6. AIR-TO-AIR COMBAT SKILLS

This chapter presents an analysis of 137 simulated air-to-air missile launches accomplished during air-to-air combat training missions by F-16C pilots from the 4th Fighter Squadron between October 1 1997 and February 28 1998. Throughout this discussion it is important to remember that air-to-air combat is one of the most cognitively and physically demanding tasks fighter pilots engage in. It demands that a pilot deftly manipulate small switches on his control stick and throttles to control radar and weapon systems while keeping track of, and responding to, opponent(s) and friendly aircraft maneuvers in a rapidly changing three dimensional environment. He or she must do this while often flying his or her aircraft at the very limits of its turning performance and straining virtually all of his or her major muscles to prevent loss of consciousness resulting from extreme g-forces. It has been likened to simultaneously playing the piccolo, driving a formula-one race car, and bench pressing 200 pounds. In addition, previous work in this area, as described in Chapter Four, supports prevailing fighter pilot intuition that air-to-air combat skills are among the most perishable fighter crew combat skills, making recent practice an important factor no matter how experienced a pilot might be.

It would be difficult to quantify all of the dimensions of such a demanding activity even if separate measures of the physical, psychological, and tactical skills involved were available. Unfortunately, the very nature of the air-to-air combat environment almost guarantees that any easily collected and quantified measure of performance in this area will be, to an even greater degree than the average bomb miss distances used previously as proxy measures for air-to-ground combat skill performance, only a rough proxy for the wide range of skills involved in air-to-air combat. In addition, fighter squadrons do not routinely collect and retain data on multiple measures of air-to-air combat performance. In fact, the best data set available consists of data on the 137 simulated air-to-air missile launches mentioned above.

DATA DESCRIPTION

The data available for analysis consisted of the same information on crew qualifications and experience that were presented in table 5.1. In addition, video tapes of aircraft heads up display (HUD) symbology and images were used to assess whether a simulated air-to-air missile launch during an air-to-air combat training sortie was within established launch parameters. The range, relative velocities, aspects, altitudes and maneuvers of the launching and target aircraft at the moment a simulated missile is launched are assessed to determine if it could have guided on and reached its intended target – or, in other words, if the missile shot was valid.

As previously mentioned the data set used here contains information on 137 simulated air-to-air missile shots made by pilots of the 4th Fighter Squadron between October 1, 1997 and February 28, 1998. Nineteen of the 137 shots (13.8 percent) were judged to be invalid. It was extensively analyzed to investigate what, if any, relationships exist between a number of pilot experience and recent practice variables, and air-to-air missile shot validity.

STATISTICAL ANALYSIS AND RESULTS

A variety of model specifications were investigated and various transformations of the available pilot qualification and practice variables were evaluated. The structure of this data set is slightly different than that of the bomb data evaluated in Chapter Five. Unlike most of the bomb data, it includes the date each simulated missile shot occurred. Therefore, it was possible to determine, for any given shot, how many days it had been since the pilot had launched his last simulated missile. A number of statistical models were evaluated using various combinations of pilot qualification and experience variables and transformations of the days since last shot variable. The median time between missile shots was just 13 days. However, pilots went 50 days between shots more than 25 percent of the time, and ten percent of the shots were taken after a lapse in practice of 115 days or more. The considerable variation in time between shots is due to the squadron’s deployment to Saudi Arabia during December 1997 and January 1998 in

support of ongoing peace operations. No simulated air-to-air combat training was conducted during the deployment.

Unlike the air-to-ground combat skill analysis presented in Chapter Five, there was no evidence of a statistically significant difference between the performance of instructors and non-instructors in firing valid simulated air-to-air missile shots.[1] However, logistic regression analysis did reveal a significant positive relationship between the log of the numbers of days since the last practice shot and the probability of an invalid shot.[2]

To further clarify the relationship between practice and the probability a pilot executes an invalid simulated air-to-air missile shot, data from all pilots were combined into four groups. The groups each contain data on 27 to 43 simulated air-to-air missile shots. Shots were grouped based on the number of days since the pilot's last simulated air-to-air missile shot. The groups included shots taken between one and three days after the last shot, shots taken four to ten days after the last shot, shots taken 11 to 30 days after the last shot, and shots taken 30 to 120 days after the last shot. Grouping the shots this way reveals just how strong the relationship between the probability of launching an invalid simulated air-to-air missile shot and the number of days since the last shot is. Figure 6.1 below reveals that only one of 27 simulated missile shots (3.7 percent) taken between one and three days were invalid. Three of 28 shots (10.7 percent) taken between 4 and 10 days were invalid. Seven of 43 shots (16.28 percent) of shots taken between 11 and 30 days were invalid. Finally, eight of 37 shots (21.6 percent) taken between 31 and 120 days were invalid.

