



Global Airline Industry Program

Airline Operations & Scheduling Research

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Industry Advisory Board Meeting
November 4, 2004



MIT

Agenda- Selected Airline Operations & Scheduling Research

- Integrated Operations Recovery:
aircraft, crew and passengers
- Airline scheduling and fleetings with
flexibility in “passenger itinerary
flexibility”
- Robust Routing and Scheduling

Integrated Operations Recovery: Aircraft, Crew and Passengers

C. Barnhart, S. Bratu

Comparison of passenger and flight delays

	Average delay (minutes)
Passengers	25.6
Flights	15.4
Ratio	166%

- Key to explaining this difference: disrupted passengers
- Key drivers of disruption
 - Flight delays of at least 45 minutes (FD)
 - Proxy for missed connections
 - Cancellation rate

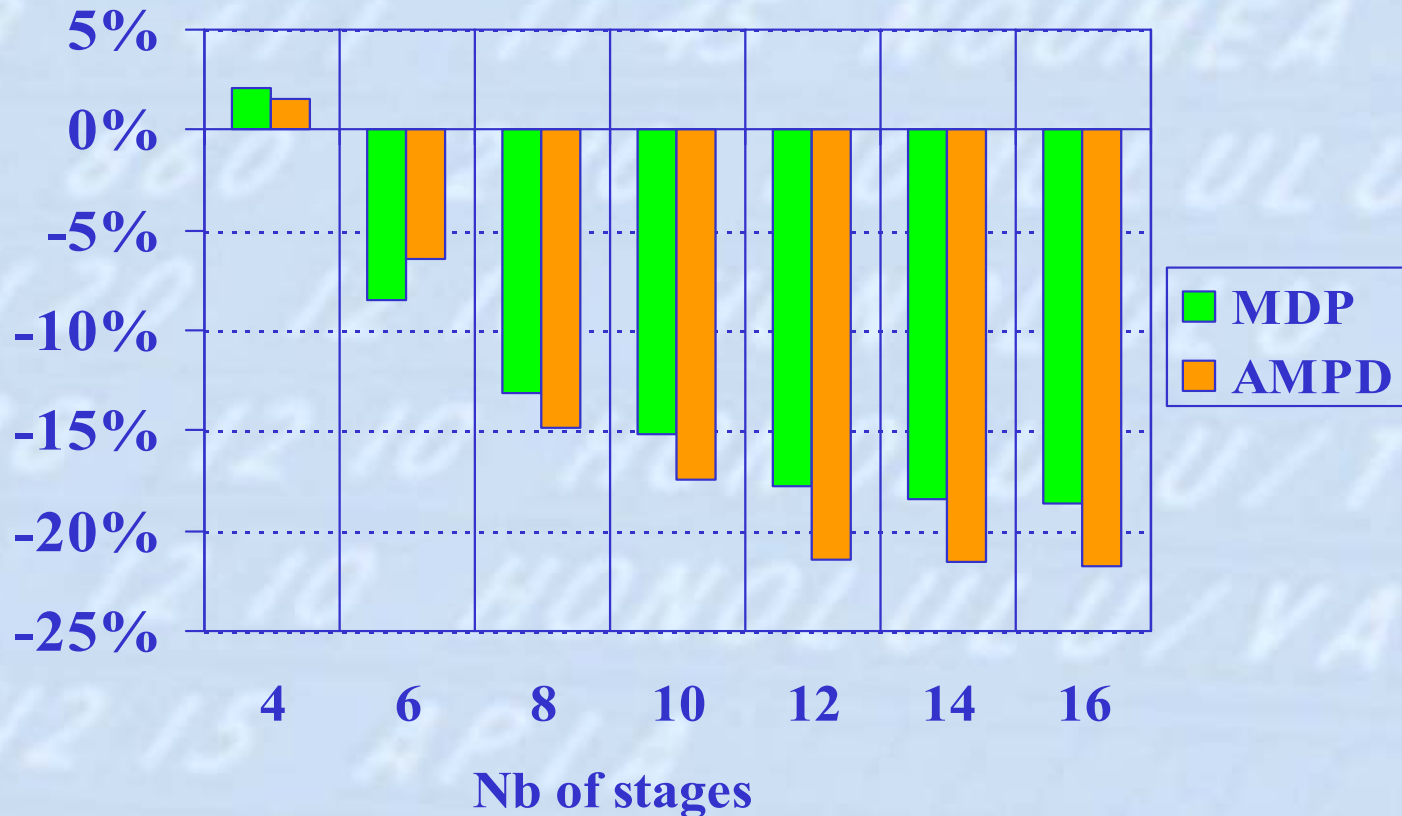
Operations recovery models incorporating passenger delays

