NASA Space Life Sciences
Strategy for Human Space Exploration

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TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

Human space exploration is on the verge of tremendous change. In addition to the planned activities of government space agencies traditionally associated with space exploration, new government space agencies and commercial entities are emerging and creating a renewed interest in and enthusiasm for human space flight.

The Vision for Space Exploration introduced by President George W. Bush in 2004 commits our Nation to the return of humans to the Moon, with a subsequent exploration initiative to Mars. The 2006 NASA Strategic Plan articulates the Agency strategy for achieving the Vision's goals.

Critical to this expansion of the human presence in space will be healthy, productive astronauts. Space life sciences will enable mission success by focusing on risk reduction and optimizing astronaut health and productivity through our human-centered science, operations, and engineering core capabilities.

This Space Life Sciences Strategy for Human Space Exploration lays out the pathway by which the Space Life Sciences Directorate will contribute to achievement of the Vision. Our strategic goals, strategies, and objectives were developed on the basis of a situational analysis conducted by key members of the space life sciences civil service and contractor community, and are consistent with Agency goals and scenarios for the future.

Our mission is to optimize human health and productivity for space exploration, and our vision is to become the recognized world leader in human health, performance, and productivity for space exploration. Our strategic goals are aimed at driving innovations in health and human system integration, adapting our portfolio and strategies to the changing environment, and creating enduring support and enthusiasm for space exploration through education.

The space life sciences envisioned future scenario and strategies emphasize integration of the space life sciences community, balancing our portfolio of products and services with strategic relationships to achieve a full complement of space life sciences core capabilities, and leveraging opportunities with the commercial space sector to encourage its development.

Our integrated risk management approach guides the prioritization and management of space life sciences activities, and ensures that research and technology development efforts are aligned with Agency goals. We understand that our success will depend upon our ability to be more flexible and adaptable to change, and we will pursue a new business model that is more efficient, focused

on customer needs, and facilitates communication of risk to the public and the value of space life sciences to our stakeholders.

We believe this Space Life Sciences Strategy for Human Space Exploration puts forth a plan to efficiently and effectively support the Agency goals for human space exploration, and best positions the Space Life Sciences Directorate to add value in the new exploration environment.

2.0 INTRODUCTION

In February 2006 NASA introduced a Strategic Plan aimed at realizing the Vision for Space Exploration. This vision commits our nation to a new era of human space exploration that will be dependent upon healthy, productive astronauts to achieve mission success, and which will require that we remain on the cutting edge of science and technology.

Beginning in May 2006, the Space Life Sciences Directorate solicited input from its NASA and contractor team members to develop a long range plan aligned with Agency and Johnson Space Center (JSC) strategies and goals. Multiple cross-functional teams were convened to conduct a situation analysis, and to develop the goals, strategies, and objectives necessary to achieve our vision and mission.

These efforts resulted in this Space Life Sciences Strategy for Human Space Exploration, which articulates our vision for enabling expansion of the human presence in space. This plan addresses three timeframes consistent with Agency milestones:

- Near-term (1-5 years)
- Mid-term (6-10 years)
- Long-term (11 – 20 years)

3.0 SPACE LIFE SCIENCES MISSION STATEMENT

"To optimize human health and productivity for space exploration."

All Space Life Sciences human health and countermeasures research, medical operations, habitability and environmental factors activities, and directorate support functions are ultimately aimed at achieving this mission. Our activities enable mission success, optimizing human health and productivity in space before, during, and after the actual space flight experience of our flight crews, and include support for ground-based functions.

4.0 SPACE LIFE SCIENCES VISION STATEMENT and ENVISIONED FUTURE SCENARIO

Vision Statement

"To become the recognized world leader in human health, performance and productivity for space exploration."

Envisioned Future Scenario

To achieve the Vision for Space Exploration, we must drive human health, performance, and productivity innovations, adapting our strategies to the changing environment. To do this, we envision a future scenario for Space Life Sciences with the following characteristics:

- To successfully manage human health and performance risks for exploration mission success, our future core capabilities will include the expertise to address space medicine, the physiological and behavioral effects of space flight, space environment definition and its effects on human health and performance, and space human factors.

- We will develop integrated research plans on the basis of a standards-based risk mitigation approach to ensure Space Life Sciences goals are aligned with Agency goals.

- Civil servants will balance delivery of health and performance services and focused research and technology development with smart buyer and management expertise to integrate space life sciences efforts. Civil servants will also provide a translational function, bridging the gap from lower countermeasure/technology readiness level efforts to operational applications.

