

Verification and Validation Activities for Embedded Systems

A Feasibility Study on a Reading Technique for SysML Models

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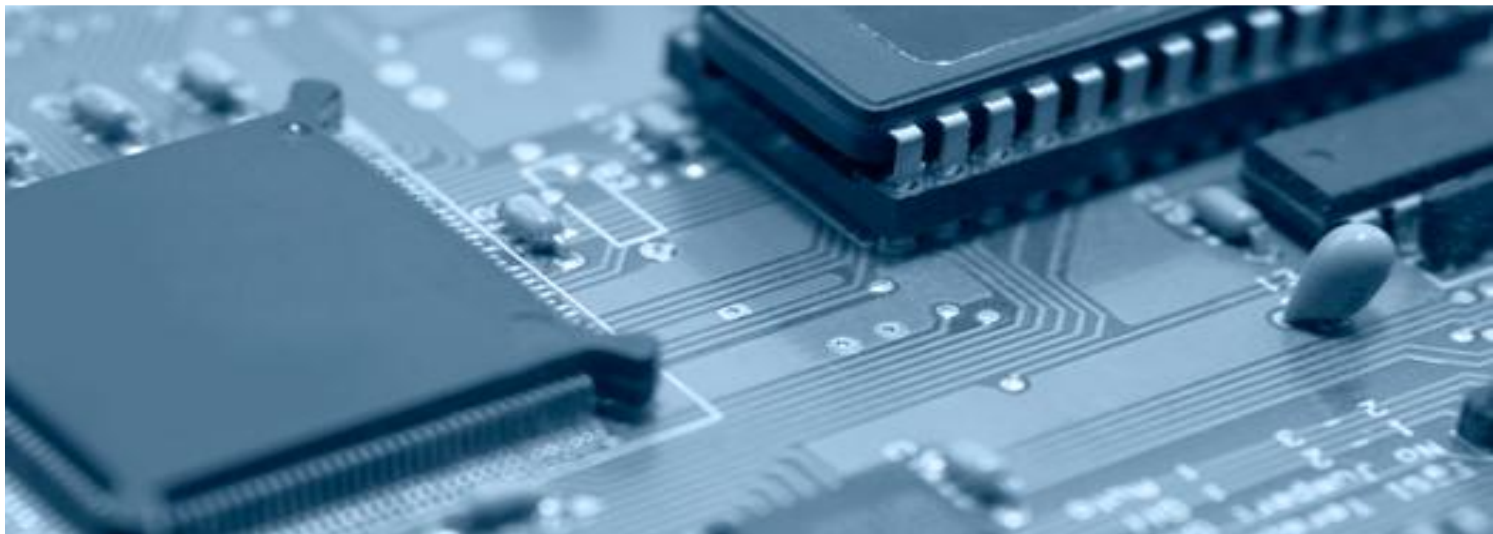


Guidelines

- Introduction
 - Motivations for Quality Control in Models
- Background
 - Systematic Mapping for V&V Activities
- A Family of RTs for SysML/Simulink Models (RTSS)
 - SYSMOD with RTSS
 - Characteristics of RTSS
- The Feasibility Study
- Conclusions

Embedded Systems (ES)

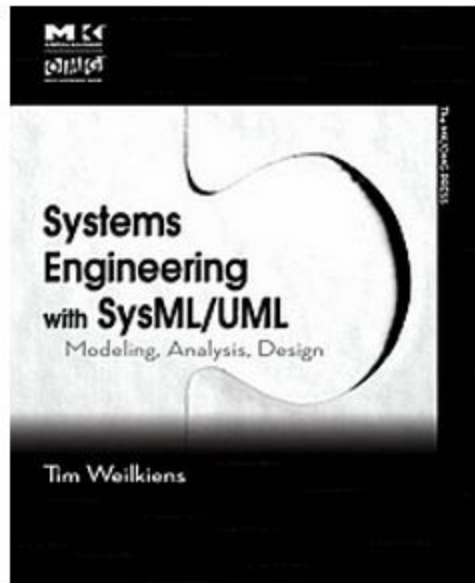
- ES are a central ingredient of technical products;
- They requires strict definition of **functional** and **non-functional requirements**:
 - Time constraints (real-time);
 - Reliability; and
 - Accurate requirements definition.



