General Aviation Activities

Whitney Rounds

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Table of Contents

Chapter 1 - Aerial Photography

Chapter 2 - Aerobatics and Air Racing

Chapter 3 - Angel Flight and Air Ambulance

Chapter 4 - Air Charter

Chapter 5 - Air Show

Chapter 6 - Aerial Firefighting

Chapter 7 - Gliding

Chapter- 1

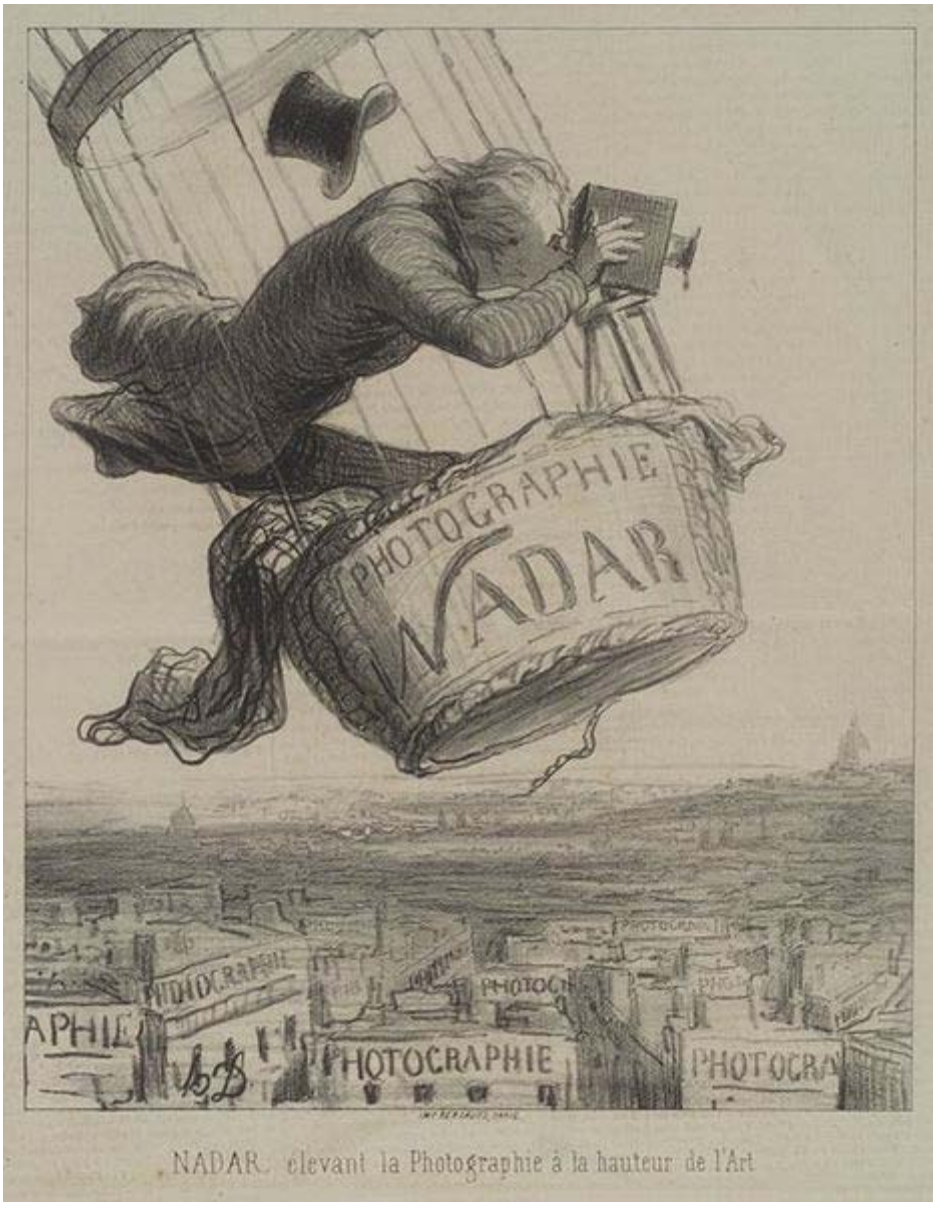
Aerial Photography

The Georgian terrace of Royal Crescent (Bath, England) from a hot air balloon

London Docklands in the fog from an Eurocopter AS355

Aerial photography is the taking of photographs of the ground from an elevated position. The term usually refers to images in which the camera is not supported by a ground-based structure. Cameras may be hand held or mounted, and photographs may be taken by a photographer, triggered remotely or triggered automatically. Platforms for aerial photography include fixed-wing aircraft, helicopters, balloons, blimps and dirigibles, rockets, kites, poles,parachutes,vehicle mounted poles. Aerial photography should not be confused with Air-to-Air Photography, when aircraft serve both as a photo platform and subject.

History



Honoré Daumier, "Nadar élevant la Photographie à la hauteur de l'Art" (Nadar elevating Photography to Art), published in *Le Boulevard*, May 25, 1862.

Aerial photography was first practiced by the French photographer and balloonist Gaspard-Félix Tournachon, known as "Nadar", in 1858 over Paris, France.

The first use of a motion picture camera mounted to a heavier-than-air aircraft took place on April 24, 1909 over Rome in the 3:28 silent film short, *Wilbur Wright und seine Flugmaschine*.

The first special semiautomatic aerial camera was designed in 1911 by Russian military engineer — Colonel Potte V. F. This aerial camera was used during World War I.

The use of aerial photography for military purposes was expanded during World War I by many others aviators such as Fred Zinn. One of the first notable battles was that of Neuve Chapelle.

With the advent of inexpensive digital cameras, many people now take candid photographs from commercial aircraft and increasingly from general aviation aircraft on private pleasure flights.

Uses of imagery

Reflection of a hot air balloon, partially obscured by a pier, an example of low-altitude aerial photography

Giza pyramid complex, photographed from Eduard Spelterini's balloon on November 21, 1904

Fogo island aerial shot taken from an Airbus cockpit by the pilot himself

Aerial photography is used in cartography (particularly in photogrammetric surveys, which are often the basis for topographic maps), land-use planning, archaeology, movie production, environmental studies, surveillance, commercial advertising, conveyancing, and artistic projects. In the United States, aerial photographs are used in many Phase I Environmental Site Assessments for property analysis. Aerial photos are often processed using GIS software.

Radio-controlled aircraft

Advances in radio controlled models have made it possible for model aircraft to conduct low-altitude aerial photography. This has benefited real-estate advertising, where commercial and residential properties are the photographic subject. Full-size, manned aircraft are prohibited from low flights above populated locations. Small scale model aircraft offer increased photographic access to these previously restricted areas. Miniature vehicles do not replace full size aircraft, as full size aircraft are capable of longer flight times, higher altitudes, and greater equipment payloads. They are, however, useful in any situation in which a full-scale aircraft would be dangerous to operate. Examples would include the inspection of transformers atop power transmission lines and slow, low-level flight over agricultural fields, both of which can be accomplished by a large-scale radio controlled helicopter. Professional-grade, gyroscopically

stabilized camera platforms are available for use under such a model; a large model helicopter with a 26cc gasoline engine can hoist a payload of approximately seven kilograms (15 lbs).

Recent (2006) FAA regulations grounding all commercial RC model flights have been upgraded to require formal FAA certification before permission to fly at any altitude in USA.

Because anything capable of being viewed from a public space is considered outside the realm of privacy in the United States, aerial photography may legally document features and occurrences on private property.

Types of aerial photographs

Oblique photographs

Photographs taken at an angle are called oblique photographs. If they are taken almost straight down are sometimes called low oblique and photographs taken from a shallow angle are called high oblique.

Vertical photographs

Vertical photographs are taken straight down. They are mainly used in photogrammetry and image interpretation. Pictures that will be used in photogrammetry was traditionally taken with special large format cameras with calibrated and documented geometric properties.

Combinations

Aerial photographs are often combined. Depending on their purpose it can be done in several ways. A few are listed below.

- Several photographs can be taken with one hand held camera to later be stitched together to a panorama.
- In pictometry five rigidly mounted cameras provide one vertical and four low oblique pictures that can be used together.
- In some digital cameras for aerial photogrammetry images from several imaging elements, sometimes with separate lenses, are geometrically corrected and combined to one image in the camera.

Orthophotos

Pteryx UAV, a civilian UAV for aerial photography and photomapping with roll-stabilised camera head

Vertical photographs are often used to create orthophotos, photographs which have been geometrically "corrected" so as to be usable as a map. In other words, an orthophoto is a simulation of a photograph taken from an infinite distance, looking straight down from nadir. Perspective must obviously be removed, but variations in terrain should also be corrected for. Multiple geometric transformations are applied to the image, depending on the perspective and terrain corrections required on a particular part of the image.

Orthophotos are commonly used in geographic information systems, such as are used by mapping agencies (e.g. Ordnance Survey) to create maps. Once the images have been aligned, or 'registered', with known real-world coordinates, they can be widely deployed.

Large sets of orthophotos, typically derived from multiple sources and divided into "tiles" (each typically 256 x 256 pixels in size), are widely used in online map systems such as Google Maps. OpenStreetMap offers the use of similar orthophotos for deriving new map data. Google Earth overlays orthophotos or satellite imagery onto a digital elevation model to simulate 3D landscapes.

Aerial video

With advancements in video technology, aerial video is becoming more popular. Orthogonal video is shot from aircraft mapping pipelines, crop fields, and other points of interest. Using GPS, video may be embedded with meta data and later synced with a video mapping program.

This ‘Spatial Multimedia’ is the timely union of digital media including still photography, motion video, stereo, panoramic imagery sets, immersive media constructs, audio, and other data with location and date-time information from the GPS and other location designs.

Aerial videos are emerging Spatial Multimedia which can be used for scene understanding and object tracking. The input video is captured by low flying aerial platforms and typically consists of strong parallax from non-ground-plane structures. The integration of digital video, global positioning systems (GPS) and automated image processing will improve the accuracy and cost-effectiveness of data collection and reduction. Several different aerial platforms are under investigation for the data collection.

Chapter- 2

Aerobatics and Air Racing

Aerobatics

The UK Utterly Butterly display team perform an aerobatic maneuver with their Boeing Stearmans

Red Arrows BAE Hawks in Apollo formation. (2010)

Patrouille de France producing colored smoke during an air show

Aerobatics is the practice of flying maneuvers involving aircraft attitudes that are not used in normal flight. Aerobatics are performed in airplanes and gliders for training, recreation, entertainment and sport. Some helicopters, such as the MBB Bo 105, are capable of limited aerobatic maneuvers.

Most aerobatic maneuvers involve rotation of the aircraft about its longitudinal (roll) axis or lateral (pitch) axis. Other maneuvers, such as a spin, displace the aircraft about its vertical (yaw) axis. Maneuvers are often combined to form a complete aerobatic sequence for entertainment or competition.

Aerobatic flying requires a broader set of piloting skills and exposes the aircraft to greater structural stress than for normal flight. In some countries, the pilot must wear a parachute when performing aerobatics.

While many pilots fly aerobatics for recreation, some choose to fly in aerobatic competitions, a judged sport.

Overview

In the early days of flying, some pilots used their aircraft as part of a flying circus to entertain. Maneuvers were flown for artistic reasons or to draw gasps from onlookers. In due course some of these maneuvers were found to allow aircraft to gain tactical advantage during aerial combat or dogfights between fighter aircraft.

Aerobatic aircraft fall into two categories — specialist aerobatic, and aerobatic capable. Specialist designs such as the Pitts Special, the Extra 200 and 300, and the Sukhoi Su-29 aim for ultimate aerobatic performance. This comes at the expense of general purpose use such as touring, or ease of non aerobatic handling such as landing. At a more basic level, *aerobatic capable* aircraft, such as the Cessna 152 Aerobat model, can be dual purpose—equipped to carrying passengers and luggage, as well as being capable of basic aerobatic figures.

