Can airpower be used effectively against terrorism and insurgence?

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Introduction

The last two decades have seen the maturation of airpower. After years of teething problems during which weapons and navigation were inaccurate and the capability to survive a Surface to Air Missile (SAM) belt were slim, airpower became the prime offensive weapon. Thanks to GPS it achieved an accurate navigation capability and was equipped with precise guided weapons and targeting systems. And thanks to at least some stealthy aircraft and cruise missiles the threat of enemy air defense could be mitigated. Thus, airpower advocates claimed that airpower was able to 'hit every target anywhere at any time'. A more realistic statement would probably be that the United States certainly has that airpower capability but has never been challenged by an equal opponent. This air superiority has allowed the USA to exploit its capability in conventional wars.

Due to its enormous warfare capabilities, no opponent in his right mind will try to engage the USA up front in a conventional battle. Because terrorism, insurgence and guerilla warfare are military answers where a conventional battle will not achieve political goals, we should not be surprised that we are faced with these threats at this moment.

Terrorism, insurgence and guerilla warfare may differ considerably from conventional warfare in terms of objectives, strategies, targets and weapons. They do, however, present a modern air force with similar problems. The enemy is very difficult to locate and even when he is visible, it may only be for a short period. This article will only differentiate between types of unconventional warfare if they present divergent military problems. The key question I will try to address is: can airpower adapt to counter these threats?

In approaching this problem, the adaptation potential of airpower will be considered first, after which the adaptation potential of any opponents will be looked at. This adaptation can be both in a technical area (the *machine*) as well as in the way we conduct our operations (the *man*). I will then evaluate the present use of air power in air defense, air reconnaissance, and conventional attack scenarios against non-conventional opponents. The next step is to look at the direction in which airpower theorists point and to see if and how airpower can adapt.

Airpower development

The machine

Airpower has adapted considerably over the last century. This in itself is not surprising for a new branch in the war business. On the contrary, it is a very common pattern in every new type of business, and is described by several theorists. However, after a period of rapid development, the normal pattern is that the rate of change will decrease and will eventually result in a bureaucratic and conservative organization. Presently, the perception of many air force officers is that their air force is a high-tech fast-changing organization. If this were the case, the air force might have the inherent capability to adjust rapidly to new threats. However, once air forces have reached the more bureaucratic stage, changing the organization is much harder. This is the first issue I will have to address. The second and even more difficult issue is what changes (if any) are necessary to cope with these threats.

In the last three decades, most changes in airpower capability have consisted of the incorporation of computer, communication and sensor improvements. Airframes and engines have seen only minor improvements. The B52, which first flew in 1952, is still flying and will remain in service for several more decades[1]. The proposed replacement of the F-16, the F35, has about the same speed and maneuverability as its predecessor, but will differ considerably in computer, sensor and stealth capability. A careful analysis will show that the implementation of these changes is extremely slow. Just a few examples may suffice to prove the point. The development of the F15 replacement (which finally became the Raptor) started in 1985 with a small project office at Wright Patterson Air Force Base. When I visited the office in January 1985, they (a three-man office!) had just started to draw up initial requirements and were hoping to have the real aircraft flying in a decade. The Raptor is presently just starting to go into service, twenty years after the first initiative. However, in the meantime the whole political and military situation has changed. A Dutch example: the F-16 Mid-Life update project was started in the late 80s but then it took ten years to complete the design and testing. This slow process has several causes. Part of the problem might be attributed to the slow political approval process, but that is not the key issue. Aircraft (military and civilian) have become complex systems. Building complex systems is a tough job. For example, presently aircraft software consists of several million lines of code. Validating all these processes and ensuring safety has become a gigantic task. Every aircraft industry employs a rigid development structure with several tests during the development stage. But with every new capability which is added to the design, the number of possible errors and conflicts increases[2]. Theoretically, the number of combinations increases with the faculty of the number of processes. For example, if the software can handle 10 different tasks there are 3,628,800 possible combinations of tasks, adding an eleventh will raise the number of combinations to 39,916,800. Of course the real number is significantly smaller because software engineers will employ techniques to prevent cross-interference of running processes as much as possible. But during my experience of more than 20 years as an experimental test pilot I was never able to release new software to the service without any remaining errors. And during operational use more errors will surface. Of course, software errors are a common experience for anybody who works with a Microsoft product. But there is a huge difference between a bomb or a missile behaving wrongly or a word processor quitting because it has performed an illegal operation. Another interesting difference is that by releasing beta versions of its software, Microsoft creates an enormous test force without paying a penny. This is of course completely impossible in military developments.

