# Legal Trust CP

## NC Tools

### NC Shell - Short

#### TEXT: The Outer Space Treaty ought to be amended to establish an international legal trust system governing outer space.

#### The Legal trust would include private property rights and would ensure the sustainable development as well as the equitable distribution of space resources.

Finoa ’20 – Ivan Finoa [Department of Law, University of Turin], “An international legal trust system to deal with the new space era,” 71st International Astronautical Congress (IAC) – The CyberSpace Edition, (12-14 October 2020). <<https://d1wqtxts1xzle7.cloudfront.net/66728932/_IAC_20_E7.VP.8.x58518_An_international_legal_trust_system_to_deal_with_the_new_space_era_BY_IVAN_FINO-with-cover-page-v2.pdf?Expires=1642044926&Signature=asvt6StaK5n9UnpXuJIlo4ziI839WzFYjDZy37bm70ObGy3vFJyHwWNGxhn2beze4QzYDPPX0pVEXAwYvDaINVNxN01Ify8YwG5loNRddlat-grf3iawic7KvwqPowxFe2GuemVvbB-KW8ZVBxigwS-gelSKIVy4KYR9UgiDrM6e6deEBnUTcULSwmsH-JdHNg13ytZ3vNVMMlxZW2MPOCRuB2WlOHdCLoC86VqafSoMwuec-d~Aisbgyt5F2vO-GjvI60bR7h2MSp0iT6P7apIDUUpHUsDGbvcdxp22HSxXdlvr7lSqtLnL5rKxujGDYq~R9B~WuGiorVL2hn74UQ__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA>>CT

Considering the worsening climate change, in the future outer space might be our last Noah’s Ark. Now, humans must look to space as an opportunity to support growing resource requirements. Asteroids are rich in metals, which could be transported back to Earth. Unfortunately, the existing international legal framework discourages investments in the space economy. Once an enterprise invests billions of dollars in discovering and developing a mining site, it cannot claim any ownership because of the non-appropriation principle stipulated in Article 2 of the Outer Space Treaty (OST). Thus, other entities could legally access and exploit the same resource without any participation in the initial financial investment, increasing the risk of potential conflict. Bearing this in mind, the question arises, which legal regime could ensure effective allocation of resources, avoiding a chaotic space race to acquire valuable assets? The aim of this research is to argue that the first two articles of OST should be amended, to set up an international legal trust system which would guarantee different kinds of rights, dependently on the nature of the celestial body. E.g., property rights could be preferable to a lease over asteroids, as they could be exploited to their disappearance. This proposed system would be led by the United Nations Office for Outer Space Affairs (UNOOSA), as the main trustee. The co-trustees would be the nations of the world. Prior to initiating any space activity, every entity would send a request to their national government. If all the legal parameters are respected, the nation would forward the operational request to the UNOOSA. In the case of acceptance, UNOOSA would record the permit on an international public registry. The country in which the company has been registered would investigate whether the activities of its national company are consistent with the permit. This would be the ordinary model. The extraordinary model would be when the applicant for the space activity is a state, then the trustee would be the UN. All lucrative activities would be subject to benefit-sharing. Finally, this research will demonstrate the valuable outcome of the International Legal Trust System and its advantages for all humankind. Private companies would rely on property rights, while the benefit-sharing could be used to finance the 17 Sustainable Development Goals adopted by the UN in 2015, which address peace, climate change, inequalities and poverty.

# Debris DA

#### It’s now or never to clean up debris, but only private companies are capable of making a dent.

Nitin **Sreedhar, 21** - ("The race to clean up outer space," Mintlounge, 16-01-2021, 10-10-2021https://lifestyle.livemint.com/news/big-story/the-race-to-clean-up-outer-space-111610719274127.html)//AW

