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Planning the unplannable: Scenarios on the future of space☆

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Abstract

This article explores the use of scenario analysis as a methodology to rigorously analyze potential space futures, particularly with respect to space security challenges, in the context of rapid and uncertain change across several dimensions of human space activities. The successful use of scenario analysis in other (e.g. corporate and military) sectors is described and results of an initial scenario analysis workshop are presented. Scenario analysis is recommended as a promising approach to evaluating the long-term consequences of various policy choices in the context of uncertainty, and as a process well-suited to fostering communication and building consensual knowledge among diverse stakeholders.

1. Introduction

The future of the human presence in space has many faces.[1] The uses of satellites in daily life are now ubiquitous. Dramatic telescopic images reveal the grandeur of the cosmos as never before. Robotic rovers have spent years exploring the surface of our nearest neighboring planet, while new precise measuring techniques have revealed the existence of hundreds of planets around nearby stars. China recently sent its first human into space, and the USA has established plans for human travel to Mars. Even recreational uses of space are now at hand. The 21st century will see the human presence in space develop into an integral aspect of human social and economic life.

These prospects raise many issues. Accordingly, policies shaping current space activities are much debated in many arenas around the globe. The agenda of issues is wide-ranging, including improving space surveillance data and traffic management, preventing and mitigating space debris, concerns over space security and possible weapons deployment, the use of space travel for scientific advancement, the implications of "space tourism," and the possibility of eventual "space colonization" for scientific, exploratory and commercial purposes.

These debates benefit from considerable ongoing efforts to generate relevant information, both technical and political. The decision-making processes often reflect the input of the many constituencies with near-term stakes in their outcomes. But lacking from these debates is a comprehensive and informed set of visions for the overarching objectives of the advancing human presence in space.

This absence is ironic, given that human interests in space are intrinsically visionary. Perhaps no other element of contemporary human life so inspires the imagination. Science fiction wonderment has motivated careers. In many nations, space-related achievements epitomize national purpose and pride. At this level, we are rife with visions.

But dreams do not constitute a basis for serious public policy planning. Lacking are what might best be termed "realistic visions" — that is, a set of integrated ideas about possibilities cast against the background of varying constraints, tradeoffs, and uncertainties. Realistic visions would map out how interests and forces operating within the expanding human presence in space will interact to produce outcomes over longer-term time frames.

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[1] "Human presence" as used here refers to all facets of human space-related activities, including biological, mechanical and observational.

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Visions must also account for variance on ultimate aspirations. Hence, no single vision can suffice; such visions are not themselves policy-setting directions. Rather, creative visions of this nature contribute to contemporary policy debates by providing a foundation, beyond simple speculation, for tracing the potential longer-term consequences of immediate policy questions. Even in the absence of global value convergence, such visions can enable policy makers to anticipate and preemptively solve many of the challenges that the advancing human presence in space will pose.

Without such reflection, policy making is driven by extant knowledge, current political forces and short-term objectives. As in many other areas of human life, the long-term consequences of a perpetually *ad hoc* and unintegrated decision-making process may please no-one. The incorporation of serious visions into policy-making processes will not insure the "best" outcomes – impossible in the absence of global values consensus – but they can help avoid the worst outcomes, which are easier to identify.

The future of the human presence in space is, of course, unpredictable. Uncertainty pervades two discrete dimensions: we do not know how technology and the material prospects of the human presence in space will evolve, and we do not know how space-relevant human organizational processes will evolve either on or off the Earth. This unpredictability greatly complicates the development of policy-useful visions of the long-term human presence in space.

This article addresses that challenge. The first section begins with an overview of contemporary space security dilemmas: their disposition will fundamentally shape humanity's space future. But space security is also only one of many issue areas within which dilemmas of unanticipated outcomes exist. The second section then outlines the objectives and techniques of a scenario-building process successfully utilized in military and business sectors to provide structured assessment of potential future directions across multiple issue-areas in the context of high uncertainty. The third section describes an initial effort, undertaken by two of this article's authors, to apply this process to questions of space futures. The article concludes with comments on some prospects for applying this approach more extensively.

2. The future of space security

Space security cuts across the uncertainty of the future of humanity's presence in space. The concerns and controversies over the potential of warfare to be conducted in or through space highlight these uncertainties. No-one favors such a prospect, of course. But there is no agreement on the means of avoiding it – or even on the priority of avoiding it, in the context of other terrestrial security tradeoffs.

For the better part of the past decade, the focus of these concerns has been the prospect of space weaponization. But here as well, there is no consensus on the definition of a "space weapon" or even agreement on whether or not such capabilities have already been deployed.[2] Certainly, a number of governments currently maintain capabilities in space that facilitate terrestrial (land, sea or air) military activities, including use of force. However, many of these capabilities unambiguously promote peace and stability – satellites providing early warning of missile launches and surveillance, for example, enable national technical verification of arms control agreements, daily reassurance of the absence of malicious intentions and deterrence-enhancing confidence in crisis-response capabilities.

The factors driving space-based security and military considerations are complex and opaque. Debate on space security issues tends to highlight opposing conceptions of autonomy and collectivity among spacefaring states; what James Clay Moltz has termed "space nationalism" and "global institutionalism".[3] But there are also common threads among these positions less apparent than their divergences.

The USA, widely acknowledged to be the world's dominant military space power, increasingly relies on both military and civilian satellite resources for a wide array of terrestrial military functions.[4] Many strategists perceive US space reliance as exposing potential vulnerabilities in broader US force postures. The rapid pace of technological change has fueled concerns that the timelines for maintaining adequate degrees of confidence are unpredictable. China's January 2007 launch of a missile to destroy a defunct Chinese satellite, displaying anti-satellite weapon capabilities, punctuated these concerns.[5]

[2] For a recent comment on this problem, see Brian Weeden, "Alternatives to a space weapons treaty," *Bulletin of the Atomic Scientists*, April 17, 2009 (http://www.thebulletin.org/web-edition/op-eds/alternatives-to-space-weapons-treaty). Considerations of this issue too often overlook that definitions are not given objectively; they are merely arbitrary boundaries linking a set of concepts for linguistic clarity. Hence, definitions are never factually right or wrong; they are either more or less useful in advancing communication and analysis. Conceptual clarity alone should determine whether or not, for example, a satellite providing guidance data to an ICBM should count as a "space weapon." Unfortunately, the political consequences of such debates obscure this otherwise purely academic exercise: whether or not the "space weapons' threshold is *perceived* to have been crossed already has policy-relevant normative import regardless of the facts in orbit.

[3] Moltz usefully distinguishes two intermediate but qualitatively distinct positions, "technological determinism" and "social interactionism." James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Stanford: Stanford University Press, 2008).

[4] While in the U.S. there is political and programmatic demarcation between civil and military space activities, there is also spillover between the sectors and the generally perceived security interest flowing from any perceived threats to vital commercial capabilities. U.S. military reliance on commercial communication bandwidth in certain circumstances is a poignant example; for assessments see Patrick Rayermann, "Exploiting Commercial SATCOM: A Better Way," *Parameters*, Winter 2003-04, pp. 54–66 (http://www.carlisle.army.mil/usawc/Parameters/03winter/rayerman.htm); Benjamin D. Forest, "An Analysis of Military Use of Commercial Satellite Communications," Master's Thesis, Naval Postgraduate School, September 2008 (http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA488621).

[5] Specifically, the Chinese action spotlighted concerns over "asymmetric vulnerability" of space assets – i.e., vulnerabilities costlier to protect than for adversaries to attack, and therefore not remedied by significant U.S. capability advantages.