So, what is left of the rapidly developing airpower which we used to have a few decades ago? The truth of the matter is that the aircraft industry today is so slow to incorporate new computers and sensors in its platforms that the most threatening problem is diminishing replacement of resources. The computers and components which were used in the design phase of the aircraft are obsolete by the time the aircraft comes into service. At the same time the aircraft has become more and more expensive as its capabilities increased and a growing part of the cost of an aircraft can be attributed to this very expensive development. The military combat aircraft has also become an all-round fighting machine. It is no longer a specialized aircraft for either air defense or ground attack but a fighter-bomber that can perform both. The positive effect of this change is that fewer aircraft are required to do the job; a modern fighter bomber can protect itself on its way to the target and can be re-rolled if necessary. On the other hand, more roles imply more complexity.

So, where do we stand today with airpower? We do have capable highly complex aircraft, but only in limited numbers because of the high cost. These aircraft have proven their capabilities during past conventional conflicts. They are expensive to maintain and adding new capabilities to these aircraft requires a considerable and expensive effort which will take at least several years of development and testing.

The man

But it is not only the machine; airpower is that fine combination of man and machine. How flexible are our pilots in changing tactics and procedures? My experience is that pilots do adapt to new situations. The air force is an environment in which there are not so many players and every pilot is a professional. Authority and respect among pilots is more based on skill and experience than on rank or power. In this type of environment it is easier to be flexible than in an army where you have to deal with large numbers or organizations which are often controlled by rank and power alone. Even in peace time tactics constantly change as a result of experience gained by pilots during exercises. When you have been away from operational flying to do a desk job you will notice quite a change in tactics when you return to flying status. Also during debriefings by operators who participated in past conflicts I learned that they had constantly adapted procedures during the campaign to cope with the unexpected. Flexibility is indeed a key characteristic of airpower operators.

Opponent capability

The machine

How does this compare to our adversaries? First, we have to admit that our knowledge about our adversaries is limited. Some observations about their 'machines' can be made. They may have very old-fashioned weapons, but simple rocket propelled grenades can down helicopters and car bombs can be constructed from fertilizer and detonators. The weapons used in 9/11 were simple box cutters[3]. But that is not the complete story. Thanks to the great advances in the field of communication they, like everybody else, can communicate with each other from almost anywhere in the world, using the Internet and cellular phones. They can use these same phones to trigger explosive devices from a distance. By rapidly changing devices and using prepaid telephone cards, they are able to hide their identity. Through the Internet they have access to a lot of information and if they wish they can also communicate with each other in fairly secure ways[4]. Encoding programs can be downloaded freely. On top of that, the Internet may also be used as an advertising and recruiting device. And with the present cheap means of international transport people can move quickly and freely as long as they are not linked to terrorist groups. In short, our open, highly technological, society can be used to their advantage.

So, it appears that our adversaries are presently using low-technology weapons in a high-technology environment. In theory, it should be possible for terrorists to build small cruise missiles based on GPS, computers and remote control aircraft components, which are readily available in specialized hobby shops. This might be a much safer way to engage in an aerial attack than hijacking an airplane and hard to counter. Or they may produce some cheap chemical or biological weapons of mass destruction.

However, up to now terrorists have mostly attacked using old fashioned means, without using all the technology which- in theory at least- is available to them.

