NASA GRC UAS Project
Communications Modeling and Simulation Status

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GRC UAS Communications Modeling - Simulation Objectives

Primary Objective of Simulation Activity

Use Modeling and Simulation to perform analysis to support recommendations for integration of UAS CNPC systems for safe and efficient operation of UAS in the NAS.

Develop Models of representative Radio Technologies for UAS CNPC operations

- Investigate UAS Radio Technologies Design and Performance for UAS CNPC
- Assist with GRC UAS Flight Test Radio development
- Generate recommendations for UAS CNPC radio requirements (from simulation results)

Develop Large-scale , NAS-wide Simulation capability with NAS ATM Communications and integrated UAS CNPC Communications

- Perform Simulations with varied UAS in the NAS Communication System Architectures
- Analyze NAS ATM Communication System Performance with the introduction of UAS ATM communications traffic.
- Analyze the Performance Impact on NAS ATM Communication System operations due to UAS Air Traffic loading
- Provide recommendations for UAS in the NAS Comm System Architecture requirements

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GRC UAS Communications Mod/Sim Approach

Develop UAS Radio Models using Opnet Modeler

Opnet provides Discrete event modeling environment for simulation of Processes, Protocols, Applications, System Devices and Communications Devices

- Develop Models with varied radio technologies (for Characterization/Perf. Comparisons)
- Develop One Model to match the ongoing GRC Flight Test Radio design. (Validated Model)
- Perform simulations within the Opnet environment to study detailed Radio performance

Develop Large-Scale UAS in the NAS Comm Architectures using NASA 'ACES' application

ACES = Airspace Concepts Evaluation System (Developed at NASA ARC for Airspace Concept Research)

- Provides NAS fast-time, airspace simulations with NAS ATM Component Models
- Customizable, Single-flight to Day-in-the-NAS flight traffic loading
- Aircraft Models for Commercial and General Aviation A/C and several UAS (recently developed)

- Use of ACES gives our simulations complete NAS Airspace Architecture and Operations
- Leverage previous experience integrating Comm Models/Comm Infrastructure into ACES
- Develop one Relay and one Non-Relay UAS Comm System Architecture for analysis.

Integrate Opnet CNPC Radio models into Large-scale Simulation Architectures

- Provides interoperability between NAS Airspace operations, NAS air traffic loads, UAS Air traffic loads, existing ACES ATM Comm and new CNPC UAS Comm Systems
- Allows us to characterize NAS Comm Message Traffic levels and profiles that will exist with UAS
- Provides data to assess NAS ATM Comm Performance/Impacts and UAS CNPC link performance in same simulation environment.

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Technical Assessments

Performed a Comm Technology Assessment to determine best suited Radio Technologies for a CNPC Datalink Radio

- Evaluated over 40 technologies using technology rating methodology
- Selected 802.16, LTE, P-34, TETRA Release 2 (TEDS) as top four candidate technologies
- 802.16 will be used for GRC Flight Test Radio Design
- LTE, P-34, TETRA Release 2 (TEDS) radios will be developed for performance comparison

Performed Architecture Assessment of RTCA SC203 (CC005) Communication Architectures

- Evaluated 8 High Level Architecture Concepts (4 Relay / 4 Non-relay) presented in CC005
- Interpreted the Architecture Options (based on authors definitions for link functionality) and developed next lower level system drawings.
- Incorporated Datalink radio as Primary CNPC link in parallel with Satcom
- Performed a functional evaluation to determine the ability of each architecture to provide connectivity required for critical UAS operating scenarios
- Performed a technically subjective evaluation of subsystems using a rating/ranking process. (Eval Criteria: Complexity, Technical Readiness, Scalability, Flexibility)
- Resulted in the selection of CC005 UA Relay #4 and UA Non-Relay #4 as our target Architectures.

