



Ground operations occurrences at Australian airports 1998 to 2008

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- fostering safety awareness, knowledge and action.

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Abstract

The aviation industry has been slow to acknowledge the risks associated with ground operations. While most occurrences on airport aprons and taxiways do not have consequences in terms of loss of life, they are often associated with aircraft damage, delays to passengers and avoidable financial costs to industry. The focus of this report is to examine ground occurrences involving high capacity aircraft operations.

This report examines occurrences involving ground operations and foreign object debris that occur at Australian airports which receive high capacity aircraft. It uses occurrence and investigation data reported to the Australian Transport Safety Bureau to create a picture of ground occurrences. This picture begins when an aircraft is being prepared for takeoff and ends when passengers and crew have disembarked from the aircraft. It explores contributing factors associated with each type of occurrence, with the objective of providing some insight into what happened and why various events occurred. The key to preventing ground occurrences appears to revolve around ensuring effective communication between pilots, ground crews and air traffic services through a process of checks and balances.

Figure 1: Australian airport apron



INTRODUCTION

At airports all around the world, aircraft, people, and equipment converge, every day of the week, and at all times of the day and night. An airport is a complex interface between the air and ground, where control, access and separation must be maintained and optimised. On the whole, airport traffic flow works well, and the travelling public has learned to expect an efficient and safe journey. This is, in no small part, due to a significant focus by the aviation industry, since the 1970s, on developing risk controls for pilots and air traffic services. There has been less industry-wide attention on risk controls to improve safety in ground operations. Subsequently, there has been little change in the frequency of ground operations events for the last few decades in Australia.

Different sources of data can be used to create a picture of ground operations; some primary sources of data include operational audit¹ and investigations data, occurrence data, compensation and insurance data, and regulatory data. This report focuses on occurrence data involving high-capacity aircraft ground safety occurrences, specifically those dealing with ground operations on the airport apron and taxiway, and foreign object debris (FOD); collectively they are referred to as ground occurrences. These ground occurrences were reported to the Australian Transport Safety Bureau (ATSB) over 11 years between 1 January 1998 and 31 December 2008, and have occurred in Australia.

Definitions

High capacity aircraft are those with a maximum payload exceeding 4,200 kilograms or more than 38 seats. Most reported high capacity aircraft ground occurrences involve regular public transport (RPT) services between major airports, but these data also include some freight and charter operations; for example, those services operating to mines and regional centres.

Ground operations occurrences were defined as operations involving aircraft handling, and operations on the airport apron and taxiways, as well as movements around the aerodrome. Occurrences involving active runways are excluded from these data.

Foreign object debris is defined as any object found in an inappropriate location that – as a result of being in that location – can damage equipment or injure crew, passengers, or airport personnel.

In addition to a review of occurrence types, this report tables the contributing factors to ground operations occurrences. Contributing factors are events and conditions that increase risk - thereby increasing the likelihood of an event or condition, the severity of an adverse event, or both the likelihood and severity of an adverse event.

Background

Ground operations are potentially one of the most dangerous areas of aircraft operation. They include any services necessary to manage an aircraft's arrival and departure from an airport. Commercial aviation generally operates on small profit margins, and short aircraft turnaround² times are critical for airline efficiency. Servicing must be performed concurrently, efficiently, and with compatible equipment. For many high capacity RPT aircraft this takes place in a window of time, usually between 30 minutes and 2 hours in length; the size and destination of the aircraft influences turn-around times. Traditionally, ground handling includes terminal services (passenger check-in, baggage and freight handling) and ramp handling services (embarkation and disembarkation of passengers and crew, aircraft marshalling and pushback, refuelling, loading and unloading, catering, toilet and water services, aircraft cleaning, de-icing, ground power supply, and engineering repair of minor faults). This

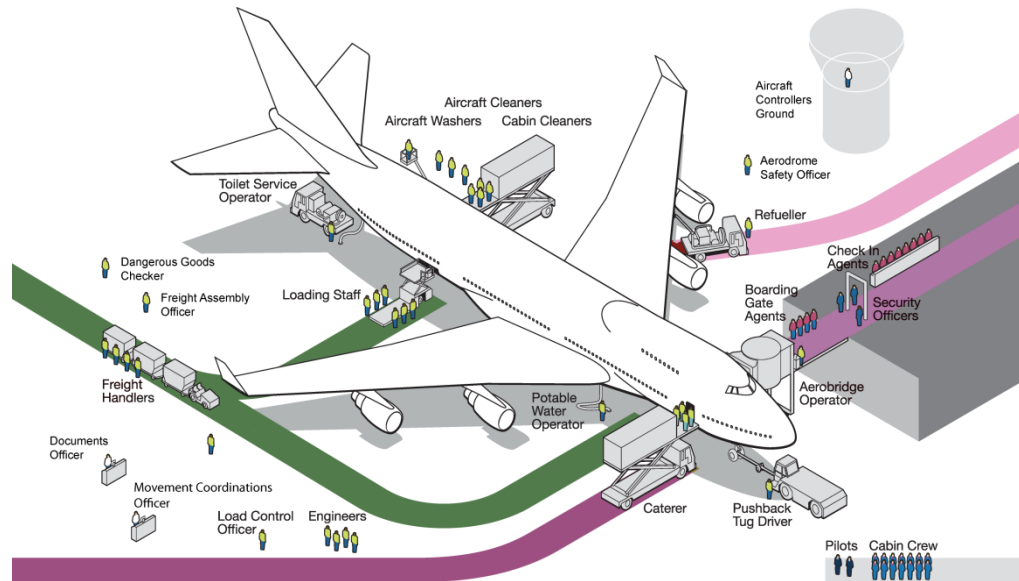
1 For example, the International Air Transport Association (2008) Safety Audit for Ground Operations.

