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High Road or Low Road: Where are we headed in the space arena?

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Abstract

We are starting the decade of the 2020s with much promise for space activities, in terms of new capabilities, new actors and new markets, but also much peril in terms of governance challenges, debris, orbital congestion, and a proliferation of counterspace activities. How will the space arena develop over the next 30 years? Will we be on a High Road to a bright future of space as an expanded sphere of human economic activity, characterized by international cooperation and the peaceful exploration and use of space for the benefit of all? Or will we be on a Low Road to a space environment threatened by poor governance, irresponsible actors, increased nationalism and the potential for conflict in space? We have used foresight methods to attempt to answer these questions by imaging a set of possible futures in the High Road and Low Road scenarios. We identify some potential signals for the emergence of these different types of scenarios.

Keywords: space governance, space sustainability, space security, space commerce, future studies

1. Introduction

Many who grew up in the Apollo era will recall the optimistic visions of the 1960s that portrayed humanity's destiny in space. Perhaps that optimism is best exemplified by Stanley Kubrick's 1968 film *2001-A Space Odyssey*, which was remarkably prescient for its time. The film portrayed a future in which human spaceflight in cis-lunar space is routine, and where commercial entities provide transportation and infrastructure to support space activities.

In the post-Apollo era, these grand visions of space as a common experience for humans kept being pushed forward in time – always 20 to 30 years in the future. It is only in the past ten years or so, with the mix of New Space, venture capital and wealthy visionaries such as Richard Branson, Elon Musk and Jeff Bezos who were willing to plough their personal fortunes into commercial space projects, that we have seen a tremendous acceleration in the pace of developments and a tremendous growth in the number and diversity of space actors.

We are also witnessing the emergence of completely new kinds of space activities that would be foundational for creating a future space economy. These activities include on-orbit servicing, refuelling, relocation, life-extension, end-of-life disposal, and active debris removal, which could all be viable commercial services. There is also potential for exploiting the characteristics of microgravity for developing new materials and new

medicines and medical treatments. The ability of spacecraft to operate safely in close proximity to each other and to manipulate and interact with each other will enable the manufacturing and assembly of very large structures in space that could never be launched from Earth. Many of these activities could be carried out by private sector entities for clients in the public or private sector. The emerging megaconstellations that are being put up by private sector actors could provide the impetus and market to develop a number of the capabilities mentioned above.

But there is also a dark side to all of these developments. The vast increase in the number of space actors has also led to concerns about growing congestion in space and the chances of satellites colliding to produce orbital debris which could threaten other space systems. This is on top of the debris already in space from the first 60 years of the Space Age. Many of the large legacy objects in orbit pose a collision hazard for active satellites as well as debris, giving rise to fears that were realized with the Cosmos 2251 – Iridium 33 collision in February 2009.

Another cause for concern is that the same technologies that allow on-orbit servicing and other close-proximity operations, can be weaponized to be used for counterspace operations. As more countries become critically reliant on their military space capabilities for national security and defence, they are taking steps to be in a position to deny, degrade or destroy the space capabilities of potential adversaries, giving rise

to concerns about a possible arms race in outer space, or irresponsible actions that could produce yet more debris.

And so, as we reflect on how the space arena might evolve, we must consider the interplay of a wide range of factors. How will these factors interact with each other over the next 20 – 30 years? What will the space arena of 2050 look like? Of course, it is not possible to predict the future with mathematical certainty, but one can take a few educated guesses at what several possible alternative futures *might* be like, and then to work backwards from there to try to identify developments and factors that seem to be leading us towards some particular futures and away from others. In this paper, we apply the methodology of scenarios to describe a range of possible future scenarios and explore the characteristics of those scenarios across the political, civil, commercial and military dimensions of space activities.

2. The role of scenarios in strategic foresight

Scenario planning is one of the tools that can be used to describe what the future may look like and the likely challenges of living in that future. Scenarios are not about what *will* happen. They are provocative pictures of what *could* happen. Scenario planning is a tool to help us understand how the world around us may change and how those changes might impact us. It also helps us to make decisions that can impact which scenarios play out over time.