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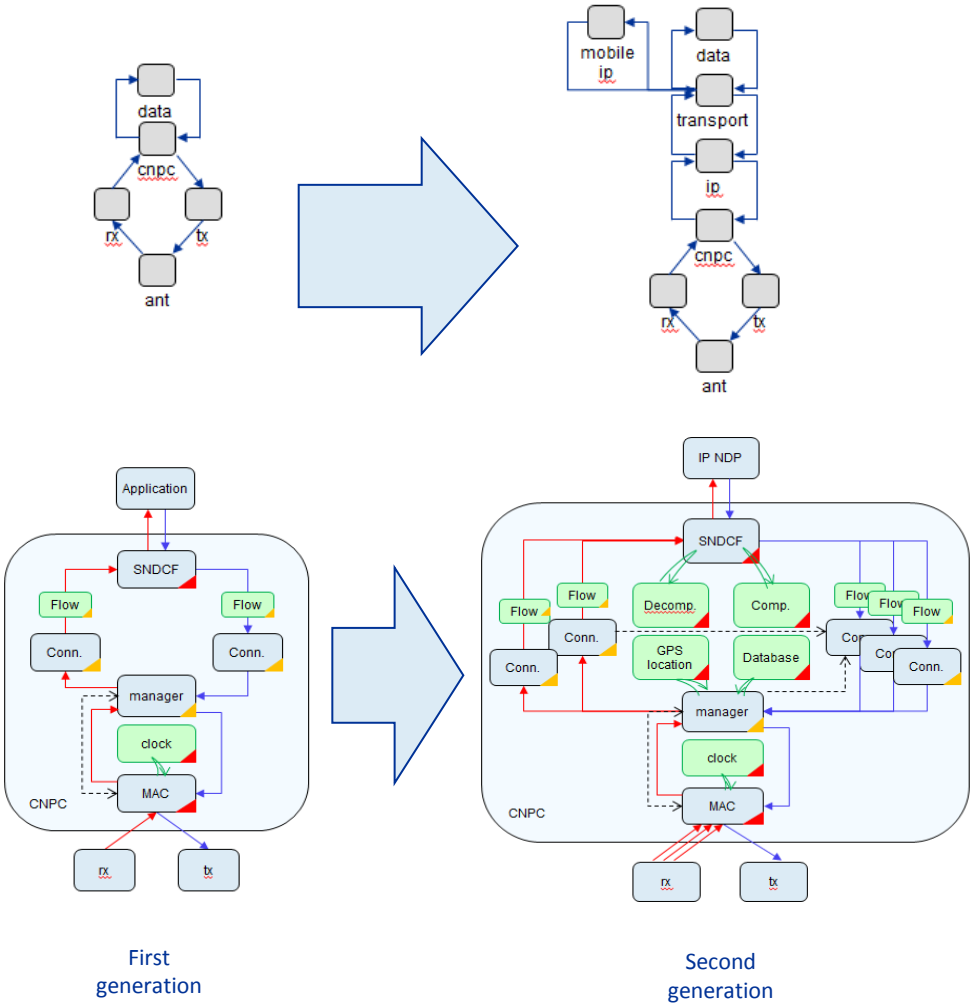
Opnet Radio Model – CNPC Radio Model Development Approach

RADIO MODEL INFRASTRUCTURE



First generation

Second generation

- Develop the CNPC radio model architecture to follow the spiral development approach being used for GRC Flight Test radios
  - Start simple, add features and functionality in second and third spiral
  - Increase functionality / increase analysis detail
- Develop a platform compatible with the prototype radio as well as the alternative technologies

