MACS ATC Overview

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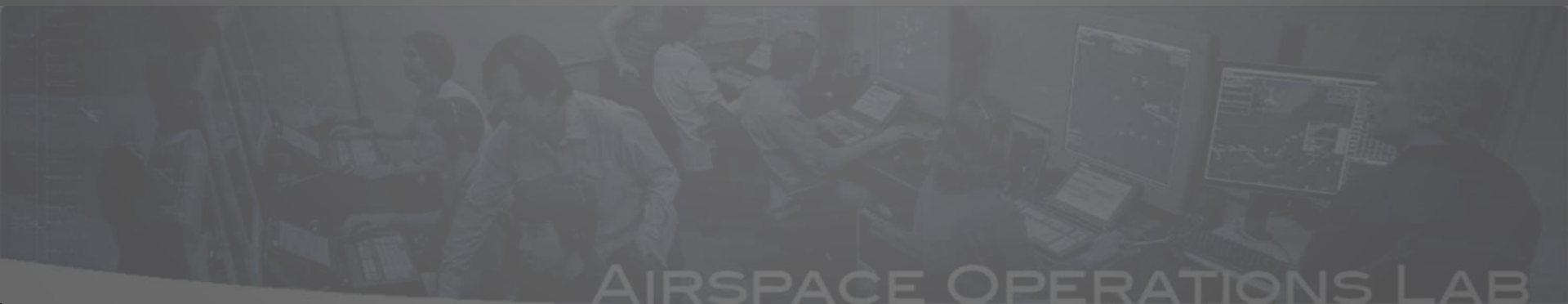
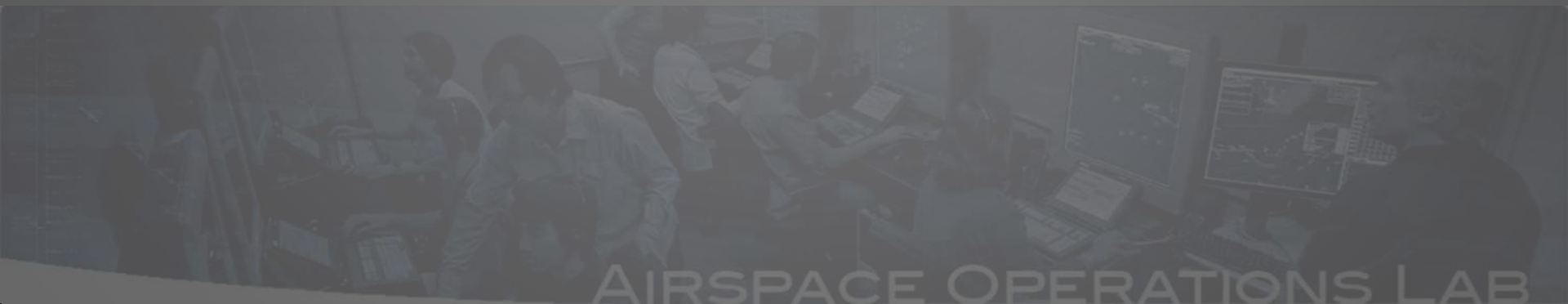


Overview

- Terminal area controller stations
- Enroute controller stations in the near- and mid-term
- Traffic flow and airspace management stations
- Automated enroute controller stations in the far-term

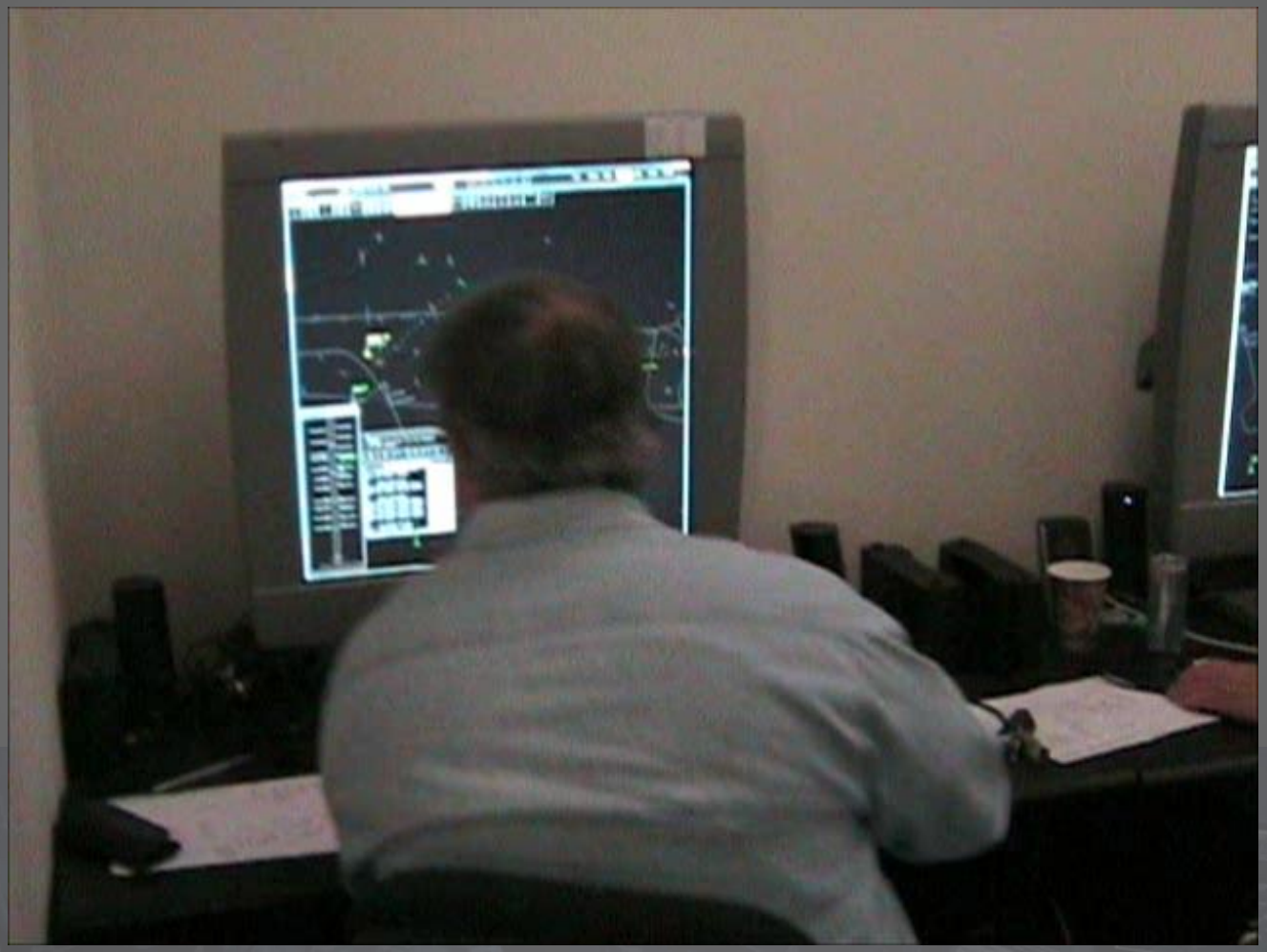


Multi Aircraft Control System (MACS)

TERMINAL AREA CONTROLLER STATIONS

- Arriving aircraft pass through feeder and final sectors. Today there is little to no automation support and all communication is voice. MACS provides some advanced capabilities.
- Video shows a Controller Managed Spacing simulation

