

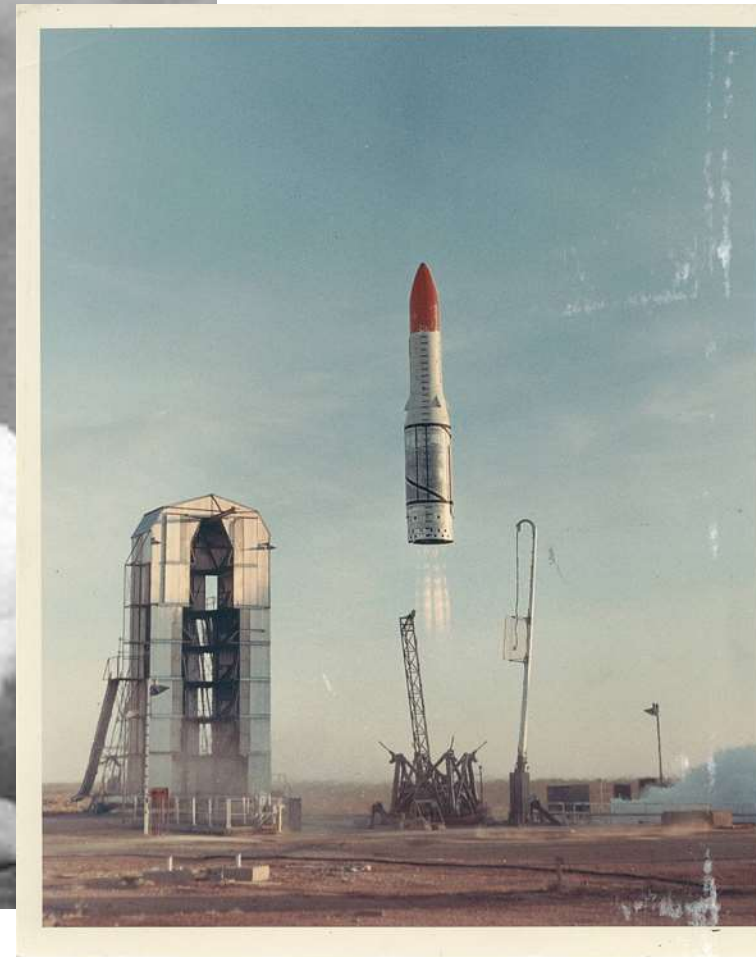
The legal, regulatory and medical foundations for commercial space tourism in the UK – the story so far and current and future challenges



Dr Stuart Mitchell
UK Civil Aviation Authority



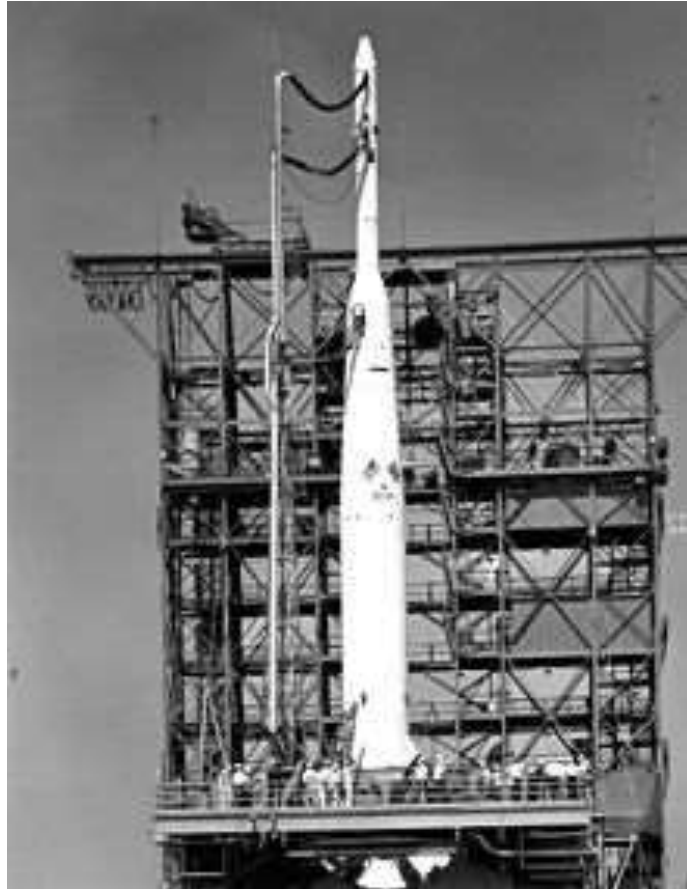
UK Space Launch History



Blue Streak – UK Ballistic Missile 1950's



1962 – 3rd Country to control a satellite in orbit
Ariel 1 Satellite 62kg – Geocentric low-earth orbit 397km
Thor Delta 9 (US) Rocket



