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

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

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- **Motivation and objectives**

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- Volume and effort estimation

- Discussion and conclusions

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 how their tasks
  - Cost factors
- Can we look at the estimation problem differently, that is from the client's perspective?
  - Functional requirements
  - Non-functional requirements

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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

- Motivation and objectives

Background

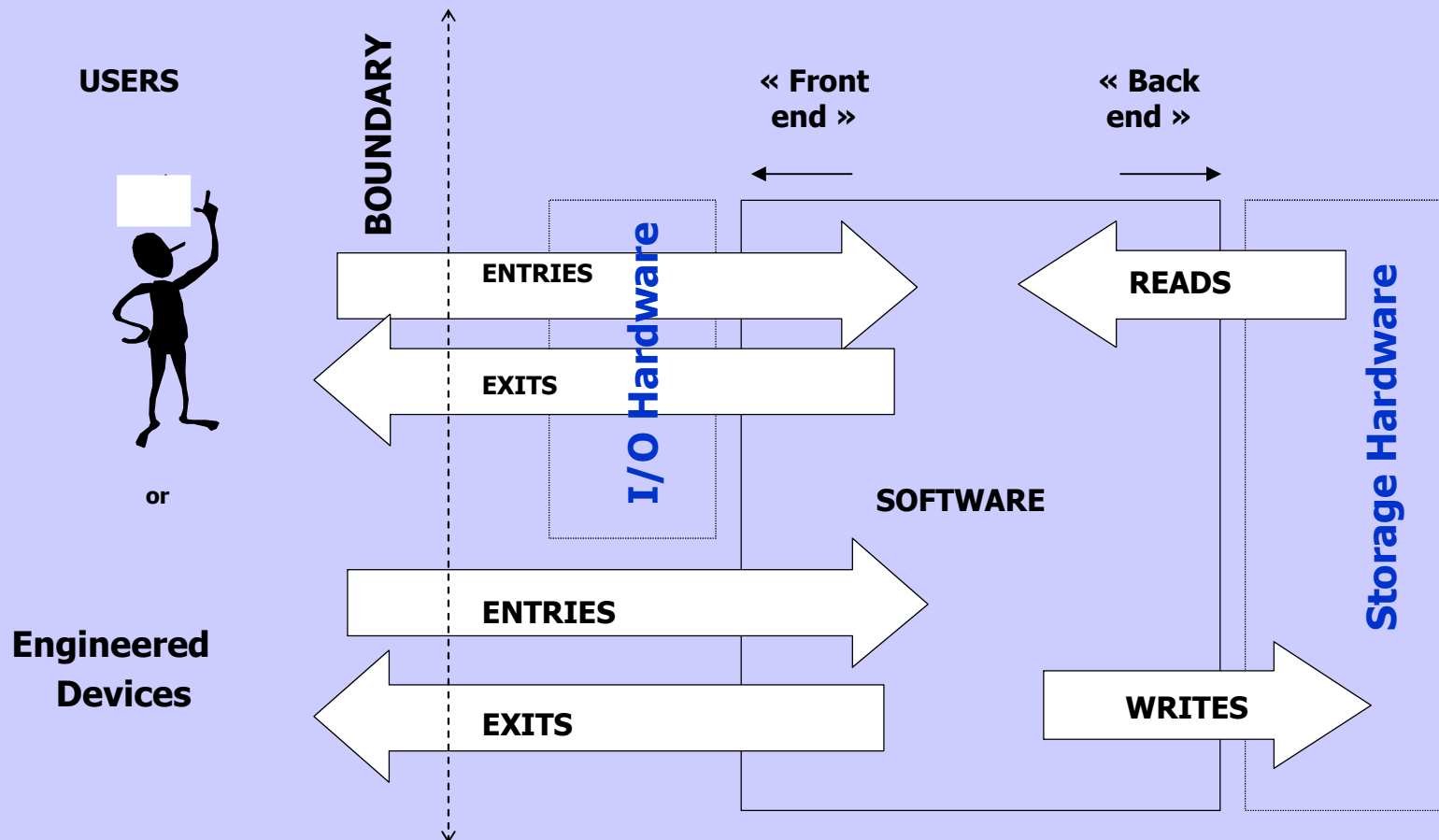- Volume and effort estimation
- Conclusions