- Develop online optimization tools to reduce passenger delay and *disruptions* through improved flight cancellation and departure postponement decisions
- Enforce crew and aircraft maintenance feasibility of the operation

Performance relative to the base case for day d1

	DPM	PDM	APDM
Passenger delay	-17.8%	-23.0%	-21.4%
Disrupted passengers (DP)	-44.2%	-31.1%	-32.3%
Missed connections DP	-45.9%	2.8%	-4.0%
Cancellations DP	-43.7%	-40.5%	-40.2%
Overnight DP	-57.9%	-63.7%	-63.1%
Delay of disrupted passengers	-4.5%	-18.3%	-15.9%
Delay of non-disrupted passengers	12.3%	3.5%	2.1%
Canceled flights	-36.7%	-33.3%	-33.3%
Passengers per canceled flight	-11.1%	-8.5%	-8.0%

Difference in average passenger delay compared to base case for day d1



Re-optimization benefit decreases with the number of stages, showing very little benefit after 12 stages

Exploiting Passenger Flexibility in Airline Fleeting and Schedule Design

Barnhart and Jiang

- **Segment passengers into**
 - Time-sensitive passengers who want a specific, guaranteed itinerary
 - Flexible passengers who are price-sensitive and willing to accept itineraries within a departure and an arrival window. Exact itinerary is unknown until a certain time before departure.
- **Find the optimal flight schedule and associated fleet assignment**
 - Flexible passengers can be (re-)assigned, as demand materializes, to itineraries with sufficient capacity, thereby opening up seats for high revenue passengers

