How the implementation of machine learning (ML) is being used to match hand written ATA fault codes to detect reoccurring and repetitive aircraft technical faults. CaseBank Technologies' ChronicX system provides a solution for airlines using traditional paper-based fault reporting.

Eliminating the problem of repetitive aircraft technical defects & faults

A commercial aircraft generates about 140 maintenance items per month in the form of technical faults that occur during operation. This means that an airline with a fleet of 200 aircraft produces almost 1,000 new records daily. In the case of many airlines, some of these technical faults are recorded manually by crew members and line mechanics via paper technical logs. About 40% of paper entries will be poorly categorised due to inherent weaknesses in the system.

All technical faults must be reported, usually first via a technical log, and then transferred into the airline's maintenance & engineering (M&E) IT system, before a work order is prepared and sent to the relevant department so that a fix can be executed. To manage the volume of reports, an Air Transport Association (ATA) code is used to identify which system has the problem.

Reporting faults starts with the ATA numbering and chapter system. This is a common referencing standard for commercial aircraft documentation. It permits greater ease of identification and reporting for pilots, aircraft maintenance technicians and engineers.

The different physical parts, components and systems on the aircraft are described using the ATA chapter system. Each ATA chapter has two digits: chapters 21 to 57 for the aircraft systems, and chapters 61 to 85 for the engines.

The chapters include the more complex systems: communications (23), avionics and instruments (22, 31, 34, 42 and 45), electrical power (24), electricals (39), pneumatics (36), hydraulics (29), fuel (28), pressurisation and air conditioning (21) and flight controls (27).

The less complex items are airframe structures, included in chapters such as the aircraft's interior furnishings and equipment (25), fire protection (26), cargo compartment (50), doors (52), fuselage (53), stabilisers (55) and wings (56).

All systems, components, structures and sub-structures on the aircraft are described using a system of multiple pairs of digits. The location or identification of each item are described by using the ATA chapter as a prefix. A fuel transfer pump, for example, in the aircraft's fuselage will be described with a number starting with 28-. Subsequent digits will give a more detailed description of the item.

The ATA chapter system is also used to help describe a fault.

Types of fault

Some technical faults and defects are those detected by components' built-in test equipment (BITE), and so generate fault codes that are reported by the aircraft's central maintenance computer (CMC). Fault codes use several pairs of digits, and the prefix is the ATA chapter of the related system. CMC fault codes are generated for monitoring items on the aircraft with sensors and BITE. This will help line mechanics and engineers to record, locate and diagnose the fault.

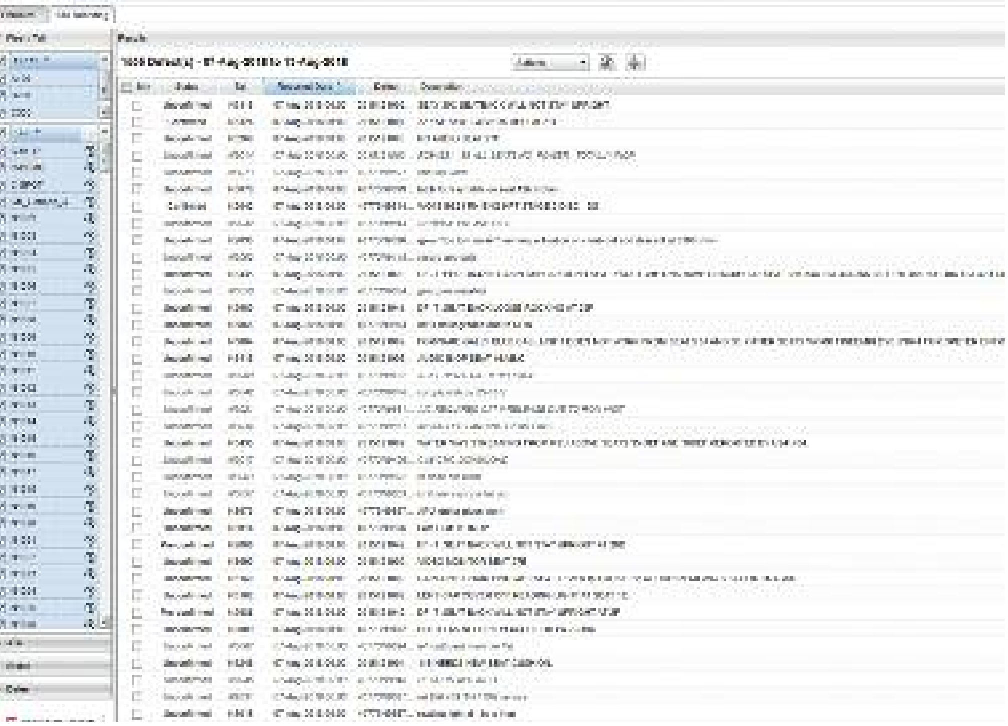
Obviously, many parts of the aircraft cannot generate CMC codes, particularly the cabin and airframe structures, so line mechanics or crew members need to manually write descriptions of the problem during turnaround times between flights. ATA chapter 100 is a standard for writing documents, and contains the reference to the ATA chapter numbers.

