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**NAVAL
POSTGRADUATE
SCHOOL**

MONTEREY, CALIFORNIA

THESIS

**CREATING AN EFFECTIVE MULTI-DOMAIN WIDE-
AREA SURVEILLANCE PLATFORM TO ENHANCE
BORDER SECURITY**

by

Randall S. Parsley

March 2008

Thesis Co-Advisors:

Richard Bergin
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**CREATING AN EFFECTIVE MULTI-DOMAIN WIDE-AREA SURVEILLANCE
PLATFORM TO ENHANCE BORDER SECURITY**

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B.A., Colorado Christian University, 1998
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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)**

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ABSTRACT

North American Aerospace Defense Command (NORAD) and United States Northern Command (USNORTHCOM) lack persistent, multi-domain, wide-area surveillance (WAS) to conduct their assigned homeland defense and homeland security missions. Wide-area surveillance allows military operators to see vast expanses of the homeland. For example, it is the difference between a view of Texas and a view of the broad U.S. southern border – from Texas to California. With WAS, the Department of Defense (DoD) would have access to the big picture. Without WAS, gaps in radar coverage could allow potential terrorists — or people transporting drugs into the United States — to cross the border undetected. DoD or Customs would never see them.

This thesis examines how NORAD-USNORTHCOM could and must achieve consistent, wide-area surveillance for the U.S. borders, both southern and northern. This can be achieved by combining the existing manned and unmanned radars with Over-the-Horizon Radars capabilities. By combining all three systems to form a family of radar surveillance systems, working as one consistent radar surveillance system, NORAD-USNORTHCOM will be more effective in homeland defense and homeland security missions.

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I. PROBLEM STATEMENT

North American Aerospace Defense Command (NORAD) and United States Northern Command (USNORTHCOM) lack persistent, multi-domain, wide-area surveillance (WAS) to conduct their assigned homeland defense and homeland security missions. Wide-area surveillance allows military operators to see vast expanses of the homeland. For example, it is the difference between a view of Texas and a view of the broad U.S. southern border – from Texas to California. With WAS, the Department of Defense (DoD) would have access to the big picture. Without WAS, gaps in radar coverage could allow potential terrorists — or people transporting drugs into the United States — to cross the border undetected. DoD or Customs would never see them. NORAD and USNORTHCOM do not have consistent low-level (low-level is any target that is below 2,000-3,000 feet above ground level) or 24/7 coverage along the southern, northern, eastern or western borders or shorelines. This lack of low-level coverage causes NORAD and USNORTHCOM's Area of Responsibility (AOR) to be vulnerable to low-flying aircraft, maritime assets that include vessels that range from small, privately owned vessels to large tanker, and land assets.

USNORTHCOM AOR is an imaginary line around the United States that extends approximately five hundred nautical miles from the shoreline to Alaska. Canada has its own command, Canada Command, which is now handling all Canadian domestic homeland security and homeland defense missions within Canada. They are working closely with USNORTHCOM, which would come to the aid of Canada if needed. The absence of constant and consistent surveillance capabilities along U.S. land and maritime borders means that America is effectively unable to monitor individuals and groups attempting to access its territory; this, clearly, has significant implications with respect to defending and securing the U.S. homeland from terrorist and criminal threats. Failure to effectively monitor land borders and maritime boundaries means that America is not only vulnerable to individual terrorists accessing her territory, but also, given the remoteness of many land borders and most maritime boundaries, to the introduction of larger weapons systems, including weapons of mass destruction. Given this threat, and the

inability to create a robust and comprehensive surveillance and monitoring system, we are faced with the potential of a serious breach of security with devastating implications for the security of the American homeland and American citizens.

A. DEFICIENCIES IN EXISTING SYSTEMS

Current surveillance technologies can be divided into two categories of systems: manned and unmanned. Manned systems include Airborne Warning and Control Systems and Joint Surveillance Airborne Radar Systems, which are systems that fly specific airborne missions for the DoD. Unmanned Platforms include High Altitude Airships and Tethered Aerostats Radar System, in which no personnel are flying on the platforms. Airships and Tethered Aerostats are based on the same principle, as both are balloons. High Altitude Airships involve a larger, possibly thicker, balloon, but appearing identical to a tethered aerostat. The main difference will be that TARS is tied to a tether and the HAA is driven by a motor. Unmanned platforms are remotely operated from the ground by a person sitting in front of a screen that looks like a computer game; most of the time the individual is located hundreds of miles away. Both manned and unmanned systems are weather dependent, which means that both platforms lack the capacity for full-time, year-round surveillance of land and maritime boundaries.

In addition to the inability to operate in all types of weather conditions, existing systems have other problems.

Tethered Aerostats Radar Systems (TARS) have been around for over twenty years, and the number of operating systems has been reduced from ten to six over the past eight years. Losing four systems has created gaps in radar coverage. Even with the Joint Surveillance Radar System (JSS) helping with overlapping coverage with TARS, there are still holes in the coverage. JSS has a nice surveillance footprint and, with the curvature of the earth, the radar will have blind spots, precluding the surveillance of aircraft flying at lower levels (below 2,000-3,000 feet above ground level). Aircraft can hide behind hills and mountains where the JSS radar cannot see them. TARS are capable of seeing targets if they are at altitude and are able to look down in the valleys. If weather is a factor, however, TARS would have to be lower in altitude, thus not able to see low-

flying targets. Employing Airborne Warning and Control Systems (AWACS) and Joint Surveillance Airborne Radar System (JSTARS) to fill these gaps in the radar detection is very expensive; because of expense and current Operational Tempo, the military is reluctant to employ either system unless it is a high-visibility mission or it has good intelligence of a high-interest target. AWACS and JSTARS could be used to fill gaps when radars are down or when the DoD agrees to take the risk of not pursuing radar coverage in a particular area.

Consistent low-level and wide-area surveillance is not currently. Even if all the AWACS and JSTARS were available, they could not keep a continuous, all-altitude and all-domains (air, land and sea) surveillance.

Wide Area Surveillance (WAS) has extended and has become a factor since 9/11. The lack of WAS to include low-level aircraft, maritime and land assets. If the next terrorist attack happens, it could come from any of the domains or come across one of the borders.

B. RESEARCH QUESTION

Could manned and unmanned platforms, combined with Over-the-Horizon Radar (OTHR) become a family of systems and become DoD's primary future surveillance system for border security missions?

C. LITERATURE REVIEW

The research shows that leading DoD personnel have recognized the need to improve the early warning and wide-area surveillance functions in the low-level, maritime domain, as well as borders capabilities. Four categories will be discussed in this literature review: manned platforms, unmanned platforms, Over-the-Horizon Radar (OTHR), and a platform currently in use in Australia, known as the Jindalee Operational Radar Network (JORN). Both manned and unmanned platforms are currently operating in the United States.

1. Manned Platforms

Manned platforms consist of any airborne platform that has to be operated by an individual. Those platforms consist of Airborne Warning and Control System (AWACS), Joint Surveillance Airborne Radar System (JSTARS), Rivet Joint and Hawkeye Early Warning Aircraft. For this review, only two systems are discussed for the manned platforms: AWACS and JSTARS, both of which are now used by the United States Air Force. The AWACS is a modified Boeing 707-320 with Westinghouse Doppler radar and an Identification Friend or Foe IFF/SIF (Selective Identification Feature) interrogator installed in a rotating rotodome above the fuselage.

The AWACS has an unusually robust communications suite, which includes more than a dozen ultrahigh frequency (UHF) radios, two high frequency (HF) radio, and two satellite-communication radios (SATCOM).¹

It usually carries more than twenty personnel. JSTARS is a joint effort with the Army. The JSTARS is a surveillance platform similar to AWACS except that its radar scans the ground, rather than the air. As the name suggests, the JSTARS is a joint project between the Army and the Air Force. Both the Army and the Air Force were seeking a platform that could identify, target and prepare to attack second-echelon forces. These forces are usually one hundred and fifty miles from the forward line of their own troops (FLOT) and may engage friendly ground forces within two to three days. Army doctrine emphasizes engaging this type of target as “preparation of the battlefield.”²

Army corps commanders can task and receive data from JSTARS via a weapons system unique data link to a Common Ground Station (CGS). The CGS is portable and can be carried on a five-ton truck or on a high-mobility, multipurpose, wheeled vehicle (HMMWV, pronounced Humvee). An individual JSTARS can interface with more than

¹ Military Analysis Network (FAS), “Airborne Warning and Control System (AWACS)” <http://www.fas.org/dod-101/sys/ac/e-3.htm> (accessed January 8, 2008).

² Douglas M. Carlson, Joint STARS. Success in the Desert. What Next?” research paper (Maxwell AFB, Alabama: Air War College, April 1992), 1. <http://stinet.dtic.mil/oai/?&verb=getRecord&metadataPrefix=html&identifier=ADA258360> (accessed November 4, 2007).

twelve CGS.³ While the JSTARS is the only sensor connected to the CGS, the CGS also receives data from numerous other Army Intelligence sources and is seen as an essential element of the corps commander's intelligence preparation of the battlefield.⁴

The JSTARS radar contributes to the commander's preparation of the battlefield by providing two types of information: the location and movements of vehicles, and detailed maps. The radar can make detailed pictures of the ground "capable of discriminating specific items such as vehicles, buildings and aircraft, but without highlighting moving targets."⁵

JSTARS aircraft are so new to the inventory that their acquisition is not yet complete. Originally, the JSTARS was built on refurbished Boeing 707 airframes, which drives up maintenance costs more quickly than if a newer airframe were used. Additionally, only a limited number of aircraft were purchased for the JSTARS system (seventeen) as opposed to thirty aircraft that were purchased for the AWACS. Despite the different missions of the two aircraft, the crew complement of the JSTARS is very similar to that of the AWACS. The JSTARS typically carries twenty-two to thirty-four individuals, divided into the same four functional areas as AWACS (flight personnel, technicians, surveillance personnel and weapons directors), plus an airborne intelligence officer or technician. While flight and weapons personnel are all Air Force members, the surveillance section includes Army personnel. Because of its intelligence mission, in JSTARS, both the surveillance and weapons sections are roughly equal in importance. Like AWACS, JSTARS can only see a limited distance behind front lines, whereas unmanned platforms of HAA and UAS assets can see far beyond enemy lines without limitation because of the orbiting altitudes of 60,000–65,000 feet). Orbiting at these altitudes expands their horizon capability and they are unmanned, so this keeps personnel out of harm's way.

³ Richard J. Yasky, "Changing the View of Operational Surveillance," research paper (Newport, R.I.: Naval War College, June 17, 1994), 13.

⁴ Kenneth K. Young, "Operational Consideration of Joint STARS: Are We Missing the Opportunity?" research paper (Newport, R.I.: Naval War College, February 7, 1997), 5.

⁵ Ibid.

Part of the crew on the JSTARS is Army personnel. Both manned platforms are great platforms, but are very expensive to operate; the detection range is suspect, and the availability rate is getting worse each year because the aircrafts are over thirty years of age. Opposite of the manned platform is the unmanned platform.

2. Unmanned Platforms

Unmanned platforms are any aircraft, including drones, balloons and airships, on which no individuals are performing operations. All personnel are on the ground controlling all function of the platform. Various types of unmanned platforms include High Altitude Airships (HAA), Tethered Aerostat Radar Systems (TARS) and Unmanned Aircraft Systems (UAS), which have different platforms to conduct their mission because of different companies fielding platforms: High Altitude Airships (currently, the funding has been lifted off this program, but Congress is behind the program) and Global Observer High Altitude Long Endurance (HALE) Unmanned Aircraft System (UAS). Both of these systems have the capability of staying airborne for seven to thirty days without interruption, and are capable of tracking ground and surface targets. Because of this, they can be used for Missile Defense. Additionally, personnel can operate systems without being put in harm's way.

Navigating through lower airspace to get to the operational altitude between 60,000–65,000 feet — and avoiding other air traffic and weather — is challenging. The same is true for another unmanned platform, UAS.

NORAD is also evaluating Global Observer High Altitude Long Endurance (HALE) Unmanned Aerial System (UAS).

NORAD recommends supporting the Joint Capability Technology Demonstration (JCTD) efforts (sponsored by USSOCOM) and evaluating the potential of Global Observer to contribute to both NORAD and USNORTHCOM missions.⁶

⁶ NORAD-USNORTHCOM, *Point Paper on Global Observer*, Colorado Springs: NORAD-USNORTHCOM, 2007.

Global Observer is a UAS capable of flying at 55,000–65,000 feet for up to seven days on-station with a 330-pound payload. The prototype Global Observer plans to spiral to the Falcon Global Observer that has a larger wingspan, can carry 1,000 pounds and add one more day on-station.

NORAD believes the objective Falcon Global Observer vehicle can be a valuable near-term gap-filler as a surveillance sensor platform to defend against low altitude/low observable threats, including cruise missiles and lethal Unmanned Aerial Vehicles.⁷

UAS can detect objects while orbiting over water. It can also detect objects over land, as can TARS, which is conducting the mission along the southern border of the United States.

The final member of the unmanned platforms is TARS. Tethered Aerostat (TARS) are the two unmanned platforms. TARS have been operational for over twenty years along the southern border. The system is a balloon base, meaning the airship and aerostat has weather dependencies, attached by a tether, limited to 250 nautical miles (footprint) of surveillance range. Reduced operational availability funding is being lifted yearly. During the late 1990s, TARS had ten operational systems operating along the southern border. With the cuts in defense spending and more money going to the Middle East to fight the war on terrorism, the program has been hit hard, and they have been reduced to six fully operational systems. TARS can stay airborne for about five days without being taken off station, unless weather is involved, and is not a system that takes a large amount of personnel to operate.

TARS are not as heavy on the personnel endeavor because all the platforms are unmanned. TARS have approximately five people per crew, to be available 24/7 to launch, monitor and recover. All three systems in the unmanned platform are good surveillance systems, but the one system that can accomplish all three missions would be Over-the-Horizon Radar.

⁷ NORAD-USNORTHCOM, *Point Paper on Global Observer*.

3. Over-the-Horizon Radar

Worldwide, only two operational OTHR radar systems exist at this time. One is in the U.S. and looks toward South America; the other one is in Australia. The one in North America is used for drug interdiction (mainly by JIATF-South and Customs).

In 1956 the Naval Research Laboratory concluded a definitive set of experiments that showed that the ionosphere is generally sufficiently stable for High Frequency (HF) sky wave radar to succeed for over-the-horizon aircraft detection.⁸

Use of the High Frequency (HF) Band (3 to 30 Megahertz) permits extending radar ranges beyond the horizon, 500-2,000 nautical miles, using sky wave propagation where the ionosphere can be thought of as providing a virtual mirror. In addition, modest extensions of line-of-sight range can be obtained in this frequency band by using surface wave propagation over the sea. In the Naval Research Laboratory's (NRL) initial development program of HF over-the-horizon radar, essentially all of the elemental feasibilities were discovered and demonstrated.⁹ OTHR radar uses the "bounce" system, in that when a signal is sent, it bounces off the ionosphere. Everything is signal bounce; it goes further but gets weaker. This bouncing off the ionosphere enables the system to see a very long way. OTHR is capable of targeting and identifying ships over 1,000 miles from the transmit site. All operational HG sky wave radar designs rely heavily on 1970's thinking and technology. They scan serially in azimuth and range (frequency) to cover an area where scan rates are governed by coherent dwell and revisit requirements. This mode of operations previously required multitasking for different class targets, one at a time. It now has the capability to simultaneously track multiple targets including aircraft, ships, missiles and sea states. By sharing information with Australia, OTHR has been able to employ a parallel target-tasking philosophy, which increases performance capability against a particular target class and enables multitasking.

