UKPOP

Future Space Population Study

From Measurements to Understanding:
MASTER Modelling Workshop
2nd - 4th March 2021

Study funded by:

Supported by:

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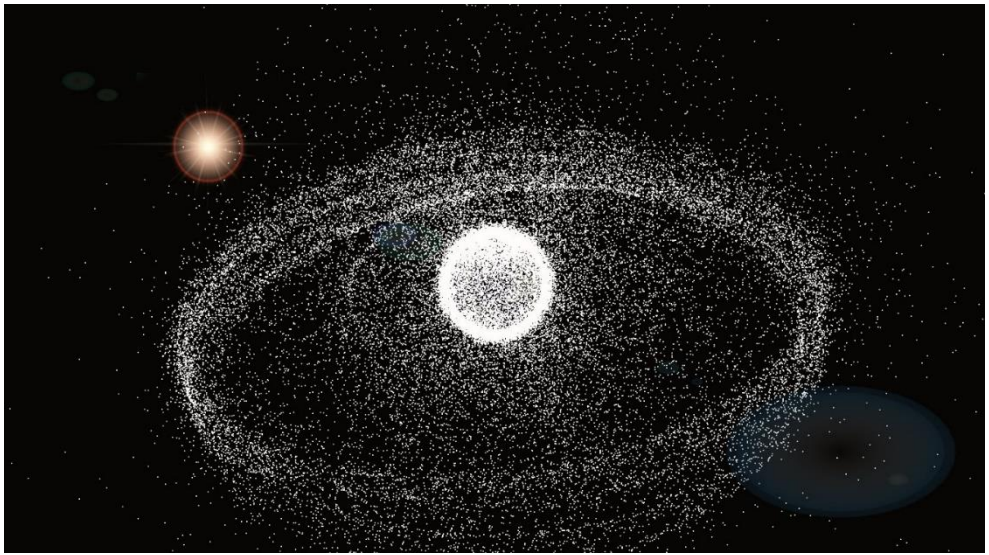
Objective

Examine the future space object population, using expected trends in the short, medium, and long term.



Credit: Dr Hugh G. Lewis

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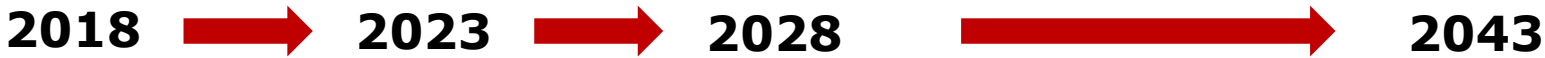
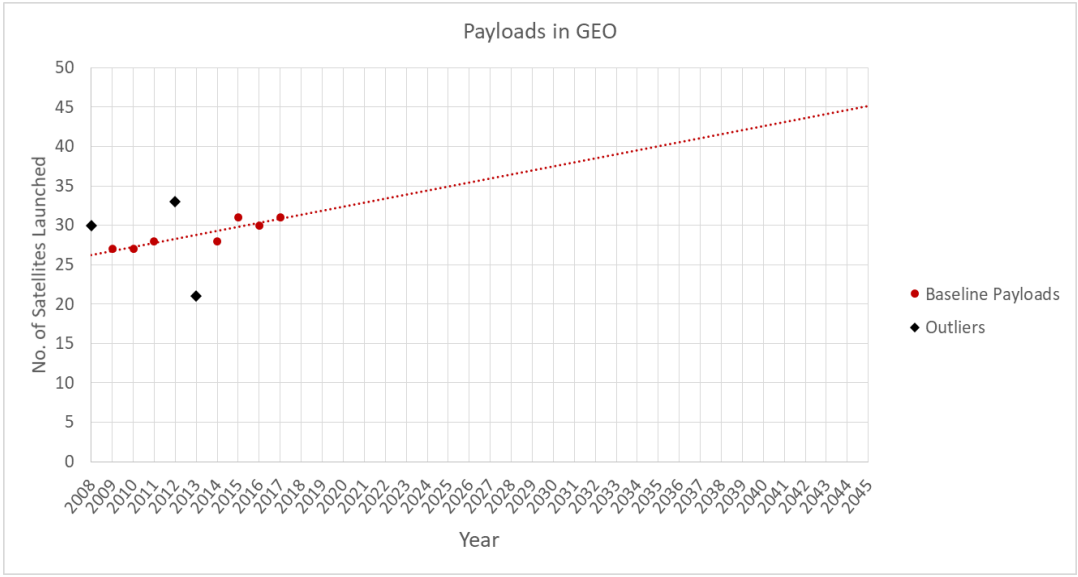
Project Outline

