

Flight Test Safety Fact



FLIGHT TEST SAFETY
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Chairman's Comments: A Common Taxonomy for Risk

Tom Huff

When this edition hits your inbox, the Society of Experimental Test Pilots (SETP) 63rd Symposium and Banquet will be in the books. I contemplated holding off on discussing the event until November, but I thought it worthy to mention recent recognition bestowed upon one of our members, Ms. Barbara Gordon of U.S. Naval Test Pilot School. Barb is a rotary and fixed-wing staff instructor (government civilian) as well as the Director of Safety at the school. We have recognized Barb Gordon and LT Mark Hargrove of USNTPS as the 2019 recipients of the Tony LeVier Flight Test Safety Award. Their tremendous contribution to safety at the schoolhouse and within NAVAIR was evident in the award package, and it will have been an honor to recognize their accomplishments with the Society and members of the LeVier family. I just didn't want to wait to share this news, and the timing was perfect considering Barb's other accolades in this issue.

I'd like to return to the topic of risk management (RM) in flight test. You may recall that this was the subject of the 2018 Flight Test Safety Workshop in Dallas. During the tutorial, I suggested that source documents such as the FAA Risk Management Handbook and FAA Order 4040.26B differ in defining what constitutes a hazard versus a risk. I encourage you to see the Workshop podcast [here](#) (21:23), as I won't go into detail. It appeared that we have a common tendency to conduct hazard analyses by entering the safety event flow at the consequence and declare that the hazard.

For example, consider an identified hazard of "ground impact" during an asymmetric store Vmca (minimum control speed, airborne) test. Would you agree that this is a future, catastrophic consequence of something that occurred further upstream and wasn't sufficiently controlled? Order 4040.26B characterizes the ground impact as an effect. Somewhere along the way we lost control (Loss of Control Inflight or LOCI), perhaps due to high beta-rate buildup, too slow an airspeed, etc. Not going too far off the reservation here for those that have done this type of testing! I submit "LOCI" is a better hazard and meets the FAA definition of "dangerous condition" as well. Excessive beta-dot, airspeed decay, or too high an AOA would be in the causes column of the analysis with appropriate mitigations targeted to each. It's worth mentioning that there are differences between the FAA's and other international regulatory agencies' view of these definitions. This is more a concern for those living in the FAA Part 5 "approved SMS" world but nonetheless, it serves as a launch pad for my next soap box, the need for a common taxonomy for aviation safety risk RM.

(continued next page)

Gordon and Grandstaff earn US Army's Broken Wing Award at USNTPS

Congratulations to [Barb Gordon](#), a civilian rotary wing instructor at the USN Test Pilot School (TPS), and Chief Warrant Officer 3 [Sylvia Grandstaff](#) (then) a student at the USN TPS, both SETP members, who accepted the US Army's Broken Wing Award. According to [the Navy press release](#): "Highly regarded and rarely awarded, the Army gives the Broken Wing to aircrew who have minimized or prevented loss of life and aircraft through outstanding airmanship during inflight emergencies. Gordon's award marked the first time the Army presented the Broken Wing outside of the service." The brief story is harrowing, and I hope Gordon and Grandstaff present a more detailed talk at a future symposium. [According to the Army](#): "During the single-engine test technique with one engine at idle, the helicopter suffered failure on the opposite engine. [The crew] had less than five seconds to recover the aircraft and experienced rates of descent between 9,000 and 12,000 feet per minute. According to the investigation, the mishap would have been catastrophic if not for the immediate actions by Gordon and then student Grandstaff."



U.S. Naval Test Pilot School rotary instructor, Barb Gordon, the Navy's first to receive the Army's Broken Wing Award, prepares for a performance flight demonstration in the same UH-60L Black Hawk she successfully recovered during what would have been a catastrophic ground collision on a demo flight with an Army test pilot under instruction. Gordon received the highly regarded and rarely awarded honor during a ceremony June 6 at Patuxent River, Maryland. (USN photo)

Flight Test Safety Committee

Tom Huff, Chairman

chairman@flighttestsafety.org

Society of Flight Test Engineers

edir@sfte.org

Society of Experimental Test Pilots

setp@setp.org

Contact *Flight Test Safety Fact*

Mark Jones Jr, Editor

mark@flighttestfact.com



Chairman's Comments (continued)