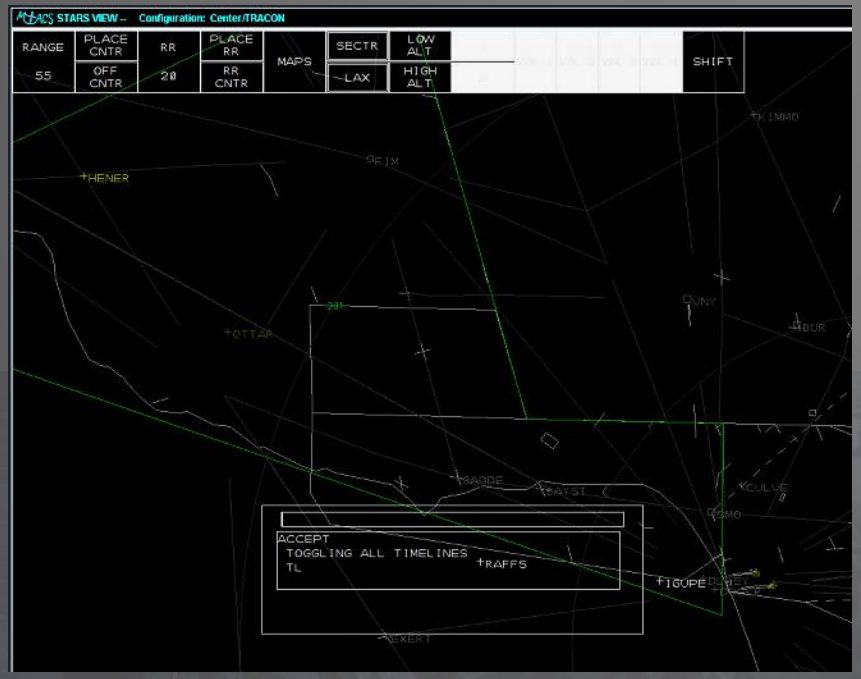
Terminal Area Air Traffic Control



ATC in the Terminal Area

Operator-Mode:
TRACON-Controller

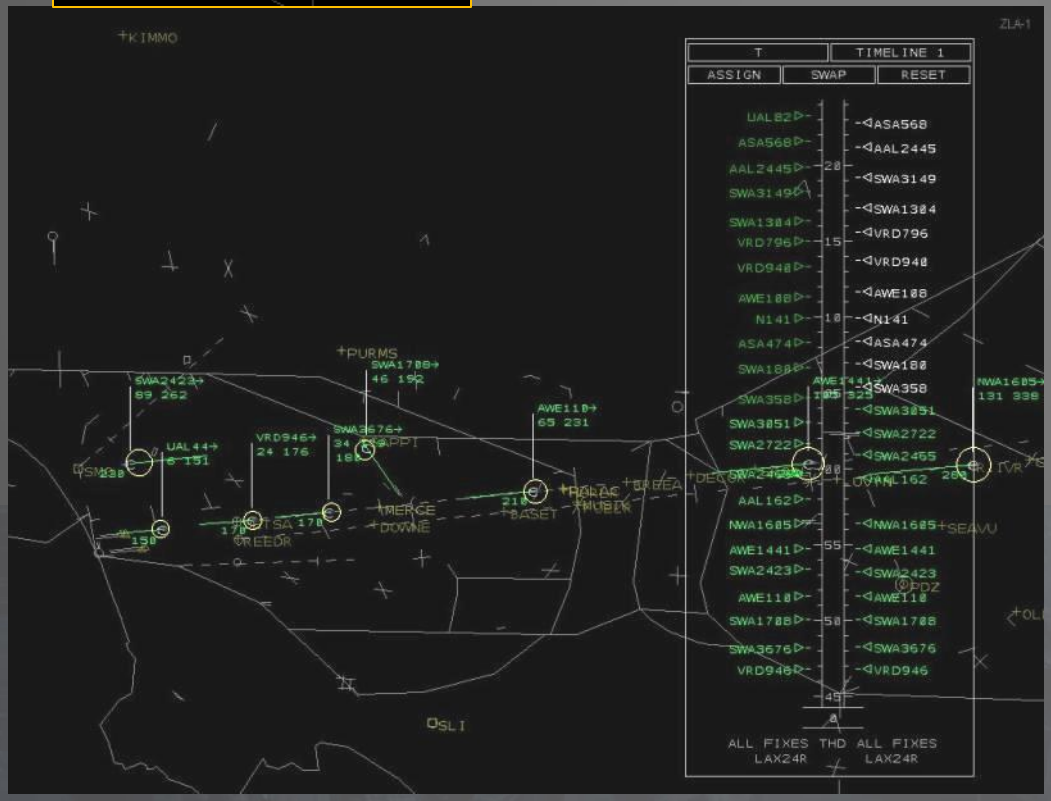
Primary Display:
STARS View
STARS: Standard Terminal Automation Replacement System



Most Relevant Setup Files:

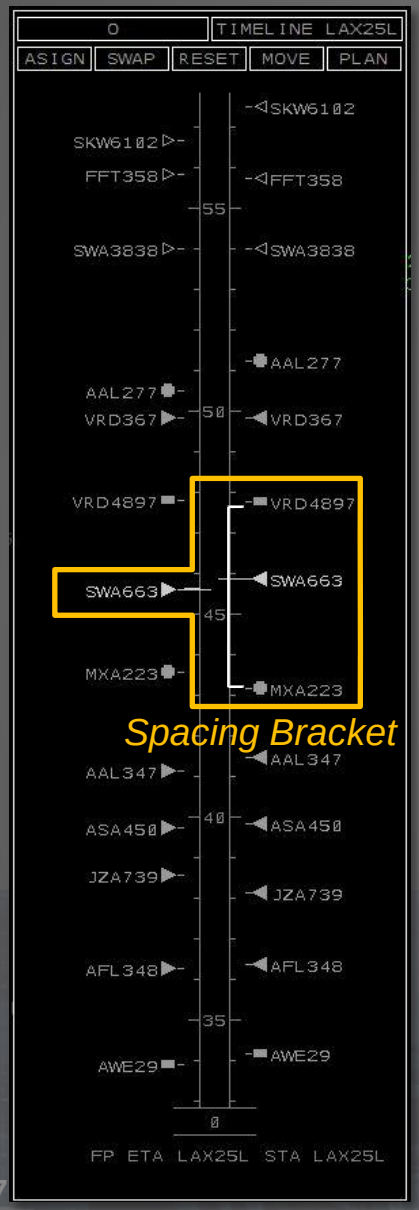
- ATC DST Configuration
- ATC DST Sector Configuration
- STARS Data Tag Rules Setup
- STARS Plan View Setup
- STARS Sector Plan View Setup
- STARS Timeline Setup
- Scheduler Setup

Advanced Terminal Area Tools



- Simple Scheduling Capabilities
- Controller Managed Spacing Tools
  - Slot Markers
  - Timelines
  - Speed Advisories
- ATC procedures
- CTAS TMA Integration

Controller Support for Managing OPDs



Spacing Bracket

Three Successively More Advanced Toolsets

"Timeline"

Early/Late Indication

"Slot Marker"

Early/Late Indication + Slot Marker

"Speed Advisory"

Slot Marker + Speed Advisory

Display elements available in all conditions:

- Timeline with dwell-able required spacing brackets
- Airspeed next to aircraft target
- J-rings, route display, LA spacing ('splat')
- Terminal proximity alert spacing cones ('bats')

Multi Aircraft Control System (MACS)

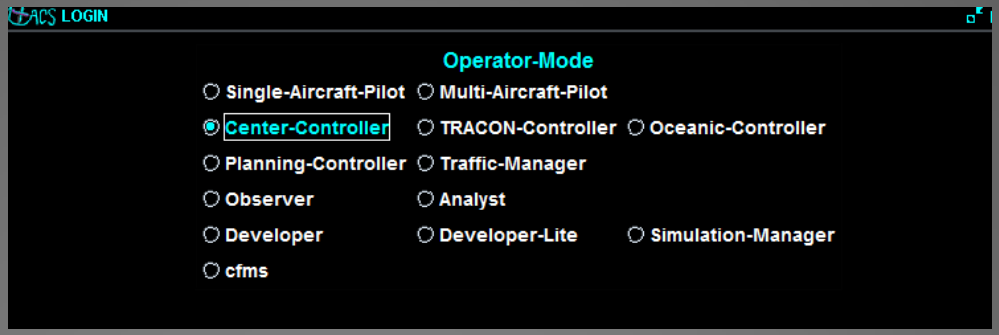
EN ROUTE ATC OPERATIONS NEAR-TERM / 2016

