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A Very British Coup: Lessons from the draft UK Regulations for Cubesats.

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Introduction

From an apparent standing start in the early years of the 21st Century, the United Kingdom has recently embraced the challenges of diversifying its economy by investing heavily in space activity. One of the perceived obstacles to developing this area of growth was the regulatory framework enshrined within the Outer Space Act 1986 was overly burdensome on small companies. Recognising this, the UK Space Agency has recently promulgated draft recommendations for changes to the regulatory framework governing Cubesats.[1] These proposals if enacted, will trim much of the unnecessary administration and repetition from the process of obtaining a licence whilst retaining enough regulation to effectively discharge the UK government's responsibility under the Outer Space Treaty 1967.

This discussion does not attempt to evaluate the technical or engineering implications of the Cubesat phenomenon nor it does not attempt to critique the draft UK recommendations from that perspective. Instead, this discussion will focus on the legal and regulatory efficacy of the proposals. This article will

critically evaluate the proposed UK Cubesat regulations in the context of the current UK attempts to expand its share of the world space economy. Crucially, however, this discussion will also look beyond the UK and explore the role of regulation more broadly within the small satellite industry. The light touch solution proposed by the British will be compared and contrasted to the current regulation employed by the United States. It will be discussed how the British approach might benefit the current U.S. system and influence other state actors as well as the broader international community.

The UK Space Economy: Setting the context for reform

The economic imperative for a revised legislative approach can be found in the 'Case for Space' study commissioned by the UK Space Agency, and conducted by London Economics[2]. This report found the UK space economy had trebled in real terms since the turn of the century. In 2012/13 it was valued at an aggregate turnover of £11.8bn (around $18.5bn) with a compound annual growth rate of 8.6% since 2008/9[3]. Closer examination of these figures shows the vast majority of this turnover is accounted for by the direct to home (so called Satellite) television market[4]. Space manufacturing accounts for just under a £1bn ($1.5bn) of the UK space economy and it is in this area government and private industry are looking to expand.

The UK Innovation and Growth Strategy (IGS), published in 2010 set a target of growing the UK's share of the global space market to 10% by 2030[5]. Such a target may appear ambitious given the relatively late entry in the arena of space activity. It is, however, not without substance. Satellite manufacturers such as

Surrey Satellite Technology Limited (SSTL) and Airbus Defence and Space have recently signed high profile contracts to produce small satellite constellations covering a wide range of applications[6]. Recent trade missions to Asia[7] and America[8] have sought to develop the UK space market share. The mission to America focused specifically on fostering links between nine small satellite startup companies to counterparts in the US. In addition to all of this commercial activity, is the prospect of the UK finally entering the sphere of human spaceflight and the attendant domestic attention this will bring to nascent UK space ambitions.

Regulation in the UK: The Outer Space Act 1986

Despite being the world's third spacefaring nation with the launch of Ariel-1[9], the UK was late in realizing the potential of space activity to provide sustained economic benefit. It is now, however, wasting no time in trying to cultivate commercial space opportunities. It is somewhat surprising, therefore, that the underpinning regulatory regime has remained untouched for nearly 30 years. The legal basis for all space activity carried out by the United Kingdom is to be found in the Outer Space Act 1986. This piece of primary legislation is the way in which the UK Government discharges its obligations under the Outer Space Treaty 1967. The Act establishes a regime of regulation to which *all* entities under its jurisdiction must comply if connected with space activity in the UK and confers the power to licence space activities upon the Secretary of State[10].

