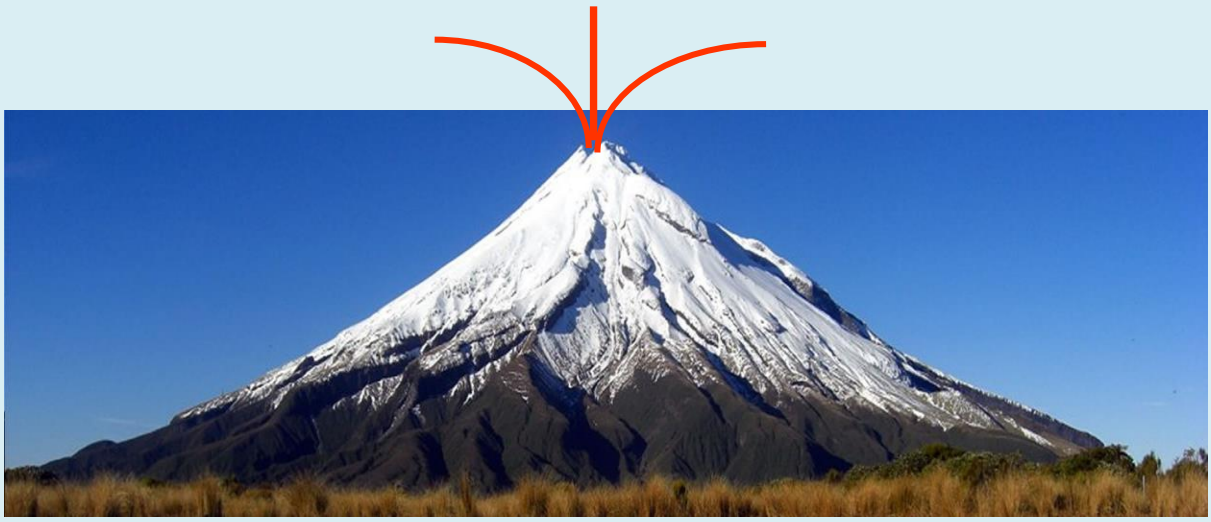
TEAM 1148 REPORT 2014

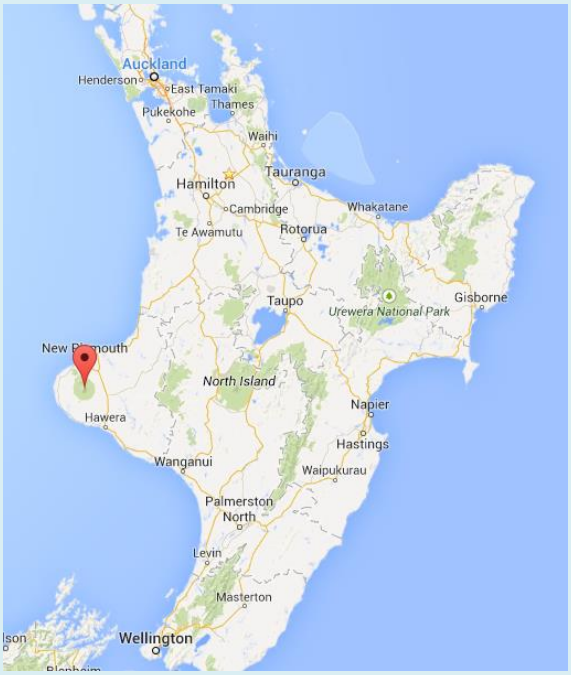
If Mount Taranaki erupted, how much would it cost the aviation industry?



Introduction:

New Zealand is home to over 60 volcanoes, this is because of the boundaries of the Australasian and pacific volcanic plates that New Zealand is located smack bang in the middle of. Making new Zealand a volcanic hotspot, that has created volcanoes nationwide. The thing with New Zealand is that it also brings over 2,700,000 tourist into the country annually.

Mt Taranaki is situated in New Plymouth which is slightly under the centre of the north island of New Zealand on the west coast shown in the picture to the right. Now if an eruption from Mt Taranaki occurred sending tephra (volcanic ash) into the sky it would definitely have an effect on the domestic flights of New Zealand. Like when Mt Eyjafjallajökull in Iceland erupted in 2010 producing over 0.25 cubic kilometres of tephra. Closing down around 20 countries airspace and costing the airline industries an estimated $200 million USD per day (estimated by the International Air Transport Association).
So it is our task to investigate and find out how much it would cost the aviation industry if Mt Taranaki was to erupt.



