UK SPACE AGENCY

British High Commission Singapore

Science and Technology Facilities Council

Space Growth Partnership

SGUK

PARTNERSHIP FOR THE FUTURE

UK Singapore Space Sector Grand Challenge Workshop February 2020

Final Report

March 2020

Introduction

The UK and Singapore have a long history together, they just marked 2 centuries of their relationship last year by launching the SG-UK Partnership for the Future campaign, spanning across the areas of Digital Economy, Sustainable Business & Innovation, Security & Defence, and Education, Culture & Youth. Over the course of 2019, we have witnessed 24 MOUs between the UK and Singapore in the areas of science research, education, medical technology, climate resilience including green finance and cyber security. There is now the opportunity to elevate the relationship between UK and Singapore in the space sector. Singapore has a relatively new but growing space sector, the UK has a more mature sector; there are similarities in objectives and capabilities between the two markets that make them ideal for collaboration.

This mission was a very timely demonstration of UK intent; the week after exiting the European Union, over 30 UK delegates representing over 20 organisations visited Singapore. STFC RAL Space, together with the British High Commission and the UK Space Agency organised a visit to Singapore to coincide with Global Space Technology Convention (GSTC) 2020, Asia's premier space technology event. The need for this mission had transpired as a result of years of engagement between Singapore and UK and many visits to the GSTC. A catalyst for proposing this workshop is the current success of the UK Singapore Quantum Key Distribution satellite mission, 'QKD Qubesat', due to launch at the end of 2022. This collaboration is a serious demonstration of commitment from both sides to progress UK - Singapore relations in the space sector. The £10m bilateral satellite mission is partly funded by the UK Industrial Strategy to test and demonstrate quantum key distribution from space over global spanning distances.

Discussion with STFC, the British High Commission, Singapore's Defence Science Organisation (DSO) and the Singapore Space Technology Association (SSTA) outlined the desire to identify future collaborative partnerships that could follow on from this exciting mission, the first of its kind between the UK and Singapore. This would then be an opportunity to bring sector leads together from across research and enterprise to create and develop ideas into something that could be implemented in future.

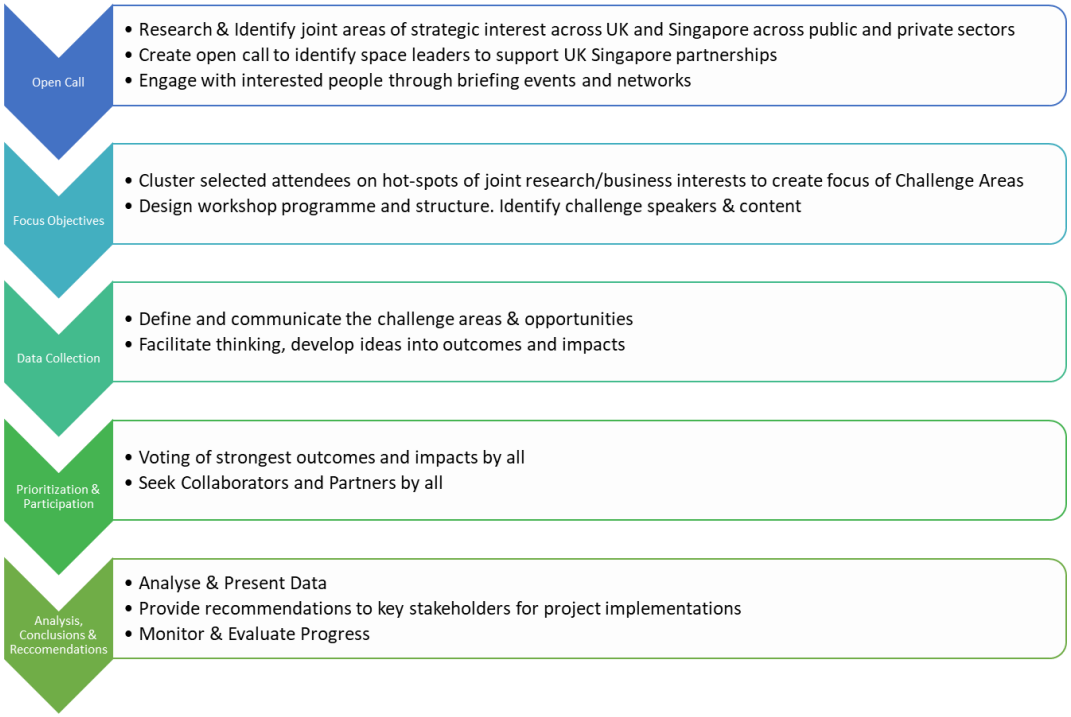
The week long mission also included a set of activities including several tours to Singapore's world leading space businesses and Universities, attendance of this workshop, attendance of an organised UK Singapore evening reception networking event hosted by the British High Commissioner of Singapore, plus form part of a purpose-built UK Pavilion and brochure at GSTC 2020.

