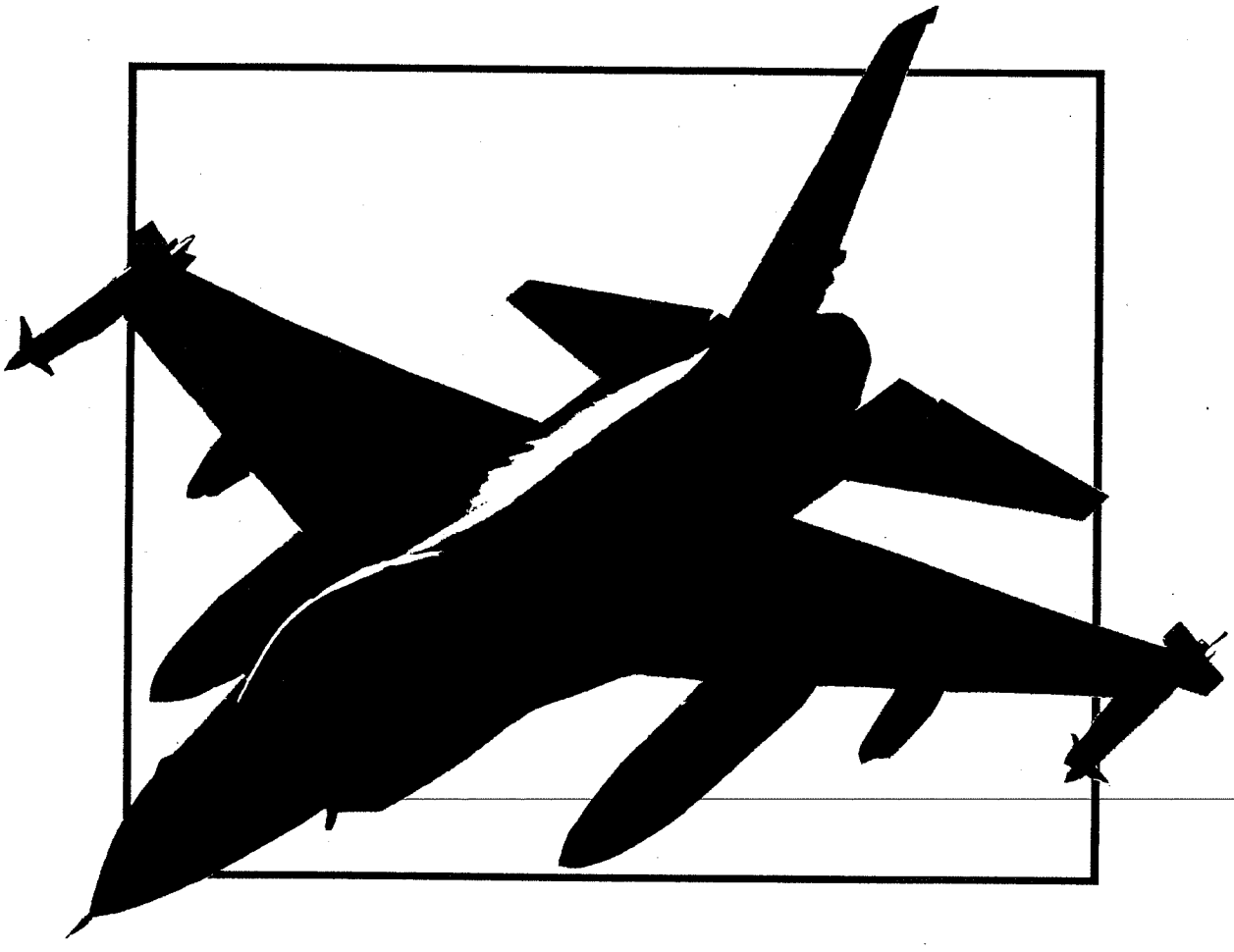
Examining NATO military low-flying and its future prospects

Low-flying and security posture

By Alan H. Bloomgarden



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About this paper

This paper is drawn from a review of the Canadian Department of National Defence (DND) 1994 Environmental Impact Statement (EIS) of Military Flying Activities in Labrador and Quebec, which **Alan H. Bloomgarden** conducted on behalf of the Innu Nation. There are two dimensions of the EIS specifically, and of the review process more generally, which were of chief concern for his analysis.

First, he evaluated the EIS and supporting documentation submitted by the DND against the requirements set out by the Environmental Assessment Review Process (EARP) Panel. Then, he examined the rationale for low-level military flying and corresponding flight training along with the context in which the DND has proposed to expand such training at Goose Bay.

This paper presents material from the latter study, and seeks particularly to provide insight and analysis useful to those groups and individuals now trying to understand the military arguments for and against low-level flight training in the post-Cold War security arena.

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Low-flying and security posture

Examining the historical and current contexts of NATO military low-flying and its future prospects

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Introduction

The Project on Defense Alternatives (PDA) seeks to adapt security policy to the challenges and opportunities of the post-Cold War era. Today the world is poised between a past in which nations sought to ensure their security primarily through armed deterrence and exclusive military alliances and a future in which inclusive global agencies and nonmilitary means can play the leading role in guaranteeing peace.

Ensuring the transition from old to new requires a positive, transitional security policy—one that can build confidence in the willingness and capacity of nations to pursue their security goals in common. From the project's perspective, the components of a transitional, "confidence-building" security policy would:

- guarantee reliable, cost-effective defence against aggression;
- rely on military structures that do not contribute to interstate tensions, "crisis instability," or arms races;
- allow significant reductions in the level of armed forces and military spending;
- foster progress in arms control and in the gradual demilitarization of international relations; and,
- facilitate greater reliance on collective and global peacekeeping agencies and on nonmilitary means of conflict prevention, containment, and resolution.

Although PDA emphasizes the reformulation of US defence policy, it has contributed since its inception to the development of defence alternatives in Europe and has pioneered proposals for the "defensive restructuring" of armed forces in the developing world. As part of this latter effort, the project has designed arms control measures that would reduce the offensive character of existing conventional armed forces and reorient the arms trade along defensive lines.

The Project on Defense Alternatives is a program of the Commonwealth Institute, Cambridge, MA and is affiliated with the European Study Group on Alternative Security Policy, Bonn, Germany.

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Preface

by Bill Robinson

One of the glaring gaps in the debate about military low-level flight training in the Innu homeland of Nitassinan (most of Labrador and part of north-eastern Quebec) has been the absence of any substantive discussion of the role and implications of low-level flying in the defence and security policies of Canada and its allies.

An effective defence policy must do more than promise victory on the battlefield. It must also help prevent war, avoid provoking a costly and destabilizing arms race, and reduce, rather than create, pressures to resort to force during crises. It must reassure other countries of our defensive intentions. Above all, it must contribute to the success of our broader efforts to build a sustainable peace—to eliminate the prospect of the battlefield by making lasting friends of potential enemies.

These requirements can be difficult to balance: a military capability that increases both the likelihood of victory on the battlefield and the likelihood of war, for example, is not necessarily a net contribution to security. How does low-flying measure up in this context? Does an extensive low-flying capability contribute to or detract from the overall goals of our defence and security policies? The Department of National Defence has never addressed this question.

Also missing from the debate has been any substantive discussion of the military "necessity" of low-level flying. This issue is far more complex than the bland assertions of the Department of National Defence would suggest. The operational experiences of the past, the changing circumstances of the present, and the potential technological developments of the future all raise questions about the appropriateness of low-flying as a military tactic.

The following study by Alan Bloomgarden of the Project on Defense Alternatives was commissioned by the Innu Nation, and published by Project Ploughshares at the request of the Innu. The first part of the paper examines low-flying in the broad context of defence and security policy. The second part takes a detailed look at the case for and against low-flying as a tactic.

