

A History of Airport Technology

The aircraft tug comes in all shapes and sizes and either uses a tow bar to manoeuvre the aircraft or a hydraulic cradle to lift the nose wheel off the ground during push back. (KEY - Duncan Cubitt)



Much of the everyday infrastructure that we take for granted at airports helps to speed our journey and make it more comfortable. **Lucy Budd** investigates how some of these commonplace items came about.

The history of airport technology is one of continued development and specialisation. The progressive introduction of new aircraft, combined with the gradual liberalisation of the airline industry throughout the second half of the twentieth century, led to a huge rise in passenger numbers and required the development of new equipment to facilitate efficient turnarounds and speed up the flow of passengers through the terminal. This article describes some of the innovations that have been introduced to meet the specific design challenges of commercial aviation and charts

the origin and development of some familiar pieces of airport equipment.

Airport design and development

In the early days of commercial aviation, airport facilities were very rudimentary, but as the twentieth century progressed, airports were forced to expand and modernise to cater for the ever-growing numbers of passengers. In order to accommodate the additional check-in counters, security lanes, departure lounges, retail areas, piers, and

gates, huge expansion programmes were undertaken and new buildings constructed. As a consequence, the walk between the check-in hall and the departure lounge increased dramatically and, by the mid-1970s, distances of 1,500ft (457m) - the length of around five football pitches - were not uncommon at major American airports. For a time, the long concourses at Chicago O'Hare were known colloquially as 'cardiac alley' because of the possibility of transfer passengers suffering a heart attack while hurrying along them. In recognition that the distance between check-in and their aircraft was not only tiring passengers but also hindering their on-time arrival at the gate, a technological innovation was deployed that would reshape the airport experience and become a common sight around the world.

Moving walkways

It is widely reported that the first moving walkway was installed in Dallas Love Field in Texas in 1958 to help passengers traverse the 1,000ft (305m)-long concourses between the main terminal and the departure lounges. Travelling at the sedate pace of around one-and-a-half miles an hour, the horizontal moving walkway aided the on-time arrival of passengers at the gate without wearing them out. The device proved a success and, six years later, American Airlines inaugurated its new 'astroway' - a rubberised moving walkway - in the terminal at Los Angeles. Instead of having to carry or drag heavy cases, passengers could stand next to them



In addition to travelers many airports have also introduced people-movers to speed passengers between far flung terminals, as illustrated here at Detroit. (KEY Collection)

on the walkway and be transported down long corridors with the greatest of ease. Naturally, such walkways could only be installed in linear (straight line) concourses and not in round or curved terminals unless they incorporated linear projections to adjoining satellite terminals (such as Terminal One at Paris Charles de Gaulle).

Today, although faster and more robust than their predecessors, moving walkways or travelators remain a key feature of many airports, speeding up the passage of passengers and providing endless entertainment for young (and not so young!) children who invariably try to run 'backwards' along them against the intended direction of movement.

Airbridges

In addition to expediting the movement of passengers through the terminal building, several systems have been developed to accommodate passenger boarding, including airstairs, airbridges, and mobile departure lounges. Historically, aircraft were parked on the apron and aligned either nose-in or nose-out to the terminal for self taxi in and out. Passengers were escorted across the apron to the aircraft by ground staff and invited to board either via an integral set of airstairs installed in the aircraft or via a flight of steps that was placed at, or wheeled to, the main door of the aircraft. While this system proved adequate for small low-density airport operations in favourable



The humble travelator, or moving walkway, is one of the most obvious pieces of technology that has revolutionised the airport experience for millions of passengers. Found at most of the world's major airports, these simple but effective devices help take the strain out of the long distances often found between check-in and the departure gate. (KEY Collection)



climates, passengers reportedly did not like being exposed to the noise, fumes, and weather conditions on the apron; while ground staff expressed concern at the safety and security aspects of escorting growing numbers of people across an active apron. In the 1930s, a forerunner of the modern airbridge was put into operation at London's Gatwick airport. The device consisted of an extendable fabric-covered enclosed walkway that ran on metal rails and was wheeled out onto the apron to meet arriving flights. Disembarking passengers were led through the tunnel into the terminal to protect them from the inclement weather and the dangers on the airfield. To facilitate efficient turnarounds and ensure public

safety, aircraft movements were strictly choreographed and procedures that had first been practised in the 1930s were enshrined in airport operating manuals. Consequently, passengers always board and disembark an aircraft from its left-hand side, while catering and servicing occurs on the right. With the arrival of larger aircraft in the 1950s, the idea of constructing permanent aircraft 'loading sleeves' was proposed. These devices were to be finger-like extensions, built at right angles to the terminal building, that jutted out onto the apron. The aircraft would then be connected to the terminal via four or more flexible corridors that would allow boarding to occur through multiple doors simultaneously.

