PVVC Environmental Impact Assessment

PVCC MISSION & PVCC SATELLITE

– With Arianespace VEGA-C –

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Distribution list

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Reference documents

[RD1] VEGA-C USER'S MANUAL
[RD2] ESA/ADMIN/IPOL (2014)2 SPACE DEBRIS MITIGATION POLICY FOR AGENCY PROJECTS
[RD3] ESSB-HB-U-002 ESA Space Debris Mitigation Compliance Verification Guidelines
[RD4] ECSS-U-AS-10C Space systems – Space Debris Mitigation Requirements
[RD5] CSG-NT-SBU-16687-CNES Payload Safety Handbook
[RD6] CSG-RP-SPX-20778-CNES Bilan 2020 des plans de mesures environnement réalisés au Centre Spatial Guyanais
[RD7] CNES/ONF 2020. Plan de gestion de la Biodiversité du Centre Spatial Guyanais 2021 – 2030.
[RD8] TEC-SY/129/2013/SPD/RW Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Projects
[RD9] TEC-SY/128/2013/SPD/RW Tailored ECSS Engineering Standards for In-Orbit Demonstration CubeSat Projects

Abbreviations and Acronyms

ASL	Aerospacelab
CNES	Centre National des Etudes Spatiales
COTS	Commercial Off-The-Shelf
CROC	Cross-section of Complex Bodies
CSG	Centre Spatial Guyanais
DHU	Data Handling Unit
DRAMA	Debris Risk Assessment and Mitigation Analysis
ESA	European Space Agency
IOCR	In-Orbit Commissioning Review
IOD	In-Orbit Demonstration
LTDN	Local Time Descending Node
NASA	National Aeronautics Space Administration
OSCAR	Orbital Spacecraft Active Removal
PVCC	PROBA-V Companion CubeSat
QA	Quality Assurance
SARA	Bodies (Re—Entry) Survival and Risk Analysis
SSC	Swedish Space Corporation
SSO	Sun-Synchronous Orbit
VGT-CC	Previous name for PVCC

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Preamble

This document completes the official form filled in for the request of authorization following the law of the 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects and following the text of the Royal Implementing Decree of 19 March 2008 and the Royal Decree implementing certain provisions of the Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects.

INTRODUCTION

Aerospacelab is an active "New Space" scale up founded by Benoit Deper in 2018. The company aims to become the European leader in Geospatial Intelligence.

After successful experiences at NASA, ESA, in a Californian startup and as the CTO of Swiss Space System, the founder of Aerospacelab realized that the market potential of the satellite image sector was not fully exploited despite its potential. Indeed, active companies in the sector face 3 main challenges:

- The commercial offer is limited
- Raw images are difficult to interpret
- Images can often be a sole source with low revisit frequency

To tackle such challenges, Aerospacelab has developed technologies covering the capture and automatic processing of satellites images fused with non-geospatial data serving the defense sector, business intelligence activities, infrastructure monitoring and smart farming. The ultimate purpose of Aerospacelab is to transform data into actionable information.

The workforce of Aerospacelab is growing exponentially, from 45 employees in 2020 to about 200 employees by the end of 2022. The company is now paving a new path for the Belgian space industry with the opening of 2 satellite factories by the end of 2022 for the first one, and by 2024 for the second one. In addition, Aerospacelab benefits from the financial support and trust of several key political and economic players, among which the European Union, Airbus Venture, ESA, and the Federal and Regional Belgian governments.

To be present and up to date with the satellite market needs and challenges, Aerospacelab's board of advisors gathers several professionals from the space sector, including the former Director General of ESA, Jean-Jacques Dordain.

The technologies developed by Aerospacelab cover a broad spectrum of activities such as borders' monitoring to analyze migrants' flow or support precision farming thanks to the acquisition of useful data for R&D and yield management or to discuss food security. Such a diversity of experiences allows Aerospacelab to take an active part in the creation of positive societal impact.

1. PART 1: GENERAL OVERVIEW OF THE MISSION

This section aims to give an overview of the PROBA-V Companion CubeSat (PVCC) mission. PVCC was previously denominated VGT-CC.