The man

We should be even more careful when we make assumptions about "the man". We are certainly not talking about a homogeneous group and there does not seem to be a generally accepted theory on why someone becomes a terrorist[5]. However, the Frustration Aggression Hypothesis (FAH)[6] developed by Berkowitz has been compelling, particularly in its simplicity. Therefore, it would be better to focus on how they operate to expose possible weaknesses[7]. We might assume that terrorists have a problem organizing and recruiting[8]. Recruiting is a long process which slowly draws people into the system. Recruiting the right mix of personnel takes time. Training and testing (in secrecy) is much harder than for a conventional army. This might be a reason why until now most terrorist have used relatively simple methods of attack. Even with highly skilled personnel, it requires much iteration and several specialists to make weapons that are more advanced and it also requires more training. An interesting article in *Natuur en Techniek*, a Dutch scientific magazine[9], gave a few examples of how terrorist have failed (up to now) to produce adequate chemical and biological weapons. Maybe we should be thankful that making weapons of mass destruction is more complicated than is often suggested. On the other hand, because their simple methods are still effective the need to use more complex approaches might also be small.

To summarize, when we look from our perspective, we see complex weaponry that is difficult to change, with flexible and well-trained professionals as operators. Our opponents, however, have a high degree of flexibility in terms of machines, but problems recruiting, organizing and training personnel. This will hamper them in making more complex weaponry and necessitates more time to plan and execute attacks.

The use of airpower against unconventional opponents

Air defense

The air defense network has always been the most sophisticated part of airpower. It was the first to use a network centric approach with coupled radar stations, centralized command and control agencies that direct SAM batteries and highly sophisticated fighter aircraft equipped with beyond visual range missiles. However, the whole system is intended to fight an enemy from outside, in which case the radars will give ample warning time to launch fighters. But the system is far less capable of countering a threat from within, as was proven on 9/11. The readiness state on 9/11 was of course not high, but even today with higher alert states the defense against a 9/11-type attack remains difficult. Let us look at the physics first.

We assume an aircraft in the air is hijacked and directed to a target that is 30 minutes' flying away[10]. Assuming a speed of Mach 0.8 (standard), the aircraft will fly approximately 240 nautical miles. Air defense has two options to counter this hijacked plane. The best result is achieved by having aircraft fly Combat Air Patrols and directing them to the threat if required. However, to have two fighter aircraft (the minimum) airborne 24 hours a day and 7 days a week is extremely expensive and would cost around 20,000 flying hours a year[11]. That is close to the total number of RNLAF yearly flying hours, so it would drain all the resources.

A more economical way is to have aircraft on quick reaction alert (QRA) and scramble them only when needed. But scrambling aircraft costs precious minutes and calculations show that it is hard to intercept an aircraft that is past the scrambling base and flying away[12]. On the other hand, if the hijacked aircraft were flying straight towards the threat the situation would be more favorable. The distance covered by the hijacked airplane and our interceptor can be added which means that an interceptor can easily be scrambled against a target that is still 300 nm away and approaching. It will complete the intercept in 20 minutes at half distance, which will leave 10 minutes to decide what to do and get permission to fire if conditions so dictate. The latter example was always the case in a classical war situation. The enemy is detected when flying towards our country and is met head on by our scrambled fighters. But in a terrorist scenario this will not work. First, it is not always clear what the hijacked airplane's target is and even if we did know the most likely target(s), we would not be able to reposition our airfields over night. Theoretically, fighters should be located close to possible target(s), which enables them to meet the threat head on. The bottom line is that aircraft on alert can intercept some aircraft, but certainly not all aircraft and the shorter the time is from the hijack moment to the target impact, the harder it will be.

A third way to defend the air space is to use SAM batteries. A tricky choice, of course. There is no way to ascertain whether the aircraft is having navigational or communication problems, the only choice is to either shoot or hold fire. It is possible to have a no-fly zone for certain special areas and for some time periods, but experience has shown that most real scrambles are against planes which are not hijacked at all but have some other kind of problem.

