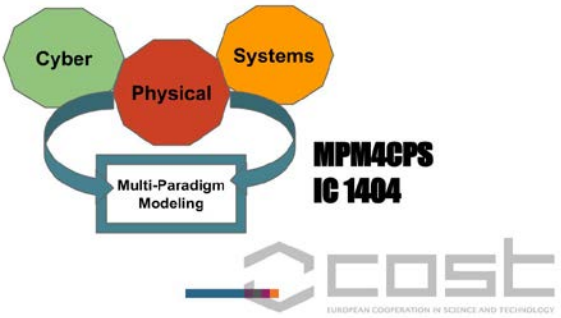

Short Term Scientific Report COST IC1404

Title of the STMS:	Integrating units, precision and uncertainty in software models
Working Group:	1 (Foundations)
Beneficiary:	Loli Burgueño, University of Málaga, Spain
Host:	Manuel Wimmer, TU Wien, Austria
Period:	March 15 - March 22, 2017
Reference code:	COST-STSM-ECOST-STSM-IC1404-200317-083908

1. Initial purpose of the visit

The visit was planned to carry out discussions about further research to extend UML/OCL software models to support the representation of elements of cyber-physical systems. Both the host and the applicant institution were previously working on this topic.

By the moment in which the STSM started, the two research groups had already created a prototype of a library extending the type *Real* and providing operations for specifying and performing computations with measurement uncertainty and units in attributes representing properties of entities of the physical world. This prototype had been implemented for USE, OCLinEclipse and SysML.

2. Description of the work carried out during the STSM

During this STSM, we worked on concrete models of CPS to discuss what needs to be added to our proposal to make it more complete and concise. Apart from our own experience, when designing our solution, we took into account the experience and feedback from people from companies such as Siemens (which we also met thanks to this COST project). With all these insights, after several sessions of discussions we came up with different possible optimizations for our proposal.

First of all, we saw the need to include magnitudes to our measures so that quantities can be represented not only base units (meters, seconds, etc.) but also in the different orders of magnitudes (kilometers, centimeters, milliseconds, etc.). Then, we discussed the way to apply

operations such as the multiplication or the addition of two quantities represented in different orders of magnitude.

Apart from gaining expressiveness, the use of magnitudes helps solve the problem of the precision of the values. When a CPS uses very small of very large numbers, an important problem that arises is whether the software systems and/or platforms in which they are being modelled are precise enough to represent them or whether there will be some data loss due to the rounding. Representing a number in the proper order of magnitude can avoid this data loss.

We also extended our approach to consider, not only SI units, but also the units defined in the ISO/IEC 80000, which includes types to represent data storage information, the entropy of an information system, traffic intensity, etc.

We have deeply studied existing cases studies provided by SysML and MARTE and have detected inconsistencies regarding the type system. We plan to replace their type system by ours and prove the improvements that our approach provides to their solutions. We have also worked on the definition of new case studies in order to cover all the aspects that can appear in different situations and/or systems.

We have also discussed several lines of future work such as including uncertainty in Boolean values, for instance, to be able to say what is the reliability with which we can affirm that two uncertain values are equal. That would need the inclusion of fuzzy logic functions.

Although not directly related to CPS but related to modelling, we have also developed ideas to create a compiler from the model transformation language ATL to the efficient model transformation engine LinTra and to automatically generate classifying terms for testing model transformations.

3. Description of the main results obtained

As the results of this STSM we can highlight our fruitful discussions in which we came up with a solution for problems we already were aware of and, the definition of new lines of work to improve and extend our proposal.

In a more technical level, the software products implemented during this visit are the extension of our library of units in order to support magnitudes and the units defined in the ISO/IEC 800000 and, the case studies that we have selected and created to prove the effectiveness of our approach.

4. Future collaboration with the host institution (if applicable)

As we have been doing since 2012, we plan to continue working together as we consider that our research is being fruitful. This report already mentioned the future work on which we plan to work next.

5. Foreseen publications/articles and other contributions (e.g., tools, software, etc.) resulting from the STSM (if applicable)

We have decided to submit the work about units once it is ready to a good quality journal, in concrete to Information & Software Technology, which is indexed in the first quartile of the Journal Citation Report (JCR) with an impact of 1,569 in 2015.

The mapping from ATL to LinTra will be submitted to Transaction on Software Engineering, a journal indexed in the JCR with an impact factor of 1,614 in 2014.

Finally, the work about classifying terms will be submitted to a workshop.

6. Confirmation by the host institution of the successful execution of the STSM

I, Manuel Wimmer, confirm that we have realized our goals concerning the following topics: (i) extension of the unit metamodel for computer science related quantities, (ii) conceptual framework to reason about uncertain values in comparison operations, (iii) establishment of mappings between ATL and Lintra concepts, (iv) reformulation of classifying terms development as an optimization problem.

I also confirm that the next steps will be publishing our results in two journal publications (i+ii)(iii) as well as a workshop publication (iv).

7. Other comments (if any)