<http://www.embedded.fraunhofer.de/en.html>

Embedded Systems and Models

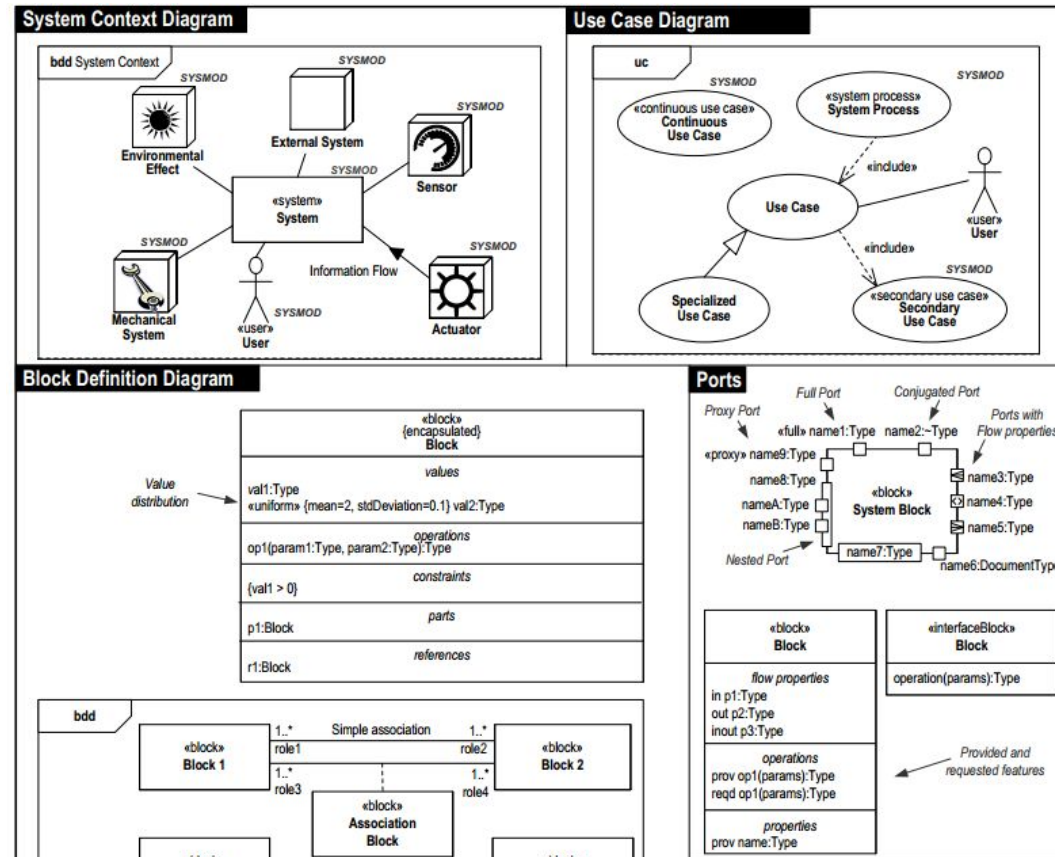
- To provide improvements in modelling for ES several approaches have been proposed, such as:
 - Unified Modeling Language (UML) and extensions RT and MARTE; and
 - SysML;
 - System Modelling (SYSMOD)



<http://sysmod.system-modeling.com/>

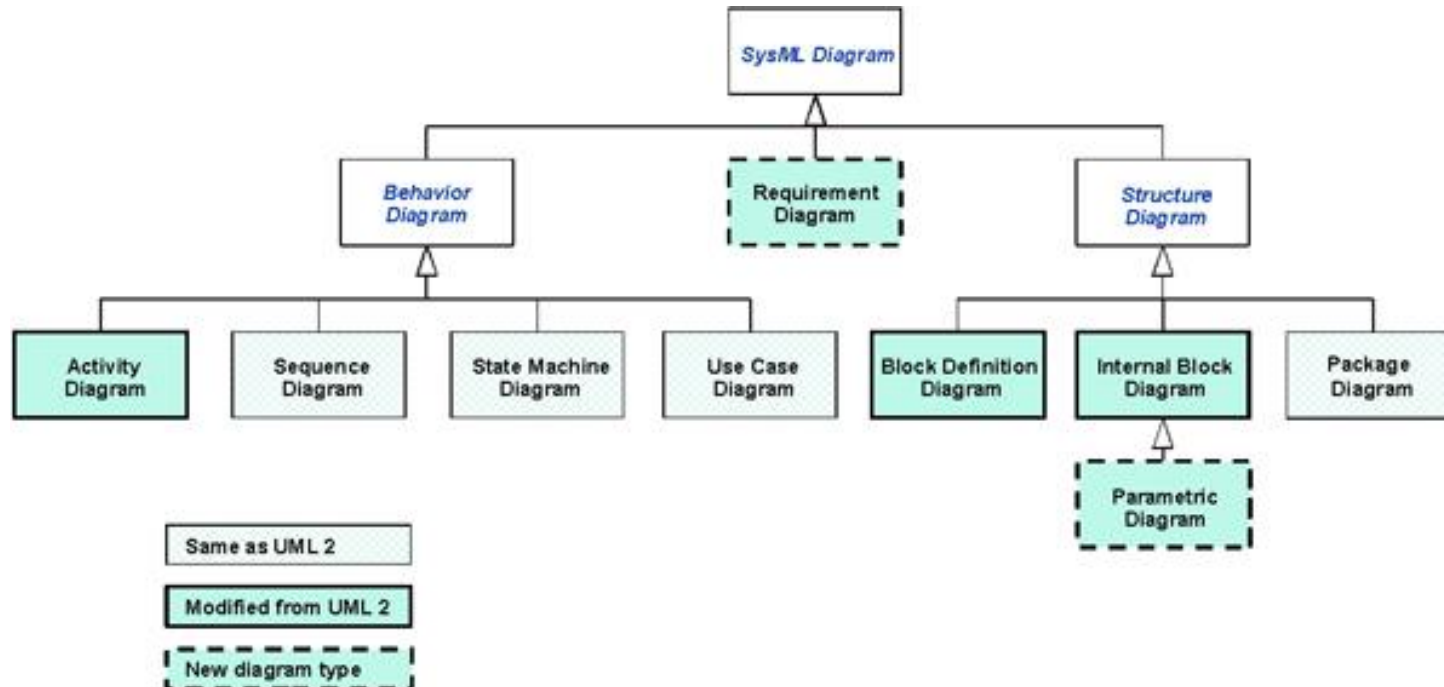
SYSMOD (1/3)