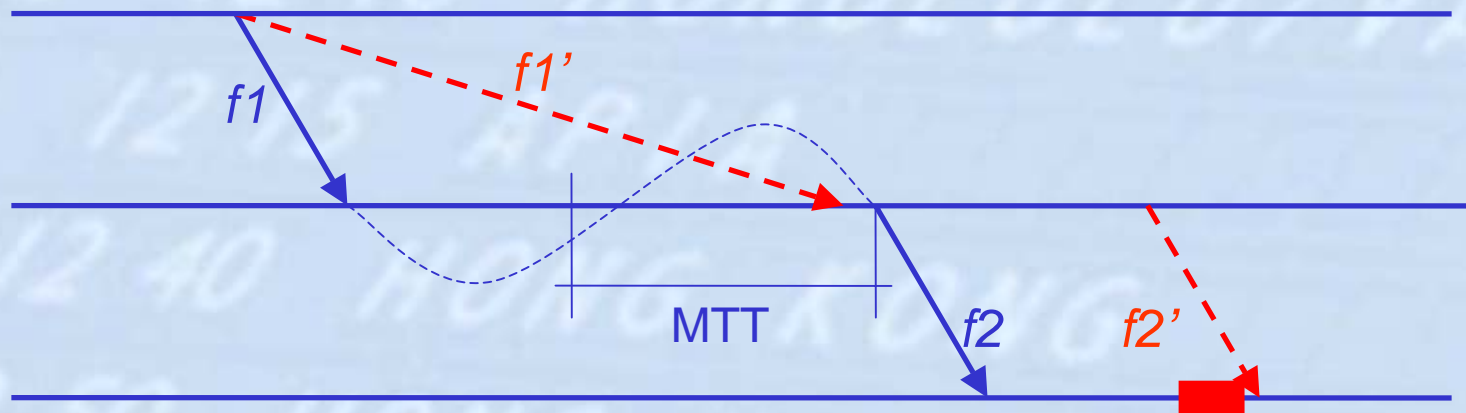
Robust Aircraft Routing and Scheduling

Agbokou, Barnhart, Clarke, Lan, Samardi

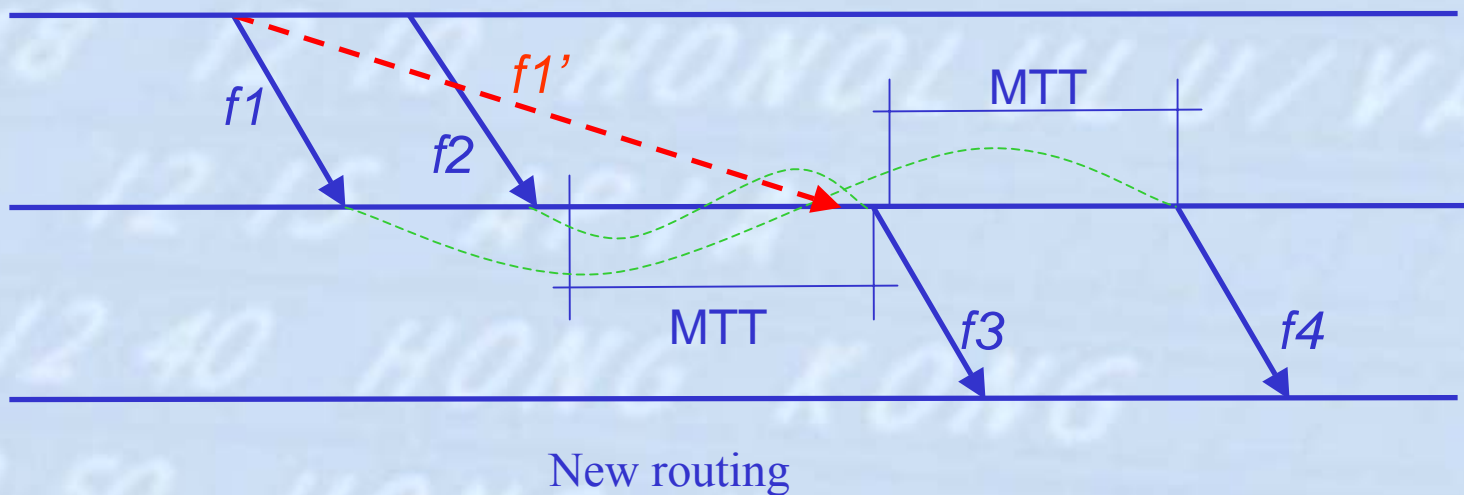
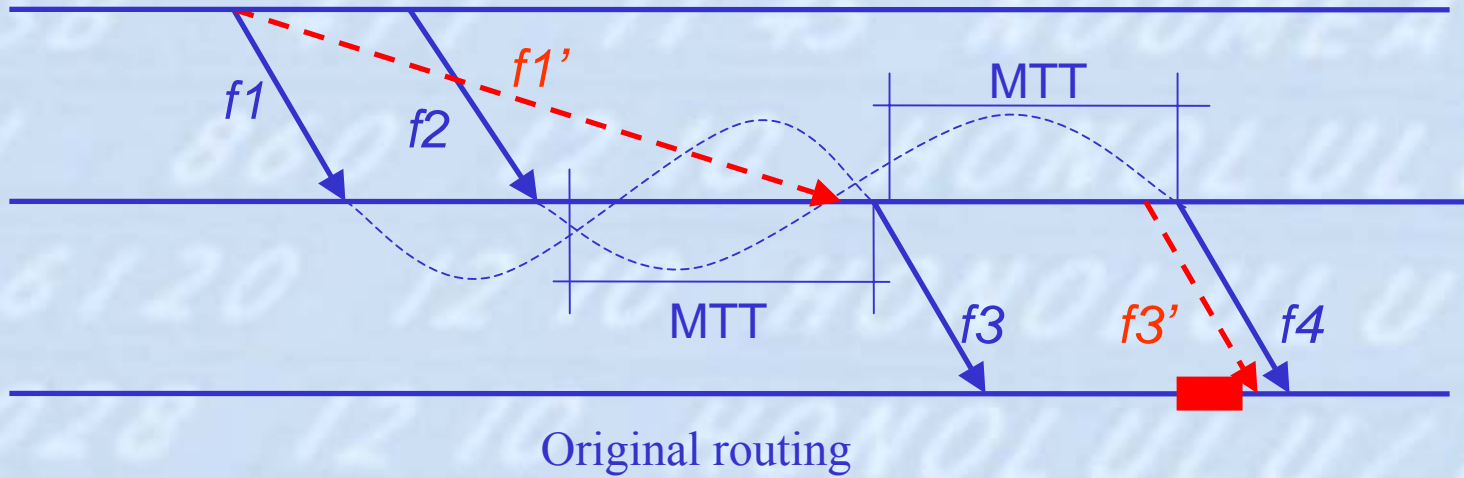
- **Two ways to provide “robustness”**
 - Re-optimize schedule after disruptions occur (operations stage)
 - Build robustness into the schedules (planning stage)
- **Difficult to balance cost that airlines are willing to pay for robustness versus cost of operation**
- **Looking for robust solution without significant added costs**
 - Aircraft maintenance routing problem: the financial impact is relatively small → It is more a feasibility problem
 - Aircraft routes impact flight, passenger, and crew delays