The UK Singapore Grand Challenge workshop objectives

Identify, discuss and develop synergies in addressing global and technological challenges that will support future partnerships between UK and Singapore, providing a basis for future international partnership agreements in 2020 and beyond, research & innovation collaborations & joint space missions that support economic growth and societal benefit for all.

The workshop organisation and attendance was carried out with strong help and support from Singapore Space Technology Association (SSTA), the lead organisers of GSTC2020. SSTA were essential in attracting and identifying attendees from Singapore and securing the event location, the Grand Hyatt Hotel. David Tan, Exec Director at OSTIn was also instrumental in representing all of the Singapore attendees and the opportunities it could provide. The workshop was also supported by the UK Space trade association and the Space Growth Partnership. Both the UK Space Agency and British High Commission also took an active role in the workshop programme and activities on the day.

Process used in creating the Workshop



I. Open Call

In total there were over 75 expressions of interest for the open call for the workshop and around 65 attended on the day. The roles and organisations of attendees are listed below:

Role	Organisation	Origin
CEO & Founder	Astropreneurs HUB	SG
Head of Investment	Cap Vista	SG
Head	ST Engineering Ventures	SG
CEO	Aliena Pte Ltd	SG
Director	A*STAR Science and Engineering Research Council	SG
Editor	SpaceTech Asia	SG
Strategic Planning Manager	ST Engineering Electronics Ltd	SG
Director	MetaSensing AP Pte Ltd	SG
EMBA Student / Engineer	Cornell University	SG
Head of Global Business	FATOS APAC	SG
Engineering Director	Insituit	SG
Project Manager	PTGEM	SG
Deputy Director Ops Tech	Maritime Port Authority	SG
CEO	NuSpace Pte Ltd	SG
Program Management HOD	Flex	SG
Engineer	Godrej Aerospace	SG
Researcher	Symbiosis	SG
SEA Reg. Manager	Synspective Inc.	SG
Director	DSO National Laboratories	SG
CTO	Infinite Orbits PTE Ltd	SG
Director	Flex	SG
Deputy CEO	Network Integrity Assurance Technologies Sdn Bhd	SG
CTO	SpeQtral	SG
Executive Chairman	Surrey Satellite Technology Ltd	UK
Business Line Manager - Earth Observation	Surrey Satellite Technology Ltd	UK
Regional Head Business Development	Surrey Satellite Technology Ltd	UK

