ESTIMATING THE REQUIRED TEST VOLUME AND EFFORT FOR SOFTWARE VERIFICATION AND VALIDATION

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Contents

- Motivation and objectives
- Background
- Volume and effort estimation
- Conclusions and discussion
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Motivation

- ECSS-e40 B states the need to determine the effort for the verification and validation for a project (clauses 5.6.2.1 and 5.8.2.1)
- Process and automation receive often attention but not so much estimation
- Estimation of test volume and effort may help in several directions
Objectives

- This is an initial study that intends to approach the estimation of V&V test volume and effort based on functional size measurement in the context of ECSS-e40 B standard.
- A proposal to use non-functional requirements to make adjustments is also included. For this:
  - a method to assess and rate non-functional requirements is provided
- Some issues such as automation of this approach are outlined
Contents

- Motivation and objectives
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- Conclusions
Functional size

- Measurement/estimation
- Functional Requirements
- Units: points (UFP), Cosmic Units (Cfsu)
- Methods
  - ISO 19761:2003 COSMIC-FFP
  - ISO 20926:2003 Function Point Analysis (e.g. IFPUG 4.1, unadjusted function points - UFP only)
  - ISO 20968:2002 Mk II
  - ISO 24570:2005 NESMA
**Software Types which can be measured with COSMIC-FFP**

<table>
<thead>
<tr>
<th>Business</th>
<th>Business Application Software</th>
<th>Embedded or Control Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Utility Software</td>
<td>Users Tools Software</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Developers Tools Software</td>
</tr>
<tr>
<td></td>
<td>Systems Software</td>
<td>Software</td>
</tr>
</tbody>
</table>
Cosmic-FFP concept

![Diagram showing Cosmic-FFP concept with users, engineered devices, I/O hardware, boundary, entries, exits, front end, back end, reads, writes, and software.](image-url)
V&V engineering processes

Following ECSS-e40 B

- Verification process implementation;
- Validation process implementation;
- Verification activity;
- Validation activity; and
- Joint technical review process.
The following documents maybe relevant as information sources for estimation (counting points):

- Requirements baseline (RB)
- Interface Requirements Document (IRD)
- Software Requirements Document (SRS)
- Interface Control Document (ICD)
Requirements in ECSS-e40

- **Functional requirements**
  - Performance requirements
  - Interface requirements
  - Operational requirements
  - Resource requirements
  - Design requirements and implementation constraints
  - Security and privacy requirements
  - Portability requirements
  - Software quality requirements
  - Software reliability requirements

- **Software maintainability requirements**

- **Software safety requirements**

- **Software configuration and delivery requirements**

- **Data definition and database requirements**

- **Human factors related requirements**

- **Adaptation and installation requirements**

- **Others requirements**
Functional Size

A data set of 15 software projects (units in Cfsu – ISO 19761)
Visual identification

![Graph showing the relationship between Function Points and Work Effort for the C Language. The graph includes a scatter plot with dots representing Function Points and circles highlighting specific data points.](chart.png)
Contents

- Motivation and objectives
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V&V Volume estimation

- Requirements to consider
  - Functional Requirements
  - Other non-functional requirements
- The functional requirements must exactly be mapped onto the set of functional tests
- The size can be referred to as the functional testing volume.
- Testing volumes can then be expressed using the same size units
  - Cfsu (COSMIC functional size unit) for ISO 19761
  - Function Points (FP) for ISO 20926.
Non-functional requirements

- Issues
  - Different efforts can be found for the same number of FP
  - How to ‘size’ such other types of requirements
  - What is their impact on V&V effort
- COCOMO-like approach
  - For each type of requirement a 4-interval classification is defined
### A project assessed

<table>
<thead>
<tr>
<th>Types of requirements</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Nominal</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>1 Performance requirements</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Interface requirements</td>
<td>Low</td>
<td></td>
<td></td>
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<tr>
<td>3 Operational requirements</td>
<td>Low</td>
<td></td>
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<tr>
<td>4 Resource requirements</td>
<td>Low</td>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>5 Design req.&amp; implementation constraints</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6 Security and privacy requirements</td>
<td>Low</td>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>7 Portability requirements</td>
<td>Low</td>
<td>Nominal</td>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>8 Software quality 1requirements</td>
<td>Low</td>
<td></td>
<td></td>
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<tr>
<td>9 Software reliability requirements</td>
<td>Low</td>
<td></td>
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<tr>
<td>10 Software maintainability requirements</td>
<td>Low</td>
<td>Nominal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Software safety requirements</td>
<td>Low</td>
<td></td>
<td></td>
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<tr>
<td>12 Software configuration and delivery req.</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Data definition and database req.</td>
<td>Low</td>
<td></td>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>14 Human factors related requirements</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Adaptation and installation req.</td>
<td>Low</td>
<td>Nominal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Others requirements</td>
<td>Low</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Profile of the combined assessment of the 16 types of requirements for this simulated project</td>
<td>9 Low</td>
<td>3 Nominal</td>
<td>2 High</td>
<td>2 Very High</td>
</tr>
</tbody>
</table>
V&V Effort Estimation