2 This is the time between aircraft arrival at a gate and pushback from the gate for the next departing flight.

report focuses on ramp handling services, rather than terminal services. In Australia, ground handling services are provided by a combination of airlines, and several different independent companies, including owners of airports.

In some circumstances, ground operations do not go as planned or as required, resulting in safety occurrences which are the focus of this report. To flesh out the context for ground operation occurrences, it is useful to first review what we know about airport vehicles and operations.

Figure 2: Ground handling and operations



Source: Adapted from Juanita Frantzi, Aero Illustrations, Flight Safety Magazine, June 2009, Civil Aviation Safety Authority.

Different types of ground vehicles are found at airports, all with specific purposes and roles. There are safety vehicles which inspect runways and marshal other work vehicles, vehicles belonging to the Australian Customs and Border Protection Services, catering vehicles, refuelling vehicles, tugs and trailers to handle freight and baggage, toilet service operators, ground power units, and tugs and power push units (PPU) for pushing back³ aircraft to the taxiway. Airport rules and regulations state that these vehicles must give way to moving aircraft, and seek permission to join and cross taxiways and runways. Vehicles must operate within specific clearance areas on the apron so that they do not come into conflict with aircraft. When an aircraft is stopped at the gate, ground crews must wait until the anti-collision beacon is turned off before approaching the danger zones of the aircraft. While an aircraft is at the gate, vehicle drivers must position vehicles next to aircraft to perform specified functions. When an aircraft departs from the gate, all service and handling equipment must be removed from around the aircraft and positioned behind the clearance lines.

A sequence of events must be followed when an aircraft is pushed back onto the taxiway. This includes connecting the push unit, releasing the aircraft brakes, pushing the aircraft back onto the taxiway and disconnecting the push unit. A clear line of communication is required at all times between flight and ground crew. With PPU and tug towbar pushes, a large amount of energy is exerted on the aircraft nose or main landing gear to provide enough inertia to move the aircraft. Sometimes these components fracture and fail and this poses a significant risk to the tug unit and driver, as the driver is usually positioned under the aircraft.

³ Pushback is where an aircraft is pushed backwards away from an airport gate by external power. It involves a tug connected to the nose wheel, or a power unit connected to the main landing gear.

Ground operations occurrences are usually considered to be those that occur close to the terminal (apron); however, from a safety perspective, many of the errors on the apron share similar mechanisms to those occurring on taxiways and runways: for example, deviating from a clearance, or operating without a clearance. For this reason, taxiway occurrences are included in this report and it categorises occurrences by phase of ground operation.

GROUND OPERATIONS OCCURRENCES REPORTED TO THE ATSB

Due to the nature of the ATSB's function to improve safety and public confidence in aviation, most of the occurrence data reported to the ATSB is aircraft-centric; that is, an event occurs when an aircraft is boarded for flight, is in flight, or affects other aircraft operations. This means, for example, that injuries to a baggage handler will not usually be recorded as safety occurrences by the ATSB. Data for this type of occurrence is held by companies, and occupational health and safety (OHS) organisations, such as State and Territory Workcover, or the Commonwealth OHS body Safe Work Australia. These types of occurrences are important, but not typically investigable matters under the *Transport Safety Investigation Act 2003*.

This report presents part of the safety picture that emerges from ground occurrences. The data used for this report is largely based on occurrence reports, rather than ATSB investigations. Over the 11 year period studied, the ATSB investigated a total of 41 ground occurrences - five occurrences involving foreign object damage (FOD), 36 related to ground handling issues. Occurrences that were investigated in greater detail via an on-site investigation involved damage to aircraft or potential risk to passengers or flight crew.

Figure 3: View of an aircraft from the aerobridge



Data relating to aircraft loading issues are not specifically addressed in this report, unless loading equipment collided with an aircraft. Although aircraft loading issues are broadly related to occurrences on the ground, they are specific to different aircraft, and involve different types of occurrences (including carriage of hazardous goods, aircraft weight and balance, including overloading and over-fuelling, and stowing and storing freight and cargo).

Big picture of ground occurrences

Between 1 January 1998 and 31 December 2008, there were 398 ground occurrences reported to the ATSB involving high capacity aircraft operations. This equates to about 1.5 per cent of all reported high capacity occurrences, taking place at an aerodrome, both per year, and across the entire reporting

period. Since 1998, reported ground occurrences have stayed at about 40 per year. Over the same period, the total number of incidents, serious incidents and accidents reported to the ATSB with the potential to affect high capacity services (approximately 24,000) has risen from about 1,900 per year in 1998 to 2,800 per year in 2008.⁴

Total high capacity RPT aircraft movements (takeoffs and landings) have steadily increased from about 619,000 movements per year to about 985,000 movements (BITRE, 2010).⁵ Aircraft movements are used as a denominator for calculating the rate of ground occurrences per 10,000 movements.

