TACKLING UNCERTAINTY IN CYBER-PHYSICAL SYSTEMS WITH AUTOMATED TESTING (U-TEST)

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www.u-test.eu

U-TEST

- **Objective:** Improve the dependability by Cost-Effective Uncertainty testing
- **Means:** Model-based and Search-based Testing
- **Objective will be achieved by:**
  - Uncertainty Taxonomy
  - Holistic Modeling and Testing Frameworks
  - Standards

OVERALL CONSORTIUM

Research Partners

[simula . research laboratory]
- by thinking constantly about it

Fraunhofer FOKUS

TU WIEN

Test Bed Provider

NORDIC MEDTEST

Case Study Providers

future position | 60°40'17" North 17°06'29" East 213.141.90.204

ULMA Handling Systems

Exploitation

IK4 IKERLAN Research Alliance

Tool Vendors

Fokus! MBT

easy global market

Dissemination/ Administration/ Financial

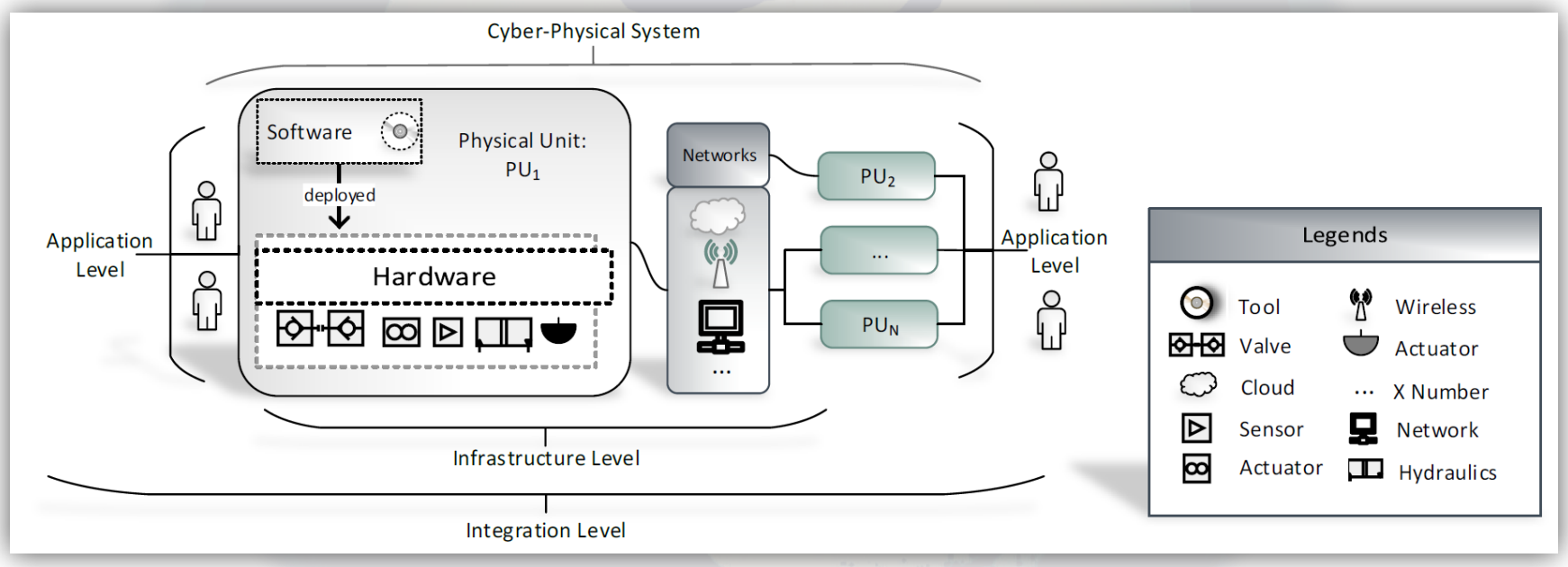
Oslomedtech

TESTING CPS UNDER UNCERTAINTY

- Motivation
  - ✓Uncertainty is inherent in CPSs
  - ✓Handling uncertainty in a graceful manner during the real operation of CPS is critical.
- Definition
  - ✓The lack of certainty (i.e., knowledge) about the timing and nature of inputs, the state of a system, a future outcome, etc.
- Steps
  - ✓Understanding Uncertainty
  - ✓Modeling Uncertainty
  - ✓Testing Uncertainty

TESTING LEVELS FOR CPS

- **Application** Level : Events and data coming from the user space, e.g., from applications and human
- **Infrastructure** Level : Events and data coming from, e.g., physical units, network equipment, and cloud infrastructure
- **Integration** Level : Interactions between the above two levels



M. ZHANG, B. SELIC, S. ALI, T. YUE, O. OKARIZ AND R. NORGREN, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual ModelIn European Conference on Modelling Foundations and Applications (ECMFA)., 2016.
M. Zhang, B. Selic, S. Ali, T. Yue, O. Okariz and R. Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model, https://www.simula.no/file/u-modeltrfinalpdf/download

UNDERSTANDING UNCERTAINTY WITH U-TAXONOMY

U-TAXONOMY

- The ***U-Taxonomy*** takes a *subjective* approach to represent uncertainty.
- Provide a unified and comprehensive description of uncertainties.
- Classify uncertainties with the aim of identifying common representational patterns.
- Provide a reference model for systematically collecting uncertainty requirements.
- Serve as a methodological baseline for modeling uncertain behaviors in CPS.

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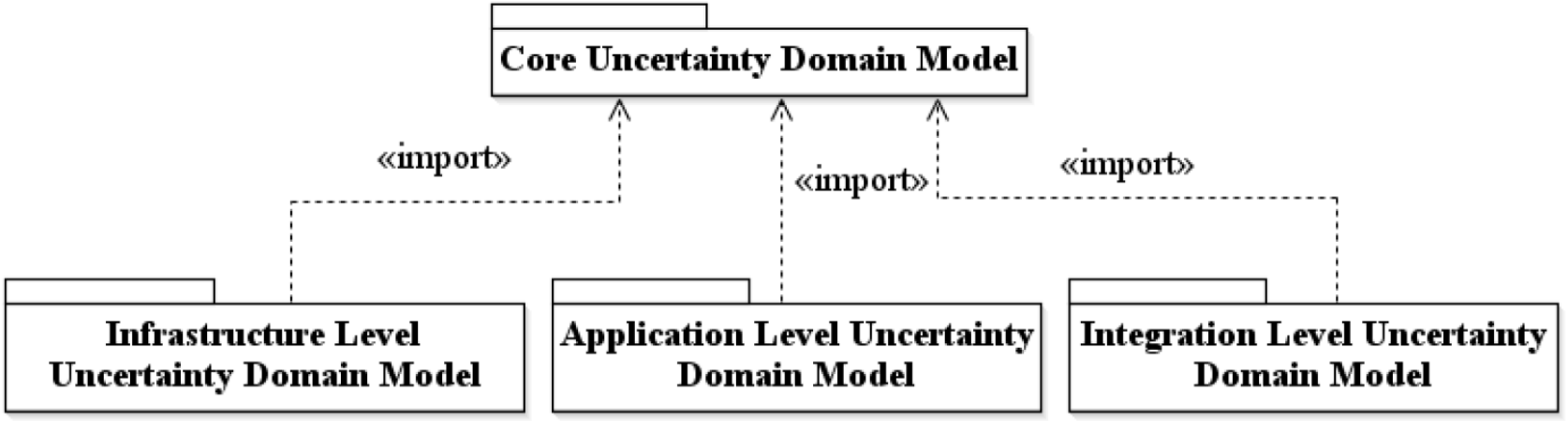
STRUCTURE OF U-TAXONOMY



