## t

#### Interpretation: debaters must defend a significant portion of the resolution

#### Violation: They only defend two private entities

#### Standards:

#### 1—kills topic education which is uniquely bad in LD because we only have 2 months to debate the topic – forcing a rush to the margins of the topic kills small school accessibility and core topic ground. Net worse bc it means some people can no longer participate in debate AND we don’t gain portable skills

#### 2 – ground –affs that defend a small part of the rez kill neg ground by taking away most disads and counterplans and ability to read pics – mooting neg generics and just neg options sets a terrible norm that incentivizes affirmative debaters to write the tiniest, most unnegatable affs– kills fairness because aff always wins if there’s no neg lit base and kills education because the neg can’t debate the topic and is forced to read generics everyone’s already heard

#### TVA – read your aff as an advantage of a wholeres plan

#### Voters –

#### 1 -- Fairness – you need fairness to evaluate debate rounds – the judge needs to vote for the better debater not the better cheater. Unfair advantages in debate rounds make decisions illegitimate and hurt our ability to access real world skills. If they try to go for “fairness bad” then just vote neg because it means you’re under no obligation to evaluate their arguments fairly.

#### 2 – education – it’s a voter because it’s the reason schools fund debate and the only portable skills we gain from debate are a result of education – knowing how to discuss the merits of broad policy options has more real world implications than knowing how to go for an rvi or knowing how to defend policies that are so obscure they’d never be passed.

#### Paradigm issues –

#### 1 – No RVIs

#### a] logic – you don’t get to win just for proving you’re topical

#### b] chilling effect – rvis disincentivize debaters from checking abuse

#### c] theory baiting – rvis incentivize affs to be as unnegatable as possible so they can bait t or theory and win

#### 2 – competing interpretations over reasonability

#### a] arbitrariness – reasonability is arbitrary and invites judge intervention

#### b] brightlines mean competing interps – it becomes a debate of whose brightline is best which is the same thing as competing interps – you’re debating about whose model is best

#### c] resolvability – don’t view debate through a lens of who reasonably meets something – everyone has a different conception of reasonable even with a brightline – takes the debate out of the debaters hands

#### 3 – drop the debater

#### a] logic – drop the argument doesn’t make sense – the shell indics their entire advocacy

#### b] severance – if they go for drop the argument it’s severance and an independent reason to negate – kicking out of the aff no-links all neg offense and forces us to restart and finish the debate in the 2nr – means there’s no way the neg can access the ballot because 2ar gets recontextualizations

## t boeing one web

**Interpretation: the affirmative must defend that ALL private entities appropriation of outer space is unjust. To clarify, they can’t choose a only some private entities**

**Violation - they only defend** The Boeing Company and The OneWeb

**Standards**

**1 – limits – there are infinite definitions of what private appropriations of outer space could mean – our card lists a few. Specifying justifies infinite affs and kills the neg’s ability to engage – we can’t be expected to prep for each of these affs – kills fairness bc big schools will always have access to more prep and kills education bc we wont be able to have substantive discussions on the aff.**

**2 – clash – the aff leads to two ships passing in the night bc the neg doesn’t have substantive, well-researched objections to the aff. kills education bc we never learn anything about both sides of the topic – aff is more likely to win bc they’re ahead on the research about their specific type of appropriation.**

**CA paradigm issues**

## collaboration cp

#### CP text: we advocate for public-private partnerships in space in line with the ISS model or a sponsored program model

**ISS National Lab** [International Space Station National Laboratory – Center for the Advancement of Science in Space, “Research on the ISS, No Date, <https://www.issnationallab.org/research-on-the-iss/public-private-partnerships-in-space/>] //neth

Public-private partnerships are a key component to driving innovation and national leadership. With the potential to address a wide array of modern challenges from technology development to infrastructure modernization, and from education to the economic development of space, public-private partnerships unlock new possibilities unavailable when we rely solely on public or private investment. The International Space Station (ISS) National laboratory is a great example of a public-private partnership model that is working in space. The ISS National Lab opens up the incredible possibilities of the space station research environment to a diverse range of researchers, entrepreneurs, and innovators that could create entirely new markets in space. The ISS National Laboratory – Accelerating Utilization of the ISS The ISS offers a unique research and development platform, unlike any on Earth, enabling research that benefits both exploration and life on Earth. In an effort to expand the research opportunities this unparalleled platform provides to the nation, the ISS United States Orbital Segment, through bipartisan legislation, was designated as a U.S. National Laboratory in 2005, enabling research and development access to a broad range of commercial, academic, and government users. After final assembly of the ISS in 2011, the Center for the Advancement of Science in Space, a (501)(c)(3) organization, was selected by NASA to manage the ISS U.S. National Laboratory. The ISS National Lab fulfills its mission to accelerate space-based research by engaging a variety of nontraditional space users, operating in the fields of life science, physical science, technology development, and remote sensing. The ISS National Lab engages primarily with organizations that pay toward the value obtained on the ISS, as well as with other organizations addressing national science and research priorities. This research serves commercial and entrepreneurial needs and other important goals such as the pursuit of new knowledge and education. Since 2011, the ISS National Lab has stewarded more than 200 ISS research projects, ranging from developing new drug therapies, to monitoring tropical cyclones, to improving equipment for first-responders, to producing unique fiber-optics materials in space. Working together with NASA, the ISS National Lab aims to advance the nation’s leadership in commercial space, pursue groundbreaking science not possible on Earth, and leverage the space station to inspire the next generation. Prior to the ISS National Lab model, NASA traditionally funded all aspects of ISS research, whether it was research needed to further exploration, or discovery-based space research that expanded upon its scientific agenda. As the ISS evolved into a National Laboratory, the ISS National Lab has increased the diversity of users by accelerating utilization of the ISS as an innovation platform for a wide variety of partners. These include Fortune 500 organizations, small businesses, educational institutions, philanthropic and research foundations, federal and state government agencies, and other thought leaders in pursuit of groundbreaking technology and innovation who are interested in leveraging microgravity to solve complex research problems on Earth. The ISS National Lab plays a role in not only attracting a diverse set of users, including private companies, to utilize the ISS, but also in engaging the private sector through various research and cost-sharing arrangements. Sponsored Programs – Accelerating Third-Party Funding for Space Research The ISS National Lab has developed a successful Sponsored Program model that attracts third-party funding from private industry and other government agencies to solve big problems or address target challenges. These programs translate into projects on the ISS National Lab. The Sponsored Program model enables an organization to ask new questions and explore key variables, using the ISS National Lab environment as a tool in their innovation portfolio. In return, the organization creates opportunities for targeted research and development projects and STEM education projects or fosters novel ideas of startup companies. Fortune 500 companies, government agencies, and regional incubators have successfully used the ISS National Lab Sponsored Program model. This unique research and development model is flexible to meet the needs and budget of a partnering organization. Successful Sponsored Programs include Boeing Mass Challenge, Massachusetts Life Sciences Center, National Science Foundation (NSF) fluid dynamics and combustion Sponsored Program, and the National Institutes of Health (NIH) National Center for Advancing Translational Sciences (NCATS) organ-on-chip technologies Sponsored Program, totaling more than $20 million in third-party funding over the last two years. Additional Sponsored Programs totaling close to $5 million in 2017 with Fortune 500 organizations are imminent and will target major challenges to humankind as well as STEM education initiatives.

