"Three Country-Trusted Broker": An Effective Public-Private Model for Orbital Debris Remediation

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ABSTRACT

Space use by governments and private industry is growing for scientific, commercial and military purposes. Orbital debris jeopardizes everyone's future use of space. Three countries account for virtually all existing debris: China, Russia and the United States of America. They are also the largest users of space for scientific, commercial and military purposes. They remain rivals, although spheres of cooperation exist. Each aspires to world leadership.

Many technical solutions have been proposed to remediate certain types of debris, but legal, political, national security, economic and funding issues have prevented their implementation.

Remediation of orbital debris could best be accomplished by a small private company independent from China, Russia or the United States. The company would also be independent from, and not a competitor to, companies offering remediation technologies. It would identify debris targets and select the best technologies to accomplish remediation. It would contract with China, Russia and the United States ("Three Country") for projects, and with the selected remediation companies. It would insulate and protect each country's independent interests, and it would stand between the countries and for-profit remediation companies, as a "Trusted Broker".

Contracting with all three countries responsible for most of the debris could effectively mitigate legal risks which to date have contributed to inaction. Acting through a "Trusted Broker" could relieve political and national security concerns embedded in the debris or in the selected remediation technology. Centralizing all remediation decisions in one company could result in the most cleanup for the least amount of money and provide a means to share the cost burden among the three countries.

Most importantly, the model would establish a cooperation spiral among the three leading space powers. Over time, it could lead to broader international participation and commercial opportunities.

The paper will examine the "Three Country-Trusted Broker" model.

I. Introduction and Methodology

A. Introduction

Why now? Orbital debris[1] has reached a tipping point[2] where waiting to act is no longer a prudent option. Experts have determined that a future single collision of two uncontrolled high mass objects in Low Earth Orbit (LEO), followed by their inevitable fragmentation into thousands of un-trackable yet still lethal pieces, is only a matter of time. Forecasting the exact date when this will begin is not possible, but statistical projections suggest the next collision may be imminent, especially in light of the recent exponential growth in numbers of satellites in LEO.[3] Although not as imminent, possible follow-on collisions with other objects could become unstoppable and irreversible, resulting in effective loss of use of entire regions of space for centuries. Waiting to begin debris remediation until after the next collision will greatly increase its ultimate cost.

When the cascade, also known as the "Kessler Syndrome", was first predicted in 1978,[4] technology was not available to address the problem. Fortunately, today due to the efforts of many individuals and institutions across the world describing the debris environment,[5] there is broad consensus on leading targets for remediation (e. g., high mass derelict objects in high inclination sun-synchronous orbits in LEO),[6] and there is a wide range of mature and evolving technologies developed by governments and private industry capable of tackling a variety of debris types in creative, safe and economically feasible ways.[7] In fact, China, Russia, the U. S. and other

countries use remediation technology today in space, albeit for other purposes. Private commercial and civilian efforts to characterize existing orbital debris have also taken flight, propelled by growing commercial space use and concerns about a space traffic management system dictated solely by military considerations.[8]

Space is a vastly different place today than it was in 1957 when Sputnik was launched. It has become an international commercial marketplace, and more and more governments use space for a variety of reasons in fulfilling their national purpose. Space is a shared and increasingly crowded resource that the world relies upon, and is part of the landscape along humanity's path seeking meaning in life.

Why three countries? China, Russia and the U. S. are legally responsible for virtually all orbital debris in space, and they have jurisdiction over or rely on more space-based assets than any other country, for military, civil and commercial purposes.[9] They have the most future opportunity to gain by remediation, as well as the most to lose by failing to avert the impending cascade. In a Westphalian world, they each aspire to leadership in space.

Although collaboration among these three countries seems unlikely today, cooperation among rivals is not unprecedented. Private commercial relations cut across sovereign geographical boundaries and bind the world together. Sometimes checked, but undaunted by political choices or forms of government, commerce forms the backbone of most country's international relations. Chinese, Russian and U. S. businesses are integral parts of each other's ground-based and space-based economies. For example, in space-based activity, China's Tencent Holdings Ltd. has invested in Moon Express, one of the companies chosen by NASA for its Commercial Lunar Payload Services program. Tencent also invested in Planetary Resources (now acquired by ConsenSys, Inc.) and Satelogic, an Argentinian company specializing in satellite imagery. NanoRacks, a private U. S. space company, established a commercial partnership with Kuang-Chi Science Ltd. in 2018.[10] Russia participates in the International Space Station along with several other countries under a treaty-based arrangement, and provides rocket engines to U. S. companies under commercial contracts.

China, Russia and the U. S. also seek to influence others through international business activities. The Marshall Plan, China's Belt and Road initiative, and Russia's Greater Eurasian Partnership, are examples where the three countries have sought to lead through international engagement, using private commercial tools to their advantage. Economic cooperation can be a powerful weapon, both as an instrument of leadership as well as helping countries avoid war.

Why "Three Country-Trusted Broker"? Marriages are sometimes facilitated through third-party intermediaries whom both principal parties trust. So too, within the community of nation-states, foreign relations often involve trusted, independent brokers. Throughout human history, neutral third parties, including unaligned countries like Switzerland, intergovernmental organizations such as the United Nations,[11] and private nongovernmental organizations like the Red Cross, have assisted nations in achieving beneficial shared objectives. Likewise, in dispute resolution proceedings, including judicial tribunals and less formal arrangements such as arbitration and mediation, adversaries universally rely on neutral third parties. After all, objectivity and trust free humans from barbarism and war.

