MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

esa simulation & egse facilities for space programmes
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European Space Agency

Analysis of the Simulation Model Platform Adoption in the Context of INPE's Simulators

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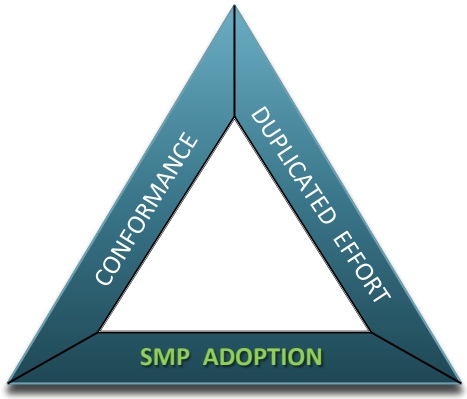
Objectives

Assessment of INPE's satellite simulators concerning to:



Conformance Level

Compliance with *Facilities Specific* defined by technical memorandum *System Modelling and Simulation (ECSS-E-TM-10-21A*), aiming to evaluate the effort needed to use these simulators in different phases of a space mission.

Duplicated Effort

The amount of rework in the simulators development**.**

SMP Adoption

Whether the SMP adoption could aggregate complementary effort and reduce rework in the simulators development.

Analysed Simulators

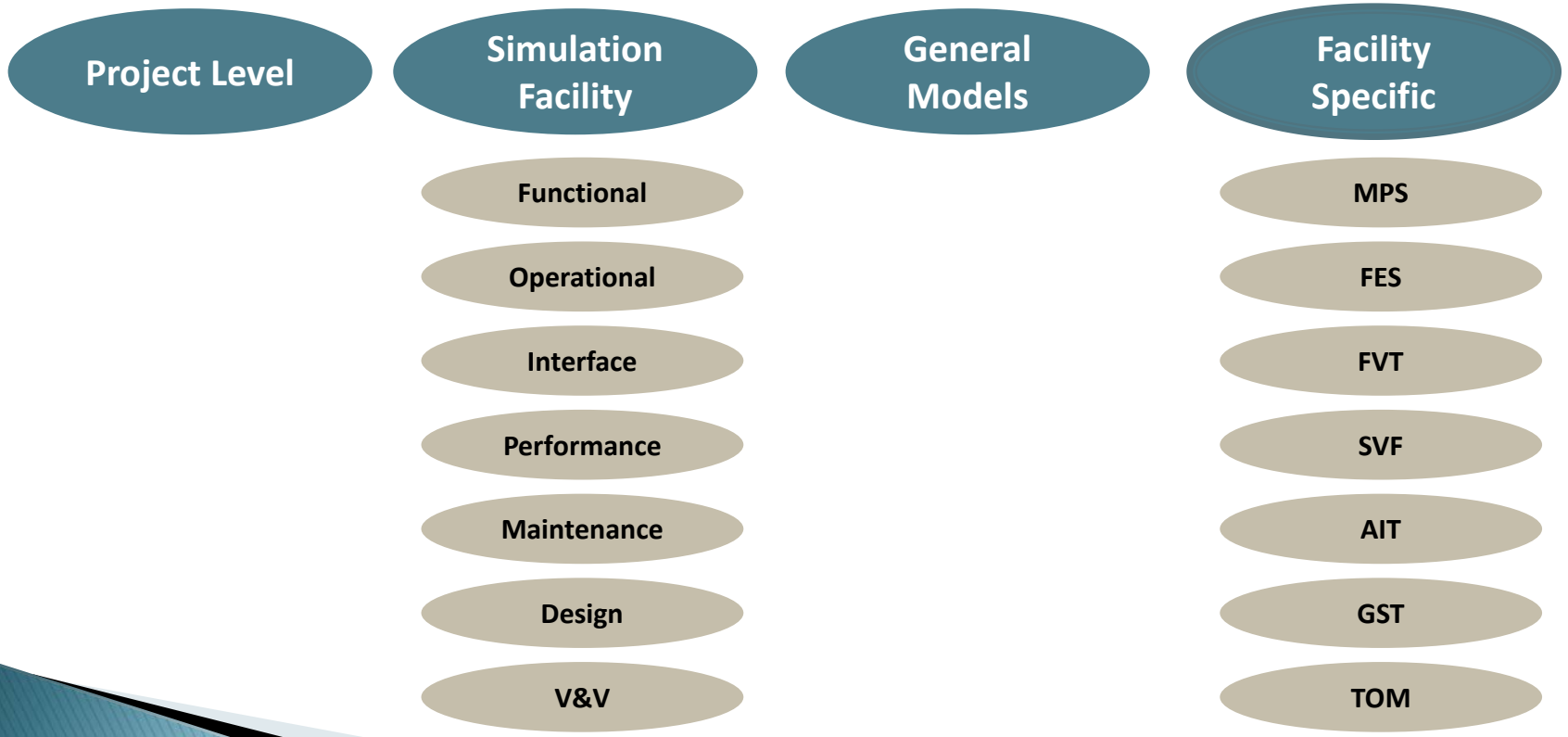
Simulators

SIM-A	SIM-B	SIM-C
• Operator training • Validation of operational procedures.	• System & Mission analysis • OBSW and OBC V&V • V&V of associated equipment.	• OBSW and OBC V&V • V&V of associated equipment.

The assessment process has been implemented based on simulators requirement documentation and expert knowledge.

Requirements Selection

Selection and classification of requirements from ECSS-E-TM-10-21A into different sets according to their relevance to our research.