Flight formation aerobatics are flown by teams of up to sixteen aircraft, although most teams fly between four and ten aircraft. Some are state funded to reflect pride in the armed forces whilst others are commercially sponsored. Coloured smoke trails may be emitted to emphasise the patterns flown and/or the colours of a national flag. Usually each team will use aircraft similar to one another finished in a special and dramatic colour scheme, thus emphasising their entertainment function.

Teams often fly V-formations (otherwise known as echelon formation)— they will not fly directly behind another aircraft because of danger from wake vortices or engine exhaust. Aircraft will always fly slightly below the aircraft in front, if they have to follow in line (the "trail formation").

The UK Swift Aerobatic Display Team at Kemble Battle of Britain Weekend 2009. A Swift glider is performing continuous full rolls while towed by a Piper Pawnee

Aerobatic maneuvers flown in a jet powered aircraft are limited in scope as they cannot take advantage of the gyroscopic forces that a propeller driven aircraft can exploit. Jet powered aircraft also tend to fly much faster which increases the size of the figures and the length of time which the pilot has to withstand increased g-forces. Jet aerobatic teams often fly in formations which further restricts the maneuvers that can be safely flown.

To enhance the effect of aerobatic maneuveres smoke is sometimes generated; the smoke allows viewers to see the path travelled by the aircraft. Due to safety concerns, the smoke is not a result of combustion but is produced by the vaporization of fog oil into a fine aerosol, achieved either by injecting the oil into the hot engine exhaust or by the use of a dedicated device that can be fitted in any position on the aircraft. The first military aerobatic team to use smoke at will during displays was Fleet Air Arm 702 Squadron "The Black Cats" at the Farnborough Air show in September 1957.

Training

Aerobatics are taught to military fighter pilots as a means of developing flying skills and for tactical use in combat. Aerobatics and formation flying is not limited solely to fixed wing aircraft, helicopters are also used—the British Army, Royal Navy, Spanish Air Force and the

Indian Air Force, among others, have helicopter display teams. All aerobatic maneuvers demand training and practice to avoid accidents. Such accidents are rare but can result in fatalities; safety regulations are such that there has not been an airshow spectator fatality in the USA since the 1950s. Low-level aerobatics are extremely demanding and airshow pilots must demonstrate their ability before being allowed to gradually reduce the height at which they may fly their show.

Patty Wagstaff show at JeffCo Airport

"Blue Impulse" (JASDF)

Competition

Competitions start at Primary, or Graduate level and proceed in complexity through Sportsman, Intermediate and Advanced, with Unlimited being the top competition level. Experienced aerobatic pilots have been measured to pull +/-5g for short periods while unlimited pilots can perform more extreme maneuvers and experience higher g levels -possibly up to +8/-6g. The limits for positive g are higher than for negative g and this is due to the ability to limit blood pooling for positive g maneuvers, but it is generally accepted that +9 g for more than a few seconds will lead to loss of consciousness (also known as GLOC).

Air racing

A pair of Sport Class racers passing the finish pylon at the Reno Air Races

Air racing is a motorsport that involves small aircraft.

History

The first event in air racing history was held on May 23, 1909 - the Prix de Lagatinerie, held at the Port-Aviation airport south of Paris, France. Four pilots entered the race, two actually started and nobody completed the full race distance. Léon Delagrange, who covered more than half of the ten 1.2-kilometre laps was declared the winner.

Some other minor events were held before the August 22-29 1909 Grand Week of the Champagne at Reims, France. This was the first major international air race, drawing many of the most important plane makers and pilots of the era, as well as celebrities and royalty. The premier event — the Gordon Bennett Trophy — was won by Glenn Curtiss, who beat second place finisher Louis Blériot by five seconds. Curtiss was named "Champion Air Racer of the World". This event was held yearly at different locations.

In 1934, the MacRobertson Air Race from England to Australia took place with the winning de Havilland Comet flown by C.W.A. Scott and Tom Campbell Black.

Between 1913 and 1931 the Schneider Trophy seaplane race was run, which was significant in advancing aeroplane design, particularly in the fields of aerodynamics and engine design, and would show its results in the best fighters of World War II.

In 1921, the United States instituted the National Air Meets, which became the National Air Races in 1924. In 1929, the Women's Air Derby became a part of the National Air Races circuit. The National Air Races lasted until 1949. The Cleveland Air Races was another important event.

That year, pilot Bill Odom suffered a crash during a race, killing himself and two other people in a nearby house. In 1947, an All-Woman Transcontinental Air Race (AWTAR) dubbed the "Powder Puff Derby" was established, running until 1977.

In 1964, Bill Stead, a Nevada rancher, pilot, and unlimited hydroplane racing champion, organized the first Reno Air Races at a small dirt strip called the Sky Ranch, located between Sparks, Nevada, and Pyramid Lake. The National Championship Air Races were soon moved to the Reno Stead Airport and have been held there every September since 1966. The five-day event attracts around 200,000 people, and includes racing around courses marked out by pylons for six classes of aircraft: Unlimited, Formula One, Sport Biplane, AT-6, Sport and Jet. It also features civil airshow acts, military flight demonstrations, and a large static aircraft display. Other promoters have run pylon racing events across the USA and Canada, including races in Mojave, California in 1978; at Moose Jaw, Saskatchewan in 1984; at Hamilton, California, in 1988; in Phoenix, Arizona in 1994 and 1995; and in Tunica, Mississippi in 2005.

In 1970, American Formula One racing was exported to Europe (Great Britain, and then to France), where almost as many races have been held as in the U.S.A. Also in 1970, the California 1000 Air Race started at the Mojave Airport with an 66 lap unlimited air race that featured a Douglas DC-7 with one aircraft completing the circuit.

Air racing in England: the Red Bull Air Race heat held at Kemble airfield, Gloucestershire. The aircraft fly singly, and have to pass between pairs of pylons

Red Bull has created a series called the Red Bull Air Race World Championship in which competitors fly singularly through a series of air gates, between which they must perform a prescribed maneuvers. Usually held over water near large cities, the sport has attracted large crowds and brought substantial media interest in air racing for the first time in decades.

The newest air racing competition to enter the sport is the Aero GP, based in Europe, which has held at least one air race per year since 2005, including 2 grand prix in 2008. Aero GP air racing is based on the classic format of multiple planes racing together and against each other in a tight pylon circuit. Aero GP air races are broadcast on television in hundreds of millions of homes worldwide, establishing the events as credible fixtures in the air racing world.

Classes

Restricting aircraft to a specific type or design creates a competition that focuses on pilot skill. Air racing events such as the Reno air races, incorporate multiple classes or aircraft. These may be defined by the race organizer, or by a sanctioned group. Some air races are limited to a single class.

Class	First Race	Primary Desription	Course Field	Sanctioned
T-6 Air Racing		T-6 Texan, Harvard, and SNJ powered by a Pratt & Whitney Wasp R-1340-AN-1 Radial Engine	Pylon	
Formula One Air Racing	1970	200 cubic inch engines	Pylon	International Aeronautics Federation
Formula V Air Racing	1972	1600cc Volkswagon Engine	Pylon	

Chapter- 3

Angel Flight and Air Ambulance

Angel Flight

Angel Flight is the name used by a number of groups whose members provide free transportation for needy patients and perform other missions of community service. Such a non-profit organization may be located in the United States, Europe, Australia, or Canada and they, like other Public Benefit Flying (PBF) organizations, help arrange free, non-emergency transportation for patients who require medical treatment but who cannot afford to pay for a commercial flight. Transportation is provided by volunteer pilots, often using their own private general aviation aircraft. In most of Canada, the Volunteer Pilot Program of Hope Air provides a similar service, along with Angel Flight of Vancouver.

A list of all the Angel Flight and other Public Benefit Flying Organizations is maintained by the Air Care Alliance.

How Angel Flight Works

The Angel Flight organizations themselves do not provide the transportation. Instead, each acts as a "matchmaker," connecting people who have a compelling need for transportation but can not afford it with individual pilots who are willing to provide free flights as a charity.

Angel Flight volunteers typically serve patients who require specialized medical treatment at a facility far from their homes—for example, a clinic that has expertise in the treatment of a particular form of a disease. In some cases, other compelling human needs are served, such as transportation to visit a hospitalized family member, or transportation helping in time of emergencies or disasters. Many of the public benefit flying groups helped in the aftermath of Hurricane Katrina, for example.

The Angel Flight process usually begins when a referring health professional, usually a social worker, contacts an Angel Flight organization. The referrer describes the points between which transportation is needed, the total number of people and weight, and the condition of the patient.

Not every patient is eligible for transportation. For example, patients usually must be medically stable and capable of walking on their own and sitting upright unassisted. The flight must also not be for treatment of a medical emergency, because weather or other factors may cause last-minute cancellation of the flight. Often a doctor's signoff is required. Therefore, these flights are not considered to be air ambulance services.

If the flight request is deemed appropriate then information concerning the date, source, destination, and total passenger count is added to an "available mission list" on that Angel Flight web site or other notification list. Pilot volunteers periodically check the mission list and can assign themselves to a mission that is appropriate to their aircraft and schedule.

Angel Flight Pilots

Angel Flight missions are made possible by pilots who volunteer their time, their skills, and the funds required for aircraft operating expenses. Many pilots provide Angel Flights in their own personal aircraft, although some do so using rented aircraft. Pilots must usually meet certain minimum flight experience requirements before they are allowed to command an Angel Flight mission. They also receive training on the special procedures required for Angel Flight.

Pilots have a variety of reasons for volunteering for Angel Flight missions. Most do so simply because they enjoy flying, and because providing charity transportation is more constructive than getting the proverbial $100 hamburger or "drilling holes in the sky" (flying just for the sake of flying). The aircraft operating expenses are also generally tax-deductible (not in Australia however).

History of Angel Flight

Angel Flight's first organizations under that name were founded in 1983.

Formed in Santa Monica, California, Angel Flight of California, now known as Angel Flight West, and formed in Atlanta, Georgia, Angel Flight Georgia, were the first two organizations formed under the name.

Air ambulance

A Eurocopter EC 145 of Switzerland's Rega air rescue service

An air ambulance helicopter landing in a car park

An **air ambulance** is an aircraft used for emergency medical assistance in situations where either a traditional ambulance cannot reach the scene easily or quickly enough, or the patient needs to be transported over a distance or terrain that makes air transportation the most practical transport. These and related operations are referred to as **Aeromedical**. Air ambulance crews are supplied with equipment that enables them to provide medical treatment to a critically injured or ill patient. Common equipment for air ambulances includes ventilators, medication, an ECG and monitoring unit, CPR equipment, and stretchers.

