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Deconstructing Myths about the Build-up Approach

Allan "Kreepy" Jespersen

Test plans contain critical elements that serve to capture many aspects of a flight test effort. The document is a product of the thorough research by the test team and serves to capture the flight test philosophy and risk mitigation strategies the team will follow. **One of the key parts of any test plan is the buildup methodology that subsequently shapes test point progression.** One possible methodology may be primarily informed by the test envelope and focus on how to move incrementally from lower perceived risk to higher perceived risk. Below is a potential buildup methodology, described in a test plan that uses this build-up approach: "Test points will progress from low normal acceleration (N_z) to high N_z; small controller force and displacement inputs prior to larger inputs; low specific excess power (P_s) prior to high P_s, low airspeed prior to higher airspeed, and low frequency prior to high frequency inputs."

Each part of the statement appears to be sufficient and reasonable, but each can have pitfalls if additional factors are not considered. The buildup methodology presented in a test plan should be intricately crafted to suit the needs of the test plan and consider other aspects of test execution, not just those aspects normally related to the test envelope. Consider two other criteria that may be useful to assess whether a buildup methodology is appropriate and complete: test point execution complexity, and aircraft attitude/behavior at the completion of a test point.

Let us re-examine the test plan statement above and consider how each of the parts may not be sufficient to capture suitable buildup for two aircraft with known handling and flying qualities.

…from low N_z to high N_z

The T-6B has a lot of excess power at low altitudes. Low N_z wind-up turns can be very difficult to execute when the PCL is at max power. Low N_z points may involve a significant nose high attitude to control airspeed and may quickly result in being out of data tolerances or an unusual attitude. In contrast, a higher N_z point may simply involve a level turn across the horizon.

Figure 1 – US Navy Test Pilot School T-6B (https://www.navair.navy.mil/nawcad/usntps).

…from small inputs to large inputs

The T-6B rolls slowly at low to medium airspeeds. When performing a 360 degree roll, a small lateral stick input will bury the nose significantly as the aircraft becomes inverted, resulting in a steep dive on completion of the roll. Similar unusual attitudes can occur at high alpha in the T-38C. Larger inputs initially are safer, because the aircraft attitude at the completion of the test point is more predictable.

…from low P_s to high P_s

The T-38C has very little excess power at high altitudes. High N_z wind-up turns at fast airspeeds are only achievable by significantly overbanking the aircraft and pulling near vertical through the altitude band. There is a high potential to inadvertently go supersonic as the test point is terminated.

…from low airspeed to high airspeed

The T-38C has a compressor stall/flameout susceptibility region at high altitude and lower relative speeds where the pilot must apply measured throttle movements. Even normal throttle manipulations in this region following the termination of a test point may result in an unintended flameout, for example. Targeting higher airspeeds initially would preserve flexibility in throttle manipulation between test points.

…from low frequency inputs to high frequency.

The T-38C performs very sluggishly in the pitch axis at slow speed, and is extremely sensitive to longitudinal stick inputs at high speed. The pilot may tend to overdrive the controls in rate/magnitude at slow airspeeds when experiencing sluggish performance as a form of compensation for a pitch pointing task; however, if the pilot applies that learned behavior to subsequent test points at higher airspeeds, they will likely overstress the aircraft. Beginning at a faster airspeed may preclude the negative transfer a pilot may experience; scaling up compensation magnitudes/rates as you decelerate may be less risky than scaling down.

Flight test philosophy and risk mitigation strategies should not be stagnant artifacts in a test plan. Buildup methodology should consider the test envelope primarily, but as flight test progresses and learning occurs, the team should be ready to revisit the sequence of planned test points and consider whether their methodology still makes sense. Buildup and many other aspects of a test plan should be considered as living organisms that require care and feeding from the test team, and teams should be open to re-baselining techniques, expectations and assumptions.

Biography

Allan "Kreepy" Jespersen is currently a test pilot school instructor with 5 years of experience. Previously he was an operational F/A-18C/E pilot with tours in Lemoore, CA, and Japan. In flight test, he spent time at VX-23 in Patuxent River, MD, where he was the X-47B project officer and part of the team that performed the first carrier landings and takeoffs with an autonomous aircraft. Kreepy is headed to USAF Test Pilot School on an instructor exchange program for the new year.

