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**Sustainable management  
of cultural heritage**

## **From semantic reverse-engineering to virtual reality tool box for digital heritage objects**

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**Keywords :** Digital heritage, reverse-engineering, history

**Abstract :** The national project ReSeed aims to offer an alternative allowing both semantic (2D sources) and physical (3D) modeling for our scientific, technical and industrial heritage; while guaranteeing authenticity and integrity of knowledge. The digital integration of heterogeneous knowledge is ambitious; the project team then demonstrated that designing a unique tool is not possible. ReSeed's proposal is one digital container of self-structured knowledge created simultaneously with the digital double of the heritage object studied. Considered as an "Augmented Historical Reality" defined by a virtual tool instead of the usual "paper" procedures, ReSeed nonetheless remains a tool for asset decision support.

The recent democratization of the digital world has allowed new possibilities for capitalizing, analyzing and enhancing our heritage, tangible or intangible, in order to face the lack of the Humanity knowledge. Today, digital techniques are invading the field of cultural heritage for studies, conservation and valorisation, and they are constantly developing. In a few years, fields of use of digital techniques have become numerous and diversified: volume scanning (artefacts, monuments, landscapes), virtual restitution, databases, multiple requests and artificial intelligence aiming to coordinate representation: 2D (map), 3D (volume), 3D + t (dynamic) with information (archive, printed text, sound, image, movies, ...). The main rules applied today are practical rules of feasibility. They are evaluated essentially from the point of view of their technical efficiency and specifications are mostly functional. However, if data acquired are intelligible and interoperable, they are rarely presented to the public or to experts. This low use can be explained because of the big amount of data to be handled, which greatly exceeds the capacities of current computers and the skills of those carrying this knowledge. Indeed, the use of digital tools for different types of cultural heritage projects and programs involves multiple professional and scientific communities: architects, heritage' curators, historians, archaeologists, geographers, computer scientists, engineers and etc. Communities with diverse interests appear to be involved in the projects: owner of the heritage in question and its projects, consultants and implementing companies, academics and research projects, institutions and conservation rules, etc.

Beyond simply using 3D tools for graphical visualizations, new approaches and tools allowing the semantic linking of objects through databases must fit as new standards. The ReSeed project aims to offer an alternative allowing both semantic (2D sources) and physical (3D) modeling, without going through a filtering process, synonymous of loss of information and knowledge.

Nowadays, reverse engineering is widely used in manufacturing industries in order to record geometrical data from the products. However, digitizing physical data does not provide any knowledge about the products. Capitalizing this know-how and knowledge is critical to advance tomorrow's products.

The aim of those researches is to develop methods and technologies for the heritage and museological field in the new field of the so called Digital Humanities. These innovative researches are interdisciplinary: both Human Sciences and Engineering Sciences.

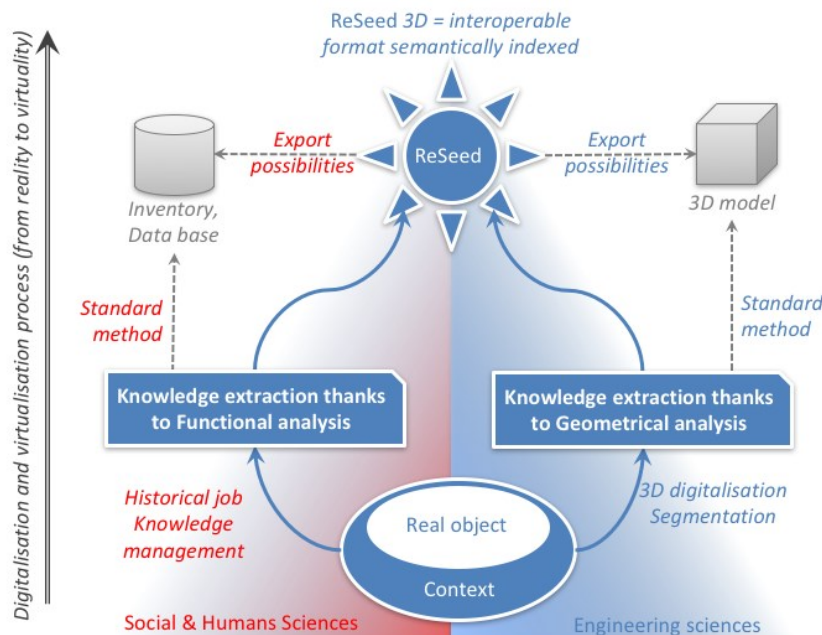
Two approaches have been identified:

