COSMIC

Bringing functional size measures to all software environments

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COSMIC-FFP Field Trials:
2000 Status Report

Pam Morris  *(Total Metrics)*
(on behalf of the COSMIC Core Team *)
ACOSM (ASMA) Conference - Sydney Australia October 2000

(* Alain Abran, Charles Symons, Jean-Marc Desharnais, Peter Fagg, Pam Morris, Roberto Meli, Serge Oligny, Jolijn Onvlee, Risto Nevalainen, Grant Rule, Denis St Pierre, Moritsugu Araki, Reiner Dumke)

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Agenda

• COSMIC FFP project aims
  • Field trials Aims and Status
  • Findings - overview
  • Standards Updates
  • Other Activities
  • Conclusions
COSMIC Project Aims

To develop, test, bring to market and gain acceptance as an industry standard, a new generation of software functional sizing methods which are applicable:

• for *performance measurement*

• as a component of *estimating* methods from early in a software item’s life

• in as wide a *range of software ‘domains’* as possible; priority to be given to business and real-time software (e.g. process control, operating systems, telephony, embedded, etc.)
Evolution of COSMIC FFP V2

FFP V1 Experience
V2 Aims - COSMIC
V2 Principles
V2 Field Trials
Research
Tools, etc
Prepare market acceptance
Promotion

On-going
On-going
On-going
On-going

1998  1999  2000

Today
COSMIC aims to be able to measure the size-impact of requirements on software in any functional layer and gives guidance for recognising layers.

Example: impact of requirements for Software Item ‘X’

- The principal Software Item ‘X’ to be built
- New utility
- Modification to the OS
- New device driver

User

Application Software

‘Middleware’

Operating System

Device Drivers

Hardware
Agenda

- COSMIC FFP project aims
- **Field Trials Aims and Status**
  - Findings - Overview
  - Standards Updates
  - Other Activities
  - Conclusions
The Field Trial Aims:

• to test for a common, repeatable interpretation of Version 2 COSMIC Measurement Manual (under widely-varying conditions: organisations, domains, development methods, etc).

• to establish the detailed procedures, where necessary to ensure repeatable interpretation

• to test:
  – that the measures properly represents functionality
  – and/or correlates with development effort

• to enable a full transfer of FSM technology to the trial ‘Partners’
The Field Trials Process

Initial Planning
- Gain commitment
- Select projects

Preparation
- Training
- Repeatability Exercise

Data Collection
- Mainly a Partner task
- COSMIC Team support

Central Analysis (UQAM)
- Method refinements
- Calibration
- Convertibility
- Benchmarks

Individual Performance Reports

Local/Regional Feedback

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COSMIC FFP V2 Field Trials Participation as of October 2000

Data collection completed 5 countries in Formal contexts:

- European Aerospace Manufacturer
- UK Bank (MIS systems)
- European telecommunications manufacturer
- Australian Defence software contractor

+ Other data from:

- Australian Defence contractor
- Australian real-time software house
- Australian aerospace manufacturer
- Canadian small software house
- Canadian Defence contractor
- Canadian Energy Transportation organization
Agenda

- COSMIC FFP Project Aims
- Field Trials Aims and Status
  - Findings - Overview
- Standards Updates
- Other Activities
- Conclusions
Experimental Model: Measurement Method and Its Use

Step 1: Design of the measurement method
Step 2: Application of the measurement method rules
Step 3: Measurement result
Step 4: Exploitation of the measurement result
Experimental Model: Measurement Method and Its Use

Step 1
Design of the measurement method

Step 2
Application of the measurement method rules

Step 3
Measurement result

Step 4
Exploitation of the measurement result
User view of software functional requirement components

**Users**
- People
- Engineered devices
- Other software

**Boundary**
- DATA IN ('ENTRY')
- STORE PERSISTENT DATA ('WRITE')
- DATA MANIPULATION OR TRANSFORMATION
- RETRIEVE PERSISTENT DATA ('READ')
- DATA OUT ('EXIT')
COSMIC Model of Software