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The Bush administration came to power pushing ambitious goals for research and development of space-related weapons systems while stone-walling diplomatic initiatives to restrain such efforts. The administration's 2006 National Space Policy articulated the underlying purposes to sustain "unhindered" US space access, to oppose any legal regimes or arms control agreements restricting US space activities, and to "develop and deploy space capabilities that sustain US advantage."[6] This posture reinforced earlier US military doctrinal developments establishing intentions to maintain US dominance in space for the foreseeable future, and reflected wider administration military force posture intentions.[7]

In truth, there has never been unanimity even among US military strategists that qualitative leaps forward in weaponizing space would satisfactorily answer immediate threat concerns. Indeed, many of the doctrinal ambitions for developing space weapons resulted not from unified national policy aims but from parochial bureaucratic processes and political competitions. The Bush administration considerably increased funding for research and development of advanced space weapons, but as time passed funding flows also fell short of doctrinal ambitions.[8]

Behind these concerns, however, has been a consistent presumption that the increasing militarization of space and the ever-present potential for space-related combat are an inevitable result of natural historical progression. For example, the US Space Command's widely-circulated 1998 "Vision for 2020" anticipated that space would eventually "evolve into a separate and equal medium of warfare" and outlined requisite US preparations for that inevitability.[9] The subsequent and more notorious report of the Commission to Assess United States National Security Space Management and Organization, chaired by soon-to-be US Secretary of Defense Donald Rumsfeld, viewed the eventual extension of warfare into space a "virtual certainty", famously warning of an impending "Space Pearl Harbor", and recommended that the USA "vigorously pursue" full-scale capabilities for space weapons deployment.[10]

The Obama administration seems set to take US space policy in different directions, but reflecting convergent concerns. As a candidate, the future president explicitly opposed "the stationing of weapons in space and the development of anti-satellite weapons" but simultaneously recognized the need "to protect [US] assets in space" and supported programs "to make US systems more robust and less vulnerable."[11] Shortly after his inauguration, President Obama reaffirmed this position by declaring his intention to seek a ban on space weapons; but White House policy emphasized barring weapons that could interfere with US satellites, thereby linking the policy directly to securing US space-based capabilities.[12]

The new directions of the present administration encourage long-standing advocates of more multilateral approaches to space security challenges. However, these directions are ambivalent on the deeper presumption of the inevitability of space-based conflict, if not weaponization. Recent interest among US military strategists in the prerequisites for establishing and maintaining "space deterrence"[13] reflect continuity in this vein of thinking.

Driven in large measure by concerns over US intentions, most other countries categorically oppose weaponization of space and have supported efforts to expand the Outer Space Treaty (OST) to control and limit future military expansions into space.[14] Evolving coalitions of states have consistently endorsed negotiation of a further Prevention of an Arms Race in Outer Space (PAROS) agreement. In the past decade, Russia and China have led these efforts; but at times

[6] "U.S. National Space Policy," White House Office of Science and Technology Policy (OSTP), October 6, 2006 (http://www.ostp.gov/html/US%20National%20Space%20Policy.pdf). This document updated policy dating to the Clinton administration. Cf. Wade Boese, "U.S. Nixes Arms Control in New Space Policy," *Arms Control Today*, November 2006 (http://www.armscontrol.org/act/2006_11/ACSpace); Moltz, *The Politics of Space Security*, chapter 7.

[7] See, for example, the US 2001 Quadrennial Defense Review (available at http://www.defenselink.mil/pubs/qdr2001.pdf) and *The National Security Strategy of the United States of America*, White House, September 2002 (available at http://www.globalsecurity.org/military/library/policy/national/nss-020920.pdf). For discussions of these broader contexts, see Wade L. Huntley, "Smaller State Perspectives on the Future of Space Governance," *Astropolitics* 5:3 (Fall 2007), pp.237-71, at pp.240-45, and Wade L. Huntley, "Threats All The Way Down: U.S. Strategic Initiatives in a Unipolar World," *Review of International Studies* 32:1 (January 2006).

[8] For an assessment near the end of the Bush administration's tenure, see Theresa Hitchens, Victoria Samson and Sam Black, "Space Weapons Spending in the FY 2008 Defense Budget," Center for Defense Information, February 21, 2007, <http://www.cdi.org/PDFs/Space%20Weapons%20Spending%20in%20the%20FY%202008%20Defense%20Budget.pdf>.

[9] United States Space Command, *Vision for 2020*, p.4. Available at: http://www.fas.org/spp/military/docops/usspac/visbook.pdf. US Space Command was formed in 1985 but disbanded in October 2002; its responsibilities were transferred to US Strategic Command (STRATCOM).

[10] *Report of the Commission to Assess United States National Security Space Management and Organization*, January 11, 2001. The full report is available at http://www.defenselink.mil/pubs/space20010111.html.

[11] Obama for America, "Advancing the Frontiers of Space Exploration," N. D. (http://www.barackobama.com/pdf/policy/Space_Fact_Sheet_FINAL.pdf).

[12] Turner Brinton, "Obama's Proposed Space Weapon Ban Draws Mixed Response," *Space News*, February 4, 2009 (http://www.space.com/news/090204-obama-space-weapons-response.html). The Obama administration is due to deliver a Congressionally-mandated Space Posture Review in December 2009, and is undertaking a space policy review intended to produce a new National Space Policy by the middle of 2010.

[13] See Ambassador Roger G. Harrison, Major Deron R. Jackson, and Collins G. Shackelford, "Space Deterrence: The Delicate Balance of Risk," Eisenhower Center for Space and Defense Studies; in *Space and Defense* (forthcoming); for a critique, see Nancy Gallagher, "A Reassurance-based Approach to Space Security," International Security Research and Outreach Programme, Department of Foreign Affairs and International Trade Canada, October 2009, pp. 23-5 (http://www.cissm.umd.edu/papers/files/a_reassurance_based_approach_to_space_security.pdf).

[14] While the OST reserves space "exclusively for peaceful purposes," it prohibits only the stationing in space of "nuclear weapons or other weapons of mass destruction." Just as freedom of navigation on the high seas does not preclude warships' use of the oceans, the "Rumsfeld Report" explicitly portrays unprohibited space weaponization as consistent with "peaceful use" and with US obligations under the UN Charter and the Outer Space Treaty. *Report of the Commission to Assess United States National Security Space Management and Organization*, January 11, 2001, p.17 (http://www.defenselink.mil/pubs/space20010111.html).

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many significant US allies (such as Canada) have joined the call.[15]

Notably, many supporters of establishing treaty-based control of future military-related space activities share the judgment that technological advancement is creating genuine security implications rendering existing space regulation increasingly insufficient, and encouraging the expectation that, absent stronger controls, weaponization may indeed be inevitable. Here also, China's ASAT-testing satellite shoot-down has been taken as a demonstration of these conclusions.[16] Whereas space nationalists and space globalists differ markedly on *prescriptions*, the underlying diagnoses of contemporary forces and prospects are more convergent.

This observation casts light on the common view that ambitions to create a binding space governance regime merely reflect idealist aspirations for global cooperation. But states supporting treaty-based restraints on space weapons development typically have made appraisals of their national space security interests just as realist as those by the USA. The different responses to these concerns by these countries reflect the differences in the content of their interests and in their relative capabilities to pursue them.

The USA, as the dominant military space actor, often expresses a familiar ''great power'' response to space security developments. Other countries' perspectives may differ along three dimensions. First, they face the consequences of possessing less – or no – capacity to redress their space security concerns by their own resources.[17] Second, their interests may include more relative attention to civil and commercial space activities, with space security concerns limited to the prerequisite of a peaceful space environment in which to conduct those activities. Finally, they may worry that, because of their smaller role, their interests may be abused not only from others' malice but from their ignorance and neglect. States for which these differences hold take the perspective of ''lesser powers'' with respect to space security. Each of these differences motivates lesser powers to pursue their interests through some form of structured *relationship*, which may include either exclusive alliances or inclusive regimes.[18]

The particular nature of space-related issues exaggerates these tendencies. All states have an equivalent ''proximity'' to space, and many, as consumers of space-based communications and imaging products, tend to perceive immediate interests in activities there. For this reason, weaker states tend to view the consequences of conflict in space in absolute rather than proximate terms, even if their capacity to influence events in space is particularly limited – akin to weaker states' outlooks on nuclear conflict. This convergence between particular and generalized interests induces these states to perceive broadly shared interests; in turn, the absolute nature of the consequences of space conflict increases the perceived utility of broad-based multilateral collaboration (versus exclusive alliances). Hence, advocacy of shared international principles and multilateral agreements by such states reflects a realistic response to the particular circumstances they face.

