ENSEMBLE Embedded Software Integration Platform

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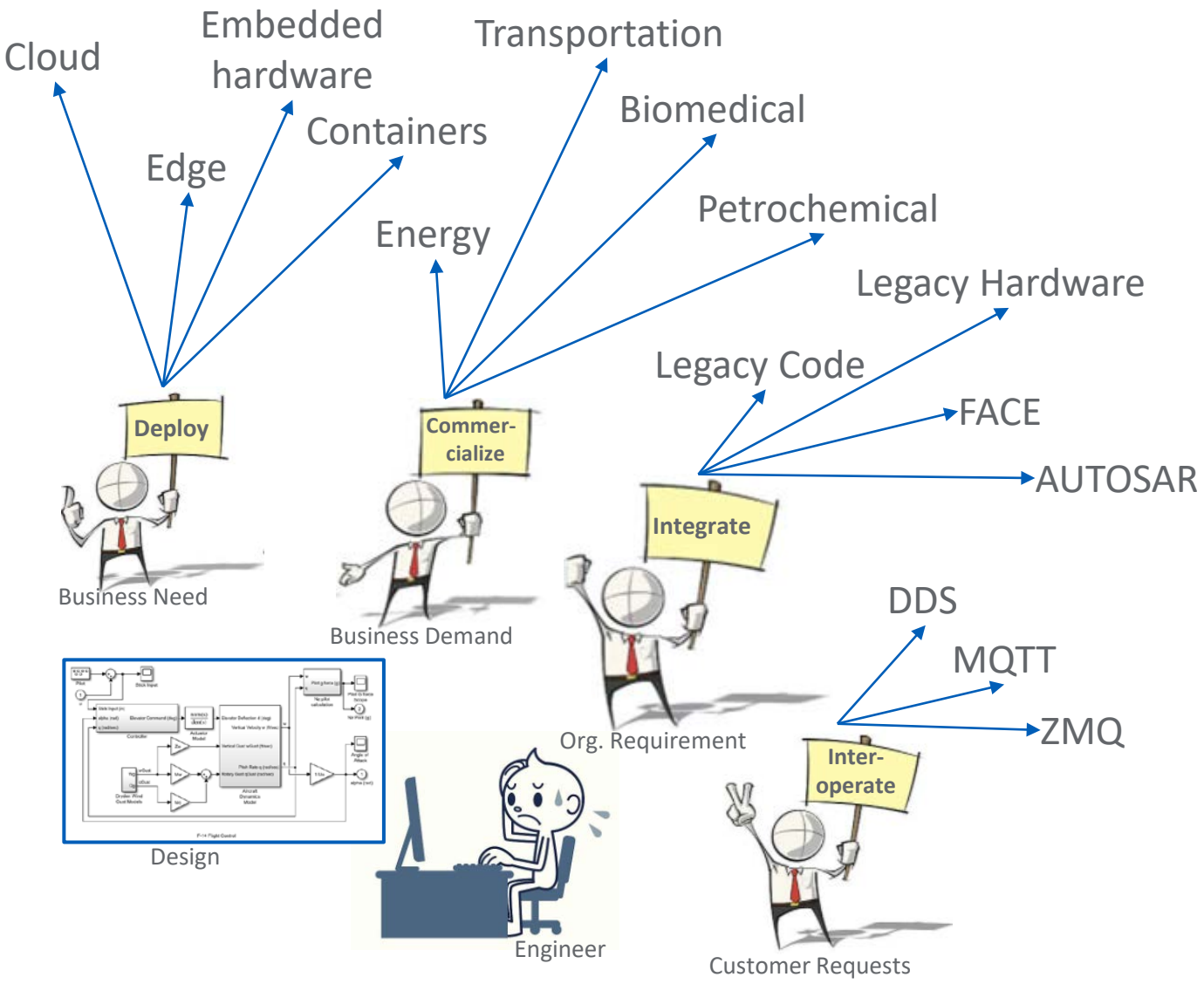
INTRODUCTION

Challenges faced by many today



Engineers face numerous challenges:

- Accelerated path to production
- Diversity in deployment ecosystems
- Wide variety of target hardware platforms
- Need for complex interoperability
- Diversity in business application spaces

GE Research developed an embedded software integration platform called Ensemble, which helps engineers:

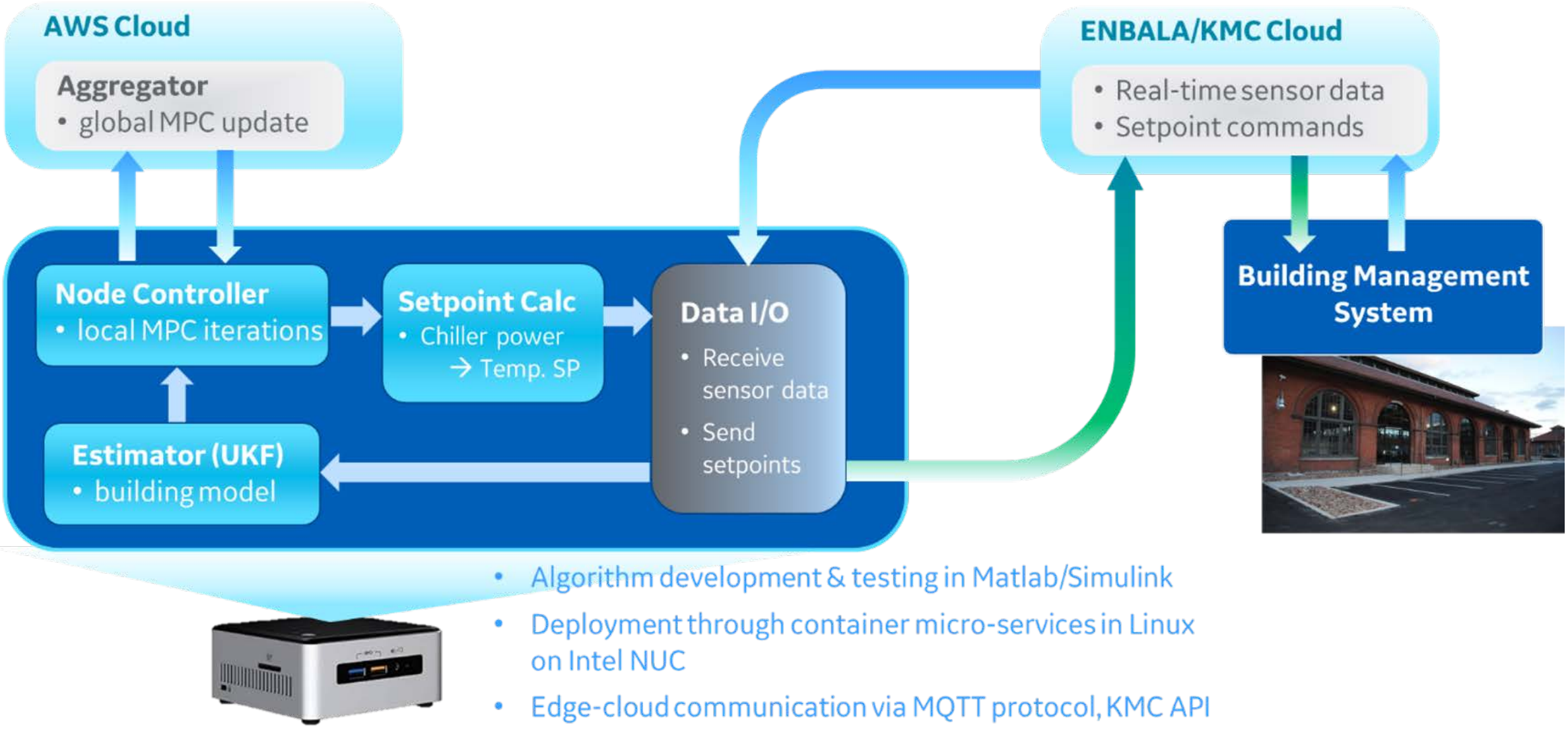
- to maximize the use of automation and code generation to take over mundane development aspects
- to enable engineers to spend more time developing core functionality, and less time focused on intricacies of deployment
- to facilitate team collaboration, testing, verification, and maintenance of embedded applications

