What Commercial Space Told Space Force About 2032 and Beyond

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The United States Space Force (USSF) was established in 2019 in response to the rapid growth of space as a critical domain for national security. To help balance short-term demands with long-term strategy, USSF has embarked on an integrated program of strategic foresight exercises that build upon the North American Treaty Organization's (NATO) Strategic Foresight Analysis. These iterative exercises have engaged government, academic, and commercial participants to envision a range of possible futures with a particular focus on science and technology development, ultimately contributing to the body of strategic information that help guide USSF's role and scope into the future. Our research serves to supplement this USSF strategic foresight effort. More specifically, this paper focuses on the results of a survey regarding the future of space in the years 2032 and 2045. The survey was administered in 2023 by NewSpace Nexus and garnered over 500 raw responses. Respondents were largely U.S. citizens from the commercial industry with more than 10 years of professional experience. Comparing 2032 to today, respondents indicated that commercial and government investment in space would increase, as well as competition among nations and the pace of scientific and technological advancements. Respondents envisioned increasing space activity and people in space. While they predicted continued U.S. leadership in space, almost three quarters said that spacepower advantage would be essential to national security, with less than 1% calling it irrelevant. Looking to 2045, respondents saw new capabilities providing opportunities for new leverage in spacepower advantage. To boost spacepower advantage, respondents prioritized investing heavily in research, development, science, and technology. Respondents indicated that the commercial sector should lead investment in most capabilities but that a military space force should be responsible for defending them. Statistical analysis of responses yielded widespread agreement across different demographics and responses. Statistically significant differences were identified and analyzed between government and commercial respondents and between respondents with distinct levels of experience. Echoing the results and insights outlined in this paper back to their source in industry may illuminate useful trends for companies, investors, and policymakers and may stimulate more discussion between industry and national security professionals on these important topics.

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I. Nomenclature

df	=	degrees of freedom
F	=	F Statistic
N	=	natural number
p	=	probability

II. Introduction

Advances in science and technology drive changes in capabilities in every domain. The emergence of a new capability can shift patterns of operations abruptly and unpredictably. In some cases, it can provide accelerating advantage to those who possess that capability, opening the door to significant geopolitical disruption and threats to national security. Advances in science and technology, however, can require investments in time and money that generate uncertain returns in a non-linear fashion. These investments must compete with the immediate needs of the service and require thoughtful prioritization. The objective of the strategic foresight work is not to predict the future. Instead, it is to apply that necessary thoughtfulness to the prioritization of uncertain investments. It asks what technologies may evolve over time, what space-related capabilities may result from those technologies, and which of those space-related capabilities may provide the highest level of new strategic advantage. Those questions are probed using different techniques over different time horizons and with different participants from government, academia, and commercial industry in separate events, increasing the diversity of perspectives and reducing the likelihood of unanticipated technological disruption. A key investment itself, the USSF strategic foresight effort provides information that supports the identification of strategies and investment portfolios that ensure the military service is prepared to possess and defend strategic capabilities, as well as to deny them to potential adversaries, if necessary.

In this paper, we will focus on the foresight work with industry so far, which has been administered for the USSF by NewSpace New Mexico (now NewSpace Nexus). The goal of this work was to gather commercial views on the future of space. Some other workshops, conferences, and studies that join industry with defense look at what the military needs and ask what companies are doing to support the military's objectives. The approach in this case was different. This effort was designed to understand and quantify industry perspectives on what space will be like in the future, independent of military interests, even if not necessarily exclusive of them. With those perspectives laid out, we explored implications for USSF strategy and investment, including the role of USSF in defending lines of commerce in space.

To provide background, we will very briefly highlight topics covered in the 2022 Space Futures Workshop with Industry and its attendant pre-workshop survey of participants. A formal report resulted from both of those efforts, "Commercial Planning Assumptions for the United States Space Force: Findings from the Space Futures Workshop with Industry" [1]. The remainder of the paper will investigate the results of a new and previously unpublished survey of commercial space, "20 Questions About Space in 2032 and Beyond" [2], hereinafter referred to as "20 Questions." We will review the goals and results of the survey, along with a statistical analysis of response patterns, and provide a roadmap for the path forward. We also outline limitations and future research.

III. Background

NewSpace Nexus on behalf of the Headquarters USSF Office of the Chief of Space Technology and Innovation (HQ USSF/CTIO) organized and conducted the Space Futures Workshop with Industry on 29-30 November 2022. Prior to the workshop and to set the stage and framework for discussions, invitees were given the opportunity to complete a pre-workshop survey that gathered quantitative data on participants' visions for space capabilities in 2032 and the implications of those visions for United States (U.S.) national security. 69 individuals representing a mixture of early, mid, and later career professionals and working in commercial, defense, academic, and non-profit organizations responded to the pre-workshop survey. They considered five categories of space capabilities, data, logistics, visibility (or observation), industrial foundations, and human presence. The five categories encompassed 50 individual capabilities.

Building upon the framework set with the pre-workshop survey, the Space Futures Workshop with Industry involved 61 participants from the commercial space industry, USSF, Air Force Research Laboratory (AFRL), and Defense Innovation Unit (DIU). The workshop's goal was to quantify the state of commercial space in 2032 and 2045 and the implications of those states for the USSF, specifically, the commercial space capabilities that the USSF could use or exploit in joint operations and may be required to fund, defend, or deny. The workshop aimed to understand and quantify impressions on the state of commercial space capabilities in these timeframes to inform long-term USSF strategic planning and investments.

The workshop and pre-workshop survey both included a characterization of space activity in 2032 in general and in each of the five categories of space capabilities. During the workshop, working groups selected top capabilities in each category and the metrics by which those capabilities could be measured. Then the working groups estimated a potential range in those metrics. Top capabilities that would need to be defended or denied to potential adversaries were explored in both the pre-workshop survey and workshop, as well as top capabilities that could be useful for joint military operations with space as both a supporting and a supported domain. Then the likelihood that a capability would be commercially available by 2032 was considered and quantified. Finally, vignettes describing possible 2045 scenarios relating to national security and commercial space operations were created and discussed in the workshop. The pre-workshop survey also sought to characterize the five categories of space capabilities with respect to importance, advancements, activity levels, U.S. leadership, and the need to be defended, as well as dual usefulness for both joint military operations and defending lines of commerce. The results of the workshop and prior survey are summarized in the official report [1].

IV. Method

A. Survey Design

Based on the information gleaned from the previous work, a new survey, 20 Questions, was developed to zoom in on the top capabilities identified from the pre-workshop survey and workshop. This new and previously unpublished online survey, detailed in the appendix, benefits from factors that differentiate it from the prior work in the pre-workshop survey and workshop. It was designed after the execution of the workshop and the interpretation of the pre-workshop survey results. As a result, it could focus on the top capabilities that emerged from the prior work, rather than on all of the capabilities in each of the prior five categories of space capabilities. Table 1 shows the count of individual capabilities explored in the different space futures exercises with industry, the prior survey, the workshop, and 20 Questions. It demonstrates that we reduced the total number of individual capabilities from 50 to 17. 20 Questions covers the state of space in 2032 as before but also explores opinions on the relationship between spacepower advantage and national security, as well as the distribution of responsibilities to invest in and defend capabilities. The survey also benefited from a larger distribution and resulting dataset, which allowed us to pursue statistical analysis of the results.

Table 1. Number of Individual Capabilities in Each Category Explored in Each Space Futures Exercise

Capability Categories	Description	Prior Survey	Workshop	20 Questions Survey
Data	Processing, Transfer, Communications, Internet, Cybersecurity	8	8	5
Visibility	Earth and Space Observation, Space Domain Awareness	10	10	2
Logistics	Launch, Transport, Mobility, Servicing	10	10	5
Industrial Foundations	Manufacturing, Mining, Construction, Materials Processing, Power	11	11	4
Human Presence	Habitats, Food, Sanitation, Life Support, User Interfaces, Medical	11	11	1
Total		**50**	**50**	**17**

20 Questions was designed to be distributed publicly to capture a larger dataset from the space ecosystem. For the exact phrasing of all 20 questions, please see the Appendix. Questions will be referred to as the capital letter Q followed by the question number.

20 Questions was developed in four sections to usher respondents through the questions. Section 1 covered the demographics of the respondent and included four questions. The goal was to assess perspectives from commercial space industry, but a survey for public distribution will have respondents across a variety of demographics. Q1 asked about primary citizenship to understand data trends between U.S. and international respondents. Q2 asked for career stage. If responses differed among earlier career, mid-career, and later career respondents, then the data might offer some insight into predictive trends over time. Q3 asked for organization type, including small, mid-sized, large, and very large commercial companies, civil and defense government organizations, NGOs, and academic organizations. These data would allow for the identification of differences in various aspects of perceived space futures. Q4 asked whether the respondent would go to space if they could. This question was designed to attempt to identify bias toward the importance of space. If the data showed no difference between those who reported wanting to go to space and

those who reported not wanting to go to space, then the overall results might possibly have more credibility with an audience of defense leaders not focused on space in particular.

Section 2 of the survey addressed the big picture and included six questions. Q5 asked about which from a list of societal trends would be greater in 2032 than today. This was intended to put predictions for space futures into a broader context. Q6 asked how many people will be in space at any given time in 2032. This was intended to provide context for how the respondent views the balance of human versus non-human assets in any predictions of growth or change. This was the first question that also provided an opportunity for comment and asked, “Why do you believe this will be the case.” Q7 asked about the change in the level of space activity and assets between now and 2032 and also offered the opportunity to explain why the selected answer was given. This was intended to capture a broad view of the trajectory of the space economy. Q8 had two parts. For a list of 16 capabilities listed in Table 14 in the Appendix, it asked which would have the greatest technological advancement and which would have the greatest increase in activity level between now and 2032. Each respondent was to select five capabilities from the list for each of the two parts of the question. For the same list of 16 capabilities, Q9 asked whether commercial, civil, or national security should lead investment in the development of that capability. Respondents could indicate that no sector should invest at all. This was to help guide USSF on investment priorities and respondents’ impressions of USSF’s responsibilities. Q10 asked whether the owner/operator or a military space force should be responsible for defending from attack each of the same 16 capabilities as in earlier questions. This provided data on the perceived scope of USSF’s future responsibilities to commercial industry.

Section 3 of the survey introduced the concepts of spacepower, as described in early USSF doctrine [3], and spacepower advantage. It had six questions. Spacepower is defined in 20 Questions as the entire astronautical capability of a nation. Spacepower advantage is the relative advantage one nation has over another with respect to its spacepower. Lacking or losing spacepower advantage can result in comparatively less diplomatic, informational, military, and/or economic power. Q11 asked how important spacepower advantage would be to national security in 2032 and offered the opportunity for comments. Collecting data on this relationship was important because it might inform challenging decisions about the prioritization of investments. Q12 also had two parts. For the same 16 space capabilities as before, it asked which would be most important to spacepower advantage in 2032 and 2045. Respondents were asked to select five capabilities for each year. This is the first question in which respondents were asked about 2045. The purpose of this question was to prioritize capabilities and then investigate how those priorities might evolve over time. In Q13 and Q14, the same sort of information was sought as in Q12’s two parts. In the case of those new questions, we asked the question in a new way. If a capability is important to spacepower advantage, we postulated, then a nation might regret underinvesting in its development. Q13 asked how much a nation in 2032 would regret falling behind in 11 capabilities due to underinvestment by government. The 11 capabilities were considered more near-term concerns. Q14 asked the same question for 2045 but included a different but overlapping list of seven capabilities that lean a bit more into the future. Q15 had two parts and asked which of seven capabilities would provide the greatest new leverage in spacepower advantage in 2032 and 2045. This question’s two parts provided another opportunity for respondents to reflect changing priorities over time that may require current investment across technologies that might become important at different times in the future. Respondents were given the opportunity to comment on their reasoning. Q16 asked when seven emerging space capabilities would be commercially and operationally available. This question was asked to test alignment between respondents’ expectations of timing of development with their estimates of importance at a given time.

Section 4 had four final questions that delved deeper into spacepower advantage with an international angle. Q17 asked how much the respondent’s country’s spacepower advantage will increase or decrease between now and 2032. This question was designed to gather perceptions not only on U.S. leadership in space but also how other countries were perceived. Q18 asked respondents to predict what country or group of countries would lead each of four categories of space capabilities in 2032, specifically, logistics, industrial activity, enabling technologies, and data/information/communications. This question was designed to draw out perceptions of where the U.S. faced the largest threat of being surpassed. It was thought that comparing this question to others in Sections 3 and 4 may give some insight on whether the threat of falling behind is timely or important for the U.S. Q19 asked respondents to rank actions that could most support spacepower advantage. Q20 asked for any additional comments. No question on the survey was required, and respondents were informed that they could skip any questions and still submit the survey.

