BALLOONS

What have they ever done for us?

The contribution of the balloon to the history of air power

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One of the more enjoyable aspects of my job in Defence Studies (RAF) is giving lectures on air power to University Air Squadron students. I often start by asking them the following question: when was a manned aircraft first used for a military purpose? A simple enough question; however, although there are often a number of ‘spotters’ in the audience, no one has yet given me the correct answer. In fact, it is widely accepted that the first military use of a manned aircraft occurred on 26 June 1794, when the French used a balloon to observe Austrian troop movements at the Battle of Fleurus. I use this question to make two points: firstly, that air power is not just a twentieth century phenomenon – its history goes back over two hundred years; and secondly, that for the first half of its history, air power could only be generated by means of the humble balloon.

Given that balloons have played such a seminal part in the history of air power, it is perhaps surprising that so little has been written about their use. What may also be surprising is the wide range of military uses to which the balloon has been put. British Air Power Doctrine (AP 3000 3rd Edition), which was published last year, identifies seven core capabilities of air power and outlines the roles that are derived from them. For those who are not familiar with this publication, the seven core capabilities are: Information Exploitation; Control of the Air; Strategic Effect; Indirect and Direct Air Operations; Combat Support Air Operations; Force Protection; and Sustainability. The purpose of this article is to show that a role for balloons has been found, or at least envisaged, in respect of all seven core capabilities.

It is important to stress at the outset that I shall only be considering the use of balloons – not airships, dirigibles, blimps or zeppelins. The addition of a source of power – other than the wind – makes for an entirely different kind of platform, one which is beyond the scope of this article.

INFORMATION EXPLOITATION

"Reconnaissance, or observation, can never be superseded; knowledge comes before power; and the air is first of all a place to see from."

Sir Walter Raleigh

Reconnaissance is as old as war itself. Five centuries before the birth of Christ the Chinese strategist Sun Tzu instructed his captains to "know your enemy and know yourself and you can fight a hundred battles without disaster". More recently, the Duke of Wellington ascribed much of his success to his care in studying what was happening "upon the other side of the hill". The best military commanders have always been those who realised that the more they knew of their opponent's positions, the greater was their opportunity for engaging him at a time and place most calculated to ensure his defeat. Air power platforms and systems play a vital role in gathering data and information, and the timely exploitation of information is thus a key core capability of air power.

Until the end of the eighteenth century, however, reconnaissance was restricted to that which could be seen from the top of a hill or from the back of a horse. The development of the flying machine changed all this. The first manned flight, by the Marquis d'Arlandes and Jean-Francois Philatre de Rozier in a Montgolfier hot air balloon on 21 November 1783, seemed to offer a new dimension to the art of warfare. Typically, perhaps, the military establishment in Britain regarded ballooning as an amusing new sport rather than as a means of gaining advantage in warfare. The French, however, took a different view and, in the war against Austria and Prussia which followed the Revolution in 1789, they developed a mobile apparatus for producing hydrogen on the battlefield. In April 1794 the world's first military aviation unit, La Premiere Compagnie d'Aerostiers Militaires, was formed near Paris, and in June its first balloon, *L'Entreprenant*, was deployed to Meubeuge, Belgium, for use by the French Republican Army against the Austrians. The first operational ascent was made on 26 June when a certain Captain Coutelle carried out a series of observations of Austrian forces manoeuvring on the battlefield at Fleurus. Coutelle was airborne for a total of ten hours and was accompanied later in the day by the French commander, General Jourdan. Messages were transmitted to the ground by means of semaphore, luminous balls hung on the basket or written information slid in sandbags down the mooring cable. The observations made a decisive contribution to the French victory.[1]

This ascent led to a classic military response to the air weapon. The Austrian troops panicked at the sight of the balloon – a typical reaction when soldiers first come up against a 'secret' weapon. Not long afterwards came the next almost inevitable

step – the disbandment of the balloon company by Napoleon in 1799. The reason given was that the balloons' speed of deployment did not comply with his concept of fast moving operations, although there is also a suggestion that he disapproved of the glamorous reputation that soon became attached to the French aeronauts – the 'brylcreem boys' of the Republican Army. History can only reflect on what would have happened at the Battle of Waterloo in 1815 had Napoleon possessed a balloon which could have peered over the Mont St Jean Ridge and seen Wellington's troop dispositions.