Ensemble Platform Applications

Ensemble platform has been used by the following GE projects

- GE Power Digital Ghost program for cyber-security power generation infrastructure protection
- GE Digital power grid state estimation and monitoring
- GE Renewable Energy Grid Automation Controls Software Platform
- GE Research ARPA-E building control automation program
- GE Research DOE coal power plant advanced control program
- GE Research Controls and Optimization infrastructure development project

Automation of Adaptive HVAC Building Control



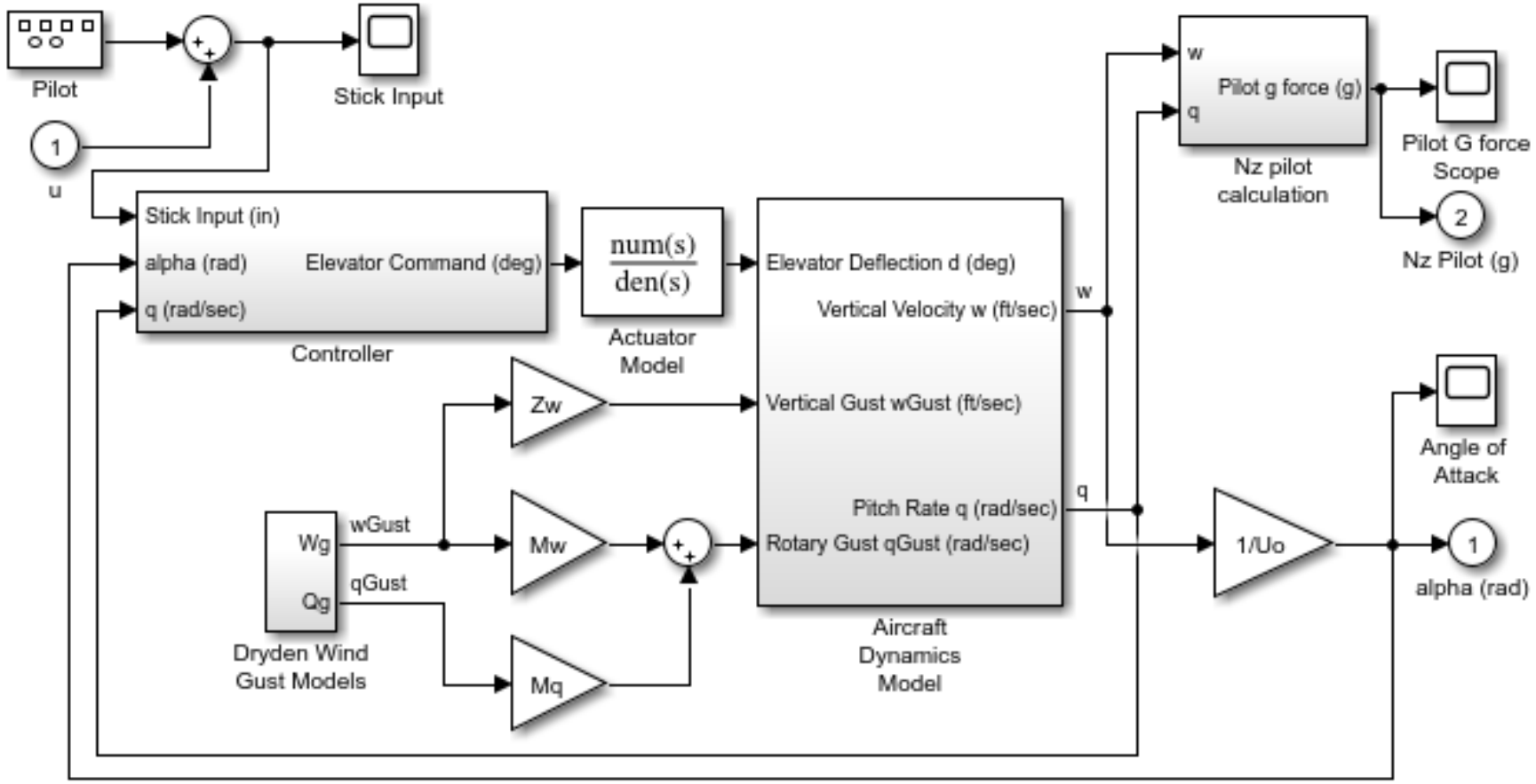
- Algorithm development & testing in Matlab/Simulink
- Deployment through container micro-services in Linux on Intel NUC
- Edge-cloud communication via MQTT protocol, KMC API

