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LEGAL | MEDICAL

DON'T LOSE FOCUS:

Situational Awareness and Accident Prevention for Pilots

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BRAIN FREEZE: PART I

Brain freeze, tunnel vision, and task fixation are potential reactions to stress and are only a small part of a broader stress-related syndrome known as "tunnel senses." Don't get me wrong; concentrating on something is a good thing, just not to the exclusion of everything else in the environment.

If you like tongue twisters, try saying this one three times fast: "Sphenopalatine Ganglioneuralgia." More commonly known as "brain freeze" or "ice cream headache," this happens when something really cold touches the roof of your mouth. It can be a temporary inconvenience at the county fair but the other connotation of brain freeze, when you get totally stuck on something and can't see the big picture, is a real problem for pilots. We talked a little about this in the last few articles with "tunnel vision" and "task fixation" and how dangerous this can be in the cockpit. Let's take a deeper look into it, how it happens and what pilots can do to avoid it.

Brain freeze, tunnel vision, and task fixation are potential reactions to stress and are only a small part of a broader stress-related syndrome known as "tunnel senses." Don't get me wrong; concentrating on something is a good thing, just not to the exclusion of everything else in the environment. You don't have to leave the ground to see the consequences of fixating on something other than the most important task at hand. Just look at the statistics related to those ocular magnets we call cell phones that we have all become so addicted to lately. The NTSB has affectionately called these devices PEDs (portable electronic devices) and has repeatedly warned of their dangers. The NTSB studied hundreds of thousands of auto accidents over the last few years and found that PED and cell phone distraction accounted for 52 percent of auto crashes. A driver fixated on sending text messages or talking on the phone is 580% more likely to have an accident than drivers who maintain their focus on driving their cars. They reported that last year there were 10 distraction-related driving deaths per day (3,450 in 2017) on American roads and those deaths accounted for 10% of auto-related fatalities.

Task fixation, or more broadly "tunnel senses," in the cockpit can have just as dismal consequences. The NTSB has reported GA fatalities attributed to PEDs after identifying the cause of one crash that was due to the pilot updating his Facebook page while flying. Also, the FAA and NTSB have attributed a number of commercial airline disasters to this syndrome. As a matter of fact, the whole science of Crew Resource Management (CRM) was developed in response to one of the most famous disasters,

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the 1972 crash of Eastern Air Lines Flight 401 in the Florida Everglades. The flight crew was so task fixated on the landing gear indicator lights that, as the NTSB report cited, they "failed to monitor the flight instruments" – totally analogous to failing to watch the road while texting and driving. The NTSB went on to conclude that "preoccupation with a malfunction of the landing gear position indicating system distracted the crew's attention from the instruments and allowed the aircraft descent to go unnoticed." CRM became the science of assigning one or two members of the crew to devote their entire brain function to the immediate problem while assigning another crew member to keep the big picture in focus, like noticing that the autopilot was descending the airplane into the swamp.

Willingly fixating your brain on a single task like the pilots of Eastern 401, or using your phone while flying or driving, demonstrates the danger of tunnel senses syndrome. This syndrome can take over your brain when you're operating under stress! Tunnel senses affect every portion of the brain, and any or all of your senses can become tunneled when under the stress of imminent danger.

We talked about decision areas of the brain in previous posts, and another one of those important regions is called the "thalamus." This little guy is a critical part of the limbic system complex (fight or flight system) that we also discussed a few months ago in the post on stress. The thalamus receives sensory inputs from the outside world and functions as a kind of switchboard that directs nerve impulses around the brain in response to visual and auditory stimulation. Along with some nearby nerve centers (called the "amygdala"), this area of the brain weighs the potential danger of the incoming signals. If there is no perceived immediate risk, signals are directed to the cortex (thinking part of the brain) for thoughtful responses. Under more stressful conditions it directs these signals away from the cortex to action and motor parts of the brain. But the thalamic switchboard sends the response only one way or the other. Once the deliberative process is removed from the brain's reaction to the threat, attention is tunneled ("super focused") to one stimulus and the rest of the big picture is lost. It is this intense focus on a single source that becomes the tunneled sensations syndrome. Everything else is blocked out as the brain directs efforts to cope with the stress and dangers at hand.

