



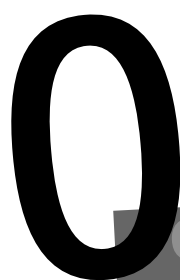
Observatory of French Nuclear Weapons

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Observatoire des armes nucléaires françaises

France and Nuclear Proliferation



Bruno BARRILLOT



Observatoire

des armes nucléaires

françaises

The Observatory of French Nuclear Weapons looks forward to the elimination of nuclear weapons in conformity with the aims of the Nuclear Non-Proliferation Treaty. To that end, the Observatory disseminates follow-ups of information in the forms of pamphlets and entries on the World Wide Web:

- on the evolution of French nuclear forces;
- on the on-going dismantling of nuclear sites, weapons, production facilities, and research;
- on waste management and environmental rehabilitation of sites;
- on French policy regarding non-proliferation;
- on international cooperation (NGO's, international organizations, nations), toward the elimination of nuclear weapons;
- on the evolution of the other nuclear powers' arsenals.

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Translation : Robert Davis

Initials and acronyms used

ANDRA	Agence nationale des déchets radioactifs / <i>National Agency for Radioactive Waste Management</i>
AMIP	Atelier mobile d'intervention principal / <i>Principal movable workshop for maintenance</i>
ASMP	(missile) air-sol moyenne portée ; -A amélioré / <i>Air to ground medium range ; -A improved</i>
ASLP	(missile) air-sol longue portée / <i>Air to ground long range air-to-ground</i>
BIST	Bulletin industriel scientifique et technique / <i>Industrial, Scientific and Technical Bulletin</i>
CAEPE	Centre d'achèvement et d'essais des propulseurs et engins / <i>Engine Completion and Testing Center</i>
CDRPC	Centre de documentation et de recherche sur la paix et les conflits <i>Center for Documentation and Research on Peace and Conflicts</i>
CEA	Commissariat à l'énergie atomique / <i>Atomic Energy Commissariat</i>
CEL	Centre d'essais des Landes / <i>Test Center of the Landes</i>
CESTA	Centre d'études scientifiques et techniques d'Aquitaine / <i>Scientific and technical study Center of the Aquitaine</i>
CPRA	Comité des prix de revient des fabrications d'armements / <i>Committee on cost of armaments manufactures</i>
DAM	Direction des applications militaires / <i>Division of Military Applications</i>
DCN	Direction des constructions navales / <i>Division of Naval Construction</i>
DGA	Délégation générale pour l'armement / <i>General Delegation for Armament</i>
EADS	European Aeronautic Defence and Space Company
ENEA	Agence européenne de l'énergie atomique / <i>European Agency of Nuclear Energy</i>
IPSN	Institut de protection et de sûreté nucléaire / <i>Institute for Protection and Nuclear Safety</i>
MCO	Maintien en condition opérationnelle / <i>Maintenance in operational condition</i>
M€	Millions of euros
MF	Millions of francs
MSBS	(missile) mer surface balistique stratégique / <i>Missile sea surface ballistic strategic</i>
ONG	Organisation non-gouvernementale / <i>Non-governmental organization</i>
OTAN	Organisation du traité de l'Atlantique Nord / <i>Nations Against Terrorist Organizations (NATO)</i>
OPRI	Office de protection contre les rayonnements ionisants / <i>Office of Protection against Ionizing Radiation</i>
PPI	Plan particulier d'intervention / <i>Specific response plan</i>
SERE	Service d'études et de recherche sur l'environnement / <i>Environmental Study and Research Service</i>
SNA	Sous-marin nucléaire d'attaque / <i>Nuclear attack submarine</i>
SNLE	Sous-marin nucléaire lance engins ; -NG nouvelle génération <i>Nuclear missile-launching submarines ; -NG New Generation</i>
START	Traité de réduction des armes nucléaires stratégiques / <i>Strategic Arms Reduction Treaty</i>
STSN	Service technique des systèmes navals / <i>Naval systems technical service</i>
TN	Tête nucléaire / <i>Nuclear Warhead</i>
TNA	Tête nucléaire aéroportée / <i>Air-ported nuclear warhead</i>
TNO	Tête nucléaire océanique / <i>Oceanic nuclear warhead</i>
TNP	Traité de non-prolifération / <i>Non-Proliferation Treaty (NPT)</i>

The Breakdown of Nuclear Disarmament

On July 1, 1992, France ratified the Non-Proliferation Treaty (NPT). Although it grants certain privileges to signatory states that are “*equipped with nuclear weapons*”, the NPT does not give them all rights. This treaty aims at forbidding (or limiting) the increase in the number of states possessing nuclear weapons (against horizontal multiplication), but it also aims to contribute to the nuclear disarmament of countries already possessing them (against vertical proliferation). Thus, article VI of the NPT stipulates that “*each of the parties to the treaty commits itself to good faith negotiations on effective measures for the cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty for general and complete disarmament under strict and effective international control*”.

For many diplomats and governmental experts of the nuclear powers, the NPT is a treaty not for disarmament but for limiting the membership in their club. That is not our view, however. Indeed, the constraints imposed on states “*not equipped with nuclear weapons*”, notably measures for on-site inspection and verification, ought to have counterparts for states “*equipped with nuclear weapons*”. These counterparts are mentioned, in fact, in Article VI, but unfortunately with no precise deadline or constraining measure. Article VI of the NPT should now be reinforced by the negotiation of an instrument of international law—a convention or a treaty—aimed at the elimination of nuclear weapons, just as such instruments (albeit of unequal scope) exist for chemical and biological weapons and for anti-personnel mines...

France and nuclear disarmament

Governmental experts retort that paths have already been explored and actions taken in that direction by bilateral disarmament measures, as in the START agreements between the US and Russia (which finally ratified START II on April 14, 2000), and by measures for unilateral nuclear disarmament, such as those taken by France.

In fact, France is exemplary in this regard, having taken significant initiatives since the end of the Cold War:

- withdrawal of the Pluton short-range ground-to-ground nuclear missiles;
- withdrawal from service and dismantling of the AN52 gravity nuclear bombs carried by Jaguar and Mirage III aircraft;
- reduction of the number of missile-launching nuclear submarines (SNLE) from six to four;
- reduction of the program, and then cancellation and withdrawal from the Hades ground-to-ground nuclear missile program;
- withdrawal of the Mirage IV strategic nuclear bombers;
- cancellation and dismantling of the ground-to-ground strategic missiles from the Albion Plateau;
- closing and dismantling of the Polynesian test sites;
- de-targeting, announced in 1997, of all of the French nuclear weapons;
- closing of military grade enriched plutonium and uranium production facilities at Marcoule and Pierrelatte.

All of these measures are real, and taken together, they amount to a reduction by half of France’s nuclear arsenal in ten years. However, it should be noted that France has only conformed to the test ban treaty and has retired only weapons that were out-of-date or politically inappropriate. Although France no longer manufactures nuclear materials, she recycles those from the de-activated weapons to make new nuclear warheads; and although she no longer conducts full scale tests at Muroroa, she is setting up a program of large scale simulated tests.

In the multilateral arena, after having ratified the non-proliferation treaty and the test ban treaty, France is helping in the dismantling of Russian nuclear weapons and is supporting the establishment of nuclear weapon free zones. Thus, in 1996, she ratified the Rarotonga treaty that makes the South Pacific a nuclear free zone and the Pelindaba treaty that establishes a nuclear free zone in all of Africa.

Therefore, it is clear that France, by means of all of these measures, reaffirms that her policy is to maintain only the level of nuclear capability necessary for deterrence.

Disarmament bogged down

However, at the international level, nuclear disarmament is presently bogged down in the twists and turns of diplomacy. The installation of the new Bush administration, in the United States, does not facilitate the resumption of negotiations on disarmament with Russia. Thus, discussions begun within the framework of the Geneva Disarmament Conference on the ban on production of fissile materials have been in an impasse for years. Moreover, the refusal of the US Senate to ratify the test ban treaty jeopardizes the future of this treaty: how can India, Pakistan, and Israel be persuaded to join when the principal nuclear power refuses to ratify the treaty?

The US, apparently desirous of embarking on an anti-missile program, is throwing into doubt the ABM Treaty on the limitation of anti-missile missile systems signed with the USSR on May 26, 1972. These American initiatives run the risk of ruining the prospect of completing the START nuclear disarmament process between the US and Russia.

Toward a strong French initiative

In the present state of Russian-American relations, the tendency seems to be toward a nuclear status quo. So prospects for disarmament depend on initiatives by the other nuclear powers, notably the two European nuclear states. The Observatory of French Nuclear Arms therefore suggests that France take a strong initiative in the

area of nuclear disarmament —with a precise calendar— in order to bring about, as happened in 1992 for chemical disarmament, an international process toward the elimination of nuclear weapons. Toward that end, the Observatory supports the constructive proposal by David Martin and Michel Rocard asking France and the United Kingdom to announce a joint plan for nuclear disarmament by stages as “a first step toward a system of international relations that is adapted to the end of the Cold War and to the exchanges of the 21st Century rather than to a return of the confrontations of the 19th Century”¹.

It has to be recognized that current French defense policy is not oriented in that direction. In fact, based on Article VI of the NPT, most of France’s modernization program for maritime strategic nuclear weapons —the SNLE-NG program— may be deemed to be in contradiction to her signature of the non-proliferation treaty.

Like the other nuclear powers, France appears like a naughty schoolboy in the proliferation issue by getting rid of her obsolete nuclear weapons while keeping the most recent ones. By installing new generations of weapons, she will cause the nuclear threat to continue weighing on the world for several more decades.

This study of the program of new generation missile-launching nuclear submarines has as its objective to demonstrate the amplitude of this program, which will mobilize considerable industrial resources and energy to the detriment of other security alternatives. ▲

1) Martin, David & Michel Rocard. “La menace des armes nucléaires ne doit pas être éternelle”, *Politique étrangère*, 1/2000, spring 2000, pp. 213-223.

The SNLE-NG Program Counter to Non-Proliferation

On June 24, 1981, France decided to construct four new generation nuclear missile-launching submarines to replace the six SNLEs of the *Redoutable* class (cf. the chronology on the following page).

The program includes three large “sectors” which we shall present separately: submarines, MSBS (sea-to-ground strategic ballistic) missiles, and the nuclear warheads of the missiles.

Submarines

At its inception, the SNLE-NG program envisaged the construction of six new-generation submarines to replace each of the *Redoutable* class SNLEs. The program was reduced to four new submarines, the last not ordered until 2000.

With the passage from an old to a new generation of submarines, the most sophisticated technologies have been incorporated in the ships. The major innovation of the SNLE-NG is the acoustic refinement, according to the chief engineer Duval, the architect of the “Coelacanth” SNLE-NG program.: “There will be an improvement to a factor of about 1000 in the noise level emanating from the *Triomphant* compared to our [present] submarines, which already do very well in this respect”¹.

Obviously, all of these innovations have brought about an increase in the cost of these new generation submarines (see details later), to the point that one SNLE-NG will cost twice as much as one of the first generation. But this budgetary information was hardly mentioned when the program was launched: it was not until 1998, when the program was nearly complete, that the Committee on costs of armaments manufactures published in a few paragraphs the over-all costs of the SNLE-NG program.

On the other hand, the military engineers have hardly made any innovations regarding the operational life expectancy of the SNLE-NG. The chief engineer Duval, in 1991, reckoned on a life of

SNLE-NG CHRONOLOGY	
Mar. 10, 1986	Order for the first SNLE-NG, <i>Le Triomphant</i>
June 9, 1989	Beginning of construction of <i>Le Triomphant</i>
1989	The Aerospatiale Co. launches the M45 missile program Order for <i>Le Téméraire</i> , the second SNLE-NG
July 1, 1992	France ratifies the Nuclear Non-Proliferation Treaty
Mar. 21, 1997	Commissioning of <i>Le Triomphant</i>
Mar. 29-May 20 1997	First mission at sea of <i>Le Triomphant</i> , armed with M45 missiles ¹
Dec. 23, 1999	Commissioning of <i>Le Téméraire</i>
Jan. 2000	Beginning of first operational mission of <i>Le Téméraire</i>
May 2000	Delivery of second batch of M45 missiles, with their TN75
July 28, 2000	Order for the fourth SNLE-NG, <i>Le Terrible</i>
2003	Delivery of third batch of TN75
July 2004	Commissioning of <i>Le Vigilant</i> , the third SNLE-NG
2008	Commissioning of <i>Le Terrible</i> , the fourth SNLE-NG and commissioning of the M51 missile with TN75 on <i>Le Terrible</i> -NG
2015	Installation of the new TNO on the M51

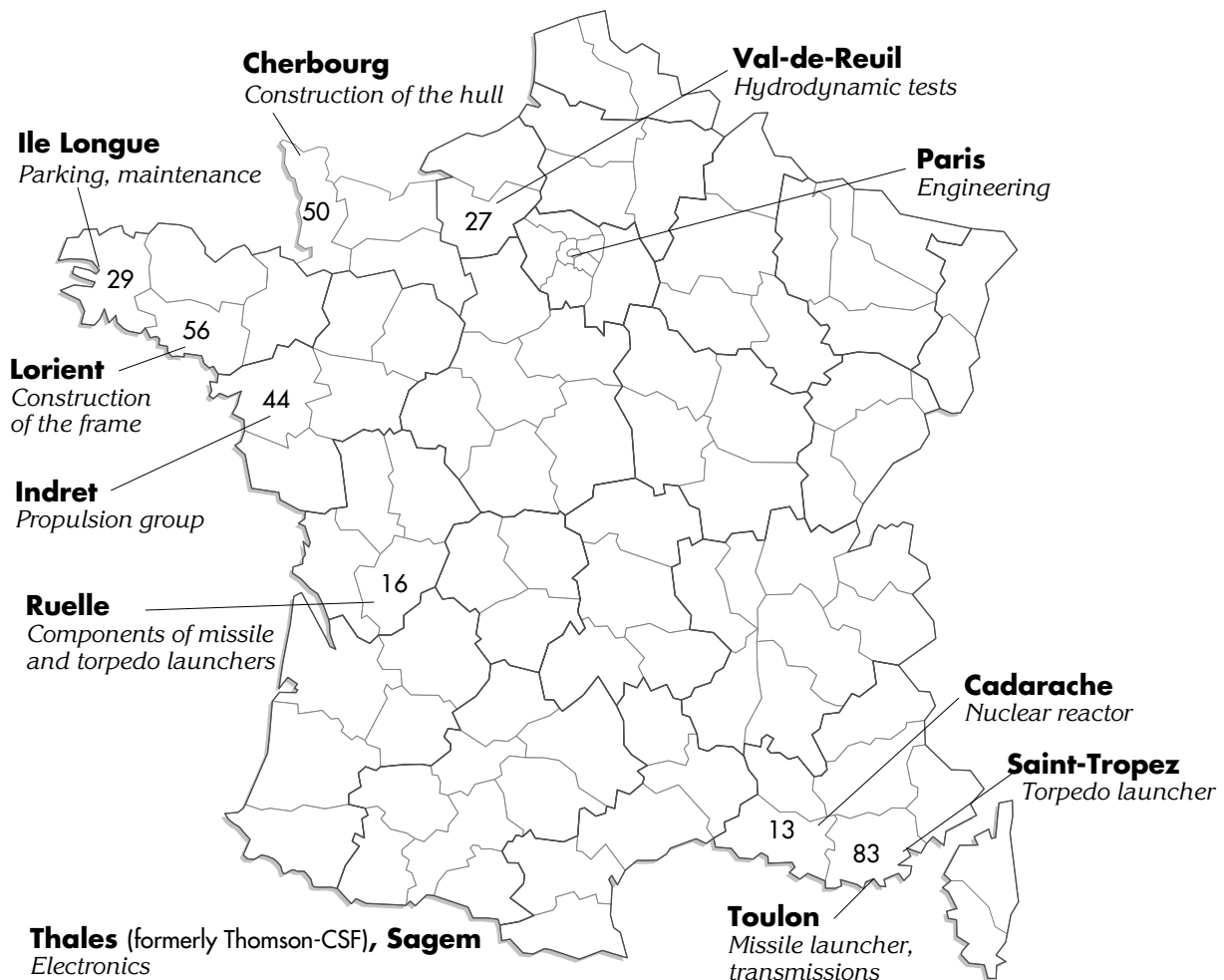
1) *Le Télégramme de Brest*, Sept. 13, 1997.

twenty-five years, a figure hardly different from that of the SNLEs of the *Redoutable* class, which have lasted from twenty to twenty-six years, approximately. It is very curious, moreover, that the experts of the Committee on costs of armaments manufactures have made their calculation of the “possession cost” of the SNLE-NG by estimating their life expectancy at thirty-five years (see later).

