Prevention of Runway Incursions, Inadvertent Takeoff and Inadvertent Landing on a Closed Runway

Abstract

For 24 days commencing 7 April 2002, the “Main Runway” at Auckland International Airport (05R/23L) was closed for the rehabilitation of the centre portion of the main runway. To permit continued operations, the formally named “Main Taxiway” was converted into a runway at an earlier time and made available as a “Temporary Runway” (05L/23R) during reconstruction period.

In light of a number of aircraft accidents and incidents where aircraft have landed on other than the active runway, attempted to takeoff on a closed runway, or inadvertently entered an active runway thereby precipitating an accident, measures were undertaken to mitigate against such events occurring at Auckland Airport not only during the works program, but also as part of normal operations thereafter.

Introduction

Large catastrophic disasters in industry are in general terms rare events and the transport industry has certainly had its fair share of disasters such as the capsize of the Herald of Free Enterprise at Zebbrugge, the destruction of the Challenger Space Shuttle at Cape Canaveral, the London Underground King’s Cross Station fire, and what still remains the world’s greatest air disaster – the collision at Tenerife between and a KLM Dutch Airlines Boeing 747 on takeoff

and a PanAm Boeing 747 taxiing for departure. Disastrous accidents directly attributed to the Air Traffic Services are fortunately very rare events. No human endeavour or enterprise is free of risk. No accident is acceptable, however risk can be identified and managed to reduce the chance of an accident.

A safety management system is a means by which a systematic and explicit approach can be taken to manage risk. The major accidents in the 1980s mentioned above underline the fact that safety has a management responsibility and as a service provider, it is not satisfactory relying on experience, a good track record in the past or good luck as the basis of a safety plan. Ad hoc or intuitive methods of dealing with safety issues associated with major changes in technology, systems and procedures that would accompany a re-equipment program will not suffice; a systematic approach is required if the safety aspects of major change is to be managed effectively. It goes without saying that it is essential to ensure the integrity and safety of the service at all times during the introduction of new technology or procedures.

Airways Corporation of New Zealand Ltd (Airways) in collaboration with Auckland International Airport Ltd. have been actively involved in the design and implementation of processes and procedures required to activate a taxiway as a runway at Auckland International Airport. Previous accidents and incidents elsewhere played a vital part in increasing the knowledge base

for the building of procedures in what for Airways was a new trail-blazing venture.

Runway Incursions And Other Airport Surface Incidents

The prevention of runway incursions and other airport surface incidents including aircraft landing and taking off on closed runways, has prompted numerous safety recommendations (NTSB, 2000). It has been noted by safety agencies that the number of reported near-collision ground incidents has increased significantly and prompted the issuing of new safety recommendations to reduce the frequency of runway incursions. In the United States alone, runway incursions have ranged from a low of 186 in 1993 to a high of 325 in 1998 (NTSB, 2000).

A study of a number of incident and accident reports indicates that runway incursions or landing/takeoff errors take various forms:

1. Taxiing errors – the pilot makes an inadvertent deviation from the assigned taxi route leading to the aircraft entering the active runway or attempting to takeoff on a non-active runway. A subset of this group is
    - Misidentifying taxiways through poor signage
    - Inadequate charting
    - Disorientation, where the pilot is unsure of his or her position, or lost because of reduced visibility
    - Inattention

2. Runway misidentification during the approach phase leading to a landing on an inappropriate surface.

3. Error of transmission –
    - Incorrect or ambiguous instructions issued
    - Correct instructions issued but misunderstood because of radio jamming or interference, equipment shortcomings, language and cultural factors
    - Hearback/readback – “I thought I heard you say this, I read back what I thought you said, I made a wrong assumption” – therefore the error is perpetuated.

In light of incidents at London Gatwick in 1988 (AAIB, 1989) and again in 1993 (AAIB, 1994), plus other notable accidents at Tenerife, Milan and Taipai, the safety focus at Auckland Airport with the runway rehabilitation project has been in two directions:

- to prevent the misidentification of the active runway that might lead to an inadvertent runway incursion while taxiing, and
- the prevention of landings or takeoffs on the closed parallel runway that is undergoing repairs and reconstruction.