Taranaki has had a long history of eruptions, right back to 130, 000 years ago. Since then, Taranaki has been actively erupting every 500 years with many of the eruptions being of a Plinian type. Plinian eruptions are a specific type/process of eruptions that have specific qualities about them that differentiates them from many other types of eruptions. Plinian eruptions can be distinguished by columns of gas and volcanic tephra reaching high up into the stratosphere (around 15-30km upwards). The main characteristic of Plinian eruptions are the large amounts of pumice and ash throughout a very powerful continuous gas blast eruption. Plinian eruptions can last varying amounts of time, from a few hours to days or even months. Depending on the length of the eruption, Plinian eruptions may begin with large clouds of volcanic ash, then progressing onto pyroclastic flows and then the amount of magma starts to increase during which Plinian eruptions may generate loud noises. An example of these would be the volcano Krakatoa which could be heard 100km away in Australia while the eruption was occurring in Indonesia. Plinian eruptions can be violent and the volume of magma erupted can be so massive that the volcano may collapse, thus creating a caldera. The large clouds of volcanic ash would then drift in the air depositing over large areas.

Plan of attack:

- So first of we decided to find out the area that the tephra would spread and cover
- Then to find out how many airports would shut down and cancel flights.
- To finally come up with our outcome to what the cost to the aviation industry this natural disaster would cause.

So in 1755 Mt Taranaki erupted which was an extremely powerful Plinian eruption which was similar to the size of Mt Ruapehu's eruption in1995. So we are basing our results on the assumption that it will be similar to that of its 1755 Plinian eruption. So by researching Taranaki's previous eruptions we have found that the average plume height was 10,400m above sea level and that it erupted for an average of about 7 hours. Because we are basing this report on a worst case scenario where it released a large amount of ash about 0.94 km^3 which was the largest eruption of mount Taranaki giving us an average discharge rate (Q_{avg}):

$$Q_{avg} = \frac{V}{t}$$

$$= \frac{940000000m^3}{25200s}$$

$$= 37300m^3s^{-1}$$

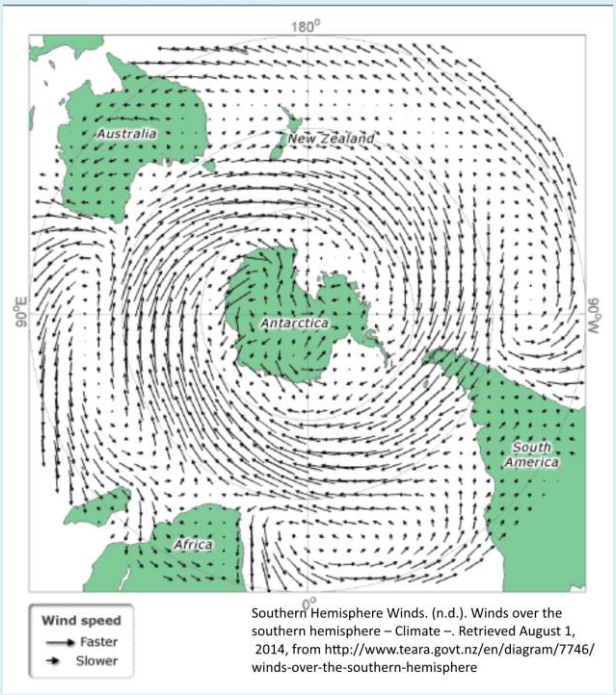
Average wind speed in new Plymouth throughout the year was around 18.3 km/h. so if we use this average wind speed as our wind speed during the eruption. Plus if we use the prevailing wind direction of the north island which is westerly. We can use this to calculate the length of the ash cloud after the eruption has stopped. Assuming that the ash will move at the same velocity as the prevailing easterly we have calculated it to be around 128km in length:

$$L = V\ X\ duration$$

$$= 18.3\ X\ 7$$

$$= 128km$$

The diagram below shows the average wind directions of the whole world. It shows that New Zealand's prevailing wind is in fact westerly, being westerly in New Zealand the ash cloud will spread out as shown on the diagram coming up. We have also taken into account the ability for the wind to change slightly so we have decided to use ±30^{o} uncertainty lines from our westerly on the diagram of our ash cloud.



