WorldVu Satellites Limited
U.S. Business Office:
1400 Key Boulevard, Suite A1
Arlington, VA 22209

June 24, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch
Federal Communications Commission
Office of the Secretary
445 12th Street, SW
Washington, DC 20554

Re: WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System
IBFS File No. SAT-LOI-20160428-00041

Dear Ms. Dortch:

WorldVu Satellites Limited, doing business as OneWeb ("OneWeb"), respectfully responds to the International Bureau, Satellite Division's ("Bureau") letter dated June 10, 2016. That letter requested additional information from OneWeb concerning the above-referenced application for U.S. market access for OneWeb's proposed non-geostationary satellite orbit ("NGSO") Fixed Satellite Service ("FSS") system. The attachment to this letter repeats each of the questions and points raised in the Bureau's letter and provides OneWeb's response.

Please contact the undersigned with any questions regarding this response.

Very truly yours,

/s/ Kalpak S. Gude

Kalpak S. Gude
Vice President of Legal-Regulatory
WorldVu Satellites Limited

OneWeb Response to the Commission's Letter dated June 10, 2016

Each of the questions and points raised by the Commission in its June 10 letter are repeated below, together with a OneWeb response:

1. *FCC: OneWeb seeks to operate its NGSO FSS system in the Unites States in the 17.8-18.6 GHz band. The 17.8-18.3 GHz band is not allocated to the FSS for non-Federal systems in the United States. Although the 18.3-18.6 GHz band is allocated to the FSS in the United States, the Commission's Ka-Band Plan designates this band for the use of space stations operating in the geostationary orbit. If OneWeb wishes to operate its NGSO FSS system in the 17.8-18.6 GHz band in the United States, it must seek a waiver of the U.S. Table of Frequency Allocations, Section 2.106 of the Commission's rules, and the Commission's Ka-Band Plan.*

   OneWeb Response: OneWeb seeks waiver of Section 2.106 of the Commission's rules and the Commission's Ka-band plan to operate a NGSO system in the 17.8–18.6 GHz band. The 17.8–18.3 GHz band is allocated to Fixed Service ("FS"), and footnote NG164, restricts use of the 18.3–18.8 GHz band by the fixed-satellite service to GSO systems.[1] OneWeb uses the 17.8–18.6 GHz band in the space-to-Earth direction for links to a relatively small number of gateway earth stations in the U.S.

   Under Section 1.3 of the Commission's rules, the Commission has authority to waive its rules "for good cause shown."[2] Good cause exists if "special circumstances warrant a deviation from the general rule and such deviation will serve the public interest" better than adherence to the general rule.[3] In determining whether waiver is appropriate, the Commission should "take into account considerations of hardship, equity, or more effective implementation of overall policy."[4]

   In considering requests for non-conforming spectrum uses, the Commission has indicated it would generally grant such waivers when there is little potential for interference into any service authorized under the U.S. Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services.[5] The pending Petition demonstrates that the OneWeb System has been designed to prevent interference to FS and GSO systems. As explained in the Technical Narrative, the only potential interference path is from the transmitting FS station into the sidelobes of the OneWeb receiving gateway earth station antenna.[6] In the unlikely event that potential interference would be caused to the OneWeb gateway earth station by FS, OneWeb will accept any such interference and take the necessary measures to prevent it from impacting the earth station operations. Moreover, the OneWeb NGSO satellite system has been designed to provide the necessary interference

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1 47 C.F.R. § 2.106, NG164.

2 47 C.F.R. § 1.3; *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969).

3 *Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

4 *WAIT Radio*, 418 F.2d at 1159.

5 *Contactmeo Communications, LLC*, Order and Authorization, 21 FCC Rcd 4035, 4044 (IB 2006).

6 Petition, Attachment A at 40-41.

protection to GSO satellite networks in all frequency bands, including in the Ka-band, as required under Article 22 of the ITU Radio Regulations.[7] Finally, grant of this waiver is consistent with FCC precedent.[8]

2. *FCC: At Attachment A, page 13, OneWeb states that "every point on the Earth's Surface will see … a OneWeb satellite at an elevation no less than 55°." Attachment A, page 31, however states there is "always a OneWeb satellite visible from any point in the service area at a high elevation angle – typically greater than 50°." Please clarify the apparent contradiction.*

   OneWeb Response: At Attachment A, page 13, the reference to minimum elevation angle was intended to be simply related to the geometry of the constellation, regardless of whether service is provided. In other words, there will always be a OneWeb satellite visible in the sky above 55° elevation angle. On page 31, it was intended to refer to the elevation angles at which communications from the OneWeb user terminals may take place, and in some cases this is less than 55° because of the need to protect GSO networks through EPFD limit compliance. This is addressed further in the point immediately below. To clarify, the language at Attachment A, page 31 could have stated:

   > "The OneWeb constellation has sufficient satellites to ensure that there is always a OneWeb satellite with which communications may take place ~~visible from any point in the service area~~ at a high elevation angle – typically greater than 50°."

