UK SPACE AGENCY

Licensing space activities in the era of New Space

ESA-ECSL Space Debris Workshop

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Contents

International treaties and standards

United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS)

- 1967 **UN Outer Space Treaty (OST)**: basic legal framework of international space law (e.g. prohibits weapons of mass destruction in space, claiming celestial bodies etc..)

- 1972 **UN Space Liability Convention (SLC)**: expands on the liability rules created in the Outer Space Treaty
  - If an object was launched from a State's territory, facility, or if the State caused the launch to happen, then that State is ***fully*** liable for damages that result from that space object.

- 2007 **UN Space Debris Mitigation Guidelines:** 7 Key recommendations to international community to limit pollution of the orbital environment

UK Acts and licensing

In the UK, these conventions are conveyed through:

- 1986 **UK Outer Space Act (OSA)**: Provides *current* UK framework to **license** launches for UK licensed payloads outside the UK, and UK operations in orbit.

- 2018 **UK Space Industry Act (SIA)**: *Will* provide the future framework to **license** launches *from* the UK (with or without UK payloads), and UK operations in orbit.

- **Licensing**: If an operator wants to operate from the UK, then UKSA can license subject to **insurance, financial** and **technical** criteria being met.

- The UK executive *licensing authority* is the **UK Space Agency**

- UKSA will not grant a licence to an operator unless the activities authorised by the licence will:
  - not jeopardise public health or the safety of persons or property
  - be consistent with the international obligations of the United Kingdom
  - not impair the national security of the United Kingdom

- Further the licensee must conduct their operations in such a way as to prevent
  - the contamination of outer space (**e.g. Debris**)
  - adverse changes in the environment of the Earth (**e.g. Debris**)
  - interference with activities of others in the peaceful exploration and use of outer space (**e.g. Debris**)

- **Its about getting the right balance between mitigating risk and enabling novel technologies.**

Licensing process

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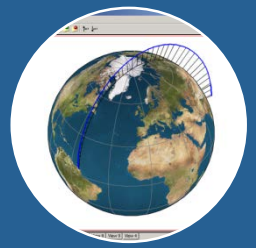
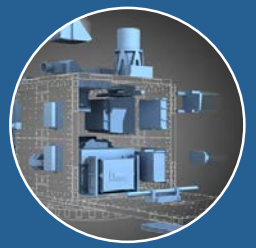


PHASE 0
Mission Analysis

PHASE A
Feasibility



PHASE B
Preliminary Definition

PHASE C
Detailed Definition

PHASE D
Qualification & Production

PHASE E
Launch & Operations

PHASE F
Disposal

Preliminary Design Review (PDR)

Critical Design Review (CDR)

Flight Readiness Review (FRR)

