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OSIRIS: A TOOL TO SUPPORT REUSE OF COST SAVING IDEAS

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1. Introduction

Design to cost (DtC) can be defined as a design management method that prompts designers to consider cost as an input of the design, at the same level as technical requirements [Michaels J. V. et al. 1989]. Cost targets are defined from the beginning of the project and are cascaded to lower levels. During a DtC operation, designers propose cost saving ideas to update the baseline design in order to reach the target. Therefore cost saving ideas must be managed during the design process, i.e. they must be captured, classified and assessed. This evaluation is based on the opportunity they offer to bridge the gap with the agreed targets. Such an approach allows deciding whether or not a cost saving idea should be implemented.
In order to support current aircraft programs at the development stage, a DtC approach has been implemented within an Aeronautic company. This method is supported by a Design to Cost tool, currently deployed at this company. It supports cost saving ideas management, each saving idea is captured and traced in the tool until its final validation.
Design to Cost implementation appeals to designer's creativity to propose modifications that let expect to reach targets. In Aeronautics, support of cost saving ideas proposal through the memorizing and reuse of past ideas is identified as an underlying need linked to Design to Cost implementation [AngénioL S. et al. 2005]. Therefore, we study in this article how cost saving ideas stored in the DtC tool can be reused for future DtC operations. Consequently, we define a tool that supports the process of cost saving ideas proposal: OSIRIS (Optimizer for Saving Idea Reuse & Information Sharing). Firstly, we review main approaches proposed in the literature linked to indexing and retrieval issues. As no promising solution fitting our needs and context has been identified for indexing, retrieval and reuse of design ideas, we define, in a second section, the conceptual model supporting OSIRIS. It is decomposed into, first, the model used for indexing cost saving ideas, and second, the model used for describing the context of a request for ideas. This conceptual model is implemented using semantic web technologies, enabling advanced search and reasoning on ideas description. The last section of the paper illustrates OSIRIS capabilities with a usecase scenario.

2. State of the art

Many systems propose the reuse of previous designs. Ball *et al.* [Ball L. J. et al. 2001] classify limiting factors linked to design reuse into 5 categories:

1. indexing and retrieval problems;
2. misunderstanding of prior designs;
3. modification issues linked to the adaptation of prior designs to the current use;

4. satisfying tendencies: risk to study a single alternative instead of studying all possible alternatives;
5. organisational matters: reluctance to use other's design or to make their design available for future reuse.

In this communication, we focus on the first category of problems and present below concepts highlighted in the literature that enable indexing and/or retrieval of ideas; 4 types of methods/tools have been identified.

- *Ideas management systems* enable ideas indexing. Mc Kinsey has developed a DtC tool that indexes cost saving ideas in order to track ideas' maturity and to ensure their successful implementation. Other systems manage innovation ideas, those web-based systems enable the management of employees' suggestions and ideas [Frey C. 2003]. The proposed tools (IdeaCentral from Imaginatik, NextNet from GeneralIdeas and IdeaCenter from Akiva) focus on the ripening process of an idea (creation, assessment and decision).
- *Case Based Reasoning (CBR)* is a method proposed to reuse design experience. It is based on the assumption that similar problems are solved by similar solutions. A case describes a past experience and is represented as a pair: a problem and its associated solution. In order to solve a current problem, a CBR system retrieves similar, past problem (and its solution) by measuring the similarity between the actual problem and those stored in the case base [Avramenko Y. et al. 2005]. Mansar *et al.* [Mansar S. L. et al. 2003] describe CBR for Business Process Redesign (a case consists of a best practice implemented on a type of process). Users can retrieve similar cases thanks to two types of information, the studied process (the aim is to retrieve best practices applied to this type of process) and the type of best practice (the aim is to retrieve examples of implementation of this type of best practice).
- The concept of contextual access to information is the major issue of *Knowledge Management* research area. The main existing approaches aim at reusing information (mainly in document) in a specific organization's context and enable a collective to share knowledge and activities in a domain. An example of applications is a web based document repository that allows groups to share qualified (annotated) documents relative to its activities [Longueville B. 2005]. In these cases, the knowledge model is embedded in an ontology to provide a consensual conceptual vocabulary for labelling and qualifying documents. Reasoning capabilities are used to deduce new properties from the existing documents and annotations.
- The problem of indexing technical ideas have also been addressed by researchers on *TRIZ* theory since the fifties [Altshuller G. 1979]. In order to develop methodologies to support problem solving activities, *TRIZ* researchers have extracted from patents databases the underlying principles of these solutions. In addition they have developed a way to model the problem solved by innovations, this model is the concept of *technical contradiction*. Then, methodologies allowing to find applicable ideas in order to solve problems have been developed. They are based on the principle illustrated by Figure 1: (i) analysis of the initial situation (the specific problem), (ii) formulation of the abstract problem, which is a generic understanding of the problem to be solved, (iii) formulation of the abstract solution for this problem, which is a domain independent principle of solution (iv) formulation of this solution adapted and transformed for the specific conditions.

