The Benefits of Artificial Intelligence Technology to the Airline Industry

PIEDMONT AIRLINES · PAN AM · CONTINENTAL · USAIR

AI Solutions for Passenger and Freight Carriers Can Save Significant Money and Improve Quality Service

Air Carrier Applications*

- Maintenance
  - Diagnostic/repair procedures
  - Scheduling
- Operations Exception Scheduling
  - Modification of flight schedules and flights
  - Based on delays, cancellations, transferring passengers, etc.
- Marketing
  - Travel agency systems
  - Leisure travel systems
  - Home computer systems
- Training
- Telecom Network Control

* *Under discussion, proposal or execution*

Air Carrier Applications*

- **Fare Management**
  - Computing optimal fares for a given market
- **Yield Management**
  - Computing mix of fares on a given flight
- **Gate Management**
  - Gate scheduling, assignment, and reassignment

* *Under discussion, proposal or execution*

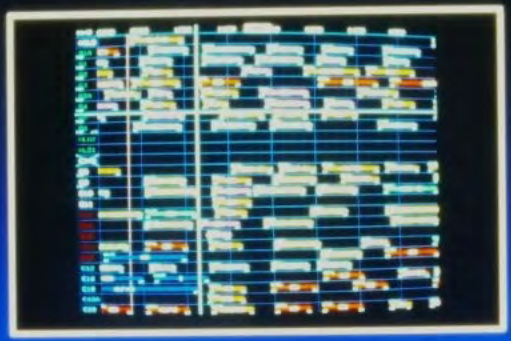
Air Carrier Applications*

- **Load Management**
  - Managing weights, freight, and baggage handling
- **Crew Management**
  - Assignment and scheduling of crews
  - Based on senority, other people factors, as well as home cities, flights, training, seat/plane movement, etc.
  - Re-scheduling of crews
  - Based on illegalities, missed and cancelled flights, etc.
- **Fuel Management**
  - Computing optimal fuel on long-haul flights with current weather data modifying results

* *Under discussion, proposal or execution*

Gate Assignment Display System

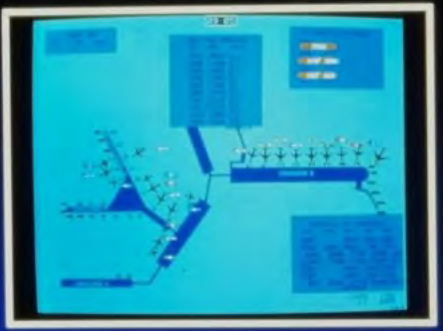
Computerized Gate Board



Many New Features Not Found on Manual Gateboard

Gate Assignment Display System

New Airport Aerial View Capability

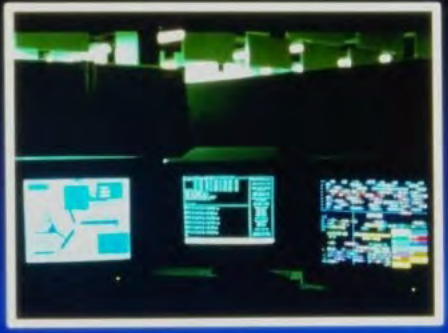


Show Physical Usage of Gates at Any Time
Present or Future

Gate Assignment at United Airlines

A Two Decade Leap in Technology

Old Manual Gateboard



New GADS System


0000
0500
1000
1100
E1A
E1
E2
E8A
E3
E4
E8
E9
E7
E5
G10
F1
F1A
B1A
B1
B2
B3
B3A
B4
B5
B6
HLD2
HLD1
HOLD
CHK
B9
B10
B11
B12
B14
B15
B16
B17
C12
C16
C18
C18A
C20
C22
C24
C26
C28
C30
C31
C29

The AI Approach

Why is AI the Only Solution to Airline Irregular Operations?

- O.R. Techniques Only Provide Batch Solutions
- Frequent Changes Cannot Be Handled By Conventional Solutions
- Rapid-Prototyping is Required to Develop Better Solutions
- AI Workstations Provide Better User Interfaces For High-Stress, Real-Time Environments

Other AI Solutions

Many Airport Ground Operations Can Benefit From An AI Solution

- Arrival to Departure Management
  - Food services
  - Fueling
  - Baggage handling

Other AI Solutions

Many Airport Ground Operations Can Benefit From An AI Solution

- Connection Delay Management
  - Revenue-based decision tools vs. numerical-based

Other AI Solutions

Many Airport Ground Operations Can Benefit From An AI Solution

- Gate Management
  - More effective use of gates
  - Scheduling with connecting information
  - Reduce ground turn around time

Benefits of AI Solutions

AI Solutions Allow More Effective:

- **Management**
- **Scheduling of Expensive Resources**

Benefits of AI Solutions

Airlines Number One Concern
Maintenance and Weather Delays

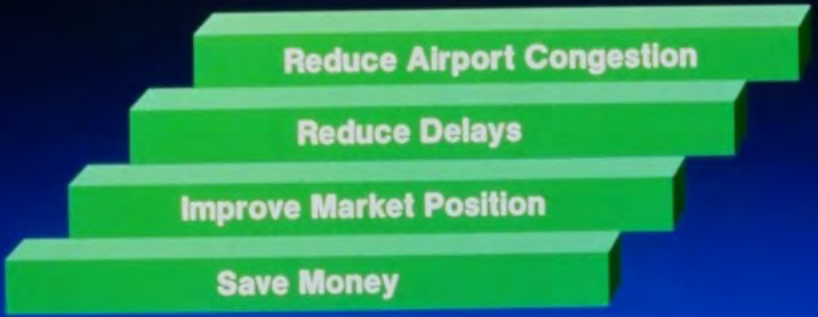
Impact on Operations

- Requires More Slack Time in System
- Requires Extra Crews and Planes

AI Solutions : Allow Efficient Rescheduling
Impact : Postpone Equipment Purchase
Savings : $500,000/Month/Each Deferred Purchase

Benefits of AI Solutions

How Will Applying AI Help You?



Application of Artificial Intelligence

Problem	Approach
• Capturing of Expert Knowledge	• Expert Systems - Rules
• Complex Set of Options/ Configurations	• Knowledge Based System - Structure/Inheritance
• Resource Planning/ Scheduling/Simulation	• Knowledge Based System - Semantic Network
• Text Interpretation/ Data Base User Query	• Natural Language Interface
• Poor Definition/No Spec	• Rapid Prototyping

The AI Approach

Are Airline Irregular Operations too Big to Tackle?

- Division into Smaller Problem Areas
  - Crews
  - Equipment
  - Weather
  - Maintenance
  - Ground operations
- 3 Stages to AI Solution
  - Prototype
  - Manage critical resources
  - Re-schedule critical resources

The AI Approach

Are Airline Irregular Operations too Big to Tackle?