The first and maybe most important of the senses that become tunneled with stress is the thinking process itself, and as we have talked about before, this is called "task fixation". The brain's thalamic switchboard can block out every other sensory input to focus on a perceived threat. You become so locked into coping with one threat that you are totally unaware of other potential safety risks and the overall deterioration of the broader situation. Not only do you lose other cues from around you, you also lose the ability to consider more than one alternative solution to the problem. A few months ago I talked about this in the post on stress where I noted your first reaction is often not the best solution. To safely resolve the threat, you have to scroll through your knowledge and experience files to find a better option; otherwise, your response is a reaction, not a deliberation.

Adding to the tunneled sensations syndrome, the thalamic switchboard also assigns priority to visual or auditory inputs if one seems more threatening than the other. When visual signals pose the most threat during a stressful situation, the thalamus narrows visual input to see images from only one small area of the retina (where images are concentrated in the eyes' nerves) that has the highest visual acuity and filters out input from everything else, reducing your visual field to a narrow "tunnel." This part of the retina, the fovea, provides the highest resolution images from your eyes but the total visual input is reduced to no more than a few degrees (which equates to about a 12-inch circle at 20 feet). Under normal circumstances, the brain is receiving input from the entire retina that gives you a view of about 200 degrees. But with tunneling of the visual sensation, the big picture is reduced so much it's like trying to solve the emergency while peeking through a keyhole. Many things could be happening in your peripheral vision that will be lost when vision is tunneled. You can prove how seriously limited your vision can become to yourself right now. Stare at any word on this page and without moving your eyes from that word try to identify another word three or four words away. It's easy to see the word you're focused on in high resolution, but every other word on the page appears in low resolution and most likely can't be read at all.

Hearing is another victim of the tunneled senses syndrome. I talked about this a few months ago in the article about not hearing the barking dog and making a gear up landing. Neuroscientists have found that a person intently focused on a visual threat will have diminished hearing. In some cases, when the stress is severe enough and the brain concentration narrows in one small area, the hearing receptors in the brain may be completely shut off. This is called auditory exclusion. You can imagine the risks in the cockpit if you are so focused on a visual threat that you can't hear the radio, crew communications, alarms (like the landing gear horn), or engine sounds. Selective auditory exclusion happens all the time; just try getting a kid's attention when he's playing a video game. This is nothing more than the brain's sensory areas prioritizing one input signal over another. It's an everyday function of our cortex that allows us to selectively process sensory input and accomplish the task at hand. However, once the brain's alarm circuits have been fired, the brain's switchboard (the thalamus) will literally halt the flow of other signals to the cortex. As far as the brain is concerned, everything else just disappears.

These factors add up to the physiological definition of loss of situational awareness. When you are suffering from tunneled senses your situational awareness and big picture perception is pretty much gone and you are likely to miss important clues and cues that could make the situation better. Neuroscientists and aviation safety experts recognize the risks of tunneled senses and have come up with some helpful ways to avoid having your brain freeze up and lose critical opportunities to avoid a disaster. Stay tuned (always!) and in the next post we'll discuss this in more detail.

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BRAIN FREEZE: PART II

We left off Italking about how our head functions to process information, or block it out, and the cognitive activities that define situational awareness (SA).

We also talked about what goes on in a pilot's brain when the senses become tunneled and SA disappears. Tunneled senses pose one of the greatest safety risks in the cockpit, as a pilot is simply not aware of all problems that may exist. This results in a loss of situational awareness and that's like a big ugly boogeyman sneaking up behind you. Even in the face of a great risk, you are blindly unaware he's there about to strike. Let's dig deeper into skills needed to maintain SA or, if SA is lost, to reestablish the big picture and get it back before disaster strikes.

