QUANTIFYING THE BENEFITS OF PRE-EMPTIVE REBOOKING:
A CASE STUDY FOR A NETWORK CARRIER (JAN 12, 2012)

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Abstract

Changes in technology and procedures have the potential to facilitate improvements in airline passenger mobility in the presence of forecast irregular operations that lead to large scale cancellations. First, increased coordination among National Airspace (NAS) operational stakeholders enables airlines to pro-actively plan for reduced capacity events (e.g. snowstorms, equipment outages, labor shortages). Second, ubiquitous, inexpensive, reliable broadband communications between airlines and passengers increases opportunities for coordination. Coupled together, these changes provide an opportunity for airlines to leverage passenger's willingness to adjust their travel plans by *pre-emptively* rebooking flights up to a day in advance of planed flight cancellations.

This paper describes a Monte Carlo analysis of the feasibility and benefits of pre-emptive rebooking of passengers on cancelled airline flights. A case study for domestic operations of a major U.S. network carrier operating a mid-west hub for a single day cancelation event (January 12, 2012) showed that: (i) pre-emptive rebooking is feasible accommodating 73% of the passengers seeking to rebook pre-emptively, (ii) previous day rebooking is not required as a majority of the passengers (>95%) can be accommodated earlier on the same day, (iii) airlines could have recouped up to $388K by avoiding airfare refunds, and (iv) corporations sponsoring business travel could have saved up to $62.9K. The implications of these results are discussed.

INTRODUCTION

Large-scale airline flight cancellation events are an infrequent occurrence (Figure 1), however when they do occur they can have a significant impact on airline revenue (i.e. refunded tickets), corporate travel expenses (i.e. unbudgeted costs), and passenger inconvenience costs. In many cases, these large-scale events can now be reliably forecast with enough advance warning to facilitate a pro-active response from the airlines.
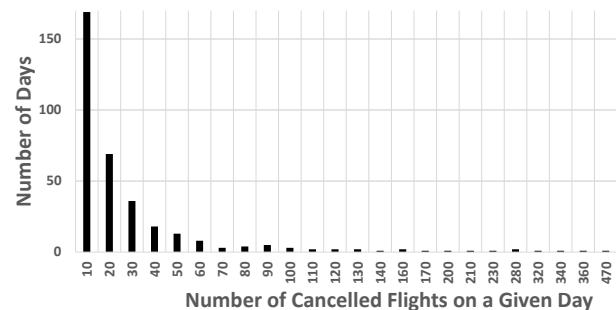

Figure 1. Frequency of occurrence of large-scale airline flight cancellation events for a network carrier in 2012.

The traditional airline *modus-operandi* in the presence of uncertainty in the weather forecast, and the response to the weather by Air Traffic Control and (competing) airlines, is for the airline to adopt a *wait-and-see* approach leading up to the scheduled flight time. In this way it is common practice for the airline to wait until approximately two hours before the scheduled departure time to announce the flight cancellation. Passengers, already at the airport, are then re-booked on alternate flights by on-site customer service agents, or increasingly, self-service kiosks or on-line websites.

Since not all the passengers can be re-accommodated on the same day, a large percentage of passengers must overnight for rebooked flights the following day. This increases travel costs for all passengers and adds unbudgeted travel costs to corporations with employees on business travel. Further, passengers may be eligible for resulting in a loss of revenue for the airline.

With increased coordination amongst National Airspace (NAS) operational stakeholders, there are reduced airport and airspace capacity events (e.g. snow storms, labor shortages, infrastructure closures, equipment failures) in which flights can be cancelled by the airlines well in advance of the scheduled departure time. This coupled with advances in ubiquitous, instantaneous, inexpensive, broadband communication with passengers, allows airlines to leverage passengers willingness to re-schedule flights to better manage these large scale cancellation events.

This paper examines the feasibility of pre-emptive rebooking and the benefits to airlines, passengers, and corporate sponsors of travel. A case-study of a one-day cancellation event of 56 flights impacting 5,250 passengers ticketed on a U.S. carrier operating a mid-west hub on January 12, 2012 showed that:

- pre-emptive rebooking is feasible by accommodating more than 73% of the passengers seeking to rebook pre-emptively

- previous day rebooking is not required as it did not change (<4%) the percentage of passengers rebooked pre-emptively.