**Functional User Requirements**

**F.U.R.**

Software

Functional process type

Sub-process types

Data movement types

AND

Data manipulation types

Functionality = **Data movements and Data manipulations**

© COSMIC Core Team 2000
Functionality = Data movements and Data manipulations

F.U.R. - Functional process type

Data Movements Measured
- DATA IN ('ENTRY')
- DATA OUT ('EXIT')
- STORE PERSISTENT DATA ('WRITE')
- RETRIEVE PERSISTENT DATA ('READ')

Data movement types

Data manipulation types

Sub-process types

Future Releases of COSMIC
Field Trials - Decision required on the size units of the Data Movements
Key Questions

Are all Data Movement Types (Entries, Exits, Reads, Writes) the same size?

Will we need to decompose to the level of Data Attributes to determine the sizes?

Does the ratio (Data Attributes / Data Movement) vary by data Movement Type?

Does the ratio (Data Attributes / Data Movement) vary by Domain?
Some Initial Results

Data movements and their Data Attributes

![Bar chart showing number of data attributes moved for ENTRY, EXIT, READ, and WRITE sections]

- **ENTRY**: 3,1
- **EXIT**: 2,9
- **READ**: 3,5
- **WRITE**: 4,7

**Average +/- 1 std. dev.**

- **Constraint**
- **Average value**

**Writes - have slightly more attributes**
Some Initial Results

- Writes - Slightly more attributes

Proportion of data movements vs. Number of data attributes moved

© COSMIC Core Team 2000
Some Initial Results

Average Size of Functional Processes

<table>
<thead>
<tr>
<th>Project ID</th>
<th>No. of Func.</th>
<th>TOTAL Software size (Cfs units)</th>
<th>Average Size of Functional Process (Cfs units)</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>32</td>
<td>3,6</td>
<td>0,5</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>76</td>
<td>9,5</td>
<td>1,9</td>
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<td>3</td>
<td>8</td>
<td>56</td>
<td>7,0</td>
<td>2,1</td>
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<tr>
<td>4</td>
<td>46</td>
<td>142</td>
<td>3,1</td>
<td>0,7</td>
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<td>5</td>
<td>4</td>
<td>8</td>
<td>2,0</td>
<td>0,0</td>
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<tr>
<td>6</td>
<td>18</td>
<td>142</td>
<td>7,9</td>
<td>7,1</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>93</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>4,9</strong></td>
<td><strong>4,1</strong></td>
</tr>
</tbody>
</table>
Some Initial Results

Size of Functional Processes: Average & Distribution

Overall Average Size of Functional Process

1 2 3 4 5 6 7 8 9 10

Average: 3.1
+/-1 std. dev.: 3.6
Constraint: 7.0
Average value: 7.9

Actual range found is four to five fold

Two-fold IFPUG allowed range

(Cosmic Functional Size Units)
Experimental Model: Measurement Method and Its Use

- **Step 1**: Design of the measurement method
- **Step 2**: Application of the measurement method rules
- **Step 3**: Measurement result
- **Step 4**: Exploitation of the measurement result
PARTICIPANTS FEEDBACK:

‘The Measurement Model of Functional Processes decomposed into Data Movements is equally easy to apply to MIS and real-time software’

• ‘Easy to measure without being a measurement expert’
• ‘Project Teams were able to grasp the elements of the method easily and were enthusiastic about the method’
• ‘Documentation and effort needed is similar to that for applying the IFPUG method, though there is an extra step to identify functional layers’
Measurement Method Application

Comparisons with IFPUG parallel measurements:

• classifying Elementary Processes as External Inputs, Outputs or Inquiries is OK in the MIS world, but often difficult for real-time software:
  – incorrect classification
  – has impact on size (‘|weights’) assigned (in IFPUG, different weights by function type)
  – restricts maximum size for process with a large number of sub-processes

