



# Assuring destruction forever: 2015 EDITION

REACHING CRITICAL WILL OF THE  
WOMEN'S INTERNATIONAL LEAGUE FOR  
**PEACE & FREEDOM**

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Edited by Ray Acheson

Research and writing by John Ainslie, Merav Datan, Hans Kristensen, Greg Mello, Zia Mian, Pavel Podvig, M.V. Ramana, Trish Williams-Mello, Hui Zhang

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Fly Moskito

# France

Hans M. Kristensen

France spends about a third of its defence budget on nuclear forces. Like all of the other nuclear-armed states, France is in the middle of a broad modernisation of its nuclear forces involving submarines, aircraft, missiles, warheads, and production facilities. And studies of next-generation weapon systems have begun.

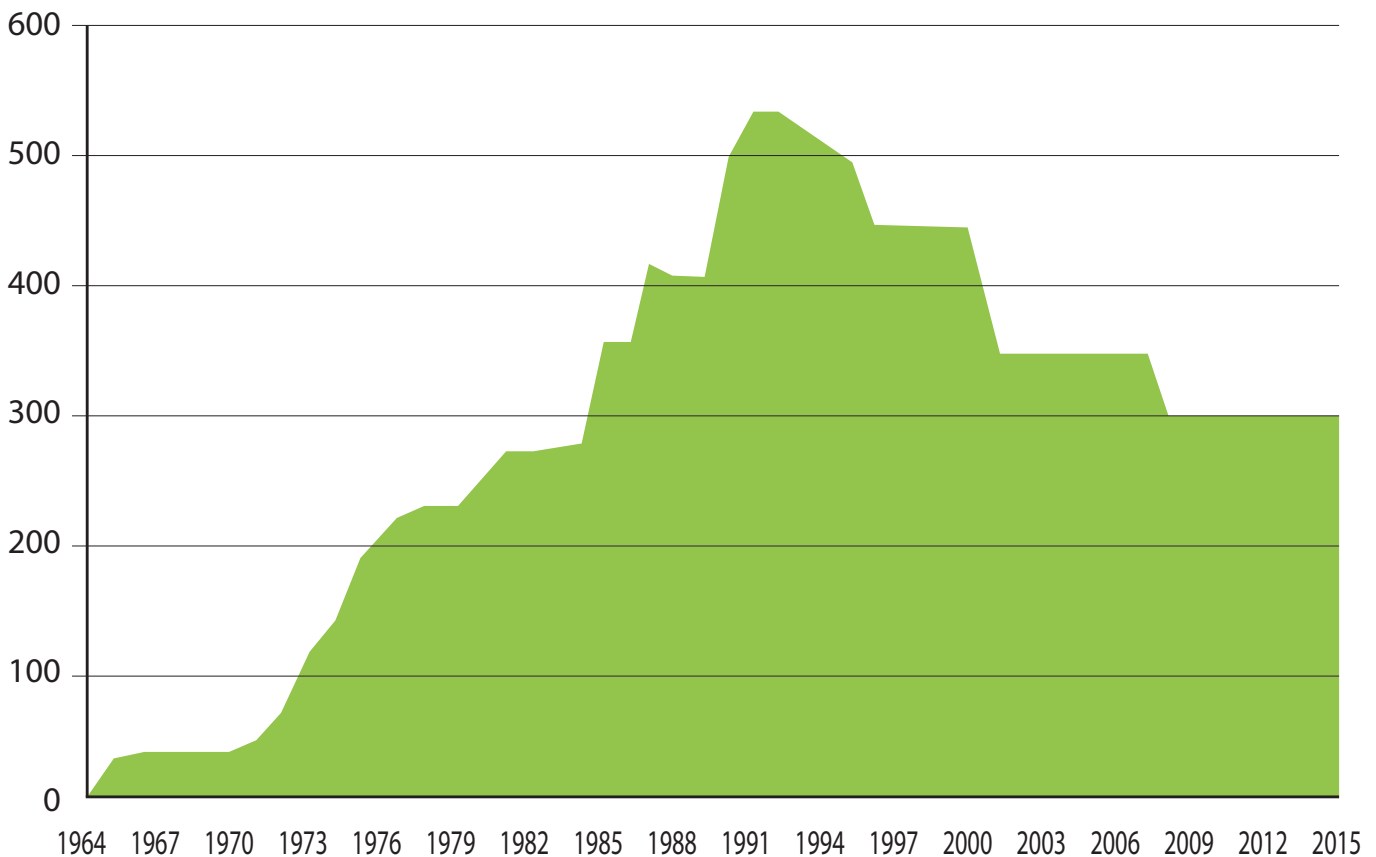
Having reducing its air-delivered nuclear forces by one-third in 2008, France does not appear to have plans to reduce its nuclear forces for the foreseeable future. The Hollande government has rejected further cuts and reaffirmed the existing nuclear posture. The absence of plans or negotiations for further reductions are, especially when considered in context with its substantial nuclear modernisation, in conflict with France's obligations under the nuclear Non-Proliferation Treaty to pursue additional reductions of nuclear weapons.

