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Strategic Perspectives on the Future of Systems Engineering at NASA

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Summary

NASA's Model-Based Systems Engineering (MBSE) Infusion and Modernization Initiative (MIAMI) chartered a strategy group comprising early to middle career NASA subject matter experts with diverse experiences to look into the future of systems engineering (SE) at NASA. The purpose of the group was to provide a vision for the future state of SE practices and to develop a strategic plan to enable the evolution of the art up to 20 years in the future. The strategy group used a design-thinking approach to gather ideas. The group obtained insight into current engineering processes and domain outlook by interviewing engineers of varying expertise and experiences who had worked on teams of different sizes for missions large and small. The group built a roadmap to highlight future needs, projected capabilities, and technology and competency gaps and developed a strategic plan to ensure the expedient introduction of these capabilities. The resulting strategic plan recommends capability development and workforce strategies and provides guidance for Agency-wide SE policy. Artifacts, details, and raw data from the strategy team's work are contained in NASA/TM-20205002911/SUPPL, Strategic Perspectives on the Future of Systems Engineering at NASA: Supplemental Information: Appendixes A to K.

Acronyms

AI	artificial intelligence
CLT	Capability Leadership Team
HQ	Headquarters
IDEF	Integrated DEFinition
INCOSE	International Council on Systems Engineering
MBSE	model-based systems engineering
MIAMI	Model-Based Systems Engineering (MBSE) Infusion and Modernization Initiative
NACA	National Advisory Committee for Aeronautics
NESC	NASA Engineering and Safety Center
OSMA	Office of Safety and Mission Assurance
SE	systems engineering
SMA	Safety and Mission Assurance
STEM	science, technology, engineering, and math
SWOT	strengths, weaknesses, opportunities, and threats
SysML	Systems Modeling Language

Introduction

In 2018, NASA's Model-Based Systems Engineering (MBSE) Infusion and Modernization Initiative (MIAMI) commissioned a strategy group comprising subject matter experts with diverse experiences and bold ideas to look into the future of systems engineering (SE) at NASA. The group's purpose was twofold: to provide a vision for the future state of SE practices and to develop a strategic plan to enable the evolution of the art up to 20 years in the future. The team began by applying a systems approach in considering how the nature of engineering work in general may change due to advancing technologies and a changing workforce. The resulting vision provides top-level goals and objectives of future engineering capability and provides a basis from which investments in the workforce and capabilities can be evaluated. The strategic plan will help provide a fresh perspective on new capability development, workforce strategies, and Agency-wide SE policy, and it proposes potential on-ramps for investment consideration. From the vision, strategic plan, and roadmap, further refinement of the day-to-day work of systems engineers can be derived.

This report presents an overview of the MBSE Strategy Group vision and roadmap. Supplemental information is contained in NASA/TM-20205002911/SUPPL (Ref. 1) in appendixes organized by various components of the group's work: the June 2018 kickoff meeting (Appendix A); the group charter (Appendix B) and work plan (Appendix C); advisory board reviews and lessons learned (Appendix D); NASA engineer interviews (Appendix E); the strategy group's vision (Appendix F), roadmap (Appendix G), and strategic plan (Appendix H); and meeting notes (Appendix I). The supplement also includes a bibliography (Appendix J) and an acronym list (Appendix K).

Background

The NASA Engineering and Safety Center (NESC) Systems Engineering Technical Discipline Team established MIAMI in October 2017. The goals of MIAMI are to make SE easier, realize the potential benefits of digitization, establish an MBSE capability, link the work with other NASA efforts, and communicate the efforts. This initiative continued and expanded the work conducted under the MBSE Pathfinder in 2016 and 2017, which evaluated the use of MBSE on real NASA missions and provided over a dozen use cases with qualitative and quantitative benefits, challenges, and lessons learned (Ref. 2). The effort grew under MIAMI to include an Agency-wide MBSE Community of Practice, an advisory board, and a strategy group (Ref. 3). The MBSE Community of Practice is a digital practitioner community whose objectives are to find, develop, and promote modeling best practices; define options and recommendations for the infrastructure necessary for MBSE and collaborative environments; and serve as points of contact to communicate between the MIAMI work and the MBSE working groups and communities of interest at NASA centers. The advisory board is an expert practitioner panel whose experience spans NASA mission areas and centers. The board members assess work and plans and provide advice and guidance.