3. *FCC: In Annex 1, page A1-5, paragraph (c), and page A1-15, paragraph (d), OneWeb states that the value of the minimum elevation angle used in the equivalent power-flux density (EPFD) analysis is 45°. However, in Attachment A, page 13, OneWeb states that "every point on the Earth's surface will see … a OneWeb satellite at an elevation no less than 55°." Please explain the rationale for selecting 45° for the analysis.*

   OneWeb Response: While the statement that "every point on the Earth's surface will see … a OneWeb satellite at an elevation no less than 55°" is true, it is a purely geometrical fact of the constellation, as explained in the point immediately above, and doesn't necessarily describe how the OneWeb system operates. In actuality, the OneWeb satellites will sometimes communicate with a user terminal at an elevation angle below 55° elevation, in order to limit EPFD into GSO networks. For example, if one satellite is at 60° elevation as viewed from the user terminal, but within only a few degrees of the GSO arc, the OneWeb system would require the user terminal to instead communicate with a satellite that is at 45° elevation, but at a much greater angular separation from the GSO arc. The use of slightly lower elevation angles will inherently apply only at lower latitudes because of the geometry of the GSO. The minimum elevation angle is 45° for any user terminal and so this was used in the analysis.

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[7] Petition, Attachment A at 33-34.

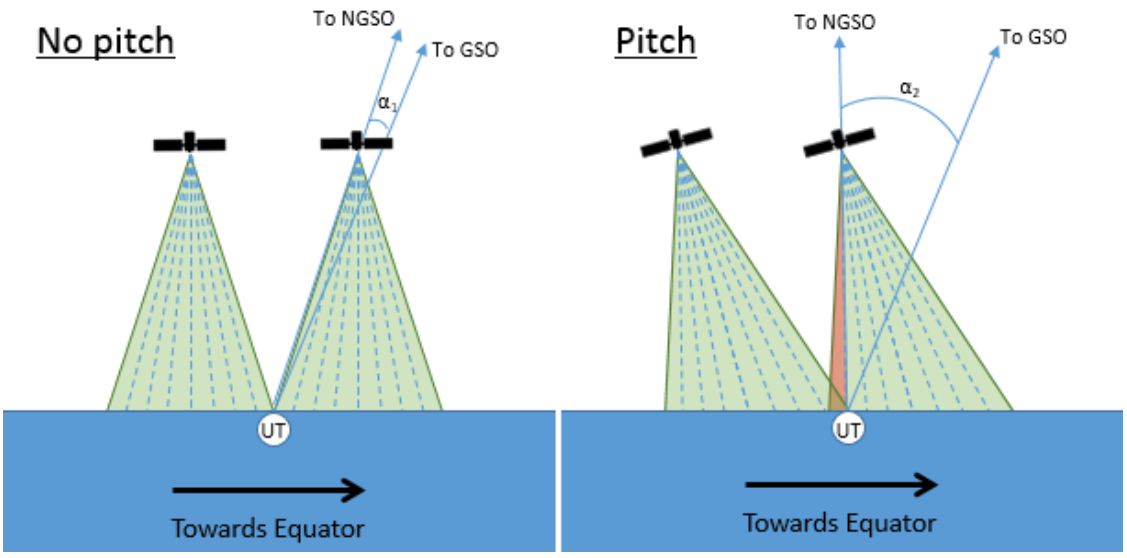
[8] *See* Letter to Ms. Suzanne Malloy, Vice President, Regulatory Affairs O3b Limited, 29 FCC Rcd 11348 (2014).

4. *FCC: Provide a detailed technical explanation of the pitch bias function used to steer the antenna footprint that is the basis for the generation of the power flux density masks used to demonstrate EPFD compliance. This explanation should address the following: how the pitch bias function works; the latitude range; when the latitude adjustment is triggered; if every orbital plane has the same latitude trigger mechanism; and any other information that will assist Commission staff in understanding this algorithm.*

OneWeb Response: The principal factor that determines the EPFD levels from OneWeb into GSO networks is the **GSO exclusion angle**. For the downlink interference case, from transmitting OneWeb satellites into receiving GSO earth stations, this is a function of the minimum off-axis angle, measured at the GSO receiving earth station, at which the OneWeb satellite transmits towards that earth station. For the uplink interference case, it is the minimum off-axis angle between the boresight of the transmitting OneWeb earth station antenna and any point along the GSO arc. Due to the effect of antenna gain roll off, it can be generalized that increasing this **GSO exclusion angle** will decrease EPFD levels. Therefore, OneWeb's EPFD compliance is primarily enabled by implementing a minimum **GSO exclusion angle,** which is accomplished in two ways:

- physically pitching the satellite in the north-south direction, which pitches the fixed antenna array towards the equator, and
- turning off overlapping beams, which electronically achieves the same effect as pitching.

This can be seen in the diagram below where the **GSO exclusion angle**, α, is increased by both pitching the satellite, and turning off certain beams. In this diagram, the two NGSO OneWeb satellites are in the same orbital plane and are viewed from the West/East direction.

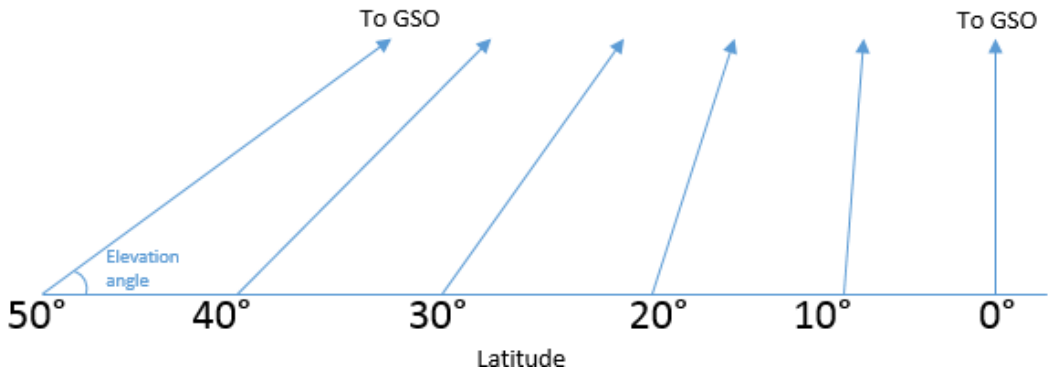


In the no pitch case (left diagram) the OneWeb user terminal (shown as a white circle) is in the location which results in the minimum **GSO exclusion angle** (α_1) possible within the NGSO's footprint. In this geometry, a user terminal transmitting up to the NGSO would result in the maximum $EPFD_{up}$ at a GSO satellite, and similarly the NGSO transmitting down to this user

