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Perimeter Defence and the Evolving Threat to North America

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Abstract

For the past two and a half centuries, C4ISR and precision strike technology have provided the principle means to ensure the continental security of North America. Over time, these methods have changed, and various revolutions in military affairs have impacted the efficacy of the technological means in use. More often than not, supremacy in C4ISR and precision strike technologies have spawned a counter-revolution in technology which has redefined continental defense requirements. The latest Revolution in Military Affairs, and its prospects for near term evolution, would appear to be on track to deliver an unparalleled level of security to the continent and its approaches. However, if the history of sea power and air power in defence of the continent are reliable indicators, the seeds of technical counter-revolution have already been planted. Maintaining a constant watch toward technical trends has been, and will remain an integral process to ensuring the future security of the continent.

Perimeter Defence and Technical Revolution

> "Those far-distant storm beaten ships, on which Napoleon's soldiers never looked, stood between them and the Dominion of the World.[1]"
>
> -Alfred Thayer Mahan

In September of 1762 a force of some 800 British and American troops landed at Torbay, on the island of Newfoundland. Their purpose was to dislodge a French occupation force lodged at St John's, and in so doing consolidate a British victory against the remaining French presence in North America. The ensuing Battle of Signal Hill was the final battle of the Seven Years war in North America, the last conflict in which the North American continent was successfully invaded and conquered by the land forces of an Eurasian power.

Military threats to North America over the centuries since Signal Hill have remained, and evolved. Incursions by the French fleet during the Napoleonic wars, British blockades and raids during the war of 1812, German submarine efforts off the Atlantic coast and the Japanese invasion of the Aleutians in World War Two have all threatened the continental defensive perimeter. The Cold War defined new threats to the continent in the form of Soviet long range atomic bombers and intercontinental ballistic missiles. Terrorists covertly breached the perimeter to achieve the impressive material and psychological effects of 9-11. However, since the battle of Signal Hill, the task of securing the North American continent from direct military threats has remained primarily an issue of securing the continent's sea, air and space approaches, rather than

[1] John Van Duyn Southworth, *War at Sea: The Age of Sails*. (New York: Twayne

defending the continent's beaches against incursion by a foreign continental army.

This perception of relative security "on the beaches" has been reflected over time in the continent's defence policies. Policy for the defence of North America has traditionally evolved in tandem with the threat to the continent's approaches, and interests. Early American concerns over British blockade and bombardment from the sea resulted in the United States developing its own sea control force. The advent of air power, space power, and atomic weaponry evolved new doctrines of flexible nuclear deterrence to achieve the desired perimeter security. In order to achieve a further measure of defense in depth, North American defensive policy efforts have further emphasized expeditionary operations abroad. By way of example, Canadian expeditionary forces have left the continent to contest the Boer war, two World Wars, the Korean War, the Gulf War, the Kosovo conflict and, most recently, the war in Afghanistan. This focus on defeating security threats to the continent overseas has dominated North American defense policies over the past century. These policies have been largely successful, with North Americans being more at risk today from a global economic downturn or recession than a direct military threat.

However, this expeditionary approach to defence policy has always been contingent upon the security and control of the extensive sea and aerospace approaches to the North American continent. Since the war of 1812, a state of relative security from invasion has existed along the continent's long perimeter, which has enabled both expeditionary defence policies and expeditionary operations as the principle methodology of North American defence. Technology has traditionally provided the means to obtain, and maintain this requisite defensive barrier. In particular, it has been the evolution, and

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Publishers, 1968), 338.

revolution, in command, control, communication, computer, information, surveillance, reconnaissance (C4ISR) and precision strike technology that has played the pivotal role in countering military threats to the North American perimeter. Perhaps more interestingly, it has also traditionally been evolution in C4ISR and precision strike technologies which have driven the development of future military threats to the continent.

With this trend in mind, clear potential exists for the current Revolution in Military Affairs (RMA), typified by the evolution of global precision strike, to impact continental security. This next "military-technical revolution" was foreseen as early as the 1970's by the Soviets, who thought advances in microelectronics, sensors, precision-guidance, automated control systems, and directed energy would change the fundamental nature of warfare[2]. Although the "shock and awe" of recent expeditionary campaigns has proven the foresight of these Soviet planners, the current RMA has also impacted the means and ways in which defence of the North American continent is, and will be, conducted. In so doing, it has also set the conditions for the evolution of future military threats to the continent. To understand this evolution, and its potential impact on defence of the continent, it is useful to analyze how historic "revolutions" in military affairs have affected the defense of North America, and other continental perimeters. The demise of these past RMAs hold lessons as to the future of the current RMA, the future evolution of C4ISR and precision strike, and the future of continental defence for North America.

<u>Sea Power and Perimeter Defence</u>

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[2] Theodor W. Galdi, *Revolution in Military Affairs?: Competing Concepts, Organizational Responses, Outstanding Issues,* CRS Report for Congress, (Washington:

> "What is the use of battleships as we have hitherto known them? None! Their one and only function - that of ultimate security of defense - is gone - lost!"[3]
>
> John Arbuthnot Fisher, First Sea Lord - 1905

At the close of the Seven Years War, continental defence was typified by the use of standing fortifications and garrisons to protect key points against assault from the sea. The vast expanse of the ocean meant that an enemy could arrive unannounced at any time upon ones own shores. Successfully repelling an attack meant ensuring that a garrison was amply supplied until reinforcements could arrive from the home country, and that naval forces stood ready at key ports to intercept an enemy. The interdiction of enemy reinforcements, and supplies to the defending garrisons, required exercising sea control at the point of departure, or point of arrival. The principal method of achieving this was the close blockade, where a squadron or more of ships kept constant vigil outside an enemy port, preventing any enemy ships from leaving or entering. By way of example, in their conquest of North America, British projection of force from the sea was accompanied by an equally successful sea control and blockade campaign in ensuring the successive captures of Louisburg, Quebec and Montreal and the re-taking of St.John's. In fact, it was the efforts of Admiral Edward Hawke in resupplying his squadrons at sea while blockading Brest which prevented the French reinforcement of Canada, and secured Wolfe's victory at Quebec.[4]

Effective sea control in support of homeland defence in the eighteenth century

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Foreign Affairs and National Defense Division, December 11, 1995).

3 Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 482*.

4 Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 287*.

required a sound application of command, control, communication, information, surveillance and reconnaissance principles in order to bring strike forces to bear. Over a period of several hundred years, the Royal Navy had evolved this capacity for command and control, and achieved a degree of proficiency well ahead of their closest rivals. For the British, their status as an island nation meant that control of the sea and homeland defence was a matter of national survival. Mistakes could be costly. In the age of sail, communication means were limited to the messages that packet ships could carry between distant garrisons and fleets, and the passing of flag hoist messages between ships or signal towers spaced at distant intervals. Using these methods, information flow was slow, and the area of surveillance was limited. A message sent to India by way of the Cape of Good Hope could not expect a reply for some nine months.[5]

By modern standards, surveillance at sea in support of homeland defence was impressive for the level of technology involved. A frigate at sea commanded a field of view in good weather some thirty miles across, and could pass visual signals to other frigates at the edge of visual range. Although this surveillance was adequate for a close blockade of an enemy port, it limited the effectiveness of surveillance efforts in the open ocean. Frigates also provided routine and urgent communication between fleets at sea and the Admiralty. Once the frigate arrived in port, the message was relayed over land by the fastest available means. A semaphore telegraph provided the Lords of the Admiralty the necessary final connecting link between the harbour at Portsmouth and London.[6] Ports not connected by semaphore utilized dispatch riders and stages to deliver messages

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5 Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 3.

6 Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 3.

within a day. Information used by the Admiralty and its commanders was further not limited to information gathered by warships at sea. Heavy use was also made of intelligence that could be gathered by agents in ports, spies in foreign capitals and from passing ships by both the Admiralty and at-sea commanders.

This command and control system was complex, often unreliable, but necessary. In order to achieve success at sea with the limited striking resources available, reliable surveillance information was key. The striking force of the day consisted of the line of battle - wooden sailing ships sailed in close order with batteries of 74-100 short range cannon. To bring such a fleet to bear upon the enemy required a certain measure of luck, good seamanship, favorable winds and, above all, reliable information on the enemy's location and intentions. The pursuit of the French fleet by Admiral Nelson in the summer of 1805 prior to the battle of Trafalgar provides a useful case study in the difficulties of C3ISR, perimeter defence and sea control in the early nineteenth century.

In 1805 Napoleon, long frustrated in his invasion plans for England, hatched a plan to overcome the sea control efforts of the British Fleet. The British had succeeded in denying the French free use of the seas through a system of close blockade on French and Spanish ports, which forced the French and their Spanish allies to confront a superior force upon attempting to put to sea, or tracked them to allow a superior striking force to be concentrated against them. These tactics curtailed the ability of the French Army to embark in transports and be escorted safely across the channel to invade England. Napoleon's plan, entrusted for execution to his principal Admiral Villeneuve, attempted to circumvent this problem by having the French and Spanish fleets use favorable weather conditions to escape port and subsequently reform the fleet in the Caribbean on the far side of the Atlantic. The combined fleet of French and Spanish warships would then return unexpectedly to France, embark the French Army before the scattered British Fleet could react, and within a day sail across the English Channel to invade England.

The French plan capitalized on the weaknesses of the slow C3I process, limited surveillance capacity and slow speed of transit for the British battle fleet. Upon execution, it also nearly succeeded. In support of the British blockade effort, Admiral Horatio Nelson had set up a distant blockade on the port of Toulon. Unlike the close blockades maintained by his counterparts, a single frigate always kept watch upon the port, and relayed sightings by flag signal via a line of five other frigates to Nelson's main body some 150 miles away. By keeping his main body at a distance from the French port, Nelson hoped to lure the French out to sea where they could be destroyed. The key to success in Nelson's plan was the ability to send detailed information over long distances by flag signal. Over the previous fifteen years, the British had methodically evolved their standard system of flag signals. Improvements by Lord Howe in 1790 and subsequent refinement by the Admiralty had evolved the flag signal system into a highly refined tactical system which could send over 340 messages.[7] Further evolution of the system of signals by Admiral Home Popham in the months prior to the Battle of Trafalgar had created a system which could report a myriad of enemy movements, and forward tactical direction from a commander, with minimal flag signals. The result was a minor revolution in military affairs, which resulted in the British possessing in the period just to Trafalgar the most advanced command, control and communication system yet put to sea.

However, like all C3 systems, the flag signals required proper assessment of the

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7 Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 374*.

information. On March 29th, 1805 Admiral Villeneuve took advantage of prevailing winds to depart Toulon with his fleet. Two British frigates spotted the French sortie, and relayed the information to Nelson on his distant blockade. Making the bold assumption that the French were enroute to a target in the Mediterranean, Nelson directed his fleet to head east to intercept. No signs of the French were forthcoming, and for several weeks British agents ashore and ships passing at sea were worked for information as to the French intentions. Finally, on April 16th word was received that the French fleet had been sighted off the south of Spain. Nelson was horrified: "If this account is true, much mischief may be apprehended. It kills me, the very thought."[8] The limitations of C3ISR at sea in the early 19th century, and the timeless problems of command assessment, had combined to place the defence of the British homeland in peril.

Fortunately, British depth in C3ISR and strike technology was sufficient to mitigate Nelson's error in judgment. News of the French sailing from Toulon had reached London from spies in Paris at about the same time as they were received by Nelson, and this news was confirmed by a dispatch from Nelson received in London on June 3rd - two months after Villeveuve had left Toulon for Cadiz. With no certain idea as to the destination of the French, The First Lord of the Admiralty, Lord Barham, had no choice but to use his finite resources to station a curtain of warships for surveillance and reconnaissance across the entire western approaches to the English Channel, while maintaining a close blockade of the remaining French and Spanish ports[9]. Enemy contact reports from the screen could then be used to concentrate the British line of Battle at a time and place of their choosing. That this feat could be achieved was due only to the

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[8] Adam Nicolson, *Seize the Fire* (New York: HarperCollins Publishers, 2005), 78.
[9] Adam Nicolson, *Seize the Fire* (New York: HarperCollins Publishers, 2005), 79.

Royal Navy's full state of mobilization against a cross channel invasion. As such, it reflected the upper limit of what could be achieved by the C3ISR technology of 1805 against an enemy approaching from the vast expanses to seaward.

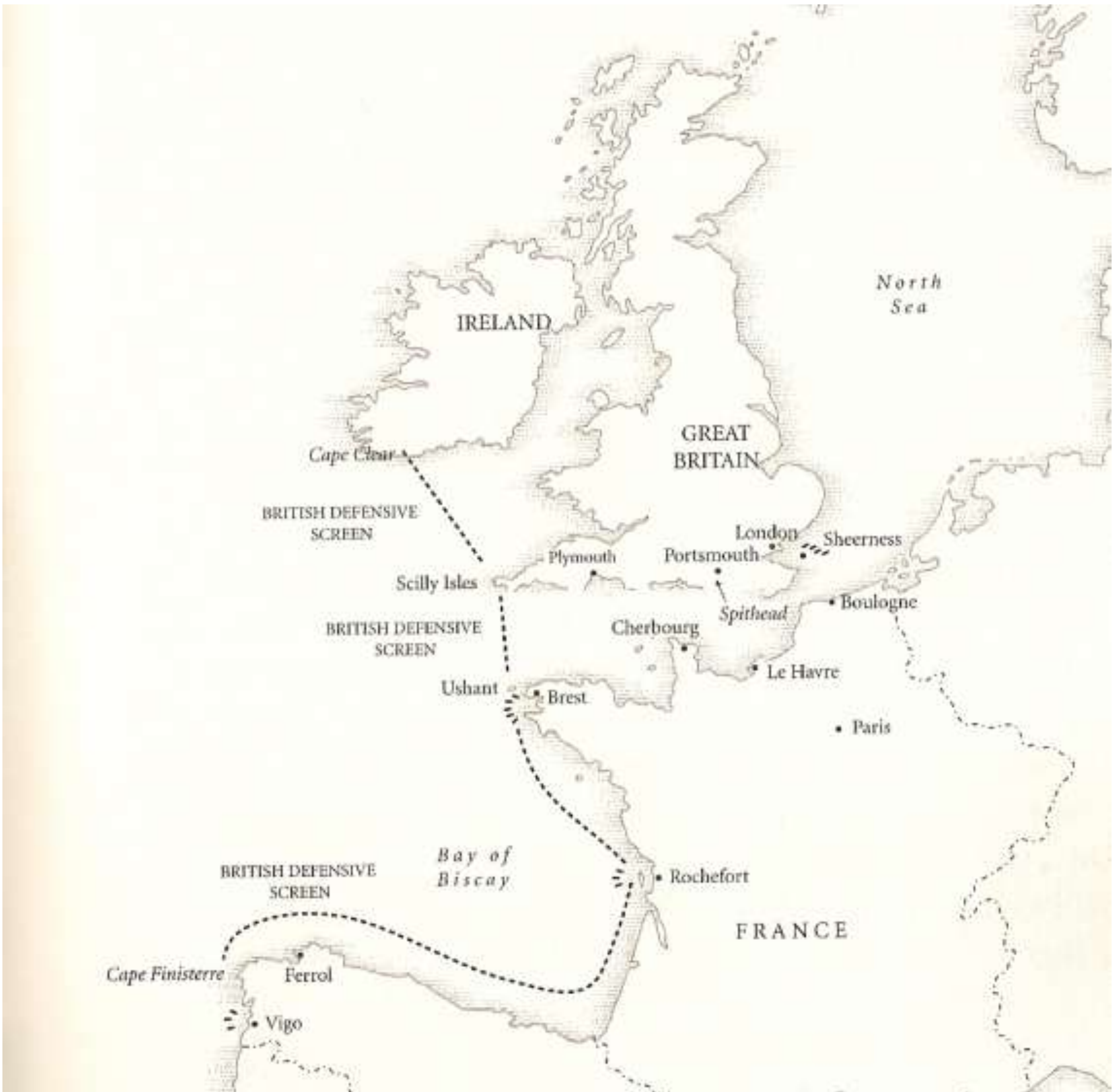

Figure 1.1 The British Defensive Screen[10]

Fortunately for Barham, the capability and mobility of British seaborne strike forces gave him further options. Although the position of the enemy at sea at a given time was unknown, intelligence and shrewd assessment could be used to ascertain probable enemy operating areas and allow a concentrated striking force to hunt them down. The British enjoyed two advantages in this respect. To begin, a British battle fleet with its accompanying frigates and flag signal enabled C3ISR structure could engage in surveillance over a frontage of some 400 miles in conditions of good visibility. Furthermore, a revolution in warship design had greatly increased the capability of the British strike force over the French. In 1762 a method was found to bolt sheets of copper to a ship's hull using lead capped iron bolts. This technique greatly extended the life of a ship by protecting its hull from a variety of threats such as the teredos shipworm. More importantly, however, this treatment rendered the ship invulnerable to fouling by crustaceans and seaweed - which gave the vessels of the time a greater measure of speed and lightness of handling. A new design of carronade and a flintlock firing system for the main guns further gave the British a two to one gunnery advantage over their closest rival[11]. The British had used these tactical advantages to good effect in 1782, when Admiral Rodney had defeated a French fleet and secured the future of the British presence in North America at the Battle of the Saintes.

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[10] Adam Nicolson, *Seize the Fire* (New York: HarperCollins Publishers, 2005), 84.

[11] Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 314-317*.

