Office of Technology, Policy, and Strategy

Technology Scouting Phase 1 Report

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September 22, 2023

Report ID 20230011409

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Executive Summary

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Purpose of the Study

Identifying emerging technologies is critical to a mission-oriented agency such as NASA that is always endeavoring to achieve first-of-a-kind human and scientific exploration goals. While NASA attempts to embrace faster and novel development approaches, there have been several recent examples where the Agency has been outpaced in technology research and development, especially by emerging companies. This is in part due to the democratization of space, as seen in the flood of new space companies and capital, and because capabilities and performance levels that used to be almost exclusively demanded by space missions are now scattered across many industries. Also, NASA tends to focus on technologies and techniques developed internally, within the space sector, or in clearly related disciplines.

In this context, the overall goal of the Technology Scouting project is to develop an approach to conduct effective technology scouting within NASA by first assessing the need for such a capability, evaluating current and recommended approaches, and then developing a strategy to address any weaknesses in the current approach. The study was designed to be conducted in three phases, each with its own goals and objectives:

- Phase 1: Validate whether NASA's technology scouting capability is consistent with best practices from industry, academia, and other government organizations, and identify whether there is the appetite for adopting a more rigorous technology scouting capability across the Agency.
- Phase 2: Identify specific opportunities and challenges to adopting a more comprehensive technology scouting program through a pilot effort.
- Phase 3: Define the implementation approach for the more comprehensive technology scouting program that is in response to the information learned during the earlier phases of the study.

This report addresses the first phase of the study, which explored two specific questions:

1. Benchmarking: How do industry, academia, and other government organizations conduct and structure their technology scouting activities? What are the characteristics of an effective technology “scout” and how they are developed? Are there any best practices from industry, academia, and other government organizations that NASA should adopt?
2. Gap analysis: What is the current state of technology scouting at NASA? In particular, how do “end users” use the products that emerge from technology scouting activities?

During Phase 1, we sought to address these study questions by conducting discussions with U.S. government organizations and international space agencies, including the Defense Advanced Research Projects Agency (DARPA), the Canadian Space Agency (CSA), and the Japan Aerospace Exploration Agency (JAXA), and reviewing 14 pieces of literature. Through discussions with 26 technologists and mission planners at NASA, we also sought to identify whether there is the appetite for adopting a more rigorous technology scouting capability across the Agency.

Based on this information, we propose candidates for an expanded technology scouting program that NASA can further explore during Phase 2 before developing an implementation approach for a more comprehensive NASA-wide technology scouting program in Phase 3. The overall intended outcome of all three phases is a more robust technology scouting capability at NASA.

Key Findings: Benchmarking

How do industry, academia, and other government organizations conduct and structure their technology scouting activities?

In conducting discussions with 15 external organizations, we captured a wide range of technology scouting definitions, approaches, and timelines. Often the definition provided was closely tied to the objectives of the organization and how they intended to use the “scouted” information. Nearly all external organizations we consulted came to their technology scouting processes through organic approaches, with gradual improvements guided by unique organizational cultures. There were a few notable exceptions of organizations (e.g., DARPA) that had been established with the specific charter to conduct technology scouting and to identify disruptive technologies.

After evaluating a range of organization types, our team identified three basic models for technology scouting: near-term gap filling, needs incubator, and horizon scanning (see table “Features of three basic technology scouting models” below). We base each model on the relevant time horizon and goals for the technologies—specifically, how narrowly the model focuses on addressing a specific gap or mission need. We also identified two distinct cadences for conducting these activities: opportunistic/ad hoc and highly structured. In general, the organizations we consulted from industry tended to be the most organic in their approach, while Federally funded research and development centers (FFRDCs), nonprofits, and academia tended to be most structured.

Criteria	Near-Term Gap Filling	Needs Incubator	Horizon Scanning
Time Horizon	1 to 5 Years	5 to 10 Years	10 Years +
Technology Type	Critical technologies to fill a near-term and well-defined need	Enabling technologies anticipated to fulfill an anticipated future need	Disruptive technologies that represent a significant leap
Description	Focused on finding existing or emerging technologies from new sources to meet a need for a defined mission	Finding and supporting organizations pursuing low-TRL technologies that have the potential to fill future gaps	Foresight activities often focused on emerging and long-term technology trends
Guidance Focus Areas	Direct interaction with developers based on a specific request	Long-term needs statements, strategies, roadmaps, concepts of operations. Forecast of likely future weakness or strategic need	Emerging concepts that could have broad applicability looking across multiple domains
Primary Tools	Technology calls, focused searches from nontraditional sources, advancements from new sectors, crowd sourcing	Focus on finding promising new technologies, incubating and fostering companies that may build a new market to address future needs	Data analysis of leading indicators of technology advancements, patents, publications, interactions with academia. Big data tools, data analytics, and developing watch lists for long-term tracking

Features of three basic technology scouting models

What are the characteristics of effective technology “scouts” and how are they developed?

Most organizations we consulted considered technology scouting an intrinsic part of the job function of their employees, performed as part of normal responsibilities. Most training to perform this work is done on-the-job rather than formally. As a result, organizations generally felt that the best matches for technology scouting come from individuals who can understand the technical aspects of the technology and the design criteria for its application (e.g., engineers working on a program, systems engineers, or technologists) and that this understanding was gained over time. While discussion around characteristics of effective technology "scouts" was mostly on the understanding for technology, communicating and disseminating the information is also a critical skill required.

Are there any best practices from industry, academia, and other government organizations that NASA should adopt?

We found that NASA's current technology scouting practices are generally consistent with those of other government organizations (both U.S. government organizations and international space agencies), but there are differences between how governmental and nongovernmental organizations approach technology scouting, given the customer-centric nature of their work and investments in tools.

Based on our discussions and literature review, we identified three common areas where NASA and other organizations expressed desire to enhance current activities:

- Resource Availability: In the absence of a formal process or prioritization of technology scouting, many organizations described how resource limitations impact their ability to conduct effective technology scouting, either because employees do not have sufficient bandwidth or because there are limited funds to conduct a large number of technology scouting activities. NASA could provide resources (i.e., time and money) to allow employees to increase their participation in conferences, workshops, panel reviews, and other activities to maintain awareness of the latest developments in their fields.
- Transparency: Effective technology scouting requires a high degree of transparency in order to understand what technologies are available and how to match them to known needs. NASA could create greater transparency around areas of technology interest to promote collaboration and operational efficiency across organizations and with outside entities.
- Integration: As systems become more complex and new capabilities become available, effective technology scouting activities must integrate information from an increasingly diverse array of sources. To support this work, NASA could integrate technology scouting activities across disciplines, combining advancements in different technology areas, and promote interoperability by including systems experts in the process.

