Université du Québec
École de technologie supérieure

Software Engineering Research Laboratory

UPM
UNIVERSIDAD POLITÉCNICA DE MADRID

System and Software Technology Group

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

A. Abran
Université du Québec
aabran@ele.etsmtl.ca

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

SDSS 2005   ESTEC, Noordwijk   17-20 October 2005

Contents

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

Contents

- **Motivation and objectives**
- Background
- Volume and effort estimation
- Discussion and conclusions

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 a 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 is outlined

Contents

- **Motivation and objectives**

- # Background

- Volume and effort estimation
- 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

COSMIC-FFP

Software Types which can be measured with COSMIC-FFP

Business	Business Application Software	Embedded or Control Software
Infrastructure	Utility Software	Users Tools Software	Developers Tools Software
	Systems Software		

Cosmic-FFP concept
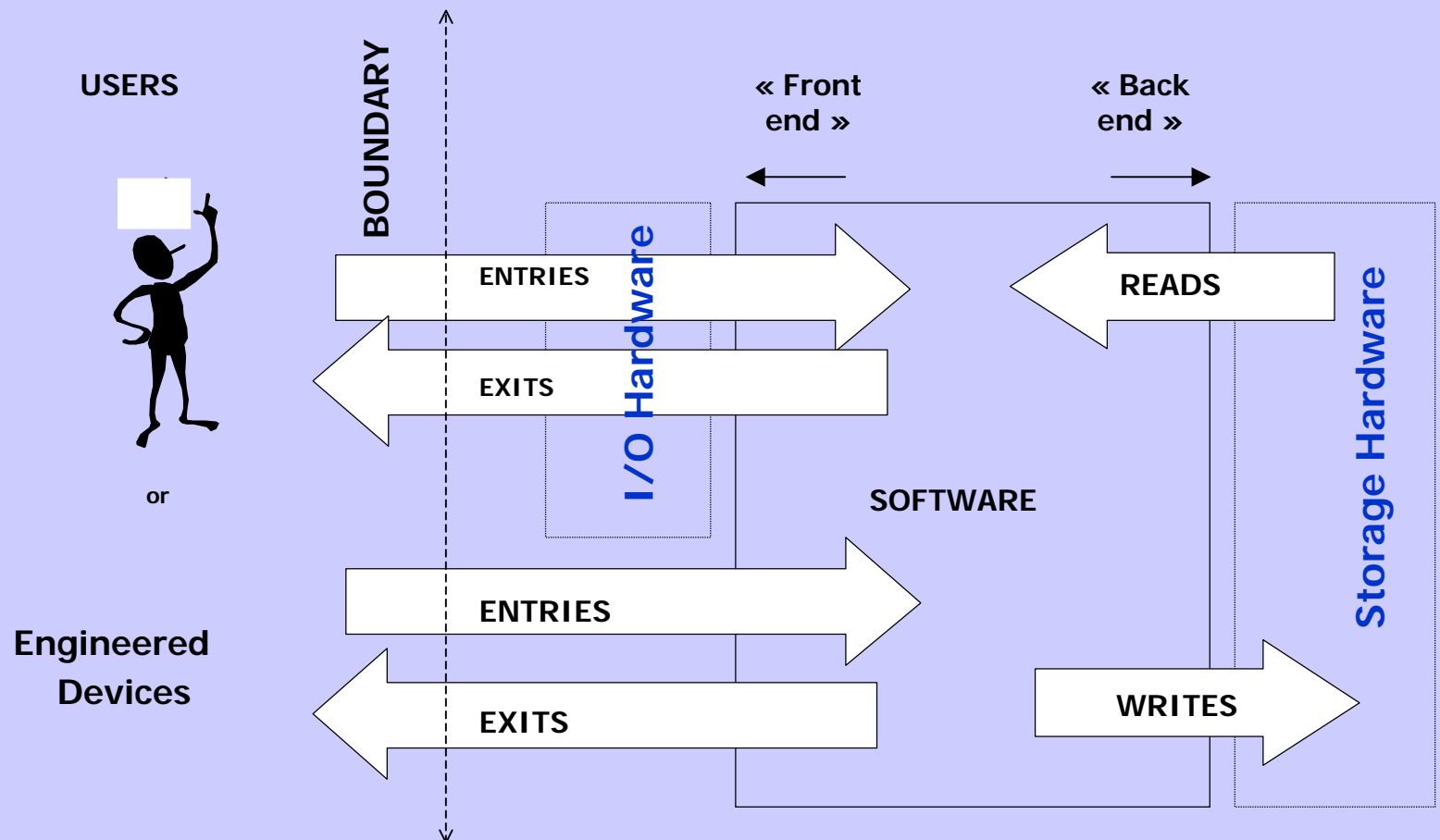
V&V engineering processes