B. Data Collection

The survey was administered in Survey Monkey, the hyperlink for which was distributed by NewSpace Nexus via email and LinkedIn posts to an intended audience of commercial space professionals. The public nature of the survey's distribution, however, allowed responses to come from a broader community, as outlined in Section V. Responses were collected between 13 March and 29 May 2023, with most responses being submitted by 17 April 2023. A small wave of 37 additional responses after 8 May 2023 was a result of publicizing the survey at the State of Space Industrial Base conference in Albuquerque, New Mexico, and online.

V. Analysis & Findings

Analysis of data was executed in a multimethod manner, and no personal information was used in any of the methods of analysis or interpretation. First, frequency analysis using Microsoft Excel (Version 2403) was performed to glean an initial understanding of respondent opinions. A qualitative analysis was also performed on respondent comments to identify key themes and gather insights into respondents' rationales for their responses. Finally, statistical analysis ensued to understand significant associations and differences among key demographic groups. The results of each of these methods are detailed in the following subsections.

A. Responses and Initial Findings

The survey received a raw dataset of 526 responses. 390 respondents answered at least one question beyond the demographic section. The survey also gathered 1,157 total comments on Q6, Q7, Q11, Q15, Q18, and Q20 combined. The results of the initial frequency analysis using this smaller dataset of 390 respondents are shown in Figures 1 through 14 and Tables 2 and 3 below and included all responses provided for each individual question, except where otherwise indicated. We utilized both manual binning and OpenAI large language model, ChatGPT (GPT-4o), to synthesize comments by question. (AI was used only as part of the analysis of the comment responses, and any outputs used were edited. No other aspect of this paper leveraged AI.) In the later section on the statistical analysis, further work was performed on data quality, and a cleaner subset of data was used.

Figure 1 shows the results of the demographic questions in Section 1 for 390 respondents who answered at least one question outside of the demographic section. Thus, data shown in this section and in the appendix provide relatively raw data. A heavy weighting of responses for wanting to go to space precluded a statistically significant comparison of the two populations, so whether a desire to go to space is correlated with more bullish responses remains untested.

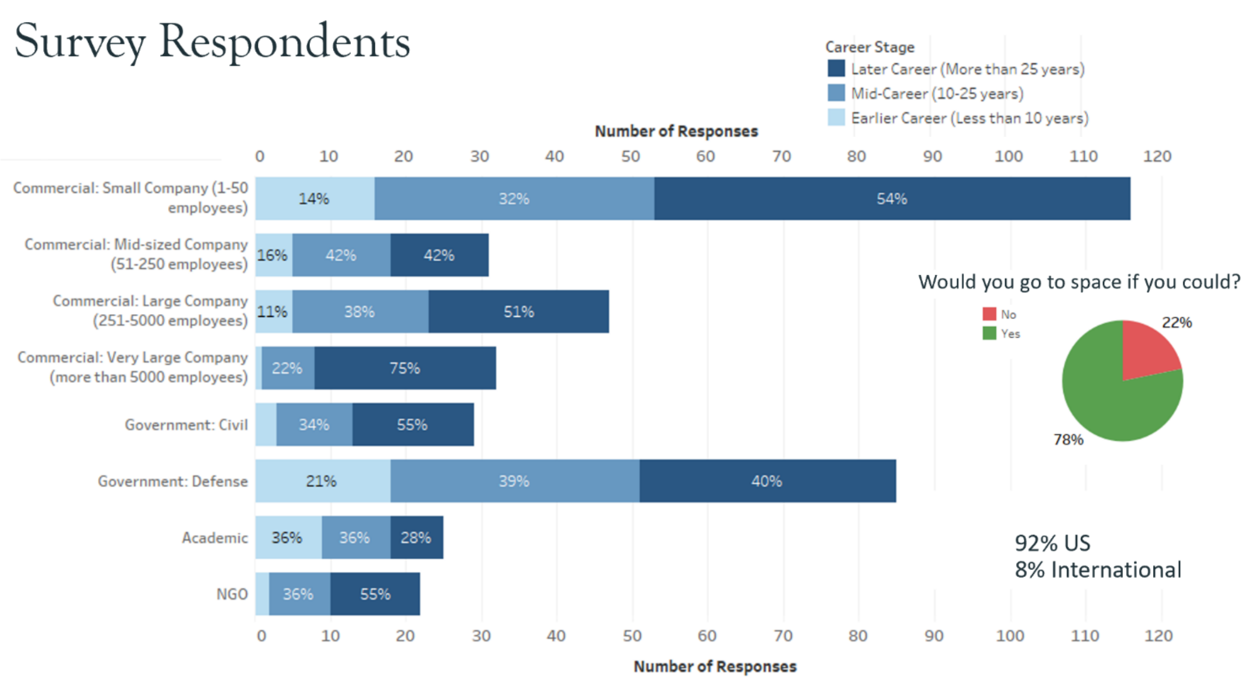

Fig. 1 Demographic responses (N=390)

Figure 2 shows all 390 responses to Q5. Greater than half of respondents indicated that investment by all categories, competition among nations, and the pace of science and technology developments would be greater in 2032 than today. Effectiveness of legislation and regulation and global economic health were each selected by only about a quarter of respondents.

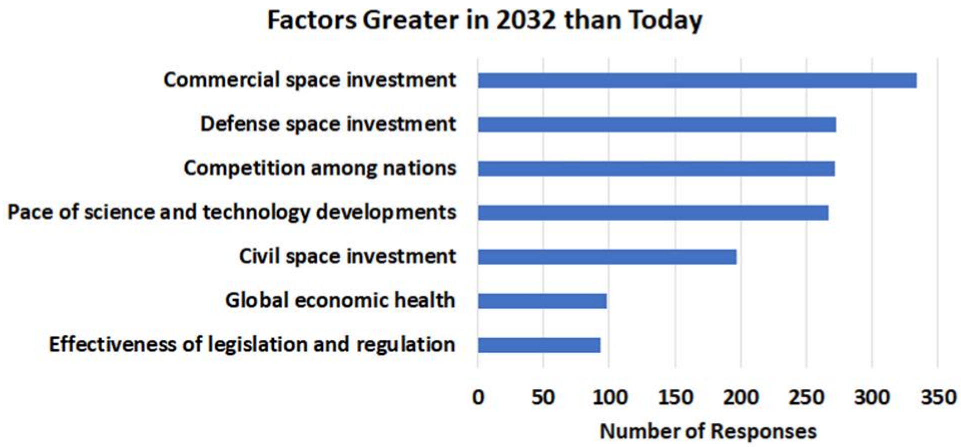

Fig. 2 Q5 responses (N=390)

Figure 3 shows all 390 responses to Q6. The most respondents selected 21-50 people in space.

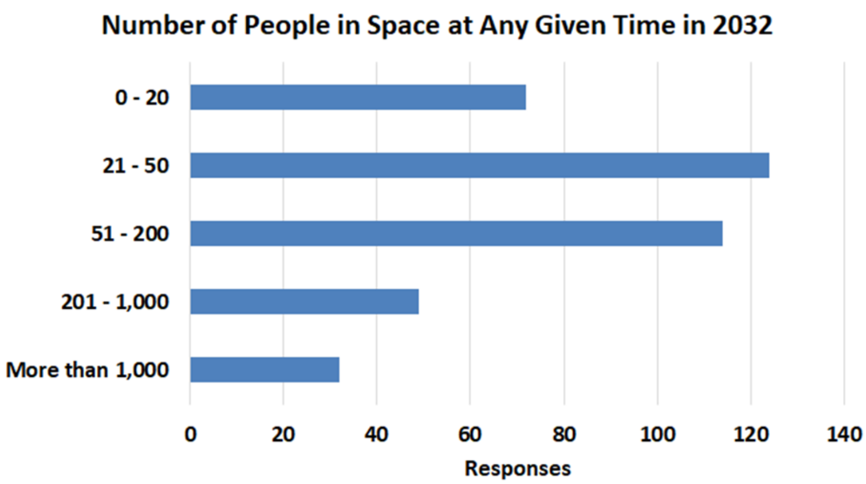

Fig. 3 Q6 responses (N=390)

332 out of 390 people (85.13%) that answered Q6 provided a comment to the question "Why do you believe this will be the case?" At the time the survey was administered, there were fewer than ten humans in space while a total of 51 people traveled to space in 2023. The more pessimistic respondents who answered "0-20" (18.41%) cited high costs, technology challenges, slow pace of infrastructure development, and limited business incentives. There was also a sense by many of these respondents that robotics are more efficient and better suited for operations in space. On the other hand, the most optimistic respondents selecting "more than 1000" (8.18%) believed that the accelerating pace of innovation and investment would make space more accessible to a broader population. They foresaw rapid advancements in space technology, cost reduction, and increased commercial and infrastructure development over the next decade that would enable large-scale human presence for living and working in space. Respondents who answered "21-50" (31.71%) cited expanding commercial ventures and national space program activities, including multiple space stations and some lunar activities, but believed these developments will be in early stages and not sufficient for large-scale human presence. These respondents highlighted the potential for more space tourism and a mix of scientific and exploratory missions. They also expressed skepticism about rapid growth, however, pointing to financial,

technical, and regulatory hurdles. Those who answered “51-200” (29.16%) projected significant advances in commercial space travel and tourism. They envisioned several space stations, lunar outposts, and emerging space industries, such as mining and manufacturing. Lower costs of space travel increased global competition, and the development of more robust space infrastructure were seen as key drivers. Despite this optimism, they acknowledged challenges and programmatic inertia as reasons for not achieving more widespread human presence in space. Finally, those who selected “201-1000” (12.53%) cited similar reasons and were more optimistic about the rise of space tourism and manufacturing, along with the strategic importance of research activities on the Moon as major factors. Those respondents also mentioned the necessity of maintaining human presence for economic and exploratory purposes, projecting a more extensive human footprint in space.

Figure 4 shows all 389 responses to Q7. 2 to 5X greater received the highest number of responses.

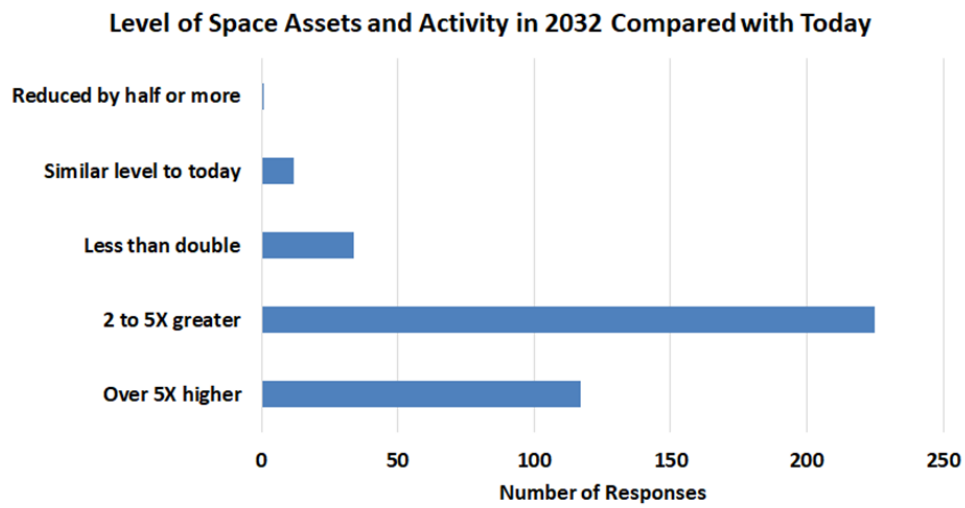

Fig. 4 Q7 responses (N=389)

309 out of 389 people (79.43%) that answered Q7 provided a comment to the question “Why do you believe this will be the case?” Respondents selecting “2 to 5X greater” (57.69%) anticipated significant growth driven by commercial expansion, government and private investments, and technological advancements. They expected a surge in low Earth orbit (LEO) constellations, new commercial ventures, increased international competition, and more cost-effective access to space. They foresaw a plateau in growth, however, once current technological advantages are fully leveraged. Those that answered more optimistically “over 5 times higher” (30.00%) envisioned an exponential growth fueled by technological advancements, decreasing launch costs, and a booming commercial space economy. They highlighted the potential for mega constellations, increased interest from non-state entities, and the emergence of new markets such as space tourism and lunar exploration. The rapid pace of current advancements and the expanding role of space in global infrastructure underpinned their optimistic outlook. Those expecting “less than double” (8.72%) compared to today believed that progress will be steady but not rapid enough to double by 2032. They mentioned the high costs and complexity of space endeavors, a slow growth rate for space startups, and economic and geopolitical challenges. Incremental advancements and a cautious pace of development are anticipated, along with a shift towards more small satellites and commercial partnerships. Those predicting “similar to today” (3.08%) cited challenges such as the need to deorbit old systems, space congestion and debris, and shifting priorities towards addressing climate and environmental issues on Earth. Economic constraints, policy limitations, and insufficient funding were also seen as barriers to significant growth. The individual who selected “reduced by half or more” (0.26%) believed that technological advances would allow the industry to do more with fewer assets.