- Analysis of **historical data** to establish "**realistic**" future launch trends
- **Identification of appropriate initial population** that includes object **origin**, **mission** and **status**
- **Propagation of population,** combined with future launch trends to produce future populations at set epochs



Launch Trends

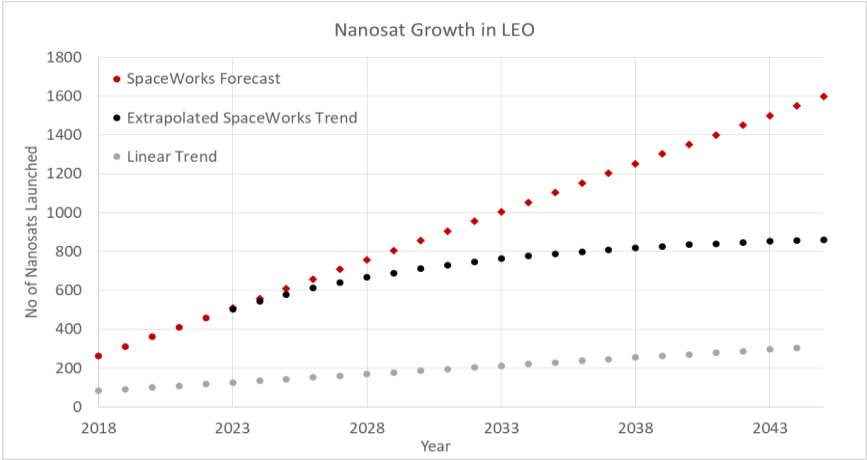
- Future launches split by **orbital regime**
- **Linear** increase forecast for **HEO** and **GEO**
- **MEO** managed by **constellation**

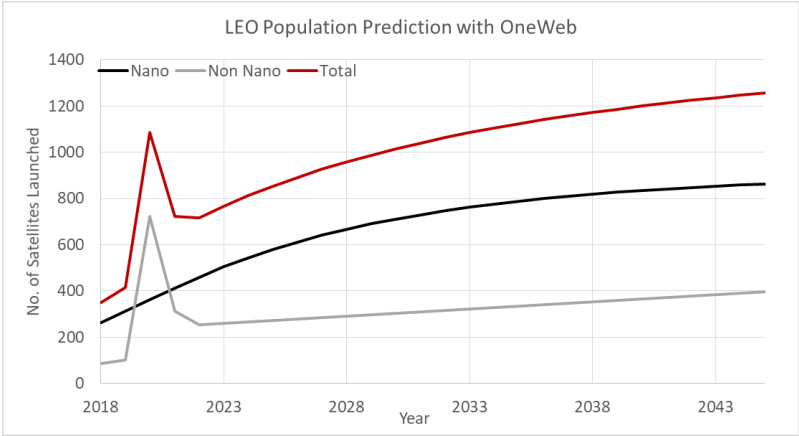


MEO Constellation	Total Size	Lifetime	Resupply Rate per Year
O3b	16	10	2 (1.6)
Galileo	24	12	2
GPS	30	12	3 (2.5)
GLONASS	24	10	3 (2.4)
BeiDou	27	10	3 (2.7)
O3b mPower*	7	10	1 (0.7)
		TOTAL	**14**

