Airline Passenger Transportation System: Structure and Dynamics

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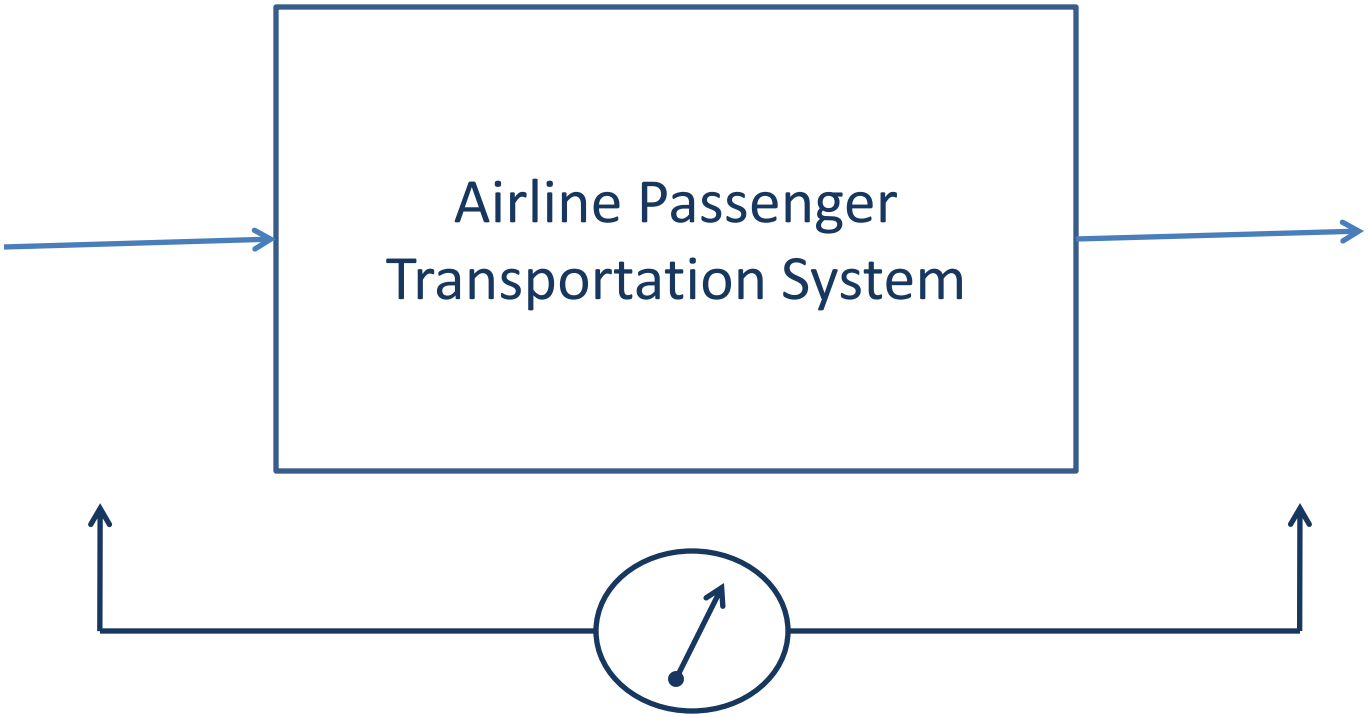
Airline Passenger Transportation System (APTS)

- System that provides transportation of passengers:
  - Passengers that provide value at their destinations (e.g. consult, exchange technology, sales, …)
  - Passengers that spend money at their destinations (e.g. vacation)
- This mode of transportation is characterized by:
  - Service across long geographic distances
  - Rapid
  - Affordable
  - High levels of safety

Airline Passenger Transportation System (APTS)

- Transportation accomplished through the *interaction of multiple agents*:
  - Airlines
    - Ticketing
    - Check-in
    - Flights
    - Baggage
  - Airports
    - Ground transportation
    - Security
    - Terminal services
    - Airside service (e.g. de-icing, snow removal, …)
  - Air Navigation Service Providers
    - Navigation infrastructure
    - Surveillance function
    - Flow Management, Separation, …
  - Other supply chain enterprises (rental cars, fuel providers, concessionaires, … equipment manufacturers)

Airline Passenger Transportation System (APTS)



1. **Quality (i.e. passenger safety)**
2. **Cost (i.e. airfares + other costs, externalities)**
3. **Time (i.e. scheduled trip time, reliability = actual trip time)**

(1) Quality of APTS

- mortality risk of passenger air travel
- a passenger chooses a (nonstop) flight completely at random, what is the probability that the passenger will be killed during the flight?

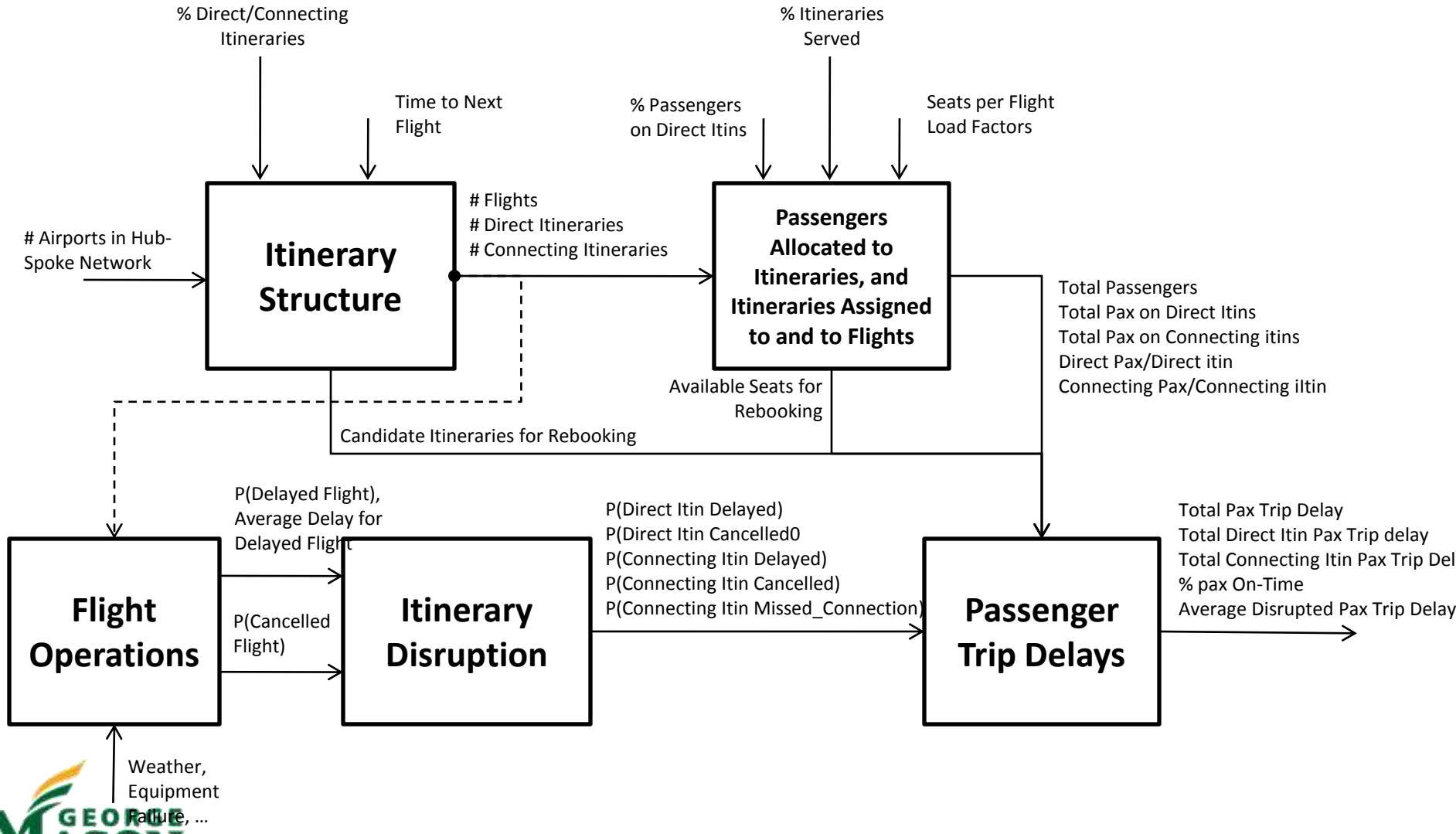
(2) Cost of APTS

- Airfares + Other Costs of APTS determine demand for air travel
  1. Cost-based pricing
     - Direct and Indirect Operating Costs
  2. Demand-based pricing
     - Supply vs Demand
     - Competition
  3. Service-based pricing
     - Differentiation

(3) Time & Reliability of APTS

- *T = Ground access/egress + Flight time + Schedule displacement*
  - Ground Access/Egress
    - Airport processing
  - Flight Time is Scheduled "block time"
    - Includes "schedule padding"
  - Schedule Displacement
    - Time between when passenger wants to depart/arrive and flight is scheduled to depart/arrive
- Reliability = Passenger Trip Delays
  - Actual arrival time – Scheduled arrival time
  - Includes: delayed flights, diverted flights, rebooking for cancelled flights, missed connections, over-booking

APTS System Structure



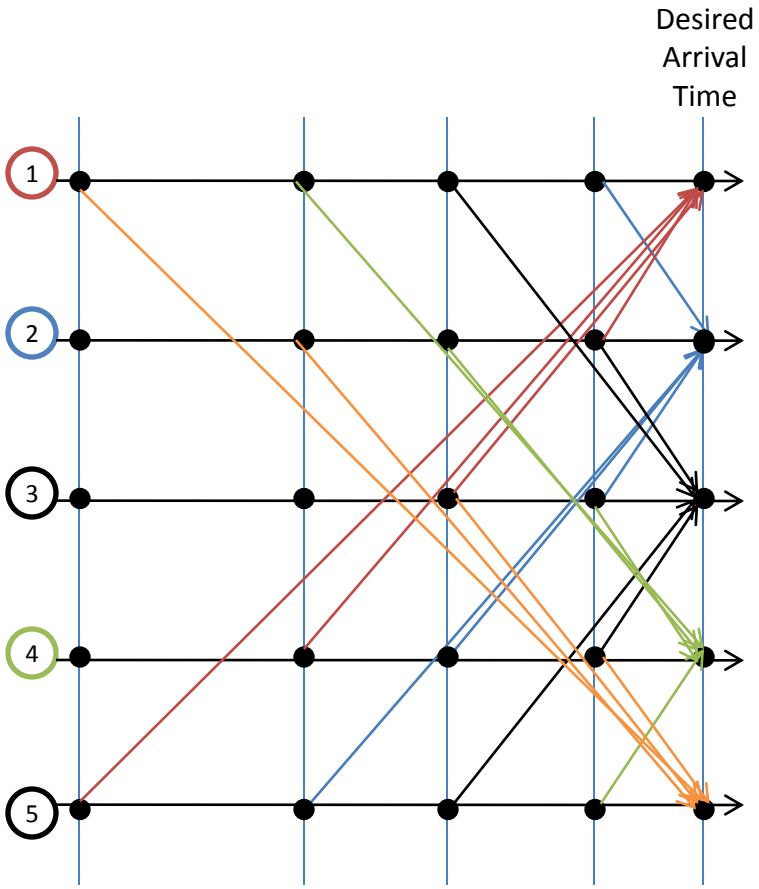
Network

APTS Network

- Network is the manner in which airports are connected by flights
  - Network is a space-time network
  - Network determines the itineraries
- Two distinct types of networks
  - Point-to-point
  - Hub-and-Spoke

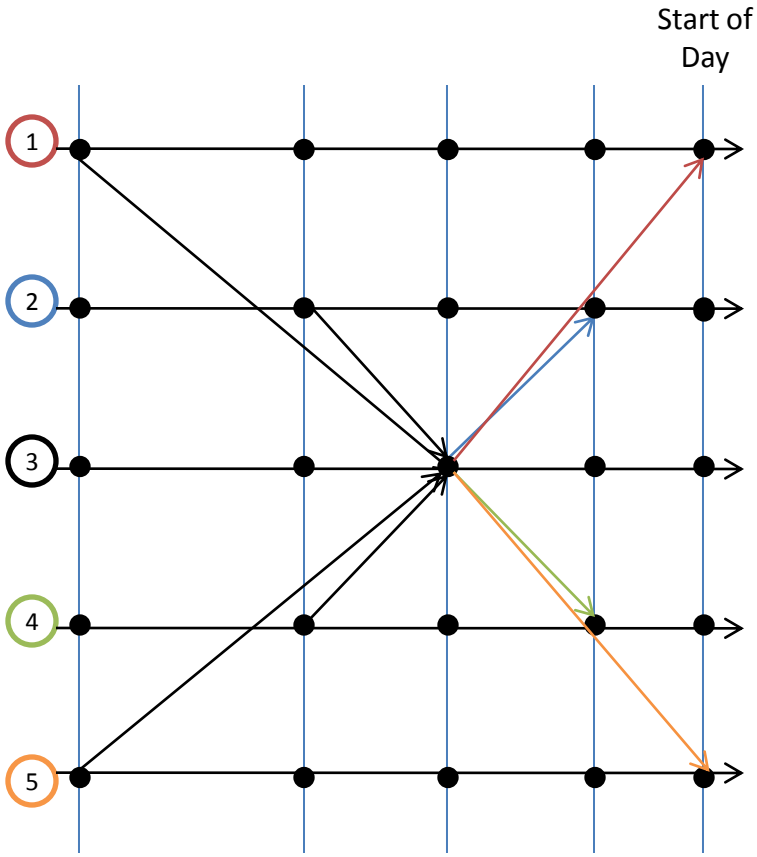
Direct Network

- Each Origin is connected to each Destination (e.g. 1-2, 1-3, 1-4, 1-5)
- Flights depart Origin in time to reach Destination at desired time (e.g. start of business day)
- # Flights required to provide service = (n-1)n
  - 4* 5 = 20
- # Aircraft = # Simultaneous Flights = 20



Hub-and-Spoke Network

- Each Origin is connected to each Destination via a Hub (i.e. 3)
  - (e.g. 1-3-2, 1-3-4, 1-3-5)
- Flights depart Origin in time to reach Destination at desired time (e.g. start of business day)
- # Flights required to provide service = (n-1)2
  - 4* 2 = 8
- # Aircraft = # Simultaneous Flights = 4