Figure 5 shows the 385 responses to both parts of Q8. The differentiated focus of each part is labeled in purple text in the title, and the selections are ordered from most selected at the top to least selected at the bottom for each part, with the top five selections for each part shown in green text. Heavy launch and maneuvering appeared in the top five selections on both parts of the questions. In addition, satellite servicing, autonomy via artificial intelligence (AI), and manufacturing were most selected for greatest technological advancement, and space domain awareness (SDA), communication, and earth/space observation were most selected for greatest increase in activity.

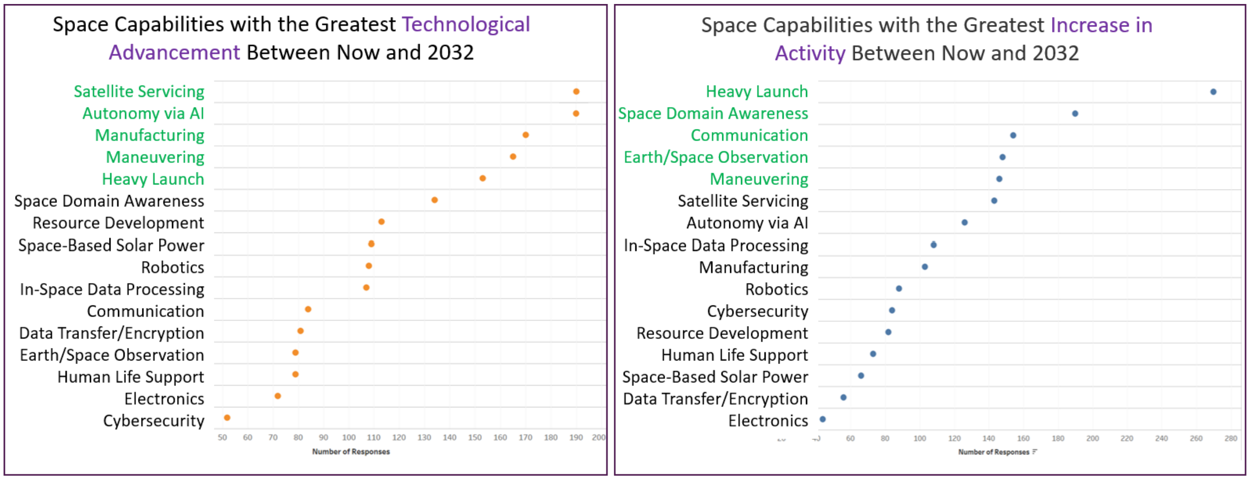

Fig. 5 Q8 responses (N=385)

Table 2 summarizes which sector was selected by most respondents to lead investment in each capability in Q9.

Table 2. Sector That Should Lead Investment in Each Capability (N=381)

Commercial	National Security	Civil
Heavy Launch	Cybersecurity	Human Life Support
Manufacturing	Data Transfer/Encryption	
Electronics	Space Domain Awareness	
Servicing		
Robotics		
In-Space Data Processing		
Resource Development		
Autonomy via AI		
Maneuvering		
Communication		
Space-Based Solar Power		
Earth/Space Observation		

Table 3 shows which entities respondents most selected in Q10 for defense by the owner/operator and by a military space force.

Table 3. Entity That Should Defend Each Capability (N=376)

Owner/Operator	Space Force
Robotics	Space Domain Awareness
Electronics	Cybersecurity
Manufacturing	Communication
In-Space Data Processing	Data Transfer/Encryption
Autonomy via AI	Earth/Space Observation
Resource Development	Maneuvering
Servicing	Space-Based Solar Power
	Heavy Launch
	Human Life Support

Most respondents to Q11 indicated that spacepower advantage would be essential to national security in 2032, as shown in Figure 6.

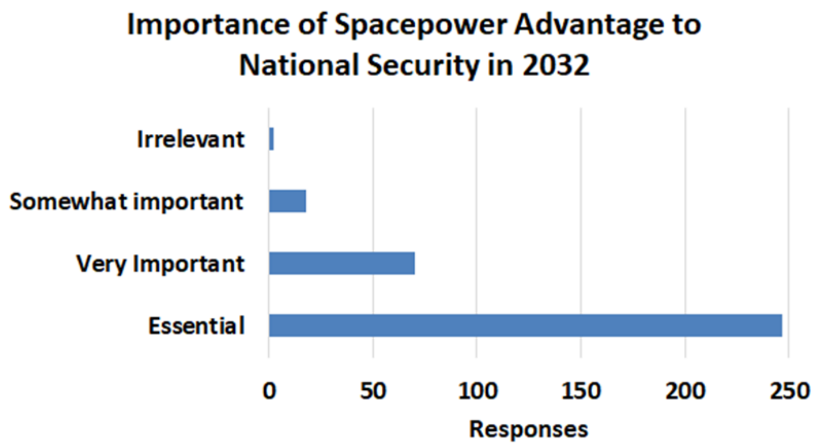

Fig. 6 Q11 responses (N=337)

226 out of 337 people (67.06%) that answered Q11 provided a comment to the question "Why do you believe this will be the case?" Those who responded "essential" (73.29%) argued that it will become the foremost domain of power projection and control, surpassing even nuclear capabilities. They emphasized that space systems are vital for various aspects of modern life, from banking to military operations. Controlling space was seen as crucial for maintaining global leadership and protecting against potential adversaries. They believed that dominance in space will be the defining factor of a nation's overall power, necessary for defending critical infrastructure and ensuring economic and geopolitical stability. The importance of setting norms and maintaining space security to prevent hostile actions was also stressed. Respondents who selected "very important" (20.77%) highlighted its current critical role in intelligence, communication, and military operations. They stressed that space is increasingly essential for national defense and economic stability. The concept of space as the ultimate high ground was frequently mentioned, along with concerns about maintaining a balance of power, particularly regarding China and Russia. They foresaw a future in which space assets are integral to day-to-day life and military strategy, requiring robust protection and continuous investment. The potential for orbital threats and the need to safeguard critical infrastructure were also noted. Those who thought spacepower will be somewhat important (5.34%) acknowledged its growing significance but emphasized that many other factors will remain more crucial. They argued that defense should focus on Earth-based threats while allowing space to grow commercially. Some hoped for a more cooperative international approach to space, similar to cooperation they perceive to be ongoing on the International Space Station. They believed economic and terrestrial military power will still dominate and that the world will be more multipolar, distributing influence among various nations. Additionally, they pointed to ongoing regional conflicts and technological limitations that could prevent spacepower from becoming a decisive factor. Only one person (0.59%) chose "irrelevant," noting the fragility of the space environment and the perception that spacepower has reached a point of diminishing returns, where additional investment yields minimal strategic advantage.

For Q12, SDA and heavy launch were selected as the most important capabilities for spacepower advantage in 2032, with communication, observation, and cybersecurity rounding out the top five, as show in Figure 7. As in Figure 5, the selections are ranked from most selected at the top to least selected at the bottom, and the top five selections are shown in green text.

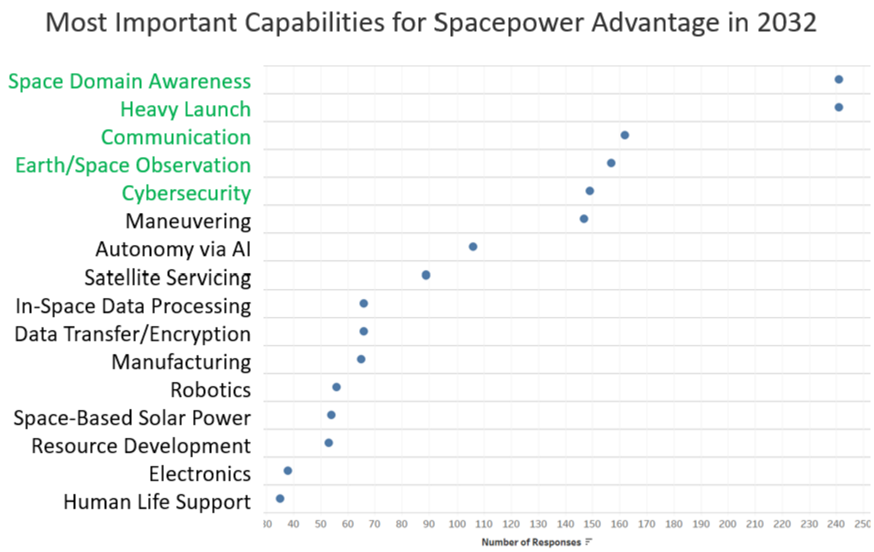

Fig. 7 Q12, part 1, responses (N=330)

Figure 8 shows that in 2045, SDA was still selected as a top capability for spacepower advantage, with resource development, maneuvering, satellite servicing, and space-based solar power rounding out the top five. Selections are ordered from most selected at the top to least selected at the bottom, with the top five selections shown in green text. This significant change in what was perceived by respondents to influence spacepower advantage between 2032 and 2045 suggests that broader investment in technology development for both near-term and long-term futures is necessary.

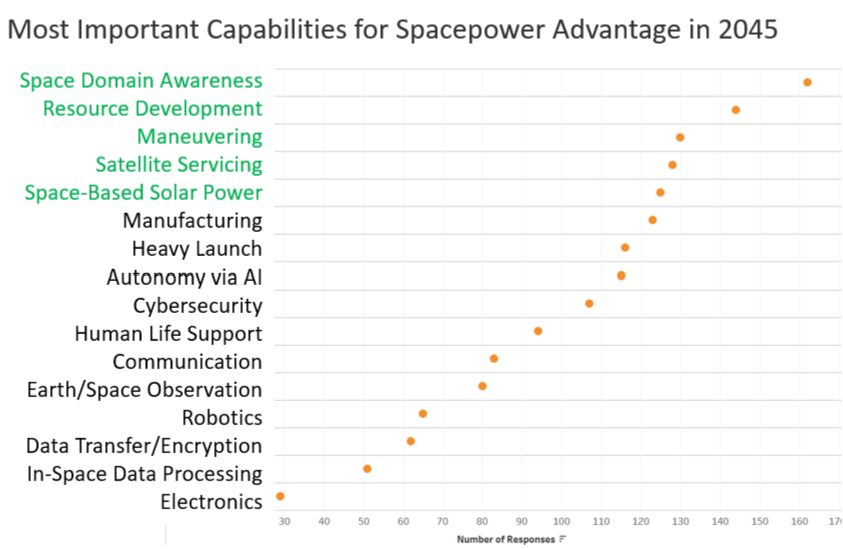

Fig. 8 Q12, part 2, responses (N=330)

When asked about regret in Q13, respondents allocated the highest response rates of high regret to cybersecurity and SDA followed by communications and data transfer/encryption. The highest response rate of no regret was assigned to human life support. Figure 9 shows increasing levels of regret in progressively darker shades of blue. The capabilities with the highest levels of high regret are shown in red text, and the capability with the highest level of no regret is shown in green text.

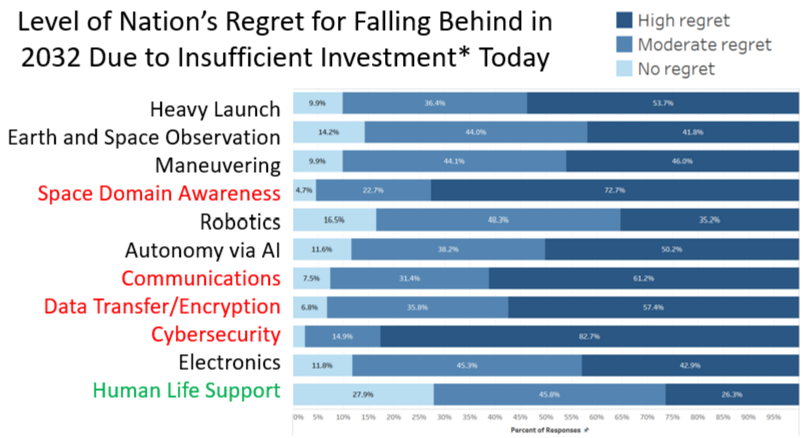

Fig. 9 Q13 responses (N=326)

For 2045 (Q14), little difference in levels of regret was indicated among these seven capabilities, as shown in Figure 10. Colored text was not used in this case due to the similarities in responses.

