AECOM Imagine it. Delivered.

THERE'S MORE TO US THAN YOU MIGHT THINK

THE AVIATION EDITION

aecom.com

FOREWORD

Airports and connecting transportation networks are vital to the continued growth and economic prosperity of cities, regions and countries.

With demand for air travel set to double over the coming two decades, airports around the world need to modernise and expand to be ready.

The coming 10 years will be a pivotal time for civil infrastructure, including aviation, driven by disruptive technologies. In AECOM's 2019 Future of Infrastructure report passengers stated that having faster connections to airports is an increasingly important factor to their quality of life.

Today, the aviation industry faces some tough challenges. Infrastructure is not being built fast enough and, as demand grows, the lack of supply is causing problems.

AECOM is a global provider of technical services to airport owners, investors, airlines and aviation clients — leading and supporting programmes for airports of all sizes and forms.

Building on our global network of expertise and local knowledge, AECOM's multidisciplinary, skilled professionals are experienced in delivering integrated, collaborative aviation solutions across projects and continents, from finance and analysis to masterplanning, programme management, design and construction services.

By combining our unrivalled expertise and reach, we are built to support the world's most complex aviation programmes. Read on to learn more about some of our headline projects.

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WE'RE DIFFERENT

We're a 90,000-strong global team, with over 1,000 aviation professionals, with skills across the entire aviation lifecycle. We're able to offer an unrivalled interconnected set of global skills and expertise, and are equipped to deliver a wide range of aviation services. This includes specialised support to create the innovative solutions required to tackle present and future challenges.

Single team
To leverage the expertise and reach of a single global aviation team, we recently brought together our aviation specialists from around the world into one combined group. This enables us to select the best people for the job from a pool of industry experts. Whether a project calls for waste management and materials reuse, pavement design or strategic masterplanning, our agile team of global aviation professionals can quickly mobilise to pool their collective industry intelligence, boosting creativity, coordination and productivity.

Respond to complex problems
We are ready to respond at pace to complex programmes, bringing our wide-ranging, highly specialist and often unique capabilities to provide progressive and sustainable solutions from the project lifecycle.

THERE'S MORE TO US THAN YOU MIGHT THINK

Some of our specialist aviation services include:

- Masterplanning and design
- Policy planning: Development Consent Order
- Cost management
- Business case development
- Digital engineering
- Environmental and waste management
- Surface access
- Aviation fuel
- Airfield and civil engineering
- Civil / asset inspection works
- PFAS
- Pavements
- Airfield ground lighting
- Process and automation
- Acoustics
- Baggage handling
- Modern construction techniques
- Construction and programme management
- Connected and autonomous vehicles
- Sustainability and resilience
- ORAT

WHAT DO WE DO?

Our extensive range of expertise means we are able to support any project every step of the way.

We offer a vast menu of services from programme and project management, airside and landside masterplanning, demolition services, freight and servicing strategies through to energy conservation programmes, cybersecurity and resilience programmes, modular construction and road safety and pedestrian reviews, and automated inline baggage screening.

Our pavement engineering team is one of the largest in the world, providing services for airports around the globe. Our technical specialists offer pavement structural design, value engineering, materials innovation, research, sustainability and asset management to airport clients.

OUR INTEGRATED OFFER

Our philosophy in aviation is to deliver innovative solutions to complex challenges, whatever the size or scope, while also maintaining our world-class safety record. Drawing on our integrated offer, we design, build, finance and operate, and ensure business continuity.

Our integrated offer reflects who we are today: it is at the heart of what we do. Where required, we can provide a seamless service from designing and building to financing and operating, delivering all four together to minimise risk and speed up delivery or offering individual and bespoke services. Our aim is to provide creative solutions that are effective, efficient, economical and environmentally sustainable.

MASTERPLANNING AND DESIGN

SUSTAINABLE PLACES FOR PEOPLE

We focus on the complex interaction between aircraft, passengers and environment to prepare masterplans that cater for future growth flexibly and deliver on the client's business, operational and commercial plans.

AECOM recognises that the masterplan is not an academic exercise in engineering. It is a living document 'born' from the business plan that it supports, presenting a coherent set of agreed principles, by which future development will be brought forward, within an accepted and rational business environment. Prior to considering a masterplan, therefore, we believe it is essential to understand the business drivers.

We are used to working closely with the many organisations involved in planning an airport: regulators, government bodies and border authorities, airport operators, aviation agencies, airlines, contractors and investors.

Architecture
Multidisciplinary design
Site selection and evaluation
Airspace analysis
Land-use planning
Masterplanning
Capacity analysis
Airfield simulation
Airfield design
Passenger terminal simulation
Functional design of passenger and cargo terminals
Landside simulation
Surface access design
Design of support systems
Investment planning
Planning application advice
Environmental impact assessment
Economic impact assessment

CASE STUDY

FCO

ROME-FIUMICINO INTERNATIONAL AIRPORT

Rome, Italy

We were commissioned to develop a masterplan for the North Terminal at Fiumicino Airport. The masterplan project focused on addressing Fiumicino Airport's immediate capacity constraints as well as developing a long-term strategic vision for the airport's future development — with an ambition to increase annual passenger-handling capacity from 35 million to over 100 million in 2044. The recommended solution included the creation of a new terminal and associated infrastructure.

Building on this, in 2015, AECOM, together with GMW Mimarlik architects, conducted a feasibility study for Aeroporti di Roma (AdR). The study included: a terminal planning exercise and assessment of the access roads, curbside, Ground Transportation Centre (GTC), rail/metro/APM terminal interface, and apron requirements. We also established a capex programme according to the AdR regulatory framework agreement, and produced a comprehensive set of tendering documents to manage the tender process, in line with EU and Italian competitive tender rules.

Rome-Fiumicino International Airport

CASE STUDY

HKG

HONG KONG AIRPORT

Hong Kong

AECOM was appointed as the lead Consultant for HKG's masterplan study, providing a comprehensive assessment of the airport's operational requirements up to 2030 and beyond.Our masterplan was based on adding a third parallel runway and a 50-gate, wide-bodied remote satellite concourse, situated on a 650 hectare reclamation to the north of the existing airport island.

AECOM conducted a detailed analysis of the terminal area to assess how to covert the existing T2 departures terminal into a full 50 million passenger departures and arrivals terminal. Past master planning had only considered a duel parallel runway configuration. The scope of work comprised:

- A review of primary air traffic forecasts
- Development of busy-hour forecasts
- Capacity assessment of existing facilities and infrastructure, future facility demand requirements, runway and taxiway requirements, and terminal development options
- A landside traffic impact assessment
- Airport city and commercial development planning
- Passenger and cargo stand development strategies
- Cargo, Air Traffic Control and other facilities
- Production of multiple airport layout configuration options, and
- Assessment and evaluation of a preferred masterplan layout.

Our work at HKIA continues with, T2 Design, TRC Design, ITT Design, Airside Vehicular tunnels design APM Depot Design, BIM Consultancy.

CASE STUDY

KWI

KUWAIT INTERNATIONAL AIRPORT, SUPPORT TERMINAL/T4

Kuwait City, Kuwait

The Directorate General of Civil Aviation (DGCA) commissioned a separate support passenger terminal building, Terminal 4 (T4), to generate an additional handling capacity of 4.5 million passengers per year and support the current Terminal Building, Terminal 1 (T1). T4's systems are currently operating and fully integrated with the rest of the airport's facilities.

We provided full detailed design services for the development, beginning with a value engineering study to assess the optimum size of the terminal facility and the preparation of a strategic brief incorporating all of the stakeholder requirements, including operators' input and buildability issues, as well as assisting CENGIZ during the construction process. The study concluded with a set of employer's requirements that formed the approved concept design for the whole development, as well as meeting the minimum technical requirements of the main contract between Cengiz Insaat and the Kuwait Airport Authority.

The scope of the project works includes: a terminal building (approx. 55,000 m²); a new passenger car park with 650 slots; a connecting pedestrian bridge from the existing car park to the terminal building (approx. 2,400 m²); a satellite building (approx. 1,400 m²); all associated access roads, landscape, and utilities with ancillary buildings; a line maintenance building;, a bus operating centre; and cabin maintenance (around 2,400 m²).

Terminal 4 was opened on August 2018 for all Kuwait Airways operations. In addition, in the future, it will be possible for other airlines to be accommodated in this building to provide an effective link between T4, T1 and the future Terminal 2.

CASE STUDY

IST

ISTANBUL AIRPORT, AIR TRAFFIC CONTROL TOWER

Istanbul, Turkey

Our winning submission for Istanbul Airport's Air Traffic Control (ATC) tower saw us partnering with Pininfarina — the design house renowned for its car designs for Ferrari and Alfa Romeo, among others.

This collaboration combines the expertise of AECOM's architectural and engineering teams with Pininfarina's distinctive architectural style that, influenced by automotive design, epitomises speed and movement.

The ATC tower will stand as a landmark for Istanbul Airport, which is set to be the world's largest new airport in terms of annual passenger capacity. The competition's scope was to deliver concept designs for the tower that showcased contemporary sustainable architectural design and reflected the history and multicultural character of Istanbul city.

The AECOM and Pininfarina design evokes the aerodynamic forms used in automotive and aviation design, and includes an elliptical tower that will be visible to all passengers flying in and out of the new airport. The tower shape is inspired by the tulip, which has been the symbol of Istanbul for many centuries and is an important cultural reference in Turkish history.

CASE STUDY

LIM

JORGE CHÁVEZ INTERNATIONAL AIRPORT, NEW TERMINAL

Lima, Peru

Working with the preferred consortium, AECOM is providing technical design support for the design and build of the new midfield terminal, apron and associated works at Lima Airport.

Our services include apron planning. This involves an assessment of the number of stands needed to satisfy the requirements in the main request for proposal and a Simmod Simulation to provide a real-time visualisation of aircraft movements from on/off airfield to arrival/departure on stand as well as an illustration of the possible constraints or delays and graphs/ tables of movements on each element of the airfield at different times of day.

Istanbul Airport

POLICY PLANNING: DEVELOPMENT CONSENT ORDER

PLANNING FOR PEOPLE AND PLACES

Our planning and consents team delivers documents that guide policy, strategy and site configuration. We are experienced in working with government, local authorities, infrastructure owners and developers to advise on local and national policies. Our work on policy has extended to gain Development Consent Order (DCO) approval on Thames Tideway, the largest DCO in UK history.

Specialist assessments
Viability assessments
Sustainability appraisals
Preparation of documentation
Stakeholder engagement
Community consultations
Support as an expert witness

CROSS-SECTOR SPOTLIGHT

DEVELOPMENT CONSENT ORDER FOR THAMES TIDEWAY TUNNEL

London, UK

We have been involved with the Thames Tideway Tunnel scheme since 2005. Alongside other consultants, our work involved securing planning approval for this complex tunnel. A central challenge for the programme — which required linear infrastructure to be incorporated within a dense built environment running underneath many of London's iconic landmarks — was that the entire project had to be implemented for the sewer to function. As a result, the consents could not be secured in stages, and the team gained approval for the DCO without any extensions. This was a major accomplishment for a programme of this scale and scope.

To do so, the team ensured that the correct governance processes and procedures were in place to facilitate rapid responses such as identifying budget holders equipped to make effective decisions often at short notice, and also planned for zero extensions. All of the deadlines were met on time.

In addition, delivering a comprehensive consultation process was essential. The 2008 Act provisions mean that a judicial review is only possible at the end of the process. People can, therefore, store up potential challenges across a number of years. The team regularly engaged with multiple local authorities and communities — providing evidence every step of the way that they were listening and responding to the feedback they received. This meant that, at the end of the DCO, there was no successful judicial review.

Further to our planning team obtaining the DCO, AECOM is also the lead design consultant for the contractor working on the central section of the new sewer. This is the largest of the three tunnel sections, spanning 12.6 km.

Largest DCO
in UK history
—
25km
Tunneling
—
7m
Diameter
—
Judicial review
Not successful
—
Extension
No extension to the DCO sought

COST MANAGEMENT

DESIGN TO BUDGET

Our cost management services provide specialised expertise across project lifecycles to reduce client risk and improve value.

We align ourselves around client sectors to provide industry-relevant advice and specialised expertise. Our integrated approach creates bespoke client teams that bring together technical delivery experts, strategists and other in-house specialists. We work together to achieve viable developments that realise client objectives through value-driven and efficient designs. Costs are controlled through rigorous change-management and risk-management processes and reporting.

We have access to unprecedented cost data on projects across a diverse range of contexts and sectors. Based on that intelligence and analysis, we have generated industry-leading, global benchmarking data sets. This means that, along with our extensive experience and specialist knowledge of end markets and building types, we can provide more accurate advice on the cost implications of client requirements.

Cost modelling and cost planning
Benchmarking
Value and risk analysis
Lifecycle costing
Procurement
Post-contract cost management and final account settlement
Cost intelligence

Amsterdam Schiphol Airport

CASE STUDY

AMS

AMSTERDAM SCHIPHOL AIRPORT, NEW PIER

Amsterdam, Netherlands

We were commissioned to manage all of the cost control and budgeting for a new pier development at Schiphol Airport, Amsterdam. As part of a multidisciplinary design team, our cost managers have worked closely with the designers, stakeholders and client team to influence and deliver a 'design to budget' approach. The stringent budget requirements for the project, set within a wider significant capital programme, were outlined at the outset of the project and our team worked to deliver the complex operational requirements of the facility, while adhering closely to them.

We have utilised a tried-and-tested methodology to proactively drive the budgeting and control, and management. We used project benchmarking and historic 'as built' cost data to determine how the budget related to our previous experience in the aviation sector, This includes taking into account specific details for the project, such as substructure and frame solutions, aspirations for envelope treatment, the desired finishes palette and the specialist systems that need to be incorporated.

To maximise our expertise and experience, we use Global Unite, AECOM's unique global cost database, which contains information from approximately 15,000 projects to benchmark a project, interrogate cost and performance criteria and review cost trends across geographies and specific workstreams, including aviation. Working with clients, this enables us to compare their project against industry best practice, identify key cost drivers and establish an auditable process to identify meaningful conclusions about how the project should be developed.

CASE STUDY

SIN

SINGAPORE CHANGI AIRPORT

Singapore

Singapore's Changi Airport Group is proposing to build one of the world's largest terminals, with a ground-breaking Terminal 5 complex. In addition to a terminal and concourse building equipped to facilitate 54 million passengers per annum, a significant amount of airfield development works will be required. This includes additional runway enhancement works and the construction of a new cargo complex to the north of the site.

We are providing cost estimating services for the early functional-planning stage of the project. Our work involves advising on cash flow and the implications of the overall programme of works.

We produced a comprehensive project budget and developed a work breakdown structure for the whole of the project, which enabled Changi Airport Group to make submissions to their funding parties for the initial drawdown of project expenditure. In addition to the overall detailed cost plan for the project, we have assisted the client with procurement advice, detailed quarterly cash flows and benchmarking to support the levels of expenditure being proposed.

SOLUTION

GLOBAL UNITE

Worldwide

Using the wealth of untapped data we generate worldwide to bring unique value to projects, Global Unite is AECOM's cost planning, cost control and benchmarking tool that gives our clients unparalleled access to quality global and local knowledge. The tool collects and shares project performance data from our daily quantity surveying and cost consultancy work across the whole of AECOM.

Taking knowledge from our cost planning and measurement systems, Global Unite applies data mapping rules to manage differences in geographic definitions. By creating a direct comparison of a project with global data, we can show our clients what is best practice and how their project compares.

CASE STUDY

DWO

AL MAKTOUM INTERNATIONAL AIRPORT

Dubai, UAE

The Al Maktoum International Airport site in Jebel Ali comprises four additional runways, two terminals and four concourses that will support up to 220 million passengers per annum in a two-phase delivery strategy.

We have been working on the project since early 2014, from the masterplan to the functional planning and concept design stages of the project. Our services, so far, have involved: developing the masterplan; providing quantity surveying services across the programme of works; defining the budget for the project; supplying full pre-contract cost management services, securing the necessary approvals from Dubai's leaders; and devising the roadmap for maintaining the project's budget parameters through the recently completed concept design stage of the programme.

As part of our support across the project, we have provided cost and spatial benchmarking advice, procurement strategy guidance, also covering build operate transfer/design build finance maintain operate/bill of quantities preparation for early advance works and enabling works packages, sustainability option analysis, lifecycle costing, risk and value management, and tender documentation preparation.