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[1] See implications section below for a discussion of this somewhat counter-intuitive finding.

[2] Logistic regression is a standard statistical analysis used when the dependent variable – in this case whether a simulated missile shot is valid or invalid – is binary. The model yielded a odds ratio of 1.42, z-statistic of 1.96 and p-value of exactly 0.050.

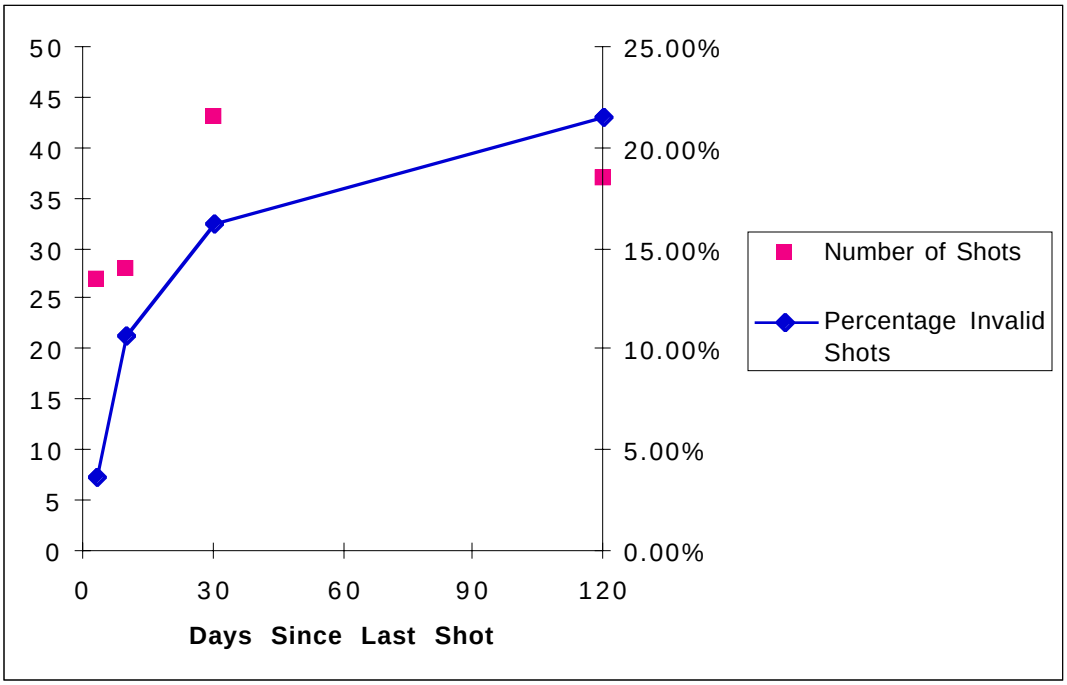

Figure 6.1 – Graph of Air-to-air Missile Shot Groups Showing Number of Shots and Percentage of Invalid Shots in Each Group

Further analysis of these grouped shots reveals a very strong logarithmic relationship between the probability a pilot launches an out of parameters simulated air-to-air missile shot and the number of days since he last exercised his air-to-air combat skills. Figure 6.2 below plots a curve based on this logarithmic relationship against the actual probabilities of invalid shots first presented in figure 6.1.