Black Knight / Black Arrow 1960s



Facilities



HIGH DOWN, ISLE OF WIGHT



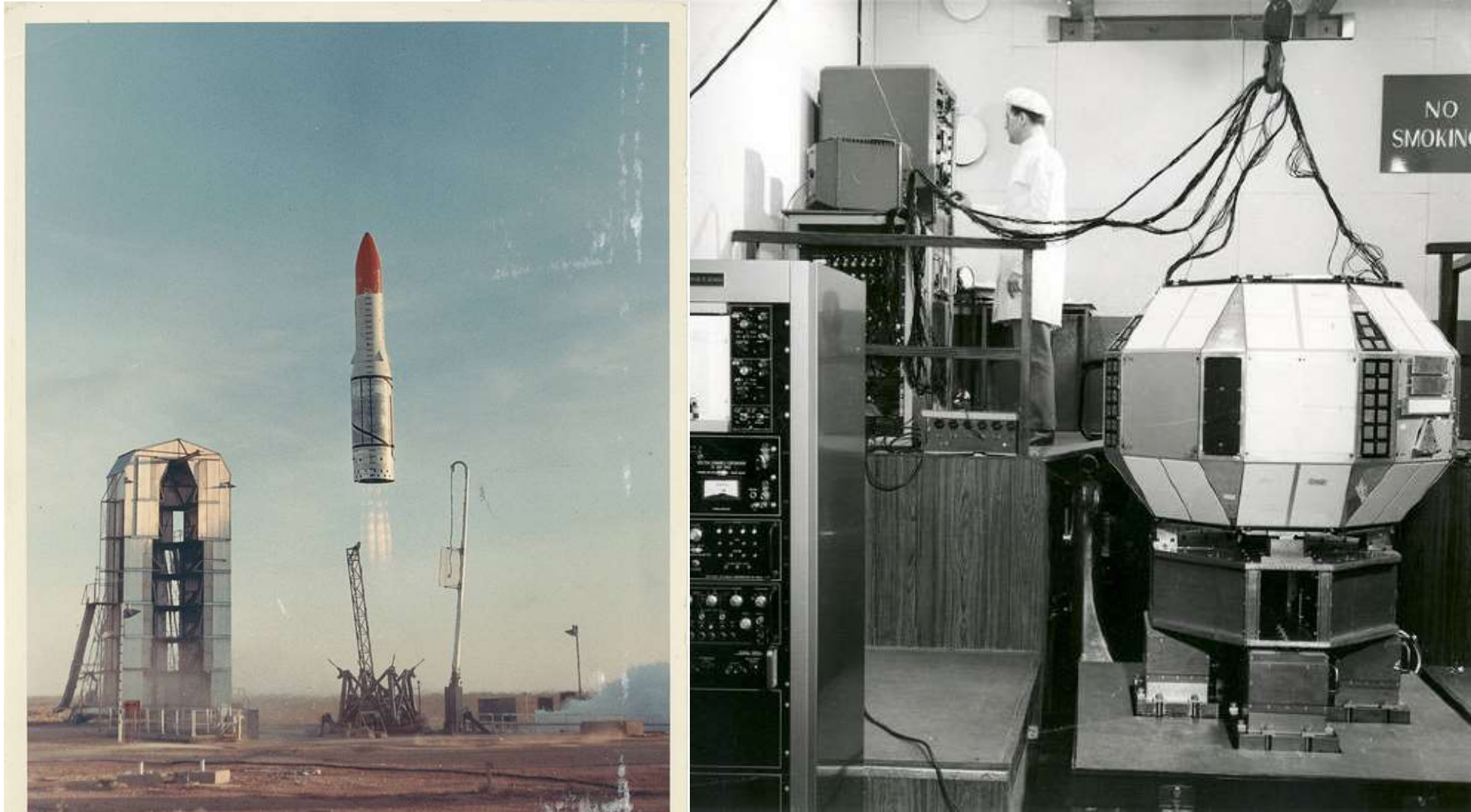
CUMBRIA



WOOMERA

1971 – 6th Country to Launch own orbital satellite with own system

Satellite Prospero aboard Black Arrow

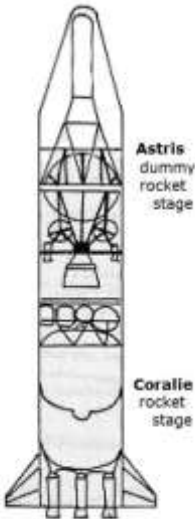


Europa Project 1960-1971

(European Launch Development Organisation)



Flight	Date	Model	Stages	Payload	Launch site
01	5 June 1964	<u>Blue Streak</u>	1	-	Woomera
02	20 October 1964	<u>Blue Streak</u>	1	-	Woomera
03	22 March 1965	<u>Blue Streak</u>	1	-	Woomera
04	24 May 1966	<u>Blue Streak</u>	1	upper stage mockups	Woomera
05	15 November 1966	<u>Blue Streak</u>	1	upper stage mockups	Woomera
06	4 August 1967	Coralie	2	third stage mockup	Woomera
07	5 December 1967	Coralie	2	third stage mockup	Woomera
08	30 November 1968	Europa 1	3	third stage mockup	Woomera
09	31 July 1969	Europa 1	3	satellite mockup	Woomera
10	6 June 1970	Europa 1	3	satellite mockup	Woomera
11	5 November 1971	Europa 2	4	satellite mockup	Kourou



Since then...

- Skynet satellite programme (Military Comms) from 1969
last launch (Ariane V) 2012
- Falstaff Hypersonic test rocket 1969 - 1979
- **Revival of 'National Space Programme' in 1982**
 - HOTOL spaceplane project (funding cancelled)
 - **Engine technology development**
- Helen Sharman – First UK (female) Astronaut – Project Juno – Soyuz
 - (Private/USSR funded)
- **Successful space technology and satellite manufacturing industry**



...and work with European Space Agency

- 1985 – 2010 British National Space Centre
 - Funding to ESA for science and robotics
e.g. Beagle 2 to MARS 2003.
 - No contribution to ISS or other manned missions
- 2010 – Present: UK Space Agency
 - Increased funding to ESA
 - International Space Station
 - Major Tim Peake ESA Astronaut 2015
 - Skylon Spaceplane Project



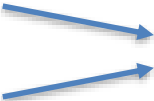
And..



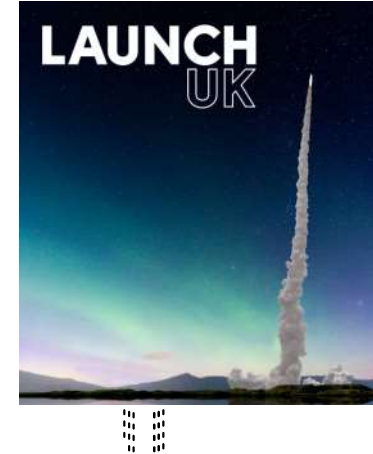
Requirements to be a 'full' player in the 'Commercial Spaceflight Game'

- Funding
 - A Market for payload and Investment
- Legislative framework
 - Public Safety and International agreements
- Airspace
 - ...And Range control
- Launch sites
- Vehicles to launch

Requirements to be a 'full' player in the 'Commercial Spaceflight Game'

- **Funding**
 - **A Market for payload and Investment**
- *Legislative framework*
 - *Public Safety and International agreements*
- *Airspace*  *And Range control*
- *Launch sites*
- *Vehicles to launch*

Commercial Spaceflight: Key Milestones 2012-2018



CAA were tasked by the DfT to carry out a review to better understand the options for the regulation of commercial spaceplane operations in the UK.

2012

Summary recommendations were presented to Government ministers (CAP 1198) The results of the review were made public with the publication of the technical report at the Farnborough Airshow (CAP 1189)

2014

With the publication of the UK Space Innovation and Growth Strategy (IGS) the government decided it wanted to enable all options for the launch of small satellites and sub orbital flights from the UK. This was necessary to meet the stated aim of achieving 10% of the global space market by 2030. As a result in 2016 the CAA space team was a key partner assisting government to draft a Bill for UK space launch.

2016

The UKSA as an agency of BEIS put together a grant fund (£50m) to encourage commercial space launch providers to partner with a prospective spaceport location to enable launch from 2020 onwards. The winners of the Grant process will be announced at this year's Farnborough airshow.

2018

Funding Approach by UK Government

- Continue and enhance engagement with ESA and other International Projects
- For the UK...
- Vertical Launch of small satellites
 - Evolving competitive market, particularly polar orbits
- Commercial Sub-orbital Space Tourism
 - Evolving market for high net worth individuals and scientific research

Requirements to be a 'full' player in the 'Commercial Spaceflight Game'

- *Funding*
 - *A Market for payload and Investment*
- **Legislative framework**
 - **Public Safety and International agreements**
- *Airspace*
- *Launch sites*
- *Vehicles to launch*



And Range control

Legislative Framework

“Space is the most remote environment to operate in and access remains one of humankind’s greatest engineering achievements.

High standards are paramount in overcoming the engineering challenges, and the legal and financial....

Nations which establish comprehensive and clear regulatory standards will give confidence to investors, a stable environment for operators and assurance to the general public about the safety and security of launch operators”



UK Legislation



Outer Space Act 1986

CHAPTER 38

ARRANGEMENT OF SECTIONS

Application of Act

Section

1. Activities to which this Act applies.
2. Persons to whom this Act applies.

Licensing of activities

3. Prohibition of unlicensed activities.
4. Grant of licence.
5. Terms of licence.
6. Transfer, variation, suspension or termination of licence.

Other controls

7. Register of space objects.
8. Power to give directions.
9. Warrant authorising direct action.
10. Obligation to indemnify government against claims.

General

11. Regulations.
12. Offences.
13. Minor definitions.
14. Index of defined expressions.
15. Short title, commencement and extent.



Space Industry Act 2018

CHAPTER 5

CONTENTS

Regulation of spaceflight etc

- 1 Introduction
- 2 Duties and supplementary powers of the regulator
- 3 Prohibition of unlicensed spaceflight etc
- 4 Exemptions from licence requirement

Range control

- 5 Range
- 6 Range control services
- 7 Provision of range control services

Licences

- 8 Grant of licences: general
- 9 Grant of operator licences: safety
- 10 Grant of spaceport licence
- 11 Grant of licences: assessments of environmental effects
- 12 Terms of licences
- 13 Conditions of licences
- 14 Licences granted for specified periods
- 15 Transfer, variation, suspension or termination of licence

Exercise of regulatory functions by bodies other than Secretary of State

- 16 Power of Secretary of State to appoint person to exercise functions

Individuals taking part in spaceflight activities etc

- 17 Informed consent
- 18 Training, qualifications and medical fitness

Outer Space Act 1986

- Primarily for Licensing the launch of space objects
- UK Space Agency acts on behalf of the Secretary of State



Outer Space Act 1986

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Space Industry Act 2018

- Aims include...
- To accommodate and legislate for (horizontal) suborbital spaceplane operations from a location(s) in the UK
- For the purpose of:
 - Space tourism, Micro gravity experiments, Satellite launches