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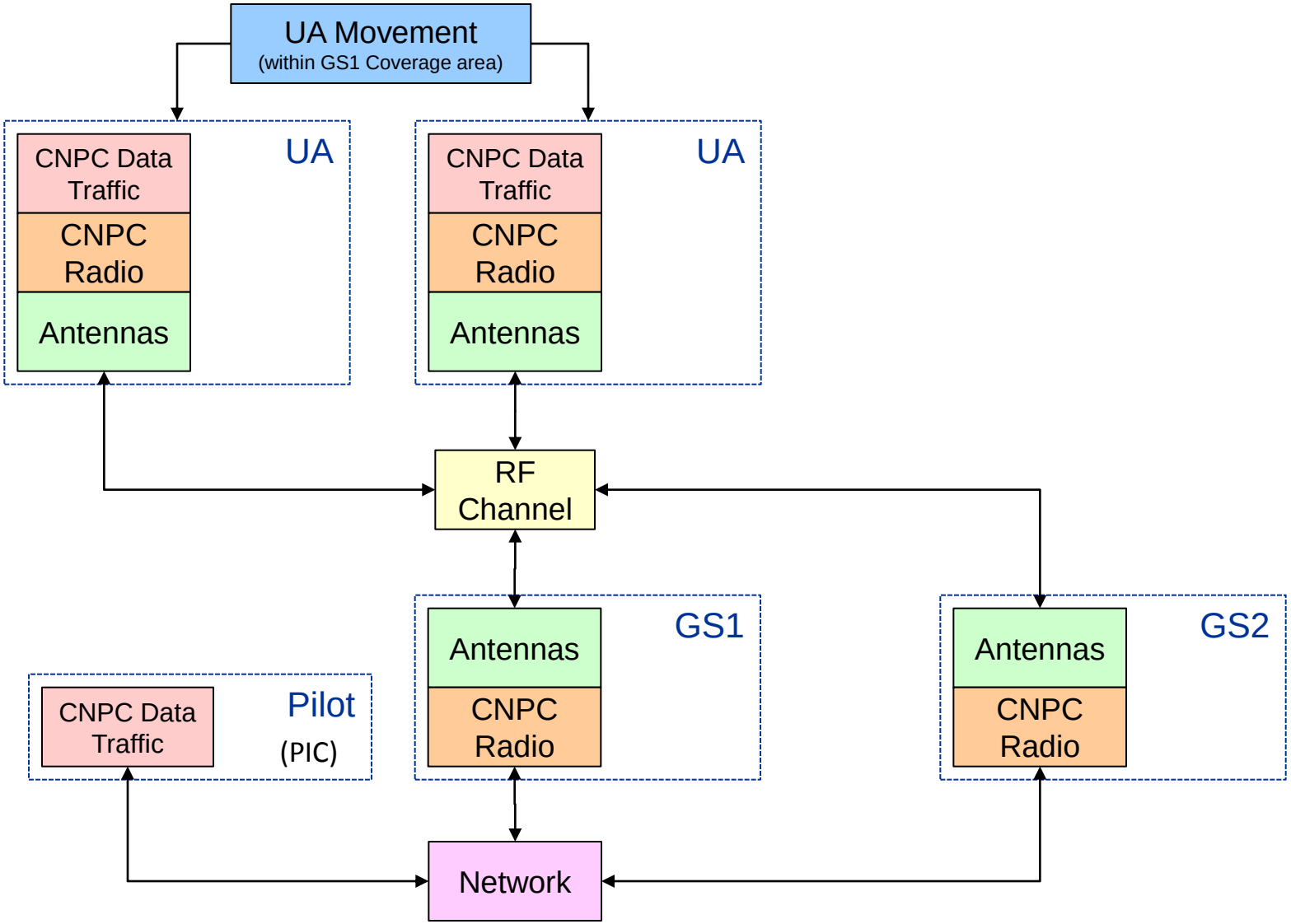
Opnet Radio Model – High Level Radio Model Elements



