Using Big Data to Improve Pilot Training and Aviation Safety

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No one disagrees we can still improve aviation safety despite the excellent record we have. Getting there, however, is the problem as illustrated by the fact that the needle with respect to training has not moved to create meaningful safety improvements. That means we need to examine how we change that.

Aviation is no stranger to using Big Data as evidenced by FAA's development of the Aviation Safety Information Analysis and Sharing (ASIAS) in 2007 using safety data and information across government to identify emerging systemic safety issues. But its development has been hampered and, according to the U.S. Department of Transportation Inspector General, it still lacks the predictive capabilities and dissemination of analysis needed to effect safety improvements. While ASIAS has grown with the inclusion of data from 41 airlines – 99% of air carrier operations – there remains no robust process to prioritize analysis requests. ASIAS sources includes important information such as data gleaned from Flight Operations Quality Assurance (FOQA), Aviation Safety Action Program (ASAP), Air Traffic Safety Action Program (ATSAP), Mandatory Occurrence Reports, Digital Flight Data, ATC Voice Data, Surveillance and Weather data, and data from National Flight Data Center. The agency expects to make incremental enhancements leading up to 2025 when its predictive capabilities will be available.

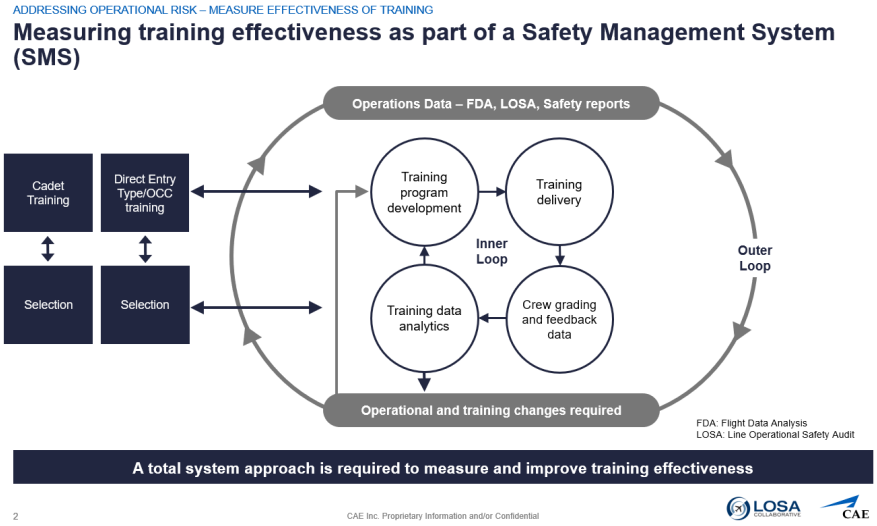
The timeline means industry must develop other sources to improve safety in any number of areas but specifically in pilot training. What we have found is, with the adoption of new, powerful tools, we can dramatically improve pilot training by using data to identify weak areas and the current human centered evaluation of competencies. In other words, Big Data and Artificial Intelligence can pave the way for the future.

Using data, of course, is all part of an Integrated Safety Management System (ISMS) with which we are all familiar and applying it to measure training effectiveness is an integral part of a successful ISMS. This solution enhances that system by incorporating the ISMS risk-based mentality into pilot training. These are the lessons learned by CAE from its broad-based experience from ab initio, business aviation and commercial airline training at its 60 training centers worldwide, which train 135,000 pilots per year.

We know it is either the OEM, the customer or the regulatory authority that drives the training program. The OEM, in cooperation with regulators, develops the footprint is traditionally followed. The airlines overlay their Advanced Qualification Program which is a significant undertaking based on a job task analysis approach and not necessarily a risk-based approach. Some operators call this evidenced based training which also has a regulatory specific application and definition in some parts of the world.

However, by using Big Data to develop both micro and macro adaptive learning programs, we can move that needle. Micro Adaptive Learning tailors the courseware to the individual's learning style. It is an algorithm measuring what they missed or what their competency is and how fast or slow they

accomplish a task. The Macro Adaptive Learning examines the overall data coming from various sources including the learners to identify problem areas.



The system is driven by two data loops – the inner loop and the outer loop. The Inner Loop, data derived from training events, includes the training delivery data, crew data as well as training analytics data that looks at things like repetitions to proficiency and the pass/fail rate of the training development program.

