Wet van 17 september 2005 met betrekking tot de activiteiten op het gebied van het lanceren, het bedienen van de vlucht of het geleiden van ruimtevoorwerpen - Koninklijke uitvoeringsbesluit - Bijlage **3**

FORMULIER VOOR DE AANVRAAG VAN EEN MACHTIGING

Dit formulier moet worden ingevuld door de operator, conform artikel 3, 2°, van de wet van 17 september 2005 met betrekking tot de activiteiten op het gebied van het lanceren, het bedienen van de vlucht of het geleiden van ruimtevoorwerpen (hierna "de Wet").

De aandacht van de aanvrager wordt erop gevestigd dat de gegevens vereist uit hoofde van dit formulier niet noodzakelijk exhaustief zijn en dat de aanvrager in elk geval ertoe gehouden blijft alle gegevens mee te delen vereist uit hoofde van artikel 7, §2, 8°, van de Wet of uit hoofde van het koninklijke uitvoeringsbesluit ervan.

De aanvrager is er voorts toe gehouden alle aanvullende informatie te verschaffen vereist door de Minister of de door hem aangewezen personen alsmede alle nuttige gegevens tijdens de uitvoering van de activiteiten, in het bijzonder de gegevens waarvan sprake in artikel 16, §1, van de Wet.

I. Soort van aanvraag

1. Betreft de aanvraag : ☑ nieuwe activiteiten ?
☐ ~~een overdracht van activiteiten ?~~

2. Indien de aanvraag een overdracht van activiteiten betreft, gaat het om :

☐ activiteiten die het voorwerp zijn van een machtiging verleend uit hoofde van de Wet ?

nr./ref. van de machtiging:

☐ activiteiten die het voorwerp zijn van een machtiging of een licentie verleend door een buitenlandse overheid ?

Staat die de machtiging of licentie heeft verleend :

nr./ref. van de machtiging/licentie :

DEEL 1/2: 1ste lancering - ISS - 32 satellieten

Gemodificeerde for Atlas-5 raket (in rood) en verwijdering van BE05-Qarman

II. Identificatie van de aanvrager

1. vakjes bestemd voor aanvragen ingediend door natuurlijke personen

naam

voornaam

woonplaats

adres

land

verblijfplaats in België (indien niet dezelfde als woonplaats)

adres

nationaliteit

beroepsbezigheid

doel van de beoogde activiteiten

2. vakjes bestemd voor aanvragen door rechtspersonen

firmanaam
Von Karman Institute for Fluid Dynamics

rechtsvorm
iVZW

inschrijvingsnr. in het Nationaal handelsregister (indien handelaar)
—

land
België

maatschappelijke zetel
Waterloosesteenweg 72

adres
1640 Sint-Genesius-Rode

land
België

vestiging in België (indien niet dezelfde als maatschappelijke zetel)
—

adres
—

hoofdaandeelhouders
Niet van toepassing

aandeel in het kapitaal van andere ruimte-operators
Geen

beschrijving van de andere activiteiten verricht door de aanvrager

- op het gebied van de bediening of de navigatie van ruimtevoorwerpen
  (Machtiging 2014/1)
  Periode: *van* 19 06 2014 *tot* heden
- op het gebied van het ontwerp, de ontwikkeling of de bouw van ruimtevoorwerpen
  Periode: *van* *tot*
- op andere gebieden
  Stromingsdynamiek
  Periode: *van* 20 12 1956 *tot* heden

3. financiele garanties

- speciale garanties gesteld voor de beoogde activiteiten
  Geen
- verzekeringen die de beoogde activiteiten dekken
  Geen

4. technische garanties

- beschrijving van het systeem of de systemen voor inveiligheidstelling of gecontroleerde vernietiging
  Systeem voor gecontroleerde vernietiging van de lanceerraket: zie bijlage 2 (*Milieu-effectenstudie*)
  CubeSats: natuurlijke opbranding/vernietiging tijdens re-entry in de atmosfeer (na maximum 5 jaar voor de gekozen baan).
- identificatie van de verantwoordelijke voor het activeren van de inveiligheidstelling
  United Launch Alliance (aanbieder van lanceringdienst)
  9950 E. Easter Ave., Unit A, ; Centennial, CO 80112 ; USA

• beschrijving van de procedures en de specificaties van de kwaliteitsgarantie
1. CubeSat Design Specification (CDS) Rev. 12 (zoals vastgelegd door de California Polytechnic State University)
2. QB50 System Requirements and Recommendations Issue 7
3. Veiligheidsmaatregelen van NASA & JAXA, zoals gerapporteerd door Nanoracks.

• Zijn de kwaliteitsgarantie en de veiligheidseisen conform de volgende normen ? (indien ja, kruis het desbetreffende vakje aan)

☐ NBN-normen opgelegd of omgezet in het kader van de wet van 9 februari 1994 betreffende de veiligheid van producten en diensten
☐ normen opgelegd door het Europese Ruimte-agenschap
☐ normen opgesteld door het IADC (*Inter-Agency Space Debris Coordinating Committee*)

• identificatie van de verantwoordelijke voor de kwaliteitsgarantie
Von Karman Institute for Fluid Dynamics (VKI) voor 1 & 2
Nanoracks + ISS Payload Safety Review Panel voor 3

III. Beschrijving van de activiteiten

1. soort van activiteiten

☑ lancering
☑ bedienen van de vlucht – ruimtenavigatie
☐ in een nieuwe baan brengen
☐ uit de baan nemen
☐ buitendienststelling
☐ terugkeer in de atmosfeer

• beknopte beschrijving van de activiteiten
Lancering en handelingen van 35 satellieten (CubeSat soort) in het kader van het QB50 FP7 Europese project. Duur missie: 2 jaar.

2. doel van de activiteiten

• beknopte beschrijving van de objectieven
Wetenschappelijke metingen doen van bestanddelen van de thermosfeer in het kader van het QB50-project dat erop gericht is om een netwerk van 50 CubeSats in een lage baan om de aarde te brengen. Het QB50-project betreft een samenwerking tussen 50 universiteiten.

3. gebruik van radiofrequenties

gebruikte radiofrequentie(s) voor de activiteiten (Vermeld **M** voor Mega, of **G** voor Giga, in het vet omkaderde vakje)

* ____ , __ ☐Hz ____ , __ ☐Hz ____ , __ ☐Hz ____ , __ ☐Hz

nr./ref. van de machtigingen verleend door de Belgische of buitenlandse overheid verantwoordelijk voor de toekenning van de frequenties

Zie bijlage 3

* Zie bijlage 1 (*Table of QB50 CubeSats*) voor de frequenties van elke satelliet.

4. gegevens betreffende de lancering van het ruimtevoorwerp

4.1. lancering vanaf de grond

Lanceerplaats Cape Canaveral Air Force Station Space Launch Complex 41, Florida - USA

geografische coördinaten (in graden/minuten/seconden. Vermeld **N** voor noord, **Z** voor zuid, **W** voor west of **O** voor oost in het vet omkaderde vakje)

breedtegraad : 28 grad. 35 min. (00 sec.) N

lengtegraad: 080 grad. 34 min. (59 sec.) W

Gaat het om een plaats onder het rechtsgebied van een of meer Staten ? ☑ ja ☐ neen
Indien ja, welke ?

Verenigde Staten

Gaat het om een plaats onder het rechtsgebied van een intergouvernementele of supranationale internationale organisatie ? ☐ ja ☒ neen
Indien ja, welke ?

Gaat het om een plaats onderworpen aan een specifieke internationale regeling ? ☐ ja ☒ neen
Indien ja, welke ?

Welke uitrusting of installaties worden gebruikt ?

1 Assemblage hall
2 Test faciliteiten
3 Integratie hall
4 Lanceerbasis

eventueel inschrijvingsnummer

1
2
3
4

Welke voertuigen worden gebruikt ?

1
2

eventueel inschrijvingsnummer

1
2

4.2. lancering vanop zee

Lancerplaats

geografische coördinaten (in graden/minuten/seconden. Vermeld **N** voor noord, **Z** voor zuid, **W** voor west en **O** voor oost in het vet omkaderde vakje)

breedtegraad: grad. min. (sec.) ☐

lengtegraad: grad. min. (sec.) ☐

Gaat het om een plaats onder het rechtsgebied van een of meer Staten ? ☐ ja ☐ neen
Indien ja, welke ?

Gaat het om een plaats onder het rechtsgebied van een intergouvernementele of supranationale internationale organisatie ? ☐ ja ☐ neen
Indien ja, welke ?

Gaat het om een plaats onderworpen aan een specifieke internationale regeling ? ☐ ja ☐ neen
Indien ja, welke ?

Welke uitrusting, installaties en/of schepen worden gebruikt ?

1
2
3
4

eventueel inschrijvingsnummer

1
2
3
4

4.3. lancering vanuit de lucht

Lanceerplaats

geografische coördinaten (en graden/minuten/seconden. Vermeld **N** voor noord, **Z** voor zuid, **W** voor west of **O** voor oost in het vet omkaderde vakje)

breedtegraad: grad. min. (sec.) ☐

lengtegraad : grad. min. (sec.) ☐

hoogte: m

Gaat het om een plaats onder het rechtsgebied van een of meer Staten ? ☐ ja ☐ neen
Indien ja, welke ?