⁸ G. K. Jenson and C. L. Uniacke, "Spectral Bandwidth of Backscatter Signals," *NRL Report 4976*, August 1957.

⁹ J. M. Headrick, and M. I. Skolnik, "Over-the-Horizon Radar in the HF Band," *Proceedings of the IEEE* 62, no. 6, June 1974.

4. JINDALLE Operational Radar Network (JORN)

JORN was not born overnight but as the result of a long series of experimental and theoretical studies, negotiations with authorities in Australia and the U.S., and a good deal of wheeling and dealing in the 1970s — at a cost of \$1.8 billion dollars. The Australian JINDALLE Operational Radar Network (JORN) was activated in May 2003. JORN provides wide-area surveillance (WAS) of air and sea approaches up to 3,000 km (unclassified distance) away from Australia's coastline. JORN is designed to monitor air and sea movements across 37,000 km of largely unprotected coastline and 9 million square kilometers of ocean. It is being used to cast a security shield across Australia's remote northern approaches without the high cost of maintaining constant maritime and air patrols.

Australians have used OTHR system to detect and track illegal immigrants. Most of Australia's northern waters are unguarded. Australian custom authorities have used JORN to gain intelligence to apprehend illegal immigrants on a monthly basis. JORN can also measure wave height and wind directions for meteorological reports.¹⁰

Since then, the network has detected and tracked hundreds of surface vessels and aircraft beyond the horizon along a 15 million square kilometer stretch from Geraldton in Western Australia to Cairns in Queensland. The mission is air sovereignty, border protection and maritime domain awareness; operations are from three sites: Longreach, Alice Springs and Laverton. The JORN system has been in development for over twenty years and the system was developed through collaboration with United States OTHR community, facilitated by a Memorandum of Agreement (MOA) between the U.S. and Australia's Defense Science & Technology Organization; U.S./Australia collaboration continues to yield operational improvements. All three sites have transmit and receive sites and are separated by 170 Kilometers (102 miles). Radio frequency energy is

¹⁰ "JORN assures early warning for Australia," *Defence Systems Daily*, <http://defence-data.com/features/fpage37.htm> (accessed January 8, 2008).

bounced off the Ionosphere, energy is reflected from the backscatter to the receiver, where high performance computers process the returned energy and airborne and surface targets are tracked.

The Alice Springs site, which can be operational, is used mainly as a research and development facility. Australia has had OTHR collaboration for more than twenty years, and is eager to build on the current operational relationship. Additionally, Australia has activated its OTHR Research and Development program by allocating over 50 million dollars so far. Listed below is what has been implemented and those with whom Australia has been working. Australia has integrated OTHR into its National Defense since 1992, including Overhead Non-Imaging Infra-Red (ONIR), sensor-to-shooter connectivity, Coast Watch, DoD, Customs and illegal immigration control.

Jindalee over-the-horizon radar was used to track and detect military aircraft from 1,500 kilometers away. It has also detected a Stealth aircraft because the Jindalee radar bounces down from the ionosphere onto upper surfaces that include radar-reflecting protrusion for cockpit, engine housings and other equipment.¹¹

The NORAD-USNORTHCOM OTHR Technology Development Roadmap and Fiscal Year (FY) 08 Combatant Initiative Fund (CCIF) will identify the engineering design tasks for an initial OTHR subscale prototype system and subsequent spiral development phases leading to the incremental production of an operational, multi-mission OTHR system for homeland defense/security.

Persistent, wide-area surveillance of the approaches to North America has been a long-standing requirement for NORAD-USNORTHCOM. The enduring nature of the homeland defense mission — the large volume of airspace and ocean to constantly monitor, and line-of-sight limitations of surface-based radars against low-altitude targets — exclude most conventional sensor solutions.

¹¹ “JORN assures early warning for Australia.”

D. ARGUMENT

There are pros and cons with fielding the OTHR system as the main operating radar system and having manned and unmanned work as a family of system.

Pros for Manned Platforms:

- Both AWACS and JSTARS have a good detection capability and are always moving, because the aircraft are always moving. They are able to look in a large area and can look down in the ravines and valleys where low-level aircraft like to hide.
- Availability rate of both AWACS and JSTARS are high, and both systems have a great ability; if one aircraft breaks prior to takeoff they can go jump on another aircraft until they find one that works.
- AWACS and JSTARS would be a great radar hole filler because of their capability to direct their radar to a certain region or narrow their search down to a certain area, such as the border.

Cons for Manned Platforms:

- The yearly operational cost per aircraft and personnel being used. Fuel prices are soaring, and AWACS and JSTARS burn or use about 8,000 gallons of fuel per hour. Both airframes are over thirty years old and both have participated in multiple events that have lasted for long periods of time.
- Procurement cost for either aircraft is in the hundred of millions per aircraft, and the number of aircraft that would be needed to give complete or partial radar coverage would be astronomical.
- Detection Range is very limited for both airframes. Both systems have more directional radar. AWACS and JSTARS detection range is constant; detection capability can change because of weather or the flight orbit.

- AWACS and JSTARS have one of the worst operational tempos with the different conflicts they have covered, counterdrug missions and continued training at different locations.
- Availability can be a pro or con because they can keep going to different aircraft until they find one that works. That would show a great availability rate, but they had to go through two or three aircraft before they found one that worked. They also have problems once they are on station (meaning flying at altitude and conducting their mission) when communication or the radar will go down and they will have to return to base and pick up another aircraft. Both aircraft are weather-dependent; they would have to move orbit when the weather is bad and could affect the radar.

Pros for Unmanned Platforms:

- Compared to manned platforms, the unmanned platforms have a low operating cost. The yearly budgets for unmanned platforms like TARS and UAS are very low because they can stay aloft for long periods of time.
- Operational Tempo is very low because most of the personnel operating at each site is located at that site and do not have to deploy to different locations for long periods of time. UAS will deploy and the operator will have to deploy with them, but not for long periods of time.
- Detection Capability is good on both systems. They are like manned platforms when it comes to being weather dependent, but when they are airborne, they provide a concise air picture. High Altitude Airship (HAA) is not mentioned because everything about HAA is still notional and has not been fully tested.

Cons for Unmanned Platforms:

- Detection Range is limited because of the altitudes they can fly. The higher they fly, the further they could see, and there are plans for the UAS to be able to someday orbit at over 60,000 feet. They both are limited to less than 250 nautical miles.
- Availability is very low because of both systems being weather-dependant. They both have had incidents of falling out of the air. There have been approximately four incidents with TARS where lightening has struck the balloon and the system has fallen out of the air. UAS has also had their problem, with flying with multiple incidents on takeoff and landings.
- Unmanned platforms have had a budget reduction on the TARS system when they lowered the operational platforms from ten to six. HAA had their entire budget lifted by Missile Defense Agency (MDA) in 2007, but Congress is attempting to get HAA fully funded so they can continue testing.

Pro for OTHR:

- Detection capability is one of the strengths with the OTHR. The system has a good cross section (where they can see very small aircraft and small maritime vessels).
- OTHR detection can range from 500-2,000 nautical miles during the daylight hours.
- OTHR availability rate has been listed in the high 90-percent range from the current operational systems in Australia and working in the Caribbean.
- Operational tempo is very low with each site needing a minimum amount of personnel to operate the system on an everyday schedule. Personnel need not leave their daily duty location.
- Operational cost is minimal compared to manned, and lower than the unmanned platforms when it comes to actual money.

- Procurement cost on an OTHR system is low when compared to manned platforms, and compare about the same as unmanned platforms when it comes to procurement cost.

Cons for OTHR:

- Detection capability reduces during darkness. OTHR layers reduces during the hours of darkness, but it only reduces from being able to detect from 100-2,000 nautical miles to around 500-700 nautical miles.
- Currently, there is no altitude readout (meaning when a target is detected the controller cannot determine at which altitude the target is located. The FAA, U.S. and Australian, are currently working the issue and hope to have this flaw corrected within the near future.

Over the past few years, Department of Defense (DoD) leaders have begun to investigate high-altitude air space and over-the-horizon operations because the Department of Defense believes that the transition from an airborne platform to a high-altitude platform should be seamless. General Ronald R. Fogleman, United States Air Force Chief of Staff, introduced the future concept of find, fix, target, track, and engage (F² T² E) any target anywhere on the earth. In order to accomplish F² T² E functions performed by the E-3 airborne warning and control system (AWACS) and the E-8 joint surveillance, target attack radar system (JSTARS) will need to migrate to a new platform that includes High Altitude Airships (HAA), Unmanned Aircraft System (UAS) and Over-the-horizon radar surveillance (OTHR) technologies.

Continuing to throw money into upgrades to the airframe and all internal systems, in an effort to extend its life and continue to provide useful service until 2025, is probably not the best option, given all the new technology that can perform the AWACS and JSTARS functions. This is not to suggest that manned and unmanned platforms are bad systems, only to imply that, in light of research and interviews, it was established that OTHR could fill the role of the main operating surveillance system. Manned and unmanned platforms would fill a better void in the gap-filler role while conducting operations within North America.

E. METHODOLOGY

1. Interviews

Interviews with experts from the Department of Defense (DoD) military, civilian and civilian contractors were conducted to establish the current environment in the Manned (AWACS and JSTARS), Unmanned (High Altitude Airships, Tethered Aerostats Radars System and Unmanned Airship System) platform surveillance systems and over-the-horizon radar activity. Interviews touched on four variables: cost, detection capability, availability and operational tempo. Each expert was asked twenty-four questions. During the interviews, each expert was asked how they rated manned, unmanned platforms and OTHR systems, using a scale of one to ten, with ten being the highest rating. Each platform will be evaluated in term of the importance of cost, detection capability, availability and operational tempo, and how well each performs in each category.

2. Comparative Analysis of Manned, Unmanned and OTHR Platforms

An analysis will be carried out using four variables associated with Manned (AWACS and JSTARS): Unmanned Platforms (TARS, HAA and UAS) and Over-the-Horizon Radars (OTHR). The four variables are cost, detection capability, availability and operational tempo. Strength, Weakness, Opportunity and Threat (SWOT) charts were accomplished for each platform and OTHR. Definitions of each variable are listed below, along with the data source (how the information was weighed for all platforms and OTHR). Everything was compared across the board, using the same variables.

Cost – Cost is the monetary value of expenditures for supplies, services, labor, products, equipment and other items purchased for use by a business or other accounting entity.¹²

Availability – Availability is the ability of a component or service to perform its required function at a stated instant or over a stated period of time. It is usually expressed

¹² Merriam Webster online Dictionary, <http://www.merriam-webster.com/dictionary/cost>, accessed February 2008.

as the availability ratio, the proportion of time that the service is actually available for use by the customers within the agreed service hours.¹³ It is the degree to which a system, subsystem, or equipment is operable and in a committable state at the start of a mission, when the mission is called for at an unknown, i.e., random, time. Simply put, availability is the proportion of time a system is in a functioning condition.

Detection Capability – Detection means the special discipline of reconnaissance with the aim to recognize the presence of an object in a location or ambience. It is a method of estimating the distance or travel speed of an object by bouncing high-frequency signals off the object and measuring the reflected signal, measuring instruments in which the echo of a pulse of microwave radiation is used to detect and locate distant objects.¹⁴

Operational Tempo – Personnel/Operational Tempo (OPSTEMPO) as the amount of time that a member of the armed forces or civilian personnel is engaged in their official duties that makes it infeasible to spend off-duty time at the member's home, home port (for Navy or in the member's civilian residence).¹⁵ OPSTEMPO has been and continues to be high for military and civilian personnel.

Military planners develop future equipment maintenance and replacement needs on the basis of anticipated levels and kinds of use. AWACS/JSTARS recorded significant flight hours from the early 1980s through 2005. Immediately following 9/11, multiple AWACS were airborne over major cities. This continued for almost a year, substantially surpassing their planned use levels, increasing maintenance costs and shortening the planned lifespan of several planes. This high demand on equipment is straining AWACS/JSTARS budgets, which are low on the Department of Defense's list of priorities, and is leaving units dangerously low on critical equipment needed during homeland security operations.

¹³ Merriam Webster online Dictionary, <http://www.merriam-webster.com/dictionary/Availability>, accessed February 2008.

¹⁴ Merriam Webster online Dictionary, <http://www.merriam-webster.com/dictionary/detection>, accessed February 2008.

¹⁵ General Accounting Office, *Homeland Defense: DoD Needs to Assess the Structure of U.S. Forces for Domestic Military Missions*.

3. Data Collection

Cost Data will be taken from a twenty-year life cycle cost data that was estimated based on data obtained by the identified sources evenly across both platforms and OTHR. Engineering assessments were made by in-house personnel with extensive experience in the sensor and surveillance arena. Alternate estimates for Bistatic Receivers provided by Joint Theater Air and Missile Defense Organization (JTAMDO) and AFI 65-503 costs for AWACS were used.

Detection Capability Data Source: Nine experts will be interviewed with experience in OTHR, Manned and Unmanned platform Detection Capability.

Availability Data Source: Data was obtained through analysis section within NORAD/USNORTHCOM (via their end-of-the-year brief on availability of radar systems) and pending interviews with experts of manned, unmanned platforms and OTHR. Most of the availability ratio for all the systems is classified and accurate information is not available. Availability for each system was obtained at the higher level of availability.

Operational Tempo Data Source: Data was obtained through pending expert interviews of individuals who know the recent trends of deployment rates of individuals on both platforms and OTHR system.

F. SPECIFIC RESEARCH OBJECTIVE

The objective of this research is to show that the significance of a system like OTHR is underscored by the fact that there are simply not enough High Demand/Low Density (HDL) surveillance assets (AWACS, E-2C, AEIGS destroyers) to satisfy the requirement for round-the-clock surveillance of the homeland. Eventual deployment of the OTHR network in the homeland would shore up the current system, validate capability gaps and preclude the need to impose additional operational tempo (OPTEMPO) strains on limited HDL surveillance assets to protect the homeland. The new paradigm will identify recommendations for improving operational capability, reducing operational cost and reducing OPTEMPO. This research will focus on

developing a strategy to expand the current OTHR function throughout the various disciplines that are inherent in modern radar systems, and to identify readily available sources of information that might have been missed by DoD personnel analysts.

G. SIGNIFICANCE OF RESEARCH

The possibilities or recommendations that this paper could produce include:

- NORAD-USNORTHCOM elevates recommendation to higher authorities, the Department of Defense accepts changes and they are implemented.
- Department of Homeland Security (to include Customs, Border Patrol and other civilian agencies) embraces the recommendations and opens up a dialog with DoD.

1. Immediate Consumer

The thesis is designed to serve the Department of Defense and Department of Homeland Security/Defense. Currently, NORAD-USNORTHCOM are responsible for Defense of North America (land, air and maritime). NORAD-USNORTHCOM and Missile Defense Agency (MDA) have and are preceding full speed ahead attempting to get support and funding for testing. NORAD-USNORTHCOM would be the primary consumer, and multiple civilian agencies would be the secondary users of the OTHR technology. NORAD-USNORTHCOM would ultimately be responsible for promulgation and implementation.