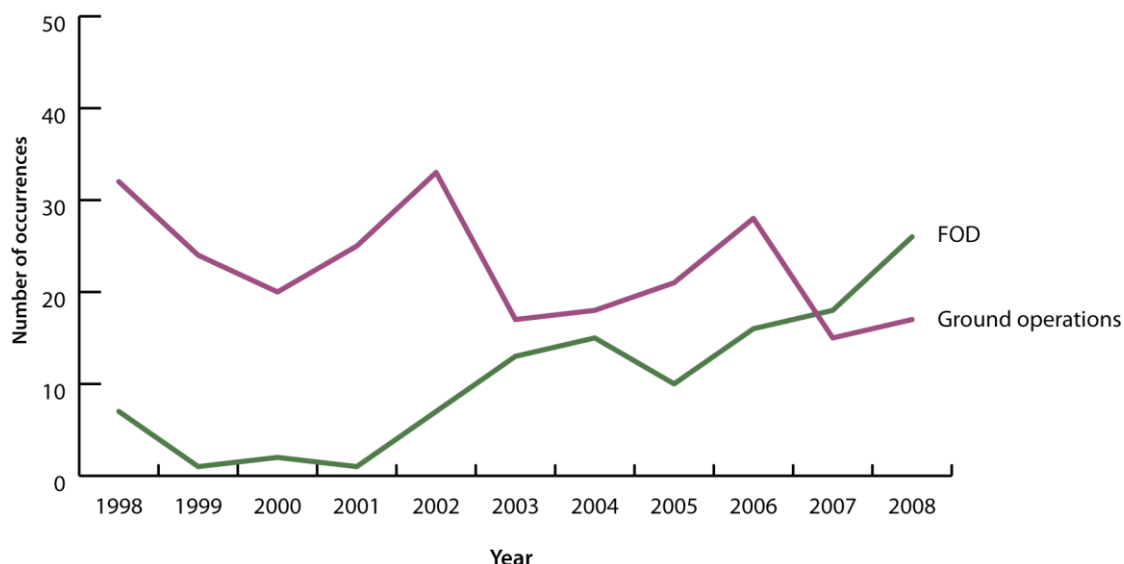
SUMMARY OF OCCURRENCES

Of the 398 ground occurrences, about 70 per cent related to ground operations and 30 per cent related to foreign object debris (FOD) (Figure 4). The most notable increase over the reporting period was in FOD, while a slight downward trend was seen in occurrences involving ground operations across the reporting period. Two peaks were observed in ground operations data, the first in 2002 and the second in 2006.

Over the reporting period, ground operations occurrences have been as low as 12 per million movements, and as high as 34 per million movements. About one ground operations occurrence took place per 50,000 aircraft movements when ground operations data were pooled. In relation to FOD, these occurrences have been as low as 1 per million movements, and as high as 20 per million movements. When the data for FOD is pooled, the FOD occurrence rate is 1 per 115,000 aircraft movements.

There are many different types of FOD and ground operations occurrences each year, and the number of occurrences in each category has varied over time. These data are now explored in the following sections of this report.

Figure 4: Ground occurrences by year, 1998 to 2008



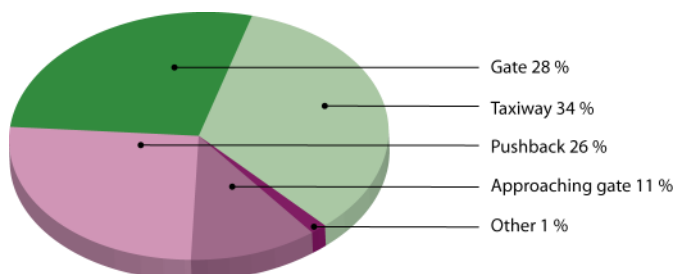
⁴ This increase is in part due to the introduction of the *Transport Safety Investigation Act 2003*.

⁵ High capacity movement figures are those involving RPT services. The movements figures will be slight larger than those reported here, as some high capacity charter figures are not included.

GROUND OPERATIONS OCCURRENCES

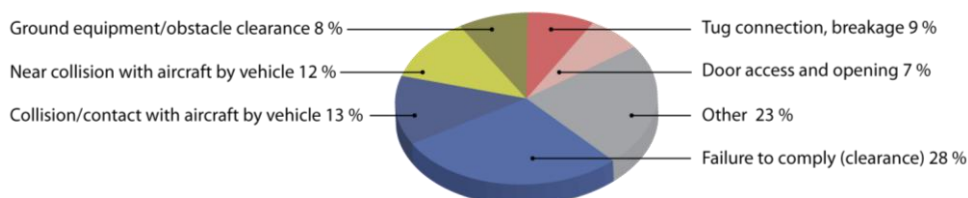
Between 1 January 1998 and 31 December 2008, there were 282 ground operations occurrences in Australia. These occurrences varied in their locations/phase of operations (Figure 5).

Figure 5: Ground operation occurrences by phase/location 1998 to 2008



The most commonly reported phase or location of ground operations occurrences was on a taxiway, accounting for about 34 per cent of occurrences. This was followed by gate occurrences at about 28 per cent, pushback at about 26 per cent, and approaching the gate at about 11 per cent. Similar types of occurrences were seen between different locations/phases. Six different types of occurrences accounted for about 75 per cent of all ground operations occurrences (Figure 6), with failure to comply with a clearance being the most frequently reported occurrence type. The *other* category (about 25 per cent) included a mixture of collision or near collision occurrences with aircraft by aircraft, aircraft collisions with objects, buildings or vehicles, refuelling occurrences, flight crew perceptions, jet blast, weather-related and injury, animal strikes, and engine start up and shutdown.

Figure 6: Ground operations by occurrence type, 1998 to 2008



About a quarter of the reported ground operations occurrences involved aircraft damage. The vast majority of damaging occurrences related to ground crew collision with a stationary aircraft, and about two per cent of occurrences related to flight crew colliding with an object on the ground. Less than one per cent required disembarkation.

Table 1: Consequences of ground operations occurrences, 1998 to 2008

Consequential events	Number	Per cent
None	217	77.0
Ground handling damage	55	19.5
Aircraft ground collision	6	2.1
Disembarkation	2	0.7
Jet blast damage	2	0.7
Total	282	100

The following sections table the type of occurrence by phase/location of operation.