Why am I suggesting that standardizing our approach—especially in flight test—might be beneficial? I guess I would counter with “why is it advantageous to be different?” Let me start with some terms that I see in flight test RM in planning—“alleviation” and “minimization.” To me, alleviation is better suited for medicine (related to pain) or traffic congestion solutions. Minimization and mitigation are commonly used interchangeably, but what are we minimizing, the probability or consequence or both? Many can't really say which, and frequently these “minimization procedures” aren't directly tied to a hazard CAUSE. In all, I submit that these ill-defined and non-standard terms only muddy the waters and don't enhance the ability to thoroughly IDENTIFY HAZARDS and MITIGATE RISK during flight test planning. Also, during the 2018 Workshop tutorial, Pat “Oxy” Moran did a wonderful job walking through several examples to reinforce a repeatable and effective method to conduct RM. He strongly suggested: “tell the story,” making a logical progression through the safety event flow. Once mitigations are exhausted and safety control is lost, we then shift focus to preservation of life over saving the air vehicle (read well-defined Emergency Procedures). In the end, our goal is to implement mitigation solutions and strategies such that residual (post-mitigation) risk is as low as reasonably practicable. If we had a common taxonomy, wouldn't sharing RM results across our community benefit all? How about the ability to better adapt the THAs from the Flight Test Safety Database to your planning efforts? You do use it in planning, don't you? Let us know what you think. Launch an air mail to chairman@flighttestsafety.org.

Tom Huff, Chairman

Training for Tomorrow's Flight Test –A Limited Survey of Flight Test Education

According to widely accepted [projections](#) from [multiple sources](#), the demand for aircrew of all kinds of aircraft will increase significantly in years to come. Currently, the industry is already feeling the demand surge and resultant shortage. Changes in demographics also affect the turnover and longevity of flight test professionals in the workforce. These trends, along with the diversity of aircraft entering the market and technological innovations like artificial intelligence, will certainly influence the way we educate and train flight test professionals for years to come. This month, we highlight several sources of flight test safety training and education.

The first example is [Florida Institute of Technology \(FIT\)](#), led by Dr. Brian Kish, a retired US Air Force (USAF) Flight Test Engineer (FTE), USAF TPS graduate and former instructor, and SFTE member. In 2018, FIT partnered with Eglin AFB to provide short courses on site. According to the [press release](#), “The first Eglin students for this short course were Air Force officers, an Air Force civilian engineer and flight test engineers from Gulfstream Aerospace Corporation.” FIT also offers courses at the university's Extended Studies Site in Patuxent, Maryland. Kish plans to partner with the FTSC's Tom Huff to develop a graduate level course on Hazardous Flight Test. The course “examines planning and execution of hazardous flight test. Includes case. Covers the flight test safety review process including the development of general minimizing procedures as well as test-unique hazard analyses. Includes demonstrations of control room equipment and protocols.” FIT welcomes input from readers on improving its course material.

The SFTE Tech Council (TC), led by [Al Lawless](#), has worked up a well-received webinar series reviewing flight test mishaps, material that anyone could review for refresher training and annual briefings. Each has been [posted on the SFTE website](#). The TC conducted three webinars earlier this year and plans a fourth at 12:00 EDT on October 16th. The TC always invites new content for this effort. For questions or contributions contact Al or any TC member.

Two more examples appear in this limited survey. Col Doug “Beaker” Wickert, PhD, has taken the reins as the Department Head of the Aerospace Engineering Department at the US Air Force Academy: He describes the undergraduate flight test training elective course given to cadets. Additionally, Lorenzo Trainelli, PhD, professor and flight test program director at Politecnico di Milano University (PoliMI), describes the graduate instruction provided in a similar elective course.

This broad background should provide readers with two things: 1) examples of the courses currently available for ongoing training and professional development, and 2) a network of flight test professionals with whom to discuss innovation and development of flight test safety training. Both will benefit our profession and industry as we move toward an uncertain future.

Mark Jones Jr., Editor



Chief Warrant Officer 3 Sylvia Grandstaff at USNTPS

From page 1: Gordon and Grandstaff earn Broken Wing Award

Educating Graduate Engineers on Safety through Flight Testing *L Trainelli*

The Flight Testing graduate course at the [Politecnico di Milano University](#) (PoliMI) is an elective taken in the second (last) year of the Master of Science in Aeronautical Engineering. The aim of the course is to provide fundamental concepts and skills on the Flight Test process, principles, techniques, operational organization, and practical execution. The university first offered the course in 2005, part of the radical change in the Italian academic framework related to the “Bologna process” (a major initiative bringing more coherence to the Higher Education system across Europe). This brought the opportunity to review the Aeronautical Engineering curriculum and introduce several new elements, both theoretical and applied.