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

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

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Cosmic-FFP concept

USERS

or

Engineered Devices

BOUNDARY

« Front end »   « Back end »

I/O Hardware

ENTRIES

EXITS

READS

SOFTWARE

ENTRIES

EXITS

WRITES

Storage Hardware

V&V engineering processes

- ## ECSS-e40 B

  - E-40 Part 1B Software – Part 1: Principles and requirements - 28 November 2003
  - E-40 Part 2B Software – Part 2: Document requirements definitions (DRDs) - 31 March 2005
  - Q-80BSoftware 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
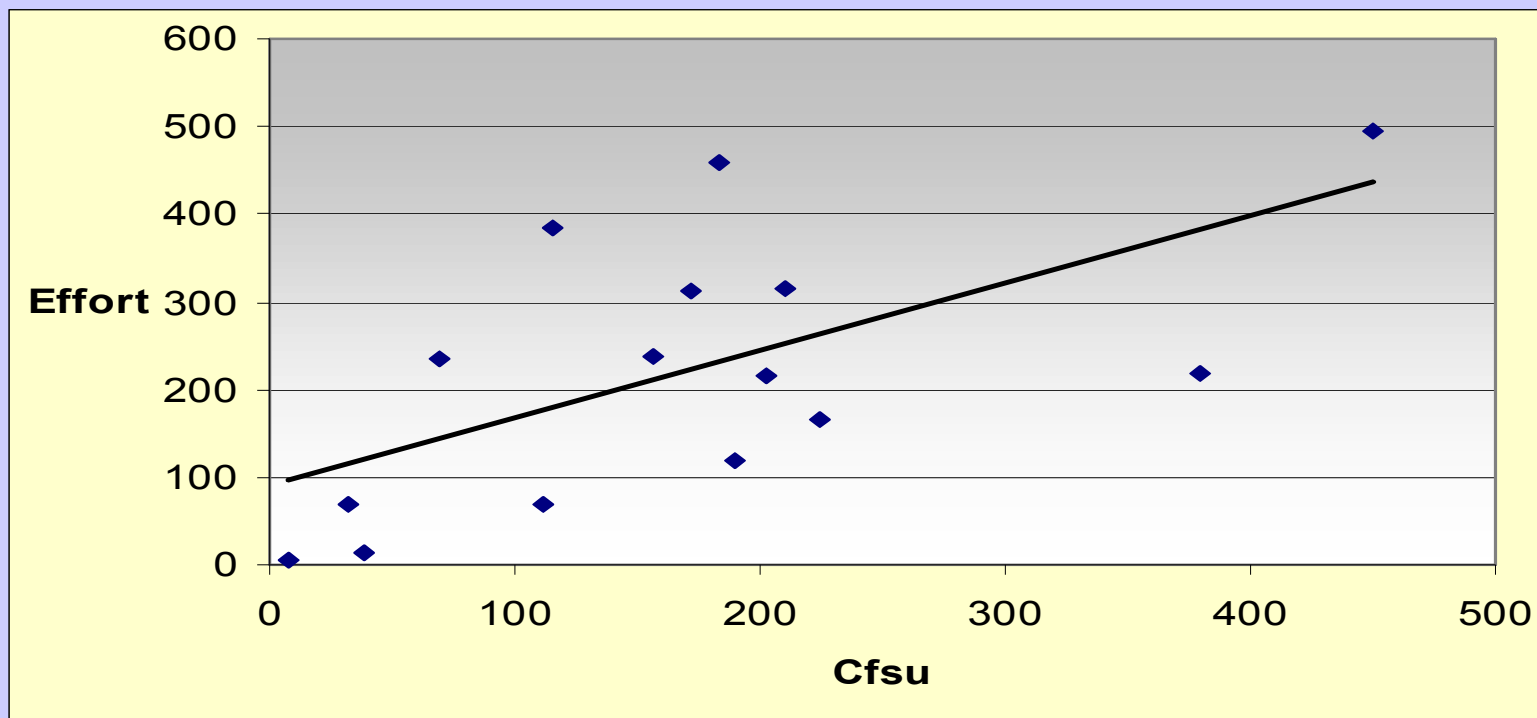- Others requirements