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1) Duval, chief engineer, at a press conference before accredited defense journalists, Dec. 17, 1991.

PRINCIPAL INSTALLATIONS RELATED TO THE SNLE-NG



Summary of service of the SNLE-NGs

- SNLE-NG *Le Triomphant*: commissioned March 21, 1997. Put into dry dock for seven months at the end of 1999
- SNLE-NG *Le Téméraire*: commissioned December 23, 1999. First operational tour beginning January 2000.
- SNLE-NG *Le Vigilant*: to be commissioned July 2004, coordinated with the de-commissioning of *L'Indomptable*.
- SNLE-NG *Le Terrible*: ordered July 28, 2000; commissioning scheduled for July 2008. This order for the fourth SNLE-NG in 2000 will necessitate keeping *L'Inflexible* in service until July 2006.

Companies involved in submarine construction

The number of companies and personnel involved in the industrial organization of submarine construction is large. Oversight of the SNLE-NG is provided by the Division of Naval Construction (Direction des constructions navales, or DCN) at Cherbourg, but all of the 4000 partner companies and the various units of the DCN have been put to work in the program. The responsibilities of the DCN for submarine construction alone can be

summarized as follows:

- DCN Cherbourg: oversight, construction and assembly of the hull;
- DCN Indret: oversight of the propulsion system in coordination with Technicatome (a subsidiary of the CEA, located at Cadarache), which manufactures the nuclear reactor. DCN Indret is also responsible for the fresh water production system as well as for the steam circuit for domestic use;
- DCN Toulon: manufacture of the missile-launching system, the “conventional” combat system, and the transmission and applications of the acoustics [silencers].
- DCN Saint-Tropez: completion of the launching system, handling and loading of the torpedoes (and of anti-torpedo decoys);
- DCN Lorient builds mainly the forward structure of the SNLE;
- DCN Ruelle makes the main mechanical components of the missile-launching system and the torpedo tubes;
- DCN Brest performs the sea trials of the submarines, which has necessitated big changes at Ile Longue and the creation of specific installations in the Brest harbor;

- DCN Engineering oversees the over-all architecture of the SNLE-NGs; it is the study office of the program;
- STSN (Naval systems technical service), in Paris (at the Hull Basin) and in the hydrodynamic tunnel at Val-de-Reuil, directs studies and trials of hydrodynamics, of acoustics, and of submarine detection...

In addition to the DCN, other large companies participate in the program, principally Thales (formerly Thomson-CSF) and Sagem for the electronic equipment. A listing by magnitude of participation of companies in the program was given at the time it was begun. Some of them amount to around 5% of the program:

DCN Cherbourg	50.0%
DCN Indret	12.3%
Thales	7.0%
Sagem	4.5%
Techniatome	5.2%

Portion of the military budget for the years 2000 & 2001 allocated to nuclear submarines

It is difficult to do over-all estimates that show the real expenses of the SNLE-NG program, mainly because they are spread out over several decades. Although the desirable transparency is still far off, more precise information has been given in parliamentary budget reports, making it possible to identify funds allocated to the various components of the SNLE-NG program. We shall attempt, therefore, to add up the expenditures made solely for submarines in the 2000 and 2001 defense budgets (*see table on following page*).

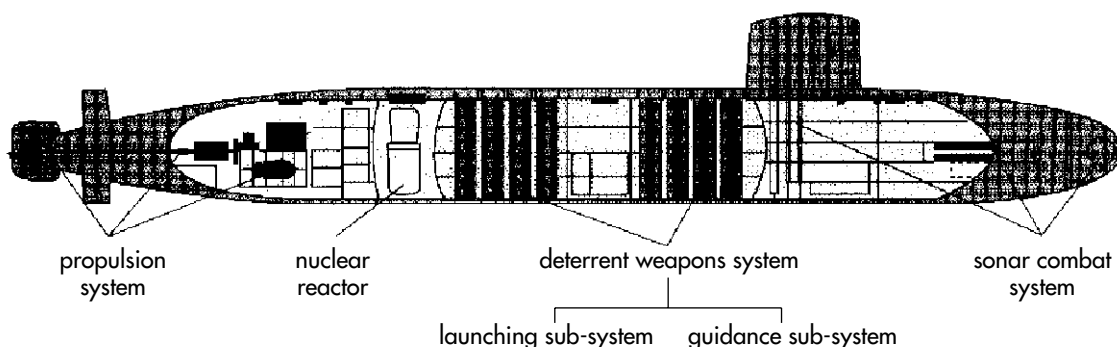
These funds pertain only to equipment expenditures for nuclear submarines. They come to a little more than 10% of the expenditures for equipment in the military budget for 2000 and 9.7% for 2001.

FUNDING FOR THE SNLE-NG IN 2000 AND 2001	2000		2001	
	MF	M€	MF	M€
Construction of the SNLE-NGs ¹	1,771	270	1,937	295
Maintenance in an operational state of the SNLE ²	1,297	198	1,255	191
Adaptation SNLE-NG for M51	358	55	397	61
Miscellaneous SNLE-NG expenses	426	65	348	53
Total SNLE-NG	3,852	587	3,937	600

1) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2000, Rapport*, Assemblée nationale, n° 1861, annexe n° 40, p. 119 et sq. et *Projet de loi de finances pour 2001*, n° 2624, annexe n° 40, p. 136 et sq.

2) René Galy-Dejean, *Défense, Projet de loi de finances pour 2000 Avis*, Assemblée nationale, n° 1964, tome II, p. 68 et *Projet de loi de finances pour 2001*, n° 2627, tome II, pp. 25-40.

INDUSTRIAL ORGANIZATION OF THE PROGRAMME SNLE-NG PROGRAM



Missiles

The M45 missile

Each of the first three SNLE-NGs will be equipped with sixteen M45 missiles, which derive from the M4 missile of the *Redoutable* class of submarines. So the plan was to build three batches of M45 missiles. Although it was decided in the 1998 review of the program to reduce from three to two the number of batches of M45s², it was later decided to go ahead with the construction of a third batch and to adapt the *Inflexible*, a first generation SNLE, to this M45 missile³.

These three batches of missiles went into service on the following dates⁴:

- March 1997, first batch of sixteen M45s, on *Le Triomphant*;
- May 2000, second batch, on *Le Téméraire*;
- first quarter of 2001, third batch, on *L'Inflexible*.

The M45 missile differs from the M4A or the M4B (which equipped the old generation submarines) essentially by the “stealthier” new TN75 nuclear warheads that it carries and by heightened penetrability: military people speak of “hardening” with regard to the effects of nuclear aggression in flight. It is not certain that entirely new M45 missiles have been built. In fact, several parliamentary reports mention that three of the four batches of M4 missiles “will be transformed into M45 versions”⁵. The range of the M45, like that of the M4, is over 4000 kilometers⁶ (in some this range is up to 6000 km⁷), and the differences between the M4 and M45 involve only 3% of their mass outside the nuclear warhead.

A batch of missiles is not assigned to a particular sub: it is transferred from one sub (of the same class) to another depending on factors of availability and dry-docking for maintenance. Thus, it appears that *Le Téméraire* will take on, in January 2000, the batch of M45s from *Le Triomphant*, which went into dry-dock at the end of 1999 for seven months. The second batch of M45s will enter service with the return to duty of *Le Triomphant* about May 2000⁸.

According to parliamentary information, at the same time (May 2000), a batch of 16 M4B missiles adapted to the SNLEs of the *Redoutable* class will be de-commissioned. This means that beginning May 2000, there will be only one batch

CHRONOLOGY OF THE M45/M51 PROGRAM

1989	The Aerospatiale Company initiates the M45 program
Dec. 10, 1991	First trial firing of the M45 prototype at the Test Site in the Landes region
July 1, 1992	France ratifies the Nuclear Non-Proliferation Treaty
Dec. 10, 1992	M5 program launched at Aerospatiale
Feb. 14, 1995	First exercise firing of the M45 from the SNLE-NG <i>Le Triomphant</i>
1996	M5 program abandoned for the M51 version
Sept 19, 1996	Failure of an M45 firing from <i>Le Triomphant</i>
Mar. 29, 1997	The M45 is put into service on <i>Le Triomphant</i> (first mission)
May 1999	Qualifying firing of the propulsion system of M51 at Caepe
May 4, 1999	Test firing of the M45 from <i>Le Téméraire</i>
Dec. 23, 1999	M45 put in service on <i>Le Téméraire</i> (first mission)
2008	M51 scheduled to be put into service on the 4th SNLE-NG, <i>Le Terrible</i>

of M4B missiles left. This last batch will remain assigned to *L'Indomptable* until December 2003, when this submarine will be taken out of service.

From the first quarter of 2001 until December 2003, the four available submarines (two of the old generation, two of the new) will have at their disposal three batches of sixteen M45 missiles and one batch of the M4Bs. Thus, during that period, there will be two maintenance lines for four batches of missiles, which will probably increase their maintenance cost.

The M51 Missile

It is anticipated that the M51 missile will replace the M45s. Originally, M4s were to be replaced by M5's, for which research had begun in 1988⁹. The increased cost of this program was such that the 1997-2002 military budget law opted for a less onerous M51 program.

A first batch of M51 missiles will go directly into service in 2008 on the fourth SNLE-NG.

2) Comité des prix de revient des fabrications d'armements (CPRA), *Vingt-deuxième rapport d'ensemble*, May 16, 2000, p. 6.

3) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2001*, op. cit., p. 139.

4) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2000*, op. cit., p. 120.

5) Jacques Baumel, *Défense, Dissuasion nucléaire, Projet de loi de finances pour 1997*, Avis, Assemblée nationale, n° 3033, tome IV, October 10, 1996, p. 24.

6) René Galy-Dejan, *Défense, Projet de loi de finances pour 1999*, Avis, Assemblée nationale, n° 1114, tome II, October 8, 1998, p. 62.

7) *Air & Cosmos*, May 14, 1999, p. 31.

8) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2000*, op. cit., p. 120.

9) Bruno Barrillot, *Audit atomique*, CDRPC, Lyon, 1999, pp. 154-157.

Subsequently, the three other SNLE-NGs (*Le Triomphant*, *Le Téméraire*, and *Le Vigilant*) are to be re-fitted, between 2008 and 2014 approximately¹⁰, for the M51 missiles. Three batches of M51 missiles are to be built¹¹.

The M51 has some very different characteristics from the M45, notably its mass of 56 tons, while that of the M45 is only 35 tons. Its announced range is around six thousand kilometers with its nuclear load and penetration aids¹². However, as is often the case when test firings have not yet been made, the announced range of the M51 is “variable” in an optimistic direction; thus, the journal *Air & Cosmos*, using information supplied by the Ministry of Defense, reports a range of eight to ten thousand kilometers for the M51¹³.

There will be two versions of the M51 missile:

- the M51-1 (a batch of sixteen missiles), with a TN75, will be deployed on the fourth SNLE-NG in 2008;
- the M51-2 version (two batches of sixteen missiles) with a TNO will go into service beginning 2015, as the first three SNLE-NGs are refitted.

Variations in the cost of the M51

As already indicated, it is the increased cost of the M5 program which upset the project. In 1991, its cost was estimated at 64 billion francs, but two years later, the same program had been revised upward to 73 billion francs¹⁴.

According to the 1997-2002 military budget law, the less ambitious M51 program is not to rise above the fateful bar of 30 billion francs.

In fact, this projected cost is only a technical and budgetary arrangement. Thus, in his report on the 2001 funding bill, Deputy Jean-Michel Boucheron writes that: “the development cost of the M51 missile is estimated at 29.63 billion francs”¹⁵.

The deputy explains that this figure does not take into account the nuclear warheads (see below) or the costs of adapting the first three SNLE-NGs and some infrastructures to the M51. But neither does it account for the production of the M51 missiles, for at this time, we are only in the development phase¹⁶. And it is planned to build three batches of these missiles!

Supplementary costs for “adaptations”

When a new program is launched, the cost spiral becomes hellish because, generally, prior estimates are always subject to re-evaluation. The M51 missiles will be designed for the fourth SNLE-NG, *Le Terrible*, when it goes into service in 2008, but it is planned to upgrade the three other SNLE-NGs to the M51 standard, necessitating several important operations. Each of the first three SNLE-NGs, of the *Triomphant* class, carried sixteen M45 missiles 11 meters long and weighing 35 tons. But the M51 is larger, almost 12 meters long and weighing 56 tons. Thus the adaptations will be large and costly, since it will be necessary to modify the submarines themselves.

The manufacturers and the General Delegation for Armament (DGA) therefore foresaw a program to adapt the SNLE-NGs to the M51, added to the M51 program itself. This program, estimated (in 2000) at 8.1 billion francs, includes the following operations¹⁷:

- adaptation of the on-board component of the weapon system (methods of stocking and firing, stabilization during firing, surveillance and activation installations);
- adaptation of the maritime base on Ile Longue (pyrotechnics, harbors);
- adaptation of the training and instruction center (replacement of desks and control bays in simulation installations).

One may well wonder about the numbers put forward for the adaptation of the three submarines to the M51. In 1998, the Committee on costs of armaments manufactures (CPRA) gave a figure of 9,487 million francs¹⁸, while in 2000, the parliamentary reports announced a cost of 8,100 million francs. What savings were planned by the parliament, since in 1998, the CPRA prudently indicated a possible under-estimation of the cost of this adaptation of the M51 to the SNLE-NGs?

Re-evaluation of industrial costs

In the year 2000, European defense industries were re-structured, with the integration of the French company Aérospatiale into the private consortium EADS (European Aeronautic Defense

10) Jean-Yves Le Drian, *Défense, Marine, Projet de loi de finances pour 2000*, Avis, Assemblée nationale, n° 1864, tome V, October 14, 1999, p. 29.

11) *Idem*.

