Vision for a Net Centric Aviation Ecosystem

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Abstract

This document represents the company-neutral industry consensus view of the Network Centric Operations Industry Consortium ™ (NCOIC) of the elements to be considered in transformational programs leading to a netcentric aviation ecosystem. The term, "ecosystem," as characterized for netcentric aviation, will be defined in the body of this paper. The document defines six areas of benefit to be derived from a transition of the current global aviation ecosystem to one built upon the principles of netcentricity. This document represents a vision of anticipated benefits of a netcentric aviation ecosystem, with the expectation that methods and tools to accomplish these tasks will be reflected in future work of NCOIC and other organizations.

Introduction

The effectiveness of the Aviation Ecosystem can best be judged by the quality of service it provides to consumer. Each consumer has a set of expectations regarding the type and quality of service they require or expect. Business travelers desire predictability of travel, particularly minimal delays and cancellations, while recreational travelers desire greater choice and lower costs. The capabilities enabled by a network-centric ecosystem are sufficiently broad and adaptable that the increased networking effect will provide more timely and relevant information for participants to make better decisions. As the market requirements evolve, and expectations for service change, the network-centric ecosystem will be able to evolve and adapt to these new requirements. In addition to the aviation ecosystem providers, the traditional triad of Flight Deck, Air Traffic Service Providers, and Airline Operations Centers, as shown in Figure 1, aviation stakeholders also include the external consumers/users such as:

Business and pleasure commercial airline travelers
Business and pleasure private aircraft travelers
Cargo shippers
Commercial space travelers
Departments or Ministries of Defense
Disaster management and emergency response authorities
General Aviation and recreational users
Government authorities

Operators of Unmanned Aerial Vehicles
Scientific users
Security Personnel

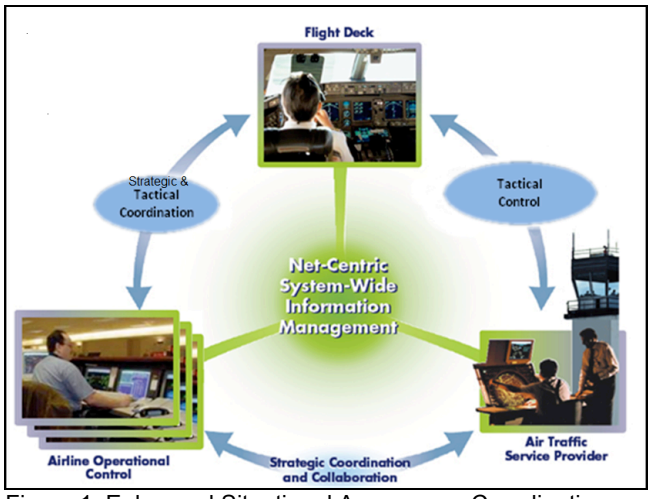

Figure 1. Enhanced Situational Awareness, Coordination, and Information Distribution
(Courtesy of NASA Ames Research Center Virtual Airspace Modeling and Simulation Project)

Another important measure of the effectiveness of the Aviation Ecosystem is the extent to which it impacts the larger community, through phenomenon such as energy consumption, noise and emission pollution or safety risk. A shift of the Aviation Ecosystem toward net centricity will provide benefits to these constituents and environmental situations through improvements in the areas of Capacity, Safety, Efficiency, Agility, Security and Sustainability.

We use the term "Ecosystem" in relation to net-enabled systems (including personnel, platforms, equipment, hardware & software, and system-of-systems) to also describe the environment in which the systems reside, and the interaction between the systems and their environment.

When describing the ecosystem, we will examine the technology and the physical environment, as well as the institutions, people and processes that work with the technologies, as well as the social and cultural environment that promotes or constrains the use of technology.

When we speak of an ecosystem, we use the analogy of a biological system to recognize the interaction of technology, institutions, people, processes, and culture in the design, operation, and use of net-enabled systems.

The nature of such interaction in an ecosystem can be cooperative to achieve common goals, can be competitive for access to (or control of) scarce resources,

can be relatively static or evolutionary or incremental or even revolutionary over time, or any dynamic combination of the above.

This initial version of our vision for Net Centric aviation is intentionally focused on benefits to consumers/users within the ecosystem. Later iterations will address the benefits to providers of air navigation and other services, and include additional complexities.

Capacity

Capacity in the current global airspace is constrained by a number of factors, including:

- the current need for defined air navigation lanes, governed by terrestrial navigation equipment
- the parceling of airspace into restricted use such as military and government Special Use Airspace
- the restriction of most high speed aviation traffic to high altitudes
- restrictions due to terrain and obstacles
- restrictions on airspace use based on regulations by governments.