Case Study: Testing and V/V

- **How to estimate testing volume?**
- **How to estimate effort?**

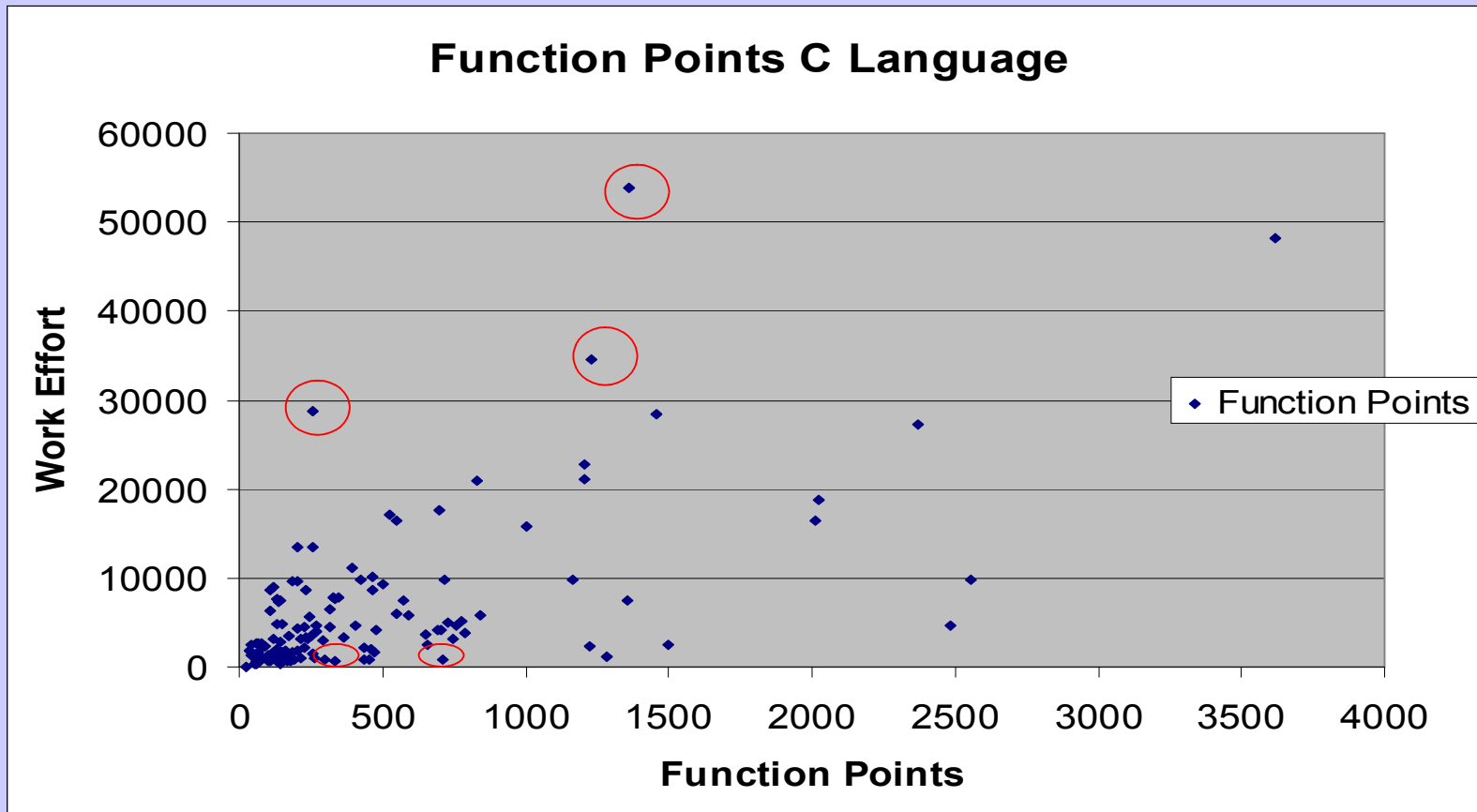- **Available data set: ISBSG release 9**