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

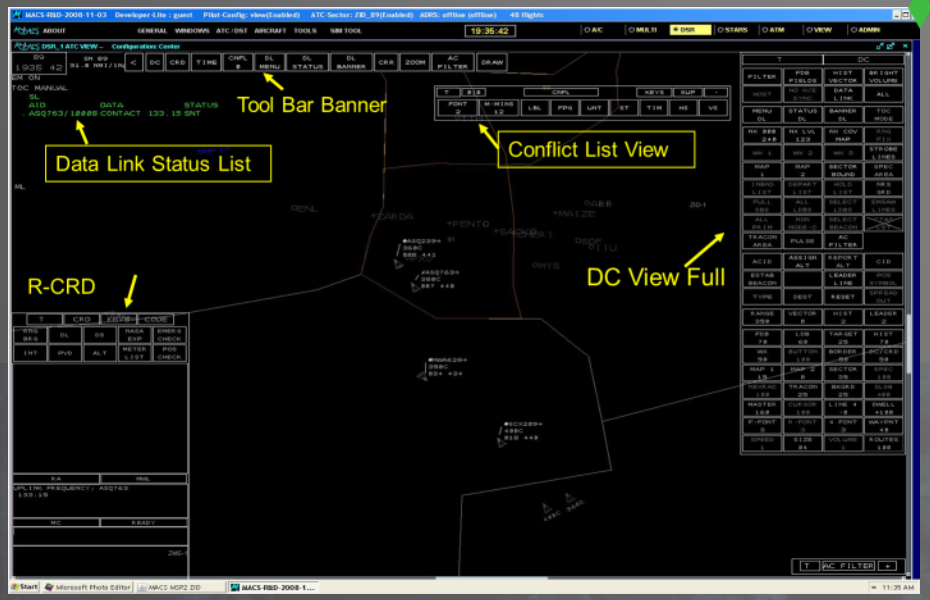
Air Traffic Control

En Route Controller Positions

Operator-Mode:
Center-Controller



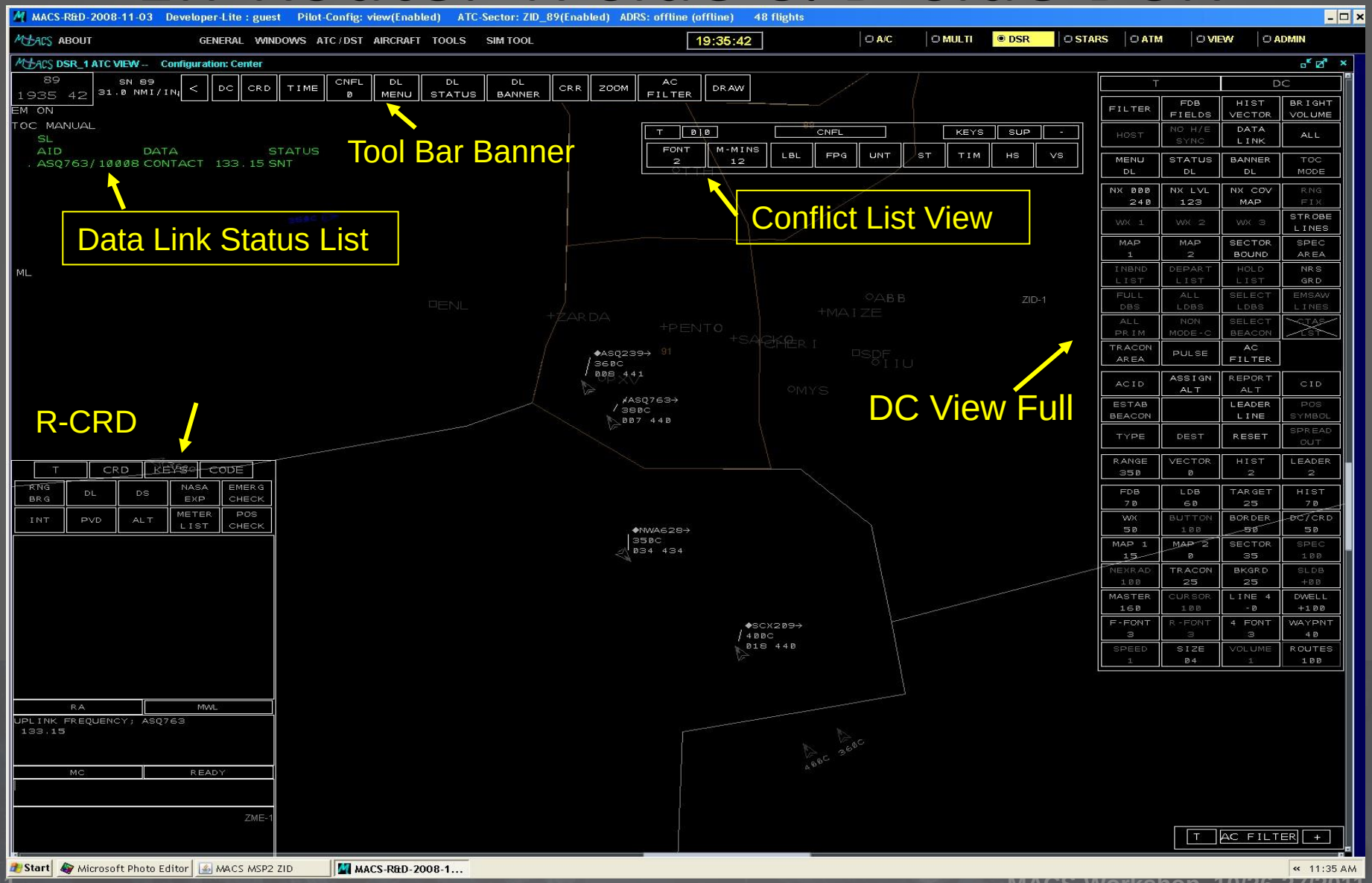
Primary Display:
DSR View
DSR: Display System Replacement



Most Relevant Setup Files:

- ATC DST Configuration
- ATC DST Sector Configuration
- DSR Data Tag Rules Setup
- DSR Plan View Setup
- DSR Sector Plan View Setup
- DSR Timeline Setup

En-Route: R-side & D-side DSR



Near- to Mid-Term Controller Tools

- 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
- Multi-layered rapid feedback conflict probing
- Weather penetration probe
- Data comm. integration
- Fully automated, semi-automated, manual operations
- AAC Auto-Resolver with Weather avoidance

- Most functions are configured via the ATC DST Configuration

Conflict Probe FDB

Flight Data Block Conflict Information

Font Color Coding for Time-to-Conflict values

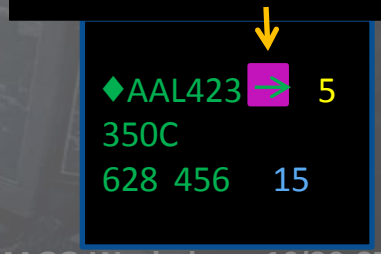
- Red Font: time-to-loss of separation is < 3 minutes
- Yellow Font: time-to-loss of separation is > 3 minutes ≤ 5 minutes
- White Font: time-to-loss of separation is > 5 minutes but < 12 minutes

Trial Planning

- Trial Plan Options
  - Single or Multi-Aircraft
  - Typed Commands into DSR CRD
    - FF- selects aircraft for group trial planning
    - TT- opens basic route trial plan
    - TA- opens an altitude trial plan
    - TR- opens a more specified route trial plan
  - Interactive Flight Data Block (FDB)
    - Arrow next to the aircraft call sign- opens basic route trial plan
    - Same arrow (but magenta-colored)- to review a suggested trial plan
    - Altitude line of the FDB- opens an altitude trial plan
    - Conflict number to start a automated trial plan resolution to solve for the predicted traffic conflict
    - Weather number to start a trial plan to solve for the predicted weather penetration
  - Drag and Drop Route Line
    - Lat/Long
    - Waypoint

Multiple Aircraft Trial Plan- FF

FDB Trial Plan Portal



Air/Ground Data Communication

Key Uplink Capabilities

- Trajectory information [or parameters] and trajectory constraints (route modification uplinks, altitudes, profile speeds, required times of arrival)
- transfer of communication (i.e. frequency changes)
- free text (encode anything in text format)
- responses to aircraft initiated requests

Key Downlink capabilities

- Responses (wilco, reject)
- Free text (encode anything in text format)
- Requested trajectory changes

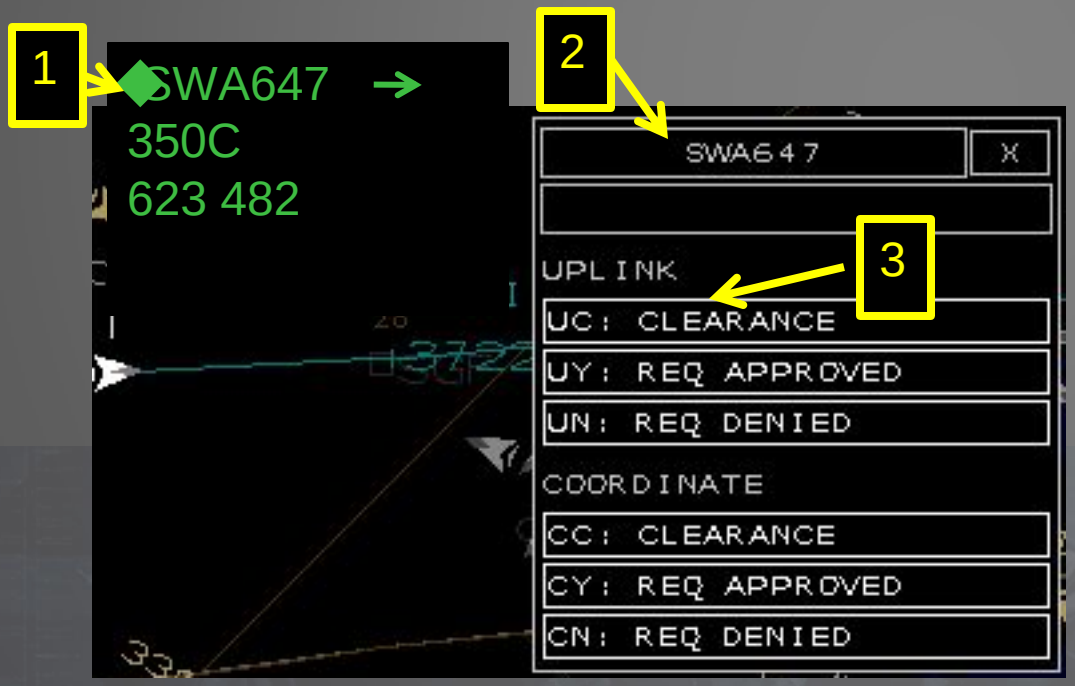
Broadcast/ downlink capabilities

- Aircraft state and velocities
- Short term intent and flight modes (i.e. flight control system settings)
- FMS trajectory reports
- FMS inputs (e.g. speed profile, weight)

Data Comm: Mixed Equipage

Equipped Data Comm Clearance

Uplink Clearance to Aircraft (Point and Click)
1. Pick on data link portal (filled triangle)
2. Drop down box appears next to FDB
3. Pick on UC: Clearance to uplink to aircraft



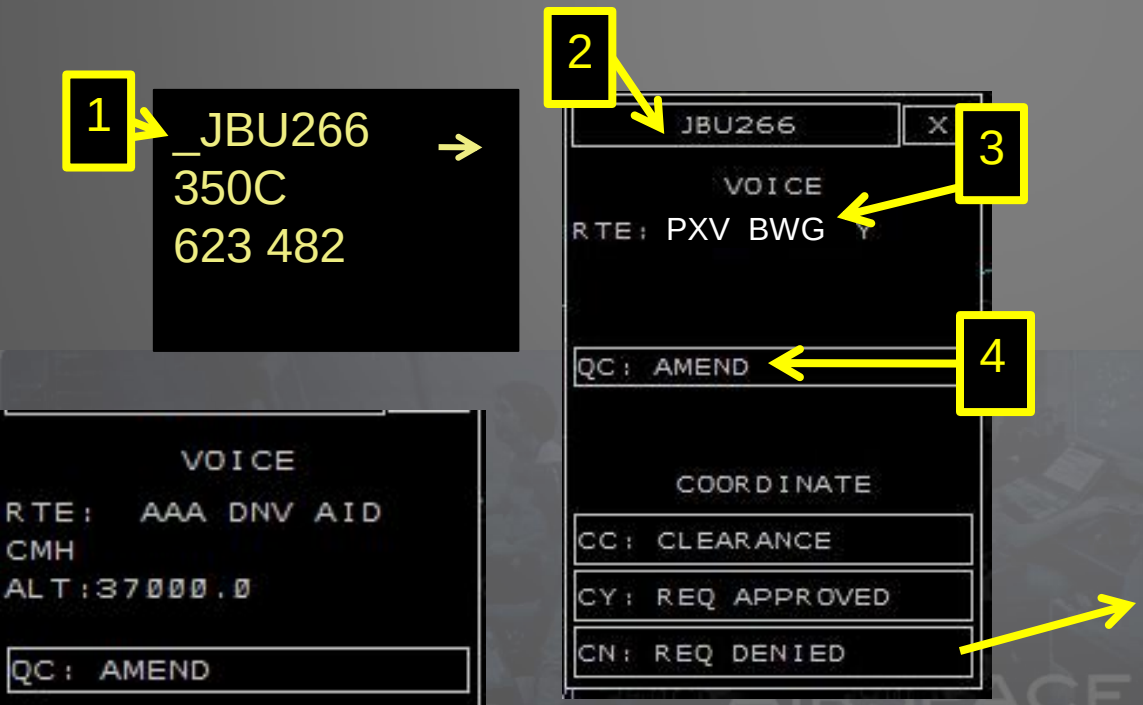
Uplink Clearance via Keyboard
- Type UC [CID] ENTER