- Strategic relationships will be utilized to achieve the full complement of space life sciences core capabilities necessary to achieve our vision and enable mission success.

    - In some endeavors, Space Life Sciences will transition from being a managing partner to a contributing partner, leveraging the resources and innovations of other organizations to meet specific exploration needs.
    - Space Life Sciences will serve as a pipeline for next generation research and technology development, leveraging partner innovations developed for another application to solve space flight issues.

- Operations will effectively transition the people skills and facilities from Shuttle and ISS to Exploration, and we will assess and engage in additional government and commercial space flight operations opportunities where appropriate. We will continue to evolve our occupational health practices with

an emphasis on prevention for future exploration initiatives, consistent with Institute of Medicine recommendations.

- We will have an expanded customer base that may include additional international and academic partners, as well as commercial alliances.

- Our success will depend upon our ability to be more flexible and adaptable to change. The use of new or improved procurement vehicles such as Space Act Agreements or Cooperative Research and Development Agreements that can be executed in a more timely fashion will be necessary to effectively develop and manage future relationships.

5.0 SITUATION ANALYSIS and KEY PLANNING ASSUMPTIONS

5.1 Situation Analysis

A situation analysis was conducted to determine where we are today relative to our mission, and to identify the factors most likely to influence our strategy development and affect achievement of our goals and objectives. Our assessment of the current situation, our stakeholders, trends in life sciences and space flight, and our internal and external environments is presented in Appendix A. The following assumptions were developed on the basis of this situation analysis.

5.2 Key Planning Assumptions

- The Agency will achieve established exploration roadmap milestones over the next ten years, excluding significant delay or a catastrophic event.

- Humans will continue to be an important component of the Vision for Space Exploration, and as a result there will be an ongoing need for Space Life Sciences core capabilities including human-centered science, operations, and engineering to mitigate the health and performance risks of human space flight.

- In the longer term, there will be a greater focus on crew autonomy and increased human-robotics interaction as mission durations increase and are extended to travel to and on planets, and as a result, there is a continued need for research and development activity focused on exploration risk reduction.

- The pace of biomedical change will continue to be more rapid in external versus internal environments over the planning timeframe. State-of-the-art solutions are more likely to be developed external to NASA.

- Suborbital commercial human space flight will emerge in the next five years and grow into orbital space flight over the next 20 years.

- Other nations will develop the capability to send humans into space, in both the governmental and commercial sectors.

- Space life sciences will be resource-constrained within the Agency. There will be insufficient Center Maintenance and Operations budgets to fund core capabilities, therefore NASA will continue to fund core capabilities through programs. Programs will want to minimize costs.

- As exploration milestones are achieved and commercial human space flight becomes a reality, public interest in and support for space exploration will grow.

6.0 STRATEGIC GOALS

The following four strategic goals were developed on the basis of our situational analysis and envisioned future scenario. They define what we will strive to achieve in pursuing our Space Life Sciences mission and vision, and are aligned with NASA strategic goals. Goal-specific objectives for the near-, mid-, and long-term timeframes are presented in Section 8.0 of this document.

6.1 Definition and Management of SLSD Portfolio

Over the next 20 years, the Space Life Sciences Directorate will assess and restructure its portfolio of competencies, products and services to focus on exploration consistent with the Vision for Space Exploration, and to encourage and leverage the development of the commercial space flight sector. Elements to be considered will be identification and pursuit of new opportunities and service lines; appropriate balance between exploration and LEO operations activities; and facilitating transfer of appropriate LEO activities to the commercial sector.

6.2 Health Innovations

The Space Life Sciences Directorate will drive advances in medical and environmental health for space flight in order to meet established space flight health standards and mission needs. State-of-the-art practices and innovations in medicine and biomedical/environmental technology and processes will be developed, implemented, and incorporated into mission architecture. These innovations will also have potential terrestrial application.

6.3 Human System Technologies

The Space Life Sciences Directorate will drive advances in human performance and productivity by improving space flight systems in order to meet established space flight human systems integration standards and mission needs. State-of-the-art practices and technologies in human factors engineering, habitability design, and human-robotics interaction will be developed, implemented, and incorporated into mission architecture solutions to address the human as an element of the overall space system. These innovations will have potential terrestrial application.

6.4 Education

The Space Life Sciences Directorate will ensure that we are trained in multidisciplinary life sciences, that there is a legacy of experts in exploration life science, and that there is a continuous infusion of space life science into the public, government, academic, and commercial sectors, thereby creating enduring support and enthusiasm for space exploration.

