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photo: Jewers Doors

Hangar design and construction

***Joanne Perry* finds out about the latest developments and trends in aircraft hangar design and construction, and how new concepts, techniques and materials can increase operational efficiency, environmental performance and safety.**

With no little fanfare this November, Monarch Aircraft Engineering (MAEL) announced major plans to expand its facilities at Birmingham International Airport, UK, with what the company says will be a "state-of-the-art" hangar incorporating "industry-leading design and build standards". The 110,000ft² facility is due to become operational in 2013 and will be able to handle widebody aircraft such as the 777, the 747 and the upcoming A350, having the capacity to house two 777-300ERs or 10 narrowbody aircraft simultaneously. The hangar will furthermore be the first in the UK to cater for 787 maintenance. The overall design will include multiple component repair and back shops and the expansion will be manned by a workforce of up to 300 personnel.

Mick Adams, MD of the maintenance, repair and overhaul provider (MRO), commented that the addition of the new facility to existing operations in London and Manchester will ensure that MAEL can provide customers with "a leading maintenance and repair service in key, strategically-important MRO locations across the UK". Meanwhile, the executive chairman of Monarch Group, Iain Rawlinson, described the expansion as a "signal" of the parent company's intent to drive the growth of its maintenance division.

A pragmatic means of housing aircraft during maintenance activities; a much-needed resource for carriers operating new aircraft types; a focal point for recruitment; a geographically strategic investment; and a symbol of success and hope for the future — a new hangar is all these things and more. But in 2012, what features of design and construction make a commercial aircraft hangar "state-of-the-art" and capable of facilitating the kind of activities which form the core of an MRO's business?

"We believe that several facility design features can promote efficiency in aircraft maintenance operations," says Ted Oberlies, SVP of engineering at architecture and engineering company Ghafari Associates, whose Aviation Group is based in Chicago. "From proper facility configuration to the use of natural daylighting, positive design relates to productive operations," he states.

According to Oberlies, the main objective when developing a new commercial aviation hangar is to create an environment which allows personnel to focus on the tasks at hand, eliminate workarounds and reduce the unnecessary movement of materials. Within this context, he says that a "significant efficiency enabler" is the matching of material handling and access equipment to the maintenance environment. Further operational improvements are gained by a design which reduces the upkeep of the building itself and enhances the comfort of the workforce. It goes almost without saying that an effective hangar design also promotes a high level of safety for the benefit of both the employees and the employer.

At Ghafari, the design process is enhanced by 3-D modelling software which enables the creation of virtual environments and the validation of the plans by clients. Oberlies describes such techniques as "clearly an advancement in design" and believes they will play a role in the future lifecycle management of capital facility assets. Ghafari is currently working on a major MRO facility in Saudi Arabia which will involve taking the project from concept to final design as well as supporting the construction consortium which is responsible for building the 550,000ft² complex.

Philip McNayr, principal at Oklahoma-based architecture and engineering company Frankfurt Short Bruza (FSB), names two key factors for increasing the efficiency of aircraft maintenance operations through hangar design. The first is the allocation of space immediately adjacent to the aircraft for the storage of components which are removed from the aircraft, including racks for seat sets and overhead bins. The second is the proximity of support shops to the aircraft servicing bay — "the closer the shops, the less travel time and less opportunity to misplace parts or components," explains McNayr.

For new hangar designs, McNayr lists the typical work scope criteria as follows: servicing bays; utility systems; overhead bridge cranes; fall-arrest systems; support shops; parts storage or warehousing; offices; shipping or delivery docks; aircraft ramp parking; and employee parking. Like other building types, hangars also need to be sustainable, with as small an environmental footprint as possible. Depending on the type and extent of the maintenance which is to be performed, McNayr says that the work scope "can vary from minimal to extensive aircraft maintenance support functions and systems". FSB undertakes renovations and repurposing projects as well as designing new hangars.

While fundamental efficiency, safety and environmental considerations obviously need to be met, Oberlies and McNayr agree that there is significant potential for customisation within hangar design and construction. McNayr says the client's budget is "the only real limitation" and that each hangar concept "usually contains specific design criteria that are unique to that particular customer". Recent special requests received by FSB were for aircraft hydraulic systems and variable height mezzanine-level support shops adjacent to the aircraft.

According to Oberlies, in commercial MRO there is not only "great potential" for customisation in hangar design but the demand for it, as clients are increasingly focused on matching their busi-

Oklahoma-based architecture and engineering company FSB says that work scopes for commercial aviation can range from minimal to extensive aircraft maintenance support functions and systems.

According to FSB, the efficiency of maintenance operations can be increased through two key aspects of hangar design: the allocation of parts storage space adjacent to the aircraft and the proximity of the support shops to the servicing bays.