CASE STUDY

LTN

LONDON LUTON AIRPORT

London, UK

Supporting London Luton Airport's FutureLuToN DCO masterplan to increase the capacity of the airport from 16 to 38 million passengers per annum, we're delivering CAPEX cost estimates for various airfield design elements. The cost estimates will support the business and financial cases for the project and statutory consultation, as well as the overarching Development Consent Order (DCO) submission.

Collaborating with AECOM's design team on the project to obtain quantities from sufficiently developed design elements using either 2D drawings or 3D models, our cost management team are carrying out CAPEX estimates for a fuel farm, fire station, ancillary buildings, airfield layout, utilities corridors and infrastructure, and security and fencing.

SOLUTION

INFRASTRUCTURE COST INTELLIGENCE — IMPROVING INVESTMENT DECISION MAKING

Worldwide

Cost intelligence is the digital transformation of cost management practices to improve investment decision making. Supporting and improving cost management at all project lifecycle stages, AECOM's infrastructure cost intelligence team help facilitate the combination of cost data, estimating knowledge and technical expertise, delivering value by developing approaches to cost estimation that identify the whole life cost of assets. We work with our infrastructure clients to create a wider approach beyond commercial and financial assurance to unlock further savings and reduce risk.

Our solutions range from cost modelling, digital transformation, regulatory support, and inflation and market support. Understanding of the market is essential for airports as they tend to have a higher cost of construction than comparable market construction rates in the same locality. We help airport owners and operators gain a more accurate prediction of tender return prices by taking account of the additional costs that can occur. This market knowledge then enables the optimisation of projects before the tender process begins, and can increase the efficiencies in project delivery from inception to completion.

CASE STUDY

DUB

DUBLIN AIRPORT, MASTERPLAN COST ESTIMATE

Dublin, Ireland

Helping inform the Dublin Airport masterplan, our cost intelligence team developed a schedule of rates to address the capital investment costs of new developments at the airport, covering rates for approximately 60 commonly used assets and building types. The schedule of rates was developed using costs and quotations from previous Dublin Airport projects, global benchmark data from aviation and civil engineering projects, build-up from first principles, and in-house collated and analysed rates from the AECOM cost research department.

BUSINESS CASE DEVELOPMENT

SUPPORTING ECONOMIC DEVELOPMENT

The business case model provides confidence that the funding proposal is worth pursuing. We have experience in the development of business cases for the aviation sector, as well as the highways, rail, infrastructure, water, manufacturing and digital sectors.

Using our expertise across all aspects of the business case process from the assessment of value for money, to scheme costing and affordability, deliverability and feasibility, we help our clients progress funding proposals efficiently through the decision making process. Our experience includes providing independent evidence to clients for submission to the UK Airports Commission, an independent commission established to consider how the UK can improve the use of existing runway capacity to meet future demand.

Delivering at all stages of the decision making framework, we take funding proposals forward from the initial sifting and optioneering stage, through to determining the way forward as part of the Government's preferred approach for major investment decisions. We recognise the importance of proportionality within the process, noting that in some instances, smaller or straightforward investments may require fewer phases, creating time and resource efficiencies by providing solutions tailored to individual project needs. Our ability to provide wider services including engineering, construction and technical support enables us to offer an integrated and holistic approach to scheme development, alongside the business case production for our clients.

Strategic evidence-based assessments

Qualitative and quantitative assessments

Cost benefit analysis — value for money, gross value added, and net present value

Assessment of wider impacts

External cost estimates

Cost modelling

Review of procurement routes and contractual mechanisms

Risk management workshops

End-to-end monitoring an evaluation advice

CASE STUDY

GLA

GLASGOW AIRPORT ACCESS PROJECT

Glasgow, UK

We successfully developed the outline business case (OBC) for the £144 million Glasgow Airport Access Project — the flagship project for the £1.13 billion Glasgow City Region City Deal. This followed our involvement in preparing the initial transport appraisal — in line with Scottish Transport appraisal guidance. Transport modelling was employed to assess demand and revenue impacts. In December 2016, the Glasgow City Region Cabinet approved the OBC for further development to a full business case.

CROSS-SECTOR SPOTLIGHT

CROSSRAIL 2

London, UK

Supporting the Crossrail 2 scheme, we provided extensive land use, economic and development impact and urban design assessment analysis for Transport for London (TfL). Impacts were assessed across 170 different geographies (2,700 sites sifted) and development effects analysed for more than 740 sites across London and the South East using two multi-criteria planning scenarios to reflect future policy evolution.

We also produced five different masterplans covering development potential around eight Crossrail 2 stations inside and outside London. Our team were recognised for supporting Crossrail 2 by winning the Institute of Economic Development (IED) 2018 award for the project with the greatest economic impact.

DIGITAL ENGINEERING

A SINGLE SOURCE OF TRUTH

Recent advances in technology have brought new ways to optimise project delivery, increase productivity and create efficiencies throughout the design and construction process. By rethinking the way we use digital technologies — improving how we use today's tools and establishing radical new solutions — we are transforming project delivery and unlocking the full power of our integrated offer.

Through the development of integrated, consistent processes and workflows, digital engineering generates greater opportunity for efficiency and informed decision making.

A critical element to successfully implementing digital engineering solutions is the creation of a common data environment (CDE) that aligns digital information systems and related datasets, such as CAD, GIS, BIM, electronic documentation, project controls (time, cost, risk and scope) and asset information. Building on the foundation of construction 'single source of truth' models, we can maintain the end-to-end, whole-asset library to capture every detail of an asset from design, build, commission, maintain and rebuild through to decommission.

BIM strategy services
Model authoring and management
Information management
Digital asset management
Digital estate solutions

CASE STUDY

DEN

DENVER INTERNATIONAL AIRPORT, BIM+GIS

Colorado, US

We provide quality assurance (QA) services for BIM implementation on multiple programs at Denver International Airport. We are currently providing full-time, on-site QA for the major capital improvement programme, comprising the hotel and transit centre, as well as all landside and airside civil infrastructure projects.

During the past five years, we have provided BIM services on eight runway and apron improvement projects.

The primary goal of our BIM model was to ensure accessibility for all design partners and stakeholders. With such a large site and complex central model, the site plans and models were distributed on tablet devices to limit paper plans and store new content centrally. The airport's BIM-based asset management solution is available to view on mobile devices. QR codes can be scanned to find out more information on a particular asset, and BIM has become the primary tool set for new and ongoing projects at DEN. The model will be used for maintaining the critical assets and mechanical, electrical, plumbing and security systems that run the airport. The process is about creating a detailed intelligent model that informs all ongoing actions, and not on creating visualisations. While this major expansion illustrated the full scope of a BIM project with transition to operations, DEN has also been using this approach to capture information in other parts of the airport on smaller projects.

Although currently there isn't a highly detailed as-built model for the whole facility, the airport does have an overall skeletal model – which can been expanded with details from each project as they become available.

One key benefit is the capability to do detailed feasibility studies using the model. It is possible to quickly design and scope a new element, based on a detailed model of what is currently there. If the project is approved, then the early conceptual feasibility work helps to jumpstart the design. Having the model to do the study eliminates the need to survey and measure and capture what's there. Being able to avoid lengthy and expensive consultant time on feasibility studies adds up to big savings long term. In addition, while harder to quantify, the time saved and safety gains achieved through not having workers walking across an active job site are also positive factors.

Denver International Airport

CROSS-SECTOR SPOTLIGHT

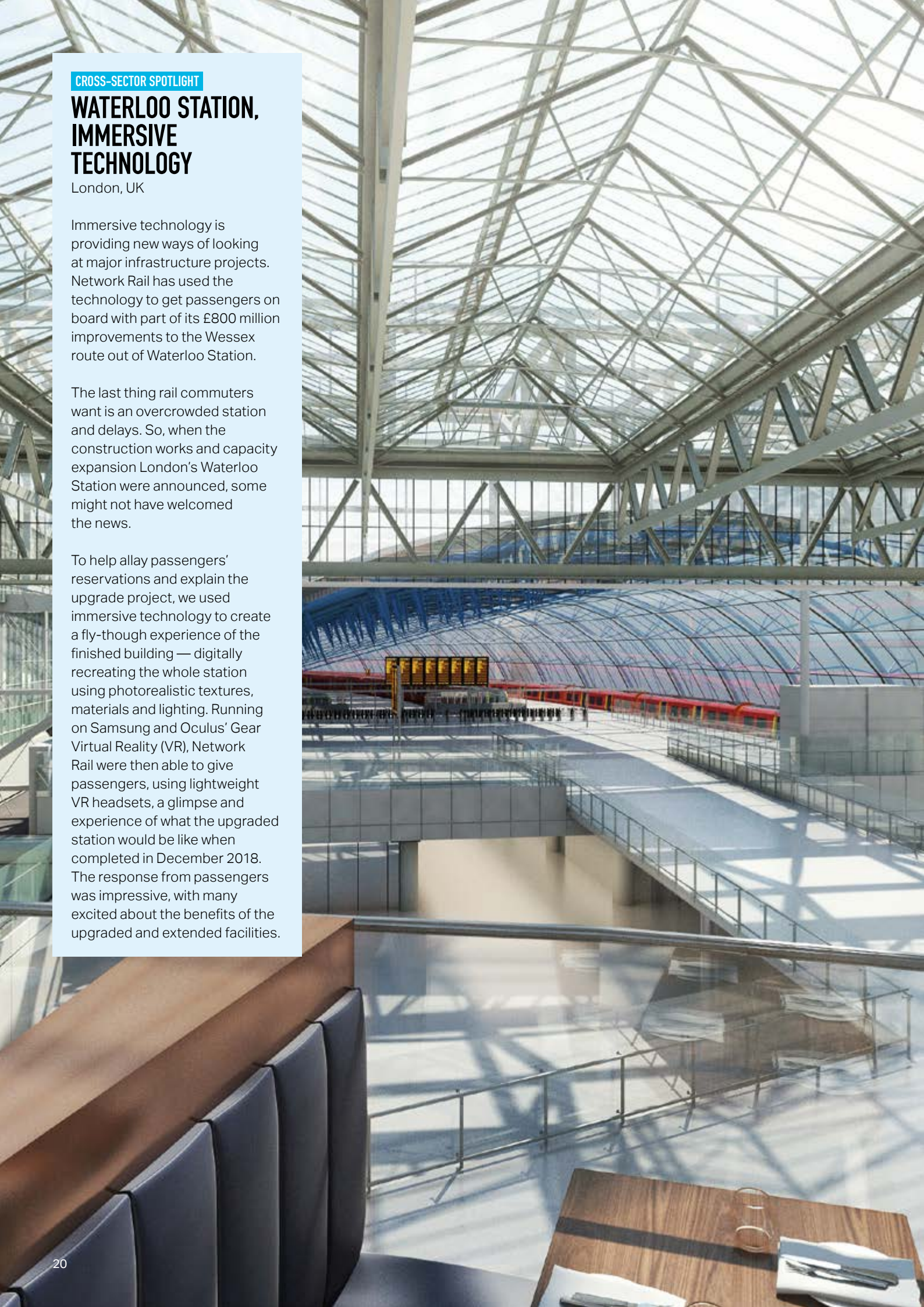
WATERLOO STATION, IMMERSIVE TECHNOLOGY

London, UK

Immersive technology is providing new ways of looking at major infrastructure projects. Network Rail has used the technology to get passengers on board with part of its £800 million improvements to the Wessex route out of Waterloo Station.

The last thing rail commuters want is an overcrowded station and delays. So, when the construction works and capacity expansion London's Waterloo Station were announced, some might not have welcomed the news.

To help allay passengers' reservations and explain the upgrade project, we used immersive technology to create a fly-though experience of the finished building — digitally recreating the whole station using photorealistic textures, materials and lighting. Running on Samsung and Oculus' Gear Virtual Reality (VR), Network Rail were then able to give passengers, using lightweight VR headsets, a glimpse and experience of what the upgraded station would be like when completed in December 2018. The response from passengers was impressive, with many excited about the benefits of the upgraded and extended facilities.



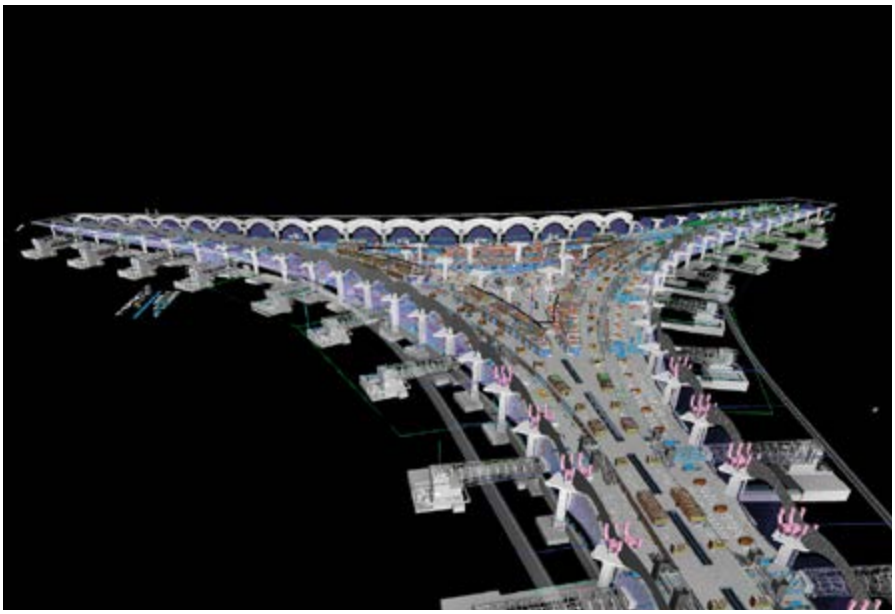
CASE STUDY

KIA

KUWAIT INTERNATIONAL AIRPORT, TERMINAL 2

Kuwait City, Kuwait

The operator of Kuwait International Airport (KIA) commissioned a new terminal building to increase capacity and establish Kuwait as a new regional air hub in the Gulf. The scope of works included architecture, multidisciplinary design coordination and BIM management for the Terminal, which is a 750,000m² project based on a Norman Foster and Partners' design. The new terminal is 3,300,000m² and will be delivered within six years. Our team created the project's BIM standards and ongoing BIM strategy, and developed specific quality assurance quality control BIM tools under Dynamo, Python and Revit API. The team managed a complex and large model for 3D coordination, construction sequence (4D), quantification (5D) and lifecycle management (6D). To support stakeholder engagement, we've used immersive technology to create a virtual reality experience of the model.



CASE STUDY

BWI

BALTIMORE/WASHINGTON INTERNATIONAL AIRPORT, CONNECTOR AND SECURITY CHECKPOINT

Maryland, US

We are the prime consultant in a multidisciplinary team, comprising three other organisations (Apple Designs Inc., Arora Engineers Ltd and Shah Associates), working on the multiphased, multitask terminal expansion programme at Baltimore-Washington International Airport (BWI). Working in an operational airport environment, we are directly responsible for project management, architectural design and engineering services. The project required an accelerated design schedule, with multiple design packages to be completed within 12 months.

The primary goal of this programme is to connect concourses D and E, boosting international passenger growth and providing a seamless passenger experience at the airport.

To meet the client's (Maryland Aviation Administration) expedited schedule, the project team established processes to ensure efficient and consistent communication and collaboration across the multidisciplinary team. AECOM's use of a robust building information model (AutoCAD Revit) was combined with weekly in-house design progress meetings and scrum sessions to secure results.

We secured consensus among the many project stakeholders for a unified vision for this programme under schedule constraints, as the airport stated they wanted gates operational by early 2017. The AECOM team utilised LIDAR survey technology to document the extensive existing condition interfaces and BIM modelling to develop the project in 3D to solicit stakeholder input and promote rigorous coordination across the different disciplines.

The project manager continually kept the project team abreast of issues and decisions made at the client design meetings via the weekly scrum sessions and internal design working meetings. A 'Design Issues Action List' was continually updated and distributed to the project team for action. It also served as the basis for weekly design-coordination workshops to address and resolve open issues. As the project moved into construction, AECOM used the Prolog Converge platform for the timely management of responses to contractor requests for information, and shop drawing review and action. This helped drive progress, and ensured a full audit trail and prompt action where necessary.