The regulatory burden that this licensing requirement imposes upon (especially but not exclusively) small space startups is considerable. Section 4 of the 1986

Act provides the conditions under which a licence will be granted. A licence will not be granted unless the Secretary of State (via the UK Space Agency regulator) is satisfied the activities authorized will not jeopardize public health[11], will be consistent with the international obligations of the UK[12] and will not impair the national security of the UK[13]. The grant of a licence, in practice involves an assessment process during which there will be a financial, safety and environmental assessment of the application[14]. Recognised as being 'high cost' this process looks back over the development of the project and also seeks to look forward, assessing potential areas of risk and liability arising from the proposed activity. Section 5 of the 1986 Act states that the grant of a licence is conditional on the requirement that the licensee prevents the contamination of outer space, prevents adverse changes in the environment of the Earth and avoids interference with the activities of others in the peaceful exploration and use of outer space. In the consultation document first promulgated in June 2015, the UK Space Agency recognized the current regulatory regime is not well suited to deal with Cubesats. It is against the backdrop of this concern the UK Space Agency has made recommendations to reform the regulations regarding the licensing of Cubesats.

Regulating Cubesats: The traffic light approach

In redrafting the regulations, the UK Space Agency has had to balance the regulatory duties in respect of risk and liability with need to fully explore the undoubted economic potential offered by low cost, modular Cubesat platforms. The stated aim of the consultation into the specifics of Cubesat regulation is to:

> "*… evaluate the risk presented to, and posed by, such systems and consider how its regulatory approach might be tailored for Cubesat systems. Recognising the common aspects of such missions, there is an opportunity for the UK Space Agency to exploit a range of pre-determined technical assessments and associated likely regulatory outcomes for a range of likely Cubesat systems, presented in the form of a traffic light system (GREEN = low risk, AMBER = medium risk- may require further consideration such as evaluation of safety- critical systems, RED = high risk- likely to present unacceptable hazard to operational population which cannot be mitigated cost-effectively.)*"[15]

For those within the commercial sector, these outcomes could, at the discretion of the regulator, be 'reflected in the need for insurance and other requirements normally included in the license'. This points to two key characteristics of the new Cubesat regime. First, the regulators are seeking to develop a system with a number of harmonized elements that can be used to speed up the application and reduce costs. Second, rather than creating blanket immunity from regulation for Cubesat missions, the UK Space Agency recognizes the need for some form of ongoing regulatory oversight in this area.

The standardized nature of Cubesat systems has enabled the consultation to break down the risks posed by any Cubesat mission into three fundamental elements: the launch system, platform characteristics and the orbit into which the Cubesat will be inserted[16]. From this, the report outlines eight recommendations designed to facilitate the introduction of a traffic light system, providing a matrix of the three elements above, which will be 'Green' in terms of licensing

requirements. As the report states: '*This is analogous to but not equivalent to certification of tried and trusted systems*'. Recommendation 7 seeks to promote the creation of a series of criteria that correspond to the Green evaluation for each element of the mission outlined above[17]. In effect, this traffic light system will enable developers to produce Cubesat platforms that, upon successful mapping to the Green rating, will be able to be certified in a streamlined, harmonized process.

The first two recommendations are focused towards the launch system and are relatively straightforward. By virtue of Articles III and IV of the Liability Convention 1972 (which themselves build on Article VII of the Outer Space Treaty 1967), a state attracts absolute liablity for compensation for damage caused by a space object either on the surface of the Earth or to an aircraft in flight (as opposed to fault based liability for damaged caused to other space objects in orbit). Given the small mass of a Cubesat, it is unlikely any elements reentering from orbit would survive. The UK Space agency therefore recognises that absolute liability for damage caused by a Cubesat is likely to be limited to the launch phase of the mission. From a regulatory perspective, ensuring the use of recognised launch providers can largely discharge the burden of absolute liability, which rests upon the state. Using such providers means launch insurance (and in-orbit liability cover for a year) will usually be provided as part of the launch contract[18].