12) René Galy-Dejan, *Défense, Projet de loi de finances pour 1999*, op. cit., p. 62.

13) *Air & Cosmos*, May 3, 1996, p. 34 et 14 mai 1999, p. 31.

14) Cf. Bruno Barrillot, *Audit atomique*, op. cit., pp. 154-157.

15) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2001*, op. cit., p. 141.

16) *Journal officiel*, Question de Georges Sarre, March 19, 2001.

17) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2001*, op. cit., p. 142.

18) CPRA, *Rapport*, May 12, 1998, p. 4.

BUDGET FOR SNLE-NG MISSILES	2000		2001	
	MF	M€	MF	M€
Maintenance of M4B-M45 ¹⁾	835	127	685	104
Development and manufacture of M45	107	16	72	11
Development of M51	2,373	362	2,320	354
Total missiles	3,315	505	3,077	469

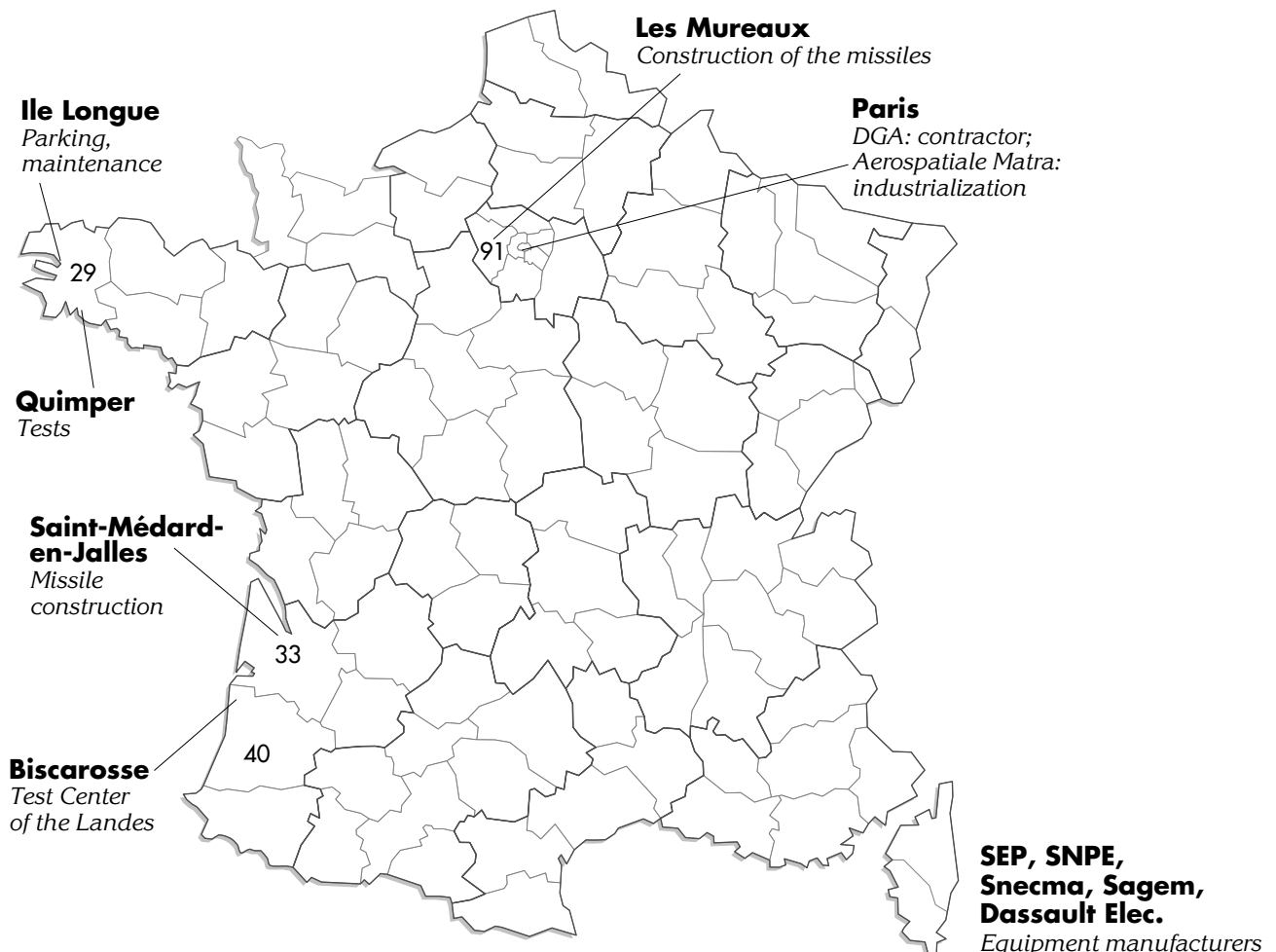
1) Les Échos, November 30, 2000.

and Space Company), including mainly Matra (France and the UK), Dasa (Germany), and Casa (Spain). This restructuring constitutes a very important change in French industrial practice in the area of nuclear armaments. Until the present time, it was the General Delegation for Armament (DGA) which negotiated industrialization contracts with French companies in which the government had a considerable amount of the capital, either the majority or all of it. Today, the DGA must negotiate with private industrial partners, and foreigners, moreover. In the particular case of the M51 program, France is dealing with two main parties: EADS LV (Launch Vehicles) and the G2P group consisting of the French com-

panies Snecma and SNPE for the propulsion system of the missile.

Problems soon came to light when EADS wished to re-negotiate the contract made in 1998 by the DGA and Aerospatiale. Basing its claim on the institution of the 35 hour work week in France, EADS presented a new estimate of 20.76 billion francs (not including taxes), whereas the DGA was prepared to spend only 16.5 billions francs (not including taxes). The impasse brought work to a halt in the the EADS factories at Mureaux and Saint-Médard-en-Jalles for ten days in the last quarter of 2000. On December 27, 2000, an agreement was finally made, with the DGA consenting to contribute a total of **18.7 billion**

THE MAIN INSTALLATIONS RELATED TO THE M45/M51 MISSILES



The financial burden of the M51 program

In June 1999, the Committee on costs of armaments manufactures (CPRA) reviewed the M51 program and pointed out that “its financial weight will likely reach around forty billion francs”, despite the reduction by 23% of the development cost estimate compared to what was proposed in 1992 (a reduction of 7.5 billion francs)¹. In any case, the CPRA was doubly cautious in noting that “the savings announced are still only cost estimates”.

Yet, these reservations on the part of the CPRA did not temper the optimism of the National Assembly Finance Committee chairperson, who announced for 2001 a cost estimate of 29.630 billion for the M51 program. Less than 30 billion, that is the goal! But that is far off the mark, and the CPRA estimates are probably closer to reality. In fact, since the M51 program is entirely new compared to the M4-M45 program, the expenditures designated for the M51 are more easily identifiable in budgetary information. Obviously, we have no figures on the “production” part of the program, that is, the three batches of sixteen missiles, or a total of at least forty-eight. One may suppose that the missiles to be used in the test firings are accounted for in the development cost. On the other hand, when missiles are in service on a sub, an average of one firing per year is made to verify their readiness, for a total of twenty-five extra missiles, assuming a life of twenty-five years for the SNLE-NG program. The following table details the budget for the M5-M51 program (the M51 being a variant of the M5 program) from 1998 to 2000, that is what has really been spent (according to parliamentary information) as well as the prior estimates mentioned above:

.....

1) CPRA, *Rapport*, June 5, 1999, p. 6.

2) Bruno Barrillot, *Audit atomique*, op. cit., p. 155.

DECLARED EXPENDITURES FOR THE DEVELOPMENT OF THE M51 PROGRAM (1988-2008)		
Year	Thousands of currents francs	Thousand of 1999 francs
1988-1992 ²		467
1993	417	450
1994	804	855
1995	997	1,042
1996	1,310	1,341
1997	1,501	1,519
1998	1,472	1,479
1999	1,800	1,800
Total 1988-1999		8,953
Estimates 2000-2008 (EADS)		18,700
Estimates 2000-2008 (G2P) ?		5,300
Adaptation of SNLE-NG to the M51		8,100
Estimated total		41,053
Production of three batches and tests		unknown

francs to the M51 program for EADS¹⁹. The motorization of the missile, to be propelled by G2P, will be supported by 5.3 billion francs, according to other sources²⁰. It is unclear from either the press or the official accounts whether or not the 5.3 billion francs for G2P are part of the 18.7 billion francs.

Some annex installations related to the M51 program

The Syrinx program

Since the M51 missile is intended to carry nuclear warheads, it has to be protected from enemy attacks so that in the event that it is used, its nuclear weapons (six per missile) reach the programmed destination. Military engineers are therefore designing what they call “hardening” of the missile against an enemy nuclear explosion in the upper atmosphere which, even if it did not destroy the missile, could damage its electronic

systems. A program dubbed “Syrinx” installed at the study center of the DGA at Gramat (Lot) makes it possible to experiment with a system that would protect the M51 against what is called electromagnetic impulsion. For that purpose, they possess systems capable of producing around eight million amperes in a few hundred billionths of a second. The DGA is collaborating with the US on this system. But France is far from the performance of the American Z generator at Albuquerque, New Mexico, which produces a current of twenty million amperes in a few hundred billionths of a second. The power thus obtained is greater than that produced by all of the power plants in the world!

The French are going to carry out a few experiments at Albuquerque, but this is expensive, since each one costs \$50,000 (350,000 francs). The DGA states that this will cost less when the French system is installed, about 50,000 francs an experiment. But the installation cost at Gramat is not mentioned.

.....

19) *Air & Cosmos*, December 8, 2000, p. 45 and *Journal officiel*, Question de Georges Sarre, March 19, 2001.

20) *Les Échos*, November 30, 2000.

The Cetace program

The development of a new missile necessitates other installations, especially to do test firings in conditions resembling those to be encountered by sailors on board the SNLE-NGs. In the past, a test submarine, the *Gymnote*, was used for these experiments, but it had to be modified for each new generation of missiles, and it was taken out of service in 1986 after 136 missile firings off the coast of France²¹. For the M51, the DGA had the Division of Naval Construction at Brest build the “Caisson d’essai de tir pour l’analyse et la conception de la fonction éjection” [called by the anagram “Cetace”]. It consists of a large system including a launching tube submersible to sixty meters deep. The first tests are expected in 2002 off the coast at Toulon, after going through the Test Center of the Landes²².

The manufacturing of strategic missiles for submarines

The construction of submarine missiles (called MSBS, for “mer surface balistiques stratégiques”) is carried out under the responsibility of the chief director of the “Coelacanthé” program of the SNLE.

The body responsible for the missile system is the Division of force systems and planning, Service of naval programs, of the General Delegation for Armament (DGA), coordinated with the CEA for the nuclear warheads part.

The industrial director for missiles is the Aerospatiale/Matra Company/Strategic and Space Launchers, which oversees the completion of about 55% of the program.

The M45 and M51 missiles are built (or transformed) in the Aerospatiale Matra Lanceurs (now called EADS) factories at Mureaux (department of Yvelines) and at Saint-Médard-en-Jalles (department of Gironde), which, at the end of 1999, employed 3,450 workers (about 2,200 at Mureaux and 1,200 at St.-Médard). After the cancellation of the Hades and the Albion Plateau missiles, also built in these two factories, a reduction in personnel was announced. By the end of 2003, they will have only 2,900 employees, of which about 1,000 at Saint-Médard-en-Jalles by 2001²³.

Other companies also are involved in the construction of M45 and M51 missiles:

- the propulsion system is divided between the “Société européenne de Propulsion” [European

Propulsion Company] (17% of the program), which is now a division of the aeronautical engine manufacturer Snecma and the “Société nationale des poudres et explosifs” [National Powder and Explosives Company] (8% of the program);

- Dassault Electronique and Sagem are in charge of the guidance system;
- the various components of the missiles are perfected and provided by various equipment manufacturers, mainly Thales (formerly Thomson-CSF), Thomson-Sintra, Crouzet, Air Equipement, Sfena, Saft...

The M51 missile construction program is in the development stage. Tests of the propulsion system began at the “Centre d’achèvement et d’essais des propulseurs et engins” [Engine Completion and Testing Center] (Caepe), a branch of the DGA located on 2,600 hectares of land between Saint-Jean-d’Illac and Saint-Médard-en-Jalles (Gironde)²⁴. A specific test bed “EB-4” for propulsion tests of the M51 was inaugurated late in 1997 at Caepe; this equipment cost 70 million francs²⁵.

Maintenance of submarine missiles

The upkeep of the missiles is carried out under the responsibility of the Division of Naval Construction at Brest (sub-directorate of strategic missiles). This maintenance of submarine missiles in service is performed, however, at Ile Longue by personnel of the Aerospatiale Company. About forty people are assigned to these operations designated by the term “*maintenance in operational condition*” (MCO), which occurs in the underground zone of the Pyrotechnics (the red zone). The assembly of the stages of the missiles is accomplished according to minutely detailed procedures in several shops.

It is also in these maintenance shops that the missiles are prepared for the test shots to qualify the SNLEs that are either entering service or reentering after dry-docking.

The missile tests are performed in coordination with the Test Center of the Landes (CEL), the CEL branch at Quimper, and the measurement building —*Le Monge*— located at the intended impact site. The test firings of the M45 were all made from the SNLE-NG *Le Triomphant*, and the first qualifying firing of the second SNLE-NG *Le Téméraire* with the M45 was done from this ship on May 4, 1999²⁶.

21) Bruno Barrillot, *Audit atomique*, op. cit., pp. 133-136.

22) *Le Télégramme de Brest*, March 28, 2000.

23) *Les Échos*, December 2, 1999.

24) *Cols bleus*, March 13, 1999, p. 23 ; *Info DGA*, June 1999, pp. 13-15.

25) *Air & Cosmos*, December 5, 1997, p. 30.

26) *Cols bleus*, September 25, 1999, p. 23.

The twenty-second report of the Committee on costs of armaments manufactures provides new details on the maintenance of the M45 missiles²⁷. This report confirms that there is scarcely any difference between the M4 and M45 missiles and that these two models really form a single program of nearly forty years duration, from its inception in 1973 to the expected termination of the M45 in 2012. Since the initial plan for seven SNLE-NGs was finally reduced to four, an excess of spare parts was built. The report even notes that presently (in May 2000), the program has the equivalent of 5.5 missiles. This “equivalent” consists of spare parts necessary for maintaining the missiles in operational condition; it is evaluated at 8 billion francs! Moreover, since these parts were ordered more than ten years ago, they are reaching expiration dates. Between the lines, one can see that, here too, public money has been squandered...

The report estimates the cost of maintenance of the M4-M45 missiles (without nuclear warheads) in operational condition at nearly a billion francs per year. But the experts of the Committee on costs had banked on a cancellation, by the program review of 1998, of a third batch of M45s, thus making possible a saving of 1.75 billion francs in the MCO. Indeed, even though the “politicians” did decide on a program review, the military administration did not follow through and the third batch was built. Farewell to savings... Moreover, the Committee on costs was prudent. Its analysis concludes by saying that “*the age of the M4 components creates the risk of late-stage obsolescence, which could result in possibly very high operational maintenance costs*”.

