National Aeronautics and Space Administration
Ames Research Center

Statement of Work
For
Rotary Wing Technology Development

I. Introduction

This Statement of Work (SOW) describes the general scope of rotary wing research and development to be performed under this contract. Specific requirements for technology development will be defined by subsequent Task Orders (TOs). As requirements are generated during the contract period, the Contracting Officer will authorize individual TOs which will provide a detailed task Statement of Work, period of performance, and deliverables. The individual tasks may support a broad array of technology areas important to rotary wing technology. The U.S. Government and Industry have established long-range technology development plans which identify tasks critical to support future rotorcraft utilization by both civilian and military operators. Technologies that enhance vehicle productivity, range, speed, capacity, performance, design tool development, design cycle reduction, dual-use (civil and military utility), safety, survivability, and environmental and community compatibility are included under this Statement of Work.

II. Background

The evolution of rotorcraft technology from the 1970's has seen significant developments including the use of composite structures, bearingless rotor designs and composite rotor blades, advances in rotor aerodynamics and acoustics, greater reliance on first-principle analysis and design tools, wider use of high performance computing tools, and safer aircraft with significant improvements in controls, flight dynamics, and cockpit design. In this period completely new aircraft types (e.g., canard rotor wing, optimum speed rotor operation, lift offset rotors, and quad tilt rotor designs) have been conceived. In the case of the tiltrotor aircraft, demonstration has progressed through the prototype stage to the production aircraft for the Marines, the MV-22 Osprey aircraft, and the CV-22 for the Air Force. The advances have been accompanied by analytical capability in comprehensive analysis, structural dynamics, fluid mechanics, rotor aerodynamics, aeroacoustics, flight dynamics and adaptive control methodologies.

It has long been recognized that while the vertical takeoff and landing aircraft (VTOL) imposes a penalty for its vertical performance, it also offers the potential of alleviating airspace congestion and runway gridlock, easier access to the air transportation network, and reduce door-to-door transportation of people, goods, and services. However, civil noise acceptance standards have become more stringent so that yesterday's technical solutions are no longer acceptable if rotorcraft are to become acceptable within the community and enable the greatest benefit to society through wide-spread use. Additionally, safety and productivity equivalent to or competitive with other

transportation modes are necessary to assure rotorcraft are accepted in order to take full advantage of the potential for rotorcraft in the national air traffic system.

III. Scope of Work

Task Order assignments will be drawn from the spectrum of technology assessments, analysis, design, fabrication, and testing requirements (model-scale, full-scale, and flight) with rotorcraft, including but not limited to aerodynamics, structures, computational fluid dynamics, acoustics, comprehensive analysis, cockpit design and control systems, handling qualities, human factors, prognostics and health management assessments, and systems and economics analysis. The following areas are listed as examples:

Assessment of Advanced Rotorcraft Technologies

The offeror shall conduct studies to analyze advanced/emerging/leap frog technologies and the potential payoff to the national airspace system passenger, rotorcraft operator, and rotorcraft manufacturer. Payoffs include increase passenger-capable VTOL aircraft, benefits to purchase cost, reliability, operating costs, and passenger ticket costs. Offeror shall identify and review concepts of technology insertion to existing fleets, new rotorcraft variants, or entirely new vertical lift aircraft. Offeror shall analyze designs, develop technology plans, identify critical technologies and areas of technical risk, and develop alternative risk mitigation plans.

Assessment of Rotorcraft Requirements in the Next Generation Air Traffic Management System

The offeror shall examine current helicopter operations and the deficiencies or problem areas of current IFR and proposed simultaneous non-interfering operations with respect to rotorcraft; identify requirements necessary to integrate rotorcraft into future generation ATM systems; formulate research and technology plans to address these needs. Efforts can include describing major rotorcraft missions, applications, and operating environments; providing market size, passengers carried statistics; conduct economic impacts of the rotorcraft industry on the national and international economies.

Prognostics and Health Management Assessments

The offeror shall conduct studies and analyses on prognostics and intelligent vehicle health management (IVHM) technologies. The offeror shall identify promising new technologies that have the potential to significantly reduce rotorcraft operations and support costs. Offeror personnel may work with NASA, U.S. Army, U.S. Navy and FAA liaisons to understand the leveraging technologies under development by the U.S. Government.

Research Flight Testing

The offeror shall provide an airworthy helicopter, tiltrotor, and/or advanced vertical lift vehicle (manned or unmanned) including the ground and flight crew members required to conduct safe flight operations in accordance with a Government provided or approved test plan. The aircraft will be operated in hover, climb, transition, cruise, maneuver, and descent. The aircraft may be required to fly in formation flight with

another Government-provided aircraft. The offeror will incorporate GFE instrumentation into the offeror's aircraft as required and specified. Data will be acquired using the offeror's data acquisition, reduction and storage system and provided in reduced format to the Government together will all pertinent documentation of sensor calibration and signal processing.

Wind Tunnel Test Stands

The offeror shall provide a fully capable small/large/full-scale wind tunnel test stand (including all cabling and control consoles) for model helicopter/tilt rotor testing in Government and private industry test facilities. The hardware design and analyses shall demonstrate conformance to all pertinent Government requirements. Design reviews (Conceptual, Preliminary, and Detailed Design Reviews) and reports will be prepared, reviewed by Government personnel, modified and approved. The offeror will prepare hardware and documentation necessary for full operation of such stands with Government, the offeror, or third party rotor systems installed. Full design, stress, quality assurance, FMEA, instrumentation, health monitoring, operation, and maintenance documentation will be provided. The offeror can be required to provided training and/or support personnel on site in the use and operation of the test stand at Government, offeror, or third party test sites.