Key Findings: Gap Analysis

What is the current state of technology scouting at NASA? In particular, how do "end users" use the products that emerge from technology scouting activities?

NASA's technology scouting activities are typically mission-driven, to identify either a specific technology to fill an unmet need or an area of opportunity for future investment. The nature of the technology scouting and the relevant time horizon varies across the Agency, with more near-term gap filling done at the center and project level and more longer term horizon scanning done at the mission directorate level. Most technology scouting activities at NASA are being done organically and opportunistically, as part of people's everyday jobs, as a way to maintain currency in a particular field, and there is limited information-sharing once someone has conducted a technology scouting activity. People we consulted generally felt that there was opportunity for improvement, and there was broad interest in changing NASA's culture to be more collaborative and transparent. We identified several mechanisms currently in development across the Agency, including the creation of information-sharing workshops and pilot testing of technology scouting tools, that could contribute to this shift.

Do "end users" believe a more rigorous technology scouting capability will be useful for them?

People we consulted acknowledged that current technology scouting activities are highly labor-intensive and that people often have limited resources or bandwidth to perform this work. Given the disparate needs for technology scouting, a single one-size-fits-all solution is unlikely to address everyone's needs. However, consulted individuals were generally supportive of more robust and more centralized capabilities as a way to increase transparency and promote collaboration. We identified several pilot efforts underway to develop technology scouting tools.

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Background and Rationale for the Study

Identifying emerging technologies is critical to a mission-oriented agency such as NASA that is always endeavoring to achieve first-of-a-kind human and scientific exploration goals. As shown in Figure 1, there are multiple pathways that NASA can take to close a particular technology gap. To fill technology gaps, NASA can pursue a make, buy, or re-use approach. By re-using or buying, NASA can take advantage of investments and an increased pace of innovation. However, that requires awareness of advancements in external technologies and innovations outside of NASA. This study focuses on technology scouting approaches that bring the awareness and knowledge required to support the buy and re-use strategies.

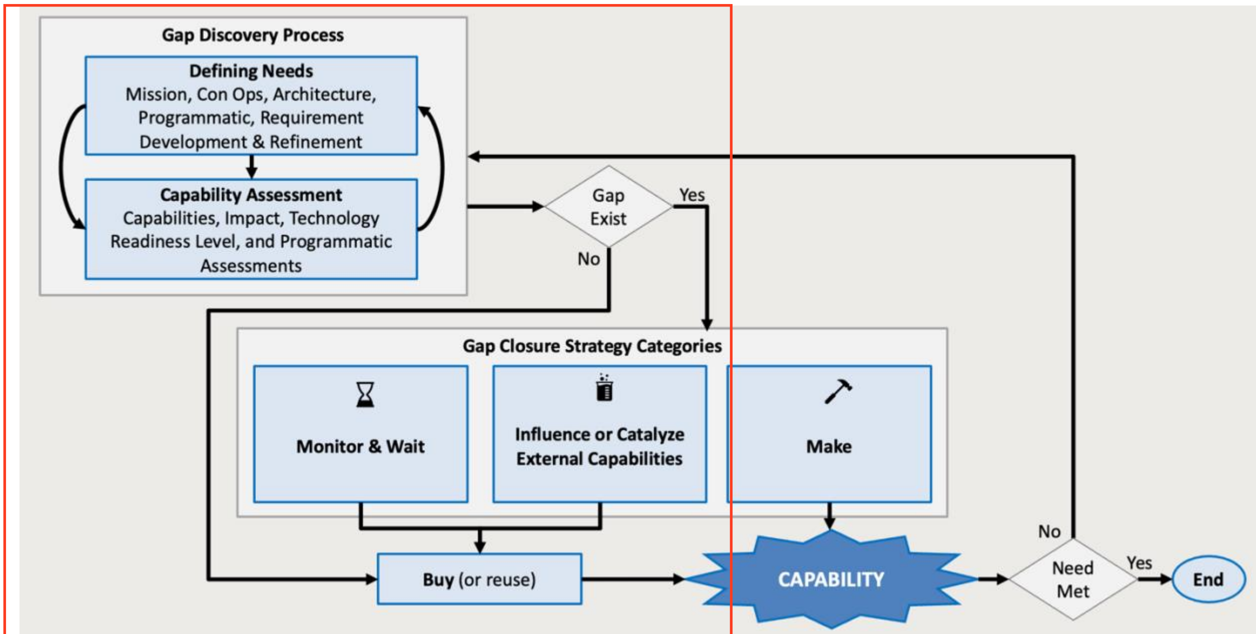

Figure 1. Gap Discovery and Closure Strategy Overview (credit to B. Schwing, JSC)

Advancements in the commercial space sector have enabled space technology research and development to flourish outside of NASA. At times, certain advancements have outpaced technology development within NASA, even with NASA embracing some faster and novel technology development approaches. As an example, SpaceX was able to develop new spacesuits faster and more cheaply than NASA. This is in part due to the democratization of space, as seen in the flood of new space companies and capital. Furthermore, capabilities and performance levels once almost exclusively demanded by space missions are now scattered across many industries; programs such as Commercial Lunar Payload Services (CLPS) are an explicit recognition of the commercial sector's technical capabilities.

Also, NASA tends to focus on technologies and techniques developed internally, within the space sector, or in clearly related disciplines. For example, the Technology Portfolio

Management System (TechPort)[1] is an effective tool to track NASA's technology investments. However, there is no approved Agency-wide solution to provide similar insights for non-NASA technology investments. To identify new technologies that can have major impacts, and match them to NASA's needs, requires new technology management techniques and practices.

What Is Technology Scouting?

"Technology scouting" is a term that companies, government organizations, nonprofits, academia, and others apply to a wide range of activities for technology discovery. For example, Futures Platform identified nine discrete methodologies (see Appendix B for definitions) that companies use to conduct foresight, depending on the relevant timespan and the qualitative or quantitative nature of the particular methodology.[2] Other techniques exist as well, such as crowd-sourcing and gap-based mapping. Technology scouting exists within the space defined by these foresight methods, by helping to define both mature solutions for near-term needs and maintaining awareness of emerging trends.