Space debris poses a danger not only to exploration missions but also to newer activities such as private space tourism. In the near future, space travel will be open to individuals. Companies like Virgin Galactic hope to make space tourism affordable—but space junk presents a unique risk. “It’s getting bigger and bigger. Current data says there are some 3,000 dead satellites and a little over 30,000 pieces of junk which are larger than 10cm in size. The number is critical,” says Jahnavi Phalkey, science and technology historian and director of Science Gallery Bengaluru. “It’s dangerous also to newer missions. The speed at which these things travel, it could damage a new satellite, a manned-space mission or the International Space Station (ISS), where you actually have people living,” she says on the phone. There are very real fears that there may be so much space debris soon that it could inhibit new launches. In fact, the Kessler Syndrome, a term proposed by astrophysicist and former Nasa scientist Donald J. Kessler in 1978, describes a situation where the amount of man-made space debris reaches such a critical point that just one instance of collision between space debris could lead to a cascade of collisions—and ultimately, a runaway chain reaction. Think of it as a domino effect in space. The ESA’s Annual Space Environment Report, released in September, notes that while the amount of mission-related objects, such as payloads and rockets, released into space since the 1960s is declining steadily, the number of pieces, the debris’ combined mass and area has only grown. This has resulted in “involuntary collisions” between operational payloads and space debris. After a point, even limiting the number of new space launches will not help. Collisions between existing debris will continue to produce more pieces of space junk. In 1978, astrophysicist and former Nasa scientist Donald J. Kessler described a situation where the amount of man-made space debris could reach such a critical point that just one instance of collision between space debris could lead to a cascade of collisions. (Photo credit: ESA) This is something space missions in certain Earth orbits already have to factor in daily, says Stijn Lemmens, a senior space debris mitigation analyst at ESA’s Space Debris Office in Darmstadt, Germany. “In particular in low Earth orbits, i.e. orbits with an altitude below 2,000km above Earth’s surface, missions need to be prepared to receive, and in some cases act when the risk of collision is too high.... For example, in ESA’s fleet this implies on average one collision avoidance manoeuvre per satellite per year, and a 24 hours by 7 days monitoring of the risk,” Lemmens explains on email. The ISS, for instance, has had to make 28 collision avoidance manoeuvres since 1999, data from Nasa’s Orbital Debris Program Office shows; this includes three such manoeuvres last year. It’s almost like avoiding a rogue vehicle on a highway that might hit you head on. The fact that these have to be done more frequently now only highlights how severe the problem has become. Space-faring nations around the world have begun to acknowledge the issue, while some startups and private companies are devising technologies to deal with space waste. A different kind of race is unfolding now: a race to clean up space. ClearSpace SA, a Switzerland-based startup founded in 2018, is aiming to launch the world’s first active debris removal mission in collaboration with ESA by 2025. The mission, which actually hopes to remove a piece of space debris, will be the first of its kind. In India, a young Bengaluru-based space startup, Digantara Research and Technologies, is working on setting up orbit debris tracking and monitoring services. Japanese company Astroscale’s ELSA-d mission, all set to launch from Kazakhstan’s Baikonur Cosmodrome in March, hopes to demonstrate multiple ways of capturing and removing defunct objects from orbit. Another company from Japan, Sumitomo Forestry, working with researchers from Kyoto University, is hoping to develop and launch the world’s first wooden satellites, called LignoSat, by 2023 to cut down on space junk. They believe these satellites, made from wooden material that is highly resistant to temperature and harsh environments, will burn up during re-entry, without releasing harmful elements into the atmosphere. The Indian Space Research Organisation (Isro) has also firmed up its space situational awareness capabilities—knowing the exact location of your space assets, tracking and predicting any possible threats—in recent months, launching a dedicated centre and project to protect its space assets from debris. One of the worst space collisions occurred in February 2009 when two communications satellites collided approximately 800km above Siberia. One of them was a decommissioned Russian communications satellite, Cosmos (Kosmos) 2251, the other a still-functioning US commercial communications satellite, Iridium 33. Their combined weight was around 1,560kg. The collision produced around 2,000 pieces of space debris. While some of the trackable satellite fragments eventually re-entered Earth’s atmosphere and burnt up, this accidental hypervelocity, or high-speed collision of two orbiting satellites, became a prime example of the threat that space debris poses to functioning satellites and other spacecraft. Anti-satellite (Asat) testing, which involves intercepting and destroying a satellite, as well as destruction of spacecraft that are no longer operational, has contributed to the problem. China’s 2007 Asat test on one of its own old weather satellites, the Fengyun-1C, created some 3,000 fragments of space debris. In March 2019, India conducted a similar Asat test demonstration, dubbed Mission Shakti, using a ballistic missile to destroy its Microsat-R