Data Comm: Mixed Equipage

Un-Equipped Verbal Clearance

Issue TP or CC Clearance to Aircraft (Point and Click)

1. Pick on data link portal (underscore symbol)
2. Drop down box appears next to FDB
3. Voice clearance appears, issue to aircraft Direct PXV, BWG rest of route unchanged
4. Pick on QC: Amend in Automation (HOST)



Data Comm FDB Information

status the following data link status symbols are found in the flight data block (left of the call sign):

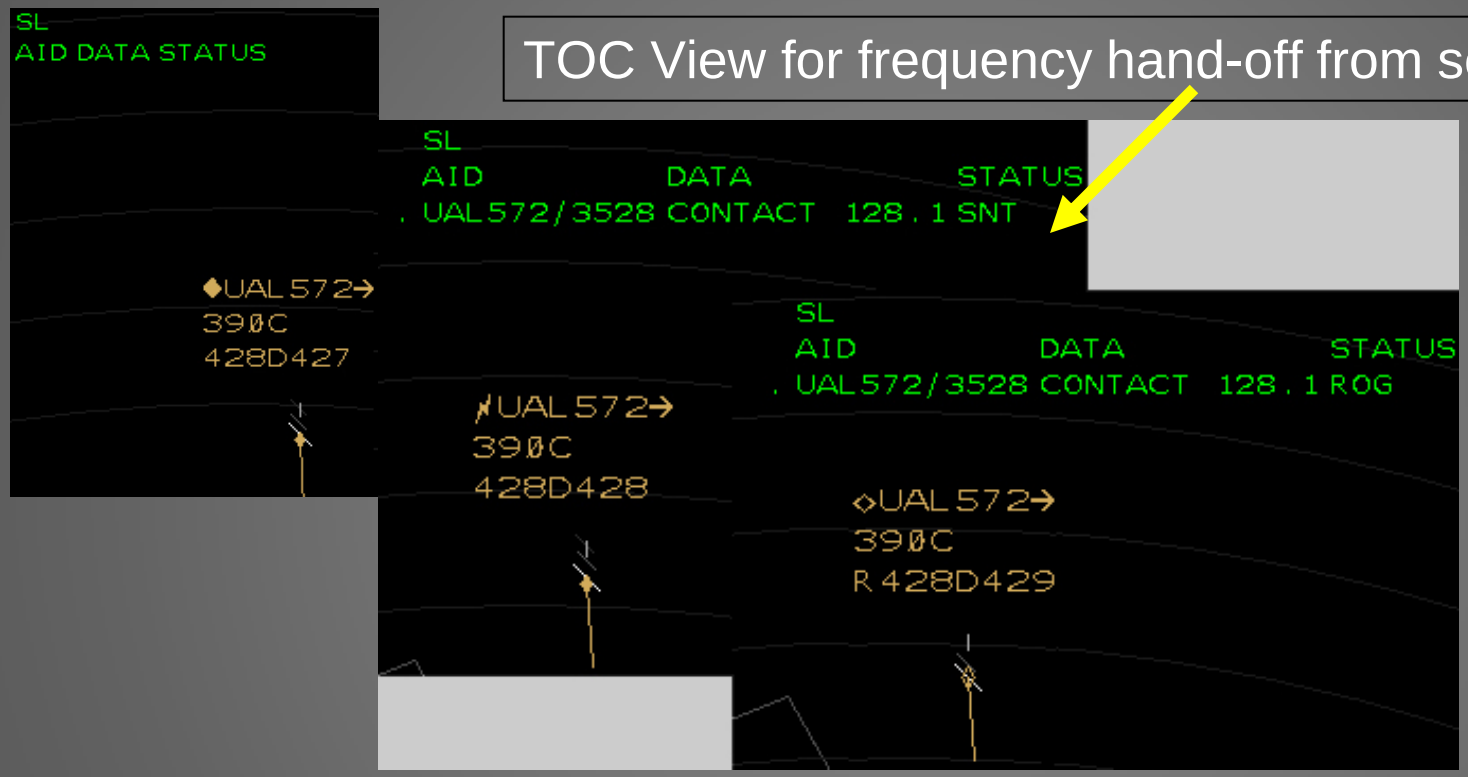
symbols : eligibility : no eligibility : TOC in progress : uplink in progress

: coordination request (right of callsign)

- A filled diamond ( ) indicates that the sector has "eligibility", and can send and receive messages to the aircraft. Data link eligibility usually accompanies track control, but the transfer mechanism is separate.
- An unfilled diamond ( ) indicates that the sector does not have "eligibility" (i.e., cannot communicate with this aircraft via CPDLC).
- A lightning bolt ( ) indicates that a transfer of communication (and transfer of eligibility) is in progress.
- An up arrow ( ) indicates that a message has been "uplinked" from the controller to the aircraft. The uplink may be a clearance, frequency, or text message.
- A magenta arrow ( ) indicates a coordination request which is a clearance request sent to the CPDLC eligible controller from another ground position or MSP.

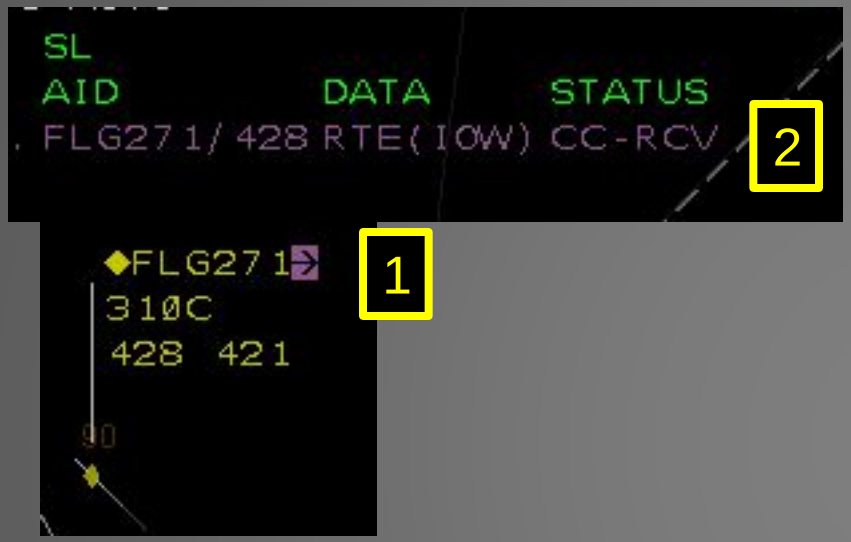
Sample Data Comm Transfer of Communication (Air-to-Ground)

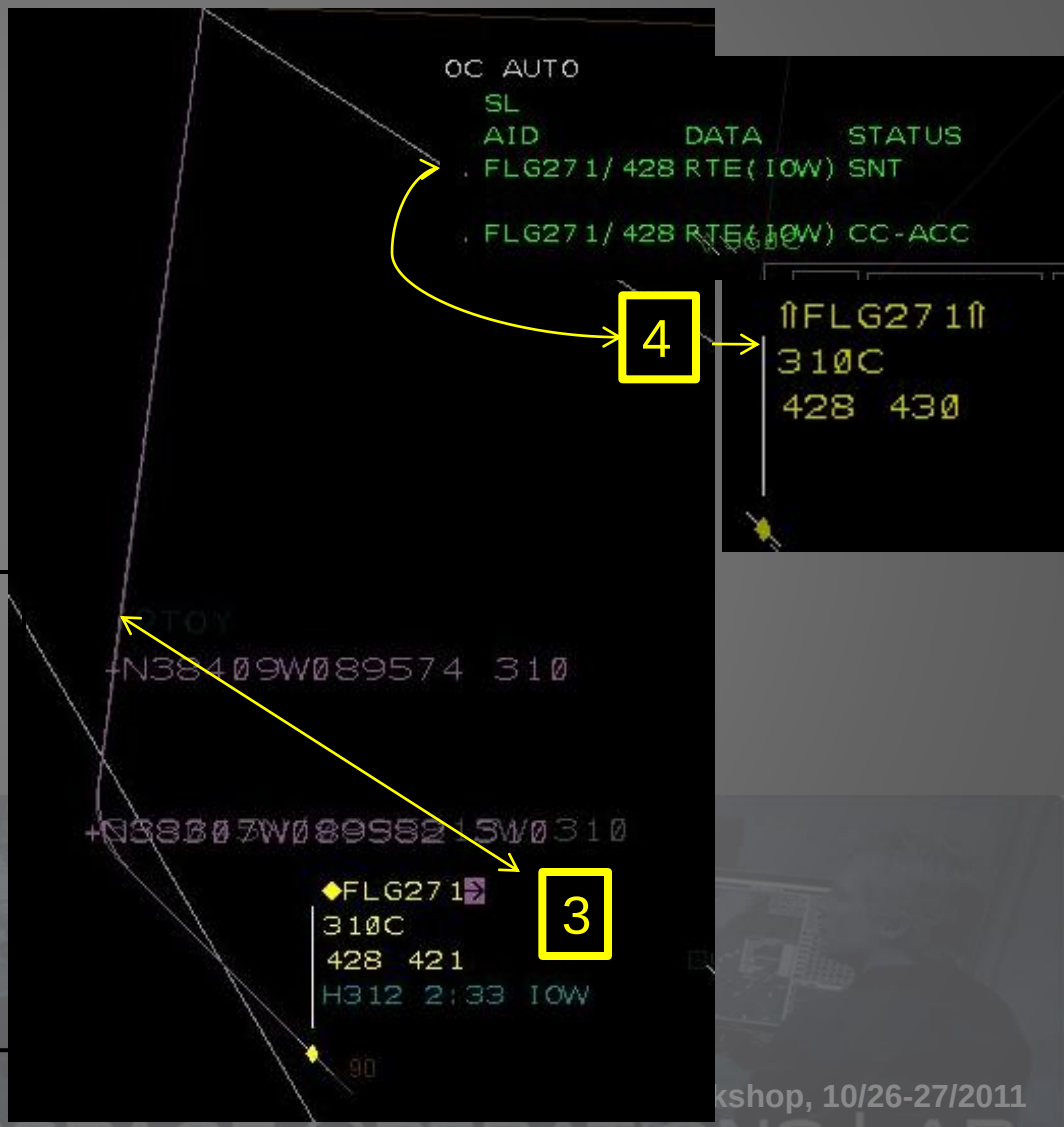
TOC View for frequency hand-off from sending sector:



TOC View for accepting hand-off frequency change from receiving sector:

Sample Data Comm Request from Planners (Ground-to-Ground)





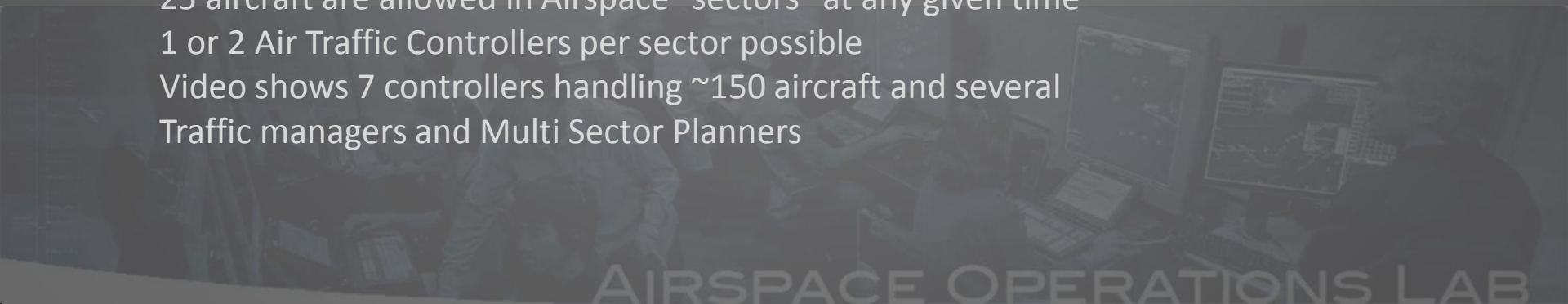
Coordination Request from MSP

1. Pink coordination request in FDB
2. Coordination Request Received in data link status list.
3. PICK on Request Portal to view request (pink route line).
4. UC up to aircraft to send route to aircraft and acceptance to Planner.

Multi Aircraft Control System (MACS)

MULTI SECTOR 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 and several Traffic managers and Multi Sector Planners

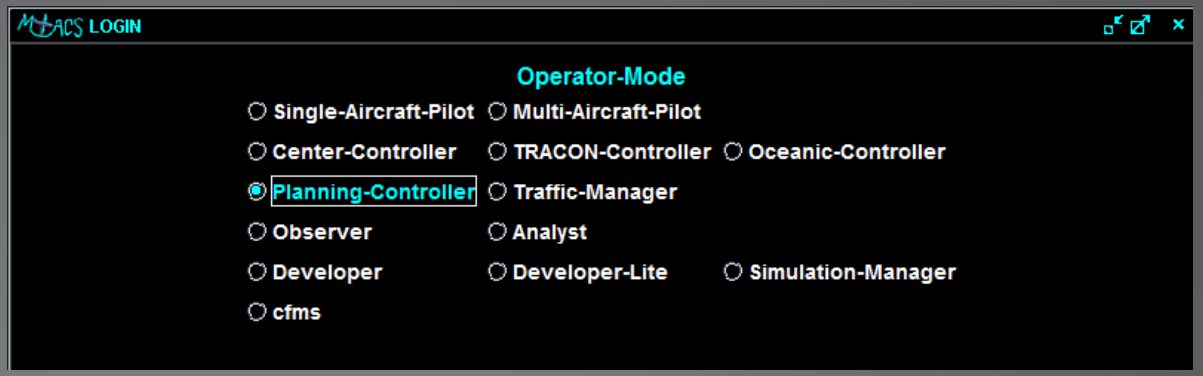


Air Traffic Control in the Mid-Term

Planner Stations
Area Supervisor & Traffic Management Unit

Planning Controller Positions

Operator-Mode:
Planning-Controller



Primary Displays:
DSR View
DSR: Display System Replacement
TSD: Traffic Situation Display
Load tables and graphs

Most Relevant Setup Files:

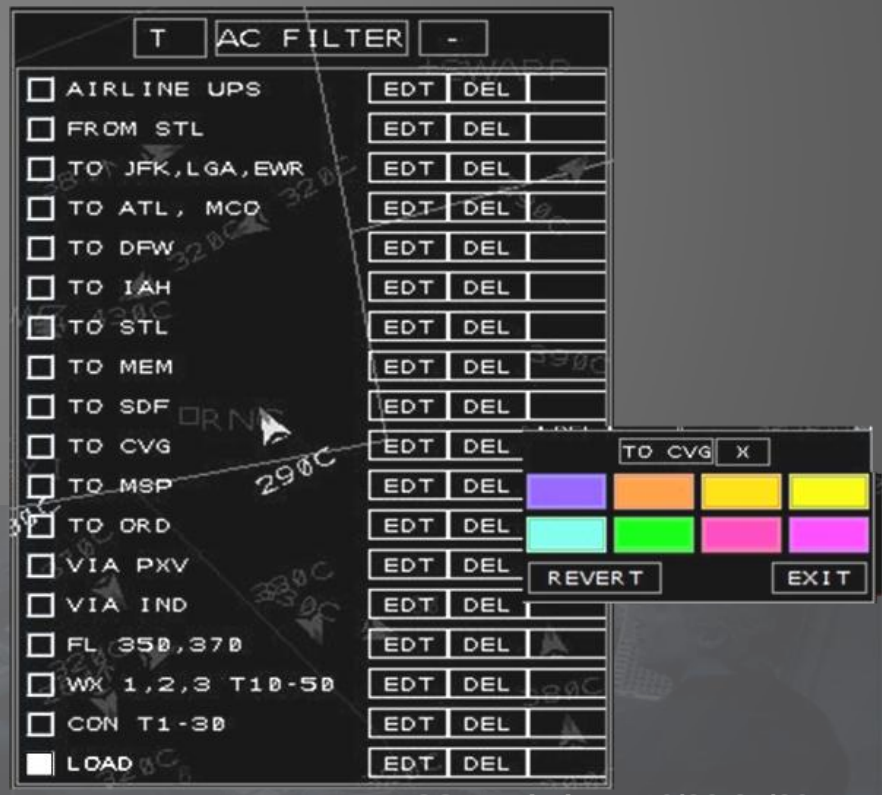
- ATC DST Configuration
- ATC DST Sector Configuration
- DSR/TSD Data Tag Rules Setup
- DSR/TSD Plan View Setup
- DSR/TSD Sector Plan View Setup
- DSR/TSD Timeline Setup
- Traffic Load Setup

Flow Based Trajectory Management Tools Assessment and Modification

- Assessment Tools
  - Load Display Control Window
  - Load Table Window
  - Load Graph Window
  - Aircraft (AC) Filters
- Modification Tools
  - “trial plans” for single or multi-aircraft trajectories
    - Altitude
    - Route
    - Both Altitude and Route
  - Conflict avoidance, Weather avoidance or Airspace congestion
- Coordination Tools
  - Air-to-Ground Data Comm
  - Ground-to-Ground Data Comm

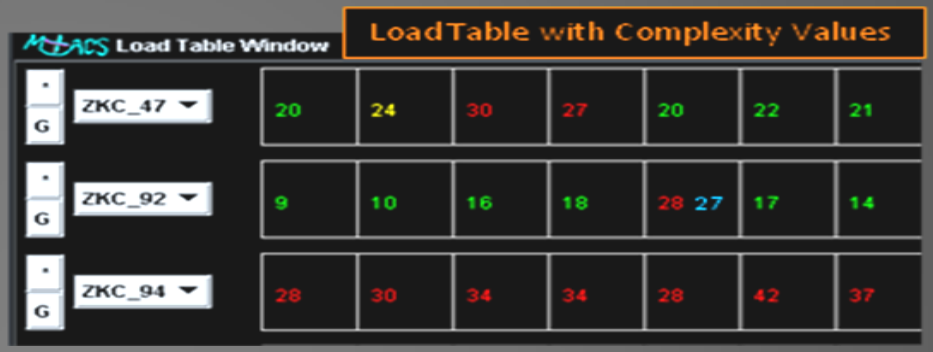
Situation Assessment Tools

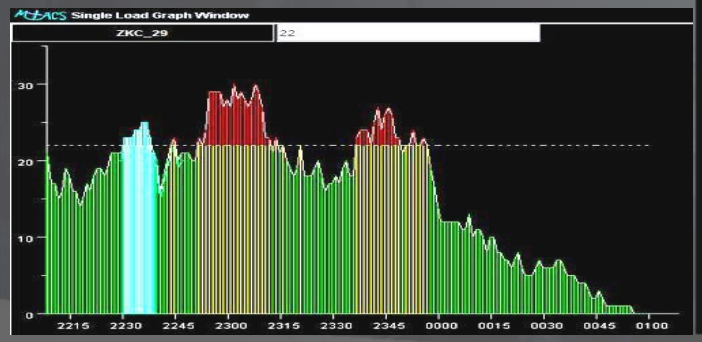
- AC Filter
  - Gain awareness of current and predicted traffic subsets
  - Highlight particular aircraft sets
    - TO or FROM specific airports
    - VIA routes or waypoints
    - FL- specific altitude stratums
    - GEO specific areas
    - DRAW-dynamically drawn objects
    - WX- forecasted weather areas
    - LOAD- traffic load and complexity tables/graphs
    - Color Code optional
    - ETC….