terminal would result in the maximum $EPFD_{down}$ at a GSO earth station at that same location. It can be seen that a user terminal (or a GSO earth station) positioned farther to the right will result in a larger **GSO exclusion angle**, and a user terminal farther to the left will be in the footprint of the next NGSO, which will also result in a larger **GSO exclusion angle**.

Pitching the NGSO (right diagram) directly increases the **GSO exclusion angle** and it also elongates the beam footprints, thus increasing overlap between adjacent satellites. This redundant coverage allows OneWeb to power down or turn off certain beams (shown as an orange beam) which has the same effect as further increasing the pitch, in terms of resultant **GSO exclusion angle**. In the pitch case (right diagram) the illustrated user terminal is in the location which results in the minimum **GSO exclusion angle** (α_2) possible within the NGSO's footprint. It can be seen in the diagram that α_2 is considerably greater than α_1 and therefore would result in a significantly less EPFD into GSO networks.

Nominally, OneWeb satellites will have their antenna footprints centered towards nadir. However, because GSO earth station antenna boresight elevation angles vary with latitude, the EPFD from nadir-fixed OneWeb satellites would increase as they move from high latitudes to low latitudes. This can be deduced from the simplified diagram below, wherein the blue arrows represent the antenna boresight vectors of GSO earth stations. As latitude decreases, the GSO earth stations must point closer and closer to zenith. This geometry results in decreased **GSO exclusion angle** in regards to NGSO systems, and thus increased EPFD.



To counter this effect, OneWeb uses Progressive Pitch, which works by automatically commanding each satellite, as a function of decreasing latitude, to gradually orient its antenna footprint away from nadir and towards the equator, thus maintaining an acceptable **GSO exclusion angle**. This pitch-by-latitude profile, which will be identical for every satellite and orbital plane, will be predetermined by OneWeb and uploaded to the satellites to ensure the constellation never violates EPFD limits. Similarly, the radiated power in every OneWeb satellite beams will also be controlled as a function of latitude in order to manage EPFD. Progressive Pitch is utilized for NGSO satellites transmitting between 55° and 15° latitude, while power control is utilized over all latitudes. Both methods are captured and expressed in OneWeb's submitted PFD masks.

5. FCC: *In Annex 1, EPFD, page A1-3, paragraph (c), OneWeb discusses how, to meet the EPFD limits, downlink equivalent isotropically radiated power is progressively reduced in some beams and some the beams are turned off. Please provide technical details as to how meeting the EPFD limits is achieved and in what latitude ranges this takes place.*

   OneWeb Response: As illustrated in the points above, the GSO exclusion angle decreases as the NGSO satellites move from higher latitudes to lower latitudes. Because smaller exclusion angles result in higher off-axis EIRP, OneWeb will, in addition to pitching, power down and turn off certain beams in order to keep EPFD levels below the limits. The ability to reduce radiated power in certain beams while maintaining coverage is enabled by the increased footprint overlap which results from satellite pitching. The power profile is controlled over all latitudes, and is fully expressed in OneWeb's submitted PFD masks.

6. FCC: *In addition, we note that instead of submitting OneWeb's plan for orbital debris mitigation, OneWeb states that its orbital debris mitigation plan is subject to direct and effective regulation by the United Kingdom. In order to assist our analysis of the debris mitigation plans for large deployments of NGSO satellites, we ask OneWeb to provide any publicly available materials discussing the criteria applied by the United Kingdom to assess the debris mitigation plans of NGSO satellite systems.*

   OneWeb Response: OneWeb refers the FCC to the Guidance for Applicants document which outlines the license application and approval process for the United Kingdom.[9] The process requires the applicant to provide extensive technical details of the mission to ensure that the launch and operation of the space object conform to international treaties and law and do not pose a risk to lives or property. The process also requires the applicant to demonstrate a clear understanding of the hazards involved in the space activity and that a reasonable attempt has been made to limit those hazards. The United Kingdom will judge this demonstration against criteria derived principally from ISO documents, including ISO 24113 which is the international standard for Space Debris Mitigation Requirements.

7. FCC: *Also, in Attachment A, page 10, OneWeb states "[t]he user terminals, which will be deployed in large numbers, are typically in the range 30 cm to 75 cm in equivalent antenna diameter and will include fixed and transportable ground-based terminals as well as mobile terminals on board aircraft, maritime vessels and land vehicles." The Commission's rules do not include rules governing the operation of earth stations in motion transmitting to NGSO space stations in frequencies allocated to the FSS. Therefore, applications for the operation of such earth stations may require the filling of appropriate waivers.*

   OneWeb Response: OneWeb will address this matter with appropriate waivers at the time it makes applications for earth station licenses.

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[9] Revised Guidance for Applications, Outer Space Act 1986, *available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/464931/Guidance_for_applicants_-_October_2015.pdf* (attached).

