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NIGHT AIR COMBAT

A UNITED STATES MILITARY-TECHNICAL REVOLUTION

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Preface

The Gulf War provided the opportunity to see both the extent and limitations of United States air power, particularly when applied at night. As an F-15E "*Strike Eagle*" instructor pilot and mission commander, it became obvious that some missions, though risky at night, would have been significantly more perilous in daylight. Fighting at night, with excellent training and equipment, provided the extra cover of darkness that exposed fliers appreciate. *Night air combat* is not a new phenomenon. The current measures of effectiveness and potential for even greater capability in this area are important to consider if the United States Air Force is to maintain relative superiority over potential enemies. Questions come to mind, however, regarding US night fighting capability. How did the United States become the premiere night-fighting air force: was it planned or simply fortuitous application of technology? Could leaders use the lessons distilled while learning to fight at night to translate future technological improvements more rapidly and economically into increased combat capability?

This paper is a result of close work with Mr. Budd Jones, who helped in an analysis of the Military Technical Revolution (MTR), evaluated the historic review of night air combat, and assisted in developing sound conclusions. His assistance in investigating the concept of night air combat as an MTR, and in the study of military revolutions in general, was critical to this endeavor.

Abstract

Night fighting is one competency in which the United States possesses global superiority. After witnessing the devastating effect of twenty-four hour flight operations during Operation Desert Storm, many tacticians now promote initiating offensive air combat operations at night to exploit our apparent advantage over potential adversaries. Understanding how the United States reached the critical jump in military effectiveness through the application of night air combat technologies is critical to project future military revolutions based on technical innovations. Although previous wars and conflicts have had limited night aerial operations, it is possible to detect a revolutionary shift in the effectiveness of night air combat and in the frequency of night airpower employment. This paper explores the development and non-linear maturation process of night air combat, examining this capability with regard to the theory of the military technical revolution (MTR).

An investigation of the MTR concept begins this study, followed by a historic review of night air combat. Finally, this paper links theory and history to provide conclusions. Night air combat, as a specialized type of combat in which the United States military retains a distinct advantage due to technology, training, and application, fits the characteristics of MTR theory—and is part of the continuing greater Revolution in Military Affairs.

Chapter 1

A United States Military-Technical Revolution

> *Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.*
>
> —Guilio Douhet

> *In this increasingly competitive, often hostile and rapidly changing world, Americans seem to have only one real choice. Clearly our national well-being cannot be based on unlimited raw materials or on unlimited manpower and cheap labor. Rather it must be based on our ability to multiply and enhance the limited natural and human resources we do have. Technology thus appears to offer us our place in the sun—the means to insure our security and economic vitality.*
>
> —Dr. Malcolm Currie

Modern war is an around-the-clock effort. Operation Desert Storm demonstrated the unique scope of ability the United States air forces possessed by prosecuting the air war regardless of weather or time of day. These impressive accomplishments are part of a key advantage the United States now has over its enemies—the ability to conduct the full spectrum of military operations at night nearly as well as, or as well as during daylight operations. Indeed, air combat planning and training are currently geared to fighting the next war at any time, day or night. Night fighting is now considered one of the areas in which the United States possesses global superiority, and many tacticians promote initiating offensive air combat operations at night to exploit our advantage over potential adversaries. This sets the stage for a discussion of night air combat as a revolutionary capability in warfare—a revolution in which the United States military forces are actively involved.

Although previous wars and conflicts have had limited night aerial operations, it is possible to detect a revolutionary shift in the effectiveness of night air combat and in the frequency of night airpower employment. This paper explores the development and non-linear maturation process of night air combat, examining this capability with regard to the theory of the military technical revolution (MTR).

Why is it important to explore night air combat with regards to the MTR theory? Tracing the non-linear maturation of the USAF ability to fight with devastating effectiveness regardless of the time of day may help in the recognition of how emerging technologies can better and more quickly be translated into combat capability. This understanding could ultimately save time and money in the current environment of shrinking budgets and declining popular interest in military functions.

This study looks beyond the historical significance of the emergence of night air combat as a revolutionary change in both extent and affect of United States Air Force war-fighting capabilities. This investigation also examines the process by which fighters and bombers went from day, visual-only artillery observation posts, to around-the-clock, multi-role and profoundly flexible weapons systems. The discussion of the concept of military revolutions is particularly important, however. If it is possible to identify an MTR while it is emerging, then astute leaders can harness aspects of that MTR to create more efficient results, and contribute to the greater goal: continuing and advancing the current revolution in military affairs (RMA). The final outcome is overall increased combat capability for the United States Armed Forces.

What is night air combat? Broadly, this study defines night air combat as any air-to-air or air-to-ground weapons employment accomplished during darkness. Many aspects of night air combat are closely related to all-weather aircraft employment due to the challenges of this operating environment, particularly the lack of visibility. This paper highlights both air-to-air and air-to-ground night fighter operations. Since night "terror" bombing occurred at very early stages in the evolution of air power, and the effect of such early bombing was not drastically different than could be accomplished by high altitude bombers in daylight, it is not investigated. Particularly, before the emergence of capable night air interceptors, night bombing was more risky for want of navigational aids and precise aeronautical instruments than for the risk of attacking enemy fighters. Necessarily, the emergence of capable night fighters caused the tactics and capabilities of night bombers to evolve.

Night air combat covers a wide spectrum of operations and capabilities. This paper uses selected examples to illustrate specific points. The focus is on specialization in the night air combat fighters and in later multi-role fighters (or dual-role: i.e., with both air-to-air and air-to-ground capabilities). Other specific technological elements, such as the ground control radar, the laser, electro-optical and infra-red (IR) seekers on precision guided munitions, night-vision goggles, and terrain-following radar (TFR) are all technological steps upon which US night air combat capability ascends. These technical improvements, in the context of this analysis, remain only parts of a complex non-linear increase in a night air combat capability.

This study begins with some background on MTR theory. Next follows a historical discussion of night air combat, emphasizing the non-linear development of capabilities.

The use of night fighters is traced from WWI to the present, concentrating on US technology, tactics, operations and organizations, including training. This investigation includes the development of the capability of the United States Air Force to engage in night air combat, including: the equipment, key technological improvements, the strategy for use of these technological improvements, changes in tactics, and employment.

Following this historical analysis, the paper moves to deal with the question of whether modern night air combat as practiced by the USAF is indeed an MTR. The focus in this chapter being whether the incorporation of RADAR, precision guided munitions, and night navigation aids results in an arguably “revolutionary” new type of military engagement capability. Specifically concerned are manned aircraft weapons systems that may be employed with a high degree of efficiency around the clock—continuing effective prosecution of the enemy at night or in poor weather. The organizational structures and the critical training components that support night air combat capabilities are also examined, particularly with respect to their relationship to night air combat as an MTR.

Finally, this study concludes with considerations of how closely the MTR model reflects the true capability and application of these night air combat technologies, arguing that night air combat is an MTR. Indeed, as an MTR in progress, night air combat is an illustration of both efficient and inefficient applications of technology for the consideration of leaders to assist improving future technological integration.

Chapter 2

Military-Technical Revolution Theory

> *Another debate concerns the interaction of technology and doctrine: Which should be paramount? Should technology serve doctrine and so produce weapons that fit preconceptions and prejudices? Or should doctrine be adapted to make best use of what technology has to offer.*
>
> —Jonathan Alford

This chapter acquaints the reader with MTR theory. It begins with a quick introduction to familiarize the reader with the terms and possible points of confusion in military revolution discussions, then follows a more detailed presentation of the four elements of an MTR. The similar and popular concept of the Revolution in Military Affairs (RMA) is then contrasted with the MTR theory in more detail. Subsequently, there is a brief discussion on evolution versus revolution and key strengths and weaknesses of the MTR theory. Finally, the chapter concludes with a discussion of the relevance of the MTR, and its use for future planning. The information and definitions given in this chapter provide a frame of reference for the next chapter's historical discussion of night air combat with respect to the MTR.

Military Technical Revolution theory grew from Soviet military studies of the 1960s and 1970s where they noticed fundamental changes in the conduct of war based on revolutionary technological improvements or innovations. They felt that "converting science into a direct productive force" was an essential ingredient in current technical revolutions. Additionally, they considered “fundamental shifts” in the processes governing the development and use of technology when describing revolutionary advances.[1] It is important to note, however, that the technical improvement alone rarely changes much. The effective use and integration of that technology is essential in judging its role and acquiring a relative advantage over an enemy.

The integration of the technological improvement involves four elements, or characteristics, that define an MTR. In 1992, Dr. Andrew Krepinevich published a review of the MTR concept from an American perspective, and described its four characteristics: *technological change, military systems evolution, operational innovation,* and *organizational adaptation*.[2] These elements are expounded upon in the next section of this chapter.

The RMA theory is a Western outgrowth and currently a more popular derivative of the MTR theory. Because the theories are similar and share the same basic elements, they are frequently confused or the terms are used interchangeably. Technical innovation typically initiates an MTR. Conversely, leaders must plan in advance for an emerging RMA, determining a need before creation or extensive military use of a technical application, and resultant organizations, tactics, and systems development. Many consider the MTR a technology “push” while the RMA is a “conceptual pull.”[3] This distinction is fundamental. Table 1 shows a quick reference for the concepts discussed in more detail later in this chapter.

Table 1. Differences between MTR and RMA

RMA is a technology pull	MTR is a technology push
RMA results in broad changes	MTR has less broad changes
RMA is a result of a deliberate decision	MTR is the inevitable consequence

Source: Maj Matt Caffrey, Lesson Plan TH503, 2. Table 1 was created from ideas expressed in Caffrey's lesson plan.