It Appears to Be One Large Problem.

AI Can Serially or in Parallel
Solve and Deliver Solutions to
Each of the Dozen Sub-Problems

Applying AI To Operations

The "Symbolic Spreadsheet™" A New Concept with Broad Impact!

- Based on "Semantic Networks" and "Object-Oriented Programming"
- Applies To Situations with Many "Independent" Dynamic Factors That Are Ever-Changing
  - Airplanes
  - Crews
  - Airports
  - Gates
- "Symbolic Spreadsheet™" is a Natural Expansion of Concepts Originated in Financial Spreadsheet
- A Frame and Programs Replace Each Cell
- Many New Relationships Replace Simple "Row and Column" Relationships

"What-If" Capability for Everything!

Planning/Scheduling/Simulation

Decision Support

Algorithmic Relationships

	KES	Sales	Income
1965	10	100	50
1970	60	280	100
1975	150	350	150
1980	200	800	300
1985	250	1,200	650
1990			

Symbolic Relationships

A New Capability The Symbolic Spreadsheet™

The AI Approach

Why is AI the Best Solution to Airline Maintenance and Scheduling?

- O.R. Techniques Designed for Optimal Solutions From Static Constraints
- Knowledge-Based Techniques Provide Dynamic Constraint Handling
- Frequent Changes Cannot Be Handled By Conventional Solutions
- Rapid-Prototyping is Required to Develop Better Solutions
- AI Workstations Provide Better User Interfaces For High-Stress, Real-Time Environments

Irregular Operations Dynamic Scheduler

Action Menu and Log Display

- Logs Arrivals/Departures from Network
- Shows All Scheduling Changes
- Allows User to Get More Information
- Drives Interaction With Graphics Displays

The Symbolic Spreadsheet™

Irregular Operations Dynamic Scheduler

Flight Map Status & Planning Display

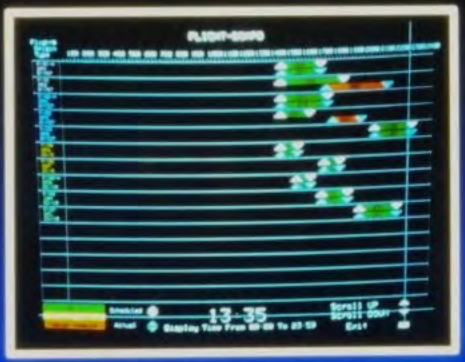
- Tied to Knowledge Base and Real-Time Data Network
- Current Status of Worst Flights in the System or in a Bank
- Planning and "What-if" Capability to See Down-Line Problem Impact
- All Graphics Interactive

The Symbolic Spreadsheet™

Irregular Operations Dynamic Scheduler

Flight Board Status and Planning Display

- Different View of Same Information as Flight Map
- Closer to Paper and Magnet Boards User Has Now
- Scroll to See All Flights and Any Times
- Planning and "What-If" Capability
- All Graphics Interactive



The Symbolic Spreadsheet™

Knowledge Based Software

Solutions For Airport Congestion

Gate Assignment Display System

Texas Instruments/United Airlines

"Gate Assignment is one of the most complex and demanding problems in airline operations"

Gate Assignment Display System

Problem Definition

- Deregulation Has Changed the U.S. Air Traffic System Enormously
- Competition Has Put an Emphasis on Efficiency of Operations
- Hub & Spoke Flight Scheduling Exceeds Today's Aircraft Capacities
- Delays for Aircraft Departures and Arrivals Cost Customer Loyalty

Gate Assignment Display System

Problem Definition

- Average Fuel Cost for Idling Aircraft is $30/minute
- Gate-related Delays Cost Approximately $100K/day in Fuel Charges Alone
- O'Hare Handles 400 Flights Per Day and Stapleton Handles 250
- Number of Gates at O'Hare and Stapleton Will Double in 1987
- Managing Gate Assignment is a High Stakes Game Done Manually

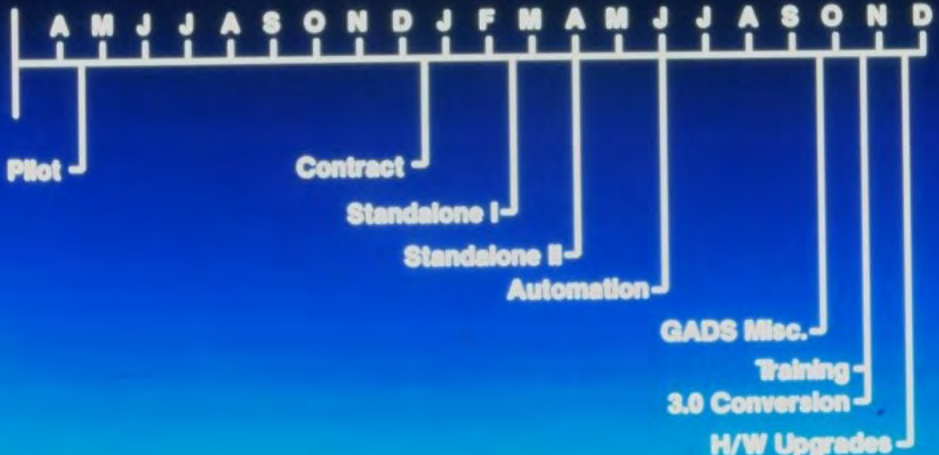
Gate Assignment Display System

Project Approach

- Automate Gate Operations at Major Hub Airports
- Use Artificial Intelligence Techniques to Rapidly Develop Solutions to Airport Problems
- Provide Basis for Expert Systems to Help Handle "Irregular Operations"