Many of the arguments in the second part of the paper imply retaining (at least temporarily) offensive air power roles and capabilities that Project Ploughshares does not support.

As the standard disclaimer on our working papers states, "the views expressed and proposals made in these papers should not be taken as necessarily reflecting the official policy of Project Ploughshares."Nonetheless, we feel that this viewpoint is an important contribution to the debate. The controversy over low-level flying is not just a battle between "pro-military" and "anti-military" positions. There are strong military arguments against extensive reliance on low-flying tactics, and these arguments need to be heard.♦

A military capability that increases both the likelihood of victory on the battlefield and the likelihood of war is not necessarily a net contribution to security.

There are two major reasons to question the necessity for continued extensive low-level flight training by Canada and its allies. The first, and more important of these, relates to the role of low-flying in overall security policy. The military capabilities developed through low-flying training form a constituent component of national security postures, which in turn help define the NATO alliance's own posture.

The first section of this paper will make the case that the capabilities developed by low-flying adversely affect the overall stance of these security postures, emphasizing offensive capabilities at the expense of more stable, mutually secure defence postures. Insofar as recent events and current trends point toward the need for improved systems of security that promote and ensure the common security of all parties, offensive military capabilities should be minimized, and the offensive capabilities served by certain kinds of low-flying training should be constrained. In the specific case of NATO, current and future demands of UN- or internationally-sanctioned *peace support operations** also require greater attention to more sophisticated, multi-national, and multi-service military training.

The second major reason to question extensive low-level flight training concerns its continuing usefulness (from a military perspective) as a tactic. Low-flying proved a costly enterprise in the Gulf War, one which was of indeterminate value in the circumstances. The early abandoning of low-flying in the defence environment most often portrayed by air planners as the one in which it could be most useful calls into question the suitability of such missions for future scenarios involving strong *air defences*. Less threatening scenarios might not demand an intensive radar-evasion effort at all.

Military alternatives to low-flying existed for air forces before the Gulf War, were used effectively by other Coalition air forces during the war and also (less effectively) by air forces trained mainly for low-level missions, and continue to be developed at the tactical and technological levels as a direct result of lessons learned in the war. Too many questions concerning the continuing need for such radar evasion and bombing tactics remain for current training policy to proceed without a fundamental reassessment of inherent military threats and potential conflict scenarios.

Air power and security policy

Low-flying as a tactic contributes directly to specific air power strategies, and these strategies form collectively the structure and character of defence policy more generally. The tactic, then, has an indirect but significant impact upon the security posture of the deploying nation, or, in this case, more broadly the NATO alliance, as several members participate in constructing an air power strategy built on low-flying. Security derives both from NATO members' capability to respond to any likely threats and from a well-founded and widespread sense in NATO's neighbours and potential opponents that they need not fear an offensive threat from NATO military forces.[1] Low-flying capabilities can affect both of these aspects of security.

To evaluate properly the impact of the practice of low-flying tactics on the character of defence policies within NATO it is important to sort out the meanings of the various levels and dimensions of the distinction between "offence" and "defence." Otherwise, as is often the case, the distinctions become blurred and confused when different dimensions of the issue are mixed in the same argument.

Offence and defence can exist at all three of the classical levels of warfare: tactical, operational, and strategic. Most often the distinction is made on the basis of scale. Tactical, in the context of this paper, refers to specific actions taken by a single aircraft or a squadron to accomplish an immediate goal, such as evading radar, attacking an opposing aircraft or tank, etc. The operational level of warfare is the level at which air forces seek to achieve battle victories over an opponent. For example, many aircraft may act together to perform such activities as attacking enemy air defences and airbases; their success or failure in such operations may or may not affect the overall outcome of the war. At the strategic level, air force actions join with other military and non-military actions to push for overall victory. Air forces employ tactics like low-flying to conduct operations which they hope will contribute to strategic victory over an enemy.

The distinction between offence and defence applies to low-flying in the following ways:

- Tactically, low-flying is mostly offensive. It is a cost-effective way of evading an enemy's air defences

over its own territory. The secondary use for *close air support missions* is more properly defined as a defensive tactic. However, as is true with most defensive tactics, low-flying for close air support can be used in combination with other tactics and arms for operational and strategic offensives.

- Operationally applied, low-flying tactics, which expand the theatre of operations deep into enemy territory, are preponderantly offensive. Before violent conflict erupts, an air force's orientation toward such tactics poses a potent and immediate threat that increases tensions—and may in fact create an incentive for an enemy to attack first. During an armed conflict, such orientations quicken the pace of hostilities, as the threat of deep and indefensible attacks from the air continues to invite preemptive attack or early counter-attack. An offensive posture affects not only the pace but also the intensity of violence, through a self-driven cycle of mounting destruction.
- Because of its potential to invade an enemy's defended air space, low-flying could be a key component, at least initially, of a strategic offensive campaign; Coalition forces used low-flying as a strategic offensive against Iraq in 1991. As was the case in Iraq, low-flying's surprise element makes it possible to avoid an enemy's air defences, making it an important manoeuvre at the onset of war, particularly large-scale offensives. A large air force trained in low-flying tactics must therefore be judged as capable of acting offensively.

Arguably, low-flying is operationally defensive when the intent is to maintain air superiority over one's own territory by destroying the air threat at its source—on the ground. However, a potential opponent, understanding that low-flying can functionally be offensive, will doubt that it will only be used defensively; the actual capability or possibility of low-level flying in a given situation may determine how an opponent perceives the intent of that flying. The absolute amount and intensity of planned NATO low-flying training are important for evaluating whether the resulting posture is offensive or defensive. Tactical, operational, and strategic military capabilities exist in a national and international political context. The political context can sometimes act as a real constraint on the use of military capabilities. At other times the combination of particular capabilities and political context will exacerbate international tensions and contribute to regional instability. These political factors influence the way in which low-flying capabilities are perceived, as offensive or defensive.

During the Cold War, NATO leaders and planners referred frequently to the "defensive" nature of the alliance when questioned about their offensive tactics and operational preparations. NATO defined itself as defensive for two fundamental reasons: its aggregate forces were not sufficient to mount a strategic conventional campaign against the Soviet Union, and the alliance's political structure would effectively veto any unprovoked initiation of a strategic offensive. Soviet leaders may have been reassured privately by the arguments that NATO was not planning a surprise war with them, but they probably took very seriously the possibility of a NATO strategic (counter-) offensive into Soviet territory should a large-scale East-West war break out. Since the political doctrine of the Soviet Union was to prepare for the eventuality of war with the West, it was practically irrelevant that NATO was intent on being defensive strategically before the war began. What counted was NATO's capability in wartime.

In this decade of massive political transition in Europe it is critical to consider what kind of messages military postures convey. Postures that suggest threat to the vital strategic interests or assets of other nations will make European stability and integration, as well as conditions for lasting peace, more difficult to attain. Any assessment of NATO tactical training plans must consider fully the effect that enhancing its specific military capability will have on international relations.

The former Soviet republics have entered a period of massive economic, political, and military insecurity. Russia has moved from commanding the vast Soviet armed forces to controlling Russian forces with an aggregate capability of probably half of the total Soviet forces of five years ago. Looking west, Russia sees a still strong NATO alliance—which many of its former allies in eastern Europe are clamouring to join. The Cold War's balance of power has shifted strongly to the west. This shift negates the argument that NATO's tactically offensive capabilities do not imply strategic offensive capabilities.