ENVIRONMENTAL AND WASTE MANAGEMENT

REUSE AND RESTORATION

We work collaboratively with clients and communities to solve their most complex environmental challenges from asset development, operations optimisation, integrated products, and restoration and reuse. We understand the pressures to reduce waste and carbon emissions to drive project efficiencies. Our team has been developing innovative solutions tailored to the individual needs of each project.

- Waste management
- Remediation and restoration
- Air-quality engineering
- Management of information services
- Civil design
- Contract supervision
- Geotechnical design
- Ground investigation
- Mix design for stabilised earthworks
- Topographic survey
- PFAS and contamination
- Aircraft noise contours
- Ground based noise assessment
- Ecology
- Environmental impact assessments

CASE STUDY

BCN

PLAN BARCELONA–EL PRAT AIRPORT

Barcelona, Spain

As part of our support to Plan Barcelona – the Barcelona – El Prat Airport expansion scheme - we helped implement the airport's environmental management system (certified to ISO 14001), as well as delivering the coordination and integration of the various projects that make up the Plan.

Our range of services included implementing the environmental management system, as well as other environmental and social management services. These included protective, corrective and compensatory measures; habitat restoration and recovery of native flora and fauna; and Centre for Conservation and Recovery of Marine Animals (CRAM).

Additionally, our work on the expansion covered the preparation of preliminary studies and planning, project leading and management, project and works supervision, works planning and monitoring, cost and deadlines control, and other technical advisory work.

Barcelona El Prat Airport

SOLUTION

WALLASEA ISLAND

Essex, UK

During the construction of London's landmark Crossrail line, more than three million tonnes of spoil was excavated from beneath the capital and shipped to Wallasea Island in the eastern Thames estuary to create Europe's largest man-made wetland. We carried out the design of the site earthworks for this ambitious conservation project, which will help to replace the marshland lost along the Essex coast. The created habitat will include salt marshes, mudflats, salt marsh pools, water creeks, lagoons, grazing marshes, seawalls and bunds.

As Wallasea Island is two metres below sea level, various embankments and earthworks are to be built around the site, using the earth excavated from Crossrail. During excavation, it became apparent that there was less waste material than anticipated. AECOM's ground engineers, working closely with the Royal Society for the Protection of Birds (RSPB), were tasked with redesigning the site earthworks, using the redesign to enhance the ecological value of the island, and provide a diverse range of new habitats while ensuring the tidal flow of water on and off the island would be managed.

130,000
tonnes of aggregate recycled

—

Continuity
Airbase operated throughout construction

—

Recycled
Tar bound material

CASE STUDY

LIPPITTS HILL AIR SUPPORT UNIT

Epping Forest, UK

Stabilising a proposed helicopter landing site, we designed and supervised a major earthworks project at Lippitt's Hill Air Support Unit to improve soil material properties by treating them to increase their strength and performance when under load. The main helipad at Lippitts Hill Air Support Unit was too small to accommodate any abortive take-off leading to delays in aircraft deployment. Adjacent land was available to provide a suitable 300m-long landing strip but was steeply sloping. Major earthworks were required, therefore, to provide a level surface.

Carrying out a ground investigation and laboratory testing led to ground soils being reused on site to stabilise the land, and created the environmental benefit of reducing 2,500 lorry movements through the sensitive Epping Forest area.

4 WAYS TO KEEP GROUND MATERIALS ON SITE

Expanding or building a major airport typically involves moving large amounts of ground materials to and from the site to create earthworks that will withstand the various performance demands of the new infrastructure development. But this activity can inadvertently generate waste, produce carbon emissions, and is expensive and usually programme critical. Substantial haulage of ground materials can have a big negative impact on communities too. Moving materials to and from constrained sites, which are often in urban areas and in proximity to closed landfills or other contaminated land, as is the case with many airports, adds extra logistical challenges and costs.

Global environmental targets and national policies mean infrastructure, and particularly aviation projects, need to meet increasingly tough carbon emission targets. This makes the sustainable onsite reuse of locally available ground materials a top priority for infrastructure owners and operators. Here are four ways to use what's already on site to reduce ground risk, optimise soil and material reuse, and reduce the transportation of materials off site as waste.

1/ IMPROVE WHAT YOU HAVE

It It is possible to improve soil material properties by treating them to increase their strength and performance when under load. There are a number of ground materials improvement techniques, including dynamic compaction and stabilisation, to name but two. We stabilised a proposed helicopter landing site at Lippitts Hill, south east England, avoiding around 2,500 lorry movements through a forested area. The steep, sloping site, made of predominantly London Clay, was accessible only by minor roads used by recreational traffic. To meet planning consent requirements, traffic had to be kept to a minimum, creating a strong driver to reuse the clay soil. Our preliminary ground investigations revealed the clay was naturally too wet to properly compact as engineered fill, as required to level out the site. Traditionally, this would have meant disposing of the clay off site and bringing in stone, requiring a large number of lorry movements. Following ground investigation and laboratory testing, we added lime to create acceptable moisture content, followed by slag to mitigate any resulting unfavourable ground conditions. Following further trials, we added water to avoid the lime drying out too much and meet optimum criteria for compaction. All onsite soils were reused, significantly reducing lorry movements while delivering the helicopter landing surface on time and to budget.

2/ MAKE BETTER USE OF WHAT YOU HAVE

Poor quality onsite materials can be used where engineering loads and demands are relatively low, such as for banks and slopes to create noise or screening bunds, and for landscaping. A highly effective way to stabilise these materials is to incorporate web, mesh or grid systems, known as geosystems. The Waste and Resources Action Programme's (WRAP) Axis Business Park project in Liverpool, where onsite materials and geosystems were used to create a bund to reduce noise from a 24-hour warehouse reaching adjacent properties, avoided the offsite disposal of 4,000 tonnes of materials, equating to £236,000 savings in haulage costs, landfill tax and gate costs. The chosen geosystems design also eliminated the need to import large volumes of granular fill material, leading to £112,045 savings. Overall, the chosen geosystems led to savings of around 89 per cent in embodied CO_2 and 96 per cent in cost terms. WRAP is a leading UK organisation helping businesses and local authorities reduce waste and recycle more.

Many aviation projects involve significant earthworks that can influence overall project success more than any other stage of a development. With major infrastructure owners and operators under pressure to reduce waste and carbon emissions and improve overall project efficiencies, environment and ground engineering specialist **Patrick Cox** and aviation specialist **Richard Gammon** look at some of the best ways to reuse ground materials on site.

3/ REDEFINE WHAT YOU HAVE

Often, it is the range of ground materials found on a site that can be the biggest problem. When building airport infrastructure on top of landfill for example, the ground conditions may vary greatly in composition and strength, depending on the age of the landfill and the type of waste it contains. The ground may be impacted by soil and groundwater contamination, requiring different treatment solutions, some of which will allow for reuse. Some of the waste materials may be degradable, decaying over time, resulting in loss of ground mass strength and volume. This may be critical in its effect on ground settlement given the minimal tolerances acceptable for airport infrastructure. We are increasingly using segregation trials following site investigations as a technique to evaluate the potential to reuse elements of the existing landfill as part of developments. Through the trials, it is possible to confirm the suitability of processes to remove unsuitable materials and allow reuse of other more suitable materials, with and without remedial treatment.

4/ RECONSIDER WHAT YOU HAVE

Many infrastructure owners and operators are interested in how best to manage excavated ground material on site, without incurring the environmental and financial cost of off-site disposal. Options include the use of a Materials Management Plan (MMP) under the CL:AIRE Definition of Waste: Development Industry Code of Practice (CoP), under which it may be feasible to beneficially reuse material on site without it being classified as waste. An MMP must demonstrate the protection of human health and the environment, suitability of use of the ground material without treatment, certainty of use and quantity of the material. The Environment Agency considers the CoP when deciding whether to regulate materials on site as a waste. By following the CoP, it is unlikely that the ground materials will be classified as waste if used to develop land. This means being able to reuse the material, bypassing waste controls such as applying for an Environmental Permit, which can be costly and time consuming.

Major Infrastructure Infrastructure Group: optimising resources guidance

The award-winning Major Infrastructure–Resource Optimisation Group (MI-ROG) is a forum for the UK's infrastructure operators to collaborate across the circular economy theme, meeting the challenge of major infrastructure delivery in a constrained economy. The group has recently established a working group specifically addressing the need to increase the use of recycled and secondary aggregates in infrastructure development, undertaking a survey of current practice and targets, goals and systems among MI-ROG members and is now establishing potential best practice through a series of working sessions with the aim of developing industry guidance. MI-ROG was set up by AECOM in 2013.

For more information, see the white paper, 'Measuring circular economy performance' at aecom.com

SURFACE ACCESS

MAKING CONNECTIONS

We are leaders in the design and project management of landside infrastructure for airports. We plan and design facilities that enable infrastructure equipped for long-term sustainable growth, while also ensuring that the surrounding environment is protected.

As landside infrastructure forms the primary physical interface between the core aviation functions of an airport and its surrounding communities, we use sustainable surface access to promote local economic development and help to lower the impact of airport operations on local communities.

- **Terminal curbs and forecourts**
- **Automated people movers**
- **High-speed, regional and metro-rail connections**
- **Public transport interchanges**
- **Surrounding airport-city commercial developments**
- **Personal rapid transit**

CASE STUDY

DUB

DUBLIN INTERNATIONAL AIRPORT

Dublin, Ireland

As the main component of AECOM's input to the project's masterplan, we developed a surface access strategy that provided a detailed plan of the infrastructure required to support increased capacity at the airport. As the existing network around the airport is already heavily congested, significant infrastructure improvements were identified to help meet passenger growth forecasts. The strategy also incorporates the proposed development of a light-rail link to the city centre. We assessed the existing surface access conditions at the Airport through detailed analysis of: the existing access arrangements; the link and junction capacity, the bus interchange and parking facilities, the travel behaviour of passengers and staff and the existing freight arrangements. We undertook benchmarking of the surface access arrangements at major European airports and generated strategic transport modelling using the National Transport Authority's multi-modal Eastern Regional Model (ERM).

We produced future-year mode share projections and future-year traffic flows, and provided identification, preliminary design, phasing and costing of the road network improvements required to facilitate the estimated future-year traffic flows, as well as setting out the public transport services and infrastructure needed to support the passenger projections. Our demand-management strategy also included parking and staff mobility management.

Dublin International Airport

CASE STUDY

LHR

HEATHROW AIRPORT, SURFACE ACCESS

London, UK

We are currently supporting delivery of the Heathrow Expansion Programme at Heathrow Airport, working towards a Development Consent Order (DCO) application for a third runway, the associated facilities and supporting infrastructure. As part of this work, we are developing a new strategic highway assignment model, and are also involved in the surface access strategy and masterplan development and appraisal work.

CASE STUDY

GRR

GERALD R. FORD INTERNATIONAL AIRPORT, ACCESS CONTROL AND SECURITY SYSTEM UPGRADES

Michigan, US

At Gerald R. Ford International Airport in Grand Rapids, Michigan, AECOM was the sole provider of security masterplanning and design services for the replacement Access Control System throughout the entire airport. The project included vulnerability analysis, FAA security compliance review (CFR part 49 1542), market analysis in support of system selection, and design and construction support. The system contained about 50 card readers, which were made biometrics capable, and five perimeter gates. Three taxiway microwave beams secure the terminal area. At the perimeter, some gates and fences were relocated to better meet Federal requirements. In addition, the CCTV system was replaced by a new digital video system. The project included an upgraded communication backbone to support these requirements, and the system uses the GSA GSIS compatible contactless smart cards. This was the first installation of such cards at an airport within the United States.

Another unusual project feature was the microwave 'security fence', which separates the air carrier operations from general aviation operations at Gerald R. Ford International Airport. This electronic fence was upgraded during the project and uses microwave beams rather than wire or chain link to deter intruders. It allows aircraft to taxi from one side of the airport to the other, but triggers an alarm to the tower when people or vehicles attempt to enter the air carrier operations area.

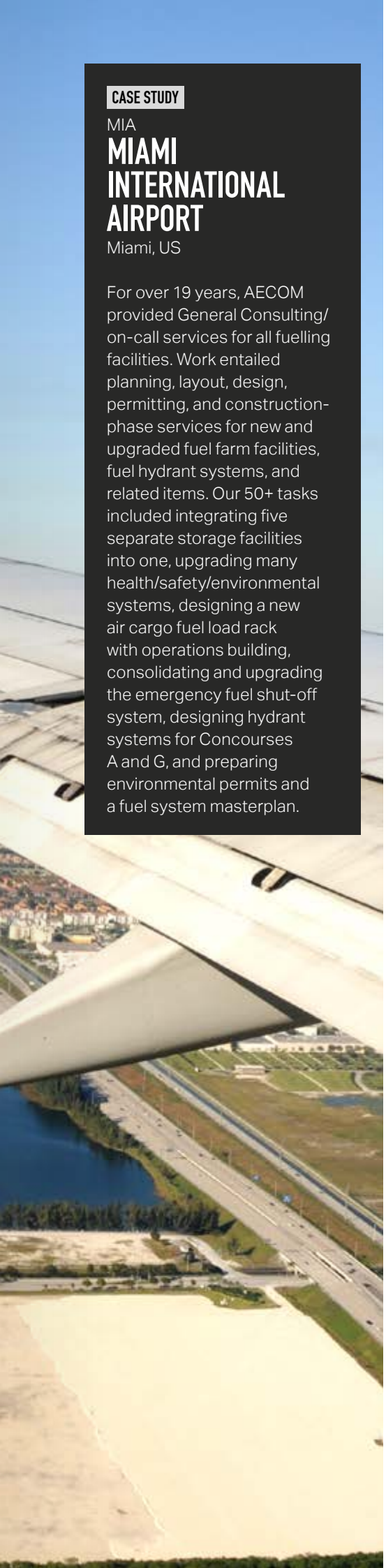
AVIATION FUEL

TAKING FLIGHT

Our aviation fuel experts have an in-depth understanding of technical and aviation regulations. We are skilled in working on airfields of all sizes and forms. We offer comprehensive in-house support for the design and construction of aviation fuelling systems and facilities.

We are adept in designing aviation offloading, storage, pumping and hydrant facilities from the ground up, as well as working on major upgrades while minimizing disruption to normal day-to-day operations. Our projects have involved the full range of investigation, design, materials, procurement and construction support services. We've been providing aircraft fuelling related services throughout the world for over three decades.

- **Planning, conceptual design and detailed design**
- **Cost estimating and economic analysis**
- **Procurement of equipment & construction material**
- **Construction management**
- **Operational and maintenance manuals**
- **Environmental permitting for air emissions, storm water, and industrial waste**
- **Spill prevention, control and counter-measure (SPCC) plans**
- **Demolition plans and specifications**
- **Pipeline abandonment and closure**



CASE STUDY

MIA

MIAMI INTERNATIONAL AIRPORT

Miami, US

For over 19 years, AECOM provided General Consulting/ on-call services for all fuelling facilities. Work entailed planning, layout, design, permitting, and construction-phase services for new and upgraded fuel farm facilities, fuel hydrant systems, and related items. Our 50+ tasks included integrating five separate storage facilities into one, upgrading many health/safety/environmental systems, designing a new air cargo fuel load rack with operations building, consolidating and upgrading the emergency fuel shut-off system, designing hydrant systems for Concourses A and G, and preparing environmental permits and a fuel system masterplan.

CASE STUDY

BOS

LOGAN INTERNATIONAL AIRPORT

Boston, US

AECOM provided investigation, design and construction-phase services to replace all fuelling facilities at the airport, which has totalled approximately US$84 million. The initial award-winning US$63-million project was completed on time and US$4.5 million under budget. This work included a distribution system serving all aircraft gates, a new enlarged-capacity fuel farm to replace five old ones, an operations building with sophisticated monitoring/controls, environmental safeguards, and provision for recovery/reuse of fuel. Subsequently, we performed all follow-on work to complete the fuel hydrant systems throughout the airport. The project has won multiple awards.

CASE STUDY

EXXON MOBIL

Central & South America and the Caribbean

AECOM's on-call services required the complete range of engineering disciplines for fuel hydrant and storage systems. We provided these services continuously for 13 years, until ExxonMobil began doing this work in-house. Assignments entailed planning, layout, design, permitting, materials procurement, and construction-phase services for new and upgraded hydrant systems, fuel farms, pumps, controls, dikes, automated control and monitoring systems, and design/build control systems.