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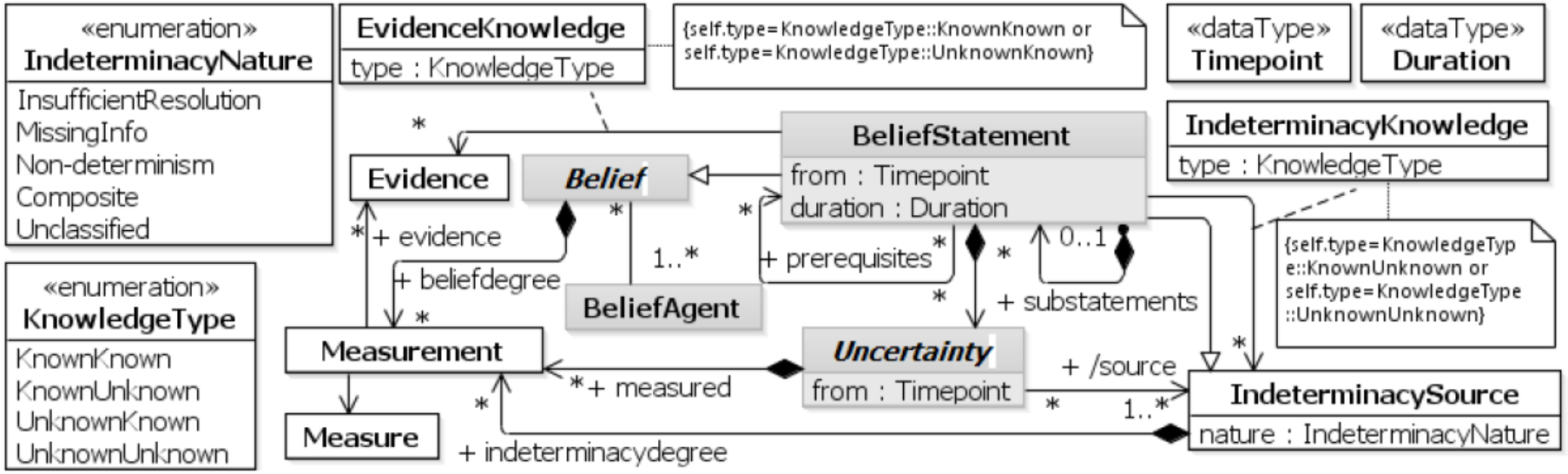
CORE UNCERTAINTY DOMAIN MODEL



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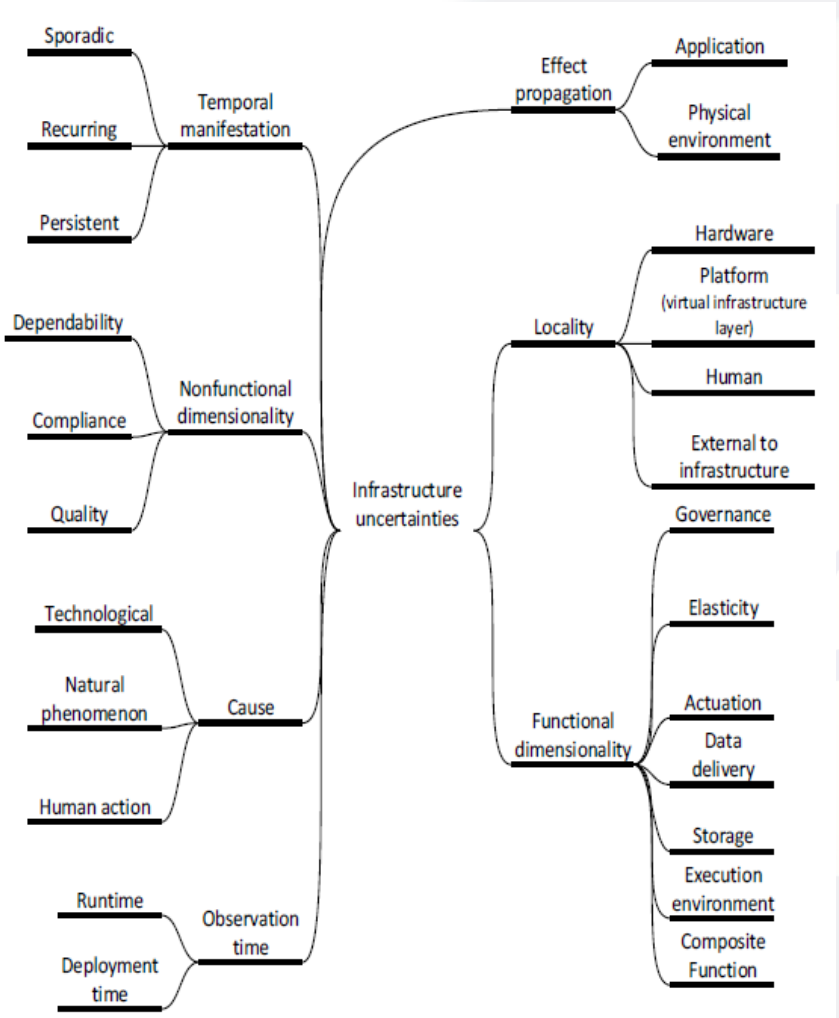
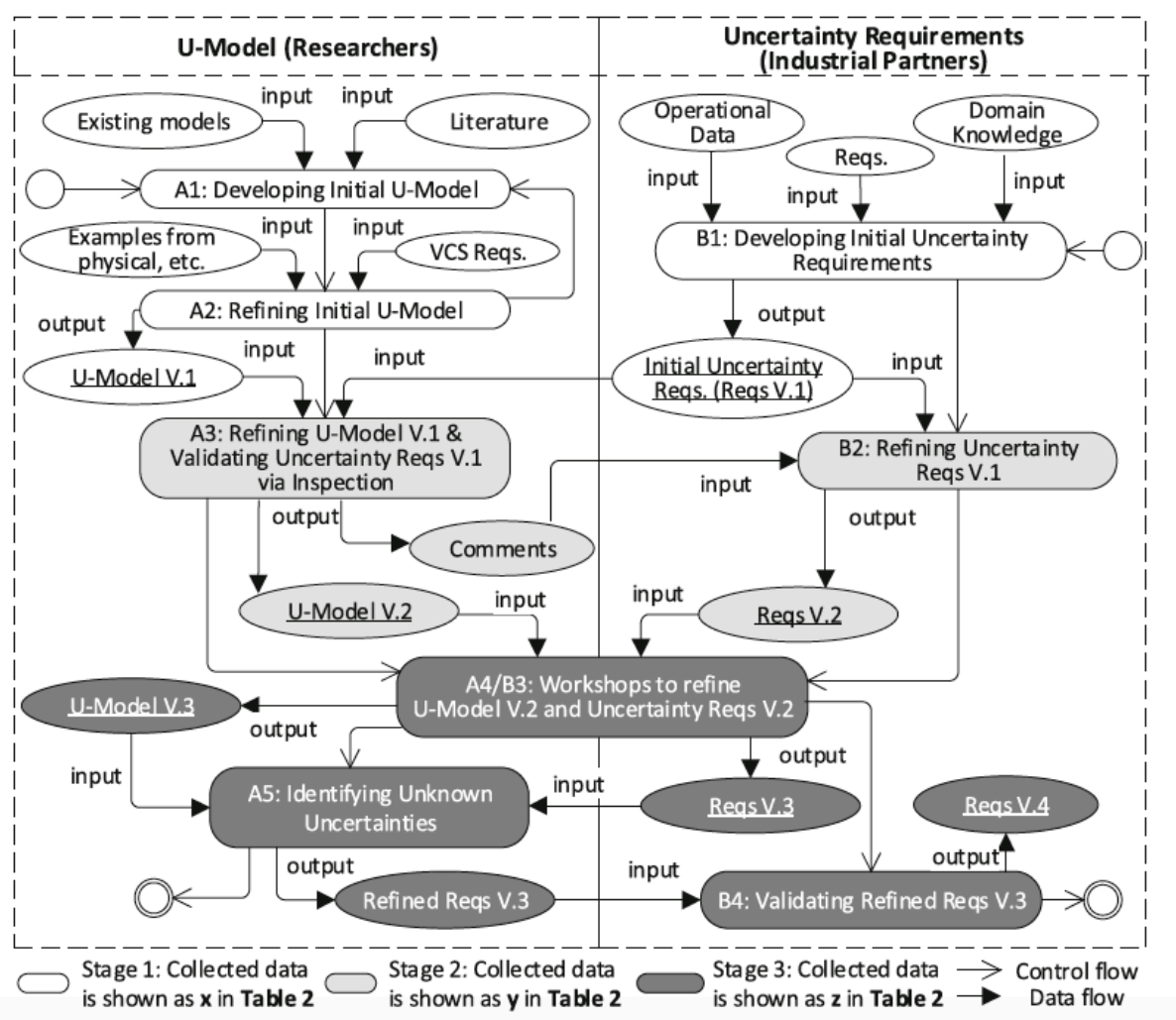
INFRASTRUCTURE LEVEL TAXONOMY



