# Considering Abstraction Levels on a Case Study

### **Casper Thule & René Nilsson**

2016-11-07



www.into-cps.au.dk



- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## Introduction

- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## Introduction

- Cyber-physical Systems
  - Interaction between cyber parts and physical entities.
    - E.g. a UAV
  - Complexity is challenging
- Co-simulation
  - Models of constituent components
  - Discrete Event and Continuous Time
- Technologies
  - Crescendo
  - INTO-CPS
- Goal





# History

- CT model
  - No prior knowledge of UAV dynamics
  - Abstract modeling
  - Model refinement









## History

- DE model
  - APM:Copter
  - Reverse engineering







- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## **CT Model**

• Block diagrams and differential equations in 20-sim





## DE Model

- APM:Copter reverse engineering
- Modeled with VDM-RT





- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## Basics of a UAV

• Hardware







## Abstraction

• Waypoint



• Abstracted control models (P & PID)





- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## Results

 Co-simulation results. - Goal: 3, 2 and 4 meters



#### **Drone Altitude**

• Total error

Ρ	PID	Original
~6.78 meters	~3.34 meters	~3.89 meters



## Reflection

- 6 hours to create abstractions
  - files/Lines of Code

Ρ	PID	Original
12/307	12/333	42/2270

High-level behavior vs low level details



• Breadth approach





- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## INTO-CPS

- Tools
- Functionality



• Max diff: 11.8 cm





- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## Conclusion

- Abstraction useful for prototyping
  - Gain insight
  - Handle complexity
  - 6 hours
  - Different expertises
- Transition to INTO-CPS technology
  - Only interface variable changes



- Introduction
- Model description
- Model abstraction
- Results
- INTO-CPS
- Conclusion
- Future work



## **Future Work**

- Utilize additional INTO-CPS features
  - Design Space Exploration
  - Hardware-In-the-Loop simulation
  - Software-In-the-Loop simulation
- Generic components for Overture
  - Vector, controllers, drivers etc.
  - Improve tool support, reduce development time
- Future case study
  - Battery management
  - Very low abstraction level



"The purpose of abstraction is not to be vague, but to create a new semantic level in which one can be absolutely precise"

- Edsger W. Dijkstra



**Considering Abstraction Levels on a Case Study**