> "The closer the shops [to the servicing bay], the less travel time and less opportunity to misplace parts or components."
> Philip McNayr, principal, FSB

ness plans as closely as possible to their facility investments, including equipment and support systems. "We typically receive requests for flexible environment design and application of newer technologies to promote productivity, consistency and safety in the workplace," says Oberlies. He adds that customers are also placing a higher priority on sustainable design, a policy which Ghafari supports in the knowledge that MRO hangars "tend to be legacy facilities" and "should be designed for long-term value and operational turnover".

Gordon Collins, director of marketing at Rubb USA, says there is "a fair amount" of potential for customisation of the re-locatable, frame-supported membrane hangars his company produces. Rubb uses hot-dip galvanised steel as the skeleton for modular, prefabricated structures which are bolted together on-site, in Collins' words "like a giant erector set". He explains that the structures are designed so that they can be lengthened or shortened as easily as they can be relocated; such adaptation and relocation capabilities come into play during projects such as airport modernisation. According to Collins, the PVC-coated membrane is also modular and attached to the structure "in manageable pieces" to form a weather-proof outer shell, able to be removed in the same way for transportation at a later date. "Essentially it's re-locatable without loss of material," he states. By contrast, Collins says that any attempt to relocate a typical pre-engineered metal structure with welded pieces will result in the loss of the roof at the minimum.

The largest hangar Rubb has built in this fashion is a 270ft-wide line maintenance hangar for AirTran Airways in Atlanta, Georgia, which can accommodate two 737-900NGs. The company is currently working on a similar size hangar for Hawaiian Airlines which is set to be used for A350-800 aircraft. Collins says the outer limit for the design would be a 300ft hangar capable of handling A380s.

Hangar conditions, safety and the environment

The physical conditions within an aircraft hangar, such as lighting, temperature and air quality are important for both operational efficiency and the wellbeing of the workforce. Collins believes that one of the big advantages of Rubb hangars, with their tensioned membrane ceilings, is that the translucent white material allows natural light to penetrate, reducing the need for artificial lighting, decreasing electricity usage and making the working environment

Radiant heating solutions from Schwank can assist cladding in maintaining the temperature of a hangar.

more pleasant. To the same end, FSB has also included translucent fabric in its designs in the form of hangar doors which allow diffused light into aircraft servicing bays.

According to Collins, hangar roof membranes are also effective at preventing excessive temperatures because, unlike other fabric shelters such as tents, the white membrane "reflects most of the light and heat from the sun". Conversely, it can be difficult to keep hangars warm enough. As pointed out by Steve Sherman, MD of heating solutions company Schwank UK, the induction of a large aircraft which has been left outside in low temperatures "can act like a gigantic ice cube, causing temperatures to plummet". According to Schwank, the opening of the hangar doors can also result in wholesale air renewal within 30 seconds. In order to complement conventional cladding in the structure of the hangar, Schwank therefore offers infrared radiant heating equipment which begins to restore the status quo within three to five minutes, with zonal targeting to save energy. Schwank has implemented such heating projects for EADS and Air New Zealand.

In addition to the design and material choices of the walls and ceiling, the hangar doors play a key role in controlling the internal environment. Jonathan Jewers, Esavian director at Jewers Doors, says that the weather sealing efficiency of the hangar entrance is "as important in particularly hot and dusty conditions as it is in extremely cold climates". According to Jewers, the newest hangar cladding materials successfully reduce air leakage and heat loss. "Developments in polycarbonate technology mean that these systems can now provide high levels of light translucency whilst still achieving good thermal properties and minimal solar gain," he explains. Jewers notes that energy efficiency is a "hot topic" which has "grown dramatically in importance" in recent years.

The management of hangar conditions is particularly important for painting operations and leads to special design and construction considerations, "primarily in mechanical and electrical building systems" according to Oberlies. However, there is considerable variation in the complexity of painting hangars. "Even today, the range of sophistication varies from open air facilities to the most environmentally sealed and controlled buildings," states Oberlies. He says the industry standard is a three-stage filtering of paint process air, with ventilation and air quality requirements incorporating temperature and humidity control

Equipment such as this teleplatform system from CTI Systems of Luxembourg facilitate access to the aircraft within the hangar. The CTI system installed at MNG Technic consists of four bridge cranes and four teleplatform units for painting aircraft up to 777 size.

as well as provision for air recirculation where permitted. Additional considerations relate to safety; fire protection systems must be able to suppress flash vapour fires and electrical systems are often classified for spark and explosion-proof operations. According to FSB's McNayr, it is also important to consider how slick the hangar floors may become with coating and painting products.

More generally, McNayr says that hangar safety planning must take into account appropriate building codes "first and foremost", plus: ground-based or suspended docks providing elevated access to the aircraft; catwalks or portable lifts which enable overhead building maintenance activities without damage to the aircraft below; fall-arrest systems which protect personnel traversing the aircraft wings or fuselage; and the efficacy with which burning fuel can be removed from the servicing bays.