Approaching gate

Thirty occurrences were reported while approaching the gate, accounting for about 11 per cent of all occurrences involving ground operations. Figure 7 shows that the most commonly reported occurrence was near collision with aircraft by vehicles (about 37 per cent). These occurrences required immediate braking action by the flight crew or vehicle driver in order to avoid a collision. Occasionally, cabin crew were injured during these events, as they were out of their seats preparing for arrival; the act of sudden braking threw them off balance.

A related occurrence type, obstacle/object clearance, accounted for 30 per cent of approaching the gate occurrences. These mostly involved a vehicle operating outside the equipment clearance lines as an aircraft approached the gate. Occasionally, unmanned ground equipment (such as portable stairs or tugs) was outside the equipment clearance lines. About 80 per cent of near collision/obstacle clearance occurrences occurred during the day.

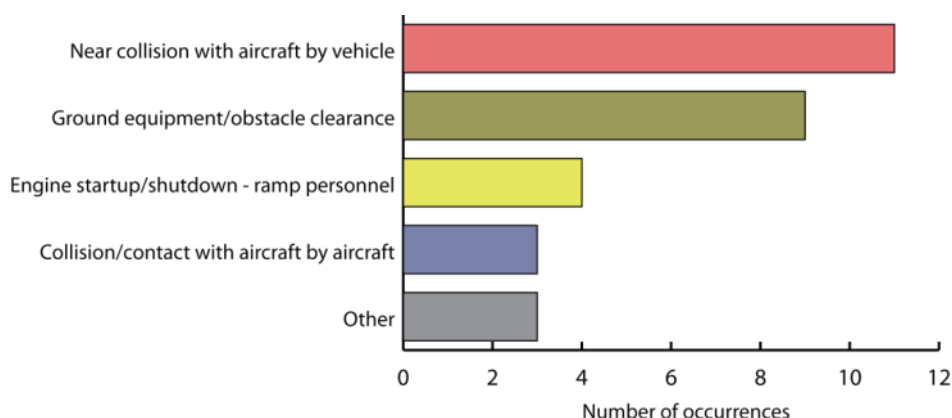
The third most prevalent type of occurrence on approaching the gate involved ground personnel being too close to engines during start up and shut down activities. In four occurrences, ramp personnel came close to operating aircraft engines, or infringed upon hazard zones, as the aircraft was being positioned at the gate. No personnel were ingested into aircraft engines, but the occurrences were noted by flight crews as potential hazards. It appears that ramp personnel were eager to prepare for the imminent arrival of the aircraft.

Speedy trolley tug

As the aircraft was approaching the gate, a trolley tug appeared from under the terminal finger and moved at high speed between the aircraft and another aircraft at an adjacent gate. The crew applied the brakes and stopped as the tug was operating on the aircraft side of the equipment lines.

In three occurrences, aircraft being marshalled by ground staff struck parked aircraft at adjacent bays wingtip-to-wingtip. Two aircraft had high wing configurations, while the third had a low wing configuration. Two of these occurrences took place in the late afternoon, and the third at night.

Figure 7: Approach to gate occurrences, 1998 to 2008



Occurrences in the *other* category involved disembarking passengers, flight crew taxi techniques, and ground crew approaching the aircraft engines before the aircraft had stopped. In the first occurrence, the flight crew were cleared to enter a terminal gate, but upon entry, found disembarking passengers from an adjacent aircraft gate in their path. The second occurrence involved a pilot using a sharp-manoeuvring taxi technique close to terminal ground support equipment.

Damage to aircraft on approach to the gate occurred in five reported occurrences. Three involved positioning the aircraft under the guidance of a marshal. Two involved equipment positioned outside the equipment clearance lines – in one instance a tug and baggage trailer, and in the other, a set of portable stairs. In the tug occurrence, the tug operator, the receipt and dispatch line engineer, and the

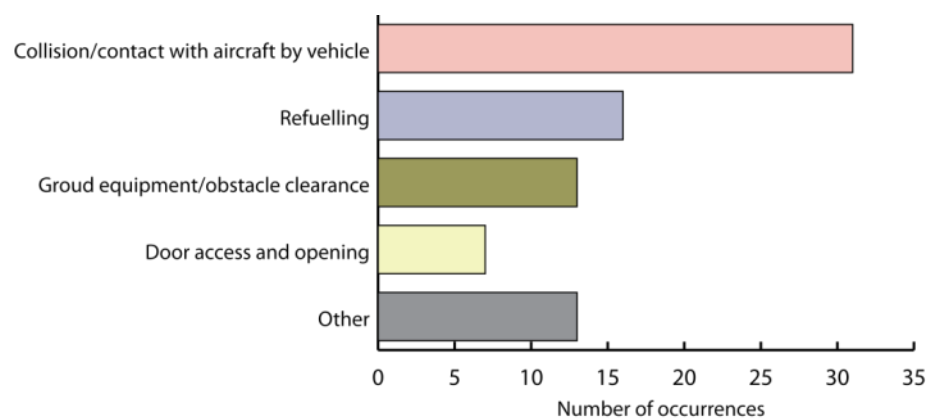
customer service officer did not notice the tug was positioned incorrectly. The other event involving portable stairs occurred at first light in drizzling rain. One aircraft collided with a temporary blue apron edge marking light, but the aircraft was not damaged.

Gate occurrences

Of all ground operations occurrences, those that took place at the gate were the second most frequently reported (about 27 per cent). As discussed in the introduction, the ATSB only receives a subset of all safety occurrences that occur at the gate. Such occurrences only include incidents and accidents that involve an aircraft that is being prepared for takeoff or before passengers and crew disembark the aircraft.