1.1. Mission Overview

The PVCC mission is consisting of a satellite hosting the spare Spectral Imager from the Proba-V mission on a 12 units (12U) CubeSat. PVCC is an Earth Observation In-Orbit Demonstration (IOD) mission conducted under the support of the European Space Agency (ESA) through the GSTP Fly program. It aims to prove the technical capabilities of Aerospacelab in providing an ambitious satellite platform with a strong flexibility and versatility by incorporating external components at the request of its customers. The operational purpose of PVCC is to provide data to support the calibration of CubeSat Earth observation missions.

PVCC is an ESA mission conducted within a consortium led by Aerospacelab as the prime contractor with VITO as one of the subcontractors in charge of the user segment.

Since the beginning of Aerospacelab, its developments have been conducted within an agile framework by relying as far as possible on Commercial Off-The-Shelf (COTS) components qualified for the space environment. The technical purpose of PVCC is to test the performance of a known payload flown on Proba-V and provided by OIP, on a 12-units CubeSat platform built in-house; this point is the core of the innovative feature of the mission. Indeed, PVCC relies on several technologies embarked on Aerospacelab's first satellite, ARTHUR-1, launched in 2021, and for the PVCC mission, some components have been improved and developed due to the different interface between the Proba-V instrument and the platform. Hence, the mission will focus on testing:

- New Data Handling Unit (DHU) and Power Supply Unit (PSU) electrical interfaces
- New payload manager software
- New compression algorithm in the software
- The update of the Baffle design and related manufacturing process
- New optical bench mechanical interface and thermal insulation
- The integration of a known payload on a CubeSat platform

The production and quality assurance staff are working closely to ensure a tight feedback loop. The development also includes regular hardware-in-the-loop testing allowing the complete verification of the whole mission.

1.2. Mission Objectives

The primary objective of the PVCC mission is to deliver images from a known payload, OIP VGT instrument, on a tailored CubeSat platform. If this objective is achieved, the PVCC mission will thus support the calibration of CubeSat used for Earth observation imagery by testing the VITO future product CalibrEO, which is not part of the mission, but developed in parallel.

Additionally, a secondary objective has been identified within the frame of a strategic partnership between ESA and a New Space company. As PVCC is an in-orbit demonstration mission, its success will allow the development of business relations with ESA and other public actors.

More generally, PVCC is an opportunity for Aerospacelab to demonstrate its expertise on a vertical manufacturing processing while caring about the customers' needs and expectations through the integration of external components in its own design and structures.

1.3. Mission Characteristics

As the payload was designed for a different direct environment, namely on the mechanical loads, the mission is made possible through the use of a load isolation system integrated in the CubeSat deployer.

The launch is planned to take place from Kourou in early 2023 aboard the VEGA-C launch vehicle as part of its VV-23 mission. The launch window starts on 20/01/2023 and lasts one month. For further information on the general overview and specifications of the VEGA-C launcher, please refer to [RD1].

The injection orbit is a Sun-Synchronous Orbit (SSO) at an altitude of 564km and a Local Time of Ascending Node of 22h30. As there is no propulsion on-board, this will remain the operational orbit for the duration of the mission, with an altitude that will slowly decrease due to residual atmospheric friction.

The baselined ground stations to communicate with the PVCC spacecraft for Telecommand and Monitoring (TM/TC) are Redu, Belgium (ESEC/REDU) and Kiruna, Sweden (Swedish Space Corporation, SSC). There are two Payload Data Ground Stations located in Kiruna, Sweden (SSC) and Inuvik, Canada (SSC). An overview of the ground segment elements is presented in Appendix 2.

The detail of the contractual terms between AEROSPACELAB and ESA does not yet cover the operational phase after the commissioning phase. It is however expected that the above mentioned ground station would be used for the nominal operations.

1.4. Environmental impact

It should be noted that the environmental impact assessment inputs for the PVCC mission have been obtained directly from the launch provider. For such information, please refer to [RD5].