Entering the ATA coding is required of the technicians and mechanics when reporting defects. Furthermore, there are legal requirements for aircraft operators to log defects pertaining to major aircraft system faults in ATA format. All faults are recorded in a maintenance logbook chronicling the many defects that occur during the aircraft's operational life.

The fault code is associated with a system, which has an ATA code that is thereby associated with the fault. The fault code may or may not have an associated title and is unique to the aircraft. It can be alpha-numeric, numeric, or any other combination. "BZ", "042", and "B1-004932" are all valid fault codes from different systems. For example, a mechanic can say "this engine reported fault code B1-004932 ("THRUST REVERSER FAIL") in chapter 78-30 yesterday". The code and its title will normally be transcribed by a mechanic or crew into a technical log entry identifying the system (first two digits), and sub-system (second two digits).

The four digits are split into pairs. The first pair, the prefix, is the ATA chapter to which the fault relates, and the second pair is a sub-chapter of the title. Examples are 21-10. A fault recorded with a prefix of 21 relates to chapter 21 which is the air conditioning system, while 10 relates to its compression system.

There are, however, several inherent problems with this manual process, and these lead to errors in reporting. Experienced mechanics may be able to recall the first two digits from memory, as well as many of the pairs of second digits



CaseBank Technologies' ChronicX will identify two or more faults reported under different ATA codes that relate to the same fault. It is possible to analyse defects at an individual aircraft level or at a fleet level.

in the ATA chapters. For example, they will know 27-51 relates to the aircraft's flight controls (Chapter 27) and flaps, while 34-43 relates to navigation (Chapter 34) and the weather radar.

However, because there are a large number of ATA code combinations, it is impossible for mechanics to remember all of them, so codes for lesser known faults can often get recorded incorrectly.

A paper look-up sheet that lists ATA type codes and subsets enables the identification of a component or system. Typically, an airline's check-sheet will include about 150 ATA subsets. These are usually the most commonly occurring faults. An aircraft, however, will have in excess of 7,000 subsets listed in the operator's maintenance library.

An inherent problem is that the check sheet will not list every single ATA code. The mechanic will often be unaware of the downline implications of incorrectly reporting a fault, and the associated importance. His focus will be to dispatch the aircraft on time. Paper data entry slows this down.

The drawback to using the ATA coding system is that it becomes difficult to identify, report and record defects at a granular level, especially in the aircraft's cabin area where there are many fixtures and fittings, but subset codes are not well known. Many mechanics will know that ATA chapter 25 relates to the cabin, yet many are unlikely to know the sub-set for the toilet door latch, for example. The problem is compounded because many of these lesser known faults will not be included in the mechanic's check sheet.

Recording a defect for a cabin seatback display switch, for example, could be described as 25-00, as easily as it could be logged as 25-20. The end result is that the defect reports will not have ATA codes at a detailed ATA subset level. Analysis of the resultant data in the M&E system is bound to produce less than optimal correlations.

If two or more faults with identical ATA codes are correctly entered in an aircraft's technical logbook over a short period, technicians recognise this as a repeat defect and prescribe remedial action.

Operational considerations

Once the mechanics have logged the defects, the details have to be transcribed from the paper log by manually inputting them into the airline's M&E system.

Normally there is a delay before this is done, ranging from one hour to two days, depending on the airline. Some operators will do all the data entry when the aircraft returns to its main base.

The problem is aggravated by the time taken by technicians in maintenance control to identify ATA defects that are incorrectly logged. It is not uncommon for correction of these errors to take 30 days if they are identified. Delays and errors in getting correct information into the M&E system hinder the repeat defect identification process and the calculation of reliability statistics.

When a technical defect is reported, the mechanic's number one priority is to fix it and despatch the aircraft as quickly as possible. If they must repair the aircraft, they will likely call the back-office, or go back to the office and start troubleshooting the problem.