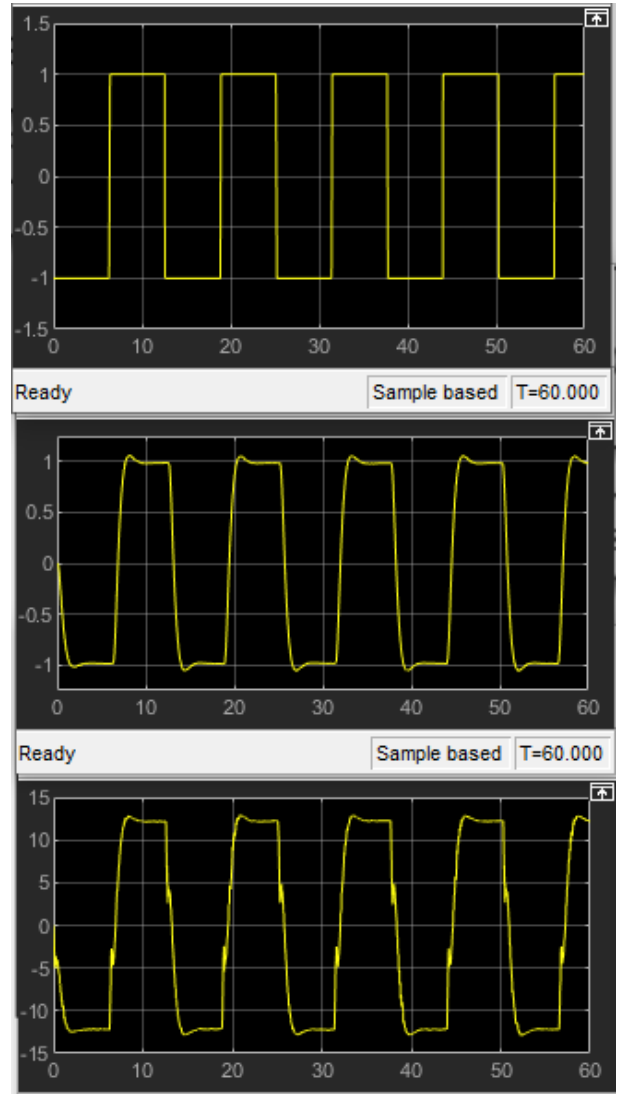
ENSEBLE PLATFORM APPLICATION EXAMPLE DEMO

DEPLOYING F14 ELEVATOR CONTROLLER IN A DOCKER CONTAINER

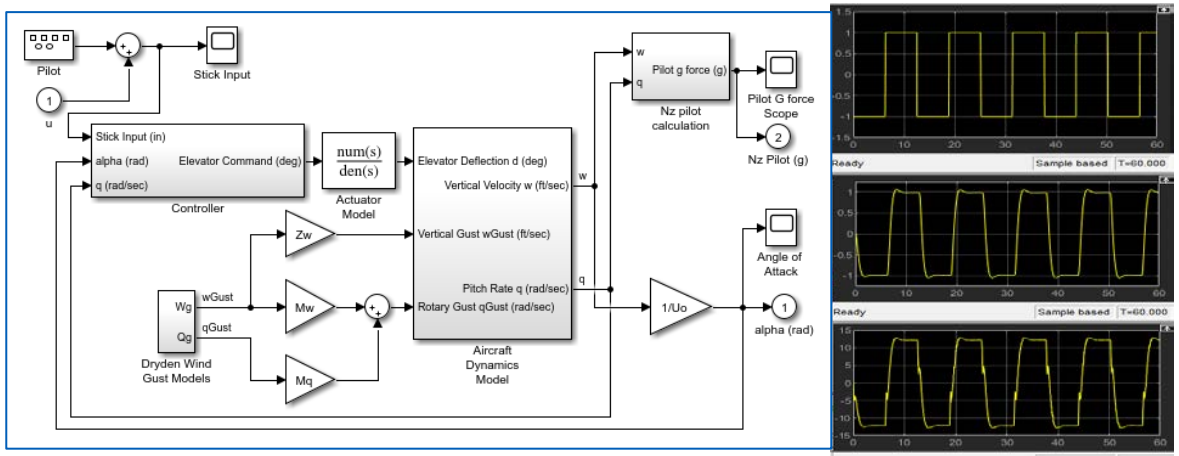
Deploying F14 elevator control application

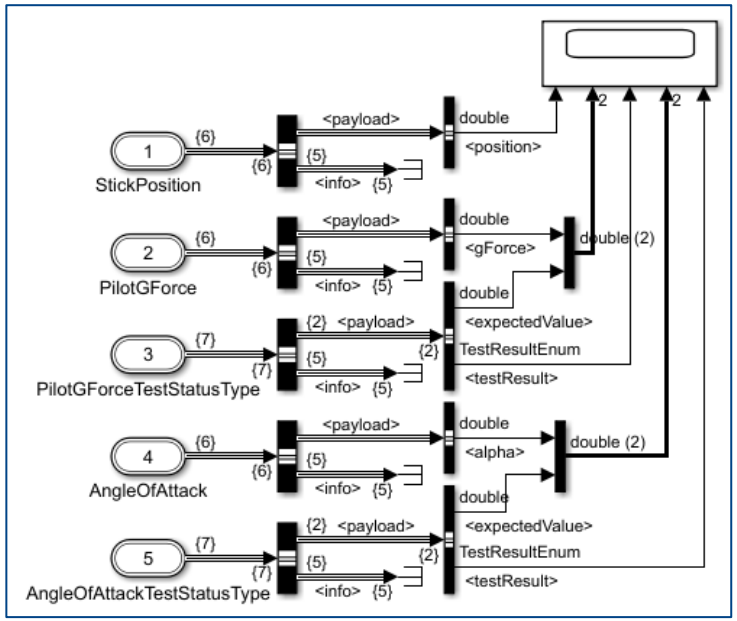
F14 Elevator Control Example from Simulink Demo Suite