Unfortunately the final report for the Milan accident has not been released to date, however sufficient information is in the public domain to draw useful conclusions. The major ongoing issue at Auckland following the completion of

the runway works and the return to normal operations is the obvious visual choice of two runways that are only 200 metres apart.

Planning

During preparation for the runway closure and the inevitable changes to procedures, it was quickly found that there is very little established precedent for closing a runway for a 30 day period and operating from a taxiway that had been converted into a runway in all weather conditions, 24 hours a day, and with normal traffic loads. The closest example was at London Gatwick where the main runway is closed periodically for maintenance. At Gatwick the temporary or "emergency" runway that was formerly a taxiway, is used only at night and only under restricted traffic and operating conditions. There is no direct instrument approach other than a surveillance radar approach and the runway and airfield lighting is different from the standard configuration.

Fortunately at Auckland, it was possible to use the incident and accident reports mentioned above and try to establish the risk factors that might lead to the type of air safety breaches described in the reports, then endeavour to engineer hardware and software solutions to mitigate the risk to acceptable levels. In fact it became clear that the major issue at Auckland was not one concerning "runway crossings" but rather:

1. Preventing the inadvertent landing on the closed runway under repair or on any of the associated parallel taxiways.

2. Preventing the inadvertent takeoff from the closed runway under repair or from any of the associated parallel taxiways.
3. Preventing inadvertent incursions onto the active temporary runway while taxiing.

London Gatwick proved to be an excellent source of information as the airfield layout is very similar to Auckland including

- The proximity of the main runway to the temporary runway – about 200 metres centreline to centreline
- The relationship of the temporary runway to the parallel taxiway – about 100 metres centreline to centreline
- The overall proximity of the runways and taxiways to the terminal buildings.

Valuable lessons could be gleaned from the two non-injury accidents at Gatwick in April 1988 and October 1993. These reports in conjunction with reports from the NTSB, and available information from the two more recent accidents at Taipai and Milan, Italy were used to learn valuable lessons.

The two accidents concerned were Singapore Airlines Flight SQ006 which crashed while attempting to takeoff from a closed runway at Taipei, Taiwan (ASC, 2002) in October 2000, and the Scandinavia Airline Systems MD87 aircraft which crashed during takeoff into a privately owned Cessna Citation II at Milan, Italy in October 2001 (Cable News Network, 2002)

Gatwick Incident – 1988

The first Gatwick incident referred to involving a British Island Airways BAC1-11 that landed on the parallel taxiway in 1988, centered on a number of factors:

1. The temporary runway was known as the “emergency runway” and reverted back to being known as a taxiway when not used as a runway. Therefore, the same part of the manoeuvring area had different names, depending on what it was being used for.
2. Advice of the change of runway from the main runway to the emergency runway occurred approximately 20 minutes prior to top of descent. The change of ATIS reflecting the runway change did not occur until four minutes after the aircraft had commenced descent, therefore there was conflicting information on the runway in use.
3. When the ATIS was changed to reflect the runway change, the ATIS identifying letter was not changed. Therefore for a time, the same ATIS identifier was advertising both runways as being the active runway.
4. The work on the main runway was for an 8 month period and was notamed for the work to occur nightly between 2100 and 0445 local.
5. Though the pilots were both familiar with the airfield layout, they did not discuss airfield lighting details during the approach and pre-landing brief.
6. It was an unfortunate coincidence that the crew was able to utilise the active runway’s PAPI for the approach and landing onto the parallel taxiway without being alerted to anything untoward.

It was concluded in the report that there was a low probability of the crew repeating the incident, however it was necessary to consider ways of reducing the probability of other crews making similar mistakes. Therefore a number of recommendations were made of which the notable ones are -

1. Discontinue the term “emergency runway” to describe the temporary runway and identify it always as a runway even when used only as a taxiway.
2. The ATIS should have a new identifier each time the broadcast is amended.
3. The ATIS should be used to broadcast details of the relevant lighting systems and in particular to confirm the lighting in use which positively identifies the runway.
4. Review the airfield lighting -
    - Reduce the minimum lighting intensity for the green centreline taxiway lights so that they are not unnecessarily conspicuous
    - Provide sequenced strobe centreline lighting to the active runway

Gatwick Incident – 1993

In 1993 an Air Malta Boeing 737 also inadvertently landed on the same parallel taxiway at Gatwick during scheduled runway works. An analysis of this incident found marked similarities between this and the 1988 incident. In both cases, the flight crews were aware that the temporary runway was active but never-the-less convinced themselves that the parallel taxiway with its standard green centreline lighting was the active runway and therefore landed

on it. Also the pilots in both cases probably considered themselves sufficiently familiar with the airfield and therefore a further briefing on the airfield layout was not necessary. In their discussion after landing however, the pilots of the second incident commented on the confusion of the overall lighting pattern, including a great many contractors' vehicles.