Southern Hemisphere Winds. (n.d.). Winds over the southern hemisphere – Climate –. Retrieved August 1, 2014, from http://www.teara.govt.nz/en/diagram/7746/winds-over-the-southern-hemisphere

Once the entire ash cloud is in the sky we assume that the cloud will move as one to the east at the 18.3km/h we have as the average speed and would slowly disperse outwards. Because the distance from Taranaki to the east coast is 350km we also calculated that the time that it would take to clear from the east coast of the north island. Would be 19 hours:

$$t = \frac{d}{v}$$

$$= \frac{350km}{18.3km}$$

=19.13hours

=19 hours

NORTH ISLAND

2.77ms^{-1}

Ash may also be found

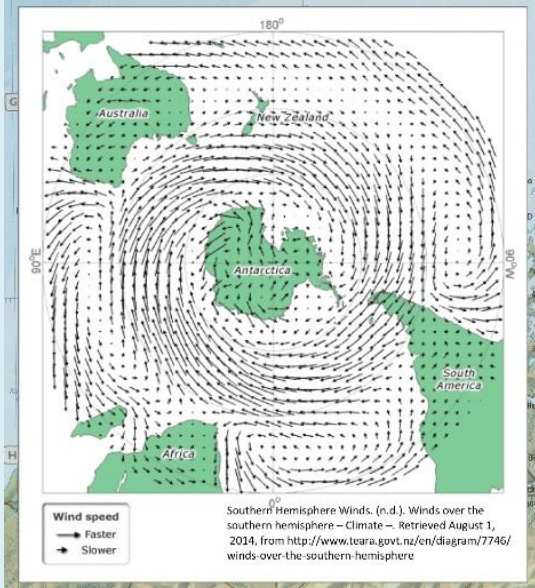
Orginal area of eruption

Main path of ash cloud where thickest

The length of cloud as eruption finishes

Possible for lower quantities of ash could potentially drift or exist in the airspace

Ash cloud will slowly dissipate outwards

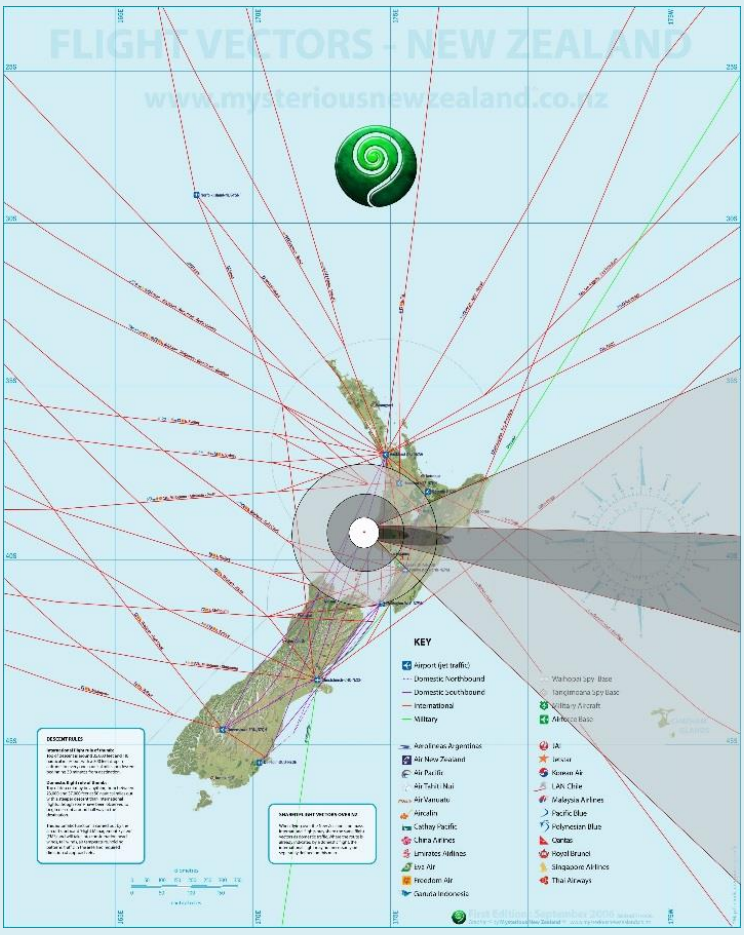


Southern Hemisphere Winds. (n.d.). Winds over the southern hemisphere – Climate –. Retrieved August 1, 2014, from http://www.teara.govt.nz/en/diagram/7746/winds-over-the-southern-hemisphere