Air defense was never easy. In all classical wars, aircraft were able to penetrate air defense systems. Air defense against a terrorist threat is not easy either. It is either dangerous (when using SAMs), has limited effectiveness (when using QRA aircraft) or is cost prohibitive (when using CAPs). From this analysis, it is clear that prevention is the only feasible option when trying to defend against a 9/11-type scenario. But we should also be aware that 9/11 was just one type of scenario. Terrorists might invent other ways to get control over an airliner or to terrorize airspace. Building a simple cruise missile is theoretically within reach. Detecting and defending against such a threat poses a different kind of problem. It is tough to detect and identify small and slow flying objects. On the positive side, those objects will probably not carry a heavy payload.

Reconnaissance

Reconnaissance is the oldest use of airpower. The high ground has always been the favourite position to watch the battle and the use of balloons and aircraft hugely improved the quality of reconnaissance. During the Cold War, the most common reconnaissance platforms were fast combat aircraft equipped with cameras. Of course there was a limited number of very specialized aircraft such as the SR-71 and the U-2 (TR-2), which could fly unchallenged above (some) enemy territory, but all other aircraft were vulnerable to enemy fighters and SAMs and needed speed and agility[13]. So, combat aircraft were used. But combat aircraft have little endurance and could not loiter over the target area. Neither could reconnaissance satellites stay above the target area because they have to be in low orbits (to get a better view of their targets) and low obits are not geo-stationary. The result was that all information gathered by reconnaissance assets was always outdated by the time the aircraft came back. But low-intensity conflicts, where one party had air superiority, made it possible to employ a different kind of bird, the reconnaissance UAV. The combination of large wings, low speed and being unmanned in a theatre without any threat made it possible to loiter over the target area for more than a day using a relative simple and cheap UAV. The tactical consequence was that one could move from reconnaissance to surveillance. No wonder Israel was one of the first users of UAVs. Having air supremacy above its own country and part of the southern Lebanon it used simple UAVs to spot rocket attacks on its settlements in the north of Galilee. When a rocket firing was spotted, the operators were able to track the shooters and follow them to their hideouts and within half an hour of the attack a combat aircraft, equipped with laser-guided weapons would attack them. A perfect example of networking and of what surveillance can do. Today, Predators are doing the same job for the USA. To even shorten the cycle, some Predator-Bs are now equipped with weapons as well so they can immediately react to a threat. This is an interesting development, because whereas the UAV was initially a cheap an expendable aircraft, when you start to integrate weapons into the system, it will become more complex. The more expensive it is, the harder you will seek to prevent it from crashing (which is what UAVs tend to do at a much higher rate than combat aircraft). To prevent it from crashing you have to add redundancy into the system, which will make it even more expensive and more complex, and finally you may as well add a crew! There should be some optimal point up to which you would want to invest in UAVs or you might end up with the equivalent of combat aircraft in terms of price and complexity, but without the versatility and adaptability to new tasks of manned aircraft.

There are, however, some limitations to these systems. At 15,000 feet you may be able to oversee an area of more than 20 square nautical miles[14] but the sensor will only look at a small spot at a time, typically an area of 500 by 500 feet[15] And the picture needs to be interpreted. To carefully scan the complete area (a few seconds in each direction) will take four hours[16]. Therefore, this will only work if the operators have some information on where to look or whether the whole area is deserted. And of course, if an explosion triggers the operators they might immediately direct the cameras to the troubled spot. But you can imagine that with a car bomb that was positioned hours ago with an explosion triggered from a distance, it will be hard to find any trace of the suspects. It will also be difficult to prevent the taking of hostages and suicide attacks. Only if the enemy has a limited area of operation and exposes himself, like, for example, in the insurgence in Fallujah, is the UAV able to make the difference. In terrorist attacks like those that took place in London and Madrid it is difficult to see a role for a UAV.

Ground attack

The final airpower role to discuss is in ground attack. Airpower today is able to strike any ground target with precision once it is located. The preferred way of operation is a composite air operation in which the attack aircraft, protected by air defense fighters and electronic warfare assets, will attack targets that were selected from a target list. To develop target lists requires a lot of work. However, the USA maintains a large peacetime effort to build target lists for all possible contingencies. Reconnaissance assets like satellites and electronic intelligence aircraft are able to locate most stationary targets in preparing for conventional conflicts. During the battle itself, real-time JSTAR aircraft can 'see' moving wheeled and tracked vehicles with their powerful synthetic aperture radar.