Typically, the troubleshooting manual (TSM) or fault isolation manual (FIM) in the M&E system that the mechanic uses to fix the problem will recommend installing the most likely component to resolve the defect based on fleet data.

Ultimately, airlines experience the problem of repetitive faults. An aircraft typically flies several flight sectors to different airports, with different line maintenance crews, in a day and over a period of several days. Repetitive faults occur for two main reasons.

The first is that recording aircraft defects via a paper system typically means the aircraft has flown at least two or three flight sectors before the M&E system has been updated. In fact, it can be several days before a fault has been entered. Many will have already been fixed by the mechanic several hours or days before appearing in the M&E system.

The second main reason is that some of these faults will inevitably have been incorrectly recorded, because the incorrect subset of the ATA code has been entered into the report. The fault will therefore be incorrectly diagnosed and fixed.

The fault will then reoccur on a later flight and be dealt with by another mechanic at a different airport. This mechanic will be unaware of any recent defects the aircraft has recently had. The fault will then be reported differently, possibly using a different ATA code subset. This could be correct or incorrect.

The situation therefore arises where the same fault occurs several times, but a different ATA code is reported each time. This makes a single fault appear to be several individual faults.

Guided by the TSM and FIM, the mechanic will go through the exact same process of elimination to solve the repetitive problem. Using the fault elimination process in the TSM or FIM can often result in the same component being changed.

The TSM/FIM process cannot contain every possible cause of a problem, so it focuses on the most common ones. This works well about 70% of the time, but the rest of the time it gives the wrong recommendation and leads to a repeat defect on the aircraft and an NFF test result on the incorrectly removed component.

The average cost of an avionics component, for example, can be $80,000. The process of repeatedly changing parts blindly to rectify a recurring fault will be expensive.

NFF results in wasted costs incurred for transport, logistics and inspection.

Diagnosing repeating defects using the traditional system of referring to the FIM, can mean that there could be four or five fixes and component changes before analysts at maintenance control identify a repeat fault.

Clearly, if operators can avoid removing that component through better initial fault reporting and diagnosis, then fewer inventory parts will be needed, partly because the incidence of NFF is lowered. Repetitive faults will continue until they are correctly identified by the maintenance control department. It will schedule a more thorough repair at the nearest available opportunity.

ChronicX® by ATP CaseBank, can bridge the gap between the inconsistent reporting of faults and defects in the aircraft's technical log by mechanics, and the information that gets entered into the M&E system. This gives an airline the ability to dramatically improve aircraft reliability.

ChronicX

ChronicX is a standalone software system that has been developed by ATP CaseBank. Its main purpose is to perform textual analysis of maintenance logs to identify repeat defects, reducing the importance of ATA coding in performing this task. A recent secondary function is the ability to determine and assign the correct ATA code to a defect record. The value split is about 80% for identification of the repeats, and 20% for improvement of the ATA classification.

According to CaseBank research, technicians incorrectly tag ATA codes relating to faults about 40% of the time. Maintenance control corrects 90% of these later after an extended period, while the remaining 10% are left undetected.

ATP CaseBank, chief technology officer, Mark Langley says: "Working to only about 60% accuracy means that 40% of defects are not flagged correctly to maintenance control because the problem has been reported under incorrect ATA chapters."

Incorrect defect reporting poses problems for M&E systems, which typically rely on the ATA code to identify repeat defects. An incorrectly coded defect can lead to two problems. First, the repeat defect is not identified when it should be because one of the defect records is incorrectly coded. Second, a false positive is triggered where the incorrectly coded defect is grouped with a second, entirely unrelated defect, due to matching codes