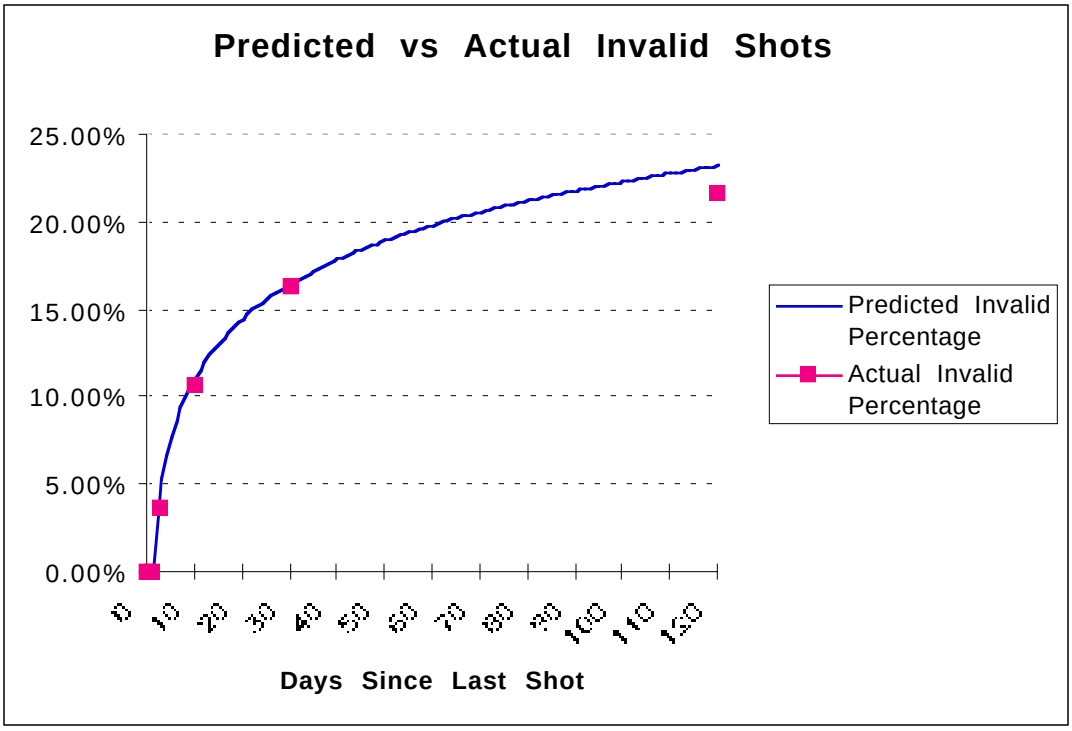

Figure 6.2 – Predicted vs Actual Invalid Air-to-air Missile Shots Based on Days Since Last Shot

IMPLICATIONS

What does this analysis reveal about air-to-air combat skills? First, it supports fighter pilot intuition[3], and findings of the Osborn and Hammon and Horowitz studies that air-to-air combat skill performance is much more dependent on frequent, regular practice than on experience when compared with air-to-ground combat skills. Both the lack of any statistically significant evidence that experience or instructor status has an impact on the likelihood of invalid simulated missile shots and

[3] RAND colleague, and former USAF F-4E squadron commander, Bill Taylor and Col Thomas "Snake" Donaldson, current ACC/DOT commented that this counter-intuitive conclusion makes perfect sense to them. They explained that long after they were experienced they have been soundly trounced in air-to-air combat training after significant lapses in training by much less experienced crews with lots of recent practice. Conversely, they both pointed out that experienced crews with little recent practice could go to the bombing range with little recent practice without fear of embarrassing themselves.

the rapid increase in the probability of launching an invalid shot as time passes since the last practice support this conclusion. However, it is important to note that with a larger sample of simulated air-to-air missile shots it is possible a difference in invalid shot probability in favor of instructors might emerge, and that experience is an essential prerequisite for successfully leading and employing formations of two or more aircraft in air-to-air combat.

Second, the analysis sheds some light on the impact of peace operations on air-to-air combat skills. On average, before deploying to Saudi Arabia 4th Fighter Squadron pilots went, on average, nine days between simulated air-to-air missile shots. This analysis indicates pilots who practice air-to-air combat once every nine days have about a ten percent chance of launching an invalid missile shot. None of the 4th Fighter Squadron pilots who deployed to Saudi Arabia logged a simulated air-to-air missile shot during the deployment. On average, by the end of the deployment these pilots had gone about 70 days without air-to-air combat practice. During this time their chances of launching an out of parameters missile doubled to over 20 percent.