On the whole, today's airports are a wonder of modern technology, making use of equipment and innovations that we all take for granted. Without the development of such items the traveller would have a much tougher time and airports would struggle to cope with today's soaring passenger numbers. (KEY Collection)

In 1958, United Airlines introduced the first such 'aero gangplank' at Chicago's O'Hare airport to speed up passenger boarding. The device was similar in design to the loading sleeve concept, but featured a single three-section enclosed telescopic ramp that was powered by a small motorised dolly. One end was attached to the side of the terminal building at first-floor level, while the open end could be aligned to fit over the aircraft's doorway. When an aircraft arrived on stand, the gangplank could swivel sideways through a 120° arc and telescope out to meet the aircraft's main door. The apparatus could extend from its retracted length of 55ft (16.7m) to the maximum length of 107ft (32.6m) in 90 seconds and could be elevated at the open end to any height between 4ft 6in (1.36m) and 13ft 6in (4.10m) above the ground to allow it to service different aircraft types. The open end was fitted with a rubberised seal that conformed to the contours of the aircraft's fuselage to keep out wind and rain. Windows and fluorescent lights were installed in the ramp to make the interior appear bright and roomy and the whole device was soundproofed.

In 1959, American Airlines introduced an extension of the aero-gangplank system at Los Angeles. Unlike its predecessor, this device consisted of not one, but two, elevated corridors that led from the terminal building and ended at adjustable sections fitted at right angles to the main corridor. This enabled one section to be positioned over the front door of a Boeing 707, while the second section was positioned against the rear door. Not only did this system save passengers from climbing the eleven steps up to a B707 and braving the elements on the apron, but the airline also claimed it helped them board 112 passengers in less than three minutes. Though fewer ground



The introduction of the airbridge from the late 1950s provided airports with a means to board and disembark passengers quickly and comfortably, without them needing to use airstairs and then walk across the apron, often in inclement weather. However, today most LCCs prefer not to use airbridge-equipped gates as doing so often incurs additional charges from the airport and in some cases is slower than using two sets of stairs. (KEY - Steve Fletcher)

staff were required to supervise passenger boarding, the high purchase and installation costs associated with the new device meant airbridges were initially only installed at a few airports.

Given the variable distances that exist between the level of the terminal building and height of different aircraft door sills, between the centreline of the stand and the relative position of different aircraft door sills, and between the ground and the height of different aircraft, many variations of telescopic and non-telescopic, mobile and immobile 'airbridges' or 'jetways' have been developed and installed at the world's airports. Of these, the generic 'apron loader bridge' is perhaps the most versatile, as it can be moved in both the vertical and horizontal planes and can accommodate a wide variety of different aircraft types.

Today, nose-in parking coupled with enclosed passenger airbridges appears to be the preferred configuration for passenger boarding at most of the world's major airports, as this system consumes less apron space, reduces the time taken for aircraft turnarounds, facilitates efficient passenger boarding, and is superior in terms of passenger comfort, security and safety. The airbridges themselves are usually constructed from solid metal panels, and while some incorporate windows, many do not, and it has been said that this may increase the anxiety experienced by some nervous passengers, as they cannot see the aircraft they are about to board. Ever alert to potential marketing and revenue opportunities, however, many airport operators sell advertising space on the sides of airbridges or use them to reinforce the brand identity of the airport. While this practice may enliven their appearance, it has had the effect of turning some airports into giant billboards.

Washington Dulles pioneered the use of mobile lounges which take passengers straight from the aircraft cabin to the arrivals hall, and from the departure lounge direct to the aircraft. Some of these vehicles can hold 150 people. (KEY - Tony Dixon)



Mobile lounges

While airbridges are a common method of boarding passengers, some airports were designed to use a totally different system based on the use of mobile lounges. Instead of constructing long concourses and installing moving walkways to help passengers reach distant gates, a number of airports relied on mobile lounges to take them to their aircraft. Upon reaching the correct gate, passengers would board a 'mobile departure lounge' or a 'terminal on wheels' that would drive them across the apron to their remotely-parked aircraft. This system had the advantage of enabling all airport functions to be centralised in a main terminal building (thereby eliminating the need for long piers or satellite terminals), but it did require the construction of specialised high-lift, high-capacity vehicles.