Gaat het om een plaats onder het rechtsgebied van een intergouvernementele of supranationale internationale organisatie ? ☐ ja ☐ neen
Indien ja, welke ?

Gaat het om een plaats onderworpen aan een specifieke internationale regeling ? ☐ ja ☐ neen
Indien ja, welke ?

Welke luchtvaartuigen worden gebruik ?
1 2
eventueel inschrijvingsnummer
1 2

4.4. *lancering vanuit de kosmische ruimte*

Gebeurde de lancering door middel van een ruimtevoorwerp (raket, ruimteinfrastructuur) onder het rechtsgebied van een Staat of een internationale organisatie ? ☑ ja ☐ neen

Indien ja, welke ?
International Space Station (ISS)
eventueel inschrijvingsnummer van het voorwerp gebruikt voor de lancering
1998-067A

5. activiteiten verricht voor rekening van derden

Worden de activiteiten verricht voor rekening van derden ? ☐ ja ☑ neen
identificatie van de opdrachtgevende derde

6. activiteiten verricht met de hulp van derden

Worden de activiteiten verricht met de hulp van derden ? ☑ ja ☐ neen
identificatie van de hulpverlenende derden
Europese Commissie / Nanoracks
beschrijving van de hulp of de bijstand
Europese Commissie: financiering lancering (FP7)
Nanoracks : CubeSat dispenser en lanceringscampagne coördinatie

IV. Beschrijving van het voorwerp

* Zie bijlage 1 voor informatie over elke satelliet.

1. soort van voorwerp
30 dubbele CubeSats+2 driedubbele CubeSats *
2. functie
Metingen doen in de thermosfeer
3. eigenaar(s)
*
4. constructeur(s)
*
5. voornaamste boordtechnologieën
*

6. gebruik van kernenergiebronnen ☐ ja ☑ neen

soort van bron (kernreactor / isotopengenerator)

exploitatie-orbit

aard van de gebruikte kernbrandstof

initiële massa van de gebruikte kernbrandstof

overblijvende massa van de gebruikte kernbrandstof (raming voor het einde van de exploitatie)

systeem voor het terugbrengen en controleren van de satelliet na zijn exploitatieperiode (kernreactoren) beschermings- of opsluitingssystemen (isotopengeneratoren)

maatregelen genomen conform de aanbevelingen van de Internationale commissie voor radiologische bescherming

maatregelen genomen conform de aanbevelingen van nationale of internationale adviesorganen

raming van het niveau van blootstelling aan straling indien een ongeval zich voordoet

acties of procedures voor het bijsturen en vermijden van defecten van de veiligheidssystemen

7. vlucht of missiekarakteristieken

geplande lanceerdatum en -uur (UTC) om u min

Periode (venster):
1 maart 2017 - 30 juli 2017

parameters van de omloopbaan = baanparameters van ISS bij de lancering, typisch:

knopenlijn-omloopstijd (minuten): 92.79 min

inclinatie ((graden): 51.66°

apogeum (km): 418 km

perigeum (km): 403 km

exploratiemissie

V. Gegevens mee te delen onmiddelijk na de lancering

mislukte lancering ☐ ja ☐ neen

effectieve lanceerdatum en -uur (UTC)

☐☐ ☐☐ ☐☐☐☐ om ☐☐ u ☐☐ min

reëlle omstandigheden versus nominale omstandigheden

____

____

____

beschrijving van de onregelmatigheden opgetreden bij de lancering en/of tijdens de fase van het op positioneren

____

____

____

corrigerende acties en resultaten

____

____

____

VI. Gegevens mee te delen tidens de exploitatiefase van het ruimtevoorwerp

beschrijving van onregelmatigheden tidens de exploitatie

corrigerende acties en resultaten

overdracht van activiteiten

identificatie van de operator cessionaris

VII. Gegevens mee te delen na afloop van de bediening van het ruimtevoorwerp

terugkeer in de atmosfeer: gebied en periode (UTC) van de eventuele inslag van brokstukken

of gebied en periode (UTC) van het neerkomen of de berging

preventiemaatregelen voor het terugkeren van het voorwerp in de atmosfeer

maatregelen voor het positioneren en/of neutraliseren in de omloopbaan

Gezien om te worden gevoegd bij Ons besluit van houdende uitvoering van sommige bepalingen van de wet van 17 september 2005 met betrekking tot de activiteiten op het gebied van het lanceren, het bedienen van de vlucht of het geleiden van ruimtevoorwerpen.

Vu pour être annexé à Notre arrêté du portant exécution de certaines dispositions de la loi du 17 septembre 2005 relative aux activités de lancement, d'opération de vol ou de guidage d'objets spatiaux.

VAN KONINGSWEGE:

De Minister van Economie,
Zelfstandigen en Landbouw,

PAR LE ROI:

La Ministre de l'Economie,
des Indépendants et de l'Agriculture,

Sabine LARUELLE

To be registered in Belgium?	CubeSat Name	Short name	Owner	Manufacturer(s)		CubeSat type (Double = 100*100*227 mm3 ; Triple = 100*100*340.5 mm3)	QB50 scientific instrument	Other experiments	Other main technologies	Maneuverability type (*)	Used frequencies		Use of nuclear power source
				Main	QB50 scientific instrument						Uplink	Downlink	
Yes	**SUSat**	**AU01**	UNIVERSITY OF ADELAIDE North Terrace SA 5005 Australia	University of Adelaide (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	Measurement of atmospheric species based on GPS pseudorange, inter-satellite communications	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	436.775 & 145.835 MHz	436.775 & 145.835 MHz	No
Yes	**UNSW-EC0**	**AU02**	UNIVERSITY OF NEW SOUTH WALES SYDNEY NSW 2052 Australia	University of New South Wales (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	GPS receiver & related experiment, electronics experiments	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	436.525 MHz	436.525 MHz	No
Yes	**i-INSPIRE II**	**AU03**	UNIVERSITY OF SYDNEY NSW 2006 Australia	University of Sydney (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	Nanophotonic spectrograph, radiation counter, microdosimeter, GPS receiver	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	436.330 MHz	436.330 MHz	No
Yes	**ZA-AEROSAT**	**AZ01**	STELLENBOSCH UNIVERSITY Faculty of Engineering RW Wilcocks Building, room 2037 Victoria Street Stellenbosch 7602 South Africa	Stellenbosch University (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Star Camera	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.905 MHz 2405-2445 MHz	437.2 MHz	No
Yes	**nSIGHT-1**	**AZ02**	SCS-SPACE 3rd Floor, St Andrews Building Somerset Links Office Park De Beers Avenue, Somerset West, Cape Town Western Cape, South Africa 7130	SCS-SPACE (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Imager, GPS receiver	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.9625 MHz	435.900 MHz 2405 - 2445 MHz	No
~~Yes~~	~~**QARMAN**~~	~~**BE05**~~	~~VON KARMAN INSTITUTE FOR FLUID DYNAMICS~~ ~~Chaussée de Waterloo, 72~~ ~~1640 Rhode-Saint-Genèse~~ ~~Belgium~~	~~VKI~~ ~~(see "owner" for address)~~	~~N/A~~	~~Triple~~	~~N/A~~	~~Study of the re-entry in the atmosphere by the use of: spectrometer, pressure and temperature measurements~~	~~Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system.~~ ~~In addtion: Thermal Protection System for atmospheric re-entry.~~	~~2~~	~~437.16 MHz~~	~~437.160 MHz~~	~~No~~
~~Yes~~	~~**14-BISat**~~	~~**BR01**~~	~~INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA FLUMINENSE (IFF)~~ ~~R. Dr. Siqueira, 273~~ ~~Campos/RJ, 28030-130~~ ~~Brazil~~	~~IFF~~ ~~(see "owner" for address)~~	~~TECHNICAL UNIVERSITY OF DRESDEN~~ ~~Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering~~ ~~01062 Dresden,~~ ~~Germany~~	~~Double~~	~~FIPEX~~ ~~(Atmospheric sensor: Flux Probe Experiment)~~	~~Innovative communication system (including inter-satellite communications)~~	~~Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system~~	~~1~~	~~145.985 MHz~~ ~~2405-2445 MHz~~	~~437.475 MHz~~ ~~2405-2445 MHz~~	~~No~~
Yes	**YUsend-QB50**	**CA01**	YORK UNIVERSITY Lassonde School of Engineering 4700 Keele Street Toronto ON M4J 1P3 Canada	York University - Lassonde School of Engineering (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Innovative communication system (including inter-satellite communications)	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	437.680 MHz	437.680 MHz	No
Yes	**ExAlta-1**	**CA03**	UNIVERSITY OF ALBERTA 2-22 Campus Tower 8625 - 112 Street Edmonton, Alberta T6G 2E1 Canada	University of Alberta (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Triple	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	Digital fluxgate magnetometer	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	436.705 MHz	436.705 MHz	No
Yes	**BUSAT-1**	**CN01**	BEIHANG UNIVERSITY School of Astronautics 37 Xueyan Road Haidian District Beijing 100191 China	Beihang University (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	BeiDou receiver	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.955 MHz	436.375 MHz	No
Yes	**LilacSat-1**	**CN02**	HARBIN INSTITUTE OF TECHNOLOGY NO.92 Xidazhi Street, Nangang District Harbin China	Harbin Institute of Technology (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	IR camera, amateur radio transponder	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.98 MHz 2405-2445 MHz	145.985MHz 436.510MHz 437.985MHz	No

