ATC AUTOMATION CONCEPTS

Heinz Erzberger
NASA Ames Research Center
RESEARCH PROGRAM IN ATC AUTOMATION

OBJECTIVE:

DESIGN OF HUMAN-CENTERED AUTOMATION TOOLS FOR TERMINAL AREA AIR TRAFFIC CONTROL

SCOPE:

• AUTOMATION CONCEPTS
• TRAJECTORY PREDICTION AND CONTROL ALGORITHMS
• SCHEDULING AND SEQUENCING ALGORITHMS
• HUMAN-SYSTEM INTERFACE DESIGN
• TEST AND EVALUATION OF CANDIDATE CONCEPTS
• TECHNOLOGY TRANSFER

PAYOFFS AND PRODUCTS

PAYOFFS

• INCREASED FUEL EFFICIENCY
• REDUCED DELAYS
• EFFECTIVE RESPONSE TO CONTINGENCIES
• IMPROVED WORK ENVIRONMENT FOR CONTROLLERS

PRODUCTS

• CONCEPTS AND DESIGN METHODS FOR AUTOMATED ATC SYSTEMS
• AUTOMATION SOFTWARE
• CONTROLLER SYSTEM INTERFACE AND CONTROLLER PROCEDURES
• TESTS AND EVALUATIONS OF KEY CONCEPTS AT OPERATIONAL SITE

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OUTLINE

• DESIGN PHILOSOPHY
• AUTOMATION CONCEPT
• CONTROLLER SYSTEM INTERFACES
• TESTS & EVALUATIONS

BROAD GUIDELINES

• CONTROLLER RESPONSIBILITIES UNCHANGED

• AUTOMATION TOOLS ASSIST BUT DO NOT REPLACE CONTROLLER FUNCTIONS

• PROVIDE ADVISORIES FOR BOTH NORMAL AS WELL AS ABNORMAL SITUATIONS

• CONTROLLERS DECIDE WHETHER TO USE OR IGNORE ADVISORIES

• NO ADDITIONAL SENSORS REQUIRED ON THE GROUND OR ONBOARD

• PROVIDE A BASIS FOR DESIGN OF FUTURE AUTONOMOUS ATC SYSTEMS
OBSERVATIONS AND APPROACH

AIR TRAFFIC CONTROL IS A TEAM PROCESS

- Each team member is an expert in his position; but works closely with other team members
- Communications and coordination between team members is a dominant feature

DESIGN OF AUTOMATION SYSTEM IMITATES STRUCTURE OF MANUAL CONTROL PROCESS

- Hierarchy of supervision and control
- Expert advisors designed for each controller position
- Complex communication protocols between expert advisors
ATC AUTOMATION TOOLS

Traffic List → Traffic Management Advisor → Traffic Manager

Traffic Data → Communications Manager → Controller Test Subjects

Descent Advisor Arrival Gate → Descent Advisor Arrival Gate → ARTCC TRACON

Final Approach Spacing Tool → TRACON Controller Test Subject

Traffic Manager Display

Plan View Display

FAST Display

ORIGINAL PAGE IS OF POOR QUALITY
TRAFFIC MANAGEMENT ADVISOR: WHAT IS IT?

OPTIMUM SCHEDULING ALGORITHMS

- Coordinate and merge traffic, conflict free
- Minimize average delay, FCFS, etc.
- Meet separation standards

FLOW CONTROL ALGORITHMS

- Capacity management
- Rerouting: gate balancing, frontal system avoidance, runway change
- Flow monitoring

INTERACTIVE GRAPHICAL TOOLS FOR MANAGING ALGORITHMS IN REAL TIME

COMMAND AND COMMUNICATIONS INTERFACE FOR DA'S AND FAST
TWA233

CO92

UA787

SP404

PA001

CO711

PA666

EA999

02:17:00

YELLOW AIRCRAFT ARE IN THE SCHEDULING WINDOW

SCHEDULING WINDOW

BLOCKED INTERVAL

HEAVY SLOT

MANUALLY SCHEDULED AIRCRAFT

BLUE AIRCRAFT ARE FROZEN

FREEZE HORIZON

20 MINUTE TIME GAP

SCHEDULE TIMELINE

ETA TIMELINE

CO711

PA666

EA999

02:17:00
DESCENT ADVISOR: WHAT IS IT?

A SET OF INTERACTIVE TOOLS FOR ASSISTING CONTROLLERS IN MANAGING ARRIVAL TRAFFIC EFFICIENTLY UNDER DIVERSE CONDITIONS, FROM CRUISE TO FINAL APPROACH.

• FUEL OPTIMAL DESCENT ADVISORIES ADAPTED TO AIRCRAFT TYPE, AIRLINE PREFERENCE AND WIND PROFILE.

