ABSTRACT

TITLE OF THESIS: Chasing Demons: The Potential for Nuclear Proliferation in Latin America

STUDENT:

CLASS NUMBER: JMIC 2007 **DATE:** June, 2007

THESIS COMMITTEE CHAIR:

COMMITTEE MEMBER:

This thesis set out to answer the following research question: What is the potential for current or future nuclear proliferation in Latin America? The work focused on Brazil and Venezuela as case studies, but presented a method by which any state in the region can be analyzed for proliferation potential. The thesis concludes that there is currently no danger of nuclear proliferation in Latin America. However, Brazil and Venezuela represent states that given the right set of circumstances, could pursue the nuclear option. Although nuclear proliferation is a top US intelligence priority, Latin America has received little attention in this area. To assist in the dissemination of this work, which fills a knowledge gap where nuclear proliferation is concerned and provides a method to assess future proliferation, all of the material used in the creation of this thesis is unclassified.

The research conducted in the formation of this thesis has three main foci. First, a comprehensive background of nuclear issues as they relate to Latin America was undertaken. This background serves to both compile the available knowledge about the

nuclear infrastructure of Latin America and provide evidence for analysis in this thesis. The second focal point of the research was an in-depth examination of Brazil and Venezuela. This examination includes an evaluation of the current situation, an evaluation of the impact of economic and social trends, and an assessment of leadership for each state. Finally, all of the evidence collected for each state in the course of the research was examined using the Analysis of Competing Hypotheses (ACH) technique.

The results of the ACH confirm that, given their current situations, neither Brazil nor Venezuela is likely to pursue nuclear weapons at this point. The ACH goes further to show the likely path of proliferation if one of the two states decides to pursue nuclear weapons.

If nuclear proliferation does occur in Latin America, this thesis can be used as a baseline for examining the issue. Moreover, the techniques used in the research for this thesis attempted to capture the most current and relevant information and compile it for each state. Thus it can serve as an analog for examining proliferation in any region of the world, as well as a baseline to assist in assessing the effectiveness of non-proliferation efforts.

CHASING DEMONS: THE POTENTIAL FOR NUCLEAR PROLIFERATION IN LATIN AMERICA

by

[redacted]
United States Army
NDIC Class of 2007

Unclassified thesis submitted to the faculty
of the National Defense Intelligence College
in partial fulfillment of the requirements for the degree of
Master of Science of Strategic Intelligence

June 2007

DEDICATION

I dedicate this work to my wife, [redacted], and Payton. Though they may never read this thesis or care about its content, their unwavering support has carried me throughout my career. In the past year they have dealt with my almost constant writing and research in pursuit of this work and my MSSI degree. I love them all dearly and hope they understand that I am more dedicated to them than I could ever be to a paper or degree.

CONTENTS

LIST OF FIGURES

Figure **Page**

CHAPTER 1

IMAGINING THE UNIMAGINABLE: NUCLEAR PROLIFERATION IN AMERICA'S BACKYARD

A NEW TWIST ON AN OLD THREAT

The United States has not faced the specter of nuclear proliferation in the Western Hemisphere since the Cuban Missile Crisis ended with the removal of Soviet weapons from Cuba in 1961. Two states in Latin America, Argentina and Brazil, had fledgling nuclear weapons programs until they were abandoned in the mid-1990s. US influence, the prohibitive cost of nuclear weapons programs, and the general commitment of Latin American countries to non-proliferation have all played key roles in ensuring states in the region have remained free of nuclear weapons and intentions to acquire them.

However, the potential for global nuclear proliferation is perhaps at its highest level ever. The detonation of a nuclear weapon by North Korea in late 2006 and the continued defiance of Iran in pursuing nuclear weapons clearly call the Non-Proliferation Treaty (NPT) and the ability of the international community to curb proliferation into question. The unraveling of the A.Q. Khan network in 2004 raises serious questions about nuclear technology transfer in the modern age and again highlights a perceived inability on the part of the global community to prohibit it. The pursuit of the Global War on Terror by the United States could make certain states less secure and more prone

towards a nuclear option.[1] Even peaceful pursuit of nuclear energy as a cleaner, more efficient alternative to fossil fuels raises the question of dual use technology and proliferation.

Policymakers, academics, and the intelligence community necessarily focus their proliferation efforts on so called "rouge" states, like Iran and North Korea, which represent the greatest potential threat to US National Security. Scant attention has been paid to Latin America even though it has two states, Argentina and Brazil, potentially capable of producing nuclear weapons in a short period of time. Venezuelan President Hugo Chavez, who has made overtures to the likes of North Korea and Iran, may desire nuclear weapons. Though Venezuela has no current nuclear capability, the prospect of the virulently anti-American Chavez in possession of nuclear weapons is harrowing. That Chavez has made statements professing to desire a nuclear power program shows that this issue should not go unaddressed. Keeping Latin America free from proliferation once required a concerted effort on the part of the US However, with its attention currently diverted elsewhere, the question could shift from how to keep nuclear weapons out of Latin America to how deal with the nuclear weapons its members possess.

FUTURES INTELLIGENCE: THE DIFFICULTY OF PREDICTING PROLIFERATION

Predicting nuclear proliferation is not an easy task. There are myriad factors thought responsible for leading a state to pursue nuclear weapons, including external threats, domestic issues, the unstoppable economic and political momentum of a weapons

[1] Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons: A Debate Renewed* (New York: W.W. Norton and Company, 2003), introduction.

program, and even the disposition of the state leader. A recent quantitative study published in *The Journal of Conflict Resolution* cites security concerns and technology as determinants of whether states form weapons programs while security concerns, economics and domestic politics are the best determinants of actual nuclear weapon possession.[2] This and many other studies present a variety of views on nuclear proliferation, but nothing published to this point presents a failsafe formula for predicting it. The inability to accurately forecast nuclear proliferation is a product of the myriad complicated factors behind the nuclear decision.

Nuclear proliferation is a topic of obvious import for US national security. Preventing and countering the spread of weapons of mass destruction is the number two strategic mission objective in the current National Intelligence Strategy, behind only defeating terrorism.[3] The consequences of proliferation and the difficulty in divining nuclear intentions make this a foremost issue for the US intelligence community. Two of the largest intelligence failures of the past decade involved nuclear proliferation. The first was India's unexpected nuclear test in 1998. While India's burgeoning nuclear capability was documented, the actual decision to conduct the test and the physical setup for the test itself went largely unnoticed. More recently, the decision to unseat Iraqi dictator Saddam Hussein was, at least publicly, based on the idea that Saddam was almost capable of producing a nuclear weapon. Time has shown that Iraq's nuclear program had been largely dismantled and was nowhere close to producing a weapon. Considering

---

[2] Dong-Joon Jo and Erik Gartzke, "Determinants of Nuclear Weapons Proliferation," *The Journal of Conflict Resolution*, February 2007, Proquest document ID# 1230885261, accessed via Proquest 25 May 2007.

[3] "The National Intelligence Strategy of the United States of America," online ed. (October 2005), URL: <http://www.dni.gov/publications/ NISOctober2005.pdf>, accessed 31 May 2007.

these recent failures, the current global security environment, and the threat nuclear weapons present to national security, the US intelligence community should be aware of the indications of proliferation from even the unlikeliest corners of the globe.

THESIS OVERVIEW

Research Question

This work seeks to assess the potential for current and future nuclear proliferation in Latin America.

Justification

Could the current global security environment encourage nuclear proliferation in Latin America? Admittedly, this question is not at the forefront of the US foreign policy and intelligence mindset. But the present existence of many factors in the region conducive to future proliferation underscores the need to explore this issue further. Weapons of mass destruction represent an ever-present threat to US national security, and the intelligence community would be remiss if it did not consider even the remotest of nuclear proliferation possibilities. The need to anticipate such threats is underscored in the first paragraph of the National Military Strategy to Combat Weapons of Mass Destruction, published in 2006.

> Weapons of mass destruction (WMD) pose a serious threat to the United States and to the international community. In the hands of our enemies, these weapons could enable them to inflict massive harm on the United States,

including our military forces at home and abroad, and our friends and allies. The cost of insufficient preparation against such an attack would be substantial.[4]

Scope

This study will present a comprehensive overview of the current nuclear infrastructure and capability of Latin America. However, it will focus on two states, Brazil and Venezuela, when dealing with the issue of proliferation. Brazil is the state in Latin America with the most well developed nuclear program and the closest state in Latin America to producing a nuclear weapon, even though at this time there is no evidence to suggest it is attempting to do so. Venezuela presents a problem of a different sort, even though it possesses no current nuclear capability. Among Latin American leaders, Hugo Chavez best fits the profile of a leader who could be persuaded to acquire nuclear weapons. Combined with his anti-American stance and the import of Venezuela's oil to the US, the potential for a nuclear Venezuela is compelling.

Argentina, which possesses a nuclear power program and once made an attempt at nuclear weapons, also seems a likely state for examination in this work. However, Argentina and Brazil present as similar case studies. Brazil currently owns more advanced nuclear power and ballistic missile programs than Argentina and has also recently been at odds with the International Atomic Energy Association (IAEA), making it a more compelling choice for study. Thus in this study I choose to examine what I perceive to be the most likely and the most dangerous avenues for Latin American nuclear proliferation.

---

[4] Joint Chiefs of Staff, "National Military Strategy to Combat Weapons of Mass Destruction," online ed. (13 February 2006), URL: <www.defenselink.mil/pdf/NMS-CWMD2006.pdf>, accessed 4 October 2006.

Hypothesis

This study proposes that although Brazil and Venezuela each have the potential to pursue nuclear weapons, neither will do so in the foreseeable future.

As their current situations differ, the paths Brazil and Venezuela would take to nuclear proliferation are also different. Within this work I will conduct an analysis of competing hypotheses for each country in an effort to support my overall hypothesis. For each country I present four hypotheses, all of which will be analyzed in future chapters.

Brazil. Figure 1 contains the hypotheses concerning Brazil's proliferation potential.

1) H1: Brazil will pursue an overt nuclear weapons program;
2) H2: Brazil will continue its pursuit of an autonomous nuclear fuel cycle but not pursue nuclear weapons (status quo);
3) H3: Brazil will clandestinely develop a "run up" nuclear capability and gain the ability to quickly produce nuclear weapons;
4) H4: Brazil will abandon its attempt at an autonomous fuel cycle, open itself completely to the IAEA, and maintain only the ability to produce nuclear energy.

Figure 1: Hypotheses – Brazil Nuclear Proliferation

Venezuela. Figure 2 contains the hypotheses concerning Venezuela's proliferation potential.

1) H1: Venezuela will pursue an indigenous nuclear weapons program;
2) H2: Venezuela will develop a nuclear power capability;
3) H3: Venezuela will not pursue any type of nuclear capability (status quo);
4) H4: Venezuela will attempt to acquire nuclear technology, knowledge, or weapons through technology transfer.

Figure 2: Hypotheses - Venezuela Nuclear Proliferation

How This Study is Unique

Literature on nuclear proliferation abounds. However, since the dismantling of the nuclear programs of Argentina and Brazil in the early 1990s, scant attention has been paid to nuclear proliferation in Latin America. In light of the current global situation and with the significant focus on the nuclear ambitions of Iraq and North Korea, a relative dearth of writing on this topic is understandable. But as intelligence surprises in India and Iraq have shown, many unforeseen possibilities exist where proliferation is concerned. This study is unique in that it fills knowledge gaps concerning the current nuclear situation in Latin America and concerning the nuclear aims of two of its more important states. A 1996 Joint Military Intelligence College thesis discussed Brazil's potential for proliferation, but this work focused primarily on its ballistic missile program. I could find no work on Venezuela's nuclear potential. I believe my chapter on Venezuela may be the only true assessment of its nuclear potential in current literature.

In addition to the chapter on Venezuela, Chapter 2 provides a complete evaluation of Latin America's nuclear capability. In it I discuss nuclear power production, the state of the nuclear fuel cycle in Latin America, and even present a brief history of Latin American nuclear weapons programs. Though the pieces of this chapter were pulled from existing literature and databases, the compilation of this material in one place makes it the most current and comprehensive assessment of Latin American nuclear capabilities available today.

Finally, in my analysis I bring together proliferation evidence from both the traditional schools of thought on the subject and the very new ones. I have yet to see Jacques Hymans' idea of national identity conception applied outside of his work, and feel that doing so in this thesis contributes to both its thoroughness and uniqueness.

REVIEW OF RELATED LITERATURE

Overview

Considering the small number of nuclear energy programs in Latin America and the historical absence of nuclear threats from the region, there is a paucity of literature that directly addresses my topic. However, there is a wealth of information on most aspects of the nuclear puzzle. The topics most relative to my nuclear research deal with the energy sector as a whole, the motivations states have to pursue nuclear weapons, the conversion of nuclear power programs into ones that develop weapons, and the defunct weapons programs of Brazil and Argentina. I will also delve into the international nuclear proliferation agreements and treaties countries in the region are signatory to in

order to determine their impact on Latin America's nuclear future. A final theme of my research concerns background information on the region with a focus on political, military, and economic factors related to nuclear development.

Exploring the decision to go nuclear

One of the critical questions I seek to answer about Brazil and Venezuela concerns the basic motivations each would have for pursuing nuclear weapons in the future. A seminal work that examines this topic in detail is titled *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*. Written in 2004 by Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss, this work examines nuclear policy at the state level with a focus on the factors behind nuclear decisions states make. Of particular interest are the case studies of individual states that the book presents. Though each case study is different, the work outlines common factors affecting the decisions of each study. Although *The Nuclear Tipping Point* does not discuss any states in Latin America, it does provide a conceptual framework for examining the strategic situation facing Brazil and Venezuela and assists in assessing the likelihood each has of choosing nuclear options in the future.

A precursor to *The Nuclear Tipping Point* is an article entitled "Why States Go—And Don't Go---Nuclear." Despite being a cold war era article, it nonetheless furthers an excellent discussion of economic, political, and military factors that figure in to the nuclear decision. The author concludes that the incentives for developing a nuclear capability outweigh the disincentives. Moreover, the disincentives available to governments seeking to discourage proliferation are limited and lie mainly in the political

realm.[5] This observation describes the situation today with Iran's nuclear program, as Iran appears to be largely ignoring U.N. sanctions and other political threats in doggedly pursuing its nuclear ambitions.

An article in this same vein and timeframe is entitled "Nth Powers of the Future", written in 1977 by Ashok Kapur. Though his article is dated, Kapur makes some important insights into the question of proliferation. He argues that proliferation will slow in the 1980s because of economic concerns and a lack of threats to potential proliferators' security. However, he postulates that the rate of proliferation will greatly increase if the security situation changes. This parallels a situation in which I see Latin American proliferation as a possibility. Kapur goes further to state that likely proliferation will be in the form of nuclear options as opposed to weapons.[6] Brazil fits this mold as it possesses many nuclear options and may look to possess even more.

In *The Spread of Nuclear Weapons: A Debate Renewed*, authors Scott D. Sagan and Kenneth N. Waltz explore the consequences of nuclear proliferation. Each takes an opposite side on the issue. Waltz argues that more states with nuclear weapons will be better for the international system, as more deterrence promotes more stability. Sagan says the world will be worse off with proliferation as states with nuclear weapons will be prone to preventative war, nuclear accidents, and lack of focus on conventional forces and security.[7] Also important in this work is Waltz' writing on the motivations and

---

[5]William Epstein, "Why States Go -- And Don't Go – Nuclear," *Annals of the American Academy of Political and Social Science* 430, no. 1 (March 1977): 16.

[6]Ashok Kapur, "Nth Powers of the Future," *Annals of the American Academy of Political and Social Science* 430, no. 1 (March, 1977): 84.

[7] Sagan and Waltz, viii.

characteristics of new nuclear states, a topic that is important when examining Venezuela and Argentina.

Jacques E. C. Hymans' *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy* takes a different approach to nuclear proliferation. He explores the disparity between the number of states that have nuclear weapons and those that have the capability to produce them. Hymans' unique focus is on the leaders of nuclear or potential nuclear states. He argues that the leaders of nations who pursue proliferation, under the influence of a variety of factors, feel it absolutely necessary to acquire or develop nuclear weapons.[8] Hymans further argues the US intelligence community focuses on technical indicators while failing to think through the human decisions behind the decision to go nuclear.[9] With its compelling hypothesis, this work allows room for a more comprehensive and modern examination of the nuclear ambitions of Venezuela and Brazil. If Hymans' assertions are correct, then an examination of Hugo Chavez and Brazilian President Lula de Silva utilizing his method helps provides a deeper understanding of each state's nuclear intentions. Hymans also presents a coherent discussion of US foreign policy options when dealing with proliferation.

Characteristics of a nuclear program

In order to assess the potential of Brazil or Venezuela to develop or acquire nuclear weapons, it is essential to describe the characteristics of a nuclear program that could lead to weapons development. At a basic level are the facilities, knowledge, and

[8] Jacques E. C. Hymans, *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy* (Cambridge: Cambridge University Press, 2006), 3.

[9] Hymans, 216.

resources required to run a nuclear program. In addition, a fundamental understanding of the nuclear fuel cycle, which documents the steps necessary to produce, utilize, and dispose of nuclear material, greatly assists in comprehending nuclear intentions. In Brazil's case, this knowledge helps frame the current status of its nuclear program. For Venezuela, nuclear program knowledge aids in providing future indications and warning that the state may be attempting to develop a nuclear capability.

This knowledge can be gained from a variety of sources. *Megawatts and Megatons: The Future of Nuclear Power and Nuclear Weapons* is an excellent primer on both topics. In addition, the work discusses the use of nuclear power and how it can be used for peaceful purposes and not geared towards proliferation. If Venezuela does pursue a nuclear power program, indicators for the program potentially being used for weapons will be of the utmost importance. *Megawatts and Megatons* assists in cataloging these indicators.

The nuclear programs of Brazil and Argentina

Most of the works concerning the now-defunct nuclear weapons programs of Brazil and Argentina are dated. Nonetheless, they provide valuable insight into these programs and serve as a basis for a current assessment of them. One such work is an occasional paper by John Redick of the Stimson Center entitled *Nuclear Illusions: Argentina and Brazil.* The focus of Redick's work, written in 1996, is the embracement of the non-proliferation regime by both states. Perhaps more importantly it does an excellent job summarizing the nuclear programs of each, providing valuable background information. Another summary work, "Looking Back: Lessons from the

Denuclearization of Brazil and Argentina", published in *Arms Control Today*, provides a good synopsis of each program and factors surrounding each state's decision to abandon nuclear weapons. In addition, the author argues that the best way to promote non-proliferation is to reduce the incentives that lead to the decision to acquire weapons in the first place.[10]

Energy

A nuclear power program provides the basic framework for most nuclear weapons development. Argentina and Brazil have power programs; Hugo Chavez has publicly stated that he desires such a program for Venezuela,[11] ostensibly to help refine Venezuela's heavy crude oil. Alarmists immediately equate this statement with the tacit desire by Chavez to develop a weapons program. However, the basic underlying question implied by Chavez' rhetoric is the actual need for nuclear power in Venezuela. The healthy reserves of oil and sources of energy that Venezuela possesses seem to obviate the need for nuclear power, so further exploration of Venezuela's energy sector is necessary in order to examine the rationale for such a program. Moreover, future forecasts for the price of oil are important to evaluating the health of Venezuela's economy, another potential indicator of proliferation. Current energy statistics and forecasts are available online from organizations like the Energy Information Administration.

---

[10] Jose Goldemburg, "Looking Back: Lessons from the Denuclearization of Argentina and Brazil," *Arms Control Today*, April 2006, URL: <http://www.armscontrol.org/ act/2006_04/lookingback.asp>, accessed 17 April 2007.

[11] Larry Rhoter and Juan Forero, "Venezuela's Leader Covets a Nuclear Energy Program," *New York Times*, 27 November 2005, 1:14.

Other Sources

One of the main foci of this work is to provide an update to the nuclear situation in Latin America. As such, the study will rely heavily on current reporting. Valuable sources of information to this end include current news publications like *The Economist*; journals such as *Arms Control Today, The Journal of Conflict Resolution, Bulletin of the Atomic Scientists,* and *The Non-Proliferation Review*; and online resources such as the websites of the International Energy Administration and the International Atomic Energy Association.

METHODOLOGY

Overview

This study will explore the research question and hypothesis using Analysis of Competing Hypotheses (ACH) on both Brazil and Venezuela. ACH, explained below forces an analyst to consider many hypotheses and weigh all available evidence against each hypothesis. Thus it is a much more comprehensive process than choosing one hypotheses and setting out to prove that it is true. Conducting an ACH against Brazil and Argentina allows me to explore my overall hypothesis in a comprehensive manner.

Important to using ACH and to my methodology is the collection of evidence applicable to my research question. To collect this evidence I rely on the aforementioned sources of data. I have intentionally limited the scope of this study to evidence available as open source material. I want the results of the study to be available for consumption by anyone dealing with nuclear proliferation issues, not just the intelligence community.

The trade-off inherent in this decision is that I may not capture all available evidence. This is also a limitation of the ACH process in general. I risk not capturing all applicable evidence even in the open source arena. Additionally, the ACH can suffer if too much evidence is presented. Analytical bias can also creep into ACH; the steps most prone to bias in ACH are the selection of evidence and interpretation of results.

Analysis of Competing Hypotheses

Satisficing, or choosing the first solution to a problem that seems reasonable, is a common analytical pitfall. It is cognitively simple to focus on one possible solution to a problem, picking out evidence supporting the solution while ignoring evidence that would discount it.[12] In his book *Psychology of Intelligence Analysis*, Richards J. Heuer, Jr. discusses satisficing and other potential analytical mistakes. He also proposes a solution to many common analytical problems: using ACH. ACH is a methodical procedure, and as such helps to limit some of the cognitive biases that make predictive analysis difficult.[13] ACH is grounded in the scientific method and seeks evidence that refutes hypotheses and well as evidence that confirms them.[14] This provides for a solid analytical foundation. ACH is particularly well suited for application to the questions this work seeks to answer about the nuclear futures of Venezuela and Brazil. It would be easy, especially in the case of Venezuela, to come up with a single, reasonable hypothesis

[12] Richards J. Heuer, *Psychology of Intelligence Analysis* (Pittsburg, PA: Government Printing Office, 1999), 44.

[13] Heuer, 95.

[14] Heuer, 109.

and then try to prove or disprove it. But the many potential avenues that both Brazil and Venezuela could take with regard to nuclear weapons merit a broader examination.

ACH is an eight step process. The following section discusses each step in brief, as this work will apply ACH to both Brazil and Venezuela in later chapters.

Step 1 – Identify the possible hypotheses to be considered

Generating multiple hypotheses is often difficult, especially when a single individual is attempting to do so. For various reasons, individuals have a hard time considering all possibilities, especially when a complex problem exists. For this reason, Heuer recommends using a group of analysts to brainstorm potential hypotheses. He also cautions analysts to distinguish between unproven and disproved hypotheses. Disproved hypotheses can be rejected out of hand, but unproven ones should be explored. Heuer also cautions about having too many hypotheses.[15] Even though ACH is a tool for evaluating multiple ideas, having too many can cloud the results of the process. Earlier in this chapter the hypotheses, four for Brazil and four for Venezuela, which I will use in the ACH were presented.

Step 2 – Make a list of significant evidence and arguments for and against each hypothesis

The search for evidence should cast a wide net. It should not be limited to current intelligence reports but should also include open source reports and the assumptions and deductions of the analyst. This is especially important for this work; a dearth of intelligence on the subject at hand is one of the primary reasons for undertaking the

[15] Heuer, 98.

project. Heuer directs the analyst to consider both general evidence and evidence that pertains to individual hypotheses. He also states that the absence of evidence can also be important.[16]

Step 3 – Prepare a matrix with the hypotheses and evidence in order to analyze "diagnosticity" of the evidence

This step analyzes each piece of evidence against all hypotheses. The analyst can decide how to annotate the relationship between each piece of evidence and the hypotheses. At the very least, each piece of evidence should be assessed as consistent or inconsistent with each hypothesis. The idea is to determine which pieces of evidence are truly diagnostic and which are not. Evidence that shows consistency with each hypothesis likely has little diagnostic value. The analyst can also choose to add weighted scales to the matrix to make it more comprehensive.[17]

For this study, I have chosen to use five levels to evaluate the diagnostic value of my evidence. These levels are consistent, very consistent, neutral, inconsistent, and very inconsistent. In addition I can assess a piece of evidence as not being applicable to a hypothesis. I am also using additional weighted scales to assess the credibility and relevance of each piece of evidence.

[16] Heuer, 99.

[17] Heuer, 100-102.

Step 4 – Refine the matrix

There are two important aspects of this step. First, it calls for a refinement of the original hypotheses. Based on the evidence presented, some may need to be reworded, combined, or discarded altogether. Evidence could also result in a new hypothesis being proposed.

The other important aspect of this step is a reconsideration of the evidence presented. If any of the hypotheses are influenced by evidence not presented, then that evidence should be added. Along the same lines, evidence that shows no diagnostic ability should be discarded.[18]

Step 5 – Draw tentative conclusions about the relative likelihood of each hypothesis

In this step the hypotheses are examined one at a time against all evidence for or against. The analyst seeks to disprove hypotheses rather than prove them, which is in line with the scientific method. Heuer states that the hypothesis with the least amount of evidence against it is probably the most plausible, while the one with the largest amount of inconsistent evidence is the least likely. He does however caution against using the matrix as an absolute. To Heuer, this step should help clear up the analyst's judgment about which evidence is most important and should also help the analyst understand how the evidence is related to each hypothesis. The analyst is free to disagree with the results of the matrix; in the end, it is the judgment of the analyst that matters most when attempting to solve an intelligence problem. If the matrix and this judgment are not consistent, then there is likely missing evidence that needed to be added to the process.

[18] Heuer, 103.

In any case, the strength of this step and of ACH in general is that it forces the exploration of less probable hypotheses and at the very least provides the analyst a tool for organizing evidence.[19]

Step 6 – Analyze how sensitive your conclusion is to a few critical pieces of evidence

Once conclusions are reached, the analyst should take a close look at both the critical evidence supporting that conclusion and the assumptions behind it. There are many things to look for to evaluate the evidence. It could be incomplete, open to a different interpretation, or even deliberately misleading. Just as important as examining evidence is doing the same for assumptions. In the case of either, the analyst should at this point realize if additional research is merited.[20]

Step 7 – Report Conclusions

Implicit in this part of the process is an explanation of all the hypotheses considered, not just the most likely one. To Heuer, complete analysis doesn't end with the selection of the most likely hypothesis. Rejected hypotheses and the reasons for rejecting them should also be addressed. Additionally, the analyst should discuss the relative likelihood of each hypothesis considered. In the case of this study, the assessed relative likelihood of each hypothesis will be subjective, as I am not relying entirely on quantifiable data and therefore cannot conduct a thorough statistical analysis of any conclusion.

---

[19] Heuer, 104-105.

[20] Heuer, 105-106.

Step 8 – Identify milestones for future observation that may indicate events are taking a different course

Indicators that events are taking a path toward a certain hypothesis are important to any intelligence analysis. Although Heuer prompts the analyst in this step to identify events indicative of the chosen hypothesis being wrong, I plan to also use this step to also outline indicators that the preferred hypothesis is coming true. In my opinion, this makes the final assessment a much more useful tool.

CHAPTER 2

NUCLEAR BASICS: FROM POWER TO PROLIFERATION

"The discovery of nuclear reactions need not bring about the destruction of mankind any more than the discovery of matches."

--Albert Einstein

THE IMPORTANCE OF NUCLEAR POWER

The production of nuclear weapons is a complex and expensive process. The typical modern path to proliferation is for it to occur under the guise of a seemingly peaceful and legitimate nuclear energy program. Thus it is important to understand the basics of nuclear power. The ability to enrich uranium within the nuclear fuel cycle implies the ability to further enrich it for weapons use. Certain types of nuclear power plants also produce plutonium, as does spent fuel reprocessing, which can be used for weapons production. Understanding the nuclear power process is paramount in determining indicators of nuclear proliferation.

RADIOACTIVITY AND URANIUM

Isotopes of certain elements are considered radioactive; that is, they are unstable and spontaneously decompose. By-products of this decomposition include atomic components such as electrons, neutrons, and protons. Most importantly for nuclear

energy generation, a large amount of energy is also released during the decomposition.[21] Neutrons released when radioactive material decays have the ability to split the nuclei of other radioactive atoms in a process known as nuclear fission. A nuclear chain reaction takes place when fission occurs continuously. It is this chain reaction that is critical to creating the energy for nuclear power production and for nuclear weapons.[22]

The most commonly used element in nuclear power production is uranium. Uranium occurs naturally in nature and is found in many different types of rocks. Uranium concentrations sufficient for extraction are usually found in sedimentary rock, such as sandstone. In most types of rocks uranium exists in very small quantities making extraction of these amounts cost prohibitive. However as rock containing uranium undergoes chemical weathering, the uranium can be put into solution and eventually deposited as a component of sedimentary rock. The uranium concentrations in locations where this deposition takes place are much higher than in most rock, making extraction economical.

The most common isotope of uranium found in nature is uranium-238 (U_{238}), accounting for over 99% of natural uranium. U_{238} is not a fissionable material but it does play a key role in the production of nuclear weapons nonetheless. The most commonly used isotope for nuclear power production is the fissionable uranium-235 (U_{235}), accounting for less than 1% of all natural uranium.[23] Uranium is spread geographically around the world, though only 17 states currently produce it. In 2005, Canada was the

---

[21] Eldon Enger and Bradley Smith, *Environmental Science: A Study of Interrelationships*, 10th ed. (Boston: McGraw Hill, 2006), 221.

[22] Enger and Smith, 222.

[23] Carla Montgomery, *Environmental Geology*, 7th ed. (Boston: McGraw Hill, 2006), 332.

world's largest producer, followed closely by Australia. Other important uranium producing states include Kazakhstan, Russia, Namibia, Niger, and the United States.[24]

THE NUCLEAR FUEL CYCLE

Turning U_{235} into fuel suitable for producing nuclear power involves a complex process called the nuclear fuel cycle. The resources involved and the complexity of the fuel cycle make it a good indicator of nuclear activity and an important process to understand, especially if a state is attempting to secretly develop a nuclear weapons capability. Much harder to discern are the intentions of states that already utilize nuclear power commercially, as the fuel cycle by itself is essential to peaceful nuclear uses and doesn't necessarily indicate untoward objectives. The nuclear fuel cycle includes a number of front-end steps that take place before the fuel is consumed, utilization of the fuel for generating power, and back end steps that take place after consumption:

Step 1 – Uranium Mining and Milling

Ore containing uranium is extracted from the earth's surface or subsurface. Once extracted, it is crushed and treated to place the uranium in solution. This process, called milling, produces uranium oxide in a form that is commonly known as yellowcake, so named for its color and consistency.[25]

---

[24] "Graph: World Uranium Production," Web-only graph, 7 November 2006, URL: <http://www.uxc.com/fuelcycle/uranium/production-uranium.html>, accessed 26 February 2007.

[25] Enger and Smith, 228.

Step 2 – Conversion

To prepare the yellowcake for the next step, enrichment, it must be converted to uranium hexafluoride, or UF_6. A complex process produces UF_6, a substance that can easily be changed to a gas by raising its temperature slightly. This property is essential for successful enrichment.[26]

Step 3 – Enrichment

The concentration of fissionable U_{235} in nature is very low, on the order of .7% of natural uranium. For uranium to be useful as fuel in nuclear power plants, it must be enriched to a concentration of at least 3%. Gaseous diffusion and gas centrifuge are the two most common methods of enrichment. Diffusion, the primary method used by the United States, involves filtering gaseous UF_6 through a membrane to separate U_{235} from the more common U_{238}. The centrifuge method uses complex arrays of centrifuges, known as cascades to separate U_{235} and U_{238}.[27] One of the largest current nuclear issues with regards to Iran involves its use of centrifuges to enrich uranium.

---

[26] "Conversion: Yellowcake to Uranium Hexafluoride," Web-only essay, 2007, URL: <http://www.nei.org/ index.asp?catnum=3&catid=181>, accessed 22 April 2007.

[27] Richard L. Garwin and Georges Charpak, *Megawatts and Megatons: A Turning Point in the Nuclear Age?* (New York: Alfred A Knopf , 2001), 118.

Step 4 – Fuel Fabrication

Enriched uranium is fabricated into fuel by first converting it into uranium dioxide (UO_2). The UO_2 is ground into a powder, and then compressed into pellets. These pellets are placed into metal rods, which are utilized in nuclear reactors as fuel.[28]

Step 5 – Utilization

Once the fuel rods are ready for use, they are typically bundled and cycled into use at a nuclear reactor, the operation of which is discussed later in this chapter. Over time, the amount of U_{235} in the rods decreases as they are used. Fuel rods typically last three years before they are considered spent and must be replaced.[29]

Step 6 – Back End Activities

One of the more controversial aspects of nuclear power is what to do with nuclear fuel that has lost its ability to sustain a chain reaction. Even after use, nuclear fuel rods contain appreciable amounts of U_{235} and U_{238}. In addition, the rods also contain plutonium-239 (PU_{239}), a by-product of the chain reaction. As a typical nuclear plant produces 25 tons of used fuel rods each year, careful management of this radioactive spent fuel is necessary.[30] Options include interim storage, disposal, and reprocessing. Further complicating matters is the fact radioactive waste decomposes on a millennial scale. The time is takes typical spent fuel rods to return to natural levels of radioactivity

---

[28] "Introduction to Nuclear Power," Web-only essay, 2007, URL: <http://www.eia.doe.gov/oiaf/nuclear/page/intro.html>, accessed 12 March 2007.

[29] Enger and Smith, 228.

[30] Garwin and Charpak, 119.

is approximately 600,000 years. Over that amount of time, what originally seems an optimal storage site or solution may be much less attractive in the long term.[31]

Like all countries in the world, the United States lacks a permanent disposal facility for high-level nuclear waste and instead utilizes interim storage to manage it. High-level radioactive waste, which contains high concentrations of plutonium, is currently stored at a temporary facility in New Mexico. A permanent site at Yucca Mountain, Nevada is under development. Most solutions concerning waste disposal involve burial in a stable geologic formation. The Yucca Mountain site provides a location that is 300 meters underground and 300 meters above the water table. In the dry climate of Nevada, there is little danger of radioactive waste entering the water supply. As ideal as this site seems, it remains controversial and has been subject to repeated opposition from the state of Nevada, and many lawsuits currently challenge it in federal courts. Even if the site is completed, the amount of high level waste the US has to store exceeds the capacity of the site.[32]

Most US low level wastes, which are mainly wastes related to nuclear power production but also include items such as medical waste, are stored at nuclear power plants in holding ponds or in above ground facilities, with some permanently buried at sites in South Carolina and Washington state.[33]

Reprocessing spent nuclear fuel represents a final and still controversial method of dealing with high level nuclear waste. The U_{235} and PU_{239} that remains in spent fuel

---

[31] Garwin and Charpak, 122.

[32] Enger and Smith, 236.

[33] Enger and Smith, 238.

rods can be enriched and again used as nuclear fuel. This provides a short cut in the nuclear fuel cycle and also reduces the amount of nuclear waste that has to be stored. While this is a more efficient method of dispensing with nuclear wastes than straight disposal, the controversy lies in the fact plutonium extracted for use as fuel can conceivably be used as a component of nuclear weapons. Nonetheless many nations, such as France and the United Kingdom, reprocess nuclear waste. The United States does not.[34]

LATIN AMERICA AND THE NUCLEAR FUEL CYCLE

Globally, only the United States and Russia have the ability to operate complete nuclear fuel cycles. Other nuclear states rely on outside help, typically in the form of raw uranium or uranium enrichment, to complete their cycles and produce fuel for nuclear power. Different states in Latin America possess parts of the nuclear fuel cycle, especially uranium mining or the potential for it, but none has overtly completed it. Brazil is very close to having a complete cycle; it lacks only commercial conversion and enrichment capabilities. However, Brazil recently put into partial operation an enrichment facility and will soon be able to enrich uranium on its own. Additionally, Brazil has a pilot plant for conversion that should be operational by 2008.

Argentina and Brazil have many parts of the nuclear fuel cycle, reflecting the nuclear weapons programs that each country once possessed. On the other hand, Mexico's less developed infrastructure for processing nuclear fuel is indicative of a program used for power only. For the purposes of this work, the front and back end

[34] Enger and Smith, 228.

activities present in Latin America are discussed below. The utilization step is discussed in greater detail later in this chapter.

Step 1 – Uranium Mining and Milling

Numerous states in Latin America contain uranium deposits, but only a very few of these deposits are mined. Countries where only prospecting for uranium is currently taking place include Bolivia, Colombia, Guatemala, Paraguay, and Peru.

Argentina possesses two major uranium deposits with reserves estimated at approximately 8000 tons. At one time it had seven uranium mining and processing facilities but today it maintains once facility, Sierra Pintada, in a standby mode. Though no mining is currently taking place at either deposit, Argentina has plans to open Sierra Pintada and resume production of uranium. The mine is capable of processing 120 tons of uranium per year.[35] Argentina does not have a large need for nuclear fuel with only two power plants; even a small amount of production at Sierra Pintada would reduce or eliminate its dependency on others for uranium.[36] There is substantial public opposition, based mainly on environmental concerns, to re-opening the mine. Even though Argentina's Atomic Energy Commission (CNEA) has a responsibility to reclaim environmental damage before resumption of uranium, three marches against re-opening

---

[35] International Atomic Energy Association Nuclear Fuel Cycle Information System, Web-only database, 2007, URL: <http://www-nfcis.iaea.org/NFCIS/NFCISMAin.asp?Region=The%20World&Country=All&Type=All&Status=All&Scale=All&Order= 2&Page=1&RightP=List&Table=1>, registration and password required, accessed 17 March 2007. Cited hereafter as NFCIS.

[36] World Nuclear Association, "Nuclear Power in Argentina," Web-only essay, September 2006, URL: < http://www.world-nuclear.org/info/inf96.html>, accessed 7 March 2007.

took place in 2006.[37] Argentina currently imports enriched uranium for use in fuel production.

Brazil has extensive uranium resources at 143,000 tons in three main deposits, accounting for 4% of the world's total. Two mines once operated in Brazil, but only the Lagoa Real mine remains open. Lagoa Real, which still operates with only a start-up license, produces 340 tons of uranium per year for domestic use in Brazil's nuclear power industry.[38]

Mexico has uranium reserves of approximately 2000 tons but does not currently mine them. It imports enriched uranium to run its two nuclear power plants. Mexico at one time operated an experimental uranium milling plant at Villa Aldama, Chihuahua, but closed the plant long ago.[39]

Step 2 – Conversion

Argentina imports most of its uranium hexafluoride, though it does operate a small conversion facility at Pilcaniyeu, capable of processing 62 metric tons of UF_6 per year.[40] Argentina also converts uranium dioxide for use in its reactors at its Cordoba facility, with a capacity of 150 metric tons per year.

---

[37] "Issues At Operating Uranium Mines and Mills – Other Countries: Argentina," Web-only essay, 1 April 2007, URL: <http://www.wise-uranium.org/umop.html#AR>, accessed 7 March 2007.

[38] World Nuclear Association, "Nuclear Power in Brazil," Web-only essay, June 2006, URL: < http://www.world-nuclear.org/info/inf95.html>, accessed 7 March 2007.

[39] World Nuclear Association, "Nuclear Power in Mexico," Web-only essay, March 2007, URL: < http://www.world-nuclear.org/info/inf106.html>, accessed 7 March 2007.

[40] "Nuclear Power in Argentina: Briefing Paper #96," Web-only essay, November 2006, URL: < http://www.uic.com.au/nip96.htm>, accessed 11 March 2007.

Brazil is also capable of converting mined and milled uranium into uranium hexafluoride, though it does not currently do so. Brazil's Institute of Energy and Nuclear Research operated a conversion facility in Sao Paulo. Closed in 1993, the capacity of this facility was 90 metric tons per year. Brazil does have a pilot plant for conversion currently under construction at its Navy-run Aramar Demonstration Center is Sao Paulo. Due to be operational in 2008, the facility will be able to process 40 metric tons of UF_6 per year.

Step 3 – Enrichment

In Argentina, the Pilcaniyeu facility is also capable of uranium enrichment, and did so from 1983-1989. It is currently in stand-by mode. CNEA wants to once again enrich uranium at the facility, and has been upgrading Pilcaniyeu's equipment involved in the process. Argentina's state owned Investigacion Aplicada (INVAP) is a significant exporter of nuclear research, development, and services. Restarting enrichment activities would ostensibly maintain Argentina's right to do so, and increase INVAP's potential for foreign earnings from the process.[41]

Brazil's enrichment program is an offshoot of the Brazilian Navy's use of nuclear propulsion for its submarines. Aramar has a pilot plant capable of enriching U_{235} at 5% and a research plant capable of enriching U_{235} to over 19%. Both use the gas diffusion enrichment method. After operating a demonstration plant for some time, Brazil put its commercial enrichment facility at Resende online in May 2006. One enrichment cascade utilizing gas diffusion is currently operational. At capacity, the Resende plant will be

[41] "Nuclear Power in Argentina."

able to process 120 metric tons of separative work units of uranium (MTSWU) yearly.[42] The process developed by the Brazilian Navy is reportedly much more efficient that other enrichment efforts. When fully operational, Resende will provide as much as 60% of the enriched fuel needed to run Brazil's nuclear reactors.[43]

Step 4 – Fuel Fabrication

Argentina and Brazil are both able to fabricate fuel for use in their nuclear reactors. Argentina converts UF_6 to UO_2 at its Cordoba Mill Complex. Fuel rod fabrication takes place at its Nuclear Fuel Manufacture Plant in Ezeiza. Overall fuel fabrication capacity is 160 metric tons per year.[44]

Brazil completes all aspects of commercial fabrication, including conversion of UF_6 to UO_2, creation of UO_2 pellets, and fabrication of the UO_2 pellets into fuel rods at its Resende facility. Overall fuel fabrication capacity is 240 metric tons per year. Brazil also maintains a laboratory-scale facility for pellet production at the Aramar Demonstration Center in Sao Paulo. Fuel element fabrication for research reactors also takes place in Sao Paulo.[45]

Mexico maintains a fuel fabrication facility in stand-by mode. The plant, located in Toluca, is capable of processing 20 fuel elements per year, but is not currently in

---

[42] NFCIS, 2007.

[43] "Brazil: Enrichment Plant, Resende," Web-only database, 6 May 2006, URL: < http://www.wise-uranium.org/epruj.html#BR >, accessed 11 March 2007.

[44] NFCIS, 2007.

[45] NFCIS, 2007.

operation. Other than its nuclear reactors, this is the only nuclear fuel cycle related facility that Mexico possesses.[46]

Step 6 – Back End Activities

CNEA is responsible for managing Argentina's nuclear waste. Power plant waste is stored on-site at each facility, a common practice in the nuclear industry. Argentina maintains two storage facilities, one at Embalse and the other at the aforementioned plant in Ezeiza. The Ezeiza facility also has a pilot plant capable of reprocessing spent fuel, although this plant is in a deferred status and is not currently operational.[47]

Brazil also stores its spent fuel and other nuclear waste at its nuclear power plants. Legislation was passed in 2001 for the creation of a permanent storage facility, though none has been constructed. Brazil does not reprocess spent nuclear fuel.[48]

Mexico stores spent fuel at its reactors, as well as operating a storage center for low level nuclear waste at Maquixco. It also has a storage site for low level waste at Piedrera, though this site has not been operational since 1987.[49]

NUCLEAR POWER PLANTS

The goal of a nuclear power plant is essentially the same as a traditional coal-fired power plant: to produce heat, convert water to steam, turn turbines with that steam, and

---

[46] NFCIS, 2007.

[47] "Nuclear Power in Argentina."

[48] "Nuclear Power in Brazil."

[49] "Nuclear Power in Mexico."

produce electricity. In a traditional power plant the heat is produced by burning coal; in a nuclear power plant it is produced by allowing fission to take place in a nuclear reactor core.

In addition to the previously discussed fuel rods, the reactor core also contains control rods. These rods are made of material that absorbs neutrons, allowing operators to control the rate of fission in the core. When put into the core, the control rods absorb neutrons, slowing fission. The fuel and control rods are surrounded by a reaction moderator. Typically water or graphite, the moderator absorbs energy. This absorption slows the speed of the neutrons in the chain reaction. Slower neutrons produce more efficient fission. Also present in the reactor core is coolant, used to moderate the temperature of the nuclear fission. Water and carbon dioxide are common coolants.[50]

The most common type of nuclear reactor is known as a light water reactor, which uses regular water as both moderator and coolant. There are two types of light water reactors: boiling water reactors (BWR) and pressurized water reactors (PWR). Boiling water reactors heat water in the core directly, turning it into steam. This steam in turn turns turbines, producing electricity. After passing through turbines, the steam passes through a condenser, cooling it back to water. This water can then be cycled back into the reactor core and the process repeated.[51]

[50] Enger and Smith, 223.

[51] Enger and Smith, 223.

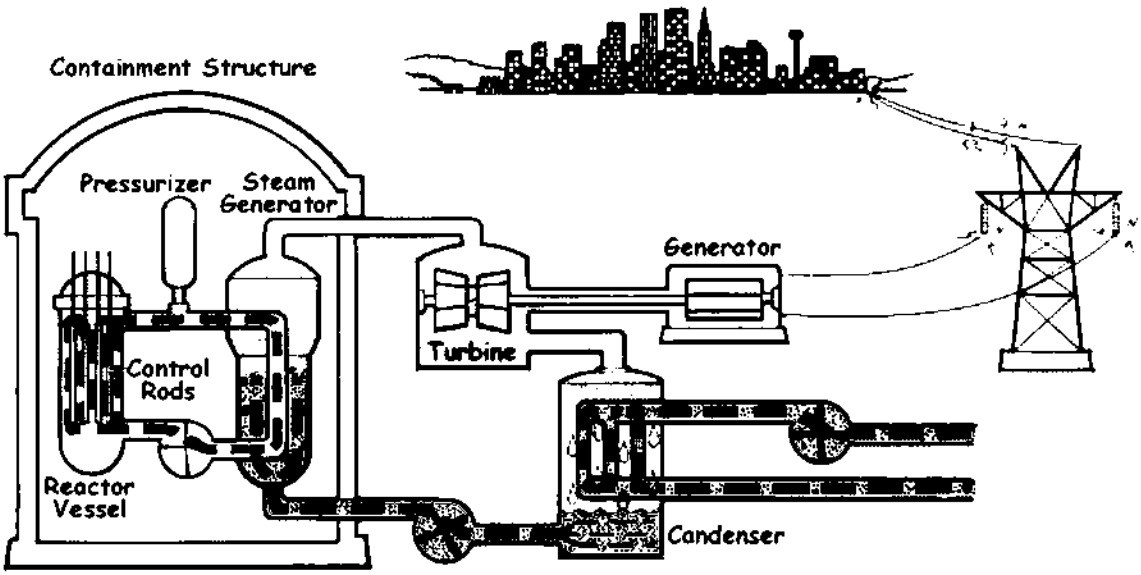

Figure 3: Typical Pressurized Water Reactor

Source: Nuclear Regulatory Commission Website, 2007.

The most common type of reactor in use today is the pressurized water reactor, pictured in Figure 1. In a pressurized water reactor, the water heated in the core is kept under pressure so it doesn't reach the boiling point. The heat in this water is transferred to another "loop" of water which is allowed to reach the boiling point and become steam, subsequently turning the plant's turbine. Though more costly than a BWR, one distinct advantage the pressurized water reactor has is the radioactive water in the process remains in the core and as such doesn't have to be treated before it generates power.[52]

Pressurized heavy water reactors (PHWR) use water that has deuterium in its molecular structure and is thus heavier than ordinary water, consequently serving as a better moderator. Heavy water reactors are structured much like regular pressurized water reactors. The main difference, and a distinct advantage of a HWR, is the heavier water allows for the use of natural uranium for fission because of the excellent

[52] Enger and Smith, 223.

moderating properties of the heavy water.[53] In terms of the nuclear fuel cycle, heavy water reactors can essentially skip the enrichment step, which serves as a huge cost reduction and makes the entire process much simpler. Also in this vein are gas cooled reactors (GCR). Again similar in structure to a PWR, the gas cooled reactor uses carbon dioxide as a coolant, graphite as a moderator, and is able to use natural uranium as fuel.[54]

Some nuclear reactors actually produce more fuel than they consume. Known as breeder reactors, these reactors use a liquid sodium moderator. The liquid sodium allows the neutrons to move faster than water does, allowing for the formation of plutonium in the fuel rods as the chain reaction takes place. After about 10 years of operation, a typical breeder reactor has produced enough fuel to power a second reactor. Though seemingly efficient, breeder reactors are very costly and have many safety issues, most of which are related to the liquid sodium. As a result, only five of these reactors are in operation worldwide today.[55]

[53] Enger and Smith, 223.

[54] Enger and Smith, 223.

[55] Enger and Smith, 227.

THE VIABILITY OF NUCLEAR POWER

> The United States knows that peaceful power from atomic energy is no dream of the future. That capability, already proved, is here--now--today. Who can doubt, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, that this capability would rapidly be transformed into universal, efficient, and economic usage.[56]
>
> -Dwight Eisenhower
> December 5, 1953

President Dwight Eisenhower's vision of universal nuclear power has yet to be realized; indeed it may never be. Though nuclear power has always held promise, many factors have prevented nuclear power from being more fully utilized for power production.

