ATC Zero: Estimating the Impact of the Chicago Control Center Fire

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March 30, 2015

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Abstract

On September 26, 2014, the Chicago Air Route Traffic Control Center went offline for seventeen days. Brian Howard, a disgruntled contractor, had set fire to the intricate communications network that controls some of the busiest airspace in the country. Ninety-one thousand square miles of air space were affected as workers scrambled around the clock to restore functionality to the center. This paper seeks to analyze the true economic impact of the event, including the costs of time, fuel and operational expenses. This paper also seeks to answer a more general question—what are the economic and environmental implications of an "ATC Zero" event?

1 Introduction

Beyond the immediate implications of an emergency event at one of the nation's busiest airports, every delayed and canceled flight carries with it its own blow to the economy—travelers do not infuse their destination with tourism dollars and frustrated fliers sit idly or make alternate arrangements, losing valuable time. Airlines waste fuel rerouting planes, circumnavigating ground stops[1], and circling airspace as they are metered into airports. They also lose business as customers find other means to get to their destinations. Thus, every hour an airport is under a Traffic Management Initiative (TMI)[2] results in an economic impact which can be measured.

In this particular incident, serious fire damage required a massive 24/7 effort to replace twenty racks, three hundred eighty-five telecommunication circuits and ten miles of cable as well as clean-up from the soot and water damage [6]. Traffic in the Chicago airspace wasn't impacted for just hours; it was affected for seventeen continuous days.

Because the Chicago ARTCC was offline, 91,000 square miles of airspace were in the dark at normal cruising altitudes (above 10,000 feet). This meant that until the center could be restored, traffic would have to be routed through TRACON[3] airspaces (which normally control traffic up to 10,000 feet or within about 40 miles of the airport). See Figure 1 for a visual of how air traffic is managed. Figure 2 shows the Chicago ARTCC airspace. Generally, an ATC goes to zero for minutes or hours. The fire at the Chicago Center was unprecedented. Because the communications network had been destroyed, controllers at the TRACONs had to map flight plans by hand and read every clearance to all controlling agencies before releasing an aircraft [6]. The controllers at the Chicago Center were dispersed among the regional TRACONs to assist with their higher flight volumes.

2 Methods

Flight data was obtained through the Bureau of Transportation Statistics for September and October of 2014 [8] for Chicago O'Hare (ORD) and Midway (MDW) airports for commercial passenger flights only. The data was combined and then manipulated using Microsoft Access in order to sort

[1]A ground stop requires all flights scheduled to arrive at a location to be held at their departure locations until the stop is lifted

[2]TMIs include ground stops, ground delay programs, and special traffic management programs

[3]Terminal Radar Approach Control

for arrivals into and departures originating from ORD and MDW airports. This information was further delineated into two groups for each category of arrivals and departures: flight data from the date of the incident through the date in which systems were restored (September 26 to October 13) and all other data from September and October prior to and after the incident which was then used to normalize the data from the disruption.

2.1 Normalizing the Flight Data from the ATC Zero Event

In order to compare the impact of the disruption, the data prior to and after the event was used as the normalizing data (a total of 44 days). As an example, to calculate the impact of cancellations during the outage the total number of cancellations during the normal period was summed and divided by the number of days in the normal data set. This was the expected daily cancellation rate. This was then multiplied by the duration of the outage (17 days) in order to get the expected number of cancellations for that time. The delta between what occurred during the event and what could have been expected during normal operations was then used to estimate costs:

$$1,188 \text{ flights}_{\text{norm}} * \frac{1}{44 \text{ days}_{\text{norm}}} * 17 \text{ days}_{\text{inc}} = 459 \text{ flights}_{\text{exp}}$$

$$4,299 \text{ flights}_{\text{inc}} - 459 \text{ flights}_{\text{exp}} = 3,840 \text{ flights}_{\text{canc}}$$

To determine average fuel burn per minute, fuel burn data from the FAA was averaged over various speeds from altitudes between 10,000 and 29,000 feet. This produced an average burn of 96.4 kg/min. Only major aircraft used by major commercial airlines were considered when calculating the average [9].