In December 1990 the Canadian Minister of National Defence wrote to the Minister of the Environment, Robert R. de Cotret, that it "...behoove[d] DND to explain the defensive nature of allied activities at Goose Bay in light of public criticism over the past few years regarding the alleged "offensive" nature of their training." This explanation was never forthcoming. In light of these changes to the context of the proposed training at Goose Bay it behooves the Minister of Defence more than ever to articulate fully the defensive nature of the capabilities sought and how they will contribute to a secure Canada and world community. (A useful example of a fundamental and comprehensive re-examination of Canadian security policy, built largely upon notions of common security, can be found in the recent publication *Canada 21: Canada and Common Security in the Twenty-First Century*, compiled by an impressive selection of academics and public leaders.[2])

Tactical requirements

Canada's Department of National Defence has failed to address the continuing tactical necessity and utility of military low-flying in the post-Cold War world.

NATO's emphasis on low-flying arose in response to the specific military circumstances of the Cold War. Following an earlier preoccupation with nuclear warfare, NATO air forces prepared through the late 1980s for a sustained effort against the resilient air defences of the Warsaw Pact.[3] The overriding planning presumptions that affected NATO air strategy directly were:

- that the Warsaw Pact countries, the Soviet Union in particular, possessed an overwhelming numerical superiority to NATO conventional forces in central Europe, that was combined with structures and strategies oriented toward massive and rapid forward movement. These threats increased the importance of those assets said to be NATO's most effective in defending the *"central front"* in Europe, its air forces;
- that despite its highly-trained, well-equipped ground forces deployed along the East German border, NATO would be forced quickly into retreat or escalation by the sheer mass and pace of opposing forces;
- that NATO's best response to this situation would be to employ a mobile defence combined with a potent tactical counter-offensive capability to delay, disrupt, and destroy invading forces, so as to prevent or limit further forward movement and destruction; and
- that to do this, NATO forces required air superiority as a prerequisite to any other effective ground or air operations to defend western Europe, adding what planners called the strategically defensive mission of *offensive counter air operations* to the already extensive and challenging *interdiction* roles assigned to NATO air forces.

This last "requirement" suggested that NATO expend a significant effort to debilitate the Warsaw Pact's air defences. But the fear was that there was no way NATO could manage to hamper so formidable an air defence network as appeared to face them in Central Europe. Therefore, NATO's stated need was to construct a force capable of continually penetrating those defences and conducting both interdiction and offensive counter air missions.

Air superiority was the goal, and it was to take two forms: direct (or offensive) superiority, or defeating an enemy's ability to withstand or prevent air attack or surveillance operations over its territory; and indirect air superiority, or preventing an enemy from doing the same over one's own ground forces. Low-level attacks were said to be necessary, first because medium- or high-altitude attacks were deemed insufficiently accurate against interdiction and strategic targets, and more importantly because Soviet and Warsaw Pact air defence radars, *surface-to-air missiles* (SAMs), and *anti-aircraft artillery* presented a dense and lethal obstacle to anything but low-level, radar-evading flight patterns.

The sheer number and mass of Soviet-style air defences always posed an apparently capable threat to NATO air operations. Low-flying tactics have been developed to defeat many types of air defence configurations, but it is the volume, *redundancy*, and overall threat posed by Soviet-made and-designed systems which have had the greatest impact on the planning for such offensive air tactics. Yet examining quickly several instances in which modern (and in most cases NATO or NATO member-equipped) air forces have chal-

lenged such air defences goes a long way toward deflating this ominous threat.

Presented here is not a comprehensive look at western air power experiences in the last two decades, but rather some illustrative analyses of a few modern air power encounters with Soviet-style air defences. While such hindsight cannot tell us definitively whether NATO would have won in a war with the Warsaw Pact, it can illuminate experiences relevant to current strategy, and specifically to the "evasion" and "suppression" of air defences, taken from conflicts similar in some ways to those that NATO must consider following the end of the Cold War.

The Vietnam War

According to David Isby, a prominent analyst of Soviet military capabilities, US air power found the largely Soviet-made North Vietnamese air defences surrounding Hanoi in 1972 somewhat less than overwhelming, despite their having been operated by Soviet- and Chinese- assisted and trained personnel:

> *In 1972 Hanoi was defended by 6,000 anti-aircraft guns (three times the number that ringed Berlin), half of them radar-controlled, supplemented by 156 SA-2 launchers with stockpiles big enough to permit the firing of up to 100 missiles simultaneously. However, five days of intensive US air strikes defeated even those powerful forces, and US aircraft roamed the skies of North Vietnam at will.*[4]

Another Vietnam War historian wrote that "Hanoi gained the reputation as the world's most heavily defended city."[5] A far greater threat than ground-based air defences came in the form of the fighter aircraft arriving from the Soviet Union and China for air defence.[6] US air power bore many shackles during the Vietnam War, but the North Vietnamese air defences were not among the more problematic operational constraints.

The 1973 "Yom Kippur" war

Continuing in a critique of Soviet-style air defences, Isby writes about the "Yom Kippur" war of 1973;

> *The Egyptian air-defence belt along the Suez Canal in 1973 was as dense as that around Moscow itself, the SAM sites and their attendant radars being fortified by reinforced concrete and ringed by light AAA [anti-aircraft artillery]. The combined expertise of Soviet technicians and Egyptian combat veterans left nothing to chance. In the first three days of the war the Egyptians and Syrians fired off more SAMs than NATO currently [1988] possesses, but while the Israelis suffered heavily, the defences destroyed almost as many Arab aircraft as Israeli. Even the modern SA-6 hit a target only about once in every 50 launches, and this was against an air force that was surprised, suffering from overconfidence, and lacking adequate ECM* [electronic countermeasures] *and effective tactics in the first crucial days of the war.*[7]

Isby rightly points out that at least the latter effort was still costly to the attacking air forces, and that inflicting even moderate levels of cost upon those forces may constitute a relative success for the air defences by reducing the effectiveness of the attacker's efforts or drawing its forces away from its own defence. Still, this was not an impressive showing for Soviet-style air defence systems or structures.

The 1982 air war over Lebanon

In 1982 we saw perhaps the most spectacular example of eastern air defences meeting western air power and tactics during the air war over Lebanon. Executing a carefully planned and timed combination of artillery strikes, specialized *standoff air defence suppression missile* attacks, and low-level air attacks, Israeli air forces destroyed nearly 20 surface-to-air missile (SAM) sites in the Beka'a Valley and possibly in nearby Syrian territory.[8] F-4 and F-16 aircraft using low-altitude *ingress* and *egress* techniques were clearly a feature of Israeli success, but the sheer inability of the Syrian air defences to evade destruction from standoff ranges demonstrates the significant impact this less risky technique was able to have upon Soviet-style forces and systems.

Elsewhere

Updating his classic work, *How to Make War*, James F. Dunnigan wrote in 1993:

> *It is still questionable just how effective anti-aircraft defences are. A recent example can be found in Angola, where, during the late 1980s, the Soviets constructed*

Capabilities developed by low-flying adversely affect the overall stance of security postures, emphasizing offensive capabilities at the expense of mutually secure defence policies.

the most elaborate air defence system found outside Europe. Over 70 radars and two dozen missile bases were supported by nearly 100 interceptors. Most of this was maintained by East German mercenaries. Yet South African aircraft regularly penetrated this system. Some things never change, and many potential buyers of Russian weapons took notice. They are apparently not trying to keep up with all the western advances in "stealth" and air defence suppression. The embarrassments their air-defence forces have suffered over the years are having their effect.[9]

The composite picture of widely feared Soviet-style air defences, then, is not one of an impenetrable wall but rather, at best, of an uncertain threat to well-trained and modern western air forces, and at worst a terribly inadequate shield against any but the most poorly conceived, resourced, and executed attack.