Assoc Prof	NTU	SG
Assistant Director	NTU	SG
Chief Executive	Qubitor Pte Ltd	SG
Programme Manager	DSTA	SG
CEO	Transcelestial	SG
Head of Investment	Cap Vista	SG
CEO	Cap Vista	SG
Founder	Photonicity Pte Ltd	SG
ASEAN Region Associate	SPOTTITT	SG
BD Manager	RAL Space	UK
VP Market Development	Open Cosmos	UK
CEO	Archangel works	UK
Director	CST	UK
Director	UK Launch Services Ltd	UK
Stream Manager	Enersys ABSL	UK
Professor of Space Physics	Uni of Leicester	UK
Managing Director	UK Space	UK
International Development Manager	NPL	UK
CEO Founder	Spottit	UK
Regional Director, Asia	OneWeb	UK
Director/CTO	In-Space Missions Ltd	UK
Director	Arqit	UK
AI Engineer	GMV	UK
Business Development Director	Spur Electron Ltd	UK
CEO	OSS	UK
CEO	RCM Ltd	UK
Lead for Export and Investment	UKSA	UK
International Policy Manager	UKSA	UK
Head of Telecommunication Strategy	UKSA (UK Lead Delegate)	UK
BD Manager	OSS	UK
Head of International	NPL	UK
Senior Project Manager	STFC	UK
Head of Business Development	STFC	UK
Head of Disruptive Technology	STFC	UK
Engineer	OneWeb	UK

ii. Focus of Objectives

From a combination of strategic interest areas of UK and Singapore Space sectors, plus the interest areas highlighted in UK participants application forms, 4 key challenge areas were identified where it was likely useful and impactful interaction and discussion could be made

Workshop Challenge Focus Areas

1. **Climate Resilience, Sustainability & Green Growth**

Climate Change is an area that both the UK and Singapore are focussing on, and have common goals both in country and in the wider world. Space technologies and the services they enable not only have the ability to monitor the effects of climate change up to a global level, but also the ability to reduce the impact of climate change, mitigate against the consequences and adapt to change. The UK and Singapore also have the opportunity to utilise its world class expertise in driving sustainability in our cities, and creating innovative financial and investment models to support green growth.

2. **The Quantum Revolution (Upstream & Downstream)**

Quantum Technologies from Space and the services they enable will completely transform our world in future, going from a society that today almost entirely relies on the digital economy, to one that

will be underpinned by a Quantum economy. The way we communicate, locate, provide the only solution to secure the IoT , and observe the earth will be driven by Quantum technologies. Countries are investing billions of dollars in securing their market leading position in this Quantum arms race, with the UK and Singapore already having a strong interaction to support innovation in this area, with the QKD Qubesat mission.

3. The IoT and Global Communications

A fully interconnected world is perhaps only truly possible with a space element that helps to connect devices irrespective of where you are on land, sea, in the air, or in space. Also major private capital investment in global connectivity mega-constellations is driving more investment into space companies within the supply chain. The UK and Singapore are some of the best places in the world to set up and grow a space or space service company, with an ability to explore an enormous range of vertical markets.

4. Research & Innovation Funding, and Commercial partnerships and investment (2 Challenges)

UK and Singapore are two of the best places in the world to set up and grow a space or space service company, with an ability to explore an enormous range of vertical markets across the West and East. Not only this, but the UK and Singapore are home to Universities that are ranked some of the best in the world for research excellence and level of innovation. The opportunity and challenge is how to collaborate effectively and commercialise advanced space concepts that have the potential to transform and disrupt.