Safety considerations also need to be factored into the hangar doors. Jewers explains that, as a minimum, all powered systems such as the Jewers Doors range must comply with exacting standards for industrial doors and that safety capability must apply in both normal operation and emergency situations. In fact, Jewers says that the evolution of hangar doors has brought innovations in control systems and that the introduction of wireless and industrial Bluetooth technology has enabled doors to be linked to building management systems, resulting in safety and security enhancements.

Since aircraft hangars must be situated in geographically strategic locations, it is necessary for their design and construction to offer some protection against extreme environmental conditions such as hurricanes. As Jewers points out, not only the overall structure but the doors need to be capable of enduring "exceptionally high forces" in severe weather conditions while still retaining integrity "in all aspects of their design". One only need consider the $235m insurance settlement required by Spirit AeroSystems this year for the repair of its Kansas facility to gauge the potential for costly operational disruption. Spirit's infrastructure sustained considerable damage during a tornado in April, although it did at least succeed in protecting the valuable production equipment inside. As regards freak weather, Collins notes that the repair or replacement of the membranes on Rubb's re-locatable hangars is "easily done and quickly done", meaning that the building is not lost to use for an extended period of time. He says that in the event of other incidents such as fires the "self-venting" membranes also help to minimise damage to the frame.

Oberlies is keen to emphasise that the safety of both hangar buildings and personnel "are not areas of compromise", irrespective of the fact that when attempting to achieve efficient yet safe and eco-friendly designs "cost remains a primary challenge". McNayr gives examples of scenarios where efficiencies and environmental considerations must be balanced against cost: firstly, the choice between convenient but expensive floor utility pits for aircraft connections and wall-mounted utilities which leave cables trailing across the floor; secondly, aqueous film forming foam (AFFF) may be distributed at floor grates or else overhead, which risks more foam reaching aircraft interiors. Regardless of the challenges, McNayr says that safety remains "paramount".

Developments and trends

The good news is that technology is moving on, and in terms of achieving modern, sustainable hangar environments, McNayr says that photovoltaic panels, ground source heat pumps and non-toxic fire suppression systems and agents are all now available to companies involved in the development of new facilities. As for the materials used in construction, he says that subtle changes in their types, strengths and properties offer greater flexibility in design, particularly in fire detection/protection systems and hangar doors such as the vertical lift fabric variety. Collins concurs that there has been no "great leap" in technology in terms of construction materials — "basically, it's steel". In terms of sustainability, though, Oberlies is "generally encouraged by recent progress in the construction material industry and its focus on eco-friendly products".

The most visible trend in hangar design and construction is the tendency towards larger buildings. "In the late '80s and early '90s, hangars were typically 140m wide and up to 23m high to accommodate two 747 aircraft side by side, which was the largest commercial jet," says Jewers. He explains that hangars have become wider in order to accommodate more aircraft simultaneously. The largest set of doors Jewers Doors has produced, for Royal Airwing in Dubai, featured immense dimensions of 584m by 25.85m and a track system with a radius of 1.26km. The company is currently working on a substantial project for Emirates Engineering, also in Dubai, involving four sets of doors to add to eight which were supplied previously.

Following the introduction of the double-deck A380, the world's largest commercial aircraft with a wingspan of 79.8m and a tailfin 24.1m tall, there was also — literally — an upwards pressure on hangar height. Jewers says that 26m-high doors thus "became the norm" for most Code F hangars. The company has supplied such doors for a four-bay A380 hangar for Ameco Beijing, which are not only 26.88m high but 350m wide. Oberlies says the A380 additionally requires special consideration for the floor loading, support systems such as preconditioned air and even the placement of hangars at airports where airfield restrictions limit infrastructural height. The introduction of new aircraft types also leads to increasingly mixed fleets and McNayr adds that this has resulted in a growing need for flexibility in the design of servicing bays.

Jewers Doors has noted an increase in business from the Middle East, and has supplied hangar doors to customers such as Qatar Airways and Emirates Engineering.

Considering the large size of many hangars today, it is fortunate that modern fabrication and structural erection techniques have "increased the speed, quality and safety in construction of large clear-span hangar roofs", as Oberlies notes. However, Collins says that in the uncertain economic climate of the past few years "cost has become a major concern" for many clients. Yet there are distinct differences between different geographic markets. Oberlies has observed a trend toward "conservative and economical" facility investments in mature markets like North America and Europe which stand in stark contrast to "aggressive and dramatic" investments in emerging MRO markets in China and the Middle East. Jewers, too, confirms that in the Middle East and Asia "huge sums of money" are becoming available for such endeavours and that the phrase being used increasingly frequently is "mega projects".