• ACCURATE TIME CONTROL AT FEEDER GATE AND ON FINAL APPROACH:
  • TOP OF DESCENT, MACH/IAS, SPEED ADVISORIES
  • ON-ROUTE AND OFF-ROUTE HORIZONTAL GUIDANCE ADVISORIES

• LONG LEAD TIME CONFLICT PREDICTION AND RESOLUTION ALONG COMPLEX DESCENT/APPROACH TRAJECTORIES

DESCENT ADVISOR TOOLS

TRAFFIC MANAGEMENT

• DISTANCE SPACING MARKERS AND ADVISORIES
• TIME AT METERING FIX MARKERS AND ADVISORIES
• CONFLICT PREDICTION MARKERS AND ADVISORIES

HORIZONTAL TRAJECTORY MANAGEMENT

• ON-ROUTE ADVISORIES
• DIRECT-TO-WAYPOINT ADVISORIES
• ROUTE INTERCEPT ADVISORIES

SPEED AND ALTITUDE PROFILE MANAGEMENT

• DESCENT SPEED (MACH/IAS PROFILE), RANGE TO TOP OF DESCENT
• CRUISE SPEED, STANDARD AIRLINE DESCENT PROFILE
• CRUISE + DESCENT

TRAJECTORY TRACKING INFORMATION

• ACCUMULATED TIME ERRORS OF "CLEARED" AIRCRAFT
• BROKEN CLEARANCE INDICATOR
Integrated controller display illustrating waypoint capture guidance to Drako and STAs on the time line.
FINAL APPROACH SPACING TOOL (FAST): WHAT IS IT?

A TOOLBOX OF GRAPHICAL ADVISORIES AND CONTROLLER SELECTABLE OPTIONS TO ASSIST TRACON CONTROLLERS IN SEQUENCING AND SPACING ARRIVAL TRAFFIC ON FINAL APPROACH

- ADVISORIES PROVIDED FOR ON-ROUTE AND OFF-ROUTE AIRCRAFT

- DYNAMIC RESCHEDULING AND ADVISORIES FOR ON SCHEDULE AND OFF SCHEDULE AIRCRAFT SUCH AS MISSED APPROACH AND POP-UP
Fast Display
AIR TRAFFIC SIMULATION

SIMULATION EVALUATIONS

<table>
<thead>
<tr>
<th>EVALUATION DATE (DURATION)</th>
<th>CONTROLLER SUBJECTS</th>
<th>TEST CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAY 1988 (3 WEEKS)</td>
<td>9, RETIRED OAKLAND CENTER</td>
<td>INTRAIL SPACING MODE MVSRF-727, LINE PILOTS</td>
</tr>
<tr>
<td>MARCH 1989 (3 WEEKS)</td>
<td>2, ACTIVE DENVER CENTER 4, RETIRED OAKLAND CENTER 3, RETIRED BAY TRACON</td>
<td>TIME CONTROL MODE; INTEGRATION OF TRAFFIC MANAGEMENT ADVISOR (TMA), DA, AND FINAL APPROACH SPACING TOOL (FAST); MVSRF-727, LINE PILOTS</td>
</tr>
<tr>
<td>JULY 1989 (3 WEEKS)</td>
<td>6, ACTIVE OAKLAND CENTER 2, RETIRED BAY TRACON</td>
<td>TIME CONTROL MODE; INTEGRATION OF 4D EQU. AIRCRAFT; TMA + DA + FAST; TSRV-737, LINE PILOTS</td>
</tr>
<tr>
<td>JAN - JUNE 1990?</td>
<td>ACTIVE CENTER AND TRACON CONTROLLERS</td>
<td>SHADOW CONTROL OF LIVE DENVER ARRIVAL TRAFFIC</td>
</tr>
</tbody>
</table>
EFFECTIVENESS OF DESCENT ADVISORIES
COMPOSITE TRAJECTORIES FROM ATC SIMULATION OF DENVER AREA

• ALL ARRIVALS INITIALLY SCHEDULED CONFLICT-FREE TO TOUCHDOWN AT TOP OF DESCENT
• TRAFFIC LOAD AT RUNWAY CAPACITY

WITHOUT ADVISORIES

WITH ADVISORIES

CONCLUDING REMARKS

• PRIMARY BASIS FOR AUTOMATION TOOLS IS AN ACCURATE AND VERSATILE TECHNIQUE FOR PREDICTING TRAJECTORIES AT LEAST 30 MINUTES INTO THE FUTURE

• ACCURATE PREDICTION TECHNIQUE IS ESSENTIAL FOR EFFECTIVE PLANNING AND CONTROL

• COMPUTER GENERATED PLANS AND ADVISORIES SHOULD NOT BE INCOMPATIBLE WITH ACCEPTED CONTROLLER TECHNIQUES.

• TOOLS FOR ESSENTIAL CONTROLLER NEEDS TAKE PRECEDENCE OVER TOOLS FOR FLOW OPTIMIZATION.

• AFTER MEETING ESSENTIAL NEEDS, TOOLS SHOULD HELP MINIMIZE DELAYS AND FUEL CONSUMPTION.

• WELL DESIGNED TOOLS OFFER INTELLIGENT ADVISORIES UNDER ABNORMAL AS WELL AS NORMAL SITUATIONS.
CONCLUDING REMARKS
(continued)

• DESIGN OF GRAPHICAL AND OTHER INTERFACES POSES THE MOST DIFFICULT DESIGN CHALLENGE.

• TO BE EFFECTIVE TOOLS MUST BE CUSTOM-DESIGNED FOR EACH TYPE OF CONTROL POSITION.

• ADVISORY TOOLS ARE A NECESSARY TRANSITIONAL STEP TOWARD A FUTURE AUTOMATED ATC SYSTEM.