#### Creates competitive markets and has the net benefit of increasing the amount of research we can do

**ISS National Lab** [International Space Station National Laboratory – Center for the Advancement of Science in Space, “Research on the ISS, No Date, <https://www.issnationallab.org/research-on-the-iss/public-private-partnerships-in-space/>] //neth

Commercial Services Providers – A Competitive Marketplace for Space Services As the demand for space research and development projects increases, the supply of access to space and research and development facilities will need to be augmented. In space, private-sector commercial research and development facility operators are on the forefront of a new era of space research on the ISS and future space platforms. These organizations operate their facilities internally and externally on the ISS. They provide users with more choices to address unique research needs and are the pathfinders for a marketplace in low Earth orbit. Many of these companies have used their own resources to invest in in-orbit research and development facilities, reducing the risk for the federal sector to develop these facilities and services. In its first five years, the ISS National Lab has supported growth in the number of these research and development facility operators from one in FY12 to five in FY16—with four additional facilities expected to begin in-orbit operations by FY18. The ISS National Lab fosters healthy competition between these supply partners by allowing them to bid on each commercial customer project, seeking the best solution for the customer. The current commercial facility operators are: NanoRacks – Since 2009, NanoRacks has provided hardware and services for the International Space Station National Laboratory. Three internal research platforms can house plug-and-play NanoLabs and provide critical capabilities such as centrifugation and microscopy. Additionally, the NanoRacks External Platform was launched in FY15 and provides capabilities for Earth and deep space observation, sensor development, and testing for advanced electronics and materials. BioServe – In-orbit offerings from BioServe include multiple life sciences facilities and kits, including the multi-purpose Space Automated Bioproduct Laboratory (SABL), launched in FY15. SABL supports myriad initiatives for commercial life sciences research as well as physical and material science experiments. TechShot – Launched in FY15, the TechShot Bone Densitometer is a commercial bone-density scanner for use in spaceflight rodent research. In just one year, the successful operation of this facility has already demonstrated its utility as a catalyst for disease modeling research and commercial biomedical initiatives in space. Made In Space – In FY16, the Additive Manufacturing Facility developed by Made In Space launched to the International Space Station, enabling 3D printing projects from commercial, educational, and government entities interested in the development of objects for experiments and technology demonstrations. These objects will be produced onboard the International Space Station in a fraction of the time currently required to have such objects manifested and delivered to the station using traditional ground preparation and launch. Space Tango – TangoLab-1 is a general research platform launched in FY16. This facility from Space Tango allows multiple automated experiments in the life and physical sciences to run simultaneously. This architecture minimizes crew member interaction and reduces complexity while increasing scalability, enabling improved throughput for users. In addition to currently available capabilities, a growing pipeline of commercial ISS National Lab facilities in preparation (from Teledyne Brown, AlphaSpace, STaArS, and HNu Photonics) will advance research in remote sensing, materials testing, molecular biology, and tissue culture. Companies are exploring how these capabilities might transition onto future low Earth orbit platforms, from free-flying spacecraft to expandable modules. Through support of such companies, the ISS National Lab and NASA are enabling the International Space Station National Laboratory to serve as an incubator for the low Earth orbit market and U.S. private sector spaceflight interests, and are using public-private partnership funding models to share the risk and benefits of these emerging human space flight activities.

### space debris

#### Private organizations already have debris tracking technology – partnership would be the safest and most efficient

**Moore & van Burken 2021** [Adrian Moore, Vice President of Policy, and Rebecca van Burken, Policy Analyst, “As Commercial Space Travel Becomes Reality, Debris and Space Traffic Management Becomes More Important,” Reason Foundation, August 5, 2021, <https://reason.org/commentary/as-commerical-space-travel-becomes-reality-debris-and-space-traffic-management-becomes-more-important/>] //neth

With Richard Branson and Jeff Bezos soaring into suborbital space, three U.S. flights to the International Space Station (ISS) in July, and SpaceX delivering 88 satellites to orbit in the last six weeks, space traffic is surging. And this is just the beginning of increased commercial and governmental activity in space. August will see several more trips to the ISS and more launches of satellites. Additionally, the Biden administration signed an agreement with the European Space Agency to use more satellites to address climate change through earth science research. This increased space traffic serves a wide array of purposes and represents vast investments by the private space industry and government. But these investments are going to increasingly be jeopardized by the massive amount of space junk already circling Earth. There’s plenty of room to fly up there, but, believe it or not, NASA estimates there are already 23,000 pieces of debris larger than 10 centimeters and over 500,000 pieces of smaller junk in orbit. This space junk, or orbital debris, travels at high speeds and even a small piece can cause serious damage or destruction if it hits a spacecraft or satellite. The space debris includes thousands of dead and retired satellites, parts of spacecraft from decades of missions, items exploded in warfare testing, and more. Dodging space junk is a regular requirement for spacecraft in orbit. The International Space Station had to maneuver 25 times between 1999 and 2018 to avoid collisions, and it had to dodge debris three times in 2020. Monitoring this debris is going to be a major issue as private space travel and the space economy grow. In 2019, the global space economy amounted to about $366 billion. Of this, $271 billion was in the satellite industry and $123 billion was directly in satellite services. As the world increasingly becoming reliant on satellites U.S. and global satellite businesses bear the brunt of the failure to track and remove orbital debris. As Sen. John Hickenlooper (D-Colo.), chair of the Senate Commerce Committee’s Subcommittee on Science and Space, said recently, we need to be proactive on space debris “rather than learning by a terrible accident … but we don’t quite have the sense of urgency we need.” Urgency means committing to better space traffic management, and tracking and removing orbital debris. Orbital debris management is not well organized within the government. Right now, the Department of Defense (DOD) does most tracking of space debris for the U.S. out of the need to protect military satellites and national security interests. NASA has its own less advanced systems for tracking debris. However, orbital debris management is not just about tracking debris anymore. It is also about forming collision warning systems and safely managing traffic in space. To do this efficiently, we need a civil repository for all orbital debris components, something that many commercial space companies have already created on their own to stay aware of orbital debris and help protect their satellites in space. Tracking debris may be a national security priority, but providing space traffic control is not really in the Defense Department’s mission. We should be utilizing the private sector’s expertise and advancements in this area. For example, Astroscale has contracts with both the Japanese and European space agencies to develop orbital debris removal capability. And responsibility for developing collision warnings and space traffic management would be best suited for the Office of Space Commerce, an office with existing connections to the commercial space industry, NASA and DOD. Partnering with the debris tracking and removal systems private companies are developing while freeing up DOD to focus on military awareness and NASA to focus on research and development would be the most efficient way forward. If the government works with private industry through strategic public-private partnerships, the U.S. can best address the threats posed by orbital debris and create sustainable policies for safe space exploration.