- **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

Function Points C Language

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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 classifyng
    - ### 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.
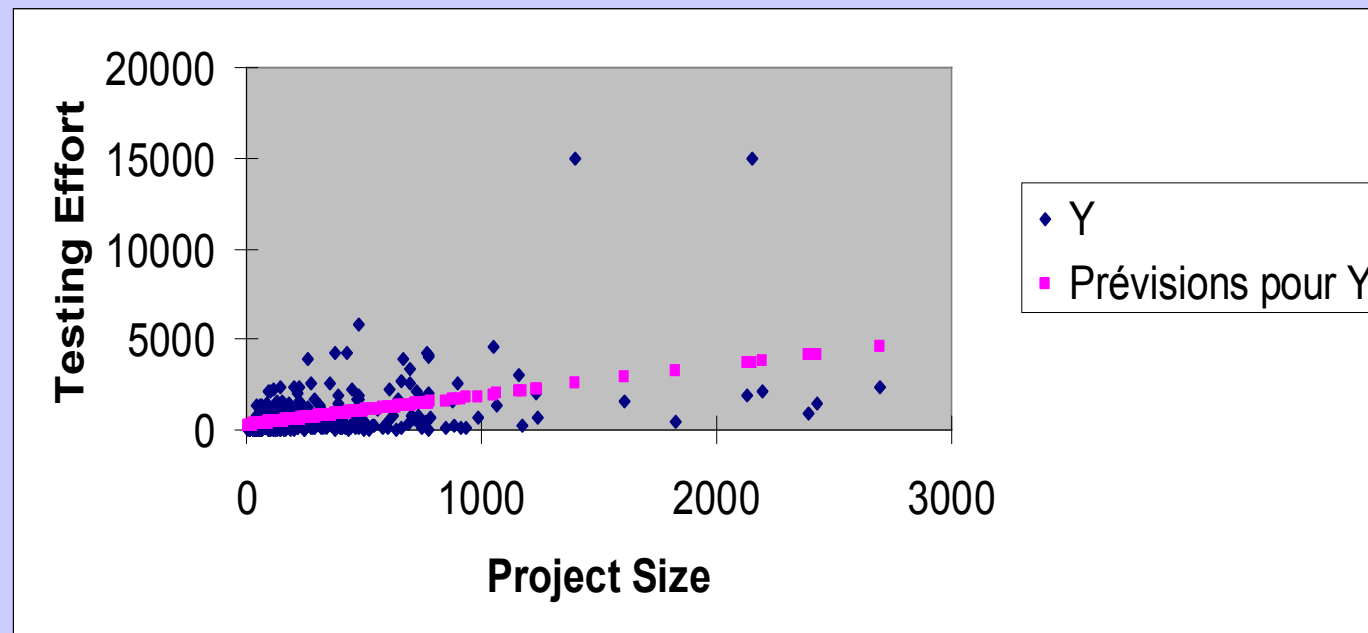
V&V functional test volume