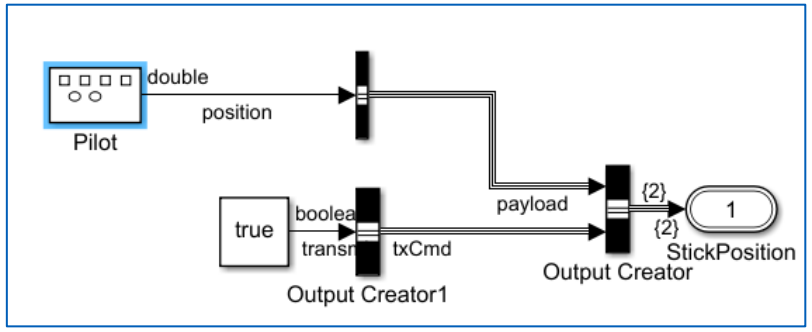


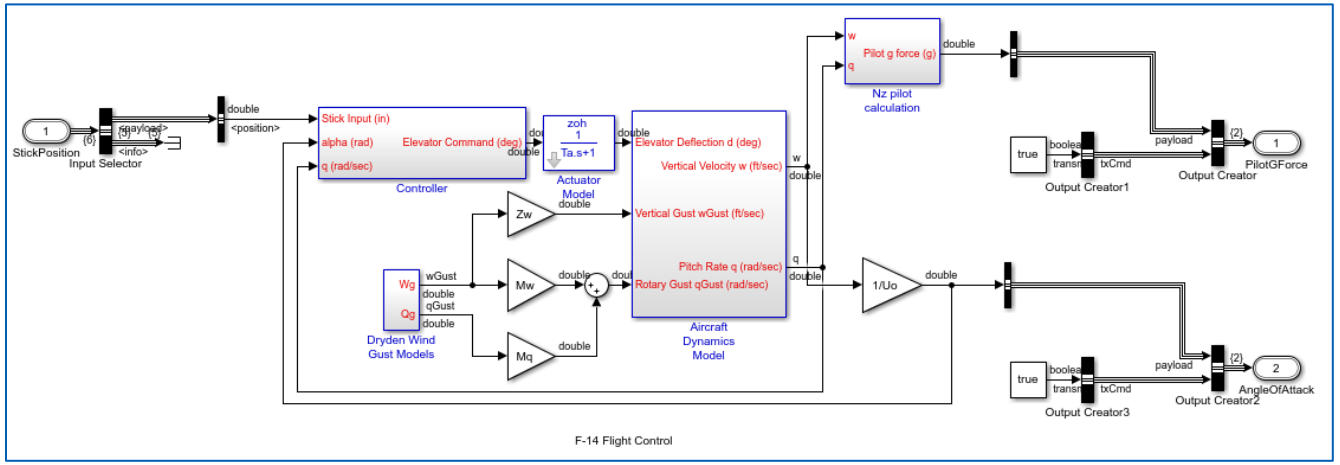


Deploying F14 elevator control application

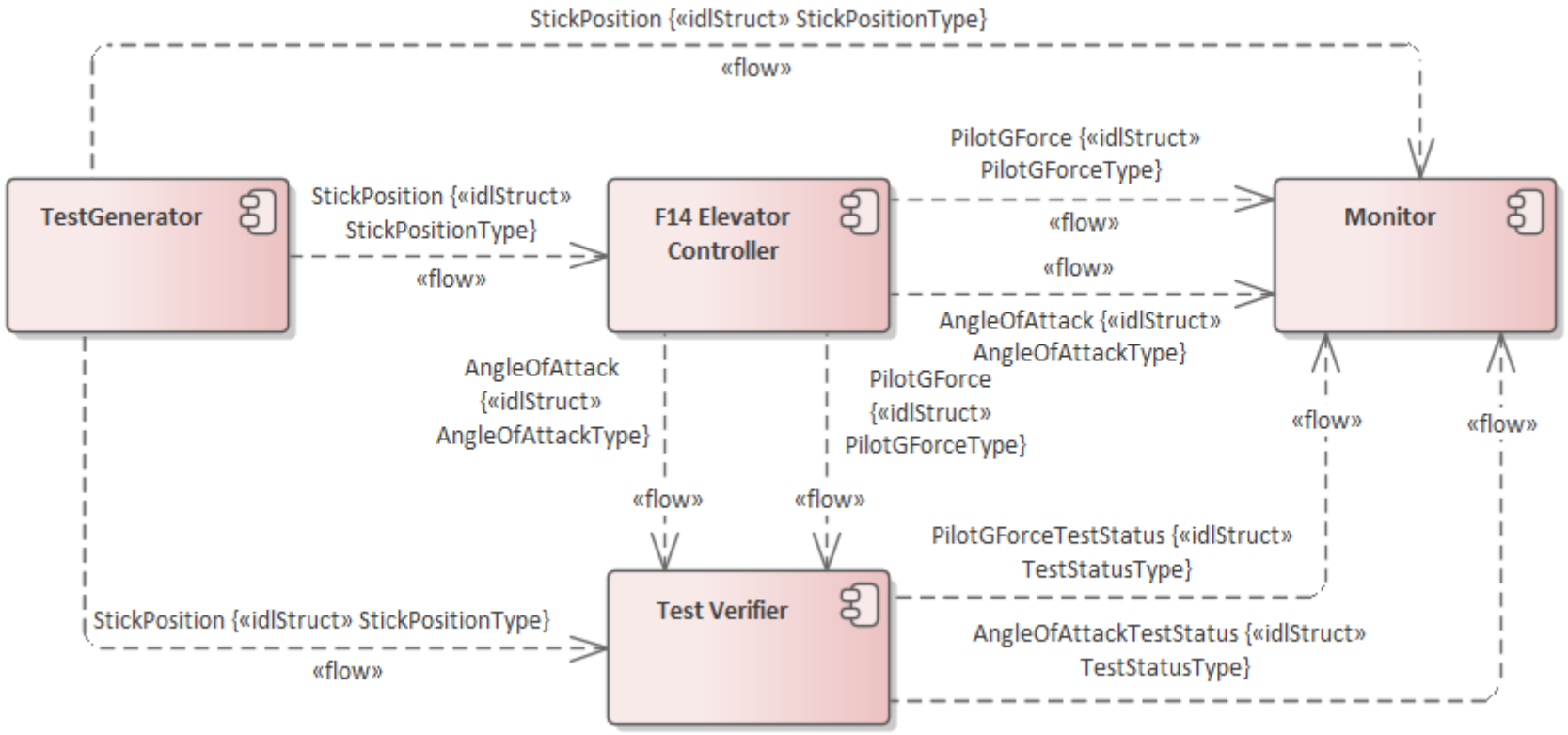




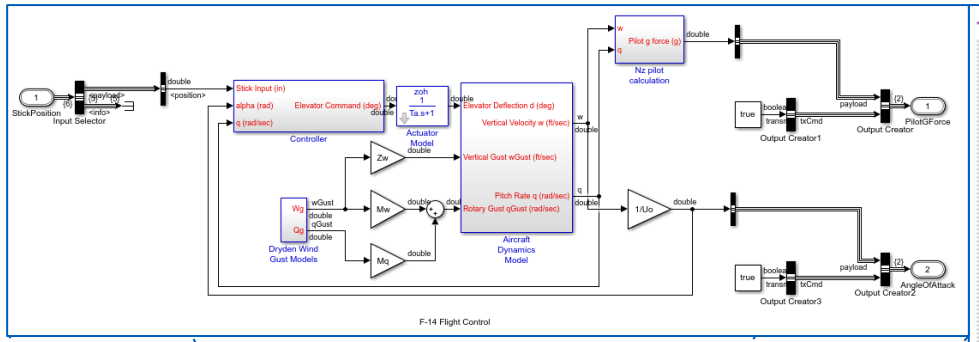




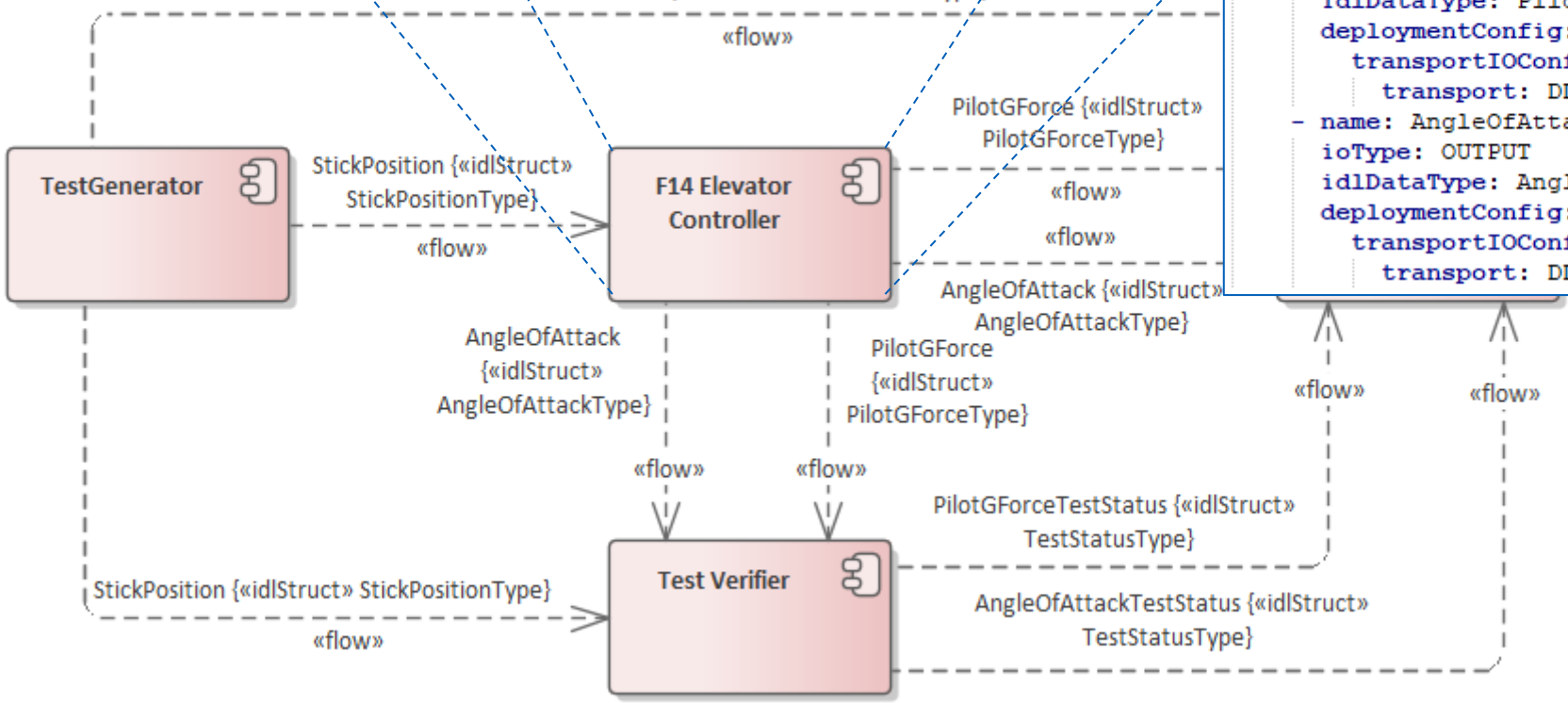
Deploying F14 elevator control application