## Status of French nuclear forces

As of early 2015, France possessed a stockpile of an estimated 300 nuclear warheads. Nearly all of these warheads are deployed or operationally available for deployment on short notice. A small number of additional warheads are in maintenance or awaiting dismantlement.

The current forces level is the result of recent adjustments made to the posture following former President Nicolas Sarkozy's announcement on 21 March 2008, that the "arsenal" would be reduced to "fewer than 300 warheads" by cutting one of three nuclear bomber squadrons.<sup>1</sup> This posture was reaffirmed by President François Hollande on 25 February 2015, when he declared that France has a stockpile of 300 warheads for "three sets of 16 submarine-based missiles and 54 ASMPA delivery systems."<sup>2</sup>

The 300-warhead stockpile is, Sarkozy declared in 2008, "half of the maximum number of warheads we had during the Cold War."<sup>3</sup> The peak occurred in 1991-1992 at end of the Cold War, and the size of today's stockpile is about the same as in 1984 (see Figure 1), although the composition is significantly different.



The roughly 300 nuclear warheads in the current French nuclear weapons stockpile correspond to about half of the peak stockpile size at the end of the Cold War, and about equal to the stockpile size in 1984.

## Delivery systems

France's nuclear posture is based on two types of delivery vehicles: aircraft and ballistic missiles (see Table 1). The aircraft exist in two forms: land- and sea-based fighter-bomber jets.

DELIVERY VEHICLE	NO. OPERATIONAL	YEAR DEPLOYED <sup>a</sup>	RANGE (KILOMETERS) <sup>b</sup>	WARHEAD X YIELD (KILOTONS)	WARHEADS
<b>LAND-BASED AIRCRAFT</b>					
Mirage 2000 NK3 /ASMPA	20	1988/2009	2,750	1 TNA X Variable to 300	20
Rafale F3/ASMPA	20	2008/2010	2,000	1 TNA X Variable to 300	20
<b>CARRIER-BASED AIRCRAFT</b>					
Rafale F3/ASMPA	10	2010/2011	2,000	1 TNA X Variable to 300	10
<b>SLBM<sup>c</sup></b>					
M45	16	1997	>5,000	up to 6 TN75 x100 <sup>d</sup>	80
M51.1	32	2010	>6,000	up to 6 TN75 x100 <sup>e</sup>	160
M51.2	n.a.	2016	>6,000+	up to 6 TN75 x150	n.a.
M51.3	n.a.	(2020)	?	?	n.a.
<b>TOTAL</b>	<b>98</b>				<b>~300</b>

a For aircraft, the first number is for the aircraft, the second is for when the ASMPA first became operational with that aircraft.

b For aircraft the number listed is maximum range without refueling. Combat range is shorter but is extended by air refueling from tanker aircraft. The maximum range of the ASMPA is 500 kilometers. For SLBM ranges, see: French Navy, "Missiles balistiques stratégiques (MSBS)," updated 11 March 2015, <http://www.defense.gouv.fr/marine/decouverte/equipements-moyens-materiel-militaire/missiles/missiles-balistiques-strategiques-msbs>

c Three sets of missiles are available for three of four SSBNs in the operational cycle.

d Compared with its predecessor, the M4, the M45 carries "higher-performance TN75 nuclear warheads (stealthier RV and penetration aids)."

e The M51.1, which first became operational on the Terrible in late-2010, has "significantly greater range and payload capacity, as well as greater accuracy" than the M45. Payloads on individual missiles may vary significantly depending on mission.

### Land-based aircraft

The land-based aircraft are organized under the Strategic Air Forces (Forces Aériennes Stratégiques, or FAS), which operates two nuclear-capable fighter-bombers in two squadrons: the Mirage 2000N K3 with the 2/4 "La Fayette" squadron at Istres Air Base in southern France, and the Rafale F3 with the 1/91 "Gascogne" squadron at Saint Dizier Air Base about 190 km east of Paris. Approximately 40 aircraft (20 of each type) are thought to be assigned a total of 40 ASMPA cruise missiles.

The Mirage 2000N K3, which first entered operations in 1988, carries two pilots and has an unrefueled combat range of approximately 1480 km. The standard nuclear

strike configuration is with the ASMPA on the centerline pylon and two 1700-liter fuel tanks under the wings. The remaining Mirage 2000Ns at Istres will be replaced by the Rafale in 2018.