• Repeatability and Reproducibility
Model: Measurement Method and Its Use

- Step 1: Design of the measurement method
- Step 2: Application of the measurement method rules
- Step 3: Measurement result
- Step 4: Exploitation of the measurement result
Trial Data - Project Profile
Productivity Data Sets

Development projects: 15 projects from 4 organizations:

- 13 New Developments & 2 Enhancements
- Platforms: 7 PC, 4 DEC, 2 HP and 1 Compaq
- Completed between March 1999 and May 2000
- Duration: from 5 to 75 months
# Trial Data - Project Environment Profile

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Hardware</th>
<th>Operating system</th>
<th>Prog. language</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hewlett-Packard</td>
<td>Unix 11</td>
<td>SLEL</td>
</tr>
<tr>
<td>B</td>
<td>Personal computer (PC)</td>
<td>MS Windows NT (4.0)</td>
<td>C++</td>
</tr>
<tr>
<td>C</td>
<td>Personal computer (PC)</td>
<td>MS Windows NT (4.0)</td>
<td>C++</td>
</tr>
<tr>
<td>D</td>
<td>Hewlett-Packard</td>
<td>HP - UX</td>
<td>C</td>
</tr>
<tr>
<td>E</td>
<td>Not available</td>
<td>HP - UX</td>
<td>C</td>
</tr>
<tr>
<td>F</td>
<td>Personal computer (PC)</td>
<td>MS Windows NT</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>Pentium PC</td>
<td>MS Windows NT 4.0</td>
<td>C++</td>
</tr>
<tr>
<td>H</td>
<td>DEC Vax</td>
<td>VMS</td>
<td>Ada</td>
</tr>
<tr>
<td>I</td>
<td>DEC Alpha</td>
<td>Unix</td>
<td>Ada</td>
</tr>
<tr>
<td>J</td>
<td>Compaq Alpha</td>
<td>Unix</td>
<td>Ada 95</td>
</tr>
<tr>
<td>K</td>
<td>DEC Vax</td>
<td>VMS</td>
<td>Ada</td>
</tr>
<tr>
<td>L</td>
<td>Dec Vzx</td>
<td>VMS</td>
<td>Ada</td>
</tr>
<tr>
<td>M</td>
<td>Pentium III</td>
<td>Windows NT</td>
<td>VB6</td>
</tr>
<tr>
<td>N</td>
<td>Pentium III</td>
<td>Windows NT</td>
<td>VB6</td>
</tr>
<tr>
<td>O</td>
<td>Pentium III</td>
<td>Windows NT</td>
<td>VB6</td>
</tr>
</tbody>
</table>
## Trial Data - Project Effort Profile

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Plan &amp; Track</th>
<th>Specify</th>
<th>Build</th>
<th>Test</th>
<th>Implement</th>
<th>TOTAL</th>
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<tr>
<td>A</td>
<td>n.a.</td>
<td>n.a.</td>
<td>252</td>
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<td>n.a.</td>
<td>252</td>
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<tr>
<td>B</td>
<td>220</td>
<td>381</td>
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<td>401</td>
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<td>2459</td>
</tr>
<tr>
<td>C</td>
<td>89</td>
<td>68</td>
<td>487</td>
<td>335</td>
<td>n.a.</td>
<td>979</td>
</tr>
<tr>
<td>D</td>
<td>n.a.</td>
<td>136</td>
<td>643</td>
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<td>779</td>
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<td>556</td>
<td>14186</td>
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<td>H</td>
<td>1718</td>
<td>n.a.</td>
<td>15815</td>
<td>1372</td>
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<td>I</td>
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<td>66000</td>
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<td>295000</td>
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<tr>
<td>L</td>
<td>10000</td>
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<td>93000</td>
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<td>9</td>
<td>5</td>
<td>37</td>
<td>17</td>
<td>14</td>
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<tr>
<td>O</td>
<td>9</td>
<td>7</td>
<td>88</td>
<td>50</td>
<td>52</td>
<td>205</td>
</tr>
</tbody>
</table>
Model: Measurement Method and Its Use