satellite. The demonstration reportedly created more than 400 pieces of debris, most of which re-entered the atmosphere. India currently has 100 active and defunct spacecraft in orbit and 121 spent rocket bodies and catalogued debris, according to Nasa’s November 2020 Orbital Debris Quarterly News, which publishes the latest in orbital debris research, including data from the US Space Surveillance Network. Figures from 2019 indicate that India had 163 rocket bodies and pieces of debris in space. Explosions caused by leftover batteries and energy sources in rockets and spacecraft too cause more fragments to scatter in space. (Photo credit: ESA) ESA has noted that explosions caused by leftover batteries and energy sources in rockets and spacecraft too cause more fragments to scatter in space. As is the case every year, hundreds of space missions and rocket launches are planned for 2021. China’s main space contractor, the China Aerospace Science and Technology Corporation, is aiming for 40 orbital launches this year. Isro is not only planning its Chandrayaan-3 launch this year, it also hopes to execute India’s first manned mission in December. Kessler’s “collision cascading” scenario becomes an important factor here. “It is difficult to predict when we will reach, or indeed if we have already crossed the point that certain regions (in space) become too cluttered with space debris to effectively use them,” says Lemmens. “However, it is clear that our current global practices of leaving too many objects stranded in orbit or at risk of explosion are not sustainable, and that once the point of ‘too much’ is reached, it will be very hard to undo it.” Cleaning up the mess There appears to be no single solution to the problem of exponential increase in space debris. But initiatives like ClearSpace SA are trying to tackle the problem. In December, ESA signed an €86 million (around ₹766 crore) contract with an industrial team of companies led by ClearSpace to purchase the world’s first active debris removal mission, ClearSpace-1, scheduled to be launched in 2025. Apart from the Swiss outfit, the industrial team includes companies from European countries like the Czech Republic,Germany, Sweden, Poland, Portugal and Romania. The UK too is part of the exercise. “ClearSpace’s goal is to bring in a solution to clean (space debris) and prevent this exponential (growth). We want to make sure that we never get to the full end of that exponential. Where we are today, collisions between space debris will keep on happening,” says Muriel Richard-Noca, co-founder of ClearSpace SA, in a video call from Lausanne. “We want to diminish that effect as much as we can. We are at the point where, if we don’t do anything today, there will be big consequences tomorrow. If we don’t start cleaning now, in a few decades it is going to be really hard for us to place more satellites in space.” The ClearSpace-1 chaser spacecraft will attempt to rendezvous and capture a piece of space debris with the help of four robotic arms. (Photo: ClearSpace SA) The ClearSpace-1 chaser spacecraft will initially be launched into a lower 500km orbit. It will then be raised to a target orbit of 660km, where it will attempt to rendezvous and capture the upper part of a Vespa (or Vega Secondary Payload Adapter), which was used for a rocket launch in 2013, with the help of four robotic arms. This object, which weighs around 112kg ( almost as much as a small satellite), has been in a “gradual disposal” orbit—where satellites or objects are placed when they are no longer operational. Once it has been captured, both the piece of debris and chaser spacecraft will de-orbit and burn up during re-entry. Studies conducted by ESA and Nasa have shown that active debris removal missions can be efficient in eventually stabilising the space environment. But planning a removal sequence—based on the size of the debris or object, the kind of collision threat it poses and whether it’s located in a densely populated orbit—will be crucial. Several active debris removal demonstrations—with mock pieces of debris—have been conducted in the past. The University of Surrey’s RemoveDEBRIS mission in 2018-19, which was led by researchers at the Surrey Space Centre, is a case in point. It successfully demonstrated multiple technologies that could be used to capture debris, including a tethered space harpoon and nets. Astroscale too is aiming to showcase multiple techniques of spotting and capturing pieces of orbital debris through its ELSA-d mission. "Technology-wise, ELSA-d is the first end-to-end debris removal demonstration mission. When the servicer satellite is up there, it first needs to identify and approach an object or piece of debris," says Nobu Okada, founder and CEO, Astroscale, in a video call from Tokyo. "After a synchronised capture, the object will then be stabilised and de-orbited. We will be carrying a mock object—a client satellite—which will be separated in space and then captured by the servicer using proximity-rendezvous technology and a magnetic docking mechanism," he explains. Capturing a moving piece of debris in space, however, is by no means easy. “There are two main challenges. What we are creating is a space robot that will reach the target debris, look at it and calculate how it is tumbling,” says Richard-Noca. “Objects in space are free-floating and they can tumble on every axis at quite high speeds or low speeds…. The intent here is to analyse and reconstruct the object’s movement once we get there with advanced image processing techniques such as deep-neural networks. These techniques will enable autonomous navigation around the debris and its capture. That is the image-processing challenge,” she adds. The second technological obstacle—how do you capture an object in space that is tumbling? “When a cargo