# Concurrent engineering and fast-mapping/crowd-mapping using IoT, Big Data and Cloud Computing

*George Suciu*
*BEIA Consult International*
*R&D and Innovation Manager*
*Str. Peroni 16, Bucharest, Romania*
*george@beia.ro*

*Adrian Pasat*
*BEIA Consult International*
*R&D Department*

*Laurentiu Bezdedeanu*
*BEIA Consult International*
*R&D Department*

*Iulian Iordache*
*INCDIE ICPE-CA*
*Scientific Researcher, Advanced Materials Department*
*Splaiul Unirii 313, Romania, Bucharest*

*Gabriela Iosif*
*INCDIE ICPE-CA*
*Project Manager, Knowledge and Information Management Office*
*Splaiul Unirii 313, Romania, Bucharest*

*Emil Costea*
*INCAS*
*Head of Technical Department*
*Iuliu Maniu 220, Romania, Bucharest*

## ABSTRACT

Information sciences and technologies are clustering, heading towards a mixture of computer platforms, operating systems, data containers, communication technologies, and delivery methodologies. So, knowing that for technology to be successfully deployed and embraced, we need computing professionals who can assess and select appropriate technologies, and design integrated solutions. This paper presents the approach of the E-STAR project, which aims to increase the capacity of Romanian research and industry entities, facilitating their participation in programs of science and technology integration, through applications that have specific objectives in mind, namely: creating a framework for developing partnerships between industry and research areas such as space, air, soil, subsoil, water; developing an IT platform for concurrent engineering, ensuring the integration of relevant data from ESA; advance and promote applications based on satellite telecommunications and Earth observation (satellite data); creating a database containing information pulled from different research areas. As mentioned, the key factor within the E-STAR platform will be the synthesis of concurrent engineering basic tools and principles with significant data from relevant sources, including IoT (Internet of Things) and fast-mapping/crowd-mapping. We envision advancing an innovative tool focused on optimizing the engineering design processes, substituting the traditionally sequential flow by integrating multidisciplinary teams working

collectively, in parallel, at the same place with the objective of making a design in the most efficient and consistent way possible, right from the start.
The E-STAR platform will implement adequate search engines like EXALEAD OnePart and EXALEAD CloudView solutions, that would offer the possibility to search within the platform files and also connect to relevant big data sources (ESA, ROSA, etc.).
Also, the platform will allow the design of new parts by using software solutions like Solidworks and CATIA in the cloud. Beside 3D Experience platform from Dassault Systèmes, we analyzed and compared two other PLM (Product Lifecycle Management) architectures: Team Center from Siemens and Windchill from PTC.
The platform would be accessible to the companies and institutions which are interested to work in areas related to space datasets. Future work must take into consideration the issues related to licenses, security, technical problems, competition and access to resources.

**KEYWORDS**: *Concurrent engineering, fast-mapping, crowd-mapping, IoT, Big Data, Cloud Computing*

## 1 INTRODUCTION

The first time the term concurrent engineering (CE) appeared was in 1989 and can be called as well Simultaneous Engineering, implying a systematic approach which includes a concurrent design of products and other processes that are related and have in their build the manufacture and support [1].
Traditionally, CE was used the sequential engineering method where people from various departments worked one after the other on successive phases of development, method which has a linear format. After a task is completed it is left alone and then everything is concentrated on the next one, being a lengthy process. It often led to a lot of design changes when the prototype testing began, due to production problems, delays or design flaws. Then, concurrent engineering was implemented in industry, and not only, as an approach directed to engineering cycles and optimization, as shown in Fig. 1.