Space Industry Act 2018

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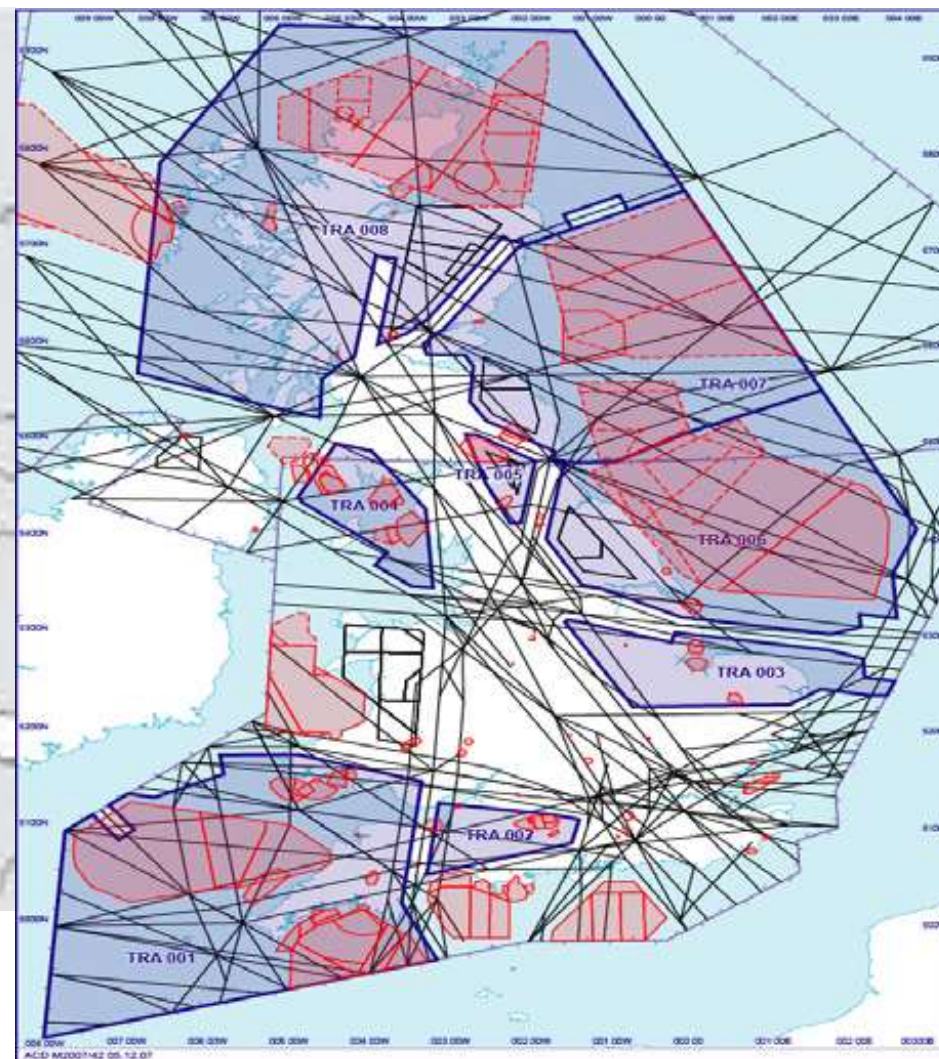
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Requirements to be a 'full' player in the 'Commercial Spaceflight Game'

- *Funding*
 - *A Market for payload and Investment*
- *Legislative framework*
 - *Public Safety and International agreements*
- **Airspace**
- **Launch sites**
- *Vehicles to launch*

And Range control

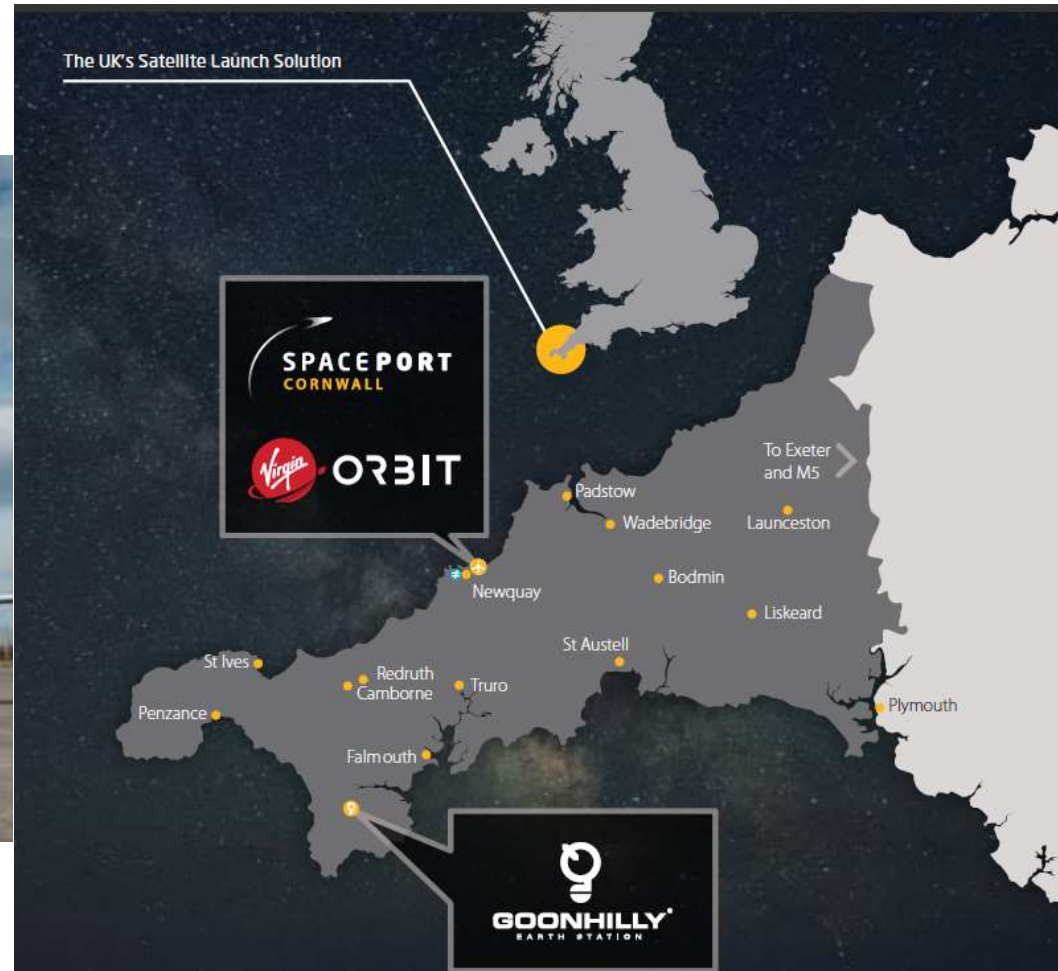
The Need for Launch Capability: Airspace



The Need for Launch Capability (vertical)