#### Empirics prove – public-private collaboration has succeeded for deflection projects

**CNN Wire 2021** [CNN Wire, “NASA's DART mission will deliberately crash into an asteroid's moon in the name of planetary defense,” ABC7 Chicago, October 7, 2021, <https://abc7chicago.com/asteroid-2021-nasa-space/11096045/>] //neth

A spacecraft that will deliberately crash into an asteroid is preparing to launch. The DART mission, or NASA's Double Asteroid Redirection Test, will lift off at 10:20 p.m. PT on November 23 aboard a SpaceX Falcon 9 rocket from Vandenberg Space Force Base in California. After launching in November, NASA will test its asteroid deflection technology in September 2022 to see how it impacts the motion of a near-Earth asteroid in space. The target of this asteroid deflection technology is Dimorphos, a small moon orbiting the near-Earth asteroid Didymos. This will be the agency's first full-scale demonstration of this type of technology on behalf of planetary defense. Near-Earth objects are asteroids and comets whose orbits place them within 30 million miles of Earth. Detecting the threat of near-Earth objects, or NEOs, that could potentially cause grave harm is a primary focus of NASA and other space organizations around the world. Didymos and Dimorphos Two decades ago, a binary system involving a near-Earth asteroid was found to have a moon orbiting it, dubbed Didymos. In Greek, Didymos means "twin," which was used to describe how the larger asteroid, which is nearly half a mile across, is orbited by a smaller moon that is 525 feet in diameter. At the time, the moon was known as Didymos b. Kleomenis Tsiganis, a planetary scientist at the Aristotle University of Thessaloniki and a member of the DART team, suggested that the moon be named Dimorphos. "Dimorphos, which means 'two forms,' reflects the status of this object as the first celestial body to have the 'form' of its orbit significantly changed by humanity - in this case, by the DART impact," said Tsiganis. "As such, it will be the first object to be known to humans by two, very different forms, the one seen by DART before impact and the other seen by the European Space Agency's Hera, a few years later." In September 2022, Didymos and Dimorphos will be relatively close to Earth and within 6,835,083 miles (11 million kilometers) of our planet. It's the perfect time for the DART mission to occur. DART will deliberately crash into Dimorphos to change the asteroid's motion in space, according to NASA. This collision will be recorded by LICIACube, a companion CubeSat or cube satellite provided by the Italian Space Agency. The CubeSat will travel on DART and then be deployed from it prior to impact so it can record what happens. "Astronomers will be able to compare observations from Earth-based telescopes before and after DART's kinetic impact to determine how much the orbital period of Dimorphos changed," said Tom Statler, DART program scientist at NASA Headquarters, in a statement. "That's the key measurement that will tell us how the asteroid responded to our deflection effort." A few years after the impact, the European Space Agency's Hera mission will conduct a follow-up investigation of Didymos and Dimorphos. While the DART mission was developed for NASA Planetary Defense Coordination Office and managed by the Johns Hopkins University Applied Physics Laboratory, the mission's team will work with the Hera mission team under an international collaboration known as the Asteroid Impact & Deflection Assessment, or AIDA. "DART is a first step in testing methods for hazardous asteroid deflection," said Andrea Riley, DART program executive at NASA Headquarters, in a statement. "Potentially hazardous asteroids are a global concern, and we are excited to be working with our Italian and European colleagues to collect the most accurate data possible from this kinetic impact deflection demonstration." A mission of firsts Dimorphos was chosen for this mission because its size is relative to asteroids that could pose a threat to Earth. DART will crash into Dimorphos moving at 14,763.8 miles per hour. A camera on DART, called DRACO, and autonomous navigation software will help the spacecraft detect and collide with Dimorphos. This fast impact will only change Dimorphos' speed as it orbits Didymos by 1%, which doesn't sound like a lot -- but it will change the moon's orbital period by several minutes. That change can be observed and measured from ground-based telescopes on Earth. It will also be the first time humans have altered the dynamics of a solar system body in a measurable way, according to the European Space Agency. Three years after the impact, Hera will arrive to study Dimorphos in detail, measuring physical properties of the moon, studying the DART impact and study its orbit. This may sound like a long time to wait between the impact and follow-up, but it's based on lessons learned in the past. In July 2005, NASA's Deep Impact spacecraft launched a 815-pound copper impact into a comet, Tempel 1. But the spacecraft was not able to see the crater that resulted because the impact released tons of dust and ice. However, NASA's Stardust mission in 2011 was able to characterize the impact - a 492-foot gash. Together, the valuable data collected by DART and Hero will contribute to planetary defense strategies, especially understanding what kind of force is needed to shift the orbit of a near-Earth asteroid that may collide with our planet.