Prior to and during the establishment of MIAMI, the MBSE Pathfinder leadership team recognized the importance of a long-term vision for SE modernization. Recent internal NASA assessments identified the lack of an Agency SE strategy and vision and opportunities for improvement. The digital revolution provides new solutions for these problems and offers new capabilities. Influencers such as the International Council on Systems Engineering (INCOSE) and the United States Department of Defense have a vision (Ref. 4) and digital engineering strategy (Ref. 5), respectively, that rely heavily on a digital future for their implementation. The NASA Capability Leadership Team (CLT) management further requested all engineering disciplines to develop a long-term strategy, or strategic vector, which focused on a 20-year future horizon.

The MIAMI leadership established the MBSE Strategy Group in 2018 based on the successes and learning from the MBSE Pathfinder and in recognition that NASA programs and projects are increasingly in new areas, cyberphysical, interconnected, and with varied life cycles. The MIAMI lead responsible for the long-term vision extended invitations to individuals from multiple NASA centers, organizations, technical disciplines, and career experiences. The deliverables from the strategy group were a vision, roadmap, and strategic plan that defined and planned a digital future for 20 years in the future.

Strategy Group Members

The desired characteristics of the individuals, and the strategy group collectively, were knowledge of trends in political, technological, educational, organizational, and engineering areas; discipline expertise in areas related to SE; and adeptness in one or more new technologies (e.g., augmented reality, virtual reality, gaming, MBSE, Internet of Things, data analytics, machine learning, natural language processing, etc.). The individuals were also early to middle career; willing to experiment with unproven ideas; able to work virtually and across geographic locations; able to communicate and discuss ideas; self-starters; and interested in culture change, innovation, and creativity. In summary, the strategy group, charged with charting the future for SE at NASA, was a team of individuals with diverse experiences and ideas that went beyond traditional SE and even MBSE, and they would inherit the benefits of the thought process.

As part of MIAMI, the strategy group members also benefited from opportunities to gain technical leadership experience and influence Agency-wide engineering practice. Group members had the opportunity to interact with experts and peers inside and external to the Agency in many disciplines. In return, the members committed to spend at least 5 percent of their time, on average, working on strategy group assignments, and to attend at least two face-to-face meetings. The MIAMI lead advised and guided the strategy group.

Kickoff Meeting

The strategy group gathered for the first time at a 2-day face-to-face kickoff meeting at the NASA Glenn Research Center. For many of the group members, this was the first time they had met. Therefore, they took time to get to know each other and begin developing as a team. They discussed and agreed on how to work together and covered topics such as meeting management, working together to produce or review deliverables, use of technology, communications, decision making and problem solving, and conflict management. A strategic ideation session was part of the face-to-face meeting.

A facilitator led the group in the use of creativity and innovation tools to generate a focus statement and ideas on the strategic vision. The focus statement was “Ways to disrupt the current state of NASA engineering to become more agile in our response to the changing needs of the Agency or the Public.” The strategy group members exchanged initial ideas and decided on their immediate next steps.

The strategy group deliverables were in two categories: (1) charter and work plan, and (2) vision, roadmap, and strategic plan. The charter (Ref. 1, Appendix B) contained top-level membership, goals and objectives, operations, and process for decisions. The work plan described the approach to develop, get buy-in and feedback, and finalize the vision, roadmap, and strategic plan. The content for the charter and the work plan were developed at the kickoff meeting.

The kickoff face-to-face meeting established the trust and relationships necessary for the strategy group to work effectively and virtually for months at a time between face-to-face meetings. The strategy group met periodically for intensive team work and training. The strategy group presented their accomplishments and lessons learned to the MIAMI leads and the advisory board and received their feedback.

All of the appendixes to this paper are in Reference 1. Appendix A contains artifacts from the kickoff meeting, including the challenge questions (A.1), the kickoff slide presentation (A.2), the concept fan (A.3), the kickoff summary presentation (A.4), and notes from the strategic ideation session (A.5). Appendix B contains the MBSE Strategy Group Charter. Appendix C contains work plan artifacts, including the communication plan (C.1), and the final work plan (C.4). Annual review and lessons learned presentations and feedback are in Appendix D. Strategy group meeting notes are excerpted in Appendix I.

