E-Enablement, big data analytics and internet-of-things programmes are developing at an increasing pace. These will deliver the potential to generate and analyse large quantities of maintenance-related aircraft data. M&E systems will have to evolve to keep up with these developments.

Can M&E systems fit into e-Enablement strategies?

The past few years have seen the initial development of big data analytics, the Internet of Things (IoT), and e-Enablement. When combined, these developments have the potential to allow airlines to improve the efficiency of hundreds or even thousands of elements of their operations. Although each improvement may only be small, the overall result of these combined efficiency improvements will be large.

Operations, and maintenance and engineering (M&E) are just two departments that will be affected by the introduction of the IoT and e-Enablement into an airline's processes and procedures. IT systems for these two departments have been designed and implemented as standalone systems, which reflects the silo nature of organising airline departments. However, implementation of IoT, data analytics and processing, and e-Enablement mean that M&E and operations IT systems will have to fit into an overall larger IT structure.

Technology developments

The first and underlying development is IoT. This allows all devices and computers used by an organisation to be connected for data transfer via the Internet. For an airline, the IoT for Aviation also includes all electronic flight bags (EFBs) and other tablet computers used by crew and various members of flight operations, maintenance, and ground operations departments.

"The first main benefit of the IoT is that an airline does not incur the high cost of developing and implementing its own network to connect all its devices," says Michael Bryan, principal at Closed Loop Consulting. "Companies, such as SITA and ARINC, have been the external network providers for airlines for several decades, but only for small portions of the overall operation.

"The IoT for Aviation will allow data to be transferred between all devices and all departments via the internet, negating the need for an internal network," continues Bryan. "The IoT for Aviation will be completed by a rapidly growing number of sensors on the aircraft and within other areas of the airline, and by e-Enabling connectivity systems and the internet. This evolution is driving the IoT for Aviation, which forms the whole basis of big data analytics and e-Enablement."

e-Enablement

Integrating and linking an airline's entire data, devices, systems, departments, standard and defined procedures, and data analysis and processing is the e-Enablement of its operations. "By linking all departments and processing data, this provides actionable intelligence, which is used to improve the efficiency of process," explains Bryan. "The large quantity of data generated is made possible by the IoT. The use of IoT and e-Enablement requires a shift from the traditional approach of developing separate IT systems for each department, and keeping each department independent and in a silo."

If e-Enablement is achieved, it will allow the development of system-wide information management (SWIM). A SWIM approach requires an industry-level sharing of specific data that can be integrated across airline departments.

SWIM may also include automatic data analytics, which allows the near-instant use of data to make management decisions. "An important and far-reaching characteristic of the IoT is the change in the way that content will be generated. Traditionally, content and data on the Internet have been created by a person," says Paul Saunders, solution manager at Flatirons Solutions. "In the case of the IoT, content and data will be generated and put onto the internet automatically by a component or a device. In the case of aircraft and airline operations, an example would be failure or performance data generated by a smart device. These data may then be processed for another device, or used after a short time by another device or a system."

Data analytics

The next main element of combining the IoT and e-Enablement is processing and analysing aircraft data. This includes big data analytics *(see Big data analytics: are airlines entering a new era of operations? Aircraft Commerce, February/March 2016, page 28)*.

"Data analytics across an entire airline's operation is driven by an e-Enablement strategy and provides large volumes of data from thousands of parameters," says Bryan.

"By creating algorithms, the data generated by these smart devices can be processed as soon as it is received," says Saunders. "Data processing can then trigger other events. This replaces the traditional systems used by airlines that involved a lot of manual intervention, in particular the reviewing of data, such as reporting and recording technical defects and malfunctions on an aircraft through the aircraft's technical log. Traditional paper-based processes involve duplicates of paper records being passed to multiple departments and offices, including flight operations, line mechanics, line maintenance and maintenance control, as well as sub-departments in the M&E department, such as rotable inventory. If a replacement component is required, the IT system will record its removal and replacement.