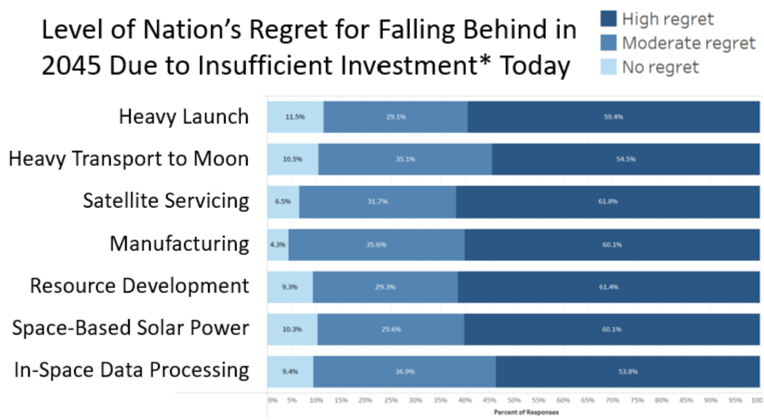

Fig. 10 Q14 responses (N=325)

Figure 11 shows the two parts of Q15, which asked about the greatest new leverage in spacepower advantage in 2032 and 2045, respectively. In each plot, capabilities are ranked from top to bottom, with the top selections highlighted in green text. The complete reversal in the top priorities selected among seven capabilities for generating new spacepower advantage in 2032 versus 2045 could again indicate that technology development across a wide spectrum for near-term and long-term capabilities will be required to keep pace with new spacepower advantage over time.

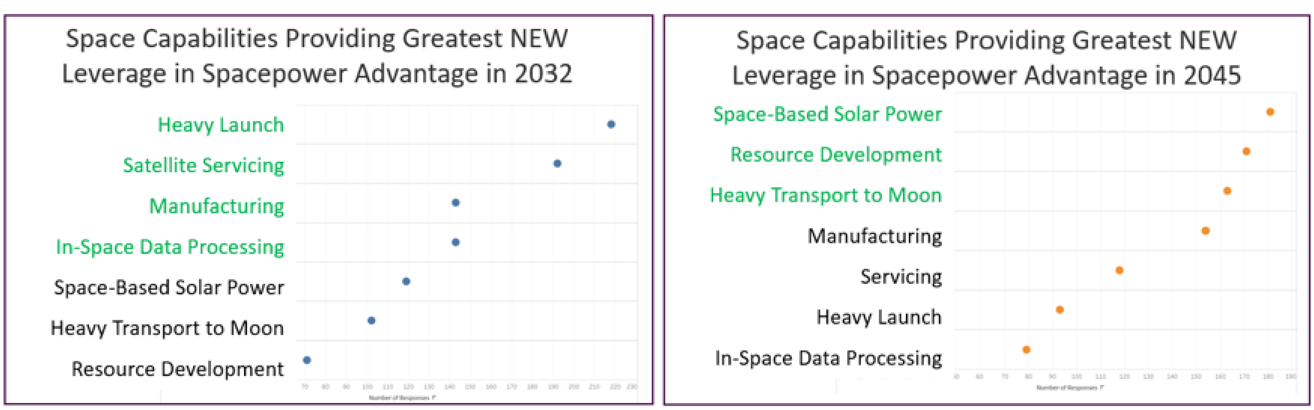

Fig. 11 Q15 responses (N=325)

141 out of 326 people (43.25%) that answered Q15 provided a comment to the question "Why do you believe this will be the case?" 2032 capabilities were seen as transformative in the near term and a foundational steppingstone for future developments. Establishing robust infrastructure and capabilities closer to Earth in the nearer term can pave the way for more complex operations by 2045. Respondents emphasized sustainability, autonomy, and the interconnectedness of capabilities as important factors for longer term success in space. They also called out the importance of building a strong infrastructure and efficient logistics chain. Respondents emphasized the strategic importance of a strong presence in cislunar space and beyond as pivotal for national security, economic power, and technological leadership. As technology advances, respondents anticipated that there will be a shift from relying on Earth-based resources to utilizing in-space resources and manufacturing. They noted that space capabilities are closely tied to economic and national power, influencing diplomatic, informational, military, and economic leverage. Finally, respondents highlighted the need for innovative solutions to overcome current limitations, such as the high cost of launch and the need for autonomous systems in space.

Heavy launch led the introduction of new capabilities on a predicted timeline, followed by in-space data processing, satellite servicing, heavy transport to the Moon, in-space manufacturing, space-based solar power, and then resource development. Figure 12 shows the timeline predicted by respondents, with the date with the most responses highlighted in white for each capability.

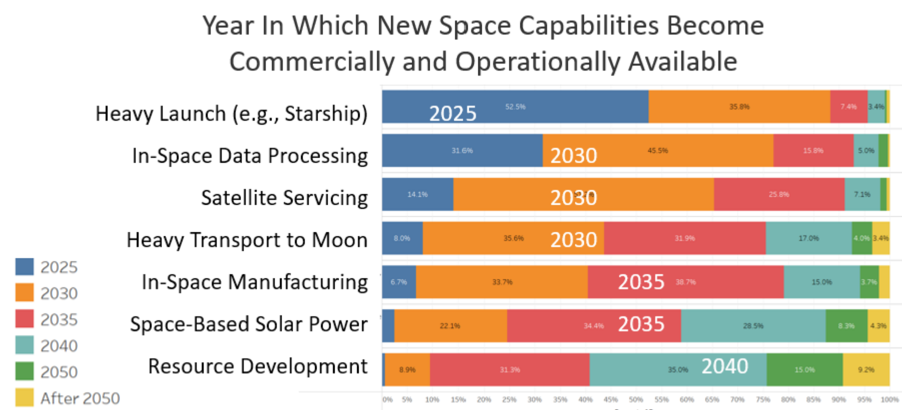

Fig. 12 Q16 responses (N=327)

U.S. respondents, on average, predicted that U.S. spacepower advantage would increase. Out of 297 U.S. and international respondents to Q17, the average expected change in spacepower advantage was an increase of 40%. Given that most respondents hold primary citizenship in the U.S., this question contributed less to any comparison of different countries. For Q18, China was shown to be a close second to the U.S. in industrial activity, like mining, power generation, and manufacturing, in 2032, as shown in Figure 13, which shows responses as a percentage of the total.

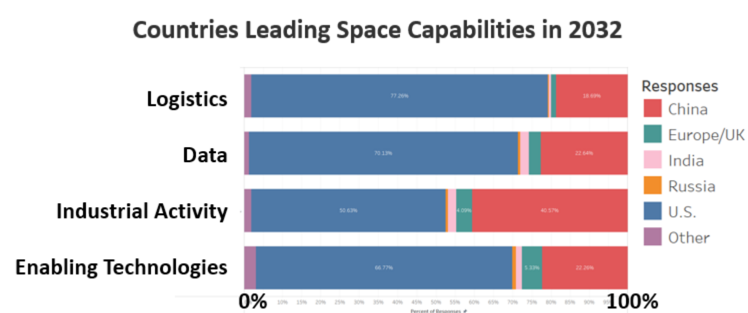

Fig. 13 Q18 responses (N=321)

50 out of 321 people (15.58%) who answered Q18 provided a comment in response to a comment box that said, “If other, please specify and elaborate.” Most of the respondents used this comment box to share their thoughts when they did not select “other” as a response. Key insights from the comments provided included the importance of collaboration and investment among Western nations (e.g., U.S., European nations, UK, Canada, Australia) to maintaining leadership on the global stage. There was a strong belief that the commercial sector, especially US-based companies, will drive advancements in various categories. Some respondents indicated that U.S. leadership could be hindered by regulatory and political challenges, emphasizing the need for strategic regulatory changes. Many respondents who provided a comment believed that China's significant investments and commitment to space dominance, particularly in human-rated missions and industrial activities, are seen as major factors that could shift global leadership. Finally, countries like Canada, Japan, UAE, and potential Pan-African alliances are recognized as emerging players that could impact global space capabilities.

In making recommendations for USSF (Q19), respondents indicated that investment in research, development, science, and technology was their top-ranked choice for actions related to maintaining or increasing spacepower advantage. Figure 14 compares the responses.

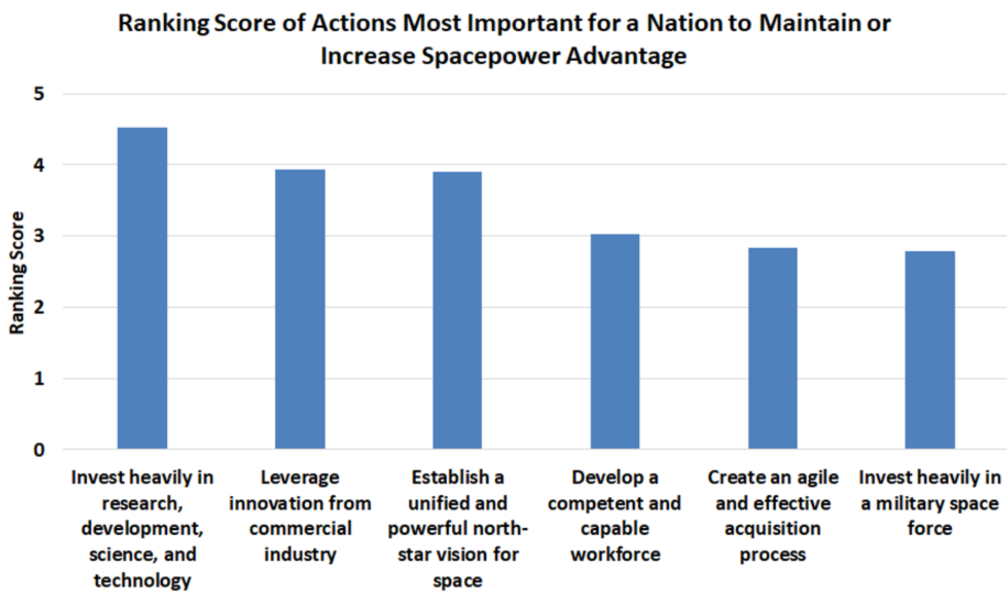

Fig. 14 Q19 responses (N=323)

99 respondents provided a comment on Q20 when asked “Is there anything else you’d like to share?” Numerous comments highlighted the importance of continued investment in space exploration and technology, from both a national security and commercial perspective. Respondents emphasized the need for innovation, the protection of space assets, and maintaining competitive advantages. Several respondents discussed the role of government investment and policy in shaping the future of space exploration. Some emphasized the need for clear norms of behavior in space, while others warned against over-reliance on government funding that could distort markets. There was a strong focus on the need for sustainable commercial business models and establishing industrial capabilities in space to support future space activities. Respondents pointed out the critical role of commercial entities and the need for the government to act as a predictable customer. The necessity of a space force to protect commercial and national interests in space was frequently mentioned. Respondents compared the need for a space force to historical examples like the Navy protecting sea trade routes. Comments stressed the importance of advancing various space technologies, including propulsion systems, manufacturing, robotics, and autonomy. There was a call for rapid prototyping, steady funding, and better facilities to support these advancements. Concerns were raised about the geopolitical implications of space exploration, particularly regarding competition with China. Respondents urged vigilance and preparedness to counter potential threats and highlighted the existential nature of the competition for space dominance. The importance of workforce development was also noted, with some respondents calling for more emphasis on education

and training to support the growing space industry. Finally, several comments expressed gratitude and enthusiasm about our research and highlighted its importance and uniqueness.

Going beyond the question-by-question results but before embarking on our statistical analysis, we investigated three other questions about the results. First, we searched the comments for mentions of "Moon," "lunar," and "cislunar." 127 comments, just over 10%, included one or more of those keywords, and those mentions covered every question that provided the opportunity for comment, even though there were no questions that were specifically about the Moon.

Then we reviewed all the questions that addressed space capabilities. We broke these into two groups: 2032 and 2045. For 2032, these questions were Q8 parts 1 and 2, regarding the greatest technological advancement and greatest increase in activity, Q12, regarding importance to spacepower advantage, Q13, regarding regret, and Q15 part 1, regarding new leverage. When reviewing the top capabilities selected by respondents on these questions, we saw recurring themes. Table 4 demonstrates these recurring themes by shading by a different color for each repeated capability. Q8, 12, and 13 show a top five, and Q15 part 1 shows a top three. Ties and near ties added a capability to the top lists of Q8 part 2, Q12, and Q15. Repeated capabilities, for which the exact phrasing is provided in Table 14, included Launch, SDA, Servicing, Communications, Maneuvering, Manufacturing, Observations, and Cybersecurity.

Table 4. Top Capabilities for 2032, Ranked by Question and Shaded by Repeated Capability

Ranking	Q8 (Tech Advancement)	Q8 (Activity Level)	Q12 (Spacepower)	Q13 (Regret)	Q15 (New Leverage)
1	Servicing	Launch	Launch	Cybersecurity	Launch
2	Autonomy	SDA	SDA	SDA	Servicing
3	Manufacturing	Communications	Communications	Communications	Manufacturing
4	Maneuvering	Observation	Observation	Data Transfer	In-Space Data Processing
5	Launch	Maneuvering	Cybersecurity	Launch	
6		Servicing	Maneuvering		

Table 5 repeats the same exercise for 2045 with Q12 part 2, regarding importance to spacepower advantage, Q14, regarding regret, and Q15 part 2, regarding new leverage. Q12 and Q14 show the top five capabilities while Q15 shows the top three, with ties and near ties added to Q12 and Q15. Repeated capabilities were Resource Development, Power, Manufacturing, and Servicing.