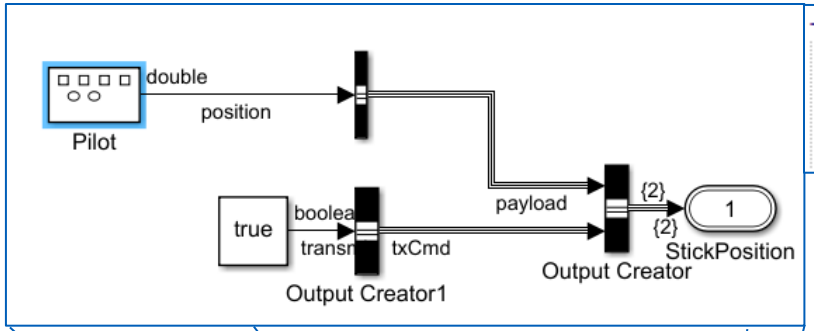
Deploying F14 elevator control application



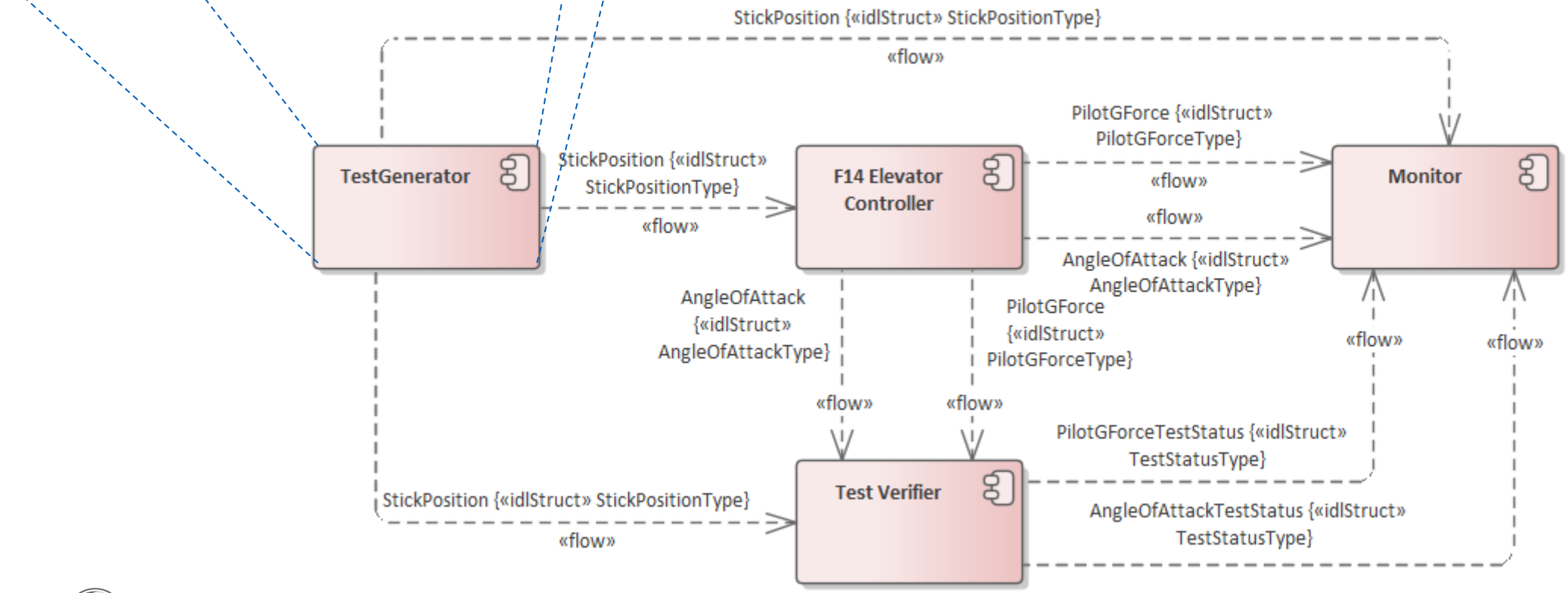

```
- name: F14_ElevatorController
  deploymentConfig:
    targetType: DOCKER
  ioDescriptors:
    - name: StickPosition
      ioType: INPUT
      idlDataType: StickPositionType
      deploymentConfig:
        transportIOConfig:
          transport: DDS
    - name: PilotGForce
      ioType: OUTPUT
      idlDataType: PilotGForceType
      deploymentConfig:
        transportIOConfig:
          transport: DDS
    - name: AngleOfAttack
      ioType: OUTPUT
      idlDataType: AngleOfAttackType
      deploymentConfig:
        transportIOConfig:
          transport: DDS
```



