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
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
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
SCHEDULING HORIZON -45 min TO TOUCH DOWN

SCHEDULING WINDOW

TRACON BOUNDARY & RESCHEDULING HORIZON -15 min TO TOUCH DOWN

N.W. ARRIVALS AREA

N.E. ARRIVALS AREA

DRAKO

KEANN

S.W. ARRIVALS AREA

S.E. ARRIVALS AREA

BYSON

KIOWA

TRACON RESCHEDULING REGION

FREEZE HORIZON -35 min TO TOUCH DOWN

TRACTION FREEZE HORIZON -10 min TO TOUCH DOWN

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Screen photograph of Traffic Management Advisor display.
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
SIMULATION EVALUATIONS

<table>
<thead>
<tr>
<th>EVALUATION DATE</th>
<th>CONTROLLER SUBJECTS</th>
<th>TEST CHARACTERISTICS</th>
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<tbody>
<tr>
<td>MAY 1988 (3 WEEKS)</td>
<td>9, RETIRED OAKLAND CENTER</td>
<td>INTRAIL SPACING MODE MVSRF-727, LINE PILOTS</td>
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<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 EQUI. 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>
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</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

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.