The two-seater Rafale F3 nuclear version, which first entered service in 2009 at Saint Dizier airbase, has an unrefueled combat range 1850 km. As with the Mirage 2000N, the standard nuclear strike configuration for the Rafale F3 is with the ASMPA on the centerline pylon and two fuel tanks under the wings. Initially projected at 294 aircraft (232 for the Air Force and 60 for the Navy), the Rafale programme has been scaled back significantly to 132 aircraft for the Air Force (and 48 Ms for the Navy).

France operates a fleet of 14 Boeing-produced C-135FR tankers to refuel its nuclear strike aircraft. The tankers are organized under the 0/93 Bretagne squadron at Istres airbase. The C-135FR is being replaced with 12 new Phénix (Airbus 330) tankers, the first two in 2018.

The ASMPA is a nuclear enhanced medium-range air-to-ground missile with a ramjet engine and a maximum range of 500 km. The missile carries the new TNA warhead with an estimated maximum yield of 300 kilotons, although lower yield options are thought to be available. MBDA Missile Systems states that the TNA is a “medium energy thermonuclear charge, a concept validated during the last nuclear testing campaign [in 1995-1996]. Simulators have proven its effective operation.”<sup>6</sup> Although validated by live nuclear tests, the French Ministry of Defence states that the TNA is the only nuclear warhead that has been designed and certified by simulation rather than nuclear tests.<sup>7</sup>

Following initial design development in 1997, the ASMPA production contract was awarded in 2000 to Aerospatiale Matra Missiles at a value of more than five billion French Francs (\$1 billion).<sup>8</sup> Aerospatiale Matra Missiles later merged with other companies to form the MDBA, the current producer of ASMPA. The 2015 budget includes 26.6 million (\$29 million) for maintaining ASMPA reliability.

The ASMPA first became operational on 1 October 2009, on the Mirage 2000Ns of the 3/4 “Limousin” Fighter Squadron (since re-designated as the 2/4 “La Fayette” squadron) at Istres airbase in southern France. The ASMPA was declared operational on the Rafale F3s of the 1/91 “Gascogne” Fighter Squadron during a ceremony at Saint-Dizier airbase (Air Base 113) on 1 July 2010. Production and delivery of the ASMPA and its TNA warhead was completed in 2011. The warheads for the ASMPAs are thought to be stored at the two bases as well as the Avord Air Base 200 km south of Paris.

Following the announcement by President Sarkozy in 2008 that the air-based nuclear posture would be reduced by one-third, the Strategic Air Force has been significantly reorganised in recent years. Of the three nuclear fighter-bomber squadrons that existed in 2008, two have been disbanded, one transferred, and an earlier disbanded squadron has been re-established at a new location. Of the two squadrons previously based at Luxeuil airbase, one (1/4 Dauphine) was disbanded in 2010 and the other (2/4 La Fayette) was moved to Istres airbase where it replaced the 3/4 Limousin squadron in 2011. Two squadrons now remain: the 2/4 “La Fayette” squadron at Istres airbase near Marseille and the 1/91 “Gascogne” squadron at Saint Dizier airbase east of Paris (see Table 2).

Although the ASMPA became operational in 2009, France has already started design development of a next-generation air-launched nuclear cruise missile. The new missile will have increased range and stealth features.

Along with reorganization and modernisation of the aircraft and their weapons, the nuclear custodial units have also been reorganized. The nuclear weapons custodial unit at Istres has been converted to ASMPA, and the nuclear weapons unit at Luxeuil has been disbanded. The nuclear weapons custodial unit at Saint Dizier that previously provided ASMP support to one of the two nuclear squadrons that used to be at Luxeuil, has now been converted to ASMPA to support the new 1/91 Gascogne squadron at Saint Dizier.

The airbase at Avord (BA 702) continues to provide nuclear support to the fighter squadrons. The base has a nuclear weapons storage area managed by a nuclear weapons custodial unit and recently converted to the new ASMPA missile.

Due to the relatively short range of the Mirage 2000N and Rafale aircraft, France’s air-base nuclear weapons depend on refueling aircraft. The current tanker fleet, the

BASE	2008	2015
Avord (BA 702)	14.004 DAMS	91.532 DAMS
Istres (BA 125)	3/4 Limousin Sq Mirage 2000N K3/ASMP 11.004 DAMS	2/4 La Fayette Sq Mirage 2000N K3/ASMPA 11.004 DAMS
Luxeuil (BA 116)	1/4 Dauphine Sq Mirage 2000N K3/ASMP 2/4 La Fayette Sq Mirage 2000N K3/ASMP 13.004 DAMS	No nuclear units but might serve as dispersal base
Saint Dizier (BA 113)	18.004 DAMS*	1/91 Gascogne Sq Rafale F3/ASMPA 18.004 DAMS
Key: ASMP = Air-Sol Moyenne Portee; ASMPA = Air-Sol Moyenne Portee Amélioré; BA – Base Aériennes; DAMS = Dépôt Atelier de Munitions Spéciales (special weapons depot); Sq = Squadron.		



