Published in Cwerner S, Kesselring S, and Urry J (Eds.)
(2009) *Aeromobilities* London, Routledge pp115-134

Air craft: producing UK airspace

Lucy C S Budd

> 'It's a tricky business directing traffic at 35,000 feet. There are no traffic lights. No road signs. No roundabouts either. But, fortunately, for the two million flights and 220m passengers that pass though UK airspace every year, there's NATS…'
>
> – NATS recruitment advertisement

The United Kingdom contains some of the most densely trafficked airspace in the world. In 2006, an average of over 5400 commercial flights a day shared the skies with hundreds of military jets, private aircraft, helicopters, airships, hot-air balloons, and gliders. They were protected from collision by the skill and vigilance of their pilots and air traffic controllers, the careful arrangement of airways and control zones, and increasingly sophisticated collision avoidance software, yet the only time many of us get to hear about this complex, largely invisible, interlocking aerial geography of command and control is when things go wrong and flights are delayed, diverted, or cancelled due to adverse weather conditions, computer failure, or industrial action. Most of the time, the safe, efficient, and punctual production of airspace forms a vital part of a largely taken-for-granted airworld.

While much has been written about the development and utilisation of new aeronautical technologies, the evolution of airline networks, the growth of airports, and aviation's apparent ability to 'shrink' global space-time, airspace remains an under-researched and under-theorized site of aeronautical activity. Where it has been considered, it has often been described as a mere 'conduit' or 'space of flows', negating any detailed investigation into how it is socially produced, maintained, and contested through ongoing practices of management, negotiation, and opposition. Such is the paucity of research into the everyday, yet largely hidden, spatial practices of Air Traffic Control (ATC) and piloting commercial aircraft, those not directly involved in its production are largely ignorant as to how airspace 'works' and why the sky is configured and used in particular ways. This has important implications at a time of continued passenger demand and widespread public opposition to airport expansion.

In order to bring questions of airspace production to the forefront of academic inquiry, this chapter contains five distinct, but intrinsically interrelated, sections. The first, entitled 'crafting the sky', provides an overview of the development of airspace legislation from the early twentieth century to the present day. It examines how the sky has been crafted into an important geopolitical space that is simultaneously governed by a multitude of domestic and international law. In an effort to expose the complex 'hidden' geographies of the air that have been created, section two provides a brief description of the contemporary structure and classification of UK airspace. Sections three and four then explore how these unique aerial spatialities are reproduced and mediated by practices of air traffic control and piloting commercial aircraft. The final section draws on recent examples of anti-airport protest in the UK to suggest that airspace is not only produced 'in the air' by air traffic controllers and pilots, but is actively negotiated and contested on the ground by communities who oppose its use.

Crafting the sky

The development and utilisation of powered flight in the early twentieth century demanded the extension of traditional Cartesian understandings of territory to embrace the third (aerial) dimension. While some praised the freedom and emancipation flight afforded, predicting it would bind the nations of the world together in a new era of international peace and understanding (Finch 1938), others were concerned about the combined military and commercial threat aircraft posed. As Dargon (1919: 146) noted, 'whereas other vehicles…are compelled to keep to existing tracks, aircraft are free to manoeuvre in space and can rapidly and easily surmount all obstacles which have hitherto constituted effective barriers to other forms of locomotion', and individual states felt compelled to defend themselves against uninvited or hostile 'winged visitors' though a collection of hastily formulated aerial legislation (Brittin and Watson 1972).

As long as a pilot took off, flew within a state's navigable airspace and landed within its national borders there was no problem, but the challenge international services posed to the territorial integrity of individual states produced one of the longest and most acrimonious debates in aeronautical politics. Nation-states sought to cede as little and seize control of as much airspace as possible, and manipulated international agreements governing economic regulation for their own commercial advantage while retaining control over their borders for reasons of defence and national security (Petzinger 1995).

Countries with rapidly developing aviation interests, including the UK and US, advocated complete freedom of the skies, cautioning against any bureaucratic intervention (other than that which helped secure their aerial hegemony), arguing 'The road of the air is a free and universal thoroughfare for all mankind. As wide as the world, and almost everywhere navigable, it is unhampered by any barrier, obstacle or limitation…Any restriction to its usage will be an arbitrary restriction imposed by the will of man' (Burney 1929: 167). One of the main obstacles to agreement was that while national claims to land, lakes, rivers and adjoining seas had been common since Roman times, claims to airspace were entirely new concepts. Nevertheless, it was agreed that some form of transnational regulation was required, and the first coherent attempt to bring international air services under unified control occurred at Paris in 1910. However, the mutually incompatible visions held by the representatives of different aerial nations meant that unanimous agreement on the use and regulation of airspace was not forthcoming (Veale 1945).