Table 5. Top Capabilities for 2045, Ranked by Question and Shaded by Repeated Capability

Ranking	Q12 (Spacepower)	Q14 (Regret)	Q15 (New Leverage)
1	SDA	Servicing	Power
2	Resource Development	Resource Development	Resource Development
3	Maneuvering	Manufacturing	Moon Transport
4	Servicing	Power	Manufacturing
5	Power	Launch	
6	Manufacturing		

B. Statistical Analysis and Results

Following the frequency analysis of Section V.A., data were further screened for missing data and outliers per the guidelines of Mertler and Reinhart [4] to establish a robust dataset for statistical analysis. The resulting number of usable responses totaled 329. Based on respondent identification, the final data set for statistical analysis was composed of

- 6.7% academic;
- 5.8% non-government organization (NGO);
- 28.6% government (6.4% civil and 22.2% defense);
- 58.9% commercial (29.2% small size companies (1-50 employees); 7.6% midsize companies (51-250 employees); 13% large companies (251-5000 employees); and 9.1% very large companies (>50 employees)).

Additionally, 93.3% of the respondents were from the U.S.

1. Descriptive Statistics

The analysis was performed using International Business Machines Statistical Package for the Social Sciences (IBM SPSS) Statistics V27, Release 27.0.1.0 [5]. The survey items chosen for further statistical testing and their descriptive statistics prior to transformations and standardization are listed in Table 6. The number of responses (N) ranged from 291 to 329. Scale ranges varied from 3 point (pt) to 5 pt except for Q17 (-100% to 100%). Question numbers in the table correspond to the survey question order listed in the Appendix.

Table 6. Chosen Survey Items and Descriptive Statistics

Item	Scale	N	Min	Max	Mean	Std. Dev.
Q6 Number of people in space	5 pt	329	1	5	2.62	1.176
Q7 Level of space activity and assets in 2032	5 pt	328	1	5	4.17	.718
Q11 Importance of Spacepower Advantage to National Security in 2032	4 pt	326	1	4	3.67	.602
Q13 2032 Level of Regret Launch	3 pt	322	1	3	2.44	.668
Q13 2032 Level of Regret Earth and Space Observation	3 pt	321	1	3	2.28	.695
Q13 2032 Level of Regret Maneuvering	3 pt	322	1	3	2.37	.653
Q13 2032 Level of Regret Space Domain Awareness	3 pt	320	1	3	2.68	.552
Q13 2032 Level of Regret Robotics	3 pt	319	1	3	2.19	.698
Q13 2032 Level of Regret Autonomy of Systems	3 pt	317	1	3	2.38	.686
Q13 2032 Level of Regret Communications	3 pt	320	1	3	2.53	.633
Q13 2032 Level of Regret Data Transfer/Encryption	3 pt	321	1	3	2.51	.623
Q13 2032 Level of Regret Cybersecurity	3 pt	321	1	3	2.80	.458
Q13 2032 Level of Regret Electronics	3 pt	320	1	3	2.32	.670
Q13 2032 Level of Regret Human Life Support	3 pt	321	1	3	1.98	.739
Q14 2045 Level of Regret Launch	3 pt	320	1	3	2.48	.695
Q14 2045 Level of Regret Heavy Transportation	3 pt	322	1	3	2.44	.673
Q14 2045 Level of Regret Servicing	3 pt	319	1	3	2.55	.616
Q14 2045 Level of Regret Manufacturing	3 pt	320	1	3	2.56	.579
Q14 2045 Level of Regret Resource Development	3 pt	321	1	3	2.53	.657
Q14 2045 Level of Regret Power Generation	3 pt	319	1	3	2.50	.672
Q14 2045 Level of Regret In-Space Data Processing	3 pt	318	1	3	2.45	.656
Q17 Increase/Decrease Change in Spacepower Advantage	Scale	291	-100	100	40.36	43.808

Bivariate correlations were assessed using the Pearson product-moment correlation method. The importance of correlation analysis allows for examination of association between participant responses by variable pairs. Table 7 lists the variables examined. As shown, most variables exhibit positive correlation at either the $p<0.01$ or $p<.05$ level; there were no negative correlations that were statistically significant. Anticipated number of people in space in 2032 (Q6) and the level of space activity and assets in 2032 (Q7) were positively correlated with a coefficient of .327 ($p<.01$), as might be expected. Q6 responses were also correlated with Q17 responses (change in spacepower advantage) and all of the 2045 regret responses in Q14, but only some of the 2032 regret responses in Q13. Q6 responses were not correlated with responses for spacepower and national security (Q11) or level of regret in 2032 for observation, autonomy of systems, data transfer or cybersecurity (Q13) as shown by lack of statistical significance. Only six additional variables were positively correlated to Q7 responses, that is, spacepower advantage and national security (Q11), 2045 level of regret (Q14) for launch, heavy transport, servicing, resource development, and increase/decrease change in spacepower advantage (Q17) (0.109 ($p<.05$); 0.128 ($p<.05$); 0.224 ($p<.01$); 0.127 ($p<.05$); 0.143 ($p<.05$);

and 0.183 (p<.01), respectively). So, like Q6, Q7 responses were positively correlated with more 2045 regrets than 2032 regrets. As noted above, both Q6 and Q7 were positively correlated with Q17, which was also positively correlated with more 2045 than 2032 regrets. Q11 and Q17 were not statistically significantly correlated, meaning that respondents' estimations of increase in spacepower advantage were not associated with respondents' views on whether or not spacepower advantage is important to national security.

Table 7. Correlation Coefficients of Survey Items of Interest

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1) People in space in 2032	1																					
2) Level of space activity and assets in 2032	.327**	1																				
3) Spacepower Advantage and national security	.085	.109*	1																			
4) Regret 2032 Observation	.089	-.109	.060	1																		
5) Regret 2032 Launch	.126*	.089	.162**	.233**	1																	
6) Regret 2032 Maneuvering	.172**	.076	.159**	.160**	.327**	1																
7) Regret 2032 Space Domain Awareness	.112*	.084	.157**	.317**	.190**	.294**	1															
8) Regret 2032 Robotics	.150**	.003	.145**	.172**	.227**	.396**	.103	1														
9) Regret 2032 Autonomy/AI	.074	-.016	.089	.081	.275**	.322**	.075	.590**	1													
10)Regret 2032 Comm	.135*	.009	.170**	.309**	.305**	.152**	.229**	.243**	.327**	1												
11) Regret 2032 Data Transfer	.068	-.041	.151**	.180**	.232**	.240**	.172**	.235**	.203**	.488**	1											
12) Regret 2032 Cybersecurity	.068	-.060	.206**	.216**	.185**	.213**	.264**	.138*	.175**	.360**	.491**	1										
13) Regret 2032 Electronics	.165**	-.063	.215**	.178**	.339**	.330**	.239**	.427**	.344**	.385**	.401**	.340**	1									
14) Regret 2032 Human Life	.204**	-.047	.073	.209**	.279**	.264**	.120*	.324**	.258**	.243**	.234**	.120*	.380**	1								
15 Regret 2045 Launch	.150**	.128*	.143*	.163**	.704**	.245**	.259**	.158**	.206**	.304**	.230**	.222**	.317**	.227**	1							
16) Regret 2045 Heavy Transport	.297**	.224**	.156**	.117*	.436**	.347**	.217**	.244**	.222**	.334**	.279**	.210**	.354**	.442**	.450**	1						
17) Regret 2045 Servicing	.187**	.127*	.154**	.201**	.323**	.490**	.325**	.372**	.294**	.273**	.217**	.189**	.329**	.308**	.389**	.517**	1					
18) Regret 2045 Manufacturing	.195**	.092	.114*	.154**	.366**	.391**	.259**	.362**	.251**	.247**	.240**	.097	.355*	.402**	.301**	.483**	.544**	1				
19) Regret 2045 Resource Dev.	.247**	.143*	.100	.082	.294**	.250**	.196**	.278**	.172**	.165**	.148**	.094	.277**	.483**	.262**	.532**	.422**	.577**	1			
20) Regret 2045 Power Generation	.196**	.039	.143*	.174**	.275**	.220**	.215**	.231**	.218**	.328**	.261**	.210**	.293**	.413**	.287**	.516**	.372**	.437**	.610**	1		
21) Regret 2045 In-Space Data Process	.152**	-.035	.202**	.237**	.231**	.209**	.172**	.355**	.354**	.374**	.287**	.342*	.447**	.234**	.271**	.295**	.309**	.361**	.237**	.310**	1	
22) Change in Spacepower Advantage	.271**	.183**	.107	-.058	.244**	.076	-.046	.203**	.176**	.091	.077	-.034	.189**	.219**	.244**	.198**	.164**	.209**	.139**	.132**	.143**	1

* Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Q11 spacepower advantage to national security and Q13 level of regret 2032 Cybersecurity were positively correlated (.206, p<.01), but Q11 responses were not correlated to Q17 Change in Spacepower Advantage. These results reiterate respondents' beliefs of the importance of cybersecurity to national security. For Q17, recall that spacepower advantage, defined in the survey for participants' use, goes beyond national security.

For the "level of regret" variables in Q13 and Q14, responses exhibited positive and significant correlations at either the p<.01 or p<.05 levels *with the exception* of the following variable pairs (listed below). These exhibited no statistically significant correlations in either positive or negative direction. The lack of significant association does not imply respondents did not feel there would be various levels of regret, but that these items may have lacked a strong association in the minds of the participants between capability listed and spacepower advantage or between the capabilities themselves.

- Level of Regret 2032 Observation (Q13) and Level of Regret 2045 Resource Development (Q14)
- Level of Regret 2032 Observation (Q13) and Level of Regret 2032 Autonomy of Systems (Q13)
- Level of Regret 2032 Robotics (Q13) and Level of Regret 2032 SDA (Q13)
- Level of Regret 2032 Autonomy of Systems (Q13) and Level of Regret 2032 SDA (Q13)
- Level of Regret Manufacturing 2045 (Q14) and Level of Regret 2032 Cybersecurity (Q13)
- Level of Regret 2045 Resource Development (Q14) and Level of Regret 2032 Cybersecurity (Q13)

Following a review of the descriptive statistics and correlations, data were transformed using standard procedures for skewness and standardized to accommodate scale differences prior to further statistical analysis on group differences.

2. Group Differences by Organizational Type

Data on the variables of interest in Table 6 were assessed for group differences in organization type (commercial versus government). Respondents were recoded into two groups (commercial versus government) based on their chosen demographics. We then examined responses between commercial (N=179) and government (N= 84) respondents for a total N = 263.

As shown, in Table 8, descriptive statistics indicate commercial respondents expected a higher number of people in space in 2032 (Mean = 2.66 on a scale of 1-5); a higher level of regret for both Earth and Space Observation (Mean = 2.35 on a scale of 1-3) and Human Life Support 2032 (Mean = 2.01 on a scale of 1-3); and a higher percentage increase change in Spacepower Advantage (Mean = 43.06 on a scale of -100 to 100) than the government respondents.

Table 8. Descriptive Statistics for Organization Type Group Differences

Variable	Group	N	Mean	Std. Dev.
Q6 People in space in 2032	Commercial	193	2.66	1.206
	Government	94	2.35	1.065
Q13 Level of Regret 2032 Observation	Commercial	189	2.35	.673
	Government	91	2.12	.728
Q13 Level of Regret 2032 Human Life	Commercial	189	2.01	.722
	Government	91	1.85	.773
Q17 Change in Spacepower Advantage	Commercial	171	43.06	43.858
	Government	82	31.07	44.685

To assess statistically significant differences, Analysis of Variance (ANOVA) was implemented as it is reasonably robust to both non-normality and heterogeneity of variance [4]. Unequal cell sizes were acceptable [4]. Differences in responses were statistically significant as shown in Table 9, that is, anticipated number of people in space in 2032 ($F (1, 285) = 4.047, p<.05$); in level of regret for both Earth and Space Observation ($F (1, 278) = 6.722, p<.01$) and Human Life Support for 2032 ($F (1, 278)=3.038, p<.10$); and in Change in Spacepower Advantage ($F (1, 251)=4.089, p<.05$). Welch's Test results (used when homogeneity is not assumed) supported the ANOVA results. There were no statistically significant differences found for the remaining variables listed in Table 6 for organization type; commercial and government participants responded similarly.