- Airlines can recoup airfares that would have to be refunded if not pre-emptively rebooked, to the equivalent of ($7.7K • % passengers Rebooked Preemptively). For example if 51% of the passengers were accommodated pre-emptively, the airline would be able to recoup up to $380K.

- Corporations can save by enabling pre-emptive rebooking for employees on business travel equivalent to ($23K • % Passengers Rebooked Pre-emptively). For example if 51% of the passengers were rebooked preemptively, the total corporate expenses saved would be approximately $62.9K.

- Passengers opting for pre-emptive rebooking did not experience longer trip times than their original ticketed trip time.

- Pre-emptive rebooking is robust to passenger selection. Random selection of passengers for pre-emptive rebooking did not results in significant variance in percentages of categories of rebooking (e.g. previous day, same day early, same date later, and next day).

These results show that the combination of airline passengers travel flexibility, reliable airline-passenger communication, and pro-active Air Traffic Flow Management can yield a win-win for airlines, passengers and corporations that rely on business travel.

This paper is organized as follows: Section 2 describes the concept-of-operations. Section 3 describes the method of analysis. Section 4 describes the results of a case-study for one day for a large U.S. network carrier. Section 5 discusses the implications of these results.

PRE-EMPTIVE REBOOKING CONCEPT-OF-OPERATIONS

The traditional concept-of-operations is for the airline to wait until a few hours before departure time to cancel the flight. There are several reasons for this. First, cancelling as late as possible leaves as many options open for the airline to achieve an on-time flight through aircraft swapping (in the case of a maintenance issue), or slot allocation (in the case of an ANSP coordinated delay program). Second, up until now there was no way to rapidly, inexpensively contact passengers and re-

accommodate them to suit their individual needs.

Collaborative decision-making has changed the way flight operations are managed from a reactive to a pro-active *modus-operandi*. Capacity shortfalls at airport runways are now identified at the start of the day. In some cases, in the event of a planned shutdown (e.g. runway closure) or predictable severe weather (e.g. heavy snow storm), the impacted flight operations can be identified 48 to 72 hours in advance. As a result, flights that are planned to be cancelled are known well in advance.

The internet coupled with interactive airline reservation systems and broadband/wireless communication now enables airlines to contact and coordinate changes in reservations rapidly at low cost considered unimaginable a decade ago.

These factors have all conspired to provide an opportunity to change the paradigm and facilitate more choice in addressing irregular operations from a passenger standpoint. The sequence of events from a passenger view point for the traditional and proposed mode of operations are described below and summarized in the Event Sequence diagram in Figure 2.
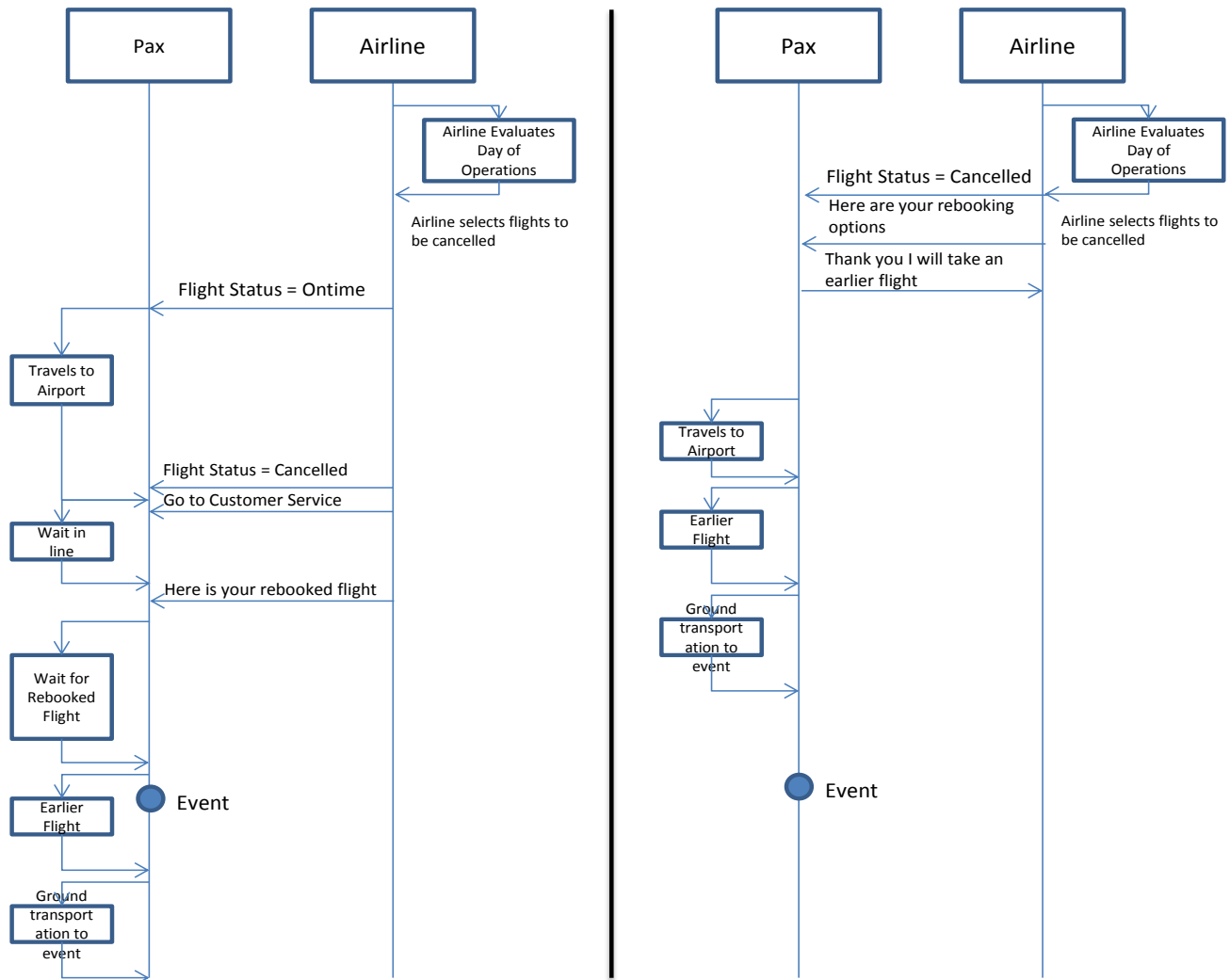