To be registered in Belgium?	CubeSat Name	Short name	Owner	Manufacturer(s)		CubeSat type (Double = 100*100*227 mm3 ; Triple = 100*100*340.5 mm3)	QB50 scientific instrument	Other experiments	Other main technologies	Maneuverability type (*)	Used frequencies		Use of nuclear power source
				Main	QB50 scientific instrument						Uplink	Downlink	
Yes	**NJUST-1**	**CN03**	NANJING UNIVERSITY OF SCIENCE AND TECHNOLOGY (NJUST) 200 Xiao Ling Wei Street Nanjing 210094 China	Nanjing University of Science and Technology (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.960 MHz 2405-2445 MHz	436.570 MHz	No
Yes	**Ao Xiang-1**	**CN04**	NORTHWESTERN POLYTECHNICAL UNIVERSITY (NPU) Shaanxi Laboratory for Microsatellites 127 Youyi West Road Xi'an Shaanxi 710072 China	NPU (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.96 MHz	436.150MHz	No
Yes	**SOMP2**	**DE02**	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	TU Dresden (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Thermoelectric generator test bed, carbon nano tubes test bed, Magnetometer, software payload	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	437.405 MHz	437.405 MHz	No
Yes	**QBITO**	**ES01**	UNIVERSIDAD POLITECNICA DE MADRID (UPM) E-USOC, ETSIA Calle Ramiro de Maeztu, 7 28040 Madrid Spain	E-USOC, ETSIA, Universidad Politécnica de Madrid (UPM) (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	Phase change material, ADCS experiment	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.935 MHz	436.81 MHz	No
Yes	**Aalto-2**	**FI01**	AALTO UNIVERSITY School of Electrical Engineering, Department of Radio Science and Engineering P.O. Box 13000 00076 Aalto Finland	Aalto University (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	437.335 MHz	437.335 MHz	No
Yes	**X-CubeSat**	**FR01**	ECOLE POLYTECHNIQUE Route de Saclay 91128 Palaiseau cedex France	Ecole Polytechnique (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.86 MHz	437.020 MHz	No
Yes	**ENTRYSAT**	**FR02**	INSTITUT SUPERIEUR DE L'AERONAUTIQUE ET DE L'ESPACE (ISAE) 10, avenue Edouard-Belin - BP 54032 31055 Toulouse cedex 4 France	ISAE (see "owner" for address)	N/A	Triple	N/A	Study of the re-entry in the atmosphere (pressure and temperature sensors)	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.96 MHz	436.95 Mhz	No
Yes	**IP2 SAT**	**FR03**	INSTITUT SUPERIEUR DES SCIENCES ET TECHNIQUES (INSSET) 48 rue Raspail BP 422 02109 Saint-Quentin cedex France	INSSET (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.835 MHz	437.645 MHz	No
Yes	**SpaceCube**	**FR05**	MINES PARISTECH 60, Boulevard Saint-Michel 75272 Paris cedex 06 France	École des Mines Paristech (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.86 MHz	436.880 MHz	No
Yes	**DUTHSat**	**GR01**	DEMOCRITUS UNIVERSITY OF THRACE Department of Electrical and Computer Engineering Kimmeria Campus, Building B Xanthi 67100 Greece	Democritus University of Thrace (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	Telemetry board	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.81 MHz	436.420MHz	No
Yes	**UPSat**	**GR02**	UNIVERSITY OF PATRAS Applied Mechanics Lab. Patras University Campus GR-26504 Rio Patras Greece	University of Patras (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	Camera facing the Earth	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.860 MHz	435.765 MHz	No

ANNEX 1: Table of QB50 satellites - ISS launch

To be registered in Belgium?	CubeSat Name	Short name	Owner	Manufacturer(s)		CubeSat type (Double = 100*100*227 mm3 ; Triple = 100*100*340.5 mm3)	QB50 scientific instrument	Other experiments	Other main technologies	Maneuverability type (*)	Used frequencies		Use of nuclear power source
				Main	QB50 scientific instrument						Uplink	Downlink	
Yes	**Hoopoe**	**IL01**	HERZLIYA SPACE CENTER 3 Jabotinsky st. 46100 Herzliya Israel	Herzliya Science Center (see "owner" for address)	N/A	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	None	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.905 MHz	437.74 MHz	No
Yes	**Anusat-2**	**IN01**	ANNA UNIVERSITY Departement of Electronics and Communication Engineering, College of Engineering Chennai 600025 India	Anna University (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Innovative communication system (including inter-satellite communications), AIS receiver	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.905 MHz 2405-2445 MHz	437.580 MHz 2405.2445 MHz	No
No, will be registered by South Korea	**LINK**	**KR01**	KAIST Department of Aerospace Engineering 291 Daehak-ro Yuseong-gu, Daejeon 305-701 South Korea	KAIST (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	Langmuir probe (atmospheric sensor)	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.885 MHz	436.030 MHz	No
No, will be registered by South Korea	**SNUSAT-1**	**KR02**	SEOUL NATIONAL UNIVERSITY 504-B141 1 Gwanak-ro, Gwanak-gu 151-742 Seoul South Korea	Seoul National University (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Algorithm, low resolution imager	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.935 MHz	436.09 MHz	No
No, will be registered by South Korea	**SNUSAT-1b**	**KR03**	SEOUL NATIONAL UNIVERSITY 504-B141 1 Gwanak-ro, Gwanak-gu 151-742 Seoul South Korea	Seoul National University (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Algorithm, low resolution imager	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.905 MHz	435.950 MHz	No
~~Yes~~	~~**GAMASAT**~~	~~**PT01**~~	~~TEKEVER Rua Musas, 3.30 1990-113 Lisboa Portugal~~	~~Tekever (see "owner" for address)~~	~~TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany~~	~~Triple~~	~~FIPEX (Atmospheric sensor: Flux Probe Experiment)~~	~~Innovative communication system (including inter-satellite communications), re-entry capsule~~	~~Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system~~	~~1~~	~~145.985 MHz 2405-2445 MHz~~	~~437.090 MHz 2405-2445 MHz~~	~~No~~
Yes	**RoBiSAT / RO-01**	**RO01**	INFLPR - INSTITUTE OF SPACE SCIENCE Atomistilor, 409 077125 Magurule, ILFOV Romania	Institute of Space Science (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	Inter-satellite communication	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	435.950 MHz 2401.5 MHz	435.950 MHz 2401.5 MHz	No
Yes	**SamSat-QB50**	**RU01**	SAMARA STATE AEROSPACE UNIVERSITY (SSAU) 34, Moskovskoe Shosse Samara 443086 Russian Federation	Samara State Aerospace University (SSAU) (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	Attitude control system, navigation receiver	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.86 MHz	436.180 MHz	No
No, will be registered by Sweden	**qbee**	**SE01**	OPEN COSMOS LTD 20-22 Wenlock Road London N1 7GU England & LULEA UNIVERSITY OF TECHNOLOGY Dpt. Of Computer Science, Electrical and Space Engineering SE-971 87 Lulea Sweden	Open Cosmos Ltd. & LuleaUniversity of Technology (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	On-board computer, radiation counter	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	435.800 MHz	435.800 MHz	No
Yes	**BEEAGLESAT**	**TR01**	ISTANBUL TECHNICAL UNIVERSITY Faculty of Aeronautics and Astronautics 34469 Maslak Sariyer Istanbul Turkey	Istanbul Technical University (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	X-ray detector	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.985 MHz	437.370 Mhz	No
Yes	**HAVELSAT**	**TR02**	HAVELSAN Mustafa Kemal Mah. 2120 Cad, No: 39 06510 Ankara Turkey	Havelsan (see "owner" for address)	UNIVERSITY OF OSLO Department of Physics P.O. Box 1048 Blindern NO-0316 Oslo Norway	Double	mNLP (Atmospheric sensor: multi-Needle Langmuir Probe)	Communication system (S-band transmitter)	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.935 MHz	436.845 Mhz	No

To be registered in Belgium?	CubeSat Name	Short name	Owner	Manufacturer(s)		CubeSat type (Double = 100*100*227 mm3 ; Triple = 100*100*340.5 mm3)	QB50 scientific instrument	Other experiments	Other main technologies	Maneuverability type (*)	Used frequencies		Use of nuclear power source
				Main	QB50 scientific instrument						Uplink	Downlink	
Yes	**PHOENIX**	**TW01**	NATIONAL CHENG KUNG UNIVERSITY (NCKU) Dept. Of Electrical Engineering 1 University Road Tainan, Taiwan 70101 Republic of China	NCKU (see "owner" for address)	MULLARD SPACE SCIENCE LABORATORY(MSSL) University College London Holmbury Hill Road, Dorking UK Surrey RH5 6NT United Kingdom	Double	INMS (Atmospheric sensor: Ion-Neutral Mass Spectrometer)	Solar ultra-violet sensor	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.86 MHz	436.915 MHz	No
Yes	**PolyITAN-2-SAU**	**UA01**	NATIONAL TECHNICAL UNIVERSITY OF UKRAINE Kyiv Polytechnic Institute Peremohy Avenue 37 03056 City of Kyiv Ukraine	National Technical University of Ukraine (see "owner" for address)	TECHNICAL UNIVERSITY OF DRESDEN Institute of Aerospace Engineering, Faculty of Mechanical Science and Engineering 01062 Dresden, Germany	Double	FIPEX (Atmospheric sensor: Flux Probe Experiment)	GPS-Glonass receiver, momentum wheel	Classical CubeSat platform: power supply, on-board computer, communication system, attitude determination and control system	1	145.96 MHz	436.600 MHz	No