History

Military

As with many innovations in Emergency Medical Service (EMS), the concept of transporting the injured by aircraft has its origins in the military, and the concept of using aircraft as ambulances is almost as old as powered flight itself. It is often stated that air medical transport likely first occurred in 1870 during the Siege of Paris when 160 wounded French soldiers were transported by hot-air balloon to France, but this canard has been definitively disproven. During the First World War air ambulances were tested by various military organizations, and were used regularly for crash rescue by the American Army within the United States, though none were actually used in combat. Aircraft were still primitive at the time, with limited capabilities, and the effort received mixed reviews. The exploration of the idea continued, however, and fully-organized air ambulance services were used by France during the African Colonial Wars of the 1920s-- over 7,000 casualties were evacuated by the French during this period. By 1936, an organized military air ambulance service was evacuating wounded from the Spanish Civil War for medical treatment in Nazi Germany. The first use of helicopters to evacuate combat casualties was by German luftwaffe, and the first dedicated use of helicopters by U.S. forces occurred during the Korean War, during the period from 1950-1953. While popularly depicted as simply removing casualties from the battlefield (which they did), helicopters in the Korean War also expanded their services to moving critical patients to more advanced hospital ships once initial emergency treatment in field hospitals had occurred. Knowledge and expertise of use of aircraft as ambulances continued to evolve along with the aircraft themselves, and by 1969, in Vietnam, the use of specially trained medical corpsmen and helicopters as ambulances led U.S. researchers to conclude that servicemen wounded in battle had better rates of survival than motorists injured on California freeways. This conclusion inspired the first experiments with the use of civilian paramedics in the world. The US military has recently employed UH-60 Black Hawk helicopters to provide air ambulance service during the Iraq War to both civilians and military personnel. The use of military aircraft as battlefield ambulances continues to grow and develop today in a variety of countries, as does the use of fixed wing aircraft for long distance travel, including repatriation of the wounded. The next step in this development may be shown by a current NATO working group which is investigating the possible future use of Unpiloted Aerial Vehicles (UAVs) for casualty evacuation.

Early Air Ambulance Efforts

Older version of a Danish air ambulance

Light helicopters like this Bell 47 Sioux removed the wounded from the battlefield (Korea)

H-19 moves wounded to more advanced care offshore (Korea)

Civilian

The first civilian uses of aircraft as ambulances were probably incidental. In northern Canada, Australia, and in the Scandinavian countries, remote, sparsely populated settlements were often inaccessible by road for months at a time, or even year round. In some cases in Scandinavia, particularly in Norway, the primary means of transportation between communities was by boat. Early on in aviation history, many of these communities began to receive service from civilian "bush" pilots, flying small aircraft and transporting supplies, mail, and visiting doctors or nurses to the isolated communities. Bush pilots probably performed the first civilian air ambulance trips, albeit on an ad hoc basis, but clearly, a need for such services existed. In 1928 the first formal, full-time air ambulance service was established in the Australian outback. This organization became the Royal Flying Doctor Service and continues operating to the present. In 1934, the first civil air ambulance service in Africa was established in Morocco by Marie Marvingt.

Australia's Royal Flying Doctor Service

King Air 200 Ambulance

King Air

Pilatus PC 12/45

Air ambulances were useful in remote areas, but their usefulness in the developed world was still uncertain. Following the end of the Second World War, the first civilian air ambulance in North America was established by the Saskatchewan government in Regina, Saskatchewan, Canada, which had both remote communities and great distances to consider in the provision of health care to its citizens. The Saskatchewan air ambulance service continues to be active as of 2009.

Back in the United States, 1947 saw the creation of the Schaefer Air Service, the country's first air ambulance service. This service was founded by J. Walter Schaefer, of Schaefer Ambulance Service in Los Angeles, California. Schaefer Air Service was also the first FAA-certified air ambulance service in the United States. At the time of the creation of the Schaefer and Saskatchewan services, paramedicine was still decades away, and unless the patient was accompanied by a physician or nurse, they operated primarily as medical transportation services.

A great deal of the early use of aircraft as ambulances in civilian life, particularly helicopters, involved the improvised use of aircraft belonging to branches of the military. Eventually this would become more organized. This mode of usage occurred not only in the United States, but also in other countries, and persists to this day.

Military Aircraft Supporting Civilian Air Ambulance

Swedish Search and Rescue

Dutch Search and Rescue

Israeli Military Helicopter as Air Ambulance

Two programs were implemented in the U.S. to assess the impact of medical helicopters on mortality and morbidity in the civilian arena. Project CARESOM was established in Mississippi in 1969. Three helicopters were purchased through a federal grant and located strategically in the north, central, and southern areas of the state. Upon termination of the grant, the program was considered a success and each of the three communities was given the opportunity to continue the helicopter operation. Only the one located in Hattiesburg did so, and it was therefore established as the first civilian air medical program in the United States. The second program, the Military Assistance to Safety and Traffic (MAST) system, was established in Fort Sam Houston in San Antonio in 1969. This was an experiment by the Department of Transportation to study the feasibility of using military helicopters to augment existing civilian emergency medical services. These programs were highly successful at establishing the need for such services. The remaining challenge was in how such services could be operated most cost-effectively. In many cases, as agencies, branches, and departments of the civilian governments began to operate aircraft for other purposes, these aircraft were frequently pressed into service to provide cost-effective air support to the evolving Emergency Medical Services.

Government Agency Aircraft Performing Double Duty

German 'Christoph' Air

Hong Kong Government Flying Service

Ambulance of the Federal Ministry of the Interior

Italian Dauphin of the Autonomous Province of Trento also used in Mountain Rescue missions

As the concept was proven, dedicated civilian air ambulances began to appear. On November 1, 1970, the first permanent civil air ambulance helicopter, *Christoph 1*, entered service at the Hospital of Harlaching, Munich, Germany. The apparent success of *Christoph 1* led to a quick expansion of the concept across Germany, with *Christoph 10* entering service in 1975, *Christoph 20* in 1981, and *Christoph 51* in 1989. As of 2007, there are about 80 helicopters named after Saint Christopher, like *Christoph Europa 5* (also serving Denmark), *Christoph Brandenburg* or *Christoph Murnau*. Austria adopted the German system in 1983 when *Christophorus 1* entered service at Innsbruck. The first civilian, hospital-based medical helicopter program in the United States began operation in 1972. Flight For Life Colorado began with a single Alouette III helicopter, based at St. Anthony Central Hospital in Denver, Colorado. In Ontario, Canada, the air ambulance program began in 1977, and featured a paramedic-based system of care, with the presence of physicians or nurses being relatively unusual. The system, operated by the Ontario Ministry of Health, began with a single rotor-wing aircraft based in Toronto. An important difference in the Ontario program involved the emphasis of service. 'On scene' calls were taken, although less commonly, and a great deal of the initial emphasis of the program was on the interfacility transfer of critical care patients. Operating today through a private contractor (ORNGE), the system operates 33 aircraft stationed at 26 bases across the province, performing both interfacility transfers and on-scene responses in support of ground-based EMS. Ornge operates the largest and most sophisticated program of aero-medical transport in North America. Over 17,000 admissions are dispatched annually, making Ornge North America's largest operator in the field of transport medicine. Today, across the world, the presence of civilian air ambulances has become commonplace, and is seen as a much-needed support for ground-based EMS systems.

Modern Civilian Air Ambulances

German Air Rescue - DRF

Devon Air Ambulance Trust

West Palm Beach, Florida

STARS - Alberta, Canada

Polish Air Rescue - Poland

Swedish King Air

Organization

Air ambulance service, sometimes called Aeromedical Evacuation or simply Medevac, is provided by a variety of different sources in different places in the world. There are a number of reasonable methods of differentiating types of air ambulance services. These include military/civilian models and services that are government-funded, fee-for-service, donated by a business enterprise, or funded by public donations. It may also be reasonable to differentiate

between dedicated aircraft and those with multiple purposes and roles. Finally, it is reasonable to differentiate by the type of aircraft used, including rotary-wing, fixed-wing, or very large aircraft. The military role in civilian air ambulance operations is described in the History section. Each of the remaining models will be explored separately. It should also be noted that this information applies to air ambulance systems performing emergency service. In almost all jurisdictions, private aircraft charter companies provide non-emergency air ambulance service on a fee-for-service basis.

Government operated

In some cases, air ambulance services will be provided by government, either directly or by means of a negotiated contract with a commercial service provider, such as an aircraft charter company. Such services may focus on the transfer of critical care patients, may support ground-based EMS on scenes, or may perform a combination of these roles. In almost all cases, the government will provide guidelines for use to both hospitals and EMS systems, in order to keep operating costs under control, and may specify operating procedures in some level of detail in order to limit potential liability, but almost always takes a 'hands-off' approach to the actual running of the system, relying instead on local managers with subject matter (physicians and aviation executives) expertise. Ontario's ORNGE program and the Polish LPR are examples of this type of operating system. In North East Ohio, including Cleveland, the Cuyahoga County-owned MetroHealth Medical Center uses its Metro Life Flight to transport patients to Metro's level I trauma and burn unit. There are 5 helicopters for North East Ohio and, in addition, Metro Life Flight has one fixed-wing airplane.

In the United Kingdom, the Scottish Ambulance Service operates two helicopters and two fixed-wing aircraft twenty-four hours per day. These represent the UK's only government-funded air ambulance service.

Multiple purpose

Snowy Hydro SouthCare Bell 412 helicopter in Australia

In some jurisdictions, cost is a major consideration, and the presence of dedicated air ambulances is simply not practical. In these cases, the aircraft may be operated by another government or quasi-government agency and made available to EMS for air ambulance service when required. In southern Queensland, Australia, the helicopter that responds as an air ambulance is actually operated by the local hydroelectric utility, with the Queensland Ambulance Service or New South Wales Ambulance Service providing paramedics, as required. In some cases, the flight paramedic will be provided to the aircraft operator by local EMS on an as-needed basis. In other cases, the paramedic will staff the aircraft full-time, but will have a dual function. In the case of the Maryland State Police, for example, the flight paramedic is a serving State Trooper whose job is to act as the Observer Officer on a police helicopter when not required for medical emergencies.

Fee-for-service

Switzerland REGA Fee-for-service

In many cases, local jurisdictions do not charge for air ambulance service, particularly for emergency calls. This is not, however, universally true. The cost of providing air ambulance services is considerable, and many such services, including government-run ones, charge for service. There are certain groups which, in particular, charge for service. These tend to be privately-owned companies, such as aircraft charter companies, hospitals, and some private-for-profit EMS systems. Within the European Union, almost all air ambulance service is on a fee-for-service basis, except for those systems which operate by private subscription. Many

jurisdictions have a mix of operation types. Fee-for-service operators are generally responsible for their own organization, but may have to meet government licensing requirements. Rega of Switzerland is an example of such a service.

Donated by business

German Auto Club

In some cases, a local business or even a multi-national company may choose to fund local air ambulance service as a goodwill or public relations gesture. Examples of this are common in the European Union, where in London the Virgin Corporation funds the Helicopter Emergency Medical Service, and in Germany and the Netherlands a large number of the 'Christoph' air ambulance operations are actually funded by ADAC, Germany's largest automobile club. In Australia and New Zealand, many air ambulance helicopter operations are sponsored by the Westpac Bank. In these cases, the operation may vary, but is the result of a carefully negotiated agreement between government, EMS, hospitals, and the donor. In most cases, while the sponsor receives advertising exposure in exchange for funding, they take a 'hands off' approach to daily operations, relying instead on subject matter specialists.

Public donations supported

Public donations

In some cases, air ambulance services may be provided by means of voluntary charitable fundraising, as opposed to government funding, or they may receive limited government subsidy to supplement local donations. Some countries, such as the U.K., use a mix of such systems. In Scotland, the parliament has voted to fund air ambulance service directly, through the Scottish Ambulance Service In England and Wales, however, the service is funded on a charitable basis via a number of local charities for each region covered, although the service to London receives most of its funding through the National Health Service.

Great strides were made in the UK between 2005 - 2008 when the independent charities formed themselves into the national association of air ambulance charities (AAAC) This organization is widely credited for having created the political climate which resulted in the helicopter industry and National Health Service recognising the enormous contribution that charities made to trauma care in the UK. In 2008, NHS partners joined the association and it was re-named the **Association of Air Ambulances**

In recent years, the service has moved towards the physician- paramedic model of care. This has necessitated some charities buying expensive clinical governance services from independent "for profit" companies. The industry is currently divided over whether it is ethically acceptable that income derived through philaphropy and altruism should be spent on buying this essential governance from profit-driven entrepreneurs. Research has been commissioned (March 2010) and it is expected that in future, clinical governace will be provided either free or on a not-for-profit basis.