Situation Assessment Tools (Cont)

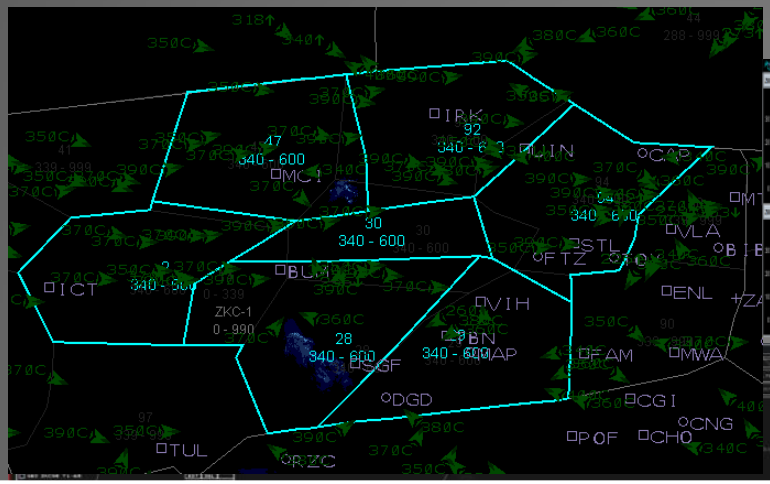
- Load Tables and Graphs
  - Traffic Loads
  - Tables/Graphs
    - Specific Sector
    - Specific Time (15 min. intervals)
  - Complexity Factors
    - Unequipped
    - Transitioning aircraft
    - Conflict predictions
    - Weather penetrations
    - Sector shape and size

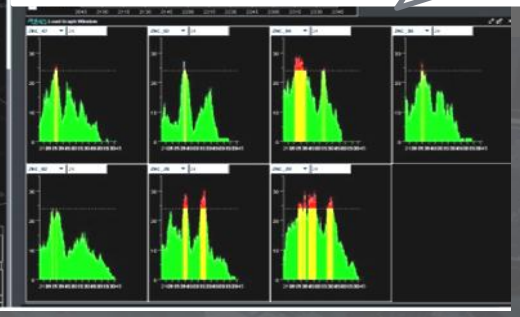




Situation Assessment Tools (Cont)

- Flexible Airspace Management with Dynamic Airspace Configurations





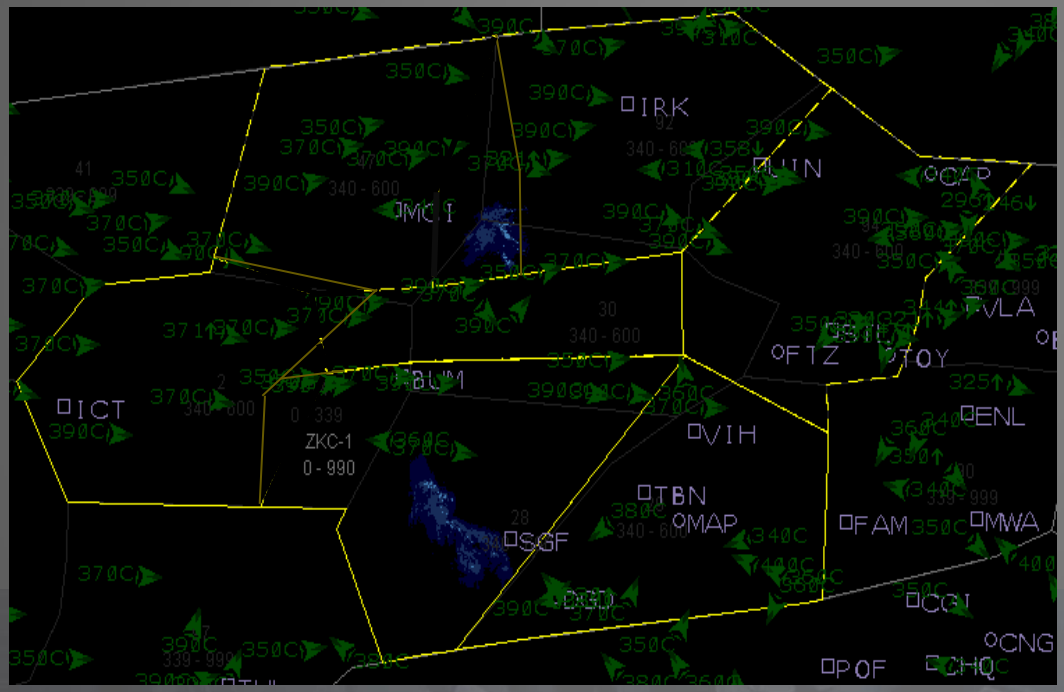
- Peak traffic reduced significantly
- Additional reroutes necessary

Situation Assessment Tools (Cont)

Flexible Airspace Management Video

Situation Assessment Tools (FAM Cont)

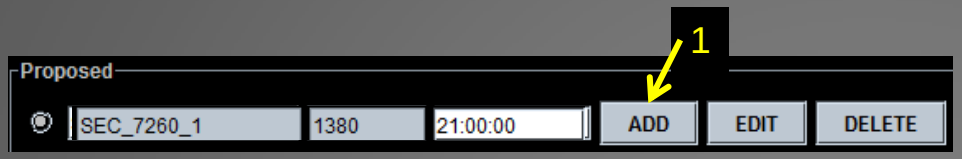
Select, share, and coordinate the configuration with other Sups/ TMCs



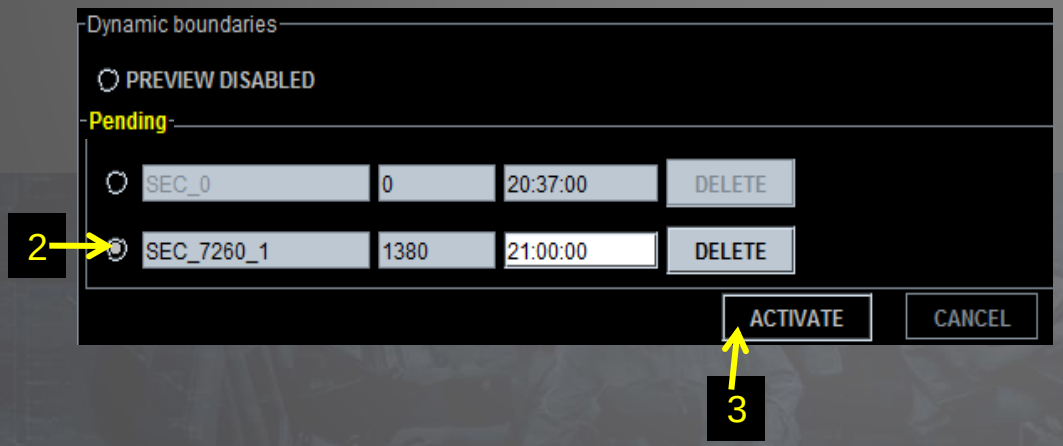
- Coordinate with other Sups and TMCs to implement the new airspace configuration
- Share the airspace configuration with other Sups and TMCs
- Call the Sups/TMCs and ask them to review the configuration
- Agree on the time to make the configuration change

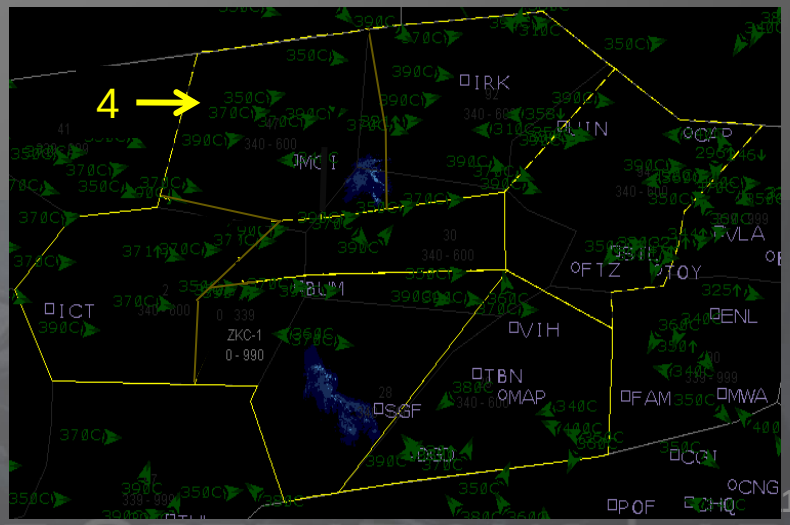
Situation Assessment Tools (FAM Cont)

Implement (activate) the configuration change



1. Set the UTC time when the airspace configuration will change
   - Set UTC at 10+ min into the future to allow Sup-controller coordination and 5 min boundary preview
2. New configuration is moved to "Active area"
3. Click on ACTIVATE button to put the new configuration in the queue.
4. The new configuration will be active at the assigned UTC time.



