

# The Brazilian Navy's Nuclear and Submarine Program

Admiral Bento Costa Lima Leite De Albuquerque Junior's presentation on the program's origins, current focus, and outlook



# The Brazilian Navy Nuclear and Submarine Program: Origins, Current Focus, and Perspectives\*

by Admiral Bento Costa Lima Leite De Alburquerque Junior, the incoming Minister of Mines and Energy

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## INTRODUCTION

Good morning everyone. I would like to begin by saying how grateful and honored I am for the invitation from Mr. Paulo Sotero to take this opportunity to present some information about two Brazilian Defense industry priority projects: the Brazilian Navy Nuclear Program and the Nuclear-Powered Submarine Program known as PROSUB.

As we will see in the slides to follow, these programs are related to the security of our people, to our energy security, and to our technological sovereignty. I would also like to emphasize that these two Brazilian programs focus on the peaceful use of nuclear energy, an aspect established and fulfilled in accordance with our Federal Constitution and National Defense Strategy.

### **Overview**

Our presentation will follow this overview, which will begin by introducing some key points about Brazil. We will go on to talk briefly about the basis of our governance so as to identify the rationale for these programs.

Then we will touch upon the topic of security, which we divide into three main dimensions: defense, energy and technology.

We will make our case for the submarines, which will be instrumental in serving as the basis for that prescribed in our National Defense Strategy. We will then talk about the origins of the Navy Nuclear Program and PROSUB, relating them to the National Defense Strategy.

Our final remarks will address technological impacts, the supply of fuel for civilian use and the development of a Brazilian Multipurpose Reactor. We will be happy to discuss any issues you might have during the question and answer period at the end of our presentation.

### ***Brazil's Territory***

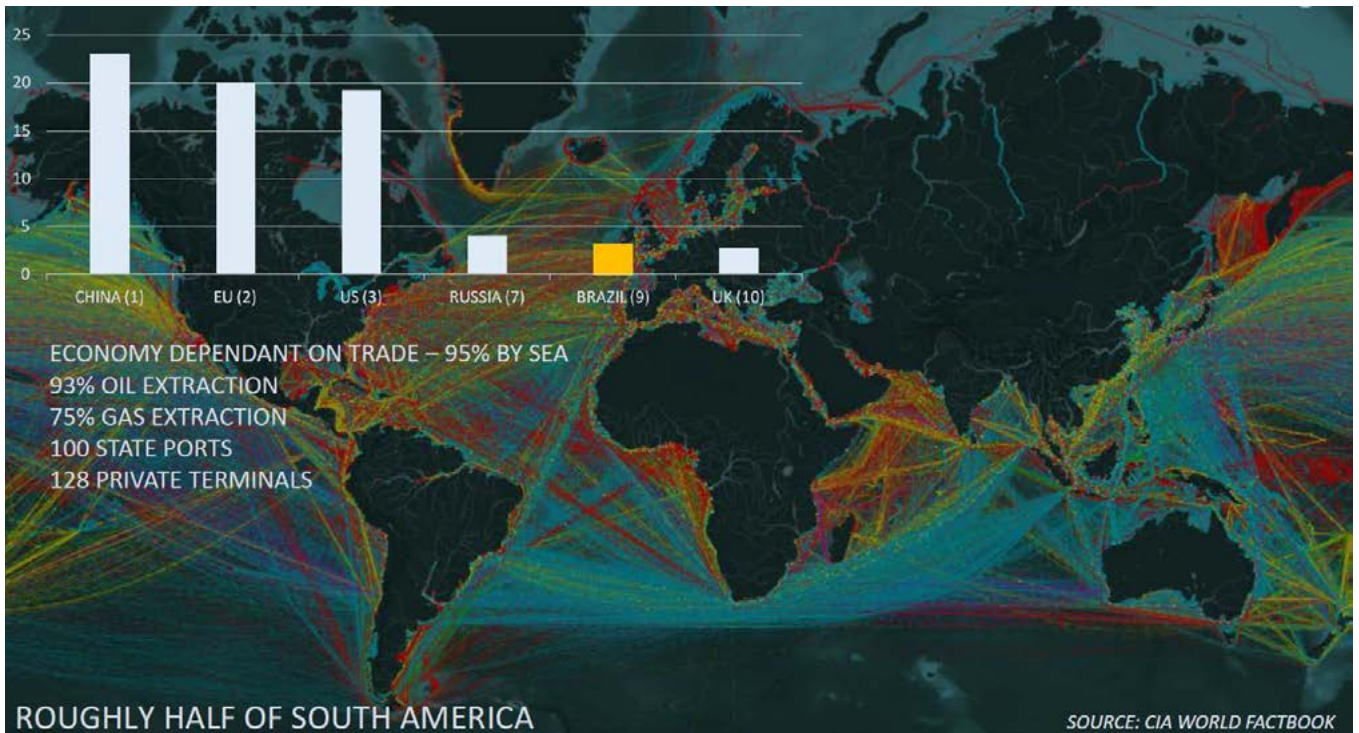
Brazil is the world's sixth largest country by area, behind the US and China.

