Innovation in a Bipolar Air Force

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If it's not broke, don't fix it. This seemingly sound policy is a double-edged sword. A 2016 RAND Corporation study observed that USAF innovation hinges largely upon problem recognition, finding Airmen to be remarkably innovative once they have identified a problem.[1] But the USAF sometimes fails to identify problems, declaring them not broke when in fact they are. In these cases, the Air Force will, with the best of intentions, vigorously do whatever is necessary to "not fix" the problem that it failed to recognize. This bipolar love/hate relationship with innovation leaves Air Force innovators unsure if they'll be promoted or shown the door.

We're going to look at innovation with the same type of approach used in a fighter debrief. Fighter pilots dislike the word *maybe*, as in maybe we'll be better innovators if we implement Quality Air Force, Six Sigma, Lean Air Force, or Air Force Smart Operations of the 21st Century (AFSO21). No, fighter pilots focus upon mission objectives. If they meet their objectives, then it's "well done, beers are on me." But if they don't meet their objectives, then it's time for a long debrief. They determine *exactly* where the problem occurred, and they look at the tapes and ask questions until they determine *exactly* what went wrong. Once the problem is identified, they focus on specific corrective action.

USAF leaders are not providing the type of clarity found in a mission debrief. In his 2013 *Vision for the United States Air Force*, Gen Mark A. Welsh, the previous USAF chief of staff (CSAF), commends the Air Force for a long history of innovative thinking. So maybe it's mission accomplished and beers on the CSAF, but the same document tells all Airmen to "look for smarter ways of doing business" and cautions leaders to "empower Airmen to think creatively, find new solutions, and make decisions."[2] So maybe these are things we aren't currently doing, and it's time to settle in for a long debrief. Leaders need to clarify whether we are meeting the standards of innovation or not. If we aren't, then they need to identify the problem. We're going to examine a case study on aircraft deconfliction to show that the Air Force does indeed have an innovation problem. Spoiler alert: the problem is problem recognition, so we'll look at that first to provide a proper lens through which to view the case study.

Innovation and Problem Recognition

We like to think of ourselves as rational beings, capable of reliably identifying problems and developing good solutions. However, cognitive scientists have amassed an unassailable body of knowledge that demonstrates humans are not always as rational as we would like to believe. Their explanation is surprising, fascinating, and valuable to our quest for innovation.

> Reasoning is generally seen as a means to improve knowledge and make better decisions. However, much evidence shows that reasoning often leads to epistemic distortions and poor decisions. This suggests that the function of reasoning should be rethought. Our hypothesis is that the function of reasoning is argumentative. It is to devise and evaluate arguments intended to persuade. Reasoning so conceived is adaptive given the exceptional dependence of humans on communication and their vulnerability to misinformation. A wide range of evidence in the psychology of reasoning and decision making can be reinterpreted and better explained in the light of this hypothesis. Poor performance in standard reasoning tasks is explained by the lack of argumentative context. When the same problems are placed in a proper argumentative setting, people turn out to be skilled arguers. Skilled arguers, however, are not after the truth but after arguments supporting their views. This explains the notorious confirmation bias. This bias is apparent not only when people are actually arguing, but also when they are reasoning proactively from the perspective of having to defend their opinions. Reasoning so motivated can distort evaluations and attitudes and allow erroneous beliefs to persist. Proactively used reasoning also favors decisions that are easy to justify but not necessarily better. In all these instances traditionally described as failures or flaws, reasoning does exactly what can be expected of an argumentative device: Look for arguments that support a given conclusion, and, ceteris paribus, favor conclusions for which arguments can be found.[3]

In other words, people have a genetic blind spot for problem recognition. The word *adaptive*, used in the biological sense, means that evolution favors argumentation and persuasion. An individual who can persuade others has a survival edge over individuals who cannot. A society that can be persuaded into unified action has a survival edge over societies that cannot. Evolution has designed confirmation bias to serve as a built-in mental filter that helps us argue—we subconsciously capture the data that supports our beliefs and discard the data that might disprove them. But the same bias that helps us persuade others to adopt our beliefs also makes it difficult to see when our beliefs are wrong.