8. *FCC: Finally, OneWeb must be prepared to work with other NGSO FSS operators in order to ensure compliance with the applicable limits for aggregate EPFD in the space-to-Earth direction ($EPFD_{down}$) contained in Sections 25.208(h) and 25.208(m) of the Commission's rules, 47 CFR §§ 25.208(h), (m), as well as in Resolution 76 of the Radio Regulations of the International Telecommunication Union.*

   OneWeb Response: OneWeb commits to work with other NGSO FSS operators in order to ensure these aggregated $EPFD_{down}$ limits are met.

REVISED GUIDANCE FOR APPLICANTS
OUTER SPACE ACT 1986

Please note that the application should be made as soon as possible, ideally at least six months in advance of any plans for launch or operation of a space system (see notes below). Delays in making the application could result in the project having to be delayed.

Introduction & background

The Outer Space Act 1986 (the Act) is the legal basis for the regulation of activities in outer space carried out by organisations or individuals established in the United Kingdom or one of its Overseas Territories (OTs) or Crown Dependencies (CDs).

The Act confers licensing and other powers on the Secretary of State for Business, Innovation and Skills, who carries these powers out through the UK Space Agency. The Act seeks to ensure compliance with the UK's obligations under international treaties and principles covering the use of outer space, including liability for damage caused by space objects, the registration of objects launched into outer space and the principles for the remote sensing of the Earth.

Download a copy of the Outer Space Act 1986, plus the amendments made to the Act by section 12 of the Deregulation Act 2015. Applicants are strongly advised to make themselves familiar with its provisions, before completing the application form.

Do I need a licence?

The Outer Space Act 1986 applies to United Kingdom nationals (as defined in the Act), Scottish firms, and bodies incorporated under the law of any part of the United Kingdom, the Bailiwick of Guernsey, the Bailiwick of Jersey, or the Isle of Man. carrying out the following activities in the United Kingdom or elsewhere:

- launching or procuring the launch of a space object;
- operating a space object;
- any activity in outer space

The following activities do not in our view require a licence:

- the leasing of space segment satellite capacity (transponders) from international inter-governmental satellite organisations or privately owned entities for use by the lessee or by a person sub-letting the capacity;
- the utilisation of space segment capacity (transponders) using earth stations for either transmission or reception purposes. **N.B.** This exception does not apply to persons involved in telemetry, tracking and control of satellites in orbit.

Notes:

- **Applicants should consult UK Space Agency (contact details may be found at the end of these notes) if they are in any doubt as to whether they need a licence. The Agency encourages applicants to contact them as early as possible to discuss the best way forward for their mission.**

- **Applications should be submitted at least six months in advance of any plans for launch or operation. In certain circumstances it may be possible to process an application in a reduced timescale (in some cases in as little as three months), although we are unable to guarantee this. Please contact us in plenty of time to discuss if a reduced timescale would be possible and the steps you would have to take.**

- **Applicants from one of the UK's Overseas Territories to which the Act has been extended (Cayman Islands, Gibraltar, Bermuda) will need to apply to their own Governor's office for an OSA licence.**

- **Applicants from one of the UK's Overseas Territories to which the Act has not been extended should approach the Government of the Overseas Territory, which would then liaise with the Foreign and Commonwealth Office (FCO) and UK Space Agency over whether it was appropriate to extend the Act to that territory. If decided upon, extension of the Act would be by Order in Council. This is a lengthy process and could take many months.**

Obligations of licensees:

It is an offence for a person to whom the Act applies to carry on a licensable activity without a valid licence.

Under section 10 of the Act, all persons to whom the Act applies must indemnify the UK Government against any claims for damage or loss arising out of licensable activities.

Licences for space activity granted onwards of 1 October 2015 under the Outer Space Act include a cap on the liability imposed on licensees (see Annex B for full details). Please note, currently the liability cap does not apply in the Crown Dependencies and Overseas Territories to which the Outer Space Act has been extended.

In addition, the Secretary of State has discretion to attach conditions to the grant of a licence. Download a copy of a typical licence, which includes our standard conditions.

UK Space Agency standard insurance requirement (at clause 6 of the attached sample licence) is that licensees must insure themselves against third party liabilities arising from each licensed activity (i.e. the launch and in-orbit phases of the mission). For each licence application, a risk assessment will be performed to consider the potential risks posed by the mission and a commensurate level of insurance cover will be determined. In the majority of cases, involving single satellite missions employing established launchers, satellite platforms and operational profiles, this insurance cover would be limited to €60 Million. The UK Government must be named as an additional insured party and in the case of applications from companies in the Overseas Territories and Crown Dependencies, the relevant territorial Government should also be named.

Additional conditions may be imposed, depending on the circumstances of each application.

Application for a licence

Applications for licences under the Outer Space Act may be made either in hard copy or electronically (e.g. a .pdf of the signed application form), using the application form. Other supporting material as requested on the application form or that the applicant sees fit to include should be submitted at the same time.

The following information will be required as a minimum:

- the nature of the space activity the applicant is proposing to carry out;
- the relationship of the applicant with other parts of the corporate group (if applicable);
- the applicant's financial standing (including certified accounts for the two most recent years, accounts information for parent companies may also be required if the applicant is a subsidiary); If you are unable to provide two years of accounts alternatives can be explored (please contact us for details).
- mission costs;
- insurance arrangements for launch (if applicable) and in-orbit phase of the mission (including copies of all certificates and policies);
- technical details of the mission (including copies of the launch services contract, satellite supply contract and technical specifications and ground station specification);
- plans for disposal of space object at end of life;
- emergency procedures;
- radio frequencies and powers used during the mission;
- orbital location information.