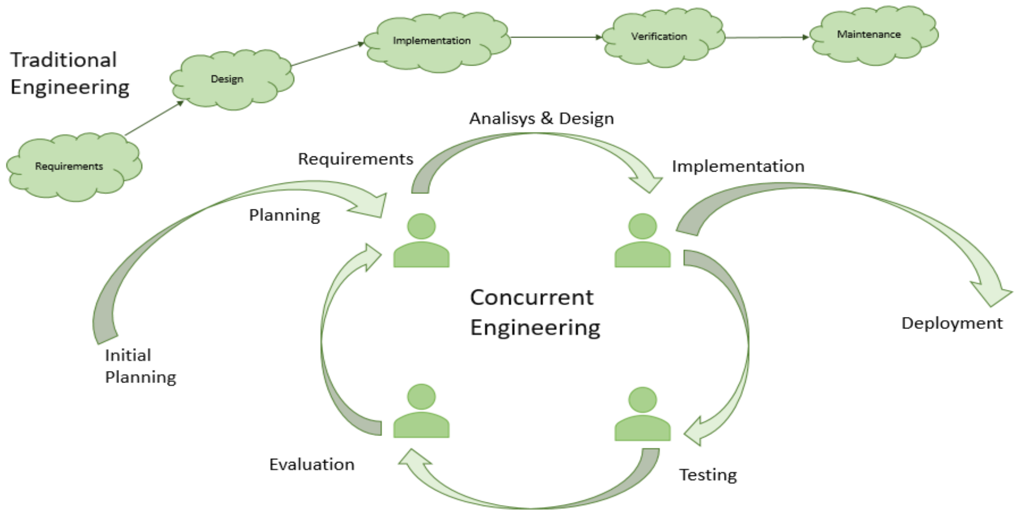


**Figure 1: The difference between concurrent engineering and traditional engineering**

Although, initially, concurrent engineering was adopted in the industry for product design, subsequent, it was adopted also in information and content automation field. Essentially, concurrent engineering provides a collaborative, co-operative and simultaneous engineering working environment [2].
The concurrent engineering approach is based on five key elements:

- a process

- a multidisciplinary team
- an integrated design model
- a facility
- a software infrastructure

Fast mapping is used in the context of data acquisition, through Earth Observation service, and it is related to ongoing crisis and post crisis situations [3]. There are several projects, which aim to increase automation of disaster mapping chains by fast production and monitoring cycles, and Big Data. This can be done by optical and radar data from French, German, Romanian Space Agency (ROSA), European Space Agency (ESA) Sentinel, and Copernicus Emergency Management Service rapid mapping activation sources [4].
Another concurrent engineering approach is crowd-mapping, which is a form of collaborative work that empowers users to share geographic knowledge [5]. One good example of crowd-mapping would be OpenStreetMap which is a crowd-sourced geographical map dataset. The system behind crowd-mapping is crowd-sourcing which introduces the concept of knowledge gathering whereas people are put to gather and keep a lot of information, such as Wikipedia. Crowd-mapping can make very detailed real-time data, which any other kind of map would not be possible to copy it. This concept appeared in a global disaster relief movement, because online maps were not enough to keep track of some medical supplies in the disaster of Haiti and Chile, these kind of maps being created through text messages and social media [6].
Furthermore, concurrent engineering is closely related to Product Lifecycle Management (PLM) [7] which defines a solution for the improvement of development processes for a product and of bringing to the market faster, through a better management of information and collaboration during the entire lifecycle of the product, from the idea until the withdrawal of this.
Such PLM platforms, which consider the simulation of the lifecycle of the product and the impact on the environment, can be used as a decision system in early phases of design [8]. Moreover, the product-service systems are business models, which can be considered smart products [9].
Also, for a modular product-service system, there are designed collaborative integrated platforms, which can gather valuable information for the decision process with the help of smart sensors networks [10].
Hence, in the rest of the paper, we will present in Section 2 an overview of the PLM architectures implemented in industry and other CE systems. In Section 3 we present the experimentations with Big Data tools, while in Section 4 we will describe the CE platform architecture and its functionality. Also, we realize a SWOT analysis of PLM solutions for concurrent engineering. In section 5 we draw the conclusions.