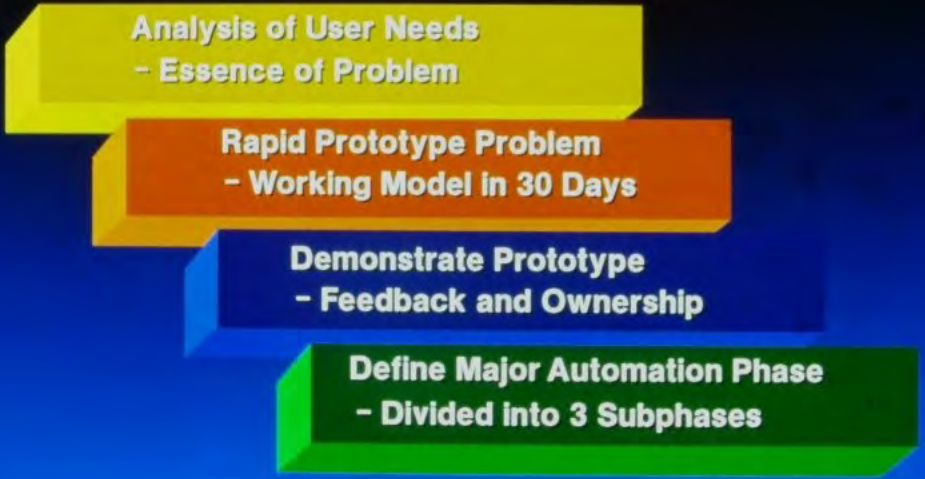
Gate Assignment Display System

Project History

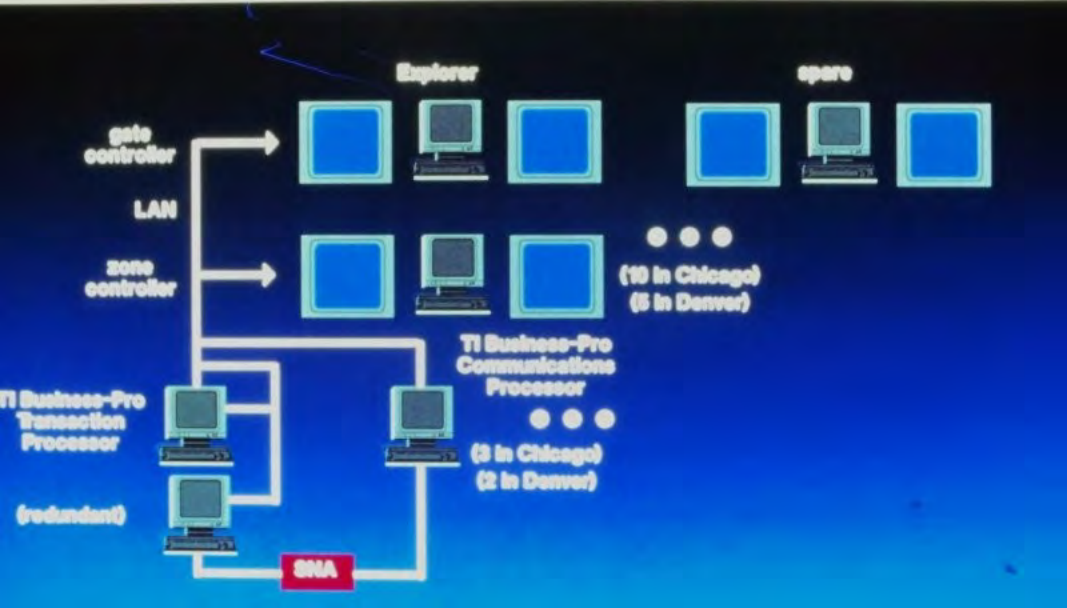


Gate Assignment Display System

Technical Approach



Gate Assignment Display System



Scheduling

Common Global Goals

- Meet Demand Due Date
- Maximize Flow
- Optimize Critical Resource
- Minimize Inventory or WIP

Intelligent Dynamic Scheduling System

New Capabilities

- Comprehends Concept of Time
- Deals With Dynamic Events
- Solution Via Structuring the Problem in a Knowledge Base
- Solution Tuned to Amount of Decision Time for Processing
- Use of Simulation to Understand Decision Consequences

Applying AI To Operations

The "Symbolic Spreadsheet™" A New Concept with Broad Impact!

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- Applies To Situations with Many "Independent" Dynamic Factors That Are Ever-Changing
  - Airplanes
  - Factories
  - National sales forces
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- Many New Relationships Replace Simple "Row and Column" Relationships

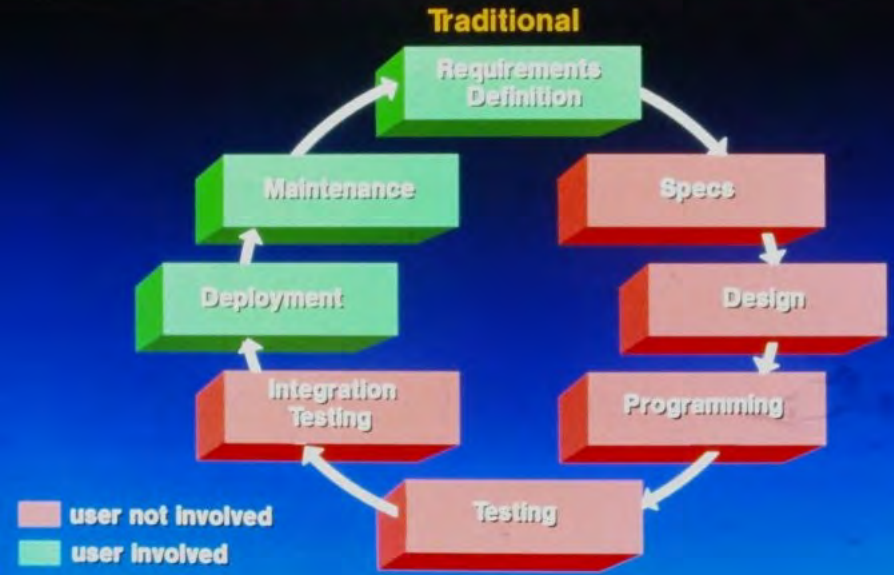
"What-If" Capability for Everything!

Common Requirements Associated With a Scheduling Request

- Planning
  - Used by a variety of people with differing time horizons
- Scheduling
  - Creation of the schedule itself
- Dispatching
  - Distributing the schedule to the implementors or equipment controllers
- Simulation
  - Useful for capacity planning, anticipation of future conditions, for dynamic scheduling "WHAT-IF" analysis
- Information Collection/Distribution
  - MIS DATA BASE Linkage, Network Attachment, Floor Control Systems