Nuclear Warheads

Each submarine missile has six nuclear warheads. As of January 1, 2000, two types of nuclear warheads were in service on submarines:

- the thermonuclear warhead TN71 (six on each M4 missile). With a mass of 120 kilos, it carries a thermonuclear load of 150 kilotons. At the beginning of 2000, 192 TN71s armed the two batches of sixteen M4B missiles on the first generation SNLEs. Dismantling of these TN71s will begin in 2003²⁸. With the withdrawal of the M4B missiles expected in December 2003, the TN71 warheads will be permanently retired from service;
- the thermonuclear warhead TN75 (six on each M45 missile) is smaller and stealthier than the

CHRONOLOGY OF THE TN75 AND TNO NUCLEAR WARHEADS

1987	the CEA begins research on the TN75
1989	the CEA completes developmental work on the TN75
July 1, 1992	France ratifies the nuclear non-proliferation treaty
December 1993	Deputy Rene Galy Dejean states that 22 test firings have made possible the completion of the TN75
March 1997	first batch of TN75s put into service on <i>Le Triomphant</i>
Early 2000	beginning of the feasibility phase of the TNO
May 2000	second batch of TN75s put into service on <i>Le Téméraire</i>
2003	third batch of TN75 to be put into service feasibility stage of the TNO
2011	beginning of production of the TNO
2015	TNO to be put into service

TN71. It began service in March 1997 on the SNLE-NG *Le Triomphant*²⁹. A second batch of TN75s was due to enter service in May 2000, at the same time as the second batch of M45s. The third batch of TN75s will be delivered in 2003, at the same time as the third batch of M45 missiles. Then France will have 288 TN75 warheads for her submarines.

The oceanic (maritime) nuclear warhead

The replacement of the TN75 is already being prepared. It is planned to put a “thermonuclear warhead TNO” (*tête nucléaire océanique*) in service on the M51 missile beginning in 2015. According to official information, the nuclear charge of the TNO is an outcome of the last nuclear testing done by France (in 1995-1996). However, this TNO will be the first nuclear weapon perfected by simulations; hence the correspondence in dates of the two programs³⁰.

At the beginning of 2000, the TNO program was in the feasibility stage, it will be in the finishing stage in 2003 and in production in 2011³¹.

Funds budgeted for nuclear warheads for the SNLE-NGs in 2000 and 2001

These funds appear under three headings: TN75 funds for the construction of the third batch of TN75 due to go into service in 2003; funds for

27) CPRA, *Vingt-deuxième rapport d'ensemble*, May 16, 2000, pp. 5-6.

28) René Galy-Dejean, *Défense, Projet de loi de finances pour 2000*, op. cit., p. 62.

29) *Idem*.

30) *Idem*.

31) *Idem*.

FUNDS FOR NUCLEAR WARHEADS	2000		2001	
	MF	M€	MF	M€
TN75 funds	666	102	523	80
TN75 maintenance	147	22	145	22
TNO funds	393	60	386	59
Total for nuclear warheads	1,206	184	1,054	161

FUNDS FOR SIMULATED NUCLEAR TESTS	2000		2001	
	MF	M€	MF	M€
Simulation Program	1,844	281	2,016	307

maintenance in operational condition of the two batches of TN75 presently in service on *Le Triomphant* and *Le Téméraire*; funds budgeted for the completion of the future TNO warhead. The amounts shown are probably partial since the parliamentary reports indicate that these three headings do not include “nuclear materials”³².

To the funds budgeted for the TNO should be added a large portion of the funds earmarked for the nuclear tests that are officially designated for the completion of the two future models of nuclear warheads for the French arsenal: the TNO and the TNA (airborne nuclear warhead) which will be adapted to the future ASMP-A missile for the Rafale aircraft. The simulation test funds for 2000 and 2001 appear as follows.

The manufacturing of TN75 nuclear warheads

This will be accomplished under the responsibility of the Division of Military Applications (DAM) of the CEA, but this body is not the only one involved in this program.

The basic materials of the TN75, as for any thermonuclear warhead, include three principal elements, said to be of “military quality”: uranium, plutonium, and tritium. Uranium that is highly enriched in the isotope 235 comes from the military enrichment factory of Pierrelatte (Cogéma), which was permanently shut down in mid-1977, since France has a stock of military uranium deemed to be sufficient. Likewise, military quality plutonium, which must contain at least 97% of the isotope 239, comes principally from the plutonium factory UP1 at Marcoule (Cogéma), which was shut down at the end of 1997. Tritium is provided by the Celestin I & II reactors of Marcoule (owned by the CEA), which are still in operation.

Other elements of nuclear warheads are manufactured by companies “external” to CEA: such is the case with the neutron generators that “initiate” the chain reaction and which are produced by the Sodern Company at Limeil-Valenton.

The various centers still working for the DAM division of CEA (and their sub-contractors) are involved in the manufacturing of the nuclear warheads themselves: the Valduc center (near Dijon) is general supervisor and does the machining of the nuclear materials; the Ripault center (near Tours) produces the chemical explosives necessary for creating the pressure and temperature conditions that permit the triggering of the chain reaction; le Cesta du Barp (near Bordeaux) completes the “militarization” of the nuclear elements of the bomb (warhead cluster, penetration and stealth systems, protection against attack...).

Pending delivery to the designated military authorities (the Navy for the TN75), the parts of the nuclear warheads are stocked at the Military Storage Center at Valduc (CSMV), a property of the Ministry of Defense contiguous to the Valduc CEA center.

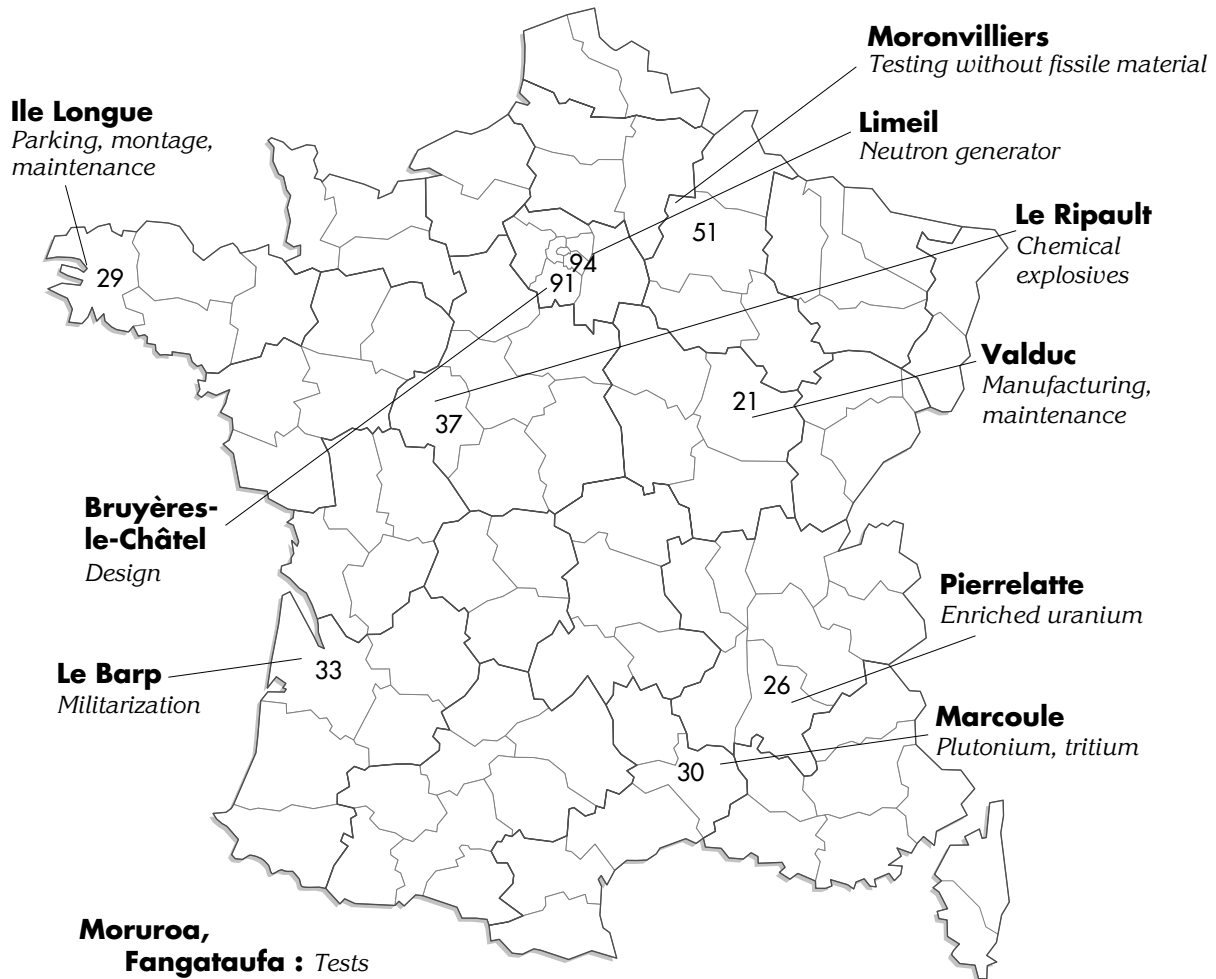
Assembly and maintenance of the SNLE nuclear warheads

Assembly

The CEA (DAM branch) assembles the nuclear warheads for the SNLE missiles. This operation is carried out in certain buildings of the CEA Unit (“Antenne CEA”) of the Ile Longue pyrotechnics by a staff of thirty people, most of whom are attached to the weapons service of the technical department of Le Cesta (Le Barp, near Bordeaux).

32) René Galy-Dejean, *Défense, Projet de loi de finances pour 2000*, op. cit., p. 63, *Défense, Projet de loi de finances pour 2001*, op. cit., pp. 38-40 ; Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2001*, op. cit., pp. 140-142.

THE PRINCIPAL INSTALLATIONS CONNECTED WITH THE TN75 AND TNO



All these components are assembled by the CEA Unit according to well-defined procedures worked out specifically for each type of nuclear warhead. The procedures applied are supposed to make impossible any situation that might endanger the safety of the personnel or affect the environment. Likewise, a series of “quality criteria” must be integrated into these procedures. These are essential elements ensuring the identical functioning of weapons assembled over time intervals that may amount to several years.

Specific tooling for each nuclear warhead is designed for these assembly operations. Simulated assemblies with inert parts are performed in order to test the procedures.

Maintenance

Another operation performed by the CEA Unit of Ile Longue is the maintenance of the nuclear warheads. CEA does periodic check-ups of the short-lived elements of the nuclear warheads, certain ones of which must be changed following a program set in advance. CEA verifies mainly the computer circuits. But important procedures must be carried out on the nuclear materials, which undergo significant evolution over the

years, possibly compromising the functioning of the bomb. These procedures consist of renewing the tritium, a radioactive isotope of hydrogen present in each warhead, and which (for military people) has the disadvantage of a rapid decrease in radioactivity; likewise, components containing plutonium must be changed in order to avoid the accumulation of isotopes of americium, which, because of their toxicity, would necessitate important protective measures for the personnel who handle the weapons.

Although the maintenance procedure is covered by military secrecy, it may be supposed that the tritium container of each nuclear warhead, filled at Valduc, is simply replaced by one with new tritium at the CEA Unit of Ile Longue. Likewise, chemical operations consisting of skimming off americium contained in the plutonium parts are done in the high-security installations at Valduc: thus it is likely that at Ile Longue plutonium components to be renewed are merely replaced by new ones manufactured at Valduc.

According to public information, the assembly of the second batch of ninety-six TN75s was completed in May 2000, and the third and last equal batch is to be assembled by the CEA Unit at Ile Longue and delivered to the Navy in 2003.

Estimate of the total cost of the SNLE-NG program

RECAPITULATION OF FUNDS FOR THE TOTAL PROGRAM	2000		2001	
	MF	M€	MF	M€
Total SNLE-NG	3,852	587	3,937	600
Total missiles	3,315	505	3,077	469
Total nuclear warheads	1,206	184	1,054	161
Grand totals	8,373	1,276	8,068	1,230

Estimates by the CPRA

The Committee on costs of armaments manufactures (CPRA) has made its own estimate of the SNLE-NG program in two stages.

The twentieth general report (May 12, 1998) examines the **acquisition cost** of the four new generation submarines, begun in 1986. This acquisition cost takes into account neither the *Fost* (Forces océaniques stratégiques) transmission program, nor the three batches of M45 missiles, nor the acquisition cost of the nuclear warheads, "the calculation of which is the responsibility of the CEA"³³.

The latest estimate by the CPRA for the acquisition (construction) of the four SNLE-NGs comes to 45,114 million francs (in 1986), or 60,633 francs (in 2000).

The twenty-first general report (June 5, 1999) evaluates the **possession cost** of new generation missile-launching nuclear submarines³⁴, that is to say, the cost of up-keep for the SNLE-NGs for their entire life of thirty-five years. The basis of the calculation by the committee includes the following factors:

- cost of maintenance of the ships by the DCN;
- cost of nuclear fuel;
- cost of maintenance of ground installations;
- cost of refitting the SNLE for the M51 missile;
- cost of mid-life modernization of the ships;
- cost of maintenance of missiles and warheads;
- cost of dismantling.

The CPRA comes up with the following figures:

- around 45 to 50 billion francs for the four ships themselves, for thirty-five years, including refitting the M51³⁵;
- around 1 billion 350 million (1,350,000,000) francs per year for the three batches of missiles and their nuclear warheads until their replacement by the M51 missiles.

In thirty-five years, the possession cost would be practically 100 billion francs, according to the CPRA. The committee offers an even more startlingly specific figure of about 2 million francs per day per SNLE, just for its operation. If one includes the acquisition and the possession costs of the four SNLE-NGs as defined by the CPRA, one ends up with a total of around 161 billion francs (2000).

Comparison with the *Atomic Audit* figures

In February 1999, the CDRPC had published its evaluation of the cost of the SNLE-NG program in the *Atomic Audit*³⁶. The elements included in the calculation base were practically the same as those of the CPRA except that the cost of manufacturing the missiles and the nuclear warheads had been added.

Contrary to the CPRA, the *Atomic Audit* estimated the life span of the SNLE-NGs at twenty-five years (not thirty-five), noting that the first generation SNLEs had lasted twenty-three years at the most. Moreover, since the fourth SNLE-NG had not yet been ordered in 1999, the *Audit* included only three in its evaluation. Based on the data of the *Audit* and re-evaluating the totals in francs of the year 2000, the following figures emerge, taking account of both the manufacturing and the anticipated operation for twenty-five years:

According to the calculations of the *Atomic Audit*, the total cost of 211 billion francs for the SNLE-NG program is 50 billion higher than the calculation of the CPRA.

The average annual expense, according to the *Audit*, amounts to around 8,400 million francs (2000). Assuming a life of 25 years for the SNLE-NG program, one gets a total of 210 billion francs (8,400 million francs x 25 years), which verifies that the estimate of the *Audit* is more "realistic" than that of the CPRA.

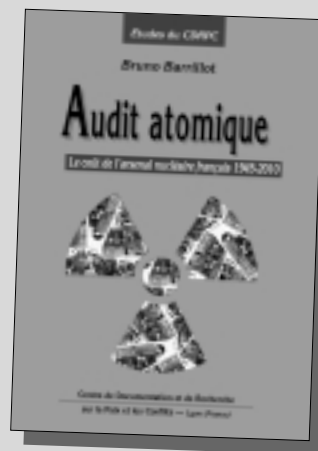
33) CPRA, *Rapport*, May 12, 1998, p. 3.