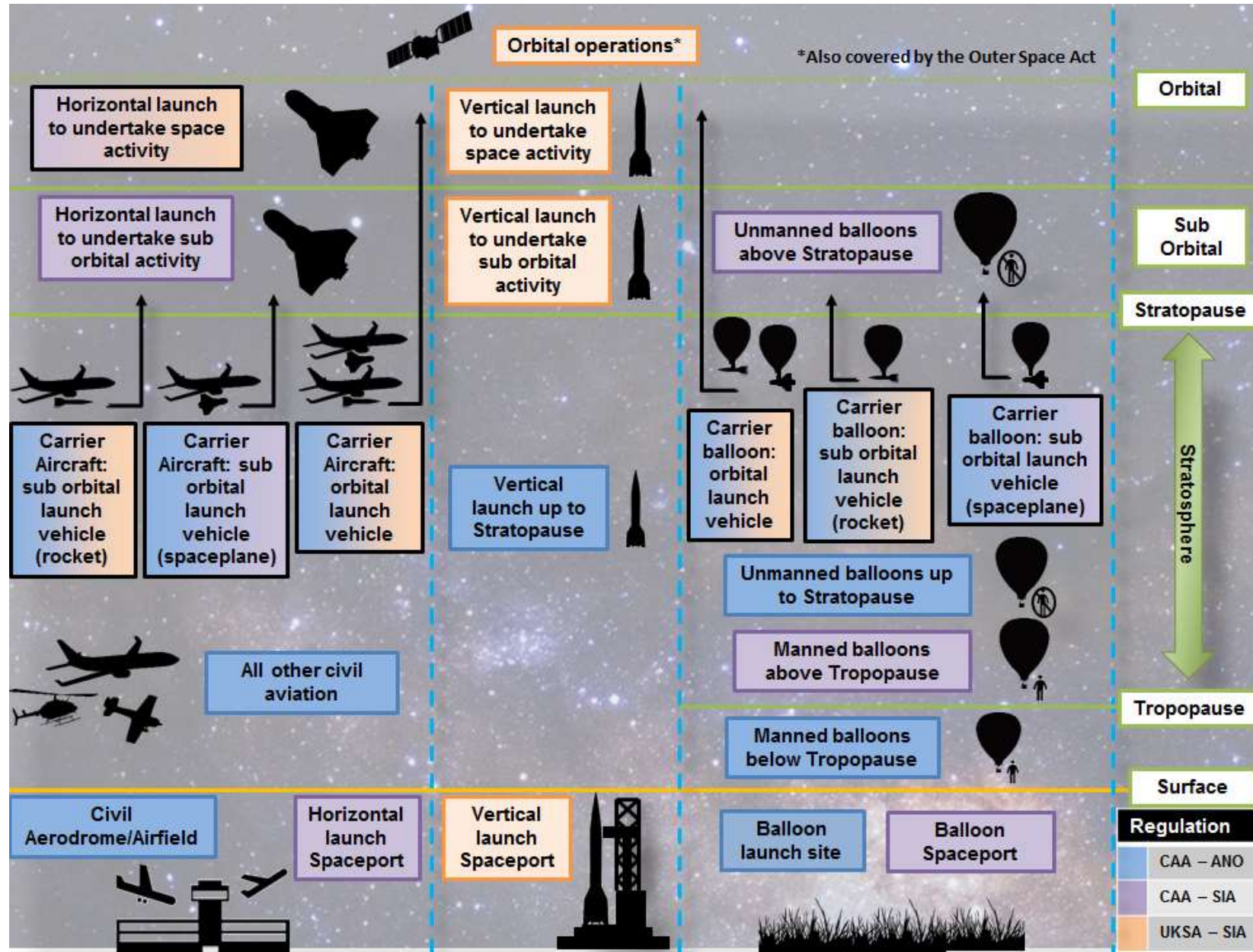
The Need for Launch Capability (horizontal)



Requirements to be a 'full' player in the 'Commercial Spaceflight Game'

- *Funding*
 - *A Market for payload and Investment*
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 - *Public Safety and International agreements*
- *Airspace*
 - *And Range control*
- *Launch sites*
- **Vehicles to launch**

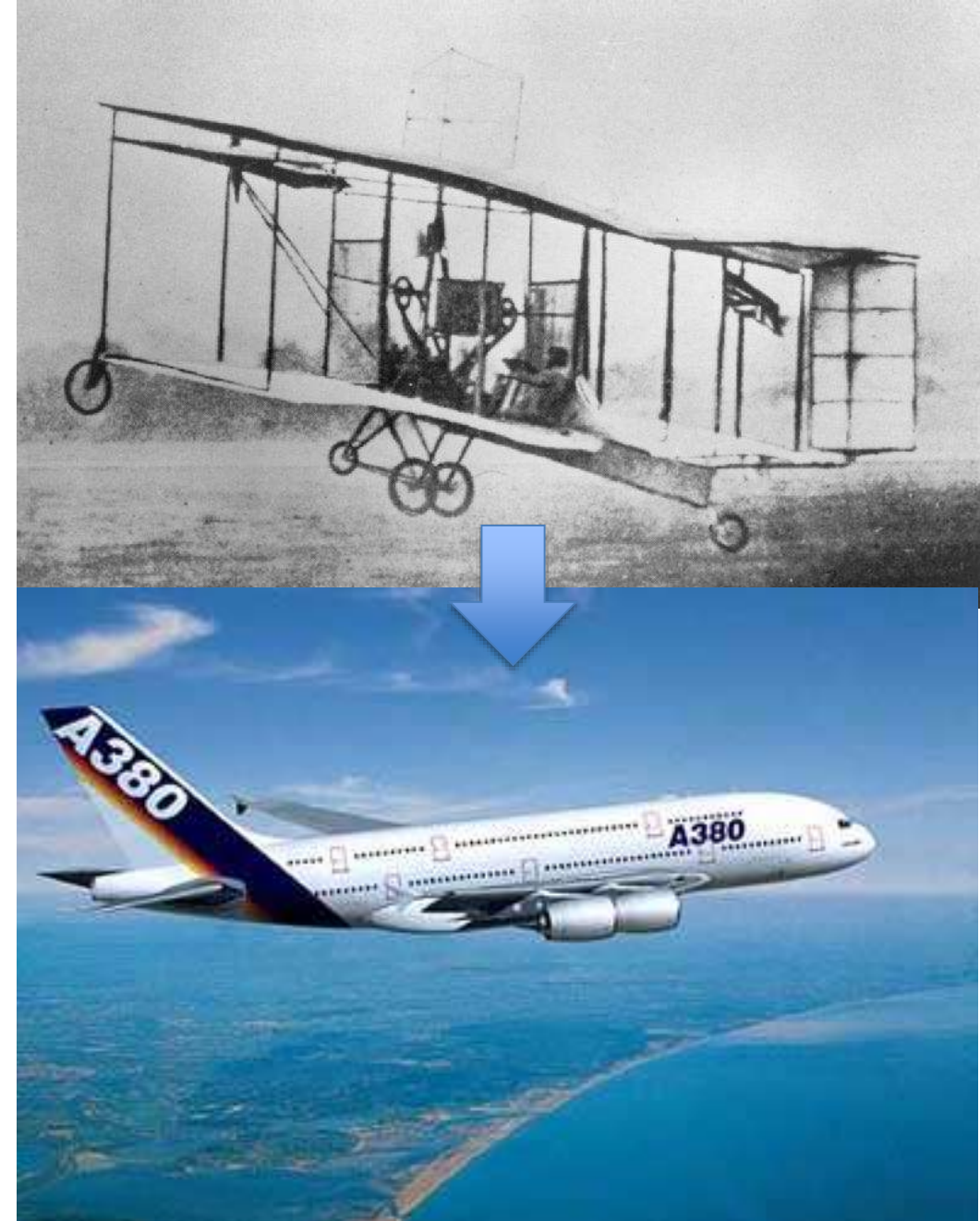
Space Vehicles and the secondary legislation requirement



CAA - ANO
CAA - SIA
UKSA - SIA

Regulatory Approach

- Different to what we are used to
 - i.e. commercial / private aircraft operations
 - Safety targets and risk management
 - Strong regulations, means of compliance and guidance material
 - Detailed inspection and oversight programme



Risk Management⁽¹⁾

- **Current UK 'Acceptable' Risks**
 - **Commercial Air Transport (CAT) – approx. 1 in 10,000,000 hours of flight**
 - **General Aviation – approx. 1 in 10,000 to 1 in 100,000 flight hours**
- **NASA 'target' <1 in 1,000 flight hours for orbital operations
<1 in 10,000 flight hours for sub-orbital
(NASA 'actual' <1 in 100 flights)**
- **FAA AST 'Acceptable' Launch Vehicle Risks**
 - **Public risk of operator activity < 3 deaths per 100,000 launches/missions**
 - **Individual public risk < 1 death per 1,000,000 launches/missions**