The definitions of technology scouting further illustrate this diversity. For example, the Science and Technology Directorate within the Department of Homeland Security defines technology scouting as "the process of identifying, locating, and evaluating existing or developing technologies, products, services, and emerging trends."[3] The National Institute of Standards and Technology (NIST) provides a more informal definition, namely that "technology scouting helps when you need a technology but don't know where to find it. It taps into existing but unknown sources of information to find solutions that can save…time, money and frustration."[4] Alternatively, the University of Tennessee provides a definition that focuses on process and approach, noting "technology scouting is a systematic approach to help manufacturing clients find existing technology solutions for their unmet company needs."[5]

To allow for the wide range of activities discussed in this study, we do not provide an explicit definition of technology scouting. However, three characteristics of technology scouting provide a basis for questions within this study:

- Process: Technology scouting is a deliberate process that can either be systematic and formal or informal and opportunistic.

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[1] https://techport.nasa.gov
[2] https://www.futuresplatform.com/blog/9-foresight-methodologies-successful-companies-use-stay-ahead
[3] https://www.dhs.gov/science-and-technology/technology-scouting
[4] https://www.nist.gov/mep/technology-scouting
[5] https://www.cis.tennessee.edu/advanced-manufacturing-solutions/technology-scouting

- Discovery: Technology scouting is focused on discovery and can include identifying emerging or disruptive technologies, identifying innovative companies and processes, or increasing understanding of technology trends. Several organizations use technology scouting to avoid or exploit "technology surprise."
- Grounded in application: The technology scouting process is focused on meeting a known objective. It may include identifying new solutions, enabling strategic decisions, or supporting curation of a technology investment portfolio.

Given this basis, our study includes all processes of technology discovery that address a specific goal.

What Is the Value Proposition of Technology Scouting?

Technology scouting exploits the reality that innovation across the broader ecosystem dwarfs innovation within a single organization. NASA's Center of Excellence for Collaborative Innovation (CoECI) uses a model, shown in Figure 2, to demonstrate the power of looking externally to accelerate and augment research and development activities. CoECI promotes collaboration because there is only so much expertise that an organization can realistically have in house, and because the level of that expertise is often overestimated.

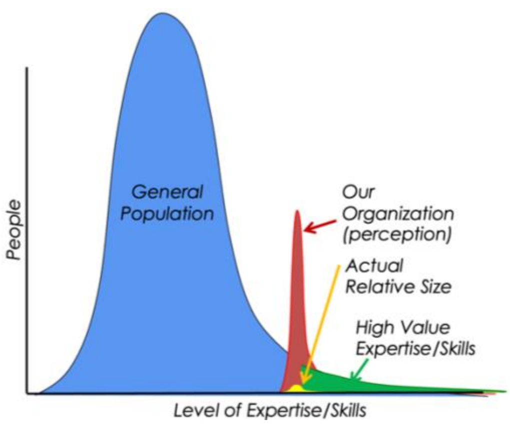

Figure 2. Availability of expertise and skills (credit to NASA CoECI)

Stephen Shapiro, a thought leader on innovation, proposed a framework[6] for when organizations should look internally vs. externally to drive innovation. This framework encourages organizations to focus on those challenges that they are best equipped to solve and to look externally in instances where either the challenges have already been solved and may be available for purchase or license or where challenges are highly complex or outside of an organization's area of expertise and may need a highly diverse solver group to address. The technology scouting process leverages this disparity by discovering and exploiting external ideas that apply to an organization's mission, thereby allowing the organization to specialize in niche research or focus on internal processes that allow the organization to more rapidly adapt to and incorporate new ideas. The technology scouting process can also allow for identification of overarching trends that help inform strategic investments and realize the art of the possible.

[6] https://stephenshapiro.com/are-you-smarter-than-a-phd/

The specific value and impact of technology scouting activities depend on the approach and how technology information is used. We consulted a range of organizations and captured different objectives of their technology scouting activities (See Figure 3 and Appendix A). These organizations tailor their technology scouting processes to maximize impact and alignment with their intended objectives. The effectiveness of technology scouting activities appears to often be subjective, in that many of the organizations we consulted did not use metrics to quantify their activities. Whether this is due to organizational self-preservation, a lack of established procedure, or a general faith in the value of technology scouting may vary by organization. While some more operationally driven organizations did maintain metrics, being an operations-focused organization did not seem to predicate the use of success metrics in technology scouting.

Why Should NASA Care?

As shown in Figure 1, NASA's missions, and the gaps to meet those missions, drive decisions about specific capabilities and technology investment choices. NASA has many different pathways to match missions with relevant technologies, from developing the technologies in house to procuring them from outside entities.

Technology scouting allows NASA to identify capabilities that address a mission need or other set of requirements. In some cases, these needs are expected to materialize in the near term (i.e., within the next five years). Technology scouting can identify mature solutions that are directly responsive to the known needs. For example, we frequently heard that when a center needs a specific technology to be advanced or available within a short time span, the team relies heavily on their networks to help find a solution. For example, Goddard Space Flight Center (GSFC) was able to quickly fill a remote sensing laser gap for a mission that relied on integrated photonics.

In other cases, technology scouting enables NASA to stay on the cutting edge of a particular field by identifying new opportunities and capabilities to integrate into NASA's future mission set. For example, we heard from several organizations within NASA that use technology scouting to maintain awareness in cutting-edge developments for quantum sensors and quantum computing. They view these as areas that hold significant future promise, but where we need to process cautiously before making significant or sustained investment. In this instance, the organizations watch outside entities' progress in this field, looking for when the capabilities are mature enough to include in future mission planning.

Technology scouting fits well into NASA's competitive model, as the Agency does not have the resources to duplicate expertise readily available elsewhere. Scouting of internally developed technologies helps NASA centers and mission directorates partner more effectively. NASA can also identify externally developed technologies that are readily available or that industry can develop more cost-effectively. For longer term needs, technology scouting recognizes that external ecosystems move at more accelerated timescales than government procurement cycles. NASA can use effective technology scouting to maximize traditional vehicles' effectiveness in the absence of major contracting refits. NASA can also incentivize commercial development of certain capabilities by using information gathered through technology scouting activities to inform future Small Business Innovation Research (SBIR) calls or Requests for Proposals (RFPs). For example, NASA can create SBIR subtopics to incentivize industry partners to produce technologies that are a stretch beyond current terrestrial applications.