A huge territorial expanse, in our case, is synonymous with significant natural reserves, extensive borders – both land and sea – and the enormous challenge of monitoring and protecting it all. Altogether, there 23,000 km of borders. Brazil has 7,500 km of South Atlantic coastline, which corresponds to one-third of its borders. This entire expanse requires constant presence through governance, exercised at sea by the Navy.

*Editor's Note:* Admiral Bento originally gave this presentation at the Wilson Center in April 2018, followed by a discussion under Chatham House rules with key stakeholders in the U.S. government and think-tank community. Several months later, as a continuation of the conversation started at the Wilson Center, the Brazilian Navy welcomed a U.S. delegation from the National Nuclear Security Administration to the Centro Tecnológico da Marinha de São Paulo, one of the navy's research and enrichment facilities for nuclear propulsion and nuclear energy—the first U.S. delegation to visit the center.

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\*Translated by Kim F. Olson.



Slide 5 from Admiral Bento's presentation at the Wilson Center

Today, the ocean holds enormous importance for our territorial integrity and serves as a key link to progress, in much the same way as in the past, when we secured our independence and national unity.

### **Brazil's Population**

Our population has now surpassed 200 million inhabitants and projections point to that figure reaching 250 million by 2050. Today Brazil is the world's fifth most populous country.

Its population is characterized by diversity and integration, the fruit of migratory waves throughout its history, reflected in the background of this slide, which is a painting entitled "Operários" [Workers] by one of Brazil's greatest artists, Tarsila do Amaral. Our population is our greatest asset.

### **Brazil's Economy (GDP)**

Our economy is based on trade, a rapidly developing manufacturing industry and a promising service industry. Although Gross Domestic Product is the indicator most frequently used, we will show you other numbers that express important aspects of our economy.

Like most countries in the globalized world, we depend on trade. Our products are essential

to the world's development. Our geopolitical position turns us seaward. Our trade relations are conducted almost exclusively by sea: 95% of everything that comes into and goes out of Brazil does so by sea. Ten percent of trade flow at sea, at this exact moment in time, comes from or is on its way to some Brazilian port. In other words, 10% of the world's freight passes through Brazilian ports. Our largest trading partners are China, the US and Argentina. With regard to the first two, nearly everything is transported by sea; and even with respect to Argentina, our largest mode of trade is maritime.

As a country, Brazil is only viable when it uses the ocean! Our security depends on our maritime safety.

### **Brazil and the World**

Brazil is thus a vast and populous country and is among the world's largest economies.

On this slide, which illustrates the notion of "Monster Countries," as first described by US historian and diplomat George Kennan, we have identified an intersection where Brazil appears like countries such as the United States, Russia, China, India and the European Union.

We would like to point out that of these, only Brazil, the United States and Russia have significant quantities of uranium and the associated nuclear technology, and of these, Brazil is the only one that uses nuclear energy solely for peaceful purposes.

### **Brazilian Governance**

And how are we organized?

Article IV of our Federal Constitution, among other things, sets forth the basic principles of peace, liberty and free-will of its peoples, in addition to peaceful resolution of conflicts and non-intervention. Article 21 holds that nuclear activity within our territory will only be allowed for peaceful purposes.

Consistent with our constitutional principles, Brazil is a founding partner of the International Atomic Energy Agency. We are also signatories to the Treaty of Tlatelolco, which established a nuclear-weapon-free zone in Latin America, the Antarctic Treaty, which protects that part of the globe from nuclear proliferation, and the South Atlantic Peace and Cooperation Zone, which through a Brazilian initiative, seeks to ban nuclear weapons from the region and promote the multilateral development of countries in the South Atlantic.

All of these treaties signed by Brazil help keep the South Atlantic region largely free of nuclear weapons.