Operating model

The operating model for the EMS system is often a valid way of differentiating air ambulances. The Anglo-American model tends to be paramedic-led, with occasional in-field involvement by physicians and nurses. In these cases, the emphasis is on the transport of the patient to definitive care, usually a hospital. While supportive and life-saving care may occur, the aircraft exists primarily as a means of transportation for the patient. Many hospital-based systems in the U.S. are examples of this model. In the Franco-German model, the response is physician-led, with a doctor attending on almost every call. The emphasis here is to bring definitive care rapidly to the patient, wherever they are. This may involve considerable 'on-scene' times, as physicians attempt complex interventions which would, in the other model, not be attempted until the patient reached the hospital. In these cases, the helicopter is a means of delivery of the physician and support staff (paramedic or nurse) to the scene. Further transport is generally accomplished using a ground ambulance, and air transport occurs only in the most dire of circumstances. The French SAMU system is an example of this model. The lines of distinction can be somewhat blurred between these models, as systems which use the Anglo-American model for ground ambulances may instead use the Franco-German approach to air ambulance service. The Dutch system is an example of this, as is the HEMS program in London, England.

Operating Models

Franco-German model

Dutch Crossover model

Anglo-American model

"Heavy-lift"

Recently retired USAF C-9 Nightingale air ambulance

A final area of distinction which requires mention is the operation of truly large aircraft, generally fixed-wing in nature, as air ambulances. The infrequency of demand for such a service in the civilian sphere means that the majority of such operations are confined to the military, which requires them in support of overseas combat operations. Military organizations with a capability of this type of specialized operation include the United States Air Force, the German Luftwaffe, and the British Royal Air Force. Each operates aircraft staffed by physicians, nurses, and corpsmen/technicians, and each has the capability of providing long distance transport, along with all required medical support, to dozens of injured persons simultaneously. One exception to the 'military-only' rule is the German automobile club, ADAC, which operates a large air ambulance aircraft specifically for the repatriation of individuals who subscribe to their own or affiliated travel insurance and protection plans.

Heavy lift capability

German Luftwaffe A310

German Auto Club Dornier 328

USAF C-17 Globemaster

Standards

Aircraft and flight crews

HAL Dhruv air ambulance in Bangalore, India

In most jurisdictions, air ambulance pilots must have a great deal of experience in piloting their aircraft because the conditions of air ambulance flights are often more challenging than regular non-emergency flight services. After a spike in air ambulance crashes in the United States in the 1990s, the U.S. government and the Commission on Air Medical Transportation Systems (CAMTS) stepped up the accreditation and air ambulance flight requirements, ensuring that all pilots, personnel, and aircraft meet much higher standards than previously required. The resulting CAMTS accreditation, which applies only in the United States, includes the requirement for an air ambulance company to own and operate its own aircraft. Some air ambulance companies, realizing it is virtually impossible to have the correct medicalized aircraft for every mission, instead charter aircraft based on the mission-specific requirements.

While in principle CAMTS accreditation is voluntary, a number of government jurisdictions require companies providing medical transportation services to have CAMTS accreditation in

order to be licensed to operate. This is an increasing trend as state health services agencies address the issues surrounding the safety of emergency medical services flights. Some examples are the states of Colorado, New Jersey, New Mexico, Utah, and Washington. According to the rationale used to justify the state of Washington's adoption of the accreditation requirements, requiring accreditation of air ambulance services provides assurance that the service meets national public safety standards. The accreditation is done by professionals who are qualified to determine air ambulance safety. In addition, compliance with accreditation standards is checked on a continual basis by the accrediting organization. Accreditation standards are periodically revised to reflect the dynamic, changing environment of medical transport, with considerable input from all disciplines of the medical profession.

Other U.S. states require either CAMTS accreditation *or* a demonstrated equivalent, such as Rhode Island, and Texas, which has adopted CAMTS' Accreditation Standards (Sixth Edition, October 2004) as its own. In Texas, an operator not wishing to become CAMTS accredited must submit to an equivalent survey by state auditors who are CAMTS-trained. Virginia and Oklahoma have also adopted CAMTS accreditation standards as their state licensing standards. While the original intent of CAMTS was to provide an American standard, air ambulance services in a number of other countries, including three in Canada and one in South Africa, have voluntarily submitted themselves to CAMTS accreditation.

Japanese Physician Delivery Helicopter

Medical staffing

The makeup of the medical crew staffing an air ambulance varies depending on country, area, service provider, and type of air ambulance. In services operating under the Anglo-American model of service delivery, the helicopter is most likely to be used to transport patients, and the crew may consist of Emergency Medical Technicians, Paramedics, flight nurses, a Respiratory Therapist, or in some cases, a physician. Services with a primary focus on critical care transport are more likely to be staffed by physicians and nurses. In the Franco-German model, the aircraft is much more likely to be used as a method of delivering high-level support to ground-based EMS. In these cases, the crew generally consists of a physician, often a surgeon, anesthetist, trauma specialist or similar specialty, accompanied by a specially-trained advance care paramedic or nurse. In these cases, the object is the rapid delivery of definitive care, occasionally even performing emergency surgical procedures in the field, with the eventual transport of the patient being accomplished by ground ambulance, not the helicopter.

Medical control

The consultant led Emergency Medical Retrieval Service in Scotland

The nature of the air operation will frequently determine the type of medical control required. In most cases, the available skill set for an air ambulance staffer is considerably greater than that of a typical paramedic. As a result, those operating in this environment will often be permitted by medical control to exercise more latitude in medical decision-making. Assessment skills tend to

be considerably higher, and, particularly on interfacility transfers, permit the inclusion of such factors as the reading of x-rays and the interpretation of lab results. This allows for advance planning, consultation with supervising physicians, and the issuing of contingency orders in case they are required during the flight. Some systems operate almost entirely off-line, using protocols for almost all procedures and only resorting to on-line medical control when protocols have been exhausted. Some air ambulance operations have full-time, on-site medical directors with pertinent backgrounds (e.g., emergency medicine); others have medical directors who are only available by pager. For those systems operating on the Franco-German model, the physician is almost always physically present, and medical control is not an issue.

Equipment and interiors

Most aircraft used as air ambulances, with the exception of charter aircraft and some military aircraft, are equipped for advanced life support and have interiors that reflect this. The challenges in most air ambulance operations, particularly those involving helicopters, are the high ambient noise levels and limited amounts of working space, both of which create significant issues for the provision of ongoing care. While equipment tends to be high-level and very conveniently grouped, it may not be possible perform some assessment procedures, such as chest auscultation, while in flight. In some types of aircraft, the aircraft's design means that the entire patient will not be physically accessible in flight. Additional issues occur with respect to pressurization of the aircraft. Not all aircraft used as air ambulances in all jurisdictions have pressurized cabins, and those which do typically tend to be pressurized to only 10,000 feet above sea level. These pressure changes require advanced knowledge by flight staff with respect to the specifics of aviation medicine, including changes in physiology and the behaviour of gases.

Equipment and interiors

Typical helicopter interior

Typical helicopter interior

Fixed-wing interior

Challenges

Beginning in the 1990s, the number of air ambulance crashes in the United States, mostly involving helicopters, began to climb. By 2005, this number had reached a record high. Crash rates from 2000–2005 more than doubled the previous five year's rates. To some extent, these numbers had been deemed acceptable, as it was understood that the very nature of air ambulance operations meant that, because a life was at stake, air ambulances would often operate on the

very edge of their safety envelopes, going on missions in conditions where no other civilian pilot would fly. As one side result, of all EMS personnel who lose their lives in the line of duty in the United States, nearly fifty percent do so on air ambulance crashes. In 2006, the United States National Transportation Safety Board (NTSB) concluded that many air ambulances crashes were avoidable, eventually leading to the improvement of government standards and CAMTS accreditation.

Cost-effectiveness

Whilst some air ambulances do have effective methods of funding, in the UK, they remain almost entirely charity funded, as improved cost-benefit ratios are generally achieved with land based attendance and transfers. Health outcomes, for example from London's Helicopter Emergency Medical Service, remain largely the same for both air and ground based services.

Chapter- 4

Air Charter

Air charter is the business of renting an entire aircraft (i.e., chartering) as opposed to individual aircraft seats (i.e., purchasing a ticket through a traditional airline). While the airlines specialize in selling transportation by the seat, air charter companies focus on individual private aircraft and itineraries, urgent or time-sensitive freight, cargo, air ambulance and any other form of ad hoc air transportation.

Air charter is also known as air taxi (though this term has other senses), executive charter, jet charter and is part of general aviation. In the United States air charter and air taxi operations are governed by Part 135 of the Federal Aviation Regulations, unlike the larger scheduled airlines, which are governed by more stringent standards of Part 121 of the FARs, which are regulations designed for scheduled air carriers.

History

The growth of corporate aviation and related air taxi and air charter suppliers, boomed following the close of World War II. With surplus aircraft available, air charter companies entered the business of charter flights for executives, high end travelers, special missions (such as organ donor flights, critical auto parts freight, etc.), sports teams, entertainers, etc.

Boeing 737-300 of the UK charter airline Titan Airways

Technology and business structure

The 1960s saw the arrival of the first small jets, such as the Learjet. The Learjet was adopted by some of the first jet air charter operators, such as Hop-A-Jet and Clay Lacy. Both companies still exist today as larger charter management firms. Charter management became popular at the dawn of the private jet age as a way for companies to own aircraft "off their books" - namely away from the prying eyes of shareholders. Local entrepreneurs realized that by managing the aircraft that belonged to another entity (one that could afford to buy the multi-million dollar aircraft) they could help offset the cost of ownership through rental income and aggregate owner costs for insurance, fuel, maintenance, etc. Today, this type of aircraft ownership arrangement forms more than 75% of the on-demand air charter industry for the United States, which encompasses about 70% of the air charter activity in the world.

In 2004, the FAA began the process to re-regulate the Part 135 industry, mainly due to the widespread problems created by the tension between aircraft owners and management companies. The FAA felt that air carriers (the air charter companies) had in some cases begun to lose operational control. The term "operational control" indicates which entity (aircraft owner, management company, broker, etc.) is controlling the aircraft's movements, crewing and compliance with applicable government regulations. In 2006 the FAA released a new Operations

Specification regulation and guidance which more clearly defined the requirements for operational control of an aircraft performing a private charter flight.

Growth factors

Beginning in the late 1990s air charter benefited from the following growth factors:

- **Internet Communication**: Because air charter was never part of the major GDS or travel distribution systems, it could not reach wider audiences. With the advent of the Internet, distribution of information regarding the availability of aircraft, placement, pricing etc., became more available to the increased broker and buyer community.
- **Growing Popularity**: Air charter became more available to the public through brokerage businesses able to connect passengers with aircraft for charter nationwide and worldwide. Where previously passengers were limited to a few local yellow pages listings, they could now access aircraft through brokers specializing in locating aircraft. Brokers could offer a wider selection, and potentially lower cost options including one-way charters where an aircraft was available without positioning or empty leg charges.
- **Airline Problems**: Growing dissatisfaction with the scheduled airlines over security and congestion related delays. While not all airline passengers could afford alternatives, well-off airline passengers sought ways to stop flying commercially and started to explore corporate aviation, fractional, jet cards or air charter.
- **Very light jets** or VLJs popularized the concept of small jets that would bring the capital carrying cost of aircraft down enough so that many more could be sold and operated. The first VLJs entered the market in 2008, and have been rolling out of several factories since. VLJ companies with aircraft currently in production, certified and flying include Eclipse Aviation, Cessna, and Embraer. Several other companies VLJ type jets in development.
- **Uniting the Industry**: In an effort to encourage air taxi & air charter industry and market development, the Air Taxi Association, ATXA, was formed. Backed by leading air taxi operators, ATXA has been a contributing factor for growth of the industry.