292 projects of new software
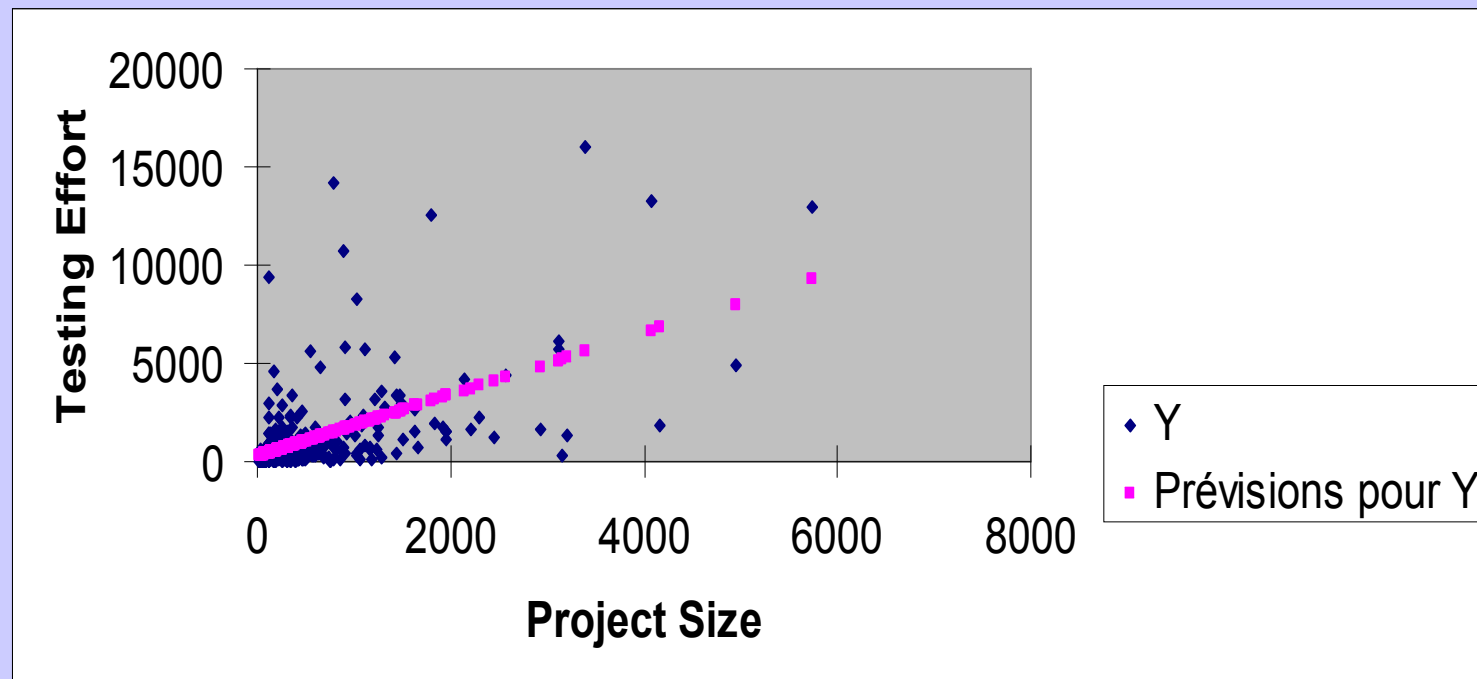
$$Effort = 1.57 \text{ hours/FP} \times No. \text{ of FP} + 248 \text{ hours}$$
$$\text{with an } R^2 = .31$$

ISBSG - Data set

366 enhancement projects

$$Effort = 1.63 \text{ hours/FP} \times No. \text{ of } FP + 236 \text{ hours}$$
$$R^2 = .20$$

