The following is the final report out of NASA's October 2010 Aviation Unleashed Conference in Hampton, Virginia, as compiled by NASA's leadership team:

Aviation Unleashed Day 3 Feedback

On day three of the conference the participants were assigned to five breakout groups. Approximately 50 participants remained for the breakout sessions representing a broad cross section of the organizations attending (industry, academia, and entrepreneurs). The groups were sampled early in their deliberations and found to contain 32 non-NASA participants and 11 NASA employees, with two of the teams containing only one NASA employee. This count was taken to ensure the feedback represented external opinions and does not necessarily represent the actual number of participants as additional individuals joined as the day progressed. Each group considered the same three questions:

Given what you have heard the past two days and your own insights address the following three questions:

1. Role of Aviation: What do you think the role of aviation will be in the farterm (several decades)? Consider the civil/defense/security uses.

2. Vehicles and Missions: What will the vehicles and missions be in this time frame and what needs to be done to get there (technology, operating concepts, national policy or regulatory changes, collaboration)? What are the most important technologies or system developments?

3. System Architecture: What should the system architecture accomplish, or how should it change, to enable these vehicles and missions? The system being the air traffic management system, ground infrastructure, information technology and networks, CNS, and the domain of technologies and operating concepts in which vehicles perform their missions.

The feedback painted a vision of a wide variety of vehicles and missions, significant increases in autonomy, and architectures that accommodate this diversity of uses. In a general sense the feedback suggested that the role of aviation will compete with advanced communication services (virtual reality), and autos. The role of aviation can either be legacy incremental progression, or embrace new world exponential growth. One team considered that Europe developed with transportation technologies of 1000 years ago (walking, horse) resulting in being centralized. The U.S. developed 100 years ago (train, auto) resulting in increased distribution. India, China, Africa will develop with the technology of today, resulting in massive distribution that promotes their ability to compete. Our legacy infrastructure will be an economic drag, instead of an enabler (promoting higher cost with less flexibility). The future aviation markets have the potential to overcome existing societal inertias that will otherwise constrain economic development. The teams also provided feedback suggesting that different policy and regulatory concepts are needed to enable the vision, to enable the "disruptive innovation", and to encourage innovation across missions/vehicles and facilitate the entire value network collaboration.

Q1: Role of Aviation

The feedback to the question of aviation's role contained both attributes and specific

uses of aviation.
Multiple teams suggested significant increases in autonomy and distribution of services; increased on-demand, point-to-point, and door-to-door. Additionally the teams suggested increased and novel uses in security, law enforcement, emergency services, power generation, and provision of sensor and communication networks. The existing roles of aviation will continue (long haul, business, recreational, disaster relief). Aviation will be key to globalization and societal integration and understanding. Significant increases in autonomy will enable new vehicles and missions, and passenger-carrying unpiloted vehicles will be accepted. One team asked when, 5 years or 50 years from now, people will say, "I do not want to be on a plane driven by a human." Intra-city transportation to avoid ground congestion will become possible.
Enablers to these roles include autonomy and energetics; electric or other propulsion for some aircraft. Constraints include energy consumption, access to resources, environmental emissions, security and safety concerns, individual wealth, and regulatory environment.
Specific uses included:
- **Transportation:** Regional/cross-country and international solutions for people movement, realization that people travel (not cattle) to a destination (not an airport). Enable personal mobility, aged and infirm mobility, lifestyle flexibility (live wherever). Ubiquitous transportation of cargo & material goods; rapid, point-to-point, delivery of ALL things (people, goods, etc).
- **Package and Freight Delivery:** Prescription drug delivery (Hummingbird UAV), Amazon (Carrier pigeons), automated delivery.
- **Emergency and Security Services:** Firefighter (Canary UAV), Lifeguard (Pelican rescue UAV), Police (Bumblebee UAV to sting/incapacitate criminals), Airport bird protection (Hawk UAV), Border roaming security (Raven UAV). Search and rescue.
- **Information Gathering, Monitoring and Agile Sensor Networks:** massively distributed solutions (bird-like myriad of operations and diversity), swarming information services with automatic collection and redistribution (i.e. meso-scale weather). Traffic reporting and infrastructure inspection. In-situ observance and action for science, infrastructure, resource management. Communications networks.
- **Homeland Security and Military Use:** On-demand aerial satellites (high and low altitude) with omni-present capabilities.
- **Industrial and Agricultural Aerial Robotics:** Tends/manages crops, animal management, industrial services, etc. Power generation, tethered windmills.

- **Regional Geographical solutions:** Countries choose how to use this new capability (inhibit or maximize freedom).
- **Recreation:** Exploring the world, thrill seeking, experiencing new cultures.
- **Exploration:** Oceans and other planets.