Vision

The vision emerged from a design-thinking approach to gather ideas. The strategy group obtained insight into current processes and domain outlook by interviewing 12 engineers of varying expertise and experiences who had worked on teams of different sizes for missions large and small. The strategy group posed the following interview questions to help focus the vision and begin building the roadmap:

1. What do you think NASA will be working on in 20 years?
2. How do you think NASA will be working in 20 years? (Processes, methodologies, approaches) Would the way we work need to change to enable those future missions?
3. What do you like about your work today/currently? Dislike? Why?
4. Do you see any big changes to your job in the next decade or so?
5. What is the "hot topic" in your domain right now? Are there any "transformative" activities underway? What are your thoughts on that "hot topic?" (Is it buzz or something real? Why?)
6. What kinds of decisions do you make in your role? (Technical/data-driven vs. strategic vs. consensus building vs. process/approach, etc.) (Also... Literally, what decisions? Buy A vs. B; truss A vs. B; contract mechanism A vs. B, who gets funding, etc.)
7. Do you have all the information you need to do your job?
8. What are the major problems in your workflow? The best aspects of your workflow (what's working)?
9. What might some sort of "computer helper" do for you to enable you to do your job better/faster/easier/etc.?
10. Do you feel you have the opportunity to be innovative in your role? If yes, what innovative change would you propose? If no, what is preventing/prohibiting you from being innovative?

In separate interviews, the 12 engineers shared their vision of NASA's future; current and future processes, methods, and approaches within their work; aspects of their work that are successful; pitfalls (such as a risk-averse posture and schedule constraints) that should be mitigated and solved; and technology that could help improve their work. The strategy group clustered answers into a dozen themes to better understand current status and future needs. Appendix C of the supplement (Ref. 1) contains the interview rubric and questions (C.2) and overview (C.3). Appendix E contains the interview responses (E.1 through E.12) and a chart of the compiled themes (E.13).

The vision ultimately developed by the MBSE Strategy Group provides top-level goals and objectives of future SE capability and provides a basis from which investments in the workforce and capabilities can be evaluated. The vision is this: "NASA engineers enable extraordinary, unprecedented missions by adopting system-focused, human-centered, influential technologies for the benefit of all."

Depicting the Vision

The strategy group developed a graphical depiction of the vision to illustrate how NASA systems engineers will perform their roles in the year 2039 (Figure 1 to Figure 3). A detailed, text-based description appears in Appendix F of the supplement (Ref. 1) with other artifacts of the group's design-thinking process (F.1 to F.3). The graphic depicts what systems engineers' working environments might look like, how they might collaborate with other engineers, and how they might interact with data.

The strategy group envisioned a future of automated mission design that is human centered and data driven (Figure 1). New technologies and applications will blur the boundaries of physical, digital, and biological worlds, changing the way we live, work, interact, and communicate (Figure 2). Immersive, collaborative environments will enable rapid interaction in a distributed, seamless way and will provide deeper insight into mission design requirements and constraints (Figure 3). For instance, a four-dimensional (4D) manufacturing capability can manipulate materials to refine the design in a dynamic environment.