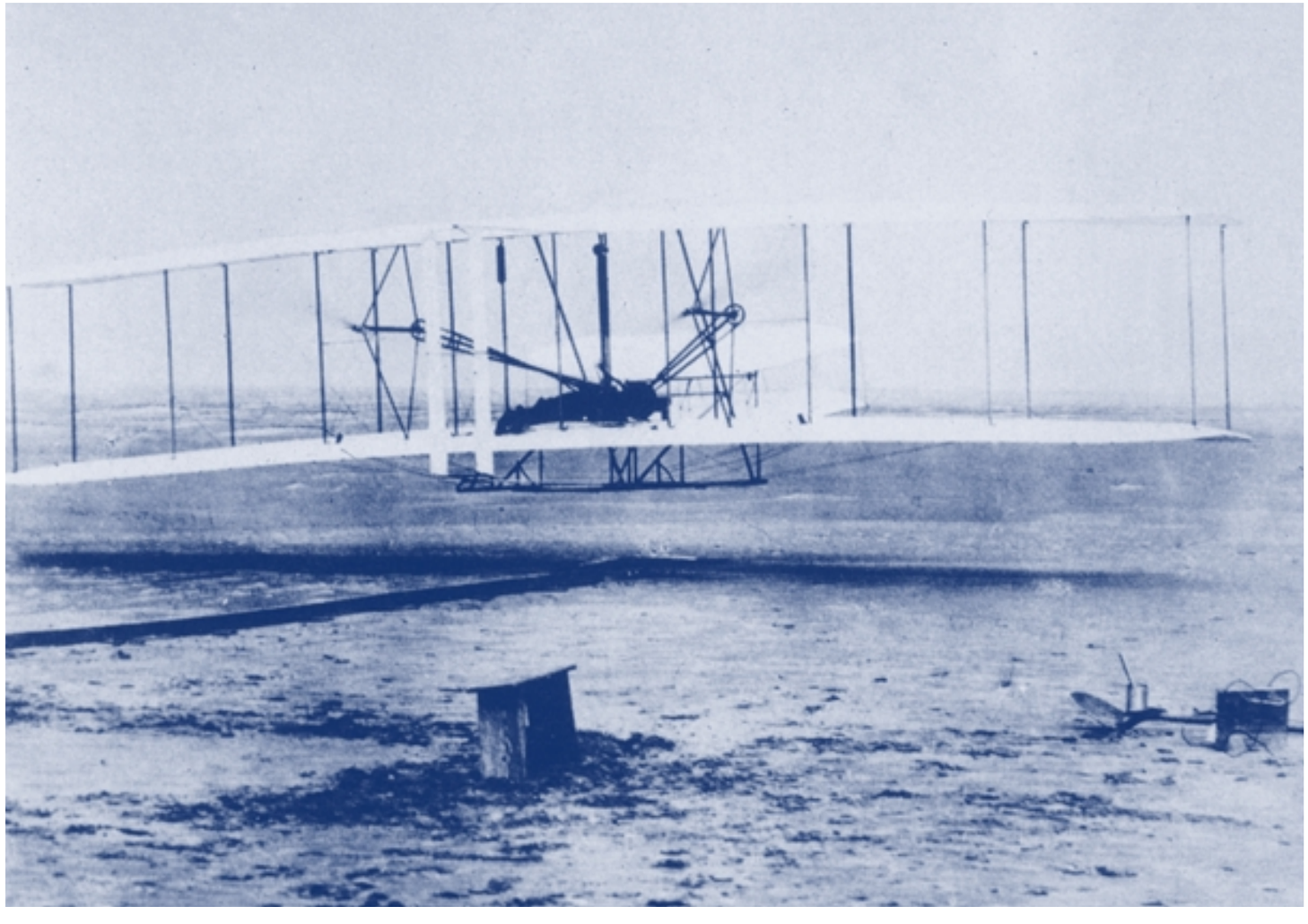
With the peace in Europe which followed the defeat of the French at Waterloo, the military development of observation balloons stalled. It was not until the 1860s, when significant progress was made in the fields of photography and telegraphy, that interest was renewed.