## 2 RELATED WORK

Product development companies have an interesting way of providing customers the best of their services, as they reuse old quality assured designs while introducing them to new products [6]. The reuse of parts it's not profitable because sometimes customers' wishes or requirements can hectically change. Though to avoid the development lead-time, another type of reuse is needed. Studies shown in this thesis demonstrate that literature based on information searched through platforms do not provide the need to support holistic platform development over a lifecycle. To solve this issue configurable system elements are created through model platforms. In addition, some platforms for development can be backed by a Product Lifecycle Management architecture for engineering-to-order configuration.
Satellite systems are becoming more complex day by day so that the conceptual design key is even more expensive to have [11]. A solution is to establish a collaborative systems engineering environment and to adopt a model-driven engineering approach (MDE). This introduces a new application of a novel knowledge-based software tool, called SatBudgets, which is based on satellite SysML (Systems Modelling Language).
Scientists and public institutions face a lot of problems when it comes to geospatial data that has a lot of heterogeneous data [12], using automatic metadata extraction approach which generates

distinctive optical data from different kind of satellite missions (i.e. MODIS, LANDSAT, RapidEye, Suomi-NPP VIIRS, Sentinel-1A, Sentinel-2A), Geonetwork Open Source stores all important metadata information regarding satellite data and all of this is put in an online catalog. The EURAC research group institute for Applied Remote Sensing works in real time to manage all data for Earth observation, meaning data processing, metadata extraction and so on, such as the TESSA [13] project is an interoperable data platform solution and it allows fast navigation and entry to data from a data archive. It is for scientists mainly and situational sea awareness high-level services which is the decision support system (DSS). It can be accessed through three parts: the Data Access Service (DAS), the Metadata Service and the Complex Data Analysis Module (CDAM). In paper [14] the open platform amePLM is described, which is made on a semantic data model. It enables an integrated view of data and information available software system and the linking of the solution to existing engineering software systems.

With the diversity of IT infrastructure, it is difficult to think of a fusion between the production system and information technology, such as big data fusion and analysis platform using cloud computing [15].

The Internet of Things field (IoT) produces data that maps the surroundings of sensing objects and send notifications to a data processing platform for supplementary investigation. The notion of background attentiveness of applications is done by merging this observed data, or by altering the linked data. The article [16] presents MASSIF, an information driven stage for the semantic explanation and thinking on IoT information. It permits the joining of various measured thinking administrations that can work together in an adaptable way to encourage complex basic leadership forms.

In [17], an object-oriented manner to deal with the advancement of item stages is proposed to expand effectiveness through reuse and adaptability of outlines among a group of items. Two methods of the stage improvement handle are tended to: stage planning and stage execution. Stage planning endorses the techniques expected to show stage objects, utilizing upgraded work that implies models and set-based concurrent engineering techniques. All along the stage execution procedure, sets of outline options can be designed simultaneously all through the theoretical, structure, and point by point periods of the stage advancement.

In paper [18], the authors present how item stage arranging can enormously bolster item variation plan, which is of extraordinary help to the usage of mass customization (MC). Most of the item stage arranging strategies, item modules and item families have been generally preplanned before items are planned. In this paper, we propose a strategy for item stage arranging utilizing the current item information in product lifecycle management (PLM) database. The proposed technique presents two key innovations, i.e., pruning investigation and property coordinating. The pruning investigation is utilized to discover the sharing parts of various item families, which constitutes the fundamental structure of item stage. The adequacy of the proposed technique is confirmed by the item information in the PLM database for valves. The proposed technique enormously enhances the reuse rate of existing item assets, giving a successful and quick path for ventures to execute the MC procedure.

Nowadays, fabricating is heading towards client driven and learning is based on dedicated development, as presented in [19]. Shorter product life cycles prompt to expanded elaboration in fields like item and process outline, industrial facility organization and generation operations. To deal with this unpredictability, new information based techniques and advancements are expected to demonstrate, trigger, advance and screen fabricating frameworks. Learning based and collaborative process administration include a blend of organized and non-organized procedures. Organized procedures administration can be diminished to an arrangement of completely characterized rules prompting high productivity and additionally, low adaptability, whereas the administration of non-organized procedures is not inclined to a full formalization. A mix of both organized and unstructured administration approaches is required with a specific end goal to accomplish a fruitful compromise between effectiveness, adaptability and controllability. Huge undertaking data frameworks, force organized and unsurprising work processes, while learning based community oriented procedures are erratic to some degree, including high extents of

