ESTIMATING THE TEST VOLUME and EFFORT FOR TESTING & VERIFICATION-VALIDATION

A. Abran
École de technologie supérieure - Université du Québec
Alain.abran@etsmtl.ca

J. Garbajosa
Universidad Politécnica de Madrid
jgs@eui.upm.es

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Contents

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

- How can we estimate testing & V&V early in the life cycle?
- Traditional estimation models are typically built from the perspective of how the developers will carry their tasks
  - Cost factors
- Can we look at the estimation problem differently, that is from the client’s perspective?
  - Functional requirements
  - Non-functional requirements
Objectives

- Build an estimation approach based on users’ perspective:
  - Functional requirements
  - Non-functional requirements
- Build using standards:
  - ISO 19761: COSMIC
  - ECSS-e40 B
- Illustrate the approach using a large data set - ISBSG
Contents

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  - Conclusions
Functional size

- Measurement/estimation
- Functional Requirements
- Units: Function points or COSMIC Units
- 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
COSMIC-FFP

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</td>
<td>Software</td>
</tr>
</tbody>
</table>
Cosmic-FFP concept

\[\text{Cosmic-FFP concept}\]

\[\text{I/O Hardware}\]

\[\text{SOFTWARE}\]

\[\text{Storage Hardware}\]

\[\text{BOUNDARY}\]

\[\text{« Front end »}\]

\[\text{« Back end »}\]

\[\text{ENTRIES}\]

\[\text{EXITS}\]

\[\text{READS}\]

\[\text{WRITES}\]

\[\text{« Front end »}\]

\[\text{« Back end »}\]

\[\text{Engineered Devices}\]

\[\text{or}\]

\[\text{Engineered Devices}\]
V&V engineering processes

- ECSS-e40 B
  - E-40 Part 2B Software – Part 2: Document requirements definitions (DRDs) - 31 March 2005
  - Q-80B Software product assurance - 10 October 2003
  - Aligned with ISO concept of quality (ISO 9000 and 12207)
Some more info on ECSS

- The European Cooperation for Space Standardization is an initiative established to develop a coherent, single set of user-friendly standards for use in all European space activities.

- Domain of activities
  - Project management
  - Engineering
  - Production
  - Operations
  - Product assurance

- http://www.ecss.nl/
Requirements in ECSS-e40B

- **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**
Case Study: Testing and V/V

- How to estimate testing volume?
- How to estimate effort?
- Available data set: ISBSG release 9
Typical distribution of software engineering data sets:

- (from either single or multi-organisations data sets)
Functional Size

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

![Graph showing Function Points C Language](image)

- Function Points
- Work Effort

0 500 1000 1500 2000 2500 3000 3500 4000

60000
50000
40000
30000
20000
10000
0

0 500 1000 1500 2000 2500 3000 3500 4000

Function Points
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 classifying
    - 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>
<td></td>
<td></td>
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<tr>
<td>4 Resource requirements</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Design req.&amp; implementation constraints</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
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<tr>
<td>6 Security and privacy requirements</td>
<td></td>
<td>High</td>
<td></td>
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<tr>
<td>7 Portability requirements</td>
<td></td>
<td>Nominal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Software quality requirements</td>
<td>Low</td>
<td></td>
<td></td>
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<tr>
<td>9 Software reliability requirements</td>
<td>Low</td>
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<tr>
<td>10 Software maintainability requirements</td>
<td>Low</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>11 Software safety requirements</td>
<td>Low</td>
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<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></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></td>
<td>Nominal</td>
<td></td>
</tr>
<tr>
<td>16 Others requirements</td>
<td>Low</td>
<td></td>
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</tr>
</tbody>
</table>

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

- Low
- Nominal
- High
- Very High
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

292 projects of new software

Effort = 1.57 hours/FP x No. of FP + 248 hours with an $R^2 = .31$
ISBSG - Data set

366 enhancement projects

![Graph showing the relationship between Project Size and Testing Effort with the equation Effort = 1.63 hours/FP x No. of FP + 236 hours and R² = .20]
Initial effort estimation model

- Based on functional test volume
- Regression model
  - a New Software project with a functional size of 1,000 FP, the regression model would predict:
    - Effort = 1.57 hours/FP x 1,000 FP + 248 hours
    - Effort = 1,570 hours + 248 hours = 1,818 hours
  - Where max is approximately 15,000 hours and min is approximately 10 hrs
- Functional Req. explains 31% of the effort variation while other types the other 69%
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 (or most) non-functional requirements highest in the 4-interval scale.
- Projects with “low” effort: all (or most) 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

Estimating Test Volume & Effort
Non functional values estimates

- From the graph:
  - Maximum at 1,000 FP is approximately 15,000 hours (e.g. the Very High value),
  - Minimum is approximately 10 hours (e.g. the Very Low value).
- The high value = the mid-value within the range of (model and very high values):
  - High Value = (Model value + Very High value) / 2
  - High Value = (1,818 hours + 15,000 hours) / 2
  - High Value = 16,818 / 2 = 8,409 hours
Estimations

Project assessed

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<th>Class 4</th>
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<tbody>
<tr>
<td>Project assessed</td>
<td>Low</td>
<td>Nominal</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Performance requirements</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface requirements</td>
<td>Low</td>
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<td>Others requirements</td>
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<td></td>
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<td></td>
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<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>
## Estimations

<table>
<thead>
<tr>
<th>Non-functional interval class</th>
<th>Number within a class</th>
<th>Effort on the dataset for a class</th>
<th>Impact $(3) = (1) \times (2)$</th>
<th>Normalized value $(= /16 \text{ classes})$ $(4) = (3) / 16$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>9</td>
<td>10 hours</td>
<td>90</td>
<td>6</td>
</tr>
<tr>
<td>Nominal</td>
<td>3</td>
<td>1,818 hours</td>
<td>5,454</td>
<td>341</td>
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<tr>
<td>High</td>
<td>2</td>
<td>8,409 hours</td>
<td>16,818</td>
<td>1,051</td>
</tr>
<tr>
<td>Very high</td>
<td>2</td>
<td>15,000 hours</td>
<td>30,000</td>
<td>1,875</td>
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<tr>
<td>Total</td>
<td>16</td>
<td></td>
<td>52,362</td>
<td>3,273 hours</td>
</tr>
</tbody>
</table>
Ranges at 1,000 FP for ISBSG

New Software projects - N = 292 projects
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- Motivation and objectives
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Conclusions and discussion
Conclusions

- This paper has presented a study on the use of the functional size approach to estimate V&V test volume and effort in the context of ECSS-e40 B, ISO 20926 and ISO 19761
- A method for assessing and rating non-functional requirements has been proposed
- A proposal for using non-functional requirements in an effort estimation process has been introduced
Discussion

- The applicability of this estimation approach to a specific context would require data obtained from whatever context to obtain accurate results.
- Further work will be required to measure consistently non-functional requirements.
- More extensive case studies:
  - Other phases
  - All phases combined