As a conclusion to this overview, although several approaches linked to indexing and retrieval issues are proposed in the literature, there is no simple method enabling indexing, retrieval and reuse of ideas. Indeed, Ideas management systems contain information required to make decisions but not those needed to understand and reuse ideas out of context. In our context, CBR's limits are mainly due to the fact that the idea model may evolve: this might lower retrieval performances of the method; moreover the similarity function is hard to define as there is much textual information in DtC saving ideas. KM existing approaches focus on informal documents access, procedural knowledge associated to engineering processes, they are not targeting technical ideas reuse. Finally, *TRIZ* is too heavy and focuses on inventive problems whereas our target is to implement several times more systematic solutions. This conclusion raises the need for a new specific approach for idea reuse.

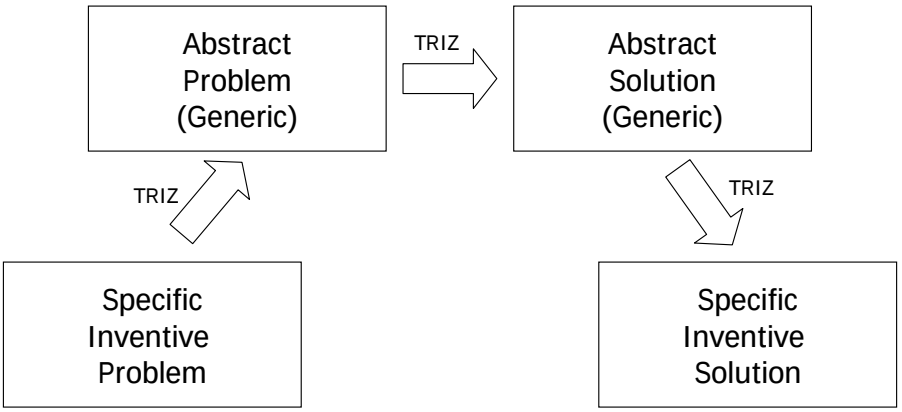

Figure 1. TRIZ model of problem solving, (adapted from [Altshuller G. 1979])

3. Knowledge Model

In this section, we define the OSIRIS knowledge model. First, we describe requirements linked to the tool. Then, we split our contribution into two different parts:

- the definition of a new conceptual model linked to idea description,
- the implementation of this model using semantic web technologies.

3.1 Requirements

The primary objective of this tool is to provide designers (who have to lower the cost of a given part or sub-system) with applicable saving ideas from past DtC operations. The tool's usefulness depends on proposed saving ideas' relevance to the search context. The criteria for selecting ideas must be their applicability in the current design context (i.e. the fact that they can make sense and be successfully selected).

The tool aims at supporting the creative process in DtC operations, through the retrieval of applicable past cost saving ideas. It should satisfy the following requirements:

- Idea description should enable the understanding of a past and solved problem with limited amount of additional information (compared to information required today in the DtC tool).
- Access to past ideas should be flexible, depending on available information.
- Retrieval capabilities should propose a limited number of saving ideas, and should propose relevant saving ideas (i.e. ideas that can be applicable to the context of the designer).