The very act of articulating a vision of a desirable future gives us something to work towards. Conversely, articulating a vision of a very undesirable future suggests things we could or should do to avoid that future coming to pass. Therefore, the value of scenario thinking is that it provides perspective and context to guide present-day decisions about how to prepare for an uncertain future.

3. Boundary conditions for High Road and Low Road scenarios

For the purposes of this analysis, we will look at a timeframe of thirty years into the future, to the year 2050. The first step is to identify the drivers shaping the evolution of the environment. We have identified three dimensions for further analysis: humans in space; commercial potential of space activities; and space governance. This is not to say that these are the only factors shaping the evolution of the space arena, but they provide a useful lens through which to explore the dynamics of change. We will explore the limits of change in these three dimensions. The most optimistic limits in each dimension define the High Road and the most pessimistic limits in each dimension define the Low Road.

3.1 Humans in space (2050)

High Road

In the High Road scenarios for humans in space, thousands of people from many nations live and work in LEO, cis-lunar space, on the Moon, and perhaps even on Mars. This human presence drives commercial, civil and military developments in space. Artificial intelligence and robotics support a vibrant human space exploration program. Sustained space tourism and a human presence on Moon (and perhaps even on Mars) creates demand for logistics support from commercial space transportation, space manufacturing, and space resources utilization.

Low Road

In the Low Road scenarios, there are marginally more humans in space than the current levels. Mostly, humans still go to space for exploration and research, extensively supported by artificial intelligence and robots. Space tourism is only for a few ultrawealthy people. Humans have returned to the Moon, maybe even visited Mars, but there is no sustained human presence on either body.

3.2 Commercial potential for space activities (2050)

High Road

In the High Road scenarios, the volume and spectrum of commercial space activities have shown a phenomenal increase since 2020, with many new kinds of commercial space activities and services. These include on-orbit servicing, refuelling, debris removal, space manufacturing, space resource extraction and beneficiation, etc. Commercial space transportation has become highly reusable, reliable and increasingly affordable – even for private individuals. The space economy has grown to be worth several \$ Trillion and reaches several per cent of the global economy.

Low Road

In the Low Road scenarios, commercial space is basically the same as it is today. Profitable commercial space activities are confined to LEO/GEO applications for Earth observation, communications, and position, navigation and timing. Commercial space transportation remains risky, still largely relying on expendable vehicles, and remains prohibitively expensive. In these scenarios the space economy reaches perhaps 0.5%-1% of the global economy.

3.3 Governance of space activities (2050)

High Road

In the High Road scenarios for space governance, a shared global vision of space has emerged. This has enabled governments to agree on cooperative governance approaches to address challenges such as space debris, space resources and space security. States strive for common understandings on emerging challenges and adhere to international norms of behaviour. States have resolved the debris problem by removing legacy objects from the early days of the space age and enforcing strong environmental protection rules to keep important orbital regions usable. Space is a rules-based domain where non-State actors behave responsibly and where States agree not to pursue courses of actions that could lead to tension & conflict in space.

Low Road

In the Low Road scenarios for space governance, many more countries are operating in space, but there is no collective global vision for our future in space. Governance in space has become a fragmented patchwork that extends the existing international order, rivalries and tensions on Earth to outer space. Nationalism dominates, resulting in unilateral interpretations of international instruments and unilateral actions. Multilateral fora have become weak and ineffective. Counterspace capabilities have proliferated, and conflict in space has ensued, adding to the debris problem. In the absence of collective action, the debris problem has grown to the point that certain orbits are effectively rendered unusable. Unscrupulous actors exploit the lack of regulatory clarity to behave irresponsibly, motivated only by self-interest, and outer space becomes the Wild West.

4. Critical axes of uncertainty

Having identified the boundary conditions, we now identify the critical axes of uncertainty, which describe the alternative ways in which a critical uncertainty will play out. These axes of uncertainty will delineate our space of possible futures. Axes that come to mind include: Commercial Space; Governance; Political Factors; and Humans in Space. One can readily think of other potential axes of uncertainty.

The important thing is that one assumes that the axes are independent of each other. This is usually strictly not the case, because the phenomena in all the axes are interconnected at some level in the real world, but the point is that we are setting up a framework for thinking about the issues, and not defining an orthogonal mathematical coordinate system.