34) CPRA, *Rapport*, June 5, 1999, p. 5.

35) It is curious that the CPRA is counting on a life of 35 years for the SNLE-NGs whereas the program designer, the general engineer Duval, estimated a life of 25 years.

36) Bruno Barrillot, *Audit atomique*, op. cit., 1999.

RECAPITULATION OF FUNDS ALLOCATED TO THE <i>AUDIT ATOMIQUE</i>	1997	2000	
	MF	MF	M€
Construction of the four SNLE-NG	58,919	60,628	9,243
Maintenance of the SNLE-NG (25 years)	31,171	32,075	4,890
Personnel, SNLE-NG (25 years)	11,488	11,821	1,802
Manufacturing of 3 lots of M45	17,889	18,408	2,806
Maintenance of M45s (25 years)	23,400	24,079	3,671
M51 missile program	41,053	42,244	6,440
Manufacturing of 3 lots of TN75	11,500	11,834	1,804
Maintenance of the TN75 (25 years)	3,625	3,730	569
Development of the TNO (15 years)	5,775	5,942	906
Totals	204,830	210,771	32,130



FOR FURTHER INFORMATION

- *Audit atomique. Le coût de l'arsenal nucléaire français 1945-2010*
Bruno Barrillot, 1999, 376 p. 180 FF / 27,44 € (postage included)
- *Uranium appauvri. Un dossier explosif*
Bruno Barrillot, 2001, 128 p. 79 FF / 12,04 € (postage included)
- *Cahier de l'Observatoire des armes nucléaires françaises,*
« La recherche et la fabrication des armes nucléaires en France aujourd'hui »,
n° 6, 2001, 40 FF / 6,10 € (postage included)

Reports available at the CDRPC, 187, montée de Choulans, 69005 Lyon, France
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Nuclear Submarines, Safety, and Health

To bring up the question of safety and health may appear provocative or out of place, since in their pronouncements on the submarine program, officials have been careful to present it as a model of innovation and technological perfection. Nonetheless, on the one hand, the Army and the CEA have long since put in place an intervention plan in case of incident or accident in a nuclear weapons system, and on the other hand, radiological incidents have been noted in new generation submarines.

The Armed Forces-CEA nuclear intervention plan

In 1963, from the very beginning of the nuclear deterrence force, a national nuclear intervention organization involving the armed forces and the Atomic Energy Commissariat (CEA) was set up at ministerial direction. This plan of action is intended to intervene in case of incident or accident possibly involving a nuclear weapon either during transport of sensitive elements of nuclear charges, or during the assembly, operation, or maintenance in operational condition of these weapons. The plan applies also to incidents or accidents on the nuclear reactor of submarines.

The mission and the area of responsibility of this organization were established in a decree of January 17, 1983 detailing the powers of the *“Joint Commission of the Armed Forces and the Atomic Energy Commission for Nuclear Safety”*.

This armed forces-CEA arrangement differs from the *“Plan particulier d’intervention (PPI)”*, which establishes communications among civil authorities, affected population, and the “nuclear operator” [“exploitant nucléaire”]; but that does not mean that links do not already exist, since in the armed forces-CEA plan, there is a liaison with civilian safety and the prefecture. The articulation among the plans of the PPI, the safety service, and the nuclear operator (in this case Ile Longue for the SNLEs), and the Armed Forces-CEA nuclear intervention plan is explained quite specifically in the description of a training exercise that took place at the Ile Longue base in February 1999.

The Armed Forces-CEA intervention plan necessitates regular training and validation in order to test the over-all organization, the training of the personnel involved in the rescue teams, the

interfaces among the armed forces, the CEA, and civilian assistance, the effectiveness of measures and their availability. In 1994, four annual exercises were conducted at the national level between the armed forces and the CEA, but the administrative and ministerial crisis command posts are involved only once every two or three years.

The organization of Armed Forces-CEA nuclear emergency response

Role of the armed forces

According to the known information, the armed forces function mainly as support for emergency response, which is carried out for the most part by the Division of military applications (DAM) of the CEA. In the military ports, the national navy, considered as the “operator”, is the most immediately concerned. During the first phase of an accident or an incident—first aid, marking the perimeters of security and confidentiality—the commander of the military site is responsible for the organization; in the case of an accident or incident occurring during the transport of a weapon, the national highway police assumes this responsibility.

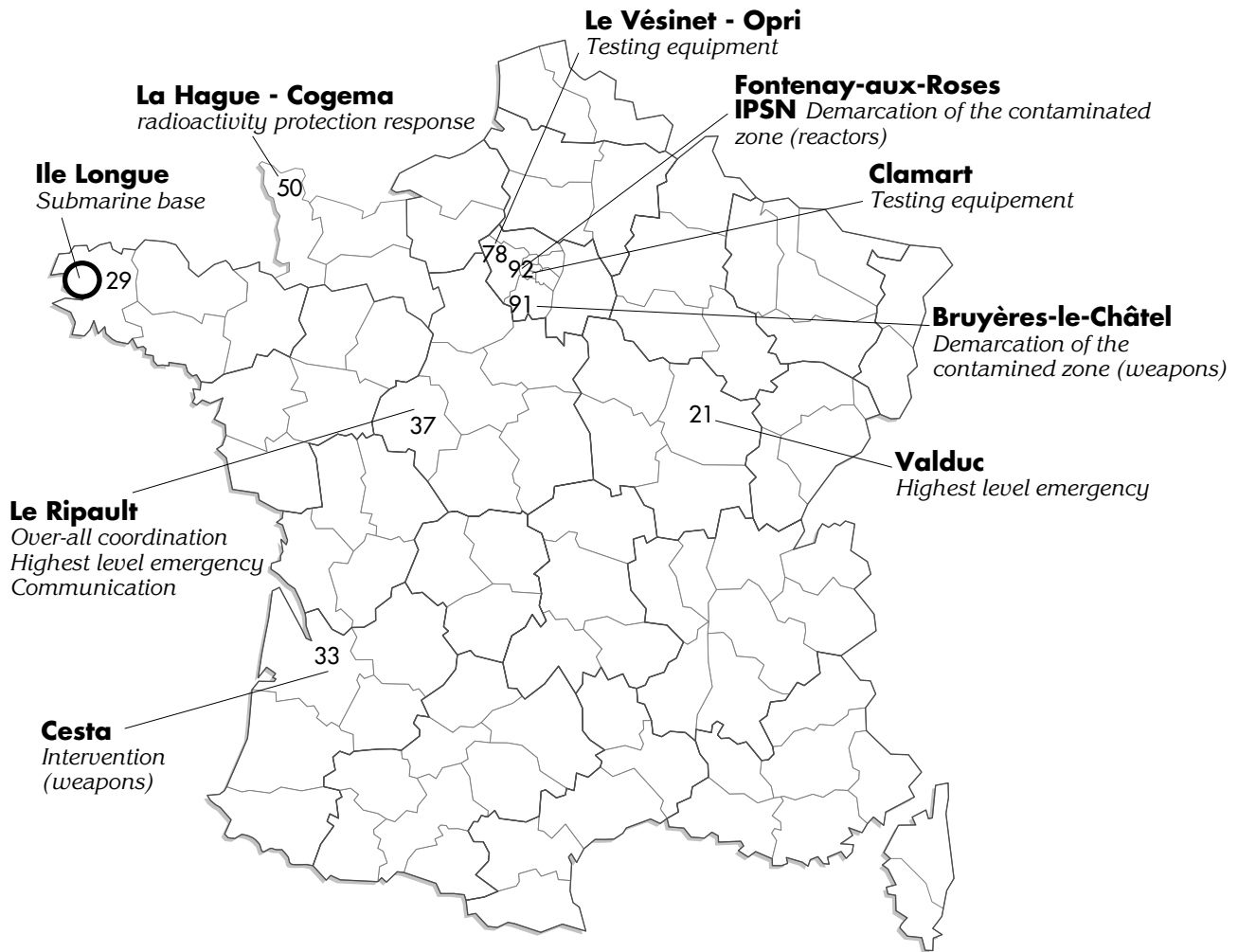
The armed forces also serve the emergency response organization by providing means of transportation and communication to assistance teams.

Role of the Division of military applications (DAM) of the CEA

As the designer and manufacturer of nuclear weapons, the CEA is necessarily involved in cases of accident or incident. In fact, only the DAM has precise knowledge of these weapons and can therefore intervene adequately. CEA’s emergency response procedure is very precise and strictly organized.

Responsibility for the organization and preparation of nuclear emergency response on behalf of the armed forces has been assigned to the Ripault study center. This center is responsible for initiating intervention procedures, and for the formation, preparation, training, and coordination of the teams. In close contact with the Joint Armed

RESPONSE OF THE CEA IN THE EVENT OF AN ACCIDENT AT ILE LONGUE



Forces Operational Center. it begins the broadcasting of alerts for military affairs. A specialized unit —the Intervention Operation Section (SIO)—has been set up. The Ripault center is qualified in emergency response questions because of its history: indeed, until 1987, this center was responsible for construction, assembly, and technical assistance on military bases for the Pluton system. Moreover, the Ripault center builds all of the chemical explosives that are installed in a nuclear warhead, and it is the presence of these explosives that constitute the principal danger in case of accident, for the CEA considers that the likelihood of dissemination of nuclear materials is extremely small.

In case of incident or accident, a team from Ripault is alerted and possibly sent to the site. It includes: an engineer, knowledgeable about weapons, to take the first security measures around and on the weapon and to manage the coordination of teams and resources; two agents responsible for emergency communications and equipment; and two specialists in pyrotechnics, an engineer and a technician.

The DAM center of Valduc, which is charged with the manufacturing of nuclear warheads, is

also part of the response structure in case of incident or accident. A team from Valduc, simultaneously with that of Ripault, is alerted and possibly sent to the site. It includes an engineer and five technicians who are specialists in protection from radioactivity, from weapons in particular (detection, radiation measurement, decontamination, taking of samples).

In parallel to these two teams, a technical advisor on nuclear intervention, who is a specialist on radiation protection and weapons safety, is sent to the site. He represents the CEA at the site of the incident (or the accident). This engineer is one of the eight sent by the director of DAM, four from the Bruyères-le-Châtel center, four from Valduc.

In case of an attack on a weapon, the weapons specialist engineers from le Cesta (center near Bordeaux responsible for the “militarization” of the nuclear warheads), may be summoned to direct the technical intervention.

In case of a radiation accident, it is possible to call a small radiation protection team from the nearest CEA center; thus assistance can be on the way in one or two hours. For this purpose, the CEA has divided France into ten first level intervention zones (Zipe) [“zones d’intervention de

premier échelon"]. In the case of an emergency response on the SNLEs at Ile Longue, a team from Cogéma at La Hague is responsible.

The measures put into effect by the various services of the DAM of the CEA in case of accident or incident are of two types: demarcation of the possibly contaminated zone, and means of communication.

The detection measures on the ground and the estimates of the areas of contamination and of the health effects of the fallout are done by the Radiation Protection Service of Bruyères-le-Châtel if the incident involves weapons, or by the technical crisis center of the Institute for Protection and Nuclear Safety (IPSN) of Fontenay-aux-Roses (CEA) if it involves submarine reactors. The demarcation of the zone is supposed to be done in less than two hours. To refine the measures, the Valduc center has designed a large-scale procedure called "Helinuc": it is a helicopter-borne gamma mapping system that can be activated within twelve hours. Depending on the results, the authorities could take measures necessary to protect public health and to restore the site, using the resources of the CEA, the armed forces, and possibly Civilian Protection.

As for contamination control, according to participants in a simulated accident response in the reactor building of Ile Longue (*see below*), the Office of Protection against Ionizing Radiation (OPRI) of le Vésinet and the Armed Forces Radiation Protection Service (at Clamart) send their specialized equipment for contamination control to the site of the accident.

Information and communication are essential for management of the crisis. Emergency communication equipment is put in place to broadcast the alert and to communicate between the site and the various crisis cells through the Ripault center. In case of a prolonged crisis, the Detection and Geophysics Laboratory (LDG) of Bruyères-le-Châtel is responsible for bringing in heavy communication equipment.

Local organization of nuclear intervention

The "Montségurnat 1999" exercise which occurred on Ile Longue, February 2, 1999, is a good illustration of the coordination between the Army-CEA technical response described above and the local assistance organization¹. The imaginary incident at the beginning of the exercise takes place in the reactor building of Ile Longue.

The first measures of this nuclear safety exercise are taken within the framework of the Internal

Emergency Plan (PUI), which sets up the crisis cell of the local coordinator, the commandant of the Ile Longue base. The intervention is organized in conformity with the Port Intervention Plan (PIP). The commandant of the Brest maritime district alerts the Finistère prefect who activates the Particular [or Specific] Intervention Plan (PPI). At the same time, the Armed Forces-CEA nuclear emergency response arrangement described above is activated.

The local civilian means by which the various administrations respond are organized by the Operational Prefectural Center (CPO), following the Particular Intervention Plan, and it is the prefect of Finistère who is responsible for informing governmental authorities and for requesting national assistance resources. In coordination with the maritime prefecture, the prefect provides information to the media and to the public.

Radioactivity incidents at Ile Longue

In November 1996, during operations in preparation for the installation of the new TN75s on the SNLE-NG *Le Triomphant*, incidents occurred in the buildings for assembly and maintenance of nuclear warheads, in the pyrotechnics section at Ile Longue. Radiological analyses showed that the radioactivity rate exceeded allowed norms, or more precisely, in the words of the CEA, that this rate "*slightly exceeded the dose limit for the general public*". The thirty or so technicians had to stop work, and before any resumption of activity "*a monitored radiation zone and a medical follow-up for concerned personnel were set up*"².

According to press reports, an employee of a DCN sub-contractor who had worked at Ile Longue from June 1996 to July 1997 developed acute leukemia. He worked regularly on board nuclear submarines just above the missile compartments. Social Security classified his illness as job-related in April 1998³.

In fact, the measures taken at Ile Longue have shown that the TN75s released more ionizing radiation than did the nuclear charges previously in service⁴. But what particularly bothered the pyrotechnics personnel of Ile Longue was the fact that the TN75s had been handled since 1994, for almost two years, without any special protection being recommended or anything communicated about the risks incurred⁵. The unions were perplexed at having to wait for two months after the first measurements were taken to find out the results.

1) *Cols bleus*, March 6, 1999, pp. 22-24.