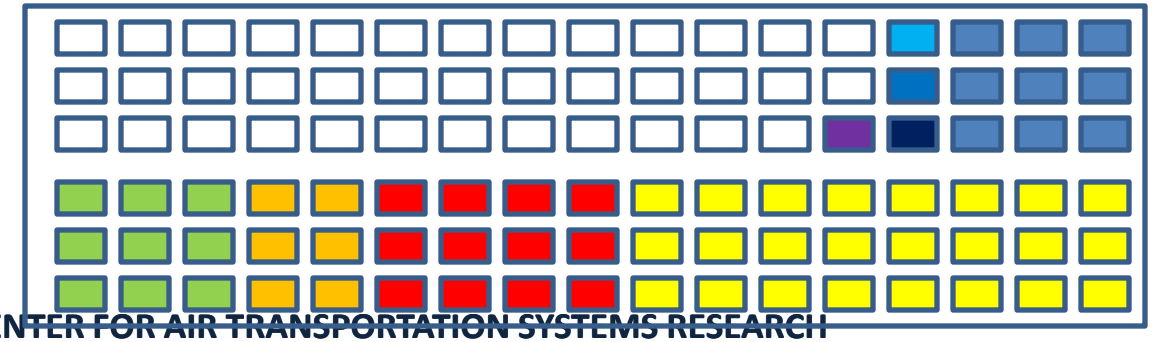
Hub-and-Spoke

- Bank
  - Flights arrive from Origins at Hub, then depart from Hub to Destinations
- Typical hub network has 5 – 8 banks per day
  - Depends on geography/routes served
    - USAirways at CLT vs JetBlue at JFK
- Advantage of Hub – economies of scale
- Disadvantage of Hub – Flight time

Itineraries

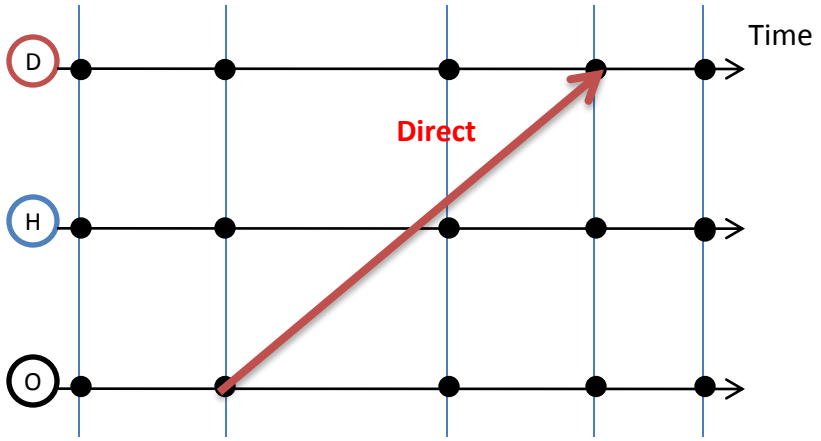
Itineraries

- Itinerary is the sequence of flights taken by a *given passenger* from Origin to Destination
  - Direct Itinerary
  - Connecting Itinerary
- By definition a given flight (in a hub-and-spoke network) will have passengers on board different itineraries

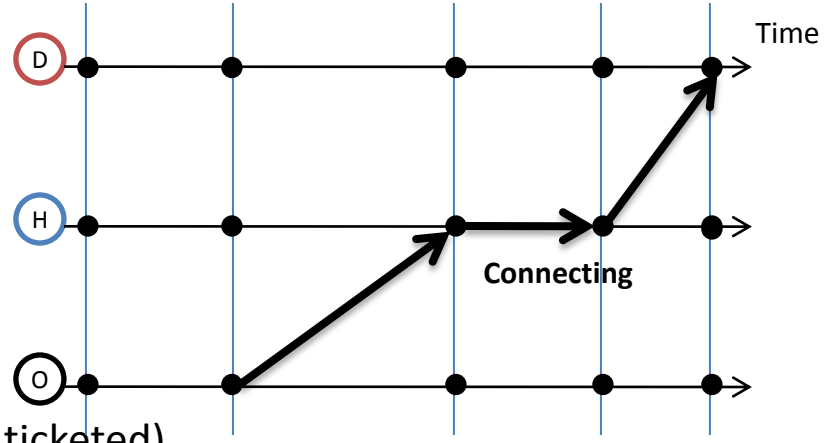


Direct Itinerary

- Direct Itinerary:
  - Origin
  - Destination
  - Scheduled Departure Time Origin (as ticketed)
  - Scheduled Arrival Time Destination (as ticketed)
  - Flight Number
  - Flight Seat Capacity
  - Type: Direct



Connecting Itinerary



- Connecting Itinerary
  - Origin
  - Hub
  - Destination
  - Origin-Hub
    - Scheduled Departure Time – origin (as ticketed)
    - Scheduled Arrival Time - Hub (as ticketed)
    - Flight Number
    - Flight Seat Capacity
  - Hub-Destination
    - Scheduled Departure Time – origin (as ticketed)
    - Scheduled Arrival Time - Hub (as ticketed)
    - Flight Number
    - Flight Seat Capacity
  - Type: Direct

Actual Itineraries (Hub ATL)

ORIGIN	DEST	HUB	AIRLINE	DB1B PAX	FL_1_NUM	Seats	T100 Load Factor	FL_2_NUM	Seats	T100 Load Factor	Pax Flight Itin Pax
DCA	ATL	NULL	DL	63	1137	143	0.853146853	NULL	NULL	NULL	19
LGA	ATL	DCA	DL	18	1961	134	0.507462686	1137	143	0.853146853	10
LGA	ATL	DCA	DL	18	1963	134	0.507462686	1137	143	0.853146853	10
DCA	BHM	ATL	DL	27	1137	143	0.853146853	574	146	0.739726027	8
DCA	CHS	ATL	DL	16	1137	143	0.853146853	1164	142	0.866197183	5
DCA	TPA	ATL	DL	19	1137	143	0.853146853	836	201	0.815920398	6

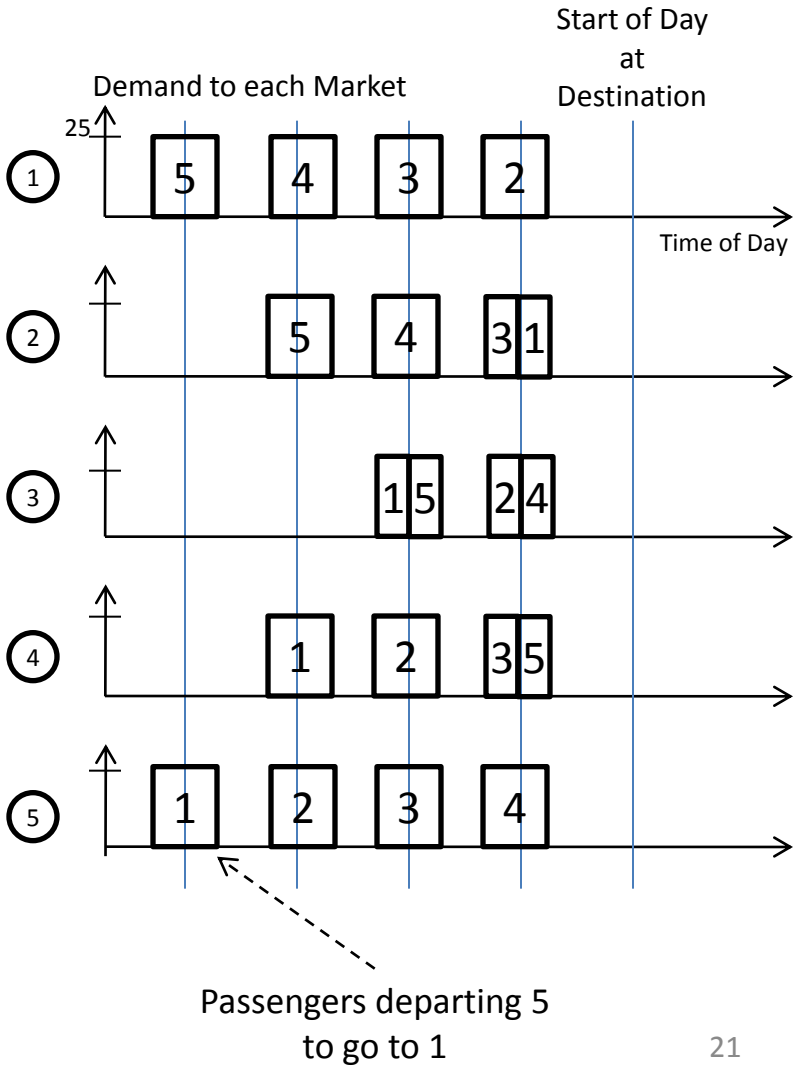
Example APTS Network

Example APTS (5 Airport)

- Markets
  - Five
  - Located in same Time Zone
  - Equal distance apart
- Transportation Service at each Market
  - Each market has own airport
  - Travel time = 1 Unit Time between airports
  - (e.g. Travel Time 1 to 4 = 4)

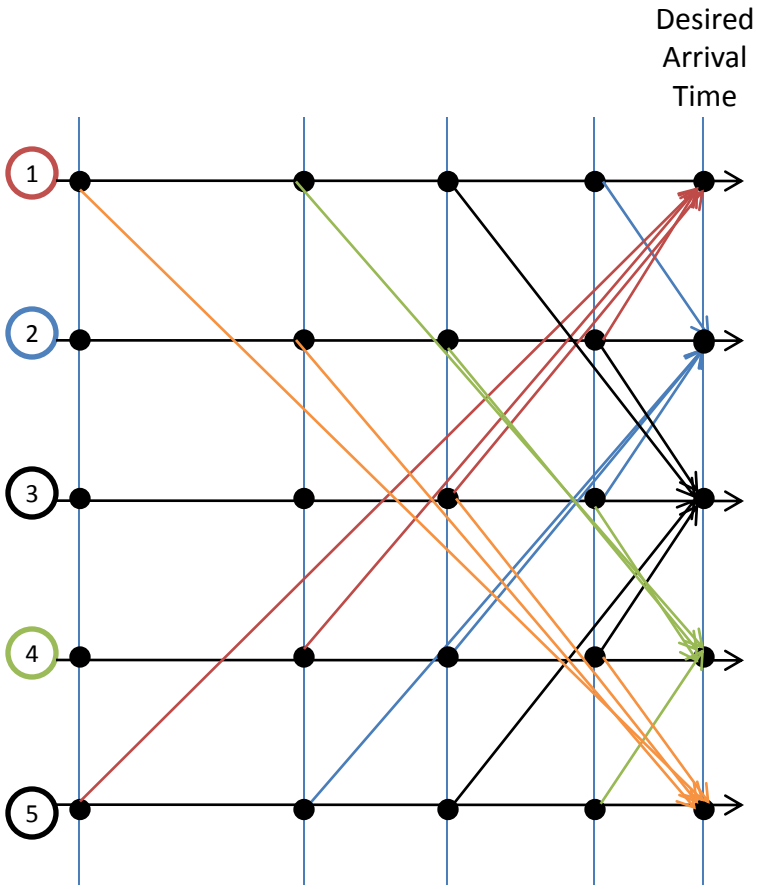
Transportation Demand

- Transportation demand
  - Total of 500 passengers
  - 100 passengers to each Destination Market
  - 100 passenger from each Origin Market
  - 25 passenger trips from each Origin market to each Destination Market
  - Passengers are required to be at Destination for start of day, so depart with enough time
  - Demand for travel at each Origin to arrive at Destination at start of day (shown on right)
    - 100 pax leave each market
    - 100 pax arrive at each market



Direct Flight Network

- Total Passengers = 500
- Total Itineraries = 20
- # Flights = 4 * 5 = 20
- Aircraft Size 25 seats
- Distance Traveled =
  - 4+3+2+1 = 10
  - 3+2+1+1 = 7
  - 2+1+1+2 = 6
  - 3+2+1+1 = 7
  - 4+3+2+1 = 10
  - 40
- Total Trip Time = 40
- Total Arrival Displacement Time = 0 (all pax arrive at required time)
- Average Trip Time = 40/20 = 2
- Max Simultaneous Arrivals at each airport = 4 (at each airport)
- Max Simultaneous use of airspace = 5 (at each TRACON)

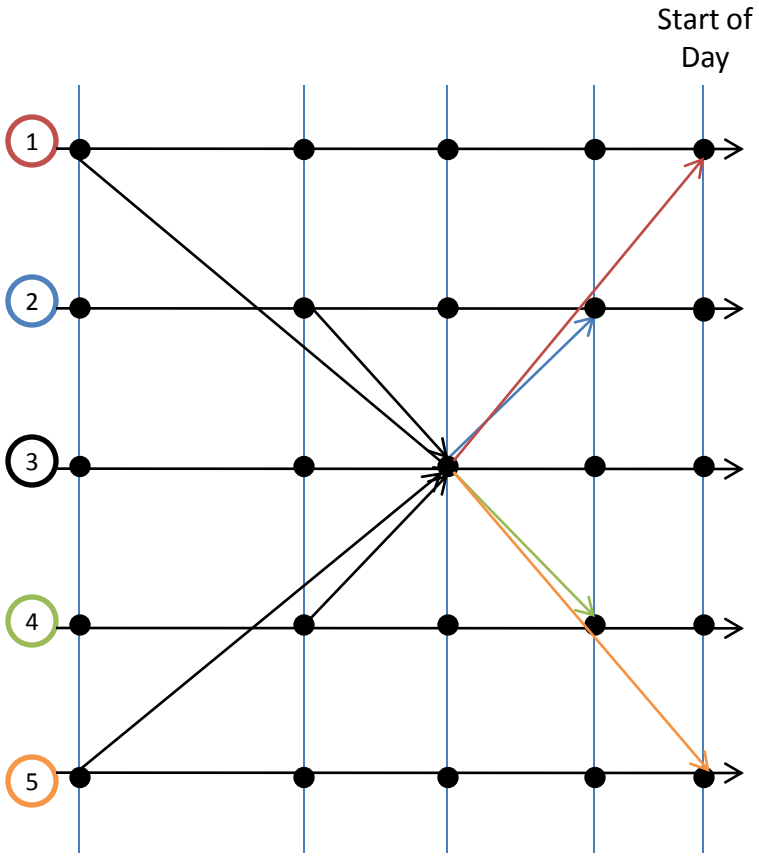


Direct Flight Network

Origin	Originating Pax	Destination	Itinerary = Flights	Pax per Itineray = Flight	Trip Time	Arrival Displacement
1	100	2 3 4 5	1-2 1-3 1-4 1-5	25 25 25 25	1 2 3 4	- - - -
2	100	1 3 4 5	2-1 2-3 2-4 2-5	25 25 25 25	1 1 2 3	- - - -
3	100	1 2 4 5	3-1 3-2 3-4 3-5	25 25 25 25	2 1 1 2	- - - -
4	100	1 2 3 5	4-1 4-2 4-3 4-5	25 25 25 25	3 2 1 1	- - - -
5	100	1 2 3 4	5-1 5-2 5-3 5-4	25 25 25 25	4 3 2 1	- - - -
TOTAL	500			500	60	0

