-assistance systems are designed to improve the efficiency and the effectiveness of the decision-takers by facilitating the information exchange, the way the information is accessed and used, the diminution of the specific deficiencies related with the design activities, the key-presence of some members, the social pressure, the inhibition of expression and so on.

There are nowadays many information and distributed computing systems that have been built to support the collaborative design and decision-making process. According to their different purposes and/or focuses, these systems can be generally grouped into the following categories: collaborative product data / information management systems for engineers to timely obtain the necessary product data and knowledge; network-based collaborative design systems (web-independent and web-dependent); process-centered collaborative design and workflow management systems; conflict detection, management and resolution systems for collaborative design; flexibility and security focused collaborative design system; interoperability approaches in heterogeneous collaborative design systems. Since most of them are developed for the needs of collaborative design, current systems can assist designers in one way or another in collaboration. Of those collaborative design information and support systems, notable ones include SHARE, NEXTLINK, DIS, DICE, EDN, MADEFast, NIIIP, RaDEO, etc. Other typical proof-of-concept systems include NetFeature, CooperativeARCADE, WebSPIFF, CSCW-FeatureM, TOBACO, CyberCAD, etc. [7]. There are also a number of commercial software packages purporting to perform many of the services that the system described supplies. Examples include: Alibre (http://www.alibre.com), Co-Create (http://www.cocreate.com), NexPrise (http://www.netprise.com), CollabCAD (http://www.collabcad.com), etc. Modern product data management (PDM) systems such as PTC Windchill and UGS Teamcenter (iMAN) also provide some of the functionality described for collaborative design and development.

2.The IDDesign project

The IDDesign project (**Intelligent system for assisting decisions in advanced product and process planning and design** – *i*DDesign) is financed by National authority for scientific research, the Partnership programme, starting with September 2008. The project aims at **improving the decision** occurring in product and process advanced planning and design, from the stage of identifying customer requirements, product / process planning, to prototype validation and production. It is our purpose to use modern tools that are related to intelligent decision support systems, and integrate them in process / product planning in order to reduce or eliminate the existing deficiencies, such as the geographical distribution of meeting participants, the subjectivism, and the dominant characters of some members, the social pressure, and the restraint.

The project is undertaken by a consortium made up of two universities, a SME with IT research profile, and a well known big automotive company. The partners are experienced in international (FP5, FP6 and FP7) and national (CNCSIS, CEEX, PNCDI) projects, and have a long cooperation in research projects. The solution will be developed together by all the partners involved, and will be implemented at COMPA, the automotive company.

The project is approaching an interface domain between the planning and advanced design system of the product, processes and decision-assistance systems. The acquired results of the research in both of the domains, **independently studied**, are remarkable. We have realized that the application of the decision-assistance systems in planning and advanced design of the products and processes is still far from achieving the supposed results.
Some quality techniques extremely used especially in the automotive industry as FMEA, QFD, TRIZ, decision matrixes, value analyze and so on are basing their results effectively on the decisional process, but there are currently not completed and interfaced with the decision-assistance systems.

Figure 1 presents the planning and advanced design process of the product and processes and on these process we located (using “D” letter) the areas where the decision occurs. The decision occurs starting with the initial stages of the customer requires identification and it continues to the stage when the product is in the prototype phase, respectively the validation of the 0 series.

In more than 90% of the cases the decision is still taken by the simple consent of the members of the group, respectively by vote, based on the intuition and the experience of the participants and often the reality (more exactly the panning process following stages as fabrication and the usage of the product) confirms that the decision was not a correct one. The reasons depend on the participants’ subjectivism, the dominant character of some specific members, the impedimental access to great quantities of information to name just a few.

The innovation of the project we propose lays in the way in which the facilitation support is actively assisted by the system based on the users’ intentional attitude. As in any group decision problem, the collaborative nature changes as the cooperation moves through the decision process. This emphasizes more the going-concert group dynamics towards concluding the final goal than the goal itself, as in common collaboration tools, the system-use more than the system itself. The application supports and structures the interaction concerning how to achieve the meeting goal in the situated context. Involving methods and tools inspired by the social and behavioural sciences, the users have the opportunity to intervene directly in the decisional process, evaluating and learning the consequences of their actions, and improving the practice and knowledge of the group.