The Gulf War

Using a formidable combination of precision weaponry, advanced guidance techniques, electronic warfare systems, and other important aerospace technologies, the United States led Coalition forces into an air attack on Iraq's communications infrastructure, which devastated its air defence network, including air defence radar and tracking facilities.

Following these early blows, Coalition forces engaged in an air campaign of strategic bombardment, interdiction raids, and an intense offensive counter-air (OCA) campaign aimed at debilitating the Iraqi air defence network quickly and at grounding, then destroying, their air forces. US-led Coalition air forces simultaneously embarked on a strategic attack on command and control infrastructure (C3I) in or near Baghdad, and, more significantly for this report, on a sustained drive to gain air superiority and destroy the Iraqi Air Force.

The UK's Royal Air Force (RAF) had hoped to play a pivotal role in this effort. For at least the previous 10 years, the RAF had trained and equipped its front-line fighter forces to make a significant contribution to NATO interdiction and *airbase denial missions* against Warsaw Pact countries. UK forces, by the late 1980s deploying predominantly Tornado aircraft equipped with a range of *precision-guided munitions* as well as *area denial munitions*, most notably the British designed and manufactured JP-233 submunitions dispenser system, were complemented in NATO by German Tornado forces also equipped with airbase denial munitions (the MW-1) and by Italian Tornados. Airbase or runway denial became a major preoccupation with NATO and RAF air planners during the 1980s, with the Tornados designed specifically for such low-flying capabilities. This was the view of two of the RAF's leading air power scholars:

Improved Warsaw Pact air defences have been matched by the ability of aircraft such as [the] Tornado to fly at extremely low-altitudes protected by self-screening electronic warfare equipment and other self defensive devices. Moreover, when one remembers the Pact's cardinal requirement of sustained pressure, and its associated need to mount closely coordinated supporting air attacks, the considerable impact of attacks that delay or disrupt advancing enemy forces becomes obvious. Runways closed even for 30 minutes can deny an armoured offensive air support at a critical moment and force the Pact air forces to attack piecemeal rather than in concert. Runways closed for hours can check operations altogether or force diversion of aircraft to other airfields not so well protected and not so well equipped to rearm and turn round increasingly sophisticated Soviet aircraft.[10]

It is hardly surprising, then, when considering its contribution to Coalition efforts in the Gulf, that the RAF was prepared and willing to engage in this effort against Iraq. Some analysts have charged that by virtue of this preoccupation, low-level missions were the only way in which the RAF could make a significant contribution to Desert Storm.

The RAF was the largest non-US air contingent in the region, but nevertheless a small fish in a big American sea. Demonstrating its value to the Coalition demanded carrying out specific roles in which it had specialized....A decision not to be at the cutting edge of the offensive counter-air mission would have been a difficult choice institutionally, and would have raised serious doubts about the RAF's capability, training, and will to fight.[11]

But what was the full impact of the RAF's contribution, and how well did low-flying tactics work for them or for other air forces in the Coalition? Their contribution was clearly a costly effort, as the RAF lost four Tornados flying low during the first week of the war after having lost two Tornados and a Jaguar aircraft during low-level training before the war. Later, British commander in the Gulf General Sir Peter de la Billiere admitted that during the first days of the war he had observed:

> *The RAF are having a bad time, with heavy losses in percentage terms compared with the Allies. It could be they've got the wrong philosophy—ultra-low-approach—for this sort of campaign. Very understandable, and of course the US spend far more on their aircraft. We approach at 900 kph, down to a hundred feet, while the US come in at 10,000 feet plus and are above the Triple A [anti-aircraft artillery] and flying easy.*[12]

Soon thereafter, the RAF (as had the USAF in the months before the war[13]) elected to prohibit further low-level missions.

The US Air Force officer relieved of his post in the months before the war for being excessively frank about the tack US air power would take against Iraq, General Mike Dugan, observed in his analysis of the war that

> *attacking runways is not a high-payoff activity when the other guy knows how to fix them. If you go to an airfield, you want to hit other things: the pump for the fuel manifolds, the power supplies, the water supplies, or the dining hall at lunch hour.*[14]

Dugan makes two relevant points: first, that a response to runway attacks—re-surfacing strips of damaged runway—is not necessarily so difficult or so costly that it will cause serious setbacks; and second, that airbase facilities other than runways are logistical targets which, once destroyed, can be left to take their toll, while runway denial operations must constantly be repeated. In Dugan's view, like that held more generally through the USAF, precision attacks on air force infrastructure facilities are more worthwhile than attacks designed to limit airbase use by destroying runways.

Even Col. John Warden, America's most influential contemporary advocate of air superiority as the primary goal for air power in war, and arguably the Gulf War's most influential air planner, makes the insightful comment that

> *[i]f equipment, doctrine, or will suggest that the enemy will never use, or effectively use, [its] air forces, then it would be pointless to expend great effort to destroy them merely because of one's own doctrine.*[15]

Both of these comments bear directly upon low-flying tactics. Effective runway attack, particularly in the case of the British and German weapons systems (the JP-233 and the MW-1, respectively), requires low-altitude delivery that can be quite costly when attacking aircraft must face enemy ground artillery or SAM fire. Some weapons delivery systems require a low altitude for accuracy.

Are the costs worth it? The USAF has decided that the costs involved in such efforts are excessive, and has pursued both a procurement program oriented towards weapons delivered at medium or high altitudes and a broader strategy that holds facilities like bunkers and other structures, destroyable only through precision attack, to be of higher value than those that can be damaged through area attack like runways or airbases. The largest remaining problem facing US planners in this regard centres on the capacity to execute operations in poor weather, when cloud levels may leave low-level delivery as the only viable alternative. Still, as the experts reviewing Gulf War air power experiences for the USAF have noted,

> *Low-altitude visual attacks against defended targets were and are inherently dangerous. If visibility is good enough for the pilot or bombardier to see the target, it is good enough for defending gunners to see and engage the attacking aircraft.*[16]

The *Gulf War Air Power Survey*'s authors implicitly criticize Tornado and other Coalition aircraft efforts in the following statement:

> *Generally speaking, training was focused on a NATO Central Region conflict and emphasized low-altitude tactics. In addition, weapons systems, aircraft, and munitions had been designed to complement this think-*

ing. By contrast, the tactical realities of Iraqi defences in Desert Storm required Coalition aircraft to drop a wide variety of "dumb" bombs from medium and high altitudes. The Gulf War was thus a useful test case for highlighting the differences between low- and medium-altitude bombing accuracy and demonstrated a need for a more accurate way to deliver unguided ordnance from medium altitude.[17]

The Tornado force switched to higher level munitions delivery after losses early in the war during low-level bombing runs. An examination of the missions that Tornado aircraft were assigned during the air war is revealing. Reproduced in Table 1 are excerpts from a chart published in the independent *Gulf War Air Power Survey*, conducted by academic air power experts on behalf of the US Air Force.

Analysis of the data on the table, in light of other information now available, indicates how Tornado operations changed several times during the course of the war. Initially, the RAF Tornado GR.1 force engaged exclusively in attacks upon Iraqi airbases and the defences surrounding them. These attacks involved low-level delivery utilizing the JP-233, and also included use of the anti-radiation ALARM missiles and 1,000-lb gravity bombs. On the 24th of January, following US General Colin Powell's declaration that the Coalition had attained "air superiority," the RAF shifted away from further low-level flights. RAF leaders could argue nominally that the RAF was able to change its tactics as a result of allied air power success in grounding the Iraqi air force to this point, but the fact remains that by 24 January the RAF had lost or damaged eight Tornado GR.1s, many as a result of low-level operations (ground fire or otherwise).[18]

From 24 January to 2 February 1991, RAF Tornado GR.1s were prohibited from any low-level runway attacks, but were still ill-equipped to tackle any precision attack missions as they lacked laser designator equipment. The thermal imaging and laser designating (TIALD) pod, sent into action ahead of schedule but only in limited numbers, added some capability later in the war, but it was only in tandem with other aircraft carrying designators that the Tornado was able to deliver precision, laser-guided munitions for most of the air campaign.

