NATIONAL MISSILE DEFENCE: IT *IS* ROCKET SCIENCE

Robert P. Harrison

Writing on the US National Missile Defence initiative in our August issue, military analyst Scot Robertson of the Royal Military College suggested Canada had two choices — participation or irrelevance. Since Ottawa was not being asked to contribute to NMD development, only to support it, Ottawa's decision could determine whether NMD would be under the command of NORAD, in which Canada as the junior partner would at least have a say. That's the politics of NMD, also known as the Missile Defence Shield. But what about the science of it, asks Robert Harrison, a doctoral candidate in engineering. More precisely, it *is* rocket science, largely untested and unproven rocket science. The challenge is to hit a "small unpredictable warhead whizzing through the upper atmosphere at 10 times the speed of sound." Canada would certainly be in the path, if not in the way, of any incoming missile launched by terrorists or a rogue state. Leaving politics aside, Harrison writes, it's time for some answers on the feasibility of NMD.

À propos de l'initiative américaine de défense antimissile, l'analyste Scot Robertson, du Collège militaire royal, écrivait dans notre numéro d'août que le Canada avait le choix d'y participer ou de renoncer à toute influence. Les États-Unis ayant demandé à Ottawa de soutenir le projet sans contribuer à sa mise au point, la décision canadienne pourrait toutefois déterminer si ce projet passera sous le commandement de NORAD, au sein duquel le Canada a au moins son mot à dire en tant que partenaire junior. Voilà pour la dimension politique du « bouclier antimissiles ». Mais qu'en est-il de l'aspect scientifique de ce projet spatial, dont on est encore loin d'avoir démontré l'efficacité ? s'interroge Robert Harrison, candidat à un doctorat en génie. Car il s'agit ni plus ni moins d'intercepter sans préavis une petite ogive « filant dans la haute atmosphère à une vitesse dix fois supérieure à celle du son ». Or le Canada serait certainement dans la trajectoire, sinon dans la voie, de tout missile lancé par des terroristes ou un État voyou. Au-delà de l'enjeu politique, note l'auteur, il est temps d'obtenir des réponses claires sur la faisabilité scientifique de ce bouclier.

On March 24, 1989, I was in a smoky Montreal tavern with three friends discussing a news story that had made headlines around the world the previous day: Researchers Discover Cold Fusion. Two of these friends have degrees in Engineering Physics from Queen's University, the other a Ph.D. in Metallurgy from McGill. Over beer and pastrami sandwiches, we had a heated debate on the feasibility of this "discovery", moving salt and pepper shakers around to represent atoms, and scribbling on paper placemats. Within ninety minutes, we had reasoned that it was probably infeasible — the "Hitler Diaries of Science" in the words of one of the Queen's grads.

Four engineers and a pitcher of beer can reach a lot of correct answers, even without access to privileged information. Any new idea, theory or technology must fit into three hundred years' worth of accumulated scientific fact. Economists can be divided into various schools, like Keynesians and supply siders, but there is no such thing as a "Newtonian" or a "Pasteurian", because all scientists share a single objective view of the world.

Richard Feynman, the Nobel Prize-winning physicist who blew the whistle on the Space Shuttle Challenger's O-rings, used to say that "Science is a way of trying not to fool yourself." What happens when we apply this approach to National Missile Defence? Much of the debate surrounding

Canada's participation in the NMD program has centred upon political, social and military subjects, but the laws of physics appear to have been left at the coat-check.

This is not a case where the big picture is political, and science a mere detail or afterthought best left to the experts. Unfortunately, though, NMD is a confusing subject not only because of its inherent difficulties, but also because of the specialized vocabulary normally used by experts. Scientists use jargon, military personnel use acronyms. And everybody, for or against, applies spin.

Some have argued that NMD is a complete waste of human productivity, energy and endeavour. It cannot stop a terrorist from smuggling a nuclear or other bomb via land, air or sea into the US and detonating it in the middle of a metropolitan area. Others claim it is just a natural and logical extension of NORAD, and essential to Canada's very sovereignty. I am intentionally limiting this piece to the technological questions, and not the equally important political or social ones. For once, let's just stick to the science and see where it leads us.