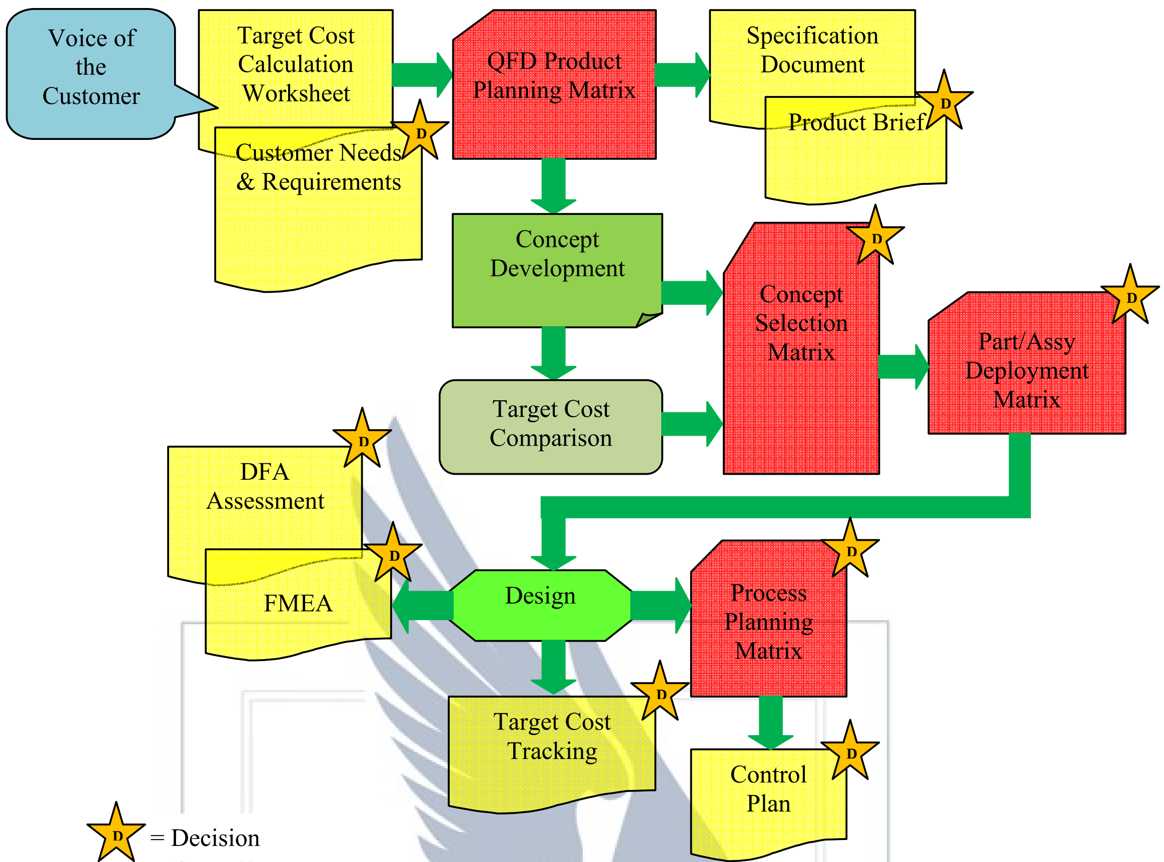

Fig 1. Planning and advanced design process of the product and processes with decision fields

Thus, the group is able to appropriate the available technology in its own spirit and not in the one imposed by the system designers. This significantly contributes towards extending the acceptance and understanding of collaborative technology.

The project is organized in six stages as follows:

- analysis of the system requirements
- development of the specific IDDesign models
- system creation
- system validation
- technological transfer, installation and instruction
- dissemination, exploitation

In the first stage we described the decision process and also group decision support systems and also we identified and described the Planning and advanced design process of the product and processes from Compa. We are now working for the second stage, that is development of the specific IDDesign models.