Table 9. ANOVA and Welch Test Results for Organization Type Group Differences

Variable	Group	Sum of Squares	df	Mean Square	F	Sig.
Q6 People in Space in 2032	Between Groups	8.094	1	4.047	4.082	.044**
	Within Groups	282.526	285	.991		
	Total	286.572	286			
Q13 Level of Regret 2032 Observation	Between Groups	13.444	1	6.722	6.805	.010***
	Within Groups	274.595	278	.988		
	Total	281.317	279			
Q13 Level of Regret 2032 Human Life	Between Groups	6.076	1	3.038	3.041	.082*
	Within Groups	277.746	278	.999		
	Total	280.785	279			
Q17 Change in Spacepower Advantage	Between Groups	15922.742	1	7961.371	4.089	.044*
	Within Groups	488734.976	251	1947.151		
	Total	496696.348	252			

Robust Tests of Equality of Means

Variable	Test	Statistic	df1	df2	Sig.
Q6 People in Space in 2032	Welch	4.974	1	206.451	.027**
Q13 Level of Regret 2032 Observation	Welch	6.640	1	165.986	.011*
Q13 Level of Regret 2032 Human Life	Welch	2.897	1	167.242	.091***
Q17 Change in Spacepower Advantage	Welch	4.035	1	157.145	.046**

*Significant at the $p<.01$ level (two-tail)
**Significant at the $p<.05$ level (two-tail)
*** Significant at the $p<.10$ level (two-tail)

Two-way contingency tables were developed to assess how commercial versus government participants responded to Q10 Primary Responsibility for defending against attacks in 2032. Table 10 summarizes the results.

The majority of respondents, regardless of organization affiliation, felt the military space force was primarily responsible for defending earth observation (62.8%), launch (53.7%), maneuvering (60.7%), SDA (86.5%), power generation (59%), communications (70.7%), in-space data transfer (65.8%), cybersecurity (72.8%), and human life support (52.9%). Conversely, most respondents felt owner/operators were primarily responsible for defending servicing (53%), manufacturing (63.8%), resource development (52.0%), robotics 66.3%), autonomy of systems (56.1%), in-space data processing (57.3%), and electronics (64.6%). However, there are some notable distinctions between the commercial versus government respondents in key areas. For SDA, 91.1% of government respondents felt that the military space force has responsibility to defend while 84% of commercial respondents did. Government respondents were split between owner/operator and military space force responsibility for launch (50%/50%), power generation (50%/50%), and human life support (50.6%/49.4%), while commercial respondents slightly favored military space force (55.5%, 63.3%, 54.5%, respectively). For servicing, commercial respondents were nearly split between owner/operator and military space force (49.2% and 50.8%, respectively), however government respondents preferred owner/operator over military space force (61.1% to 38.9%).

Table 10. Contingency Table for Organization Type and Q10 Primary Responsibility

Capability	Respondent	Count	Owner/Operator	Military Space Force	Total
Earth Observation	Commercial	Count	67	123	190
		% of Total Commercial	35.30%	64.80%	100%
	Government	Count	38	54	92
		% of Total Government	70.30%	28.10%	100%
		Total Count	105	177	282
		% of Total	37.20%	62.80%	100.00%
Launch	Commercial	Count	85	106	191
		% of Total Commercial	44.50%	55.50%	100%
	Government	Count	45	45	90
		% of Total Government	50%	50%	100%
		Total Count	130	151	281
		% of Total	46.30%	53.70%	100.00%
Maneuvering	Commercial	Count	73	116	189
		% of Total Commercial	38.70%	61.30%	100%
	Government	Count	37	54	91
		% of Total Government	40.70%	59.30%	100%
		Total Count	110	170	280
		% of Total	39.30%	60.70%	100.00%
Space Domain Awareness	Commercial	Count	30	162	192
		% of Total Commercial	15.60%	84.40%	100%
	Government	Count	8	82	90
		% of Total Government	8.90%	91.10%	100%
		Total Count	38	244	282
		% of Total	13.50%	86.50%	100.00%
Servicing	Commercial	Count	94	97	191
		% of Total Commercial	49.20%	50.80%	100%
	Government	Count	55	35	90
		% of Total Government	61.10%	38.90%	100%
		Total Count	149	132	281
		% of Total	53.00%	47.00%	100.00%
Manufacturing	Commercial	Count	115	76	191
		% of Total Commercial	60.20%	39.80%	100%
	Government	Count	65	26	91
		% of Total Government	71.40%	28.60%	100%
		Total Count	180	102	282
		% of Total	63.80%	36.20%	100.00%
Resource Development	Commercial	Count	93	98	191
		% of Total Commercial	48.70%	51.30%	100%
	Government	Count	53	37	90
		% of Total Government	58.90%	41.10%	100%
		Total Count	146	135	281
		% of Total	52.00%	48.00%	100.00%

Capability	Respondent	Count	Owner/Operator	Military Space Force	Total
Robotics	Commercial	Count	122	66	188
		% of Total Commercial	64.90%	35.10%	100%
	Government	Count	61	27	88
		% of Total Government	69.30%	30.70%	100%
		Total Count	183	93	276
		% of Total	66.30%	33.70%	100.00%
Autonomy of Systems	Commercial	Count	105	85	190
		% of Total Commercial	55.30%	44.70%	100%
	Government	Count	52	38	90
		% of Total Government	57.80%	42.20%	100%
		Total Count	157	123	280
		% of Total	56.10%	43.90%	100.00%
Power Generation	Commercial	Count	69	119	188
		% of Total Commercial	36.70%	63.30%	100%
	Government	Count	45	45	90
		% of Total Government	50%	50%	100%
		Total Count	114	164	278
		% of Total	41.00%	59.00%	100.00%
Communications	Commercial	Count	60	130	190
		% of Total Commercial	31.60%	68.40%	100%
	Government	Count	22	68	90
		% of Total Government	24.50%	75.50%	100%
		Total Count	82	198	280
		% of Total	29.30%	70.70%	100.00%
In-Space Data Processing	Commercial	Count	109	80	189
		% of Total Commercial	57.70%	42.30%	100%
	Government	Count	51	39	90
		% of Total Government	56.70%	43.30%	100%
		Total Count	160	119	279
		% of Total	57.30%	42.70%	100.00%
Data Transfer	Commercial	Count	67	124	191
		% of Total Commercial	35.10%	64.90%	100%
	Government	Count	29	61	90
		% of Total Government	32.30%	67.70%	100%
		Total Count	96	185	281
		% of Total	34.20%	65.80%	100.00%
Cybersecurity	Commercial	Count	59	132	191
		% of Total Commercial	30.60%	69.40%	100%
	Government	Count	17	71	88
		% of Total Government	19.30%	80.70%	100%
		Total Count	76	203	279
		% of Total	27.20%	72.80%	100.00%
Electronics	Commercial	Count	126	64	190
		% of Total Commercial	66.30%	33.70%	100%
	Government	Count	55	35	90
		% of Total Government	61.10%	38.90%	100%
		Total Count	181	99	280
		% of Total	64.60%	35.40%	100.00%
Human Life Support	Commercial	Count	87	104	191
		% of Total Commercial	45.50%	54.50%	100%
	Government	Count	45	44	89
		% of Total Government	50.60%	49.40%	100%
		Total Count	132	148	280
		% of Total	47.10%	52.90%	100.00%

2. Group Differences by Career Stage

Data on the variables of interest of Table 6 were also assessed for group differences in respondent career stage: Earlier Career (less than 10 years), Mid-Career (10-25 years), and Later Career (More than 25 years) with N = 47, 112, 158 respectively, for a total N = 329. This data set included all organization types identified.

As shown, in Table 11, descriptive statistics (prior to data transformation/standardization) indicate later career individuals predicted a higher level of regret in 2032 for SDA (Q13) than earlier and mid-career respondents (Mean = 2.77 on a scale of 1-3). Earlier career individuals anticipate a higher level of regret in 2045 (Q14) than mid and later career individuals for in-space data processing (Mean = 2.64 on a scale of 1-3). Mid-career individuals anticipate a higher percentage increase positive change in Spacepower Advantage (Q17) than the other 2 group categories (Mean = 50.74 on a scale of -100 to 100).

Table 11. Descriptive Statistics for Career Stage Differences

Variable	Group	N	Mean	Std. Dev.
Q13 Level of Regret 2032 SDA	Earlier Career	46	2.54	.585
	Mid-Career	115	2.63	.584
	Later Career	158	2.77	.507
Q14 Level of Regret 2045 In-Space Data Processing	Earlier Career	47	2.64	.529
	Mid-Career	112	2.44	.655
	Later Career	158	2.41	.678
Q17 Change in Spacepower Advantage	Earlier Career	46	37.80	50.251
	Mid-Career	102	50.74	41.738
	Later Career	142	33.67	42.043

To assess statistically significant differences, ANOVA was again implemented for its robustness to both non-normality and heterogeneity of variance [4]. The ratios of unequal cell sizes were acceptable [4]. ANOVA results indicate statistically significant differences in the same three variables as shown in Table 12, that is, in Level of Regret for SDA in 2032 ($F (2,316) = 4.287$, $p<.05$), Level of Regret for Data Processing in 2045 ($F (1,314) = 2.283$, $p<.10$), and Change in Spacepower Advantage ($F (2,287) = 4.697$, $p<.01$). Results of Welch's Test (where homogeneity cannot be assumed) supported the ANOVA results. There were no statistically significant differences found for the remaining variables listed in Table 6 for career stage. That is, participants responded similarly regardless of career stage.

Post hoc tests were conducted to verify which groups were different. They confirmed statistically significant differences between later career respondents and earlier career respondents (Tamhane, $p<.05$) and mid-career (Tamhane, $p<.10$) on Q13 Level of Regret SDA, that is, later career anticipated a higher level of regret than the other two groups. For Level of Regret in 2045 In Space Data Processing (Q14), there was a statistically significant difference between earlier career and later career (Tamhane, $p< .05$), that is, earlier career respondents anticipated a higher level of regret than later career (Mid-career and later career scored similarly). In Change in Spacepower Advantage, mid-career indicated a higher level of increase than later career (Tamhane, $p<.01$). Mid-career and earlier career scored similarly.

Table 12. ANOVA and Welch Test Results for Career Stage

Variable	Group	Sum of Squares	df	Mean Square	F	Sig.
Q13 Level of Regret 2032 SDA	Between Groups	8.418	2	4.209	4.287	.015**
	Within Groups	310.239	316	.982		
	Total	318.656	318			
Q14 Level of Regret 2045 In-Space Data Processing	Between Groups	4.486	2	2.243	2.283	.104***
	Within Groups	308.421	314	.982		
	Total	312.906	316			
Q17 Change in Spacepower Advantage	Between Groups	17637.344	2	8818.672	4.697	.010*
	Within Groups	538812.536	287	1877.396		
	Total	556449.879	289			

Robust Tests of Equality of Means

Variable	Test	Statistic	df1	df2	Sig.
Q13 Level of Regret 2032 SDA	Welch	4.189	2	118.284	.017**
Q14 Level of Regret 2045 In-Space Data Processing	Welch	2.926	2	135.897	.057***
Q17 Change in Spacepower Advantage	Welch	4.979	2	116.159	.008*

*Significant at the p<.01 level (two-tail)
**Significant at the p<.05 level (two-tail)
*** Significant at the p<.10 level (two-tail)

Like organization type, contingency tables were also developed to assess how participant career stage impacted responses to entity responsibility for defending against attacks in 2032 (Q10). Table 13 summarizes the results. Most respondents, regardless of career stage, felt the military space force was primarily responsible for defending earth observation (60.7%), launch (51.9%), maneuvering (58.6%), SDA (86.3%), power generation (57.7%), communications (69%), data transfer (64.3%), cybersecurity (73.3%), and human life support (51.6%). Conversely, most respondents felt owner/operators were primarily responsible for defending servicing (53.1%), manufacturing (63.9%), resource development (53.1%), robotics (67%), autonomy of systems (56.7%), in-space data processing (58.2%), and electronics (65.2%). Again, there are some notable differences in key areas. For launch and in-space data processing, earlier career respondents were split between owner/operator (51%) and military space force (49%) for both variables. For maneuvering and resource development, earlier career responses were again nearly split between owner/operator and military space force (49%/51% for both). However, for maneuvering, the majority of mid and later career participants choose the military space force (58% and 61.4%, respectively). For resource development, most later career respondents (58.2%) felt the owner/operator bore responsibility compared to 48.7% (mid-career) and 49% earlier career. For communications, earlier career respondents overwhelmingly marked the military space force as primary responsibility (81.3%) as opposed to mid (65.2%) and later career (67.9%). For human life support, later career participants noted that the owner/operator had primary responsibility (54.8%) as opposed to earlier career (34.7%) and mid-career (45.5%).