The ''realism'' of the appeal among lesser-powered states of treaty-based regime solutions to space weaponization concerns underscores the observation, noted above, that ''great'' and ''lesser'' powers share a similar diagnosis of the underlying space security condition: namely, that inevitable technological advancement combined with the anarchic rivalry of states will, in the absence of restraint, lead ineluctably to the weaponization of space. These outlooks vary less on the nature of the political forces driving current circumstances than on the possibility and desirability of containing those forces. Hence, the alternative to weaponization is sometimes presented as the preservation of space as a peaceful ''sanctuary'', holding at bay the terrestrial pressures that would otherwise invade the pristine space environment.[19]

This presumption that weaponry and warfare in space can be prevented only by restraining the endemic forces of human conflict suggests a limitation of vision. The concept is one of straightforward negation, as in a dike holding back a surging sea or a wall resisting encroaching hordes. Negation goals omit the prospect that the underlying pressures themselves may be in some manner relieved. With respect to space security, this means addressing whether the security dynamics generating potential for weaponization and conflict in space

[15] A recent and more developed Russia-China joint proposal is: ''Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Space Objects,'' February 12, 2008 (http://www.mfa.gov.cn/eng/wjb/zzjg/jks/kjfywj/t408357.htm, accessed November 2009). On Canada's role, see ''Space Security,'' Canadian Department of Foreign Affairs and International Trade, July 15, 2008 (<a href=http://www.international.gc.ca/arms-armes/non_nuclear-non_nucleaire/space_security-securite_spatiale.aspx?lang=en&menu_id=120&menu=R, accessed March 2009). The Obama administration's stated embrace of a negotiated space weapons treaty may prove less auspicious than is at first apparent; with the common ground of opposition to US resistance eliminated, genuine negotiations may reveal divergent interests among other states as to exactly what such a treaty should look like.

[16] See, e.g., K.K. Nair, ''China's ASAT Test: A Demonstrated Need for Legal Reform,'' *Journal of Space Law* (Summer 2007). Arms control advocates saw the February 2008 US use of a modified sea-based theater missile defense interceptor to destroy a malfunctioning US satellite as further evidence of a potential space arms race dynamic emerging. US officials, however, cited several differences in the situations to contend the US action was not a parallel ASAT test.

[17] What matters here is not an absolute capacity to develop any relevant military space capabilities, but a capacity to do so *relative* to one's rivals. Therefore, an ability to develop a capability that is easily and less expensively neutralized by an adversary does no good. On the other hand, a cheap asymmetric capability that effectively balances an adversary's more extensive capabilities may be sufficient, especially in redressing a specifically-defined security concern. China's interest in ASAT technologies and Israel's pursuit of autonomous capabilities are examples. For a discussion of the competitive and self-reliant nature of space security, see Barry D. Watts, ''The Military Use of Space: A Diagnostic Assessment,'' Center for Strategic and Budgetary Assessments, February 2001 (http://www.csbaonline.org/4Publications/PubLibrary/R.20010201.The_Military_Use_o/R.20010201.The_Military_Use_o.pdf).

[18] ''Great'' and ''lesser'' powers as used here represent ideal types; states, including the United States, may express elements of both outlooks. For an elaboration of these observations, see Wade L. Huntley, ''Smaller State Perspectives on the Future of Space Governance,'' *Astropolitics* 5:3 (Fall 2007), pp.237-71, at pp.252–7.

[19] Representatively: Michael E. O'Hanlon *Neither Star Wars nor Sanctuary: Constraining the Military Uses of Space* (Brookings Institution Press, 2004); Bruce M. Deblois, ''Space Sanctuary: A Viable National Strategy,'' *Airpower Journal* 12:4 (Winter 1998), pp.41–57.

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might be redressed at a deeper, more self-sustaining level than dependence upon static treaty structures allows.

That deeper level involves the dynamic nature of state interests themselves. Most proposals for international cooperation in space security activities, whether a full-fledged formal PAROS-like treaty, or more modest arrangements to fashion ''rules of the road'', emphasize the potential to realize states' existing common interests. Such cooperation, even when institutionalized, may endure only so long as the underlying interest convergence persists; and given the energetic expansion and evolving nature of the human presence in space, the persistence of interest convergence cannot be assumed. As circumstances move tectonically, the energies required to keep intact the structures built upon those foundations increase to a point of unsustainability. Conflict's trumping of regimes remains, in some sense, inevitable.[20]

Few space security analysts have focused on the possibilities for cooperation to function more organically as an element of the evolution of human space activities, rather than simply as a structure applied to that evolution. The more organic possibility reflects the potential over time for cooperative agreements and institutions to change state interests themselves. Processes facilitating such evolution include strategic interest convergence, information creation and sharing, ''spillover'' and ''feedback'' effects, issue scope expansion and integration, and the facilitation of transnational linkages. Interacting synergistically with the interests they are influencing, such cooperation evolves dynamically as well. As such cooperation deepens its roots among all parties, it can begin to endure self-sustainably.[21]

The potential for more organic principles and cooperative institutions to shape the nature of political relations themselves suggests a more expansive concept of the underlying nature of interstate relations – one that need not always resemble the realist image of a Hobbesian ''war of all against all''. Hedley Bull's ''anarchical society'' and Daniel Deudney's ''negarchy,'' for example, capture the past and present existence of international political orders that, despite the absence of hierarchical government, have functioned as qualitatively distinct governance systems.[22] Application of concepts of qualitatively distinct political ordering principles to developing governance conditions of the future human presence in space is as yet largely unexplored.[23] The fluidity of interests and capabilities with respect to space activities suggests a relatively large potential for organized cooperation to influence their evolution. Such cooperative principles and institutions would then become intrinsic to the dynamic political forces shaping the expanding human presence in space, growing and evolving with them, rather than acting as exogenous static structures seeking to constrain those forces.[24]

The rate and uncertainty of change in both the technological and political dimensions of expanding human space activities complicates this task. Herein lies the value of ''realistic visions''. Rigorous articulations of the interplay of the wide variety of constraints, tradeoffs, uncertainties, and values entailed in human expansion into space can facilitate evaluation of the applicability of alternative governance concepts to human space activities in the context of dynamic change.

Among other things, such visions can explore how alternative futures in space are intimately linked to terrestrial conditions. As the human presence in space develops into an integral aspect of global life, it will increasingly reflect the prevailing conditions of global life. Anticipation of space weaponization premises continued earthly insecurity and conflict, while ambitions for growing commercial and exploratory development of space presume increasing international integration and collaboration. A future in which space becomes a domain of conflict and arms race competition may be irreconcilable with visions for increasing peaceful human presence embodied in today's growing commercial and exploratory activities. Choices among alternative futures for the human presence in space may depend upon choices among alternative futures for life on Earth as well.

The following section reviews the potential for scenario-building techniques to inform these choices by providing rigorous detailed visions of future worlds that account for a wide range of current realities and span the spectra of the most important uncertainties. The resulting plausible, integrated visions can yield feasible policy-relevant insights that demonstrably enable current policy making to be more far-sighted. Beyond the fruits of the exercises themselves, the longer time-frames entailed in scenario building also facilitate dialogue among diverse parties divided on nearer-term questions. The collaboration enabled can inspire innovation and

[20] Realists are right to further observe that this type of fixed cooperation can occasionally be more deleterious to preventing conflict than had it never existed, such as if a crisis-driven collapse of a cooperative regime exacerbates the crisis itself.

[21] For a good introduction to the copious literature on this topic, see Robert Jervis, ''Realism, Neoliberalism, and Cooperation: Understanding the Debate,'' *International Security,* 24:1 (Summer 1999), pp.42-63, at pp.58-62. Jervis notes that cooperative institutions capable of shaping the interests of states can potentially take on ''a life of their own,'' producing unforeseen and unintended – and potentially communally undesirable – outcomes (*Ibid*, p59 & p60n47). This prospect underscores the utility of vision-building as a means to better anticipate consequences and shape the design of cooperative principles and institutions.

[22] Hedley Bull, ''Society and Anarchy in International Relations,'' *Diplomatic Investigations: Essays in the Theory of International Politics*, ed. Herbert Butter field and Martin Wight (Cambridge, MA: Harvard University Press, 1966); Daniel Deudney, ''The Philadelphia System - Sovereignty, Arms-Control, and Balance Of Power in the American States-Union, Circa 1787–1861,'' *International Organization* 49:2, (Spring 1995), pp. 191–228.