However, during unconventional battles, there might not be a target list and the enemy's truck is hard to spot by JSTAR if it does not stand out in the normal traffic flow. And instead of proceeding to a target from the list, attack aircraft in low-threat scenarios are presently orbiting until they are called up to intervene. What is true for air defense combat air patrols also holds for ground attack air patrols. They consume a large amount of flying hours and are expensive to maintain. However, given the empty battlefield, airpower is the logical choice because of its ability to protect a large area with fewer assets. Good and fast cooperation between spotters and shooters enhances those capabilities.

Because of the cost involved in having expensive fighter bombers loiter, it is logical to look at the cost of an armed UAV as well. However, one thing should not be overlooked and that is response time. The speed of a fighter-bomber is more than five times higher than that of a UAV. If ground spotters detect a target and want immediate fire support, a fighter-bomber can deliver that five times faster than a UAV. Or, to put it differently, if for a certain area airpower is required to give fire support within, let us say, 30 minutes, you need 5 squared (= 25) times more UAVs than fighter bombers to do the job. The same holds true if you compare an attack helicopter with a fighter-bomber because the attack helicopter has about the same speed as a UAV.

It seems logical to conclude that attack helicopters and armed UAVs are more suited to a small area that is relatively target-rich. However, to cover a fast, not target-rich environment the fighter-bomber is the better choice. Special attention should also be given to the weapons used. A drawback might be that most weapons are still oversized for the role. If the price of stopping the insurgence in Fallujah is ruining the city, that price may be excessive and the resulting situation may backfire and trigger more unrest. There is a definite requirement for smaller and if possible non-lethal munitions so that collateral damage is much smaller. Precision alone is definitely not good enough.

Unconventional war and the airpower theory

The theory

The crucial question of course is: do our airpower strategies provide answers to the problems we are facing now? An interesting exercise is to apply some airpower theory and see if it can give any inspiration. One of the most popular theorists in the airpower arena is John Boyd with his famous OODA loop (Observe, Orient, Decide and Act)[17]. John Boyd realized that fighting an enemy is a process. As an educated engineer, he was well aware of the ins and outs of system and control theory. To control a process you have to observe and orient, make a decision, carry it out and then start all over again because the situation is changing. The use of control theory in other than mechanical processes became popular in last part of the previous century, for instance, in economics, biology and, thanks to Boyd, in the art of warfare. An important fact in the control and process theory is that the control should be swift enough to prevent the system from running wild. One example of a system running wild by running too slow is of course the famous "pork price curve" and we should try to prevent that from happening. To put it in layman's terms, if your loop is too slow the war is controlling you instead of the other way around. Here, I want to point out the common misconception that the OODA loop is only a decision loop. The A for Act is vital and a decision is just a part of it. And our whole loop should be quicker than that of our opponent. Another interesting point is that if you try to change a system faster than the system can handle, it will basically not change at all. This is a common experience in organizations were they reorganize constantly at a speed that their staff cannot handle. They might simply stop changing and become lethargic.

Another important phenomenon that was recognized by Boyd, and also by Warden, is that our opponent is a living organism, constantly changing, adapting to new situations as we are, in order to survive. Therefore, the orientation phase is very essential. If, for example, we were controlling a simple system like an airplane, the loop could be shortened to simply Observe, Decide and Act, in which case the decision is based on known algorithms. The flight control system of the F-16 is doing just that and is able to control even an unstable airplane. The orientation phase is important to discover our opponent's changes in tactics and strategy and exploit them to keep the initiative on our side.

A further important consideration is that there is not just one loop. The loop that is most commonly known is the Air Task Order (ATO) cycle that repeats itself every 24 hours. However, the OODA loop for a pilot engaged in air-to-air combat is measured in seconds instead of hours. The same is true for a Patriot missile operator. On the other hand, if we consider our procurement and development cycle, as we discussed above, the process takes a few decades and the OODA loops should be measured in years.