OUTER SPACE ACT LICENSING PROCESS

Pre-Application Consultation

Application Submission

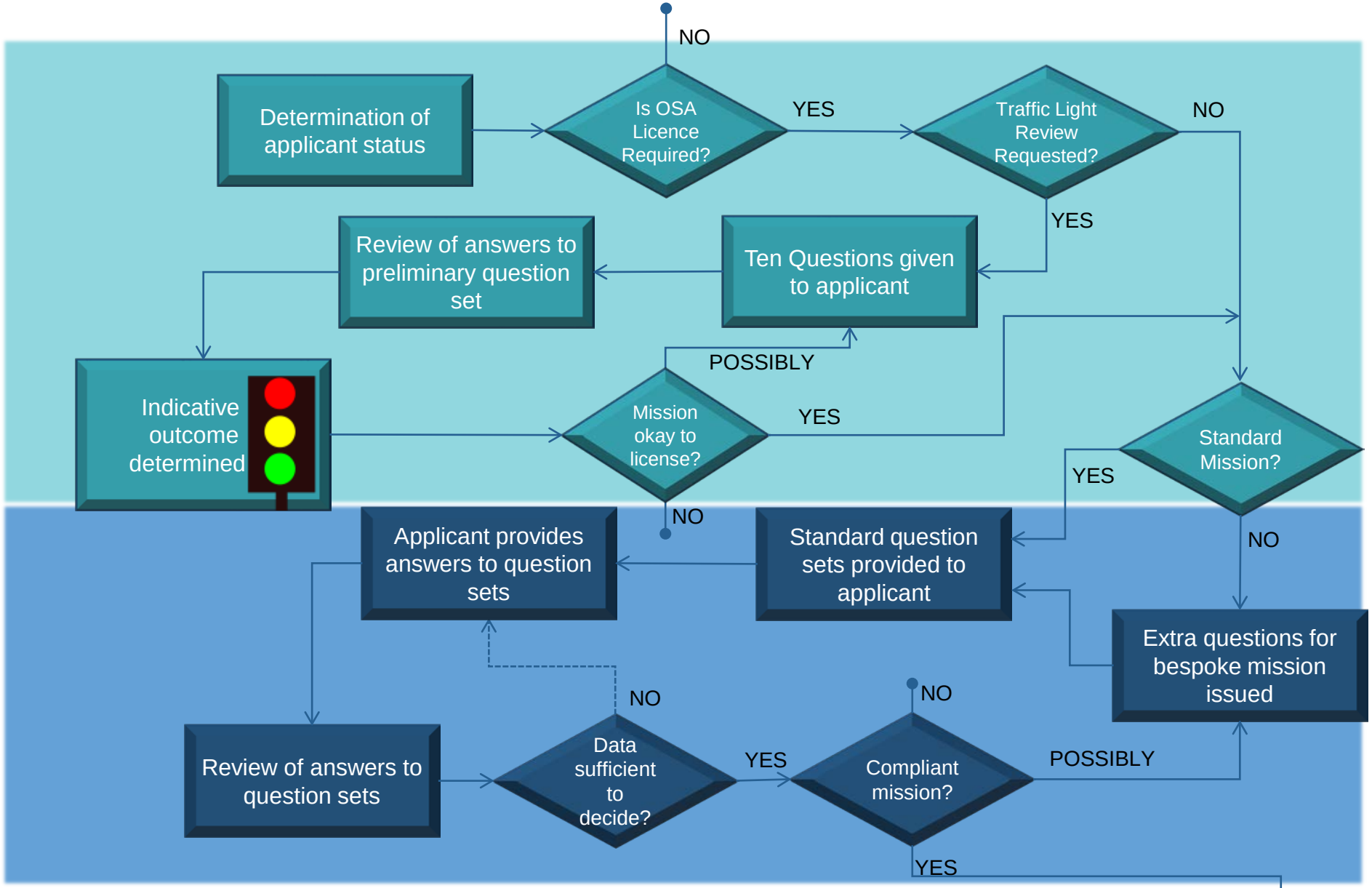
Analysis of Data Provided

Licencing Decision

Compliance Monitoring

AUTHORISATION

SUPERVISION



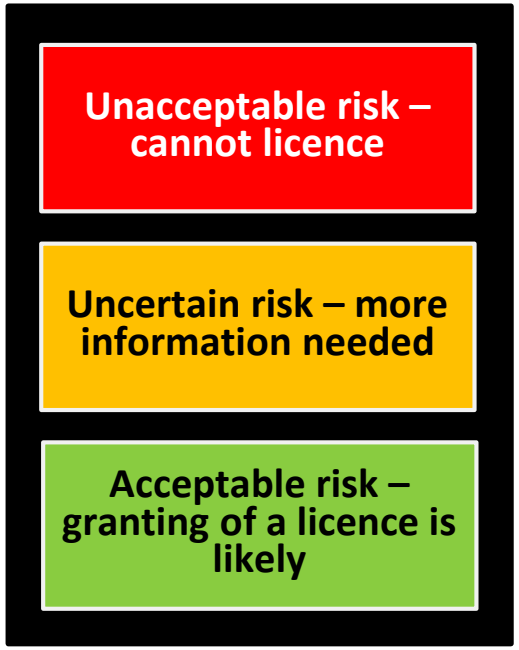
Pre-application

Application

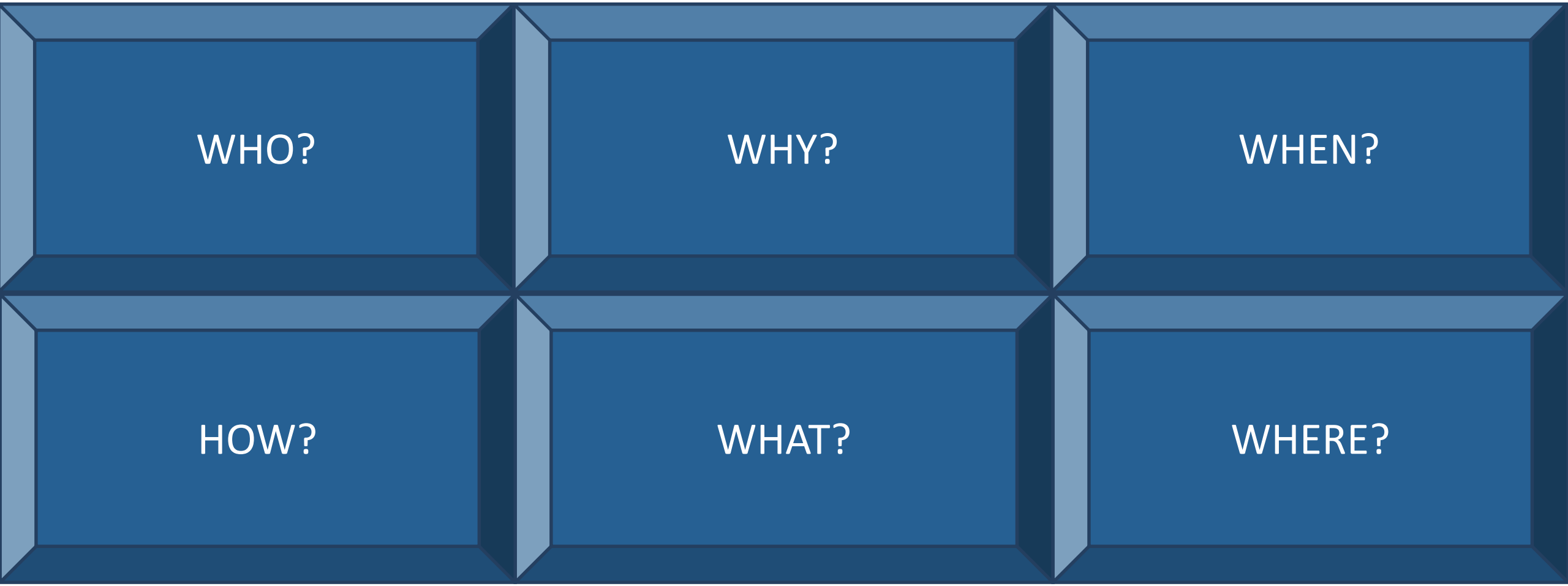
License authorisation

Authorisation: Pre-application

- UKSA have recently introduced a ‘traffic light’ scheme as part of pre-application
- Greater transparency of technical assessment process
- Reduced process burden on operator/applicant
- Improved predictability of timescales/outcomes
- Promotion of safe, secure, sustainable access to space



Authorisation: Licensing considerations



Authorisation: Licensing considerations

OPERATOR

Mission responsibility
Operator capability
Operator experience
Training
Information sharing
Emergency procedures

MISSION OBJECTIVES

Technology demonstrator	Single satellite
Path-finder mission	Multiple satellites
Commercial service	Small /Medium / Large constellation
Follow-on mission	Rendezvous mission
	Proximity mission

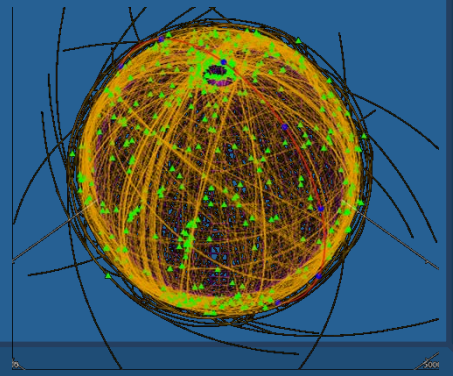
MISSION PHASES

PHASE: LEOP
PHASE: OPERATIONAL ORBIT ESTABLISHMENT
PHASE: DISPOSAL
PHASE: CONSTELLATION ESTABLISHMENT
PHASE: ORBIT MANOEUVRING
PHASE: TARGET ACQUISITION AND ENGAGEMENT
PHASE: IN-SERVICE OPERATIONS
PHASE: TARGET UNDOCKING AND RETREAT

