A Proposed Measurement Role in the Rational Unified Process and its Implementation with ISO 19761: COSMIC-FFP

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Abstract *: ISO 19761 (COSMIC-FFP) defines the standards for measuring the functional size of software and represents the second generation of functional size measurement methods. While there is a large offering of software tools to support the development process, including integrated environments such as RUP, measurement of functional size had until recently been almost exclusively a manual process. This paper presents an approach and a tool for the automation of functional size measurement with RUP. The design of this tool is based on the direct mapping between COSMIC-FFP and UML concepts and notation, a foundation from which the required Rational Rose artifacts can be extracted to proceed to the software project measurement operation. This makes it possible not only to derive the accurate functional size once all specifications have been completed, but also to derive early size indicators when only high-level information is available.*

Keywords *: ISO 19761, COSMIC-FFP, Rational Unified Process, Rational Rose, Software engineering, Size units, Function points*

1 Introduction

Software engineering is a discipline devoted to the development of software within a concurrent set of multiple, and sometimes conflicting, constraints in terms of cost, quality and deadlines. Many of its underlying tasks, such as requirements engineering, design, construction, testing, etc., need to be conducted with a great deal of vigilance. To plan, monitor and control the progress of these tasks, measurements, including software project size, are needed. Size can be assessed either by measures of length (e.g. lines of source code in a module, pages in a requirements specification document) or functionalities (e.g. function points in a specification). Functional size measures can be derived directly from the specifications and be obtained fairly early in the development life cycle, which makes them extremely useful for planning purposes and during the whole project life cycle. The first generation of functional size measures was developed in the late 1970s, and it is only in the last few years that a second generation of such measures has emerged, and been rapidly adopted as an international standard: ISO/IEC 19761: 2003 COSMIC-FFP: A functional size measurement method.

Measurement of the functional size of software has up to now been almost entirely a manual process and, as such, is both time-consuming and prone to human error. While there were a few attempts in the early 1990s at automation of the initial Function Point Analysis method, such efforts were considered basically as failures. This was mainly because of the intricacies of the initial design of the method, which provided no clear, underlying model of functionality from which unambiguous rules could be formulated for automation specifications. In addition, this design was centered around MIS concepts, and as such could not easily migrate to other types of software, such as real-time software and software for new information needs, such as Web-based and Internet applications. The researchers who tackled these constraints in the early 2000s introduced a second-generation design of the functional size measurement method, which included a much more explicit model of the functionality of software while remaining fairly simple, even though it could be applied to as many software layers as required for measurement purposes.

2 Technology issues

The technology issues are now discussed in terms of the required mapping between the COSMIC-FFP, UML, RUP and Rational Rose environments.

2.1 ISO 19761: COSMIC-FFP Method

COSMIC-FFP (ISO 19761) is a functional size measurement method which generalizes the measurement process to address management information systems issues, as well as real-time and hybrid software projects. It conforms to the ISO meta-standard on functional size measurement (ISO 14143-1) and uses only the FURs (Functional User Requirements) of the software project as inputs to the measurement process [1].

The COSMIC-FFP process is based on two phases, as shown in Figure 1:

- The Mapping phase, in which a COSMIC-FFP model of the FURs suitable for the measurement phase is generated.
- The Measurement phase, where the measurement rules are applied to this FUR model to derive size on the basis of the ISO standard for COSMIC-FFP.

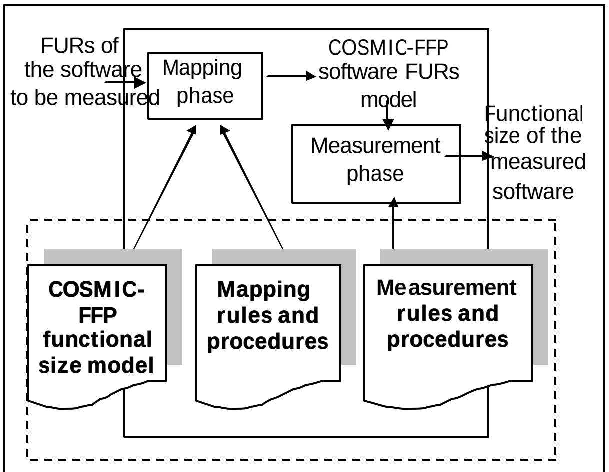


Figure 1 : COSMIC-FFP process Model

COSMIC-FFP takes into account that the software FURs can be decomposed into a set of functional processes, and that each of these functional processes is a unique set of sub-processes performing either a data movement or a data manipulation (Figure 2).