Cultural conditioning is one reason the 1960s-1970s Soviet concept of the MTR differs from the 1980s Western RMA. By concentrating on fielded military forces and the inherent power of technology, the Soviets applied a more narrow vision to specific technical improvements and their subsequent dramatic affect on warfare. American theorists, modifying the theory and its scope, proposed the more broad RMA theory. This widening of the scope of military revolution theory includes the technical innovations and applies them to a more broad increase in their synergistic effects. Many believe the US is currently undergoing a RMA. Two "defining characteristics" of the current RMA that many theorists generally agree upon include long-range precision strikes and "an increasing interest in informational warfare."[4]

The confusion between the theories typically resides in the commonality of the characteristics. Generally, there exist three important differences between the two theories. First, there is an East versus West perspective contrasting the MTR with the RMA. Secondly, there exists a difference in scope between the two theories. Finally, there is a differing focus of the technical "push" for the MTR as contrasted to the technology "pull" in an RMA.

The MTR theory has lost popularity in the mid-1990s due to its narrower scope compared to the RMA. A question comes to mind: Why use the less popular MTR theory in the discussion of night air combat? Simply, the more narrow scope of the MTR theory and its emphasis on technology leading the integration of military use, organizations and systems developments, describes the US night air combat capability non-linear maturation more accurately. When certain specific technological "pushes" are considered, the MTR theory can fold comfortably under the umbrella of a broader RMA. The RMA then integrates numerous technical improvements, some of which may fulfill the characteristics used to define an MTR.

The integration of many technologies creates even greater leaps in capability by the synergistic application of those technologies along with the critical elements of the organizations, tactics and system improvements. It is therefore possible to have an MTR, or more than one MTR, within the greater RMA. Separately, the specific MTRs must retain all four elements of the theory, and provide for a terrific jump in capability or change in the nature of warfare. When combined with other technologies, additional MTRs, and a comprehensive long-range plan, specific MTRs may be integrated into a larger RMA paradigm where the need for more expansive changes leads to comprehensive technical, organizational and tactical improvements.

Through analysis, it is possible to determine, after the fact, whether a technological innovation came before the military adapted it (MTR) or if a need was recognized and technology later filled the need (RMA). Typically, historians identify a revolution after the fact. In the case of night air combat, the revolution (and its maturation) continues. Night air combat is a capability that can be considered an MTR separately, or in the context of the current RMA, a component of the greater revolution in military affairs. The current night air combat capability of the United States is relatively superior to the capability of its potential enemies to fight at night. Its impact is many orders of magnitude greater than the night air combat capability available in previous wars. As a contributor to the current RMA, night air combat capability is now fundamentally a given—it is required and considered a basic US military capability.

The ultimate purpose for studying MTR theory is twofold. First, the MTR theory and the RMA theory suggest that there is a revolutionary change occurring in warfare, creating a new way to fight a war. Understanding the characteristics of this change is important to encourage the potential US advantage. Additionally, when military and civilian leaders understand the process by which a technical innovation can change the way war is fought, they may then direct resources toward the technology through the elements of the MTR. This focus integrates the technology more efficiently into currently existing military organizations and operations and inevitably leads to superior economic and operational application integration.

Four Elements of an MTR

To discriminate an MTR from a mere military technical improvement, four characteristics must be apparent: *technological change*, *military systems evolution*, *operational innovation*, and *organizational adaptation*.[5] It is not the technical innovation itself that constitutes a "revolution." The blending of an emerging technology, for use in military environs, with operational changes and alterations in established organizations, provides the basis for a fundamental alteration, or revolution, in a particular military application of force.

This MTR concept was investigated in a March 1993 study by the Center for Strategic and International Studies (CSIS) in Washington, DC: *The Military Technical Revolution, A Structural Framework*. The CSIS defined an MTR as "a fundamental advance in technology, doctrine, or organization that renders existing methods of conducting warfare obsolete."[6]

It was determined from Soviet writings that it was "necessary to exploit all the elements that characterize such revolutions" before an MTR was mature.[7] By comparing the relative difference in maturity of a given MTR (that two opposing states are simultaneously undergoing), it is possible to see the advantage possessed by the side with better integration of the four elements. The historical analysis in the next chapter examines the relative maturity of night air combat forces faced by the United States.

Technological change is at the core of MTR theory. This change may be an improvement of an older idea, or a new invention applied to military use. Through integration with the other three elements of the MTR, the technical innovation enables a non-linear, or revolutionary, effect. Understanding this method of change is critically important because, as the CSIS predicted:

> . . . MTR technologies will help US defense planners deal with the constraints, both budgetary and political, on military policy in the years ahead. The MTR allows militaries to do more with less, and to conduct military operations at less cost.[8]

Operational innovation is a key to the maturation of an MTR. Dr. Krepinevich notes: "Dramatically different operational concepts, to include doctrine and tactics, must be developed to derive the full military potential from advances in technology."[9] The device or technical improvement itself is merely a tool. The application of new tactics or creation of new doctrine to enhance the use of the technology is essential to ensure the effective exploitment and employment of the technical improvement. Nilolai Galay, in a 1966 paper from the Institute of the Study of the USSR in Munich, provides an example of the necessary link between technology and doctrine in the MTR. He establishes this connection through a discussion of technological improvements leading to doctrinal changes. This results in a change in the character of (future) warfare, and enhancement of the Soviet version of nuclear deterrence.

> Krushchev's new military doctrine, introduced in 1960, represented an attempt to take advantage of such opportunities. The Soviet Union then had better long-range rockets than the United States and had placed the first cosmonauts in orbit around the earth. Krushchev openly expressed his confidence that the Soviet Union would achieve a decisive technical breakthrough. The parallel creation of the new Soviet doctrine on nuclear war, featuring destruction not only of military objectives but of industrial and political targets as well, was in conjunction with the reorganization of the armed forces, a key step toward absorption of the military revolution.[10]

Systems development is another element of the MTR that requires both technological prowess and economic investiture. Krepinevich uses the term "preconstitution" to reflect the US commitment to "preparing for conflict in a new military-technical regime against potential adversaries who are themselves moving ahead and mastering Cold War era technologies and systems."[11] Developing new systems and technology enhance the MTR by helping it mature. This leads to an increasingly more effective application of the technological concept with acquisition of newer systems guided by operational innovation in development of new tactics and doctrine.

The last of the four elements is *organizational innovation*. Dr. Krepinevich notes that creating new technologies, applying them to military applications with innovative operational techniques, "is not sufficient to effect a military-technical revolution."[12] He cites the development of British interwar armor theory as an example. The British had innovative theorists, such as Fuller, and technological changes in both light and heavy tanks. Nevertheless, they did not develop the Blitzkrieg. The Germans, in contrast, exploited lessons learned from World War I resulting in significantly more effective armor application.[13]

The four characteristics must be evident to label a capability a Military Technical Revolution. The elements must be linked together to create a change of at least an order of magnitude to indicate a true revolution. Relative maturity is still essential when comparing MTRs. When projecting military superiority between sides with similar numbers, the side with the more matured MTR has an advantage in the conflict. Though greater numeric superiority of an enemy could, in some cases, overcome the combatant with a more matured MTR.[14] To emphasize the advantages of an MTR, the CSIS underscores the need for a synergy between the elements:

> Without a coherent joint doctrine to guide their employment and an effective organization to focus their efforts on the battlefield, even the most advanced technologies will not reach their full potential.[15]

The Revolution in Military Affairs

The MTR theory is commonly confused with the RMA theory and observers and theorists frequently use the terms RMA and MTR interchangeably. The confusion occurs because these theoretical constructs share the same four basic characteristics but differ in origin, scope and focus, as described earlier. In a discussion of the characteristics of military revolutions, Metz and Kievit point out that a revolution in military affairs “dramatically increases combat effectiveness” through the “four types of simultaneous and mutually supportive change."[16] They note that the relative priority of these elements depends upon the revolution. In recent Army, Air Force and Navy Roundtable RMA forums, participants considered these same four elements, bolstering the importance for the successfully integration of the elements.[17]

There is a philosophical difference in the acceptance of the MTR since it was a Soviet idea and rooted in the exaltation of technology and the "revolution." Western theorists adapted and expanded the concept. Practically, the scope of an MTR is smaller than that of an RMA, making the MTR a more manageable concept to evaluate jumps in capabilities with a technological lead.

In the case of night air combat, this MTR is a part of the larger United States revolution in military affairs. For example, specific precision weapons systems may have caused an MTR: today, a single aircraft with a single bomb can create more damage than an entire WWII bomber squadron could do, with less collateral damage. Now, policy dictates minimizing collateral damage and loss of life. Military tactics and organizations, necessarily, adapted themselves to relying on precision employment technology to carry out this policy. Policy (which leads to strategy and then to tactics) followed the technical improvement, in this case. Dr. Earl Tilford provides an example of the link between an MTR and the current RMA:

> In the Information Age, one can argue that a military-technical revolution brought about by the advent of the microprocessor and precision-guided munitions is fostering a revolution in military affairs.[18]

The current US RMA has many more characteristics than precision alone. Multiple sources mention variations on this theme, including: integrating long-range precision strike capabilities, information warfare, unmanned aerospace vehicles, global employment capability, stealth technology integration, decrease in collateral damage through precision, and deterrence vice direct action.[19] The night air combat consideration in the current RMA is generally a given; US preeminence in night fighting is critical to maintain a twenty-four hour wartime advantage. Bolstering this argument, Admiral Owens states:

> We now have a pretty good idea that the American RMA stems from the way several particular technologies will interact. Most senior military and civilian leaders agree that the specific technologies are those that allow us to gather, process, and fuse information…and that provide us the capacity to use force with speed, accuracy, precision, and great effect over long distances…We have decided to build what some of us call the *system of systems*; namely, interactions that will give us dominant battlespace knowledge and the ability to take full military advantage of it.[20]

The USAF Air Command and Staff College (ACSC) makes the distinction that an MTR involves *technological innovations* that are *subsequently* applied to alter military efforts while an RMA is a *military concept* that *leads* to a technological innovation, which is then applied in battle.[21] This focus implies a "Push-pull" relationship described by numerous experts. Krepinevich, in his 1992 study, emphasized this relationship:

> Just as there is a "technological push" from the laboratory to forces in the field, there is also a "conceptual pull": operational concepts emerge which cannot be implemented with existing technologies. However, operational concepts have seldom predated technological breakthroughs. Thus, a simultaneous "push-pull" relationship should be sought.[22]

For the purpose of this paper, the general differences previously described in Table 1 define the context of an MTR, and help relate the MTR concept to night air combat. Additionally, maturity of an MTR or the RMA is a product of all four of the component elements. The scope of the MTR theory, and its initial focus on technology "pushing" the other characteristics of the revolution better fits the lineage of United States night air combat capability and the focus of this paper.