Mobile lounges were an innovation that was first introduced at Washington Dulles International Airport in 1962. For various reasons, including noise insulation and facilitating jet manoeuvres under power,

the nearest stands were constructed over 1,100ft (335m) away from the main terminal building, and specially-built vehicles, capable of seating just over 100 passengers and raising and lowering themselves to match the height of the terminal and the doors of individual aircraft, were required.

In December 1961, the FAA awarded a contract valued at over \$4.6m for 21 mobile lounges to the Chrysler Corporation. The initial batch of vehicles, which were 15 x 60ft (4.5 x 18.3m) long, could accommodate up to 102 passengers and essentially took the terminal to the aircraft, eradicating the long distances passengers would otherwise have had to walk to the departure gate. The original fleet of vehicles was subsequently augmented by the introduction of 12 second-generation models, called 'Plane-Mates'. These could carry up to 150 passengers and were designed to support the new wide-bodied jets such as the B747. One hundred and fifty-seat mobile lounges, or PTVs (Passenger Transfer Vehicles), were also used at Montreal's Mirabel Airport to shuttle travellers between the

One of the commonest forms of ground guidance is the marshaller, using a pair of 'bats' to signal to the pilot. (KEY - Steve Fletcher)



terminal and their aircraft or, in the case of transfer passengers, drive them directly to their connecting flight.

Ground guidance systems

While airbridges and mobile lounges went some way towards addressing the need for developing safer, more comfortable, and faster boarding procedures, they relied on aircraft being precisely positioned on the stand, as poor manoeuvring and parking could prevent ground support equipment from interfacing with the aircraft. As a consequence, new stand guidance systems were developed to help pilots identify the location of individual stands and position their aircraft correctly on them.

During the 1960s and 1970s, some very fanciful 'solutions' to the problem of aircraft docking and passenger boarding were proposed. One intriguing suggestion involved loading passengers into mobile containers at check-in and then driving them straight to the aircraft. Another proposal, the Krupp mass passenger loading system, involved seating passengers in self-contained fuselage crates (complete with aircraft seats, galley and lavatories) that could be loaded, in their entirety, into the fuselage of the aircraft like giant freight pallets. It was thought that this system would reduce turnaround times as each passenger crate could be cleaned and serviced on the ground after it was offloaded, while fully-boarded, clean and replenished units could be installed in their place.

Similarly inventive ideas were planned on the apron to aid the manoeuvring of aircraft onto stands. One idea involved

constructing turntables in the apron onto which aircraft would taxi before being rotated onto the stand, while another required 'drag lines' to be installed under the tarmac to pull aircraft into the gate along a predefined track. Under this regime, the nose wheel assembly of the aircraft would be attached to a perpetually moving subterranean cable (much like the mechanism of a cable car, albeit it underground) and towed to its gate. This system had the advantage that the aircraft would be correctly positioned on stand, but the projected installation and ongoing maintenance costs proved extortionate.

Similarly intriguing was a proposal for an above-ground device that manoeuvred aircraft onto stands. A powerful tractor, fitted with telescopic arms, would position itself underneath the aircraft's fuselage between the main landing gear struts. The arms would then extend, and the aircraft would be propelled into position on the stand by the tractor driver exerting differential force on the landing gear. Perhaps unsurprisingly, this idea never received widespread support. Nevertheless, the problem of aircraft alignment on stand and docking remained a serious one, and so a range of visual docking guidance systems, which provide flight crew with alignment and stopping information, was developed.

Outsize cargo is often loaded aboard specialist freighter aircraft, such as this B747F, using equipment specifically designed for the task. (KEY Collection)



The simplest way to guide an aircraft on to its stand is using markings painted on the tarmac/concrete surface. But these alone do not tell a pilot exactly when to stop so that he is aligned with the airbridge and ground equipment. (KEY Collection)



Aircraft docking systems

There are a number of different visual docking guidance systems currently in use at airports around the world, including AGNIS (Azimuth Guidance for Nose-In Stands), APIS (Aircraft Positioning and Information System), Safegate, and Airpark. AGNIS provides guidance advice on the stand centreline and is often used in conjunction with either parallax aircraft parking aids (PAPA), side marker boards (SMBs) or side marker lines (SMLs), which provide information on the correct stop point. These systems are designed for use from the left pilot position, and information is usually communicated to the flightdeck through a combination of identification labels and lights. At smaller airports, or on remote stands, marshalling guidance is provided by a member of ground staff who uses illuminated light wands or brightly coloured marshalling bats to communicate with the flightdeck by using a series of internationally recognised arm and hand signals.