Photo: Flickr/Todd Lappin

US-supplied KC-135, is based at Istres airbase, one of the two nuclear airbases. Under current plans, the KC-135 will be replaced with the multi-role Airbus 330 tanker-transport, known as A330 MRTT Phoenix. A total of 12 A330s have been ordered at a cost of Euro 3 billion (\$3.3 billion) with first delivery in 2018.<sup>9</sup>

### *Sea-based aircraft*

The aircraft carrier Charles de Gaulle (R91) is equipped to carry ASMPA cruise missiles for delivery by Rafale MF3 fighter-bombers organized under the 12F squadron. This mission was previously performed by the Super Étandard, but the Rafale MF3 is taking over this mission and the Super Étandard is scheduled to be retired in 2016. The first of 10 Rafale F3s was delivered in 2014 and the last will be delivered in 2017 at a cost of 240 million (\$261.9 million).

When not deployed on the carrier, the air wing is based at Landivisau in northern France. When deployed, the Charles de Gaulle does not carry nuclear weapons under normal circumstances. Its complement of ASMPA missiles is probably stored at one of the air bases, probably Istres airbase.

Management of the ASMPA cruise missile for the Rafale MF3 on the Charles de Gaulle carrier is supported by the centre d'expérimentations pratiques et de réception de l'aéronautique navale (the center for practical experiments and integration of naval aviation, CEPA/10S) at Istres airbase (AB 125).

According to the French Navy, the Nuclear Naval-Air Force (FANU) based on the carrier is "[l]ess powerful" than the nuclear submarines "but more conspicuous" and "boasts great flexibility in terms of positioning and in demonstrating the power of the aircraft carrier."<sup>10</sup>

Suggestions in 2013 that the carrier-based nuclear capability be retired<sup>11</sup> were rejected by the Hollande government, which decided to retain the force.<sup>12</sup>

### *Sea-launched ballistic missile submarines*

France operates four Triomphant-class nuclear-powered ballistic missile submarines (SSBNs) equipped with nuclear-armed long-range ballistic missiles (SLBMs). The fleet, which is known as the FOST (La Force Océanique Stratégique), is based at the Ile Longue peninsula near Brest. Of the four SSBNs, at least two are always fully operational, one of them at sea on "deterrent patrol". A patrol reportedly lasts about 10 weeks.<sup>13</sup>

Ballistic missiles for non-deployed submarines or stored onboard the submarine at the Ile Longue base or in unique silos at the base. The warheads, if not loaded on the missiles, are at the weapons storage facility near Saint-Jean approximately four kilometers south of the Ile Longue.

The French SSBN force is in the middle of an upgrade from the M45 to the M51 missile. Currently, one of the four SSBNs is equipped to carry the M45, two carry the M51, and one is undergoing conversion to the M51.

The M45 entered service in 1997, has a range of more than 4000 km and can carry up to six TN75 thermonuclear warheads. The TN75 was proof tested during France's final nuclear test series at Mururoa in 1995–1996.

The current version of the M51 is known as M51.1. It first became operational on Le Terrible in late-2010. The production contract was awarded to EADS Astrium SPACE Transportation in 2004 at a price of Euro 3 billion (\$3 billion).<sup>14</sup> The 2015 budget includes Euro 610.9 million (\$666.6 million) to maintain and modify the M51, and another Euro 190.9 million (\$208.3 million) to adapt the M51 for the next-generation SSBN.<sup>15</sup>

The M51.1 carries the same warhead (TN75) as the M45, but the M51.1 reportedly has "significantly greater range and payload capacity, as well as greater accuracy."<sup>16</sup> Increasing the payload makes little sense today so the M51 probably carries the same number of warheads as its predecessor, or less, to maximize countermeasures and range.<sup>17</sup>

SSBN	2015	2018	2020
Le Triomphant (S 616)	M51.1/TN75	M51.2/TNO	M51.2/TNO
Le Téméraire (S 617)	M45/TN75	M51.2/TNO	M51.2/TNO
Le Vigilant (S 618)	M51.1/TN75	M51.1/TN75	M51.2/TNO
Le Terrible (S 619)	M51.1/TN75*	M51.1/TN75	M51.3/TNO?

Note: Only three sets of missiles and warheads are produced. The fourth SSBN will be in overhaul at any given time.

\* The Terrible became operational with the M51 SLBM in December 2010.

Conversion of the remaining three SSBNs to the M51 has happened during their normal maintenance and refueling cycles. Conversion of the final boat (Téméraire) is planned for completion in 2018.<sup>18</sup>

From 2016, the modified M51.2 will be introduced on the Triomphant, which will carry a new warhead known as the TNO (Tête Nucléaire Océanique).<sup>19</sup> The development contract was awarded to EADS Astrium Space Transportation in the third quarter of 2010. Work on a third version of the M51, known as M51.3, began in 2014 and is scheduled for deployment around 2020, possibly on the Terrible.