Stefan Nastic and Hong-Linh Truong, Infrastructure-Level Uncertainties V2.0, http://dsg.tuwien.ac.at/staff/snastic/public/u-taxonomy.pdf

EVALUATION



Man Zhang, Bran Selic, Shaukat Ali, Tao Yue, Oscar Okariz and Roland Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model, 12th European Conference on Modelling Foundations and Applications (ECMFA), 2016, pdf link: https://www.simula.no/publications/understanding-uncertainty-cyber-physical-systems-conceptual-model

RESULTS

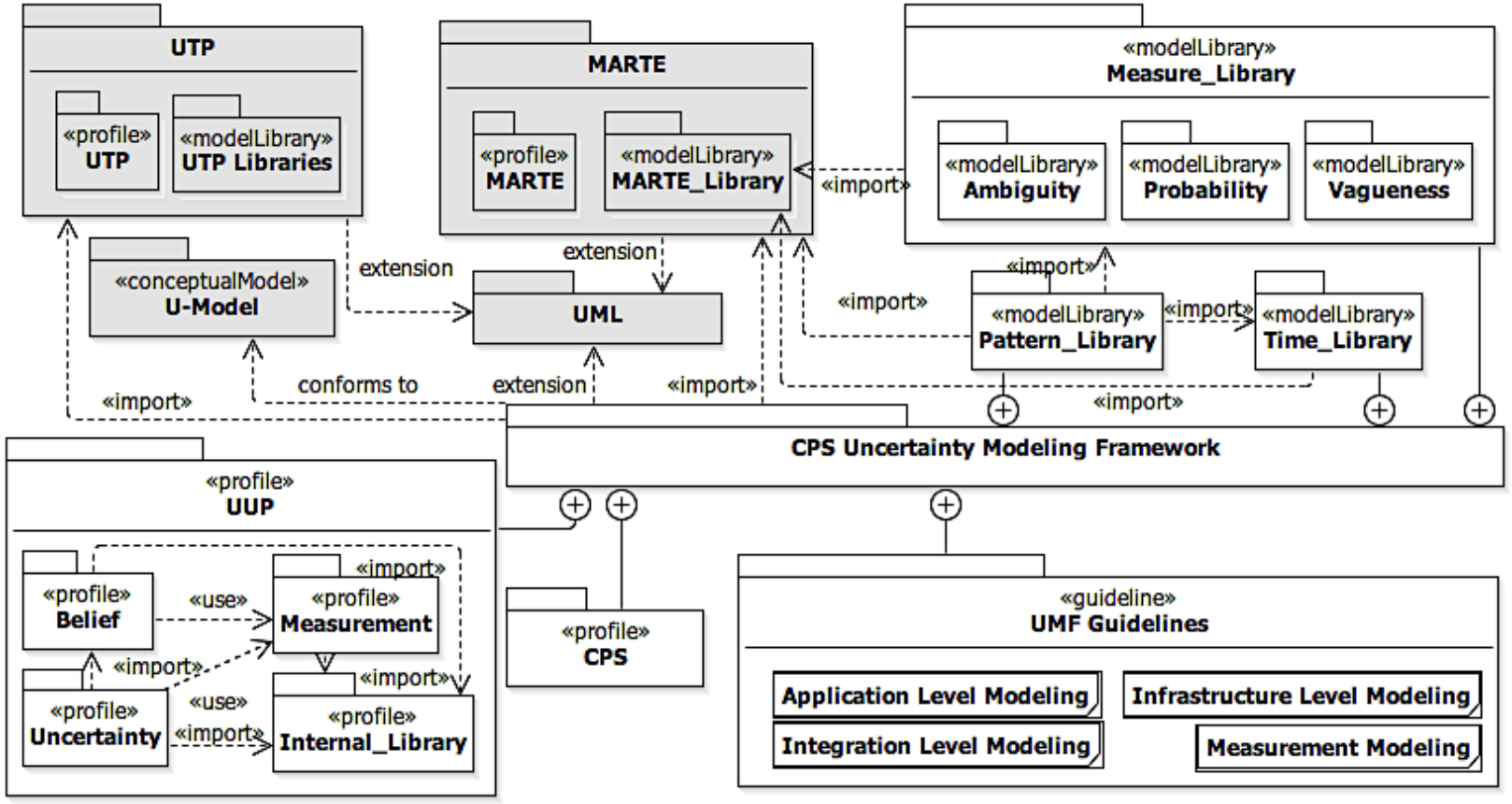
Concept		AW					GS					Freq
		x	*y*	*z*	*R1**	*R2**	*x*	*y*	*z*	*R1*	*R2*	*Total*$^{+}$
Uncertainty	*Content*	14	36	55	1.57	0.53	16	20	36	0.25	0.80	91
	Time	6	16	28	1.67	0.75	5	11	22	1.20	1.00	50
	Occurrence	27	81	126	2.00	0.56	6	50	79	7.33	0.58	205
	Environment	13	15	22	0.15	0.47	4	6	10	0.50	0.67	32
	Geographical Location	4	11	14	1.75	0.27	3	11	17	2.67	0.55	31
Sum for x, y, z/Average for R1, R2		**64**	**159**	**245**	**1.43**	**0.51**	**34**	**98**	**164**	**2.39**	**0.72**	**409**
Indeterminacy	*Insufficient Resolution*	7	18	24	1.57	0.33	11	14	18	0.27	0.29	42
	Non-determinism	7	45	52	5.43	0.16	11	20	37	0.82	0.85	89
	MissingInfo	2	19	24	8.50	0.26	0	5	7	N/A	0.40	31
Sum for x, y, z/Average for R1, R2		**16**	**82**	**100**	**2.67**	**0.43**	**22**	**39**	**62**	**0.55**	**0.57**	**162**
Measure	*Fuzziness*	6	22	51	2.67	1.32	6	15	25	1.50	0.67	76
	NonSpecificity	16	40	73	1.50	0.83	12	26	46	1.17	0.77	119
	Probability	18	56	98	2.11	0.75	4	37	50	8.25	0.35	148
Sum for x, y, z/Average for R1, R2		**40**	**118**	**222**	**2.09**	**0.96**	**22**	**78**	**121**	**3.64**	**0.60**	**343**