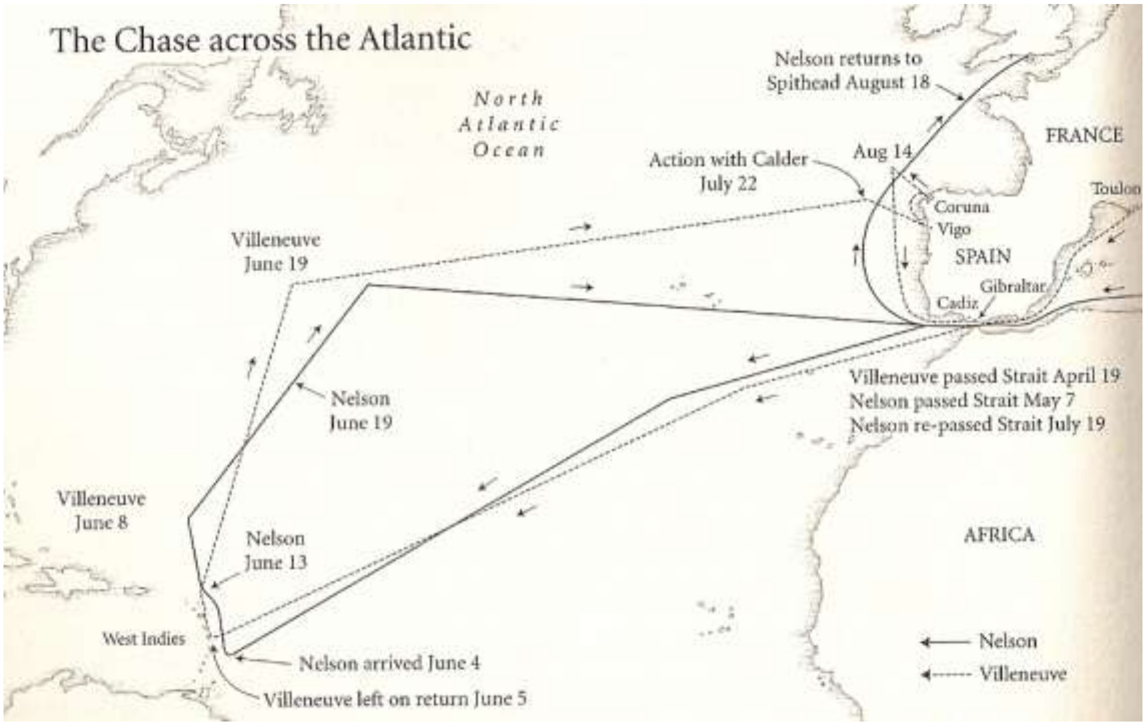

Figure 1.2 Nelson's pursuit of Villeneuve[12]

By 1805 the entire British Fleet had been converted to copper bottoms, and Nelson was aggressively using his advantages in area surveillance, speed and superior gunnery to bring his striking force to bear against Villeneuve in the Caribbean. Departing Gibraltar a month after the combined French and Spanish Fleet, the British were able to gain two full weeks in transit. Word of Nelson's arrival in the Caribbean, and a knowledge of the capabilities of the British fleet against his own prompted Villeneuve's early departure. After an eight day search, Nelson concluded Villeneuve had departed and dispatched the fast brig CURIEUX to report this assessment and his own intentions to continue the intercept to the Admiralty. Remarkably, the CURIEUX encountered Villeneuve's fleet during it's return transit, thus confirming Nelson's assessment. Racing ahead, the CURIEUX was able to warn the Admiralty of the fleet's approach by July 9th.

First Lord Barham did not hesitate, breaking off the blockades on the ports of Brest, Ferrol and Rochefort to bring his remaining strike forces to bear against the returning French and Spanish fleet[13]. This triumph of British C3ISR at sea reached culmination at the Battle of Cape Finisterre on July 22nd, but the results were inconclusive. The combined French and Spanish fleets were able to reach Coruna in Spain with minimal losses.

The months of constant C3ISR directed efforts by the Royal Navy had, however, achieved its aim. Although Napoleon waited patiently at Boulogne for transport with the largest invasion army in history, the constant harrying of the combined French and Spanish fleet by powerful striking forces had undermined the nerve of its commanders. Villeneuve departed Coruna on August 11th, but turned south toward Cadiz after two days - reaching it on 22 August. The British squadron blockading Cadiz under Collingwood moved aside to allow the ships to enter, then duly dispatched word to the Admiralty. The news reached Portsmouth and the recently arrived Nelson on September 12th, and by September 28th Nelson had arrived off Cadiz in the *Victory* to head a striking force of 27 ships of the line. A distant blockade was set, and on the 19th of October the frigate *Sirius* hoisted a 26 flag signal indicating "Enemy have their topsails hoisted".[14] The signal was duly relayed in turn to the frigates *Euryalus*, *Phoebe*, *Mars* and thence to the battleship *Bellerophon* some 48 miles away. Nelson was appraised on the *Victory,* and promptly signaled "General chase - southeast" to the fleet.[15] Two days later the combined French

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12 Adam Nicolson, *Seize the Fire* (New York: HarperCollins Publishers, 2005), 83.

13 Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 380*.

14 Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 345*.

15 Ibid.

and Spanish fleet was overhauled and annihilated at the battle of Trafalgar, eliminating for over a century any direct continental threat to the Britain, and its possessions abroad. Numerically superior fleets and armies had been defeated at the perimeter homeland by intelligent application of available technology. The disciplined application of C3ISR and strike forces as the primary tool in achieving homeland defence had come of age.

The British Victory at sea during the Napoleonic wars indirectly established the conditions for security along the North American perimeter for well over the next century. The view of this security from the North American Continent was, however, largely bifurcated. Within British North America, defense of the perimeter by the Royal Navy's uncontested control of the seas guaranteed an absolute security against an American invasion. The United States, in contrast, viewed the possibility of blockade and bombardment of its coastal cities by the British fleet as the single greatest threat to its economic survival. The war of 1812 and particularly the successful British raid on Washington in 1814 lingered long in the memories of U.S. statesmen, whose interpretation of manifest destiny did not include the risks inherent in an occupation of Canada. Although relatively prosperous, the insurmountable lead of the Royal Navy in sheer numbers of striking vessels and C3ISR technology of the time meant that the British fleet would remain a threat along the American perimeter, and a measure for security to Canada, for the first half of the 19th century. Although the U.S. Navy was a credible force for sea denial of American ports, and the protection of limited American commercial interests abroad, it did not have the resources or means with existing technology to challenge British hegemony at sea. This did not forestall efforts by the United States to establish a more secure perimeter by diplomatic means. The Monroe

Doctrine of 1823 attempted to establish the Americas as an area free from European colonial excursions. However, this diplomatic act did not reflect the fact that incursions against the North American perimeter lay solidly within the whims of British sea control.

However, British control of the seas, within the scope of British interests, did not represent uniform security for all. Although the Royal Navy and its implicit threat against the U.S. port cities and economy ensured the security of British interests in Canada, threats to Mexico did not constitute a vital British interest. As a result, the seaborne threat against the southern perimeter of the North American continent in the early 19th century remained very real. In 1838 the French Navy, with tacit British permission, used a claim by an obscure French pastry chef against the Mexican government as a reason for punitive action. Upset over millions in unpaid Mexican debts, the French Navy instituted a naval blockade from Yucatan to the Rio Grande, and destroyed the fledgling Mexican Navy at it's main port of Vera Cruz. British diplomatic intervention ended the "Pastry War", and resulted in the Mexican government paying the claim. The Mexican American war of 1846-1848 saw the United States land seaborne forces in both California and Vera Cruz, and resulted in Mexico losing half of its territory to the "manifest destiny" of the United States, again with limited British interference. Unpaid Mexican debts resulted in the return of French, British and Spanish naval forces in 1861. The French lost the support of their allies by further using the venture to attempt colonization, but withdrew in 1867 with the victory of Mexican Republican forces.[16] The contrasts during this period between the relative security of Canada, the state of détente along the U.S. coastal frontier, and the active foreign engagements along the Mexican perimeter served to

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[16] "*Wars of Mexico*", http://en.wikipedia.org/wiki/Category:Wars_of_Mexicohttp://en.wikipedia.org/wiki/Cate

highlight the issues of Homeland perimeter security based upon the sea power of a foreign nation. This was not merely a North American problem, but a greater problem for European nations who felt unduly limited, and threatened, by the British mastery at sea. The worldwide hegemony of British sea power thus became the target of a number of nations, and drove the adaptation of sea denial technology through the 19th century to overcome the British C3ISR and strike advantage. The end result of this technological drive would result in a revolution in military affairs which would fundamentally alter the dynamics of homeland defence for Britain, and North America. However, evolution of existing sea power technology would delay the full impact for nearly a century.

With the rise of the industrial revolution, the state of the art in modern strike forces entered a period of rapid change. Wooden hulled sailing ships mounting batteries of muzzle loading cannon had defined this technical state of the art for several centuries. The introduction of long range gunnery, steam propulsion and armored steel hulls represented a technical revolution which would have a profound impact upon traditional methods of sea control, and defence against forces from the sea. The French Navy began experimenting with explosive shells in 1824, and by 1838 the technology had advanced sufficiently in the Royal Navy that *HMS Excellent* was able to accomplish the destruction of the hulk *Prince Regent* at a range of 1200 yards.[17] Long range gunnery continued this progression in leaps and bounds. The long 32 pounder gave way to the 68 pounder, and were followed by the 10 inch and 12 inch gun muzzle loading gun. In order to increase the effective rate of fire against an enemy, these large guns were placed in a trainable turret. The weight of these turret structures caused significant design issues, including the

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gory:Wars_of_Mexico, accessed 14 March 2006.

17 Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004),*

capsizing of the prototype *HMS Captain in 1870*. The answer was the *Devastation,* the first warship built without masts, and their unstable topweight. Launched in 1871, *Devastation* mounted two turrets with a pair of 12 inch guns. Lack of masts meant that the guns could be trained through a wide arc fore and aft, allowing 700 pound shells to be directed at the enemy from any aspect.[18]

The advent of the heavyweight explosive shell doomed the wooden warship as an instrument of sea power. Defence against high powered artillery required armor protection. From the advent of *HMS Warrior,* the first all iron warship in 1860, the Royal Navy was quick to embrace armor as the panacea for the evolving gunnery revolution at sea. *Devastation* possessed turret armor more than a foot thick, with equally thick side plating running the length of the waterline. The *Inflexible* of 1876 carried four sixteen inch guns, and two foot thick armor around her central citadel with three feet of teak backing. Twin screws and steam propulsion allowed her to steam at a speed of fifteen knots, and steam generators provided power for both electrical lighting and searchlights. At 11,800 tons, *Inflexible* and her sisters marked the dawn of a new age of traditional sea power. Beyond their obvious advantages in gunnery and armor, the Crimean war

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[18] Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 459*.

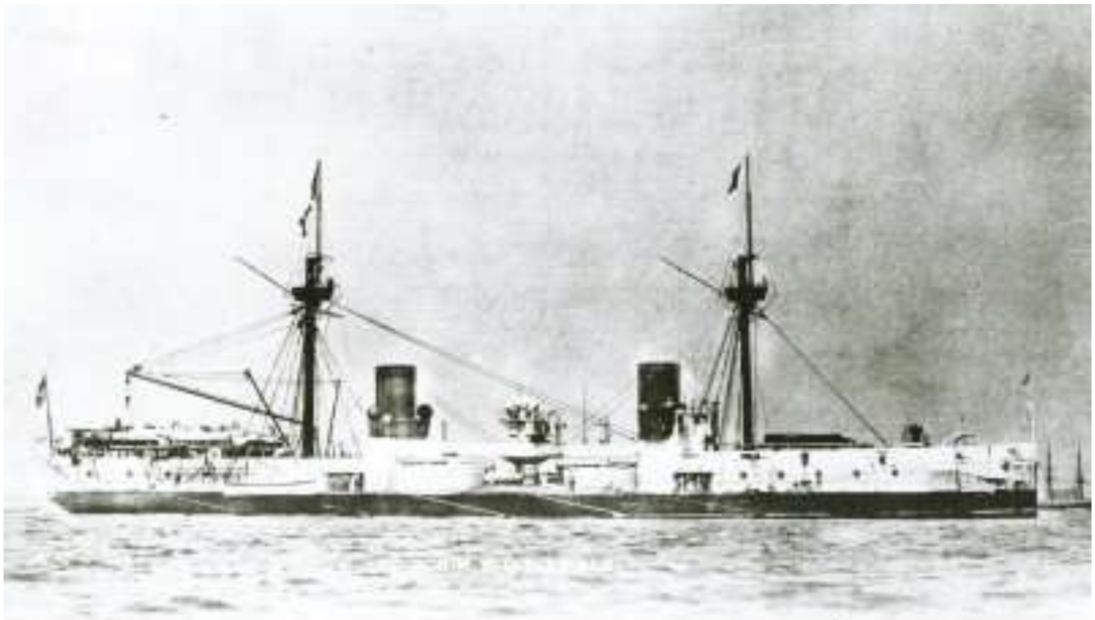

Figure 1.3 *HMS Inflexible* circa 1881[19]

of 1853-56 had demonstrated conclusively the advantage that steam powered warships had in warfare at sea. Steam powered vessels could transit at high speed independent of wind direction. They were thus able to bring force to bear against an enemy fleet or coastline at a time and place of their choosing.

Concurrent with the evolution of the "battleship", improvements in strategic communications had greatly improved the command and control of the battle fleets. The advent of steam propulsion had made communication by packet steamer both faster and more reliable over long distances. More importantly, however, was the invention of the telegraph. First conceived by the American Samuel Morse in 1828, the telegraph evolved rapidly, along with railways, as a method to rapidly pass information over long distances. Telegraph lines spread rapidly across Europe, Britain and the United States through the 1830s and 1840s. By 1851 the first submarine telegraph cable was laid between Britain and France, connecting the Admiralty with the telegraph systems of the continent. That same year the Admiralty was informed that the electric telegraph was open throughout the whole of North America. In 1857 the first attempt was made to lay a transatlantic telegraph cable, and thus connect the telegraph systems of the two continents. The attempt failed, but a second cable laid a year later operated for three months. Finally, in 1866 a successful cable was landed at Heart's Content, Newfoundland by the *Great Eastern*, the largest ship then afloat.[20] Just over one hundred years after the expulsion of French troops, a revolutionary force for homeland defence had been put ashore a mere 50 miles from Signal Hill.

North America and Europe were now connected by near real time communication. For the Admiralty, this meant instant communication with Halifax, the northern base of the America and West Indies station, and with Pacific Fleet base at Esquimalt via trans-continental cable. More importantly for North America, the means now existed to provide intelligence, surveillance and warning of events in Europe before they directly impacted North American shores. The possibilities of this new technology for homeland defence were soon demonstrated. In 1866 the Italian fleet sailed from Ancona to attack the Austrian island of Lissa. The island was connected by cable to the mainland, which allowed warning of the impending landing to be relayed to the Austrian fleet. Warned of the Italian approach, the Austrians sailed to prevent the landing. The Battle of Lissa was an Austrian victory, and represented the first engagement between fleets of armored and steam propelled ships. The virtues of rifled gunfire and ramming attacks in the age of steam became the topic of much discussion in naval circles. More importantly, however, was the role that C3ISR had played in bringing the battle about.

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[19] Taken from http://www.battleships-cruisers.co.uk/hms_inflexible.htm

[20] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter

Lissa had proven conclusively that modern C3ISR systems could allow a distant fleet to be instantly dispatched to defend against an attack. Without the benefit of a telegraph, the Battle of Lissa would not have taken place.[21]

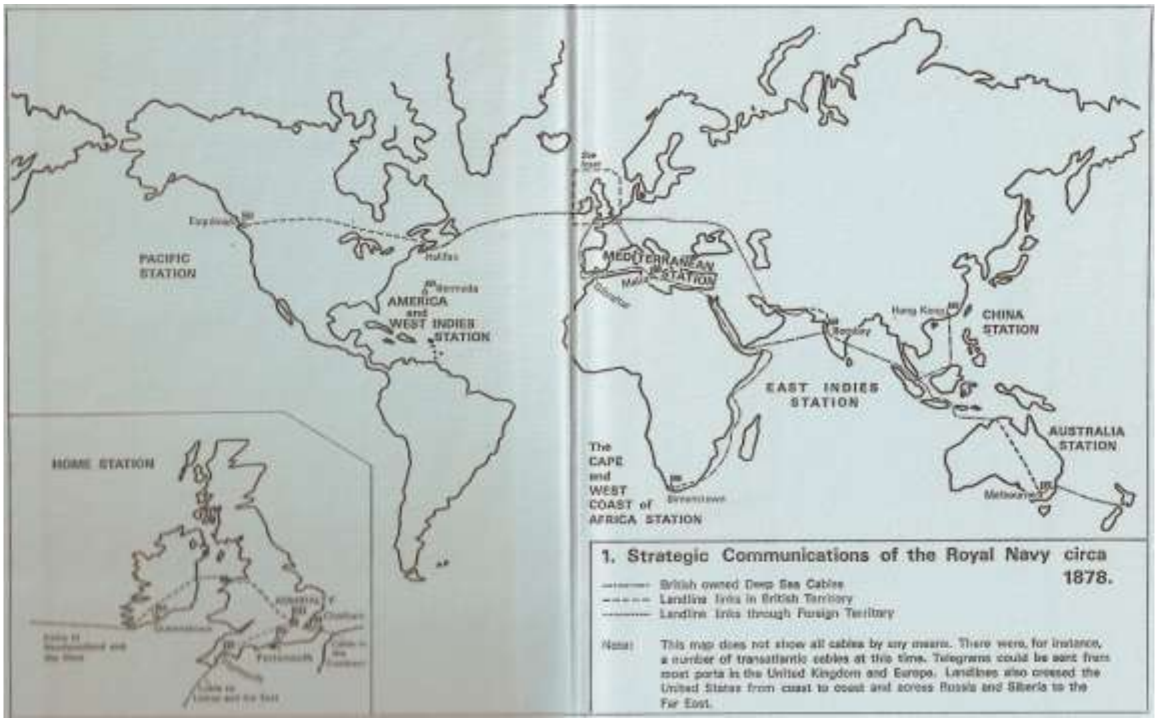

Figure 1.4 Strategic communications of the Royal Navy circa 1878[22]

With a worldwide Empire to police, the Royal Navy was a quick convert to the utility of the telegraph in directing Naval forces. By 1878 a worldwide network of strategic telegraphs, undersea cables, and high speed dispatch vessels had been constructed to allow the centralized control of naval striking forces. Messages could be received from far off stations, and be answered with orders in a matter of hours. As British interests owned the majority of cable systems, and coded ciphers could be used on

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Davies Ltd., 1975), overleaf.

[21] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 17.