Third, the implications of an increased probability of launching an invalid air-to-air missile shot probably go beyond the mere wasting of an expensive piece of ordinance. The decision to launch an air-to-air missile is one of the most important decisions a pilot makes during an air-to-air engagement. Mistaken missile launches are almost certainly associated with lower performance in other important air combat skills such as radar searches, tactics, formation integrity, visual lookout, and g-tolerance to name a few. In addition, launching a missile out of parameters indicates a pilot has either fundamentally misjudged the relative position of his or her aircraft and the target, misread information on the HUD, thrown the wrong switches, or otherwise misunderstood or mishandled the situation. In short it demonstrates a lack of what fighter pilots refer to as “situation awareness”. This is a most important aspect of air combat. The pilot, or group of pilots, who maintains the best understanding of where friends and foes are relative to their own position during the confusing, time compressed air combat engagement will most likely emerge the victor.

Fourth, air superiority missions, just like ground attack missions, require successful completion of a long string of important tasks. To the extent that valid air-to-air missile shot rates are positively correlated with radar searches and sorts, tactics, formation integrity, visual lookout, etc the overall probability USAF crews will successfully complete air superiority missions declines *much more* than an examination of the decline in valid missile shot rate during peace operations deployments indicates. Therefore, if a major war broke out, pilots who had recently engaged in peace operations deployments would be less prepared to achieve air superiority than their counterparts were during Operation Desert Storm. Obviously, this could lead to more air-to-air combat losses, an increase in the length of time required for US and allied forces to achieve air superiority, or both. It is even possible that decreased air-to-air combat effectiveness could allow a clever and bold adversary to employ fighters to disrupt USAF offensive operations for a considerable period of time as the North Vietnamese did during Operations Rolling Thunder, Linebacker I and Linebacker II.[4]

Finally, throughout the history of air warfare the side that consistently fielded the superior fighting force has been able to inflict unacceptable losses on its adversaries and eventually achieve air superiority. A fighting force can be described according to the number of personnel and weapons it possesses, the quality of its equipment and the skill of its personnel. This last aspect – operator skill – has been especially important in air-to-air combat.

At the beginning of 1944 the US 8th Air Force and the German Luftwaffe had approximately the same number of single engine fighters

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[4] North Vietnamese MiGs remained a threat to USAF operations throughout the entire air campaign against North Vietnam. In addition to damaging and shooting down literally hundreds of USAF fighters, they forced thousands of strike aircraft to jettison their bombs in order to maneuver to survive MiG attacks, and forced strike formations to adopt tactics, formations and other measures that dramatically reduced the effectiveness of USAF operations. See Marshall L. Michel III, Clashes: Air Combat over North Vietnam 1965-1972, Naval Institute Press, Annapolis MD, 1997 for a detailed analysis of the impact of MiG attacks on USAF strike packages during the Vietnam War.

engaged in the struggle for air superiority over occupied Europe.[5] The quality of the opposing aircraft was approximately equal in terms of combat performance.[6] By June of 1944 the Luftwaffe fighter forces had suffered 2262 fighter pilot losses from an average fighter pilot strength of 2283 – a staggering 99 percent attrition rate over a six month time period with monthly pilot loss rates averaging over 16 percent.[7] This was achieved with a loss of only about 250 US fighters in air-to-air combat for an exchange ratio of 9.1:1.[8] This superior performance of US fighters against German adversaries with similar equipment is generally attributed to the large, and as time went on, increasing gap in basic and operational training the American fighter pilots enjoyed. Overoptimistic German assumptions of quick victory in 1942 and early 1943 resulted in a bottleneck in pilot training capacity. The over tasked flying schools attempted to meet increasing demands for fighter pilots as the combined allied bomber offensive progressed by decreasing the length (and therefore the quantity and quality) of student training. Less skilled pilots lead to higher combat losses which further increased the pressure on the training schools to churn out ever larger numbers of progressively less skilled pilots resulting

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[5] Williamson Murray, Luftwaffe, The Nautical & Aviation Publishing Company of America, Baltimore, MD pp. 224-227.

[6] While not wishing to join the long, and ongoing, debate over which aircraft was the best fighter of World War Two, it is important to acknowledge that the three US fighter types involved – the P-38, P-47 and P-51 – achieved this essential equality in combat performance (a function of speed, ceiling, maneuverability) combined with combat radii previously attainable only by much larger bomber aircraft. The large combat radii were part and parcel of their primary bomber escort mission, but came at the expense of firepower. Their German opponents – principally late model Me-109 and FW-190 fighters – did not have the same range (and generally did not need it as they were operating over their home territory) but carried much heavier armament. The German fighters carried multiple 20mm and 30mm cannon designed to blast heavy bombers out of their tight formations. These weapons had much greater range and hitting power than the smaller 0.50 inch (12.7mm) machine guns that were the mainstay of the American fighters' armament.