Our research has shown that technology scouting is often a labor-intensive process that can rely heavily on personal networks to be effective, particularly in the absence of dedicated organizations. Most people within NASA who perform technology scouting do so as part of their day-to-day jobs to maintain currency in their particular field, rather than as a discrete duty. Other work responsibilities and resource limitations can constrain the effectiveness of these technology scouts. As NASA considers issues related to its workforce, including workload for current employees and composition of the future workforce, questions regarding who conducts technology scouting on behalf of the Agency and how they perform this work should be addressed.

Study Questions and Key Assumptions

The overall intended outcome of all three phases of the technology scouting study is identify if there is a need for a more robust technology scouting capability at NASA, and if so, develop a strategy and implementation plan to improve the current approach. The intended outcome for Phase 1 is to validate whether NASA's technology scouting capability is consistent with best practices from industry, academia, and other government organizations and to identify whether there is the appetite for adopting a more rigorous technology scouting capability across the Agency.

Phase 1 of the study had two main elements: benchmarking and a gap analysis. For the benchmarking assessment, the team sought to answer the following questions:

- How do industry, academia, and other government organizations conduct and structure their technology scouting activities?
- What are the characteristics of effective technology "scouts" and how are they developed?
- Are there any best practices from industry, academia, and other government organizations that NASA should adopt?

For the gap analysis, the team sought to answer the following questions:

- What is the current state of technology scouting at NASA (i.e., centers and mission directorates)? In particular, how do "end users" use the products that emerge from technology scouting activities?
- Do "end users" believe a more rigorous technology scouting capability will be useful for them?

Methodology

For the Phase 1 study, the team conducted a literature review and held discussions with key stakeholders to understand how technology scouting is done at NASA and elsewhere. Appendix A lists the consulted individuals and organizations by date. We prepared a series of open-ended questions and shared these with the individuals ahead of time, our discussions were typically 30 to 60 minutes in length.

External to NASA, the team conducted a literature review and held discussions with representatives from industry, academia, and other government organizations to understand how they currently perform technology scouting activities and any lessons learned to improve this capability. The team met with three representatives from other government organizations, five representatives from international space agencies, six representatives from industry, and five representatives from other organizations (e.g., FFRDCs, academia, and nonprofits).

Within NASA, the team met with 27 individuals, including the chief technologists from several mission directorates and all NASA centers, including the Jet Propulsion Laboratory (JPL), and conducted a roundtable with Principal Technologists (PTs) and Systems Capability Leaders (SCLs) to understand whether they currently conduct any technology scouting activities, what institutional practices support or hinder these activities, and what types of technology scouting activities or capabilities might benefit their work. Of those consulted, 44% had a mission pull role in their organization.

In this report, we share aggregated results from these data collection efforts to present trends rather than individual responses.

Findings from Outside of NASA

Finding 1: Among the wide range of approaches to technology scouting outside of NASA, we identified three basic models, based on the relevant time horizon and goals for the technologies.

In holding discussions with 15 external organizations, we captured a wide range of technology scouting definitions, approaches, and timelines. However, a few trends in approaches to technology scouting emerged from the team's benchmarking discussions and research across government, industry, nonprofits, and international organizations.

Often the definition provided was tied to the organization's objectives and its intent for the "scouted" information. For example, organizations looking to address specific gaps through a technology pull process saw technology scouting as a tool to match needs and solutions. Innovation accelerators noted that their definition of technology scouting is closely tied to the identification of innovative companies with solutions likely to survive the process of creative destruction.[7] Large firms may look to technology scouting to identify underlying or hidden trends that inform how to invest research funds. Many organizations noted that they did not have a defined technology scouting role and may instead look to related horizon scanning or foresight activities; however, broadly speaking, most organizations we consulted see value in a forward-looking effort that informs technology investment.

While nearly all organizations we consulted came to their processes through organic approaches, with gradual improvements guided by unique organizational cultures, three models of approaching technology scouting shined through: near-term gap filling, needs incubator, and horizon scanning. The primary differentiator of these models was a combination of the time horizon for the scouting and how narrowly the model focused on addressing a specific gap or mission need. These factors tended to drive the structure of the technology scouting approaches of the organizations we consulted.

Table 1 details the three basic models that emerged from the benchmarking. Later, Figure 5 shows how the organizations we consulted fall into these models.

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[7] The Theory of Creative Destruction was proposed by Joseph Schumpeter in his 1942 book "Capitalism, Socialism, and Democracy" as a way to describe disruptive technologies that can revolutionize markets, driving out the old and replacing with the new.

Criteria	Near-Term Gap Filling	Needs Incubator	Horizon Scanning
Time Horizon	1 to 5 Years	5 to 10 Years	10 Years +
Technology Type	Critical technologies to fill a near-term and well-defined need	Enabling technologies anticipated to fulfill an anticipated future need	Disruptive technologies that represent a significant leap
Description	Focused on finding existing or emerging technologies from new sources to meet a need for a defined mission	Finding and supporting organizations pursuing low-TRL technologies that have the potential to fill future gaps	Foresight activities often focused on emerging and long-term technology trends
Guidance Focus Areas	Direct interaction with developers based on a specific request	Long-term needs statements, strategies, roadmaps, concepts of operations. Forecast of likely future weakness or strategic need	Emerging concepts that could have broad applicability looking across multiple domains
Primary Tools	Technology calls, focused searches from nontraditional sources, advancements from new sectors, crowd sourcing	Focus on finding promising new technologies, incubating and fostering companies that may build a new market to address future needs	Data analysis of leading indicators of technology advancements, patents, publications, interactions with academia. Big data tools, data analytics, and developing watch lists for long-term tracking