Figure 2: Summary of Concept-of-Operations without (left) and with (right) Pre-emptive Rebooking

(Traditional) Irregular Operations Rebooking Sequence of Events

The airline starts the day with an assessment of expected operations. On days where flights must be cancelled due to severe weather events or ANSP delay programs, the flights that are likely to be affected (e.g. cancelled or delayed) are identified. Due to the uncertainty in the airspace system, the airlines keeps their options open by listing the flight status to the ANSP and passengers as scheduled on-time.

Within approximately two hours of scheduled departure time, the airline publicly announces the cancellation of the flight to the ANSP and to the passengers. The information to passengers is posted on airport flight status monitors and airline websites. A "flight status" text message, email or voicemail is sent to passengers.

At this time, most airline's reservation systems, unilaterally automatically rebook the passenger based on next available flight. Preference is given to passenger considered high value passengers by Frequent Flyer status or other indications. The initial rebooking is made to expedite airline operations.

At this time the passengers can use customer service agents at the airport, reservation kiosks at the airport, or airline websites to accept or renegotiate the rebooking.

Unless a destination has "shuttle" operations with high frequency, it is likely that the passenger on an itinerary with a cancelled flight will have to wait a significant amount of time (e.g. > 3 hours) for the next flight. Further, passengers on an itinerary with a cancelled flight late in the day will generally be required to overnight.

In some cases the passenger, will not arrive at the destination in time for an event on the same day as the ticketed flight.

Pre-emptive Irregular Operations Rebooking Sequence of Events

In this scenario, the airline starts the day with an assessment of expected operations. On days where flights must be cancelled due to severe weather events or ANSP delay programs, the flights that are likely to be affected (e.g. cancelled or delayed) are identified. Due to the level of collaboration and planning available from the ANSP, the airline immediately lists the flight status to the ANSP and passengers as cancelled.

At this time, the airline proactively contacts the passenger and offers pre-emptive rebooking options. The passenger selects the option that works best, *under the circumstances of the planned travel*, for the individual passenger.

The passenger adjusts their personal schedule and is able to take advantage of the proactive rebooking and arrive on-time for their event at the destination.

METHOD OF ANALYSIS

To analyze the impact of pre-emptive rebooking strategies the PTD Calculator [5], [6] is embedded in a Monte Carlo Simulation (Figure 3). The PTD Calculator, Monte Carlo Simulation, and the Design of Experiment are described in this section.