3.Supporting decisions in Advanced Product Quality Planning (APQP). Case study at COMPA

Advanced product quality planning is a structured method of defining and establishing the steps necessary to assure that a product satisfies the customer [1]. The goal of product quality planning is to facilitate communication with everyone involved to assure that all required steps are completed in time. The main principles of implementing APQP plan are [1]:

- organize the team: the supplier's first step in product quality planning is to assign responsibility to a cross functional team. Effective product quality planning requires the involvement of more than just the quality department. The initial team should include representatives from engineering, manufacturing, material control, purchasing, quality, sales, field service, subcontractors and customers, as appropriate;
- define the scope: it is important for the product quality planning team in the

earliest stage of the product program to identify customer needs, expectations and requirements;

- team-to-team: the product quality planning team must establish lines of communication with other customer and supplier teams. This may include regular meetings with other teams. The extent of team-to-team concept is dependent upon the number of issues requiring a solution;
- training: the success of a product quality plan is dependent upon an effective training program that communicates all the requirements and development skills to fulfill customer needs and expectations;
- customer and supplier involvement: the primary customer may initiate the quality planning process with a supplier;
- concurrent engineering: it is a process where crossfunctional teams strive for a common goal. It replaces the sequential series of phases where results are transmitted to the next area for execution. The purpose is to expedite the introduction of quality products sooner;
- control plans: control plans are written descriptions of the systems for controlling parts and processes. A separate control plan covers three distinct phases: prototype, pre-launch and production;
- concern resolution: during the planning process, the team will encounter product design and/or processing concerns. These concerns should be documented on a matrix with assigned responsibility and timing. Disciplined problem-solving methods are recommended in difficult situations;
- product quality timing plan: the product quality planning team's first task should be the development of a timing plan (see Fig. 2). The type of product, complexity and customer expectations should be considered in selecting the timing elements that must be planned and charted;
- plans relative to the timing chart: the success of any program depends on meeting customer needs and expectations in a timely manner at a cost that represents value.

Concurrent engineering performed by product and manufacturing engineering activities working concurrently is the driving force for error prevention.

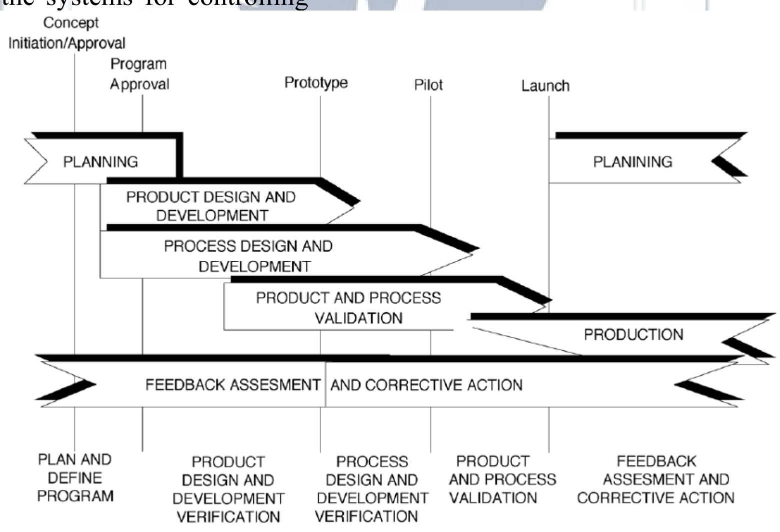

Fig. 2. Product quality timing plan

COMPA is company producing parts for automotive industry, located in Sibiu, the center of Romania. The main products manufactured at COMPA are: telescopic shock absorbers, brake equipments, elastic elements, stamped parts, drive shafts, steering gears, die casted parts, tools, etc. As a requirement of ISO / TS 16949:2009 standard (*Quality management systems - Particular requirements for the application of ISO 9001:2008 for automotive production and relevant service part organizations*) and also as the commitment to continually improve the quality of its products, COMPA has invested a lot of efforts in designing and manufacturing high quality products. The planning process at

COMPA has the purpose to plan the product quality and its development stages in order to satisfy customer requirements, according to SR ISO/TS 16949:2009.