human-choice. Moreover, the article [19] presents an arrangement of ideas, strategies and instruments of an imaginative Hybrid Process Management approach approved by a genuine business case in the car business.
Necessity administration speaks to one of the key procedure in the perplexing product life cycle since it is included toward the start, as well as in the further stages where the meaning of the specialized details at times involves prerequisites tradeoff because of discordances [20]. Hence, the part of RM instruments and strategies, that regularly depicts a solitary arrangement, needs to change and to be more incorporated in the Product Lifecycle Management stage. Presently, a genuine shared incorporated RM arrangement does not exist and hence it is important to equip a system for supporting the customization of the accessible RM answers. Furthermore, [21] presents a systematic approach that combines client focused plan standards into the customization procedure of the mechanism. The proposed philosophy puts the client, as opposed to the framework, at the focal point of the procedure on account of that the RM arrangement could be viewed efficiently just if it is capable of sparing time and cash in the information administration, by clients. In addition, this device evaluation technique can help associations productively establish applicant utensils.

## 3 TOOLS EXPERIMENTATION

In this section we will present the development and experimentation of the following Big Data tools for concurrent engineering: Exalead OnePart, Exalead CloudView, and Exalead Onecall [22]. To test the CE and PLM applications, we deployed on our private cloud computing platform several Virtual Machines (VMs), with the specifications presented in Table 1.

**Table 1: System's specifications**

| | |
|---|---|
| OS Name | Microsoft Windows Server 2012 R2 Standard |
| Version | 6.3.9600 Build 9600 |
| System Name | VM-WIN2012R2-EX |
| System Type | x64-based PC |
| Processor | Intel(R) Xeon(R) CPU E5-2620 0 @ 2.00GHz, 1995 Mhz, 4 Core(s), 4 Logical Processor(s) |
| BIOS Version/Date | VMware, Inc. VMW71.00V.0.B64.1607292324, 29.07.2016 |
| BIOS Mode | UEFI |
| System Directory | C:\Windows\system32 |
| Boot Device | \Device\HarddiskVolume2 |
| Locale | Romania |
| Hardware Abstraction Layer | Version = "6.3.9600.17196" |
| Time Zone | GTB Daylight Time |
| Installed Physical Memory (RAM) | 16,0 GB |
| Total Physical Memory | 16,0 GB |
| Available Physical Memory | 15,0 GB |
| Total Virtual Memory | 18,4 GB |
| Available Virtual Memory | 17,4 GB |
| Page File Space | 2,38 GB |

### 3.1 Exalead OnePart

Exalead OnePart is a set of applications that help order company assets, find master parts which reuse old information, this happens while the company is monitoring over time the execution of company police. It was installed on the VM and has a user friendly interface as seen in Fig. 2.

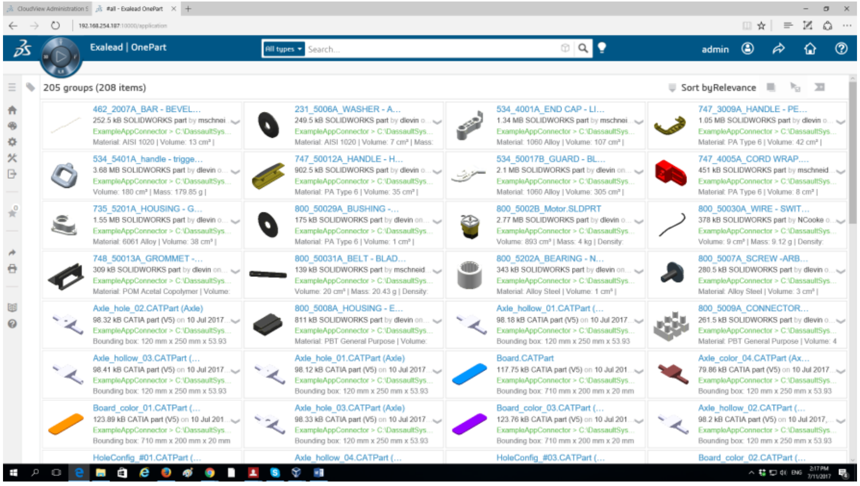

**Figure 2: Exalead OnePart dashboard**

Exalead OnePart main characteristics are: access and reutilize parts, drawings, specifications, test results and connected data in the entire enterprise.
During the experimentation, OnePart suggests many elements that match according to the author, material, etc. Then the number of elements that fit the research appears. The results of the research are shown under listed form in the panel on the right side and in the one on the left there are the facets. These can be used for refining the research and for filtering. OnePart can even found miswritten parts and detect the number of holes in the geometry of each searched part
After selecting the part from the list, on the left side there is the preview and on the right are shown:

- The components' attributes; extracted from a binary file;
- The OnePart attributes; calculated by OnePart;
- The containers' attributes; supplied by the source

Also, OnePart shows the connected documents with parts and we developed a page where the selected elements can be compared to the reference element on the first column. The attributes that differ from the reference element are highlighted with red. In the case of sets, it is possible to browse the product structure.
Furthermore, EXALEAD OnePart provides a full set of applications to organize company assets, find master parts for reuse, and assure engineers select the preferred part, while tracking over time the accomplishment of company policy. Even more, Sourcing and Procurement will influence these applications to optimize ordering by grouping orders or choosing the right price of technically feasible alternative solutions.
The key capabilities experimented included search for parts, sets, drawings, documents, patents, images in more than 200 formats, access to many sources with different data: files systems, SOLIDWORKS PDM Professional, ENOVIA SmartTeam, ENOVIA Designer Central, and many other PDMs, ERPs and data bases. Moreover, we performed searches for complete text with automated fill of the users' interrogations, advanced search with dynamically and disjunctive faceted search, including searches with 3D mechanically characteristic (locating parts based on holes, supports, channels and other characteristics), which discover part through 3D lookalike. We configured real-time analysis charts that enables better data understanding, automated arrangement of the identical files, labeling the parts and the documents by the users, for easy finding and workflow.

Finally, declarative, audited security mechanisms guarantee the users to see only the content to which they have permission

### 3.2 Exalead CloudView

Exalead CloudView is a search engine that collects unstructured and structured data from any kind of source and it makes it into a single structured information source, which is the basis of Exalead OnePart. Exalead CloudView uses the best web technologies to create enterprise information systems that exploit all your business data resulting in the most reactive, intelligent systems on the market. Modern search engines like Exalead CloudView provide database connectors that allow a user to search databases without learning database query syntax.
Furthermore, Exalead Cloudview features database connectors which give the possibility to the user to search a database without having to know database query syntax. Worth mentioning is that Exalead CloudView is based on semantic search and we developed the search mash-up using the following structure:

- CloudView semantic platform
- Natural language processing
- Semantic for content and classification
- Semantics for search presentation

The platform architecture is composed out of 4 services, as presented in Fig. 3:

- COLLECT: Gathers unstructured and structured data from any kind of sources
- PROCESS: The collected data is transformed into one single structured resource
- ACCESS: The enhanced data, the processor user and application queries are updated
- INTERACT: The interaction via a customizable Web interface