Passenger Trip Delay Calculator

The "Passenger Trip Delay Calculator (PTDC)" is used to generate statistics for trip delays for each ticketed passenger itinerary [5] [6]. The PTDC takes as an input each individual passenger itinerary. This includes both direct itineraries and connecting itineraries. The itineraries are compared with actual performance of the flights associated with the itinerary. If a flight is on-time, no passenger trip delay is accrued. If a flight is simply delayed, the passenger delay in excess of 15 minutes is calculated. If a flight is cancelled or if a passenger on a connecting
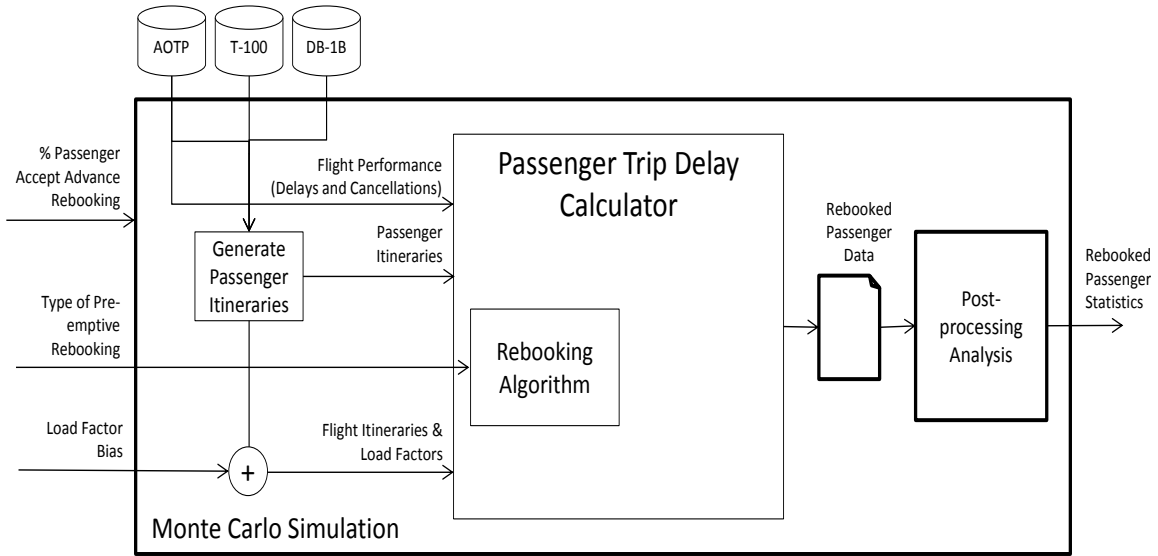
Figure 3: PTD Calculator, embedded in a Monte Carlo Simulation.

itinerary misses their connection (due to a delay on the flight to the connecting hub airport), then the passengers are rebooked.

Passengers are rebooked on flights operated by the same airline or their subsidiaries with departure times after the scheduled departure of the cancelled or miss connected passenger. Passengers are not accommodated on the same day, are considered "overnight" passengers. These passengers are rebooked on the following day on the same airline and its subsidiaries. Passengers that cannot be accommodated in this way after 2 days are considered "not rebooked passengers."

The ability to get rebooked is dependent on the availability of flights from the passenger's location (i.e. origin airport or hub airport) to their destination, as well as the availability of seats on those flights. In this way the Seat Size of the aircraft along with the Load Factor (i.e. % seats occupied) determines the ability for passengers to get rebooked.

Metrics for Pre-emptive Rebooking

Passenger Trip Delay (*PTD*) is a measure of the delay between each passenger's scheduled arrival time and their actual arrival time (assuming that a window of up to 15 minutes is not considered a delay). If a passenger arrives before the ticketed time (either due to preemptive rebooking, or an early arrival), the PTD is zero.

$$PTD = \sum_{i=1}^{n} \max(0, ActArrival(i) - SchArrival(i) - 15\text{min})$$

where:

i: Itinerary, assuming that there are *n* itineraries, numbered 1 through *n*.