[7] Murray, . 228.

[8] Statistical Summary of Eighth Air Force Operations, European Theater, 17 August 1942 – 8 May 1945, p. 29, p. 61.

in a catastrophic downward spiral in pilot quality.[9] By early 1944 US fighter pilots had, on average twice as much flight training as their German counterparts and over three times as much training in air-to-air combat and other operational skills.[10]

US Air Force pilot skill was again a key factor in the success of F-86 equipped fighter squadrons against less well trained communist MiG-15 pilots over "MiG Alley" in northwestern Korea from 1950-1953. During this conflict USAF F-86 pilots shot down 792 MiG-15s in air-to-air combat while losing only 78 F-86s for a kill ratio of 10.15:1.[11] Here again both sides possessed aircraft with remarkably similar performance. It was the superior training and experience – many USAF fighter pilots in Korea were veterans of World War II – that made the difference.

The importance of quality training in air-to-air combat was demonstrated by the US experience in Vietnam and Israeli experience in the Middle East. The dramatic increase in the Navy's MiG kill ratio after it adopted its "Top Gun" training program during the Vietnam war (discussed previously in Chapter 2) provides additional evidence of the importance of training in air-to-air combat. Israeli Air Force leaders attribute the resounding success of their pilots in air-to-air combat in the 1973 Yom Kippur War where they achieved a 50:1 kill ratio largely to "their own razor sharp pilot training that never stops."[12] Israeli pilots expressed similar sentiments again after the air battles against Syrian pilots over Lebanon in 1982 where they achieved a 85:1 kill

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[9] The next section on the long term impact of peace operations on describes how peace operations could be contributing to a similar downward spiral in overall USAF fighter crew quality.

[10] Murray p. 240, 262. See also Wesley Craven, ed., et al. The Army Air Forces in World War II: Volume III, University of Chicago Press, 1951, p. 62-63 for more details on how the Luftwaffe pilot quality problem led to defeat in the battle for air superiority over Europe in early 1944.

[11] Robert F. Futrell, The United States Air Force in Korea, Office of Air Force History, Washington DC, 1983, p. 695.

[12] Robert Holtz, "Israeli Air Force Faces New Arab Arms," *Aviation Week & Space Technology*, 10 March 1975, p. 16. Quoted by Peter deLeon, The Peacetime Evaluation of the Pilot Skill Factor in Air-to-air Combat, RAND, Santa Monica, 1977, p. 12.

ratio.[13] While it might be argued the Israelis had the advantage of superior equipment, a senior Israeli Air Force officer pointed out "They (the Syrians) could have flown the best fighter in the world, but if they flew it the way they were flying, we would have shot them down in exactly the same way. It wasn't the equipment at fault, but their tactics"[14] In short, the type, quantity and timeliness of air combat training pilots receive is a critical factor in air-to-air combat.

The analysis presented so far in this chapter shows the long lapse in air-to-air combat training associated with peace operations deployments increases the probability USAF pilots will launch air-to-air missiles outside parameters – decreasing their combat effectiveness and their ability to enforce the no-fly zones they patrol while deployed. In addition, they probably decrease pilot situation awareness during air combat engagements and negatively impact other important air combat skills such as radar search and sort skills, tactics, formation, etc. As with air-to-ground mission profiles, the cumulative effect of decreased proficiency across a broad range of air-to-air combat skills almost certainly has a much larger impact on the ability of crews to successfully accomplish MTW air superiority missions than the increase in proportion of invalid missile shots alone would indicate. These factors increase the probability pilots and aircraft will be lost in the event no-fly zone patrols are challenged. In addition, in combination with historical experience this analysis indicates that the ability of USAF fighter pilots to rapidly achieve and maintain air superiority during a MTW without suffering excessive losses could be substantially decreased for pilots with little or no recent air-to-air combat training.

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[13] Benjamin S. Lambeth, Moscow's Lessons from the 1982 Lebanon Air War, RAND, Santa Monica, 1984, p. 9.