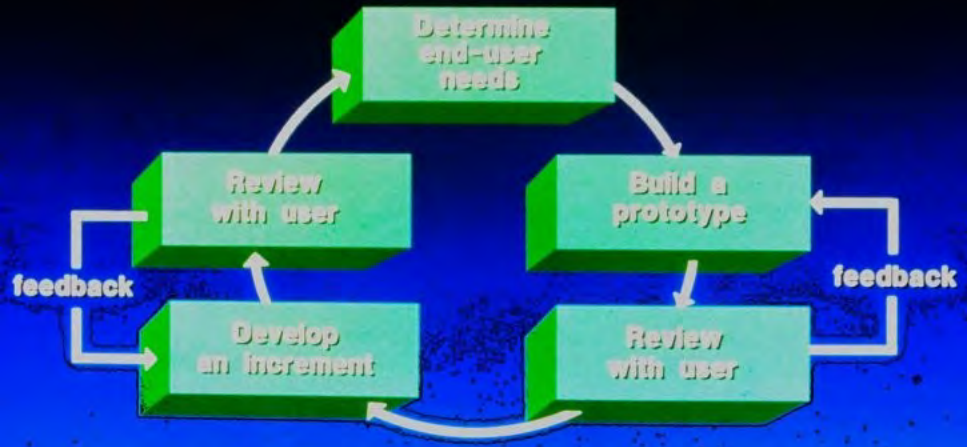
Major Categories Within Schedulers

Software Development Cycle



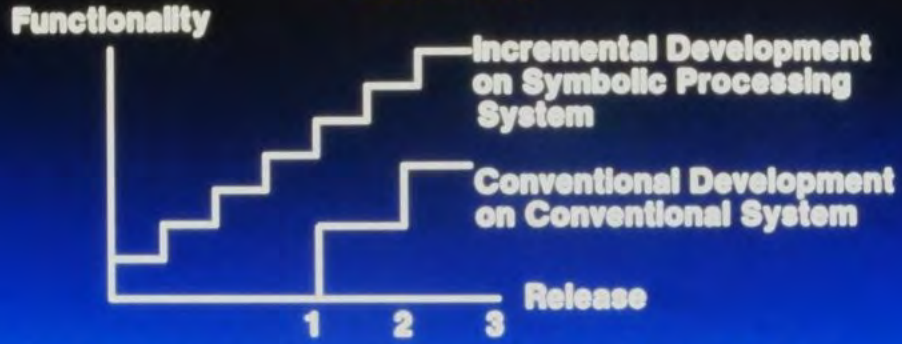
Software Development Cycle

Rapid Prototyping



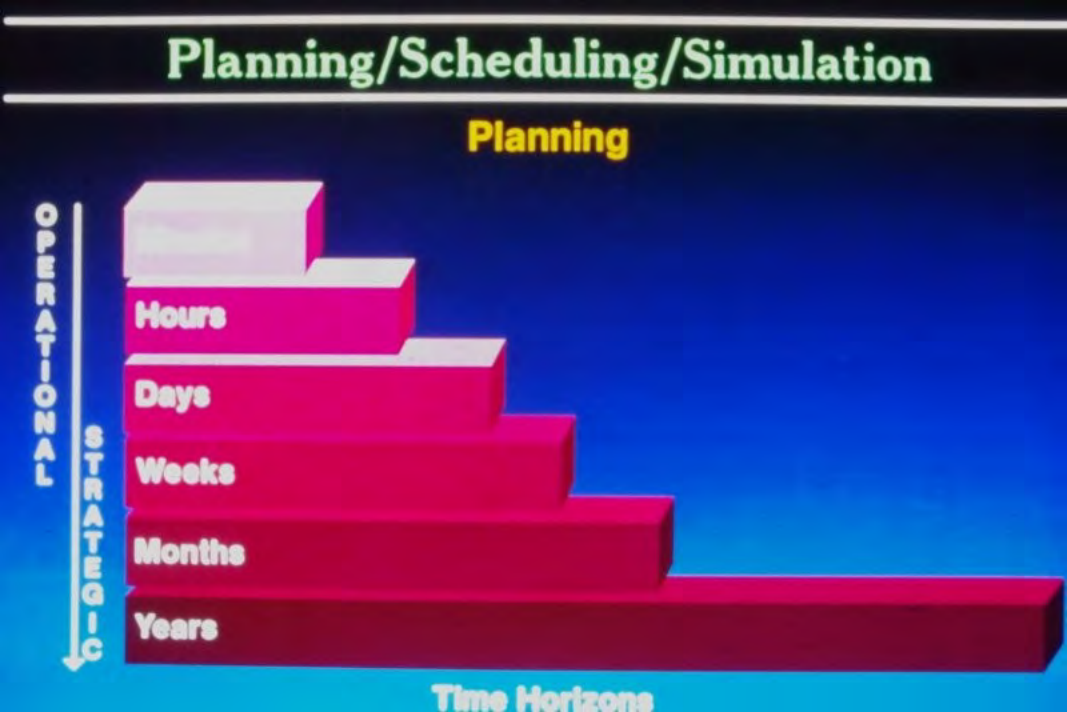
Rapid Prototyping and Incremental Development

Summary



- Development in Reviewed Increments Achieves Higher Functionality Solution in Less Time Than Conventional Development
- Symbolic Processing System Contributes Initial Building Blocks

Planning/Scheduling/Simulation



Symbolic Spreadsheet™

What Is in this Toolkit?

- TI Has Experimented and Developed Scheduling Systems for More Than 5 Years
- We Have Spent Well Over 50 Manyears on Various Scheduling Projects
  - FRESH
  - Semiconductor MFG.
  - Trinity Mills
  - Multiple TI assembly lines
  - Customer manufacturing schedulers
  - Airline schedulers

Symbolic Spreadsheet™

What Is in this Toolkit?(cont.)

- We Have Extracted the Best Techiques from A Proven Set of Methodologies to Incorporate in the Symbolic Spreadsheet™
- Continued Commitment to Product Enhancement
- Contains Manyears of Extensions Over Standard Knowledge Base Shells to Provide:
  - Real time system integration
  - Decision support
  - Application-specific user interfaces
  - Multiple workstation KB orientation

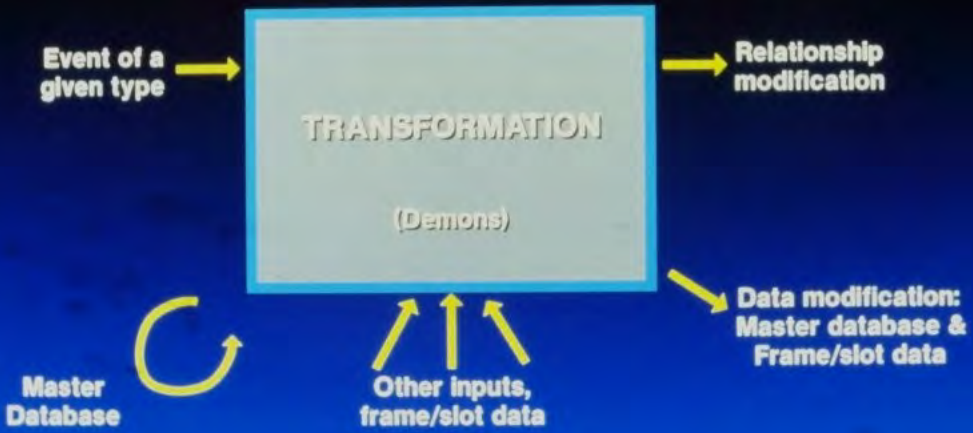
Symbolic Spreadsheet™

How & Why Does It Work?