SchArrival (i): Scheduled arrival time of passenger (i)

ActArrival(i): Actual arrival time of passenger (i)

Change in Total Trip Time (ΔTTT) is a measure of the difference in trip time from the original schedule to the rebooked schedule.

$$\Delta TTT = TTT_{Rebooked} - TTT_{Sch}$$

where:

Total Trip Time (*TTT*) is a measure of the time that each passenger is scheduled to travel, from initial departure to final arrival.

$$TTT_{Original} = \sum_{i=1}^{n}[SchArrival(i) - SchDeparture(i)]$$

$$TTT_{Rebooked} = \sum_{i=1}^{n}[SchArrival_{Reb}(i) - SchDeparture_{Reb}(i)]$$

Airfares Not Refunded (ANR) is the difference in Airfare refunded by the airline without pre-emptive rebooking and with pre-emptive rebooking.

*ANR= [PAX$_{RebND}$ (No pre-emptive) - PAX$_{RebND}$ (Pre-emptive)] * \$377*

Where:

PAX_{RebND}: Number of passengers rebooked Next Day.

$377 is the average airfare (Source: Bureau of Transportation Statistics, BTS Air Fares).

Corporate Travel Expense Savings (*CTES*) is the difference additional travel expenses accrued by corporate travelers without pre-emptive rebooking and with pre-emptive rebooking that are required to overnight due to rebooking the next day. The additional cost for an overnight stays is estimated to be $250 ($160 for hotel accommodation and $90 for food and transportation expenses). It is assumed that 50% of the passengers are not at their home town airport and would require overnight hotel accommodation. Further 50% of these passengers are travelling on corporate expense accounts.

CTES($) = 250 • (PaxRebookedND (No Premp) – PaxRebookedND (Preemptive) • 0.5 •0.5

Monte Carlo Simulation

To achieve the objectives of the analysis various parameters that are inputs to the PTDC are modified over multiple runs in the Design of Experiment (see below). Parameters that are modified include:

- Passengers selected for pre-emptive rebooking is chosen randomly from a uniform distribution (i.e. on each run of the Monte Carlo simulation, each passenger has equal likelihood of being selected for pre-emptive rebooking)

- Percentage of passengers that seek a pre-emptive rebooking option.

- The time in advance that the pre-emptive rebooking option is made available to passengers (i.e. Same Day Earlier, or Previous Say and Same Day Earlier).

The Monte Carlo Simulation is executed 25 times for each replication. The results are stored and then used to generate statistics by a processing algorithm.

Design of Experiment

The Design of Experiment for the case-study for a domestic, mid-west based carrier with a 56 flight cancellation event on January 12, 2012 is shown in Table 3. Two preemptive rebooking options are considered: (1) Same Day Earlier (ticketed scheduled departure time), and (2) Previous day and Same Day Earlier. The percentage of passengers rebooking is incremented from none (i.e. 0%), 10%, 30%, 50%, 70%. The 0% is the baseline (i.e. no pre-emptive rebooking).

CASE-STUDY RESULTS

A case-study was conducted for the scheduled domestic flights for a U.S. network carrier operating from a mid-west hub for an event on January 12, 2012. Snow accumulation of 4.7" started around Noon and lasted through the evening [2]. There were a total of 56 cancelled flights to or from the hub airport (Figure 4) impacting an estimated 5250 passengers (Table 1).
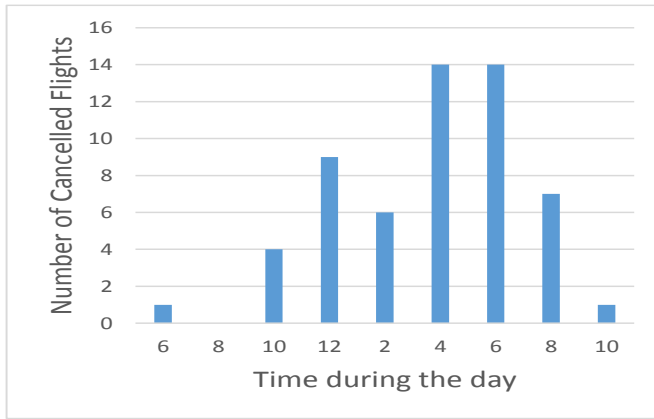
Figure 4 Cancelled flights by time of day for Jab 12, 2012 for a mid-west Network Carrier

The average load factor was 80% with a minimum of 32% and maximum of 96% (Table 2).