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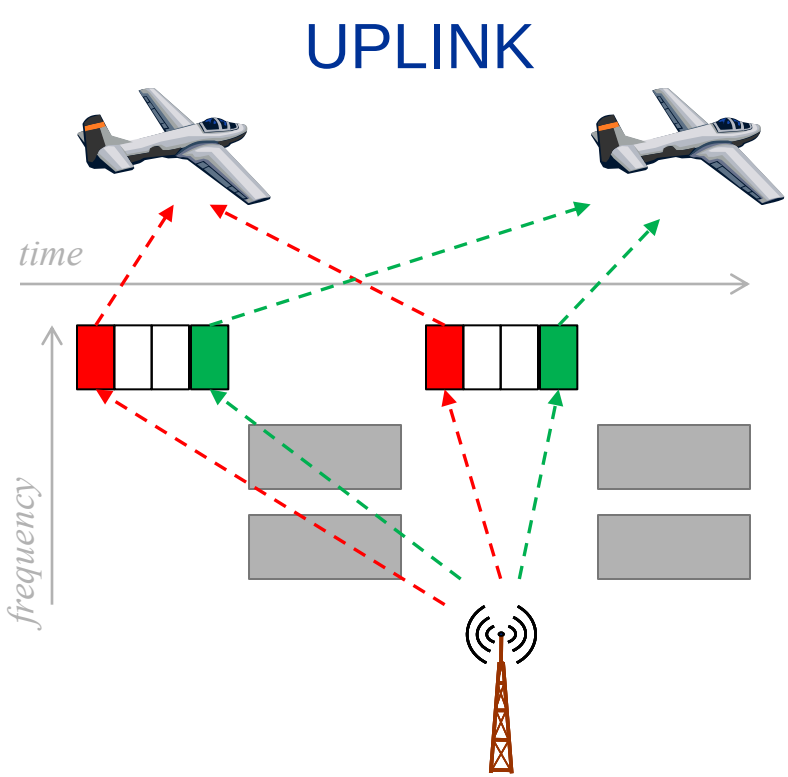
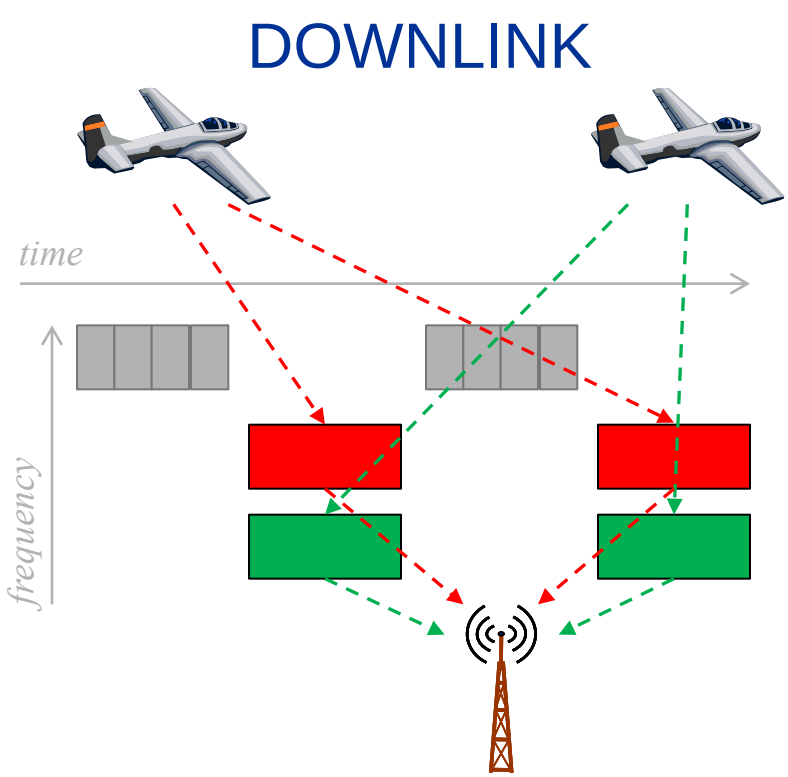
Opnet Radio Model – CNPC Radio Overview

- Uplink: Time Division Multiple Access
- Downlink: Frequency Division Multiple Access
- Uplink/Downlink Duplexing: Time Division Duplexing
- L and C Band radios platforms