Quite often, projects were contracted with ExxonMobil, then expanded to include Shell and Texaco as a joint effort. Typically, costs ranged from US$500,000 to US$6 million. Work was performed at airports in Brazil, Jamaica, the Bahamas, the Dominican Republic, Aruba, El Salvador, Honduras, Nicaragua, and Chile.

AIRFIELD AND CIVIL ENGINEERING

SEAMLESS SOLUTIONS

We recognise that asset replacement is not always the ideal solution, and work closely with clients to understand their underlying business needs. This helps us ensure that our physical solutions reflect the objectives and constraints of the business. We are also able to offer clients access to all the engineering disciplines they need within a one-stop-shop consultancy, guaranteeing a seamless engineering approach.

Our holistic service seeks to optimise short-term investment — maximising operational efficiency and whole-life cost — and to minimise the environmental impact of construction and operation.

AECOM's services include: concept, preliminary and detailed design; procurement and contract advice; site and construction supervision, operation and maintenance strategies; and optimisation for all infrastructure requirements.

Aprons, runways, taxiways and landside infrastructure

Airfield special systems — apron systems, airfield ground lighting (AGL) and navigational aids (Navaids)

Soil investigations, and pavement design and engineering

Drainage-system design and engineering

Preparation of tender documents

Contract management

CASE STUDY

BHX

BIRMINGHAM AIRPORT

Birmingham, UK

We have been advising Birmingham Airport since the 1980s, covering the feasibility, planning and engineering of the runway extension that opened in 2014. The extension of the runway created a Take Off Run Available (TORA), exceeding 3000 m in the principal direction of operation and the associated infrastructure. This comprised a 550 m extension of the runway and the diversion of the A45 Coventry Road and complex utilities diversion. The scheme also involved full resurfacing of the existing runway, new instrument landing system equipment, new AGL, amended threshold position and approach lighting.

We prepared the detailed planning application; assisted during the planning determination process following their submission; developed a phased solution to enable the scheme to be funded and approved by the Airport Board and produced the works information for a design and construct contract.

The team worked with the airport to develop the appropriate constraints for the design and construct contract, balancing the contractor's need for reasonable possession and the client's need to maintain operations. The contract was tendered using a competitive dialogue process. As part of this, we helped in the administration of the tender process, attended mid-tender interviews and evaluated the technical aspects of the submitted tenders. During the construction phase, we provided technical advice to the employer, project manager and supervisor.

Birmingham Airport

CASE STUDY

IST

ISTANBUL NEW AIRPORT

Istanbul, Turkey

A new airport is being developed in Istanbul, Turkey, to meet the growing demand for air travel and hub traffic. The project client is Istanbul Grand Airport, a group of five leading Turkish contractors who won the concession to develop and operate the airport, and are also the Engineering, Procurement and Construction (EPC) contractor.

As part of the project, AECOM has provided services including: the engineering design of runway, taxiway and aprons and associated infrastructure, and design of the AGL and airfield systems, which involve Level 4 Advanced Surface Movement Guidance and Control System (A-SMGCS), Navaids, meteorological installations, Avian Radar and foreign object debris Radar.

We are also designing the airside works for the airport, which comprise the three initial runways, taxiways, apron, associated drainage systems, AGL and Navaids.

AECOM has partnered with Pininfarina to design the winning entry for the Air Traffic Control Tower Design Competition (see page 8 for more information).

CASE STUDY

AMS

AMSTERDAM SCHIPHOL AIRPORT

Amsterdam, Netherlands

This multidisciplinary project is focused on strengthening the position of Europe's main hub — Schiphol Airport, Amsterdam — by developing it into a multimodal hub. The project will increase the airport's passenger capacity by 14 million passengers per year.

Along with our architectural partners Cepezed, we have been commissioned to deliver a comprehensive masterplan of the new pier development. Drawing on our global expertise, we have also been retained for the preliminary and technical design stages, taking the project through to construction tendering.

The new pier is expected to be operational in late 2019, and will give Schiphol eight new gates. This includes five new gates for narrow-body aircraft on the north side, and three gates for wide-body aircraft on the south side, which will also be used to connect six narrow-body aircrafts.

In a later stage, two additional widebody gates will be created on the south side of the new pier. The Pier will handle three categories of passengers, Schengen, non-Schengen and non-Schengen from non-secure destinations, and will be connected to a new terminal development.

CIVIL INSPECTION WORKS

SAFETY FIRST

Ensuring the best quality assurance, our civil inspection services range from physical inspection to other works including examining proposed plans and reviewing the social and economic effects of a construction project.

Heathrow Airport, London, UK

CASE STUDY

LHR

HEATHROW AIRPORT, CIVIL INSPECTIONS

London, UK

Acting as a consultant to Heathrow Airport Limited, AECOM are providing inspection and maintenance design services to all of Heathrow's civil assets. Typical assets include: bridges and tunnels; multi-storey car parks; terminal and general operation buildings; control posts, electrical sub-stations, surface car parks; stillages; bus shelters; camera masts; head of stand gantries; and approach light support steelwork, with assets located both landside and airside across the airport campus.

We are commissioned to undertake principal and general inspections and, special inspections, building surveys, and assessments in accordance to the Heathrow technical guidance documents. We also provide a 24/7 emergency response service to Heathrow, in the event of any structural or civil engineering emergencies on any of their civil assets. This is a safety critical service to Heathrow as it allows them to respond to emergencies in real time and no undue delays to its operations and services. AECOM's staff have full airside and landside security clearance, which enables us to access all areas.

We are also working in collaboration with Heathrow's maintenance contractor, Dyer & Butler for provision of access and associated equipment. Our deliverables are produced to provide a clear and accurate description of the structures' condition, including a summary of defects, drawings, structure inspection record forms, structure specific information forms, building element and defect records.

Example work packages delivered include, but are not limited to, the following:

- Principal bridge inspections
- Terminal 1, Pier 4A Principal inspection
- General bridge inspections
- Landside car parks and bus shelters — general inspection
- Airside stillages — general inspections
- Camera mast — general inspections
- Building surveys
- Terminal 4 building survey
- M4 spur camera mast assessment
- D'Albiac House roof assessment
- BA car park inspection and repairs
- Terminal 2 parapets' extension
- Terminal 5 support steelwork inspection
- A30 Shrewsbury Road assessment

CASE STUDY

LGW

GATWICK AIRPORT, CIVIL INSPECTIONS

London, UK

AECOM were commissioned by Gatwick Airport to undertake a number of principal and general inspections, building surveys and assessments of various assets to be delivered in accordance with the required Gatwick Airport guidance document. These vary from bridges, buildings, terminal buildings and stillage's, with all assets located landside and airside across the Gatwick campus.

All inspections are to be carried out in collaboration with Marco Airport Facilities and Gatwick Group, Gatwick Airport's approved supplier. In accordance with various Gatwick Airport's guidance documents the reports are to provide a clear and accurate description of a structures condition at the time of its inspection, including various appendices specific to guidance document required, such as defect drawings, an exposed structure inspection record form, a structure specific information form, a building element defect record form and a building element condition assessment form — all as appendices to a report.

Example work packages delivered:

- Principal bridge inspections
- General bridge inspections
- Inter terminal transit system (ITTS) bridge inspection
- ITTS joint replacement design
- Special building inspections
- Ancillary buildings inspections
- South terminal boiler decentralisation design
- Baggage stillage inspections

PFAS MANAGEMENT

INVESTIGATION, MANAGEMENT AND REMEDIATION

AECOM is recognised as a global industry leader in PFAS management, having worked on over 200 projects globally. Our vision is to identify long-term solutions for our clients to investigate, manage and remediate PFAS. While our work includes investigation and management of PFAS, we're also developing, trialling and commercialising world-first PFAS destruction technology.

Per- and Poly-Fluoroalkyl Substance or 'PFAS' is an emerging contaminant. A manufactured chemical that has been used in the aviation industry for over 50 years, PFAS is most commonly used in legacy firefighting foam for training defences including aviation firefighting facilities. Due to its emerging status, PFAS is difficult to quantify, risk assess and subsequently remediate.

The uniquely engineered properties of PFAS mean that conventional technologies stop well short in effectively addressing this contaminant. PFAS is highly soluble, mobile and bio accumulative, which means it can travel long distances through soil and water. Long-term use of the chemical has resulted in contamination of the environment where PFAS was used.

Site assessment

Community and stakeholder engagement

Human health risk assessment

Ecological risk assessment

Toxicology report

Technology development

Remediation solutions (incorporating AECOM's destruction technology)

SOLUTION

NEW TO MARKET DE-FLUORO™

Worldwide

Our dedicated PFAS technology team was formed to strategically solve the challenging environmental issues that PFAS can create by developing a cost-effective, sustainable solution. The team developed a treatment technology system called DE-FLUORO™, an electrochemical oxidation (EO) process that uses highly conductive, chemically-inert, low-cost proprietary electrodes to effectively degrade PFAS.

DE-FLUORO™ offers a complete on-site PFAS destruction solution that can be used as a coupling technology. The team are currently undertaking trials in AECOM's Newcastle office in New South Wales, using PFAS impacted wastewater from sites across Australia.

The technology will be commercialised in 2019 and potential applications include:

- Groundwater
- Industrial wastewater
- Drinking water
- Investigation-derives wastewater
- Liquid waste
- Surface water

CASE STUDY

AUSTRALIAN AIRPORTS, PFAS INVESTIGATIONS

Australia

AECOM is currently undertaking PFAS investigations at a number of airports across Australia. The persistent nature of the emerging contaminant has resulted in a high level of environmental regulatory scrutiny globally, and within Australia. A key focus on PFAS assessments has been within the aviation sector due to the use of historical aqueous film forming foam (AFFF) formulations during aviation rescue fire fighting services across a large number of airport sites.

The contamination investigations have focused on identifying the extent of PFAS contamination and have included assessing human health and ecological risks, and assisting clients with identifying and implementing long-term management actions including remediation strategy and community engagement.

PAVEMENTS

WHOLE LIFECYCLE INFRASTRUCTURE

Our pavements team led by Dr Bachar Hakim is a global centre of excellence. The team has gone from strength to strength and its capabilities are impressive — operating a cradle-to-grave service.

The team has gone from strength to strength and its capabilities are impressive — operating a cradle-to-grave service. This comprises the whole lifecycle of pavement infrastructure from designing new pavements, specifying the materials, testing during construction for quality, surveying and monitoring existing pavements to assess performance, asset management, deterioration modelling, treatment prioritisation and, finally, research and development to update/rewrite the design standards.

Consultancy/design

Materials specification and design standards

Construction management and operations

Support from our independent in-house laboratory

CASE STUDY

IST

ISTANBUL AIRPORT

Istanbul, Turkey

One of the main challenges of our work at Istanbul New Airport was the need to develop a solution that could be constructed rapidly using readily available materials. Settlement was also a big issue onsite, with large embankments and very poor quality clay-based ground material. Although, new pavements could not be designed to accommodate differential settlement, mitigation measures could be implemented.

Our solution was to implement a value-management strategy incorporating whole-life cost, future maintenance and operational restrictions. Based on the strategy, we recommended flexible and rigid pavement constructions with appropriate transitions for different areas as a function of settlement levels, traffic and access sensitivity.

New airport

—

6

Runways

—

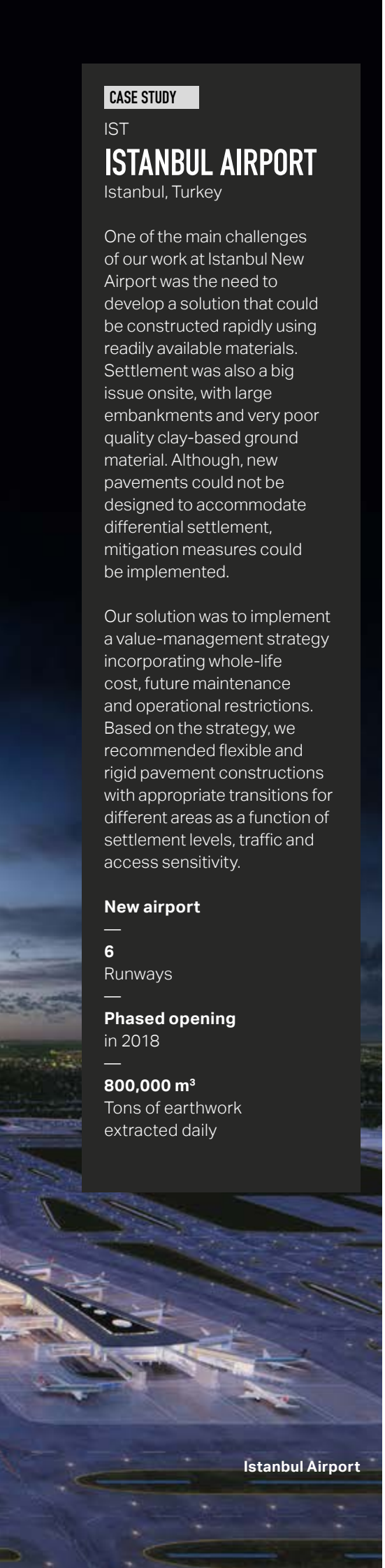
Phased opening

in 2018

—

800,000 m³

Tons of earthwork extracted daily



Istanbul Airport

SOLUTION

PACING THE WAY — FRENCH AIRFIELD ASPHALT

Our material and research team investigated the use of French airfield asphalt (Béton Bitumineux pour Chaussées Aéronautiques — BBA) surfacing and High Modulus Base (Enrobé à Module Elévé 2 — EME2) and introduced them to UK airfields. Since their introduction by AECOM, these materials have been used at eight UK airports and successfully demonstrated environmental, performance and financial benefits. BBA asphalt, can be laid at thicknesses 15 per cent less than Marshall Asphalt while providing equivalent strength, using less aggregate and exhibiting greater sustainability. Shorter construction timeframes also results in reduced fuel consumption and carbon emissions.

SOLUTION

TEMPERATURE RESISTANT CONCRETE

We developed a high-temperature resistant concrete to cope with F35B Lightning II aircraft that are capable of vertical landing, resulting in surface temperatures of 482°C. The team developed a UK specification with UK/EU aggregates.

SOLUTION

DESIGN STANDARDS

We develop and contribute to design standards around the world, such as the independent review of the American Association of State Highway and Transportation Officials' (AASHTO) new Mechanistic-Empirical Pavement Design Guide and Software, Concrete Society's Technical Report 66 and Britpave airfield guidance notes.

HOW TO DELIVER RUNWAYS FASTER, SMARTER AND BETTER

When it comes to new airport runways, the dream is to achieve a pavement design that is smart, innovative, low maintenance, sustainable and fast to construct writes world-leading pavement specialist **Dr Bachar Hakim**.

As airline passenger numbers continue to grow — exceeding four billion worldwide for the first time in 2018* — there is increasing pressure on airports to optimise their existing assets and expand to meet demand. This trajectory looks set to continue with a stream of new and replacement airports such as the New Airport Istanbul, Beijing Daxing International Airport and Jewel Changi Airport, Singapore along with expansion of others including Los Angeles International, Kuwait International and London Heathrow.

Against this backdrop of rising demand is the reality faced by asset owners. Budgets are being stretched, worker and passenger safety thankfully has risen to the top of the agenda, and we see the introduction of ever-tougher environmental regulation on noise, air pollution, low-carbon infrastructure and sustainability. In response to these new pressures the industry must find innovative ways to deliver increased and improved capacity and service. Long-term infrastructure resilience needs to be achieved through using innovative materials, construction and monitoring techniques, digital technology and asset management.

Key to accommodating greater passenger capacity is the runway. Existing assets must perform better, last longer, and be maintained more easily and efficiently, and new runways can benefit from recent innovations in design, materials and construction.

So, there are many, many reasons why airports need a fresh and revised approach to their most important asset — the runway.

Here are three key runway innovations and approaches to help airports meet growing demands.