Nuclear energy currently accounts for approximately 17.5% of world electricity production.[57] In Europe, nuclear power accounts for almost 30% of electricity generated. France is the country most dependent on nuclear power in the world, with 80% of its power generated through nuclear means.[58] Nuclear energy accounts for varying portions of electricity production in other developed parts of the world. Startup costs for nuclear plants are high, but once up and running they can produce energy more cheaply than fossil fuel based power plants.

Because peaceful use of nuclear energy was borne of nuclear weapons research, nuclear power has always been overshadowed by the stigma of real or potential weapons production. One of the main reasons that the United States does not reprocess spent

---

[56] Dwight D. Eisenhower, speech given to the United Nations, 8 December 1953, URL: <http://www.eisenhower.archives.gov/atoms.htm>, accessed 4 March 2007.

[57] "International Energy Agency Key World Energy Statistics 2006," Web-only database, 2006, URL: <http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2006/key2006.pdf>, accessed 4 March 2007.

[58] "International Energy Agency Monthly Electricity Statistics, November 2006," Web-only database, November 2006, URL: <http://library.iea.org/Textbase/stats/surveys/mes.pdf>, accessed 4 March 2007.

nuclear fuel is because of the possibility for the plutonium created in reprocessing to be used in weapons. Aside from safety concerns, this dual use nature of breeder reactors makes them an unattractive political alternative.

Another reason nuclear power is not more prevalent is safety. Though rare, accidents at nuclear power plants can have huge ramifications. The main danger in nuclear power plant accidents is the release of radiation into the atmosphere. For efficiency, most plants are located close to the population centers that they service, magnifying the potential danger of a radiation release. For example, the Indian Point nuclear plant is located on the Hudson River, less than 30 miles from downtown New York City.

High profile accidents at nuclear power plants have heightened public awareness of the dangers of nuclear power and, in the case of the United States, made nuclear power an unpopular method of electricity generation. The worst nuclear accident in US history was the near core meltdown of Reactor 2 at the Three Mile Island nuclear facility near Harrisburg, Pennsylvania in 1979. Though no deaths or injuries were ultimately attributed to the accident, it turned into a public relations nightmare for US nuclear power. Since 1978, no new orders for nuclear power plants have been placed in the US and many existing orders were cancelled notwithstanding the huge economic cost of abandoning a plant already under construction.[59] Seven years after Three Mile Island, a far worse accident at the Chernobyl nuclear plant in what is now Ukraine heightened global awareness of the dangers of nuclear power. Radiation released from Chernobyl spread over a wide geographic area. Thirty-one deaths were immediately attributable to

[59] Montgomery, 338.

the accident, though the long term health and environmental implications for the region are likely to be far worse that the initial human toll.[60]

Though tragic, accidents like the one at Chernobyl are rare in the history of nuclear power. In fact, Three Mile Island and Chernobyl remain the only accidents of consequence globally in over 12,000 reactor years of operation.[61] A 1970's study projected accidental deaths from a typical nuclear power plant at 0.2 per year, though admittedly little data existed at the time to support this assertion. A like-sized coal power plant's accidental death rate is much higher at around 4 per year.[62]

Aside from accidents, nuclear power plants are also perceived as excellent targets for terrorism. The potential for release of nuclear radiation is certainly fear-inducing in any population, and nuclear infrastructure is a high profile target. However, the likelihood of any type of terrorist attack being able to penetrate the containment vessel of a modern nuclear reactor is extremely low. Numerous studies have shown that even flying a jet aircraft into a nuclear reactor would not result in the breach of the containment facility, and even if this were possible, the resultant release of radiation would have minimal effect. Nuclear power plants remain much more resistant to terrorist attacks than other energy infrastructure.[63]

Another object of terrorist activity could be the spent fuel and other radioactive wastes found at nuclear power plants and storage sites. This nuclear waste has the

---

[60] Montgomery, 336.

[61] "Safety of Nuclear Reactors," Web-only essay, January 2007, URL: <http://www.world-nuclear.org/info/inf06.html>, accessed 5 March 2007.

[62] Montgomery, 337.

[63] "Safety of Nuclear Reactors."

potential to be used in a so-called dirty bomb. A dirty bomb is one in which conventional explosives are used to spread the radiation in the nuclear waste. Even though this scenario has been popular in media speculation, the difficulty involved in obtaining, transporting, and fabricating appreciable quantities of nuclear waste into a bomb while being exposed to the intense radiation in nuclear waste makes this scenario an unlikely one.[64]

Its drawbacks notwithstanding, nuclear power could experience resurgence in the future. Though uranium is technically a non-renewable resource, the supply of uranium that can be economically removed from the Earth would provide for a virtually unlimited supply of nuclear fuel. Moreover, uranium resources are not concentrated in regions of the world prone to political turmoil, like fossil fuels are. Further, when compared to other alternate sources, nuclear energy provides a continuous source of power, unlike other forms of alternate energy such as solar and wind power that depend on the environment.[65]

In the current debate surrounding carbon emissions and global warming, nuclear power is generally seen as a clean alternative. Aside from nuclear waste, which is not introduced back into the environment, nuclear power plants are relatively pollution free. They do put large amounts of water vapor, a greenhouse gas, into the atmosphere. However, since the amount of water vapor that the atmosphere can hold is relatively

---

[64] Lewis Z. Koch, "Dirty Bomber, Dirty Justice," *Bulletin of the Atomic Scientists*, January / February 2004, Ebscohost document ID #11787826, accessed via Ebscohost 5 March 2007.

[65] Eugenio Fernández-Vázquez and Juan Pablo Pardo-Guerra, "Latin America Rethinks Nuclear Energy," Web-only essay, 12 September 2005, URL: <http://americas.irc-online.org/am/558>, accessed 7 March 2007.

constant, this is not a large concern. The emissions from nuclear power generation are on par with wind and solar power.

The other big pollution concern from nuclear power is thermal pollution. Water used to cool and moderate nuclear reactions is eventually introduced back into the environment. Usually this water is warmer than the lake or river it is put into, and this can have adverse effects. On the whole though, nuclear power is relatively clean. It is feasible that a non-nuclear power state could start a program under the guise of wanting to reduce greenhouse gas emissions. Hugo Chavez justified his May, 2005 announcement that Venezuela would begin research into nuclear power by highlighting a need to diversify Venezuela's energy sources, curb global warming, and find alternatives to fossil fuels.[66]

NUCLEAR POWER IN LATIN AMERICA

Argentina, Brazil, and Mexico all maintain nuclear power programs; however nuclear energy does not play a major role in the overall energy production for any of these states. While energy production from nuclear sources is well under 10% for each of these countries, it is important to catalog each country's nuclear program as the potential for proliferation exists in one form or another wherever nuclear power is generated.

[66] Fernández-Vázquez and Pardo-Guerra "Latin America Rethinks Nuclear Energy."

Nuclear Power in Argentina

Argentina maintains two nuclear reactors that meet approximately 10% of the country's energy needs. The Atucha-1 plant, located near Buenos Aires, was constructed by Siemens and completed in 1974. Atucha-1, a PHWR, has a capacity 335 megawatts (MW) of power. Embalse, the second reactor, is located on the Rio Tercero Reservoir in Cordoba province. It was constructed by Canada Deuterium Uranium (CANDU), a consortium of companies from Canada. With a capacity of 600 MW, Embalse has nearly double the capacity of the Atucha-1 reactor. Argentina also initiated construction of a second reactor by Siemens at Atucha with a capacity of 600 MW. However, due to a lack of funding, this reactor is only 81% complete. Though there is no current expected completion date, a feasibility study for completion of the reactor was undertaken in 2003 and the state is currently exploring financing options. Argentina also maintains six research reactors.[67]

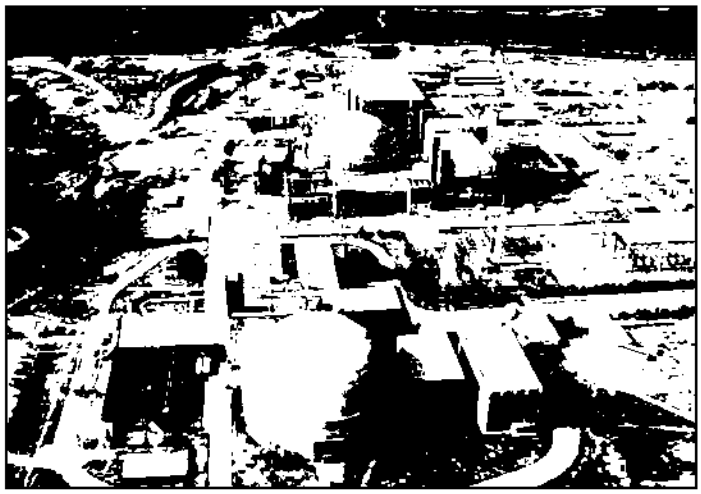

Figure 4: Argentina's Atucha-1 Plant

Source: CNEN Website.

Argentina possesses the most advanced nuclear research and development capability in Latin America. The country's Nuclear Regulatory Authority (ARN),

[67] "International Atomic Energy Agency Country Report: Argentina," Web-only report, December 2004, URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/ CNPP_Webpage/ countryprofiles/Argentina/Argentina2004.htm>, accessed 15 March 2007.

maintains high educational standards for operators in its nuclear industry. This manifests itself in three universities that offer courses and majors in subjects such as nuclear engineering and nuclear reactor design. Argentina's nuclear intellectual sector is so well developed that is a large exporter of nuclear materials and services. Its main nuclear exports are research reactors and radioisotopes, which are mainly for industrial and medical use. In addition, CNEA and INVAP are active in development of the Central Argentina Modular Reactor (CAREM) project. CAREM represents an efficient PWR design, and is a reference design for the International Atomic Energy Agency's (IAEA) International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).[68]

In general, Argentina has a healthy nuclear industry. Its power plants have had no accidents and have been relatively problem free. Nuclear power provides for a very cost effective means of energy production, and electricity generated by both nuclear reactors is very competitive in Argentina's privatized energy sector. Though no plans for future nuclear power exist past the potential completion of Atucha-2, the nuclear power option is a viable one for Argentina's future.

Nuclear Power in Brazil

Brazil maintains two nuclear reactors that provide for around 4% of its energy needs. Its first reactor, Angra-1, was commissioned in 1970 and constructed by Westinghouse Electric Corporation of the United States between Rio de Janeiro and Sao Paulo. Commencing operation in 1984, Angra-1 is a PWR and is capable of producing 626 MW at peak capacity.

[68] "International Atomic Energy Agency Country Report: Argentina."

In 1975 Brazil embarked on an ambitious plan to build eight 1300 MW nuclear reactors. Through a technology transfer agreement with the Federal Republic of Germany, work on the first two reactors, Angra-2 and Angra-3, was started almost immediately. The bulk of the parts for both of these reactors came from Kraftwerk Union, a West German company. Due to various issues, including economic woes in Brazil, the project with West Germany stalled and was ultimately never completed. Angra-2, a PWR with a capacity of 1270 MW, finally came online in 2000 following a re-organization of Brazil's nuclear industry and an economic upturn for the country. Angra-3 stands at 70% completion. Feasibility studies have been drafted for its completion, though as yet none has been approved or acted on. In addition to its two power generating reactors, Brazil maintains four research reactors.[69]

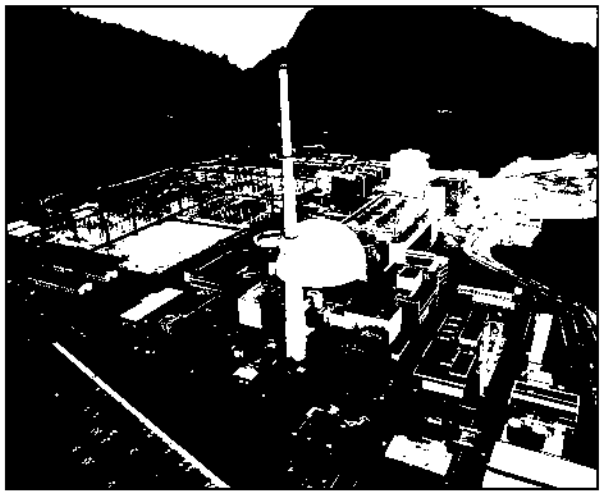

Figure 5: Brazil's Angra-2 Plant

Source: www.schillerinstitute.org.

Like Argentina, Brazil maintains a healthy research and development capacity in the nuclear field. CNEN has over 2,500 personnel dedicated directly to research and development, and works through various universities in Brazil to educate its nuclear professionals. Half of CNEN's researchers hold college degrees, with 25% of these degrees being at the master's level or higher. These researchers take part in Brazil's

[69] "International Atomic Energy Agency Country Report: Brazil," Web-only report, December 2004, URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/ CNPP_Webpage/ countryprofiles/Brazil/Brazil2004.htm>, accessed 15 March 2007.

efforts with the International Reactor Innovative and Secure (IRIS) program. The IRIS program is centered on producing a small, economic, safe, and environmentally friendly PWR reactor. Among its more desirable characteristics is that IRIS is not a type of reactor that is prone to proliferation.[70]

Brazil's generation of electricity is heavily dominated by hydroelectric power generation. Supplying over 83% of the country's electricity needs in 2004, the prevalence of hydro power would seem to preclude the expansion of Brazil's nuclear industry. However, since hydro power is dependent on water flow it is subject to the environment. Less than average rainfall means less power generation, and Brazil experienced a drought in 2001 that resulted in electricity rationing and rolling blackouts. In addition, Brazil's demand for energy as the country's population and economy has grown has outpaced its power sector's ability to provide electricity.[71] As nuclear energy is not dependent on the environment and Brazil already has nuclear know-how, this may present an attractive option for electricity generation in the future. The first step in this direction would be restarting construction of Angra-3, though as of March, 2007 no official decision has been made on this issue.

Nuclear Power in Mexico

Mexico's nuclear program is less robust than either Argentina or Brazil, boasting two reactors responsible for 4% of the country's energy needs. Both reactors are part of the Laguna Verde Nuclear Power Plant. Laguna Verde-1 is a BWR with a capacity of

[70] "International Atomic Energy Agency Country Report: Brazil."

[71] "Energy Information Association Brazil County Analysis Brief," Web-only brief, 2005, URL: < http://www.eia.doe.gov/emeu/cabs/Brazil/ Electricity.html>, accessed 19 March 2007.

680 MW that was put into operation in 1990. Laguna Verde-2 was put into operation in 1995 and is identical to Laguna Verde-1. Both reactors were constructed by General Electric of the United States. Mexico maintains a minimal nuclear research and development capability; it is essentially able to maintain its nuclear power plants. It has research agreements with the United States and imports a significant amount of nuclear knowledge.[72]

Nuclear power would not appear to have much of a future in Mexico. In fact, Laguna Verde was nearly shut down early in this century as the energy it was producing was not profitable in the country's energy market. However, Mexico's energy industry is heavily reliant on fossil fuels and the state has publicly stated the need to diversify. Though still an energy exporter, Mexico is facing rapidly increasing demand for energy as are many developing nations. Mexico's Energy Ministry recommended in late 2006 that the country construct a second nuclear power plant and opened bidding on two new reactors for the plant, which could begin operation as early as 2010.[73]

Figure 6: Mexico's Laguna Verde-1 Plant

Source: http://www.ajenm.org.mx/.

[72] "International Atomic Energy Agency Country Report: Mexico," Web-only report, December 2004, URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/ CNPP_Webpage/ countryprofiles/Mexico/Mexico2004.htm>, accessed 15 March 2007.

[73] "Energy Information Association Mexico County Analysis Brief."

Cuba's Failed Nuclear Power Program

Cuba possesses two partially completed nuclear reactors at its Juragua nuclear power facility. The Juragua reactors are Soviet designed PWRs commissioned in 1983 in a joint Cuban-Soviet venture to bring nuclear power to Cuba. That the reactors are not completed is due to many factors, chief among them the collapse of the Soviet Union and resultant economic woes for Cuba. Although the reactors are in the same family as the Chernobyl reactor they are more advanced and considered safer.

Figure 7: Cuba's Juragua Site

Source: www.cubamcud.org

Nonetheless safety concerns also plagued Cuba's reactors from their inception. The potential for restarting work on the reactors, at an estimated completion price tag of around 1 billion dollars, resurfaced in the late 1990s and caused concern among nuclear watchdogs. However, Fidel Castro put what seems to be a permanent end to the project, choosing instead to pursue more economic forms of alternate energy. There appears to be no future for nuclear power in Cuba.[74]

Though no other states in Latin America have nuclear infrastructure or are pursing nuclear power, the possibility this may occur in the future exists. Latin American states are generally considered developing states. In other words, they are undergoing important demographic changes. In many Latin American states the birth rate far

[74] Pascal Fletcher, "Cuba rejects Russian nuclear plant offer," *Financial Times*, 19 December 2000, Proquest document ID# 65278301, accessed via Proquest 20 March 2007.

exceeds the death rate, leading to quick population increases that put pressure on region's resources. Chief among these pressures is an ever increasing demand for energy. Hugo Chavez has been able to gain large amounts of influence in Latin America is through his PetroCaribe energy subsidy program whereby he provides cheap energy to other states. The long term forecast has demand for energy in Latin America increasing 75% by 2030. In the same timeframe, demand for electricity will increase over 140%.[75]

The need for more energy will result in the increased use of most if not all current energy technologies in the region. Nuclear power, efficient and relatively friendly to the environment, could be an option for states that do not currently use it. Chile provides an excellent example. Chile decided not to pursue nuclear power after exploring the option in the 1970s. However, its current situation has led Chile to once again ponder using nuclear power. Chile's use of natural gas has risen to 25%, meaning that it is extremely vulnerable to the Argentine natural gas market, from which it draws most of its imports. Chile's economy is heavily dependent on copper mining, which consumes large amounts of energy. Chile has virtually no energy resources of its own and instead must rely on other states. Thus Chile has the motivation to create and maintain an energy source of its own, with nuclear power being an attractive option. To that potential end, the Chilean government stated in March, 2007 that it would set up a commission to explore nuclear power.[76]

---

[75] "Future development and poverty reduction tied to gains in renewable energy, says IDB President," Inter-American Development Bank Press Release, 18 March 2007, URL: <http://www.iadb.org/NEWS/articledetail.cfm?artid=3691&language=En>, accessed 21 March 2007.

[76] Gideon Long, "Strapped for Energy, Chile Looks at Nuclear Option," Reuters News Service, 12 March 2007, URL: <http://www.planetark.org/dailynewsstory.cfm/newsid/ 40789/story.htm>, accessed 21 March 2007.

NUCLEAR WEAPONS

To better understand the ability of states to create or procure nuclear weapons, a basic understanding of these devices is necessary. States attempting nuclear proliferation can take a variety of avenues to this end. Existing nuclear energy infrastructure can be used to mask and pursue a weapons program, a course charted by the likes of India and Pakistan. States may take a more direct route, forgoing the veil of nuclear power and striving directly for weapons production. Though not likely an action that would be condoned by the international community today, this is the path chosen by the United States in the 1940s. More recently, a new type of proliferation has come into play. The breakup of the Soviet Union and subsequent issues involving the safeguarding of its nuclear materials allow for the possibility that states or transnational groups could attempt to purchase nuclear weapons or material on the black market or even steal this material. The exposure of the A.Q. Khan network shows the reality of this type of proliferation. Still another proliferation possibility involves the transfer of weapons from nuclear states to non-nuclear states or entities.

According to Richard Garwin and Georges Charpak in their work *Megawatts and Megatons*, there are a few basic requirements for the actual production of nuclear weapons. First and foremost is the brain power necessary to mount such an undertaking. States in possession of nuclear power programs have much of the requisite knowledge already. Garwin and Charpak argue that there are plenty of out of work nuclear engineers in the wake of the break-up of the Soviet Union that could be available to assist a program. Moreover, they argue that the information sharing arrangements created under the NPT actually serve to encourage the transfer of knowledge concerning weapons

production. Other key nuclear weapons components include: chemical explosives; a neutron source for initiating the chain reaction; and finally, either plutonium or enriched uranium.[77]

Because of their densities, either U_{235} or PU_{239} makes the best fissionable material for nuclear weapons. U_{235} must be enriched until it is approximately 80% pure to be usable in weapon production. Depending on the design of the weapon, as little as 34 kg of uranium is needed.[78] Running a nuclear power program is not tantamount to creating highly enriched uranium (HEU). States desiring to create a weapon using HEU either need facilities capable of this high level of enrichment or the ability to acquire uranium that has already been enriched to this level.

The potential to use plutonium for the manufacture of weapons presents many challenges for those wishing to curb proliferation. On the one hand, it is not an easy material to handle and is thus not the preferred bomb-making material for would be proliferators. On the other hand, small quantities of plutonium, as little as 4 kg, are sufficient for weapons production. A typical nuclear power reactor produces this amount of plutonium in a normal week of operation. Over time, though, the different types of plutonium produced in the fission reaction serve to dilute the effectiveness of the weapons grade plutonium that collects in spent fuel rods. The typical life of a nuclear reactor core is 4 years. One way to avoid the dilution of weapons grade plutonium in spent fuel is to shorten the fuel cycle down to about 7 months, leaving a much higher

[77] Garwin and Charpak, 312.

[78] Garwin and Charpak, 58.

grade of plutonium in the spent fuel. HWRs are particularly suited for this type of shortened fuel cycle.[79]

Nuclear weapons employing fission are the most basic of nuclear weapons and thus the most likely to be proliferated. Fission weapons bring together enough material to sustain a chain reaction and do so in a short amount of time. An inefficient but relatively easy to create fission weapon is the gun design. Pieces of fissionable material are brought together in a barrel by a propellant, while a neutron is injected at the right instant to start the chain reaction. This technique requires about 60 kg of enriched uranium. Though not widely used today, the design of such a weapon would likely not require testing before employment.[80] This configuration has obvious advantages for potential proliferators. South Africa's clandestine weapons program produced six gun-type nuclear weapons before it was voluntarily dismantled.

Plutonium is not suitable for gun-type nuclear weapons, thus the more efficient implosion technique was designed. Implosion, whereby a sphere of fissionable material is compressed by explosives placed on the outside of the sphere, is the preferred designed for fission weapons. Implosion weapons have higher yields than gun type weapons and also require less fissionable material. Implosion weapons can be created with as little as 6 kg of plutonium or 34 kg of U_{235}.[81]

Other nuclear weapons designs exist, including boosted fission weapons, hydrogen bombs, and neutron bombs. These weapon types have increased yields though due to their complexity are not likely to serve as entry level nuclear weapons for would-

---

[79] Garwin and Charpak, 314-315.

[80] Garwin and Charpak, 59.

[81] Garwin and Charpak, 60.

be proliferators. Thus the inner-workings of these types of weapons will not be discussed in the scope of this work.

NUCLEAR PROLIFERATION

Since the dawn of the atomic age in 1945, nuclear proliferation has been slow. Technological challenges, the huge economic cost of running a nuclear program, and the nuclear non-proliferation regime have kept the number of members in the nuclear club relatively low. The United States, the former Soviet Union, France, Great Britain, and China all had nuclear weapons programs by 1964. In the years since, only India, Pakistan, and North Korea have conducted nuclear weapons tests. Israel is widely believed to have a nuclear program, though there has been no official acknowledgement of it. South Africa at one point produced nuclear weapons, but voluntarily dismantled its program before revealing it to the world.[82] Some states of the former Soviet Union instantly became nuclear powers when the Soviet Union dissolved, but all have since given their weapons to Russia. Still other countries, like Brazil and Argentina, possessed or are thought to have possessed weapons programs but voluntarily abandoned these programs before actually producing a weapon.

Thus the nuclear non-proliferation regime has remained fairly strong. Recent events, however, call the strength of global non-proliferation into question. Despite considerable international pressure not to, North Korea conducted a nuclear test in October 2006. Iran continues to pursue what appears to be a program geared towards

[82] Roy E. Horton, III, "Out of South Africa: Pretoria's Nuclear Weapons Experience," United States Air Force Institute For National Security Studies Occasional Paper #27, August 1999, URL: < http://www.fas.org/nuke/guide/rsa/nuke/ocp27.htm>, accessed 7 March 2007.

nuclear weapons even though it has been referred to the United Nations Security Council and unanimously sanctioned by that body. And in what many, including Brazil, consider hypocrisy the US tacitly accepted the nuclear revelations of states like India and, more recently, Brazil. These events, combined with the uncertainty of the current global security situation, could signal a change in the nuclear attitudes of many states. The most likely regions for proliferation are East Asia, in reaction to North Korea's nuclear capability, and the Middle East to counter Iran's pursuit of a program. Nor is it out of the question to hypothesize situations in which Latin American countries choose to pursue nuclear weapons, which is the focus of later chapters of this work.

Why States Choose the Nuclear Option

In his work *Ballistic Missile Proliferation,* author Aaron Karp does an excellent job addressing the many differing issues of proliferation. While his work centers around missiles as delivery systems rather than focusing on nuclear weapons, his points are germane to any discussion of proliferation. Rather than merely cataloging proliferation and explaining its technical basis, Karp chooses to undertake an examination of the motivations and forces behind it. In doing so, he helps put proliferation into its proper context. Karp chooses to examine different schools of thought on the question of proliferation. One school of though, technological determination, essentially holds that development and spread of new weapons is unstoppable and that governments are compelled to pursue major weapons whether not they are in that government's best interest.[83] Political determination, on the other hand, holds the position that a variety of

[83] Aaron Karp, *Ballistic Missile Proliferation* (New York: Oxford University Press, 1996), 10-11.

mainly internal political interests drive a state to pursue weapons. A derivative of both of these schools of thought is that arms races between states drive proliferation.[84] Karp's ultimate conclusion is that the answer to this question contains elements from each opinion; he also caveats this by stating that proliferation is not an inevitable consequence of any element or their combined effects.[85]

A comprehensive examination of specific factors behind nuclear proliferation is found in *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*. The authors explore the reasons non-nuclear states may choose the path of proliferation in the future. They break the potential reasons for future proliferation into five categories:

1) a change in the direction of US foreign and security policy;
2) a breakdown of the global nuclear non-proliferation regime;
3) the erosion of regional or global security;
4) domestic imperatives;
5) the increasing availability of technology.[86]

These categories provide a logical basis for exploring potential proliferation on the part of Brazil and Venezuela. As such, a brief exploration of each is warranted.

Direction of US Foreign and Security Policy. US attitude and action towards nuclear deterrence and non-proliferation guides the nuclear agenda of many states, regardless of their allegiance or ties to the US. These states count on aspects of US policy when considering their own policy and / or making nuclear decisions. In today's constantly changing security environment, actions the US has taken could erode the

[84] Karp, 13-14.

[85] Karp, 201.

[86] *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*, eds. Kurt M. Campbell and others (Washington, D.C.: Brookings Institute Press, 2004), 20.

perception of security the US fosters in other states. For example, US justification of pre-emptive war marks a huge shift in US foreign policy, and understandably complicates global perceptions of US intentions. Contributing to the idea that the US is becoming more focused on its own security are actions like its withdrawal from the 1972 Anti-Ballistic Missile (ABM) treaty, among others.[87] To be fair, that treaty was a relic of the Cold War. The US justified the withdrawal from it by expressing a desire for self-preservation after the 9/11 attacks. One of the centerpieces of US defense against future nuclear threats is the National Missile Defense, and using missiles for homeland defense is counter to provisions of the ABM.[88]

A more inwardly focused US could result in nuclear proliferation if states no longer feel confident in their own security. The recent nuclear detonation by North Korea prompted talks of nuclear development in, among other places, South Korea and Japan. If these states perceive that the US cannot provide for their security they may feel justified in pursuing a nuclear weapons program. The security environment in the Middle East, always tenuous, is currently more so because of Iran's undisguised nuclear ambitions and the seeming inability of the international community to curb same. Even a non-nuclear arms race could fuel nuclear tensions if the US proves unwilling or unable to control it; this is a potential nuclear proliferation scenario for Latin America.

A Breakdown of the Global Non-Proliferation Regime. Nuclear weapons are considered anathema to most of the global community, and nuclear intentions are

---

[87] *The Nuclear Tipping Point*, 20-21.

[88] "ABM Treaty Fact Sheet," statement by the White House Press Secretary, 13 December 2001, URL: < http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html>, accessed 12 April 2007.

generally met with international condemnation and scrutiny. However, the penalties for nuclear acts have been minor to non-existent. Most of the newest members of the nuclear club, including India, Pakistan, and Israel, received little punishment upon either testing or admitting to possessing nuclear weapons. Likely dampening US and global reaction to these nuclear revelations was the fact that the US has important security interests with each of these states.[89]

The international reaction to both North Korea's recent nuclear test and Iran's pursuit of nuclear capability has been decidedly harsher than it was for the three aforementioned states. Contributing to this reaction is the fact each state is seen as a so called "rogue" state. The perception is that nuclear weapons in the hands of North Korea of Iran are decidedly more dangerous than in the hands of more stable states like India. Also, the US sees each state as a security risk rather than partner and as such the decision to condemn the actions of each is not a hard one. Nonetheless, current international action against each state amounts to little more than slaps on the wrist for each. The high standing of some recent nuclear club members in the eyes of the US and international community and the lack of real punishment for others may signal to potential proliferators the political cost of pursuing nuclear weapons is not too great to overcome.[90]

Eroding Regional or Global Security. The previously mentioned factors can contribute the perception or reality that security at different geographic levels is becoming weaker. States may look to shore up this weakness by pursuing nuclear

---

[89] *The Nuclear Tipping Point*, 24.

[90] *The Nuclear Tipping Point*, 24.

weapons. Nuclear weapons can be seen as one option, albeit an extreme one, for restoring or shifting the balance of power between a state and its rivals.[91] Historic nuclear proliferation has often occurred between neighbors or at least regional rivals. India and Pakistan represent a good example of this type of proliferation, as do the failed nuclear programs of Brazil and Argentina. There are many potential scenarios in Latin America that could encourage nuclear proliferation along similar lines.

Domestic Imperatives. States undergoing some type of decline, such as economic trouble or political upheaval, are likely to look for options that halt or slow that decline and improve the state's security situation. Likewise states that aspire to global power or at least increased global standing may look for similar options. An obvious, though perhaps not easy, choice to accomplish these goals is the nuclear option.[92] Although it would seem that global or at least regional concerns would dominate the decision by a state to pursue proliferation, domestic concerns can certainly be a driving factor behind such a decision. There are many factors behind Iran's current pursuit of nuclear weapons, and many of them seem to be domestic in nature. Iran's desires to be a regional power and larger player on the global stage, or to at least garner some serious international attention, are internal in nature and helping to drive the state's nuclear ambitions. It is not a stretch to see Venezuela or even Brazil pursing nuclear weapons for many of the same reasons. Venezuela's economic situation is another factor that could result in a decline in its regional influence and power, and the country may soon need to explore ways to keep its power from eroding.

---

[91] *The Nuclear Tipping Point*, 25.

[92] *The Nuclear Tipping Point*, 27.

Increasing Availability of Technology. The development of a nuclear weapons program from the ground up takes large amounts of resources and time. The availability of resources remains one of the big reasons there are so few members of the nuclear club. Most states simply can't afford a complete nuclear program unless they are willing to pull from other sectors of the economy, usually at the expense of their populace. North Korea followed this track in its nuclear development, but in its case the government has almost complete control over a very deprived and easily swayed population. Developing weapons to the detriment of a constituency is much less likely to occur in more open societies.

Two events in particular have moved the idea of nuclear proliferation from a question of state economic means to a matter of locating and acquiring the weapons or their components on the open market. First, the end of the Cold War and the dissolution of the Soviet Union left a significant amount of nuclear material unaccounted for in the former Soviet states. Some of this material has yet to be accounted for.[93] Much of the accounted for material is loosely guarded and remains vulnerable to theft or purchase by those desiring to possess it.

Second, the revelations concerning Pakistani scientist A.Q. Khan and transfer of important nuclear technology for personal gain highlight the difficulty in dealing with the nuclear black market. Nuclear knowledge and equipment is readily available and can be transferred through locations where it is very hard if not impossible to track or otherwise control their movement.[94] Brazil has a well developed nuclear power program; its likely avenue for weapon proliferation would be to develop its own weapons. Venezuela, on

---

[93] *The Nuclear Tipping Point*, 28.

[94] *The Nuclear Tipping Point*, 339-340.

the other hand, has no nuclear infrastructure. If the state truly desires nuclear weapons, it may look to the black market rather than expend the capital to develop its own program.

The Human Factor in Nuclear Proliferation

In his book *The Psychology of Nuclear Proliferation*, Jacques E.C. Hymans puts forth an interesting thesis concerning proliferation. He argues that the decision to pursue the nuclear option is a result of the psychology of the leaders who make these decisions. Further, he states that nuclear decisions are based on a sense of national identity and usually influenced by emotions.[95] Hymans posits that while the states that have acquired nuclear weapons have many diverse characteristics, their leaders all see their national identity from the point of view of what he terms as an "oppositional nationalist." While Hymans' oppositional nationalists perceive an external threat to their states, they also perceive their state to be equal or better than this threat. For the leader in this position, Hymans argues, pursuing the nuclear option is not a last resort, but a question of necessity.[96]

Hymans' typology of national identity conception, or how individual leaders perceive their nations in terms of solidarity and status,[97] actually has four possible iterations. The oppositional nationalist is but one of these. Hymans' thesis is important to this work, as it pertains to the potential for Venezuela to pursue nuclear weapons. Venezuelan President Hugo Chavez seems to perfectly fit the mold of an oppositional nationalist vis-à-vis the United States. In terms of status, while Chavez likely has no

---

[95] Hymans, ix.

[96] Hymans, 2.

[97] Hymans, 18.

delusions about Venezuela's power relative to the United States, he does rally his country around the assertion that they should be considered equal if not better than Americans. For the solidarity component of national identity, Chavez definitely puts his country at opposition to the United States. In his book, Hymans takes four different sets of national leaders through a quantitative analysis of trends and actions in order to better qualify leaders in one of his four categories. This work will not subject Hugo Chavez or Brazilian President Luiz de Silva to quantitative analysis; that may be accomplished in a future work. Suffice it to say that the psychology of national leadership is an angle worth mentioning when examining the nuclear question in Latin America, especially when Hugo Chavez in particular seems to fit neatly into Hymans' definition of a leader likely to pursue nuclear weapons.

THE HISTORY OF NUCLEAR WEAPONS DEVELOPMENT IN BRAZIL AND ARGENTINA

Brazil and Argentina are the only states in Latin America that have seriously attempted to develop nuclear weapons. Both made significant progress, and both voluntarily abandoned their programs in the early 1990s. But the progress each made is important in the study of potential proliferation in Latin America. Of particular import is Brazil's former program. Gauging where it was and why it was abandoned can provide insight into the future of Brazil's nuclear ambitions.

Historical Background

Brazil and Argentina were colonial possessions of Portugal and Spain, respectively. As Portugal and Spain sought to expand their power and influence in the New World, the two colonies naturally developed an adversarial relationship with each other. Both became independent in the early 19th century but the rivalry persisted; it came to a head in 1825 with the first and only war between the two states. Although this conflict was resolved in 1828 by a peace treaty that hasn't been broken since, the two states remained largely at odds. Overtures were made, mainly by Argentina, in the 1940s and 1960s, but with limited success. Major issues between the two, such as questions over the use of the shared watershed of the Parana River, continued to surface. It was not until 1985 that a true thaw in the cool relationship between Brazil and Argentina began.[98]

In the 1950s, a nuclear arms race of sorts became an extension of the rivalry between the Brazil and Argentina. Argentina entered the quest for nuclear autonomy first; Brazil soon followed. The nuclear race between the two was less about compelling national security needs, even with respect to each other, and more about the need for each to keep pace with the other. That neither actually produced a weapon is telling in this respect. In 1980 the two states signed a cooperative agreement on the peaceful development of nuclear power, a potential signal that the nuclear competition was coming to an end. Though this agreement faltered, a more lasting and comprehensive cooperation between the two states began in 1985. The November, 1985 "Joint Declaration on Nuclear Policy" highlighted the peaceful purposes of each state's nuclear

[98] Julio C. Carasales, "The Argentine-Brazilian Nuclear Rapprochement," *The Non-Proliferation Review*, Spring /Summer 1995, URL: <http://cns.miis.edu/pubs/npr/vol02/23/carasa23.pdf>, accessed 17 April 2007.

program and was the first of a number of bilateral agreements between Brazil and Argentina.[99]

Argentina's Nuclear Program

When evaluating a failed or abandoned nuclear program, the first question that generally comes to mind concerns the progress that program made towards nuclear weapons development. In developing their nuclear infrastructure, both Brazil and Argentina made significant progress toward completing the nuclear fuel cycle, the first step in nuclear weapons autonomy. How far each progressed past the previous discussion of their fuel cycles is debatable and remains an item of contention, at least in the scholarly arena.

No direct evidence exists that Argentina actually intended to develop nuclear weapons. However, there is ample circumstantial evidence to suggest Argentina, or at least factions within its military and perhaps its government, pursued weapons development. First and perhaps foremost is its pursuit of the complete nuclear fuel cycle. Also questionable is the fact the Argentinean Navy ran the country's nuclear program. Until agreeing to abide by it in 1995, Argentina habitually opposed the global Nonproliferation Treaty. Finally, the closest physical evidence to the existence of an Argentinean nuclear weapons program is its pursuit of a medium range ballistic missile, the Condor-II.[100]

---

[99] Carasales, "The Argentine-Brazilian Nuclear Rapprochement."

[100] Aaron Karp, "Correspondence: Argentina and the Bomb," *The Non-Proliferation Review*, Spring 2000, URL: < http://cns.miis.edu/pubs/npr/vol07/71/corr71.pdf>, accessed 17 April 2007.

Argentina's Missile Program

Argentina undertook its Condor program in the late 1970s for a variety of reasons, including ongoing territorial disputes with Great Britain and Chile, the prestige of a missile program, the potential to profit from the sale of missiles on the international arms market, and rival Brazil's pursuit of ballistic missiles.[101] Argentina originally received assistance for the Condor from a variety of outside sources, including German, Swiss, and Austrian firms. Early work on the Condor-I missile soon shifted to the Condor-II, a multiple stage missile that could range, among other places, the Falkland Islands. Iraq showed interest in the missile and helped fund the program by funneling money through Egypt. The Condor-II program matured to the point that Argentina constructed a plant for its manufacture near Cordoba in the mid-1980s.[102]

However, outside forces would soon spell the end of the Condor-II program in Argentina. In the late 1980s, the Missile Control Technology Regime (MCTR) was created. Many firms assisting in the development of the Condor-II were located in states party to the MCTR, resulting in the loss of that assistance. After Italy was caught assisting Argentina in violation of the MCTR and an Egyptian-American was caught smuggling potential Condor-II missile components into Egypt, the US placed heavy pressure on Argentina to abandon the program. In May 1991, prompted largely by the end of military government in the wake of the Malvinas War with Britain, Argentina ceased work on the Condor-II.[103]

---

[101] "Argentina Profile: Missile Review," Web-only essay, October 2006, URL: < http://www.nti.org/e_research/ profiles/Argentina/Missile/index.html>, accessed 17 April 2007.

[102] "Argentina Profile: Missile Review."

[103] "Argentina Profile: Missile Review."

Today Argentina retains the aforementioned pieces of its attempt at a nuclear fuel cycle and its nuclear power program. Though each has potential application to a weapons program, there is little or no evidence to suggest any program exists. The country officially maintains no ballistic missiles; though there is speculation that Argentina developed and maintains a stock of a short range (150 km) missile capable of carrying a 400kg warhead.[104] The utility of this missile, the Alacron, for nuclear delivery is questionable. And in what is hopefully a footnote to former nuclear weapons ambitions, Argentina in July 2006 admitted to producing 3.7 kg of weapons grade uranium at a research reactor. The uranium was transferred to storage in the United States.[105]

Brazil's Nuclear Program

Like Argentina, Brazil never actually produced a nuclear weapon, but many of it actions indicated that it was pursing a weapons program. Mirroring the opportunistic strategy of Argentina, Brazil minimized its cost to develop components of the nuclear fuel cycle by seizing on technology when it became available. At least for a time, Brazil's parallel civil power program served as a mask for its weapons ambitions. In 1990, then Brazilian president Fernando Collor de Mello publicized the Brazilian military's bomb making intentions.[106]

---

[104] "Alacran," Web-only essay, 17 April 2007, URL: <http://www.missilethreat.com/missilesoftheworld/id.2/missile_detail.asp>, accessed 17 April 2007.

[105] "Argentina Profile: Missile Review."

[106] "Nuclear Weapons Programs: Brazil," Web-only essay, 18 April 2007, URL: <http://www.globalsecurity.org/ wmd/world/brazil/nuke.htm>, accessed 18 April 2007.

The circumstantial evidence for Brazil's pursuit of a weapon followed the same path as Argentina's. Brazil also sought to complete the nuclear fuel cycle, and nearly has done so. Brazil reluctantly joined the non-proliferation regime in the early 1990s, after years of obstructionist behavior towards it. Brazil also maintained a ballistic missile program, which still is in operation today. Brazil's military has consistently been heavily involved in both its nuclear sector and its development of missiles. Early in its nuclear program Brazil faced the choice of developing nuclear reactors that used natural uranium, but instead it chose the more costly, complicated and less proliferation resistant uranium enrichment process.[107] When Brazil officially began its nuclear power program in the mid-1970's, it justified doing so by stating the program was in response to the 1973 energy crisis. However, Brazil's electricity was and still is produced largely by hydroelectric power. The addition of nuclear power would do nothing, in the 1970s, to reduce Brazil's reliance on petroleum.[108] Ironically, with Brazil's current population explosion and subsequent demand for energy, this rationale for nuclear energy may actually hold water today.

Brazil received its nuclear power plant equipment and knowledge mainly from West Germany which, at the time, was not subject to International Atomic Energy Association control. Brazil took advantage of this lack of control and in 1975 started a weapons program under the code name "Solimoes." Though it failed to produce a weapon, Solimoes took many important steps towards that end, including the enrichment of uranium to 20% and the actual design of two potential nuclear devices. Investigations by Brazil's Congress in the late 1980s revealed the secret bank accounts used to fund the

[107] "Nuclear Weapons Programs: Brazil."

[108] Goldemburg, "Looking Back."

program, as well and the disturbing news that Brazil had transferred over 8 tons of partially enriched uranium to Iraq in 1981.[109]

As a result of Brazil's nuclear past, the state today has a well-developed nuclear infrastructure. It has a number of nuclear research facilities; more importantly, it has a solid core of scientists and engineers to run the country's power program and conduct research. Additionally, Brazil has an ample resource base. Perhaps most important to any future nuclear ambitions, Brazil has the technology, knowledge, and facilities to enrich uranium.[110]

Brazil's Missile Program

Brazil's missile program has reached a much more advanced level than Argentina's, and as the better of the two, is the most comprehensive missile program in Latin America. Just as Brazil's weapons program proceeded under the guise of peaceful nuclear power, its missile program doubles as a legitimate space program. Although Brazil admitted to and formally abandoned its nuclear weapons program, it continues development of its main missile program as a part of its attempt to launch its own rocket into space.

Brazil's space program has many factors driving it. One rationale for the program, especially if it aims to produce a ballistic missile, is Brazil's likely desire for technological independence.[111] This seems to have been a theme in Brazil's nuclear

---

[109] "Nuclear Weapons Programs: Brazil."

[110] "Nuclear Weapons Programs: Brazil."

[111] "Missile Programs: Brazil," Web-only essay, 18 April 2007, URL: <http://www.globalsecurity.org/wmd/world/brazil/missile.htm>, accessed 18 April 2007.

program, and could play an important role if Brazil decides to develop nuclear weapons in the future. This may also help explain why Brazil continued work on missile technology even after Argentina formally abandoned the Condor-II. Another factor behind Brazil's space program is the geographical location of its Alcantara launch center. Because Alcantara is so close to the equator, it provides a significant cost savings as rockets launched there use less fuel to achieve orbit. As a result other states and organizations have used Alcantara, providing a source of revenue for Brazil.

Brazil began work on its primary missile, the Sonda series, in 1965. In 1971, Brazil's missile program was placed under the Brazilian Commission for Space Activities, which ultimately was led by Brazil's military. The Sonda series has progressed up to the Sonda-IV rocket, which as a missile has a range of 600 km and can carry a 500 kg payload. This subjects it to restrictions under the MCTR.[112]

The Brazilian company Avibras exported rocket systems with ranges of up to 60 kilometers in the 1980s. The purchasers of these systems were all Middle Eastern countries, including Iraq. Avibras attempted development of longer ranges missiles based on the Sonda technology for export but never succeeded. The same US pressure and MTCR controls that ended Argentina's Condor-II essentially ended Brazil's time in the rocket and missile export business.

Brazil continued its push for an independent space program, albeit not without questions from the international community. In an attempt to divorce the space program from its military, Brazil established the civilian controlled Brazilian Space Agency (AEB) in 1994. The agency's centerpiece project is the Veiculo Lancador de Satelites

[112] "Missile Programs: Brazil."

(VLS), a staged rocket boosted by Sonda IV technology that is part of Brazil's attempt to put a satellite into orbit. The VLS program has largely been a failure, as two launch attempts failed to achieve orbit and a 3rd rocket exploded on the pad, killing many of Brazil's top space scientists and engineers. The VLS could be used as a ballistic missile, and it would have a range of close to 4000 km if it was. The VLS is propelled by solid fuel, which is not optimal for a ballistic missile.[113] However, Brazil and Russia are jointly developing a VLS variant that is propelled by liquid fuel. Brazil is also cooperating with China on its space program, and has launched two satellites in this venture.

LATIN AMERICA AND THE NUCLEAR NON-PROLIFERATION REGIME

With the notable exception of Brazil and Argentina's attempts to produce nuclear weapons, Latin America has eschewed the pursuit of nuclear ambitions; indeed, nuclear aims are taboo in a region that seems to pride itself in being nuclear weapons-free. Ironically, it was Brazil who, in September 1962, introduced a proposal to the U.N. General Assembly to declare Latin America a nuclear weapon free zone (NWFZ).[114]

Brazil's proposal, aided by the October 1962 Cuban Missile Crisis, eventually resulted in the 1967 Treaty of Tlateloco. Tlateloco established South America and the Caribbean as a NFWZ, the first treaty of its kind to cover populated areas. Moreover, the treaty was an attempt to stop superpower nuclear meddling in the region, as Latin

[113] "Missile Programs: Brazil."

[114] John R. Redick, "Latin America's emerging non-proliferation consensus," *Arms Control Today*, March 1994, Proquest document ID# 5208901, accessed via Proquest 19 April 2007.

American states did not want the US and Russia to turn Latin America into a Cold War nuclear battleground. Aiding in ratification of the treaty was the fact nuclear technology was not well developed in the region, so there was little practical opposition to it. The members of the nuclear club and non-nuclear states with interests in the region ratified the pertinent protocols to the treaty, which helped to legitimize it. [115]

However, states with burgeoning nuclear interests did not ratify the treaty immediately. Brazil, whose proposal to the U.N. pushed the idea of a NFWZ, underwent a military coup in 1964 and had a much different view of the treaty when it came time to sign it. Brazil ratified the treaty, but stated it would not adhere to it until all Latin American nations and states possessing territory in Latin America also ratified. This allowed Brazil to pursue its nuclear ambitions unfettered by formal treaty. Argentina, Chile, and Cuba also failed to ratify Tlatelolco. Moreover, Argentina and Brazil both reserved the right to conduct so-called peaceful nuclear explosions. The combined effect of opposition to the treaty, especially from Argentina and Brazil, lessened its effectiveness for many years.[116] Though there were abstentions from ratifying and caveats to it, the treaty was as important as it was unprecedented. Most signatories to Tlatelolco allowed the provisions of the treaty to immediately go into effect without condition.

In 1979, Brazil and Argentina began cooperation on an unparalleled level. They began by resolving energy and boundary disputes, and in 1980 the two states began formal assistance to each other with regards to the nuclear fuel cycle and also started

---

[115] Redick, "Latin America's emerging non-proliferation consensus."

[116] Redick, "Latin America's emerging non-proliferation consensus."

cooperating on nuclear policy issues. In July 1991, Brazil and Argentina formalized the Brazil-Argentine Agency for the Accounting and Control of Nuclear Materials (ABACC), designed to ensure that nuclear use in the two states remained peaceful.[117] In December 1991, though not signatories to the NPT, the two states agreed to abandon nuclear weapons and testing, set up safeguards that would meet IAEA standards, and implemented a bi-lateral inspection and verification program. The Quadripartite Treaty formalized this arrangement.[118] Another result of the cooperation between the states was the acceptance of the Tlatelolco treaty by both, which served to legitimize that treaty.[119]

Argentina and Brazil essentially agreed to make sure each other remained free of nuclear weapons and their development. Although they both accepted the provisions of Tlatelolco, pressure continued on the two states to formally sign the NPT. Pressure and time are the strengths of the NPT. While it seems powerless to completely stop a leader or regime dedicated to pursuing nuclear weapons, the NPT can and does slow proliferation efforts. Slowed for long enough, states can lose their appetite for weapons. Often this occurs with regime change; and it was ultimately the switch from military to civilian governments that ended the nuclear desires of Argentina and Brazil. For example, the US government under the NPT blocked Brazil's access to important technology, especially high-speed computers. It also either obstructed or did not assist Brazil in efforts to acquire loans from international organizations. These actions helped to slow Brazil's efforts at proliferation until a regime less inclined to proliferation took

---

[117] "Brazilian-Argentine Agency For Accounting And Control Of Nuclear Materials (ABACC), Web-only essay, 8 June 2007, URL: < http://cns.miis.edu/pubs/inven/pdfs/abace.pdf>, accessed 8 June 2007.