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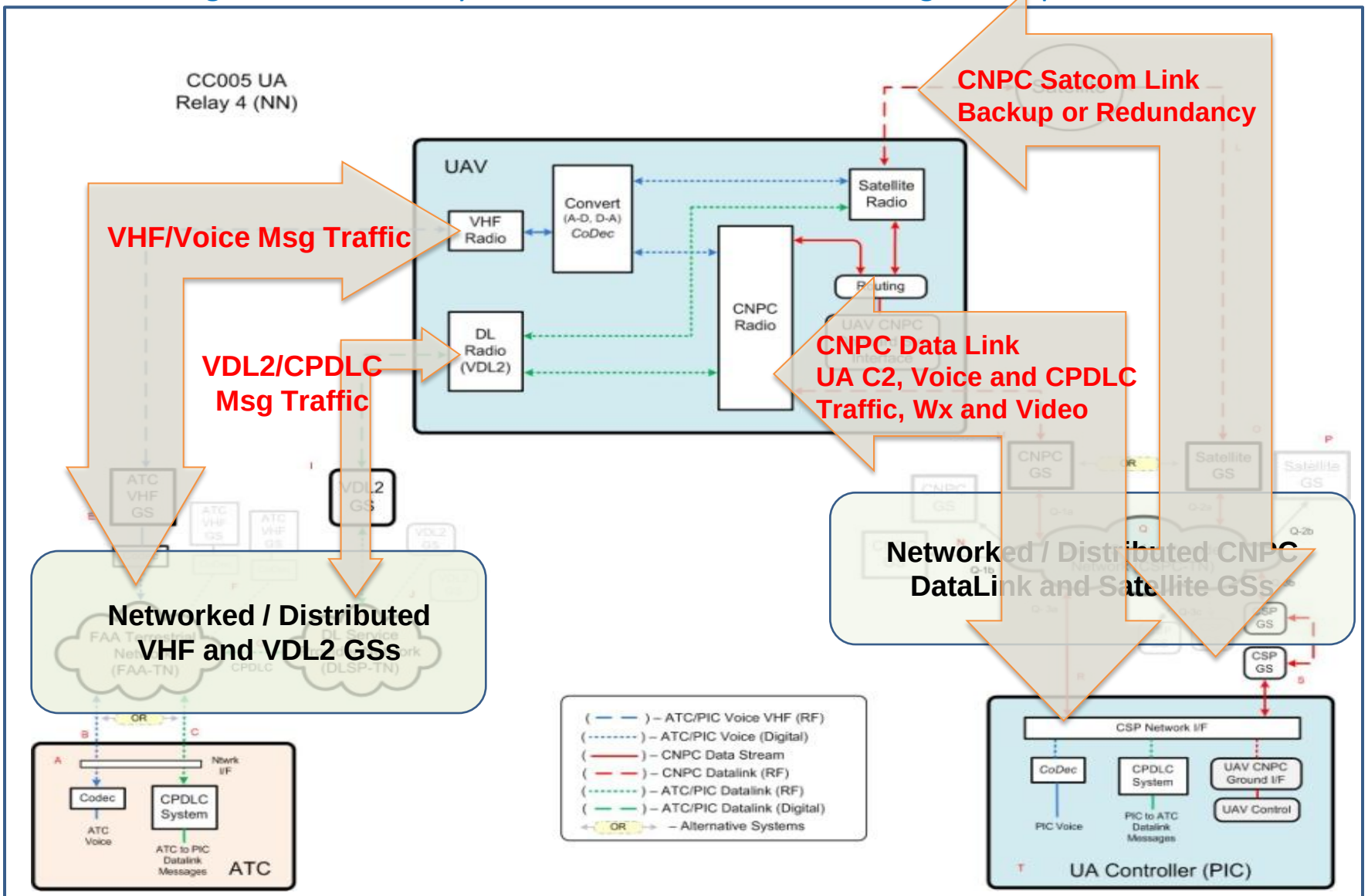
Large Scale - UA Relay 4 Architecture – Functional Diagram/Capabilities