While the 76 gate occurrences were similar to those that occurred during approach to the gate, a larger number of collisions (rather than near collisions) with aircraft by vehicles were found. Collisions with aircraft were the most common gate event, accounting for about 40 per cent of reported occurrences, while refuelling occurrences accounted for about 20 per cent of occurrences. About 12 per cent involved clearance with ground equipment or obstacles, and about 10 percent involved door opening and access issues. Ground equipment and obstacle occurrences involved equipment outside the equipment clearance lines, or use of ground support equipment. Door opening and access largely involved ground crew opening cargo doors while the anti-collision beacon was operating and ground vehicles blocking cabin access doors. Details of these collisions at the gate and refuelling occurrences are presented below (see Table 2 on page 10).

Figure 8: Gate occurrences, 1998 to 2008



The *other* category included a number of different types of occurrences:

- wind forcing an aircraft away from the gate
- an aircraft collision with infrastructure
- operating a vehicle without a clearance
- aircraft parking clearance and congestion.

Aircraft collision with infrastructure occurrences involved flight crew monitoring and uncommanded rolling of aircraft, where brakes were either not set, or failed, and the aircraft started to move.

Figure 9: Catering truck loading supplies into an aircraft parked at the gate



Damage occurred in 45 per cent of reported occurrences where the aircraft was at the gate. Most of the damage came from vehicles, but three occurrences involved ground equipment collisions and the fourth involved an aircraft rolling and striking a terminal wall. Generally, a delay in the aircraft's departure or flight cancellation will come about as a result of damage, while engineers assess its impact on the aircraft's structure and airworthiness.

Collision with aircraft at the gate

Table 2 records the type of vehicle or object that collided with aircraft at the gate. This shows that cargo loaders/containers, mobile stairs, and catering trucks more frequently collided with aircraft, based on data reported to the ATSB. Of these occurrences, about 50 percent occurred as the vehicle or object was being driven up to, or away from, a door. Approximately 23 per cent of vehicle or object collisions involved contact with a wing, horizontal stabiliser, or engine. The remaining occurrences were divided between a place on the fuselage other than a door, and other parts of the empennage.

Figure 10: Pallet loader positioned next to an aircraft at an Australian airport



It is interesting to note that airlines using predominately hand-push vehicles for loading and unloading of luggage and passengers appear to have fewer ground operations occurrences involving damage. Use of motorised vehicles around aircraft cannot be totally eliminated, as pallet container and catering trucks must continue to lift heavy items into the cargo holds of an aircraft.

Cargo container hits engine
 While parked on the ground flight planning for the return flight to [place], the crew noticed a bang and shaking through the airframe. Ground engineers advised that a cargo container being towed hit the number [x] engine causing minor damage.

Table 2: Vehicles colliding with aircraft at the gate, 1998 to 2008

Vehicle causing damage	Number	Per cent
Cargo or container loader	8	24.2
Mobile stairs	8	24.2
Catering truck	4	12.1
Aerobridge	3	9.1
Passenger lifter	3	9.1
Belt loader	3	9.1
Tug	2	6.1
Baggage trolley	1	1.3
Fuel truck	1	1.3
Total	33	100.0

In some of these occurrences there was a complicating factor, such as broken equipment being towed away or congestion. For example, a vehicle from an adjacent gate caused damage in one occurrence, and in the other, a moveable airport works barrier was blocking the path of a vehicle, which unsuccessfully attempted to drive between the barrier and the aircraft.

Aircraft damage resulting from collisions with ground vehicles or objects can be a significant safety risk if not identified and remedied prior to flight. In one instance, ground crew noticed a puncture hole in the fuselage as the aircraft arrived. The airport where the damage occurred was not known, but the damage was consistent with contact from an aerobridge. This is potentially serious, and in occurrences among overseas aircraft, has led to cabin depressurisation. On the basis of descriptions reported to the ATSB, it is not possible to classify the extent of aircraft damage, but loading vehicles were more frequently represented in collisions.

Exhaust pipe burns a hole in crew bag during refuelling
 During aircraft refuelling, crew baggage was placed on the tarmac close to the aircraft bulk cargo hold. A belt loader was positioned very close to the crew baggage, and a short time afterwards, smoke was seen coming from one of the crew bags. The exhaust pipe of the belt loader had burnt a hole through the side of the bag.

Gate refuelling

There were 16 refuelling occurrences reported to the ATSB between 1998 and 2008. Most refuelling occurrences reported had consequential events relating to fuel venting and spills. Note that none of these occurrences related to aircraft weight and balance issues.

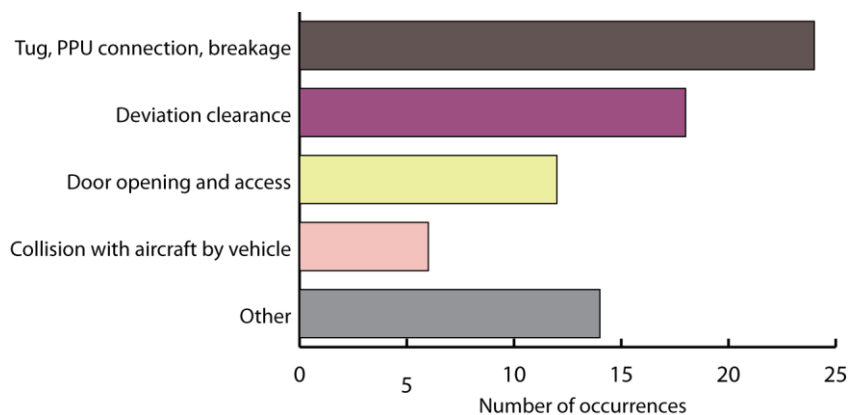
Figure 11: Concurrent refuelling and loading operations



Pushback occurrences

There were 74 pushback occurrences reported to the ATSB, making this the third most common type of ground operations occurrence (representing about 26 per cent). Ground operations events were defined as occurring in the pushback phase if they happened at any time between the connection of a tug or power push unit (PPU), and the point at which an aircraft taxis under its own power on a taxiway.