Table 1: Tornado GR-1: UK sorties by mission type

Date	Air Interdiction (AI)	Offensive Counter Air (OCA)
17 Jan 91	0	47
18 Jan 91	0	32
19 Jan 91	0	8
20 Jan 91	0	24
21 Jan 91	0	27
22 Jan 91	0	31
23 Jan 91	0	22
24 Jan 91	6	8
25 Jan 91	24	0
26 Jan 91	23	0
27 Jan 91	30	0
28 Jan 91	50	0
29 Jan 91	26	0
30 Jan 91	26	0
31 Jan 91	24	0
1 Feb 91	16	8
2 Feb 91	32	0
3 Feb 91	46	0
4 Feb 91	31	0
5 Feb 91	48	0
6 Feb 91	32	9
7 Feb 91	49	0
8 Feb 91	46	0
9 Feb 91	38	0
10 Feb 91	42	8
11 Feb 91	44	6
12 Feb 91	23	11
13 Feb 91	8	16
14 Feb 91	0	28
15 Feb 91	0	36
16 Feb 91	0	28
17 Feb 91	0	20
18 Feb 91	18	24
19 Feb 91	0	35
20 Feb 91	0	38
21 Feb 91	0	39
22 Feb 91	0	42
23 Feb 91	0	41
24 Feb 91	0	42
25 Feb 91	0	42
26 Feb 91	0	26
27 Feb 91	0	42

Source: *Gulf War Air Power Survey*, Vol. V, p. 345

For this period, then, the Tornados were tasked with missions to drop "dumb" ordnance from medium altitude (20,000 ft or above) without the option of improving delivery accuracy by flying at lower levels, or alternatively, assigned to various other attacks. Poor atmospheric conditions and ill-adjusted equipment left these attacks with 1,000-lb bombs relatively ineffective.[19] On 2 February, 1950s-designed Buccaneer aircraft (equipped in the 1980s with a daytime laser designator) began to accompany Tornados on strike missions. At this point, the aircraft conducted medium and high altitude attacks on "bridges, *hardened aircraft shelters*, and other elements of air base infrastructure,"[20] using precision-guided munitions. On 12 February, Tornados returned in part to the OCA mission to assist in the intensive effort to cause long-lasting destruction of the Iraqi air forces through hardened aircraft shelter attacks and other precision attacks on airbase facilities.

Air power historian Richard Hallion concluded about the Tornado's Gulf War contribution that

> *The Tornado's introduction to combat in the Gulf War was initially disappointing; it suffered high losses and also initially lacked the ability to do its own laser target designating, requiring it to rely on older Buccaneers hastily flown in from Great Britain to "lase" targets. Changed tactics and the Buccaneer teaming greatly improved its effectiveness toward the end of the war.*[21]

More recently, the UK House of Commons Defence Committee reported that

> *The RAF was not...well equipped or trained for the medium level role....Moreover, before the conflict little or no medium level attack training was undertaken....We remain surprised that the RAF were so unprepared for offensive operations at medium level. Even in the Central European scenario we would have expected there to be some chance that medium level action would have been appropriate.*[22]

Bosnia

For more than a year, NATO has been engaged in operation "Deny Flight," a UN-endorsed air campaign designed to limit Serbian air activity over the embattled republic of Bosnia-Herzegovina. The operation has encountered a special, though probably not unique, set of problems: the constraints of a multinational peacekeeping operation involved in a geographically and politically tangled, multi-ethnic conflict.

The precise Rules of Engagement for aircraft supporting United Nations Protection Forces (UNPROFOR) in Bosnia-Herzegovina are a tightly kept secret. Still, some information has emerged from several sources relevant to this discussion. Having flown Deny Flight sorties, Wing Commander Sweetman writes that

> *[b]earing in mind that the purpose of UNPROFOR and the aircraft supporting them is to provide protection of the safe areas and ensure that the humanitarian aid gets through, the UN have to balance the advantages of [a]ir [p]ower against the risks which its use could carry for their mission, and indeed for themselves. This balance is largely a matter for the judgement of the UN commanders on the ground, but it is also achieved through some quite specific Rules of Engagement (ROE). The unclassified nature of this article precludes a detailed analysis of the ROE, but suffice it to say that the need for minimum* collateral damage *and positive target identification obviously feature high on the list of priorities.*[23]

Supporters of the tactic claim that the potential for positive target identification and for accurate weapons delivery improves with low-level flight. However, worrying conditions for such operations in Bosnia include threats from small arms, anti-aircraft artillery, and hand-held surface-to-air missiles (SAMs). For this reason, says Sweetman, "weather permitting, aircraft tend to remain at medium level, thus compounding difficulties in the crucial task of target acquisition." The solution, he says, lies not in applying one cure-all technology or technique, but in coordinating the range of electronic and physical target marking options with target intelligence from multiple sources.[24]

Some unusual approaches to the political complexities of the UN Rules of Engagement have been noted, involving low-level flight as an intimidatory measure against offending Serb tank forces around Gorazde in early April:

> *UN rules for this engagement demanded that the Serbs first be overflown at a low level by [US F/A-18] Hornets as a warning. As if that were not enough to alert their*

Leaving a low-flying capability out of the arsenal from which an air planner may draw is not inherently an absolute good for security.

anti-aircraft units, the Serbian commanding general was contacted by radio to warn of an air attack if he did not cease shelling. When even that approach failed, the Hornets were yet again ordered to make low passes over the advancing Serb forces. Only 4.5 hours after the first overflight was the bombing undertaken.[25]

This illustrates a uniquely dangerous option for aircrews prepared for low-level flight, insofar as they may be called upon for extremely risky missions under very complicated political constraints.

Assessing the record

Low-level attacks appear to have been an expensive venture in the most recent, most extensive forum for air power, the 1991 Gulf War. While the motives behind the Iraqi Air Force's unwillingness to fly remain unclear, it is difficult to determine the precise impact the airbase denial campaign had: it seems possible that Iraq had little or no intention of challenging the overwhelmingly superior Coalition force. In this case, the high-risk, low-level attacks were of questionable value and excessive cost in a dense air defence environment.

The British air force abandoned low-flying in precisely the environment for which those tactics were designed. The early switch away from low flying begs the question of how useful it would be in future conflicts. Even in the eyes of RAF planners, the costs grew to be too high, the benefits appeared to be too low or indeterminable, or perhaps both things were true.

Experience in the Gulf War suggests that low-flying tactics are not truly attractive—or even acceptable—options for military planners anticipating another conflict involving substantial air defences. The next question is whether military planners would find low-flying necessary in less threatening environments. Perhaps there is less need for low-flying in less dense air defence environments, as the threat for which the tactic is designed is either less formidable and can be met by other means, or nonexistent altogether.