"When each department receives the paperwork, human intervention is needed and action has to be taken," continues

The 787 is an example of a new generation aircraft that is e-Enabled. It generates a larger volume of health monitoring and system performance data from a larger number of sensors than previous generation aircraft. If analysed and processed correctly, the data can be used to derive a large number of efficiency improvements.

Saunders. "Human intervention is required in virtually all cases before another step of the process is performed, so there is a pause and delay at each step of a process. If all of the steps in an established procedure can be replaced with the automatic transfer and receipt of data, followed by its automatic analysis and processing, then human intervention will be reduced to almost zero, reducing the time taken to complete a procedure. Errors will also be reduced or eliminated. This requires all steps of every standard process an airline goes through to be linked electronically.

"The overall result is that an event, and the data that is generated by it, can be acted on immediately," says Saunders.

Analytics can be automated to a degree. Automation requires careful consideration and structuring because it has not previously been possible to automatically process thousands of different types of data sets. Completely e-Enabling an airline's management structure and operation involves automating thousands of analytical processes, and has to be done piecemeal.

e-Enablement programmes

E-Enabling an airline and implementing the IoT is a strategic and holistic event across the airline. To date, airlines have only had a small portion of their operations e-Enabled. Examples are transmission of engine health monitoring (EHM) data from aircraft to trend and health monitoring systems. The main providers in this sector are engine original equipment manufacturers (OEMs). Engine OEMs have their own systems to capture some of the main engine parameters. In the case of most airlines, these data are transmitted to the ground via aircraft communications and addressing and reporting system (ACARS), and then processed for engine management purposes. This activity is siloed from the rest of the airline.

Some e-Enablement programmes have been launched in recent years for isolated departments or sub-departments. These do improve efficiencies, but all events and procedures taking place ultimately overlap with others. e-Enabling part of an airline's operation, therefore, effectively ring-fences it from the rest.

"There are now a lot more sensors on the engine, so there are a lot more data to be processed," says Bryan. "The data can be downloaded post-flight, and a lot more parameters can be processed and analysed. This is now in the realm of big data analytics, and many of the systems are built by the OEMs. An example is General Electric's Predix system.

"Even though more information can now be analysed, the IoT for Aviation, and for an airline, does not yet exist," continues Bryan. "The current systems only mimic the IoT. While there are several of an airline's systems that are connected to the internet, the aircraft is not yet connected. Aircraft data are either transferred via ACARS into networks provided by companies such as ARINC and SITA, via Ku-band satcom connectivity in a minority of cases, or via on-ground wireless systems. These are all proprietary systems, and they are not I.P. networks, which is the basis for the IoT. Moreover, a lot of data is sent to and from airline databases via a series of standalone proprietary networks."

Airlines, therefore, need to change their philosophy in order to fully realise the IoT. This only requires determination, since investment in new infrastructure is not needed. Airlines will have to develop new processes and channel different data sets, so it will be difficult for airlines to adopt all of their systems.

e-Enablement organisation

An airline's e-Enablement structure can be envisaged as three main layers. The top layer is the connected aircraft and its ecosystem, together with the EFB ecosystem.

This top layer will feed data down to the second layer, which is the analysis of data. The data analytics layer of the e-Enablement organisation and structure will receive data from the aircraft and EFB, which are the prime sources for much of an airline's data, and also from reservations and passenger-handling activities.

The bottom layer of the organisation is the IoT, the connection and network between all the data sources.

Different IT systems and networks have been implemented by various departments, including flight operations and M&E systems. These systems overlap the second and third layers. Data pass to the flight operations, M&E and other systems from the aircraft for data processing and analysis. The data can be passed on to other departments where appropriate, and then back to the aircraft and EFB ecosystem from the flight operations and M&E systems.