VLJ aircraft manufacturers maintain that the construction of cheaper, smaller and faster jets will enable point-to-point private aviation, creating a new industry. Others maintain that these new aircraft will lower the barriers to ownership enabling more wealthy individuals to own jet aircraft, but will not result in their wide adoption for commercial applications. Critics argue that basic economics, demographics, industry inertia and operational constraints will automatically limit the birth of an air taxi industry.

Air charter options available

Several options are available for flying privately, according to investment available and flight frequency desired. Fractional ownership programs popularized the notion of private aircraft use and ownership in the 1990s. A number of owners share an aircraft (or a certain type aircraft - one of many a fractional company manages). Owners purchase typically from 1/2 to 1/16 of an aircraft, pay a per-flight-hour charge, related fuel and flight fees, and divide management

expenses. Fractional aircraft ownerships growth led to the advent of regulations in the United States designed to regulate fractionally owned aircraft companies. These regulations are given in *Part 91 Subpart K* and bring fractional aircraft operations into line with existing air charter regulations, making fractional ownership into simply another flavor of ad hoc air transportation.

Jet Membership was created in 1999 by Sentient Jet, and allowed fliers to secure guaranteed access to charter aircraft in exchange for putting funds on deposit into a debit-card style account, with aircraft provided based on booking in a size category rather than by a specific aircraft model. Jet Cards became popular around 2002-2005 when fractional companies and jet charter brokerages began offering pre-pay debit accounts for per-hour private aircraft charters on specific aircraft models. Customers would pre-pay around $120,000 - $500,000 for a set number of flight hours on a particular aircraft model. Those hours may expire at a designated time or be available for partial refund. On-Demand Charter is trip by trip, pay as you go charter. One of the earliest forms of private flying and still growing, the passenger selects a specific charter quote provided by a local aircraft operator or national broker and pays for that trip alone, either before or after the flight. The 2008-2010 recession saw a 20-25% decrease in private jet charter flights and a decline in fractional ownership and Jet Cards, while some On-Demand Charter companies posted increases, as private fliers moved to less expensive flying options. Jet Membership, Jet Cards and On Demand Charter fall under more stringent FAA Part-135 of the regulations, governing aircraft for hire with paying passengers.

Shared-Ride Private Jet Service is a new entrant in on-demand private charter which is sold by the seat and is operating in major markets along the Eastern US corridor. These services comingle passengers on private jets and access smaller local private airports in order to by-pass the major airports. Seat prices can approach the affordability of full-fare airline prices when all seats are full and airports used are served only by airlines as a spoke. Some per-seat charter services like Greenjets sell themselves as "greener" and more responsible, as they are less expensive than conventional private air charter and they can potentially reduce the number of jets in the air by placing multiple passengers on a single jet instead of them flying alone. The result can be fewer planes flying burning less fossil fuel and a reduced overall carbon footprint.

Small helicopters with carrying capacity of 4-12 people have also become very popular. They cost far less than fixed winged aircraft and do not need an air strip to take off or land. They are limited however in range and speed compared to fixed-wing aircraft.

Developments

Some aviation professionals foresee the middle class traveling easily and with much less expense than is currently possible, using VLJs (very light jets) and other types of comparatively inexpensive aircraft. New technologies in engine design, airframe manufacturing methods, computer aided design and avionics as well as ATC upgrades, many say, will come together to drastically reduce cost while increasing efficiency, comfort and safety. These aircraft (such as the Eclipse 500) are said to be easier to fly and much cheaper to produce than current production jets. 5,400 small airports across the United States make point-to-point air travel on smaller jets quicker for travelers than the airline hub and spoke system. Next generation avionics and systems may also make these small airports accessible even in poor weather conditions.

RTI International, a nonprofit research organization, has developed a modeling and simulation tool which allows operators (or potential investors) the opportunity to craft a living business plan to gauge the potential of any prospective air taxi operation. Developed to answer questions about the economic and operational feasibility of the air-taxi market/business case during the SATS program, it has now been adopted in Europe and the US by a broad user base desiring to plan and optimize operations.

Skepticism of change

The relatively fast demise air-taxi market entrant DayJet, who was expected to change the industry, left many professionals skeptical on whether we can expect this mode of travel to flourish due to the decreased cost of personal air travel. The primary obstacles being that aircraft utilization is the largest limiter in reducing costs of operation (fixed overhead) not necessarily advancements in technology.

The most notable evidence / example of this problem is the fact that direct operating costs of VLJs are not substantially lower than existing turbofan and turboprop technology that can carry larger loads, greater distances, and in some cases for a smaller initial investment.

Chapter- 5

Air Show

The UK Utterly Butterly display team flying Boeing Stearman PT-17 biplanes at an English air show

Aviation Nation 2006 at Nellis Air Force Base, United States

A Finnish Airforce F-18 performs a slow pass

An **air show** is an event at which aviators display their flying skills and the capabilities of their aircraft to spectators in aerobatics. Air shows without aerobatic displays, having only aircraft displayed parked on the ground, are called "static air shows".

Some air shows are held as a business venture or as a trade event where aircraft, avionics and other services are promoted to potential customers. Many air shows are held in support of local, national or military charities. Military air firms often organise air shows at military airfields as a public relations exercise to thank the local community, promote military careers and raise the profile of the military.

Air show "seasons" vary around the world. Whereas the United States enjoys a long season that generally runs from March to November, other areas often have much shorter seasons. The European season usually starts in late April or Early May and is usually over by mid October. The Middle East, Australia and New Zealand hold their events between January and March. However, for many acts the "off season" does not mean a period of inactivity, they use time for maintenance and practice.

The type of displays seen at an event are constrained by a number of factors, including the weather and visibility. Most aviation authorities now publish rules and guidance on minimum display heights and criteria for differing conditions. In addition to the weather, pilots and organizers must also consider local airspace restrictions. Most exhibitors will plan "full," "rolling" and "flat" display for varying weather and airspace conditions.

The types of shows vary greatly. Some are large scale military events with large flying displays and ground exhibitions while others held at small local airstrips can often feature just one or two hours of flying with just a few stalls on the ground. Air Displays can be held during day or night with the latter becoming increasingly popular. Shows don't always take place over airfields; some have been held over the grounds of stately homes or castles and over the sea at coastal resorts.

Attractions

Air racing at an air show in England: the Red Bull Air Race heat held at Kemble Airfield, Gloucestershire. The aircraft fly singly, and pass between pairs of pylons

Before the Second World War, air shows were associated with long distance air races, often lasting many days and covering thousands of miles. While the Reno Air Races keep this tradition alive, most air shows today primarily feature a series of aerial demos of short duration.

Most air shows will feature warbirds, aerobatics, and demonstrations of modern military aircraft, and many air shows offer a variety of other aeronautical attractions as well, such as wing-walking, radio-controlled aircraft, water/slurry drops from firefighting aircraft, simulated helicopter rescues and sky diving.

Specialist aerobatic aircraft have powerful piston engines, light weight and big control surfaces, making them capable of very high roll rates and accelerations. A skilled pilot will be able to climb vertically, perform very tight turns, tumble his aircraft end-over-end and perform manoeuvres during loops.

RAAF F-111 performing a dump-and-burn fuel dump at the Australian International Airshow

Solo military jet demos, also known as **tactical demos**, feature one aircraft, usually a strike fighter or an advanced trainer. The demonstration focuses on the capabilities of modern aircraft used in combat operations. The display will usually demonstrate the aircraft's very short (and often very loud) takeoff rolls, fast speeds, slow approach speeds, as well as their ability to quickly make tight turns, to climb quickly, and their ability to be precisely controlled at a large range of speeds. Manoeuvres include aileron rolls, barrel rolls, hesitation rolls, Cuban-8s, tight turns, high-alpha flight, a high-speed pass, double Immelmans, and touch-and-gos. Tactical demos may include simulated bomb drops, sometimes with pyrotechnics on the ground for effect. Aircraft with special characteristics that give them unique capabilities will often display those in their demos; For example, Russian fighters with Thrust vectoring may be used to perform Pugachev's Cobra or the Kulbit, among other difficult manoeuvers that cannot be performed by other aircraft. Similarly, an F-22 pilot may hover his jet in the air with the nose pointed straight up, a Harrier or Osprey pilot may perform a vertical landing or vertical takeoff, etc.

Safety

Mountain Home Air Force Base, Idaho, September 14, 2003: U.S. Air Force Thunderbirds Captain Christopher Stricklin ejecting from his F-16 after realizing he could not pull up in time from a Split-S and ensuring the aircraft would not crash into spectators. The aircraft was destroyed less than a second later with no loss of life.

Air shows present some risk to spectators and aviators. Accidents occur, sometimes with a large loss of life, such as the 1988 disaster at Ramstein Air Base in Germany and the 2002 air show crash at Lviv, Ukraine. Because of these accidents, the various aviation authorities around the world have created set rules and guidance for those running and participating in air displays. Air displays are often monitored by aviation authorities to ensure safe procedures.

Rules govern the distance from the crowds that aircraft must fly. These vary according to the rating of the pilot/crew, the type of aircraft and the way the aircraft is being flown. For instance, slower lighter aircraft are usually allowed closer and lower to the crowd than larger, faster types. Also, a fighter jet flying straight and level will be able to do so closer to the crowd and lower than if it were performing a roll or a loop.

Pilots can get authorisations for differing types of displays (i.e. limbo flying, basic aerobatics to unlimited aerobatics) and to differing minimum base heights above the ground. To gain such authorisations, the pilots will have to demonstrate to an examiner that they can perform to those limits without endangering themselves, ground crew or spectators.

Despite display rules and guidances, accidents have continued to happen. However, air show accidents are rare and where there is proper supervision air shows have impressive safety records. Each year, organisations such as The International Council of Air Shows and The European Airshow Council meet and discuss various subjects including air show safety where accidents are discussed and lessons learnt.

Weather

Air shows, and other big shows such as agricultural shows, on grassy land, are vulnerable to continued heavy rain waterlogging the ground, and making the cloudbase too low for flying, forcing cancellation, or the show ending early, costing much money for the show's organizers, as people and parking cars have difficulty moving about and turn the land into a morass, and the organizers may be tempted to put straw or cinders down to make movement easier, and the owner of the land cannot accept the resulting damage.

Chapter- 6

Aerial Firefighting

Aerial firefighting is the use of aircraft and other aerial resources to combat wildfires. The types of aircraft used include fixed-wing aircraft and helicopters. Smokejumpers and rappellers are also classified as aerial firefighters, delivered to the fire by parachute from a variety of fixed-wing aircraft, or rappelling from helicopters. Chemicals used to fight fires may include water, water enhancers such as foams and gels, and specially formulated fire retardants.

Terminology

A wide variety of terminology has been used in the popular media for the aircraft (and methods) used in aerial firefighting. The terms **Airtanker** or **air tanker** generally refer to fixed-wing aircraft; "airtanker" is used in official documentation.

Air attack is an industry term used for the actual application of aerial resources, both fixed-wing and rotorcraft, on a fire, although colloquially, "air attack" is also a muddled up term coming from “air tac” which is in reference to air tactical group supervisor, who is in a spotter plane that is charged with directing the use of aerial resources. **Initial attack** refers to the first-response of aerial assets to suppress a fire before it grows out of control; aviation assets can usually respond to a reported blaze much more quickly than ground-based resources can. **Extended attack** refers to the continued use of aerial and other resources on an out-of-control fire, primarily to assist ground units in the establishment of firelines in advance of the fire.