Recommendation 1 requires an assessment of Cubesat launch systems/scenarios, the UK Space Agency website to identify those launchers/situations which would attract a Green rating under particular conditions[19]. Recommendation 2 looks to build on this and reuse launch vehicle

specific data and information regarding the characteristics of the launch systems. This would then provide evidence for potential customers of both mission assurance and safety assurance with only incremental changes to the operation of a launcher needing to be reassessed. Both of these recommendations are sensible and, if enacted, there is little doubt they would 'reduce the burden on the licence applicant and the regulatory authority.'[20]

The platform considerations for Cubesat regulation are, for the most part, also rooted in common sense and appear to be relatively uncontroversial. The report identifies that Cubesats differ from other satellite systems in they follow standardized approaches for many aspects of the mission. Accordingly, Recommendation 3 specifies '*applicable international standards should be employed to specify those standard aspects of Cubesats platforms that can provide safety assurances about the intrinsic hazards presented by the Cubesat satellite and its subsystems to other space systems*'[21]. Recommendation 5 recognises there will be a great deal of this commonality inherent when dealing with constellations of Cubesats and proposes such sets of satellites could be collectively authorized under a single licence fee. Given that '*smallsat constellations are, for now, the wave of the future for the space industry*'[22], adopting this recommendation represents a crucial step forward in unburdening the space manufacturing industry of oppressive regulation.

Environmental Considerations: Managing and Encouraging Sustainable Growth

The recent proliferation of Cubesat constellations has, however, led to concerns being voiced regarding the dangers of congestion in space and the resultant issues in relation to cleaning up orbital debris. This is a crucial area of Cubesat regulation as there is a lingering perception they represent an increasing menace to operations in low Earth orbit[23]. In respect of regulation it is almost axiomatic to aver the Outer Space Treaty does not specifically address the issue of orbital debris. This, however, merely reflects the modern predilection of states to subscribe to more agile, non-binding guidelines[24]. Given the increasing profile of the danger posed to current and future space activity from orbital debris, this is an area that a regulator would neglect at their peril. Recommendations 4 and 6 are aimed squarely at ensuring the regulatory role of the UK Space Agency is fully discharging its duties in respect of the long-term sustainability of space.

Recommendation 4 can be categorized as an attempt at monitoring the overall volume of Cubesats licensed '*both in terms of the number on a particular launch and the overall constellation involved, in terms of the collision risks posed to other orbital systems both during and after the operational phase of the mission, and the potential impact on long term sustainability of the orbital environment*'[25]. It has been noted that a Cubesat constellation can significantly increase the number and frequency of conjunctions when compared with a monolithic satellites[26]. Recommendation 4 is somewhat opaque as to when a constellation may be unduly onerous upon the space environment. It may be, therefore, this is intended to work in harness with the specific measures outlined in Recommendation 6.

Simulations have shown that given their ubiquity and the likelihood of their increased use, Cubesats will be inevitably be responsible for millions of

additional conjunctions, which have the potential to lead to collisions[27]. Serving to satisfy UN Debris Mitigation Guideline 6[28], Recommendation 6 seeks to limit the longer-term presence of Cubesats in LEO once they have ended their useful life. The recommendation looks to prohibit Cubesats without propulsive capability from being injected into orbits with a natural decay of 25 years. Where a mission does require a Cubesat to be inserted into an orbit with a natural decay beyond the 25-year limit, there must sufficient reliability and fuel or a proven onboard disposal system to enable the cubesat to deorbit to a lower disposal altitude that will comply with the 25-year rule. Whilst these are the irreducible minima of what might be expected, it could be argued given the dramatic increase in the Cubesat population (which these regulations are, after all, seeking to bring about) these regulations could actually be more robust in terms of their requirements. Incentivizing low perigee orbits so, where necessary Cubesats deorbit within 5 years of end of life, prompting constellations to spread perigee altitude to remove the burden on specific orbits and encouraging measures to reduce tracking uncertainty would serve to tackle orbital congestion[29] and demonstrate the UK regulators are committed to ensuring space sustainability.[30]

Waiving Insurance: The key to unlocking the sector?