Cognitive science supports RAND Corporation's observation that the USAF often has difficulty seeing problems. But we can train ourselves to smell what we can't see. Bad ideas will often exhibit a strong odor of argument because irrationality and confirmation bias are the genetic result of a brain designed to argue. It's easy to differentiate argument from invention because they are opposite mental processes. An inventor starts with a broad survey of data, then sorts through many solutions to pick the best. When presented with a new idea, an inventor will become excited, ask questions, and investigate. An arguer starts with the solution, then sorts through the data, discarding anything that doesn't support the conclusion. When presented with a new idea, an arguer will become uncomfortable or angry and will immediately try to scuttle it without investigation. Arguers are so certain of their answer that they won't reopen the question.

When we come across an idea or doctrine that is characterized by the omission of relevant data, twisted and contorted logic, and a refusal to consider alternatives, then that odor should alert us to the potential presence of bias and irrationality. We might be arguing our way to a suboptimal solution, rather than rationally inventing our way to an optimal one. We'll now examine a flight safety issue that reeks of argument.

The Deconfliction Problem

The Air Force has some good rules on deconfliction. *General Flight Rules* 3.17 and 3.18 require all pilots to "detect and avoid" other aircraft, and USAF Training Rules require pilots to knock off any engagement if safety is in question; if a dangerous situation is developing; or when situational awareness is lost. But these mandatory rules are bent and broken in subordinate training publications.[4]

For instance, the requirement to detect and avoid other aircraft has somehow morphed into the requirement for pilots to clear their flight paths, fundamentally changing the visual cross-check in ways that are not good. Rather than looking for the presence of nearby aircraft wherever they might be, they instead look for the absence of aircraft along their own flight path. An article from *Weapons Review Magazine* explains: "while both fighters should clear their own flight path, the engaged fighter has the option to completely disregard the other."[5] Substituting the specious notion of clearing the flight path in place of the requirement to detect and avoid other aircraft is a safety rule violation that has killed many pilots. The following example will illustrate.

Maverick is flying east at 300 knots. He has 12 seconds until he reaches the place he will die, just 1 mile ahead. He looks east along his intended flight path and sees the exact spot of his demise, but he doesn't see a jet there or any other indication of hazard. That's because Iceman is flying at 450 knots and is still 1.5 miles from the collision site. So where might Iceman be? The locus of points representing Iceman's possible locations forms a circle with a 1.5-mile radius from the crash site. If we drop a pencil anywhere on this circle and draw a line toward the center, then that is one of an infinite number of Iceman's potential collision vectors. We can also do this in the vertical plane, so Iceman could really be at any point on a sphere with a 1.5-mile radius from the impending fireball. From Maverick's perspective, Iceman could be at virtually any position on the horizontal or vertical clock. The only way Maverick can be sure to detect and avoid the hazard is to keep track of Iceman, but that's precisely what the *Weapons Review* article says we don't have to do.

Perhaps the requirement to clear the flight path is not to be taken literally. Maybe the guidance is intended to warn pilots to take whatever action is necessary to prevent another jet from ever becoming a flight path conflict. But that's circular reasoning—collision avoidance requires clearing the flight path, and clearing the flight path requires doing the things to avoid a collision. The question remains: exactly what are these things that pilots must do to prevent a collision?

For all other subjects related to flight safety, the USAF has logical and detailed written guidance. The guidance is refined during mishap investigation: the school of hard knocks. It's a beautiful example of the scientific method in action. For each hazard, the USAF provides what amounts to its best hypothesis on how to avoid or survive it. The hypothesis is tested on each flight. Data is gathered from each mishap to improve the hypothesis, and the cycle repeats, but somehow deconfliction has escaped this process of optimization.

The innovation we'll examine next is simply the application of the above process to the subject of deconfliction, or more specifically, element deconfliction. The flight lead and wingman pose the greatest mutual collision threat by constant exposure to one another under every conceivable variation of formation and combat maneuvering situations. We'll focus on formation deconfliction because that's where most of our collisions occur. We'll cover the proposed plan and then evaluate it with respect to logic and the school of hard knocks.