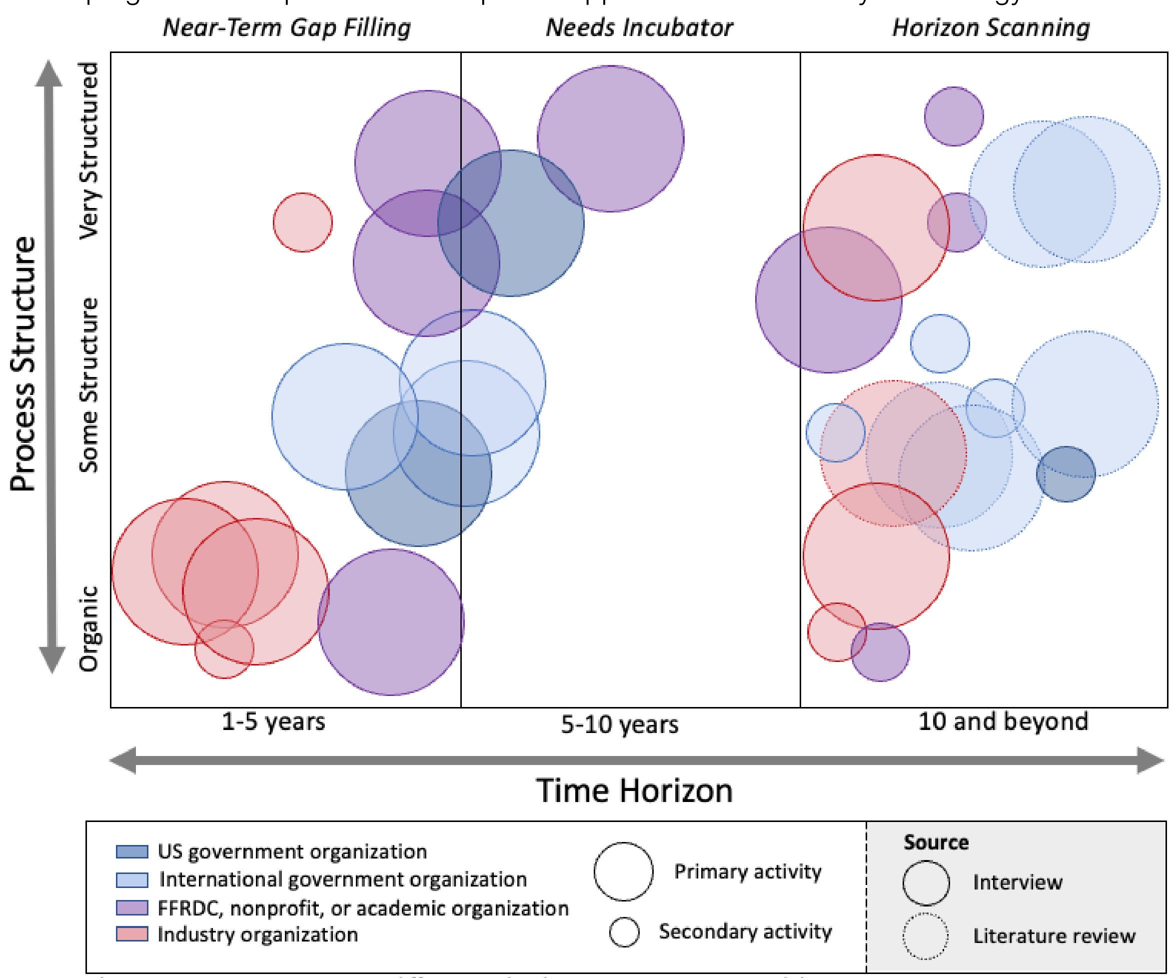
Table 1. Features of three basic technology scouting models

Finding 2: Despite the wide range of approaches to technology scouting outside of NASA, we identified two distinct cadences for conducting these activities.

The overall approach to technology scouting varies from opportunistic/ad hoc to very structured and defined. In general, the organizations we consulted from industry tended to be the most organic in their approach, while FFRDCs, nonprofits, and academia tended to be most structured.

As described in more detail in Finding 4, many of the organizations we consulted viewed technology scouting as one of many roles for employees across the organization and therefore focused technology scouting activities on opportunities to gather useful information, such as technology conferences and conversations at workshops. On the other end of the spectrum, some organizations had the defined purpose of identifying, incubating, sourcing, supporting, or fostering new technologies for a specific need. These organizations worked with a regular cadence, using strong processes, tools, and approaches for their scouting. We also identified a few organizations using a blended approach: periodic focused scouting activities around strategic planning or project initiation activities and opportunistic scouting in between.

While identifying these two distinct cadences, we found that organizations might benefit from lessons learned from organizations with different processes. Those organizations with opportunistic/ad hoc scouting frequently mentioned plans or preferences to add structure to their processes for technology scouting when asked about what they would change about their current approach. Organizations with structured technology scouting programs noted the need for keeping the door open for serendipitous opportunities to identify technology advancements.



The same organization may use different technology scouting activity models

Figure 3: Representation of all the organizations we consulted, which scouting model they primarily fell within, and how structured their processes were, by type of external organization.

Finding 3: Disruptive technology scouting was a deliberate activity undertaken by a few organizations specifically tasked with that type of work.

Most organizations we consulted focused on fairly mature capabilities for meeting near- to mid-term technology needs. A few organizations looked toward more disruptive capabilities available further in the future, but only those organizations with specific mandates to be that forward-leaning. The model for disruptive organizations placed a high value on regular calls for new ideas or new participants or employees in order to encourage innovative thinking. Organizations that did not have such a mandate rarely, if ever, actively looked towards disruptive capabilities, but were interested in maintaining awareness.

Finding 4: Most technology scouting work is done in house or through specialty organizations created for this purpose.

Most organizations we consulted considered technology scouting an intrinsic part of the job function of their employees, performed as part of normal responsibilities. Most training to perform this work is done on-the-job rather than formally. As a result, organizations generally felt that the best matches for technology scouting come from individuals who can understand the technical aspects of the technology and the design criteria for its application (e.g., engineers working on a program, systems engineers, or technologists) and that this understanding was gained over time. Early-career employees are more often assigned technology scouting activities as developmental assignments.

In some cases, government organizations established standalone entities to conduct technology scouting activities as a precursor to more substantial partnerships with outside organizations. This model provides greater flexibility because these entities often have faster contractual mechanisms and can interact directly with organizations that the government cannot. In particular, this approach enables proactive outreach. By establishing accelerated procurement timelines and enabling recurring engagement with small companies or companies that have not previously worked with the government, this approach lowers barriers to participation.

We found a few instances where organizations engaged with outside entities to support technology scouting activities. In general, this pathway was used in limited situations based on a specific need, such as hiring a consulting firm to provide an assessment on a particular area of interest.

Finding 5: Many organizations, particularly nonprofits supporting the government and in industry, use Customer Relationship Management (CRM) tools and databases for knowledge management of their scouting.