$^{*}R1 = y/x - 1$ $^{*}R2 = z/y - 1$ $^{+}Total = AW(z)+GS(z)$ *Freq is Frequency*

Man Zhang, Bran Selic, Shaukat Ali, Tao Yue, Oscar Okariz and Roland Norgren, Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model, 12th European Conference on Modelling Foundations and Applications (ECMFA), 2016, pdf link: https://www.simula.no/publications/understanding-uncertainty-cyber-physical-systems-conceptual-model

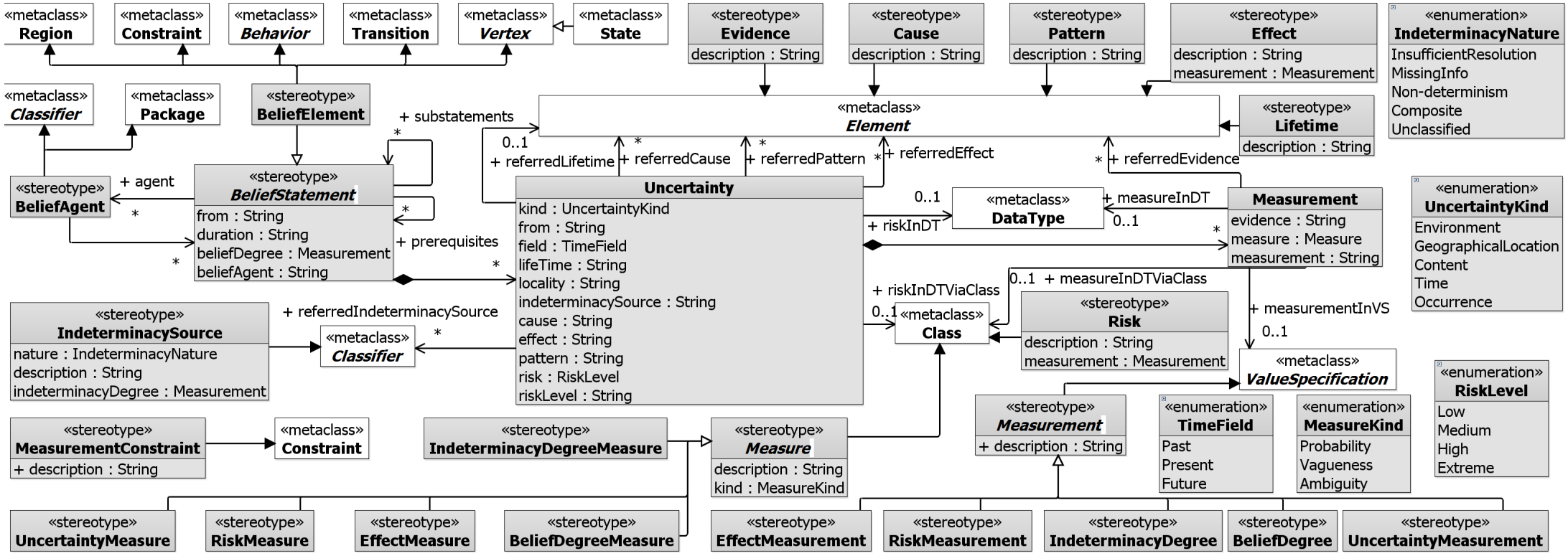
MODELING TEST READY MODELS WITH UNCERTAINTY

UNCERTAINTY MODELING FRAMEWORK (UMF)



M. Zhang, S. Ali, T. Yue and P. H. Nguyen, Uncertainty Modeling Framework for the Integration Level V.1, https://www.simula.no/file/uupv1pdf-1/download