2. PART 2: SYSTEM DEVELOPMENT

THIS PART IS NOT FOR PUBLICATION AND IS CONFIDENTIAL.

IT SHALL BE USED FOR BELSPO REQUEST ASSESSMENT ONLY.

3. PART 3: POTENTIAL IMPACT

As an operator located in Belgium, and therefore subject to the Belgian Law of 17 September 2005 on the Activities of Launching, Flight operations or Guidance of space objects, Aerospacelab is responsible to provide the Belgian authorities with an impact assessment of the launch activity.

The impact assessed covers the launch and operations of the space segment of the mission.

3.1. On Earth and the atmosphere

To provide a safe environment and to ensure the protection of people, goods and the environment, the Payload Safety Handbook [RD5] of the Centre National d'Etudes Spatiales (CNES) – Centre Spatial Guyanais (CSG) defined some functional requirements aiming to eliminate and reduce the occurrence of risks at 3 different levels: the satellite customer (i.e., Aerospacelab), the launch operator and, CNES – CSG.

As Aerospacelab is the satellite customer, it must assess 2 categories of risks on ground defined according to the severity of potential damages; those are highlighted in the table below.

Table 1: Classes of risks relative to on-ground Kourou activities (based on [RD5])

Risk classes	Definition of damage	Requirements
Risk of catastrophic consequences	- Loss of human life, immediately or later - Permanent disability - Irreversible harm to public health	Double point of failure criterion: no combination of two failures must generate a risk of catastrophic consequence
Risk of serious consequences	- Serious injury to people not leading to loss of human life, nor to permanent disability - Reversible harm to public health - Significant damage to property: • Total or partial destruction of public or private property • Total or partial destruction of a critical facility for the launch operation - Significant damage to the environment	Single point of failure criterion: no failure must generate a risk of serious or *a fortiori* catastrophic consequence

Regarding the PVCC mission, the most serious problem that may arise can be during the use of the facilities of CNES – CSG or during the launch phase.

Moreover, to continually monitor the CSG environment, some safety tests are performed at Kourou for physical, thermal and chemical elements. Samples are collected before, during and after each launch to ensure an absence a toxicity in the CSG area: such information are synthetized in a specific document named *Plan de Mesure Environnement* (PME) (in English, Environment Measurement Plan) to assess the impact of the launch on the CSG environment. Regarding this aspect, the most serious problem would be linked to the emission of harmful chemical substances during the launch vehicle operations and launch phases. As VEGA-C's environmental impact assessment is not available yet, the assessment is based on the previous analysis conducted for the VEGA family, one can assume that as for VEGA, the impact on the environment is also negligible for VEGA-C [RD6]. Please refer to APPENDIX 3 for more information.

3.2. In outer space

This part aims to present the impact of the PVCC mission in outer space.

3.2.1. VEGA-C Launcher Impact

The potential impact of VEGA-C launcher in outer space is not covered by this assessment.

3.2.2. Lifetime analysis and assessment (based on DRAMA/OSCAR)

For projects conducted in collaboration with ESA, Aerospacelab must assess the re-entry of space objects. Based on these studies, it can be assured that even in case of malfunctioning of any component or the space object itself, the satellite will naturally decay and will be fully destructed by reentering the atmosphere. Aerospacelab follows the space standards for its activities and the respect of the 25 years maximum lifetime is considered at every stage of the development [RD2]. Our calculations estimate that it will happen less than 25 years after launch for the considered orbit.

For the lifetime analysis, a worst-case scenario is considered, i.e., the satellite is not able to deploy its solar array resulting in the worst-case ballistic coefficient.

The lifetime analysis was done using DRAMA/OSCAR with a 5 solar cycle Monte-Carlo sampling. Results and the initial orbit conditions of the campaign are presented in the following tables and figures, along with the solar activity distributions.

