MACS Overview

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Overview

• MACS Use
• Capabilities
• Software
• What to expect in this workshop
Multi Aircraft Control System (MACS)

What is MACS?

• Research software for simulating and evaluating air traffic operations

Intended Use

• Provide a better understanding of roles, responsibilities, and requirements for human operators and automation in future air traffic management (ATM) systems.
• Develop and evaluate operational concepts and technologies for the Next Generation Air Transportation System (NextGen) in a high-fidelity human-in-the-loop (HITL) environment.
18 aircraft are allowed in Airspace “sectors” at any given time
Teams of 2 Air Traffic Controllers per sector required for high traffic
Video shows 8 controllers handling ~75 aircraft
Air Traffic Control
Multi Aircraft Control System (MACS)

AIR TRAFFIC CONTROL OPERATIONS MID-TERM / 2022

25 aircraft are allowed in Airspace “sectors” at any given time
1 or 2 Air Traffic Controllers per sector possible
Video shows 7 controllers handling ~150 aircraft
Air Traffic Control in the Mid-Term
AIR TRAFFIC CONTROL OPERATIONS
FAR-TERM / 2030

30, 40, or 50 aircraft are allowed in Airspace “sectors” at any given time
1 or 2 Air Traffic Controllers per sector possible
Video shows 8 controllers handling ~300 aircraft
Air Traffic Control in 2030 ...
RECAP: What is MACS?

- Portable JAVA program that emulates and simulates current and future air traffic operations in the NAS
- A comprehensive environment for large scale and small scale real-time integrated air/ground simulations
  - From standalone laptop application to 50+ networked operator stations
- Rapid prototyping environment and test bed for future air traffic concepts
  - ATC/ATM automation and interfaces
  - Flight deck automation and interfaces
  - Air/ground technologies and procedures
- System for education and training
What is the Main Idea?

• All operators (human and automation) look at the same situation from different viewpoints
  – MACS maintains a central representation of the air traffic situation and provides access to all the objects stored therein
  – The different viewpoints are realized through a variety of displays and input devices

• All operators (human and automation) need to perform many of the same functions
  – MACS provides a knowledge-base with classes and methods for commonly used functions like route parsers, trajectory generators, performance calculators, etc.
  – Displays and automation access the common knowledge-base tailored to their task
Multi Aircraft Control System (MACS)

CAPABILITIES
MACS Simulation in the AOL

- Experiment management
- Scenario Generation
- Flight decks and flight management
- Air traffic management
- Air traffic control (domestic, oceanic, approach)
- Advanced Automation
- Weather
MACS Capabilities

- Air traffic simulator/target generator
- Multi aircraft autonomous agent
- Multi aircraft control flight deck
- Single aircraft flight deck (B777 style)
- Traffic and weather generation
- Experiment control
- Aeronautical Datalink and Radar Simulator (ADRS) comm. network
- Traffic flow and airspace management workstations
- Center controller workstation (DSR)
- TRACON controller workstation (STARS)
- Oceanic controller workstation (ATOP/Ocean21)
Multi Aircraft Control System (MACS)

REAL-TIME CAPABILITIES
Aircraft Simulation and Flight Deck Displays
Aircraft Simulation and Flight Deck Displays

- Full flight simulator
- Selectable dynamics model (Motion Predictor, 4DOF/PAS-Aero, ...)
- Flight deck for external target generator
- Performance models for the majority of current aircraft types
- Selectable equipage
- Glass cockpit displays
- Full FMS capabilities with RTA (Also used in Standalone mode)
- ASAS spacing and merging logic
- Conflict detection logic for (airborne self-separation)
- FANS – style CPDLC interface
- Interface to advanced Cockpit Display of Traffic Information (CDTI)
- Automatic processing of selected data link messages with predefined delays
- Agent support for pseudo pilots (reminders or automation)
Aircraft Simulation and Flight Deck Displays

MACS pilot interface for a pseudo pilot working multiple aircraft simultaneously

MACS pilot interface with FDDRL’s Cockpit Situation Display (CSD) for participant pilot working one aircraft
ATSP capabilities and workstations
ATSP capabilities and workstations

- Highly Advanced NextGen automation:
  - Multi-layered rapid feedback conflict probing
  - Weather penetration probe
  - Data comm. integration
  - Fully automated, semi-automated, manual operations
  - AAC Auto-Resolver with Weather avoidance *(Erzberger et al.)
    - Interactive and closed loop automated
  - TSAFE conflict resolver (Erzberger & Heere)

- New Paradigms in Display Design
  - High-lighting/ low-lighting scheme with interactive filters
  - Multi Aircraft Selection and command processing
  - Multi aircraft trial planning

- Complexity Management
  - Interactive graphs and tables for various complexity factors
ATSP capabilities and workstations