Table 13. Contingency Table for Career Stage and Primary Responsibility for Attack Defense

Capability	Respondent	Count	Owner/Operator	Military Space Force	Total
Earth Observation	Earlier Career	Count	18	31	49
		% within Career Stage	36.7%	63.3%	100.0%
	Mid Career	Count	49	63	112
		% within Career Stage	43.8%	56.3%	100.0%
	Later Career	Count	59	101	160
		% within Career Stage	36.9%	63.1%	100.0%
		Total Count	126	195	321
		% of Total	39.3%	60.7%	100.0%
Launch	Earlier Career	Count	25	24	49
		% within Career Stage	51.0%	49.0%	100.0%
	Mid Career	Count	50	62	112
		% within Career Stage	44.6%	55.4%	100.0%
	Later Career	Count	79	80	159
		% within Career Stage	49.7%	50.3%	100.0%
		Total Count	154	166	320
		% of Total	48.1%	51.9%	100.0%
Maneuvering	Earlier Career	Count	24	25	49
		% within Career Stage	49.0%	51.0%	100.0%
	Mid Career	Count	47	65	112
		% within Career Stage	42.0%	58.0%	100.0%
	Later Career	Count	61	97	158
		% within Career Stage	38.6%	61.4%	100.0%
		Total Count	132	187	319
		% of Total	41.4%	58.6%	100.0%
SDA	Earlier Career	Count	8	41	49
		% within Career Stage	16.3%	83.7%	100.0%
	Mid Career	Count	15	98	113
		% within Career Stage	13.3%	86.7%	100.0%
	Later Career	Count	21	138	159
		% within Career Stage	13.2%	86.8%	100.0%
		Total Count	44	277	321
		% of Total	13.7%	86.3%	100.0%
Servicing	Earlier Career	Count	27	22	49
		% within Career Stage	55.1%	44.9%	100.0%
	Mid Career	Count	61	51	112
		% within Career Stage	54.5%	45.5%	100.0%
	Later Career	Count	82	77	159
		% within Career Stage	51.6%	48.4%	100.0%
		Total Count	170	150	320
		% of Total	53.1%	46.9%	100.0%
Manufacturing	Earlier Career	Count	31	18	49
		% within Career Stage	63.3%	36.7%	100.0%
	Mid Career	Count	69	43	112
		% within Career Stage	61.6%	38.4%	100.0%
	Later Career	Count	105	55	160
		% within Career Stage	65.6%	34.4%	100.0%
		Total Count	205	116	321
		% of Total	63.9%	36.1%	100.0%
Resource Development	Earlier Career	Count	24	25	49
		% within Career Stage	49.0%	51.0%	100.0%
	Mid Career	Count	55	58	113
		% within Career Stage	48.7%	51.3%	100.0%
	Later Career	Count	92	66	158
		% within Career Stage	58.2%	41.8%	100.0%
		Total Count	171	149	320
		% of Total	53.4%	46.6%	100.0%
Robotics	Earlier Career	Count	30	18	48
		% within Career Stage	62.5%	37.5%	100.0%
	Mid Career	Count	75	37	112
		% within Career Stage	67.0%	33.0%	100.0%
	Later Career	Count	106	49	155
		% within Career Stage	68.4%	31.6%	100.0%
		Total Count	211	104	315
		% of Total	67.0%	33.0%	100.0%

Capability	Respondent	Count	Owner/Operator	Military Space Force	Total
Autonomy of Systems	Earlier Career	Count	30	19	49
		% within Career Stage	61.2%	38.8%	100.0%
	Mid Career	Count	61	51	112
		% within Career Stage	54.5%	45.5%	100.0%
	Later Career	Count	90	68	158
		% within Career Stage	57.0%	43.0%	100.0%
		Total Count	181	138	319
		% of Total	56.7%	43.3%	100.0%
Power Generation	Earlier Career	Count	18	31	49
		% within Career Stage	36.7%	63.3%	100.0%
	Mid Career	Count	47	65	112
		% within Career Stage	42.0%	58.0%	100.0%
	Later Career	Count	69	87	156
		% within Career Stage	44.2%	55.8%	100.0%
		Total Count	134	183	317
		% of Total	42.3%	57.7%	100.0%
Communications	Earlier Career	Count	9	39	48
		% within Career Stage	18.8%	81.3%	100.0%
	Mid Career	Count	39	73	112
		% within Career Stage	34.8%	65.2%	100.0%
	Later Career	Count	51	108	159
		% within Career Stage	32.1%	67.9%	100.0%
		Total Count	99	220	319
		% of Total	31.0%	69.0%	100.0%
In-Space Data Processing	Earlier Career	Count	25	24	49
		% within Career Stage	51.0%	49.0%	100.0%
	Mid Career	Count	67	45	112
		% within Career Stage	59.8%	40.2%	100.0%
	Later Career	Count	93	64	157
		% within Career Stage	59.2%	40.8%	100.0%
		Total Count	185	133	318
		% of Total	58.2%	41.8%	100.0%
Data Transfer	Earlier Career	Count	12	37	49
		% within Career Stage	24.5%	75.5%	100.0%
	Mid Career	Count	48	63	111
		% within Career Stage	43.2%	56.8%	100.0%
	Later Career	Count	54	105	159
		% within Career Stage	34.0%	66.0%	100.0%
		Total Count	114	205	319
		% of Total	35.7%	64.3%	100.0%
Cybersecurity	Earlier Career	Count	10	38	48
		% within Career Stage	20.8%	79.2%	100.0%
	Mid Career	Count	31	81	112
		% within Career Stage	27.7%	72.3%	100.0%
	Later Career	Count	44	114	158
		% within Career Stage	27.8%	72.2%	100.0%
		Total Count	85	233	318
		% of Total	26.7%	73.3%	100.0%
Electronics	Earlier Career	Count	30	19	49
		% within Career Stage	61.2%	38.8%	100.0%
	Mid Career	Count	73	38	111
		% within Career Stage	65.8%	34.2%	100.0%
	Later Career	Count	105	54	159
		% within Career Stage	66.0%	34.0%	100.0%
		Total Count	208	111	319
		% of Total	65.2%	34.8%	100.0%
Human Life Support	Earlier Career	Count	17	32	49
		% within Career Stage	34.7%	65.3%	100.0%
	Mid Career	Count	51	61	112
		% within Career Stage	45.5%	54.5%	100.0%
	Later Career	Count	86	71	157
		% within Career Stage	54.8%	45.2%	100.0%
		Total Count	154	164	318
		% of Total	48.4%	51.6%	100.0%

VI. Discussion

This research served to supplement the USSF effort in strategic foresight and brought into the discussion the future of space in 2032 and 2045. With respondents largely drawing from the commercial sector, the top takeaways were an overall bullish sentiment on space activity, a nod to spacepower advantage's essential role in national security, and a call for heavy investment in research, development, science, and technology, leveraging commercial industry, and a north star vision for space. It makes sense that people who work in commercial industry would see the opportunity in and importance of space activity and to highlight the need for government vision, support, and partnership. Despite most respondents wanting to go to space themselves, their predictions on the number of people in space were more tempered. One surprise was how few respondents saw a flat or reduced activity in space or the risks to space infrastructure in conflict. With anti-satellite capabilities proliferating across more nations, the vulnerability of space assets in conflict is coming into focus, leading to a trend toward distributed assets and alternative routes to capabilities. To shed light on this seeming inconsistency, respondents reflected significant technological advances in areas that would reduce risk and increase resilience of space assets, specifically satellite servicing, autonomy via artificial intelligence, manufacturing, maneuvering, and heavy reusable launch.

Future capabilities, like space-based solar power and resource development, were predicted to have greater technological advancements than many data-related capabilities, including in-space data processing, data transfer/encryption, and cybersecurity. Similarly, few respondents saw opportunities to advance electronics, even though space electronics have not yet leveraged advances in terrestrial electronics that may prove to be transferable. These patterns of responses may suggest that respondents see data and electronics as supporting other capabilities, rather than as capabilities on their own, or that fewer respondents work in data-related or power-related fields. Alternatively, respondents may view data as a government focus. This alternative hypothesis of government focus is somewhat supported for cybersecurity and data transfer/encryption, as respondents indicated that the national security sector should lead investment in those capabilities and that a military space force should defend them.

Resource development and space-based solar power were seen as crucial capabilities in 2045 that the government would regret not investing in today. Energy and natural resources are significant drivers of economic growth and economic power. Should these capabilities come to fruition, they would have significant influence on geopolitics. Their successful development and implementation, however, will depend on economic and environmental competition with terrestrial alternatives and on their ability to be regulated effectively and defended successfully against various types of attacks. The tipping points on those factors may be farther into the future than anticipated in the timeline created by respondents that shows space-based solar power and resource development being commercially and operationally available in 2035 and 2040, respectively.

Respondents indicated sustained U.S. leadership in every category, with spacepower advantage of the U.S. increasing by 40% by 2032. This is a surprising result, given the widespread discussion of potential adversaries' recent activities, advancements, and stated plans. It is also surprising given that respondents selected a north star vision as one of their top recommendations for spacepower advantage, while not predicting that other nations that already have such a vision would gain ground on or surpass the U.S. Another top choice was leveraging commercial industry, which may have been seen by respondents as the differentiating factor. The downplaying of data-related capabilities noted above may also in part predict this confidence in sustained U.S. leadership, or we may have missed an opportunity to ask this question for today, 2032, and 2045 to capture the trajectory of this question, rather than a single snapshot in time. Such a trajectory may have been more useful to USSF for strategic planning than what we collected. When we collected data on trajectory on other sets of questions, it was useful. The significant change in what was perceived by respondents to influence spacepower advantage between 2032 and 2045 (Q12, parts 1 and 2) suggests that broader investment in technology development for both near-term and long-term futures is necessary. Similarly, Q13 and Q14 as a pair and Q15, parts 1 and 2, reinforce the evolution of priorities over time.

When data were viewed through the lens of statistical analysis, some interesting correlations emerged, and convergence and divergence between commercial and government opinion and among career stages were apparent. The positive correlations among responses on people in space, activity in space, and increase in spacepower advantage possibly suggest a consistency in respondents' optimism or pessimism across survey questions. More optimism in all three questions was also positively correlated with higher regret for more 2045 capabilities than 2032 capabilities, possibly indicating a confidence in short-term progress and an urgency to move on to advancing future capabilities. These correlations suggest that we may have found a useful replacement for the intended but failed use of the question, "Would you go to space if you could?" Interestingly, just because a respondent said that spacepower advantage would increase did not necessarily mean they believed that was important.

For most questions, commercial and government responses were similar, but there were interesting areas of divergence. U.S. commercial space companies, such as SpaceX, Virgin Galactic, and Blue Origin, have long envisioned a market for human space transportation. Hence, it was not surprising that commercial respondents were more optimistic than government on the anticipated number of people in space in 2032; nor was it surprising that commercial respondents also expressed a higher level of regret than government if a country fell behind in human life support capabilities due to insufficient government investment. These go hand in hand. Government respondents may have less optimism regarding humans in space due to regulatory hurdles and, perhaps, question market demand for the near term. However, government is also highly concerned with safety as paramount. Do they believe sufficient government investment in human life support is occurring? Or do they think that the investment should come from the commercial sector?

Government and commercial respondents did not differ on the anticipated level of space activity and assets in 2032, likely seeing the ever-increasing presence of the global community in space as evidence. But they differed on the level of regret 2032 for insufficient funding in earth and space observation, measurement, and interpretation with government expressing a lower level of regret than commercial. This was surprising given the government attention on earth observation improvements across myriad global concerns (e.g., climate change, weather forecasting) and space observation capability improvements for space situational awareness, among others. Based on the question, however, it is possible that government looks to commercial entities to shoulder the larger investment in these areas. Finally, commercial respondents also felt that their countries' spacepower advantages in 2032 would increase more than government respondents did. Both anticipated a positive percentage increase, but the commercial sector was more optimistic. With the majority of respondents from the U.S., there can be several reasons for this result. Spacepower advantage was defined as the relative advantage of one nation over another in space systems, capabilities, and effects. A lack thereof would result in a national disadvantage in terms of diplomatic, informational, military, or economic power. Government may have their eyes on potential adversaries on Earth and in space, which steered their estimation of power advantage to a more conservative number, while commercial companies may have viewed spacepower advantage through a lens of confidence in their own competitive edge in innovation and enabling technologies, steering them to a higher expectation.

Differences in responses due to career stage were also telling in a few variables. On average, earlier career respondents expressed a higher level of regret in 2045 for in-space data processing capabilities with respect to insufficient government investment. When examined with the larger data set in our initial frequency analysis, however, over 76% of all respondents felt that this capability would be commercially available by 2030 or before and was not considered as a top priority in new leverage for 2045. This area needs further examination to understand the implications of this result. Also, later career respondents felt a higher level of regret in 2032 in insufficient government investment in SDA than earlier or mid-career respondents. These individuals have witnessed firsthand the relatively recent and significant increase of space objects, particularly in LEO. As a result, they may feel a higher sense of urgency and concern than earlier and mid-career respondents. Lastly, mid-career respondents were clearly more optimistic than either the earlier career or later career individuals on change in spacepower advantage.