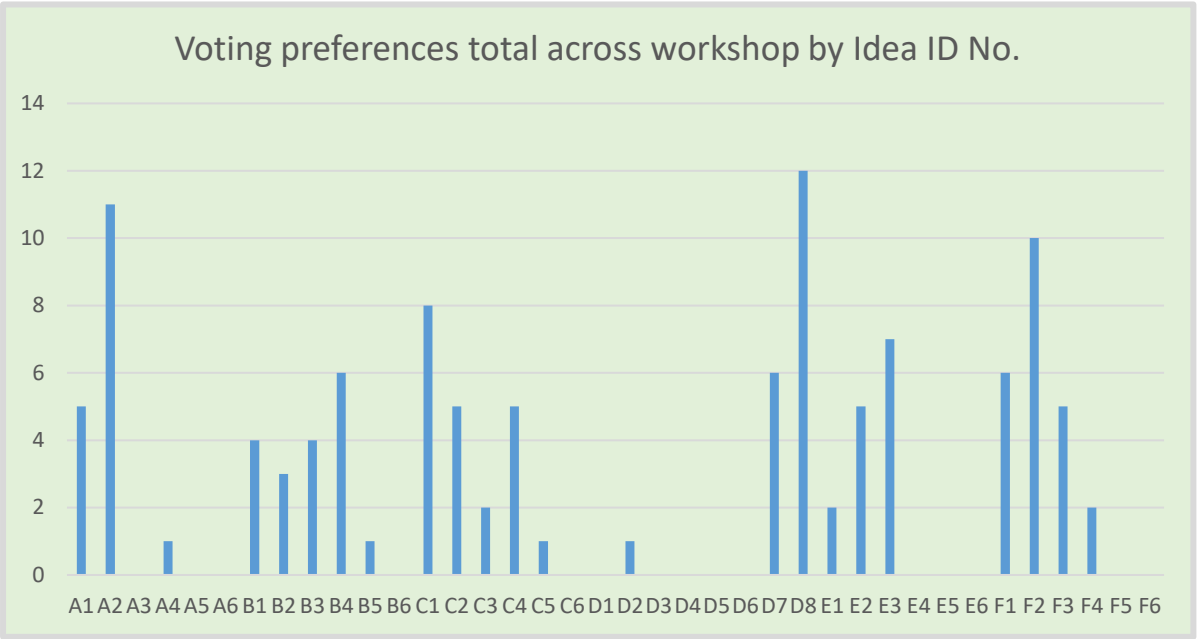
From these challenge areas the workshop programme and content was developed into the below agenda for the day

1400	Arrival – Registration, refreshments	
1410	Chairman's Welcome	Robert Elliott, Head of Business Development, UK Research & Innovation STFC
1415	Welcome to Singapore	David Tan, Executive Director, OSTIn
1420	Head of UK Delegation Introduction & Keynote – UK Space Agency	Mike Rudd, UK Space Agency
1425	Climate Resilience & Disaster Monitoring	Dr Andy Shaw – Resilience Constellation Ltd
1435	The Quantum Revolution, Singapore and UK perspectives	Prof George Loh, NRF Mr Graham Peters, Arqit
1450	Space business, research, innovation & growth, opportunities for UK & Singapore.	Alexa Silva, SSTL KHOO Teng Lip, Head of Singapore Technologies Engineering Ventures (STEV)
1505	The IoT and Global Communications	OneWeb (tbc)
1510	Rapid Introductions of workshop delegates	All
1535	Summary and description of next part of the workshop, Q&A	Robert Elliott, UKRI STFC
1545	Workshop Roundtable discussions (rotate every 15min) See Table ID's for: 1. Climate Change Resilience, Sustainability & Disaster Monitoring 2. Quantum Space Technologies 3. Quantum Space Enabled Services 4. The Internet of Things & Ubiquitous Connectivity from Space 5. Private funding & investment channels to support space business growth in UK-SG 6. Research & Innovation funding to support future UK Singapore collaboration	60 mins Table Facilitators: Robert Elliott Charlie Haire Antonio Costa Andy Vick Hanbin Zeng

1630	Indication of Participation, Voting and Selection of best ideas and topics to take forward	Everyone 15min
1645	Summary, Next Steps, Instructions for evening	Robert, Hanbin
1700	Workshop Close	

iii) Data Collection, Prioritisation & Participation

Tables were split to cover the 5/6 Challenge Areas. Teams were given 20 mins to discuss and develop 1 or more ideas and work them through to think about potential project outcomes, costs, timescales, the special relationship between UK and Singapore, plus the high-level impacts (which could be either or all societal, environmental, economic in nature). After 20 mins everyone was asked moved onto to address a different challenge. In practice, only 1 change was made in the time available (as opposed to 2) Each project idea was given a unique ID so that it could be tracked throughout the rest of the process. The projects ideas and the voting of projects are described below:



3 projects which were voted relatively highly and roughly equally from both Singapore and UK attendees are summarised below. However all projects are potentially valid and of interest to a broad range of the workshop attendees:

Project A2: 11 votes

Reducing Air Pollution in Cities through integrated & smart Land/Sea/Air management systems demonstrator.