Today, manned and unmanned platforms are not working together, and OTHR is not approved for the use in the United States. All three platforms have a viable mission, and the future is leaning more and more to ionosphere and space-based systems. The DoD needs to analyze each platform to determine (a) which system has the capability to transfer over to the future and (b) which system cannot make that leap, while conducting their current individual mission.

II. HISTORY OF SURVEILLANCE RADAR SYSTEMS

Manned, unmanned and Over-the-Horizon radar systems have developed over time, starting as far back as the early 1900s with the Zeppelin as one of the first manned platforms. It used a balloon to put a person airborne so they could get a better view. The concept of an airborne platform or individual is an early version of manned, unmanned and Over-the-Horizon radar (OTHR) technology. The early version was able to scan over wilderness and hills, which is the technology of manned, unmanned platforms and OTHR. Since the early years, DoD has invested in radar surveillance systems. Technology is always changing, but four variables have always been considered when evaluating radar technologies. The first is the cost to procure and operate. The second variable is the detection capability, meaning its efficiency at detecting, identifying and monitoring targets. The third variable is availability, considering whether the system is operationally available for a large period of time or if the system is affected by weather or needs excessive maintenance that would affect the availability rate of the system. DoD does not want technology that is not available at least 80 percent of the time. The fourth variable is *operational tempo*. Personnel and equipment that is deployed away from the home station for long periods of time and working long durations can lead to fatal incidents, moral issues and life cycle issues of the radar technology.

Military leaders have always needed know the movements of their enemy for planning purposes. Leaders would send a scout out and have their scouts to obtain the highest ground possible so they could observe enemy movements, size and composition of the enemy forces.¹⁶

The concept of being on higher ground has not changed over the years, only the manner in which DoD reaches those heights has changed. Instead of being on top of a hill or mountain with an observer (which is still used), DoD uses technologies such as manned and unmanned platforms as well as Over-the-Horizon radar to provide information that can be used for homeland defense and security along the Mexican and

¹⁶ Higher Eyes in the Sky, "The feasibility of Moving AWACS and JSTARS Functions into Space," <http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA391375> October 1999, 5 (accessed May, 2007).

Canadian borders against low-altitude air threats, land and maritime. In addition to traditional air defense threats, NORAD-USNORTHCOM need the capability to defend their Area of Responsibility against low altitude, threats such as cruise missiles, crop dusters, general aviation traffic below 5,000 feet.

Radar surveillance capability has been around for a very long time, dating back to the 1890s. The capabilities have evolved over time from the humble beginnings of the German Zeppelin, the airborne observers during World War I, through the British inventing the first ground radar surveillance system and learning off the British radar technology and morphing into manned radar surveillance platforms with the Naval E-2 Hawkeye and EC-121 aircraft during the Korean and Vietnam conflict. Department of Defense (DoD) kept striving for improvement as they added additional manned platforms (Airborne Warning and Control Aircraft), Joint Surveillance Target Attack Radar System (JSTARS) and unmanned platforms like Tethered Aerostats Radar System (TARS) and Unmanned Aerial Vehicles (UAV), which is now called Unmanned Airship Systems (UAS) along with Over-the-Horizon-Radar Systems (OTHR) technologies came onto the scene during the 1980s. Future versions of radar surveillance of High Altitude Airships (HAA) and Next Generational Over-the-Horizon Radar System (NEXGEN OTHR) are being looked at by DoD planners as the future radar surveillance platforms for DoD Wide Area Surveillance (WAS).

A. RADAR-SURVEILLANCE PLATFORMS

The concept of the lighter-than-air vehicle has been around since the early 1900s. 1783 was the year the French made the first manned ascent in a hydrogen balloon drifting over Paris and the surrounding countryside for two hours.¹⁷ Since that time, the Germans invented the Zeppelin in the late 1890s and started flying 1900s. The Zeppelin was used in the early years by mostly the military as a forward observer platform.

¹⁷ Joseph F. Vitek, Jr., "An Assessment of Lighter than Air Technology," Hydrogen, No. 147, <http://www.uh.edu/engines/epi147.htm> (accessed May 2007).

“Wartime Zeppelins were used for scouting and observation but also flew more than fifty bombing missions over England.”¹⁸

The Army established their first aeronautical division during this timeframe. Army Air Corp was the first flying division long before the United States Air Force was established. This new aeronautical division which was within the Signal Corps had both aircraft and balloons.¹⁹

Between 1909 and 1912, the first aircraft were accepted into the Army inventory, and “the military aviation division was established with seventeen pilots.”²⁰ During this time, “aircraft were formally assigned an observation role where they operated in advance of the independent cavalry in order to locate the enemy and keep track of their movements.”²¹ Balloons were used for frontline observation, while aircraft were flown deep into enemy territory to observe activities behind the lines. From their lofty vantage point, pilots and observers could see the buildup of munitions and reserves. The intelligence data they gathered enabled them to counter enemy attempts to break through the lines. This contributed to a stalemate and caused the development of fighter aircraft to prevent deep-look observations.

By the end of the war, aircraft were performing all of the modern air missions: air control, force application, and force enhancement. In the process, balloons fell out of favor as the favorite observation platform because they were vulnerable to attack by aircraft.²²

Additionally, the experiences of World War I highlighted the need for an improved early-warning ability so defending aircraft could be in the correct place to defeat incoming aircraft.

Following this, Congress authorized the Navy to build two airships that would be the largest airships ever built. They received many versions on what it should look like,

¹⁸ Vitek, “An Assessment of Lighter than Air Technology,” 6.

¹⁹ Charles W. Reeves, “The history of Tactical Reconnaissance through 1941,” research paper (Maxwell AFB, AL) 1967, 25, May 2007.

²⁰ Contrails 24 (Colorado Springs: USAF Academy, 1978). 19 (accessed May 2007).

²¹ Quoted in Robert Frank Futrell, *Ideas, Concepts, and Doctrine: Volume 1, Basic Thinking in the United States Air Force 1907-1960* (Maxwell AFB Ala: Air University Press, 1989) accessed May 2007.

²² Reeves, “The history of Tactical Reconnaissance.”

and Lockheed Martin was chosen to build the two airships. “Lockheed Martin, Akron, received its first production contract for a lighter than air vehicle in 1928.”²³

1. Pre and Post WWII

Technological advances in the period leading up to World War II and, in particular, the invention of radar, enabled the British to detect German aircraft over the English Channel. Once detected, the flight paths of enemy aircraft were plotted, and future locations were predicted. The system used a network of three types of radar: long-range radars, which could locate incoming aircraft more than 100 miles away; short-range radars, which specialized in locating low-flying aircraft at a range of about 25 miles; and mobile radar units, which could fill the gaps created when enemy aircraft damaged any of the radar sites. Ships were also fitted with radar to help them find other ships, though these had limited value because radar’s ability to illuminate a target is limited to line-of-sight and both the receiver and the target were on the earth’s surface. Radars units mounted on aircraft were more successful with airborne radar playing a key role in the Allies’ success during the Battle of Atlantic.²⁴ Airborne radars were also used to locate enemy aircraft at night, and this capability expanded into a more robust system employed in North Africa.

2. The Korea and Vietnam Eras

Further technological advances in the mid-twentieth century enabled the Allies to employ powerful radar, called Microwave Early Warning (MEW) that could provide range, azimuth and altitude on aircraft up to 200 miles away. “Additionally, the U.S. Navy became more and more concerned about fleet defense and started developing a sophisticated airborne early-warning aircraft called WV-2 — based on the Lockheed Constellation, one of the few aircraft large enough to carry state-of-the-art radar. The aircraft was later named the EC-121 Warning Star and was bought by the United States

²³ High Altitude Airship (HAA) descriptions, www.lockheedmartin.com (accessed February 2007).

²⁴ Richard Overy, *Why the Allies Won* (New York: W. W. Norton and Co., 1995), 38 and 50.

Air Force.”²⁵ The aircraft were later replaced by Airborne Warning and Control System (AWACS) in 1975. Like other airborne radars of the time, the radar in the EC-121 was most effective over water. It was less effective over ground, because the ground’s irregular surface caused false returns on the radar scope, obscuring the controller’s ability to differentiate between airborne returns and clutter (noise that is not a target). The purpose of flying the EC-121 was to extend the capability to look farther out and gain earlier detection and identification of the target. Even though the radar was plagued by ground clutter (false returns) in “look-down” mode, this problem could be overcome to some extent by flying low and projecting the radar horizontally. However, bad weather often made the solution untenable.

Even with its limitations, the EC-121 proved useful for issuing MIG alerts, controlling intercepts, and warning pilots of possible border violations and the EC-121 aircraft ultimately proved to be quite effective. The original version of identifying aircraft with the radar on the EC-121 aircraft was time-consuming and difficult to use but a new identification system was installed by 1968, which significantly improved mission effectiveness. Before the EC-121 showed its capabilities and limitations in Southeast Asia, the Air Force had begun exploring the concept of a more capable airborne early-warning platform. The concept of an Airborne Early Warning and Control System (AWACS) first appeared in 1962. Unfortunately, the conflict in Southeast Asia absorbed most of the available resources and the concept was not developed. The Air Defense Command and Tactical Air Command joined forces in 1967 to advocate procurement of a new AWACS, which were approved for service until 2025. About this time the Relocatable over the Horizon Radar (ROTHR) was being implemented in the United States.

Over-the-Horizon technology was developed during the 1950s. “Naval Research Laboratory had been conducting experiments and extensive testing on the ionosphere to see if it was capable of being used as a conduit for sky wave radar to be successful source

²⁵ Military Analysis Network (FAS), “EC-121 Warning Star,” <http://www.fas.org/man/dod-101/sys/ac/ec-121.htm> (accessed January 8, 2008).

for over-the-horizon aircraft detection.”²⁶ Use of the High Frequency (HF) Band (3 to 30 Megahertz) permits extending radar ranges beyond the horizon, 500-2000 nautical miles using sky wave propagation where the ionosphere can be thought of as providing a virtual mirror. In addition, modest extensions of line-of-sight range can be obtained in this frequency band by using surface wave propagation over the sea. “Over-the-Horizon radar capabilities were tested and the OTHR program was approved and OTHR demonstrated feasibilities were documented.”²⁷

Over-the-horizon radar technology has been around since the 1960s when Relocatable over the Horizon Radar (ROTHR) was started along the east coast of the United States. ROTHR was not considered a reliable system because of drawbacks in availability and cost; their detection capability was the only part of the system that worked correctly. Because of ROTHR inconsistencies, radar experts learned much from the system, and used lessons learned to improve Over-the-Horizon Radar (OTHR). They conducted the counterdrug mission in the Caribbean region and worked with the Australians for helping OTHR to evolve over time. Only two operational OTHR radar systems exist, with one based in the United States and looking toward South America, and the other based in Australia. The system in North America is being used for drug interdiction (mainly by USSOUTHCOM and Customs).

Since the early 1900s, radar surveillance has evolved from a scout on top of a hill looking for enemy movements to the current version of manned platforms (AWACS and JSTARS) flying at over thirty-thousand feet for up to eighteen hours at a time with detection range and communication capability of seeing and transmitting voice communications for hundreds of miles. Unmanned platforms technology (balloon type systems) have also evolved, from the launching of a balloon with an observer onboard to the current technology of a balloon system capable of detecting a target and communicate hundreds of miles away, keeping personnel free from harm. Another jump in technology is the current version of the Unmanned Airship System (UAS) and the future version of High Altitude Airships (HAA). UAS can be operated from a distance that would keep

²⁶ Jenson and Uniacke, “Spectral Bandwidth of Backscatter Signals.”

²⁷ Headrick and Skolnik, “Over-the-Horizon Radar in the HF Band.”

personnel out of harms way and can fly for over thirty hours with hopes of future UAS platforms extending their capability of at least thirty days. Another unmanned system DoD is considering is HAA, which is still future technology. Funding was recently lifted by Missile Defense Agency (MDA). HAA hopes to have funding applied back onto their program before the end of the year; Congress is fully behind the HAA program. HAA capability of orbiting above the clouds make HAA a very attractive system because it will not be affected by weather when on station, which will increase their availability rate and reduce operational tempo. Future systems are being planned for HAA to stay aloft for one year at time which if possible would enhance availability rate and would give consistent Homeland Defense and Security Mission.

On April 30, 2002, President Bush signed a new Department of Defense (DoD) Unified Command Plan (UCP), which went into effect on October 1, 2002.²⁸ Among other things, the UCP established the United States Northern Command (USNORTHCOM) to provide command and control of the DoD homeland defense efforts and to coordinate military support to civil authorities.²⁹ Part of this defense effort is to coordinate and cultivate defense and security relationships with countries in its designated Area of Responsibility (AOR), which includes Canada and Mexico. Fortunately, the United States enjoys a strong and sophisticated defense partnership with its northern neighbor, Canada, in organizations such as the North Atlantic Treaty Organization (NATO) and the North American Aerospace Defense Command (NORAD). Canada is becoming a better partner with USNORTHCOM with the establishment of the Canada Command, which is the Canadian equivalent of USNORTHCOM. Relations with Mexico, on the other hand, have not been as comprehensive, and expanded defense cooperation was, until recently, lagging due to historic and political differences. Recently, Mexico sent a Liaison Officer to USNORTHCOM as a permanent party so the Liaison Officer can work with the entire command on any type of issue, including current

²⁸ Scott Shepherd and Steve Bowman, "Homeland Security: Establishment and Implementation of the United States Northern Command," *Congressional Research Service Report for Congress* (CRS Order Code RS21322), (2007): 1. Available at <http://www.fas.org/sgp/crs/homesec/RS21322.pdf> (accessed February 2008).

²⁹ Ibid.

and future operations between the U.S. and Mexico. With both Canada and Mexico, policy and supporting structures are being re-written to support an efficient and seamless military-to-military cooperation in support of civil authorities. Closing this gap can serve as a platform for expanding U.S.-Canada-Mexico military cooperation and will be the first step toward an integrated North American defense. Understanding how far surveillance platforms have come over the past one hundred years shows how technologies have helped improve — and there is still room for more improvement of the radar surveillance technologies.

B. CONCLUSION

DoD has invested in radar surveillance systems for many years, always attempting to improve from existing radar technology. DoD uses different types of factors or variables when evaluating current and future radar technologies. Throughout this thesis, the author chose to use just four of the variables during the evaluation process. The first variable is cost — how much the system will cost to procure, testing, and full operational use. The second variable is detection capability — how well the radar can detect, identify and monitor targets. The third variable is the availability rate of the system. Does the system spend more time being worked on or being hampered by weather that could affect their availability rate. The fourth variable is operational tempo. A high level of deployment can lead to mental errors that could end in a tragedy. Long deployment and high operational tempo also leads to the life cycle of the radar technology, higher cost for maintaining the technology, and shortening the expected operational serviceability.