mission goes to the ISS, both of them talk (or communicate) to each other and remain stable. In our case, the capture is what we call ‘uncooperative’. There is no signal coming from the debris to help us and we have to catch up with its tumbling. The capture is the most critical operational challenge,” says Richard-Noca. India's space debris horizon The race to tackle orbital debris has seen space agencies place greater emphasis on space situational awareness and traffic management. Today, we rely on satellites in low Earth orbit for a host of key services: telecommunications, the global positioning system, weather and meteorological data, among other things. In such a scenario, protecting space assets becomes all the more important. However, there are no safeguards against a piece of space debris generated by one country damaging the assets of another nation. “There are no natural boundaries in space,” says Phalkey. In December, Isro set up a dedicated directorate of space situational awareness and management (DSSAM), which includes the NEtwork for space object TRacking and Analysis project, also known as Netra. This project’s control centre, set up within the Isro Telemetry, Tracking and Command Network (Istrac) campus in Bengaluru, will act as a hub for space situational awareness activities in the country. A radar and optical telescope facility will help the organisation safeguard its operational assets and predict the atmospheric re-entry of derelict satellites and rocket bodies, a press note explains. S. Chandrashekar, a former Isro scientist and visiting chair professor at the National Institute of Advanced Studies, Bengaluru, says tracking space debris is a problem for every country. “All space-operating entities and agencies need such systems today,” he says. “Without knowing what’s happening in space, how can any space agency function? If it is a transmitting satellite, you can locate and track it easily. The moment a satellite starts drifting, and at some stage it may not transmit at all, then you have a problem... It’s going to take a long time to come down but you still need to know where it is,” says Chandrashekar, who was with Isro for almost 20 years, on the phone. “In the earlier days, space was much less populated. When I was at Isro, I never heard of a satellite colliding with another satellite. Even if two satellites were in the same orbit, it’s highly unlikely they were going to hit each other. It was not such a problem. But space is very crowded now.” While ground-based monitoring systems are good at tracking orbital debris, this activity can be executed with much more precision from space. Recently, Canadian firm NorthStar Earth & Space announced that it was partnering with French-Italian aerospace manufacturer Thales Alenia Space to develop a commercial satellite system that would help track objects, such as other satellites, from space. The “Skylark constellation” is expected to launch in 2022, with a full system of 12 satellites expected in 2024, NorthStar’s co-founder Stewart Bain was quoted as saying in a Reuters report. Digantara is working on a similar system that would rely on a constellation of 40 satellites and Lidar (light detection and ranging) technology to create a database and visualisation platform that will help track and map objects in low Earth orbit. “You can think of it as something like Google Maps, but for space,” says Anirudh Sharma, co-founder of Digantara. The firm, founded in 2018, also offers services like early-launch support and orbit determination to satellite operators and launch companies. “Ground-based monitoring systems (that track objects in space) have certain limitations when it comes to line of sight, range, atmospheric disruption… That is why we are building a space platform which uses Lidar,” he says. How long could it take to stabilise the situation? Internal studies done by ESA show that if continuous debris removal actions or missions start as late as 2060, they will only have a 75% beneficial effect compared to an immediate start—so it’s a case of now or never The company hopes to launch its first satellite payload in December to demonstrate its “in-orbit space debris monitor” technology. The eventual goal is to send out the 40 satellites across three phases. “We haven’t decided where we will launch from yet. That decision will be taken six months before launch but we are hoping that our timing matches with Isro’s PSLV launch. We are looking at a window between December 2021 to February 2022,” says Sharma. To ensure its own solution doesn’t add to or create more space junk, Sharma says Digantara’s satellites will use propulsion systems to de-orbit at the end of their lifespan. How long could it take to stabilise the situation? Internal studies done by ESA show that if continuous debris removal actions or missions start as late as 2060, they will only have a 75% beneficial effect compared to an immediate start—so it’s a case of now or never. Phalkey says: “We have to go as far as required and conduct space-cleaning activities for as long as it’s required. While we create new technologies to ensure that this doesn’t happen in the future, the past needs to be cleaned up.” The task at hand, however, remains enormous. Take Vanguard-1, for instance—launched in 1958, it’s the oldest human-made object still in space. It orbits Earth as space junk and even though it doesn’t pose any significant threat or collision risk, it won’t de-orbit before 2198. It’s a problem of our own making, says Phalkey. “Instead of looking spacewards, look inwards. What have we done to the planet, the resources on Earth.... We are making it unliveable.” Like our effort now to limit climate change, clean our polluted oceans and air, the effort to clean up space for future exploration will have to be a sustained one.