FASTER

One of the most significant recent changes in UK aviation is the introduction of BBA — the French airfield asphalt concrete material, Béton Bitumineux pour chausées Aéronautiques. This offers a viable, faster to construct, cost-effective alternative to conventional asphalt surfacing. BBA provides an improvement on the conventional approach to runway rehabilitation/resurfacing as it can be laid without grooving and can be open to traffic with minimum delay. With its open-texture macrostructure, there are advantages during operation too, because this surface requires less rubber removal during runway life.

In partnership with the contractor Colas, AECOM researched and introduced a UK-modified specification of the French material. This was an ICE award-winning piece of research, with Manchester Airport being the first runway where ungrooved BBA was used. Technical, financial and operational aspects for adopting the new material were high on the agenda for the Manchester Airports Group. While this was the first ungrooved example, BBA has been deployed in other UK airports including East Midlands, Sumburgh, the Isle of Man and Jersey.

SMARTER

Still in the relatively early days of development, numerous innovations are being created to improve asset monitoring. These include embedding technologies in the pavement, settlement monitoring, improved data collection, self-healing asphalt and concrete, harvesting energy from aircraft friction, and pollution-absorbing materials. At the forefront of this work is AECOM's Centre of Excellence for Pavement Asset Management, which has the key aim of creating innovative design to help improve whole-life cost and sustainability. The team is one of the largest in the world, based in Nottingham and providing services for airports around the globe. With the goal of transferring research into practice, the team operates a cradle-to-grave service. This comprises the whole lifecycle of pavement infrastructure from designing new pavements, specifying the materials, testing during construction for quality, surveying and monitoring existing pavements to assess performance, asset management, deterioration modelling, treatment prioritisation and finally research and development to update/rewrite the design standards.

At Hong Kong Airport, for example, the team's recent research work has included the development of a stone mastic asphalt specification for airfield taxiways, investigations into cracking of the north runway pavement, and a feasibility study on the use of reclaimed asphalt pavement materials in runway foundation layers.

BETTER

Environmental and economic sustainability are major considerations for today's airport owners and great progress is being made. As mentioned, the reuse of recycled materials is becoming an accepted practice.

An impressive example of the first cold asphalt recycling in a UK runway is at RAF Waddington. Following a full pavement evaluation of the existing runway, it was clear that rehabilitation was required to replace the concrete ends and the disintegrating tar-bound asphalt layer. Because tar-contaminated material is very expensive to dispose of, we developed a foam-mix asphalt design to allow on-site ex-situ recycling to encapsulate the tar for use in the lower (base) asphalt layers of the runway.

O'Hare International Airport, Chicago, US

AIRFIELD GROUND LIGHTING

THE HEART OF AN AIRFIELD

Our Airfield Ground Lighting (AGL) team is one of the largest dedicated teams in the UK. The team has been working on a variety of intelligent lighting systems that make the visual guiding process easier, improving situational awareness by switching lights on and off according to information shared by airfield surveillance and aircraft tracking systems. This enables optimised aircraft routing to and from gates, more efficient traffic flow, and increased safety.

Fixed ground power
Apron floodlighting
Hydrant fuel mains
Hydrant fire mains
Airbridges
Baggage handling

CASE STUDY

MAN

MANCHESTER AIRPORT

Manchester, UK

Manchester Airport is undertaking a major development programme, which will involve the transformation of Terminal 2, to position the airport as a global gateway and significantly improve the experience of customers using the airport. The programme also includes the installation of new taxiways and aircraft stands on the airport's apron.

Our team has been working on the next generation of airfield lighting, such as the introduction of the new Airfield Ground Lighting Control and Monitoring System (AGLCMS). The system is capable of supporting automatic routing, using Advanced Surface Movement Guidance and Control System (A-SMGCS) technology and utilising individual lamp control for "Follow the Greens".

Manchester Airport

CASE STUDY

DUB

DUBLIN AIRPORT

Dublin, Ireland

As part of the new parallel runway programme at Dublin Airport, our AGL team designed a full CAT III AGL layout to EASA regulations. This was for a new 3,110m parallel runway. The design included all new AGL layouts for the runway exits and parallel taxiway system, tying into existing systems where required. We also designed two AGL B centres for the new runway and complete new pit and duct systems for low voltage, AGL and fibre communications to EASA Standards.

CASE STUDY

RUH

KING KHALID INTERNATIONAL AIRPORT, AGL UPGRADE

Riyadh, Saudi Arabia

AECOM is the design reviewer for the new AGLCMS, to upgrade AGL, at King Khalid International Airport. The system is being developed to achieve "Follow the Greens" capability and the potential for future automated routing.

PROCESS AND AUTOMATION

PLANNING FOR TOMORROW

Industry is changing. Big data, automation and the growing demand for customised products mean businesses need to transform today, to keep pace with tomorrow.

With this increasingly connected, data-driven landscape come great opportunities for better, faster and more cost-efficient processes. In response, we have developed our process-led design offer — to help our clients navigate the future, and understand how to integrate process and infrastructure (physical and digital) to create efficiencies and stay competitive. We know how important it is that investment in fixed production infrastructure is flexible and adaptable for the years ahead. From defining how a facility will be used, to developing long-term asset maintenance plans, we can provide process-led, technology-neutral advice across the project and asset lifecycle. Drawing on our global design and construction experience, we partner with our clients to understand their products and processes and create manufacturing facilities that are perfectly matched to their function.

Industrial architecture
Engineering
Construction

CASE STUDY

LHR

HEATHROW AIRPORT, AIRBRIDGE SEMI-AUTOMATED DOCKING AND UNDOCKING

London, UK

To help Heathrow Airport Limited change the use of one of its airbridges at Terminal 5 from manual to semi-automated, we identified the hazards and estimated the risks of the process to both the bridge and operators.

Through hazard identification (HAZID) workshops at the airport, with subject matter experts from Heathrow, British Airways and, airbridge manufacturer, ThyssenKrupp, we ensured that all relevant issues and concerns were input into the process. This helped us to identify the most severe hazards, for example, the airbridge hitting a person on the apron or impacting aircraft and equipment.

We then estimated the level of risk for each hazard and assigned a score for the likelihood of occurrence, frequency of exposure, degree of possible harm and number of persons at risk. Based on this information, we were able to identify appropriate risk reduction measures for the client to implement. This included putting in place additional operator training, revising operational procedures to cover daily functional inspections, crosschecking airbridge positioning, and organising additional CCTV monitoring around aircraft bogies.

Heathrow Airport

ACOUSTIC DESIGN

CONTROLLING NOISE AND VIBRATION

Our capability in acoustics ranges from environmental and building acoustics to electro-acoustics and sound system design. We have a design-led culture where creativity is supported by leading technical, research and development experience. With access to national and global specialists, we bring innovative and intelligent acoustic design solutions to high profile airport infrastructure projects.

Acoustics, and the control of noise and vibration, is a major consideration in the creation or redevelopment of airfields, airport terminals and runway extensions, and plays a key role in promoting a safe, efficient environment and passenger experience. Using sophisticated modelling techniques, we optimise acoustic performance to enhance functionality and achieve outstanding project outcomes. Our expertise includes delivering environmental acoustics design to minimise noise impacts on communities surrounding existing and proposed airports; designing cost-effective building acoustics that improve the sound insulation of airport terminals to reduce noise levels from aircraft and support services while integrating technical requirements with architectural vision; and ensuring the success of airport public address (PA) systems through combined electro-acoustics and sound system design.

Environmental acoustics

Building acoustics

Electro-acoustics including full sound systems design and specification

Auditing and testing

Calculation and computer modelling

Review of third party design proposals and calculations

Environmental assessments of the impact from PAVA systems

Noise impact assessments

Equipment schedules

CASE STUDY

STN

LONDON STANSTED AIRPORT, PUBLIC ADDRESS AND VOICE ALARM SURVEY

Essex, UK

Undertaking a detailed review of the combined Public Address and Voice Alarm (PAVA) systems at Stansted Airport, our electro-acoustics PAVA designers helped identify where the systems were non-compliant with relevant standards, ensuring safety by establishing the operation and condition of the installed systems.

Stansted Airport was one of the first public buildings to be installed with a Voice Alarm (VA) system. But as governing standards for the design, installation, maintenance and performance of VA systems and Sound Systems for Emergency Purposes (SSEP) had undergone numerous revisions since the initial installation, the airport's owner and operator Manchester Airport Group wanted to review the existing systems against the latest requirements and recommendations.

We carried out a desk study of available Operations and Maintenance (O&M) manuals, schematics, installation drawings and maintenance records, followed by a series of site surveys and stakeholder engagements to determine if/where equipment was no longer serviceable. We also produced a detailed summary report presenting our findings and proposed roadmaps for a phased programme of renewals.

London Stansted Airport

CASE STUDY

AMS

AMSTERDAM AIRPORT SCHIPHOL

Amsterdam, The Netherlands

Delivering the detailed design of the full PAVA system for the new pier at Amsterdam Schiphol Airport (see page 27), our electro-acoustics specialists are designing the full system, including microphones, processing, amplification and loudspeaker layout designs, with interfacing to a number of existing systems in the main terminal building.

One of Schiphol's key requirements is to minimise spill of PA messages from gate lounges to other areas. The open nature of the pier design makes this especially challenging, and requires comprise in terms of its solution. Our electro-acoustics specialists are carrying out detailed modelling to predict the sound system performance in terms of speech intelligibility for comparison with the life safety requirements in relevant standards, collaborating with AECOM's architecture, telecoms, and MEP teams, as well as external acoustic and fire engineering consultants.

SOLUTION

AECOM IMMERSIVE SOUND STUDIO (ISS)

Worldwide

Using new technology to simulate the sound of aircraft movements, our Immersive Sound Studio (ISS) provides industry-leading sound demonstrations to help communicate noise impacts during public consultations and aid the ongoing decision making processes with government officials, airport operators or community group leaders. When changes to an airport's local airspace operations are under consideration, ISS supports a range of innovative sound demonstration tools that allow non-technical stakeholders to understand the impact these changes might have for them on the ground. Stakeholders can compare options to an example of the existing situation to help make a well-informed decision by using headphones, loudspeakers, touchscreen interfaces, virtual reality headsets and even iPads.

CASE STUDY

NLIA

NEW LIBREVILLE INTERNATIONAL AIRPORT

Gabon, Africa

Carrying out an environmental and social impact assessment for the new airport at Libreville in Gabon, we assessed noise and vibration impacts during the construction phase of the project, while also evaluating noise impacts during the operational phase.

Scheduled to open in 2020, the New Libreville International Airport will provide a logistical hub comprising an aerodrome and associated infrastructure. We considered a range of noise sources during the assessment including aircraft noise, ground noise at the airport, and road traffic noise on the local road network for new and existing roads. We recommended details on mitigation measures to protect local communities from significant noise impacts, including implementing an operational management plan for the airport that demonstrated how best practice would be adopted.

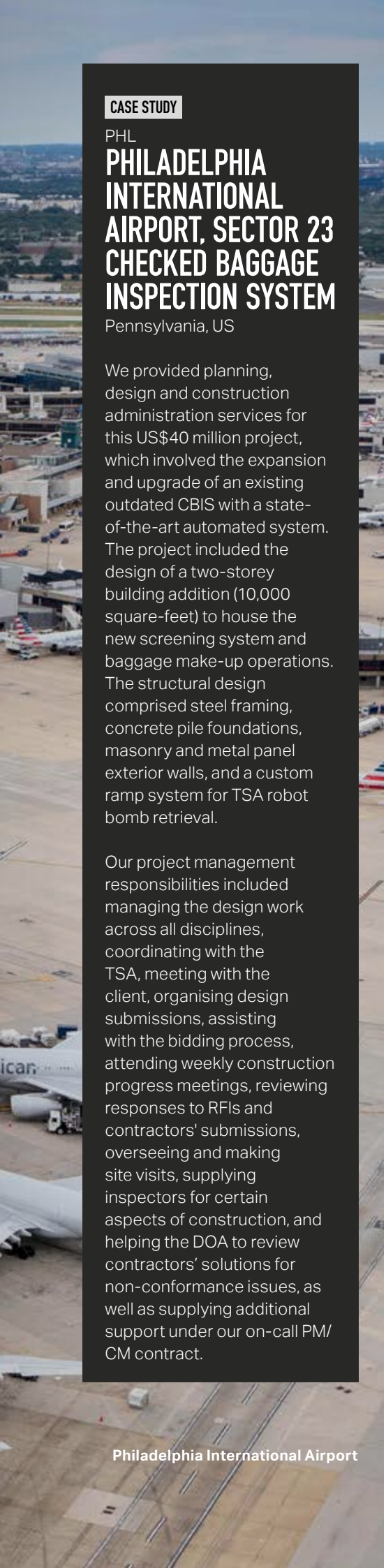
BAGGAGE HANDLING

HIGH SPEED BAGGAGE SYSTEMS

Efficient baggage handling is critical to timely aviation operations. To meet airports' needs, Baggage Handling Systems (BHS) and Checked Baggage Inspection Systems (CBIS) must not only handle today's passenger traffic, but also assure operational performance over the airport's lifecycle.

As leaders in planning, design and engineering for baggage handling and security screening systems, our professionals include mechanical, electrical, facilities, computer controls and security experts from the aviation, airline and baggage industries. We offer an integrated approach to systems' engineering, design, construction and implementation and can assist you at every project stage.

- **BHS masterplans**
- **Peer reviews**
- **Concept development and planning**
- **Contract documents' development**
- **Transportation Security Administration (TSA) submittal process**
- **Tender reviews/recommendations**
- **Commissioning and testing**
- **Program and construction management**
- **System start-up support and evaluation**
- **Design-build planning and fully integrated delivery**
- **Energy consumption assessments**
- **Safety and operational audits**



CASE STUDY

PHL

PHILADELPHIA INTERNATIONAL AIRPORT, SECTOR 23 CHECKED BAGGAGE INSPECTION SYSTEM

Pennsylvania, US

We provided planning, design and construction administration services for this US$40 million project, which involved the expansion and upgrade of an existing outdated CBIS with a state-of-the-art automated system. The project included the design of a two-storey building addition (10,000 square-feet) to house the new screening system and baggage make-up operations. The structural design comprised steel framing, concrete pile foundations, masonry and metal panel exterior walls, and a custom ramp system for TSA robot bomb retrieval.

Our project management responsibilities included managing the design work across all disciplines, coordinating with the TSA, meeting with the client, organising design submissions, assisting with the bidding process, attending weekly construction progress meetings, reviewing responses to RFIs and contractors' submissions, overseeing and making site visits, supplying inspectors for certain aspects of construction, and helping the DOA to review contractors' solutions for non-conformance issues, as well as supplying additional support under our on-call PM/CM contract.

Philadelphia International Airport

CASE STUDY

MCO

ORLANDO INTERNATIONAL AIRPORT, SOUTH TERMINAL COMPLEX C (STC-P1)

Orlando, US

Working with the Greater Orlando Airport Authority (GOAA), we've prepared a Design Criteria Package (DCP) which includes detailed performance specifications and a 30 per cent design for a new baggage screening and handling system for South Terminal C — a new 120 gate terminal complex to be implemented in six phases.

We carried out a feasibility study to determine the type of BHS technology for the terminal. After studying conventional and individual carrier systems (ICS), it was concluded that the ICS was most appropriate.

The next phase was to establish a set of generic but adaptable ICS design criteria. Then, using the airport's flight schedule, we developed baggage demand values, and determined the size of the CBS matrix (number of explosive detective system (EDS) machines). We collaborated with the rest of the terminal design team, in a full BIM environment, to establish the required space programming and right of way for the system. The screening matrix consists of nine medium speed EDS machines that can be easily converted to high speed EDS in the future. The system also incorporates a 2,500 early baggage storage (EBS) facility.

Additionally, we assisted GOAA in the preparation of the DBOM (design, build, operate and maintain) tender package and the evaluation of the vendor technical submittals. We are now serving as the client representative working with the successful vendor to complete the design, and will be the construction manager. We are also GOAA's liaison with the U.S. Transportation Security Administration (TSA) for the submittal and approval of the various deliverables during the design, construction and certification phases.

CASE STUDY

MIA

MIAMI INTERNATIONAL AIRPORT, AUTOMATED BAGGAGE HANDLING/IN-LINE SCREENING SYSTEM

Florida, US

We were contracted by American Airlines to plan, programme, and produce bid documents for the new BHS followed by coordination and management of the actual vendor design/installation and commissioning phases. The provisions for the demolition and removal of American Airlines and associated Miami International Airport baggage/screening systems had to be phased in several stages to allow the airline and its code share partners to maintain their daily operations with little or no disruption. In addition, we managed and coordinated the layout and operational logistics and requirements of the 100 per cent in-line baggage screening system with TSA and airport officials relative to the mandated integration of the multi-level baggage screening operation.