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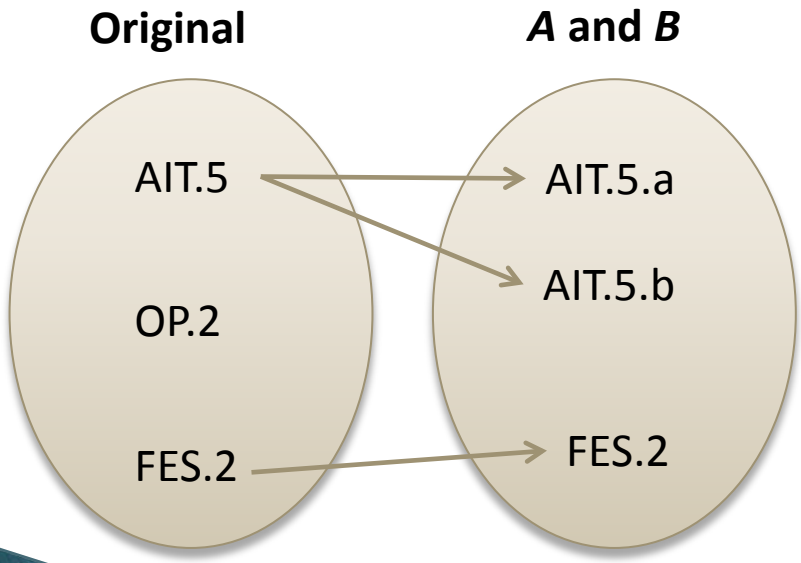

SIM.AIT.5 "*The spacecraft AIV simulator shall have the following configurations: Software only; SW + HITL (real equipment)* - **decomposed**

- SIM.AIT.5.a "*The spacecraft AIV simulator shall have the following configuration: Software only*"
- SIM.AIT.5.b "*The spacecraft AIV simulator shall have the following configuration: SW + HITL (real equipment)*

SIM.OP.2 "*The basic MMI functionalities required shall be described*" - **eliminated**

SIM.FES.2 "*The FES shall be able to perform open and close loop simulations*" - **maintained**

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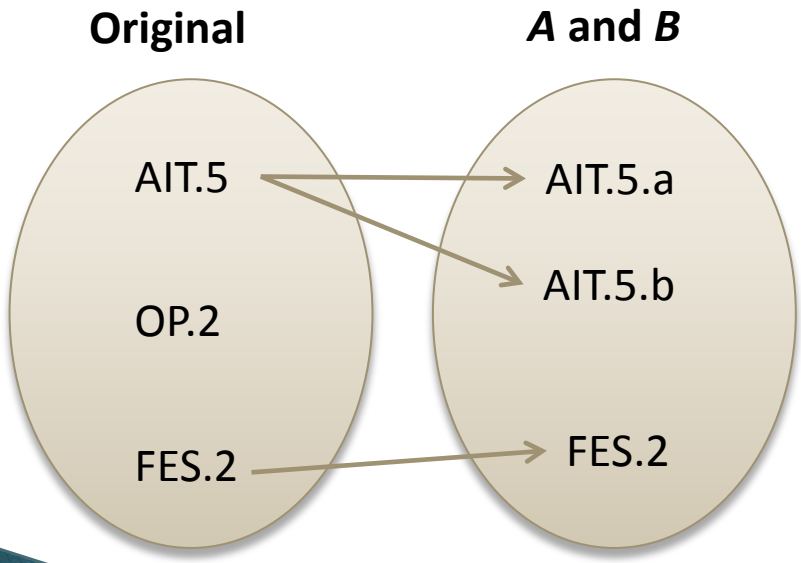
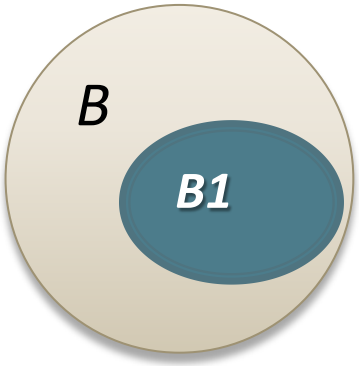


		Total Number of requirements	
		Original	Set *A*
Simulation Facility	FU	22	32
	OP	9	8
	IF	6	4
	PE	6	0
	DE	13	8
	MO	14	0
	VV	2	0

		Total Number of requirements	
		Original	Set *B*
Facility Specific	SCS	6	6
	MPS	2	5
	FES	6	15
	FVS	3	9
	SVF	6	21
	AIT	21	31
	GST	8	14
	TOM	7	15

Requirements Selection



SET *B*: complete requirement set (Facility Specific).

SET *B1*: typical requirement set (Facility Specific).

Example:

✓SIM.MPS.2-a "*The facility shall include modelling of Instruments and payloads*" **(typical requirement -> included in B1)**

✓SIM.AIT.4-a "*The simulator shall be automatically configurable with data stored in the spacecraft database*" **(common requirement -> not included in *B1*)**

		Total Number of requirements		
		Original	Set *B*	Set *B1*
Facility Specific	SCS	6	6	4
	MPS	2	5	4
	FES	6	15	7
	FVS	3	9	10
	SVF	6	21	15
	AIT	21	31	20
	GST	8	14	12
	TOM	7	15	10

Assessing the Conformance Level

For each simulator evaluated, a compliance score was given for all requirements belonging to sets *A*, *B* and *B1.*

0 - not compliant (NC)
1 - lowly compliant (LC)
2 - moderately compliant (C)
3 - highly compliant (HC)

From these scores, the compliance level was calculated using:

$$\Gamma^k = \frac{1}{3N}\sum_{i=1}^{N} s_i^k$$

Where: *s* is the score of requirement i of simulator k, and N=|A| is the number of elements in set A.

		SIM-B
1	SIM.FVT.1.a	0
2	SIM.FVT.1.b	2
3	SIM.FVT.1.c	1
4	SIM.FVT.2.a	3
5	SIM.FVT.2.b	0
6	SIM.FVT.2.c	3
7	SIM.FVT.2.d	3
8	SIM.FVT.2.e	3
9	SIM.FVT.3.a	3
Compliance Level		18 / (3 * 9)
		66,7 %

Computing the Duplicated Effort

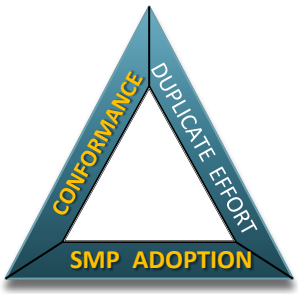
The number of requirements which are implemented by more than one of INPE's simulators .

Implemented Requirement – > score equal or greater than 2 (C or HC).