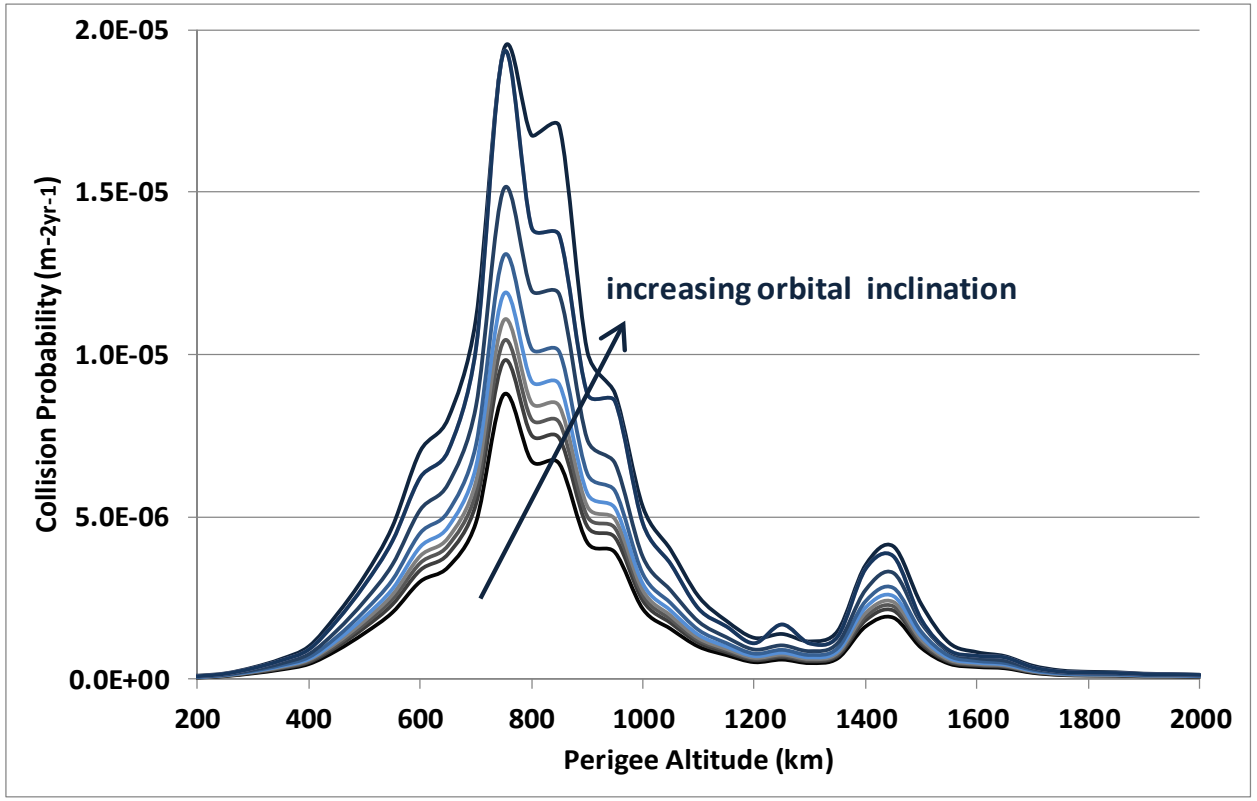
LAUNCHER & OPERATIONS

PLATFORM/PAYLOAD

ORBITS

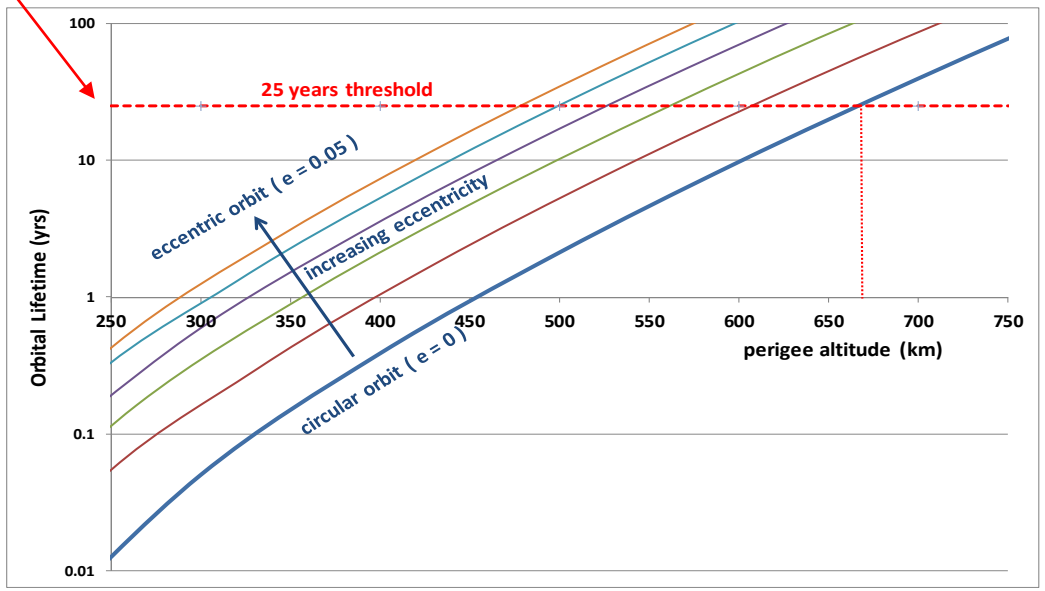


Standard mission example: debris collision risk



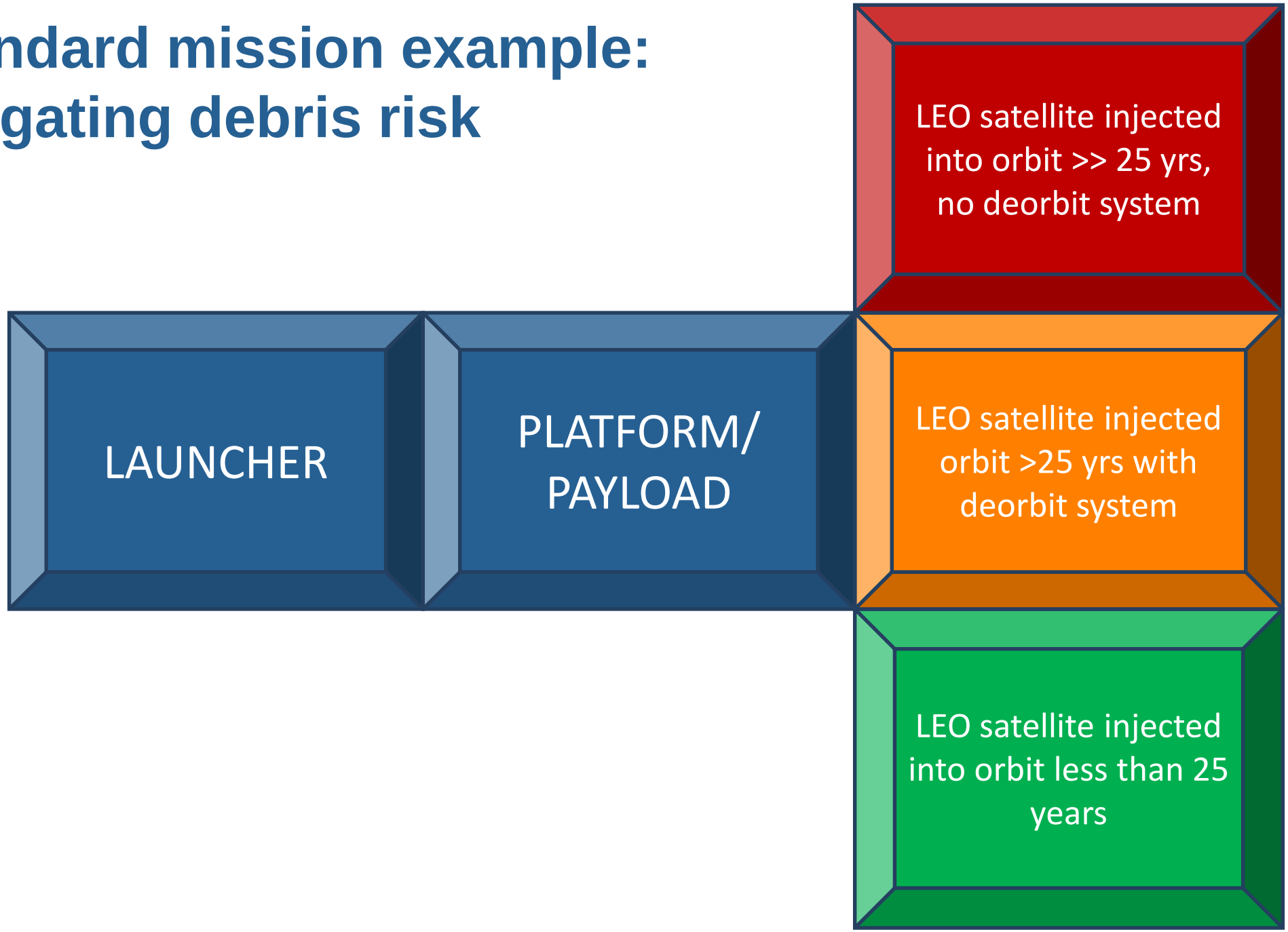
LEO collision probability with debris

25 year de-orbit time is an IADC guideline which UKSA uses as part of its licensing requirements

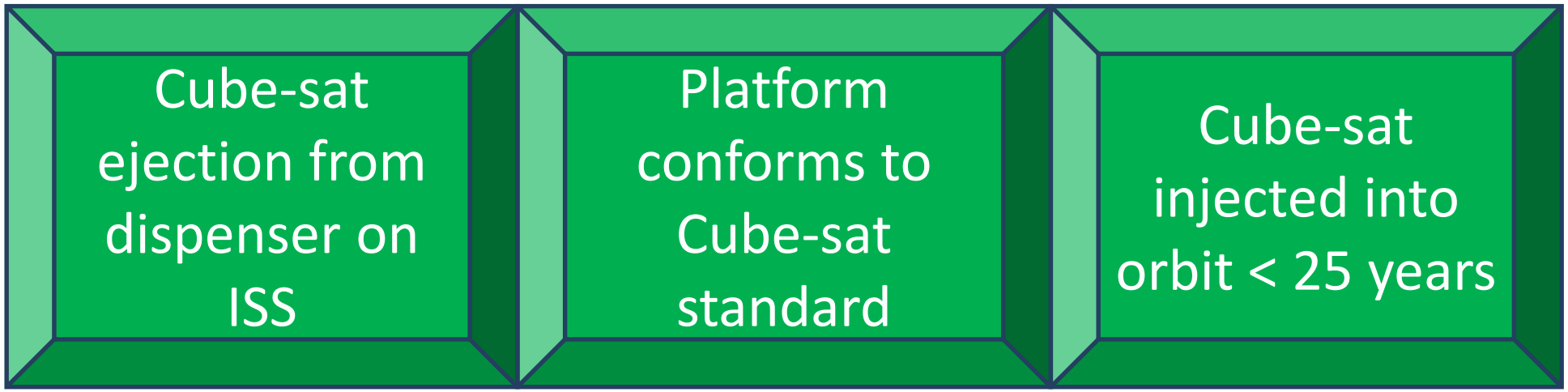


Re-entry time: Object lifetime with no station-keeping (post-mission)

Standard mission example: Mitigating debris risk



Standard mission example e.g. cube-sat