[118] Redick, "Latin America's emerging non-proliferation consensus."

[119] Goldemburg, "Lessons from the denuclearization of Brazil and Argentina."

over.[120] In what may signal potential NPT ineffectiveness in dealing with Venezuela, Hugo Chavez has recently taken steps in an effort to keep him and his supporters in power indefinitely.

Latin America remains the strongest non-proliferation region in the world because of its proactive, pragmatic attitude concerning nuclear issues. This will be a significant hurdle that any state in the region seeking nuclear weapons will have to overcome. As the global non-proliferation regime seems to become more circumspect, Latin America's views on proliferation will play a critical role in ensuring the region remains free of nuclear weapons.

[120] Goldemburg, "Lessons from the denuclearization of Brazil and Argentina."

CHAPTER 3

FUTURE NUCLEAR PROLIFERATION IN BRAZIL?

BRAZIL SITUATION UPDATE

Brazil boasts South America's foremost economy, and is acknowledged by most as the preeminent power in the region. Home to a population of over 190 million, Brazil boasts vast natural resources, including uranium, and has the labor base to develop them. Although Brazil's explosive population growth has slowed in recent years, one of its main domestic issues remains a large disparity of income between rich and poor. The country's growth has also presented a host of environmental issues, foremost among them is the deforestation of the country's diverse Amazon Basin.[121]

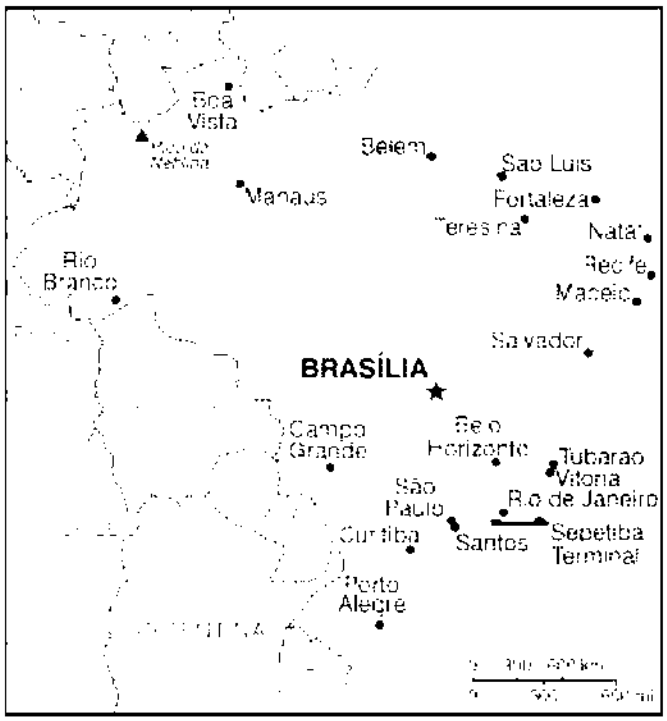

Figure 8. Brazil

Source: CIA World Factbook Online, 2007.

[121] *CIA World Factbook: Brazil*, CIA World Factbook, 10 May 2007, URL: <http://https://www.cia.gov/library/publications/ the-world-factbook/geos/br.html>, accessed 14 May 2007.

For most of the 20th century, Brazil's military played a major role in the governance of the country. This ended in 1985 with a peaceful transition to civilian leadership. It was Brazil's new civilian leadership that exposed its secret nuclear weapons program. After making the program increasingly visible for years, in 1990 then president Fernando Collor both revealed and shut down a nuclear test site at an air force base in Cachimbo Province.[122] It was also during this timeframe that Brazil began to cooperate with and ultimately join agreements such as the NPT, ABM, and MTCR. Under Collor, funding for Brazil's nuclear weapons program and technologies that supported it was cut, effectively terminating the program. With so much invested in the program, this was very unpopular with Brazil's military. In fact, a former head of Brazil's Nuclear Energy Commission (CNEN) claimed that Brazil's military continued to pursue nuclear weapons even after the program was disbanded.[123]

Lula da Silva and the Nuclear Question

Current Brazilian President Luiz Inacio Lula da Silva (Lula) was elected for a second time in October, 2006. A clear victor in the election, Lula carried over 60% of the popular vote.[124] Lula was the founded the socialist Brazilian Worker's Party (PT) in 1980, and his social programs have always been popular with Brazil's voters. However, the revolutionary views of Lula and the PT were tempered by three straight losses in national elections. Lula was finally elected in 2002 after taking steps like building a

---

[122] "Brazil's Nuclear History," *Arms Control Today*, October 2005, Proquest document ID# 924378651, accessed via Proquest 14 May 2007.

[123] "Brazil's Nuclear History."

[124] *CIA World Factbook: Brazil.*

coalition that included a right wing party and running as more of a social democrat than a revolutionary.[125] Though reluctant to share power during his first term, Lula's actions to this point in his second term indicate that he sees reaching out to all parts of his diverse government as key to advancing his agenda. He nominated a diverse cabinet that was popular with Brazil's legislature even though in doing so he weakened his own party considerably. Lula remains a popular leader and currently wields considerable power.[126]

During his presidential campaign in 2002, Lula questioned Brazil's membership in the NPT, asking "Why is it that someone asks me to put down my weapons and only keep a slingshot while he keeps a cannon pointed at me? Brazil will only be respected in the world when it turns into an economic, technological, and military power."[127] This statement prompted concern that Lula would attempt to revive Brazil's nuclear weapons program. However, he has not attempted to do so overtly, and even at the time his statement was seen both as pandering to the Brazilian military whose support he needed and also as a method to highlight his issues with the NPT.[128]

---

[125] "Profile: Luiz Inacio Lula da Silva," *The Economist*, online ed., 30 October 2006, URL: <http://news.bbc.co.uk/1/hi/world/americas/5346744.stm>, accessed 14 May 2007.

[126] "The Americas: Lula opts for a quiet life; Brazil," *The Economist*, 7 April 2007, Proquest document ID# 1250702411, accessed via Proquest 11 May 2007.

[127] Michael Flynn, "A Latin 'Axis of Evil?'" *Bulletin of the Atomic Scientists*, Oct/Nov 2003, Proquest document ID# 274909151, accessed via Proquest 14 May 2007.

[128] "A Latin 'Axis of Evil?'"

Brazil's Military and Nuclear Development

Brazil's military was heavily invested in Brazil's abandoned weapons program, and remains so in Brazil's missile and space program. If Brazil chooses to pursue nuclear weapons in the future, the effort will almost certainly be led by its military.

In 1979, the Brazilian Navy's Special Projects Commission (COPESP) began the development of a nuclear reactor suitable for submarine propulsion and also began looking into the enrichment of uranium. The Brazilian Army began development of a reactor suitable for plutonium production, and its air force looked into both enrichment techniques and breeder reactors.[129] The end of Brazil's nuclear program in 1990 meant, among other things, less funding for each of its military services involved in the process.

Brazil's Navy continues its research into nuclear propulsion for its submarines. In May 2004, the navy received $7.8 million to complete a prototype of a submarine reactor. It plans to have a contract for the new vessel by 2009, with production complete on the first ship by 2018.[130] Brazil's Army and Air Force have been less active in the nuclear technology arena, although the Air Force is heavily invested in Brazil's space program. The main launch vehicle in Brazil's space program has the potential for dual use capability as a ballistic missile.

Brazil's Nuclear Program: Recent Developments

Brazil continues to pursue its goal of achieving autonomy in the nuclear fuel cycle. Most of the recent pursuit of this aim have centered on the previously discussed

---

[129] "Brazil's Nuclear History."

[130] "Brazil Accelerates Nuclear Reactor Work For Nuclear Submarine Program," *Arms Control Today*, July 2004, Proquest document ID# 660598721, accessed via Proquest 14 May 2007.

enrichment facility at Resende, which continues its run-up to full capacity. Brazil has been less than cooperative with the IAEA in terms of inspections at Resende. An agreement was worked out between the IAEA and Brazil over Resende in 2005. However, as part of that agreement workers at Resende constructed a physical barrier around its centrifuges, which keeps IAEA inspectors from viewing them. Ostensibly this screen, similar to one the Brazilian Navy also has at a research reactor, is designed to protect the centrifuge technology being utilized by Brazil. It may also hide the source of the centrifuge technology, which saves Brazil from having to answer questions about how it received its centrifuge knowledge in the first place.[131]

Whatever the reason for the screen at Resende, it does permit the possibility of unauthorized uranium enrichment. Brazil is of the opinion that the IAEA can monitor input and output to ensure it is not abusing Resende's enrichment capability, just as it has at the naval research reactor. But if the IAEA does not have visibility on all operations at the Resende plant, Brazil could theoretically enrich uranium to weapons grade without being detected.[132] Even if Brazil holds to its pledge to only enrich uranium to 3.5%, it will have done more than half of the work required to enrich uranium to weapons grade. Using partially enriched uranium, were Brazil to decide to produce nuclear weapons it could do so relatively quickly. Theoretically the Resende plant could currently produce up to six warheads a year, a number that will increase as the plant reaches its full capacity.[133]

---

[131] Liz Palmer and Gary Millhollin, "Brazil's Nuclear Puzzle," *Science*, 22 October 2004, Proquest document ID# 725575851, accessed via Proquest 14 May 2007.

[132] "Brazil's Nuclear Puzzle".

[133] "Brazil's Nuclear Puzzle".

DOES BRAZIL HAVE A NUCLEAR TIPPING POINT?

Nuclear proliferation presents a difficult intelligence problem. History has shown that there is no "one size fits all" set of indicators and situations that drive a state towards nuclear weapons. In this section I will look at Brazil through the lens of the proliferation factors put forth by the authors of *The Nuclear Tipping Point.* Though it is but one part of my analytical framework, looking at these factors provides a comprehensive baseline for both compiling evidence and assessing Brazil's potential for proliferation.

Factor 1: Direction of US Foreign and Security Policy. US foreign policy is currently focused on Iraq, Afghanistan, the Middle East, and the Global War on Terror. Brazil disagreements with the IAEA on the issues at the Resende facility; have drawn little attention from the US. While overt pursuit of nuclear weapons would certainly mean more US and global engagement in the region and with Brazil itself, it is possible that Brazil is testing US will and its ability to back the IAEA and NPT in Latin America by not fully disclosing all activity and equipment present at Resende. Uranium enrichment to weapons grade is the largest missing link in Brazil's potential to develop nuclear weapons. If Brazil wants to again start its weapons program, the time to do so is when the US is focused elsewhere. On the other hand, Brazil's lack of cooperation with the IAEA could be nothing more than Brazil expressing its strong sense of sovereignty and its desire to protect industrial secrets and the source of its centrifuge technology.

Over the longer term, the current situation in Iraq has the potential to bring a dramatic shift in US foreign policy. Although US policy has been generally expansionist in recent years, as demonstrated by among other things its justification of pre-emptive

war, the situation in Iraq has shown that US power seems to have its limits. Domestic and international pressure are focusing the debate over Iraq in terms of what the US can salvage as it withdraws from the country, not what it can do to win the conflict there.[134] Although the outcome of the Iraq war is still in doubt, US failure there could bring about a more inwardly focused US foreign policy. Also pointing to a potential shift in US policy was the Democratic victory in the 2006 US Congressional elections. The 2008 presidential election will be telling, to say the least. In any case, a more inwardly focused US might be reticent to become involved in actively deterring Brazil from developing nuclear weapons. On the other side of this argument, preventing nuclear proliferation is an issue that most states generally agree on in principle. This alone may justify US action no matter what its current foreign policy stance or the going global opinion of it. Support this is the fact the US has throughout its history remained engaged in events in the Western Hemisphere regardless of its general views towards global engagement.

Factor 2: A Breakdown of the Global Non-Proliferation Regime. Although global opinion is generally against nuclear proliferation there is little, short of physical intervention, that can actually prevent it. States that strongly desire nuclear weapons and have the technological and economic means to produce them face few real hurdles. More telling may be the lack of consequences for states that actually develop nuclear weapons.

The cases of Iran and North Korea highlight the weaknesses in today's non-proliferation regime. Iran continues to defy the regime in its dogged pursuit of nuclear capability. While international opinion is strongly against a nuclear Iran, little more than

[134] Andrew J. Bacevich, "Twilight of the Republic?" *Commonweal*, 1 December 2006, Proquest document ID# 1174704891, accessed via Proquest 16 May 2007.

rhetoric and threats have stood in its way to this point. Iran, with abundant energy resources, is not a state that needs nuclear power, which is a telling factor in the underlying reasons for its nuclear program. As long as Iran retains the economic resources to continue its pursuit of a nuclear capability, and tacit pursuit of nuclear weapons, it will probably continue to do so unhindered. The global consensus against proliferation does not appear to be strong enough to stop it; only an attack on its nuclear facilities, probably at the hands of Israel or the US, seems likely to change Iran's current nuclear path.

Past states that have attained nuclear weapons capability generally have not suffered any real consequences, save for the oft cited negative short-term international opinion. Moreover, most of today's nuclear states have maintained or regained favorable status with the United States in the wake of unveiling their nuclear capability. The emergence of North Korea as a nuclear power once again tests the back-end of the non-proliferation regime. A true global fear is nuclear weapons in the hands of a so-called rogue nation like North Korea. North Korea's nuclear test caused regional saber-rattling and global ripples, but again the nation itself has suffered few tangible consequences as a result of its test. In fact, North Korea may be able to use its nuclear test as a bargaining chip and has been offered fuel oil and security guarantees for shutting its nuclear facilities and dismantling its program. Other, larger concessions to North Korea could be part of a wider deal between it and the US[135]

All told, history and current challenges to the non-proliferation regime signal that it is weak or even non-existent at this point. If Brazil decided to again pursue nuclear

[135] Carla Anne Robinson, "Wrestling Nuclear Genies Back Into The Bottle, or at Least a Can," *New York Times*, late edition, East Coast, 9 May 2007, Proquest document ID# 1267609201, accessed via Proquest 16 May 2007.

weapons many would of course question this decision, but the examples of North Korea and Iran show that any negative consequences of such an action are manageable. As it is not considered a rogue state, Brazil likely faces less backlash than North Korea, Iran, or even Venezuela if it decides to pursue nuclear weapons.

Factor 3: Eroding Regional or Global Security. Brazil faces few global or regional security threats. Although they were once embroiled in nuclear arms race of sorts, relations between Brazil and traditional rival Argentina have been warming for the better part of two decades. Nonetheless, Brazil does have security concerns, including a large frontier border that is nearly impossible to defend effectively. Additionally, a rising Venezuela could be a concern for Brazil's designs on becoming a regional hegemon. Venezuela, flush with oil money, has made a glut of arms purchases in the last couple of years, fueling fears of a regional arms race. That a potential arms race could turn nuclear is unlikely, but not out of the question.

Factor 4: Domestic Imperatives. Domestic imperatives, including a drive for more regional or global power, can fuel the decision to acquire nuclear weapons. This seems to be a large factor in Iran's pursuit of nuclear capability, and may be a consequence of North Korea's nuclear test, whether it was intended to be so or not. Brazil desires greater regional and global power.[136] The nuclear option would seem a drastic means to this end, but with the current nuclear capability Brazil already has in place it may at some point explore this avenue. Lula's nuclear statements on the

[136] "Who leads Latin America?; Brazil's Presidential Election," *The Economist*, 30 September 2006, Proquest document ID# 1139608601, accessed via Proquest 16 May 2007.

campaign trail were seen as a nod to Brazil's military. Pursing nuclear weapons could help Lula improve relations with his military and show his nationalistic spirit, though this is an improbable course of events.

Brazil's bid to assert itself as a regional power is based mainly on the strength and growth of its economy. It seems to be in the perfect position to gain strength on the back of its economy, as it is rich in many desirable natural resources. But after experiencing explosive growth through the 1970s, Brazil's economy has demonstrated only slow to moderate expansion since. Over the last four years, Brazil's economy grew an average of only 3.3% and was easily outpaced by the developing country average of 7.3%[137] Behind this slow growth are factors such as a heavy tax burden and even the vestiges of a culture that places personal bonds over rules and laws.[138] Brazil's population growth has placed additional pressure on its economy, but that growth has been slowing in recent years.

Brazil's economy does show many positive signs. Brazil has huge foreign exchange reserves, and programs enacted by Lula have brought inflation down to manageable levels. Even so, internal and external events could still hurt Brazil's economy and seriously damage its quest for increased global and regional power. Though unlikely, Brazil may choose to pursue proliferation in light of potential declining global or regional stature regardless of whether or not the decline is economically based.

Factor 5: Increasing Availability of Technology. Technology transfer has always been an enabler for the proliferation of arms, especially nuclear weapons. Rising

[137] "Brazil Economy: Land of Promise," Economist Intelligence Unit wire feed, 13 April 2007, Proquest Document ID# 1265109521, accessed via Proquest 16 May 2007.

[138] "Brazil Economy: Land of Promise."

globalization and the end of the Cold War intersected, resulting in many channels for illicit nuclear proliferation. Though no weapons have been confirmed to change hands in this manner, the materials and knowledge for making them have. Brazil is no stranger to technology transfer. Its dealings with West Germany in the 1980s were heavily scrutinized, and today's issues at the Resende facility could deal with proprietary technology that may have been obtained from another state. One would almost hope this is the issue at Resende; it is far more palatable to assume that Brazil is protecting the source of its technology than to think it is hiding attempts to enrich uranium to weapons grade. In any case, the availability of nuclear technology and material could allow Brazil to fill missing pieces in its nuclear puzzle. From a strictly practical point of view, however, Brazil is unlikely to risk the fallout that would comes as a result of being caught in the illegal transfer of nuclear material.

LULA da SILVA: NATIONAL IDENTITY CONCEPTION

In *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy*, Jacques E.C. Hymans approaches the question of nuclear proliferation by focusing on one individual: the leader of the state. Hymans argues the leader's national identity conception (NIC) is a good indicator of a leader's likelihood to push his or her state towards acquiring or developing nuclear weapons.

Hymans assesses each leader based on both status and solidarity. Hymans assesses a leader's status as nationalist if the leader holds that his state is equal or better to comparable states, or what Hymans terms as "key comparison others".[139] Conversely,

[139] Hymans, 24.

a leader is considered a subaltern if he has a negative national self-image. In terms of solidarity, a leader is considered sportsmanlike if he believes in a transcendent identity with comparative states. On the other hand, a leader is considered oppositional if he fosters an "us against them" mentality.[140] Using these categorizations, Hymans develops a typology whereby leaders can be placed into four types, or NICs. Hymans ultimately argues the oppositional nationalist is most likely to pursue nuclear weapons, although he discusses each NIC in depth.[141]

Lula fits into Hymans typology as a sportsmanlike nationalist. He continues a legacy of strong nationalism in both his country and the region. He sees Brazil as a regional power and wants to Brazil to continue its ascendancy. Under Lula, Brazil's foreign policy is highlighted by cooperation, multilateralism, and a search for compromise when issues arise. According to one assertion, these days "Brazil is everyone's friend."[142] Brazilian foreign minister Celso Amorim frames Brazil's foreign policy efforts as quiet, behind the scenes persuasion.[143]

According to Whaley, a sportsmanlike nationalist such as Lula should not pursue nuclear weapons because he doesn't fear comparable states. More tellingly, the sportsmanlike nationalist is typically interested in building a nuclear infrastructure in order to spur growth and also to gain in international standing. Brazil's pursuit of autonomy in the nuclear fuel cycle seems to underscore this assertion. Interestingly,

---

[140] Hymans, 23.

[141] Hymans, 38.

[142] Richard Lapper and Jonathan Wheatley, "Disagreements imply depth of ties for a regional leader," *Financial Times*, 22 February 2007, Proquest document ID# 1221029051, accessed via Proquest 16 May 2007.

[143] Lapper and Wheatley, "Disagreements."

Hymans says that a sportsmanlike nationalist might resist the non-proliferation regime because it makes distinctions between those who have nuclear weapons and those who do not.[144] A possible example of this is that Brazil long opposed the non-proliferation regime before Lula took power, and even today continues to limit cooperation with the IAEA at Resende.

BRAZIL: ANALYSIS OF COMPETING HYPOTHESES

Utilizing ACH provides a means to both organize the evidence for and against Brazil's potential to proliferate and to assess the likelihood that Brazil will, among other hypotheses, pursue nuclear weapons based on its current situation. The evidence presented in the course of this ACH is based on my assessments from data already reported in this thesis. At the risk of being repetitive and verbose, I will present that evidence only in list form here, choosing not to again explain each piece of it. Likewise, when I discuss the indicators that events may be pointing to a particular hypothesis I will not explore these indicators in depth.

Step 1 – Identify the possible hypotheses to be considered

As discussed in Chapter 1, there are four hypotheses that this analysis will consider for Brazil:

[144] Hymans, 39.

1) H1: Brazil will pursue an overt nuclear weapons program;

2) H2: Brazil will continue its pursuit of an autonomous nuclear fuel cycle but not pursue nuclear weapons (status quo);

3) H3: Brazil will clandestinely develop a "run up" nuclear capability and gain the ability to quickly produce nuclear weapons;

4) H4: Brazil will abandon its attempt at an autonomous fuel cycle, open itself completely to the IAEA, and maintain only the ability to produce nuclear energy.

Step 2 – Make a list of significant evidence and arguments for and against each hypothesis

Figure 9 details the evidence considered in this analysis:

-Brazil's past nuclear legacy and the military's potential resentment at its dismantling
-Lula's pro-nuclear stance during his 2002 presidential campaign
-The nuclear knowledge and facilities maintained by Brazil's military
-Brazil's navy continues development of a nuclear reactor for its submarines
-Brazil's pursuit of autonomy in the nuclear fuel cycle
-The strong Latin American non-proliferation regime
-Brazil's obstruction of the IAEA at Resende
-The US has not commented on Brazil's obstruction of the IAEA
-Brazil's failure to sign additional protocol to NPT giving IAEA inspection rights
-Former CNEN president claims Brazil's military continued to pursue weapons after program was terminated
-Brazil is signatory to the NPT and Treaty of Tlateloco
-Brazilian ambassador Campos states that nuclear project is only for peaceful purposes
-Brazil promises to only enrich uranium to 5%
-Lula fits the typology of a sportsmanlike nationalist
-Brazil continues development of a space launch vehicle, which could be used as a ballistic missile
-At present, the US is focused elsewhere
-The non-proliferation regime appears to be weakening
-Brazil's economy has shown slow, but consistent growth
-Brazil's population growth is leveling off, lessening the pressure that it places on the country
-Venezuela's actions point at a desire for more power in the region
-Brazil is heavily reliant on hydropower and lacks a consistent source of energy

Figure 9: Evidence considered in Brazil ACH Analysis

My ACH matrix[145] uses 6 different notations to assess the consistency of each piece of evidence against the proposed hypotheses. Blue shaded cells denote consistent evidence and are annotated with a 'c", while very consistent evidence is also shaded blue and annotated with a "cc". Pink shaded cells denote inconsistent evidence and are

[145] I obtained this ACH matrix from Dr. Joseph Gordon in the course of taking his Strategic Warning and Analysis class at the National Defense Intelligence College. I found a couple of errors with the matrix and corrected them.

annotated with an "i", while very inconsistent evidence is also shaded pink and annotated with an "ii". Evidence that appears neutral toward a hypothesis is noted by "n", while evidence that is not applicable to a particular hypothesis shows as "na". Neutral and non-applicable cells are not shaded.

Also included in the matrix are a measure of credibility and a measure of reliability for each piece of evidence, with both measures being evaluated as high, medium, or low. Each of these measures is evaluated based on my personal assessment supported by data collection. Raw values for each cell are tallied for each hypothesis in the unweighted score rows: inconsistency is scored on the blue row while consistency is scored on the red row. Credibility and relevance are weighted measures that contribute to the weighted inconsistency score on the green row and the weighted consistency score on the yellow row.

Evidence #	Evidence	Evidence Type	Credibility	Relevance	H1	H2	H3	H4
E1	Nuclear legacy - resentment over end		med	med	c	n	c	i
E2	Lula's 2002 pro-nuclear stance		high	low	c	n	c	i
E3	Nuclear knowledge / facilities		high	high	c	c	c	i
E4	Navy continues development of sub reactor		high	med	c	i	c	n
E5	Pursuit of autonomous fuel cycle		high	high	c	cc	cc	i
E6	Latin American non-proliferation regime		med	high	ii	c	ii	c
E7	Obstruction of IAEA at Resende		high	high	c	i	cc	ii
E8	U.S. apathy towards Resende obstruction		med	med	c	n	c	i
E9	Failure to sign NPT protocol		high	high	c	i	c	ii
E10	Claims military continued to pursue progrsm		med	high	c	n	c	n
E11	Signatory to NPT and Tlatelolco		high	med	ii	cc	i	cc
E12	Ambassador states nuclear project peaceful		med	low	i	c	i	c
E13	Promise to enrich uranium to only 5%		low	med	i	c	i	c
E14	Lulu as a sportsmanlike nationalist		high	high	i	c	i	i
E15	Continued development of space capability		high	med	c	i	cc	n
E16	U.S. focused elsewhere		med	low	c	na	c	n
E17	Weakining non-proliferation regime		med	med	cc	n	c	i
E18	Slow, consistent economic growth		high	low	i	c	i	c
E19	Lessening population pressure		med	low	i	c	i	c
E20	Desire for more regional / global power		med	med	c	i	c	i
E21	Heavily dependent on hydropower		high	med	i	c	i	cc
				Weighted **Inconsistency** Score =	-12.190	-7.827	-10.776	-18.995
				Unweighted **Inconsistency** Score =	-18	-6	-9	-12
				Weighted **Consistency** Score =	6.756	8.947	12.583	-8.885

Figure 10: ACH Matrix for Brazil

An initial look at the results of the ACH show that H2, or maintenance of the status quo, is the hypothesis with the least amount of raw and weighted inconsistent evidence. H4, abandonment of all dual use nuclear efforts and a concentration on energy only, has the most evidence against it. H1 and H3, overt and clandestine nuclear weapons pursuit, share similar evaluations and scores, with overt pursuit of nuclear weapons having slightly more evidence inconsistent with it.

While inconsistency is the most important measure in the ACH, it is interesting to note the consistency values shown in the initial evaluation of evidence. The preponderance of the consistent evidence lies with H1 and H3, with clandestine pursuit of nuclear weapons having the most. There is little evidence consistent with H4, while maintaining the status quo has a similar amount of consistent evidence to clandestine

weapons pursuit. These results, especially the unweighted scores, are skewed by the fact there is more evidence listed that would appear to support H1 and H3.

Step 4 – Refine the matrix

Although H1 and H3 are very close to each other and could probably be combined, I feel that they should ultimately remain separate. Some evidence consistent with both hypotheses is more consistent with a clandestine effort, so it is still important to make a distinction between the two.

All of the evidence presented shows some diagnostic ability, so I will keep all of it in the analysis. There is certainly additional evidence that I could include in this analysis, but I do not assess that any of the hypotheses relies heavily on evidence not presented.

Step 5 – Draw tentative conclusions about the relative likelihood of each hypothesis

H4, abandonment of dual use technology and opening up to IAEA inspections, has the most inconsistent evidence and seems the least likely of the four hypotheses presented. H2, Brazil's continued pursuit of the nuclear fuel cycle while not pursuing nuclear weapons, has the least amount of evidence against it and initially appears to be the most likely. The two hypotheses that suggest pursuit of nuclear weapons, while having more inconsistencies than the status quo, merit close examination. One of the challenges of predicting nuclear proliferation is assessing dual use technology and in Brazil's case dual-use abounds. The ambiguity of assessing dual-use technology as an intelligence indicator is magnified when a state may be pursuing a clandestine program.

What is the purpose of Brazil's pursuit of an autonomous nuclear fuel cycle? Is the VLS rocket program designed only to launch spacecraft or will it one day be geared toward using the VLS as a ballistic missile? Because these questions and others like them cannot be definitively answered at this point in time, stating that Brazil is pursuing nuclear weapons does not seem a logical conclusion. The ACH process supports this assertion. As such, the tentative conclusion this study reaches is that Brazil will continue development of its nuclear program and continue to frustrate the IAEA but will refrain from attempting to develop nuclear weapons.

Step 6 – Analyze how sensitive your conclusion is to a few critical pieces of Evidence

The conclusions reached in step 5 do not appear to be sensitive to a few critical pieces of evidence. Just as there is no evidence that absolutely discounts any single hypothesis, there exists no evidence that heavily favors any hypothesis. If anything, the conclusion relies too heavily on a distinct lack of evidence in discounting the assertion Brazil is pursuing nuclear weapons.

Step 7 – Report Conclusions

This study concludes that Brazil will continue to develop its nuclear infrastructure while not actually gearing this infrastructure for nuclear weapons production. Though the Brazilian drive for a complete nuclear fuel cycle and its limitations on inspectors at the Resende enrichment facility are questionable, there exists no clear evidence that Brazil is attempting to develop nuclear weapons or that it will attempt to develop them in the near future. Brazil's nearly completed quest for the entire nuclear fuel cycle is

probably more driven by pride and nationalism than it is for its potential to help produce nuclear weapons. The fuel cycle has a practical side to it, also, as Brazil's heavy reliance on environmentally sensitive hydropower means the state has a legitimate reason to pursue alternate sources of power.

Of the hypotheses presented, Brazil is least likely to renounce all dual use technology like the enrichment facility and its space launch program and open itself to full IAEA scrutiny. The same factors like pride and nationalism figure in the rejection of this hypothesis. Moreover, Brazil's nuclear program is a large part of its military industrial complex; to greatly reduce this capability could harm Brazil's already fragile economy. Brazil has met no international resistance to its actions vis-à-vis the IAEA and therefore faces no real pressure to change its ways. As a sportsmanlike nationalist, Lula sees his country's nuclear capability as a way to gain international standing. The completion of the nuclear fuel cycle, something that a very few countries in the world possess, would add to this standing immensely. There is nothing Brazil gains at this point by softening its nuclear stance and capability.

The evidence that points towards Brazil pursuing nuclear weapons does little to distinguish between the potential for a clandestine or overt program. By definition an overt program would show obvious signs, so the evidence that does exist suggests that Brazil is more likely to pursue a secret program. But even though the non-proliferation regime seems to be weakening and US attention is focused elsewhere, the potential backlash Brazil faces were it to develop nuclear weapons is too great for a country trying to grow its economy and become a global player. The fact that Brazil faces no real strategic threat underscores this point. It goes without saying that with its current nuclear

infrastructure, Brazil could develop nuclear weapons in a relatively short period of time. But absent a true threat to its national security, Brazil has no impetus to possess nuclear weapons now or in the near future.

Step 8 – Identify milestones for future observation that may indicate events are taking a different course

Figures 11 and 12 detail indicators Brazil's nuclear proliferation is taking a different direction than the one detailed by this thesis.

-Continued or worsening obstruction of the IAEA
-New nuclear facility construction
-Activity at closed nuclear test site
-Development of a liquid fuel version of the VLS rocket
-Any test of the VLS as a ballistic missile
-Severe economic downturn / loss of foreign investment
-World economic recession
-Evidence that Brazil is engaging in illegal technology transfer
-Deteriorating relations with Argentina
-Deteriorating relations with Venezuela
-Venezuela's emergence as a true regional power
-Conventional arms race with Venezuela
-Increased nuclear rhetoric by Lula or the Brazilian government
-Large scale social unrest
-Any move away from democracy
-Deterioration in civil/military relationship
-Return to military rule
-Dissatisfied military
-Failure to sign additional protocols to the NPT
-Pullout of any nuclear treaty or organization
-Large increases in funding for nuclear programs
-Increasingly inwardly focused US policy

Figure 11: Indicators Brazil is pursuing nuclear weapons (H1 and H3)

Evidence that Brazil is softening its nuclear stance and will only produce nuclear power (H4) includes:

-Opening of all facilities to the IAEA
-Ratification of additional protocols to the NPT
-Abandonment of attempt at complete nuclear fuel cycle
-Drastic economic improvement
-Improving relations with neighbors, especially Venezuela
-Funding cut for nuclear programs
-Abandonment of missile and / or space program

Figure 12: Indicators Brazil is softening its nuclear stance (H4)

CHAPTER 4

FUTURE NUCLEAR PROLIFERATION IN VENEZUELA?

VENEZUELA SITUATION UPDATE

Venezuela is arguably the most strategically important state in South America. The country has the largest reserves of petroleum in the Western Hemisphere, albeit most of these reserves are of a fairly low and hard to refine grade. Venezuela's geographical location gives it access to both the Caribbean Sea and the interior of South America, placing it astride important trade routes. This aspect of Venezuela's geography is particularly important to Brazil, Venezuela's southern neighbor and potential rival for Latin American dominance.

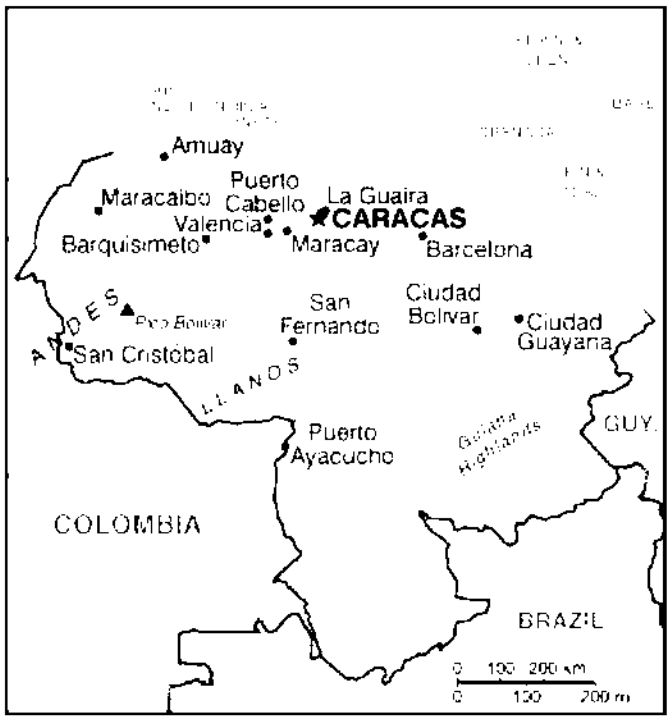

Figure 13: Venezuela

Source: CIA World Factbook Online, 2007

For much of the 20th century Venezuela's military led the state. Venezuela only transitioned to a democratically elected government in 1959. Under both types of rule,

Venezuela's leaders capitalized on its oil wealth and allowed for social reform.[146] Venezuela's current president, Hugo Chavez took office in 1999. Chavez has taken Venezuela in a decidedly different direction than previous Venezuelan leaders in both foreign and domestic policy. Chavez' "Bolivarian Revolution" has brought sweeping changes to Venezuela.

Hugo Chavez and 21st Century Socialism

On the domestic front, Chavez has taken measures to move his country in the direction of socialism. He has encouraged non-private ownership and control, encouraging the creation of cooperatives and exercising increasing state control of important industries.[147] Perhaps the most important state-owned company is Petroleos de Venezuela, S.A. (PDVSA), which runs Venezuela's petroleum industry. Venezuela's vast oil reserves combined with a peak in oil demand and prices has given Chavez almost unlimited capital. Free from worry about alienating private interests, Chavez has invested much of Venezuela's oil revenue into his social programs.[148]

Chavez has also used his country's oil wealth in helping to dictate Venezuela's foreign policy. Chavez' influence in Latin America has expanded greatly because of his PetroCaribe oil subsidy initiative. Oil wealth has also changed Venezuela's views toward the United States. Venezuela long ago supplied the United States with the majority of its petroleum and has generally been on good terms with the US. However, Chavez has

---

[146] *CIA World Factbook: Venezuela*, CIA World Factbook Website, 15 May 2007, URL: < https://www.cia.gov/library/publications/the-world-factbook/geos/ve.html>, accessed 21 May 2007.

[147] Gregory Wilpert, "The Meaning of 21st Century Socialism for Venezuela," Web-only essay, 11 July 2006, URL: <http://www.venezuelanalysis.com/articles.php?artno=1776>, accessed 21 May 2007.

[148] Wilpert, "The Meaning of 21st Century Socialism for Venezuela."

consistently attacked the US, globalization, and free trade agreements, among other things. His anti-US stance and ties with states like Iran and North Korea are cause for concern. But even as Chavez attacks the US, the two states maintain somewhat of a symbiotic relationship. The US still needs Venezuelan oil and Venezuela needs US refining capability to process its heavy crude. Venezuela still exports the largest share of its crude oil to the US.

The Venezuelan National Assembly, an elected body currently composed almost entirely of Chavez supporters, recently granted the Venezuelan leader sweeping powers. On January 30, 2007, Chavez gained the power to make law by decree for 18 months. Almost immediately he declared Venezuela's energy and communications sectors strategic, meaning that they are subject to state control. The Venezuelan government now owns controlling interest in Venezuela's largest communications company and its largest provider of electricity.[149] Other initiatives of note are the increased teaching of socialism in Venezuela's education curriculum, a formalization of the communal structure, and the proposal for the creation of a single political party in Venezuela. One troubling potential reform that Chavez is considering is

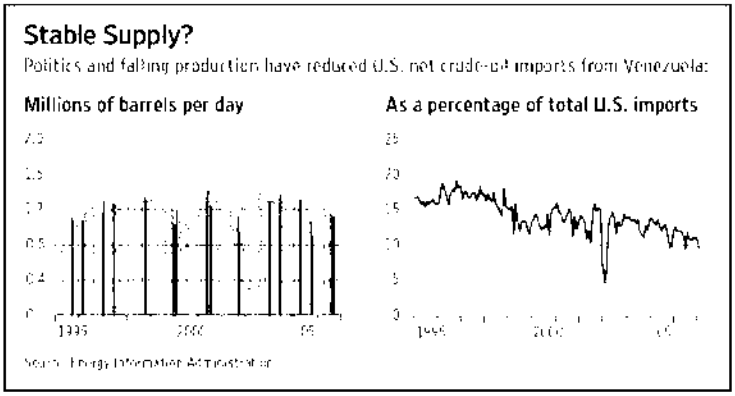

Figure 14. Venezuela Crude Oil Production

Source: Energy Information Administration Website, 2007.

[149] "Venezuelan Politics: Bolivarian Revolution Accelerates," Economist Intelligence Unit ViewsWire, 20 March 2007, Proquest Document ID# 1264439441, accessed via Proquest 21 May 2007.

the removal of the two-term limit for Venezuelan presidents. Into his second term, Chavez may be looking to lead Venezuela for the foreseeable future.[150]

Is Venezuela Creating Its Own Strategic Threat?

The United States imports about 13% of its petroleum from Venezuela. Although this percentage has been slowly dropping (see Figure 9), it still makes Venezuela the third largest supplier of petroleum to the US. Only Canada and Saudi Arabia have a larger share of the US oil market.[151] Venezuela's economy is heavily reliant on petroleum exports, with half of its income and roughly 80% of its export income derived from petroleum.[152] Conventional wisdom has long held that oil exports to the US are so vital to Venezuela's economy that the possibility of the US losing this source of energy is slim. However, recent actions by Venezuela suggest it may be attempting to diversify the foreign stake in its oil market and improving relations with US competitors. Among these relationships the ties it is creating with China stand to give it the most leverage in the future.

By hedging its bets with other energy consumers, Venezuela is attempting to reduce the reliance of its oil-based economy on the US At the same time these actions, combined with Chavez' rhetoric, place Venezuela at increasing odds with the US As Venezuela's reliance on the US purchase of its oil decreases, its power relative to the U.S increases. This is evidenced by the fact Venezuela feels it no longer need to cater to the

---

[150] "Venezuelan Politics: Bolivarian Revolution Accelerates."

[151] "Crude Oil and Total Petroleum Imports Top 15 Countries," Web-only table, 21 May 2007, URL: <http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level_imports/current/import/html>, accessed 21 May 2007.

[152] Andy Webb-Vidal, "US probe into Venezuela's oil supply threat 'absurd'," *Financial Times*, 11 July 2006, Proquest document ID# 1075025451, accessed via Proquest 21 May 2007.

US Chavez made anti-US comments before the UN in late 2006. He declared support of Iran's nuclear energy program, and Venezuela has of course sought closer relations with Iran and North Korea.[153]

Although it is strengthening relationships with many states that are considered anti-US, it is Venezuela's closer ties with China that could provide the most compelling security issues for the US. While Venezuela's relationships with Iran, North Korea, and others are troubling, none represents a true threat to US energy security. On the other hand, China is a rising superpower with voracious energy needs. Theoretically Venezuela could divert oil it currently supplies the US to China, a county willing pay a premium for energy and also a county that is not America. In a very short time China has gone from a producer to a consumer of oil. It accounted for 31% of the world's increase in oil demand in 2004, and is becoming more and more dependent on foreign sources of energy.[154]

In addition to the fact Venezuela's economy relies heavily on US purchase of its oil, most of the foreign capacity to refine Venezuela's heavy crude oil lies in the United States. The eight refineries Citgo operates in the US have more or less guaranteed a steady flow of Venezuelan oil would continue for the US[155] China currently possesses

---

[153] Humberto Mrquez, "Venezuela: Oil Wealth Helps Chavez Stand Up To Washington," *Global Information Network*, 21 February 2006. Proquest Document ID# 991086641, accessed via Proquest 21 May 2007.

[154] David Zweig and Bi Jianhai, "China's Global Hunt For Energy," *Foreign Affairs*, September/October 2005, EbscoHost reference number 17979604, accessed via EbscoHost 21 May 2007.

[155] Mrquez, "Venezuela: Oil Wealth."

limited capacity to process heavy crude[156], but it does have the economic wherewithal to expand its refining capability.

Costs to transport Venezuelan oil to distant destinations like China are much higher than costs to move it to the US. Many argue the importance of Venezuelan oil to the US is overstated, and this argument has some merit.[157] On the other hand, recent studies posit an immediate $11 a barrel, if not more, jump in the price of oil if Venezuela were to completely cut off its supplies to the US.[158] This would likely send the US economy into a tailspin. Even if oil prices did not jump as predicted the US would still be short of oil, assuming it could not makeup for the shortage by importing more from other states. Such a situation would be considered a vital US national security interest and would probably prompt the US to immediate action. But before he can even contemplate reducing or elimination oil supplies to the US, Chavez must find alternate consumers and refining capacity.

Chavez' use of oil profits and his handling of the Venezuelan oil industry may have set Venezuela's economy up for future hardship. In choosing to invest in social programs and not in his country's oil infrastructure, Chavez has overseen a decline in Venezuelan production from 3.3 million barrels in 1997 to 2.4 million barrels today.[159] Today Venezuela is the only member of the Organization of Petroleum Exporting

---

[156] Qin Jize, "Chavez Arrives in Beijing," *China Daily*, 23 August 2006, Proquest document ID# 1103843261, accessed via Proquest 21 May 2007.

[157] Mary Anastasia O'Grady, "Americas: Chavez' Oil Weapon is a Popgun," *Wall Street Journal*, 9 September 2005, Proquest document ID# 893905731, accessed via Proquest 21 May 2007.

[158] Webb-Vidal, "US Probe."

[159] J. Robinson West, "The Production Crunch: Chavez-style oil nationalism is endangering world economic growth," *Newsweek*, 14 May 2007, Proquest document ID# 1266617651, accessed via Proquest 21 May 2007.

Countries (OPEC) not meeting its production quotas. In addition to the lack of investment in infrastructure, Chavez' nationalization of Venezuela's oil industry has reduced the importance of Western energy companies, the same companies that possess the resources and knowledge to increase Venezuela's production. Instead, Venezuela's production is overseen by PDVSA, with increasing involvement of the China National Petroleum Corporation (CNPC). Neither CNPC nor PDVSA have the knowledge or wherewithal to reverse Venezuela's falling production. Chavez needs oil to remain at $60 a barrel or higher to maintain his domestic and foreign initiatives and ostensibly his influence and the viability of Venezuela's economy.[160] Although high gas prices currently dominate the US market, long term forecasts have the price of oil stagnant or falling, which could spell big trouble for Venezuela's economy.[161]

Venezuela: Nuclear Ambitions?

Venezuela possesses some uranium resources, but these resources are not economically viable to recover if the world uranium market is their intended destination.[162] Venezuela could purchase unprocessed uranium for much cheaper than it can mine its own deposits. Aside from this unrecoverable uranium, Venezuela has no real nuclear infrastructure or knowledge base. At first glance it seems an unlikely source of nuclear proliferation. However, the recent actions of Venezuela and Hugo Chavez make nuclear proliferation an interesting avenue for exploration.

---

[160] West, "The Production Crunch".

[161] EIA Annual Energy Outlook 2007, Web-only essay, February 2007, URL: <http://www.eia.doe.gov/oiaf/aeo/index.html>, accessed 21 May 2007.

[162] "Survey of Energy Resources: Uranium," Web-only survey, 21 May 2007, URL: < http://www.worldenergy.org/wec-geis/publications/reports/ser/uranium/uranium.asp>, accessed 21 May 2007.

Venezuela's vehement anti-US stance combined with the amount of oil it supplies the US make it a strategic interest for the US Stopping its flow of oil to the US could prompt US intervention. Venezuela has courted many new allies, but would these allies be willing or even have the ability to help it stand up to the US? In the case of military action by the US against Venezuela, the answer at this point in time is a definitive no. Venezuela's adversarial relationship with the US alone is likely enough to make Chavez at least consider possessing nuclear weapons as a counter to potential US intervention. Other factors such as the potential for Venezuela's economy to struggle, a desire to maintain its influence in Latin America in the face of declining oil revenues, and Chavez' general paranoia regarding the US could have him considering the nuclear option as a method for maintaining power and prestige.

In recent years rouge nations like Iran and North Korea have successfully defied the non-proliferation regime in recent years. Hypothesizing that Hugo Chavez desires nuclear weapons seems a bit of a reach. But this idea is not without basis, as Chavez has made comments that allude to nuclear energy ambitions. Moreover, Venezuela's current course frames it as the closest state in South America to earning the rogue moniker.

In the 1950s General Electric sold Venezuela a small nuclear power reactor. However, after deciding that Venezuela's energy sector didn't need nuclear power, the Venezuelan government shut down and dismantled the reactor. No evidence exists today to suggest that Venezuela needs to supplement its energy production with nuclear power. Even so, in 2005 PDVSA asked Argentina to sell it a medium sized nuclear reactor.[163] Ostensibly this reactor's purpose would be to help Venezuela refine its heavy crude oil,

[163] Andy Webb-Vidal, "US to lobby Argentina on Chavez nuclear move," *Financial Times*, 13 October 2005, Proquest document ID# 910569891, accessed via Proquest 21 May 2001.

but there are cheaper and quicker energy sources available to Venezuela. In October 2005 at the Ibero-American summit in Spain, Chavez expressed interesting in acquiring nuclear technology. His comments suggested that he sought the help of Argentina and Brazil in doing so.[164]

DOES VENEZUELA HAVE A NUCLEAR TIPPING POINT?

As I did for Brazil, I will use the proliferation factors laid out in *The Nuclear Tipping Point* to examine Venezuela. Some of these factors are external to the environments of both countries and manifest in the same way. However, the effect they have on Venezuela is generally different than the effect they had on Brazil. Some are markedly different; whereas Brazil possesses most of its own technology, Venezuela is more apt to capitalize on nuclear technology available through illicit channels should it choose to proliferate. In discussing Venezuela vis-à-vis these factors, I will not restate assertions made in the previous chapter on such subjects as the direction of US foreign policy and the viability of the proliferation regime. I will instead focus only on how these factors pertain to Venezuela.

Factor 1: Direction of US Foreign and Security Policy. Hugo Chavez has been consistently and loudly critical of the US, especially since a coup attempt in 2002 in which Chavez implicated the US The Bush administration has often matched Chavez' rhetoric; occasionally demonizing him and lambasting his "destruction" of Venezuelan

[164] "Countering Chavismo in a cool manner – Venezuela's nuclear plans require a measured response," *Financial Times*, Asia edition, 17 October 2005, Proquest document ID# 03071766, accessed via Proquest 21 May 2007.

democracy. Though the US is currently critical of Venezuela, little has been done in the way of concrete measures against the Chavez government. There are a couple of reasons the US has done little more than engage in a war of words with Chavez. First, America is focused elsewhere and has a vested interest in keeping its affairs in Latin America on an even keel. Second, Chavez and his social programs are so dependent US money that he is seen as pandering to his political base when he rails against the US, not actually trying to provoke it.[165]

Nonetheless, Chavez may perceive US engagements elsewhere and lack of response to Venezuela as a weakness to be exploited. Venezuela may seek to push its limits with the US, especially if the US becomes more inwardly focused as a result of the wars in Iraq and Afghanistan and the upcoming elections in 2008. But there is little doubt nuclear proliferation in Venezuela will merit a harsh US and international response.