Following the first scheduled passenger flight between England and France in August 1919, the production and control of global airspace became a matter of intense political concern and, as the twentieth century progressed, the sky was parcelled out between nations and subdivided into a number of discrete 'blocks' that were subject to different rules and regulations. A plethora of bilateral and multilateral air service agreements were signed which stipulated which airlines could fly, which airports (and hence airspace) they could use, how frequently the services could operate, and the airfares that could be charged (see Millichap 2000). European flag-carriers, including British Airways, Iberia, and Lufthansa, thus operated in a highly protected market, insulated from any form of effective competition. It was not until the late 1980s that any change occurred. Increased public dissatisfaction with high airfares combined with the rise of neo-liberal economic ideologies and pressures on public spending encouraged European Governments to embark on an ambitious programme of air transport liberalisation (Balfour 1994).

The removal of anti-competitive legislation, through three progressive packages of liberalization measures in the 1990s, revolutionized the industry and allowed new airlines to enter the marketplace for the first time. Many chose to undercut the airfares charged by traditional carriers by eschewing traditional in-flight ‘frills’ and operating frequent short-haul flights between secondary, less congested, regional airports (Calder 2002; Lawton 2002). Lower fares stimulated unprecedented passenger demand and a dramatic rise in passenger numbers, but the resulting increase in flights, particularly at smaller airports, posed a number of challenges for air traffic control. As one senior controller commented, ‘the skies are now full of Ryanairs and easyJets going to places you’ve never heard of. You suddenly find you’ve got 25 aircraft all wanting to go (from the UK) to Malaga at 7am on a Saturday morning and there simply isn’t room’[1]. Another remarked, ‘often the first I know about a new route is when I see an advert for it on a bus shelter. Airlines and passengers just assume they can fly wherever and whenever they want, but the reality is rather different. You might think the sky is limitless, but believe me, it isn’t.’[2] Indeed, the oft-vaunted ‘freedom’ of the air is largely an illusion and the space available for different types of flight is restricted. The existing airspace structure requires commercial aircraft to fly along strictly defined airways (the equivalent of aerial roads in the sky) and circumnavigate large areas of sky that are reserved for military use. The UK’s geographical site and situation between the old and new worlds also means that up to 80% of the capacity of certain airspace sectors can be occupied by aircraft flying between North America and Continental Europe, leaving little room for domestic or intra-European flights.

Today, the provision, regulation, and use of UK airspace are becoming increasingly politicised. Government and industry regulators want a safe, competitive, and efficient airspace system. Airlines crave the freedom and flexibility to fly where they want, when they want to, as cheaply as possible. Military and general aviation users require access to airspace for training and recreation purposes, and environmental groups and airport communities complain about levels of aircraft noise and pollution and seek to restrict the industry's growth.

Ordering the sky

At a national level, UK airspace is governed and administered by the Civil Aviation Authority (CAA) and NATS, the part-privatised national air traffic services provider, in accordance with domestic and international law. All flights within the UK's 350,000 square miles of sovereign airspace are conducted according to one of two rules of flight – VFR (Visual Flight Rules) or IFR (Instrument Flight Rules) - which determine where and when pilots can fly. Under VFR protocol, pilots assume complete responsibility for aerial navigation and the safe conduct of their flight. Newly qualified pilots are only permitted to fly in good weather and good visibility during daylight hours (though experience and the acquisition of additional licence ratings may modify these conditions). Instrument Flight Rules, in comparison, allows suitably qualified pilots to fly in Controlled Airspace (upon receipt of ATC clearance), 24 hours a day in virtually all weathers. The majority of commercial flights in UK airspace are flown according to IFR, while most general aviation users operate under VFR conditions.

To help manage the diverse operational requirements of different airspace users, UK airspace is divided into two geographical regions. 'London' is administered from the en-route air traffic control centre at Swanwick, Hampshire, while 'Scottish' sectors are controlled from Prestwick. Both regions are divided vertically, with a Flight Information Region (which is active from the ground to 19,500ft) and an Upper Flight Information Region (for airspace above 19,500ft) in each. Different sections of airspace within these regions are further classified as being 'controlled' or 'uncontrolled' depending on the nature and volume of traffic flowing through them. Controlled airspace (i.e. that which falls under the jurisdiction of ATC) can take many forms, from en-route high-altitude airways to local airport control zones, while uncontrolled airspace is relatively 'free' and can be accessed by anyone with a valid licence. To identify the different types of airspace and determine the rules that apply in each, each sector is designated as one of seven 'Classes' (identified by the letters A-G), where Class A is subject to the most control, and Class G the least[3]. These designations create a highly complex web of different control zones and sectors, all of which are effective between different altitudes, subject to different rules and regulations, and may only be active for certain periods of time. Knowing where you are, and when and where you may fly, are thus crucial to the maintenance and safe production of airspace.