"Three Country-Trusted Broker" or "TCTB", as further explained in this paper, describes a business model for active debris remediation (ADR)[12] consisting of a private commercial entity, separate from and independent of the three countries it would serve. Similarly, but primarily for economic reasons, TCTB would also be separate and independent from the remediation subcontractors it would engage to accomplish ADR projects on behalf of the three countries. Acting as an independent agent through separate "arms-length" commercial contracts with each sovereign government, TCTB would allow the three countries to achieve a universally shared objective that might not be so easily achieved acting directly together, or alone.

TCTB represents a novel approach to remediate orbital debris. A "bridge over troubled water",[13] it could protect and insulate its principals' respective confidences and other sovereign interests, while enabling accomplishment of the mutual objective of ADR.

B. Methodology

To explore the TCTB ADR thesis in detail, in addition to research, the author formed a company called TCTB, LLC.[14] TCTB prepared and submitted separate, identical ADR Proposals to China, Russia

and the U. S. in May, 2019, offering to enter into legally binding separate contracts with each country for ADR. This paper describes TCTB's business model and how it could accomplish ADR, based on the research conducted in preparing this paper, and on the work done developing and submitting the Proposals. The Proposals constitute an open invitation to China, Russia and the U. S. to join together, through TCTB, to remediate orbital debris.

II. Remediation Hurdles

Although many technical solutions have been or are being developed to remediate certain types of debris, legal, political, national security, economic and funding issues have prevented their implementation.[15]

A. Legal Obstacles

Under international law, jurisdiction, which is equivalent to ownership under international law, and liability considerations constrain ADR. A single country, if motivated to undertake ADR, would only legally be able to remediate its own debris, unless consent and relief of liability was provided by the owning/responsible country. Obtaining that authority could be problematic for many reasons: proprietary, export-controlled or classified information about the debris target could be un-releasable to the remediating country; the intentions of the remediating country might be hostile to the owning country's security interests, especially if "dual use" technology were employed in the ADR project; and it seems unlikely and unfair to expect the remediating country to absorb the cost and risk of an ADR project involving another country's property. Altruism is rare in sovereign relations.

However, by not acting to remediate, can a country avoid liability for damage or loss caused by debris under their jurisdiction? No. International law is clear that "owning" countries bear full responsibility for debris damages, and that responsibility remains notwithstanding abandonment assertions. In a legal action against the responsible country by an injured party for loss or damage, negligence for failing to remove the offending debris may be imputed by operation of law to the "owning" country, or it may even be unnecessary to prove negligence to establish liability.[16]

B. Political and National Security Difficulties

Political impediments loom larger than legal issues before prospective remediators. In our community of nations, direct interaction among sovereign countries occurs within a formal structure of international law framed by diplomacy, treaties and ratification. To actually achieve ADR within that framework would require a simultaneous confluence of external factors (e. g., problem, politics, solution)[17] to overcome bureaucratic equilibrium – in each affected country, at the same time! *A fortiori*, the difficulties China, Russia and the U. S. would face, in today's polarized world, in reaching a direct three-country ADR agreement through the traditional formal political process cannot be overestimated.

National security concerns embedded in the selected remediation technology or in the debris also prevent ADR. Several writers have commented on the "dual use" problem implicit in existing and emerging remediation technology.[18] Use of such technology for ADR by a sovereign nation could obscure its remedial purpose. Situational or technical data about certain debris is guarded long after launch because it may still reflect national military secrets, further hindering ADR efforts. Space Situational Awareness and Space Traffic Management systems used to characterize debris are products of national military organizations, although that is changing because of the increased presence of commercial activities in space.[19]

C. Economic and Funding Impediments

Viewed from an economic perspective, the cost of an ADR program would be undeniably great. Most ADR technologies involve launch, in-space rendezvous and proximity operations, ground operations and de-orbiting actions. The cost to conduct these activities safely and with a high degree of mission assurance in the vacuum of space would be quite high.

Moreover, virtually all theoretical optimum debris targeting studies are based on factors (e. g., mass, orbit, conjunction data) that best reduce the future collision risk to functional orbiting satellites, and thus they contain a mix of high mass ADR targets in LEO, primarily from China, Russia and the U. S., but also from a few other countries.[20] Technologies being developed for ADR also generally focus on this diverse universe of targets, rather than any single country subset. Cascade avoidance and remediation technologies are not driven to economic efficiency by single country solutions.

A number of commercial alternatives or incentives have been proposed for private parties to undertake ADR, but the economic payoff for such proposals is at best indirect, or not evident.[21] Finding a paying customer has also proved challenging. Private companies seeking today to develop a commercial market in LEO have not included ADR in their primary business models – their plans account for the ongoing risk posed by debris but don't clean up what is already there.

For obvious reasons, expecting one country to fund the entire cost of a technologically comprehensive and economically efficient ADR program would be unreasonable, yet it is also clear that the overwhelming majority of liability belongs to the three countries who created the risk. It also seems evident that if monetizing the value of all economic and non-economic opportunities and benefits, direct or indirect, arising from ADR were possible, China, Russia and the U. S., the largest users of space, would gain more than others.[22] Both responsibility and opportunity demonstrate that China, Russia and the U. S. are uniquely situated to undertake ADR together. Sharing the cost would proportionately reduce each country's individual burden while unlocking economic efficiency and unleashing macro-economic benefits, but the inability to reach agreement in today's political climate has prevented a three-country ADR solution to date.[23]

III. A Public-Private Model for ADR

With seemingly insurmountable obstacles facing ADR, is there a practical way to avoid the inevitable cascade?

