C-1 STATEMENT OF WORK

Research and Technologies for Aerospace Propulsion Systems
(RTAPS)

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RESEARCH AND TECHNOLOGIES FOR AEROSPACE PROPULSION SYSTEMS (RTAPS)

STATEMENT OF WORK

1.0 Objective

The objective of this proposed task order contract is to develop, demonstrate, and verify advanced propulsion system technologies as part of NASA's ongoing, long-term aerospace research programs, addressing a wide variety of propulsion issues. Applications include subsonic, supersonic, hypersonic, and rotorcraft transportation vehicles, as well as aviation safety and space exploration applications.

2.0 Scope

The Contractor shall furnish all personnel, facilities, equipment, material, supplies, and services, except as may be expressly set forth in the contract agreement as Government Furnished Property, and otherwise do all things necessary to, or incident to, performing and providing the work efforts set forth in the following areas. Contract scope includes analytical and experimental investigations covering a wide variety of propulsion components and sub-components having either Government, commercial, or military application. . This contract may be used to support all NASA Centers that require work within the scope of this Statement Of Work. The contractor shall perform task orders in the following technology areas:

2.1 RESERVED
2.2 RESERVED

2.3 Technology Area 3: Integrated Rotorcraft Propulsion – Airframe Systems Technology

The contractor shall investigate and develop advanced integrated propulsion-airframe technologies to enable future rotorcraft to obtain high cruise speed, large payload and long range capability, and ultra-safe and low noise operations that will be required of next generation vertical lift civil transport systems. The contractor shall develop integrated propulsion system technologies for a variable speed rotor, with the goal of maximizing variation of rotor rotational speed (up to 50 percent) with no impact on flight handling quality and minimum impact to propulsion system weight. A variable speed rotor will reduce the cabin and community noise while increasing rotorcraft vehicle performance. The contractor shall perform research and development in this Technology Area with particular focus on advanced transmission technologies, integrated propulsion system technologies, and airframe icing and propulsion health management technologies. The technical elements included in Technology Area 3 are as follows::

2.3.1 Concept Development and Systems Studies

The contractor shall perform concept development and system studies of nontraditional propulsion and/or vehicle arrangements and advanced aerospace systems configurations to meet NASA program goals. These concepts include unconventional airframes and engines, advanced gearboxes, electric motors, alternative fuels, heat transfer devices, propulsion integration and advanced aerospace systems. System studies include performing system analyses and designs of aerospace vehicles with emphasis on propulsion systems installations to evaluate advanced technologies and aerospace system concepts that have the potential for improving system performance, weight, emissions, fuel burn, noise and costs.

The scope of work under this element includes the following:

(1) The contractor shall develop and validate empirical, statistical, and physics-based analytical models which are robust enough to handle non-conventional configurations. These models may be used for understanding the basic underlying physical phenomenon of the system or subsystem as well as for predicting aerospace systems and/or component performance, weight, emissions, reliability, life and cost.

(2) The contractor shall define goals and figures of merit for overall systems as well as for individual technologies within the context of overall program/project goals and objectives.

(3) The contractor shall conduct technology trade studies, mission analyses and market/cost scenario studies to identify and evaluate aerospace systems and assess their contributions towards meeting program/project goals and objectives.

(4) The contractor shall perform system simulations of aerospace systems and subsystems from a 0-D level up through a multi-disciplinary 3-D level.

(5) The contractor shall perform aerospace systems conceptual, preliminary and/or detailed design studies in support of advanced concept definition, development and/or testing.

(6) The contractor shall conduct risk assessments of advanced aerospace systems.

2.3.2 Advanced Transmission Technologies

The contractor shall conduct research and development of advanced drive components and systems technologies to increase performance and durability of future rotorcraft propulsion systems while reducing systems weight and noise. The contractor shall investigate and develop advanced variable/multi-speed drive system concepts, which includes the identification, evaluation, development and demonstration of novel variable/multi-speed transmission concepts that can provide variable rotor speed capability with minimal increase in transmission weight.

The scope of work under this element includes the following:

(1) The contractor shall investigate, develop, and design advanced transmission components and subsystems. The contractor shall address structural requirements as well as durability, weight, cost and performance of these systems.