Balloons were used extensively during the American Civil War. In October 1861 the first Union Army Balloon Corps was formed under the command of Thaddeus Lowe with a complement of 50 men. By early 1862 the Corps had seven balloons. A converted coal barge was used to transport and tow the balloons during operations along the Potomac River – arguably the world's first aircraft carrier. The Balloon Corps proved its worth time and again, especially in directing artillery fire by aerial telegraph. In response, the Confederate forces operated their own balloon in the spring of 1862. It was manufactured from silk dresses donated by Southern ladies, but because the only gas supply was in Richmond, Virginia, it had to be inflated there and then towed to the front by train. The Union Army Balloon Corps, on the other hand, had portable hydrogen-making equipment.[2]

Impressed by the success of the balloons used in the American Civil War and the Franco-Prussian War (see below), the British War Office asked the Royal Engineers to look into the practicability of using balloons with the Army. The Army Balloon Equipment Store was established at Woolwich in 1878 under the command of Captain James Templar, an experienced aeronaut, who thus became the first British air commander. The first British Army balloon, named *Pioneer*, was constructed in 1879, and officers and men of the Royal Engineers were trained in aerial reconnaissance, photography and signalling. In 1884 a balloon unit travelled to Bechuanaland as part of an expedition sent to repel Boer incursions, with useful results. Another unit was sent to the Sudan the following year, after the fall of Khartoum and the death of General Gordon. In 1892 the Royal Engineers Balloon Depot was given a permanent base at Aldershot and a school of ballooning founded there.[3]

In December 1899, at the start of the Boer War, a Royal Engineers balloon detachment carried out observations during the Battle of Magersfontein. The balloon could have been used for aerial reconnaissance of the enemy trenches before the battle started, but the British commander, Lieutenant General Lord Methuen, neglected to issue the necessary orders, with the result that his forces were committed to action with no real knowledge of the Boer trench systems. The British suffered heavy casualties, which would certainly have been heavier still if balloon observation had not detected enemy movements during the battle itself. The activities of the balloon detachment persuaded some senior British officers that aerial reconnaissance was a valuable asset, although most remained convinced that scouting by cavalry remained the best method.[4]

Meanwhile, following the outbreak of war between the United States and Spain in 1898 over Cuba, a US Balloon Company was sent to the Caribbean island in support of an American expeditionary force. On 1 July 1898, some 8,000 American troops were struggling along a congested jungle path towards Spanish positions on San Juan Hill. Travelling with the troops, though a hundred feet or so above them, was a balloon from which one Lieutenant Colonel Darby attempted to make observations of the enemy positions. The jungle was so thick, however, that all Darby could see below him was a blanket of green foliage. The Spanish could not see the American troops either, but they knew exactly where they were because Darby's balloon was directly over the top of them, acting as a marker. As a result, a heavy barrage of fire rained down on the Americans, causing heavy casualties. Later that day the balloon, with a carnival aeronaut named William Ivy aboard, was badly holed by enemy fire and dropped into the water. Ivy survived and lived until 1955, with the dubious distinction of having become the first pilot in history to be shot down in war.[5]



A hundred years after their debut at Fleurus, balloons had made a useful but hardly decisive contribution to warfare. They were awkward to deploy, they lacked mobility and they were difficult to control in strong winds. Despite these shortcomings, however, they were the only aerial observation platform available. Then, on 17 December 1903, an event occurred which heralded the eventual eclipse of the use of balloons and their cousins, airships, as observation platforms. This was the first powered flight of the aeroplane *Flyer*, designed by the Wright brothers, at Kitty Hawk beach in North Carolina. Although at first this invention

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received little encouragement from the military in America or Britain, a French syndicate purchased the patent and took the lead in aeronautical progress. By the time the First World War began in 1914, aeroplane technology had developed to such an extent that heavier-than-air machines were already on the inventory of all the major combatants.

Nevertheless, the balloon was to play an important part in the First World War. The

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problem of control was solved by the German invention of the sausage-shaped *Drachen* or kite-balloon, which had tail fins to keep it pointed into wind; moreover, the static nature of trench warfare meant that the balloon's lack of mobility was rarely exposed. Thus *Drachen*-style kite-balloons were used extensively by both sides throughout the war and proved very useful for observation and artillery spotting.[6] Ultimately, however, the inherent characteristics of the aeroplane – height, speed, reach and flexibility – appeared to condemn the balloon as an observation platform to the pages of history.