[23] For an initial effort, see Wade L. Huntley, ''Smaller State Perspectives on the Future of Space Governance,'' *Astropolitics* 5:3 (Fall 2007), pp.237–71, at pp. 258–66.

[24] James Clay Moltz's description of the role of *learning* in fostering US-Soviet space security cooperation – and the role of ''unlearning'' in its demise – denotes the importance of accounting for, and if possible planning, dynamic interest evolution among principal space-faring states. See Moltz, *The Politics of Space Security*, esp. pp.59-63. Calls for building a space security regime around the principle of assurance rather than conflict also moves in this direction. See Nancy Gallagher, ''A Reassurance-based Approach to Space Security,'' International Security Research and Outreach Programme, Department of Foreign Affairs and International Trade, Canada, October 2009 (http://www.cissm.umd.edu/papers/files/a_reassurance_based_approach_to_space_security.pdf); cf. Michael Krepon and Christopher Clary, ''Space Assurance or Space Dominance? The Case Against Weaponizing Space,'' Henry L. Stimson Center, April 1, 2003 (http://www.stimson.org/wos/pdf/spacefront.pdf).

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integrated analysis among diverse experts, leading to the development of a productive "epistemic community"[25] addressing the full scope of future human space activities.

Vision development is only one aspect of long-term planning. Comprehensive knowledge generation and strategies for policy making are also required. But vision development is currently the least well advanced. All global policy debate, including US national security policy making, can benefit from having a fuller range of rigorous and credible assessments of long-term prospects from which to draw.

3. The scenario-building method

On 16 March 1966 Neil Armstrong deftly piloted the Gemini VIII within 0.9 meters of the pre-launched Agena Target Vehicle, then slowly accomplished the world's first orbital docking. Armstrong and co-pilot David Scott were still in a celebratory mood, when Scott noticed the Gemini beginning to roll. Armstrong used the Orbit Attitude and Maneuvering System thrusters, but the moment he throttled down, they started to roll again. Turning off the Agena seemed to stop the problem for a few minutes. But when it began again, the roll was accelerating. They undocked and with a long burst of translation thrusters moved away from the Agena. But the roll continued to accelerate. Tumbling now at one revolution per second, the astronauts were in danger of impaired vision and loss of consciousness. But Armstrong was able to bring the wild oscillations under control thanks in part to preparation by a flight simulation training exercise that many pilots disliked, believing the simulation was too unlikely to waste their scarce training time and energy on.[26] Fortunately, NASA did not plan the astronauts' training based on the *most likely* scenarios. Instead, they planned on the basis of *plausible* and *important* scenarios.

Developing plausible scenarios helps us take the long view in a world of great uncertainty.[27] Scenarios are narratives of the future defined around a set of unpredictable drivers, intended to expand insight by identifying unexpected but important possible directions and outcomes. Scenarios have a timeline over which meaningful change is possible. They are a useful tool for examining a number of different possible futures. They provide a means to stimulate new thinking, challenge assumptions, and provide an effective framework for dialogue among a diverse group of stakeholders. They can inspire new ideas and innovations by helping identify common goals and interests that transcend current political divides. Scenarios thus help to develop the means to work towards preferred futures.[28]

Scenarios are stories about the way the world might turn out tomorrow; they do not need to be likely, but they ought to be plausible, internally consistent, and relevant. It is precisely by considering possible, even if not necessarily likely, scenarios that we are best prepared for the unpredictability of the future. By encouraging creative thinking beyond the future we anticipate, scenarios help us become more resilient to unexpected events.

With respect to their utility in guiding policy development, three features distinguish good scenarios from simple speculations, linear predictions or fanciful musings of the future:

Scenarios are decision focused. Successful scenarios begin and end by clarifying the decisions and actions the participants must make if they are to deal successfully with an uncertain future. One common misconception of scenarios is that they are prescient, path dependent predictions of the future. On the contrary, scenarios are used to order our thoughts amid uncertainty, build common ground among differing perspectives, and think rationally about our options. The value of a set of scenarios accrues not from their accuracy or likelihood, but from their plausibility and the insights they generate.

Scenarios are imaginative. In examining a decision within the context of a number of different futures, scenarios require us to look behind fixed assumptions. They encourage participants to challenge conventional wisdom, create new contexts for existing decisions, and think creatively about options for surmounting obstacles. At their core, then, scenarios are about learning.[29]

Scenarios are logical. The scenario process is formal and disciplined in its use of information and analysis. The creativity and imagination inspired by scenarios can only be as effective as it is based in realistic assessments. In requiring participants to challenge each others' thoughts, perceptions, and mind-sets, the process helps clarify that reality.

Scenarios first emerged following World War II as a method of military planning. This approach was reflected in Herman Kahn's assertion of the need to "think the unthinkable" concerning the possibilities and implications of war in the atomic age. "In our times", Kahn wrote in 1966, "thermonuclear war may seem unthinkable, immoral, insane, hideous, or highly unlikely, but it is not impossible".[30] Kahn's motivation was, in part, recognition of the counter-intuitive notion that planning could be a necessary means of avoidance.

[25] Epistemic communities are networks whose individuals share both consensual knowledge and problem-solving ambitions. Epistemic communities differ from scientific disciplines by also sharing social action intentions, but differ from typical interest groups in not necessarily sharing norms and goals. Rather, such communities are marked by a commitment to continuing research and information gathering and self-conscious openness to revising convictions and policy goals in light of new factual data. The concept is widely applied with respect to global environmental issues. See Peter M. Haas, "Introduction: Epistemic Communities and International Policy Co-ordination," *International Organization* 1992; 46(1): 1–36.

[26] Hacker, Barton C. and Grimwood, James M., *On the Shoulders of Titans: A History of Project Gemini*, NASA Special Publication-4203 in the NASA History Series, 1977.

[27] Schwartz, Peter, *The Art of the Long View*, Currency Doubleday, 1991.

[28] Kees van der Heijden. *Scenarios: The Art of Strategic Conversation*. 2nd Edition. (West Sussex, England: John Wiley and Sons Ltd.; 2005).

[29] On the important role of learning in international relations, see Ernst B. Haas, *When Knowledge is Power: Three Models of Change in International Organizations* (Berkeley: University of California Press 1990).

[30] Kahn, Herman, *Thinking About the Unthinkable*, Avon Books, 1966.

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Analyzing scenarios reached greater methodological sophistication with the work of Pierre Wack, a planner at the London offices of Royal Dutch/Shell. Wack and his colleagues refined the application of scenario thinking to private enterprise. This work helped Shell anticipate the consequences of the emergence of a cartel among oil exporting countries, and to develop various plans to cushion the blow that would (and did) result from formation of the Organization of the Petroleum Exporting Countries (OPEC) in 1960. Shell was also able to anticipate massive economic and political change in the then USSR in the late 1980s.[31]

Scenario analysis came to be used in the political arena when associates of Wack assisted stakeholders in South Africa in the peaceful transition from apartheid to democracy. Many doubted the country's prospects; in 1987, the *Guardian Weekly* quoted Margaret Thatcher's former spokesman Bernard Ingham as saying that anyone who believed the African National Congress (ANC) would one day rule South Africa was ''living in cloud cuckoo land.''[32] But with operations in South Africa and an interest in preventing anarchy following the downfall of apartheid, Shell sent some of Wack's protégés, including Adam Kahane, to convene meetings of top governmental, religious, civic and business leaders at a conference site there called Mont Fleur. From February 1990, when Nelson Mandela was released from prison, to April 1994, when the first all-race elections were held, participants identified relatively certain and uncertain but plausible factors, and then formed into teams to research various alternative futures. In the midst of deep conflict and uncertainty, ''Mont Fleur'' brought people together from across ideological and political divides to think creatively about the future of their country. The collaboratively drafted scenarios were not a panacea, but did contribute to establishing a common vocabulary and enough mutual understanding for participants to find common ground on complex decisions. In particular, the consensus on the undesirability of three particular scenarios contributed to developing the perception of shared interests that was an important element in the success of the governmental transition.[33]

Scenario-building and analysis has become a distinct tool of US government policy making, and has been applied directly to future space security issues. For example, one major US Air Force scenario-based study evaluated 25 emerging technologies and 40 separate potential weapons systems through the lens of six ''alternative futures'' in an effort to guide future Air Force policy choices.[34] This exercise (and others like it) exemplifies the potential for applying non-linear future planning methodologies to large-scale public policy topics, including the future of space. The principal deficiency of such government-sponsored efforts is simply the narrowness of their focus – they are, by design, only concerned about a single government's decision points and are shaped by the goals, dilemmas and uncertainties most relevant to that single party. Lacking is a parallel process to achieve the same kind of expansive thinking while also incorporating a full range of stakeholders. Such exercises can hardly be generated by governments.