– NAS Controller workstation emulations: STARS, DSR, ATOP/Ocean 21, ERAM to come

– Selectable data sources:
  • Perfect, Center radar, TRACON radar, ADS-B

– Multi-Center adaptation

– Advanced ATSP automation:
  • 4D trajectory generation for flight plan routing, scheduling, reported FMS trajectories, ADS-B reported state and flight control system targets
  • Arrival scheduler and timelines
  • Medium-term Conflict detection
  • Trial planning and speed advisory functions for metering support
  • Automation for automatic transfer of communication and RTA uplinks
ATSP capabilities and workstations
Multi Aircraft Control System (MACS)

OFF-LINE CAPABILITIES
MACS Scenario Editor

• Spreadsheet-style editor
  – Error checking and correction
  – Automatic functions
  – Load graphs

• Graphical editor
  – Trajectories for aircraft and convective weather
  – Time slider
  – Weather and conflict probing
  – Trajectory planning
TRAC
(TCSim Route Analyzer/Constructor)

- Airspace design
- Fast time simulation
- Data analysis
Multi Aircraft Control System (MACS)

SOFTWARE
MACS Software (state 2010)

- 415,000 Source Lines of Code (JAVA)
- 2230 files
- Up to 194 parallel threads
- Unique automatic thread monitoring and restart
- Same software used at all MACS stations in a simulation
- Standalone version provides all capabilities of distributed simulation
- Very robust and scalable: E.g. experiment runs in 2010 of 3 hour length, 3000+ aircraft, 16 controllers and 10 pilots
Basic Software Architecture

- Each MACS station runs the identical software independently
- 1 of 12 operator modes can be selected
- Only those threads and windows are started that are required for a particular operator mode
  - Low: TRACON-Controller:
  - High: Developer:
- Thread Management Process handles 150 – 200 threads
- Each functionality and each window is controlled by its own thread
MACS Interface with Other Systems

All communication is handled by one or more networked ADRS processes.

The ADRS provides publish/subscribe interfaces for MACS, other simulators and tools and maintains the entire state of the simulation.

MACS Flight Simulators

Other simulations
VAST-RT, FFC
ACFS
757, ATOL @ LaRC

ATM tools (e.g. CTAS TMA)

Flight Plans
State data
Trajectories
Data link messages

Publish/subscribe interface (TCP/IP)

Flight Plan (filed/amendments)
Host route
Track Data

Scheduling information

MACS Controller workstation
Multi Aircraft Control System (MACS)

RESEARCH EXAMPLES
Recent Research in the AOL (2010-2011)

Flow Based Trajectory Management
*Use tools and procedures to develop and coordinate trajectory clearances that span multiple sectors, meet traffic management objectives and provide user benefit*

Flexible Airspace Management
*Dynamically change airspace to distribute capacity more evenly between sectors*

Corridors-In-The-Sky
*Use flow corridors for dominant homogeneous flows to increase airspace throughput*

Separation Assurance/Functional Allocation
*Use automation to manage aircraft separation to achieve much higher airspace capacity than today*

Controller Managed Spacing
*Use tools, displays and procedures to enable Optimized Profile Descents with High Throughput*
Multi Aircraft Control System (MACS)

WORKSHOP
What to expect from this workshop

• Overview over MACS capabilities
• Instructions on basic installation and configuration
• Detailed discussions on commonly used functions (Center/TRACON, pilot)
• Discussion of scenario and weather Editor
• Data collection and analysis
• Opportunity for questions
Day 1 schedule

- 8:30am  – Intro and MACS overview
- 10:00 am – 15 min break
- 10:15am  – Getting started with MACS
- 11:30am  – How to prepare and run a simulation
- 12:45pm  – LUNCH
- 1:45pm  – Multi aircraft flight deck overview
- 3:15pm  – 15 min break
- 3:30pm  – ATC overview
- 4:45pm  – Research community MACS usage
- 5:30pm  – End Day 1

*All presentations are followed by a 15-30 minute Q&A session*
Day 2 schedule

- 8:30am – Scenario editor and convective weather editor
- 9:45am – 15 min break
- 10:00am – MACS data output and analysis
- 11:15am – TRAC overview
- 12:30 – LUNCH
- 1:30pm – MACS development overview
- 2:45pm – 15 min break
- 3:00pm – MACS Q&A with AOL team (parallel sessions)
- 5:30pm – End Day 2

*All presentations are followed by a 15-30 minute Q&A session*
What else to expect from this workshop

• INFORMATION OVERLOAD

• VARIOUS ITEMS TO TAKE HOME

• Many More Questions ....
The MACS-Workshop Team

**AOL Presenters:**
- Connie Brasil
- Chris Cabrall
- Todd Callantine
- Sarah Gregg
- Al Globus
- Jeffrey Homola
- Rick Jacoby
- Vick Kelkar
- Michael Kupfer
- Joey Mercer
- Tom Prevot
- James Wong

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