For example:

✓SIM.AIT.4-a implemented by 2 simulators -> +1 for ***Required Effort*** and +1 for ***Rework***

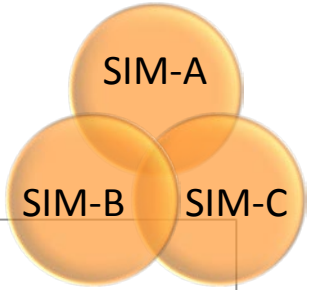
✓SIM.MPS.2-c implemented by 3 simulators-> +1 for ***Required Effort*** and +2 for ***Rework***

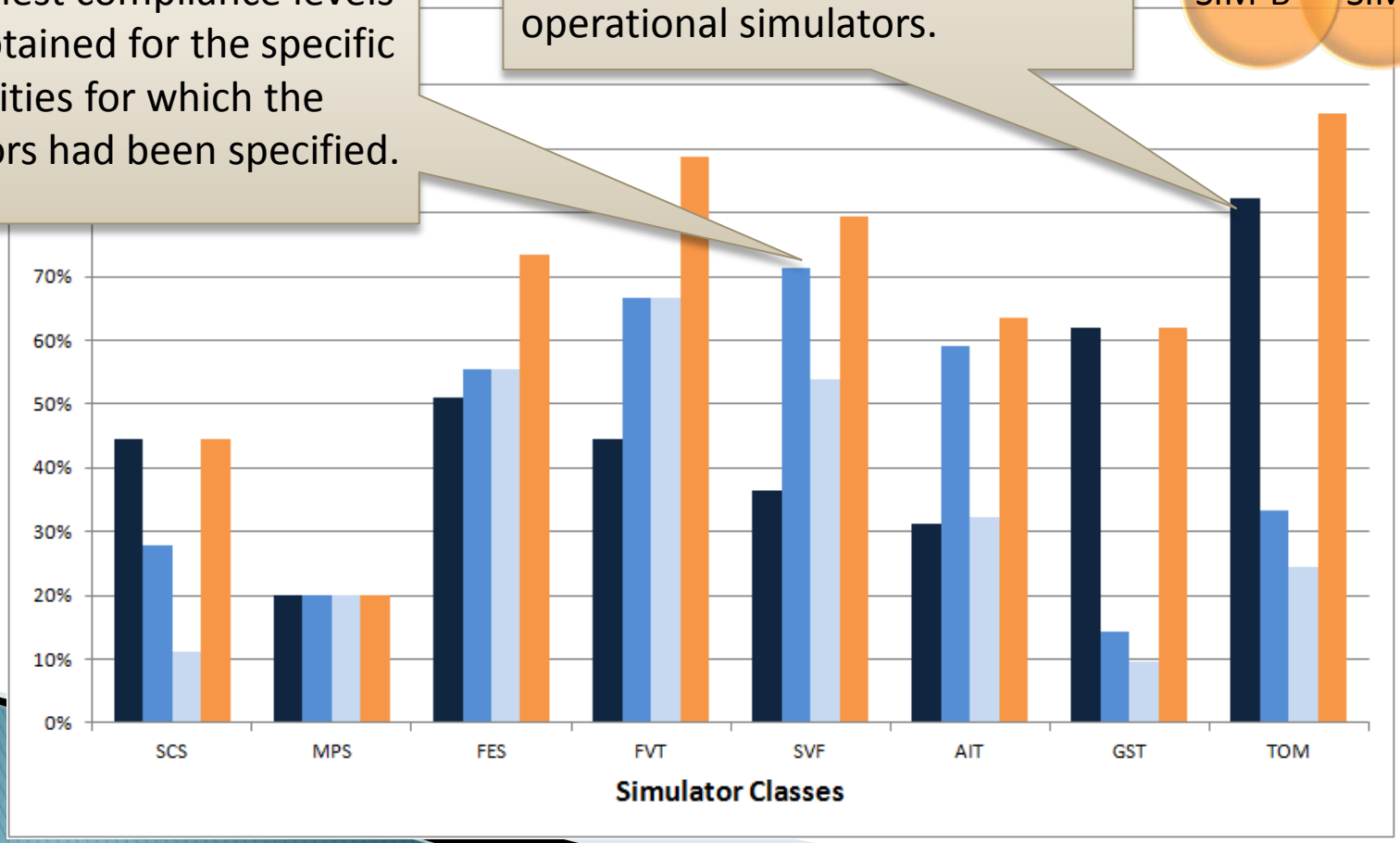


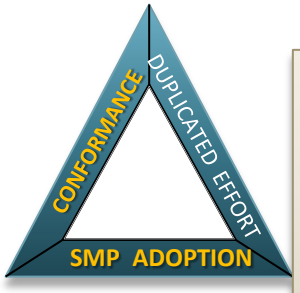
Conformance Level – Facility Specific

The highest compliance levels were obtained for the specific facilities for which the simulators had been specified.

TOM (Training , Operations and Maintenance) is the best covered facility.
Explained by INPE experience in operational simulators.