Q2: Vehicles and Missions

Feedback was provided on both the general attributes of future vehicles and specific

suggestions.
The participants suggested that future vehicles would be more autonomous, more affordable, quiet, lower emissions, safer, and consist of a mixed fleet of legacy aircraft types and entirely new types. Some would be simple to use (ala your car) to autonomous. There will be increases in infrastructure-less aircraft (Quiet Close Proximity VTOL), a merging of automotive & aviation technologies (drag reduction, propulsion systems), and a blurring of lines between aviation & automotive & trucking industries (at the low end, PAV; at the high-end, unmanned freight w/common containers). Advances in energetics, electric propulsion, automation and autonomy, and materials will enable new types of vehicles.
Specific vehicle types suggested:
• Extrapolation of Existing Infrastructure Aircraft (High efficiency subsonic transports, long haul transports, unpiloted cargo aircraft)
• Infrastructure-less Aircraft (Quiet Close Proximity VTOL)
• Climate Observation and Correction Aircraft
• Energy Generation Aircraft, airborne windmills
• Satellite Replacement Aircraft
• ExoPlanetary Exploration Aircraft
• A niche for PAV’s, Air Taxi’s
• Single person vehicles/General Aviation
• Hybrid lift bus
• “Flying soldier”
• UAV’s (The next 30 years belongs to UAV’s)
• Hummingbird or Carrier Pigeon UAVs for automated delivery of small packages
• Canary UAV for firefighters
• Pelican rescue UAV for lifeguard
• Bumblebee UAV to sting/incapacitate criminals
• Hawk UAV for airport bird protection
The technology advances foreseen to enable these aircraft include:
• **Energetics Coupled to Propulsion Systems:** Energy storage, batteries, distributed generation, energy beaming. Availability of energy.
• **Autonomy and Machine Intelligence:** Self diagnostic, self maintenance, reliable, off nominal intelligence, software V&V, vehicle health monitoring (perhaps even self healing) including software and avionics
• **Human machine interface**

• **Sensors:** Micronized, distributed, pervasive ability to touch, taste, sense, see (but not feel)
• **Robotics:** System level integration of autonomy, sensors, and other disciplines to perform functional capabilities
• **Bio Inspired Processes:** Fabrication, Diagnostics, Operations, Actuation, Maintenance, Sensing
• **Position Location Determination:** (beyond GPS) , Guidance & Navigation
• **Materials and Structures, Aerodynamics**
• **ATC/ATM:** Policy, ease of use, autonomous separation, airspace phase

management, traffic physics, formation or swarming flight.
• **Cyber Security/Secure Com**
• **Noise alleviation**
Technology alone was reported as not sufficient for the changes needed. The feedback suggested a business model or models are needed to make anything happen. Regulatory and cultural issues must be addressed (The question, when will people will say, "I do not want to be on a plane driven by a human."), and a strategy for international collaboration is required.
The team feedback for missions was similar to the responses to the question of aviation's role. Missions included:
• Metroplex-multi-modal ground transportation congestion alleviation 3D vs. 2D
• Long haul and short haul civil transport
• Intra-Urban
• Security, national defense, emergency responders, evacuation, search & rescue
• Surveillance/data relay
• Aerial application
• Training and Recreation
• Sensing

Q3: System Architecture
Feedback on architectures included attributes of the environment that aviation will operate in as well as transition paths. Key to the architectures is the need to accommodate a wide variety of operations, not all of which are known today, selfmodernizing,
and massively distributed, networked, and scaleable in nature.
Characteristics
• Architecture should be designed to enable/accommodate widest range of operations
• Fosters mission innovation & vehicles & new capabilities
• Distributed with local control (less control towers and centralized oversight)
• Decentralized control
• Independence of actions with coordination with other vehicles
• Ad-hoc adaptive network with assured connections and peer-to-peer negotiation
• Meshed network, reliable navigation, high bandwidth communications
• Development of Skyways
• Highly distributed ground infrastructure, more places to takeoff and land
• Point-to-point
• Secure (able to limit flight paths)
• Each vehicle a "network node" providing info to other nodes and selforganizing based on the collection of individual needs.
• Adaptive to mission risk & safety needs without degrading other elements of the system
• Hierarchal collaborative network or "HCN Internet"

• Global airborne sensor grid
• Self modernizing – feedback driven, Plug & Play

Requirements

• Scalable
• Regulatory coordination (with a progressive stance)
• Fail safe (continuity of operations), Self monitored/ self healing
• Robust to local failure
• Virtuous economic cycle (applies to the masses)
• Environmental compatibility (do no harm, sustainable to the planet)
• Secure, robust operations against all threats
• Take advantage of the web for aero information (airborne wireless networks, Web vs. SWIM)

Transition Path for System Development

• Viable transition strategies needed

• Overlay new aviation layers unto capabilities existing to 'do no harm to existing aviation customers'
• Coexistence is essential with long-haul aviation market
• All disruptive innovations involve a progression from lesser capability (than existing products) to greater capability products
• New aviation S-curve will start with early adopters, with progression almost certainly occurring in less regulated environments
• Evolving towards autonomous ops & ATC
• Need process to allow new/changed ground infrastructure
• Agencies should be more agile in adapting to new operations. Approvals are too difficult
• Interaction between distributed and centralized operations (transition issues)