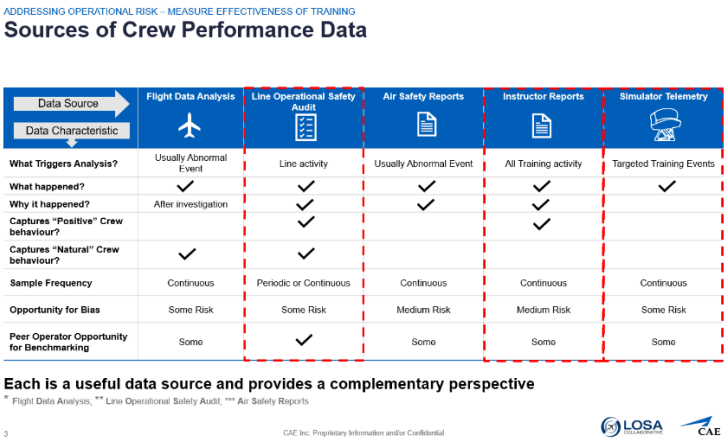
The Inner Loop is then connected to the Outer Loop – data taken from the flying environment or what we learn from daily operations. This data includes flight data monitoring analysis, line safety audits and voluntary safety reports which determines what we know from flying the line. This data informs the operational and training changes required. Complementing this is demographic information derived from cadet training and selection information and Direct Entry/OCC training. In short, we are taking a total systems approach required to measure training effectiveness and to improve it along with aviation safety.

The benefit of this approach is it replaces training through fear – the threat of being washed out. Instead, we use an improvement approach – focusing on identifying deficiencies in a positive way and which ultimately incentivizes the learner to do better. Learners are already highly motivated and tapping into that can help develop better pilots. If you show them their own the data, through self-discovery, they will be motivated to improve. It shares with them crew performance data and what the characteristics of doing it right are. You simply have them examine their micro data and put it into context with the macro data so we may facilitate improvement.

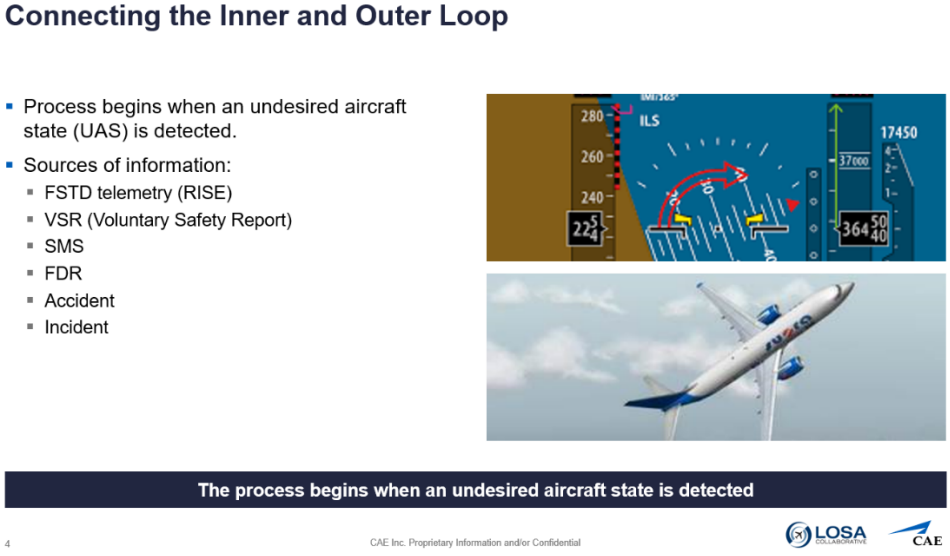
“Your test results show you are in the 88th percentile of proficiency in this maneuver so you did well,” says an instructor well versed in facilitation. “What will it take to get into the 90s?”

That is the positive way to change behavior. Using Big Data and AI helps you motivate pilots to do better. They are not competing with other pilots they are competing with themselves to improve the way they fly.

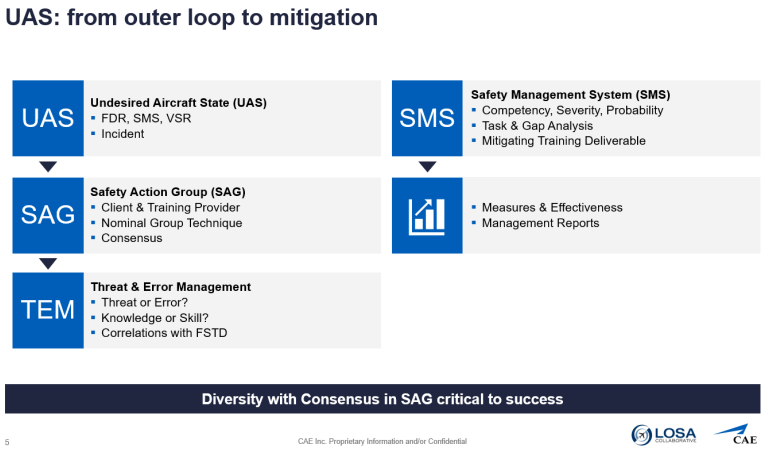
There are five different buckets or channels of information that paint the picture. While each one is important the actionable insights come when they are aggregated to tell you what is going on. These channels include Flight Data Analysis, Line Operation Safety Audit (LOSA), Air Safety Reports, Instructor Reports and Simulator Telemetry. They are triggered by an Undesired Aircraft State (UAS) and help determine what happened, why it happened, while identifying positive crew behaviors. Factored into this is the sample frequency and the opportunity for bias. We think we are moving to a continuous sample frequency as some airlines are already pioneering this. Bias is always there, but some media carry greater risk for bias than others. However, by examining all the information in an aggregate way, bias can be mitigated to provide a better picture and a complementary perspective of what the information from all the different sources is telling us.



