Implementation of the French Space Operations Act for Launchers, and Contribution to the Control of Risks

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Abstract

France has enacted the French Space Operations Act (FSOA) in June, 2008. The initial objective of this act was to set up a legal frame for space activities, appropriate to protect people against the associated hazards which surround inevitably all space operations. The main purpose of the FSOA is to be consistent with the international conventions ratified by France and to give a favorable environment for the competitiveness of the operators taking into account the security requirements.

Each space operation has to obtain an authorization from the ministry in charge of space (ministerial decree) establishes on a CNES technical conformity advice.

The objective of this article is to highlight the first implementations of this act in the field of launchers. We present the origins of regulations and their final contents, and we show how the respect of regulations and the associated controls contribute to minimize the risk without damaging the competitiveness of the launch sector.

We will show in particular that the technical requirements of the regulations were built on the basis of the best practices and thirty years of experience of Ariane launches. We had to adapt our previous safety rules with a will of standardization, in order to apply them for the new launchers Soyouz and Vega, and later to new launch systems. We will show that the authorization process and the regular operation monitoring contribute to the risk management without disrupting the launch operator.

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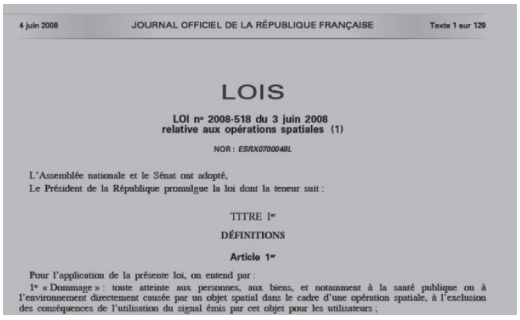
We present briefly the procedures of authorization and the required files. We also present details about the controls and the way they fit into the processes of launch operators.
Since the 10th of December, 2010, the act was enforced and Ariane 5 has continued its launches, Soyuz (October and December, 2011) and VEGA (February, 2012) have made their first launches from the Guiana space centre, while demonstrating compliance with the regulations and by satisfying the FSOA associated controls.



4 juin 2008 JOURNAL OFFICIEL DE LA RÉPUBLIQUE FRANÇAISE Texte 1 sur 129

LOIS

LOI n° 2008-518 du 3 juin 2008
relative aux opérations spatiales (1)

NOR : ESRX0700048L

L'Assemblée nationale et le Sénat ont adopté,
Le Président de la République promulgue la loi dont la teneur suit :

TITRE Ier
DÉFINITIONS

Article 1er

Pour l'application de la présente loi, on entend par :
1° « Dommage » : toute atteinte aux personnes, aux biens, et notamment à la santé publique ou à l'environnement directement causée par un objet spatial dans le cadre d'une opération spatiale, à l'exclusion des conséquences de l'utilisation du signal émis par cet objet pour les utilisateurs ;

1 Introduction

In June 2008, France adopted a domestic legislation on Space operations: the French Space Operations Act (hereafter FSOA). This legislation concerns both launch operation and control and return to earth of space object. This paper focuses on launch operations. It reminds the main features of the International legal context that led to this new framework, the decrees and the technical regulations issued from the act, the description of the treatment of request files associated with authorization, the monitoring of activities up to the launch, the situation about the application to Ariane, Soyouz and VEGA, and associated developments.

2 The FSOA's International, Legal Sources

In few words, the general purpose of the French Space Operations Act is to set up a coherent national regime of authorization and control of Space operations under the French jurisdiction or for which the French Government bears international liability either under UN Treaties principles (namely the 1967 Outer Space Treaty, the 1972 Liability Convention and the 1976 Registration Convention) or in accordance with its European commitments with the ESA organization and its Members States. The necessity of this act came from the evolution of space operations where the role of private initiative, and their diversity has led to the need of a clear and unique legal framework. For instance,

among the evolutions that led to the FSOA, we can mention the arrival of the new systems Soyouz and VEGA.
All the UN's commitments (the 1967 Outer Space Treaty, the 1972 Liability Convention and the 1976 Registration Convention…), have been regularly signed by France, ratified and published in the "Journal officiel de la République française". They had been directly enforceable under French jurisdiction, without any other formality. The rising issue then was not so much the lack of any domestic Space legislation in France than the necessity to provide common and predictable implementing measures for any new activity. These observations have led to the adoption of the FSOA.