- Passivation of all launcher objects and vehicles once no longer required
- Construct cube-sat as to limit risk during re-entry (e.g. high probability of atmospheric demise)

License supervision

- Supervision focusses on
  - Compliance of in-orbit activities
    - Regular update on UK licensed objects
    - Regular verification of UK licensed objects (Space Surveillance and Tracking or SST)
    - Annual health-check
  - End-of-life activities: re-entry and grave-yarding operations

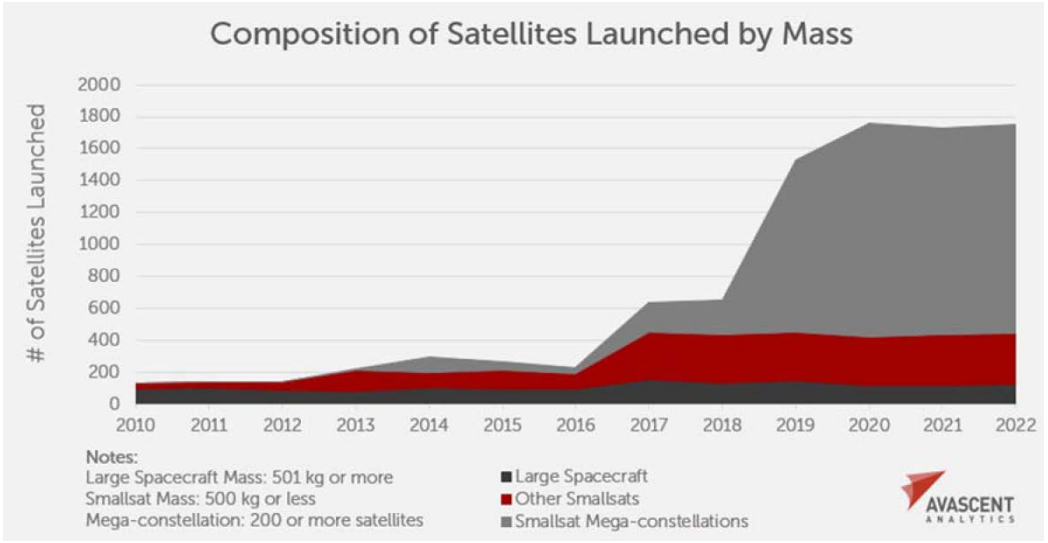
UKSA has been licensing missions for many years – what's changed?