Tractors, tugs, and tow bars

Suitable pushback facilities are a prerequisite of airports where nose-in parking is used. Traditionally, aircraft pushback was performed using special tugs and towbars and, depending on the airport and airline, required between two and four people to perform. One person would drive the tug, another would liaise with the flightdeck, while the third (and, occasionally, fourth) would

Above: Push back is the most common use of the tow bar and tug, and will be familiar to most passengers. But the system is also used to move aircraft to remote stands, or across the airport to maintenance hangars etc. (KEY Collection)

Today many airports have automated aircraft-docking systems which use sensors to precisely track the aircraft's position and a series of lights to guide the pilot and tell him when to stop. (Daimler-Benz Aerospace)




The Airbus A380 needs a giant tug – as illustrated here at London/Heathrow on March 18, 2008, the inaugural date of Singapore Airlines A380 flights to London from Changi. (KEY - Tom Allett)

act as a 'wingwalker' or look-out. Given the different dimensions and weights of individual airframes, the size and strength of the tug and towbar was crucial, and a strict series of safety procedures had to be followed to prevent injury to the crew or damage to the aircraft or tug. One of the biggest dangers was the risk of an aircraft 'jack-knifing' and a new technique of towbarless pushback and towing has been developed to combat this.

The idea of towbarless pushback and towing was first proposed during the oil crisis of the mid-1970s as a way of lowering fuel costs by reducing the length of time an aircraft's engines were running. Under this proposed regime, the aircraft would be pushed back from its stand and towed

to the runway threshold before starting its engines. The first towbarless design was fairly crude and involved a ramp that was forced under the aircraft's nose gear assembly and clamped in place around it. While undoubtedly attractive to economists, pilots and aircraft manufacturers did not greet the idea with much enthusiasm, the former expressing concern that responsibility for ground manoeuvring was relinquished to a tug driver, and the latter cautioning that the practice could damage the aircraft. The method was also found to be time-consuming and inefficient, and generated additional workload for ground controllers.

Nevertheless, the concept of towbarless tugs and dispatch towing was not dismissed entirely, and in the 1980s, Lufthansa developed the PTS-1 towbarless tug. Though this machine overcame many of the problems that had beset its predecessor, flight crew were still opposed to the idea of an aircraft being under the control of a tug driver and airframe manufacturers were reluctant to approve high-speed towing because of the potential risk of damage to the nose gear assembly during acceleration and braking. Today, the application of new technology and the introduction of a new generation of tugs mean that towbarless towing is a more viable proposition. Modern towbarless tugs feature a hydraulic cradle that surrounds the nose landing gear assembly and lifts it between 6 and 11in (150-280mm) off the ground. As 





the weight of the aircraft is transferred to the tug through the cradle assembly, the danger of damaging the nose gear is reduced.

Platforms, power units and pallets

As the physical size, systems complexity and passenger capacity of aircraft increased, a range of dedicated vehicles and ground support equipment, including pallet loaders, scissor-lifts, and refuelling bowlers, was developed to meet the needs of ever-larger aircraft. Today as soon as an aircraft arrives on stand and shuts down its engines, various pieces of purpose-designed ground support equipment swarm around it to service, clean and replenish it before its next flight.

The introduction of larger, jet aircraft, from the late 1950s onwards, presented a new range of problems. For example, the horizontal stabiliser of the Vickers VC-10 was 40ft (12m) above the apron and engineers had to use a telescopic 'Skylift' access platform to reach it. Similarly, the doors, access panels and servicing ports on the new wide-bodied Douglas DC-10, B747 and Lockheed L1011 TriStar were well out of reach of ground staff and engineers on the apron. Indeed, the sheer scale of the aircraft (in terms of their

A typical scene at Frankfurt as Lufthansa baggage containers are loaded aboard a long-haul flight. (KEY - Tony Dixon)



Above Left: Three items of equipment found at most airports are illustrated in this photo taken at London/Stansted. The scissor lift on the LCG SkyChefs catering vehicle, the plug-in ground power which averts the need for the aircraft to run its APU, and the airbridge. (KEY - Duncan Cubitt)

Above: Cargo is most often carried on pallets which can be quickly loaded and unloaded thanks to rollers on the aircraft floor and the use of scissor lifts. (KEY Collection)

de-icing gantries that shower the airframe in de-icing compounds. The spent de-icing solution is subsequently collected in special conduits and treated to minimise the risk of environmental contamination. To reduce the quantity of glycols and other chemical de-icers that are used, some airports have installed infrared de-icing gantries that gently thaw any ice or snow that has accumulated on the airframe.