### **BRAZILIAN SECURITY BIASES**

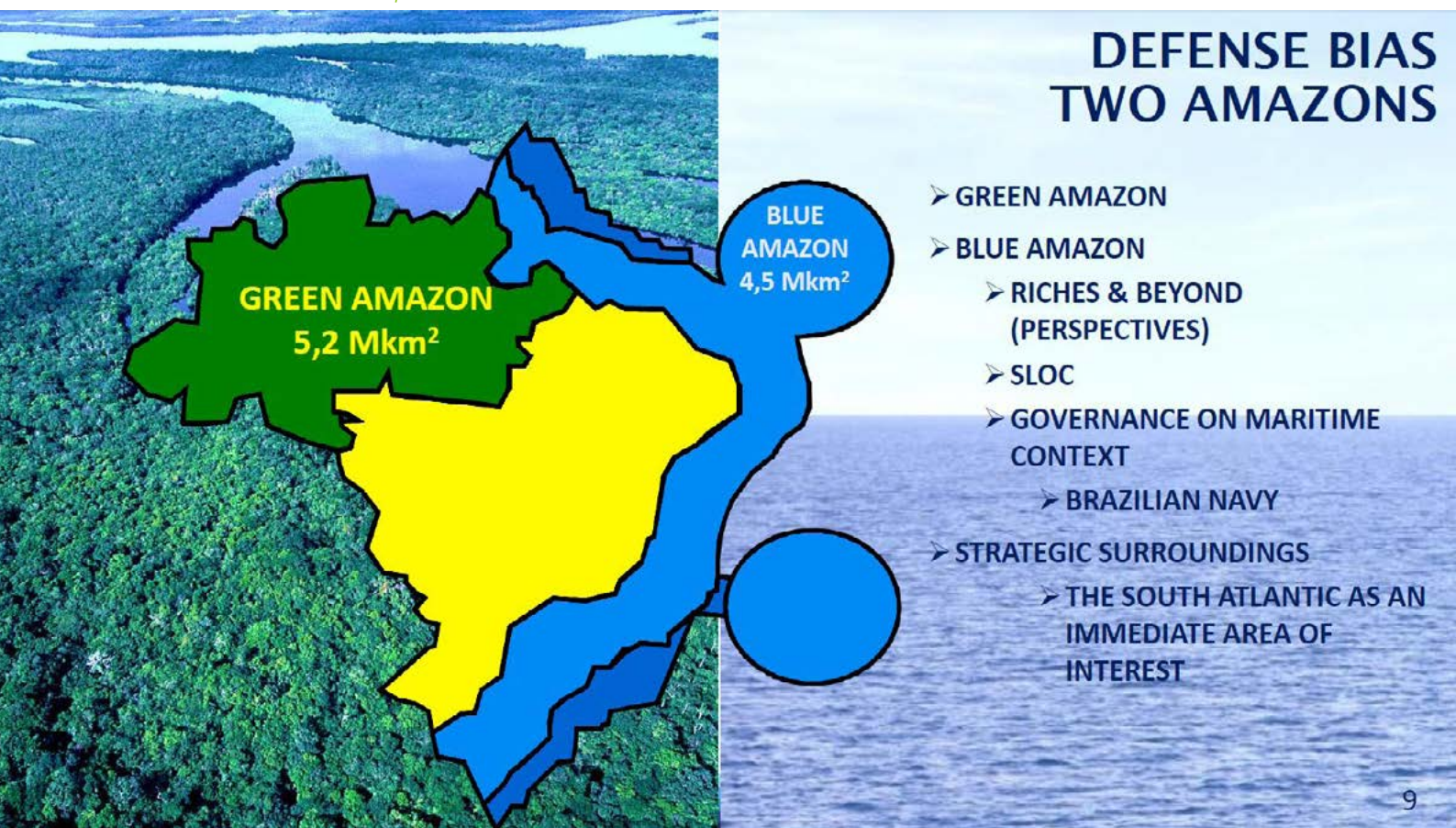
Now we are going to look at security in particular. We have selected three biases: defense, and by that we mean the military aspect of security; energy; and technology. It is on these aspects that our programs have the greatest impact. These, too, are the areas directly associated with development, Brazil's main objective.

Starting with defense, let's turn to a particular part of the ocean that is under our jurisdiction and vital to Brazil's sovereignty. We will present a new Amazon!

### **Blue Amazon**

The term Blue Amazon was coined by our Navy in the early 2000s. The goal was to make Brazilians aware of the ocean's importance to the country's development. At that time, very early in this century, we were under the impression that Brazil had turned its back on the ocean, at a time when the Green Amazon – most which is situated in Brazilian territory – had captured the world's attention.