Among non-governmental organizations, application of scenario thinking is still in its infancy. Initial efforts have concentrated on seeking to engage a broad variety of stakeholders around complex global issues. The Nautilus Institute has used the collaborative writing of scenario narratives to facilitate international dialogue in the Pacific Rim around adaptation to climate change, terrorism, and socio-technological change.[35] The Virtual ThinkNet, a scenarios-based initiative led by Weingartner Consulting, is currently using scenarios to formulate recommendations for the Canadian Department of Foreign Affairs and International Trade on the future of Canada–North Korea relations.[36] The scenario-building exercise described in the next section of this article represents a first non-governmental application of scenario thinking to space issues.

Different types of scenarios are appropriate for different needs. *Technocratic* scenarios are oriented towards states and planning. *Anticipatory* scenarios aim to help organizations survive in an uncertain world. *Generative* scenarios identify policy opportunities that may realize values and transform the future, often by embracing uncertainty as a basis of strategy.

It is this last type of scenario-building and analysis that is most appropriate for initiating and continuing dialogue around the future use of space. Generative scenarios are particularly well suited to addressing three core challenges:

- anticipating the technological changes relevant to the full range of the growing human utilization of space that will inevitably unfold over the coming decades;
- guiding and planning integration across the full range of human space activities in conjunction with evolving terrestrial political conditions;
- identifying and responding to the critical uncertainties over the directions and implications of long-term developments in both the previous dimensions.

[31] Schwartz, Peter, *The Art of the Long View*, Currency Doubleday, 1991.

[32] http://www.guardian.co.uk/politics/2006/aug/27/uk.conservatives1, accessed 1 November 2009. The ANC became the ruling party in South Africa in 1994. It gained support in the 1999 elections, and further increased its majority in 2004.

[33] Adam Kahane, *Solving Tough Problems: An Open Way of Talking, Listening, and Creating New Realities*. San Francisco: Barrett–Koehle, 2004. See also Graham Galer, ''South Africa: scenarios of the future as apartheid was ending,'' paper presented at the Oxford Futures Forum, October 22, 2005, available at http://www.oxfordfuturesforum.org.uk/Submissions.asp, accessed 29 October 09, p. 14; and Liam Fahey and Robert M. Randall, *Learning from the Future: Competitive Foresight Scenarios*. (NY: John Wiley and Sons, 1997), pp. 326–327.

[34] Air Force 2025 Executive Summary found at http://csat.au.af.mil/2025/e_s.pdf, p. 20, accessed 01 November 2009. For a more detailed recounting of this study, see Wade L. Huntley, ''Smaller State Perspectives on the Future of Space Governance,'' *Astropolitics* 5:3 (Fall 2007), pp.237-71, at pp.241–3.

[35] See: Nautilus Institute, 2006, Open Minds, Open Futures, Melbourne, http://www.nautilus.org/gps/scenarios/Scenarios2006.pdf accessed 01 November 2009.

[36] See: http://futuretrip.wordpress.com/canada-dprk-relations/ accessed 01 November 2009.

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Scenario building can address these challenges by providing rigorous, detailed visions of future worlds accounting for a wide range of variables, inevitable change and uncertainty. The collaboration entailed in scenario building can also inspire the creativity and imagination of an expert community representing diverse viewpoints on immediate issues. The resulting plausible, integrated visions, responsive to current realities and robust against future uncertainties, can yield feasible policy-relevant ideas for promoting peaceful development of the future human presence in space despite the wide range of possible future developments both in space and on Earth.

As noted earlier, vision development is only one aspect of long-term planning. A comprehensive knowledge base and strategies for policy-making are also required. By integrating expertise in these other areas into vision development, scenario-building exercises can contribute valuable long-term insights to policy debates. The following section reports the results of one such exercise.

4. Space futures scenarios

4.1. The space scenarios workshop

On 12–13 May 2008 a two-day workshop brought together experts on a diverse range of military, commercial and civil space activities, utilizing scenario building to create detailed visions of future developments in space.[37] The scenarios were intended to be highly credible, rigorously accounting for multiple driving forces in the context of inevitable change and uncertainty. The scenarios developed in this workshop engage with contemporary policy-relevant challenges and advance the goal of strategic planning for longer-term space futures.

The three scenarios produced in the workshop are not meant to be predictive. The future will undoubtedly contain elements of each, as well as many novel features the exercise did not capture. Rather, the scenarios intend to stimulate awareness among stakeholders of the potential for transformative and dramatic change, and the consequences of unpredictability for various strategies and actions.

The project had as its core purposes:

- articulation of the norms, institutions, policies and adaptations to technological change required to realize the full positive potential of human space presence in the viably imaginable worlds of 2033;
- anticipation of the prospects and obstacles to establishing governance conditions for the human presence in space in 2033 under which the absence of deployed weapons and arms races is stable, self-sustaining and consistent with terrestrial governance conditions.

[37] The workshop was convened by the Simons Centre for Disarmament and Non-Proliferation Research with the collaboration of the Center for International Relations, at the University of British Columbia, Vancouver, Canada. Co-authors of this article Wade Huntley and Miranda Weingartner facilitated the workshop. For information on participants, see Acknowledgements.

Table 1
Key drivers of the future of outer space.

Low Earth Orbit/Near Earth (LEO/NEO).
Level of awareness of populace and political demands.
Relationship between US and China, Russia, India.
Energy and degree of cooperation.
Degree of state authenticity over commercial interest.
Degree and speed of technology and proliferation of technology.
Speed of deployment of space law.
Relationship of military authority to civil or/and criminal authority.
Social aversion to war.
Rule of law versus rule of power.
Demographic shifts

These core purposes functioned as the basis for generating the workshop's "focal question", which provides the anchor for all subsequent discussions, pulls together existing knowledge and creates the platform for further exploration. The focal question for the workshop became: "Will space be weaponized by 2033?" In coalescing around this question, participants took it as a starting point that space is already militarized, if not yet "weaponized". Participants also decided to leave the definition of a "space weapon" unspecified at the outset, so that this issue could be a generative variable shaped by the scenarios themselves, rather than a fixed constraint imposed on them.

4.2. Generating the scenarios

The group then determined 'driving forces', that is, the key factors already influencing the future one way or the other. The building blocks of scenarios, driving forces bring to the table the full range of factors that influence the world in which one must operate. They are a device for honing initial judgment and helping decide which factors will be significant or insignificant.[38]

The consensus drivers were then collated into a single document, listed in Table 1.

The group was then asked to pull "key critical uncertainties" from this list. "Critical uncertainties" are those drivers that are likely to have the greatest influence on events, and drive events towards a highly unpredictable outcome. None of the original drivers is eliminated – drivers not deemed to be the "critical uncertainties" are taken into account when developing the scenario narratives. In the end, the group agreed that three critical uncertainties presented the most challenging combinations and thus served as the basis for building the scenarios. These are: power determined by the rule of force or rule of law; technological breakthrough or inertia; scarcity of resources or abundance of resources.

[38] One way to think of driving forces is as elements of the plot in a story. The story of Romeo and Juliet could be defined by three driving forces: the romantic love between the characters; the rivalry between the two families; and the filial responsibility which binds them. A thorough analysis of this Shakespearean tragedy would identify several additional forces which affect the fatal outcome for the lovers. But without the three listed above, there is no story.