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Proposed Element Deconfliction Plan

Safety is the first priority for all pilots at all times. In accordance with General Flight Rules 3.17 and 3.18, all pilots must "detect and avoid" other aircraft regardless of flight position or maneuvering role. Element members should adhere to the deconfliction contract depicted in the table below.

Table. Element deconfliction contract

Yielding pilot	*Pilot with right-of-way*
Cross-check element mate	Cross-check element mate
Detect collision geometry	Ensure mate yields
Alter course for safe separation	Take corrective action

Cross-check

The visual cross-check should be proportional to the hazard. In formation, the wingman's cross-check frequency is a function of distance. The flight lead should cross-check flight members before, during, and after initiating any action requiring a deconfliction response: rejoins, turns, formation changes, and so forth. In larger formations, all pilots should use these same cross-check techniques to maintain situational awareness on all aircraft in the flight.

During air combat maneuvering (ACM), each pilot must maintain situational awareness on the other and must again base the visual crosscheck on the hazard (distance and closure). Pilots should use the air-to-air tactical air navigation system and radio to aid in deconfliction. Clearing the flight path **does not** ensure safety and cannot substitute for an effective visual cross-check on nearby aircraft.

Collision Geometry

Collision geometry is indicated by an airplane with zero line-of-sight, frozen on the canopy, and growing larger. The yielding pilot should immediately alter course to ensure safe separation. It is not acceptable to remain on a collision vector, intending to correct the situation later (after taking a shot, for example).

Safe Separation

In cruise formation, safe separation is specified by the formation parameters. During tactical formation and ACM, safe separation is specified by major command regulations (usually 500 feet). If safe separation is in question, then the yielding pilot has failed, and pilot with right-of-way must immediately correct the dangerous situation (verbal direction, "knock it off," and/or evasive maneuvers).

Formation Integrity and Wingman Consideration

Flight leads should use "wingman consideration" techniques to avoid creating task overload during critical phases of flight. Flight leads must also correct poor formation before a dangerous situation develops. Inadequate spacing reduces reaction time, while excessive spacing and poor fore/aft positioning can lead to confusion or loss of visual. If the flight lead fails to correct such situations, it is appropriate for any flight member to make a "check formation" call.

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Deconfliction Logic

We'll examine the proposed deconfliction plan above by logically dissecting its component parts, beginning with the easily misconstrued concept of priority. Pilots often speak of priority as a time apportionment tool, but this isn't the case. Something can be a high priority and take very little time to accomplish. The definition of priority is: "something given or meriting attention before competing alternatives," so safety only interferes with tactics when these two things become mutually exclusive. That's why we try to teach pilots to be safe and tactically effective at the same time.

Pilots have a wide playing field on which to accomplish the mission. At the edges of this field are the boundaries formed by our regulations and safety rules. All pilots must know where these boundaries are and never cross them. A pilot who stays in the wide part of the playing field can be as mission-oriented as he likes. This enables pilots to spend the majority of time and brain cells on mission-related tasks while periodically asking, "Am I getting ready to lose control, or run out of gas, or hit the ground, or hit another airplane?" Usually the answer is no, and the pilot is free to continue focusing on the mission. Occasionally the answer is yes, and the pilot is faced with a situation where mission and safety have become competing alternatives. In these situations, the pilot must immediately address the safety hazard.

Both pilots should be involved in the deconfliction plan. Although it only takes one pilot to avoid a collision, resting the entire plan on the yielding pilot's shoulders is a bad idea. While it is true that USAF pilots are almost perfect, the word *almost* becomes important when we fly millions of sorties. As a general rule, any safety cross-check should be proportional to the hazard. Our ground avoidance techniques provide a good example. At high altitude, the ground hazard is nil, so the ground cross-check is nil. At low altitude, the hazard increases, so the cross-check increases. If the cross-check is too slow, the pilot can easily "die relaxed" and impact the ground before realizing the hazard. If the cross-check is too rapid, the pilot is wasting time that can be put to good use for tactical employment. For element deconfliction, the hazard level increases whenever the flight lead initiates an action requiring a response from the wingman.