Hub-n-Spoke Network

- Total Passengers = 500
- Total Itineraries = 20
- # Flights = 4 + 4 = 8
- Aircraft Size = 100 seats
- Distance Traveled = 12
- Total Trip Time =
  - Flight + Turn + Flight
  - (5+3+5+6) +
  - (5+2+4+5)+
  - (3+2+2+3)+
  - (5+4+2+5)+
  - (6+5+3+5)=80
- Total Arrival Displacement Time =
  - (some pax arrive earlier than needed)
- Average Trip Time = 80/20= 4
- Max Simultaneous Arrivals at each airport = 4 (at hub only)
- Max Simultaneous use of airspace = 4 (at hub TRACON only)



Hub-n-Spoke: Itinerary Table

Origin	Originating Pax	Destination	Itinerary	Pax per Itinerary	Total Trip Time	Arrival Displacement (Early)
1	100	2 3 4 5	1-3-2 1-3 1-3-4 1-3-5	25 25 25 25	4 2 4 5	1 2 1 -
2	100	1 3 4 5	2-3-1 2-3 2-3-4 2-3-5	25 25 25 25	5 1 3 4	- 2 1 -
3	100	1 2 4 5	3-1 3-2 3-4 3-5	25 25 25 25	2 1 1 2	- 1 1 -
4	100	1 2 3 5	4-3-1 4-3-2 4-3 4-3-5	25 25 25 25	4 3 1 4	- 1 2 -
5	100	1 2 3 4	5-3-1 5-3-2 5-3 5-3-4	25 25 25 25	5 4 2 4	- 1 2 1
TOTAL	500			500	57	16

Hub-n-Spoke: Flight Table

Origin	Destination	Pax per Flight	Total Trip Time
1	3	100	2
2	3	100	1
4	3	100	1
5	3	100	2
3	1	100	2
3	2	100	1
3	4	100	1
3	5	100	2

Load Factor

Load Factor

- Load Factor on a flight
  - Enplaned Passengers / Available Seats
- Average Load Factor for a set of flights
  - [∑ (load factors for set of flights)]/number of flights
- Network Load Factor
  - Total enplaned passengers / Total available seats
  - Alternate: RPM/ASM

Load Factors

- Airlines control Load Factors by:
  1. Adjusting Aircraft Size
  2. Revenue Management (also known as Yield Management)
     - Computerized Reservation System (CRS)
     - Internet provides price transparency

Itinerary Performance Reliability

Itinerary Performance

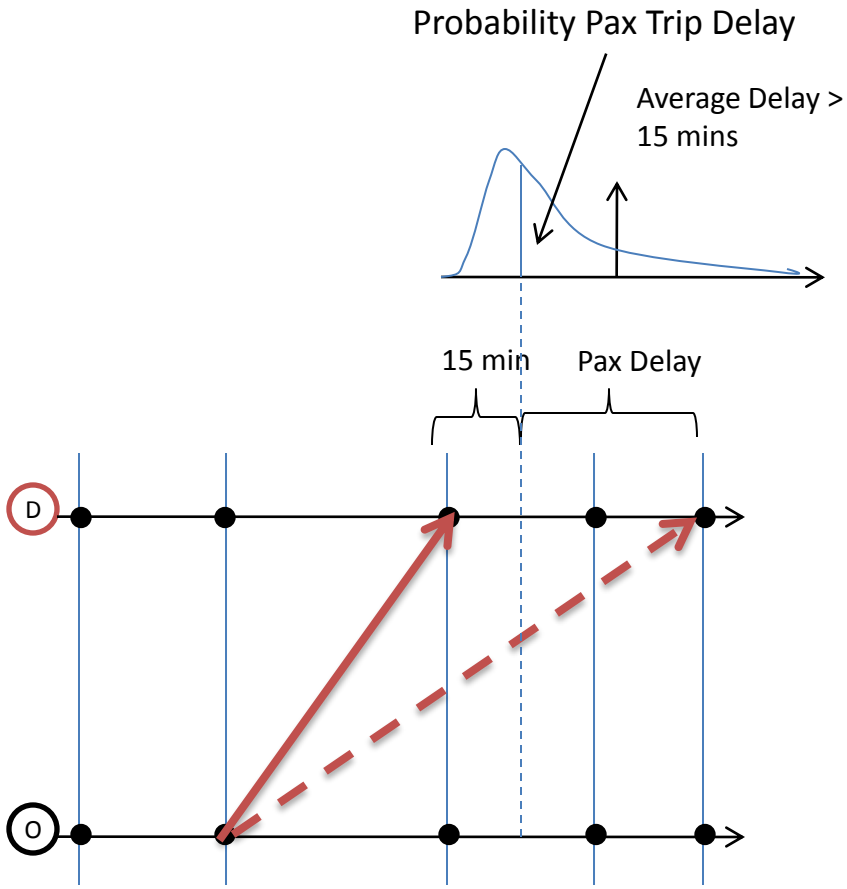
- Passenger Trip Delay = Actual Passenger Arrival Time – Scheduled (i.e. Ticketed) Arrival Time

- Disruptions resulting in Passenger Trip Delays
  1. Delayed flights
  2. Cancelled flights
  3. Diverted flights
  4. Denied Boarding
  5. Missed Connections

Direct Itin Disruption

Delayed Flight

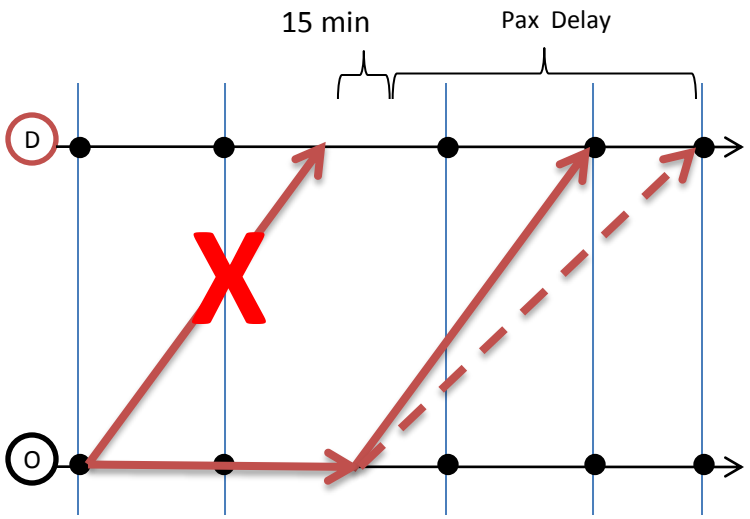
- Pax Trip Delay
  - Ticketed Arrival Time – Actual Arrival Time – 15 min
  - $D_{DelayedFlight}$
- Probability of Pax Trip Delay
  - Probability Flight Delay > 15 minutes
  - $P_{DelayedFlight}()$



Direct Itin Disruption

Cancelled Flight

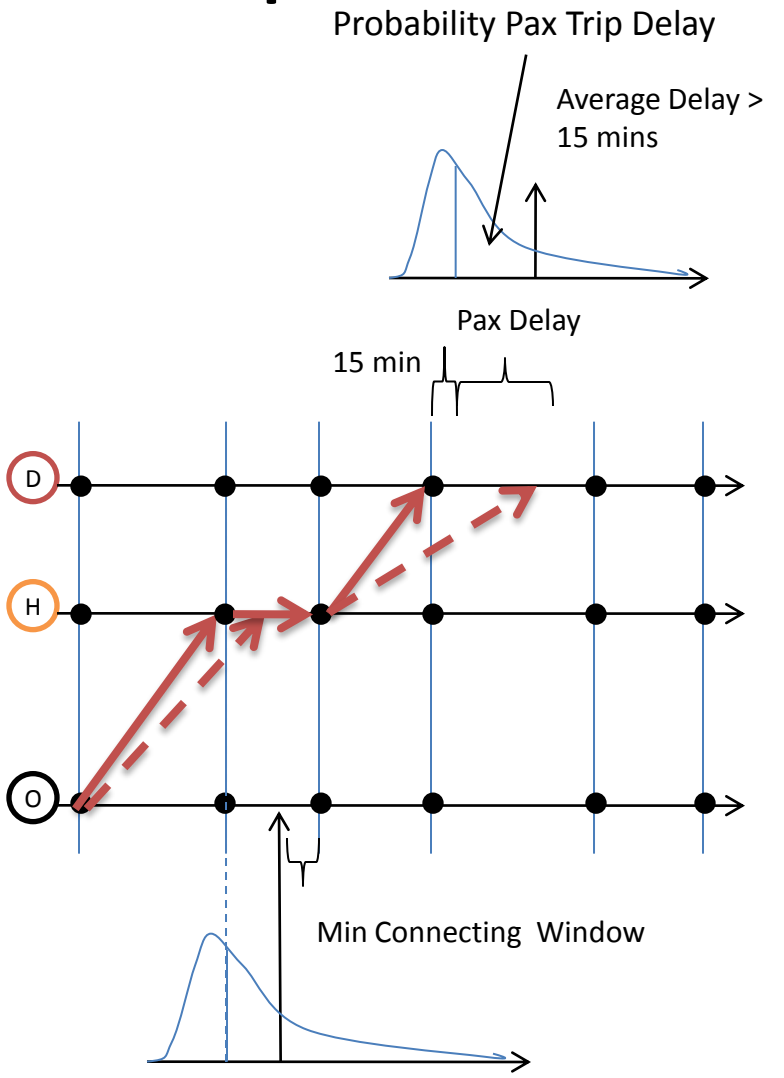
- Pax Trip Delay
  - Ticketed Arrival Time – Actual Arrival Time
  - $D_{CancelledFlight} = f$ (Frequency of Service O-D)
- Probability of Pax Trip Delay
  - Probability Flight Cancelled
  - $P_{CancelledFlight}()$



Connected Itin Disruption

Delayed Flight

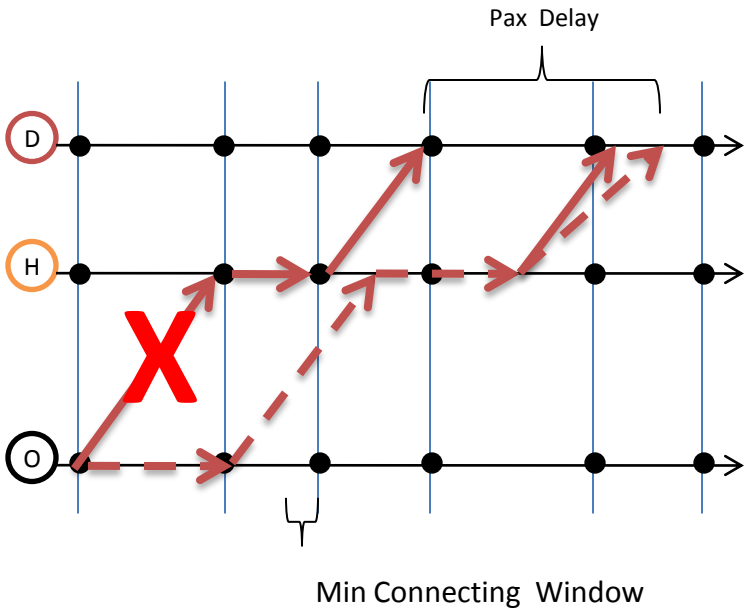
- Pax Trip Delay
  - Ticketed Arrival Time – Actual Arrival Time – 15 min
  - $D_{DelayedFlight\ H\text{-}D} = f$ (Frequency of Service O-D)
- Probability of Pax Trip Delay
  - Probability H-D Flight Delay > 15 minutes
  - $P_{DelayedFlight\ H\text{-}D}$



Connected Itin Disruption

Cancelled Flight (O-H)

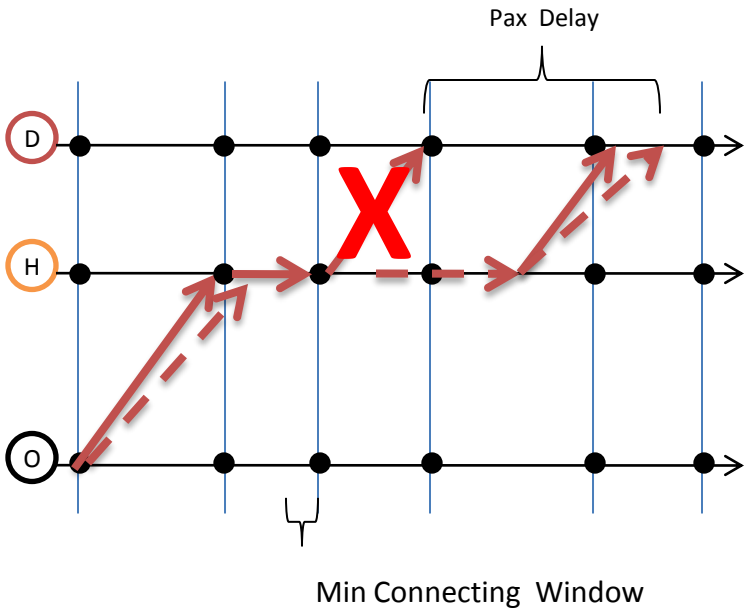
- Pax Trip Delay
  - Ticketed Arrival Time – Actual Arrival Time – 15 min
  - $D_{CancelledFlight\ withConnection} = f$ (Frequency of Service O-H, H-D)
- Probability of Pax Trip Delay
  - Probability O-H Cancelled
  - $P_{CancelledFlightO\text{-}H}$ ()



Connected Itin Disruption

Cancelled Flight (H-D)