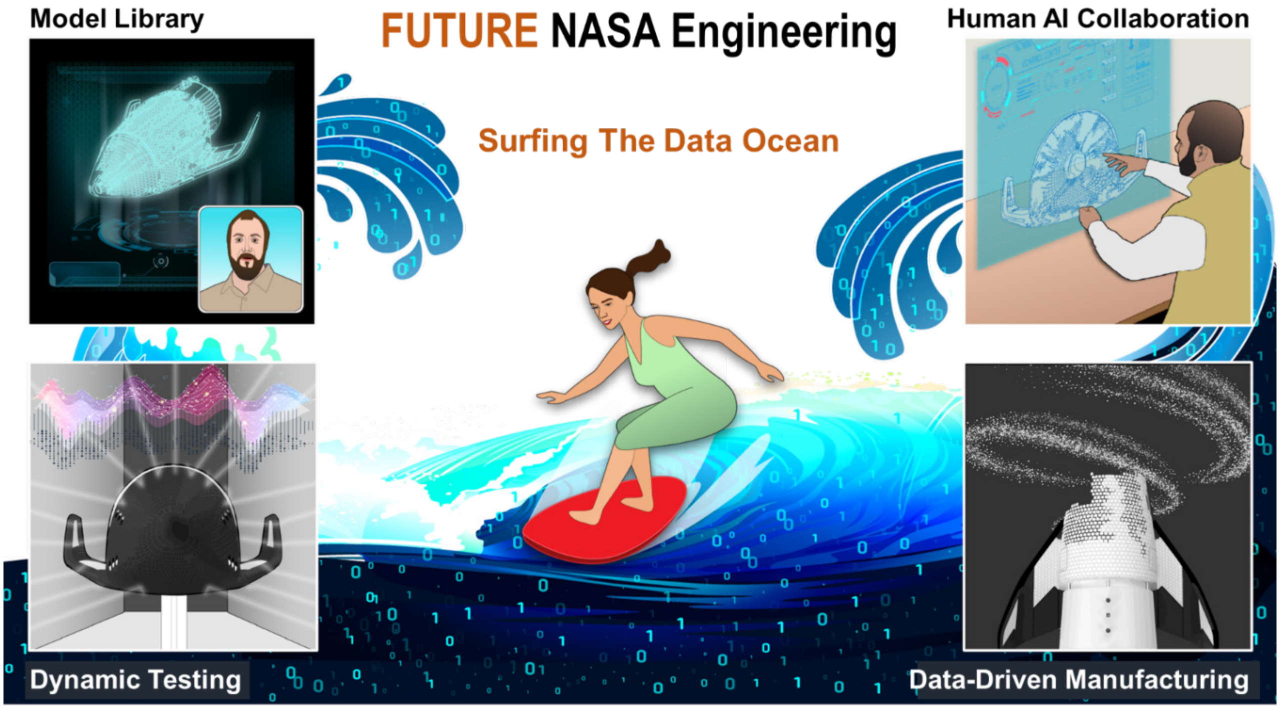

Figure 1.—Automated mission design and engineering. AI, artificial intelligence.

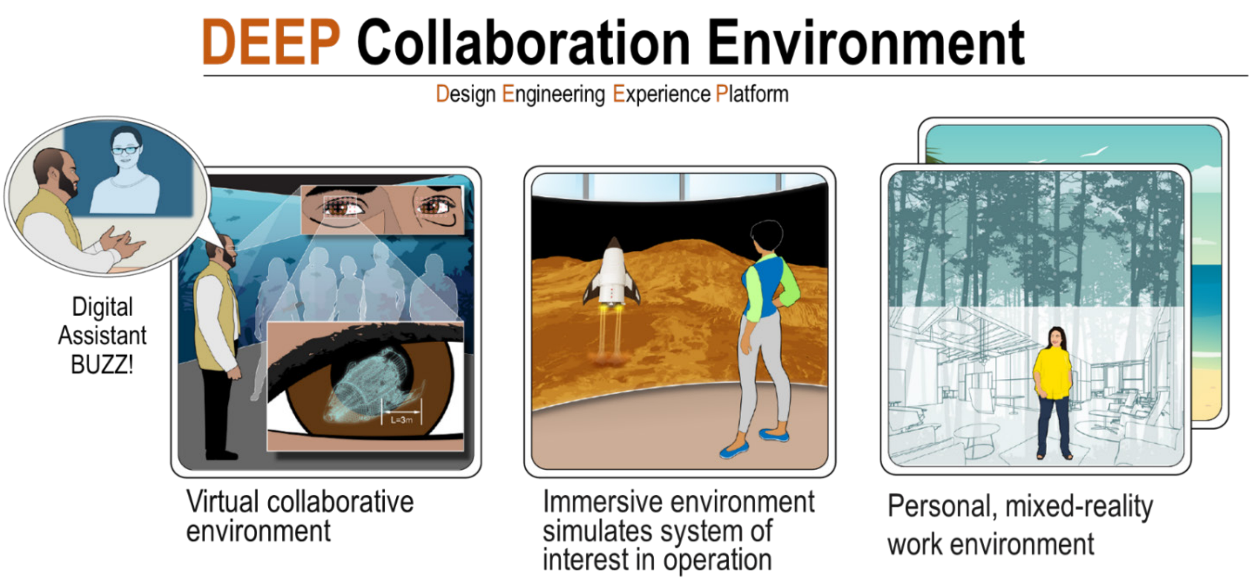

Figure 2.—Distributed, seamless collaboration.