New Space

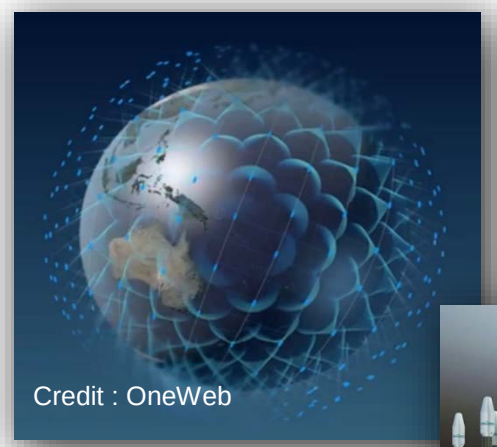
Novel and potentially disruptive technologies have begun to evolve as accessibility to space becomes cheaper and more widespread:

- **Large constellations (**aka ‘Mega-constellations’)

- **In-orbit servicing** (e.g. debris removal, satellite servicing, spacecraft refurbishment, re-fuelling, disposal and even platform construction).



Left: **Future in-orbit active population could grow enormously in the next 5 years (courtesy CSIS)**

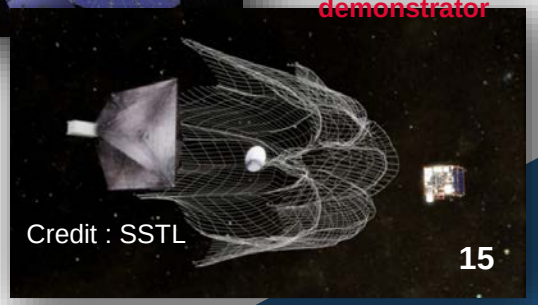


Left: **OneWeb LEO mega-Constellation**

Below: **Soyuz launch requirements for OneWeb**

Left: **Orbital ATK satellite servicing mission**

Below: **RemoveDEBRIS space debris removal demonstrator**



These new systems offer new challenges to long term space sustainability

Large constellations

- Large constellations of satellites are a type of Non-Geostationary Satellite Orbit (NGSO) system.
- As they are based in LEO they have lower latency, making them ideal for broadband communications

LEO
<50ms

MEO
>135ms

GEO
>560ms

- However, to ensure coverage, you need a **lot of satellites.**
- This means that
  - there is potential for lots of failed satellites and hence increased collision risk
  - the burden of managing the satellites is could be significant, and so conjunction risk could be higher
  - Satellites will need to be replenished regularly

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O3b
27satellites
8000km

Samsung
4600 satellites
1500km

SpaceX Starlink
4400 satellites
~1200km

Oneweb
800 satellites
1200km

Hongyan
300 satellites
1100km

Iridium
66 satellites
800km

S&SG
200 satellites
800km

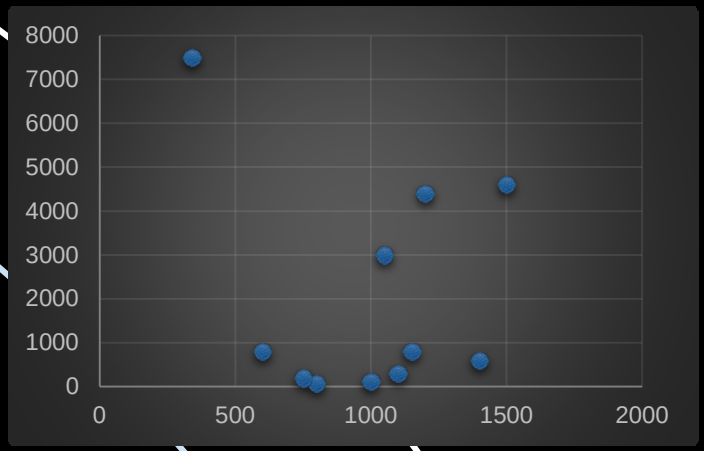
Telesat LEO
117 satellites
1000km

Commsat
800 satellites
600km

Astrome
600 satellites
1400km

SpaceX Starlink
7500 satellites
340km

Boeing
3000 satellites
1000km



There are many proposals for large LEO constellations

This may increase the active satellite population by as many as 20 times

Understanding the risks

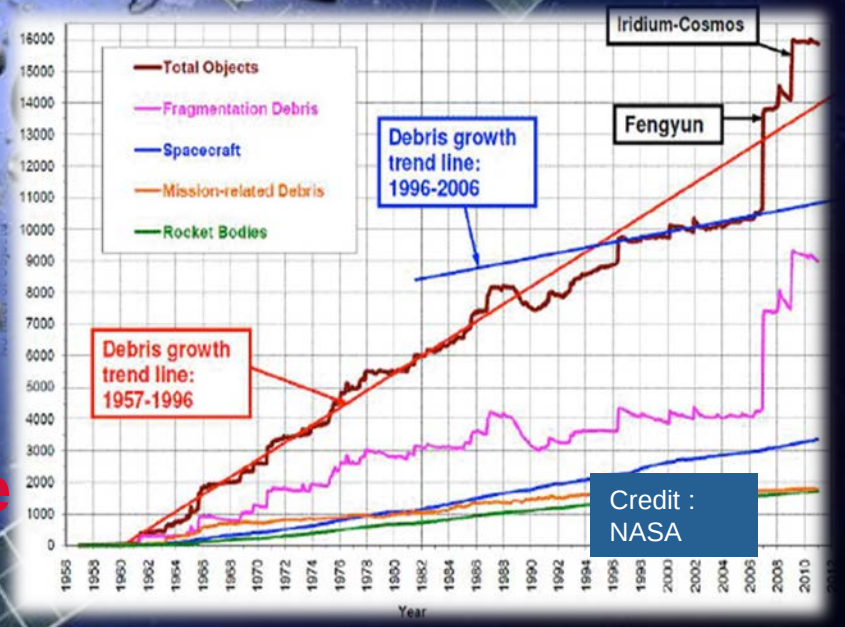
- Large Constellations present many questions on best practice:
  - Is ‘25 year rule’ good enough?
  - What is a necessary and sufficient PMD or reliability?
  - When is orbital ‘carrying capacity’ reached?
  - How should the CONOPS of these missions be assessed/regulated?