It is therefore all the more surprising that, at the end of the 20th century, balloons are enjoying something of a renaissance as high-technology surveillance communications platforms. In the USA, a chain of radar-equipped aerostats (the American term for a tethered, non-rigid, payload-carrying balloon) plays an important role in the country's anti-drug campaign. US experience of surveillance aerostats has shown the technology to be both technically and cost effective. In a senatorial hearing in 1993, the US Customs Service put on record detailed data on the operation of what has become known as the Tethered Aerostat Radar System (TARS) which forms a key part of the USA's anti-drug National Air Interdiction Strategy. The network comprises fifteen operational sites which provide continuous coverage of the USA's southern border from Puerto Rico to the Pacific Coast. The 71m aerostats, manufactured by TCOM LP and equipped with Westinghouse radars, are designed to detect a $2m^2$ radar cross-section target within a 280km radius. On-station costs per hour are $300-500, compared with $3,500 for a fixed-wing airborne early warning aircraft such as the Lockheed P-3 Orion.[7] So successful has the experiment with surveillance balloons been that other agencies are now showing an interest in developing their own capability.

CONTROL OF THE AIR

"Anyone who has to fight, even with the most modern weapons, against an enemy in complete control of the air, fights like a savage against modern European troops."

Field Marshal Rommel

One of the primary considerations of any commander is to shape the battlespace so that friendly operations can proceed at the place and time of his choosing without prohibitive interference from an opponent. A second important consideration is to ensure that friendly military forces are safe from attack. One of the core capabilities of air power is, therefore, to achieve and maintain the degree of control of the air required to ensure the success of the operation. Friendly control of the air aims to restrict an opponent's ability to use air power against friendly forces.

Following the Montgolfier brothers' successful experiments with hot air balloons in 1783, the air power theorists of the period were soon painting lurid pictures of balloon-borne fleets sailing like galleons in the sky, armed with 200 guns apiece and engaged in death grapples as part of an invasion from the sky. In 1810 a Prussian officer, Julius von Voss, wrote, apropos balloons, that they had the task of observing the enemy from afar, but "…the enemy, eager to conceal his intentions, did not hesitate to send up his own light craft in order to drive back the enemy balloons; and so in the heavens above skirmishes developed between advanced patrols…".[8] A century later, von Voss's prediction was realised over the trenches of France, but by aeroplanes rather than balloons. Dependent on the prevailing wind for their direction and speed, balloons' lack of basic manoeuvrability would limit them to a passive but nevertheless important role in the struggle for control of the air.

The concept of using balloons for air defence (or Defensive Counter-Air Operations in the modern idiom) originated in Britain before the First World War. "The general idea was to build a stockade of nets in the skies and thus enmesh hostile aircraft on their way to the defended area".[9] During the last years of the First World War, the British employed the barrage balloon in response to attacks by German Gotha bombers on London. The London Balloon Defence in 1918 consisted of seven 'aprons' formed by a chain of balloons linked by cross

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cables carrying weighted wire streamers. The aprons were regarded as an essential element of the air defence system and were designed to force enemy bombers to use a restricted height band which could be effectively covered by fighters and anti-aircraft guns.[10] A German prisoner said that the aprons were "sufficient to keep all machines at their maximum height".[11] The Germans had developed similar ideas and by 1917 had formed balloon barrage detachments to protect industrial targets. In January 1918, a British FE2b was caught in a German net and the pilot emphasised the "fearful mess which the balloon cable had made of his machine".[12]

During the Blitz, 102 German aircraft struck balloon cables, resulting in 66 crashes or forced landings

The threat of another war rekindled interest in balloons in 1936, when a second balloon barrage was designed. The Air Staff laid plans for a ring of balloons around London, without the connecting apron, spaced at about ten balloons to the mile and requiring 450 balloons. This plan was quickly changed when it was realised that a ring of balloons merely forced an attacker high to cross the ring, after which he could come down to bombing height once more. Instead, 'field siting', an irregular pattern all over the area, was adopted.[13] RAF Balloon Command was formed in November 1938 and by September 1939 a barrage of 444 balloons was flying over London. During the Blitz, 102 German aircraft struck balloon cables, resulting in 66 crashes or forced landings.[14]

"An outstanding example of the disconcerting effect balloons have upon attacking aircraft was observed at one British cathedral city in the spring of 1942. The target, already twice attacked, was provided with a defensive balloon barrage against the probability of a third visit. The enemy returned, but by far the greater proportion of his bombs were discharged well outside the city boundary".[15]