The following table (Table 1) presents the orbital parameters for the analysis:

Table 2: Parameters of PVCC used for lifetime analysis

Parameters	Value
Epoch	2023-01-01 12:00:00
Semi-major axis (km)	6935
Eccentricity	1e-3
Inclination (deg)	97.6
LTDN	10:30
Cross-sectional area (m^2)	0.080 (DRAMA/CROC)
Mass (kg)	19
Drag coefficient	2.2
Solar radiation pressure reflectivity coefficient	1.2

With these initial conditions, the lifetime of the PVCC satellite is calculated and estimated to be **15.21 years**.

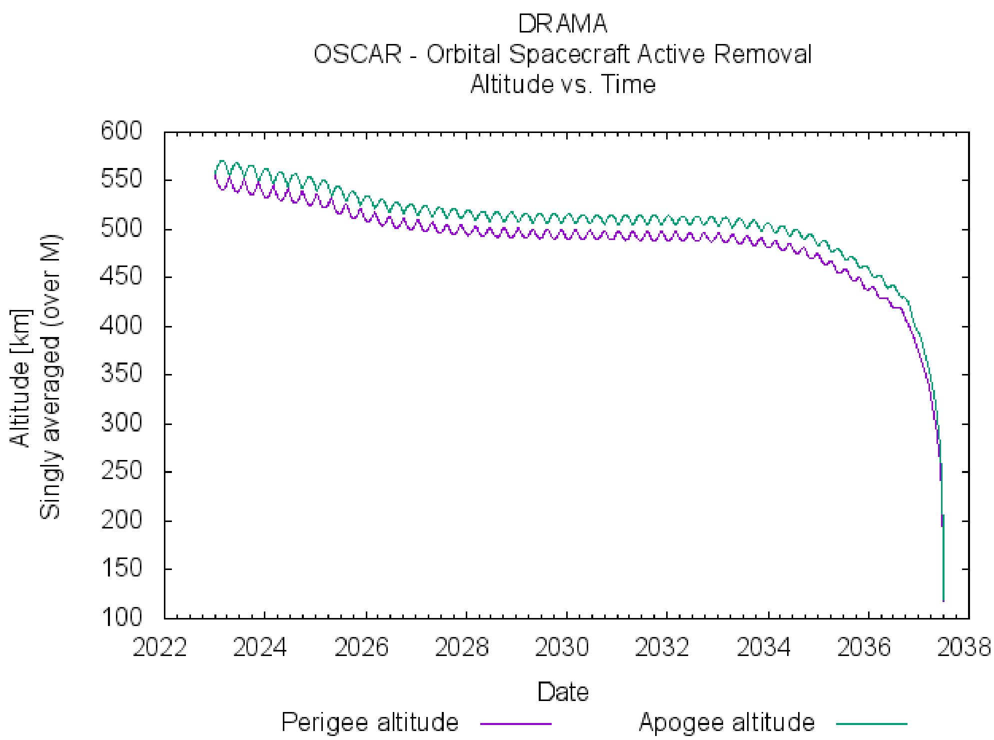


Figure 1: Satellite altitude over time

3.2.3. Casualty Risk Evaluation (based on DRAMA/SARA)

The result of the DRAMA/OSCAR calculation was used as the initial orbit condition for the casualty assessment, i.e., the re-entry risk, which was done using DRAMA/SARA.

The object is assumed to have a total mass of 19 kg (12U CubeSat) and no component of the satellite is expected to survive re-entry.

The simulations run with these configurations reveal that no parts of the objects are capable of surviving re-entry, as presented in the following screenshot.

```
trajec: Object   27, Start alt.: 78.0     Target alt.: 0.00
trajec: Object   28, Start alt.: 78.0     Target alt.: 0.00
trajec: Object   29, Start alt.: 78.0     Target alt.: 0.00
output: Writing result data
WARNING: No objects survived
The file risk.inp has not been generated. The execution stops here.
This can be the case when the configuration is invalid (e.g. no object definitions have been specified)
```

Figure 2: DRAMA/SARA output message

DRAMA version used for the simulation: issue 3.1.0

4. PART 4: NON-TECHNICAL SUMMARY

In accordance with Belgian Law of 17 September 2005 on the Activities of Launching, Flight operations or Guidance of space objects, this part aims to summarize the potential impact of the PVCC mission and proposing some guidance to reduce or limit its environmental impact.