7.0 KEY STRATEGIES

Six strategies were identified as the key courses of action we will pursue as a directorate to achieve our goals, and for which specific objectives could be defined. These cross-cutting strategies include:

- Adopting an integrated human system risk management approach
- Developing and maintaining core capabilities and core competencies
- Establishing strategic relationships
- Developing and implementing an improved business model
- Improving our customer focus
- Enhancing internal and external communication

Cross-cutting strategies formulated to support our health innovations, human system integration, and education goals will drive implementation planning for Space Life Sciences Directorate portfolio definition and management. These include the human system risk management, strategic relationships, future business model, and communication strategies. Specific objectives for the core capabilities/core competencies and customer focus strategies will be defined in the implementation plans for each of these goals in addition to ultimately being addressed at the directorate level. Goal-specific strategies were also identified and are presented in Section 8.0 below.

8.0 OBJECTIVES

Goal-specific strategies and measurable objectives for the previously defined three timeframes are presented below for each of our overarching strategic goals. These strategies and objectives will provide the foundation for implementations plans to be developed for years 1-5.

8.1 Definition and Management of SLSD Portfolio

8.1.1 Portfolio Strategic Goal

Over the next 20 years, the Space Life Sciences Directorate will assess and restructure its portfolio of competencies, products and services to focus on exploration consistent with the Vision for Space Exploration, and to encourage and leverage the development of the commercial space flight sector. Elements to be considered will be identification and pursuit of new opportunities and service lines; appropriate balance between exploration and LEO operations activities; and facilitating transfer of appropriate LEO activities to the commercial sector.

8.1.2 Portfolio Strategies

- Implement an integrated risk management approach to guide the prioritization and management of space life sciences activities
- Optimize internal core capabilities throughout the planning cycle to enable the Vision for Space Exploration within budgetary constraints
- Establish strategic relationships to achieve/maintain the full complement of life sciences capabilities necessary to be best in class
- Establish a center to integrate human health and performance efforts and expertise for space exploration worldwide
- Emphasize customer needs and achievement of 100% customer satisfaction to optimize our portfolio and enhance our recognized value
- Implement an internal and external communication plan to increase the life sciences value proposition to achieving the vision for space exploration
- Contribute to and leverage expertise/achievements of the evolving commercial space flight sector to allow us to focus our efforts and resources on enabling exploration, by transferring our knowledge and experience in LEO and evaluating and managing all data collected in-flight.

8.1.3 Portfolio Objectives

1-5 years

1. Implement and utilize a risk management approach to prioritize activities directorate-wide, including incorporation into SLSD and contract processes. Implementation to be completed by 2009, utilization to be completed by 2011.
2. Assess and prioritize the SLSD portfolio of services and products for transition to Constellation by 2008 and Exploration by 2011.
3. Baseline required core capabilities by mission architectures and portfolio goals by 2008 and complete implementation no later than 2012.
4. Identify and evaluate prospective strategic relationships/consortia and optimal types of strategic relationships for each on the basis of core capabilities evaluation and identified external needs by 2012.
5. Implement a customer plan that defines our new customer base, identifies products and service lines, and establishes a mechanism for evaluating customer satisfaction to address transition to Constellation by 2008 and Exploration by 2011.
6. Develop and implement an internal and external communication plan no later than 2008.
7. Identify opportunities to encourage and leverage within the commercial space flight sector by 2009.
8. Identify necessary attributes of a worldwide center for integrating life sciences by 2010.

6-10 years

1. Refine the risk management process through continuous improvement practices and evaluate annually throughout the planning cycle.
2. Implement the new/evolving SLSD portfolio, reviewing core capabilities against mission and developing goals, including establishment of new service lines by 2013, and evaluating annually.
3. Establish prioritized strategic relationships by 2013; complete evaluations by 2015.
4. Achieve 100% Customer Satisfaction each year throughout this timeframe.
5. Refine/manage balance of exploration / LEO operations activities / new service lines by 2016.
6. Establish worldwide space life sciences integration center by 2014.

11-20 years

1. Instantiate SLSD as an Exploration provider and a LEO consumer through a business portfolio that optimizes core capabilities and strategic relationships by 2025.
2. Become the recognized space life sciences integrator worldwide by 2018.
3. Achieve 100% Customer Satisfaction each year throughout this timeframe.

8.2 Health Innovations

8.2.1 Health Innovation Strategic Goal

The Space Life Sciences Directorate will drive advances in medical and environmental health for space flight in order to meet established space flight health standards and mission needs. State-of-the-art practices and innovations in medicine and biomedical/environmental technology and processes will be developed, implemented, and incorporated into mission architecture. These innovations will also have potential terrestrial application.