Although many of these problems appear to be intrinsic to global aviation, the reality is that some of these factors can be mitigated, and other symptoms of over-crowding caused by these factors can be mitigated through application of network centric operations.

A net centric aviation ecosystem provides for flexibility to quickly introduce new elements into the tool suite of the modern Air Traffic Manager. Today's air traffic automation systems are not adept at quickly incorporating such Decision Support Tools (DST). It is this flexibility of design and operation that is one of the greatest benefits of net-centricity. This flexibility, combined with data availability to authorized, non-traditional users, will allow for a new generation of never-before-conceived DST's to be introduced into the Capacity discussion.

Key to DSTs is timely accurate and relevant information. A net centric ecosystem is focused on enabling relevant information sharing, which supports the various roles of the aviation system participants, thus improving the ability of all participants to increase the effectiveness of air traffic management decisions. Information sharing requires robust, flexible information access and technical update capability across organizations and systems which support coordinated air traffic management operations.

The high-altitude airway structure for jet aircraft is crowded today, but ground- and air-based automation tools could allow for reduced spacing, or routine direct routing, thereby making more airspace available for increased traffic. Using net enabled DSTs, which improve speed and flexibility to schedule and release restricted

airspace, would allow auxiliary corridors to be used by flights in times of over-crowding, as was done during the holiday period of 2007 in the Eastern United States.

The airspace around congested airports requires operations to be sustained at maximum capacity during many hours of the day. Avoiding disruptions is top priority for schedule maintenance. Netcentric operations provides seamless information sharing to facilitate continuous operations between surface, oceanic, terminal, enroute, and strategic flow management domains, while taking into account the composite effect of air- and landside constraints. An additional concern is the throughput of individual congested airports in low visibility (i.e. IMC) conditions. The ability to rapidly federate multiple sensors in order to improve operations under severe circumstances, or unplanned situations, represents another key attribute of a net-centric aviation eco-system.

Safety

Safety is the most important requirement for an Aviation Ecosystem. An ecosystem that is not safe for passengers, operators and the surrounding public is unacceptable regardless of other factors. Safety is a measurable aspect of an Aviation Ecosystem, and reasonable increases in levels of safety will be expected year after year.

Safety must be maintained while the Agility and Capacity of the Aviation Ecosystem is increased to support economic growth. It is often assumed that increasing aviation Agility or Capacity decreases Safety. It is expected that evolving to a net centric ecosystem may change the interdependency between the underlying factors that currently result in an opposing relationship between Safety and Capacity, thereby allowing Agility and Capacity to increase while maintaining, or increasing, Safety.

The netcentric principle of “the right information delivered to the right people at the right time” provides for the overall Capacity of the Aviation Ecosystem to be increased safely. Decision makers will have more timely, and better, information about the changes that may be required to achieve desired effects. The changes may be implemented more rapidly, as standards will have been normalized and architectures will be designed to support change.

Net Enabled Weather, Comprehensive, Integrated Surveillance, 4D Trajectories and Destination-based Routing can increase capacity and help aircraft avoid each other and aviod dangerous conditions. Overall safety can also be increased for traffic flying across national or agency maintained airspace boundaries through integration of systems and standards.

Efficiency

Efficiency is an important characteristic of the global air transport system, and is the result of the people, processes, systems, and economics that constitute it.
In order to improve Efficiency, all the systems of the Aviation Ecosystems need to be considered. Only through a net enabled view it can be assured that all system- and sub-system interdependencies are treated according to the Efficiency performance requirements which have been established.

Efficiency of the Aviation Ecosystem is an integral part of the ICAO Key Performance Areas, in which their targets are formulated. Global homogeneous and non-discriminatory air traffic flows are improved as Efficiency improves. Design targets for an Aviation Ecosystem exhibiting Efficiency include the on-time departure and arrival punctuality, flight duration efficiency or gate-to-gate fuel efficiency. Net enabled collaborative decision making by all stakeholders, including airports, is the key for an efficient air transport management. Collaborative decision making is, and will be, a key capability for the current and for the future Aviation Ecosystem.

Net centricity supports higher efficiency by providing this collaborative decision making capability to all stakeholders. This will be enabled through the ease and timely access to the information required to plan, operate, and maintain the Aviation Ecosystem. A net centric Aviation Ecosystem will enable the efficient use of resources and – through interoperability and a service-oriented design – will make the Aviation Ecosystem of the future more flexible, robust, safe, secure and cost-efficient.