Because flights going to ORD and MDW during the outage had to fly at lower altitudes and thus slower speeds as they were passed from regional TRACONs, it can be assumed that the flights to and from Chicago had longer flight times and thus burned additional fuel. As expected, comparing the average "wheels off" flight time for various major routes into Chicago confirms that there was a significant impact to travel times which had implications for fuel costs and the cost of passenger time:

Origin	Avg Flight Time (min)	Incident Flight Time (min)	Delta (min)
Albuquerque	1172	1236	64
Boston	1273	1326	53
Wash. DC	1335	1353	18
Honolulu	1957	1907	50
Los Angeles	1229	1276	47
San Fransisco	1217	1216	−1
Seattle	1144	1153	9
Tuscon	933	952	19

The average flight time during the outage was 37 minutes longer than average for arrivals and 34 minutes longer than average for departures during the months of September and October compared to the non-impacted days. A T-test confirms with 99.9% confidence that the difference is significant:

	Arrivals		Departures	
	Incident	Normal	Incident	Normal
Flights	17258	45935	17221	45940
Average	1312	1275	1446	1412
St. Dev	484	463	490	464
Var	234321	214544	239907	214844
P-Value	8.57		7.85	
T-99.9%	>3.29		>3.29	

2.2 Data Compiled for Cost Impact Estimations and Other Factors and Assumptions

The following calculations and assumptions are used to estimate the impact of the ATC Zero event at Chicago. Where possible, factors were obtained from the FAA's Investment Planning & Analysis (IP&A) "Economic Information for Investment Analysis" workbook.

Description	**Value**	**Source**
Arrivals (9/26-10/13)	17,263 flights	Calculated
Departures (9/26-10/13)	17,221 flights	Calculated
Cancellations	3,840 flights	Calculated
Diversions	31 flights	Calculated
Total Airborne Delay	1,213,887 minutes	Calculated
Total Gate Delay	743,933 minutes	Calculated
Total Arrival Delay	619,742 minutes	Calculated
Average Fuel Burn	96.4 kg/min	FAA
Airborn Ops (no fuel)	$314/hr	FAA IP&A
Diversion Ops	$20,703/flight	FAA IP&A
Gate Ops	$234/hr	FAA IP&A
Canceled Flight Ops	$180/flight	FAA IP&A
Fuel	$2.77/gallon	BTS
CO_2 Burden	180 kg/hr	CarbonIndependent.org
Social Cost of Carbon	$39/t$CO_2$	EPA
(PVT)	$44.15/hr	FAA IP&A
PVT, Diverted	$14,175/flight	FAA IP&A
PVT, Canceled	$14,111/flight	FAA IP&A

3 Results

3.1 Impact of Lost Passenger Time

Any event which causes the traveler to experience an unexpected loss of time has an opportunity cost which is essentially what the traveler would be willing to accept as compensation for that lost time. To calculate the impact of lost passenger time, the total arrival delay is multiplied by the Passenger Value of Time (PVT). Arrival delay represents the difference in scheduled arrival versus actual arrival where negative numbers indicate early arrival. Therefore, the arrival delay takes into account any offsets to gate delays or airborne delays from shorter flight paths, jet streams, or other factors that can shorten a flight time. The average arrival delay soared from an average of 4 minutes ($s = 39$ minutes) per flight to 40 minutes ($s = 57$ minutes) per flight during the outage. The cost is thus calculated as follows:

$$10,329 \text{ hours}_{\text{delayed}} * \frac{\$44.15}{\text{hour}} = \$456,027$$

In the case of cancellations and diversions, PVT is per flight and can also be easily calculated:

$$\frac{\$14,175}{\text{diversion}} * 31 \text{ diversions} + \frac{\$14,111}{\text{cancellation}} * 3,840 \text{ cancellations} = \$54,625,665$$

The total cost of PVT from the Chicago Fire is:

$$\$456,027 + \$54,625,665 = \$55,081,692.$$

3.2 Impact to Airline Operating Costs

To assess the impact of the event on airline operations costs, the cost of diversions, cancellations, gate delays and additional airborne ops are added together after multiplying by their respective cost factors. Diversions are particularly expensive because the airline generally has to move the plane from the diverted airport to the intended destination at its own expense. Gate delays and airborne delays result in increased costs for staffing and maintenance.