Launch Trends

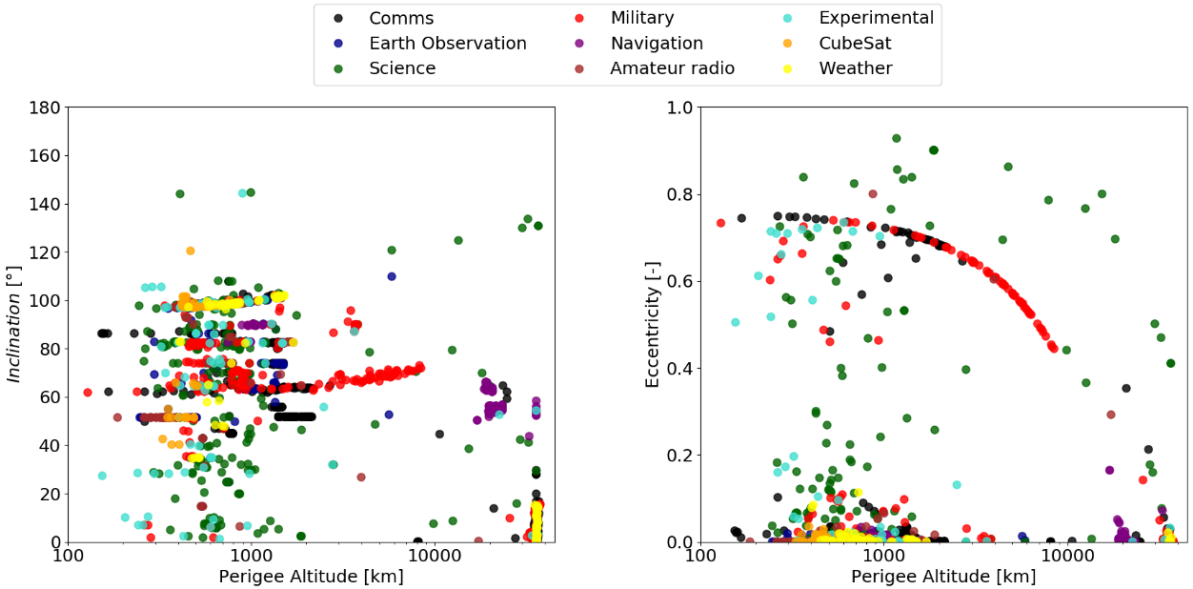
- **LEO**: Difficult to establish trends
  - Nanosats
  - Mega-Constellations
- **Saturating growth** forecast for LEO Nanosats
- **OneWeb** launches and resupply included in study
- Linear increase for non-nanosats in LEO





Initial Population

- MASTER population used as input: **No contextual information**
- Objects "**matched**" with TLE data to obtain object ID's
  - Allowed name/country/mission information to be retrieved