Over time, radar surveillance technology has evolved, starting with the German Zeppelin in the 1900s, and continuing on with the first aeronautical unit being established by the Army with both aircraft and balloons as airborne observers or scouts, who would keep an up-to-date situational awareness of movement and capability of their enemy. Technology kept evolving over time; pre- and post- World War II, the British established the first ground radar surveillance system. Military leaders always believed that they had a greater capability of knowing everything that was needed to know about their enemy

when they had higher ground to collect information and DoD started applying airborne radars to aircraft with the Navy inventing the WV-1 with a look down capability. After a few years as flying for the Navy, DoD decided the WV-1 would serve a better role flying for the Air Force and the aircraft changed their name to EC-121 “Connie.” The Air Force learned a great deal from the EC-121 and this helped during 1962 with the invention of Airborne Warning and Control Aircraft (AWACS), which was put on hold because of the Vietnam conflict. Also during this time, Over-the-Horizon Radar (OTHR) technology was being understood and tested. Unmanned platforms that were cheaper and could stay aloft for a longer period of time were tested. Tethered Aerostat Radar (TARS) were used along the United States Southern Border. DoD was successful in tracking airborne and maritime targets with AWACS and the Naval E-2 Hawkeye aircraft, but the Army was wanting some type of aircraft that could monitor systems on the ground. These included tanks and other pieces of equipment not able to be monitored by AWACS and other manned platforms. JSTARS became part of the manned radar platforms just prior to Desert Shield and Desert Storm in 1990 timeframe.

DoD planners are looking at future technology for implementation like Unmanned Airship Systems (UAS), High Altitude Airships (HAA) and Next Generational Over-the-Horizon Radar (NEXGEN). UAS is currently conducting missions along the southern U.S. border and in the Middle East.

Radar platforms have improved over history and will continue to improve in the future. Balloons were used as one of the first airborne platforms back in the 1890s and the balloon technology is still around and will continue to be used now and in the future.

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III. METHODOLOGY

The purpose of this chapter is to discuss how the research used in this thesis was carried out to explore current and future radar Wide Area Surveillance (WAS) for NORAD-USNORTHCOM Area of Responsibility (AOR). This thesis examined data that was collected from expert member of DoD military, civilian and contractor professionals. Method used was a qualitative approach to collect information through interviews with nine experts with over one hundred and fifty years of background working in manned, unmanned platforms and OTHR radar systems. Since the early years, DoD has invested in radar surveillance systems. Technology is always changing, but four variables have always been considered when evaluating radar technologies. The first is the cost to procure and operate. The second variable is the detection capability, meaning its efficiency at detecting, identifying and monitoring targets. The third variable is availability, considering whether the system is operationally available for a large period of time or if the system is affected by weather or needs excessive maintenance that would affect the availability rate of the system. DoD does not want technology that is not available at least 80 percent of the time. The fourth variable is *operational tempo*. Personnel and equipment that is deployed away from the home station for long periods of time and working long durations can lead to fatal incidents, moral issues and life cycle of the radar technology.

Using the four variable helped form a base for interviews with nine radar experts. The interviews were used to present several weighed questions dealing with four variables associated with manned, unmanned platforms and OTHR radar system. These experts were asked to assign weight from 1 (being the lowest score) to 10 (being the highest score) for the first twelve questions. Both platforms and system were given three questions apiece that dealt with four variable (cost, detection capability, availability and Operational Tempo) assigned against each platform and system. Interviews were conducted, results tallied and an average score was calculated for each platform and system dealing with the four variables by using the number coding system of one to ten. The purpose of this chapter is to discuss how the research used for this thesis was carried

out to explore a group of radar experts interviews perceived acceptance of manned, unmanned platforms and OTHR system relationship with the four variables which deal with homeland defense and security. Included in this chapter are the following sections: Interviews, Interview Procedures, Pre-Test Interviews, Identification of Potential Interviewees, Contacting Potential Interviewees and Participation, Anonymity, Interview Scheduling, Interview Documentation, Interview Questions, Comparative Analysis of Manned, Unmanned and OTHR Platforms, Data Collection and Results Summary of Weighted Questions.

A. INTERVIEWS

Interviews were conducted with experts from the Department of Defense (DoD), civilians and civilian contractors to establish the current environment in the manned platforms (AWACS and JSTARS) surveillance systems, unmanned platforms (High Altitude Airships, Tethered Aerostats Radars System and Unmanned Airship System) surveillance platforms and over-the-horizon radar (OTHR) systems. Interviews touched on four variables: cost, detection capability, availability and operational tempo. Each expert was asked twenty-four questions. (see Appendix). During the interviews each expert was asked to score from 1 (low) to 10 (high) according to how he or she rated manned platforms, unmanned platforms and OTHR systems. Each platform was evaluated in terms of the importance of cost, detection capability, availability and operational tempo.

The following procedures were utilized to conduct all interviews associated with this thesis. To ensure consistency, the author conducted each interview.

1. Pre-Test Interviews

Two pre-test interviews were conducted with control subjects, interviewees who had no background in manned and unmanned platforms or the OTHR system and their relationship to homeland security. The procedures followed with these interviewees were in strict conformity to the procedures used with all the other interviewees. The purpose of the pre-test interviews was to practice conducting the interviews and observe how the

questions worked prior to conducting formal interviews. Reasoning for selecting two people who had no background in manned, unmanned platforms or the OTHR system is to see how they would answer the questions, if they could understand the question (but might not be able to completely answer the question but at least understood the question).

2. Identification of Potential Interviewees

Interviews were conducted with participants who were actively working or had been working in the surveillance field, were member of the U.S. military, or were U.S. government civilians or contractors. Participants who were involved in the operations of each platform, manned, unmanned and OTHR, were interviewed. Additionally, in order to ensure some consistency of interviewee knowledge and background relating to homeland security and public health, the interviewees were chosen from a pool of individuals who serve in a capacity (active military or contracted government civilian) responsible for enhancing the overall security of NORAD-USNORTHCOM area of responsibility and homeland security. Interviews were conducted with nine persons from the federal government or representing the federal government. All nine individuals had extensive radar background in the three surveillance systems (manned, unmanned platforms and over-the-horizon radar). All nine experts combined had over one hundred and fifty years of radar surveillance background. The nine individuals served in a capacity where they were responsible for enhancing the overall security of NORAD-USNORTHCOM, Australia, USSOUTHCOM mission and area of responsibility and had backgrounds in homeland defense and security.

3. Contacting Potential Interviewees and Participation

The initial contact with potential interviewees was accomplished via telephone and e-mail.

4. Anonymity

As a condition of this research, all research participants were assured complete anonymity. No record of their name or their specific affiliation was provided in the

analysis section of this thesis. No future work that may result from the findings of this research may identify their names or affiliations.

5. Interview Scheduling

Face-to-face interviews, to the extent possible, were scheduled for those interviewees who agreed to participate via initial solicitation calls. The logistics of scheduling face-to-face interviews throughout the United States and the world, (one of the interviewees lives in Australia), based upon geographic distances, required several interviews to be conducted via the telephone and through electronic means. A copy of the questions to be asked was forwarded to each interviewee electronically. All interviews were conducted between 11 February and 15 February 2008.

6. Interview Documentation

This procedure applied to all interview information collected. Accountability for the information began with the initial contact with potential interviewees, and continued through the completion of the research project.

7. Interview Questions

A total of twenty-four questions were asked of each interviewee (see Appendix). The first twelve questions dealt with the weight that each person assigned to both manned and unmanned platforms and the OTHR system against one of the four variables (cost, detection capability, availability, and operational tempo). All twenty-four questions were provided to all interviewees prior to the interview. The interviewee was provided with additional time, if requested, to complete the questions.

B. COMPARATIVE ANALYSIS OF MANNED, UNMANNED AND OTHR PLATFORMS

An analysis will be carried out using four variables associated with Manned (AWACS and JSTARS): Unmanned Platforms (TARS, HAA and UAS) and Over-the-Horizon Radars (OTHR). The four variables are Cost, Availability, Detection Capability and Operational Tempo. Strength, Weakness, Opportunity and Threat (SWOT) charts

were accomplished for each platform and OTHR. Definitions of each variable are listed below, along with the data source (how the information was weighed for all platforms and OTHR). Everything was compared using the same variables.

Cost – Cost is the amount of money or the budget that will be spent for the procurement of equipment, labor products and operations of the platform and system.

Availability – Availability is the ability of a radar surveillance platform or system to be available for operational use 24/7/365 days a year. Operational availability rate is a large piece of the puzzle when a new, current or future platform or system is being looked at by DoD. Simply put, availability is the proportion of time a system is in a functioning condition.

Detection Capability – Detection Capability is the ability of a radar surveillance system to detect targets (land, maritime or air) accurately, in a timely manner and at a distance. It is a method of estimating the distance or travel speed of an object by bouncing high-frequency signals off the object and measuring the reflected signal, measuring instruments in which the echo of a pulse of microwave radiation is used to detect and locate distant objects.

Operational Tempo – “Personnel/Operational Tempo (OPSTEMPO) is the amount of time that a member of the armed forces or civilian personnel is engaged in their official duties that make it infeasible to spend off-duty time at the member’s home, home port (for Navy or in the member’s civilian residence.”³⁰ OPSTEMPO has been and continues to be high for military and civilian personnel.

C. RESULTS SUMMARY OF WEIGHTED QUESTIONS

During the interviews, each expert was asked to rate from 1 (low) to 10 (high) the manned, unmanned and OTHR platforms. Each platform will be evaluated in terms of the importance of cost, detection capability, availability and operational tempo. The

³⁰ General Accounting Office, *Homeland Defense: DoD Needs to Assess the Structure of U.S. Forces for Domestic Military Missions*.

results from each interviewee, for the first twelve questions on the three systems weighed against the four variables as they apply to each platform, are supplied in the Appendix.

Cost results — Cost was weighed across the board. The numbers varied depending on the platform and system being weighed. Manned platforms were weighed high with a total score of seventy-nine, an average score of 8.7, and a goal score between three and five. Unmanned platforms had a total score of sixty-seven or an average score of 6.2, which is closer to the goal score of between three and five. The last system weighed was OTHR, which had a total score of thirty-three or an average score of 3.6, which falls between the goal score of three to five.

Detection Capability Results — Detection Capability was weighed across the board and the numbers varied depending on the platform and system being weighed. Manned platforms fell within the goal score of seven to ten on the average, because detection capability is the most important aspect when it comes to implementing a surveillance system. Manned platforms weighed in by our experts with a total score of sixty-seven or an average score of 7.4. Unmanned platforms fell below the goal score of seven to ten, with a total score of fifty-three or an average score of 5.8. OTHR systems weighed the highest of all three, with a total score of seventy-six or an average score of 8.4.

Availability Results — Availability was weighed across the board and the numbers varied depending on the platform and system. Manned platforms fell below the accepted availability goal score of between eight and ten, with a total score of fifty-two or an average score of 5.7. Unmanned platforms scored lower than manned platforms, with a total score of forty-two or an average score of 4.6. The OTHR system scored just in the window of the goal score with a total score of seventy-five or an average score of 8.3.

Operational Tempo – Operational tempo is one of the two variables (cost is the other) where a low score is the goal. The operational tempo goal score is anything below five. The first systems weighed were manned platforms, which rated a total score of seventy-five, or an average score of 8.3. Unmanned platforms fared better than manned

platforms, and fell below the goal score, with a total score of forty-one or an average score of 4.5. The OTHR system also fell within the goal score of below five, with a total score of thirty-four or an average score of 3.7.

All interviewees identified what they felt was the specific specialization necessary to support NORAD-USNORTHCOM and homeland security. The results of these interviews were encouraging.

D. CONCLUSION

Material from the interviews with nine radar experts from DoD was used in an approach to describe and analyze cost, detection capability, availability and Operational Tempo in their past, current and future missions with manned, unmanned platforms and OTHR system. The four variables were broken down and definitions were given on how each variable was used in this thesis. As part of the methodology, the author asked the nine radar and defense community experts questions during the interview about manned, unmanned platform and OTHR mission when dealing with the four variables. Results from the interviews were constant when it came to each system with OTHR getting the overall approval of the nine experts, manned being the most expensive and the highest of the three systems with Operational Tempo category rating above goal score. Detection capability was rated as strength for all three systems even with the detection range not being as affluent as OTHR.

The expert's observations were incorporated into the final thesis. The experts agreed the majority of the time about the performance of each platform and OTHR system when it came to their approach conducting NORAD-USNORTHCOM mission homeland defense and security role.

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IV. MANNED PLATFORMS

Exploring the capability of Manned Platforms as a viable asset in the War against Terrorism is an avenue that needs further research. Making sure they are being used correctly and to their fullest potential is a must. Manned platforms have been around for many years and they could be the future radar platform being looked at by DoD. This chapter will discuss history, capability, future, four variables, and interview results. Also covered are Strength, Weakness, Opportunity and Threat analysis (SWOT), pros and cons, and recommendation of manned platforms.

A. OVERVIEW

Manned platforms consist of any airborne platforms that have to be operated by an individual. These platforms consist of the Airborne Warning and Control System (AWACS), Joint Surveillance Airborne Radar System (JSTARS), Rivet Joint, and Hawkeye Early Warning aircraft. During this thesis only AWACS and JSTARS will be discussed because of their distinct mission of being a Homeland Defense and Security along the Northern and Southern border of the United States. Rivet Joints and Naval E-2 Hawkeye missions will not be discussed because Rivet Joints mission is classified and the Naval E-2 mission is more of a mission that is conducted over water further away from both Northern and Southern borders of the United States. They could be used in the Gulf of Mexico but are more of an asset protecting the Naval Fleet during crossing of the vast oceans.

B. HISTORY

Manned airborne early warning platforms have been around since the early 1900s when military leaders would put scouts on balloons and loft the scouts in the air so they could see across enemy lines so each field commander could keep up to date information on their enemy movements, equipment and personnel capabilities. Technology evolved over the years from balloons to single seat aircraft to multiple seat aircraft and then back to the balloon when the Navy putting a radar system on ZPG-3W. This experiment ended

up being forerunner for unmanned Tethered Aerostat Radar System (TARS). After this experiment the Navy nothing so far addresses the issue of a multi seat aircraft with radar that could see simultaneously of 360 degrees, possessed automatic tracking and height finding capability. This was the dream system for DoD and the Navy had found the aircraft who soul mission was to conduct Airborne surveillance. The Naval E-2 Hawkeye was a giant step for the Navy because this was one of the first aircraft that wasn't adapted from an existing airframe. The E-2 had a rocky beginning because of the aircraft carrier they were attempting to takeoff and land on were World War II class carriers. Still to this day E-2 Hawkeye is the largest aircraft to be able to operate from an aircraft carrier flight deck. Over time E-2 Hawkeye had to have additional equipment added so maritime operation aboard aircraft carriers could be carried out and sustained. Naval carrier technology was upgraded for the arrival of jet aircraft and this helped the E-2 mission capabilities aboard aircraft carriers. During this time the Air Force was also adopting a new airborne manned radar system called the EC-121 which proved itself during one of the first deployments during the Korean and Vietnam conflict when the EC-121 issued MIG alerts, controlling intercepts, and warning pilots of possible border violations. The EC-121 aircraft were quite effective, despite their radar limitations, because they were equipped with an identification friend or foe/selective identification (IFF/SIF) interrogator system. The original version of this equipment was time-consuming and difficult to use, but a new system was installed by 1968, which significantly improved mission effectiveness. Before the EC-121 showed its capabilities and limitations in Southeast Asia, the Air Force had begun exploring the concept of a more capable airborne early warning platform. The concept of an airborne early warning and control system, or AWACS, first appeared in 1962. Unfortunately, the conflict in Southeast Asia absorbed most of the available resources and the concept was not developed. Air Defense Command and Tactical Air Command joined forces in 1967 to advocate procurement of a new AWACS. The first AWACS came off the assembly room floor in 1977 and, over the next ten years, the United States Air Force built a total of thirty-four AWACS.