Following ECSS-e40 B

- Verification process implementation;
- Validation process implementation;
- Verification activity;
- Validation activity; and
- Joint technical review process.

ECSS-e40 documents

- 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)
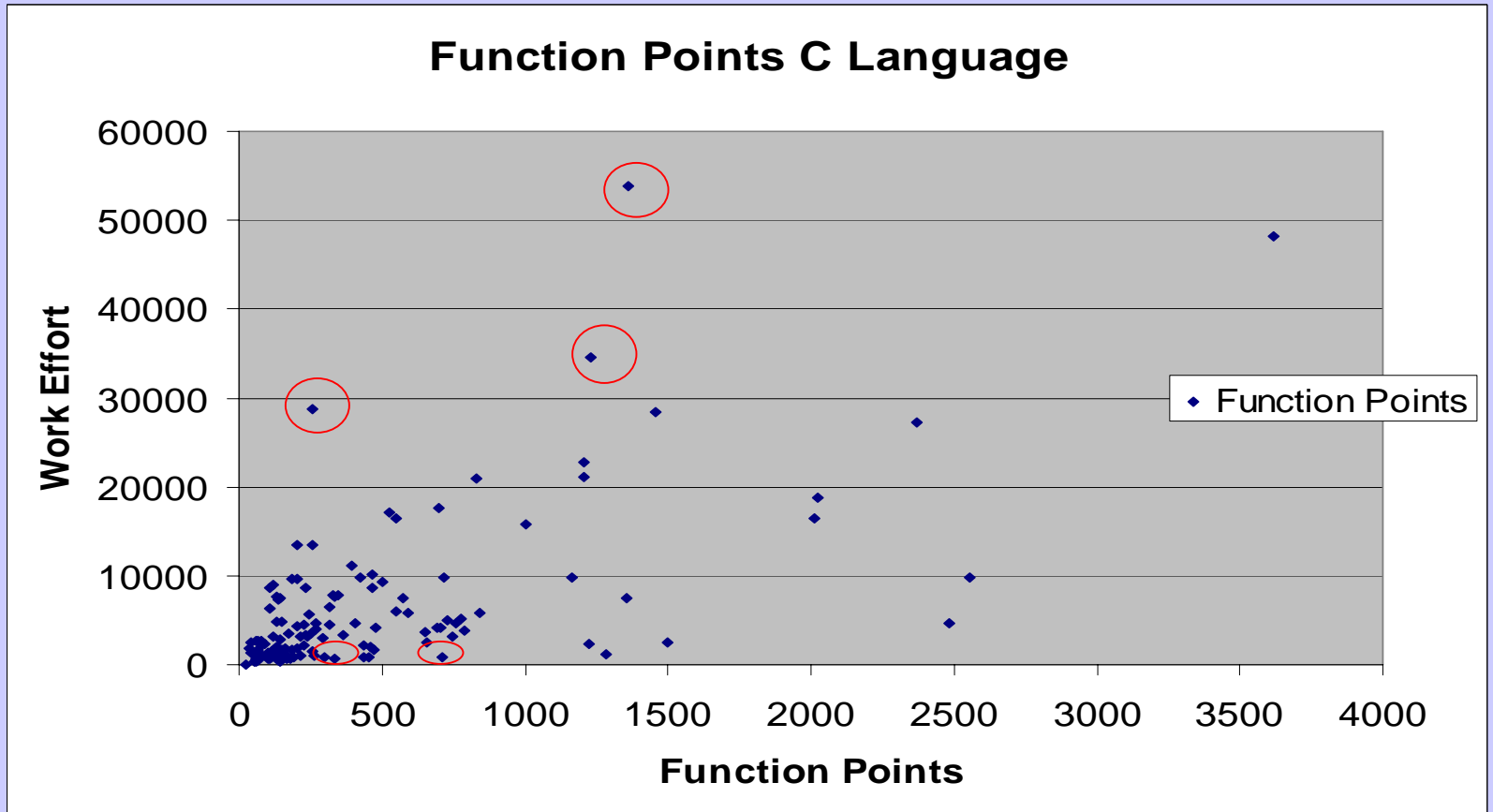
Requirements in ECSS-e40

