Document Title: Strategic Implications of Advancing Science and Technology

Author(s): George Lindsey

Date(s): 3 May 1979

Document Type/Physical Description: Type-written, point form 18pgs

Fonds/Collection Name: George Lindsey Fonds

Series: Security Technology

File/Box Number: 3/1

Original Archival Reference: N/A

Item Description: This document consists of point form notes which Lindsey wrote and used for a presentation to the National Defence College in Kingston, Ontario. It examines some of the most important developments in the advancement of military-related science and technology, and the security implications of that development in the post-1945 era.

Keywords: nuclear weapons; ballistic and guided missiles; electronic warfare; space; lasers; aircraft; reconnaissance; submarines; surface ships; sonar; tank and anti-tank weaponry; exploitation of technical potential; peace and wartime mobilization; national military service

**When citing material that has been digitized from other archives, the LMH Archive encourages users to cite the original reference information provided in the above field.*

STRATEGIC IMPLICATIONS OF

ADVANCING SCIENCE AND TECHNOLOGY

by

G.R. LINDSEY

CHIEF

OPERATIONAL RESEARCH AND
ANALYSIS ESTABLISHMENT

FOR PRESENTATION AT NATIONAL DEFENCE COLLEGE

KINGSTON, ONTARIO

3 MAY, 79

STRATEGIC IMPLICATIONS OF ADVANCING SCIENCE AND TECHNOLOGY

MOST IMPORTANT DEVELOPMENTS SINCE 1945

- nuclear weapons
- long range ballistic missiles

Probably most important in next ten years: electronic warfare, precision guided missiles, space, and lasers.

What I intend to do this morning is to say a few words about important advances in nuclear weapons, aircraft, submarines, and surface ships. Then I shall go into a bit more detail regarding detection and surveillance, electronics, and lasers, and a lot more about the various kinds of missiles. I am leaving space to another speaker.

NUCLEAR WEAPONS

- no limit to yield (upper or lower)
- some control over proportion of energy release (as among heat and blast, prompt radiation, delayed radiation)
- have given strategic offence complete dominance over defence
    - active defence hardly possible
    - passive defence only to a degree
    - the only adequate reply is threat of retaliation, i.e., counter offence
    - TNW may favour defence, but this is by no means certain ERW, ADM would, battlefield range missiles might, interdiction weapons probably would
    - TNW could play part in controlled escalation

AIRCRAFT

- race for greater aerodynamic performance (speed, altitude, and range) virtually over
- value become as dependent on avionics and armament carried as on the vehicle itself

.../2

- value now depends on avionics and armament as much as aerodynamics. All sorts of equipment can be added on externally-mounted pods (with a consequent penalty in aerodynamic performance)
- some aircraft have been adapted for many roles

A3 Skywarrior built as the first shipborne strategic bomber

- RA3 reconnaissance
- EA3 ECM
- TA3 radar/nav. trainer
- KA3 tanker
- EKA3 ECM/tanker
- RB66 reconnaissance
- B66 bomber
- RB66 electronic warfare
- WB66 weather recce
- EB66 ELINT

F4 Phantom

- F4A carrier-based all-weather interceptor
- F4C land based TAC
- RF4 recce (with cameras, radar, IR)
- F4K, F4M RAF, RN, British engines
- F4D improved radar, inertial navigator
- F4E more power, an internal gun
- EF4 defence supremacy
- 5,000 built

MIG23/27 Flogger

- 23S Flogger B single seat all weather interceptor
- 23U Flogger C dual trainer & ECM
- 27 Flogger D low level attack ECM, rough field capability

- many one or two-engined ftr bbrs can carry far more ordance than a WWII four-engined heavy bomber
- Soviets seem to be changing force structure of their Frontal aviation

.../3

- fewer air defence interceptors
- more high performance ground attack
- more reliance on SAMs for air defence

- Hi-Lo mix F15 + F16
F14 + F18
- USAF have acquired the A10 for close support-built for survivability, 30^{mm} tank busting gun (2100 r.p.m.) a cart horse instead of a race horse
- CTOL, STOL, STOVL, V/STOL
- SAMs may drive attack a/c to very low altitude
counter is automatic guns on the ground, AWACS and look-down shoot-down fighters in the air