(1) Extract from Cap 1198

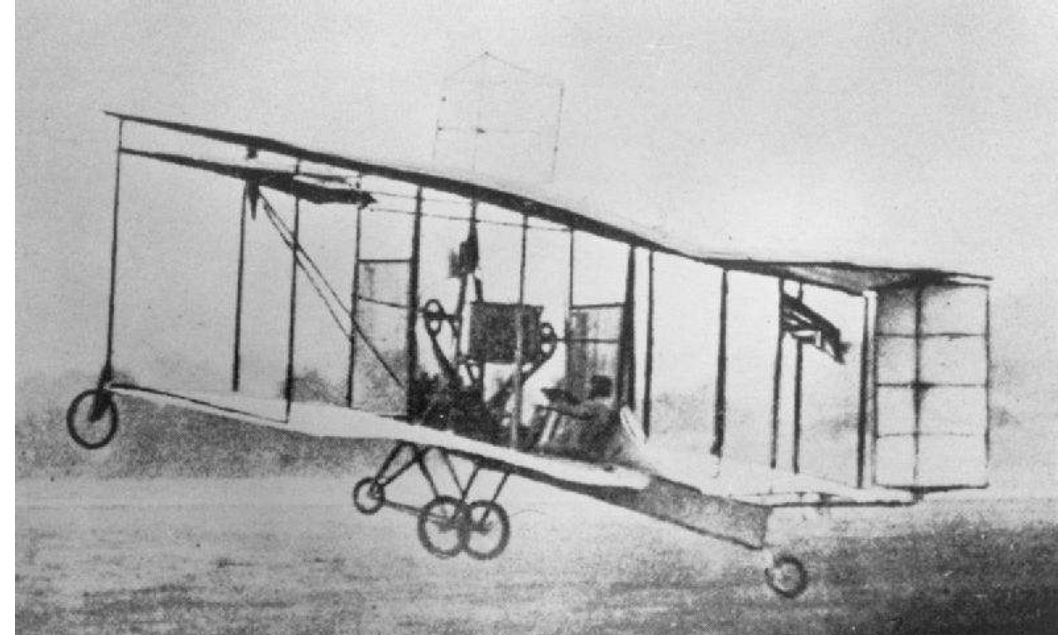
Pioneering is tough

- On 7 August 1913, Cody was test flying his latest design, the Cody Floatplane, when it broke up at 200 feet and he and his passenger, were killed.
 - The two men, not strapped in, were thrown out of the aircraft and the Royal Aero Club accident investigation concluded that the accident was due to "inherent structural weakness", and suggested that the two might have survived the crash if they had been strapped in
- On 31 October 2014, SpaceShipTwo VSS *Enterprise* suffered an in-flight breakup a premature deployment of its feathering mechanism during a powered flight test, resulting in a crash killing one pilot and injuring the other.
 - The National Transportation Safety Board cited inadequate HF design safeguards, poor pilot training, lack of rigorous federal oversight and a potentially anxious co-pilot without recent flight experience as important factors



Regulatory Approach

- *Different to what we are used to*
 - *i.e. commercial / private aircraft operations*
 - *Safety targets and risk management*
 - *Strong regulations, means of compliance and guidance material*
 - *Detailed inspection and oversight programme*
- No 'experimental aircraft category (as there is in USA)
- Risk for crew and participants is acknowledged to be substantially higher than CAT so priorities are:
 - To protect uninvolved general public
 - Principle of Informed Consent for crew and participants



Regulatory Approach (cont'd)

- The present challenge discussed in this presentation is to devise a system of regulations and guidance for operators that facilitates
 - Different spacecraft types,
 - Different trajectories and flight paths
 - Different environmental exposures
 - With or without human occupants as most of the proposed craft are still in development
- Currently only a very limited available literature of studies of individuals likely to be the crew or participants



Regulations for Training, Qualifications and Medical Fitness

- Responsibility of Operators for safety
- Regulator will oversee
- Specified Persons / Roles

The licence-holder

Launch personnel – Launch Director, designated Safety Official, Flight Safety Crew and Mission Management Controller (Launch)

Spacecraft flight crew, other crew members and remote pilots

Spaceflight participants

Operator engineering personnel – winged reusable spacecraft

Range control services personnel – Range Operations Officer and Range Safety Officer

Traditional Regulatory Approach

- Licensing
 - Training and Examining
- Flight Operations
- Medical
- Airworthiness

UK CAA

Transferable training

**individuals &
Organisations**

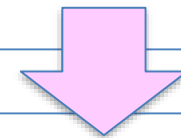
Transferable qualifications

Transferable licences

Transferable medicals

Operators work to regulatory documents and
guidance material approved by regulator

Engineering/airworthiness providers



Operators – generally doing the same things

A Different Regulatory Approach is needed

- Regulatory Inspection and enforcement regime
- ?
- ?
- ?..

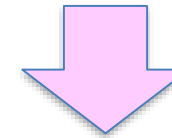
UK CAA/SA



(Pilot) Training
(Pilot) Qualifications
(Pilot) Licences
Pilot Medical certificates