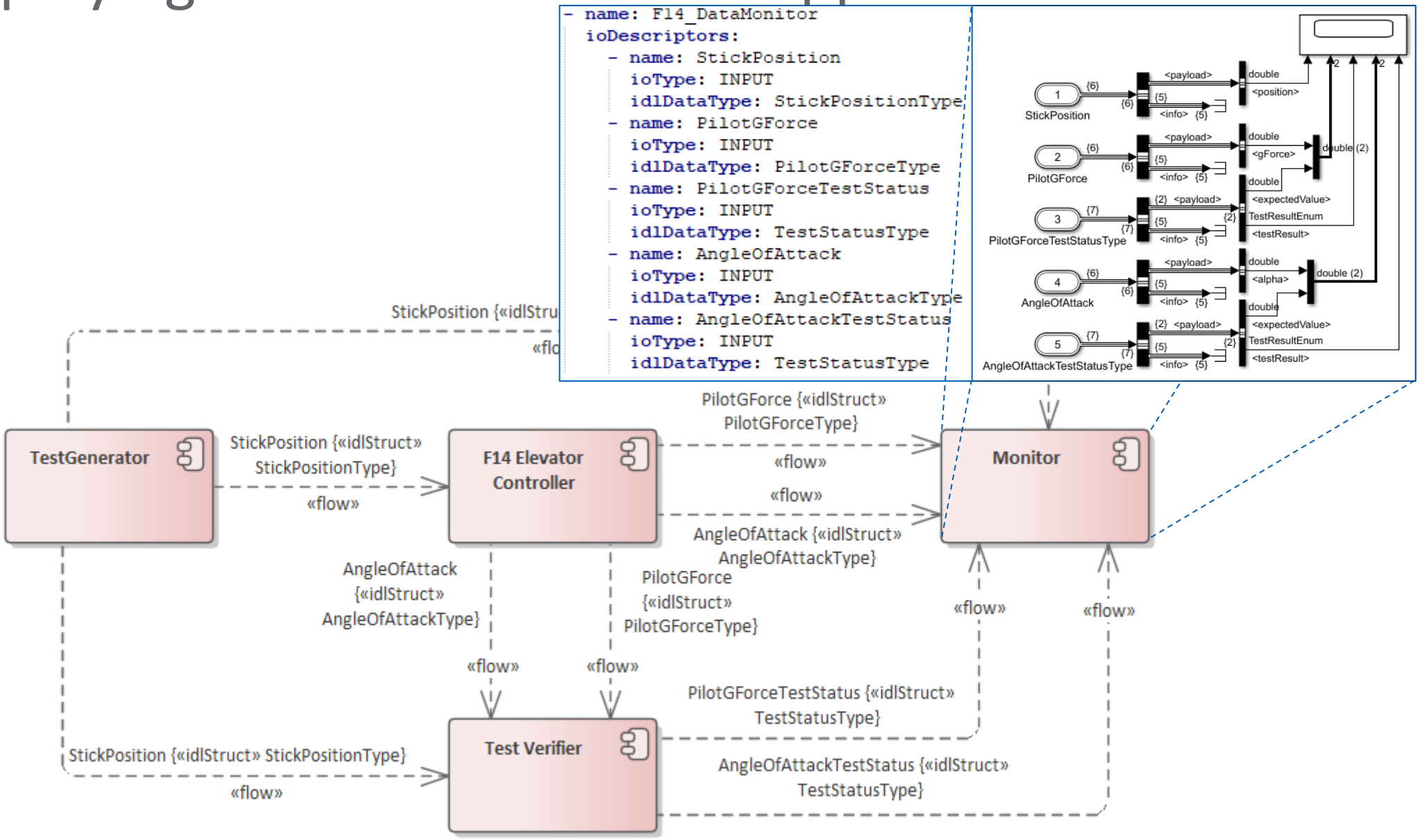
Deploying F14 elevator control application




```
- name: F14_ElevatorControl_TestGenerator
  ioDescriptors:
    - name: StickPosition
      ioType: OUTPUT
      idlDataType: StickPositionType
```



Deploying F14 elevator control application



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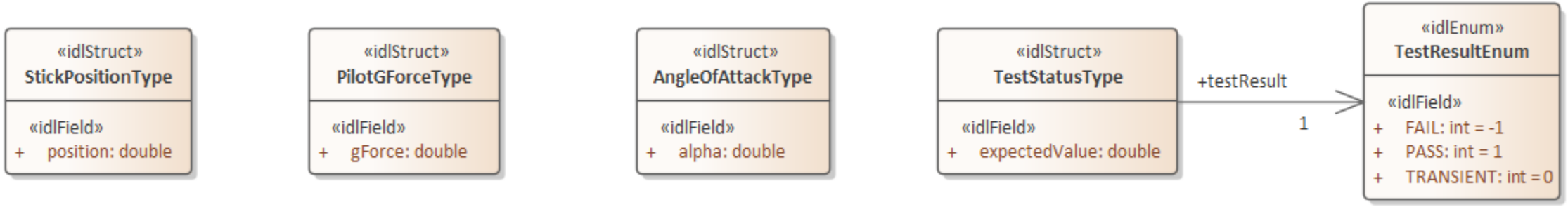
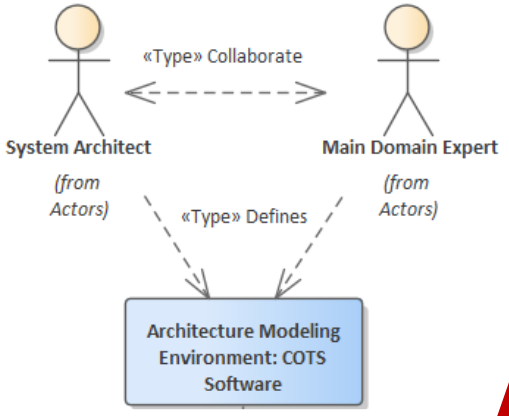



```
struct StickPositionType {
    double  position;
};

struct PilotGForceType {
    double gForce;
};

struct AngleOfAttackType {
    double alpha;
};
```

```
enum TestResultEnum {
    TRANSIENT   = 0,
    PASS        = 1,
    FAIL        = -1
};

struct TestStatusType {
    double          expectedValue;
    TestResultEnum  testResult;
};
```

ENSEMBLE PLATFORM OVERVIEW

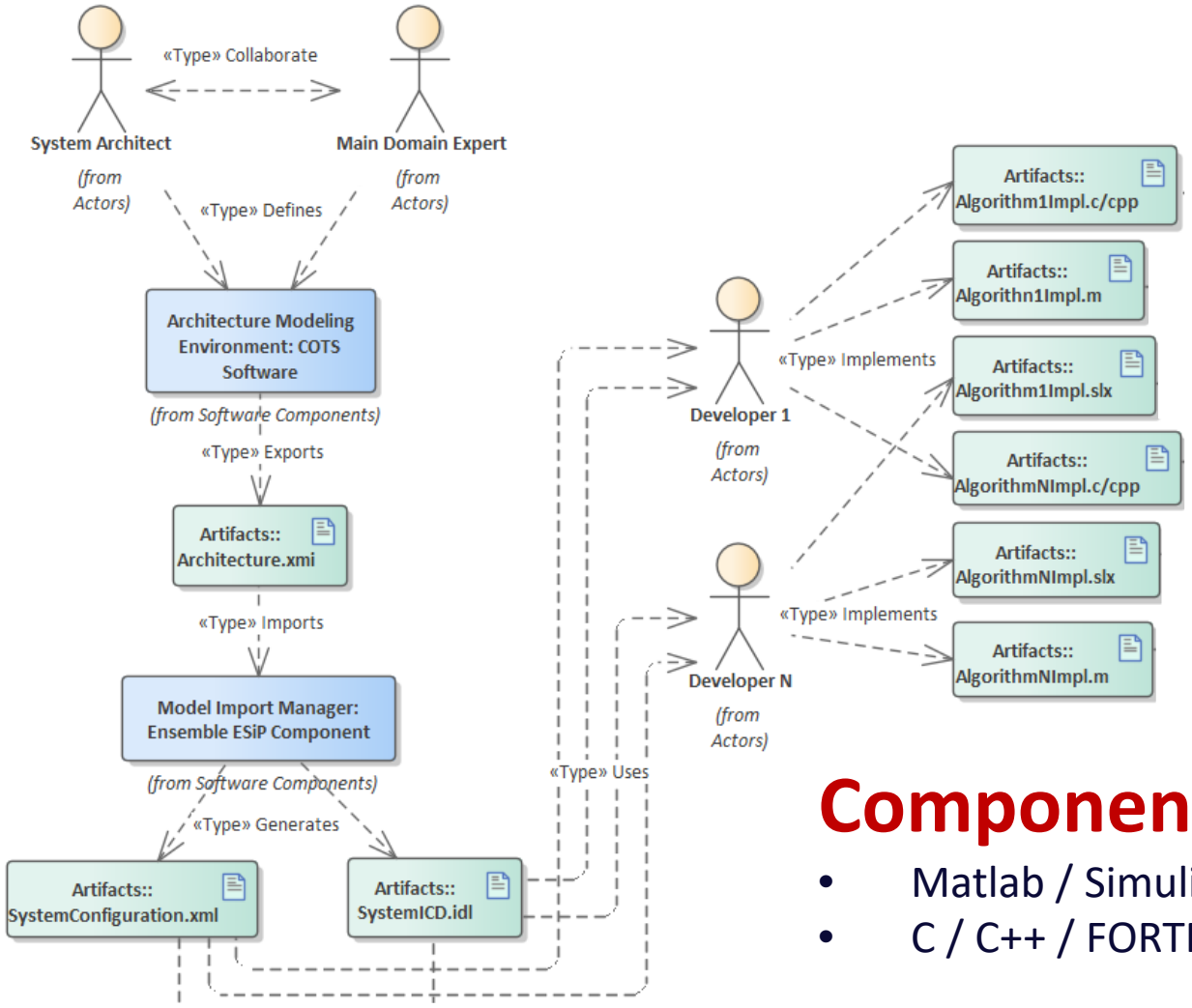
ENSEMBLE ESiP SoS Development Automation Workflow



