



ENGINEERING WORST DISASTERS– PART DEUX

DENVER INTERNATIONAL AIRPORT BAGGAGE SYSTEM

*Presentation to the Capital Area Chapter of the
Society for Information Management (SIM) – September 12, 2006*

Bernard Markowicz, Ph.D.



**decision/analysis
partners**

www.decisionanalysis.net

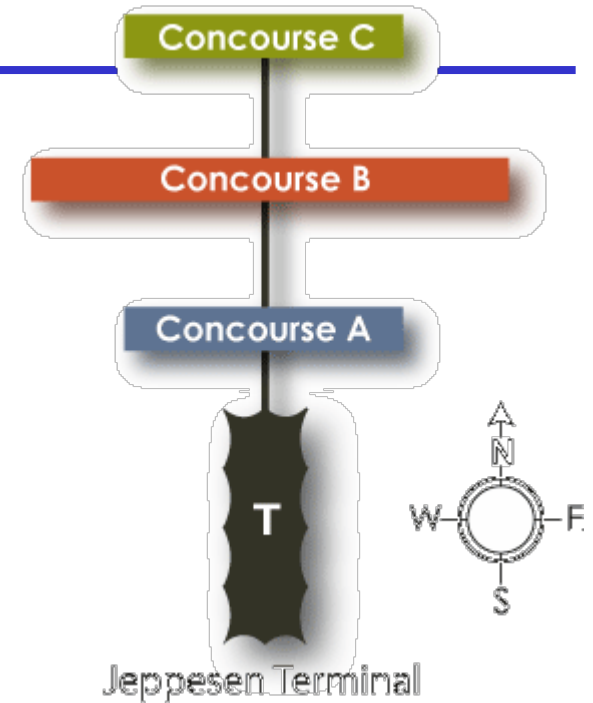
The Plan

- Stapleton was the U.S. fifth-busiest airport – DIA still is
- Federico Peña's dream (Mayor 83-91)
 - ◆ All weather airport
 - ◆ Non-stop service from Europe, South America and the Far East
 - ◆ One consultant foresaw fifty flights a week to Europe
 - ◆ 20 miles further from Denver than Stapleton
- By federal law, Stapleton was required to close the day that DIA opened
- The road to the airport is named "Peña Boulevard."
- Peña parlayed his airport experience into being appointed Secretary of Transportation...
- Wellington Webb, as the next mayor of Denver, inherited the Denver mess.
- DIA is the largest airport in the US by area
 - ◆ Voted best airport in North America by readers of *Business Traveler Magazine*.



The Plan

- Need for speed:
 - ◆ Traditional belts could not reach the end of Concourse B and C in time
 - ◆ This need for speed forced planners to look for alternate technologies
 - ◆ Boeing Airport Equipment (BAE) of Carrollton TX demonstrated this technology in a warehouse in Texas.
- An ambitious plan was conceived to use this...
 - ◆ Untested technology
 - ◆ On an untested scale
 - ◆ With unknown, undocumented requirements
 - ◆ ...and a hard deadline



The Technology

- Destination-Coded Vehicles (DCVs)
 - ◆ Fleet of 3,100 standard-size and 450 oversize
 - ◆ Linear Induction Motors (4.5 mph-19 mph)
 - ◆ RF Tags
 - ◆ Bumpers
- Tracks
 - ◆ 60 miles
 - ◆ Tunnel under the airport train known as the hell hole
 - ◆ Linear Induction Motors (4.5 mph-19 mph)
 - ◆ Timing belts
- Conveyor Belts
 - ◆ 56 laser scanners
 - ◆ Triggers DCV call & balancing logic
 - ◆ Lizard tongues
 - ◆ Power turn conveyors
 - ◆ Vertical lifts
- Control System
 - ◆ RF antennae to 44 computers
 - ◆ Raima Corp. Database on Netframes Systems
 - ◆ 300 486-class computers distributed in eight control rooms,
 - ◆ Square D programmable controllers
 - ◆ Electrical controls & cabinets
 - ◆ Fault tolerant NF250 server,
 - ◆ A high speed optic network,
 - ◆ 14 million feet of wiring,