"The problem with initial e-Enablement systems is that they cater for just one department," says Bryan. "They are also technology- and not system-based, so on their own they do not provide specific business outcomes. E-Enablement has to be viewed and created holistically by the airline and the industry as a whole. The implications of this are that existing M&E and flight operations systems will now have to be developed so that they integrate with the rest of the airline's e-Enabled structure."

The incorrect approach is for the airline to ring-fence the current network that is the EFB/ETL, the aircraft ecosystem, the data inputs from the aircraft, the flight operations system, and the M&E system.

M&E systems

Contemporary M&E systems, whose development began at least 15 years ago, are ring-fenced in their design and deployment. They have not been designed to integrate with the rest of the airline. These systems are not suitable for inclusion in an airline's holistic e-Enabled system and infrastructure, so considerable bespoke development is required.

"The first part of an airline's e-Enablement process is related to new generation aircraft," says Wayne Enis, director of sales engineering at Flatirons Solutions. "The main consideration for M&E system operators and developers is management of new generation aircraft, and aircraft ecosystems. With a traditional process, components that malfunctioned on an aircraft were physically removed and replaced by operable units. New generation aircraft have on-board computers with a high degree of capability. This includes taking over the functions of physical components in earlier generation aircraft. Many aircraft components are software on the computers of new generation aircraft, so they can now be changed via a software update. Each software piece even has a part number (P/N), as do the physical components of legacy aircraft. Since software can be updated remotely and wirelessly, there is no longer a need even to touch new generation aircraft. The software components are known as loadable software aircraft parts (LSAPs).

"The old system of replacing hardware was also complicated by each aircraft's status with respect to airworthiness directives (ADs) and service bulletins (SBs)," continues Enis. "That is, the component P/N that was allowed on the aircraft depended on its AD and SB status. Different P/Ns had to be kept for the different aircraft and sub-fleets operated by an airline.

"The same issue applies to new generation or electronic aircraft," continues Enis. "The problem is that M&E systems may have problems monitoring these issues with respect to LSAPs. The 787 and A350 in particular cause these problems."

Another issue is that different sections of an airline's organisation and parts of the aircraft can talk to each other electronically by exchanging data. The aircraft can talk to ground-based systems operated by the airline, and vice-versa. This is one step towards e-Enablement.

e-Enablement will eventually replace ACARS, which carries a limited amount of data. Instead of sending a few hundred kilobytes of selected health monitoring and flightdeck data via ACARS, hundreds of gigabytes of data can now be transferred from the aircraft via groundlink connectivity systems of WiFi or cellular networks. In the future more non-safety-related flightdeck data will be transferred via broadband satcom link to an airline's ground systems.

The IoT for Aviation means that thousands of sensors on the aircraft can generate data relating to hundreds and thousands of operational parameters. This means there is now a huge ability to trend performance and operational data. The main issue from now will be how to process these data into useable knowledge. "The data will have to be processed almost immediately, since it will be generated constantly," says Enis. "The data will also have to be interpreted constantly, hence the need to e-Enable the airline and have big data analytics in place. There are literally thousands of correlations and relationships."

To make e-Enablement happen, airlines will need to generate a huge network of connections. Universal data standards will also be needed, as well as a lot of data-processing capacity.

The main objective of using all these data is to carry out predictive maintenance by analysing the large quantity of component data to indicate how components and systems are affecting each other, and when individual parts are likely to fail, or if it is advisable to remove them. "It will be possible to stipulate when a certain maintenance activity should be done," says Enis. "This will differ from maintenance events being governed by intervals stipulated in the maintenance planning document and approved maintenance programme. By monitoring small changes it may also be possible to get marginal gains in intervals."

Using the IoT for Aviation and big data analytics, an e-Enabled airline will be able to achieve a hollistic network for every aircraft, all portable devices and every desktop computer in its organisation. This will ultimately lead to big efficiency improvements. A lot of data being processed is maintenance-related and from the airline's fleet. M&E systems will have to evolve to be part of this new network.