To compound the complexity, some areas of sky are permanently off-limits to civilian aircraft for reasons of safety and/or national security. These restricted areas include military training zones, areas around certain power installations and defence establishments, and certain wildlife reserves. Temporary restricted areas may also be introduced during major sports events or airshows. During the UK stage of the Tour de France in July 2007, six temporary restricted areas were activated above parts of London and the southeast to protect the television helicopters and other aircraft monitoring the race. Temporary restricted areas may also be established around airshows to protect both the performers and other airspace users. Details of the lateral, vertical, and temporal extent of these restrictions are communicated through airspace charts, NOTAMs (Notices to Airmen) and pre-flight bulletins. As there are no fences or 'keep out' notices in the sky, the onus is on the pilot (and, to a lesser extent, the air traffic controller) to ensure the boundaries of different types of airspace are not violated. However the system is not infallible, and controlled airspace can be, and often is, encroached by unauthorised aircraft. In 2006, 633 separate airspace infringements were reported to the CAA. Though the majority did not pose a collision risk, a small number resulted in serious 'airprox' events (so-called 'near misses'). Fortunately, none of these incidents resulted in a mid-air collision, but it is estimated that just one infringement can affect up to 30 other aircraft, delay as many as 5000 passengers, and cost over £50,000 in wasted fuel (CAA 2007).

In the early years of passenger flight, pilots navigated with reference to major landmarks such as roads and railway lines, but as the network of passenger services grew throughout the 1920s, identification codes were painted on top of railway stations, barns, and hangers to help pilots determine their exact location from the air. This system, however, required aircraft to remain below the cloud-base and converge at a few key navigation points, and simultaneously condemned passengers to an uncomfortable ride and increased the risk of mid-air collision. In 1922, seven people died in a mid-air collision over northern France and a decision was taken to regulate air routes across the English Channel. As a pre-cursor of the modern airway system, pilots flying between London and Paris were instructed to remain east of Ecouen, Abbeville, Etaples and Ashford when flying towards the French capital, and west of them on their return. To aid compliance and assist with navigation, radiotelephony stations were constructed to enable ground controllers to communicate with pilots over the Channel (NATS 2005).

By the 1930s, rising numbers of aircraft necessitated the creation of specific arrival and departure routes at airports to ensure aircraft remained a safe distance apart. The principles of this system form the basis of current airport operations, with inbound and outbound aircraft following predetermined arrival and departure routes. Current 'STARs' (Standard Arrival Routes) and 'SIDs' (Standard Instrument Departure routes) are designed to ensure aircraft can leave and join the en-route airways safely and efficiently. At large airports, these routes are highly complex, and the specific procedures pilots must follow are communicated through specialist charts (see Figures 1 and 2).

<u>FIGURES 1 and 2 ABOUT HERE (AERAD charts of LHR)</u>

As the twentieth century progressed, a national network of Very High Frequency Omnidirectional Range (VOR) radio beacons was established to aid aerial navigation and define the dimensions and contours of UK airspace. VOR beacons transmit a coded signal on a specific radio frequency that enables aircraft to 'home in' on them from any direction and 'turn corners' at the intersection of two or more beams. Individual beacons are identified by a name and a three-letter abbreviation which, like the airspace sectors above them, often have some basis in 'real world' geography, such as 'Clacton' ('CLN') on the Essex coast, 'Brookman's Park' ('BPK') near the famous motor racing circuit, and 'Trent' ('TNT') in the Peak District.

To help controllers and pilots monitor a flight's progress, over 820 reporting points and/or waypoints are located along the airways. Some of these 'Name Code Designators' also reflect their geographical location, for example 'RUGBY' and 'LESTA' (Leicester) in the English Midlands, 'MIRSI' (as in River Mersey) north of Liverpool, and 'KIDLI' near Oxford Kidlington airport. Some may also contain an implicit 'local' connection, such as 'ABBOT' near Stansted airport (named after a local Essex beer) and 'UPDUK' in Leicestershire (which has been linked to the local colloquial greeting 'hey up me duck'), but as traffic volumes have grown, and additional routes have been introduced, new names have emerged which bear no relationship to ground-based features below. Some are named after British flora and fauna (examples include 'HAZEL', 'BUZAD', and 'FINCH'), or female names (including 'KELLY', 'LINDA' and 'KATHY'), while a group of waypoints over the English Channel are named after famous nautical heroes. While it is claimed that software alone determines waypoint names, a degree of humour apparently creeps in - with 'RUGID' over the Scottish highlands, 'BARMI' over the North Sea, 'NEDUL' and 'THRED' near the South Coast, and 'GINIS' over the Irish Sea. Unlike beacons, waypoints are not marked by any built infrastructure and are 'invisible' markers designed to regulate and control flows of aircraft. Many waypoints only exist in upper or lower airspace, creating an invisible vertical geography of striated layers of airlanes and airways whose positions are irrelevant for those aircraft not operating between those altitudes.

Like roads, airways are classified and given alphanumeric identifiers, and the route a flight will follow is detailed on the flightplan as a string of letters and numbers. For example 'DTY-A47-WOD-BIG-UL9-DVR' describes a route from the Daventry beacon (DTY) to Dover (DVR) via airway A47, the beacons at Woodley (WOD) and Biggin Hill (BIG), and airway Upper Lima Nine (UL9). To ensure individual airspace sectors are not overloaded, flow management computers at Eurocontrol in Brussels analyse the spatial and temporal profile of all flights that are planning to use European airspace for some or all of their journey and impose slot restrictions or issue alternative routings, where necessary, to smooth out the flow.