1. Identification of a reference dataset: ISBSG - Data set;
2. Identification of the V&V functional test volume;
3. Building of the initial estimation model based on functional test volume;
4. Identification and classification of the set of non-functional requirements;
5. Adjusting the initial estimation model (of step 3) to take into account the integrated set of non-functional requirements of step 4.
V&V functional test volume

556 projects of new software

![Graph showing the relationship between size and test effort for new development projects.](image)
ISBSG - Data set

502 enhancement projects

![Graph showing test effort and size for 502 enhancements projects.](image)
Initial effort estimation

556 projects of new software

Regression model
V&V Effort = 1.3 *FP + 181 with an $R^2 = .24$
Initial effort estimation model

- Based on functional test volume
- Regression model
  \[ V\&V \text{ Effort} = 1.3 \times FP + 181 \text{ with an R}^2 = .24 \]
- Effort = 1.3 \times 1000 + 181 = 1300 + 181 = 1481 hours
  - Where max is approximately 15,000 hours and min is approximately 10 hrs
- Functional Req. explains 24% of the effort variation while other types the other 76%
Non functional requirements

- The regression line corresponds the expected nominal size-based effort
- Projects on the regression line: non-functional requirements in the “nominal” interval scale.
- Projects with “very high” effort: all non-functional requirements highest in the 4-interval scale.
- Projects with “low” effort: all non-functional requirements being the lowest in the 4-interval scale.
- Projects with all ‘high’ non-functional requirements: in the mid-range between the regression model estimate and the ‘very- high’ effort estimate.
Rating

Effort

Size (FP)

very high

high

nominal

low
Example: a 14 project subset

- Y = 41 + 1.35xUFP; R² = 0.60, for n=14 projects
- Y = 41 + 1.35 x 100 UFP = 41 + 135 = 176 days
- **Nominal** = 176 days
- 100 UFP: graphical analysis indicates an effort range between 75 days up to 350 days
- **Very High** = 350 d.
- **Low** = 75 d.
  - (Very High: 350 – Nominal:176) = 174d.
  - (Nominal:176 days – Low:75 days) = 101d.
- **High** = Nominal + (Very High – Nominal)/2 = 176 + (350 – 176)/2 = 176 + 87 = 263 d.
### Estimations

#### Project assessed

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<td>Very High</td>
</tr>
<tr>
<td>Interface requirements</td>
<td>Low</td>
<td></td>
<td></td>
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<tr>
<td>Resource requirements</td>
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<td></td>
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<tr>
<td>Design req. &amp; implementation constraints</td>
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<td></td>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>Security and privacy requirements</td>
<td>High</td>
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</tr>
<tr>
<td>Portability requirements</td>
<td>Nominal</td>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Profile of the combined assessment of the 16 types of requirements for this simulated project:

- **9**: Low
- **3**: Nominal
- **2**: High
- **2**: Very High
## Estimations

<table>
<thead>
<tr>
<th>Non-functional interval class</th>
<th>Number within a class</th>
<th>Effort on the data set for a class (days)</th>
<th>Impact (1) * (2)</th>
<th>Normalized value (= /16 classes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>9</td>
<td>75</td>
<td>675</td>
<td>42</td>
</tr>
<tr>
<td>Nominal</td>
<td>3</td>
<td>176</td>
<td>528</td>
<td>33</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
<td>263</td>
<td>526</td>
<td>33</td>
</tr>
<tr>
<td>Very high</td>
<td>2</td>
<td>350</td>
<td>700</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td></td>
<td>2429</td>
<td>152 days</td>
</tr>
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Conclusions

- This paper has presented an initial study on the use of the functional size approach to estimate V&V test volume and effort in the context of ECSS-e40 B
- A method for assessing and rating non-functional requirements
- A proposal for non-functional requirements in an effort estimation process
- The information required for the implementation of this estimation approach is available during the execution of projects developed in compliance with ECSS E-40
Discussion

- The applicability of this estimation approach to the ESA context would require data obtained from ESA projects.
- Automation of data analysis should be investigated. A document-based automated CASE support environment would be a good basis.
- Automation support could be provided without disturbing the software process.
Discussion

A view for automation