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# ***COSMIC Examples - What could they mean as an IT project?***

***Reiner Dumke, Anja Fiegler, Cornelius Wille***

*University of Magdeburg, Microsoft Germany,  
and Technical University of Applied Science Bingen, Germany*

## **Introduction**

The following paper uses the software sizing of the COSMIC examples (see <https://cosmic-sizing.org/publication-cat/case-studies/> ) in order to show some “fictive” estimation of typical project control data and metrics. We use the size measurement of COSMIC Function Points as **CFP** described in the different examples.

Furthermore, the estimations of the essential project data are based of our **SoftwareExpert App** (available in the Google Play Store). The estimation could be select from a list of authors for a special kind of project metrics or you can use all shown metrics building the average values. In our paper we have chosen the average metrics values (the project costs excluded).

## **COSMIC Examples – Their Sizes and their Dashboard Metrics**

In following we describe the COSMIC examples from the COSMIC community websites and our handbook of software estimation. The first examples can be summarized as real-time application software systems (see also [1], [2], [9] and [11]).

### **The Rice Cooker Example:**

In the *Rice Cooker* software system example are identified four main functional processes (see [1] and [4]): the start cooking with **3 CFP**, the Update target temperature with **5 CFP**, the check cooker temperature with **4 CFP** and the stop cooking with **3 CFP**. This small example leads to a total software size of **15 CFP**.

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**SHOW THE SOFTWARE PROJECT DASHBOARD**

Software Project Title: Rice Cooker Example

**PROJECT SIZES**

Product Size: 15 [CFP] 612 [LOC]  
 Team Size: 1 [Members]  
 Documentation Size: 283 [Pages]

**PROJECT EFFORT**

Development Effort: 0.42 [PM]  
 Testing Effort: 0.24 [PM]  
 Documentation Effort: 0.16 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 1.83 [Months]  
 Productivity: 4.98 [CFP/PM] 203.18 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 28  
 Risks Factor (in percent): 20.33  
 Estimated Number of Errors: 2

Go Estimate    Goto Derived Project Metrics    Go Main Menu for new Dashboard contents

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Software Project Title: Rice Cooker Example

**PRODUCT SIZE**

Product Size: 15 [CFP] 612 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 99.8 [%]  
 (chosen vs. complete)

Percentage of chosen Test Cases: 82.52 [%]  
 (chosen vs. all test aspects)

Errors per Team Member: 2

Percentage of Test Effort vs. Development Effort: 57.14 [%]

Percentage of Documentation Effort vs. Dev. Effort: 38.1 [%]

Costs per COSMIC Function Point: 0.0 [Euros]

Costs per Project Month: 0.0 [Euros]

Estimated Maintenance Effort: 0.84 [PM]  
 (based on the Dev. Effort):

Total Formal Verification Effort: 1.7 [PM]  
 (by Klein et al.)

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**The Valve Control System Example:**

The functional process involve the control of time during the operating cycle of the control valve and leads to a total size of **12 CFP** [5].

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Software Project Title: Valve Control System

**PROJECT SIZES**

Product Size: 12 [CFP] 489 [LOC]  
 Team Size: 1 [Members]  
 Documentation Size: 225 [Pages]

**PROJECT EFFORT**

Development Effort: 0.33 [PM]  
 Testing Effort: 0.19 [PM]  
 Documentation Effort: 0.13 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 1.7 [Months]  
 Productivity: 4.71 [CFP/PM] 192.17 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 22  
 Risks Factor (in percent): 20.33  
 Estimated Number of Errors: 1

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**SHOW DERIVED PROJECT METRICS**

Software Project Title: Valve Control System

**PRODUCT SIZE**

Product Size: 12 [CFP] 489 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 99.18 [%]  
 (chosen vs. complete)

Percentage of chosen Test Cases: 81.05 [%]  
 (chosen vs. all test aspects)

Errors per Team Member: 1

Percentage of Test Effort vs. Development Effort: 57.58 [%]

Percentage of Documentation Effort vs. Dev. Effort: 39.39 [%]

Costs per COSMIC Function Point: 0.0 [Euros]

Costs per Project Month: 0.0 [Euros]

Estimated Maintenance Effort: 0.66 [PM]  
 (based on the Dev. Effort):

Total Formal Verification Effort: 1.36 [PM]  
 (by Klein et al.)

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## The Automotive Car Control Example:

This example contains the automotive control system with all the embedded software components. Especially, the Servo functional unit has a software size of **12 CFP** [10].