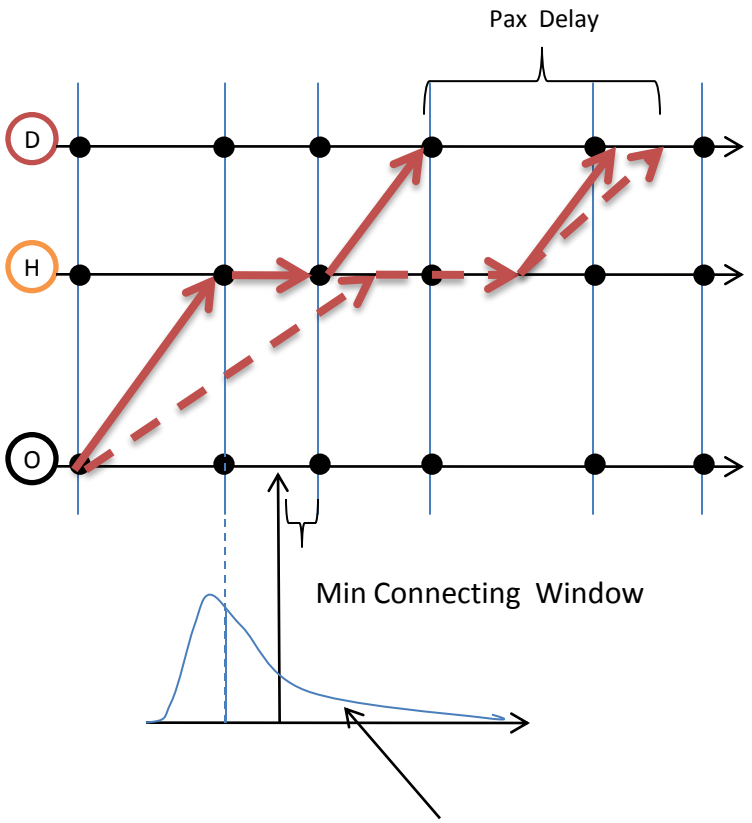
- Pax Trip Delay
  - Ticketed Arrival Time – Actual Arrival Time – 15 min
  - $D_{CancelledFlight}$ = f (Frequency of Service H-D)
- Probability of Pax Trip Delay
  - Probability H-D Cancelled
  - $P_{cancelledFlightO\text{-}H}$ ()



Connected Itin Disruption

Missed Connection Flight

- Pax Trip Delay
  - Ticketed Arrival Time – Actual Arrival Time – 15 min
  - $D_{MissedConnectionFlight} = f$ (Frequency of Service O-D)
- Probability of Pax Trip Delay
  - Probability O-H Flight Delay > 15 minutes AND Probability Pax Misses Connection
  - $P_{DelayedFlightO\text{-}H} * P_{MissedConnection}()$

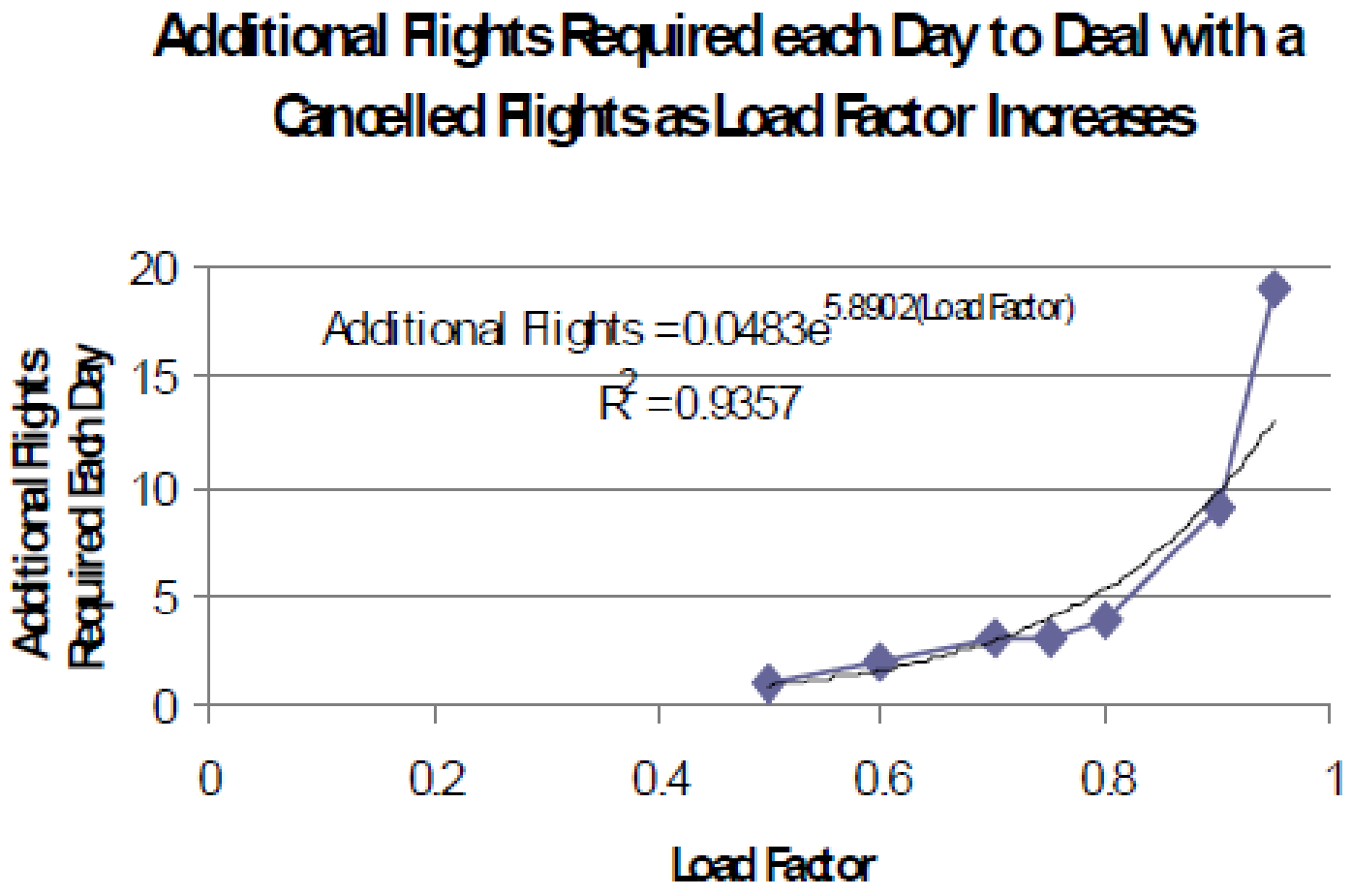


Probability Missed Connection = Probability O-H is Delayed beyond Min Connecting Window to H-D

Probability & Magnitude of Disruption

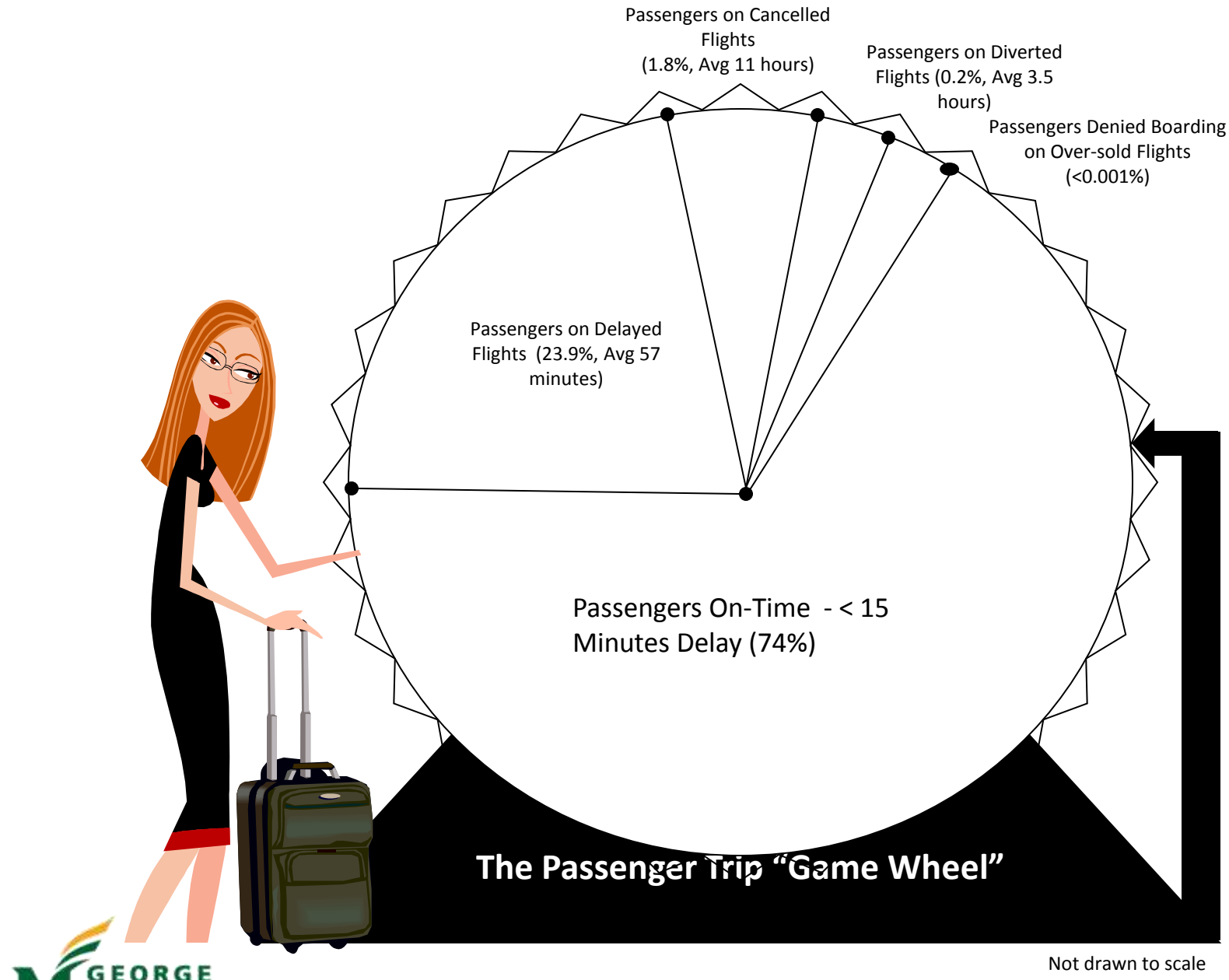
Itinerary Type	Type of Itinerary Disruption	Probability of Itinerary Disruption	Magnitude of Disruption (Average)
Direct	Delayed	Based on Probability of Delayed Flight (typical 0.3)	$10*e^{(\text{Probability of Delay Flight } *6)}$. (Typical 60 mins)
	Cancelled	$0.004^{(\text{Probability of Delay Flight } *6.67)}$. (Typical 0.02)	Based on Availability of Seats on subsequent flights and Time to next flight (average = 300 mins)
Connecting	Delayed	Based on Probability of Delayed Flight (typical 0.3)	$10*e^{(\text{Probability of Delay Flight } *6)}$. (Typical 60 mins)
	Cancelled	$2 * 0.004^{(\text{Probability of Delay Flight } *6.67)}$. Twice probability of Cancelled Flight (typical 2 * 0.02)	$(0.0483*e^{(5.8902*\text{Load Factor})})$*Time to Next Flight. Based on Availability of Seats on subsequent flights and Time to next flight (average = 645 mins)
	Missed Connection	0.1 * Probability of Delayed Flight. A function of connecting times and airline policies regarding holding flights (typical 0.03)	$(0.0483*e^{(5.8902*\text{Load Factor})})$*Time to Next Flight. Based on Availability of Seats on subsequent flights and Time to next flight (average = 645 mins)

Rebooking Passengers



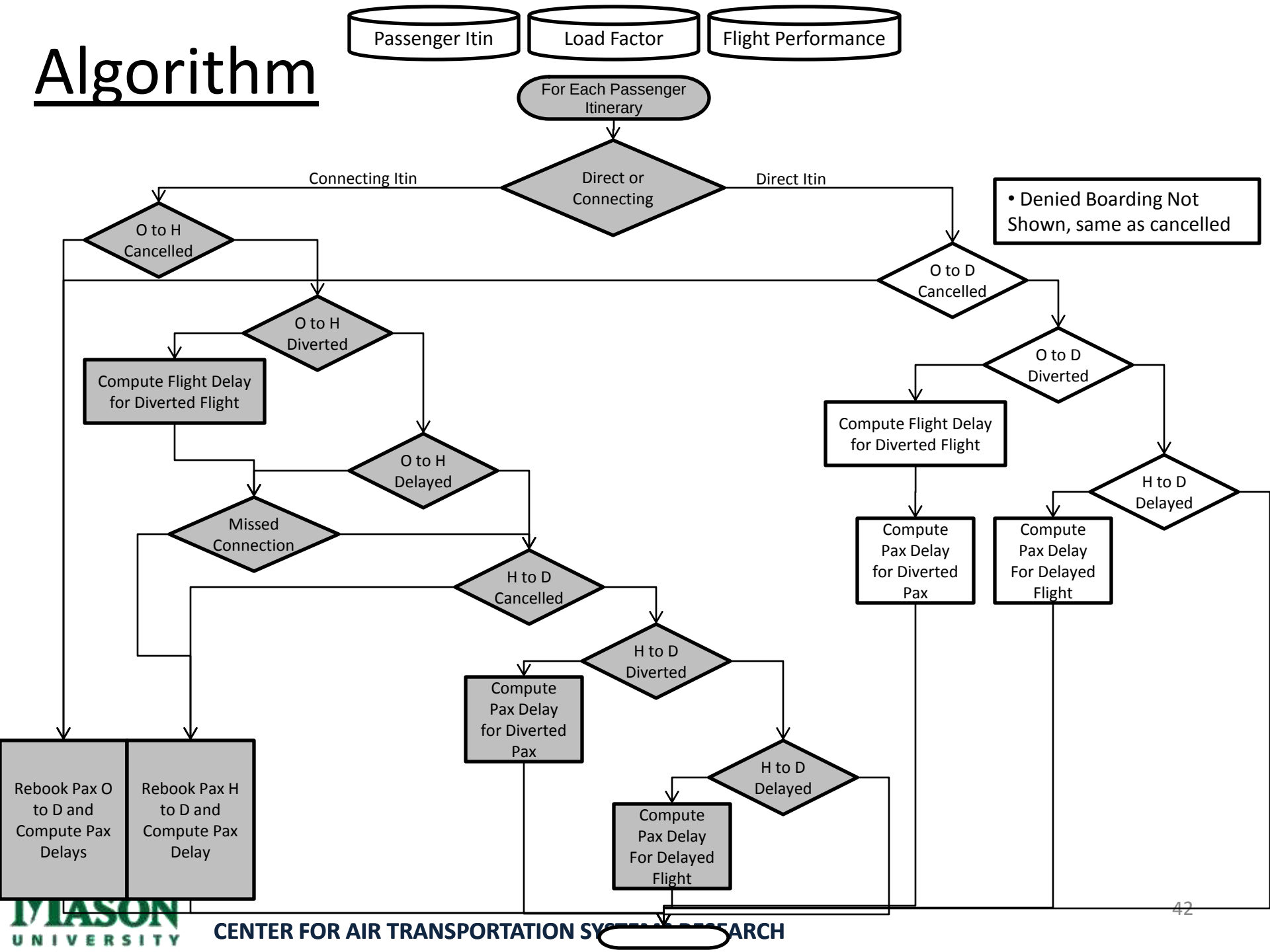
Calculating Passenger Trip Delay

	Scheduled Departure Time	Schduled Arrival Time	Seats	# Pax	Flight Status	Delay	Pax Trip Delay
O-D	06:00	08:00	100	100	Delayed	20 mins	100* 20
O-D	06:10	08:20	120	100	Cancelled		**(20 * 130)** +(50 * (210 +40)+ +(30 * 460)
O-H1-D	06:30	10:30	120	100	On-Time		0
O-D	09:30	11:50	150	100	Delayed	40 mins	100*40
O-H2-D	13:00	15:00	120	70	On-Time		0