Revolution or Evolution?

A frequent topic of debate in the discussion of revolutions, whether an MTR or RMA, involves the concern over separating a "revolution" from simple "evolution." Every innovation or improvement depends, at least to some degree, on evolutionary processes. Many consider the invention and integration of the machine gun an MTR because it dramatically changed the nature of warfighting. Combatants facing machine guns without the technology or an understanding of the effects of the new weapon were at a disadvantage. Likewise, those who had the weapon but did not change their tactics and training were also at a disadvantage facing an opponent with both the technology and the ability to exploit its inherent advantage. This asymmetric balance is not only technology dependent, but it considers organizations and their integration and use of that technology to establish relative capability. Before the invention of the machine gun, however, several other inventions were required: gunpowder, forging and tempering technologies, and shell-casing improvements, among others. Each invention was essential, but only taken together was the potential to produce effects greater than the sum of the parts. Evolution in this case differs from revolution when the leap occurred from just shooting faster to changing organizations and tactics to exploit the new weapon—creating a tremendous non-linear increase in combat capability.

The amount or magnitude of an increase in effectiveness characterizes a revolutionary change. An important point to emphasize is the characteristic of a "discontinuous increase in military capability and effectiveness."[23] In this respect, a technological innovation that does not drastically change the nature of warfare, or specific elements of combat employment, may not be revolutionary but evolutionary. Krepinevich notes that the acceptance of a change as fundamental, by those involved, defines the difference between revolution and evolution.[24] For example: when the feudal Japanese hierarchy changed from the Tachi to Katana style sword blade, their method of fighting with swords altered slightly due to the characteristics of the new weapon. There was, however, no dramatic increase in the killing capability of the sword itself, or a major change in the primary technique for use of the weapon; both typically remained cutting rather than thrusting instruments in their preferred manner of employment. Hence, without acceptance of a change as fundamental, it is evolutionary and not revolutionary change.

The evolution versus revolution discussion is a marginal debate. The MTR concept revolves around orders of magnitude, orders of effect, and orders of understanding.[25] The MTR is important to discuss, however, because by understanding the nature of the development, integration, and application of a technical innovation, it is possible to see *when* a fundamental shift in military application and effectiveness affects the conduct of war. Particularly, it is interesting to consider observing that shift while it is taking place, and altering the affect of a given technical innovation's integration.

Strength, Weakness, and Relevance of the MTR Concept

The strength of the MTR concept lies in the inherent capability of technology to act as a force multiplier in armed conflict. When comparing strengths during the assessment of an enemy, relative maturity of a particular MTR can define where tangible advantages lie. This is important in efficient application of the principles of war.

The weakness of the MTR concept is evident in the confusion between RMA and MTR theories. It is a weakness in conventionally presented definitions of the concept of "military revolutions." Since these concepts are currently evolving, definitions change, obscuring the underlying rationale that *changes in technology*, when blended with *operational innovation*, *organizational innovation*, and *systems acquisition*, can *fundamentally* change the way in which war is conducted. In short, misinterpretation and the lack of standardized terminology leads to a weakness in understanding MTR theory.

Importance of the MTR Theory

It is important to examine current emerging technologies, their relationship to MTRs, and their place in the on-going RMA, to help determine the course for warfare in the future. Fighting "the last war" results in non-optimal use of technology, and allows countries to gain on previous US advantages. Dr. Krepinevich helps explain the importance of the MTR by viewing it as a way to ensure that the United States retains dominance in "key sectors."[26] He used the junction of core competencies with the MTR to lay a plan for the future:

> To dominate the key aspects of the military-technical revolution, the United States will likely have to establish or maintain core competencies in reconnaissance, surveillance, tracking and acquisition of targets (to include space surveillance, information fusion, electronic warfare, and communications security), ranged-fire operations, simulations, and in the prompt, efficient production of related sunrise systems.[27]

Finally, the MTR is important because, as the USAF plans for the future, for the next war and beyond, it is essential to maintain focus on where money and manpower are trimmed. The current RMA is evident in statements by current USAF leaders. General Fogleman, when presenting the new "Global Engagement" vision statement in November 1996, directed:

1. Greater emphasis on military space capabilities.
2. Divestiture of support functions to civilians, leaving "operators" to train and fight.
3. Updated core competencies, to include: air and space superiority, global attack, rapid global mobility, precision engagement, information superiority, and agile combat support.
4. A "recommitment to streamline" military systems acquisition.[28]

By discussing technologies available to maintain the stated USAF core competencies in the realm of the MTR, it is possible to compare potential enemy capabilities in these areas, and determine strategies to fight. Attention is required to emphasize US strengths while minimizing weaknesses (particularly regarding: application of limited funds, minimal manpower, and the difficulty in establishing national will in an armed conflict when there exists a potential for high casualty rates).

Conclusions of Revolution Theory Examination

In conclusion, the MTR concept, springing from the revolutionary auspices of Soviet military analysis in the 1960's, is relevant as a theory for use in the Western world today. The theory involves technological improvements, along with the elements of systems acquisition, operational innovation, and organization changes that together synergistically produce a fundamental change in military effectiveness or operations. The MTR theory and the concept of the RMA originate from the same Soviet roots. They are similar theories, but the RMA has a doctrine, or requirements first, slant while the MTR has technology leading, and the RMA reflects more broad scope than the MTR. The strength of the MTR theory lies in its relevance to military implementation of technology to produce force-enhancing results during maturation. Its chief weakness lies in confusion over terminology and possible overuse, leading to a dilution of the concept of a military "revolution." As a planning tool, the MTR helps determine realistic core competencies and facilitates more rational budget planning and allocation of resources to fight the next war, not the last.

Notes

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[4] Steven Metz and James Kievit, "Strategy and the Revolution in Military Affairs: From Theory to Policy." On-line. Internet, 29 October 1996. Available from http://carlisle-www.army.mil/usassi/ssipubs/pubs95/rmastrat/smrmasss.htm, Part II, 2.

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[11] Krepinevich, *The Military-Technical Revolution: A Preliminary Assessment*, 71.

[12] Ibid., 65.

[13] Ibid., 65-66.

[14] Matt Caffrey, "Military Technical Revolutions (MTRs) & Revolution in Military Affairs (RMAs)," Lecture. ACSC, Maxwell AFB, Ala., 10 September 1996.

[15] Mazarr, CSIS, 22.

[16] Metz, "Strategy and the Revolution in Military Affairs: From Theory to Policy," Part II, 2.

[17] Ibid., Part II endnote [12].

[18] Earl H. Tilford, "The Revolution in Military Affairs: Prospects and Cautions." In *Air and Campaign Planning*, Maxwell AFB, Ala.: ACSC, 1996, 516.

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[22] Krepinevich, *The Military-Technical Revolution: A Preliminary Assessment*, 56.

[23] Metz, "Strategy and the Revolution in Military Affairs." Part II, 1.

[24] Ibid., 4.

[25] Budd Jones, Interview, 15 November 1996.

[26] Krepinevich, *The Military-Technical Revolution: A Preliminary Assessment*, 73.

[27] Ibid., 74.

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Chapter 3

A Brief United States Military-Technical Historic Review

> *The more darkness in night attacks hinders and impedes the sight, the more must one supply the place of actual vision by skill and care.*
>
> —Scipio Africanus (236-184 BC)

> *Offense is the essence of air power.*
>
> —General "Hap" Arnold

> *Fight the enemy with the weapon he lacks.*
>
> —Field Marshal Prince Aleksandr V. Suvorov

There are several different types of aviation and employment of manned aircraft at night that qualify as night air combat. Strategic bombing, interdiction, close air support (CAS), and air-to-air combat all involve night air combat. The *Interwar* and *World War II* sections of this chapter briefly discuss strategic bombardment. The *World War I* and *II* sections incorporate interdiction and close air support. There is, however, more detail on these efforts in the *World War II* to *Desert Storm* discussion. Air-to-air combat is a continuous thread, requiring some of the same technological breakthroughs as bombing, with the addition of some specific leaps in technology that apply also to all-weather and night operations. As the lines between the fighter and bomber roles blur with the emergence of multi-role fighters as the dominant and most numerous aircraft in the USAF inventory, night air combat becomes a more encompassing, essential and devastating capability. Similarly, all-weather capability remains closely tied to night fighting, particularly regarding the decreased visibility and requirement for specialized technology, training, and tactics.

World War I

World War I saw the aeroplane move from an oddity to a combat entity—a weapons system in its infancy, but with tremendous potential. Though it started the war as primarily a combination of observation post and artillery spotter, WWI aviation showed its potential mobility and increasing lethality. The lack of efficient night fighting technology limited the scope and effectiveness of night air operations. Particularly, unlighted instruments, poor (or no) navigational aids, and inaccurate weapons delivery systems (for night bombardment or aerial gunnery), hindered night air combat in the nineteen-teens.

The threat of Zeppelins to the British led to some night air combat attempts by intrepid British aviators. They flew clear of clouds, in a zigzag search pattern, and hoped to catch a glimpse of the huge Zeppelins by moonlight or by searchlight.[1] This hazardous work, made more dangerous by the lack of coordination between ground anti-aircraft artillery based near London and the British aircraft over London, afforded the Zeppelins relative impunity to deliver their massive loads from relatively higher altitudes at night. The Gothas, a large bomber appearing in the German fleet by 1917, was extensively used in night attacks against Paris, other French towns, and in raids against London. The lack of accuracy of the bombers, however, resulted in many unintentional casualties.[2] Again, the cover of night and the lack of appropriate technology to assist smaller night interceptors gave the night bombers an advantage.