A. TCTB: The Model

The Red Cross was originally formed in the U. S. by Clara Barton, a private citizen, and then later it became an "instrumentality" of the U. S. government.[24] International Red Cross and Red Crescent organizations were formed in other countries based on a similar model. Today the Red Cross is funded largely by private donations. Collectively, these organizations were formed to support the universally recognized value of humanitarian aid – the symbol, a red cross or red crescent, says "Don't shoot!" in any language. Nations, even those at war, support these organizations because they recognize they serve a fundamental humanitarian value.

Public-private relationships have also been established to employ space science to benefit life on Earth. NanoRacks, a profit-making organization, and the Center for the Advancement of Science in Space, a non-profit, non-governmental organization, now operate a portion of the International Space Station designated by the U. S. Congress as a national lab, under agreements with the National Aeronautics and Space Administration (NASA).[25]

Similar public-private partnerships are found across the globe, from Private Financing Initiatives in the United Kingdom, to Federally Funded Research and Development Centers in the U. S., to infrastructure improvement projects in China and Russia.[26] Partnering with the private sector has enabled governments to find better ways to achieve important societal needs. All public-private relationships are formalized using contracts.

In contrast to direct political relations between countries which operate under a highly structured regime, individual countries enter into bilateral contracts every day with domestic or foreign private parties to procure goods and services, subject only to legislative authorization and funding controls, executive prerogatives, and contracting rules (e. g., competition/sole source restrictions, domestic preferences and other socio-economic considerations, financing and payment limitations, statutory risk allocation conditions), utilizing mandated contracting forms.

TCTB's "separate but interdependent" business model is built on the premise that if China, Russia and the U. S., together recognizing the humanitarian value and need for ADR, could each independently establish separate commercial contracts with the same private entity, effective inter-country cooperation could be achieved through contractually established funding controls and other contractual mechanisms, avoiding some (but not all) bureaucratic complexities and delays otherwise found in direct, face-to-face international relations among sovereign states. The private entity's nature and independence facilitates accomplishment of shared objectives that might be unattainable by countries acting together without an intermediary, or alone.

B. TCTB: The Contracting Structure

In order to fully explore the TCTB concept, it was necessary to prepare and submit a fully developed three-country contracting plan. This included establishing a legally viable bidding entity, preparing Statements of Work describing the tasks to be accomplished in detail, drafting contract clauses and other documents that would be necessary in support of a formal contracting Proposal, and then writing and submitting a Proposal to China, Russia and the U. S.[27]

TCTB's contracting structure, as reflected in its Proposal, consists of three separate but not necessarily identical cost reimbursement fixed fee "prime" contracts, between TCTB and each country, under which TCTB's costs of performance would be reimbursed (and shared) by each participating country. TCTB's costs are contemplated to include travel and meeting expenses, supplies, and any costs to retain experts and support staff. As further described in the Proposals, TCTB would issue "subcontracts" to competitively selected ADR technology companies to perform ADR projects. Each prime country contract is based on standard commercial contracts used by each country for the purpose. For example, if NASA were determined to be the U. S. contracting party, the agency could employ a Space Act agreement, or a Federal Acquisition Regulation based procurement contract, with TCTB.[28]

B.1 Country Contract Phases

Each prime country contract is divided into eight separate "bite-sized" Phases of work. Phases 1 through 6 involve planning for ADR, including negotiating the prime contracts between TCTB and each country (Phase 1), developing a ranking list of targets for ADR (Phase 2),[29] drafting competitive Requests for Proposals and subcontracting forms for industry ADR subcontracts (Phases 3 and 4), conducting an international competition among prospective ADR technology companies (Phase 5), and negotiating subcontracts between TCTB and selected ADR subcontractors (Phase 6). Phase 7 encompasses ADR performance. Phase 8 covers related work ("adjacencies") and other projects that become economically feasible or desirable as ADR unfolds. Each Phase is more fully described in Table 1.

Table 1

Description	Statement of Work	Duration
Phase 1 - Prime Contract "Definitization"	Negotiation of the prime contracts between TCTB and each country. Deliverables include all prime contract documents.	3 months
Phase 2 - Target Identification	Development and ranking of initial ADR targets. Deliverables include the Initial Target Ranking Document.	6 months
Phase 3 - RFP Development	Development of a Request for Proposal (RFP) for industry seeking proposals for ADR for one or more targets identified in the Initial Target Ranking Document. Deliverables include a Draft RFP.	6 months
Phase 4 - Subcontract Development	Development of the terms of the ADR subcontract. Deliverables include a Draft Model Subcontract which will be included in the industry RFP.	6 months
Phase 5 - Subcontract Competition	Issuing an RFP and conducting a competition among prospective subcontractors for ADR of initial targets. Deliverables include evaluation and preliminary selection of an awardee.	6 months
Phase 6 - Subcontract Award	Negotiation and execution of a subcontract between TCTB and the awardee. Deliverables include a signed subcontract between TCTB and the awardee.	6 months
Phase 7 - ADR	Management of the initial awarded ADR subcontract. Deliverables include periodic Progress Reports.	1 year or more
Phase 8 - Next Steps	Follow-on ADR projects and other special projects.	Variable - TBD

To conserve country costs, TCTB is expected to have only a few employees in early Phases of work. The costs of any support or "seconded" personnel supplied by each country in support of the project would be borne separately by each providing country.[30] Separate prime contracts with gated, independent Phases and country termination rights allow each country to control the pace, scope and cost of their participation in the work. This effectively allows coordinated action, but also preserves each country's right to act (or not act) unilaterally.