[22] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), overleaf.

these cables to send secure messages, the Royal Navy possessed the first secure C3ISR network at sea.

A demonstration of the potential of this system, and the striking power of the steam powered armored battleship was not long in coming. The Suez Canal had been completed in 1869 by the French, but quickly became a strategic commercial link between Britain and its eastern possessions. By 1882 the growing European presence in Egypt due to the canal interests, and a militaristic Egyptian government under Colonel Arabi Pasha had fomented unrest in the local population. A combined British and French fleet was thus dispatched in May of that year to quell unrest. Unlike previous conflicts, strategic guidance was readily provided by their home governments via a submarine cable connecting Britain, Gibraltar, Malta, Souda Bay and Alexandria. Conditions ashore in Alexandria had so deteriorated by the time of the fleet's arrival that in early June the cable was dredged and connected to a commerical cable ship four miles offshore to provide strategic communications.[23] This event occurred none to soon, as on June 11th a riot ashore resulted in the massacre of 50 Europeans and the withdrawal of French forces.

The remaining seven British ironclads and five large gunboats represented the state of the art in British striking technology at sea. The most advanced, the *Inflexible,* was further commanded by the Royal Navy's most technically adept senior officer, Captain (later First Sea Lord) Jack Fisher. Conventional wisdom dictated "a ship was a fool to fight a fort", and the Egyptians had been reinforcing their batteries and fortifications at Alexandria for months. Clear direction was received from London that the fortifications were to be destroyed if the work was not halted, and on July 11th,1882

[23] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 18.

the British fleet commenced a ten hour bombardment of the Alexandria fortifications from some 2000 yards offshore. The fortifications were destroyed, and Arabi Pasha and his army quit Alexandria the next day - to be pursued and destroyed by an expeditionary force under General Wolseley that September. The bombardment marked the first time a naval commander on a foreign station had remained in constant touch with the central government through an engagement.[24] More importantly, it showed the decisive power that modern C3ISR technology and naval strike forces could bring to bear against a foreign coast under central strategic direction. Alexandria would also prove the end of an era, as it marked one of the last times a British battle fleet would be able to strike a foreign shore with impunity. Winds of change were blowing at sea, and the striking power of the Battleship would be the first victim of the coming sea denial storm.

The implications of Alexandria upon North American defence were not lost on the United States Government. Given its economic dependence upon exports, and history of conflict with Britain at both its founding and during the war of 1812, the United States had developed an understandable concern for the potential of British sea power. Through the middle part of the 19th century, US continental concerns with internal expansion, the war against Mexico and the Civil War had dominated the US political agenda. However, by the 1880s a number of technological and social factors would converge to impact the US approach to perimeter defense of the continent. To begin, the process of industrialization, particularly in the US Northeast had created both a target vulnerable to attack from the sea and and the latent capacity to build weapons of advanced technical capacity, such as the battleship. The modern battleship, with its combination of long

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[24] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 19.

range gunnery, armor and steam propulsion had commenced a period of rapid technical change, which made previous generations of battleship obsolete. This meant that a credible challenge to the dominance of the Royal Navy, long made impossible by its large standing forces at sea, had become possible with smaller forces due to technical obsolescence. Command and control of these smaller forces for defence of the coast had been made possible by the telegraph, which by the late 1880s connected American cities across the continent. Early warning of overseas intentions via submarine cable meant that standing Naval forces were no longer required to maintain a state of continual vigilance and coastal defence at every port. A smaller and more affordable striking fleet could be centrally coordinated and dispatched to defend as required. Finally, affluent Americans had come to see risks to trade and their economic prosperity, as demonstrated at Alexandria, as a threat they could no longer ignore.

The publication of Alfred Thayer Mahans *The Influence of Seapower upon History 1660-1783* in 1892 thus found a ready audience, who were willing to invest in sea power. The time to acquire a sea control and limited sea denial fleet to challenge the European powers had arrived for the United States. The resultant slow building programme and rise of American sea power was further accelerated by the Spanish American war of 1897. With the US battle fleet deployed to Cuba, occupants of cities such as New York, Boston, Baltimore and New Orleans realized their vulnerability to attack from the sea. Expensive coastal fortifications were seen to be of limited value with such a long coastal border, as an enemy could land further down the coast. From 1890-1910, defence of the continental perimeter for the US therefore shifted from a posture of sea denial to sea control. Recognition of the influence of sea power, and a sense of vulnerability from foreign naval forces along the long coastal frontier resulted in the US Navy developing into the world's second most potent naval force in the space of two decades. The C3ISR and naval strike technology that had defined the battleship threat to the North American coastal perimeter had been harnessed with sufficient resources to establish the sea control means to defend against and defeat the threat to the American perimeter. Unfortunately for the Americans, and their expensive new battle fleet, sea denial technology was about to render this new force obsolete.

Meanwhile, further evolution to C3ISR technological was swift in coming. On 12 December 1901, Italian inventor Guglielmo Marconi received the first transatlantic wireless transmission atop Signal Hill, not far from the site of both the final French assault of 1762 and the landing site of the first transatlantic telegraph cable. This achievement marked the culmination of four years of technical development by Marconi, particularly in his efforts to produce a useful wireless apparatus for ships at sea. From its earliest iteration in 1897, wireless technology was quickly recognized for its potential in C3ISR at sea. Scouting vessels no longer had to maintain visual sight of one another to pass signals. Main striking forces could be signaled directly once a scout sighted the enemy, and be vectored to an intercept position while the scout shadowed the opposing force. Forces at sea could send and receive messages between distant fleets at sea, without the use of dispatch vessels. Headquarters could forward important orders and intelligence information to ships at sea using high power transmitting stations. In short, the C3ISR network had become faster, wider and more mobile.

The possibilities for forces at sea were quickly realized. By the end of 1901 the Royal Navy had fitted all battleships and cruisers on the Home, Mediterranean and China stations and built six shore stations to cover the approaches to the English Channel.[25] The United States Navy also made efforts to embrace the new technology. During the 1903 summer manoeuvres a "white" raiding force was successfully tracked down and engaged by a "blue" force of wireless equipped ships.[26] This theoretical defensive success of a wireless equipped force was soon demonstrated as an operational fact in the Russo-Japanese war of 1904-05. After the destruction of the Russian Pacific fleet by the Japanese, the Russian Baltic fleet was sent to reinforce the Russian Pacific frontier. The Japanese possessed good intelligence on the movements of the Russian fleet from telegraphed reports, and set up a scouting line across the three entrances to the sea of Japan which the Russians could use to travel onward to Vladivostok. On May 27, 1905 the armed merchant cruiser Shinano Maru sighted the Russian Fleet and relayed its position. The main Japanese fleet sailed at once, receiving updated positions throughout the day from wireless equipped cruisers.[27] First contact was gained later that afternoon, and in the ensuing Battle of Tsushima the Russian Baltic Fleet was annihilated. Russian warships not sunk by the daylight striking power of Admiral Togo's battle fleet were destroyed later that night by his torpedo boat flotillas. The utility of wireless as a tool for defensive forces had been proven beyond doubt.

With merchant ships being fitted rapidly with wireless equipment, every new ship at sea now had the potential to act as a scout within the C3ISR network. Britain embarked in 1912 through a contract with the Marconi Company to create a worldwide wireless network to cover the sea approaches to its Empire. In that same year, the United States

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[25] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 37.

[26] Ibid, 41-42.

[27] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter

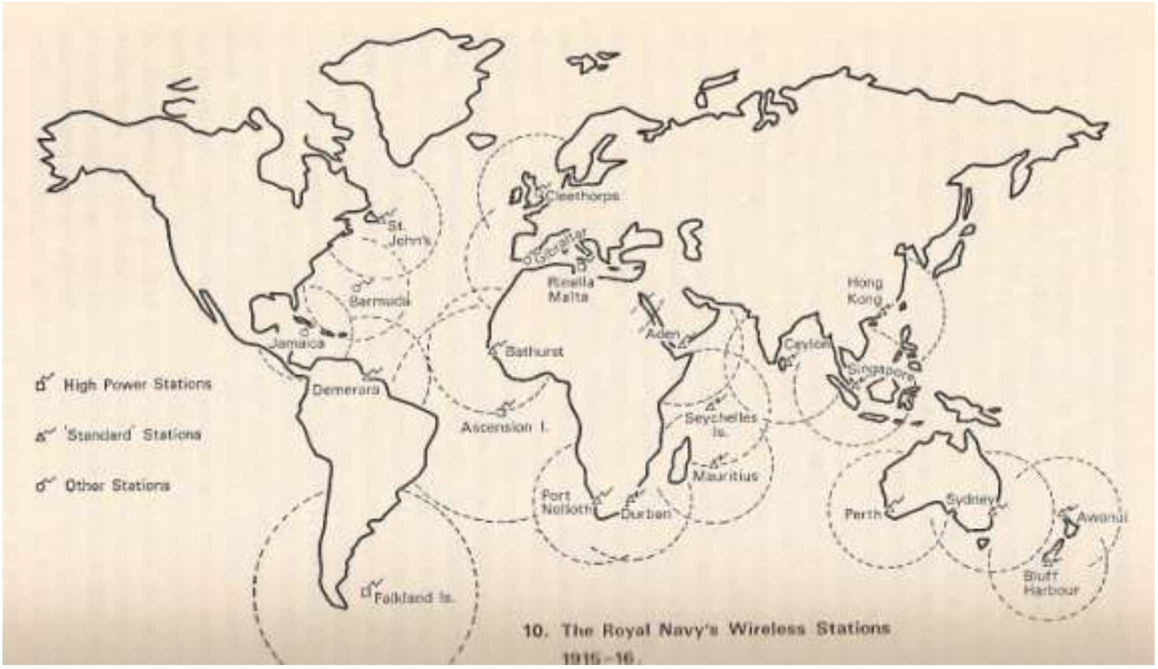

Figure 1.5 Royal Navy Wireless Stations 1915-16

embarked upon a programme to expand its network of high power wireless stations to locations at Arlington, the Panama Canal, California, Hawaii, Samoa, Guam and the Philippine islands.[28] Due to the foreign ownership of most telegraph systems, wireless communications were viewed to be particularly important to Germany and its overseas possessions. A high powered station at Nauen near Berlin provided communication with Kamina in Togoland, which could in turn contact stations at Windhoek in southwest Africa, Dar-es-Salaam in east Africa, and Duala in the Cameroons. Communications with North America, South America and the far east were provided by commercial telegraph, but a further radio network spanned the distance between Tsingtao in China, Yap and Augaur in the Carolines, Apia in the Samoas and Rabaul in the Bismarcks[29]. With the

Davies Ltd., 1975), 48.

[28] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 77.

[29] Vice Admiral Sir Arthur Hezlet, *The Electron and Sea Power* (London: Peter Davies Ltd., 1975), 77.

line of Battle tactics employed at Tsushima clearly in the mind of contemporary admirals, the buildup to World War I further saw an arms race to build yet more powerful striking forces to ensure the defense of the homeland and overseas possessions. Faster and more powerful Dreadnoughts and Super Dreadnoughts were built, with each new class rendering the previous obsolete.

In some ways, this revolution had been more of a long evolution. During the American War of Independence, British blockade and bombardment had raised the antagonism of a young American inventor by the name of David Bushnell. Determined to find a method to defeat the blockading ships, Bushnell reasoned that a gunpowder charge detonated underwater would cause the most damage by attacking the warship at its most vulnerable point. The problem lay in how to transport the charge to position safely. Bushnell's solution was ingenious - an underwater boat with detachable gunpowder charge. Borrowing heavily from the work of French inventor Denis Pepin, Bushnell spent over a year perfecting an oval submarine propelled by hand screws and carrying a 150lb mining charge. On 6 September 1776 the submarine was towed by rowboats along New York Harbour until it was within striking distance of *HMS Eagle*, Lord Howe's flagship. Drifting undetected on the tide, Bushnell's submarine was thwarted in its attack when the auger used to attach the charge failed to penetrate an iron crossbar holding the rudder[30]. Although unsuccessful, Bushnell's submarine had shown the possibilities of how a weaker naval force could inflict serious damage against a powerful enemy.

After the war of Independence Bushnell moved to France, where he met up with another young American by the name of Robert Fulton. The French were suffering the

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[30] Alex Roland, *Underwater Warfare in the Age of Sail*. (Bloomington: Indiana University Press, 1978), 78.

same British blockade and bombardment issues through the Napoleonic wars, and Fulton was able to convince them to fund a new type of weapon for trials against the common enemy. Borrowing heavily from the knowledge of Bushnell, Fulton proposed a new weapon to the French Minister of Marine;

> "…Citizens, as I firmly trust this engine will give liberty of the sea, it is importanat to experiment as soon as possible so that, if she succeeds, the terror will be scattered before the invasion of England, and the boat can be employed in assisting this invasion.[31]

Fulton's proposals were accepted, and he subsequently built a copper submarine with iron ribs which he called the *Nautilus*. The *Nautilus* embodied many features of a modern submarine, including Kingston valves for submergence and diving planes for depth control. The primary weapon was a towed mine, which was fixed to the hull of the vessel being attacked by a spike in the conning tower. Nautilus successfully used this weapon to

[31] Cdr. Murray F. Seuter., *The Evolution of the Submarine Boat, Mine and Torpedo*. (Portsmouth: J. Griffin & Co, 1907), 30.

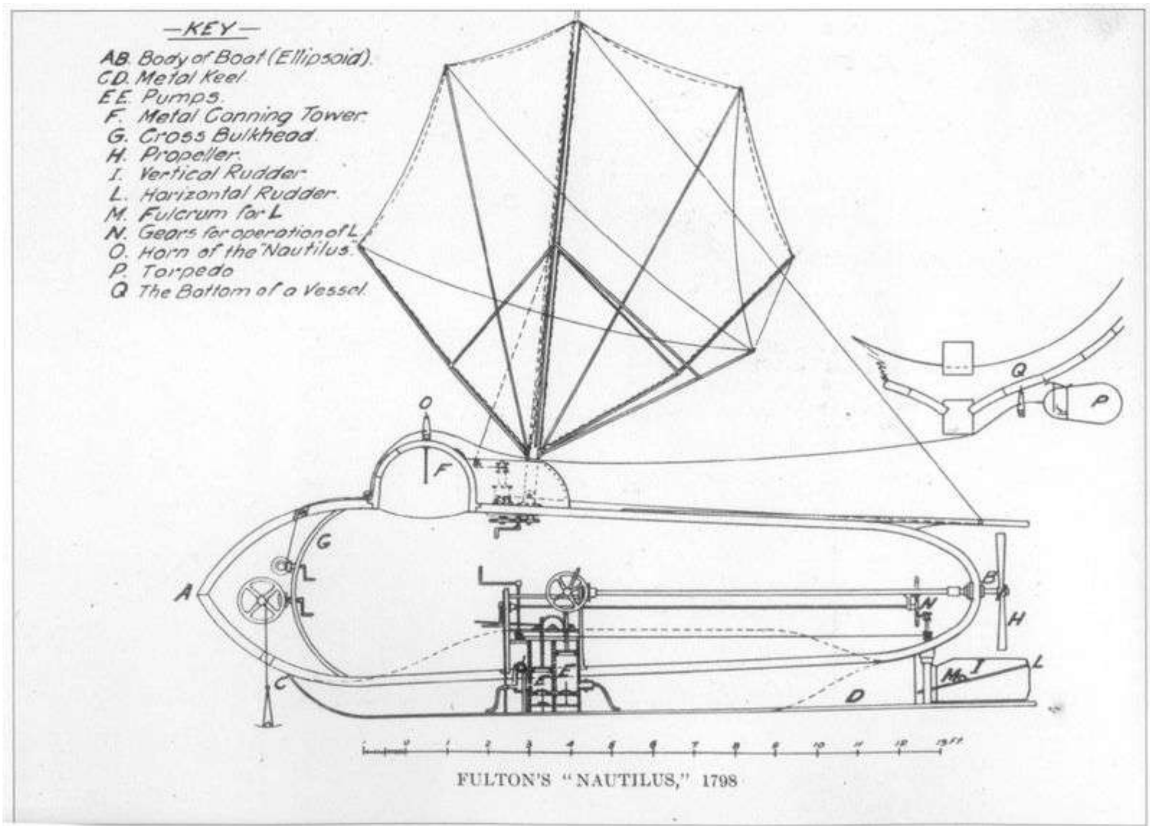

Figure 1.6 Fulton's Nautilus of 1798[32]

demonstrate the destruction of a small sloop in August of 1801[33]. Despite this apparent success, the French authorities considered the Nautilus to be un-chivalric as a weapon, and cut off funding to Fulton for further endeavours. Fulton attempted to sell his invention to the British in 1804, but met with considerable opposition. In the words of Admiral Earl St. Vincent; "Pitt was the greatest fool that ever existed to encourage a mode of warfare which those who commanded the seas did not want, and which, if successful, would deprive them of it!"[34] Fulton departed Britain for the United States in 1806, where he used his mechanical abilities to become a pioneer in the application of

[32] Taken from http://en.wikipedia.org/wiki/Nautilus_%281800%29

[33] Cdr. Murray F. Seuter., *The Evolution of the Submarine Boat, Mine and Torpedo*. (Portsmouth: J. Griffin & Co, 1907), 32.

[34] Cdr. Murray F. Seuter., *The Evolution of the Submarine Boat, Mine and Torpedo*.

steam power to marine propulsion. Through lack of interest, the submarine would lie dormant as a weapon for over a full half century.