Factor 2: A Breakdown of the Global Non-Proliferation Regime. The lessons of Iran and North Korea may show Chavez a weakness in NPT. However the international community in general and the US in particular will not take a hands-off approach if Venezuela decides to pursue nuclear weapons. The U.S has not faced a nuclear threat in the Western Hemisphere since the Cuban Missile Crisis, and the prospect of Hugo Chavez with nuclear weapons is not inviting.

Though the global non-proliferation regime seems weaker overall, it remains strong in Latin America. The Treaty of Tlatelolco and the general non-proliferation

[165] "USA / Venezuela politics: A new strategy?" Economist Intelligence Unit ViewsWire, 29 December 2006, Proquest document ID# 1188684741, accessed via Proquest 22 May 2007.

consensus in the region counter perceived weaknesses in the global regime. Chavez would have to overcome this hurdle if he decides to acquire nuclear weapons. It is plausible Brazil would be given a free pass into the nuclear community if it developed a weapon. Hugo Chavez does not have this luxury.

Factor 3: Eroding Regional or Global Security. Venezuela faces no true threats to its vital national interests. However, it has recently been at odds with neighbor Colombia. Colombia has long accused Venezuela of aiding the Revolutionary Armed Forces of Colombia (FARC), a rebel group involved in a civil war with Colombia's government. In early 2005, bounty hunters kidnapped a suspected Colombian terrorist in Caracas, prompting accusations by Chavez that the Colombian government was behind the kidnapping. Chavez recalled his ambassador to Colombia and cancelled some accords between the two countries.[166] Tensions from this incident have eased in the past two years and although conflict between the two states cannot be ruled out, it seems unlikely at this point, especially with the strong economic ties between the two states. Moreover, Venezuela is not at a strategic disadvantage when compared to Colombia so turning to nuclear weapons in this instance seems far-fetched.

Venezuela is at a strategic disadvantage when measured against the United States, a country Hugo Chavez routinely vilifies and paints as a rival. To this point the US has largely ignored Chavez' rhetoric just as Chavez has not taken any measures that would truly cause the US pause. If in the future the US / Venezuelan relations deteriorate to the

[166] James T. Kiner, "Venezuela / Colombia: Relations Turn Carnal," NACLA report on the Americas, March/April 2005, Proquest document ID# 803084811, accessed via Proquest 22 May 2007.

point conflict is possible, Venezuela could look to shore up its relative disadvantage with nuclear weapons.

Factor 4: Domestic Imperatives. Chavez has used oil wealth to win support both among his electorate with social programs and within his region with oil subsidies. A number of events could change Venezuela's economic fortunes. Among them: oil prices could stagnate or fall or Venezuela's production could continue to drop. Without a certain level of oil revenue, Chavez will not be able to continue funneling money into social programs for his population nor will he be able to continue the PetroCaribe subsidy program. With his and Venezuela's fortunes so tied to oil, Chavez stands to lose much if Venezuela's oil money slows. The potential loss of his political support at home and his influence in the region could cause Chavez to seek nuclear weapons, although an economic downturn makes the pursuit of a homegrown weapons program unlikely. Chavez could justify pursuit of nuclear weapons to his country by stoking fears of US aggression and portraying a nuclear capability as the only way to deter same.

Factor 5: Increasing Availability of Technology. If Venezuela chooses nuclear proliferation, an attractive option available is the purchase of technology and expertise it would otherwise have to invest in domestically. Lower oil prices or other economic hardship could cause Chavez to consider nuclear weapons in the first place; the same factors may lead him to the nuclear black market. As Venezuela has no current nuclear capability, technology transfer would be important to any type of nuclear proliferation on the part of the state. If Venezuela chooses to one day pursue an autonomous nuclear

capability or even just a weapon, the availability of nuclear technology and knowledge presents an enticing means to this end.

HUGO CHAVEZ: NATIONAL IDENTITY CONCEPTION

Within Jacques Hyman's NIC framework, Hugo Chavez is a nationalist, convinced that Venezuela should hold equal status with like states and even with countries like the United States. But unlike Lula de Silva, Hugo Chavez also presents as an oppositional in Hyman's solidarity dimension, at least where the US is concerned. He frames Venezuela's relationship with the US with an "us against them" mentality. Hyman's NICs are created by what he terms the "recall of emotional memories."[167] Hugo Chavez' NIC relative to the US is influenced by many factors. Among them could be his belief the US was behind the 2002 coup attempt against him, a fear that the US will intervene directly in Venezuela's affairs—perhaps via a proxy war with Colombia-- and even shame that Venezuela's economy and his Bolivarian Revolution are so dependent on oil money from the US

No matter what exactly formed Hugo Chavez' NIC, he falls into the category of oppositional nationalist, the NIC type most likely to covet nuclear weapons. In Hymans' view, a mixture of fear and pride drive the oppositional nationalist to consider nuclear weapons. Oppositional nationalists reject or accept the non-proliferation regime as it suits their needs. At the current time, Venezuela is party to the NPT and accepts the non-proliferation regime because it has no reason not to. This stance would change is Venezuela decides to acquire nuclear weapons. Oppositional nationalists will, at the

[167] Hymans, 26.

same time, demand and resent superpower assistance. However, their ultimate goal is to exist without such assistance, ostensibly in possession of a nuclear capability.[168] Venezuela's burgeoning relationship with China has the potential to take on these characteristics. If Venezuela decides that it needs nuclear weapons, it may look to China for protection as it attempts to acquire them.

Hymans' characterization of an oppositional nationalist and the desire of that NIC type to acquire nuclear weapons are, of course, conditional. Oppositional nationalist leaders who are not pursuing nuclear weapons do exist, and Hymans has to explain why. First, the leader's state has to be engaged in reasonably intense interactions with a rival. Though Chavez probably considers his interactions with the US intense, lack of an overt US threat to Venezuela's national security makes this condition questionable. Next, Hymans says the oppositional nationalist must have a degree of control over the state apparatus.[169] Chavez and his party already have a large measure of control over all of Venezuela, and this control will most likely increase markedly in the near future. Chavez has already nationalized key industry and infrastructure. He is attempting to consolidate Venezuela's legislative apparatus under one party. In the coming year, Chavez has the ability to make law in key areas by decree. With this power he could move toward tighter control of Venezuela's affairs and also extend his time in office indefinitely.

Hymans' final condition on the nuclear aims of an oppositional nationalist is the most telling where Venezuela is concerned. He states that the leader's country must have

---

[168] Hymans, 38.

[169] Hymans, 36.

some experience in the nuclear field.[170] Venezuela has almost none, save for the long ago abandoned power reactor it possessed. There is no nuclear infrastructure to speak of in Venezuela, and perhaps more importantly there is no nuclear knowledge base. Starting a nuclear program from the ground up requires a huge expenditure of capital. Chavez has access to large amounts of oil money, but diverting money to fund a nuclear program would hurt his social initiatives and oil subsidy program.

While he makes a coherent argument with this last point, I think that Hymans should have explored it further. A leader that wants to acquire nuclear weapons has to start somewhere even if his state doesn't possess the current means to do so. Hymans also fails to explore the potential for the transfer of important technology, knowledge, and even nuclear weapons themselves. Nuclear proliferation by technology transfer comes at a much lower cost than designing a program from the bottom up.

VENEZUELA: ANALYSIS OF COMPETING HYPOTHESES

Step 1 – Identify the possible hypotheses to be considered

As discussed in Chapter 1, there are four hypotheses that this analysis will consider for Venezuela.

---

[170] Hymans, 36.

1) H1: Venezuela will pursue an indigenous nuclear weapons program;

2) H2: Venezuela will develop a nuclear power capability;

3) H3: Venezuela will not pursue any type of nuclear capability (status quo);

4) H4: Venezuela will attempt to acquire nuclear technology, knowledge, or weapons through technology transfer.

Step 2 – Make a list of significant evidence and arguments for and against each hypothesis

Figure 15 details the evidence considered in this analysis.

-Venezuela seeking nuclear knowledge from Brazil and Argentina
-Chavez' comments on nuclear power
-Venezuela's ties with Iran and North Korea
-Chavez' increasing control over Venezuela
-Lack of an imminent threat to Venezuela's vital interests
-The strong Latin American non-proliferation regime
-No current nuclear infrastructure or knowledge
-Chavez fits the typology of an oppositional nationalist
-Venezuela faces uncertainty and potential loss in regional power as oil production continues to decline
-Long term oil price forecast is stagnant / declining
-Venezuela is signatory to the NPT and Treaty of Tlateloco
-Venezuela is at a strategic disadvantage to the US
-Faces harsh US and global reaction it decides to proliferate
-Venezuela has no delivery system for a nuclear weapon
-At present, the US is focused elsewhere
-The non-proliferation regime appears to be weakening
-Venezuela's actions point at a desire for more power in the region

Figure 15: Evidence considered in Venezuela ACH analysis

Step 3: Prepare a matrix with the hypotheses and evidence in to analyze "diagnosticity" of the evidence

I prepared the ACH matrix for Venezuela using the same methodology I did in preparing the matrix for Brazil.

Evidence #	Evidence	Evidence Type	Credibility	Relevance	H1 - Weapons	H2 - Nuclear Power	H3 - Status Quo	H4 - Tech. Transfer
E1	Seeks nuclear power knowledge from Brazil		high	high	c	cc	i	c
E2	Chavez comments on nuclear power		high	med	c	cc	i	c
E3	Lack of nuclear knowledge / facilities		high	med	i	i	c	c
E4	Ties with Iran and North Korea		high	med	c	n	n	c
E5	Chavez' increasing control over Venezuela		high	med	c	c	n	n
E6	Lack of imminent threat		high	high	ii	na	na	i
E7	Strong Latin American non-prolif. regime		high	high	i	ii	c	ii
E8	Desire to maintain / gain regional power		med	med	c	c	i	cc
E9	Declining oil production / loss of reg. power		med	high	c	c	n	n
E10	Long term oil forecast stagnant		low	med	c	na	c	n
E11	Signatory to NPT and Tlatelolco		high	med	ii	i	c	ii
E12	Strategic disadvantage to percieved threat (US)		med	med	c	na	i	c
E13	Fsces hsrsh reaction if decides to prolif.		med	med	i	i	cc	i
E14	Chavez as an oppositional nationalist		med	med	cc	c	i	c
E15	No delivery system for a nuclear weapon		high	low	i	na	na	n
E16	U.S. focused elsewhere		med	low	c	c	n	c
E17	Weakining non-proliferation regime		med	med	c	c	na	c
E19	High startup costs for any nuclear program		high	high	i	i	c	c
E19	Venezuela has no ballistic missiles / program		high	high	i	na	c	ii
				Weighted Inconsistency Score =	**-16.239**	**-9.826**	**-6.413**	**-13.825**
				Unweighted Inconsistency Score =	**-10**	**-6**	**-5**	**-8**
				Overall Weighted **Consistency** Score =	**-2.169**	**3.536**	**5.120**	**0.123**

Figure 16: ACH Chart for Venezuela

An initial look at the results of the ACH show that H3, or maintenance of the status quo, is the hypothesis with the least amount of raw and weighted inconsistent evidence. An interesting aspect of the initial analysis is that the nuclear power hypothesis and the technology transfer hypothesis have the same amount of inconsistency based on the evidence presented. Again, outside of the scope of this analysis there could be much more evidence presented that could alter the results. But even this basic examination seems to suggest that Chavez and Venezuela at least have some propensity towards

nuclear development, be it nuclear power or the acquisition of nuclear technology through illicit means. The strongest inconsistencies occur with the hypothesis that Chavez will try to develop his own nuclear power program. The huge start-up costs and likely international reaction to an overt nuclear move by Venezuela make this idea seem unfeasible.

Step 4 – Refine the matrix

When examined using the available evidence, each hypothesis remains distinct. The nuclear weapon and nuclear power hypotheses exhibit equivalent consistent evidence scores. With the potential for the dual use of nuclear infrastructure for weapons production, this assessment makes sense.

All of the evidence presented shows some diagnostic ability, so I will keep all of it in the analysis. The US focus on the Middle East and the weakening non-proliferation regime show the least diagnostic ability, but since both are not inconsistent with any hypothesis I will leave them in the matrix. Again, although there is additional evidence that could influence this analysis, I do not assess than any of the hypotheses relies heavily on evidence not presented.

Step 5 – Draw tentative conclusions about the relative likelihood of each hypothesis

H1, the hypothesis that Venezuela will develop a nuclear weapons program, has the most evidence inconsistent with it and seems the least likely of the four hypotheses presented. H3, maintenance of the status quo with Venezuela not pursuing any nuclear goals, has the least amount of evidence against it and initially appears to be the most

likely. One of the challenges of predicting nuclear proliferation is assessing dual use technology and in Venezuela's case this assertion is highlighted by how the ACH gives almost equal scores to the chance that Venezuela will develop a nuclear power program and the chance it will pursue nuclear aims by technology transfer. It seems simplistic to fall back on the status quo, but in this case it is a reasonable conclusion. One significant question this analysis cannot definitively answer is how Hugo Chavez truly assesses the US threat to both himself and Venezuela. If Chavez is playing up the US threat for the consumption of his electorate and the region, then favoring the status quo makes sense. If he truly believes that the US will at some point directly intervene in Venezuela's affairs for whatever purpose, then the analysis would have to favor pursuit of a nuclear answer to that threat given Chavez' NIC typology. The relatively close results of the ACH do not steer me in either direction, but I lack any concrete evidence Venezuela is doing more than talking about nuclear capability. As such, the tentative conclusion this study reaches is that Venezuela will not pursue a nuclear capability in the near future.

Step 6 – Analyze how sensitive your conclusion is to a few critical pieces of evidence

The conclusions reached in step 5 do not appear to be sensitive to a few critical pieces of evidence. In examining my personal views on the subject, however, I feel that I may rely too heavily on Hugo Chavez himself in assessing Venezuela. With his increasing control over the country, this viewpoint may not be far off. In any case, I have attempted to present a diverse range of evidence in assessing Venezuela's nuclear potential. There is no evidence that absolutely discounts any single hypothesis and there exists no evidence that heavily favors any hypothesis.

Step 7 – Report Conclusions

This study concludes that given its current situation, Venezuela will not pursue any type of nuclear capability. Hugo Chavez paints the American threat to Venezuela as genuine, and he may well believe this is true. Based on his NIC, Chavez seems to be more predisposed than not to desiring nuclear weapons. These assertions aside, though, the costs of any nuclear aims are too high for Hugo Chavez and Venezuela. A weapons development program would cost Venezuela's economy a large amount of capital and would also effectively hamstring Chavez' domestic and regional initiatives. The potential US and international reaction to a nuclear attempt by Venezuela incur a great political cost. From military intervention to economic isolation, Chavez may not be willing to risk the loss of his presidency over nuclear security.

Of the hypotheses presented, Venezuela is least likely to begin an overt weapons program. The aforementioned political and economic costs are too much to overcome. If Hugo Chavez does choose to pursue nuclear weapons, he will do so behind either the veil of a nuclear power program or the secrecy of clandestine weapon procurement. Technology transfer of a nuclear weapon seems unlikely as Venezuela possesses no ballistic missiles, among other factors. Thus another conclusion of this study is that if Venezuela decides to pursue nuclear weapons, it will do so by developing a dual-use nuclear power program. Following the model of other states that have followed this course, this program would develop slowly and tentatively as capital and / or technology comes available.

Step 8 – Identify milestones for future observation that may indicate events are taking a different course

Figures 17 and 18 detail indicators Venezuela's nuclear proliferation is taking a different direction than the one detailed by this thesis.

-Any obstruction of the IAEA
-Any nuclear facility construction
-Attempt to develop ballistic missiles or acquire missile technology
-Sharp decrease in oil prices
-Severe economic downturn / loss of foreign investment
-World economic recession
-Evidence that Venezuela is engaging in illegal technology transfer
-Deteriorating relations / armed conflict with Colombia
-Deteriorating relations with Brazil
-Venezuela's emergence as a true regional power
-Conventional arms race with Brazil or Colombia
-Increased nuclear rhetoric by Chavez or the Venezuelan government
-Large scale social unrest
-Abolishment of Venezuelan term limits by Chavez
-Loss of funding for social programs or Petrocaribe program without downturn in economy or falling oil prices.
-Pullout of any nuclear treaty or organization
-Increasingly inwardly focused US policy

Figure 17: Indicators Venezuela is pursuing nuclear weapons (H1 and H4)

-Any nuclear facility construction
-Continued degradation of Venezuela's oil infrastructure
-Any energy crisis in Venezuela
-Evidence Venezuela is attempting to acquire nuclear knowledge or technology on the open market (contracts with nuclear power nations)
-Establishment of a nuclear energy commission
-Establishment of a comprehensive nuclear studies program at the university level

Figure 18: Indicators Venezuela is pursuing nuclear power (H2)

CHAPTER 5

CONCLUSION: COUNTERING NUCLEAR PROLIFERATION IN LATIN AMERICA

COUNTERING NUCLEAR PROLIFERATION: NO EASY TASK

The history of nuclear non-proliferation shows at least five distinct attempts at discouraging proliferation since the nuclear age dawned in 1945.[171] Each attempt was designed for a different strategic threat and thus approached the question of proliferation differently. A short examination of each shows the success and failure of non-proliferation efforts and provides clues about how best to handle proliferation in the future.

The Baruch Plan

In 1946 American negotiator Bernard Baruch put forth a plan before the UN that advocated disarmament and international control of all dangerous nuclear activities. This plan was a result of the strategic assessment that there was no true deterrence for nuclear proliferation. It was designed to be a complete non-proliferation effort, though it contained no provision to disarm the US nuclear capability. The Soviet Union rejected this idea offhand. Although it had some good ideas about distinguishing between safe

[171] Henry D. Sokolski, *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation* (Westport, CT: Praeger Publishers, 2001): 2.

and unacceptable nuclear practices, the plan's emphasis on the strategic value of nuclear weapons doomed it to failure.[172]

Atoms for Peace

As Soviet nuclear capability increased, President Dwight Eisenhower and his military planners came to fear a decisive blow against America's industrial base. They calculated the amount of nuclear weapons it would take to accomplish this decisive blow and then set about to prevent any one nation from acquiring that much nuclear material. Known as the Atoms for Peace program, member nations were supposed to contribute weapons grade material and be monitored by a central organization known as the International Atomic Energy Agency. The Atoms for Peace program, though well intentioned, was a complete failure. It was based on the faulty strategic threat assessment that only a large amount of nuclear weapons would threaten the US. As we now know, small quantities of nuclear material and even a single nuclear weapon present a strategic threat to the US. Additionally, the Atoms for Peace program provided very loose controls for sharing civilian nuclear technology which could be put to dual use as parts of a weapons program.[173]

The Non-Proliferation Treaty

The NPT was based on the premise that a superpower nuclear arms race promoted international instability. In such a system, it was theorized smaller states would look to

---

[172] Sokolski, 2-3.

[173] Sokolski, 3-4.

acquire nuclear weapons as a safeguard. The NPT was designed to prevent this type of proliferation. It encouraged non-nuclear states to eschew their right to possess nuclear weapons in exchange for disarmament by the nuclear powers. In addition, it contained provisions for again transferring civilian nuclear technology as a means of allowing non-proliferating states to develop nuclear power programs. Though it is still in effect today, the NPT has its limitations. States that have signed it as non-proliferators are resistant to submit to IAEA inspections. Moreover, the NPT contains wording that allows countries to break out of the treaty if they feel threatened.[174]

Technology Control

The fear that a regional war involving ballistic missiles and nuclear weapons would draw in the superpowers and create a global conflict led to the establishment of various organizations designed to limit the technology available to potential proliferators. These organizations include the Nuclear Suppliers Group (NSG), the previously discussed MTCR, and the Australia Group (AG), which is designed to prevent the spread of chemical and biological weapons.[175] Although limiting the transfer of technology seems to be a reasonable measure the effectiveness of the aforementioned groups is questionable, especially since the collapse of the Soviet Union. Joining these regimes gives members access to technology and also safeguards members from many proliferation penalties, both of which serve to make them hard to enforce.[176]

---

[174] Sokolski, 4-5.

[175] Sokolski, 6.

[176] Sokolski, 6.

Counterproliferation

Counterproliferation efforts assume that proliferation is not preventable. It focuses on developing strategy and means to neutralize or minimize potential threats to the US[177] Counterproliferation options include preemptive strikes against states deemed threatening and the development of defensive measures and capabilities. Problems with this approach include the difficulty of developing technology that would defend against weapons of mass destruction and the tacit admission that the US is giving up on non-proliferation efforts[178], the latter of which can further weaken the NPT.

Non-proliferation in the Future?

The NPT, technology control regimes, and counterproliferation are, to varying degrees, still active in attempting to encourage nuclear non-proliferation. Unfortunately, they all are based on specific military assessments and tend to apply a "one size fits all" approach to non-proliferation. In his work *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation*, Henry Sokloski advocates less emphasis on viewing nuclear proliferation through the lens of military strategy and more emphasis on understanding emerging social, economic, and political trends.[179] His holistic approach to non-proliferation may prove to have merit over the long haul, but its importance lies in the basic understanding that the causes of proliferation or even potential proliferation are not common to every state. This is certainly true in the case of Venezuela and Brazil and

---

[177] Sokolski, 7.

[178] Sokolski, 7.

[179] Sokolski, 10-11.

is an idea I have tried to put forward in this study. Latin American states do not seem prone to proliferation based on the traditional viewpoint of proliferation because of military necessity. Most if not all Latin American states lack a true threat to their national interests that would need to be countered with nuclear weapons. This study concludes that Venezuela and Brazil will not pursue nuclear weapons in the foreseeable future, and this assessment is not solely based on military necessity. It includes other factors such as economic health, democratic trends within the respective governments, and even a glimpse into the personality and motivations of Hugo Chavez and Lula de Silva. The lesson for intelligence professionals is that indicators of proliferation are not always militarily based and are likely to be different for each state. For policy makers, dealing with nuclear proliferation requires an approach tailored to specific states or situations.

COUNTERING PROLIFERATION IN LATIN AMERICA: U.S OPTIONS

Since this study concludes there is no true threat of nuclear proliferation in Latin America at this time, US policy should be geared to maintain Latin America's nuclear free status. Though global nuclear proliferation has been slow over the years, it will continue to occur. Both state and non-state actors are likely to pursue nuclear weapons in the future, and many will threaten the US by the mere act of possessing nuclear weapons. The US faces many current strategic threats, and it certainly has a vested interest in keeping nuclear weapons out of the Western Hemisphere. The following policy options are based on that goal.

Promoting Democracy

Though Henry Sokolski's approach to countering proliferation seems to be more comprehensive than past efforts, it engenders more of a wait and see approach. Facing nuclear proliferation in Latin America, the US is not likely to sit back and hope that encouraging democracy will solve the issue. However given the current lack of a credible proliferation threat by Venezuela, Brazil, and other Latin American states, the US should encourage democratic movements and economic freedoms as methods to counter future threats in the region. Many of the indicators this study put forth for Venezuela and Brazil are politically and economically based, and the US should monitor those indicators to help assess the health of non-proliferation in the region. In general, a better understanding of what drives states to proliferate is the first step in understanding how to best control proliferation.[180] Brazil's government is doing well in this area, but Hugo Chavez and Venezuela present a different problem. His well documented moves away from democracy and consolidation of power are cause for concern and an issue that should be addressed by the US, especially in light of democratic moves in Brazil and Argentina that resulted in each eschewing nuclear weapons.

A More Flexible Non-proliferation Regime

With the relative ease of technology transfer in today's global economy, the past emphasis on technology control for non-proliferation is not likely to be as successful as it once was.[181] In Latin American states like Brazil and Argentina, much of the requisite technology for nuclear weapons is already in place; tighter controls for these two states is

[180] Hymans, 219.

[181] Hymans, 220.

not likely to avert proliferation. Technology control may have more success in Venezuela which does not currently possess any nuclear infrastructure. However, a state convinced of a need for nuclear weapons is not likely to be dissuaded by tighter controls on technology even if this presents its largest hurdle to overcome.

The non-proliferation regime needs to take a more open, receptive tack when dealing with modern proliferation. States should be allowed to create bilateral or regional non-proliferation agreements that will be accepted by the international non-proliferation regime as legitimate or they should be allowed to join the regime at varying degrees of participation.[182] In fact, Latin America should be promoted as a model of this type of non-proliferation. The bilateral non-proliferation agreement between Brazil and Argentina and the regional Treaty of Tlatelolco put Latin America at the forefront of such non-proliferation initiatives. Moreover, highlighting Latin America as an example of successful non-proliferation may help to discourage future proliferation in the region.

Military Intervention

Using military action to force regime change in a state attempting to develop nuclear weapons remains a viable option for the US, even in the wake of the current conflict in Iraq. Given the issues regarding the reasons for pursuing the current war in Iraq, history may yet show that the first Gulf war and its aftermath were the events that ultimately prevented nuclear proliferation in Iraq.[183] At the very least, the US has served notice to potential proliferators that it will not hesitate to act when it perceives nuclear proliferation as a threat to its vital interests. Another side of this argument holds that an

[182] Hymans, 221.

[183] Hymans, 223.

aggressive and pre-emptive US actually encourages more proliferation among states looking to deter such an action.

In either case, in the wake of Iraq it is likely the US will be more cautious next time it decides to intervene with military force to stop nuclear proliferation. The US will require more concrete evidence of proliferation and intentions, as well as ensuring that international opinion is in its favor. With regards to this study, the US is much more likely to consider military intervention against a vehemently anti-US Hugo Chavez than it is against Brazil. How the current nuclear crises with Iran and North Korea play out will be telling in terms of future US policy in this area.

A Focus on Leadership

I have used Jacques Hymans' ideas concerning national identity conception extensively in this work, and I would be remiss if I did not address the role of the national leader in US efforts to prevent proliferation. A recognition of the NIC of a leader may well be key to shaping non-proliferation policy towards a particular state. Lula da Silva is a sportsmanlike nationalist; according to Hymans the US should support his agenda while at the same time understanding the nature of his nuclear ambitions.[184]

Hymans' true concern is the oppositional nationalist, personified in Latin America by Hugo Chavez. He presents a couple of solutions to the problem oppositional nationalists present to the non-proliferation regime. One is to keep them out of power in the first place. Hymans proposes educating domestic and international leaders on the nuclear propensity that oppositional nationalists exhibit. Theoretically, the US should deny support for oppositional nationalists running for national office. Another solution to

[184] Hymans, 226.

handling an oppositional nationalist leader is to ensure that nuclear safeguards are built in to the decision-making process of a state such that no one person can make crucial nuclear decisions.[185]

Unfortunately for the US and the non-proliferation regime, Hugo Chavez is already a national leader and is consolidating his control over Venezuela. If Chavez does decide to go nuclear, either militarily or commercially, he is unlikely to build safeguards into his program. Instead he will retain sole control over his country's nuclear decisions. Hymans offers no guidance on dealing with the oppositional nationalist already in power and without safeguards. The US and global non-proliferation regime are left with the other options recommended by this work or others not mentioned when dealing with Hugo Chavez if he decides Venezuela needs nuclear weapons.

CONCLUSION

Overview

In this work, my research question involves the potential for future nuclear proliferation in Latin America. Rather than try to assess every state in Latin America, I chose two states that have the potential to pursue nuclear weapons, albeit for different reasons. Brazil is a state with a large nuclear infrastructure and one that is currently attempting to achieve an autonomous nuclear fuel cycle. As such, I judged it the state in Latin America most likely to proliferate. Venezuela is a state with no nuclear capability. However, Hugo Chavez in possession of nuclear weapons would represent a true threat to

---

[185] Hymans, 226.

national security. I judged nuclear proliferation in Venezuela to be the most dangerous course of Latin American proliferation for the US.

I then examined each state from a variety of angles. I used the framework set forth in *The Nuclear Tipping Point* to assess each state's current situation. I used Hymans idea of national identity conception to assess the current leaders of each state and their propensity to proliferate. Finally, I compiled this evidence along with other applicable evidence gleaned from open source intelligence to conduct an analysis of the proliferation potential for each state. I did this by using the analysis of competing hypotheses method. I chose not to do a statistical examination of the numbers the ACH produced and indeed chose to downplay numerical results. Although the numbers produced by each ACH support my findings, ACH was more valuable to me and to this study in that it provided a methodical way in which to organize and analyze my evidence.

Findings and Implications for Theory and Policy

This hypothesis I put forth in the beginning of this study stated that neither Brazil nor Venezuela would pursue nuclear weapons in the foreseeable future but each had the potential for proliferation. My findings support my hypothesis, but I want to emphasize my assertion that for each state the potential for proliferation, however small, does exist. As an intelligence document, a main goal of this study was to present evidence and indicators for each state. If either makes a future move to acquire nuclear weapons, it is important that we understand the indicators as well as the motivation for such an action.

Brazil, as a nuclear weapon capable state, has no real internal or external forces driving it towards nuclear weapons. Moreover, Lula da Silva does not fit the profile of a leader that desires nuclear weapons for his country. For Brazil, while the means for nuclear weapons are present, the motivation is not.

Venezuela, on the other hand, possesses motivation but not means. Hugo Chavez is the type of leader that does want his country to possess nuclear weapons, and he is motivated by the real or perceived threat the US presents him. Based on a variety of current or potential factors, Venezuela could easily find itself in a situation where nuclear weapons are plausible or even desirable, although it lacks the apparent means to attain them.

Based on my findings, I advocate an approach to dealing with proliferation in Latin America that is both measured and grounded in realism. The use of a single policy for dealing with proliferation in the region of globally is unfeasible. The current situation and future developments in Brazil, Venezuela, and the rest of the region should be monitored closely and US policy tailored to each developing situation. The US is the biggest player in any non-proliferation efforts in Latin America, but needs to understand its role and also understand what can be reasonably accomplished as each issue presents itself. The policy options presented here are not new options, but by and large they are not in line with the prevailing views on non-proliferation, which tend to call for things like tighter controls on technology and complete disarmament by nuclear weapons states. With a non-proliferation failure in North Korea behind us and another potential one looming in Iran, clearly new approaches to the subject warrant exploration. In a region that is both vitally important to the US and one that is progressive in its thinking on

nuclear proliferation, the nonproliferation measures suggested in this work may well prove to be the right answer in Latin America.

This work was not intended to make great advances in the arena of non-proliferation theory. Its main purpose was to fill what I perceived as an information gap in intelligence thinking and literature. Much has been written on the nuclear pasts and disarmament of Brazil and Argentina, but very little on their nuclear futures. Venezuela, although it has made some nuclear overtures, remains unaddressed in the literature as a proliferation problem. By providing a framework for assessing the nuclear intentions of Venezuela and Brazil and also by highlighting indicators of potential proliferation, I hope this study will advance the knowledge on a relatively unknown subject while also providing a basis for though and dialogue should proliferation rear its head in Latin America.

Recommendation for Future Research

As with any document that makes an assessment of potential events, I recommend that this work be updated as new evidence presents itself. Changing leaders and changing governments, declining economies and new security threats are but a few of the myriad events that could change the nuclear direction of Brazil or Venezuela. As things change, the results of this work should be updated. This study can also serve as an analog for the examination of other states in the region with proliferation potential. Chief among these states at this point in time is Argentina with its nuclear power program and past nuclear weapon pursuit.

Without relying too much on Hymans', I think the evidence he presents in support of his NIC idea is solid and his overall hypothesis has merit. To that end, a complete, statistical assessment of the NIC of each current and future Latin American leader is warranted. This assessment would be much more in depth than the cursory glance I have given Hymans in this work. A Latin American state with an oppositional nationalist leader could then be more closely examined for nuclear potential, perhaps using the methodology of this study. Although leaders and governments come and go, a string of like-minded individuals in power can steer a country toward nuclear development.

Finally, a comprehensive study of future non-proliferation trends needs to be undertaken. There is a plethora of literature that addresses the factors and details of non-proliferation now and in the near future. My study has mentioned many of these works. As events unfold and these ideas are tested or ignored, their validity needs to be continually assessed in order to better strengthen the global non-proliferation regime and prevent nuclear weapons from falling into the wrong hands.

GLOSSARY

ABM	Anti-Ballistic Missile Treaty
ABACC	Brazil-Argentine Agency for the Accounting and Control of Nuclear Materials
ACH	Analysis of Competing Hypotheses
AEB	Brazilian Space Agency
AG	Australia Group
ARN	Nuclear Regulatory Authority, Argentina
BWR	Boiling Water Reactor
CANDU	Canada Deuterium Uranium
CAREM	Central Argentina Modular Reactor
CNEA	Atomic Energy Commission, Argentina
CNEN	Nuclear Energy Commission, Brazil
CNPC	China National Petroleum Corporation
COPESP	Brazilian Navy's Special Projects Commission
FARC	Revolutionary Armed Forces of Colombia
GCR	Gas Cooled Reactor
GDP	Gross Domestic Product
HEU	Highly Enriched Uranium
IPEN	Institute of Energy and Nuclear Research, Brazil
IAEA	International Atomic Energy Association

INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INVAP	Applied Research, State Enterprise, Argentina
IRIS	International Reactor Innovative and Secure
MCTR	Missile Control Technology Regime
MTSWU	Metric Tons of Separative Work units of Uranium
MW	Megawatts
NIC	National Identity Conception
NPT	Non-Proliferation Treaty
NRC	Nuclear Regulator Commission, United States
NSG	Nuclear Suppliers Group
NWFZ	Nuclear Weapons Free Zone
OPEC	Organization of Petroleum Exporting Countries
PDVSA	Petroleos de Venezuela, S.A.
PHWR	Pressurized Heavy Water Reactor
PWR	Pressurized Water Reactor
PT	Worker's Party, Brazil
PU_{239}	Plutonium 239
VLS	Veiculo Lancador de Satelites
U_{235}	Uranium 235
U_{238}	Uranium 238
UF_6	Uranium Hexaflouride
UO_2	Uranium Dioxide
WMD	Weapons of Mass Destruction

BIBLIOGRAPHY

"ABM Treaty Fact Sheet." Statement by the White House Press Secretary, 13 December 2001. URL: < http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html>. Accessed 12 April 2007.

"Alacran." Web-only essay, 17 April 2007. URL: <http://www.missilethreat.com/missilesoftheworld/id.2/missile_detail.asp>. Accessed 17 April 2007.

"Argentina Profile: Missile Review." Web-only essay, October 2006. URL: < http://www.nti.org/e_research/ profiles/Argentina/Missile/index.html>. Accessed 17 April 2007.

Bacevich, Andrew J. "Twilight of the Republic?" *Commonweal*, 1 December 2006. Proquest document ID# 1174704891. Accessed via Proquest 16 May 2007.

"Brazil Accelerates Nuclear Reactor Work For Nuclear Submarine Program." *Arms Control Today*, July 2004. Proquest document ID# 660598721. Accessed on Proquest 14 May 2007.

"Brazil Economy: Land of Promise." Economist Intelligence Unit wire feed, 13 April 2007. Proquest Document ID# 1265109521. Accessed via Proquest 16 May 2007.

"Brazil: Enrichment Plant, Resende." Web-only database, 6 May 2006. URL: <http://www.wise-uranium.org/eproj.html#BR >. Accessed 11 March 2007.

"Brazilian-Argentine Agency For Accounting And Control Of Nuclear Materials (ABACC). Web-only essay, 8 June 2007. URL: <http://cns.miis.edu/pubs/inven/pdfs/abacc.pdf>. Accessed 8 June 2007.

"Brazil's Nuclear History." *Arms Control Today*, October 2005. Proquest document ID# 924378651. Accessed via Proquest 14 May 2007.

Carasales, Julio C. "The Argentine-Brazilian Nuclear Rapprochement." *The Non-Proliferation Review*, Spring/Summer 1995. URL: <http://cns.miis.edu/pubs/npr/vol02/23/carasa23.pdf>. Accessed 17 April 2007.

CIA World Factbook: Brazil. CIA World Factbook, 10 May 2007. URL: <http:// https://www.cia.gov/library/publications/ the-world-factbook/geos/br.html>. Accessed 14 May 2007.

CIA World Factbook: Venezuela. CIA World Factbook, 15 May 2007. URL: < https://www.cia.gov/library/publications/the-world-factbook/geos/ve.html>. Accessed 21 May 2007.

"Conversion: Yellowcake to Uranium Hexafluoride." Web-only essay, 2007. URL: <http://www.nei.org/index.asp?catnum=3&catid=181>. Accessed 22 April 2007.

"Countering Chavismo in a cool manner – Venezuela's nuclear plans require a measured response." *Financial Times*, Asia edition, 17 October 2005. Proquest document ID# 03071766. Accessed via Proquest 21 May 2007.

"Crude Oil and Total Petroleum Imports Top 15 Countries." Web-only table, 21 May 2007. URL: <http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/ company_level_imports/current/import/html>. Accessed 21 May 2007.

"EIA Annual Energy Outlook 2007." Web-only essay, February 2007. URL: <http://www.eia.doe.gov/oiaf/aeo/index.html>. Accessed 21 May 2007.

Eisenhower, Dwight D. Speech given to the United Nations, 8 December 1953. URL: < http://www.eisenhower.archives.gov/atoms.htm>. Accessed 4 March 2007.

"Energy Information Association Brazil County Analysis Brief." Web-only brief, 2005. URL: < http://www.eia.doe.gov/emeu/cabs/Brazil/ Electricity.html>. Accessed 19 March 2007.

"Energy Information Association Mexico County Analysis Brief." Web-only brief, 2005. URL: < http://www.eia.doe.gov/emeu/cabs/Mexico/ Electricity.html>. Accessed 19 March 2007.

Enger, Eldon and Bradley Smith. *Environmental Science: A Study of Interrelationships*, 10th ed. Boston: McGraw Hill, 2006.

Epstein, William. "Why States Go -- And Don't Go – Nuclear." *Annals of the American Academy of Political and Social Science* 430, no. 1(March 1977): 16-28.

Fernández-Vázquez, Eugenio and Juan Pablo Pardo-Guerra. "Latin America Rethinks Nuclear Energy." Web-only essay, 12 September 2005. URL: <http://americas.irc-online.org/am/558>. Accessed 7 March 2007.

Fletcher, Pascal, "Cuba rejects Russian nuclear plant offer." *Financial Times*, 19 December 2000. Proquest document ID #65278301. Accessed via Proquest 20 March 2007.

Flynn, Michael. "A Latin 'Axis of Evil?'" *Bulletin of the Atomic Scientists,* Oct/Nov 2003. Proquest document ID# 274909151. Accessed via Proquest 14 May 2007.

"Future development and poverty reduction tied to gains in renewable energy, says IDB President," Inter-American Development Bank Press Release, 18 March 2007. URL: <http://www.iadb.org/NEWS/articledetail.cfm?artid=3691&language=En>. Accessed 21 March 2007.

Garwin, Richard L. and Georges Charpak. *Megawatts and Megatons: A Turning Point in the Nuclear Age?* New York: Alfred A Knopf, 2001.

"Graph: World Uranium Production." Web-only graph, 7 November 2006. URL: <http://www.uxc.com/ fuelcycle/uranium/production-uranium.html>. Accessed 26 February 2007.

Goldemburg, Jose. "Looking Back: Lessons from the Denuclearization of Argentina and Brazil." *Arms Control Today*, April, 2006. URL: <http://www.armscontrol.org/ act/2006_04/ lookingback.asp>. Accessed 17 April 2007.

Heuer, Richards J. *Psychology of Intelligence Analysis.* Pittsburg, PA: Government Printing Office, 1999.

Horton, Roy E. III. "Out of South Africa: Pretoria's Nuclear Weapons Experience." United States Air Force Institute For National Security Studies Occasional Paper #27, August 1999. URL: < http://www.fas.org/nuke/guide/rsa/nuke/ ocp27.htm>. Accessed 7 March 2007.

Hymans, Jacques E.C. *The Psychology of Nuclear Proliferation: Identity, Emotions, and Foreign Policy.* New York: Cambridge University Press, 2006.

"International Atomic Energy Agency Country Report: Argentina." Web-only report, December 2004. URL: <http://www.pub.iaea.org/MTCD/publications/PDF/ cnpp2004/ CNPP_Webpage/ countryprofiles/Argentina/Argentina2004.htm>. Accessed 15 March 2007.

"International Atomic Energy Agency Country Report: Brazil." Web-only report, December 2004. URL: <http://www.pub.iaea.org/MTCD/publications/ PDF/cnpp2004/CNPP_Webpage/countryprofiles/Brazil/Brazil2004.htm>. Accessed 15 March 2007.

"International Atomic Energy Agency Country Report: Mexico." Web-only report, December 2004. URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/CNPP_Webpage/countryprofiles/Mexico/Mexico2004.htm>. Accessed 15 March 2007.

International Atomic Energy Association Nuclear Fuel Cycle Information System, Web-only database, 2007. URL: <http://wwwnfcis.iaca.org/NFCIS/NFCISMAin.asp?Region=The%20World&Country=All&Type=All&Status=All&Scale=All&Order=2&Page=1&RightP=List&Table=1>. Registration and password required. Accessed 17 March, 2007.

"International Energy Agency Key World Energy Statistics 2006." Web-only database, 2006. URL: < http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2006/key2006.pdf>. Accessed 4 March 2007.

"International Energy Agency Monthly Electricity Statistics, November 2006." Web-only database, November 2006. URL: < http://library.iea.org/Textbase/stats/surveys/mes.pdf>. Accessed 4 March 2007.

"Introduction to Nuclear Power." Web-only essay, 2007. URL: <http://www.eia.doe.gov/cneaf/nuclear/page/ intro.html>. Accessed 12 March 2007.

"Issues At Operating Uranium Mines and Mills – Other Countries: Argentina." Web-only essay, 1 April 2007. URL: <http://www.wise-uranium.org/umop.html#AR>. Accessed 7 March 2007.

Jize, Qin. "Chavez Arrives in Beijing." *China Daily*, 23 August 2006. Proquest document ID# 1103843261. Accessed via Proquest 21 May 2007.

Jo, Dong-Joon and Erik Gartzke. "Determinants of Nuclear Weapons Proliferation." *The Journal of Conflict Resolution*, February 2007. Proquest document ID# 1230885261. Accessed via Proquest 25 May 2007.

Joint Chiefs of Staff. "National Military Strategy to Combat Weapons of Mass Destruction," online ed. 13 February 2006. URL: <www.defenselink.mil/pdf/NMS-CWMD2006.pdf>. Accessed 4 October 2006.

Kapur, Ashok. "Nth Powers of the Future." *Annals of the American Academy of Political and Social Science* 430, no. 1(March, 1977): 84-95.

Karp, Aaron. *Ballistic Missile Proliferation*. New York: Oxford University Press, 1996.

_____. "Correspondence: Argentina and the Bomb." *The Non-Proliferation Review*, Spring, 2000. URL: <http://cns.miis.edu/pubs/npr/vol07/71/ corr71.pdf>. Accessed 17 April 2007.

Kimer, James T. "Venezuela / Colombia: Relations Turn Carnal." NACLA report on the Americas, March/April 2005. Proquest document ID# 803084811. Accessed via Proquest 22 May 2007.

Koch, Lewis Z. "Dirty Bomber, Dirty Justice." *Bulletin of the Atomic Scientists*, January / February 2004. Ebscohost document ID #11787826. Accessed via Ebscohost 5 March 2007.

Lapper, Richard and Jonathan Wheatley. "Disagreements imply depth of ties for a regional leader." *Financial Times,* 22 February 2007. Proquest document ID# 1221029051. Accessed via Proquest 16 May 2007.

Long, Gideon. "Strapped for Energy, Chile Looks at Nuclear Option." Reuters News Service, 12 March 2007. URL: <http://www.planetark.org/dailynewsstory.cfm/ newsid/ 40789/story.htm>. Accessed 21 March 2007.

"Missile Programs: Brazil." Web-only essay, 18 April 2007. URL: <http://www.globalsecurity.org/wmd/world/brazil/missile.htm>. Accessed 18 April 2007.

Montgomery, Carla. *Environmental Geology*, 7th ed. Boston: McGraw Hill, 2006.

Mrquez, Humberto. "Venezuela: Oil Wealth Helps Chavez Stand Up To Washington." *Global Information Network*, 21 February 2006. Proquest Document ID# 991086641. Accessed via Proquest 21 May 2007.

"Nuclear Power in Argentina: Briefing Paper #96." Web-only essay, November 2006. URL: <http://www.uic.com.au/nip96.htm>. Accessed 11 March 2007.

"Nuclear Weapons Programs: Brazil." Web-only essay, 18 April 2007. URL: <http://www.globalsecurity.org/wmd/world/brazil/nuke.htm>. Accessed 18 April 2007.

O'Grady, Mary Anastasia. "Americas: Chavez' Oil Weapon is a Popgun," *Wall Street Journal*, 9 September 2005. Proquest document ID# 893905731. Accessed via Proquest 21 May 2007.

Palmer, Liz and Gary Millhollin. "Brazil's Nuclear Puzzle." *Science*, 22 October 2004. Proquest document ID# 725575851. Accessed via Proquest 14 May 2007.

"Profile: Luiz Inacio Lula da Silva." *The Economist*, online ed., 30 October 2006. URL: <http://news.bbc.co.uk/1/hi/world/americas/5346744.stm>. Accessed on 14 May 2007.

Redick, John R. "Latin America's emerging non-proliferation consensus." *Arms Control Today*, March 1994. Proquest document ID# 5208901. Accessed via Proquest 19 April 2007.

Rhoter, Larry and Juan Forero. "Venezuela's Leader Covets a Nuclear Energy Program." *New York Times*, 27 November 2005, 1:14.

Robinson, Carla Anne. "Wrestling Nuclear Genies Back Into The Bottle, or at Least a Can." *New York Times*, late edition, East Coast, 9 May 2007. Proquest document ID# 1267609201. Accessed via Proquest 16 May 2007.

"Safety of Nuclear Reactors." Web-only essay, January 2007. URL: <http://www.world-nuclear.org/info/inf06.html>. Accessed 5 March 2007.

Sagan, Scott D. and Kenneth N. Waltz. *The Spread of Nuclear Weapons: A Debate Renewed*. New York: W.W. Norton and Company, 2003.

Sokolski, Henry D. *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation*. Westport, CT: Praeger Publishers, 2001.

"Survey of Energy Resources: Uranium." Web-only survey, 21 May 2007. URL: <http://www.worldenergy.org/wec-geis/publications/reports/ser/uranium/uranium.asp>. Accessed 21 May 2007.

"The Americas: Lula opts for a quiet life; Brazil." *The Economist*, 7 April 2007. Proquest document ID# 1250702411. Accessed via Proquest 11 May 2007.

"The National Intelligence Strategy of the United States of America," online ed. October 2005. URL: <http://www.dni.gov/ publications/NISOctober2005.pdf>. Accessed 31 May 2007.

The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices. Eds. Kurt M. Campbell and others. Washington, D.C.: Brookings Institute Press, 2004.

"USA / Venezuela politics: A new strategy?" Economist Intelligence Unit ViewsWire, 29 December 2006. Proquest document ID# 1188684741. Accessed via Proquest 22 May 2007.

"Venezuelan Politics: Bolivarian Revolution Accelerates." Economist Intelligence Unit ViewsWire, 20 March 2007. Proquest Document ID# 1264439441. Accessed via Proquest 21 May 2007.

Webb-Vidal, Andy. "US probe into Venezuela's oil supply threat 'absurd'." *Financial Times*, 11 July 2006. Proquest document ID# 1075025451. Accessed via Proquest 21 May 2007.

_____. "US to lobby Argentina on Chavez nuclear move." *Financial Times*, 13 October 2005. Proquest document ID# 910569891. Accessed via Proquest 21 May 2001.

West, J. Robinson. "The Production Crunch: Chavez-style oil nationalism is endangering world economic growth." *Newsweek*, 14 May 2007. Proquest document ID# 1266617651. Accessed via Proquest 21 May 2007.

Wilpert, Gregory. "The Meaning of 21st Century Socialism for Venezuela," Web-only essay, 11 July 2006. URL: <http://www.venezuelanalysis.com/articles.php?artno=1776>. Accessed 21 May 2007.

"Who leads Latin America?; Brazil's Presidential Election." *The Economist*, 30 September 2006. Proquest document ID# 1139608601. Accessed via Proquest 16 May 2007.

World Nuclear Association. "Nuclear Power in Argentina." Web-only essay, September 2006. URL: <http://www.world-nuclear.org/info/inf96.html>. Accessed 7 March 2007.

_____. "Nuclear Power in Brazil." Web-only essay, June 2006. URL: < http://www.world-nuclear.org/info/inf95.html>. Accessed 7 March 2007.

_____. "Nuclear Power in Mexico." Web-only essay, March 2007. URL: < http://www.world-nuclear.org/info/inf106.html>. Accessed 7 March 2007.

Zweig, David and Bi Jianhai. "China's Global Hunt For Energy." *Foreign Affairs*, September/October 2005. EbscoHost reference number 17979604, accessed via EbscoHost 21 May 2007.