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**SHOW THE SOFTWARE PROJECT DASHBOARD**

Software Project Title: Automotive Car Control

**PROJECT SIZES**

Product Size: 12 [CFP] 489 [LOC]  
 Team Size: 1 [Members]  
 Documentation Size: 225 [Pages]

**PROJECT EFFORT**

Development Effort: 0.33 [PM]  
 Testing Effort: 0.19 [PM]  
 Documentation Effort: 0.13 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 1.7 [Months]  
 Productivity: 4.71 [CFP/PM] 192.17 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 22  
 Risks Factor (in percent): 20.33  
 Estimated Number of Errors: 1

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**SHOW DERIVED PROJECT METRICS**

Software Project Title: Automotive Car Control

**PRODUCT SIZE**

Product Size: 12 [CFP] 489 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 99.18 [%]  
 (chosen vs. complete)  
 Percentage of chosen Test Cases: 81.05 [%]  
 (chosen vs. all test aspects)  
 Errors per Team Member: 1  
 Percentage of Test Effort vs. Development Effort: 57.58 [%]  
 Percentage of Documentation Effort vs. Dev. Effort: 39.39 [%]  
 Costs per COSMIC Function Point: 0.0 [Euros]  
 Costs per Project Month: 0.0 [Euros]  
 Estimated Maintenance Effort: 0.66 [PM]  
 (based on the Dev. Effort):  
 Total Formal Verification Effort: 1.36 [PM]  
 (by Klein et al.)

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## The Board Electronic Example:

The whole system of board electronics has more than hundred thousand line of code. Using the COSMIC based conversion rules, we obtain a software size of **14732 CFP**.

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Software Project Title: Board Electronic

**PROJECT SIZES**

Product Size: 1473 [CFP] 60106 [LOC]  
 Team Size: 233 [Members]  
 Documentation Size: 278506 [Pages]

**PROJECT EFFORT**

Development Effort: 525.44 [PM]  
 Testing Effort: 235.71 [PM]  
 Documentation Effort: 162.05 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 17.62 [Months]  
 Productivity: 551.49 [CFP/PM] 22500.79 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 30786  
 Risks Factor (in percent): 0.0  
 Estimated Number of Errors: 2717

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**SHOW DERIVED PROJECT METRICS**

Software Project Title: Board Electronic

**PRODUCT SIZE**

Product Size: 14732 [CFP] 60106 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 100.0 [%]  
 (chosen vs. complete)  
 Percentage of chosen Test Cases: 92.38 [%]  
 (chosen vs. all test aspects)  
 Errors per Team Member: 11  
 Percentage of Test Effort vs. Development Effort: 44.86 [%]  
 Percentage of Documentation Effort vs. Dev. Effort: 30.84 [%]  
 Costs per COSMIC Function Point: 0.0 [Euros]  
 Costs per Project Month: 0.0 [Euros]  
 Estimated Maintenance Effort: 1050. [PM]  
 (based on the Dev. Effort):  
 Total Formal Verification Effort: 1670. [PM]  
 (by Klein et al.)

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The next examples can be characterized a business applications (see also [9], [10] and [14]).

### The Car Hire Example:

This example consists of eight functional processes [6]: the customer list with **4 CFP**, the view customer summary with **5 CFP**, the view customer details with **3 CFP**, the preview customer details with **3 CFP**, the update customer details with **3 CFP**, the display invoice print preview with **6 CFP**, the add of new customer with **3 CFP** and the view customer booking details with **6 CFP**. This lead to a total size of **33 CFP**.



### The Course Registration Example:

This system example requirements below describe the functionality of the software to be developed by a project that will replace the existing Course Registration System (CRS) with an on-line system ("C-Reg") that allows students and professors access through PC clients [15]. This system includes 19 functional processes and leads to a total number of **102 CFP**.



## The Machine Learning Example:

In Machine Learning, a neural network is a software application that can 'learn' to classify input data with the help of 'training examples' of that input data [3]. The considered example has seven functional processes and a total number **39 CFP**.

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Software Project Title: Machine Learning

**PROJECT SIZES**

Product Size: 39 [CFP] 1591 [LOC]  
 Team Size: 1 [Members]  
 Documentation Size: 736 [Pages]

**PROJECT EFFORT**

Development Effort: 1.16 [PM]  
 Testing Effort: 0.62 [PM]  
 Documentation Effort: 0.43 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 2.47 [Months]  
 Productivity: 6.61 [CFP/PM] 269.69 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 76  
 Risks Factor (in percent): 48.0  
 Estimated Number of Errors: 6

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**SHOW DERIVED PROJECT METRICS**

Software Project Title: Machine Learning

**PRODUCT SIZE**

Product Size: 39 [CFP] 1591 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 99.82 [%]  
 (chosen vs. complete)  
 Percentage of chosen Test Cases: 86.15 [%]  
 (chosen vs. all test aspects)  
 Errors per Team Member: 6  
 Percentage of Test Effort vs. Development Effort: 53.45 [%]  
 Percentage of Documentation Effort vs. Dev. Effort: 37.07 [%]  
 Costs per COSMIC Function Point: 0.0 [Euros]  
 Costs per Project Month: 0.0 [Euros]  
 Estimated Maintenance Effort: 2.32 [PM]  
 (based on the Dev. Effort):  
 Total Formal Verification Effort: 4.42 [PM]  
 (by Klein et al.)