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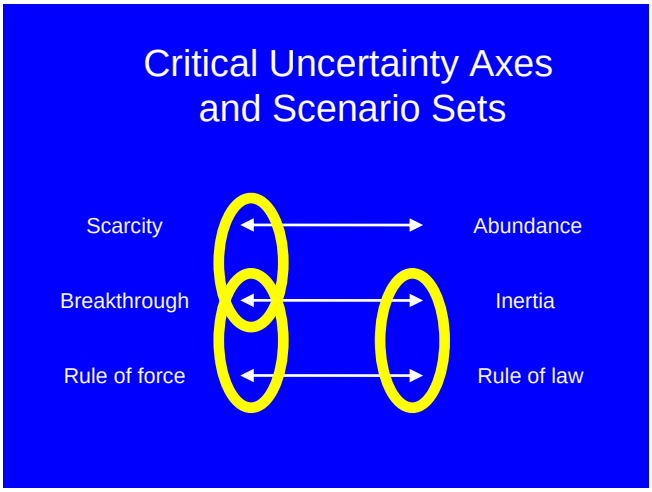

Fig. 1. The critical uncertainty axes.

Discussion then focused on selecting the combination of endpoints from the three critical uncertainty axes that would define the scenarios.[39] They are presented in Fig. 1.

The workshop participants were then divided into three teams to develop the narratives of the scenarios. Each team of participants presented three distinct stories and rationale of plausible futures.

4.3. Scenario A: ''Back to the Future''

''Back to the Future'' describes a future characterized by a high degree of technological breakthrough wherein power is projected by rule of force.

In 2009 global tensions create an atmosphere where nations increasingly test new defensive technology. In 2010 India explodes a satellite out of Low-Earth orbit (LEO) and the USA tests an orbital interceptor. Gazprom invests $1 billion in the development of a nanotechnology research lab. There is also a steady erosion of Outer Space Treaty norms and limits to protect commerce. By 2013 NATO is dissolved, seen as no longer relevant. The EU alliance shifts towards defending its borders. Human spaceflight continues, in an increasingly competitive atmosphere. The USA launches Aries I, with a crew. Generation Y seems more interested in environmental issues than space. By 2014 many nations begin deploying anti-satellite (ASAT) technology. In 2015 China, the USA, India and Russia field rival ASATs in orbit, as LEO orbits are at risk from debris. Commercial interests give up on LEO and eye the Moon, which fuels the race to establish a presence there. An increasingly protectionist USA leaves the World Trade Organization (WTO). In response, China recalls its debts from the USA. Meanwhile, European and Asian growth continues and, in 2018, a Chinese factory begins production of bulk carbon nanotubes. The USA and China race to produce the first space elevator. The civil lunar programs move forward. By 2020 a joint US–EU team land on and 'reclaim' the Moon. Lunar bases and the space elevator are established, as resources continue to dwindle on earth. Rival moon bases compete over mining rights and orbital lasers promote a defensive arms race in space. NATO is replaced by a new European Defence Organization (EDO). A coalition emerges, including the USA, the EU and India, in opposition to Russia and China. By 2025 African nations reject the influence of major powers and, thanks to the proliferation of technology, become space powers in their own right. In 2028 major powers withdraw from the Outer Space Treaty. Saudi oil fields are now officially empty, and the lunar colonies' major export is solar power. Military bases on the Moon defend against rival solar farms. A Russian–Chinese coalition attacks the space elevator, which essentially strands the US–EU lunar colonies and seriously impairs energy availability on Earth. The UN breaks down and is dismantled. Treaties are ignored and tensions increase. The earth is highly militarized, and conflict occurs both on earth and in space. The future is tense, dark and uncertain. By 2030 Californian scientists claim to have discovered an alleged artificial signal from outer space. The signal offers the possibility of a new reason for hope.

4.4. Group observations on Scenario A

In this scenario technological breakthroughs add to the rule of force rather than providing a means for international cooperation. States come together and drift apart based on their perceived interests. The group acknowledged the importance of ''giving teeth'' to the Outer Space Treaty and other treaties in order to enhance means of overcoming conflict in the future. However, treaties do erode when states or blocs of states perceive these no longer to serve their interests. Further, norms of the Outer Space Treaty may be eroded through the commercialization of space, rather than by conflict and militarization. The group recognized that cooperation is possible on some, but not all, issues.

Following the Chinese recent ASAT test there were efforts to clarify the situation for all parties concerned and prevent repeat occurrences. This suggests in part that the UN breaking down is not realistic, and that there might be greater political will to move in a collaborative direction than the scenario suggests.

The competition for resources breaks down liberal order and traps states into a situation where the rule of force is perceived as the only option. In this scenario democracies are not less likely to militarize. Politicians bear the responsibility for the implications of their actions. NASA remains a remnant of the Cold War, while the EU space plan is geared towards a broader array of concerns. The voice of civil society is then squashed. (There is also an option of a scenario where, instead of the EU, China becomes a regional champion, bringing other

[39] A standard scenario-building technique involves arranging two critical uncertainty axes orthogonally, yielding a matrix of scenario spaces capturing all four endpoint combinations. Workshop participants determined during discussions to develop three scenarios from the three axes.

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regional leaders like Brazil under a new transparent framework.) The rule of force is also justified for the protection of investments. An entity such as the US-Soviet Standing Consultative Commission (SCC), which was convened when one side thought there had been a violation by the other, might be helpful.

Driving factors come not necessarily from the bottom or the top, but rather from mid-level officials who can promote a discussion on the consequences of space weaponization. It is important to reach out to the non-space community, to help a wider constituency relate to the issues and take greater interest. Getting away from focusing on big, one-off, prestige programs is one way to elicit such an interest.

Technological innovation, while important, does not necessarily lead to an advantage for the country of origin. Rapid dissemination of technologies among a certain community can affect the security of the countries of origin. For this reason, if weaponization of space is inevitable, countries should operate as much as possible in a collaborative, transparent fashion. This suggests the utility of a global regime controlling the technology.

Cooperative leadership among youth could be developed to help ensure future cooperation. This group underlines the importance of reaching young people today in order to stimulate awareness in the next generation of leaders of the negative spirals that could develop. All parties must be made aware that it is in no one's interest to attack each other's satellites; both sides need the information and need freedom to access space. A non-interference pact could be developed, which might name the kinds of weapons not to be used.

One omission in the scenario is the role of domestic space institutions. It was argued that EU institutions tend towards more openness than American ones, largely because American space institutions developed during the Cold War in an atmosphere of secrecy.

4.5. Scenario B: ''Sisyphus'' (or ''The Never Ending Story'')

Sisyphus describes a future challenged by a scarcity of resources but enjoying a high degree of technological breakthrough.

In 2010 oil prices reach $350 per barrel, resulting in massive investment in new energy technology by the USA, India, China and Russia. These investments lead to a leap in computing capacity. The high price of oil causes global food shortages. These in turn cause disruptions in the political order of many nations and massive displacement of populations towards Northern regions. Canada closes its borders and calls for the UN to assist its management of US ''economic'' refugees. Severe water shortages send shockwaves in the Western world. Famine breaks out in the Russian Far East. By 2015 10 million people have perished worldwide from hunger. The global order reorganizes itself in two opposing blocs. The Union of Democracies (UD) includes the USA, EU and allies. China signs an armistice with Russia and Japan, thereby building the opposing block to the UD. Under civilian pressure, nations scramble to find a solution to the energy crisis and increase their cooperation over energy. Turkey and Iran agree to a water pipeline to the Middle East, increasing tensions between Israel and surrounding nations. In 2020 a researcher in Zurich discovers a new element (Fidelium) which leads to nuclear fusion. The US Air Force tests its first hypersonic spaceplane. Meanwhile, thanks to increased computing efficiency, artificial intelligence makes its appearance on the scene. The USA and allies begin the construction of a space elevator. By 2025 interest increases in mining for water on Mars. Artificial nutrient capsules are now mass-produced and help mitigate the effects of hunger, but only for those who can afford it leading to an increasing gap between haves and have-nots. Tensions increase in the Middle East water-war peace process and Turkey storms out of talks. AI computers are handed management of the US nuclear forces. By 2030, thanks to small fusion, bringing resources from space is now feasible and economical. Fidelium is confirmed abundant in space, thanks to asteroid sampling missions. Russia and China condemn Western refusal to share the fusion formula and threaten to destroy both the space elevator and the nascent mining colony in the asteroid belt with a laser weapon installed in LEO. Space is now, unequivocally, weaponized.