Another value proposition is the fact that analyzing data helps operators compare and benchmark their training program with others. Many airlines have been audited so it is possible to compare information. Operators can compare the strengths and weakness of each area of data. As with putting a learner's performance into context, this system puts one operator into context with the rest of the industry, providing operators motivation to improve.



One fundamental of connecting the Inner and Outer loops is looking at the UAS which comes from the simulator telemetry (CAE Rise), voluntary safety reports, ISMS, flight data monitoring or an accident or incident. Detecting the UAS is the beginning of the process and must be accompanied by a process to find an effective mitigation.



This process includes the creation of a Safety Action Group including the client and training department or third-party training providers, operations safety, and training program development. The mission of this nominal group technique is to develop a consensus on what and why it happened and what to do about it.

Was it a threat or error? Was it a knowledge or skill in play? Data from other sources, especially the training device or simulator from the inner loop is then correlated to determine the competency in question, the severity of the problem and the probability it will happen again. Using a task, threat, error-and-gap analysis, the Safety Action Group must then determine the mitigating training deliverable. Specifically, how does the operator train pilots going forward so the risk is minimized as much as possible.

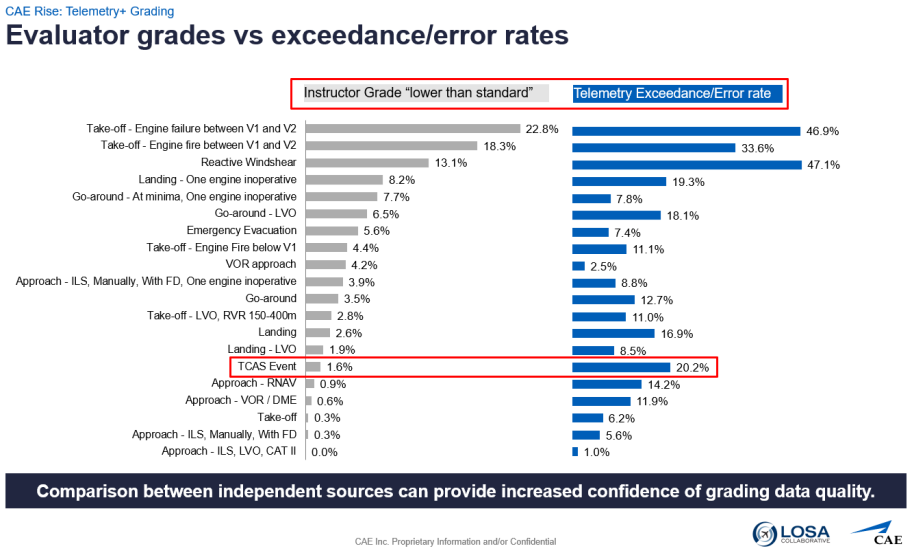
Finally, the group establishes the measures and effectiveness of what the training changes need to be and then delivers stakeholder reports so the effectiveness can be constantly monitored.

The most important factor in this process and the reason for having all the stakeholders at the table is to provide for thought diversity – the ability to look at the issue from different perspectives to establish a mitigation that take all factors into consideration.

Data can also identify issues with human evaluators by comparing what the telemetry tells us with human analysis of what happened, why it happened and what to do about it.

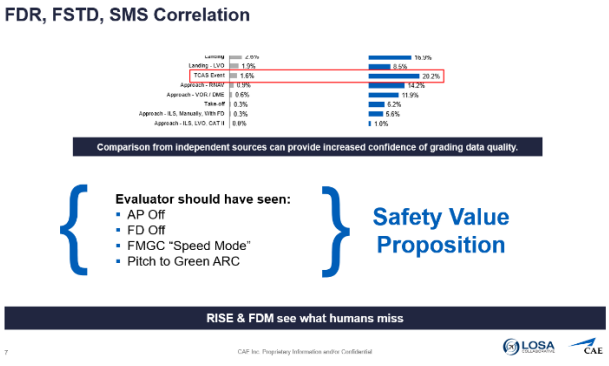
Let’s take a TCAS event as an example. Here we see the instructor graded the pilot with a less than satisfactory response 1.6% of the time. But the telemetry data – primarily from the simulator – graded the performance less than satisfactory 20.2% of the time. The big question here is why. Why is one data

source so significantly different than another? By comparing the data between independent sources, we can increase confidence in grading quality driven by data rather than human judgment.