UML UNCERTAINTY PROFILE (UUP): IMPLEMENTATION OF U-TAXONOMY



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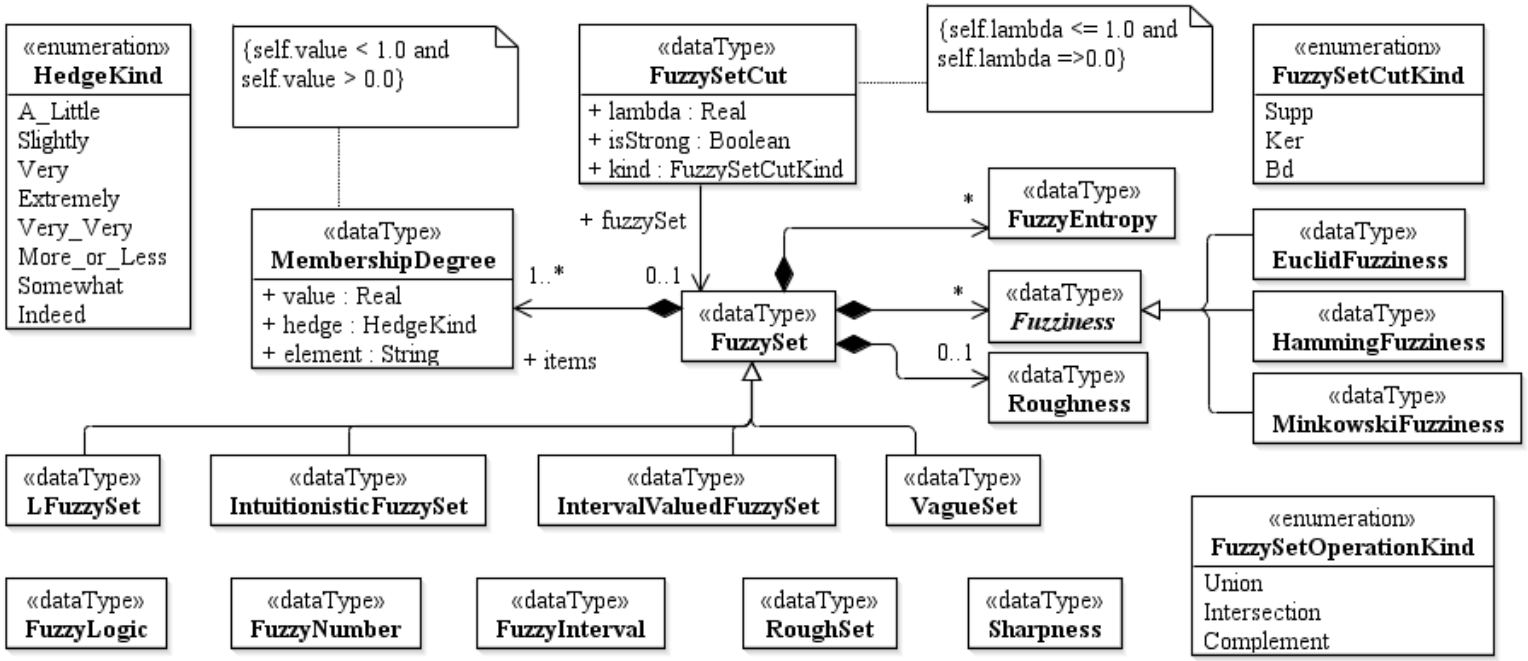

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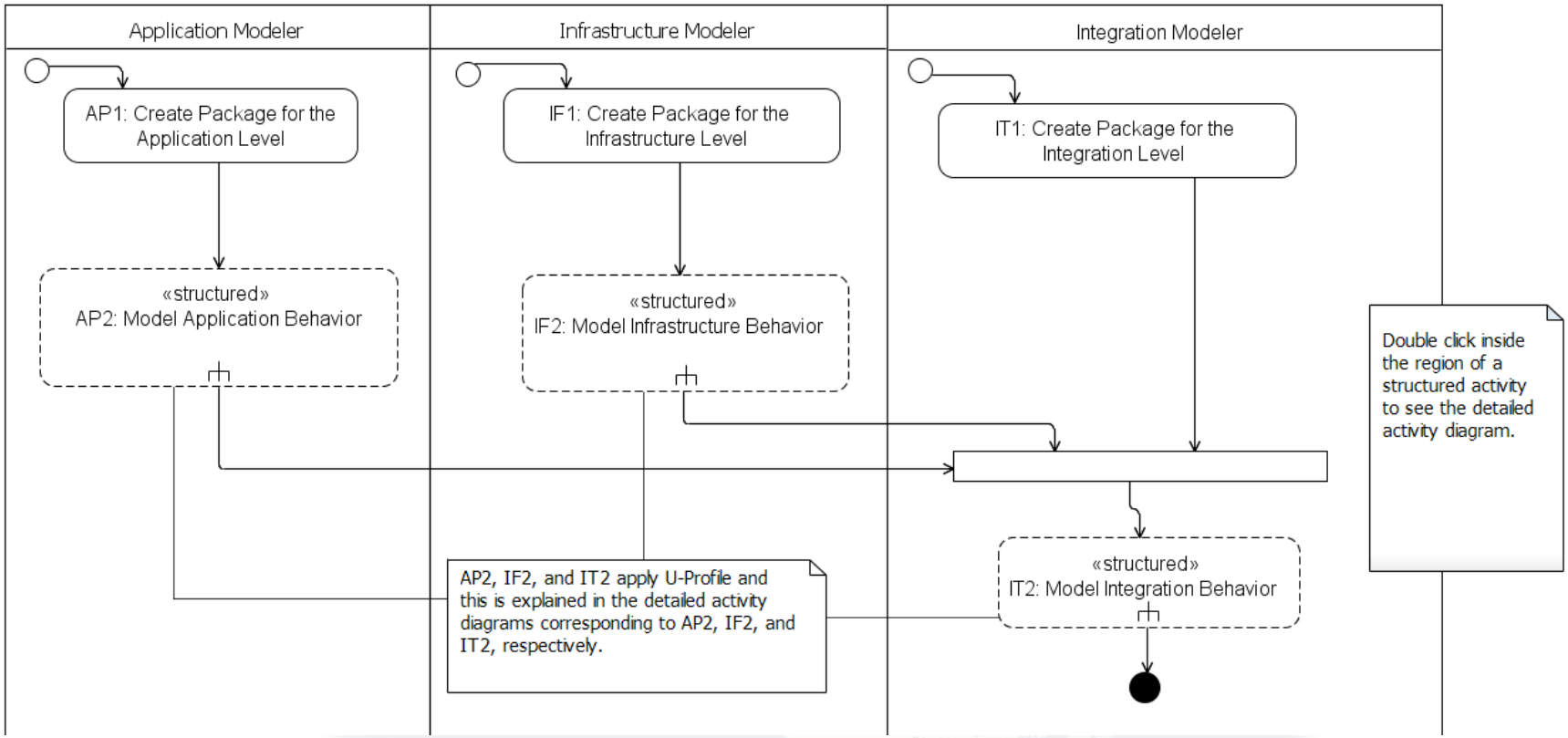
METHODOLOGY EXAMPLE (1/2)