B.2 Country Contract Common Clauses

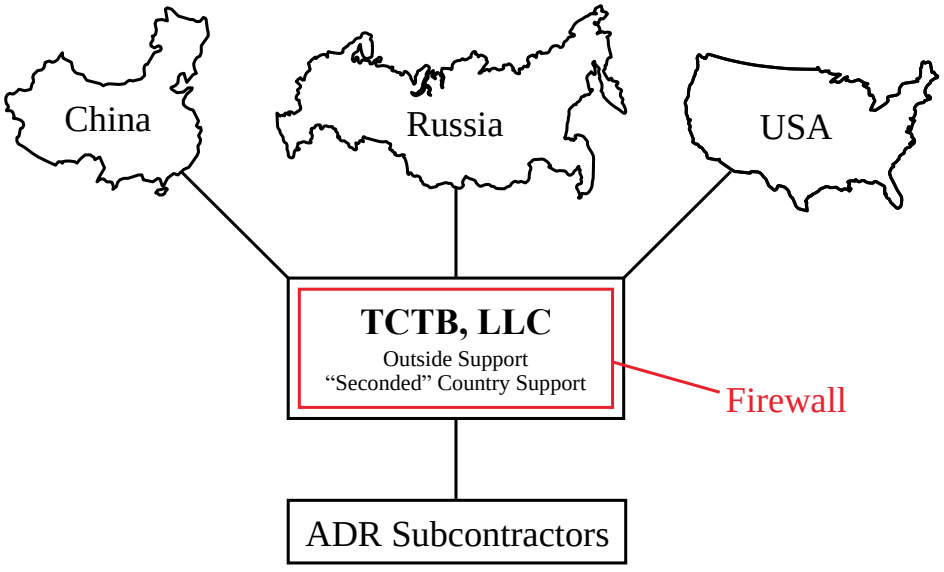
Each prime country contract would contain identical provisions addressing consent for remediation of that country's debris by TCTB and its subcontractors (to satisfy international legal requirements); audit and periodic reconciliation (for effective sharing of costs); the right to terminate for country convenience at any time (preserving independence and sovereignty); equitable allocation of risks (shared responsibility);[31] and non-disclosure obligations and firewalls (protecting national security and other confidences). Each contract would also contain a binding dispute resolution mechanism,[32] provision for country oversight/insight of ADR subcontracts, any necessary export authorizations needed by the ADR subcontractor, and common purpose/interpretation declarations acknowledging the overarching purpose of all three separate prime contracts. Except for these common clauses, each country contract would otherwise be based upon the particular country's standard procurement contracting forms or templates.

B.3 Overall Contracting Strategy

It should be reiterated that under TCTB's plan, no interaction among participating countries is required. The first six Phases leading up to ADR essentially only reimburse TCTB's minimal costs involved in planning the work, so each country could participate or not, without putting much at risk. Trust among countries may also grow during any early Phase cooperation - a key facet of TCTB's "Trusted Broker" formula. Based on and using the products developed by TCTB and participating countries in earlier Phases, Phase 7 would involve performance of the ADR subcontracts by the selected awardees. TCTB would award and manage the subcontracts with assistance of the country prime contractors. Any large dollar value subcontracts issued by TCTB to industry for ADR work under Phase 7 would be dependent upon funding provided to TCTB under the country prime contracts. The ADR subcontracts are expected to be firm fixed price;[33] TCTB's costs to manage that work will be reimbursed by the participating countries under their prime contracts.[34] Privity of contract principles will limit the availability of legal remedies by the subcontractors or prospective subcontractors against the three countries.[35] A diagram of the prime and subcontract relationships is contained in Figure 1.

Figure 1

PRIME AND SUBCONTRACT RELATIONSHIPS



IV. Confronting Remediation Hurdles Using TCTB

How would TCTB's model conquer the legal, political, national security, economic and funding challenges facing ADR today?

A. Overcoming Legal Obstacles to ADR

Limiting targets to Chinese, Russian and U. S. debris not only ensures a target-rich environment, it also resolves fundamental legal issues under international law which to date have contributed to inaction. As noted previously, under international law, jurisdiction (ownership) and liability considerations constrain ADR. Under separate prime contracts with TCTB, China, Russia and the U. S. would each consent to the removal of each other's debris, and they would address ADR liability concerns through a negotiated mix of insurance, self-insurance, indemnity and/or party cross-waiver provisions in the prime contracts and flowed to the subcontracts to effectively share the risk. The project could be accomplished within the existing international space law framework.

B. Relieving Political and National Security Difficulties

Acting through a "Trusted Broker" would relieve political and national security concerns embedded in the selected remediation technology or in the debris, using legally enforceable firewalls inside TCTB.[36] Sensitive information of one country used by TCTB for ADR would remain inside TCTB and would not be disclosed to the other participating countries. The same protection could not be as easily achieved if the three countries were to act directly together without an intermediary.