Parallels with Auckland

General

As can be seen from the two Gatwick incidents, the prime issue in both cases was with airfield lighting leading to the misidentification of the active runway which ultimately led to the aircraft landing on a taxiway. Though potentially a major issue at Auckland, the confusion between the active temporary runway versus the parallel taxiway is greatly reduced because the parallel taxiway at Auckland has a bend away from the runway at the eastern and western ends. Therefore the taxiway does not appear visually as one straight surface. Taxiway Bravo as it is now known, was built in stages over a number of years as the airport grew in size. When the eastern and western portions of the taxiway were constructed at a later date, it was in the knowledge that the main taxiway would need to be used as a runway at some stage in the future. As side clearances would become an issue, the eastern and western ends of Taxiway Bravo were displaced by about 15 metres to the north, i.e. further away from the proposed temporary runway. Because the taxiway visually both by day and by night (represented by and the row of green lights) does not appear as a straight-line surface but rather with two bends in it, the

assumption is therefore that pilots will not land on a surface that is not straight.

Airfield Lighting

The basic runway and approach lighting systems for both the main runway and the temporary runway at Auckland are similar and conform to ICAO standards. The temporary runway is without some features e.g. there is no runway centreline lighting, nor is there a high-intensity approach lighting system. Both runways have a Runway Edge Identifier Lighting system (REILs) that consists of two white variable intensity strobe lights, one situated on each side of the green threshold wing bar lights marking the runway end. Also to assist with runway identification, each runway is fitted with three-sequenced strobe centreline lights. These lighting systems coincide with the Gatwick safety recommendations of making the active runway more apparent.

To further deter pilots from landing on the non-active runway, lighted crosses are situated prior to the landing threshold of the non-active runway. When work is being undertaken on the main runway, another cross is positioned on this runway approximately 1000 metres down the runway to further indicate that the runway is closed and dissuade pilots from selecting it for landing.

Approach Monitoring Aid

In the first Gatwick incident, a brief note was made concerning the ground movement radar display that is available to air traffic controllers in the tower. This was quickly discounted as a useful tool for the prevention of the landing

on the taxiway because the radar is designed for ground movements only. The landing aircraft was effectively on the ground before the first radar returns were displayed.

Although the air traffic controller at Gatwick had a clear view of the approaches to the active runway, it was almost impossible to identify visually which runway or taxiway the aircraft was going to land on until it was too late. Parallax error when viewing runways from a control tower is typically difficult as through necessity the tower must be offset from the runway.

Auckland Airport is not equipped with a ground movement radar display, and also suffers from the same parallax errors from the control tower when observing aircraft during approach and landing. As mentioned above, the problem of an aircraft landing on the taxiway had effectively been discounted because of the bends in the taxiway, but the risk of an inadvertent landing on the non-active runway was a real concern and several methods of providing a "last line of defense" were considered. They were:

1. Position a person in a vehicle near the landing threshold. This person would visually monitor all approaches and radio to the tower if an aircraft was not correctly aligned with the active runway during the final stages of the approach.
2. Monitor all approaches via a Closed Circuit TV camera situated at the landing threshold and positioned to look up the final approach track.

3. Install some form of approach monitoring aid that would electronically monitor all approaches and that would sound an alarm if an aircraft was not correctly positioned at a preset “decision point”.