For the first few years, the course was entrusted to professionals from the industry: The lectures were given by Paolo Chimetto, then Flight Test & Experimental Flight Line Manager of the AleniaAermacchi M346 program (now CTO – Head, Ground & Flight Validation and Verification, Leonardo Aircraft); and the labs were charged to Giovanni Bonaita, a senior FTE and CVE with a long experience in both fixed- and rotary-wing at SIAI Marchetti, AleniaAermacchi, and AgustaWestland. Their experience gave the course a markedly job-oriented flavor and stimulated the possibility of offering the students a practical flight test activity. This was readily accomplished in 2006 by holding a flight test campaign using an instrumented ultralight two-seater and was done yearly ever since [1,2].



Safety checklist and manual data acquisition prior to take-off

The current teacher, [Lorenzo Trainelli, PhD](#), is an associate professor in Flight Mechanics and Aircraft Design at the [Department of Aerospace Science and Technology, PoliMI](#). He teamed with Chimetto and Bonaita from the very start, looking after the organization and execution of the flight test campaign, while learning the basics of the art from the two industry experts. Trainelli’s partner in crime is Alberto Rolando, adjunct professor of Aircraft Instrumentation and Navigation Aids at PoliMI and designer/developer of the Mnemosine system, a modular, minimally intrusive Flight Test Instrumentation (FTI) suite dedicated to small aircraft [3]. This system, undergoing continuous upgrade and expansion, is capable of retrieving over 40 time-stamped flight parameters and successfully supported the type certification of two Italian LSA models in 2010 and

2018 according to [German](#) and other European regulations [4,5]. The Mnemosine FTI is always installed on the test airplane for the duration of the annual educational campaign, providing a wealth of data for technical analysis (above).

In performing the campaign, which typically includes 20 to 30 flight missions, each student is called to act as the responsible Flight Test Engineer (FTE) for a test mission [6]. Therefore, he plans the activity, producing a FT Planning Document ahead of the test. Then he performs the test flying alongside an expert instructor pilot, and finally, the FTE carries out the data analysis, presenting his/her findings in a FT Report. Further collateral tasks include the preparation of FTI calibration reports, weight and balance reports, and debriefing sheets. The teacher reviews and assess all this documentation, acting as FT manager, in cooperation with all other functions involved: FTI, airplane manufacturer, pilot, and airfield operator.

An important part of the planning work is related to flight safety. Indeed, a section of the FT Planning Document is entitled “Safety Considerations” and includes a Test Hazard Analysis (THA). For the first time outside the university campus facilities, the students are asked to be part of a safety management process by analyzing in first person the possible risks connected to their specific flight tasks. These tasks include performance and flying qualities, stalls, climbs, glides, level accelerations/decelerations, longitudinal and lateral-directional static and dynamic stability. The execution follows the applicable FT discipline and techniques, as found in the CS-23 Flight Test Guide, MIL-STDs, recommended practices, and other applicable references.

The THA includes the identification of the hazards, the assessment of the risks involved, the proposal of mitigating procedures, and the issuance of related recommendations. Typically, a Hazard Analysis Risk Management Matrix, complete with Hazard Severity category and Hazard Likelihood level, is required. An example of safety considerations applicable to the test topics of interest is represented by the case of stall testing. Here, among other issues, the inherent loss of altitude is identified as a possible hazard, as it may cause proximity to ground and possible conflict with other traffic. Mitigation by assigning higher altitudes conflicts with the very low ceiling allowed to ultralight aviation in the test range (either 1,000 or 2,000 ft AGL), so this typically results in performing the stall tests at or about the maximum altitude permitted and not over the airfield whenever other aircraft may interfere.