- Uses Semantic Network to Represent and Interrelate Entities
- Uses Object Oriented Programming to Depict Behavior of Entities
- Uses Event-driven Demon Methodology to Update Data & Trigger "Down-line Effects"
- Uses Object-oriented Graphics for User Interface
- Uses Hypothetical Knowledge Bases for What-iffing, with a Fixed Past and Multiple Futures
- Uses Prioritized Criteria-based or Weight-based Best-fit Repair Algorithms for Re-scheduling
- Uses Simple Rule Mechanism to Allow User Editting of Re-scheduling Strategies

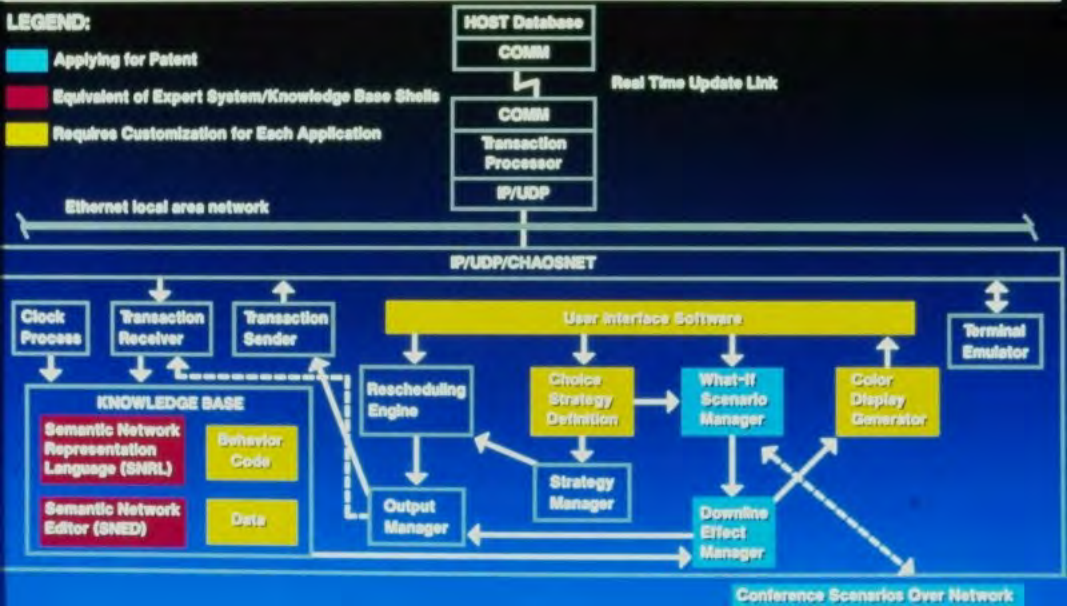
Symbolic Spreadsheet™ Architecture

What Is a Behavior?



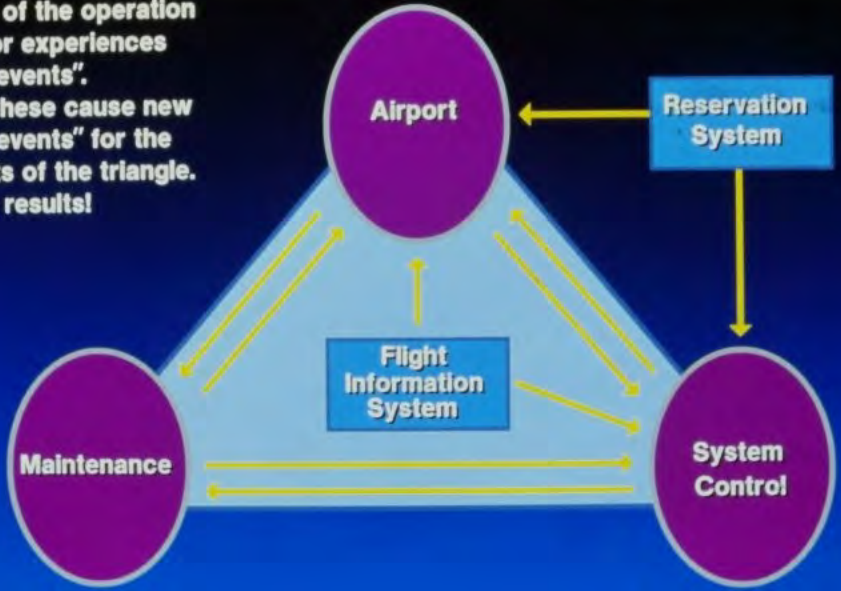
Behaviors Drive All Strategy and Activity

Symbolic Spreadsheet™ Architecture Direction



The Airline Operations Problem

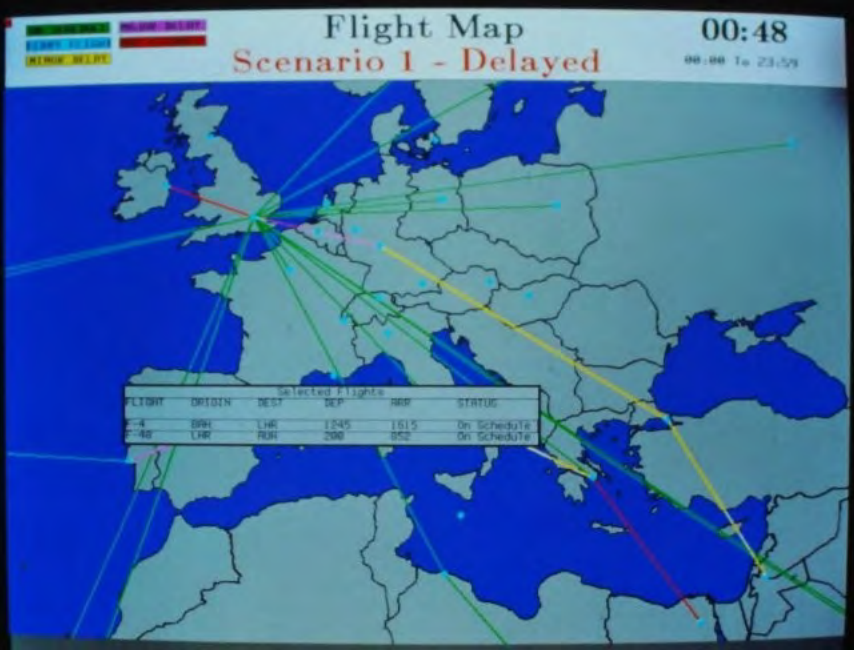
Each part of the operation receives or experiences "problem events". Handling these cause new "problem events" for the other parts of the triangle. Feedback results!