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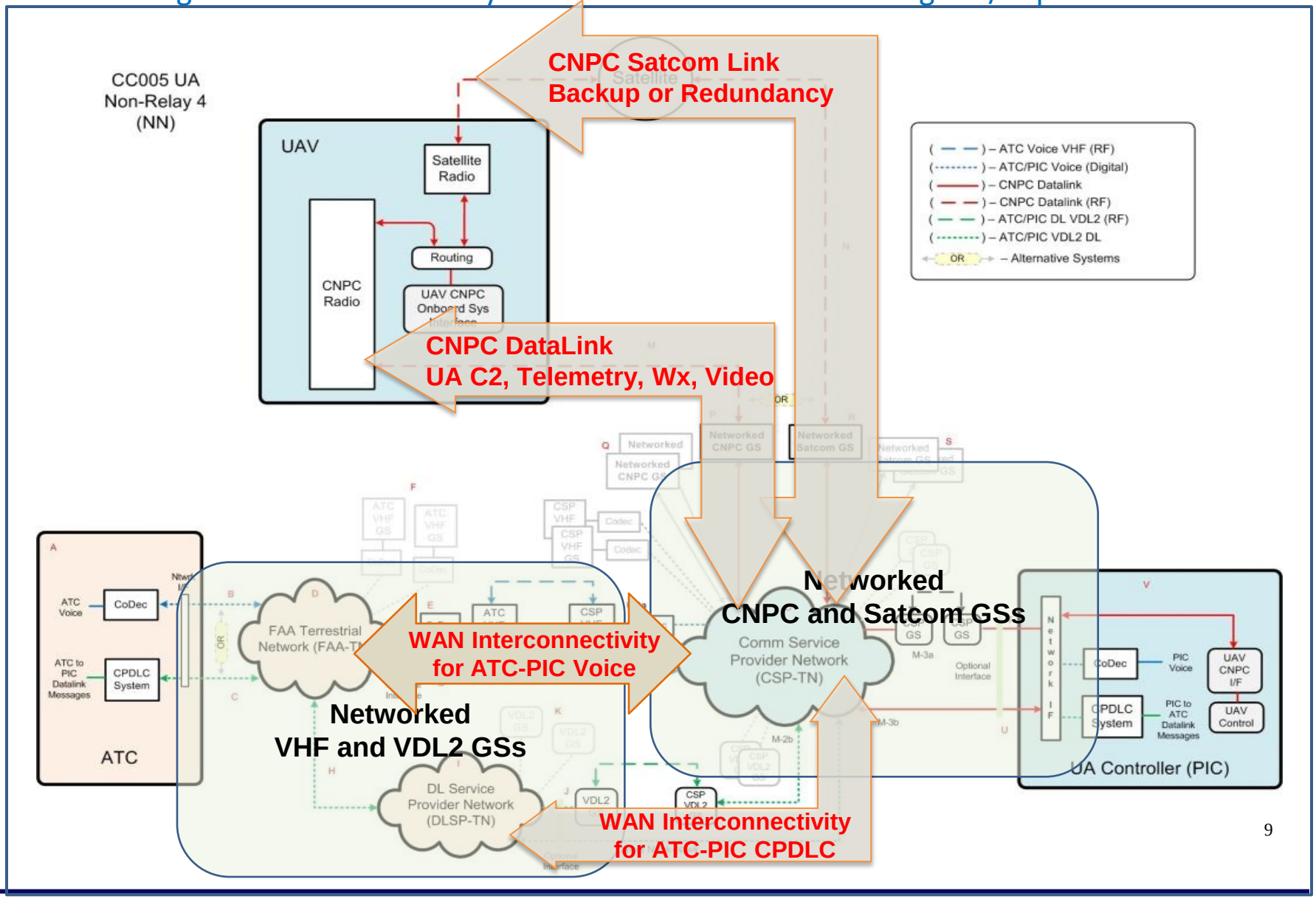
Large Scale - UA Non-Relay 4 Architecture - Functional Diagram/Capabilities