APQP is a very complex process and hard to be managed; for this reason we focused for the beginning on a part of this process - *design activity analysis,* and used FMEA (Failure Mode and Effect Analysis) technique (please identify this process on fig. 1).

Failure mode and effects analysis (FMEA) is a methodology to evaluate a system, design, process or service for possible ways in which failures (problems, errors, risks and concerns) can occur [10]. FMEA was first developed as a formal design methodology in the 1960s by the aerospace industry with their obvious reliability and safety requirements. It represents a powerful and documented method for engineers to present in a structural and formalized manner with their subjective thinking and experience in terms of three main questions: What might go wrong? What might cause it to wrong? And what effect would it have? [12]. FMEA is a **group decision function** and cannot be done on an individual basis. The FMEA team often demonstrates different opinions and knowledge from one team member to another and produces different types of assessment information such as complete and incomplete, precise and imprecise and known and unknown because of its cross-functional and multidisciplinary nature [2, 10].

We have created a FMEA process model in order to better emphasizes its steps, the functions involved and also the decisions fields. Such a model created using iGrafx for six sigma 2003 is presented in figure 3 [10].

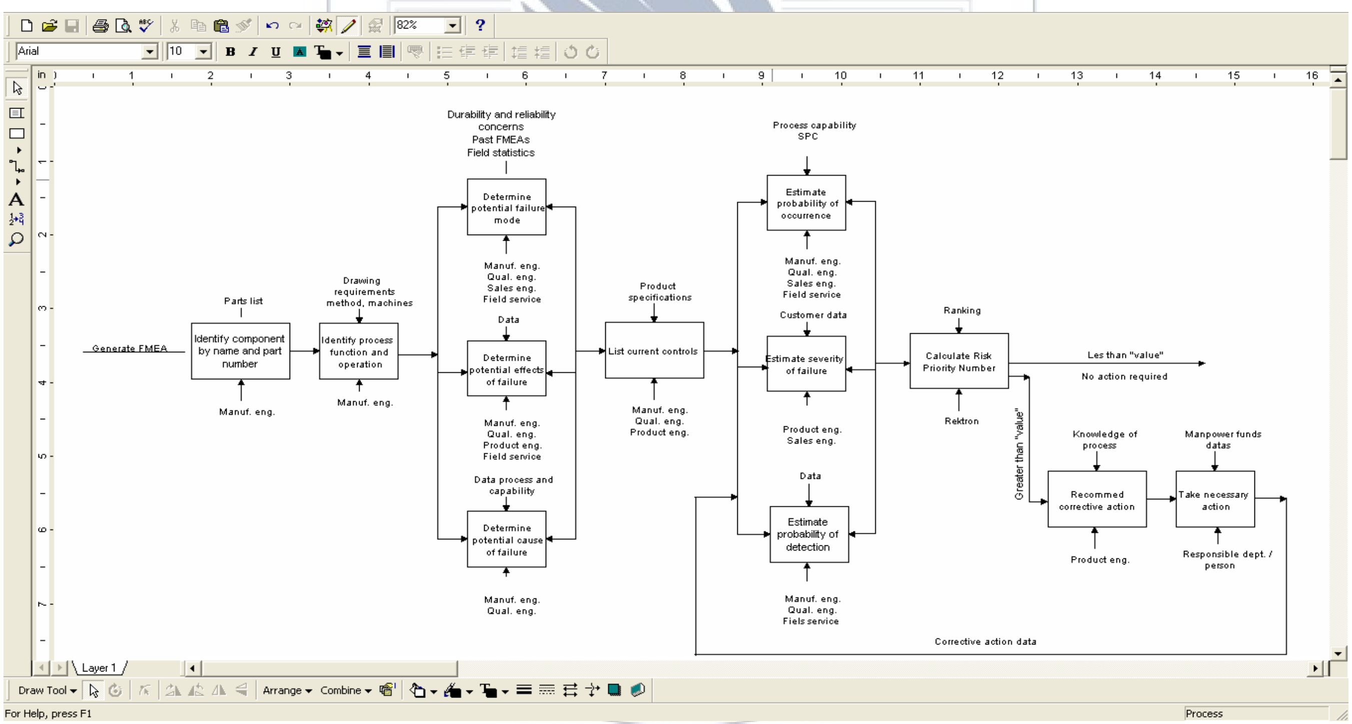

Fig. 3 – The FMEA process

The part selected for analysis is an element of the drive shafts which is manufactured on a CNC machine at COMPA. In table 1 a description of the process is presented; process function, product and process characteristics and specification are all information needed in subsequent phases of FMEA.

Table 1. Description of the process

Process ID	Function ID Operation description	Product characteristic	Process characteristic	Specifications and / or tolerances
1a	Receiving / inspection		Part identification	Operator must insure material label is correct
2a	Transfer part		Part position	Part placed in proper position
3a	Transfer part		Correct part	Part marked and located in correct bin
4a	Drill hole on front side	Hole location		5.680 – 7.433
5a			First pass depth.. of hole	0.10
6a			First pass diam. of hole	2.224+ / - 0.20
7a			Circularity of hole	0.0025
8a			Circular runout	0.10
9a		Final diam. of hole		3.823 + / - 0.20
10a		Final depth of hole		Thru

Figure 4 is presenting the FMEA analysis for this product; the analysis was done in traditional way just to have a common understanding for the whole team.

In the next stages we plan to integrate in decision processes the iGDSS platform [12]. iGDSS is a collaborative decision – making support system developed in the framework of project Ceex 23 / 2006 – eCollaborativeDecisions and it is based on the principles of GDSS, interactive software and related development technique.

As presented in figure 5, IGDSS is composed of the following: a) a main server which supports the basic functions and manages decisional process logic; b) a relational database (Postgre, MySQL, SQL Server, or Oracle); c) the web server that runs the user interface; d) the collaborative platform (which communicates with the main server through CORBA); e) the iGDSS tools. The entire solution is built using Java J2EE solution.