Security

Security can be enhanced in a net centric environment by matching the right information to the right information assurance controls. National Security, Border Security and Public Safety and Security, via a common airspace operating picture, can have the information required to make faster decisions from information on current weather conditions, location of aircraft, locations of threats and status of resources. In order to realize these business benefits, Confidentiality, Integrity, Availability, Non-repudiation and Authentication must become more robust than in current operations.

Information System Security protects the systems that make up the Aviation Ecosystem, as well as the information contained in those systems, from a wide variety of threats. Information System Security must be considered in conjunction with information sharing to provide precision and protection to information consumers in a networked environment. Security protects the aviation critical-infrastructure and enables commerce in a global aviation community. Security and information sharing are critical to the success of NextGen and SESAR. Security key design features are:

- **Confidentiality:** the assurance that aviation information is not disclosed to unauthorized persons, processes, or devices. It includes both the

protection of operational aviation information and the Information Assurance of password or configuration files.

- **Integrity:** assures that aviation information is not modified by unauthorized parties or through unauthorized processes Integrity supports the assurance that aviation information is not accidentally or maliciously manipulated, altered, or corrupted. Integrity also means that there detection occurs when information has been altered, and identifies the alteration source.
- **Availability:** assures timely, reliable access to aviation data and information systems by authorized users. Availability controls protect against degraded capabilities and denial of service conditions. A key tenant of NextGen is to provide the most current information to decision makers, requiring highly available systems.
- **Non-repudiation:** assurance that the data sender is provided with proof of delivery, and the recipient is provided with proof of the sender's identity, assuring that sender and receiver processing of the data.
- **Authentication:** assurance of the identity of message senders and receivers. Authentication supports the validation of messages and information system requests.

The net centric security capability protects, detects, and responds to cyber attacks against the aviation system information technology (IT) assets. Protection is provided by stopping cyber attacks that originate from outside the aviation system, and by guarding critical interior aviation systems from insider attacks, accidental or malicious. Protection is achieved by authenticating critical data sources, providing information integrity, and ensuring confidentiality when needed. The net centric security detection capability continuously monitors aviation IT for symptoms of malware and anomalous behavior and alerts network security operations personnel when a cyber incident is detected. The net centric cyber incident response capability provides both a real-time response for cyber attack situations and planned preventative measures to proactively and automatically scan and patch IT vulnerabilities before they become a problem. Net centric security will enable the aviation system to function while under the constant threat of cyber attack and even during an actual cyber attack, relying on the holistic net centric approach of protection, detection, and response.

Effective national security, border security and public safety and security require a netcentric Aviation Ecosystem. In a netcentric Aviation Ecosystem, these forces have the information they need to develop a common operating picture across agencies and national borders.

Agility

Agility is the ability to quickly respond to changing conditions or unexpected events. Agility is particularly important to an Aviation Ecosystem as a critical capability enabling adaptation to changing world economies and unexpected events. Agility in the Aviation Ecosystem is inherently challenging due to the

broad range of partners involved across public and private sectors, and international boundaries. Collaboration and coordination are the hallmarks of network centric operations, and the netcentric aviation ecosystem requires the capacity to support dynamic changes in coordinated operations. In addition, the highest levels of safety must be maintained during any changes to the ecosystem.

In an Aviation Ecosystem that is agile, decision makers have the right information at the right time. They have the ability to consult with appropriate experts and collaborate with a broad range of stake holders. Once decisions are made, the information must be distributed, and in many cases, action coordinated by multiple organizations. Decisions and resulting actions must be assessed and revised in real time as events unfold.

Examples of unexpected events that require Aviation Ecosystem agility are:

- Natural Disasters, such as Hurricane Katrina in the Gulf of Mexico or the 2005 Banda Aceh Tsunami in the Indian Ocean
- Security events, such as the 2001 World Trade Centers attacks
- Economic changes such as the rapid rise in fuel costs, or labor unrest
- A pandemic requiring sever restrictions on travel, such as the SARS epidemic in Asia.
- A future announcement of a widespread safety defect in a common airframe
- Airport response to unexpected changes in demand and capacity.

The JPDO Net Enabled Operations (NEO) Spiral 1 Demonstration is a case study of the effectiveness of net centricity in creating an agile Aviation Ecosystem. The NEO demo assumes that all necessary information and tools are available to decision makers at the right time, regardless of the source agency or company. The demonstration explores how the Aviation Ecosystem can respond to unexpected events, such as a hurricane. The demonstration clearly shows how decisions can be made more accurately, actions executed more quickly and with better coordination. The result is that consumers dependent on aviation receive better more effective service. This often means an outcome that saves additional lives, relieves more suffering or reduces economic loss.