#### Under I-Law, it is appropriation for private entities to remove space junk, means the aff severely limits private junk capture ability.

Ramin **Skibba, 21** - ("The US Space Force Wants to Clean Up Junk in Orbit," Wired11-17-2021, 1-2-2022https://www.wired.com/story/the-us-space-force-wants-to-clean-up-junk-in-orbit/)//AW

The answer lies in “remediation”: removing just five large objects per year, for example, could prevent a chain reaction. If governments attempt to clean up this mess themselves, the cost could run into the trillions. Intergovernmental organizations and space agencies alike are discussing the merits of active removal, which would see new spacecraft launched specifically to take other, redundant satellites out of orbit. Other options being discussed include the use of nets, harpoons, tethers, ion thrusters and lasers, all of which would be costly to build and tedious to implement. Even so, the international community needs to sort through the myriad legal issues that would currently frustrate attempts to clean up space. At the moment, international law permits only the launching nation or agency to come into contact with a specific object in orbit, something that would prevent, for example, commercial debris-removal activities. The framework for this international law began with the Outer Space Treaty, which was established in 1967. The treaty involves 96 state parties that are working to “limit activities on the Moon and other celestial bodies exclusively to those for peaceful purposes and forbids the development of military bases, installations, fortifications or weapons testing of any kind on any celestial body.” Therefore, it would be beneficial for a large international agency such as the United Nations to create an international space union that could coordinate all of the debris-removal activity and create a framework for equitable use of orbits among all countries engaged in space exploration. Another critical weakness in the international law on space debris lies in the fact that existing space law is related to the use of space and not to debris regulation itself. The rules within the Outer Space Treaty are helpful in facilitating boundaries in space use, but they do not directly apply to the space debris issue. Until the legal issues are sorted out, all proposed solutions will remain hypothetical, or at best, limited to a small number of debris pieces. In the meantime, the threat continues to grow. Government regulations covering orbital debris are still rudimentary. For now, the federal agencies that have authority over commercial launches are waiting to see if the private sector can deal with the problem on its own.