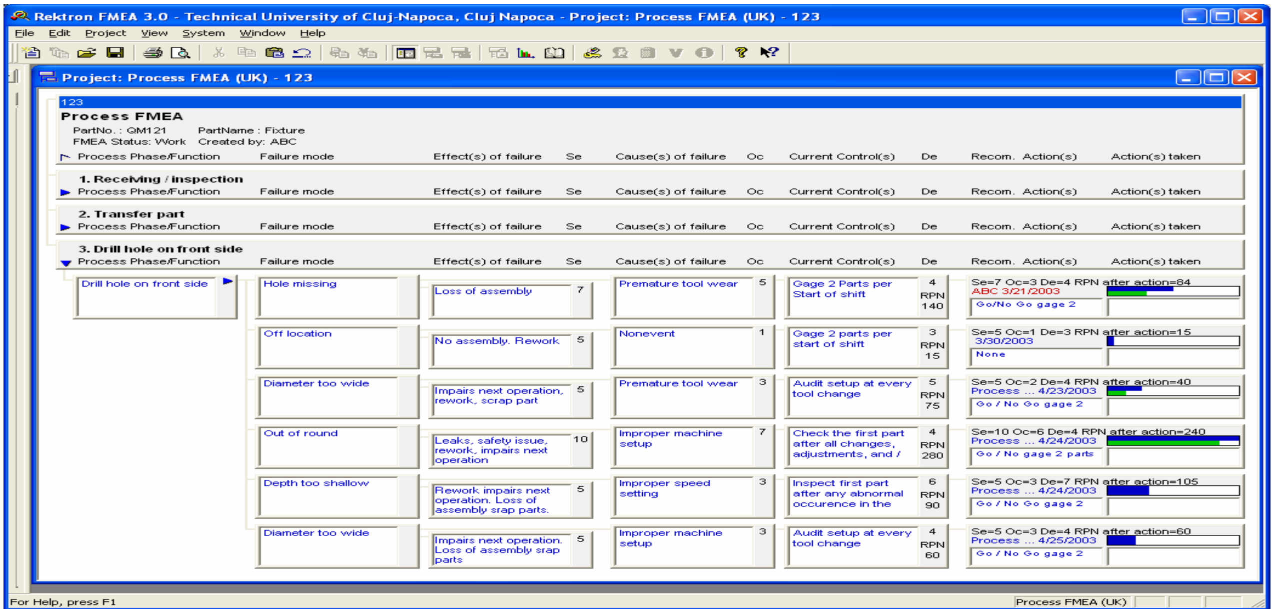

Fig. 4. The FMEA analysis

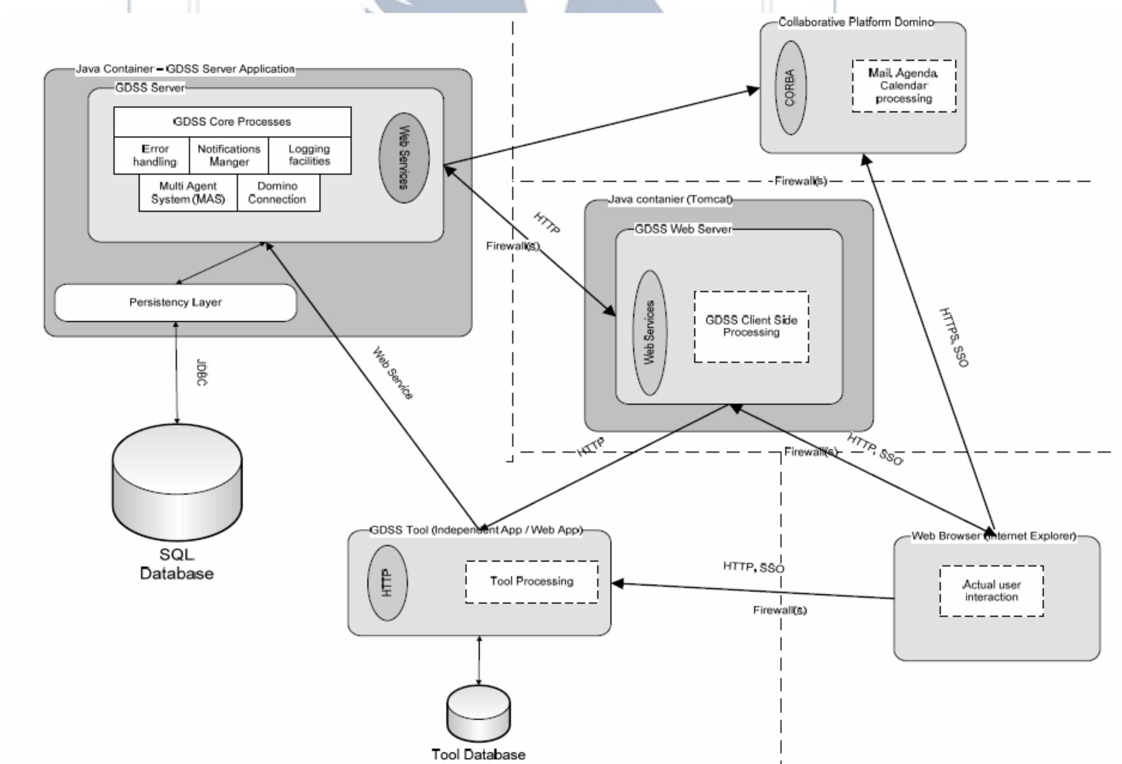

Fig. 5. IGDSS architecture

4.Conclusions and future developments

The IDDesign project presented in this paper aims at **improving the decision** occurring in product and process advanced planning and design, from identifying customer requirements, product / process planning, to prototype validation and production. It is our purpose to use modern tools that are related to intelligent decision support systems, and integrate them in process / product planning in order to reduce or eliminate the existing deficiencies, such as the geographical distribution of meeting participants, the subjectivism, and the dominant characters of some members, the social pressure, and the restraint. We identified he 1st stage of the project the decision fields from APQP process and we are worgin now to integrate iGDSS in the FMEA process.

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