The yielding pilot's cross-check is based upon the worst-case assumption that the flight lead could initiate action at any time. In the closest formation (fingertip), a collision could occur almost instantly, so the wingman must stare almost continuously at the flight lead. In the loosest formation (tactical) it might take 10 seconds for a collision to develop, so the wingman can relax the cross-check to that time interval. By contrast, the flight lead does not have to assume worst case because he knows when he will do something that will increase the hazard. A flight lead should cross-check his wingman (all of them) before initiating a turn, rejoin, or any other action requiring a deconfliction response.

With a good cross-check established, pilots must be able to recognize collision vectors. Because collision geometry is identical to rejoin geometry, the visual indications are exactly what the USAF teaches during rejoin training: a jet with zero line-of-sight rate, frozen on the canopy, and getting bigger. Once collision vectors are recognized, wingmen must know the safe separation standards that guide their actions. The proper criteria for safe separation also provides a margin of safety that gives the flight lead adequate time to realize that the wingman has fumbled, then to take whatever action is needed to prevent the collision.

Finally, pilots should avoid situations that unnecessarily aggravate the collision hazard, like poor formation and bad wingman consideration. In other words, they shouldn't poke the bear and create a predicament from which they will subsequently have to extract themselves.

Deconfliction School of Hard Knocks

We'll look at five randomly selected collisions to see what patterns emerge.

1. Misawa AB, Japan: G-awareness turn (fatal)[6]
2. Hill AFB, Utah: 30-degree check turn during a tactical intercept (fatal)[7]
3. Nellis AFB, Nevada: Rejoin (fatal)[8]
4. Hulman Field, Indiana: Tactical 180-degree turn (fatal)[9]
5. Kadena AB, Japan: Slight check turn during a tanker intercept[10]

All five collisions resulted from a chain of events that, if broken at any link would have prevented the crash. The proposed deconfliction plan provides detailed instruction for the wingman: the most obvious link in the collision chain. But we also address the two adjacent links: we teach all pilots to avoid situations that unnecessarily increase the potential for conflict, and we teach flight leads to verify that the wingman is properly yielding during critical times. These other two links are easy to address and effective at preventing collisions.

In all five mishaps, the flight paths of all ten aircraft were clear until the instant of impact. For example, at Kadena (fig. 1), the flight paths were clear to the west, but the collision axis was north/south. At Misawa (fig. 2), the jets were turning to a south heading. The flight paths of both jets were clear to the south, but the collision axis was east/west. The jets were turning hard in a 90-degree bank, so the flight lead was actually below the wingman's feet, obscured by the floor of the aircraft. The wingman was directly above the flight lead's head, or slightly behind. In these two crashes and the other three, clearing the flight path could not have prevented collision.