Crucially, however, it is the final recommendation is potentially the most far reaching. In recognizing the OSA regulatory regime is not conducive to growth within the Cubesat industry, the unspoken central issue for much of the report is not technical but economic. The expense of the application process is only part of the story. The main criticism of the 1986 Act is reserved for the requirement under section 10. This imposes an obligation upon all applicants (irrespective of

the nature of the project) to indemnify the government fully against any third party liability (TPL) claims brought as a result of damage or loss arising out of activities. Currently, this represents unlimited liability on licensees and, according to one observer 'the concept of "unlimited liability" offers little financial certainty when fund raising and, compared with other space faring nations, poses a competitive disadvantage to UK operators.'[31] This concern chimed with the view of the Regulatory Policy Committee, which stated '*the treatment of contingent liabilities under the Act is inconsistent with practice in other space faring nations and in other UK sectors that have comparable contingent liabilities*.'[32]

Accordingly, from October 1st 2015, licenses for space activity granted under the 1986 Act now include a cap on the unlimited liability. Whilst a risk assessment will be performed for each new licence application to determine the appropriate liability cap, it is anticipated the majority of cases the cap will be set at €60 million ($67 million)[33]. The cap will not apply automatically to existing licenses; however, there is provision for the cap to be applied to existing satellites upon request to the UK Space Agency. According to a report commissioned by Innovate UK, when this reform occurs, the UK regulatory regime will be on a similar level to other players in the space industry[34]. Whilst an obvious improvement in the commercial environment, there are two critical issues that need considering. First, the 1986 Act retains the requirement that TPL insurance is needed for *all* aspects of the mission, including on-orbit TPL insurance, whereas most other countries require TPL insurance for launch only. Second, the 1986 Act requires TPL insurance for all aspects of the mission, irrespective of the size and expense of the satellite.

Despite the aforementioned desire to empower the space manufacturing sector, it is clear the ongoing licensing requirement for TPL insurance, (notwithstanding the cap at €60 million, including on-orbit coverage) poses a challenge to precisely the sort of SME space startup that the IGS is seeking to encourage. Assuming a premium of 0.1% of the rate covered, the TPL insurance requirement would typically see a small startup having to pay €60k for a Cubesat may well have only cost less than that amount to manufacture. This means many SME space startups looking to utilize Cubesats are stillborn.

Any attempt to reform the regulation of Cubesats clearly needed to address this issue. Accordingly, Recommendation 8, states that the UK Space Agency should conduct a financial impact assessment examining the benefit to the Cubesat industry of waiving the TPL insurance requirement for Cubesat missions judged not to expose the UK to potential in-orbit liability. The example given within the report was of a Cubesat launched into a low orbit with a lifetime of 5 years. Given this is well below the 25-year limit and in accordance with best practice, it is unlikely the UK would be liable on the fault basis associated with on-orbit collisions. In such circumstances the requirement for TPL insurance *could* be waived. The report goes on to state '*As it is often argued that third party liability insurance is a major barrier to entry for some Cubesat operators, this measure in itself could facilitate the emergence of new actors within the Cubesat market.*'[35]

It is clear the UK Space Agency is reluctant to introduce a blanket waiver for Cubesats. Given the aforementioned tension between the regulatory role and the need to champion the emerging Cubesat industry this is perhaps not surprising. But it has already been identified that the purchase of on-going TPL insurance presents UK startups with a disadvantage. The requirement of a financial impact

assessment on this will provide the policy impetus within Government to lessen this advantage. Given the choice of traffic light regulation for Cubesat, a blanket waiver was never a realistic prospect, nor is it necessarily desirable. A regulatory framework needs flexibility and rather than have a waiver with the risk some missions may be refused a license because of their risk, a discretionary waiver for low risk missions seems a sensible way to proceed. The litmus test for success will not be in the granting of the waiver, but whether the waiver actually does serve to unshackle the nascent space-manufacturing base within the UK.

A Comparative View and Possible Lessons for Other Actors.