[14] "Beka'a Valley Combat," *Flight International*, October 16, 1982, p. 1109. Quoted by Lambeth IBID, p. 9.

POSSIBLE LONG TERM IMPACT OF PEACE OPERATIONS DEPLOYMENTS ON USAF COMBAT CAPABILITY

Up to this point this discussion of reduced USAF fighter crew combat effectiveness has focused on quantitatively measurable variables that indicate considerable short term decreases in the average ability of USAF fighter squadrons to conduct MTW air-to-air and air-to-ground combat missions as a result of peace operations deployments. However, the long family separations and breaks in tactical training associated with peace operations deployments impact the long run combat effectiveness of USAF fighter squadrons in two related ways.

First, there are a large number of anecdotal accounts, supported by exit interviews and surveys, that the long family separations, the poorly articulated rational for peace operations and the booming civilian job market are contributing to unsustainably low retention rates among USAF fighter crews as well as maintenance and support personnel. The following quote from a recent article by a retired USAF Lieutenant General summarizes this concern well:

> Critical-skill personnel aren't leaving just for the money, although that is a factor. They are leaving because they can't justify to their families the need for being away from home half the year when US interests really aren't at stake. And, just as importantly, they can't justify to themselves not being the best.
>
> We don't train like we used to. We used to be a cohesive fighting force, serving with unlimited liability to protect and defend the United States," a pilot said. "We were called to the profession of arms. The 'Evil Empire' was the focus of our training and we had a clear understanding of what constituted the United states' vital interests. Those times are gone, and we're tired of droning holes in the sky; protecting allied airspace where we're not welcome. They shackle us in the air, on the ground and during our time off.[15]

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[15] Harley Hughes, *Bailing Out: Air Force Retention is in a Tailspin, and the Worst is Yet to Come*, Armed Forces Journal International, September 1998, p. 45.

The same article points out that so far this year only ten percent of USAF pilots has accepted a six-year commitment beyond the initial obligation required for pilot training despite the increased $110,000 bonus package. This is expected to lead to a shortfall of between 1500 and 1700 experienced pilots by the end of FY 98. Future prospects for addressing the shortfall are not promising.[16]

The pilot quoted above alludes to the second way peace operations deployments impact long term USAF combat readiness when he mentions training. Both this chapter and Chapter Five show that the training value of no-fly zone sorties is essentially zero for many important MTW combat skills. While the proficiency lost during the deployments may return in a matter of a few weeks or months once normal training resumes at home, the weeks or months of tactical training opportunities lost during the deployment can not be recovered. This results in slower "tactical seasoning" of USAF fighter crews and is already causing problems for squadron leadership, and over the long run may result in a significant decrease in USAF combat effectiveness.[17]

The following example provided by the operations officer of an F-15C squadron from the 1st Fighter Wing at Langley AFB, VA illustrates this problem. During an interview in late 1997 he explained that by the end of their first operational tour in the F-15C, pilots today have only flown about half as many tactical training missions as their counterparts from seven to ten years ago. There are two main reasons for this.

First, the average length of a pilot's initial operational tour has decreased from about four years during the late 1980s and early 1990s to about two years eight months today. There are a number of reasons for this including the need to bring "banked" pilots into operational units and requirements for experienced fighter pilots to serve as instructors at Undergraduate Pilot Training (UPT) bases.

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[16] IBID, p. 42.

[17] Note: The idea that peace operations deployments result is slower tactical seasoning of USAF fighter crews is consistent with psychological research discussed in Chapter 3 that emphasized the importance of deliberate practice, rather than general exposure, in producing expert performance in a variety of mental and physical tasks.

Second, the training value of these shorter tours is diluted by several lengthy deployments in support of no-fly zone operations. The typical 1st Fighter Wing pilot now spends about nine months of their average thirty-two month initial operational tour flying circles over Iraq. As a result, they have only about one year eleven months of high quality tactical training sorties at the end of their first assignment. So, while the typical pilot seven to ten years ago went off to his second assignment as a 4-ship flight lead or even an instructor pilot, his counterpart today usually leaves the 1st Fighter Wing as a brand new 2-ship flight lead. The bottom line is that current USAF fighter pilots who participate in peace operations deployments have not experienced as much high quality tactical training at a given point in their career, as measured by total fighter hours, as their counterparts seven to ten years ago had.