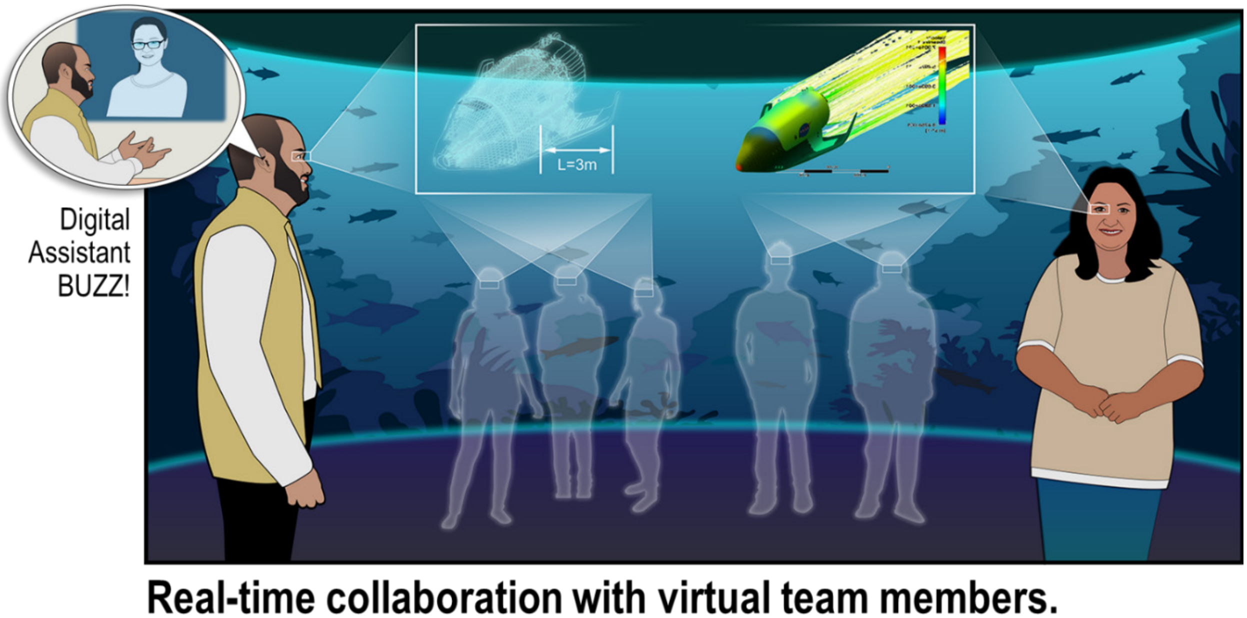

Figure 3.—Immersive, collaborative environment.

How Will Engineers Work in the Future?

The strategy group's vision anticipates that four forces—mission, people, technology, and place—will interplay (Ref. 6). We will integrate human creativity with machine capabilities, and engineers will use system-focused, human-centered technologies to design bold new missions. Engineers and technologies will interact in the following ways:

- Future SE frameworks will facilitate good communication and increased interaction among team members.
- Digital personal assistants will help increase productivity.
- The machine will know NASA guidelines and account for them in the design; the human will tailor guidelines as appropriate for each design.
- Engineers will make sound decisions by fully understanding the impact of changes to parameters and interfaces when the machine presents alternatives.
- Technical training will be more efficient and enjoyable through knowledge-sharing infrastructure and personalized interactions with the machine.
- The machine will retain and provide wisdom of pioneers, such as Kepler scientists, Mars mission operators, Apollo engineers, Space Shuttle program managers, the National Advisory Committee for Aeronautics (NACA) designers, and wind tunnel technicians.
- Development cycles will evolve to take advantage of that wisdom. There will be continuous data gathering and incremental learning.

Roadmap

From the themes that emerged in the NASA engineer interviews, the strategy group derived a roadmap for top-level desired capabilities (Table I). This roadmap highlights future needs, projected capabilities, and technology and competency gaps. It defines broad categories of workforce development and engineering capabilities and marks desired waypoints over time to achieve these. The roadmap segments these into four timeframes: now, mid-term, far-term, and Data Zen, which refers to adequate and quality data that "exists in its own state, without our perspectives and views of it," as described by Charles Tupper (Ref. 7). This data "can be shaped, molded, viewed, illustrated, structured, and understood" (Ref. 7) now and in the future, and it stays fresh and relevant.

This tabular roadmap highlights the evolving nature of engineering capabilities and marks desired waypoints over time to achieve these.

Appendix G of the supplement (Ref. 1) contains several artifacts of the strategy group's roadmap development process: a graphic depiction of ideas that informed the roadmap (G.1), three presentations showing working drafts of the roadmap (G.2 to G.4), and photographs of the whiteboard from a group brainstorming session (G.5).

TABLE I.—PROJECTED CAPABILITIES IN FOUR TIMEFRAMES

Evolving aspect	Now	Mid-term	Far-term	Data Zen
Mission risk tolerance	Mostly low risk, some high risk	More calculated and understood risk, high reward	More radical innovation, giant leaps	Bolder missions, huge breakthroughs
Mission design and operations	Scripted mission operations with human monitoring	Autonomous, remote, reactive science	Human-guided, machine-generated mission design	Machine-driven operational decisions
Software architecture	Monolithic: hard-to-scale to large, distributed systems	Microservices architecture: scalable, efficient	Flexible, independently deployable	Adaptive, learning architecture
Software and services marketplace	Purchase from established, large companies	License from emerging, small companies; continuous digital transformation	Automated verification and validation of software; radical digital transformation	Software-generated software; rapid adoption of emerging technology
Artificial intelligence tools	Clustering, classification; natural language processing	Human-assisted design decisions and change approvals	Autonomous decisions; continuous learning	Automated model design, creation, test, and refinement
Use of data	Stewardship of fragmented data, tagged for future use	Distributed data warehouse provides information when queried	Automated data queries provide knowledge when asked	Machine-generated, data-driven designs provide insight
Analytics	Descriptive: What happened?	Diagnostic: Why did it happen?	Predictive: What will happen?	Prescriptive: How should we react to what will happen?