SYSMOD is a *top-down* process that uses the artifacts of the SysML language



<http://model-based-systems-engineering.com/>

SYSMOD and SysML (2/3)



SYSMOD process use several artifacts from SysML languages

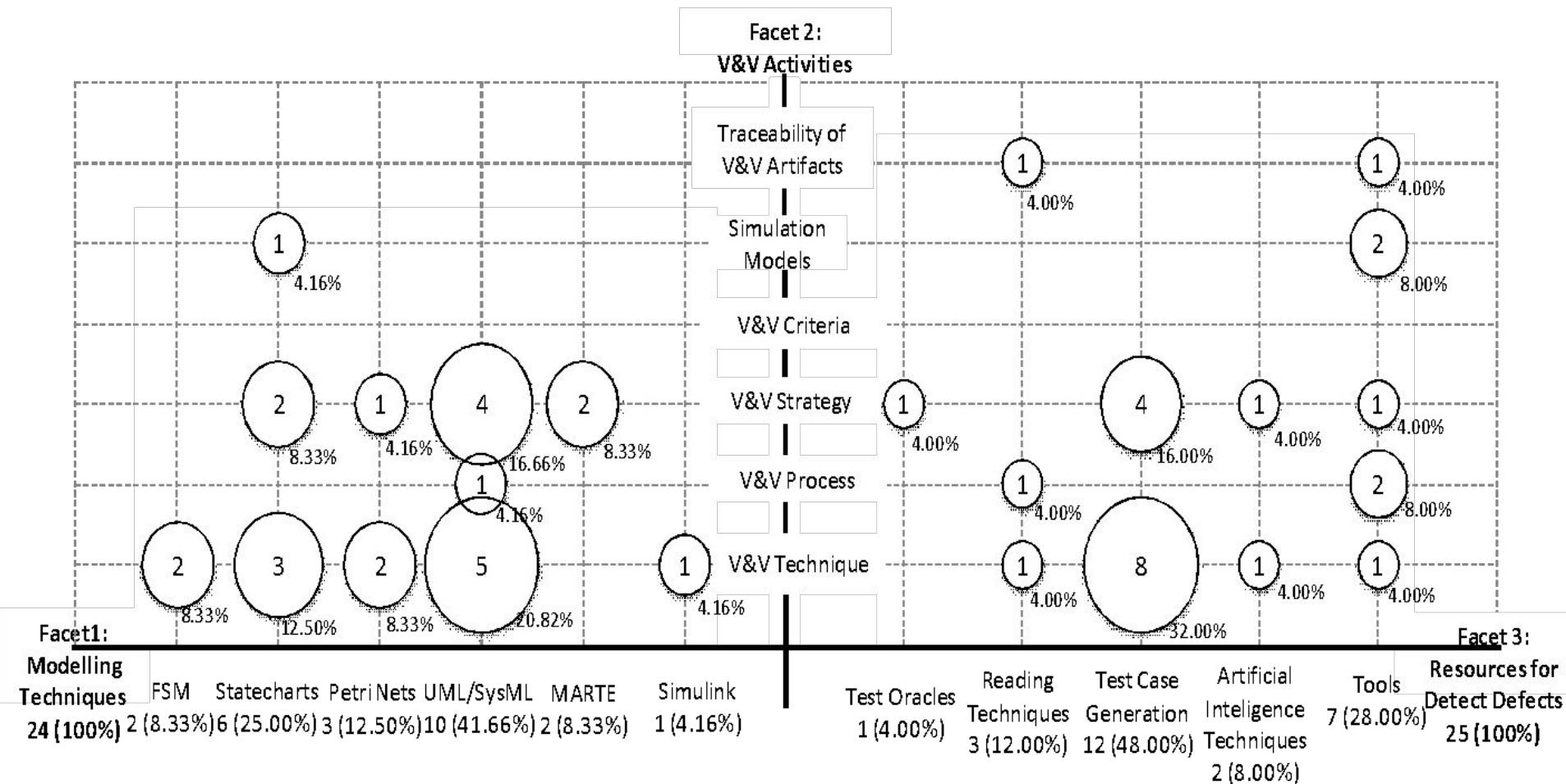
SYSMOD and SysML (3/3)

Despite the SYSMOD provide guidelines for modeling in SysML, **it don't have control quality points.**