Aircraft Routing
00:26
00:00 To 23:59
Scroll UP


Flight Map
00:37
00:00 To 23:59


Flight Map
Scenario 1 - Delayed
00:47
00:00 To 23:59
Selected Flights
FLIGHT ORIGIN DEST DEP ARR STATUS
-188 BKK SIN 1122 1356 Major Delay
-99 SIN BKK 0945 1103 Major Delay
-56 SIN BKK 1034 2112 On Schedule
-105 SIN BKK 0800 1403 On Schedule


Flight Map
Scenario 1 - Delayed
00:48
00:00 To 23:59
Selected Flights
FLIGHT ORIGIN DEST DEP ARR STATUS
F-4 BAH LHR 1245 1515 On Schedule
F-48 LHR AUH 200 852 On Schedule


Flight Map
Texas Instruments

Knowledge Technologies:™

TI helps United Airlines use artificial intelligence to make more on-time flights a reality.

"Providing the best customer service is the first order of business for United today. Texas Instruments helped us reach this goal through strategic applications of AI — an approach that's working at O'Hare for United Airlines."
— John Zerman, UAL Executive Vice President of Marketing and Planning.

You're inside United Airlines new "Terminal of Tomorrow" at Chicago's O'Hare Airport. Daily, 400 flights carrying 40,000 passengers leave here. It's the world's largest airline boarding operation. And thanks in part to Texas Instruments technology, it's also one of the smartest.

United's new Gate Assignment Display System masterminds the flow of aircraft to and from their 52 gates. The system is also up and running at Denver's Stapleton Airport. It was developed by TI knowledge engineers and United's system engineers working side by side with United's ground operations experts. The system uses artificial intelligence to capture these experts' knowledge onto its program. It also connects to United's central computer, so it knows which planes are at which gates and what flights are scheduled later.

With all this information at their fingertips, United's controllers make faster and better gate assignment and ground service decisions. The result: more on-time flights for United Airlines passengers.

By giving controllers an up-to-the-minute view of all gates, United's new Gate Assignment Display System provides United Airlines an immediate payback in improved customer service.

Get the best of AI from TI.
Artificial intelligence is a powerful tool for making your people more productive and your company more competitive. And no one in the world puts AI to work more extensively than Texas Instruments. We're doing this through a top-priority, companywide program called Knowledge Technologies. These are real products, programs, people and tools that help you capitalize on the vast potential of AI.

TI and this United Airlines team cut system development time nearly in half by using artificial intelligence.

We can start by working with you to identify which of your company's projects would benefit most from AI. Our range of solutions spans every level of investment and need. At one end, we can help you plan and implement entire corporatewide AI strategies. These plans often include TI's Explorer™ II, computers, the most powerful AI workstations in the world. At the other end, we help businesses develop their own expert systems using inexpensive TI software on industry-standard PCs.

Whether your needs are large or small, the important thing is to get started on your AI initiative right away. And you can start very easily by phoning Texas Instruments, today. Call toll-free, 1-800-527-3500. Or write to: Office of the President, Texas Instruments Incorporated, Data Systems Group, MS 2068, P.O. Box 2909, Austin, Texas 78769.

TEXAS INSTRUMENTS

Gate Assignment Expert System Reduces Delays at United's Hubs

CAROLE A. SHIFRIN/DALLAS

United Airlines is using Texas Instruments-developed artificial intelligence technology in a new gate management system that is helping reduce travel delays at Chicago O'Hare and Denver Stapleton Airport, officials of United and Texas Instruments said.

The new system, called Gate Assignment Display System (GADS), is designed to increase the effectiveness of United's gate controllers in assigning aircraft to gates in an attempt to reduce flight delays related to ground operations. Gate management is one of several areas in which officials of Texas Instruments' Data Systems Group believe their artificial intelligence technology can be used by air carriers in solving operational and scheduling problems (AWAST Oct. 19, 1987, p. 43).

United's system uses an artificial intelligence program that was created by drawing on the experience and knowledge of United's systems analysts and gate controllers through the process of knowledge engineering transfer. The program, or knowledge-based system, is driven by Texas Instruments Explorer symbolic processing workstations, which are designed for working problems that cannot be solved efficiently with traditional computing techniques. GADS uses companion Explorer Tech displays for high-resolution, multiple-color graphic representations.

GADS also receives up-to-date information directly from United's Unimatic flight information data system, a computerized system that tracks every United flight, holding all the routing and flight information.

GADS was implemented fully in August at both Chicago O'Hare, where United operates 804 daily departures and arrivals using 50 gates, and Denver Stapleton, where United operates 380 daily departures and arrivals from 27 gates.

"It has provided immediate payback in efficiency of gate assignment and aircraft zone control," Mark S. Teflian, United's vice president of technical planning and systems engineering, said. GADS also is providing first-hand experience with a technology that has the potential to improve other hub-management operations, he said.

Gate assignment at the two airports previously was handled by United personnel, who used a wall-sized scheduling board full of magnetic symbols to depict arrivals and departures. The board was used first to depict the plan for the day, with flights assigned to certain gates. Throughout the day, however, as information became available on weather problems, flight delays or mechanical problems, a gate controller would move the magnetic pieces to different places on the board to reflect changes in flights and gate assignments.

United Airlines employee assigns aircraft to gates at O'Hare International Airport using a Texas Instruments Explorer workstation and an accompanying Boxtar Tech display. A second display is used for high-resolution graphic representations of the Gate Assignment Display System.

At O'Hare, the board was located in the center of a room, so that it was visible to all who needed to see it: the gate controller, who assigns all flights in and out of the gates; a back-up gate controller, and 10 zone controllers, who are assigned five gates each. For their assigned gates, the zone controllers are responsible for every aspect of getting an aircraft into the air—making sure that the aircraft has fuel, that required maintenance is done; that the flight crew is there; the aircraft is clean; the food and baggage are loaded, and passengers are boarded.

> *Texas Instruments believes artificial intelligence can help airline operational and scheduling problems*

Under the old procedure, the gate controller would gather information on flight status from Unimatic—available on a screen and by printout—and then apply it to the board, so that the zone controllers would know current data. "It was a physical and mental process," Janet Wejman, United's project manager for GADS, said.

When gate controllers assigned new gates—as weather and other factors affected the flight schedule—they had to rely largely on their memory and knowledge for many details about flights and gates, such as which gates could accommodate which types of aircraft, and which flights have large numbers of passengers connecting to other flights, Wejman said. "Most of the information was in the mind of the gate controller, who would remember, as an example, that Gate F-10 can't handle a DC-10," she said.