## Case

#### China does not want war

Blaxland 21 (John Blaxland, Professor, Strategic and Defence Studies Centre, Australian National University, May 4, 2021, China does not want war, at least not yet. It’s playing the long game, <https://theconversation.com/china-does-not-want-war-at-least-not-yet-its-playing-the-long-game-160093>) SJ

China is so far avoiding open war. Meanwhile, China has metamorphosed both economically and militarily. An exponential [growth in China’s military capabilities](https://www.rand.org/paf/projects/us-china-scorecard.html)has been matched by a steep rise in the lethality, accuracy, range and quantity of its weapons systems. On top of this, Beijing has ratcheted up its [warlike rhetoric and tactics](https://www.theglobeandmail.com/world/article-china-using-warlike-tactics-against-taiwan-former-defence-minister/). Last month, Xi made a [muscular speech to the Boao Forum Asia](https://theconversation.com/xi-jinping-sends-message-to-us-on-chinas-rising-power-in-boao-address-159324), calling for an acceptance of China not only as an emerging superpower but also as an equal in addressing global challenges.  Sometimes actions speak louder than words. And China’s actions so far have avoided crossing the threshold into open warfare, refusing to present a [“nail” to a US “hammer”](https://diplomacybeyond.com/to-a-man-with-a-hammer-everything-looks-like-a-nail-chinas-foreign-ministry-spokesperson-zhao-lijian-hits-back-at-us/). This is for good reason.  If war did break out, China would be vulnerable. For starters, it shares [land borders with 14 countries](https://www.chinahighlights.com/travelguide/countries-bordering-china.htm), bringing the potential for heightened challenges, if not open attack on numerous fronts.  Then there are the economic concerns. China has significant [Japanese](https://www.scmp.com/economy/china-economy/article/3095951/china-increasingly-worried-about-losing-face-japan-bankrolls), [US and European industrial investments](https://www.nordeatrade.com/en/explore-new-market/china/investment), and is also overwhelmingly dependent on energy and goods passing through the Malacca Strait between Malaysia, Singapore and Indonesia, the Indo-Pacific’s jugular vein.

#### No one’s going to war over a downed satellite

Bowen 18 [Bleddyn Bowen, Lecturer in International Relations at the University of Leicester. The Art of Space Deterrence. February 20, 2018. <https://www.europeanleadershipnetwork.org/commentary/the-art-of-space-deterrence/>] brett

Space is often an afterthought or a miscellaneous ancillary in the grand strategic views of top-level decision-makers. A president may not care that one satellite may be lost or go dark; it may cause panic and Twitter-based hysteria for the space community, of course. But the terrestrial context and consequences, as well as the political stakes and symbolism of any exchange of hostilities in space matters more. The political and media dimension can magnify or minimise the perceived consequences of losing specific satellites out of all proportion to their actual strategic effect.

#### There’s no nuclear winter. Prefer our study – it has 9 PhD’s with experts in every relevant scientific field.

**Reisner et al 2018[** [Jon Reisner](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Reisner%2C+Jon) - Climate and Atmospheric Sciences PhD at Los Alamos National Laboratory; [Gennaro D'Angelo](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=D%27Angelo%2C+Gennaro) – PhD [Los Alamos National Laboratory](https://www.researchgate.net/institution/Los_Alamos_National_Laboratory), [Theoretical Division](https://www.researchgate.net/institution/Los_Alamos_National_Laboratory/department/Theoretical_Division2) [Eunmo Koo](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Koo%2C+Eunmo) - Ph.D., Mechanical Engineering, University of California at Berkeley, Expertise: Atmospheric fluid dynamics, Modeling fluid-solid interactions, Fire spread in urban and wildland environment, Wind energy harvest, High-performance computing simulations; [Wesley Even](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Even%2C+Wesley) - Ph.D. Physics - Louisiana State University, Expertise: Computational Physics, Astrophysics [Matthew Hecht](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Hecht%2C+Matthew) – Expert in Climate and Ocean Modeling [Elizabeth Hunke](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Hunke%2C+Elizabeth) - Ph.D., Program in Applied Mathematics, University of Arizona, Expertise: Sea Ice Models; [Darin Comeau](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Comeau%2C+Darin) – PhD, Applied Mathematics, University of Arizona , Expert in High dimensional data analysis, statistical and predictive modeling, and uncertainty quantification, with particular applications to climate science, as well as process-based modeling of the cryosphere; [Randall Bos](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Bos%2C+Randall) – PhD, Expert in Nuclear Weapon Effects Modeling and Simulation [James Cooley](https://agupubs.onlinelibrary.wiley.com/action/doSearch?ContribAuthorStored=Cooley%2C+James) - Ph.D. -- Physics, University of Maryland, Expert in Weapon Physics, Emergency Response, Computational Physics, Verification, and Validation (2018). Climate impact of a regional nuclear weapons exchange: An improved assessment based on detailed source calculations. Journal of Geophysical Research: Atmospheres , 123 , 2752 – 2772. https://doi.org/10.1002/2017JD027331 Received 20 JUN 2017 Accepted 1 FEB 2018 Accepted article online 13 FEB 2018 Published online 14 MAR 2018 ©2018. The Authors. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distri- bution in any medium, provided the original work is properly cited, the use is non-commercial and no modi fi cations or adaptations are made.] LHSBC

Abstract We present a multiscale study examining the impact of a regional exchange of nuclear weapons on global climate. Our models investigate **multiple phases of the effects of nuclear weapons** usage, including growth and rise of the nuclear fireball, ignition and spread of the induced fi restorm, and **comprehensive Earth system modeling** of the oceans, land, ice, and atmosphere. This study follows from the scenario originally envisioned by Robock, Oman, Stenchikov, et al. (2007, https://doi.org/10.5194/acp-7-2003-2007), based on the analysis of Toon et al. (2007, https://doi.org/10.5194/acp-7-1973-2007), which assumes a regional exchange between India and Pakistan of fi fty 15 kt weapons detonated by each side. We expand this scenario by modeling the processes that lead to production of black carbon, in order to re fi ne the black carbon forcing estimates of these previous studies. When the Earth system model is initiated with 5 × 10 9 kg of black carbon in the upper troposphere (approximately from 9 to 13 km), the impact on climate variables such as global temperature and precipitation in our simulations is similar to that predicted by previously published work. However, while our thorough simulations of the fi restorm produce about 3.7 × 10 9 kg of black carbon, we fi nd that the vast majority of the black carbon **never reaches an altitude above weather systems** (approximately 12 km). Therefore, our Earth system model simulations conducted with model-informed atmospheric distributions of black carbon produce signi fi cantly lower global climatic impacts than assessed in prior studies, as the carbon at lower altitudes is more **quickly removed from the atmosphere**. In addition, our model ensembles indicate that statistically signi fi cant effects on global surface temperatures are limited to the fi rst 5 years and are much smaller in magnitude than those shown in earlier works. None of the simulations produced a nuclear winter effect. We fi nd that the effects on global surface temperatures are not uniform and are concentrated primarily around the highest arctic latitudes, dramatically **reducing the global impact on human health and agriculture** compared with that reported by earlier studies. Our analysis demonstrates that the probability of significant global cooling from a limited exchange scenario as envisioned in previous studies is **highly unlikely**, a **conclusion supported by examination of natural analogs,** such as large forest fires and volcanic eruptions.