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## The Hotel Reservation Example:

The example of a hotel reservation software system includes six functional processes and has a total size number of **43 CFP** (an example of Abran described in [10]).

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Software Project Title: Hotel Reservation

**PROJECT SIZES**

Product Size: 43 [CFP] 1754 [LOC]  
 Team Size: 1 [Members]  
 Documentation Size: 812 [Pages]

**PROJECT EFFORT**

Development Effort: 1.29 [PM]  
 Testing Effort: 0.69 [PM]  
 Documentation Effort: 0.47 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 2.55 [Months]  
 Productivity: 6.84 [CFP/PM] 279.07 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 86  
 Risks Factor (in percent): 48.0  
 Estimated Number of Errors: 7

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**SHOW DERIVED PROJECT METRICS**

Software Project Title: Hotel Reservation

**PRODUCT SIZE**

Product Size: 43 [CFP] 1754 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 99.89 [%]  
 (chosen vs. complete)  
 Percentage of chosen Test Cases: 88.42 [%]  
 (chosen vs. all test aspects)  
 Errors per Team Member: 7  
 Percentage of Test Effort vs. Development Effort: 53.49 [%]  
 Percentage of Documentation Effort vs. Dev. Effort: 36.43 [%]  
 Costs per COSMIC Function Point: 0.0 [Euros]  
 Costs per Project Month: 0.0 [Euros]  
 Estimated Maintenance Effort: 2.58 [PM]  
 (based on the Dev. Effort):  
 Total Formal Verification Effort: 4.88 [PM]  
 (by Klein et al.)

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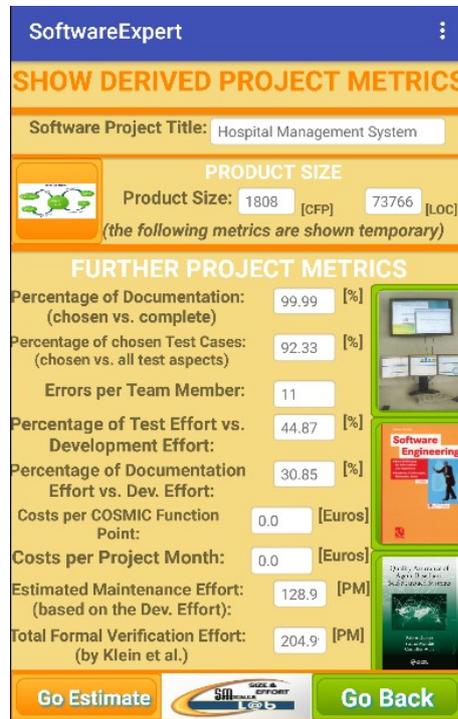
## The Web Advice Module Example:

The Web Advice Module is a special module on the website of a commercial bank to assist (young) customers with the choice whether they are going to rent a house or buy one with a mortgage (see [16]). The system consists of nine functional processes and summarizes **40 CFP**.



## The Hospital Management System Example:

The hospital management software system considers 12 functional processes (see [10] and [13]) and leads to **1808 CFP** as total number of COSMIC function points.



## The Cloud Computing Example:

This example is based on a real implementation of a cloud system at German Telekom and has four large components [described in [10]]: the interaction layer with **9657 CFP**, the process layer with **5843 CFP**, the functional layer with **13662 CFP** and the operational layer with **15500 CFP**. Hence, the whole system has **44662 CFP**.

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Software Project Title: Cloud Computing

**PROJECT SIZES**

Product Size: 4466 [CFP] 18222 [LOC]  
 Team Size: 707 [Members]  
 Documentation Size: 844330 [Pages]

**PROJECT EFFORT**

Development Effort: 1592.95 [PM]  
 Testing Effort: 714.59 [PM]  
 Documentation Effort: 491.28 [PM]

**PROJECT EFFICIENCY**

Project Costs: 0.0 [Euros]  
 Project Duration: 25.84 [Months]  
 Productivity: 1646.69 [CFP/PM] 67184.95 [LOC/PM]

**PROJECT QUALITY**

Chosen Number of Test Cases: 93340  
 Risks Factor (in percent): 0.0  
 Estimated Number of Errors: 8238

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SHOW DERIVED PROJECT METRICS