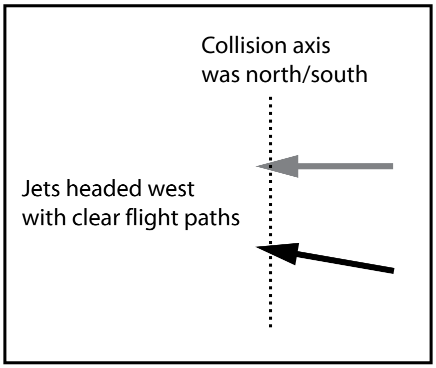

Figure 1. North/south collision axis

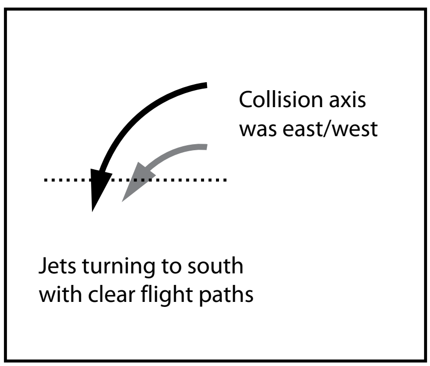

Figure 2. East/west collision axis

In three of five accidents, the jets were grossly out of position. At Misawa and Hill, the pilots were flying at less than half the proper spacing. This increased the potential for conflict and reduced reaction time. At Hulman, the 4-ship was spread out over 10 miles—more than twice the proper spacing. This certainly contributed to the number two wingman's loss of situational awareness. Making matters worse, the flight lead called for an operations check in the middle of a turn, causing all pilots to go heads-down into the cockpit instead of heads-up to monitor the formation. After rolling out of the turn, number two began flying formation off of the wrong jet and collided with his flight lead. There were eight pilots in these three flights, and they all silently accepted situations that greatly aggravated the collision hazard. The proposed deconfliction plan teaches pilots the dangers of bad formation and poor wingman consideration and empowers anyone in the flight to say something about it. This single measure would have prevented all three of these accidents and saved three pilots.

In four of five accidents, the wingmen showed poor cross-check techniques. At Kadena and Hill, the cross-check was too slow in relation to the distance between the aircraft. The flight leads changed direction and covered the intervening distance before the wingman noticed. At Nellis and Hulman, the wingmen were not visual on all three other jets in their four-ship; nor did they think that this lack of awareness merited a radio call. They both began flying formation off the wrong jet and collided with their flight leads. We should also note that a proper cross-check by the noninvolved members of these four-ships would have given them the opportunity to see and prevent the impending collision between their element mates. The proposed deconfliction plan teaches proper cross-check techniques for wingmen. This single measure surely would have prevented the mishaps at Nellis and Hulman, saving two pilots. It would have lessened the likelihood of the Kadena and Hill mishaps, but it's impossible to eliminate momentary lapses of attention. This is why we must teach flight leads to cross-check the wingmen during predictable times of increased collision hazard.

In all five accidents, the flight leads exhibited no effective cross-check whatsoever. Each initiated an action without glancing over to notice that the wingman was either distracted, confused, or not in a position to safety react to the event. The proposed plan teaches flight leads to cross-check when they initiate action that requires a deconfliction response from the wingman. This single, low-effort measure would have easily prevented all five of these crashes, saving the lives of four pilots.

We've seen that properly addressing any one of the three links in a typical accident chain is very effective in reducing collisions. Teaching all pilots to address all three links is exponentially more effective. Almost any of the 14 pilots in these 5 mishap flights could have prevented the collision at multiple links. Good deconfliction training would have prevented all five accidents with near certainty.

Improving our element deconfliction guidance also improves our mission effectiveness. A collision is a highly negative mission outcome: we've not only failed to accomplish that particular mission, but we've also lost the use of those aircrews and aircraft for all future missions. The safety techniques pilots must learn to keep track of their wingmen can be put to tactical use in keeping track of enemy aircraft in complex situations. Any pilot who demonstrates the inability to maintain awareness of his wingman is not only unsafe, but also unready for large force employment like Red Flag Exercises or actual combat.

Before we conclude this section, we'll note one final pattern: collisions are expensive. These five midair collisions cost four highly trained pilots and eight combat aircraft worth $144.6 million. That dollar figure does not include the value of human life, the cost to train the pilots or the cost of the accident investigation and aircraft salvage operations. The jets from our examples were older fourth-generation fighters valued at about $20 million. But now that fifth-generation fighters cost upwards of $100 million per copy, we're starting to talk about real money.

Innovation and Problem Identification

So why hasn't the USAF recognized the deconfliction problem? There has been ample opportunity. Midair collision is historically one of the leading causes of airborne Class A mishaps. Our five example accidents were drawn from a 10-year period (1997–2007) when Air Combat Command alone experienced 18 Class A element collisions involving 4 A-10s, 10 F-15s, and 22 F-16s. If we include Class B and C mishaps, the number grows to 26 collisions involving 52 aircraft.[11]

The accident reports from our five collisions are notable for two reasons. Firstly, three of the boards reached conclusions that were simply wrong. The reports from Kadena, Hill, and Misawa mention a failure to clear or deconflict flight paths even though the jets involved were displaced from each other's flight paths by 90, 60, and 90 degrees respectively. Lastly, all of the boards made some great observations that should have been captured in our element deconfliction guidance but were not. To consistently find these two failures in a series of accident reports is rare, troubling, and indicative of confirmation bias. The boards subconsciously selected and interpreted the data to fit to their preexisting belief that we have good deconfliction guidance.