The Germans learned the hard way that balloons could enhance low-level defences

Both fixed and mobile barrages were widely used during the Second World War to deny the enemy use of low-level airspace from where accurate bombing was possible. At its maximum strength, Balloon Command consisted of 52 operational squadrons, equipped with almost 2,500 balloons and manned by 33,000 personnel.[16] Besides cities, balloons protected ports and fleet anchorages, and balloons mounted in boats defended estuaries against mine-laying aircraft. Four thousand balloon personnel even took part in the invasion of Normandy, crossing the channel to protect beach heads, artificial harbours and ammunition dumps.[17]

The Germans learned the hard way that balloons could enhance low-level defences. Only after the Ruhr dams had been breached did they erect an aerial barrage to prevent repetition of the raid by 617 Squadron. Since its success depended upon low-level weapon release, the raid could not have been accomplished had a balloon barrage been earlier incorporated into the dams' defences.

The increased service ceiling of bombers coupled with the improvement in weapon aiming techniques from high level and at night diminished the importance of balloon barrages during the latter part of the war. The hazard to friendly aircraft posed by balloons and cables up to 20,000 feet was also not inconsiderable. Barrage balloons did, however, go out with a bang. To help combat the threat created by the use of V1 flying bombs in 1944, the 'largest balloon curtain in history'[18] formed the last layer of Britain's defences, and was credited with 278 kills. Nonetheless, Balloon Command was eventually disbanded in February 1945. Though used in small numbers by US forces in Korea, balloons have not figured significantly in air defence planning since 1944.

STRATEGIC EFFECT

“ Air power has become predominant, both as a deterrent to war and, in the eventuality of war, as the devastating force to destroy an enemy’s potential and fatally undermine his will to wage war.”

General Omar Bradley

The concept of ‘centres of gravity’, first espoused by Clausewitz as a way of describing how to compel an opponent in conflict to bend to your will, has stood the test of time. In Clausewitz’s day, the enemy’s army was considered to be his centre of gravity; in modern times, an opponent’s centre of gravity may take many forms. Air operations for strategic effect are intended to destroy or disrupt the defined strategic centre of gravity of an opponent and thus undermine his ability, will and means to continue fighting.

When the Marquis d’Arlandes and Jean-Francois Philatre de Rozier made their historic ascent in a Montgolfier hot air balloon in November 1783, one of the onlookers that day was the US envoy Benjamin Franklin. Alive to the sense of a new age dawning, Franklin wrote of the flight: “The invention of the balloon appears to be a discovering of great importance and may possibly give a new turn to human affairs. Convincing sovereigns of the folly of wars may perhaps be one effect of it, since it will be impractical for the most potent of them to guard his dominions. Five thousand balloons capable of raising two men each could not cost more than five ships of the line; and where is the prince who could afford to cover his country with troops for its defense that 10,000 men descending from the clouds might not in many places do an infinite mischief before a force could be brought to repel them?”[19]
Franklin’s concern about the irresistible nature of the new way of war predates by 150 years Stanley Baldwin’s famous assertion in 1931 that “The bomber will always get through”. His idea acquired credibility when a hydrogen balloon crossed the English Channel for the first time in January 1785. Thus, when England and France once more went to war in 1793, it was tempting for propagandists and alarmists to inspire the dread of airborne invasion at a time when the Royal Navy prevented any such happening by sea. The Mongolfier brothers themselves had a strategic purpose in mind for their balloon: nothing less than the capture of the British garrison at Gibraltar. They planned to build a whole fleet of balloons and lift

The invention of the balloon appears to be a discovering of great importance and may possibly give a new turn to human affairs

thousands of French soldiers to the top of the Rock. Fortunately for a large number of unnamed French soldiers, the Montgolfiers were prevailed upon to move more slowly.[20]

It was thus the potential strategic effect of balloons that first caught the theorists' imagination, and although balloons actually began their military career in observation work, their strategic possibilities were not forgotten. Ironically, it was the Austrians, who had panicked at the sight of the new aerial phenomenon at the Battle of Fleurus in 1794, who were the first to put the concept into practice. During the siege of Venice in March 1849, the Austrians conceived a plan which, they hoped, would force the Venetians to surrender without the need to storm the city: they would bomb the civilian population. Two hundred small, unmanned hot-air balloons were constructed, each fitted with a 30lb bomb which would be released by a time fuse. The idea was simple: the balloons would be floated over the city to release their deadly cargo on the unsuspecting Venetians, whose will to continue fighting would thus be broken. When at last the wind was favourable and the attack launched, it produced reactions among both the victims and the attackers which were to be seen again during the strategic bombing campaigns of the twentieth century. Though at first alarmed, the citizens of Venice rapidly assumed a disdain for the new method, particularly since no casualties resulted. The Austrians, on the other hand, made exaggerated claims of the damage and casualties they had inflicted and the effect on their opponents' morale they felt must have ensued. Nonetheless, the experiment was not repeated.[21]