*Slide 9 from Admiral Bento's presentation at the Wilson Center*



The Navy took advantage of the discovery of petroleum reserves on our continental shelf, and attempted to show that the ocean represents an enormous asset for us. We can start by its size, which is nearly 90% the size of the Green Amazon. Its resources present new possibilities in continuous discovery, and finally, its sea lines of communication are how our riches are transported. Defense of the Blue Amazon essentially requires that the ocean be governed. Today that key role is played by the Navy.

But Brazil is also responsible for search and rescue operations in an area that goes beyond its jurisdictional waters. Not surprisingly, we established the South Atlantic as our strategic environment and area of immediate interest given expectations for its growth in importance.

**The South Atlantic**

In its study entitled "The Ocean Economy in 2030," the Organization for Economic Cooperation and Development (OECD) stated that global maritime trade will grow 380% in the next 12 years. The economic center will also shift to the East as a result of increased purchasing power on the part of the middle class from the world's largest population centers.



*Old Brazilian Submarines at port*

Brazilian sea lines of communication will grow in importance, but it will not just be them: the entire South Atlantic will grow in importance. These same sea lines of communication could lead Brazilian Naval power beyond the strategic environment established today to well beyond the Blue Amazon.

Within the strategic environment, Brazil is undertaking a commitment to regional stability and is increasingly present. On the west coast of Africa, for example, Brazil, together with its naval allies, is contributing to the training and preparation

*Images of the Brazilian Navy, from Admiral Bento's powerpoint*



of new navies as well as participating in regional operations and exercises aimed at creating stability and security of trade flows.

Thus, there is an increasing need for governance on the part of the Brazilian Navy. But who are we?

### ***Brazilian Navy***

We are a Navy of nearly 100 ships, operating on oceans and rivers. Our work force numbers 85,000, including military and civilian personnel together with our Marine Corps that is made up of approximately 20,000 men and women. Our doctrine, the result of ongoing actions, thus reflects our context. That doctrine evolves from the requirements presented to our Naval Forces at an ever-increasing pace.

We have a considerable expeditionary capability, as we have demonstrated in Haiti and more recently in Lebanon. That capability has led Brazil to assume new international commitments, reinforcing its role as global player.

We also operate submarines. In fact, we have done so for over 100 years!

### ***Submarine Program***

We began operating submarines before the effectiveness of this weapon was even recognized. We started with Italian submarines back in 1914 and then progressed to US submarines. We were

able to achieve high operational standards with the British Oberon class, built for Brazil during the 1970s. Late in the last century, we embarked on a plan to acquire technology by building German submarines and we are now building French-designed conventional submarines customized to our operational needs.

The Brazilian Navy recently placed its submarine rescue capability at the disposal of the multinational effort engaged in search and rescue operations for the Argentine submarine ARA San Juan.

The fruit of a century of operations, today we have our own doctrine that evolves according to our strategic context. We instruct and train our own people and when asked, do the same for our naval allies.

In the background is a photo from 2014 when we welcomed submarines from naval allies at commemorations for the 100th anniversary of Brazil's submarine force. Nuclear submarines from the US, France and the United Kingdom docked at our naval base in Rio de Janeiro.

Consistent with the challenge of defending our country, we reaffirmed our mission to operate submarines through the 2008 National Defense Strategy approved by Brazil's Congress.

It provides for the existence of a large-scale submarine force, comprised of conventional and nuclear-powered submarines, both built in Brazil, using Brazilian technology.



*Photo from the 100th Anniversary Celebration of Brazil's Submarine Force (2014)*

- 75,7% INSTALLED
  - HYDROELECTRIC/ 52,3% USED (RAIN CONDITIONS)
- 2,2% NUCLEAR
- 7TH RESERVE OF THE WORLD
  - 100 YEARS IF ONLY NUCLEAR
- COMMITMENT TO FUTURE GENERATIONS
- BASIS FOR DEVELOPMENT
- DIVERSIFY TO SECURE

*Slide 15 from Admiral Bento's presentation at the Wilson Center*

We will operate two types of submarines and it could not be otherwise. We have to maintain existing capability, primarily responsible for the defense of our coastal waters, for which we already have a reliable doctrine.

The nuclear-powered submarine (SN-BR) is today a capability under development, to be added to the Navy in the near future. That capability will deliver additional scope to the existing capability represented by conventional submarines.