Applicants should also attach the additional information listed at Annex A.

Licence fee

The application should be accompanied by a non-refundable fee of **£6,500** in the form of a cheque or banker's order made payable to: **UK Space Agency**. Electronic payment details can be provided upon request.

Please contact us if you are applying to launch a constellation of satellites as we may not need to charge a fee for every satellite.

Note: Recognised educational institutions carrying on an activity to which the Act applies for the purpose of scientific research or teaching are not required to pay the fee.

Applications should be sent by post or email to:

Louise Hughes
Outer Space Act Licensing Manager
UK Space Agency
SFS Polaris House
North Star Avenue
Swindon
Wiltshire SN2 1SZ

E-mail: louise.hughes@ukspaceagency.bis.gsi.gov.uk

In case of enquiries, please email or telephone Louise Hughes on: 01793 418068

UK Space Agency licensing procedure under the Outer Space Act

The information provided with the initial application is assessed and UK Space Agency may need to seek further information or clarification of particular points from the applicant in the course of assessing the application. UK Space Agency will normally seek a meeting with the applicants at an early opportunity to help us to understand the activity to be licensed. In particular, we will wish to ascertain whether there are any novel or special circumstances that might have a bearing on the licence. At all stages of the licensing process, UK Space Agency will keep the applicants informed and explain the reasons for any decisions or additional requests for information.

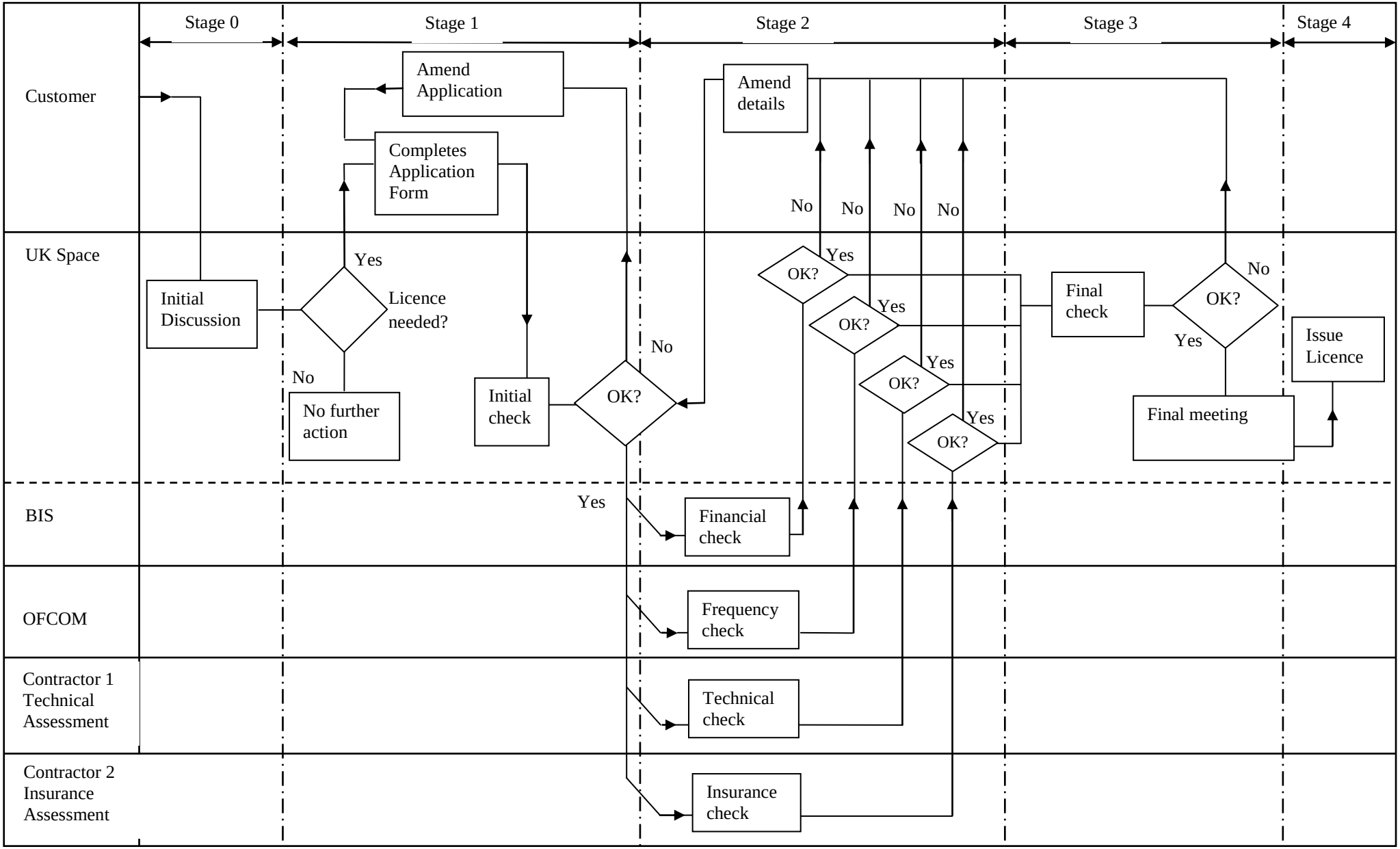
Normally, the main stages of the licensing process are:

- identification of whether a licence is required and initial contact /consultation: to explain the licensing process to the applicant and for UK Space Agency to learn whether there are any special circumstances related to the mission **(Stage 0)**;
- completed application form and initial information, together with fee received by UK Space Agency **(Stage 1)**;
- suitability of applicant's insurance cover: to ensure that the cover for the mission provides appropriate cover for the UK Government under the conditions of the licence **(Stage 2)**;
- applicant's financial status: to ensure that the applicants have adequate resources to carry out the proposed activity and to meet and maintain their obligations under the licence (e.g. continuing to meet insurance premium payments) and that the applicant is sufficiently sound to enable a licence to be issued (bearing in mind (i) the UK Government's potential liabilities for the activity under international treaties, and (ii) the statutory indemnity in favour of the Government from everyone to whom the OSA applies and which is contained in the OSA) **(Stage 2)**;
- technical assessment: to ensure that the launch and operation of the space object conform with international treaties (e.g. the requirements on liability and registration) and law and that they do not pose a risk to lives or property **(Stage 2)**;
- checks with OFCOM to ensure that correct ITU filings have been made (i.e. that the frequencies used will not cause interference issues) **(Stage 2)**;
- licence application review - political and legal: UK Space Agency liaise as appropriate with other Government Departments and partners (e.g. MoD, PPARC, NERC) to ensure that the licensed activity does not affect Government activities **(Stage 2)**;
- final decision: UK Space Agency ensures that all checks are complete and decides whether or not to issue the licence. Licence prepared, adding conditions where necessary (e.g. in response to advice from any of the above process) **(Stage 3)**;
- final meeting with applicant to explain any conditions in the licence **(Stage 3);**
- licence issued or refused **(Stage 4)**.

Conditions for the grant of a licence

Before a licence can be granted UK Space Agency must be satisfied that the proposed activities will not jeopardise public health, the safety of persons or property, or national security. UK Space Agency will also wish to be satisfied that the proposed activities will not compromise the UK's ability to carry out its obligations under the various international treaties and agreements that govern space activities.

During the licensing process set out above, UK Space Agency and its advisors will assess any information submitted. Should special conditions be required for a particular licence (e.g. a parent guarantee to be in place when a licence is granted to a subsidiary company), these will be explained to the applicant.


Stage 0
Stage 1
Stage 2
Stage 3
Stage 4
Customer
UK Space
BIS
OFCOM
Contractor 1
Technical
Assessment
Contractor 2
Insurance
Assessment
Amend
Application
Completes
Application
Form
Amend
details
Initial
Discussion
Yes
Licence
needed?
No
No further
action
Initial
check
No
OK?
Yes
No
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No
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OK?
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Yes
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Final
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No
Yes
Issue
Licence
Final meeting
Yes
Financial
check
Frequency
check
Technical
check
Insurance
check

ANNEX A

1 Revised launch licensing questions

1.1 General

It is intended that for launch only licence applications, questions from section 1.2 should be answered. Where in orbit activities are also subject to licensing, questions from sections 1.2, 1.3, and 1.4 should be answered.

The questions in this section are intended to allow the applicant to demonstrate:

- A clear understanding of the hazards involved in the space activity;
- That a reasonable attempt has been made to limit those hazards.

The information should be sufficient to allow the UK Space Agency safety assessor to understand the potential for all liabilities arising through launch, in orbit operations and after disposal. In particular, the safety assessor will consider six main categories of information:

- System design, functionality, and performance
- System qualification, history, and reliability
- System and mission risk assessment
- Safety plans and procedures
- Safety requirements, constraints, rules and criteria
- Safety organisation, roles, and authorities

The process is expected to be iterative and time should be allowed for further questions. The applicant should first indicate which phase of the mission is subject to UK launch licensing (i.e. launch and/or in-orbit).

The criteria by which the applicants responses are judged are derived principally from the following standards:

[1] ISO 14620-1:2002, “Space systems — Safety requirements — Part 1: System safety”,2002.
[2] ISO 14620-2:2000, “Space systems -- Safety requirements -- Part 2: Launch site operations”, 2000.
[3] ISO 14620-3:2005, “Space systems -- Safety requirements -- Part 3: Flight safety systems”, 2005.
[4] IADC-02-01, “IADC Space Debris Mitigations Guidelines”, IADC,15th October 2002,
[5] IADC-04-06, “Support to the IADC Space Debris Mitigation Guidelines”, 5th October 2004,
[6] ISO 24113, “Space debris mitigation”
[7] ISO 23339, “Propellant mass estimation”
[8] ISO 26872, “GEO disposal”
[9] ISO 27852, “Orbit lifetime estimation”
[10] ISO 27875, “Re-entry risk management”
[11] ISO 11227, “Test procedures for HV1 material ejecta”
[12] ISO 11233, “Orbit determination and estimation”
[13] ISO 14222, “Atmosphere density models”
[14] ISO 14200, “Process based meteoroid/debris environment models”

[15] ISO N608, “Collision avoidance”
[16] ISO N615, “Disposal of spacecraft in LEO”
[17] ISO N617, “Spacecraft passivation”
[18] ISO N619, “Survivability against meteoroid/debris impact
[19] ECSS-E-30 Part 5.1A Liquid and electric propulsion for spacecraft
[20] ISO 23041, “Unmanned spacecraft operational procedures”
[21] ISO 14623, “Pressure vessels and pressurised structures – design and operation”
[22] ISO 26870, “Launch pad and integration site operational documents”
[23] Satellite Users Interference Reduction Group http://suirg.org
[24] ECSS E ST 10 -04C Space environment
[25] ECSS E ST 33 11 Space engineering - Explosive systems and devices
[26] ECSS Q ST 40C Safety

