ITU/AU Air Traffic Control Network Simulator for Design, Development and Testing of Automated ATM Systems

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EXTENDED ABSTRACT
Revolutionary approach of the SESAR and NextGen programs requires a shift in the roles and responsibilities across both airborne and ground level flight operations [10][28]. SESAR and NextGen aim to remove bottleneck constraints in the current air transportation system and support wider range operations with new capabilities [14][17]. These new capabilities include 4 dimensional trajectory based operations and high-density arrival/departure/route management tethered along a network-centric approach [15][29][30]. ITU/AU ATM Joint Research Program is initiated to support research and technology development activities, and conceptual demonstration of SESAR and NextGen ATM concepts. In this paper we review the infrastructure and the cornerstones of this joint RDD program.

**Figure 1. AU Radar Control Simulator**

ITU/AU ATM Research infrastructure includes two remote simulator platforms connected through a network. In this infrastructure, while the ATM Operation Simulator (AU) emulates the ground segment (including ATC and Tower Operations), Flight Deck Simulator (ITU) emulates the airborne segment as seen from the flight deck of a commercial airliner. This integrated facility and network architecture supports collaborative research on air traffic control modeling [19] and air flow optimization, pilot decision support and augmented reality systems in the air traffic and self separation operations, new data/voice communication concepts and human factors for changing/increasing pilot responsibilities [11].

In the ground segment, ATM Research Laboratory in Anadolu University (AU) includes both Radar Control Simulator and Airport Tower Control Station. In the Radar Control Simulator (Figure 1), 12 controller working positions, 12 pseudo pilots and one supervisor desk are linked over the network to operate in the same simulated airspace environment. The current system supports an “almost-real” air traffic control operation including voice communication links and operator displays. This system is being modified through virtual supervisor and with the addition of external voice and data links to allow remote units (such ITU CAL Flight Deck Simulator) to enter into the simulation scenario via remote network connection. The functional diagram of the composite system as seen from the flight-deck perspective is illustrated in Figure 3.

**Figure 2. AU 360 degree Airport Tower Station**
Figure 3. Functional diagram of the integrated system from Flight Deck Simulator perspective
For realistic departure/approach operation simulations, ATM Operation Simulator includes an Airport Tower Control Station (Figure 2). This station supports an "almost-real" airport control, ground control and clearance delivery managed by a supervisor, 4 operator and 2 pseudo pilot desks. Airport Tower Station includes a variety of major international airport views and the system can not only visualize a 360-degree out-of-tower view but also allow simulation of various weather conditions and daily/night operation effects.

In this ATM Operation Simulator facility, ITU/AU ATM Joint Research Program has initiated a) air traffic management and modeling [6] [27] [33] [35], b) air traffic flow modeling and optimization [3,4] and c) ATC operator decision support and augmented reality research activities [5] [9] [18] [24] [31]. Air traffic management modeling activity includes evaluating the local (Europe, Middle-East and Near East) air traffic flows and capacities, and developing mathematical modal-based hybrid models [32] of basic flight operations and ATC operational procedures. This framework will be used for integration of the new hardware and operation procedures including data communication concepts and structures, weather information flows and satellite based navigation systems. ITU/AU Joint Research Program also aims predicting airflow capacities and potential obstacles and limitations, and developing near-real time airflow optimization procedures [4] [12] in different situations such as abnormal air traffic congestion initiated by conditions such adverse weather situations [26], natural disasters or armed conflicts.

In the airborne segment, Istanbul Technical University (ITU) Controls and Avionics Laboratory (CAL) houses a Flight Deck Simulator (Figure 4) which enables flight control [2] and dynamic modeling [32] research including in-cockpit mission command and control operations across cooperative manned and unmanned fleets [16]. This system is being modified with a virtual server, external voice and data links for to remotely connect to the ATM Operation Simulator at Anadolu University.

Figure 4. ITU Flight Deck Simulator

All levels of the ITU CAL Flight Deck Simulator’s modular architecture are redesigned for the SESAR and NextGen compliant in-cockpit research and development activities. ITU CAL also includes an Air Traffic Monitoring Desk (Figure 5), which monitors real-time air traffic via ADS-B receiver in order to incorporate real-time air traffic into virtual traffic of the simulation. In this segment of the joint research program, this simulator serves as the experimental platform on which a) 4D flight route generation and self-separation algorithms [12] [25] and b) pilot decision-support and augmented reality technology systems are demonstrated [1][18].

Figure 5. ITU Air Traffic Monitoring Desk

New Pilot Interface Architecture

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Figure 6. New Pilot Interface Architecture
Specifically en-route real-time automated conflict detection and potential conflict avoidance [19] strategy development for both manned and unmanned vehicles [20] [21] [22] has historically been one of the major subjects of research within the CAL flight simulator. Within the joint program, this existing heritage is being tailored to the ATM realm with new approaches. The new approaches include a) considering the uncertain natures of the models while generating real-time solutions [19] and b) representing the generated solutions within new cockpit displays (Figure 5) and augmented reality for decision-support of the flight crew in 4D flight operations (Figure 6).

As illustrated, the ATM Operation Simulator (AU) and Flight Deck Simulator (ITU) facilities and integrated network architecture supports collaborative research covering both the ground and airborne segments. In that respect, the infrastructure not only supports operator and pilot level design and development of the new automated ATM system concepts, but also allows cross-impact testing across ground and airborne segments in a consistent simulation realm.

REFERENCES
10. Federal Aviation Administration (FAA), Fact Sheet - NextGen, FAA Online Articles, February 14, 2007
16. Karaman, S., Inalhan, G., Large-scale Task/Target Assignment for UAV Fleets Using a Distributed Branch and Price Optimization Scheme, Int. Federation of Automatic Control World Congress (IFAC WC'08), Seoul, South Korea, July 2008
17. Karlin Toner, NextGen 2025; Loking Forward to Trajectory Based Operations, AIAA Aviation


22. Koyuncu, E., Ure, N.K., Inalhan, G., A Probabilistic Algorithm for Mode Based Motion Planning of Agile Air Vehicles in Complex Environments, Int. Federation of Automatic Control World Congress (IFAC WC’08), Seoul, South Korea, July 2008


28. Single European Sky ATM Research (SESAR) Programme Office, The SESAR Programme; Sustainable Development and Technological Revolution in Air Traffic Management, SESAR factsheet, N 01/201


33. Uslu, S., Cavcar, A. An evaluation model for air traffic systems. Turkish Journal of Engineering and Environmental Sciences, v. 34-2, 2010


35. Woldring, M., Team resource management in European Air Traffic Control. Air & Space Europe, Volume 1, Issue 1, January-February 1999, Pages 81-84, ISSN 1290-0958, DOI: 10.1016/S1290-0958(99)80045-8