Strategic Plan

The strategy group worked to develop a strategic plan to ensure the expedient introduction of the roadmap's desired capabilities. Appendix H of the supplement (Ref. 1) contains an early draft of the plan (H.1) as well as a later draft presented for advisory board review (H.2). Appendix H also contains several presentations the group used in their strategic plan development process: market analyses of blockchain (H.3), cloud delivery (H.4), machine learning (H.5), and systems engineering (H6); and an analysis of future trends (H.7).

Strengths, Weaknesses, Opportunities, and Threats

As part of the effort to develop a strategic plan, the strategy group performed an analysis of NASA's strengths, weaknesses, opportunities, and threats (SWOT) to examine the internal and external factors that could help or impede the realization of the roadmap's desired capabilities.

In a SWOT analysis, strengths are what an organization excels at and what separates it above the rest. Weaknesses are areas that need to improve to remain competitive. Opportunities are favorable external factors that could give the organization a competitive advantage. Threats are factors that can potentially harm the organization.

A summary of the group's NASA SWOT analysis is shown in Figure 4.

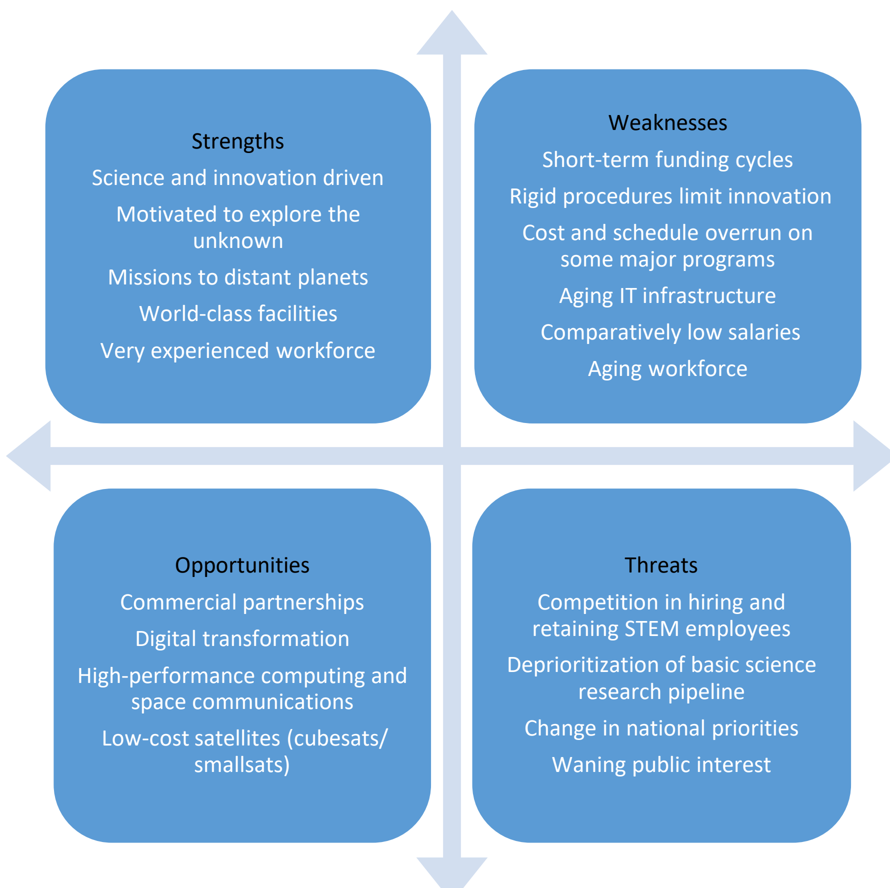

Figure 4.—NASA's Strengths, Weaknesses, Opportunities, and Threats.

Goals of the Strategic Plan

The strategy group's strategic plan seeks to align Agency values, objectives, strategy, tactics, and controls. The plan recommends investments to achieve the waypoints and endpoints in the roadmap. In particular, it highlights resources needed to design and implement increasingly autonomous systems for complex missions of the future. It identifies emerging trends that can benefit the SE and discipline engineering communities at NASA. To chart SE's possible path(s) from now to the future, this strategy aims to fulfill NASA's anticipated needs for crewed and uncrewed exploration of the Moon, Mars, and the rest of the solar system, and for earth science, heliophysics, astrophysics, and aeronautics.