Clever minds would continue to work the problem of countering blockading and bombardment forces through the 19th century. Fulton himself would fashion a number of gunpowder filled devices, delivered by various means such as drifting catamarans or explosive tipped harpoons. Although his inventions generated some interest among British and American authorities, they were viewed as mere curiosities rather than as a practical means to sink ships. The Crimean War of 1854-56 saw the Russians deploy contact mines with chemical fusing to protect the harbours of Sebastopol, Sveaborg and Cronstadt. Although one of these mines exploded under *HMS Merlin,* the small 25lb charge was insufficient to cause major damage.[35] It would be the efforts of the Confederate States Navy against the Union during the American Civil war which would bring the potential of underwater attack against a blockading fleet to fruition. The first successful mine attack in history took place on 12 December 1862, when the armored gunboat *USS Cairo* struck two mines on the Yazoo river in Mississippi. Further success was achieved by the Confederates with the Torpedo ram - a gunpowder charge rammed into the hull of a vessel by a boat or submersible. On 5 October 1863 the 3486 ton *New Ironsides* was struck by the torpedo ram of a human powered submersible named, aptly, David. The CSS Hunley later achieved distinction as the first submarine to sink a major warship on 17 February 1864, sinking the *USS Houstanic*.[36] Nonetheless, these attacks had been costly - sinking four union warships by spar torpedo cost the lives of three

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(Portsmouth: J. Griffin & Co, 1907), 34.

35 Cdr. Murray F. Seuter., *The Evolution of the Submarine Boat, Mine and Torpedo*. (Portsmouth: J. Griffin & Co, 1907), 267.

36 Cdr. Murray F. Seuter., *The Evolution of the Submarine Boat, Mine and Torpedo*.

submersible crews. Further advances in technology would be needed to mitigate the dangers. By the end of the Civil War, the trend was clear. Underwater attacks by mines and submersibles had damaged 49 Union vessels, twenty nine of which had sunk.[37] Battle fleets were becoming vulnerable to attack by vessels much smaller than themselves.

Further technical developments in the latter half of the 19th century would grow to threaten the battle fleets, even as revolutions in steam, gunnery and armor increased their effectiveness. In 1860 an Austrian Naval Captain named Giovanni Luppis had an idea to create a self propelled "coast saviour", an explosive charge which would run under its own power to attack a blockading vessel. To make his "salvacoste" more practical, he enlisted the aid of Robert Whitehead, a British engineer working for an engine factory in Fiume. Whitehead saw the technical and commercial potential of the weapon, and over a period of seven years developed the Whitehead-Luppis torpedo. The torpedo was a unique weapon, in that it used compressed air to propel an explosive charge toward a vessel at a constant underwater depth. The debut of the weapon in 1867 caused great interest, and by 1869 the technology had been purchased by the Royal Navy. Torpedo technology advanced quickly with the industrial revolution of the late 19th century, and by 1900 Whitehead's heated air torpedo was reaching speeds of 30 knots, and using gyroscopic control to run within 8 yards of a perfectly straight line at a distance of 1500yds.[38]

Torpedo boats quickly became the scourge of the modern battle fleet. In the 1891 Chilean Civil war the armored vessel Blanco Encalada was torpedoed and sunk by a 14

(Portsmouth: J. Griffin & Co, 1907), 46.

[37] Alex Roland, *Underwater Warfare in the Age of Sail*. (Bloomington: Indiana University Press, 1978), 162.

[38] Cdr. Murray F. Seuter., *The Evolution of the Submarine Boat, Mine and Torpedo*.

inch Whitehead torpedo. The Brazilian Civil War three years later saw the rebel naval vessel *Aquidaban* being sent to the bottom of its anchorage by torpedo boats in a night attack. The Japanese Navy followed up to good effect in 1895 during the Sino -Japanese war, putting the Chinese battleship Ting Yuen out of action over the course of several nights. Countermeasures against torpedo boats were swift in coming. Anti-torpedo nets were rigged around major warships at anchor. Quick firing guns were fitted to engage the torpedo boats before they could close to torpedo range. Electrical generators and searchlights were fitted to all capital ships to allow counter attacks by torpedo boats at night. A new class of vessel, the torpedo boat destroyer, joined the fleet to provide a protective screen around major warships.

All these measures served to decrease the probability of a successful attack by torpedo flotillas. The solution to defending the torpedo boat against the withering gunfire of the battleship and its escorts was simple - the torpedo boat would have to attack from under the water as well. Throughout the 1880s and 1890s improvements in torpedo guidance and propulsion were matched by vastly improved submarine technology to produce a truly submersible torpedo boat. The subject of steady research since the American Civil war, by 1904 the success of early French "Narwhal" and American "Holland" class boats in conducting covert attacks against modern battleships had convinced the British First Sea Lord Jack Fisher that a revolution was at hand. "Suffice it to say," Fisher predicted in April 1905, "in three or four years from this date …the English Channel and the Western basin of the Mediterranean will not be habitable by a fleet or squadron"[39] Long a proponent of improving the striking power of the British

(Portsmouth: J. Griffin & Co, 1907), 308

[39] Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004),*

Fleet, and an active participant in improving gunnery, speed, and hitting power, Fisher understood only too well the implications of the submarine on the modern line of battle. A revolution in military affairs was at hand. The early days of World War I would see the clash of these new sea denial forces against the C3ISR enabled striking power of the combined British fleet. The results would not go as expected, and force careful reconsideration of the ways and means of the future of homeland defence.

Upon the outbreak of World War I, the German C3ISR network was subjected to the first large scale network warfare attack in history. German owned cables in the channel were dragged up and cut. Naval bombardments of key wireless stations were conducted in Africa and the Pacific. Ground troops were sent ashore and overland to put the remaining stations out of action. By September of 1914 the British had succeeded in isolating German overseas possessions, and its deployed Naval forces. With an operating C3ISR network, and periodic reports from telegraph nodes and merchant shipping, the British were slowly able to locate and eliminate the remaining German warships at sea. Difficulties were still encountered on the fringes of the C3ISR net. The Battle of Coronel off the coast of Chile proved an unexpected loss, and the *SMS Emden* managed to bring shipping in the Indian Ocean to a standstill until tracked down and destroyed. Nonetheless, by December of 1914 the German surface raider threat had been eliminated, along with German hopes for a traditional guerre de course against shipping. The achievement was impressive, particularly in view of the fact that it had been done without the future improvements to surveillance that the invention of radar and aerial reconnaissance would bring.

However, while the C3ISR battle for the sea lanes against the threat of guerre de

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course had gone relatively well, the Dreadnoughts which constituted the offensive striking power of the British Grand Fleet sat at Scapa Flow in a state of siege. Although they continued to represent a powerful deterrent force in the protection of the British homeland, their capacity to move at will to strike foreign shores had been severely curtailed. The battleship, and its C3ISR enablers had defined the requirement for sea denial forces, and these new forces had now achieved a revolution in military affairs at sea. Jack Fisher had been right. On 5 September 1914 the British light cruiser *Pathfinder* became the first victim of the modern submarine. Two weeks later the cruisers Aboukir, Cressy and Hogue fell victim to the submarine U-12 in the space of less than an hour, killing 1460 British sailors. The contact mine, which had become a highly refined weapon in the decades since the American Civil War, sank *HMS Amphion* off the Thames estuary in the first week of the war, and *Audacious* in the Irish Sea on October 17th. The Royal Navy found itself in a panic. The Fleet was sequestered in ports in Ireland and western Scotland until defenses could be prepared at Scapa Flow and Rosythe in Scotland. Captains wondered whether they were safe even in home port. The mood was captured by Admiral Beatty in a letter to his wife from Rosyth; "We are nervous as cats, afraid of losing lives, losing ships and running risks".[40]

The threat posed by the most powerful striking fleet on earth, enabled by the most sophisticated C3ISR network in history, had been squarely met. Over a century of evolution in strike and surveillance technology in support of Britain's perimeter defence had been defeated by a counter-revolution in sea denial technology. The main British Fleet would sail periodically during World War I, but the threat posed by submarines,

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[40] Arthur Herman, *To Rule the Waves* (*New York: HarperCollins Publishers, 2004), 428*.

mines and torpedo boats would prevent it from sailing to bombard the German fleet or even remaining outside the protective nets of Scapa Flow for too long a time. Several decades before the advent of air power, flotillas of small craft had rendered the modern battleship vulnerable to threats other than its own kind. This realization that small flotillas now possessed the power to destroy the largest capital ships profoundly affected the British view of sea power. In 1934 Admiral Herbert Richmond expressed the problem as so;

> "…these are great changes; and it is proper to consider whether, in the new conditions which they have introduced into that struggle for control which constitutes naval warfare, it is now, or will continue to be, possible for a nation to possess such a far reaching measure of sea power.." [41]

The evolution of C3ISR and strike technology had fostered a revolution in sea denial technology which had redefined the threat to the homeland defence perimeter.

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[41] Admiral Sir Herbert Richmond, *Sea Power in the Modern World*. (London: G. Bell and Sons, 1934), 8.

Air Power and Perimeter Defence

> "..the elaborate defenses which we erected against the Soviet's bomber threat in the 1960's no longer retain their original importance. Today, with no defence against the major threat, Soviet ICBMs, our anti-bomber defenses alone would contribute very little to our damage limiting objective and their residual effectiveness after a major ICBM attack is highly problematical."[42]
>
> -Robert McNamara, Secretary of Defense - February 1966

The advent of air power in the early decades of the 20th century brought new opportunities, and problems, to the question of homeland defence. The steady decline of the battleship as the primary means to prevent attack and invasion along a county's perimeter had commenced with the arrival of sea denial technology, and would be finished within a few decades by the evolution of air power. The rapid advance of air power technology in the 1920's and 1930's also had an enduring effect on C3ISR, strike technology, and the options available for defence of the homeland perimeter.

To begin, aircraft allowed the surveillance of wide areas of the earth's surface, with a correspondingly large field of view. Aerial reconnaissance at sea extended surveillance well beyond the thirty of so miles a ship could achieve in clear visibility, and covered large areas much more quickly. Aircraft equipped with wireless, and in due course airborne radar, thus greatly expanded the C3ISR network which had enabled the battle fleets. Homeland defence from seaborne invasion was greatly enhanced by the mobility, surveillance and strike capability of land based air power. This ability of land based aircraft to act as a defensive striking force against seaborne attack was proven in

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42 David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. (Langley AFB:United States Air Force Air Combat Command,

1921 by the US Army Air Force, sinking both the captured German warship *Ostfriesland* and the decommissioned cruiser *Alabama* in aerial bombing trials. The possibilities of air power as a striking force were also not lost on naval planners. The potential of "airborne flotillas" in a striking role led to the development of aircraft carrier technology in the 1920's and 1930's by the Royal Navy, USN, and Imperial Japanese Navy. The resultant extended reconnaissance and attack ranges of carrier based aircraft returned a measure of invulnerability to Naval forces during strikes against targets ashore and at sea .

Clearly, air power represented a revolution in military affairs in its own right. However, as with sea power before it, it would be C3ISR technology which would provide air power with the enablers required to make it truly effective as a defensive, and offensive, striking force. Defense of the British Nation during World War II , and the North American perimeter during the early days of the Cold War, would see the ascension of C4ISR (C3ISR plus computers) enabled airpower as the primary means of homeland defence. However, as with battleship-based sea power before it, the evolution of C4ISR enabled aerial strike technology would drive and define future threats to the homeland. Revolution in counter-technology would result in the eventual negation of air power in the defensive role. The Battle of Britain, the Evolution of NORAD, and the transition to the missile age provide a useful case study in further demonstrating this trend.

The birth of air power as a striking force coincided with the death of the battleship as the predominant striking power of the time. On 25 August, 1914 a German Zeppelin dirigible appeared in the night skies over Antwerp Belgium and dropped a few bombs on the city. Although limited in its effect, this Zeppelin attack represented the first strategic

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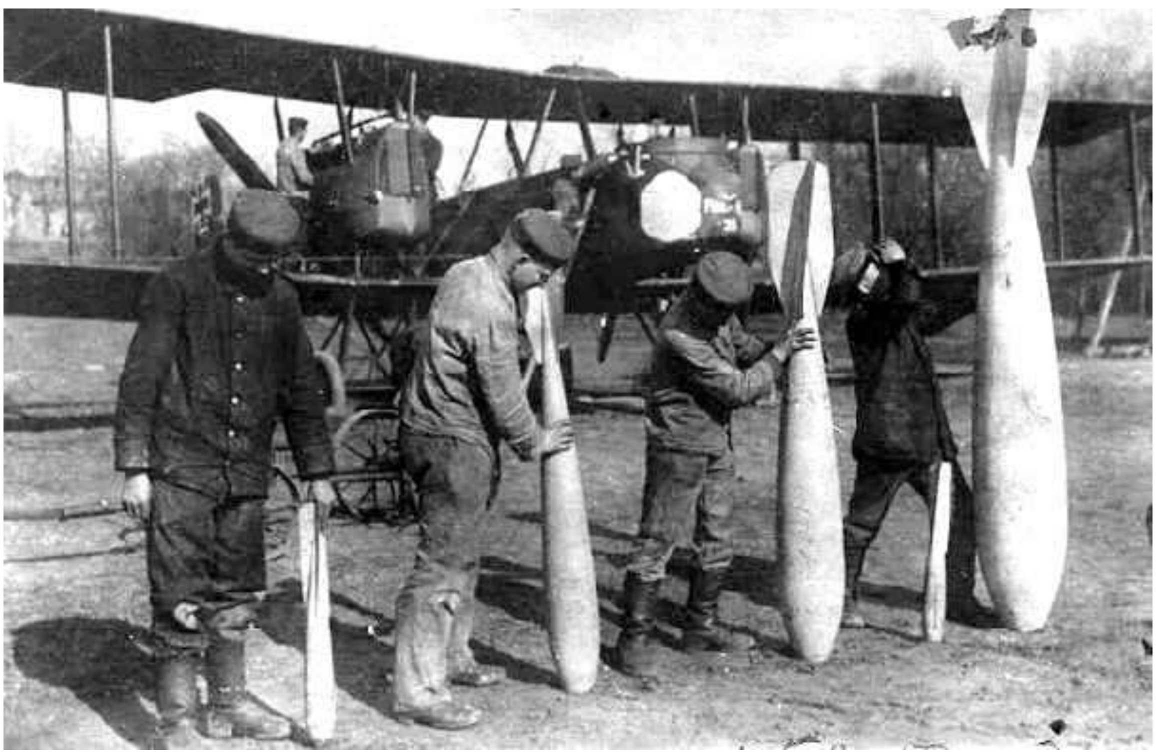
1997), 37.

bombing event in history. Further Zeppelin attacks against London and towns on the east coast of Britain through 1915 represented a new challenge to perimeter defence. The problem was compounded in 1917, when Germany introduced the Gotha G-IV, the world's first strategic bomber. On the night of 13 June, 1917 a force of 14 Gothas dropped a total of 118 bombs on London, and killed 160 people[43]. Unlike the slow moving Zeppelins, the Gothas were a difficult target for the fledgling Royal Air Force. A study on the problem commissioned by the Prime Minister concluded "this new form of warfare would prove so powerful that all other forms of military and naval action would become secondary and subordinate".[44]



[43] Harry G. Stine , *ICBM - The Making of the Weapon that Changed the World*. (New York: Orion Books, 1991), 135.

[44] Harry G. Stine , *ICBM - The Making of the Weapon that Changed the World*. (New York: Orion Books, 1991), 135.

Figure 2.1 - The Gotha IV Bomber and ordnance[45]

British defensive measures concentrated on a local defence. The most dependable method of detecting the bombers at night turned out to be the sound of their engines. A Large apparatus using a pair of inverted megaphones for bearing, and another for height, were deployed to search the night skies and provide a measure of warning. Barrage zones were established around London which included searchlights, observation posts and anti-aircraft artillery. Barrage balloons with suspended cables and the use of total blackouts further complicated the bombers tasks. However, it was the recall of hundreds of fighters from France which eventually turned the tide[46]. Early in the age of air power, the British had discovered that strategic bombers were vulnerable to fighter aircraft.

The interwar period saw the development of a number of C3ISR technologies which would greatly improve anti-air defences. The first was the advent of radar. In 1935 an English physicist by the name of Robert Watson-Watt published a report entitled "The Detection of Aircraft by Radio Methods" his report intrigued the British Ministry of Defence, and he was given a contract to further his work. Work in radio detection methods was also underway in the United States. On December 14th , 1936 the Army Signal Corps laboratory employed a prototype pulse radar to bounce a radio wave off an aircraft at a range of 7 miles[47]. These respective streams of research would result in the development of the air defence radars employed for perimeter of defence for Britain and the United States during World War II. Britain would develop the "Chain Home" and

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45 Taken from http://www.angelfire.com/hi5/tgenth/gotha/GothaGIVe.htm

46 David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. (Langley AFB:United States Air Force Air Combat Command, 1997), 7.

47 David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. (Langley AFB:United States Air Force Air Combat Command,

"Chain Home Low" radar systems to provide perimeter air defence coverage during the Battle of Britain. While not an ideal system, it possessed the technological advantage of being available for immediate implementation. The United States developed the SCR-268, SCR-270 and SCR-271 series of radars. It would be an SCR-270 radar system stationed at Kahuku point on the island of Oahu which would detect the first wave of the Japanese attack on Pearl Harbour. Unfortunately, the report of the two radar operators was dismissed as a false report.[48] Clearly, radar information without an established command and control system was ineffective as a defence.

Fortunately, in other quarters C3ISR technology had advanced the state of the art in air defence. In the early 1930's Captains Claire L. Chenault and Gordon P. Saville theorized that the effectiveness of pursuit aircraft against bomber formations could be greatly improved by the use of ground controlled intercept (GCI) techniques. By 1935, the US Army Airforce had conducted a successful trial of GCI, using high frequency radios to vector fighters against bomber formations sighted by ground observers. However, it was in the Battle of Britain in which GCI came of age. Known as the "Dowding system" after its chief architect Air Chief Marshal Sir Hugh Dowding, the British GCI system in place for the summer of 1940 was the most advanced air defence C3ISR system in the world. Initial detection of Luftwaffe raids would be achieved by the "Chain Home" radar sites. Reports from these sites, and reports from ground observers, were sent by telephone to the ground floor of the interception direction room. Markers indicating the position of the raid were placed on a large horizontal map. Overlooking the

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1997), 9.

[48] David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. (Langley AFB:United States Air Force Air Combat Command, 1997), 9.

map from a balcony, fighter controllers used HF radio to relay instructions to individual fighter squadrons to conduct the interception. Squadrons of Hurricane and Spitfire aircraft could be vectored to within 5 miles of the approaching raid using these techniques, which placed the fighter pilots in range for a visual interception.

