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The Next Generation Air Transportation System's Joint Planning Environment: A Decision Support System

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Abstract

In support of Next Generation Air Transportation System (NextGen) planning efforts, the Joint Planning and Development Office (JPDO) developed a web-based decision support system, the Joint Planning Environment (JPE). The development of the JPE was in direct response to JPDO requirements for an enterprise-level information system to support informed, responsive decision making. At its core, the JPE is a relational database tying together foundational NextGen information concerning the Concept of Operations, Integrated Work Plan, Enterprise Architecture, and Portfolio Analysis. The JPE provides decision-maker support for critical aspects of NextGen, including analyses of alternatives and what-if scenarios, focused on optimizing NextGen benefits.

In addition to the discussion of the JPE, this paper includes brief descriptions of the development and focus of the NextGen foundational documents. Processes that the JPDO is using to update, integrate and align the foundational data with federal partners are also addressed.

I. Introduction

By 2025, U.S. air traffic is predicted to increase significantly compared to today's traffic levels. The traditional air traffic control system may not be able to manage this growth without increases in capacity, efficiency, and productivity. The Next Generation Air Transportation System (NextGen) is the solution. NextGen refers to a wide-ranging initiative to transform the Nation's air transportation system from the departure airport curb to the curb of the destination airport. It focuses on leveraging new technologies and real-time information sharing to improve the efficiency, safety, security and scalability of our current system and provide the ability to absorb predicted increases in air transportation demand.

Under the tenets of the VISION 100 – Century of Aviation Reauthorization Act (P.L. 108-176)[1] Congress established the requirements for an integrated plan for NextGen. Within this context, the Joint Planning and Development Office (JPDO) was established within the Federal Aviation Administration (FAA) to manage the public/private collaborative work related to NextGen. The JPDO is the central organization that coordinates the specialized efforts of the Departments of Transportation, Defense, Homeland Security, and Commerce; the FAA, National Aeronautics and Space Administration (NASA), and the White House Office of Science and Technology Policy. In addition to the Federal departments and agencies, the JPDO accesses subject matter expertise of many companies in the aerospace and related industries through the NextGen Institute.

The mission of the JPDO is to achieve the transformational goals and benefits of NextGen by identifying, facilitating and integrating the activities, commitments and contributions of partner agencies, industry, and other key stakeholders. Part of the mission involves gathering, analyzing and reporting NextGen-related planning information that describes the integration and reshaping of capabilities across all aspects of the air transportation system. This planning information comprises descriptions of NextGen concepts and capabilities, specific operational and system-

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related architecture information, as well as information describing target delivery dates and responsible organizations for NextGen capabilities and operational improvements including research, development, and policy implications. To avoid inconsistent interpretations and definitions across the NextGen stakeholder community, the JPDO required a scalable and flexible solution to provide a unified view of the NextGen enterprise and enable organizations to make informed decisions founded on consistent planning and analysis data and information.

This paper provides a summary of the approach taken by the JPDO in developing the NextGen Joint Planning Environment[2] (JPE), a decision support system that quickly extracts, integrates and normalizes disparate sets of data from various stakeholders, models, tools, and technologies to create immediate access to consistent, accurate, and reliable NextGen information. First, an overview of the NextGen environment is presented and the requirements for a decision support system are described. Next, the JPE functionality is analyzed and examples of how the JPE is being utilized are provided. Lastly, this paper provides a status of the current JPE development effort and a preview of planned/possible future functionality.

II. The Next Generation Air Transportation System

While the demand for safe, reliable, and efficient aviation services is growing, the nation's ability to successfully manage air traffic is under severe strain given the status of current capabilities and resources. NextGen represents the long-term transformation of the National Airspace System (NAS), including our national system of airports, using 21st century technologies to ensure future safety, capacity and environmental needs are met. The transformation to NextGen will be realized through careful integration and collaboration of advanced concepts by private industry and Federal partner agencies, as well as investments in research and development, emerging technologies, and enhanced operations.

NextGen focuses on leveraging innovative technologies, such as satellite-based navigation and surveillance, to create a NAS scalable enough to support a two- to three-fold increase in air vehicle operations, integrating security and national defense requirements, and ensuring that aviation remains an economically viable industry in the decades ahead. Furthermore, the vision involves a system that is flexible enough to manage variations in demand, capacity and aircraft fleet types, but also allows all communities to participate in the global marketplace, provides services tailored to individual customer needs and capabilities, and seamlessly integrates civil and military operations.