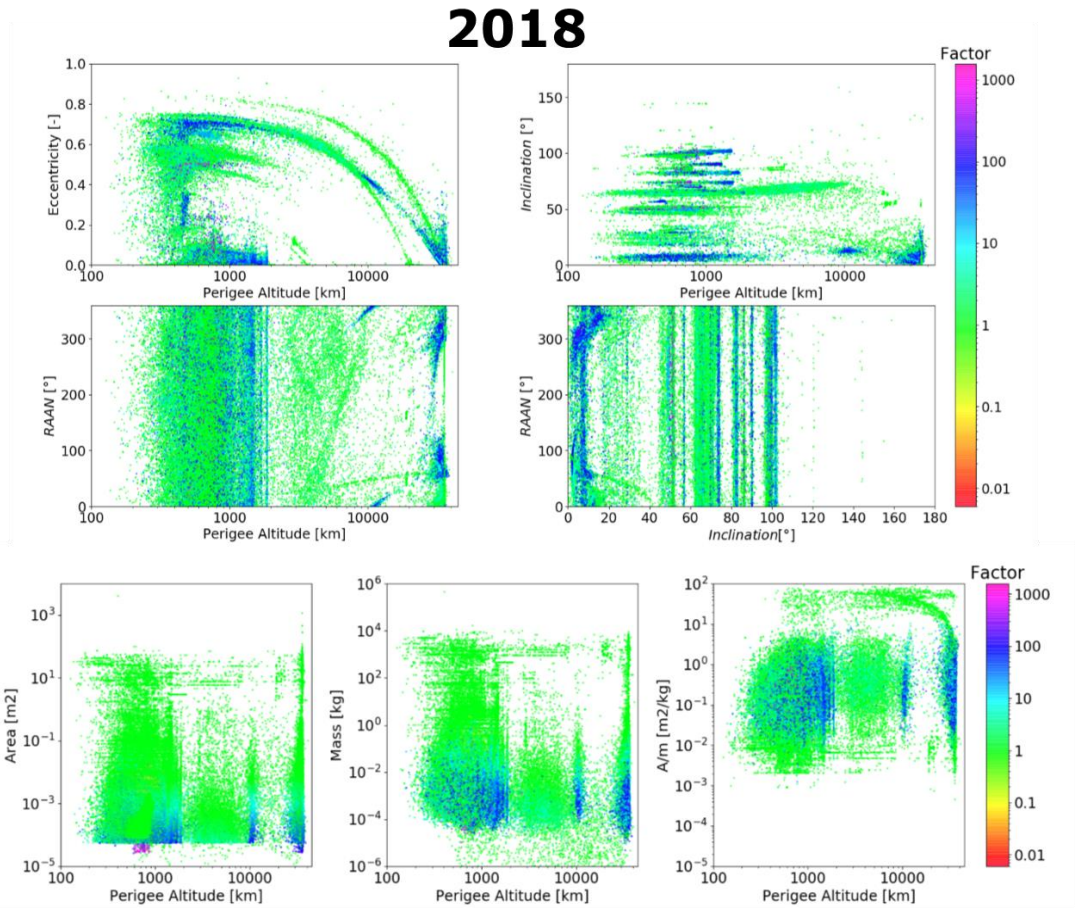
Minimum size requirements per regime:

- LEO: ≥ 1cm
- MEO: ≥ 5cm
- GEO: ≥ 10cm

Other catalogues not suitable (e.g. 18th SPCS)

Initial Population

- Matching done via **orbital and physical comparison**
  - **Sensible limits** used when mass was not known
- Possible missed matches:
  - MASTER propagation
  - Satellite manoeuvres
  - Missing objects in MASTER
- Initial population = MASTER + additional payloads



DAMAGE Overview

- **D**ebris **A**nalysis and **M**onitoring **A**rchitecture to the **G**eosynchronous **E**nvironment
- Originally designed to investigate the **long-term** evolution of the debris environment in High Earth Orbit
- Researcher: **Dr Hugh Lewis – University of Southampton**
- Used to support UK Space Agency's role in **IADC** since 2004
- Semi-analytic propagator, supported by:
  - Breakup model, collision prediction algorithms
  - Satellite failure model, **constellation manager**