4.6. Group observations on Scenario B

Scarcity of resources leads to people investigating space for resources. When water is found to be available from space, there is a race to acquire the resource, and a scramble to develop the technology that would enable its acquisition.

Technology breakthrough leads to a strong divide between developed and developing countries. Technological breakthrough may therefore have a more negative impact on international relations in the context of resource scarcity. Whoever has the breakthrough holds the advantage, leading to greater competition among nations and conflict over who gets to control the benefits. If the breakthrough is in space technology, then space becomes the arena wherein conflicts will arise. A key finding is that conflicts pre-dating the technological breakthrough are not mitigated by it.

A possibility seldom examined is how technological breakthroughs may have huge unanticipated ramifications. One example is how increased access to computing power afforded by a cheaper microchip will bring new players to the field. New players alter the dynamic. The role of the private sector is also tenuous in this scenario.

Another actor relevant to the scenario is Israel. Israel is already considering the development of space weapons. Where would Israel's allegiance lie? In this scenario, there are significant Israel–Iran tensions over water leading to ground conflict.

Ideology strongly dominates this scenario. It is assumed that under UD leadership, democracy and the rule of law prevail. However, the UD may impose its own rule of law

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rather than abide by international law. There is also a strong assumption that the UD nations develop the breakthrough technologies first, and actively prevent development elsewhere.

In this future, there would be pressure against cooperative commercial trade. Civil society would also face pressure from states trying to harness and control it. These states would not wish the private sector to be in cooperation with rival blocs.

One major point this scenario illustrates is that technology, including shared technology, does not necessarily solve the problem of resource scarcity. Here technology is always driven by the impulse to compensate for dwindling resources, but technology itself becomes a driver of tension and impels the UD to harden its security apparatus.

4.7. Scenario C: ''Pax Necessitas'' (or ''Peace through Boredom'')

''Pax Necessitas'' describes a future characterized by a world where there is little technological advancement and power is expressed by rule of law.

This scenario begins in 2010, when the USA announces to the world its intention to form a multilateral treaty on the use of space, under its leadership. China and Russia fail to attend and boycott the conference. The EU, for its part mainly concerned with harmonizing its own national laws, calls on China and Russia to cease posturing. Some factions within the EU also call for the expulsion of the USA from the UN. The EU becomes divided from within. International tension escalates. In January 2013 a nuclear weapon is detonated in a major US city. A new administration more committed to international cooperation accepts international assistance to hunt, apprehend and prosecute the guilty. Investigation reveals that materials used in the bomb are of Chinese origin. The USA and China begin dialogue behind closed doors, in an effort to solve the issue. Meanwhile, the 4000th satellite is launched. Because of the increased traffic in space (including the presence of debris), the Satellite Industry Association (SIA) calls for international space traffic management - which requires a high degree of international cooperation (much like air or sea traffic). Countries reach multilateral agreements around the sharing of satellite benefits, such as telecommunications, space research and technology development. Talks begin around developing international laws governing protection of intellectual property. The SIA also calls for transponders on satellites. 2018 is a challenging year for China. The rising cost of oil and dwindling freshwater supplies mean soaring food prices and global economic depression. A space station failure strands Chinese taikonauts, who are rescued by a joint Russian–EU effort. Chinese authorities, already struggling with a famine that threatens 280 million in the northwest, find themselves faced with accusations that corruption caused the space station failure. Civil unrest turns to civil war. The Chinese military brokers a deal with the emerging Chinese democratic movement, which then gains power. The military recover from the ''taikonauts'' scandal and place defensive space objects in orbit, arguing that they are for peaceful defense against asteroid impact. States struggle to establish means of cooperation to facilitate massive humanitarian relief, without the need for sovereign consent from nations. In 2023 an international lunar base is established mainly for the purposes of developing and seeking new sources of energy. Space tourism, one way of funding lunar expeditions, is endorsed by the private sector. A series of talks is underway to develop a (new) ''Moon treaty'' dealing with issues such as appropriation of energy resources. An agreement is reached for resource distribution, which includes the commercial sector. Astronauts are granted diplomatic immunity. Nations begin to collaborate on joint efforts with greater success. By 2028 the first international solar power satellite (SPS) is launched, generating power to five countries. Meanwhile, however, water shortage in the Great Plains of the USA, caused by deterioration of the Ogalala aquifer, dramatically reduces grain production, exacerbating disruption in food supply. India and the USA pursue orbital nuclear power as per multilateral agreements, to tackle energy demand. Global food shortages now outstrip humanitarian capacity. In 2030, in an international summit, world leaders begin a global rationing of resources. People connect and coordinate efforts through telecommunications. Nations begin to discuss the possibility of establishing a base on Mars, opening up the possibility of evacuating human populations into space. A coalition of 15 countries agrees to limit orbital nuclear power. The coalition insists there has to be a collective response on asteroids, and an international consensus on how to use energy for building the Mars base. An ICJ Advisory Opinion states that intentionally destructive space objects are prohibited per *jus cogens*.

4.8. Group observations on Scenario C

The group struggled with defining technological inertia. They settled on the uncomfortable consensus that for the purposes of this exercise, ''technological inertia'' is best described as ''status quo'', or the absence of breakthroughs that redefine the operating landscape. In this scenario, it is still prohibitively expensive to get into space, and the pace of discovery is slow.

Legal tools promote solutions, but ultimately, it all comes down to political will. What is needed are institutions to reduce the likelihood of conflict on Earth, and international legal agreements. In this scenario, it is the internationally cooperative nature of space activity that diminishes the likelihood of weapons in space being used against adversaries on Earth.

The crucial assumption in this scenario is that, despite all these global catastrophes, there still seem to be sufficient resources to make it into space.

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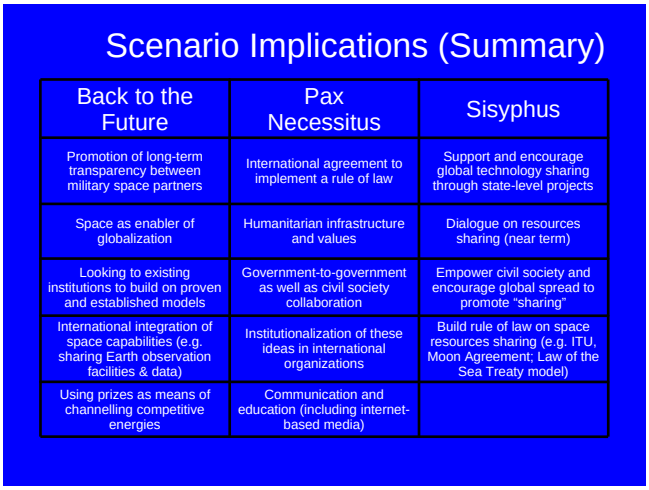

Fig. 2. Summary of the implications of the three scenarios.

4.9. Implications

A summary of the implications of the three scenarios is presented in Fig. 2.

Participants noted that in none of the scenarios does technology solve anything in and of itself. Less surprising was that the quality of diplomatic relations on Earth drove conflict, and so was a key to solving conflict. Participants also realized that, where the scenarios were Sino-US focused, they had often projected forward lessons of the history of bipolar Cold War, uncovering an assumption that a Chinese superpower would behave similarly to the Soviets. This assumption may not be wrong, but it is far from certain.

The scenarios showed that, as more nation-states develop an interest in expanding their footprint into space, conflict in space will increasingly affect neutral third parties. Just as with nuclear deterrence relations, conflict among a few parties can prove catastrophic for all. As a small-scale example, the 2007 Chinese ASAT significantly increased appreciation for the effect of space debris. A crucial recommendation therefore is to strengthen existing international agreements as a basis for dialogue, including military-to-military confidence building. Such a strategy would require identifying common interests and challenges and fostering international cooperation through joint ventures and the sharing of technology.

The private sector is crucial to technological progress and the development of less costly ventures into space. In all three scenarios, governments took advantage of private sector innovation, but nationalized vital space and satellite technology industries in order to advance perceived national interests. This had a strangling effect on innovative entrepreneurial ventures. Business requires a stable and secure environment to thrive, which argues for international conventions if only to regulate as well as protect commercial transactions.