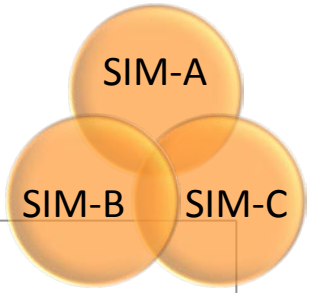


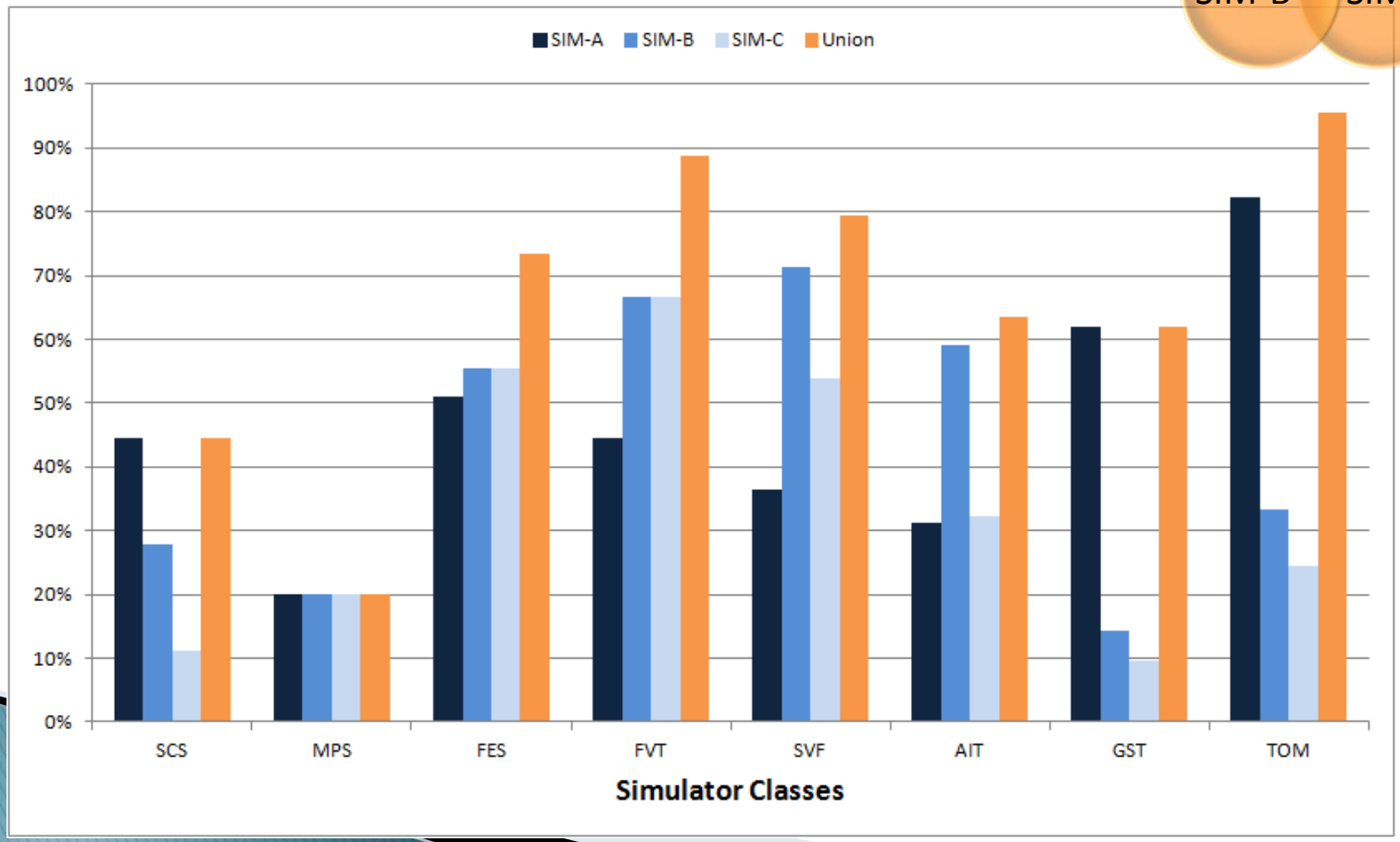


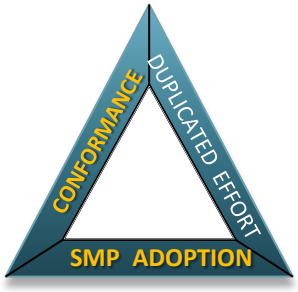


UNION scenario where model interchanging and infrastructure reuse would have been adopted.