The SN-BR does not stop at defense! It also makes very important contributions to the energy and technology sectors. The National Defense Strategy also provides for the use of nuclear mineral resources, the development of the fuel cycle and the development of a nuclear reactor for peaceful purposes. One of the goals is to expand the nuclear option to Brazil's energy matrix, in a way that is green, reliable and diversified, as we will see next.

## **Energy**

The Brazilian energy matrix is green and for the most part renewable. Approximately 76% of the

country's energy comes from hydroelectric power plants. But because of variable rainfall patterns, only 52% of the energy produced today comes from that source. The rest has been basically supplied by fossil fuels.

Brazil gets only 2.2% of its energy from nuclear power. Such a paradox for a country that has the seventh largest uranium reserves in the world, from what has been surveyed! Just to give you an idea, if today's entire energy matrix were nuclear, we would have enough uranium to operate for 100 years!

Because energy is a key pillar in the development of any country, investments in nuclear technology will surely become a commitment to future generations of Brazilians!

## **Technology**

With respect to the impact on technology, the Nuclear Program and PROSUB currently involve 700 Brazilian companies, 18 universities and research institutes, and have created 4,800 direct



*Image from Slide 19 of Admiral Bento's presentation at the Wilson Center*

jobs and 12,500 indirect jobs. This demonstrates their contributions to the country's development! Hence, we see that the Nuclear-Powered Submarine Program is not viewed purely through the lens of defense. It goes well beyond that to be viewed as SECURITY, encompassing the three important aspects we just addressed: defense, energy and technology. The greatest outcome is DEVELOPMENT!

But where are we in all of this? We would like to give you a little history about our program and headline its current stage of development.

## **THE NAVY NUCLEAR PROGRAM**

### ***Origins***

We will begin by providing details about our time line, which begins in 1979, with the close association between the Brazilian Navy and the Secretariat for Strategic Affairs, currently, the Ministry of Science and Technology. At that time, the Navy was already planning to master the

nuclear fuel cycle and the technology used for Pressurized Water Reactor (PWR)-type power reactors.

In order to do this, many laboratories and factories were built and utilized, including a low power research reactor (critical unit), which was undertaken in partnership with the Nuclear and Energy Research Institute (IPEN) located on the campus of the University of São Paulo (USP), in downtown São Paulo, where we became established in 1981.

This facility in particular began testing in November 1988.

But before we continue, we will look back a little further into the past, to the 1950s, where we find the key figure in the establishment of Brazil's nuclear technology.

### ***Background***

One naval officer in particular played a major role in Brazil's nuclear research. Admiral Álvaro Alberto,



scientist by vocation, suggested that scientific and technological development is closely related to the country's prosperity.

He represented Brazil on the United Nations Atomic Energy Commission from 1946 to 1948, when he had two opportunities to preside over that commission.

Back in Brazil, he was the first president of the National Council for Scientific and Technological Development where he coordinated establishment of the National Commission for Nuclear Energy (CNEN), which became active in 1954.

In addition, he expressed interest in isotope separation, having acquired three centrifuges from Germany on which to explore the technical concepts involved.

In the pursuit of training to build and design submarines, in the 1980s we acquired five German-designed submarines through a transfer of the technology required to build the second one and beyond at the Rio de Janeiro Navy Yard.

In the 1980s and 1990s, we began two separate submarine projects that were discontinued due to lack of consistent investment. At the turn of the 21st century, Brazil still lacked the tools it needed to conduct projects of this complexity.

### **The Navy Submarine Program**

One can say that today the Navy Submarine Program has two major subprograms: the Navy Nuclear Program and the Submarine Development Program (PROSUB). One complements the other and they are coming together to obtain the first Brazilian nuclear-powered submarine (SN-BR). While the first subprogram is tasked with propulsion, the second advances the design and construction of the entire non-nuclear portion of the SN-BR.