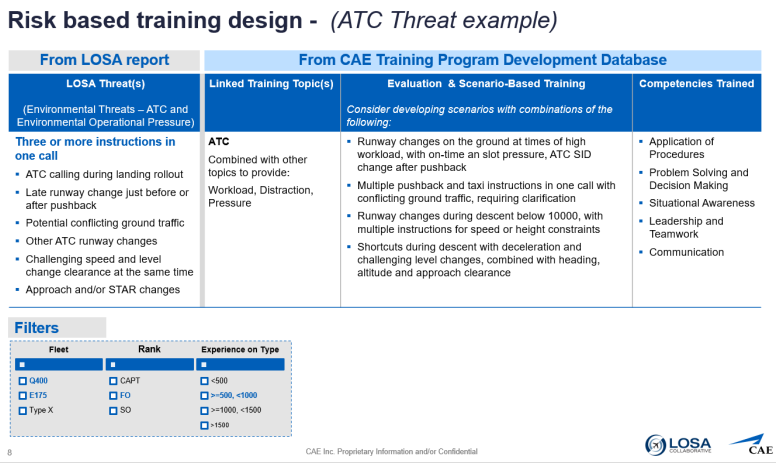
Drilling down a little further found the instructor missed critical information the machine caught. The instructor should have seen the autopilot off, flight director off and the flight guidance defaulted to speed mode when the flight director was selected off. The flight crew should have pitched the airplane up or down into the green arc.

It is very likely the evaluator saw autopilot off and the pitching activity by the crew into the green arc on the TCAS escape guidance or vertical speed indicator. Investigating more closely we found the crew failed to turn flight director off and failed to verify the flight guidance went into speed mode. This particular aircraft is an Airbus and, with auto throttle engaged with the flight director, the airplane did not go into speed mode and the auto throttle system fought with crew input into the side stick controller during the TCAS Resolution Advisory Escape maneuver.

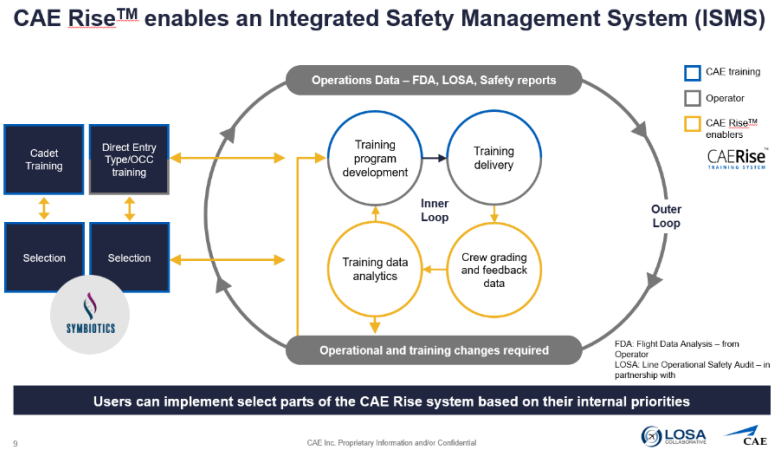


The bottom line is data often see what humans miss.

Once the analysis of what happened and why using the data from all sources is completed, the Safety Action Group can contemplate the mitigation. In this case we see an ATC threat example. We can also see from a LOSA report the actions the courseware developers performed linking the data to the training topics and entering the information into evaluation and scenario-based training. Frustratingly, telemetry captures mistakes but does not provide a record of positive crew behavior, but LOSA gives you the most complete look at the data to identify positive behavior because it looks for specific competencies for the crew to resolve. This would complete the process up until the continuous measurement point.



So here we are back at our original Inner/Outer Loop only this is more colorful denoting how the system works. The gold colors are data or data enablers being exchanged in various parts of the process. The gray color is the responsibility of the operator to provide data and to participate in the process. Finally, the blue is something the training system – in this case CAE training – provides.



We also have a new Symbiotics logo on this chart, an important part of the equation. It is a psychology test instrument used where a lot of data is collected. It enables us to look at cadets and entry-level pilots and their demographics and biases to see how it affects both the training and outcome data.

Users can select whether they want to use parts or all of the process depending on their internal priorities. But Big Data – operations data, flight data recordings, LOSA data, voluntary safety reports coupled with the inner and outer loops can be leveraged to improve the training system, make it more efficient and improving the safety outcome. That's what it takes to move the needle.