The challenge is that space is one particular area where ideological–doctrinal ideas seem to govern space law, reinforcing the need to cultivate a vision of humanity's future in space beyond purposes of national defense. In essence, the commercialization of space was seen as having great potential to mitigate conflict on Earth, much in the same way that business links between nations can deepen interdependence, thus raising the stakes for out-and-out warfare.[40]

Participants realized that they did not fully think through the effect of the globalization of information and technology in their scenarios. Recent assessments challenge the assumption that globalization will continue according to present trends, particularly that it will disproportionately benefit the developed world.[41] The global rise of connective technologies, and decreasing cost of technology, may level the playing field in unexpected ways. It certainly may mean new dialogue partners from the middle powers or even developing regions of the world.

In the plenary, participants noted that in all the scenarios there is an assumption of the importance of the state system. But the state is not necessarily the actor that will drive the weaponization of space. Globalization could enable a non-state actor to obtain capabilities to attack satellites or conduct espionage. A ''rogue'' actor could be a state or someone associated with the state (keeping that state responsible), but could also be a non-state actor. At the same time, the proliferation and globalization of information and ideas encourages the involvement of civil society (Generation Y in ''Back to the Future''; humanitarian organizations in ''Pax Necessitas'') in powerful ways.

Participants noted that if there is only vague interest in the rule of law, there is also only vague commitment to enforce. The difficulty of enforcement in the international arena (small and weak countries can be checked and punished by larger powers, but not vice versa) reinforces how enforcement strategies are hamstrung in the absence of mutual interest. Commitments to principle need to be girded by actors having a vested interest in the legal system itself. But gaining buy-in to a system of norms, laws and regimes will involve factors from outside that system. There is a synergistic, ''chicken/egg'' relationship between formulating laws and regimes and adherence to the rule of law.

This also presents an important opportunity. The empowerment of civil society, a driver of humanitarian values and concerns, could be a key to sustaining the peaceful use of space. Particularly where resource scarcity is a potential driver for international conflict, engagement of civil society may be a mitigating force. This would, however, require decreasing the current knowledge gap between space experts and civil society. Large ambitious projects such as reaching Mars do not hold much appeal for a society increasingly concerned with the cost of energy and global humanitarian and environmental crises.

[40] The assertion that expanding international commercial links dampens the likelihood of conflict is, of course, contested within international relations scholarship. For principal viewpoints on this question, see Robert O. Keohane and Joseph S. Nye, *Power and Interdependence: World Politics in Transition* (Glenview, Il: Scott, Foresman, 1989); Richard Rosecrance, *The Rise of the Trading State: Commerce and Conquest in the Modern World* (Basic Books, 1986); and Kenneth N. Waltz, "Structural Causes and Economic Effects," chapter 7 of *Theory of International Politics* (McGraw-Hill, 1979).

[41] Brand Steward, City Planet, Global Business Network, 2005 http://gbn.com/articles/pdfs/City-Planet_StewartBrand.pdf, accessed 18 November 2009.

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5. Conclusion

The results of the space scenarios workshop satisfied the conveners' goals of generating insights into how disparate key variables might interact in shaping long-term space futures, and in demonstrating the utility of scenario-building exercises in stimulating these insights. There was no attempt in the workshop to generate specific policy-relevant conclusions. Instead, the scenarios were generated, and are presented here, with the aim of stimulating thinking about such applications among a broader audience.

The conveners also anticipated the limitations of the scale of the exercise relative to the enormity of the focal question. For this reason, the workshop concluded with an evaluation of the process participants had just experienced, and a discussion of the opportunities and obstacles of potential future applications. Some of the following observations draw from that discussion.

As anticipated, one important merit of the process was that it generated constructive dialogue around complex issues. Common themes emerged even though participants came from diverse professional backgrounds. Thus there was a strong desire to continue the dialogue generated by the workshop, both to adjust for ongoing events and to examine some of the findings in more depth. Areas of potentially deeper analysis include specific turning points (such as those where conflict emerged), the implications of increasing the commercialization of space, and a breakdown of the involvement and interests of the various actors (states, institutions, non-state actors). The goal would be to project common elements likely to be in a family of international instruments cutting across public, private and communal sectors, or to identify codes of conduct.

Workshop participants did note that most were from North America, and that different sets of assumptions and conclusions may have emerged if the process was held with Chinese, Indian or European participants. This observation reinforced the conveners' pre-existing judgment: because successful scenario building depends upon the ''friction'' of diverse knowledge and outlooks, international participation would be vital to the success of more extensive exercises. Moreover, scenario analysis can also be an ideal vehicle for broaching sensitive topics in an international dialogue. Because the process is designed to identify shared critical uncertainties and focus on longer-term challenges, it is ideally suited to provide a forum wherein participants divided by contentious near-term issues can find a common basis for engagement. Thus, scenario-building exercises can yield community-building benefits independent of their substantive results.

In this vein, the process can also help generate ''buy-in'' among divided parties with very different interests to the minimal objective of identifying a shared set of long-term future concerns (as the Mont Fleur experience shows). It is not necessary for participants to possess, at the outset, common core values. It is sufficient that there be agreement on common *process* values within the exercise, the most important being commitment to the goals of the exercise and a willingness to think about matters imaginatively. Participants do not need to leave their opinions at the door – indeed, the ''friction'' of that diverse input is vital to the success of the process. They need only be ready and able also to view things from others' points of view.

Achieving that atmosphere also depends in part on the design and facilitation of the exercises. Particularly when incorporating international participation, it is essential to account for asymmetry of power among the participants. The success of the Mont Fleur process resulted, in part, because no authority had the power to enforce solutions.[42] That is not the case in the space domain insofar as the USA and other key actors do have disproportionate power, at least in the short run.

Another challenge in garnering greater international participation is the scope of the exercises themselves. Typically, scenario building and analysis involves a group of 20-30 people, a limit allowing for full participation. A single scenario-building exercise including representatives of all stakeholders both internationally and with respect to issue areas (security, commerce, etc.) would be ungainly in size. Useful results will require a design involving an iterated set of differentiated exercises.

Scenario analysis is a promising approach for developing visions of the future of space that can help build global consensus around values and contribute to more far-sighted government policy making. As noted earlier, the use of scenario analysis as a tool in international public policy making on issues of war and peace is nascent. But its utility with respect to the many issues enveloping the expanding human presence in space is particularly appropriate, both because of the high levels of uncertainty in two discrete dimensions (technological and sociological/political) and because the human emergence into space expresses the most visionary side of the human experience.

Many space enthusiasts today were weaned on the science fiction of the *Star Trek* television and movie franchise. Those familiar with the *Star Trek* universe know that behind its entertainment devices lies a vision of the future, several centuries hence, in which Earth is prosperous and peaceful, and humanity has joined a ''federation'' with other extraterrestrial sentient beings dedicated to benevolent interstellar exploration. Of course, galactic conflict still exists (the original series self-consciously overlaid Cold War political dynamics in its representations). Nevertheless, humanity was deemed to have progressed beyond potential collective self-destruction.

A closer examination of this vision, however, reveals a telling turn in the storyline: all this progress, both technological and social, originated with extraterrestrial contact.[43] That contact had both benevolent and malicious long-term implications; but above all the discovery of an interstellar ''them'' provided the foundation for the unifying conceptualization of a worldwide ''us'' to become the driving force of

[42] Adam Kahane, *Tough Problems: An Open Way of Talking, Listening, and Creating New Realities* (San Francisco: Barrett–Koehler, 2004).

[43] This plot element is most developed in the 1996 film, ''Star Trek: First Contact.'' See http://www.imdb.com/title/tt0117731/.

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human governance. This storyline is not so original, for human history is rife with examples of communities coalescing into larger entities precisely to fruitfully engage – or find protection from – other newly encountered communities.

Here is where the *Star Trek* vision fails us. We cannot depend upon the equivalent of a propitious Vulcan visitation to inspire us to discover the commonalities requisite to peaceful expansion of the human presence in space. Our destiny lies not in our stars, but in ourselves.

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