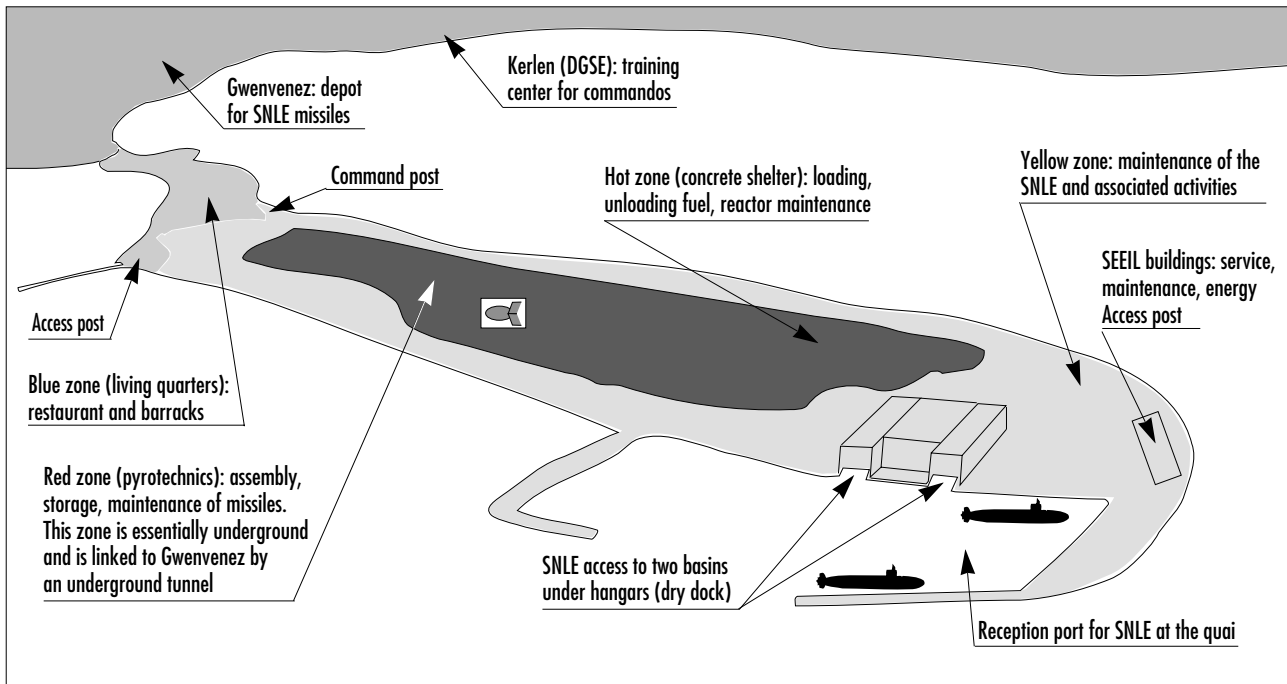
2) *Le Télégramme de Brest*, November 26, 1996.

3) *Charlie hebdo*, January 20, 1999.

4) *Libération*, November 26, 1996.

5) *Ouest France*, November 26, 1996.

DIAGRAM OF ILE LONGUE



No abnormality, according to the Navy

The naval authorities immediately minimized the facts: *"In any case, even if extra control measures are deemed necessary, it can be stated today that exposure in the immediate surroundings of the warheads will be only slightly above the norms allowed for the general public and will remain compatible with the rules for medical checks and follow-ups presently in effect for personnel on board the SNLEs"*. The Navy tries to be equally reassuring by stating that, during the course of two hundred patrols, there has been no abnormality on board a submarine attributable to the presence of nuclear weapons⁶.

Despite this way of presenting the facts, the military authorities have seen fit to transform the pyrotechnics shops of Ile Longue into controlled zones, to ensure obligatory training for the personnel, to classify them in category B thus entailing medical check-ups, to provide them with film and with bubble dosage meters that measure only neutron radiation. The Ministry of Defense may even have ordered measures for all nuclear weapons systems, including the dismantled Hades system⁷.

As for the origin of the neutron radiation, which is *"well below the maximum level allowed by work regulations"*, according to the Brest DCN communique, it is due to the *"different characteristics"* of the TN75 compared to warheads of the previous generation.

Nuclear safety in doubt

The fact that, despite the extremely precise security system in case of a nuclear accident or incident with a nuclear weapon or with a nuclear propulsion reactor, some "radiological incidents" have occurred on the very sites where submarine weapons are maintained, raises some questions. Some of these concern the adequacy of the "heavy" emergency response plan designed in case of a serious accident and that of the daily management of risks incurred during the maintenance operations on weapons or reactors. Others concern the security system planned for new types of nuclear warheads (the TN75s).

Overall, one notices that neither the armed forces-CEA nuclear emergency response system nor the local radiological surveillance system at Ile Longue have functioned to detect radioactive "abnormalities" in the immediate environment of the TN75s. After the discovery of these abnormalities, the Ile Longue authorities have had to institute preventive measures to improve the protection of the personnel maintaining the nuclear warheads or working near these weapons. It is not known if systematic radiological tests on persons maintaining nuclear warheads have been carried out, or if they have been, if the results have been published or at least communicated to these persons.

In the particular case of the TN75—the most "modern" of the nuclear warheads manufactured by the CEA—a few questions remain unanswered:

6) *Cols bleus*, November 30, 1996, p. 21.

7) Fédération nationale des travailleurs de l'État CGT (*National federation of state worker*), document dated February 26, 1997.

- Have the efforts of the CEA experts to improve the stealth and to lighten the TN75 been made to the detriment of, or without taking into account, the radiological protection of those who would have to handle it?
- Did the plutonium used for these TN75 contain a higher proportion of americium 241 (from the radioactive decay of plutonium 239), which is known to be much more radioactive than pure plutonium?
- Were the twenty nuclear tests effected for the completion of the TN75⁸ insufficient for taking into account the radiological security in the handling of these warheads? In other words, should these weapons have been approved?
- What measures have been taken to find remedies for the problems of this “neutron radiation” coming from the TN75? Have they reached all the way back to the parties responsible—the research departments—for what must be called a technological failure?

Up to now, there has been no answer—at least no public answer—to these questions: the military authorities are keeping completely silent on the consequences of the pyrotechnics incident at Ile Longue, although they did announce, in December 1996, that the risk assessment “will be validated before the first operational patrol” of the *Triumphant*⁹, which occurred March 29, 1997. As far as we know, no epidemiological or radiological report has been published since the *Triumphant* entered service.

What to do in case of an accident at sea?

After the tragedy of the *Kursk*, Deputy Rene Galy-Dejean, spokesperson for the nuclear deterrence budget, presented the means at France’s disposal in case of incident or accident on one of the missile-launching nuclear submarines, and more generally on all units of the French submarine fleet. We are quoting here the entire document, for it shows that this question of an accident at sea is not being evaded by the national Navy¹⁰.

“In case of damage on a submarine, the crew is trained to put into operation a certain number of procedures designed to prolong its chances of survival until the arrival of external help or even to permit it to evacuate the ship. These ship evacuation maneuvers presuppose possession of air-filled waterproof suits, which adjust continuously to the surrounding water pressure by means of valves.

The means of external response on an endangered submarine are of four types:

—The first type of maneuver is intended to maintain or to prolong to the maximum the oxygen supply. In a normally operating submarine, oxygen is produced by hydrolysis of water and carbonic gas absorbed by decarbonization equipment. In case of damage that jeopardizes these oxygen production processes, it is important to limit the proportion of carbonic gas with granules of lime with sodium spread on the flat surfaces of the ship and to produce oxygen with candles which free it by a chemical reaction. Moreover, there is a technique making it possible to pipe air into the damaged sub with an external rescue system at the surface;

—the diving bell represents the second escape tool for a crew in distress. Attached by a cable to a surface vessel and guided by divers, the bell is placed on a panel of the sub so as to be water-tight creating equal pressures in the sub and the rescue apparatus. Such a method implies that the damaged vessel is lying in such a way that the water-tightness can be achieved;

—a third means of rescue is the “pocket submarine.” Russia has two vessels of this type which work on the same principle as the diving bell but which are self-propelled, making them more maneuverable. The United States also has two small submersibles, the Deep Submergence Rescue Vehicle (DSRV), based in San Diego, which can be secured to the submarines and take on twenty-four people. Unlike the Russian vessels of the same type, they do not operate from a surface vessel that puts them in the water but rather from a carrier submarine. The United Kingdom also has a pocket sub, the LR5, manufactured by the Slingsby firm and utilized by the engineering firm Rumic. According to the latter, the LR5 is the only apparatus in the world capable of being connected, thanks to a circular airlock, to a submarine lying on its side. Ten meters long, this pocket sub can take on sixteen people;

—finally, the utilization of divers is the fourth rescue technique for a submarine in trouble.

France offered this kind of help to Russia at the time of the tragedy. Other countries, such as Italy, the United Kingdom, and Norway, for example, have developed expertise in this area. In the case of the latter two, the development of the offshore petroleum industry has impelled these countries to provide themselves with professional deep water divers. Indeed, these experts are responsible for maintenance of the oil platforms as well as for the placement and inspection of underwater pipelines. They are accustomed to dives to 200 meters of depth and more. Consequently, this technique requires time: in order to get used to living “in

8) Cf. *Audit atomique*, op. cit., p. 84.

9) *Libération*, December 3, 1996.

10) René Galy-Dejean, *Défense, Dissuasion nucléaire, Projet de loi de finances pour 2001*, op. cit., pp. 29-32.

saturation" at such a depth, the divers must spend several hours or a whole day in a compression chamber, a small enclosure in which they ingest gradually, in order to accustom themselves to them, the gases they will encounter under water. When they are ready, they are lowered, without leaving this environment, in sealed bells.

France has put in place a complete setup for her own fleet, based on three principles:

—to permit independent [self] rescue (down to 180 meters of depth). For this purpose, the crew undergoes regular special training and has specialized equipment;

—to prolong life on board. To this end, the vessels have refuge compartments with air, food, heat, and communication equipment. Moreover, there are ways to connect with the exterior (for depressurization and ventilation in particular). The French Navy has also set up external rescue systems, with either divers or various robots functioning according to agreement. The Navy has an agreement with Comex;

—to organize and carry out a collaborative rescue: in this case, an emergency mission within forty-eight hours by an American rescue sub (DSRV) is planned based on an agreement valid until 2005, at which time it will be replaced by a different system designed and developed by a group of European countries.

Joint exercises with the Americans, and several NATO exercises, have made it possible to test the materiel and procedures. Likewise, regular training for all submarine personnel is conducted at a specific center on Ile Longue.

In the present situation, these different means of intervention and training aim to make the best possible use of existing equipment. Planning for permanent adaptation of our means to the real needs is continuing. They are part of our overall

Submarine accidents

Submarine accidents (outside of wartime) are not as rare as one might think. The tragedy at Kursk reminds us that dramatic nuclear submarine accidents have occurred in the past not only in the Soviet¹ and American fleets, but also in our Navy. Let us recall the following accidents:

- **September 25, 1952**, the diesel submarine *Sibylle* sinks with all hands off Toulon, causing forty-six deaths;
- **January 27, 1968**, the diesel submarine *Minerve* sinks with all hands off Toulon, causing fifty-two deaths;
- **March 4, 1970**, the diesel submarine *Eurydice* sinks with all hands off Toulon, causing fifty-seven deaths;
- **February 2, 1971**, the SNLE *Le Redoutable* collides with a fishing boat off Brest;
- **August 17, 1993**, the nuclear-powered attack submarine (SNA) *Rubis*, collides with an oil tanker off Toulon;
- **March 2, 1994**, the SNA *Amethyste* runs aground off Cap-Ferrat as a result of faulty maneuvers;
- **March 30, 1994**, an explosion takes place on board the SNA *Emeraude* between Toulon and Corsica, causing ten deaths. ▲

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1) Lev Giltsov, Nicolai Mormoul, Leonid Ossipenko, *La dramatique histoire des sous-marins nucléaires soviétiques* [The Dramatic History of Soviet Nuclear Submarines], Robert Laffont, Paris, 1992.

policy of undersea emergency rescue, and are focused especially on optimal use of means and time of response as well as development of cooperation with other navies faced with the same risks." ▲

Nuclear Submarines and the Environment

The environmental impact of the activity of the SNLE-NGs must be considered during two principal stages: maintenance operations, notably of the nuclear reactors, but also of the nuclear warheads, and the normal operation of the submarine.

Work on the SNLEs, maintained on Ile Longue, is administered by a specific organization which is responsible for logistics and acts as an intermediary between the DCN at Brest and the Technicatome Company. The furnishing of materials and spare parts occurs on site, but the maintenance of nuclear components takes place at Cadarache (headquarters of Technicatome)¹

The maintenance of SNLE-NG reactors

The ports receiving nuclear-powered vessels are equipped with a set of ground installations composed of stationary and mobile shops, docks, basins, and floating docks and equipment². These facilities make it possible to effect maintenance and repair operations on the vessels and their nuclear installations, and to collect, stock, and treat liquid and gaseous effluents (components of the primary circuit), and solid wastes.

On Ile Longue, the "Reactor Shop", or "hot zone" is a concrete shelter between two basins where the SNLEs can be put in dry-dock. All operations on the nuclear power plant (as well as loading the missiles) are performed in this shop located in a military zone, while repairs of the hull and other parts of the submarine are carried out in Basin 10 of the Brest arsenal³. The reactor shop is closed by two huge armor-plated doors. It is here that the parts of the nuclear power plant are taken out, checked, and re-tested. The radioactive elements of the nuclear fuel can be stocked in a pool⁴.

The most important maintenance mechanism is a mobile shop providing the principal access (Atelier mobile d'intervention principale, or Amip)⁵. Once the submarine has descended into the basin, the Amip is put in place and forms a link, continuous or by an airlock, between the sub and

the nuclear workshop. It is then the obligatory passageway for the personnel and all radioactive material being moved in or out between the shop and the reactor enclosure. The Amip confinement area is reinforced by a continuous ventilation and filtration system. The operations of the Amip may be divided into two categories:

- operations on the reactors necessitating the opening of the reactor compartment without involving the fuel elements;
- programmed operations including the loading and unloading of fuel elements before and after overhauling, and in exceptional cases, operations following damage to a reactor component necessitating the removal of the core.

Like civilian nuclear installations, military nuclear installations are required to submit to the competent authorities a report on the environmental impact of possible pollutants inherent in the normal functioning of the installation or resulting from an incident or accident. However—and this is an important problem—this impact report from military nuclear installations is not made public and does not have to be sent to a Local Information Council.

However, impact studies and the environmental radiological follow-up of military nuclear installations in ports are done by the Environmental Study and Research Service (SERE), an internal organism of the CEA. As is often the case in the military nuclear area, the operators are being examined by themselves. Between 1957 and 1991, SERE carried out more than one hundred studies of sites, including the three large French military ports, Brest, Toulon, and Cherbourg. For example, in the summer of 1991, SERE did an update of a radio-ecological study of the Brest harbor in order to evaluate the environmental impact "of pollutants possibly resulting from the normal operation of support installations for the missile-launching nuclear submarine *Le Triomphant* and the nuclear aircraft carrier *Charles-de-Gaulle*"⁶.

1) Accès. *Le magazine des portes de l'Europe*, July 1993, p. 43.

2) Text reprinted in *La Technique moderne*, n° 5-6, 1991, pp. 7-9.

3) *Le Télégramme de Brest*, February 13-14, 1993.

4) *Info DGA*, n° 44, April 1992, pp. 10-11.

5) Pierre Martin, Michel Geeraert and Jean-Marie Quinault, « Installations nucléaires à terre. Compte-tenu de l'environnement », in *La Technique moderne*, n° 5-6, 1991, pp. 7-8.

6) *Journal Officiel*, Assemblée nationale, Questions et Réponses des ministres, September 2, 1991, p. 3518.