3.2 Conceptual Model

A saving idea is a proposal for modification which should enable cost reduction. Four types of information make up an idea in the current DtC tool. Firstly, in the modification description are explained changes that would involve the idea implementation. Indeed, an idea can lead to the modification of design, manufacturing, sourcing, or any field that is linked to the development of a new aircraft. Secondly, the idea localisation describes which part of the aircraft is modified by the idea. In addition, a saving idea contains the assessment of its cost and weight impacts. And finally, decisions linked to the ripening process of the idea are captured.

DtC tool is an Idea management system containing the information previously mentioned, implemented in a decision making perspective. Therefore, we need to refine the idea description to enable retrieval and reuse of saving idea.

3.2.1 Idea description

The main difficulty linked to idea description is summarized in the following contradiction:

- Idea description should be as detailed as possible to enable the understanding of past ideas and to identify contexts of possible reuse,
- Idea should be described with as little data as possible as idea description is expensive (in time and cost).

In order to develop an efficient way of finding and reusing ideas, we propose to set up a similar approach than the one developed in *TRIZ* methodologies. In *TRIZ*, the problem is modelled by technical contradictions and the solution is abstracted by solution principles, such as inventive standards. Nevertheless, as discussed in section 2, *TRIZ* approaches are efficient for inventive problem solving and require much effort. In our context, ideas are not necessarily inventive and we are not in a process where contradictions can be easily expressed due to a lack of time and resources. Consequently, our proposal is to keep the principle of having an abstract and generic model of the problem as well as generic models of solution principles attached to problems and idea solutions. But we are using the specificities of the DtC context (non inventive problem and A/C design) in order to simplify these abstract models. Consequently, we propose to develop two abstract models: (i) a model of the problem (ii) a model of the solution as shown by Figure 3.

To illustrate our proposal of a conceptual model of idea description, we take the example of a saving idea. It consists in merging two separate parts (a spar and a fitting – see Figure 2) into a single part in order to decrease the assembly cost. The current description and the proposed conceptual model are shown in Table 1.

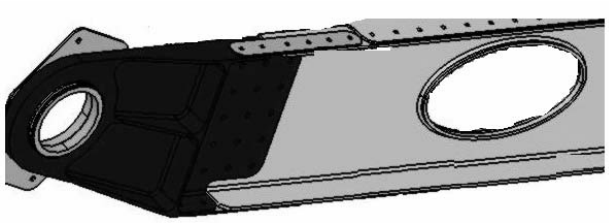

Figure 2. Example {spar + fitting}

Table 1. Conceptual model of idea description

<table>
<tr><td colspan="2">Current description</td><td></td><td colspan="2">Proposed conceptual model of idea description</td></tr>
<tr><td>--</td><td>--</td><td rowspan="3"></td><td>Studied part: {spar+fitting}</td><td rowspan="4">Problem</td></tr>
<tr><td>--</td><td>--</td><td>Cost contributor: assembly cost</td></tr>
<tr><td>--</td><td>--</td><td>Cost drivers: number of screws, assembly technology</td></tr>
<tr><td>Idea localisation</td><td colspan="3">Part of the aircraft concerned by the idea</td></tr>
<tr><td>Idea description</td><td colspan="3">Title: Integrate the fitting in the spar
Detailed description</td><td rowspan="4">Solution</td></tr>
<tr><td>--</td><td>--</td><td></td><td>Type of modification: Merge two elements into a single one</td></tr>
<tr><td>Impact evaluation</td><td colspan="3">Impacts on recurring and non recurring costs, weight and any other parameters</td></tr>
<tr><td>Associated decisions</td><td colspan="3">Ripening process of the idea (whether it is validated or cancelled)</td></tr>
</table>

In this model, the concepts of cost contributor (expensive element in the studied part) and cost drivers (parameters that explain why a cost contributor is expensive) are introduced.

In order to avoid additional work to fill the new fields, we use a typology of modifications, called *modification types* (this can be compared to Inventive principles in *TRIZ*) and a typology of *cost drivers*. In addition, we are working on a typology of *studied parts*.