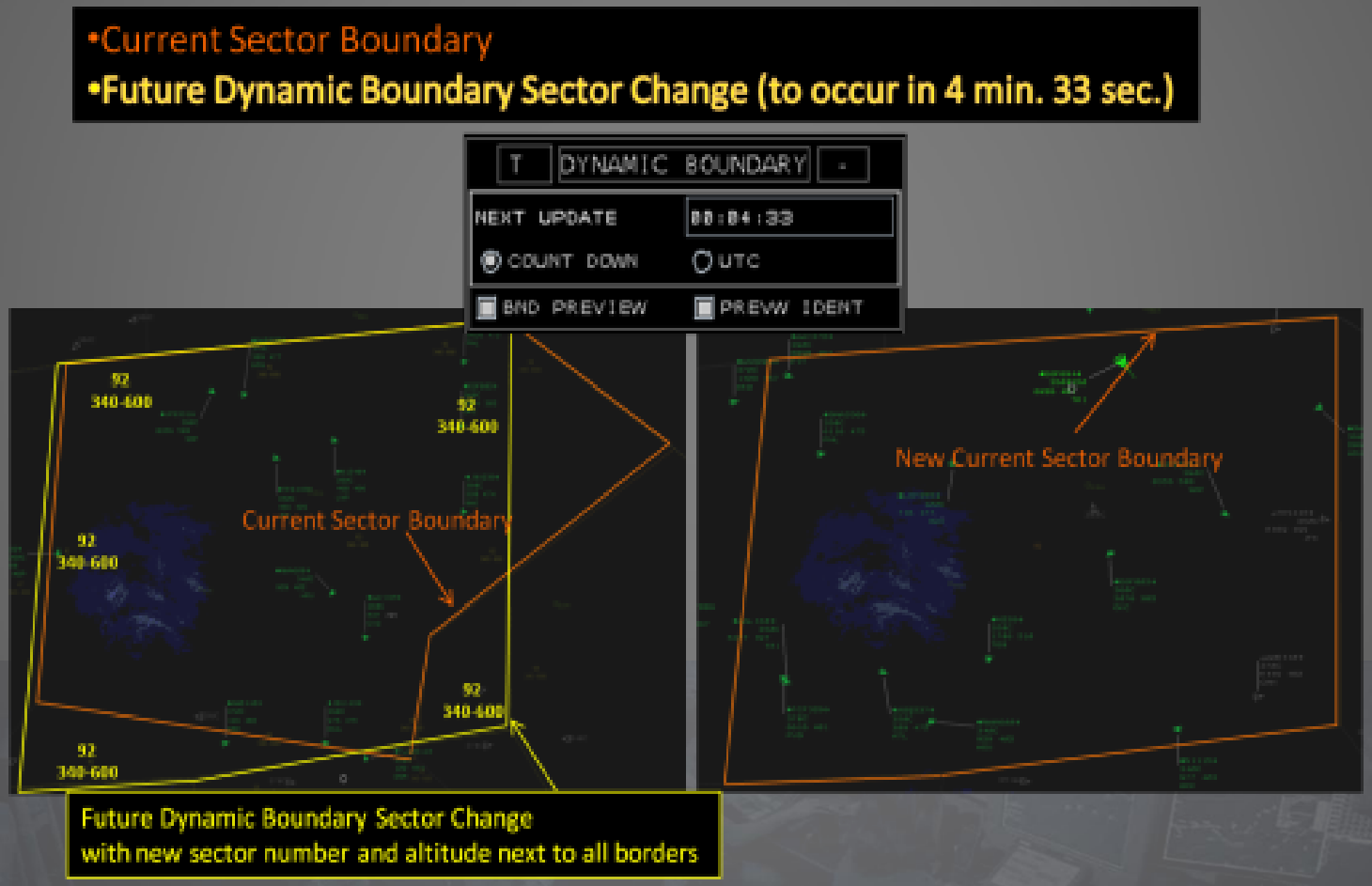


Situation Assessment Tools (FAM Cont)

- Sup informs the controllers that a configuration change is planned.
- Sup displays the new configuration on the overhead projector.
- Controllers see the preview of the new airspace boundaries at 5 minutes prior to the change.

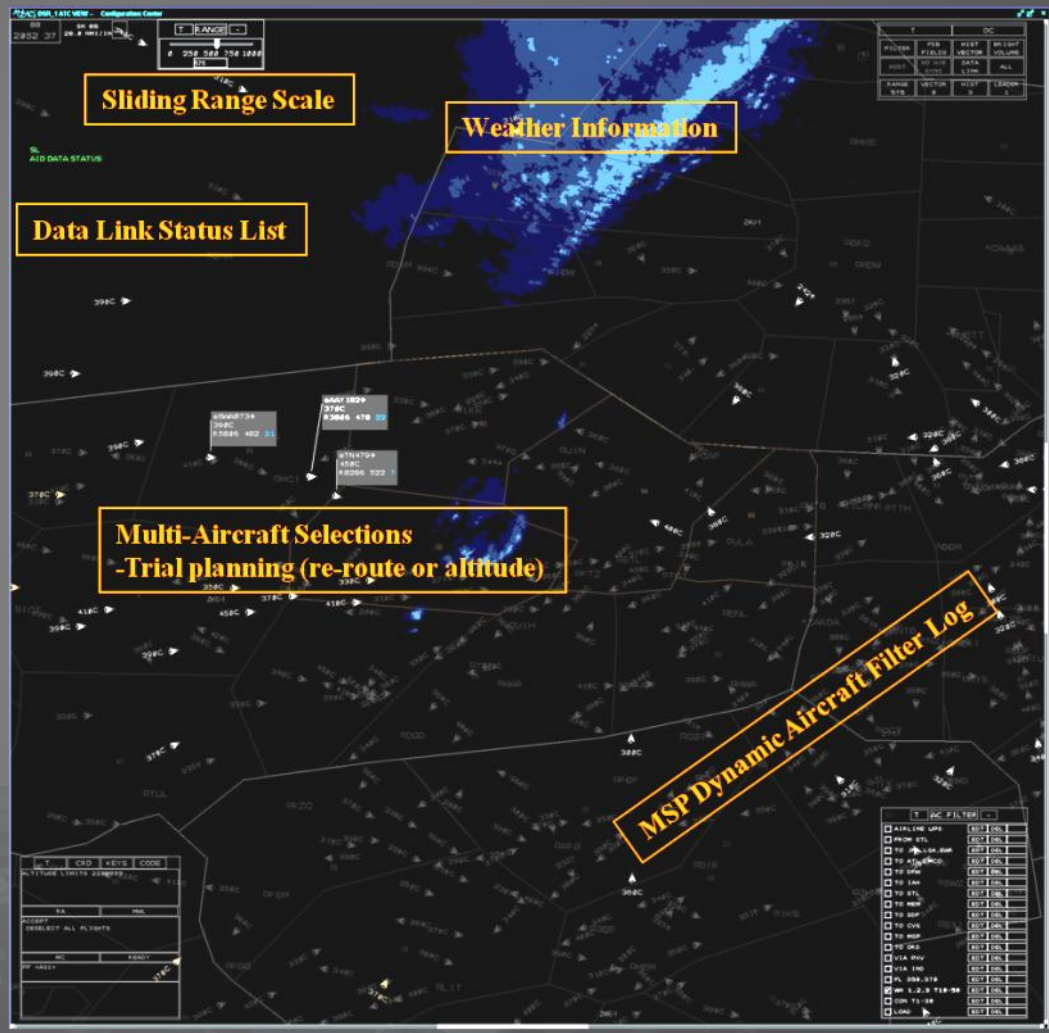
Situation Assessment Tools (FAM Cont)

- Boundary Preview for the Controllers



Trajectory Planning and Coordination

- Display System Replacement (DSR)
  - Interactive Trial Planning Tool
    - Single or Multi-aircraft
    - Altitude, Route, or Both
  - AC Filter Options
  - Data Comm
    - Air-to-ground
    - Ground-to-ground
  - Weather Information

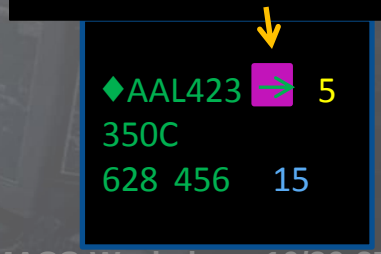


Trajectory Planning and Coordination

- Trial Plan Options
  - Single or Multi-Aircraft
  - Typed Commands into DSR CRD
    - FF- selects aircraft for group trial planning
    - TT- opens basic route trial plan
    - TA- opens an altitude trial plan
    - TR- opens a more specified route trial plan
  - Interactive Flight Data Block (FDB)
    - Arrow next to the aircraft call sign- opens basic route trial plan
    - Same arrow (but magenta-colored)- to review a suggested trial plan
    - Altitude line of the FDB- opens an altitude trial plan
    - Conflict number to start a automated trial plan resolution to solve for the predicted traffic conflict
    - Weather number to start a trial plan to solve for the predicted weather penetration
  - Drag and Drop Route Line
    - Lat/Long
    - Waypoint

