

Hans Vangheluwe (<http://msdl.uantwerpen.be/people/hv>)

Short **summary** of CV: Licentiate (MSc) Theoretical Physics (1986), Licentiate (MSc) Computer Science (1988), Doctorate Science (2000) from Ghent University, Belgium. Researcher at the Centre de Recherche Informatique de Montréal (CRIM) (1991), Montréal, Canada and at the Concurrent Engineering Research Center (CERC), WV, USA (1992, 1996). Associate Prof. at McGill University, Montréal (2000 – 2011). Full Prof. ((gewoon) hoogleraar) at the University of Antwerp (2011 - present). Core Research Lab of Flanders Make strategic research centre (2014 - present).

The goal of my research is to **design foundations, methods, techniques and tools to support engineering of complex Cyber-Physical Systems (of Systems)**. Convergence of Science and Engineering workflows is a closely related interest.

Below is an **overview** of my main achievements in **Modelling Language Engineering** and **efficient and accurate simulator building**. This research is carried out at the University of Antwerp, in my Modelling, Simulation and Design Lab (MSDL), part of the Antwerp Systems and Software Modelling (AnSyMo) group, of which I am the spokesperson.

WEST Mid 90s, I built the [WEST tool](#) for *simulation-based optimal design* of bio-activated sludge Waste Water Treatment Plants. This tool, now distributed by DHI was the first to provide a truly domain-specific modelling environment in this application domain, with its own Equation-based Object-Oriented modelling Language (EOOL) MSL-USER and supporting symbolic and numerical simulation and optimization.

Modelica Based on my MSL-USER experience, I joined the design team of the Modelica (<http://www.modelica.org>) EOOL. Influence of Modelica has since grown tremendously, in particular in automotive and aerospace domains. Modelica is a modular, *object-oriented equation-based* hybrid language supporting continuous-time, discrete-time and discrete-event abstractions. My research into the foundations of Modelica led to the μ Modelica language and its compiler. I have applied Modelica in diverse application domains, from modern computer games to mechatronics. **DEVs** I have also contributed to the development of the *Discrete-Event System Specification* formalism DEVs. DEVs can be used as a common target language for behaviour-preserving transformations of heterogeneous languages. This, as a basis for multi-formalism modelling.

In particular, our [PythonPDEVs simulator](#) is widely used, including as the engine for integrated environments such as DEVsSimPy (university of Corsica) and FPGA synthesis (LAAS/CNRS). High performance is achieved by providing computational activity prediction information to the (distributed) simulator and, where possible, adaptive abstraction. PythonPDEVs is used in a variety of domains, including (in my own research) for deployment and real-time guarantees in automotive applications.

T-Core Model transformation is the heart and soul of Model Based Systems Engineering (MBSE). We developed T-Core, a framework and library for the development of *rule-based model (graph) transformation* languages and their efficient execution (a.o., by introducing a notion of *scope*).

SyVOLT We also support model transformation *contracts*, and analyze transformations through our symbolic execution framework SyVOLT.

MPM The complexity of *Cyber-Physical Systems* (CPS) is commonly addressed through complex workflows, involving models in a plethora of different formalisms, each with their own methods, techniques and tools. Some workflow patterns, combined with particular types of formalisms and model operations, are used successfully in engineering practice. To identify and re-use them, we refer to these combinations of workflow and formalism patterns as modelling paradigms. I introduced the concept of Multi-Paradigm Modelling (MPM) in the 90s. MPM has been further developing over the years with conference tracks, workshops, a COST action, and several books (see <http://msdl.uantwerpen.be/hosted/MPM>). MPM proposes to model every part and aspect of a system explicitly, at the most appropriate level(s) of abstraction, using the most appropriate modelling formalism(s). An MPM framework and supporting tools to manage models unifies all my research.

DSL methods and tools Building *(collaborative) domain-specific (visual) modelling and simulation environments* is difficult and labour intensive. Over the years, we have developed a number of new techniques and supporting tools ([AToM³](#), [AToMPM](#), and the [Modelverse](#)) for *modelling language engineering* to support synthesis of such environments, applying Multi-Paradigm Modelling principles.

ProMoBox The languages for specifying design and requirements must be matched, in particular in the case of domain-specific languages. My ProMoBox framework allows for the *co-development* of these (and other) *closely related languages* such as trace (counter-example in the case of model checking), snapshot, initialization, and environment modelling languages.

Co-simulation To (black-box) combine multiple simulation models, we developed new co-simulation techniques, both numerical and symbolic, using model transformation (i.e., semantic adaptation). Given the complexity of co-simulation engineering, certainly from the point of view of accuracy and stability, we developed a hints framework for co-simulation, in collaboration with Boeing Research.

Debugging With Autodesk Research, we modularly added debugging to simulators of models in various formalisms, based on explicit modelling and synthesis. We subsequently modelled and synthesized a *live modelling* environment which allows for changing models during a simulation. This work received the 2019 overall best paper award of the Software and Systems Modeling (SoSyM) journal.