There is a great diversity of knowledge management tools used by external organizations. Although no organization had one tool that solved all their technology scouting needs, a few functions were improved with off-the-shelf tools referenced in our discussions. Many organizations mentioned using CRM tools, such as Salesforce, HubSpot, and Pitchbook, to track information about companies and contacts and generally as a knowledge management tool for the scouted information within a distributed team. Several organizations also mentioned using databases that consolidate information from across many sources as tools for researching emerging technologies or companies. Examples mentioned include Crunchbase and Ratio Exchange for identifying companies.

For several of the organizations, doing outreach is a critical component of their overall process. Social media and survey tools such as SurveyMonkey are useful in those activities.

Findings from Inside of NASA

We assessed both the current state of technology scouting within NASA and opportunities for improvement in the future.

Current State

Finding 1: NASA's technology scouting process is generally aligned with that of other government organizations but varies from that of industry.

As previously discussed, we identified three models to characterize how outside organizations approach technology scouting. In general, these three models were recognized by NASA and other organizations in government and industry. While the approaches and processes within these models varied, we found that NASA's overall approach was more consistent with that of organizations in government than in industry. Table 2 summarizes the major process differences we noted.

Criteria	NASA	Other Government Agencies	Industry
Purpose	Mission-driven	Mission-driven	Customer-driven
Primary Mechanism	Individual expertise	Individual expertise	Tools
Primary Data Sources	Personal networks Conferences/workshops Literature reviews	Personal networks Conferences/workshops Literature reviews	Databases Websites/social media
Availability of Resources	Low	Low	Scales with size of organization

Table 2. Comparison of NASA's technology scouting activities with organizations in other government and industry.

The remaining findings in this section provide additional detail on the current state of NASA's technology scouting activities.

Finding 2: Technology scouting activities at NASA are generally mission-driven, to identify either a specific technology to fill an unmet need or an area of opportunity for future investment. The nature of the technology scouting and the relevant time horizon varies across the Agency.

As a mission-driven agency, nearly all of the examples of technology scouting we discovered at NASA were to support a specific mission need. Furthermore, different organizations have different needs for technology scouting depending on where in the project lifecycle the need arises, as shown in Table 3. While this approach makes sense in theory, our team identified few success stories to validate whether it meets NASA's needs in practice.

Criteria	Near-Term Need	Project Formulation	Incubation	Horizon Scanning
Time Horizon	1 to 5 Years	5 to 10 Years	10 Years +	10 Years +
Lead Organizations	NASA Centers, Programs and Projects	NASA Centers, Programs and Projects, Mission Directorates	Mission Directorates	Mission Directorates
Technology Type	Technology needed now, either to support real-time operations or mature mission development work	Mission-enabling capabilities that are state-of-the-art and mature enough for inclusion in a new project	Low TRL technologies that could be applicable to future mission concepts but are not yet ready for adoption	Disruptive technologies that could be applicable to future mission concepts but are not yet ready for adoption
Description	Focused on finding existing technology from new sources to meet a defined need for a mission in development	Identifying technologies relevant to new mission concepts	Early-stage investments in technologies that could enable future missions	Forward-leaning efforts to inform future mission architectures and transform what is possible
Guidance Focus Areas	Project Requirements, Gaps	Announcements of Opportunity, Requests for Information	Architecture Studies, Decadal Surveys	Envision Futures

Table 3: Needs for technology scouting relative to NASA project lifecycle

Some but not all centers create technology strategies that focus on particular areas of interest based on long-term mission needs. For example, every five years JPL produces a Strategic

Technologies report[8] that identifies technology thrust areas of interest to JPL. However, most centers rely on StarPort and the expertise of PTs and SCLs to identify gaps. Additionally, STMD relies on non-NASA experts to inform technology planning and engages with other Mission Directorates to gauge interest in developing programs in new technology areas.

Given the disparate needs for technology scouting, a single one-size-fits-all solution is unlikely to address everyone's needs.

Finding 3: Most technology scouting activities at NASA are done organically and opportunistically, as part of employees' everyday jobs, as a way to maintain currency in a particular field.

Most people we consulted viewed technology scouting as an activity performed as part of one's regular responsibilities, not as a standalone responsibility, and few routinely conduct technology scouting outside their area of expertise. The most common ways that employees conduct technology scouting are through routine interactions with members of the relevant community, such as attending conferences and workshops, and staying current with recent publications. This approach is generally consistent with other government organizations. Several consulted individuals expressed concerns about lacking resources to attend enough conferences or workshops in a given year.

Other organizations are considered an important source of information about new technologies. In some instances, consulted individuals participated in other organizations' review panels, such as those of the National Science Foundation (NSF), as a way to learn about emerging ideas. The Department of Defense (DoD) was often cited as an important partner, with employees actively tracking new technologies for potential NASA applications.

We heard from several centers that they provide a small amount of funding to employees through efforts such as the Center Innovation Fund (CIF), Internal Research and Development (IRAD) Program, Convergent Aeronautic Solution (CAS) Program, and other calls for innovative proposals. These awards enable employees to stay current with their subject area and bring that information back to their home center.

Finding 4: There is little information-sharing once someone has conducted a technology scouting activity.

Given that technology scouting is primarily done organically, this activity often relies on an individual's personal networks and personal knowledge. Most frequently, people had files

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[8] For the most recent report, see the 2019 JPL Strategic Technologies: https://scienceandtechnology.jpl.nasa.gov/sites/default/files/documents/JPL_Strategic_Technologies_2019.pdf

stored on their computers to capture what they learned, to refer to at another time. This was identified as an area for improvement in many discussions.

As noted in Finding 3, attendance at conferences and workshops is one of the most common ways that technology scouting is currently done. While we found that some Center Chief Technologists created information-sharing mechanisms within their home center after a major conference (e.g. trip reports), this practice is not universal and the information is typically not shared more broadly.

We found a few examples of where people implemented formal mechanisms to capture and share knowledge, most notably the effort underway in STMD and ESDMD to document in StarPort technology areas of interest as they relate to the Envision Futures Priorities, sharing this information within the PT and SCL community and beyond. The CoECI Program, discussed in more detail in Finding 6, posts information from technology scouting activities on the NASA Engineering Network, accessible through the OTPS-funded Innovation Portal.

Finding 5: NASA is starting to host focused workshops, competitions, and other discussions as a way to bring attention to emerging technology needs.