Research Gap in V&V Activities

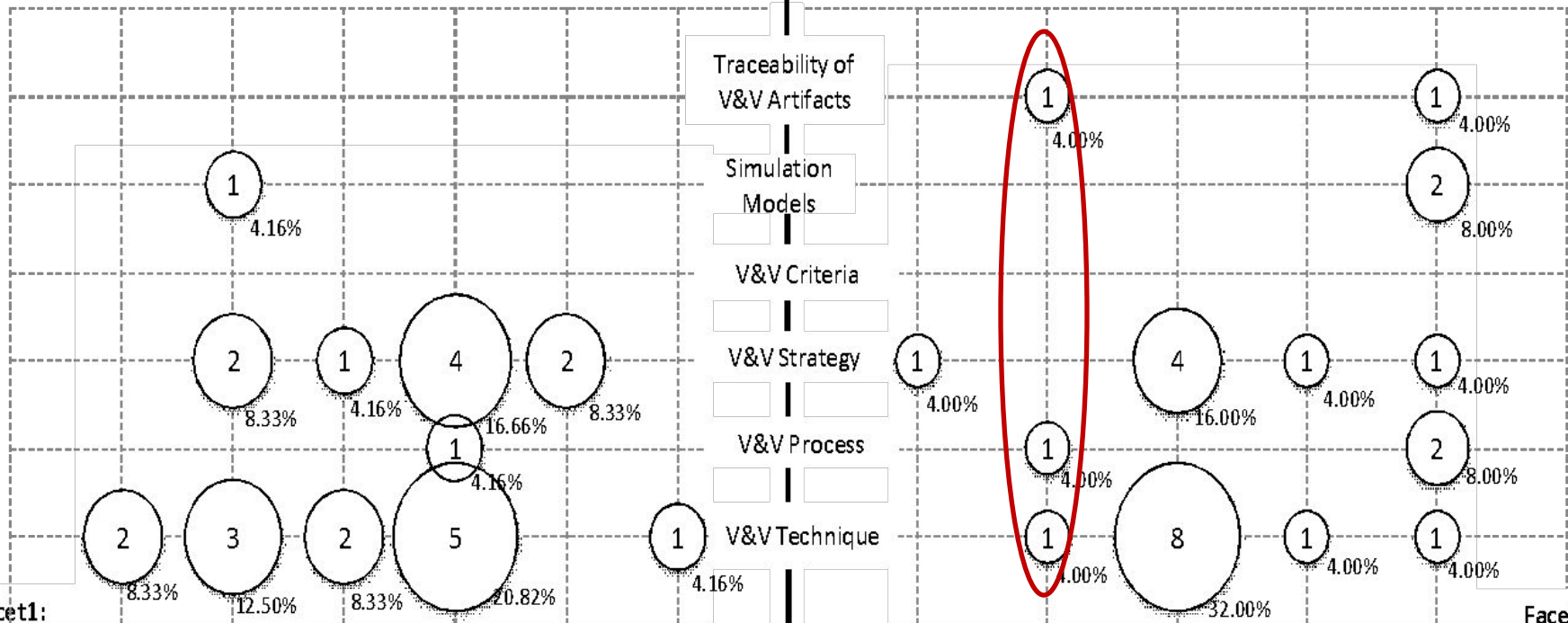
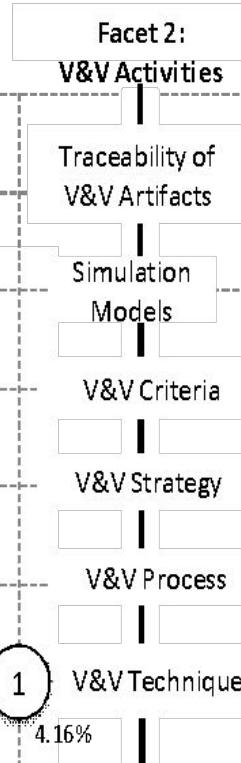
- To provide a round map about V&V Activities for Embedded Systems a Systematic Research (SM) was performed;
- The aim of the SM was identify *researches gap* in the context Embedded Systems; and
- The SM was performed, depicting V&V activities, modeling techniques and resources used