SUBMARINES

- great importance of quietness
- max depth
- to some extent like a/c, in that their sensors and weapons are beginning to matter more than the hydrodynamic performance of the vehicle itself
- may build underwater facilities for support

SURFACE SHIPS

- hydrodynamic performance is if anything deteriorating rather than improving
- because, even more than for a/c or s/m it is the senor and weapon suit which matters
- large CVA, even CVAN may be nearing end of its era
- vulnerability, cost, future probably depends on development of high performance VSTOL a/c
- smaller carriers, thru-deck cruisers, helo carriers, sea control ships,.....)
- Soviet KIEV class have half ships devoted to air defence vice US solution of large escort force
- destroyers striving (but not succeeding) to have good ASW and good AAW in one small hull

.../4

- small fast craft may have great future (because of missile armament)
- sea skimmer, hydrofoil, small waterplane area twin hull
- large SEV for troop delivery? 200K over marsh and flat land

MARINE MINES

- great ingenuity, CAPTOR, significance for a/s barriers
- ability to identify ship types?
- propelled ascent
- helos for laying and for MCM

DETECTION AND SURVEILLANCE

- Radar - can detect almost anything above local horizon
  - OTH can detect large moving objects beyond the horizon
  - limitation is set by unwanted background signals (competing with wanted signal from target): small target stands out in empty space
- Phased Array Radar - hard, agile, high data rate
- Synthetic Aperture Radar
- AMTI - look-down capability vs low flying a/c
  - SLAR
  - recce a/c, recce satellites
- SONAR -impressive progress in passive sonar, fixed, towed
  - sonobuoys, acoustic processing
  - hull mounted active sonar may have approached its natural limit
- Photography - IR, esp., satellite-borne
  - combination of signals from different sensors to allow "signature analysis"

ELECTRONICS AND COMPUTERS

- an integral part of many of the things being discussed

.../5

(data processing, missile guidance, displays, communication)
- subject to self-generated interference, probably very vulnerable to the electromagnetic pulse radiated by a high-altitude nuclear burst

- Electronic Warfare
    - vulnerability of/dependence on proper functioning of electronics
    - guidance, communication, navigation...
    - includes passive surveillance and interception of energy transmissions, ECM, ECCM...
    - decoys, jammers, chaff, deception
    - special aircraft being configured for electronic support EF-IIIA, EA-6B, 4 place, 4 pods
    - every attack a/c will have to be provided with self-protection
    - very fast moving - quick reaction vital, computer control, SURPRISE

LASERS

- ability to concentrate radiant energy on a distance target without a huge mirror (coherent radiation of short wavelength)
- no fundamental limit to attainable range
- but (to date) difficult to generate high power; chemical as well as electrical methods
- energy absorbed by clouds, mist, rain, dust, etc.
- successful military applications
    - instrument to direct high explosive weapon
    - range finder, target marker
- energy density sufficient to damage human eyesight, can burn unprotected flesh
- fairly soon - damage to thin-skinned targets such as aircraft
    - US have destroyed a TOW ATGM in flight with a laser beam
    - probably not enough energy density to destroy tanks

- ground to space, atmosphere penetration, accurate pointing
    - probably powerful enough to damage a satellite's eqpt
    - probably not powerful enough to damage reentry body heat shield
- space to ground, limitation to size and weight
- space to space, anti-satellite weapons, a real possibility, USSR may have now

SPACE

- wild enthusiasms of early 1960s not realized for military applications
- bombs in orbit, fight for occupation of the moon, fighter planes in space, transport by suborbital rockets, satellite-borne BMD systems
- BUT - recce satellites, photo, ELINT, COMINT, radar
    - communication satellites, telephone, radio, TV, relay, many military
    - meteorological satellites
    - navigation satellites, TRANSIT/SINS
    - geodetic satellites
    - exploration of moon, planets, extraterrestrial space
- for strategic deterrence, very important are missile warning satellites
- great dependence on communication satellites and intelligence gathering on slower time scale
- soon will be able to perform surveillance on ships, later on aircraft, using active radar and passive IR
- GEODS Ground Based Electro-Optical, Deep space Surveillance
- satellites are very vulnerable, sensitive instruments, visible orbits, GPS (NAVSTAR) for navigation (and detection of nuclear explosion)
- 1967 outer space treaty bans placing of weapons of mass destruction in outer space or on celestial bodies (therefore, they don't intend to!)