CONSTRUCTION AND PROGRAMME MANAGEMENT

KEEPING TRAFFIC MOVING

As an industry leader in programme management and construction management services for large capital programmes, we oversee activities ranging from planning, coordination, scheduling and cost control, to design, construction and commissioning.

Large programmes require the management, coordination and integration of multiple, concurrent assignments. From concept through completion, we provide necessary technical and administrative services to help our clients meet their programme objectives. We act as an extension of our clients' staff, protecting their interests as our own.

- **Programme planning and management**
- **Master scheduling/ schedule analysis**
- **Master budget development**
- **Design management**
- **Cost management**
- **Delivery and contracting strategies**
- **Cost estimating**
- **Change order management**
- **Value engineering**
- **Commissioning**
- **Facility condition/ lifecycle assessments**

London Luton Airport

CASE STUDY

LTN

LONDON LUTON AIRPORT

Luton, UK

Providing multi-disciplinary services for the major expansion of Luton Airport, including PMO, airfield design and construction services, we are helping make best use of existing infrastructure during the expansion while planning and designing the development of landside and airside infrastructure.

Luton Airport is preparing to submit a Development Consent Order planning application to increase its capacity from its existing single runway from 18 million passengers per annum to 36–38 million by 2042. In our role as Technical Advisor we are helping plan and design a new terminal, rail link, airside infrastructure, road network improvements, business park and country park. Significantly, the project includes an earthworks shift of around six million cubic metres and complex construction phasing requirements.

We are providing multidisciplinary services including:

- PMO
- Airfield design
- Surface access modelling
- Geotechnical investigation (acting as contractor)
- Environmental consultancy services
- Architecture
- Digital information management (including BIM)
- Construction services
- Drainage
- Earthworks
- Structures
- Masterplanning/sift
- CDM/principle designer
- MEP/building services
- Geophysics
- Heritage/archaeology survey contractor

CASE STUDY

ATL

HARTSFIELD–JACKSON ATLANTA INTERNATIONAL AIRPORT, FIFTH RUNWAY PROJECT

Georgia, US

Often compared to the Golden Gate Bridge in terms of its complexity, Hartsfield–Jackson International Airport's (ATL) fifth runway project required the design and construction of Georgia's first runway tunnel, and the world's longest runway bridge. The bridge spans 500 ft and 10 lanes of traffic across Atlanta's Interstate 285 Highway loop (I-285), which encircles Georgia for 63.98 miles and connects three major interstate highways.

We provided construction management services on this project and multiple other large-scale projects under the Hartsfield-Jackson Development Program — which aims to improve infrastructure, boost growth, improve efficiency and enhance customer experience at the airport. Completed airfield projects include the US$1.2 billion Runway 10-28, the US$92 million demolition and reconstruction of ATL's Runway 8R and its parallel taxiway within 60 days, and multiple other airfield reconstruction and enhancement projects.

Under the fifth runway project's five-year contract specifically, AECOM led the joint-venture, design-build team and successfully implemented six interwoven contracts, delivering on time and under budget. The project also won the Airports Council International-North America (ACI-NA) Environmental Achievement Award in the Large Hub category.

400 ft
Bridge spanning the state interstate

—

+18M yards
of engineered embankment

—

9,000 ft
Runway opened

CASE STUDY

AUH

ABU DHABI INTERNATIONAL AIRPORT, MIDFIELD TERMINAL

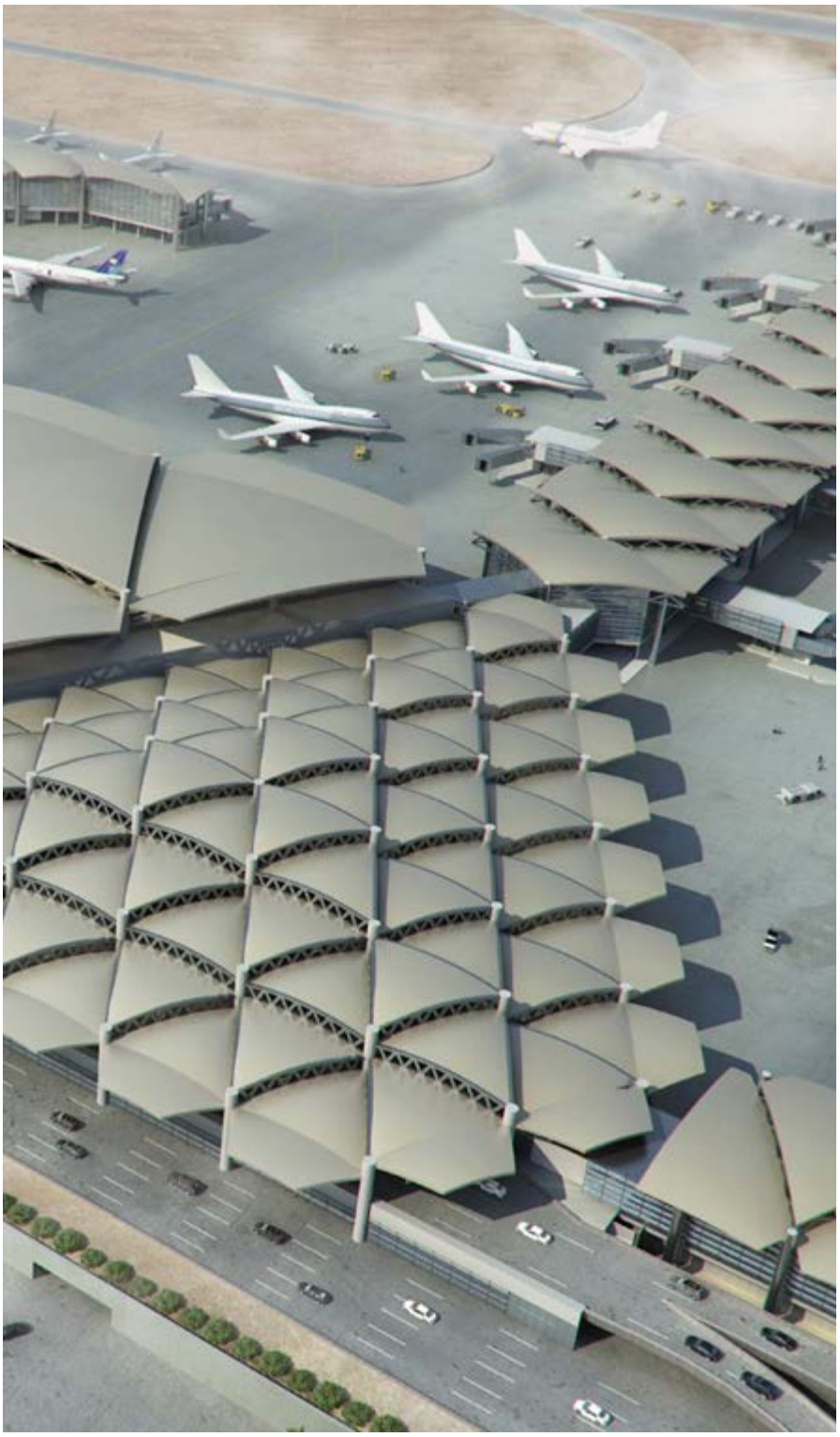
Abu Dhabi, UAE

We are providing the construction management services to deliver this Midfield Terminal Building's (MTB) unique architectural features and optimised form. The building will help increase capacity and operational efficiency to process 30 million passengers per annum and 65 aircrafts, including multiple Airbus A380s at AUH.

The passenger facilities will also include more than 27,500 m² of airline hospitality lounges, a transit hotel, and heritage and culture museum in addition to the 11 subprojects that make up the Midfield Terminal Complex (MTC), involving car parks, landside and airside roads and ancillary buildings.

As the Construction Management Agent for the complex, we cover a wide range of responsibilities from construction activities, commissioning and Operational Readiness and Airport Transfer (ORAT) to regulatory compliance and managing project constraints, and stakeholder and client expectations. Subsequently, the MTB project management plan (PMP) has been specifically developed and tailored for other airport construction projects, and the Project Controls Management (PCM) is part of the PMP. Our ambition is to build on the project controls schema and solutions that the team have developed during this programme, to advance industry best practice.

Abu Dhabi International Airport



CASE STUDY

RUH

KING KHALID INTERNATIONAL AIRPORT

Riyadh, Saudi Arabia

Leading a joint venture, we were appointed to deliver the redevelopment and expansion of King Khaled International Airport (KKIA) in Riyadh, Saudi Arabia. The five-year, US$72m contract is intended to help the airport reach a future capacity of 30 million passengers per year. The project is part of a programme led by Saudi Arabia's General Authority of Civil Aviation to transform KKIA into a new commercial airport that meets industry-leading standards.

We are providing programme support in addition to project and construction management services, such as administration, project planning, design and construction management, as well as information and data management.

WHEN THE HIGHWAY MEETS THE RUNWAY:

CONDITIONS CRITICAL FOR SUCCESS

Large aviation expansion programmes can involve integrating new and existing infrastructure. Aviation Director **Derek Holden** looks at some smart ways to deliver these types of projects not only safely and sustainably, but more innovatively and efficiently.

Major airport expansions and developments are always opportunities for innovation. And when space and time are critical factors, the pressure is on to produce successful results first time.

To match the ambitious changes at airports, ambitious responses are required. This is especially the case when space is limited, leading to the requirement to build new airport infrastructure over, through or around existing roads, railways, major utilities or other structures. Along with complex technical challenges, other requirements include maintaining a business-as-usual service, maximising safety, minimising disruption to the public and passengers, reducing the carbon footprint and, of course, delivering on time and to budget.

A GUIDE TO KEY TOOLS AND APPROACHES

Based on our recent experience, here are some of the key tools and approaches used to deliver major aviation projects, where new and existing assets must work together.

1/ CONTRACTING

Constructing a runway over existing infrastructure, such as a highway, is inevitably challenging. The driving theme behind any construction contracting strategy to deliver these types of projects efficiently and safely should be clear and appropriate allocation of risk between all parties, and development of key details prior to award of any final contract for delivery.

When considering the contract approach, key to success is understanding the required outcome. In addition to the priority of maintaining safe highway and airport operations, this can be particular construction methods, such as large-scale pre-casting and prefabrication, alongside good communication with and buy-in from the supply chain before launching any tender. Using a design-build (DB) delivery method can enable the greatest opportunity for innovation of the structure crossing the existing infrastructure. Depending on the selection process, the builder and designer can complement each other's strengths and creativity. Compared to the traditional plan-design-bid-build process, the DB approach merges design and construction responsibility into a single contract with a single point of accountability allowing for phased construction, simplified management and more efficient overall project delivery.

The intelligent use of early contractor involvement provides the perfect vehicle to identify, or at least sufficiently detail and apportion, the key risks. Ultimately the owner/operator would need to be clear on the objectives driving their contracting strategy, balancing cost, schedule and risk certainty with other less tangible aspirations which determine what successful delivery looks like to them.

2/ DESIGN

Creating a virtual vision of the runway before starting construction makes it easier to the trained eye to spot any design anomalies. Technologies and applications such as 3D fly-through, immersive technology, driver simulations and 4D, 5D and 6D technology can enable the design and construction teams to gain a holistic view of the proposed project which is simply not possible in two-dimensional design. In addition, the use of BIM with its potential to drill down into the smallest detail, opens up a whole new world of better coordinating design and construction, and maintaining operations and maintenance. The BIM model can be the single source of truth for even the most complex project, and its usefulness is strengthened by including input from the existing infrastructure owner, adjoining property owners and businesses and first responders in the design review process.

Using the DB delivery approach will save time by enabling the contractor to perform some work in advance of a completely accepted design, and design costs can be reduced. It is, however, crucial that DB design reviewers and selection teams are open to new ideas: the Hartsfield Jackson Atlanta International Airport Firth Runway Project runway structure procurement resulted in a design concept foreign to what the airport and Georgia Department of Transportation anticipated. The concept was novel, but was accepted after much discussion and review against the criteria, saving over US$50 million from the project budget.

3/ EARLY ACCESS TO MATERIALS

Large-scale aviation projects often require importing significant amounts of fill, especially where ground levels need to be raised. When building a runway over an existing railway or highway, locating, accessing and buying the rights to large quantities of fill early on in the project lifecycle is crucial to avoiding project delays and being able to place material of the right specifications in the optimal locations, maximising overall re-usage. On the Atlanta project, the amount of imported fill was significant. Gaining early access to the fill and developing an innovative means to transport it helped to mitigate what would have been a traffic and logistical nightmare. The delivery speed of fill allowed us to collaborate with the contractor to develop and quantify an approved placement method and quality acceptance protocol to keep placement of the fill in sync with material delivery. At Fort Lauderdale, an apron pavement reconfiguration project was being delivered simultaneously to the main works contributing some of the required fill. Having access to abundant amounts of fill or finding, vetting and purchasing it can save millions in contractor billings.

4/ INNOVATIVE CONSTRUCTION METHODS

Speed of delivery and increasingly tough environmental standards, such as carbon emission targets, are driving the requirement for quicker and more sustainable constructing methods. To import the required fill at Atlanta, the team used an elevated conveyor belt which moves dirt at a rate of one cubic yard per second. The 26,000-foot-long (eight-kilometre-long) conveyor, removing truck trips on Georgia's roadway system and eliminating well over 2,6000 tonnes of polluting emissions. The conveyor crossed over five active roadways, creating safer construction conditions than a conventional truck-based soil transport system.

5/ METICULOUS SITE LOGISTICS

The size and volume of equipment needed to deliver major aviation projects require continuous and systematic attention to site logistics. The many contractors, utility companies and stakeholders need to be coordinated at all times. As construction manager of the Atlanta project, where we helped build a runway over 10 lanes of interstate traffic, we developed and put in place a detailed logistics plan for the project's five-year construction programme. The 'living document', which was updated on a regular basis defined limits of work by package, landside access, emergency response procedure, staging, safety and security access and coordination points.

CASE STUDY

ATL

HARTSFIELD JACKSON ATLANTA INTERNATIONAL AIRPORT FIFTH RUNWAY

Georgia, US

Often compared to the Golden Gate Bridge in terms of complexity, the Hartsfield Jackson Atlanta International Airport (ATL) Fifth Runway Project included the design and construction Georgia's first runway tunnel and the world's longest runway bridge spanning 500 foot (152 metres) and up to 18 lanes of traffic across Atlanta's Interstate 285 Highway loop (I-285), which encircles Georgia, connecting three major interstate highways.

AECOM provided construction management services on the project and multiple other large-scale projects under the Hartsfield-Jackson Development Programme. During the relocation of Sullivan Creek underneath the runway, we encountered differing site conditions. Identifying that the original project designer's methodology would have delayed the placement of fill on site, we presented a second designer's opinion to mitigate the delay and allow for schedule corrections. The project was delivered early due to rigorous schedule oversight of 12 contracts and US$200 million under budget.

The Hartsfield-Jackson Development Programme is a massive programme to improve infrastructure to enable and promote growth, improve efficiency and enhance customer experience at the airport. Completed airfield projects include the US$1.2 billion Runway 10-28, the US$92 million demolition and reconstruction of ATL's Runway 8R and its parallel taxiway within 60 days, and multiple other airfield reconstruction and enhancement projects.

Under the Fifth Runway Project five-year contract specifically, AECOM led the joint venture design-build team in the successful implementation of four interwoven contracts. The end result was delivery on time and under budget with project winning the Airports Council International-North America Environmental Achievement Award in the Large Hub category.

Longest airport runway highway crossing in the US

—

The runway's two bridge structures span nearly 500-foot (152 metres) of interstate

—

More than 18 million yards of engineered embankment placed in 22 months using a conveyor system for soil transport.

—

When the 9,000-foot (2.7-kilometre) runway opened, ATL became one of four airports in the US where three commercial airplanes can land simultaneously.