The COSMIC-FFP software model distinguishes four types of data movement: entry, exit, read and write, as identified in the context model (Figure 3). All data movements move data contained in exactly one data group. Entries move data from the user across the boundary to the inside of the functional process; exits move data from inside the functional process across the boundary to the user; reads and writes move data from and to persistent storage.

In COSMIC-FFP, each data movement is assigned a single unit of measure of 1, which is, by convention, equal to 1 Cfsu (Cosmic Functional Size Unit). The total size of the software being measured corresponds, therefore, to the addition of all data movements recognized by the COSMIC-FFP method. See [1] for the detailed measurement rules.

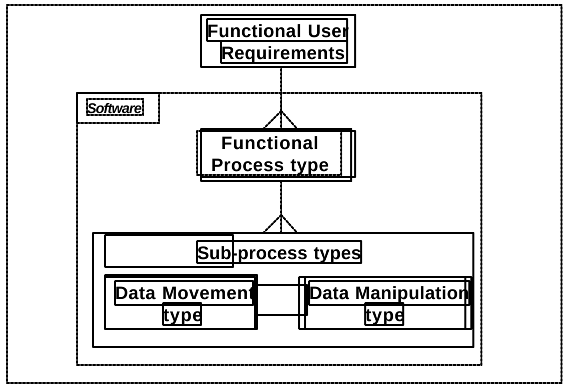


Figure 2 : A generic software model for measuring functional size [1]

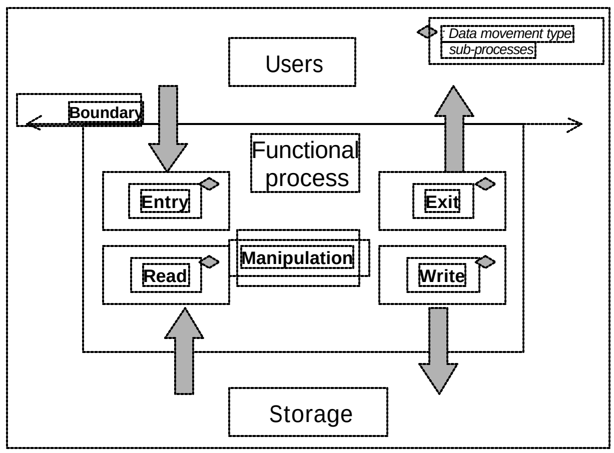


Figure 3 : COSMIC-FFP Movement types [1]

2.2 Mapping of COSMIC-FFP concepts to UML

As with all functional size measurement methods, the design and rules for this method are independent of technologies and development approaches. When measuring a software document using a specific approach and notation, such as UML, it is necessary to establish how the generic measurement concepts are implemented into any notation. The mapping of COSMIC-FFP concepts has been documented in [6] and [9]. An overview of such mapping is presented in Table 1, with the COSMIC-FFP concept in the lefthand column, and the corresponding UML equivalent in the righthand column.

COSMIC-FFP Concept	UML equivalent
Software boundary	Use case diagram
Software Layer	No UML equivalent
COSMIC-FFP user	UML actor
Functional process	Use case
Data movement	Operation (message)
Triggering event	No UML equivalent
Data group	UML class
Data attribute	Class property

Table 1 : Mapping of COSMIC-FFP and UML concepts

It can be observed that, while five COSMIC-FFP concepts (boundary, user, functional process, data groups and data attributes) have direct UML equivalents (use-case diagram, actor, use case, operation, class and class property), two COSMIC-FFP concepts (layer and triggering event) do not have direct UML equivalents.

Because the RUP process is mainly based on UML, it is expected that the major concepts in use in this RUP method will have concepts directly corresponding to them in UML notation.

2.3 RUP and Rational Rose environments: Measurement challenges

The 2003 version of the RUP environment is impressively rich in terms of activities and roles for the development process ([7] and [8]). In the Rational environment, the Clear Case and Clear Quest software tools provide a large number of automated measurements, but these are mostly of a technical nature, and none explicitly addresses functional size measurement or related concepts.

This version does not, therefore, provide support for either the manual (or automated) measurement of software functional size when all the details are known at the end of the specifications stage, nor for the approximation of functional size when only some of the information is available at the project's inception.

This means that, for functional size measurement in the RUP and Rational Rose environments, it is necessary to establish a full mapping of COSMIC-FFP-related concepts to RUP on the one hand, and, on the other, to implement this mapping using the Rational tool set environment for automated measurement.

2.4 Functional size: Measurement and estimation issues

The COSMIC-FFP method uses the FURs as its only inputs to the measurement process and, as illustrated in Table 1, in the RUP and UML environments these FURs are instantiated into use cases and their corresponding artifacts when developed within integrated environments. There are therefore two types of issues to tackle: size measurement issues and size estimation issues, each type with its own challenges.