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
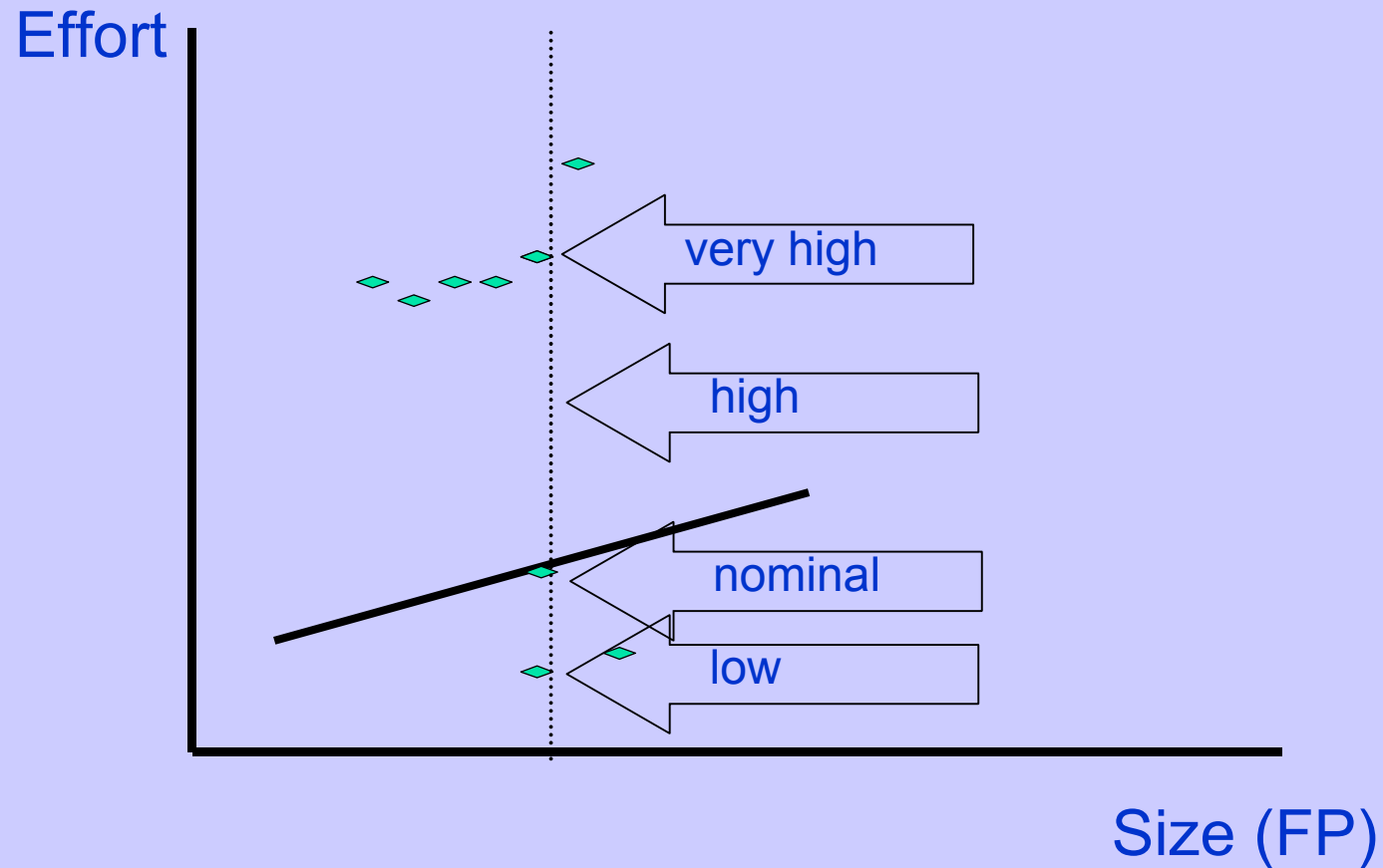
Non functional values estimates

- 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

	Types of requirements	Class 1	Class 2	Class 3	Class 4
		Low	Nominal	High	Very High
1	Performance requirements	Low			
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Estimations

Non-functional interval class	Number within a class (1)	Effort on the dataset for a class (2)	Impact (3) = (1) * (2)	Normalized value (= /16 classes) (4) = (3) / 16
Low	9	10 hours	90	6
Nominal	3	1,818 hours	5,454	341
High	2	8,409 hours	16,818	1,051
Very high	2	15,000 hours	30,000	1,875
Total	**16**		**52,362**	**3,273 hours**