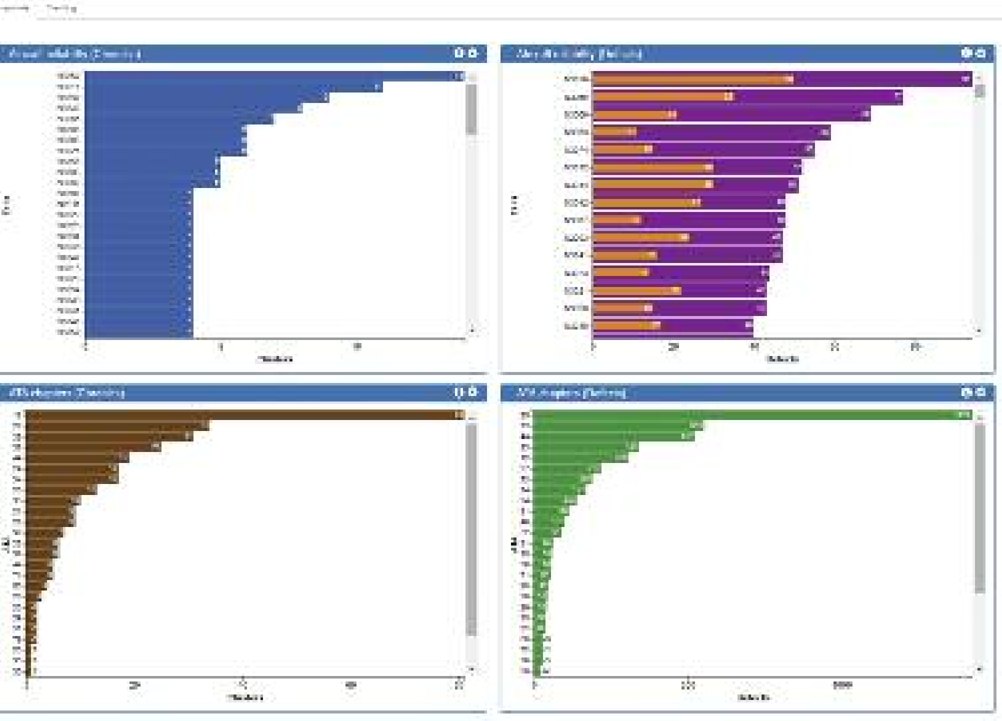
The ChronicX system works by analysing and matching written text from the maintenance logbook report. Similar descriptions of a fault written by different line mechanics can be used to help match two faults that were entered using different codes. The system does this using natural language processing (NLP). By amalgamating linguistics and artificial intelligence, NLP analyses and categorises large amounts of natural language data.

ATP CaseBank has developed its NLP libraries to be optimised to work with the text that is generally found within maintenance records.

"Historically, academic researchers have developed NLP algorithms around large amounts of structured text that is typically pulled from media headlines, such as the New York Times. Therefore, traditional NLPs are designed to work with structured traditional English text," says Langley.

The language and text-abbreviations that feature in aircraft technical logs are too specialist for traditional NLPs to recognise and understand.

"Manually written maintenance logbooks contain very short text that is full of line mechanics' abbreviations and mis-spellings," says Langley. "Line mechanics are professional maintainers, not typists, so it can take them a long time to type out the record. Also, it is not uncommon for mechanics to do what they can to abbreviate the content."



ChronicX can provide the user a series of dashboards. These can the most frequent defects, defects per ATA chapter, defects per aircraft, and bespoke reports.

Implementing machine learning means that ChronicX can expand its own library of aviation-related acronyms, abbreviations and synonyms. The more the system is used, the better able it is to identify and match defect records, even if their ATA coding is incorrect.

According to Langley the implementation of recording synonyms is important because many words will otherwise be missed by working on raw text alone. To this extent, synonym replacement means that equipment with many colloquial names can still be identified and matched.

ChronicX can also identify records that have been logged but have no relation to repetitive faults. An example of this are tyre checks. "Airlines do tyre checks all the time based on the number of landings. We do not need to highlight, for example, 40 routine tyre issues to the airline each day," says Langley.

Much of the development of ChronicX includes interior items, and an understanding of the geometry of the aircraft.

"If you are talking about an outage, perhaps the loss of electrical power with the inflight entertainment system (IFE), in one instance you have got an outage being reported at seat '27B', yet another outage log records a defect relating to the whole seat row '27A-C'," says Langley. "ChronicX will understand that there is a problem with the group of seats A to C, yet it will identify that seat B had a fault twice. So a repeat fault is detected, even though seat B was not mentioned in the second log."

ATP CaseBank has put a lot of intelligence in the system. As a result, users say they can identify several faults as a repeat issue in a fraction of the time it used to take.

As the system represents a marked improvement in finding repeat defects, one of the benefits of using it is saving maintenance control analysts' time. This is time that would be used to match faults that were incorrectly entered as being different to each other, when in fact they were repeats of the same fault. This means they can be tasked with other important fleet maintenance issues.

Ultimately capturing repeat defects earlier leads to better on-time departure times, because faults are being addressed earlier, consequently reducing delays and flight cancellations.