(*): Two types of maneuverability are defined:
- Type 1: The CubeSat is placed into its orbit by the NRCSD CubeSat deployer. Upon release from the upper stage, the CubeSat will rotate to change its positioning ensuring that the science sensor point into the predefined flight direction. The CubeSat has no maneuvering capabilities that allow it to change its orbit (altitude, inclination) which is fixed (low Earth orbit). The orbit of the launched CubeSat will decay naturally due to residual atmospheric drag in space. 8.1 NanoRacks will command the satellite deploy from the ISS into space upon authorization of the von Karman Institute only.
- Type 2: The CubeSat has maneuvering capabilities that allow it to change its orbit (altitude, inclination) by means of a propulsion system or/and drag increasing system. All maneuvers are performed under VKI authority, as stated in Annex 4.

Annex 2

QB50

Milieu-effectenstudie

(Environmental Impact Assessment)

-

ISS Launch
with Atlas-V 401 rocket
and the International Space Station
procured through NanoRacks LLC

CONTENTS

PART I: ACTIVITIES AND OBJECTIVES

1. Objective of the activity and implementation through nanosatellites

The launch described in the present document (so-called *QB50 "ISS" launch*) has been procured by the von Karman Institute for Fluid Dynamics (VKI, Belgium) in the framework of the EU FP7 QB50 Project[1].

The QB50 mission aims to launch a network of (around) 50 nanosatellites (CubeSats) built by University Teams all over the world to perform first-class science in the largely unexplored lower thermosphere. More specifically, the constituents of the thermosphere will be measured by three types of scientific instruments carried by the CubeSats. Some CubeSats will also demonstrate new technology developments.

QB50 will make use of two different launch campaigns to complete the orbital injection of all the CubeSats, as shown in Table 1. Each of the campaigns will be the object of a request for authorization and of an environmental impact assessment. The present document reports on the ISS launch campaign.

Launch campaign	Launcher	Main objective	Number of CubeSats	Launch period
ISS	Atlas-V (United Launch Alliance & Orbital ATK) and ISS facilitated by Nanoracks	Scientific + technology demonstration	37 *(32 to be authorized by Belgium + 4 authorized and registered by the USA)*	March – July 2017
Polar	PSLV	Polar scientific measurement and In-Orbit Demonstration (IOD)	8	Q2-Q4 2017

Table 1 - Definition of the QB50 launch campaigns.

The ISS mission will focus on high-resolution scientific measurements of constituents of the thermosphere at low latitude between 200 - 380km altitude, which is the least explored layer of the atmosphere. To explore this region, atmospheric explorers were flown in the past in highly elliptical orbits (typically 200 km perigee, 3000 km apogee); they carried experiments for single-point, in-situ measurements but the time spent in the region of interest was only a few tens of minutes. By contrast, QB50 will provide multi-point, in-situ measurements for a time period on the order of months, instead of minutes.

Nowadays, sounding rocket flights provide the only in-situ measurements. While they do explore the whole lower thermosphere, the time spent in this region is rather short (a few minutes). There are only a few flights per year and they only provide measurements along a single column. Powerful remote-sensing instruments on board Earth observation satellites in higher orbits (600–800 km) receive the backscattered signals from atmospheric constituents at various altitudes. While this is an excellent tool for exploring the lower layers of the atmosphere up to about 100 km, it is not ideally suited for exploring the lower thermosphere because there the atmosphere is so rarefied that the return signal is weak. The same holds for remote-sensing observations from the ground with lidars and radars.

[1] "QB50: An international network of 50 CubeSats for multi-point, in-situ measurements in the lower thermosphere and re-entry research". EU FP7 Grant Agreement Number 284427

The multi-point, in-situ measurements of QB50 will be complementary to the remote-sensing observations by the instruments on Earth observation satellites and the in-situ measurements by sounding rockets. All atmospheric models, and ultimately thousands of users of these models, will benefit from the measurements obtained by QB50 in the lower thermosphere.

To this end, 34 double nanosatellites (34 “double CubeSats”) of approximate dimensions 20x10x10cm and 2 triple nanosatellites (2 “triple CubeSats”) of approximate dimensions 30x10x10cm are being built and launched. Figure 1 shows a double CubeSat. Almost all CubeSats will carry one instrument out of the 3 different QB50 instruments.[2]

Figure 1 – A double CubeSat (QB50p1 satellite).

The QB50 ISS launch (object of the present document) will take place using the Atlas-V rocket built and operated by United Launch Alliance (ULA), in partnership with Orbital ATK Inc. The launch base is located in Florida, USA (see Figure 2).

[2] Please note that amongst the 36 CubeSats for the ISS launch, only 32 have to be authorized by the Belgian state. Four CubeSats will be authorized and registered by the United States.

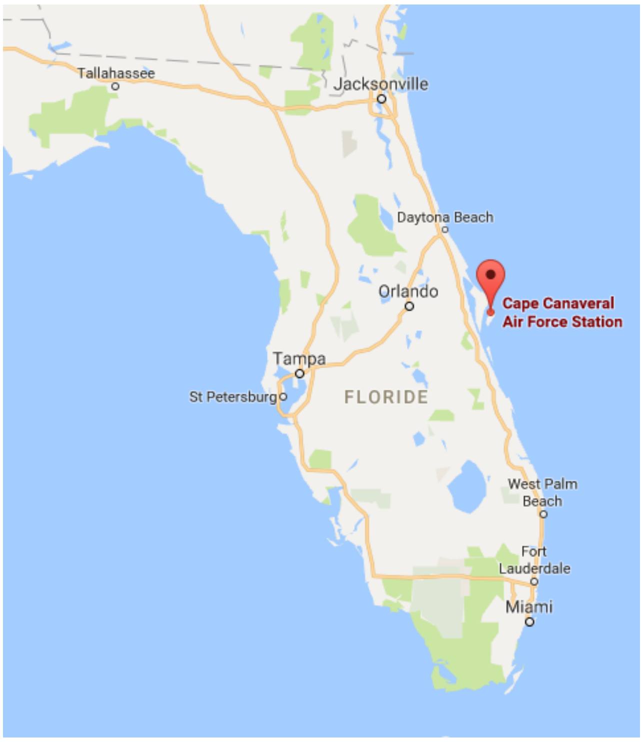


Figure 2 - Wallops Flight Facility

The QB50 CubeSats will be boarded as cargo in the Orbital ATK Cygnus automated spacecraft. Cygnus is itself launched by the ULA Atlas-V rocket that delivers it to a 230 km orbit 21 minutes after launch. From there, Cygnus begins orbit adjustments and phasing manoeuvres in order to dock with ISS that orbits Earth at an altitude of 410 km. After a few days, Cygnus is finally grabbed by the robotic arm and berthed to the International Space Station.

All along the process, CubeSats are stored in Nanoracks CubeSat Deployers (NRCSD). The NanoRacks CubeSat Deployer (NRCSD) is a self-contained CubeSat deployer system that mechanically and electrically isolates CubeSats from the ISS, cargo resupply vehicles, and ISS crew. For a deployment, NRCSD are attached to a platform, which is moved outside via the Kibo Module's Airlock and slide table that allows the Japanese Experimental Module Remote Manipulator System (JEMRMS) to move the deployers to the correct orientation for the satellite release and also provides command and control to the deployers. Each NRCSD is capable of holding six CubeSat Units (2 or 3 QB50 CubeSats).

Figure 3 shows CubeSats being deployed out of the NRCSD.

Figure 3 - CubeSats being deployed from the ISS.

The launch window for the Atlas-V flight for the ISS campaign has been established from 1st March 2017 until 30th July 2017. The CubeSats will be deployed from the ISS in two batches: the first batch a few weeks after the Atlas-V launch and the second batch 2-3 months later.

The launch is procured by VKI through Nanoracks LLC, which coordinates and takes care of all activities involving Orbital ATK and NASA.

2. Atlas-V 401 launch vehicle

2.1. General overview

Atlas-V 401 is a two-stage vehicle that provides low-Earth orbit launch capability for payloads weighing up to 10,000 kg.

A general overview of the launch vehicle is shown in Figure 4.