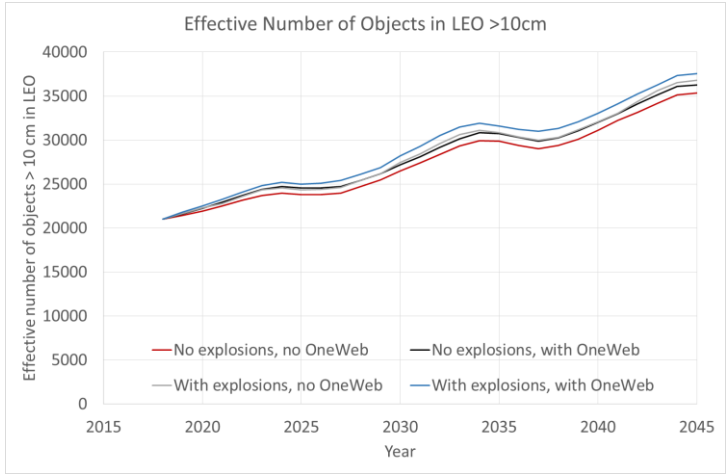
Simulation Setup

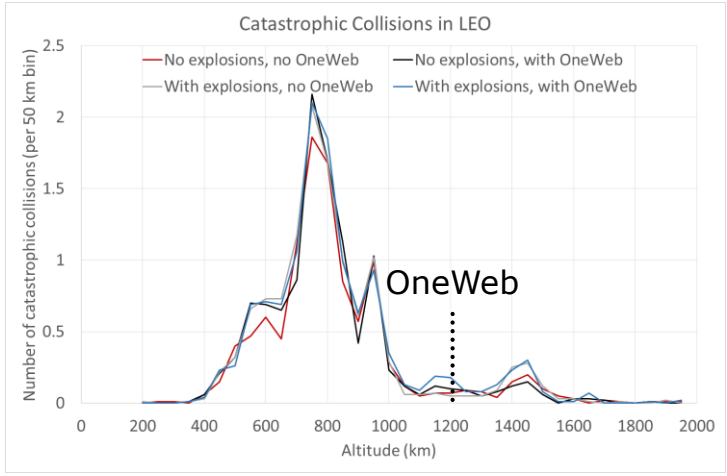
- Population **with & without OneWeb** to be simulated
- Four scenarios considered
  - No explosions, no OneWeb
  - No explosions, with OneWeb
  - With explosions, no OneWeb
  - With explosions, with OneWeb
- **~110 Monte Carlo** runs per scenario
  - Allow analysis of stochastic effects considered (Collisions)

- MASTER populations used as reference for comparisons

Results

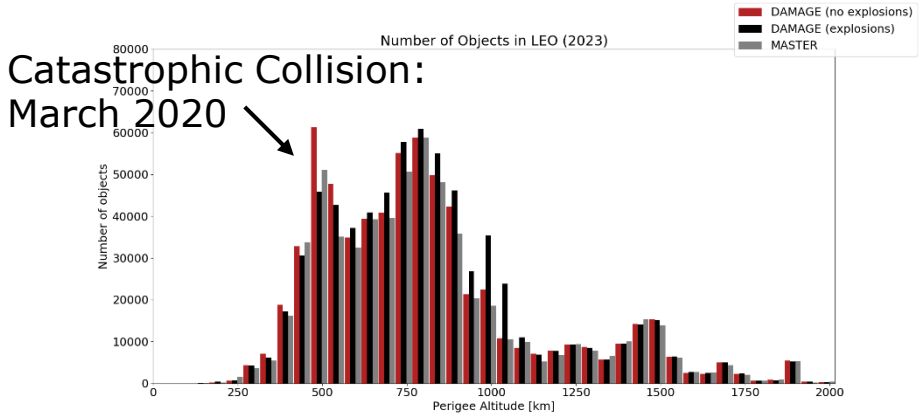
- Results taken from one representative Monte Carlo run
- Visible increase in LEO objects from OneWeb
- No noticeable increase in collisions from OneWeb
  - High PMD success rate: 95%??