Figure 3 summarizes our proposed conceptual model compared to the existing one.

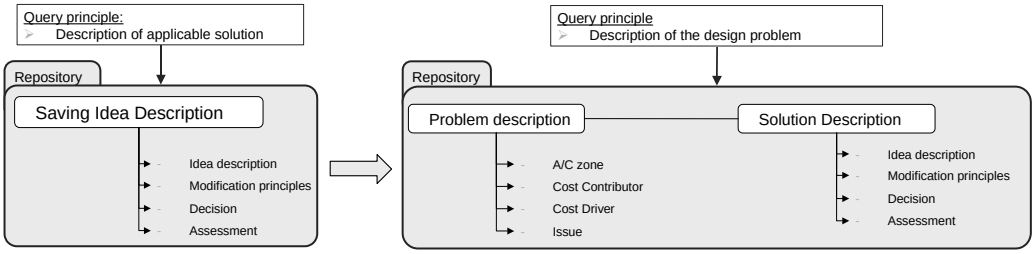

Figure 3. Existing approach vs. our proposal

3.2.2 Search context description

A search for ideas context is represented by the description of the studied part (type of part, localisation on the aircraft), the cost contributor and its associated cost drivers.
The main difficulty is the fact that a search for saving ideas in a given context depends on the user's experience, his/her knowledge of the product as well as his/her culture of costing sensitivity. Finally, it is strongly dependent on the way he or she describes his/her redesign problem. Table 2 provides an example of such discrepancies.

Table 2. Example of variability in the problem description

User 1	User 2	User 3
Decrease the cost of a spar and its fitting = **studied part**	Decrease the assembly cost between a spar and its fitting = **studied part and cost contributor**	Decrease the assembly cost between a spar ant its fitting which is mainly due to the number of screws = **studied part, cost contributor and cost driver**

3.3 Model Implementation

The definition of the conceptual model of OSIRIS raises the question of its implementation. The existing DtC tool is based on a classical Relational Databases Management Systems (RDBMS). But within this kind of solution, the implemented model is static and coded in the database structure. Evolutions or modifications of the model are very expensive. Therefore, the main limitations of those systems are (i) the lack of advanced search functionalities on information resources and (ii) the lack of advanced functionalities to analyse, combine, and deduce new knowledge from existing resources.
Consequently, we decided to implement our model using semantic web (SW) technologies. The reason for this choice relies on the nature of the model we must implement. This shared knowledge model of the problem and the solution is evolving as long as we perform experimentations with teams' members as well as with users needs and behaviours to search for ideas. In addition, the main interest relies in the innovative features of SW architecture, such as ontology based search and inference rules. Indeed, the SW approach allows:

- Information sharing between humans and computers by using a common and evolving representation of a domain: this knowledge is represented by ontologies used to describe contents. Problem model and Solution model are represented by classes and relations (See Figure 4).
- Reasoning on web information by using inference engine, processing inference rules representing specific knowledge of a domain. This is used to improve information retrieval or information clustering. We have enriched the model with inference rules in order to complete missing information as well as deduce applicability of ideas based on engineering knowledge (See usecase scenario in section 4.2.).

- More efficient retrieval (while searching for information) by using semantic search engine that are able to understand the knowledge describing web contents. Examples of queries are illustrated in section 4.2.