Turbo Talk – Chairman's Corner *Art "Turbo" Tomassetti*

I started the description for the December Flight Test Safety podcast with a reference to the classic scene from *2001 - A Space Odyssey:* the HAL 9000 computer tells astronaut Dave Bowman that he can't open the pod bay doors. This is not the first example in film of a computer turning against its human creators, for that you have to go a little further back to the early 50s and the computer NOVAC from the movie "GOG" (yes you can stop reading for a minute and google that, and come back when you are done).

Today, autonomy is all around us and becoming more and more a part of our everyday lives. My car has self-driving capability—I still have to be involved, and it isn't perfect. But it's not bad and it learns. So it will get better. I think I can comfortably say that in my career around airplanes, I watched autonomy evolve from some basic autopilot capability to where we are today with modern digital flight control systems and the beginning of AI. As a pilot, I knew the importance of understanding my aircraft and how it worked. I am not talking about lift, drag and other complex equations stuff here, I am talking about deep knowledge on the systems inside the aircraft and how they worked. Knowing my aircraft and how it worked was one of those things that could, (everyone together now), SAVE MY LIFE ONE DAY! I knew that if I did certain things in my aircraft certain things would happen. Move this control and this surface on the aircraft does this. Flip that switch then this happens in the aircraft. But things eventually got a little more complex. There were switches that had AUTO as a position and fuel controls that were digital, and auto-eject. Ugh! More pages to read in the flight manual, more complexity, and harder to understand. Then one day a flight control engineer said a phrase that I will never forget when describing how the digital flight control system worked. He had to explain it in words because when he showed me the equations on the bar napkin, I kept turning it trying to figure out which side was right side up. He said the words "non-unique solution" which meant, to my simple Marine brain, for any given input I could make as the pilot, the system could do something different every time in order to do what I wanted. Well, that doesn't sound like end of the world Skynet stuff. It just means that if I move the stick this way, then the aileron moves that way…this time. Next time it may move the horizontal stab, or maybe both. (I think maybe I can hear the 2001 music starting now.) But the aircraft can't choose not to do what I want, right? "No of course not." Ok then. "Unless you try to do something stupid, then it won't let you do that." Oh well that's good…wait…what? Who gets to decide what is stupid?

You see were this is going? Now we have machines that will protect the humans when the humans do things that humans are sometimes prone to do, i.e., stupid, dangerous things. I would feel really good about that, but it's obvious I watched too many sci-fi movies in my life. I will be honest; I am not sure that I could get to the same depth of system knowledge on this stuff as I used to in older aircraft. Maybe I could just rely on green is good, yellow is less than good, and red is bad. I like that. It's not complicated like this autonomy stuff, and would mean a lot less studying. But despite its complexities, there are some things I think you have to understand about your system and how it works. Even if you don't know what the system is going to do next, you must know what it is doing right now. When the aircraft is smoothly holding a condition, it may be using everything it has available right now to do that and you need to understand what that means. You also have to know what the system is going to try to do when you select AUTO and what you should be monitoring to ensure that is happening.

Maybe autonomy isn't so bad after all, and as long as we test this stuff to make sure it all works the way we want, I guess I am good with it. I mean we do test this stuff, right? Yes, we do, and that ladies and gentlemen is exactly what you can hear about in the recent Flight Test Safety podcast. I talked about some of the challenges in operating these types of systems—imagine the challenges in testing something with "non-unique solutions" or that has the ability to learn. And be sure to check out our recent podcast if any of this interests (or scares) you. Be Safe, Be Smart. Be Ready

Turbo ***Art Tomassetti***

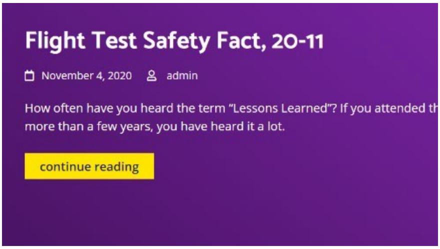
Better than Lessons Learned

Mark Jones Jr.