Firewalls would ensure that any sensitive technology used by TCTB or its ADR subcontractors in the remediation activity will be used only for that purpose – the so-called "dual use" problem. A private party has no sovereign objectives and thus poses no threat to the security of any nation whose assets are subject to ADR "dual use" operations like rendezvous and proximity operations, grappling arms, lasers in space or on-orbit servicing.

Regarding sensitive information embedded in the debris, firewalls within TCTB and the ADR subcontractors would protect sensitive information of each country from disclosure to the other countries. For example, one country might disclose confidential information about one of its debris targets which TCTB shares with the selected subcontractor but not with the other countries who have no need to know. No classified targets are envisioned, but ADR would be possible for such targets under TCTB's firewall construct. If classified information is required for targeting purposes, it would be shared with the ADR subcontractor (who will be under similar use and disclosure restrictions) but not with the other countries. Persons seconded from each country to support the project will be bound by personal non-disclosure obligations while acting inside TCTB, and may not have access to certain information.

Finally, ADR subcontractors would be required to obtain any necessary export licenses for performance of the work, avoiding sharing of export-controlled information among countries.

C. Overcoming Economic and Funding Impediments

Centralizing in, and ceding all remediation decisions to, one company acting in the best interests of ADR would facilitate the most cleanup for the least amount of money, and would provide a simpler contractual mechanism (an accountant employed by TCTB), rather than a treaty-based arrangement, to share the cost burden among the three countries. Equally sharing the cost of ADR immediately reduces each country's funding obligation by two-thirds.[37] Sharing is facilitated by audit and reconciliation[38] provisions in each country contract which ensure that TCTB's financial information is transparent and visible to all country participants. Besides accepting the burden (and opportunity) that is rightfully theirs, sharing costs among the three countries also allows each country to individually spread their own now smaller portion to benefitting domestic users (and their customers, even across national borders!) through taxes, fees or other mechanisms, if they choose to do so.

ADR target ranking and selection by TCTB would ensure that parochial, domestic preferences or other limitations imposed by individual country political constraints would not impede overall economic efficiency. (As previously noted, all target ranking studies published to-date include, almost exclusively, targets from all three countries.) The private entity would also be freed from most similar preferences that could constrain competitive selection of the best ADR technology throughout the world - authorizing a world-wide competitive process for TCTB to select

Phase 7 subcontractors ensures fairness and maximum economic utility.

Notwithstanding these macro-economic benefits, participating countries would still individually be able to provide for domestic preferences by subsidizing, and thus enhancing the competitiveness of, local bidder's proposals to TCTB for Phase 7 ADR.

D. Other Benefits to a Public-Private ADR Model

There are also other benefits that flow from TCTB's model.

Designing the competitive Phase 7 ADR RFPs broadly enough, with the help of the three country stakeholders, will encourage innovation, and even spur the growth of new industries for ADR. Developing broad evaluation and award criteria (Phases 3 and 4) for subcontractor selection (Phases 5 and 6), coupled with wide latitude for target selection criteria (Phase 2), will allow more prospective subcontractors to propose novel solutions for large numbers and varieties of debris targets, further enhancing overall economic efficiency.[39]

Once ADR has begun, numerous opportunities for other projects for a variety of customers, both commercial and government, become possible. Phase 8 of TCTB's contracting structure provides an excellent opportunity to stimulate world-wide commercial activity in adjacent, nascent markets. Phase 8 includes open-ended tasks including civil or commercial "adjacency" projects. Just as with Phase 7, Phase 8 opportunities will be enhanced by using a private entity to seek the widest range of commercial proposals. Such projects, envisioned to be between TCTB and the selected ADR subcontractor, would be subject to participating country approval if they impacted the Phase 7 ADR missions. To the extent that countries have provided funding or resources for ADR which benefitted or facilitated the adjacent project, they could be compensated accordingly through negotiations under the affected prime country contract with TCTB. For example, a satellite operator might approach TCTB or its subcontractor about repairing a satellite during an ADR project using a particular technology which could also be used to repair the operator's satellite. The resulting servicing contract between TCTB, its ADR subcontractor, and the satellite operator, if approved by the countries, could provide a share of the ADR-related savings to the three countries.

Phases 7 and 8 are two-way streets leading to a host of economic benefits and opportunities for countries and industry, all enabled by TCTB's public-private model.

Finally, under TCTB's "Three Country Trusted Broker" construct, other countries may join, with the consent of the participating countries, by signing an equivalent prime contract with TCTB. Cost sharing and other interdependencies among the contracts could apply to four or more countries as easily as three, further reducing individual country costs. Adding countries under a commercial contracting construct would be considerably easier than through a diplomatic, treaty-based, direct country-to-country approach. Adding debris targets under the jurisdiction of other countries would further enable economic efficiency. Early candidates for participation include France, Japan, India and the European Union/European Space Agency, based on their existing levels of debris and their expected share of future space use.

E. Political Will – Still Necessary Yet More Easily Achievable

Although TCTB's model contemplates no bilateral contracts between countries, or direct country-to-country relationships, the need for some political coordination within each country is acknowledged.[40]

For example, in the U. S., the Wolf Amendment prohibits NASA from using appropriated funds to engage in certain bilateral relations with China without Congressional consent.[41]

Some political controls are embedded in the contracting process. Although NASA has funding today from Congress for ADR research,[42] which might be used to contract with TCTB for prime contract Phases 1-6, further U. S. Executive and Legislative branch endorsements would be needed to authorize and fund Phase 7 ADR, as well as determining which agency would be given that money to spend. Those decisions are yet to be made by the National Space Council and the U. S. Congress. Similar authorizations would be needed in China and Russia.