Delay Propagation

- Arrival delay may cause departure delay for the next flight that is using the same aircraft if there is not enough slack between these two flights
- Delay propagation may cause aircraft, passenger and crew disruptions for downstream flights (especially at hubs)



Dampening Delay Propagation through Routing

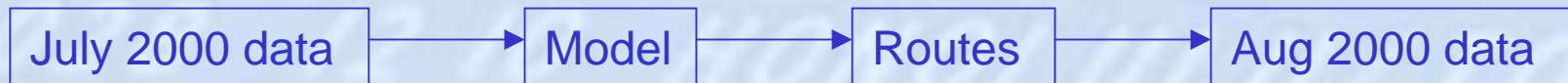


Computational Results

- **Test Networks**

Network	Num of flights	Num of strings
N1	20	7,909,144
N2	59	614,240
N3	97	6,354,384
N4	102	51,730,736

- **Model Building and Validation**



- **Propagated delays (August 2000)**

Network	Old PD	New PD	PD reduced	% of PD reduced
N1	6749	4923	1826	27%
N2	4106	2548	1558	38%
N3	8919	4113	4806	54%
N4	14526	9921	6940	48%
Total	34300	21505	15130	44%

Results - Delays

- **Total delays and on-time performance**

	Total delay			on-time performance		
	> 15 min	> 60 min	> 120 min	15 min	60 min	120 min
Old	22.3%	7.9%	2.9%	77.7%	92.1%	97.1%
New	20.7%	6.9%	2.6%	79.3%	93.1%	97.4%

- **Passenger misconnects**

Network	Total num of D-pax	D-pax reduces	D-pax reduced (%)
N1	986	147	14.9%
N2	1070	79	7.4%
N3	1463	161	11.0%
N4	3323	355	10.7%
Total	6842	742	10.8%

Ongoing Research I

- **Flight departure re-timing to reduce passenger disruptions (Lan, Clarke and Barnhart)**

Time window	Tot num of D-pax	Output	D-pax reduced	D-pax reduced (%)
±15min(7 copies)	18,808	11,348	7,460	39.7%
±10min(5 copies)	18,808	12,732	6,076	32.3%
±5min(3 copies)	18,808	15,042	3,766	20.0%

- **Integrated flight departure re-timing and robust aircraft maintenance routing model (Sarmadi, Barnhart and Clarke)**
 - to minimize propagated delay
 - to minimize the expected number of misconnecting passengers
- **Flight departure-retiming model to provide potential misconnecting passengers with alternative recovery options (Sarmadi, Barnhart and Clarke)**

Ongoing Research II

- **Robust fleet assignment model to generate fleeting solutions with a limited number of aircraft families at spoke airports (Agbokou, Barnhart and Clarke)**
 - Fleeting solution facilitates recovery, yields shorter passenger delays
- **Robust crew pairing model with time windows (Agbokou, Barnhart and Clarke)**
 - Generate an aircraft routing solution based on robust aircraft routing model
 - Reschedule and postpone departures to generate a feasible crew pairing solution with a minimum number of critical connections, reducing the number of crew misconnections.
- **Integrated robust aircraft and crew planning (Agbokou, Barnhart and Clarke)**
 - Integrate aircraft routing and crew scheduling to keep aircraft with crews, when crew connections are critical.
- **Examine the impact on robustness of American Airline's and American Eagle's debanking policy at Dallas-Fort Worth (Agbokou, Barnhart and Clarke)**