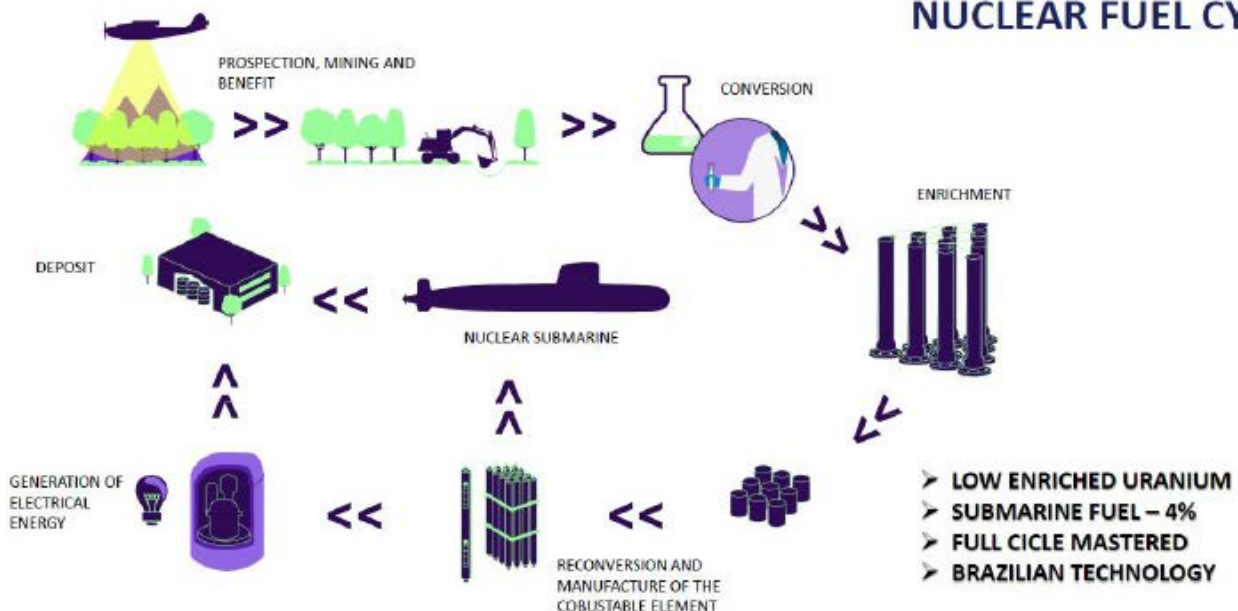
As a result of a 2008 agreement and strategic partnership with France, we have acquired training for design of the non-nuclear portion of the SN-BR, in a situation that is best described as the proverbial "Red Line." Right now, we are building four conventional submarines at the same facilities that will house the construction of the Nuclear-Powered Submarine. But we will talk about that a little later.

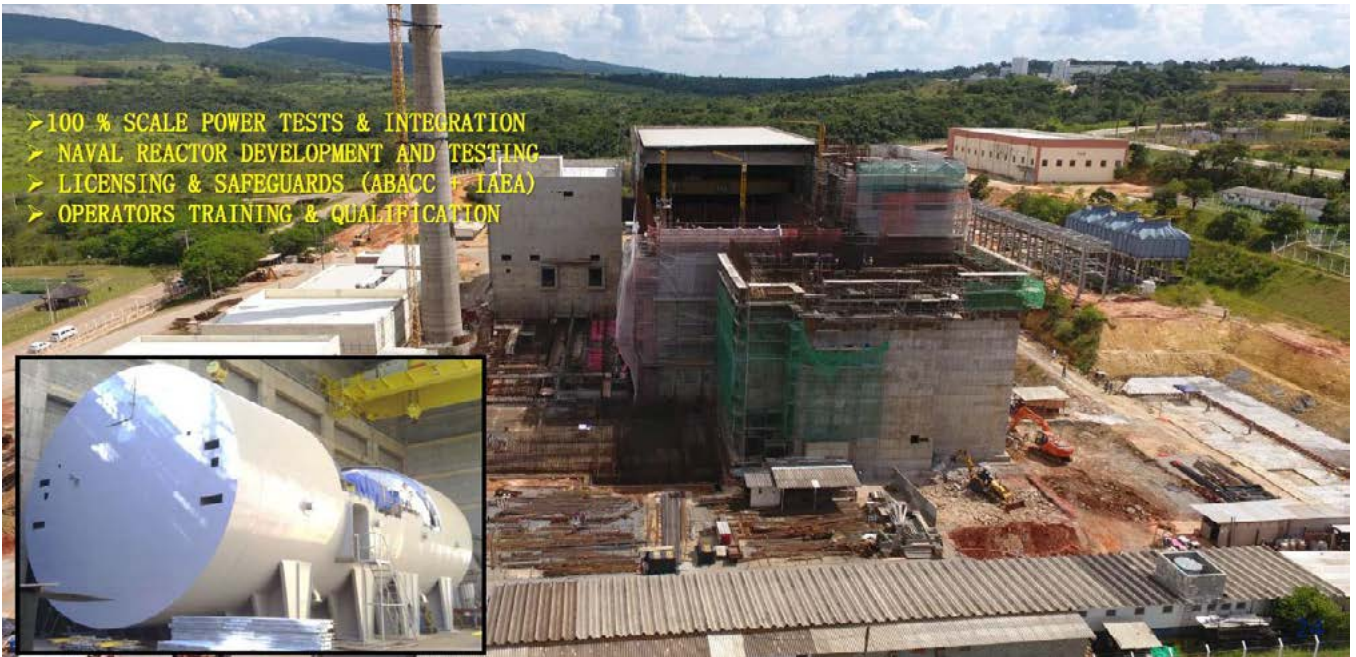
Let's turn to the one that started first: the Navy Nuclear Program.