#### Space debris will inevitably set off a chain of collisions.

Chelsea **MuñOz-Patchen, 19** - ("Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty," University of Chicago, 2019, 12-6-2021, https://cjil.uchicago.edu/publication/regulating-space-commons-treating-space-debris-abandoned-property-violation-outer-space)//AW

Debris poses a threat to functioning space objects and astronauts in space, and may cause damage to the earth’s surface upon re-entry.29 Much of the small debris cannot be tracked due to its size and the velocity at which it travels, making it impossible to anticipate and maneuver to avoid collisions.30 To remain in orbit, debris must travel at speeds of up to 17,500 miles per hour.31 At this speed even very small pieces of debris can cause serious damage, threatening a spacecraft and causing expensive damage.32 There are millions of these very small pieces, and thousands of larger ones.33 The small-to-medium pieces of debris “continuously shed fragments like lens caps, booster upper stages, nuts, bolts, paint chips, motor sprays of aluminum particles, glass splinters, waste water, and bits of foil,” and may stay in orbit for decades or even centuries, posing an ongoing risk.34 Debris ten centimeters or larger in diameter creates the likelihood of complete destruction for any functioning satellite with which it collides.35 Large nonfunctional objects remaining in orbit are a collision threat, capable of creating huge amounts of space debris and taking up otherwise useful orbit space.36 This issue is of growing importance as more nations and companies gain the ability to launch satellites and other objects into space.37 From February 2009 through the end of 2010, more than thirty-two collision-avoidance maneuvers were reportedly used to avoid debris by various space agencies and satellite companies, and as of March 2012, the crew of the International Space Station (ISS) had to take shelter three times due to close calls with passing debris.38 These maneuvers require costly fuel usage and place a strain on astronauts.39 Furthermore, the launches of some spacecraft have “been delayed because of the presence of space debris in the planned flight paths.”40 In 2011, Euroconsult, a satellite consultant, projected that there would be “a 51% increase in satellites launched in the next decade over the number launched in the past decade.”41 In addition to satellites, the rise of commercial space tourism will also increase the number of objects launched into space and thus the amount of debris.42 The more objects are sent into space, and the more collisions create cascades of debris, the greater the risk of damage to vital satellites and other devices relied on for “weather forecasting, telecommunications, commerce, and national security.”43 The Space Debris Mitigation Guidelines44 were created by UNCOPUOS with input from the IADC and adopted in 2007.45 The guidelines were developed to address the problem of space debris and were intended to “increase mutual understanding on acceptable activities in space.”46 These guidelines are nonbinding but suggest best practices to implement at the national level when planning for a launch. Many nations have adopted the guidelines to some degree, and some have gone beyond what the guidelines suggest.47 While the guidelines do not address existing debris, they do much to prevent the creation of new debris. The Kessler Syndrome is the biggest concern with space debris. The Kessler Syndrome is a cascade created when debris hits a space object, creating new debris and setting off a chain reaction of collisions that eventually closes off entire orbits.48 The concern is that this cascade will occur when a tipping point is reached at which the natural removal rate cannot keep up with the amount of new debris added.49 At this point a collision could set off a cascade destroying all space objects within the orbit.50 In 2011, The National Research Council predicted that the Kessler Syndrome could happen within ten to twenty years.51 Donald J. Kessler, the astrophysicist and NASA scientist who theorized the Kessler Syndrome in 1978, believes this cascade may be a century away, meaning that there is still time to develop a solution.52

#### Laundry list of impacts.

George **Dvorsky, 15** - ("What Would Happen If All Our Satellites Were Suddenly Destroyed?," 6-4-2015, 12-10-2021https://gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681)//AW