The ash cloud will leave the island over the course of 19 hours from the start of the eruption. Because the calculations are done based on assumptions and are purely theoretical, it is impossible to calculate the actual spread of the ash cloud and the chart above is based on similar eruptions and on a worst case scenario situation. The wind direction (as seen top left) is based on the average wind direction around New Zealand. This wind would be moving at a speed of 2.77ms^{-1} and would carry the ash towards the right and also dissipate the cloud into a wider cloud with a higher density of ash in the center of it. The largest eruption from Taranaki was in 1755 where it was classified as a 5 on the VEI scale and loosed a total of 0.94km^{3} of ash being ejected into the stratosphere. This eruption is based on the data collected from the eruption. The white circle represents the immediate eruption zone where larger Tephra would be found. The lighter Tephra (ranging from 0.5mm - 4mm) would then create the ash clouds that would continue to drift through and up into the stratosphere. This smaller sized Tephra is what interferes with planes because it gets into engines and disrupts equipment.

North Island Map. (n.d.). New Zealand Small Scale Topographic Maps. Retrieved August 1, 2014, from http://www.linz.govt.nz/topography/topo-maps/nz-small-scale-maps

The reason that airlines do not allow their aircraft to fly through the volcanic ash cloud, is due to the fact that major erosion and wear will happen, as the volcanic ash is much like sand at high speeds. This high speed and grit combination causes a sandblasting effect to take its toll on the aircraft leading edges and main control surfaces, as well and the windscreen. This can cause the windscreen to white out completely due to the ash and pilots will have to land the aircraft blind, and will only be able to rely on their instruments for landing. But even the instruments will be effected and may not be working properly as ash may get into wind speed tubes and other sensors that older aircraft still have, so it is extremely unsafe for pilots to attempt to land. However the main factor that causes aircraft to be grounded during an ash cloud is that the ash enters the engine and causes it to run inefficiently and stall. It all starts when the gritty ash wears away at all the precision edges and blades inside of the compression fan, causing a lower combustion pressure, which means the plane has much less power. And then the ash enters the turbine blades where it gets melted into small fragments of glass causing it to do major damage as it exits the jet turbine. After long periods of ash running through the jet motor, the ash will build up on the blades of the intake, and they will build up to a stage that will stop sufficient air reaching the combustion chamber, causing the plane to stall, mid –air. So in order to fly safe, the airways must be clear of ash. So the airlines cancel and shut down any flights that would be effected by the ash cloud.



By looking at the relationship between the position of the mountain and its ash cloud and a map of the flight paths of aircraft in New Zealand (see image right) we were able to ascertain that flights between Auckland and Queenstown, Christchurch, Palmerston North and Wellington would have to be either cancelled or redirected. Due to the high possibility of damage to aircraft and personnel from even a small amount of ash present in the air we assumed that it would be unlikely that carriers would even try to redirect aircraft around the ash plume in case of a miscalculation and accidental flight through the ash plume. Also there was a very high probability of the ash cloud being directly overhead of New Plymouth, Taupo, Napier and Gisborne airports meaning that all aircraft both in and out of these airports would have to be cancelled without exception. Upon researching the interconnecting flights between these airports we found a total of 172 flights per day comprised of:

- Flights between two places:

18 Flights between Auckland and Queenstown
8 Flights between Auckland and Dunedin
38 Flights between Auckland and Christchurch
12 Flights between Auckland and Palmerston North
39 Flights between Auckland and Wellington

- Flights to and from a airport:

22 Flights in and out of New Plymouth Airport
3 Flights in and out of Taupo
18 Flights in and out of Napier
14 Flights in and out of Gisborne

These would have to be cancelled. The vast majority of these aircraft were in the 110 to 150 seat range. Mostly in the Airbus A320 Family or the Boing 737 Family. We were able to find an average passenger load factor of 83.4% from Air New Zealand that upon further research was across the board. This allowed us to ascertain more accurately the number of passengers that the company's had on these aircraft:

- 17239 people in large aircraft
- 53 people in small aircraft

In total there was 17292 passengers a day that would be grounded due to the ash plume. This equated to a total of 57% of Air New Zealand's Domestic Daily air travel. We then calculated the average seat cost of all of these seats which came out at $204 per seat. This is based on an average priced seat in an average length flight. With the simple calculation $204x17292 we realised a value of $3,527,568 to be the cost of the eruption of Mt Taranaki to the aviation industry over a 24 hour time period. Due to the fact that we calculated that the disaster would continue for a total of 19 hours however we have to adjust this value. By dividing it by 24 and then multiplying it by 19 we get the final value of $2792678. Because the company wouldn't be incurring running costs for their aircraft the actual cost of the eruption to the airlines will be much less. By finding an income statement published by Air New Zealand we can get a fairly good estimate of the gross profit percentage for the airlines (with the calculation Gross Profit/Total Revenue which equals 1224000/4618000x100. This gives us the percentage of 26.504%) and then apply this to the lost revenue to get a value of the gross profit lost for the airlines. This value is $740198.

So if Taranaki was to erupt, what would be the cost to the airline industry?

Using our calculated worst case scenario being similar to the biggest eruption of Mt Taranaki, using our average wind speed (18.3km/h) in the area and also prevailing wind (westerly), it would take around 19 hours to clear the airspace over New Zealand enough for flights to continue. Through vigorous calculating and thinking we have found the cost to the aviation industry to be $740,198.00

References

- Air New Zealand: Book Flights NZ & International Online - New Zealand Site. (n.d.). Air New Zealand. Retrieved August 2, 2014, from http://www.airnewzealand.co.nz/
- Automatic Bibliography Maker. (n.d.).BibMe: Fast & Easy Bibliography Maker. Retrieved July 31, 2014, from http://www.bibme.org/
- Eruption column. (2014, July 22). *Wikipedia*. Retrieved August 2, 2014, from http://en.wikipedia.org/wiki/Eruption_column
- Inns, a. H. (n.d.). Luxury Lodge and Bed and breakfast accommodation in New Plymouth, Taranaki and Wanganui. *Heritage Inns*. Retrieved August 2, 2014, from http://www.heritageinns.co.nz/new-plymouth-taranaki-and-wanganui/
- MATHalino.com. (n.d.). *Discharge*. Retrieved July 31, 2014, from http://www.mathalino.com/reviewer/fluid-mechanics-and-hydraulics/discharge-flow-rate
- Mount Taranaki . (n.d.). Wikipedia. Retrieved August 1, 2014, from http://en.wikipedia.org/wiki/Mount_Taranaki#References
- New Plymouth Climate History. (n.d.).September Climate History for New Plymouth. Retrieved August 1, 2014, from http://www.myweather2.com/City-Town/New-Zealand/New-Plymouth/climate-profile.aspx?month=9
- North Island Map. (n.d.). *New Zealand Small Scale Topographic Maps*. Retrieved August 1, 2014, from http://www.linz.govt.nz/topography/topo-maps/nz-small-scale-maps
- Plinian eruption. (2014, July 22). *Wikipedia*. Retrieved August 2, 2014, from http://en.wikipedia.org/wiki/Plinian_eruption
- Pyroclastic Eruptions. (n.d.). Pyroclastic Eruptions. Retrieved February 8, 2014, from http://www.geo.umass.edu/courses/volcanology/Pyroclastics%201.pdf
- Southern Hemisphere Winds. (n.d.). *Winds over the southern hemisphere â€“ Climate â€“*. Retrieved August 1, 2014, from http://www.teara.govt.nz/en/diagram/7746/winds-over-the-southern-hemisphere
- Taranaki/Egmont Volcano Geology. (n.d.). *Volcano Geology and Hazards*. Retrieved August 1, 2014, from http://www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/New-Zealand-Volcanoes/Volcano-Geology-and-Hazards/Taranaki-Egmont-Volcano-Geology
- Telegraph. (2010, April 15). Volcanic ash Q&A. *The Telegraph*. Retrieved August 2, 2014, from http://www.telegraph.co.uk/travel/travelnews/7593010/Volcanic-ash-QandA.html
- Te Ara Encyclopedia of New Zealand. (n.d.). Winds over the southern hemisphere – Climate –. Retrieved August 1, 2014, from http://www.teara.govt.nz/en/diagram/7746/winds-over-the-southern-hemisphere
- Volcanic Explosivity Index. (2014, July 27). *Wikipedia*. Retrieved August 1, 2014, from http://en.wikipedia.org/wiki/Volcanic_Explosivity_Index
- Volcanic Hazards: Tephra. (n.d.). *Volcanic Hazards: Tephra, including volcanic ash*. Retrieved August 2, 2014, from http://volcanoes.usgs.gov/hazards/tephra/
- Windfinder.com - Wind and weather statistic New Plymouth Airport. (n.d.). Windfinder.com. Retrieved August 1, 2014, from http://www.windfinder.com/windstatistics/new_plymouth
- Air New Zealand. (n.d.). Air New Zealand. Retrieved February 8, 2014, from http://www.ifids.airnewzealand.com/transform?transform=FISA&cursite=www.airnz.co.nz&type=a&range=a&airportcode=GIS
- Air New Zealand. (2014, July 30). Wikipedia. Retrieved August 2, 2014, from http://en.wikipedia.org/wiki/Air_New_Zealand
- Air New Zealand Assets. (n.d.). Air New Zealand. Retrieved February 8, 2014, from http://www.airnewzealand.co.nz/assets/PDFs/2013-december-investor-update.pdf
- Airbus A320. (n.d.). Wikipedia. Retrieved August 2, 2014, from http://en.wikipedia.org/wiki/Airbus_A320-200#A320
- ArrivalsAndDepartures. (n.d.). ArrivalsAndDepartures - Auckland Airport. Retrieved August 2, 2014, from http://www.aucklandairport.co.nz/FlightInformation/ArrivalsAndDepartures.aspx?range=I&leg=D
- Boeing 737. (n.d.). Wikipedia. Retrieved August 2, 2014, from http://en.wikipedia.org/wiki/Boeing_737-300#737-300
- Chem Trails Nz. (n.d.). New Zealand Chem Trails. Retrieved August 2, 2014, from