The measurement issues to be addressed are:

- Instantiate into the RUP process the mappings of COSMIC-FFP – UML concepts already identified in the literature (that is: boundary, users, functional processes, data movements and data attributes)
- Add to RUP the two COSMIC-FFP concepts without direct mapping (that is: layer and triggering event).
- Introduce and integrate into the RUP process a new 'measurement activity' with corresponding role and RUP tool-tailoring
- Carry out, in an automated fashion, the measurement of functional size based on the mappings.

There are, similarly, a few estimation issues:

- Identify the early functional size indicators at the project's inception
- Identify the next set of early functional size indicators at the model design stage
- Analyze data collected on a sufficiently large number of case studies and derive a meaningful set of ratios across the indicators and final size measurement results

Of course, it would not be realistic to expect, in initial exploratory research on these issues such as that reported here, to solve them all at once, nor to do so in a definitive manner.

3 Technology issues to be addressed

There are, therefore, two types of technology issues to be tackled: those related to RUP methodology and those related to the Rational Rose tools environment.

3.1 RUP methodology

In RUP, a new activity needs to be created, the purpose of which will be to fulfill all the necessary measurement-related tasks. This activity is to be integrated into the RUP process and will act as an interface between the RUP environment and the designed tool: The project manager who is responsible for this activity will use the RUP tool to fulfill all the measurement needs of the other RUP process workers.

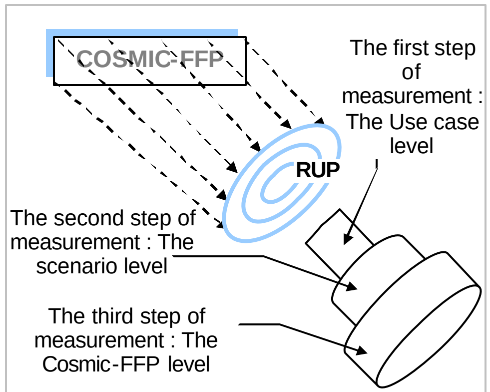


Figure 4 : COSMIC / RUP mapping

3.2 Rational Rose tool environment

The automation tool will provide a software size at three stages of the development life cycle, as shown in Figure 4. It is integrated into Rational Rose environment as a script executed from the tools menu.

3.3 Project objectives

The first specific objective of this project was to define the new RUP measurement activity based on the ISO 19761 standard of the COSMIC-FFP method and to integrate it into the RUP process. The second objective was to design a software tool to provide software size (either an exact measurement or an early indicator) at the major steps of the development process of the project life cycle.

4 The new RUP measurement activity

The new RUP measurement activity introduced in this research project is aimed at organizing the measurement process. Its divides the RUP process disciplines into two groups (see Figure 5): The first group is concerned with all the tasks that generate the information for the measurement process, which is in turn used by the tool, such as in business modeling, requirements analysis, functional analysis and design. The second group is concerned with the tasks that use the size calculated by the tool to estimate time, effort, etc. (such as in project management, configuration management and change management, implementation, tests and deployment). The specific mapping instantiated from COSMIC-FFP/ UML into RUP is presented in Table 2, in particular for the software layers, the data movements and the triggering events concepts