Not drawn to scale

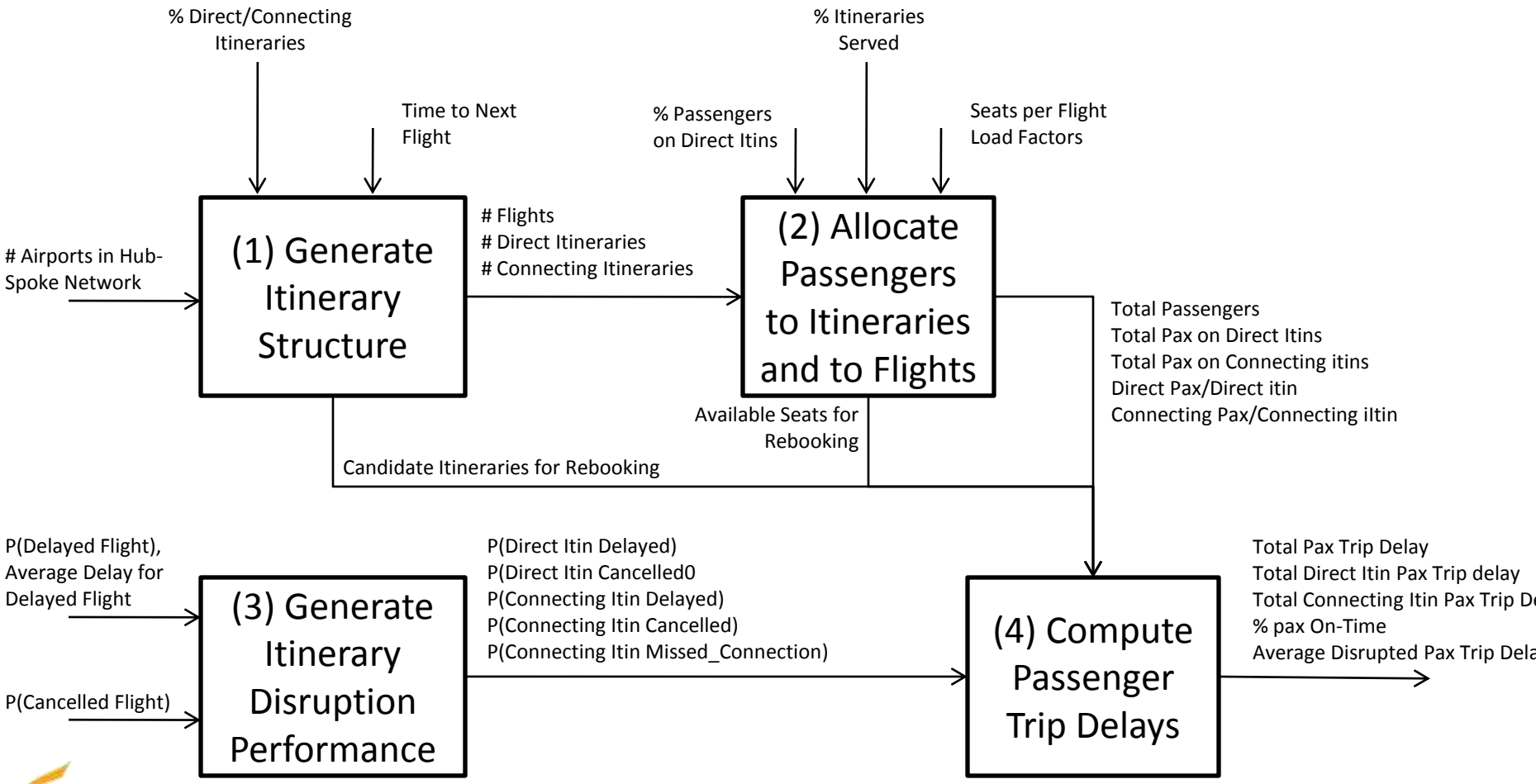
Algorithm


Passenger Itin
Load Factor
Flight Performance
For Each Passenger Itinerary
Direct or Connecting
Connecting Itin
Direct Itin
• Denied Boarding Not Shown, same as cancelled
O to H Cancelled
O to D Cancelled
O to H Diverted
O to D Diverted
Compute Flight Delay for Diverted Flight
Compute Flight Delay for Diverted Flight
O to H Delayed
H to D Delayed
Missed Connection
Compute Pax Delay for Diverted Pax
Compute Pax Delay For Delayed Flight
H to D Cancelled
H to D Diverted
Compute Pax Delay for Diverted Pax
H to D Delayed
Compute Pax Delay For Delayed Flight
Rebook Pax O to D and Compute Pax Delays
Rebook Pax H to D and Compute Pax Delay

Data Sources

- T-100 Domestic Segments Data (U.S. Carriers) – domestic segment data aggregated by month
- DB1B Coupons Data – a 10% sample of domestic itinerary data aggregated by quarter
- Flight On-Time Performance Data (ASQP) – daily on-time arrival data for domestic flights operated by major U.S. carriers
- FAA Aircraft Registry, which includes seating capacities by carrier and aircraft type
- Other secondary sources

Airline Passenger Transportation System



Network Performance Characteristics

- Transportation System has:
  - 16 itineraries
  - 500 trips
- Transportation Service is provided by:
  - Network Structure
  - Direct Flights vs. Hub-n-Spoke
- Each Flight has:
  - Seat Capacity = SC
  - Seat Utilization = Load Factor = LF
  - Likelihood of experiencing delay = P(D)
  - Likelihood of cancellation = P(C)
- Each Trip has Average Trip Delay
  - Trip Delay due to Delayed Flight = DDelayedFlight
  - Trip Delay due to Cancelled Flight = DCancelledFlight
  - Trip Delay due to Missed Connection = DMissedConnection

Network Performance

- Total Passenger Trip Delays =

Total Passenger Trip Delay from Delayed Flights +
Total Passenger Trip Delay from Cancelled Flights

- Total Passenger Trip Delay from Delayed Flights =
$\sum_{i=1,n,\, j=1,n} LF_{Oi\text{-}Dj} * SC_{Oi\text{-}Dj} * P(D)_{Oi\text{-}Dj} * D_{DelayedFlight\ Oi\text{-}Dj}$
- Total Passenger Trip Delay from Cancelled Flights

$= \sum_{i=1,n,\, j=1,n} LF_{Oi\text{-}Dj} * SC_{Oi\text{-}Dj} * P(C)_{Oi\text{-}Dj} * D_{CancelledFlight\ Oi\text{-}Dj}$

Network Performance

- Under assumption of homogeneous fleet, flight leg performance ….
  - $LF_{O1\text{-}D1} = LF_{O1\text{-}D2} = LF_{O1\text{-}D3} = \ldots = LF$
  - $SC_{O1\text{-}D1} = SC_{O1\text{-}D2} = SC_{O1\text{-}D3} = \ldots = SC$
  - $P(D)_{O1\text{-}D1} = P(D)_{O1\text{-}D2} = P(D)_{O1\text{-}D3} = \ldots = P(D)$
  - $D_{DelayedFlight\ O1\text{-}D1} = D_{DelayedFlight\ O1\text{-}D2} = \ldots = D_{DelayedFlight}$
- Total Passenger Trip Delay from Delayed Flights = $\sum_{i=1,n,\ j=1,n} LF_{Oi\text{-}Dj} * SC_{Oi\text{-}Dj} * P(D)_{Oi\text{-}Dj} * D_{DelayedFlight\ Oi\text{-}Dj}$

= #Flights * LF * SC * P(D) * $D_{DelayedFlight}$

Performance Metrics

1. % Disrupted Passengers
   - Total Disrupted Passengers
     - Passengers on Delayed Flights
     - Passengers on Cancelled Flights
2. Total Passenger Trip Delay
3. Average Passenger Trip Delay
4. Average Disrupted Passenger Trip Delays
   - Average Passenger Trip Delays due to Delayed Flights
   - Average Passenger Trip Delays due to Cancelled Flights
   - Average Passenger Trip Delays due to Missed Connections

Performance: Direct Network

- Total Disrupted Passengers = [P(D) + P(C)] *(#Flights*LF*SC)
- % Passengers Disrupted = P(D)+P(C)
- Total Passenger Trip Delay = #Flights*LF*SC [(P(D)* $D_{DelayedFlight}$)+ (P(C)* $D_{CancelledFlight}$)]
- Average Trip Delay = Total Passenger Trip Delay/#Pax
- Average Disrupted Passenger Trip Delays = Total Passenger Trip Delay/Total Disrupted Passengers

Performance: Hub-n-Spoke Network

- Total Disrupted Passengers =

$(P(D)_{H\text{-}D} * \#Flights_{H\text{-}D} * LF*SC) +$
$(P(D)_{O\text{-}H} * P(MC) * \#Flights_{H\text{-}D} * LF*SC) +$
$(P(C)_{O\text{-}H} * \#Flights_{O\text{-}H} * LF*SC) +$
$(P(C)_{H\text{-}D} * \#Flights_{H\text{-}D} * LF*SC)$

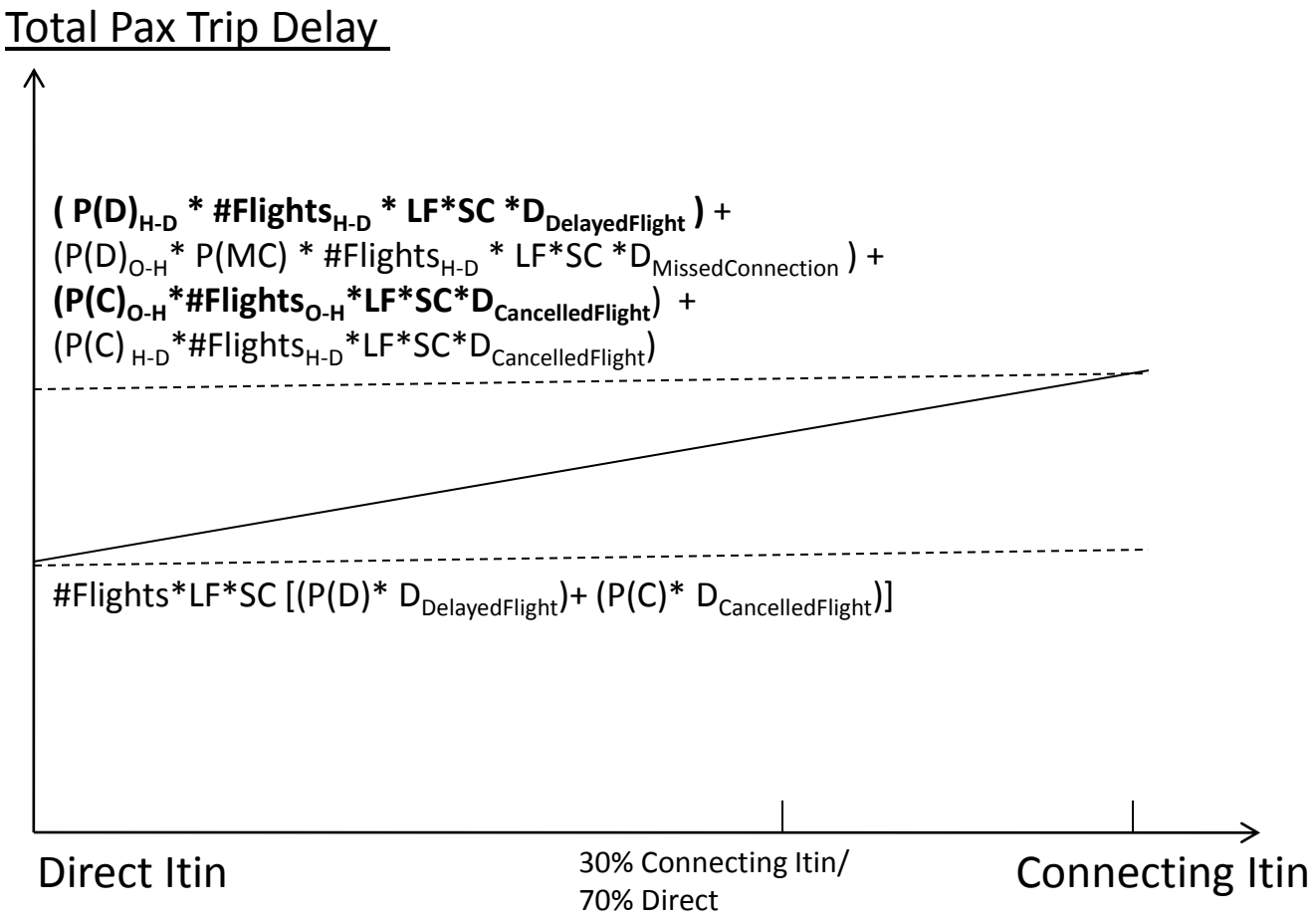
- % Passengers Disrupted = $P(D) + [P(D)*P(MC)] + 2P(C)$