Dr. Mica Endsley, a former chief scientist for the United States Air Force, has studied this topic extensively and defines the big picture of SA as the combined product of three stages: (1) the perception of elements in an environment, (2) the integration of those elements into a comprehensible meaning, and (3) the projection of that meaning into the future. In order to form this big picture, the brain has to use the elements of sensory input and data processing I have talked about over the last few months. Unfortunately, these are the same processes that are so at risk to fail during stressful situations. These include working memory, perceptual capacity, motor skills, visual processing ability, and temporal processing ability. When any of these thought processes or sources of sensory input get tunneled, the big picture disappears.

To prove our model that tunneled senses is the cause of the loss of SA, it's interesting to layer our scheme onto real aviation accident data and see how it fits. The types of aviation accidents that are attributed to loss of SA have been studied in the Aviation Safety Reporting System (ASRS) database. The errors were grouped into the three major categories that comprise the three stages of SA. Digging into the ASRS data, researchers have identified Level 1 errors as things like a failure to correctly perceive information or failure to monitor and observe available information. That's what happens when the pilot suffers from auditory or visual tunneling. Think back to the example last month of the pilots who landed gear up with the gear position warning horn blaring away. Level 2 errors are failure to comprehend the situation that in our model would be attributed to

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tunneling of the thinking process. This is what happened to the pilots on Eastern flight 401 that plunged into the Everglades while the pilots focused only on the landing gear lights. Level 3 errors are due to a failure to accurately project the situation into the future like grabbing the first instinctual reaction and not making carefully thought out actions.

The large majority (76%) of the mistakes were identified as failing to perceive or understand information (Endsley's Level 1 SA); 20% were Level 2 (incomplete mental model or using an incorrect mental model); and only a handful (3%) were Level 3, reflecting failure to make correct projections into the future. These data fit our model of tunneled senses nicely. The vast majority of accidents are due to losing the big picture that is caused by stress-related tunneling or intentionally tunneling your senses. This is proven by the high incidence of accidents due to talking on the phone or texting while flying or driving and not concentrating on the most important tasks.

With this understanding, it's time to figure out how to maintain SA or get it back if lost. The first step in getting back the big picture sounds trite, but still is true. Don't lose your SA in the first place. The amount of time that any person can concentrate and maintain their focus varies among individuals and circumstances. Factors that negatively impact our ability to hold onto the big picture include fatigue, altitude (decreased density altitude means decreased oxygen concentration), distraction (like hunger) and boredom. I talked about all these factors in the post a while back on diet and energy use.

The 3-stage picture is time sensitive; it's very short-lived and needs to continuously update. Maintaining SA requires diligence and constant reassessment of the all three elements of SA. To accomplish this requires repeated instrument scans and scans outside the cockpit that refocus your brain on your surroundings and flight parameters. This needs to be done several times each minute or boredom sets in, senses are dulled, and that ugly boogeyman creeps into the cockpit. All this effort to maintain your SA is well worth it, since getting your SA back is a much harder task than keeping it while you have it.

Neuroscientists who study SA use the term "situational awareness recovery" to refer to the process of getting SA back after it is lost. They use the acronym SAR, which also stands for "search and rescue," a term our military pals use and which is a perfect analogy to outline the important steps of reorienting perception and sensory input. The loss of situational awareness takes place when there is an interruption, either self-induced or due to a sudden change in flight dynamics. SA loss is worsened by an oversight, a hasty inference, or a decision based on incomplete knowledge or misinformation, especially under conditions of heavy workload or the added stress of time compression.