ABSTRACT

TITLE OF THESIS: Chasing Demons: The Potential for Nuclear Proliferation in Latin America

STUDENT: Michael Edward Senn, MSSI, 2007

CLASS NUMBER: JMIC 2007 **DATE:** June, 2007

THESIS COMMITTEE CHAIR: CDR Gerald Sherrill

COMMITTEE MEMBER: Mr. William Ortman

This thesis set out to answer the following research question: What is the potential for current or future nuclear proliferation in Latin America? The work focused on Brazil and Venezuela as case studies, but presented a method by which any state in the region can be analyzed for proliferation potential. The thesis concludes that there is currently no danger of nuclear proliferation in Latin America. However, Brazil and Venezuela represent states that given the right set of circumstances, could pursue the nuclear option. Although nuclear proliferation is a top US intelligence priority, Latin America has received little attention in this area. To assist in the dissemination of this work, which fills a knowledge gap where nuclear proliferation is concerned and provides a method to assess future proliferation, all of the material used in the creation of this thesis is unclassified.

The research conducted in the formation of this thesis has three main foci. First, a comprehensive background of nuclear issues as they relate to Latin America was undertaken. This background serves to both compile the available knowledge about the

nuclear infrastructure of Latin America and provide evidence for analysis in this thesis. The second focal point of the research was an in-depth examination of Brazil and Venezuela. This examination includes an evaluation of the current situation, an evaluation of the impact of economic and social trends, and an assessment of leadership for each state. Finally, all of the evidence collected for each state in the course of the research was examined using the Analysis of Competing Hypotheses (ACH) technique.

The results of the ACH confirm that, given their current situations, neither Brazil nor Venezuela is likely to pursue nuclear weapons at this point. The ACH goes further to show the likely path of proliferation if one of the two states decides to pursue nuclear weapons.

If nuclear proliferation does occur in Latin America, this thesis can be used as a baseline for examining the issue. Moreover, the techniques used in the research for this thesis attempted to capture the most current and relevant information and compile it for each state. Thus it can serve as an analog for examining proliferation in any region of the world, as well as a baseline to assist in assessing the effectiveness of non-proliferation efforts.

CHASING DEMONS: THE POTENTIAL FOR NUCLEAR PROLIFERATION IN LATIN AMERICA

by

MAJ Michael Senn
United States Army
NDIC Class of 2007

Unclassified thesis submitted to the faculty
of the National Defense Intelligence College
in partial fulfillment of the requirements for the degree of
Master of Science of Strategic Intelligence

June 2007

DEDICATION

I dedicate this work to my wife, Kristen and my children, Mason, Nolan, and Payton. Though they may never read this thesis or care about its content, their unwavering support has carried me throughout my career. In the past year they have dealt with my almost constant writing and research in pursuit of this work and my MSSI degree. I love them all dearly and hope they understand that I am more dedicated to them than I could ever be to a paper or degree.

CONTENTS

LIST OF FIGURES

Figure **Page**

CHAPTER 1

IMAGINING THE UNIMAGINABLE: NUCLEAR PROLIFERATION IN AMERICA'S BACKYARD

A NEW TWIST ON AN OLD THREAT

The United States has not faced the specter of nuclear proliferation in the Western Hemisphere since the Cuban Missile Crisis ended with the removal of Soviet weapons from Cuba in 1961. Two states in Latin America, Argentina and Brazil, had fledgling nuclear weapons programs until they were abandoned in the mid-1990s. US influence, the prohibitive cost of nuclear weapons programs, and the general commitment of Latin American countries to non-proliferation have all played key roles in ensuring states in the region have remained free of nuclear weapons and intentions to acquire them.

However, the potential for global nuclear proliferation is perhaps at its highest level ever. The detonation of a nuclear weapon by North Korea in late 2006 and the continued defiance of Iran in pursuing nuclear weapons clearly call the Non-Proliferation Treaty (NPT) and the ability of the international community to curb proliferation into question. The unraveling of the A.Q. Khan network in 2004 raises serious questions about nuclear technology transfer in the modern age and again highlights a perceived inability on the part of the global community to prohibit it. The pursuit of the Global War on Terror by the United States could make certain states less secure and more prone

towards a nuclear option.[1] Even peaceful pursuit of nuclear energy as a cleaner, more efficient alternative to fossil fuels raises the question of dual use technology and proliferation.

Policymakers, academics, and the intelligence community necessarily focus their proliferation efforts on so called "rouge" states, like Iran and North Korea, which represent the greatest potential threat to US National Security. Scant attention has been paid to Latin America even though it has two states, Argentina and Brazil, potentially capable of producing nuclear weapons in a short period of time. Venezuelan President Hugo Chavez, who has made overtures to the likes of North Korea and Iran, may desire nuclear weapons. Though Venezuela has no current nuclear capability, the prospect of the virulently anti-American Chavez in possession of nuclear weapons is harrowing. That Chavez has made statements professing to desire a nuclear power program shows that this issue should not go unaddressed. Keeping Latin America free from proliferation once required a concerted effort on the part of the US However, with its attention currently diverted elsewhere, the question could shift from how to keep nuclear weapons out of Latin America to how deal with the nuclear weapons its members possess.

FUTURES INTELLIGENCE: THE DIFFICULTY OF PREDICTING PROLIFERATION

Predicting nuclear proliferation is not an easy task. There are myriad factors thought responsible for leading a state to pursue nuclear weapons, including external threats, domestic issues, the unstoppable economic and political momentum of a weapons

[1] Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons: A Debate Renewed* (New York: W.W. Norton and Company, 2003), introduction.

program, and even the disposition of the state leader. A recent quantitative study published in *The Journal of Conflict Resolution* cites security concerns and technology as determinants of whether states form weapons programs while security concerns, economics and domestic politics are the best determinants of actual nuclear weapon possession.[2] This and many other studies present a variety of views on nuclear proliferation, but nothing published to this point presents a failsafe formula for predicting it. The inability to accurately forecast nuclear proliferation is a product of the myriad complicated factors behind the nuclear decision.

Nuclear proliferation is a topic of obvious import for US national security. Preventing and countering the spread of weapons of mass destruction is the number two strategic mission objective in the current National Intelligence Strategy, behind only defeating terrorism.[3] The consequences of proliferation and the difficulty in divining nuclear intentions make this a foremost issue for the US intelligence community. Two of the largest intelligence failures of the past decade involved nuclear proliferation. The first was India's unexpected nuclear test in 1998. While India's burgeoning nuclear capability was documented, the actual decision to conduct the test and the physical setup for the test itself went largely unnoticed. More recently, the decision to unseat Iraqi dictator Saddam Hussein was, at least publicly, based on the idea that Saddam was almost capable of producing a nuclear weapon. Time has shown that Iraq's nuclear program had been largely dismantled and was nowhere close to producing a weapon. Considering

---

[2] Dong-Joon Jo and Erik Gartzke, "Determinants of Nuclear Weapons Proliferation," *The Journal of Conflict Resolution*, February 2007, Proquest document ID# 1230885261, accessed via Proquest 25 May 2007.

[3] "The National Intelligence Strategy of the United States of America," online ed. (October 2005), URL: <http://www.dni.gov/publications/ NISOctober2005.pdf>, accessed 31 May 2007.

these recent failures, the current global security environment, and the threat nuclear weapons present to national security, the US intelligence community should be aware of the indications of proliferation from even the unlikeliest corners of the globe.

THESIS OVERVIEW

Research Question

This work seeks to assess the potential for current and future nuclear proliferation in Latin America.

Justification

Could the current global security environment encourage nuclear proliferation in Latin America? Admittedly, this question is not at the forefront of the US foreign policy and intelligence mindset. But the present existence of many factors in the region conducive to future proliferation underscores the need to explore this issue further. Weapons of mass destruction represent an ever-present threat to US national security, and the intelligence community would be remiss if it did not consider even the remotest of nuclear proliferation possibilities. The need to anticipate such threats is underscored in the first paragraph of the National Military Strategy to Combat Weapons of Mass Destruction, published in 2006.

> Weapons of mass destruction (WMD) pose a serious threat to the United States and to the international community. In the hands of our enemies, these weapons could enable them to inflict massive harm on the United States,

including our military forces at home and abroad, and our friends and allies. The cost of insufficient preparation against such an attack would be substantial.[4]

Scope

This study will present a comprehensive overview of the current nuclear infrastructure and capability of Latin America. However, it will focus on two states, Brazil and Venezuela, when dealing with the issue of proliferation. Brazil is the state in Latin America with the most well developed nuclear program and the closest state in Latin America to producing a nuclear weapon, even though at this time there is no evidence to suggest it is attempting to do so. Venezuela presents a problem of a different sort, even though it possesses no current nuclear capability. Among Latin American leaders, Hugo Chavez best fits the profile of a leader who could be persuaded to acquire nuclear weapons. Combined with his anti-American stance and the import of Venezuela's oil to the US, the potential for a nuclear Venezuela is compelling.

Argentina, which possesses a nuclear power program and once made an attempt at nuclear weapons, also seems a likely state for examination in this work. However, Argentina and Brazil present as similar case studies. Brazil currently owns more advanced nuclear power and ballistic missile programs than Argentina and has also recently been at odds with the International Atomic Energy Association (IAEA), making it a more compelling choice for study. Thus in this study I choose to examine what I perceive to be the most likely and the most dangerous avenues for Latin American nuclear proliferation.

---

[4] Joint Chiefs of Staff, "National Military Strategy to Combat Weapons of Mass Destruction," online ed. (13 February 2006), URL: <www.defenselink.mil/pdf/NMS-CWMD2006.pdf>, accessed 4 October 2006.

Hypothesis

This study proposes that although Brazil and Venezuela each have the potential to pursue nuclear weapons, neither will do so in the foreseeable future.

As their current situations differ, the paths Brazil and Venezuela would take to nuclear proliferation are also different. Within this work I will conduct an analysis of competing hypotheses for each country in an effort to support my overall hypothesis. For each country I present four hypotheses, all of which will be analyzed in future chapters.

Brazil. Figure 1 contains the hypotheses concerning Brazil's proliferation potential.

1) H1: Brazil will pursue an overt nuclear weapons program;
2) H2: Brazil will continue its pursuit of an autonomous nuclear fuel cycle but not pursue nuclear weapons (status quo);
3) H3: Brazil will clandestinely develop a "run up" nuclear capability and gain the ability to quickly produce nuclear weapons;
4) H4: Brazil will abandon its attempt at an autonomous fuel cycle, open itself completely to the IAEA, and maintain only the ability to produce nuclear energy.

Figure 1: Hypotheses – Brazil Nuclear Proliferation

Venezuela. Figure 2 contains the hypotheses concerning Venezuela's proliferation potential.

1) H1: Venezuela will pursue an indigenous nuclear weapons program;
2) H2: Venezuela will develop a nuclear power capability;
3) H3: Venezuela will not pursue any type of nuclear capability (status quo);
4) H4: Venezuela will attempt to acquire nuclear technology, knowledge, or weapons through technology transfer.

Figure 2: Hypotheses - Venezuela Nuclear Proliferation

How This Study is Unique

Literature on nuclear proliferation abounds. However, since the dismantling of the nuclear programs of Argentina and Brazil in the early 1990s, scant attention has been paid to nuclear proliferation in Latin America. In light of the current global situation and with the significant focus on the nuclear ambitions of Iraq and North Korea, a relative dearth of writing on this topic is understandable. But as intelligence surprises in India and Iraq have shown, many unforeseen possibilities exist where proliferation is concerned. This study is unique in that it fills knowledge gaps concerning the current nuclear situation in Latin America and concerning the nuclear aims of two of its more important states. A 1996 Joint Military Intelligence College thesis discussed Brazil's potential for proliferation, but this work focused primarily on its ballistic missile program. I could find no work on Venezuela's nuclear potential. I believe my chapter on Venezuela may be the only true assessment of its nuclear potential in current literature.

In addition to the chapter on Venezuela, Chapter 2 provides a complete evaluation of Latin America's nuclear capability. In it I discuss nuclear power production, the state of the nuclear fuel cycle in Latin America, and even present a brief history of Latin American nuclear weapons programs. Though the pieces of this chapter were pulled from existing literature and databases, the compilation of this material in one place makes it the most current and comprehensive assessment of Latin American nuclear capabilities available today.

Finally, in my analysis I bring together proliferation evidence from both the traditional schools of thought on the subject and the very new ones. I have yet to see Jacques Hymans' idea of national identity conception applied outside of his work, and feel that doing so in this thesis contributes to both its thoroughness and uniqueness.

REVIEW OF RELATED LITERATURE

Overview

Considering the small number of nuclear energy programs in Latin America and the historical absence of nuclear threats from the region, there is a paucity of literature that directly addresses my topic. However, there is a wealth of information on most aspects of the nuclear puzzle. The topics most relative to my nuclear research deal with the energy sector as a whole, the motivations states have to pursue nuclear weapons, the conversion of nuclear power programs into ones that develop weapons, and the defunct weapons programs of Brazil and Argentina. I will also delve into the international nuclear proliferation agreements and treaties countries in the region are signatory to in

order to determine their impact on Latin America's nuclear future. A final theme of my research concerns background information on the region with a focus on political, military, and economic factors related to nuclear development.

Exploring the decision to go nuclear

One of the critical questions I seek to answer about Brazil and Venezuela concerns the basic motivations each would have for pursuing nuclear weapons in the future. A seminal work that examines this topic in detail is titled *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*. Written in 2004 by Kurt M. Campbell, Robert J. Einhorn, and Mitchell B. Reiss, this work examines nuclear policy at the state level with a focus on the factors behind nuclear decisions states make. Of particular interest are the case studies of individual states that the book presents. Though each case study is different, the work outlines common factors affecting the decisions of each study. Although *The Nuclear Tipping Point* does not discuss any states in Latin America, it does provide a conceptual framework for examining the strategic situation facing Brazil and Venezuela and assists in assessing the likelihood each has of choosing nuclear options in the future.

A precursor to *The Nuclear Tipping Point* is an article entitled "Why States Go—And Don't Go---Nuclear." Despite being a cold war era article, it nonetheless furthers an excellent discussion of economic, political, and military factors that figure in to the nuclear decision. The author concludes that the incentives for developing a nuclear capability outweigh the disincentives. Moreover, the disincentives available to governments seeking to discourage proliferation are limited and lie mainly in the political

realm.[5] This observation describes the situation today with Iran's nuclear program, as Iran appears to be largely ignoring U.N. sanctions and other political threats in doggedly pursuing its nuclear ambitions.

An article in this same vein and timeframe is entitled "Nth Powers of the Future", written in 1977 by Ashok Kapur. Though his article is dated, Kapur makes some important insights into the question of proliferation. He argues that proliferation will slow in the 1980s because of economic concerns and a lack of threats to potential proliferators' security. However, he postulates that the rate of proliferation will greatly increase if the security situation changes. This parallels a situation in which I see Latin American proliferation as a possibility. Kapur goes further to state that likely proliferation will be in the form of nuclear options as opposed to weapons.[6] Brazil fits this mold as it possesses many nuclear options and may look to possess even more.

In *The Spread of Nuclear Weapons: A Debate Renewed*, authors Scott D. Sagan and Kenneth N. Waltz explore the consequences of nuclear proliferation. Each takes an opposite side on the issue. Waltz argues that more states with nuclear weapons will be better for the international system, as more deterrence promotes more stability. Sagan says the world will be worse off with proliferation as states with nuclear weapons will be prone to preventative war, nuclear accidents, and lack of focus on conventional forces and security.[7] Also important in this work is Waltz' writing on the motivations and

---

[5]William Epstein, "Why States Go -- And Don't Go – Nuclear," *Annals of the American Academy of Political and Social Science* 430, no. 1 (March 1977): 16.

[6]Ashok Kapur, "Nth Powers of the Future," *Annals of the American Academy of Political and Social Science* 430, no. 1 (March, 1977): 84.

[7] Sagan and Waltz, viii.

characteristics of new nuclear states, a topic that is important when examining Venezuela and Argentina.

Jacques E. C. Hymans' *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy* takes a different approach to nuclear proliferation. He explores the disparity between the number of states that have nuclear weapons and those that have the capability to produce them. Hymans' unique focus is on the leaders of nuclear or potential nuclear states. He argues that the leaders of nations who pursue proliferation, under the influence of a variety of factors, feel it absolutely necessary to acquire or develop nuclear weapons.[8] Hymans further argues the US intelligence community focuses on technical indicators while failing to think through the human decisions behind the decision to go nuclear.[9] With its compelling hypothesis, this work allows room for a more comprehensive and modern examination of the nuclear ambitions of Venezuela and Brazil. If Hymans' assertions are correct, then an examination of Hugo Chavez and Brazilian President Lula de Silva utilizing his method helps provides a deeper understanding of each state's nuclear intentions. Hymans also presents a coherent discussion of US foreign policy options when dealing with proliferation.

Characteristics of a nuclear program

In order to assess the potential of Brazil or Venezuela to develop or acquire nuclear weapons, it is essential to describe the characteristics of a nuclear program that could lead to weapons development. At a basic level are the facilities, knowledge, and

[8] Jacques E. C. Hymans, *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy* (Cambridge: Cambridge University Press, 2006), 3.

[9] Hymans, 216.

resources required to run a nuclear program. In addition, a fundamental understanding of the nuclear fuel cycle, which documents the steps necessary to produce, utilize, and dispose of nuclear material, greatly assists in comprehending nuclear intentions. In Brazil's case, this knowledge helps frame the current status of its nuclear program. For Venezuela, nuclear program knowledge aids in providing future indications and warning that the state may be attempting to develop a nuclear capability.

This knowledge can be gained from a variety of sources. *Megawatts and Megatons: The Future of Nuclear Power and Nuclear Weapons* is an excellent primer on both topics. In addition, the work discusses the use of nuclear power and how it can be used for peaceful purposes and not geared towards proliferation. If Venezuela does pursue a nuclear power program, indicators for the program potentially being used for weapons will be of the utmost importance. *Megawatts and Megatons* assists in cataloging these indicators.

The nuclear programs of Brazil and Argentina

Most of the works concerning the now-defunct nuclear weapons programs of Brazil and Argentina are dated. Nonetheless, they provide valuable insight into these programs and serve as a basis for a current assessment of them. One such work is an occasional paper by John Redick of the Stimson Center entitled *Nuclear Illusions: Argentina and Brazil.* The focus of Redick's work, written in 1996, is the embracement of the non-proliferation regime by both states. Perhaps more importantly it does an excellent job summarizing the nuclear programs of each, providing valuable background information. Another summary work, "Looking Back: Lessons from the

Denuclearization of Brazil and Argentina", published in *Arms Control Today*, provides a good synopsis of each program and factors surrounding each state's decision to abandon nuclear weapons. In addition, the author argues that the best way to promote non-proliferation is to reduce the incentives that lead to the decision to acquire weapons in the first place.[10]

Energy

A nuclear power program provides the basic framework for most nuclear weapons development. Argentina and Brazil have power programs; Hugo Chavez has publicly stated that he desires such a program for Venezuela,[11] ostensibly to help refine Venezuela's heavy crude oil. Alarmists immediately equate this statement with the tacit desire by Chavez to develop a weapons program. However, the basic underlying question implied by Chavez' rhetoric is the actual need for nuclear power in Venezuela. The healthy reserves of oil and sources of energy that Venezuela possesses seem to obviate the need for nuclear power, so further exploration of Venezuela's energy sector is necessary in order to examine the rationale for such a program. Moreover, future forecasts for the price of oil are important to evaluating the health of Venezuela's economy, another potential indicator of proliferation. Current energy statistics and forecasts are available online from organizations like the Energy Information Administration.

---

[10] Jose Goldemburg, "Looking Back: Lessons from the Denuclearization of Argentina and Brazil," *Arms Control Today*, April 2006, URL: <http://www.armscontrol.org/ act/2006_04/lookingback.asp>, accessed 17 April 2007.

[11] Larry Rhoter and Juan Forero, "Venezuela's Leader Covets a Nuclear Energy Program," *New York Times*, 27 November 2005, 1:14.

Other Sources

One of the main foci of this work is to provide an update to the nuclear situation in Latin America. As such, the study will rely heavily on current reporting. Valuable sources of information to this end include current news publications like *The Economist*; journals such as *Arms Control Today, The Journal of Conflict Resolution, Bulletin of the Atomic Scientists,* and *The Non-Proliferation Review*; and online resources such as the websites of the International Energy Administration and the International Atomic Energy Association.

METHODOLOGY

Overview

This study will explore the research question and hypothesis using Analysis of Competing Hypotheses (ACH) on both Brazil and Venezuela. ACH, explained below forces an analyst to consider many hypotheses and weigh all available evidence against each hypothesis. Thus it is a much more comprehensive process than choosing one hypotheses and setting out to prove that it is true. Conducting an ACH against Brazil and Argentina allows me to explore my overall hypothesis in a comprehensive manner.

Important to using ACH and to my methodology is the collection of evidence applicable to my research question. To collect this evidence I rely on the aforementioned sources of data. I have intentionally limited the scope of this study to evidence available as open source material. I want the results of the study to be available for consumption by anyone dealing with nuclear proliferation issues, not just the intelligence community.

The trade-off inherent in this decision is that I may not capture all available evidence. This is also a limitation of the ACH process in general. I risk not capturing all applicable evidence even in the open source arena. Additionally, the ACH can suffer if too much evidence is presented. Analytical bias can also creep into ACH; the steps most prone to bias in ACH are the selection of evidence and interpretation of results.

Analysis of Competing Hypotheses

Satisficing, or choosing the first solution to a problem that seems reasonable, is a common analytical pitfall. It is cognitively simple to focus on one possible solution to a problem, picking out evidence supporting the solution while ignoring evidence that would discount it.[12] In his book *Psychology of Intelligence Analysis*, Richards J. Heuer, Jr. discusses satisficing and other potential analytical mistakes. He also proposes a solution to many common analytical problems: using ACH. ACH is a methodical procedure, and as such helps to limit some of the cognitive biases that make predictive analysis difficult.[13] ACH is grounded in the scientific method and seeks evidence that refutes hypotheses and well as evidence that confirms them.[14] This provides for a solid analytical foundation. ACH is particularly well suited for application to the questions this work seeks to answer about the nuclear futures of Venezuela and Brazil. It would be easy, especially in the case of Venezuela, to come up with a single, reasonable hypothesis

[12] Richards J. Heuer, *Psychology of Intelligence Analysis* (Pittsburg, PA: Government Printing Office, 1999), 44.

[13] Heuer, 95.

[14] Heuer, 109.

and then try to prove or disprove it. But the many potential avenues that both Brazil and Venezuela could take with regard to nuclear weapons merit a broader examination.

ACH is an eight step process. The following section discusses each step in brief, as this work will apply ACH to both Brazil and Venezuela in later chapters.

Step 1 – Identify the possible hypotheses to be considered

Generating multiple hypotheses is often difficult, especially when a single individual is attempting to do so. For various reasons, individuals have a hard time considering all possibilities, especially when a complex problem exists. For this reason, Heuer recommends using a group of analysts to brainstorm potential hypotheses. He also cautions analysts to distinguish between unproven and disproved hypotheses. Disproved hypotheses can be rejected out of hand, but unproven ones should be explored. Heuer also cautions about having too many hypotheses.[15] Even though ACH is a tool for evaluating multiple ideas, having too many can cloud the results of the process. Earlier in this chapter the hypotheses, four for Brazil and four for Venezuela, which I will use in the ACH were presented.

Step 2 – Make a list of significant evidence and arguments for and against each hypothesis

The search for evidence should cast a wide net. It should not be limited to current intelligence reports but should also include open source reports and the assumptions and deductions of the analyst. This is especially important for this work; a dearth of intelligence on the subject at hand is one of the primary reasons for undertaking the

[15] Heuer, 98.

project. Heuer directs the analyst to consider both general evidence and evidence that pertains to individual hypotheses. He also states that the absence of evidence can also be important.[16]

Step 3 – Prepare a matrix with the hypotheses and evidence in order to analyze "diagnosticity" of the evidence

This step analyzes each piece of evidence against all hypotheses. The analyst can decide how to annotate the relationship between each piece of evidence and the hypotheses. At the very least, each piece of evidence should be assessed as consistent or inconsistent with each hypothesis. The idea is to determine which pieces of evidence are truly diagnostic and which are not. Evidence that shows consistency with each hypothesis likely has little diagnostic value. The analyst can also choose to add weighted scales to the matrix to make it more comprehensive.[17]

For this study, I have chosen to use five levels to evaluate the diagnostic value of my evidence. These levels are consistent, very consistent, neutral, inconsistent, and very inconsistent. In addition I can assess a piece of evidence as not being applicable to a hypothesis. I am also using additional weighted scales to assess the credibility and relevance of each piece of evidence.

[16] Heuer, 99.

[17] Heuer, 100-102.

Step 4 – Refine the matrix

There are two important aspects of this step. First, it calls for a refinement of the original hypotheses. Based on the evidence presented, some may need to be reworded, combined, or discarded altogether. Evidence could also result in a new hypothesis being proposed.

The other important aspect of this step is a reconsideration of the evidence presented. If any of the hypotheses are influenced by evidence not presented, then that evidence should be added. Along the same lines, evidence that shows no diagnostic ability should be discarded.[18]

Step 5 – Draw tentative conclusions about the relative likelihood of each hypothesis

In this step the hypotheses are examined one at a time against all evidence for or against. The analyst seeks to disprove hypotheses rather than prove them, which is in line with the scientific method. Heuer states that the hypothesis with the least amount of evidence against it is probably the most plausible, while the one with the largest amount of inconsistent evidence is the least likely. He does however caution against using the matrix as an absolute. To Heuer, this step should help clear up the analyst's judgment about which evidence is most important and should also help the analyst understand how the evidence is related to each hypothesis. The analyst is free to disagree with the results of the matrix; in the end, it is the judgment of the analyst that matters most when attempting to solve an intelligence problem. If the matrix and this judgment are not consistent, then there is likely missing evidence that needed to be added to the process.

[18] Heuer, 103.

In any case, the strength of this step and of ACH in general is that it forces the exploration of less probable hypotheses and at the very least provides the analyst a tool for organizing evidence.[19]

Step 6 – Analyze how sensitive your conclusion is to a few critical pieces of evidence

Once conclusions are reached, the analyst should take a close look at both the critical evidence supporting that conclusion and the assumptions behind it. There are many things to look for to evaluate the evidence. It could be incomplete, open to a different interpretation, or even deliberately misleading. Just as important as examining evidence is doing the same for assumptions. In the case of either, the analyst should at this point realize if additional research is merited.[20]

Step 7 – Report Conclusions

Implicit in this part of the process is an explanation of all the hypotheses considered, not just the most likely one. To Heuer, complete analysis doesn't end with the selection of the most likely hypothesis. Rejected hypotheses and the reasons for rejecting them should also be addressed. Additionally, the analyst should discuss the relative likelihood of each hypothesis considered. In the case of this study, the assessed relative likelihood of each hypothesis will be subjective, as I am not relying entirely on quantifiable data and therefore cannot conduct a thorough statistical analysis of any conclusion.

---

[19] Heuer, 104-105.

[20] Heuer, 105-106.

Step 8 – Identify milestones for future observation that may indicate events are taking a different course

Indicators that events are taking a path toward a certain hypothesis are important to any intelligence analysis. Although Heuer prompts the analyst in this step to identify events indicative of the chosen hypothesis being wrong, I plan to also use this step to also outline indicators that the preferred hypothesis is coming true. In my opinion, this makes the final assessment a much more useful tool.

CHAPTER 2

NUCLEAR BASICS: FROM POWER TO PROLIFERATION

"The discovery of nuclear reactions need not bring about the destruction of mankind any more than the discovery of matches."

--Albert Einstein

THE IMPORTANCE OF NUCLEAR POWER

The production of nuclear weapons is a complex and expensive process. The typical modern path to proliferation is for it to occur under the guise of a seemingly peaceful and legitimate nuclear energy program. Thus it is important to understand the basics of nuclear power. The ability to enrich uranium within the nuclear fuel cycle implies the ability to further enrich it for weapons use. Certain types of nuclear power plants also produce plutonium, as does spent fuel reprocessing, which can be used for weapons production. Understanding the nuclear power process is paramount in determining indicators of nuclear proliferation.

RADIOACTIVITY AND URANIUM

Isotopes of certain elements are considered radioactive; that is, they are unstable and spontaneously decompose. By-products of this decomposition include atomic components such as electrons, neutrons, and protons. Most importantly for nuclear

energy generation, a large amount of energy is also released during the decomposition.[21] Neutrons released when radioactive material decays have the ability to split the nuclei of other radioactive atoms in a process known as nuclear fission. A nuclear chain reaction takes place when fission occurs continuously. It is this chain reaction that is critical to creating the energy for nuclear power production and for nuclear weapons.[22]

The most commonly used element in nuclear power production is uranium. Uranium occurs naturally in nature and is found in many different types of rocks. Uranium concentrations sufficient for extraction are usually found in sedimentary rock, such as sandstone. In most types of rocks uranium exists in very small quantities making extraction of these amounts cost prohibitive. However as rock containing uranium undergoes chemical weathering, the uranium can be put into solution and eventually deposited as a component of sedimentary rock. The uranium concentrations in locations where this deposition takes place are much higher than in most rock, making extraction economical.

The most common isotope of uranium found in nature is uranium-238 (U_{238}), accounting for over 99% of natural uranium. U_{238} is not a fissionable material but it does play a key role in the production of nuclear weapons nonetheless. The most commonly used isotope for nuclear power production is the fissionable uranium-235 (U_{235}), accounting for less than 1% of all natural uranium.[23] Uranium is spread geographically around the world, though only 17 states currently produce it. In 2005, Canada was the

---

[21] Eldon Enger and Bradley Smith, *Environmental Science: A Study of Interrelationships*, 10th ed. (Boston: McGraw Hill, 2006), 221.

[22] Enger and Smith, 222.

[23] Carla Montgomery, *Environmental Geology*, 7th ed. (Boston: McGraw Hill, 2006), 332.

world's largest producer, followed closely by Australia. Other important uranium producing states include Kazakhstan, Russia, Namibia, Niger, and the United States.[24]

THE NUCLEAR FUEL CYCLE

Turning U_{235} into fuel suitable for producing nuclear power involves a complex process called the nuclear fuel cycle. The resources involved and the complexity of the fuel cycle make it a good indicator of nuclear activity and an important process to understand, especially if a state is attempting to secretly develop a nuclear weapons capability. Much harder to discern are the intentions of states that already utilize nuclear power commercially, as the fuel cycle by itself is essential to peaceful nuclear uses and doesn't necessarily indicate untoward objectives. The nuclear fuel cycle includes a number of front-end steps that take place before the fuel is consumed, utilization of the fuel for generating power, and back end steps that take place after consumption:

Step 1 – Uranium Mining and Milling

Ore containing uranium is extracted from the earth's surface or subsurface. Once extracted, it is crushed and treated to place the uranium in solution. This process, called milling, produces uranium oxide in a form that is commonly known as yellowcake, so named for its color and consistency.[25]

---

[24] "Graph: World Uranium Production," Web-only graph, 7 November 2006, URL: <http://www.uxc.com/fuelcycle/uranium/production-uranium.html>, accessed 26 February 2007.

[25] Enger and Smith, 228.

Step 2 – Conversion

To prepare the yellowcake for the next step, enrichment, it must be converted to uranium hexafluoride, or UF_6. A complex process produces UF_6, a substance that can easily be changed to a gas by raising its temperature slightly. This property is essential for successful enrichment.[26]

Step 3 – Enrichment

The concentration of fissionable U_{235} in nature is very low, on the order of .7% of natural uranium. For uranium to be useful as fuel in nuclear power plants, it must be enriched to a concentration of at least 3%. Gaseous diffusion and gas centrifuge are the two most common methods of enrichment. Diffusion, the primary method used by the United States, involves filtering gaseous UF_6 through a membrane to separate U_{235} from the more common U_{238}. The centrifuge method uses complex arrays of centrifuges, known as cascades to separate U_{235} and U_{238}.[27] One of the largest current nuclear issues with regards to Iran involves its use of centrifuges to enrich uranium.

---

[26] "Conversion: Yellowcake to Uranium Hexafluoride," Web-only essay, 2007, URL: <http://www.nei.org/ index.asp?catnum=3&catid=181>, accessed 22 April 2007.

[27] Richard L. Garwin and Georges Charpak, *Megawatts and Megatons: A Turning Point in the Nuclear Age?* (New York: Alfred A Knopf , 2001), 118.

Step 4 – Fuel Fabrication

Enriched uranium is fabricated into fuel by first converting it into uranium dioxide (UO_2). The UO_2 is ground into a powder, and then compressed into pellets. These pellets are placed into metal rods, which are utilized in nuclear reactors as fuel.[28]

Step 5 – Utilization

Once the fuel rods are ready for use, they are typically bundled and cycled into use at a nuclear reactor, the operation of which is discussed later in this chapter. Over time, the amount of U_{235} in the rods decreases as they are used. Fuel rods typically last three years before they are considered spent and must be replaced.[29]

Step 6 – Back End Activities

One of the more controversial aspects of nuclear power is what to do with nuclear fuel that has lost its ability to sustain a chain reaction. Even after use, nuclear fuel rods contain appreciable amounts of U_{235} and U_{238}. In addition, the rods also contain plutonium-239 (PU_{239}), a by-product of the chain reaction. As a typical nuclear plant produces 25 tons of used fuel rods each year, careful management of this radioactive spent fuel is necessary.[30] Options include interim storage, disposal, and reprocessing. Further complicating matters is the fact radioactive waste decomposes on a millennial scale. The time is takes typical spent fuel rods to return to natural levels of radioactivity

---

[28] "Introduction to Nuclear Power," Web-only essay, 2007, URL: <http://www.eia.doe.gov/oiaf/nuclear/page/intro.html>, accessed 12 March 2007.

[29] Enger and Smith, 228.

[30] Garwin and Charpak, 119.

is approximately 600,000 years. Over that amount of time, what originally seems an optimal storage site or solution may be much less attractive in the long term.[31]

Like all countries in the world, the United States lacks a permanent disposal facility for high-level nuclear waste and instead utilizes interim storage to manage it. High-level radioactive waste, which contains high concentrations of plutonium, is currently stored at a temporary facility in New Mexico. A permanent site at Yucca Mountain, Nevada is under development. Most solutions concerning waste disposal involve burial in a stable geologic formation. The Yucca Mountain site provides a location that is 300 meters underground and 300 meters above the water table. In the dry climate of Nevada, there is little danger of radioactive waste entering the water supply. As ideal as this site seems, it remains controversial and has been subject to repeated opposition from the state of Nevada, and many lawsuits currently challenge it in federal courts. Even if the site is completed, the amount of high level waste the US has to store exceeds the capacity of the site.[32]

Most US low level wastes, which are mainly wastes related to nuclear power production but also include items such as medical waste, are stored at nuclear power plants in holding ponds or in above ground facilities, with some permanently buried at sites in South Carolina and Washington state.[33]

Reprocessing spent nuclear fuel represents a final and still controversial method of dealing with high level nuclear waste. The U_{235} and PU_{239} that remains in spent fuel

---

[31] Garwin and Charpak, 122.

[32] Enger and Smith, 236.

[33] Enger and Smith, 238.

rods can be enriched and again used as nuclear fuel. This provides a short cut in the nuclear fuel cycle and also reduces the amount of nuclear waste that has to be stored. While this is a more efficient method of dispensing with nuclear wastes than straight disposal, the controversy lies in the fact plutonium extracted for use as fuel can conceivably be used as a component of nuclear weapons. Nonetheless many nations, such as France and the United Kingdom, reprocess nuclear waste. The United States does not.[34]

LATIN AMERICA AND THE NUCLEAR FUEL CYCLE

Globally, only the United States and Russia have the ability to operate complete nuclear fuel cycles. Other nuclear states rely on outside help, typically in the form of raw uranium or uranium enrichment, to complete their cycles and produce fuel for nuclear power. Different states in Latin America possess parts of the nuclear fuel cycle, especially uranium mining or the potential for it, but none has overtly completed it. Brazil is very close to having a complete cycle; it lacks only commercial conversion and enrichment capabilities. However, Brazil recently put into partial operation an enrichment facility and will soon be able to enrich uranium on its own. Additionally, Brazil has a pilot plant for conversion that should be operational by 2008.

Argentina and Brazil have many parts of the nuclear fuel cycle, reflecting the nuclear weapons programs that each country once possessed. On the other hand, Mexico's less developed infrastructure for processing nuclear fuel is indicative of a program used for power only. For the purposes of this work, the front and back end

[34] Enger and Smith, 228.

activities present in Latin America are discussed below. The utilization step is discussed in greater detail later in this chapter.

Step 1 – Uranium Mining and Milling

Numerous states in Latin America contain uranium deposits, but only a very few of these deposits are mined. Countries where only prospecting for uranium is currently taking place include Bolivia, Colombia, Guatemala, Paraguay, and Peru.

Argentina possesses two major uranium deposits with reserves estimated at approximately 8000 tons. At one time it had seven uranium mining and processing facilities but today it maintains once facility, Sierra Pintada, in a standby mode. Though no mining is currently taking place at either deposit, Argentina has plans to open Sierra Pintada and resume production of uranium. The mine is capable of processing 120 tons of uranium per year.[35] Argentina does not have a large need for nuclear fuel with only two power plants; even a small amount of production at Sierra Pintada would reduce or eliminate its dependency on others for uranium.[36] There is substantial public opposition, based mainly on environmental concerns, to re-opening the mine. Even though Argentina's Atomic Energy Commission (CNEA) has a responsibility to reclaim environmental damage before resumption of uranium, three marches against re-opening

---

[35] International Atomic Energy Association Nuclear Fuel Cycle Information System, Web-only database, 2007, URL: <http://www-nfcis.iaea.org/NFCIS/NFCISMAin.asp?Region=The%20World&Country=All&Type=All&Status=All&Scale=All&Order= 2&Page=1&RightP=List&Table=1>, registration and password required, accessed 17 March 2007. Cited hereafter as NFCIS.

[36] World Nuclear Association, "Nuclear Power in Argentina," Web-only essay, September 2006, URL: < http://www.world-nuclear.org/info/inf96.html>, accessed 7 March 2007.

took place in 2006.[37] Argentina currently imports enriched uranium for use in fuel production.

Brazil has extensive uranium resources at 143,000 tons in three main deposits, accounting for 4% of the world's total. Two mines once operated in Brazil, but only the Lagoa Real mine remains open. Lagoa Real, which still operates with only a start-up license, produces 340 tons of uranium per year for domestic use in Brazil's nuclear power industry.[38]

Mexico has uranium reserves of approximately 2000 tons but does not currently mine them. It imports enriched uranium to run its two nuclear power plants. Mexico at one time operated an experimental uranium milling plant at Villa Aldama, Chihuahua, but closed the plant long ago.[39]

Step 2 – Conversion

Argentina imports most of its uranium hexafluoride, though it does operate a small conversion facility at Pilcaniyeu, capable of processing 62 metric tons of UF_6 per year.[40] Argentina also converts uranium dioxide for use in its reactors at its Cordoba facility, with a capacity of 150 metric tons per year.

---

[37] "Issues At Operating Uranium Mines and Mills – Other Countries: Argentina," Web-only essay, 1 April 2007, URL: <http://www.wise-uranium.org/umop.html#AR>, accessed 7 March 2007.

[38] World Nuclear Association, "Nuclear Power in Brazil," Web-only essay, June 2006, URL: < http://www.world-nuclear.org/info/inf95.html>, accessed 7 March 2007.

[39] World Nuclear Association, "Nuclear Power in Mexico," Web-only essay, March 2007, URL: < http://www.world-nuclear.org/info/inf106.html>, accessed 7 March 2007.

[40] "Nuclear Power in Argentina: Briefing Paper #96," Web-only essay, November 2006, URL: < http://www.uic.com.au/nip96.htm>, accessed 11 March 2007.

Brazil is also capable of converting mined and milled uranium into uranium hexafluoride, though it does not currently do so. Brazil's Institute of Energy and Nuclear Research operated a conversion facility in Sao Paulo. Closed in 1993, the capacity of this facility was 90 metric tons per year. Brazil does have a pilot plant for conversion currently under construction at its Navy-run Aramar Demonstration Center is Sao Paulo. Due to be operational in 2008, the facility will be able to process 40 metric tons of UF_6 per year.

Step 3 – Enrichment

In Argentina, the Pilcaniyeu facility is also capable of uranium enrichment, and did so from 1983-1989. It is currently in stand-by mode. CNEA wants to once again enrich uranium at the facility, and has been upgrading Pilcaniyeu's equipment involved in the process. Argentina's state owned Investigacion Aplicada (INVAP) is a significant exporter of nuclear research, development, and services. Restarting enrichment activities would ostensibly maintain Argentina's right to do so, and increase INVAP's potential for foreign earnings from the process.[41]

Brazil's enrichment program is an offshoot of the Brazilian Navy's use of nuclear propulsion for its submarines. Aramar has a pilot plant capable of enriching U_{235} at 5% and a research plant capable of enriching U_{235} to over 19%. Both use the gas diffusion enrichment method. After operating a demonstration plant for some time, Brazil put its commercial enrichment facility at Resende online in May 2006. One enrichment cascade utilizing gas diffusion is currently operational. At capacity, the Resende plant will be

[41] "Nuclear Power in Argentina."

able to process 120 metric tons of separative work units of uranium (MTSWU) yearly.[42] The process developed by the Brazilian Navy is reportedly much more efficient that other enrichment efforts. When fully operational, Resende will provide as much as 60% of the enriched fuel needed to run Brazil's nuclear reactors.[43]

Step 4 – Fuel Fabrication

Argentina and Brazil are both able to fabricate fuel for use in their nuclear reactors. Argentina converts UF_6 to UO_2 at its Cordoba Mill Complex. Fuel rod fabrication takes place at its Nuclear Fuel Manufacture Plant in Ezeiza. Overall fuel fabrication capacity is 160 metric tons per year.[44]

Brazil completes all aspects of commercial fabrication, including conversion of UF_6 to UO_2, creation of UO_2 pellets, and fabrication of the UO_2 pellets into fuel rods at its Resende facility. Overall fuel fabrication capacity is 240 metric tons per year. Brazil also maintains a laboratory-scale facility for pellet production at the Aramar Demonstration Center in Sao Paulo. Fuel element fabrication for research reactors also takes place in Sao Paulo.[45]

Mexico maintains a fuel fabrication facility in stand-by mode. The plant, located in Toluca, is capable of processing 20 fuel elements per year, but is not currently in

---

[42] NFCIS, 2007.

[43] "Brazil: Enrichment Plant, Resende," Web-only database, 6 May 2006, URL: < http://www.wise-uranium.org/epruj.html#BR >, accessed 11 March 2007.

[44] NFCIS, 2007.

[45] NFCIS, 2007.

operation. Other than its nuclear reactors, this is the only nuclear fuel cycle related facility that Mexico possesses.[46]

Step 6 – Back End Activities

CNEA is responsible for managing Argentina's nuclear waste. Power plant waste is stored on-site at each facility, a common practice in the nuclear industry. Argentina maintains two storage facilities, one at Embalse and the other at the aforementioned plant in Ezeiza. The Ezeiza facility also has a pilot plant capable of reprocessing spent fuel, although this plant is in a deferred status and is not currently operational.[47]

Brazil also stores its spent fuel and other nuclear waste at its nuclear power plants. Legislation was passed in 2001 for the creation of a permanent storage facility, though none has been constructed. Brazil does not reprocess spent nuclear fuel.[48]

Mexico stores spent fuel at its reactors, as well as operating a storage center for low level nuclear waste at Maquixco. It also has a storage site for low level waste at Piedrera, though this site has not been operational since 1987.[49]

NUCLEAR POWER PLANTS

The goal of a nuclear power plant is essentially the same as a traditional coal-fired power plant: to produce heat, convert water to steam, turn turbines with that steam, and

---

[46] NFCIS, 2007.

[47] "Nuclear Power in Argentina."

[48] "Nuclear Power in Brazil."

[49] "Nuclear Power in Mexico."

produce electricity. In a traditional power plant the heat is produced by burning coal; in a nuclear power plant it is produced by allowing fission to take place in a nuclear reactor core.

In addition to the previously discussed fuel rods, the reactor core also contains control rods. These rods are made of material that absorbs neutrons, allowing operators to control the rate of fission in the core. When put into the core, the control rods absorb neutrons, slowing fission. The fuel and control rods are surrounded by a reaction moderator. Typically water or graphite, the moderator absorbs energy. This absorption slows the speed of the neutrons in the chain reaction. Slower neutrons produce more efficient fission. Also present in the reactor core is coolant, used to moderate the temperature of the nuclear fission. Water and carbon dioxide are common coolants.[50]

The most common type of nuclear reactor is known as a light water reactor, which uses regular water as both moderator and coolant. There are two types of light water reactors: boiling water reactors (BWR) and pressurized water reactors (PWR). Boiling water reactors heat water in the core directly, turning it into steam. This steam in turn turns turbines, producing electricity. After passing through turbines, the steam passes through a condenser, cooling it back to water. This water can then be cycled back into the reactor core and the process repeated.[51]

[50] Enger and Smith, 223.

[51] Enger and Smith, 223.

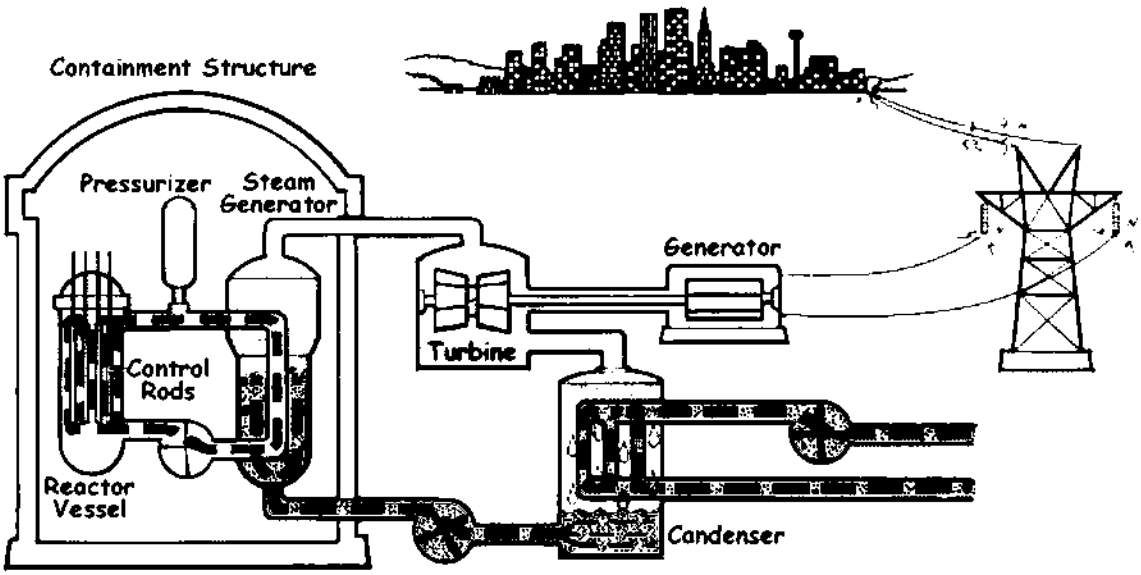

Figure 3: Typical Pressurized Water Reactor

Source: Nuclear Regulatory Commission Website, 2007.

The most common type of reactor in use today is the pressurized water reactor, pictured in Figure 1. In a pressurized water reactor, the water heated in the core is kept under pressure so it doesn't reach the boiling point. The heat in this water is transferred to another "loop" of water which is allowed to reach the boiling point and become steam, subsequently turning the plant's turbine. Though more costly than a BWR, one distinct advantage the pressurized water reactor has is the radioactive water in the process remains in the core and as such doesn't have to be treated before it generates power.[52]

Pressurized heavy water reactors (PHWR) use water that has deuterium in its molecular structure and is thus heavier than ordinary water, consequently serving as a better moderator. Heavy water reactors are structured much like regular pressurized water reactors. The main difference, and a distinct advantage of a HWR, is the heavier water allows for the use of natural uranium for fission because of the excellent

[52] Enger and Smith, 223.

moderating properties of the heavy water.[53] In terms of the nuclear fuel cycle, heavy water reactors can essentially skip the enrichment step, which serves as a huge cost reduction and makes the entire process much simpler. Also in this vein are gas cooled reactors (GCR). Again similar in structure to a PWR, the gas cooled reactor uses carbon dioxide as a coolant, graphite as a moderator, and is able to use natural uranium as fuel.[54]

Some nuclear reactors actually produce more fuel than they consume. Known as breeder reactors, these reactors use a liquid sodium moderator. The liquid sodium allows the neutrons to move faster than water does, allowing for the formation of plutonium in the fuel rods as the chain reaction takes place. After about 10 years of operation, a typical breeder reactor has produced enough fuel to power a second reactor. Though seemingly efficient, breeder reactors are very costly and have many safety issues, most of which are related to the liquid sodium. As a result, only five of these reactors are in operation worldwide today.[55]

[53] Enger and Smith, 223.

[54] Enger and Smith, 223.

[55] Enger and Smith, 227.

THE VIABILITY OF NUCLEAR POWER

> The United States knows that peaceful power from atomic energy is no dream of the future. That capability, already proved, is here--now--today. Who can doubt, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, that this capability would rapidly be transformed into universal, efficient, and economic usage.[56]
>
> -Dwight Eisenhower
> December 5, 1953

President Dwight Eisenhower's vision of universal nuclear power has yet to be realized; indeed it may never be. Though nuclear power has always held promise, many factors have prevented nuclear power from being more fully utilized for power production.