- SALT I (1972) prohibits interference with national technical means of verification

- BUT - rapidly increasing dependence of western military systems on satellite-based equipment (largely for support and routine operations)
    - plus extreme vulnerability
    - plus evidence that USSR is developing capability to intercept and destroy satellites

MISSILES

Intercontinental Missiles

- ICBM, improving accuracies, MIRV
- a counterforce hard-target capability? SS-18, SS-19 vs Minuteman, 2 Soviet RV per MM will only take less than half their warheads
- MARV (in case of active defence)
- mobility; multiple protective structures, or air portable
- BMD depended on nuclear warhead
- (soft X-rays for exo-atmospheric kill neutrons for endo-atmospheric)
- was developed in USA as area defence
- better possibilities of hard-site defence
- deployment (but not R&D) forbidden by ABM Treaty of 1972
- non-nuclear interceptor (exoatmospheric) with terminal homing?

Theatre Ballistic Missiles

- SS20
- Pershing will have terminal guidance

Cruise Missiles

- VI, and counter measures
- US - Snark, Navaho, Regulus, Mace, Matador in 1950's

.../8

- in 1960's USSR; Shaddock, Sark, Styx on surface ships and s/m
- Kennel, Kipper, Kitchen ASM
- Exocet, Otomat, Gabriel, Sea Killer, Harpoon
- now greatly improved guidance systems (inertial, GPS, TERCOM)
- much more efficient propulsion system (turbofan)
- cruise missile can now fly at very low altitude, using evasive routing
- can be made into long range strategic weapon
- land based GLCM, air launched ALCM, ship or a/m launched SLCM
- US Tomahawk
    - strategic version 1500-2000 nm range
    - nuclear or conventional warhead
    - subsonic
    - inertial guidance and radiometric terrain methodology
    - wings fold - can be launched from torpedo tube
- B52 can carry 20 ALCMs of 750 mi range
    - a wide-bodied aircraft could probably carry up to 60
    - a Tornado could probably carry two
- CM potentially more accurate than ICBM or SLBM
    - may fly too fast and be too small for air defences
    - cheaper than long range BM
- GLCM can be made mobile, and is easily concealed (e.g. in woods)
- cruise missile of fairly long range could become available to many countries

ANTI-TANK G.M.s

- newer models belong to family of PGMs "one-shot-one-kill"
- several successful types wire guided
- 1st generation - operator steers missile into tgt
- 2nd generation - operator follows target; missile homes on it
- 3rd generation - operator acquires target, missile homes on it (launch and leave - fire and forget)
- ATGM can be on ground, in vehicle, on helicopter
- kill mechanism usually a shaped charge
    - can hole thick armour even if hits at low velocity

.../9

- other mechanisms to defeat tank armours include
    - kinetic energy i.e., fast heavy long solid round gun-fired AP APDS squash head
- gun can be rifled (spin-stabilized round has least drag, can't be very long) or smooth bore (fin-stabilized round can have high l/d, but greater drag and dispersion)
- ~~gun~~ ATGW better ATK weapons than gun at long range (no need to "aim off" for target motion, or estimate range)
- 1973 success of Soviet-made ATGMs used by Egyptians vs unsupported Israeli tank attacks during the first three days
- BUT ATGMs are vulnerable to artillery, infantry, and air attack and they depend on clear visibility (less available in Europe than the Middle East, and easily prevented by use of smoke)
- AND tanks will be employing armour specially designed vs shaped charge attacks (composite spaced armour)
- other types of guidance for ATGM include laser designation
    - observer, who could be on ground, in a vehicle, helo, of fwd a/c, designates tgt by pointing it out with a laser beam
    - ATGW, which could be a rocket fired from ground, vehicle, helo, or fwd a/c, homes on the laser spot
    - alternatively, missile could be fired from a gun, using indirect fire, and then home on tgt by aero-dynamic steering as it descends (Copperhead)
- Unlikely that radar will be useful homing means
- Ideally, ATGM launcher should be mobile and armoured
    - soon becomes another tank!
- Conclusion is NOT that tank has ceased to be a key weapon of the land battle, BUT that tanks must be employed as part of a combined arms team, and need to limit their exposure at long range, by appropriate selection of ground, approach routes, weather, smoke