At a lower level of "politics", an exception to the U. S. Competition in Contracting Act's (CICA) full and open competition requirement would require agency head approval to issue a contract to a private entity like TCTB on a sole source basis, but TCTB's novel proposal would allow a sole source exception or waiver to be granted.[43] Alternatively, NASA currently

has authority to enter into a Space Act agreement with TCTB without obtaining a waiver under the CICA, since its "Other Transaction Authority" under the NASA Act[44] is exempt from CICA.

Working through a private non-governmental entity can streamline the ADR process by removing or shortening some of the bureaucracy inherent in direct inter-governmental relations. Under TCTB's proposed plan, there is no direct country-to-country interaction, yet a cooperation spiral has arisen from the efforts of the private third party.

While these political processes play out in each country, TCTB could begin planning for ADR under one or more single country contracts, with little money or risk to the pathfinder country or countries, until Phase 7 ADR.[45]

V. TCTB: Turning Theory into Reality

"Traveler, there is no path. Paths are made by walking."[46]

Always pushing boundaries, humanity's journey through history today has reached space. Whether our future lies in space remains to be seen. Although military boots led us there, space today encompasses commercial and civil interests, for public and private purposes, spanning a wide range of uses including telecommunications, remote sensing, exploration, resource exploitation and human space travel. This broad range of interests and constituencies exposes new conflicts each day, but we must remember we are all travelling together.

Orbital debris threatens everyone's use of space. There is unanimous international accord that ADR is needed, yet its achievement remains in doubt. Traditional routes seem blocked; a new path is needed. Waiting for a confluence of interest among the countries responsible for the problem, an economic miracle, or until an accident happens, would be irresponsible. Ironically, without action, the inevitable collisions and fragmentation will result in a forced sharing of massive liability decided, case by case, by neutral, independent third parties in courts of law.

TCTB is the only company of its kind in the world. TCTB's "Three Country Trusted Broker" path allows the three countries most responsible for orbital debris, and with the most to gain from remediation, to manage and mitigate their liability, and realize the benefits. By partnering to remediate orbital debris, China, Russia and the U. S. could demonstrate world leadership and, more importantly, they could establish a cooperation spiral and a powerful precedent for international harmony in space for the benefit of all mankind. What better shared objective than insuring space sustainability through ADR, leading the world in space!

End Note

The author, Chuck Dickey, is the former Deputy General Counsel for Lockheed Martin Space, and a member of the International Institute of Space Law. Armed with decades of experience in space law, international law, corporate governance, government contracts law, export regulations, data protection and firewalls, and with a reputation for working collaboratively in a competitive business environment, Chuck formed TCTB both as a research tool and to accomplish ADR as outlined in this paper and in its Proposal.

TCTB has established a website, threecountrytrustedbroker.com, where additional information may be found regarding TCTB, its business plan, the ADR legal, political and technical environment, and other relevant material. The website is designed to be interactive – both to educate others as well as to improve TCTB's three-country offering. Separate access-controlled areas within the website provide protected areas for country participants and subcontractors/bidders.

Acknowledgments

The author is grateful for the support and counsel of his sons, Charlie and John, for their passion for space, for Charlie's inscrutable technical support in helping to establish threecountrytrustedbroker.com, and for their unconditional love of their father despite his many failures.

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[1] "Orbital debris is any man-made object in orbit about the Earth which no longer serves a useful function. Such debris includes nonfunctional spacecraft,

abandoned launch vehicle stages, mission-related debris and fragmentation debris." From NASA's website, "Space Debris and Human Spacecraft", September 26, 2013 (https://www.nasa.gov/mission_pages/station/news/orbital_debris.html).

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[4] D. J. Kessler, B. G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt", Journal of Geophysical Research, Vol. 83, No. A6, 2637-46 (1978). *See* also, D. J. Kessler, N. L. Johnson, J.-C. Liou, M. Matney, "The Kessler Syndrome: Implications to Future Space Operations", American Astronautical Society, AAS 10-016 (2010).

[5] The three most comprehensive studies of the problems presented by orbital debris are (1) National Research Council, "Orbital Debris: A Technical Assessment", National Academy Press, Washington, D. C., 1995 (https://doi.org/10.17226/4765); (2) National Research Council, "Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs", National Academies Press, Washington, D. C., 2011 (http://nap.edu/13244); and (3) International Academy of Astronautics, "IAA Situation Report on Space Debris – 2016", Editors: Christophe Bonnal and Darren S. McKnight, IAA, Paris, France 2017 (https://iaaweb.org/iaa/Scientific%20Activity/sg514finalreport.pdf).

[6] E. g., *see* J.-C. Liou, "Engineering and Technology Challenges for Active Debris Removal", Progress in Propulsion Physics, Volume 4, pages 735-748, 2013 (http://dx.doi.org/10.1051/eucass/201304735); J.-C. Liou, "An Active Debris Removal Parametric Study for LEO Environmental Remediation", Advances in Space Research, Volume 47, Issue 11, pages 1865-1876, 2011. (https://doi.org/10.1016/j.asr.2011.02.003).

[7] E. g., *see* Eugene Levin, "Orbital Debris: Time to Remove", Google TechTalk, August 11, 2011 (https://www.youtube.com/watch?v=ZtdRG7gAL_4) ; C. Priyant Mark, Surekha Kamath, "Review of Active Space Debris Removal Methods", Journal of Space Policy 47 (2019), pp. 194-206 (https://doi.org/10.1016/j.spacepol.2018.12.005).