1.2 Questions applicable to launch only activities

1	Please identify the proposed launch vehicle (eg variant of Ariane 5, Soyuz …. etc), baseline launch date, and whether the launch is shared with other satellites (if so, please indicate the deployment order from the launch vehicle).
2	Please provide an overview description of the launch indicating site location, range size, overflight of countries, and drop locations for the stages. Please identify how the downrange area is cleared in advance of the launch, indicating if any evacuation notifications are provided in advance (eg to airmen, seamen, or landmasses overflown).
3	Is there a high level safety plan aimed at limiting the hazards resulting from the launch activity? Please provide the document reference and identify the originating and approval organisations. If the originator of the document is not the applicant, please identify whether the document has been approved by the applicant. Also, please identify the flow of responsibilities between the relevant organisations in the safety process, specifically addressing the preparation for launch, launch, range definition control and flight path.
4	Is there a risk assessment and mitigation plan addressing the hazards to persons and property, including third parties, and the environment (including contamination) under nominal and failure conditions for the following phases – preparation for launch (including storage and handling of toxic propellants), ignition/initial ascent, trajectory down range to attainment of orbital status, and impact/disposal/recovery of launch related objects at the Earth's surface? For each risk assessment and plan, please also identify the originating and approval organisations.
5	Has a formal methodology been adopted in the identification of failure modes (eg FMECA) that could result in hazards to persons and property during the above mentioned launch phases? Please briefly describe the approach and refer to any public standards that have been applied. Please identify the extent of the exclusion zone around the launch site, and how this has been judged to be adequate to protect the public in the event of an explosion. Also, please indicate the extent of any emergency services available on site to contain such occurrences.
6	Please summarise the means by which the specific launch event in question has been approved by the national administration(s) responsible for assuring public safety in the domain of the launch site. Please identify each organisation with roles in the approval process. Please describe any known guarantees relating to liabilities of procuring states. Please cite probability of casualty in the proximity of the launch site and drop zones, either due to termination down range, or due to a toxic cloud developing at the launch site.
7	If the selected launch vehicle has experienced a recent launch failure, please indicate what corrective action has been taken to ensure that a similar failure will not occur again? What is the probability of failure to the launch vehicle propulsion system, and the flight guidance and control system, which could lead to premature termination of the mission.
8	What additional state territories could be at risk in a failure situation, for example in the event of a deviation in trajectory? What processes are in place for termination eg through range safety officer, or autonomous multiple redundancy voting etc, and how can these processes be judged to be fail safe? In the event of termination, please describe how the dispersal of debris is minimised, and how the detonation of remaining propellants is prevented.
9	Please identify the orbit of any final stage, and the expected orbital lifetime. Please identify any steps taken to minimise the lifetime in this orbit. In addition, please specify the probability of accidental break up of the final stage.
10	Please identify the passivation of any upper stage, eg venting of remaining propellant to prevent possible explosion or release of debris.
11	Please identify the potential for release of debris during separation of the spacecraft from the upper stage. In doing so, please cite mechanisms such as pyrotechnic devices (if included, are they fail safe devices), and expected maximum size of debris particles if greater than 1mm.

1.3 Questions applicable to in-orbit activities

1	Please provide the currently planned range of dates and orbital parameters for the intended operation of the space system. Please include both the 'transfer to on station' and 'on station' phases. Please identify the company responsible for the design and manufacture of the satellite.
2	Is there a high level plan aimed at limiting the hazards resulting from the in-orbit activity (eg disabling or fragmentation of the in-orbit system)? Please identify the document reference.
3	Is debris release possible in normal operation (eg through pyrotechnics during release of solar arrays)? If pyrotechnics are included, are they fail safe devices, and what is the maximum size of particle which can be ejected. Please also state the risk assessment report reference(s).
4	Has a formal methodology (eg FMECA) been adopted in the identification of failure modes that could result in the release of debris or the disabling of any manoeuvre capability of the space system? Please reference the FMECA report, and specify an overall probability of accidental breakup.
5	Has any impact survivability testing/analyses been performed on structural elements? If so, what sizes of particles can be sustained at what velocities? Please describe any design features of the spacecraft in terms of impact protection from debris or micrometeorites. The focus here should be the limitation of further debris release (eg protection of pressurised systems), and reference should be made to compliance with any relevant standards. What size of particles and total mass is expected to be ejected as a consequence of impact?
6	For the battery system, please indicate the following information: 1. What is the battery type (eg Lithium ion) and name of supplier? 2. What battery parameters are monitored (eg voltage, temperature) at what frequency? 3. Is there any redundancy in the sensors or hardware (including charge regulation)? 4. What are the operational temperature limits, and how are they maintained (eg via radiators or heaters). If heaters, is there redundancy? If passively what are the predicted temperature excursions? 5. How is overcharging of the batteries prevented, and what protection exists to prevent explosion of the batteries?
7	For the wheels, please indicate the following information: 1. What is the name of the supplier? 2. What is the orientation of the wheels with respect to pitch, yaw, and roll axes? 3. What sensors are used to monitor /control the wheel speed (at what frequency)? 4. What is the design failure rpm and the maximum expected operating rpm? 5. How are the wheels desaturated (eg autonomously/manual commanding through thrusters or magnetorquers)? 6. Is there any redundancy in the sensors or hardware (including wheel drive electronics)? 7. Can software override the wheel torque/momentum limit? 8. If the wheels become disconnected from the wheel drive electronics, would attitude control recourse be through manual commanding of the thrusters or magnetorquers?
8	For the propulsion system, please indicate the following information: 1. What are the names of the suppliers for the thrusters, tanks, and valves? 2. What are the pressurant/propellants? 3. What tank parameters are monitored (eg temperature/pressure) at what frequency? 4. Is there any redundancy in the sensors or thrusters? 5. How many pressurant/propellant tanks are there, and what procedures exist for equalising pressure between the tanks? 6. What is the safety factor applied to the tanks and how have the tanks been qualified (eg test to failure of engineering model, and NDE testing of flight units)? 7. What protection is employed to prevent explosion (eg leak before burst)?
9	Please list any other form of stored energy on board the space system (eg pumped thermal control