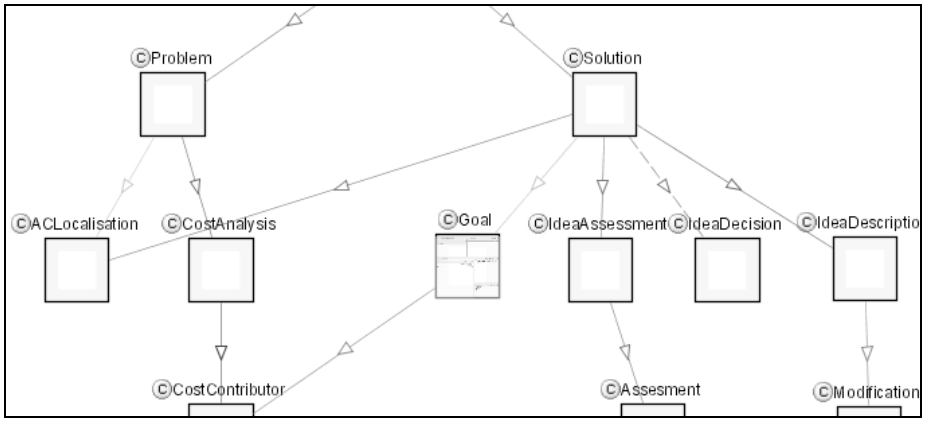

Figure 4. Problem - Solution Ontology (extract)

4. Implementation

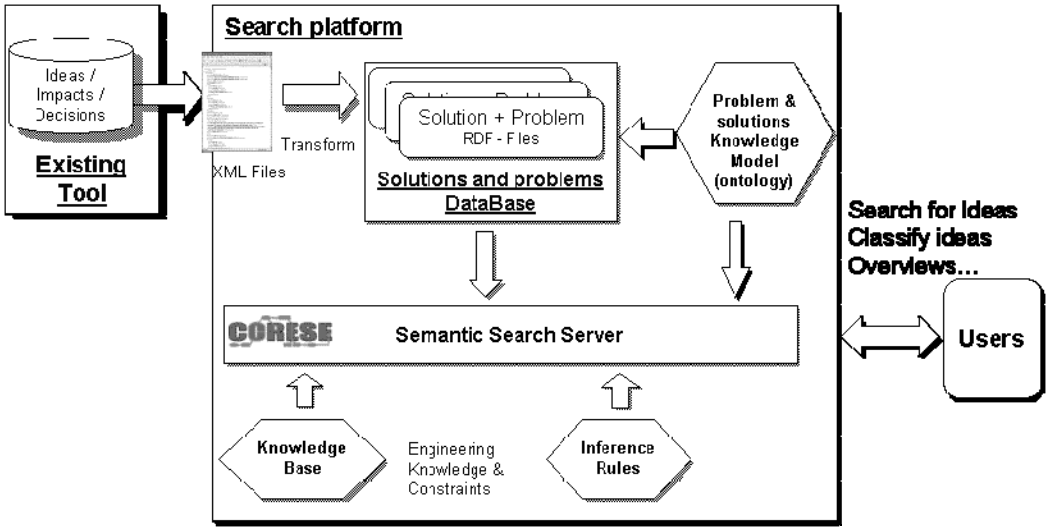

Figure 5. OSIRIS Architecture

4.1 Presentation of architecture and search engine

For the implementation phase, we use the KINOA prototype platform [Longueville B. 2005]. As shown by Figure 5, it contains a semantic search server and a solutions and problem repository. By transformation of existing ideas stored in DtC database, a Solution and Problem database is created. It consists in resources files whose structure matches a problem and solution ontology. The Semantic Search Server indexes these resources files in order to process user's queries to find ideas. This server uses ontologies and inference rules to support search functionalities. Ideas and problem resources can be enriched and modified by an annotation editor (not represented on the figure).
Solutions and problems are stored in files, in RDF format (Resource Description Framework) which is the W3C model to represent meta-data. The ontology is written in RDFS (Resource Description

Framework Schema). KINOA Annotation platform prototype consists in the integration of the Corese Semantic search engine [Corby O. et al. 2004] with specific EADS developments for the annotation editor and search page results.

4.2 Usecase scenario

Design alternative proposed to reach cost targets are required in two types of contexts:

- Designers create themselves a design alternative. Then, during reviews, the steering committee studies each created design alternative and accepts it for evaluation or not;
- Multidisciplinary meetings are organised by the DtC team; these meetings aim at creating new design alternatives that are directly accepted for evaluation.

In this section, we propose a use case scenario to illustrate the use of OSIRIS on the second case.
During a multidisciplinary meeting, actors are trying to reduce the cost of the cockpit floor of an aircraft. They study each elementary part of the cockpit floor and focus on a spar and its associated fitting. Identified drivers are the assembly technology and the number of screws. Figure 6 illustrates the query and OSIRIS answers to the cost driver technology. The results are displayed in a table organised by Recuring cost impact and Aircraft zone.