Predict faults

Maintenance control analysts look for many things, such as fleet-wide issues. If a part is frequently failing across an entire fleet, it is possible to customise alerts and notifications for aircraft that have not yet been affected. By recording the recurring fault behavioural patterns from the afflicted aircraft, ChronicX can recognise the symptoms of an impending failure. This is a further benefit of the system.

"A system that is degrading and beginning to fail, will often start to perform intermittently. Therefore, if a part is repeatedly failing and not performing to specification, it is possible that it needs to be replaced and inspected," says Langley. "It is common to see intermittent problems that repeat many times over the course of a month."

ChronicX will work either as a standalone service or by integrating it with other maintenance and engineering IT solutions. Normally, airlines use it via a secure FTP site that they use to upload the maintenance records and files. ChronicX will ingest these on a regular basis to update the application and allow the data to be viewed via an Internet portal.

"If a repeat defect is picked up in the ChronicX system, we display it and optionally send out a notification. This enables the defect to be checked by maintenance control," says Langley.

Maintenance control can then analyse the issue and if they agree, they can raise the required work order to get the defect resolved. Alternatively, ChronicX can feed the notification directly into the users' M&E system to automatically create a work order.

The parameters for the alert can be set to the maintenance control analysts' requirements to best match the nature and urgency of the fault. Alerts can be configured for an aircraft type, specific ATA chapters, defect text, etc.. – as well as to time periods and the number of reoccurring failures over a given time.

Alerts are sent out via a messaging system to a targeted number of personnel in engineering and line maintenance. The alerts advise that ChronicX has detected an issue and provide all the needed details.

"Some of the bigger airlines have departments with many people reviewing and correcting ATA errors in fault reports," says Langley. "ChronicX is now driving accuracy via machine learning, from the hand-written fault descriptions, to what the ATA codes should have been when faults were entered by the mechanics. From there, we detect the repeats and issue the custom alerts, rivalling what the subject matter experts in a reliability group can produce."

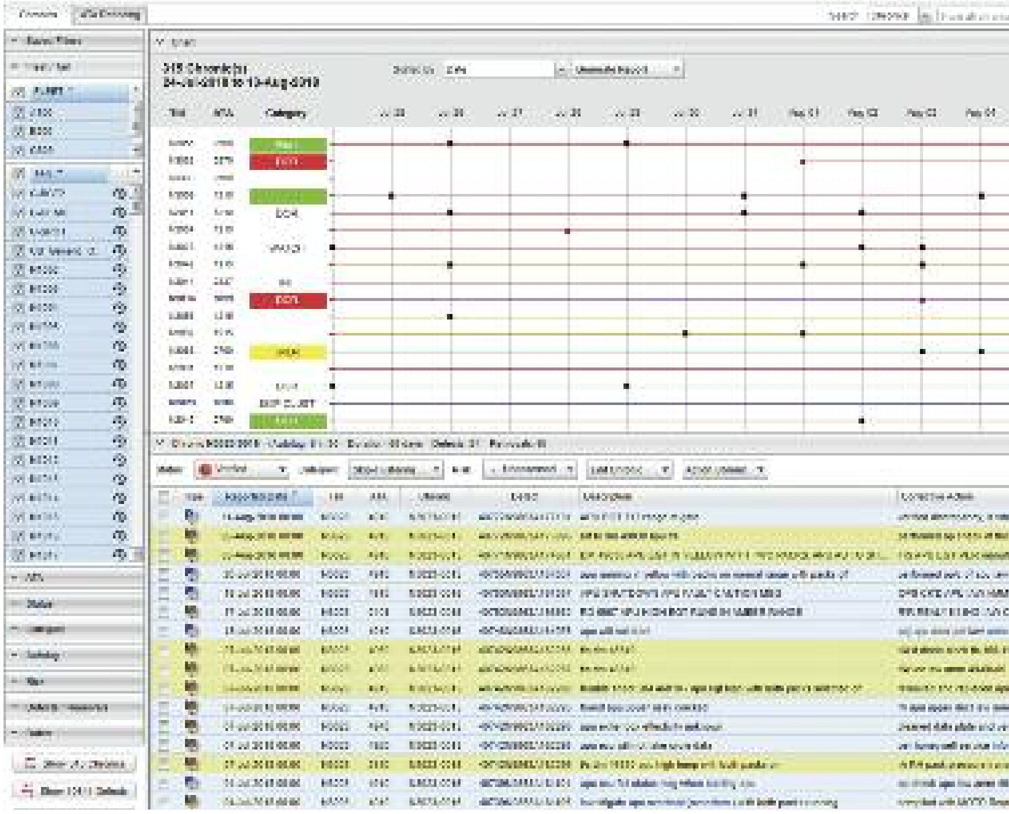
Airline applications

Under a traditional fault reporting system, an airline will wait for a technical logbook to come in under a traditional fault reporting system. Before it can do anything with the information, it has to be processed into the M&E system.