Overall, we were pleased with the response rate and surprised by the enthusiasm with which comments were entered. Although we gathered some valuable data, we saw opportunities to improve future surveys as we analyzed these results. Goals of improvements might to reduce respondent fatigue, produce clearer results, and increase our ability to interrogate the data further. First, the number of capabilities may have been overwhelming to respondents. One example of why we considered this possibility is that cybersecurity was least selected out of 16 capabilities to have the greatest technological advancement between now and 2032. That may be real, or it may suggest that respondents initially favored capabilities near the top of the list, using up their five selections before reviewing all 16 capabilities, especially on early questions.

On that same theme, the survey itself may have been too long or too dense. We discarded 37% of respondents for statistical analysis, many of whom did not come close to finishing the survey. On the other hand, a high rate of those who finished the survey took extra time to write comments and were willing to disclose their identities. This may reflect that only the most passionate were willing to endure. One persevering respondent commented, "I feel misled that this was a 20 question survey." To address both problems, we might approach future surveys with fewer capabilities or do multiple separate surveys, each focused on a single space-related topic.

Alignment among respondents began from early results of the prior survey (pre-workshop survey), though the final results of that survey, and through the 20 Questions survey. It included statistically significant alignment between government and industry respondents, and earlier and later career respondents, with only a handful of statistically significant differences between each of those two pairs of respondent groups. The reasons for this alignment may be that the future drawn out of these results is very likely, or that respondents are in an echo chamber, or that there are weaknesses in the survey design that did not provide adequate opportunity for respondents to express their differences.

In future surveys, we might also provide more differentiation in response options. For example, instead of asking a yes/no question, like "Would you go to space if you could," we might instead ask, "To what extent do you feel a personal desire for in-space activity to grow," and provide 5 options for responses on an ordinal scale, such as Likert. During this survey's design, discussion took place on this sort of change to several questions. Concern over the possibility of respondent fatigue with more response choices overruled that path forward. In the future, we would reduce the scope of the survey to allow for more response choices. Additional consideration of richer quantitative and qualitative analysis methods during survey development will allow expansion of research questions and ultimately impact survey design and data collection.

During design of the workshop, prior survey, and 20 Questions, it became clear that some space terms are not used consistently or understood similarly by different audiences. For example, the term cislunar is sometimes used to denote the entire Earth-Moon system, including Lagrange points. At other times, it might be reduced to mean the space between the Moon's surface and the Earth's surface, the space between the Moon's surface and GEO, the space between GEO and the Moon, exclusive of the Moon's surface. the lunar surface and orbits around the Moon, or only lunar orbits. The survey design assumed a certain common vocabulary and common understanding of key issues among respondents across the different demographics. We also coined terms for capabilities that were not defined in the survey. Although we learned in the workshop that some of these assumptions were faulty, our attempts at improvements may not have landed. If we pursued a shorter, tighter design for future surveys, we would be able to define our terms, leading to more clarity in the intent of the question and the meaning of the possible responses.

The distribution of the survey could have been broader with more prior planning, and a question about level of space knowledge should be added. Getting perspectives from those working in other industries could also be extremely valuable if they are measured as such.

The 2022 Space Futures Workshop with Industry and its two associated surveys were key exercises within the broader USSF strategic foresight effort, which informed both the DoD Commercial Space Integration Strategy [6] and the USSF Commercial Space Strategy [7]. As part of continued USSF strategic foresight efforts, another round of space futures exercises is under consideration for 2025-2026 under the new USSF Space Futures Command [8]. The recommendation from this round is to continue to include surveys but to keep them to a manageable scope so that they can be better designed, administered, and interpreted.

VII. Conclusion

What did commercial space tell Space Force about 2032 and beyond in the 20 Questions survey? Commercial space conveyed its vision of space futures with accelerating activity levels and rapid technological advancement of key capabilities that would have significant impact on spacepower advantage. It affirmed its view of spacepower advantage as essential to national security, while forecasting that leverage in spacepower advantage would come from different capabilities over time. Although it called on the private sector to lead investment in most capabilities, it voiced the expectation that government would also invest today in both near-term and farther-future space capabilities or feel the weight of regret later. It also asked USSF to take on the responsibility of defending most space capabilities presented in the survey. Even though it expressed confidence in continued US leadership in space, it recommended actions for maintaining and increasing spacepower advantage. Without having the opportunity to rank the urgency of its recommendations relative to other competing national priorities, it advocated most heartily for heavy investment in research, development, science, and technology, followed by leveraging its own strengths as commercial industry and developing a north star vision for space. USSF aggregated this information into its larger body of work to inform its decisions about policy and investment. The recent creation of a USSF Space Futures Command acknowledged the value of the kind of work outlined in this paper, and the results of the strategic foresight exercises with industry, alongside other considerations, informed both the new DoD Commercial Space Integration Strategy and the USSF Commercial Space Strategy.

Appendix

Table 14 shows the capabilities referenced in the survey questions. The survey questions follow.

Table 14. Capabilities Referenced in Questions

Question	8	9	10	12	13	14	15	16	18
Earth and Space Observation, Measurement, Interpretation	X	X	X	X	X				
Launch: Low-Cost, Heavy-Lift, Reusable, Frequent	X	X	X	X	X	X	X	X	
Heavy Transportation to Cislunar Space						X	X	X	
Maneuvering: Rendezvous, Proximity, Approach, Docking, Propulsion	X	X	X	X	X				
Space Domain Awareness, Space and Launch Traffic Management	X	X	X	X	X				
Servicing: Refueling, Repair, Maintenance	X	X	X	X		X	X	X	
Manufacturing: Additive, Assembly, Construction at Scale	X	X	X	X		X	X	X	
Resource Development: Mining, Recycling, Materials Processing at Scale	X	X	X	X		X	X	X	
Robotics	X	X	X	X	X				
Autonomy of Systems through Artificial Intelligence	X	X	X	X	X				
Power Generation: Space Based for Earth/Moon Use	X	X	X	X		X	X	X	
Communications: Global, Space-to Space, Spectrum-Agnostic, Radio, Non-Radio	X	X	X	X	X				
In-Space Data Processing: Computational Capability, In-Situ Software Updates/Upgrades	X	X	X	X		X	X	X	
Data Transfer and Encryption, including Quantum, Non-Radio	X	X	X	X	X				
Cybersecurity	X	X	X	X	X				
Electronics: Space-Capable Chips, Power Converters	X	X	X	X	X				
Human Life Support: Atmosphere, Nutrition, Health	X	X	X	X	X				
Logistics Category: Launch, In-Space Propulsion, Rovers, Rendezvous, Docking, Servicing, Fueling, Deorbiting									X
Data, Information, Communications Category: Data Collection, Observation, Communications, Processing, Transfer, Security, Encryption, Command, Control									X
Industrial Activity Category: Power, Mining, Materials Processing, Manufacturing, Advanced Manufacturing, Construction									X
Enabling Technologies Category: Robotics, Electronics, Human Life Support, Autonomy of Systems									X

Survey Questions: “20 Questions about Space in 2032 and Beyond”

1. In what country do you have primary citizenship? [drop down menu]
2. At what stage of your career are you?
    a. Earlier Career (less than 10 years)
    b. Mid-Career (10-25 years)
    c. Later Career (More than 25 years)

3. What type of organization do you work for?
    a. Commercial: Small Company (1-50 employees)
    b. Commercial: Mid-sized Company (51-250 employees)
    c. Commercial: Large Company (351-5000 employees)
    d. Commercial: Very Large Company (more than 5000 employees)
    e. Government: Civil
    f. Government: Defense
    g. Academic
    h. NGO
4. Would you go to space if you could?
    a. No
    b. Yes
    c. I have been to space
5. Which of the following factors will be greater in 2032 than today? Check all that apply.
    a. Competition among nations
    b. Defense space investment
    c. Civil space investment
    d. Commercial space investment
    e. Effectiveness of legislation and regulation
    f. Pace of scientific and technology developments
    g. Global economic health
6. How many people will be in space at any given time in 2032?
    a. 0 – 20
    b. 21 – 50
    c. 51 – 200
    d. 201 – 1,000
    e. More than 1,000

    Why do you believe this will be the case? [short answer]
7. What will be the level of space activity and assets in 2032 compared with today?
    a. Reduced by half or more
    b. Similar level to today
    c. Less than double
    d. 2 to 5X greater
    e. Over 5X higher

    Why do you believe this will be the case? [short answer]
8. Which of the following 16 space capabilities will have the greatest **technological advancement** (check 5) and **increase in activity level** (check 5) between now and 2032? (*See Table 14 for list of capabilities*)
    a. Greatest Technological Advancement (Check only 5 Capabilities)
    b. Greatest Increase in Activity Level (Check only 5 Capabilities)
9. Which sector do you believe SHOULD lead investment in each space capability today to prepare for the future? (*See Table 14 for list of capabilities*)
    a. Commercial
    b. Civil
    c. National Security
    d. No sector should invest
10. Which entity should be **primarily responsible for defending** each of the following 16 space capabilities against attacks in 2032? Some examples of attacks are cyberattacks, physical attacks (on-orbit or terrestrial), nuclear detonation, directed energy (radio frequency and laser weapons), and electromagnetic pulse. (*See Table 14 for list of capabilities*)
    a. Owner/Operator
    b. A Military Space Force

11. How important will Spacepower Advantage[4] be to **national security** in 2032?
    a. Irrelevant
    b. Somewhat Important
    c. Very Important
    d. Essential

    Why do you believe this will be the case? [short answer]
12. Which of the following 16 space capabilities will be most important to **Spacepower Advantage** in 2032 (check 5) and 2045 (check 5)? (*See Table 14 for list of capabilities*)
    a. 2032 (Check Only 5 Capabilities)
    b. 2045 (Check Only 5 Capabilities)
13. How much would a country **regret falling behind** on the following capabilities in **2032** due to insufficient government investment today? (*See Table 14 for list of capabilities*)
    a. No regret
    b. Moderate regret
    c. High regret
14. How much would a country **regret falling behind** on the following emerging capabilities in **2045** due to insufficient government investment today? (*See Table 14 for list of capabilities*)
    a. No regret
    b. Moderate regret
    c. High regret
15. Which of the following capabilities can provide the greatest **new leverage in spacepower advantage** in 2032 (check 3) and 2045 (check 3)? (*See Table 14 for list of capabilities*)
    a. 2032 (Check Only 3 Capabilities)
    b. 2045 (Check only 3 Capabilities)

    Why do you believe this will be the case?
16. In what year will the following 7 emerging space capabilities become **commercially and operationally available** (beyond testing and R&D)? (*See Table 14 for list of capabilities*)
    a. 2025
    b. 2030
    c. 2035
    d. 2040
    e. 2050
    f. After 2050
17. How much will your country's Spacepower Advantage increase or decrease between now and 2032? [sliding scale from -100% or greater decrease to +100% or greater increase]
18. What country will lead each category of space capabilities in 2032? (*See Table 14 for list of categories*)
    a. China
    b. Europe/UK
    c. India
    d. Russia
    e. U.S.
    f. Other

    If other, please specify and elaborate

[4] Spacepower is defined as the entire astronautical capacity of a nation. Spacepower Advantage is the relative advantage one nation has over another nation with respect to its Spacepower (e.g., space systems, capabilities, and effects). Lacking or losing Spacepower Advantage can result in comparatively less diplomatic, informational, military, and/or economic power.

19. What actions are most important to maintaining or increasing Spacepower Advantage for a nation? Rank the options with "1" being the most important. [1-6 ranking]
    a. Establish a unified and powerful north-star vision for space
    b. Invest heavily in research, development, science, and technology
    c. Invest heavily in a military space force
    d. Leverage innovation from commercial industry
    e. Create an agile and effective acquisition process
    f. Develop a competent and capable workforce
20. Comments and contact information. This is your opportunity to tell us what you think about the survey, along with how to reach you for future discussion.
    a. *Is there anything else you'd like to share?* [short answer]
    b. Name
    c. Company or Organization
    d. Email address

Acknowledgments

The authors wish to thank Peter Garretson and Gabriele Rizzo for their participation in the design of both surveys and the workshop. We are grateful to Andrew MacKenzie (NewSpace Nexus) and Dr. David Hardy for their efforts in supporting the planning, execution, and documentation of the workshop. We acknowledge Ruth Galaviz-Schomisch and Martin Edwards for their advice on survey design and support of generating survey graphics and preliminary analysis. We also wish to thank Dr. Joel Mozer (USSF) for his leadership of the strategic foresight efforts and Casey DeRaad and NewSpace Nexus (www.newspacenexus.org) for their support of this work. Finally, we are indebted to the workshop participants and pre-workshop survey respondents, as well as the many people who responded to the 20 Questions survey, especially those who pushed through to the end. Thank you.

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