Building Airport Surface HITL Simulation Capability

FutureFlight Central
Outline

• SimLabs facilities
  • What is FutureFlight Central?

• Features and Capabilities

• Components of a Tower Simulation

• FFC Architecture and Visual Airport Model

• FFC Processes
  • Reconfigurable Image Generator (RiG)
  • Airspace Target Generator (ATG)
  • Ground Pilot Station User Interface
  • Connectivity
  • Out-the-window Image Generation
  • Audio System

• Data Collection

• HITL Simulation Process

• Summary
SimLabs Facilities

Unique facilities capable of a wide range of aerospace systems research

VMS

FFC

CVSRF
FutureFlight Central (FFC)
What is FutureFlight Central?

• National Air Traffic Control/Air Traffic Management test facility dedicated to solving the present and emerging challenges facing our national airspace system (NAS)

• Offers full-scale, real-time simulation of an airport where controllers, pilots and airport personnel participate to optimize expansion plans, augment operating procedures, and evaluate new technologies
Features and Capabilities (1)

• Visual Airport Model
  
  • 3D airport database model displayed on twelve projection screens provides 360-degree out-the-window view of the airport

• Multiple Views
  
  • Database supports views of the airport from any location
Features and Capabilities (2)

• Real-time Traffic Simulation
  • Traffic scenarios encompass the terminal air space and airfield surface

• Radar Displays
  • Supports all air and ground positions controlling traffic: ASDE-X, DBRITE
  • Additional displays can be added to meet research requirements

• Built-in Voice Communications System
  • Can be configured to support all radio frequencies operating at an airport control tower
Features and Capabilities (3)

• Data Recording
  • Collect measurements of surface performance for ground vehicles and aircraft, controller/pilot communications, and audio/video observational data

• Aircraft Library
  • Aircraft model database contains over 100 3D aircraft and ground vehicle models containing detailed liveries of airlines represented in the simulation
Components of a Tower Simulation (1)

- Out the Window (OTW) display
  - Image Generator (IG)
  - Airport database
- Tower Controller Tools
  - Airport Surface Detection Equipment – Model X or ASDE-X
  - Digital Bright Radar Indicator Tower Equipment – DBRITE
- Target Generator
  - Traffic airborne /surface
- Communication system
- Data collection
Components of a Tower Simulation (2)

- Human operators:
  - Tower controller
  - TRACON controllers
  - Ramp controllers
  - Pseudo-pilots
  - Engineers to operate the simulation
Reconfigurable Image Generator (RiG)

• Provides real time, out-the-window renderings, allowing targets to be visualized in our simulation environment

• Is highly scalable and can run any number of rendering view ports allowing the eye point to change.

• Entities can be followed, tracked, and centered-on for a (non-cockpit) point-of-view matching that of the entity

• Dynamic weather generation:
  • Clouds, Rain, Lightning, sleet, snow
  • Time of Day and Night

• NASA Developed Tool
  • Flexibility and control over development of visual databases
Airspace Target Generator (ATG) Components

- **Simulation Manager**
  - The simulation engine to drive targets (airborne and ground dynamics)
  - Configure region and traffic scenario
  - Validates input files and scenario files
  - Controls the activation of targets
  - Captures state data for collection
  - Controls the simulation clock

- **Ground Manager**
  - Serves all the ground pilot stations
  - Performs anti-stacking, anti-collision capability

- **Pilot Station**
  - Provides GUI for pseudo-pilots to control targets
  - Required for datalink messages to be parsed and passed to targets
  - Provides situational awareness with a variety of state and ground parameters
External Decision Support Systems

Provides Track, DL commands, Notifications, CD&R

Provides FP’s, Track, Passes DL commands
Ground Pilot Station User interface

• Ground maps are tightly coupled to the visual system
• Two different map views are supported for each station
• Configurable set of data per each Flight
  • Flight list
  • Status list for a single flight
  • Icon tags
• Configurable set of panels (location, scale, on/off)
• Variety of ways to input or control targets
  • Commander Panel (buttons, menus)
  • Hot Keys Panel (customizable commands)
  • Text Entry Panel
Example Pilot Station Ground MAP and User Interface
FFC Architecture

Visual Airport Model
- RiG
- Proj
- Screens
- IG Toolbox
- Other Simulation Facilities

Real-time Traffic Simulation
- Pseudo-pilot Stations
- ATG Toolbox
- Controllers

Radar Displays
- ATM Controller Tools/Displays
- ATM Toolbox

Radio/Communication Backbone
- Comm System Server
- Comm Station
- Comm Station

Tools/Displays
- ATG
- ATM
- Controllers
Connectivity (1)
• High Level Architecture (HLA)
  • A technology for developing distributed systems
  • An open international standard, developed by the Simulation Interoperability Standards Organization (SISO) and published by IEEE
  • A document of standards that describes the components of HLA and what interfaces and properties they must have. Anyone can develop any software component of HLA.
  • Its topology is a number of systems that have one single connection to a service bus that is called the Runtime Infrastructure (RTI)
Connectivity (2)

- **Pitch RTI**
  - Runtime Infrastructure - Software that provides the HLA service bus. The RTI provides information, synchronization, and coordination services.