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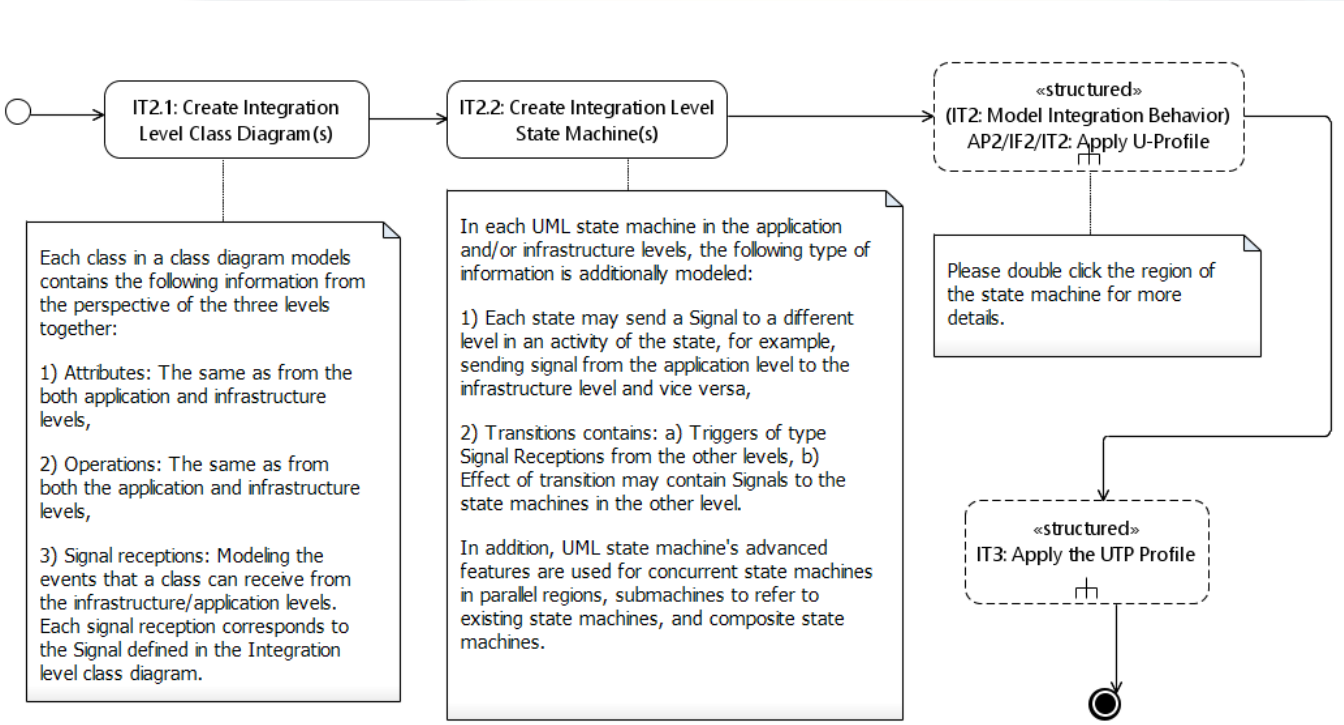
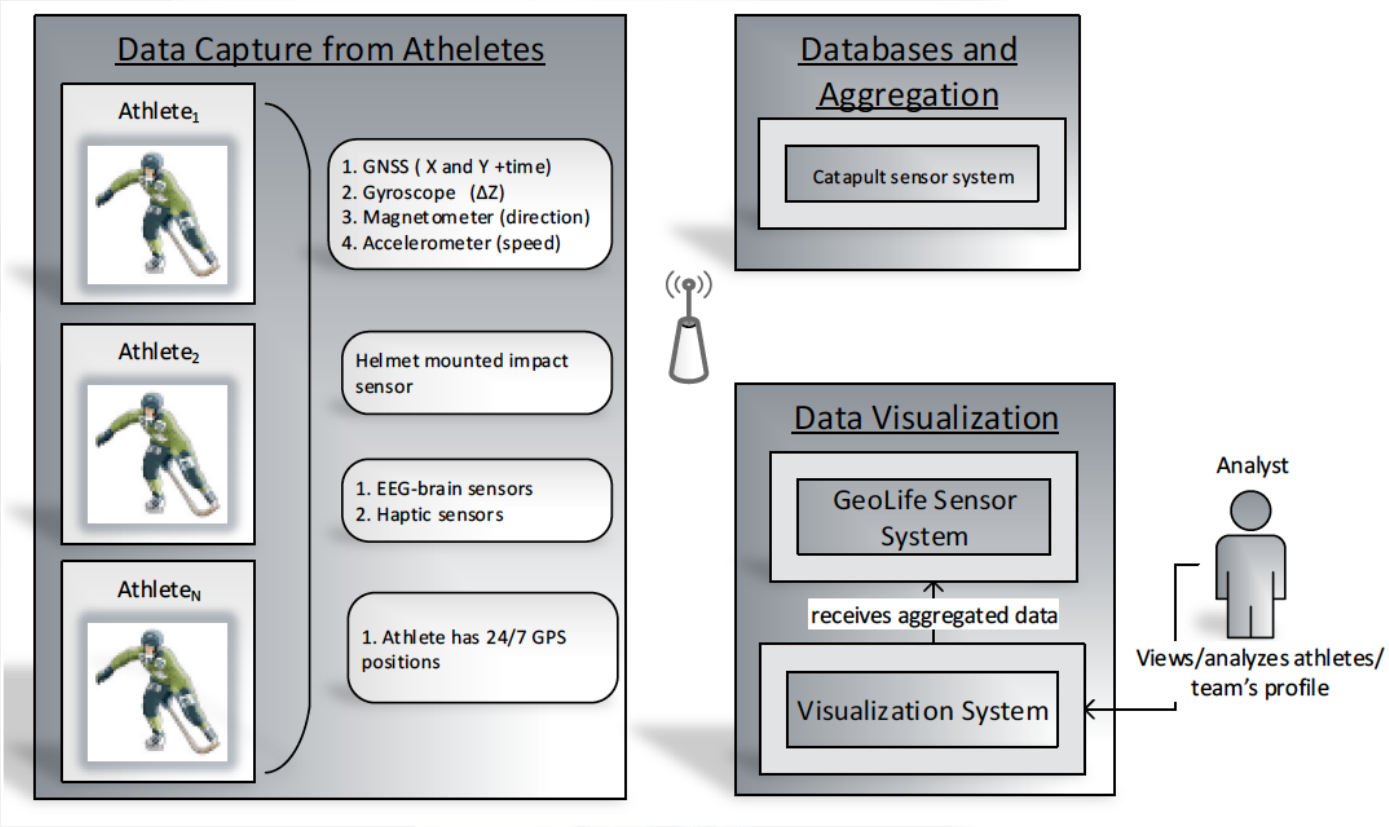
METHODOLOGY EXAMPLE (2/2)