The Technology



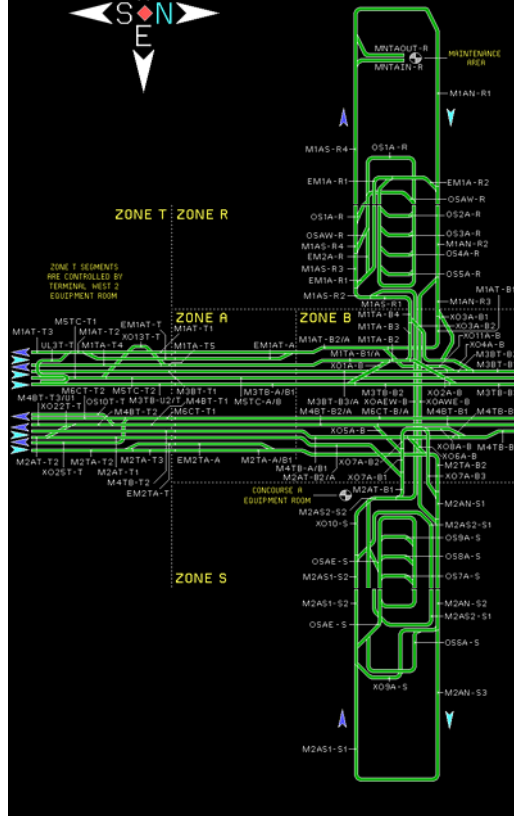
The Implementation...

- DIA scheduled to open **10/31/93**
- **March 2, 1993:** Denver Mayor Webb announces 7 weeks delay
- **March 1, 1994** Mayor Webb announces the 3rd airport opening delay to May 15 because of the baggage system
- **In April 1994**, the city invites reporters to observe the first test of the new baggage system.
- Mayor **Cancels** planned May 15 opening.

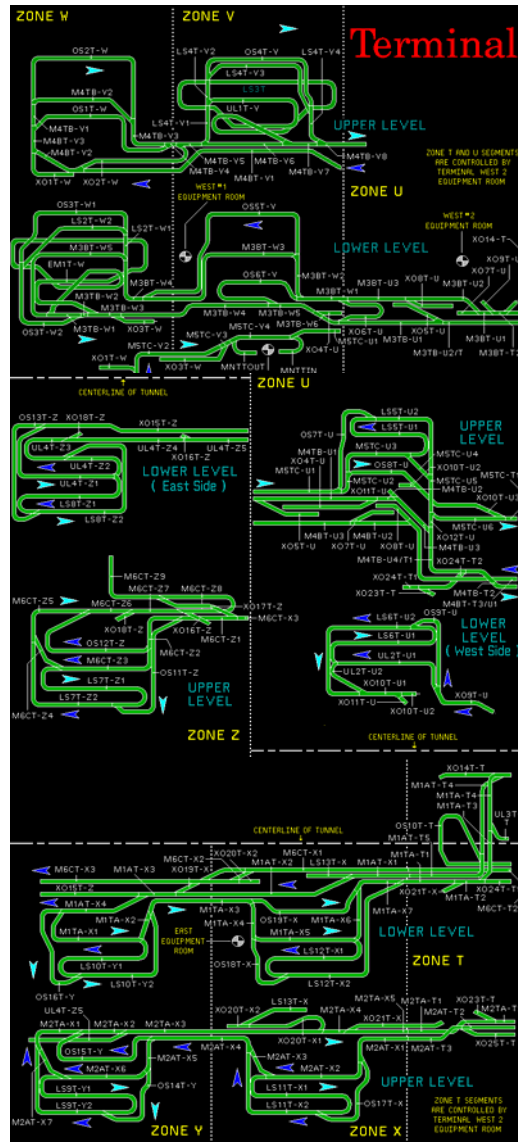


- **June 1994:** **Four** steps are required before opening:
 - ◆ including that BAE's baggage system must operate for an unspecified period of time at an acceptable level.
- **August 1994**
 - ◆ The city spends \$50 million to build an airport-wide tug and cart luggage system.
 - ◆ Webb announces port will open on February 28, 1995.
- **September 94:** United Airlines starts to work with BAE alone
- **January 23, 1995** at midnight, a huge convoy of trucks and carts moved from Stapleton to DUA
- **February 28, 1995**, Stapleton finally closed its gates
- **August 2005:** United abandons the system