Operation of the SSBN force reportedly costs more than \$2 billion (Euro 1.5 billion) per year,<sup>20</sup> and a French audit report in 2010 found that the unit cost of the SSBNs had increased by more than 50 percent.<sup>21</sup>

Although not nuclear-armed themselves, Rubin-class nuclear-powered attack submarines play an important part in the nuclear mission by providing protection to SSBNs deploying on patrol.<sup>22</sup> The Rubin-class will be replaced in this mission by the Barracuda-class starting in 2018.

## Fissile materials

France is no longer thought to be producing fissile materials for nuclear weapons. Large quantities produced during the Cold War are more than sufficient for the current warhead level. Plutonium production at the Marcoule facility ceased in 1992 with an estimated six tons remaining. HEU production ended in 1996 with an estimated 26 tons remaining, and the HEU production plant at Pierrelatte has been dismantled.<sup>23</sup>

## The nuclear weapons complex

France's nuclear weapons complex is managed by the DAM (Direction des Applications Militaires), a department within the Nuclear Energy Commission (Le Commissariat à l'Énergie Atomique et aux Énergies Renouvelables, CEA). DAM is responsible for research, design, manufacture, operational maintenance, and dismantlement of nuclear warheads. Of CEA's 15,000 employees, more than 4,700 are working for the DAM. In 2010, the DAM received Euro 1.7 billion (\$1.9 billion) of the Euro 4.2 billion allocated to CEA. Following the decision to end nuclear testing in 1996, France has reorganized its nuclear weapons centers. Today, DAM operates six sites (see Table 4).

NAME OF FACILITY	LOCATION (COORDINATES)	ROLE
Centre d'Études de Valduc (CEA Valduc)	Burgundy (47°34'37.02"N, 4°52'6.79"E)	Warhead production and dismantlement. Hydrodynamic test center added from 2014.
DAM-Ile-de-France (CEA Bruyères-le-Châtel)	Ile-de-France (48°35'40.53"N, 2°12'0.30"E)	Warhead design research and computer simulation.
Centre d'Études de Ripault (CEA Ripault)	Centre (47°17'26.05"N, 0°40'13.66"E)	Research and production of non-nuclear components, including high explosives.
Centre d'Études Scientifiques et Techniques d'Aquitaine (CESTA)	Aquitaine (44°38'46.70"N, 0°47'42.20"W)	Design of equipment for nuclear weapons, reentry vehicles, and coordinates the development of nuclear warheads. The site is the location of the Mejoule facility designed to study the fusion process of secondaries.
Centre d'Études de Vaujour-Moronvilliers (CEA Moronvilliers)	Champagne-Ardenne (49°14'5.32"N, 4°19'16.88"E)	Airix x-ray machine used to study hydrodynamic behavior of pre-fission implosion of primary. Airix being moved to Valduc.
Centre d'études de Gramat (CEA Gramat)	Midi-Pyrénées (44°44'23.44"N, 1°44'3.05"E)	National center for studying vulnerability of nuclear weapons systems to nuclear effects.

Warhead design and simulation of nuclear warheads take place at the DAM-Ile-de-France (Bruyères-le-Châtel) Centre approximately 30 kilometers south of Paris. The centre houses Tera 100, a super computer that went into operation in July 2010. The previous generation super computer, Tera 10, is also located at the centre, which employs about half of the people affiliated with the military section (DAM) of the CEA.

The Valduc Center (Centre d'Études de Valduc, or CEA Valduc) is responsible for nuclear warhead production, maintenance, and dismantlement. It is located approximately 30 kilometers northwest of Dijon and is undergoing expansion to accommodate new facilities resulting from the 2010 French-British defence treaty. The AIRIX x-ray radiography facility is being moved to Valduc from the Moronvilliers center to become operational in 2014. A second radiography facility will be added by 2019, and a third by 2022 to form the Epure facility.

The CESTA (Centre d'Études Scientifiques et Techniques d'Aquitaine) near Le Barp is responsible for the design of equipment for nuclear weapons, reentry, and coordinates the development of nuclear warheads. The site is also the location of the new Megajoule laser, France's equivalent of the US National Ignition Facility. Construction of Megajoule, which will study the thermonuclear process in warhead secondaries, began in 2005 and was scheduled for completion in 2014. A smaller Laser Integration Line (LIL) laser has been operating at CESTA since 2002 to validate the Megajoule design. The Megajoule reportedly costs Euro 3.5 billion (\$3.8 billion).<sup>24</sup> CESTA was established in 1965 and employs 970 people.

The Vaujour-Moronvilliers Centre 60 kilometers east of Reims includes the Airix x-ray pulse machine established in 2000 to study the pre-fission hydrodynamic behavior of imploding high explosives in a nuclear warhead primary. The results are used to validate warhead simulation computer codes. Airix was scheduled to be re-established at Valduc in 2014.