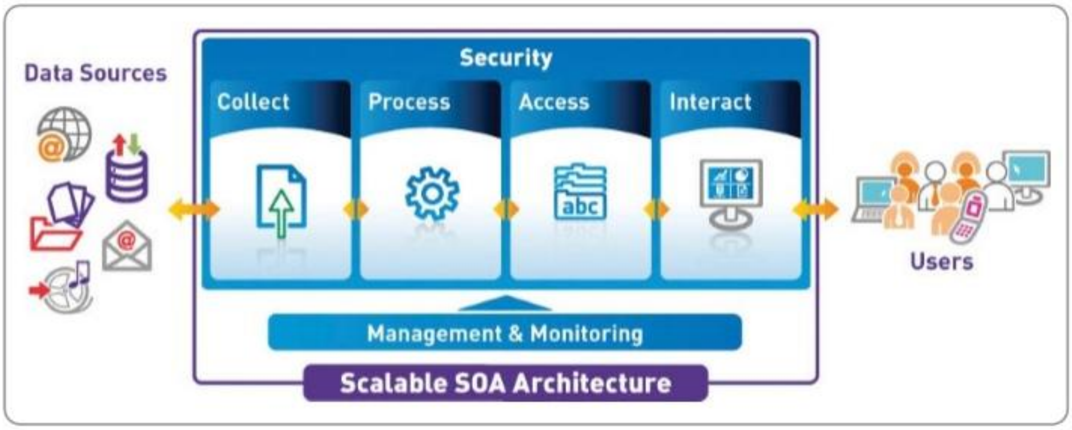


**Figure 3: Cloud interface**

### 3.3 Exalead OneCall

The Exalead OneCall solution, is capable of addressing the Big Data challenge for communication tasks in concurrent engineering. OneCall is a unique search engine that connects all data sources. The tool makes comprehensive use of data to provide a multi-channel vision that centralizes all the information about the customer experience, delivering a consistent 360° vision of the relationship between the customer and the company, an example being shown in Fig. 4.

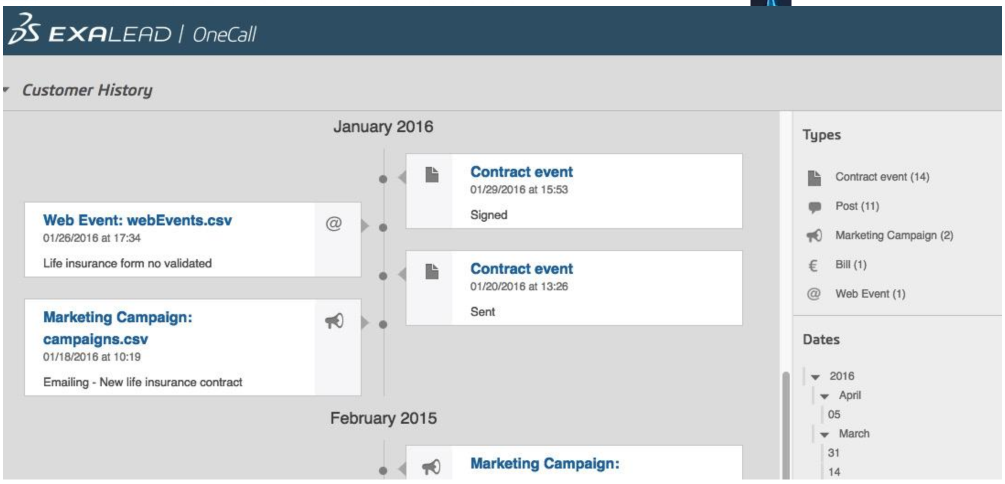


**Figure 4: History of multi-channel events**

OneCall requires at least 25 GB of available disk space, so we needed to increase the storage space of the VM. To maximize the I/O performances when indexing, it is recommended to use the SCIS, SAS, SAN over FC or SSD disks (unlike SATA disks), for storing files with data. For reasons of performance and reliability, the data directory cannot be on a network file system such as NFS, CIFS and so on. Also, we increased the memory to 8 GB RAM. OneCall comes with a SQLite server for the backend storing services, for client profiles. It is recommended, however, a data base already prepared, like MySQL or Oracle.

## 4 PLATFORM ARCHITECTURE

In the project E-STAR [23], the coordinator ICPE and partners INCAS and BEIA developed a concurrent engineering platform architecture, integrating the Exalead tools into the PLM collaborative platform as presented in Fig. 5. Basically, we use Exalead OnePart functionalities to search through various documents (emails, PDF documents, CAD designs, etc.) and we will use Exalead CloudView to collect data from external links (ROSA database, ESA, telemetry platforms), while managing communications with Exalead OneCall.