### **Fuel Cycle**

In 1988, we mastered the fuel cycle, developed entirely through the use of domestic technology with no outside support.

## **BRAZILIAN NAVY NUCLEAR PROGRAM NUCLEAR FUEL CYCLE**





*Top: Navy Technology Center in São Paulo; Bottom: Nuclear Power Generation Laboratory*

Uranium prospecting is carried out by a state-run company. From then on, the Navy is in charge, converting the processed uranium to uranium hexafluoride gas. The gas is enriched up to 4% through ultracentrifugation and made into fuel pellets.

That technology is also used to manufacture fuel for our nuclear plants, contributing to that sector's supply chain.

The fuel produced by the Navy will supply the onshore prototype naval power reactor and the SN-BR, and is protected by domestic and international nuclear safeguards.

### ***Navy Technology Center in São Paulo (CTMSP)***

Research and development in the nuclear industry is conducted at two separate sites, under the responsibility of the CTMSP.

On the first site, located in the city of São Paulo, on the campus of the University of São Paulo, we have the Nuclear Development Directorate (DDNM), which uses laboratories and other resources for nuclear system design and tests, and the Submarine Development Center (CDS), which is dedicated to submarine design.

That site employs approximately 1,200 people, mostly civilians, who make up nearly 70% of its staff.

### ***Aramar***

The second site, located 120 km from the city of São Paulo, employing nearly 1,800, civilians and military alike, is the Aramar Industrial Nuclear Center, which houses laboratories and industrial workshops, including a Nuclear Training Center and a Marine Corps Chemical, Biological, Radiological and Nuclear Defense Battalion (CBRN).

## **Nuclear Power Generation Laboratory**

One step in the process of obtaining the nuclear reactor is its onshore operation under conditions of extreme security for the purpose of conducting the tests and integration required for project development.

Our facility will be completed by 2020. We implemented operations of the first turbine last March.

Some important steps have been made towards the nuclear submarine in addition to the onshore prototype of the propulsion plant. The basic design

was completed in January 2017 and certified with French assistance, and we are currently in the detailing phase.

## **Safeguards**

At this point, we would like to highlight the implementation of safeguards in our programs. As far as we know, our case is unlike any other in the world with regard to transparency and use of nuclear safeguards. The photos on the slide show the opening ceremony of our enrichment laboratory in 1988, attended by the presidents of Brazil and Argentina.

That was the beginning of the surveillance system proposed by the two countries, based on the safeguards approach to materials and control of nuclear technology. That initiative has evolved and since 1991, we have had a regional safeguards agency, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), which works with teams from the International Atomic Energy Agency to conduct inspections in both countries. Incidentally, more than 300 inspections have been carried out at our facilities, announced and unannounced.

## **IAEA Visit to the CTMSP**

These photos show two important IAEA officials on a visit to our nuclear facilities: Dr. El Baradei, in December 1996, and Dr. Amano, in October 2016.

## **UFEM and EBN Naval Base and Shipyard**

The other subprogram known as PROSUB came out of a strategic partnership with France, due to the need to develop a new submarine design. We should mention again that this partnership only includes technologies that do not involve the nuclear systems.

On the top of the slide is the Metal Structures Manufacturing Unit (UFEM), responsible for



*Top: Opening ceremony of the Brazilian Navy's enrichment laboratory in 1988.*

*Middle: Dr. El Baradei visits the Aramar site.*

*Bottom: Dr. Amano visits the Aramar site, and learns about the Multi-Purpose Reactor (for medicine and materials testing).*



*Slide 28 from Admiral Bento's presentation at the Wilson Center*

manufacturing hull sections of submarines. We began construction in 2010 and the unit became operational 2 years and 8 months later.

On the bottom of the slide is the Navy Shipyard responsible for assembly of the sections. Its construction began in 2009 and in 2018, it started assembling sections of the first submarine.

Notice in the photos how quickly work progressed, up to the actual start of operations at the facilities. It is important to note that there are currently 1,154 workers at the complex, only six of whom are French. The rest are Brazilian.