https://chemtrailsnz.files.wordpress.com/2013/02/nzflightvectors_lowres.jpg
- Domestic Flights NZ - Sunair The Big Little Airline. (n.d.). Domestic Flights NZ - Sunair The Big Little Airline. Retrieved August 2, 2014, from http://www.sunair.co.nz/
- Eyjafjallaj Eruptions. (n.d.). Wikipedia. Retrieved February 14, 2008, from http://en.wikipedia.org/wiki/2010_eruptions_of_Eyjafjallaj%C3%B6kull
- Gisborne Airport. (n.d.). Eastland Group. Retrieved August 2, 2014, from http://www.eastland.co.nz/gisborne-airport/arrivals-departures-tickets/
- Investor Updates. (n.d.). - Announcements. Retrieved August 2, 2014, from http://www.airnewzealand.co.nz/monthly-operating-data
- Mushroom cloud. (2014, January 8). Wikipedia. Retrieved August 2, 2014, from http://en.wikipedia.org/wiki/Mushroom_cloud
- New Plymouth Airport. (n.d.). Flight Schedule. Retrieved August 2, 2014, from http://newplymouthairport.com/arrivals.html
- One year since the second phase of EyjafjallajÃƒÂ¶kull volcano eruption started. (n.d.). Iceland geology. Retrieved August 2, 2014, from http://www.jonfr.com/volcano/?p=812
- The Mushroom Cloud. (n.d.). atomicarchive.com: Exploring the History, Science, and Consequences of the Atomic Bomb. Retrieved August 2, 2014, from http://www.atomicarchive.com/Effects/effects9.shtml
- Utility nav. (n.d.). Wellington International Airport. Retrieved August 2, 2014, from http://www.wellingtonairport.co.nz/flights/
- Volcanic Ash Advisory System. (n.d.). Volcanic Ash Advisory System. Retrieved August 2, 2014, from http://www.caa.govt.nz/Meteorology/Volcanic_Ash_Advisory_System.htm
- AIR.NZ Income Statement | Air New Zealand Limited (NS) Or Stock - Yahoo! New Zealand Finance." *AIR.NZ Income Statement | Air New Zealand Limited (NS) Or Stock - Yahoo! New Zealand Finance*. N.p., n.d. Web. 2 Aug. 2014. <https://nz.finance.yahoo.com/q/is?s=AIR.NZ&annual>.

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