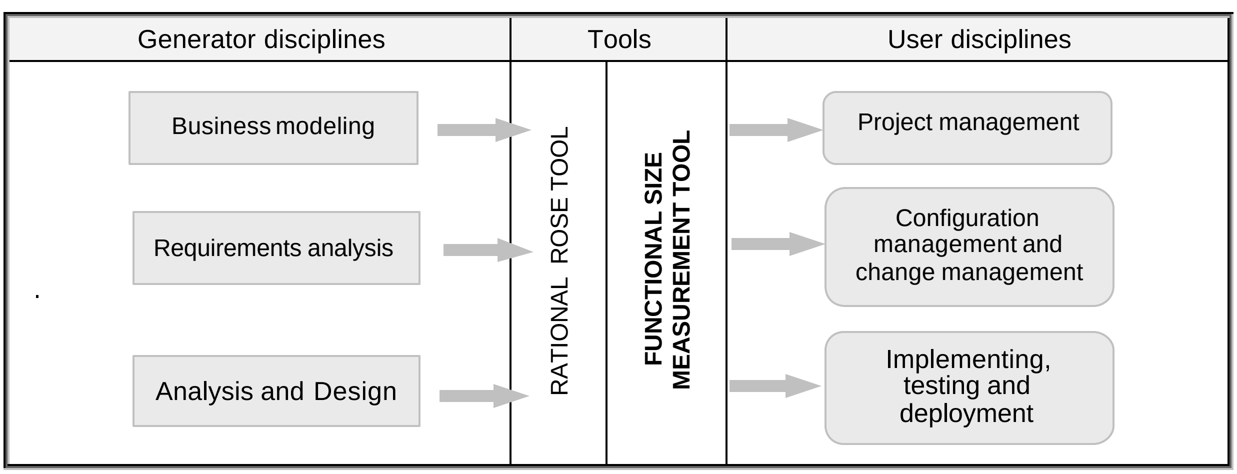


Figure 5 : Measurement and related RUP disciplines and processes

COSMIC-FFP Concept	UML equivalent	Comments
Software boundary	Use case diagram	
Software Layer	No UML equivalent	Has to be identified manually
COSMIC-FFP user	UML actor	
Functional process	Use case	
Data movement	Operation (message)	To distinguish the type of a data movement (Entry, Exit, Read and Write), the actor by whom it has been used and the persistence properties of classes involved in the UML message
Triggering event	No UML equivalent	A new UML stereotype is created to distinguish a trigger event from a simple message in use-case diagrams.
Data group	UML class	
Data attribute	Class property	

Table 2 : Mapping Solutions in RUP

5 Solution architecture

The architecture of the solution is presented in Figure 6. The lefthand side presents the elements required to define the procedures and rules to be used for the automation of both the estimation and measurement of the functional size. The righthand side presents the environments from which the inputs for measurement will be obtained: for instance, the inputs to the COSMIC measurement process will be extracted from the Rational Rose tool, using the Rational Extensibility Interface (REI).

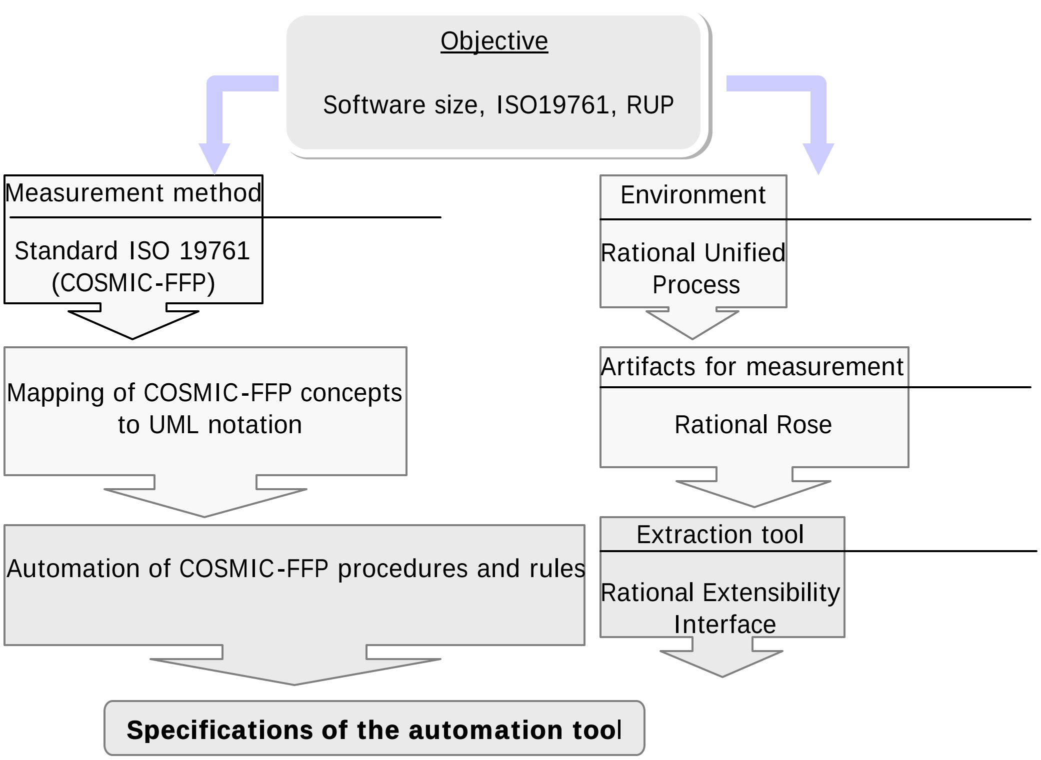


Figure 6 : Architecture of the solution

The artifacts are directly extracted from the Rational Rose tool environment, and this can be done using different types of artifacts, each corresponding to a different level of detail in the description of the requirements. This is illustrated in Table 3, along with the three levels of measurement that have been recognized at this time. Each level, of course, has its own level of granularity and its own unit of measurement. Below is a description of the three levels of measurement:

- <u>At the business modeling and requirements analysis level:</u> the use-case diagrams are used as artifacts from which the functional size is calculated. The size unit at this level is referred to as a ***U**se case* **f**unctional **s**ize **u**nit **- Ufsu**.
- <u>At the analysis level:</u> the scenario diagrams are used as artifacts from which the functional size is calculated. The size unit at this level is referred to as a ***S**cenario* **f**unctional **s**ize **u**nit. – **Sfsu**
- <u>At the analysis (and sometimes design) level:</u> the detailed scenario diagrams are used as artifacts from which the functional size is calculated, the size unit at this level corresponds exactly to the ISO 19761 ***C**OSMIC* **f**unctional **s**ize **u**nit – **Cfsu**.

Development phase	RUP artifacts used	Unit convention
• Business modeling • Requirements analysis	• Use-case diagrams	Ufsu
• Analysis / Design	• Scenarios	Sfsu
• Analysis / Design	• Detailed scenarios	Cfsu

Table 3 : Distinct size units based on the development phase

The first two levels provide only early indicators of functional size measurement. These can be measured precisely at the third level using the international measurement conventions for COSMIC-FFP / ISO 19761. While these two high levels do not provide the exact size, they provide information on which to build a foundation for projections of project size, which itself can be measured with accuracy only when all the requirements are fully described in the detailed scenarios.

6 The tool overview

This section presents both a summary of the tool characteristics and their main outputs.

6.1 Technology characteristics

The COSMIC-RUP automated tool was developed using the following technology characteristics and components:

- An item embedded within the Rational Rose environment as an option in the tools menu labeled “COSMIC-FFP Functional Size”.
- Scripts using the REI (Rose Extensibility Interface) language.
- Information extracted from the models (mainly the use-case view and the logical view) of the projects designed in a Rational Rose environment and selected to be measured.
- Artifacts required to complete the measurement process; use-case diagrams and scenario diagrams.

- A new stereotype (with the corresponding icon) designed in the Rational Rose environment to identify a message as a triggering event.
- A Microsoft Access database designed to contain a history of project measurements for all three levels of measurement results (Ufsu, Sfsu and Cfsu)
- A means to distinguish the type of data movement, the actor by whom it is used and the persistence properties of Rational Rose model.
- Measurement results which are displayed on screens and can be sent to Microsoft Excel where they can be arranged, saved, printed, etc.

6.2 Main output screens

The three main screens of this tool are presented in Figure 7 to 9 (Refer to [2] for more information):

- The principal measurement outputs, by unit level (use cases, scenarios and COSMIC-FFP size units)
- Measurement output by functional process
- Measurement output by data movement type.

To test this RUP COSMIC-FFP measurement-related tool, as well as for illustration purposes, the measurement case study of the '“Rice Cooker' was used, specifically, the January 26, 2003 version [3].

6.3 Current limitations

The ultimate goal of this project is full measurement automation, but, of course, much more time will be required to fully achieve this, and the initial project objective was limited to demonstrating the feasibility of the approach selected.

The current tool developed in the context of this project has, therefore, a number of limitations, such as:

- The tag for identifying a triggering element in RUP must be added manually
- The project scope must be identified manually, and within a single layer
- The measured project has to be designed within the Rational Rose environment where the use-case and scenario diagrams must be completely defined (if a collaboration diagram is used, this has to be translated into a scenario diagram prior to the measurement process)
- No large-scale testing has yet been carried out, either independently or with a larger number of case studies

7 Summary and observations

Automated measurement, in comparison to manual measurement, is expected to provide quicker results, greater precision and at a lower cost.