[8] E. g., American Institute of Aeronautics and Astronautics (AIAA) "Space Traffic Management (STM): Balancing Safety, Innovation and Growth", AIAA Space Traffic Working Group, October 2017 (https://aiaa.org/advocacy/Policy-Papers/Institute-Position-Papers).

[9] E. g., *see* David Wright, "The Current Space Debris Situation", Beijing Orbital Debris Mitigation Workshop, 2010 (https://swfound.org/media/99971/wright-space-debris_situation.pdf); J.-C. Liou, "An Update on LEO Environment Remediation with Active Debris Removal", Orbital Debris Quarterly News, Volume 15, Issue 2, April 2011 (https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv15i2.pdf).

[10] Namrata Goswami, "China's Grand Strategy in Outer Space: To Establish Compelling Standards of Behavior", August 5, 2019 (http://thespacereview.com/article/3773/1).

[11] The United Nations has experienced increasing difficulty in obtaining international consensus among its many member nations on space related issues, although unanimity seems to exist on remediation of orbital debris. The Inter-Agency Space Debris Coordination Committee (IADC), an inter-governmental forum, with thirteen national or international space and state organizations, including China, Russia and the U. S., has no mandate or funding beyond providing technical recommendations concerning orbital debris to the world space communities. The Orbital Debris Co-ordination Working Group (ODCWG) is one of the working groups within the International Organization for Standardization (ISO). ISO is a non-governmental entity with members from most United Nations countries. ODCWG's charter is limited to development of international standards for orbital debris mitigation.

[12] ADR is defined broadly for the purpose of this paper to include active movement of space objects, including removal from orbit and Just-in-Time Collision Avoidance (JCA). E. g., *see* Darren McKnight, "The Orbital Debris Hazard: Fact or Fiction", presentation to MIT Alumni Club, April 8, 2015.

[13] Simon and Garfunkel, "Bridge Over Troubled Water", New York: Columbia, 19701979.

[14] TCTB, LLC is a limited liability company organized under Texas law in Houston, Texas, the home of America's manned space program. A Texas venue for incorporation was chosen for simplicity, cost savings and to insure rule-of-law accountability for the entity. As a Texas company, TCTB is subject to U. S. and local law (including treaties and international agreements binding the U. S.) including the right and obligation to sue and be sued in Texas courts.

Operating from a jurisdiction under the rule of law, whether in China, Russia or the U. S., provides an advantage to all countries and contracting parties by assuring enforceability of contract obligations. Selecting an alternative totally neutral jurisdiction for incorporation, such as Luxembourg, would not materially affect the rights and obligations of the parties.

[15] E. g., *see* Brian Weeden, "Overcoming Legal, Policy, and Economic Hurdles to Active Debris Removal", Organization for Economic Cooperation and Development (OECD) Workshop on Economics of Space Debris, Montreal, Canada, June 19-20, 2019 (https://swfound.org/media/206465/bw_oecd_overcoming_non-technical_challenges_adr_june2019.pdf); Brian Weeden, "Overview of the Legal and Policy Challenges of Orbital Debris Removal", IAC-10.A6.4.4, Prague, 2010 (https://swfound.org/media/17963/legal-policy-orbital-debris-iac-bw-2010.pdf); Megan Ansdell, "Active Space Debris Removal: Needs, Implications and Recommendations for Today's Geopolitical Environment", Princeton University Journal of International and Public Affairs, Volume 21, Spring 2010 (https://jpia.princeton.edu/sites/jpia/files/space-debris-removal.pdf).

[16] The well-settled international standards for liability for in-space and on-the-Earth damage were recently reiterated by Joanne Gabrynowicz, Professor Emerita, University of Mississippi School of Law, in testimony before the U. S. Congress Subcommittee on Space and Aeronautics of the Committee on Science, Space and Technology U. S. House of Representatives on July 10, 2019 (https://science.house.gov/hearings/a-review-of-nasas-plans-for-the-international-space-station-and-future-activities-in-low-earth-orbit).

[17] Brian Weeden, "U. S. Space Policy, Organizational Incentives, and Orbital Debris Removal", The Space Review, October 30, 2017 (https://www.thespacereview.com/article/3361/1).

[18] E. g., *see* Steven A. Hildreth, Allison Arnold, "Threats to U. S. National Security Interests in Space: Orbital Debris Mitigation and Removal", Congressional Research Service, January 8, 2014 (http://crsreports.congress.gov/product/pdf/R/R43353).

[19] Ibid., AIAA, note 7.

[20] E. g., *see* L. Anselmo, C. Pardini, "An Index for Ranking Active Debris Removal Targets in LEO", 7th European Conference on Space Debris (2017) (https://conference.sdo.esoc.esa.int/proceedings/sdc7/paper/152); F. Letizia, C. Colombo, H. G. Lewis, H. Krag, "Extending the ECOB Space Debris Index with Fragmentation Risk Estimation", 7th European Conference on Space Debris (2017) (https://pdfs.semanticscholar.org/6825/d0f4e3c7fceb40676002a4f328bc8f9b7287.pdf).