Lastly, there’s the Kessler Syndrome to consider. This scenario was portrayed in the 2013 film Gravity. In the movie, a Russian missile strike on a defunct satellite inadvertently causes a cascading chain reaction that formed an ever-growing cloud of orbiting space debris. Anything in the cloud’s wake—including satellites, space stations, and astronauts—gets annihilated. Disturbingly, the Kessler Syndrome is a very real possibility, and the likelihood of it happening is steadily increasing as more stuff gets thrown into space. Given these grim prospects, it’s fair to ask what might happen to our civilization if any of these things happened. At the risk of gross understatement, the complete loss of our satellite fleet would instigate a tremendous disruption to our current mode of technological existence—disruptions that would be experienced in the short, medium, and long term, and across multiple domains. Compromised Communications Almost immediately we’d notice a dramatic reduction in our ability to communicate, share information, and conduct transactions. A visualization from the Opte Project showing the various routes through a portion of the Internet (Opte/cc) “If our communications satellites are lost, then bandwidth is also lost,” Jonathan McDowell tells io9. He’s an astrophysicists and Chandra Observatory scientist who works out of the Harvard-Smithsonian Center for Astrophysics. McDowell says that, with telecommunication satellites wiped out, the burden of telecommunications would fall upon undersea cables and ground-based communication systems. But while many forms of communication would disappear in an instant, others would remain. All international calls and data traffic would have to be re-routed, placing tremendous pressure on terrestrial and undersea lines. Oversaturation would stretch the capacity of these systems to the limit, preventing many calls from going through. Hundreds of millions of Internet connections would vanish, or be severely overloaded. A similar number of cell phones would be rendered useless. In remote areas, people dependent on satellite for television, Internet, and radio would practically lose all service. Submarine cable map (TeleGeography) “Indeed, a lot of television would suddenly disappear,” says McDowell. “A sizable portion of TV comes from cable whose companies relay programming from satellites to their hubs.” It’s important to note that we actually have a precedent for a dramatic—albeit brief —disruption in com-sat capability. Back in 1998, there was a day in which a single satellite failed and all the world’s pagers stopped working. Get Out Your Paper Maps We would also lose the Global Positioning System. In the years since its inception, GPS has become ubiquitous, and a surprising number of systems have become reliant on it. Lockheed-Martin’s GPS-III-AHI satellite “Apart from the fact that everyone has forgotten to navigate without GPS in their cars, many airplanes use GPS as well,” says McDowell. Though backup systems exist, airlines use GPS to chart the most fuel-efficient and expeditious routes. Without GPS and telecomm-sats, aircraft controllers would have tremendous difficulty communicating with and routing airplanes. Airlines would have to fall back to legacy systems and procedures. Given the sheer volume of airline traffic today, accidents would be all but guaranteed. Other affected navigation systems would include those aboard cargo vessels, supply-chain management systems, and transportation hubs driven by GPS. But GPS does more than just provide positioning—it also provides for timing. Ground-based atomic clocks can perform the same function, but GPS is increasingly being used to distribute the universal time standard via satellites. Within hours of a terminated service, any distributing networks requiring tight synchronization would start to suffer from “clock drift,” leading to serious performance issues and outright service outages. Such disruptions could affect everything from the power grid through to the financial sector. A somewhat alarmist video produced by the Marshall Institute, but one that raises some relevant points. In the report, “A Day Without Space: Economic and National Security Ramifications,” Ed Morris, the Executive Director of the Office of Space Commerce at the Department of Commerce, writes: If you think it is hard to get work done when your internet connection goes out at the office, imagine losing that plus your cell phone, TV, radio, ATM access, credit cards, and possibly even your electricity. [...] Wireless services, especially those built to CDMA standard, would fail to hand off calls from one cell to the next, leading to dropped connections. Computer networks would experience slowdowns as data is pushed through finite pipelines at reduced bit rates. The same would be true for major networks for communication and entertainment, since they are all IP-based today and require ultra-precise timing to ensure digital traffic reaches its destination. The lack of effective synch would hit especially hard in banking, where the timing of transactions needs to be recorded. Credit card payments and bank accounts would likely freeze, as billions of dollars could be sucked away from businesses. A financial crash is not out of the question. The Loss of Military Capability The sudden loss of satellite capability would have a profound effect on the military. Useless without GPS: The U.S. Navy’s Harpoon missile (U.S. Navy) The Marshall Institute puts it this way: “Space is a critical enabler to all U.S. warfare domains,” including intelligence, navigation, communications, weather prediction, and warfare. McDowell describes satellite capability as as the “backbone” of the U.S. military. And as 21st century warfare expert Peter