8.2.3 Health Innovation Strategies

- Assess and restructure our approach to health innovations for exploration to encourage and leverage collaborations with other agencies, industry, and academia.

- Seek to use existing data and knowledge as a base for launching health technologies and practices for pioneering advancements.

- Provide opportunities for facilitating transfer to terrestrial applications through collaborations and improved communication.

8.2.3 Health Innovation Objectives

1-5 years

1. Implement a data mining project by 2007 to reflect:
    a. Improved methods and practice of recording data that has more direct relevance to the Agency goals for human exploration.
    b. More sophisticated and comprehensive approaches toward data mining to continuously sustain best levels of evidence for answering operational and clinical questions regarding human health, safety and performance during space flight and exploration.
    c. An evidence-based risk management approach to prioritize tasks, funding, etc.

2. Form a partnership office within the SLSD as a conduit to external organizations by 2008.
    a. Partners will include academia, other government agencies, industry (biomedical), and commercial space flight entities.
    b. Identify potential partnerships who would be interested in becoming our research and development partners.
3. Drive advances in medical and environmental health for space flight through initiatives that engage the public and commercial entities by 2009.
    a. Establish an X-Prize-like concept for specific innovations by 2009.
    b. Balance the portfolio for research announcements versus narrower directed studies to meet the Agency needs along with a diverse distribution of basic science v. operational research v. tech advancements by 2007.
4. Develop requirements based on risk beginning in 2007 and continuing throughout this timeframe.
    a. Identify accepted risks.
    b. Identify levels of care for lunar and Martian scenarios.
    c. Develop risk models based on evidence.
5. Develop optimized, autonomous health care systems and practices for exploration missions by 2009.
    a. Develop standardized common interfaces and modular systems across all flight health systems that can be custom-selected to support a variety of flight-types.
6. Form organizational integration and alliances by 2007 between:
    a. Space Medicine and researchers to foster stronger communication and cooperation.
        i. Require new hires to 'rotate' through operations and research for a select period to obtain the perspective of cross-cultural training and perspective.
        ii. Develop a 'basic training' of required activities established for developing the new culture.
    b. Other NASA organizations and SLSD (specifically, Constellation).
        i. Establish single points of contact for the organization.
7. Use benchmarking techniques from other organizations for establishing SLSD practices and policies to avoid re-inventing the wheel by learning from others. Beginning in 2008:
    a. Investigate practices of data archiving, analysis/mining, and reporting from the Center for Health Statistics.
    b. Copy approaches for state-of-the-art practices.
8. Streamline in-house NASA expertise and leverage relationships with extramural experts throughout the planning timeframe.

a. Establish relationships with target organizations and specialists by 2008.
b. Nurture active relationships throughout the planning cycle.

6-10 years

1. Focus innovations on established levels of care for Moon and Mars, revising and rebalancing the portfolio of research and technology/practice as knowledge advances throughout the planning cycle.
2. Use test-beds to evaluate practices and technology on ISS and lunar bases by 2017.
3. Continue data-mining and reporting to improve the evidence-base using longitudinal data on ISS and lunar-base throughout the planning cycle.
4. Establish partnerships for development of health innovations throughout the planning cycle.
5. Distribute awards for novel innovations.

11-20 years

1. Validate the doc-in-a-box practices and technologies on a lunar outpost.
2. Continue to build an evidence base for operations in fractional gravity environments.

8.3 Human System Integration Technologies

8.3.1 Human System Integration Strategic Goal

The Space Life Sciences Directorate will drive advances in human performance and productivity by improving space flight systems in order to meet established space flight human systems integration standards and mission needs. State-of-the-art practices and technologies in human factors engineering, habitability design, and human-robotics interaction will be developed, implemented, and incorporated into mission architecture solutions to address the human as an element of the overall space system. These innovations will have potential terrestrial application.

8.3.2 Human System Integration Strategies

- Benchmark human systems integration (HSI) by identifying and learning from other organizations that are successful with HSI.

- Establish a unified vision for HSI within SLSD, JSC, and NASA by successfully promoting the importance and value of HSI and coordinating a cohesive team strategy.

- Protect, evolve, and expand core HSI capabilities and technologies by acquiring and maintaining expertise and state-of-the-art technologies.

- Expand into areas of opportunity for HSI--e.g., ground operations and other areas that have not traditionally benefited from HSI expertise.