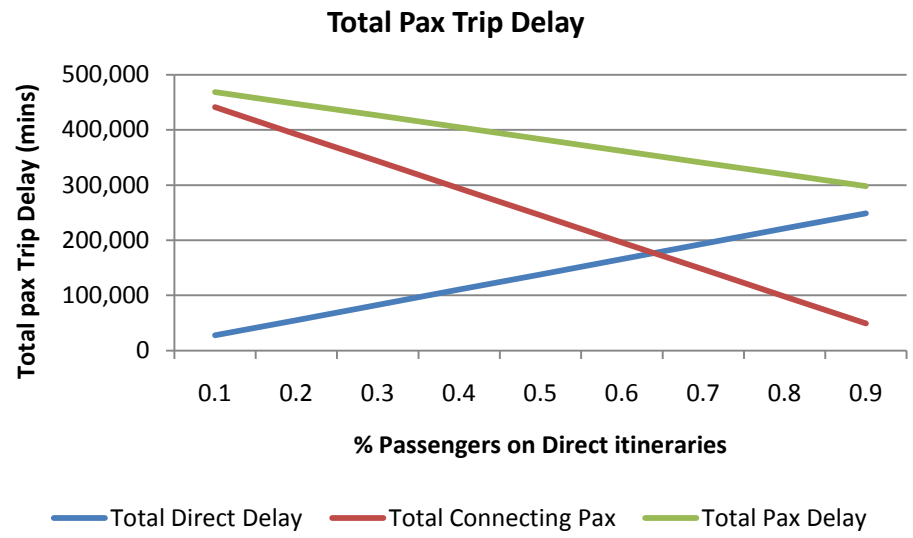
- Total Passenger Trip Delay =

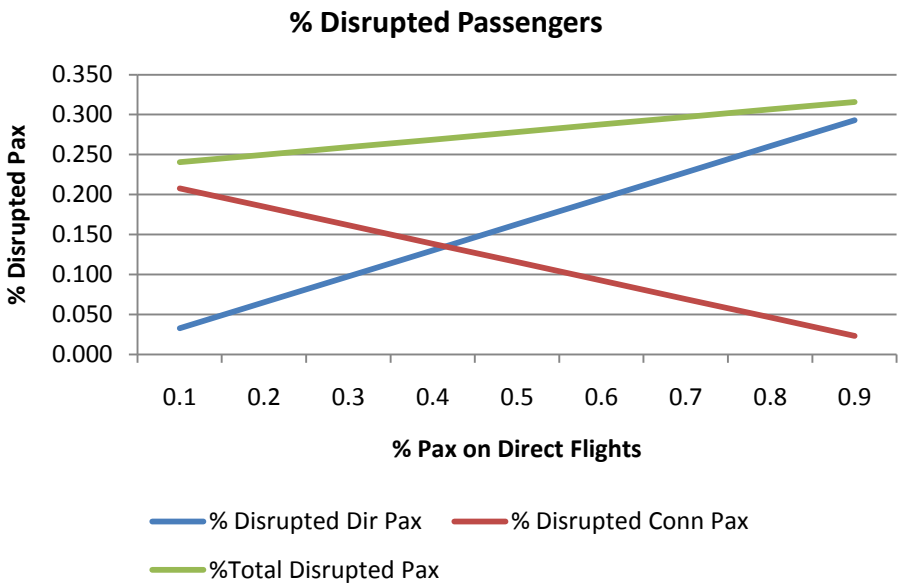
$(P(D)_{H\text{-}D} * \#Flights_{H\text{-}D} * LF * SC * D_{DelayedFlight}) +$
$(P(D)_{O\text{-}H} * P(MC) * \#Flights_{H\text{-}D} * LF*SC * D_{MissedConnection}) +$
$(P(C)_{O\text{-}H} * \#Flights_{O\text{-}H} * LF * SC * D_{CancelledFlight}) +$
$(P(C)_{H\text{-}D} * \#Flights_{H\text{-}D} * LF * SC * D_{CancelledFlight})$

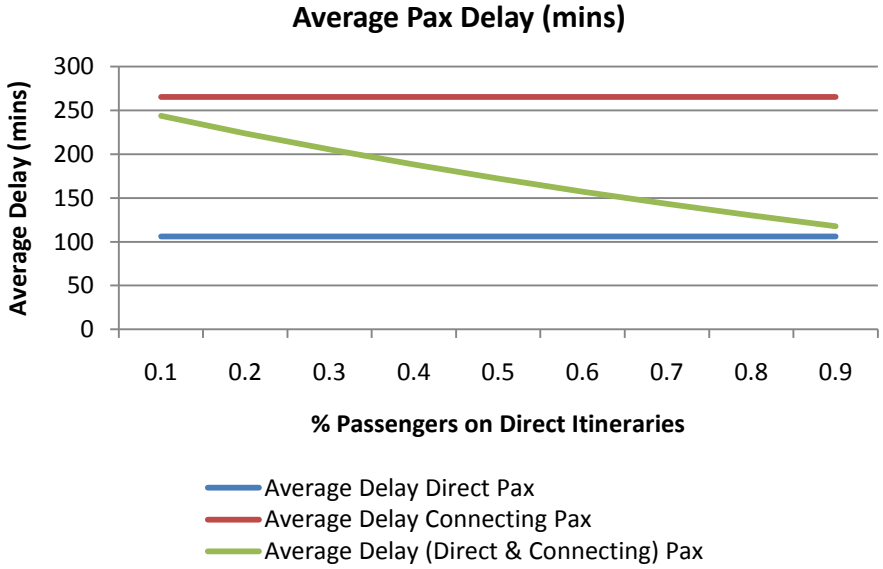
- Average Trip Delay = Total Passenger Trip Delay/#Pax

Network Performance

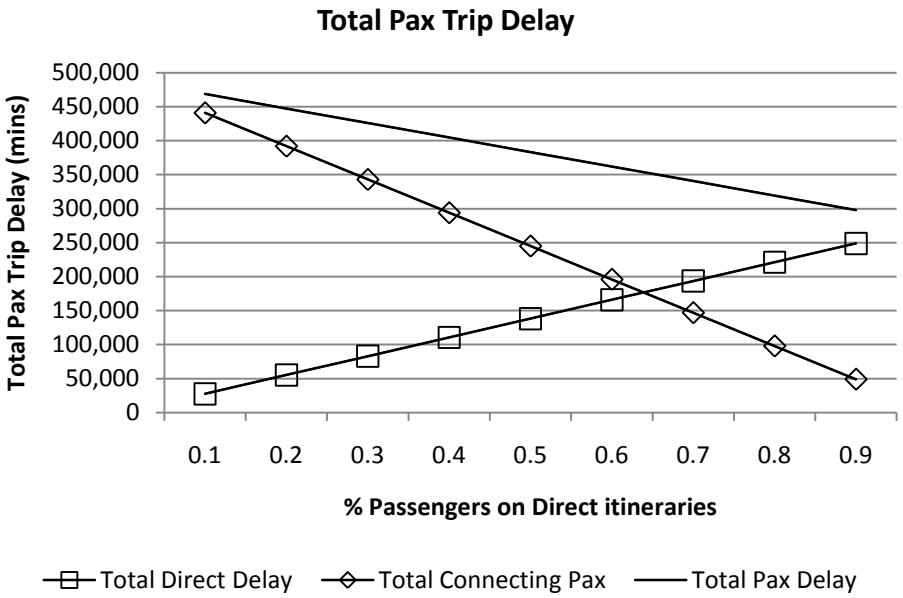


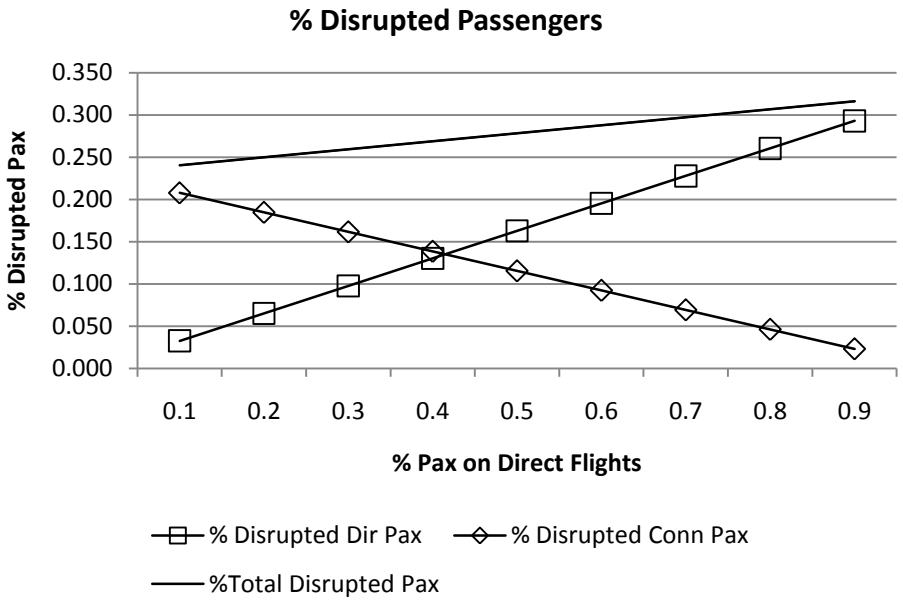


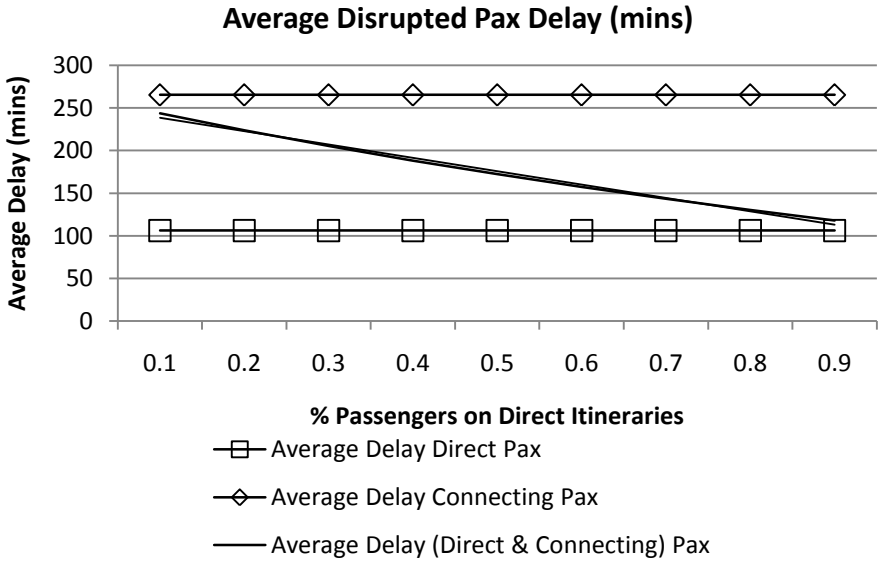


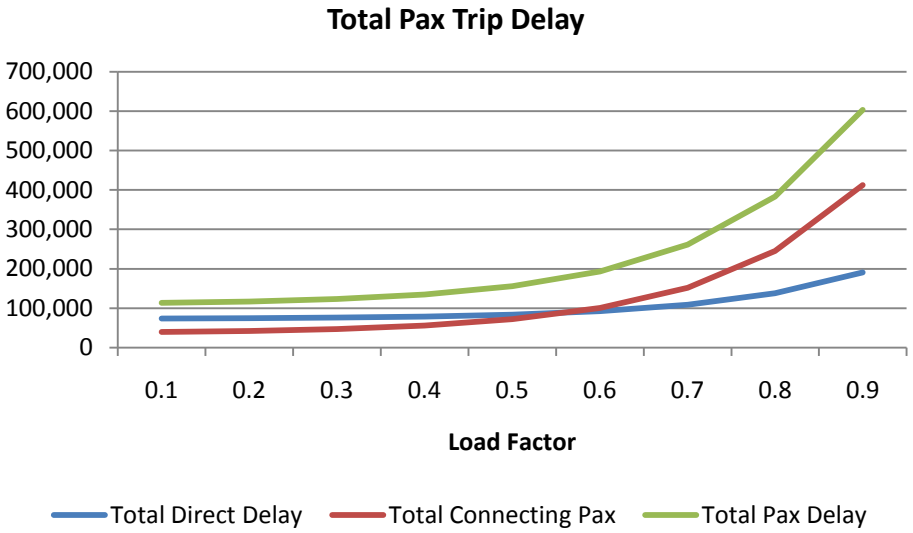


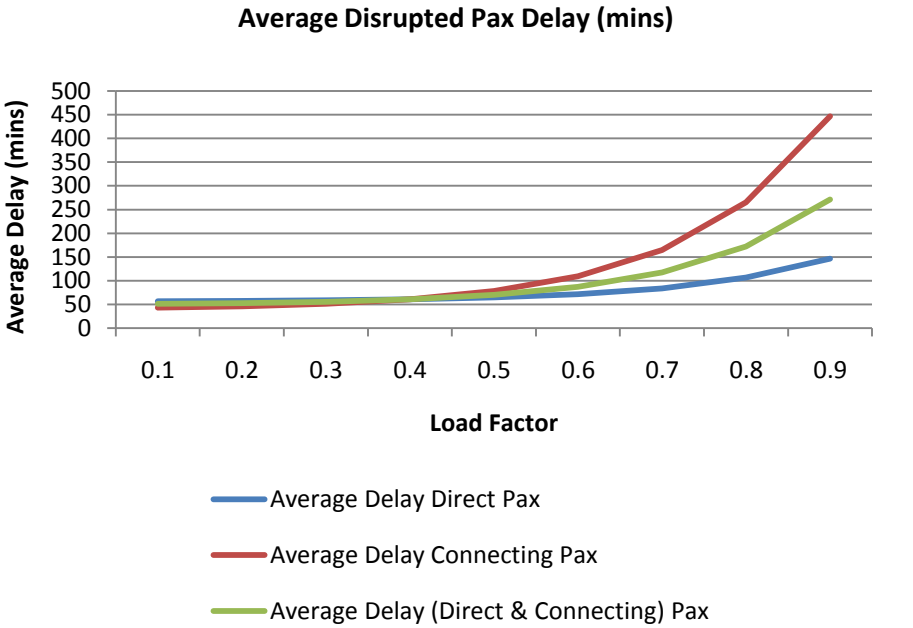
% Passengers on Direct Itineraries

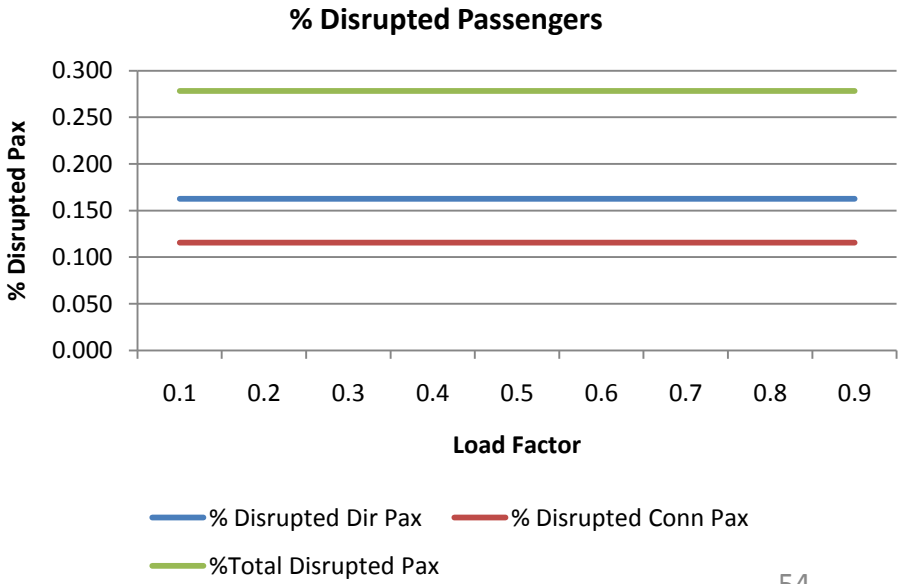

Total Pax Trip Delay
Total Pax Trip Delay (mins)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
% Passengers on Direct itineraries
Total Direct Delay
Total Connecting Pax
Total Pax Delay


