TECHNICAL AREAS

Six (6) technical areas are described below. The descriptions are intentionally broad in scope to span the potential technical requirements anticipated over the contract period.

1.0 Advanced Materials and Structural Systems

Research and technology development in the area of advanced materials and structural systems includes applications related to aerospace vehicles; structural mechanics and concepts; durability, damage tolerance, and reliability; structural dynamics; and advanced materials and processing. This area involves conduct of analytical and experimental research to develop and study advanced materials and complex structures, at length scales ranging from atomistic to full-scale structural tests, under static and dynamic mechanical and thermal loading conditions.

Research in this technology area includes, but is not limited to:

- Development and integration of new aerospace materials, including the modeling and analysis, experimental synthesis, processing, fabrication, characterization, environmental exposure, and testing
- Structural deformations and failure modes, as well as linear and nonlinear structural response phenomena of undamaged and damaged structures
- Stability, strength, damage tolerance, and structural integrity
- Failure criteria and progressive damage analysis methods, as well as development of constitutive laws describing advanced material behaviors
- Efficient structural concepts for future aircraft, space structures, and space transportation systems that exploit the benefits of advanced material systems
- Advanced design methods that reduce design cycle time; including sizing, optimization, and uncertainty
- Validated methods to predict, verify, and control dynamic responses of complex aerospace structures, and to improve the safety and handling performance of aircraft during all-weather ground operations, including takeoff, landing impact, and ground handling phenomena

2.0 Aerodynamics, Aerothermodynamics, and Acoustics

Research and technology development in the areas of aerodynamics, aerothermodynamics, and acoustics include configuration aerodynamics, computational modeling and simulation, flow physics and control, aeroelasticity, flight dynamics and controls, noise and vibration prediction and control, aerothermodynamics, hypersonic air-breathing propulsion, and model systems. Research is anticipated to cover a variety of aerospace vehicle concepts for both Earth and other planetary flight applications. Vehicle configurations may include traditional concepts and non-traditional concepts requiring substantial integration of propulsion within the airframe. Flight speed regimes of interest extend from subsonic to hypersonic speeds. Research may span a range of maturity

levels, from fundamental tool and technology development through integrated flight demonstrations.

Research in this technology area includes, but is not limited to:

- Low boom supersonic aircraft, ultra-efficient commercial transports with minimal environmental impact, and vehicles for space access with maximum launch flexibility
- Active, aeroelastically-tailored designs that dramatically improve vehicle performance
- Integrated propulsion/airframe concepts, including scramjet-powered vehicles and low noise configurations for advanced subsonic transport
- Technologies in flight dynamics and control, such as self-modeling and self-adapting technologies to enable refuse-to-crash flight vehicles
- Noise control technologies of interest include new vehicle concepts with active and adaptive technologies, flow control, and low-boom configurations to reduce community noise
- Multi-scale methods for physics-based modeling and simulation, which are high-fidelity, integrated, validated, multi-disciplinary, and with uncertainty quantification
- Methods for certification by analysis

3.0 Integration, Systems Analysis and Concepts

Research and development in the area of systems analysis and concepts delivers advanced concepts, system analyses, studies, and multidisciplinary methods in support of Projects and Programs.

Research in this technology area includes, but is not limited to:

- Mission design and campaign analysis
- Future architectures, which provides detailed system analysis for both revolutionary and evolutionary vehicle/configuration design
- Layout packaging
- Aerodynamics and aerothermodynamics
- Thermal analysis and thermal protection systems
- Radiation shielding
- Propulsion systems
- Airframe and engine subsystems
- Trajectory/ flight mechanics
- Vehicle integration
- Sizing and closure
- Life cycle cost
- Reliability, affordability, operational concepts
- Technology assessment and prioritization

4.0 Entry, Descent, and Landing

Research and technology development in the area of entry, descent, and landing includes evolutionary and revolutionary technologies and vehicle designs for planetary atmosphere. The research in this area will involve design analysis and fabrication of test articles.

Research in this technology area includes, but is not limited to:

- Advanced thermal protection systems
- Inflatable structures
- Aeroassist techniques and guidance navigation and control systems
- Advanced material development
- Flight mechanics and performance analysis
- Systems analysis and trade studies
- Vehicle systems integration

5.0 Measurement Systems

Research and technology development in the area of measurement systems includes experimental measurement and sensing devices, techniques, and systems, as well as nondestructive measurement systems for aerospace applications, and computational modeling.

Research in this technology area includes, but is not limited to:

- Advanced sensing technologies, methods and systems including laser based diagnostics, analytical chemistry, optical physics, advanced sensors and actuators
    - Advanced sensors utilizing emerging technologies, such as nanotubes, quantum dots, and advanced fiber-based sensor concepts
    - Miniaturization of sensors and measurement systems
    - Radical new techniques to measure and characterize aerodynamic properties and flow in advanced vehicle concepts
- Quantitative nondestructive evaluation sciences for advanced measurement and characterization of materials and structures
    - Ultrasound, acoustic emission, acoustic microscopy, electromagnetics, optics, radiography, fiber optics, computed tomography, terahertz imaging, and thermography.
- Prototype instrumentation, systems, nondestructive evaluation, and inspection techniques for materials and structures which are applicable both in the laboratory and in the field
- *In situ* sensors and systems to monitor the state of a vehicle's structural, dynamic, and electromagnetic state
    - Algorithms and approaches for real-time data reduction, processing, and analysis of massively parallel and high speed data streams to provide manageable output for human or automated interpretation

- Theoretical, analytical, and computational models to simulate function of sensors and measurement systems supporting design and application

6.0 Intelligent Flight Systems

Research and technology development in the area of intelligent flight systems incorporates new technologies, new vehicle concepts, and new operational concepts, and validates the performance of these systems, through physical (ground and flight) and virtual (modeling and simulation) testing in relevant operating conditions.

Research in this technology area includes, but is not limited to:

- Autonomy: Algorithms and tools to implement autonomy on various levels such as: pilot autonomy relative to ground control; on-vehicle autonomy for cases of partial loss of capability; autonomy for unmanned air vehicles, singly or in formation; flight deck-based multi-craft air traffic control
- Adaptive systems: Algorithms and software that estimate vehicle state and health and reconfigure augmentation on the fly, utilizing adaptive controls, artificial intelligence, and machine learning
- Complex airspace: Intelligent flight systems for the ground and the cockpit to manage safety, operational efficiency, and environmental impact with respect to air traffic control, and advanced air traffic control schemes using model airspace systems
- Human-automation integration: Integration between humans and automated systems for flight deck and ground crew
- Verification and validation: Assurance frameworks, methods and tools for validating increasingly autonomous systems
- Technology demonstrations: Demonstrations of the advanced technology developed using simulators, unmanned air vehicles, or piloted aircraft, as appropriate