- Rendezvous and Proximity Operation (RPO) and formation missions present similar questions

- These issues are explored through international forums such as the IADC

- **UKSA needs to be able to understand and assess the risks of long-term impact of licensing new missions.**

Below: **Illustration of the growing issue of space debris in orbit**



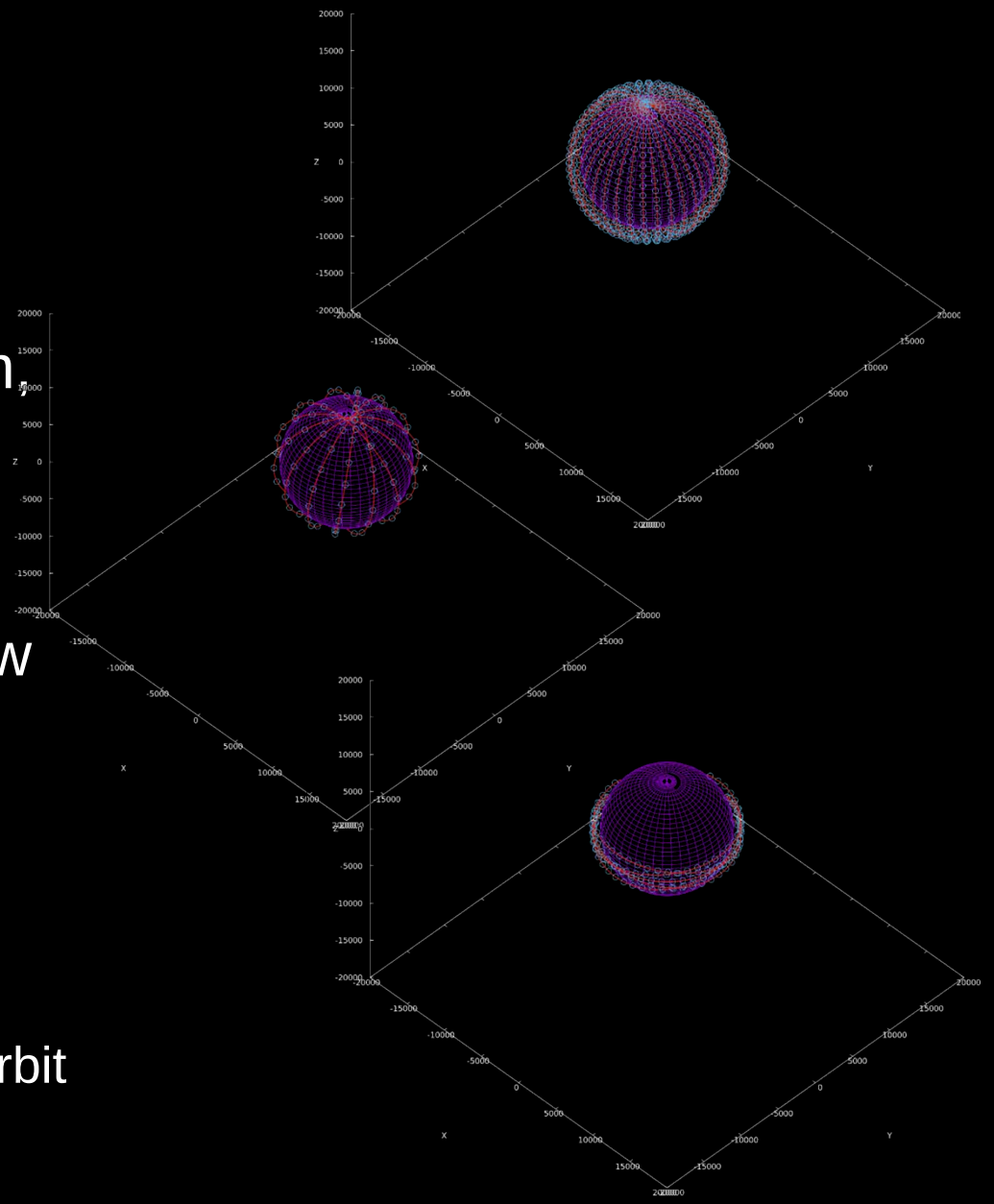
Credit : NASA

Improving authorisation: new capabilities

- To authorise future licenses, UKSA is significantly uplifting our capability to perform technical assessments.

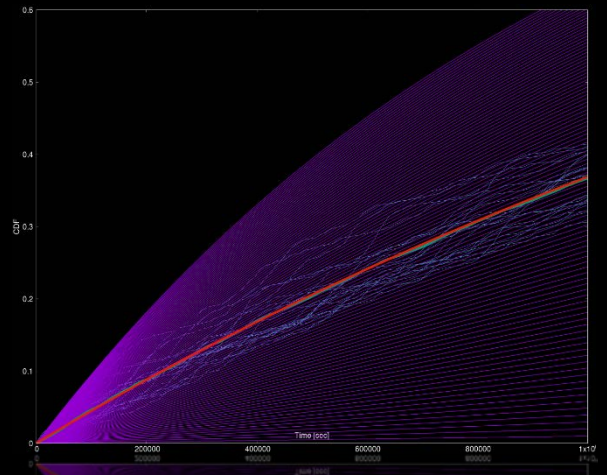
- We are recruiting and training a new technical team consisting of engineers, physicists and operations experts

- We are developing in-house expertise to create new predictive Orbital Environment models to
  - Determine *likelihood* of close encounters between spacecraft
  - Determine collision *likelihood* of failed spacecraft
  - Understand the *impact* of a collision fragmentation on the environment
  - Understand the potential financial *impact* of an event in orbit



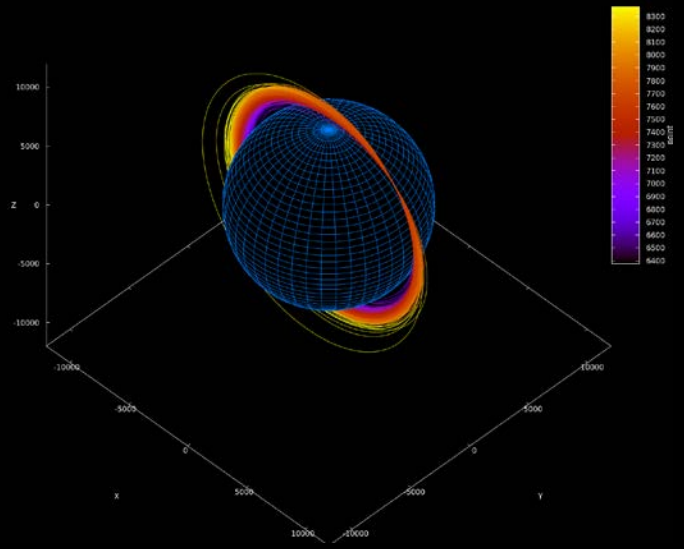
Improving authorisation: new capabilities