% Disrupted Passengers
% Disrupted Pax
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
% Pax on Direct Flights
% Disrupted Dir Pax
% Disrupted Conn Pax
%Total Disrupted Pax

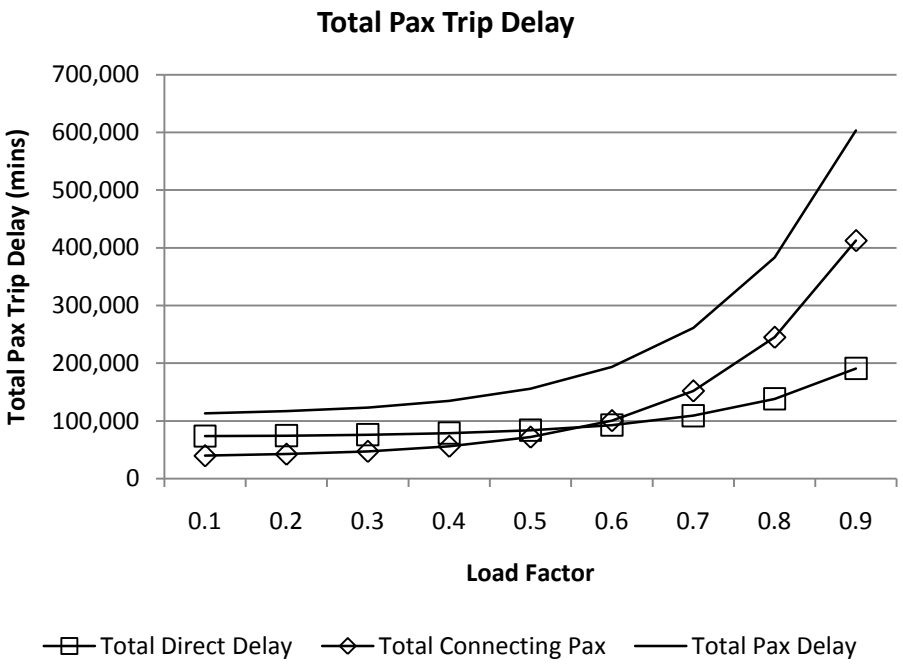

Average Disrupted Pax Delay (mins)
Average Delay (mins)
300
250
200
150
100
50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
% Passengers on Direct Itineraries
Average Delay Direct Pax
Average Delay Connecting Pax
Average Delay (Direct & Connecting) Pax

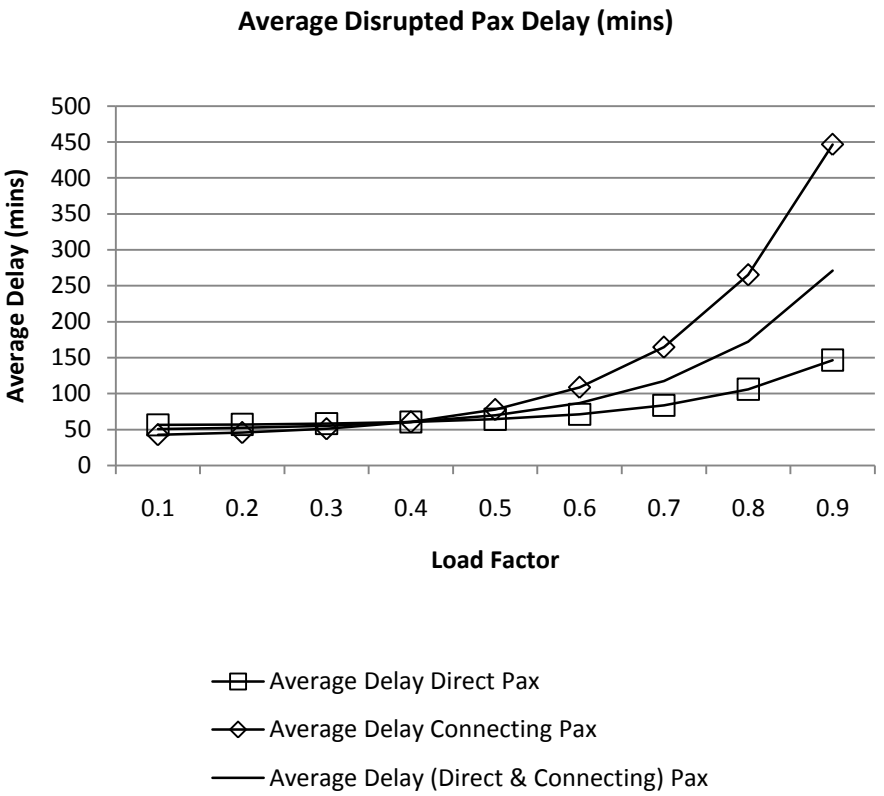

Total Pax Trip Delay
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Load Factor
Total Direct Delay
Total Connecting Pax
Total Pax Delay

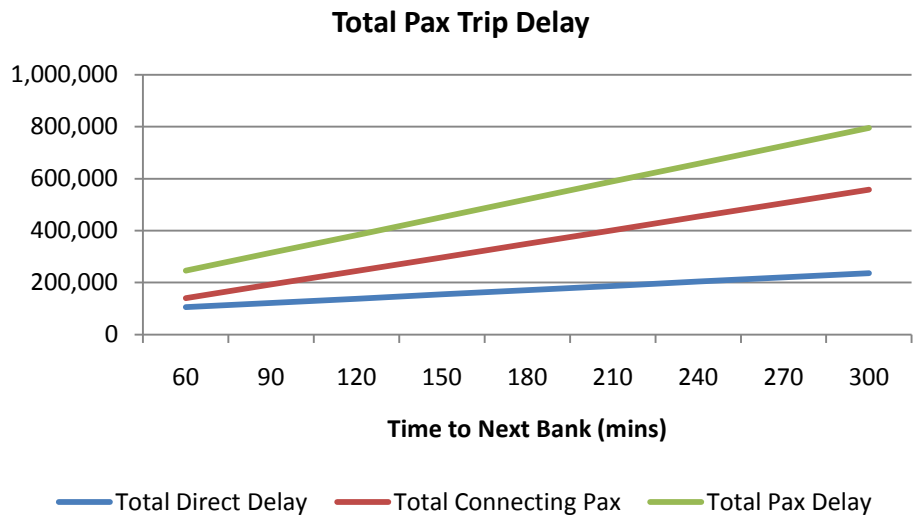

Average Disrupted Pax Delay (mins)
Average Delay (mins)
500
450
400
350
300
250
200
150
100
50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Load Factor
Average Delay Direct Pax
Average Delay Connecting Pax
Average Delay (Direct & Connecting) Pax

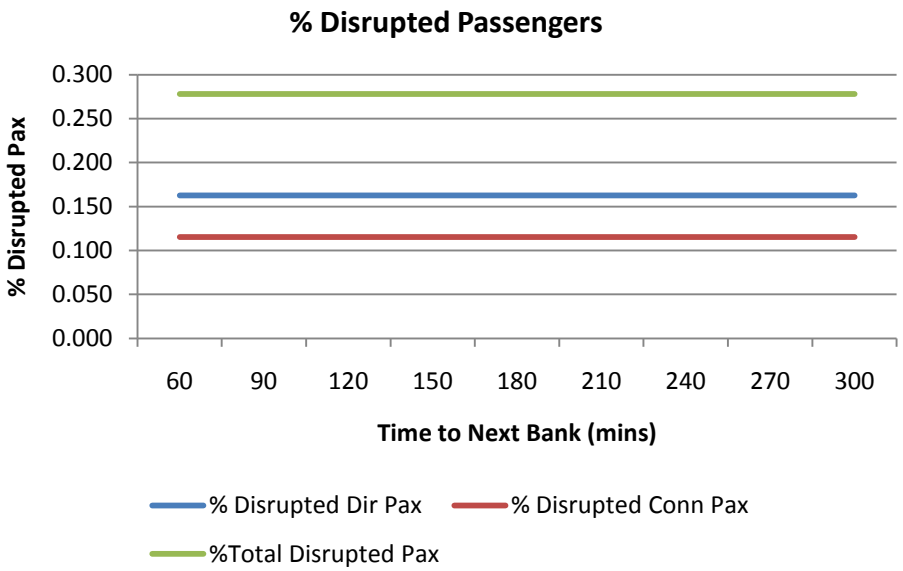

% Disrupted Passengers
% Disrupted Pax
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Load Factor
% Disrupted Dir Pax
% Disrupted Conn Pax
%Total Disrupted Pax

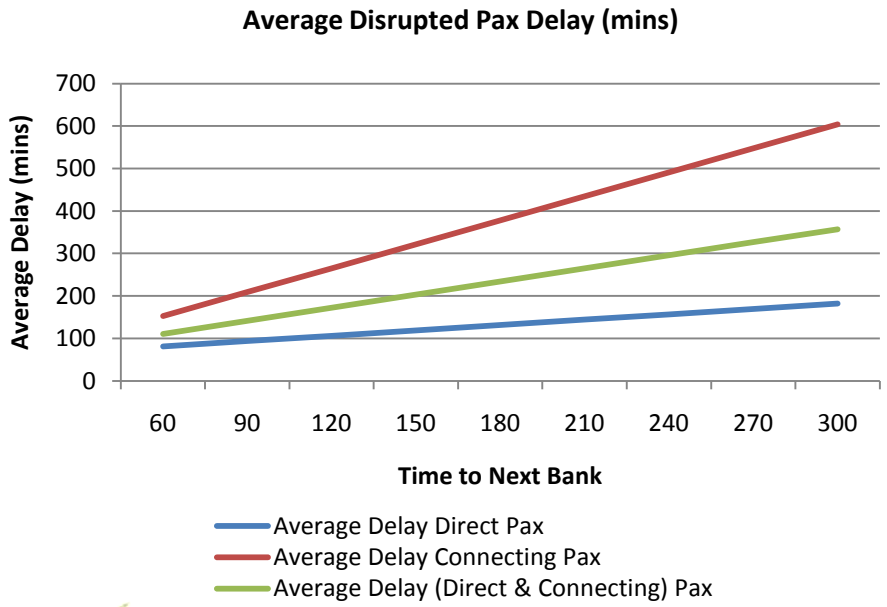
Load Factor


Total Pax Trip Delay
Total Pax Trip Delay (mins)
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Load Factor
Total Direct Delay
Total Connecting Pax
Total Pax Delay

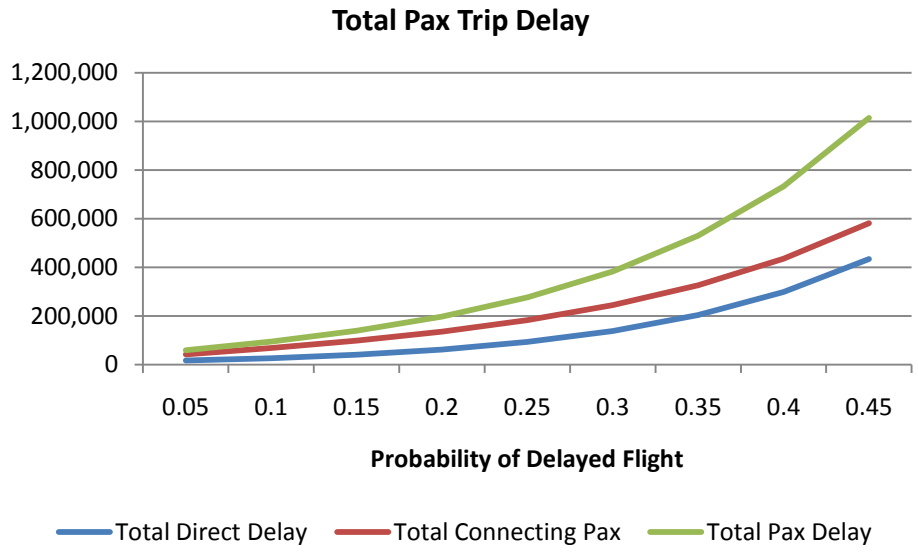

Average Disrupted Pax Delay (mins)
Average Delay (mins)
500
450
400
350
300
250
200
150
100
50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Load Factor
Average Delay Direct Pax
Average Delay Connecting Pax
Average Delay (Direct & Connecting) Pax