Ranges at 1,000 FP for ISBSG
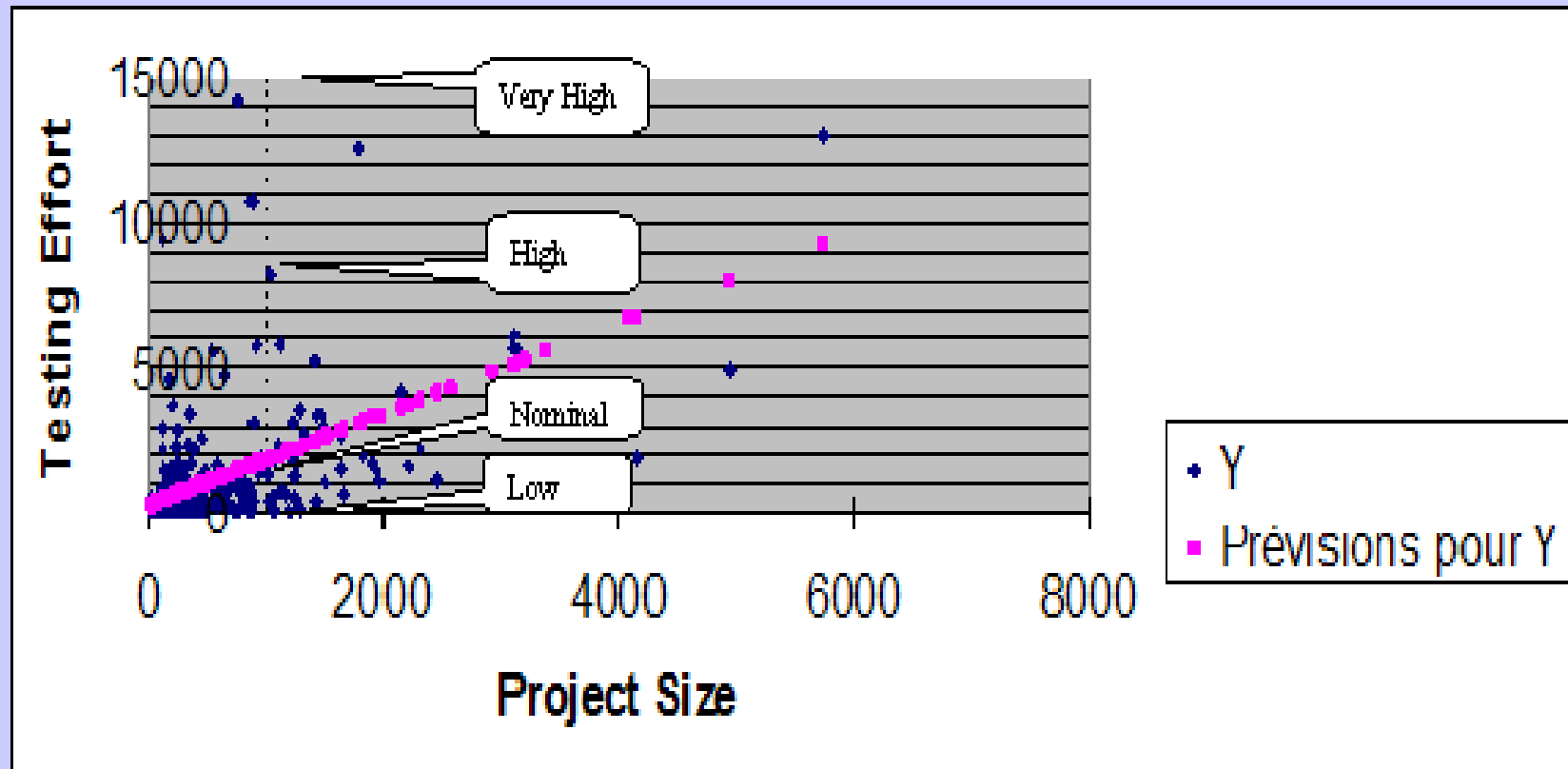
New Software projects - N = 292 projects

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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

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