The Interwar Period

Between the World Wars, the Air Corps Tactical School (ACTS) was established at Maxwell Field, Alabama, to train future leaders for the service, and to serve "as a focal point for air strategy and tactics development."[3] Students and faculty discussed theories on the employment of air power, and studied war theorists such as Clausewitz, Douhet, Mitchell, and Trenchard, incorporating their concepts into the early doctrine of Strategic Bombardment. The 1926 text, *Employment of Combined Air Force,* suggested that instead of using air power in a close air support role, attacking enemy infantry, the air component was better used attacking an enemy's "vital centers," such as the capital, "commerce, and industrial centers."[4] The ACTS focus on destroying a nation's vital centers or centers of gravity (COG) became known as the "industrial web theory."[5] The theory involved striking the vital COGs with battleplanes, large self-protecting bombers, instead of entering long wars of attrition. These bombers, according to popular dogma, needed no fighter escort because of their lethality, speed, and high altitude capabilities.

Because of the technology available at the time, ACTS proponents considered daylight precision bombing the best method available to exploit their industrial web theory. Since highly accurate weapons and the precise means to employ them did not exist, there was a vacuum between doctrine and technology:

> A new emphasis on bombardment aviation began to surface. Unfortunately, these innovative ideas remained, for the most part, abstract due to the fact that no aircraft existed to test these theories. A weapon was needed to accompany the vision. This doctrinal and technological demand led to the development of the long range bomber and the navigational aids needed to carry out the strategic bombing mission.[6]

A doctrinal push on technology indicates a possible MRA, when considering the strategic bombardment concept. Prior to 1931, the "night attack" was considered the best way to employ air forces to destroy *high threat targets* deep behind enemy lines.[7] But because of the precision required to accurately and reliably destroy deep strategic targets, ACTS doctrine emphasized daylight precision bombing, and concentrated their technological improvement requirements in that direction. Instructors "stressed the need to increase aircraft ceilings and rates of climb" to avoid threats like anti-aircraft artillery and enemy fighters as a response to the anticipated enemy threat.[8]

There were several effects of this doctrinal shift. Except for a few officers, such as Claire Chennault, few advocates espoused the necessity for pursuit (fighter) aircraft improvements. In fact, the ACTS instructors appear to have not seriously considered that "single-seat pursuit aircraft" could effectively engage high-fast bombers in massed formations.[9] In addition, throughout their airpower theory development, because of lack of technical foresight, ACTS did not emphasize exploration of night air combat, either in the air-to-air or air-to-ground roles. ACTS doctrine, therefore, ignored nearly half of the available fighting time available to prosecute the enemy by concentrating primarily on daylight bombing (i.e., precision bombardment at night)—a decision made based on established technology without regard to emerging innovations.

There were some technical breakthroughs, however unintentional, that later applied to US air combat. In 1930, Dr. Lawrence Hyland made the first detection of an airplane with the use of a radar device, though he was intending to investigate the properties of aircraft high frequency antennas.[10] A "lack of interest within the government" hampered this unintentional success of radar.[11] Concurrently, the Navy, Army, Bell and RCA laboratories, and the British investigated various aspects of radar, including both pulsed wave and continuous wave signals, but they did not fully cooperate until World War II began in Europe.[12] In May 1939, the British "developed what could be considered the first truly operational AI (airborne intercept radar)."[13] They continued mounting AI radar on aircraft as well as research on ground control interception (GCI) radar and identification friend or foe (IFF) equipment.

A 1940 text used at the ACTS, Portway's *Military Science To-day,* mentions night attack, but stresses the devaluation of pursuit aviation and exposition of World War I night air employment tactics. He considered night bombing, but not for precision bombardment. Likewise, low altitude flying was a fighter activity, for daytime only—with great costs due to the increased risk from ground threats.[14]

> The gaining and maintenance of air superiority is of first importance. . . . By day, bombing is normally carried out in formations, bombs being released upon a signal from the leader. . . . Night attacks are normally carried out by single aircraft arriving over the objective at irregular intervals, it being advisable to have more than one aircraft over the objective at once, and is taken to adjust sights and to drop bombs. This does not apply to mass attacks on a city like Warsaw or London.[15]

Portway discusses other aspects of air combat, but only briefly notes night fighter operations. He observes that: "Fighter aircraft required for night fighting are fitted with night-fighting gear, and wingtip flares."[16] This is in a ground attack context, foreshadowing similar techniques in use until the aftermath of Desert Storm.[17] Night air-to-air employment is conspicuously absent from the 1940 night fighting discussion. Ostensibly, this is because dogma of the time was the perception that the battleplane will always get through, a given at the time due to the technical limitations that made finding enemy planes and targeting them difficult at night or in foul weather. ACTS and Portway apparently followed Douhet's assertion that: "Aircraft in the air can evade each other in the air so easily that their defensive value is small, and as weapons they are primarily offensive."[18]

World War II

After the Battle of Britain, the American military learned of the application potential of the new radar devices. General Carl Spaatz learned of British "technical innovations," such as radar and IFF. General Spaatz also examined "new combat tactics, especially night bombing and defensive fighter deployment; and organizational and manufacturing problems and solutions which would help his own planning in the United States."[19] As noted by Pape and Harrison:

> From the reports of the multitude of American observers that had traversed the Atlantic coupled with British information and the experience of trying to establish a defensive system for the United States, one fact had been brought home quite clear. An interceptor capable of locating and destroying enemy aircraft in inclement weather and in hours of darkness was a necessity.[20]

A new plane was required to fulfill the night interceptor role due to the size of the radar equipment. The British used two engine, two seat aircraft, so there was room for a pilot, radar operator (RO) and the equipment. In January 1941, the US Army Air Corps contracted with Northrop for a new United States fighter, the P-61. As Northrop designed and refined the new aircraft, other scientists made improvements in radar technology.[21]

By watching the British, Air Corps leaders drew on lessons learned, and began discussing tactics as well as requirements for a night fighter. Other elements of the MTR became evident beyond the appearance of technical innovations. General "Hap" Arnold wrote General Spaatz:

> It is becoming clearer as time passes that the present war in Europe is developing the necessity for pursuit planes of new capabilities and type. . . . The radio detector is a necessity for all night fighters. . . . It would therefore appear that we must develop a night fighter that has a detector and probably the search-light in a lead plane of a flight with heavily armed planes capable of delivering the maximum volume of fire from the other planes in that flight.[22]

Colonel Ira Eaker reported the need for night fighters and their role to General Arnold, in 1941. His comments are noteworthy because, although the basic technology was previously developed (two engine fighters, spotlights, and AI radar), the integration of that technology into tactics and new airplanes was slow. The genesis of a technical capability moving to a MTR is obvious seeing Colonel Eaker's 1941 recommendation:

> If, as appears likely, a large portion of bombing is to be done at night then night fighters become a definite requirement. Night fighting is a specialized form of aerial fighting requiring specialized equipment and training. It is better to have a night fighter squadron in each group than to have a separate night fighter group. It is best that we should at once organize a night fighter squadron in each of our fighter groups and begin this specialized tactical training without delay.[23]

An example of a *technological change* inherent in the night air combat MTR is the use of AI radar on an aircraft, dramatically increasing the capability for night air combat. GCI and aeronautical instrument improvements are also be part of this technical innovation. Commissioning the P-61, looking at other stopgap measures (putting AI radar into older planes until the P-61 was operational), and the remarks by General Arnold show the *military systems evolution.* Colonel Eaker clearly expressed the *organizational adaptation* required in an MTR by recommending a specialized night fighter squadron in each group. At the heart of this organizational change was the training required to successfully employ night fighters. Necessarily, in this case of emerging technologies, training led to *operational innovation*, as tactics and doctrine developed through experience.

It is important to note the relevance of training and technology in this discussion of night air combat as an MTR because it is apparent that after stumbling onto the potential inherent in night fighters, the Air Corps subsequently developed the organizations and tactics to use the technology. At the Fighter Command School in Orlando Florida, Colonel Willis R. Taylor, the chief planner for the Air Defense operational Training Unit, planned to include a “Night Fighter Division under the Fighter Department.”[24] July 4, 1942, he wrote to Colonel Saville, the Director of Air Defense, concerning his plans. Colonel Taylor, as the unit’s history records shows:

> . . . erected his ideas on the night fighter training into a policy. He felt that the pilots must be brought to a high level of training in instrument flying, blind landings and takeoffs, night formation, night gunnery, operator-pilot airborne interception teamwork, GCI control, and general air defense procedures. Most important was the necessity that all pilots become temperamentally at ease in night operations.[25]

Radar operators, maintainers, and pilots were all part of the training plan. Colonel Dick Ehlert, an early student at the Florida school, wrote: “When the USAAC awoke to the fact that there was in fact a thing called ‘RADAR’…they immediately hit the panic switch and said we got to have this.”[26] This is an interesting statement, considering the initial indifference with which the development of the radar was welcomed in the US, and it’s hesitant acceptance on fighters as demonstrated in the 1930s.

General Oris B. Johnson, the first commander of the 422nd Night Fighter Squadron, the first trained and organized US night fighter squadron in the European theater, said that training in Florida and in Britain emphasized the air-to-air interception role for the P-61 crews.[27] As the war progressed, strafing ground targets became another part of the fighter's role. In aerial engagements, the P-61 crew received vectors from a GCI controller, to intercept an aircraft. The P-61 pilot would then fly using GCI instructions and his RO's directions until the pilot achieved visual identification of the enemy aircraft. Then, if in a position to shoot, the P-61 pilot shot the enemy. If not in position, the pilot "backed-out," and obtained a position to reattack.[28] Weather and moonless nights complicated the visual identification problem. Additionally, V-1s, V-2s, and manned enemy aircraft were targeted and subsequently destroyed by the P-61 night fighter crews.