This project would set up a joint programme of city level sensor networks, space based networks, proposals for improvement, smart transport demos to reduce air pollution to support congestion charging to alter air quality, planned arrival of boats, autonomous vehicle 'smartquality'

Initial Interested Participants: A Star, NPL, NTU, In-Space missions ltd

Project D8: 12 Votes

Satellite Quantum Key Distribution Service trial between London & Singapore financial Centres.

This project would carry out a a QKD time service between London and Singapore, to provide a test bed
Immediate financial service with economic impact, financial resilient, tracking of transactions, regulatory framework, challenge of adoption, scale, user req's
Trial a QKD time service, London to Singapore, (can expand to eg HK, NY), an unprecendented test

Initial Interested Participants: Arqit, In-Space, NPL, Archangel, Speqtral, RAL Space.

Project F2: 10 Votes

Improving Maritime Security through a UK SG partnership to address upstream supply chain gaps and demonstrate services

lower insurance rates, safety of life at sea, improved maritime security
more accurate forecasting, NRT info, particularly in bad weather, better situational awareness
new project to improve/create new maritime info and capabilities-addressing upstream gaps and establishing new demonstration services

Initial Interested Parties: SSTL, Spottit, Anna Chua, NTU

The full written notes for all projects are provided below:

Climate Challenge Ideas

Project	**#A1**	**#A2**
Economic Impact/Societal Benefit	Better Use of Agri products, long term sustainability	Air Quality monitoring for marine diesel, waiting space for containers, cars
Project Outcomes	New finance/insurance models for Agri	congestion charging to alter air quality, planned arrival of boats, autonomous vehicle 'smartquality'
Activities	- Economic Impact Analysis (e.g Palm Oil), -brio-engineering to change crops, - new supplier identification, -information analysis & intervention assessment, -Government driven trade agreements leading to policy, insurance, agri. - supplier of avocados leads to insurance provider	City level sensor networks, space based networks, proposals for improvement, smart transport demos to reduce air pollution

Participants	wrote down govt, insurer, ngos, monsanto, Spottit input from workshop group	A Star NPL, NTU, Inspace missions ltd

IoT & Ubiquitous Comms Table

Project	**#E1**	**#E2**	**#E3**
Economic Impac/Societal Benefit	Lower Maintenance Costs		Ground Applications Development
Project Outcomes	Provision of new services, different applications, crops, castle, connectivity	Quantum-style encryption for IoT devices	-Solve traffic management issues. For DHL and other shipping countries
Activities	-Develop Low cost, mass prodcued user terminals '- Target a $2 user terminal (3yrs to develop)		
Participants		PQC (post quantum cryptography), SpeQtral	Oneweb, OSS, Infinate Orbits

Science, Research & Innovation Programmes & Partnership Model Ideas Table

Project	**#B1**	**#B2**	**#B3**	**#B4**	**#B5**

Economic Impac/Societal Benefit	Strengthen Bi and Uni lateral ties (B2B), (G2G) etc. DIT: encourgae SG Co's to setup in UK. Encourage SG investors to invest in UK tech companies. Design stds, international framework compliance and benefits	UK supplying components targetted at SG needs	first to market	clean space, lowering risk	Protecting assets
Project Outcomes	providing tech challenges for deep space gateway, lunar cubesats, towards components to supply the deep space gateway	Identification of relevant space tech, expertise for larger missions, going beyond earth orbits	larger antennas, more resolution on SARs, first to provide technology	capability ot imtigate against space waste, redcue risk to space vehicles and objects	Ability to give early warning of CME events
Activities	going beyond LEO thorugh a cubesat project to look at components, protective electronics	lunar exploration	In-orbit assembly & robotics	Tackling space debris	Space weather Monitoring
Participants	GMV	ABSL	GMV, Infinate Orbits, In space missions	ONEWEB, Infinate orbits	