2.1 Obligation for the French Government to Authorize and to Check National Space Activities Carried Out by Non-Governmental Entities

France as any State Party of the 1967 Outer Space Treaty is bound by obligations, specified in articles VI and VIII, to authorize and to control national space activities carried out by its national non-governmental entities (private companies) and to exercise its full jurisdiction and control on its registered Space Objects.

2.2 Absolute Liability for Damage Caused on the Surface of the Earth or in the Airspace

As a "Launching State" on the basis of the 1972 Liability Convention, France potentially bears at the first level, i.e. toward victims, the full burden of indemnification for damage that could be caused to third parties:
- on ground or Air Space, by a French private space Launch Service Provider (Arianespace, Starsem…), or;
- by any launch service provider operating from the French territory or jurisdiction (especially from the Guiana Space Center, the European Launch Base, under French territory) or;
- by any French satellite operator that procures a launch service from a foreign country or to a foreign company (example: French operator having one's satellite launched from Russia or by Sea Launch…);

French Government's liability can also be retained, without any time limit, for damage, in orbit or on earth reentry, caused by a foreign satellite having being launched under French responsibility without having being registered by their appropriate State.

3 French Space Operations Act Main Features

3.1 Concerned Activities: Definition – Perimeter

A certain number of definitions are given in the first article of the FSOA. These definitions help to define the perimeter of application of the Space Operations Act:
- Definition of "Space operation": « any activity consisting in launching or attempting to launch an object in outer space, or of ensuring the command

of a space object during its journey in outer space, including the Moon and other Celestial Bodies, as well as during its return on Earth ».
– Definition of the « operator »: "any entity carrying out, under its responsibility and in an independent way, a space operation (i.e. Arianespace, Eutelsat, Astrium, …)". Not a subcontractor under operator's authority.

Definition of "Launching Phase" and "Phase of Command":
– "Launching phase": the period of time which, as part of a space operation, starts at the moment when the launching operations become irreversible and which, without prejudice to provisions contained, if necessary, in the authorization granted pursuant to the present act, ends when the object to be put in outer space is separated from its launch vehicle.

In this act, there is no specific reference to: human flights - activities in the Moon and other Celestial Bodies.

3.2 FSOA Authorization and Control Regime

3.2.1 General Principles

Authorizations are granted by the administrative authority competent for issuing authorizations which is the research ministry in charge of Outer Space Affairs (art. 1 Authorization Decree) after completion of the following process:
An administrative review by the ministry in charge of outer space affairs so that the ministry shall assess moral, financial and professional guarantees of the operator.
A technical review of the space system definition and procedures to be carried out by the applicant, in order to check the compliance with the technical regulation issued by the ministry in charge of outer space affairs. The technical assessment related to the operation is delegated to CNES (article 4). Exemptions of technical assessment (see art. 4.4 for foreign operations) may be granted by the ministry.
Operations carried out by CNES in the scope of a "public mission" (Governmental programs, Science, development of space systems…), are not subjected to this authorization process. Nevertheless, CNES cannot disregards the law and must have an exemplary internal management. Each satellite developed by CNES have to be check through internal procedures. It makes sure also that none of its activities could interfere or rise any conflicts of interest with its responsibilities on FSOA implementation: CNES conformity control activity must be fully independent from CNES program activity
Concerning the launch of a space object, the administrative authority, or the agents acting on its authority and empowered by it to this end, may at any moment give instructions and require any measures they consider necessary for the safety of persons and property, the protection of public health and the environment.

3.2.2 Specific Regime

Two specific regimes are covered by the FSOA:
Launch from a foreign country:
See article IAC-09.E8.6.2

Development phase:
A preliminary and non mandatory "consultation regime" which is independent from the FSOA formal authorization procedure is possible. In this regime, Any person responsible for designing or developing a launch system, or the propulsion subsystem of a launcher, may submit a file to the CNES describing the general technical characteristics and the development plan, so as to enable the centre to certify its compliance, in whole or in part, with the above-mentioned technical regulation. This consultation enables CNES to certify systems or sub-systems under development at given milestones. Such certification issued by CNES may be used by the future operator as enforceable document in the authorization procedure to facilitate the granting of the overall authorization.

ESA who is responsible of the development launch systems operated in French Guiana has asked the Minister to benefit to this consultation regime on the development of launchers and the launch under its responsibility.