W. Singer from New America Foundation tells io9, “He who controls the heavens will control what happens in the battles of Earth.” Singer summarized the military consequences of losing satellites in an email to us: Today there are some 1,100 active satellites which act as the nervous system of not just our economy, but also our military. Everything from communications to GPS to intelligence all depend on it. Potential foes have noticed, which is why Russia and China have recently begun testing a new generation of anti-satellite weapons, which in turn has sparked the U.S. military to recently budget $5 billion for various space warfare systems. What would happen if we lost access to space? Well, the battles would, as one U.S. military officer put it, take us back to the “pre digital age.” Our drones, our missiles, even our ground units wouldn’t be able to operate the way we plan. It would force a rewrite of all our assumptions of 21st century high tech war. We might have a new generation of stealthy battleships...but the loss of space would mean naval battles would in many ways be like the game of Battleship, where the two sides would struggle to even find each other. Moreover, and as McDowell explains to io9, the loss of satellite capability would have a profound effect on arms control capabilities. Space systems can monitor compliance; without them, we’d be running blind. “The overarching consideration is that you wouldn’t really know what’s going on,” says McDowell. “Satellites provide for both global and local views of what’s happening. We would be less connected, less informed—and with considerably degraded situational awareness.” Compromised Weather Prediction and Climate Science One great thing satellites have done for us is improve our ability to forecast weather. Predicting a slight chance of cloudiness is all well and good, but some areas, like India, Pakistan, and Bangladesh, are dependent on such systems to predict potentially hazardous monsoons. And in the U.S., the NOAA has estimated that, during a typical hurricane season, weather satellites save as much as $3 billion in lives and property damage. Hurricane Ivan (NOAA) There’s also the effect on science to consider. Much of what we know about climate change comes from satellites. As McDowell explains, the first couple of weeks without satellites wouldn’t make much of a difference. But over a ten-year span, the lack of satellites would preclude our ability to understand and monitor such things as the ozone layer, carbon dioxide levels, and the distribution of polar ice. Ground-based and balloon-driven systems would help, but much of the data we’re currently tracking would suddenly become much spottier. Without satellites, you can say goodbye to maps like this (NOAA) “We’re quite dependent on satellites for a global view of what’s happening on our planet—and at a time when we really, really need to know what’s happening,” says McDowell. It’s also worth pointing out that, without satellites, we also wouldn’t be able to monitor space weather, such as incoming space storms. Time to Recover With all the satellites gone, both governmental and private interests would work feverishly to restore space-based capabilities. Depending on the nature of the satellite-destroying event, it could take decades or more to get ourselves back to current operational standards. It would take a particularly long time to recover from a Carrington Event, which would zap many ground-based electronic systems as well. The U.S. military is already thinking along these lines, which is why it’s working on the ability to quickly send up emergency assets, such as small satellites parked in Low Earth Orbit (LEO). Cube satellites are increasingly favored, as an easy-to-launch, affordable, and effective solution—albeit a short-term one. The U.S. Operationally Responsive State Office is currently working on the concept of emergency replenishment and the ability to “rapidly deploy capabilities that are good enough to satisfy warfighter needs across the entire spectrum of operations, from peacetime through conflict.” Cubesats in orbit (NASA) As for getting full-sized, geostationary satellites back into orbit, that would prove to be a greater challenge. It can take years to built a new satellite, which typically requires a big, costly rocket to get it into space. Lastly, if a Kessler Syndrome wipes out the satellites, that would present an entirely different recovery scenario. According to McDowell, it would take a minimum of 11 years for LEO to clear itself of the debris cloud; any objects below 500 km (310 miles) would eventually fall back to Earth. Thus, we would only be able to start re-seeding LEO in a little over a decade following a Kessler event. Unfortunately, the area above 600 km (372 miles) would remain out of touch for a practically indefinite period of time; objects orbiting at that height tend to stay there for a long, long time. We’d probably lose this band for good—unless we manually removed the debris field, using clean-up satellites or other techniques. It’s worth noting that a single Kessler event could hit the LEO zone or the GEO zone (geosynchronous orbit) but realistically not both; LEO debris could never reach GEO, and vice versa—though a spent rocket in GTO (geosynchronous transfer orbit) or SSTO (supersynchronous transfer orbit) passes through or near both zones and could potentially affect either of them. The spent rockets in GTO do not stay too close to the GEO arc for long due to orbital perturbations, so a GEO Kessler event is very unlikely to be triggered by one of them. Suffice to say, we should probably take the prospect of a Kessler Syndrome more seriously, and be aware of what could happen if we’re no longer able to use these spaces.