- **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)
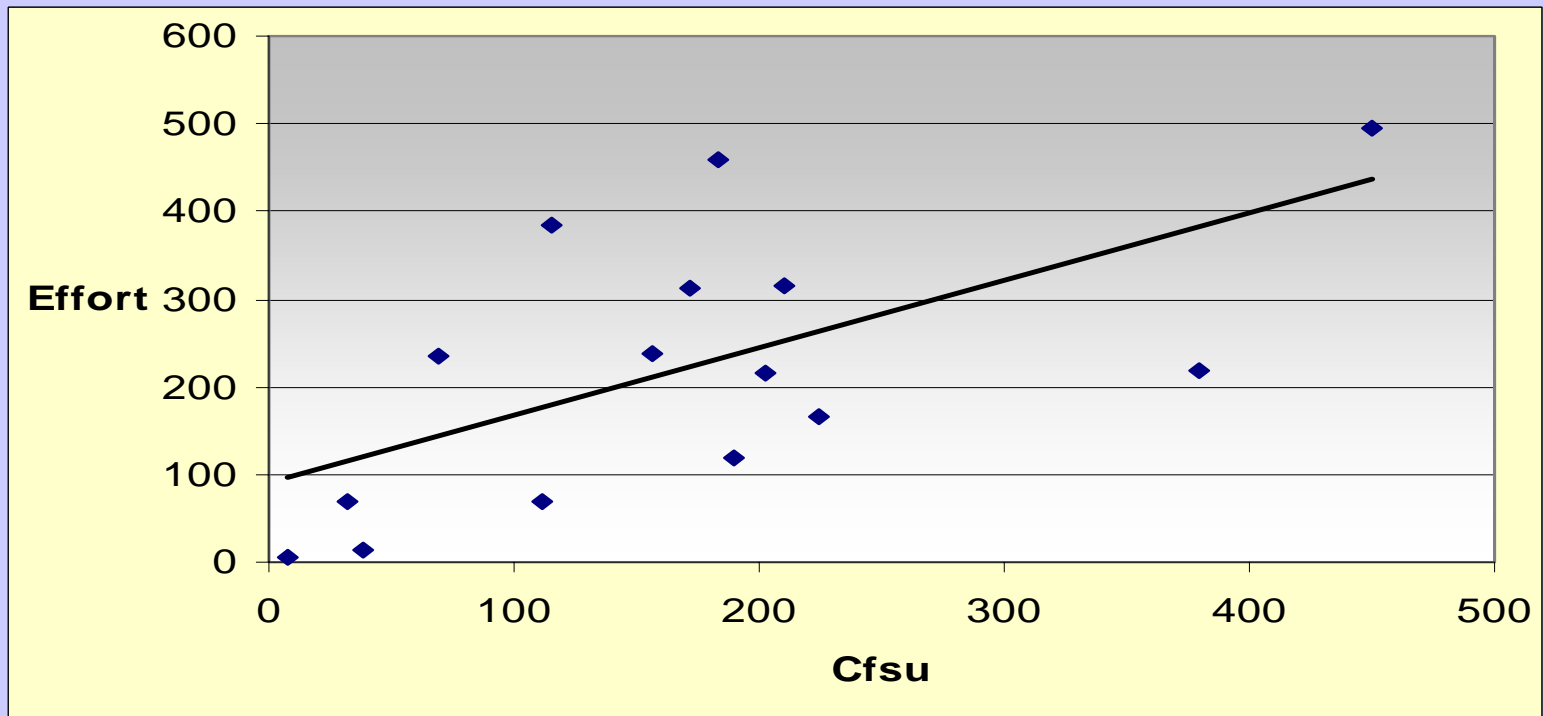
Université du Québec
École de technologie supérieure