As demonstrated above, the UK recommendations to abridge the regulatory structure for cubesats represents a centralized, coordinated effort to address the growing proliferation of commercial cubesats. To the extent that the proposed UK regulatory structure is designed to streamline the approval process for cubesats, a comparative look at the regulatory structure the United States employs to approve cubesats appears to already meet that end. The United States boasts the largest contingent of commercial cubesat operators, but lacks a centralized system like the proposed UK regulatory structure to license and regulate cubesats. This lack of a centralized authority stems not from a lack of attention to growing use of cubesats, but rather it is a result of national space policy. Specifically, the current National Space Policy states as one of its principals that:

"A robust and competitive commercial space sector is vital to continued progress in space. The United States is committed to encouraging and facilitating the growth of a U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the generation of new markets and innovation-driven entrepreneurship."[36]

The National Space Policy goes on to direct U.S agencies to:

"*Minimize, as much as possible, the regulatory burden for commercial space activities and ensure that the regulatory environment for licensing space activities is timely and responsive...*"[37]

The National Space Policy follows a similar tenor of its predecessors starting with the Reagan National Space Policy of 1982, which first facilitated commercial space activities. Since this inception of the concept, national space policy has directed regulation be subordinated to technological and commercial development, including the development and deployment of cubesats by the commercial sector. That is not to say cubesat regulation is non-existent. Both the United States and the UK have an international legal responsibility under Article VI of the Outer Space Treaty for activities of private and commercial actors under their respective jurisdictions and as mentioned beforehand retain liability for those actors pursuant to Article VII of the Outer Space Treaty and by extension Articles III and IV of the Liability Convention.

As an extension of that responsibility Congress passed the Commercial Space Launch Act of 1984, which evolved into the current statutory body of law under 51

U.S.C. §§ 50101-51105 and specifically the authority of the Federal Aviation Administration (FAA) to issue commercial launch licenses under 51 U.S.C. §§ 50901-50923 and the subsequent regulations under 14 CFR §§ 400.1 - 401.5. Nevertheless, the statutory and regulatory authority granted to issue launch licenses under these sections is broad and not specific to any particular vehicle or payload, including cubesats. Private/commercial cubesats within the United States unlike the proposed UK cubesat regulations are regulated and licensed in a decentralized manner based on function by the executive agency with the statutory jurisdiction to administer that function.

For instance, the Secretary of Commerce pursuant to 51 U.S.C. § 60121 is authorized to license private sector parties to operate private remote sensing space systems for such period as the Secretary may specify and in accordance with the provisions of United States law. This authority is delegated by the Secretary of Commerce to the National Oceanographic and Atmospheric Agency (NOAA) and requires any private entity under the jurisdiction of the United States to obtain a license to operate a private remote-sensing system, which includes a private/commercial cubesat that will employ a remote-sensing capability.

To obtain and maintain an operating license from NOAA, a cubesat operator of a remote-sensing platform must comply with 51 U.S.C. § 60122(b) and 15 CFR 960.11, which covers collection and dissemination of remote sensing data and orbital debris mitigation, to include operating the system in such manner as to preserve the national security of the United States and to observe the international obligations of the United States;[38] making available to the

government of any country (including the United States) unenhanced data collected by the system concerning the territory under the jurisdiction of such government as soon as such data are available and on reasonable terms and conditions; make unenhanced data available to NOAA; upon termination of operations under the license, make disposition of any satellites in space in a manner satisfactory to orbital debris mitigation guidelines; furnishing NOAA with complete orbit and data collection characteristics of the system, and immediately inform NOAA of any deviation; and notifying NOAA of any significant or substantial agreement the licensee intends to enter with a foreign nation, entity, or consortium involving foreign nations or entities.[39]

Conversely, private cubesats whose purpose involves the use of radio spectrum are required to comply with regulations of the Federal Communications Commission (FCC). Until recently, most of the FCC regulations associated with cubesats related to the amateur radio service under 47 CFR 97.207 where a permitted amateur radio licensee may operate a "space station" operating within authorized frequencies.[40] It is noteworthy the permit of a cubesat for amateur operations is not a license per se, but rather a permission to an FCC licensed amateur to operate a "space station" (cubesat).