United officials realized they were developing a few people whose expertise was in their head, rather than in a system that could be used by new controllers coming on line, she said. In addition, the gate controllers had to move around a room to do their jobs, which is not considered efficient in a systems world, she added.

GADS has eliminated totally the gate board, and consequently the need to move around the room. It also has incorporated the knowledge of the experts. The information that was shown on the board is now produced by GADS in a similar display on computer monitors.

The new system, however, allows display of more current information and a greater variety of flight status information than was available with the old board. For instance, the gate board's magnetic pieces that represented flights were all the same size. Now a bar is longer or shorter depending on the time the flight is at a gate, Wejman explained. Also, the color of a bar denotes the type of aircraft.

GADS displays more current information and a greater variety of flight status information than the previous system

The display also shows the nose number of an aircraft, whether flights are terminating, travelling through or turning around, and whether the aircraft becomes another flight. In addition, a controller can use a mouse to call up additional information on a flight by putting the cursor on the bar/flight; the desired data pops up in a window.

GADS also provides up-to-date aerial views of all gates, showing the location of aircraft and status information on each flight. The different aircraft are identifiable by their outlines and engine arrangements. A controller can see all United gates in one view or can show different sections of a concourse and enlarge a portion. A Seiko color copier is attached to the system to provide a paper copy of what happened during the day.

In the new system, Unimatic feeds flight information directly into GADS, and the gate controllers, in turn, can update this information as the gate assignment plan is changed. At present, the controller must update Unimatic, but the process will be made automatic.

GADS also handles much of the routine mechanics of gate assignment, freeing the controllers to concentrate on more difficult problems that may crop up. Under current procedures, a gate plan is established monthly and downloaded to GADS as a starting place. If United has a perfect day at O'Hare, according to Wejman, the plan in GADS would go according to schedule. As there are problems, however, the plan has to be adjusted. When an aircraft is delayed, the updated information contained in Unimatic goes directly to GADS, which then updates the gate plan automatically, utilizing a rule-based system.

For example, if an aircraft is coming in an hour late from Hong Kong because of bad weather and another aircraft already is using the gate to which the Hong Kong flight would have been assigned, GADS would act on information gleaned from Unimatic and automatically reassign the Hong Kong flight to another appropriate gate and make necessary follow-on changes.

A gate controller also has the option to make changes in the gate plan GADS comes up with by taking a mouse and moving an aircraft from one gate to another.

In some cases, a gate controller might want to alter the gate plan before new information comes to GADS through Unimatic. If the gate controller gets information that could affect the gate plan before Unimatic does, Wejman said, for instance, if he learns from a mechanic that an aircraft has a flat tire that will take an hour to fix, or if officials decide to delay a flight to wait for connections, the controller can determine the gate plan by using the mouse to reassign flights to different gates.

One display available to gate assignment personnel using United's Gate Assignment Display System is an overhead view of one of United's terminals, including a graphic depiction of various types of aircraft at the gates and information about which ones are about to depart.

PROBLEM SOLVER

The system also permits the controller to try out different aircraft-gate combinations in dealing with problems that might come up before setting in motion a changed gate plan. As the controller uses the mouse to move a flight from one gate to another, GADS will readjust the gate plan automatically so the controller can see the effects of any action.

"The gate controller now has the ability to play 'what if?' games," Wejman said. "In the past, we dealt with moment-by-moment changes; we didn't see how something would affect us five hours down line.

"With GADS, we can avoid problems and conflicts before they happen."

When the controller uses the mouse to make a change in gate assignment, GADS automatically will check each change with its list of rules to make sure it can be done, for instance, that the gate will accommodate the aircraft type in question. If the controller moves a DC-10 to a 747 gate, the computer will tell the controller it cannot be done. "We've made the machine 'expert,'" Wejman said, "and a less-experienced gate controller can perform as efficiently as someone who has been there many many years."

United and Texas Instruments developed GADS using an artificial intelligence technique called knowledge-based rapid prototyping, in which portions of the system were designed and built and then shown to the users for their comments and suggestions. "This system has been the most favorably accepted of any I've ever built," Wejman said. "The controllers feel this has enhanced their job greatly. The information gathering has improved; they don't have to hold all the information in their heads, and they can start planning ahead."

The GADS system at O'Hare uses seven Explorer workstations, with one each for the gate controller and backup gate controller, and five Explorers shared by the 10 zone controllers. Each zone controller has his or her own raster screen, and each of the gate controllers has two rasters because of the overall number of gates. ☐

Air Transport World

AIRLINE AUTOMATION REPORT

Artificial intelligence invades airline operations

Knowledge-based and expert systems promise to produce a big impact on profits by improving operational efficiency. *By Danna K. Henderson.*

To those whose world revolves around operation of airlines rather than distribution of the airline product, CRS globalization and the personal computer invasion of the travel agency community are yesterday's news.

Today's technology is artificial intelligence, and its impact on future airline operations and profits may be at least as great as that of the CRS. Commonly known as AI, the new technology is the province of "knowledge engineers" and the products they are producing are called "knowledge-based" and "expert" systems.

The current leader among suppliers in putting AI to work for airlines is the Data Systems Group of Texas Instruments (TI), which developed the first full-scale knowledge-based system to become operational in the airline industry: United's Gate Assignment Display System (GADS) now in use at Chicago O'Hare and Denver Stapleton.

"Five years from now, the knowledge-based real-time decision-support system will be as ubiquitous as the CRS is today," predicts Mike Irrgang, manager-airline systems for TI's Advanced Systems Division. "By the early 1990s airlines are all going to be relying on AI-based decision support to improve their asset and people utilization and as a key part of their profit calculations." TI thinks dramatic savings are possible through AI—estimating, for example, that operating efficiency "can be increased by a minimum of ten percent through better delay management."

GADS and a similar product developed by Texas Air Corp.'s System One and Ascent Technology, called Gatekeeper, are the crest of a wave that will be breaking across the airline shores in 1989. TI expects to have several knowledge-based heavy maintenance systems and a delay management system in place by the middle of next year. A number of airlines in the U.S. and Europe are developing AI systems as well, with yield management, fuel management, and planning systems nearing implementation. Other areas that can benefit from AI, says TI, are crew allocation, route planning and scheduling, training and marketing.

Different systems

Irrgang explains the differences among conventional, knowledge-based and expert systems this way:

The conventional computer system "stores data and allows the user to access and manipulate that data." A CRS, for example, contains information on flight schedules and fares, and a travel agent calls up that information in various forms and revises it by booking a seat. On the operational side, the computer comes up with an ideal schedule or plan, but daily realities like weather or mechanical problems disrupt that plan and force the operations staff to develop "patches" manually. Unfortunately, says TI, these patches are made possible "only by building a certain amount of slack into the operation in the form of excess airplanes and crew ... a much less than perfect utilization of resources."