Individual

Department
for Transport



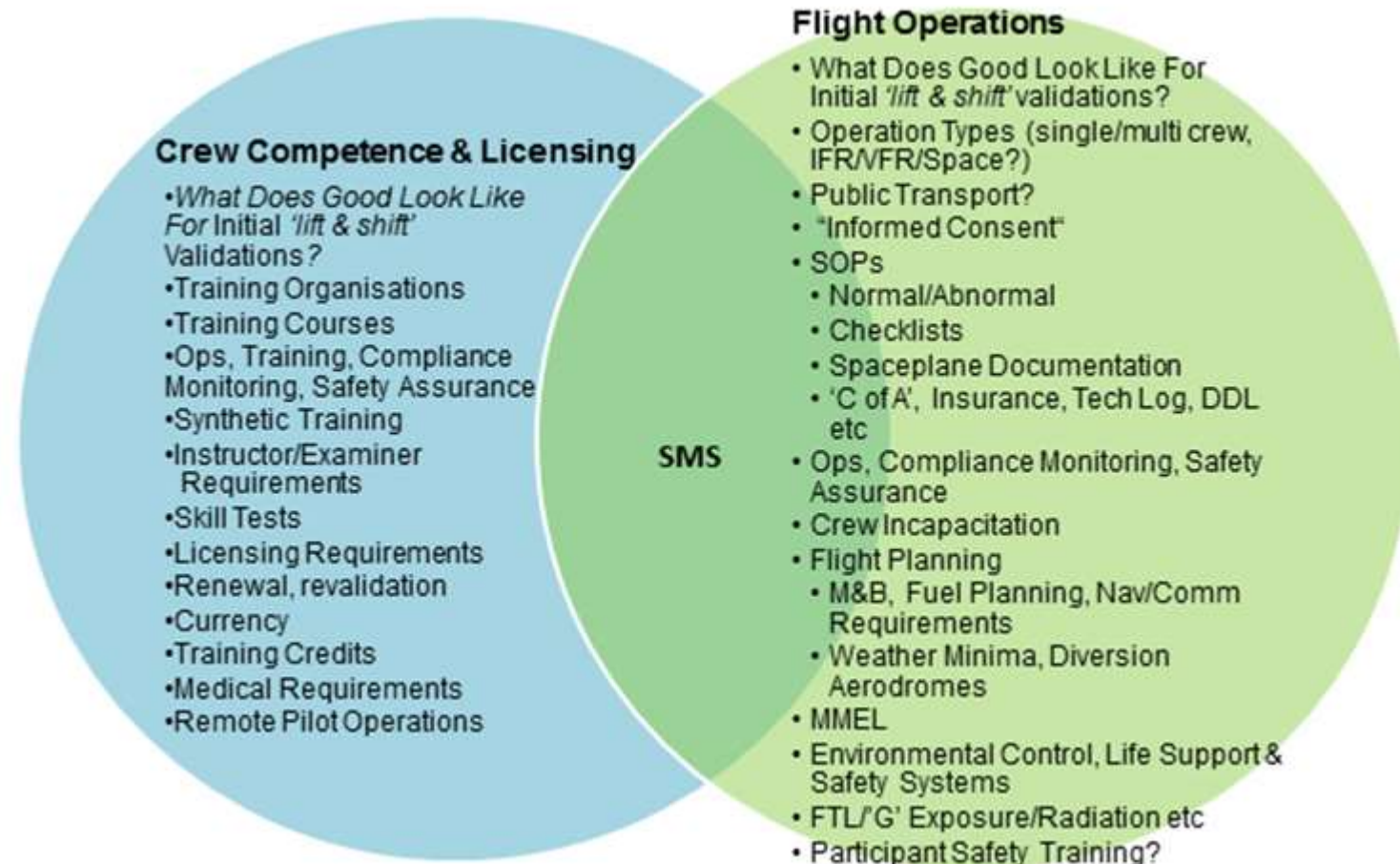
Individual Operators

Integrated Operation-specific Qualifications, Training and Testing, Medical and Operations

- Airworthiness

2 Key Current CAA Medical Work areas relating to Crew & Participants

- Informed consent
- Training qualifications and Medical Fit



Clause 17 Space Industries Act 2018:

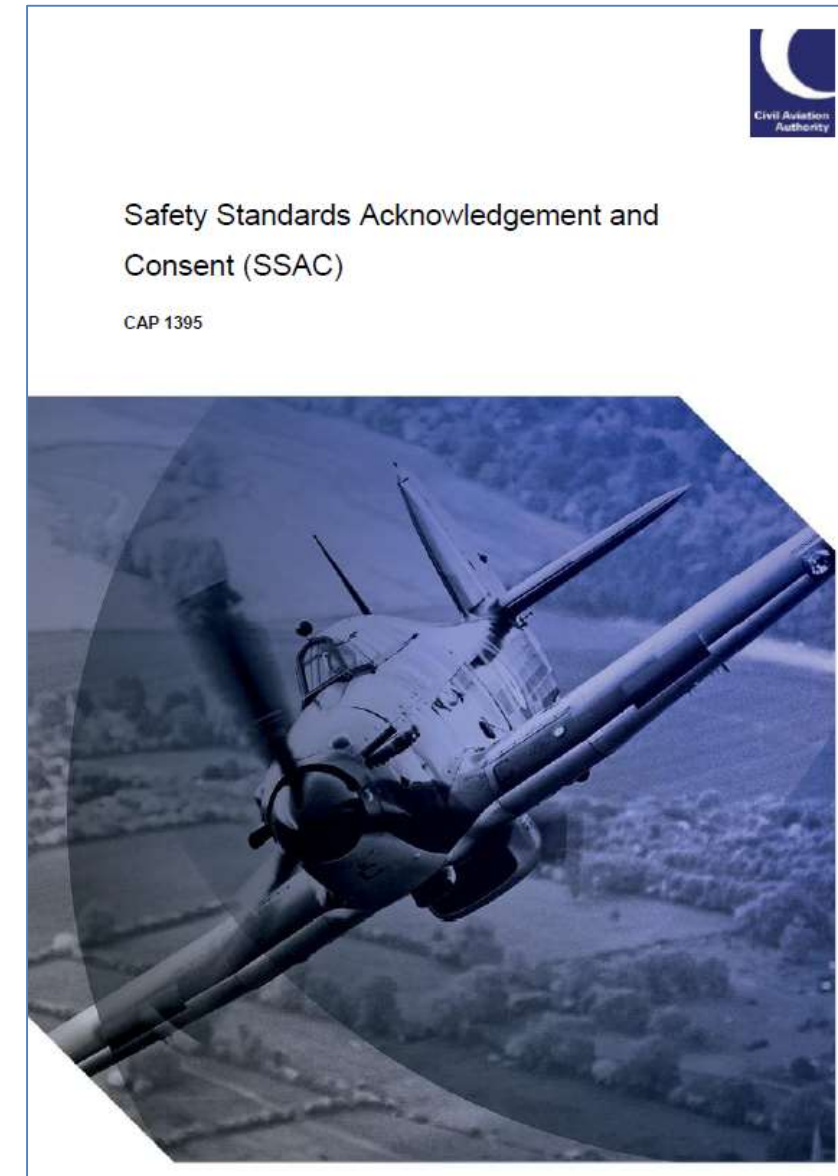
Informed consent

17 Informed consent

- (1) The holder of an operator licence (the “licensee”) must not allow an individual to take part, in a prescribed role or capacity, in spaceflight activities carried out by the licensee unless the individual –
 - (a) has signified his or her consent to accept the risks involved in those activities, and
 - (b) fulfils prescribed criteria with respect to age and mental capacity.
- (2) Consent to accept the risks involved in spaceflight activities must be signified by signing a document (a “consent form”) that gives details of the risk assessment carried out for those activities under section 9.
- (3) Regulations may make –
 - (a) provision about the form and content of consent forms;
 - (b) provision about information to be given to individuals before they sign consent forms;
 - (c) provision imposing evidential and procedural requirements with regard to the signification of consent.
- (4) It is an offence for a licensee to contravene subsection (1).

UK Safety Standards Acknowledgement and Consent

- Aircraft operators are be able to offer flights to paying participants without having to apply the very high safety standards normally applied to commercial flights provided that:
 - The passengers are informed of the key risks involved with participating in the activity.
 - Having been informed of the risks the passengers are willing to participate in the activity.
 - The expected high level of safety to the general public, including other airspace users, – those not participating – is maintained.



Informed Consent:

Issues for secondary legislation and guidance

- **Definitions**

- Crew vs Flight crew vs Cabin crew
- Participants vs passengers

- **Applicability**

- Both crew and participants

- **Mental capacity**

- Regional Law: England & Wales, Scotland and Northern Ireland
- Minimum Age
- Medical and Legal meanings and usage of terms

- **Provision of Information by the Operator**

- Overall figures for the industry including number of activities, and number of persons who have died, sustained an injury or had a medical emergency; during testing, development or commercial operations
 - Similar figures for the spaceflight activities carried out by the licensee and other relevant safety information
 - Information about and risk assessment of the specific activity that the person will participate in
- Updating material and opportunity to ask questions

Informed Consent:

Issues for secondary legislation and guidance

- **Specification for the consent form**
 - Details of the signatories
 - Statements pertaining to acceptance of risk
- **Timings** of provision of information and signing in relation to the flight
- **Witnesses**
- **Keeping of records**

Clause 18 Space Industries Act 2018: Training, Qualifications and Medical Fitness

18 Training, qualifications and medical fitness

- (1) Regulations (referred to in this Act as “training regulations”) may make provision with respect to the training, qualifications and medical fitness of individuals –
 - (a) taking part in, or otherwise engaged in connection with, spaceflight activities or the provision of range control services, or
 - (b) working at sites used for or in connection with spaceflight activities or the provision of range control services.
- (2) Schedule 2 gives examples of particular kinds of provision that may be made by training regulations.
That Schedule does not limit subsection (1).
- (3) The regulator may issue guidance about how a person carrying out spaceflight activities, operating a spaceport or providing range control services may comply with requirements imposed by training regulations.
- (4) The holder of a licence under this Act must not allow an unqualified individual –
 - (a) to take part in, or to be otherwise engaged in connection with, activities authorised by the licence, or providing services the provision of which is authorised by the licence, in a specified role or capacity;
 - (b) to work in a specified role or capacity at a site used for or in connection with the activities or services to which the licence relates.

An individual is “unqualified” for the purposes of this subsection if he or she does not fulfil specified criteria with respect to training, qualifications and medical fitness.
- (5) In subsection (4) “specified” means specified in training regulations.
- (6) It is an offence for the holder of a licence under this Act to contravene subsection (4).
- (7) An individual commits an offence if –
 - (a) a person commits the offence in subsection (6), and
 - (b) the person’s commission of that offence is due to an act or default of the individual.

