<https://en.wikipedia.org/wiki/Space_debris>

Basically, space junk accumulates as satellites are thrown into orbit and just stay there. There have been several large collisions that have spread debris over large areas of LEO; there’s some debate about what this means in terms of Kessler Syndrome. Apparently, LIDAR is used to track things, and can be used to track debris down to .5 in (1 cm). Returned spacecraft impact zones can be used to study sub-millimeter debris fluxes. Gabbard diagrams are used to map fragment trajectories after collisions.

Plans for junk removal include laser ablation, nets, drones, etc. EDeorbit is an interesting mission that’s supposed to launch in 2023 to remove space junk.

<https://orbitaldebris.jsc.nasa.gov/>

<https://www.orbitaldebris.jsc.nasa.gov/library/satellitefraghistory/13theditionofbreakupbook.pdf>

NASA’s satellite fragmentation bible.

<https://orbitaldebris.jsc.nasa.gov/modeling/engrmodeling.html>

ORDEM, Nasa’s spacejunk modelling software, is available to researchers! Totally cool!

They also have another one, but it appears to be not as available: https://orbitaldebris.jsc.nasa.gov/modeling/evolmodeling.html

<file:///C:/Users/timny/OneDrive/Documents/ME578/SpaceJunkProject/SDJ-2000-01.pdf>

Discussion of problems with geostationary orbits. These could also have problems with Kessler syndrome. I believe that these problems are farther into the future than LEO problems.

<https://permanent.fdlp.gov/websites/ntrs.nasa.gov/pdf-archive/19920016139.pdf>

Proposal for a removal system (1 to 50 cm). Uses nets and a drone system to capture spacecraft and then drag them down to earth.

<http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?letter=.&classic=YES&bibcode=1997ESASP.393..699B&page=&type=SCREEN_VIEW&data_type=PDF_HIGH&send=GET&filetype=.pdf>

Proposal for a laser removal system. Ablates the surface of debris, lowering the apogee and causing it to fall to earth. Estimated costs are 60 million in 1997 dollars. Estimates that the system could remove almost all debris of medium size within a few years. Wants a demonstration system to be built.

<https://spacenews.com/experts-active-removal-key-countering-space-junk-threat/#.Ub3dSuce2Zc>

Space junk matters, and will cause an end of the space age unless we take active measures. However, nobody wants to pay for it and governmental actors are in gridlock (I’m shocked! Shocked, I say!)

<https://www.nature.com/articles/d41586-018-06170-1>

This discusses some tracking mechanisms, including databases such as ASTRIAGraph. Has a good infographic discussing how much junk is in space. The Iridium-Cosmos collision is discussed briefly.

<https://www.nasa.gov/mission_pages/station/news/orbital_debris.html>

This discusses NASA’s plans for space debris. It highlights the fact that some categories cannot be tracked effectively, but are still dangerous (greater than .5 in, less than 4 in). Also talks about some of the maneuvers taken by the ISS.

<https://en.wikipedia.org/wiki/2007_Chinese_anti-satellite_missile_test>

Notable contributor to modern space garbage: serious problem moving forward. Any kind of serious war will destroy space

<https://web.archive.org/web/20100527195029/http://webpages.charter.net/dkessler/files/KesSym.html>

Discussion of Kesseler Syndrome, where breakup accelerates.

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.394.6767&rep=rep1&type=pdf>

More Kessler.

<https://spacenews.com/envisat-pose-big-orbital-debris-threat-150-years-experts-say/>

Notable large piece of dangerous space garbage: The Envisat.

<https://en.wikipedia.org/wiki/Whipple_shield>

For small debris, Whipple shields are effective.

* Key learnings:
  + Big debris can mostly be avoided.
  + Small debris can mostly be shielded.
  + Medium debris is difficult to see, but also difficult to shield against. The .5 in to 4 in range seems to be the most dangerous. There are also a lot of them.

For my discrete event simulator, I generated a taxi cab modelling system. I've had to wait for taxis before, and I wanted to understand roughly how many taxis are necessary to reduce wait times to acceptable levels. In this simulation, passengers appear according to a normal distribution centered around rush hour. As taxis become available, passengers are picked up and delivered to their destinations (modelled by a normally distributed delay function). After a brief additional delay period to represent time spent looking for a customer, the taxi then picks up its next passenger. \par

Although this model is useful, it has significant limitations. First, passenger pickups are FIFO. In the real world, taxis do not know who in the city has been waiting the longest, and geography almost certainly plays an important role in taxi wait times. There are several ways this limitation could be improved—a simple fix would involve randomly selecting a passenger among those waiting instead of choosing the one who’s been waiting longest. However, even this misses out on important information; perhaps an ABM could capture geographical information better.

Second, the model is limited in the way it simulates taxi delays in finding passengers. The time it takes taxis to find a new passenger is random and small. In real life, this parameter probably varies based on time of day, where in the city the passenger was delivered to, and a host of other criteria. Certainly, additional geographical information in this section of the model would improve accuracy; the solution might look a lot like the one suggested above.

Third, model is limited in that it does not support variations in traffic. In real life, traffic jams and heavy traffic during peak travel times can substantially affect taxi availability (each trip takes dramatically longer). The number of taxis and passengers on the road should affect this, and form a sort of feedback loop for wait times. However, these dynamics are not easily modelled with discrete event simulation. A first attempt to improve this could add a delay function to each delivery based on the number of people waiting for a taxi (or perhaps the number of people in one), but in order to get really good data you’d need a more complex modelling technique.