C. AWACS

The result was the now familiar Boeing E-3 Sentry, commonly called the AWACS. The AWACS is a modified Boeing 707-320, with Westinghouse Doppler radar and an Identification Friend or Foe IFF/SIF (Selective Identification Feature) interrogator installed in a rotating rotodome above the fuselage. “The E-3 has an unusually robust communications suite, which includes more than a dozen ultrahigh frequency (UHF) radios, two high frequency (HF) radios, and two satellite-communication radios (SATCOM).”³¹ It usually carries more than twenty personnel. They are divided into four functional areas. The first functional area includes flight deck operations personnel who are responsible for flying the aircraft. The second area includes technicians who operate the systems including computers, radios and radar and, if necessary, can conduct in-flight repairs of the radios, radar, and computer systems. The third area includes the surveillance personnel who detect and identify all traffic within radar range. The fourth area includes the weapons controllers who warn friendly aircraft about enemy aircraft identified by the surveillance section and direct friendly fighters to intercept them. In contingencies such as the ones in Southwest Asia, fighter aircraft are not permitted to fly into potentially dangerous areas without the electronic vision of AWACS keeping them safe from ambush. However, the AWACS fleet is aging as it is more than thirty years old and has seen far more action than originally anticipated. AWACS operations have been synonymous with high operations tempos almost since their inception in 1977. They participated in the Iran and Iraq wars from the early 1980s until 1988, then Desert Shield/Storm from 1990 until 1993 flying up to three 24/7/365 orbits, and during the invasion of Iraq in 2002, they flew continuous multiple orbits for over two years. Currently there are thirty-three AWACS in the U.S. inventory.

D. JSTARS

The E-8 JSTARS is a surveillance platform similar to AWACS except that its radar scans the ground rather than the air. As the name suggests, the E-8 is a joint project

³¹ Military Analysis Network (FAS), “Airborne Warning and Control System (AWACS)” <http://www.fas.org/dod-101/sys/ac/e-3.htm> (accessed January 8, 2008).

between the Army and the Air Force. Both the Army and the Air Force were seeking a platform that could identify, target and prepare to attack second echelon forces. These forces are usually 150 miles from the forward line of troops (FLOT) and may engage friendly ground forces within two to three days. Army doctrine emphasizes engaging this type of target as “preparation of the battlefield.”³²

Army corps commanders can task and receive data from JSTARS via a weapons system unique data link to a common ground station (CGS). “This system has to be carried on a large truck. JSTARS is capable of interfacing with up to twelve CGS and is considered valuable assets for receiving intelligence data from numerous Army sources and will be a valuable intelligence preparation for the battlefield.”³³

The JSTARS radar contributes to the commander’s preparation of the battlefield by providing two types of information: the location and movements of vehicles and detailed maps. The radar can make detailed pictures of the ground “capable of discriminating specific items such as vehicles, buildings and aircraft, but without highlighting moving targets.”³⁴

“JSTARS technology has been around for around twenty years which can be considered not that old by some sources but still DoD is looking to migration of AWACS and JSTARS for several reasons.”³⁵ Originally, the JSTARS were built on refurbished Boeing 707 airframes, which drove up maintenance costs more quickly than if a newer airframe had been used. Additionally, only a limited number of aircraft were purchased for the JSTARS system (seventeen total) as opposed to the thirty aircraft that were purchased for the AWACS. Despite the different missions of the two aircraft, the crew complement of the JSTARS is very similar to that of the AWACS. The JSTARS typically carries twenty-two to thirty-four individuals, divided into the same four functional areas as AWACS (flight personnel, technicians, and surveillance personnel and weapons

³² Carlson, Joint STARS, “Success in the Desert.”

³³ Young, “Operational Consideration of Joint STARS, 5.

³⁴ Ibid.

³⁵ Intelligence Resource Program (FAS). “Joint Surveillance Target Attack Radar System (Joint Stars/JSTARS).” <http://www.fas.org/irp/program/collect/jstars.htm> (accessed December 8, 2007).

directors) plus an airborne intelligence officer or technician. While flight and weapons personnel are all Air Force members, the surveillance section includes Army personnel. Because of the JSTARS intelligence mission, both the surveillance and weapons sections are roughly equal in importance. Like AWACS, JSTARS can only see a limited distance behind front lines, whereas HAA, UAS and OTHR assets can see far beyond enemy lines without limitation because of their orbiting altitudes (60,000 – 65,000 feet).

E. THE FUTURE OF MANNED PLATFORMS

The AWACS and JSTARS were slated to be replaced by the E-10A Multi-sensor Command and Control Aircraft (MC2A) based upon the Boeing 767-400ER airframe and equipped with the Multi-Platform Radar Technology Insertion Program (MP-RTIP) 2-d AESA radar. The E-10 project has zero funding for the Fiscal Year 2008 budget and it is unknown whether the Secretary of Defense will reinstate funding for the 2008 funding of the program.

Both AWACS and JSTARS have been approved for extended service until the year of 2025. Extending both aircraft to the year 2025 for operational use will show how the effects of flying surveillance 24/7/365 days a year for 6 years during the Iran/Iraq conflict, two wars (Desert Storm and Iraq) and flying multiple orbits for almost a year in the aftermath of 911 will have any effect on the up keep cost, detection capability and availability of both aircraft.

F. RESULTS SUMMARY OF WEIGHTED QUESTIONS

During the interviews, each expert was asked to rate from 1 (low) to 10 (high) the manned, unmanned and OTHR platforms. Each platform will be evaluated in terms of the importance of cost, detection capability, availability and operational tempo. The results from each interviewee, for the first twelve questions on the three systems weighed against the four variables as they apply to each platform, are supplied in the Appendix.

G. INTERVIEW RESULTS

Questions and results of the questions can be found in the Appendix.

Cost – All nine of the interviewees rated cost as the highest variable when rating the manned platforms. A low rating is the goal score when it comes to cost and manned platforms scored high. Manned Aircraft (AWACS & JSTARS) are over 30 years of age. They have a combined annual operating cost of approximately \$350 million dollars was a concern from all of the interviewees and with the current fuel prices rising daily the interviewees were concerned their operational cost would only keep rising. They all also agreed that a continuous orbit is not obtainable because of the cost of keeping aircraft airborne, airframes availability and lack of personnel.

Detection Capability – Manned platforms rated within the goal score of between seven and ten. All the experts believed manned platforms had a very good detection capability and was considered strength by all of the experts. Most believed that the detection range was a weakness because of their line of site capability.

Availability – Manned platforms were rated below the goal score of between eight and ten on their availability. Both aircraft in the manned platform are over thirty years old and their reliability (aircraft problems or radar problems) add to the availability problem manned platforms are occurring. Availability rate of manned aircraft was considered strength from the experts but two or three had a small concern what lengths AWACS & JSTARS have to go to keep that availability rate. Two or three explained when a mission is planned for manned platform they will have two or three aircraft standing by to make sure the one mission is completed and that is good except when an event occurs and they are covering multiple orbits and cannot have additional aircraft standing by. They stated as long as it is performing a peace time mission they think they have a very good availability rate. Additional experts viewed this as a weakness and strength. They viewed as a weakness because of personnel and strength because of the lengths that DoD will go through to make sure the mission is complete.

Operational Tempo – Manned platforms are some of the most deployed aircraft in DoD inventory. Personnel are deployed constantly and because of this each

interviewee rated the manned platform with a high score of having a very high operational Tempo per squadron. All nine interviewees agreed upon this answer when talking about Operational Tempo of the manned platform. They all believe that the aircraft and personnel are deployed away from home station more than any other platform in DoD inventory and is considered a large weakness.

H. SWOT ANALYSIS

In order to properly show the Strength, Weaknesses, Opportunities and Threats of the Manned Platforms, it is helpful to perform a basic SWOT (Figure 1) pertaining to all four variables. By taking into consideration the current internal and external environments affecting both AWACS and JSTARS, specific conclusions can be drawn to address the strategic gaps that need to be filled. As Bryson notes, “an important outcome of a (SWOT) analysis may be specific actions to deal with challenges and weaknesses, build on strengths (including distinctive core competencies), and take advantage of opportunities (including improving performance on key success factors).”³⁶

Table 1. Manned Platforms (AWACS AND JSTARS)

<p><u>STRENGTH</u> - Detection Capability - Availability rate is approx. 95%</p>	<p><u>WEAKNESS</u> - Annual Maintenance and Operating Cost - Procurement Cost - Detection Range - OPSTEMPO – Personnel being deployed - Availability - Dependency of personnel</p>
<p><u>OPPORTUNITY</u> - Used as a gap and surge capability</p>	<p><u>THREAT</u> - OPTEMPO - Potential of personnel in harm’s way - Availability - OTHR taking over the major part of Manned Platforms mission - Detection Capability - Border Security (Northern and Southern)</p>

³⁶ John M. Bryson, *Strategic Planning for Public and Nonprofit Organizations: A Guide to Strengthening and Sustaining Organizational Achievement*, 3rd ed. (San Francisco: Jossey-Bass, 2004), 127.

SWOT analysis showed all four variables emerged in the weaknesses field and they are:

- Annual Maintenance and Operating Costs are very high and procurement costs would be very high if additional assets had to be procured.
- Detection range is limited
- Operational Tempo is the highest because of its operational demand.
- Availability rate is not good because of dependency on personnel.

I. ANALYSIS OF PROS AND CONS

There are pros and cons with fielding the OTHR system as the main operating radar system and having manned and unmanned work as a family of systems.

Pros for Manned Platforms:

- Both AWACS and JSTARS have a good Detection Capability and are always moving because the aircraft are always moving. They are able to look in a large area and can look down in the ravines and valleys where low-level aircraft like to hide.
- Availability rate of both AWACS and JSTARS is high, and both systems have a great feature; if one aircraft breaks prior to takeoff, it can jump on another aircraft until they find one that works.
- AWACS and JSTARS would be great radar GAPS or hole-fillers because of their ability to direct their radar to a certain region, or narrow their search down to a certain area, such as a border.

Cons for Manned Platforms:

- The yearly Operational Cost per aircraft and personnel being used is very high. Fuel prices are soaring and AWACS and JSTARS burn or use about 8,000 gallons of fuel per hour. Both airframes are over thirty years old and both have participated in multiple events that have lasted long periods of time.
- Procurement Costs for either aircraft is in the hundreds of millions per aircraft and the number of aircraft that would be needed to give complete or partial radar coverage would be astronomical.

- Detection Range is very limited for both airframes. Both systems have more directional radar. AWACS and JSTARS detection range is constant; detection capability can change because of weather or the orbit they might be flying in.
- AWACS and JSTARS have one of the worst Operational Tempos with the different conflicts they have covered, including counterdrug missions, and they are still conducting training at different locations.
- Availability can be a pro or a con because these platforms can keep going to different aircraft until they find one that works. This would indicate a great availability rate, but they may have to go through two or three aircraft before they find one that works. They also have problems once they are on station (meaning flying at altitude and conducting their mission), when the communication or radar go down and will not work and they have to return to base and pick up another aircraft. Both aircraft are weather-dependent and they have to move orbit when the weather is bad, and weather can also affect the radar.

J. CONCLUSION

This chapter explores manned platforms, which are any airborne surveillance aircraft that has personnel onboard the platform. For this study only AWACS and JSTARS were evaluated because of their homeland defense and security mission. There are other manned platforms that were not discussed like E-2 Hawkeyes and Rivet Joints. They were not discussed because of Rivet Joints mission being classified and E-2 Hawkeye mission being more of a maritime mission and protector of the fleet when ships are deployed. This chapter started with history of manned radar platforms from past, current and future use. There were nine experts identified who have over one hundred and fifty years of experience in manned, unmanned and Over-the-Horizon Radar (OTHR) system and also in Homeland Defense and Security. During the interviews each expert were ask about manned platforms and how they applied to the four variables that are considered valuable measuring tool for past, current and future technology for DoD. The

four variables are cost, detection capability, availability and operational Tempo. Using the results of the interviews were used to compile a Strength, Weakness, Opportunity and Threat (SWOT) analysis on manned platforms. Overall, manned platforms had more weaknesses or opportunities than strengths and threats and SWOT analysis was also used to build pros and cons for the platform.

All the interviewees liked manned platforms and think they still have a mission in Homeland Defense and Security and their mission should be adjusted to meet the ever-changing DoD operational mission.

The United States Air Force has looked at combining the two manned platforms that were discussed in the paper into one manned platform but the funding for the future aircraft was cut and consequently this possible solution is unlikely to be implemented. There were also plans back in the late 1990s that both systems would be transferred to become more of a spaced based system but that program has also lost some of its steam, though it is still being discussed but lacks support from operators outside of the space realms. AWACS and JSTARS have been approved for operational use until the year 2025 and, until then, will need to be used to their fullest potential.

V. UNMANNED PLATFORMS

Exploring the capability of Unmanned Platforms as a viable asset in the War against Terrorism is an avenue that needs further research in order to ensure that they will be used to their fullest potential. Unmanned platforms have been around for many years and they are also the future radar technology vehicle being looked at in the context of High Altitude Airships (HAA) and Unmanned Airships Systems (USA). Future technology that is able to fly at altitudes above the weather is being planned with both HAA and UAS. Designs are underway for both to stay airborne for up to thirty days—with an HAA goal of staying airborne for up to a year at a time.

A. UNMANNED PLATFORMS

Unmanned platforms can be defined as any aircraft, including drones, balloons and airships, on which no individuals are present on the platforms. All personnel are on the ground controlling all function of the platform. “Unmanned platforms are any powered airborne platform that no pilot is needed nor any humans will be onboard, will and can operate remotely and can carry lethal, nonlethal payload or radar.”³⁷ Various types of unmanned platforms include High Altitude Airships (HAA), Tethered Aerostat Radar Systems (TARS) and Unmanned Aircraft Systems (UAS), which have different platforms to conduct their mission due to the fact that different companies field the different platforms. For this review, only three systems will be discussed for the unmanned platforms: High Altitude Airships (HAA), Tethered Aerostats Radar System (TARS) and Unmanned Aircraft System (UAS). These are the only systems that have the capability of remaining airborne for seven to thirty days without interruption, and are capable of tracking ground and surface targets. Because of this, they can be used for Missile Defense. Additionally, personnel can operate systems without being put in harm’s way.

³⁷ Unmanned System Roadmap 2007-2032, <http://www.acq.osd.mil/usd/Unmanned%20Systems%20Roadmap.2007-2032.pdf> (accessed December 2007).

B. HISTORY

“The earliest Unmanned Platform was A.M. Low’s Aerial Target of 1916”.³⁸ A number of remote-controlled airplane advances followed, including the Hewitt-Sperry automatic airplane, during and after World War I. “Jet engines were applied after World War II, in such types as the Teledyne Ryan Firebee I of 1951, while companies like Beechcraft also produced the Model 1001 for the United States Navy in 1955.”³⁹ These aircraft were little more than remote-controlled airplanes.

With the maturing and miniaturization of applicable technologies as seen in the 1980s and 1990s, interest in Unmanned Platforms grew within the higher echelons of the United States military. Unmanned Platforms were seen to offer the possibility of cheaper, more capable fighting machines that can be used without risk to aircrews. Initial generations were primarily surveillance aircraft, but some were fitted with weaponry, such as the Predator.