Figure 1, known as the NextGen Community Model, provides an overall operational view of the NextGen environment, including the concepts and capabilities envisioned in the 2025 timeframe. The NextGen Community Model provides a mechanism for the aviation stakeholder community to conceptually discuss the improvements needed to develop and refine the policy agenda and encourage the research needed to achieve the national and global goals for air transportation. It also presents the complexities associated with a multi-stakeholder system as multifaceted as NextGen, highlighting changes in organizational structures, strategies, policies, and business practices, including the shifts in government and private sector roles that are required to fully exploit new technological solutions.

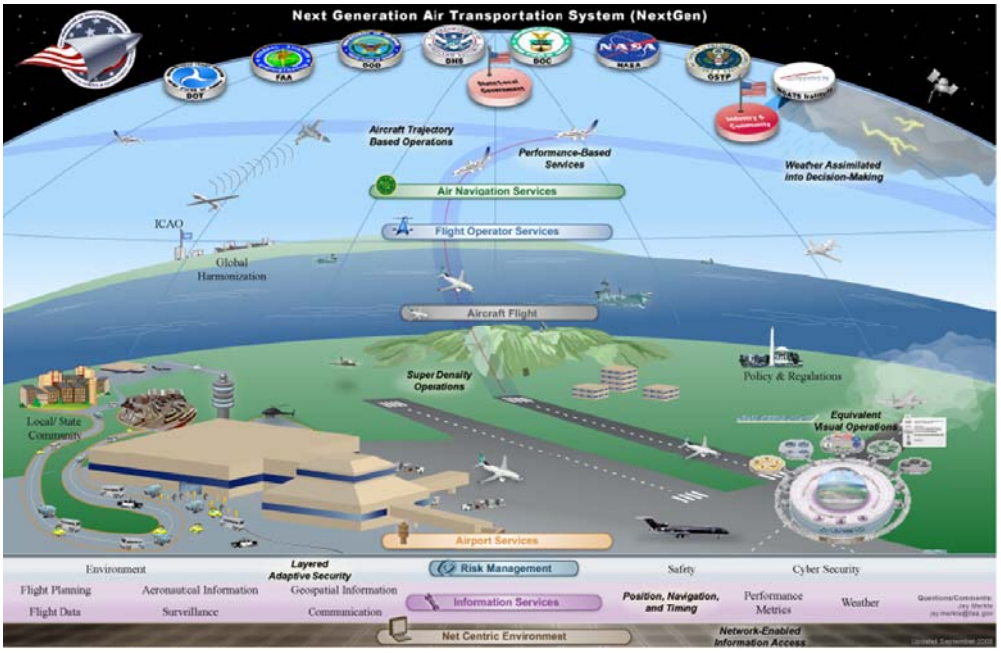

Figure 1. The NextGen Community Model.

The Community Model portrays NextGen concepts such as trajectory-based operations, performance-based services, network-enabled information access, weather assimilated into decision making, and layered, adaptive security, designed around high-level roles within the NAS. These concepts are further described through a comprehensive set of nine capabilities that represent transformational improvements achieved through various combinations of enabling solutions, such as new policies and incentives, new procedures, and advances in technology and automation. The nine NextGen capabilities are:

- **Provide Collaborative Capacity Management**: Collaborative capacity management provides the ability to dynamically balance anticipated/forecasted demand and utilization, and allocate NAS resources through proactive and collaborative strategic planning with enterprise stakeholders and automation (e.g., decision support systems, etc.), using airspace and airport design requirements, standards and configuration conditions with the consideration of other air transportation system resources.
- **Provide Collaborative Flow Contingency Management**: Flow contingency management provides optimal, synchronized, and safe strategic flow initiatives and ensures the efficient management of major flows of traffic while minimizing the impact on other operations in collaboration with enterprise stakeholders, through real or near real time resolutions informed by probabilistic decision making within established capacity management plans.
- **Provide Efficient Trajectory Management**: Efficient trajectory management provides the ability to assign trajectories that minimize the frequency and complexity of aircraft conflicts within the flow through the negotiation and adjustment of individual aircraft trajectories and/or sequences when required by resource constraints.
- **Provide Flexible Separation Management**: Flexible separation management establishes and maintains safe separation minimums from other aircraft, vehicles, protected airspace, terrain, weather, etc., by predicting conflicts and identifying resolutions (e.g., course, speed, altitude, etc.) in real time, and accommodates increasing capacity demands and traffic levels by using automation (e.g., decision support systems, etc.) while also introducing reduced separation standards.
- **Provide Integrated NextGen Information**: Integrated NextGen information provides authorized aviation stakeholders timely, accurate, and actionable information (e.g., weather, surveillance, aeronautical information, operational and planning information, position, navigation and timing information, etc.) to shorten decision cycles and improve situational awareness using a net-centric environment managed

through enterprise services that meets the information exchange requirements of the NextGen stakeholder community.