Architecture Modeling Phase

- Enterprise Architect
- Magic Draw
- IBM Rational Rhapsody
- MathWorks System Composer

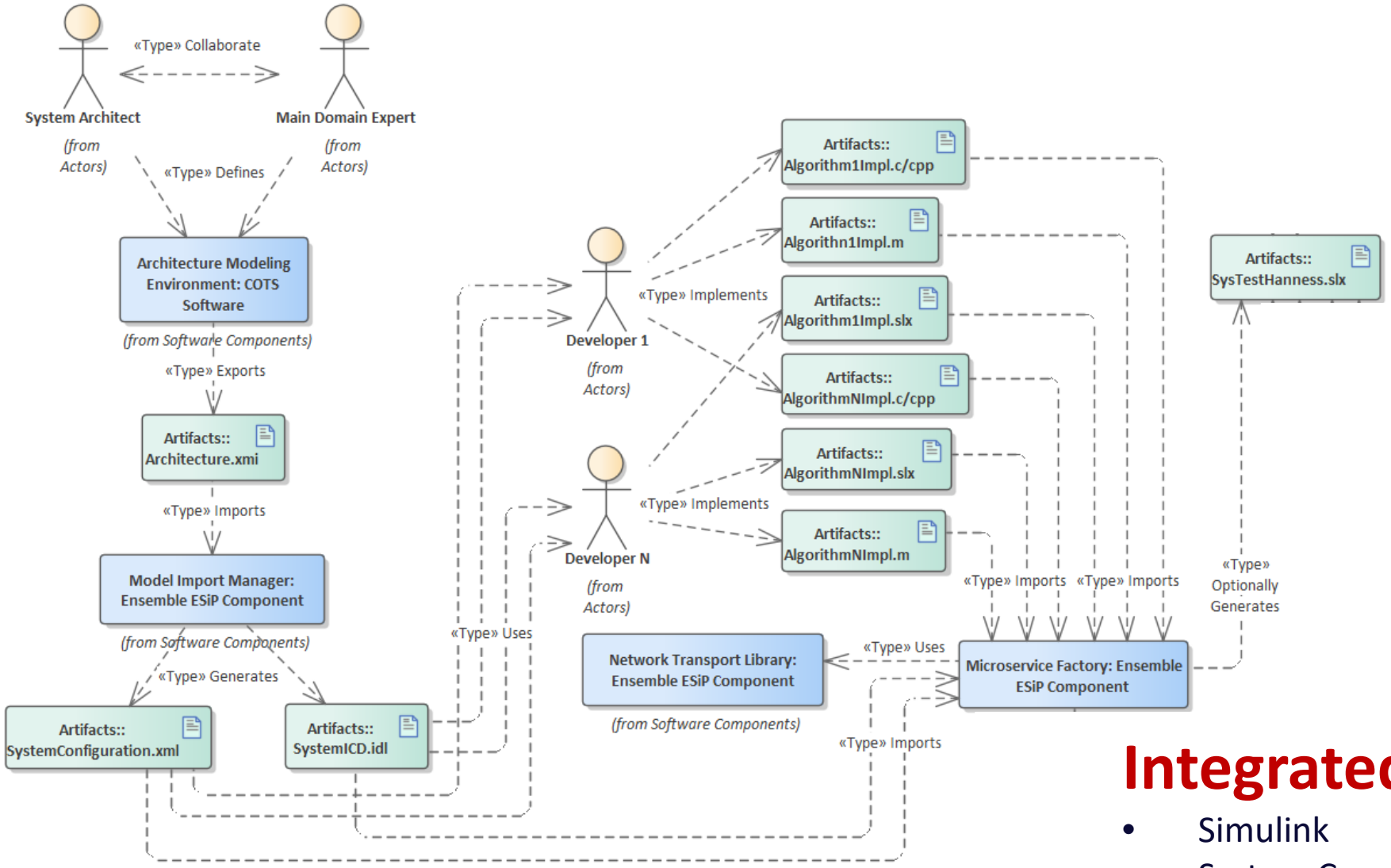
ENSEMBLE ESiP SoS Development Automation Workflow



Component Implementation Phase

- Matlab / Simulink /Stateflow
- C / C++ / FORTRAN /Ada (compiled languages)