Options 1 and 2 were discarded in favour of the approach monitoring aid (AMA) because they would require a person to monitor all approaches rather than the more passive electronic monitoring provided by the AMA. Airways developed the AMA over a matter of months in late 2001 and this aid has been operating successfully though not without teething troubles. Basically the AMA is a radar picture of the last 4 miles of an aircraft’s approach. This is displayed on a desktop computer that receives it’s feed from the Aircat radar. Coupled with the visual display is an audio alarm. If the aircraft on approach has more of a bias towards the non-active runway at 2½ miles from touchdown, then an audio alarm sounds and the controller will challenge the pilot to confirm the active runway. If the alarm sounds at 1 mile from touchdown, the controller will issue a mandatory “go-around” to the aircraft.

Naming of Runways

Following upgrade work on the Main Taxiway to bring it up to runway standard, the name was changed to Runway 05 Left & 23 Right. Naturally the main runway became Runway 05 Right & 23 Left. This is a permanent change. All taxi clearances via any of the runways is in reference to the new nomenclature. All takeoff and landing clearances include the runway in use and a readback of the runway name is mandatory with all landing and takeoff clearances.

ATIS

Previous incidents at Auckland have seen aircraft landing short on the runway during displaced threshold operations. Details of work activities have been published well in advance by Class II Notam and AIP Supplement. On the day of the work activities despite the ATIS broadcast, verbal advice while on approach and also a qualified landing clearance with instructions to "follow the displaced PAPI and land after the displaced threshold", aircraft have still managed to land at the standard runway touchdown point 1100 metres before the required displaced touchdown zone. Investigations found that the standard LLZDME, VORDME and NDBDME approaches (Glidepath not available for displaced operations) all positioned the aircraft at the normal decision point for a full runway length approach. However for inset threshold operations, the aircraft would be required to maintain level flight for between 1100 and 1336 metres in order to land at the displaced touchdown zone. Clearly, no provision had been made for a different profile to achieve this result. Therefore purpose built approach procedures were designed for displaced threshold operations. Furthermore, in the interests of highlighting the special nature of the approaches,

- Each approach plate has a special unambiguous identifier
    - The LLZDME approaches became ZULU for LLZ.
    - The VORDME approaches became VULCAN for VOR
    - The NDBDME approaches became NOVEMBER for NDB (NZAIP,2001), and

- To highlight the special nature of these approaches, all AIP approach and airfield plates pertaining to displaced threshold operations are published on yellow paper.

Therefore, when we came to planning for two parallel runways, we had the mechanism in place to further extend the use of colour with the approach plates. For temporary runway operations (Runway 05L/23R), new instrument approaches were designed and these were published on Green paper. Furthermore, to circumvent those who wish to photocopy the green pages onto white paper, the word “green” was printed around the border of the green pages. On all approach charts for non-standard runway operations i.e. all charts not published on white paper, a cautionary note was added highlighting the non-standard feature. This note states:

- (For Green Pages) - “Caution: Use this chart only when Runway 05L/23R operating” , or
- (For Yellow Pages) - “Use this chart only when Runway 05R (23L) threshold is displaced”.

In conjunction with the White, Yellow, and Green pages, the ATIS format was changed not only to include the fact that there is now a Left and Right runway, but also the mode of operation for that runway. The broadcast includes. “Refer to Jeppesen or Flight Guide White (Yellow or Green) pages”. A software change was also made to prevent the incorrect linking of a runway in use to an incorrect mode of operation during ATIS input.

These fixes did not directly address the Gatwick recommendation that the lighting configuration be added to the ATIS broadcast, however it was considered a far more elegant solution as the Auckland operation is a 24 hour operation. During daylight hours, a reference to the lighting configuration at Auckland would not be entirely appropriate. In any event, experience at Auckland has shown that the more information included on the ATIS broadcast, then the more likelihood that important details will be buried or lost in the text of the message and therefore not assimilated by pilots.

Inadvertent Takeoff

Thus far, the discussion has been centred around the Gatwick incidents and the prevention of aircraft landing on a non-active runway or taxiway. The next issue is the prevention of inadvertent takeoff from a non-active runway. The accident at Taipei concerning Singapore Airlines Flight SQ006 illustrates how issues concerning signage, lighting, charting, the environment, and a host of human factors matters led to the accident. Once again, it is not intended to discuss this accident in this paper; never-the-less lessons can be learned.