C. HIGH ALTITUDE AIRSHIPS (HAA)

The HAA is an unmanned lighter-than-air vehicle that will operate above the jet stream in a quasi-geostationary position to deliver persistent station keeping as a telecommunication relay, and also a weather observer and surveillance platform. This concept of a proven technology could take lighter-than-air vehicles into a realm that gives users capabilities on par with satellites, at a fraction of the cost. In position, an airship could survey an area approximately 775 miles in diameter and millions of cubic miles of airspace. United States Missile Defense sent Congress an \$8.9 billion spending request for 2008 and, in that request, the HAA program was terminated. Since that time, Congress has approach the Missile Defense Agency about resurrecting the HAA program. “According to the North American Aerospace Defense Command (NORAD), eleven high-altitude airships would provide overlapping radar coverage of all maritime and southern border approaches to the continental United States, and may be a significant

³⁸A. J. P. Taylor, *Jane’s Book of Remotely Piloted Vehicles*, http://en.wikipedia.org/wiki/Unmanned_aerial_vehicle (accessed February 7, 2007).

³⁹ *Ibid.*

asset in homeland defense efforts. The Stratospheric Platform System (SPS) dirigible operates just barely within the outer limits of the earth's atmosphere and is emerging as part of the military's twenty-first century transformational mindset."⁴⁰

Navigating through lower airspace to get to the operational altitude between 60,000-65,000 feet — and avoiding other air traffic and weather — is challenging. The same is true for another unmanned platform, UAS.

NORAD is also evaluating Global Observer High Altitude Long Endurance (HALE) Unmanned Aerial System (UAS). “Commander NORAD recommends supporting the Joint Capability Technology Demonstration (JCTD) efforts (sponsored by USSOCOM) and evaluating the potential of Global Observer to contribute to both NORAD and USNORTHCOM missions.”⁴¹ Global Observer is a UAS capable of flying at 55,000-65,000 feet, for up to seven days on-station, with a 330-pound payload. The prototype Global Observer plans to spiral to the Falcon Global Observer that has a larger wingspan, can carry 1,000 pounds and add one more day on-station. “NORAD believes the objective Falcon Global Observer vehicle can be a valuable near-term gap-filler as a surveillance sensor platform to defend against low altitude/low observable threats, including cruise missiles and lethal Unmanned Aerial Vehicles.”⁴² UAS can detect objects while orbiting over water and can also detect objects over land, as can TARS, which is conducting the mission along the southern border of the United States.

D. UNMANNED AIRCRAFT SYSTEM (UAS)

REPEATED INFORMATION NORAD is also evaluating Global Observer High Altitude Long Endurance (HALE) Unmanned Aerial System (UAS). “NORAD-USNORTHCOM Commander is fully behind testing and recommends supporting the Joint Capability Technology Demonstration (JCTD), looking at evaluating the potential of Global Observer which contributes now and in the future to NORAD-

⁴⁰ Global Security.org, *Intelligence, High Altitude Airship (HAA)*, www.globalsecurity.org/intell/systems/haa.htm (accessed February 7, 2007).

⁴¹ NORAD-USNORTHCOM Point Paper on Global Observer.

⁴² Ibid.

USNORTHCOM mission.”⁴³ Global Observer is a UAS capable of flying at 55,000-65,000 feet for up to seven days on-station with a 330-pound payload. The prototype Global Observer plans to spiral to the Falcon Global Observer that has a larger wingspan, can carry 1,000 pounds and add one more day on-station. “NORAD-USNORTHCOM believes Global Observer can fill a valuable gap-filler surveillance mission along the southern and northern borders where they can defend against low-altitude/low-observable threats, including cruise missiles and lethal Unmanned Airship vehicles.”⁴⁴

E. TETHERED AEROSTAT RADAR SYSTEM (TARS)

The final member of the unmanned platforms community is the TARS. Tethered Aerostat (TARS) constitute the two unmanned platforms. TARS have been operational for over twenty years along the southern border. The system is a balloon base, meaning the airship and aerostat has weather dependencies, attached by a tether, limited to 250 nautical miles (foot print) of surveillance range; reduced operational availability funding is being lifted yearly. During the late 1990s, TARS had ten operational systems operating along the southern border. With the cuts in defense spending, and more money going to the Middle East to fight the war on terrorism, the program has been hit hard; they have been reduced to six fully operational systems. TARS can stay airborne for about five days without being taken off station, unless weather is involved, and is not a system that takes a large amount of personnel to operate.

TARS do not require a significant investment in personnel because all the platforms are unmanned. TARS have approximately five people per crew, to be available 24/7 to launch, monitor and recover. All three systems in the unmanned platform are good surveillance systems, but the one system that can accomplish all three missions would be Over-the-Horizon Radar.

⁴³ NORAD-USNORTHCOM Point Paper on Global Observer.

⁴⁴ Ibid.

F. UNMANNED PLATFORM FUTURE

In the future, it is expected that an increasing number of roles will be performed by unmanned platforms. Bombing and ground attacks will be added to the surveillance mission and search and rescue missions will be performed by unmanned platforms with heat sensors to help find humans lost in the wilderness, trapped in collapsed buildings, or adrift at sea by using HAA, TARS and UAS.

Both TARS and UAS have been operating along the southern border with TARS operating for the past twenty years. The HAA budget has been lifted and, if the budget is approved, it will still not be available to start operational use until the year 2012. The TARS program has been reduced to six operational systems, and the budget is being readdressed each year. The UAS role along the southern border is limited to a military working area because a deal with Federal Aviation Administration has not been addressed regarding flying the UAS outside of the military working areas. With these constraint on unmanned platforms, the effects of the operating and maintenance cost, detection capability, and availability of all three systems could be an issue.

G. RESULTS SUMMARY OF WEIGHTED QUESTIONS

During the interviews, each expert was asked to rate from 1 (low) to 10 (high) the manned, unmanned and OTHR platforms. Each platform will be evaluated in terms of the importance of cost, detection capability, availability and operational tempo. The results from each interviewee, for the first twelve questions on the three systems weighed against the four variables as they apply to each platform, are supplied in the Appendix.

H. INTERVIEW RESULTS

Questions and results of the questions can be found in the Appendix.

Cost – Seven of the nine of the interviewees rated cost as above five (which is the high end of the goal score) when rating the unmanned platforms. Reasoning for the higher scores in the unmanned platforms is the uncertainty of High Altitude Airships (HAA) funding being lifted. Most of the seven fill it will cost more to field the systems

because of the delays. All nine of the experts rated unmanned platforms as above the goal score but they all agreed unmanned cost were considerable lower than manned platforms and they considered it high with the capability DoD would be receiving. Only five of the nine considered unmanned platform as a strength and four thought it was a weakness. Overall cost was considered strength.

Detection Capability – Unmanned platforms rated outside the goal score on detection capability because of being weather dependent and the radar can be affected by the weather. All the experts believed unmanned platforms considers platform strength but they also consider detection range a weakness. Detection capability was rated both strength and threat because of lack of capability for detection along the Northern Border and limited detection capability along the Southern Border.

Availability – Unmanned platforms were rated below the goal score of between eight and ten on their availability. All nine of the interviewees rated the availability of unmanned platforms as the worse because one of the platforms is balloon based and has to be reeled in when weather come close and has to be lowered for maintenance often. UAS availability problems are from not being able to fly in certain areas because of flight restrictions and the early incidents they were having and still have not has often but wrecks still occur. All experts rated availability as a weakness.

Operational Tempo – Unmanned platforms are hardly ever deployed and because of this our experts rated the platform below the goal score line of five or below being a good rating. Personnel are only deployed when a UAS is deployed to a region for real world event or and exercise. Experts responded that they thought the units were attempting to keep the deployments to a minimum by rotating new personnel in and out every thirty days or so. Seven of the nine experts rated Operational Tempo as a strength.

I. SWOT ANALYSIS

To properly show the Strength, Weaknesses, Opportunities and Threats of the Manned Platforms, it is helpful to perform a basic SWOT (Figure 1) pertaining to all four variables. By taking into consideration the current internal and external environments affecting HAA, UAS and TARS, specific conclusions can be drawn to address the

strategic gaps that need to be filled. As Bryson notes, “An important outcome of a (SWOT) analysis may be specific actions to deal with challenges and weaknesses, build on strengths (including distinctive core competencies), and take advantage of opportunities (including improving performance on key success factors).”⁴⁵

Table 2. Unmanned Platforms (HAA, UAS & TARS)

<p><u>STRENGTH</u> - Low Operating cost - Detection Capability - OPSTEMPO - Less dependent on Personnel</p>	<p><u>WEAKNESS</u> - Detection Range - Operational Availability - Availability - Weather Dependent</p>
<p><u>OPPORTUNITY</u> - OPSTEMPO – Reducing the number of personnel involved. - Used as a gap and surge capability - One system not available until 2012</p>	<p><u>THREAT</u> - One of the systems lacks of funding (Cost). - Detection Capability - Border Security (Northern and Southern)</p>

SWOT analysis showed two of the four variables emerged in the weaknesses field and they are:

- Detection range is limited
- Availability rate is not good because of being weather dependent and operational availability is limited because reduction in the number of equipment.

SWOT analysis also showed three of the four variables emerged in the strength field and they are:

- Unmanned Platforms have a good Detection Capability
- Compared to manned platform the cost of unmanned platforms are considerably less
- Operational Tempo is lower than manned platform

⁴⁵ Bryson, *Strategic Planning for Public and Nonprofit Organizations*, 127.

J. ANALYSIS OF PROS AND CONS

There are pros and cons with fielding the OTHR system as the main operating radar system and having manned and unmanned work as a family of system.

Pros for unmanned Platforms:

- Compared to Manned Platforms, the Unmanned Platforms have a low operating cost. The yearly budgets for unmanned platforms like TARS and UAS are very low because they can stay aloft for long periods of time.
- Operational Tempo is very low because most of the personnel operating at each site are located at that site and do not have to deploy to different locations for long periods of time. UAS will deploy and the operator will have to deploy with them, but not for long periods of time.
- Detection Capability is good on both systems. They are like manned platforms when it comes to being weather dependent, but when they are airborne, they provide a concise air picture. High Altitude Airship (HAA) is not mentioned because everything about HAA is still notional and has not been fully tested.

Cons for unmanned Platforms:

- Detection Range is limited because of the altitudes they can fly. The higher they fly, the further they could see, and there are plans for the UAS to be able to someday orbit at over 60,000 feet. They both are limited to less than 250 nautical miles.
- Availability is very low because of both systems being weather dependant. They both have had incidents of falling out of the air. There have been approximately four incidents with TARS where lightening has struck the balloon, and the system has fallen out of the air. UAS has also had their problems, with multiple incidents on takeoff and landings.
- Unmanned Platforms have had Budget Reduction on the TARS system when they lowered the operational platforms from ten to six. HAA had their entire

budget lifted by Missile Defense Agency (MDA) in 2007, but Congress is attempting to get HAA fully funded so they can continue testing.

K. CONCLUSION

This chapter explores unmanned platforms, which are any platforms to include drones, balloons and airships, on which no individuals are present on the platforms. For this study Tethered Aerostat Radar System (TARS), Unmanned Airship System (UAS) and future High Altitude Airship (HAA) were evaluated because of their homeland defense and security mission. This chapter started with history of unmanned radar platforms from past, current and future use. There were nine experts identified who have over one hundred and fifty years of experience in manned, unmanned and Over-the-Horizon Radar (OTHR) system and also in Homeland Defense and Security. During the interviews each expert were ask about unmanned platforms and how they applied to the four variables that are considered valuable measuring tool for past, current and future technology for DoD. The four variables are cost, detection capability, availability and operational Tempo. Using the results of the interviews were used to compile a Strength, Weakness, Opportunity and Threat (SWOT) analysis on unmanned platforms. Overall unmanned platforms had more strengths and threats than weaknesses and opportunities and SWOT analysis was also used to build pros and cons for the platform.

All the interviewees liked unmanned platforms costs and think they still have a mission in Homeland Defense and Security and their mission should be adjusted to meet the ever changing DoD operational mission.

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VI. OVER-THE-HORIZON RADAR

Exploring the capability of Over-the-horizon radar (OTHR) system as a viable asset in the War against Terrorism is an avenue that needs further research. Making sure the system would be used to the fullest potential. OTHR systems have been around for many years, conducting USSOUTHCOM and Austrian missions. NORAD-USNORTHCOM future planners are looking at OTHR as constant radar, the backbone of NORAD-USNORTHCOM radar systems for their Area of Responsibility (AOR). Over-the-horizon radar system is like combining manned and unmanned platforms together without leaving the ground. OTHR uses the ionosphere to bounce off waves to generate a response from air, land or maritime targets.

OTHR technology acts by looking down on targets (as do manned and unmanned platforms) but OTHR platforms are not affected by the weather, unlike manned and unmanned platforms.

A. OVER-THE-HORIZON RADAR

OTHR radar uses the “bounce” system, in that when a signal is sent, it bounces off the ionosphere. Everything is signal bounce; it goes further but gets weaker. This bouncing off the ionosphere enables the system to see a very long way. OTHR is capable of targeting and identifying ships over 1,000 miles from the transmit site. All operational HG sky wave radar designs rely heavily on 1970’s thinking and technology. They scan serially in azimuth and range (frequency) to cover an area where scan rates are governed by coherent dwell and revisit requirements. This mode of operations previously required multitasking for different class targets, one at a time. It now has the capability to simultaneously track multiple targets including aircraft, ships, missiles and sea states. All personnel are on the ground controlling all function of the system. For this review, only OTHR systems will be discussed. OTHR has the capability of staying operational for long periods of time (up to thirty days) without interruption, and are capable of tracking ground, maritime and surface targets. Because of this, they can be used for Missile Defense. Additionally, personnel can operate systems without being put in harm’s way.

B. HISTORY

In 1956, the Naval Research Laboratory concluded a definitive set of experiments that showed that the ionosphere is generally sufficiently stable for High Frequency (HF) sky wave radar to succeed for over-the-horizon aircraft detection.⁴⁶

Use of the High Frequency (HF) Band (3 to 30 Megahertz) permits extending radar ranges beyond the horizon, 500-2,000 nautical miles, using sky wave propagation where the ionosphere can be thought of as providing a virtual mirror. In addition, modest extensions of line-of-sight range can be obtained in this frequency band by using surface wave propagation over the sea. In the Naval Research Laboratory's (NRL) initial development program of HF over-the-horizon radar, essentially all of the elemental feasibilities were discovered and demonstrated.⁴⁷ By sharing information with Australia, OTHR has been able to employ a parallel target-tasking philosophy, which increases performance capability against a particular target class and enables multitasking.

C. OVER-THE-HORIZON RADAR (OTHR)

Worldwide, only two operational OTHR radar systems exist at this time. One is in the U.S. and looks toward South America; the other one is in Australia. The one in North America is used for drug interdiction (mainly by JIATF-South and Customs).

JORN was not born overnight but as the result of a long series of experimental and theoretical studies, negotiations with authorities in Australia and the U.S., and a good deal of wheeling and dealing in the 1970s — at a cost of \$1.8 billion. The Australian JINDALLE Operational Radar Network (JORN) was activated in May 2003. JORN provides wide-area surveillance (WAS) of air and sea approaches up to 3,000 km (unclassified distance) away from Australia's coastline. JORN is designed to monitor air and sea movements across 37,000 km of largely unprotected coastline and 9 million

⁴⁶ Jenson and Uniacke, "Spectral Bandwidth of Backscatter Signals."

⁴⁷ Headrick and Skolnik, "Over-the-Horizon Radar in the HF Band."

square kilometers of ocean. It is being used to cast a security shield across Australia's remote northern approaches without the high cost of maintaining constant maritime and air patrols.