Business Investment Table Ideas

Project	#f1	#f2	#f3	#f4
Economic Impact/Societal Benefit	responsible use of space, sharing burden, reduced costs	lower insurnace rates, safety of life at sea, improved maritime security		
Project Outcomes	uk and singapore shared platforms via coordinated programme for on psace testing/demonstrations	more accurate forecasting, NRT info, particularly in bad weather, better situational awareness	low latency comms to bandwidth sold	
Activities	sharing inorbit test platforms and launches	new project to improve/create new maritime info and capabilities-addressing upstream gaps and establishing new demonstration services	uk sG bandwidth project given geogrpahical locations	land reclamationb,climatechange mitigation ans insurance
Participants	infinite orbits, oneweb, in space missions ltd	SSTL, spottie, Anna Chua NTU	GMV, Qubiter, GMV	fintech sector, london to singapore link to Asia

Quantum Technologies Table Ideas

Project	#c1	#c2	#c3	#c4	#c5
Economic Impact/Societal Benefit	future qkd markets and services	Quantum computing for asteroid mining, Qtech subsystems for future QKD services		full value chain for a Newspace maritime environmental surveillance	global secure clock sync for military applications, secure gnss, worldiwde timnig stds
Project Outcomes	study of qkd business neeeds and how to translate those into QVD mission CONOPS	Space Qual Quanutm Prog to cover LEO to GEO	low light level surveillance	Hyperspectral Imaging data, efficient domo	
Activities	deplotable aperture also useful for laser comms, fast steering mirror. Realtime weather data for qkd distribution (and supprt EO and HTS)	Quantum machine learning, quantum algorithms for identifying appropriate asteroid for space minin. UK-SG IOD for (Atomic clocks, laser stability, q random number enerator, single photon detection, to raise TRL of devices	Quantum 3d imaging	hyperspectral +QKD+optical datalink+air+ground	intersatellite q comms for clock sync and qkd

Participants	In Space, SpeQtral SSTL	Archngel, SpeQtral	Uni of Leicester	CQT, spectral archangel, RAL DSO, SSTL, NPL	npl, archangel,. Speqtral

Quantum Enabled Services Table Ideas

Project	**#d7**	**#d8**
Economic Impact/Societal Benefit	Evidence of impact/benefit of QKD, stimulating and accelerating adoption, reduce risk of interference with CNI	Immediate financial service with economic impact, financial resilient, tracking of transactions, regulatory framework
Project Outcomes	1. idneitfy candidate sectors for joint demos. 2. run demo projects as next step	challenge of adoption, scale, user req's
Activities	study to identify market verticals for demo of qkd applications in uk & Singapore & between UK and Singapore	Trial a QKD time service, London to Singapore, (can expand to eg HK, NY), an unprecedented test
Participants	Archangel, speqtral	Inspace, NPL, Archangel, Speqtral. Others listed by table), Arqit

Iii Analysis & Reccomendations

The workshop produced over 25 project ideas generated by UK and Singapore domain experts, policy leaders and innovation leads, that could be taken forward either individually or as a joint programme of activity. In terms of taking the outputs of this workshop forward it would be recommended to do the following

1. **Share the report with all attendees of the workshop and ask for feedback on any opportunities and ideas they will be taking forward as a result of the event**
2. **As part of the report dissemination, invite key individuals to form part of a small Task Group with both SG & UK to take opportunities forward,**
3. **As part of the Task Group take some of the outputs to build as high profile cases or collaborative programmes for future investment and bilateral activity**
4. **Put in place a Monitoring & Evaluation process to measure the success of the workshop outputs**