#### Turn: Nuke war won’t cause extinction, but it’ll spur political will for meaningful disarmament.

Deudney 18 [Associate Professor of Political Science at Johns Hopkins University. 03/15/2018. “The Great Debate.” The Oxford Handbook of International Security. www.oxfordhandbooks.com, doi:10.1093/oxfordhb/9780198777854.013.22] // Re-Cut Justin

Although nuclear war is the oldest of these technogenic threats to civilization and human survival, and although important steps to restraint, particularly at the end of the Cold War, have been achieved, the nuclear world is increasingly changing in major ways, and in almost entirely dangerous directions. The third “bombs away” phase of the great debate on the nuclear-political question is more consequentially divided than in the first two phases. Even more ominously, most of the momentum lies with the forces that are pulling states toward nuclear-use, and with the radical actors bent on inflicting catastrophic damage on the leading states in the international system, particularly the United States. In contrast, the arms control project, although intellectually vibrant, is largely in retreat on the world political stage. The arms control settlement of the Cold War is unraveling, and the world public is more divided and distracted than ever. With the recent election of President Donald Trump, the United States, which has played such a dominant role in nuclear politics since its scientists invented these fiendish engines, now has an impulsive and uninformed leader, boding ill for nuclear restraint and effective crisis management. Given current trends, it is prudent to assume that sooner or later, and probably sooner, nuclear weapons will again be the used in war. But this bad news may contain a “silver lining” of good news. Unlike a general nuclear war that might have occurred during the Cold War, such a nuclear event now would probably not mark the end of civilization (or of humanity), due to the great reductions in nuclear forces achieved at the end of the Cold War. Furthermore, politics on “the day after” could have immense potential for positive change. The survivors would not be likely to envy the dead, but would surely have a greatly renewed resolution for “never again.” Such an event, completely unpredictable in its particulars, would unambiguously put the nuclear-political question back at the top of the world political agenda. It would unmistakeably remind leading states of their vulnerability It might also trigger more robust efforts to achieve the global regulation of nuclear capability. Like the bombings of Hiroshima and Nagasaki that did so much to catalyze the elevated concern for nuclear security in the early Cold War, and like the experience “at the brink” in the Cuban Missile Crisis of 1962, the now bubbling nuclear caldron holds the possibility of inaugurating a major period of institutional innovation and adjustment toward a fully “bombs away” future.

#### Too much debris exists in space now – that destroys satellites

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Earth orbit is getting more and more crowded as the years go by. Humanity has launched about 12,170 satellites since the dawn of the space age in 1957, [according to the European Space Agency](https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers) (ESA), and 7,630 of them remain in orbit today — but only about 4,700 are still operational. That means there are nearly 3,000 defunct spacecraft zooming around Earth at tremendous speeds, along with other big, dangerous pieces of debris like upper-stage rocket bodies. For example, orbital velocity at 250 miles (400 kilometers) up, the altitude at which the ISS flies, is about 17,100 mph (27,500 kph). At such speeds, even a tiny shard of debris can do serious damage to a spacecraft — and there are huge numbers of such fragmentary bullets zipping around our planet. ESA estimates that Earth orbit harbors at least 36,500 debris objects that are more than 4 inches (10 centimeters) wide, 1 million between 0.4 inches and 4 inches (1 to 10 cm) across, and a staggering 330 million that are smaller than 0.4 inches (1 cm) but bigger than 0.04 inches (1 millimeter). These objects pose more than just a hypothetical threat. From 1999 to May 2021, for example, the ISS conducted 29 debris-avoiding maneuvers, including three in 2020 alone, [according to NASA officials](https://www.nasa.gov/mission_pages/station/news/orbital_debris.html). And that number continues to grow; the station performed [another such move in November 2021](https://www.space.com/space-station-dodging-chinese-space-junk-spacex-crew-3), for example. Many of the smaller pieces of space junk were spawned by the explosion of spent rocket bodies in orbit, but others were more actively emplaced. In January 2007, for instance, China intentionally destroyed one of its defunct weather satellites in a much-criticized test of anti-satellite technology that generated [more than 3,000 tracked debris objects](https://swfound.org/media/9550/chinese_asat_fact_sheet_updated_2012.pdf) and perhaps 32,000 others too small to be detected. The vast majority of that junk remains in orbit today, experts say. Spacecraft have also collided with each other on orbit. The most famous such incident occurred in February 2009, when Russia's defunct Kosmos 2251 satellite slammed into the operational communications craft Iridium 33, producing [nearly 2,000 pieces of debris](https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf) bigger than a softball. That 2009 smashup might be evidence that the Kessler Syndrome is already upon us, though a cataclysm of "Gravity" proportions is still a long way off. "The cascade process can be more accurately thought of as continuous and as already started, where each collision or explosion in orbit slowly results in an increase in the frequency of future collisions," [Kessler told Space Safety Magazine in 2012](http://www.spacesafetymagazine.com/space-debris/kessler-syndrome/don-kessler-envisat-kessler-syndrome/)

#### Their models are old and don’t assume appropriate solar activity decay – debris is stable

**Wang and Liu 19** – Advances in Astronomy(Xiao-wei and Jing, PhDs, National Astronomical Observatories, Chinese Academy of Sciences, “An Introduction to a New Space Debris Evolution Model: SOLEM”, https://www.hindawi.com/journals/aa/2019/2738276/)