This has been studied in the lab by interrupting test subjects carrying out an assigned mental task. The duration of these interruptions was only about 4-6 seconds. But even with those short bursts of interruptions, accuracy when returning to the task at hand was significantly reduced, indicating deterioration in SA. In addition, after each interruption participants took longer to initiate the next action, indicating further delayed SAR. The decreased level of SA from repeated interruptions required the study participants to engage in SAR to refresh their memory. For this to happen, study subjects had to "re-fixate" on objects that were previously looked at (scanned) in order to re-prime their memory and refocus on the environment and the task. In reacquiring their previous SA, the study subjects had to reactivate their original goal through something they called "associative priming."

After being interrupted during SAR, participants fixated more on objects that were previously looked at and fixated on relevant novel objects less than during continuous task performance. Re-fixations act as contextual cues that prime the memory for the situation and reestablish SA. The perceptual and cognitive processes needed for SAR include re-fixating on cues in the environment, increasing your scanning frequencies, and shortening fixation durations on one element in the cockpit. This study also showed why it's so important to hold onto SA as the opposite is also true; when there is no interruption SA is higher, enabling the participant to allocate attention to detect and solve new problems that pop up.

All these studies prove the things we have speculated on. When SA is lost and senses tunneled, new wrinkles in the environment are harder to spot and it takes longer to react and solve novel problems. A simple method pilots can use to find lost SA is to change your point of view. Take a giant step back to observe your perceptions from a distance. To maintain your level 1 SA, constantly rescan the instruments and scan outside the cockpit. Maintain level 2 SA by continuously reestablishing exactly where you are and reassessing the flight conditions. Describe everything you observed. Start with the broader picture and then capture all the details, formulate a plan, and plan your outs. In the fancy words of neuroscientists, "re-fixate." Explore possibilities that will help you see more opportunities and solutions around you. For example, fly with the GPS on the "nearest airport" page when things get dicey so projecting a plan out into the future to get your Level 3 SA back is as simple as pushing the "direct to" key. Don't let boredom and routine distract you from understanding what's different in the here and now. Looking for small signals and cues will train your mind to be alert and not stray too far from your big picture.

In the words of an old Air Force flight instructor who taught me how to fly a long time ago, "Never let this airplane take you somewhere your head hasn't already been five minutes ago." Even in the old days of flying before pilots understood all the subtleties of the three levels of situational awareness, they knew how to avoid the boogeyman that creeps into your cockpit when you lose the big picture.

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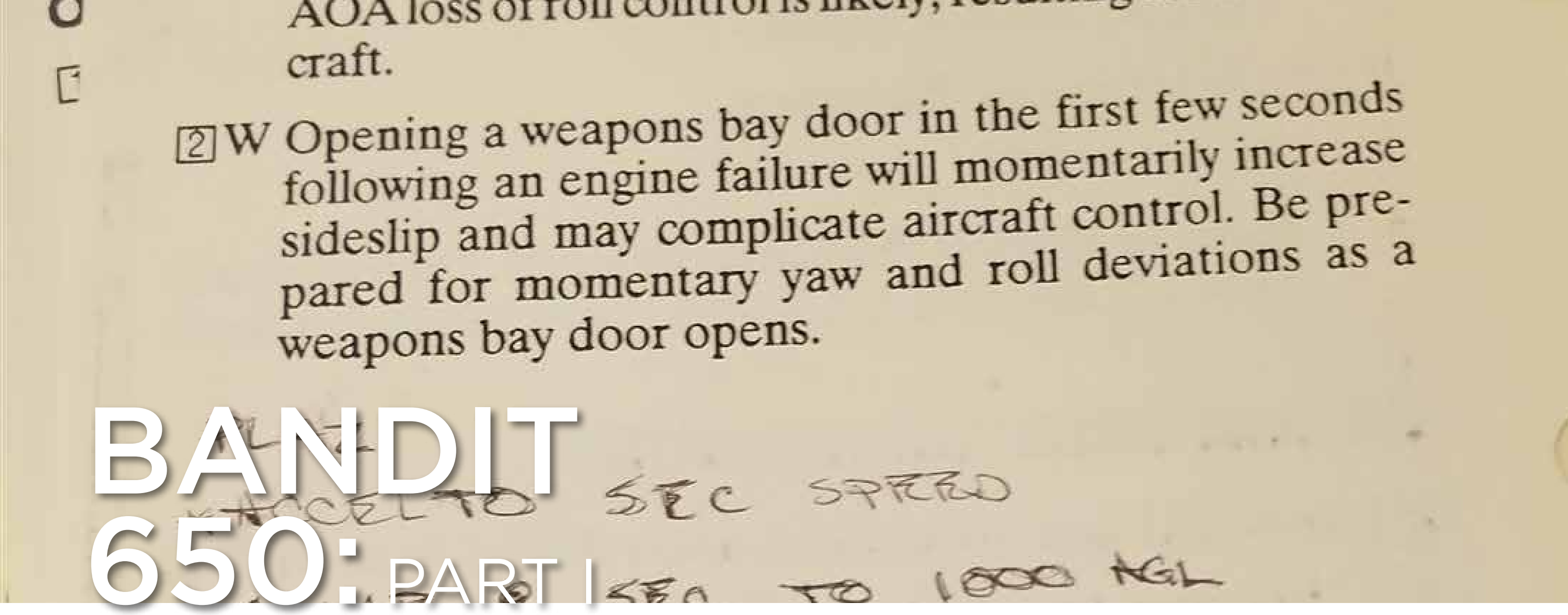