For ground attack missions, pilots used the P-61s (and A-20s) in a ground-strafing role both in the day and at night, sometimes without an RO in the P-61.[29] The night fighters also attacked various enemy airfields, lines of communication, and targets of opportunity at night.[30] Jim Postlewaite succinctly described the night bombing tactics: "Night bombing, leaflet drops, we did it all. We dropped some flares, and then were supposed to fly down underneath the flares looking for enemy troop concentrations."[31] In the Pacific, night fighters, feeling underused in a defensive role as air interceptors, modified their planes, themselves, to carry extra fuel, three 1000-pound bombs, home-made napalm bombs, and time delayed fuses.[32] Bolstering the convenience and contribution of a night combat "dual-role fighter" (i.e. air-to-air and air-to-ground capable), the XIX Tactical Air Command report, "Tactical Air Operations in Europe," stated:

> Except during the Luftwaffe's brief resurgence in connection with the Ardennes Counter-Offensive, German night operations in the XIX TAC area did not justify much effort in defensive patrols. Offensive intruder missions proved a far more profitable employment of our night fighter squadron (the 425th). Several of the P-61s were equipped to carry HVAR as well as high-explosive bombs, incendiaries, and napalm. . . . Night

> intruder operations form an important and necessary complement to daylight fighter-bomber activity, giving the enemy no rest.[33]

Another important World War II innovation in the night air combat arena included the development radar bombing, initially using British technology for heavy bomber radars, which allowed improved accuracy for night and through-overcast bombing. By late 1943, the Eighth Air Force had only twelve H2X radar equipped B-17s, which they used as "pathfinders," or lead aircraft, to allow overcast bombing in Europe.[34] General Spaatz asked General Arnold for more planes with radar because of the potential for more accurate delivery of ordnance through the clouds, and at night. The policy of bombing Germany by "non-visual means," begun by General Eaker, was a watershed event in USAAC doctrine change. "Blind-bombing" showed the importance of night and inclement weather bombing: "Its adoption of this policy marked the AAF's acceptance of the reality that daylight precision bombing alone could not win the air war."[35]

General Spaatz told General Giles in December 1944: "Our war is becoming a radar war."[36] It should be noted that Germany also had night fighters. The importance of American and British radar, tactics, and training superiority is cannot be overlooked. In September 1940, when General Spaatz noticed that the Germans had switched to night terror bombing, he commented to a war correspondent that:

> . . . the Germans can't bomb at night—hell, I don't think they're very good in daylight—but they haven't been trained for night bombing. Nope, the British have got them now. They've forced them to bomb at night.[37]

The Germans had night flying Ju-88s, Me-110s, and Do-17s, which carried devices controlled by German ground radar.[38] German tactics were less evolved and their bombing and night airborne fighting was less effective. For example, Major Hajo Herrmann commanded three squadrons named the *Wilde Sau,* or Wild Boars. Their tactic was to blindly (without radar) dive FW-190s directly through the night bomber formations of the Allied forces, just hoping to visually acquire and simultaneously arrive in a position to shoot at the bombers.[39]

The American Pacific campaign dramatically demonstrated the effectiveness of US night fighting, as evidenced by the devastating effectiveness of night bombings on the Japanese war machine and populace. In 1945, General Curtis LeMay's B-29s flew night, low altitude, firebomb attacks in combat boxes vice single ship formations, and used a combination of night radar navigation (via pathfinders), night visual bombing, and incendiary cluster type bombs.[40] These innovative tactics were precursors to F-111, F-15E, and F-16 tactics seen fifty years later in Desert Storm.

The Korean War

Night air combat during the Korean War saw the night fighter role as night defender expanded to include more offensively directed activities. Though putting radar in single seat jet fighters met with resistance from the "gunfighters" of World War II, pioneers like General Johnson, using their extensive combat experience, slowly convinced the airmen of the 1950s.[41] Most of the fighters used in the Korean War were primarily day fighters, without radar or special night equipment. B-26s were the core night fighter-bomber, and they primarily accomplished ground attack. B-29s, as in World War II, provided heavy night bombing capability with little or no self-defense capability. Night air combat, however, was not enormously successful in Korea.

> . . . the US Air Force had to confront its greatest operational limitation: its slight capacity to conduct tactical ground attack operations at night. There was even less capability than there had been at the end of the world war,

> for there were no longer any units trained as night intruders. Nor were there any aircraft suited to the role.[42]

The B-26 had "no radar altimeter, short-range navigation radar, or blind-bombing radar, and with its poor maneuverability, the aircraft was a hazard to fly at night in Korea's mountainous terrain."[43] The solution was to have one aircraft drop flares while the others in the flight strafed, similar to World War II tactics. F-4s in Vietnam and A-10s in the Desert Storm revisited this tactic due to its simplicity and lack of technical improvements in night air-to-ground fighter employment. C-47s and B-29 flare droppers were attempted, but they were not successful. Typically, the terrain and the lack of night vision equipment required the strafers to shoot from too high an altitude, in order to avoid the mountains. However, the night intruders did account for the majority of killed vehicles in June 1951, during Operation Strangle.[44] Their claimed kills mounted with modified B-26s, but were unverifiable due to lack of good navigation equipment; the pilots "rarely had anything like an exact idea of where they had executed an attack."[45]

In 1952, the Fifth Air Force generated an investigation, and as reported in the *US Air Force Operations in the Korean Conflict, 1 Nov. 1950-30 Jun 1952* report: "The current night intruder program is not effective in destroying enemy vehicles because of [an] inability to hit the targets."[46] Little progress was made in air-to-ground night interdiction technology since World War II. Nevertheless, regardless of the lack of progress, the importance of night air combat remained evident, particularly when it is noted that:

> The Chinese first limited FEAF's access to their air space while steadily making their communications more defensible. The process began with the battle for the Yalu bridges. First flak, and then the MiGs, put crucial bridge complexes beyond the reach of the B-29s. Then, during the fall of 1951 the MiGs *halved the striking power of Bomber Command by denying it the daytime sky over North Korea*.[47] (Italics added).

B-29s were ordered to attack at least one North Korean airfield every night ("to reduce losses"[48]), but because of effective defensive radar coverage, the North Koreans they knew when the bombers were inbound. The defenders of North Korean airfields used three types of radar to defeat B-29 attacks: "air early warning, fire control, and GCI."[49] In order to gain intelligence, command did not permit the B-29 crews to drop chaff until 1951. Additionally, orders stood to not enemy GCI communications, though, in an attempt to reduce radar reflectivity, non-reflective paint was used on the bombers (an early attempt at stealth technology).[50]

North Korean GCI vectored MiGs to intercept the bombers while "Searchlight radars" targeted the bombers and directed powerful lights to illuminate them. The MiGs attacked only if they saw a bomber visually, by moonlight or searchlight.[51] The B-29s frequently flew unescorted, using altitude and tighter formations for defense, because Air Force Headquarters did not want to risk losing the highly advanced F-94, with the plane's sensitive and effective AI radar.[52] Ineffective Marine F7Fs then more capable Marine F3D-2s were used for patrol or escort until the USAF was convinced by the Marine's success and Bomber Command's pleas to allow the F-94 to assist the B-29s in night air combat. Fortunately, technical superiority allowed the Americans greater success at night than the North Koreans or Chinese. AI and IFF allowed fighters to escort and protect the bombers, and navigation and radar bombing permitted improved accuracy, though interdiction and fighter-bomber technology had not greatly improved. Late in the Korean War, the USAF saw improvements in automatic radar gun-sights on fighters, and after the war, the introduction of an infrared heat-seeking missile, the Sidewinder. As Thomas Hone recounts official USAF history:

> Night fighter tactics were far more cautious than daytime tactics, and at night, more than in daylight, the advantage lay with the attacking fighters. Fifth Air Force had trouble escorting the B-29s during the day; bomber losses to MiGs equipped with air intercept radars might have been prohibitive.[53]

In this case, the relative maturity of the United States night air combat MTR was greater than the capability of the North Korean, who were hampered by lack of an AI radar and other doctrinal considerations. The result was the increased survivability of the United States night bombers.

Vietnam

Between Korea and Vietnam, there were numerous USAF technical improvements in fighters, bombers, electronics (radars, jammers, communications, and computers) and munitions. Generally, Korea proved that fighter jets were superior to fighter planes with propellers, and training was essential to proficiency in air combat. The proliferation of missiles, both air-to-air and air-to-ground varieties, and the threat of nuclear war affected USAF doctrine. The F-105, developed after the Korean war to deliver tactical nuclear weapons, was not designed to conduct a continuous conventional bombing campaign like the one envisioned in 1964, because it was not night and all-weather capable, and the pilots were not trained for the conventional campaign.[54]

By the time Operation Rolling Thunder began, the introduction of Navy A-6s provided night and all-weather capabilities, and the F-4 provided a platform that could employ missiles using the aircraft’s organic radar, while possessing an IFF to allow identification of enemy aircraft before visual contact. Unfortunately, rules of engagement (ROE) prohibited firing without visual identification, limiting the utility of beyond-visual-range (BVR) missiles. Walleyes, used first primarily on the A-6 then later on the F-4, were precursors to precision munitions and electro-optical (EO) weapons, though their numbers were few and the warhead was small.[55] Additionally, F-105s showed increased ability to use radar attacks to crater runways.[56]

In 1971, by the beginning of Linebacker, technology innovations allowed night and all-weather air combat a degree of increasing effectiveness. Thomas Hone notes three differences between Rolling Thunder and Linebacker that are important in light of the impact of technical improvements in night air combat:

1. USAF strike forces carried laser-guided bombs (LGBs) which provided tremendously increased accuracy.
2. B-52s began attacking North Vietnam, "mostly at night," using ground-attack radars and with F-4 escorts, plus the F-4E used "Hunter-Killer" packs to attack enemy radars and missiles.
3. The USAF sent F-111s to supplement all-weather interdiction attacks.[57]

AC-130s and AC-119Ks also acted as interdictors. Though not fighters, they used extensive night sensor equipment later adapted for fighter use, including: "infrared detectors to pick up the heat of engines and exhausts, low-light television, and ignition detectors to register the electrical emanations of operating internal combustion engines (Black Crow)."[58] Major General Alton B. Slay, Seventh Air Force Deputy Chief of Staff for Operations during Commando Hunt VII, attributed the lack of success for missions interdicting trucks in Vietnam to the weaknesses of the F-4 (and B-57), including: lack of maneuverability, limited fuel and limited sensors. He said: "The F-4 was handicapped by its lack of terrain-avoidance radar and of any of the sensors that made the AC-130 so effective."[59] These problems were corrected in the late 1980's with the replacement for the multi-faceted F-4E, the dual role F-15E, which had improved TFR sensors, similar to the

F-111, more range than other multi-role fighters, and it possessed a FLIR, like the gunships.