—

ATL is one of the busiest passenger airports in the world

Fort Lauderdale–Hollywood International Airport

CASE STUDY

FLL

FORT LAUDERDALE–HOLLYWOOD INTERNATIONAL AIRPORT

Florida, US

To minimise flight delays and accommodate larger commercial aircraft, Fort Lauderdale–Hollywood International Airport (FLL) needed to extend its South Runway, giving the airport two parallel commercial runways, helping keep flight delays to a minimum, reduce taxi time to and from the terminals and increase safety. But limited space for the expansion meant building a 60-foot-high (18-metre-high) man-made embankment and concrete bridge structures to allow the runway and adjacent taxiway to cross over US Highway 1 and the Florida East Coast Railroad line.

As programme manager, AECOM oversaw the elevation of the runway and taxiway structure to cross the highway and railroad, extended the runway, demolished reconfigured the existing concourse buildings and relocated facilities while maintaining business as usual and minimising disruption to the traveling public.

The South Runway has been extended from 5,276 to 8,000 foot (1.6 to 2.4 kilometres)

—

The runway elevates 65-foot (20 metres) at its eastern end

—

Using recycled pavement from the old runway eliminated 1,229 trucks hauling fill to site

—

The project included restoring 29 acres of wetlands and relocating over 1,300 trees

—

Fill was transported via a railroad, eliminating 26,736 dump truck trips

—

Six structures support the runway

—

Six structures support the taxiway

—

2,648 concrete pilings installed

8,000,000 cubic yards of fill used — enough to fill the Louisiana Super Dome more than 1.5 times.

CONNECTED AND AUTONOMOUS VEHICLES (CAV)

MAKING THE CASE FOR AUTONOMY

Airport operators are embracing smart technology more than ever and are continually developing and trialling new technologies to improve the time to travel for passengers from the minute they set off from their home until they leave the runway.

AECOM is helping develop autonomous vehicle technology such as automated 'pods' to meet the needs of users looking for a personalised, on-demand service, supporting the end-to-end movement of people between city and campus environments.

Pods can replace the need for fixed conveyors and sorting systems at airports. The process of moving passengers through an airport needs to be secure, seamless and quick, while still offering a positive experience. Delays will occur if the baggage handling system is not sufficient no matter how efficient a passenger journey is. Enabling pods to move between fixed drop-off points to collect and offload cases would mean they can determine their own optimal route through an airport. This can provide an airport with a flexible system, operational certainty, and a reduced footprint of conveyor systems.

- **Strategic planning**
- **Policy, regulation and standards**
- **Infrastructure preparedness**
- **Pilot / trial planning and evaluation**
- **Operational delivery**
- **Innovative business models**

CASE STUDY

CAPRI

Trials across the UK

The first UK project to trial pods on public roads, Capri is an exciting new research project that is building passenger, regulatory and market confidence in autonomous pods as a practical, safe and affordable way to travel. Aiming to go further than previous pod trials, Capri is working to demonstrate a fully integrated and interactive autonomous pod service that will allow members of the public to hail a pod via an app, choose their end destination, pay and have access to relevant information and customer support.

The Capri project is awarded by The Centre for Connected and Autonomous Vehicles (CCAV), the government department set up to support the early market for Connected and Autonomous Vehicles (CAVs), and commissioned by Innovate UK, the UK's innovation agency. It is being delivered by an AECOM-led consortium comprising 19 partner organisations across the public, private and academic sectors.

Capri won a share of the government's £100 million Intelligent Mobility Fund through the CAV2 competition. Focused on highly automated solutions with real-world benefits, the competition is looking at how autonomous vehicles will work as part of a wider transport system and the business models to enable them. All successful projects are industry-led and jointly funded by government and industry.

Driverless pods have been trialled at Filton Airfield, Bristol, as part of a pilot scheme that will pave the way for the use of connected and autonomous vehicles to move people around airports, hospitals, business parks, shopping and tourist centres.

During the two-week trial, the pods' safety critical features were assessed along with participant comfort testing. The trial will inform the pods' first public appearance later this year when they will transport members of the public around The Mall at South Gloucestershire's Cribbs Causeway retail park. The project will culminate in an on-road public trial at London's Queen Elizabeth Olympic Park, a diverse estate that includes retail, recreation, residential and business centres.

Capri, an AECOM-led consortium

SUSTAINABILITY AND RESILIENCE

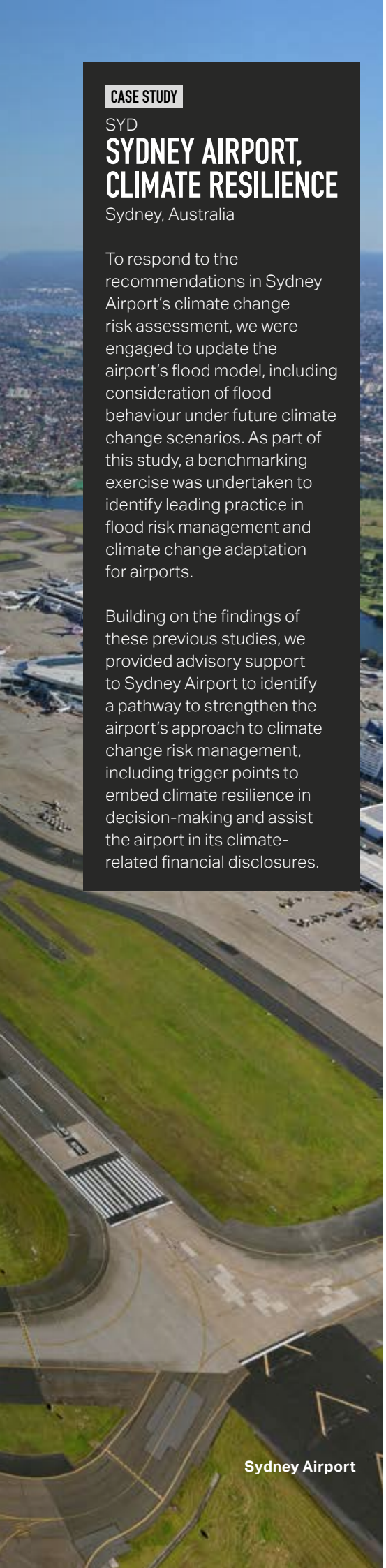
As industry interest and the uptake of recommendations from expert bodies, such as the Taskforce on Climate-related Financial Disclosures (TCFD), escalates, airports and other infrastructure owners/ operators are increasingly seeking to understand their exposure to climate-related physical and transition risks and ensure they contribute to the broader resilience of the cities they serve.

In June of 2018, Airports Council International called for airports to take action to prepare their infrastructure and operations for the physical impacts of climate change. This resolution was in recognition of the increasing risk to many low-lying airports that are susceptible to the impacts of sea level rise and increasing rainfall intensities under climate change.

Transition risks relate to the global transition to a low carbon economy and represent a material gap for many. This transition has the potential to expose airports to additional pressure from investors, along with a range of issues related to legal liability, policy changes, market and technology shifts and reputational damage.

Building on our existing relationships and knowledge of airport operations, we offer advisory services to help airports better understand and plan for climate-related physical and transition risks and opportunities, as well as providing broader sustainability and resilience services across a number of areas.

- **Climate change risk assessment**
- **TCFD climate change scenario analysis**
- **Translation of transition risks and opportunities into business strategy**
- **Adaptation and resilience planning**
- **Organisational, executive and stakeholder engagement**
- **Flood studies for future climate scenarios**
- **Sea level rise constraints analysis**
- **Interdependency analysis**
- **Climate resilience and sustainability input to airport masterplans**
- **Broader urban resilience**
- **Sustainability strategy**
- **Sustainability ratings**
- **Carbon accounting (Scope 1, 2 and 3)**
- **Airports Carbon Accreditation**



Sydney Airport

CASE STUDY

SYD

SYDNEY AIRPORT, CLIMATE RESILIENCE

Sydney, Australia

To respond to the recommendations in Sydney Airport's climate change risk assessment, we were engaged to update the airport's flood model, including consideration of flood behaviour under future climate change scenarios. As part of this study, a benchmarking exercise was undertaken to identify leading practice in flood risk management and climate change adaptation for airports.

Building on the findings of these previous studies, we provided advisory support to Sydney Airport to identify a pathway to strengthen the airport's approach to climate change risk management, including trigger points to embed climate resilience in decision-making and assist the airport in its climate-related financial disclosures.

CASE STUDY

SYD

SYDNEY AIRPORT, GREEN STAR COMMUNITIES RATING MASTER PLAN

Sydney, Australia

As a trusted advisor, we have worked closely with Sydney Airport to develop the Sydney Airport 2039 Master Plan. Works included embedding sustainability in to planning and design through an integrated and innovative approach to cater for future expansion and airport needs in alignment with the Sydney Airport Sustainability Principles and Green Building Council Australia's (GBCA) Green Star-Communities rating. Through this work, the Airport was awarded a 4 Star Green Star-Communities rating, one of the first airports in Australia to do so. We also continue to support the airport in the analysis and reporting of Scope 3 emissions to maintain its Airport Carbon Accreditation (ACA) Level 3 status.

CASE STUDY

SFO

SAN FRANCISCO AIRPORT

San Francisco, US

San Francisco Airport (SFO) is seeking an accredited flood protection system to mitigate coastal and riverine flooding and remove the recently imposed Special Flood Hazard Area (SFHA) designation.

Although Federal Emergency Management Agency (FEMA) requirements were SFO's primary concern, AECOM's project also addressed the effects of sea level rise (SLR), including future projections for the years 2050 and 2100. To improve the airport's overall resilience, seismic improvements were included in the flood protection design alternatives. For SFO's shoreline structures, this included liquefaction and lateral spreading, as well as lateral deformation of the shoreline protection systems.

CASE STUDY

OAK

THE PORT OF OAKLAND

Oakland, US

The Port of Oakland retained AECOM to conduct a vulnerability assessment, prepare environmental documents for government compliance, develop improvement strategies, and design improvements for the existing airfield perimeter dyke at the Oakland International Airport for both seismic and flood conditions.

The objectives of the Perimeter Dyke project were to: perform a vulnerability assessment of the dyke in light of the threats posed by seismic events and climate change; develop improvement strategies to upgrade the perimeter dyke system to strengthen its seismic performance and secure FEMA certification of the dyke for a 100-year flood; and prepare conceptual designs and estimate the cost to upgrade the perimeter dyke.

After a successful first phase, AECOM also produced Environmental Documents (and an Initial Study/ Mitigated Negative Declaration to comply with the California Environmental Quality Act), as well as plans, specifications and estimates for the construction of the proposed improvements. We developed and evaluated 10 alternatives and three were identified as the most favourable, with conceptual designs and cost estimates prepared for these. Modelling and analyses were performed to demonstrate the effectiveness of the improvement concepts in reducing the seismic and climate change risks.

ORAT

SEAMLESS TRANSITION FROM PROJECT DELIVERY TO OPERATION

Operational Readiness, Activation and Transition Services (ORAT) is the comprehensive approach to managing the transition of a new service or facility from project delivery into active operations.

It is a recognised and proven approach that integrates the operational goals of an airport operator and its stakeholders into a single programme to seamlessly transition new products, services and facilities from project delivery into operations. ORAT combines project delivery and operational readiness activities into one plan that ensures that an airport can maximise its potential and return of investment from day one.

Our ORAT approach reduces overall time to market and ensures a predictable and sustainable outcome with effective and efficient operations. We have a successful track record of delivering large-scale projects while providing a safe, sustainable, and smooth transition from project completion through to facility operations. Our approach focuses on two key themes: creating the 'environment for success' – through connected leadership and governance, and creating the 'structure for success' - by adopting a proven ORAT framework and approach. Our experience is drawn from airport projects from around the world, including North America, Middle East and Asia.

Operational planning
Operational readiness
Activation
Trials
Transition

CASE STUDY

SAN

SAN DIEGO INTERNATIONAL AIRPORT

San Diego, US

We have provided project and construction management services for San Diego International Airport since 2006 and successfully completed several major projects. Our team is a stakeholder on the Activation Team who provide ORAT for the aviation department. The Activation Team has helped deliver the following projects:

- Green build — US$820 million LEED Platinum terminal expansion
- Rental car center — US$316 million, 2.1 million square foot facility
- Parking plaza — US$127 million 2,900 parking space garage
- Flight Information Service (FIS) project — US$229 million project to convert six existing gates to international swing gates and provide a 1,000 passengers per hour processing capacity

San Diego International Airport

CASE STUDY

AUH

ABU DHABI INTERNATIONAL AIRPORT, MIDFIELD TERMINAL COMPLEX

Abu Dhabi, UAE

As the Construction Management Agent (CMA) for Abu Dhabi International Airport's Midfield Terminal Complex (MTC) expansion program (see page 46), we have developed an ORAT trials strategy, approach and plan that is aligned to key construction and systems readiness milestones, which enables the progressive build-up of trials' scope, scale and complexity - ensuring all aspects of operations are thoroughly proven leading up to the airport opening date.

Our strategy is built on a trial methodology that introduced what could be done during construction to gradually increase confidence and capabilities. The methodology starts with the unit's 'Demonstration' phase, which focuses on product and linking systems to areas, followed by the 'Strips' phase, which connects the operation process together from facility, process, system and people. Finally, after the construction completion will be the 'Volume' phase where the trial will verify the end-to-end passenger journey emulating day of operation.

CASE STUDY

FLL

FORT LAUDERDALE-HOLLYWOOD INTERNATIONAL AIRPORT, NEW SOUTH RUNWAY AND TERMINAL 4 REPLACEMENT

Florida, US

As programme manager for the Fort Lauderdale-Hollywood International expansion (see page 51), we developed the commissioning guideline for the new south runway and Terminal 4 replacement and performed as a stakeholder in the ORAT process as an extension of client staff. The ORAT process supported the successful delivery of a complex phasing project to replace an existing 10-gate facility with a new 14-gate facility, while maintaining airport operations. Additional projects include a flight information service (FIS), Checked Baggage Inspection System (CBIS) and aviation department offices.

SOLUTION

OPERATIONAL READINESS EXCELLENCE

Worldwide

Operational Readiness Excellence (OREx) is our advanced information management for ORAT. OREx was developed collaboratively by AECOM to leverage our decades of experience to provide an effective management tool for ORAT. It is a comprehensive approach that focuses on delivering assets from construction and the activities required for an operational facility. OREx is easily tailored to the specific project needs of an airport owner or operator.

Key features:

- Increase accountability
- Efficiently utilise work breakdown structure to manage large and complex projects
- Track critical issues and overall progress
- Monitor actual versus scheduled performance
- Identify change events and integrate into project

CROSS-SECTOR SPOTLIGHT

MODERN CONSTRUCTION TECHNIQUES

It's no secret that the infrastructure industry is changing. The impact of technological advancements in recent years has been nothing short of transformative. With a widening infrastructure gap and productivity at a low, digital transformation is being hailed as the key to unlocking the power of integrated delivery, and accelerating the progress of the critical infrastructure that is essential to economic growth.

Recent advances in technology have brought new ways to optimise project delivery, increase productivity and create efficiencies throughout the design and construction process. By rethinking technology's role in how design, build and operate we are unlocking the best outcomes for our clients – better quality, greater reliability, faster delivery and the highest safety standards.

As well as utilising digital engineering solutions, visualisation techniques and harnessing the power of data, we're also embracing new construction techniques that are changing the way we build. Technologies and processes such as manufacturing, offsite construction, 3D printing and robotics have the potential to fundamentally change the way we build.

Modular construction

Site intelligence

Design for manufacturing and assembly (DfMA)

3D printing

CROSS-SECTOR SPOTLIGHT

DIGITAL LIBRARIES

With standard design components that can be used on multiple projects, our fabrication-ready digital libraries are streamlining project delivery.

In a traditional design process, where detail is added to design components throughout, components must be designed from scratch for each project, creating re-work as more precision is built into the design. Digital libraries allow the creation, storage and reuse of fabrication ready design components on multiple projects from the outset, dramatically reducing the time needed to design a building.

The use of digital libraries continues to create efficiencies in the construction phase. Standardized components, specifications and tutorials stored within the model help speed up construction and procurement and, where required, facilitate modular and off-site construction.

CROSS-SECTOR SPOTLIGHT

3D PRINTING

No longer a far-flung dream, 3D printing in construction is fast becoming a reality — and is set to revolutionize how we design and build.