Software Project Title: Cloud Computing

**PRODUCT SIZE**

Product Size: 44662 [CFP] 18222 [LOC]  
 (the following metrics are shown temporary)

**FURTHER PROJECT METRICS**

Percentage of Documentation: 100.0 [%]  
 (chosen vs. complete)  
 Percentage of chosen Test Cases: 92.39 [%]  
 (chosen vs. all test aspects)  
 Errors per Team Member: 11  
 Percentage of Test Effort vs. Development Effort: 44.86 [%]  
 Percentage of Documentation Effort vs. Dev. Effort: 30.84 [%]  
 Costs per COSMIC Function Point: 0.0 [Euros]  
 Costs per Project Month: 0.0 [Euros]  
 Estimated Maintenance Effort: 3185 [PM]  
 (based on the Dev. Effort):  
 Total Formal Verification Effort: 5063 [PM]  
 (by Klein et al.)

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## Summary of the Measurement and Estimation Results

Of course, it is not a surprise that small examples leads to small project data and large ones to big data. Furthermore, the examples have different motivations and intentions. But, some measurements could be interesting and meaningful. Note, the size based estimation don't differ between the kind of system (real-time or business etc.).

In following we show some tables and leave the interpretation to the reader for his own needs (PM means personal month).

<b>COSMIC Example</b>	<b>Team size</b>	<b>Documentation size (in pages)</b>	<b>Lines of Code</b>
<b>Rice Cooker</b>	1	283	612
<b>Valve Control System</b>	1	225	489
<b>Automotive Car Control</b>	1	225	489
<b>Board Electronic</b>	233	278506	60106
<b>Car Hire</b>	1	622	1346
<b>Course Registration</b>	2	1927	4161
<b>Machine Learning</b>	1	736	1591
<b>Hotel Reservation</b>	1	812	1754
<b>Web Advice Module</b>	1	755	1632
<b>Hospital Management System</b>	29	34178	73765
<b>Cloud Computing</b>	707	844330	18222

**Tab. 1:** Team size and software estimation

Note, our estimations are “classical”. We don’t consider “documentation less” software implementation. Furthermore, most of the examples are very small, which better helps to explain the COSMIC method

<b>COSMIC Example</b>	<b>Dev. Effort in PM</b>	<b>Test Effort in PM</b>	<b>Documentation Effort (in PM)</b>
<b>Rice Cooker</b>	0.42	0.24	0.16
<b>Valve Control System</b>	0.33	0.19	0.13
<b>Automotive Car Control</b>	0.33	0.19	0.13
<b>Board Electronic</b>	525.44	235.71	162.05
<b>Car Hire</b>	0.97	0.53	0.36
<b>Course Registration</b>	3.54	1.63	1.12
<b>Machine Learning</b>	1.16	0.62	0.43
<b>Hotel Reservation</b>	1.29	0.69	0.47
<b>Web Advice Module</b>	1.2	0.64	0.44
<b>Hospital Management System</b>	64.48	28.93	19.89
<b>Cloud Computing</b>	1592.95	714.59	491.28

**Tab. 2:** Effort estimations

It is interesting to see whether the actual effort required for testing and documentation is actually taken into account.

<b>COSMIC Example</b>	<b>Project Duration in month</b>	<b>Number of Test Cases</b>	<b>Maintenance Effort (in PM)</b>
Rice Cooker	1.83	28	0.84
Valve Control System	1.7	22	0.66
Automotive Car Control	1.7	22	0.66
Board Electronic	17.62	30786	1050
Car Hire	2.34	65	1.94
Course Registration	3.36	212	7.08
Machine Learning	2.47	75	2.32
Hotel Reservation	2.55	86	2.58
Web Advice Module	2.49	82	2.4
Hospital Management System	8.65	3776	128.9
Cloud Computing	25.84	93340	3185

**Tab. 3:** Project duration and further characteristics

In addition to component, integration and acceptance testing, the test cases also take into account quality aspects such as security, performance and reliability.

<b>COSMIC Example</b>	<b>Estimated Number of Errors</b>	<b>Errors per Team Member</b>	<b>Verification Effort (in PM)</b>
Rice Cooker	2	2	1.7
Valve Control System	1	1	1.36
Automotive Car Control	1	1	1.36
Board Electronic	2717	11	1670
Car Hire	5	5	3.74
Course Registration	18	9	11.56
Machine Learning	6	6	4.42
Hotel Reservation	7	7	4.88
Web Advice Module	7	7	4.54
Hospital Management System	333	11	204.9
Cloud Computing	8238	11	5063

**Tab. 4:** Quality assurance estimation

In particular, the use of formal test methods helps in quality assurance. However, the effort involved should not be underestimated.

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