Systematic Mapping for V&V Activities



Systematic Mapping for V&V Activities

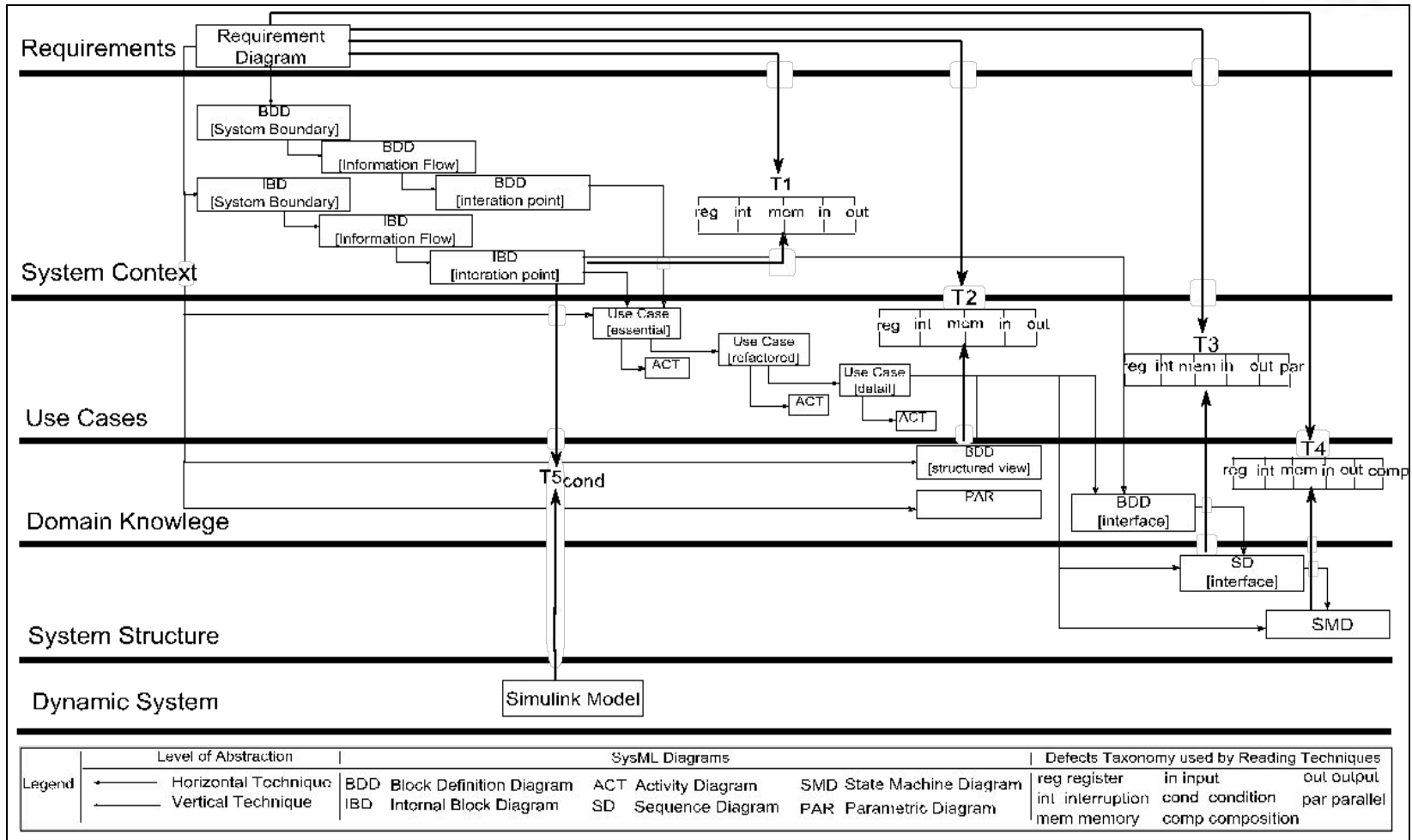
Denger, C., Ciolkowski, M., 2003. **High Quality Statecharts through Tailored, Perspective-Based Inspections**, in: EUROMICRO Conference. IEEE Computer Society, Los Alamitos, CA, USA, p. 316.



A Family of RTs for SysML Models and Simulink Models

Due to the importance V&V Activities for quality in software development, in particular, for SYSMOD and SysML/Simulink diagrams, **was defined a family of Reading Techniques (RTs) using the SYSMOD process as reference.**