Visual identification

Function Points C Language

Contents

- **Motivation and objectives**
- **Background**

Volume and effort estimation

- **Discussion and Conclusions**

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
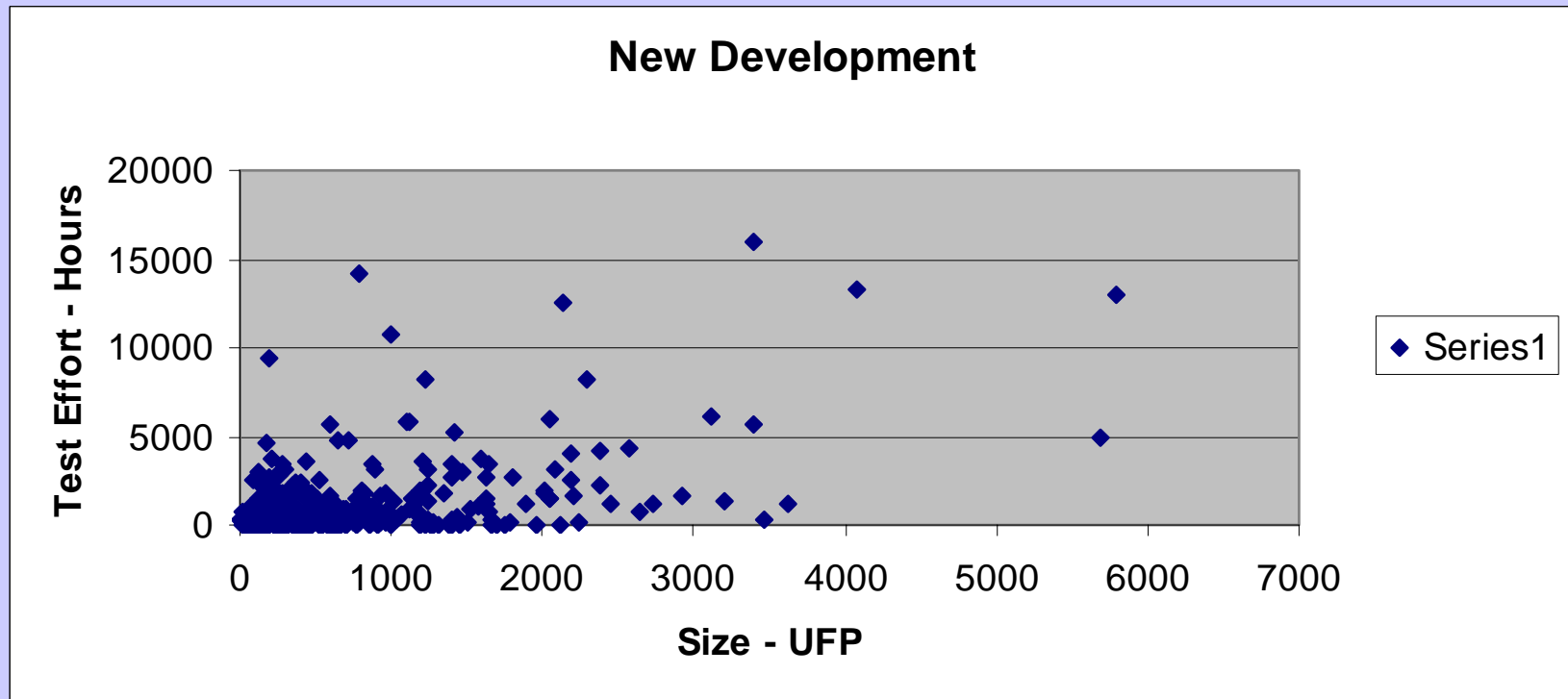 - For each type of requirement a 4-interval classification is defined