Nuclear energy currently accounts for approximately 17.5% of world electricity production.[57] In Europe, nuclear power accounts for almost 30% of electricity generated. France is the country most dependent on nuclear power in the world, with 80% of its power generated through nuclear means.[58] Nuclear energy accounts for varying portions of electricity production in other developed parts of the world. Startup costs for nuclear plants are high, but once up and running they can produce energy more cheaply than fossil fuel based power plants.

Because peaceful use of nuclear energy was borne of nuclear weapons research, nuclear power has always been overshadowed by the stigma of real or potential weapons production. One of the main reasons that the United States does not reprocess spent

---

[56] Dwight D. Eisenhower, speech given to the United Nations, 8 December 1953, URL: <http://www.eisenhower.archives.gov/atoms.htm>, accessed 4 March 2007.

[57] "International Energy Agency Key World Energy Statistics 2006," Web-only database, 2006, URL: <http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2006/key2006.pdf>, accessed 4 March 2007.

[58] "International Energy Agency Monthly Electricity Statistics, November 2006," Web-only database, November 2006, URL: <http://library.iea.org/Textbase/stats/surveys/mes.pdf>, accessed 4 March 2007.

nuclear fuel is because of the possibility for the plutonium created in reprocessing to be used in weapons. Aside from safety concerns, this dual use nature of breeder reactors makes them an unattractive political alternative.

Another reason nuclear power is not more prevalent is safety. Though rare, accidents at nuclear power plants can have huge ramifications. The main danger in nuclear power plant accidents is the release of radiation into the atmosphere. For efficiency, most plants are located close to the population centers that they service, magnifying the potential danger of a radiation release. For example, the Indian Point nuclear plant is located on the Hudson River, less than 30 miles from downtown New York City.

High profile accidents at nuclear power plants have heightened public awareness of the dangers of nuclear power and, in the case of the United States, made nuclear power an unpopular method of electricity generation. The worst nuclear accident in US history was the near core meltdown of Reactor 2 at the Three Mile Island nuclear facility near Harrisburg, Pennsylvania in 1979. Though no deaths or injuries were ultimately attributed to the accident, it turned into a public relations nightmare for US nuclear power. Since 1978, no new orders for nuclear power plants have been placed in the US and many existing orders were cancelled notwithstanding the huge economic cost of abandoning a plant already under construction.[59] Seven years after Three Mile Island, a far worse accident at the Chernobyl nuclear plant in what is now Ukraine heightened global awareness of the dangers of nuclear power. Radiation released from Chernobyl spread over a wide geographic area. Thirty-one deaths were immediately attributable to

[59] Montgomery, 338.

the accident, though the long term health and environmental implications for the region are likely to be far worse that the initial human toll.[60]

Though tragic, accidents like the one at Chernobyl are rare in the history of nuclear power. In fact, Three Mile Island and Chernobyl remain the only accidents of consequence globally in over 12,000 reactor years of operation.[61] A 1970's study projected accidental deaths from a typical nuclear power plant at 0.2 per year, though admittedly little data existed at the time to support this assertion. A like-sized coal power plant's accidental death rate is much higher at around 4 per year.[62]

Aside from accidents, nuclear power plants are also perceived as excellent targets for terrorism. The potential for release of nuclear radiation is certainly fear-inducing in any population, and nuclear infrastructure is a high profile target. However, the likelihood of any type of terrorist attack being able to penetrate the containment vessel of a modern nuclear reactor is extremely low. Numerous studies have shown that even flying a jet aircraft into a nuclear reactor would not result in the breach of the containment facility, and even if this were possible, the resultant release of radiation would have minimal effect. Nuclear power plants remain much more resistant to terrorist attacks than other energy infrastructure.[63]

Another object of terrorist activity could be the spent fuel and other radioactive wastes found at nuclear power plants and storage sites. This nuclear waste has the

---

[60] Montgomery, 336.

[61] "Safety of Nuclear Reactors," Web-only essay, January 2007, URL: <http://www.world-nuclear.org/info/inf06.html>, accessed 5 March 2007.

[62] Montgomery, 337.

[63] "Safety of Nuclear Reactors."

potential to be used in a so-called dirty bomb. A dirty bomb is one in which conventional explosives are used to spread the radiation in the nuclear waste. Even though this scenario has been popular in media speculation, the difficulty involved in obtaining, transporting, and fabricating appreciable quantities of nuclear waste into a bomb while being exposed to the intense radiation in nuclear waste makes this scenario an unlikely one.[64]

Its drawbacks notwithstanding, nuclear power could experience resurgence in the future. Though uranium is technically a non-renewable resource, the supply of uranium that can be economically removed from the Earth would provide for a virtually unlimited supply of nuclear fuel. Moreover, uranium resources are not concentrated in regions of the world prone to political turmoil, like fossil fuels are. Further, when compared to other alternate sources, nuclear energy provides a continuous source of power, unlike other forms of alternate energy such as solar and wind power that depend on the environment.[65]

In the current debate surrounding carbon emissions and global warming, nuclear power is generally seen as a clean alternative. Aside from nuclear waste, which is not introduced back into the environment, nuclear power plants are relatively pollution free. They do put large amounts of water vapor, a greenhouse gas, into the atmosphere. However, since the amount of water vapor that the atmosphere can hold is relatively

---

[64] Lewis Z. Koch, "Dirty Bomber, Dirty Justice," *Bulletin of the Atomic Scientists*, January / February 2004, Ebscohost document ID #11787826, accessed via Ebscohost 5 March 2007.

[65] Eugenio Fernández-Vázquez and Juan Pablo Pardo-Guerra, "Latin America Rethinks Nuclear Energy," Web-only essay, 12 September 2005, URL: <http://americas.irc-online.org/am/558>, accessed 7 March 2007.

constant, this is not a large concern. The emissions from nuclear power generation are on par with wind and solar power.

The other big pollution concern from nuclear power is thermal pollution. Water used to cool and moderate nuclear reactions is eventually introduced back into the environment. Usually this water is warmer than the lake or river it is put into, and this can have adverse effects. On the whole though, nuclear power is relatively clean. It is feasible that a non-nuclear power state could start a program under the guise of wanting to reduce greenhouse gas emissions. Hugo Chavez justified his May, 2005 announcement that Venezuela would begin research into nuclear power by highlighting a need to diversify Venezuela's energy sources, curb global warming, and find alternatives to fossil fuels.[66]

NUCLEAR POWER IN LATIN AMERICA

Argentina, Brazil, and Mexico all maintain nuclear power programs; however nuclear energy does not play a major role in the overall energy production for any of these states. While energy production from nuclear sources is well under 10% for each of these countries, it is important to catalog each country's nuclear program as the potential for proliferation exists in one form or another wherever nuclear power is generated.

[66] Fernández-Vázquez and Pardo-Guerra "Latin America Rethinks Nuclear Energy."

Nuclear Power in Argentina

Argentina maintains two nuclear reactors that meet approximately 10% of the country's energy needs. The Atucha-1 plant, located near Buenos Aires, was constructed by Siemens and completed in 1974. Atucha-1, a PHWR, has a capacity 335 megawatts (MW) of power. Embalse, the second reactor, is located on the Rio Tercero Reservoir in Cordoba province. It was constructed by Canada Deuterium Uranium (CANDU), a consortium of companies from Canada. With a capacity of 600 MW, Embalse has nearly double the capacity of the Atucha-1 reactor. Argentina also initiated construction of a second reactor by Siemens at Atucha with a capacity of 600 MW. However, due to a lack of funding, this reactor is only 81% complete. Though there is no current expected completion date, a feasibility study for completion of the reactor was undertaken in 2003 and the state is currently exploring financing options. Argentina also maintains six research reactors.[67]

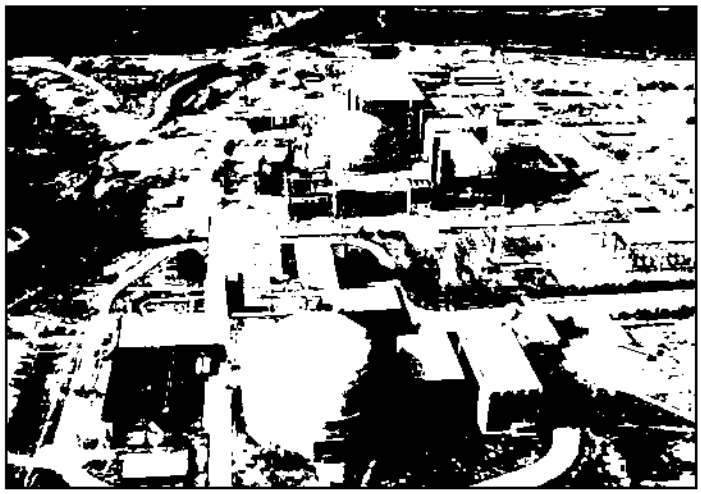

Figure 4: Argentina's Atucha-1 Plant

Source: CNEN Website.

Argentina possesses the most advanced nuclear research and development capability in Latin America. The country's Nuclear Regulatory Authority (ARN),

[67] "International Atomic Energy Agency Country Report: Argentina," Web-only report, December 2004, URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/ CNPP_Webpage/ countryprofiles/Argentina/Argentina2004.htm>, accessed 15 March 2007.

maintains high educational standards for operators in its nuclear industry. This manifests itself in three universities that offer courses and majors in subjects such as nuclear engineering and nuclear reactor design. Argentina's nuclear intellectual sector is so well developed that is a large exporter of nuclear materials and services. Its main nuclear exports are research reactors and radioisotopes, which are mainly for industrial and medical use. In addition, CNEA and INVAP are active in development of the Central Argentina Modular Reactor (CAREM) project. CAREM represents an efficient PWR design, and is a reference design for the International Atomic Energy Agency's (IAEA) International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).[68]

In general, Argentina has a healthy nuclear industry. Its power plants have had no accidents and have been relatively problem free. Nuclear power provides for a very cost effective means of energy production, and electricity generated by both nuclear reactors is very competitive in Argentina's privatized energy sector. Though no plans for future nuclear power exist past the potential completion of Atucha-2, the nuclear power option is a viable one for Argentina's future.

Nuclear Power in Brazil

Brazil maintains two nuclear reactors that provide for around 4% of its energy needs. Its first reactor, Angra-1, was commissioned in 1970 and constructed by Westinghouse Electric Corporation of the United States between Rio de Janeiro and Sao Paulo. Commencing operation in 1984, Angra-1 is a PWR and is capable of producing 626 MW at peak capacity.

[68] "International Atomic Energy Agency Country Report: Argentina."

In 1975 Brazil embarked on an ambitious plan to build eight 1300 MW nuclear reactors. Through a technology transfer agreement with the Federal Republic of Germany, work on the first two reactors, Angra-2 and Angra-3, was started almost immediately. The bulk of the parts for both of these reactors came from Kraftwerk Union, a West German company. Due to various issues, including economic woes in Brazil, the project with West Germany stalled and was ultimately never completed. Angra-2, a PWR with a capacity of 1270 MW, finally came online in 2000 following a re-organization of Brazil's nuclear industry and an economic upturn for the country. Angra-3 stands at 70% completion. Feasibility studies have been drafted for its completion, though as yet none has been approved or acted on. In addition to its two power generating reactors, Brazil maintains four research reactors.[69]

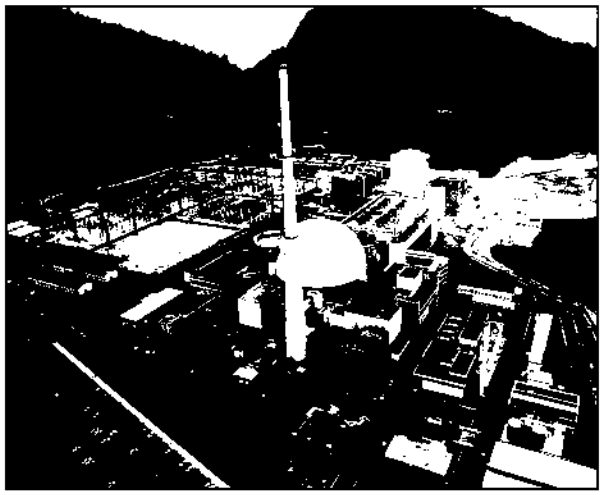

Figure 5: Brazil's Angra-2 Plant

Source: www.schillerinstitute.org.

Like Argentina, Brazil maintains a healthy research and development capacity in the nuclear field. CNEN has over 2,500 personnel dedicated directly to research and development, and works through various universities in Brazil to educate its nuclear professionals. Half of CNEN's researchers hold college degrees, with 25% of these degrees being at the master's level or higher. These researchers take part in Brazil's

[69] "International Atomic Energy Agency Country Report: Brazil," Web-only report, December 2004, URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/ CNPP_Webpage/ countryprofiles/Brazil/Brazil2004.htm>, accessed 15 March 2007.

efforts with the International Reactor Innovative and Secure (IRIS) program. The IRIS program is centered on producing a small, economic, safe, and environmentally friendly PWR reactor. Among its more desirable characteristics is that IRIS is not a type of reactor that is prone to proliferation.[70]

Brazil's generation of electricity is heavily dominated by hydroelectric power generation. Supplying over 83% of the country's electricity needs in 2004, the prevalence of hydro power would seem to preclude the expansion of Brazil's nuclear industry. However, since hydro power is dependent on water flow it is subject to the environment. Less than average rainfall means less power generation, and Brazil experienced a drought in 2001 that resulted in electricity rationing and rolling blackouts. In addition, Brazil's demand for energy as the country's population and economy has grown has outpaced its power sector's ability to provide electricity.[71] As nuclear energy is not dependent on the environment and Brazil already has nuclear know-how, this may present an attractive option for electricity generation in the future. The first step in this direction would be restarting construction of Angra-3, though as of March, 2007 no official decision has been made on this issue.

Nuclear Power in Mexico

Mexico's nuclear program is less robust than either Argentina or Brazil, boasting two reactors responsible for 4% of the country's energy needs. Both reactors are part of the Laguna Verde Nuclear Power Plant. Laguna Verde-1 is a BWR with a capacity of

[70] "International Atomic Energy Agency Country Report: Brazil."

[71] "Energy Information Association Brazil County Analysis Brief," Web-only brief, 2005, URL: < http://www.eia.doe.gov/emeu/cabs/Brazil/ Electricity.html>, accessed 19 March 2007.

680 MW that was put into operation in 1990. Laguna Verde-2 was put into operation in 1995 and is identical to Laguna Verde-1. Both reactors were constructed by General Electric of the United States. Mexico maintains a minimal nuclear research and development capability; it is essentially able to maintain its nuclear power plants. It has research agreements with the United States and imports a significant amount of nuclear knowledge.[72]

Nuclear power would not appear to have much of a future in Mexico. In fact, Laguna Verde was nearly shut down early in this century as the energy it was producing was not profitable in the country's energy market. However, Mexico's energy industry is heavily reliant on fossil fuels and the state has publicly stated the need to diversify. Though still an energy exporter, Mexico is facing rapidly increasing demand for energy as are many developing nations. Mexico's Energy Ministry recommended in late 2006 that the country construct a second nuclear power plant and opened bidding on two new reactors for the plant, which could begin operation as early as 2010.[73]

Figure 6: Mexico's Laguna Verde-1 Plant

Source: http://www.ajenm.org.mx/.

[72] "International Atomic Energy Agency Country Report: Mexico," Web-only report, December 2004, URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/ CNPP_Webpage/ countryprofiles/Mexico/Mexico2004.htm>, accessed 15 March 2007.

[73] "Energy Information Association Mexico County Analysis Brief."

Cuba's Failed Nuclear Power Program

Cuba possesses two partially completed nuclear reactors at its Juragua nuclear power facility. The Juragua reactors are Soviet designed PWRs commissioned in 1983 in a joint Cuban-Soviet venture to bring nuclear power to Cuba. That the reactors are not completed is due to many factors, chief among them the collapse of the Soviet Union and resultant economic woes for Cuba. Although the reactors are in the same family as the Chernobyl reactor they are more advanced and considered safer.

Figure 7: Cuba's Juragua Site

Source: www.cubamcud.org

Nonetheless safety concerns also plagued Cuba's reactors from their inception. The potential for restarting work on the reactors, at an estimated completion price tag of around 1 billion dollars, resurfaced in the late 1990s and caused concern among nuclear watchdogs. However, Fidel Castro put what seems to be a permanent end to the project, choosing instead to pursue more economic forms of alternate energy. There appears to be no future for nuclear power in Cuba.[74]

Though no other states in Latin America have nuclear infrastructure or are pursing nuclear power, the possibility this may occur in the future exists. Latin American states are generally considered developing states. In other words, they are undergoing important demographic changes. In many Latin American states the birth rate far

[74] Pascal Fletcher, "Cuba rejects Russian nuclear plant offer," *Financial Times*, 19 December 2000, Proquest document ID# 65278301, accessed via Proquest 20 March 2007.

exceeds the death rate, leading to quick population increases that put pressure on region's resources. Chief among these pressures is an ever increasing demand for energy. Hugo Chavez has been able to gain large amounts of influence in Latin America is through his PetroCaribe energy subsidy program whereby he provides cheap energy to other states. The long term forecast has demand for energy in Latin America increasing 75% by 2030. In the same timeframe, demand for electricity will increase over 140%.[75]

The need for more energy will result in the increased use of most if not all current energy technologies in the region. Nuclear power, efficient and relatively friendly to the environment, could be an option for states that do not currently use it. Chile provides an excellent example. Chile decided not to pursue nuclear power after exploring the option in the 1970s. However, its current situation has led Chile to once again ponder using nuclear power. Chile's use of natural gas has risen to 25%, meaning that it is extremely vulnerable to the Argentine natural gas market, from which it draws most of its imports. Chile's economy is heavily dependent on copper mining, which consumes large amounts of energy. Chile has virtually no energy resources of its own and instead must rely on other states. Thus Chile has the motivation to create and maintain an energy source of its own, with nuclear power being an attractive option. To that potential end, the Chilean government stated in March, 2007 that it would set up a commission to explore nuclear power.[76]

---

[75] "Future development and poverty reduction tied to gains in renewable energy, says IDB President," Inter-American Development Bank Press Release, 18 March 2007, URL: <http://www.iadb.org/NEWS/articledetail.cfm?artid=3691&language=En>, accessed 21 March 2007.

[76] Gideon Long, "Strapped for Energy, Chile Looks at Nuclear Option," Reuters News Service, 12 March 2007, URL: <http://www.planetark.org/dailynewsstory.cfm/newsid/ 40789/story.htm>, accessed 21 March 2007.

NUCLEAR WEAPONS

To better understand the ability of states to create or procure nuclear weapons, a basic understanding of these devices is necessary. States attempting nuclear proliferation can take a variety of avenues to this end. Existing nuclear energy infrastructure can be used to mask and pursue a weapons program, a course charted by the likes of India and Pakistan. States may take a more direct route, forgoing the veil of nuclear power and striving directly for weapons production. Though not likely an action that would be condoned by the international community today, this is the path chosen by the United States in the 1940s. More recently, a new type of proliferation has come into play. The breakup of the Soviet Union and subsequent issues involving the safeguarding of its nuclear materials allow for the possibility that states or transnational groups could attempt to purchase nuclear weapons or material on the black market or even steal this material. The exposure of the A.Q. Khan network shows the reality of this type of proliferation. Still another proliferation possibility involves the transfer of weapons from nuclear states to non-nuclear states or entities.

According to Richard Garwin and Georges Charpak in their work *Megawatts and Megatons*, there are a few basic requirements for the actual production of nuclear weapons. First and foremost is the brain power necessary to mount such an undertaking. States in possession of nuclear power programs have much of the requisite knowledge already. Garwin and Charpak argue that there are plenty of out of work nuclear engineers in the wake of the break-up of the Soviet Union that could be available to assist a program. Moreover, they argue that the information sharing arrangements created under the NPT actually serve to encourage the transfer of knowledge concerning weapons

production. Other key nuclear weapons components include: chemical explosives; a neutron source for initiating the chain reaction; and finally, either plutonium or enriched uranium.[77]

Because of their densities, either U_{235} or PU_{239} makes the best fissionable material for nuclear weapons. U_{235} must be enriched until it is approximately 80% pure to be usable in weapon production. Depending on the design of the weapon, as little as 34 kg of uranium is needed.[78] Running a nuclear power program is not tantamount to creating highly enriched uranium (HEU). States desiring to create a weapon using HEU either need facilities capable of this high level of enrichment or the ability to acquire uranium that has already been enriched to this level.

The potential to use plutonium for the manufacture of weapons presents many challenges for those wishing to curb proliferation. On the one hand, it is not an easy material to handle and is thus not the preferred bomb-making material for would be proliferators. On the other hand, small quantities of plutonium, as little as 4 kg, are sufficient for weapons production. A typical nuclear power reactor produces this amount of plutonium in a normal week of operation. Over time, though, the different types of plutonium produced in the fission reaction serve to dilute the effectiveness of the weapons grade plutonium that collects in spent fuel rods. The typical life of a nuclear reactor core is 4 years. One way to avoid the dilution of weapons grade plutonium in spent fuel is to shorten the fuel cycle down to about 7 months, leaving a much higher

[77] Garwin and Charpak, 312.

[78] Garwin and Charpak, 58.

grade of plutonium in the spent fuel. HWRs are particularly suited for this type of shortened fuel cycle.[79]

Nuclear weapons employing fission are the most basic of nuclear weapons and thus the most likely to be proliferated. Fission weapons bring together enough material to sustain a chain reaction and do so in a short amount of time. An inefficient but relatively easy to create fission weapon is the gun design. Pieces of fissionable material are brought together in a barrel by a propellant, while a neutron is injected at the right instant to start the chain reaction. This technique requires about 60 kg of enriched uranium. Though not widely used today, the design of such a weapon would likely not require testing before employment.[80] This configuration has obvious advantages for potential proliferators. South Africa's clandestine weapons program produced six gun-type nuclear weapons before it was voluntarily dismantled.

Plutonium is not suitable for gun-type nuclear weapons, thus the more efficient implosion technique was designed. Implosion, whereby a sphere of fissionable material is compressed by explosives placed on the outside of the sphere, is the preferred designed for fission weapons. Implosion weapons have higher yields than gun type weapons and also require less fissionable material. Implosion weapons can be created with as little as 6 kg of plutonium or 34 kg of U_{235}.[81]

Other nuclear weapons designs exist, including boosted fission weapons, hydrogen bombs, and neutron bombs. These weapon types have increased yields though due to their complexity are not likely to serve as entry level nuclear weapons for would-

---

[79] Garwin and Charpak, 314-315.

[80] Garwin and Charpak, 59.

[81] Garwin and Charpak, 60.

be proliferators. Thus the inner-workings of these types of weapons will not be discussed in the scope of this work.

NUCLEAR PROLIFERATION

Since the dawn of the atomic age in 1945, nuclear proliferation has been slow. Technological challenges, the huge economic cost of running a nuclear program, and the nuclear non-proliferation regime have kept the number of members in the nuclear club relatively low. The United States, the former Soviet Union, France, Great Britain, and China all had nuclear weapons programs by 1964. In the years since, only India, Pakistan, and North Korea have conducted nuclear weapons tests. Israel is widely believed to have a nuclear program, though there has been no official acknowledgement of it. South Africa at one point produced nuclear weapons, but voluntarily dismantled its program before revealing it to the world.[82] Some states of the former Soviet Union instantly became nuclear powers when the Soviet Union dissolved, but all have since given their weapons to Russia. Still other countries, like Brazil and Argentina, possessed or are thought to have possessed weapons programs but voluntarily abandoned these programs before actually producing a weapon.

Thus the nuclear non-proliferation regime has remained fairly strong. Recent events, however, call the strength of global non-proliferation into question. Despite considerable international pressure not to, North Korea conducted a nuclear test in October 2006. Iran continues to pursue what appears to be a program geared towards

[82] Roy E. Horton, III, "Out of South Africa: Pretoria's Nuclear Weapons Experience," United States Air Force Institute For National Security Studies Occasional Paper #27, August 1999, URL: < http://www.fas.org/nuke/guide/rsa/nuke/ocp27.htm>, accessed 7 March 2007.

nuclear weapons even though it has been referred to the United Nations Security Council and unanimously sanctioned by that body. And in what many, including Brazil, consider hypocrisy the US tacitly accepted the nuclear revelations of states like India and, more recently, Brazil. These events, combined with the uncertainty of the current global security situation, could signal a change in the nuclear attitudes of many states. The most likely regions for proliferation are East Asia, in reaction to North Korea's nuclear capability, and the Middle East to counter Iran's pursuit of a program. Nor is it out of the question to hypothesize situations in which Latin American countries choose to pursue nuclear weapons, which is the focus of later chapters of this work.

Why States Choose the Nuclear Option

In his work *Ballistic Missile Proliferation,* author Aaron Karp does an excellent job addressing the many differing issues of proliferation. While his work centers around missiles as delivery systems rather than focusing on nuclear weapons, his points are germane to any discussion of proliferation. Rather than merely cataloging proliferation and explaining its technical basis, Karp chooses to undertake an examination of the motivations and forces behind it. In doing so, he helps put proliferation into its proper context. Karp chooses to examine different schools of thought on the question of proliferation. One school of though, technological determination, essentially holds that development and spread of new weapons is unstoppable and that governments are compelled to pursue major weapons whether not they are in that government's best interest.[83] Political determination, on the other hand, holds the position that a variety of

[83] Aaron Karp, *Ballistic Missile Proliferation* (New York: Oxford University Press, 1996), 10-11.

mainly internal political interests drive a state to pursue weapons. A derivative of both of these schools of thought is that arms races between states drive proliferation.[84] Karp's ultimate conclusion is that the answer to this question contains elements from each opinion; he also caveats this by stating that proliferation is not an inevitable consequence of any element or their combined effects.[85]

A comprehensive examination of specific factors behind nuclear proliferation is found in *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*. The authors explore the reasons non-nuclear states may choose the path of proliferation in the future. They break the potential reasons for future proliferation into five categories:

1) a change in the direction of US foreign and security policy;
2) a breakdown of the global nuclear non-proliferation regime;
3) the erosion of regional or global security;
4) domestic imperatives;
5) the increasing availability of technology.[86]

These categories provide a logical basis for exploring potential proliferation on the part of Brazil and Venezuela. As such, a brief exploration of each is warranted.

Direction of US Foreign and Security Policy. US attitude and action towards nuclear deterrence and non-proliferation guides the nuclear agenda of many states, regardless of their allegiance or ties to the US. These states count on aspects of US policy when considering their own policy and / or making nuclear decisions. In today's constantly changing security environment, actions the US has taken could erode the

[84] Karp, 13-14.

[85] Karp, 201.

[86] *The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices*, eds. Kurt M. Campbell and others (Washington, D.C.: Brookings Institute Press, 2004), 20.

perception of security the US fosters in other states. For example, US justification of pre-emptive war marks a huge shift in US foreign policy, and understandably complicates global perceptions of US intentions. Contributing to the idea that the US is becoming more focused on its own security are actions like its withdrawal from the 1972 Anti-Ballistic Missile (ABM) treaty, among others.[87] To be fair, that treaty was a relic of the Cold War. The US justified the withdrawal from it by expressing a desire for self-preservation after the 9/11 attacks. One of the centerpieces of US defense against future nuclear threats is the National Missile Defense, and using missiles for homeland defense is counter to provisions of the ABM.[88]

A more inwardly focused US could result in nuclear proliferation if states no longer feel confident in their own security. The recent nuclear detonation by North Korea prompted talks of nuclear development in, among other places, South Korea and Japan. If these states perceive that the US cannot provide for their security they may feel justified in pursuing a nuclear weapons program. The security environment in the Middle East, always tenuous, is currently more so because of Iran's undisguised nuclear ambitions and the seeming inability of the international community to curb same. Even a non-nuclear arms race could fuel nuclear tensions if the US proves unwilling or unable to control it; this is a potential nuclear proliferation scenario for Latin America.

A Breakdown of the Global Non-Proliferation Regime. Nuclear weapons are considered anathema to most of the global community, and nuclear intentions are

---

[87] *The Nuclear Tipping Point*, 20-21.

[88] "ABM Treaty Fact Sheet," statement by the White House Press Secretary, 13 December 2001, URL: < http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html>, accessed 12 April 2007.

generally met with international condemnation and scrutiny. However, the penalties for nuclear acts have been minor to non-existent. Most of the newest members of the nuclear club, including India, Pakistan, and Israel, received little punishment upon either testing or admitting to possessing nuclear weapons. Likely dampening US and global reaction to these nuclear revelations was the fact that the US has important security interests with each of these states.[89]

The international reaction to both North Korea's recent nuclear test and Iran's pursuit of nuclear capability has been decidedly harsher than it was for the three aforementioned states. Contributing to this reaction is the fact each state is seen as a so called "rogue" state. The perception is that nuclear weapons in the hands of North Korea of Iran are decidedly more dangerous than in the hands of more stable states like India. Also, the US sees each state as a security risk rather than partner and as such the decision to condemn the actions of each is not a hard one. Nonetheless, current international action against each state amounts to little more than slaps on the wrist for each. The high standing of some recent nuclear club members in the eyes of the US and international community and the lack of real punishment for others may signal to potential proliferators the political cost of pursuing nuclear weapons is not too great to overcome.[90]

Eroding Regional or Global Security. The previously mentioned factors can contribute the perception or reality that security at different geographic levels is becoming weaker. States may look to shore up this weakness by pursuing nuclear

---

[89] *The Nuclear Tipping Point*, 24.

[90] *The Nuclear Tipping Point*, 24.

weapons. Nuclear weapons can be seen as one option, albeit an extreme one, for restoring or shifting the balance of power between a state and its rivals.[91] Historic nuclear proliferation has often occurred between neighbors or at least regional rivals. India and Pakistan represent a good example of this type of proliferation, as do the failed nuclear programs of Brazil and Argentina. There are many potential scenarios in Latin America that could encourage nuclear proliferation along similar lines.

Domestic Imperatives. States undergoing some type of decline, such as economic trouble or political upheaval, are likely to look for options that halt or slow that decline and improve the state's security situation. Likewise states that aspire to global power or at least increased global standing may look for similar options. An obvious, though perhaps not easy, choice to accomplish these goals is the nuclear option.[92] Although it would seem that global or at least regional concerns would dominate the decision by a state to pursue proliferation, domestic concerns can certainly be a driving factor behind such a decision. There are many factors behind Iran's current pursuit of nuclear weapons, and many of them seem to be domestic in nature. Iran's desires to be a regional power and larger player on the global stage, or to at least garner some serious international attention, are internal in nature and helping to drive the state's nuclear ambitions. It is not a stretch to see Venezuela or even Brazil pursing nuclear weapons for many of the same reasons. Venezuela's economic situation is another factor that could result in a decline in its regional influence and power, and the country may soon need to explore ways to keep its power from eroding.

---

[91] *The Nuclear Tipping Point*, 25.

[92] *The Nuclear Tipping Point*, 27.

Increasing Availability of Technology. The development of a nuclear weapons program from the ground up takes large amounts of resources and time. The availability of resources remains one of the big reasons there are so few members of the nuclear club. Most states simply can't afford a complete nuclear program unless they are willing to pull from other sectors of the economy, usually at the expense of their populace. North Korea followed this track in its nuclear development, but in its case the government has almost complete control over a very deprived and easily swayed population. Developing weapons to the detriment of a constituency is much less likely to occur in more open societies.

Two events in particular have moved the idea of nuclear proliferation from a question of state economic means to a matter of locating and acquiring the weapons or their components on the open market. First, the end of the Cold War and the dissolution of the Soviet Union left a significant amount of nuclear material unaccounted for in the former Soviet states. Some of this material has yet to be accounted for.[93] Much of the accounted for material is loosely guarded and remains vulnerable to theft or purchase by those desiring to possess it.

Second, the revelations concerning Pakistani scientist A.Q. Khan and transfer of important nuclear technology for personal gain highlight the difficulty in dealing with the nuclear black market. Nuclear knowledge and equipment is readily available and can be transferred through locations where it is very hard if not impossible to track or otherwise control their movement.[94] Brazil has a well developed nuclear power program; its likely avenue for weapon proliferation would be to develop its own weapons. Venezuela, on

---

[93] *The Nuclear Tipping Point*, 28.

[94] *The Nuclear Tipping Point*, 339-340.

the other hand, has no nuclear infrastructure. If the state truly desires nuclear weapons, it may look to the black market rather than expend the capital to develop its own program.

The Human Factor in Nuclear Proliferation

In his book *The Psychology of Nuclear Proliferation*, Jacques E.C. Hymans puts forth an interesting thesis concerning proliferation. He argues that the decision to pursue the nuclear option is a result of the psychology of the leaders who make these decisions. Further, he states that nuclear decisions are based on a sense of national identity and usually influenced by emotions.[95] Hymans posits that while the states that have acquired nuclear weapons have many diverse characteristics, their leaders all see their national identity from the point of view of what he terms as an "oppositional nationalist." While Hymans' oppositional nationalists perceive an external threat to their states, they also perceive their state to be equal or better than this threat. For the leader in this position, Hymans argues, pursuing the nuclear option is not a last resort, but a question of necessity.[96]

Hymans' typology of national identity conception, or how individual leaders perceive their nations in terms of solidarity and status,[97] actually has four possible iterations. The oppositional nationalist is but one of these. Hymans' thesis is important to this work, as it pertains to the potential for Venezuela to pursue nuclear weapons. Venezuelan President Hugo Chavez seems to perfectly fit the mold of an oppositional nationalist vis-à-vis the United States. In terms of status, while Chavez likely has no

---

[95] Hymans, ix.

[96] Hymans, 2.

[97] Hymans, 18.

delusions about Venezuela's power relative to the United States, he does rally his country around the assertion that they should be considered equal if not better than Americans. For the solidarity component of national identity, Chavez definitely puts his country at opposition to the United States. In his book, Hymans takes four different sets of national leaders through a quantitative analysis of trends and actions in order to better qualify leaders in one of his four categories. This work will not subject Hugo Chavez or Brazilian President Luiz de Silva to quantitative analysis; that may be accomplished in a future work. Suffice it to say that the psychology of national leadership is an angle worth mentioning when examining the nuclear question in Latin America, especially when Hugo Chavez in particular seems to fit neatly into Hymans' definition of a leader likely to pursue nuclear weapons.

THE HISTORY OF NUCLEAR WEAPONS DEVELOPMENT IN BRAZIL AND ARGENTINA

Brazil and Argentina are the only states in Latin America that have seriously attempted to develop nuclear weapons. Both made significant progress, and both voluntarily abandoned their programs in the early 1990s. But the progress each made is important in the study of potential proliferation in Latin America. Of particular import is Brazil's former program. Gauging where it was and why it was abandoned can provide insight into the future of Brazil's nuclear ambitions.

Historical Background

Brazil and Argentina were colonial possessions of Portugal and Spain, respectively. As Portugal and Spain sought to expand their power and influence in the New World, the two colonies naturally developed an adversarial relationship with each other. Both became independent in the early 19th century but the rivalry persisted; it came to a head in 1825 with the first and only war between the two states. Although this conflict was resolved in 1828 by a peace treaty that hasn't been broken since, the two states remained largely at odds. Overtures were made, mainly by Argentina, in the 1940s and 1960s, but with limited success. Major issues between the two, such as questions over the use of the shared watershed of the Parana River, continued to surface. It was not until 1985 that a true thaw in the cool relationship between Brazil and Argentina began.[98]

In the 1950s, a nuclear arms race of sorts became an extension of the rivalry between the Brazil and Argentina. Argentina entered the quest for nuclear autonomy first; Brazil soon followed. The nuclear race between the two was less about compelling national security needs, even with respect to each other, and more about the need for each to keep pace with the other. That neither actually produced a weapon is telling in this respect. In 1980 the two states signed a cooperative agreement on the peaceful development of nuclear power, a potential signal that the nuclear competition was coming to an end. Though this agreement faltered, a more lasting and comprehensive cooperation between the two states began in 1985. The November, 1985 "Joint Declaration on Nuclear Policy" highlighted the peaceful purposes of each state's nuclear

[98] Julio C. Carasales, "The Argentine-Brazilian Nuclear Rapprochement," *The Non-Proliferation Review*, Spring /Summer 1995, URL: <http://cns.miis.edu/pubs/npr/vol02/23/carasa23.pdf>, accessed 17 April 2007.

program and was the first of a number of bilateral agreements between Brazil and Argentina.[99]

Argentina's Nuclear Program

When evaluating a failed or abandoned nuclear program, the first question that generally comes to mind concerns the progress that program made towards nuclear weapons development. In developing their nuclear infrastructure, both Brazil and Argentina made significant progress toward completing the nuclear fuel cycle, the first step in nuclear weapons autonomy. How far each progressed past the previous discussion of their fuel cycles is debatable and remains an item of contention, at least in the scholarly arena.

No direct evidence exists that Argentina actually intended to develop nuclear weapons. However, there is ample circumstantial evidence to suggest Argentina, or at least factions within its military and perhaps its government, pursued weapons development. First and perhaps foremost is its pursuit of the complete nuclear fuel cycle. Also questionable is the fact the Argentinean Navy ran the country's nuclear program. Until agreeing to abide by it in 1995, Argentina habitually opposed the global Nonproliferation Treaty. Finally, the closest physical evidence to the existence of an Argentinean nuclear weapons program is its pursuit of a medium range ballistic missile, the Condor-II.[100]

---

[99] Carasales, "The Argentine-Brazilian Nuclear Rapprochement."

[100] Aaron Karp, "Correspondence: Argentina and the Bomb," *The Non-Proliferation Review*, Spring 2000, URL: < http://cns.miis.edu/pubs/npr/vol07/71/corr71.pdf>, accessed 17 April 2007.

Argentina's Missile Program

Argentina undertook its Condor program in the late 1970s for a variety of reasons, including ongoing territorial disputes with Great Britain and Chile, the prestige of a missile program, the potential to profit from the sale of missiles on the international arms market, and rival Brazil's pursuit of ballistic missiles.[101] Argentina originally received assistance for the Condor from a variety of outside sources, including German, Swiss, and Austrian firms. Early work on the Condor-I missile soon shifted to the Condor-II, a multiple stage missile that could range, among other places, the Falkland Islands. Iraq showed interest in the missile and helped fund the program by funneling money through Egypt. The Condor-II program matured to the point that Argentina constructed a plant for its manufacture near Cordoba in the mid-1980s.[102]

However, outside forces would soon spell the end of the Condor-II program in Argentina. In the late 1980s, the Missile Control Technology Regime (MCTR) was created. Many firms assisting in the development of the Condor-II were located in states party to the MCTR, resulting in the loss of that assistance. After Italy was caught assisting Argentina in violation of the MCTR and an Egyptian-American was caught smuggling potential Condor-II missile components into Egypt, the US placed heavy pressure on Argentina to abandon the program. In May 1991, prompted largely by the end of military government in the wake of the Malvinas War with Britain, Argentina ceased work on the Condor-II.[103]

---

[101] "Argentina Profile: Missile Review," Web-only essay, October 2006, URL: < http://www.nti.org/e_research/ profiles/Argentina/Missile/index.html>, accessed 17 April 2007.

[102] "Argentina Profile: Missile Review."

[103] "Argentina Profile: Missile Review."

Today Argentina retains the aforementioned pieces of its attempt at a nuclear fuel cycle and its nuclear power program. Though each has potential application to a weapons program, there is little or no evidence to suggest any program exists. The country officially maintains no ballistic missiles; though there is speculation that Argentina developed and maintains a stock of a short range (150 km) missile capable of carrying a 400kg warhead.[104] The utility of this missile, the Alacron, for nuclear delivery is questionable. And in what is hopefully a footnote to former nuclear weapons ambitions, Argentina in July 2006 admitted to producing 3.7 kg of weapons grade uranium at a research reactor. The uranium was transferred to storage in the United States.[105]

Brazil's Nuclear Program

Like Argentina, Brazil never actually produced a nuclear weapon, but many of it actions indicated that it was pursing a weapons program. Mirroring the opportunistic strategy of Argentina, Brazil minimized its cost to develop components of the nuclear fuel cycle by seizing on technology when it became available. At least for a time, Brazil's parallel civil power program served as a mask for its weapons ambitions. In 1990, then Brazilian president Fernando Collor de Mello publicized the Brazilian military's bomb making intentions.[106]

---

[104] "Alacran," Web-only essay, 17 April 2007, URL: <http://www.missilethreat.com/missilesoftheworld/id.2/missile_detail.asp>, accessed 17 April 2007.

[105] "Argentina Profile: Missile Review."

[106] "Nuclear Weapons Programs: Brazil," Web-only essay, 18 April 2007, URL: <http://www.globalsecurity.org/ wmd/world/brazil/nuke.htm>, accessed 18 April 2007.

The circumstantial evidence for Brazil's pursuit of a weapon followed the same path as Argentina's. Brazil also sought to complete the nuclear fuel cycle, and nearly has done so. Brazil reluctantly joined the non-proliferation regime in the early 1990s, after years of obstructionist behavior towards it. Brazil also maintained a ballistic missile program, which still is in operation today. Brazil's military has consistently been heavily involved in both its nuclear sector and its development of missiles. Early in its nuclear program Brazil faced the choice of developing nuclear reactors that used natural uranium, but instead it chose the more costly, complicated and less proliferation resistant uranium enrichment process.[107] When Brazil officially began its nuclear power program in the mid-1970's, it justified doing so by stating the program was in response to the 1973 energy crisis. However, Brazil's electricity was and still is produced largely by hydroelectric power. The addition of nuclear power would do nothing, in the 1970s, to reduce Brazil's reliance on petroleum.[108] Ironically, with Brazil's current population explosion and subsequent demand for energy, this rationale for nuclear energy may actually hold water today.

Brazil received its nuclear power plant equipment and knowledge mainly from West Germany which, at the time, was not subject to International Atomic Energy Association control. Brazil took advantage of this lack of control and in 1975 started a weapons program under the code name "Solimoes." Though it failed to produce a weapon, Solimoes took many important steps towards that end, including the enrichment of uranium to 20% and the actual design of two potential nuclear devices. Investigations by Brazil's Congress in the late 1980s revealed the secret bank accounts used to fund the

[107] "Nuclear Weapons Programs: Brazil."

[108] Goldemburg, "Looking Back."

program, as well and the disturbing news that Brazil had transferred over 8 tons of partially enriched uranium to Iraq in 1981.[109]

As a result of Brazil's nuclear past, the state today has a well-developed nuclear infrastructure. It has a number of nuclear research facilities; more importantly, it has a solid core of scientists and engineers to run the country's power program and conduct research. Additionally, Brazil has an ample resource base. Perhaps most important to any future nuclear ambitions, Brazil has the technology, knowledge, and facilities to enrich uranium.[110]

Brazil's Missile Program

Brazil's missile program has reached a much more advanced level than Argentina's, and as the better of the two, is the most comprehensive missile program in Latin America. Just as Brazil's weapons program proceeded under the guise of peaceful nuclear power, its missile program doubles as a legitimate space program. Although Brazil admitted to and formally abandoned its nuclear weapons program, it continues development of its main missile program as a part of its attempt to launch its own rocket into space.

Brazil's space program has many factors driving it. One rationale for the program, especially if it aims to produce a ballistic missile, is Brazil's likely desire for technological independence.[111] This seems to have been a theme in Brazil's nuclear

---

[109] "Nuclear Weapons Programs: Brazil."

[110] "Nuclear Weapons Programs: Brazil."

[111] "Missile Programs: Brazil," Web-only essay, 18 April 2007, URL: <http://www.globalsecurity.org/wmd/world/brazil/missile.htm>, accessed 18 April 2007.

program, and could play an important role if Brazil decides to develop nuclear weapons in the future. This may also help explain why Brazil continued work on missile technology even after Argentina formally abandoned the Condor-II. Another factor behind Brazil's space program is the geographical location of its Alcantara launch center. Because Alcantara is so close to the equator, it provides a significant cost savings as rockets launched there use less fuel to achieve orbit. As a result other states and organizations have used Alcantara, providing a source of revenue for Brazil.

Brazil began work on its primary missile, the Sonda series, in 1965. In 1971, Brazil's missile program was placed under the Brazilian Commission for Space Activities, which ultimately was led by Brazil's military. The Sonda series has progressed up to the Sonda-IV rocket, which as a missile has a range of 600 km and can carry a 500 kg payload. This subjects it to restrictions under the MCTR.[112]

The Brazilian company Avibras exported rocket systems with ranges of up to 60 kilometers in the 1980s. The purchasers of these systems were all Middle Eastern countries, including Iraq. Avibras attempted development of longer ranges missiles based on the Sonda technology for export but never succeeded. The same US pressure and MTCR controls that ended Argentina's Condor-II essentially ended Brazil's time in the rocket and missile export business.

Brazil continued its push for an independent space program, albeit not without questions from the international community. In an attempt to divorce the space program from its military, Brazil established the civilian controlled Brazilian Space Agency (AEB) in 1994. The agency's centerpiece project is the Veiculo Lancador de Satelites

[112] "Missile Programs: Brazil."

(VLS), a staged rocket boosted by Sonda IV technology that is part of Brazil's attempt to put a satellite into orbit. The VLS program has largely been a failure, as two launch attempts failed to achieve orbit and a 3rd rocket exploded on the pad, killing many of Brazil's top space scientists and engineers. The VLS could be used as a ballistic missile, and it would have a range of close to 4000 km if it was. The VLS is propelled by solid fuel, which is not optimal for a ballistic missile.[113] However, Brazil and Russia are jointly developing a VLS variant that is propelled by liquid fuel. Brazil is also cooperating with China on its space program, and has launched two satellites in this venture.

LATIN AMERICA AND THE NUCLEAR NON-PROLIFERATION REGIME

With the notable exception of Brazil and Argentina's attempts to produce nuclear weapons, Latin America has eschewed the pursuit of nuclear ambitions; indeed, nuclear aims are taboo in a region that seems to pride itself in being nuclear weapons-free. Ironically, it was Brazil who, in September 1962, introduced a proposal to the U.N. General Assembly to declare Latin America a nuclear weapon free zone (NWFZ).[114]

Brazil's proposal, aided by the October 1962 Cuban Missile Crisis, eventually resulted in the 1967 Treaty of Tlateloco. Tlateloco established South America and the Caribbean as a NFWZ, the first treaty of its kind to cover populated areas. Moreover, the treaty was an attempt to stop superpower nuclear meddling in the region, as Latin

[113] "Missile Programs: Brazil."

[114] John R. Redick, "Latin America's emerging non-proliferation consensus," *Arms Control Today*, March 1994, Proquest document ID# 5208901, accessed via Proquest 19 April 2007.

American states did not want the US and Russia to turn Latin America into a Cold War nuclear battleground. Aiding in ratification of the treaty was the fact nuclear technology was not well developed in the region, so there was little practical opposition to it. The members of the nuclear club and non-nuclear states with interests in the region ratified the pertinent protocols to the treaty, which helped to legitimize it. [115]

However, states with burgeoning nuclear interests did not ratify the treaty immediately. Brazil, whose proposal to the U.N. pushed the idea of a NFWZ, underwent a military coup in 1964 and had a much different view of the treaty when it came time to sign it. Brazil ratified the treaty, but stated it would not adhere to it until all Latin American nations and states possessing territory in Latin America also ratified. This allowed Brazil to pursue its nuclear ambitions unfettered by formal treaty. Argentina, Chile, and Cuba also failed to ratify Tlatelolco. Moreover, Argentina and Brazil both reserved the right to conduct so-called peaceful nuclear explosions. The combined effect of opposition to the treaty, especially from Argentina and Brazil, lessened its effectiveness for many years.[116] Though there were abstentions from ratifying and caveats to it, the treaty was as important as it was unprecedented. Most signatories to Tlatelolco allowed the provisions of the treaty to immediately go into effect without condition.

In 1979, Brazil and Argentina began cooperation on an unparalleled level. They began by resolving energy and boundary disputes, and in 1980 the two states began formal assistance to each other with regards to the nuclear fuel cycle and also started

---

[115] Redick, "Latin America's emerging non-proliferation consensus."

[116] Redick, "Latin America's emerging non-proliferation consensus."

cooperating on nuclear policy issues. In July 1991, Brazil and Argentina formalized the Brazil-Argentine Agency for the Accounting and Control of Nuclear Materials (ABACC), designed to ensure that nuclear use in the two states remained peaceful.[117] In December 1991, though not signatories to the NPT, the two states agreed to abandon nuclear weapons and testing, set up safeguards that would meet IAEA standards, and implemented a bi-lateral inspection and verification program. The Quadripartite Treaty formalized this arrangement.[118] Another result of the cooperation between the states was the acceptance of the Tlatelolco treaty by both, which served to legitimize that treaty.[119]

Argentina and Brazil essentially agreed to make sure each other remained free of nuclear weapons and their development. Although they both accepted the provisions of Tlatelolco, pressure continued on the two states to formally sign the NPT. Pressure and time are the strengths of the NPT. While it seems powerless to completely stop a leader or regime dedicated to pursuing nuclear weapons, the NPT can and does slow proliferation efforts. Slowed for long enough, states can lose their appetite for weapons. Often this occurs with regime change; and it was ultimately the switch from military to civilian governments that ended the nuclear desires of Argentina and Brazil. For example, the US government under the NPT blocked Brazil's access to important technology, especially high-speed computers. It also either obstructed or did not assist Brazil in efforts to acquire loans from international organizations. These actions helped to slow Brazil's efforts at proliferation until a regime less inclined to proliferation took

---

[117] "Brazilian-Argentine Agency For Accounting And Control Of Nuclear Materials (ABACC), Web-only essay, 8 June 2007, URL: < http://cns.miis.edu/pubs/inven/pdfs/abace.pdf>, accessed 8 June 2007.