- Facilitate JSC becoming recognized as the HSI center for the Agency thereby optimally utilizing JSC's significant core capabilities devoted to human space flight.

- Establish and maintain strategic relationships to maximize HSI capabilities and utilization across the Agency.

- Develop contractual and programmatic mechanisms to ensure HSI implementation.

8.3.3 Human System Integration Objectives

1-5 years

1. Develop an HSI strategy and obtain Constellation Program endorsement by 2008.
2. Integrate HSI into the Systems Engineering Handbook and other appropriate program/project management documentation by 2008.
3. Secure changes in the procurement process to require HSI in the procurement of EVA Suits by 2008 and the Lander project by 2009.
4. Facilitate acceptance and incorporation of an HSI approach by making formalized HSI training courses available onsite by 2008 and expanding availability by adding HSI training into the Academy of Program/Project and Engineering Leadership (APPEL) course curriculum by 2010.
5. Through our working relationship with the military and industry, identify and select best practices/technologies to refine our HSI strategy by 2009.
6. Incorporate HSI processes into the Human Integration Design Handbook (HIDH) by 2009.
7. Develop advocacy for an HSI discipline involvement in ground operations by 2010.
8. Provide tools and models to help engineers integrate human factors into hardware and spacecraft designs by 2011.
9. Provide tools for HSI personnel to verify requirements by 2011.
10. Identify technology gaps and incorporate them into Space Human Factors Engineering (SHFE) gap analysis plans annually.
11. Assess technology trends / new development annually.

6-10 years

1. Continue integrating HSI into Constellation operations with a Lunar Sortie/Outpost focus by 2012.
2. Embed the HSI discipline into ground control process development for exploration missions by 2012.
3. Secure changes to NASA's top level acquisition documentation to require HSI in all hardware procurements by 2012.
4. Develop a joint lessons learned database with private industry for HSI by 2013.
5. Establish the Space flight Human System Standards (both volumes) as an international (ISO) standard to facilitate commercial sector and international applicability by 2013.
6. Ensure HSI operations concepts are captured by Constellation Level 2 and Level 3 operations concept for Lunar Sortie missions by 2015.

11-20 years

1. Continue integrating HSI into Constellation operations (Mars focus).
2. Ensure HSI ops concepts are captured by Constellation Level 2 and Level 3 Ops Con for Mars missions.

8.4 Education

8.4.1 Strategic Goal

The Space Life Sciences Directorate will ensure that we are trained in multidisciplinary life sciences, that there is a legacy of experts in exploration life science, and that there is a continuous infusion of space life science into the public, government, academic, and commercial sectors, thereby creating enduring support and enthusiasm for space exploration.

8.4.2 Education Strategies

- Conduct an intensive education program that ensures diversity, achievement, and a succession of experts in Space Life Sciences.
- Leverage partnerships for exploration biomedical research with government agencies and universities.
- Create a Space Life Sciences Academy that addresses education, mentorship, continuous education, and sabbatical opportunities.
- Leverage partnerships for commercial development and training opportunities.
- Institute career ladders with temporal milestones.

- Conduct regular public outreach events.
- Use approved communication structures for outreach to federal and local government entities.

8.4.3 Education Objectives

1-5 years

1. Assess and coordinate all existing educational activities in Space Life Sciences within the Agency, Office of Education, Langley Research Center, and supported institutions by 2008.
2. Solidify existing and develop new industrial relationships for exchange of personnel, competencies, data, and technology by 1010.
3. Identify the career opportunities for existing personnel and provide the education and training opportunities to meet career goals by 2010, and continuing throughout the planning cycle.
    a. Plan pre- and post-doctoral fellowships by 2008.
    b. Establish pilots to test staffing strategies by 2009.
    c. Support sabbaticals for our personnel to obtain critical skills and to advance career opportunities by 2011.
    d. Exchange programs with other Space Agencies by 2010.
4. Complete agreements with parallel federal agencies and commence communication among member professionals by 2012.
5. Establish an annual Space Life Sciences Day that is open to the field center, community, and academic institutions by 2011.
6. Maintain a continuum of interaction with the NASA Advisory Council (NAC) (and others to be defined), legislative affairs office, and local congressional representatives as permitted by 2008.
7. Construct the charter and implementation plan for the Space Life Sciences Academy by 2009.
8. Foster National Laboratory status for ISS by 2012.
9. Set the criteria for metrics that assess progress toward education objectives and conduct demonstration assessments by 2009.