l – Facility Specific

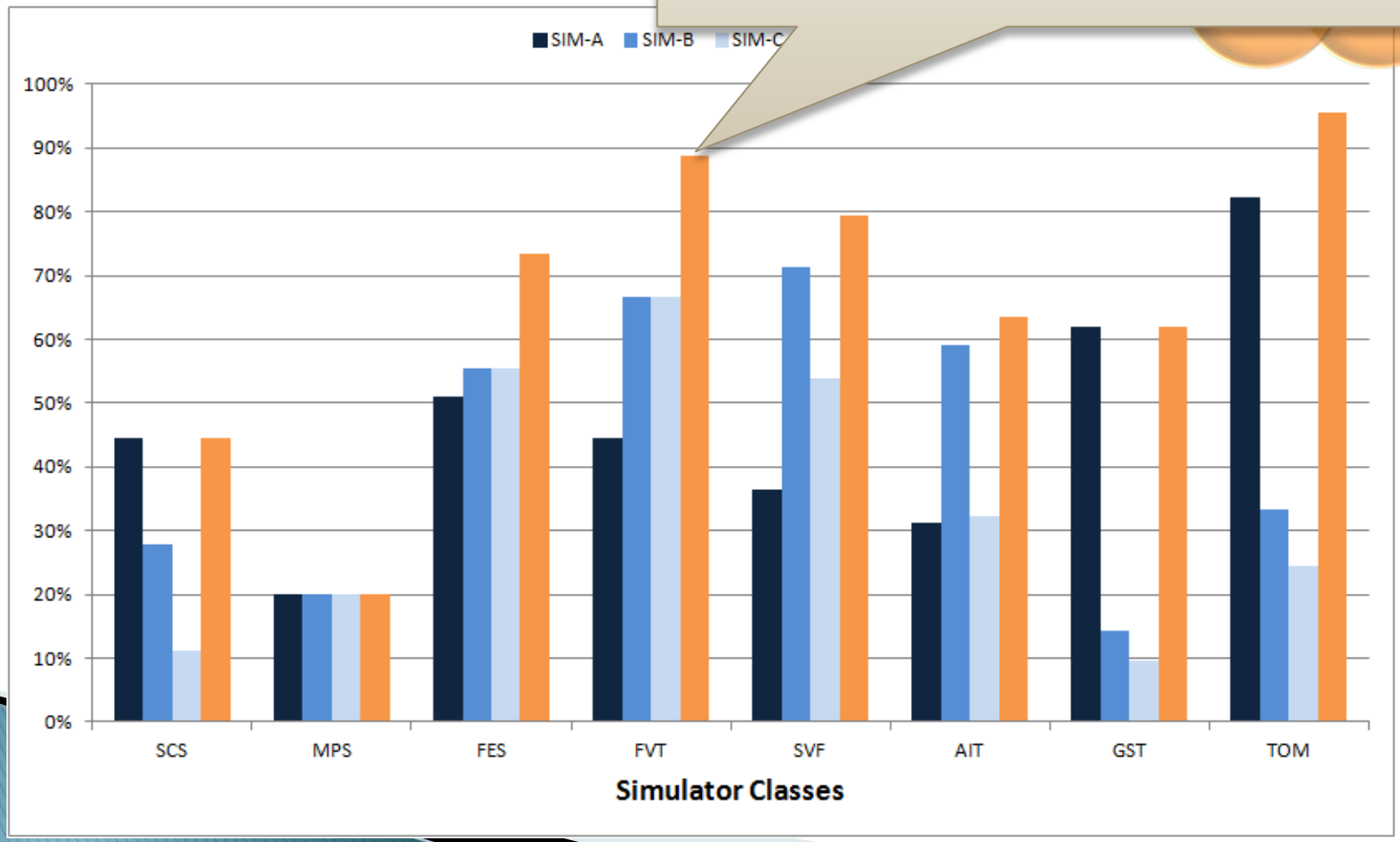


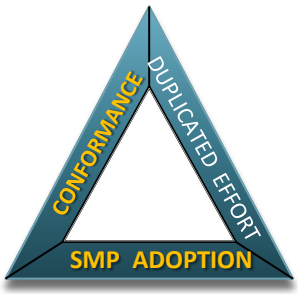




Conformance Level – Facility Specific

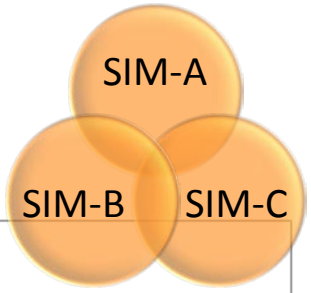
For FVT (Functional Validation TestBench) 29% new requirements would be implemented, which corresponds to a 50% gain.



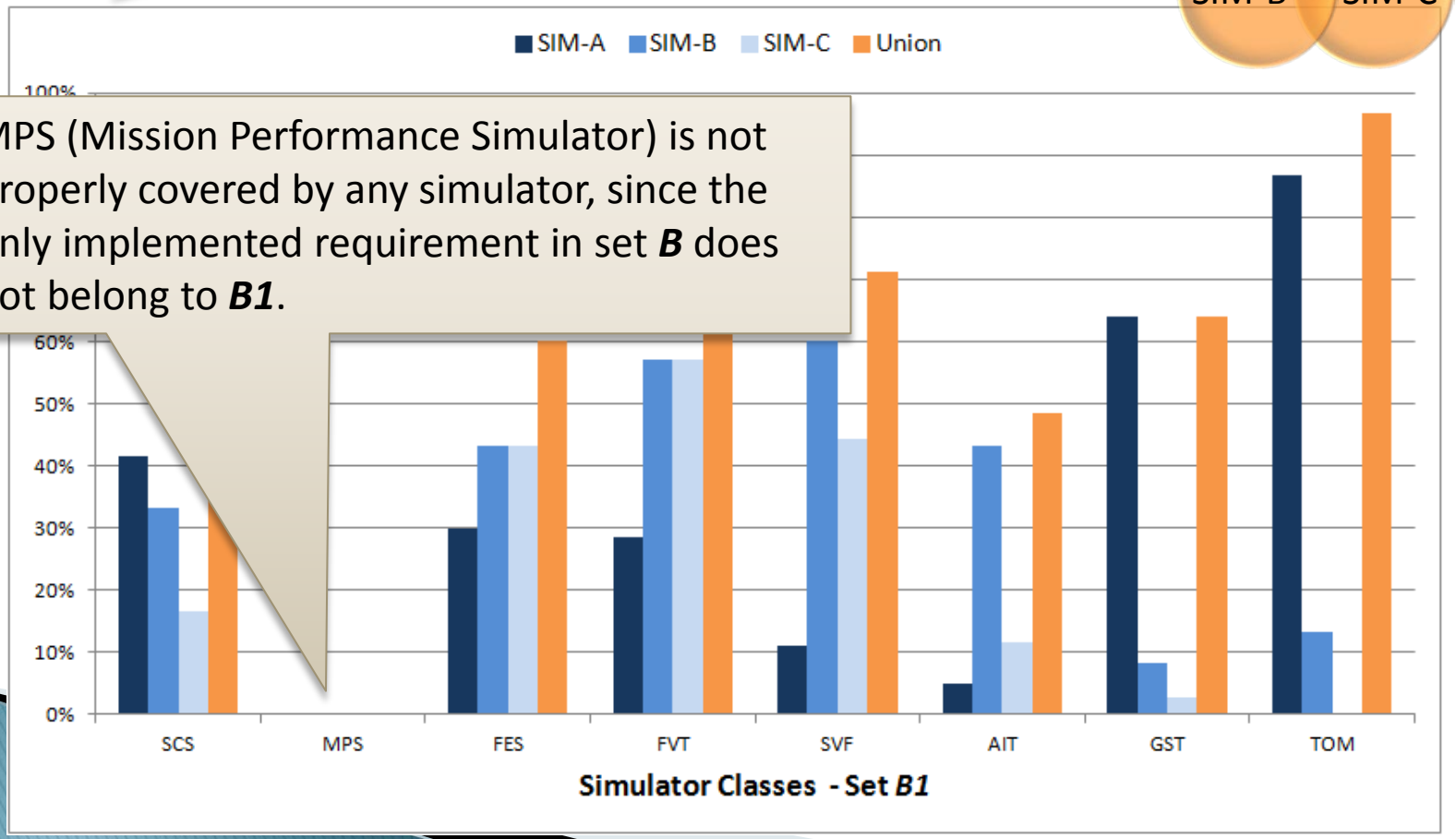


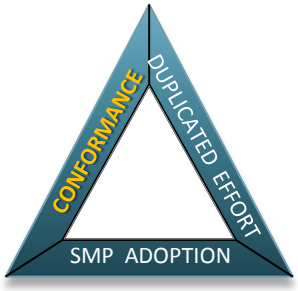
The characteristic set (B1) gives a more realistic view of how close a simulator is to a facility type.
It does not consider neither infrastructure requirements nor general models requirements.