Table 1: Flight statistics, for the event January 12, 2012

%Flights Cancelled	Cancelled Flights	Passengers	Passengers on the Cancelled Flights
16.4%	56	29,052	5,250

Table 2: Load Factor Statistics, January 12, 2012

LF percent	Number of cancelled flights (with Origin/Destination in the hub)	Number of flights	Number of flights with Origin/Destination in the hub
0-50%	0	24	3
50%-60%	3	92	22
60%-70%	24	163	75
70%-80%	19	446	97
80%-90%	10	617	133

The statistics for pre-emptive rebooking for January 12, 2012 are shown in Table 3.

Baseline Rebooking (After Cancelled Flight)

For the existing re-booking paradigm, assuming all passengers are to be rebooked, 55% of the cancelled passengers are accommodated with seats on the same day after the departure time of the cancelled flight (Table 4). Forty-three percent must be rebooked on flights the following day. Approximately 1% of the cancelled passengers cannot be rebooked due to the absence of available seats to their desired destination. The upper bound for refunded airfares is $833K. The upper bound for unplanned (i.e. unbudgeted) Corporate Travel Expenses is $292.8K.

Pre-emptive Rebooking Same Day Before

Monte Carlo simulation of randomly selected passengers seeking pre-emptive rebooking for the cancelled flights were accommodated 72.89% of the time (σ=6%). The relationship between the percent of Pre-emptively Rebooked Passengers and the percent of Passengers seeking Pre-emptive Rebooking is as follows (R^2=0.996):

*% Pax Preemptively Rebooked = 0.7289 * % Pax Seeking Rebooking*

For example, for this case study, when 10% of the passengers pursued pre-emptive Same Day Early Rebooking, 7.2% were accommodated. When 70% of the passengers pursued pre-emptive Same Day Early Rebooking 51% were accommodated.

For the passengers that sought pre-emptive rebooking but could not be accommodated, it was due to the absence of seats on flights, not the absence of itineraries.

Pre-emptive rebooking accepted by random passengers from the cancelled flights has the effect of freeing-up seats on flights after the cancelled flight. This allows passengers that would otherwise be rebooked the next day to rebooked on the same day. The <u>% Reduction in Pax Rebooked on the Next Day</u> as a function of the % Passengers Rebooked Pre-emptively is

Table 3: Results for January 12, 2012 Cancellation Event

Treatment		Results							
Pre-emptive Rebooking Time	% Passengers Attempting to Rebook before Cancelled Flight	% Cancelled Pre-emptive Rebooked Previous Day	% Cancelled Pre-emptive Rebooked Same Day Before Cancelled Flight	% Pax Rebooked Same Day After Cancelled Flight	% Pax Rebooked Next Day	% Pax NOT Rebooked	Total Cost to Passengers $K)	Maximum Airline Revenue not Refunded ($K)	Corporate Travel Expense Saving $K)s
Same Day Before	0%			55%	43%	1.04%	228.8		
	10%		7.2%	50.9%	40.7%	1.04%	213.9	76.6	25.4
	30%		21%	41.8%	35.3%	1.04%	185.3	184.6	61.2
	50%		36%	32.3%	30.25%	1.04%	158.8	284.5	94.3
	70%		51%	22.5%	25.4%	1.04%	133.5	379.9	125.9
Dame day Before plus Previous	0%			55%	43%	1.04%	228.8		
	10%	0.64%	7.25%	50.85%	40.32%	0.9%	211.7	85.2	28.3
	30%	1.98%	21.9%	41.7%	33.7%	0.72%	177.1	215.7	71.5
	50%	3.3%	36.4%	32.1%	27.6%	0.54%	145.0	336.5	111.6
	70%	4.56%	50.9%	22.3%	22.3	0.44%	117.4	440.7	146.2

represented by the equation below (R^2 = 0.9987).

*% Reduction in Pax Pre-emptively Rebooked on the Next Day = 0.35 * %Pax- Pre-emptively Rebooked +0.12*

For example, for this case study, the pre-emptive rebooking of 7.2% of the passengers reduced the percentage of passengers rebooked overnight by 14%. The pre-emptive rebooking of 51% of the passengers, reduced the percentage of passengers rebooked overnight by 29.9%%.

Pre-emptive rebooking also has the effect of reducing the number of overnight passengers that could be eligible for airline refunded tickets. The upper bound for Airfares Not Refunded (ANR) to passengers is represented by the following relationship:

*ANR ($) = 7,703 * % Pax Preemptive Rebooked*

For example, the upper bound of ANR when 7.2% of the passengers are pre-emptively rebooked is $76.6K. The upper bound of ANR when 51% of the passengers are pre-emptively rebooked is $379.9K.