M&E system development

The first implication of these issues is that M&E systems in the future will have to ingest larger quantities of data than they currently do. Second, the M&E system will have to process the data, so it will need to be programmed with all the necessary algorithms. The third step will be that M&E systems will have to make informed decisions with the processed and analysed data.

This raises the issue of whether M&E systems will have the data and the big data processing and analytics taken away from them. Several OEMs have already developed and set up big data analytics systems, including General Electric's Predix. Rolls-Royce has recently announced a collaboration with Microsoft, and Pratt & Whitney a collaboration with IBM. The OEMs, therefore, have an ability to use the data.

There are a lot of opportunities for IT suppliers and vendors to offer services for developing algorithms and data processing. These can be standalone systems that interface with M&E systems, or new developments within the functionality of M&E systems.

Brendan Viggers, product and sales support at IFS, says that M&E systems will still be used to provide governance over the maintenance of an airline's fleet.

"The problem is that if M&E systems cannot participate in this future method of managing aircraft maintenance, then they face a real prospect of dying out," claims Enis. "It remains to be seen how many of the current M&E systems can develop this way. One possible development path will be for M&E systems to co-develop with an airline that has access to this data."

Viggers expects that analytics systems are unlikely to develop to the point where they can perform all the functions of an M&E system. He, therefore, expects big data analytics systems to interface with M&E systems. M&E systems will have to use the processed data to perform prognostics of anticipating systems and component malfunctions. They will, therefore, have to be connected to the airline's e-Enabled network. M&E systems will also have to develop where there is less human interaction. e-Enablement means an existing M&E system could have its functionality upgraded more easily. IFS has made it possible for a customer to develop its own version of IFS via modifications to suit its own requirements, such as adding extra fields to a purchase order.

One big project involves Emirates, which is in the process of developing a big data project with its M&E system vendor Ultramain. "An analytics service will definitely be required for an M&E system to fit into an airline's e-Enablement programme and the IoT for Aviation, and overall new process for managing maintenance in the future," says John Stone, vice president for product management at Ultramain. "The recent version of Ultramain already has the system architecture to go after global data. This takes data from anywhere, processes them, and triggers certain maintenance actions. Aircraft and processed data can be used to create work orders, issue instructions and several other processes, so a new data schema in the M&E system would allow all of this to happen automatically. Moreover, system customers can set up new data channels in their own way. This will allow them to design automatic processes, according to their own, rather than a generic, way of operating.

"Because the IoT for Aviation is already developing so quickly, the system architecture was developed so that the IoT could operate universally," continues Stone. "Ultramain will need the ability to take data from anywhere and have it conform to Ultramain's native data structures. That is, the way that Ultramain operates with it. It should even be possible to operate with data when Ultramain does not know what the received data were. Ultramain will also need to be able to pump out data that can be universally used by all other external systems. This has been done over the past two years by developing our V9 version of Ultramain. The new system architecture is going into service with three new operators: two maintenance providers and one airline, all with an e-Enablement strategy."

Stone explains that in the past projects to turn a maintenance process or a facility into a paperless entity failed because it was not known how to deal with all the data that was generated. "This is being solved by making the paperless and e-Enablement processes capable of handling data from a large number of outside sources," says Stone. "This is made possible by Ultramain having an integration architecture, so that data can talk to all levels of external systems. This requires all the systems to have the same standards and protocols to speak with all other systems. Two examples of data protocols are REST and JASON. In the future, M&E systems will all have to speak the same interface languages. This could make it difficult for M&E systems to catch up and keep pace with the shift to combined paperless and IoT of Aviation. This development is going to happen fast."

Stone expects to see a rise in third-party data analytics services, and that these will be systems that can interface with airlines' M&E systems. Stone also predicts the development of specialist sensors. An airline will need to have a system that can use all the data, rather than large quantities going to dead ends and not being acted upon. AC