- **RiG Toolbox**
  - Paired interfaces to connect the RIG to the HLA service bus

- **ATG Toolbox**
  - Interface between ATG and the HLA service bus
FFC Architecture

Visual Airport Model
- RiG
- IG Toolbox
- Proj

Real-time Traffic Simulation
- Pseudo-pilot Stations
- ATG Toolbox
- ATG

Radar Displays
- Controllers
- ATM Controller Tools/Displays
- ATM Toolbox

HLA Backbone

Other Simulation Facilities

Toolbox

Radio/Communication Backbone
- Comm System Server
- Comm Station
- Comm Station
Out-the-Window Image Generation (1)

- 3D database/airport map generation
  - 3D sources
    - Computer Aided Design drawings, Google Earth, FAA or researcher supplied
    - Stationary models, Moving models / Aircraft Models
    - 3D database development in “creator”
  - Convert 3D model for use in Image Generator(RiG)
  - Import 2D map to ATG (Airspace Target Generator)
    - Conversion or layers of 3D database to 2D image for use in Target Generator
    - Generating airport map in ATG
  - Ground Route Development in ATG
Out-the-Window Image Generation (2)

• Scenario Development
  • Research airport operations:
    • Number of arrivals, departures, airport operations
    • Fleet mix, airline mix
    • Gate utilization
    • Ground routes
    • Standard Instrument Departure (SID)
    • Standard Terminal Arrival Route (STAR)

• Alignment between ATG and visuals
Audio System

• Voice communication at each station
• Touch screen with multiple frequencies
• Radio, telephone, direct dial, intercom emulation
• Record/playback capability
• Used for communication between pseudo-pilots and controllers
• Separate channel for coordination by FFC staff
Data Collection

• Airport statistics
• Out-the-window screen capture
• Audio and Video recordings
  • Communications and cameras at the controllers
• Workload assessment
• Surveys
• Other
  • Blood pressure
  • Heart rate
HITL Simulation Process

1. Requirements from the researchers
2. Design system architecture
3. Development and internal testing
4. Integration testing
5. Train external participants on the simulator and the ATM tools
6. HITL simulation
7. Data collection
FutureFlight Central

• Test bed for new concepts and technologies
  • Technologies evaluated with realistic air traffic operations in a safe environment
  • Repeatable off-nominal or infrequent cases per research requirements
• Tool for surface operations human factors research
  • Controllers are able to interact with new tools
  • Data capture and analysis demands for human in the loop simulations
• Evaluation of proposed airport physical and procedural modifications
  • New proposed structures such as runways, buildings, or taxiways can be added to the existing visual database of an airport
Air Traffic Generator

Provides FP’s, Track, Passes DL commands

External Decision Support Systems

Provides Track, DL commands, Notifications, CD&R
Agenda

• Simulation Manager
• Ground Manager
• Pilot Stations
  • Input files
  • User Interface and Control
  • Edit mode
Simulation Manager

- The simulation engine to drive targets (airborne and ground dynamics)
- Configure region and traffic scenario
- Validates input files and scenario files
- Controls the activation of targets
- Captures state data for collection
- Controls the simulation clock

ATG Ground Manager → PA → SM → PB → Simulation Manager → ATM Decision Support Tool
Dynamics

**Airborne**
- 4 DOF (x,y,z plus roll for directional control)
- great circle navigation equations
- designed for commercial fleet mix performance characteristics

**Ground**
- 2 DOF (flat airport, rectangular coordinates)
- Cubic Bezier curves define the path (aircraft ride on a rail)
- Kinematic modeling for speed control (linear)
Cubic Bezier Curves

Control Nodes 1 and 2 define the shape of the curve

As seen in the Surface Pilot Station
Files Required for Running

• Adaptation
  • Airport (maps, routes)
  • Airspace (STAR’s, SID’s, etc.)
  • Sector definitions

• Scenario
  • Aircraft List
  • Turnaround Departure List (optional)
  • Command files (optional)

• Aircraft Performance Files

• Weather  (if not selected, then standard day, calm air)
## Aircraft List

<table>
<thead>
<tr>
<th>Column Item</th>
<th>Description</th>
<th>Arrival Example</th>
<th>Departure Example</th>
<th>Req/Opt</th>
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## Aircraft List (continued)