.../10

SURFACE-TO-AIR MISSILES

- as with ATK weapons, a gun is a very good AA weapon at very short range
- but because of the rapid (and unpredictable) movement of the tgt, the probability of hitting an a/c at medium or long range with an unguided projectile is very low
- SAM have the very great advantage that their target is silhouetted against the empty sky, by its visibility, its radar echo, and its heat emission
- SAM can fly a collision course or a pursuit course, or follow commands
- system can be fully active, semi-active, or passive
- links between missile and control can be optical, infrared, radar, radio, or telemetry by wire

- In Vietnam, the Russian-built SA2 was overcome by defence suppression, at a considerable expense in sorties
- electronic jamming, chaff, evasive manoeuvre, underflying, direct attack, anti-radiation missiles
- counter measures included guns for low altitude, mobility, camouflage, emission control, optical tracking

- Arab/Israel 1973 Egyptian SAM and AAA and surprise ground attack requiring support of IAF for army
    - IAF obliged to mount campaign vs SAMs
    - IAF could out-manouevre the SA6. ECM more difficult than vs SA2
    - 90% IAF losses were due to ground-based missiles and guns
- Soviets have SA8 and SAX10
- Manoeuvre capability has a "threshold"; either it works almost never or almost always
- ultimately SAM should be able to stand more acceleration than aircrew

- small man-portable heat-seeking SAMs are in several armies
  - SA-7 Strela
    Blowpipe, Redeye, Stinger
  - esp. effective vs. helicopters
- guns with high rate of fire, esp. radar controlled, can be very effective vs. low-flying a/c, optical override
- conclude that, as for tanks, a/c can no longer expect to operate freely over a battlefield armed with SAMS and AA guns, unless strong measures are taken to suppress the defences

AIR-TO-AIR MISSILES

- problem of ground clutter, IR reflections - Soviets like 1/2 semi-active radar, 1/2 IR seeker
- AIM-54 Phoenix on F-14, multiple engagements at long range
AIM-7 Sparrow, beyond usual range (problem of identification)
AIM-9 Sidewinder, short-range, heat-seeking
-"fire and soon forget" missiles to permit engagement of multiple targets

AIR-TO-SURFACE MISSILES

- began with German guided glide bombs
- now include long-range nuclear-armed ASMs with inertial guidance; and ALCM with terrain comparison guidance
- reduce vulnerability of bomber aircraft
- may be used to open path through defences
- most ASM are much smaller and more difficult tgts than a/c
- can be optically guided (TV)
- can home on radiation
- "smart bomb" homes on laser designation aimed by same a/c, other a/c, ground
- possibility of countermeasures
- depend on good visibility

.../12

ANTI-SHIP MISSILES

- torpedo is a type of antiship missile, and modern versions are all guided, most are homing
- Kamikaze aircraft 1945
- most important are ASMs
    - target on sea much more clearly distinguishable than on land - radar, heat, visibility
    - ship cannot hide, has very little capability for evasive maneouvre
- very similar are antiship missiles launched by surface ships or submarines
    - can be mounted on small fast patrol boats
      Soviet, Styx, Israeli Gabriel, French Exocet
- sea skimmers hard to detect or intercept, high altitude versions dive steep and fast
- line of sight/intermediate guidance/worldwide satellite surveillance of sea surface
- small craft can sink a large one
- submarines can launch submerged, at a range far beyond torpedo range
- ship defence - ECM, decoys
    - high rate of fire AA-type guns, merging of anti-air and anti-missile defence
    - rapid-acting anti-missile missile
      threat of simultaneous attack is hard to counter
      (Seawolf intercepted a 5^{mm} shell in flight)
- conclude that even more than for tanks, or a/c, surface ships are at very serious risk from PGM, with only limited chances of countermeasures

CONCLUSIONS RE PGMS

- extreme vulnerability of a few high-value targets
- increased importance of dispersion and concealment

.../13

- less collateral damage than heavy barrages of HE or unguided bombs
- AA defence now much more effective on land
- at sea - vulnerability of ships increased, to a/c, s/m, surface ships (incl small vessel)
  - coastal defence strengthened greatly
  - amphibious assault correspondingly more difficult
- loser may be he who runs out of ammunition first

THE EXPLOITATION OF TECHNICAL POTENTIAL

There were periods in the past (World War II, and the height of the Cold War in the 1950's) when certain weapon systems such as aircraft and radars went through successive stages of replacement by improved models in short succession. It was almost automatic that today's model would be succeeded by a more advanced model tomorrow, and that of technological improvement it could be said, "If it can be done, it will be done", at least for the major powers.