3.2.3 Authorization/Licenses

Administrative licenses certifying for a determined time period that a space operator satisfies moral, financial and professional guarantees may be granted by the research ministry in charge of Space Affairs.
Arianespace has obtained such a licence On 2010, December.
Every launch is subject to authorization. In order to simplify the authorization procedures, technical licenses can be obtained for each specific type of launch system.
Licenses may also attest the compliance of the systems and procedures referred to the FSOA with the technical regulations set forth. These licenses will simplify the technical file associated with a dedicated launch operation, by treating the recurrent part of it, covering the definition of the system, the quality organization, a.s.o. The license will not be worth authorization for launch operations. A complementary justification file covering all the aspects specific of the mission and the model used is required, for any launch operation.

3.2.4 "Prescriptions" Associated to Authorization

The authorizations granted pursuant to the present act may include "prescriptions" set forth for the safety of persons and property, protection of public health and the environment.
Authorizations are granted on the basis of technical information available at the moment of the request. The remaining work to be done up to the launch is described in the request. Prescriptions can concern technical key points who have to be solved before the flight in compliance with the associated FSOA requirements. The non respect of a prescription can lead to a suspension of the concerning authorization.

Prescriptions shall mention in particular the conditions under which the agents commissioned pursuant to article 7 of the SOA may control the preparation of the space operations (article 7 Draft Authorization Decree).

3.2.5 Control

The process of control regime carry on until the take off and have to verify that all the prescriptions contained in the authorization/license is set up. State's agents (including authorized CNES agents) are allowed to carry out the required verifications in order to ensure that the operators comply with the obligations set forth in the aforementioned prescriptions:

- Visit and inspection of the buildings, offices and facilities from which the operations are undertaken, including the space object;
- Requirement of any useful document or file Controls during the carrying out of the operation;
- Technical administrative investigation in case of serious incident, or in case of an accident;
- Measures considered as necessary to guarantee the safety of people and property, the protection of public health and the environment:
- The ministry in charge of outer space affairs may take any emergency measures concerning the launching or and the on orbit command of a space object for the protection of people, goods, public health and the environment;
- Mission delegated to CNES President (Article 8 and article 21 SOA);
- These measures can be prescribed before the carrying out of the operation (on ground) or during the carrying out of the operation.

3.3 Regime for Operation from CSG (Guiana Space Centre)

The President of the Centre National d'Etudes Spatiales exercises on behalf of the State the special Police for the safe exploitation of the facilities of the Guiana Space Centre, within a perimeter defined by the competent administrative authority. As such, it shall be in charge of a general mission of "safeguard" consisting in controlling the technical risks related to the preparation and carrying out of the launches from the CSG in order to ensure the safety of persons, property, public health and the environment, on the ground and during the flight, and it shall set out to this end the specific regulations applicable within the limits of the perimeter defined above.

Under the authority of the Government representative in the *Département* of Guiana, the President of CNES Spatiales shall coordinate the implementation by companies and other entities settled in the perimeter defined in part I. above of measures taken in order to ensure the security of the facilities and of the activities undertaken therein, and shall verify that those companies and agencies fulfil their obligations in this respect.

The President of CNES may take for any space operation, by delegation of the administrative authority mentioned in Article 8 of the Act n° 2008-518 dated June 3rd relating to space operations, the necessary measures provided for in the same article "to ensure the safety of persons and property, as well as the protection of public health and the environment".

The president of CNES is responsible for the special policing of the Guiana Space Centre. To that end, he formulate the safeguard actions applicable to the facilities located within the perimeter of the Guiana Space Centre, in particular as regards the activities of designing, preparing, producing, storing and transporting space objects and their constitutive parts, as well as the tests and operations performed within the perimeter or out of the Guiana Space Centre.

4 FSOA Documentary Declination

The FSOA has led to issue a complete set of documentation described underneath.

4.1 Organization

Decree n°2009-643 of 9th June 2009, on the authorizations issued in accordance with FSOA relative to space operations
This decree details the process of authorization (Who, when, how, content of files). This process is described in (6.1).
DECREE n°2009-644 of 9th June 2009 amending decree no. 84-510 of 28th June
1984 relating to the Centre National d'Etudes Spatiales (French space agency)

This decree details:
- the provisions relating to the keeping of the space object register by the Centre National d'Etudes Spatiales
- the powers of the president of the Centre National d'Etudes Spatiales at the Guiana Space Centre, for the ' Safety mission', the 'Safety and security measure coordination', the 'Terms and conditions of inspection', the Emergency measures necessary for the safety of people and property and for the protection of public health and the environment'.