1. Introduction During the past decades, the number of space objects has been growing rapidly. Until now, the cataloged in-orbit space objects number has reached about 24,000, about 19000 of which are publicly listed at Space Track [1]. Uncataloged objects number with smaller size has approximately reached hundreds of millions. These space objects, mostly space debris, pose great threats to operational safety of in-orbit spacecraft. Adopting space debris mitigation measures is an important way to relieve the threats from space debris and prevent the number of resident space objects from growing. However, some studies indicated that the space debris environment would be stable for only 50 years under current mitigation measures, even without new launches in future [2]. This statement has aroused widespread concern over the world. In order to check and quantify the effectiveness of mitigation measures on controlling the growth of space debris in future, many space debris evolution models are established and compared to study the long-term stability of the future space environment. At present, the well-known space debris evolution models mainly include the LEGEND model from National Aeronautics and Space Administration (NASA) [3], DAMAGE model from United Kingdom Space Agency (UKSA) [4], MEDEE model from Centre National d’Etudes Spatiales (CNES) [5], DELTA model from European Space Agency (ESA) [6], LUCA model from Technische Universität Braunschweig [7], and NEODEEM model from Kyushu University and the Japan Aerospace Exploration Agency (JAXA)[8]. Some of these models have been used to study the stability of the future space environment in the joint research organized by Inter-Agency Space Debris Coordination Committee (IADC) [9, 10]. Besides, further work on the uncertainties affecting the long-term evolution of space debris is encouraged in international community to better assess the uncertainty induced by the modelling assumptions [11]. Therefore, more space debris evolution models are welcomed to participate in such research activities, which may provide the technical support for making new space debris mitigation guidelines as well as other related policies for space traffic management to guarantee the long-term sustainability of outer space activities. SOLEM (Space Objects Long-term Evolution Model) is a Low Earth Orbit (LEO) space debris long-term evolution model established by China. It has participated in the joint researches of IADC as a representative of China National Space Administration (CNSA). SOLEM is capable of predicting the number evolution trends of space debris, estimating the rate of collision events of space objects during the evolution in future, and analyzing the effects of different mitigation and remediation measures or other potential uncertainties on the long-term evolution of space debris. The reliability of SOLEM has been validated during the joint research of IADC. This paper introduces the components, algorithms, and workflow of SOLEM. After that, the effects of different mitigation measures based on SOLEM model are analyzed. 2. The SOLEM Model The space debris evolution model is expected to predict the evolution of space debris population and possible collision rates for a long period in future, usually for decades and even centuries. It can be used to study the evolution processes with various assumptions. The future evolution of space debris is affected by natural factors such as various perturbations, atmosphere evolutions, periodic solar activities, accidental explosions, and even the surface degradations. In fact, it could also be affected by human space activities such as launches, collision avoidance manoeuvres, mitigation and remediation measures. In space debris evolution model, usually the most important source and sink mechanisms are considered. Generally, a space debris evolution model is composed of orbital propagation model, collision probability estimation model, fragment generation model, future launch model, postmission disposal model, and active debris removal model (if the active debris removal measures are considered). These components will significantly affect the model evolution results if some key parameters are changed. The composition of space debris evolution model is illustrated in Figure 1. Figure 1: The general components of space debris evolution models. The left components are the main source mechanisms, and the right components are the main sink mechanisms. 3. Orbital Propagation Orbital propagation is to project the current orbits of space objects to the future. It is the core component of space debris evolution model. Through orbital propagation, the space debris evolution model is able to obtain the space objects orbital distribution at any moment in future. There are three basic orbital prediction algorithms: numerical method, analytical method, and semianalytical method. Numerical method has the highest precision but takes the most time in orbit propagation. Due to the long evolution time of space debris, usually from decades to hundreds of years, moreover, the high-precision position has no practical significance in long-term evolution; it is more appropriate to use analytical method or semianalytical method. SOLEM model adopts a simplified semianalytical orbital propagator, in which the integration is done on the perturbation functions with the short-periodic terms removed. Essentially, it is performed on the averaged orbital dynamic system. At present, SOLEM covers only LEO region, including objects residing in LEO with near-circular orbits and those crossing LEO with high eccentricity orbits. For near-circular orbits, the main perturbations considered include the Earth’s nonspherical gravity perturbation J2, J3, J4, J2,2, and atmospheric drag. For high eccentricity orbits, besides the Earth’s nonspherical gravity and atmospheric drag, the perturbations due to solar radiation pressure and gravity of the Sun and Moon are also considered. The atmosphere density model used for drag calculation is the NRLMSIS00 model. The values of solar radiation flux at 10.7 cm and the geomagnetic index can be read from a configuration file which can be replaced according to assumptions. In order to verify this orbital propagator of SOLEM, we conducted an experiment on the evolution of a small population. It is to compare the SOLEM propagation results with historical data for the number evolution of a small population in a statistical view. We used all the 1021 cataloged LEO-crossing objects on 1980.01.01 to do the experiment. It includes 38 objects with high eccentricity orbits () and 983 objects with near-circular orbits (). The area-to-mass ratio of these objects is calculated according to the UNW type of perturbed motion equation together with the method of least squares, using the orbital data for months previously. For SOLEM propagation, we used historical solar activities recorded in CelesTrak website [12] considering no collision avoidance and station keeping manoeuvres. The real decay information of the 1021 objects is drawn from SSR on the Space Track website [13]. The propagation result of SOLEM orbital propagator and the real data of historical evolution of the 1021 objects are compared in Figure 2, which shows a high consistency with a relative error of about 2%. Figure 2: The statistical results comparison of SOLEM propagation (denoted as test) and historical evolution (denoted as real). The semianalytical method has a limit precision in orbit propagation. However, comparing with the evolution of a single orbit, the space debris long-term evolution model cares more about the number evolution of the whole population in statistics. Considering the experiment above, we think the SOLEM orbital propagator is applicable to space debris long-term evolution model. 4. Fragment Generation Model In-orbit breakup is one important source of space debris growth. Therefore, the accuracy of fragment generation model simulating the breakup events has an important impact on the simulation results of space debris evolution model. The fragment generation model is to simulate the space debris collisions or explosions and give the instantaneous information of generated fragments which is necessary for the subsequent evolution prediction. The information includes the fragments number and each fragment’s mass, size, velocity, etc. In SOLEM, we adopt NASA’s standard breakup model to simulate the generation of fragments produced by in-orbit breakups. NASA’s standard breakup model is the most popular fragment generation model at present. The implementation is following the process presented in paper [14, 15]. 5. Collision Probability Estimation When considering the fragmentation due to in-orbit collisions, there is a key component in the space debris evolution model, that is, the collision probability estimation algorithm. In SOLEM, we adopt an Improved-CUBE (I-CUBE) model to do the calculation of collision probabilities. It is based on the CUBE method proposed by NASA [16, 17]. In CUBE model, the evolution system is uniformly sampled in time. At each sampling moment, the space around the Earth is discretized in small cubes in geocentric Cartesian coordinates. By obtaining updated orbital elements, the location of each space objects is calculated. CUBE model assumes that the collision probability only exists between objects residing in the same cube. And the collision probability is calculated by where and are the spatial densities of objects and in the cube, is the collision cross-section, is collision speed, is the volume of the cube, and is the time interval between two sampling moments. Actually, calculated by (1) is the mean number of collisions between objects and in the volume during the propagation time interval . The time interval is given as 5 days, i.e., seconds. As it does not approach 0, for some objects with collision cross-section large enough, will reach a value greater than 1. That is not reasonable. To avoid this, in I-CUBE model, we used (2) to express the collision probability with the consideration that the collision process follows a Poisson distribution. where represents the collision probability and is the mean number of collisions between objects and in the volume during the propagation time interval . According to Heiner Klinkrad [18], the approximation yields results with less than 10% error for . That means, for , the approximation will bring error bigger than 10%. For most space objects, the approximation is well suited. But for those with collision cross-sections large enough (dozens or even hundreds of square meters), the collision probability may be greatly overestimated if still using the approximation. Besides, CUBE model assumes that only the objects residing in the same cube are considered for collisions. For space debris evolution, the divided cube size is given as 10 km. However, it has been queried by CNES for the effects on evolution results from the divided cube size [19, 20]. In I-CUBE model, we assume that collision probability exists in all close approaches with a distance from the target satisfying the threshold. The distance threshold is the diagonal of the divided cube. Thus, the value of in (1) is no longer the volume of cube, but the volume of a sphere with radius equal to the distance threshold; i.e., where is the divided cube size. As relates to the spatial densities, and are now the spatial densities of objects and in the volume of the sphere. The two-dimensional representation is illustrated in Figure 3. Figure 3: Two-dimensional representation for considering possible collisions between debris residing in neighbouring cubes. In this approach, the divided cube size will never influence the evolution result of space debris evolution models. The comparison results using CUBE and I-CUBE model running by SOLEM are presented in Figure 4. The divided cube size varies from 5 km to 50 km. Except for the divided cube size, all the other configurations are the same. Every curve is the average result of 50 Monte Carlo runs. Figure 4: Comparison of simulation results with different cube size. (a) Using CUBE model. (b) Using I-CUBE model. 