Figure 12: Pushback occurrences, 1998 to 2008



Pushback is designed to occur when all general service vehicles and equipment have been placed behind equipment clearance lines and a pushback clearance has been given by the surface movement controller (SMC). Commonly, pushback might involve up to four ground personnel, including a tug or PPU driver, a dispatcher, and possible observers. The dispatcher plays a pivotal role in coordinating the pushback, and in cases where a tug is used for pushback, removes the nose steering bypass pin (allowing the tug driver to directly control aircraft nose-wheel steering).

Four occurrence types accounted for about 80 per cent of all pushback occurrences; these were tug or PPU connection and breakage, failure to comply with pushback clearance procedures, inadvertent aircraft door opening, and collision with aircraft by vehicle.

By far, the most frequently reported pushback occurrence involved tug or PPU connections and disconnections (33 per cent), including breakages while the aircraft was moving. These connections and disconnections occur for a variety of reasons which revolve around communication between the dispatcher, flight crew, and tug or PPU driver.

Figure 13: Pushback tug positioned airside



The following points summarise tug or PPU occurrences at Australian airports:

- pushback commenced with the aerobridge still connected
- pushback commenced without inserting the steering lockout pin
- premature tug disconnection occurred, and the aircraft rolled forward or backward
- incorrect PPU remote control hand unit was used, and when the button to move the PPU was depressed, this made an aircraft in another bay move
- incorrect tug for the aircraft – tug roof contacted the fuselage of the aircraft
- turning too sharply or jack-knifing
- two-man connection procedure attempted as a one-man procedure
- standing while driving a tug.

The next most frequently reported category of pushback occurrence involved failure to comply with pushback clearance (22 per cent). These occurred where an aircraft was pushed back:

- beyond published aerodrome limits
- into a taxiway for which clearance had not been given
- in the wrong sequence.

Pushing back beyond published aerodrome limits accounted for the majority of occurrences. Sometimes an engine cross-start procedure was performed in an unauthorised area. Engine cross-starts must be performed at a safe distance from people and equipment – in some instances, this took the aircraft beyond established boundaries.

Door opening to load late arriving baggage and/or passengers accounted for about 17 percent of pushback occurrences. In the normal sequence of events, once a pushback clearance has been given and the anti-collision beacon is operating, ground staff must not approach an aircraft without the permission of the flight crew. Similarly, cabin staff must not open a door to accept late passengers without obtaining the approval of the flight crew. The door openings in this report mostly occurred while the aircraft was stationary, but occasionally involved a moving aircraft being pushed on to a taxiway which was required to stop while bags or cargo were loaded. Often the first sign of a door opening to the flight crew is the illumination of a cargo door annunciator light.

Anti-collision beacon ignored by catering truck

After receiving pushback clearance from air traffic control and with appropriate aircraft lighting on, the crew noticed that a catering truck had arrived in close proximity to the aircraft, with the reported intention of removing stores. The pushback was delayed.

Collisions with aircraft by vehicles accounted for about eight per cent of pushback occurrences. These all involved tugs or PPUs making contact with an aircraft and causing damage. In these occurrences, the reason for the tug or PPU contact was that the:

- tug was incompatible with the aircraft
- towbar was not the correct length
- PPU roller assemblies had fractured or failed.

Figure 14: Pushback tug, with towbar, awaiting connection to the nose wheel



The remaining 20 per cent of pushback occurrences were a combination of:

- near aircraft-aircraft collisions
- near vehicle-aircraft collisions, where pushback was stopped to avoid a collision
- flight crew monitoring lapses, including making sure the aircraft dispatcher is disconnected before starting to taxi
- ground crew being in close proximity to an operating aircraft engine.

Pushback is a phase where ground and flight crew interact, and where ground crew, particularly the dispatcher, must stay in close contact with moving aircraft, and potentially be exposed to hazard zones around landing gear and aircraft engines. Overall, damage to aircraft was reported in about 23 per cent of all pushback occurrences reported to the ATSB.

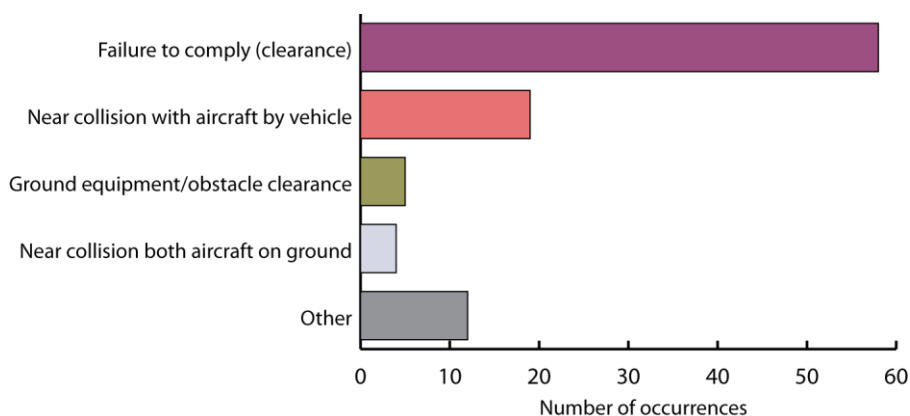
Figure 15: Powerpush unit attached to the main landing gear



Taxiway occurrences

Ninety-eight taxiway occurrences were reported to the ATSB over the reporting period. About 77 per cent of taxiway occurrences involved a deviation by vehicles from a surface movement controller clearance (not a runway incursion), or a near collision with aircraft.⁶ The remaining occurrences related to reduced clearance with ground equipment and obstacles, actual and near aircraft-aircraft collisions, jet blast, and vehicle clearance on taxiways, including near collisions with aircraft by vehicles.