To help pilots comprehend increasingly complex air routes and airspace sectors, dedicated aeronautical charts began to be published to aid navigation and spatial orientation. The first series of aerial navigation charts designed specifically for commercial use appeared in the immediate aftermath of World War Two and were produced to facilitate the development of regular international passenger services. At one level, early airspaces were relatively easy to map, and the physical architecture and topology of the network was simply superimposed over a conventional map and represented using an appropriate form of cartographic visualisation. But as aircraft began flying progressively further, faster, longer, and higher, new universal classification systems had to be devised.

The current portfolio of paper and electronic aerial navigation charts available to pilots is extensive, and includes everything from small-scale high and low altitude en-route IFR charts, regional airspace information supplements, and aerodrome booklets that show the layout of runways, taxiways and gates and detail the specific arrival and departure procedures that should be followed at each facility, to VFR charts for the private pilot. All these publications code the sky in different ways and require the user to be familiar with the distinct language and symbology of airways, airspace exclusion zones, minimum safe altitudes, radar vectoring areas, and associated information (see Figure 3).

FIGURE 3 ABOUT HERE (extract of UK IFR chart)

Controlling the sky

Irrespective of the number of maps and charts depicting where different types of aeromobility can occur, aircraft cannot enter controlled airspace without ATC authorisation, and the day-to-day production of UK airspace relies on controllers producing space for aircraft. In common with the rest of the industry, the spatial practice of ATC is highly regulated and is mediated by specialised technology which help controllers 'see' the airspace under their command and enable them to order and police the sky at a variety of scales, often from remote sites.

Radar is one of the most important tools of ATC and is employed at all control centres to monitor the progress of individual flights and help controllers visualise traffic flows. Modern radar involves two discrete systems operating in tandem, Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR). PSR produces coloured 'blips' showing the location of any object (including aircraft, high-sided vehicles, storm clouds and areas of high ground) that causes an echo to be reflected back to the receiver. In order to positively distinguish aircraft from other 'ghost' echoes, all passenger aircraft over a certain weight are required by law to carry a small radio device, called a transponder, in the flightdeck. Transponders automatically respond to interrogation from ground-based radar pulses and send a unique coded identification 'squawk' signal, which contains salient information about the aircraft's speed, altitude, and rate of climb or descent, back to the ground. ATC computers then translate these transponder signatures back into flight data, providing controllers with information about the operator, callsign, altitude, origin/destination, speed, and rate of climb or descent (if it exceeds 500 feet per minute) of individual aircraft, before showing this data alongside the relevant 'blip' depicting the aircraft's physical position in space.

The resulting two-dimensional images of aircraft flying through three-dimensional space are layered on top of a static grid of lines and symbols demarcating different airspace sectors and the position of airports, navigation beacons, and waypoints, and produce a complex assemblage of different objects flying through multiply encoded spaces. The responsibility for interpreting these images rests with individual controllers, and many report they develop detailed three and four-dimensional mental pictures of the airspace they are working. One controller commented that aircraft 'bounce off' flightlevels in her head, while a colleague remarked that the construction of mental images 'is not something we do consciously, it just happens – I look at a radar display and instinctively see it in 3D'[4].

To lessen the risk of incomprehension and misunderstanding, all ATC messages are conducted in English and each sector of airspace is administered using a dedicated airband frequency to minimise interference. As every pilot can hear all the transmissions between the controller and the other aircraft operating on that particular frequency, they can develop situated understandings of the relative position and trajectory of the air traffic around them. The use of readback, whereby flightcrew repeat the controller's instruction alongside their callsign, acts as another safety device, ensuring all instructions have been received and understood. Nevertheless, in 2004-2005 538 separate communication incidents were reported in UK airspace which involved pilots either mishearing or misunderstanding ATC instructions (Jones 2005).

To help controllers keep track of the clearances and instructions they issue, they continually annotate Flight Progress Strips (FPS), which accompany every flight throughout its journey. Before take-off, data about a particular service (including callsign, operator, aircraft type, intended routing, requested altitude, anticipated airspeed, scheduled time of arrival or departure, and details of any en-route delays) is uploaded from the flightplan, encoded, and printed onto lengths of card (or displayed on electronic screens in some control centres). Once processed and approved, flight data is automatically sent to all the control centres that will handle that flight. Before an aircraft departs or arrives in a particular sector of airspace, these strips are printed, placed in coloured holders to differentiate between different types of services, and positioned in chronological order in strip-racks near the radar screen. New strips are inserted at the top of the rack furthest from the controller and, as flights land or leave the sector, the remaining strips move down to take their place, bringing aircraft closer to the controller in time and space (with the relative 'height' of strips on the rack standing proxy for either the altitude of arriving aircraft as they descend towards the airport or the sequence in which they must be handled).

Once a strip becomes live and the aircraft to which it refers is under active control, every salient detail about the flight, including heading changes, altitude clearances, speed restrictions, or special instructions, are added to update the basic printed information. As these instructions are dependent on emerging contingencies, no two strips are ever the same and individual controllers literally 'author' the sky to reflect their personal view of the airspace under their command. Depending on traffic volumes and weather conditions, individual strips can become covered in annotations, showing how the process of control creates airspace in flexible ways. This act of inscribing information defines the airspace in the controller's own terms, but while every controller 'produces the sky' in different ways, the information is presented in a universally structured manner (Figure 4).