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Almost one hundred years later, on 18 April 1942, sixteen B-25 bombers from the aircraft carrier USS *Hornet*, led by General James H Doolittle, bombed Tokyo in retaliation for the attack on Pearl Harbour four months previously. The raid did little physical damage, but the Japanese Imperial High Command were shocked at the violation of their homeland. Reprisal raids were demanded, but there were no suitable airfields within striking distance of the continental United States and precious aircraft carriers could not be risked. Enter the balloon! Japanese balloon technology was the most advanced in the world, and Japanese scientists knew that intercontinental, free-flight balloons were possible. By making use of the prevailing wind currents, they could send death-dealing balloons to US shores within a matter of days.

Two years later, at a cost of nine million yen (about two million pre-war US dollars), the Japanese had perfected a weapon that could travel over 6,000 miles to American shores, drop a payload of incendiary and anti-personnel bombs and, with a small explosive device, self-destruct. On 3 November 1944, the first balloon rose slowly and silently from its launching site on Honshu's eastern seaboard. More than 9,000 bomb-carrying balloons would follow.

When the first balloons began drifting over US shores, there was confusion and panic. It was soon established that the source of the balloons was Japan and, as more and more balloons reached the United States and Canada, their detection and interception became a top priority. Of vital concern was the payload the balloons carried. The destructive explosive power was small, but the incendiary threat was incalculable. With huge forests all along the West Coast and extending inland, a massive incendiary raid during the dry season could envelop the entire area in a gigantic, uncontrolled holocaust. From this alone, the loss of lives and property would be enormous.

Under great pressure, the US military was forced to establish a defence against the balloons. The *Sunset* project, initiated in early 1945, aimed to track the balloons by radar and shoot them down. Scores of interceptor aircraft of the US Fourth Air Force, including P-38 Lightnings and P-61 Black Widows, and literally thousands of military personnel were tied up in balloon defence. Thus did the balloons achieve a strategic effect, although not the one for which they had been conceived.

The Japanese balloons did cause some damage. Not only were six people in Oregon killed by the balloon explosives, but in a strange twist of fate, one of the balloons landed on transmission lines leading to the Hanford Engineering works in Washington where a portion of the top-secret *Manhattan* atomic energy project – soon to bring vast destruction to their own shores – was taking place. A power failure did occur, but safety controls triggered and electric current immediately resumed.[22]

JOINT FORCE EMPLOYMENT – INDIRECT AND DIRECT AIR OPERATIONS

"The greatest lesson of this war has been the extent to which air, land and sea operations can and must be co-ordinated by joint planning and unified command."

General 'Hap' Arnold, 1946

The inherent characteristics of air power – height, speed, reach and flexibility – give commanders a range of options to exploit it in joint operations. Indirect air operations are intended to destroy, disrupt, neutralise or delay the military potential of opposing forces before they can be brought to bear effectively against friendly forces – so-called 'shaping the battlespace'. Direct air operations are conducted against hostile targets that are in direct contact with friendly forces on the battlefield itself.

The same inherent lack of basic speed and manoeuvrability that would prevent balloons from being used in offensive counter-air operations would also effectively disqualify them from being employed *directly* in anti-surface force operations, although the idea

has been put forward on at least one occasion. During the war between the United States and Mexico in 1846 (which arose out of a dispute over the ownership of New Mexico), a Pennsylvania balloonist named John Wise suggested using a balloon to drop "a thousand percussion bombshells" on the fort of San Juan de Ulloa at Veracruz, whose gun batteries were holding up the advance on Mexico City of American forces under General Winfield Scott. Typically, the idea was ignored by the War Department, and the fort was eventually taken only after a bloody land assault.[23]

Nonetheless, balloons can certainly be used *indirectly* in anti-surface force operations. Their observation and artillery spotting roles have already been covered, and recent advances in balloon and cable technology have opened up more exciting possibilities. In 1995, as part of the Pentagon's attempt to create a limited, operational counter-battery capability to destroy heavy weapons in the event of an attack by North Korea, senior US military officials in South Korea began examining the use of moving target indicators combined with synthetic aperture radars on board tethered balloons to monitor North Korea's mobile artillery and missiles.[24] The balloons' cables could be used to carry secure data links that would allow controllers to guide the flight of cruise missiles from a ground station or ship. Indeed, the accuracy of a whole range of precision guided munitions could be increased during the final minutes of flight by allowing a person to take over terminal guidance of the weapon.