In addition to these pieces of equipment, new ground support technologies had to be developed to assist in the loading and unloading of increasing volumes of baggage and freight. In 1959, United Airlines developed fibreglass baggage containers for use in their DC-8s. These containers could be pre-loaded with 25 pieces of baggage or 1,100lb (499kg) of freight and were loaded into the aircraft by an electronic winch. Rollers on the base of the containers ran along rails inside the aircraft's cargo hold and enabled eleven fully-loaded containers to be moved and stowed with relative ease. The use of these containers reportedly reduced loading times from 14 to three minutes.

Today, depending on the airline and type of aircraft operating the flight, battered metal baggage containers, or pallet dollies,

emblazoned with the airline's logo are used carry baggage and freight and can be seen on the ramps at many of the world's major airports. Owing to their size and weight, these containers are offered up to the aircraft on special loading platforms. Outsized cargo may be placed in wooden crates and loaded in a similar fashion or conveyed in dedicated cargo aircraft such as the Antonov An-124 and B747F. On smaller aircraft, individual pieces of baggage are still loaded by hand, though mobile conveyor belts may be positioned next to the aircraft to speed up the process. On arrival, bags are offloaded and taken into the terminal where they are presented for retrieval on revolving baggage carousels.

Baggage handling facilities

Arguably, baggage-handling facilities are one of the most important systems in an airport terminal and perhaps one of the most maligned. Though it may sound ironic today, baggage systems and carousels were initially conceived and designed to speed up the processing of luggage and to ensure bags were loaded onto the correct flight(s) and quickly delivered undamaged to the baggage reclaim hall on arrival. Though the precise specifications of the various systems installed at individual airports may differ from one another, all are designed to increase the speed with which passengers are reunited with their luggage. At smaller airports, much of the baggage handling activity is done by hand, whereas larger airports, particularly those that have a higher proportion of transfer traffic, have more elaborate systems that can process thousands of bags an hour and (theoretically at least) keep track of individual pieces of luggage as they move along the miles of conveyor belts and guideways.

At check-in, each bag is tagged with a unique identification number and the three-

letter IATA code for the destination airport. These tags are colour-coded according to origin (for example, those on flights originating from within the European Union have a green border to help screeners, loaders, and customs officials quickly identify their source). At larger airports, baggage tags are bar coded and given a ten-digit key number called a Baggage Source Message (BSM) or 'licence plate' that helps identify them. These tags contain a wealth of textual and coded information, including the passenger's name, their intended route, carrier, flight number, and the date. Automatic scanners then read these tags and direct the bags into different chutes for loading. Bags that cannot be automatically sorted are processed and loaded by hand. The system should ensure

The use of bar code technology to identify individual bags is now standard and is vital to monitoring the whereabouts of the millions of items that move around the world every day. New radio frequency tracking techniques are being introduced to follow bags even more precisely. (KEY - Mark Nicholls)



that bags are not mislaid or loaded onto the wrong flight.

Passengers can reduce the likelihood of losing their luggage by choosing to travel with only hand luggage or by ensuring that their bags are carefully tagged and the baggage receipt retained. It is hoped that trials involving radio frequency tags will be successful and that the introduction of more sophisticated baggage handling software will restore confidence in this essential component of the airport system and reduce the occurrence of mishandled baggage.

Assuming that the bags were correctly tagged and loaded at the point of origin, all the luggage from a flight is offloaded at the destination and delivered to the baggage hall where it is usually presented on one of three generic types of baggage carousel; a simple straight belt, a circulating unit that is fed from the same level, or a circulating unit that is fed from above or below. Each system has its own particular foibles and is suited to different volumes of traffic.

Airport technology past, present and future

The history of commercial aviation is one of continual and rapid innovation. In a little over 100 years, air travel has gone from being the exclusive preserve of a few rich and foolhardy spirits to the transport mode of choice for millions of passengers every year. The progressive introduction of new aircraft, together with rising passenger numbers, required the development of new technologies and equipment to support airport operations. Many of these new systems were borne of necessity to combat problems that were, ironically, created by aviation's success and development, such as airbridges to expedite safe passenger boarding and scissor-lifts to reach the doors of aircraft that stood many feet above the apron. Already, new and enlarged equipment has been introduced for the A380, and innovative ideas and equipment will undoubtedly be introduced to service the aircraft and airports of the future.



The moving baggage belt is a familiar sight to passengers but even that has changed a lot over the years. Some are still flat but the majority of the larger ones are inclined at an angle which allows the luggage to be loaded automatically by gravity from a chute and has the added benefit of making it easier for the traveller to remove the bag from the belt. (KEY - Steve Fletcher)