The license grantee of permission for operation of cubesat must comply with 47 CFR 97.207(g), which is heavily focused on orbital debris mitigation, and requires the permit holder to make written notifications to the international branch of the FCC to make several statements to include: that the space station licensee has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space

station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal; that the space station licensee has assessed and limited the probability of accidental explosions during and after completion of mission operations;[41] that the space station licensee has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations; provide a detailed post-mission disposal plan for the space station at end of life, including the quantity of fuel-if any-that will be reserved for post-mission disposal maneuvers; and if any material item described in the notification changes before launch, which mandates that a replacement pre-space notification be filed with the International Bureau of the FCC no later than 90 days before integration of the space station into the launch vehicle.

As has been noted already, Cubesats are becoming more commonplace in the commercial sector, especially with proposed cubesat constellations such as OneWeb. The FCC regulates commercial satellites and by extension cubesats through existing federal regulations, including 47 CFR §§ 25.101 - 25.701, which regulates satellite communications and specifically 47 CFR §§ 25.140 - 25.149, which focuses on technical standards and operations. The FCC addresses orbital debris mitigation for commercial satellites and cubesats under 47 CFR § 25.114(d)(14) and requires operators to provide a description of the design and operational strategies that will be used to mitigate orbital debris, which are similar to the requirements of amateur-class cubesats under 47 CFR 97.207(g).[42]

Private/commercial cubesats will continue to proliferate and occupy a greater portion of the radio spectrum, which is prompting calls for more coordination in applying for and entering frequency information with the International Telecommunications Union (ITU).[43] This is one potential area where the FCC could amend its regulations regarding cubesats to ensure compliance with ITU mandates and avoid future spectrum interference. For the time being cubesat regulation in the United States will follow the lead of the National Space Policy and regulation will remain decentralized and utilize the existing regulatory framework while still providing a permissive regulatory environment as envisioned by the proposed UK cubesat regulations. Even though cubesat regulations are decentralized in the United States, they do mirror and address some if not all of the concerns relevant to the proposed UK regulations, and in essence parallel each other even though the proposed UK regulations are focused to one agency and cubesat regulation within the United States is spread across multiple agencies.

Overreaching is the United States' obligations under Article VI of the OST 1967, which may require it to revisit the decentralized approach to cubesat regulation in the future.[44] As private, commercial use of cubesats becomes more prolific and certain orbits become saturated, the United States may have to reconsider its approach and designate one agency to issue a license to a private operator and require that agency to coordinate with other agencies such as NOAA, the FCC and other agencies as necessary. Complicit with centralization could be standard regulations and requirements for cubesats consistent with the proposed UK regulations. It is ironic that the approach of the UK (based as it is on relatively recent engagement in space activity), could well serve as a model for

the United States. Whether such a centralized approach is necessary or desirable is contingent on the tone of future national space policy, Congressional legislation, and subsequent regulation. However, unless there is strong international pressure and presuming the treatment of commercial space activity vis-a-vis national space policy remains relatively unchanged, the United States will resist the centralized approach taken by the proposed UK regulations. Instead they will allow the responsible agencies to modify their regulations to address the growing cubesat population and future space traffic management and the liability associated with it.[45]

Apart from the regulatory approach for cubesats used by the United States, emerging space-faring nations might see cubesats as an economical means to join the commercial space race. If that is the case, the proposed UK cubesat regulations would be an attractive model for a regulatory scheme to meet their respective obligations under the Outer Space Treaty and other international accords they are party to and provide a permissive regulatory environment to facilitate commercial cubesat development. Consequently, the UK is sure to have an international audience observing the implementation and enforcement of the proposed regulatory structure and might find itself as the focal point of private cubesat regulation much in the way the United States is the focal point for the creation of the legal and regulatory regime for commercial launch and spaceflight.