- **Provide Air Transportation Security**: Air transportation security provides the ability to identify, prioritize, and assess national defense and homeland security situations and appropriately adjust resources to facilitate the defeat of an evolving threat to critical NAS infrastructure and key resources using a layered, adaptive, and collaborative approach (e.g., appropriate tactics, techniques, procedures, etc.) without unduly limiting mobility, making unwarranted intrusions on civil liberties, and minimizing impacts to airline operations or aviation economics.
- **Provide Improved Environmental Performance**: Improved environmental performance ensures environmental management considerations, including flexibility in identifying, preventing, and proactively addressing environmental impacts, are fully integrated throughout the air transportation system decision making process, through increased collaboration and improved tools, technologies, operational policies, procedures, and practices that are consistent and compatible with national and international regulations.
- **Provide Improved Safety Operations**: Improved safety operations ensures safety considerations are fully integrated throughout the air transportation system through increased collaboration and information sharing, improved automation (e.g., decision support systems, etc.), prognostic safety risk analysis, and enhanced safety promotion and assurance techniques that are consistent and compatible with national and international regulations, standards and procedures.
- **Provide Flexible Airport Facility and Ramp Operations**: Flexible airport facility and ramp operations provides the ability to reallocate or reconfigure the airport facility and ramp assets to maintain acceptable levels of service that will accommodate increasing passenger and cargo demand levels, or changes in operational requirements, through infrastructure development, predictive analyses, and improvements to technology (e.g., automation and decision support systems, etc.) and procedures.

Many of the NextGen capabilities emphasize system flexibility, scalability, robustness and resiliency. They also stress the importance of distributed decision making, international coordination, increased user focus, and the provisioning of information to users while reducing the need for government intervention and resource control. The concepts and capabilities presented have not been validated, but are envisioned as potential initiatives to maximize the benefits and flexibility for NextGen stakeholders. They were developed iteratively and encompass five years of input and feedback from the aviation community, including hundreds of aviation professionals, engineers, subject matter experts, analysts and planners across the Federal government, industry and the public.

III. NextGen Foundational Planning Documents

To foster communication, understanding, and consensus among the NextGen stakeholder communities, the JPDO developed three foundational NextGen planning documents: the Concept of Operations[3], the Enterprise Architecture[4], and the Integrated Work Plan[5]. These documents represent a significant collection of planning information to assist NextGen stakeholders with their respective budget and capital planning efforts, and their understanding of the end state and required components (e.g., policies, systems, avionics, etc.). Many possibilities exist, and much will depend on the insights gained from the evolution of the NextGen foundational documents.

As NextGen planners iteratively reach common understandings, and as research, implementation, models, policy, budget realities, and other findings are assessed, the NextGen vision will continue to evolve and mature. Accordingly, the NextGen planning information will continue to be updated to reflect the evolution and maturation of the NextGen vision.

A. Concept of Operations

The NextGen Concept of Operations (ConOps) provides an overall, integrated view of NextGen operations in the “end-state”. The ConOps describes in prose form how the nine capabilities are envisioned to provide an integrated operational “curb-to-curb” vision of how NextGen will operate by 2025. It represents the transformations necessary to achieve the overall goals of NextGen. These transformations affect how air traffic and airports are managed, how security is provided to protect our airspace and people, how the environment is protected and enhanced, and how safety and efficiency are achieved. The ConOps forms a baseline to initiate dialogue with the aviation stakeholder community to develop the policy agenda and encourage the research to achieve national and global air transportation goals. The ConOps provides the following specific benefits:

- A clear, articulate vision for NextGen in a manner easily communicated to broad audiences;
- Identification of potential research and development activities; and,
- A discussion of implementation solutions to mature NextGen.

In many cases, the NextGen ConOps presents "aggressive" concepts that have not been validated, but are envisioned as potential initiatives to maximize benefits and flexibility for NextGen users. These concepts include: Network-Enabled Information Access; Performance-based Services; Weather Assimilated into Decision Making; Layered Adaptive Security; Trajectory-based Operations; Equivalent Visual Operations; Super Density Operations; and Position, Navigation, and Timing Services. As NextGen concepts and underlying capabilities continue to mature, research and other findings are realized, and as further dialogue refines common goals and priorities, the NextGen ConOps will be refined to reflect additional information attained.