Concourse A

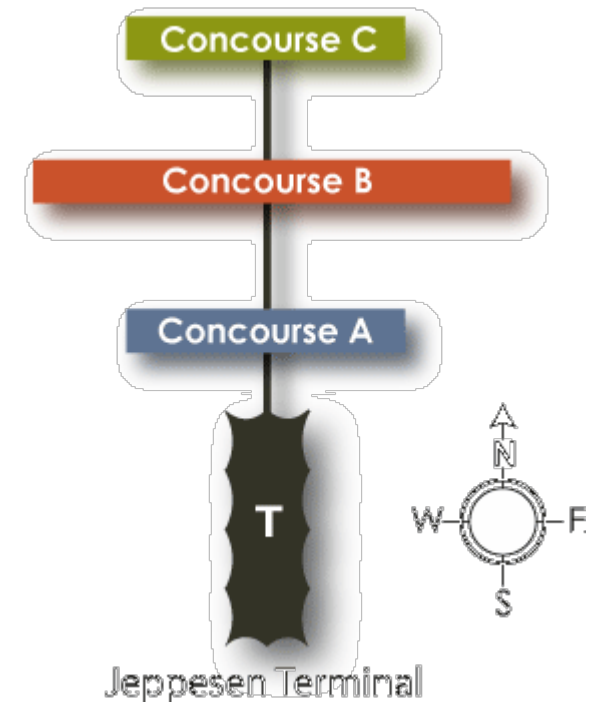


Legend	
■	Available
■	Unavailable - faulted condition
■	Unavailable - restarting cars
■	Unavailable - out of service



A 60-mile Railroad

- One fleet – One track – Shared capacity
 - ◆ 60-miles of track
 - ◆ 3100 standard DCVs
 - ◆ 450 oversize DCVs
- Line balancing
 - ◆ Outbound: Near random
 - ◆ Inbound: Batch
 - Lizard tongues
 - Proximity of Widebodies!
 - ◆ Transfer loop
 - Prone to overload
 - Tailspin conditions
- Startup conditions



My Involvement

- Joined AT&T Solutions in 1996
 - ◆ Connection between Managing Director & United CIO
 - ◆ Volunteered based on knowledge of railroads
- Put together a team of eventually 12-14 consultants
 - ◆ 4-5 consultants
 - ◆ 3 IT specialists
 - ◆ 3 engineering specialists
 - ◆ 3-4 simulation specialists
- Part remediation – part litigation support
 - ◆ Learning about the system
 - ◆ Diagnostic Report
 - ◆ Running tests
 - ◆ Building a realistic simulation
 - ◆ Writing a report for the lawyers

Testing

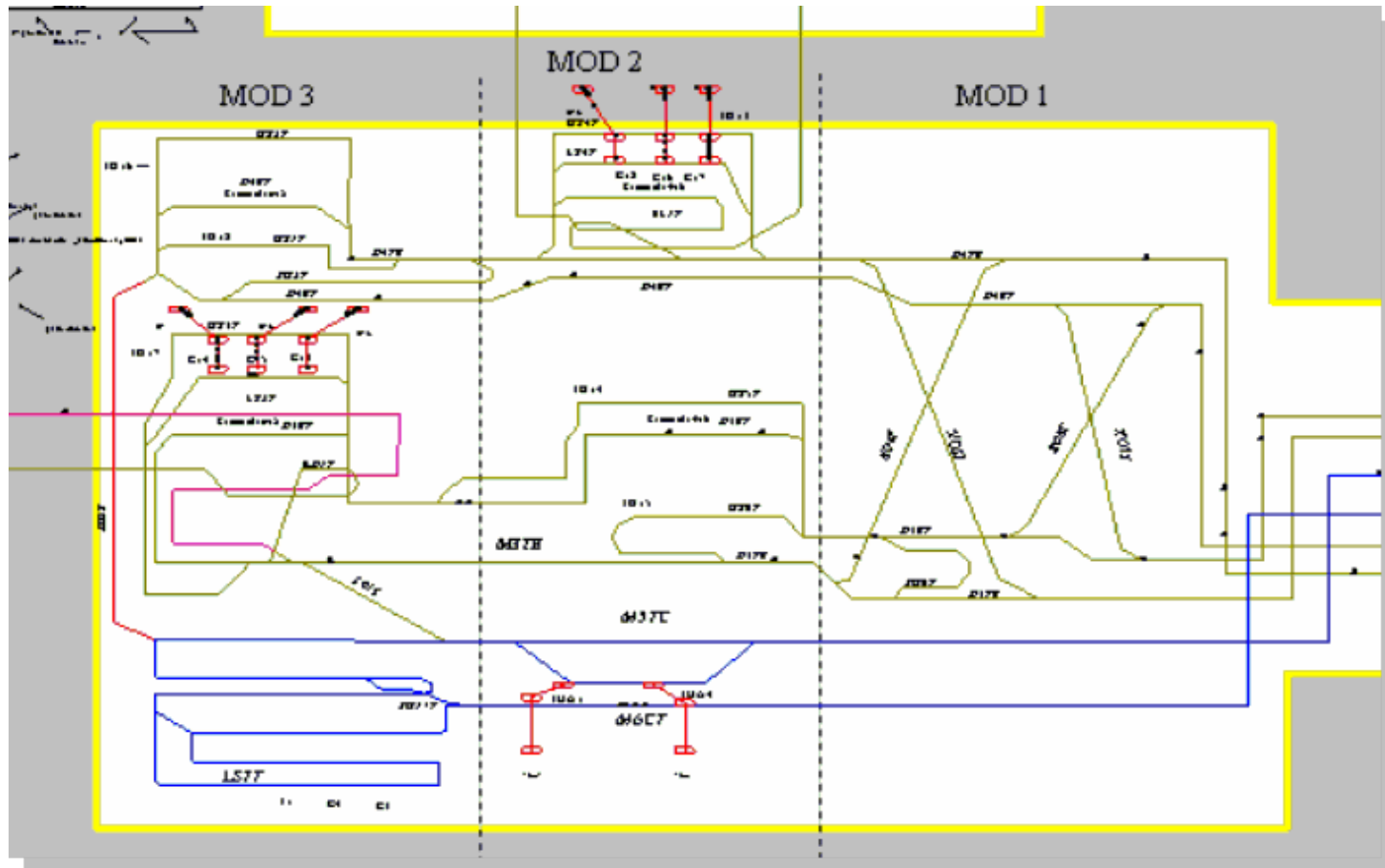
- Testing was done late at night
 - ◆ When last aircraft had arrived (9:30 – 10:00 PM)
- Using “test” luggage
 - ◆ Bad Samsonite luggage used by United
 - ◆ Stuffed with computer paper
 - ◆ Using 120 temps for loading bags onto belts
- Programs were carefully designed
 - ◆ Number of insertion points
 - ◆ Pre-printed barcodes
 - ◆ Carefully timed insertion (laptop program)
- Independent Measurement
 - ◆ Handheld scanners for measurement at destination
 - ◆ Taping of tests with multiple cameras