Equipment

A wide variety of helicopters and fixed-wing aircraft are used for aerial firefighting. In 2003, it was reported that "The U.S. Forest Service and Bureau of Land Management own, lease, or contract for nearly 1,000 aircraft each fire season, with annual expenditures in excess of US$250 million in recent years".

Helicopters

Helicopters may be fitted with tanks or carry buckets. Buckets are usually filled by submerging in lakes, rivers, reservoirs, or portable tanks. The most popular of the buckets is the flexible Bambi Bucket. Tanks may be filled on the ground or water may be siphoned from lakes or reservoirs through a hanging snorkel. Popular firefighting helicopters include variants of the Bell 204 and the Erickson S-64 Aircrane helitanker, which features a sea snorkel for filling while in flight.

Kern County (California) Fire Department Bell 205 dropping water during a training exercise at the Mojave Spaceport

S-64 Erickson Air-Crane photographed at Ioannina airport, Greece

Tanker 910 during a drop demonstration in December, 2006

A Mars bomber, one of the largest water bombers still flying in the world

Airtankers

A PZL M-18 Dromader drops water near Mobridge, SD

PBY Catalina flying boat

Airtankers or **water bombers** are fixed-wing aircraft fitted with tanks that can be filled on the ground at an air tanker base or, in the case of flying boats and amphibious aircraft, by skimming water from lakes, reservoirs, or large rivers.

Various aircraft have been used over the years for firefighting. Though World War II-era bombers were for a long time the mainstay of the aerial firefighting fleet, and are still in use newer purpose-built tankers are coming online. The smallest are the Single Engine Air Tankers (SEATs). These are agricultural sprayers that generally drop about 800 gallons of water or retardant. An example is the Airtractor AT-802F, which can deliver around 3000lt of water or fire retardant solution each drop. Medium aircraft include the S-2 Tracker (retrofitted with turboprop engines as the S-2T) as used by the California Department of Forestry & Fire Protection (CDF), as well as Conair Group Inc. of Abbotsford, British Columbia, while the Douglas DC-4, the DC-7, the Lockheed C-130 Hercules, P-2V Neptune, P-3 Orion and others have been used as heavy tankers.

The largest aerial firefighter currently in use is a Boeing 747 aerial firefighter, known as the Evergreen Supertanker that can carry 24,000 gallons fed by a pressurized drop system.The Supertanker entered service for the first time in 2009, fighting a fire in Cuenca, Spain. The tanker made its first American operation on August 31, 2009 at the Oak Glen Fire.

The next largest aerial firefighters currently in use include two converted Martin Mars flying boats in British Columbia (one of which was brought to southern California in September 2007

to help battle the wildfires there). Each Martin Mars can carry approximately 7,200 U.S. gallons of water or fire retardant each, and the Tanker 910, a converted McDonnell Douglas DC-10 that can carry 12,000 gallons of water or retardant. The Russian Ministry of Emergency Situations operates convertible-to-cargo IL-76 airtankers that can carry up to 15,000 gallons but have been operating with 11,000 gallon tanking systems, and a few of Beriev Be-200 amphibians.

Bombardier's Dash 8 Q Series aircraft are the basis for two new ventures. Cascade Aerospace has converted two pre-owned Q400s to act as part-time water bomber and part-time transport for France's Sécurité Civile, one of which is registered F-ZBMC, while Neptune Aviation is converting a pre-owned Q300 as a prototype to augment their P2V aircraft.

Similar in configuration to the World War II–era PBY Catalina, the Canadair CL-215 Scooper, and Bombardier CL-415 SuperScooper are designed and built specifically for firefighting. The "Super Scoopers" are not common in the United States where only 2 operate seasonally in southern California. Los Angeles County leases two CL-415s from the Province of Quebec during the fall when the Santa Ana winds are at their worst. 6 American owned CL-215s operate for various State and Federal agencies. Critics of scoopers in the US claim that there is not enough suitable water in fire prone states. CL-215s have been employed with success in North Carolina, Minnesota, Michigan, Wisconsin, Washington, Alaska, Northern Idaho, and Montana.

French "Sécurité Civile" owns the entire Canadian CL-xx series, a handful of Grumman Trackers and some Russian Mil Mi-6 helicopters. Their pilots are usually recruited amongst the best pilots from "l'Armée de l'Air", usually from "Aéronavale" (Navy pilots on aircraft carriers) or acrobatic teams like "La Patrouille de France". It is a highly risked job that requires very skilled aerial fighters.

Croatian Air Force owns six Canadian CL-415 planes, as well as the six Air Tractors for firefighting and other purposes.

Another amphibian is the Russian Beriev Be-200. It can carry a maximum payload of about 3,170 gallons (12,000 litres) of water, making "scoops" in suitable stretches of water in 14 seconds. It was successfully used to fight fires in the southern European countries such as Greece and Portugal.

Leadplanes

The Lead Plane function directs the activities of the airtankers by both verbal target descriptions and by physically leading the airtankers on the drop run. The O-2 Skymaster and OV-10 Bronco have both been used as spotter and lead plane platforms. The Ontario Ministry of Natural Resources has also used the Cessna 337. The Beechcraft Baron was long used as a leadplane or air attack ship, but most were retired in 2003; more common now is the Beechcraft King Air, used as an air attack ship and leadplane.

Fleet grounding

In the United States, most of these aircraft are privately owned and contracted to government agencies, and the National Guard and the U.S. Marines also maintain fleets of firefighting aircraft. On May 10, 2004, The U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) suddenly announced that they were cancelling contracts with operators of 33 heavy airtankers. They cited liability concerns and an inability to safely manage the fleet after the wing failure and resulting crash of a C-130A Hercules in California and a PB4Y-2 in Colorado during the summer of 2002. Both aged aircraft broke up in flight due to catastrophic fatigue cracks at the wing roots. After subsequent third-party examination and extensive testing of all USFS contracted heavy airtankers, three companies were awarded contracts and now maintain a combined fleet of 23 aircraft.

Fire retardant

A MAFFS-equipped Air National Guard C-130 Hercules drops fire retardant on wildfires in southern California

Borate salts were used in the past to fight wildfires but were found to sterilize the soil, were toxic to animals, and are now prohibited. Newer retardants use ammonium sulfate or ammonium polyphosphate with attapulgite clay thickener or diammonium phosphate with a guar gum derivative thickener. These are not only less toxic but act as fertilizers to help the regrowth of

plants after the fire. Fire retardants often contain wetting agents, preservatives and rust inhibitors and are colored red with ferric oxide or *fugitive* color to mark where they have been dropped. Brand names of fire retardants for aerial application include Fire-Trol and Phos-Chek.

Some water-dropping aircraft carry tanks of a guar gum derivative to thicken the water and reduce runoff.

Tactics and capabilities

A helicopter dips its bucket into a river to drop water on a wildfire in California

Helicopters can hover over the fire and accurately drop water or retardant. The S-64 Helitanker has microprocessor-controlled doors on its tank. The doors are controlled based on the area to be covered and wind conditions. Fixed-wing aircraft must make a pass and drop water or retardant like a bomber. Spotter (Air Tactical Group Supervisor) aircraft often orbit the fire at a higher altitude to coordinate the efforts of the smoke jumper, helicopter, media, and retardant-dropping aircraft; while lead planes fly low-level ahead of the airtankers to mark the trajectory for the drop, and ensure overall safety for both ground-based and aerial firefighters.

Water is often not dropped directly on flames because its effect is short-lived. Fire retardants are typically dropped ahead of the moving fire or along its edge and may remain effective for two or more days. This can create artificial firebreaks where the terrain is too rugged or remote for ground crews to cut fireline.

Helicopters are also used to deliver firefighters or ignite backfires and controlled burns. A driptorch slung beneath the helicopter (*helitorch*) can be used for this purpose. Another device called a Delayed Aerial Ignition Device (DAID) can be used, which shoots a stream of flaming "ping-pong balls" into the forest. The small plastic spheres which contain potassium permanganate are individually injected with ethylene glycol or glycerine just before they are ejected from the aircraft. This method's delayed redox exothermic reaction, which results in vigorous fire soon after mixing the chemicals, poses less of a danger to the helicopter than transporting burning materials. The ping-pong ball system works best in continuous fuels or in areas where a mosaic burn pattern is desired.

Aerial firefighting is almost always used in conjunction with ground-based efforts, as aircraft are only one weapon in the firefighting arsenal. However, there have been cases of aircraft extinguishing fires long before ground crews were able to reach them.

Some firefighting aircraft can refill their tanks in mid-flight, by flying down to skim the surface of any body of water. One example is the Bombardier 415. This is particularly useful in rural areas where flying back to an airbase for refills may take too much time.

Chapter- 7

Gliding

A Ventus 2 glider landing while jettisoning water that has been used as ballast

Gliding is a recreational activity and competitive air sport in which pilots fly unpowered aircraft known as gliders or sailplanes using naturally occurring currents of rising air in the atmosphere to remain airborne. The word *soaring* is also used for the sport.

Gliding as a sport began in the 1920s. Initially the objective was to increase the duration of flights but soon pilots attempted cross-country flights away from the place of launch. Improvements in aerodynamics and in the understanding of weather phenomena have allowed greater distances at higher average speeds. Long distances are now flown using any of the main sources of rising air: ridge lift, thermals and lee waves. When conditions are favorable, experienced pilots can now fly hundreds of kilometres before returning to their home airfields; occasionally flights of more than 1,000 kilometres (621 mi) are achieved.

Some competitive pilots fly in races around pre-defined courses. These gliding competitions test pilots' abilities to make best use of local weather conditions as well as their flying skills. Local and national competitions are organized in many countries, and there are biennial World Gliding Championships. Techniques to maximize a glider's speed around the day's task in a competition have been developed, including the optimum speed to fly, navigation using GPS and the carrying of water ballast. If the weather deteriorates pilots are sometimes unable to complete a cross-

country flight. Consequently they may need to land elsewhere, perhaps in a field, but motorglider pilots can avoid this by starting an engine.

Powered-aircraft and winches are the two most common means of launching gliders. These and other launch methods require assistance and facilities such as airfields, tugs, and winches. These are usually provided by gliding clubs who also train new pilots and maintain high safety standards. Although in most countries the standards of safety of the pilots and the aircraft are the responsibility of governmental bodies, the clubs and sometimes national gliding associations often have delegated authority.

The sport is facing challenges to maintain its popularity. Many factors have put pressure on the movement such as the increasing demands on people's time, cost of insurance and fuel, competition from other air sports and the growing requirement for land and controlled airspace.

History

The development of heavier-than-air flight in the half century between Sir George Cayley's coachman in 1853 and the Wright brothers mainly involved gliders. However, the sport of gliding only emerged after the First World War, as a result of the Treaty of Versailles, which imposed severe restrictions on the manufacture and use of single-seat powered aircraft in Germany's Weimar Republic. Thus, in the 1920s and 1930s, while aviators and aircraft makers in the rest of the world were working to improve the performance of powered aircraft, the Germans were designing, developing and flying ever more efficient gliders and discovering ways of using the natural forces in the atmosphere to make them fly farther and faster. With the active support of the German government, there were 50,000 glider pilots by 1937. The first German gliding competition was held at the Wasserkuppe in 1920, organized by Oskar Ursinus. The best flight lasted two minutes and set a world distance record of 2 kilometres (1.2 mi). Within ten years, it had become an international event in which the achieved durations and distances had increased greatly. In 1931, Gunther Grönhoff flew 272 kilometres (169 mi) on the front of a storm from Munich to Kadaň (Kaaden in German) in Western Czechoslovakia, further than had been thought possible.

