Hydrogen is the most likely fuel to enable future zero emissions aircraft and High Altitude Long Endurance Remotely Operated Aircraft (HALE ROA). Due to the increased volume required for hydrogen systems as compared to current hydrocarbon fueled aircraft, key technologies are required to reduce feed system weight while maximizing propellant storage efficiency. To be a viable technology for future aircraft systems, hydrogen feed components most likely will require life cycles approaching 10,000+ with an expectation of 20+ years in service, a significant difference from current state-of-the-art for space flight systems. For HALE ROA systems, vehicle mass must be kept low enough for flights up to altitudes exceeding 60,000 ft. Insulation systems must be lightweight and designed for minimum maintenance. Hydrogen storage and feed systems can be either cryogenic or gaseous depending upon the vehicle configuration. Tank mass fraction requirements (mass of storage system/mass of hydrogen) for liquid hydrogen on the order of 15% are expected to meet mission requirements. Hydrogen tank systems applications will be expected to provide storage for flight vehicles for up to 14 days duration with cryogenic systems and 6 months for aircraft with gaseous hydrogen. System safety is a critical factor in the design and development of any hydrogen system. To ensure public safety it is important that highly-sensitive, low-power-use sensors and instrumentation are developed to identify and diagnose potential problems with the hydrogen systems. Technology focus areas will include storage, distribution, and propellant conditions. Innovations are solicited in the following areas:

Storage and Distribution Components

- Lightweight, low thermal conductivity on-board cryogenic storage tanks, feed lines, valves, and relief devices;
- Lightweight, low thermal conductivity insulation for tanks and feed lines that requires minimal inspection and maintenance;
- Lightweight, low permeable gaseous hydrogen storage tanks and feed lines; and
- Low power, high-sensitivity sensors for hydrogen leak detection and condition monitoring.

Propellant Conditioning Components and Technologies
• Innovative methods to reduce the volume of stored hydrogen while minimizing system weight;

• Technologies for the reformation of hydrocarbon based fuels to hydrogen;

• **Advanced technologies to minimize losses during loading and unloading of hydrogen, including autonomous operations, tank transfers, delivery to propulsion system, venting, and/or hydrogen recovery;**

• **Advanced technologies to minimize hydrogen losses and reduce energy requirements for system pre-chill, delivery to propulsion system, venting and/or hydrogen recovery, and long duration temperature.**

Proposals must show improvements to the state-of-the-art and viable application to aircraft.