Multiple Aircraft Trial Plan- FF

FDB Trial Plan Portal



Trajectory Planning and Coordination

- Trajectory Plan Coordination via Data Comm
  - Ground-to-Air Data Comm
    - Uplink the trajectory modification directly to the aircraft
  - Ground-to-Ground Data Comm
    - Coordinate the clearance with the radar controllers who have track control of those aircraft, upon approval, they can uplink it to the aircraft directly
    - Send a modified Coordination Plan to other team members
  - Voice Communications: VSCS Emulation
    - Available at all times (one to one or party line)
    - Required for Mixed-equipage

Multi Aircraft Control System (MACS)

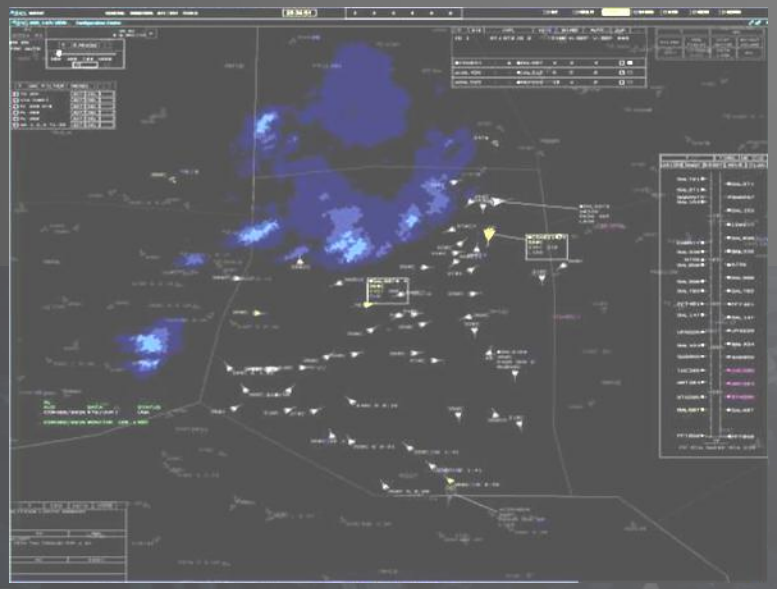
AIR TRAFFIC CONTROL OPERATIONS FAR-TERM / 2030

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 …

Function Allocation used in Study

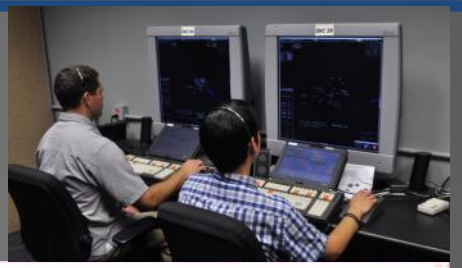
Automation	Controller
•Detect Separation and weather Conflicts •Resolve trajectory-based conflicts (if within tolerances) •Resolve all time-critical traffic conflicts •Alert controller to urgent problems •Provide trajectory planning assistance •Use data comm. to communicate	•Supervise the automation •Resolve trajectory conflicts flagged by the automation •Monitor and maintain schedule compliance •Implement weather reroutes with automation support •Place aircraft back on trajectory following automated tactical maneuvers

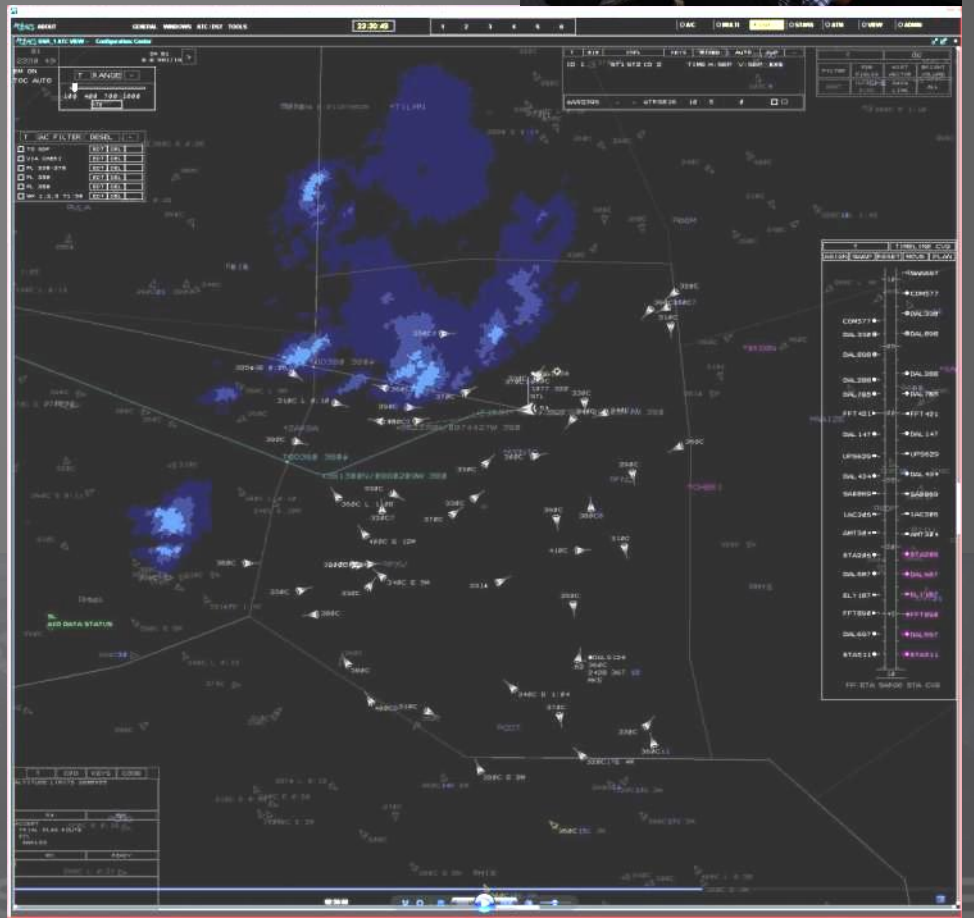


Prototype System

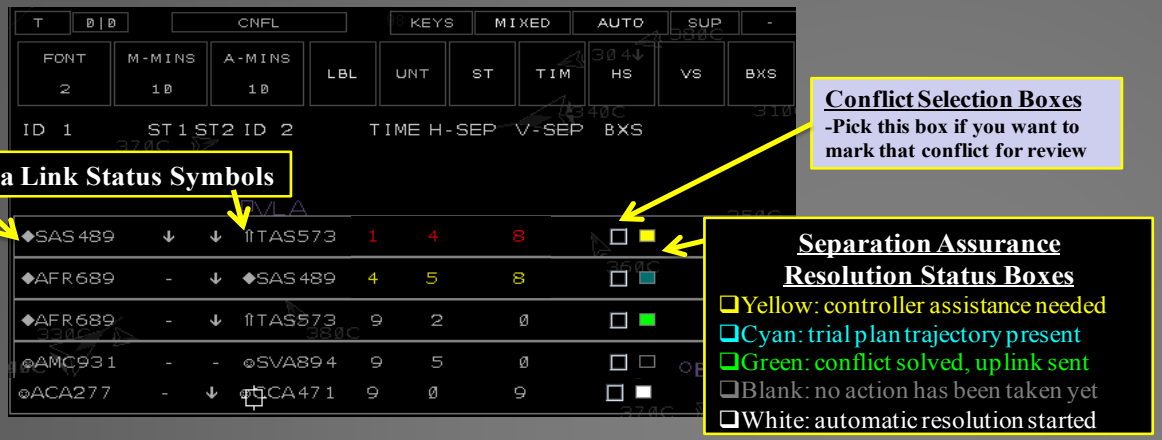
Integrated controller workstation with

- Trajectory planning
- Data communication
- Conflict probing
- Trajectory-based conflict resolution
- Short-term conflict alert and resolution
- Weather avoidance
- Scheduling and time-based metering





Trajectory-based CD&R



Automation status indication integrated in relevant places on the displays

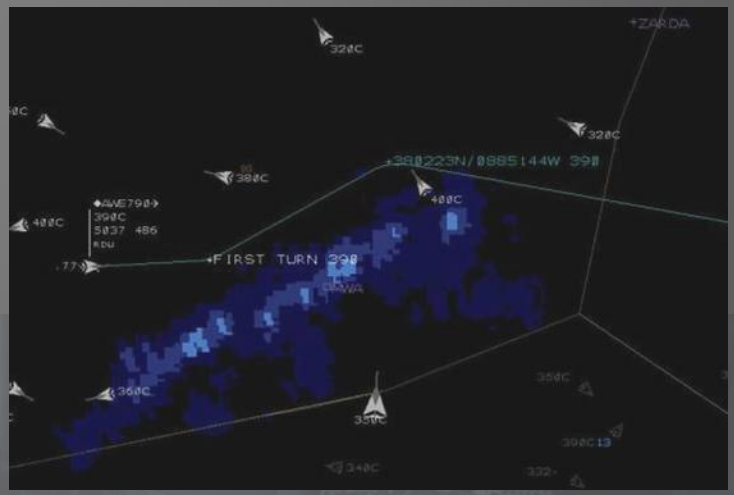
(e.g. resolution, conformance data link status)

Tactical Short-Term CD&R

Vectoring solutions are highlighted in data tag and sent by the automation

Improvements

- Automation
  - Altitude fly-out menu with real-time conflict feedback
  - Free-track trajectory automation
  - Semi-automated weather avoidance
- Human Automation Interaction and Procedures



Questions?

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