The author has tried to alert the Air Force to its deconfliction problem. He has written two articles published in *Combat Edge* magazine, contacted the Air Force Safety Center, AFSO21, and attempted to engage leadership. The answer at every level was "we don't see the problem, so we aren't looking into it." The Catch-22 is that they won't see the problem *unless* they look into it. Given the high quality of Air Force officers, the deconfliction problem is inexplicable until we view it through the lens of confirmation bias. USAF education does address bias but tends to approach it from a historical perspective. Airmen study examples of biased decision making, along with the familiar warning that those who are ignorant of history are condemned to repeat it. The implication is that those who are familiar with history can avoid the mistakes of the past, so we think we have a good handle on bias, but cognitive science tells a different story.

Science tells us that history is a rich source of data, but that enlightenment only occurs after we synthesize the data to find patterns and causes. For example, in the early days of aviation pilots caught in clouds were taught to fly by the seat of their pants. We racked up a history of mishaps, each seeming to show how important it was for pilots to rely very carefully upon their senses to maintain attitude. Finally, we synthesized the data and discovered that our senses were easily duped by the peculiar motions of flight. Thus enlightened, we developed gyroscopic instruments. Now we teach pilots to rely upon their gauges because our senses lie to us.

Cognitive scientists tell us that our brains often lie to us. When we believe something, the bias resulting from our genetic proclivity for argument and persuasion naturally leads us to collect only the evidence that our belief is correct. Innovation requires us to search for evidence that our beliefs might be wrong. In short, an innovative Air Force doesn't argue with its innovators. Instead, the USAF must engage with its innovators to look for patterns and root causes that reveal new ideas and beliefs. This article provides the opportunity to do exactly that.

Here are the patterns to look for in our element collision records. These are simple yes/no questions that can be answered in a half-hour per collision. Every "yes" answer provides evidence that we need a new deconfliction plan. The 5 collisions we've examined have already produced 22 yes answers out of a possible 25, and studying additional formation mishaps will further confirm these patterns.

1. Were the flight paths clear before the collision?
2. Was bad formation or poor wingman consideration involved?
3. Did the flight lead just initiate an action requiring a deconfliction response?
4. Did the flight lead perform this action without cross-checking the wingman?
5. Did the wingman exhibit a slow cross-check, or fail to account for all jets in the flight?

Approaching the deconfliction problem with the mentality of a fighter debrief will produce two desirable outcomes. First, we will have solved an unrecognized safety problem that has the potential to save a squadron of aircraft worth more than a billion dollars during the next 10 years. That's not far-fetched: If we prevent only 1 collision per year, then that's 20 jets. As more fifth-generation fighters enter the fleet, we'll start to see single collisions that cost hundreds of millions.

The second outcome is harder to quantify but far more valuable. The deconfliction problem is not just a safety failure—it's also an innovation failure. If we are to learn from this, we must determine *exactly* what went wrong. The authors of *Air Force Tactics, Techniques, and Procedures* should have produced effective and compliant deconfliction doctrine but did not. The USAF Safety Center should have corrected the problem, but did not. Leadership should have stepped in, but did not. Applying a fighter debrief mentality to these issues will produce quantum improvements concerning tactics, doctrine, safety, professional military education, and our main subject: innovation.

Conclusion

We began with the axiom if it's not broke, don't fix it, and we'll end with the related axiom that necessity is the mother of invention. Although the USAF claims to value innovation, it has done little to address its blind spot for problem recognition. Time will tell whether it has a senior officer with the vision and leadership to recognize and fix the deconfliction problem before events make it necessary. Otherwise, the day might come when a *60 Minutes* news team knocks on the CSAF's door with a copy of this article, asking why we just had a $300 million F-22 collision that scattered flaming, toxic wreckage onto the community below.