6-10 years

1. Establish a "faculty" in Space Life Sciences by 2014.
2. Secure third-party funding for educational programs (K-16), fellowships, and sabbaticals by 2015.
3. Through partnerships, establish a Space Life Sciences Agenda for national science meetings, university and high school career days by 2015.
4. Implement annual opportunities in pre- and post-doctoral fellowships and sabbaticals at partnering universities by 2015.
5. Co-host annual interagency space biological and biomedical meeting workshops by 2014.
6. Expand Space Life Sciences Day to take place in other locations (universities, field centers, etc.) by 2014.
7. Formalize relationships through agreements and new funding authority. Interface with the IAA and initiate work in the political aspects of space by 2015.
8. Implement Space Life Sciences Academy which will be staffed by NASA personnel, universities, students, faculty, and trainees from our programs by 2013.
9. Use of the ISS National Laboratory as a platform for research and education programs by 2014.
10. Formalize and adopt metrics to perform annual reviews and implement metrics for annual assessment by 2014.

11-20 years

1. Baccalaureate and advanced degrees in Space Life Sciences exist at multiple institutions by 2018.
2. Achieve a cadre of trained staff, competent personnel for succession by 2019.
3. Conduct annual inter-agency meetings and participate in national science meetings sponsored by major science organizations by 2018.
4. Use Space Life Sciences Day as an annual focus on the Life Sciences needs and opportunities for space exploration by 2019.
5. Institute a program that focuses on the politics and legal aspects of space life sciences by 2019.
6. Incorporate Space Life Sciences into secondary education curricula by 2018.

7. Conduct annual exchange programs with universities, industry, and government by 2018.
8. Establish a Space Life Sciences Professional Organization by 2018.
9. Use commercial space carriers for education and research in Space Life Sciences by 2021.
10. Assess the progress and the products of the education initiative and set goals for the exploration mission by 2019.

APPENDIX A: SITUATION ANALYSIS
Conducted in May 2006

A.1 Current Situation

Space Life Sciences has changed considerably in the last two years as a result of changes in national space priority, NASA administration, and Agency programs and processes, including realigning our activities to support the Vision for Space Exploration. Reductions in program content and budget resulted from the Exploration Systems Zero Base Review and the Exploration Systems Architecture Study, and program management and process changes resulted in assignment of level II program responsibility for the Human Research Program to the JSC.

In the past our organization had a central budget, conducted fundamental as well as applied research, utilized NASA Research Announcements, grants, and NASA funded partnerships, and received funding for institutional costs (core capabilities) from the programs. Our FY 06 budget reflects a 40% reduction from the previous year's budget and is expected to remain flat. Core capabilities are funded primarily by programs who are seeking ways to reduce fixed costs. Our research and development activity is directed and focused on exploration risk reduction, through both the development of standards, and the development of countermeasures and capabilities to allow the standards to be met.

A.2 Stakeholder Analysis

Current Space Life Sciences Directorate customers include the Exploration Systems Mission Directorate, the Space Operations Mission Directorate, and the Office of the Chief Health and Medical Officer at Headquarters; the Constellation, STS, ISS, and Human Research Program Offices at JSC; Flight Crew Operations, Mission Operations, and Engineering and Safety and Mission Assurance Directorates at JSC; and our international partners: ESA, CSA, JAXA, and Russia.

In addition to our current customers, future stakeholders may include other government agencies and additional international partners, and we may build upon existing relationships to develop new academic and commercial partnerships.

A.3 External Assessment

A.3.1 Trends: What We Expect to Change

Projected changes and trends that will impact space life sciences fall into two broad categories: trends specific to human space flight, and trends in terrestrial life sciences that will drive changes in human space flight practices and processes.

Trends in Human Space flight

Over the next ten years (2007-2017), the biggest change drivers for space life sciences will result from the transition of current NASA programs to exploration programs, and the emergence of new players in human space flight.

During this timeframe, the Space Shuttle will be retired and the CEV program will become operational, NASA operation of the ISS will be phased out, and Agency resources will be focused on achieving CEV capability and engaging in lunar launch, landing, and surface activity development efforts (see Appendix A: NASA's Exploration Roadmap). These changes will require the transition of necessary skills and facilities from the Shuttle and ISS programs to the CEV program. Additionally, ongoing budget threats to our supporting organizations may result in the loss of some outside assets. Agency budgets are expected to remain flat, and integration between Centers is expected to increase. The result will be fewer NASA astronauts traveling and working in space and fewer NASA sponsored opportunities to conduct life sciences research in space.

