



NASA STTR 2011 Phase I Solicitation

T8.02 Autonomous Systems for Atmospheric Flight and Remote Sensing

Lead Center: LaRC

Increasing levels of automation capabilities in the aviation arena, provides unique opportunities and challenges for civil aviation, and the aerial transport communities. Flight will be transformed as these capabilities mature and evolve in to integrated systems. In particular, autonomous and robotic, manned and unmanned civil aircraft systems will lead to a plethora of new markets, vehicle, and missions. These new systems with broad range of capabilities, and a huge diversity of shapes and sizes, must safely utilize the future National Airspace System. Both operational and machine autonomy will require tremendous breakthroughs through the new technology frontiers in machine intelligence, autonomy, robotics, and inter-connections of these technologies. Breakthroughs in these areas could lead to such societal capabilities as autonomous cargo carrying, surveillance, air taxis, small unmanned civil aircraft, Zip aircraft, on-demand VTOL aviation, airborne wind energy platforms and a host of other emerging distributed aviation systems. For purposes of this solicitation, autonomous vehicles have varying levels of autonomy that range from automated capability to fully autonomous flight where the system has the ability to learn, reason, and adapt. Military applications have demonstrated the ability to do automated flight but their use in civil aviation requires additional research and development. The primary interest of this sub-topic is to advance the technologies for robotic and autonomous vehicle perception, cognition, as well as system integration. Proposals should be written around one of the following themes described below:

- Autonomous and robotic air-vehicles can enable new markets reduce operational cost, and improve safety. Autonomous systems can be applied far beyond remotely piloted aircraft. Maximum machine effectiveness can only be realized through vehicle autonomous systems ability to learn, reason and adapt. Current practice is to have a reliance on stored information, which is complemented by GPS position information. If there is an on-board, real-time means to sense and react to the local environment (including air and ground features and traffic), then autonomous and robotic air-vehicle can be fully utilized. But addressing how adaptive systems can still be 'trusted' in critical flight environments and achieve FAA certification is a technical issue that must be resolved. Proposals are sought to develop innovate approaches and enabling technologies for autonomous, robotic, and embodied intelligent air-vehicles. Example scenarios could include but are not limited to carrying passengers and cargo through the NAS, search, rescue, and surveillance operations, and sentries to patrol coastal waters, and land borders. Proposal should consider perception, cognition, as well as GPS enabled, GPS-denied, and cooperating and non-cooperating traffic environments.
- There are a broad range of technical subjects relevant to these new aviation markets and highly diverse aircraft operations include Machine and Operational Autonomy, Off-Nominal Autonomy, Future Consensus and Statistically Based Regulatory Processes, Safety Assurance, Software Certification, Electric and

Redundant Propulsion Systems, Airspace Separation Assurance and Detection, Peer-to-Peer Deconfliction, Wireless Sensor Networks for Smart Aircraft Sub-Systems, Fault Tolerant Systems, and Multi-Spectral Sensing and Data Fusion. Proposals are also sought in the integration of these technologies in combination to achieve new societal capabilities across specific aircraft configurations. Therefore, emergent vehicle autonomy platforms that can showcase capabilities that were previously unable to be performed (without autonomy). One example would be the ability to follow complex flight paths such as dynamic soaring, where autonomy enables an entirely new ability through both predictive and optimal trajectory planning and execution. Likewise extreme Short and Vertical Takeoff and Landing aircraft have key gust response sensitivities that could be greatly enhanced through degrees of autonomy within the control loop to achieve much faster response, and therefore new flight capabilities. Of particular interest is the ability to showcase how spiral development and rapid experimentation in aerial robotics can provide early lessons learned and guidance for future larger-scale technology investment. Such efforts could leverage the ability of dynamically-scaled sub-scaled vehicle testing to push very low high risk technology readiness levels to higher levels that more easily justify research investment.

- Autonomous Remote Sensing Measurement Technologies required to support Advanced Flight Testing, Earth Science, and Intelligence, Surveillance and Reconnaissance (ISR) Applications. NASA's HYTHIRM project (AIAA-2010-241) has demonstrated an emerging capability to obtain quantitative global thermal surface temperatures associated with a hypersonic vehicle in flight. The available technology adequately measured the acreage surface temperature of the Shuttle lower surface during reentry. Future hypersonic cruise vehicles or advanced launcher configurations will challenge affordable human-in-the-loop remote imaging capability in terms of high speed tracking, spatial/spectral resolution and temperature sensitivity. A next generation system would entail a "smart payload" with a UAS optimally designed around it. The payload would ultimately permit autonomous long range target acquisition, tracking, image stabilization and enhancement, real-time sensor re-configuration and aircraft attitude/orientation to optimize the data collect thus significantly increasing mission flexibility while reducing operational costs. Phase I proposal should include an assessment of current imaging technology capabilities for spatially resolved thermal imagery along with requirements for a next generation autonomously controlled sensor/platform system. Proposals should consider Identification of technology gaps and lay out of a technology development roadmap. Software and hardware demonstrations are encouraged. Integration and autonomous control of the following technologies include: system simulation software; advanced high resolution focal plane array development including multi-color focal plane arrays; large apertures; miniaturization of high frame rate multi-waveband (i.e., visible, NIR, SWIR, MWIR, LWIR) including spectral/hyperspectral sensors; advanced radiometric simulation software; real time imaging processing and post processing deconvolution algorithms; adaptive optics; target recognition and low latency tracking algorithms; active feedback for platform command and control functions and local navigation and communication. Subsequent activities would include component and system developments in accordance with the roadmap, leading to the development of a prototype system capable of integrating with a UAS.