6. Future Launch Activities The launch of spacecraft in future is another important source of space debris increase. However, it is highly related to technical development and space policies which cannot be predicted. Therefore, the future launch model usually takes the current launch level as a reference. The data of a launch model includes all the characteristics of launched objects, such as the launched number, each object’s type, mass, area, or/and size, target orbit, and launch time. In SOLEM model, we adopt the launch traffic during the last 8 years, from September 1, 2009, to August 31, 2017, as future launch model. It will be repeated during the overall simulation time. The traffic data is collected mainly from websites of Space Launch Report [21], Space Track [22], and Union of Concerned Scientists [23]. It is prepared previously as a configuration file containing the information of launched numbers, types (including satellites, rocket bodies, and mission-related objects), each object’s mass, area (or/and size), target orbit, launch date, etc. 7. Postmission Disposal Postmission Disposal (PMD) is an important mitigation measure to stop space debris population from growing. In SOLEM model, PMD measures are implemented on nonfunctional satellites and rockets launched during the evolution time. For newly launched satellites, the mission life is uniformly set as 8 years by default. It can also be set as other values by user. For rockets, the mission life will end at once when the carried satellites are sent into the target orbits. When the mission life of a satellite or rocket ends, the natural orbital lifetime will be estimated. If the natural orbital lifetime exceeds 25 years, the satellite or upper stage of the rocket will be deorbited to a disposed orbit that will naturally decay within 25 years, complying with the 25-year rule. The PMD success rate in SOLEM can be set freely by users. Currently this value is estimated to be lower than 20% for region above 600 km. The procedure of PMD is shown in Figure 5. Figure 5: The procedure of PMD. For mission ended satellites or rockets (R/Bs), if the evaluated natural orbital lifetime exceeds 25 years, it will be disposed to a new orbit complying with the 25-year rule. 8. Active Debris Removal To better limit the growth of LEO space debris populations, measures of active debris removal (ADR) are suggested. Although the ADR has not become practical due to the technical difficulties and high costs, its effects on space debris evolution have been proved through computer simulations. Considering the developing technology, ADR will be another important measure in stopping the growth of the space debris population in future. As suggested, ADR measure is to remove existing large and massive objects from regions where high collision activities are expected [24]. The selection criterion that should be used in choosing which objects to remove has also been researched, and the criterion based on the mass and collision probability of each object has been proposed [25–27]. By annually removing several targets, the space environment can be stabilized according to computer simulations. In SOLEM model, the selection criterion is implemented as follows: where is the mass of object and is the cumulated collision probabilities between object and object , where during the last year. Their product is the selection index for ADR. The larger the value of , the more dangerous the object . At the beginning of each projection year, all objects in orbit are sorted in descending order by the value of . A predefined number of space debris objects with the largest s will be immediately removed from orbits. Only the operating satellites and objects with high eccentricity orbits are excluded. The beginning year of implementing ADR measures is set by users. In SOLEM, it is set as 2030 by default. 9. The Initial Population Space objects initial population is the baseline of space debris evolution model. It is the description of current space environment. For SOLEM, the population data on 2017.09.01 is used as initial population. Just like the future launch model, the information of space objects is obtained from Space Track, Space Launch Report, and Union of Concerned Scientists. The orbital distribution and the area-to-mass ratio (A/M) versus size distribution are shown in Figures 6 and 7. Figure 6: The semimajor axis versus eccentricity distribution of population data of 2017.09.01. Figure 7: The A/M versus size distribution of population data of 2017.09.01. 10. The Workflow of SOLEM Model The workflow of SOLEM model is simply represented by Figure 8. As presented, before projection, initialization will be done first by setting key parameters which are based on simulated assumptions, taking prepared initial population data as input. All space objects contained in the initial population are propagated after initialization. As time evolves, the newly launched objects from future launch model will also be propagated. If the newly launched active satellite or rocket ends its mission, the PMD measure will be done. All space objects with size over 10 cm are included for collision consideration. Once a collision happens, the breakup model will be used to generate new fragments. And the population for next propagation step will be updated. Figure 8: The workflow of SOLEM model. 11. Model Application As key parameters of each module are flexible to users, SOLEM model is able to simulate the evolution of space debris under various assumptions with high flexibility. Since 2015, SOLEM, as a representative of CNSA, has participated in a joint research of IADC. With uniform input data and assumptions, SOLEM has achieved results consistent with other space debris evolution models (IADC internal reports). In this paper, the effects of different mitigation measures on space debris evolution are analyzed with the SOLEM model. 11.1. Input Data The initial input data and relevant assumptions are shown in Table 1. Three scenarios are performed with PMD rate set as 30%, 60%, and 90%, and the other input data and assumptions are all the same. For each scenario, 50 Monte Carlo simulation runs are performed to obtain the averages. Table 1: Assumptions of scenarios simulated by SOLEM model. The solar activity used in SOLEM for future evolution is shown in Figure 9. It is generated according to the monthly fit formula offered by CelesTrak website [12]. The geomagnetic index is set as a constant median value of Ap=9. Figure 9: The solar activity recorded in history (green line, denoted as real) and the solar activity model adopted in SOLEM (purple line). 11.2. Simulation Results In the evolution results, space objects are classified into three types: intact objects include all satellites, R/Bs, and mission-related objects; old fragments are all the DEB already existing in the initial population; new fragments are all the DEB generated during the evolution time. Separating new fragments from old fragments can help us have a clear view of the increasing process of space debris population. The space debris evolution results of the scenario setting PMD rate as 30% is presented in Figure 10. It is the average result of 50 Mont-Carlo runs by SOLEM. As Figure 10 shows, the total number of objects in LEO shows a decrease in the first two decades, then turns into increase throughout the evolution time, and finally reaches more than 115% of the initial population. This scenario predicts 34 catastrophic collisions and 25 noncatastrophic collisions in average in future 200 years. Figure 10: The evolution results of scenario 1, with PMD rate of 30%. (a) The population evolution. The line of total is plotted with the error bar of 1 σ standard deviation. (b) The cumulative number of collisions. Figure 11 shows the evolution results of the scenario setting PMD rate as 60%. The reinforcement of such mitigation measure makes the final effective number of LEO objects in future 200 years decrease greatly comparing with the baseline scenario. The final total effective number of LEO objects is only 23% more than the initial population. And the cumulative number of collisions also decreases greatly in both collision types. Figure 11: The evolution results of scenario 2, with PMD rate of 60%. (a) The population evolution. The line of total is plotted with the error bar of 1 σ standard deviation. (b) The cumulative number of collisions. In Figure 12, the evolution result shows, with PMD rate of 90%, there is a clear decrease by approximately 30% in the total effective number of space objects crossing LEO orbits for the next 50 years, and then the population remains at a long-term stable level. The decrease in the first 50 years is mainly due to the natural decay of old fragments. The number of new fragments generated by breakup events increases in nearly the whole evolution time with a low rate and finally seems to stop increasing at the end of evolution. The cumulative number of catastrophic collisions is decreased down to 15, and for noncatastrophic collisions the number is only 7. Generally, this scenario predicts a space debris environment becoming better with PMD rate as high as 90%. Figure 12: The evolution results of scenario 3, with PMD rate of 90%. (a) The population evolution. The line of total is plotted with the error bar of 1 σ standard deviation. (b) The cumulative number of collisions. Simulation results of the three scenarios are quantified in Table 2. It can be seen that, with PMD rate increasing, the space debris population after 200 years will greatly decrease, as well as the average catastrophic collision rates. High PMD rates will make the current space environment better and safer. Table 2: Quantification of evolution results of the three scenarios simulated by SOLEM model. Taking the IADC comparison study about “Stability of the Future LEO Environment” [9, 10] as a reference, the evolution results shown above look rather optimistic. The IADC comparison study predicted about +30% changes in population after 200 years and one catastrophic collision every 5 to 9 years with PMD rate of 90%. And we predict -30% change in population and one catastrophic collision every 13 years with the same PMD compliance level. That might be mainly due to the differences in solar activity model and the input initial population used for simulation. The solar activity used in this paper (Figure 9) is in a higher level than those used in [9, 10], which is shown in Figure 13. This will make more objects decay during the evolution. Besides, the initial population we used in this paper is obtained from the public data on 2017.09.01, which is about 13000 space objects. While the initial population used in [9, 10] is the reference population of MASTER2009 on 2009.05.01, which is about 17000 space objects, the difference in initial population is as high as about 24%. Additionally, the area-to-mass ratio distribution of the initial population in this paper (Figure 7) is also different from [9, 10], which is shown in Figure 14. From the area-to-mass ratio distribution of the initial population, it can be seen that the initial population we used does not exclude those objects with high area-to-mass ratio. Figure 13: Solar flux projections used in IADC comparison study. Figure 14: Area-to-mass ratio distributions of the initial population used in IADC comparison study. The differences in solar activity projection and initial population including both the number and area-to-mass ratio finally lead to a very different evolution result. 12. Summary and Future Work This paper mainly introduced the composition, submodel algorithm, and workflow of SOLEM, the space debris long-term evolution model of China. The reliability of SOLEM has been validated during the joint research of IADC. After that, the application work of SOLEM model on analyzing the effects of different mitigation measures on the evolution of space environment is presented. The result shows, with higher PMD rate, the current space environment will become better and safer. SOLEM is a LEO space debris evolution model with high flexibility. It is capable of simulating the space environment evolution with various assumptions. Therefore, it can be used to simulate and analyze the uncertainties affecting the space debris evolution, such as the future launches, solar activities, manual collision avoidance measures, and mitigation and remediation measures. Through simulation and analysis, SOLEM can help us to deeply understand the evolution process of space environment and provides technical support for making space policies and laws to guarantee the sustainability of space activities in future. At present, the orbital range covered by SOLEM is limited to LEO region from 200 km to 2000 km. In the next step, the orbital range covered by SOLEM will be expanded from LEO region to GEO (Geostationary Earth Orbit) region. Besides, the postmission disposal model will be optimized, including the disposed orbit selection process and the computation time.