Workforce Engagement

We are entering a golden age where technology is expanding what is possible. Old assumptions about what is impossible are no longer valid. NASA systems engineers need the courage to try new technology enablers for previously improbable missions. Which specific technology capabilities are needed to achieve NASA's science goals? What are the drivers of complexity and their associated costs?

To deliver bold missions with finite resources, it is imperative to align technology and people with future mission needs. To address its aging workforce, NASA must continuously assess, refresh, and replenish talent.

There are two aspects to engaging the workforce in shaping the future of SE: competency and culture.

Competency and technical savvy can be increased through training and hands-on experience to gain relevant, domain-specific knowledge. For new as well as experienced systems engineers, it involves stepping out of their comfort zones and feeling comfortable about trying new things.

To keep up with the pace of technology in a cost-constrained agency, NASA should

- Be selective about picking the right combination of mission, people, and technology.
- Encourage systems engineers to actively network at conferences, workshops, and training courses.
- Nudge everyone to contribute to a library of knowledge on a continuous basis.
- Provide shared innovation spaces, laboratories, equipment, and hardware.
- Incentivize adoption, dissemination, and championing of innovative technologies.

Cultivating a culture of innovation adoption is a more difficult challenge. It can be nurtured in one or more of these ways:

- Strong leaders and guides tackle the difficult mountain to ease the way for their followers.
- Passionate experts aggregate knowledge, build expertise, and curate Communities of Practice.
- Workforce adopts effective tools recommended by peers.
- Leaders acknowledge cultural resistance to technology leaps and help overcome barriers to adoption.

Target Customers

The target customers of this strategic plan are NASA’s key stakeholders, who play a critical role in shaping the future of SE:

- Policymakers/Oversight
  - Administrator Staff Offices
    - Office of the Chief Engineer: Ensures NASA's development efforts and mission operations are planned and conducted on a sound engineering basis with proper controls and management of technical risks
      - Engineering Management Board: Contains engineering directors and chiefs from across the Agency, from centers, mission directorates, and the Office of Safety and Mission Assurance (OSMA)
        - Guides policy to fit Agency, center, and mission engineering strategies
        - Forecasts the needs of engineering activities across the Agency
        - Mitigates risk and ensures safety of crew and hardware
      - Chief Knowledge Officer/Academy of Program/Project & Engineering Leadership:
        - Ensures corporate knowledge is captured, retained, shared, and learned
        - Trains the workforce to ensure skillsets match Agency, center, and mission needs
    - Office of the Chief Health and Medical Officer:
      - Oversees health and medical activities (and many human factors activities)
      - Ensures health, medical, and human factors policy is meeting Agency needs
    - OSMA:
      - Ensures safety, reliability, maintainability, and quality assurance
        - Wants traceability for failure analysis
        - Performs verification and validation
      - Model-Based Mission Assurance
        - Provides a model that allows personnel to run simulations and tests in real time to reduce time taken by a program or project to perform assurance analyses
    - Office of the Chief Information Officer: Understands information being handled across Agency in order to
      - Provide software solutions that meet Agency’s needs
      - Provide infrastructure that facilitates digital collaboration/connectivity
        - Headquarters (HQ): NASA Information Architecture
      - Provide a secure environment, restricted access by authorized parties (trade off security against collaboration and a connected ecosystem)
    - Office of the Chief Technologist:
      - Provides technology that takes advantage of the latest and greatest capabilities, as well as forecasted future capabilities
        - Digital Transformation Team
  - Mission Directorates
    - Aeronautics Research Mission Directorate, Human Explorations and Operations Mission Directorate, Science Mission Directorate, and Space Technology Mission Directorate
      - Influence policy in their respective areas
      - Provide low-level requirements necessary for mission success
      - Oversee programs and projects