A project assessed

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

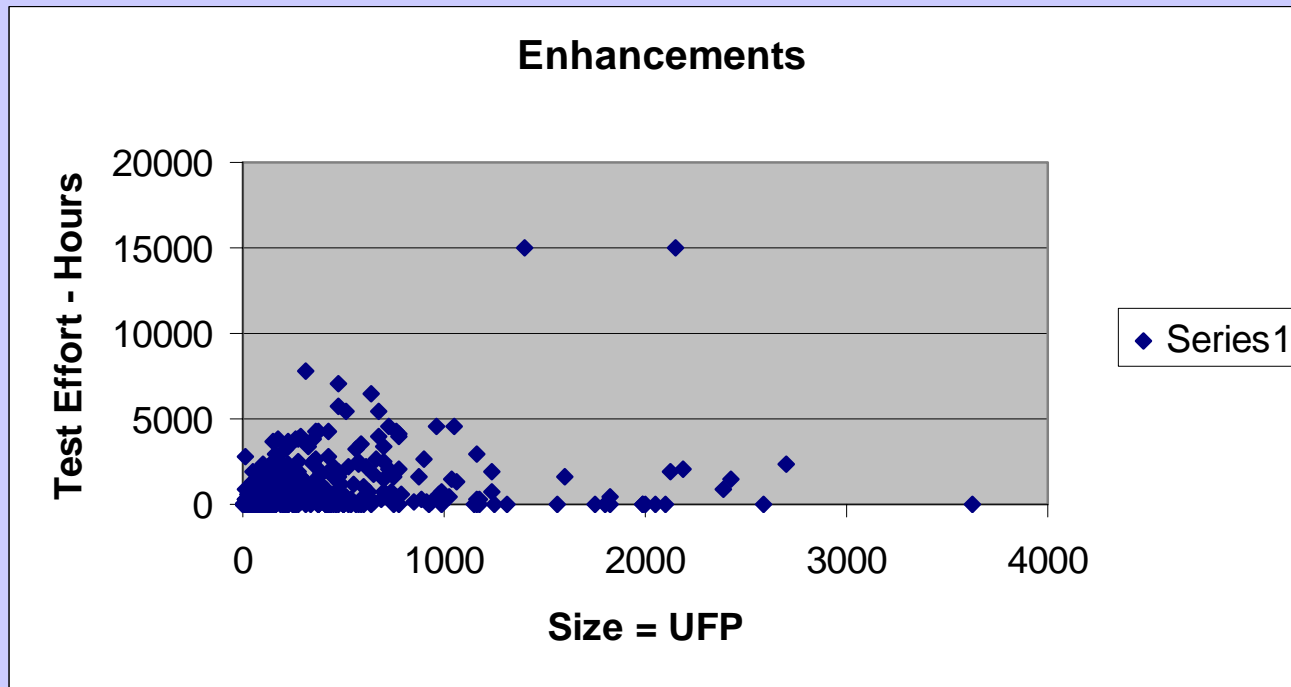## 556 projects of new software

New Development

Chart: Test Effort - Hours (y-axis, 0 to 20000) vs Size - UFP (x-axis, 0 to 7000). Series1.