BANDIT 650: PART I

Pilots love to sit around telling airplane stories, but none I've ever heard can even come close to that of a really good friend of mine, Doug Downey.

Besides being an awesome guy, Doug is a retired USAF Lt Col who is an Academy grad and flew as a fighter pilot in the F-16 Viper and the F-117 Nighthawk. Nighthawk pilots call themselves "Bandits" and each of the 558 Air Force pilots who have flown the F-117 has a Bandit number that started at 150 and added on sequentially from there. Doug was the 500th pilot in the jet and flew with the call sign "Bandit 650."

He flew the jet in multiple combat tours in the Balkans and the Middle East and also served as a combat logistician, wing commander, an instructor pilot, check pilot, and air show demonstration pilot. He was an advance agent for Air Force One and President G.W. Bush for five years and later a diplomat in Pakistan and a military advisor to the Pakistani Air Force. If all that's not enough, he is genuine hero and his story puts all the elements of SA that we have been picking apart over the last few months into perspective.

Doug survived a near disaster in the F-117 that we had spoken about a couple of times a while back. Last month Doug gave me more details of his story while we were sitting around over beers, steaks and airplane tales in Wichita KS at the Bombardier Safety Stand Down. It happened on February 5, 2004, a crisp, clear New Mexico afternoon, while Doug was practicing emergency procedures and simulated single engine approaches at Holloman AFB. The training procedure required the simulated flame out engine retarded to 65% RPM but not completely to idle as the jet is already thrust limited. Standard practice at the base was that the go-around be conducted no lower than 100 feet off the ground. Because of an internal design flaw in the F-117 engine that made an untimely first appearance just at that moment, the "good engine" flamed out before the engine that he had retarded power on had time to spool back up.

The slow speed, limited available thrust, high angle of attack (AOA) and adverse yaw put the jet in a non-aerodynamic flight envelope that resides on the "bad" side of the power curve and a place we all like to avoid. As we talked about last month, Doug's new "real' reality was that his stealth fighter was suddenly a stealth glider. Doug put all the elements of SA together to avoid letting his crippled jet crash onto the base or into a park full of families on a Sunday picnic at White Sands National Park adjacent to the field. This would have been a disaster that would have killed him along with