The individual is liable to be proceeded against and dealt with accordingly.
- (8) For the purposes of subsection (7) it does not matter whether or not proceedings are taken against the person committing the offence in subsection (6).

Clause 18 Space Industries Act 2018: Training, Qualifications and Medical Fitness

18 Training, qualifications and medical fitness

(4) The holder of a licence under this Act must not allow an unqualified individual—

- (a) to take part in, or to be otherwise engaged in connection with, activities authorised by the licence, or providing services the provision of which is authorised by the licence, in a specified role or capacity;
- (b) to work in a specified role or capacity at a site used for or in connection with the activities or services to which the licence relates.

An individual is “unqualified” for the purposes of this subsection if he or she does not fulfil specified criteria with respect to training, qualifications and medical fitness.

Clause 18

Space Industries Act 2018:

Training, Qualifications and Medical Fitness

Responsibility of Operators for safety

Regulator will oversee operator

Persons

- General licence-holder responsibilities and requirements
- Launch personnel – Launch Director, designated Safety Official, Flight Safety Crew and Mission Management Controller (Launch)
- Spacecraft flight crew, other crew members and remote pilots *
- Spaceflight participants *
- Operator engineering personnel – winged reusable spacecraft
- Range control services personnel – Range Operations Officer and Range Safety Officer

TRAINING REGULATIONS: FURTHER PROVISION

- (1) Training regulations may make provision requiring an individual's competence—

 - (a) to take part in, or otherwise to be engaged in connection with, prescribed activities in a prescribed role or capacity, or
 - (b) to work at a prescribed place, or to work at a prescribed place in a prescribed role or capacity, to be assessed by a person approved by, or on behalf of, the regulator.

(2) Training regulations may prescribe what a person may or must do in order to fulfil any prescribed criteria with respect to training and qualifications or medical fitness.
- (1) Training regulations may make provision requiring training to be provided only by a person approved by, or on behalf of, the regulator.

(2) Training regulations may make provision—

 - (a) requiring training to cover prescribed matters;
 - (b) requiring the content of training to be approved by, or on behalf of, the regulator.

(3) Training regulations may make provision about—

 - (a) training facilities;
 - (b) craft or vehicles to be used for the purposes of training;
 - (c) the use of training devices.

(4) Training regulations may make provision about inspection of approved training providers and approved assessors.
- Training regulations may make provision about keeping records of training undertaken or provided.
- Training regulations may—

 - (a) make provision about how applications for any authorisation, approval or other document required by the regulations are to be made, considered and determined (including provision about the examinations and tests to be undergone);
 - (b) make provision for any such document to be granted subject to conditions or limitation of time;
 - (c) make provision about the suspension, revocation, recognition, renewal or variation of any such document (including provision about the examinations and tests to be undergone);
 - (d) make provision about the form, custody, protection, cancellation, suspension, endorsement and surrender of any such document.

UK Approach to Sub-orbital Medical Fitness



“Stuart is doing a preliminary study of re-inventing the wheel”



Medical-Physiological Considerations Summary: Crew and Participants

Exposure Risk & Protection Against The External Environment

- Hypobaric exposure / Hypoxia / Barotrauma
- Temperature
- Radiation

Knowledge and Training

- The Space environment
- The Cabin Environment
- The Mission

Spacecraft Related Physiological Challenge

- Noise
- Vibration
- Motion sickness
- Acceleration → +Gx / +Gz / 0G
- Anxiety
- Normal/emergency Ingress/egress

Key Interactive Medical Conditions

- Visual
- Neurological
- Audio-Vestibular
- Cardiovascular
- Respiratory / ENT
- Psychiatric
- Musculoskeletal disability

Starting point considerations...

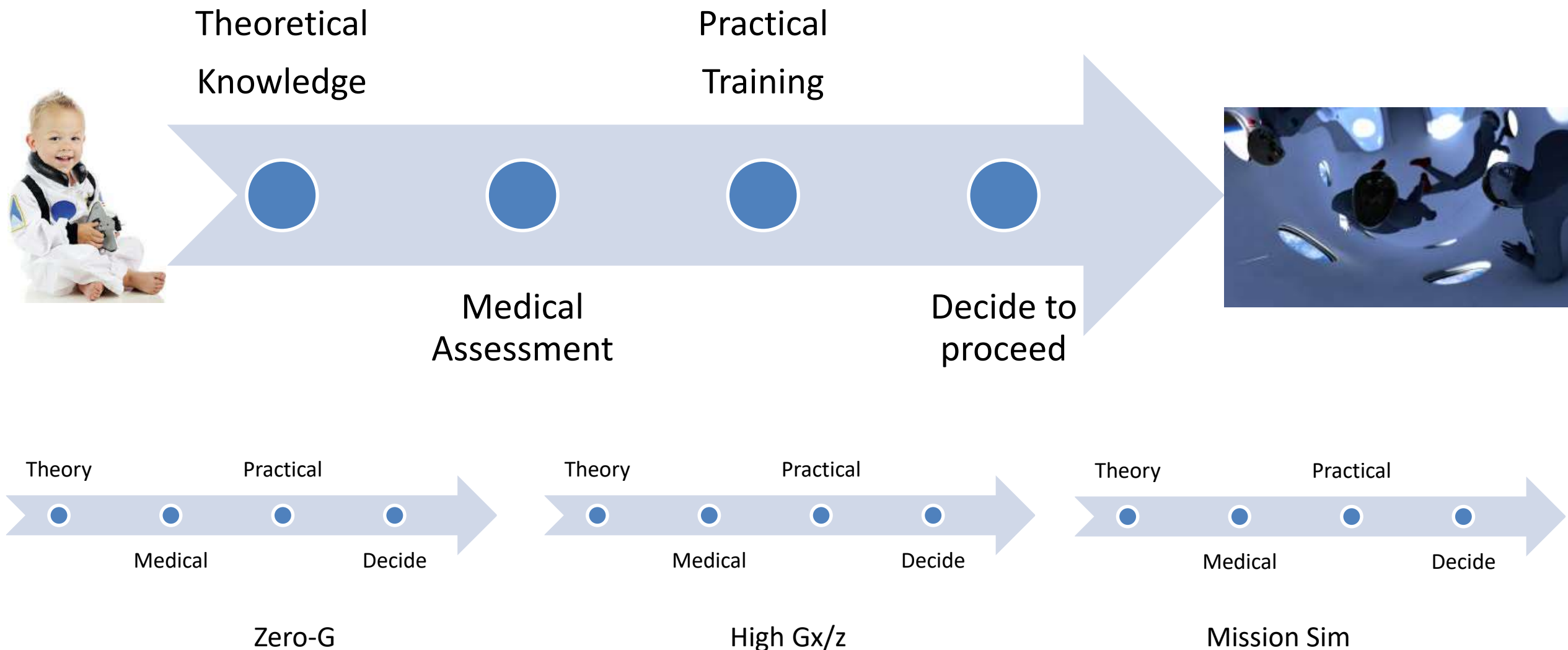
- **Acceptance of Existing Systems**
 - ICAO ATPL
 - (Unrestricted) Class 1 Medical

- **'Manage the Delta'**
 - Existing /evolving conditions – referral to regulator