The operation of naval propulsion reactors

Types of wastes and discharges

The *Industrial, Scientific, and Technical Bulletin (BIST)*, an old bulletin produced by the CEA, examines the particular case of nuclear-propelled vessels concerning the wastes they can discharge and therefore produce. This bulletin indicates that “the two principal kinds of radioactive wastes that could be discharged by nuclear-propelled ships are composed of:

a) a weakly contaminated liquid coming from the primary coolant;

b) ion exchanging resins used to decontaminate the primary coolant.

The liquid would contain weak concentrations of active corrosion products, and much weaker concentrations of fission products. The ion exchanging resins would contain higher activities of the same elements”.

This article of the *BIST* (March 1963) is a good indication of the attitude that prevailed in “scientific” circles at the beginning of nuclear propulsion in the absence of any international regulation. It recommends that nuclear-powered vessels be equipped with reservoirs to collect effluent liquids when the vessel is in a zone where any discharge is impossible, but it does not exclude such discharges. Thus, we find this written: “In a zone extending from two to twelve miles from shore, the discharge of effluent liquids may be made provided it remain below what an evaluation for each area shows possible. But given that this is often a fishing zone, the discharge of solids will have to be prohibited...The rest of the continental shelf, when it extends more than twelve miles from shore, can absorb a certain amount of activity without causing danger on condition that the operation stay outside of fishing zones”⁸.

The first international regulations were established at the time of waste discharge operations in the Atlantic organized by the ENEA in 1967⁹, but they nonetheless admitted the principle of discharge at sea. So it is not unthinkable that liquid effluents from nuclear propulsion might have been discharged at sea by the first French SNLEs¹⁰. It appears, however, that stricter rules were applied very soon. Thus, two French specialists on naval nuclear reactor propulsion, J. de Ladonchamps and J.-J. Verdeau, write in 1972: “Radioactive liquid effluents and solids must not be discharged at sea. Only gaseous effluents, normally accumu-

lated in the water tank of the primary circuit or in the pressurizer, can be removed by a special ventilation circuit provided certain precautions are observed, depending on the position of the vessel at the time of the discharge and the wind direction. Therefore, it is necessary to have on board means of storing solid effluents, like resins and filter for example, and liquid effluents especially”¹¹.

Beginning in 1972, there was apparently greater concern particularly for the management of wastes from contamination of the primary circuit of naval propulsion reactors and for the danger of ruptures in the cladding covering the fuel elements of the reactor. In one of their books, J. de Ladonchamps and J.-J. Verdeau confirm this danger, since they write that contamination of the primary circuit would be due “to fission products emitted by the fuel in case of rupture of the cladding”, but also “to various products of corrosion activated by neutron bombardment when they cross through the core” (12).

As in the United States, it appears, however, that submarine fuel is manufactured with extreme care, much more so than for an ordinary water reactor in a power plant: so there are far fewer cladding breaks and consequently effluents that are less radioactive.

The treatment of ion exchanging resins

The principal wastes produced by the operation of naval propulsion reactors come from ion exchanging resins that are used for the decontamination of the primary coolant. The same ion exchanging resins are used to decontaminate the water in temporary fuel storage pools in installations at the military ports (Cherbourg, Toulon, Ile Longue).

The CEA (Cadarache center), then Technicatome since 1974, which are responsible for the maintenance of naval propulsion reactors, have used different ways of treating these resins. Generally, ion exchange resins are considered low or medium activity resins, and they are encased either in concrete, in bitumen, or in resins hardened by heat. In 1984, an installation for encasing ion exchange resins in heat-hardened resins (epoxy resins) was developed by Cadarache and Technicatome. This procedure “is intended for the conditioning of ion exchangers from the treatment of liquid wastes from reactors of the Navy”¹³. This encasing system was conceived by Technicatome at Cadarache: it is a mobile

7) « Le cas particulier des navires à propulsion nucléaire », *BIST*, March 1963, pp. 35-36.

8) *Idem*, p. 36.

9) See for the details of these operations, Bruno Barrillot and Mary Davis, *Les déchets nucléaires militaires français*, CDRPC, Lyon, 1994, pp. 185-188.

10) The first French SNLE, *Le Redoutable*, entered service December 1, 1971.

11) J. Lefèvre de Ladonchamps and J.-J. Verdeau, *Réacteurs nucléaires à eau pressurisée. Théorie, technologie et applications à la propulsion navale*, Masson, Paris, 1972, p. 158.

12) *Idem*, p. 153.

13) CEA, *Rapport annuel 1984*, p. 26.

installation called SETH 200 that treats wastes in 200 liter barrels¹⁴.

These naval propulsion waste treatment operations are performed in maintenance shops located in the military ports (Cherbourg, Toulon, and Ile Longue) and at the Cadarache center for prototype reactors. CEA's *Five Year "Effluents and Wastes" Plan* notes that several campaigns have been carried out by Technicatome to encase ion exchanging resins, notably those from the Navy, with the "nuclearized mobile installation SETH 200"¹⁵.

However, the CEA does note problems with the procedure of encasing by heat-hardened epoxy resins, which "have the disadvantage of being rather costly and delicate to handle (control of exothermic factors, recovery of water from encasements...)". The present inclination would be to replace the resin matrix by cement or by cement-resin matrix¹⁶.

The CEA documents consulted do not clearly indicate that the treated wastes will end up in epoxy resins. However, it is known that studies have been made of the characteristics of packages manufactured by the SETH 200 with a view to sending them to storage sites¹⁷ and that stocks of REI at the Cogéma (Marcoule) and La Hague sites should be at capacity in 1993¹⁸. It appears that these resins are now sent to Andra's Aube storage center, at Soullaines. That at least is what emerges from the Inventory of the Andra Observatory, which refers to a mere "buffer" stock of 0.7 liters of ion exchanging resins¹⁹.

Other wastes

Ground maintenance operations of naval propulsion reactors also produce other wastes related to handling (gloves, boots, protective clothing, oils, filters from the Principal Intervention Mobile Shop, or Amip...) as in all nuclear installations. By analogy with what is done in the civilian nuclear area, these low or medium activity wastes must be treated in sacks or barrels and sent to the Andra storage centers²⁰. Thus the work suits worn by the persons working in the "hot building" on Ile Longue are sorted according to their degree of contamination; the most contaminated ones are stored in barrels of wastes, the others are washed in the laundry.

According to information that we have received, some of the protective clothing is washed in the "reactor shops" of the three military ports. On Ile Longue, for example, in the reactor maintenance building there is a laundry where the protective clothing for work in the "hot zone" is cleaned. The cleaning is done by personnel from external companies who undergo the same radiological controls as "directly affected personnel" (civilian employees of the Brest arsenal working at Ile Longue base) but who are ill informed of the risks incurred²².

CEA's *Five Year "Effluents and Wastes" Plan* indicates that management of the laundry wastes is one of the concerns of Technicatome, which has developed "a new procedure based on the separation of solids by tangential filtration" applied successfully to laundry effluents of the Cadarache center²³. Probably this procedure is used also in the laundry shop on Ile Longue.

Destination of liquid effluents

We have found no public documentation on the destination of liquid effluents produced by marine propulsion reactor maintenance. These effluents are composed of water from the primary circuit after filtration by epoxy resins, water from the reactor shop pool where reactor fuels are temporarily stored when they are in the process of being renewed (on principle, this same water also is filtered by epoxy resins), and laundry water. It is notable that the Inventory of the Andra Observatory indicates no presence of liquid effluents on Ile Longue, but only "purification water filters"²⁴.

According to what we have been told, on Ile Longue in the 70's, there was a special tanker, called the *Minirem* by the personnel, that anchored alongside each SNLE that returned, in Basin 10, and recovered the contaminated water. The *Minirem* then went off to discharge this water off shore from the island of Ouessant. Presently, the *Minirem* is supposed to have been transferred to Toulon, and now two tanker trucks get the contaminated water, once a month, from the Ile Longue reactor shop. These trucks, one of which is empty (in case the full one has an accident?) leave Ile Longue under heavy police escort for a destination that no one has been able to identify with certainty²⁵. ▲

14) CEA, *Rapport annuel 1985*, p. 93.

15) CEA, *Plan quinquennal de R&D "Effluents et déchets" du CEA (1990-1994)*, March 1990, p. 107.

16) *Idem*, p. 70 and p. 107.

17) *Idem*, p. 120.

18) *Idem*, p. 123.

19) See Observatoire des armes nucléaires françaises, *Cahier n° 2*, March 2000, fiche VI, p. 21.

20) *Idem*.

21) Oral testimony received by the authors of the study.

22) Interview carried out at Brest by the authors of the study, April 28, 1993.

23) CEA, *Plan quinquennal...*, *op. cit.*, p. 78.

24) See Observatoire des armes nucléaires françaises, *Cahier n° 2*, March 2000, Fiche VI, p. 21.

25) Interview carried out at Brest by the authors of the study, April 28, 1993.

The New Generation Submarine Program and the Requirements of the Non-Proliferation Treaty

The last Review Conference of the Non-Proliferation Treaty was concluded in New York on May 19, 2000. The final text adopted by the participants in this conference announces *“the unequivocal commitment of the nuclear states to achieve the total elimination of their nuclear arsenals”*. Hereafter, the nuclear powers no longer link this commitment, as they did in Article VI of the NPT, to the utopian idea of *“general and complete disarmament”*.

The commitment of the nuclear states is far, however, from meeting the expectations of all those —citizens, NGOs, non-nuclear states— who desired the start of a program to eliminate nuclear weapons. In fact, no calendar for nuclear disarmament detailing the commitment of the five nuclear powers was set at the outcome of the New York conference.

We have the unfortunate experience of the non-application of Article VI of the NPT, which has [supposedly] been in force since 1970. This time, the nuclear states have their backs to the wall: they must go into action and no longer be content with eliminating their obsolete weapons while continuing to modernize their nuclear arsenals.

Moreover, this is the proposal made jointly by the Englishman David Martin, vice-president of the European Parliament, and the Frenchman Michel Rocard in an opinion piece published in the review *Politique étrangère*¹. The two statesmen judge that France and Great Britain are in the best position to take the initiative in nuclear disarmament. *“For the first time in their history”, they write, “the two countries have no identified enemy and intend to play an important role in international affairs [...] If the two countries announced jointly a plan of nuclear disarmament by stages, which they would be prepared to apply provided that the other states also commit themselves to it, their initiative would be supported immediately by the other members of the European Union, but also by numerous other countries (Japan in particular) and by public opinion throughout the world. If this plan is realistic, it could present advantages in the eyes of the other three countries officially equipped with [nuclear] weapons. It would then be difficult for*

India, Israel, and Pakistan to reject a plan accepted by the three large nuclear powers.”

Once again, we repeat that nuclear disarmament initiatives are not restricted to the good will of the two Great Powers. The traditional argument of official French circles— *“Let the big superpowers, the United States and Russia, begin first”*— is no longer valid.

France's first step toward the elimination of nuclear weapons

As we have noted, almost all of France's new generation submarine program has been carried out after her ratification of the Non-Proliferation Treaty, in direct conflict with the spirit of Article VI of this treaty. The commitment made by France on May 19, 2000 in New York must be realized by a series of measures that would demonstrate her will to eliminate nuclear weapons. Pending concerted measures with the four other nuclear powers, the following ones could be taken:

- cancellation of the order for the fourth new generation nuclear submarine;
- cancellation of the program for M51 missiles (which are supposed to be put in service on the fourth SNLE-NG);
- cancellation of the program of nuclear test simulations (especially of the Megajoule laser) planned for the perfection of the oceanic nuclear warhead (TNO), which is intended to arm the M51 missile.

Thus, the savings over twenty years would be about 82 billion francs! Part of the funds thus freed could be made available for study and research to begin a national program to eliminate nuclear weapons, to restore former nuclear materials test and production sites, to study a compensation plan for civilian and military personnel whose health has been affected by nuclear tests and production.

In this way, a real program for French nuclear disarmament could be submitted to a democratic debate both in public opinion and among the authorities of our institutional system: the parliament and the executive.

1) « La menace des armes nucléaires ne doit pas être éternelle », *Politique étrangère*, 1/2000, Spring 2000, pp. 213-223.

CANCELLED PROGRAMS	<i>MF</i>	<i>M€</i>
Cancellation of the fourth SNLE-NG	15,000	2,287
Cancellation of the program M51	42,000	6,403
Cancellation of the simulation program ¹	25,000	3,811
Total	82,000	12,501

1) Jean-Michel Boucheron, *Défense, Projet de loi de finances pour 2001*, op. cit., p. 132.

The first cancellation measures could be taken in preparing the future military budget bill.

This process begun by France would constitute a powerful international incitement to begin dis-

cussing a treaty to totally eliminate nuclear weapons, matched with a system of effective control.



Annex

The airborne ASMP-A missile program

Another program that further contradicts France's commitments under the Non-Proliferation Treaty is the modernization of the ASMP ("air-sol moyenne portée"=air to ground medium range) missiles, which equip the aircraft of three squadrons of Mirage 2000N of the air forces and some Super-Etendard of the naval air force. In total, ninety ASMP missiles have been built and eighty TN80/81 nuclear warheads have been assigned to these missiles.

As with the new generation submarine program, the three elements of this nuclear weapons system are going to be modernized or built: the carrier plane will be the Rafale, in a naval version and an air force version, the missile will be the ASMP-A (A for "*amélioré*"=improved), and a new model of nuclear warhead—the TNA or airborne nuclear warhead—will be adapted to the ASMP-A.

History of the ASMP-A

Beginning in 1988, contacts were made between British and French defense ministers to consider a common plan for an airborne missile. In April 1990, France made a proposal to Great Britain to develop jointly a long range air-to-ground missile (ASLP). Beginning in 1990, preliminary studies for the missile were made by the Aérospatiale Company¹.

At first, French experts considered the ASLP, whose range might vary from 140 to 1,300 kilometers depending on the configuration of the firing, as a pre-strategic device². The idea behind the development of this successor to the ASMP was to "*reinforce and enhance the value of the Rafale program*", which was presented as the successor to the Mirage IVP³. Subsequently, parliamentary reports refer to the ASLP program as the ASMP, capable of a double mission, one strategic and the other as final warning. On October 18, 1993, Britain announced that it was withdrawing from the ASLP program for economic reasons and for its lack of strategic suitability⁴.

After the British withdrawal, the services of the General Delegation for Armament set up a task force called MANS ("Missiles aéroportés nucléaires supersoniques"= supersonic airborne nuclear missiles) which made several proposals for the successor to the ASMP⁵:

- the "renovated" ASMP, with modernized electronics and of lighter weight, adaptable to the 2000N and

2000D Mirages, to the Super-Etendard, and even to the Rafale. This proposal is the least costly, but offers no improvement in the performance of the ASMP;

- the ASMP, which would be renovated with a range of around 500 kilometers and adaptable to the 2000N and 2000D Mirages and to the Rafale. This version could also be used with a conventional warhead. Its development is estimated at 5 billion francs;
- the ASLP, as envisaged in the joint Franco-British project would cost between 10 and 15 billion francs, a very large margin;
- the ASLP "Gigogne", equipped with a tank that is releasable in flight, but whose feasibility appears doubtful because it is compatible only with the Air Force Rafale and necessitates significant changes on the air bases.

Finally, in February 1996, the President of the Republic came out in favor of an "improved" ASMP, for which research had already been undertaken by Aérospatiale⁶.