ISBSG - Data set

502 enhancement projects

Université du Québec
École de technologie supérieure

Initial effort estimation

556 projects of new software

X Variable 1 Line Fit Plot
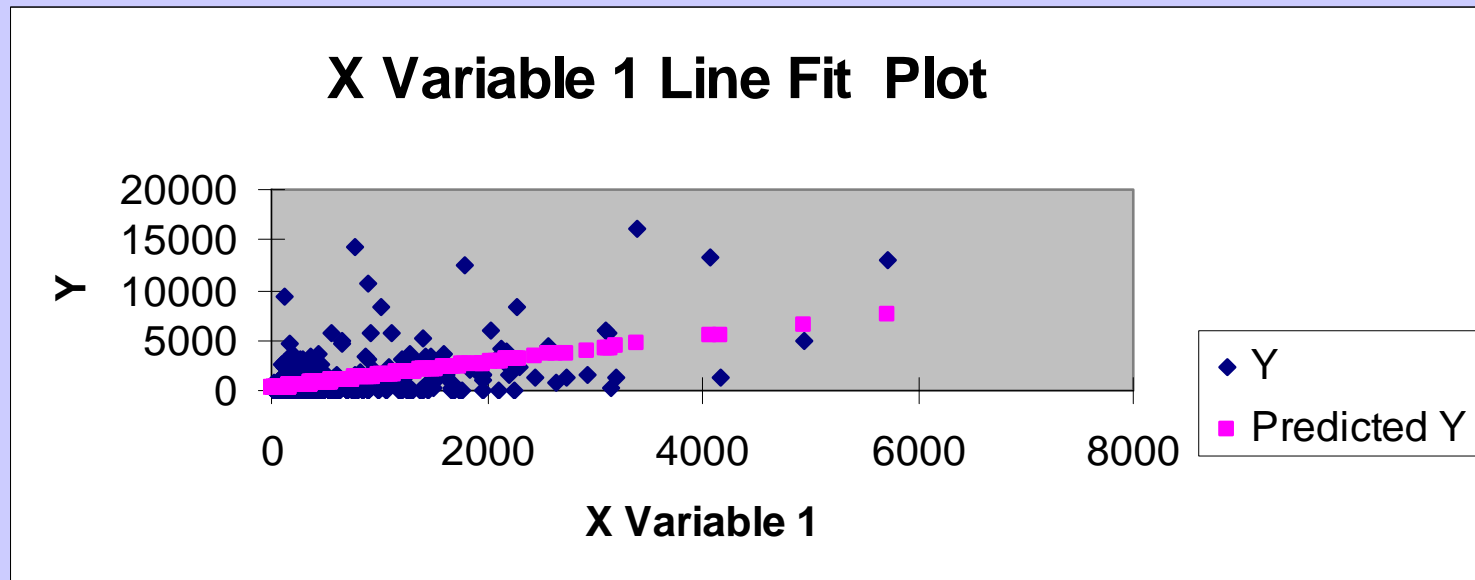
Regression model
V&V Effort = 1.3 *FP + 181 with an R^2 = .24