In the longer term, there will be a greater focus on crew autonomy and increased human-robotics interaction as mission durations increase and are extended to travel to and on planets. Factors driving change in life sciences across our planning horizon include continuing pressure to meet established schedules, changing administrations resulting in changing legislative priorities and leadership capabilities, a continued focus on translational and applied research, and a limited budget which will force us to become more innovative and proactive.

In addition to changes within NASA, the emergence of new national space agencies will create competition and political implications for the Agency, including the potential for increased military presence in space. Commercial human space flight will emerge with Commercial Orbital Transportation Services (COTS) providers and space tourism, which will facilitate associated technology development and a dramatic increase in the number of space travelers.

Trends in Terrestrial Life Sciences

Trends in terrestrial life sciences during our planning horizon that will serve as change drivers for space life sciences include advances in nanohealth, genetics, biocybernetics, self-constructing materials, human computer interfaces, medical diagnostics, customized pharmaco-prevention and pharmaco-therapeutics, multi-scale physiological modeling, and other biomedical technologies. New partnerships in medicine and engineering are emerging and are expected to lead to additional breakthrough technologies. Decentralization of healthcare to a distributed model that is easier to outsource is a national trend that NASA may also consider.

Also impacting space life sciences will be the ongoing trend of fewer students entering the math and science fields resulting in a diminished pool of prospective life sciences workers, and retirement of the baby boomer generation resulting in a younger and less experienced workforce.

A.3.2 Trends: What We Think Will Remain the Same

Attributes of NASA that are expected to remain unchanged include NASA's low tolerance for risk and emphasis on risk quantification and reduction activities, a potential lack of credibility with our international and community partners, and the overall burden of working in a bureaucratic government organization. The media's tendency to focus on mistakes rather than accomplishments is also expected to continue.

While we think NASA will continue to operate in a vehicle-centric mode, we also believe that humans will remain an important component of space exploration. As a result, there will be an ongoing need for the Space Life Sciences role of protecting and providing health care for astronauts. Competition for resources will always be an issue for life sciences, and the influence of national and global events on space flight will continue to influence the Agency as a whole.

Something that we believe will never change is the human desire to explore the unknown: our inherent need to be inspired, to discover, and to communicate our discoveries with others.

A.3.3 Main Opportunities

The following key opportunities for Space Life Sciences were identified, and serve as the basis for our envisioned future scenario, goals, and strategies.

Partnerships/Collaborations

The creation of new strategic partnerships, within NASA, with other U.S. government agencies, and externally with new international partners, academia, and commercial entities represents our greatest opportunity. By combining financial resources and intellectual capabilities, these partnerships will enhance the value of space life sciences to exploration in a cost-effective manner, and increase our probability of success for each of the opportunities described below.

Constellation Program

The Vision for Space Exploration offers Space Life Sciences the significant opportunity to play a central role in Constellation Program development, design, and operations. Human-robotic integration, human factors of robotics, and emerging technologies in human systems integration, food systems, and environmental systems all represent key opportunities for strengthening and expanding our programmatic contributions. Our operations experience can be leveraged to facilitate transition to operationally-focused research and development efforts, inform the development of human performance standards and requirements, and drive optimal design solutions.

Risk Reduction

Assurance of crew health and performance, based on established human space flight standards, will become even more critical for advanced exploration missions. Development and implementation of an accurate standards-based risk quantification and management tool will enhance recognition of our role in mission success by lending credibility to our activities and the time needed to complete them, increasing operational efficiencies, and facilitating the development of a referencable evidence base.

Biomedical Advances

Advances in biomedical technology will offer increased flexibility and reliability for exploration programs, and enhance our ability to maintain crew health and performance at the necessary levels to ensure mission success. Space Life Sciences has the opportunity to take the lead in developing and sustaining a scientific pipeline leading to advancements and technology spin-offs in areas such as habilitation, medical and environmental autonomy, and application of fractional gravity knowledge.

Commercial Space flight

The success of commercial space flight may enable the development of new academic/commercial partnerships, provide additional opportunities for research and an increased pool of test subjects, and result in revenue opportunities for

commercial human space flight support. Our operations experience may result in opportunities for consulting in flight medicine and other disciplines.