Figure 16: Taxiway occurrences, 1998 to 2008



⁶ There were also about 500 occurrences involving aircraft failing to comply with a taxiway clearance not included in these data.

Failure to comply (with a clearance) occurrences involved vehicles:

- using an incorrect taxiway
- failing to stop at a taxiway holding point
- failing to stay on the surface movement control radio frequency
- failing to seek a clearance.

Figure 17: A typical taxiway intersection at an Australian airport



The occurrences where vehicles nearly collided with aircraft involved a range of vehicles, including cars belonging to the Australian Customs and Border Protection Service, catering trucks, tugs, and fuel trucks. Almost 70 per cent of these occurrences involved a taxiing aircraft arriving at an airport.

Near aircraft-aircraft collisions on ground were infrequent, but potentially serious. Separation standards apply to aircraft in the air, but there are no specific separation standards on taxiways - much the same as cars on the road. A common sense approach must be taken to separating aircraft on the ground. In the near aircraft-aircraft collision occurrences reported to the ATSB, some aircraft were taxiing at a high ground speed, in one case estimated to be 30 kts; there are no speed limits for taxiing aircraft. In another occurrence, two aircraft almost collided because their aircraft lights may have been silhouetted against numerous other background lights. In one occurrence, a taxiing aircraft wing passed underneath the wing of another aircraft situated at gate.

Figure 18: Taxiway aircraft-aircraft collision showing winglet damage



One taxiway occurrence during the reporting period involved an aircraft-aircraft collision. An experienced pilot in a Boeing 747 aircraft deviated from a taxiway clearance, attempting to squeeze past a Boeing 767 aircraft which was protruding into the taxiway. The pilot in command of the 747 misjudged the distance between the wingtip of the 747 and the right horizontal stabiliser of the 767, resulting in a collision (Figure 18).

Jet blast is another potentially serious event, and in one instance reported to the ATSB, a passing high capacity jet aircraft caused a smaller parked aircraft weighing approximately 2,800 kg to move 45 degrees from its parked position.

Three taxiway occurrences led to aircraft damage - two were due to jet blast, and the third was the aforementioned collision between two aircraft.

Other occurrences

Four occurrences involved locations other than taxiways and apron areas. These involved:

- a vehicle that was parked in the Instrument Landing System critical area when weather was below the minima
- vehicles on perimeter roads, operating contrary to traffic lights used to stop vehicles when aircraft land (two occurrences)
- a large aircraft making a 180 degree turn on the flight strip, damaging lighting and pavement on the flight strip,

Contributing factors for ground operation occurrences

The most common contributing factor to ground operations occurrences were individual actions. For occurrences between 1998 and 2008, these most frequently involved action errors, where a person deviated either from plans or standard operating procedures. Common examples were towbar connection procedures and pushback errors, like turning back too sharply with the tug and damaging the nose or landing gear of the aircraft. Less frequently, individual action errors were associated with a violation, information, or decision error. Violations involved a deliberate intention to deviate from standard operating procedures. Examples included opening the doors while the aircraft anti-collision beacon was operating, or vehicle drivers failing to give-way to aircraft on the apron or taxiways. Decision errors indicated that planned actions were not adequate for the situation; for example,

deviating from a pushback clearance, or overriding an automatic fuel shut-off valve. Information errors were associated with a failure to perceive or understand the situation; for example, misidentifying taxiways and clearance of vehicles or objects from the aircraft.

Other types of contributing factors to occurrences involving ground operations related to risk controls associated with equipment. These included such factors as tug design, and standardisation of safety equipment for different tugs.

FOREIGN OBJECT DEBRIS

Foreign objects debris (FOD) has the potential to damage aircraft, particularly in the case of jet-powered aircraft, where objects can be ingested into an engine. In Australia, there were 116 FOD occurrences reported to the ATSB between 1998 and 2008 that affected high capacity air transport aircraft. The number of FOD occurrences has increased in a curvilinear fashion from 7 in 1998 to 26 in 2008. Most FOD occurrences took place at major airports, but they were also recorded at regional airports, and remote localities such as mine sites. Foreign object debris occurrences were most frequently reported during the busiest hours of operation at most airports in Australia (between 7 am and 7 pm).

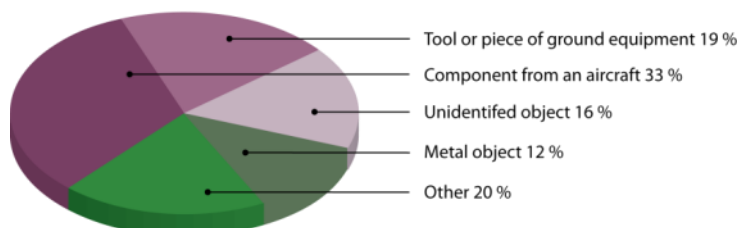
Foreign object debris comes from many sources. Material sometimes falls from aircraft, maintenance vehicles, and aircraft handling equipment onto runways, taxiways, and the airport aprons. In the case of aircraft, the physical stresses exerted during takeoff and landing place high loads and vibrations on tyres, engines (reverse thrust), and landing gear components, which can cause poorly secured components to loosen and separate. Weather also influences the prevalence of FOD, with winds blowing debris on to runways, but occasionally aircraft contaminate a runway or taxiway with rocks and dirt as a result of jet blast.