[21] E. g., *see* Eniko Molnar, Stella Virve, "Space Debris Removal as an Effective Business Model – Challenges and Opportunities", Toulouse Business School Professional Program in Aerospace Management, Toulouse 2016 (http://chaire-sirius.eu/wp-content/uploads/2016/10/Molnar-Virve-2016-Space-Debris-Removal-as-an-Effective-Business-Model-Challenges-and-Opportunities-Unknown.pdf).

[22] In the U. S., NASA and the Department of Defense have long recognized the societal benefit that results from technology developed under government funding that is then unleashed within the private sector. Examples of technology "spin-offs" include GPS, thermostats, digital photography, duct tape and the internet.

[23] *See* Brian Weeden, "The Economics of Space Sustainability", The Space Review, June 4, 2012 (http://thespacereview.com/article/2093/1), for an assessment of economic incentives that might drive an ADR program in LEO. As the author notes, the vast majority of economic value deriving from LEO stems from government programs or provides government benefits.

[24] Wikipedia contributors, "American Red Cross", *Wikipedia, the Free Encyclopedia*, (https://en.wikipedia.org/w/index.php?title=American_Red_Cross&oldid=915173085) (accessed September 19, 2019); Congressional Charter of the American National Red Cross, 36 U. S. C. Section 300101-300113, recodified 2007.

[25] (https://www.nasa.gov/mission_pages/station/research/overview.html)

[26] Wikipedia contributors, "Public-Private Partnership", *Wikipedia, the Free Encyclopedia*, (https://en.wikipedia.org/w/index.php?title=Public%E2%80%93private_partnership&oldid=916203458) (accessed September 19, 2019).

[27] Detailed information regarding TCTB and its Proposal, contracting structure and business model, and other information about ADR in general, may be found at TCTB's website, threecountrytrustedbroker.com. (https://www.threecountrytrustedbroker.com).

[28] Although funding for ADR research exists within NASA, the U. S. government, led by the National Space Council, is considering which agency should take responsibility for Space Traffic Management (STM) and ADR. Brian Weeden, "U. S. Space Policy, Organizational Incentives, and Orbital Debris Removal", The Space Review, October 30, 2017 (http://thespacereview.com/article/3361/2).

[29] TCTB's Phase 2 target selection process could employ a technical "dream team" tasked to develop a

"Top 50-100" list of high-priority targets, or a "nomination" process whereby each country would separately identify approximately 25 of its own targets.

[30] Seconded country support would be subject to information protection mechanisms (e. g., firewalls, non-disclosure agreements, cybersecurity, training) to ensure country confidences are preserved.

[31] Sharing responsibility for potential ADR liability to project participants and third parties during Phase 7 would be accomplished through a negotiated mix of insurance, self-insurance, indemnity and party cross-waiver provisions in the prime contracts and flowed to the subcontracts. That negotiation would occur in earlier Phases.

[32] A more detailed discussion of the dispute resolution mechanism envisioned by TCTB for the country prime contracts may be found on TCTB's website under the "FAQ" Link.

[33] ADR subcontractors will be expected to provide any necessary launch service.

[34] Private venture capital might be sought by TCTB during Phases 7 and 8, depending on the negotiated level of risk TCTB agrees to assume in those Phases. Additional detail regarding the fee structure proposed by TCTB may be found on TCTB's website.

[35] ADR subcontractor selection by TCTB would also insulate countries from bid protests by disappointed non-selected subcontractors.

[36] Firewalls, including non-disclosure agreements, information protection systems for documents, cybersecurity and employee training, are often employed by companies in antitrust scenarios (e. g., Consent Decrees) as a means of obtaining regulatory consent for a particular business combination while preserving competition. The U. S. Missile Defense Agency and industry have used firewalls to create national teams of industry competitors to jointly develop important missile defense systems. The same mechanisms could be used to protect any country secrets used in ADR projects from the other participating countries.

[37] Although other sharing formulas are possible based on a number of rationales, TCTB strongly recommends equal shares for each participating country.

[38] Reconciliation would account for differences in country participation due to timing. For example, if one country did not join until Phase 3, the costs of Phases 1 and 2 could be retroactively shared among all three countries.

[39] Designing ADR projects around existing technology products or companies would constrain efficiency.

[40] Political coordination among all three countries does not appear necessary under TCTB's plan, but given the wide-ranging, multi-forum nature of political interaction among countries, it cannot be discounted entirely.

[41] An excellent description of the Wolf Amendment, its historical context, legislative history and implementation, is contained in a Georgetown Law Journal article by Hannah Kohler, "The Eagle and the Hare: U. S–Chinese Relations, the Wolf Amendment, and the Future of International Cooperation in Space", at Volume 103, pages 1135-1162 (2015).

[42] NASA has funding for research but not ADR. Debra Werner, "NASA's Interest in Removal of Orbital Debris Limited to Tech Demos", SpaceNews, June 22, 2015 (https://www.spacenews.com/nasas-interest-in-removal-of-orbital-debris-limited-to-tech-demos/).

[43] All three countries permit contracts with non-domestic companies; all three countries protect proprietary information received from others; all three countries permit sole source contracts.

[44] National Aeronautics and Space Act, 51 U. S. C. Sections 20113(e), Public Law 111-314 (2010); NASA Space Act Agreements Guide, September 29, 2017 (https://nodis3.gsfc.nasa.gov/NPD_attachments/N_AII_1050_001D.pdf).

[45] TCTB has estimated it would take approximately three years to accomplish Phases 1-6.

[46] Antonio Machado, "Proverbios y Cantares XXIX", "Campos de Castilla" (1912).