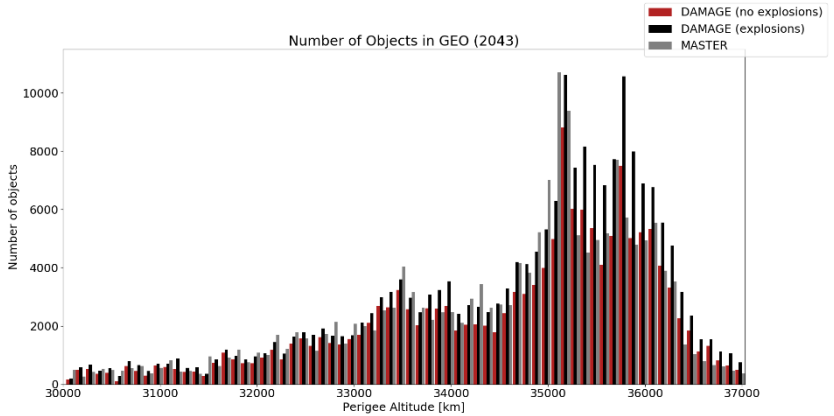




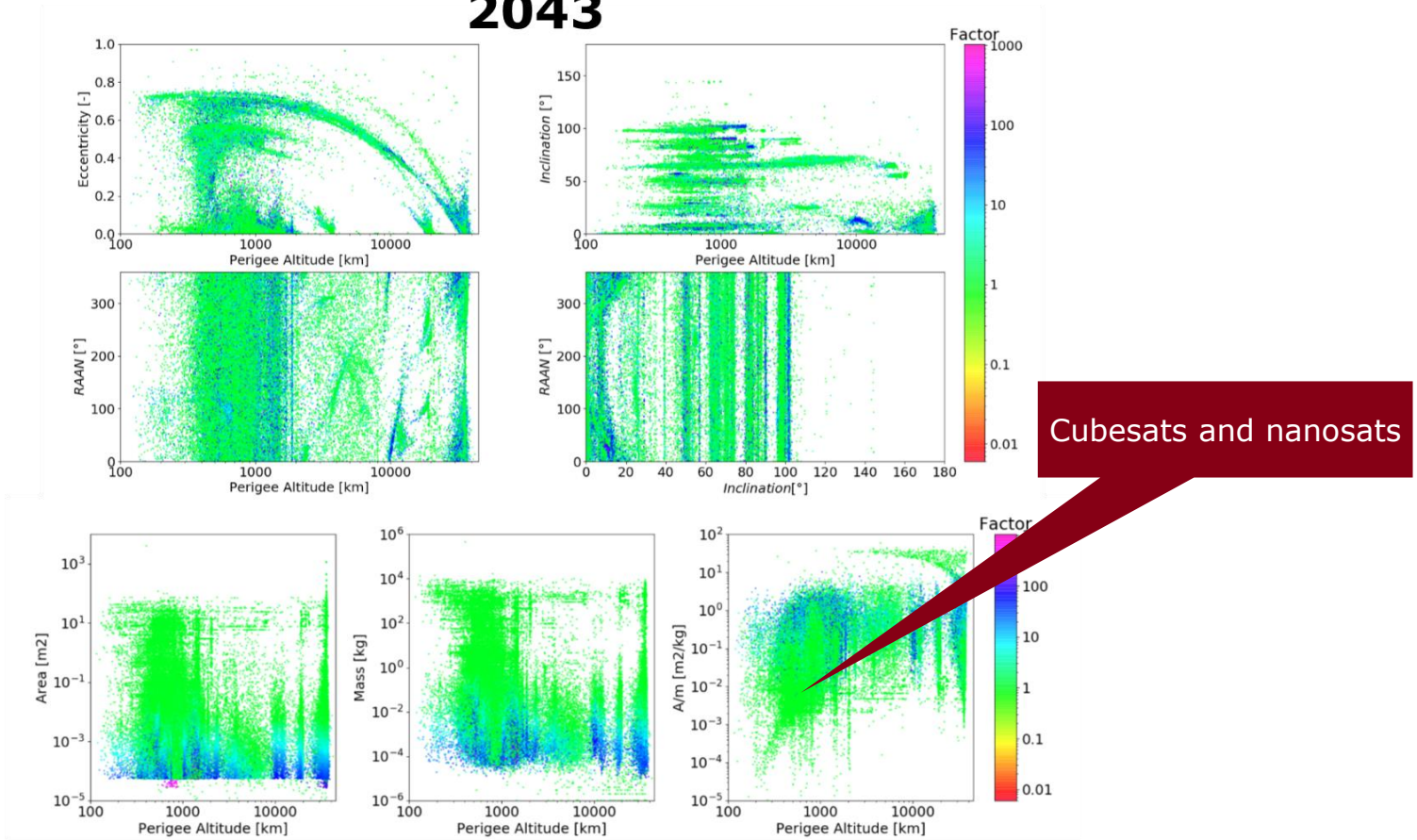
Results

- Short term:
  - Good agreement with MASTER
  - Local variations from collisions and explosions
- Long term:
  - Similar trend
  - MASTER has more objects in GEO
  - Collisions? Graveyard orbits?





Results



Conclusions

- Lack of **contextual** information in **MASTER**
  - Matching with TLEs was **effective** but **not entirely successful**
- Difficult to **foresee future launch** traffic
  - GEO communication market (dependant on LEO constellations)
  - Mega-constellations (**Starlink**)
  - Nano/CubeSat Market
- **PMD** success of constellations? → Assumed 95% (realistic??)
- Future active debris removal activities?

Thank you

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