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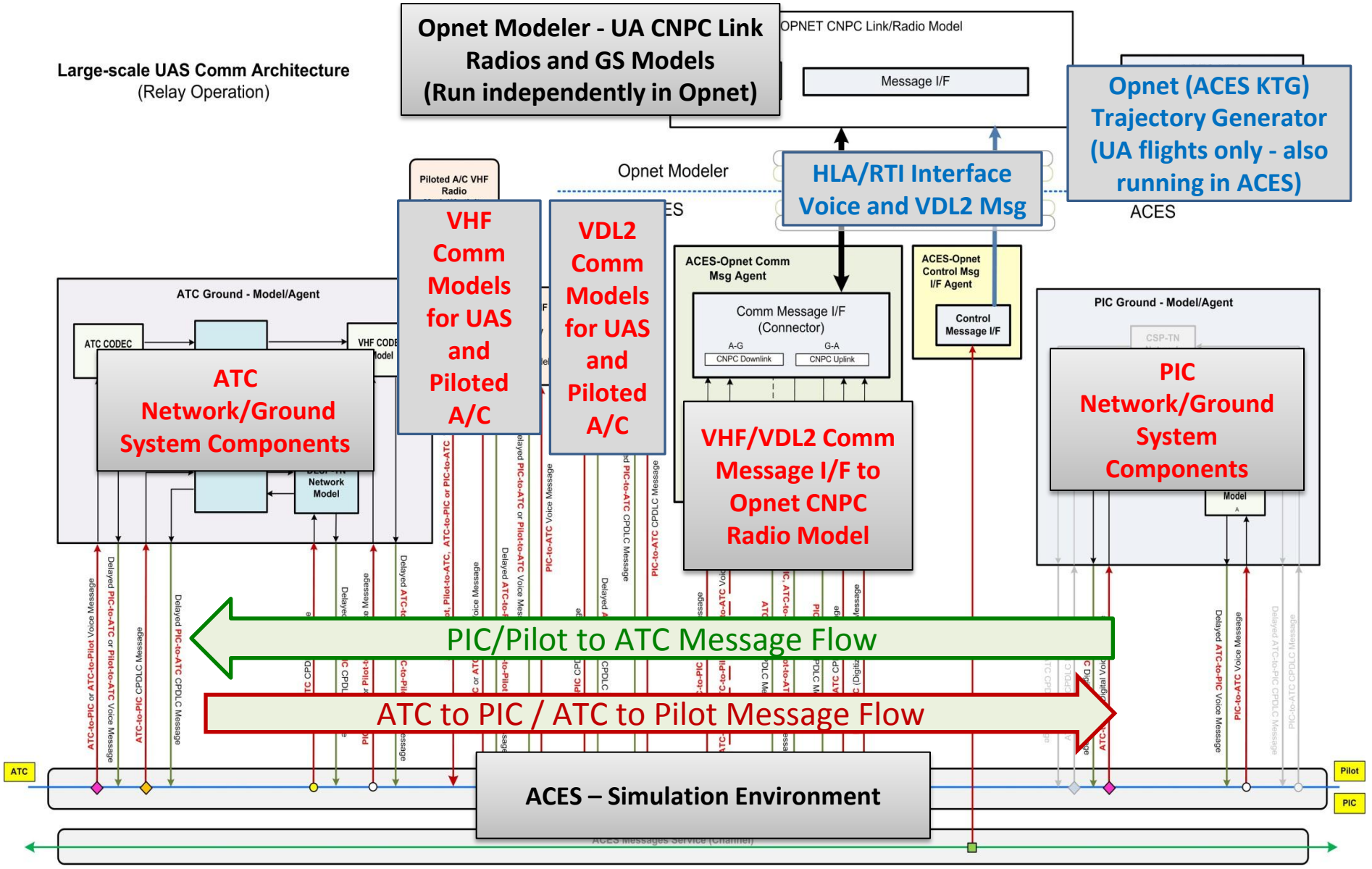
UA Relay – Large-scale (ACES-Opnet) Simulation Architecture