This example highlights the need for the student to consider simultaneous—and possibly competing—aircraft limitations, airspace limitations, and other elements such as weather, airfield conditions, schedule, etc.. Notwithstanding the basic character of the tests and the fact that the test vehicle is already well known and shall be operated in its safe envelope by a pilot having much experience on that specific model, the students are encouraged to look at safety management in a proactive way. Sometimes, either the analysis of the FT Planning Document or the discussion in the pre-flight briefing, clearly point out a

limited safety consciousness, which is all too natural for the students, having previously been engaged mainly in theoretical studies, with perhaps a few experiences of running experimental activities in a university lab under close tutorship by faculty and technicians. Therefore, even if relatively limited in scope, the safety analysis required in the planning phase and application during the FT campaign is considered an important contribution to the wealth of experience gained by the course students and a valuable introduction to future professional assignments in experimental activities. *Lorenzo Trainelli*



The briefing between FTEs and test pilot includes flight test safety

Endnotes

1. Trainelli L., "Politecnico di Milano Flight Test Exercise at Italian Naval Aviation Test and Evaluation Center", Flight Test News, Society of Flight Test Engineers, 49 (6), 2018.
2. Trainelli L., "Politecnico di Milano Educational Flight Test Campaign", Flight Test News, Society of Flight Test Engineers, 49 (10), 2018.
3. Rolando A., Rossi F., Castelletti T., Reghenzani F., "Mnemosine Mark-V: the Fifth Generation of an Ultra Light Machine-Dedicated FTI System", 27th Annual Society of Flight Test Engineers European Chapter Symposium, Nuremberg, Germany, May 10-12, 2016. (<http://www.sfte-ec.org/node/946>)
4. Trainelli L., Rolando A., "Reliable and Cost-effective Flight Testing of Ultralight Aircraft", Journal of Aircraft, 48 (4): 1342-1350 (2011). (<http://dx.doi.org/10.2514/1.C031277>)
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6. Trainelli L., Rolando A., Bonaita G., Chimetto P., "Experiences in Academic Flight Testing Education", Aircraft Engineering and Aerospace Technology, 86 (1): 56-66 (2014). (<http://dx.doi.org/10.1108/AEAT-10-2012-0178>)

Lorenzo Trainelli

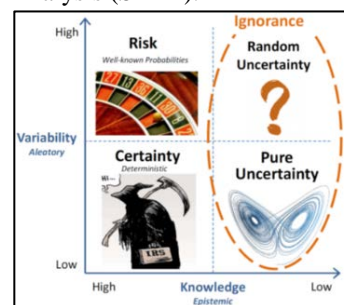
Teaching Flight Test Safety at USAFA

Doug Wickert

Risk Management is taught in three different academic contexts at the US Air Force Academy. A senior-level course on Project Management, taught by the Management Department, introduces risk from a program manager's perspective, namely cost, schedule, and performance risk. Additionally, Systems Engineering majors are taught risk from a traditional, system decomposition approach, e.g., failure modes and effects analysis (FMEA) and other reliability based models. Both approaches use the traditional Risk Matrix in which risk is represented as the product of a likelihood (probability of occurrence) and a severity. A senior-level, Flight Test Techniques course, taught by the Aero Department, also uses the Risk Matrix to depict unmitigated flight test risk as well as the expected result of any mitigation or minimizing conditions.

The Risk Matrix, imperfect as it is, is the devil we know, and it is an almost universal practice with both industry and military. There has been recent, widespread discussion on what tools or frameworks might replace the Risk Matrix, but it is likely that these will only ever be supplements or complements to the conventional Risk Matrix. In [a recent white paper](#), Professor Nancy Leveson of MIT summarizes a few alternatives to the Risk Matrix. Thus, the pedagogical conundrum for an institution like USAFA is whether to teach a tool that is widely practiced, however flawed, or to introduce a novel approach (that will not be widely known) when graduates enter the field as a practicing engineer, pilot, or program manager.

In light of this, USAFA is continuing to teach the Risk Matrix as an industry standard, but as an addition to the standard Risk Matrix, we are emphasizing that there are significant error bars on estimates of likelihood or probability of occurrence. This introduces the concept of uncertainty and the important point that risk is, fundamentally, uncertainty. Then the course introduces uncertainty characterization and scenario planning. With uncertainty characterization, cadets learn about the two fundamental types of uncertainty: random variability (aleatory) and knowledge (epistemic) uncertainty. With regard to scenario planning, cadets learn that the possibility of an event occurring is more important in safety planning than the probability that it occurs. Professors then introduce tools for robust scenario planning, such as System Theoretic Planning Analysis (STPA).



Evolution of safety planning and risk management beyond the sometimes cursory treatment it currently receives will take time. Educating the next generation on underlying concepts and approaches to decision making under uncertainty is a first step to improving the next generation of risk management in flight test.

Doug "Beaker" Wickert