Training was a critical issue in Vietnam. Since "Vietnam was not a conflict of fighter-on-fighter but of offensive systems against defensive systems," technical improvements and training to use those improvements allowed airmen to effectively employ against surface-to-air missiles, radar guided anti-aircraft artillery, and missile equipped enemy fighters, day and night, despite restrictive ROE.[60] Thomas Hone points out that: "Finally, the fighter and fighter-bomber missions were combined. . . ."[61]

Although the Korean War initially showed a slide in progress of interdiction tactics, the Vietnam conflict demonstrated the reintroduction of a capable multi-role, P-61 type of aircraft, the F-4. It could fly day or night AI missions, while retaining credible ground attack ability. The F-111, along with EO and LGB precision guided munitions heralded a rise in the application extremely new technology, leading toward a precise night, all-weather attack capability. Although F-4s still used flares at night for interdiction or CAS (similar in employment to fighters since World War II), by summer of 1972, with the help of F-111s, about one third of "all tactical strike sorties were at night;" it was necessary to fight at night to stop the Communists who increasingly moved under cover of darkness.[62] Railway and other attacks during Linebacker were also hugely successful because of the extensive use of LGBs, particularly the Paveway I GBU-10, inflicting more damage with less aircraft and men risked because of increased accuracy, requiring less sorties.[63] Leaders and operators noted that PGMs possessed tremendous night capability, though that was hampered by several factors, including: laser acquisition, targeting computers, navigation instruments, 1970s IR technology, and the increased surface-to-air missile (SAM) threat.

El Dorado Canyon

The 14-15 April 1986 air strike against Libya showed many lessons foreshadowing the success in Desert Storm as well as problems encountered again by the night air combat forces in 1991. Strategists used the cover of night, joint operations including integration of Air Force and Navy assets, and extensive training using “look-alike” targets.[64] This training approach was reminiscent of training prior to the Ploesti raid, in 1943, when B-24 crews trained exhaustively in Libya, flying low and fast against practice targets.[65]

Extensive coordination took place between USAF electronic-jamming units, flying EF-111s, Navy anti-SAM units, flying EA-6s, A-7s, and F/A-18s, E-2 flight following coverage, and F-14 and F/A-18 air cover and the F-111 fighter-bomber crews.[66] This joint integration was necessary to attain mission objectives and minimize US aircraft losses. Interoperability, communications, timing, and command and control were all potential problems. Winnefeld and Johnson argue that “the future holds more El Dorado Canyons than Desert Storms.”[67] Nevertheless, the application of these night air combat forces fostered a mind-set in the USAF that it is possible to conduct successful air operations at night, emphasizing US technological prowess while minimizing casualties.

Desert Shield, Desert Storm, Desert Resolve

Night air combat in the Gulf War and in its aftermath is in some respects similar to World War II, and in others, quite different and more like traditional day air combat. Though World War II had the P-61, which flew primarily at night, and the Korean War had B-26s flying at night, in Desert Storm, F-117s, F-111s, A-6s, and F-15Es flew almost exclusively at night (over enemy held territory during combat). Predictably, most of these aircraft had laser designation capability for LGB employment, as reported by the 1993 *Gulf War Air Power Survey*. Importantly, the USAF, which flew sixty percent of the ground attack missions, expended ninety percent of the guided bombs and ninety-six percent of the air-to-surface guided missiles.[68]

The around-the-clock pressure of the air war in the Gulf contributed to the relative ease by which the coalition ground forces succeeded in retaking Kuwait. Though actual battle damage to Iraqi personnel is contentious, there is no argument that the US night air combat equipment, operators, and support structure succeeded in pressuring Iraq throughout their country and the entire time of the two-month war.

After the Gulf War, US air forces, particularly F-15C, F-16 and F-15E units, flew combat air patrol twenty-four hours a day over Iraq, Kuwait, and Saudi Arabia. These missions gradually changed and now operate by more limited ROE depending upon which airspace they are protecting, whether Iraq, Bosnia, or Kuwait. A result of the success of US airpower in the Gulf War is that the twenty-four hour nature of effective air combat is now undeniably taken for granted as a US capability by the National Command Authority (NCA).

Today and Projections

Over the past several years, various operational and test units continued to engage in refinement and development of night air combat technology, doctrine, training, and planning. The 422nd Test Squadron at Nellis AFB, Nevada, conducted operational tests using A-10, F-15C, F-16, and F-15E weapons systems incorporating night vision goggles (NVGs) in fixed wing USAF fighter combat mission execution. The USN and specialized

Army and USAF helicopter units also use these night vision devices, further enhancing night air combat capability by providing an expanded field of view to the crew beyond the terrain following radar and FLIR limitations possessed by specialized fighters in Desert Storm.[69] Additionally, night air combat testing was done on theater missile defense, precision guided munitions employment, combat identification, and other related night intensive combat operations.

Training is also constantly evolving with the pronounced necessity to operate effectively at night. Real world commitments in Bosnia, Iraq, and other future potential conflict areas require continuing reliance upon night proficiency to maintain credible US flexible deterrent options through the use of around-the-clock military air presence or air occupation. NVG training continues to expand, and night operations training for Weapons Instructors compromise a large part of the syllabus for fighter, bomber, intelligence, controller, and rescue portions of the USAF Weapons School, due to demands from the field requiring night capable tacticians and highly qualified instructors.[70]

Notes

[1] Wilbur Cross, *Zeppelins of World War I*, New York, NY: Barnes and Noble, 1993, 71-84.

[2] Ibid., 27-28.

[3] Dwight Griffin, et. al., *Air Corps Tactical School: The Untold Story*, Maxwell AFB, Ala.: Air University Press, May, 1995, 1.

[4] Ibid., 16.

[5] Ibid., 16.

[6] Ibid., 17-18.

[7] Ibid., 18.

[8] Ibid., 18.

[9] Ibid., 18-19.

[10] Garry R. Pape and Ronald C. Harrison, *Queen of the Midnight Skies: The Story of America's Air Force Night Fighters*, West Chester: Schiffer Publishing Ltd., 1992, 15.

[11] Ibid., 16.

[12] Ibid., 16.

Notes

[13] Ibid., 21.

[14] Donald Portway, *Military Science To-day,* Oxford: Oxford Press, 1940, 148.

[15] Ibid., 147.

[16] Ibid., 145.

[17] Various fighters trained to use flares to assist in night bombing, without using any special night vision equipment. Recently, as in Vietnam, F-4Es in the 1980s practiced dropping flares and bombing by flare-light. In Desert Storm, A-10s used the same basic tactic. Portway described a 1940 tactic that was evident in the US until the wide acceptance of LANTIRN and other night vision equipment allowed for more operational innovation in night air-to-surface weapons employment.

[18] Ibid., 143.

[19] Richard D. Davis, *Carl A. Spaatz and the Air War in Europe,* Washington, DC: Center for Air Force History, 1993, 56-57.

[20] Pape, *Queen of the Midnight Skies*, 27.

[21] Ibid., 30-41.

[22] Ibid., 43.

[23] Ibid., 45.

[24] Ibid., 48-49.

[25] Ibid., 50.

[26] Ibid., 51.

[27] Ibid., 201-206. Also, this information was confirmed and illuminated during personal discussions with BG Johnson, at the 422nd Test and Evaluation Squadron/Night Fighter Squadron reunion and at the WWII Night Fighters Convention, Las Vegas, Nevada, 25-26 June 1996.

[28] Personal discussions with BG Johnson, at the 422nd Test and Evaluation Squadron/Night Fighter Squadron reunion and at the WWII Night Fighters Convention, Las Vegas, Nevada, 25-26 June 1996.

[29] Pape, *Queen of the Midnight Skies,* 213.

[30] Personal discussions with BG Johnson, at the 422nd Test and Evaluation Squadron/Night Fighter Squadron reunion and at the WWII Night Fighters Convention, Las Vegas, Nevada, 25-26 June 1996. In addition, several other WWII night fighter pilots and R/Os also had similar stories, both in Italy, North Africa, and to a lesser extent, in the Pacific Theater. Pape and Harrison also mention numerous accounts of various night bombing and air interception missions. The unit history of the 422nd Night Fighter Squadron notes the details of several missions.

[31] Pape, *Queen of the Midnight Skies*, 266.

[32] Ibid., 315.

[33] Ibid., 304.

[34] Davis, *Spaatz*, 296-297.

[35] Ibid., 298.

[36] Davis, *Spaatz*, 521.

[37] Ibid., 52.

[38] Edward Jablonski, *Airwar,* New York: Doubleday, 1979, Part IV, 44.

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[39] Ibid., 45-46.

[40] Jablonski, *Airwar,* 168-172.

[41] Personal discussions with BG Johnson, at the 422nd Test and Evaluation Squadron/Night Fighter Squadron reunion and at the WWII Night Fighters Convention, Las Vegas, Nevada, 25-26 June 1996.