Beyond serving as a model for national regulatory schemes, the proposed UK regulations might also form the basis of a non-binding international norm for cubesats. As a result, the UK's domestic approach to cubesats might bring about

a bottom-up rule that is adopted as an international non-binding norm for other nations to emulate if not adopt outright much in the same way that NASA's Orbital Debris Mitigation Guidelines have been adopted by the United Nations and subsequently state actors. To that end, the UK might keep in mind not only other interested nations will be looking over their shoulder but the international community as well.

Conclusion

Examining the UK and the United States approach in a side-by-side fashion is illuminating, illustrating the different directions taken by the two states in respect of managing their obligations under the Outer Space Treaty. The UK Space Agency is part cheerleader, part regulator and, as such fulfils roles undertaken by both NOAA and the FCC, albeit on a much smaller scale. Given the relatively late entry into space manufacturing, the UK regulatory model is much more a product of revolution rather than the evolution that has emerged in the United States. As identified above, the move to a centralized, light-touch regulatory model in the United States would provide a number of key advantages at a relatively low cost and with little practical intrusive impact. Such an approach would not be incompatible with the National Space Policy, serve to act as a focal point for the developing Cubesat industry and future-proof the United States from regulatory intrusion at a later date. That's not to say that the United States should follow the regulatory lead of the UK, but its policy, legislative and regulatory organs should keep an open mind to a different approach to cubesat regulation if the current system proves unmanageable.

Whilst the regulations are only in draft form at the moment, there is little doubt that a consultation with UK stakeholders will yield a positive response. Properly implemented, the UK's proposed cubesat regulations should provide a conducive base for private/commercial cubesat development in the UK. Notwithstanding the decentralized approach of the United States, (and given the increased engagement of the UK with ESA and other international space actors), the proposed UK regulatory scheme will stand on its own and provide a model for other state actors seeking to implement their own domestic cubesat regulatory scheme.

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[1] The term "cubesat" as used in this article includes spacecraft that are also termed smallsat and nanosat.

[2] London Economics, The Case for Space: The impact of space on the UK economy A study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency, July 2015.

[3] The Case for Space, p.10

[4] BSkyB lease satellite capacity to provide subscription TV for 11.5 million subscribers. This produced a turnover of over £7.6bn (The Case for Space, p.14)

[5] UK Space Agency, UK Space Innovation and Growth Strategy: 2015 Update report, July 2015 at p.4

[6] Jeff Foust, The ups and downs of smallsat constellations, The Space Review, June 22, 2015

[7] Mark Johnson, Cameron's SE Asia trade mission yields UK space deal, Relocate Global Magazine, 28 July 2015

[8] Jeff Foust, British trade mission focuses on Smallsats, Space News, August 12 2015

[9] The Case for Space, p.1

[10] The Secretary of State here will be the Minister of State for Universities and Science. Currently this position is held by Jo Johnson MP. For further details see https://www.gov.uk/government/ministers/minister-of-state-universities-and-science-department-for-business-innovation-and-skills. In practice, this function will be delegated to civil servants with appropriate expertise who work within the UK Space Agency.

[11] Outer Space Act 1986, s4(2)(a)

[12] Outer Space Act 1986, s4(2)(b)

[13] Outer Space Act 1986, s4(2)(c)

[14] Professor Richard Crowther, The United Kingdom's Outer Space Act, 9 March 2012.

[15] UK Space Agency, Draft Cubesat regulation recommendations, 2 June 2015, p.2.

[16] Id. at p.3.

[17] Id. at p.9.

[18] Id. at p.3.

[19] Id. at p.4.

[20] Id. at p.4.

[21] Id. at p.6.

[22] Jeff Foust, The ups and downs of smallsat constellations, The Space Review, June 22, 2015.

[23] Jeff Foust, The ups and downs of smallsat constellations, The Space Review, June 22, 2015.

[24] ESA, COPUOS and the IADC have all promulgated space debris mitigation guidelines and NASA has developed the OD guidelines that provided the foundation for the UN and IADC guidelines. The guidelines developed by NASA are mandatory for both NASA and DoD missions, unless a waiver is authorized. Notably, these guidelines are also mandatory for government cubesats.