Over the past few years, NASA has created several new mechanisms to bring together thought leaders from within and outside NASA for focused conversations on emerging technology. In some cases, these workshops have highlighted a particular technology of future interest to NASA (e.g., NASA Engineering & Safety Center (NESC) Quantum Sensing Workshop in September 2022), while others promote dialog and build connections in support of near-term mission concepts (e.g., SMD Technology Showcase for Planetary Science in January 2023). Competitions have engaged academia and others in imagining and designing future technologies to meet existing needs (e.g., Aeronautics Research Mission Directorate's Gateways to Blue Skies: Airports of Tomorrow).

Finding 6: Several NASA organizations have invested in pilot tools to support technology scouting activities.

All NASA employees currently have access to the CoECI mechanisms for technology scouting, which are most commonly used by JSC and for human spaceflight applications. CoECI can conduct technology scouting on behalf of NASA customers, while also supporting NASA's prizes and challenges.

CoECI is currently operating near capacity due to constrained resources. NASA customers represent about half of the total CoECI business. CoECI also provides end-to-end service to assist other government organizations in the use of crowdsourced challenges through the NASA Tournament Lab.

We consulted several organizations developing tools to support technology scouting, particularly to help with the scouting process, but we found limited commonality between the tools being piloted, which generally used different data sources for their reports. The NASA Library has access to some tools, such as Quid, that could support this type of work, but it is not clear how widely these tools are used. Developers want their tools adopted NASA-wide, but there does not seem to be a significant amount of collaboration. The utility of these tools has not yet been demonstrated.

Future State

Finding 1: There is broad interest in having more robust technology scouting capabilities at NASA, including centralized coordination of these activities.

People we consulted acknowledged that current technology scouting activities are highly labor-intensive and that people often have limited resources or bandwidth to perform this work. They were generally supportive of more robust and more centralized capabilities as a way to increase transparency and promote collaboration. In addition to a centralized tool to conduct technology scouting activities, there was also interest in a centralized repository to store information collected during the technology scouting process. However, we did not find such a capability being piloted at this time, despite previous efforts as part of NASA's innovation portfolio and framework. We are concerned that people would not regularly populate a standalone tool.

As previously discussed, most of the technology scouting activities we identified were to support specific mission needs, and the people doing the scouting often had a close affiliation with the missions. We found limited examples of where technology scouting was to address a NASA-wide gap, primarily coming from STMD. We also heard from several people that the NASA Chief Technologist would be the appropriate person to manage technology scouting capabilities on behalf of the Agency and to identify emerging technologies that can contribute to the fulfillment of NASA's mission.

Conclusion and Next Steps

Our study has shown that technology scouting is an important tool used by many organizations in government, industry, and academia. For a mission-driven agency such as NASA, technology scouting activities are generally aligned to support mission needs, either based on current gaps or to inform future investment choices.

Despite this importance, technology scouting activities are generally organic and highly labor-intensive. While some organizations, primarily in industry, rely on consultants or tools to conduct their technology scouting activities, most of the people we consulted described technology scouting as something that was done as part of their day-to-day jobs to maintain currency with their field. As a result, there is typically little information-sharing. Data is collected and knowledge is retained only by the person doing the scouting. NASA organizations recognize that there are limitations to the current approach to technology scouting and see value in adopting a more robust approach.

Appendix A: List of Consulted Individuals and Organizations

The team thanks the following individuals and organizations for speaking with us during the study. Discussions were held in the September – December 2022 timeframe.

- Mike Ahn, Senior Administrator, International Cooperation Office, KARI
- Reginald Alexander, Manager, Partnerships and Formulation Office, NASA MSFC
- Jonathan Bowie, Deputy Director, Strategic Planning and Integration, NASA STMD
- John Carr, Deputy Chief Technologist, NASA MSFC
- Brad Chedister, Chief Technology & Innovation Officer, DefenseWERX
- Teresa Cicerone, NRO
- Ronald Clayton, Deputy Chief Technologist, NASA JSC
- John Dankanich, Center Chief Technologist, NASA MSFC
- Yann Denis, Manager, Planning, Engagement and Innovation, Space Science and Technology, CSA
- Andre Doumitt, Director of Innovation Development, Aerospace Corporation
- Steve Eckersley, Head of Mission Concepts Group, Surrey Satellite Technology Ltd
- Bernard Edwards, Chief Communications Systems Engineer, NASA GSFC
- Guillaume Faubert, Manager, Governance, Integration and Tech Scouting, Space Science and Technology, CSA
- Terry Fong, Senior Scientist for Autonomous Systems, NASA ARC
- KiMar Gartman, Program Director, Catalyst Accelerator
- Daniel Gillies, Senior Space Technology Policy Analyst, NASA STMD
- Mark Hilburger, Principal Technologist for Structures, Materials, and Nanotechnology, NASA STMD
- Jason Hyon, Chief Technologist for Earth Science, JPL
- Michael Interbartolo, Human Lunar Lander Crew Module SE&I Team, NASA JSC
- Amy Kaminski, Program Executive for Prizes, Challenges, and Crowdsourcing, NASA STMD
- Angela Krenn, Thermal Principal Technologist, NASA KSC
- Ron Litchford, Principal Technologist for Propulsion, NASA MSFC
- Alesyn Lowry, Director for Strategic Planning & Integration, NASA STMD
- Jeremy Lui, Head of R&D, ExoLaunch
- David Marsh, Space Station Strategy Lead, Nanoracks
- Joshua Mehling, Principal Technologist for Robotics, NASA JSC

- Carolyn Mercer, Chief Technologist, NASA SMD
- Michelle Munk, Acting Chief Architect, NASA STMD
- Bo Naasz, Senior Technical Lead, Rendezvous and Capture System Capabilities, NASA GSFC
- Charles Norton, Acting Chief Technologist, JPL
- Masami Onoda, Director, Washington D.C. Office, JAXA
- Harry Partridge, Chief Technologist, NASA ARC
- Anne Peek, Chief Technologist, NASA SSC
- Thomas Prince, Director, Keck Institute for Space Studies
- Philip Root, Director, Strategic Technology Office, DARPA
- Kurt Sacksteder, Deputy Center Chief Technologist, NASA GRC
- Gerald Sanders, ISRU System Capability Lead, NASA JSC
- John Scott, Principal Technologist for Power and Energy, NASA JSC
- Ryon Stewart, CoECI Challenge Coordinator, NASA JSC
- Kohei Tani, Deputy Director, Washington D.C. Office, JAXA
- Caleb Wehrmann, Research Engineer, NRO
- Julie Williams-Byrd, Chief Technologist, NASA LaRC

Note: Three companies were consulted on a non-attribution basis and their names are not included in this list.