FIGURE 4 ABOUT HERE (Flight progress strips)

While the spatial practice of air traffic control appears very prescribed, with tasks mediated by international regulations, manuals, and protocols, controllers do have the flexibility to choreograph the production of airspace in different ways according to emerging contingencies. The importance of controller discretion, or flexibility, within defined operating parameters should not, therefore, be underestimated. A violent thunderstorm may require aircraft to deviate from prescribed routes, or an in-flight emergency may necessitate prioritising one aircraft above all others. However, any disruption to normal flow patterns, no matter how seemingly slight, can have significant knock-on effects on the whole network, with delays in one sector affecting traffic hundreds of miles away. Controllers thus seek to keep aircraft moving through the sky as safely and efficiently as possible, but rely on pilots to enact their instructions. The role of the human pilot is therefore also of fundamental importance to the production of airspace and must be explored.

Navigating the sky

Flying a commercial aircraft is an inherently spatial act, where the interdependence and interaction between multiple encoded infrastructures, technologies, and practitioners is integral to the production of airspace. Yet, far too often, social scientists have treated aircraft as objects to be observed, their routes plotted and their service frequencies analyzed, while the everyday practices of piloting that produce airspace for thousands of passengers every day have been largely ignored.

As far as many passengers are concerned, catching a flight is relatively straightforward; you book and pay for your ticket, present yourself at the correct airport on the right day in time for your flight with your luggage and identification, check in, clear security, board the appropriate aircraft, and deplane several hours later at your destination. Indeed, some industry trade names, including Air*bus*, *easy*Jet, and the now-defunct Sky*train* (my emphasis), encourage the notion that flying is a routine, everyday activity. However, before the passengers check-in, tens of thousands of electronic transmissions and dozens of pieces of paperwork will have been produced, circulated, and checked to ensure that the right aircraft is at the correct gate at the right airport at the right time, fully serviced, fuelled, and crewed (see

Peters elsewhere in this book). All of these documents, from load sheets and flightplans to weather reports and checklists, combine to produce airspace in a particular way for a particular flight.

While some scholars have begun investigating the complex relationship that exists between the introduction of new forms of technology and the production of certain types of social space (see Graham and Marvin 2001 and Thrift and French 2002), little or no research has been conducted into how commercial airline pilots develop and communicate situated understandings of airspace through the interpretation of flightdeck displays and the routine practice of completing flight-phase related activities. This academic lacuna is due, in part, to strict security protocols that render permission to conduct such research problematic, and because aviation's technical language and unique operating procedures render it an intimidating prospect for study. Whilst understandable, this omission is serious, as many tragic accidents involving commercial aircraft have been attributed to pilots exhibiting poor spatial awareness or misinterpreting or unquestioningly trusting malfunctioning flightdeck instruments (Beaty 1991; Faith 1996). Indeed, it could be argued that rarely is the accurate production and unambiguous interpretation of space, as mediated through increasingly sophisticated electronic avionics software, more critical than on the flightdeck of a commercial airliner. Building on a range of sociological research into the mundane and practical elements of work, social interaction, and technology in complex organisational environments (see Heath *et al* 1999), this section examines the work of flightcrew, who continually interact with complex technology to pilot their aircraft through the sky in accordance with a highly regulated ATC system.

In recent years, geographers have begun to explore the extent to which computer software (or code) is deeply embedded within the infrastructure of contemporary capitalist societies and how it has become central to the spatial formation of everyday life (Dodge and Kitchin 2005, 2005; Graham 2005). In the context of commercial aviation, the sheer number of computer components installed in modern aircraft reveals the extent to which computer code mediates the production of airspace. The Boeing 777 is controlled by over 2.6 million lines of software code (Norris and Wagner 1996), while the new A380 'super jumbo' contains over 350 miles of wiring (Fortson 2007).

Dodge and Kitchin (2004) have suggested that the increasing sophistication of electronic aircraft systems means pilots fly through real space virtually using a plethora of digital instruments and sensors. Drawing inspiration from the work of Castells (1996), they explore how the production of specialist computer code mediates the production of different 'code/spaces' of aviation, from check-in counters, security checkpoints, departure lounges and aircraft cabins, to baggage reclaim belts and retail areas. They posit that the use of computerized systems at every stage of every flight means the practice of travelling by air has become virtualized to the extent that corporeal aeromobilities are totally reliant on the safe, efficient, and routine functioning of a multitude of different networked computer systems, from reservation databases to flight planning software and passenger manifests. For the most part, these systems are taken for granted and dependence on them only exposed when a computer breakdown grounds flights or a malfunctioning baggage system misroutes luggage. According to their thesis, modern aircraft can be considered contemporary 'code/spaces' *par excellence* on account of the number of, and near total reliance on, sophisticated avionics and life-support systems (see Dodge and Kitchin elsewhere in this book).