Intercepting a ballistic missile is not child's play. American ingenuity solved many problems putting a man on the moon, which no doubt seemed insurmountable at the time. The moon, however, is a huge target whose motion can be calculated to within a fraction of a metre, years ahead of time. This is nothing compared to hitting a small, unpredictable warhead whizzing through the upper atmosphere at ten times the speed of sound, with only a few minutes' notice.

There are only two feasible stages of a ballistic missile's trajectory for intercept. The first is during lift-off, when it is moving slowly and predictably in a gradual arc. The second is as it re-enters the atmosphere at an altitude of around 40 to 80 kilometres, after it has shed any decoys and debris, but before the atmosphere is dense enough to make its path erratic. The rest of the time the missile is either too far above the Earth, or surrounded by ingenious radar-fooling decoys, or both.

Right off the bat, Canada would have a big problem with the lift-off option. The curvature of the earth would likely oblige the Americans to use space-based weapons, which goes against all our treaty obligations (and ethics). In any case, it seems rather far-fetched that anybody could build a powerful laser, get it into space, and provide it with enough energy. At best, this technology is totally unproven; at worst, it is a James Bond villain's fantasy. In any case, nuclear warheads are designed to withstand the intense heat of re-entry, so zapping them with a laser may not destroy them.

The second option is intercepting the missile during re-entry. This poses other problems for Canada, even if we do not participate in NMD. The United States is flanked east and west by wide-open ocean, but a missile aimed at America's third-largest city, Chicago, would probably re-enter the atmosphere over Canadian airspace. I have plotted some basic trajectories, and it seems that to hit Chicago from Libya, Iran, Iraq, Syria, China, North Korea, Russia, Afghanistan, Pakistan, India or the Sudan, a missile would have to pass over Canadian territory (you have to use a globe to see this; flat maps are always distorted).

This is not politics, it is simple geography, and the Americans know it already. Many of the animations on the official Pentagon Web site (www.acq.osd.mil/bmdo) show radar stations and interceptor missile sites located in a country that looks suspiciously like Canada, only with some of the coastline changed. As Robin Williams said, Canada is the greatest country north of the United States — and of course the only one.

The so-called "layered" defence would involve both techniques, i.e., attempted interception during both lift-off and re-entry. While intended to reassure the public, the layered defence is really an admission that neither technique is 100 percent effective. This means that a combination of the two cannot give 100 percent protection either, just better odds, like playing Russian roulette with fewer bullets.

Unlike targets in science fiction movies or video games, real objects do not simply "disappear" when they are intercepted. Some Russian-made nuclear warheads are reportedly rigged to detonate if struck by a foreign object, although some physicists doubt this is possible. Nevertheless, even without a detonation there could be radioactive (or chemical or biological) debris landing on our territory, hopefully in one fuming lump, but possibly in the form of dust scattered over thousands of square kilometres. Without wanting to sound too alarmist, in a worst-case scenario this could be the "Chernobyl" version of the Space Shuttle Columbia disaster — right over Canada.

Collateral damage aside, the intercept of a Chicago-bound missile would take place in the atmosphere over our territory, in other words in our sovereign airspace. Not being a lawyer, I have no idea what legal implications this has, but certainly from a political or diplomatic standpoint Canada would have something to say about it. Other countries will notice what we say and do, including our NATO allies.

Sometimes, the ideas coming out of the Pentagon seem to represent ideology stretched to its illogical limits. The "Terrorism Betting Plan", also known as the terror futures index, proposed in the summer of 2003 is a case in point. Another is the outrageously positive spin that has been put on the Patriot missile, despite Congressional hearings, independent analyses from MIT, and Israeli reports all pointing to its dismal performance in both Gulf Wars. If the Patriot missile is so reliable, then why are the Israelis spending a small fortune developing their own Arrow anti-missile defence system?