B. Enterprise Architecture

The NextGen Enterprise Architecture (EA) represents a management tool for developing, documenting, and communicating the various near-, mid-, and far-term NextGen capabilities to achieve the concepts described in the ConOps. The NextGen EA is intended to provide consistency in defining the future operational and system environment and a common reference for NextGen stakeholders to leverage as they coordinate their respective architectures, investments, and implementation plans. The EA provides the following specific benefits:

- Describes NextGen from multiple perspectives to provide a "big picture" of the 2025 air transportation system;
- Enhances collaboration between and among the stakeholder communities by providing consistent definitions and descriptions;
- Depicts relationships and dependencies across various dimensions of NextGen (e.g., operational and system views of information and processes, etc.);
- Facilitates analyses for evaluating relationships, constraints, gaps, duplication, and opportunities for collaboration, and improvement or adjustments to stakeholder priorities and resources; and,
- Enables efficient, effective, and informed decision making within and across NextGen stakeholder communities.

The JPDO is developing and refining the NextGen EA using the Department of Defense Architecture Framework[6] (DoDAF) and the Federal Enterprise Architecture[7] (FEA) Framework. The integration of these two frameworks addresses the broad composition of the NextGen stakeholder communities and establishes a common lexicon to describe the scope of NextGen. The NextGen EA focuses on the operational aspects of the enterprise, depicting the relationships among people, operating centers, activities, and information, while providing linkages to stakeholder EAs for system-specific details needed for implementation. More specifically, the JPDO is developing an integrated architecture comprising the artifacts listed in Table 1.

View	*Product Name*	*Description*
AV-1	*Overview*	*Documents the scope, vision, context, and stakeholders for the architecture*
AV-2	*Integrated Dictionary*	*Provides definitions for all architecture elements*
OV-1	*High-Level Operational Concept*	*Provides a high-level graphical/textual description of operational concept*
OV-2	*Operational Node Connectivity Description*	*Describes the operational nodes, connectivity, and information exchange needlines between nodes*
OV-3	*Operational Information Exchange Matrix*	*Describes the information exchanged between nodes and the relevant attributes of that exchange*
OV-5	*Operational Activity Decomposition/Operational Activity Model*	*Describes the capabilities, operational activities, relationships among activities, inputs, and outputs; overlays can show cost, performing nodes, or other pertinent information*
OV-6c	*Operational Event-Trace Description*	*Describes the operational activities by tracing actions in a scenario or sequence of events*
SV-1	*Systems Interface Description*	*Identifies the system nodes, systems, and system components and their interconnections, within and between nodes*
SV-3	*System-System Matrix*	*Describes the relationships among planned and actual systems identified*
SV-4	*Systems Functionality Description*	*Describes the functions performed by systems and the system data flows among system functions*
FEA Reference Models	• *Performance Reference Model* • *Business Reference Model* • *Service Component Reference Model*	*The FEA Reference Models provide a common framework to assist agencies in better managing their information resources to improve mission performance.*

Table 1. NextGen EA Views.

The JPDO continues to further refine and evolve the NextGen EA through related and coordinated efforts including enterprise system architecture view development, segment architecture decomposition, partner agency architecture federation, and far-term operational scenario and use case development efforts. Each of these development methodologies brings together the broader community of NextGen stakeholders to facilitate detailed discussions and decomposition of the NextGen concept and future operational and system environments.

C. Integrated Work Plan

The inherent complexities of transformational change require the detailed execution of many elements in a synchronized, integrated, and systematic manner. If one considers that the ConOps and the EA taken together provide a comprehensive description of the NextGen 2025 vision, then the NextGen Integrated Work Plan (IWP) describes a transitional pathway from the present to NextGen. Accordingly, the IWP is intended to be a master planning document that depicts the collaborative stakeholder efforts that are needed to implement the NextGen vision. It is important to note that the IWP describes numerous paths to realize the expected outcomes but not the specific program steps, resources or implementation activities such as facility rollout, training, or decommissioning of systems. The detailed planning is the responsibility of the NextGen implementing partner that has accepted the element as part of their overall mission. As each planning element is validated by the NextGen partners and is aligned with agency plans, the result is a reflection of the near term priorities of each partner agency. The NextGen IWP provides the following specific benefits:

- Provides a consolidated master plan supporting the coordinating role of the JPDO;
- Supports the identification of gaps, exceptions, and collaboration opportunities between current NextGen investments and planned NextGen activities;
- Provides input to JPDO and partner agency budget development and capital planning processes to analyze expected performance, alternatives, cost and benefits; and,
- Guides the effective and efficient use of resources to achieve the goals and objectives of NextGen.

The IWP sequences the needed improvements and describes the current understanding of the research, development, program, and policy activities that are needed to achieve the NextGen capabilities. There are five basic planning element types within the IWP.