4.1. Potential impact on terrestrial environment, atmosphere, and natural and human environment

4.1.1. Regarding the launch site environment

The continuous monitoring of the CSG launch site after each launch, through the *Plan de Mesure Environnement* (PME) (in English, Environment Measurement Plan), is a genuine guarantee of protection of the terrestrial, the atmosphere, the natural and human Guyana environments. Such PME make possible to understand exactly the potential impact of a specific launcher. As the assessment of VEGA-C's environmental impact is not available yet, it is complicated to assess its specific impact on the CSG ecosystem but based on the previous analysis conducted for the VEGA family, it is proposed to assume that VEGA-C's launches will not create significant impact.

It is also interesting to note that the CNES is dedicated to preserve the biodiversity of the CSG and has established *a Plan de Gestion de la Biodiversité du CSG* (Biodiversity Management Plan of the CSG) for the 2021 – 2030 period to allow the coexistence of spatial operations and biodiversity [RD7]. The study covers different resource areas such as fauna and flora, cultural resources, geology and soils, land use, climate.

4.1.2. Regarding the launch vehicle selection

The preference for a European launcher was stated by the customer, ESA. The launch services providers proposed launch opportunities based on orbit parameters requirements for the PVCC mission and availability if secondary payload slots. The launch vehicle VEGA-C matched the programmatic and technical constraints for the launch.

Recommendations to limit and reduce the environmental impact (including the launcher choice, launch environment)

As illustrated previously through the environmental impact of launching from Kourou site, several elements shall be considered to reduce and/or limit any environmental impact linked to the launch of PVCC:

- The launch provider shall commit to protecting the environment as much as possible
- The launch vehicle shall limit the use of radioactive substances
- The launch operation shall be notified to the population living around

- The PME performed by CNES – CSG after each launch from the Kourou spaceport shall be detailed for VEGA-C to concretely understand and assess its impact on the terrestrial and atmospheric environment
- CNES – CSG should pay special attention to its *Plan de Gestion de la Biodiversité du CSG* in its *Plan de Mesure Environnement* to respect the existing ecosystem in Kourou.
- CNES shall establish a clear Environmental Impact Assessment for the CSG

4.2. Potential impact on outer space

The table below recaps the impact of the PVCC mission on outer space.

Table 3: Impact on Outer space summary

Source of the potential impact	Identified potential impact
VEGA-C launcher	- The launcher is following French regulations for operating in French Guyana. More information are available on request.
PVCC CubeSat	- No significant impact in case of malfunction - The orbital lifetime of the satellite in its launch configuration (SAA stowed) is lower than 25 years - PVCC energy storages (chemical and mechanical) will be passivated upon the end of operation phase - The satellite will be passively deorbited

Recommendations to limit and reduce the environmental impact (Space debris mitigation guidelines + ISO and ESA standards)

Aerospacelab is committed to following the best standards for its activities and especially any standards targeting space debris proliferation [RD3]. Aerospacelab ran simulations on software developed by ESA to assess the sustainability of the PVCC mission revealing that:

- No parts of PVCC would survive re-entry in the atmosphere
- The lifetime of the satellite is inferior to 25 years in the worst case scenario of "dead-on-arrival" (Solar panels stowed and satellite is tumbling)

As required by ESA and ISO [RD4]. Therefore, we consider that the measures taken to reduce or limit any environmental impact of PVCC on outer space are efficient.

However, Aerospacelab will remain attentive to any technological development supporting the mitigation or reduction of environmental impact in space.

5. APPENDIX 1

Frequency allocation request confirmation by IBTP and ITU

E_TSUM Requested by: BENJAMIN	Date: 12.11.2020 16:45:21	DB: IFIC2933.MDB	Plan Id.:	Notice type: NONGEO
A	*A1a* Sat. Network VGT-CC	*A1f1* Notif. adm. BEL	*A1f3* Inter. sat. org.	*BR1* Date of receipt 26.08.2020	*BR20* BR IFIC no. 2933
BR6a/BR6b Id. no. 120545206	*BR3a* Provision reference 9.1/IA	*BR2* Adm. serial no.	