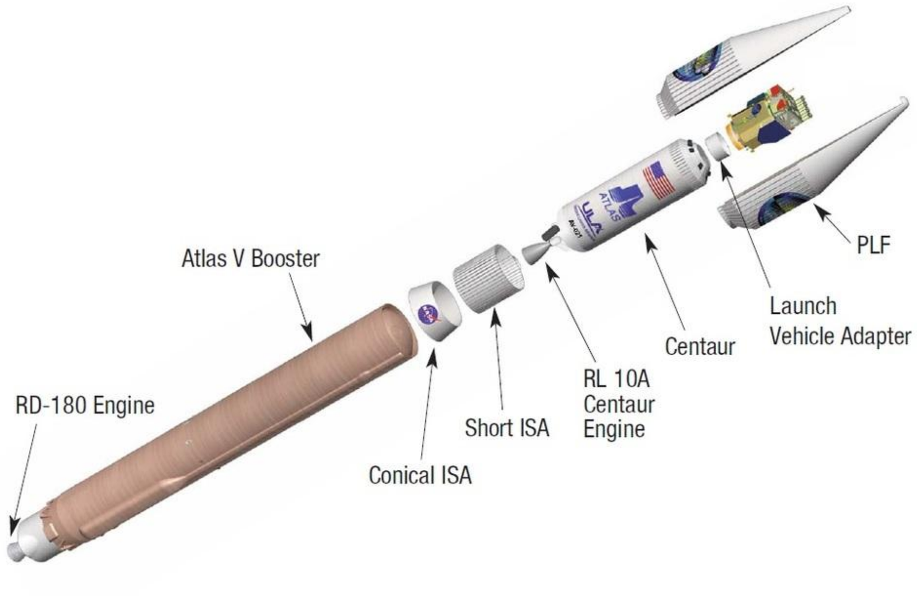


Figure 4 - Expanded view of Atlas-V 401 launch vehicle.

In the Atlas-V 401 configuration, the first stage is an Atlas Common Core Booster that is 32.46 meters long and has a diameter of 3.81 meters. It is powered by a single RD-180 engines. It burns kerosene and liquid oxygen.

The second stage is a Centaur Stage. Centaur is 3.05 meters in diameter and 12.68 meters in length. It is a cryogenic rocket stage using liquid hydrogen and liquid oxygen as propellants.

Atlas V 401 features a 4.2-meter payload Fairing under which it can carry payloads of up to 10,470 Kilograms to Low Earth Orbit. For the launch of interest, it will carry the Cygnus spacecraft.

Cygnus is an American automated cargo spacecraft developed by Orbital ATK. The QB50 CubeSats (loaded into their deployers) will be carried in the Pressurized Cargo Module of Cygnus.

2.2. Launcher quality controls

United Launch Alliance (ULA) organizations utilize a process-management approach to add value to their products and services. With this approach, a variety of process owners and people working within a process use objective measures to understand, evaluate, sustain, and improve the performance of their processes.

ULA tracks progress toward improvement through established process-improvement goals that support both the process and the customer's expectations, while tracking progress toward these goals. ULA seeks to understand, anticipate, and be responsive to customer requirements and expectations. ULA establishes processes to ensure the resulting products and services comply with customer requirements and that customer satisfaction has been achieved.

ULA operates an AS9100 (Quality Management Systems-Aerospace-Requirements) registered quality management system. ULA is internationally accredited through National Quality Assurance (NQA) under registration number 12317. The registration was conferred in October 2004, and includes ULA's Centennial, CO; Pueblo, CO; Decatur, AL; San Diego, CA; Harlingen, TX; Cape Canaveral Air Force Station, FL: and Vandenberg Air Force Base, CA facilities. The change scope of the registration includes the acquisition, final assembly, preparation, test, payload integration and launch of space system launch vehicles. This includes the design, development, installation, test and operation of associated launch facilities and ground support equipment.

NQA annually revalidates adherence to the AS9100 quality standard as an independent, third party registrar. In addition, the U.S. Government's Defense Contract Management Agency (DCMA) monitors AS9100 compliance onsite and maintains insight into ULA processes.

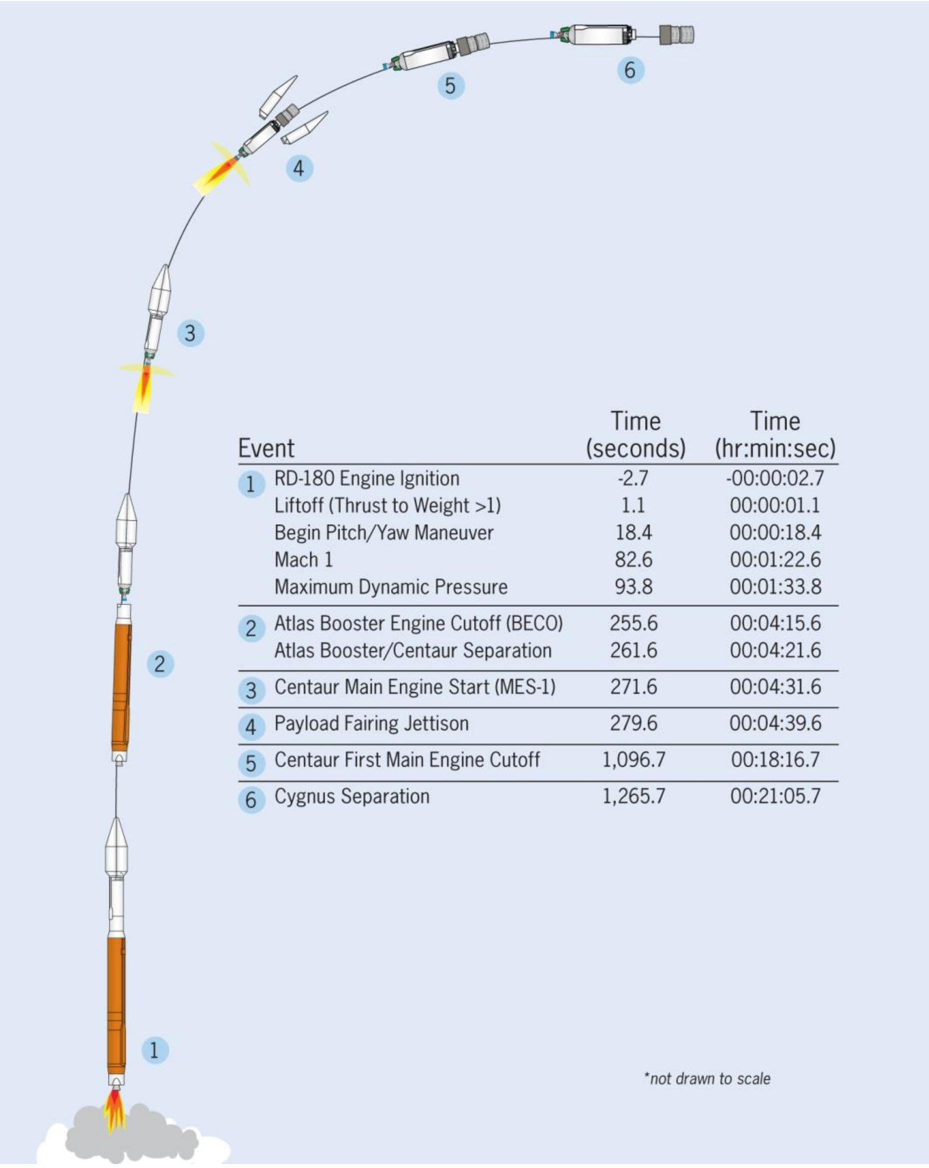
AS9100 is executed through ULA's internal command media, which is described in the *Quality Management System Manual (QS-100)* and CPS-033, ULA command media. AS9100 is a comprehensive quality management system that provides a framework of operating requirements.

ULA maintains its AS9100 registration to the latest released version of the standard. ULA's registration also certifies compliance to ISO 9001:2008.[3]

2.3. Atlas-V mission profile

Figure 5 gives a detailed overview of the mission profile of the Atlas-V 401 launch vehicle with Cygnus payload.

[3] Source: Atlas V Launch Services User's Guide, Revision 11, March 2010.



	Event	Time (seconds)	Time (hr:min:sec)
1	RD-180 Engine Ignition	-2.7	-00:00:02.7
	Liftoff (Thrust to Weight >1)	1.1	00:00:01.1
	Begin Pitch/Yaw Maneuver	18.4	00:00:18.4
	Mach 1	82.6	00:01:22.6
	Maximum Dynamic Pressure	93.8	00:01:33.8
2	Atlas Booster Engine Cutoff (BECO)	255.6	00:04:15.6
	Atlas Booster/Centaur Separation	261.6	00:04:21.6
3	Centaur Main Engine Start (MES-1)	271.6	00:04:31.6
4	Payload Fairing Jettison	279.6	00:04:39.6
5	Centaur First Main Engine Cutoff	1,096.7	00:18:16.7
6	Cygnus Separation	1,265.7	00:21:05.7

Figure 5 - Mission Profile of Atlas-V 401.

2.4. Atlas-V launch vehicle performance characteristics

Figure 6 below gives an overview of the performance of the Atlas-V launch vehicle for circular low earth orbits at for various configurations. The payload mass the launch vehicle can carry for each of the configurations and altitudes is mentioned. As mentioned before, the QB50 launch will take place with the 401 configuration.