4.2 Technical regulations

Technical requirements are expressed in two different regulations:
- Decree concerning technical regulation implementing decree 2009-643 concerning licenses issued pursuant to FSOA (RT) of 2011, March 31st

This decree covers the responsibility of the state in flight, independently of the launch range, it is associated to the authorization regime.
- Decree regulating the operation of the Guiana Space center facilities (REI)

This decree covers the safeguards rules on ground and in flight specific for the launch range 'Guiana space centre'.

Both regulations are set forth, in particular for the safety of persons and property, the protection of public health and the environment. These regulations must be considered together. CNES organizes its work of verification in order

to give coherent advices on both regulations. A common organization has been set-up in order to give coherent advices as regards both regulations.

4.3 Guide of Good Practices

A guide of good practices is issued in order to characterise certain practices in force, that help to demonstrate compliance with the technical regulation (RT). This guide is based on practices validated by the experience acquired in the development, operation and inspection of space systems. It is in particular based on standards, technical specifications constituting standards, and standards recognised by the profession relating to the safety of life, property, public health and the environment within the context of space operations. The contents of this guide comply with the applicable requirements for protection of intellectual property as well as industrial and scientific assets.

5 Elaboration of Regulations

5.1 Process of Elaboration of the Regulations

The risks concerned by FSOA covers feared events caused by launchers causing damages to people, property, public health and environment.

The management and treatment was not new, when the act was introduced. An experience of more than thirty years of control of risks existed acquired on the program Ariane. Although the legal frame was different, an existing regulation called Doctrine of safety and CSG Range safety regulation (*Règlement de sauvegarde du CSG*) was applicable.As regards the protection of extra-atmospheric environment the European code of conduct on debris mitigation had been approved by several European agencies, and was enforceable for their programs.

When the work of writing the new regulation was decided it has been conducted mainly on the basis of this existing previous regulation : CSG Range safety regulation, and the European code of conduct on debris mitigation. In the process of elaboration of the regulations other sources have been taken into account : the work of international group on different norms (COPUOS, IADC, ISO,ESA-SM (Specification of Management for launchers), ECSS), and a benchmark of other regulations either in France in others fields of activity, or abroad in space activities.

The regulation covers both launcher and satellites. It has been elaborated in a common group of work with specialists of both field. The objectives was to have common requirements for common topics. The result is a regulation with requirements either common for both launcher or satellite, or with expression very similar taking in account the specificities of each field.

The regulation has been elaborated in different steps, initial proposition by CNES, and then consultation of the profession.

For the Technical Regulation the final writing was made by the Minister in charge of Space and a consultation of the European Commission was made to

check its agreement with the rules concerning concurrence. It was then signed by the Minister in charge of Space.
According to the act, the Decree regulating the operation of the Guiana Space Centre facilities was signed by the President of CNES.

5.2 Main Features of the Regulations

5.2.1 Control of Risks: Principles

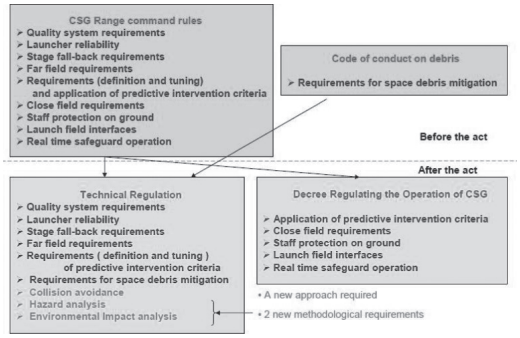
The control of risks, like in many activities, is based on prevention and treatment of feared events.
– Prevention

The aim of prevention is to avoid to be in situation of risk through
– Management of quality
– Launch system reliability
– Choice of trajectories
– a.s.o
– Treatment

The aim of the treatment of risk is the limitation of the consequences of a failure through
– Limitation of the number of people exposed
– Limitation of hazard from the Launch system
– Intervention for neutralization in case of dangerous behaviour in flight

5.2.2 Origin of Requirements for Launchers

The following scheme shows the evolution of rules before the act and after the act. Before the act, the rules where contains in the CSG Range safety regulation, and in the European code of conduct on debris mitigation on the form of recommendations. After the act, rules have been dispatched in the two regulations RT and REI.