### **PROSUB**

This program involves the outfitting of a construction shipyard, a maintenance shipyard and a naval base. All of it is 60 km from the city of Rio de Janeiro, near the Angra dos Reis nuclear power plants. This is the site for construction of four conventional submarines with a high level of domestic industry participation.

When all is complete, we will build the SN-BR and that will be its base, fully equipped for this purpose with all the support and security required for nuclear-powered submarines.

The background photo shows the submarine Riachuelo, first of the series, at the launching ceremony for the final assembly phase in February 2018. The submarine will be launched in December 2018. The three remaining conventional submarines will follow at an average rate of one per year.

### **FINAL REMARKS**

Before we move on to the discussion phase, we would like to highlight some of the important connections with the Navy Nuclear Program that we touched upon briefly in the presentation.

#### ***Spin Offs – Technological Impacts***

We will begin with some of the technological impacts provided to the civil sector, such as:



*Admiral Bento speaking at the Wilson Center*

- Testing of steam turbines manufactured in Brazil by private companies;
- Tests on some of the safety systems of the Angra dos Reis nuclear power plants;
- R&D of inertial systems for the oil industry;
- The machining of mechanical components for hydroelectric plants; and
- Support for design and construction of the Oceanic Science Station on the Saint Peter and Saint Paul Archipelago because of seismic protection requirements.

### ***Spin Offs – Nuclear Industries of Brazil (INB)***

Under the framework of energy security, the INB operate six enrichment cascades, utilizing technology developed by the Navy, in line with the concept of ensuring the supply of fuel to the Angra dos Reis Nuclear Power Plants.

The seventh, more advanced, cascade is scheduled to be opened this month and tested at our Aramar Industrial Nuclear Complex.

We should note that this enrichment facility is also under domestic and international nuclear safeguards.

### ***Spin Offs – Brazilian Multipurpose Reactor (BMR)***

With respect to our partnership with the technology sector, the design and implementation of the BMR at our facilities at Aramar are being carried out by the National Commission for Nuclear Energy, and the Navies of Brazil and of Argentina. This reactor is intended for R&D of radiopharmaceuticals, which will not only enhance the quality of life of Brazilians and Argentines alike, but will increase mutual trust between the two countries.

### ***Conclusion***

Finally, we would like to show that our programs are transparent, intended for peaceful purposes and strive for safety! That should be understood here as for actual defense, energy security and technological sovereignty.

Our goal is development! We are looking to make Brazil better for future generations as well as contributing to world peace, as part of our responsibility to the international community.



**Admiral Bento Costa Lima Leite de Albuquerque Junior** currently serves as the Director General of Nuclear and Technological Development for the Brazilian Navy. He has been nominated as the incoming Minister of Mines and Energy.

Born in Rio de Janeiro (RJ), Admiral Bento began his career as a Brazilian Navy Officer in 1973. Since then, he has held various positions, including Congressional Political Affairs Adviser; Commanding Officer of the “Tamoio” and “Tonelero” Submarines; Officer in Charge of Military Planning, War Games and Policy and Strategy Studies at the Naval War College; Commanding Officer of the “Almirante Castro e Silva” Submarine Base; Adviser to the Navy Chief of Staff; Chief of the Congressional Political Affairs Staff of the Head of the Navy; Commanding Officer of the Submarine Force; Navy’s Chief of Staff; Commander in Chief of the Fleet; and Secretary of Science, Technology and Innovation.


He has also served overseas, including as Military Observer of the United Nations Forces in the Sectors of Sarajevo - Bosnia and Herzegovina, and Dubrovnik - Croatia; and Director General of the Secretariat of the Inter-American Defense Board.

Admiral Bento earned degrees from the Naval Academy (1973-1975); the Naval College (1975-1979); Submarine Officer’s Course; a graduate degree in Political Science from the National University of Brasília; an MBA in International Management from COPPEAD - Federal University of Rio de Janeiro; an MBA in Public Management from the Getúlio Vargas Foundation; Command and Staff Training Course and Naval Warfare Superior Course, both at the Naval War College; Future Submarine Commanders Course; and Policy and Strategy High Studies Course from the Superior War College.

In recognition of his service and accomplishments, Admiral Bento received several medals and decorations in Brazil and abroad. These include the Naval Merit Order - Gran Cruz; French Medal of National Defense - silver grade; Inter-American Defense Board Medal - one silver star; and the “In Service of Peace” Medal of the United Nations.



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