Australians have used OTHR systems to detect and track illegal immigrants. Most of Australia's northern waters are unguarded. Australian custom authorities have used JORN to gain intelligence to apprehend illegal immigrants on a monthly basis. JORN can also measure wave height and wind directions for meteorological reports.⁴⁸

Since being deployed, the network has detected and tracked hundreds of surface vessels and aircraft beyond the horizon along a 15 million square kilometer stretch from Geraldton in Western Australia to Cairns in Queensland. The mission is air sovereignty, border protection and maritime domain awareness; operations are from three sites: Longreach, Alice Springs and Laverton. The JORN system has been in development for over twenty years and the system was developed through collaboration with the United States OTHR community, facilitated by a Memorandum of Agreement (MOA) between the U.S. and Australia's Defense Science & Technology Organization; U.S./Australia collaboration continues to yield operational improvements. All three sites have transmit and receive sites and are separated by 170 Kilometers (102 miles). Radio frequency energy is bounced off the Ionosphere, energy is reflected from the backscatter to the receiver where high performance computers process the returned energy, and airborne and surface targets are tracked.

The Alice Springs site, which can be operational, is used mainly as a Research and Development facility. Australia has had OTHR collaboration for more than twenty years, and is eager to build on the current operational relationship. Additionally, Australia has activated its OTHR Research and Development program by allocating over \$50 million so far. Listed below is what has been implemented and those with whom Australia has been working. Australia has integrated OTHR into its National Defense since 1992, including Overhead Non-Imaging Infra-Red, (ONIR), sensor-to-shooter connectivity, Coast Watch, DoD, Customs and illegal immigration control.

⁴⁸ *Defence Systems Daily*, "JORN assures early warning for Australia," <http://defence-data.com/features/fpage37.htm> (accessed January 8, 2008).

Jindalee Over-the-Horizon Radar was used to track and detect military aircraft from 1,500 kilometers away. It has also detected a Stealth aircraft because the Jindalee radar bounces down from the ionosphere onto upper surfaces that include radar-reflecting protrusion for cockpit, engine housings and other equipment.⁴⁹

The NORAD-USNORTHCOM OTHR Technology Development Roadmap and Fiscal Year (FY) 08 Combatant Initiative Fund (CCIF) will identify the engineering design tasks for an initial OTHR subscale prototype system and subsequent spiral development phases leading to the incremental production of an operational, multi-mission OTHR system for homeland defense/security.

Persistent, wide-area surveillance of the approaches to North America has been a long-standing requirement for NORAD-USNORTHCOM. The enduring nature of the homeland defense mission — the large volume of airspace and ocean to constantly monitor, and line-of-sight limitations of surface-based radars against low-altitude targets — exclude most conventional sensor solutions.

This mode of operations previously required multitasking for different class targets, one at a time. It now has the capability to simultaneously track multiple targets including aircraft, ships, missiles and sea states. By sharing information with Australia, OTHR has been able to employ a parallel target-tasking philosophy, which increases performance capability against a particular target class and enables multitasking.

D. THE FUTURE OF OVER-THE-HORIZON RADAR

The future is bright for OTHR. Austrians and United States are working closely together on a partnership of sharing information of the upgrade of the OTHR to Next Generational Over-the-horizon radar (NEXGEN). NEXGEN system will upgrade software that could give OTHR the capability of determining altitude of aircraft and reducing the affects of reduction in radar capability during nighttime hours. Because of the close relationship between the two nations the affects to keep the cost down, detection

⁴⁹ *Defence Systems Daily*, “JORN assures early warning for Australia.”

capability sharp and availability of the system at a high operational rate will keep the OTHR program on an upward trend now and in the future.

E. RESULTS SUMMARY OF WEIGHTED QUESTIONS

During the interviews, each expert was asked to rate from 1 (low) to 10 (high) the manned, unmanned and OTHR platforms. Each platform will be evaluated in terms of the importance of cost, detection capability, availability and operational tempo. The results from each interviewee, for the first twelve questions on the three systems weighed against the four variables as they apply to each platform, are supplied in the Appendix.

F. INTERVIEW RESULTS

All the results can be found in the Appendix.

Cost – Seven of the nine of the interviewees rated cost as above five (which is the high end of the goal score) when rating the unmanned platforms. Reasoning for the higher scores in the unmanned platforms is the uncertainty of High Altitude Airships (HAA) funding being lifted. Most of the seven fill it will cost more to field the systems because of the delays.

Detection Capability – OTHR systems rated outside the goal score on detection capability because of being weather dependent and the radar can be affected by the weather. All the experts believed unmanned platforms have an adequate detection capability.

Availability – Unmanned platforms were rated below the goal score of between eight and ten on their availability. All nine of the interviewees rated the availability of unmanned platforms as the worse because one of the platforms is balloon based and has to be reeled in when weather come close and has to be lowered for maintenance often. UAS availability problems are from not being able to fly in certain areas because of flight restrictions and the early incidents they were having and still have not has often but wrecks still occur.

Operational Tempo – Unmanned platforms are hardly ever deployed and because of this our experts rated the platform below the goal score line of five or below being a good rating. Personnel are only deployed when a UAS is deployed to a region for real world event or and exercise. Experts responded that they thought the units were attempting to keep the deployments to a minimum by rotating new personnel in and out every thirty days or so.

G. INTERVIEW RESULTS

Questions and results of the questions can be found in the Appendix.

Cost – Seven of the nine interviewees rated cost within the goal score of between three and five. Two experts rated the cost above the goal score. Overall the rating of OTHR system was considered strength by our experts. Only two of the experts thought the cost could escalate but both also expressed that the cost would not be at the manned or unmanned platform range.

Detection Capability – OTHR systems scored at or above the goal score of between seven and ten. All nine experts rated OTHR detection capability with high marks. Experts expressed the capability of being able to detect and monitor targets at distances of over 1,000 miles and when ask about nighttime tracking eight of the nine expressed the capability reduces to between 500-600 miles which is more than manned and unmanned platforms unclassified listed detection capability performance.

Availability – Availability was rated with high marks also. Range of the goal score was from eight to ten and OTHR was rated by seven of the nine experts with an eight or above rating. All nine believed the OTHR system had the best overall availability ratio than any of the other platforms. Even during reduced capability of nighttime performance, OTHR out performed both manned and unmanned platforms. OTHR still have performance limitations of its own during certain conditions and therefore must be operated as part of a family of system architecture was a sentiment of at least seven of the experts.

Operational Tempo – Unlike the manned platforms OTHR systems do not deploy because transmit and receive sites are located in an area and cannot move. They are located at a facility that is maintained on a 24 hour basis. All nine experts believe the only time an operational Tempo might arise is if an event occurs and all personnel are called to their respected site because management wants additional personnel on duty for any type of crisis or for extra security. OTHR scored well below the goal score of five or below. A Homeland Defense and Security network of OTHR systems would relieve the Operational Tempo demands on High Demand/Low Density (HDL) assets, freeing them up to perform other missions or help with gap filling missions.

H. SWOT ANALYSIS

To properly show the Strength, Weaknesses, Opportunities and Threats of the Manned Platforms, it is helpful to perform a basic SWOT (Figure 3) pertaining to all four variables. By taking into consideration the current internal and external environments affecting OTHR, specific conclusions can be drawn to address the strategic gaps that need to be filled. As Bryson notes, “An important outcome of a (SWOT) analysis may be specific actions to deal with challenges and weaknesses, build on strengths (including distinctive core competencies), and take advantage of opportunities (including improving performance on key success factors).”⁵⁰

⁵⁰ Bryson, *Strategic Planning for Public and Nonprofit Organizations*, 127.

Table 3. Over-The-Horizon Radar (OTHR)

<p><u>STRENGTH</u> - Procurement Cost - Operating cost - Detection Capability - System availability - Missile Detection - OPSTEMPO – Quality of life - Availability - Minimal of personnel</p>	<p><u>WEAKNESS</u> - Capability reduces during darkness</p>
<p><u>OPPORTUNITY</u> - NORAD-USNORTCOM main radar</p>	<p><u>THREAT</u> - Detection Capability - Border Security (Northern and Southern)</p>

SWOT analysis showed one of the four variables emerged in the weaknesses field and it is:

- OTHR capability reduces during the nighttime hours because of the ionosphere layers.

SWOT analysis also showed four of the four variables emerged in the strength field and they are:

- OTHR have a great Detection Capability.
- Compared to manned and unmanned platform, the costs of OTHR are considerably less.
- Availability if a strength and a weakness. During the daylight hours OTHR availability is exceptional.
- Operational Tempo is lower than manned and unmanned platforms.

I. PROS AND CONS

There are pros and cons with fielding the OTHR system as the main operating radar system and having manned and unmanned work as a family of system.

Pros for OTHR:

- Detection capability is one of the strengths with the OTHR. The system has a good cross section (where they can see very small aircraft and small maritime vessels).
- OTHR Detection Range can range from 500-2,000 nautical miles during the daylight hours.
- OTHR Availability rate has been listed in the high 90-percent range from the current operational systems in Australia and working in the Caribbean.
- Operational Tempo is very low with each site needing a minimum amount of personnel to operate the system on an everyday schedule. Personnel need not leave their daily duty location.
- Operational cost is minimal compared to manned and lower than the unmanned platforms when it comes to actual money.
- Procurement Cost on an OTHR system is low when compared to manned Platforms, and compare about the same as unmanned platforms when it comes to procurement cost.

Cons for OTHR:

- Detection capability reduces during darkness. OTHR layers reduces during the hours of darkness, but it only reduces from being able to detect from 100-2,000 nautical miles to around 500-700 nautical miles.

- Currently, there are no altitude readout (meaning when a target is detected the controller cannot determine at which altitude the target is located). The FAA, U.S. and Australia are currently working the issue and hope to have this flaw corrected within the near future.

J. CONCLUSION

This chapter explores OTHR system radar uses the “bounce” system, in that when a signal is sent, it bounces off the ionosphere. OTHR technology acts by looking down on targets (as do manned and unmanned platforms) but OTHR platforms are not affected by the weather, unlike manned and unmanned platforms. For this study Over-the-Horizon System was evaluated because of their Homeland Defense and Security mission. This chapter started with history of OTHR from past, current and future use. There were nine experts identified who have over one hundred and fifty years of experience in manned, unmanned and Over-the-Horizon Radar (OTHR) system and also in Homeland Defense and Security. During the interviews each expert were ask about OTHR and how they applied to the four variables that are considered valuable measuring tool for past, current and future technology for DoD. The four variables are cost, detection capability, availability and operational Tempo. Using the results of the interviews was used to compile a Strength, Weakness, Opportunity and Threat (SWOT) analysis on OTHR system. Overall rating of OTHR was very good with all four variables being rated in the strength field. Only one variable (detection capability) was rated in weakness. Detection capability was rated in strength and weakness by the expert because of the reduced night hour’s operations and SWOT analysis was also used to build pros and cons for the platform.

All the interviewees really liked all four variables of OTHR system and think OTHR have a great capability to bring to NORAD-USNORTHCOM mission set for Homeland Defense and Security. OTHR mission should be adjusted to meet the ever changing DoD operational mission.

VII. RECOMMENDATION/CONCLUSION

To make North America secure for the future, we need integrated, coordinated and seamless measures in place at, within, and beyond our borders to provide our people and our infrastructure with the highest possible common level of protection from terrorists and other criminal elements, as well as from the common threats of nature.⁵¹

—Joint Statement by President Vicente Fox Quesada, President George W. Bush, and Prime Minister Paul Martin March 23, 2005.

A. INTRODUCTION

The previous chapters of this thesis discussed several issues that NORAD-USNORTHCOM and DoD leadership should consider when discussing NORAD-USNORTHCOM lack persistent multi-domain Wide Area Surveillance (WAS) to conduct their assigned Homeland Defense and Homeland Security missions. It also collected data to assist with identifying potential problems regarding manned, unmanned platforms and Over-the-Horizon Radar (OTHR) system. This research used both literature and interviews to collect data from experts with over one hundred and fifty years of background in manned, unmanned radar surveillance platforms and Over-the-Horizon Radar. Major findings of the analysis include lack of multi-domain Wide Area Surveillance, strength and weaknesses of manned and unmanned platforms. Three courses of action will be discussed to assist NORAD-USNORTHCOM and DoD leadership when deciding to embrace a culture of integrating manned, unmanned platforms and Over-the-Horizon Radar (OTHR) system or whether to keep things the way they are and work out any radar overload, maintenance or shortage problems as they come up.

The first course of action would be to maintain the status quo; the second would be increasing funding for, aircraft, TARS and UAS fleet procurement. The third course

⁵¹ Security and Prosperity Partnership of North America, Report to Leaders, June 2005. Available at <http://www.embamexcan.com/ECONOMY/SPP-report%5B1%5D.pdf> (accessed February 4, 2008).

of action would be approving funding for OTHR program to include procurement, testing and full operational approval and forming a family of radar systems with manned and unmanned platforms. The chapter concludes with several recommendations to consider if the decision is made to integrate all three systems.

B. COURSES OF ACTION

1. Do Nothing

The first course of action would be to maintain the status quo and not support the implementation of a family of radar systems. The only possible advantage associated with the status quo is that the radar communities would not be to change because organizations are used to working with manned and unmanned current radar configuration. In contrast, three disadvantages associated with the status quo decision will be identified. The first is that manned and unmanned platforms are unable to conduct a full multi-domain surveillance mission for NORAD-USNORTHCOM Area of Responsibility without tripling (course of action 2) their current configuration and they would not be able to sustain continuous operations because of the cost of fuel, parts and material, availability of equipment and personnel Operational Tempo for both manned and unmanned platforms. Continuing with status quo still leaves a lack in persistent multi-domain Wide Area Surveillance (WAS).

2. Increasing Funding for Aircraft, TARS and UAS Fleet Procurement

The second course of action would be to implement a program of spending more money on manned and unmanned platforms by adding additional AWACS, JSTARS aircraft, UAS and TARS platforms. Adding additional assets would be very expensive because the AWACS and JSTARS fleet would have to be tripled for complete coverage and even if this would take time, be very expensive with fuel, maintenance, and parts cost and maintaining this Operational Tempo on people and equipment would be hard to maintain for a long period of time. Manned platforms have been identified for retirement by the year of 2025. If the fleet were not increased Homeland Defense and Security

would suffer because the problem of lack of persistent multi-domain Wide Area Surveillance would still be lacking. Continuing this course of action is would be very expensive and DoD is asking people to do more with less because of more and more money being spent and organizations being ask to reduce budget so more defense money can be pushed toward the war in Iraq. Manned aircraft are suitable only for limited-duration contingency operations, and only for a limited geographic area.

3. Approving OTHR Funding, Testing, Operational Use and Combining All Three Assets to Form a Family of Radar Systems

The third course of action would be to implement a OTHR program to include funding, feasibility studies, procurement of equipment, testing and full implementation of a fully mission capable OTHR system as the main 24/7/365 days a year radar system for NORAD-USNORTHCOM Area of Responsibility (AOR). The advantage of this course of action is DoD would have a consistent everyday multi-domain radar system capable of locating, indentifying, monitoring targets continuously. Manned and unmanned platforms have strengths that need to be highlighted and the weaknesses can be silenced by combining with OTHR strengths would form an alliance between past, present and future technology that would give NORAD-USNORTHCOM a multi-domain consistent all altitudes radar system. Manned and unmanned platforms weaknesses of availability, detection range, operational Tempo would be covered or overlapped with OTHR strengths of detection range, availability and operational Tempo. Areas that have a high concentration of air, maritime and land traffic as is along the southern U.S. border could be overlap coverage with unmanned platforms of TARS, UAS and in the future HAA. If for any reason a system would go down there would always be a backup system watching the area and this could give manned and unmanned platforms the capability their radar system as more of a directional radar. They could point the radar to a specific area because of receiving Intel of specific operations. Combining systems would also free up manned platforms for missions outside of NORAD-USNORTHCOM AOR and could reduce Operational Tempo of manned platforms.