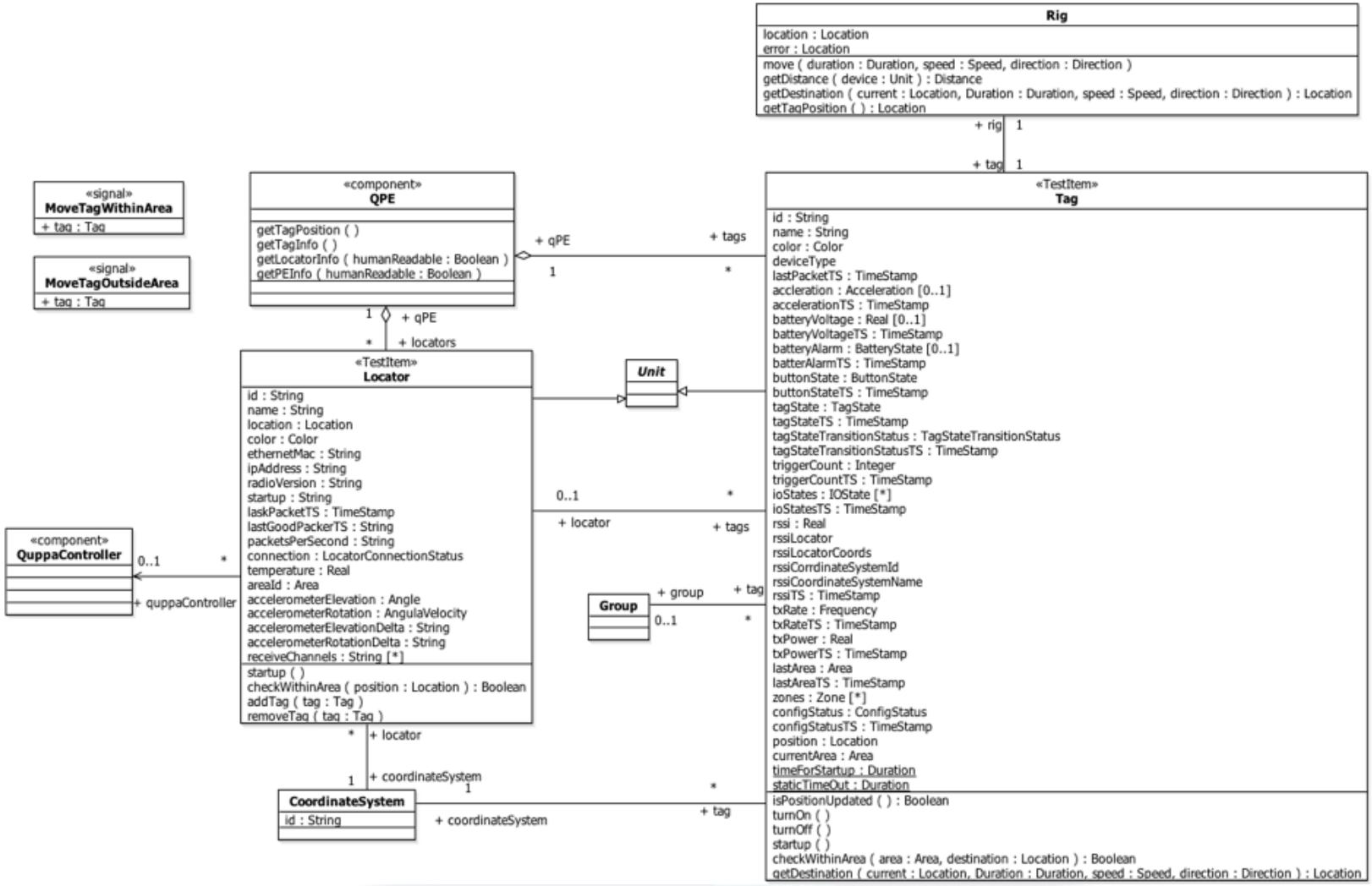
M. Zhang, S. Ali, T. Yue and P. H. Nguyen, Uncertainty Modeling Framework for the Integration Level V.1, https://www.simula.no/file/uupv1pdf-1/download