RTSS in SYSMOD

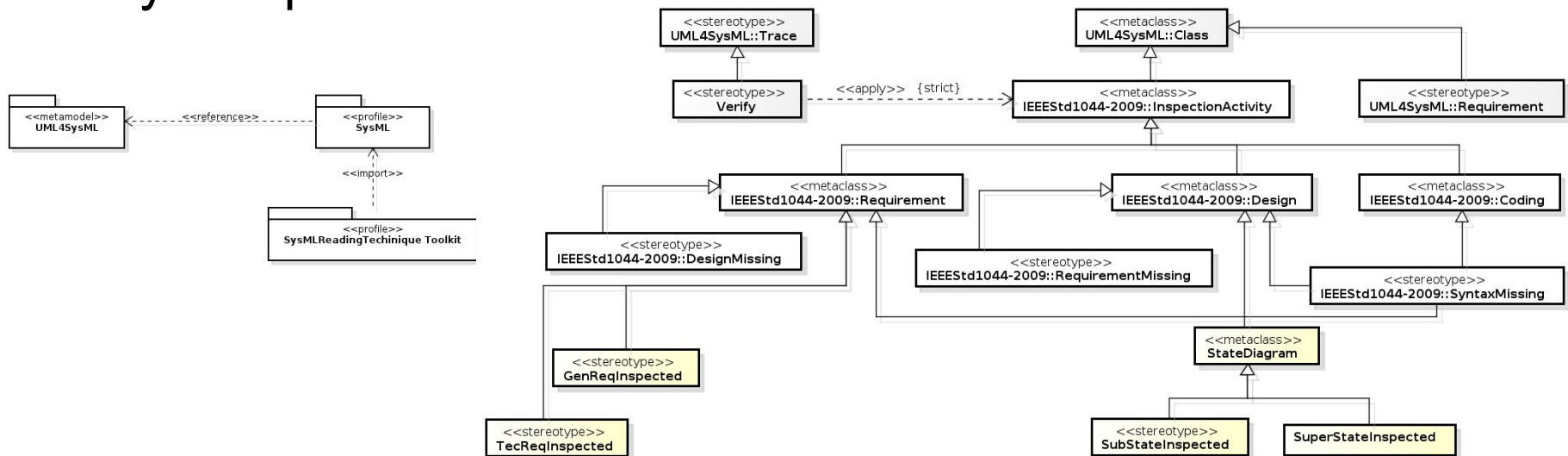


Characteristics of RTSS

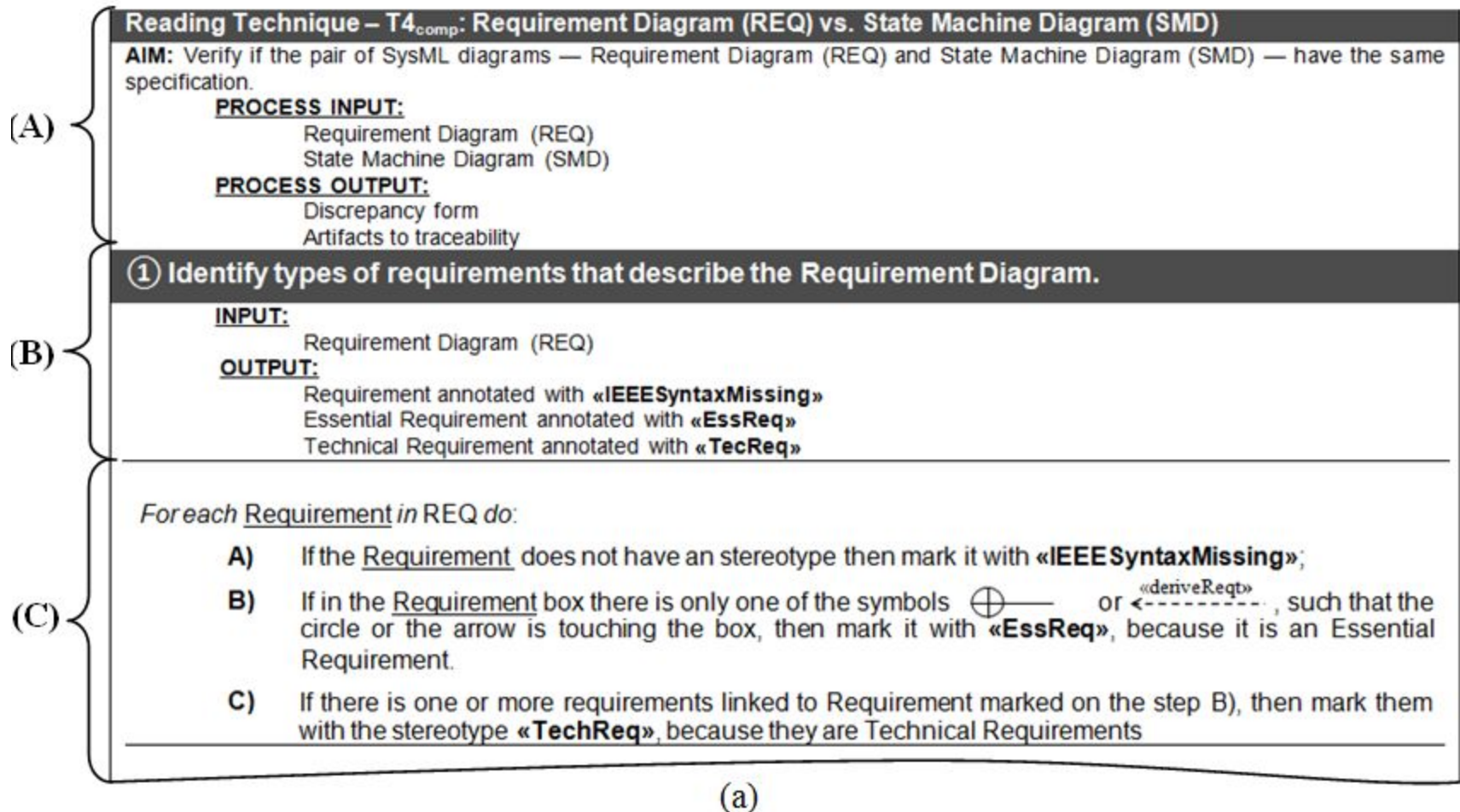
- RTSS verify if the transcription of information from one diagram to another diagram is correct using four fonts of defects:
 - **Taxonomy is based on the Std1044 IEEE-2009;**
 - provides a taxonomy of defects
 - **International Certification UL-98;**
 - provides commons terms associated with ES certification
 - **International Certification DO178C;**
 - provides commons terms associated with Aircraft certification
 - **Syntactic/Semantic properties of SysML language**
 - provides terms associated with SysML language