DTDesign Within the Flanders Make Digital Twin Design project, we developed a proof of concept *federated model management* system to allow workflow modelling and enactment, version control and unified access to heterogeneous models, data and (simulation and analysis) services. Multi-domain reasoning uses ontologies.

Twinning Development of a *workflow and reference architecture* for Twinning. Application in various domain such as the nautical value chain (with Port of Antwerp) and robotics.

Some representative publications. Google Scholar H-index in March 2026: 48, 10030 citations.

- [1] Juan de Lara, Hans Vangheluwe. *AToM³: A Tool for Multi-formalism and Meta-modelling*. FASE 2002: pp.174-188.
- [2] Claudio Gomes, Casper Thule, David Broman, Peter Gorm Larsen, Hans Vangheluwe. *Co-simulation : a survey*. ACM Computing Surveys. 51(3):49:1-33, 2018. [IF 2020: 10.282]
- [3] Bart Meyers, Hans Vangheluwe, Joachim Denil, and Rick Salay. *A framework for temporal verification support in domain-specific modelling*. IEEE Transactions on Software Engineering (TSE), 46(4):362-404, 2020. [IF 2020: 6.226]
- [4] Arkadiusz Ryś, Lucas Lima, Joeri Exelmans, Dennis Janssens, Hans Vangheluwe. *Model management to support systems engineering workflows using ontology-based knowledge graphs*. Journal of Industrial Information Integration, volume 24, pp. 100720-100743, 2024. [IF 2024: 10.4]
- [5] Eugene Syriani, Hans Vangheluwe, Brian LaShomb. *T-Core : a framework for custom-built model transformation engines*. Software and Systems Modeling (SoSyM). 14(3):1215-1243, 2015. [IF 2018: 2.66]
- [6] *Multi-Paradigm Modelling for Cyber-Physical Systems: Foundations*. Springer 2020. 153 pages. Editors Paulo Carreira, Vasco Amaral, and Hans Vangheluwe. [Open Access textbook. 5 out of 9 chapters co-authored by me].
- [7] Moussa Amrani, Dominique Blouin, Robert Heinrich, Arend Rensink, Hans Vangheluwe, Andreas Wortmann. *Multi-paradigm modelling for cyber-physical systems: a descriptive framework*. SoSyM. 20(3): 611-639, 2021. [IF 2022: 2.0]
- [8] Joeri Exelmans, Jakob Pietron, Alexander Raschke, Hans Vangheluwe, Matthias Tichy. *A new versioning approach for collaboration in blended modeling*. J. Comput. Lang. 76: 101221, 2023. [IF 2023: 2.64]
- [9] Istvan David, Hans Vangheluwe, Eugene Syriani. *Model consistency as a heuristic for eventual correctness*. J. Comput. Lang. 76: 101223, 2023. [IF 2023: 2.64]
- [10] Henk Vanhooren, Jurgen Meirlaen, Youri Amerlinck, Filip Claeys, Hans Vangheluwe, Peter A Vanrolleghem. *WEST: modelling biological wastewater treatment*. Journal of Hydroinformatics, 5 (1), 27-50, 2003. [IF 2023: 2.7]

Other scientific output and impact

Leading **community research efforts**: Co-founder and coordinator of the EU ESPRIT Basic Research Working Group 8467 "Simulation in Europe" 1993 - 1996. Chair of the EU COST Action IC1404 "[Multi-Paradigm Modelling for Cyber-Physical Systems](#)" (MPM4CPS) 2015 - 2018.

Best paper awards: SoSyM (2019), ICMT (2018), ICMT (2015), SpringSim (2014), DEVS Symp. (2010).

Keynote lectures: "The Twinning Paradigm" at DS-RT 2025 (Prague), "[A 'most appropriate' talk](#)" at MoDELS 2023 (Västerås), "[Multi-Paradigm Modelling of Cyber-Physical Systems](#)" at MODELSWARD 2019 (Prague), "[Co-simulation: A Research Agenda](#)" at SimulTech 2019 (Prague), "Multi-Paradigm Modelling of Cyber-Physical Systems" at Software Engineering for Smart Cyber-Physical Systems at ICSE 2018 (Gothenburg), "Co-simulation: Serving Multiple Masters" at the 48th Summer Simulation Multi-Conference 2016 (Montréal), ...

Invited tutorials on modelling and simulation of physical systems (and Modelica in particular) at the MoDELS series of conferences (2014, 2015, 2019), at FSE (2026) and at the Winter Simulation Conference (on DEVS, and Twinning).

Committees Scientific Advisory Board of ECSEL RIA project AIDOaRt; project and research programme evaluator for National Science and Engineering Research council (NSERC, Canada), Vinnova (Sweden), Research Council of Norway (RCN), Swiss National Science Foundation (SNSF); jury of Nokia Bell Scientific Award and of IBM Innovation Award. Served on about 100 conference and workshop advisory, organizing and programme committees. Served on over 70 PhD committees world wide, including as "opponent" in Sweden.

Projects see <https://www.uantwerpen.be/en/staff/hans-vangheluwe/research/> for an overview of recent projects.