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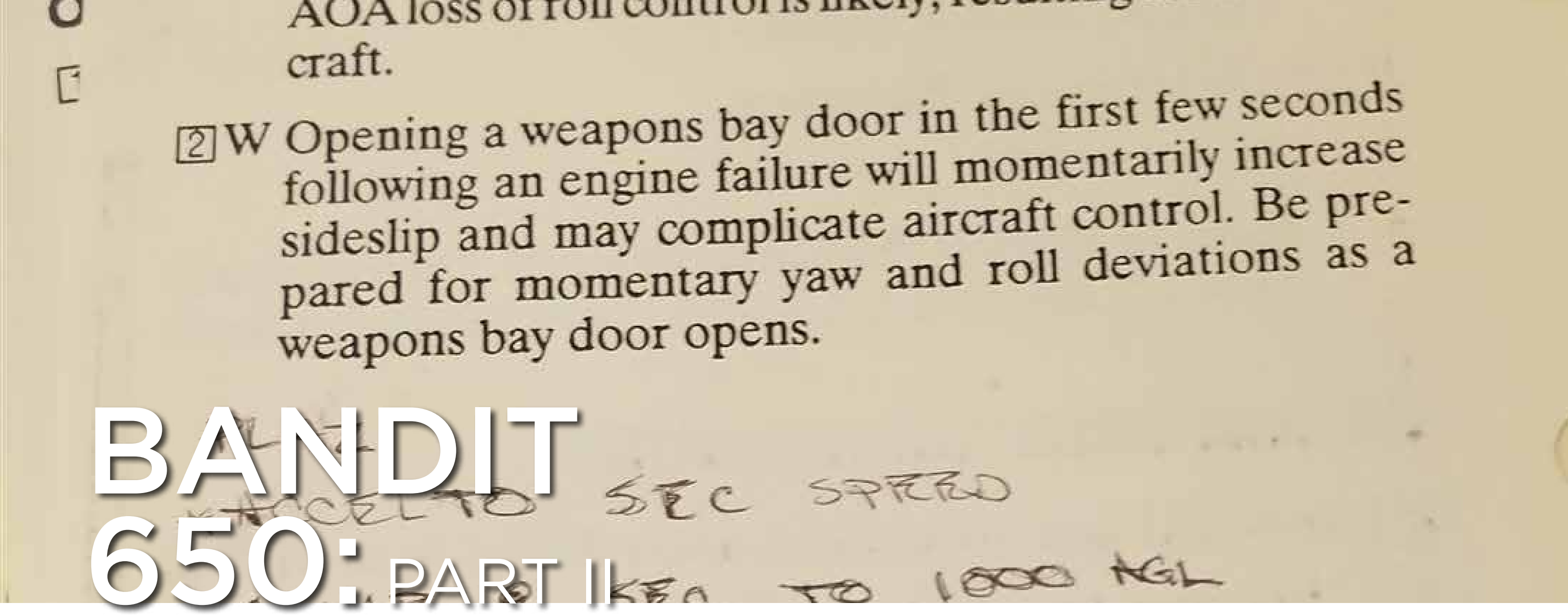
dozens of kids and their parents on the ground. Not to spoil the ending, he was eventually able to turn the plane around and coax the jet back onto the runway.

The seeds of this near disaster were planted long before that February day. Back in 1964 a Soviet mathematician named Pyotr Ufimtsev published a paper modestly titled "Method of Edge Waves in the Physical Theory of Diffraction." The study ushered in the era of stealth technology by proving that the strength of radar returns from an object (jet wing) are related to edge configuration, not size. Based on this work, the stealth technology project was taken up in 1975 at the Lockheed Skunk Works with a model they dubbed the "Hopeless Diamond." This was a pun on words because of the similar shape of the prototypes to the Hope Diamond. The finished product became the nearly invisible F-117 stealth fighter that weighed 30,000 lbs but still had a radar cross-sectional area that is less than a golf ball and unimaginably small, only 0.001 m2 (0.0108 sq ft).