Appendix B: Future Forum's Foresight Analysis Methodologies

Forecasting is about making projections or estimations of the future whose outcomes are uncertain. Prediction refers to precise estimations.

War Game Simulations mostly deal with competitive operations of various kinds. In a business context, these strategic games simulate different competitive settings and competitor actions and responses.

Roadmaps are often seen in technical contexts. Technology roadmaps literally map out projected milestones in the development of new technologies or products.

Backcasting starts with defining a plausible and desirable future. After that, the team works backwards to identify actions and programs that will connect that future with the present.

Wild cards are low-probability, high-impact events. They are also generally referred to as "black swans," though they can refer to positive events. Weak signals are lower impact or more distant events. Their observation attempts to link small developments and phenomena to the potential occurrence of emerging issues or changes in current trends.

Trends and Emerging Issues Analysis:

Trends analysis is the practice of collecting information and attempting to spot patterns. It also deals with the impact of these patterns over time. Emerging issues, on the other hand, are "events" that do not seem to fit into any existing patterns but may develop new ones.

Horizon scanning is the systematic gathering of information to detect early signs of potentially important developments. It's also used to identify new and emerging trends. This activity is often based on desk research, assisting in the development of the big picture of future changes. A solid horizon scanning process can help develop strategies to align with future changes. It can also be a way of identifying new trends that are later used in scenarios.

Scenario planning helps organizations anticipate change, prepare responses, and create robust strategies. The process typically starts with the combining of known facts about the operating environment with uncertain factors about the future context. Then, one selects a number of these "uncertainties" or "drivers of change" in the future and converts plausible paths of development into two or more alternative stories, or "scenarios." As the future unfolds, some paths generally begin to emerge as more plausible and others as less plausible. Often, the future involves a combination of paths.

The Delphi Method is a structured and interactive forecasting activity that relies on a panel of experts. The experts answer questionnaires and argue different positions. This is usually done over a few rounds. During this process, the range of answers narrows down. This is based on the reassessment of given arguments and consensus-building. In the final round, the group of experts converges toward a final “correct” answer about the future.

Appendix C: Technology Scouting Tools

The list below includes 13 tools referenced by consulted individuals that can be used for technology scouting and could be leveraged by NASA. This list is not meant to be exhaustive and inclusion does not constitute endorsement by the study.

- Crunchbase: prospecting platform with detailed business information on companies, including investment and funding data, mergers and acquisitions, leadership team, news, market segmentation, and industry trends. (link)
- Goldfire: cognitive search platform leveraging AI algorithms for sorting through large quantities of data. (link)
- HubSpot: CRM software platform for storing and managing information. (link)
- Lucy: AI-powered knowledge management platform that uses natural language generation to synthesize search results, directly answer users' questions, mine previous research, and recall files and data. (link)
- PitchBook: A suite of products including research services and software tools for collecting, organizing, analyzing, and visualizing industry data. (link)
- Planview Spigit (now Planview IdeaPlace): Innovation management software to combine market information, including speed to market, cost to impact, crowdsourced input, metrics, and other data points to identify needs and trends. (link)
- Quid: web-based tool that uses sentiment analysis and artificial intelligence to help answer strategic questions by supporting search, analysis, and visualization of the world's collective intelligence. (link)
- Ratio Exchange: sourcing platform for consolidating information to help manage and analyze data. (link)
- Salesforce CRM: cloud-based software to collect, manage, and analyze industry information, including trends. (link)
- TechPort (NASA): NASA resource for locating information on NASA-funded technology to identify existing technologies and gaps. (link)
- Vulcan (DoD): innovation scouting platform used to track and collect information on technologies of interest, assess solutions collaboratively, and share technology scouting reports. (link)
- Wellspring: web-based technology scouting software with tools to search over 400M records, use machine learning to scan organization portfolios, and draw landscape insights in different technology areas. (link)
- Yet2: technology scouting and crowdsourcing services and tools for identifying and analyzing technology solutions and market opportunities, including customized open innovation portals. (link)

Appendix D: Acronyms

Acronym	Definition
CIF	Center Innovation Fund
CLPS	Commercial Lunar Payload Services
CoECI	Center of Excellence for Collaborative Innovation
CRM	Customer Relationship Management
CSA	Canadian Space Agency
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
FFRDC	Federally Funded Research and Development Center
GSFC	Goddard Space Flight Center
IRAD	Internal Research and Development
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
NASA	National Aeronautics and Space Administration
NESC	NASA Engineering & Safety Center
NIST	National Institute of Standards and Technology
NSF	National Science Foundation
OCHCO	Office of the Chief Human Capital Officer
OTPS	Office of Technology, Policy, and Strategy
PT	Principal Technologist
SBIR	Small Business Innovation Research
SCL	Systems Capability Leader
SMD	Science Mission Directorate
STMD	Space Technology Mission Directorate

Acronym	Definition
TechPort	Technology Portfolio Management System
TRL	Technology Readiness Level

References

Bibliography

National Institute of Science and Technology Policy. 2019. “The 11th Science and Technology Foresight: S&T Foresight 2019 - Summary Report.” Tokyo, Japan. https://nistep.repo.nii.ac.jp/index.php?action=pages_view_main&active_action=repository_action_common_download&item_id=6657&item_no=1&attribute_id=13&file_no=15&page_id=13&block_id=21

National Institute of Science and Technology Policy. Accessed November 22, 2022. “Science and Technology Foresight and Science and Technology Trends.” https://www.nistep.go.jp/en/?page_id=56#target01

Korea Institute of S&T Evaluation and Planning. Accessed November 22, 2022. “Foresight and Future Strategy for S&T.” https://www.kistep.re.kr/menu.es?mid=a20201000000

European Defence Agency. Accessed November 22, 2022. “Technology Watch & Foresight.” https://eda.europa.eu/what-we-do/all-activities/activities-search/technology-watch-foresight#

Scapolo, Fabiana. “Foresight as an instrument for research priorities identification.” Presentation, European Commission Joint Research Center, Vienna, June 2011. http://www.foresight-platform.eu/wp-content/uploads/2011/05/Scapolo-EC-JRC.pdf

Center for Strategic Futures. Accessed November 22, 2022. “Our Approach.” https://www.csf.gov.sg/our-work/our-approach/