If we restrict ourselves for a moment to the cycle of the military operation, we observe that the enemy's cycle is normally fairly long. To plan and execute a 9/11-type attack took more than a year. And even a simpler attack like the one in Madrid needed several weeks to organize. If we compare the operational loop of our opponent to ours, we seem to be in the lead. Given the proper alert state, we can scramble an aircraft in minutes. In air defense and ground attacks, we have developed time-sensitive targeting procedures that facilitate a quick connection (preferably data link) between ground observers/Special Forces and combat aircraft. An OODA loop can take as little as 30 minutes and in some situations, for example, with armed UAVs or a combat aircraft loitering above a trouble spot, the reaction time can be measured in minutes.

The biggest problem is of course not the fact that our opponent's loop is shorter than ours, but that most of his loop is hidden. Should we then change John Boyd's rule to say that we must operate quicker than the visible part of the loop of our opponent? I believe this is the consequence. Non-visible parts do not count[18]. And there we have it. If the opponent can limit his visible part of the loop to a few minutes, which is theoretically possible in a 9/11-type aerial attack, or even to zero in the case of a car bomb, we are operationally outmaneuvered. He is controlling us and we have lost the initiative. This is exactly the type of conflict, according to our airpower theorists, we should not engage in. Being defensive and reactive requires an immense number of personnel, and victory is hard to obtain. And for airpower a defensive posture is also extremely expensive, as was illustrated by the number of aircraft needed to man just one CAP over the Netherlands.

Future outlook

What is the role of airpower if we can make the opponent's loop more visible?
The type of opponent and how early he is detected definitely makes the difference here. If, for example, a small group of terrorists is detected well in advance you might not need airpower at all. Maybe some helicopters are appropriate when an arresting team takes them in, but "nice to have" is definitely not the same as necessary.

However, the larger the group of opponents, the better armed they are. The later they are detected, the more appropriate it seems to use airpower. When you are fighting an insurgency, or when some of your troops on the ground are ambushed, airpower might be your only option to concentrate enough firepower on the right spot. This is of course logical as airpower combines high firepower with high speed.

There are some other things airpower can do to alleviate, for example, the problems of an occupying force on the ground. Air transport, given air supremacy, can be a smarter way to move than ground transport. But the basic problem in engaging in non-conventional conflicts is exposing the opponent sooner.

How to make the opponent's loop visible?
In we put ourselves in the position of a terrorist, we will discover that having a magnificent plan to kill a few thousand people might seem easy in theory but in reality it is not easy at all. We would need an organization, money, weapons, training and time. This means that terrorist groups are vulnerable to entrapment, infiltration and other forms of good human intelligence. Another important point is that we need broad popular support. If we do not win the hearts and minds of the population of the country we are fighting in, the terrorist will have a massive support base, whereas we will lack the

essential information base. We must also maintain the moral high ground (as Boyd pointed out). Using non-lethal weapons as far as possible and treating captured prisoners humanely are some of the essential ingredients, not only to win the hearts and minds of the countries we might be fighting in but also to guard the hearts and minds of our own soldiers.

What can technology do?

Theoretically, technology can achieve a lot but not everything is practically possible. To mix fertilizer with a negative catalyst that will degrade its explosive potential and does not harm crops, or to protect all our weapons with devices that prevent unauthorized use might both be feasible. However, the problem is that there are millions of weapons around and at thousands of different fertilizer firms, which will make such ideas practically impossible.

Another approach might be to try and improve our high-tech weapons with more features. My estimation is that those weapons are very effective in their present roles but improving them is a costly and time-consuming effort. What we should do is make use of existing Commercial Off the Shelf (COTS) equipment and adapt it for military use. We need, for instance, more sensors, and not just a few, but probably thousands. We should try to find the easiest way to implement this new equipment with rapid prototyping and with a fast interaction between engineers and operators[19], and not necessarily in complicated weapon platforms. Some options are being investigated.