Given the inherent complexity of aircraft systems, and the need to monitor their performance, modern flightdecks feature a seemingly bewildering array of buttons, dials, levers, lights and electronic displays, all of which convey information about different aspects of the aircraft's operation and performance. These instruments are grouped according to function, and pilots are trained to check them in a particular order and consider a flight as a series of flows of information.

The Primary Flight Displays are situated immediately in front of both pilots and convey all the 'basic' information about the flight, including the aircraft's attitude relative to the horizon, altitude, airspeed, and vertical speed. Neighbouring Navigation Displays present information on the aircraft's track and routing, as well as information from the weather radar and the onboard collision avoidance software. The latter system, TCAS (Traffic Control and Collision Avoidance System), enables pilots to 'see' the position of other air traffic in the vicinity by providing abstract two-dimensional representations of the position and flight characteristics of all aircraft in the surrounding airspace. Working on the same principle as secondary surveillance radar, TCAS identifies and interrogates the transponder of any aircraft in the vicinity to determine whether its proximity (in terms of track, altitude, vertical speed, or heading), poses a collision risk. The system automatically codes each threat and provides a series of visual and aural warnings to help pilots avoid collision.

Given the computer-mediated environment in which they work, the perceptual demands placed on pilots are considerable. They must continually synthesize accurate spatial awareness from a considerable amount of coded raw data, a task that requires training, skill, discipline and judgement in an uncertain and changing environment, together with quick, prudent decision-making based on a knowledge of the aircraft's systems and natural environment, crew capabilities and personal limitations. Pilots must remain 'ahead of the plane' in time and space to anticipate what they are likely to encounter in the short-term and take actions to avoid potential problems. The maintenance of this spatial awareness requires continually monitoring the status, attributes, and dynamics of the flight (including airspeeds, position, altitude, heading, ATC transmissions, TCAS returns, and weather radar), while simultaneously comprehending their meaning and significance and projecting their status into the near future.

While computer code helps produce airspace on the flightdeck, the role of the human pilot remains crucial. As with ATC, experience and discretion are fundamentally important to the safe production of airspace, and pilots proactively negotiate the airspace through which they fly. For example, a pilot 'must not only comprehend that a weather cell – given its position, movement and intensity – is likely to create a hazardous situation within a certain period of time, but s/he must also determine what airspace will be available for route diversions, and ascertain where other potential conflicts may develop' (Endsley *et al* 1998: 2). Thus, even if nominally following the same flightplan, no aircraft uses the sky in the same way, even though safety regulations dictate all manoeuvres fall within the boundaries of acceptable practice. Thus, as Dodge and Kitchin (2004) recognize, the production of airspace on the flightdeck is not universal or technologically determined, but contingent upon the embodied performances and practices of individual pilots, who use their discretion and experience to interact with nominally identical, yet subtly different, systems, equipment, and environments.

So far, this chapter has explored some of the ways in which controllers and pilots mediate the production of airspace above the UK. Significantly, however, the ways in which airspace is used is often dictated, to a greater or lesser extent, by the topographical and socio-economic characteristics of the ground beneath it. The RAF choose to conduct much of their low-level flight training in mid Wales and the Scottish highlands, not only because of the challenging terrain but also because the noise associated with these operations will affect relatively few people. Similarly, at some airports, commercial aircraft may fly sub-optimal departure or arrival routes to avoid overflying densely populated urban areas. The following section explores how communities on the ground have started to challenge how the airspace above them is used.

Contesting the sky

Commercial air travel is becoming an increasingly emotive subject, and the debate surrounding who should benefit, and, perhaps more importantly, who should suffer the impacts of aircraft noise and airport development has had a long pedigree. Given society's current socio-economic reliance on, and apparent 'addiction' to flying, this controversy appears to be intensifying as the relative cost of air travel declines and the number of flights increases. In the UK, passenger numbers have increased five-fold in the last 30 years and forecasts suggest as many as 400-600m passengers a year could be using UK airports by 2030 (DfT 2003).

While air traffic controllers and pilots work to create airspaces that are safe for flight, they are also increasingly aware of their social and environmental responsibilities to reduce noise and emissions as far as possible. While the phenomenon of anti-airport protest is not new, current expansion plans and rising levels of public concern about aviation's contribution to climate change have caused the issue to rise up the political agenda. Some 25 anti-airport expansion groups are currently active in the UK, and range from small local campaigns with limited membership to national pressure groups. Some of the larger organisations, including HACANClearskies (based at Heathrow) and SSE (Stop Stansted Expansion) have been instrumental in producing alternative understandings of airspace that challenge the dominant economic and operational discourses employed by airports, airlines, and other pro-aviation lobbies (see Griggs and Howarth 2004 for a detailed study of the HACANClearskies campaign).

While the majority of campaigns oppose the development of new infrastructure, such as additional runways or new terminals, others are challenging changes to airspace that have resulted in commercial flights flying over their homes and communities for the first time. In 2005, the Dedham Vale Society won a High Court ruling against Stansted Airport and forced them to withdraw new flightpaths that, the group claimed, were ruining the rural tranquillity of 'Constable Country' (Millward and Clover 2006). At East Midlands Airport (EMA), ELVAA (East Leicestershire Villages

Against Airspace) also opposed plans to reorganize the airport's controlled airspace on grounds of noise, rural landscape despoliation, and property devaluation.