Although primitive by modern standards, this manual plotting system resulted in the interception of the majority of Luftwaffe raids. Additional C3ISR warfare efforts to disrupt the beam navigation system employed by the Germans to navigate to their targets, and misrepresent the factual results of their bombings, further hindered the Luftwaffe bombing efforts. Further defensive layers consisting of observation posts, searchlights, anti-aircraft artillery and barrage balloons also caused aircraft losses. By the end of 1940, GCI enabled fighters and additional defence in depth had resulted in unacceptable attrition of Luftwaffe aircraft and aircrews. In the end, Luftwaffe bomber attacks against Britain were broken off in the summer of 1941 to provide air support to the invasion of the Soviet Union. C3ISR in support of air power had achieved a defensive victory, and saved Britain from a German cross channel invasion.

Conversely, Allied efforts in strategic bombing against the less integrated air defenses of Japan and Germany had fully demonstrated the potential of strategic air power as a striking force. The firebombing of Japan, and the wholesale destruction of the German war economy in Europe fully demonstrated the destructive potential of strategic bombers armed with conventional explosives. The addition of the B-29 bomber and the atomic bomb to the strategic arsenal marked a new plateau for offensive striking power. By the end of World War II air power had reached its zenith as both a system for defence of the homeland perimeter and a means for strategic strike. The striking power of air power at sea had redefined the methodology of naval engagements and the evolution of wide area search by radar equipped aircraft made a surprise attack by ships across an ocean barrier a near impossibility. The means of perimeter defence changed rapidly in the aftermath of these developments. Coastal artillery batteries were recognized as an obsolete force, as aircraft provided a faster, more effective, and more maneuverable defense. The limited striking range of the battleship, and its requirement to close within the range of sea denial and air flotillas to conduct an attack, ended its utility as a primary means of offense and defense. The age of air power had arrived.

No party was more concerned by this fact than the Soviet Government. In 1945-46 the Soviets had sent teams into central Europe to recover industrial equipment and machine tools as part of war reparations. The extent of the destruction that had been wrought by the Allied strategic bombing campaign impressed the Soviet observers. As the scale of destruction that had been wrought in Germany and Japan became clear, Stalin refocused the efforts of the recovery teams from recovering machinery to recovering German scientists connected with air defence plans and missile technology[49]. The Soviets, along with the Americans and British, were particularly interested in the new guided missile technology that the Germans had attempted to employ in the face of overwhelming air superiority. Of particular interest were the facilities at Peenemunde and Nordhausen, where the German missile program had been based. Conveniently, both of these locations fell within the Soviet occupation zone.

Although the Americans had gathered up most of the scientists associated with the German V2 missile program, and a large portion of the available V2 documentation and

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[49] Steven J.Zaloga, *Soviet Air Defence Missiles*. (Surrey: Janes information Group, 1989), 5.

parts, the Soviets were able to collect a large number of scientists associated with the air defence effort. The Soviets studied the German experience against allied heavy bombers, and quickly developed their own system of early warning radar, intercept fighters and radar directed anti-aircraft artillery. American intelligence in the early 1950's was flabbergasted at the speed at which the Soviets had developed and manufactured hundreds of sophisticated air defence radars. Although the Soviets understood the principals of effective World War II air defence, and particularly the value of air defence artillery, they were slower to realize the implications of strategic bombing in the atomic age. Although effective flak batteries had accounted for as much as ten percent of allied bomber casualties in raids upon Germany, this level of attrition was now meaningless. A single plane breaking through the air defences with an atomic weapon now had the capacity to destroy an entire city in a single attack[50]. The effectiveness of Soviet air defences were also called into question by the experiences in the Korean war in 1950-52. American B-29 bombers, flying at night, could not be located and engaged by the new MIG-15 fighters. Air defence artillery lacked the accuracy and volume of fire to seriously disrupt the American bombers. Soviet air search radars, based upon lend-lease radars, were easily jammed by the Americans[51]. Something more would be needed to defeat strategic air power in the atomic age, and the Soviets were determined to find it to ensure their own security.

The first Soviet venture was the development of their own strategic atomic forces. The Soviets detonated their first atomic weapon on August 29, 1949. Within four years, the Soviets had demonstrated the potential of using lithium hydride to create a fusion

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[50] Ibid.

[51] Steven J.Zaloga, *Soviet Air Defence Missiles*. (Surrey: Janes information Group,

reaction, and on November 22, 1955 they detonated their first “true” hydrogen bomb. Delivery of these heavy atomic weapons over long distances required a sophisticated delivery system, and the Soviets thus pressed ahead with a strategic bomber program. The first Soviet Strategic bomber was the Tupolev TU-4 “Bull”. A nearly exact copy of American B-29s confiscated during World War II, it gave the Soviets intercontinental, albeit one way, reach. Soviet strategic bomber development in the early 1950’s was rapid. The TU-4 was followed by the TU-16 “Badger“, the TU-95 “Bear” and the Molot M-4 “Bison“. By the mid-1950s, the Soviets had built a credible strategic bomber force to counter the American strategic threat.

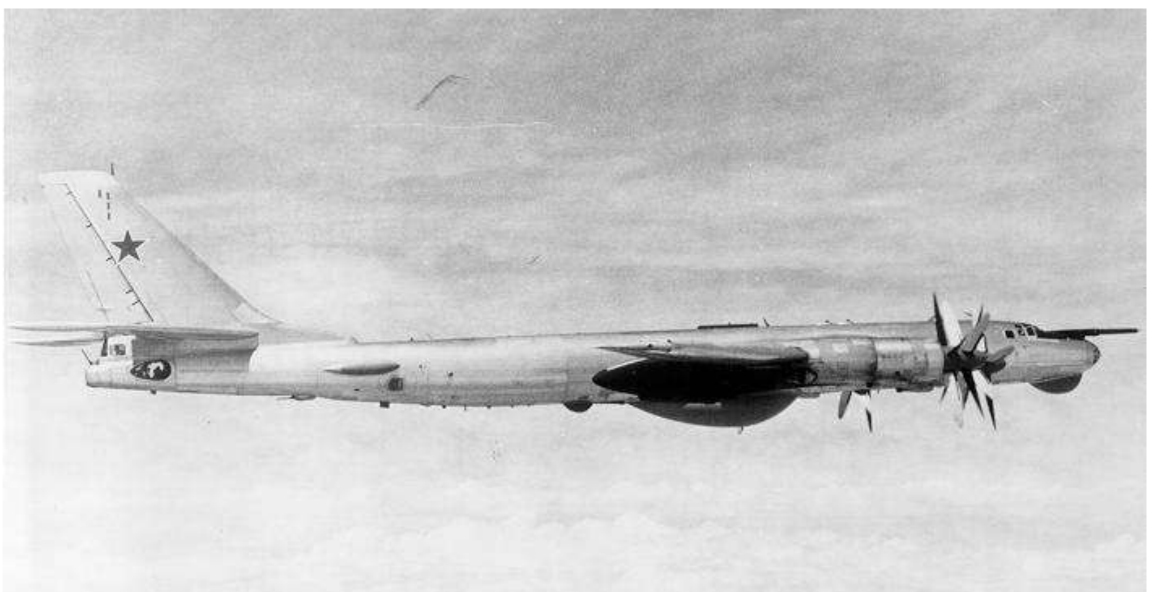

Figure 2.2 - Tupolev TU-95 Strategic Bomber[52]

The detonation of the Soviet atomic bomb took the Americans by surprise, and resulted in the rapid implementation of an air defence program. Continental air defence had been allowed to atrophy as early as 1943, when American victories in the Pacific had

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1989), 7.

[52] Image taken from http://www.fas.org/nuke/guide/russia/bomber/tu-95d_3.jpg

largely negated a Japanese threat to the US Homeland. The pressures of the Soviet bomber threat and the emerging strategic reality of the Korean War resulted in intense pressure to secure the United States to secure the continent from an Air threat. The first stage of this effort involved the stationing of obsolete air defence radars from World War II to provide surveillance over critical infrastructure. Appropriately named "Operation Lashup", the system was temporary and marginally effective at best[53]. 1952 saw the emergence of a more permanent network, which attempted to merge information from ground observers, perimeter radars, picket ships and radar towers at sea, and the newly developed EC-121 airborne early warning aircraft. Local Air Defense Identification Zones (ADIZ) collated this information, utilized radio waves to conduct identification friend or foe (IFF) interrogation of all inbound aircraft, and scrambled fighters to visually identify those which required further investigation.

Unfortunately, the C3ISR techniques which had succeeded in the battle of Britain were insufficient to meet the challenges of the jet age and broad expanses of American Airspace. The "permanent network" of radars established in 1952 required each radar site to conduct GCI of fighters or to pass the information to a nearby GCI centre. Contacts detected by the system were plotted manually on plexiglass boards at the local ADIZ, which coordinated the GCI intercept in the region. Reports from the ADIZ were sent to Air Defense Command headquarters at Ent AFB in Colorado. Here Airmen charted the progress of bombers on the world's largest plexiglass board, while air defense commanders attempted to coordinate continental defence. The system, which ran on a system of telephone and teletype reports, was simply too slow to control the air battle

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[53] David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. *(*Langley AFB:United States Air Force Air Combat Command,

over so wide an area. Moreover, the warning time provided by the system of perimeter radars was insufficient.

The answer was the development of the world's first semi-automated air defense system. The Semi-Automatic Ground Environment (SAGE) used newly developed numerical computer technology to automatically process reports from radar ground pickets, and gave commanders a near real-time picture of the air defence picture along the continental perimeter. SAGE was the worlds first C4ISR system, and its development in the 1950's cost the United States some eight billion dollars - four times the expense of the Manhattan Project.[54] SAGE was complimented by the construction of further perimeter radar and microwave pickets at the Pinetree line, the Mid-Canada line, and the Distant Early Warning line. Conclusion of a North American Air Defense pact with Canada in 1957 allowed the use of all the continent's interceptors and airspace to be used to counter the threat of Soviet bomber attack. By 1962 as system of 238 radar stations, EC-121 AEW aircraft and picket ships, 41 interceptor squadrons totaling 800 combat aircraft, seven Bomarc missile squadrons and scores of Army NIKE missile batteries under the C4ISR coordination of SAGE represented the most effective air defense system ever built.

1997), 17.

[54] David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. (Langley AFB:United States Air Force Air Combat Command, 1997), 37.

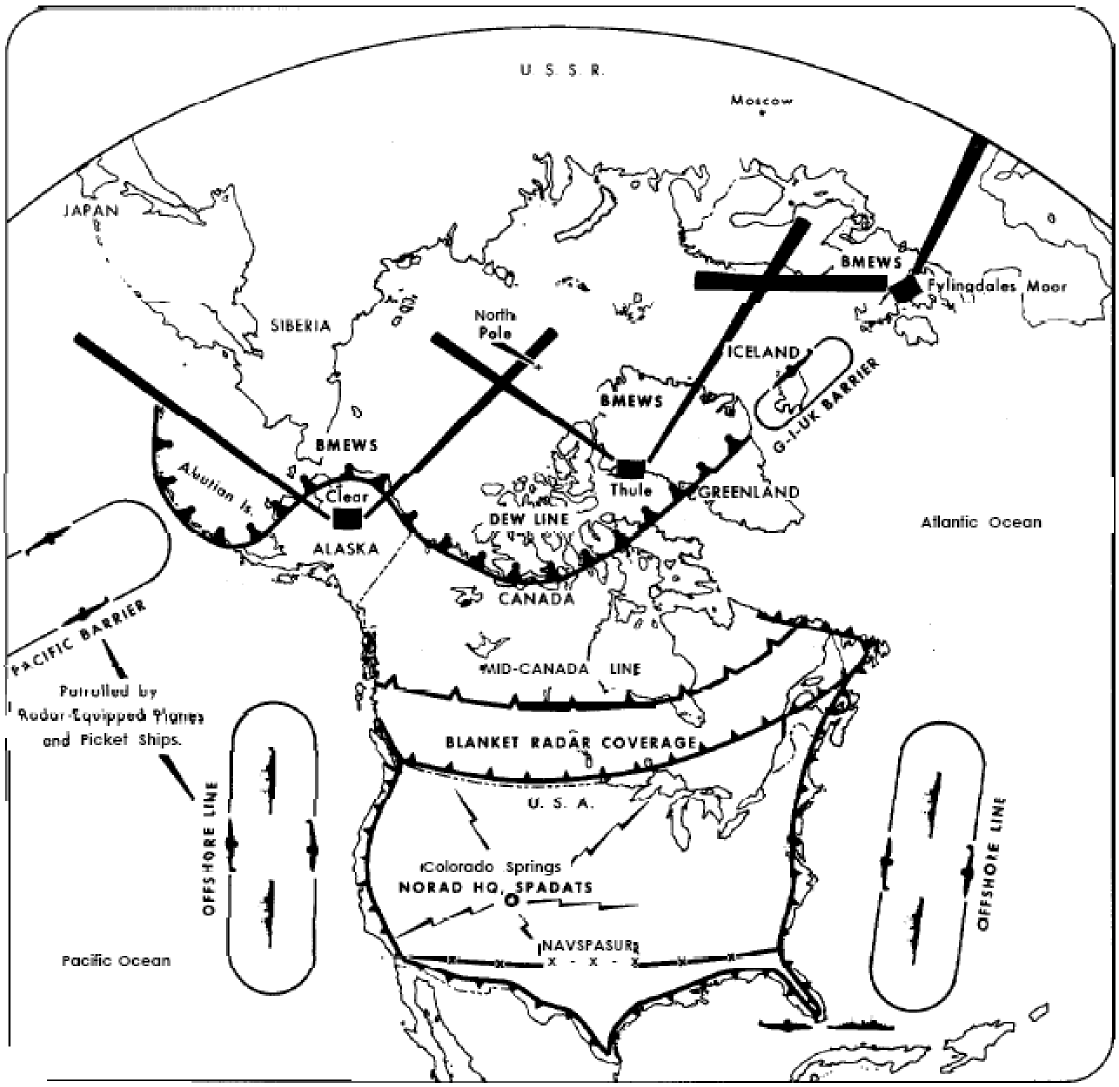

Figure 2.3 - North American air defense coverage circa 1962[55]

Unfortunately, it was also largely irrelevant. The C4ISR enabled NORAD air defense network, and the offensive striking capability of Strategic Air Command's long range bomber forces, had both been rendered largely immaterial by the Soviets.

Three technical offshoots of the German wartime missile program had evolved to counter the supremacy of American Air power. The first was the intercontinental ballistic

[55] David F. Winkler, *Searching the Skies - the Legacy of the United States Cold War Defence Radar Program*. *(*Langley AFB:United States Air Force Air Combat Command, 1997), 38.

missile. The German missile program had produced the A4 (otherwise known as the V2), a functional ballistic missile with the range to strike against targets in England from the European mainland. The Soviets clearly understood the strategic possibilities represented by the fledgling A4 technology, and on March 15, 1947 Stalin order his council of ministers to proceed with the development of a transatlantic rocket.[56] Soviet rocketry was not a backward science - it had in fact been on a par with that of the Germans until 1937, when Stalinist purges had crippled the pool of talent.

At the conclusion of World War II the available German scientists and technicians were gathered at Peenemunde inside the Soviet control zone and put to work rebuilding the German missile program. By the summer of 1946 a team of German and Russian scientists under Sergei Korolev had redesigned the A4 to achieve twice the range with improved accuracy. After a year, the knowledge gained from these efforts was transferred to the Soviet Union, and work on the transatlantic rocket proceeded at a breakneck pace. The development of a three ton thermonuclear warhead and a reliable inertial guidance system by the Soviets in 1953 overcame the last technical obstacles. On August 3rd, 1957 the first Soviet R-7 intercontinental ballistic missile lofted skyward from the Baikonur Cosmodrome in Kazakhstan. Two weeks later, another 325 ton R-7, with four boosters and 32 main engines hurled a dummy ablative warhead aloft to a splash point in the pacific 8000 kilometers away. The ballistic trajectory and speed of the warhead meant there was no defence against the R-7 once it was airborne. In one technical leap forward, the Soviets had made strategic bombers obsolete, and negated the air defence value of NORAD.

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[56] Harry G.Stine, *ICBM - The Making of the Weapon that Changed the World*. (New York: Orion Books, 1991), 126.