5.3 Content of the Technical Regulation (RT)

The technical regulation covers the following topics:

- Glossary;
- Technical files to be prepared by the applicant:
  a. The description of the space operation and systems and procedures;
  b. General notice of conformity with RT;
  c. The Internal standards and quality management provisions;
  d. Hazard study;
  e. Impact assessment;
  f. Hazard management measures;
  g. Emergency measures.;
- Quality system requirements in order to grant the management of risks.
- Technical requirements :
  a. General technical requirements linked to the launch operation, with required proof attached to the launch system, and specific mission analysis;
  b. On-board neutralisation systems;
  c. Flight tracking and associated experience feedback;
  d. Quantitative objectives for human safety;
  e. Space debris limitation;
  f. Prevention of risks of collision with manned space objects;
  g. Prevention of risks arising from fall-back by the launcher or fragments thereof;
  h. Particular hazards (Nuclear safety, Planetary protection);
  i. Technical requirements concerning the launch site.
- Preliminary conformity with the regulation.
- Guide of good practice.
- Interim and final provision.

5.4 Content of the REI

The decree regulating the operation at CSG covers the following topics:

General requirements

a. Glossary, scope, control procedures; Organisational and professional requirements

Access and traffic rules

Facilities siting rules

General safety objectives

a. Hazard classes for ground based activities
b. Hazard classes for in-flight activities
c. Requirements concerning in-flight activities

Safety submission process

Safety rules applicable on the ground

Rules on the ground specific to launchers and payloads

In-flights safety rules

a. Neutralization system
b. Positioning system
c. Telemetry system

6 Application of the Regime of Authorization on the Different Launch Systems

6.1 Authorization and License Scheme

6.1.1 Operator

The Operator requests to the minister in charge of space:
– the administrative license
– the authorization for a given mission

He may request a technical license for a given launch system. This will simplify the technical file associated to an authorization.
The operator manages the production of the launcher proceed to the preparation of the launch mission, and control all the associated risk, and then proceeds to the launch. The FSOA requests that the operator gives the full visibility to CNES controllers of the preparation of the launch until take off..

6.1.2 Minister in Charge of Space

The minister in charge of space Analyses the administrative file Requests CNES technical analysis Authorize the launch

6.1.3 CNES Conformity

CNES in his role of inspectors:
– Monitors technical conformity
– Reports to the ministers.

Once the authorization is given, CNES monitors the activities of preparation to check their compliance with the conditions described in the request file.
An important point to mention is the fact that the role of technical monitoring given to CNES is a new role that is added to its previous roles. To comply with this situation, CNES has organized the inspectors in independent teams separated from project, quality and operational teams. Main inspectors are empowered by FSOA, to proceed with the necessary controls in order to ascertain that its obligations are respected.

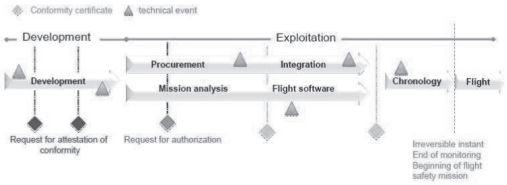
6.1.4 Industry

Under the control of the operators, the industry produces all the parts of the launcher, and prepare all the software necessary for the launch and performs the mission analysis.

6.2 Monitoring as Regards the Life Cycle

The risks concerned by the act are the ones happening during the activities on the launch range, and the ones during flight up to the return on earth of the elements of launchers. Considering that, these risks are generated by the activities and choices performed during the development phase as well as the preparation phase for a given mission, this has led to built the control of

risk since the beginning of development of the launch system up to the latest activities of preparation and the flight itself.
Based on the previous principles, the cycle for monitoring conformity follows the preparation of a launch mission, from the beginning of development, thus limited in the RT to begin to preliminary design review (PDR), goes on during the different phases of development and qualification, goes on during the launcher preparation and the mission analyses and ends at lift-off.



We can mention that for a given launch system it is requested to have fully analysed a given flight, before proceeding to the next one.