ENSEMBLE ESiP SoS Development Automation Workflow



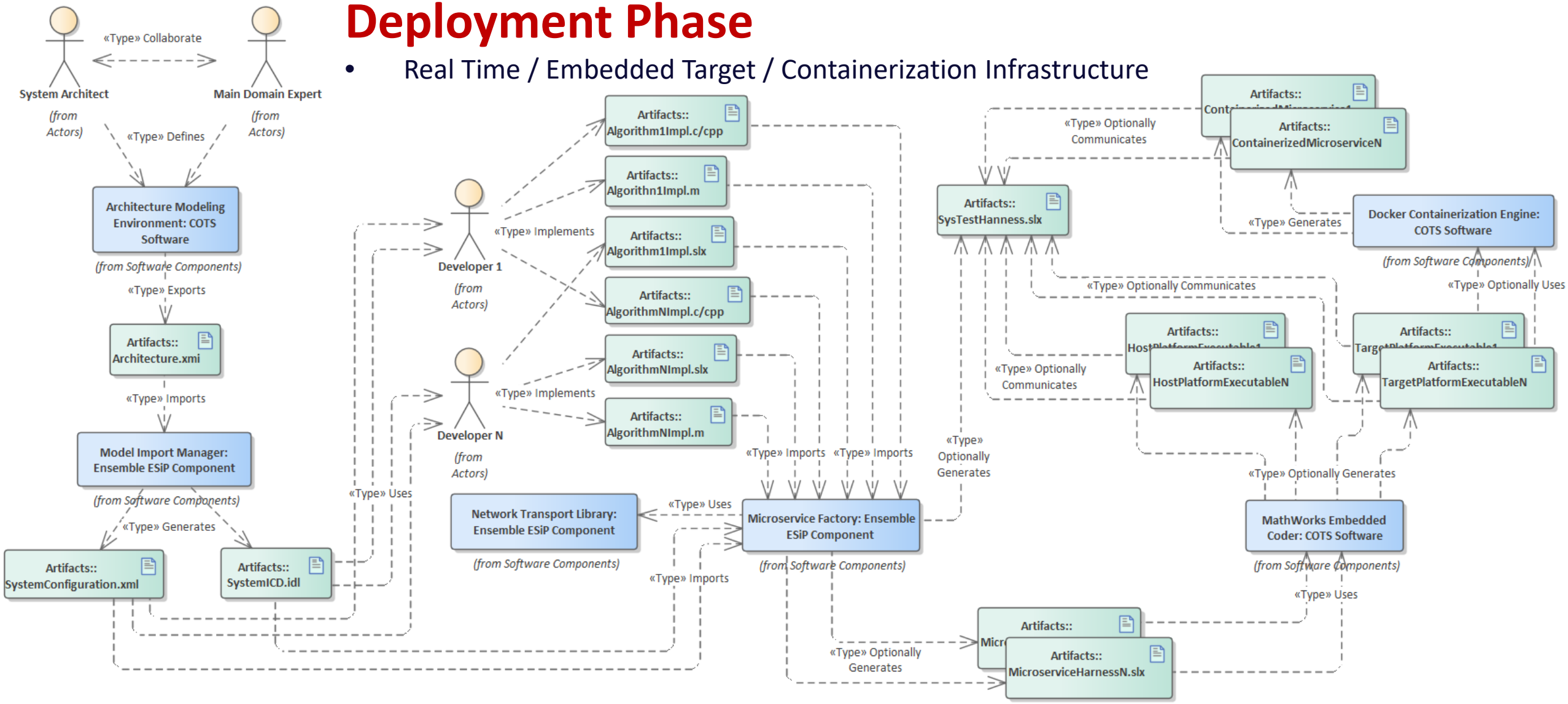
Integrated Testing Phase

- Simulink
- System Composer

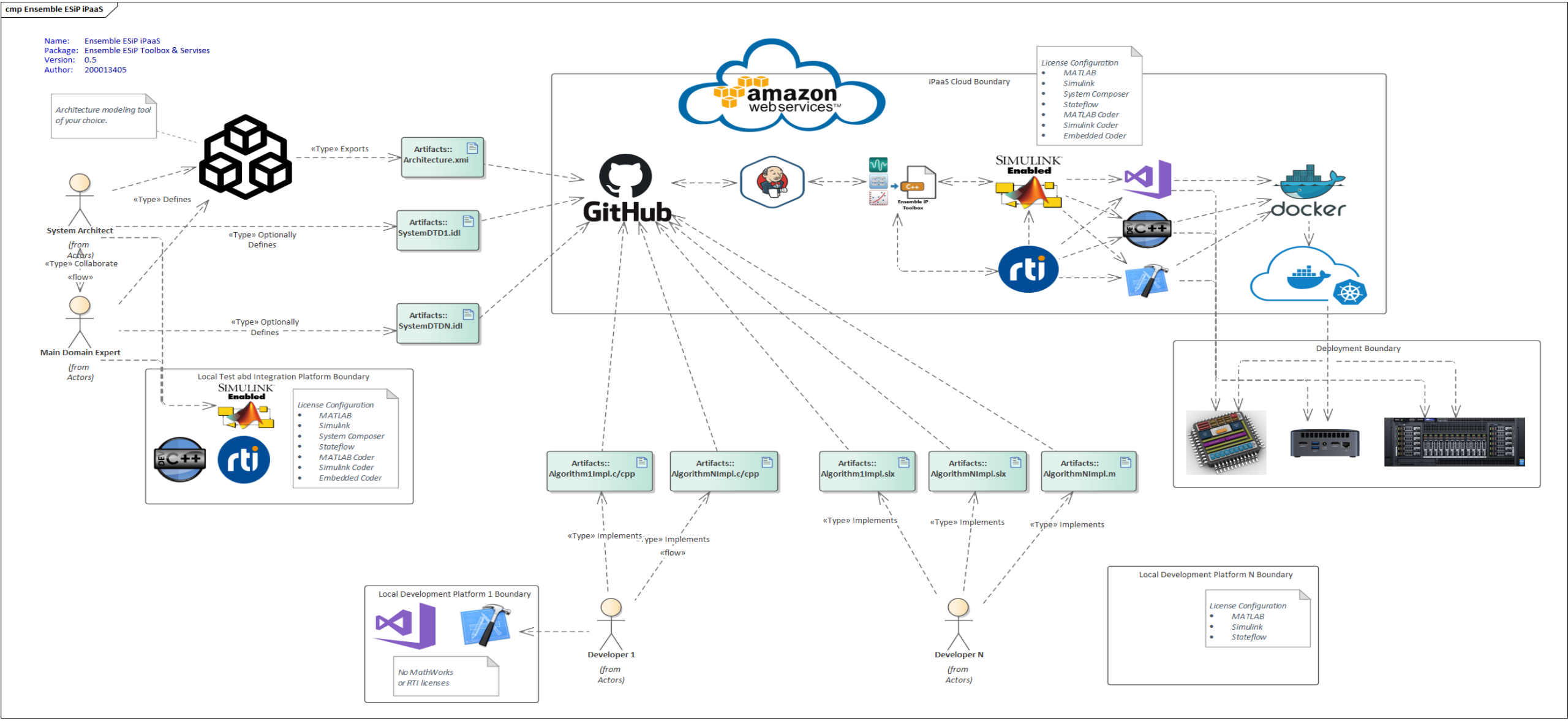
ENSEMBLE ESiP SoS Development Automation Workflow

Deployment Phase

- Real Time / Embedded Target / Containerization Infrastructure



ENSEMBLE integration Platform as a Service (iPaaS)



SUMMARY

Summary

- Ensemble is the Embedded Software integration Platform (ESiP) for MATLAB/Simulink/Stateflow/C/C++ based applications
- It uses automation, code generation and a variety of common middleware implementations to simplify production of large sets of embedded application microservices
- Use of this platform substantially increases productivity of embedded software development teams.
- It reduces the need of development teams to perform costly manual integration steps and allows them to focus on core embedded system capabilities and not on integration issues
- This platform paves the way to better Continuous Integration and Continuous Delivery (CI/CD) paths for embedded software applications

Additional Resources

A detailed application case study using Ensemble platform can be found in:
R. Ghaemi, A. Kumar, P. Bonanni and N. Visnevski, "Scalable Optimal Flexibility Control, modeling and estimation of commercial buildings," 2020 American Control Conference (ACC), Denver, CO, USA, 2020, pp. 2318-2325.

In depth examination of the Ensemble platform can be found in:
N. Visnevski, "A Novel, Model-Based, Specification-Driven Embedded Software Integration Platform “, 2021 Aerospace Conference

In depth analysis of deployment aspects of the platform can be found in:
N. Visnevski, T. Hubscher-Younger, A. Rajhans and B. Meng, "Automatic Synthesis of Information Flow Driven Execution Managers for Embedded Software Applications," 2020 AIAA/IEEE 39th Digital Avionics Systems Conference (DASC), San Antonio, TX, USA, 2020, pp. 1-9.