ypical Set (B1)



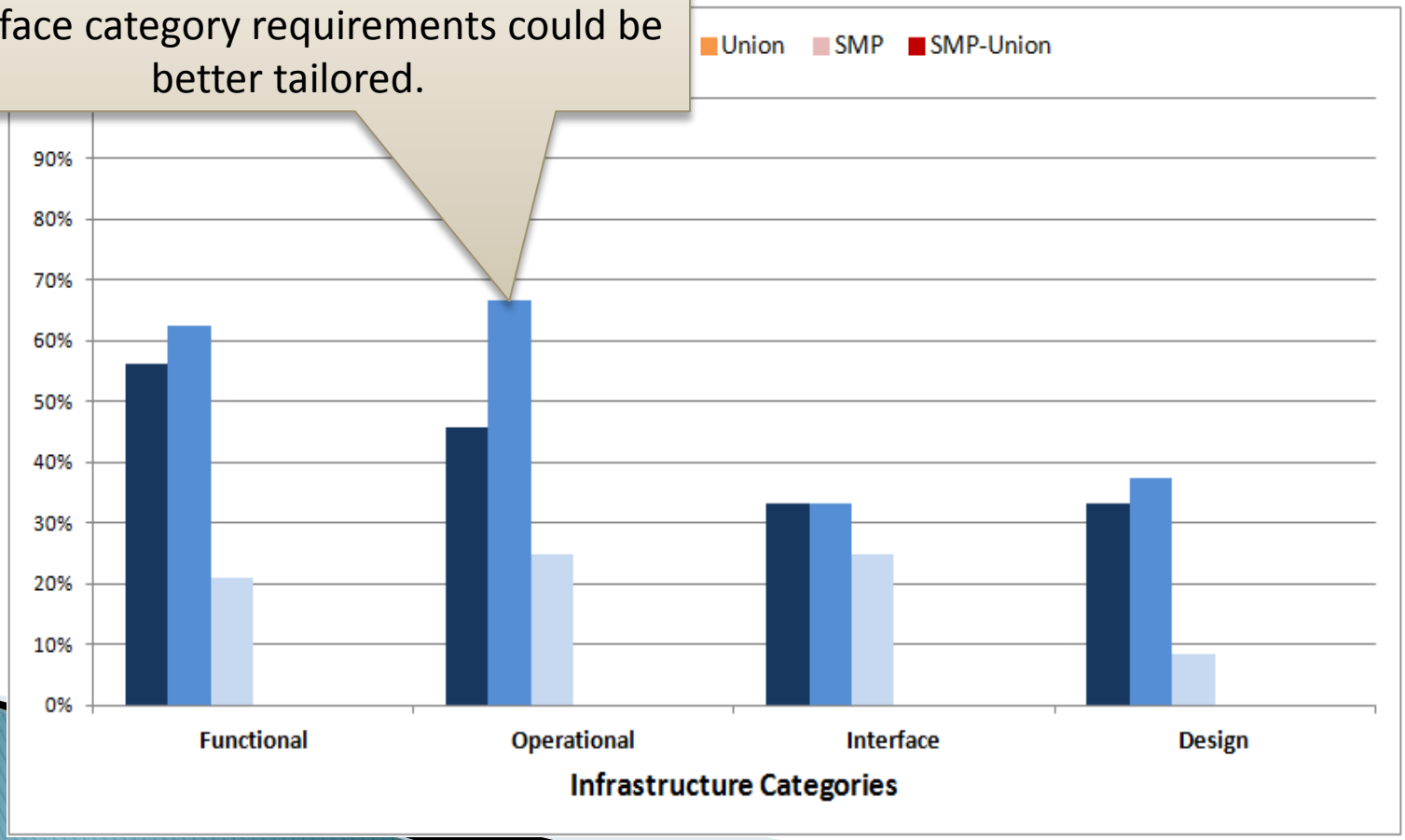
MPS (Mission Performance Simulator) is not properly covered by any simulator, since the only implemented requirement in set ***B*** does not belong to ***B1***.

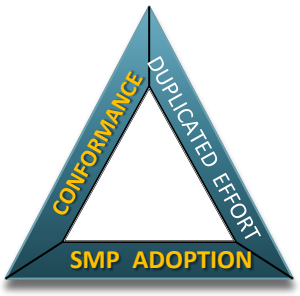




Conformance Level – Simulation Facility

The flexible infrastructure of SIM-B covered a higher number of simulation facility requirements. However, the interface category requirements could be better tailored.