The "gull wing" Göppingen Gö 3 Minimoa produced in Germany from 1936

In the 1930s, gliding spread to many other countries. In the 1936 Summer Olympics in Berlin gliding was a demonstration sport, and it was scheduled to be a full Olympic sport in the 1940 Games. A glider, the Olympia, was developed in Germany for the event, but World War II intervened. By 1939 the major gliding records were held by Russians, including a distance record of 748 kilometres (465 mi). During the war, the sport of gliding in Europe was largely suspended, though several German fighter aces in the conflict, including Erich Hartmann, began their flight training in gliders.

Gliding did not return to the Olympics after the war for two reasons: a shortage of gliders, and the failure to agree on a single model of competition glider. (Some in the community feared doing so would hinder development of new designs.) The re-introduction of air sports such as gliding to the Olympics has occasionally been proposed by the world governing body, the Fédération Aéronautique Internationale (FAI), but has been rejected on the grounds of lack of public interest.

In many countries during the 1950s a large number of trained pilots wanted to continue flying. Many were also aeronautical engineers who could design, build and maintain gliders. They started both clubs and manufacturers, many of which still exist. This stimulated the development of both gliding and gliders, for example the membership of the Soaring Society of America increased from 1,000 to 16,000 by 1980. The increased numbers of pilots, greater knowledge and improving technology helped set new records, for example the pre-war altitude record was

doubled by 1950 and the first 1,000-kilometre (620 mi) flight was achieved in 1964. New materials such as glass fiber and carbon fiber, advances in wing shapes and airfoils, electronic instruments, the Global Positioning System and improved weather forecasting have since allowed many pilots to make flights that were once extraordinary. Today over 550 pilots have made flights over 1,000 kilometres (620 mi). Although there is no Olympic competition, there are the World Gliding Championships. The first event was held at the Samedan in 1948. Since World War II it has been held every two years. There are now six classes open to both sexes, plus three classes for women and two junior classes. The latest worldwide statistics in 2004 indicate that Germany, the sport's birthplace, is still a center of the gliding world: it accounted for 30 percent of the world's glider pilots, and the three major glider manufacturers are still based there. However the meteorological conditions that allow soaring are common and the sport has been taken up in many countries. At the last count there were over 116,000 active glider pilots, plus an unknown number of military cadets. Clubs actively seek new members by giving trial flights, which are also a useful source of revenue for them.

Soaring

Glider pilots can stay airborne for hours by flying through air that is ascending as fast or faster than the glider itself is descending, thus gaining potential energy. The most commonly used sources of rising air are

- thermals (updrafts of warm air);
- ridge lift (found where the wind blows against the face of a hill and is forced to rise); and
- wave lift (standing waves in the atmosphere, analogous to the ripples on the surface of a stream).

Ridge lift rarely allows pilots to climb much higher than about 600 metres (2,000 ft) above the terrain; thermals, depending on the climate and terrain, can allow climbs in excess of 3,000 metres (9,800 ft) in flat country and much higher above mountains; wave lift has allowed a glider to reach an altitude of 15,447 metres (50,679 ft). In a few countries such as the UK, gliders may continue to climb into the clouds in uncontrolled airspace, but in many European countries the pilot must stop climbing before reaching the cloud base.

Thermals

Good gliding weather: Competitors studying *cumulus humilis*, which suggest active thermals and light winds

Thermals are streams of rising air that are formed on the ground through the warming of the surface by sunlight. If the air contains enough moisture, the water will condense from the rising air and form cumulus clouds. When the air has little moisture or when an inversion stops the warm air from rising high enough for the moisture to condense, thermals do not create cumulus clouds. Without clouds or dust devils to mark the thermals, thermals are not always associated with any feature on the ground. The pilot must then use both skill and luck to find them using a sensitive vertical speed indicator called a variometer that quickly indicates climbs and descents. Occasionally reliable thermals can be found in the exhaust gases from power stations or from fires.

Once a thermal is encountered, the pilot can fly in tight circles to keep the glider within the thermal, so gaining altitude before flying towards the destination or to the next thermal. This is known as "thermalling". Alternatively, glider pilots on cross-country flights may choose to 'dolphin'. This is when the pilot merely slows down in rising air, and then speeds up again in the non-rising air, thus following an undulating flight path. Dolphining allows the pilot to minimize

the loss of height over great distances without spending time turning. Climb rates depend on conditions, but rates of several meters per second are common and can be maximized by gliders equipped with flaps. Thermals can also be formed in a line usually because of the wind or the terrain, creating cloud streets. These can allow the pilot to fly straight while climbing in continuous lift.

A Scimitar glider ridge soaring in Lock Haven, Pennsylvania USA

As it requires rising heated air, thermalling is most effective in mid-latitudes from spring through late summer. During winter the sun's heat can only create weak thermals, but ridge and wave lift can still be used during this period.

Ridge lift

A ridge soaring pilot uses upward air movements caused when the wind blows on to the sides of hills. It can also be augmented by thermals when the slopes also face the sun. In places where a steady wind blows, a ridge may allow virtually unlimited time aloft, although records for duration are no longer recognized because of the danger of exhaustion.

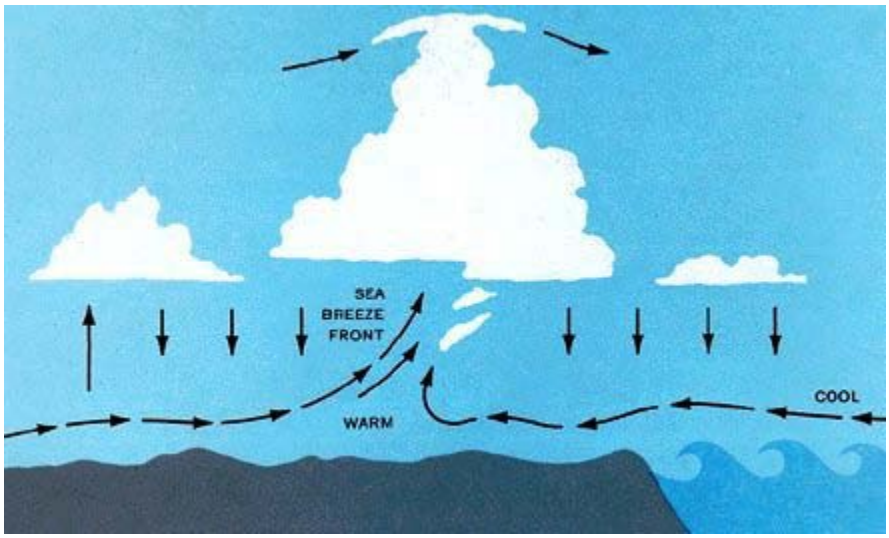
Wave lift

A lenticular cloud produced by a mountain wave

The powerfully rising and sinking air in mountain waves was discovered by glider pilot, Wolf Hirth, in 1933. Gliders can sometimes climb in these waves to great altitudes, although pilots must use supplementary oxygen to avoid hypoxia.

This lift is often marked by long, stationary lenticular (lens-shaped) clouds lying perpendicular to the wind. Mountain wave was used to set the current altitude record of 15,453 metres (50,699 ft) on 29 August 2006 over El Calafate, Argentina. The pilots, Steve Fossett and Einar Enevoldson, wore pressure suits. The current world distance record of 3,008 kilometres (1,869 mi) by Klaus Ohlmann (set on 21 January 2003) was also flown using mountain waves in South America.

A rare wave phenomenon is known as Morning Glory, a roll cloud producing strong lift. Pilots near Australia's Gulf of Carpentaria make use of it in springtime.



Schematic cross section through a sea breeze front. If the air inland is moist, cumulus often marks the front.

Other sources of lift

The boundaries where two air masses meet are known as convergence zones. These can occur in sea breezes or in desert regions. In a sea-breeze front, cold air from the sea meets the warmer air from the land and creates a boundary between two masses of air like a shallow cold front. Glider pilots can gain altitude by flying along the intersection as if it were a ridge of land. Convergence may occur over considerable distances and so may permit virtually straight flight while climbing.

Glider pilots have occasionally been able to use a technique called "dynamic soaring" allowing a glider to gain kinetic energy by repeatedly crossing the boundary between air masses of different horizontal velocity. However, such zones of high "wind gradient" are usually too close to the ground to be used safely by gliders.

Launch methods

Most gliders do not have engines or at least engines that would allow a take-off under their own power. Various methods are therefore used to get airborne. Each method requires specific training, therefore glider pilots must be in current practice for the type of launch being used. Licensing rules in some countries, such as the USA, differentiate between aerotows and ground launch methods, due to the widely different techniques.

Aerotowing

A tug aircraft aerotowing a glider

In an aerotow a powered plane is attached to the glider with a tow rope. Single-engined light aircraft or motor gliders are used. The tow-plane takes the glider to the height and location requested by the pilot where the glider pilot releases the tow-rope. A weak link is often fitted to the rope to ensure that any sudden loads do not damage the airframe of the tow-plane or the glider. Under extreme loads the weak link will fail before any part of the glider or plane fails. There is a remote chance that the weak link might break at low altitude, and so pilots plan for this eventuality before launching.

During the aerotow, the glider pilot keeps the glider behind the tow-plane in either the "low tow" position, just below the wake from the tow-plane, or the "high tow" position just above the wake. In Australia the convention is to fly in low tow, whereas in the United States and Europe the high tow prevails. One rare aerotow variation is attaching two gliders to one tow-plane, using a short rope for the high-towed glider and the long rope for the low tow. The current record is nine gliders in the same aerotow.

Winch launching

A DG1000 being winch-launched

Gliders are often launched using a stationary ground-based winch mounted on a heavy vehicle. This method is widely used at many European clubs, often in addition to an aerotow service. The engine is usually a large diesel, though hydraulic fluid engines and electrical motors are also used. The winch pulls in a 1,000 to 1,600-metre (3,000 to 5,500 ft) cable, made of high-tensile steel wire or a synthetic fiber, attached to the glider. The cable is released at a height of about 400 to 700 metres (1,300 to 2,200 ft) after a short, steep ride.

A typical winch

Winch launches are cheaper than aerotows and have the advantage that many members of a club can be taught to operate the equipment. A winch may also be used at sites where an aerotow could not operate, because of the shape of the field or because of noise restrictions. The height gained from a winch is usually less than from an aerotow so pilots need to find a source of lift soon after releasing from the cable, otherwise the flight will be short. A break in the cable of the weak link during a winch launch is a possibility for which pilots are trained.

Auto-tow

Another method of launching, the "autotow", is rarer nowadays. The direct autotow requires a hard surface and a powerful vehicle that is attached to the glider by a long steel cable. After gently taking up slack in the cable, the driver accelerates hard and as a result the glider rises rapidly to about 400 metres (1,300 ft), especially if there is a good headwind and a runway of 1.5 kilometres (0.93 mi) or more. This method has also been used on desert dry lakes.

A variation on the direct autotow is known as the "reverse pulley" method. In this method, the truck drives towards the glider being launched. The cable passes around a pulley at the far end of the airfield, resulting in an effect similar to that of a winch launch.

Bungee launch

A bungee launch at the Long Mynd by the Midland Gliding Club

Bungee launching was widely used in the early days of gliding, and occasionally gliders are still launched from the top of a gently sloping hill into a strong breeze using a substantial multi-stranded rubber band, or "bungee". For this launch method, the glider's main wheel rests in a small concrete trough. The hook normally used for winch-launching is instead attached to the middle of the bungee. Each end is then pulled by three or four people. One group runs slightly to the left, the other to the right. Once the tension in the bungee is high enough, the pilot releases the wheel brake and the glider's wheel pops out of the trough. The glider gains just enough energy to leave the ground and fly away from the hill.