The Gramat Centre (Centre d'études de Gramat) is responsible for hardening nuclear weapons against radiation. The centre was transferred to the CEA in 2010.

Combined, warhead simulation costs account for approximately Euro 505 million (\$551 million) in the 2015 budget.<sup>25</sup>

## Naval nuclear propulsion

In addition to nuclear weapons production, France spends considerable resources on building nuclear propulsion for naval vessels that carry the nuclear weapons. France currently has 11 nuclear-powered naval vessels in operation: four Triumphant-class ballistic missile submarines, six Rubis-class attack submarines, and one

Charles de Gaulle-class aircraft carrier. Although nuclear-powered attack submarines are not nuclear-armed, they play an important role in the nuclear posture by protecting SSBNs on patrol. Construction of a replacement for the Rubin-class is underway, known as the Barracuda-class, at a price of more than Euro 8.6 billion (\$9.4 billion) for six boats, with the first unit expected in 2017.<sup>26</sup>

Construction of nuclear-powered vessels happens at the naval shipyard in Cherbourg on the English Channel. Development and testing of the nuclear reactors takes place at CEA Cadarache center north of Toulon. Production of the reactors happens near Nantes at the naval propulsion factory of DCNS (Direction des Constructions Navales), the manager of the naval shipyard at Cherbourg. Refueling of the nuclear-powered vessels takes place at the naval shipyard in Toulon. The fuel-life of French naval reactor cores is probably 6 to 8 years.

## Economics

Assessing the total cost of French nuclear forces is difficult. There is no detailed official public nuclear budget and reports vary depending on sources and cost categories counted. France is generally thought to spend about a third of its annual military budget on the nuclear mission. The 2015 military budget includes Euro 2.6 billion (\$2.8 billion) for nuclear forces, Euro 93 million (\$101.5 million) for SSBN infrastructure, and Euro 450 million (\$491 million) for operations,<sup>27</sup> for a total of at least Euro 3.1 billion (\$3.4 billion) for nuclear-related costs. If adding other items, according to one assessment, annual spending on the nuclear forces comes to Euro 3.9 billion (\$4.2 billion) in the 2014-2019 plan, up from Euro 2.8 billion (\$3 billion) in the 2003-2008 defense plan and Euro 3.8 billion (\$4.1 billion) in 2009-2014.<sup>28</sup>

## International law

Although the French government will insist that its recent reduction of the land-based air-delivered nuclear force is consistent with France's obligations under article VI of the nuclear Non-Proliferation Treaty to pursue nuclear reductions, its rejection of additional reductions and its ongoing modernisation of its nuclear forces might be seen as being out of sync with those obligations.

If France were to change this policy and reduce its nuclear forces further, the most likely first option would be to phase out the carrier-based nuclear capability. An additional step could be to eliminate the air-delivered ASMPA nuclear cruise missile altogether. In addition to strengthening France's arms control saving record, doing so would save scarce military resources and free the bomber squadrons of the unnecessary burden of nuclear weapons certifications and operations to focus on the more relevant conventional mission.



Phasing out the carrier- and sea-based nuclear cruise missiles would still leave France with a robust and capable sea-based nuclear strike force sufficient to “deter” nuclear attack on France.

## Public discourse

Although there is some debate in France over the composition and cost of the nuclear forces, it is not a very prominent debate. The nuclear defense establishment is very insulated and views the future of the “force de frappe” as beyond public debate. When defence officials in 2013 rejected a proposal from a private institute to phase out the nuclear strike mission on France’s single aircraft carrier, civilian sources warned of a pro-nuclear defence lobby imposing an artificial “consensus” about French nuclear doctrine. “It’s locked down,” a defence expert said. Anyone who questions the deterrent doctrine is subject to “eviction or ridicule”.<sup>29</sup>

Not surprisingly, President François Hollande announced in February 2015 that he had decided to retain the carrier-based nuclear capability, upgrade the last remaining Mirage 2000N squadron to Rafale, begin future upgrades of the M51 SLBM, commission design studies for a new class of SSBNs to replace the current Triumphant-class submarines, and develop a new and improved air-launched cruise missile.<sup>30</sup>

Hollande rejected additional reductions for the foreseeable future. “If the level of other arsenals, particularly those of Russia and the United States, were to fall one day to a few hundred weapons, France would respond accordingly, as it always has,” he said but added: “But today, that scenario is still a long way off.”<sup>31</sup>