Résumé / Summary / Resumen

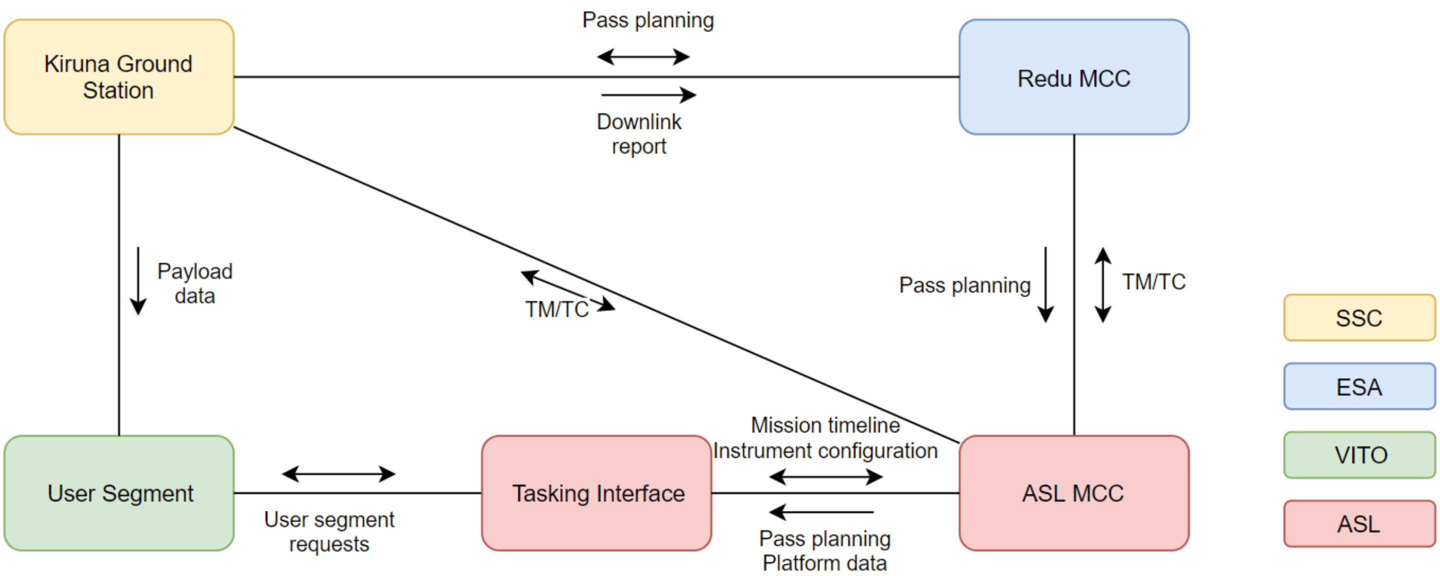
Article 9, sous-section IA / Article 9, sub-section IA / Artículo 9, sub-sección IA
第9条第1A分节 / Статья 9, подраздел IA / المادة 9، القسم الفرعي IA

B1a Beam designation	B2 Emi-Rcp	BR8 Action code	BR7a Group id.	BR9 Action code	BR47 Frequency band (MHz)	C4a Class of station
SUP	R		120660717		2044.6708 - 2045.6708	ET
SDOWN	E		120660718		2218 - 2224	ET
XDOWN	E		120660719		8135.5 - 8215.5	EW

Please note that the ITU demand was made for the satellite network VGT-CC whose name was changed by ESA in favor of PVCC. VGT-CC is therefore the network name, while PVCC refers to the Satellite.

6. APPENDIX 2

PVCC Ground Segment Infrastructure Overview



The above presented configuration refers to the implementation of the mission that will be performed for the commissioning, with the color boxes indicating the respective responsibilities.