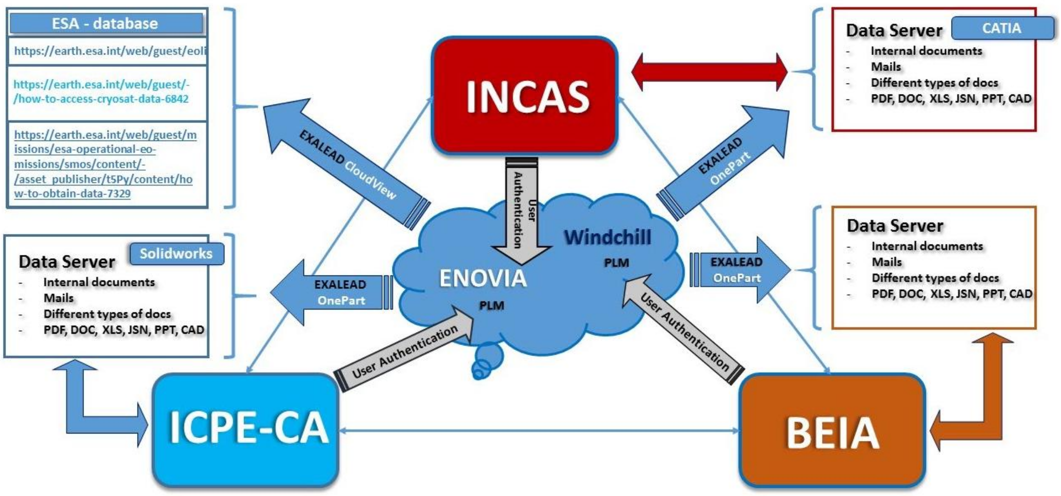


**Figure 5: E-STAR Platform Architecture**

The Exalead tools provide fast crowd-mapping functionality and allow easy integration through Java connectors into the PLM solutions. We present a comparative analysis of the PLM architectures and functionalities in Table 1.

**Table 2: PLM feature comparison**

| **Name**<br>**SWOT analysis** | **Teamcenter Siemens** | **Enovia 3DS** | **Windchill PTC** |
|---|---|---|---|
| Strong points | - designed for Industry 4.0 projects<br>- Digital Factory Planning and Optimization | - direct compatibility with CAD solutions (used by project partners)<br>- direct compatibility with Exalead solutions<br>- open API | - unlimited number of web users: viewers<br>- permanently monitoring of the database<br>- facilitates the release of managed products documentation with the mentioned solution |
| Weak points | - no maintenance<br>- no connectors<br>- does not offer many CAD solutions | - not fully extended towards manufacturing process management and product publishing | - there are no CAD connectors<br>- supplementary costs for updating the licenses |

Consequently, Teamcenter is suitable for smart manufacturing in Industry 4.0 projects, such as Product Lifecycle Management and Digital Factory Planning and Optimization. On the other side, Windchill PLM can manage the content of a product from conception to service, while IoT solutions from PTC allow safety connection of Smart Things, management and analysis of data and the creation of applications. However, Enovia solution from Dassault Systemes (3DS) was the solution

## 5 CONCLUSIONS

In this paper we presented a concurrent engineering platform for processing big data on cloud platforms from three partners in E-STAR project: ICPE-CA, INCAS and BEIA. The platform is based on the search EXALEAD CloudView search engine which will connect data from ESA, ROSA and other relevant sources. This paper presents related work and proposes a CE platform for the Romanian research community and industry. This system will integrate other PLM software from Dassault Systemes, such as Solidworks and CATIA.
Future work will focus on performance evaluation and comparison with similar PLM platforms that use concurrent engineering and focus on problems which the current platform will not be able to solve. These are related to the reuse of old parts models in the product lifecycle, access to heterogeneous satellite data, and strategies for item stage arranging. Also issues related to IoT data and their aggregation will be added into the proposed E-STAR platform.

## REFERENCES

1. S.N Dwivedi, A. K. Verma, J. E. Schneckenberger; 1991 "CAD/CAM Robotics and Factories of the Future '90"; Vol 1; Springer Verlag ; Berlin Heidelberg; pp 1-30
2. ESA; 2017; "What is concurrent engineering"
2. http://www.esa.int/Our_Activities/Space_Engineering_Technology/CDF/What_is_concurrent_engineering
3. C. Witharana et al.; 2013; "Evaluation of pansharpening algorithms in support of earth observation based rapid-mapping workflows"; Applied Geography; Volume 37; pp 63-87.