This is not the case today. New systems are becoming very much more costly, are taking longer to put into service, and are being kept in service much longer. It would be close to the truth to say that the engineers can design a system to achieve any specified technical performance criteria, representing a quantitative improvement to achievements already demonstrated, as long as there is no economic limitation. The main questions that must be answered before a proposed system is approved for production are now:

- "Does it fulfill an important strategic need?"
  and
- "Is it worth the cost in resources that could be used otherwise?"
  rather than
- "Is it technically possible?"

.../14

The answers to questions such as:

- "Can an aircraft be built to attain speed x at range y?"

is almost certainly yes.

There are important exceptions, however. It is meaningful to ask such questions as:

"Can MIRV be made accurate enough to make one missile a threat to several silos?" (Probably yes)

"Can an ABM system be built which can match missile offence in cost-effectiveness?" (Probably no)

"Can light anti-aircraft weapons effectively neutralize low-flying aircraft?" (Probably yes)

"Can cruise missiles penetrate modern air defences?" (Probably yes)

"Can anti-submarine defence effectively neutralize the missile-firing submarine?" (Probably no)

"Can antiship missiles effectively drive the large surface ship off the sea?" (Probably yes)

Is the answers to questions such as these which represent the great unknowns, the keys to future upheavals in military tactics and strategy.

.../15

MOBILIZATION FOR ACTIVE DUTY

Exception of Short War/No War

- destructive power of strategic nuclear weapons
    - good hope for success of deterring war
    - if deterrence fails, except rapid destruction to bring war to quick end
- air forces tend to plan for short wars
- navies tend to plan for long wars
- governments tend to plan for no wars
- navies and air forces depend on ships and aircraft, which take a considerable time to produce (unless they are held in a reserve - which is not the use in Canada). "The navy mans the equipment, the army equips the man".
- Canada does have NATO roles in land, sea, air
- Dependence on Forces in Being

Canada - regular force of long service professionals
small reserve
no conscription
defence procurement abroad
mobilization, initially a callout of the (small) reserve

Other Countries - refer to list

Possibility of a long crisis - a confrontation in which preparation and determination could play a crucial part

Some fear that mobilization could be seen as a provocative act

- some similarity to the attitude towards civil defence

CD---EMO---EPC

Severe dangers of this philosophy

.../16

Mobilization of Science in Time of War

- WW II in Canada
    - the pocketbook was ignored - an exhilarating experience!
    - very small base on which to draw (NRC & universities)
    - aided by UK, later US
    - much dependent on private initiative
    - took several years to bear any fruit
- somewhat more central direction in UK, US (drawing on a wider base)
- Wartime Bureau of Technical Personnel
- Postwar Canada
    - in a strong position for two decades
    - DRB a force-in-being for defence science made considerable effort to maintain an unofficial "reserve" (universities, industry) the Board
    - NRC gradually phased out defence research
- Arrow, hydrofoil, Velvet Glove....
    - severe - perhaps fatal - blow to Canadian initiative
- Present
    - defence science (and all other) much weaker
    - industry weak in terms of resident skill in R, D, design
    - DRB abolished, influence role contacts
    - As Gen Bell has already said, we do not have a national strategy, even a national plan
- Future mobilization of defence science
    - In OR - would be able to contact many former ORAE and active OR professionals in government, industry, universities
    - Other Science - probably much the same for research
        - could be worse for development, production, engineering

.../17

NATIONAL MILITARY SERVICE

VOLUNTARY	USA, UK, Canada, Australia, India, Japan, Malaysia, New Zealand, Pakistan
7 1/2 mo	Sweden
8 mo	Belgium
9 mo	Denmark
12 mo	France, Italy, Norway
14 mo	Netherlands
15 mo	FGR, Portugal, Spain, Yugo
16 mo	Romania
18 mo	GDR
20 mo	Turkey
24 mo	USSR, Bulgaria, Czecho, Hungary, Poland, Greece (Iran), Iraq, So. Africa, Vietnam, Taiwan, PRC
30 mo	So. Korea
36 mo	Egypt, Israel
60 mo	No. Korea

In some countries, military service may have importance for education, national development, as well as security.