Step 1: Design of the measurement method

Step 2: Application of the measurement method rules

Step 3: Measurement result

Step 4: Exploitation of the measurement result
## Trial Data - Project Delivery Rate (PDR)

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Hardware</th>
<th>Size - C&lt;sub&gt;fsu&lt;/sub&gt;</th>
<th>Ratio Hrs/ C&lt;sub&gt;fsu&lt;/sub&gt;</th>
<th>Prog. language</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hewlett-Packard</td>
<td>32</td>
<td>8</td>
<td>SLEL</td>
</tr>
<tr>
<td>B</td>
<td>Personal computer (PC)</td>
<td>75</td>
<td>29</td>
<td>C++</td>
</tr>
<tr>
<td>C</td>
<td>Personal computer (PC)</td>
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<td>16</td>
<td>C++</td>
</tr>
<tr>
<td>D</td>
<td>Hewlett-Packard</td>
<td>46</td>
<td>5</td>
<td>C</td>
</tr>
<tr>
<td>E</td>
<td>Not available</td>
<td>4</td>
<td>29</td>
<td>C</td>
</tr>
<tr>
<td>F</td>
<td>Personal computer (PC)</td>
<td>18</td>
<td>61</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>Pentium PC</td>
<td>97</td>
<td>36</td>
<td>C++</td>
</tr>
<tr>
<td>H</td>
<td>DEC Vax</td>
<td>150</td>
<td>27</td>
<td>Ada</td>
</tr>
<tr>
<td>I</td>
<td>DEC Alpha</td>
<td>213</td>
<td>21</td>
<td>Ada</td>
</tr>
<tr>
<td>J</td>
<td>Compaq Alpha</td>
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<td>57</td>
<td>Ada 95</td>
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<td>K</td>
<td>DEC Vax</td>
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<td>25</td>
<td>Ada</td>
</tr>
<tr>
<td>L</td>
<td>Dec Vzx</td>
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<td>Ada</td>
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<td>M</td>
<td>Pentium III - MIS</td>
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<tr>
<td>O</td>
<td>Pentium III</td>
<td>35</td>
<td>4</td>
<td>VB6</td>
</tr>
</tbody>
</table>

Project Delivery Rate = Effort Hours per COSMIC Functional Size Unit
**Analysis of Project Duration - Some European Data**

<table>
<thead>
<tr>
<th>Partner</th>
<th>Size</th>
<th>A</th>
<th>B</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>76</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>56</td>
<td>5.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>142</td>
<td>10.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>8</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>142</td>
<td>9.5</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>48</td>
<td></td>
<td>2.8</td>
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<td>B</td>
<td>3004</td>
<td>52.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
*Duration - Delivery Rate and Size*

Some European Data

![Graph showing Delivery Rate vs Size](image)

- **Delivery Rate (Size/elapsed months)**
  - 0
  - 50
  - 100
  - 150
- **Software Size (cfsu)**
  - 0
  - 5000
  - 10000

**Legend:**
- A
- B
- D
*Duration - Delivery Rate and Size*

Some European Data

![Graph showing Delivery Rate vs Size]

- **Delivery Rate vs Size**

  - Software Size (cfsu)
  - Delivery Rate (Size/elapsed months)

  - A
  - B
  - D

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Bühren & Partner have developed a simple estimating formula based on COSMIC FFP

COSMIC FFP productivity measures fit a COCOMO-like formula:

$$\text{CFFP Productivity} = a + b \times (\text{Size})^n$$

<table>
<thead>
<tr>
<th>Estimation Method</th>
<th>Traditional / Expert</th>
<th>CFFP Prod. Function</th>
<th>Artemis KnowledgePlan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute deviation range</td>
<td>-50% to +50%</td>
<td>-30% to +33%</td>
<td>-20% to +46%</td>
</tr>
<tr>
<td>Mean deviation</td>
<td>-14%</td>
<td>-2.3%</td>
<td>+1.2%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>34%</td>
<td>17%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Notes:
Some project data used to calibrate productivity formula, which was then used to predict effort for other projects
KnowledgePlan has not been set up for CFFP measurements and its performance can be improved by better calibration
Buhren will continue to use CFFP for productivity measurement and to improve its estimating (DSMA Fall 99 Conference)
Agenda