[118] Redick, "Latin America's emerging non-proliferation consensus."

[119] Goldemburg, "Lessons from the denuclearization of Brazil and Argentina."

over.[120] In what may signal potential NPT ineffectiveness in dealing with Venezuela, Hugo Chavez has recently taken steps in an effort to keep him and his supporters in power indefinitely.

Latin America remains the strongest non-proliferation region in the world because of its proactive, pragmatic attitude concerning nuclear issues. This will be a significant hurdle that any state in the region seeking nuclear weapons will have to overcome. As the global non-proliferation regime seems to become more circumspect, Latin America's views on proliferation will play a critical role in ensuring the region remains free of nuclear weapons.

[120] Goldemburg, "Lessons from the denuclearization of Brazil and Argentina."

CHAPTER 3

FUTURE NUCLEAR PROLIFERATION IN BRAZIL?

BRAZIL SITUATION UPDATE

Brazil boasts South America's foremost economy, and is acknowledged by most as the preeminent power in the region. Home to a population of over 190 million, Brazil boasts vast natural resources, including uranium, and has the labor base to develop them. Although Brazil's explosive population growth has slowed in recent years, one of its main domestic issues remains a large disparity of income between rich and poor. The country's growth has also presented a host of environmental issues, foremost among them is the deforestation of the country's diverse Amazon Basin.[121]

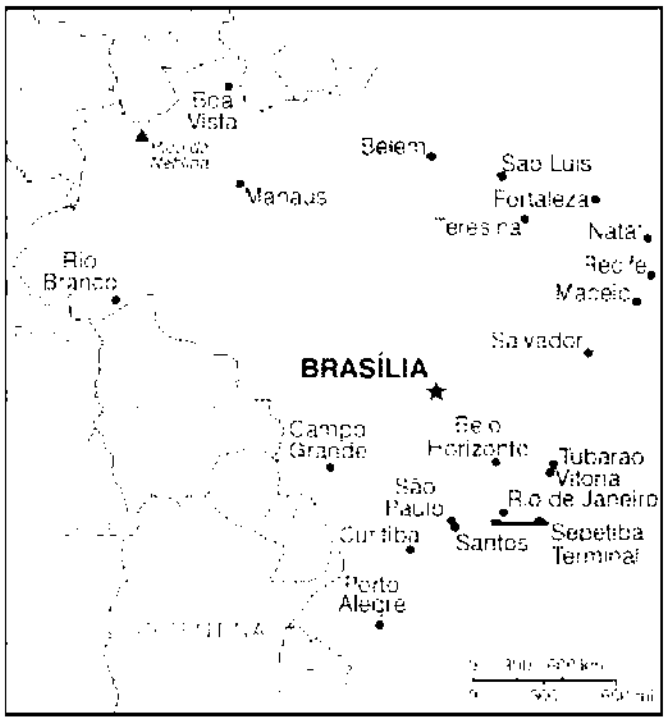

Figure 8. Brazil

Source: CIA World Factbook Online, 2007.

[121] *CIA World Factbook: Brazil*, CIA World Factbook, 10 May 2007, URL: <http://https://www.cia.gov/library/publications/ the-world-factbook/geos/br.html>, accessed 14 May 2007.

For most of the 20th century, Brazil's military played a major role in the governance of the country. This ended in 1985 with a peaceful transition to civilian leadership. It was Brazil's new civilian leadership that exposed its secret nuclear weapons program. After making the program increasingly visible for years, in 1990 then president Fernando Collor both revealed and shut down a nuclear test site at an air force base in Cachimbo Province.[122] It was also during this timeframe that Brazil began to cooperate with and ultimately join agreements such as the NPT, ABM, and MTCR. Under Collor, funding for Brazil's nuclear weapons program and technologies that supported it was cut, effectively terminating the program. With so much invested in the program, this was very unpopular with Brazil's military. In fact, a former head of Brazil's Nuclear Energy Commission (CNEN) claimed that Brazil's military continued to pursue nuclear weapons even after the program was disbanded.[123]

Lula da Silva and the Nuclear Question

Current Brazilian President Luiz Inacio Lula da Silva (Lula) was elected for a second time in October, 2006. A clear victor in the election, Lula carried over 60% of the popular vote.[124] Lula was the founded the socialist Brazilian Worker's Party (PT) in 1980, and his social programs have always been popular with Brazil's voters. However, the revolutionary views of Lula and the PT were tempered by three straight losses in national elections. Lula was finally elected in 2002 after taking steps like building a

---

[122] "Brazil's Nuclear History," *Arms Control Today*, October 2005, Proquest document ID# 924378651, accessed via Proquest 14 May 2007.

[123] "Brazil's Nuclear History."

[124] *CIA World Factbook: Brazil.*

coalition that included a right wing party and running as more of a social democrat than a revolutionary.[125] Though reluctant to share power during his first term, Lula's actions to this point in his second term indicate that he sees reaching out to all parts of his diverse government as key to advancing his agenda. He nominated a diverse cabinet that was popular with Brazil's legislature even though in doing so he weakened his own party considerably. Lula remains a popular leader and currently wields considerable power.[126]

During his presidential campaign in 2002, Lula questioned Brazil's membership in the NPT, asking "Why is it that someone asks me to put down my weapons and only keep a slingshot while he keeps a cannon pointed at me? Brazil will only be respected in the world when it turns into an economic, technological, and military power."[127] This statement prompted concern that Lula would attempt to revive Brazil's nuclear weapons program. However, he has not attempted to do so overtly, and even at the time his statement was seen both as pandering to the Brazilian military whose support he needed and also as a method to highlight his issues with the NPT.[128]

---

[125] "Profile: Luiz Inacio Lula da Silva," *The Economist*, online ed., 30 October 2006, URL: <http://news.bbc.co.uk/1/hi/world/americas/5346744.stm>, accessed 14 May 2007.

[126] "The Americas: Lula opts for a quiet life; Brazil," *The Economist*, 7 April 2007, Proquest document ID# 1250702411, accessed via Proquest 11 May 2007.

[127] Michael Flynn, "A Latin 'Axis of Evil?'" *Bulletin of the Atomic Scientists*, Oct/Nov 2003, Proquest document ID# 274909151, accessed via Proquest 14 May 2007.

[128] "A Latin 'Axis of Evil?'"

Brazil's Military and Nuclear Development

Brazil's military was heavily invested in Brazil's abandoned weapons program, and remains so in Brazil's missile and space program. If Brazil chooses to pursue nuclear weapons in the future, the effort will almost certainly be led by its military.

In 1979, the Brazilian Navy's Special Projects Commission (COPESP) began the development of a nuclear reactor suitable for submarine propulsion and also began looking into the enrichment of uranium. The Brazilian Army began development of a reactor suitable for plutonium production, and its air force looked into both enrichment techniques and breeder reactors.[129] The end of Brazil's nuclear program in 1990 meant, among other things, less funding for each of its military services involved in the process.

Brazil's Navy continues its research into nuclear propulsion for its submarines. In May 2004, the navy received $7.8 million to complete a prototype of a submarine reactor. It plans to have a contract for the new vessel by 2009, with production complete on the first ship by 2018.[130] Brazil's Army and Air Force have been less active in the nuclear technology arena, although the Air Force is heavily invested in Brazil's space program. The main launch vehicle in Brazil's space program has the potential for dual use capability as a ballistic missile.

Brazil's Nuclear Program: Recent Developments

Brazil continues to pursue its goal of achieving autonomy in the nuclear fuel cycle. Most of the recent pursuit of this aim have centered on the previously discussed

---

[129] "Brazil's Nuclear History."

[130] "Brazil Accelerates Nuclear Reactor Work For Nuclear Submarine Program," *Arms Control Today*, July 2004, Proquest document ID# 660598721, accessed via Proquest 14 May 2007.

enrichment facility at Resende, which continues its run-up to full capacity. Brazil has been less than cooperative with the IAEA in terms of inspections at Resende. An agreement was worked out between the IAEA and Brazil over Resende in 2005. However, as part of that agreement workers at Resende constructed a physical barrier around its centrifuges, which keeps IAEA inspectors from viewing them. Ostensibly this screen, similar to one the Brazilian Navy also has at a research reactor, is designed to protect the centrifuge technology being utilized by Brazil. It may also hide the source of the centrifuge technology, which saves Brazil from having to answer questions about how it received its centrifuge knowledge in the first place.[131]

Whatever the reason for the screen at Resende, it does permit the possibility of unauthorized uranium enrichment. Brazil is of the opinion that the IAEA can monitor input and output to ensure it is not abusing Resende's enrichment capability, just as it has at the naval research reactor. But if the IAEA does not have visibility on all operations at the Resende plant, Brazil could theoretically enrich uranium to weapons grade without being detected.[132] Even if Brazil holds to its pledge to only enrich uranium to 3.5%, it will have done more than half of the work required to enrich uranium to weapons grade. Using partially enriched uranium, were Brazil to decide to produce nuclear weapons it could do so relatively quickly. Theoretically the Resende plant could currently produce up to six warheads a year, a number that will increase as the plant reaches its full capacity.[133]

---

[131] Liz Palmer and Gary Millhollin, "Brazil's Nuclear Puzzle," *Science*, 22 October 2004, Proquest document ID# 725575851, accessed via Proquest 14 May 2007.

[132] "Brazil's Nuclear Puzzle".

[133] "Brazil's Nuclear Puzzle".

DOES BRAZIL HAVE A NUCLEAR TIPPING POINT?

Nuclear proliferation presents a difficult intelligence problem. History has shown that there is no "one size fits all" set of indicators and situations that drive a state towards nuclear weapons. In this section I will look at Brazil through the lens of the proliferation factors put forth by the authors of *The Nuclear Tipping Point.* Though it is but one part of my analytical framework, looking at these factors provides a comprehensive baseline for both compiling evidence and assessing Brazil's potential for proliferation.

Factor 1: Direction of US Foreign and Security Policy. US foreign policy is currently focused on Iraq, Afghanistan, the Middle East, and the Global War on Terror. Brazil disagreements with the IAEA on the issues at the Resende facility; have drawn little attention from the US. While overt pursuit of nuclear weapons would certainly mean more US and global engagement in the region and with Brazil itself, it is possible that Brazil is testing US will and its ability to back the IAEA and NPT in Latin America by not fully disclosing all activity and equipment present at Resende. Uranium enrichment to weapons grade is the largest missing link in Brazil's potential to develop nuclear weapons. If Brazil wants to again start its weapons program, the time to do so is when the US is focused elsewhere. On the other hand, Brazil's lack of cooperation with the IAEA could be nothing more than Brazil expressing its strong sense of sovereignty and its desire to protect industrial secrets and the source of its centrifuge technology.

Over the longer term, the current situation in Iraq has the potential to bring a dramatic shift in US foreign policy. Although US policy has been generally expansionist in recent years, as demonstrated by among other things its justification of pre-emptive

war, the situation in Iraq has shown that US power seems to have its limits. Domestic and international pressure are focusing the debate over Iraq in terms of what the US can salvage as it withdraws from the country, not what it can do to win the conflict there.[134] Although the outcome of the Iraq war is still in doubt, US failure there could bring about a more inwardly focused US foreign policy. Also pointing to a potential shift in US policy was the Democratic victory in the 2006 US Congressional elections. The 2008 presidential election will be telling, to say the least. In any case, a more inwardly focused US might be reticent to become involved in actively deterring Brazil from developing nuclear weapons. On the other side of this argument, preventing nuclear proliferation is an issue that most states generally agree on in principle. This alone may justify US action no matter what its current foreign policy stance or the going global opinion of it. Support this is the fact the US has throughout its history remained engaged in events in the Western Hemisphere regardless of its general views towards global engagement.

Factor 2: A Breakdown of the Global Non-Proliferation Regime. Although global opinion is generally against nuclear proliferation there is little, short of physical intervention, that can actually prevent it. States that strongly desire nuclear weapons and have the technological and economic means to produce them face few real hurdles. More telling may be the lack of consequences for states that actually develop nuclear weapons.

The cases of Iran and North Korea highlight the weaknesses in today's non-proliferation regime. Iran continues to defy the regime in its dogged pursuit of nuclear capability. While international opinion is strongly against a nuclear Iran, little more than

[134] Andrew J. Bacevich, "Twilight of the Republic?" *Commonweal*, 1 December 2006, Proquest document ID# 1174704891, accessed via Proquest 16 May 2007.

rhetoric and threats have stood in its way to this point. Iran, with abundant energy resources, is not a state that needs nuclear power, which is a telling factor in the underlying reasons for its nuclear program. As long as Iran retains the economic resources to continue its pursuit of a nuclear capability, and tacit pursuit of nuclear weapons, it will probably continue to do so unhindered. The global consensus against proliferation does not appear to be strong enough to stop it; only an attack on its nuclear facilities, probably at the hands of Israel or the US, seems likely to change Iran's current nuclear path.

Past states that have attained nuclear weapons capability generally have not suffered any real consequences, save for the oft cited negative short-term international opinion. Moreover, most of today's nuclear states have maintained or regained favorable status with the United States in the wake of unveiling their nuclear capability. The emergence of North Korea as a nuclear power once again tests the back-end of the non-proliferation regime. A true global fear is nuclear weapons in the hands of a so-called rogue nation like North Korea. North Korea's nuclear test caused regional saber-rattling and global ripples, but again the nation itself has suffered few tangible consequences as a result of its test. In fact, North Korea may be able to use its nuclear test as a bargaining chip and has been offered fuel oil and security guarantees for shutting its nuclear facilities and dismantling its program. Other, larger concessions to North Korea could be part of a wider deal between it and the US[135]

All told, history and current challenges to the non-proliferation regime signal that it is weak or even non-existent at this point. If Brazil decided to again pursue nuclear

[135] Carla Anne Robinson, "Wrestling Nuclear Genies Back Into The Bottle, or at Least a Can," *New York Times*, late edition, East Coast, 9 May 2007, Proquest document ID# 1267609201, accessed via Proquest 16 May 2007.

weapons many would of course question this decision, but the examples of North Korea and Iran show that any negative consequences of such an action are manageable. As it is not considered a rogue state, Brazil likely faces less backlash than North Korea, Iran, or even Venezuela if it decides to pursue nuclear weapons.

Factor 3: Eroding Regional or Global Security. Brazil faces few global or regional security threats. Although they were once embroiled in nuclear arms race of sorts, relations between Brazil and traditional rival Argentina have been warming for the better part of two decades. Nonetheless, Brazil does have security concerns, including a large frontier border that is nearly impossible to defend effectively. Additionally, a rising Venezuela could be a concern for Brazil's designs on becoming a regional hegemon. Venezuela, flush with oil money, has made a glut of arms purchases in the last couple of years, fueling fears of a regional arms race. That a potential arms race could turn nuclear is unlikely, but not out of the question.

Factor 4: Domestic Imperatives. Domestic imperatives, including a drive for more regional or global power, can fuel the decision to acquire nuclear weapons. This seems to be a large factor in Iran's pursuit of nuclear capability, and may be a consequence of North Korea's nuclear test, whether it was intended to be so or not. Brazil desires greater regional and global power.[136] The nuclear option would seem a drastic means to this end, but with the current nuclear capability Brazil already has in place it may at some point explore this avenue. Lula's nuclear statements on the

[136] "Who leads Latin America?; Brazil's Presidential Election," *The Economist*, 30 September 2006, Proquest document ID# 1139608601, accessed via Proquest 16 May 2007.

campaign trail were seen as a nod to Brazil's military. Pursing nuclear weapons could help Lula improve relations with his military and show his nationalistic spirit, though this is an improbable course of events.

Brazil's bid to assert itself as a regional power is based mainly on the strength and growth of its economy. It seems to be in the perfect position to gain strength on the back of its economy, as it is rich in many desirable natural resources. But after experiencing explosive growth through the 1970s, Brazil's economy has demonstrated only slow to moderate expansion since. Over the last four years, Brazil's economy grew an average of only 3.3% and was easily outpaced by the developing country average of 7.3%[137] Behind this slow growth are factors such as a heavy tax burden and even the vestiges of a culture that places personal bonds over rules and laws.[138] Brazil's population growth has placed additional pressure on its economy, but that growth has been slowing in recent years.

Brazil's economy does show many positive signs. Brazil has huge foreign exchange reserves, and programs enacted by Lula have brought inflation down to manageable levels. Even so, internal and external events could still hurt Brazil's economy and seriously damage its quest for increased global and regional power. Though unlikely, Brazil may choose to pursue proliferation in light of potential declining global or regional stature regardless of whether or not the decline is economically based.

Factor 5: Increasing Availability of Technology. Technology transfer has always been an enabler for the proliferation of arms, especially nuclear weapons. Rising

[137] "Brazil Economy: Land of Promise," Economist Intelligence Unit wire feed, 13 April 2007, Proquest Document ID# 1265109521, accessed via Proquest 16 May 2007.

[138] "Brazil Economy: Land of Promise."

globalization and the end of the Cold War intersected, resulting in many channels for illicit nuclear proliferation. Though no weapons have been confirmed to change hands in this manner, the materials and knowledge for making them have. Brazil is no stranger to technology transfer. Its dealings with West Germany in the 1980s were heavily scrutinized, and today's issues at the Resende facility could deal with proprietary technology that may have been obtained from another state. One would almost hope this is the issue at Resende; it is far more palatable to assume that Brazil is protecting the source of its technology than to think it is hiding attempts to enrich uranium to weapons grade. In any case, the availability of nuclear technology and material could allow Brazil to fill missing pieces in its nuclear puzzle. From a strictly practical point of view, however, Brazil is unlikely to risk the fallout that would comes as a result of being caught in the illegal transfer of nuclear material.

LULA da SILVA: NATIONAL IDENTITY CONCEPTION

In *The Psychology of Nuclear Proliferation: Identity, Emotions and Foreign Policy*, Jacques E.C. Hymans approaches the question of nuclear proliferation by focusing on one individual: the leader of the state. Hymans argues the leader's national identity conception (NIC) is a good indicator of a leader's likelihood to push his or her state towards acquiring or developing nuclear weapons.

Hymans assesses each leader based on both status and solidarity. Hymans assesses a leader's status as nationalist if the leader holds that his state is equal or better to comparable states, or what Hymans terms as "key comparison others".[139] Conversely,

[139] Hymans, 24.

a leader is considered a subaltern if he has a negative national self-image. In terms of solidarity, a leader is considered sportsmanlike if he believes in a transcendent identity with comparative states. On the other hand, a leader is considered oppositional if he fosters an "us against them" mentality.[140] Using these categorizations, Hymans develops a typology whereby leaders can be placed into four types, or NICs. Hymans ultimately argues the oppositional nationalist is most likely to pursue nuclear weapons, although he discusses each NIC in depth.[141]

Lula fits into Hymans typology as a sportsmanlike nationalist. He continues a legacy of strong nationalism in both his country and the region. He sees Brazil as a regional power and wants to Brazil to continue its ascendancy. Under Lula, Brazil's foreign policy is highlighted by cooperation, multilateralism, and a search for compromise when issues arise. According to one assertion, these days "Brazil is everyone's friend."[142] Brazilian foreign minister Celso Amorim frames Brazil's foreign policy efforts as quiet, behind the scenes persuasion.[143]

According to Whaley, a sportsmanlike nationalist such as Lula should not pursue nuclear weapons because he doesn't fear comparable states. More tellingly, the sportsmanlike nationalist is typically interested in building a nuclear infrastructure in order to spur growth and also to gain in international standing. Brazil's pursuit of autonomy in the nuclear fuel cycle seems to underscore this assertion. Interestingly,

---

[140] Hymans, 23.

[141] Hymans, 38.

[142] Richard Lapper and Jonathan Wheatley, "Disagreements imply depth of ties for a regional leader," *Financial Times*, 22 February 2007, Proquest document ID# 1221029051, accessed via Proquest 16 May 2007.

[143] Lapper and Wheatley, "Disagreements."

Hymans says that a sportsmanlike nationalist might resist the non-proliferation regime because it makes distinctions between those who have nuclear weapons and those who do not.[144] A possible example of this is that Brazil long opposed the non-proliferation regime before Lula took power, and even today continues to limit cooperation with the IAEA at Resende.

BRAZIL: ANALYSIS OF COMPETING HYPOTHESES

Utilizing ACH provides a means to both organize the evidence for and against Brazil's potential to proliferate and to assess the likelihood that Brazil will, among other hypotheses, pursue nuclear weapons based on its current situation. The evidence presented in the course of this ACH is based on my assessments from data already reported in this thesis. At the risk of being repetitive and verbose, I will present that evidence only in list form here, choosing not to again explain each piece of it. Likewise, when I discuss the indicators that events may be pointing to a particular hypothesis I will not explore these indicators in depth.

Step 1 – Identify the possible hypotheses to be considered

As discussed in Chapter 1, there are four hypotheses that this analysis will consider for Brazil:

[144] Hymans, 39.

1) H1: Brazil will pursue an overt nuclear weapons program;

2) H2: Brazil will continue its pursuit of an autonomous nuclear fuel cycle but not pursue nuclear weapons (status quo);

3) H3: Brazil will clandestinely develop a "run up" nuclear capability and gain the ability to quickly produce nuclear weapons;

4) H4: Brazil will abandon its attempt at an autonomous fuel cycle, open itself completely to the IAEA, and maintain only the ability to produce nuclear energy.

Step 2 – Make a list of significant evidence and arguments for and against each hypothesis

Figure 9 details the evidence considered in this analysis:

-Brazil's past nuclear legacy and the military's potential resentment at its dismantling
-Lula's pro-nuclear stance during his 2002 presidential campaign
-The nuclear knowledge and facilities maintained by Brazil's military
-Brazil's navy continues development of a nuclear reactor for its submarines
-Brazil's pursuit of autonomy in the nuclear fuel cycle
-The strong Latin American non-proliferation regime
-Brazil's obstruction of the IAEA at Resende
-The US has not commented on Brazil's obstruction of the IAEA
-Brazil's failure to sign additional protocol to NPT giving IAEA inspection rights
-Former CNEN president claims Brazil's military continued to pursue weapons after program was terminated
-Brazil is signatory to the NPT and Treaty of Tlateloco
-Brazilian ambassador Campos states that nuclear project is only for peaceful purposes
-Brazil promises to only enrich uranium to 5%
-Lula fits the typology of a sportsmanlike nationalist
-Brazil continues development of a space launch vehicle, which could be used as a ballistic missile
-At present, the US is focused elsewhere
-The non-proliferation regime appears to be weakening
-Brazil's economy has shown slow, but consistent growth
-Brazil's population growth is leveling off, lessening the pressure that it places on the country
-Venezuela's actions point at a desire for more power in the region
-Brazil is heavily reliant on hydropower and lacks a consistent source of energy

Figure 9: Evidence considered in Brazil ACH Analysis

My ACH matrix[145] uses 6 different notations to assess the consistency of each piece of evidence against the proposed hypotheses. Blue shaded cells denote consistent evidence and are annotated with a 'c", while very consistent evidence is also shaded blue and annotated with a "cc". Pink shaded cells denote inconsistent evidence and are

[145] I obtained this ACH matrix from Dr. Joseph Gordon in the course of taking his Strategic Warning and Analysis class at the National Defense Intelligence College. I found a couple of errors with the matrix and corrected them.

annotated with an "i", while very inconsistent evidence is also shaded pink and annotated with an "ii". Evidence that appears neutral toward a hypothesis is noted by "n", while evidence that is not applicable to a particular hypothesis shows as "na". Neutral and non-applicable cells are not shaded.

Also included in the matrix are a measure of credibility and a measure of reliability for each piece of evidence, with both measures being evaluated as high, medium, or low. Each of these measures is evaluated based on my personal assessment supported by data collection. Raw values for each cell are tallied for each hypothesis in the unweighted score rows: inconsistency is scored on the blue row while consistency is scored on the red row. Credibility and relevance are weighted measures that contribute to the weighted inconsistency score on the green row and the weighted consistency score on the yellow row.

Evidence #	Evidence	Evidence Type	Credibility	Relevance	H1	H2	H3	H4
E1	Nuclear legacy - resentment over end		med	med	c	n	c	i
E2	Lula's 2002 pro-nuclear stance		high	low	c	n	c	i
E3	Nuclear knowledge / facilities		high	high	c	c	c	i
E4	Navy continues development of sub reactor		high	med	c	i	c	n
E5	Pursuit of autonomous fuel cycle		high	high	c	cc	cc	i
E6	Latin American non-proliferation regime		med	high	ii	c	ii	c
E7	Obstruction of IAEA at Resende		high	high	c	i	cc	ii
E8	U.S. apathy towards Resende obstruction		med	med	c	n	c	i
E9	Failure to sign NPT protocol		high	high	c	i	c	ii
E10	Claims military continued to pursue progrsm		med	high	c	n	c	n
E11	Signatory to NPT and Tlatelolco		high	med	ii	cc	i	cc
E12	Ambassador states nuclear project peaceful		med	low	i	c	i	c
E13	Promise to enrich uranium to only 5%		low	med	i	c	i	c
E14	Lulu as a sportsmanlike nationalist		high	high	i	c	i	i
E15	Continued development of space capability		high	med	c	i	cc	n
E16	U.S. focused elsewhere		med	low	c	na	c	n
E17	Weakining non-proliferation regime		med	med	cc	n	c	i
E18	Slow, consistent economic growth		high	low	i	c	i	c
E19	Lessening population pressure		med	low	i	c	i	c
E20	Desire for more regional / global power		med	med	c	i	c	i
E21	Heavily dependent on hydropower		high	med	i	c	i	cc
				Weighted **Inconsistency** Score =	-12.190	-7.827	-10.776	-18.995
				Unweighted **Inconsistency** Score =	-18	-6	-9	-12
				Weighted **Consistency** Score =	6.756	8.947	12.583	-8.885

Figure 10: ACH Matrix for Brazil

An initial look at the results of the ACH show that H2, or maintenance of the status quo, is the hypothesis with the least amount of raw and weighted inconsistent evidence. H4, abandonment of all dual use nuclear efforts and a concentration on energy only, has the most evidence against it. H1 and H3, overt and clandestine nuclear weapons pursuit, share similar evaluations and scores, with overt pursuit of nuclear weapons having slightly more evidence inconsistent with it.

While inconsistency is the most important measure in the ACH, it is interesting to note the consistency values shown in the initial evaluation of evidence. The preponderance of the consistent evidence lies with H1 and H3, with clandestine pursuit of nuclear weapons having the most. There is little evidence consistent with H4, while maintaining the status quo has a similar amount of consistent evidence to clandestine

weapons pursuit. These results, especially the unweighted scores, are skewed by the fact there is more evidence listed that would appear to support H1 and H3.

Step 4 – Refine the matrix

Although H1 and H3 are very close to each other and could probably be combined, I feel that they should ultimately remain separate. Some evidence consistent with both hypotheses is more consistent with a clandestine effort, so it is still important to make a distinction between the two.

All of the evidence presented shows some diagnostic ability, so I will keep all of it in the analysis. There is certainly additional evidence that I could include in this analysis, but I do not assess that any of the hypotheses relies heavily on evidence not presented.

Step 5 – Draw tentative conclusions about the relative likelihood of each hypothesis

H4, abandonment of dual use technology and opening up to IAEA inspections, has the most inconsistent evidence and seems the least likely of the four hypotheses presented. H2, Brazil's continued pursuit of the nuclear fuel cycle while not pursuing nuclear weapons, has the least amount of evidence against it and initially appears to be the most likely. The two hypotheses that suggest pursuit of nuclear weapons, while having more inconsistencies than the status quo, merit close examination. One of the challenges of predicting nuclear proliferation is assessing dual use technology and in Brazil's case dual-use abounds. The ambiguity of assessing dual-use technology as an intelligence indicator is magnified when a state may be pursuing a clandestine program.

What is the purpose of Brazil's pursuit of an autonomous nuclear fuel cycle? Is the VLS rocket program designed only to launch spacecraft or will it one day be geared toward using the VLS as a ballistic missile? Because these questions and others like them cannot be definitively answered at this point in time, stating that Brazil is pursuing nuclear weapons does not seem a logical conclusion. The ACH process supports this assertion. As such, the tentative conclusion this study reaches is that Brazil will continue development of its nuclear program and continue to frustrate the IAEA but will refrain from attempting to develop nuclear weapons.

Step 6 – Analyze how sensitive your conclusion is to a few critical pieces of Evidence

The conclusions reached in step 5 do not appear to be sensitive to a few critical pieces of evidence. Just as there is no evidence that absolutely discounts any single hypothesis, there exists no evidence that heavily favors any hypothesis. If anything, the conclusion relies too heavily on a distinct lack of evidence in discounting the assertion Brazil is pursuing nuclear weapons.

Step 7 – Report Conclusions

This study concludes that Brazil will continue to develop its nuclear infrastructure while not actually gearing this infrastructure for nuclear weapons production. Though the Brazilian drive for a complete nuclear fuel cycle and its limitations on inspectors at the Resende enrichment facility are questionable, there exists no clear evidence that Brazil is attempting to develop nuclear weapons or that it will attempt to develop them in the near future. Brazil's nearly completed quest for the entire nuclear fuel cycle is

probably more driven by pride and nationalism than it is for its potential to help produce nuclear weapons. The fuel cycle has a practical side to it, also, as Brazil's heavy reliance on environmentally sensitive hydropower means the state has a legitimate reason to pursue alternate sources of power.

Of the hypotheses presented, Brazil is least likely to renounce all dual use technology like the enrichment facility and its space launch program and open itself to full IAEA scrutiny. The same factors like pride and nationalism figure in the rejection of this hypothesis. Moreover, Brazil's nuclear program is a large part of its military industrial complex; to greatly reduce this capability could harm Brazil's already fragile economy. Brazil has met no international resistance to its actions vis-à-vis the IAEA and therefore faces no real pressure to change its ways. As a sportsmanlike nationalist, Lula sees his country's nuclear capability as a way to gain international standing. The completion of the nuclear fuel cycle, something that a very few countries in the world possess, would add to this standing immensely. There is nothing Brazil gains at this point by softening its nuclear stance and capability.

The evidence that points towards Brazil pursuing nuclear weapons does little to distinguish between the potential for a clandestine or overt program. By definition an overt program would show obvious signs, so the evidence that does exist suggests that Brazil is more likely to pursue a secret program. But even though the non-proliferation regime seems to be weakening and US attention is focused elsewhere, the potential backlash Brazil faces were it to develop nuclear weapons is too great for a country trying to grow its economy and become a global player. The fact that Brazil faces no real strategic threat underscores this point. It goes without saying that with its current nuclear

infrastructure, Brazil could develop nuclear weapons in a relatively short period of time. But absent a true threat to its national security, Brazil has no impetus to possess nuclear weapons now or in the near future.

Step 8 – Identify milestones for future observation that may indicate events are taking a different course

Figures 11 and 12 detail indicators Brazil's nuclear proliferation is taking a different direction than the one detailed by this thesis.

-Continued or worsening obstruction of the IAEA
-New nuclear facility construction
-Activity at closed nuclear test site
-Development of a liquid fuel version of the VLS rocket
-Any test of the VLS as a ballistic missile
-Severe economic downturn / loss of foreign investment
-World economic recession
-Evidence that Brazil is engaging in illegal technology transfer
-Deteriorating relations with Argentina
-Deteriorating relations with Venezuela
-Venezuela's emergence as a true regional power
-Conventional arms race with Venezuela
-Increased nuclear rhetoric by Lula or the Brazilian government
-Large scale social unrest
-Any move away from democracy
-Deterioration in civil/military relationship
-Return to military rule
-Dissatisfied military
-Failure to sign additional protocols to the NPT
-Pullout of any nuclear treaty or organization
-Large increases in funding for nuclear programs
-Increasingly inwardly focused US policy

Figure 11: Indicators Brazil is pursuing nuclear weapons (H1 and H3)

Evidence that Brazil is softening its nuclear stance and will only produce nuclear power (H4) includes:

-Opening of all facilities to the IAEA
-Ratification of additional protocols to the NPT
-Abandonment of attempt at complete nuclear fuel cycle
-Drastic economic improvement
-Improving relations with neighbors, especially Venezuela
-Funding cut for nuclear programs
-Abandonment of missile and / or space program

Figure 12: Indicators Brazil is softening its nuclear stance (H4)

CHAPTER 4

FUTURE NUCLEAR PROLIFERATION IN VENEZUELA?

VENEZUELA SITUATION UPDATE

Venezuela is arguably the most strategically important state in South America. The country has the largest reserves of petroleum in the Western Hemisphere, albeit most of these reserves are of a fairly low and hard to refine grade. Venezuela's geographical location gives it access to both the Caribbean Sea and the interior of South America, placing it astride important trade routes. This aspect of Venezuela's geography is particularly important to Brazil, Venezuela's southern neighbor and potential rival for Latin American dominance.

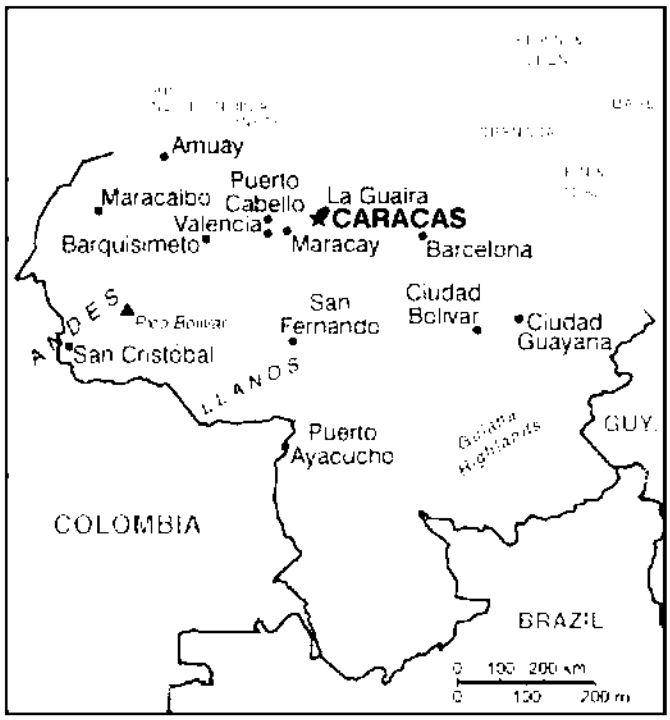

Figure 13: Venezuela

Source: CIA World Factbook Online, 2007

For much of the 20th century Venezuela's military led the state. Venezuela only transitioned to a democratically elected government in 1959. Under both types of rule,

Venezuela's leaders capitalized on its oil wealth and allowed for social reform.[146] Venezuela's current president, Hugo Chavez took office in 1999. Chavez has taken Venezuela in a decidedly different direction than previous Venezuelan leaders in both foreign and domestic policy. Chavez' "Bolivarian Revolution" has brought sweeping changes to Venezuela.

Hugo Chavez and 21st Century Socialism

On the domestic front, Chavez has taken measures to move his country in the direction of socialism. He has encouraged non-private ownership and control, encouraging the creation of cooperatives and exercising increasing state control of important industries.[147] Perhaps the most important state-owned company is Petroleos de Venezuela, S.A. (PDVSA), which runs Venezuela's petroleum industry. Venezuela's vast oil reserves combined with a peak in oil demand and prices has given Chavez almost unlimited capital. Free from worry about alienating private interests, Chavez has invested much of Venezuela's oil revenue into his social programs.[148]

Chavez has also used his country's oil wealth in helping to dictate Venezuela's foreign policy. Chavez' influence in Latin America has expanded greatly because of his PetroCaribe oil subsidy initiative. Oil wealth has also changed Venezuela's views toward the United States. Venezuela long ago supplied the United States with the majority of its petroleum and has generally been on good terms with the US. However, Chavez has

---

[146] *CIA World Factbook: Venezuela*, CIA World Factbook Website, 15 May 2007, URL: < https://www.cia.gov/library/publications/the-world-factbook/geos/ve.html>, accessed 21 May 2007.

[147] Gregory Wilpert, "The Meaning of 21st Century Socialism for Venezuela," Web-only essay, 11 July 2006, URL: <http://www.venezuelanalysis.com/articles.php?artno=1776>, accessed 21 May 2007.

[148] Wilpert, "The Meaning of 21st Century Socialism for Venezuela."

consistently attacked the US, globalization, and free trade agreements, among other things. His anti-US stance and ties with states like Iran and North Korea are cause for concern. But even as Chavez attacks the US, the two states maintain somewhat of a symbiotic relationship. The US still needs Venezuelan oil and Venezuela needs US refining capability to process its heavy crude. Venezuela still exports the largest share of its crude oil to the US.

The Venezuelan National Assembly, an elected body currently composed almost entirely of Chavez supporters, recently granted the Venezuelan leader sweeping powers. On January 30, 2007, Chavez gained the power to make law by decree for 18 months. Almost immediately he declared Venezuela's energy and communications sectors strategic, meaning that they are subject to state control. The Venezuelan government now owns controlling interest in Venezuela's largest communications company and its largest provider of electricity.[149] Other initiatives of note are the increased teaching of socialism in Venezuela's education curriculum, a formalization of the communal structure, and the proposal for the creation of a single political party in Venezuela. One troubling potential reform that Chavez is considering is

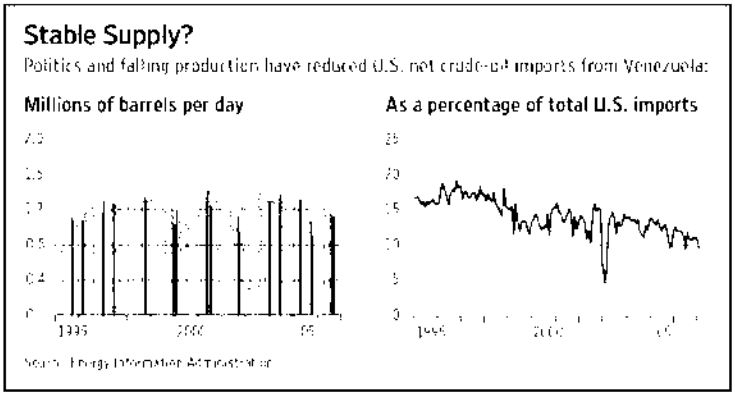

Figure 14. Venezuela Crude Oil Production

Source: Energy Information Administration Website, 2007.

[149] "Venezuelan Politics: Bolivarian Revolution Accelerates," Economist Intelligence Unit ViewsWire, 20 March 2007, Proquest Document ID# 1264439441, accessed via Proquest 21 May 2007.

the removal of the two-term limit for Venezuelan presidents. Into his second term, Chavez may be looking to lead Venezuela for the foreseeable future.[150]

Is Venezuela Creating Its Own Strategic Threat?

The United States imports about 13% of its petroleum from Venezuela. Although this percentage has been slowly dropping (see Figure 9), it still makes Venezuela the third largest supplier of petroleum to the US. Only Canada and Saudi Arabia have a larger share of the US oil market.[151] Venezuela's economy is heavily reliant on petroleum exports, with half of its income and roughly 80% of its export income derived from petroleum.[152] Conventional wisdom has long held that oil exports to the US are so vital to Venezuela's economy that the possibility of the US losing this source of energy is slim. However, recent actions by Venezuela suggest it may be attempting to diversify the foreign stake in its oil market and improving relations with US competitors. Among these relationships the ties it is creating with China stand to give it the most leverage in the future.

By hedging its bets with other energy consumers, Venezuela is attempting to reduce the reliance of its oil-based economy on the US At the same time these actions, combined with Chavez' rhetoric, place Venezuela at increasing odds with the US As Venezuela's reliance on the US purchase of its oil decreases, its power relative to the U.S increases. This is evidenced by the fact Venezuela feels it no longer need to cater to the

---

[150] "Venezuelan Politics: Bolivarian Revolution Accelerates."

[151] "Crude Oil and Total Petroleum Imports Top 15 Countries," Web-only table, 21 May 2007, URL: <http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level_imports/current/import/html>, accessed 21 May 2007.

[152] Andy Webb-Vidal, "US probe into Venezuela's oil supply threat 'absurd'," *Financial Times*, 11 July 2006, Proquest document ID# 1075025451, accessed via Proquest 21 May 2007.

US Chavez made anti-US comments before the UN in late 2006. He declared support of Iran's nuclear energy program, and Venezuela has of course sought closer relations with Iran and North Korea.[153]

Although it is strengthening relationships with many states that are considered anti-US, it is Venezuela's closer ties with China that could provide the most compelling security issues for the US. While Venezuela's relationships with Iran, North Korea, and others are troubling, none represents a true threat to US energy security. On the other hand, China is a rising superpower with voracious energy needs. Theoretically Venezuela could divert oil it currently supplies the US to China, a county willing pay a premium for energy and also a county that is not America. In a very short time China has gone from a producer to a consumer of oil. It accounted for 31% of the world's increase in oil demand in 2004, and is becoming more and more dependent on foreign sources of energy.[154]

In addition to the fact Venezuela's economy relies heavily on US purchase of its oil, most of the foreign capacity to refine Venezuela's heavy crude oil lies in the United States. The eight refineries Citgo operates in the US have more or less guaranteed a steady flow of Venezuelan oil would continue for the US[155] China currently possesses

---

[153] Humberto Mrquez, "Venezuela: Oil Wealth Helps Chavez Stand Up To Washington," *Global Information Network*, 21 February 2006. Proquest Document ID# 991086641, accessed via Proquest 21 May 2007.

[154] David Zweig and Bi Jianhai, "China's Global Hunt For Energy," *Foreign Affairs*, September/October 2005, EbscoHost reference number 17979604, accessed via EbscoHost 21 May 2007.

[155] Mrquez, "Venezuela: Oil Wealth."

limited capacity to process heavy crude[156], but it does have the economic wherewithal to expand its refining capability.

Costs to transport Venezuelan oil to distant destinations like China are much higher than costs to move it to the US. Many argue the importance of Venezuelan oil to the US is overstated, and this argument has some merit.[157] On the other hand, recent studies posit an immediate $11 a barrel, if not more, jump in the price of oil if Venezuela were to completely cut off its supplies to the US.[158] This would likely send the US economy into a tailspin. Even if oil prices did not jump as predicted the US would still be short of oil, assuming it could not makeup for the shortage by importing more from other states. Such a situation would be considered a vital US national security interest and would probably prompt the US to immediate action. But before he can even contemplate reducing or elimination oil supplies to the US, Chavez must find alternate consumers and refining capacity.

Chavez' use of oil profits and his handling of the Venezuelan oil industry may have set Venezuela's economy up for future hardship. In choosing to invest in social programs and not in his country's oil infrastructure, Chavez has overseen a decline in Venezuelan production from 3.3 million barrels in 1997 to 2.4 million barrels today.[159] Today Venezuela is the only member of the Organization of Petroleum Exporting

---

[156] Qin Jize, "Chavez Arrives in Beijing," *China Daily*, 23 August 2006, Proquest document ID# 1103843261, accessed via Proquest 21 May 2007.

[157] Mary Anastasia O'Grady, "Americas: Chavez' Oil Weapon is a Popgun," *Wall Street Journal*, 9 September 2005, Proquest document ID# 893905731, accessed via Proquest 21 May 2007.

[158] Webb-Vidal, "US Probe."

[159] J. Robinson West, "The Production Crunch: Chavez-style oil nationalism is endangering world economic growth," *Newsweek*, 14 May 2007, Proquest document ID# 1266617651, accessed via Proquest 21 May 2007.

Countries (OPEC) not meeting its production quotas. In addition to the lack of investment in infrastructure, Chavez' nationalization of Venezuela's oil industry has reduced the importance of Western energy companies, the same companies that possess the resources and knowledge to increase Venezuela's production. Instead, Venezuela's production is overseen by PDVSA, with increasing involvement of the China National Petroleum Corporation (CNPC). Neither CNPC nor PDVSA have the knowledge or wherewithal to reverse Venezuela's falling production. Chavez needs oil to remain at $60 a barrel or higher to maintain his domestic and foreign initiatives and ostensibly his influence and the viability of Venezuela's economy.[160] Although high gas prices currently dominate the US market, long term forecasts have the price of oil stagnant or falling, which could spell big trouble for Venezuela's economy.[161]

Venezuela: Nuclear Ambitions?

Venezuela possesses some uranium resources, but these resources are not economically viable to recover if the world uranium market is their intended destination.[162] Venezuela could purchase unprocessed uranium for much cheaper than it can mine its own deposits. Aside from this unrecoverable uranium, Venezuela has no real nuclear infrastructure or knowledge base. At first glance it seems an unlikely source of nuclear proliferation. However, the recent actions of Venezuela and Hugo Chavez make nuclear proliferation an interesting avenue for exploration.

---

[160] West, "The Production Crunch".

[161] EIA Annual Energy Outlook 2007, Web-only essay, February 2007, URL: <http://www.eia.doe.gov/oiaf/aeo/index.html>, accessed 21 May 2007.

[162] "Survey of Energy Resources: Uranium," Web-only survey, 21 May 2007, URL: < http://www.worldenergy.org/wec-geis/publications/reports/ser/uranium/uranium.asp>, accessed 21 May 2007.

Venezuela's vehement anti-US stance combined with the amount of oil it supplies the US make it a strategic interest for the US Stopping its flow of oil to the US could prompt US intervention. Venezuela has courted many new allies, but would these allies be willing or even have the ability to help it stand up to the US? In the case of military action by the US against Venezuela, the answer at this point in time is a definitive no. Venezuela's adversarial relationship with the US alone is likely enough to make Chavez at least consider possessing nuclear weapons as a counter to potential US intervention. Other factors such as the potential for Venezuela's economy to struggle, a desire to maintain its influence in Latin America in the face of declining oil revenues, and Chavez' general paranoia regarding the US could have him considering the nuclear option as a method for maintaining power and prestige.

In recent years rouge nations like Iran and North Korea have successfully defied the non-proliferation regime in recent years. Hypothesizing that Hugo Chavez desires nuclear weapons seems a bit of a reach. But this idea is not without basis, as Chavez has made comments that allude to nuclear energy ambitions. Moreover, Venezuela's current course frames it as the closest state in South America to earning the rogue moniker.

In the 1950s General Electric sold Venezuela a small nuclear power reactor. However, after deciding that Venezuela's energy sector didn't need nuclear power, the Venezuelan government shut down and dismantled the reactor. No evidence exists today to suggest that Venezuela needs to supplement its energy production with nuclear power. Even so, in 2005 PDVSA asked Argentina to sell it a medium sized nuclear reactor.[163] Ostensibly this reactor's purpose would be to help Venezuela refine its heavy crude oil,

[163] Andy Webb-Vidal, "US to lobby Argentina on Chavez nuclear move," *Financial Times*, 13 October 2005, Proquest document ID# 910569891, accessed via Proquest 21 May 2001.

but there are cheaper and quicker energy sources available to Venezuela. In October 2005 at the Ibero-American summit in Spain, Chavez expressed interesting in acquiring nuclear technology. His comments suggested that he sought the help of Argentina and Brazil in doing so.[164]

DOES VENEZUELA HAVE A NUCLEAR TIPPING POINT?

As I did for Brazil, I will use the proliferation factors laid out in *The Nuclear Tipping Point* to examine Venezuela. Some of these factors are external to the environments of both countries and manifest in the same way. However, the effect they have on Venezuela is generally different than the effect they had on Brazil. Some are markedly different; whereas Brazil possesses most of its own technology, Venezuela is more apt to capitalize on nuclear technology available through illicit channels should it choose to proliferate. In discussing Venezuela vis-à-vis these factors, I will not restate assertions made in the previous chapter on such subjects as the direction of US foreign policy and the viability of the proliferation regime. I will instead focus only on how these factors pertain to Venezuela.

Factor 1: Direction of US Foreign and Security Policy. Hugo Chavez has been consistently and loudly critical of the US, especially since a coup attempt in 2002 in which Chavez implicated the US The Bush administration has often matched Chavez' rhetoric; occasionally demonizing him and lambasting his "destruction" of Venezuelan

[164] "Countering Chavismo in a cool manner – Venezuela's nuclear plans require a measured response," *Financial Times*, Asia edition, 17 October 2005, Proquest document ID# 03071766, accessed via Proquest 21 May 2007.

democracy. Though the US is currently critical of Venezuela, little has been done in the way of concrete measures against the Chavez government. There are a couple of reasons the US has done little more than engage in a war of words with Chavez. First, America is focused elsewhere and has a vested interest in keeping its affairs in Latin America on an even keel. Second, Chavez and his social programs are so dependent US money that he is seen as pandering to his political base when he rails against the US, not actually trying to provoke it.[165]

Nonetheless, Chavez may perceive US engagements elsewhere and lack of response to Venezuela as a weakness to be exploited. Venezuela may seek to push its limits with the US, especially if the US becomes more inwardly focused as a result of the wars in Iraq and Afghanistan and the upcoming elections in 2008. But there is little doubt nuclear proliferation in Venezuela will merit a harsh US and international response.