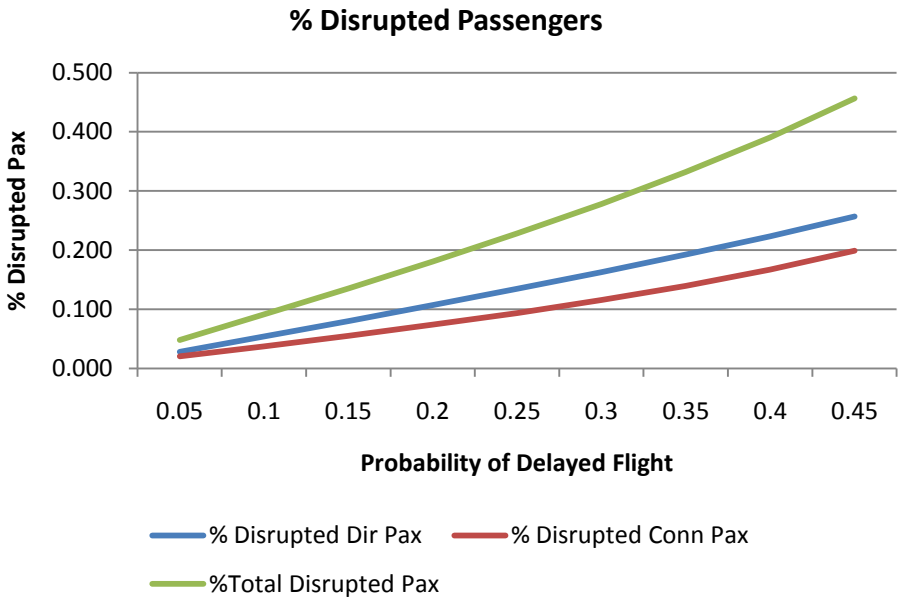


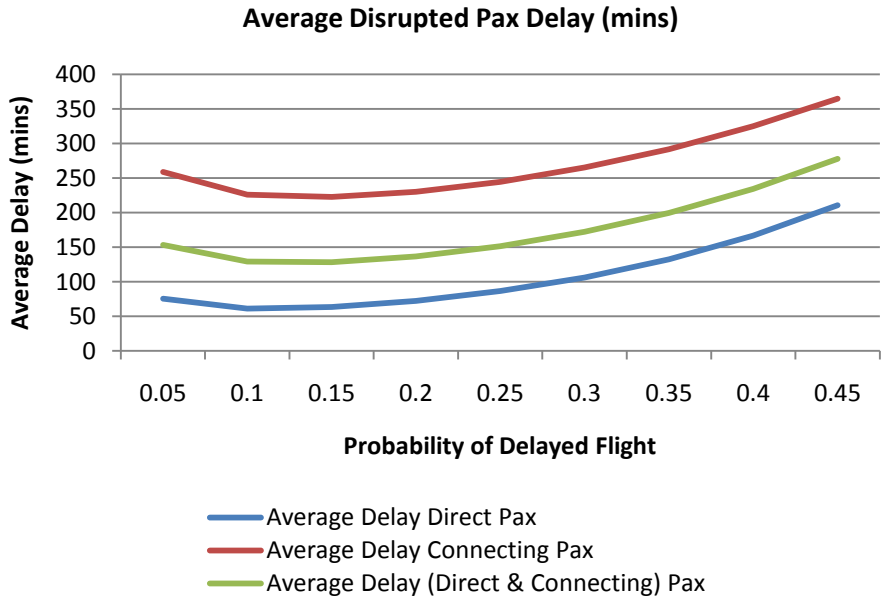




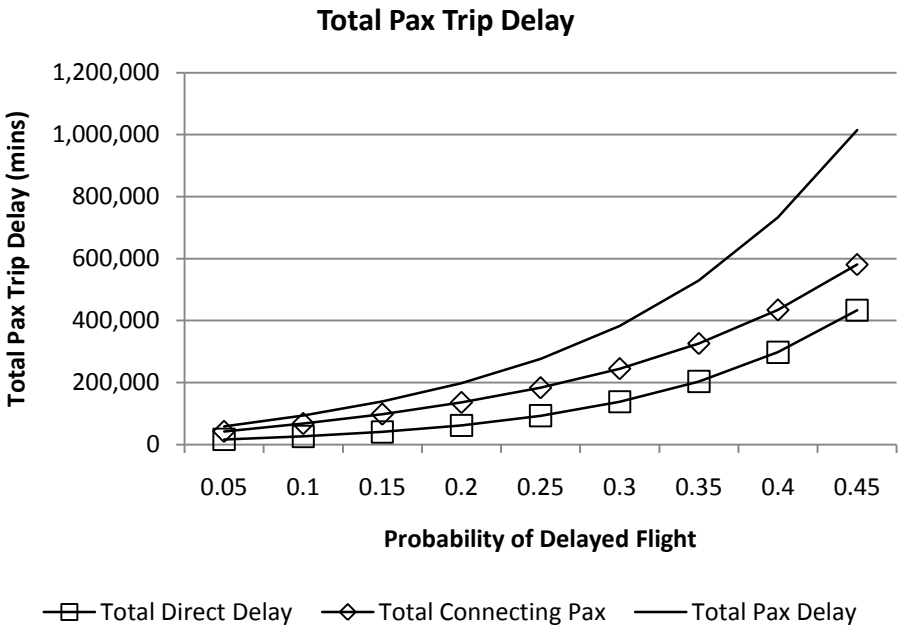
Time to Next Bank

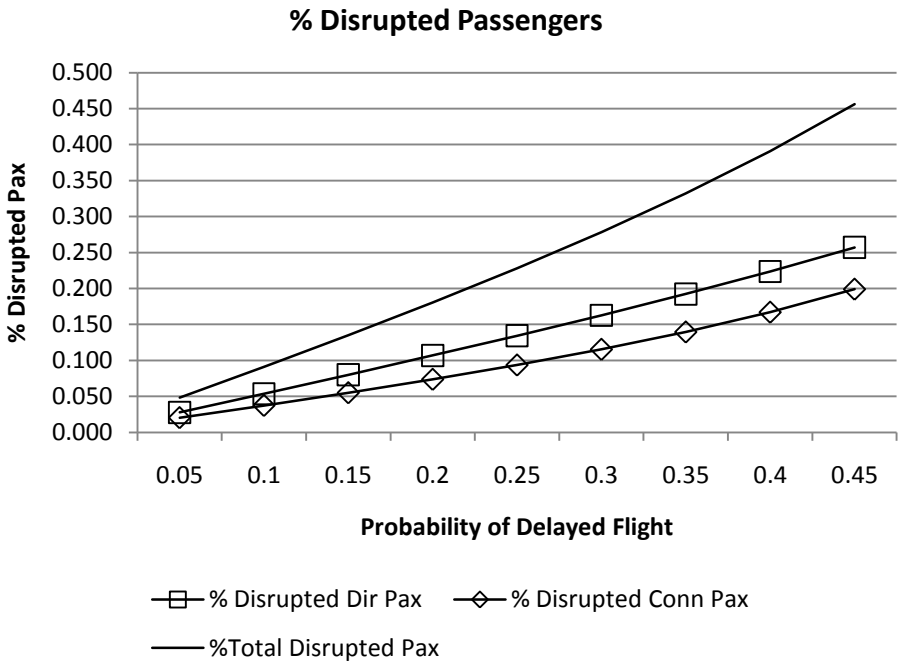

Total Pax Trip Delay
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Probability of Delayed Flight
Total Direct Delay
Total Connecting Pax
Total Pax Delay

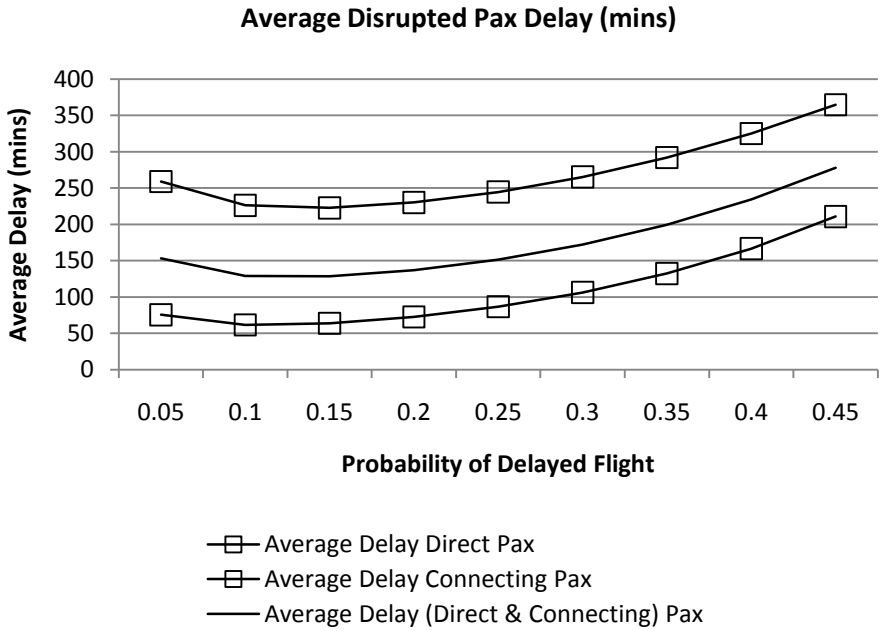

% Disrupted Passengers
0.500
0.400
0.300
0.200
0.100
0.000
% Disrupted Pax
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Probability of Delayed Flight
% Disrupted Dir Pax
% Disrupted Conn Pax
%Total Disrupted Pax

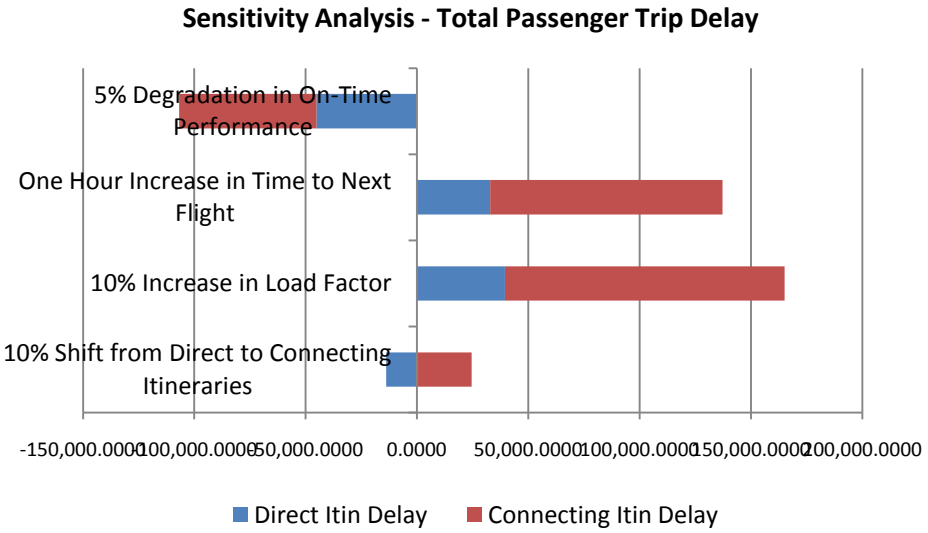

Average Disrupted Pax Delay (mins)
400
350
300
250
200
150
100
50
0
Average Delay (mins)
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Probability of Delayed Flight
Average Delay Direct Pax
Average Delay Connecting Pax
Average Delay (Direct & Connecting) Pax

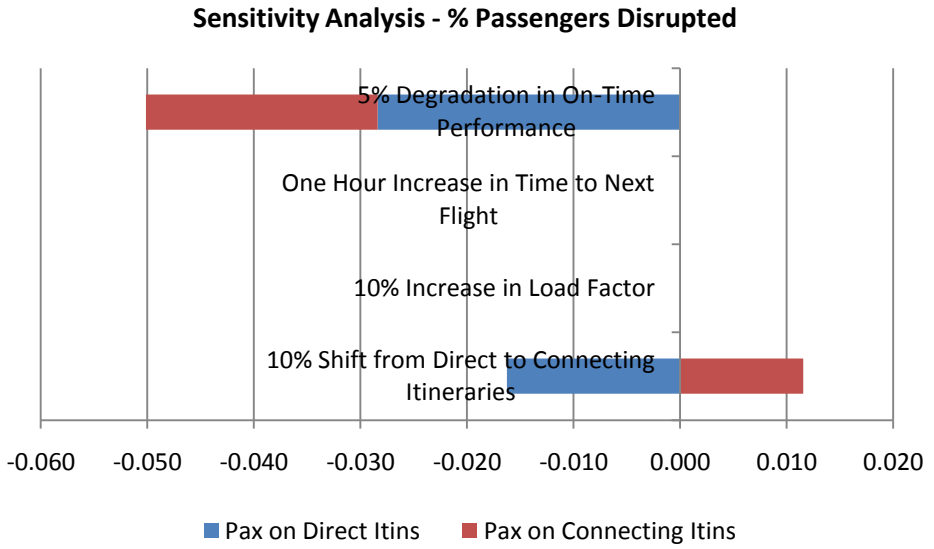
% On-time

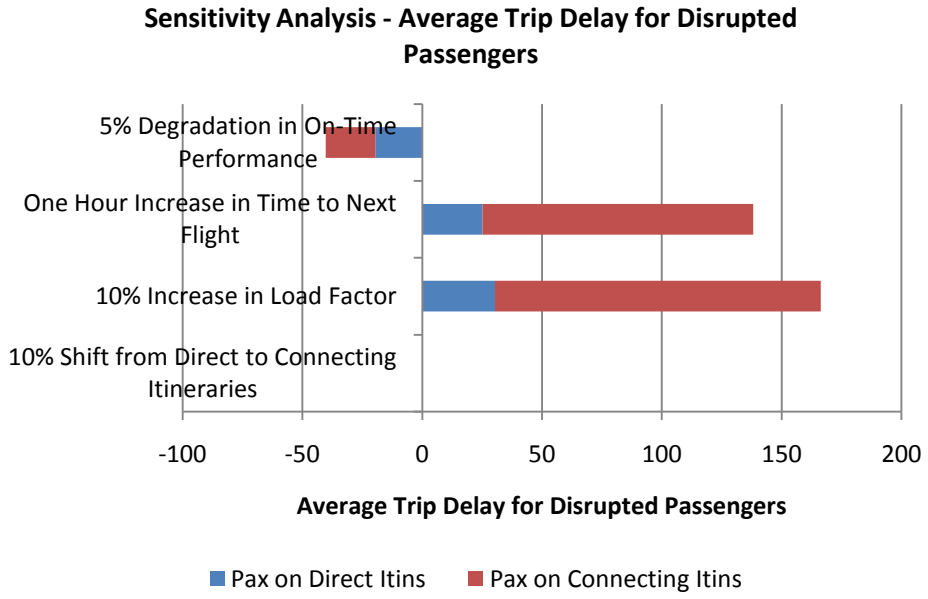

Total Pax Trip Delay
Total Pax Trip Delay (mins)
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Probability of Delayed Flight
Total Direct Delay
Total Connecting Pax
Total Pax Delay


% Disrupted Passengers
% Disrupted Pax
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Probability of Delayed Flight
% Disrupted Dir Pax
% Disrupted Conn Pax
%Total Disrupted Pax


Average Disrupted Pax Delay (mins)
Average Delay (mins)
400
350
300
250
200
150
100
50
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Probability of Delayed Flight
Average Delay Direct Pax
Average Delay Connecting Pax
Average Delay (Direct & Connecting) Pax







Sensitivity Analsysi