This situation leaves USAF leaders a stark choice. They can upgrade current pilots to four ship flight leads or instructors at the same point in their careers as pilots a decade ago – and accept the de facto reduction in standards this implies. Alternatively, they can delay upgrading current pilots until their actual tactical experience approximates that of “Cold War” pilots upgrading to the same qualification.

The first option caries with it the prospect that future instructors and flight leads will be less expert than those of the past, with negative consequences of unknown magnitude for future students and wingmen. This option could well lead to a downward spiral as these less well trained students and wingmen become even less proficient flight leads and instructors, and so on. The F-15C community is not alone in facing this problem. This first approach is essentially the approach adopted by the F-15E community toward its RTU instructors. Interviews with senior instructors and training managers at the 4th Fighter Wing indicate that the even though standards for becoming a RTU instructor are the same as in years past the actual experience and capability of crews returning from their first operational assignments to upgrade as instructors are markedly below those of the past.

The second option – delaying upgrades until current crews have experience levels equivalent to that of Cold War crews – has the advantage of maintaining historic standards, but is also problematic. Since crews typically spend up to a quarter of each year, or more, deployed in support of peace operations opting to wait for equal "tactical seasoning" means increasing the total time required to produce an instructor or flight lead by 25 percent or more. With so many USAF personnel opting to leave at the end of their initial commitment, an increase in the average time to upgrade means an eventual decline in the number of instructors, four ship flight leads, mission commanders and other specially qualified crews available to each squadron. This could, for example, result in a shortage of four ship flight leads - forcing USAF leaders to employ their fighters as two ship elements. No one knows if, or how much, this will impact the combat effectiveness of USAF fighter units. However, it is disturbing that a de facto change in operational doctrine could be adopted by the USAF as a response to a creeping decline in overall pilot qualifications rather than as deliberate change founded on the belief that smaller elements operating independently are as (or more) effective as larger elements acting in concert. This is essentially the response adopted by the 1st Fighter Wing leadership, and some squadron commanders and operations officers are already beginning to see a looming shortage of four ship flight leads.

The long term impact of peace operations on USAF combat effectiveness is even more difficult to measure than the short term impact. However, it is clear that the impact will be negative. Just how much of a difference the combination of decreased retention and reduced training opportunities will make in qualitative aspects of air operations at the individual and formation level is impossible to predict with any degree of precision. The important point to keep in mind is that there are long term deleterious effects of peace operations on USAF combat readiness in addition to the short term effects described earlier. Any proposed solution to the peace operations readiness impact problem must address the short term skill loss and long term retention/readiness issues if it is to be truly effective.

SUMMARY

This chapter has presented an analysis of data on 137 simulated air-to-air missile shots taken by pilots from the 4th Fighter Squadron between October 1 1997 and February 28 1998. The analysis indicates that practice is much more important to air-to-air combat skill proficiency than experience. In fact, there is no statistically significant evidence in the data examined here that experience has any impact at all on air-to-air combat skill performance. This is probably not strictly true. Experience may help to a certain extent. However, its impact is small relative to that of practice. In fact, it is so small that its effect was undetectable using standard statistical analysis and levels of significance in this particular data set. It is possible an experience effect could be found in a larger data set or in data from a different squadron.[18] In addition, the analysis shows that frequent practice is necessary to maintain proficiency in air-to-air combat skills. Lack of consistent practice during peace operations deployments results in a doubling of the probability that a pilot will launch an air-to-air missile out of parameters, and probably has a similar impact on other important air-to-air combat skills and overall situation awareness, and MTW combat effectiveness.

This chapter also presents more qualitative evidence that peace operations negatively impact the long term combat capability of USAF fighter crews and squadrons. This long term effect is the result of decreased retention and long-term reductions in training opportunities associated with peace operations deployments. Chapter Seven reviews the conclusions reached here and in Chapter Five. It then lays out and evaluates a variety of possible policy responses to the various USAF combat readiness costs posed by peace operations.

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[18] This last possibility is unlikely to the extent that USAF fighter pilots receive highly standardized training, are the products of a rigorous selection process, and are assigned (more or less) at random to operational squadrons. These factors tend to diminish differences between USAF fighter squadrons and therefore decrease the chances that a study of other USAF squadrons would produce results significantly different from the results presented in this chapter and Chapter Five.