# Notes:

1. *Speech by Nicolas Sarkozy, President of the French Republic, Presentation of Le Terrible in Cherbourg*, 21 March 2008, p. 8. A copy of the French version is available here: <http://www.elysee.fr/president/root/bank/pdf/president-1944.pdf>. For an overview of French nuclear forces in 2008, see: Robert S. Norris and Hans M. Kristensen, "French nuclear forces, 2008," Nuclear Notebook, *Bulletin of the Atomic Scientists*, September 2008, <http://bos.sagepub.com/content/64/4/52.full.pdf+html>.
2. *Speech by François Hollande, Visit to the Strategic Air Forces*, 25 February 2015, p. 9, <http://basedoc.diplomatie.gouv.fr/vues/Kiosque/FranceDiplomatie/kiosque.php?fichier=baen2015-02-25.html>.
3. *Speech by Nicolas Sarkozy, President of the French Republic, Presentation of Le Terrible in Cherbourg, op. cit.*
4. "French MSBS Programmes (Submarine-Launched Ballistic Missiles)," EADS, 13 June 2005, [http://www.eads.com/eads/int/en/news/press.en\\_20050613\\_MSBS.html](http://www.eads.com/eads/int/en/news/press.en_20050613_MSBS.html)
5. *Ibid.*
6. *ASMPA: Air-To-Ground Missile, Medium Range, Enhanced*, MBDA Missile Systems, n.d., [http://www.mbd-systems.com/mediagallery/files/asm-pa\\_ds.pdf](http://www.mbd-systems.com/mediagallery/files/asm-pa_ds.pdf). The yield of the TNA warhead is not known but the yields of the devices detonated in the South Pacific during the 1995–1996 probably provide a clue; the yields ranged from less than 20 to 120 kilotons. The last test conducted on 27 January 1996, had a yield of 120 kilotons. *Fifteenth Anniversary of France's Last Nuclear Test*, CTBTO Preparatory Commission, 27 January 2011, <http://www.ctbto.org/press-centre/highlights/2011/fifteenth-anniversary-of-frances-last-nuclear-test/>.
7. Le General D'Armee Aerienn Jean-Paul Paloméros, Chef D'Etat- Major de L'Armee de L'Air, *ORDRE DU JOUR N°7*, 1 July 2010, <http://www.defense.gouv.fr/content/download/76218/679550/file/01-07-10 - Allocution sur le couple Rafale - ASMPA.pdf>.
8. "The Vesta ramjet completes its development phase with a successful series of tests," *MBDA Missile Systems*, Press Release, 12 March 2001, <http://www.mbd-systems.com/mediagallery/#/news/2530>.
9. "France orders 12 "Phoenix" aerial refuellers from Airbus for €3 Billion," *Defense Update*, 21 November 2014, [http://defense-update.com/20141121\\_a330\\_mrtt.html#.VRlct4rF\\_wQ](http://defense-update.com/20141121_a330_mrtt.html#.VRlct4rF_wQ).
10. French Navy, "Navy action regarding this strategic function," 18 July 2011, <http://www.defense.gouv.fr/english/navy/missions2/deterrence>.
11. Pierre Tran, "French Cuts Spur Debate on Nuke Deterrence Budget," *Defense News*, 8 January 2013, <http://archive.defensenews.com/article/20130108/DEFREG01/301080002/French-Cuts-Spur-Debate-Nuke-Deterrence-Budget>
12. *Speech by François Hollande, Visit to the Strategic Air Forces*, 25 February 2015, p. 6, <http://basedoc.diplomatie.gouv.fr/vues/Kiosque/FranceDiplomatie/kiosque.php?fichier=baen2015-02-25.html>.
13. "Propulsion nucléaire: Quand la flotte veille au grain," CEA, n.d. [accessed 6 February 2012], [http://www.cea.fr/defense/propulsion\\_nucleaire/quand\\_la\\_flotte\\_veille\\_au\\_grain](http://www.cea.fr/defense/propulsion_nucleaire/quand_la_flotte_veille_au_grain).
14. "Contract for the production of the M51 Weapon System," *EADS*, 23 December 2004, [http://www.eads.com/eads/int/en/news/press.en\\_20041223\\_m51.html](http://www.eads.com/eads/int/en/news/press.en_20041223_m51.html).
15. French Government, *Budget Général: Mission Ministérielle, Project Annuels De Performances, Annex au Project de Loi de Finance Pour Defence*, 2015, p. 327, [http://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/farandole/ressources/2015/pap/pdf/PAP\\_2015\\_BG\\_defense.pdf](http://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/farandole/ressources/2015/pap/pdf/PAP_2015_BG_defense.pdf).
16. "French MSBS Programmes (Submarine-Launched Ballistic Missiles)," EADS, 13 June 2005, [http://www.eads.com/eads/int/en/news/press.en\\_20050613\\_MSBS.html](http://www.eads.com/eads/int/en/news/press.en_20050613_MSBS.html).