JOINT FORCE EMPLOYMENT – COMBAT SUPPORT AIR OPERATIONS

"Supply and transport stand or fall together; history depends on both."

Winston Churchill

Combat support air operations cover the full spectrum of air power roles and emphasise the utility of air power around the spectrum of conflict. Essentially, combat support enables forces on land, sea and air to undertake their combat roles; combat support air operations include air transport, air-to-air refuelling, air surveillance and reconnaissance, combat search and rescue, electronic warfare and the suppression of enemy air defences.

During the Franco-Prussian War of 1870-71, the French used balloons in the air transport role. Sixty-six balloon flights were made out of Paris, under siege by Prussian forces, to unoccupied territory. The balloons carried a total of 110 passengers, more than 2½ million letters and carrier pigeons to fly back to Paris bearing microfilm messages. The early flights from Paris were made by skilled aeronauts, but later missions were undertaken by French Navy personnel, specially trained for the task. In response, the German firm of Krupp produced the world's first anti-aircraft guns. Five balloons and their occupants were captured by the enemy; of the others, two were lost in the Atlantic and one ended up in Narvik in northern Norway after a flight of 1,400 miles.[25]

While the balloon flights out of Paris – the first airlift in history – had been something of an epic, it was clear that the venture would have been a greater success if the aeronauts had been able to steer their craft. Some bizarre suggestions were put

forward, the best of which was for a quartet of eagles to be harnessed to the balloons.[26] Ultimately, however, the Parisian experience gave impetus to the idea of building a dirigible balloon – an airship.

JOINT FORCE EMPLOYMENT – FORCE PROTECTION

"It is easier and more effective to destroy the enemy's aerial power by destroying his nests and eggs on the ground than to hunt his flying birds in the air."

General Giulio Douhet

Air power depends upon a number of component elements – platforms, weapons, bases, logistics, command and control assets – the degradation of which may reduce its effective application. Force protection means preventing an enemy from attacking vital air assets, or minimising the effects of any attack, to enable air operations to continue.

During the Cold War, the greatest threat to NATO's air power was a massive Warsaw Pact attack on the Alliance's airfields. Since the Warsaw Pact lacked large numbers of stand-off weapons, its aircraft would have had to overfly the target to deliver their bombs and, to increase their chances of survival in the face of the SAMs, rapid-fire AAA and fighters of NATO's air defence system, they would have had to make their attacks at low level. Although the British, American and German experiences with barrage balloons in the Second World War showed that balloons could be very useful in countering the low-level threat, their utility was ignored by NATO. Yet even today, for nations threatened by adversaries not equipped with precision, stand-off weapons, balloons would enhance the effectiveness of existing airfield defences at relatively low cost.

Balloons placed across valleys or along the dead side of high ground would prevent enemy aircraft from using terrain-masking to conceal their approach to a target and thus render them more vulnerable to early radar detection. Balloons deployed nearer to airfields would add to the attacking pilot's problems in reaching a position from which accurate weapon delivery were possible. Most importantly, well planned balloon barrages would force attacking pilots either to manoeuvre around or more probably pull up to avoid flying through balloons and cables. At higher level there is a much greater probability of successful GBAD engagement. Moreover, the increased time available to acquire and track targets would permit better co-ordination of missile launches against individual targets during mass attacks, thereby avoiding wasteful multiple engagements of single targets.[27]

The utility of balloons in force protection does not end with aerial barrages. The concept of balloon- (or aerostat-) mounted radars, discussed earlier in this article in connection with US anti-drug surveillance, has also been applied to defence against low-flying aircraft. Both Saudi Arabia and Israel have an aerostat-based low-altitude surveillance system (LASS) integrated into their air defence network which is used to detect low-flying aircraft at ranges up to 300km. In Kuwait, an aerostat LASS was in service for six days before the 1990 Iraqi invasion, during which it was destroyed. Nevertheless, this limited experience of

operating an aerostat system was enough to convince the Kuwaitis of its effectiveness; indeed, the system is reported to have given the first in-country indication of the invasion and may well have been instrumental in helping the Emir to escape. As a result of the Kuwaiti experience, the United Arab Emirates has also purchased an aerostat LASS.[28]