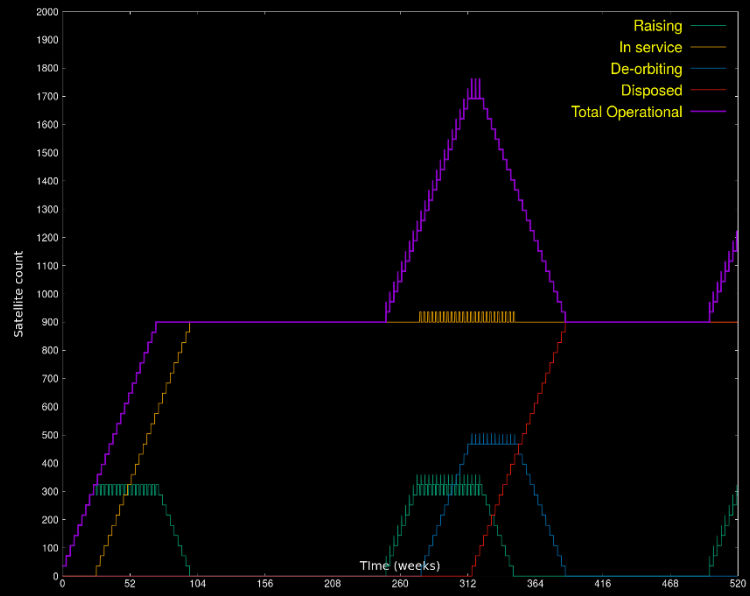
Orbital Risk Assessment Capability (**ORAC**) library



Above: Close encounter and conjunction frequency assessment

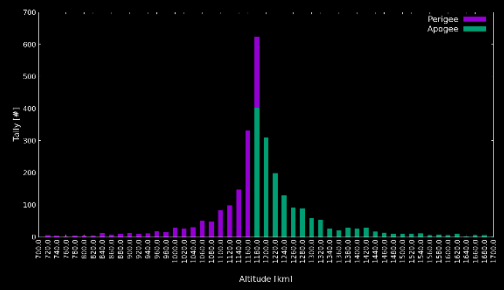
Below: **Large constellation simulation of an inter-plane polar collision and subsequent fragmentation**





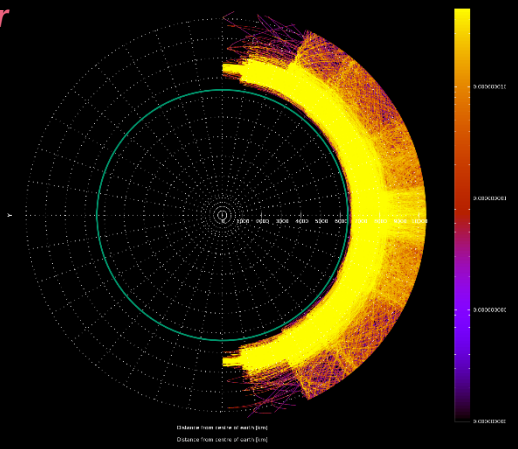
Above: Orbital traffic simulator

Below: High frequency conjunction partners used to inform financial risk models

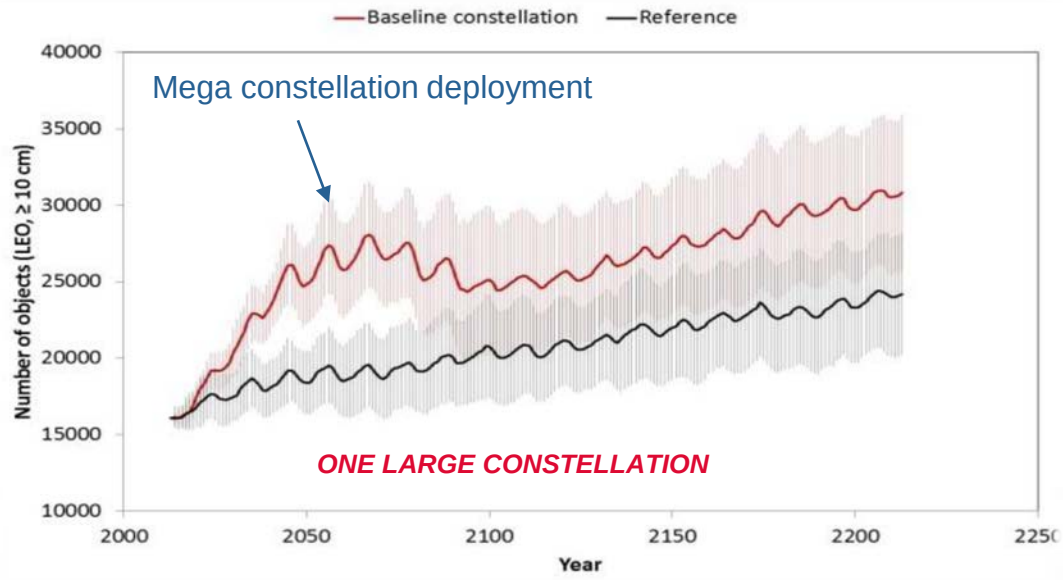


Above: **Fragmentation distribution following an in-orbit collision**

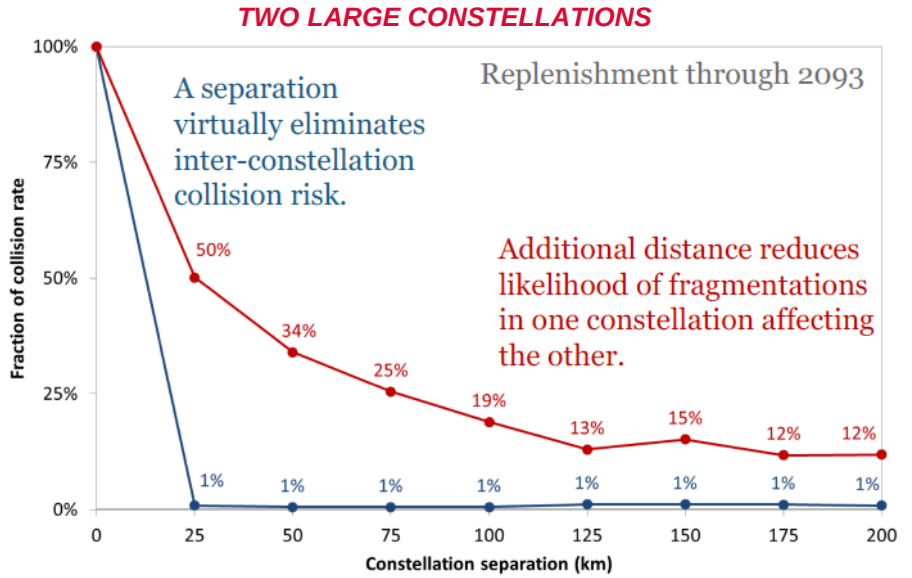
Right: Continuum based object density model