Initial effort estimation model

- **Based on functional test volume**
- **Regression model**

  V&V Effort = 1.3 *FP + 181 with an R^2 = .24

- **Effort = 1.3 * 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

very high

high

nominal

low

Size (FP)
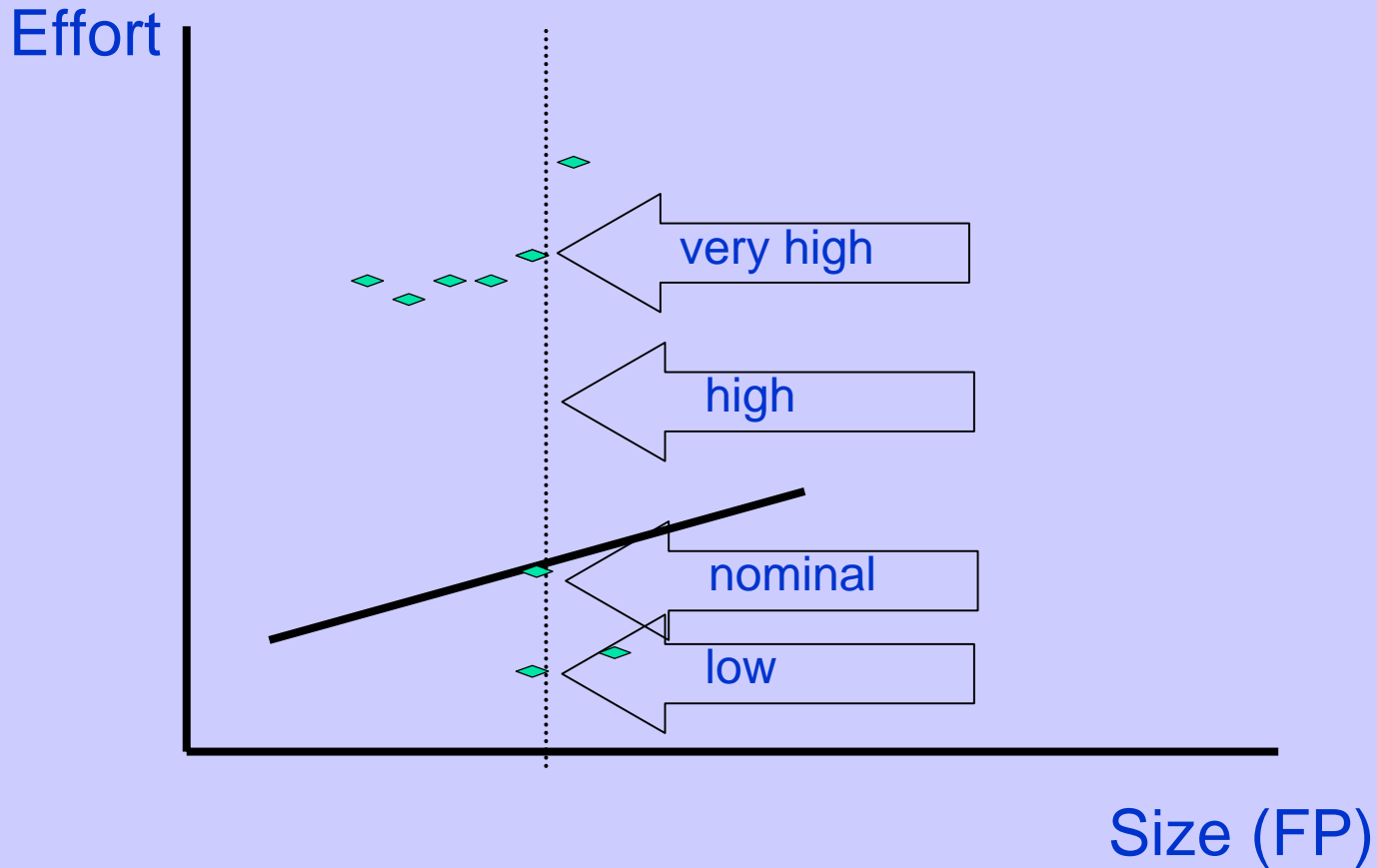
Example: a 14 project subset

- Y= 41+1.35xUFP; R^2= 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

	Types of requirements	Class 1	Class 2	Class 3	Class 4
		Low	**Nominal**	**High**	**Very High**
1	Performance requirements	Low			
2	Interface requirements	Low			
3	Operational requirements	Low			
4	Resource requirements			High	
5	Design req.& implementation constraints				Max
6	Security and privacy requirements			High	
7	Portability requirements		Nominal		
8	Software quality 1requirements	Low			
9	Software reliability requirements	Low			
10	Software maintainability requirements		Nominal		
11	Software safety requirements	Low			
12	Software configuration and delivery req.	Low			
13	Data definition and database req.				Max
14	Human factors related requirements	Low			
15	Adaptation and installation req.		Nominal		
16	Others requirements	Low			
	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

Non-functional interval class	Number within a class (1)	Effort on the data set for a class (2)	Impact (3) = (1) * (2)	Normalized value (= /16 classes) (4) = (3) / 16
Low	9	75 days	675	42
Nominal	3	176 days	528	33
High	2	263 days	526	33
Very high	2	350 days	700	44
Total	16		2429	152 days

Contents

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

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

Université du Québec
École de technologie supérieure

UPM
UNIVERSIDAD POLITÉCNICA DE MADRID

Discussion

A view for automation

Man Machine Interface

Monitoring

Software Engineering Environment

Code Generator

UUT
System/Unit Under Test

Infra-red

Caseml Repository

TOPEN

Gateway

· · 1..N

Test Results Analysis

MIB

Mission Information Base

DECODER

API Interface

HW Control