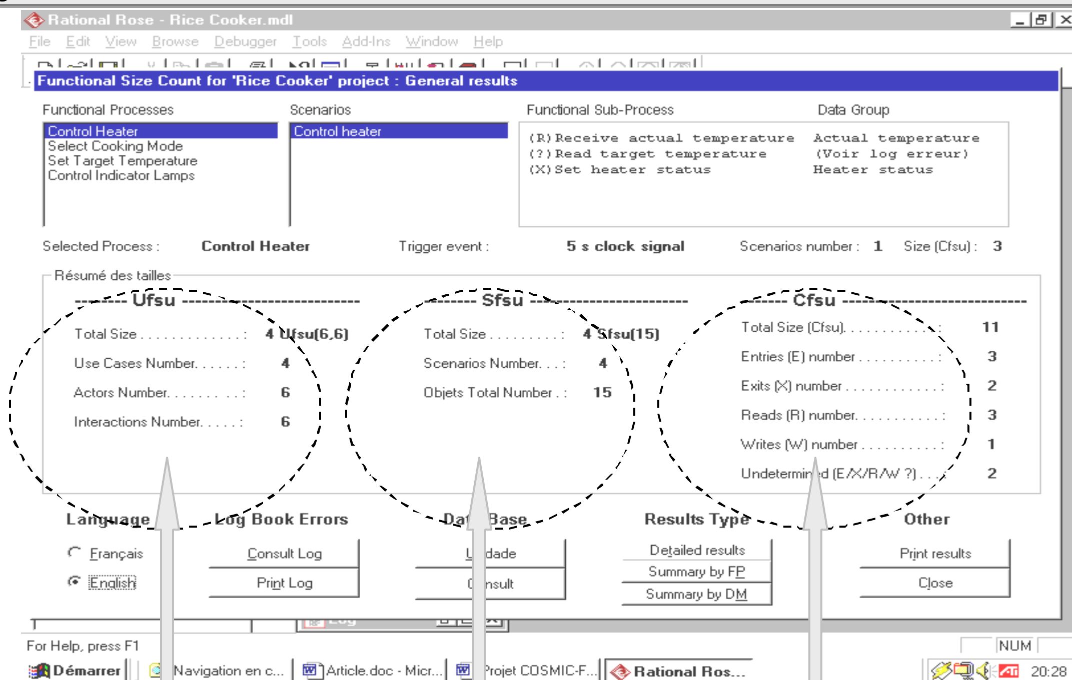
An implementation summary and expected next steps are presented in Figure 10. The inputs are the Rational Rose artifacts of the project to be measured (use cases and the interactions between them, actors and interactions with use cases, scenarios and participating objects, operations). On the righthand side, we have the COSMIC-FFP procedures and rules to be applied to these artifacts.

The measurement results of many software projects, and the necessary related information should be stored in a measurement repository which will be used to analyze the relationships between the three levels of measurement. It is expected that such ratios might vary depending on the types of software developed (management information systems, real-time and embedded software, etc.).

The extrapolation study will provide formulas between the phases of the project life cycle and by project type, with the result that the application of these formulas to the measured project at any stage of development will result in good estimation of other stages.

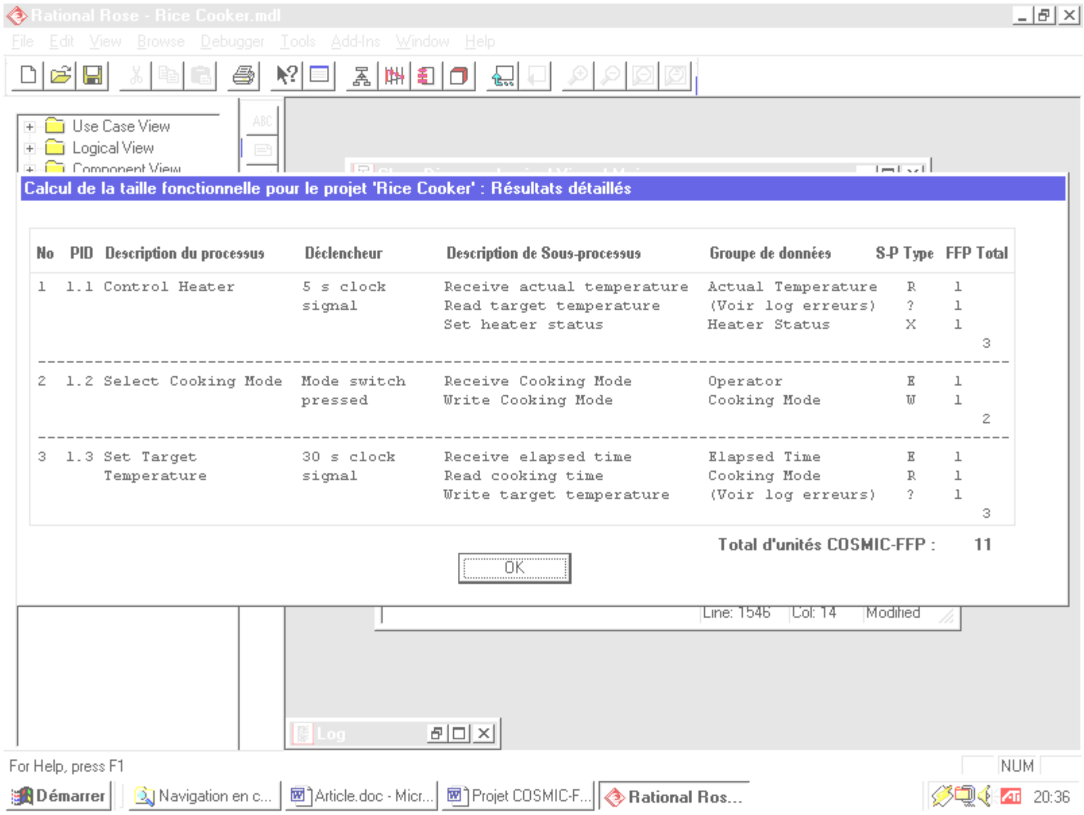
The new activity and the tool designed for this project will be very helpful to project managers in measuring functional size once the specifications are complete, or much earlier on in estimating this size when only a higher level of information is available.