Factor 2: A Breakdown of the Global Non-Proliferation Regime. The lessons of Iran and North Korea may show Chavez a weakness in NPT. However the international community in general and the US in particular will not take a hands-off approach if Venezuela decides to pursue nuclear weapons. The U.S has not faced a nuclear threat in the Western Hemisphere since the Cuban Missile Crisis, and the prospect of Hugo Chavez with nuclear weapons is not inviting.

Though the global non-proliferation regime seems weaker overall, it remains strong in Latin America. The Treaty of Tlatelolco and the general non-proliferation

[165] "USA / Venezuela politics: A new strategy?" Economist Intelligence Unit ViewsWire, 29 December 2006, Proquest document ID# 1188684741, accessed via Proquest 22 May 2007.

consensus in the region counter perceived weaknesses in the global regime. Chavez would have to overcome this hurdle if he decides to acquire nuclear weapons. It is plausible Brazil would be given a free pass into the nuclear community if it developed a weapon. Hugo Chavez does not have this luxury.

Factor 3: Eroding Regional or Global Security. Venezuela faces no true threats to its vital national interests. However, it has recently been at odds with neighbor Colombia. Colombia has long accused Venezuela of aiding the Revolutionary Armed Forces of Colombia (FARC), a rebel group involved in a civil war with Colombia's government. In early 2005, bounty hunters kidnapped a suspected Colombian terrorist in Caracas, prompting accusations by Chavez that the Colombian government was behind the kidnapping. Chavez recalled his ambassador to Colombia and cancelled some accords between the two countries.[166] Tensions from this incident have eased in the past two years and although conflict between the two states cannot be ruled out, it seems unlikely at this point, especially with the strong economic ties between the two states. Moreover, Venezuela is not at a strategic disadvantage when compared to Colombia so turning to nuclear weapons in this instance seems far-fetched.

Venezuela is at a strategic disadvantage when measured against the United States, a country Hugo Chavez routinely vilifies and paints as a rival. To this point the US has largely ignored Chavez' rhetoric just as Chavez has not taken any measures that would truly cause the US pause. If in the future the US / Venezuelan relations deteriorate to the

[166] James T. Kiner, "Venezuela / Colombia: Relations Turn Carnal," NACLA report on the Americas, March/April 2005, Proquest document ID# 803084811, accessed via Proquest 22 May 2007.

point conflict is possible, Venezuela could look to shore up its relative disadvantage with nuclear weapons.

Factor 4: Domestic Imperatives. Chavez has used oil wealth to win support both among his electorate with social programs and within his region with oil subsidies. A number of events could change Venezuela's economic fortunes. Among them: oil prices could stagnate or fall or Venezuela's production could continue to drop. Without a certain level of oil revenue, Chavez will not be able to continue funneling money into social programs for his population nor will he be able to continue the PetroCaribe subsidy program. With his and Venezuela's fortunes so tied to oil, Chavez stands to lose much if Venezuela's oil money slows. The potential loss of his political support at home and his influence in the region could cause Chavez to seek nuclear weapons, although an economic downturn makes the pursuit of a homegrown weapons program unlikely. Chavez could justify pursuit of nuclear weapons to his country by stoking fears of US aggression and portraying a nuclear capability as the only way to deter same.

Factor 5: Increasing Availability of Technology. If Venezuela chooses nuclear proliferation, an attractive option available is the purchase of technology and expertise it would otherwise have to invest in domestically. Lower oil prices or other economic hardship could cause Chavez to consider nuclear weapons in the first place; the same factors may lead him to the nuclear black market. As Venezuela has no current nuclear capability, technology transfer would be important to any type of nuclear proliferation on the part of the state. If Venezuela chooses to one day pursue an autonomous nuclear

capability or even just a weapon, the availability of nuclear technology and knowledge presents an enticing means to this end.

HUGO CHAVEZ: NATIONAL IDENTITY CONCEPTION

Within Jacques Hyman's NIC framework, Hugo Chavez is a nationalist, convinced that Venezuela should hold equal status with like states and even with countries like the United States. But unlike Lula de Silva, Hugo Chavez also presents as an oppositional in Hyman's solidarity dimension, at least where the US is concerned. He frames Venezuela's relationship with the US with an "us against them" mentality. Hyman's NICs are created by what he terms the "recall of emotional memories."[167] Hugo Chavez' NIC relative to the US is influenced by many factors. Among them could be his belief the US was behind the 2002 coup attempt against him, a fear that the US will intervene directly in Venezuela's affairs—perhaps via a proxy war with Colombia-- and even shame that Venezuela's economy and his Bolivarian Revolution are so dependent on oil money from the US

No matter what exactly formed Hugo Chavez' NIC, he falls into the category of oppositional nationalist, the NIC type most likely to covet nuclear weapons. In Hymans' view, a mixture of fear and pride drive the oppositional nationalist to consider nuclear weapons. Oppositional nationalists reject or accept the non-proliferation regime as it suits their needs. At the current time, Venezuela is party to the NPT and accepts the non-proliferation regime because it has no reason not to. This stance would change is Venezuela decides to acquire nuclear weapons. Oppositional nationalists will, at the

[167] Hymans, 26.

same time, demand and resent superpower assistance. However, their ultimate goal is to exist without such assistance, ostensibly in possession of a nuclear capability.[168] Venezuela's burgeoning relationship with China has the potential to take on these characteristics. If Venezuela decides that it needs nuclear weapons, it may look to China for protection as it attempts to acquire them.

Hymans' characterization of an oppositional nationalist and the desire of that NIC type to acquire nuclear weapons are, of course, conditional. Oppositional nationalist leaders who are not pursuing nuclear weapons do exist, and Hymans has to explain why. First, the leader's state has to be engaged in reasonably intense interactions with a rival. Though Chavez probably considers his interactions with the US intense, lack of an overt US threat to Venezuela's national security makes this condition questionable. Next, Hymans says the oppositional nationalist must have a degree of control over the state apparatus.[169] Chavez and his party already have a large measure of control over all of Venezuela, and this control will most likely increase markedly in the near future. Chavez has already nationalized key industry and infrastructure. He is attempting to consolidate Venezuela's legislative apparatus under one party. In the coming year, Chavez has the ability to make law in key areas by decree. With this power he could move toward tighter control of Venezuela's affairs and also extend his time in office indefinitely.

Hymans' final condition on the nuclear aims of an oppositional nationalist is the most telling where Venezuela is concerned. He states that the leader's country must have

---

[168] Hymans, 38.

[169] Hymans, 36.

some experience in the nuclear field.[170] Venezuela has almost none, save for the long ago abandoned power reactor it possessed. There is no nuclear infrastructure to speak of in Venezuela, and perhaps more importantly there is no nuclear knowledge base. Starting a nuclear program from the ground up requires a huge expenditure of capital. Chavez has access to large amounts of oil money, but diverting money to fund a nuclear program would hurt his social initiatives and oil subsidy program.

While he makes a coherent argument with this last point, I think that Hymans should have explored it further. A leader that wants to acquire nuclear weapons has to start somewhere even if his state doesn't possess the current means to do so. Hymans also fails to explore the potential for the transfer of important technology, knowledge, and even nuclear weapons themselves. Nuclear proliferation by technology transfer comes at a much lower cost than designing a program from the bottom up.

VENEZUELA: ANALYSIS OF COMPETING HYPOTHESES

Step 1 – Identify the possible hypotheses to be considered

As discussed in Chapter 1, there are four hypotheses that this analysis will consider for Venezuela.

---

[170] Hymans, 36.

1) H1: Venezuela will pursue an indigenous nuclear weapons program;

2) H2: Venezuela will develop a nuclear power capability;

3) H3: Venezuela will not pursue any type of nuclear capability (status quo);

4) H4: Venezuela will attempt to acquire nuclear technology, knowledge, or weapons through technology transfer.

Step 2 – Make a list of significant evidence and arguments for and against each hypothesis

Figure 15 details the evidence considered in this analysis.

-Venezuela seeking nuclear knowledge from Brazil and Argentina
-Chavez' comments on nuclear power
-Venezuela's ties with Iran and North Korea
-Chavez' increasing control over Venezuela
-Lack of an imminent threat to Venezuela's vital interests
-The strong Latin American non-proliferation regime
-No current nuclear infrastructure or knowledge
-Chavez fits the typology of an oppositional nationalist
-Venezuela faces uncertainty and potential loss in regional power as oil production continues to decline
-Long term oil price forecast is stagnant / declining
-Venezuela is signatory to the NPT and Treaty of Tlateloco
-Venezuela is at a strategic disadvantage to the US
-Faces harsh US and global reaction it decides to proliferate
-Venezuela has no delivery system for a nuclear weapon
-At present, the US is focused elsewhere
-The non-proliferation regime appears to be weakening
-Venezuela's actions point at a desire for more power in the region

Figure 15: Evidence considered in Venezuela ACH analysis

Step 3: Prepare a matrix with the hypotheses and evidence in to analyze "diagnosticity" of the evidence

I prepared the ACH matrix for Venezuela using the same methodology I did in preparing the matrix for Brazil.

Evidence #	Evidence	Evidence Type	Credibility	Relevance	H1 - Weapons	H2 - Nuclear Power	H3 - Status Quo	H4 - Tech. Transfer
E1	Seeks nuclear power knowledge from Brazil		high	high	c	cc	i	c
E2	Chavez comments on nuclear power		high	med	c	cc	i	c
E3	Lack of nuclear knowledge / facilities		high	med	i	i	c	c
E4	Ties with Iran and North Korea		high	med	c	n	n	c
E5	Chavez' increasing control over Venezuela		high	med	c	c	n	n
E6	Lack of imminent threat		high	high	ii	na	na	i
E7	Strong Latin American non-prolif. regime		high	high	i	ii	c	ii
E8	Desire to maintain / gain regional power		med	med	c	c	i	cc
E9	Declining oil production / loss of reg. power		med	high	c	c	n	n
E10	Long term oil forecast stagnant		low	med	c	na	c	n
E11	Signatory to NPT and Tlatelolco		high	med	ii	i	c	ii
E12	Strategic disadvantage to percieved threat (US)		med	med	c	na	i	c
E13	Fsces hsrsh reaction if decides to prolif.		med	med	i	i	cc	i
E14	Chavez as an oppositional nationalist		med	med	cc	c	i	c
E15	No delivery system for a nuclear weapon		high	low	i	na	na	n
E16	U.S. focused elsewhere		med	low	c	c	n	c
E17	Weakining non-proliferation regime		med	med	c	c	na	c
E19	High startup costs for any nuclear program		high	high	i	i	c	c
E19	Venezuela has no ballistic missiles / program		high	high	i	na	c	ii
				Weighted Inconsistency Score =	**-16.239**	**-9.826**	**-6.413**	**-13.825**
				Unweighted Inconsistency Score =	**-10**	**-6**	**-5**	**-8**
				Overall Weighted **Consistency** Score =	**-2.169**	**3.536**	**5.120**	**0.123**

Figure 16: ACH Chart for Venezuela

An initial look at the results of the ACH show that H3, or maintenance of the status quo, is the hypothesis with the least amount of raw and weighted inconsistent evidence. An interesting aspect of the initial analysis is that the nuclear power hypothesis and the technology transfer hypothesis have the same amount of inconsistency based on the evidence presented. Again, outside of the scope of this analysis there could be much more evidence presented that could alter the results. But even this basic examination seems to suggest that Chavez and Venezuela at least have some propensity towards

nuclear development, be it nuclear power or the acquisition of nuclear technology through illicit means. The strongest inconsistencies occur with the hypothesis that Chavez will try to develop his own nuclear power program. The huge start-up costs and likely international reaction to an overt nuclear move by Venezuela make this idea seem unfeasible.

Step 4 – Refine the matrix

When examined using the available evidence, each hypothesis remains distinct. The nuclear weapon and nuclear power hypotheses exhibit equivalent consistent evidence scores. With the potential for the dual use of nuclear infrastructure for weapons production, this assessment makes sense.

All of the evidence presented shows some diagnostic ability, so I will keep all of it in the analysis. The US focus on the Middle East and the weakening non-proliferation regime show the least diagnostic ability, but since both are not inconsistent with any hypothesis I will leave them in the matrix. Again, although there is additional evidence that could influence this analysis, I do not assess than any of the hypotheses relies heavily on evidence not presented.

Step 5 – Draw tentative conclusions about the relative likelihood of each hypothesis

H1, the hypothesis that Venezuela will develop a nuclear weapons program, has the most evidence inconsistent with it and seems the least likely of the four hypotheses presented. H3, maintenance of the status quo with Venezuela not pursuing any nuclear goals, has the least amount of evidence against it and initially appears to be the most

likely. One of the challenges of predicting nuclear proliferation is assessing dual use technology and in Venezuela's case this assertion is highlighted by how the ACH gives almost equal scores to the chance that Venezuela will develop a nuclear power program and the chance it will pursue nuclear aims by technology transfer. It seems simplistic to fall back on the status quo, but in this case it is a reasonable conclusion. One significant question this analysis cannot definitively answer is how Hugo Chavez truly assesses the US threat to both himself and Venezuela. If Chavez is playing up the US threat for the consumption of his electorate and the region, then favoring the status quo makes sense. If he truly believes that the US will at some point directly intervene in Venezuela's affairs for whatever purpose, then the analysis would have to favor pursuit of a nuclear answer to that threat given Chavez' NIC typology. The relatively close results of the ACH do not steer me in either direction, but I lack any concrete evidence Venezuela is doing more than talking about nuclear capability. As such, the tentative conclusion this study reaches is that Venezuela will not pursue a nuclear capability in the near future.

Step 6 – Analyze how sensitive your conclusion is to a few critical pieces of evidence

The conclusions reached in step 5 do not appear to be sensitive to a few critical pieces of evidence. In examining my personal views on the subject, however, I feel that I may rely too heavily on Hugo Chavez himself in assessing Venezuela. With his increasing control over the country, this viewpoint may not be far off. In any case, I have attempted to present a diverse range of evidence in assessing Venezuela's nuclear potential. There is no evidence that absolutely discounts any single hypothesis and there exists no evidence that heavily favors any hypothesis.

Step 7 – Report Conclusions

This study concludes that given its current situation, Venezuela will not pursue any type of nuclear capability. Hugo Chavez paints the American threat to Venezuela as genuine, and he may well believe this is true. Based on his NIC, Chavez seems to be more predisposed than not to desiring nuclear weapons. These assertions aside, though, the costs of any nuclear aims are too high for Hugo Chavez and Venezuela. A weapons development program would cost Venezuela's economy a large amount of capital and would also effectively hamstring Chavez' domestic and regional initiatives. The potential US and international reaction to a nuclear attempt by Venezuela incur a great political cost. From military intervention to economic isolation, Chavez may not be willing to risk the loss of his presidency over nuclear security.

Of the hypotheses presented, Venezuela is least likely to begin an overt weapons program. The aforementioned political and economic costs are too much to overcome. If Hugo Chavez does choose to pursue nuclear weapons, he will do so behind either the veil of a nuclear power program or the secrecy of clandestine weapon procurement. Technology transfer of a nuclear weapon seems unlikely as Venezuela possesses no ballistic missiles, among other factors. Thus another conclusion of this study is that if Venezuela decides to pursue nuclear weapons, it will do so by developing a dual-use nuclear power program. Following the model of other states that have followed this course, this program would develop slowly and tentatively as capital and / or technology comes available.

Step 8 – Identify milestones for future observation that may indicate events are taking a different course

Figures 17 and 18 detail indicators Venezuela's nuclear proliferation is taking a different direction than the one detailed by this thesis.

-Any obstruction of the IAEA
-Any nuclear facility construction
-Attempt to develop ballistic missiles or acquire missile technology
-Sharp decrease in oil prices
-Severe economic downturn / loss of foreign investment
-World economic recession
-Evidence that Venezuela is engaging in illegal technology transfer
-Deteriorating relations / armed conflict with Colombia
-Deteriorating relations with Brazil
-Venezuela's emergence as a true regional power
-Conventional arms race with Brazil or Colombia
-Increased nuclear rhetoric by Chavez or the Venezuelan government
-Large scale social unrest
-Abolishment of Venezuelan term limits by Chavez
-Loss of funding for social programs or Petrocaribe program without downturn in economy or falling oil prices.
-Pullout of any nuclear treaty or organization
-Increasingly inwardly focused US policy

Figure 17: Indicators Venezuela is pursuing nuclear weapons (H1 and H4)

-Any nuclear facility construction
-Continued degradation of Venezuela's oil infrastructure
-Any energy crisis in Venezuela
-Evidence Venezuela is attempting to acquire nuclear knowledge or technology on the open market (contracts with nuclear power nations)
-Establishment of a nuclear energy commission
-Establishment of a comprehensive nuclear studies program at the university level

Figure 18: Indicators Venezuela is pursuing nuclear power (H2)

CHAPTER 5

CONCLUSION: COUNTERING NUCLEAR PROLIFERATION IN LATIN AMERICA

COUNTERING NUCLEAR PROLIFERATION: NO EASY TASK

The history of nuclear non-proliferation shows at least five distinct attempts at discouraging proliferation since the nuclear age dawned in 1945.[171] Each attempt was designed for a different strategic threat and thus approached the question of proliferation differently. A short examination of each shows the success and failure of non-proliferation efforts and provides clues about how best to handle proliferation in the future.

The Baruch Plan

In 1946 American negotiator Bernard Baruch put forth a plan before the UN that advocated disarmament and international control of all dangerous nuclear activities. This plan was a result of the strategic assessment that there was no true deterrence for nuclear proliferation. It was designed to be a complete non-proliferation effort, though it contained no provision to disarm the US nuclear capability. The Soviet Union rejected this idea offhand. Although it had some good ideas about distinguishing between safe

[171] Henry D. Sokolski, *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation* (Westport, CT: Praeger Publishers, 2001): 2.

and unacceptable nuclear practices, the plan's emphasis on the strategic value of nuclear weapons doomed it to failure.[172]

Atoms for Peace

As Soviet nuclear capability increased, President Dwight Eisenhower and his military planners came to fear a decisive blow against America's industrial base. They calculated the amount of nuclear weapons it would take to accomplish this decisive blow and then set about to prevent any one nation from acquiring that much nuclear material. Known as the Atoms for Peace program, member nations were supposed to contribute weapons grade material and be monitored by a central organization known as the International Atomic Energy Agency. The Atoms for Peace program, though well intentioned, was a complete failure. It was based on the faulty strategic threat assessment that only a large amount of nuclear weapons would threaten the US. As we now know, small quantities of nuclear material and even a single nuclear weapon present a strategic threat to the US. Additionally, the Atoms for Peace program provided very loose controls for sharing civilian nuclear technology which could be put to dual use as parts of a weapons program.[173]

The Non-Proliferation Treaty

The NPT was based on the premise that a superpower nuclear arms race promoted international instability. In such a system, it was theorized smaller states would look to

---

[172] Sokolski, 2-3.

[173] Sokolski, 3-4.

acquire nuclear weapons as a safeguard. The NPT was designed to prevent this type of proliferation. It encouraged non-nuclear states to eschew their right to possess nuclear weapons in exchange for disarmament by the nuclear powers. In addition, it contained provisions for again transferring civilian nuclear technology as a means of allowing non-proliferating states to develop nuclear power programs. Though it is still in effect today, the NPT has its limitations. States that have signed it as non-proliferators are resistant to submit to IAEA inspections. Moreover, the NPT contains wording that allows countries to break out of the treaty if they feel threatened.[174]

Technology Control

The fear that a regional war involving ballistic missiles and nuclear weapons would draw in the superpowers and create a global conflict led to the establishment of various organizations designed to limit the technology available to potential proliferators. These organizations include the Nuclear Suppliers Group (NSG), the previously discussed MTCR, and the Australia Group (AG), which is designed to prevent the spread of chemical and biological weapons.[175] Although limiting the transfer of technology seems to be a reasonable measure the effectiveness of the aforementioned groups is questionable, especially since the collapse of the Soviet Union. Joining these regimes gives members access to technology and also safeguards members from many proliferation penalties, both of which serve to make them hard to enforce.[176]

---

[174] Sokolski, 4-5.

[175] Sokolski, 6.

[176] Sokolski, 6.

Counterproliferation

Counterproliferation efforts assume that proliferation is not preventable. It focuses on developing strategy and means to neutralize or minimize potential threats to the US[177] Counterproliferation options include preemptive strikes against states deemed threatening and the development of defensive measures and capabilities. Problems with this approach include the difficulty of developing technology that would defend against weapons of mass destruction and the tacit admission that the US is giving up on non-proliferation efforts[178], the latter of which can further weaken the NPT.

Non-proliferation in the Future?

The NPT, technology control regimes, and counterproliferation are, to varying degrees, still active in attempting to encourage nuclear non-proliferation. Unfortunately, they all are based on specific military assessments and tend to apply a "one size fits all" approach to non-proliferation. In his work *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation*, Henry Sokloski advocates less emphasis on viewing nuclear proliferation through the lens of military strategy and more emphasis on understanding emerging social, economic, and political trends.[179] His holistic approach to non-proliferation may prove to have merit over the long haul, but its importance lies in the basic understanding that the causes of proliferation or even potential proliferation are not common to every state. This is certainly true in the case of Venezuela and Brazil and

---

[177] Sokolski, 7.

[178] Sokolski, 7.

[179] Sokolski, 10-11.

is an idea I have tried to put forward in this study. Latin American states do not seem prone to proliferation based on the traditional viewpoint of proliferation because of military necessity. Most if not all Latin American states lack a true threat to their national interests that would need to be countered with nuclear weapons. This study concludes that Venezuela and Brazil will not pursue nuclear weapons in the foreseeable future, and this assessment is not solely based on military necessity. It includes other factors such as economic health, democratic trends within the respective governments, and even a glimpse into the personality and motivations of Hugo Chavez and Lula de Silva. The lesson for intelligence professionals is that indicators of proliferation are not always militarily based and are likely to be different for each state. For policy makers, dealing with nuclear proliferation requires an approach tailored to specific states or situations.

COUNTERING PROLIFERATION IN LATIN AMERICA: U.S OPTIONS

Since this study concludes there is no true threat of nuclear proliferation in Latin America at this time, US policy should be geared to maintain Latin America's nuclear free status. Though global nuclear proliferation has been slow over the years, it will continue to occur. Both state and non-state actors are likely to pursue nuclear weapons in the future, and many will threaten the US by the mere act of possessing nuclear weapons. The US faces many current strategic threats, and it certainly has a vested interest in keeping nuclear weapons out of the Western Hemisphere. The following policy options are based on that goal.

Promoting Democracy

Though Henry Sokolski's approach to countering proliferation seems to be more comprehensive than past efforts, it engenders more of a wait and see approach. Facing nuclear proliferation in Latin America, the US is not likely to sit back and hope that encouraging democracy will solve the issue. However given the current lack of a credible proliferation threat by Venezuela, Brazil, and other Latin American states, the US should encourage democratic movements and economic freedoms as methods to counter future threats in the region. Many of the indicators this study put forth for Venezuela and Brazil are politically and economically based, and the US should monitor those indicators to help assess the health of non-proliferation in the region. In general, a better understanding of what drives states to proliferate is the first step in understanding how to best control proliferation.[180] Brazil's government is doing well in this area, but Hugo Chavez and Venezuela present a different problem. His well documented moves away from democracy and consolidation of power are cause for concern and an issue that should be addressed by the US, especially in light of democratic moves in Brazil and Argentina that resulted in each eschewing nuclear weapons.

A More Flexible Non-proliferation Regime

With the relative ease of technology transfer in today's global economy, the past emphasis on technology control for non-proliferation is not likely to be as successful as it once was.[181] In Latin American states like Brazil and Argentina, much of the requisite technology for nuclear weapons is already in place; tighter controls for these two states is

[180] Hymans, 219.

[181] Hymans, 220.

not likely to avert proliferation. Technology control may have more success in Venezuela which does not currently possess any nuclear infrastructure. However, a state convinced of a need for nuclear weapons is not likely to be dissuaded by tighter controls on technology even if this presents its largest hurdle to overcome.

The non-proliferation regime needs to take a more open, receptive tack when dealing with modern proliferation. States should be allowed to create bilateral or regional non-proliferation agreements that will be accepted by the international non-proliferation regime as legitimate or they should be allowed to join the regime at varying degrees of participation.[182] In fact, Latin America should be promoted as a model of this type of non-proliferation. The bilateral non-proliferation agreement between Brazil and Argentina and the regional Treaty of Tlatelolco put Latin America at the forefront of such non-proliferation initiatives. Moreover, highlighting Latin America as an example of successful non-proliferation may help to discourage future proliferation in the region.

Military Intervention

Using military action to force regime change in a state attempting to develop nuclear weapons remains a viable option for the US, even in the wake of the current conflict in Iraq. Given the issues regarding the reasons for pursuing the current war in Iraq, history may yet show that the first Gulf war and its aftermath were the events that ultimately prevented nuclear proliferation in Iraq.[183] At the very least, the US has served notice to potential proliferators that it will not hesitate to act when it perceives nuclear proliferation as a threat to its vital interests. Another side of this argument holds that an

[182] Hymans, 221.

[183] Hymans, 223.

aggressive and pre-emptive US actually encourages more proliferation among states looking to deter such an action.

In either case, in the wake of Iraq it is likely the US will be more cautious next time it decides to intervene with military force to stop nuclear proliferation. The US will require more concrete evidence of proliferation and intentions, as well as ensuring that international opinion is in its favor. With regards to this study, the US is much more likely to consider military intervention against a vehemently anti-US Hugo Chavez than it is against Brazil. How the current nuclear crises with Iran and North Korea play out will be telling in terms of future US policy in this area.

A Focus on Leadership

I have used Jacques Hymans' ideas concerning national identity conception extensively in this work, and I would be remiss if I did not address the role of the national leader in US efforts to prevent proliferation. A recognition of the NIC of a leader may well be key to shaping non-proliferation policy towards a particular state. Lula da Silva is a sportsmanlike nationalist; according to Hymans the US should support his agenda while at the same time understanding the nature of his nuclear ambitions.[184]

Hymans' true concern is the oppositional nationalist, personified in Latin America by Hugo Chavez. He presents a couple of solutions to the problem oppositional nationalists present to the non-proliferation regime. One is to keep them out of power in the first place. Hymans proposes educating domestic and international leaders on the nuclear propensity that oppositional nationalists exhibit. Theoretically, the US should deny support for oppositional nationalists running for national office. Another solution to

[184] Hymans, 226.

handling an oppositional nationalist leader is to ensure that nuclear safeguards are built in to the decision-making process of a state such that no one person can make crucial nuclear decisions.[185]

Unfortunately for the US and the non-proliferation regime, Hugo Chavez is already a national leader and is consolidating his control over Venezuela. If Chavez does decide to go nuclear, either militarily or commercially, he is unlikely to build safeguards into his program. Instead he will retain sole control over his country's nuclear decisions. Hymans offers no guidance on dealing with the oppositional nationalist already in power and without safeguards. The US and global non-proliferation regime are left with the other options recommended by this work or others not mentioned when dealing with Hugo Chavez if he decides Venezuela needs nuclear weapons.

CONCLUSION

Overview

In this work, my research question involves the potential for future nuclear proliferation in Latin America. Rather than try to assess every state in Latin America, I chose two states that have the potential to pursue nuclear weapons, albeit for different reasons. Brazil is a state with a large nuclear infrastructure and one that is currently attempting to achieve an autonomous nuclear fuel cycle. As such, I judged it the state in Latin America most likely to proliferate. Venezuela is a state with no nuclear capability. However, Hugo Chavez in possession of nuclear weapons would represent a true threat to

---

[185] Hymans, 226.

national security. I judged nuclear proliferation in Venezuela to be the most dangerous course of Latin American proliferation for the US.

I then examined each state from a variety of angles. I used the framework set forth in *The Nuclear Tipping Point* to assess each state's current situation. I used Hymans idea of national identity conception to assess the current leaders of each state and their propensity to proliferate. Finally, I compiled this evidence along with other applicable evidence gleaned from open source intelligence to conduct an analysis of the proliferation potential for each state. I did this by using the analysis of competing hypotheses method. I chose not to do a statistical examination of the numbers the ACH produced and indeed chose to downplay numerical results. Although the numbers produced by each ACH support my findings, ACH was more valuable to me and to this study in that it provided a methodical way in which to organize and analyze my evidence.

Findings and Implications for Theory and Policy

This hypothesis I put forth in the beginning of this study stated that neither Brazil nor Venezuela would pursue nuclear weapons in the foreseeable future but each had the potential for proliferation. My findings support my hypothesis, but I want to emphasize my assertion that for each state the potential for proliferation, however small, does exist. As an intelligence document, a main goal of this study was to present evidence and indicators for each state. If either makes a future move to acquire nuclear weapons, it is important that we understand the indicators as well as the motivation for such an action.

Brazil, as a nuclear weapon capable state, has no real internal or external forces driving it towards nuclear weapons. Moreover, Lula da Silva does not fit the profile of a leader that desires nuclear weapons for his country. For Brazil, while the means for nuclear weapons are present, the motivation is not.

Venezuela, on the other hand, possesses motivation but not means. Hugo Chavez is the type of leader that does want his country to possess nuclear weapons, and he is motivated by the real or perceived threat the US presents him. Based on a variety of current or potential factors, Venezuela could easily find itself in a situation where nuclear weapons are plausible or even desirable, although it lacks the apparent means to attain them.

Based on my findings, I advocate an approach to dealing with proliferation in Latin America that is both measured and grounded in realism. The use of a single policy for dealing with proliferation in the region of globally is unfeasible. The current situation and future developments in Brazil, Venezuela, and the rest of the region should be monitored closely and US policy tailored to each developing situation. The US is the biggest player in any non-proliferation efforts in Latin America, but needs to understand its role and also understand what can be reasonably accomplished as each issue presents itself. The policy options presented here are not new options, but by and large they are not in line with the prevailing views on non-proliferation, which tend to call for things like tighter controls on technology and complete disarmament by nuclear weapons states. With a non-proliferation failure in North Korea behind us and another potential one looming in Iran, clearly new approaches to the subject warrant exploration. In a region that is both vitally important to the US and one that is progressive in its thinking on

nuclear proliferation, the nonproliferation measures suggested in this work may well prove to be the right answer in Latin America.

This work was not intended to make great advances in the arena of non-proliferation theory. Its main purpose was to fill what I perceived as an information gap in intelligence thinking and literature. Much has been written on the nuclear pasts and disarmament of Brazil and Argentina, but very little on their nuclear futures. Venezuela, although it has made some nuclear overtures, remains unaddressed in the literature as a proliferation problem. By providing a framework for assessing the nuclear intentions of Venezuela and Brazil and also by highlighting indicators of potential proliferation, I hope this study will advance the knowledge on a relatively unknown subject while also providing a basis for though and dialogue should proliferation rear its head in Latin America.

Recommendation for Future Research

As with any document that makes an assessment of potential events, I recommend that this work be updated as new evidence presents itself. Changing leaders and changing governments, declining economies and new security threats are but a few of the myriad events that could change the nuclear direction of Brazil or Venezuela. As things change, the results of this work should be updated. This study can also serve as an analog for the examination of other states in the region with proliferation potential. Chief among these states at this point in time is Argentina with its nuclear power program and past nuclear weapon pursuit.

Without relying too much on Hymans', I think the evidence he presents in support of his NIC idea is solid and his overall hypothesis has merit. To that end, a complete, statistical assessment of the NIC of each current and future Latin American leader is warranted. This assessment would be much more in depth than the cursory glance I have given Hymans in this work. A Latin American state with an oppositional nationalist leader could then be more closely examined for nuclear potential, perhaps using the methodology of this study. Although leaders and governments come and go, a string of like-minded individuals in power can steer a country toward nuclear development.

Finally, a comprehensive study of future non-proliferation trends needs to be undertaken. There is a plethora of literature that addresses the factors and details of non-proliferation now and in the near future. My study has mentioned many of these works. As events unfold and these ideas are tested or ignored, their validity needs to be continually assessed in order to better strengthen the global non-proliferation regime and prevent nuclear weapons from falling into the wrong hands.

GLOSSARY

ABM	Anti-Ballistic Missile Treaty
ABACC	Brazil-Argentine Agency for the Accounting and Control of Nuclear Materials
ACH	Analysis of Competing Hypotheses
AEB	Brazilian Space Agency
AG	Australia Group
ARN	Nuclear Regulatory Authority, Argentina
BWR	Boiling Water Reactor
CANDU	Canada Deuterium Uranium
CAREM	Central Argentina Modular Reactor
CNEA	Atomic Energy Commission, Argentina
CNEN	Nuclear Energy Commission, Brazil
CNPC	China National Petroleum Corporation
COPESP	Brazilian Navy's Special Projects Commission
FARC	Revolutionary Armed Forces of Colombia
GCR	Gas Cooled Reactor
GDP	Gross Domestic Product
HEU	Highly Enriched Uranium
IPEN	Institute of Energy and Nuclear Research, Brazil
IAEA	International Atomic Energy Association

INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INVAP	Applied Research, State Enterprise, Argentina
IRIS	International Reactor Innovative and Secure
MCTR	Missile Control Technology Regime
MTSWU	Metric Tons of Separative Work units of Uranium
MW	Megawatts
NIC	National Identity Conception
NPT	Non-Proliferation Treaty
NRC	Nuclear Regulator Commission, United States
NSG	Nuclear Suppliers Group
NWFZ	Nuclear Weapons Free Zone
OPEC	Organization of Petroleum Exporting Countries
PDVSA	Petroleos de Venezuela, S.A.
PHWR	Pressurized Heavy Water Reactor
PWR	Pressurized Water Reactor
PT	Worker's Party, Brazil
PU_{239}	Plutonium 239
VLS	Veiculo Lancador de Satelites
U_{235}	Uranium 235
U_{238}	Uranium 238
UF_6	Uranium Hexaflouride
UO_2	Uranium Dioxide
WMD	Weapons of Mass Destruction

BIBLIOGRAPHY

"ABM Treaty Fact Sheet." Statement by the White House Press Secretary, 13 December 2001. URL: < http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html>. Accessed 12 April 2007.

"Alacran." Web-only essay, 17 April 2007. URL: <http://www.missilethreat.com/missilesoftheworld/id.2/missile_detail.asp>. Accessed 17 April 2007.

"Argentina Profile: Missile Review." Web-only essay, October 2006. URL: < http://www.nti.org/e_research/ profiles/Argentina/Missile/index.html>. Accessed 17 April 2007.

Bacevich, Andrew J. "Twilight of the Republic?" *Commonweal*, 1 December 2006. Proquest document ID# 1174704891. Accessed via Proquest 16 May 2007.

"Brazil Accelerates Nuclear Reactor Work For Nuclear Submarine Program." *Arms Control Today*, July 2004. Proquest document ID# 660598721. Accessed on Proquest 14 May 2007.

"Brazil Economy: Land of Promise." Economist Intelligence Unit wire feed, 13 April 2007. Proquest Document ID# 1265109521. Accessed via Proquest 16 May 2007.

"Brazil: Enrichment Plant, Resende." Web-only database, 6 May 2006. URL: <http://www.wise-uranium.org/eproj.html#BR >. Accessed 11 March 2007.

"Brazilian-Argentine Agency For Accounting And Control Of Nuclear Materials (ABACC). Web-only essay, 8 June 2007. URL: <http://cns.miis.edu/pubs/inven/pdfs/abacc.pdf>. Accessed 8 June 2007.

"Brazil's Nuclear History." *Arms Control Today*, October 2005. Proquest document ID# 924378651. Accessed via Proquest 14 May 2007.

Carasales, Julio C. "The Argentine-Brazilian Nuclear Rapprochement." *The Non-Proliferation Review*, Spring/Summer 1995. URL: <http://cns.miis.edu/pubs/npr/vol02/23/carasa23.pdf>. Accessed 17 April 2007.

CIA World Factbook: Brazil. CIA World Factbook, 10 May 2007. URL: <http:// https://www.cia.gov/library/publications/ the-world-factbook/geos/br.html>. Accessed 14 May 2007.

CIA World Factbook: Venezuela. CIA World Factbook, 15 May 2007. URL: < https://www.cia.gov/library/publications/the-world-factbook/geos/ve.html>. Accessed 21 May 2007.

"Conversion: Yellowcake to Uranium Hexafluoride." Web-only essay, 2007. URL: <http://www.nei.org/index.asp?catnum=3&catid=181>. Accessed 22 April 2007.

"Countering Chavismo in a cool manner – Venezuela's nuclear plans require a measured response." *Financial Times*, Asia edition, 17 October 2005. Proquest document ID# 03071766. Accessed via Proquest 21 May 2007.

"Crude Oil and Total Petroleum Imports Top 15 Countries." Web-only table, 21 May 2007. URL: <http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/ company_level_imports/current/import/html>. Accessed 21 May 2007.

"EIA Annual Energy Outlook 2007." Web-only essay, February 2007. URL: <http://www.eia.doe.gov/oiaf/aeo/index.html>. Accessed 21 May 2007.

Eisenhower, Dwight D. Speech given to the United Nations, 8 December 1953. URL: < http://www.eisenhower.archives.gov/atoms.htm>. Accessed 4 March 2007.

"Energy Information Association Brazil County Analysis Brief." Web-only brief, 2005. URL: < http://www.eia.doe.gov/emeu/cabs/Brazil/ Electricity.html>. Accessed 19 March 2007.

"Energy Information Association Mexico County Analysis Brief." Web-only brief, 2005. URL: < http://www.eia.doe.gov/emeu/cabs/Mexico/ Electricity.html>. Accessed 19 March 2007.

Enger, Eldon and Bradley Smith. *Environmental Science: A Study of Interrelationships*, 10th ed. Boston: McGraw Hill, 2006.

Epstein, William. "Why States Go -- And Don't Go – Nuclear." *Annals of the American Academy of Political and Social Science* 430, no. 1(March 1977): 16-28.

Fernández-Vázquez, Eugenio and Juan Pablo Pardo-Guerra. "Latin America Rethinks Nuclear Energy." Web-only essay, 12 September 2005. URL: <http://americas.irc-online.org/am/558>. Accessed 7 March 2007.

Fletcher, Pascal, "Cuba rejects Russian nuclear plant offer." *Financial Times*, 19 December 2000. Proquest document ID #65278301. Accessed via Proquest 20 March 2007.

Flynn, Michael. "A Latin 'Axis of Evil?'" *Bulletin of the Atomic Scientists,* Oct/Nov 2003. Proquest document ID# 274909151. Accessed via Proquest 14 May 2007.

"Future development and poverty reduction tied to gains in renewable energy, says IDB President," Inter-American Development Bank Press Release, 18 March 2007. URL: <http://www.iadb.org/NEWS/articledetail.cfm?artid=3691&language=En>. Accessed 21 March 2007.

Garwin, Richard L. and Georges Charpak. *Megawatts and Megatons: A Turning Point in the Nuclear Age?* New York: Alfred A Knopf, 2001.

"Graph: World Uranium Production." Web-only graph, 7 November 2006. URL: <http://www.uxc.com/ fuelcycle/uranium/production-uranium.html>. Accessed 26 February 2007.

Goldemburg, Jose. "Looking Back: Lessons from the Denuclearization of Argentina and Brazil." *Arms Control Today*, April, 2006. URL: <http://www.armscontrol.org/ act/2006_04/ lookingback.asp>. Accessed 17 April 2007.

Heuer, Richards J. *Psychology of Intelligence Analysis.* Pittsburg, PA: Government Printing Office, 1999.

Horton, Roy E. III. "Out of South Africa: Pretoria's Nuclear Weapons Experience." United States Air Force Institute For National Security Studies Occasional Paper #27, August 1999. URL: < http://www.fas.org/nuke/guide/rsa/nuke/ ocp27.htm>. Accessed 7 March 2007.

Hymans, Jacques E.C. *The Psychology of Nuclear Proliferation: Identity, Emotions, and Foreign Policy.* New York: Cambridge University Press, 2006.

"International Atomic Energy Agency Country Report: Argentina." Web-only report, December 2004. URL: <http://www.pub.iaea.org/MTCD/publications/PDF/ cnpp2004/ CNPP_Webpage/ countryprofiles/Argentina/Argentina2004.htm>. Accessed 15 March 2007.

"International Atomic Energy Agency Country Report: Brazil." Web-only report, December 2004. URL: <http://www.pub.iaea.org/MTCD/publications/ PDF/cnpp2004/CNPP_Webpage/countryprofiles/Brazil/Brazil2004.htm>. Accessed 15 March 2007.

"International Atomic Energy Agency Country Report: Mexico." Web-only report, December 2004. URL: <http://www.pub.iaea.org/MTCD/publications/PDF/cnpp2004/CNPP_Webpage/countryprofiles/Mexico/Mexico2004.htm>. Accessed 15 March 2007.

International Atomic Energy Association Nuclear Fuel Cycle Information System, Web-only database, 2007. URL: <http://wwwnfcis.iaca.org/NFCIS/NFCISMAin.asp?Region=The%20World&Country=All&Type=All&Status=All&Scale=All&Order=2&Page=1&RightP=List&Table=1>. Registration and password required. Accessed 17 March, 2007.

"International Energy Agency Key World Energy Statistics 2006." Web-only database, 2006. URL: < http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2006/key2006.pdf>. Accessed 4 March 2007.

"International Energy Agency Monthly Electricity Statistics, November 2006." Web-only database, November 2006. URL: < http://library.iea.org/Textbase/stats/surveys/mes.pdf>. Accessed 4 March 2007.

"Introduction to Nuclear Power." Web-only essay, 2007. URL: <http://www.eia.doe.gov/cneaf/nuclear/page/ intro.html>. Accessed 12 March 2007.

"Issues At Operating Uranium Mines and Mills – Other Countries: Argentina." Web-only essay, 1 April 2007. URL: <http://www.wise-uranium.org/umop.html#AR>. Accessed 7 March 2007.

Jize, Qin. "Chavez Arrives in Beijing." *China Daily*, 23 August 2006. Proquest document ID# 1103843261. Accessed via Proquest 21 May 2007.

Jo, Dong-Joon and Erik Gartzke. "Determinants of Nuclear Weapons Proliferation." *The Journal of Conflict Resolution*, February 2007. Proquest document ID# 1230885261. Accessed via Proquest 25 May 2007.

Joint Chiefs of Staff. "National Military Strategy to Combat Weapons of Mass Destruction," online ed. 13 February 2006. URL: <www.defenselink.mil/pdf/NMS-CWMD2006.pdf>. Accessed 4 October 2006.

Kapur, Ashok. "Nth Powers of the Future." *Annals of the American Academy of Political and Social Science* 430, no. 1(March, 1977): 84-95.

Karp, Aaron. *Ballistic Missile Proliferation*. New York: Oxford University Press, 1996.

_____. "Correspondence: Argentina and the Bomb." *The Non-Proliferation Review*, Spring, 2000. URL: <http://cns.miis.edu/pubs/npr/vol07/71/ corr71.pdf>. Accessed 17 April 2007.

Kimer, James T. "Venezuela / Colombia: Relations Turn Carnal." NACLA report on the Americas, March/April 2005. Proquest document ID# 803084811. Accessed via Proquest 22 May 2007.

Koch, Lewis Z. "Dirty Bomber, Dirty Justice." *Bulletin of the Atomic Scientists*, January / February 2004. Ebscohost document ID #11787826. Accessed via Ebscohost 5 March 2007.

Lapper, Richard and Jonathan Wheatley. "Disagreements imply depth of ties for a regional leader." *Financial Times,* 22 February 2007. Proquest document ID# 1221029051. Accessed via Proquest 16 May 2007.

Long, Gideon. "Strapped for Energy, Chile Looks at Nuclear Option." Reuters News Service, 12 March 2007. URL: <http://www.planetark.org/dailynewsstory.cfm/ newsid/ 40789/story.htm>. Accessed 21 March 2007.

"Missile Programs: Brazil." Web-only essay, 18 April 2007. URL: <http://www.globalsecurity.org/wmd/world/brazil/missile.htm>. Accessed 18 April 2007.

Montgomery, Carla. *Environmental Geology*, 7th ed. Boston: McGraw Hill, 2006.

Mrquez, Humberto. "Venezuela: Oil Wealth Helps Chavez Stand Up To Washington." *Global Information Network*, 21 February 2006. Proquest Document ID# 991086641. Accessed via Proquest 21 May 2007.

"Nuclear Power in Argentina: Briefing Paper #96." Web-only essay, November 2006. URL: <http://www.uic.com.au/nip96.htm>. Accessed 11 March 2007.

"Nuclear Weapons Programs: Brazil." Web-only essay, 18 April 2007. URL: <http://www.globalsecurity.org/wmd/world/brazil/nuke.htm>. Accessed 18 April 2007.

O'Grady, Mary Anastasia. "Americas: Chavez' Oil Weapon is a Popgun," *Wall Street Journal*, 9 September 2005. Proquest document ID# 893905731. Accessed via Proquest 21 May 2007.

Palmer, Liz and Gary Millhollin. "Brazil's Nuclear Puzzle." *Science*, 22 October 2004. Proquest document ID# 725575851. Accessed via Proquest 14 May 2007.

"Profile: Luiz Inacio Lula da Silva." *The Economist*, online ed., 30 October 2006. URL: <http://news.bbc.co.uk/1/hi/world/americas/5346744.stm>. Accessed on 14 May 2007.

Redick, John R. "Latin America's emerging non-proliferation consensus." *Arms Control Today*, March 1994. Proquest document ID# 5208901. Accessed via Proquest 19 April 2007.

Rhoter, Larry and Juan Forero. "Venezuela's Leader Covets a Nuclear Energy Program." *New York Times*, 27 November 2005, 1:14.

Robinson, Carla Anne. "Wrestling Nuclear Genies Back Into The Bottle, or at Least a Can." *New York Times*, late edition, East Coast, 9 May 2007. Proquest document ID# 1267609201. Accessed via Proquest 16 May 2007.

"Safety of Nuclear Reactors." Web-only essay, January 2007. URL: <http://www.world-nuclear.org/info/inf06.html>. Accessed 5 March 2007.

Sagan, Scott D. and Kenneth N. Waltz. *The Spread of Nuclear Weapons: A Debate Renewed*. New York: W.W. Norton and Company, 2003.

Sokolski, Henry D. *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation*. Westport, CT: Praeger Publishers, 2001.

"Survey of Energy Resources: Uranium." Web-only survey, 21 May 2007. URL: <http://www.worldenergy.org/wec-geis/publications/reports/ser/uranium/uranium.asp>. Accessed 21 May 2007.

"The Americas: Lula opts for a quiet life; Brazil." *The Economist*, 7 April 2007. Proquest document ID# 1250702411. Accessed via Proquest 11 May 2007.

"The National Intelligence Strategy of the United States of America," online ed. October 2005. URL: <http://www.dni.gov/ publications/NISOctober2005.pdf>. Accessed 31 May 2007.

The Nuclear Tipping Point: Why States Reconsider Their Nuclear Choices. Eds. Kurt M. Campbell and others. Washington, D.C.: Brookings Institute Press, 2004.

"USA / Venezuela politics: A new strategy?" Economist Intelligence Unit ViewsWire, 29 December 2006. Proquest document ID# 1188684741. Accessed via Proquest 22 May 2007.

"Venezuelan Politics: Bolivarian Revolution Accelerates." Economist Intelligence Unit ViewsWire, 20 March 2007. Proquest Document ID# 1264439441. Accessed via Proquest 21 May 2007.

Webb-Vidal, Andy. "US probe into Venezuela's oil supply threat 'absurd'." *Financial Times*, 11 July 2006. Proquest document ID# 1075025451. Accessed via Proquest 21 May 2007.

_____. "US to lobby Argentina on Chavez nuclear move." *Financial Times*, 13 October 2005. Proquest document ID# 910569891. Accessed via Proquest 21 May 2001.

West, J. Robinson. "The Production Crunch: Chavez-style oil nationalism is endangering world economic growth." *Newsweek*, 14 May 2007. Proquest document ID# 1266617651. Accessed via Proquest 21 May 2007.

Wilpert, Gregory. "The Meaning of 21st Century Socialism for Venezuela," Web-only essay, 11 July 2006. URL: <http://www.venezuelanalysis.com/articles.php?artno=1776>. Accessed 21 May 2007.

"Who leads Latin America?; Brazil's Presidential Election." *The Economist*, 30 September 2006. Proquest document ID# 1139608601. Accessed via Proquest 16 May 2007.

World Nuclear Association. "Nuclear Power in Argentina." Web-only essay, September 2006. URL: <http://www.world-nuclear.org/info/inf96.html>. Accessed 7 March 2007.

_____. "Nuclear Power in Brazil." Web-only essay, June 2006. URL: < http://www.world-nuclear.org/info/inf95.html>. Accessed 7 March 2007.

_____. "Nuclear Power in Mexico." Web-only essay, March 2007. URL: < http://www.world-nuclear.org/info/inf106.html>. Accessed 7 March 2007.

Zweig, David and Bi Jianhai. "China's Global Hunt For Energy." *Foreign Affairs*, September/October 2005. EbscoHost reference number 17979604, accessed via EbscoHost 21 May 2007.