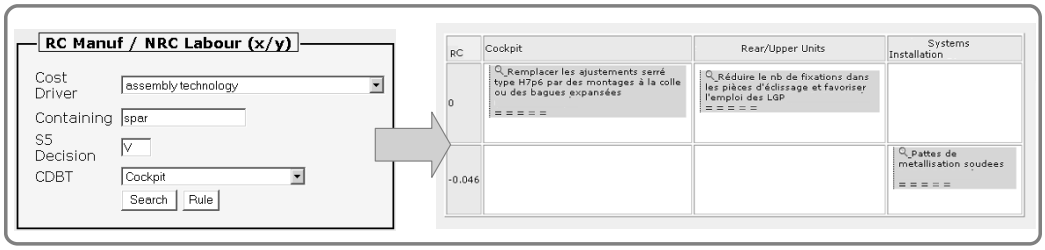

Figure 6. Illustration of a query with OSIRIS

The multidisciplinary team is not satisfied with proposed saving ideas. Consequently, an inference rule is applied. It concerns missing information completion. Its purpose is to deduce automatically, for ideas concerning assembly technology, the potential cost driver information if it's originally missing. This rule is based on the knowledge of specialists. The implementation of the rule leads to additional ideas (See Figure 7).

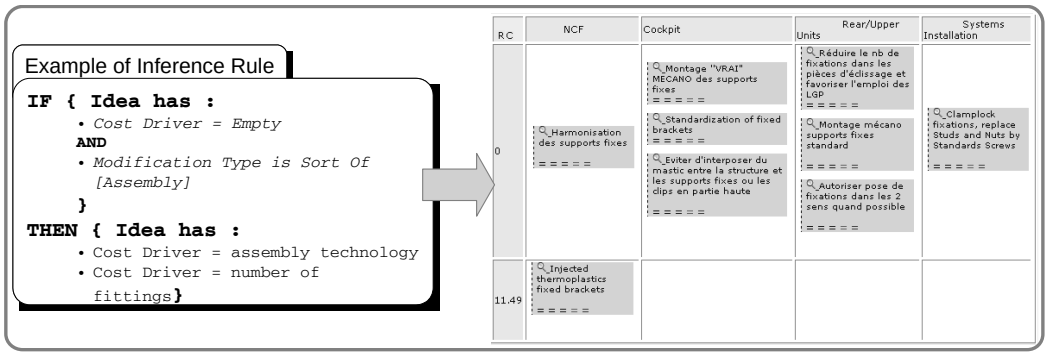

Figure 7. Inference rule illustration

We are currently developing a base of such inference rules. For that purpose, we are studying available ideas and defining inference rules in collaboration with design, manufacturing and procurement experts. We expect to significantly increase the performance of the retrieval system and the applicability of proposed ideas in a given context.
This simulation has been done with a basis of 900 ideas, concerning the same project and late in the life cycle of the product.

5. Conclusion and perspectives

Reuse of previous design knowledge is a potential important way to improve design efficiency [Ball L. J. et al. 2001]. We propose a system (OSIRIS) that enables indexing and retrieval of cost saving ideas proposed in past "Design to Cost" operations. OSIRIS is based on a conceptual model that enables the description of saving ideas with a model of the problem and a model of the solution. This model is implemented with semantic web technologies, and more particularly with KINOA prototype platform that contains an annotation editor and a semantic search server.

OSIRIS provides an innovative way of access in past ideas through the design problem description. Ontology based search enables search by type of concept and search by relations between concepts. Moreover, specific knowledge of a domain can be added to the information of the repository by using inference rules.

Today, inference rules proposed in OSIRIS are basic. Therefore, the next step will be used with experts, to define inference rules that will increase the applicability of proposed ideas in a given context. Moreover, the interface of the tool will be improved in order to classify proposed ideas depending on its assessed applicability and depending on its potential impacts.

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