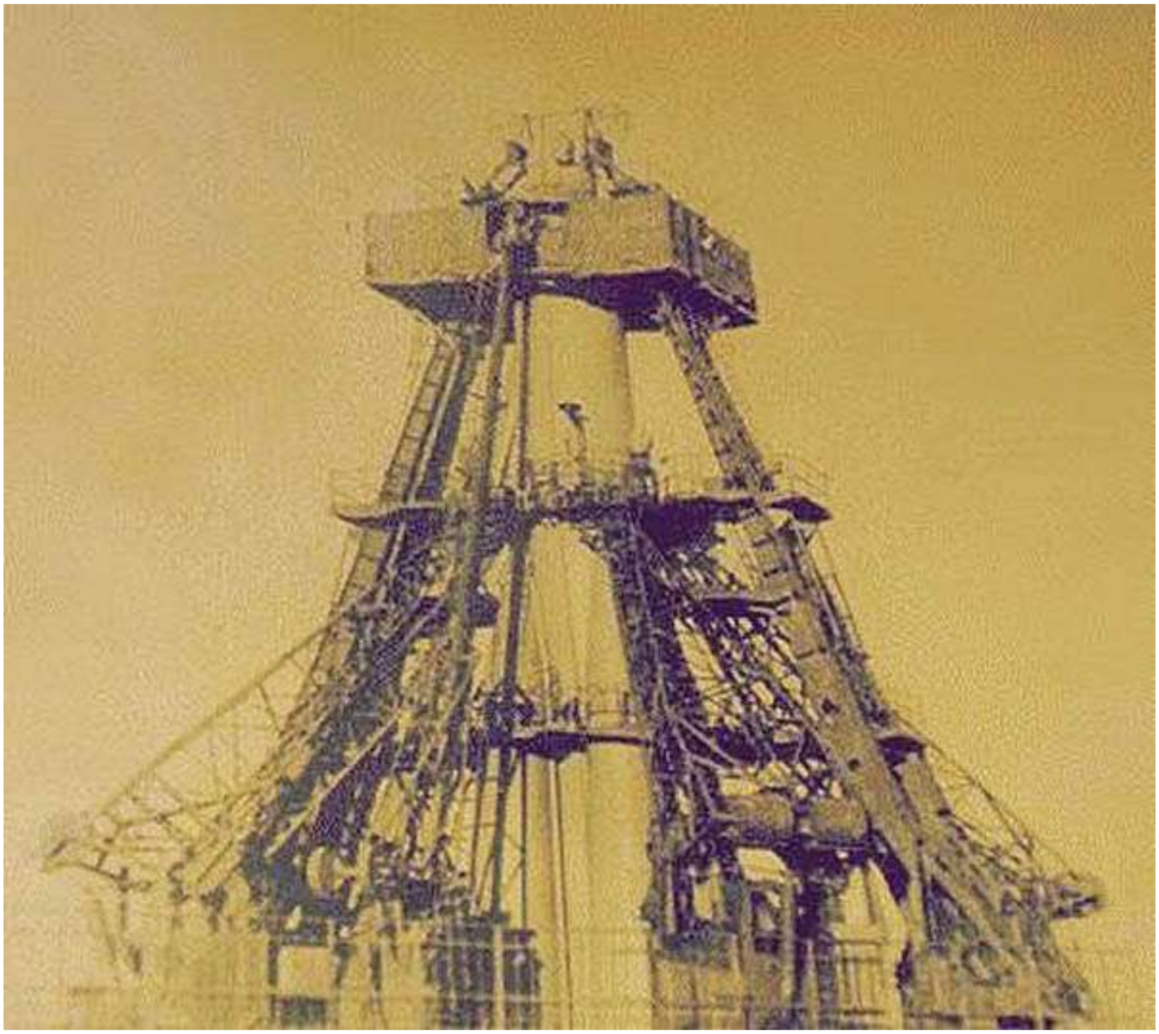

Figure 2.4 - The R-7 Intercontinental Ballistic Missile

Although the R-7 was invulnerable in the air, its liquid fuel technology required a long period of preparation prior to launch. It was thus vulnerable to offensive strikes by American bombers. This problem, and the problem of defending Soviet cities from nuclear bomber attack would be resolved by the Soviet adaptation of two other products of Peenemunde technology. Late in the war German missile efforts had focused on building air defense missiles to defeat allied air power. The result had been the Wasserfall and Scmetterling guided anti-bomber missiles, which had reached the verge of mass production by the war's end in 1945. Although superb aerodynamic designs, the missiles lacked a useful terminal guidance system.[57] Continual Soviet refinement of the German missile technology resulted in the production of the R-113 missile (SA-1 Guild). By 1956 an impressive 3400 R-113 missiles arranged in defensive belts protected Moscow against bomber attack.[58] While an adequate stopgap measure, a more sophisticated missile was needed to deal with new bomber threats such as the high altitude B-52. By 1956, Soviet rocketeers had developed the V-75 Dvina (SA-2 Guideline), which during field testing scored an impressive 80 percent success rate. By 1958 some 4000 V-75 missiles had been ordered to provide nationwide coverage of the Soviet Union, at a cost of 30 billion dollars. This expenditure was massive, representing 15 times the expense of the Manhattan project[59].

Although the R-7 and its protective fields of surface to air missiles represented a quantum leap forward in strategic strike technology, they were still vulnerable to attack by strategic bombers. The simple fact was that one bomber with a single atomic weapon could do great damage to the Soviet missile fields. Combining the mobility of sea power with nuclear missile strike technology was a logical method of ensuring a mobile, and survivable, nuclear strike capability. Faced with a strong American C4ISR and airborne strike capability at sea, the Soviets opted to utilize the submarine as a covert, and therefore survivable, weapons carrier.

Once again, the Germans had taken the initial steps at Peenemunde. In 1942 a young German rocket engineer named Ernst Steinhoff had surmised that striking at the

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57 Steven J.Zaloga, *Soviet Air Defence Missiles*. (Surrey: Janes information Group, 1989), 8.

58 Ibid, 10.

59 Ibid, 13.

United States directly would be a much more efficient method of stemming the tide of war supplies to Britain. He therefore had convinced his brother, a U-Boat commander, and his own commander at Peenemunde, to participate in an experiment. The U-Boat was fitted with a series of mortar tubes upon its upper deck, each of which contained a small rocket. The submarine submerged to a depth of 74 feet on the Peenemunde test range, and moments later a rocket broke the surface and impacted the target area two miles distant. Although the German Navy showed little interest in the new weapon, research on the concept continued. The end of the war saw the design of a teardrop shaped canister inside which an A4 missile could be towed underwater across the Atlantic and launched by a submarine against North American targets.[60] Fortunately for the Allies, the canister was never built.

The Soviets were quick to adapt the German technology to their own uses. Ashore tests were begun with a SS-1B Scud missile in 1953, and then with a modified Zulu class submarine. Between 1955 and 1956 seven Zulu class submarines were modified with an 11 metre section of hull containing two launch tubes. The first ballistic missile launch from a submarine took place on September 16th, 1955, with the missile flying several hundred kilometers before impacting the target area. The concept had been proven. Within six years the Soviets would have a fleet of twenty Golf class missile submarines at sea, providing a survivable nuclear deterrent strike force which was immune from the effects of air power.

The success of air power in achieving homeland defence had seen a quick rise and fall with the dawn of the missile age. Within a span of fifteen years after 1945, the

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60 James Barr and William E. Howard, *Polaris*. (New York: Harcourt, Brace and Company, 1960) 3-7.

supremacy of air power could not defend the continental perimeter against attack, nor attack another continent without unacceptable losses. The newly developed intercontinental ballistic missile was more cost effective, faster, and did not subject aircrews to substantial risk. Air defense missile systems greatly endangered and complicated the mission of the high-altitude, high speed bomber. The advent of submarine launched ballistic missiles placed strategic nuclear strike forces out of reach, and provided a secure means to breach the homeland defence perimeter. The impact on defensive and strategic air power procurement plans was immediate. In 1961 the US cancelled development of the Mach 3 capable B-70 Valkyrie intercontinental bomber. Likewise, the Soviets had already seen the writing on the wall in 1960, and cancelled the Myasishchev M-50 "Bounder" supersonic intercontinental bomber. NORAD reached the peak of its air defense power in 1962, and then quietly disbanded squadrons of fighters and missiles in favour of ballistic missile detection technologies. Once again, the evolution of C4ISR and strike technology had fostered a revolution in technology which had redefined the threat to the homeland defence perimeter.

RMA and the Evolution of Perimeter Defence

> "The Americans have once again launched a futile and cowardly attack upon us, hiding behind their great technology which god has given them."[61]
>
> Saddam Hussein - 3 September 1996

The current revolution in military affairs has been largely defined by the evolution of global strike as a method of warfare. Improvements in satellite reconnaissance and intelligence, precision navigation, strike weaponry and information networks. The ability of the United States to gather information and then convert it to precision strategic strike has largely defined its status as the sole remaining superpower in the modern age.

Thoughout the 1990's, technical evolution in C4ISR and precision striking power allowed defence of the North American perimeter to be focused primarily on a policy of expeditionary strike. Although the events of 9-11 have again focused efforts on the North American perimeter and internal security, fast-paced evolution in C4ISR and strike technology continue to underpin the enforcement of North American security policy overseas. Fighting the enemy "over there" remains a hallmark of North American defense policy, as demonstrated by the 2001 Invasion of Afghanistan and the 2003 Invasion of Iraq. As with previous "Revolutions in Military Affairs", the advent of the current RMA and its inherent global precision strike capability has begun to define the means and methods of future threats to the North American continent. The technologies and methodologies of the current RMA have most likely already planted the seeds for a future revolution in technology that will lead to its downfall.

In September 1996 Operation Desert Strike was conducted by the United States

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[61] Michael Russell Rip and James M. Hasik, The *Precision Revolution - GPS and*

against Iraq in retaliation for the Iraqi incursion into the Kurdish City of Irbil. This Operation was unique, as it marked the first battle in history in which all the weapons employed were autonomously guided to their targets. Fourteen BGM-109 Tomahawk land attack missiles were fired from two warships in the Northern Persian Gulf, with a further thirteen AGM-86C conventional air launched cruise missiles being launched by two B-52H aircraft operating from Diego Garcia in the Indian Ocean.[62] The technology employed in this attack represented the state of the art in Global strike, and was the result of a long evolution in C4ISR and strike technology.

In 1978 the US launched the first NAVSTAR GPS satellite for trials. GPS technology utilized precise timing and the orbital comparison of at least four different satellites in a low earth orbit constellation to provide positional and timing information within metres and nanoseconds to any place on, or above, the earth's surface. On 8 December, 1993 the system achieved initial operational capability after the last of the required constellation of 24 satellites was put into orbit. The achievement of GPS final operational capability was announced by Air Force Space Command on 27 April 1995.[63] The achievement of FOC meant that forces on the ground, at sea and in the air could now operate continuously with a hithero unknown degree of navigational precision, and coordination in timing, anywhere on earth. GPS timing signal were so precise that uses in civilian technology, such as coordination of timing signals for cellular phone networks, soon became commonplace. More importantly, the advent of GPS meant that autonomous weapons could now be guided to within a few metres of a target, in all

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the Future of Aerial Warfare. (Annapolis: Naval Institute Press, 2002), 3.

[62] Michael Russell Rip and James M. Hasik, *The Precision Revolution - GPS and the Future of Aerial Warfare*. (Annapolis: Naval Institute Press, 2002), 3-5.

[63] Michael Russell Rip and James M. Hasik, *The Precision Revolution - GPS and*

weather conditions, without the need for laser or electro-optic designation by a manned aircraft. The dangers to manned aircraft which had been evolved during the missile age, and peaked during the 1990-91 Gulf war, could now be neatly sidestepped without the recourse to expensive stealth or terrain hugging technologies. GPS represents the first of a number of precision position systems available for military and public use. The Russian GLONASS system now has 14 of its final 21 satellites operational, with further launches scheduled. The European Union has embarked upon the Galileo positioning system. Expected to be operational by 2008, Galileo will be fully compatible with the US GPS system, but will provide a measure of navigational redundancy and independence for European nations.

The autonomous weapons which use GPS for precision strike guidance can trace their roots to the revolutions in strike technology developed by Germany during the Second World War. The Henschell 293 and SD1400 Fritz X had both been developed as guided bombs to improve attacks against shipping. Radio controlled from the launching aircraft, both achieved respective success against Russian bridges over the River Oder and Allied shipping in the Mediterranean[64]. The Fieseler FZG-76 (V1) cruise missile was the first successful cruise missile in History. Used to bombard Britain in the latter stages of the Second World War, some 10,492 missiles were launched against Britain, with 2,419 reaching their target.[65] While not perfectly effective with its limited range and crude guidance system, the missile required an extensive effort in air defence to limit its combat effectiveness. Postwar studies indicated the FZG-76 had required a relative

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the Future of Aerial Warfare. (Annapolis: Naval Institute Press, 2002), 69.

64 Michael Russell Rip and James M. Hasik, *The Precision Revolution - GPS and the Future of Aerial Warfare*. (Annapolis: Naval Institute Press, 2002), 203-204.

65 Kenneth PWerrell, *The Evolution of the Cruise Missile*. (Maxwell:Air University

expenditure in defence resources on the order of three to one in order to defend against the threat it posed.

GPS has enabled the development of a new generation of cost-effective air launched munitions. By incorporating a GPS receiver with a ring laser gyro based inertial navigation system, the US was able to create a guidance tail section which could be attached to its existing stock of Mk 83 1000 lb and MK 84 2000 lb bombs. This development allowed the conversion of existing stocks of free fall munitions into precision guided weapons - the Joint Direct Attack Munition (JDAM). Other new developments in precision munitions, such as the small diameter bomb, wind corrected munitions dispenser, AGM-154 stand off joint weapon and AGM 130 missile have all been designed or converted to take advantage of GPS technology. Enhanced and new cruise missile technology have further been developed. The BGM-109 Tomahawk missile, Stand Off Land Attack Missile, and British Storm Shadow all represent cruise munitions designed to strike precisely at a point while the launching vessel remains well outside attack range of the defender. The sight of precision munition strikes against terrorist training camps in Afghanistan, Iraqi intelligence complexes, and Yugoslav government infrastructure have all helped define the age of "cruise missile diplomacy". Ironically, the crashing of two Boeing 767 aircraft into the twin towers of the world trade centre on 11 September, 2001 also represented an example of precision strike, as it was the 767's GPS based navigation system which allowed terrorists with basic flight skills to bring the aircraft within striking range of their targets[66].

Precision guided munitions, by their nature, have a large requirement for

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Press, 1985), 60.

66 Michael Russell Rip and James M. Hasik, *The Precision Revolution - GPS and*

intelligence information. The precision strike revolution has allowed both precision in striking traditional targets, and the capacity to strike targets which hitherto would have caused too much collateral damage to have been considered for attack under the laws of armed conflict. Provision of targeting information for precision strike weapons has therefore required a new magnitude of surveillance technology, high data rate communications and the use of overhead satellite, aircraft and uninhabited air vehicle (UAV) sensors. The precise details of the imagery, signal intelligence, and radar imagery resources available to support precision strike of military targets remain classified, however the capabilities of existing commercial systems give an idea of the art of the possible. GeoEye is a newly created company which combines the remote sensing capabilities of the IKONOS, OrbView-2, OrbView-3, and Indian Remote Sensing satellites. Multispectral imagery of the earth's surface with a ground resolution of 1 metre can be purchased commercially by any user. In addition, plans are underway by the company for OrbView-5, slated for launch in early 2007, which will have a ground resolution of 0.41-meters and offer both panchromatic and multispectral (color) imagery. Canada, Italy, Japan and the European Union also operate earth observing radar satellites. Project Polar Epsilon is a Canadian Government project to use RADARSAT 2 imagery to provide surveillance of the Canadian Arctic. RADARSAT 2 data will further be used by France to conduct surveillance of the ocean around the French possession of Kerguelen Island, in the south Indian ocean.

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the Future of Aerial Warfare. (Annapolis: Naval Institute Press, 2002), 424-427.

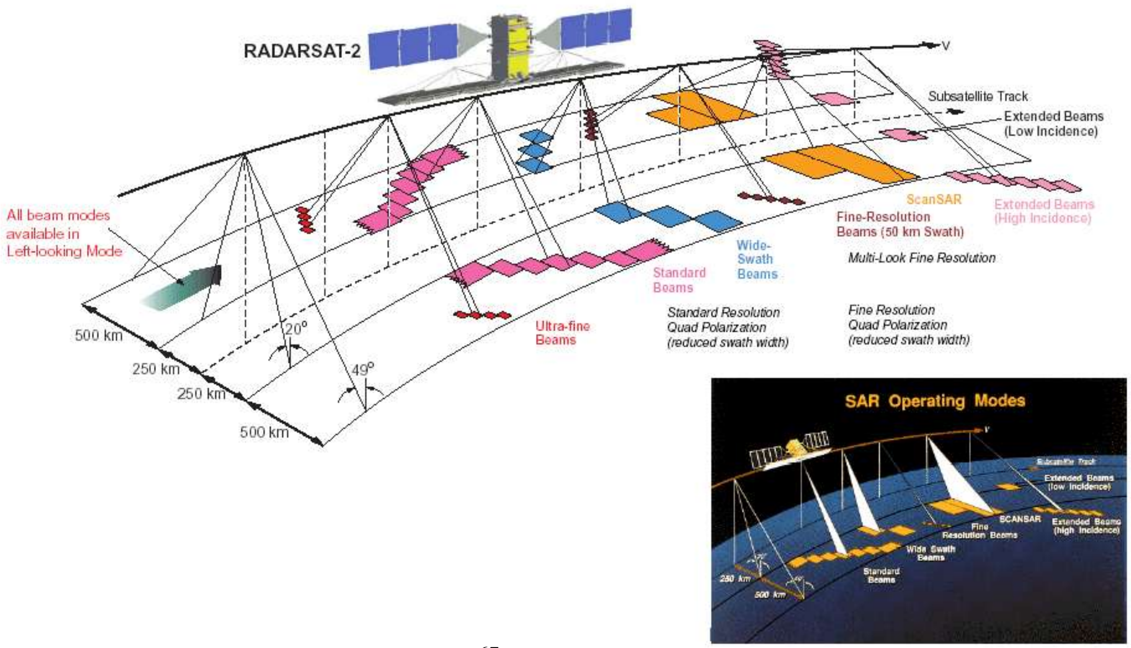

Figure 3.1 - RADARSAT 2 Imagery[67]

In order for collected air and space imagery to be useful to the precision strike process, reliable exchange of data across global distances must be achieved. Communications satellite technology has therefore been a mainstay of both military and commercial space exploitation since the earliest days of satellite technology. The first generation of US Milstar satellites, launched in the mid - 1990s, all had onboard EHF transponders which permitted high data rate transfer between strategic sensors, C4ISR hubs, and weapon shooters[68]. Commercial satellite technology and data transfer rates are equally impressive. The Iridium network of 66 low earth orbit satellites provides worldwide voice and low data rate communications from a simple telephone sized transceiver. Commercial "Ka band" broadband satellite communication systems, which promise worldwide communication at broadband internet speed, represent the next

67 Taken from http://www.radarsat2.info/rs2_satellite/overview.asp

68 Canada. Department of National Defence, *Space Appreciation 2000*. (Winnipeg: Directorate of Space Development, 2000), B-13.

technological leap forward in commercial communications. The envisaged network of several hundred low earth orbit satellites will fundamentally change the way data is moved, and allow such features as wireless internet connectivity from anywhere on earth.

The convergence of precision strike weaponry, satellite and airborne surveillance, high data rate communications, and intelligence assessment has been a powerful enabler for Global C4ISR and strike capabilities. However, perhaps the most important force behind the current revolution in military affairs has been the revolution in information technology. From its first uses in defensive systems such as the Semi Autonomous Ground Environment (SAGE), automatic data processing technology has evolved exponentially over the past fifty years. Equally important has been the revolution in information networking and interface technology. In 1965, the TX-2 computer in Massachusetts was connected via a low speed dial-up phone line to a Q-32 computer in California[69]. These early networks have evolved into the modern open networks such as

[69] Internet Society, "A Brief History of the Internet," http://www.isoc.org/internet/history/brief.shtml#Origins; Internet; accessed 13 March 2006.