From a military standpoint, the real question in evaluating tactical requirements for low-level flying is what alternatives exist for specific air power missions. In the case of offensive counter-air (OCA), the US air force used medium or high altitude precision weapon delivery. In the Gulf War, the USAF's F-15E and F-111F, aircraft roughly comparable to the UK Tornado, both completed OCA missions from higher altitudes, with far better loss and damage records.[26]

In both OCA and air interdiction (AI) tasks, bombing accuracy is crucial when the target itself is small or where distinction must be made among elements within a target area. Low-level bombing is one way to improve accuracy. However, planners must anticipate and consider an enemy's air defence capability during peacetime training and before adopting low-level flying as a strategy (see the *Gulf War Air Power Survey* authors' comments above).

These alternatives refer only to options for weapons delivery. Ultimately, however, that is the objective for getting attack aircraft in and out of an enemy's air defence system. While low-level training is nominally required for missions other than arms delivery, the purpose that those missions serve is nonetheless the same. Examining alternatives, then, must also include a look at fundamental alternatives to the offensive missions conducted at low-level, rather than simply considering alternative tactics to achieve the same objectives.

Operational issues

Low-level flying makes it easy for pilots to hit their targets, discriminate within a target area between structures or other equipment, and avoid collateral damage. However, those low-altitude approaches that require repeated passes or lengthy "loitering" over a target area in order to improve accuracy increase the threat of damage or destruction to an aircraft from an enemy's ground fire. Retreating to medium altitudes can improve "survivability" over a target area but can also decrease precision. In Bosnia,

[the] political and practical constraints demand a high success rate against difficult targets which must be struck with precise accuracy. This level of accuracy itself depends on successfully putting the pilot's eye on the target. With this achieved, the target can be attacked with either dumb weapons or with precision-guided munitions...for maximum accuracy and minimum collateral damage.[27]

Low-level operations in both Iraq and Bosnia illustrate an important distinction. In the case of Iraq, following the sustained air campaign waged against Iraqi strategic targets; infrastructure; command, control, communications, and intelligence (C3I) facilities; air defences; etc., Coalition forces used tactical air power to engage Iraqi armoured forces on a "tank-by-tank" basis. While area bombardment against Iraqi encampments prevented any movement by Iraq's armoured forces, the capacity of these limited-accuracy attacks (thousands of tons of gravity bombs dropped from B-52s) to debilitate Republican Guard armoured forces was low.[28]

In this case, more specific, directed attacks on pieces of armour, in the form of low-level loiter missions over enemy positions, were needed to improve the success of the Coalition's attacks against Iraq's armoured vehicles. Such missions were possible because of the severely damaged state of Iraqi air defences.

This campaign required pilots trained in low-level flying. This type of flying, however, is radically different from that required for longer-range offensive missions, as neither speed nor radar avoidance is an important characteristic of these close-air support, low-level missions. In Iraq, especially during Operations Provide Comfort and Southern Watch after the Gulf War, similar low-level capabilities have been necessary for limiting Iraq's helicopter activity. Insofar as there is a need for low-flying training, it is joint service and multinational exercises that address operational problems of close air support (e.g., for UN ground forces in peace enforcement operations). But this training requires very different facilities, with a different legal and NATO alliance mandate, from that being pursued by the DND at Goose Bay.

New technologies and trends

Technologies

There are many technologies under development or at different stages of procurement in NATO countries that could well affect future needs for low-flying. Areas for possible—and indeed likely—advance include:

- weapons delivery systems and techniques;
- air defence radar detection, tracking, and target destruction systems;
- anti-radiation munitions;
- electronic warfare systems;
- radar absorption materials and designs; and
- "stealth" technologies.

The precise ways in which weapons systems and military forces that incorporate advances in these areas would change is difficult to pinpoint; however, the potential is great for even small advances to alter low-flying requirements, especially long-range, offensive, low-level missions. (This paper does not examine possible or likely advances in simulator technologies, as these would simply alter the manner in which training for low-level missions takes place, while changes in the other areas could have a more general impact on the need for low-flying.)

The British Sea Eagle *air-to-surface missile* for attacking ships could bring to the UK Tornado fleet a delivery system which could release weapons from a safe distance and altitude. The European Fighter Aircraft (EFA) is a major procurement preoccupation for both British and German air force (the RAF and Luftwaffe, respectively) planners. The degree to which the EFA is both assigned to various support roles within the RAF and Luftwaffe, and, more importantly, shapes the overall posture of each force (with its predominantly air-to-air advantages), could well affect the general orientation of each force. The potential for EFA, if purchased and deployed in significant numbers, to encourage German and British orientation toward airborne air superiority exists, though the purchase of sizable ground-attack systems could also counter such a trend.

The RAF's planned retirement of Buccaneers, which provided Tornados in the Gulf with laser-designated precision, also affects the Dutch Air Force, whose F-16s depended on the Buccaneers for targeting their Paveway II laser-guided bombs. The Royal Netherlands Air Force (RNlAF) is acquiring targeting FLIR/laser designator pods for 10 F-16B two seaters, and FLIR navigation pods for 60 other aircraft, and for now RNlAF will use *ground designators* for laser guiding munitions delivery.[29] Overall, greater precision capabilities ensure accurate bombing from higher altitudes, leaving ingress and egress as the remaining problem for which low-flying is the solution. Electronic warfare capabili-

ties, including radar-jamming equipment as well as anti-radiation munitions, can help mitigate the ingress/egress difficulties faced by NATO aircraft. German electronic combat variants of the Tornado which began deployment in 1990 are designed to address these problems.[30]

Trends (doctrinal and international)

In 1992 NATO leaders created the Allied Rapid Reaction Corps (ARRC) to provide the alliance with a quick and organized military response option to a variety of conflict situations.[31] Though far from the most comprehensive dimension of NATO capabilities, the ARRC is clearly a prominent feature of NATO's "landscape" for this decade and beyond. The ARRC constitutes the most likely venue through which NATO forces will be committed to action, as its joint training, support networks, and overall flexibility make it the obvious choice for NATO-mandated military action.

The ARRC is considering *peace support operations* (PSOs), because NATO professionals and political leaders in member countries consider such operations the future for alliance military structures. A recent PSO-oriented training exercise, ARRCADE GUARD, emphasized the unique and demanding features of such operations which, taken individually and as a whole, could affect air power posture extensively.[32] Those features that would characterize a PSO include:

- heavy imposition of operational constraints,
- intensive reliance upon non-combat resources,
- advantageous use of reserves,
- multinationality, and
- importance of national and international political will to support PSOs.

Nominally, the ARRC seeks to take advantage of international economies of scale, suggesting participant nations rationalize force capabilities. Recently, NATO's armaments directors identified a range of equipment needs required for PSOs in a report, *Defense Equipment Implications of Peace Operations*.[33]

However, NATO's European members have also been grappling for the last several years with the question of continued US commitment to Europe, and US policy on intervention in the former Yugoslavia has left the distinct impression in some capitals that Europeans could be left to "go it alone," at least in any extensive or sustained military intervention on their side of the Atlantic. In this context, national military leaders are waging a battle to retain nationally as wide a range of operational functions as possible. This move also relates to the fear that NATO cohesion, without a clear and present threat from the East, may deteriorate or is slackening already. With public pressures upon defence resources, many in NATO-member militaries would prefer to see their reduced budgets devoted to more rather than less well-rounded forces (i.e., those capable of a range of missions rather than a NATO-required, specialized and unique skill).

Some analysts see this interdependence as a double-edged sword.

> *In the ARRC, NATO has a potent tool of foreign policy. Whether that tool can be used effectively to meet current and forthcoming challenges will be a test of the co-operation amongst politicians. The future is likely to demand that multinational armed forces be shown to succeed where national forces have failed in the past.*[34]

Many very heartening opportunities, however, are presented by such international rationalization of military capability. Such a situation encourages *de facto* restrictions on unilateral military response, and improves the standing of UN, or otherwise internationally sanctioned, use of force.