Impact	Cost (USD)
Diversions	$641,793
Cancellations	$691,200
Gate Delays	$2,901,339
Airborne Ops	$6,352,675
Total	**$10,587,007**

3.3 Impact of Wasted Fuel

One of the major impacts of this ATC Zero event was that flight times were increased due to flying through the Chicago airspace at lower altitudes and slower speeds so planes could be passed from TRACON to TRACON. Since an estimated additional flight time can be calculated per flight as well as total for all flights during the outage, the total additional flight time is about 1,213,887 minutes or 20,231 hours. The fuel burn analysis indicated a burn of 96.4 kg/min resulting in 30,913,077 gallons of additional fuel being used during those seventeen days. Since the average cost of fuel during that time frame was $2.77/gallon [1], the estimated cost of this additional fuel is $85,629,223. Airlines go to great extent to avoid flight plans that are longer than necessary or the possibility of being held in a holding pattern due to a TMI—the operating cost of gate delays is far cheaper than the cost of burning fuel unnecessarily.

3.3.1 Environmental Impact of Excessive Fuel Burn

An argument can also be made that additional flight time due to holding patterns, diversions/reroutes and flying at lower speeds has an environmental cost. This cost is often not considered in routine analysis, but is worth investigating nonetheless. If the average flight releases approximately 180 kg of CO_2 per hour [3], and the Social Cost of Carbon (SCC) is \$ 39/tCO_2 [2], the environmental impact can be easily calculated:

$$\frac{\$39}{\text{tCO}_2} * \frac{.180\ \text{tCO}_2}{\text{hr}} * 20,231\ \text{hours} = \$142,022$$

In this case, the impact is not hugely significant but it is tangible. This amount could easily add up into much more significant costs if the scope were expanded to flights across the country on a daily basis.

3.4 Total Cost of the ATC Zero Event

The total cost of the TRACON outage due to the Chicago fire is shown in the table below:

Passenger Value of Time	\$55.1M
Operating Costs	\$10.6M
Fuel Cost	\$85.6M
Environmental Cost	\$0.14M
Total	**\$151.4M**

4 Discussion

Remember, this cost does not include repairs, equipment, overtime, and various other expenses incurred to restore the actual center where the fire occurred. One disgruntled employee, angered at being relocated to Hawaii, set a relatively small fire which ended up costing airlines and the economy almost \$151M. For comparison, The Hill published an article on October 02, 11 days prior to the restoration of the ARTCC, which claims U.S. Travel Association estimated the impact to the U.S. Economy to be \$123M [7]. No information was provided on how they calculated their estimate other than that a canceled

flight results in a loss of $31,600 in economic production. It should also be noted that the estimate presented here is considered conservative because the scope of the impact was limited to flights departing from and arriving at ORD and MDW airports. It does not attempt to capture the cascading effect that a cancellation can have on later segments of a flight or additional flight time for flights that flew through the Chicago Center airspace but did not land at ORD or MDW. There was a small but significant increase in flight times for all US flights excluding those arriving at or departing from ORD and MDW of 5 minutes during the outage. It is not possible from the data to determine which flights were actually impacted by the outage, however, but if the assumption is made that it is roughly 5% based on air traffic volume by ARTCC [4] this could result in a potential upside of $1.9M. Flight data from the entire U.S shows an increase of 4,584 cancellations (an additional 744 flights) during the time of the incident which, when combined with the estimated additional flight time, can provide a good upper bound for the estimate: $164.3M.
Using the Bureau of Transportation's flight record database, this methodology can be adapted to calculate the impact for any major disruption to national air travel. When calculating increases to flight times it is important, however, to test for statistical significance as many events only cause disruptions in the form of cancellations, diversions and delays and do not result in a significant increase to actual flight time.