A truly innovative Air Force is eager to exchange a good idea with a better one. The deconfliction example shows that today's Air Force is unwilling to exchange a terrible idea for an excellent one. Our current deconfliction guidance is ineffective, irrational, violates flight rules, lacks detail, and fails to incorporate lessons learned from collision reports. The proposed deconfliction plan corrects all of those issues while simultaneously improving mission effectiveness. But the USAF considers this to be a solution for a problem that doesn't exist, despite losing scores of aircraft to collisions.

RAND observed that the Air Force fails to innovate when it fails to see problems. Cognitive science supports and explains this observation as a byproduct of a brain that evolved to argue and persuade. Instead of seeing innovative solutions that better fit the facts, arguers see only the facts that fit their favored solution. But we can smell what we can't see, because argument always produces an odor. If we catch a whiff of contorted logic, omitted data, and refusal to consider alternatives, then that should alert us to an unseen problem and trigger the innovation process. The Air Force must train its nose. ✪

Notes

1. Adam R. Grissom, Caitlin Lee, and Karl P. Mueller, Innovation in the United States Air Force: Evidence from Six Cases, RAND Report RR-1207-AF (Santa Monica, CA: RAND, 2016): vii, https://www.rand.org/content/dam/rand/pubs/research_reports/RR1200/RR1207/RAND_RR1207.pdf.

2. Department of the Air Force, *The World's Greatest Air Force, Powered by Airmen, Fueled by Innovation: A Vision for the United States Air Force* (Washington, DC: Department of the Air Force, 11 January 2013), http://www.airuniversity.af.mil/Portals/10/CMSA/documents/Required_Reading/The%20World%27s%20Greatest%20Air%20Force_A%20Vision%20for%20the%20USAF.pdf.

3. Hugo Mercier and Dan Sperber, "Why Do Humans Reason? Arguments for an Argumentative Theory," *Behavioral and Brain Sciences* 34, no. 2 (2011): 57–111, http://www.dan.sperber.fr/wp-content/uploads/2009/10/MercierSperberWhydohumansreason.pdf.

4. Air Force Instruction (AFI) 11-202, Vol. 3, *General Flight Rules*, 10 August 2016, 22–23, http://static.e-publishing.af.mil/production/1/af_a3/publication/afi11-202v3/afi11-202v3.pdf; and AFI 11-214, *Air Operations Rules and Procedures*, 14 August 2012, 12, http://static.e-publishing.af.mil/production/1/af_a3/publication/afi11-214/afi11-214.pdf.

5. Maj Kevin J. Robbins, "Element Deconfliction in the Multibogey Arena," *Weapons Review Magazine* (Winter 1999): 4.

6. Executive Summary: *F-16CJ/90-0811 and F-16CJ/90-0801 Aircraft Accident Investigation*. Misawa AB, Japan: Pacific Air Forces, 13 November 2000, https://drive.google.com/file/d/0B9HnS7GIIWBxNzlmZU9tRW5UX1E/edit.

7. Executive Summary: *F-16CG/89-2006 and F-16CG/89-2001 Aircraft Accident Investigation.* Hill AFB, UT: Air Combat Command, 25 October 2002, https://drive.google.com/file/d/0B9HnS7GIIWBxV0xQQmQxNFFoaXM/edit.

8. Executive Summary: *A-10A/79-0191 and A-10A/80-0225 Aircraft Accident Investigation*. Nellis Air Force Base, NV: Air Combat Command, 4 December 2002, https://drive.google.com/file/d/0B9HnS7GIIWBxd01WeE8xaUFLN1U/edit.

9. Executive Summary: *F-16C/85-1555 and F-16C/86-0260 Aircraft Accident Investigation.* Hulman Field, IN: Indiana Air National Guard, 17 May 2004, https://drive.google.com/file/d/0B9HnS7GIIWBxNkJfTmhlQnpuRzg/edit.

10. Executive Summary: *F-15C/85-00093 and F-15C/85-0098 Aircraft Accident Investigation*. Kadena Air Base, Japan, 4 October 2004, https://drive.google.com/file/d/0B9HnS7GIIWBxeTVScGc0ZnlULXM/edit.

11. John Sellers, "Element Deconfliction Redux," *Combat Edge* 15, no. 8 (January/February 2007) 23.

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