- UKSA are working closely with external collaborators
- For example, the University of Southampton have provided support using their evolution model, DAMAGE.
- Models such as this allow us to study the sensitivity of different constraints (e.g. PMD rate or satellite lifetime) on what the orbital environment could look like.
- This helps provide **evidence for best practice**



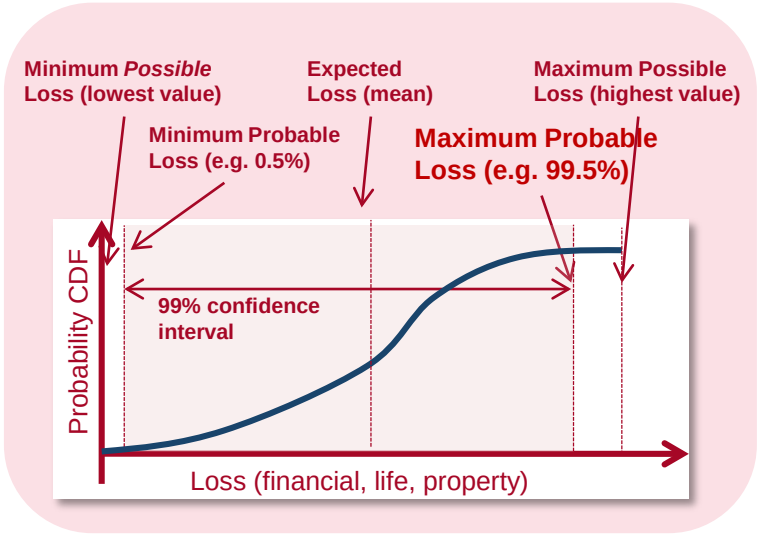
Above: **Future orbital debris prediction with and without the deployment of a large constellation *(graph courtesy Prof. Hugh Lewis)***



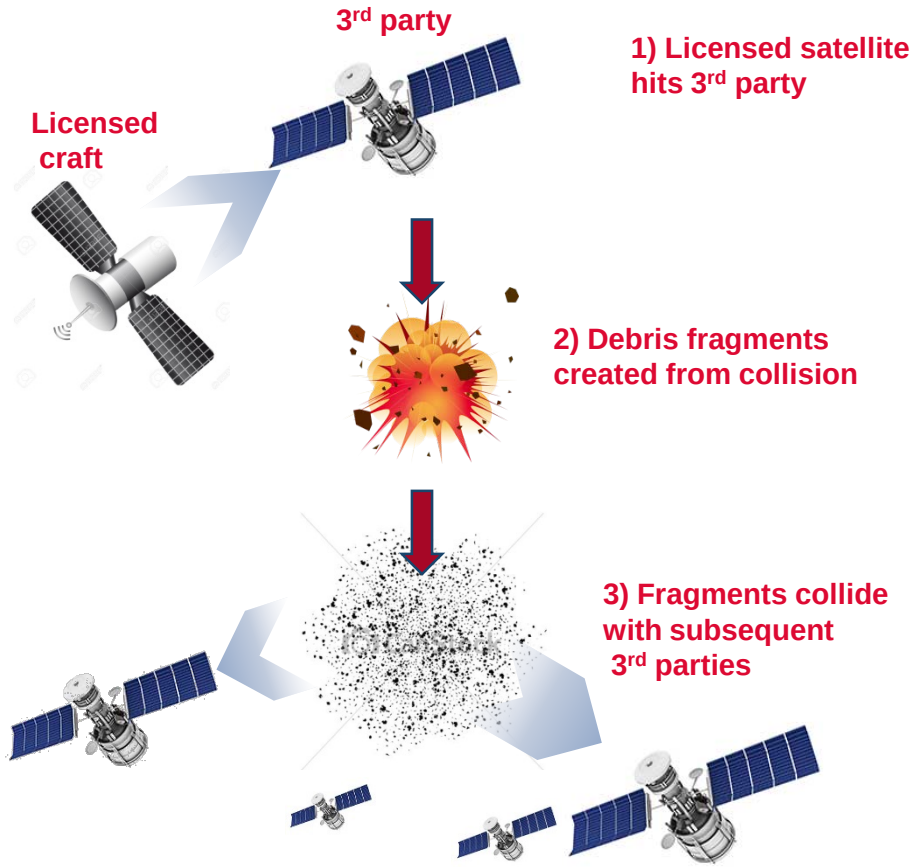
Above: Illustration of collision rate sensitivity to constellation separation distance (graph courtesy Prof. Hugh Lewis)

Quantitatively assessing liability

- As well as understanding environmental risk, we are developing models to assess financial risk
- These models will use output from our evolutionary collision risk models along with financial data about the orbital environment to provide quantitative risk estimates
- This will inform metrics such as maximum probably loss (MPL) and third party liability insurance requirements (TPL)



Right: Example Maximum Probable Loss (MPL) model



Above: An illustration of a potential liability claim through multiple collision events

Future licensing

- UKSA are currently reforming our regulatory environment and licensing approach
- How we license future missions requires evolution in how we **authorise** and **supervise**
- **Authorisation** demands a better understanding of the risks of these new missions
- **Supervision** of activities requires
  - Better objective capabilities to assess operational compliance (for example, enhanced Space Surveillance and Tracking)
  - Movement towards a partnership between UKSA and licensed operators

Summary

- UKSA currently licenses space-systems guided by principles of UN treaties and international best practice.
- Novel and disruptive technologies are now offering new technical challenges which could adversely impact the orbital environment.
- Understanding the risks of these new systems is essential in helping define international best practice, and limit adverse affects on the orbital environment.
- UKSA are developing in-house technical capability, supported by strong collaboration with academia and International Space Agencies.
- Our goal is to make evidence based decisions to ensure a sustainable future space environment for everyone.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Questions?
(Movie courtesy Dr H. Lewis, University of Southampton)