Two serendipitous things happened this week.

I.

In the first case, I was in a virtual meeting with a group of four other test professionals—friends, really—our conversation wandered about pleasantly, like a river in the flatlands. In the course of our discussion something stood out. I'll rephrase it in my own words, if only because I didn't accurately capture it when I heard it. **Everybody in the Department of Defense is doing autonomy and AI, but does anybody know who all is doing it?** The speaker targeted the acquisition community in particular, but it applies to agencies and organizations that are not strictly part of "test."



The last issue of FTSF was about "lessons learned." Coupled with the question above, this goes right to the heart of lessons learned. How are we ensuring that we talk to the right people or do the right "literature review" as we conduct this kind of test? I asked this question to two of the panelists from December's podcast, a panel discussion about AI, autonomy, and flight test, which resulted in the second serendipity.

II.

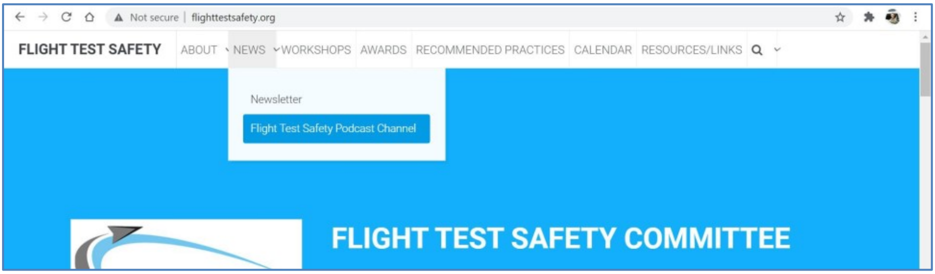
In separate correspondence with two of the podcast guests, I heard analogous opinions suggesting that we are not "organized" for this kind of test and evaluation. According to WigB: "Our organizational structure for Test doesn't help us." Avery phrased it differently, but said something similar: "Part of the problem seems to be that the topic of community involvement and collaboration—it's not the primary focus for most organizations doing this work. There is not currently a lot of funding or manpower available, so everyone has to focus on the core mission and work. Therefore, no one has much time or resources available to support collaboration efforts."

I'll jump rapidly to my conclusion. Literature review may not be appropriate for this kind of test. I think we have, inadvertently, focused on the term to our detriment. Instead, I think we should be talking to people. Ultimately, I think the Air Force Test and Evaluation Summit—as discussed in my winding conversation—got it right when they emphasized people over process.

So skip the literature review, and go sit down with someone. It may be a conversation about how we test AI or autonomy, or perhaps you'll ask about how we are organized for test. It may be about acquisitions process or private industry research and development. Finally, I hope it includes a mention of this newsletter, because at least one of the podcasts guests had never heard about it. Talking to someone will benefit you, and it will help us Reach Everyone.

Recommend our Podcast

In the December podcast, you may have heard Kristopher "WigB" Rorberg mention that his phone recommended the Flight Test Safety Channel podcast, which is a perfect example of how technology can help us Reach Everyone in our community with word of the FTSF newsletter and podcast. You can help too: **Recommend this podcast to a friend or colleague.** Sometimes it helps if you pick a specific episode that you think he or she will like, and send a link to the podcast from your mobile phone. Personally, I keep recommending the podcast to Danny Glaser, a pilot, Flight Analyst DER, and friend from Dayton, Ohio. One of these days he will read this newsletter and listen to the podcast. If you know him, and you read this, help me out and tell him to listen.



Autonomy and AI may solve some of our problems, but it still hasn't figured out how to do the "literature review" automatically. This podcast is a way to stay connected to the people who can cut through the noise and point you to the right literature, paper, or presentation. Wisdom takes work, and podcasts are a way to work smarter. Any one of us can listen to this podcast on our commute or during a workout. It doesn't take long to subscribe, and it takes even less time to recommend it to a colleague. If you have suggestions, please email them to chairman@flighttestsafety.org. Please subscribe to the Flight Test Safety Podcast on the Apple or Google podcast app. You can also navigate directly to the recording in a browser and leave comments on these platforms.

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