• COSMIC FFP project aims
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  • Standards - Update
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Other Updates

- COSMIC meeting held in Montréal September 2000 to review and discuss change requests to standards

- Change requests will be circulated in November 2000 for final review and approval

- Estimated % of changes: 1% to 2%
Agenda

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Research Activities - On-going

- Convertibility - ISO 14143-3: FFP V1, MarkII and IFPUG (Fetcke, Abran, Vinh Ho, UQAM)
- Early COSMIC-FFP (Meli & Santillo - Italy and UQAM)
- Correlation of expert view of functionality with COSMIC FFP size, using AHP (Wittig & Rudolph, Australia and UQAM)
- Procedure for UML-based specifications (Bevo, UQAM)
- Other aspects of size - algorithmic complexity and quality (Dé Desharnais & Kececi UQAM)
- Functional Reuse (UQAM and Bell Canada)
- Supporting requirements identification with Computer Based Reasoning - CBR approach (Desharnais, UQAM)
COSMIC FFP Tools, ISBSG Benchmarks

- Hierarchy Master - FFP v. 1 fully supported, V. 2 in development (Jin Ng, Australia)

- Sphera (Italy) - measurement support and estimating tool for V. 2 in development (Roberto Meli, Fall 2000)

- Commitment to deliver Field Trial results to ISBSG (and to trial participants)
There is strong international interest

- Translated into French and Spanish.
- Soon: Italian and Japanese.
- Measurement Manual has been down-loaded from over 30 countries
- Talks about COSMIC FFP at international conferences:
  - ESCOM April
  - ESEPG Amsterdam, June
  - IWSM 2000, Berlin, October
  - EURO-SPI, Copenhagen, October
  - FESMA Madrid, October
  - COCOMO, Los Angeles, October
  - Ericsson World-wide workshop, Montreal, October
  - ASCOM, Melbourne, Australia, October
  - French Association pour l’Etude de Métriques en Informatique training in November
  - Japanese study group - on-going
Training

Training Class (2 days with Case Study)
• Developed at UQAM
• Reviewed by COSMIC members
• Tested at Trial Partners sites + others (Europe, North America, Japan and Australia)
• Ready for deployment

Case Studies:
• MIS
• Real-time
• ISO 14143-4
And planning further ahead…..

Proposal submitted to ISO/IEC/JTC1 SC7 (Software Engineering) for a New Work Item to include the COSMIC FFP method through the ISO standardisation process:

Approval rate = > 90% countries

(July 2000)
Agenda

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• Conclusions
The first Functional Sizing method to:

- be designed by an international group of experts on a sound theoretical basis
- draw on the practical experience of all the main existing FP methods
- be designed to conform to ISO 14143 Part 1
- be designed to work across MIS and real-time domains, for software in any layer or peer item
- be widely tested in field trials before being finalised
Conclusion - we have made great progress!

- The acceptance from those who have tried the method is good in both MIS and real-time environments
- All the questions that have been raised have been solved OK
- Most organisations are taking longer to get started and to collect data than we had hoped, but got there
- COSMIC-FFP has matured significantly and is ready for ISO seal of approval

The COSMIC Core team would like to thank the trial participants, the researchers, and others who have helped for their support and interest.
For further information....

 Principle contact addresses:

 Web-site (generic information) : www.cosmicon.com

 Web-site (standards & publications) www.lrgl.uqam.ca/ffp

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 Charles Symons: charles_symons@compuserve.com

 Pam.Morris@Totalmetrics.com