Figure 7: Main screen results



The first step of the measurement process is localized at use-case level.	The second step of the measurement process is localized at scenario level.	The third step of the measurement process is localized at operational or Cosmic-FFP data movement level.

Figure 8: Results by Functional process

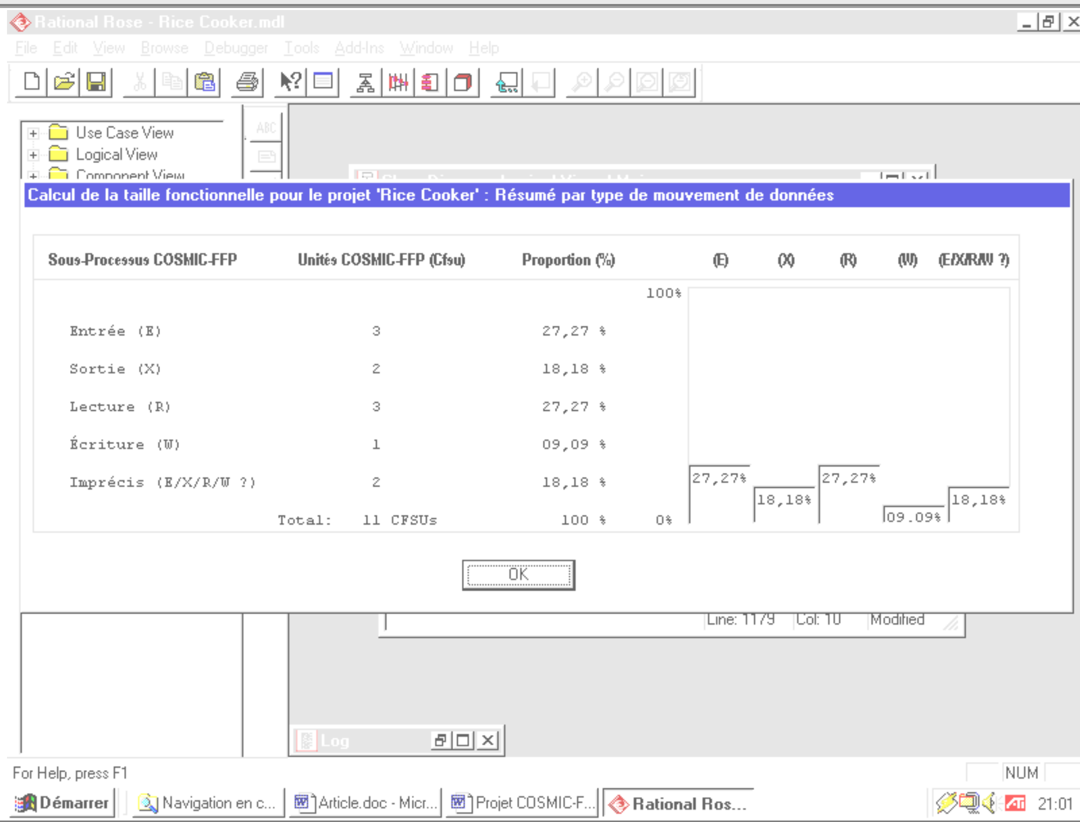


Calcul de la taille fonctionnelle pour le projet 'Rice Cooker' : Résultats détaillés

No	PID	Description du processus	Déclencheur	Description de Sous-processus	Groupe de données	S-P Type	FFP Total
1	1.1	Control Heater	5 s clock signal	Receive actual temperature	Actual Temperature	R	1
				Read target temperature	(Voir log erreurs)	?	1
				Set heater status	Heater Status	X	1
							3
2	1.2	Select Cooking Mode	Mode switch pressed	Receive Cooking Mode	Operator	E	1
				Write Cooking Mode	Cooking Mode	W	1
							2
3	1.3	Set Target Temperature	30 s clock signal	Receive elapsed time	Elapsed Time	E	1
				Read cooking time	Cooking Mode	R	1
				Write target temperature	(Voir log erreurs)	?	1
							3