    - Mission Support Directorates
        - Office of the Chief Human Capital Officer/Center Human Resources:
            - ♦ Ensures civil servant workforce skillsets match Agency and center needs, through hiring, retention, and training
        - Procurement
            - ♦ Delivers exceptional, timely acquisition business solutions
            - ♦ Delivers procurement policy that is required, clear, and easily implemented
    - Center-level policymakers have the same broad goals as Agency-level policymakers, but in their own scope—and they produce center-level policy to tweak Agency policy, accordingly.
- Program and Project Managers
    - Save time and money by detecting defects early in requirements and design phases
    - Increase project agility with access to integrated datasets, knowledge bases, model libraries, and enabling tools (MIAMI Recommendations to Digital Transformation Study)
    - Have a desire to control risk
    - Want insight into contractor design proposals and products
    - Want to communicate with common format, dataset across organizationally and geographically dispersed teams
- Science, Technology, Engineering, and Mathematics Workforce
    - Scientists and Researchers
        - Want to explore the unknown and obtain science returns
        - Must understand and communicate top-level mission drivers and requirements
    - Systems Engineers
        - Want unambiguous requirements
        - Identify pitfalls earlier through design trades, models, and simulations
        - Facilitate interaction with independent reviewers (Safety and Mission Assurance (SMA), NESC, etc.)
        - Rely on "an authoritative source of truth" for mission concept and design requirements
        - Communicate details across subsystems to all discipline engineers
            - ♦ Want traceability for impact and change analysis
    - Technicians
        - Would like to replace blueprints and diagrams with virtual models and take advantage of emerging technologies in manufacturing, assembly, and test

Investments Needed

Investment choices will have to be made in response to different and competing priorities. NASA needs a coordinated, cross-center, priority-based plan to invest its resources in these areas:

1. Technologies
    a. Hardware: processors, servers, and smartboards
    b. Software: operating systems, applications, visualization software, and collaboration tools
    c. Services: data warehousing and cloud services
2. Tools for modeling and analysis: Integrated DEFinition (IDEF) or Systems Modeling Language (SysML) SE tools from various vendors and new modeling tools
3. Equipment: virtual reality or augmented reality headsets and smart sensors
4. Methods: automated drawing generation and rapid verification and validation
5. Infrastructure: cloud networks, cybersecurity, and resilient networks

6. Process: automated design iteration, for example
7. Facilities: innovation hubs, labs, test sites, and test airspace
8. Organization: hierarchies that facilitate communication and enable engineering innovation
9. Partnerships: interagency sharing of best practices and collaboration with industry and academia
10. Workforce: refreshed and replenished for the right skill mix

The following timeline options are recommended for technology investments:

1. Invest now if
    a. Technology is maturing and issues have been worked out in field tests
    b. Commercial platforms exist and can be tailored to our needs for immediate use
    c. Other organizations are beginning to invest in early technologies
2. Watch and wait if
    a. Technology is too early and untried in the field
    b. Heavy investment in time and/or people needed to develop
3. Stay out if
    a. Technology is all hype with limited potential
    b. Technology is incompatible with SE and aerospace

Metrics Evaluation

How do we know our strategy worked? How do we evaluate progress? After considering these questions, the strategy group identified the following potential qualitative metrics:

1. How effective is the strategy in enabling extraordinary, unprecedented missions?
2. Are the new technologies system focused and/or human centered?
3. Are they resulting in a new type of system architecture or a new way of operating a mission?
4. Is “the right influential technology” selected from all possible offerings?
5. What is the pace of technology adoption on the roadmap timeline?

As an example, an initial win would look like this: In the near term, NASA starts implementing data-driven SE methods. In the longer term, a big win would be that the strategy group roadmap provides guidance for timely acquisition of emerging technologies that enable rapid design and implementation of bolder missions.

Concluding Remarks

A NASA systems engineering (SE) vision and strategy, along with new solutions from the digital revolution, provide opportunities to address problems and issues. The strategy group provided significant efforts toward a vision and strategy for SE modernization at NASA within an overall context of a transforming engineering enterprise. Their efforts show that SE practices, capabilities, and workforce in 2039 are predicted to be significantly different than those in 2019.

The strategy group used their own diversity of perspectives and interviews of other engineers to understand the problems, define a point of view, and recommend solutions in a vision, roadmap, and strategic plan. The strategy group vision is this: “NASA engineers enable extraordinary, unprecedented missions by adopting system-focused, human-centered, influential technologies for the benefit of all.” The strategy group’s vision anticipates that mission, people, technology, and place will interplay. The roadmap identifies desired technical capabilities with an emphasis on new digital technologies and new ways that the workforce will interact with data. It describes the incremental advancement of capabilities over four timeframes from 2019 to 20 years out, and beyond. The strategic plan provides recommendations on areas for NASA investments. The choices in investments will be made in response to different and competing priorities within and external to NASA.

Potential follow-on efforts could use the strategy group deliverables as the jumping-off point to do a deep dive into some aspects, broaden other aspects, and fold in additional information from leadership groups, the SE workforce, internal NASA surveys, external surveys, and research.

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