The expert system, says Irrgang, "takes the expertise of a particular person or persons and puts it in a can, and when you encounter a problem that expertise could deal with, the system helps you solve it." Efrain Zabala, president of the TWA Northwest Pars CRS, says such systems "contain a series of rules that are not necessarily hard and fast but that tell you, in effect, this is the best course of action under the circumstances that exist."

The knowledge-based system, says Irrgang, "is a more complex system in which you have data, access to that data, knowledge about that data, and on the basis of the data you can make decisions that the human expert couldn't necessarily make because the overall problem may be too complex." The knowledge-based system's "rapid prototyping" capability allows the user to simulate several possible scenarios in seconds and choose the one that best solves the problem at hand. And one of its big benefits is that it is designed to "grow" with use as new knowledge is added to it.

As an example of a knowledge-based system, Irrgang describes a product under development by TI for dealing with what airlines call "irregular operations"—a euphemism for delays. Using a TI innovation called a Symbolic Spreadsheet connected to a typical airline flight operations system, "you can see interactively what the propagation of the effects of the problem and the decisions you make will be. If, for instance, you know you have an equipment failure in Des Moines and it's going to take three hours to fix it, the system might tell you that failure is going to cause a crew to run out of time in Los Angeles four hours from now. You can then work your way through a series of 'what if' rescheduling decisions until you find the one that will cause the fewest problems to the rest of your airline."

The Symbolic Spreadsheet uses traditional spreadsheet cells to represent real world elements like airplanes, crews and airports. The cells can be linked together through descriptions of their specific relationships to create a complex, real-time model of an airline's operations. As changes are made to the various cells, the model shows dynamically the downstream effects of those changes.

These principles are used in United's GADS and System One's Gatekeeper, which were created by drawing on the knowledge of gate controllers and systems analysts. At United, a huge magnetic board that was used to keep track of arrivals, departures and gate assignments has been replaced by TI Explorer workstations tied to the carrier's Unisys Unimatic flight information data system, which tracks all United flights. Gate controllers can call up a variety of displays, such as a view of all gates that shows the location of aircraft and the status of each. When a problem crops up, such as a mechanical delay, the controller can test the effects of adjusting gate assignments. GADS automatically checks the changes against a list of rules and prevents, for example, assignment of a widebody to a narrowbody gate.

AI for maintenance

Another area that lends itself to knowledge-based systems, says Irrgang, is heavy maintenance. "In a D check, although many of the tasks are routine, you don't actually know what you're going to have to repair until you disassemble the aircraft and see what's wrong," he explains. "The knowledge-based system allows you to develop an efficient work schedule based on what the mechanics team as they open up the airplane."

In light maintenance, the less sophisticated expert systems can help technicians diagnose problems and guide them through repairs. In its work on these systems, says Irrgang, TI has found that "you have the same mean time to repair but you significantly increase the mean time between failures because you are more likely to pin down a problem that isn't clearly defined and fix it on the first try."

Knowledge-based systems for delay management, heavy maintenance or ground operations scheduling are most suitable for airlines with more than 40 airplanes, says Irrgang. They typically cost

Under development by TI is a Symbolic Spreadsheet used for dealing with flight delays. "You can see interactively what the propagation of the effects of the problem and the decisions you make will be. . . . You can then work your way through a series of 'what if' rescheduling decisions until you find the one that will cause the fewest problems to the rest of your airline."

$1 million to $4 million plus hardware, "but they can give you a one-year payback and then continue to save you millions of dollars a year."

He provides this typical benefit analysis for a heavy maintenance scheduling system: An airline has 100 aircraft, each undergoes a D check every four years, and the typical D check takes four weeks. The airline thus does 100 aircraft weeks of D checks a year, meaning it needs two extra aircraft in its fleet to compensate for downtime. If a knowledge-based system provides an improvement of 10% in downtime, the result is ten additional weeks of revenue flights. If the airline is sufficiently large, the savings can compute out to an aircraft it doesn't have to buy.

Cost benefit computations for a delay management system are more complex because they tend to be airline-specific, Irrgang says, "but it ends up giving you significantly better aircraft utilization."

TI is not, of course, the only supplier developing AI systems for the airline industry. In England, Ferranti Computer Systems recently showed a gate assignment system which is the first element of a much broader system it calls Airport Resource Planning and Management. That system, it says, is "designed to enable airport staff and management to optimize flight handling and manpower services" and was developed with the Inference Corp. ART advanced expert system.

CRS vendors also are working on AI applications but are not anxious to talk much about them yet for competitive reasons. At Pars, Zabala says that "one good application for an expert system is what we call messages that reject. The standard computer puts these messages in a queue and they're given to a human who tries to decipher them. The expert system could, for example, decide that the message has to do with seat assignment and then could look at possible ways of handling it.

"Or in a travel agency application you could provide a system that, when a customer comes in with a set of requirements for a tour, could look at the whole data base and come up with the five best options. We're exploring this area, but the big obstacle is creating the comprehensive data base that would be required."

At System One, President Richard Murray is "excited" about Gatekeeper, the first phase of which is in use at Continental's Houston Intercontinental hub and at Eastern's hub at Miami International. "We're trying to give our hub operations with a meaningful tool that models all the elements that come into play in trying to recover from a massive irregular operation," he says. Gatekeeper "suggests alternative courses of action" to those making on-the-spot decisions, and has been integrated into existing airline information systems "through connectivity software that does the job without disrupting or increasing the network traffic."

System One sees future applications for AI in such areas as catering and flight planning. It also is exploring the potential of expert systems in the maintenance area. "You could describe the symptoms of a reported aircraft malfunction and the system would give you a list of things to look at. Then you throw more information at it about the characteristics of the problem and it continues to refine or sort out among the possible causes, going through a process of elimination."

Murray expects System One to be selling expert systems in the future. "We think there's a very large market for them," he says. "Right now we're using Continental and Eastern as prototype locations, and as we progress through the various phases we will be ready to market the software."

Shown is a TI knowledge-based flight delay management system. TI thinks operating efficiency "can be increased by a minimum of 10% through better delay management."

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Summary

- Not Mainframe .vs. Workstations
- Learn from Manufacturers
  - Connectivity is Key
  - User Productivity is Key
- Lot of Operations Management Software already in Use
  - "Industrial Strength" Applications
  - Train has left the station

Summary

- User Demand is Real
  - Hardware is Available
  - Software is Available
- Workstation Cost/MIP makes Sense
- People Productivity
  - High $ and
  - Good Decisions make them Repeatable through
  - Knowledge Capture which in turn produces
  - Major Bottom Line Benefits