The control problems Doug faced when he lost his engine were largely due to aerodynamic penalties of the stealth shape and technology such as lower engine thrust due to exhaust limits in inlet and outlet jet flow, a very low wing aspect ratio, and a high sweep angle (50°) needed to deflect incoming radar waves to the sides. In addition each engine is covered with an "ice cube tray" over thrusters to deflect radar signals but at the cost of imparting drag and that acted like a wind milling prop when the engine behind it is stalled. The good engine that had been pulled back for the training mission would require almost a minute to spool back up. And now with his other engine suddenly flamed out and no use at all, Bandit 650 was about as aerodynamic as a cinder block. Doug wrestled with the airplane while executing a real-life single engine go-around on limited thrust and high AOA.

He abruptly experienced so much sink and adverse yaw that the jet veered off the runway heading and was pointed directly at the control tower. The first reaction he relates was to avoid hitting it so he pushed the jet further into the roll to steer clear of the tower. He actually passed 100 feet below the control tower cab and cleared the tower itself by only a few feet laterally. This took him off the airport and away from the runway towards the vastness of the desert and White Sands Missile Range complex. Yet another place no one really wants to be. The next problem he faced was that the jet had entered an aerodynamic flight envelope few have experienced known as "PLAZ", possible loss of aircraft zone. As the jet enters PLAZ the immediate memory action items triggered in every Nighthawk pilot's brain were to gain any altitude possible and configure the jet in a safe ejection parameter (no roll, no sink). This was so the pilot could safely eject before the jet enters an uncontrollable roll and spun into the ground. He knew he could not eject over the ancient lava flows off to his right without getting cut to ribbons. Looking the other way from less than 100 feet up, he saw dozens of families in White Sands National Park that he instinctively knew would be killed if he ejected then and let the plane crash into the park. It was time for plan B – but there was no plan B.

Next month we'll analyze how Doug managed to nurse his wounded jet back for a successful landing on the runway. We will dig into the lessons we can learn from all the elements of SA in this story and see how we can put it to use for our own safety in the sky.



BANDIT 650: PART II

The engine flame-out and successful landing by my friend Doug Downey in Bandit 650 that we talked about last month became a mandatory lesson for F-117 fighter pilots training to fly the jet.

Even knowing what was about to happen, no other Nighthawk pilot could successfully land the airplane when the same configurations and parameters were programmed into the simulator. So let's dissect just how Doug managed this incredible feat of flying skills and problem solving.

He told me that in the instant his engine flamed out everything slowed down for him and his senses became so amplified that he was able to process his situation calmly and relatively easily. This is a testimony to his experience as a pilot and was confirmed by the cockpit voice tapes that showed his voice was slow and deep with an even cadence. But it wasn't that things slowed down, it was that his brain sped up to process all the elements of his predicament (Level II SA). Psychological studies indicate that only about 10% of people can react in this way to acute stress and it's obviously a trait that the Air Force seeks in fighter pilots. It is similar to reports by some professional baseball players, whose brains can so quickly process the visual images of a baseball pitched at them at almost 100 mph that it looks like a beach ball for them to hit. If you're among the 90% of us regular folks who don't naturally possess this trait, there are some skills you can use to slow things down and think more clearly. We talked about that in an article a while back, but nothing replaces practicing and training.

In Doug's case he had accomplished this in just that way, by planning and training for the PLAZ (Possible Loss of Aircraft Zone) scenario, that wrong side of the power curve from last month, as a part of his mindset for every simulator event and before every flight. Then he handwrote it all out on the checklist he kept strapped to his leg on every flight. He said he had "mentally flown" the exact same scenario hundreds of times. He told me he ramped up his situational awareness before every flight to be ready for any emergency by thinking, "I dare this jet to fail me. I know this jet will fail, I'm waiting for it, just let me know how you will fail me and I'll be ready."