Pre-emptive rebooking also has the effect of reducing the number of overnight passengers that could accrue unbudgeted Corporate Travel

Expenses. The upper bound for <u>Corporate Travel Expense Savings (CTES)</u> is represented by the following relationship ($R^2 = 0.998$):

CTES ($) = 1,1147* % Pax Preemptive Rebooked

For example, the upper bound of CTES when 7.2% of the passengers are pre-emptively rebooked is $12.4.7K. The upper bound of ANR when 51% of the passengers are pre-emptively rebooked is $62.9K.

Pre-emptive Rebooking Same Day Before Plus Previous Day

Randomly selected passengers seeking pre-emptive rebooking for the cancelled flights were accommodated 79% of the time ($\sigma=6\%$). The relationship between the percent of Pre-emptively Rebooked Passengers and the percent of Passengers seeking Pre-emptive Rebooking is as follows ($R^2=0.996$):

% Pax Preemptively Rebooked = 0.7932 * % Pax Seeking Rebooking

For example, for this case study, when 10% of the passengers pursued pre-emptive Same Day Early Rebooking, 7.9% were accommodated. When 70% of the passengers pursued pre-emptive Same Day Early Rebooking 55.4% were accommodated.

For the passengers that sought pre-emptive rebooking but could not be accommodated, it was due to the absence of seats on flights, not the absence of itineraries.

These results were a 4% increase over the Pre-emptive Rebooking for the Same Day before only. The benefits of Previous Day rebooking are marginal.

Pre-emptive rebooking also has the effect of reducing the number of overnight passengers that could be eligible for airline refunded tickets. The upper bound for <u>Airfares Not Refunded (ANR)</u> to passengers is represented by the following relationship ($R^2=0.983$):

ANR ($) = $8.987K * Pax Preemptively Rebooked

For example, the upper bound of ANR when 7.2% of the passengers are pre-emptively rebooked is $85.2K. The upper bound of ANR when 51% of the passengers are pre-emptively rebooked is $440.7K.

Pre-emptive rebooking also has the effect of reducing the number of overnight passengers that could accrue unbudgeted Corporate Travel Expenses. The upper bound for <u>Corporate Travel Expense Savings (CNES)</u> is represented by the following relationship ($R^2 = 0.983$):

CTES($) = 1.349K * % Pax Preemptively Rebooked + 5.4K

For example, the upper bound of CTES when 7.2% of the passengers are pre-emptively rebooked is $14.1K. The upper bound of ANR when 51% of the passengers are pre-emptively rebooked is $73.1K.

CONCLUSIONS

Pre-emptive rebooking in advance of forecast large-scale cancellation events is feasible. At least 72% of the passengers seeking pre-emptive rebooking can be accommodated before their original scheduled flight time. The remaining 28% of the passengers cannot be re-accommodated due to insufficient seats.

Pre-emptive rebooking on the previous day was not required. Rebooking on the previous day did not significantly change the percentage of passengers re-accommodated.

Pre-emptive rebooking also creates a win-win for all the stakeholders. Airlines are able to recoup up to *$7.7K • %Passengers Rebook Preemptively* that otherwise might be refunded. Corporations sponsoring business travel for their employees also benefit by saving up to *$1.3K • %Passengers Rebook Preemptively* through unbudgeted overnight costs.

Pre-emptive rebooking was also robust to passengers seeking pre-emptive rebooking. The random selection of passengers did not result in significant variance of the percentage of passengers rebooked in each category.

In preliminary focus group discussions with "frequent fliers" there was unanimous approval of the concept. These consumers described removing anxiety and uncertainty out their travel scenarios and creating a sense of trust/loyalty with an airline that could provide this level of flexibility.

There is also an opportunity for airlines to generate additional revenue by offering a for-fee option that would move passengers to the front of the preemptive rebooking queue in the event of a large scale event [4].

Future work includes analysis of multiple days of large scale flight cancellations with alternative flight cancellation profiles and passenger itinerary profiles. Airlines with different route structures and cancellation policies will be examined as well. Further adjustments to ANR and CTES shall be made to account for airline refund policies and the potential for loss of revenue by rebooking into seats that might otherwise be sold at a premium for last minute ticket purchases.

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