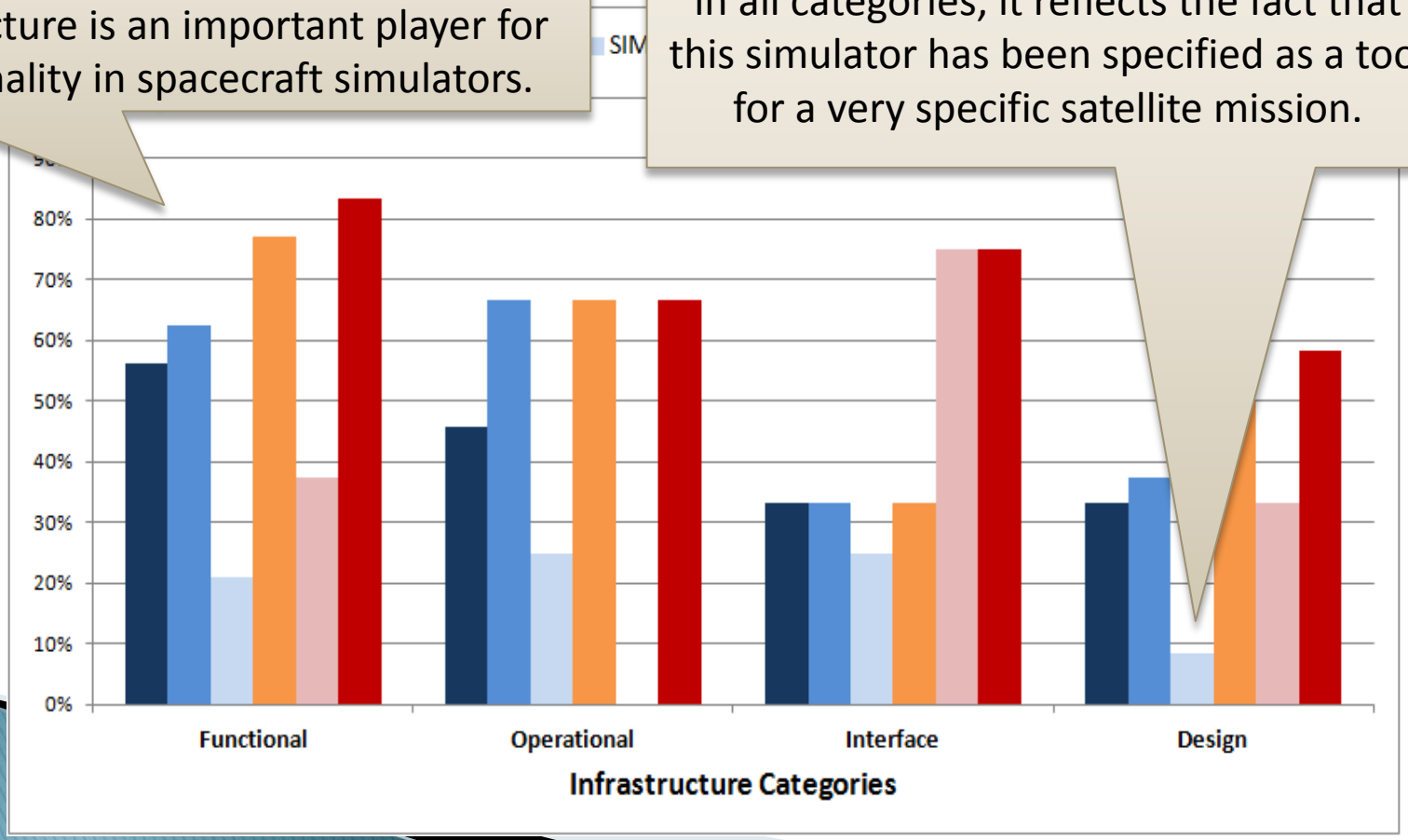


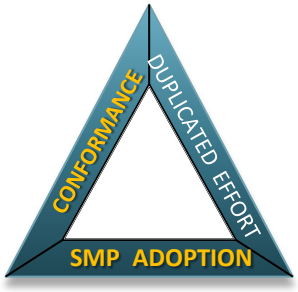


Conformance Level – Simulation Facility

Union scenario represented no much gain in the number of implemented requirements. This fact suggests that infrastructure is an important player for communality in spacecraft simulators.

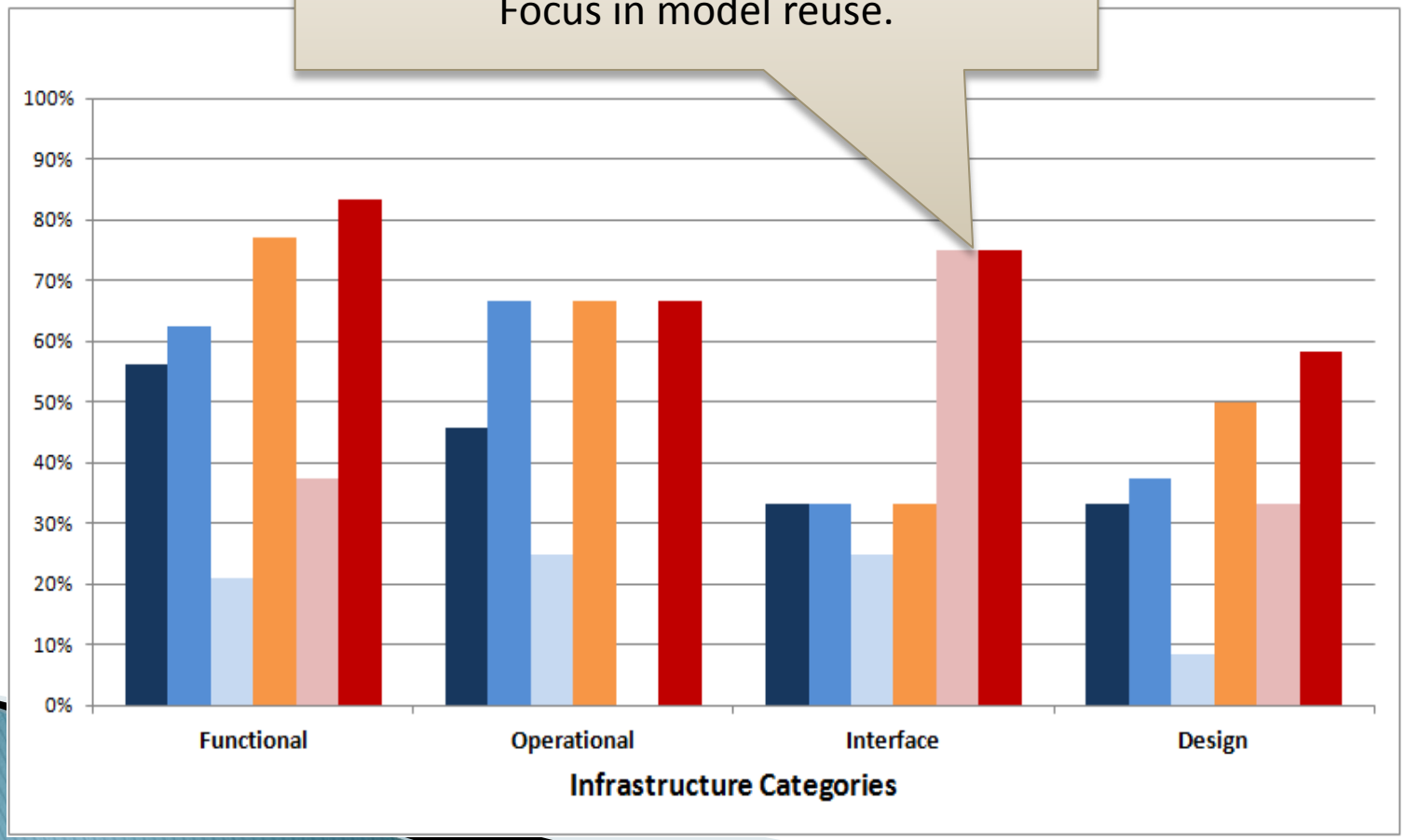
SIM-C has the lower level of compliance in all categories, it reflects the fact that this simulator has been specified as a tool for a very specific satellite mission.

