A Co-simulation Environment for ATM/UTM Demonstrations

Yan Xu[1), 2) †], Junjie Zhao[1)], Tingyu Gong[1)], Christantus Nnamani[1)] and Antonios Tsourdos[1)]

[1)] *School of Aerospace, Transport and Manufacturing, Cranfield University, United Kingdom*
[2)] *School of Electronic and Information Engineering, Beihang University, China*
[†]*email: yan.xu@buaa.edu.cn*

This article presents a co-simulation environment for testing air traffic management (ATM) and unmanned traffic management (UTM) solutions. It features a frontend for user interaction, a backend for system logic, a modular design for functionality, and a robust data model. The environment supports user authentication, strategic deconfliction, dynamic constraints, and real-time data processing. It aims to enhance system flexibility, scalability, and operational efficiency through a unified data model and modular architecture.

Key Words: Air Traffic Management, UAS Traffic Management, Co-simulation Environment, Functional Module, Data Model

1. Introduction

In this article, we introduce a co-simulation environment for testing ATM/UTM research and development solutions. It consists of four main components, including system frontend, backend, data model, and functional modules[1)], as well as three main extensions to enable richer co-simulation activities[2-3)].

2. System Frontend

Users are grouped and granted role-based permissions (e.g., airspace managers, operators). The frontend displays and filters geographic information, weather conditions, and traffic surveillance via a 2D satellite map that can switch to 3D and overlay other layers. Operators can create and submit flight plans, processed by the backend for approval. Airspace managers can create dynamic constraints, updating a central database and reviewing flight plans. The frontend also supports public information release for authorized users and real-time point-to-point communication.

3. System Backend

The backend manages the system's core logic, deployable on cloud servers. It processes frontend user requests by querying, updating, and deleting database data, and formats it for frontend return. It handles user authentication and permission control based on user groups, fully integrates core modules like strategic deconfliction, and manages external service interactions. Efficient server resource management ensures stability and high performance. Additionally, it provides a software development kit to support functional module development.

4. Functional Module

The modular design ensures system flexibility and scalability, facilitating parallel component advancement to save development time. Core functional components include pre-flight and in-flight module groups. Modules can be deployed using Docker containerization, with communication based on a unified data model. An interface allows users to adjust parameters of built-in models or algorithms within each module and obtain results under different settings. Unified interfaces between modules enable users to replace models or algorithms, ensuring a stable system architecture and optimal performance.

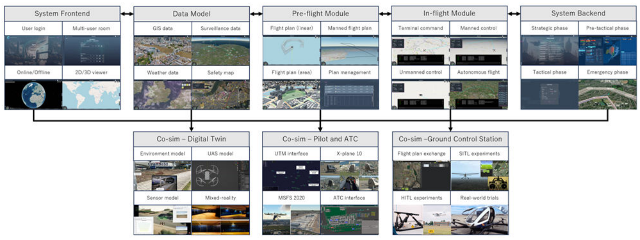

Fig. 1. Framework of the proposed co-simulation environment.

5. Data Model

The foundation is a central data model, divided into static, dynamic, and streaming data. Static data updates infrequently, following a maintenance cycle. Dynamic data supports inter-module communication and high-frequency updates, with some cached for quick access. Streaming data enhances real-time situational awareness, requiring high-performance servers for large-scale processing. An API facilitates developer access to specific data. The design of data structures and mapping relationships ensures the system's operational stability and efficiency.

References

1) Fremond, R., et. al: SESAR Innovation Days, 2022, pp. 1-9, url: https://www.sesarju.eu/sites/default/files/documents/sid/2022/paper_112.pdf
2) Zhao, J., et. al: IEEE ICNS Conference, 2023, pp. 1-10, doi: 10.1109/ICNS58246.2023.10124310.
3) Conrad, C., et. al: IEEE/AIAA DASC Conference, 2023, pp. 1-10, doi: 10.1109/DASC58513.2023.10311333.