Simulation

- CCR: Commonwealth Computing & Research, Charlottesville, VA
 - ◆ Freight train optimal scheduling using genetic algorithms (1992)
 - ◆ Postal cluster optimization (1993)
 - ◆ DIA (1996)
 - ◆ Hongkong International Terminals container port (1996)
- Arena modeling tool
 - ◆ Imbedded "C" modules
 - ◆ As the project progressed, the proportion of "C" code grew and superseded the Arena code
 - ◆ Arena ended up being used for display

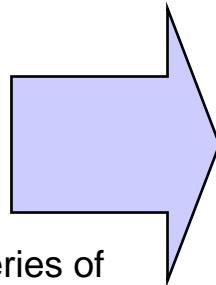
Simulation



What went wrong?

- From the beginning
 - ◆ Fast Implementation
 - ◆ Untested scale
 - ◆ Untested technology
- Integration of technologies
- Many aspects an after thought
- No IT “brain”

- A SYSTEM OF SYSTEMS
 - ◆ A “Railroad” instead of a linear series of belts



1. How do we know what we don't know?
2. How do we stop being so optimistic about technology?
3. How do we measure risks in a realistic way?

A Linear Belt versus a “Railroad”

Linear Belt

- Moving bags along
 - ◆ Local intelligence
 - ◆ Truly distributed computing
 - ◆ One bag at a time
 - ◆ Some capacity management

“Railroad”

- Association of bags and DCVs
- Traffic Management
 - ◆ Speed & Capacity
 - ◆ Merges
- Management of empty DCVs
 - ◆ Parking of empties
 - ◆ Supply and demand
 - ◆ Pre-positioning
 - Terminal?
 - Concourse B?
 - Transfer loop?
- Capacity management
- Brain speed...
 - ◆ Distributed computing
 - ◆ Interactions between brains
 - Peers
 - Industrial computers and PCs

What Went Wrong?

1. How do we know what we don't know?
 - If we don't stop and think
 - If we do not allow dissent...
2. How do we stop being so optimistic about technology?
 - The “Mission Accomplished” syndrome
 - Bottomless improvements in productivity
3. How do we measure risks in a realistic way?
 - When there is no prior experience....

Some Thoughts for Complex Project Management in the 21st Century

- Conduct a thorough independent business analysis
 - Seek divergent voices and ideas
 - Seek alternatives and price points
- Challenge technology
 - Run scenarios – evaluate obsolescence
 - Bottomless improvements in productivity
- Measure risks in a systematic fashion
 - Assign a cost to uncertainty...



Thank you...