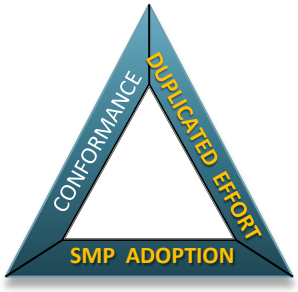




Conformance Level – Simulation Facility

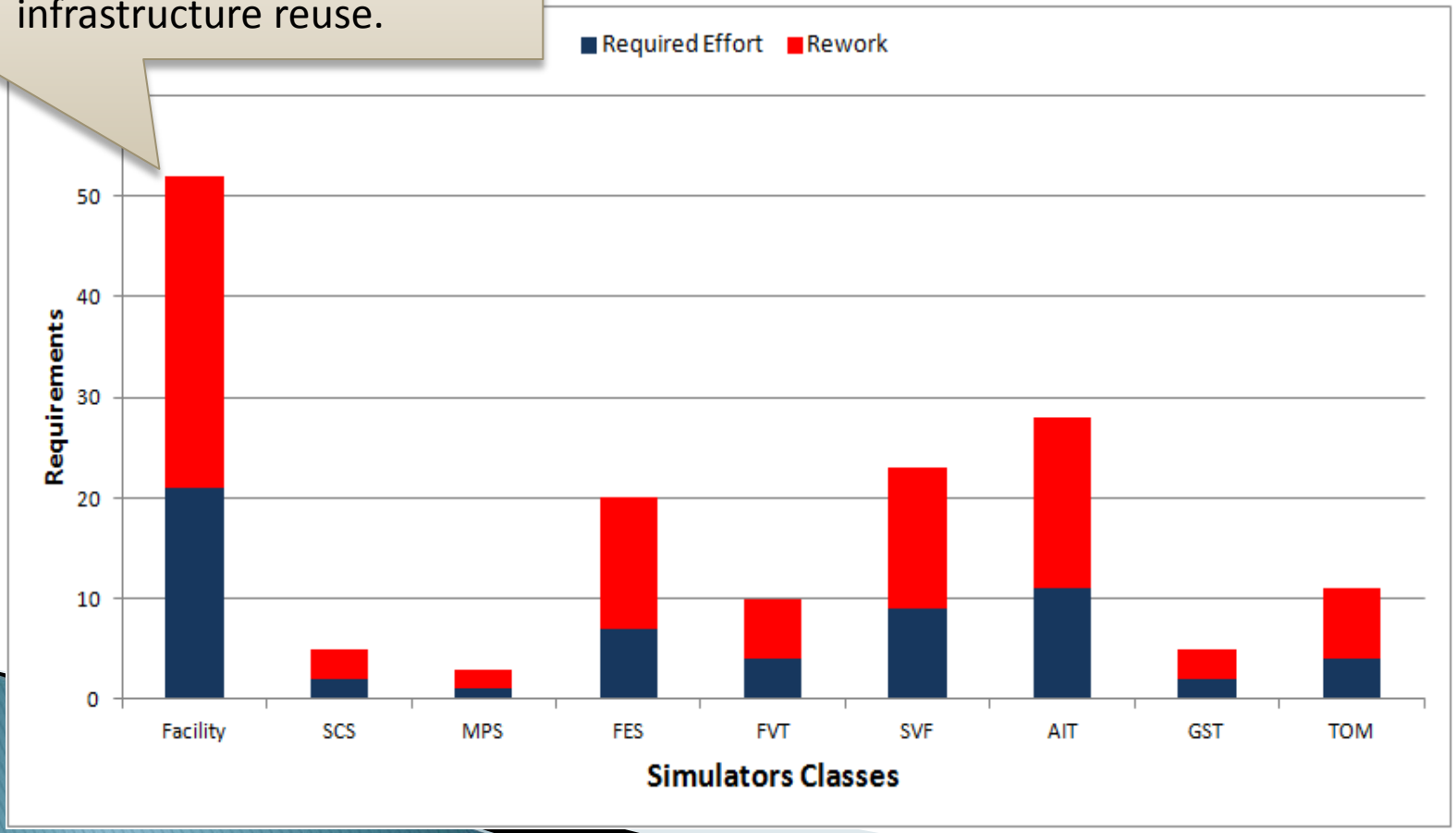
A simulation environment implementing SMP would increase the compliance level of the interface category.
Focus in model reuse.





Duplicated Effort Assessment

For the Simulation Facility requirements, the higher level of rework reinforces the concept of infrastructure reuse.



Conclusions

INPE's Simulator:

✓The results show that the simulators conform well to the classes for which they have been designed.

✓The good conformance level of operational simulators may be explained by INPE's experience with operational simulators.

SMP Adoption:

A higher conformance level would be reached if there were a policy for resources exchange between the simulation tools. This could increase the number of implemented requirements and reduce the rework at least 50%.

Since SMP standard covers infrastructure requirements and excels for model reuse, it should be considered for INPE's projects to reduce rework and aggregate complementary efforts.

This study may contribute to the definition of a Satellite Simulators development policy for future INPE missions, aimed at increasing reuse and decreasing rework.

THANK YOU!

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