Even more positively, should NATO build its image as an inclusive rather than exclusive security structure (a process at least partially begun through the Partnership for Peace program—a military cooperation and training program with former Warsaw Pact members), the potential for added stability in Europe expands. The model such cooperation could provide to other regions of the globe developing or considering collective security arrangements could be very valuable. A tension between a politically derived trend to share unique features of national militaries, on the one hand, and nations' desires to retain a gamut of capabilities, on the other, remains. There are implications at the tactical level, where cooperative training is sought between land, naval, and air forces within NATO member states, as well as among member states.

These NATO trends—reduced overall defence structures (involving either rationalized or re-nationalized procurement efforts) and increased attention to

multi-national participation in PSOs—have multiple effects on air power, and specifically on low-flying requirements. Apparently, unless or until the means of meeting NATO's stated requirement for breadth of capability and flexibility is resolved, a very strong air power dependence upon those capabilities now deployed primarily by the United States will remain for any substantial air operations. That is, should NATO be requested (i.e., by the UN) to undertake anything beyond the very limited taskings now given its air forces in Bosnia, US C3I facilities, as well as other infrastructure and combat capabilities, may be at such a premium that NATO air operations without the US become problematic—if not impossible. How far this is true and to what extent non-US NATO countries could successfully mount significant air combat operations are important questions that NATO members should address. Only an examination of the external limitations on NATO's ability to involve itself in various types of conflict can reveal the true doctrinal and training requirements of its constituent air forces.

Qualifications

Although the preceding section on tactical requirements does suggest that requirements for low-flying can be reduced in the face of incapable air defence threats, this conclusion is not without qualification. A prospective opponent's weak air defences are not a rationale for a weak air force, because it does not follow that weak air defences will not exact unacceptable costs from an air force. In principle, however, the stance that the existence of even limited air defences justifies a force that can overwhelm such a defence with low or no cost has its problems.

Even in military circles, is it proper or even efficient to seek, as a matter of principle, to prepare forces not simply to meet but to thoroughly overwhelm threats? Although this is a rhetorical question, it illustrates the different impact on security between defence strategies that seek to achieve "superiority" and overwhelming victory and those designed to halt, delay, and defeat an enemy (in a more reactive manner). The peacetime differences can be significant in the political arena, warranting a second look at purely military logic which demands an unqualified use of overwhelming force.

In a security environment that nurtures notions of common security, and in which clear and unambiguous tasking of military forces for the defensive exists, tactical inflexibility is not necessarily an absolute asset; leaving a low-flying capability out of the arsenal from which an air planner may draw is not inherently an absolute good for security. Some military situations clearly require low-flying. However, the circumstances under which that flying is conducted and the purposes to which aircraft flying fast and low are put make the judgement about the propriety of low-flying a relative assessment.

Ultimately, evaluating defence and security postures and their defensive or offensive characteristics requires a sophisticated approach. Important trade-offs emerge that, while not necessarily subtle, demand that evaluations of offence and defence remain relative and focused on the mix of forces rather than on their individual components. One trade-off takes the form of a direct inverse relationship between the amount of training, preparation, and force structuring that a state conducts to create the image of a capable offensive force, and the perception of security by the neighbours or potential enemies facing that offensive force. The question becomes one of whether security is better served by deterrence through an offensive posture or by a mutually perceived stability derived from a defensive stance on both sides. This paper takes the latter view.

Are the costs of preparing for an offensive strategy, added to the likely or potential costs of executing low-level missions, outweighed by the benefits of a secure, effective, and defensively-oriented force? Are the costs justified, in terms of financial, environmental, and human costs, in the face of sufficient or superior alternatives? Can a state gain more security from a process of engendering stability through transparent and unambiguously defensive military structures than from the construction of a deterrent posture comprising an apparent offensive capability?

Conclusions and further questions

The range of issues that can have a significant impact on the construction of air power policy, and defence policy more generally, is enormous. Most disturbing

Too many questions about the proper course of air power policy remain for NATO to continue, unreflectively, with a training and overall force posture charted during the drastically different years of the Cold War.

about the DND's rationale for expanding its low-flying training project (Chapter 5 of the 1994 EIS) is its casual and summary dismissal of a very important problem posed by modern air power—and thus by its training practices and requirements. That is, air power is an extremely flexible and capable tool of a nation's military arsenal. As such, it provides a capability whose features appeal not only to the military commanders in whose hands direct control lies, but also to a state's political leadership, who could wield air power's considerable leverage in service of foreign policy goals. The threats posed by air power raise concern not only in the hearts and minds of military commanders prepared to wage war but also in those of public leaders and national populations who worry, by and large correctly, that there are few, if any, foolproof defences against aerial attack. The postures air forces take, in their peacetime orientation, structure, and training exercises and practices, are likely to have an effect well beyond the planning rooms of military strategists. For this reason it is vital to address public and expert concern about the tactics, strategies, and policies into which this particular training practice fits.

There are many questions that this paper does not address but which nonetheless remain important for understanding and evaluating proper air power policy for this new international environment. Some are questions of assessing threat, concerning the state of air defences now and in the foreseeable future in potential enemies. Which states have exploited the flooded arms market that has resulted from dramatic reductions in the military structures and industries of NATO and Warsaw Pact member states? How far has this dismantling spread new and potent air defence capabilities, and which recipient states pose potential and credible threats to NATO security interests? What is the character of those threats, and in what ways should NATO member states respond? This last question is particularly pertinent to evaluating air training practices, as the requirements for individual tactics will be determined directly from this new threat assessment. What, most generally, is the state of the international air power offence-defence race? What technologies exist or are under development, and by whom?

This latter question uncovers an important dynamic in the pursuit of defeating air defences. Are radar avoidance and anti-air defence evasion strategies complementary or alternative strategies to anti-radiation munitions delivery and anti-air defence attack operations? How do they compare on grounds of cost-efficiency and political expediency (which better serves security policy needs)? How well do current and/or planned systems and technologies meet the needs of each strategy? The trade-offs—operational, political, and financial—should be examined.

Too many questions about the proper course of air power policy remain for NATO to continue, unreflectively, with a training and overall force posture charted during the drastically different years of the Cold War. Canada, as host to such activities, retains a fundamental interest in seeing these questions examined and answered satisfactorily. The DND's suggestion that tactical requirements for low flying are not "expected to change from shifts in the geopolitical environment"[35] is beside the point. Tactics are components of strategies. The military and security strategies that NATO members—and Canada—develop to respond to those shifts will change and are now changing in direct response to such geopolitical shifts as the breakup of the Soviet Union; the emerging independence of its former constituents and of its former allies in the Warsaw Pact; and increasing concern for civil and internal strife in the former Yugoslavia, Rwanda, and elsewhere. As those broader strategies shift, the postures developed for very different political and military ends will have to change. These changes will and surely should have an impact upon the ways in which NATO members prepare to meet security needs.♦

Endnotes

* Terms which appear in italicized text are defined in the glossary on page 17.

1 This concept, known as "mutual" or "common" security, is a well-established view that realistically assesses security as a multi-faceted equation in which the considerations and fears of two or more nations are examined together. This notion is the opposite of a "zero-sum" concept, in which one nation pursues a means of defending itself in order to provide its own "security" at the direct expense of another, from whose perspective "defensive" means may appear an "offensive" threat. For a discussion of some of the problems outlined here, see "Eliminating Offensive Capabilities: Exploring Multilateral Mechanisms Beyond Arms Reductions," by John Grin in *Unconventional Approaches to Conventional Arms Control*

Verification, John Grin and Henny van de Graaf, eds, VU University Press, Amsterdam, 1990.