Cross-country

Glider on a cross-country flight in the Alps

One of the measures of a glider's performance is the distance that it can fly for each meter it descends, known as its lift-to-drag ratio (L/D). Depending on the class, this can range in modern designs from 44:1 in the Standard Class up to 70:1 for the largest aircraft. A good gliding performance combined with regular sources of rising air enables modern gliders to fly long distances at high speeds. The weather is a major factor in determining cross-country speeds. The record average speed for 1,000 kilometres (620 mi) is 203.1 kilometres per hour (126.2 mph). required unusually good conditions, but even in places with less favorable conditions (such as Northern Europe) a skilled pilot could expect to complete flights over 500 kilometres (310 mi) every year.

As the performance of gliders improved in the 1960s, the concept of flying as far away as possible became unpopular with the crews who had to retrieve the gliders. Pilots now usually plan to fly around a course (called a *task*) via turn-points, returning to the starting point.

In addition to just trying to fly further, glider pilots also race each other in competitions. The winner is the fastest, or, if the weather conditions are poor, the furthest round the course. Tasks of up to 1,000 km have been set and average speeds of 120 km/h are not unusual.

Initially, ground observers confirmed that pilots had rounded the turn-points. Later, the glider pilots photographed these places and submitted the film for verification. Today, gliders carry secure GNSS Flight Recorders that record the position every few seconds from GPS satellites. These recording devices now provide the proof that the turn-points have been reached.

Competition grid at Lasham Airfield in 2009

National competitions generally last one week, with international championships running over two. The winner is the pilot who has amassed the greatest number of points over all the contest days. However, these competitions have as yet failed to draw much interest outside the gliding community for several reasons. Because it would be unsafe for many gliders to cross a start line at the same time, pilots can choose their own start time. Furthermore, gliders are not visible to the spectators for long periods during each day's contest and the scoring is complex, so traditional gliding competitions are difficult to televise. In an attempt to widen the sport's appeal, a new format, the Grand Prix, has been introduced. Innovations introduced in the Grand Prix format include simultaneous starts for a small number of gliders, cockpit mounted cameras, telemetry giving the positions of the gliders, tasks consisting of multiple circuits, and simplified scoring.

There is a decentralized Internet-based competition called the Online Contest, in which pilots upload their GPS data files and are automatically scored based on distance flown. Worldwide, 6,703 pilots registered for this contest in 2010.

Maximizing average speed

Soaring pioneer Paul MacCready is usually credited with developing mathematical principals for optimizing the speed at which to fly when cross-country soaring, although it was first described by Wolfgang Späte in 1938. The speed to fly theory allows the optimal cruising speed between thermals to be computed, using thermal strength, glider performance and other variables. It accounts for the fact that if a pilot flies faster between thermals, the next thermal is reached sooner. However at higher speeds the glider also sinks faster, requiring the pilot to spend more time circling to regain the altitude. The MacCready speed represents the optimal trade-off between cruising and circling. Most competition pilots use MacCready theory to optimize their average speeds, and have the calculations programmed in their flight computers, or use a "McCready ring", a rotatable bezel on the glider's variometer to indicate the best speed to fly. The greatest factor in maximizing average speed, however, remains the ability of the pilot to find the strongest lift.

On cross-country flights on days when strong lift is forecast, pilots fly with water ballast stored in tanks or bags in the wings and fin. The fin tank is used to reduce trim drag by optimizing the center of gravity, which typically would shift forward if water is stored only in the wings ahead of the spar. Ballast enables a sailplane to attain its best L/D at higher speeds but slows its climb rate in thermals, in part because a sailplane with a heavier wing loading cannot circle within a thermal as tightly as one with a lower, unballasted wing loading. But if lift is strong, typically either from thermals or wave, the disadvantage of slower climbs is outweighed by the higher cruising speeds between lift areas. Thus, the pilot can improve the average speed over a course by several percent or achieve longer distances in a given time. If lift is weaker than expected, or if an off-field landing is imminent, the pilot can jettison the water ballast by opening the dump valves.

Badges

The FAI Diamond Badge

Achievements in gliding have been marked by the awarding of badges since the 1920s. For the lower badges, such as the first solo flight, national gliding federations set their own criteria. Typically, a bronze badge shows preparation for cross-country flight, including precise landings and witnessed soaring flights. Higher badges follow the standards set down by the Gliding Commission of the Fédération Aéronautique Internationale (FAI).

The FAI's Sporting Code defines the rules for observers and recording devices to validate the claims for badges that are defined by kilometers of distance and meters of altitude gained. The Silver-C badge was introduced in 1930. Earning the Silver Badge shows that a glider pilot has achieved an altitude gain of at least 1,000 metres (3,281 ft), made a five-hour duration flight, and has flown cross-country for a straight-line distance of at least 50 kilometres (31 mi): these three attainments are usually, but not invariably, achieved in separate flights. The Gold and Diamond Badges require pilots to fly higher and further. A pilot who has completed the three parts of the Diamond Badge has flown 300 kilometres (186 mi) to a pre-defined goal, has flown 500 kilometres (311 mi) in one flight (but not necessarily to a pre-defined goal) and gained 5,000 metres (16,000 ft) in height. The FAI also issues a diploma for a flight of 1,000 kilometres (621 mi) and further diplomas for increments of 250 kilometres (155 mi).

Landing out

Glider and its trailer after an outlanding

If lift is not found during a cross-country flight, for example because of deteriorating weather, the pilot must choose a location to "land out". Although inconvenient and often mistaken for "emergency landings", landing out (or "outlanding") is a routine event in cross-country gliding. The pilot has to choose a location where the glider can be landed safely, without damaging the plane, the pilot, or property such as crops or livestock. The glider and the pilot(s) can then be retrieved by road from the outlanding location using a purpose-built trailer. In some instances, a tow-plane can be summoned to re-launch the aircraft.

Use of engines or motors

ASH25M—a self-launching two-seater glider

Although adding to the weight and expense, some gliders are fitted with small power units and are known as motor gliders. This avoids the inconvenience of landing out. The power units can be internal combustion engines, electrical motors, or retractable jet engines. Retractable propellers are fitted to high performance sailplanes, though in another category, called touring motor gliders, non-retractable propellers are used. Some powered gliders are "self launching", which makes the glider independent of a tow plane. However some gliders have "sustainer" engines that can prolong flight but are not powerful enough for launching. All power units have to be started at a height that includes a margin that would still allow a safe landing out to be made, if there were a failure to start.

In a competition, using the engine ends the soaring flight. Unpowered gliders are lighter and, as they do not need a safety margin for starting the engine, they can safely thermal at lower altitudes in weaker conditions. Consequently, pilots in unpowered gliders may complete competition flights when some powered competitors cannot. Conversely, motor glider pilots can start the engine if conditions will no longer support soaring flight, while unpowered gliders will

have to land out, away from the home airfield, requiring retrieval by road using the glider's trailer.

Aerobatic competitions

S-1 Swift—modern aerobatic glider

World and European Aerobatic competitions are held regularly. In this type of competition, the pilots fly a program of maneuvers (such as inverted flight, loop, roll, and various combinations). Each maneuver has a rating called the "K-Factor". Maximum points are given for the maneuver if it is flown perfectly; otherwise, points are deducted. Efficient maneuvers also enable the whole program to be completed with the height available. The winner is the pilot with the most points.

Hazards

Unlike hang gliders and paragliders, gliders surround the pilots with strong structures and have undercarriages to absorb impacts when landing. These features prevent injuries from otherwise minor incidents, but there are some hazards. Although training and safe procedures are central to the ethos of the sport, a few fatal accidents occur every year, almost all caused by pilot error. In

particular there is a risk of mid-air collisions between gliders, because two pilots might choose to fly to the same area of lift and so might collide. Because of this risk, pilots usually wear parachutes. To avoid other gliders and general aviation traffic, pilots must comply with the Rules of the Air and keep a good lookout. In several European countries and Australia, the FLARM warning system is used to help avoid mid-air collisions between gliders. A few modern gliders have a ballistic emergency parachute to stabilize the aircraft after a collision.

Training and regulation

A Schleicher ASK 13, a typical training glider

In addition to national laws controlling aviation, the sport in many countries is regulated though national gliding associations and then through local gliding clubs. Much of the regulation concerns safety and training.

Many clubs provide training for new pilots. The student flies with an instructor in a two-seat glider fitted with dual controls. The instructor performs the first launches and landings, typically from the back seat, but otherwise the student manages the controls until the student is deemed to have the skill and the airmanship necessary to fly solo. Simulators are also beginning to be used in training, especially during poor weather.

After the first solo flights glider pilots are required to stay within gliding range of their home airfield. In addition to solo flying, further flights are made with an instructor until the student is capable of taking a glider cross-country and of handling more difficult weather. Cross-country flights are allowed when they have sufficient experience to find sources of lift away from their home airfield, to navigate, and to select and land in a field if necessary. In most countries pilots must take a written examination on the regulations, navigation, use of the radio, weather, principles of flight and human factors. Proposals are being made to standardise the training requirements across European countries.

In addition to the regulation of pilots, gliders are inspected annually and after exceeding predetermined flight times. Maximum and minimum payloads are also defined for each glider. Because most gliders are designed to the same specifications of safety, the upper weight limit for a pilot, after allowing for a parachute, is usually 103 kilograms (230 lb). There is also a limit, 193 centimetres (6 ft 4 in), on the tallest pilots who can safely fit into a typical glider's cockpit.

Challenges for the gliding movement

According to the FAI President, gliding as a sport faces challenges in the years ahead. These include:

- Time pressures on participants: gliding typically takes whole days that many people today find harder to devote. As a result the average age of glider pilots is increasing.
- In some countries, the need for more land for housing is threatening small airfields. These airfields may also be used for other general aviation activities, and the addition of gliding may be difficult to accommodate. This can limit the number of available airfields and so it can require longer drives to reach them.
- Airspace: in many European countries, the growth of civil aviation is reducing the amount of uncontrolled airspace. In the U.S. new security requirements, and the growth of controlled airspace around cities, has also had some impact on where to fly.
- Competition from other activities: there is now a greater variety of similar sports such as hang gliding and paragliding that may attract potential glider pilots.
- Lack of publicity: without coverage by television or popular publications, many people are unaware that gliding is even a sport. Without this knowledge the public may have a poor understanding of how flying without an engine is possible and safe.
- Increasing costs: due to higher costs of fuel and insurance, and due to greater regulation requiring equipment such as new radios, or in some cases transponders, gliding costs have increased, although without the continuous use of engines and fuel, they are still considerably lower than traditional power flying.

Related air sports

The two air sports that are most closely related to gliding are hang gliding and paragliding. Although all three sports rely on rising air, there are significant differences which are listed in detail in a comparison of sailplanes hang gliders and paragliders. The main difference is that both hang gliders and paragliders are simpler, less sophisticated and cheaper aircraft that use the pilot's feet as the undercarriage. All paragliders and most hang gliders have no protective

structure around the pilot. However, the dividing line between basic gliders and sophisticated hang-gliders is becoming less distinct. For example hang gliders typically use fabric wings, shaped over a framework, but hang gliders with rigid wings and three-axis controls are also available. The lower air speeds and lower glide ratios of typical hang gliders means that shorter cross-country distances are flown than in modern gliders. Paragliders are more basic craft. They are also foot-launched, but their wings usually have no frames and their shape is created by the flow and pressure of air. The airspeeds and glide ratios of paragliders are generally lower still than the typical hang gliders, and so their cross-country flights are even shorter. Radio-controlled gliding uses scale-models of gliders mainly for ridge soaring; however thermic aeromodelling craft are also used.