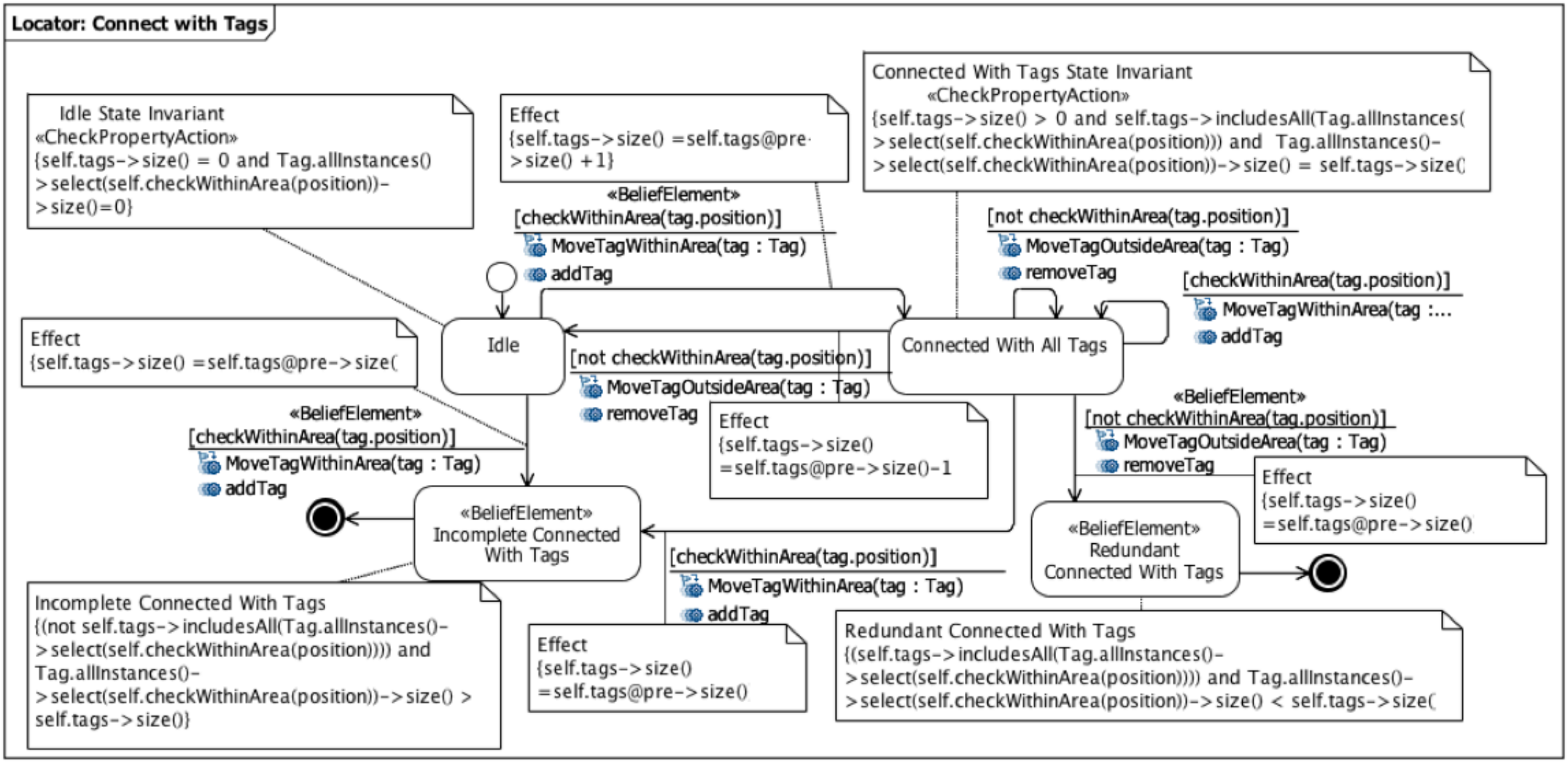
CASE STUDY PROVIDERS: GEO SPORTS



future position | 60°40'17" North 17°06'29" East 213.141.90.204

EXAMPLE MODELS: GEOSPORTS CASE STUDY

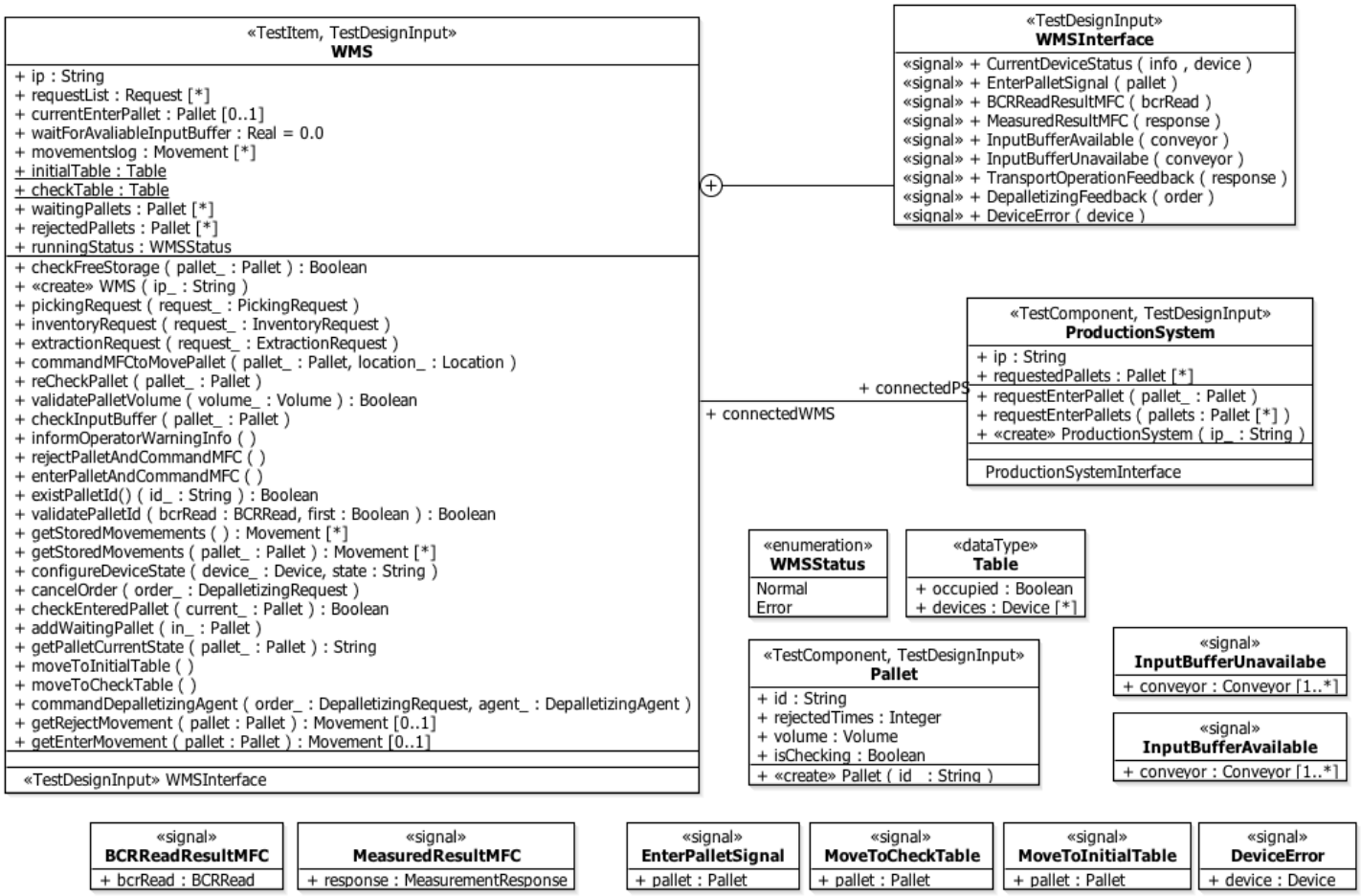



Locator: Connect with Tags
Idle State Invariant
«CheckPropertyAction»
{self.tags->size() = 0 and Tag.allInstances()
>select(self.checkWithinArea(position))-
>size()=0}
Effect
{self.tags->size() =self.tags@pre
>size() +1}
«BeliefElement»
[checkWithinArea(tag.position)]
MoveTagWithinArea(tag : Tag)
addTag
Connected With Tags State Invariant
«CheckPropertyAction»
{self.tags->size() > 0 and self.tags->includesAll(Tag.allInstances(
>select(self.checkWithinArea(position))) and Tag.allInstances()-
>select(self.checkWithinArea(position))->size() = self.tags->size(
[not checkWithinArea(tag.position)]
MoveTagOutsideArea(tag : Tag)
removeTag
[checkWithinArea(tag.position)]
MoveTagWithinArea(tag :...
addTag
Effect
{self.tags->size() =self.tags@pre->size(
Idle
[not checkWithinArea(tag.position)]
MoveTagOutsideArea(tag : Tag)
removeTag
Connected With All Tags
Effect
{self.tags->size()
=self.tags@pre->size()-1
«BeliefElement»
[checkWithinArea(tag.position)]
MoveTagWithinArea(tag : Tag)
addTag
«BeliefElement»
[not checkWithinArea(tag.position)]
MoveTagOutsideArea(tag : Tag)
removeTag
Effect
{self.tags->size()
=self.tags@pre->size()
«BeliefElement»
Incomplete Connected
With Tags
«BeliefElement»
Redundant
Connected With Tags
[checkWithinArea(tag.position)]
MoveTagWithinArea(tag : Tag)
addTag
Incomplete Connected With Tags
{(not self.tags->includesAll(Tag.allInstances()-
>select(self.checkWithinArea(position)))) and
Tag.allInstances()-
>select(self.checkWithinArea(position))->size() >
self.tags->size()}
Effect
{self.tags->size()
=self.tags@pre->size()
Redundant Connected With Tags
{(self.tags->includesAll(Tag.allInstances()-
>select(self.checkWithinArea(position)))) and Tag.allInstances()-
>select(self.checkWithinArea(position))->size() < self.tags->size(

CASE STUDY PROVIDERS: HANDLING SYSTEMS

ULMA
Handling Systems

EXAMPLE MODELS: ULMA HANDLING SYSTEMS CASE STUDY



EXAMPLE MODELS: ULMA HANDLING CASE STUDY