2 *Canada 21: Canada and Common Security in the Twenty-First Century*, by the Canada 21 Council, Centre for International Studies, University of Toronto, 1994.

3 For one analysis of NATO air power preparation during the post-WWII period, see *Air Power in the Nuclear Age, 1945-84*, by Air Marshal M.J. Armitage and Air Commodore R.A. Mason, Macmillan, 1985. A most accessible account of the full range of air operations NATO intended for a war with the Warsaw Pact countries can be found in *Air Battle Central Europe*, by Alfred Price, The Free Press (Macmillan), 1987. Included are very informative, first-hand descriptions of long-range interdiction and counter-air attacks, many of which would have been conducted at low levels.

4 *Weapons and Tactics of the Soviet Army*, by David C. Isby, Jane's Publishing Company Ltd., 1988, p. 306. Mark Clodfelter, in *The Limits of Air Power*, cites the August 1967 assessment that the North possessed roughly 200 SAM sites, 7,000 anti-aircraft guns, a sophisticated ground-controlled intercept (GCI) radar system, and 80 MiG fighters, ranging in types from the MiG-15 to the formidable MiG-21. The array caused Colonel Jack Broughton, Deputy Commander of the 355th Tactical Fighter Wing, to describe North Vietnam as "the center of hell with Hanoi as its hub." From *The Limits of Air Power*, by Mark Clodfelter, The Free Press, 1989, p. 131.

5 *The Limits of Air Power, op. cit.*, p. 131.

6 *Ibid.*, pp. 165-166.

7 *Weapons and Tactics of the Soviet Army, op. cit.*, p. 306.

8 *Moscow's Lessons from the 1982 Lebanon Air War*, by Benjamin S. Lambeth, RAND Corporation R-3000-AF, September 1984, p. 7.

9 *How to Make War*, by James F. Dunnigan, William Morrow and Company, Inc., 1993, p. 202. Dunnigan does, however, point out that air defence weaponry could begin to make better use of civilian technology, become more widely affordable and available, and presumably pose a more credible threat than western air forces currently face.

10 *Air Power in the Nuclear Age, op. cit.*, pp. 209-210.

11 "Too Close To The Ground," by Malcolm Spaven, in *The Guardian* (London) newspaper, 27 January 1992.

12 *Storm Command*, by General Sir Peter de la Billiere, HarperCollins, 1992, p. 229.

13 The US enacted flight restrictions on 11 October 1990, placing a 1,000ft floor on low-level flight training. *Gulf War Air Power Survey*, Volume V, United States Government Printing Office, Washington, DC, 1993, p. 638.

14 As quoted by Bill Sweetman in "Catching up with Doctrine," in *Jane's Defence Weekly*, 29 June 1991, vol. 15, no. 26, p. 1174.

15 Warden, *The Air Campaign*, pp. 11-12.

16 *Gulf War Air Power Survey*, Volume IV, pp. 254-255.

17 *Gulf War Air Power Survey*, Volume IV, p. 87.

18 *Gulf War Air Power Survey*, Volume V, Table 205, "Desert Storm Coalition Aircraft Attrition," pp. 642-643.

19 *Gulf Air War Debrief*, edited by Stan Morse, Aerospace Publishing London, 1991, p.152.

20 *Gulf War Air Power Survey*, Volume IV, p. 64.

21 *Storm Over Iraq*, by Richard Hallion, Smithsonian Institution Press, Washington, DC, 1992, p. 291.

22 *Implementation of Lessons Learned from Operation Granby*, House of Commons Defence Committee, Fifth Report, Session 1993-94, HC 43, HMSO, London, 14 June 1994, paragraphs 69 and 70.

23 "Close Air Support Over Bosnia-Hercegovina," by Wing Commander A.D. Sweetman in *RUSI Journal*, August 1994, pp. 1-2.

24 *Ibid.*, p. 2.

25 *Aircraft Illustrated*, July 1994, p. 7.

26 See *Gulf War Air Power Survey*, Volume V, p. 418 for strike mission records and p. 651 for attrition rates.

27 "Close Air Support Over Bosnia-Hercegovina," p. 3.

28 Not least because of the prepared positions such armour lay in.

29 *Jane's Defence Weekly*, 19 February 1994.

30 *World Air Power Journal*, Volume 3, Autumn 1990, p. 4.

31 See *International Defence Review*, October 1992, pp. 981-985 for a description of the ARRC and its origins.

32 "ARRC at the Sharp End," by Peter Saracino, in *International Defence Review*, May 1994, pp. 33-35.

33 Cited in "NATO Eyes Peacekeeping Tools," in *Defense News*, 11-17 July 1994, p. 4. This report, however, does not make clear how far NATO would go to encourage rationalization or simply nationally-driven efforts to achieve equipment and procurement improvements for these missions.

34 "ARRC at the Sharp End," p. 35.

35 *EIS: Military Flight Training, An Environmental Impact Statement on Military Flying Activities in Labrador and Quebec*, Department of National Defence, Canada, January 1994, Section 5.1.3.2, "Geopolitical Environment," pp. 5-10.

Glossary of terms

AAA: See anti-aircraft artillery.
Air defences: Systems designed to defend against air attacks.
Air defence suppression: Attempts to destroy air defence sites (i.e., missile sites, radar, etc.) to prevent air defences from operating.
Air-to-surface missiles: Missiles fired from aircraft at land or sea targets.
Airbase denial missions: Bombing missions designed to destroy an airbase or to prevent it from being used.
Anti-aircraft artillery (AAA): Guns designed to shoot down planes.
Area denial munitions: Weapons designed to prevent an entire area from being used (such weapons include landmines and chemical weapons), either by enemy forces or by civilians.
C3I: Command, control, communications, and intelligence.
Central front: The main land border between the members of NATO and the former members of the Soviet bloc (separating East and West Germany and running between West Germany and the former Czechoslovakia).
Close air support missions: Air attacks which support troops at the front lines of a conflict.
Collateral damage: Unintended civilian deaths or damage to civilian structures.
Dumb bombs: Bombs which are not guided toward a specific target.
Electronic countermeasures (ECM): Electronic equipment designed to detect or to respond to missile attack.
Egress: Flying out of enemy air space.
Ground designators: Laser equipment for marking targets, operated from positions on the ground.
Hardened aircraft shelter (HAS): A hangar designed to withstand air attack.
Ingress: Flying into enemy air space.
Interceptors: Fighter aircraft designed to shoot down other aircraft.
Interdiction: Repeated flights into enemy territory to attack enemy reinforcements, resupply convoys, etc. and to prevent them from reaching the front lines. ("Deep" interdiction means moving farther into enemy territory.)
OCA: See offensive counter air operations.
Offensive counter air operations: Attempts to destroy an enemy's ability to sustain air operations by attacking its airbases and related facilities, including radar and air defence installations as well as aircraft on the ground and in the air.
Peace support operations (PSOs): Peacekeeping, peace enforcement, humanitarian intervention, etc.
Precision-guided munitions (PGMs): Highly accurate weapons guided to targets by a variety of technologies.
PSOs: See peace support operations.
Redundancy: Multiple layers of air defences which the former USSR and Warsaw Pact countries planned to deploy in war, including air defense radars, artillery, surface-to-air missiles, aircraft equipped with air-to-air weapons, etc. The overlaps in "defensive coverage" make the system "redundant."
SAMs: See surface-to-air missiles.
Standoff missiles: Long-range missiles fired from aircraft at distant targets, enabling the aircraft to stay out of range of local air defences.
Surface-to-air missiles (SAMs): Anti-aircraft missiles fired from the ground.
Triple A: See anti-aircraft artillery.

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