It should be possible to measure metal objects without the need to pass through a detection gate and detect people with hidden arms, without them knowing that they are scanned. Every new handheld phone has a camera and exploiting this commercial technology should make it possible to change cellular phones into remote cameras forming a large network. To take full advantage of a large sensor network some automatic processing is also required. Some of these techniques are presently also being explored by police forces.

What changes are required for airpower?

General

There is a fundamental question that we must address: can airpower adapt to a quicker OODA loop or can it operate in a better way? One way to improve the loop is Network Centric Warfare (NCW)[20]. A limited implementation of NCW could be seen in recent conflicts but the question is if NCW can be exploited in non-conventional conflicts as well.

Air defense

To improve the speed of the OODA loop in air defense is difficult. Speed increases for fighter aircraft can save just a minute or so and are extremely expensive. Long-range weapons are useful in a conventional conflict but not during a terrorist attack when the pilot has to join up with the target aircraft to identify what is going on. The network centric capabilities do give the general at the top a lot of detailed information. However, when a lot of information is available at the top, the tendency is to make all the decisions at the highest possible level and preferably at the political level. The 9/11 scenario is once again a good example. Say an air force pilot has intercepted a hijacked airplane, so, fortunately, he is in time, and recognizes that the plane is on a fatal collision course with a building. All the time advantages may be lost if the minister in charge of terrorism must first be contacted to get clearance to attack. Although understandably the minister likes to take that decision himself, I wonder if he realizes how little time he has available to get informed and how much time he has left to decide. So a system that requires high-level political approval in this situation might point at an unconscious decision not to act at all. The better way would be that politicians give guidelines up front to the military and let the military, who have people on duty 24 hours a day, control the action. This was also the way of air defense during the Cold War and the way it is presently handled in the USA. This change would increase the speed of the OODA loop probably more than any technical enhancement would

Reconnaissance

What we need for better reconnaissance is more sensors. Here, we should fully exploit the capabilities of cheap cameras and cellular phones, as mentioned earlier. Network sensors with automated scene recognition might be a feasible technical development. It may be a good idea as well to increase the number of sensors on a UAV platform. This might be more cost-effective than just increasing the number of UAVs, which is limited by the availability of satellite communications. However, because the area we have to cover is so large we should not focus on UAVs alone; we must start to consider every soldier as an intelligence source and he must be connected to the network. There are other airpower solutions to increase reconnaissance capability. A USA colonel missed the small Cessna Aircraft in Iraq that was available in Vietnam! Indeed a Cessna with GPS, laser pointer and NVGs can be an asset which might be even cheaper than a Predator.

Ground attack

Ground attack needs every intelligence source -basically every soldier- to give an accurate target description and position with minimum time delay. That is what we should achieve with NCW. Furthermore, as stated earlier, we need smaller weapons and more non-lethal weapons that can be delivered from the air.

Conclusion

Airpower is limited in fighting unconventional wars. The smaller the war and the shorter the exposure time of the opponent the lesser the chances are that airpower can be used effectively. Airpower is expensive to use in a defensive position with aircraft in the air just patrolling. And this is not the way we should operate; we must take the initiative. The only way to gain that initiative is to expose the opponent earlier. Airpower can play a role in increasing the number of sensors but will never be able to do this alone. Unorthodox use of airpower, including the Cessna, might give some help.

One fact is in our favor: in counter-insurgence and counter-terrorism we normally own the sky. We can use it to transport our troops more safely, engage in reconnaissance and attack if time is available. The airpower operators can adapt and should adapt to using unconventional and maybe low-tech means and learn to work with the individual soldier in the field.