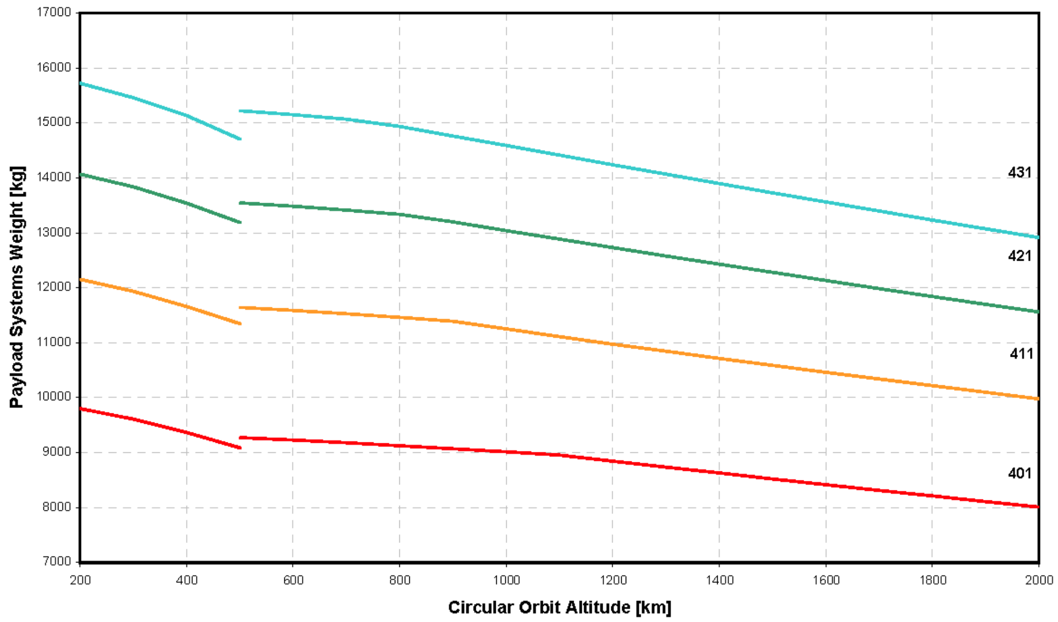


Figure 6 – Atlas-V launch vehicle performances.

2.5. Launch and track record

Since its maiden flight in August 2002, Atlas-V has a perfect mission success rate over its 65 launches. There have been two anomalous flights but without compromising the missions success.

Annex 1 summarizes Atlas-V mission history.

2.6. Conclusion

The Atlas-V rocket operated by United Launch Alliance has a perfect mission success rate. The two previous Atlas-V missions carrying Cygnus were successful launches, providing supplies and payloads (including CubeSats) to the ISS.

Therefore the QB50 Consortium, coordinated by VKI, with the cooperation of NANORACKS LLC (service provider for the CubeSat deployment) considers the Atlas-V a reliable rocket to achieve a successful upload of the CubeSats on the ISS.

PART II: POTENTIAL IMPACT OF THE ACTIVITIES ON THE TERRESTRIAL ENVIRONMENT, THE ATMOSPHERE AND THE NATURAL AND HUMAN ENVIRONMENT OF THE PLACE OF LAUNCHING

The potential impact of Atlas-V launches from Cape Canaveral SLC-41 was thoroughly studied by U.S. Air Force in two main references, from which are extracted parts of the text below.

[1] Final Environmental Impact Statement Evolved Expendable Launch Vehicle Program, April 1998.
[2] Final Supplemental Environmental Impact Statement Evolved Expendable Launch Vehicle Program, March 2000.

Document [1] has been prepared in accordance with the National Environmental Policy Act (NEPA) to analyze the potential environmental consequences of the development, deployment, and operation of Evolved Expendable Launch Vehicles (EELV) systems (such as Atlas-V). It includes analyses of potential impacts to local community (employment and population), land use and aesthetics, transportation, utilities, hazardous materials and hazardous waste management, health and safety, geology and soils, water resources, air quality (upper and lower atmosphere), noise, orbital debris, biological resources, cultural resources, and environmental justice.

Main conclusions of interest here are:

- Peak launch year emissions would not be sufficient to jeopardize the attainment status for criteria pollutants at either installation. EELV systems would have lower emissions per launch than No-Action Alternative systems, and no adverse impacts are anticipated.
- Launches would produce no estimated emissions of ozone-depleting substances, and therefore would not contribute to any degradation of the stratospheric ozone layer.
- Launch and sonic boom noise would be short-term and temporary, and no impacts to structures or humans are anticipated.
- A small, incremental contribution to the existing orbital debris population could occur; however, all EELV program vehicles would be designed to minimize orbital debris.
- Impacts to vegetation and wildlife would be minimal.

Reference [2] is an additional analysis for the addition of solid rocket boosters (SRB) to the launcher. In the 401 configuration targeted for QB50 launch, no SRB will be used so reference [2] is not further detailed.

In addition to these studies, the environmental impact is continuously monitored through NASA/Kennedy Space Center (KSC) Environmental Program.

The NASA/Kennedy Space Center (KSC) Environmental Program is managed by the Environmental Management Branch (EMB), and the Environmental Assurance Branch (EAB), part of the Center Operations Directorate. The Environmental Branches have the professional capability for environmental policy development, engineering and research. The EMB is responsible for managing the KSC Sustainable Environment Management System (SEMS) and the recycling, sustainable acquisition, hazardous materials, pollution prevention, energy management, natural resources, historic properties and National Environmental Policy Act (NEPA) programs. These responsibilities include coordination and integration of all programs in these areas and all formal contact with environmental regulatory agencies. The EAB is responsible for managing the KSC environmental permitting, compliance, and remediation programs. For these areas, responsibilities include coordination and integration of all environmental programs, all formal contact with environmental regulatory agencies, development assistance and review of environmental permits, remediation of contaminated sites, cease and desist authority for all polluting activities, and compliance monitoring and surveillance.

These services are supplied by a group of highly skilled professionals with backgrounds in civil, mechanical, chemical, environmental, and electrical engineering, as well as physics, math, geology, biology, business, and ecology. The professional services supplied by this staff include: providing guidance on regulatory requirements, providing liaison and advocacy for the Center with regulatory agencies and the general public, conducting public hearings on environmental issues, maintaining an inventory of KSC's environmental conditions, and providing technical review of designs which have environmental implications.[4]

All activities are carried out in compliance with the National Environmental Policy Act (NEPA).

[4] http://environmental.ksc.nasa.gov/index.htm

PART III: POTENTIAL IMPACT ON OUTER SPACE

1. Atlas-V rocket

The 2 stages and the fairing of Atlas-V are de-orbited. There is therefore no impact on outer space caused by the Atlas-V rocket.

2. Cygnus spacecraft

After staying typically 30 days docked to the ISS, the Cygnus spacecraft is released. It performs several engine burns to de-orbit and re-enter the atmosphere over the Pacific Ocean. During re-entry, the vehicle breaks up and burns up to some extent before surviving fragments fall into the Pacific, far away from populated land masses. There is therefore no impact on outer space caused by the Cygnus spacecraft.

3. ISS operations

The NanoRacks CubeSat Deployer (NRCSD) is a self-contained CubeSat deployer system that mechanically and electrically isolates CubeSats from the ISS, cargo resupply vehicles, and ISS crew. The NRCSD design is compliant with NASA ISS flight safety requirements and is space qualified.

4. CubeSats

The orbit of the CubeSats will naturally decay and CubeSats will be fully destructed while re-entering the atmosphere. This will happen less than 5 years after deployment for the considered orbit.

PART IV: NON-TECHNICAL SUMMARY

In the framework of the EU FP7 Project aiming at the launch of 50 CubeSats for atmospheric research, the VKI as coordinator of the project, have procured by the launch service through the US Company NANORACKS LLC, for a cargo flight to the ISS, to be performed with an Atlas-V rocket operated by United Launch Alliance in partnership with Orbital ATK (OA-7 mission of NASA). NANORACKS has extensive experience in this typology of launch service for CubeSats, foreseeing an upload to the ISS and a successive deployment from the robotic arm of the station, including everything related to safety and risk mitigation: at the date, NANORACKS has either uploaded more than 110 CubeSats to the ISS, having all of them cleared for flight from NASA, from a safety perspective.
As shown in this document, NANORACKS is supporting the launch and deployment management, for the cargo mission to upload the CubeSats on the ISS. Nevertheless, to be cleared for flight, all the hardware has to pass through a safety review from NASA.

As an Operator located in Belgium and therefore subject to the Belgian law of 17 September 2005 (revised by the law of 1 December 2013) on the activities of launching, flight operation or guidance of space objects, the VKI is responsible to providing to the Belgian authorities an environmental impact assessment of the foreseen launch activity.

As shown in section II, the safety and environmental impact of the launches with an Atlas-V rocket from the Cape Canaveral Space Launch Complex 41 was thoroughly studied and is closely monitored, guaranteeing a sustainable space launch activity.

Several mitigation activities and ongoing environmental practices contribute to reduce or limit the potential environmental impact of the launch: please refer to reference documents in section II for details.