The presidential choice was formalized in the military program budget bill for 1997-2002, which estimates that the cost of the "improved" ASMP will be two times less than that for the ASLP with a range twice that of the present ASMP⁷.

According to parliamentary reports, the "improved" ASMP (or ASMP-A) which will replace the ASMP after 2007 will be equipped with a new nuclear warhead, the "airborne nuclear warhead" (TNA), which will be designed by means of simulated nuclear tests⁸.

Cost of the "improved" ASMP

The development cost of this missile is estimated at 4.3 billion francs, and the 1997-2002 military program budget law committed 1,993 million francs, but production (after orders which should be made after 2002) is not included in this cost⁹ and will have to be added.

Funds already expended for this program are not clearly shown in the budget reports, in particular all that was assigned to "preliminary studies" before 1998 when the missile program was not yet well defined in its so-called "improved" formula.

Information on funds designated for the TNA which will equip the ASMP-A are very vague, especially

1) Aérospatiale, *Rapport annuel 1992*, p. 29.

2) Xavier de Villepin, *Rapport*, Sénat, n° 90, November 15, 1991, p. 82.

3) Xavier de Villepin, *Projet de loi de finances pour 1993*, Avis, Sénat, n° 59, November 24, 1992, p. 42.

4) Jacques Baumel, *Projet de loi de finances pour 1994*, Avis, Assemblée nationale, n° 583, October 7, 1993, pp. 31-32.

5) Jacques Baumel, *Projet de loi de finances pour 1996*, Avis, Assemblée nationale, n° 2273, October 12, 1995, pp. 40-42.

6) Aérospatiale, *Rapport annuel 1995*, p. 28.

7) Xavier de Villepin, *Rapport*, Sénat, n° 427, June 12, 1996, p. 105.

8) Jean Faure, *Projet de loi de finances pour 1997*, Avis, Sénat, n° 89, November 21, 1996, pp. 36-37 and René Galy-Dejean, *Projet de loi de finances pour 1998*, Avis, Assemblée nationale, n° 308, October 9, 1997, pp. 50-51.

9) *Idem*, p. 52.

FUNDS FOR THE ASMP-A PROGRAM ACCORDING TO 2001 BUDGET ¹ (IN MILLIONS OF FRANCS)					
	1997	1998	1999	2000	2001
Preliminary studies		41	80	52	20
Operation Vesta		190	200	193	148
ASMP-A Development		46	79	206	469
Total	340	277	469	451	637

1) Jean-Michel Boucheron, *Projet de loi de finances pour 2001, Rapport*, Assemblée nationale, n° 2624, annexe 40, November 6 2000, pp. 144-145.

FUNDS KNOWN TO BE DESIGNATED FOR TNA	2000		2001	
	MF	M€	MF	M€
TNA studies	334	51	314	48

because it is not known if part of the financing of the simulation program is designated for the perfection of the TNA. Nonetheless, payments funds known for the year 2001 and designated explicitly for the TNA amount to 314 million francs, a decrease of 6% compared to the year 2000¹⁰.

The future of the ASMP-A

The future of this successor to the ASMP seems assured, at least until the end of the 1997-2002 program budget. Plans for the next program budget for the ASMP-A are rather brief. In fact, the Ministry of Defense notes simply that *“the commitments made in the program legislation now in force remain valid for the continuation of the programs undertaken (SNLE, M51, ASMP-A, simulation) and for the portion earmarked for nuclear forces in the equipment funds of the Ministry of Defense”*¹¹. The Ministry even mentions the plan (the final target of the program) to build seventy-nine ASMP-A missiles and forty-seven warheads for the ASMP-A missile.

However, as early as 1998, there were signs of lack of unanimity in the support for the program. Thus in his report for the military equipment budget, the Deputy Jean-Michel Boucheron speaks of *“the hypothetical program for a stato-reactor strategic missile”*¹². On the other hand, the “program review” carried out by the Lionel Jospin government in April 1998 includes the ASMP-A in the *“principal unchanged programs”*.

Finally, presenting the improved ASMP missile in the budget for 2001, Jean-Michel Boucheron reiterates his doubts by referring to it as *“theoretically available”*¹³.

The ASMP-A program is the continuation of a preceding program which seems relevant only because France wanted to keep two components in its nuclear arsenal after having given up the ground component. This missile's range, that is the distance between its point of launch from the Rafale and its target, varies from 100 to 500 kilometers depending on whether it is fired from low altitude or high altitude. Thus it is one of what used to be called medium range missiles, or “pre-strategic” in French terminology. However, Russian-American agreements call for the withdrawal of this type of nuclear weapons. So, in 2000, the Americans had already withdrawn the major part of their non-strategic nuclear weapons from NATO bases. At that time, there remained only 150 American non-strategic nuclear warheads on ten bases of seven European countries¹⁴. This is why, moreover, the British decided not to modernize their airborne nuclear weapons and have abandoned that component of their arsenal.

France would do very well to cancel this ASMP-A program which has no strategic justification. Such a decision would permit joint planning with the United Kingdom with a view to the elimination of nuclear weapons as proposed by the French and British members of the European Parliament, Michel Rocard and David Martin. ▲

10) René Galy-Dejean, *Projet de loi de finances pour 2001, Avis*, Assemblée nationale, n° 2627, October 11, 2000, p. 44.

11) Ministère de la défense, *Document introductif aux choix de la prochaine loi de programmation militaire*, 2001, no dated.

12) Jean-Michel Boucheron, *Projet de loi de finances pour 1998, Rapport*, Assemblée nationale, n° 305, October 9, 1997, p. 96.

13) Jean-Michel Boucheron, *Projet de loi de finances pour 2001, op. cit.*, p. 144.

14) *The Bulletin of the Atomic Scientists*, May/June 2000, p. 71.

15) David Martin and Michel Rocard, « La menace des armes nucléaires ne doit pas être éternelle », *Politique étrangère*, 1/2000, Spring 2000, pp. 213-223.

The state of French nuclear forces as of September 1, 2001

CARRIERS	VECTORS	WARHEADS	POWER (MT)	RANGE (KM)
SNLE				
L'Indomptable	16 x M4B	96 (TN71)	14.4	4,000
L'Inflexible	16 x M45	96 (TN75)	9.6	<4,000
Le Triomphant-NG	16 x M45	96 (TN75)	9.6	<4,000
Le Téméraire-NG	(16 x M45)	96 (TN75)	9.6	<4,000
Le Vigilant-NG	(16 x M45)	96 (TN75)	9.6	
Le Terrible-NG	(16 x M51)			
	sous-total	288	33.6	
OTHER NUCLEAR WEAPONS				
3 escadrons Mirage 2000N	60 x ASMP	42 (TN81)	18	2,750
2 flottilles Super-Étendard	24 x ASMP	20 (TN81)	6	650
Total (in service)		350	57	

Missile launching nuclear submarines

SNLE *L'Inflexible*: return to service beginning of summer 1999.

It is to be adapted to the M45 (TN75) during the first quarter of 2001. Its withdrawal from service is scheduled for 2006-2008.

SNLE *L'Indomptable*: according to plans, the *Indomptable* should be withdrawn from service between the end of 2003 and mid-2004.

SNLE-NG *Le Triomphant*: in service since March 21, 1997.

SNLE-NG *Le Téméraire*: put into service at the end of 1999.

First operational voyage January 2000.

SNLE-NG *Le Vigilant*: to be put into service July 2004, coordinated with the retirement of *L'Indomptable*.

SNLE-NG *Le Terrible*: ordered July 28, 2000, to be put in service 2010. Will be equipped with the M51 missile.

With the commissioning of the second SNLE-NG *Le Téméraire*, France will have in service three SNLE-NG and therefore 288 nuclear warheads on them. After 2010, the first three SNLE-NG (*Le Triomphant*, *Le Téméraire*, and *Le Vigilant*) will be adapted, one after another, to the M51 missile.

M45 missile: this missile carries six TN75 nuclear warheads and weighs 35 tons. In May 2000, a second batch of M45s replaced a batch of M4s. In December 2003, a third batch of M45s will replace the last batch of M4s. As of this date then, the SNLEs in service (three SNLE-NGs and *L'Inflexible*) will have three batches of M45 missiles.

M51 missile: planned replacement for the M45, to be put into service in 2010 with the TN75, then in 2015 with the TNO (oceanic nuclear warhead). The weight of the M51 is 56 tons and its range may reach 6000 kilometers.

Thermonuclear warhead TN71 (six on each M4 missile): with a mass of 120 kg, it carries a thermonuclear charge of 150 kilotons. As of the beginning of 2001, there will remain in service only one batch of ninety-six TN71s equipping the remaining batch of sixteen M4 missiles of the first generation SNLEs. The TN71 will be dismantled beginning in 2003.

Thermonuclear warhead TN75 (six on each M45 missile): has less mass but more stealth than the TN71. The second batch of TN75s has been in service since May 2000, as has the second batch of M45s. The third batch of TN75 will be delivered in 2003, at which time the M4 missiles will be permanently retired.

M45 and TN 75: in 2001, the third batch of M45 missiles is being built at Aerospatiale (EADS) and the third batch of TN75s is being built at the CEA.

Airborne nuclear forces

Mirage 2000N: the three squadrons went from forty-five to sixty planes in 1996. It is probable that the eighteen ASMP [medium range air-to-ground missiles] assigned to the Mirage IVPs have been assigned to the sixty Mirage 2000N attached to the strategic air

force since September 1, 1991. During the year 2000, twenty-nine Mirage 2000Ns have been adapted to a conventional air-to-ground attack capacity, giving them a dual capacity (nuclear and conventional). The three squadrons of Mirage 2000Ns operate from five weapons depots.

The ASMP-A [A for "amélioré"="improved"] missile will be adapted to the Mirage 2000N beginning late 2007.

The Super-Étendard/ASMP: at the end of 2000, these were being adapted on the *Charles-de-Gaulle*; the ASMP will expire in 2007.

The naval Rafale: entry into service on the aircraft carrier *Charles-de-Gaulle* planned for 2008, with the "improved" ASMP, which will be "theoretically" available in 2008 with the TNA (airborne nuclear warhead).

ASMP-A ("improved") missile: according to the final "target", seventy-nine of these missiles should be built.

TNA: airborne nuclear warhead intended to equip the ASMP-A missile. According to the final "target" of the program, forty-seven TNA should be built (classified information).

Refueling planes of the strategic air forces: eleven C-135 FR and three KC 135.

Planned improvements of the French nuclear arsenal

Beginning in 1996: program of simulated nuclear tests.

First quarter 2001: a third batch of M45 missiles to be put into service on *L'Inflexible*.

2003: delivery of the third batch of TN75 nuclear warheads.

July 2004: the third SNLE-NG, *Le Vigilant*, to be put into service.

Late 2007 and 2008: ASMP-A airborne missiles to be put into service (on the Mirage 2000N, and then on the Rafale; TNA nuclear warheads to be put on the ASMP-A missiles).

2010: *Le Terrible*, the fourth SNLE-NG, to be put into service, as will the M51 missiles.

2015: the TNO nuclear warhead to be put on the M51 missile.

Withdrawals from service and dismantling

Missiles of the Albion Plateau: nuclear dismantling completed February 25, 1998.

Hades: dismantling completed in March 1998.

Mirage IVP: disarmed in July 1996.

Le Redoutable: withdrawn from service in 1991.

Le Terrible: withdrawn from service in 1996.

Le Foudroyant: withdrawn from service beginning mid-December 1997.

Le Tonnant: withdrawn from service in December 21, 1999.

L'Indomptable: to be retired between the end of 2003 and mid-2004.

L'Inflexible: withdrawn from service in July 2006.

State of other nuclear forces

AMERICAN NUCLEAR FORCES

As of Jan. 1, 2001

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
SNLE			
8 Trident I C-4	192	1,536 (W76)	154
10 Trident II D-5	240	1,920 (W76 ou W88)	336
<i>Sous-total</i>	432	3,456	490
STRATEGIC MISSILES			
Minutemann III	500	1,500 (W62 ou W78)	404
MX Peacekeeper	50	500 (W87)	150
<i>Sous-total</i>	550	2,000	554
BOMBERS			
9 B-2 Spirit	21		
44 B-52H Stratofortress	94		
<i>Sub-total</i>	115	1,750	820
General total	1,097	7,206	1,850
NON-STRATEGIC FORCES			
Missiles Tomahawk	325	320	variable
Bombardiers		1,350	variable

BRITISH NUCLEAR FORCES

As of Jan. 1, 2000

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
SNLE			
4 HMS Vanguard	64 Trident II	192 têtes	19.2

CHINESE NUCLEAR FORCES

As of Jan. 1, 1999

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
SNLE			
1 Julang-1	12	12	2.4/3,6
BOMBERS			
H-6	120	120	
Q-5	30	30	
MISSILES			
DF- 3A	40	40	
4	20	20	
5A	20	20	
21A	48	48	
Short Range Missiles		120	
General total	290	290	

RUSSIAN NUCLEAR FORCES

As of April 1, 2000

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
SNLE			
11 SS-N-18 <i>Stingray</i>	176	528	264
3 SS-N-20 <i>Sturgeon</i>	60	600	120
7 SS-N-23 <i>Skiff</i>	112	448	45
<i>Sub-total</i>	348	1,576	429
STRATEGIC MISSILES			
SS-18 Satan	180	1,800	990
SS-19 Stiletto	150	900	675
SS-24 Scalpel	36/10	460	253
SS-25 Sickle	360	360	198
SS-27 Sickle-M	20	20	11
<i>Sub-total</i>	756	3,540	2,127
BOMBERS			
Tu-95 MS6 Bear H6	29	174	?
Tu-95 MS16 Bear H16	35	544	?
Tu-160 Blackjack	6	72	?
<i>Sub-total</i>	69	790	?
General total	1,173	5,906	~ 2,556
Non-strategic forces			
Ground-to-air missiles	1,200	1,200	
Air defense	400	3,500	
Naval	?	3,400	
Total		~ 8,100	

ISRAELI NUCLEAR FORCES

in 2000

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
Ballistic missiles (medium range) Double capacity planes	about 100		

INDIAN NUCLEAR FORCES

in 2000

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
Ballistic missiles (short range)		a few tens	

PAKISTANI NUCLEAR FORCES

in 2000

WEAPONS/CARRIERS	VECTORS	WARHEADS	POWER (MT)
Ballistic missiles (short range)		a few tens	

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France and Nuclear Proliferation

The spread of nuclear weapons is a terrible risk for the future of peace. In order to put a halt to this dangerous drift, most nations of the world have committed themselves to the nuclear non-proliferation treaty. But this international agreement is unbalanced: on one hand, it authorizes the five permanent members of the Security Council to keep their arsenals, and on the other, it forbids other nations from entering the club of the nuclear powers.

So the nuclear powers have arrogated unto themselves the right to pursue modernization of their arsenals. Ten years after the end of the cold war, France is pursuing her program of so-called "new generation" nuclear submarines as well as new missiles and new nuclear warheads. She thus puts herself in the position of the poor pupil of proliferation.

Echoing proposals made by numerous individuals, this book puts envisions the prospect of France taking the first step toward the phased elimination of a nuclear arsenal with no remaining declared enemy.

Observatoire des armes nucléaires françaises

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