Total d'unités COSMIC-FFP : 11

Figure 9: Results by data movement



Calcul de la taille fonctionnelle pour le projet 'Rice Cooker' : Résumé par type de mouvement de données

Sous-Processus COSMIC-FFP	Unités COSMIC-FFP (Cfsu)	Proportion (%)
Entrée (E)	3	27,27 %
Sortie (X)	2	18,18 %
Lecture (R)	3	27,27 %
Écriture (W)	1	09,09 %
Imprécis (E/X/R/W ?)	2	18,18 %
Total:	11 CFSUs	100 %

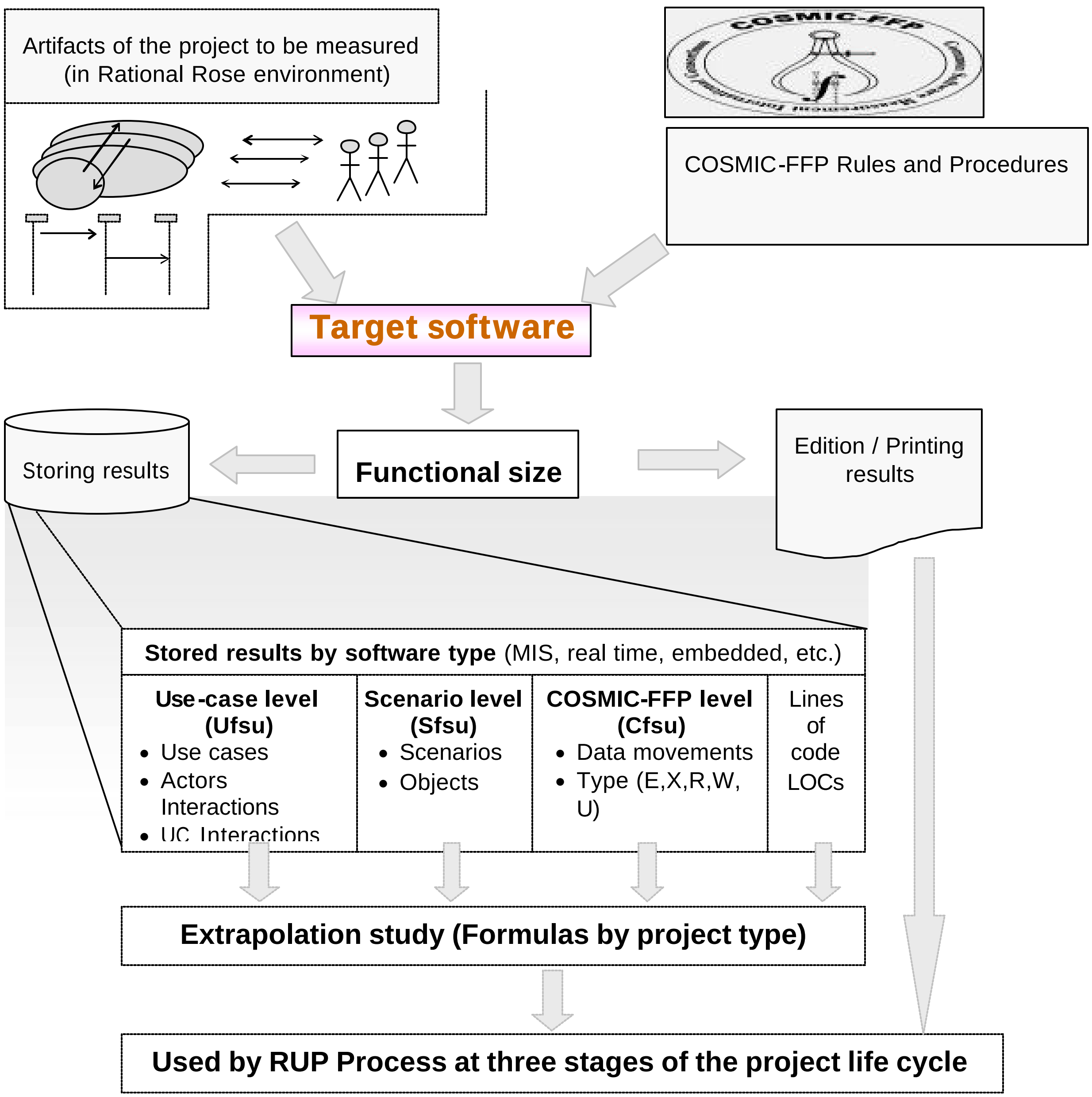


Figure 10 : Tool implementation

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