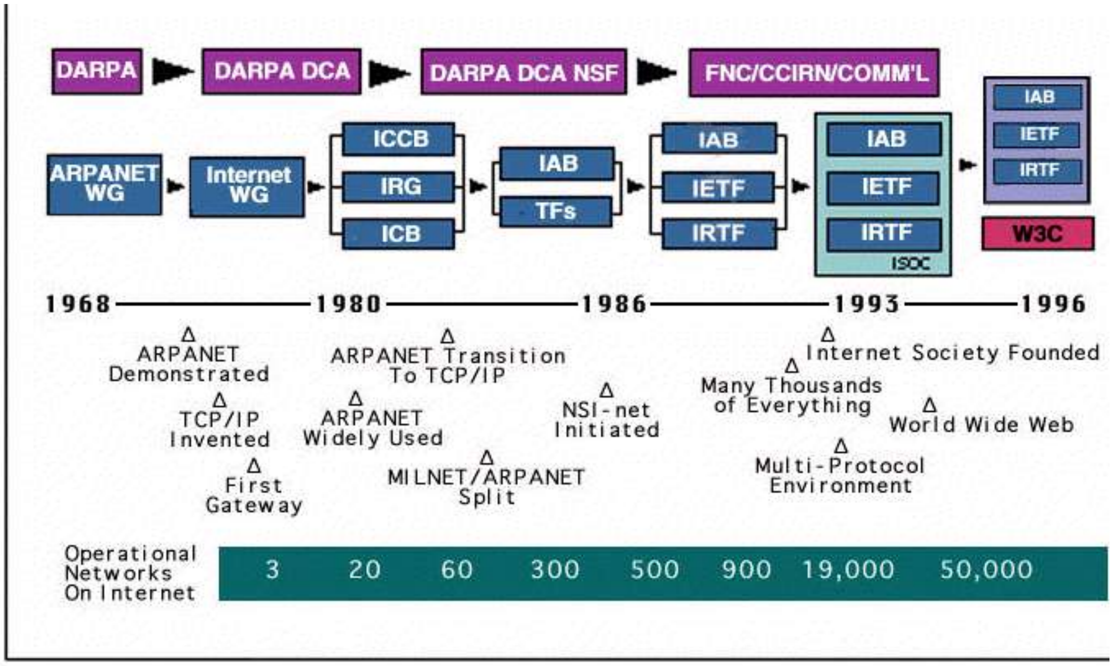

Figure 3.2 - Evolution of the Internet[70]

the Internet, and secure military networks such as SIPRNET, MCOIN II, and the Coalition Wide Area Net (COWAN). From its humble beginnings, evolutions in computer networking have evolved to allow automated information collection, assessment, sharing and fusion on a level never before achieved. This has been a particular enabler for military operations, adding enhanced connectivity and capacity to traditional military requirements for C4ISR. The basing of secure military networks on commercial software architectures and equipment has further allowed the use of commercial software such as web browsers, email, and chat nets to be employed to manage the ever expanding pool of information.

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[70] Timeline of the Internet., figure. Internet Society, "A Brief History of the Internet," http://www.isoc.org/internet/history/brief.shtml#Origins; Internet; accessed 13 March 2006

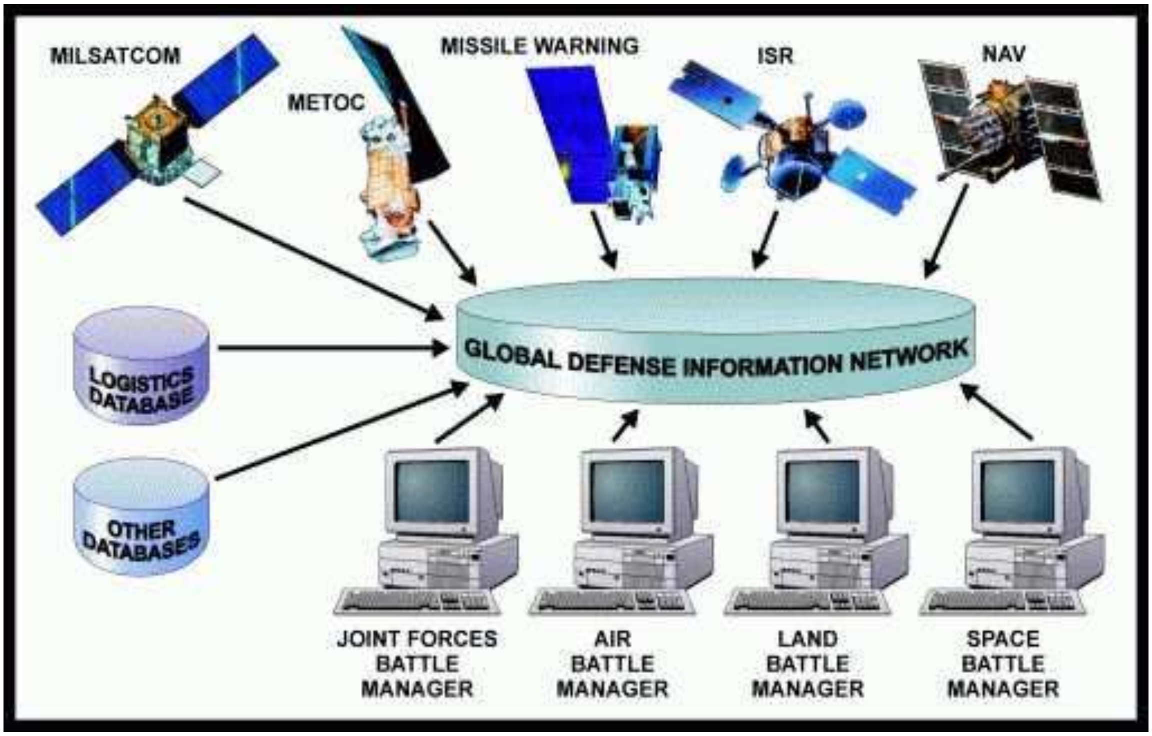


Figure 3.3 - Global Defense Information Network[71]

C4ISR and strike continue to evolve in tandem with rapid changes to technology, and its near term evolution will have fundamental impacts on the conduct of military operations in space, in the air, at sea and on land. Defense of the aerospace and sea approaches of North America will see particular impacts, many of which will be driven by rapid evolutions in space power. The United States Space Command "Long Range Plan" of 1998 laid down a vision for the future exploitation of space power by the United States. Since then, periodic updates have been provided in the Air Force Space Command Strategic Master plans for 2002, 2004, and 2006. The Strategy put forward has four pillars of development, the Control of Space, Global Engagement, Full Force Integration, and Global partnerships. Intended for implementation by the year 2020, the concept of Global Engagement, and the related enabling task of Global Surveillance, will have a

71 United States. United States Space Command Director of Plans, *United States*

particular impact on continental defence. Global surveillance and engagement effectively view the entire earth as being a part of the approaches to North America, and look to track all threats inbound to the continent from their source, fusing multi-sensor information via the global defense information network.

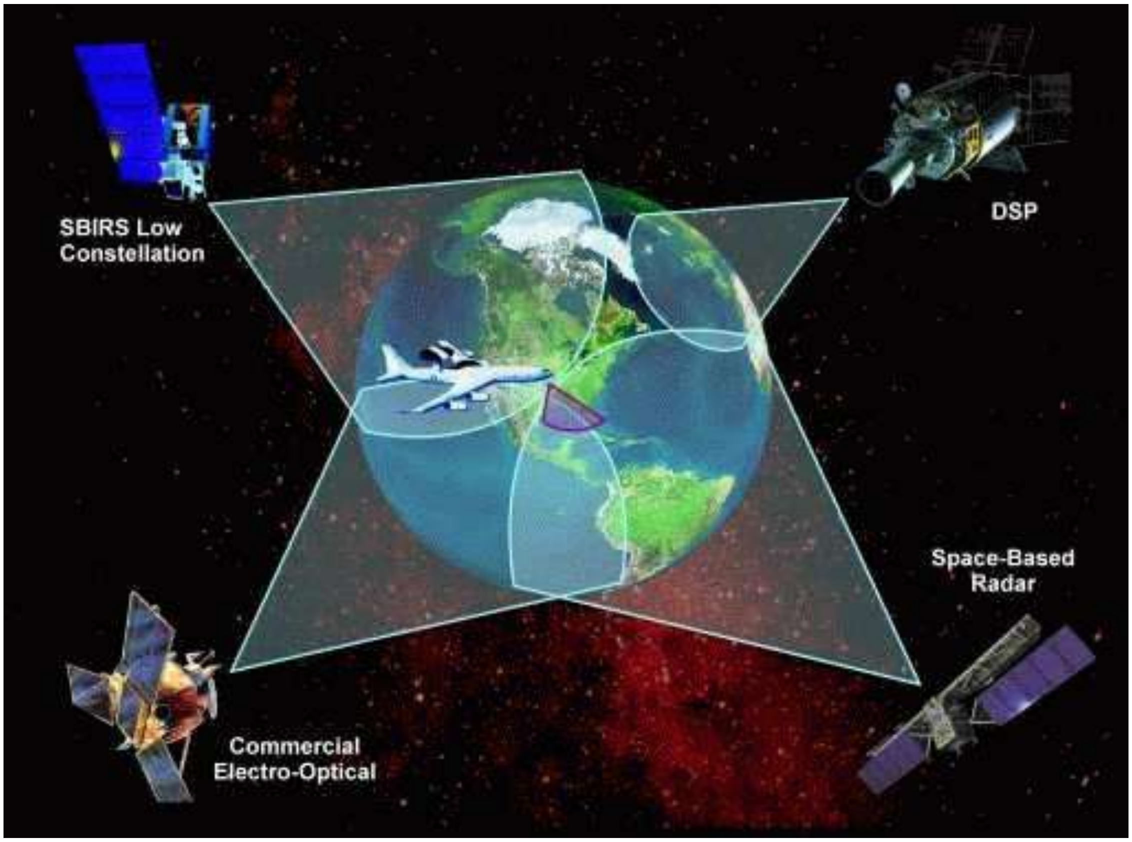
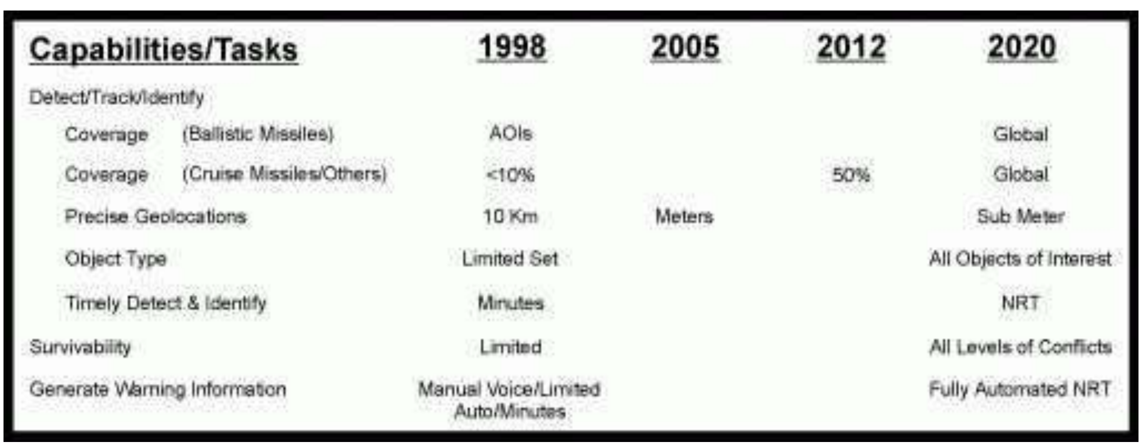


Figure 3.4 - Global Surveillance[72]

The intended surveillance capabilities are impressive. The geo-synchronous orbiting Defense Support Programme (DSP) satellites, which have provided early warning and tracking of ICBM threats since 1970, will be phased out in favor of an advanced geo-synchronous infrared system known as the Space Based Infra-Red System - High (SBIRS High). In addition to earlier detection and tracking of traditional ICBM

Space Command Long Range Plan, (Peterson AFB, 1998)
72 United States. United States Space Command Director of Plans, *United States*

threats, the SBIRS High system will provide initial warning and tracking of theatre ballistic missiles on a global scale. To further supplement missile tracking, the Space Tracking and Surveillance System (STSS), formally known as SBIRs Low, will establish a constellation of low earth orbit satellites to enable continuous Infrared tracking of missiles in space and within the atmosphere. Finally, and perhaps most impressive, will be the Space Based Radar (SBR). SBR, as currently envisioned, will consist of a constellation of satellites which will provide continual radar surveillance of the earth. In addition to its synthetic aperture radar and ground mapping features, SBR will incorporate moving target indicator technology, which will allow it to conduct air, sea and ground radar tracking missions currently performed by AEW and JSTAR aircraft. When all the elements of Global surveillance are incorporated, a continual space-based radar,



Capabilities/Tasks		1998	2005	2012	2020
Detect/Track/Identify					
Coverage	(Ballistic Missiles)	AOIs			Global
Coverage	(Cruise Missiles/Others)	<10%		50%	Global
Precise Geolocations		10 Km	Meters		Sub Meter
Object Type		Limited Set			All Objects of Interest
Timely Detect & Identify		Minutes			NRT
Survivability		Limited			All Levels of Conflicts
Generate Warning Information		Manual Voice/Limited Auto/Minutes			Fully Automated NRT

Figure 3.5 - Warning capabilities and Goals[73]

Infra-red, high resolution imagery, and electronic intelligence sensory network will conduct continuous real time surveillance of the entire surface of the earth and its

Space Command Long Range Plan, (Peterson AFB, 1998)

[73] United States. United States Space Command Director of Plans, *United States Space Command Long Range Plan,* (Peterson AFB, 1998)

atmosphere. This surveillance network will be connected via high speed satellite communications to complimentary networks of ground based sensors, local air-based sensors - such as UAVs and AEW aircraft, and data fusion networks with automated data correlation features. Global Engagement, from forward deployed strike platforms such as cruise missile equipped SSBNs or continental ICBM assets with conventional warheads, and precision guidance will complete the sensor to strike network.

The implications for the defense of the continent from external threats are profound. The most obvious impact will be the lifting of the threat of ballistic missile attack for the first time in over two generations. Integrally linked to the US Space Command vision has been the development of a credible ballistic missile defence system by the United States Missile Defense Agency (MDA). Progress on the missile defence system has been rapid. Eight ground based interceptors have now been installed at Fort Greely Alaska, with a further two at the Ronald W. Reagen Missile Defense Site at Vandenberg Air Force base in California. Upgrades to the existing Ballistic Missile Early Warning System (BMEWS) and perimeter radars (PAVE PAWS) have been made to enable refined ballistic missile tracking and provision of targeting information. The floating X-Band radar for mid course tracking and kill assessment has completed sea trials and has been moved to Pearl Harbor for further employment. Successful kinetic intercept trials have been conducted for the ground based interceptor missile, Navy Standard SM-3 Missile, Patriot PAC-3 missile and Theatre High Altitude Air Defense (THAAD) missile system. The Airborne chemical laser has completed ground trials and is on track to be operational by the end of the decade. In short, a functional missile defense capability will soon exist for the continent.

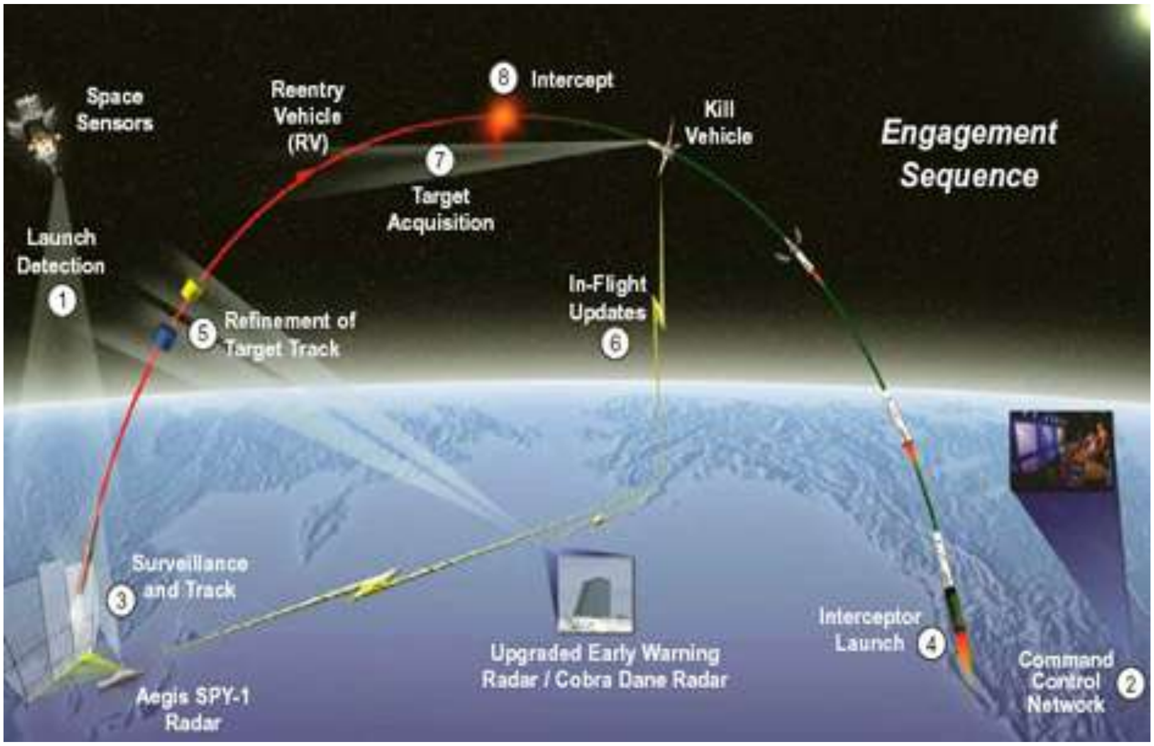


Figure 3.6 - Ballistic Missile Defence[74]

The next two decades will also likely further see the elimination of air threats to the continent. Continuous radar and infra red surveillance from space will be a key determinant, but other technical innovations will have equal impact. To begin, long range radars such as the Australian Jindalee system will add a measure of depth to space and ground based air defences. In operation in Australia since 1999, the Jindalee system utilizes ionospheric propagation to detect aircraft using high frequency radio waves at ranges beyond 3000 kilometeres. Stealth aircraft technology is ineffective against such radars, as the angle of reflection from the ionosphere is different from that of ground radars for which stealth technology was designed. Radar absorptive materials used for stealth aircraft are further ineffective, as they were designed for use against microwave

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74 Image taken from http://www.cbc.ca/news/background/us_missiledefence/

radars, not the high frequency band radars employed by Jindalee.