17. Some unofficial sources estimate the M51 range a much higher: 8,000-10,000 kilometers. See: Nicolas Pillet, "Le Terrible a tiré avec succès un M-51!" *Aeroplans*, 28 January 2010, <http://www.aeroplans.fr/Europespace/terrible-tir-m51.html>; the article appears to draw upon this wiki-type web site: "Missile M51," [http://fr.goldenmap.com/Missile\\_M51](http://fr.goldenmap.com/Missile_M51).
18. "Adaptation au M51 des SNLE," French Ministry of Defense, 3 December 2010, <http://www.defense.gouv.fr/dga/equipement/dissuasion/adaptation-au-m51-des-snle/>.
19. "M51 - Missile mer-sol balistique stratégique," French Ministry of Defense, 14 June 2011, <http://www.defense.gouv.fr/dga/equipement/dissuasion/m51-missile-mer-sol-balistique-strategique/>.
20. National Assembly, *op. cit.*
21. "French Audit Report Reveals Weapon Prices, A400M Details," 18 March 2010, <http://www.defense-aerospace.com/article-view/feature/112431/french-auditor-reveals-weapon-prices%2C-a400m-details.html>.
22. The F67-class frigate was also used to protect SSBNs. The last of the class, *Touraille*, was retired in June 2011. Some of the new FREMM-class frigates might inherit the SSBN protection mission.
23. For estimates of French fissile material production and status, see: *Global Fissile Material Report 2011: Nuclear Weapons and Fissile Material Stockpiles and Production*, International Panel on Fissile Materials, 2011; *Global Fissile Material Report 2011: Balancing the Books: Production and Stocks*, International Panel on Fissile Materials, 2010; both reports are available at <http://www.fissilematerials.org>.
24. "Laser mégajoule, des essais nucléaires en laboratoire," *Le Figaro*, 25 February 2015, <http://www.lefigaro.fr/sciences/2015/02/25/01008-20150225ART-FIG00305-laser-megajoule-des-essais-nucleaires-en-laboratoire.php>; CEA, "Le Laser Mégajoule: Des retombées pour l'industrie," 6 December 2010, [http://www.lmj.cea.fr/fr/installation/des\\_retombees\\_pour\\_l\\_industrie.htm](http://www.lmj.cea.fr/fr/installation/des_retombees_pour_l_industrie.htm).
25. French Government, *Budget Général: Mission Ministérielle, Project Annuels De Performances, Annex au Project de Loi de Finance Pour Defence*, 2015, p. 349, [http://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/farandole/ressources/2015/pap/pdf/PAP\\_2015\\_BG\\_defense.pdf](http://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/farandole/ressources/2015/pap/pdf/PAP_2015_BG_defense.pdf).
26. For background and status of the Barracuda program, see: "France's Future SSNs: The Barracuda Class," *Defense Industry Daily*, 11 December 2011, <http://www.defenseindustrydaily.com/frances-future-ssns-the-barracuda-class-02902/>.
27. French Government, *Budget Général: Mission Ministérielle, Project Annuels De Performances, Annex au Project de Loi de Finance Pour Defence*, 2015, [http://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/farandole/ressources/2015/pap/pdf/PAP\\_2015\\_BG\\_defense.pdf](http://www.performance-publique.budget.gouv.fr/sites/performance-publique/files/farandole/ressources/2015/pap/pdf/PAP_2015_BG_defense.pdf).
28. Jean-Marie Collin, "Dissuasion nucléaire : l'obstination française," GRIP, 19 February 2015, p. 2, [http://www.grip.org/sites/grip.org/files/BREVES/2015/EC\\_2015-02-19\\_FR\\_JM-COLLIN.pdf](http://www.grip.org/sites/grip.org/files/BREVES/2015/EC_2015-02-19_FR_JM-COLLIN.pdf). For 2011 estimates, see also: Bruce G. Blair and Matthew A. Brown, *Nuclear Weapons Cost Study*, Global Zero Technical Report, June 2011, p. 1, <http://www.globalzero.org/files/scott/Global%20Zero%20Cost%20Study,%20June%202011.pdf>; National Assembly, *op. cit.*
29. Pierre Tran, "French Cuts Spur Debate on Nuke Deterrence Budget," *Defense News*, 8 January 2013, <http://archive.defensenews.com/article/20130108/DEFREG01/301080002/French-Cuts-Spur-Debate-Nuke-Deterrence-Budget>.
30. *Speech by François Hollande, Visit to the Strategic Air Forces*, 25 February 2015, pp. 6, 7, <http://basedoc.diplomatie.gouv.fr/vues/Kiosque/FranceDiplomatie/kiosque.php?fichier=baen2015-02-25.html>.
31. *Speech by François Hollande, Visit to the Strategic Air Forces*, 25 February 2015, p. 9, <http://basedoc.diplomatie.gouv.fr/vues/Kiosque/FranceDiplomatie/kiosque.php?fichier=baen2015-02-25.html>.