Most scientists have stated that they do not believe effective NMD to be feasible, including the entire editorial staff of *Scientific American* magazine in their June 2001 issue. As an engineer, I have many

questions about the current NMD design based strictly on information in the public domain: thin satellite coverage; even thinner ground-based radar coverage; unproven on-board cooling system for satellite remote sensing equipment; crude 2-D imaging system on the interceptor; limited manoeuvrability of the interceptor; short reaction times even if the attacking missile is fired all the way from China; endless communications and IT challenges. Note that I have packed all that into one sentence, as a courtesy to lay readers, even though it probably merits ten pages.

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Sgt. Schultz on *Hogan's Heroes* used to say that prisoners of the Third Reich are always given a fair trial before their executions. We laugh, because a trial is not supposed to have a foregone conclusion. Well, neither is research and development. Testing is done to *find out* if something is possible. It is not just a formality; it is the very cornerstone of the scientific method. I do not know if the fellow who said "the proof of the pudding is in the eating" was a scientist, but he got it dead right. Talk is cheap, techno-babble (and endless acronyms) even cheaper.

So far, field testing for NMD technology has been sparse to say the least. A few drones shot down over the ocean, one or two experimental satellites put into orbit — nothing even remotely resembling the final, complex web of split-second, supersonic sci-fi gizmos and gadgets that must work perfectly every time. This is odd, because the Pentagon is famous for insisting on "fly-before-you-buy." In this case, however, they seem prepared to spend vast sums based on blind faith in unproven technology. Of course, I may be wrong. Maybe the Pentagon has a cunning secret plan, such as asking Wile E. Coyote from *Looney Tunes* to order a missile defence system from the ACME Corporation.

When thinking about technological projects like NMD, it is well to remember that Mother Nature was around long before money was invented, and does not give a hang about economics. Despite all the money that has been spent on cancer research, for instance, no cure has been found; perhaps none ever will be. In science and technology, more money does not guarantee success. Whether you spend a hundred dollars looking for the Sasquatch or a billion, you might still never find one.

Even allowing for the moment that NMD could work, another obvious question is the severely limited number of interceptors that are planned, 20 in the first phase and 100 later on. A single ballistic missile can carry multiple warheads, as well as decoys. To be on the safe side, it would necessary to launch several interceptors at each individual target. This means that the entire initial complement of 20 could be easily spent on a single incoming missile. Not a very well-thought-out plan. What if there are *two* missiles, twenty minutes apart, 9/11 style?

Of course, like the doomsday machine in Dr. Strangelove, the mere spectre of NMD might be enough of a deterrent, whether the thing really works or not. Furthermore, research into seemingly abstract and futuristic weapons, like aircraft- or satellite-based lasers, can yield side benefits in computing and materials technology, which can be handed down to civilian life. After all, the Internet (through which some of you are reading this article) began as a Pentagon research project. And today's digital world, powered by the microchip, is largely the result of NASA's manned space program.

Because hitting such a small, fast and unpredictable object is so difficult, it looks like terrestrial radar will be required to guide each interceptor as it zeroes in on its target. This radar must be high definition, to give the kind of detailed image required for tracking each of the incoming warheads individually. Low-definition radar works over very long distances, even across oceans, but does not give a detailed enough image, and anyway there's that pesky curvature of the Earth again.

Unfortunately, high-definition radar requires a huge amount of power, and can only work over a short distance. At sea, this is no problem for the Americans, since they can deploy dozens of navy ships, enough for proper triangulation, i.e., two radar stations locking onto the same target. However, if the US wants to protect Chicago they will probably need some radar stations on Canadian soil, already in place and operating full-time at the moment the rogue missile is launched. If we say no, they may not be able to protect all 50 states as was promised.

Again, I have no access to any privileged information, so the above points are mere conjecture based on deduction. Nevertheless, deduction is what science is all about. The overall conclusion? Canada's participation in NMD should not be automatic. Nor should our refusal. Let's get some jargon-free, acronym-free, spin-free answers first.

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