Based on financial, technical and programmatic assumptions, the selected launch vehicle, through the launch service offered by NANORACKS, offers the best guarantees for the realization of the launch objectives. Nevertheless, launching space objects into outer space is never without risks and especially potential negative impact on the environment can never be completely excluded. We think however the environmental impact has been assessed and has been analyzed. For the QB50 project, being a scientific endeavor with limited budget, the selected launch solution offers the best value for money.

PART V: MEMO ON THE EXPERTISE OF THE VON KARMAN INSTITUTE FOR FLUID DYNAMICS AS OPERATOR

1. Introduction: Implementation of the Belgian space law

The QB50 project, funded by the European Commission and executed by the von Karman Institute for Fluid Dynamics (VKI) intends to launch 45 nanosatellites into Low Earth Orbit by means of 2 distinct launches. The object of the present document is the launch of 37 nanosatellites by an Atlas-V rocket followed by a deployment from the International Space Station to an altitude of approximately 410 km at an inclination of approximately 52 degrees. The VKI will act as the Operator in the framework of the Belgian space law, but implements the launch activity through an American launch service provider (Nanoracks LLC).

The relationship between the aforementioned partners is illustrated in Figure 8.

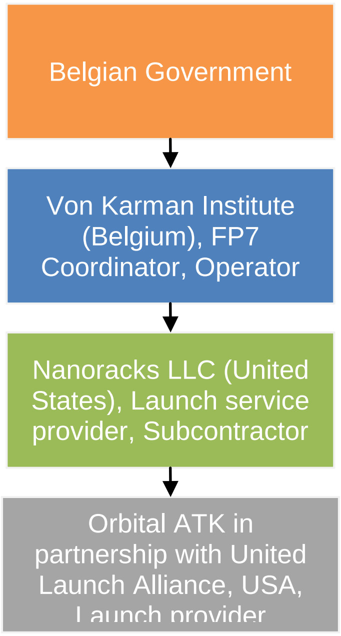


Figure 8 – Implementation of the Belgian space law with respect to the QB50 ISS launch campaign.

2. Expertise as an Operator

VKI is a non-profit international educational and scientific organization, hosting three departments[5]. It provides post-graduate education in fluid dynamics and encourages "training in research through research". The VKI undertakes and promotes research in the field of fluid dynamics. It possesses about fifty different wind tunnels, turbomachinery and other specialized test facilities, some of which are unique or the largest in the world. Extensive research on experimental, computational and theoretical aspects of gas and liquid flows is carried under the direction of the faculty and research engineers, sponsored mainly by governmental and international agencies as well as industries.

[5] Aeronautics and Aerospace (AR), Environmental and Applied Fluid Dynamics (EA), Turbomachinery and Propulsion (TU)

The VKI is or was involved in the instrumentation of all ESA re-entry spacecraft such as the Atmospheric Reentry Demonstrator (ARD), European eXPErimental Reentry Testbed (EXPERT), the Intermediate eXperimental Vehicle (IXV) and has started in 2010 to design, end-to-end, its own miniaturized re-entry vehicle called Qarman.

As of 2011, the VKI is charged with the management of the QB50 project consisting of the launch of 50 CubeSats. In the framework of the QB50 project, three precursor satellites were launched on the 19th June 2014 under the authorization number 2014/01 (objects 2014-B-SC-001, 2014-B-SC-002, and 2014-B-SC-003). They have been operated by the VKI since then.

The QB50 team of VKI involved in (the preparation of) the launch consists of the following persons:

Name	Responsibility
Dr. Jean Muylaert	Director VKI, FP7 QB50 General Supervisor
Dr. Davide Masutti	QB50 Project Manager
Thorsten Scholz	Ground Segment Engineer and Mission Analyst
Paride Testani	Launch and Space Segment Engineer
Amandine Denis	Space Segment Engineer & CubeSat Coordinator

Detailed curriculum vitae of the persons involved from VKI is attached in Annex 2.

3. Alternative launcher scenario's analysis

In accordance with the provisions of the Belgian space law, VKI conducted an in depth analysis of the European and international launchers potentially available for realizing the objectives of the QB50 ISS launch. The results of this analysis are described in this chapter.

The launch scenario consisting of the choice of provider, the launch site and further characteristics such as contractual conditions have been analysed to best match the needs of the QB50 project, the Regulations of the EU FP7 program and other constraints. The disregarded alternatives and the reasons are given below:

Launch Provider and Launcher	Reason for disregard
ESA/Arianespace • VEGA • ARIANE 5 • SOYUZ	In particular the launch cost is prohibitively high. Further reason for disregard is the timely unavailability of a launch into a suitable Low Earth Orbit
American Launch providers such as United Launch Alliance, Orbital Science, SpaceX • Atlas 5 • Antares • Falcon 9	The costs for the launch are prohibitively high. Further reason for disregard is the timely unavailability of a launch into a suitable low Earth Orbit
Chinese launch providers such as China Great Wall Industry Corporation (CGWIC) • MLVT • Long March	Mostly export related issues prevented the consideration of Chinese provided launch vehicles.
Russian launchers such as DNEPR	The DNEPR program suffers from severe delays and is apparently on-hold.

ANNEX 1 – ATLAS-V DETAILED LAUNCH AND TRACK REPORT

#	Date	Type	Launch site	Orbit	Outcome
1	August 21, 2002	401	CCAFS SLC-41	GSO	Success
2	May 13, 2003	401	CCAFS SLC-41	GSO	Success
3	July 17, 2003	521	CCAFS SLC-41	GSO	Success
4	December 17, 2004	521	CCAFS SLC-41	GSO	Success
5	March 11, 2005	431	CCAFS SLC-41	GSO	Success
6	August 12, 2005	401	CCAFS SLC-41	Heliocentric to Areocentric	Success
7	January 19, 2006	551	CCAFS SLC-41	Hyperbolic	Success
8	April 20, 2006	411	CCAFS SLC-41	GSO	Success
9	March 9, 2007	401	CCAFS SLC-41	LEO	Success
10	June 15, 2007	401	CCAFS SLC-41	LEO	Partial failure (payload reached lower than intended orbit; customer declared success)
11	October 11, 2007	421	CCAFS SLC-41	GTO	Success
12	December 10, 2007	401	CCAFS SLC-41	Molniya	Success
13	March 13, 2008	411	VAFB SLC-3E	Molniya	Success
14	April 14, 2008	421	CCAFS SLC-41	GTO	Success
15	April 4, 2009	421	CCAFS SLC-41	GTO	Success
16	June 18, 2009	401	CCAFS SLC-41	HEO to Lunar	Success
17	September 8, 2009	401	CCAFS SLC-41	GTO	Success
18	October 18, 2009	401	VAFB SLC-3E	LEO	Success
19	November 23, 2009	431	CCAFS SLC-41	GTO	Success
20	February 11, 2010	401	CCAFS SLC-41	GTO	Success
21	April 22, 2010	501	CCAFS SLC-41	LEO	Success
22	August 14, 2010	531	CCAFS SLC-41	GTO	Success
23	September 21, 2010	501	VAFB SLC-3E	LEO	Success
24	March 5, 2011	501	CCAFS SLC-41	LEO	Success
25	April 15, 2011	411	VAFB SLC-3E	LEO	Success
26	May 7, 2011	401	CCAFS SLC-41	GTO	Success
27	August 5, 2011	551	CCAFS SLC-41	Hyperbolic to Jovicentric	Success
28	November 26, 2011	541	CCAFS SLC-41	Hyperbolic	Success
29	February 24, 2012	551	CCAFS SLC-41	GTO	Success
30	May 4, 2012	531	CCAFS SLC-41	GTO	Success
31	June 20, 2012	401	CCAFS SLC-41	GEO	Success
32	August 30, 2012	401	CCAFS SLC-41	MEO	Success
33	September 13, 2012	401	VAFB SLC-3E	LEO	Success
34	December 11, 2012	501	CCAFS SLC-41	LEO	Success

35	January 31, 2013	401	CCAFS SLC-41	GTO	Success
36	February 11, 2013	401	VAFB SLC-3E	LEO	Success
37	March 19, 2013	401	CCAFS SLC-41	GTO	Success
38	May 15, 2013	401	CCAFS SLC-41	MEO	Success
39	July 19, 2013	551	CCAFS SLC-41	GTO	Success
40	September 18, 2013	531	CCAFS SLC-41	GTO	Success
41	November 18, 2013	401	CCAFS SLC-41	Hyperbolic to areocentric	Success
42	December 6, 2013	501	VAFB SLC-3E	LEO	Success
43	January 24, 2014	401	CCAFS SLC-41	GTO	Success
44	April 3, 2014	401	VAFB SLC-3E	LEO	Success
45	April 10, 2014	541	CCAFS SLC-41	GEO	Success
46	May 22, 2014	401	CCAFS SLC-41	GEO	Success
47	August 2, 2014	401	CCAFS SLC-41	MEO	Success
48	August 13, 2014	401	VAFB SLC-3E	LEO	Success
49	September 17, 2014	401	CCAFS SLC-41	GTO	Success
50	October 29, 2014	401	CCAFS SLC-41	MEO	Success
51	December 13, 2014	541	VAFB SLC-3E	Molniya	Success
52	January 21, 2015	551	CCAFS SLC-41	GTO	Success
53	March 13, 2015	421	CCAFS SLC-41	HTO	Success
54	May 20, 2015	501	CCAFS SLC-41	LEO	Success
55	July 15, 2015	401	CCAFS SLC-41	MEO	Success
56	September 2, 2015	551	CCAFS SLC-41	GTO	Success
57	October 2, 2015	421	CCAFS SLC-41	GTO	Success
58	October 8, 2015	401	VAFB SLC-3E	LEO	Success
59	October 31, 2015	401	CCAFS SLC-41	MEO	Success
60	December 6, 2015	401	CCAFS SLC-41	LEO	Success
61	February 5, 2016	401	CCAFS SLC-41	MEO	Success
62	March 23, 2016	401	CCAFS SLC-41	LEO	Success (First stage shut down early but did not affect mission outcome)
63	June 24, 2016	551	CCAFS SLC-41	GTO	Success
64	July 28, 2016	421	CCAFS SLC-41	GTO	Success
65	September 8, 2016	411	CCAFS SLC-41	Heliocentric	Success

ANNEX 2 – CURRICULUM VITAE KEY PERSONS VKI AND ISIS B.V.