Sustainability (Environmental concerns)

Environmental sustainability is becoming an increasing factor in the economic equation of the aviation industry, with fuel as the airline industry's largest cost. US Environmental Protection Agency estimates that aviation currently accounts for less than 1 percent of local air pollution nationwide and about 2.7 percent of U.S. greenhouse gas emissions (US GAO Report Aviation and the Environment,

May 2008), but these are expected to grow as air traffic increases. The environmental and economic impacts can be offset through more efficient air traffic management technologies and procedures, and more fuel-efficient and quieter aircraft engines.

The implementation of technologies such as satellite-based navigation and collaborative decision making through net enabled information exchange can reduce the carbon and noise footprint of the Aviation Ecosystem. For the airline industry, a network centric approach to flight planning and execution will enable carriers to differentiate themselves, and compete for not only lower fares, but lower emissions. An example of this can be found in the industries' acceptance for the need of noise reduction. A net centric approach can benefit the aviation industry in a number of ways, including:

- A more coordinated approach to engine start and gate release, achieved by synchronizing gate handling and tarmac control, reducing engine run time
- Considering emission standards, along with safety in making congestion control decisions on whether to hold, and at what altitudes
- Enabling advanced arrivals, through mixed use airspace, allowing aircraft to remain at cruise altitudes longer as they approach the destination airport, use lower power levels, and therefore reduce emissions and noise during landings
- Direct routes enable flights to calculate the most fuel efficient route and coordinate with other traffic to optimize airspace while in transit
- Dynamic Special Use Airspace collaboration between civilian ATM, airlines, and military operations, enable more efficient use of airspace, reduce delays, and generate fuel savings.

These environmental concerns will require operational trade-offs to ensure an optimum balance between the social and economic benefits and environmental effects realized. A growing environmental awareness and improving collaborative work among all stakeholders and countries is a prerequisite to meet this global challenge.

Business Benefit Interdependencies:

The interdependencies within the ecosystem are complex, and at times difficult to identify or control. The business benefits derived from employing the principles of net centric operations in global aviation are interdependent, but not locked into a fixed relationship of traditional trade-offs. A shift in paradigm towards net centricity provides for gain in some benefits without loss of benefit in other areas, including:

- Affordability vs. Capacity: Often, additional infrastructure is needed to increase capacity, which in turn, has a negative impact on affordability
- Financial Cost-effectiveness vs. Efficiency, Agility and Predictability: the need to reduce the cost of providing ATM capacity may have to be balanced against the need to limit the cost of delay due to capacity shortages
- Efficiency vs. Environment: Aircraft will need to adjust thrust levels to meet required time-of-arrival in order to optimize system efficiency, and therefore will increase gaseous emissions
- Capacity vs. Efficiency: the objective of providing flight trajectories closer to preferred user Business Trajectories may have to be balanced against the objective of increasing overall system capacity.

Conclusions

From a consumer perspective, Capacity, Safety, Efficiency, Agility, Security, and Sustainability are improved and enhanced through the adoption of a net centric aviation ecosystem. Net centricity will provide flexibility to introduce new data and capabilities into the current structure, enabling dynamic change and improved decision making.

Net centric operations provide seamless information sharing between surface, terminal, enroute, and strategic flow management domains, thus improving operational throughput. Improved flexibility for better situational awareness, analysis and decision making result. NCO further provides for "the right information delivered to the right people at the right time," maintaining the integrity, privacy and accuracy of the information. The integration of systems and standards will increase safety for traffic across national or agency maintained airspace boundaries.

Security can be enhanced in a net centric environment by matching the right information to the right information assurance controls. Confidentiality, Integrity, Availability, Non-repudiation and Authentication become more robust than in the current operations.

Agility is clearly improved in a net centric environment. Decisions can be made more accurately and faster when the data is quickly available to the authorized user/decision maker. Decision makers can adjust resource allocations and disseminate information/commands in response to new or different information through existing tools and data links. Improved data flow, decision tool use, and planning in a netcentric ecosystem improve Sustainability through a more coordinated approach to resource utilization.

Of significant importance to the aviation ecosystem is the ability to provide improved benefits to the consumer in selected areas, without a reduction of

benefits in another area. A net centric ecosystem provides for business efficiencies and interdependence without requiring costly or unsatisfying tradeoffs.

Whereas the Consumer is the focus of this paper, future iterations will address broader aspects of the application of net centric operations to the aviation ecosystem, and will describe the utilization of NCOIC™ tools and best practices to achieve it.