	system, fuel cells etc), and indicate how operation has been assessed to be safe and any means for passivation at end of life.
10	Please include the payload & TM/TC operational bands and include the ITU filing reference.
11	At end of life is the payload turned off, the solar arrays stopped, charge capability disconnected from the batteries, the wheels disconnected from the wheel drive electronics, the transmitter disconnected, propellant and pressurant tanks vented, and the heaters turned on to drain the batteries? In what timeframe is passivation expected to be completed, with what success probability?
12	What procedures exist for de-orbiting at end of life – is there an end of mission disposal plan including contingency planning (please reference)? For geostationary (GEO) satellites please indicate the intended re-orbit altitude and eccentricity, the propellant reserve for this manoeuvre, the uncertainty on the propellant reserve, and confirmation that the manoeuvre will be initiated allowing for this uncertainty. Please describe the manoeuvre sequence. For low earth orbit (LEO) satellites please indicate the predicted de-orbit duration, and how this has been calculated by recourse to drag, ballistic coefficient, and surface area assumptions. Details of any procedures undertaken to precipitate de-orbiting should also be provided. In particular the response should include a statement addressing how any part of the space system undergoing atmospheric re-entry has been assessed to be safe in respect of likelihood of parts of the space system surviving to reach the surface of the Earth and the consequential risk to persons and property. For both LEO/GEO, what is the vehicle mass at end of life prior to de-orbiting, and the approximate surface area in the direction of the velocity vector? What is the overall probability of successful disposal? Which method has been selected for determination of residual propellant (eg PVT, thermal gauging etc), and what is the accuracy of the orbital altitude knowledge (eg ±Xkm)?
13	What redundancy exists for the de-orbit process in terms of command, thruster, and power capability.

1.4 Questions applicable to ground segment and operational activities

1	Please provide an overview of the ground segment including number of sites, functionality, and connectivity.
2	Is the ground segment intended to be operated by the applicant or a third party? If a third party, please identify.
3	Does a teleport license exist? If so, please reference.
4	Do operational procedures exist for: - normal operations - recovery from all safe modes - identifying, reporting, correcting anomalous satellite behaviour - identifying problems with procedures - transferring data at shift handover - transferring from prime to back up operations centres
5	How frequently is battery/wheel/tank housekeeping data downlinked? Please describe the retention of down-linked data, automatic flagging of unexpected conditions and review and management of anomalous conditions. Does the spacecraft have any autonomous safeguarding measures?
6	How many staff are dedicated to the satellite, with what shifts and what responsibilities? Has the training been approved by an external party (eg SUIRG)?
7	Is there redundancy in the ground segment elements – eg mission computer, antennas, software – is there a backup control centre?
8	Is the ground segment protected by an uninterruptible power supply?
9	Are there any plans for early end of life upon a failure condition covered by the authorised operational procedures? Please reference a plan as applicable.
10	Are formal controls exercised for up-linking commands or new data or software to the space system? Please identify the process, referencing the applicable high level management plans, and if the procedures are approved by a third party (eg SUIRG).
11	What is the planned reliance on ground command (e.g. days or orbital revs between essential uplink or downlink)?
12	Please describe any plans for collision avoidance, including tracking of bodies in proximity to the satellite under consideration, procedures for manoeuvring, and coordination of manoeuvres with third parties (eg for stationkeeping for collocation).
13	Does the ground segment equipment include “Carrier ID” technology?
14	Does the applicant subscribe to a data sharing scheme with other satellite operators such as an RF interference alert system?

ANNEX B

How is the liability cap applied?

Section 10 of the Outer Space Act 1986 requires a party carrying out certain space activity to indemnify the Government against claims arising out of that activity on an unlimited liability basis.

Licences for space activity granted onwards of 1 October 2015 under the Outer Space Act include a cap on the unlimited liability.

In the majority of cases, which involve single satellite missions employing established launchers, satellite platforms and operational profiles, the cap will be set at €60 Million (Euro). For unlicensed space activity the unlimited liability will remain.

What if my licence was issued before 1 October 2015?

A liability cap does not automatically apply to these licences. However, existing licensees may write to the UK Space Agency and ask for a cap to be applied to their licensed mission. Each request will be assessed and notice of the decision will be given in writing.

Does the liability cap apply to the licensing regimes in the Crown Dependencies and Overseas Territories?

The liability cap does not apply in the Crown Dependencies and Overseas Territories to which the OSA has been extended and therefore the unlimited liability will continue to be in place in respect of missions licensed under those regimes. The authorities in each of these jurisdictions have been consulted regarding the possible extension of the new provision to their areas and further updates on if/when the liability cap will apply will be published in due course.