(2) The contractor shall fabricate and test advanced drive train components and subsystems.

(3) The contractor shall develop and validate physics-based analytical models including models as they apply to the drive train in the rotorcraft.

(4) The contractor shall develop new component and system test facilities to validate new drive systems concepts.

(5) The contractor shall develop parametric analysis methods for scaling to future integrated propulsion system demonstrations.

2.3.3 Integrated Propulsion System Technology Demonstrations

The contractor shall focus on development of technologies required to enable optimum integration of advanced engine, advanced transmission and advanced rotor concepts to meet overall rotorcraft operational, efficiency, and performance goals. The contractor will develop propulsion subsystem and system level models and conduct system level tests to characterize and validate system operating characteristics, optimum engine and transmission parameters, systems controls, and durability of these systems in a rotorcraft application. The contractor shall identify, develop, and demonstrate the most beneficial technologies for enabling integrated variable-/multi-speed propulsion systems while avoiding negative impact to weight, fuel burn, and emissions.

The scope of work under this element includes the following:

(1) The contractor shall investigate, develop, and design advanced integrated propulsion components and systems.

(2) The contractor shall fabricate and test advanced integrated propulsion components and systems.

(3) The contractor shall develop and demonstrate multi-speed shifting control methodology of integrated engine and transmission systems.

(4) The contractor shall develop and experimentally validate physics-based analytical models of the integrated engine and transmission system to identify system dynamics, performance metrics and parametric analysis for future rotor/engine/transmission tests.

(5) The contractor shall design and fabricate test fixtures and hardware to perform propulsion systems integration tests including loading effects of rotor system.

2.3.4 Rotorcraft Icing

The contractor shall perform rotorcraft icing research and technology development to address the following challenges: accurate ice accretion simulation, iced aerodynamic performance, and stability and control evaluations. .

The scope of work under this element includes the following:

(1) The contractor shall perform an assessment of advanced concepts, analytical and computational tools and barrier technologies towards understanding and mitigating the effects of rotorcraft icing.

(2) The contractor shall develop and validate empirical, statistical, and physics-based analytical and computational models for predicting rotorcraft icing and/or its effect on aerodynamic performance.

(3) The contractor shall design and fabricate test instrumentation and model hardware for the characterization, detection and measurement of rotorcraft icing and performance, as well as design and develop diagnostic systems for identifying rotorcraft icing locations and vulnerability is desired.

(4) The contractor shall demonstrate and assess rotorcraft ice accretion and performance prediction tools advanced rotorcraft icing prevention and reduction concepts and technologies on component test rigs, engine tests, and flight tests.

2.3.5 Rotorcraft Health Management Technologies

The contractor shall conduct research and development of advanced rotorcraft health management technologies that have the potential to decrease rotorcraft maintenance operations and support costs and increase rotorcraft safety, performance, airspace capacity and mobility. The contractor shall focus on the automated detection, diagnosis, and prognosis of propulsion system faults or failures.

The scope of work under this element includes the following:

The contractor shall develop and experimentally validate mathematical methods and computer algorithm tools to detect and predict the health and usage of rotorcraft dynamic mechanical systems in the engine and drive system. Specific propulsion health management technologies to be addressed by the contractor include:

(a) The contractor shall develop and validate methods for detecting onset of failure, isolating damage, and assessing damage severity and magnitude of components & systems

(b) The contractor shall develop and validate methods for predicting remaining useful life and relating prediction to maintenance actions required

(c) The contractor shall integrate health monitoring outputs with maintenance processes and procedures

(d) The contractor shall develop system models and material failure models and validate these models with data from bench fatigue tests, seeded fault tests and fielded systems

(e) The contractor shall perform data collection/management for analysis of operational mission data.

2.4 RESERVED

3.0 Work Requirements

The contractor(s) shall have the ability to perform all work in one or more of the Technology Areas as authorized in each task order issued.

The contractor(s) shall provide a program management system that includes timely insight into the technical, cost, and schedule status and risk, as well as technical and programmatic control of work performed under the task orders.