Notes

1. The information on technical development is derived from the personal experience of the author. The author graduated from the USAF Test Pilot School in 1984 and has 20 years of experience as a test pilot for the RNLAF. He participated as a test pilot in more than 100 development projects for the NF5 and F-16. He was Test Director of the Operational Test and Evaluation of the Mid-Life Update of the F-16 in 1996 and 1997. He was Head of the Fighter Requirement Branch from 1998 to 2000 and was Head of the Flight Test Department from 2000 until 2004. He participated in the Multinational Fighter Program as a member of the cockpit review team and as a member of the operational sub committee.
2. There are several ways to model complexity. A common way (Metcalf's rule) states that the value of a network increases with the square of the number of nodes (participants). Another method, used here by the author is to calculate the number of possible combinations. In that case the number of combinations is the faculty (!) of the number of players/systems or modes, where 3!=1 x 2 x 3 (6). This means that with only three systems there are six different combinations. In flight testing all these combination might have errors that only surface in a particular combination and therefore the faculty rule is the better rule to describe complexity.
3. David Clark Technology & Terrorism 2004.

4. See M.Conway's essay in Technology & Terrorism 2004. It is interesting to note that, as far as we know, to date terrorists have used old fashioned means such as semagrams and have not used more sophisticated methods, for instance, digital steganography, which, by the way, can be cracked through statistical analysis.
5. Friedland Becoming a Terrorist: 82.
6. The theory was initially developed to explain individual behavior. The use for groups, e.g. terrorists, is indeed compelling. However, there are many who are frustrated but will never turn into terrorists. See John Horgan The Psychology of Terrorism 2005: 57.
7. John Horgan The Psychology of Terrorism 2005: 31.
8. John Horgan The Psychology of Terrorism 2005: 96.
9. See Natuur en Techniek September 2005, De incompetentie van de terrorist
10. A general description on how air defense is done can be found in Brassey's Airpower Aircraft Weapons Systems and Technology series, vol. 7, 1989.
11. 24 * 2 * 365 = 17,520; adding 15% for moving to and from the CAP makes 20,148. The RNLAF produces around 25, 000 F-16 flying hours per year.
12. The following figures are valid for an F-16 and based on the T.O. F-16M-1-1 (LMTAS). It will take the pilot around 5 minutes to run to the plane, strap in and get it (and all the systems) started. To get airborne and accelerate to the preferred climb speed of 0.9 Mach will take another minute, to climb to 36,000 feet, which is the best altitude to fly supersonic takes two minutes and to accelerate to 1.5 mach takes approximately 3 minutes. So in a best-case scenario, 11 minutes after the alarm went off the interceptor is at high supersonic speed busy with the intercept and he has covered nearly 60 nautical miles. The F-16 will be able to maintain this high speed for another 4 minutes before it reaches bingo fuel and the use of afterburner must be discontinued. At that moment, the aircraft will have covered around 115 nm in 15 minutes. The aircraft will now decelerate to subsonic speed in 3 minutes and cover another 40 miles. So after 18 minutes the interceptor has covered around 155 nm and will be basically co-speed with an airliner. The hijacked plane will have covered 144 nm in those same 18 minutes. So if the hijacked aircraft was more than 11 nm past the airbase from which the interceptor was scrambled, the interceptor will not be able to catch up and join up with the hijacked airplane.
13. For a good description in airborne reconnaissance see Brassey's Airpower Aircraft Weapons Systems and Technology series, vol. 7, 1989
14. Assuming a viewing angle of 45 degrees around the aircraft the radius of the viewing area is the same as the altitude (e.g., 15,000 feet or 2.5 nm). The total area =2.5^2 * pi is ca 20 nm2.

15. That is slightly more than the size of a soccer field. It should be clear that this is probably the minimum detail an observer would like to see to scan an area. In many situations more detail is warranted but that will directly affect the total scanning time.
16. An area of 500 * 500 feet = 1/144 nm2. To scan 20 nm2 takes 20 * 144 = 2880 observations. If each observation last 5 seconds the total scan time is already 14,400 seconds or 4 hours.
17. The description of John Boyd's theory is primarily based on *Science, Strategy and War,* The Strategic Theory of John Boyd, dissertation by Frans Osinga 2005.
18. Another interesting situation might be where the enemy is intermittently visible; this will require some further analysis, which is outside of the scope of this article.
19. See also Network Centric Warfare Alberts, Garstka, & Stein 1999: 208.
20. Network Centric Warfare, Alberts, Garstka & Stein 1999.