In October 2003, EMA submitted an airspace change proposal to the CAA that sought to extend the area of controlled airspace around the airport and reorganize the way air traffic movements were handled. The plans involved amending existing approach and departure procedures, and re-siting the two holding areas or stacks to increase capacity and improve safety. While the plans were predicted to lessen the acoustic impact of aircraft operations on settlements in west Leicestershire and southern Derbyshire, a number of residents in east Leicestershire, who found themselves under the re-routed flightpaths, mobilized against the plans, believing they would cause unacceptable levels of noise pollution in a predominately rural part of the county (Staples 2004).

Following a public meeting in January 2004, a group of local residents formed ELVAA to raise awareness of the airspace change, stimulate public opposition, and act as a focal point of resistance. Significantly, ELVAA disputed the airport's claim that far fewer people would be subject to aircraft noise, and claimed over 100,000 new people would be affected (Edwards and Farmer 2004). It also commissioned its own independent reports and noise surveys to challenge the claims put forward by the airport authorities. ELVAA quickly 'learned the language' of airport protest, and supporters lobbied local MPs, wrote letters of objection, and inundated the local media with their concerns. Anti-flightpath posters and messages of defiance also appeared on telegraph poles, hedgerows, and village notice boards to try to raise awareness of (and galvanise support for) the campaign (Figure 5).

FIGURE 5 ABOUT HERE (ELVAA posters)

ELVAA's campaign was initially articulated in typical 'not-in-my-back-yard', or 'NIMBY', language, with spokespeople citing the loss of rural tranquillity and detrimental effects on quality of life that would result from the skies over east Leicestershire being turned into a '24 hour motorway for planes' (cited in the Oadby and Wigston Mail 2004). In January 2005, with the airspace reorganisation likely to go ahead, the group refocused their attention on trying to get the airport 'designated' under Section 78 of the 1982 Civil Aviation Act, which would place a cap on the number of night flights allowed at the airport, already the site of one of the UK's largest night-flying operations. Supporters of 'DEMAND' (Demand East Midlands Airport is Now Designated) as the group was subsequently renamed, argued nighttime freight flights disturbed their sleep and breached their 'right' to peace and quiet.

In May 2005, the airspace change was implemented and the new flightpaths undoubtedly changed the acoustic environment of east Leicestershire. The emotional upset this caused for some individuals helped create a territorial identity for ELVAA and DEMAND, where acceptance into the group was determined by the ability to hear aircraft noise and a willingness to protest against the perceived injustices of authority. While the majority of objections and complaints ostensibly employed the familiar rhetoric of rural landscape despoliation and feelings of being 'overwhelmed' by noise, others implied they did not understand why the airspace reconfiguration was considered necessary. Some suggested aircraft could be routed over East Anglia but, owing to the number of military air traffic zones and other areas of intense aerial activity over the region and the fact the majority of aircraft fly on a north-south trajectory, this suggestion was impractical. Though EMA remains, at present, undesignated, supporters of designation used their lived experience of the airspace change to produce alternative notions of airspace that are largely incompatible with those of the airport.

Conclusion

UK airspace is a product of numerous interlocking geopolitical, economic, environmental, social, technical, and commercial practices that operate at a variety of spatial scales and manifest themselves in different ways in different places though time. As a consequence, the existing airspace structure is a compromise, designed to ensure all users, from the Royal Air Force, to commercial airlines, air ambulances, and private pilots, can access it, albeit it in ways that are often restricted. While access to, and use of, sovereign airspace is controlled by the state, individual citizens are relatively powerless to dictate how the airspace above their personal property is used. Evidence of anti-airspace protest at EMA, Stansted, and elsewhere in the UK, suggests that many individuals are becoming increasingly intolerant of aircraft noise and disturbance.

This chapter has illustrated that airspace is simultaneously produced 'from above' by controllers and pilots and challenged by people 'on the ground' who oppose its use. It has suggested that airspace must be conceptualised not as a 'tunnel' of mobility in the sky, but as an important social space in its own right, mediated by numerous different users and agencies and imbued with meanings, values, and significance that we are only beginning to understand. As the controversy surrounding the growth of air travel intensifies, debates about the 'acceptable' use of airspace will become more common as new flightpaths are introduced to handle growing numbers of aircraft. While the technology exists to make the existing airspace structure more efficient by eliminating circuitous routes and enabling aircraft to fly a direct line from A to B, it is questionable whether the political will (and the finance) to enact such changes exist. Until they do, we must devise new ways of safely accommodating growing volumes of air traffic in an airspace system designed in the previous century. As one controller pertinently remarked, 'controlling planes is easy – pilots generally do what they're told. It's making space in the sky for them that's difficult.'[5]

References

Balfour, J. (1994) The changing role of regulation in European air transport liberalization, *Journal of Air Transport Management* 1(1): 27-36.