For the purposes of the analysis presented in this paper, we have chosen Commercial Space and Governance as our two critical axes of uncertainty. The Governance axis captures the extent to which States have managed to address governance issues internally and as part of the community of nations. This axis spans from weak, ineffective and fragmented governance at the one extreme, to strong, enabling cooperative governance at the other extreme. The Commercial Space axis captures the extent to which commercial space activities are a dominating force in the future space arena. This axis ranges from a situation where commercial space languishes and represents a tiny fraction of the global economy, to a situation where commercial space activities are driving the development of the space arena, creating a vibrant and sustainable economy *in space* that is part of the normal human experience in 2050.

5. Some possible scenarios

Figure 1 presents four possible scenarios, which we refer to as *2001*, *Avalon*, *Tartarus* and *Elysium*. The most optimistic of these, *2001*, represents a future in which strong governance and strong commercial space activities create the conditions under which humanity is starting to pursue its destiny in space, as envisaged in the film *2001*. The second scenario, *Avalon*, represents a future in which the world has managed to come together to address global challenges on Earth and in space, but society has chosen to focus on humanity's destiny on Earth, rather than in space. Human spaceflight and space exploration continue to be pursued largely as government activities and the commercial sector has turned its attention to addressing issues and markets on Earth. The third scenario, *Tartarus*, describes a bleak future in which States have failed to come together to address global challenges. Space governance has become fragmented and space activities are pursued in support of nationalistic agendas. The space environment has become highly degraded by space debris, as a result of the lack of coordinated efforts to address the issue and due to some armed conflicts in space. What few commercial space activities exist are in support of State agendas. Human spaceflight is conducted almost exclusively by governments. The fourth scenario, *Elysium*, describes a future in which governance is weak and fragmented, and the commercial sector has stepped up to fill the governance void to be the player, referee and rule-maker. Large corporations pursue very lucrative commercial space activities in orbit, cis-lunar space, on the Moon, and perhaps even on Mars, involving many humans living and working in space. Space is part of the experience of wealthy elites, but this booming space economy has left many people behind.

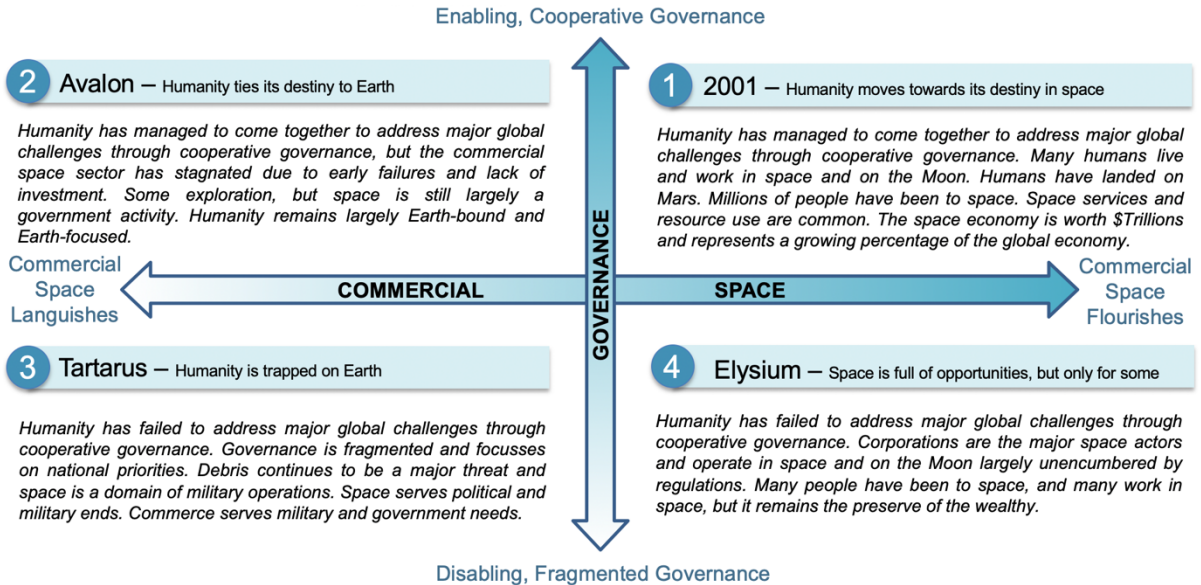


Fig. 1. Four possible future scenarios for the evolution of the space arena by 2050.