Dr. Jean Muylaert (VKI)

Personal info

Jean Muylaert received his master degree in Electromechanical Engineering from the University of Leuven (Belgium) on Electro mechanics followed by the diploma degree from the Von Karman Institute Brussels on transonic Aerodynamics. His industrial professional carrier started at DORNIER Germany where he was in charge of developing tools to improve re-entry vehicles aerothermodynamics as well as fighter aircraft design and optimization methods. While at DORNIER he was seconded to the ETW (European Transonic Wind tunnel) team in Amsterdam and later to Köln where he was in charge of the design, the commissioning and the calibration of the ETW airline components as well as leading the developments on wind tunnel wall corrections methods.

As from 1988 he joined the European Space Agency (ESA) where he has setup and led the Aerothermodynamics (ATD) section providing support for all launchers and re-entry missions associated with planetary entry and Earth re-entry vehicles as well as promoting R& D activities in the field of environmental physics, measurement techniques, CFD validation including wind tunnel and flight instrumentation developments. More recently he embarked on a series of in flight research projects in close collaboration with Russia and in particular with Makeyev and ITAM associated with critical fluid dynamic issues for design. He is the chief scientist of the European Experimental Re-entry Test bed (EXPERT) flight project involving many universities, research establishments and industries to be launched on Russian Volna launcher early 2012. As from 1 November 2008 he became the Director of the VKI.

Relevant Scientific and Research Activities

Development of instrumentation for measurements of physical parameters associated with re-entry; flush air-data systems for environmental characterization, non intrusive techniques such as emission spectroscopic measurements for thermo chemistry data basing and validation of physical models for real gas chemistry and radiation. Space weather code development and validation; Post flight analysis of planetary entry and re-entry capsules with emphasis on black out modelling and debris analysis. Low flying satellite aero analysis, DCMS computations for in orbit station keeping, orbit raising, contamination and thrusters interactions; monitoring large projects involving Makeyev Russian launchers. Managing large networks for in flight research and in orbit demonstration programmes (EXPERT, ARD, Post flight Huygens)

Honors, professional achievements

Past Member of NATO AGARD Fluid Dynamics Panel (FPD), Past member of Committee Technique Ariane (CTA) for Arianespace, Member of AIAA (USA), Member of Scientific Committees of, CNRS, ONERA, DLR, Member of Programme Committee of ICMAR/ITAM Novosibirsk, Founding Member of the EUCASS (European Conference for Aerospace Sciences), Chairman of NATO Research and Technology Organisation (RTO) WG10 on “Technologies of Propelled Hypersonic Flight”, Chairman of the ESA working group on Plasma facilities and gas surface interactions , Invited speaker at conferences (AIAA, ICMAR, AAAF, ESA), Evaluation and member of PhD Committees, Evaluation of patents, Evaluation of STW(NL), ASI(I) and EU proposals, Member of the Supersonic tunnel association (STA), Member of the IAA (International Academy of Astronautics), Trustees Board member of CEAS (Counsel of European Aerospace Societies). Received recently Title “Honorable Doctor Degree from the Siberian Branche of the Russian Academy of Sciences (SBRAS).

Publications:

He has edited 4 books, 2 Lecture Series, published more than 80 papers and is a lecturer at European universities on fluid dynamics.

Dr. Davide Masutti (VKI)

Personal info

Dr. Davide Masutti is a Senior Research Engineer at the von Karman Institute for Fluid Dynamics, Belgium. He received his M.S in Space Engineering from the University of Padova (Italy) and short after he moved to the von Karman Institute for a Research Master (formerly Diploma Course) in high speed aerodynamics. After the master, Dr. Masutti started his PhD investigating the mechanisms of boundary layer transition at hypersonic regime on the ESA EXPERT flight vehicle and he got his doctoral degree in collaboration with the Technical University of Delft (The Netherlands). Dr. Masutti joined the QB50 project with the role of CubeSat Coordinator seeking to broaden his expertise in the aerospace industry. He recently takes the position of Principal Investigator in the QB50 project to coordinate the scientific goals of the mission. His research in now focused on space weather and in particular in the characteristics of the thermosphere at low and high latitudes. Dr. Masutti became QB50 project manager in October 2016.

Relevant Experience

2016 – to date	QB50 Project Manager
2014 – to date	Mission Scientist: Coordinated an international Science Working Group for the investigation of the mid-lower thermosphere. Coordinated the manufacturing, testing and integration of the scientific payloads of the QB50 mission. Defined the LEOP and science operations for the constellation.
2013 – 2014	System Engineer: Coordinated the technical development of more than 50 CubeSats in the QB50 Project. Reviewed PDR and CDR documentations in compliance with mission requirements.
2008 – 2013	PhD in Aerospace Engineering, TU Delft, The Netherlands
2007 – 2008	VKI Diploma Course
2001 – 2007	MSc in Aerospace Engineering, Universita di Padova, Italy

Thorsten Scholz (VKI)

Personal info

Thorsten Scholz received his diploma degree in Aerospace Engineering from the University of Stuttgart (Germany) specialized in aerodynamics and light-weight design. During the study he worked on the development of a test rack for zero-G flights at EADS Space Transportation, Germany. He continued working at the University of Stuttgart after the graduation in 2009 as a lecturer for 'data processing' for one year and worked in parallel at ASTOS Solutions, Germany, as a development engineer. He was there among other things in charge of database generation and maintenance in the framework of different ESA projects and software development for the risk assessment of re-entry objects.

He joined the Von Karman Institute in 2010 and obtained a master-after-master degree in 2011 working on the aerodynamic characterization of the re-entry vehicle IXV. Afterwards he entered the PhD-programme at VKI working on the mission design of a CubeSat network and an aerodynamic stability and de-orbiting system for CubeSats.

Relevant Scientific and Research Activities:
Development of a zero-g test rack; risk assessment of re-entry vehicles; aerodynamic characterization of re-entry vehicles (IXV); mission design of a CubeSat network; system for aerodynamic stability and de-orbiting of a CubeSat.

Publications
several conference papers

Paride Testani (VKI)

Personal info
Paride Testani obtained his MsC as Astronautical Engineer in 2011 at the School of Aerospace Engineering of Rome La Sapienza. Involved in several projects about educational small satellites (CXBN in 2011 at Morehead State University, HPH.com microsatellite in 2012 and TigriSat in 2013 at the University of Rome la Sapienza), was then employed as System Engineer and AIT team leader for the UniSat-5 microsatellite in 2013 with GAUSS srl. Since 2014 he is research engineer at the Von Karman Institute (VKI) with the role of Launch Systems Engineer in the QB50 Project and deputy system engineer for the QARMAN CubeSat.

Relevant Experience

2014-present:	QB50 launch systems engineer/ QARMAN deputy system engineer
2012-2013:	Project Engineer, AIT team leader, launch campaign coordinator (UNISAT-5 Microsatellite - GAUSS)
2011-early 2012:	ADCS project engineer, qualification of (HPH.com microsatellite project and TigriSat - University of Rome "La Sapienza")
July-Nov. 2011:	CXBN attitude control system (master's thesis, Morehead State University, KY, USA)

Amandine Denis (VKI)

Personal info
Amandine Denis graduated in 2007 from the University of Liège as a physical engineer specialized in space technology. She served as teaching assistant and research engineer for the Department of Aerospace and Mechanical Engineering of the University of Liège. She was the project manager and a system engineer for the educative nanosatellite OUFTI-1. Since September 2014, she is a research engineer at the Von Karman Institute (VKI) with the role of space segment engineer & CubeSat coordinator for the QB50 project.

Relevant Experience

2014-present:	QB50 space segment engineer & CubeSat coordinator
2007-2014:	Project manager and system engineer for the educative nanosatellite (CubeSat) OUFTI-1, Dept. of Aerospace and Mechanical Engineering, University of Liège.

2007-2013: Teaching assistant and Research engineer, Dept. of Aerospace and Mechanical Engineering, University of Liège. Classes: Computer-aided design (Pr. Beckers), Astrodynamics, Satellite engineering (Pr. Kerschen).