**Their impacts take centuries and mitigation checks.**

**Lewis 15** – Senior Lecturer in Aerospace Engineering at the University of Southampton [Hugh Lewis, “Space debris, Kessler Syndrome, and the unreasonable expectation of certainty,” 2015, *Room*, <https://room.eu.com/article/Space_debris_Kessler_Syndrome_and_the_unreasonable_expectation_of_certainty>]

There is now widespread awareness of the space debris problem amongst policymakers, scientists, engineers and the public. Thanks to pivotal work by J.C. Liou and Nicholas Johnson in 2006 we now understand that the continued growth of the debris population is likely in the future even if all launch activity is halted. The reason for this sustained growth, and for the concern of many satellite operators who are forced to act to protect their assets, are collisions that are expected to occur between objects – satellites and rocket stages – already in orbit. In spite of several commentators warning that these collisions are just the start of a collision cascade that will render access to low Earth orbit all but impossible – a process commonly referred to as the ‘**Kessler** Syndrome’ after the debris scientist Donald Kessler – the reality is not likely to be on the scale of these predictions or the events depicted in **the film Gravity**. Indeed, results presented by the Inter-Agency Space Debris Coordination Committee (**IADC**) at the Sixth European Conference on Space Debris show an expected increase in the debris population of only 30% after **200 years** with continued launch activity. **Collisions** are still predicted to occur, but this is far from the **catastrophic scenario** feared by some. Constraining the population increase to a modest level can be achieved, the IADC suggested, through widespread and good compliance with **existing** space debris **mitigation guidelines**, especially those relating to passivation (whereby all sources of stored energy on a satellite are depleted at the end of its mission) and post-mission disposal, such as de-orbiting the satellite or re-orbiting it to a graveyard orbit. Nevertheless, the anticipated growth of the debris population in spite of these robust efforts merits the investigation of additional measures to address the debris threat, according to the IADC.