Figure 19: Nut and bolt found on an Australian flight strip



The most common FOD reported to the ATSB was aircraft components, and these made up about 25 per cent of all reported FOD occurrences. In terms of high capacity aircraft, components making up the engine reverse thrust assemblies were most commonly reported and included blocker doors, door assembly pins and bolts, bushes, and plates. Less commonly reported FOD items from aircraft were landing gear doors, delaminated material from flaps and control surfaces, struts, and landing lights. Most of these components were found on the runway strip rather than on or near taxiways and airport aprons.

Figure 20: Types of foreign object debris reported, 1998 to 2008



Tools or pieces of equipment were the second most common FOD event reported to the ATSB, accounting for about 19 per cent of all FOD occurrences.. The reports showed a variety of tools and equipment were found on runway strips, taxiways, and aprons, including screwdrivers, a 15 litre can of paint, spanners and wrenches, a torch, wire, a headset, and rags. Less commonly found were vehicle horns, rotating beacons, and cone markers. In about another 16 per cent of FOD occurrences, the object was not identified, and in about 12 per cent of FOD occurrences, the object found was metal, but it was not possible to tell if the component was from an aircraft or another source. These metal objects included bolts, brackets, metal plates, and poles. Loose material on the runway surface or surrounding area accounted for about four per cent FOD occurrences; these occurrences related to grass, stones, and dirt on the runway strip. Pieces of paper and plastics also represent an engine ingestion risk, and these types of FOD were found in about five per cent of FOD occurrences reported to the ATSB. Animal carcasses were found in three reported FOD occurrences, but no evidence of an animal strike was found with these occurrences. The animals were small, and this suggests that they had been dropped on the runway by birds of prey.

Phillips-head screwdriver bit causes engine damage

Shortly after takeoff, the crew of a Boeing 767 heard a series of loud bangs, followed by a rapid rise in the no-2 engine exhaust gas temperature. An emergency was declared, and the aircraft returned to the aerodrome and passengers disembarked. A boroscope inspection of the engine revealed extensive damage to the engine core, and the engine was replaced. Subsequent engine teardown found a Phillips-head screwdriver bit in the core of the engine. This probably fell into the engine through the variable bleed valves which are open when the aircraft is not operating. The aircraft was performing its first flight after a maintenance check.

Figure 21: An aircraft component (FOD) found at an Australian airport



Consequences of FOD

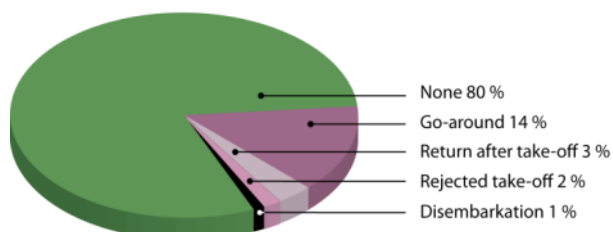
About 11 per cent of FOD occurrences reported to the ATSB led to airframe, wheel, or engine damage. Four FOD occurrences occurred during takeoff, with one resulting in engine ingestion and a subsequent return to the aerodrome, and three resulting in a tyre blowout and rejected takeoff or return to the aerodrome.

Foreign object debris occurrences leading to aircraft damage occurred not only on the runway strip, but on taxiways and at the aerodrome gate. Nine of the 116 occurrences FOD occurrences reported to the ATSB between 1998 and 2008 occurred on the aerodrome apron, and 12 occurred on taxiways. Examples of foreign objects found on aprons and taxiways included a box, paper, and plastic sheets, which are all capable of being ingested into an engine. Sometimes, the exact place where an event occurred is not known, but they are discovered at the aerodrome gate.

In three occurrences, tyres were damaged during aircraft pushback. In one instance, a tyre was punctured by a metal pin, and in the other two occurrences, an unknown metal object pierced the tyre. There were two occurrences involving engine damage from FOD at the aerodrome gate.

FOD occurrences had no effect on the aircraft operation in about 80 per cent of occurrences, but where it did, the most common consequential events were go-arounds (16 occurrences) and rejected take-offs (four occurrences).

Figure 22: Consequences of reported FOD occurrences, 1998 to 2008



Managing FOD is a shared responsibility between pilots, maintenance personnel, ground staff, air traffic services (ATS) and aerodrome operators.

Figure 23: A Boeing 737 nosewheel tyre shredded as a result of FOD impact in Australia



Contributing factors for FOD

The most common factor that contributed to FOD occurrences was individual actions relating to aircraft maintenance. These included replacing, repairing, and installing aircraft components, and the use and removal of tools and personal items from aircraft prior to the issue of a maintenance release or aircraft dispatch.

The second most common contributing factor was related to the conditions in the local physical environment. These generally related to the condition of runway and movement surface areas, which were contaminated by aircraft parts and maintenance equipment dropped from works vehicles.

SUMMARY

Airports are complex interfaces between the air and the ground, where many vehicle, people and aircraft movements occur. Many risk controls are in place at airports and within airlines to minimise the hazards associated with ground movements in general, but occurrences involving FOD and ground operations continue to happen. Australia has not experienced a major aircraft accident due to ground operations occurrences. This report articulates the scope of these occurrences from an Australian perspective as reported to the ATSB over an 11-year period. This image is not complete, but the occurrences in this report serve as a timely reminder of how ground occurrences take place, and to some degree why they occur.

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