The process requires data to be downloaded into an Excel spreadsheet, or ingested into an Access database. Only after the data has been formatted, is it possible for technicians to analyse it and check repeat maintenance occurrences.

ChronicX refreshes an M&E system six times a day, every four hours with the

It is possible to analyse the despatch reliability rate of an aircraft and determine the most dependable aircraft in a fleet. Therefore it is possible to pick the best aircraft for service.



latest technical records from the maintenance logs. An airline operator can set how frequently the M&E system is updated.

ChronicX's million-word dictionary for aircraft maintenance is constantly evolving. "There are so many examples of recording a level-one anti-ice," says Langley. "The fault can be spelt by line mechanics in many different ways, but ChronicX can detect the differences, package them together, and send an alert to the maintenance department. This ensures that nothing is missed."

As an example, it is possible to type in 'spoiler plus synonyms' in the search function to find any types of fault written up about spoilers against a tail number over a certain period.

It is possible to feed ATA matches back into ChronicX. This allows the system to learn, and become accurate at recognising, erroneous ATA inputs.

Another example is that an issue with an aircraft's anti-skid system can easily be overlooked, because it is possible to think that a tyre has simply skidded. ChronicX makes it possible to notice any concurrent ATA fault codes pertaining to the anti-skid system, so that the repeated defects are a tell-tale sign that the anti-skid system is failing.

Parameters for alerts can be set to the airline analysts' requirements that best match the nature and urgency of the fault. Alerts can also be configured for an individual aircraft type, time period and the number of reoccurring failures.

Another advantage of ChronicX is having fleet data dashboards. These give an overview of the number of defects each aircraft in the fleet has had. This helps the engineering and fleet management department look at the status of the aircraft in its control.

It is possible to look at all areas of a fleet and see how it is performing, and which areas maintenance needs to drill into. By drilling down to a tail number level, it is possible to see how individual aircraft are performing and their state of health.

By analysing the fleet's health it is possible to have a higher possibility of dispatch. The system allows an operator to select an aircraft with a good maintenance status for service. By analysing accurate repetitive fault trends, it is possible to accurately pick the most reliable aircraft in the fleet.

The system automatically sends notification e-mails to the maintenance control department. These can be sent to smartphones.

The system can be used to set an alert. For example, several gallons of hydraulic fluid can be put into an aircraft, but without any reports of a leak. The need for hydraulic fluid can reoccur at a later turnaround. A custom alert is therefore set, and the maintenance team can be notified to investigate a possible leak. A faulty hydraulic line may then be found.

Unscheduled maintenance always causes challenges around the world. Using ChronicX to highlight repetitive faults allows airlines to better plan and resolve aircraft defects.

There are additional trend charts with good information on the statistics that ChronicX is providing.

The notification system allows maintenance control to have advance warning of a repetitive defect that they might have otherwise not noticed. It is possible for maintenance control personnel to create customised alerts.

Customised alert notifications can be based on individual key words or phrases. If an issue needs to be monitored, maintenance control can enter a key word or phrase that pertains to it into ChronicX. In future if a repeated issue matches this key word, an alert notification will be sent to maintenance control.

Key word notifications do not need to be associated with a repeat fault. It is possible to set up an alert for any defect on any type of fleet of aircraft.

ChronicX has a risk-ranking function to enable users to rank aircraft defects as low, medium or high. This is fully customisable, so an airline has the choice to categorise defects that have been highlighted by ChronicX according to their own operational requirements.

Airlines are able to use their own unique terminology with ChronicX.

The solution has a reporting suite that enables users to analyse fault data within the fleet. The reporting function makes it possible for users to create their own bespoke fault reports that include data parameters that are insightful to the user.

Using the reporting function enables users to share important data in a standardised format that can be customised to include insights that are relevant to the user.

The all-defects view includes defects that have been written up by aircrew and maintenance departments. ChronicX is able to identify write-ups that are actions that are not related to repetitive defects. This could include maintenance check sign-offs or other routine events.

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There are some additional trend charts that provide good information on what is going on with the statistics that Chronic X is providing. AC