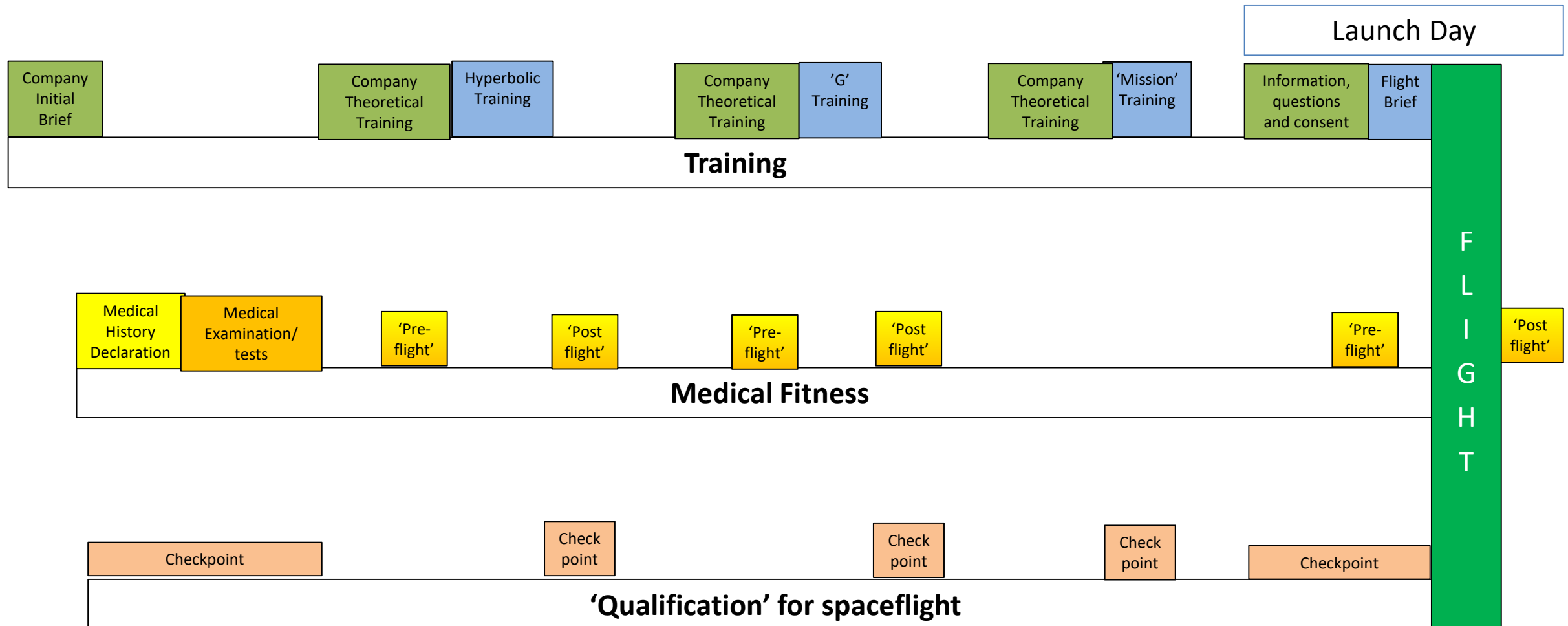
- **AME approvals for crew medicals**
 - Use current system
 - Additional qualifications/training for 'extension' of privileges

- **Operator Medical Advisers**
 - Qualifications / Experience / Training
 - Responsible for Operator's system for 'clearance' of Spaceflight participants

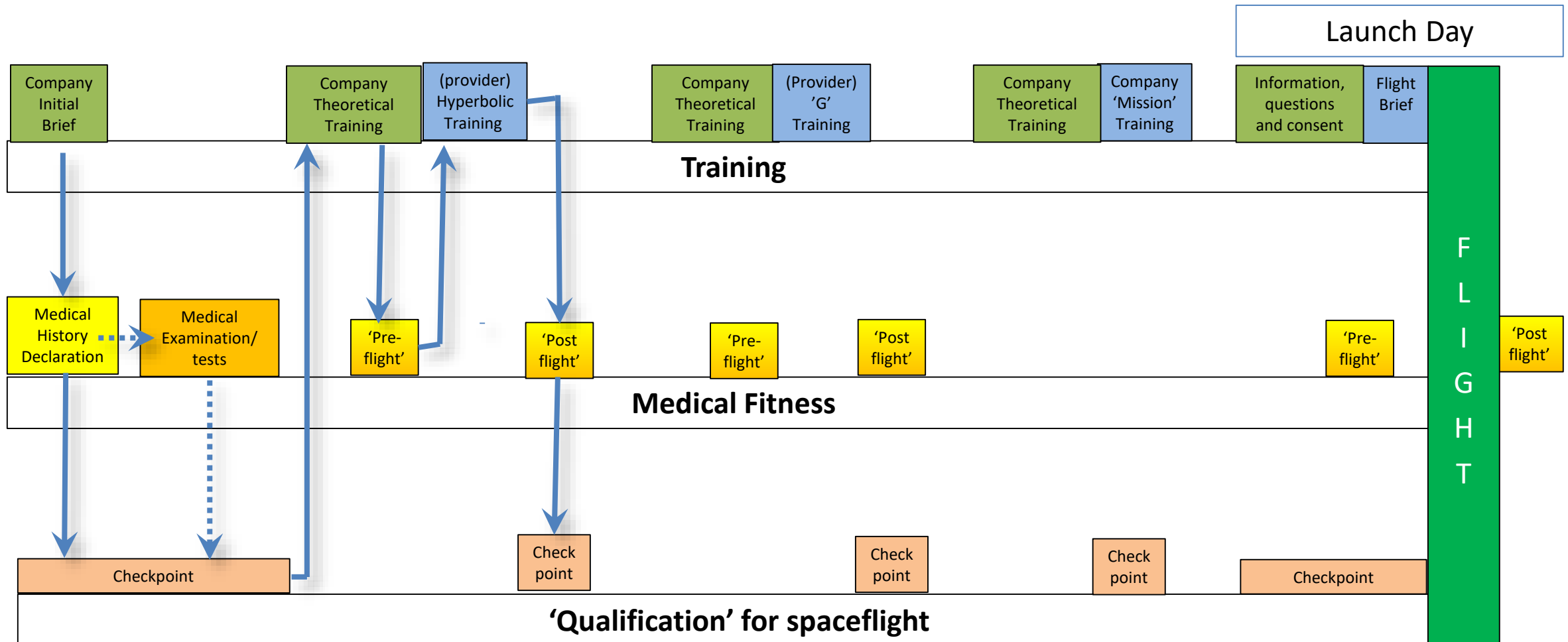
Participants: Getting from 'Zero to Hero' ... In phases?



Possible paradigm for Training Qualification and Medical Fitness Assessment of Spaceflight Participants

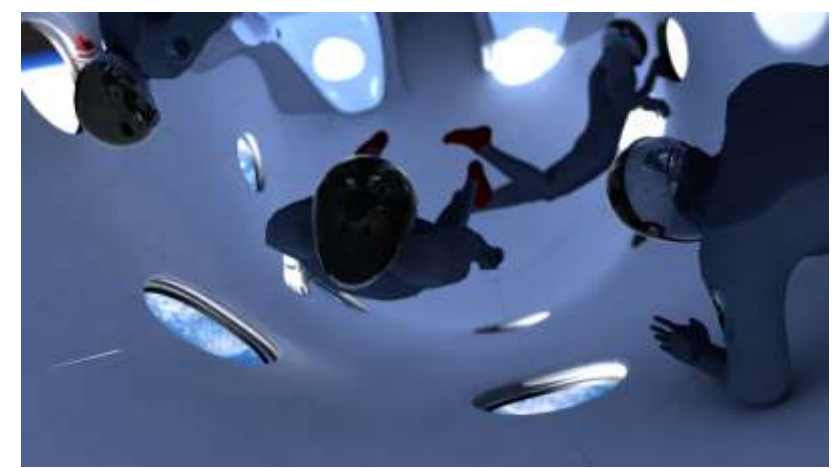


Possible paradigm for Medical Fitness Assessment of Participants



Future Challenges

- Speed of regulation and guidance development vs development of vehicle/profile and industry demand
- Good (medical) evidence on which to base regulations and guidance
 - Research
 - Audit and analysis of operator experience
- Training, Qualifications and Experience of AMEs, Medical Assessors and Medical Advisers to operators



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