[42] Eduard Mark, *Aerial Interdiction in Three Wars,* Washington, DC: Center for Air Force History, 1994, 278.

[43] Ibid., 278.

[44] Ibid., 307.

[45] Ibid., 312.

[46] Ibid., 317-318.

[47] Ibid., 318.

[48] Thomas C. Hone, "Korea," in Benjamin Cooling, ed., *Case Studies in the Achievement of Air Superiority,* Washington, DC: Center for Air Force History, 1994, 484.

[49] Ibid., 480.

[50] Ibid., 481.

[51] Ibid., 481.

[52] Ibid., 482.

[53] Ibid., 484.

[54] Hone, "Southeast Asia," 509.

[55] Ibid., 538.

[56] Ibid., 538. This fighter-bomber radar attack ability was used in the daylight, or over an overcast, but it was a precursor to night low-level radar bomber attacks seen later by F-111s and then in Libya and Desert Storm.

[57] Ibid., 549.

[58] Mark, *Aerial Interdiction*, 336.

[59] Mark, *Aerial Interdiction*, 338.

[60] Hone, "Southeast Asia," 555.

[61] Ibid., 555.

[62] Mark, *Aerial Interdiction*, 385.

[63] Earl H. Tilford, *Setup—What the Air Force did in Vietnam and Why,* Maxwell AFB, Ala.: Air University Press, June 1991, 240.

[64] James A. Winnefeld and Dana J. Johnson, *Joint Air Operations,* Annapolis, Md.: Naval Institute Press, 1993, 87.

[65] Jablonski, *Airwar*, Part II, 155-157. This type of intensive training again took place practicing for the first few days of attacks by F-15E crews in Saudi Arabia, emphasizing low-fast night ingress tactics.

[66] Winnefeld, *Joint Air Operations*, 87-93.

[67] Ibid., 95.

[68] Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey Summary Report*, Washington, DC: Government Printing Office, 1993, 200-202.

Notes

[69] Personal interview with Major Joseph Justice, F-15E Program Manager for Night Vision Tests, 19 March 1997. The author also participated in numerous NVG tests. More details may be discovered in ACC test reports, registered by topic.

[70] Personal interviews with Captain John Zentner, F-15E 1996 USAF Weapons School graduate, 20 January 1997, and Majors Michael Duvall and Christopher Bowman, USAF F-15E Weapons School Instructors, 22 November 1996 and 14 January 1997, respectively.

Chapter 4

Conclusions

> *As shocking as it might seem, revolutionary advances in precision navigation and weapons technology had largely reduced the previous experiences of interdiction to historical anecdote, not historical prediction.*
>
> —Richard P. Hallion, Air Force Historian

> *In fact, one could argue that coalition air forces, led by the American F-117s, F-15Es, and F-111s (in particular), were* more *effective at night than in daytime.*
>
> —Mann

Is Night Air Combat an MTR?

By using World War II, Korea, Vietnam, and Desert Storm as checkpoints when considering night air combat as an MTR, it is possible to see a non-linear development of capabilities. Quantitatively, it is possible to compare the gross numbers of night sorties versus total sorties for each conflict. This type of analysis produces empirical data, but the determination of a revolutionary leap in capability is not merely numbers driven. Qualitatively, comparative effectiveness in target destruction at night versus day, or along a timeline in sorties per destroyed target based on reported or actual battle damage assessments would again yield more data. The question, however, "is night air combat an MTR," and possibly a maturing revolution, is not answered so simply. There is no universal definition of a military revolution let alone an accepted instrument to measure and rate a technical change's "revolution value." Necessarily, subjective evaluation of combat capabilities and relevance to the defined theories leads to applying or denying the MTR label for the emergence of the United States night air combat capability.

As discussed in Chapter 2, this paper subscribes to the opinion that the amount, or magnitude, of the increase in effectiveness characterizes a revolutionary change. It is possible to see through the analysis presented in Chapter 3 that, in the development of early US night air combat capabilities, there were *technological changes, systems development improvements, operational innovations,* and *organizational adaptations.* These combined elements produced results significant enough to propel research and development, and tactics and training, further speeding the MTR. Likewise, these same four characteristics are generally accepted as conditions for a capability to be judged an MTR. However, the changes occurred in a non-linear manner; there were periods in which there were few changes in US night air combat capabilities (such as from the mid-1940s to the early 1950s).

If night air combat is an MTR, when did it achieve the four required elements that differentiate an MTR from any other mere technological improvement? The Interwar years yielded *technical* improvements, such as radar and bombsights, but little night *organizational adaptation* or tactics were developed. In World War II, the decision to have night-specialty squadrons in each group resulted in both doctrinal and training changes from Interwar air power theory. *Operational innovations* in tactics obviously occurred during training and operations in World War II. An example is the use of GCI radar, controllers, and aircrew required to complete a P-61 night intercept mission. This was also an example of the synergistic effect of *systems improvements*, technology, training, and tactics heretofore unseen in night (or day) air combat.

The P-61 was unique because it was developed to integrate new technologies for the specific new operational function of night air combat. Although the World War II multi-role night fighters (and night radar bombers) provided considerably more impact than attempts during the Interwar years, the net effect of WWII night attack was less than the effect of day fighters with similar missions. This is partially due to technology: radar limitations, lack of night vision equipment, and lack of truly accurate radar bombing. WWII night fighting was also less effective due to doctrine. Common perceptions indicated that daylight precision bombing was "strategic" while night strafing or light bombardment was typically considered "tactical." In addition, ACTS dogma determined that direct-support of the Army took forces away from needed strategic attacks against the enemy's "industrial web."[1] Indeed, night air combat in World War II possessed elements of all four conditions of an emerging MTR, but did not fully realize the integration of all those conditions to make the jump from evolution to revolution. It is possible to make the case that compared to World War I, the US night air combat capability in World War II was several orders of magnitude greater. However, the orders of magnitude jump in capability is even more apparent comparing WWII with Desert Storm.

The build-up to Korea and the Korean War demonstrated a stagnation period in the non-linear development of night air combat—a leveling-out of the learning curve. *Organization* had not significantly improved, and some employment tactics *(operational innovations)* actually slid back to early World War II techniques, particularly until newer fighters with advanced radars were permitted to escort night bombing missions. *Systems development* improved with the integration of radars into more fighters, and radar bombing improved, but specific night devices were not significantly refined. Night capability improved only in relation to daylight air combat improvements. Moreover, some Korean theater ROE consciously risked bombers while trying to protect the fighter technology, and limited bomber self-defense measures to gain electronic intelligence.

In Vietnam, the United States was initially limited in capabilities for night air combat due to the doctrinal emphasis on strategic bombardment and the specter of nuclear war. Again, doctrine did not call for maturation of the emerging MTR. Technical improvements in precision munitions, AI radar, IFF, radar bombing, inertial navigation, LORAN and terrain following radar finally led to operational innovations, such as: BVR missile capability, improved night landing capability, PGM attacks on point targets, and night low-altitude target ingress. The changes occurred only after the need for conventional war capability was apparent to both the USAF and budgeting sources in the government. Organizationally, some units flew more at night or in bad weather, but extensive use of night operations by the majority of all aircraft was limited. ROE further limited BVR employment capabilities at day or night. Nevertheless, the jump in night air combat capability from late in the Korean War to late in the Vietnam War was considerable. Necessity caused systems, organizational, and tactics improvements to progress more rapidly later during Vietnam than in the period from World War II until early in the Vietnam conflict.

The Libya raid was a harbinger for the leap in night air combat capability apparent in the Gulf War. El Dorado Canyon showcased the emerging increase in the effectiveness of night air combat, and a possible national predisposition for night air operations. Joint integration of forces on a long-range, precision-strike, night attack with both air-to-air and air-to-ground offensive and defensive assets demonstrated the capability. Though performance of the F-117 in Panama engendered questions to some over the effectiveness of night precision, the night fighting capabilities developmental curve rose to a confident level by the initiation of Desert Storm.

In the *Gulf War Air Power Survey*, Keaney and Cohen discuss if Desert Storm was a "Revolution in Warfare."[2] They note that the Soviets, and some American supporters of the theory, felt a revolution in military affairs had occurred due to the impression that the "'integration of control, communications, reconnaissance, electronic combat, and delivery of conventional fires into a single whole' had been realized 'for the first time.'"[3] They noted that the technical aspect of the MTR, specifically both night and precision employment, was a qualitative rather than a quantitative change in weapons employment," though FLIR and laser targeting made certain targets particularly vulnerable at night and from medium altitude.[4] However, with respect to the maturation of the concept of night air combat as an MTR, the *Gulf War Air Power Survey* presented no solution to the debate, though it highlighted the frequency and impact of the effectiveness of night sorties. Keaney and Cohen contended that due to several factors, particularly the information integration of developing attack packages, air tasking orders, and assessing bomb damage, Desert Storm was not as integrated as "those who speak of a military technical revolution would expect."[5]

On a narrower scope, however, when night air combat is considered as a separate MTR, part of the larger RMA, it showed a remarkable jump to a higher level of maturation after the proving ground of Desert Storm. Specific USAF aircraft flew almost exclusively at night in the Gulf War, such as the F-15E, F-111, and F-117. Other fighter/bomber aircraft, such as the F-16, A-10, F-15, and B-52, flew primarily in the day, though day and night operations were not uncommon.[6] Specialized capabilities of individual aircraft, FLIR, TFR, laser targeting pods, PGMs, and radar bombing capability were used in mission allocation. Additionally, all USAF fighters possessed all weather AI radar for AI offense or defense activities (except the A-10). After Desert Storm, in the months before Deny Flight commenced, multi-role fighters (F-15Es and F-16s) and air superiority fighters (F-15Cs), flew twenty-four hour combat air patrols over Iraq, Kuwait and Saudi Arabia—frequently on schedules that were not strictly regulating specific airframes to night or day only use.[7]

Although some old tactics were reconstituted, new systems development, improvements, and technical innovations made the jump in effectiveness significant. Examining a common historical thread in the night air combat MTR, two tactics employed by the B-26s dropping flares in Korea were used to great success in Desert Storm showing that more than just the technological threads of the MTR trace from World War II:

> Upon detecting a convoy, the latter (a B-26 plane designated as the strafer) would block its path with an incendiary bomb; the illuminating aircraft (another B-26, but carrying only flares) would then prepare the target for strafing by dropping its flares in a line parallel to the road. Single intruders employed a tactic more difficult to accomplish successfully: They dropped their flares and then descended to make figure-eight passes on the target.[8]

Both tactics were used successfully in Desert Storm. For night fighters, particularly the F-15E, similar tactics, but adapted to use a FLIR and IR targeting pod instead of flares (a modern night combat operational concept improvement) made these techniques more successful. The innovation, that blending technology and tactics, provides parallels to USAF night air combat tactics used in 1951, in the Korean War.[9] A-10s used flares with little change from the original World War II and Korean pattern, except that the A-10's 30mm cannon allowed more standoff range for employment. The A-10 with the AGM-65 IR missile, however, used PGM tactics similar to those used by F-111s and F-15Es, using the missile as a tool for target acquisition and attack without the necessity of flares. This aircraft truly blended any aspects of early and later technologies and operational innovations or the night air combat MTR.