Hardware Gear Testing Components

The offeror shall prepare layout and design of a new testing system to enable evaluation of loss-of-lubrication performance of high speed helical gears. Data obtained from such tests will be used to validate analytical models provided by the Government or developed by the offeror for the design, fabrication and evaluation of loss-of-lube tolerant rotorcraft drive systems. Multiple or variable speed transmission technologies will be investigated as to their benefits and design trade-offs including speed regulation, weight, maintenance and inspection requirements.

Advanced Rotor Technology/Configuration Assessments

The offeror shall analyze, fabricate and evaluate advanced rotor hub and on-blade control systems for performance improvements, vibration reduction, noise alleviation, carefree maneuvering, and stability and flight dynamics improvements. Analyses may include comprehensive analysis models, fundamental physics codes, simulation experiments, and piloted real-time simulations. The hardware to be fabricated may use new emerging materials and technologies, including adaptive and morphing structures. Rotor hardware will be model/large/full-scale and flight qualified hardware. All necessary documentation will be reviewed and concurred with by Government personnel. All hardware to interface with test stands and flight test vehicles will be designed, manufactured, and documented as well. Reports will be prepared to document all the findings from the assessment, including identification of future work necessary to mitigate identified technical and economic productivity risks.

Drive System Sensitivity Studies for Rotorcraft

The offeror shall perform sensitivity studies to determine the effect of selected drive system-related parameters on helicopter/tilt rotor/advanced rotorcraft direct

operating cost (TOC) and performance. The contractor shall furnish or be provided full mission definition and baseline vehicle descriptions, and shall identify all assumptions required to conduct such studies. The offeror shall select rotorcraft synthesis codes to evaluate the effect on TOC and performance on parameters such as mean time between removal, acquisition costs, maintenance costs, and weight. The offeror will also provide information on the effect of this parameters on reducing aviation accident rates.

Avionics Processor Equipment and GPS Upgrades
The offeror shall provide acquisition and utilization of updated avionics equipment for Government research aircraft, such as the UH-60A RASCAL aircraft. The offeror shall provide flight director equipment including ruggedized avionics processor equipment, software, licenses, graphics displays and process flight director code to be used in Government-conducted flight research test programs.

Health Usage Monitoring Systems (HUMS) Technology Assessments and Demonstrations

The contractor shall provide personnel, facilities, equipment, and material as necessary to perform investigations of onboard sensors/equipment on an offeror provided rotorcraft to improve HUMS capabilities, accuracy, and utilization. The offeror shall demonstrate application of usage monitoring techniques to rotorcraft missions using a HUMS equipped aircraft. Guidelines for certification/qualification and integration of HUMS into an operator's maintenance program will be developed. Rational procedures for obtaining maintenance credits shall be proposed. The economic impact and cost benefits of HUMS technologies will be conducted including but not limited to retirement index number, airspeed/load factor/gross weight histograms, exceedance monitoring, and torque-cycle counting. Evaluation of using damage tolerance analysis in conjunction with Flight Condition Recognition will be compared to conventional damage determination by safe-life methodology.

Engineering Analyses of Advanced Concepts
Application of computational fluid dynamics (CFD), aeroacoustics, comprehensive analysis, and other advanced computational methods for the computation and prediction of rotor aerodynamic loads and acoustics, airfoil design, vibration prediction and alleviation, and computation of interactional aerodynamic effects between various vehicle components (rotor, fuselage, tail, wings, other rotors). Design and testing of model- and full-scale rotor systems and vehicle concepts involving aerodynamics, acoustics, structures, and dynamics; and also involving analysis, design, fabrication, instrumentation, data acquisition, data reduction, correlation, and reporting may be required.

Subject Material Expert Review
Provide appropriate nationally recognized experts in any number of rotary wing technology areas as required to meet Government needs for reviewing, critiquing, and providing expert advice in Government-funded, directed, or conducted research. Provide qualified experts for advisory panels (or red teams). Insure proper prioritization and focus of new emerging technical disciplines and directions in new programs and

accurately review accomplishments and progress in single, specific programmatic situations or on a regularly schedule program basis.

Advanced Cockpit Crew Station Research
Development and operation of real-time mathematical models or rotorcraft for use in fixed and moving base simulations; design and development of control systems and crew station displays and related control laws and evaluation in both fixed and moving base simulations that may include air traffic operations; and investigation of human interface requirements for advanced cockpit designs, including displays and flight control devices, for optimum pilot workload.

IV. Glossary

ATM	Air traffic management
CFD	Computational fluid dynamics
DOC	Direct operating cost
DOs	Delivery orders
FMEA	Failure Modes and Effects Analysis
GFE	Government furnished equipment
GPS	Global positioning system
HUMS	Health utilization monitoring systems
IVHM	Intelligent vehicle health management
RASCAL	Rotorcraft aircrew system concepts airborne laboratory
SOW	Statement of work
VTOL	Vertical takeoff or landing

V. Task Ordering Procedures

Individual Task Order work statements for each Task Order shall be prepared by the Government end user and shall be transmitted to the Contractor(s) by the NASA Ames Research Center Contracting Officer (CO). The Task Ordering procedure is fully delineated in the Contract. No work will be commenced prior to receipt of written authorization for work from the Contracting Officer and assignment of a Task Order Manager who will be the primary technical contract for that order.