Special thanks to Stephen Ketcham for assistance in collecting data.

References

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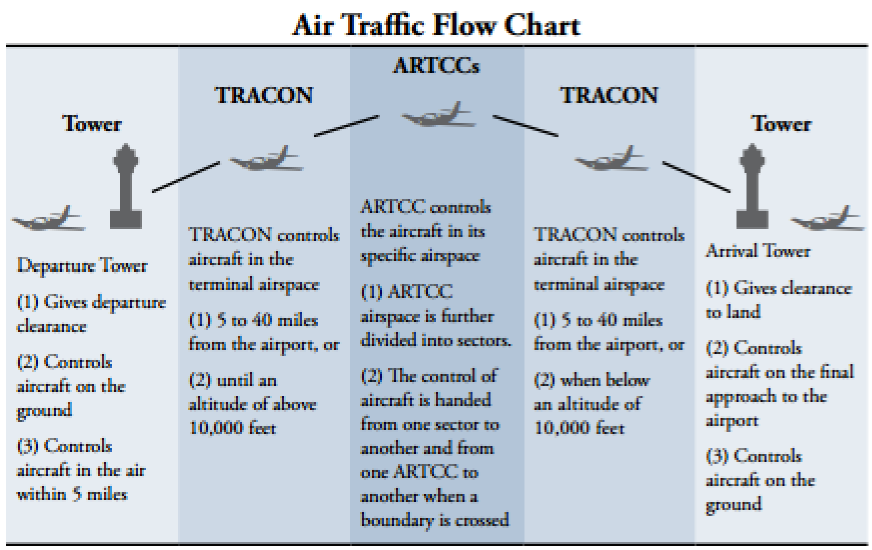

Figure 1: From "Traffic Flow Management in the National Airspace System", FAA ATO, October 2009.

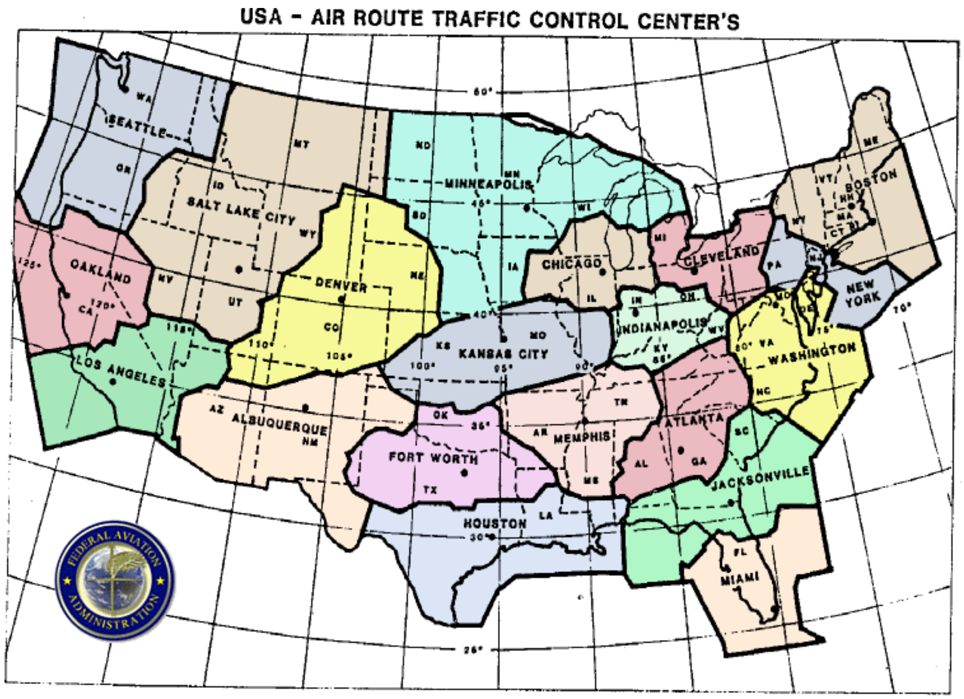
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Figure 2