The *Gulf Air War Power Survey* discusses the possibility of Desert Storm:

> . . . confirming the decade old Soviet prediction of an impending 'military-technical revolution' driven by advances in micro-electronics, automated decision-support systems, telecommunications, nonnuclear munitions, satellite and other advanced sensors, lasers, and especially, nonnuclear munitions so accurate and lethal that they could wreak levels of military damage comparable to those attainable with tactical nuclear weapons.[10]

The reference to the integration of so many technological features, ignoring the other components of the MTR theory, may more closely resemble a portion of RMA theory because of the broad scope of so many technologies interacting beyond the battlefield. Keene and Cohen conclude: "neither of these popular arguments for a revolutionary advance matches precisely what occurred in the Gulf War. . . ."[11] If the Gulf War is considered an event where all the required elements of an RMA are collectively scrutinized, this may well be the case. However, it is possible to see the scope and magnitude of the change in night air combat capabilities as an MTR by separately examining the segment of the Gulf War that comprised night air combat then tracing the emergence of the capability since World War I. The historical survey in this paper examined this non-linear development. The incorporation of the four MTR elements evident show a technology "push" beginning in World War II, and leading to today's current capability.

Summary

Andrew Krepinevich said that a military revolution:

> . . . occurs when the application of new technologies into a significant number of military systems combines with innovative operational concepts and organizational adaptation in a way that fundamentally alters the character and conduct of conflict. It does so by producing a dramatic increase—often an order of magnitude or greater—in the combat potential and military effectiveness of armed forces.[12]

By narrowing the RMA concept and regarding night air combat separately as an MTR, it is possible to see a "dramatic increase" in combat potential. Solly Zuckerman, air power advisor to Air Chief Marshal Sir Arthur Tedder, argued strenuously that bridges were too costly a target for bombers, so less expensive fighter-bombers were used to varying degrees of success in operations Strangle and Overlord.[13] In 1950, with no pressure from the MiG-15, the B-29s took an average of 13.3 sorties to destroy a bridge, and this number only got worse with increased enemy air defense.[14] In Vietnam, from 1965 to 1968, more than 350 USAF and Navy sorties failed to drop a span in the Thanh Hoa bridge, while after the introduction of PGMs, 26 F-4 sorties dropped the bridge without any losses.[15] Then in Desert Storm, 12 total F-117 and F-111F sorties allowed precision attack of 26 point targets at night while the Vietnam example reported numbers for daylight-only attacks.[16] The capability to attack precision targets (using stealth, self-escort, or escort fighters for defense) at night was dramatically more efficient in Desert

Storm than even daylight, visual bombing (with escort) was in any previous major conflict—at least an order of magnitude greater than earlier bombing capabilities.

Daily briefings during Desert Storm reported that by the third week in February, Iraqi resupply movements of vehicles were primarily restricted to night, seeking the refuge of the darkness. The United States capability to operate effective interdiction and air defense sorties at night, however, "undercut the effectiveness of this standard response to air interdiction."[17]

> Unlike the previous wars, air power operated almost effectively at night as during the day, and in some cases more so. Unable to attack or retreat in the face of Coalition air power, the Iraqi army in the Kuwait theater after Al Khafji could only hunker down and continue to suffer mounting punishment, both physical and psychological, from the air.[18]

Indeed, the emergence of the present state of night air combat, complete with independent radar interception capability, navigation, accurate radar bombing, employment of night precision guided munitions, and the incorporation of night vision devices (FLIR and NVGs), bares little resemblance to the anticipated capability of World War II. Now, the NCA expects and demands extreme competence in precision aerial attack and bombardment during night air combat operations; twenty-four hour operations are now the norm for airpower employment.

Conclusion

Is Night Air Combat a Revolution?

Night air combat appears to fill the criteria of an MTR, part of a greater concurrent revolution in military affairs. With respect to the magnitude and scope of the capability, the current level of night air combat competence for the USAF, one dominant area of military superiority, is at least an order of magnitude greater than the capability of fifty or eighty years ago. It is generally accepted now that night air power capabilities are critical. As resources are applied in the form of money for research and training to ensure superiority at night, there is a fundamental change represented in military thinking from the wars of the mid-century. Dr. Krepinevich related that acceptance of the change as fundamental is a difference between evolution and revolution.[19] Night air combat may, therefore, be considered a revolution based on both the dramatic change in emphasis and in the superior ability of the USAF to conduct operations at night now in the later stages of the maturation of the MTR.

Why is this Discussion of Night Air Combat as an MTR Important?

The development and maturation of night air combat, as shown in this paper, was non-linear. Occasionally the capability was stagnant or actually regressed, but the need for effective night air combat was always there. Considering that USAF proficiency in night air combat is still a maturing concept, the political and military leadership can staff strategies for acquisition programs that facilitate progress in military capabilities without the costly slippage or stagnation suffered over the past fifty years. Understanding the MTR maturation process and its four elements leads to better management of resources and efficient integration of technology into combat capability.

The lesson for the need of careful application of scarce resources in an era of diminishing budgets is critical to many technical programs. These programs, if successfully managed and integrated using the elements of the MTR, will only increase the military superiority of the United States, permitting the USAF to do more numerous, difficult, yet effective operations more cheaply and with less risk to airmen and costly aircraft.

Harnessing the power of an ongoing MTR, such as night air combat, is the difference between riding a wave and picking what wave to ride on.[20]

It is important to note that the goal of night air combat is not making night into day, but to exploit tactics, technology, organizations, and training to achieve the capability to employ effectively at any time. By recognizing the maturation of the MTR, and the greater RMA, it is possible to exploit the relative advantage of the US with respect to potential enemies.

Indeed, the study of night air combat and the MTR theory provides an example in assessing "revolutionary" capabilities. It also supplies an opportunity to observe and identify an ongoing revolution. Identifying a military revolution in its infancy portends the prospect of harnessing new revolutionary technologies early, and integrating the other elements of revolutionary theory for a superior result: economically efficient, rapid, and dramatic increases in military capability.

Notes

[1] Griffin, *Air Corps Tactical School: The Untold Story*, 16.

[2] Keaney, *Air Power Survey*, 235-251.

[3] Ibid., 237.

[4] Ibid., 241 and 244. Keene and Cohen note, specifically: armored vehicles and hardened shelters became vulnerable to night air attacks, from medium altitude (p. 244).

[5] Ibid., 247.

[6] Ibid., 201. Figure 33 in the *Gulf War Air Power Survey* shows a breakdown of time of mission by aircraft type, giving a rough day-night combat rotation for twenty-four hour operations.

[7] Personal experience of the author on missions from March 1991 to late June 1991, flown both night and day with a variety or ordinance.

[8] Mark, *Aerial Interdiction*, 306.

[9] William L. Smallwood, *Strike Eagle—Flying the F-15E in the Gulf War,* Washington: Brassley's Inc., 1994, 177-183 and 188-190. The author led several missions in Desert Storm employing tactics using LATIRN targeting pods and forward looking infrared (FLIR) optics in place of flares to illuminate targets. Also, the figure-eight pattern described previously in USAF tactics in the Korean War was used at both medium altitude

for "tank-plinking" and at low altitude for "dumb-bombing." As the first fighter to directly attack convoys leaving Kuwait during the Gulf War, instructor weapons systems officer, LTC Josef Seidl, and the author of this study used the Korean figure-eight tactic, and the improved handling and avionics of the F-15E, to some success. Smallwood's book discusses the 1991 version of this tactic in more detail.

[10] Lt. Col. David A. Deptula quoted in Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey Summary Report*, Washington, DC: Government Printing Office, 1993, 235.

[11] Ibid., 237.

[12] Metz, "Strategy and the Revolution in Military Affairs," from Krepinevich, "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest*, No. 37, Fall 1994, 30.

[13] Mark, *Aerial Interdiction in Three Wars,* 94-95.

[14] Ibid., 298.

[15] Keaney, *Air Power Survey*, 243, from Glenn Griffith, "The Tale of Two Bridges," in *The Tale of Two Bridges and the Battle for the Skies over North Vietnam*, ed. A. J. C. Lavalle, Washington, DC: USGPO, 1976.

[16] Ibid., 243.

[17] Ibid., 97.

[18] Ibid., 246.

[19] Metz, "Strategy and the Revolution in Military Affairs: From Theory to Policy," 4.

[20] Personal discussion on 13 Feb 97 with Budd Jones. As an analogy for why MTR theory is still relevant, the wave image is clear; having a wave crash on one is the extension of this analogy when ignoring revolution theory and the importance asymmetric forces and technologies.

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