C. RECOMMENDATION

This thesis recommends that course of action number 3 be accepted and if the decision is made to integrate OTHR with manned and unmanned platforms into the NORAD-USNORTHCOM radar community plan several recommendation are listed to assist DoD and NORAD-USNORTHCOM planners with developing a strategy to address the needs and concerns of this author. These recommendations include:

1. Complete Funding for OTHR System Program

DoD needs to approve NORAD-USNORTHCOM request for over 3 millions dollars so testing can begin. There are two OTHR currently operating in the world and they are located in Australia and one being operated in the Caribbean and NORAD-USNORTHCOM planners have been working with both organizations learning from them of their past experiences and future testing that will enhance OTHR capabilities. Incorporating 7-9 OTHR systems throughout the United States would enable NORAD-USNORTHCOM, Australia and Caribbean system to lean on and learn from each other. During interviews with nine experts interviewees confirmed it would take approximately 7-9 OTHR system for complete coverage of NORAD-USNORTHCOM AOR.

2. Funding for Procurement of OTHR System, Testing; Operational Approval and Liaison Officer Appointed

DoD planners need to approve additional funding so 7-9 OTHR systems can be constructed, tested and approved for operations. During testing manned and unmanned platforms need to work with OTHR system so a concept of operations can be written and approved so each organization will know their duties and limitations. Managers must remember that they are breaking ground with a new concept of using OTHR for Homeland Defense and Security protection. A liaison should be assigned as a liaison between manned, unmanned platforms, DoD planners, JORN system in Caribbean OTHR system. Working through the liaisons from each system, monthly meetings can be

scheduled at the stations to allow visiting and interacting with each system, thus creating the ability to develop positive social relationships that can transfer into productive working relationship during disasters.

The liaisons should be responsible for the activation of their OTHR program working with other OTHR systems because two of the three OTHR programs have the same goal of Homeland Defense and Security.

3. Implement Team Building Strategies

The intent of this recommendation is to write policies that will open lines of communication and interaction between JORN in Australia and Caribbean OTHR system. The liaison officers suggested in recommendation 2 should be utilized as the point of contact for all OTHR building opportunities. An analysis of the DoD community should be conducted to locate support structure within DoD.

New programs have a better chance of acceptance when the interest and respect filter down through the ranks. Having a team building strategy that shows everyone where they stand on the team and having each team member pulling the same direction and interaction with each employee will help a new system succeed.

D. INTERVIEWS

Interviews were conducted with nine experts that have over one hundred and fifty years in manned, unmanned platforms and OTHR systems. Interviews confirmed that not one system can be a stand alone system and accomplish multi-domain Wide Area Surveillance. Eight of the nine experts expressed combining manned, unmanned platforms with OTHR system, concentrating on their strengths and silencing the weaknesses will enable to form a relationship that is good for Homeland Defense and Security. They agreed by combining the systems would free up manned platforms to concentrate more of their mission outside of NORAD-USNORTHCOM AOR and would allow both platforms a capability of reducing their personnel operational Tempo. One of the experts had a very good response when ask about Homeland Defense and Security “Homeland defense is an enduring mission that requires persistent, wide-area

surveillance to protect the US population, critical infrastructure, and centers of government and finance. There is no projected end state to the homeland defense and security mission where victory can be declared and forces redeployed.”⁵²

E. CONCLUSION

Radar platforms have evolved overtime, from the German Zeppelins in the 1890s, to manned, unmanned and Over-the-Horizon Radar (OTHR) technology to the future evolution of High Altitude Airships (HAA) in 2012. Balloon base platform was one of the first used and still is being used as a current and future radar platform.

Nine expert radar personnel were contacted, interviewed and data collected. Collectively, the nine expert’s interviewees have over one hundred and fifty years of experience in manned, unmanned platforms and OTHR technology.

Manned, unmanned and OTHR systems history, current technologies capability, interviewees constructive comments on each of the systems, Strength, Weakness, Opportunity and Threat (SWOT) analysis, pros and cons were constructed from the interviews and literature.

Collectively, the interviews portrayed that the OTHR system where rated the highest value, rated the most strengths and fewest weaknesses. Interviews also showed that not one system could operate as a lone radar system without another system working alongside one another. Interviews showed that each system relies on one another. Homeland Security professionals appear to be nudging toward the Australia model of Over-the-Horizon Radar system being the main operating radar system for the United States. As we emulate the Panopticon vision for protecting NORAD-USNORTHCOM Area of responsibility, we must do so with protectors of society requires us to relentlessly pursue organizations that threaten the safety of our citizens. Department of Defense must have the zeal directed towards completing that task of a family of radar systems with OTHR as the backbone radar system, complemented by manned and unmanned platforms. Capitalizing on the variable strengths and silencing the variable weaknesses a

⁵² Response from Interviewee in February 2008.

three system program could be formed as a family of systems complementing each strong variable. Full implementation needs to include funding for testing, procurement and implementation of the family of systems as soon as possible.

As technology improves the ability of DoD to do more with less, consideration must be channeled toward ensuring we operate in a manner that protects our interests and our citizens in NORAD-USNORTHCOM Area of Responsibility. Forging forward with our current surveillance configuration is creating a recipe for disaster.

Staffed with intelligent and dedicated personnel, the homeland security and NORAD-USNORTHCOM discipline serves the nation in a manner unlike any other profession. Eager to protect the United States, these committed people adopt new methods and technologies quickly. It is unlikely that any other group of people is more intense about guaranteeing Americans their privacy while protecting them from danger. Over-the-Horizon Radar coupled with manned and unmanned surveillance platforms represents a tremendous opportunity to exponentially multiply the effectiveness of homeland security efforts in America. Additional research should also be conducted to evaluate the suggested recommendation toward improving NORAD-USNORTHCOM AOR multi-domain lack of Wide Area Surveillance.

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APPENDIX A. AUTHOR'S INTERVIEW QUESTIONS

Please rate each statement (3 for each variable) in terms of how strongly you agree with the statement.

Please use a 10 point scale (1-10) on each question (for each variable). 1 = Low
10=High

- Manned Platforms: AWACS & JSTARS
- Unmanned Platforms: TARS, HAA and UAS
- OTHR System: Over the-Horizon-Radar

Cost

1. Cost is usually a significant factor when spending millions of dollars on a radar system. How would you rate the Cost of operations of the Manned Platforms?
2. Cost is usually a significant factor when spending millions of dollars on a radar system. How would you rate the Cost of operations of the Unmanned Platforms?
3. Cost is usually a significant factor when spending millions of dollars on a radar system. How would you rate the Cost of operations of the OTHR?

Detection Capability

1. Detection Capability is one of the major considerations when spending millions of dollars on a radar system. How would you rate the Detection Capability of the Manned Platform?
2. Detection Capability is one of the major considerations when spending millions of dollars on a radar system. How would you rate the Detection Capability of the Unmanned Platform?
3. Detection Capability is one of the major considerations when spending millions of dollars on a radar system. How would you rate the Detection Capability of the OTHR System?

Availability

1. Availability of a system is a significant factor when spending millions of dollars on a radar system. How would you rate the Availability rate of the Manned Platforms?

2. Availability of a system is a significant factor when spending millions of dollars on a radar system. How would you rate the Availability rate of the Unmanned Platforms?

3. Availability of a system is a significant factor when spending millions of dollars on a radar system. How would you rate the Availability rate of the OTHR?

Operational TEMPO

1. Personnel operational TEMPO can be a significant factor when spending millions of dollars on a radar system. How would you rate the Personnel Operational TEMPO of Manned Platforms?

2. Personnel operational TEMPO can be a significant factor when spending millions of dollars on a radar system. How would you rate the Personnel Operational TEMPO of Unmanned Platforms?

3. Personnel operational TEMPO can be a significant factor when spending millions of dollars on a radar system. How would you rate the Personnel Operational TEMPO of OTHR?

Please answer the following question to the best of your knowledge. Please be concise and to the point.

Cost:

1. What is the budget limitation on implementation of the OTHR program for NORAD/USNORTHCOM?

2. Which system (Manned, Unmanned or OTHR) would be the most cost effective to operate 24/7/365? Explain your answer.

3. Manned Aircraft (AWACS & JSTARS) are over 30 years of age. They have a combined annual operating cost of approximately \$350 million dollars. Do you think the radar coverage we are receiving from both systems is cost effective? Please explain your answer.

Detection Capability:

1. What are the Homeland Defense (HLD)/Homeland Security (HLS) implication of each border, both from US to the other nation and from the other nation to the US when it comes to Detection Capability for Manned, Unmanned or OTHR platforms?

2. Does the Northern Border (along Canadian border) have a pervasive radar surveillance system with the detection capability that can identify low (below 5,000 feet) flying aircraft? Explain your answer.

3. Comparing all three platforms (Manned, Unmanned and OTHR) which platform gives the best Detection Capability? Explain your answer and keep it at the unclassified level. .

Availability:

1. What are the factors currently, and in the foreseeable future, affecting the availability of OTHR program?

2. How concerned are you when it comes to availability rate, that the United States Southern border can be protected with the current capability of Manned (84 percent availability rate), Unmanned Platforms (62 percent availability rate) that Department of Defense and Department Homeland Security is using? Please explain answer.

3. In your opinion do you think Manned, Unmanned and OTHR platforms would still have a mission (be available) if OTHR is adopted as the primary radar for NORAD-USNORTHCOM? Yes or no please explain.

OPSTEMPO:

1. If OTHR program is approved and implemented do you have a concern that the military forces will be able to maintain their combat readiness?

2. Manned platforms have weakness of being one of the most heavily deployed platforms DoD has. Do you think if DoD adopted a more family of systems (manned, unmanned and OTHR) their Operational TEMPO would reduce? Explain your answer.

3. Unmanned Platforms Operational TEMPO is less than the Manned Platforms. Can the Operational TEMPO be reduced even more using the OTHR system? Explain your answer.

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APPENDIX B. INTERVIEW RESULTS

Table 4. Manned Platforms Interview Results

	Manned Platforms			
	Cost	Detection Capability	Availability	Operational TEMPO
	C-1	DT-1	A-1	OT-1
Interviewee 1	7	9	8	9
Interviewee 2	8	9	6	9
Interviewee 3	9	6	6	7
Interviewee 4	10	8	7	8
Interviewee 5	9	6	5	7
Interviewee 6	8	7	4	8
Interviewee 7	10	7	3	9
Interviewee 8	9	8	7	9
Interviewee 9	9	7	6	9
Total Score	79	67	52	75
Average Score	8.7	7.4	5.7	8.3
Goal Score:	Between 3-5	Between 7-10	Between 8-10	Below 5.0
Questions	Cost is usually a significant factor when spending millions of dollars on a radar system. How would you rate the cost of operations of the Manned Platforms	Detection Capability is one of the major considerations when spending millions of dollars on a radar system. How would you rate the Detection Capability of the Manned Platform?	Availability of a system is a significant factor when spending millions of dollars on a radar system. How would you rate the Availability rate of the Manned Platforms?	Personnel operational TEMPO can be a significant factor when spending millions of dollars on a radar system. How would you rate the Personnel Operational TEMPO of Manned Platforms?
Result	A high number in the section means the platform is very expensive to operate. A lower number is preferred.	High number in the column is good because it shows a good detection capability. Anything above an 7.0 is a good detection system	Another high number is wanted in this row to show the system is operating at a high rate. Availability rate	This is the only section where a low number is good. Anything above a 6.0 shows that the personnel are deployed at a high rate. Results show Manned Platforms have a high Ops

			is above average. Both systems are weather dependent which affects their availability	TEMPO
Overall Average Score	7.525			

Table 5. Manned Platforms Interview Results

	Cost	Unmanned Platforms Detection Capability	Availability	Operation TEMPO
	C-2	DT-2	A-2	OT-2
Interviewee 1	8	6	4	5
Interviewee 2	6	6	5	6
Interviewee 3	5	7	5	6
Interviewee 4	5	5	5	5
Interviewee 5	6	5	6	4
Interviewee 6	6	5	5	5
Interviewee 7	7	7	5	3
Interviewee 8	7	7	4	4
Interviewee 9	6	5	3	3
Total Score	56	53	42	41
Average Score	6.2	5.8	4.6	4.5
Goal Score:	Between 3-5	Between 7-10	Between 8-10	Below 5.0
Questions	Cost is usually a significant factor when spending millions of dollars on a radar system. How would you rate the Cost of operations of the Unmanned Platforms?	Detection Capability is one of the major considerations when spending millions of dollars on a radar system. How would you rate the Detection Capability of the Unmanned Platform?	Availability of a system is a significant factor when spending millions of dollars on a radar system. How would you rate the Availability rate of the Unmanned Platforms?	Personnel operational TEMPO can be a significant factor when spending millions of dollars on a radar system. How would you rate the Personnel Operational TEMPO of Unmanned Platforms?

Results	A low number is wanted in this column. Even though it is lower than manned it still is high for the capability you are receiving.	This number should be high to show the system has a really good detection capability. Detection capability is only above average. Not as good as Manned platforms.	Availability number should be high showing the system is available for use as much as possible. This number should be around the 8 or 9 range. Manned and unmanned platforms are so weather dependent and this hurts their availability rate.	This is the one section that a low number is wanted. This means the people are not being deployed as much. The goal is in the 3 to 4 range in this section.
Overall Average Score	5.275			

Table 6. Over-the-Horizon Radar System Interview Results

	Over-the-Horizon Radar (OTHR)			
	Cost	Detection Capability	Availability	Operational TEMPO
	C-3	DT-3	A-3	OT-3
Interviewee 1	6	8	9	5
Interviewee 2	4	8	9	4
Interviewee 3	6	8	8	5
Interviewee 4	2	7	8	6
Interviewee 5	3	7	7	3
Interviewee 6	5	9	7	4
Interviewee 7	2	10	9	2
Interviewee 8	2	9	9	2
Interviewee 9	3	10	9	3
Total Score	33	76	75	34
Average Score	3.6	8.4	8.3	3.7
Goal Score:	Between 3-5	Between 7-10	Between 8-10	Below 5.0

Questions	Cost is usually a significant factor when spending millions of dollars on a radar system. How would you rate the Cost of operations of the OTHR?	Detection Capability is one of the major considerations when spending millions of dollars on a radar system. How would you rate the Detection Capability of the OTHR System?	Availability of a system is a significant factor when spending millions of dollars on a radar system. How would you rate the Availability rate of the OTHR?	Personnel operational TEMPO can be a significant factor when spending millions of dollars on a radar system. How would you rate the Personnel Operational TEMPO of OTHR?
Results	A low number is preferred. This shows OTHR has a low operating cost.	The higher the number the better the detection capability.	This column is the same as detection capability, the higher the number the more the system was available to the customer.	Low number here is good because it shows personnel are not deployed and away from their families.
Overall Average Score	6	The overall score is a 6.0 but OTHR scored #1 in each category.		

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