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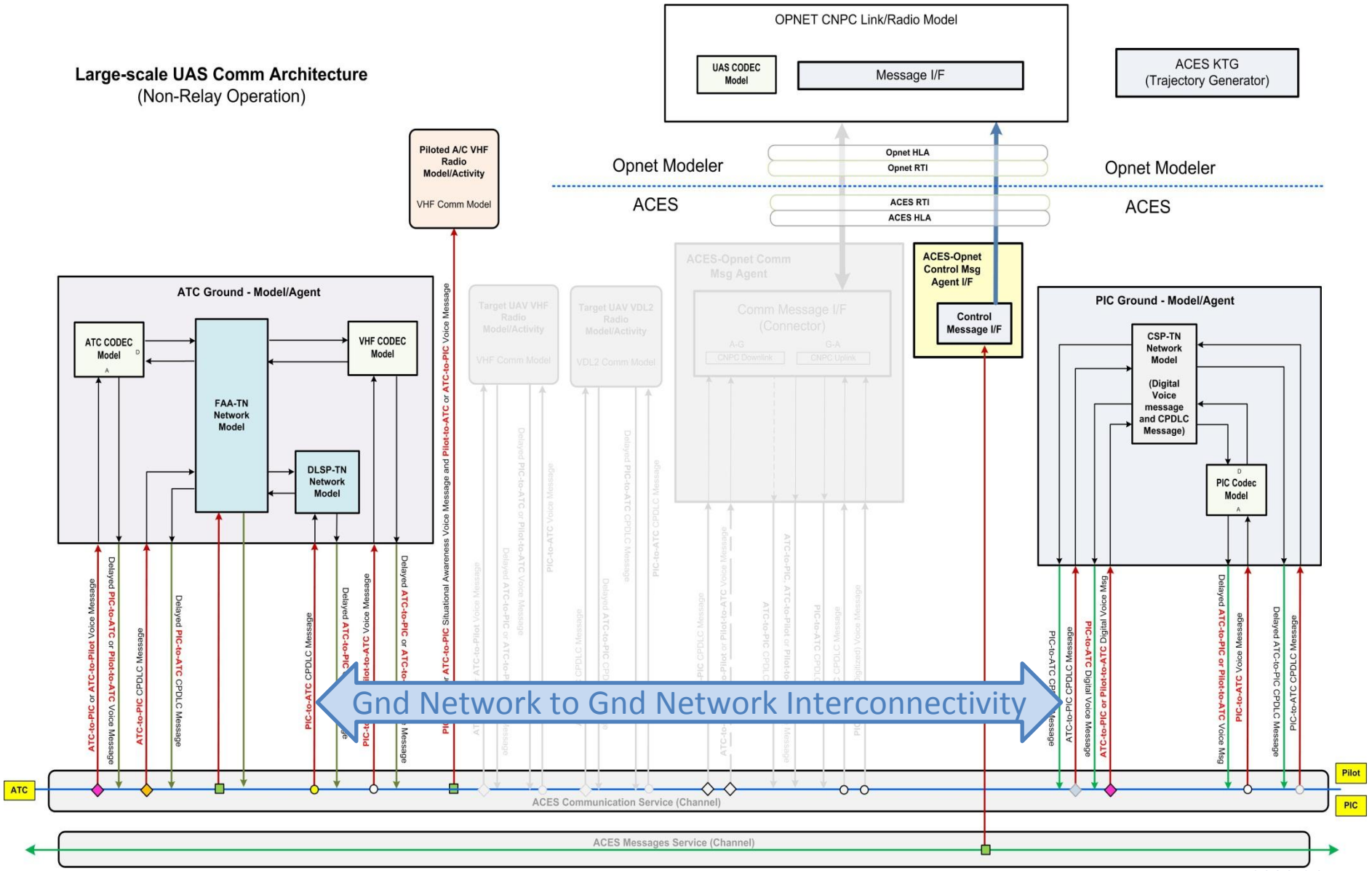
UA Non-relay Large-scale (ACES-Opnet) Simulation Architecture



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Opnet Radio Models – Development Status

- **Completed Radio Technologies down-select for GRC Flight Test Radio and 3 other optional technologies**
- **Defined model requirements and assumptions**
- **Defined the radio model architecture for all radio models** (Common architecture/framework)
- **Completed first Prototype Radio Model (Gen1 - for GRC FT Radio) in Dec 2012 – basic model framework and operation.**
- **Developed the framework and test plan for verification and validation**
- **Performed Verification of Gen1 Radio Model**
- **Preparing for validation against Gen1 prototype radio**
  - Currently working with the Datalink team on data loading and test designs
- **Preparing for Gen2 prototype development (Enhanced version of initial prototype)**

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Large-Scale Simulation – Development Status

- **Completed Down-select of Relay and Non-Relay Architectures**
- **Completed Architecture Concept Design for ACES LS Simulation (Relay and Non-relay)**
- **Completed Architecture Models development and testing (Relay and Non-relay)**
- **Currently adding Msg failure/Msg sender Wait-time conditions to Voice Model in the Relay/Non-relay architectures.**
- **Currently testing the final integration of the ACES KTG in Opnet Modeler**
  - Transfering Aircraft State data to Opnet Modeler (for multi Aircraft Simulations)
- **Verified HLA/RTI message transfers and timing synchronization between ACES and Opnet**
- **In process of developing the ACES to Opnet Comm Message Interface operations**
  - Defining the ACES-Opnet RTI Fed file for transferring Voice/CPDLC Msg data (Relay Architecture)
- **Completed initial/baseline Voice and CPDLC Message definitions and integration into ACES**
- **Currently defining ACES to Opnet Control messages (Aircraft or airspace info that will impact Opnet radio operation)**
  (e.g. UAV airspace transitions – vary CNPC link data rates)
- **LS Simulation Startup procedure for ACES/Opnet/KTG Initialization - 70% Complete**