A.3.4 Barriers and Constraints

Primary barriers and constraints to achieving our vision include:

- Limited funding for operations and research core capabilities, and the challenge of responding to an ever-changing budget
- Technological constraints and fewer on-orbit resources for conducting life sciences research and technology development
- A younger workforce less skilled in life sciences and engineering disciplines, and no growth in current staffing levels
- An uninspired public perception of space flight and lack of public support due to the current disconnect of NASA's mission with national interests
- Inefficient program processes and a lack of integration at JSC and between Centers
- Potential changes in the NASA vision due to changes in the political landscape
- NASA culture: resistance to change, inability to solidify and effectively manage international and commercial partnerships, low risk tolerance
- Potential regulatory barriers to commercial initiatives

A.4 Internal Assessment

A.4.1 Core Capabilities

<u>Current Core Capabilities</u>

The core capabilities of the Space Life Sciences Directorate enable the health, performance and productivity of crews in support of NASA's human space flight missions. The knowledge and skills present in the NASA and contractor workforce have been developed in response to the challenges of operating in space, where physiological responses are altered in the microgravity or reduced gravity environment. Other unique aspects of the space environment require specific expertise to support risk mitigation. Our unique core capabilities integrate human-centered science, operations and engineering, and are

specialized toward the ultimate goal of mitigating the health and performance risks of human space flight.

Space Life Sciences Directorate core capabilities are the following:

- Health care providers for astronauts pre-mission, mission, and post-mission
- Discipline expertise in human health and performance in the space environment
    a. Space Medicine
    b. Physiological and behavioral effects of space flight, including expertise in the disciplines most effected by space flight
        i. Bone, muscle, cardiovascular, neurosensory, immune, cell science, pharmacology, nutrition and behavioral health
    c. Space environment definition and its effects on human health and performance, including the following disciplines
        i. Microbiology, toxicology, water and food systems, space radiation
    d. Space human factors, including the following disciplines
        i. Human systems integration, Human computer interfaces, Ergonomics, Human Modeling, Anthropometry and Biomechanics
- Human-centered risk assessments and risk mitigation practices and capabilities in the human space flight disciplines of environments, medicine, physiology, behavioral health, habitability, human factors, and human performance.
- Human health, environmental and performance standards and requirements development
    a. Standard and requirement development that define acceptable risk in the areas of crew health and performance
    b. Development and evaluation of space vehicle and hardware design standards and requirements

Future Core Capabilities

The need for SLSD core capabilities in the areas of human health, performance and productivity to address the unique environment of space will remain strong as we pursue the vision for space exploration. We must work to maintain existing core capabilities while enhancing them to allow us to meet the new challenges associated with lunar and planetary exploration. Specifically, space exploration missions bring challenges such as isolation and greater crew autonomy. New environmental challenges such as fractional gravity, space radiation and lunar dust must be addressed. Bioanalytical and modeling capabilities that enable analysis and decision making from data sets with few subjects. SLSD must have the capabilities to manage human health and performance risks to ensure exploration mission

success. Additionally, we must have the necessary core capabilities in time to allow agency decision making associated with design of these vehicles and missions.

A.4.2 What We Want to Change

Our greatest strengths lie in our core capabilities: the unique space life sciences research, technology development, and operations knowledge, skills, and experience that define us as an organization. These were discussed in the previous section A.4.1.

We also assessed our organization for weaknesses and opportunities for change. Four key areas for change were identified:

Communication

Our greatest opportunity for change centers on improving communication internally and externally, which will facilitate our ability to work as a team within the directorate, enhance how we are perceived and valued externally, and ultimately strengthen our contributions to achieving the vision for space exploration. Specifically, we need to eliminate silos within the directorate, build upon our individual strengths and create synergies through multi-disciplinary teams, speak with one voice for life sciences, and find ways to clarify other organizations' understanding of our value.

New Business Model

We need to adopt a new business model that is more forward looking, flexible, incorporates continuous improvement, enables us to become a learning organization, and encourages an understanding of when "good" is "good enough." This new way of doing business should challenge paradigms such as:

- We know best (not invented here)
- Only NASA can fly a space ship
- SLSD can do everything internally
- Civil servants must be in charge
- Accept no risk
- We are the only game in town

Management Practices and Processes

Management practices and processes were also identified as key opportunities for improvement. Necessary changes include recognizing that we don't have to be the doers, but that we do have to be competent managers; changing and/or correcting accountabilities and establishing consequences; and finding the right people to do the right jobs. We need to evaluate and plan for the possibility that

the core capabilities we have now may not be the ones we need in the future. Processes should be streamlined and improved to ensure products and missions drive processes, and that implementation occurs from the top down.

Improved Customer Focus

We need to speak using our customer's language, ask our customers what they need, and improve the understanding by others of how space life sciences can add value to exploration processes so that we are perceived and welcomed as a team player. We also need to better anticipate and be prepared to address the needs of our customers.