6.3 Analyses Performed by CNES

Based on the risks analysis, CNES inspectors proceed to a large type of analysis:
- Analysis of the quality rules and its effective applicability
- independent analysis of the demonstration of reliability
- Independent technical analysis (crosscheck analysis)
- Independent analysis of technical events

These analysis are either performed in the frame of the request file for authorization or during the monitoring of activities up to the launch. This monitoring consists in particular to make thorough analysis of technical events or of particular technical studies in a large range of technical fields. This technical crosscheck leads to exchange with the technical teams of the operator in order to understand the eventual discrepancies in the results, linked to differences of method or of tools used to perform the technical monitoring. It is checked before the flights that a common understanding has been obtained on all critical topics.

CNES developed specific tools for verifying the main quantitative FSOA requirements. We can mention tools to monitor the respect of the followings requirements:
- *Electra* for quantitative objectives for human safety
- *Debrisk* for survivability of re-entering objects (in progress)
- *ARCL* for collision avoidance with human spacecraft
- *Stela* for in orbit life duration

These dedicated tools are described in the article, presented in IAC 2012:

This particular approach for monitoring risks with independent crosscheck constitutes globally a contribution to the control of risks for the people not

participating to the space operation (aim of the act), but it also contributes to the control of risks of the mission itself.

6.4 Application of the Regime of Authorization for Ariane

Ariane's operator is Arianespace SA, so the FSOA must be fully respected for the Ariane flights.
All flight since December, 2010 10th are submitted to the regime of authorization. VA199/L557 on 2010, launched on December 27th was the first flight submitted to this regime of authorization.
A period of preparation was organized between Arianespace and CNES before the full enforcement of the act. This period has lead to constitution of mock-up files for authorization, and advices towards the minister. The discussion about the understanding of the regulation were performed in the frame of the consultation process before its enforcement. Adaptation of some tools are necessary to show compliance to specific rules was also performed in this period, but this was very limited due to the stability of a large part of the requirements.

6.5 Application of the Regime of Authorization for SOYOUZ in Guiana

Soyouz's operator is Arianespace SA, so the FSOA applies fully to Soyouz. In addition to the FSOA legal frame, the agreement of 2003 between the French government and the Russian Federation is taken in consideration. This agreement defines the conditions and the organization for the implementation of Soyouz in Guiana.
According to this frame a working group was organized to prepare and organize how to respect the regulation in the Soyouz context.
From the beginning of the project in 2003, the CSG Range safety regulation, and the European code of conduct on debris mitigation had been taken in consideration. So, even if the regulation were enacted shortly before the first flight of Soyouz in Guiana, it has been possible to show the compliance of Soyouz with the new regulation.

6.6 Application of the Regulation for VEGA

Vega's operator for the first flight was ESA. For the following VEGA flights,
- ESA will be the operator for flights performed in the frame of VERTA program.
- Arianespace will be operator for launches performed in the frame the exploitation phase.

Thus ESA is not directly submitted to the FSOA but ESA has decided to apply the non mandatory consultation regime for VEGA both for the qualification flight and the VERTA flights. An exchange of letters between ESA and the French government has defined the principles to apply the regulation. An agreement between CNES and ESA defines the modalities of application. ESA propose a specific file and CNES examines its conformity and performs an independent monitoring of the activities.

A complete demonstration of conformity was made before the first flight of VEGA covering both the launch system and the launcher VV01. In this case, the late availability of the regulation was compensated by the fact that most of the requirements were already known in the existing set of rules applicable. A certificate of compliance with the regulation was issued for the first flight of VEGA (2012, February 13th).

6.7 Application of the Regulation for Developments

The new regulations (RT and REI), are now the reference for the on-going projects. In particular, these regulations are taken in consideration for the work on Ariane 5-ME and Ariane 6 projects.

7 Conclusion

The French Space Operations Act (FSOA) introduces an authorization regime allowing a balanced regime for private operators. between the constraints resulting from safety and liability requirements (derived from UN Treaties) and the benefits brought by the establishment of a strong legal framework and by the State Guarantee.
The FSOA legal frame is now complete with a set of regulations, very similar to international standard.
FSOA is applicable to all European launch systems
(Ariane, Soyouz, VEGA).
The first twenty months of application of the regime of authorization has been successfully passed, with adequate demonstration of conformity by the operators, and introduction of the CNES inspectors in the process of preparation of the launch.

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