4. C. Huber et al.; 2016; "Improving the extraction of crisis information in the context of flood, landslide, and fire rapid mapping using SAR and optical remote sensing data"; 2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS); pp. 5781-5784.
5. G. Quattrone, M. Dittus, L. Capra; 2017; "Work Always in Progress: Analysing Maintenance Practices in Spatial Crowd-sourced Datasets"; 20th ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW 2017); pp. 1876-1889
6. NESTA; 2017; "Crowdmapping. A single map is worth a thousand words" http://www.nesta.org.uk/digital-social-innovation/crowdmapping
7. X. Lu, S. Menzel, K. Tang, X. Yao; 2017; "Cooperative Co-evolution based Design Optimisation: A Concurrent Engineering Perspective" IEEE Transactions on Evolutionary Computation; pp. 1-8
8. D. Penciuc et al.; 2016; "Product life cycle management approach for integration of engineering design and life cycle engineering"; Cambridge University Press; vol. 30; issue 4; pp. 379-389
9. A. Elgammal, M. Papazoglou, B. Krämer, C. Constantinescu; 2017; "Design for Customization: A New Paradigm for Product-Service System Development"; Procedia CIRP; vol 64; pp. 345-350
10. M. Matsas et al.; "An Integrated Collaborative Platform for managing Product-service Across their Life Cycle"; Procedia CIRP; 2017; vol. 59; pp. 220-226
11. C. E. Levandowski; 2014; "Platform Lifecycle Support using Set-Based Concurrent Engineering"; Ph. D. Thesis; Chalmers University of Technology; Gothenburg
12. W. A. Dos Santos, A. Hardwick A, B.B. Leonor, S. Stephany; 2010; "Enabling Collaborative Conceptual Design for Space Systems Projects"; IDMME – Virtual Concept; pp. 1-4
13. M. Innerebner, A. Costa, E. Chuprikova, R. Monsorno, B. Ventura; 2017; "Organizing earth observation data inside a spatial data infrastructure"; Earth Science Informatics; vol. 10; issue 1; pp. 55-68
14. A. D'Anca, L. Conte, P. Nassisi, C. Palazzo, R. Lecci, S. Cretì, M. Mancini, A. Nuzzo, M. Mirto, G. Mannarini, G. Coppini; 2017; "A multi-service data management platform for scientific oceanographic products"; Natural Hazards and Earth System Sciences; vol. 17; no. 2; pp. 171-184
15. J. Lentes, N. Zimmermann; 2017; "amePLM: a platform providing information provision in engineering"; International Journal of Production Research; vol. 55; issue 13; pp. 3832-3841
16. C. Kühnert, I. M. Arango; 2016; "A Generic Data Fusion and Analysis Platform for Cyber-Physical Systems"; Machine Learning for Cyber Physical Systems; pp. 45-54
17. P. Bonte et al.; 2017; "The MASSIF platform: a modular and semantic platform for the development of flexible IoT services"; Knowledge and Information Systems; vol. 51; issue 1; pp. 89-126
18. H. Johannesson, J. Landahl, C. Levandowski, D. Raudberget; 2017; "Development of product platforms: Theory and methodology"; Concurrent Engineering; pp. 1063293X17709866
19. Q. Zhang et al.; 2017; "A method for product platform planning based on pruning analysis and attribute matching"; Journal of Intelligent Manufacturing; pp. 1-15
20. F. Ferreira et al.; 2017; "Product lifecycle management in knowledge intensive collaborative environments: An application to automotive industry"; International Journal of Information Management; vol. 37; issue 1; part A; pp. 1474-1487
21. M. G. Violante et al.; 2017; "An integrated approach to support the Requirements Management (RM) tool customization for a collaborative scenario"; International Journal on Interactive Design and Manufacturing; vol. 11; issue 2; pp. 191-204
22. A. Ochian, G. Suciu, O. Fratu, V. Suciu; 2014; "Big data search for environmental telemetry", IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom); pp. 182-184
23. E-STAR; 2017; "STAR for everyone in ESA frame program"; http://www.beiaro.eu/e-star