Beaty, D. (1991) *The Naked Pilot The Human Factor in Aircraft Accidents,* London: Methuen.

Brittin, B. H. and Watson, L. B. (1972) *International Law for Seagoing Officers,* 3rd edn, Annapolis Maryland: Naval Institute Press.

Burney, C. D. (1929) *The World, the Air, and the Future,* London: George Allen and Unwin Ltd.

CAA (2007) *Civil Aviation Authority airspace infringement statistics,* Online. Available HTTP: <www.flyontrack.co.uk> (accessed 20 July 2007).

Calder, S. (2002) *No Frills: The Truth Behind the Low-Cost Revolution in the Skies,* London: Virgin Books.

Castells, M. (1996) *The Rise of the Network Society: The Information Age: Economy, Society, and Culture Volume 1,* Oxford: Blackwell.

Dargon, J. (1919) *The Future of Aviation:* trans P Nutt London: David Nutt.

Department for Transport (2003) *The Future of Air Transport,* White Paper Crn6046 December 2003 London: HMSO.

Dodge, M. and Kitchin, R. (2004) Flying through code/space: the real virtuality of air travel, *Environment and Planning A* 36: 195-211.

Dodge, M. and Kitchin, R. (2005) Code and the Transduction of Space, *Annals of the Association of American Geographers* 95(1): 162-180.

Duke, G. (2005) *Air Traffic Control* 9th edn, Hersham: Ian Allan.

Edwards, K. and Farmer, B. (2004) 100,000 people live beneath flight paths, *Leicester Mercury* 31 July 2004: 6-7.

Endsley, M. R., Farley, T. C., Jones, W. M., Midkiff, A. H., and Hansman, R. J. (1998) *Situation Awareness Information Requirements for Commercial Airline Pilots,* International Centre for Air Transportation, Cambridge, MA: MIT Press.

Faith, N. (1996) *Black Box Why Air Safety is No Accident,* London: Boxtree Macmillan.

Finch, R. (1938) *The World's Airways,* London: University of London Press.

Fortson, D. (2007) Going like a dream, *The Independent on Sunday Business* 22 April 2007: 6-7.

Graham, S. (2005) Software-Sorted Geographies, *Progress in Human Geography* 29(5): 562-580.

Graham, S. and Marvin, S. (2001) *Splintering urbanism Networked infrastructures, technological mobilities and the urban condition,* London: Routledge.

Griggs, S. and Howarth, D. (2004) A transformative political campaign? The new rhetoric of protest against airport expansion in the UK, *Journal of Political Ideologies,* 9 (2): 181-201.

Heath, C., Hindmarsh, J., and Luff, P. (1999) Interaction in Isolation: The Dislocated World of the London Underground train driver, *Sociology* 33(3): 555-575.

Jones, P. (2005) 'Send Three and Fourpence', *focus on commercial aviation safety* United Kingdom Flight Safety Committee (UKFSC) Autumn 61: 5-7.

Lawton, T. (2002) *Cleared for Take-off Structure and Strategy in the Low Fare Airline Business,* Aldershot: Ashgate.

Millichap, R. J. (2000) *Airline Markets and Regulation,* in P Jarrett (Ed.) *Modern Air Transport Worldwide Air Transport from 1945 to the Present,* London: Putnam Aeronautical Books: 35-52.

Millward, D. and Clover, C. (2006) Constable country sees off intruders into its airspace, *The Daily Telegraph* 2 January 2006, Online. Available HTTP: <http://www.telegraph.co.uk/news> (accessed 13 January 2006).

National Air Traffic Services Ltd. (2005) *The Start of Commercial Aviation, 1919-1929,* Online. Available HTTP: <www.nats.co.uk/library/history2.html> (accessed 10 October 2005).

Norris, G. and Wagner, M. (1996) *Boeing 777,* Osceola, Wisconsin: Motorbooks International.

Oadby and Wigston Mail (2004) *Flight Fight* 17 June 2004: 4.

Petzinger, T. (1995) *Hard Landing How the Epic Contest for Power and Profits Plunged the Airlines into Chaos,* London: Aurum.

Staples, S. (2004) A rude awakening for peaceful corner of the countryside, *Leicester Mercury,* 4 August 2004.

Thrift, N. and French, S. (2002) The automatic production of space, *Transactions of the Institute of British Geographers,* NS 27(3): 309-335.

Veale, S. E. (1945) *To-morrow's Airliners, Airways and Airports,* London: Pilot Press.

Notes

[1] Source: Personal communication, Air Traffic Controller, Swanwick. Anonymous by request.
[2] Source: Personal communication, Airspace Planner, Swanwick. Anonymous by request.
[3] See Duke (2005) for a detailed description of the different Classes of airspace.
[4] Source: Personal communication, Air Traffic Controller, EMA. Anonymous by request.
[5] Source: Personal communication, Air Traffic Controller, EMA. Anonymous by request.

Acknowledgements: I would like to thank Martin Weir at bmi for his assistance and Iain Millan and Brian King at Navtech/European Aeronautical Group for permission to reproduce the airspace charts.