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<td>KCLT..BARMY1..RDU..HPW..KLG</td>
<td>Optional</td>
</tr>
</tbody>
</table>
Ground Manager

- Serves all the ground pilot stations
- Performs anti-stacking, anti-collision capability
- Monitors connections
- Ability to record and playback states captured
- Serves up to 33 stations
Conflict Detection and Resolution
Example Pilot Station Ground MAP and User Interface
Map DXF Layers (Up to 10)

- Buildings
- Runways
- Taxiways
- Ramp
- Center Lines
- Hold Short Lines
- Runway Markings
- Misc.
  - Water, roads, no engine start lines, sector boundary, Outer Markers, etc.
Ground Route Definition Files

- **Vertex**
  - Nodes (10 types supported for routes)
  - Labels (type 55, 56)

- **Segments**
  - Bezier Curve parameters

- **Runways**
  - name, elevation, true heading, touchdown node

- **Ramp**
  - pre-defined routes from spot to gate & gate to spot

- **Canned Routes**
  - All AMA taxiways
  - Runways
  - Custom routes
Super Station vs. Normal Pilot Station

• Ability to control ALL targets
• Sees All notifications
• Can take over control other pilots flights

• Configurable for supporting a sector and pilot assignment
• Only controls those assigned
• Notifications for controlled flights only
• Can “take” an uncontrolled flight
Ground Pilot Station User Interface

- Ground maps are tightly coupled to the visual system
- Two different map views are supported for each station
- Configurable set of data per each Flight
  - Flight list
  - Status list for a single flight
  - Icon tags
- Configurable set of panels (location, scale, on/off)
- Variety of ways to input or control targets
  - Commander Panel (buttons, menus)
  - Hot Keys Panel (customizable commands)
  - Text Entry Panel
  - Point and click on the Map
Types of Control

Ground
- Speed
- Pushbacks
- Full taxi clearances with holds
- Partial taxi clearances
- Stop/Go
- Cleared for Departure
- Adding holds

Airborne
- Speed
- Heading
- Altitude
- Cleared for Arrival
- Full taxi clearances with holds
- Partial taxi clearances
Datalink Clearances

• Free text format
• Supports most Ground Clearances
  • Taxi
    • Can be short or complete from rwy to gate, rwy to spot, etc.
    • Can include Hold Shorts
  • Cleared for Approach, Cleared for Departure
  • Clear Next Hold
  • Gate change
  • Runway change
• Driven from external ATM processes
• Pilot Station can Auto Accept or Manually Accept
Aircraft Performance Parameters

• Speed definitions
  • Straight, curves
  • Runway
  • Pushback
  • Ramp

• Accelerations
  • taxiways
  • Runways

• Times
  • On gate before turn around can occur
  • Spool up

• Aircraft length
  • Used for holding short, CD&R, spacing
Map Tool Bar Control

- **Back Arrow/Fwd Arrow:** Previous View/ Last View
- **Globe:** R-centers the map about the airport
- **Magnifying Glass:** + Zoom in / - Zoom out
- **Pointer:** Left-Click – Select (aircraft or point on route)
- **Hand:** Right-Click – Execute route
- Move viewpoint (right-click to zoom in / zoom out)

Right click on map background to get Arrow (Pointer) back.

Loading and Saving Configurations
Command Entry Options

Commander Panel
- Stop/Go
- Clear [next/all] holds
- Speed (menu in kts)
- SlctHld (hold point selection)
- Resume (default speed)
- CLD (cleared for departure)

Command (Hot) Key Panel
- Rts (menu of canned routes relevant to the location and orientation of the selected aircraft and its current route)
- Taxi (executes proposed taxi clearance as does a right click)

Command Text Entry Panel
- 26 AAL1853 taxi spot8e
<table>
<thead>
<tr>
<th>Icon</th>
<th>Color</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>UnOwned</td>
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<td></td>
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<tr>
<td>Arrival Owned, Parked</td>
<td>Green</td>
<td></td>
</tr>
<tr>
<td>Departure Owned, No Route</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Departure Moving</td>
<td></td>
<td></td>
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<tr>
<td>Departure Held @ Gate</td>
<td>Red</td>
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<td>Stopped</td>
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<tr>
<td>Held Enroute</td>
<td>Pink</td>
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</tr>
</tbody>
</table>
Notifications Panel

Notifications come in top to bottom chronologically and should generally be handled in a FCFS fashion.

Clicking on a notification selects the aircraft to which that notification pertains.

Clear the notification once it is handled. An empty list is a good list. Use the CLEAR button on the Notifications Panel or the “Clear Message” function key.
Flight Information Displays

Single Flight Status Panel

Target List Status Panel

Tag Menu List
Pilot Station Configured for Edit Mode
Questions?