In considering these possible futures, one should not pick just the scenario that one likes best or thinks most likely, but rather look across the possible futures to prepare in a structured way to pivot and adapt quickly as circumstances change. One should also not dwell too much on the details of the scenarios or the nuances of the two axes. Scenarios are not meant to provide detailed predictions or solutions for specific issues. This sort of scenario thinking is what enabled Shell to anticipate the Arab oil embargo in 1973, and later to anticipate and prepare for the dramatic drop in oil prices in the 1980s.

The ability to anticipate future developments comes from monitoring the environment for signals that indicate which scenarios are coming to life. These signals can be thought of as the kinds of newspaper headlines one might encounter as a given scenario unfolds. We now consider these signals in light of the four scenarios painted in Fig. 1.

- Scenario 1 *2001* – Signals that this scenario is emerging:
 - States agree on international norms of behaviour, a ban on kinetic ASAT tests, rules on space resource utilization;
 - An international space traffic management regime is implemented;
 - Investment in commercial space continues to rise year-on-year;

- More terrestrial companies extend their businesses to/through space;
- Commercial human space flight becomes viable, safe, affordable and routine.
- Scenario 2 *Avalon* – Signals that this scenario is emerging:
 - States agree on international norms of behaviour, ASAT test ban, rules on space resource utilization;
 - An international space traffic management regime is implemented;
 - Investment in commercial space dwindles, the commercial sector consolidates;
 - Governments focus on space for societal benefit, sustainable development on Earth and combatting climate change;
 - Commercial human space flight remains risky and expensive.
- Scenario 3 *Tartarus* – Signals that this scenario is emerging:
 - States fail to agree on international norms of behaviour or an ASAT test ban in LEO;
 - Multilateral fora become weak and ineffective talk shops;
 - Poor adherence to space debris mitigation and space sustainability practices;
 - Investment in commercial space dwindles, the commercial sector consolidates;
 - Counterspace capabilities proliferate;

- Commercial human space flight remains risky and expensive.
- Scenario 4 *Elysium* – Signals that this scenario is emerging:
 - States agree on international norms of behaviour, a ban on kinetic ASAT tests, rules on space resource utilization;
 - Multilateral fora become weak and ineffective talk shops;
 - Investment in commercial space continues to rise;
 - Companies initiate and fund ambitious space projects that amount to “resource grabs” in space;
 - Growing influence of companies in government decision-making processes about space.

It stands to reason that related scenarios will have many signals in common. However, each individual scenario will have a one or more distinct “signpost” signals that will serve as an early warning signal as to how a key uncertainty in the scenario framework is unfolding. Detecting these signpost signals requires constant scanning of the environment to seek out both qualitative and quantitative evidence of change. This includes scanning journals, the trade press and popular magazines. One should also include trending topics on social media, changing billboards, the trending topics of conferences, and headlines of all kinds.

6. Conclusion

The space arena is going through a period of rapid growth and evolution, characterized by an increase in the number and diversity of space actors and space activities. Space is becoming increasingly congested, contested and competitive. At the same time, it is also becoming increasingly communal, cooperative and commercial. Two significant axes of uncertainty are governance and commercial space activities. How will the trends in these two axes play out over the next 30 years? Fortunately, one does not have to predict *the* future to be able to prepare for it. Scenario planning offers a way to explore possible futures in ways that support decision-making in the present.

We have used a scenario planning approach to develop a set of global scenarios in these two axes. These scenarios are not specific predictions of the future. They are imaginary contexts that allow us to test how our current strategies and tactics would work in those contexts. They force us to look at our assumptions from a fresh perspective and provoke us to consider whether we are operating under the implicit assumption that one of these scenarios may be the “expected future” and to consider whether we need to hedge against the possibility of another future emerging. This is a work in progress. A more detailed analysis will be presented in a future publication.