In recent years, 3D printing has gone from gimmick to game-changer — from the manufacture of small objects, to its widespread use in the aerospace and automotive sectors. Using additive manufacturing techniques (extruding layer upon layer of material to create an entire element), in conjunction with digital engineering, it is now possible to 3D print construction components, and even entire buildings.

3D printing will improve the efficiency of the construction process, reducing the time from inception of an idea to its realization, improving site safety and reducing waste, increasing customization and reducing errors as design and fabrication become part of an integrated digital process.

CROSS-SECTOR SPOTLIGHT

MODULAR IN CONSTRUCTION

With the potential to speed up the construction process, provide better, higher quality buildings and reduce program and costs, modular, factory-made, buildings are an important part of our industry.

We are applying the technique to housing, education, healthcare and commercial buildings: creating manufacturing spaces for developing and testing prefabrication solutions, and, through our integrated design, fabrication and construction approach, delivering volumetric modular systems.

By optimizing off-site processes we know we can deliver better buildings. Material components adopted in the upfront design to ensure precision-engineered high-quality performance, and deliver sustainable, energy efficient buildings. And in a controlled environment many risks can be removed, so safety standards are raised, quality procedures can be enforced and design intent met.

CROSS-SECTOR SPOTLIGHT

SITE INTELLIGENCE

Site intelligence tools use artificial intelligence and machine learning to manage, measure and monitor projects by processing and analyzing real time imagery. 360 cameras and laser scanning autonomous robots advance the quality of our inspections, improve site safety and produce accurate insights into construction productivity.

Managing this data is a monumental task, so AECOM is developing an AI-powered web-and-mobile platform, called Capture, that brings 100-per cent accuracy to conventionally cumbersome, time consuming and subjective project management processes.

AECOM is also in the process of combining the components of these technologies into a new mobile app called Haystack. The app will push relevant material based on a worker's exact location on a construction site, whether that's three floors below ground or 55 stories above.

CROSS-SECTOR SPOTLIGHT

STUDIO H

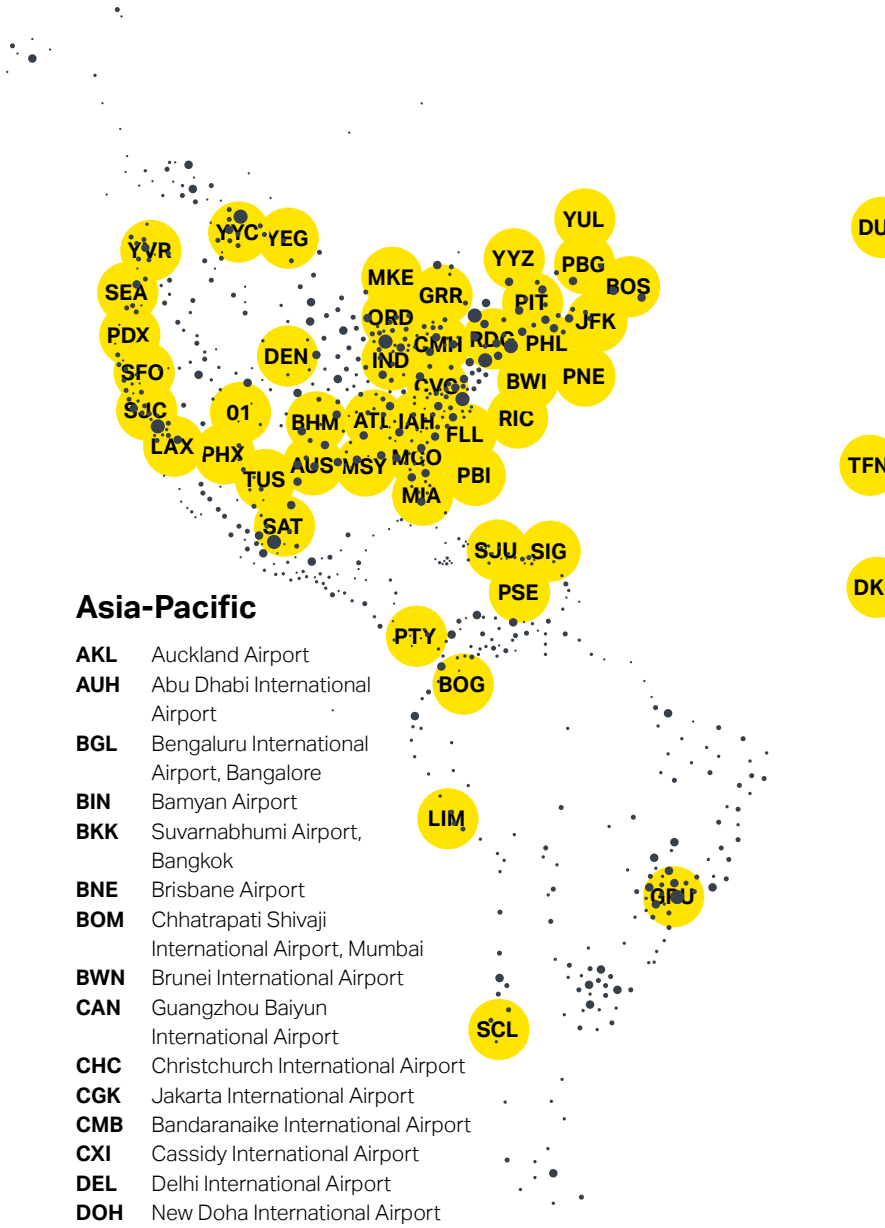
Indianapolis, Ind, United States

Faster, less expensive and improved delivery of patient care is not only life-changing, but life-saving. That's why AECOM Hunt's healthcare group created Studio H, a laboratory for testing and refining prefabrication and modular construction techniques for healthcare facilities.

Located within a warehouse in Indianapolis, Studio H is a collaborative space where AECOM construction and design professionals work with cutting-edge manufacturers to understand how different prefabricated elements fit together to improve the constructability of healthcare spaces. It's also a showroom where clients can see firsthand how modular and prefabricated construction benefits their projects, and a training facility for AECOM employees to learn how to optimize the installation of these components.

The benefits of prefabrication include reduced cost, better quality, improved construction schedules, enhanced safety performance and expedited delivery. Prefabrication can also be a remedy for local labor shortages. Since it was set up in 2015, the team has used Studio H to assemble and study many prefabricated building elements, successfully deploying them on a range of projects, producing results for clients such as UT Southwestern Medical Center's William P. Clements Jr. University Hospital in Dallas, Texas and Mount Carmel Hospital in Grove City, Ohio.

GLOBAL EXPERTISE

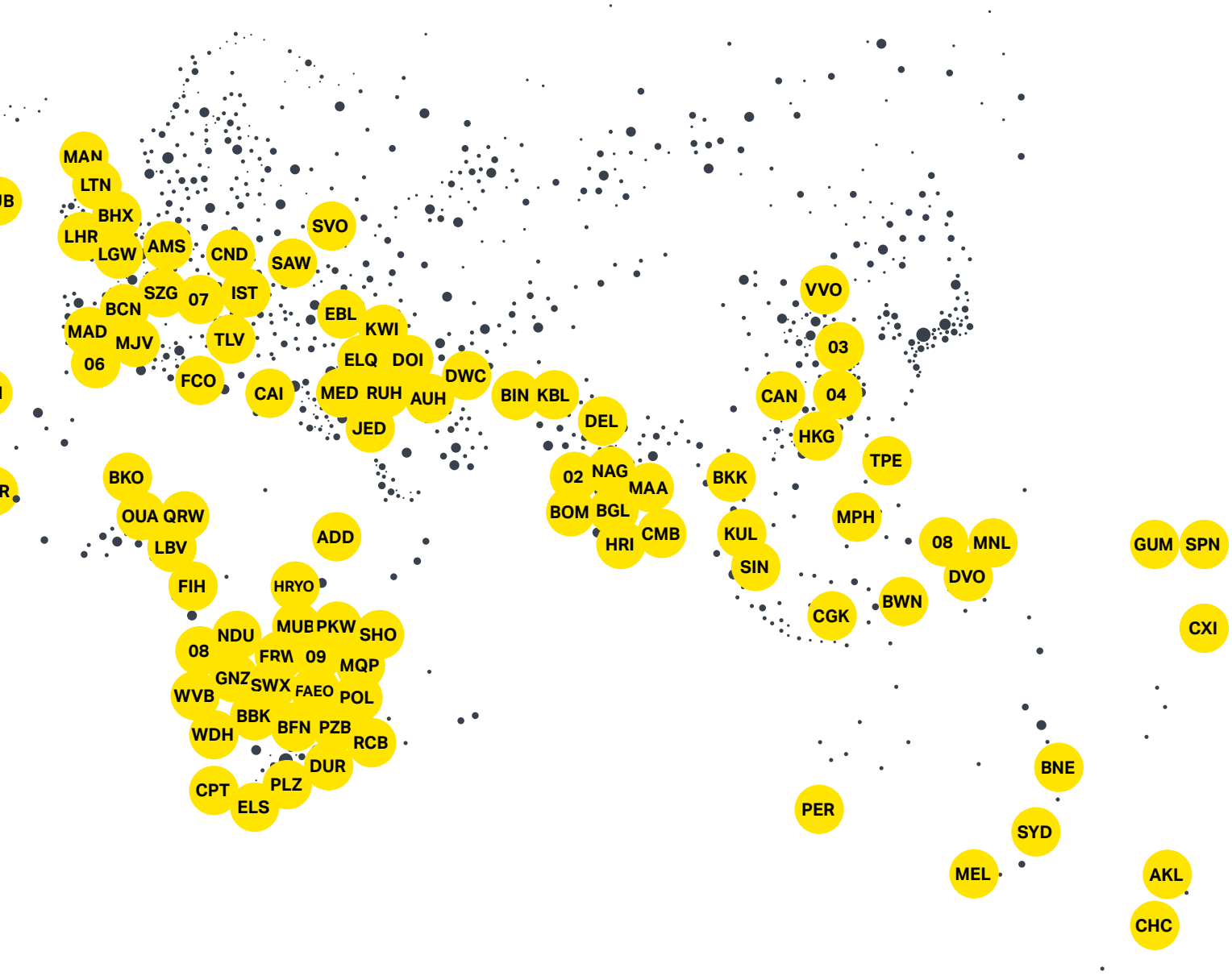


Americas

ATL Hartsfield–Jackson Atlanta International Airport
AUS Austin–Bergstrom International Airport
BOG El Dorado International Airport
BOS Boston Logan International Airport
BWI Baltimore Washington International Airport
BHM Birmingham-Shuttlesworth International Airport
CMH Port Columbus International Airport
CVG Cincinnati/Northern Kentucky Airport
DEN Denver International Airport
FLL Fort Lauderdale International Airport
GRR Gerald R. Ford International Airport
GRU São Paulo–Guarulhos International Airport
IAH George Bush Intercontinental Airport
IND Indianapolis International Airport
JKF John F. Kennedy International Airport
LAX Los Angeles Airport
LIM Jorge Chávez International Airport, Lima
MCO Orlando International Airport
MIA Miami International Airport
MKE General Mitchell International Airport
MSY Louis Armstrong Airport New Orleans
ORD Chicago O'Hare International Airport
PBG Plattsburgh International Airport
PBI Palm Beach International
PDX Portland International Airport
PHL Philadelphia International Airport
PHX Phoenix Sky Harbour International Airport
PIT Pittsburgh International Airport
PNE Northeast Philadelphia Airport
PSE Mercedita Airport
PTY Tocumen International Airport
RDG Reading Regional Airport
RIC Richmond International Airport
SAT San Antonio International Airport
SCL Comodoro Arturo Merino Benítez International Airport
SEA Seattle-Tacoma Airport
SIG Isla Grande Airport
SFO San Francisco International Airport
SJC San Jose International Airport
SJU Luis Muñoz Marin International Airport Capacity
TUS Tucson International Airport
YEG Edmonton International Airport
YUL Montréal–Pierre Elliott Trudeau International Airport
YVR Vancouver International Airport
YYC Calgary International Airport
YYZ Toronto International Airport
01 Spaceport America

Asia-Pacific

AKL Auckland Airport
AUH Abu Dhabi International Airport
BGL Bengaluru International Airport, Bangalore
BIN Bamyan Airport
BKK Suvarnabhumi Airport, Bangkok
BNE Brisbane Airport
BOM Chhatrapati Shivaji International Airport, Mumbai
BWN Brunei International Airport
CAN Guangzhou Baiyun International Airport
CHC Christchurch International Airport
CGK Jakarta International Airport
CMB Bandaranaike International Airport
CXI Cassidy International Airport
DEL Delhi International Airport
DOH New Doha International Airport
DVO Francisco Bangoy International Airport
DWC Al Maktoum International Airport, Dubai
EBL Erbil International Airport
ELQ Prince Nayef bin Abdulaziz International Airport
GUM Antonio B. Won Pat International Airport
HKG Hong Kong International Airport
HRI Hambantota International Airport
JED King Abdulaziz International Airport, Jeddah
KBL Hamid Karzai International Airport, Kabul
KUL Kuala Lumpur International Airport
KWI Kuwait International Airport
PER Perth Airport
RUH King Khalid International Airport, Riyadh
MAA Chennai International Airport
MEL Melbourne Airport
MNL Ninoy Aquino International Airport
MPH Caticlan Airport
NAG Nagpur Airport
SIN Changi Airport, Singapore
SPN Saipan International Airport
SYD Sydney Airport
TLV Ben Gurion Airport, Tel Aviv
TPE Taiwan Taoyuan International Airport
02 Navi Mumbai Airport
03 SF Express Air Cargo Hub Development
04 New Xiamen International Airport
05 New International Airport, Manilla



Europe and Africa

ADD Bole International Airport, Addis Ababa
AMS Amsterdam Schiphol Airport
BBK Kasane Airport, Botswana
BCN Barcelona Airport — El Prat
BHX Birmingham International Airport
BFN Bram Fischer International Airport
BKO Bamako–Sénou International Airport
CAI Cairo International Airport
CND Mihail Kogalniceanu Constanta Airport
CPT Cape Town International Airport
DKR Dakar international airport
DUB Dublin Airport
DUR King Shaka International Airport, Durban
ELS East London Airport
FAEO Ermelo Airport
FCO Rome Fiumicino Airport
FIH Kinshasa International Airport
FRW Francistown Airport
GNZ Ghanzi Airport
HRYO Gabiro Airport
IST Istanbul New Airport
LBV Libreville International Airport
LGW London Gatwick Airport, London
LHR Heathrow Airport, London
LTN London Luton Airport
MAD Madrid–Barajas Airport
MAN Manchester Airport
MUB Maun Airport
MUR Murcia–San Javier Airport
MQP Kruger Mpumalanga International Airport
NDU Rundu Airport
OUA Ouagadougou Airport
PKW Selebi-Phikwe Airport
PLZ Port Elizabeth International Airport
POL Pemba Airport
PRY Wonderboom Airport
PZB Pietermaritzburg Airport
RCB Richards Bay Airport
QRW Warri Airport
SAW Sabiha Gökçen International Airport
SHO King Mswati III International Airport
SVO Sheremetyevo International Airport
SWX Shakawe Airport
SZG Salzburg Airport
VVO Vladivostok International Airport
WDH Hosea Kutako International Airport
WVB Walvis Bay Airport
06 Moron Air Base, Spain
07 Greece Independent Engineers Services
08 New Libreville Airport, Gabon
09 Air Force Base Makhado

About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate critical infrastructure assets for governments, businesses and organizations. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A Fortune 500 firm, AECOM had revenue of approximately $20.2 billion during fiscal year 2018. See how we deliver what others can only imagine at aecom.com and @AECOM.

Airports and connecting transportation links are vital to the continued growth and economic prosperity of cities regions and countries. With demand for air travel set to double over the next two decades, more than 80 per cent of AECOM's 2018 'Future of Infrastructure' report respondents believe that the coming 10 years will be a pivotal time for civil infrastructure, including aviation, driven by disruptive technologies. Airports around the world need to modernise and expand to be ready.

AECOM is a global provider of technical services to airport owners, investors, airlines and aviation clients, leading and supporting programs for airports of all sizes and forms. Building on our global network of expertise and local knowledge, AECOM's multi-disciplined, skilled professionals are experienced in delivering integrated, collaborative aviation solutions across projects and continents, from finance and analysis to masterplanning, programme management, design and construction services.

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