[25] Draft Cubesat regulation recommendations, p.6.

[26] Andrew J. Abraham, Roger C. Thompson, Cubesat Collision Probability Analysis, 10 June 2015

[27] Hugh G. Lewis, An Assessment of Cubesat Collision Risk, 65th IAC, November 2014

[28] Available at http://www.unoosa.org/pdf/spacelaw/sd/COPUOS-GuidelinesE.pdf

[29] See the recommendations in Hugh G. Lewis, An Assessment of Cubesat Collision Risk, 65th IAC, November 2014 at p.10

[30] It has been suggested that the 25-year guideline is unenforceable and brings its effectiveness into question for orbital debris mitigation. A 5-year maximum for cubesats would be equally unenforceable also bringing into question its own effectiveness. *See generally*, David Finkleman, Letter | 25-year Orbit Disposal Guideline Poorly Cast, Space News, August 3, 2015.

[31] Joanne Wheeler, UK: Reform of the UK Outer Space Act, 8 June 2012

[32] Regulatory Policy Committee, Impact assessment opinion: review of the "Outer Space Act 1986", 11 December 2013

[33] UK Space Agency, Advanced notification: introduction of a liability cap for UK Outer Space Act 1986 licensees, last updated 2 June 2015.

[34] Yana Efimova, Matt Butchers, Space Insurance: KTN Report, 18 December 2014 at p. 10

[35] Draft Cubesat regulation recommendations, p.9

[36] National Space Policy of the United States of America, enacted June 28, 2010, p. 3

[37] Id. at p. 11.

[38] As part of this licensing condition, a private entity applying for a license to operate a remote-sensing system, including cubesats, must submit a plan, which explains how its proposed remote-sensing system will be able to restrict the collection and/or dissemination of imagery of Israeli territory at a level of resolution determined by the Commerce Department per the Kyl-Bingaman Amendment. The Kyl-Bingaman Amendment, requires that "[a] department or agency of the United States may issue a license for the collection or dissemination by a non-Federal entity of satellite imagery with respect to Israel only if such imagery is no more detailed or precise than satellite imagery of Israel that is available from commercial sources."

[39] In addition, under 51 U.S.C. § 60146(a) the licensee must also file an application with the FCC for radio spectrum to be used by receiving stations for the remote-sensing platform.

[40] Amateur cubesats are permitted to operate on the 17 m, 15 m, 12 m, and 10 m bands, 6 mm, 4 mm, 2 mm and 1 mm bands; and the 7.0-7.1 MHz, 14.00-14.25 MHz, 144-146 MHz, 435-438 MHz, 2400-2450 MHz, 3.40-3.41 GHz, 5.83-5.85 GHz, 10.45-10.50 GHz, and 24.00-24.05 GHz segments. These are within the international frequencies reserved for amateurs. *See* 47 CFR § 97.207(c).

[41] This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft (any energy sources include chemical, pressure, and kinetic energy)

[42] A cubesat that would occupy a fixed geosynchronous position would also be required to provide an interference analysis to demonstrate the compatibility of the proposed system with respect to authorized space stations within 2 degrees of any proposed satellite point of communication per 47 CFR § 25.140.

[43] Editorial | Cubesats Need Coordination Too, Space News, October 28, 2013.

[44] There is concern among the space situational awareness community that the lack of regulation for cubesats could create an adverse space debris environment in LEO and make the job of USSTRATCOM/JSpOC to identify and warn of potential conjunctions/collisions more onerous. Surely as the number of cubesats increase the need for proper registration and identification may require that regulations evolve to oblige these concerns.

[45] *See generally*, George Anthony Long, Small Satellites and Liability Associated With Space Traffic Situational Awareness, Embry-Riddle Aeronautical University, ERAU Scholarly Commons, Space Traffic Management Conference, November 6, 2014.

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