Since the chances of flying out of the PLAZ to a return approach and landing were considered unlikely, his pre-flight briefing always included this worst-case scenario. This is a perfect case study for the importance of using your imagination that we talked about a few months ago. Doug had imagined the loss-of-power scenario and imagined his emotions and flight dynamics with such precision that he had "pre-viewed" the solution before it

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became his new reality. Doug's imagination allowed him to "pre-live" this scene over and over so when it actually happened he told me he wasn't really surprised. All he had to do to deal with his real-life emergency was to fly his imagined plan. That included a plan on how to handle the "local" airport environment and where to safely "dump the jet" if he couldn't recover and it became necessary to eject.

There's an old adage that good pilots learn from others' mistakes since you'll never live long enough to make them all yourself. He told me a painful lesson he learned from a fellow Academy graduate and friend, 1Lt Brice Simpson, who was lost in an F16 training mission that ended in a tragic and fatal crash after an unnecessary abort and ejection. "Brice just wasn't ready for a caution light on takeoff," he told me, "and I'm never going to let that happen to me. This drove me to compulsively practice for the worst possible situation. The scenario, the parameters and predicted gauge readings were hardwired into my brain in the sim. I could visualize the exact actions I needed to take even though I never had to do it outside the sim before this flight." This is a perfect definition of how to build SA using your imagination.

There is another old adage carved into our pilot brains from day one of flight school, "Aviate, Navigate and Communicate," in that order. That is exactly what he did. The only low-altitude flight path away from the razor-sharp rocks in the ancient lava field was due west toward the open expanse of White Sands National Park. However, the view out the front canopy, now only 60 feet above the ground, quickly changed and he was looking down at crowded picnic tables and BBQ grills of the park surrounded by kids playing in the sand dunes. And there was a new addition to his problems—rising terrain. He was now headed straight toward the San Andreas Mountains with no power to climb and it was going to be hard to avoid.

This required a total change in the plans and in control input, as any knots of airspeed gained meant giving up what little altitude he needed to clear the mountains. F-117 pilots rarely need rudder in normal flight operations. Yet this predicament, with so much asymmetric drag, required total rudder inputs to counter the yaw and keep the jet within safe ejection parameters. So he was stuck; ejecting was impossible since trying to come off the rudders even for a moment immediately caused the jet to start to roll over, lose precious altitude, and point the canopy at the ground. Holding full rudder control, he coasted out over the hot white sand, where he finally found some lift that stopped him from drifting lower. When the flight profile was analyzed in the debriefs that followed, it turned out that Doug probably floated onto a bubble of warm air rising off the hot white desert sands and that's what finally arrested his sink and allowed his jet to slowly climb in ground effect. Doug described to me that the sands are so white it's like being snow-blinded on a glacier, but it kept him in the air and bought him a little much needed time. But not much; this little extra time was also running out as the rising terrain of the westerly mountains was now quickly approaching as his air speed increased. The operational standard for limited thrust was embedded in his brain from all of his hangar flying: turn within 19.3 DME from Holloman to avoid the mountains, or eject.

Finally, full power was now back up on the previously retarded engine and, fighting the drag of the "ice cube tray" from the stealth engineering, Doug was now able to start a slow turn back over the dead engine toward the base to the opposite heading runway. Level III SA, the plan B that was never there without his visualization and imagination of managing the emergency, ends with a successful landing on the Holloman runway with nobody hurt in the air or on the ground. Great work, Doug.

So learn these critical lessons from Bandit 650 and build your SA picture long before you need it in an emergency. Imagine and "pre-live" everything bad that might happen and then "pre-live" the solutions. Dare your airplane to fail you, train for it, use your imagination to plan for it, then put it all together and practice how you will manage it. Every time you "line up and wait," take a moment to review your strategy so if and when it actually happens you will be able to handle the scenario calmly and with mental clarity by replaying your imagined solutions to your new reality and end up safely back on the ground. In the end, your own imagination is the ultimate key to safe flying.