Characteristics of RTSS

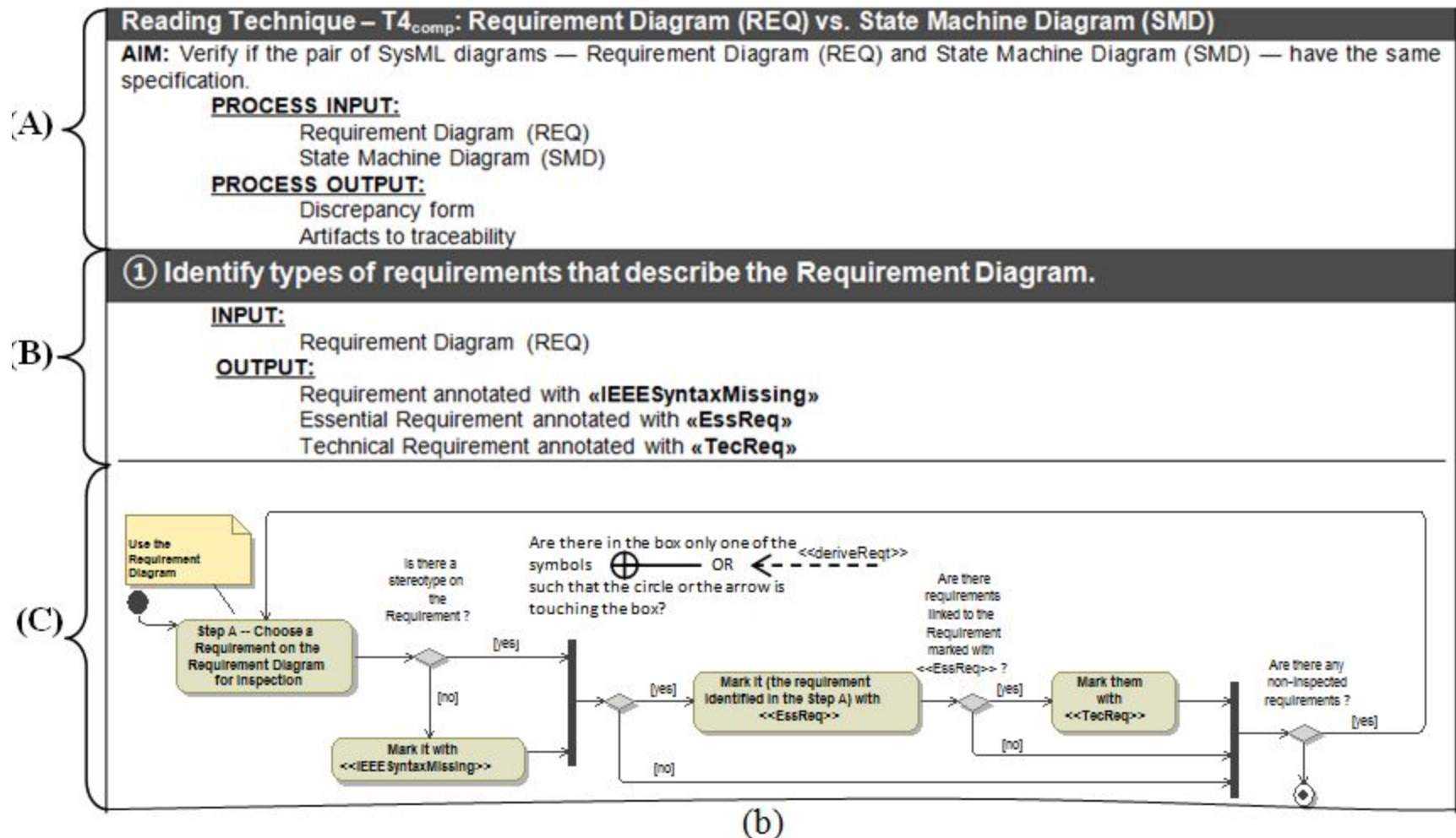
- The RTSS use a set of stereotypes to annotate the artifacts along to the inspection activity:
 - The stereotypes were created to performed inspection in SysML and Simulink models;
 - This stereotypes were created through by the extension of SysML profile.



RTSS – T4_{comp}(text)



RTSS – T4_{comp} (flowchart)



The Feasibility Study (1/3)

- The study was based on the main steps suggested by the Wohlin's experimental process. So two main questions were proposed:

(Q1) The main question aimed to evaluate if the Reading Technique $T4_{comp}$ is **feasible** to be used to inspect SysML models in terms of **effectiveness** and **efficiency**;

(Q2) The secondary question aimed to evaluate if the format the technique is written (Text or Flowchart) can interfere on the performance for identifying defects (**effectiveness** and **efficiency**).