- Classical knowledge management based on semantic sources
- Computer assisted design and scanning tools

The ReSeed project aims for the development of a new technology: a tool and an interoperable format in order to digitize both semantic and physical data about objects. Before applying the process on industrial production cases, we decided to experiment our approach on existing assets, related to identified knowledge and whose intrinsic value is firmly established: ReSeed will be tested on the industrial cultural heritage.

In the end, in case of success of the ANR ReSeed program, a cycle between the past and the present knowledge will be established. Actually, protecting, analysing and understanding these objects from the "past heritage" may turn them into "present capital". The transposition of past knowledge into contemporary form, readable and intelligible in our present socio-technical system, may become a source of inspiration to anticipate our future.

However, new technical and epistemological issues arise: what (s) new methodology (s)? What scope for digital tools? Which interoperable data formats? What new professions? How to validate the results?



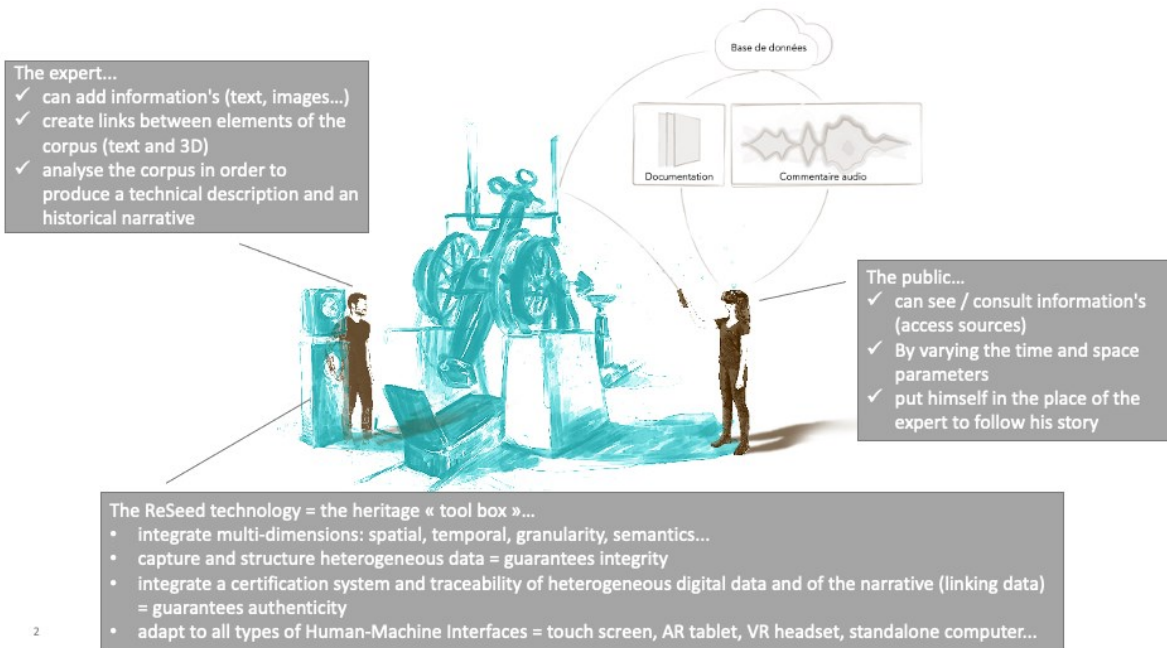
ReSeed technology covers the entire heritage process:

1. From the capture of traces of the object: here it is a question of capturing and storing 3D type elements, documentations, analyzes, archives... Two processes are put in parallel: the ability to digitize the object and the possibility of capitalizing the associated knowledge to allow its analysis and understanding (as shown by the previous figure)
2. By way of digital modeling of the physical object for processing and exploitation for purposes of expertise and chaining of knowledge. The point here is to link the elements together, by setting up, for example, a "knowledge container": associating documentation and archives with the geometry and the operating of the object.
3. Until it is valorised and stored for next human generations by viewing and using the data for transmission and mediation purposes. It is about exploiting the container of knowledge at different levels: from mediation for the general public, to the analysis tool for research in history, including the curious amateur; and in different situations: on a heritage site, in a museum, at a distance, etc.

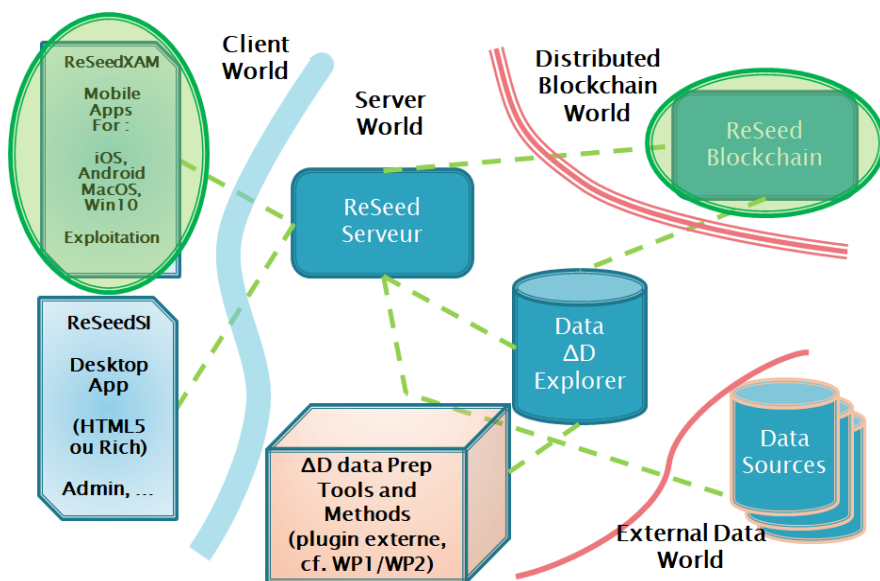
The major scientific barrier lies in the interoperability of these 3 phases, which are often compartmentalized.

Scientifically speaking, ReSeed's proposal is a digital container of knowledge which is self-structured all along the creation of the digital twin of the heritage object studied. The purpose of the ReSeed technological tool is to be an asset decision support thanks to the digital integration of heterogeneous knowledge. It is a virtual tool that replaces a "paper" catalog (with a research tool and not an inventory base): it can be defined as "Historical Augmented Reality".

Functionalities provided by the system are detailed in the figure below:



From an operational point of view, ReSeed tool is a virtual world where Lego bricks can be organized (manipulation of 3D cloud of points, addition of semantics, etc.). It allows a multiple business view. Several variations are considered: "ReSeed App" with public version, pro version and like an "heritage tool box" : "ReSeed Eye", "ReSeed Snap"... Moreover, in order to guarantee the authenticity of digital data, we are adapting the concept of blockchain to our project. It allows to trace the use of a source and its modifications. The digital tool itself becomes the certificate of authenticity: it is "ReSeed Blockchain".



Several scientific prototypes have been developed both for capturing 3D historical traces or historical archives and also the “ReSeed App”. In addition, a first prototype software based on augmented reality for smartphone and also available through virtual reality for standalone computer has been developed for mediation purposes. The prototype is applied to a use case coming from a national scientific collection (French meridian observatories) managed by the Ministry of Culture. ReSeed technology supports more than 20 GB of cloud of points and data archives which are streamed in real time on the internet. To try the prototype, go to the project website: <https://reseed.ls2n.fr/fr/the-project/prototype-reseed/>

### **More information**

[www.reseed.fr](http://www.reseed.fr)

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