7. APPENDIX 3

Extract of the Kourou Environmental Impact Assessment for VEGA VV16 launch in 2020

CENTRE SPATIAL GUYANAIS Sous-Direction Protection **Service** **Environnement et Sauvegarde Sol**	**BILAN 2020 DES PLANS DE MESURES ENVIRONNEMENT REALISES AU CENTRE SPATIAL GUYANAIS**	Réf : Ed/Rev: Date : Page :	**CSG–RP–SPX–20778–CNES** 01/00 Classe: GP **14/04/2021** 26/**107**

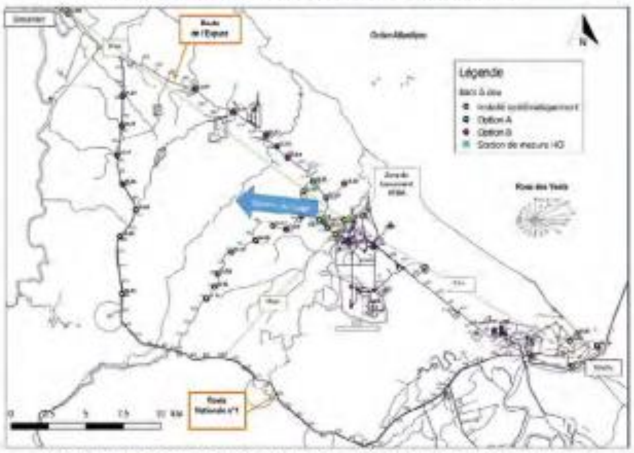
RESULTATS DU PLAN DE MESURES ENVIRONNEMENT VOL VEGA VV16

Réf : CG/SDP/ES/2021/n°51

Arrêté préfectoral N° 1655/DEAL du 06 octobre 2011 portant autorisation au CNES à exploiter les installations constitutives de l'Ensemble de Lancement VEGA (ELVEG A) situées sur le territoire de la commune de Kourou, au sein du Centre Spatial Guyanais

Mer. 02 sept 2020

Carte du CSG et répartition des capteurs d'analyse de l'air



Seuls les produits de combustion du **premier étage (P80)** sont dispersés dans l'atmosphère

Acide chlorhydrique (HCl) + **Alumine** (Al_2O_3)

VEGA

Le **mercredi 02 septembre 2020 à 22h51** (Heure locale)

Le **vol V16** en bref : ***SSMS PoC Flight***

53 micro-satellites pour le compte de 21 clients.

Emplacement des capteurs	Détails de l'instrumentation
10 sites en champ proche (Zone de Lancement)	10 bacs à eau
	2 analyseurs mobiles
35 sites en champ lointain (Kourou / Sinnamary / RN1 / CSG)	35 bacs à eau
	1 analyseur mobile
Réseau CODEX (Kourou / Sinnamary/ CSG)	24 analyseurs fixes

Paramètres de mesure	
Bacs à eau	pH / Conductivité / Aluminium particulaire / Chlorures **(Institut Pasteur de Guyane)**
Analyseurs mobiles	Acide chlorhydrique en continu
Analyseurs fixes	Acide chlorhydrique

CONCLUSIONS SUR LE PLAN DE MESURES ENVIRONNEMENT VV16

<u>Teneurs maximales en acide chlorhydrique et en alumine</u> mesurées jusqu'à 200 mètres en zone de lancement soit à l'intérieur du périmètre du CSG.

<u>Hors du CSG, les teneurs en acide chlorhydrique et en alumine</u> émises par l'environnement naturel et l'activité humaine sont similaires. Les concentrations sont faibles, parfois non imputable au lancement (soulèvement de poussière, embruns marins) ; l'impact du lancement n'est pas décelable.

L'ensemble des capteurs (45) a bien été exposé aux retombées du nuage de combustion

(OPTION B « Route de l'espace »)

Impact sur les personnes non décelé

Impact sur l'environnement non décelé

Une question ? *environnement-csg@cnes.fr*

Piste d'audit

TITRE	Signature EIA PVCC (ToC corrigée)
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IDENTIFIANT DU DOCUMENT	86cf0fb58fda00171eaec305bf063872db2153c6
FORMAT DE DATE DU DOCUMENT	YYYY / MM / DD
STATUT	Signé

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