Proposals shall include a schedule with milestones that support the evaluation of progress and highlight the achievement of goals. Decision points are acceptable as milestones.

(4.9) Potential NASA Resources

See section 6, NASA Facilities, below.

(5) Subtopic Number: AFCS-1.5

(5.1) Subtopic Name**:** Distributed Systems: Distributed Airspace Systems

(5.2) Description

A central goal of NextGen is to improve the efficiency and capacity of our nation's airports and airspace through the strategic use of existing and emerging technologies [4]. NASA envisions that automation will play a vital role in the realization of this goal through a broad range of applications such as automating low-level background activities to free human operators to focus on higher-complexity tasks, providing automated advisories to a human operator to support decision-making, or completely replacing some instances of human decision-making.

In addition to automation, NextGen will require coordination and cooperation between unprecedented numbers of disparate system elements using a wide range of communication protocols. System functions that historically have been provided locally using dedicated resources may be distributed among a network of ground, airborne and space-based resources.

(5.3) Objectives

The introduction of automation and the realization of system functions through distributed, rather than localized, resources are two significant challenges to NextGen safety assurance. Disruptions to distributed system elements that support automated functions must not adversely impact safety under any realizable conditions, and a wide arsenal of approaches will need to be available to provide conclusive evidence towards this end. The objective of the research is to develop initial capabilities to analyze and assess safety of NextGen capabilities from a distributed systems perspective.

(5.4) Approach

In view of this objective, NASA is soliciting research that specifically assesses how credible faults, disturbances, and degradations might impact NextGen automation in a manner that adversely impacts safety. NASA has selected as an initial focus area automated aircraft separation using the existing communication channels defined for NextGen.

NASA is currently researching a variety of automated separation strategies, such as:

Improved ground-based tactical conflict detection provided as advisory to human controller [2] [3].
Autonomous Flight Rules (AFR) integrated with traditional instrument and visual rules [1] [6] [7].

These, as well as other NextGen separation assurance strategies will depend on data provided through a defined set of communication platforms, such as Traffic Information Service-Broadcast (TIS-B), Automatic Dependent Surveillance-Broadcast (ADS-B) (in/out), Global Positioning System (GPS), and Controller–Pilot Data Link Communications (CPDLC) [5]. Accordingly, the approach envisioned for this research is to:

- Develop a comprehensive view of the individual and integrated failure space of NextGen communication technologies that support automated aircraft separation.
- Understand the fault detection and mitigation strategies for these communication technologies.
- Understand the dependencies of various proposed separation strategies on these communication technologies – in particular: dependencies related to safety.
- Identify the mechanisms by which communication disruptions and associated detection and mitigation may adversely affect separation assurance.

Proposals should produce an overarching framework for assessing the adverse impact of communication disruptions on separation assurance. Proposals should also address detailed analysis of one or more communication technologies. It is understood that Year One resource limitations may preclude an extensive assessment of all technologies; however, sufficient analysis should be proposed as part of Year One to demonstrate the efficacy of the proposed assessment framework.

(5.5) <u>Relevant Milestones Supported</u>

The proposed work will partially support completion of three SSAT milestones, "Publish design/evaluation guide for safe distributed systems", "Verify and document that design/evaluation guide provides safety assessment" and "Advance safety assurance to enable deployment of NextGen Flight Critical Systems".

(5.6) <u>Expected Outcome</u>

The expected outcome is technologies and mathematical models that enable rigorous, comprehensive safety analysis and assessment of functionally integrated distributed systems interacting through various structures such as communication networks and human-automation and human-human interaction, as described in (5.3).

Proposals that include cutting-edge high-risk investigations are encouraged; however, the balance of risk versus potential gains should be discussed. A high value will be placed on openly available and re-usable models and verification approaches applicable to a broad spectrum of distributed flight-critical systems V&V challenges related to integrated distributed systems. Also of interest are publically available design artifacts illustrating particularly difficult aviation V&V problems suitable for demonstrating and validating novel V&V techniques.

(5.7) Deliverables

Proposals shall identify any and all tangible research products such as all models, methods and procedures, case studies and supporting evidence developed during this effort that shall be delivered. In addition, the award recipients shall deliver the following:

- Documentation of repeatable test and experimental validation capabilities
- Interim Report(s) to NASA as a published report or presentation that contains a description of the specific research topic addressed, a review of relevant literature, and description of research approach, including suggested improvements to research approach as identified in the course of the research to date
- Final Report, to be published as a NASA CR (Contractor Report), that contains a description of the specific research topic addressed, a review of relevant literature, repeatable description of the research approach, and detailing of the results, methods and tools developed, and insights into V & V approaches
- A paper suitable for journal submission assessing the research contributions to rigorous, comprehensive analysis of functionally integrated distributed systems as described in 2.5.3 and identification of relevant open issues
- Written assessment of open issues relevant to the research topic and further research required to address them

(5.8) Duration And Expected Funding

NASA anticipates awarding two or three contracts or cooperative research agreements for this topic that addresses the objectives and specific approaches described in (5.3) and (5.4). The awards, in the $250-300K per year range, will be made for a three-year proposal. An annual review will be conducted each year. The decision whether to continue at the end of each year will be based on:

- NASA's judgment of the progress made during the year relative to quantifiable metrics defined in the proposal and agreed to by the NASA Technical Monitor at the onset of the agreement.
- NASA's judgment of the impact the findings will have on the goals of the AFCS effort.

- The availability of resources to support the proposed work for the second and third years.

Proposals shall include a schedule with milestones that support the evaluation of progress and highlight the achievement of goals. Decision points are acceptable as milestones.

(5.9) Potential NASA Resources

See section 6, NASA Facilities, below.

(6) Subtopic Number: AFCS-1.6

(6.1) Subtopic Name: Authority and Autonomy: Safety Analysis of Multiple Human-System Interactions in the NAS

(6.2) Description

The National Airspace System (NAS) can be viewed as a large complex system in which humans and automated systems interact to perform a safe air transport service, mostly the transportation of passengers and goods across the US. As it stands, the NAS is quite safe and we do not suffer from frequent catastrophic accidents. Yet, the air traffic density is expected to increase over the next 20 years. The NextGen program [8, 16] is seeking to address this increase in traffic while maintaining (and possibly improving) the NAS safety record by introducing more automation. The roles and responsibilities of humans and automation will change in NextGen and potentially introduce unforeseen safety issues. Moreover, soon, UAS will be sharing the NAS with the rest of commercial aviation and modifying further the interactions between human agents and automated agents. Therefore, it becomes critical to have techniques that can take into account the stochastic nature of the NAS and analyze how roles and responsibilities change in NextGen and what the impact on safety might be.

(6.3) Objectives

NASA is seeking proposals that deliver analytical capabilities to assess safety issues due to the interaction of humans and automation over large sections (at least three sectors and three major airports, multiple flight crews, multiple controllers) of the NAS. At this time, NASA is specifically seeking techniques that can handle the stochastic and complex nature of many elements (including automated systems, humans, environment conditions) in the NAS, especially the unpredictable nature of human responses and the safety aspects involved in trying to "game the system". Current human factor studies often assume a nominal, expert human subject and are not always capable of accounting for diversity in human responses. NASA is seeking analysis techniques that complement traditional human factor studies by addressing off-nominal conditions and coping with variability.