The Feasibility Study (2/3)

- The GQM was structured as depicted below:

Analyze the Reading Technique $T4_{comp}$
For the purpose of evaluation
With respect to effectiveness and efficiency
From the point of view of the developer
In the context of undergraduate students

The Feasibility Study (3/3)

Group	Subjects	Reading Technique T4 _{comp}	Defects (a)	Time (b)	Effectiveness (a/20)	Efficiency (a/b)
G1	S ₁	Text	16	68	0.80	0.24
	S ₂		15	58	0.75	0.26
	S ₃		16	50	0.80	0.32
	S ₄		14	50	0.70	0.28
	S ₅		15	41	0.75	0.37
	S ₆		17	45	0.85	0.38
	S ₇		9	43	0.45	0.21
	S ₈		12	46	0.60	0.26
	S ₉		12	45	0.60	0.27
	S ₁₀		17	37	0.85	0.46
	S ₁₁		10	40	0.50	0.25
	S ₁₂		12	40	0.60	0.30
	S ₁₃		18	50	0.90	0.36
	S ₁₄		15	47	0.75	0.32
G1 Average (μ)			14.1	47.15	0.70	0.30
G2	S ₁₅	Flowchart	14	73	0.70	0.19
	S ₁₆		14	65	0.70	0.22
	S ₁₇		17	62	0.85	0.27
	S ₁₈		15	60	0.75	0.25
	S ₁₉		12	55	0.60	0.22
	S ₂₀		20	49	1.00	0.43
	S ₂₁		11	60	0.55	0.18
	S ₂₂		18	50	0.90	0.36
	S ₂₃		14	46	0.70	0.30
	S ₂₄		11	35	0.55	0.31
	S ₂₅		14	40	0.70	0.35
	S ₂₆		14	45	0.70	0.31
G2 Average (μ)			14.5	53.33	0.72	0.28
Average (μ) of the G1 and G2			μ= 14	μ = 50	μ = 0.72	μ = 0.30

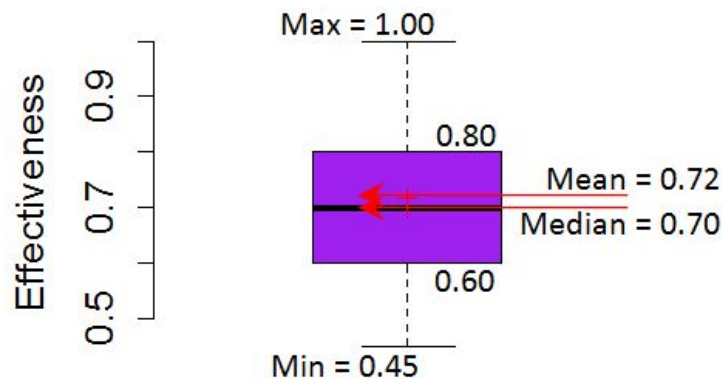
Research Question Q1 (1/2)

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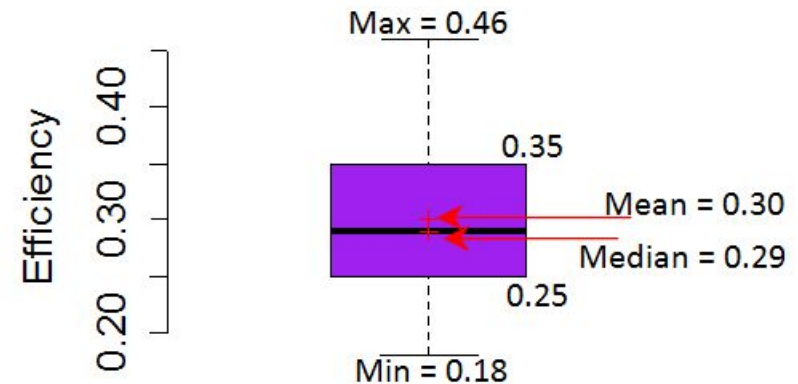
To answer the research question Q1



Research Question Q1 (2/2)



Reading Technique T4
Effectiveness of T4_{comp}.



Reading Technique T4
Efficiency of T4_{comp}.

(*) According to the hypotheses defined the Reading Technique T4_{comp} is feasible to be used to inspect SysML models in terms of effectiveness and efficiency

Research Question Q2 (1/2)

Group	Subjects	Reading Technique T4 _{comp}	Defects (a)	Time (b)	Effectiveness (a/20)	Efficiency (a/b)
G1	S ₁	Text	16	68	0.80	0.24
	S ₂		15	58	0.75	0.26
	S ₃		16	50	0.80	0.32
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G2 Average (μ)			14.5	53.33	0.72	0.28
Average (μ) of the G1 and G2			μ= 14	μ= 50	μ= 0.72	μ= 0.30

To answer the research question Q2



To answer the research question Q2



Research Question Q2 (2/2)

- Applying F-test statistic test, both failed to reveal a significant effect for the G1 ($p = 0.9853$) and G2 group ($p = 0.8290$);
- Therefore, we can say that **there is no significant difference in applying T4 in text format or flowchart format.**

Conclusions and Future works

- A family of RTs (RTSS) has been proposed from the feasibility study carried out;
- This work described the contribution of a reading technique ($T4_{comp}$) for detecting defects in SysML models;
- The results indicated that more than 70% of the defects were identified by at least 50% of the subjects;
- Feasibility study allowed that there is no difference in the effectiveness and efficiency for defects identification, independently of the format used (text or flowchart).
- Other RTs were defined in a similar way and nowadays other experimental studies are being conducted to evaluate the other techniques;



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