Upgrades to C4ISR technology in the tracking of civil aviation will further monitor the air environment. The North American Aerospace Surveillance Council, composed of representatives from NORAD, the FAA and NAV Canada have embarked upon a North American Air Surveillance Plan (NAASP) that is broad in scope. In addition to upgrading existing perimeter and interior air radars, the plan calls for the development of newer surveillance and tracking technologies. High altitude radar airships are on the agenda, with plans in place by Raytheon to develop a Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS). More fascinating is the use of passive coherent location, which uses existing atmospheric signals such as television, radio and cell phone signals to passively detect moving targets[75]. Finally, multilateration, a system in which a signal broadcast from an aircraft is triangulated is under development. This system would be complimentary to FAA plan to introduce the Automatic Dependent Surveillance Broadcast (ADS-B), essentially a VHF transmission of aircraft position, speed and heading. The end result of these surveillance upgrades, and information networking, will be an integrated air defence picture for North America against all future airborne threats. The use of continental airspace and its approaches to conduct an attack from outside, or within the continent, will have become virtually untenable.

Similar waves are taking place at sea. Satellite tracking of surface ships by satellite radar and electronic means has been successfully achieved, albeit intermittently, since the Cold War. The advent of a persistent space based radar system, network correlation of electronic intelligence from miltiple sources and fusion with internet port

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[75] Rich Tuttle. "Mind the Gap." *Defense technology International,* January-February 2006, 25-29.

and cargo information will allow continuous tracking of ships through their entire

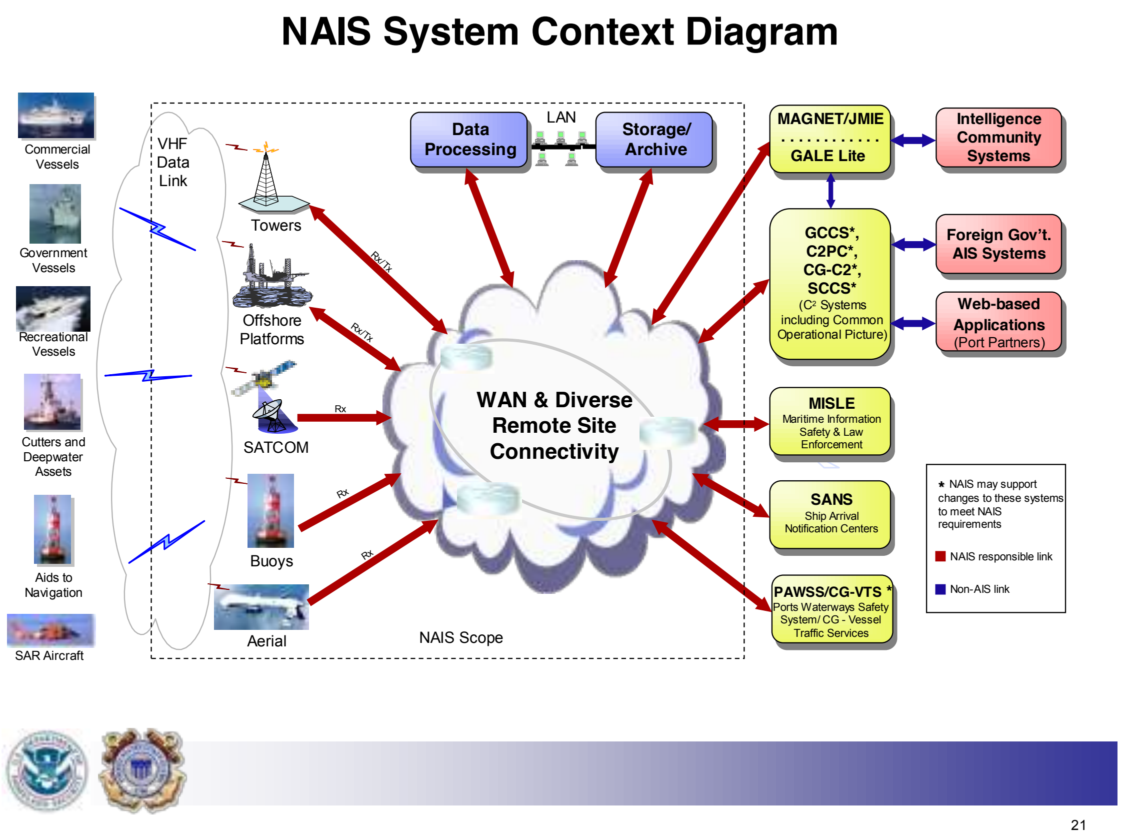

Figure 3.7 - Maritime Domain Awareness - Automatic Identification System[76]

passage. The approaches to the east coast of Canada are now monitored by a High Frequency Surface Wave Radar System, which uses surface wave propagation of radio waves to track ships several hundred miles offshore. Additional funding has been earmarked to further expand this network to the west coast. The most interesting technology by far revolves around the Automatic Identification System (AIS), which became a regulatory requirement for all merchant shipping in December 2004. AIS broadcasts a ship's identity, position, course and speed to all ships within VHF radio range. By equipping ports, buoys, offshore rigs and patrol vessels with a networked AIS

76 Commander Brian Tetreault, Presentation on Use of the Automatic Identification

system connected by Iridium or similar technology, the identity and position of all commercial vessels within VHF range of the network can be tracked. Better still, if an AIS transponder is placed on a low earth orbit satellite, wide area surveillance of the AIS identities of ships at sea can be achieved. The U.S. Coast Guard will conduct trials on such a system in 2006. Should trials progress to a satellite constellation, worldwide real time monitoring of all vessels at sea will become reality. Finally, GPS transponder tracking of shipping and individual containers have now become a commonplace feature of commercial exchange. Multiple inputs as to a cargo vessels position are therefore generally available, if the proper techniques for integrated data fusion are applied. The key to achieving such an integrated maritime picture is data fusion in a dedicated maritime surveillance centre, such as are presently maintained by the Canadian Navy and US Coast Guard. With the impending adoption of maritime surveillance as a standing NORAD mission, the potential for covert seaborne use of the continental approaches to attack the North American perimeter would seem remote.

Clearly, the present and near future state of Global C4ISR and Strike technology would seem to be rendering the air, sea and space approaches to North America invulnerable to attack by conventional means. However, as examples in the history of air power and sea power have shown, supremacy in C4ISR and Strike technology normally define the technologies which will ensure their own demise. In the case of North America, the premise that five percent of the world's population and intellectual talent will continue to hold a dominant position in Global Surveillance and Global Engagement for a prolonged period would seem unlikely, as clear economic, military and population pressures will eventually create the conditions for a successful challenge. In examining

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System for Maritime Domain Awareness, 17 October 2005.

the potential for a future technological revolution, the impacts of information networking, weapon proliferation, space control and the underwater environment will be considered.

The advent of the World Wide Web has fundamentally changed the way the human race gathers, and exchanges information. A personal computer, video device and document scanner have the capacity to turn any individual into an information node. In the era of international air travel, the dispersal of persons and information is commonplace, and largely undetectable. Al Qaeda terrorist cells have made use of these technologies to share information in the past, and it is reasonable to assume that the capabilities of foreign states are, and will be, more competent in their usage. The transfer of information between distant parts of the globe is easily achieved by means other than the internet. Commercial delivery, intercontinental fibre-optic links, and indigenous satellite links all have utility. The compilation of useful satellite data is no longer the purview of space age nations. In 2005 no less than 41 satellites in earth's orbit provided imagery or radar data of the earth's surface to the commercial market[77]. As a matter of comparison, the program Google Earth can be downloaded for free and offers medium resolution imagery of most North American cities, again for free.

The ability to gather, assess and communicate information does not translate into a direct threat against North America, but proliferation of weapons technology does. Nuclear technology altered the dynamics of air power in the strike role nearly fifty years ago, and still poses a latent threat to the continent due to legacy ICBM forces. The principle threat of nuclear technology arises from the fact that the technology is now over sixty years old. Over time, a number of players have joined - and departed - the nuclear

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77 Canada. Department of National Defence, *Space Appreciation 2000*. (Winnipeg: Directorate of Space Development, 2000), B-7.

club. Russia and the United States have been involved in the weaponry since the beginning of the Nuclear age. Second tier powers such as Britain, France and China joined shortly thereafter. Israel, with exceptional requirements for a strategic deterrent has pursued a policy of neither admitting nor denying its possession of nuclear weapons since the early 1970's. India and Pakistan, for their own deterrent reasons, have embraced the technology. South Africa, after construction of some six weapons, became the first country to revoke nuclear weaponry in the late 1980's. Other players continue to enter or drift around the field. North Korea persists in nuclear sabre rattling, and its efforts to convert its stockpiles of fuel into a usable nuclear weapon continue. Iran has recently come to blows with western diplomacy in asserting its right to possess civilian nuclear power facilities, and weapon grade enrichment facilities. Libya turned over its wholesale collection of Pakistani supplied enrichment centrifuges, and thereby entered a new age or cordiality with the west. Rumors further persist that Al Qaeda terrorists managed to acquire a "suitcase" atomic weapon in the 1990's due to the turmoil following the breakup of the Soviet Union, and are awaiting the right opportunity to bring it forth.

Given enough time, it would seem inevitable that the necessary material, techniques and "ancient" atomic knowledge base will become available to build an atomic weapon - despite the efforts of the nuclear non-proliferation regime. The probability of such a regime holding fast in the presence of near perfect Global Surveillance and Global Strike technology would seem low, given the legitimate security concerns of the rest of the world. The propensity of North American defense policy to take the fight to the enemy, our recent record of Eurasian deployments, and the security implications for other states of the new Western concept of "Responsibility to Protect" would further seem to push nuclear proliferation as an ultimate guarantor of security against outside interference for some nations. In the case of Iran and North Korea, this is likely already the case.

Although nuclear weapons do not hold more of a threat to North America than any other conventional massed kinetic or chemical weapon, they do have the some of the largest gain for the amount of volume transported, which is always an advantage when attempting to slip under a Global surveillance net. Perhaps more troubling is the thought that bacteria and viruses are smaller still. Biomedical research across the world has advanced by leaps and bounds over the past century, and modern transport and delivery systems are more than capable of transporting a deadly cargo outside the eyes of conventional surveillance techniques. Finally, nanotechnology has commenced creating small machines which were deemed beyond the technical possibilities of a decade ago. The detectability of nano-machines by a Global surveillance network would seem small, no matter how detailed the wide area sensor or network. Indeed, nano-machines designed to physically attack information fusion networks at a given time and place would seem to offer great promise in achieving foreign policy aims. Identifying the precise instrument which has the best possibility of rendering modern C4ISR and strike networks obsolete is unimportant. However, understanding that an instrument will likely come along in due course which achieves that aim, is.

Finally, in reviewing the potential threat to the perimeter one must consider the medium(s) which might profitably be used to threaten the continent. The control of space is one of the stated goals of US Space Command, particularly in protecting own force assets and denying the effective use of space to an adversary. Although the 1967 Outer

Space Treaty prohibits the use of celestial bodies for military activities, and the placing of weapons of mass destruction in orbit, the military use of space to accomplish national means cannot be discounted. The viability of future space communication, navigational and surveillance technologies are essential to the concepts of Global Surveillance and Global Engagement. Space assets therefore represent a critical enabler which would form the logical target of a future adversary. Just as the freedom of the seas was denied to the battleship, it may be expected that freedom of space may be denied to North American defence. With the Chinese space programme striving to place a man on the moon, and the Indian space programme actively investigating the problem of placing a man in orbit, a large portion of the earth's population has begun to consider the implications of space control on their own national interests. Space denial may become the Achilles heel of space power, as sea denial was for sea power.

However, beyond the technology of orbital vehicles and Hohman transfer orbits, a far simpler technology and means of delivery may prove the undoing of the C4ISR and Strike technology guarding the continent's approaches. Seventy percent of the earth's surface is water, and a few centimeters below that surface the electromagnetic waves

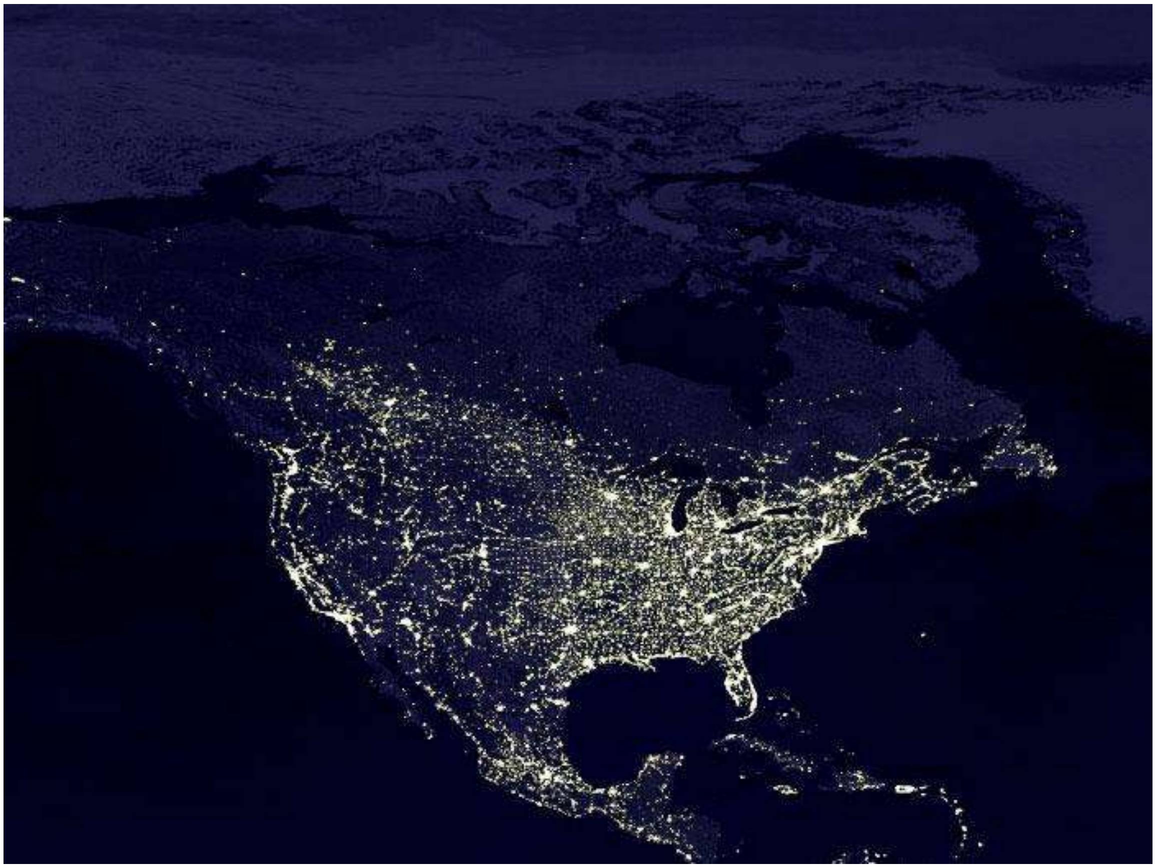

Figure 3.8 - North America at Night[78]

which constitute the primary means of wide area surveillance from both space and air are attenuated to the point that they are no longer receivable. Water is a difficult media for the transmission of all forms of energy except sound. Water further surrounds all sides of the North American continent, and - as can be seen in Figure 3.8 - provides proximate access to a large majority of the North American population. Hiding a weapon under the sea has been a practical exercise since the advent of Bushnell's "Turtle" in 1776, and the most recent rendition of this concept - the SSBN - is now a fifty year old technology. The construction of the new Chinese type 094 SSBN, the continued advancement of the Indian Navy's Advanced technology Vehicle and the wholesale acquisition of a derelict

78 Image taken from http://antwrp.gsfc.nasa.gov/apod/image/0011/earthlights_dmsp_big.jpg

Golf Class SSB by North Korea from a Japanese breaking yard should therefore not be surprising. The sea has proven itself a useful store for strategic strike weapons, particularly if the storage can remain very quiet. Autonomous underwater vehicles are also generally extremely quiet, and have carried useful loads since the invention of the earliest torpedo. Further silence and efficiency over long range can be achieved by the slocum glider, a simple cylinder which uses economic changes in buoyancy to glide underwater over long distances. The ease of global navigation and precision timing due to GPS offers limitless opportunity for use of the underwater media as a method of circumventing the global surveillance net. A Mari Usque Ad Mare should be viewed in circumspect when considering potential future threats to continental security.

For the past two and a half centuries, C4ISR and precision strike technology have provided the principle means to ensure the continental security of North America. Over time, these methods have changed, and various revolutions in military affairs have impacted the efficacy of the technological means in use. More often than not, supremacy in C4ISR and precision strike technologies has spawned a counter-revolution in technology which has redefined continental defense requirements. The latest Revolution in Military Affairs, and its prospects for near term evolution, would appear to be on track to deliver an unparalleled level of security to the continent and its approaches. However, if the history of sea power and air power in defence of the continent are reliable indicators, the seeds of technical counter-revolution have already been planted. Maintaining a constant watch toward technical trends has been, and will remain an integral process to ensuring the future security of the continent.

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