In the USA, research is also ongoing into the possibility of using balloons as a counter-stealth tool. Stealth aircraft and cruise missiles are built primarily to elude ground-based radar, so engine inlets, cockpits and other hard-to-disguise parts of aircraft are shielded from the ground but often not from an airborne sensor. Moreover, a radar looking down at fixed ground clutter can locate a moving empty spot produced by a non radar-reflective object. With improvements in balloon technology over the last decade, it ought to be possible to place an aerostat at 65,000 feet, above the most violent weather, for at least 30 days at a time. The aerostat, shorn of tail structures required for low-altitude operations and carrying a large aperture radar, would cost $10-20 million with its mooring system and ground support vehicles. But the real benefit would be in its operating costs: compared with $2,700 per hour for a Grumman E-2 Hawkeye or $8,300 for a Boeing E-3 AWACS, the balloon system would cost only $500 per hour.[29] How ironic it would be if the solution to the problem posed by stealth, the newest air power technology, should be solved by the balloon, the oldest.

SUSTAINABILITY

Sustainability is defined as the ability of a force to maintain the necessary level of combat power for the duration required to achieve its objectives. It is the function that ensures or denies the capability of air power to operate. It influences the tempo, duration and intensity of an operation. In its broadest sense, it encompasses all activities necessary for the employment of air power other than its execution.

The most important element of sustainability is personnel – the provision of trained, available manpower in sufficient numbers to man the force and to replace losses. In 1941, impressed with the part played by German paratroops in the capture of Crete, Winston Churchill called for large numbers of British soldiers to be trained in the art of parachuting. Owing to a shortage of suitable aircraft, it fell to the balloon to provide the necessary airborne platform. Parachute training with balloons began at Tatton Park near Manchester the same year. It soon became apparent that balloons are ideal for ab initio parachute training as they allow the trainee to undertake his first descent in controlled conditions; there is no slipstream, and the trainee is able to parachute as a singleton, allowing the instructor to talk him safely down to the ground. After the Second World War, the balloon remained, with the C130, the main platform for parachute training. During the Gulf War, when most of the C130s were employed elsewhere, the balloon was the only facility available for Airborne troops to remain current.[30]

Another key element of sustainability is equipment, in particular the provision of weapons that are fit for the task. Balloons have played an important role in the research and development of British weapons. In the 1960s and 70s, balloons were used in support of the Bloodhound trials and the Atomic Weapons Research Establishment tests in Australia and on Christmas Island.

More recently, they have been used for testing the Low-Level Parachute and the British Army's Starstreak hyper-velocity anti-aircraft missile.[31] Balloons were also used extensively by the United States and Soviet military for the research and development of new weapons during the Cold War.

Last but not least, it should not be forgotten what a key part the weather has always played in the tempo, duration and intensity of air operations. As recently as 1999, NATO air operations over Kosovo in the early days of Operation Allied Force were severely hampered by bad weather. Accurate forecasting of weather conditions is an essential part of operational planning, and even in the age of the satellite, the weather balloon remains an important forecasting tool.

Before the development of powered aircraft – airships and, ultimately, aeroplanes – balloons were the only aerial platform available to military commanders. It is therefore not surprising that experiments in employing balloons in a range of air power roles were carried out. The limitations of free-flying balloons quickly became apparent. Dependent on the prevailing wind for their direction and speed, balloons' lack of basic manoeuvrability soon rendered them unsuitable for active air power roles – offensive counter-air operations, strategic attack, anti-surface force operations and most combat support air operations – and accelerated the development of powered platforms. Tethered balloons, on the other hand, proved useful for aerial reconnaissance, artillery spotting, defensive counter-air operations and parachute training and continued to do so long after the advent of heavier-than-air machines.

Indeed, balloons are enjoying something of an air power renaissance at the dawn of the 21st century. Benefiting from developments in balloon and cable technology, and equipped with radar and secure data links, aerostats offer a cost-effective alternative to fixed-wing platforms in areas such as surveillance, airborne early warning, target acquisition, weapon guidance and force protection against both low flying and stealth aircraft. The wheel has come full circle, and the early pioneers – Captain Coutelle, Thaddeus Lowe, the unfortunate William Ivy et al – would be pleased at the way things have turned out.

NOTES

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