The contractor(s) shall implement a product assurance system, as appropriate, for task orders involving hardware and/or software development. The contractor's existing product assurance plans, procedures, formats, and documentation systems that support the development of safe and reliable aerospace products, are acceptable if they are shown to satisfy the objectives of the Product Assurance Requirements listed in the Product Assurance Requirements of NASA Policy Directive NPD 8730.5 NASA Quality Assurance Program Policy—URL: http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=8730&s=5
All work performed under this contract shall be in compliance with all applicable Federal, state, and local environmental regulations and those policies set forth in the NASA Glenn Research Center's Environmental Programs Manual This can be viewed at: http://smad-ext.grc.nasa.gov/shed/pub/epm/epm-manual.pdf

Task Orders will be issued in accordance with Clause H.9-H.11.

Appendix C–1

NASA has requirements for the development and demonstration of advanced engine technologies that will enable reductions in noise, emissions, fuel consumption, and sonic boom (high speed aircraft). Specific goals have been defined by NASA's Subsonic Fixed Wing (SFW) and Supersonic Projects and are summarized in Tables 1 and 2, respectively. NASA's Subsonic Rotary Wing Project has defined the goal of 50 percent variation of main rotor rotational speed needed to achieve efficient VTOL and Mach 0.5 1000 NM cruise capability, with no impact on flight handling and minimum impact to propulsion systems weight, in addition to advancing engine capabilities for future civil rotorcraft.

TABLE 1.—GOALS FOR SUBSONIC FIXED WING PROJECT

Corners of the trade space	N+1 (2015)[a] Generation Conventional Configurations relative to 1998 Single Aisle	N+2 (2020)[a] Generation Unconventional Conigurations relative to 1997 Large Twin Aisle	N+3 (2025)[a] Generation Advanced Aircraft Concepts (relative to user-defined reference)
Noise (cum. below Stage 4)	–32 dB	–42 dB	-71dB
LTO NOx emissions (below CAEP/6)	–60%	–75%	Better than –75%
Performance: aircraft fuel burn	–33%[b]	–40%[b]	Better than –70%
Performance: field length	–33%	–50%	Exploit metro-plex concepts[c]

[a]Technology Readiness Level Range = 4 to 6
[b] An additional reduction of 10 percent may be possible through improved operational capability.
[c] Concepts that enable optimal use of runaways at multiple airports within the metropolitan areas.

TABLE 2.—GOALS FOR SUPERSONICS PROJECT

	N+1 Supersonic Business Class Aircraft (2015)	N+2 Small Supersonic Airline (2020)	N+3 Efficient Multi-Mach Aircraft (beyond 2030)
Environmental goals			
Sonic boom	65 to 70 PLdB	65 to 70 PLdB	65 to 70 PLdB low boom flight; 75 to 80 PldB overwater flight
Airport noise (cum. below stage 4)	Meet with margin	10 EPNdB	10 to 20 EPNdB
Cruise emissions	Equivalent to current subsonic	< 10	< 5 and particulate and water vapor mitigation
Performance goals			
Cruise speed, Mach	1.6 to 1.8	1.6 to 1.8	1.3 to 2.0
Range, nmi	4000	4000	4000 to 5500
Payload, passengers	6 to 20	35 to 70	100 to 200
Fuel efficiency, pass-miles per lb of fuel	1.0	3.0	3.5 Š 4.5

Flight regime related factors include

Subsonic: Focus is on Ultra-High Bypass (UHB) ratio engine technologies for the N+1 goals and embedded engine and variable engine technologies for the N+2 goals, and also includes development of lower Technology Readiness Level (TRL) advanced technologies enabling propulsion systems for the N+3 time frame.

Supersonic: Focus is on variable cycle engine technologies for the N+2 goals and may also include development of advanced technologies enabling propulsion systems for the N+3 time frame. Some work may also be included to address N+1 system as required.

Rotary Wing: Focus is on engine and transmission technologies needed for wide operability, variable speed propulsion systems (i.e. 50percent variable speed power turbine) for rotorcraft vehicles that meet performance, environmental (noise, emission), weight and cost goals that enable high speed (0.5 M), large payload (~90 passenger), long range civil transports. In addition, the Subsonic Rotary Wing Project is developing technologies to enable advanced engine capabilities for future civil rotorcraft.