In effect there are two reports on the one accident - the “official report from the Taiwan Aviation Safety Council and the dissenting Singapore Ministry of Transport report. Despite the contradictions, claims and counter-claims, certain conclusions can be arrived at from both reports. These can be summarised as follows:

- The runway markers and signage caused confusion

- There was confusion with airfield lighting
- Airport navigation charts were deficient
- Runway closure markers or barriers were inadequate
- Human factors as they relate to crew resource management was a factor

These issues and others have been implemented at Auckland to prevent the inadvertent takeoff from a closed runway and are detailed below.

Signage

As part of the recent runway upgrade program, new lighted Movement And Guidance (MAG) signs in conformance with ICAO standards have been installed on the airfield. The previous signage was not up to ICAO standards and also was not lit. Though there has been some confusion amongst some pilots as they have attempted to interpret the signs especially the holding point signs, change in itself often leads to some “resistance” and therefore confusion from the users. There are still some issues with the placement of signs near the International Terminal Building, however moves are afoot to resolve these issues.

Airfield Lighting

This has been addressed above in detail though it must be said that an unusual feature with the Auckland configuration is the use of parts of the main runway for taxiing when full-length departures or full-length landings are required. Approximately 500 metres of the main runway is made available for

taxiing. At night this is lit not as a taxiway i.e. green centreline lights, but with blue edge lights.

Charting

Taxi routes have been published in green pages for temporary runway operations. The routes are in both pictorial and word descriptor format. Air traffic controllers have been advising pilots of the expected taxi route at the clearance delivery stage so that the pilots can brief themselves well in advance of engine start. A thorough briefing with 'no surprises' when underway leads to a smooth operation.

Runway closure markers or barriers

As mentioned above, when the main runway is closed, two lighted crosses are plainly visible to pilots. The link taxiways between the two runways are closed with red and white barriers that are lit with red obstruction lights. Additionally the taxiways that lead out directly from the two terminal buildings are barriered off in a similar fashion. Experience has shown that a number of aircraft have inadvertently entered the temporary runway when it was only being used as a taxiway. Clearly this would be an intolerable situation when the temporary runway becomes active as a runway, therefore the definitive measure of closing the link taxiways has prevented incursions occurring.

Other Procedures

The Taipei accident may have been prevented by the tower by not issuing a takeoff clearance until the Singapore Airlines Boeing 747 aircraft was

observed to have lined up, or at least had taxied to a position where it was not possible to takeoff on any surface other than the active runway. At Auckland, procedures have been established where a takeoff clearance will not be issued until the departing aircraft has been visually observed by the Aerodrome Controller to be lining up on the active runway. In conditions where the visibility is reduced to the extent that the departing aircraft is not visible from the control tower, then further checks are required from a vehicle strategically placed on the airfield to confirm that the aircraft is lining up on the correct runway prior to the issuance of a takeoff clearance.

The Milan Accident

Though the final accident report is not available at the time of writing, lessons can be learned from reports of this accident in conjunction with the Tenerife accident. Both accidents occurred in reduced visibility brought about by fog. In both cases a departing aircraft was attempting to takeoff when another aircraft was taxiing on the same runway but not visible due to the fog.

At Auckland this issue has been addressed in a number of ways. Firstly, when an aircraft is not visible from the control tower or visual separation by the pilots when taxiing cannot be applied, then only one aircraft may taxi, takeoff or land at a given time. Therefore as in the Milan accident, if a pilot misidentifies a taxiway or enters the active runway inadvertently, then it is of no consequence because there is only one aircraft moving on the airfield. Once again, in poor visibility when a departing aircraft is not visible from the

control tower, then a person in a vehicle is required to confirm that the aircraft is lined up on the correct runway prior to the issuance of a takeoff clearance.

Closing the taxiways that link the terminal buildings that link directly to the runway also prevents this type of runway incursion.

Conclusion

The option of closing the main runway for a significant period of time without an alternative runway being available is not economically viable. Therefore an alternative solution had to be sought. The challenge of using a taxiway as a runway is not without risk. The number of documented examples of how to effect such a change are few. Undoubtedly as other airports grapple with the issues involved and document “how they did it”, then a greater understanding of the processes involved will be gained. In the interim and with a lack of precedent for the type of operation engaged in at Auckland, the major source of information has come through someone else’s misery. Fortunately we have learned through other’s mistakes plus some good old Kiwi ingenuity, to make a difficult situation work safely and successfully.

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