- **Operational Improvement (OI)**: OIs describe the operational changes needed to achieve the operational concepts defined in the ConOps and EA. An OI describes a specific stage in the transformation of operations and the performance improvements expected at that point in time. The improvements described in each of the OIs are needed to achieve the NextGen capabilities and each OI is mapped to only one capability.
- **Enabler (EN)**: An Enabler describes the initial realization of a specific NextGen functional component needed to support one or more OIs or other Enablers. Enablers describe both materiel components such as communication, navigation, and surveillance systems; and non-materiel components such as procedures, algorithms, and standards. The realization of these components is necessary to achieve the improvements they support. A single Enabler may support multiple Enablers or OIs.
- **Policy Issue (PI)**: Many of the OIs and Enablers require policy changes to support their realization, particularly related to interoperability, standardization, and governance. Policy Issues are intended to encourage decision-maker consideration of viable options. These options can range from further analysis and open discussion for issues that are currently not well defined or understood, to specific policy recommendations for more mature issues.
- **Development Activity (DA)**: Development activities describe the results needed from ongoing development or demonstration programs to support other NextGen planning efforts.
- **Research Activity (RA)**: Research activities describe basic or applied research programs and the results needed to support other NextGen planning efforts.

These planning elements define the core set of building blocks utilized within the IWP. The current attributes of each IWP planning element include a target initial operational or availability date, suggested stakeholders with primary and/or collateral responsibility, and the dependencies of the element with other elements in the IWP. Through the definition of dates, dependencies, and organizations, the IWP is structured to define the proposed time-based, functional and organizational relationships needed to achieve the NextGen vision. The sequencing of IWP planning elements creates a highly interdependent environment of predecessor and successor relationships. The relationships and dependencies between IWP planning elements are modeled to illustrate support towards the achievement of one or more OIs. A summary of the potential supporting relationships is provided in Table 2.

	Supporting Relationship				
IWP Element Type	**OI**	**EN**	**DA**	**RA**	**PI**
Operational Improvement (OI)	●				
Enablers (EN)	●	●			
Development Activities (DA)		●	●		●
Research Activities (RA)		●	●	●	●
Policy Issue (PI)	●	●	●	●	●

Table 2. Supporting Relationship between IWP Planning Elements.

As depicted in Table 2, a PI may support one or more IWP elements of any type. RAs may support ENs, DAs, PIs, or even other RAs. DAs may support ENs, PIs, or other DAs. ENs may support one or more OIs, or support other ENs that in turn support OIs.

IV. The Joint Planning Environment

Soon after the release of the three foundational documents, the JPDO recognized that NextGen stakeholders, engineers and decision makers alike, required the ability to directly access and analyze the latest NextGen planning information to support their respective budget development and capital planning efforts. Furthermore, government oversight bodies, such as the Office of Management and Budget (OMB) and the General Accounting Office (GAO), as well as Congressional staff also required the ability to survey NextGen planning information to understand the dependencies and implications of alternative solutions, ensure proper alignment of stakeholder investments, and identify and track transformational progress and risks. Enabling transparency, from strategy to investment, is a key challenge in a system as complex as NextGen. NextGen planning information is scattered across multiple stakeholders and static documents (i.e., ConOps, EA, and IWP), each representing a data boundary that is difficult to transcend and challenging to analyze and visualize. Communicating, presenting, and managing the full set of relationships and interdependencies also proved to be a challenge and made it difficult for the JPDO to model, analyze and report the cost, benefit, and risk implications of one alternative solution over another. To address these challenges, the JPDO needed a scalable and flexible framework along with a robust web-based decision support system to communicate a unified view of the NextGen enterprise and enable informed decision making founded on consistent planning and analysis information.

In 2007, the JPDO initiated two complementary efforts, the first being the design of a Joint Planning Framework (JPF) to organize the comprehensive suite of NextGen planning information, and the second, a process to evaluate, select, and deploy a dynamic and integrated decision support system called the Joint Planning Environment (JPE). The remainder of this chapter describes the JPF and the steps leading up to the first release of the JPE in May 2008. This chapter also describes how the JPE is currently being used to support the JPDO and NextGen stakeholder community, as well as future plans for additional JPE functionality.

A. The Joint Planning Framework

The Joint Planning Framework (JPF) represents an evolution in the structure and analytical approach used by the JPDO to guide the development and application of the NextGen ConOps, EA and IWP. The JPDO analyzed the contents of the three NextGen foundational planning documents, and other JPDO deliverables, as well as the strategic plans, roadmaps, and architectures of the NextGen partner agencies to derive the structure of the JPF. The materials already specified the “who, what, how, when, and why” of NextGen, however the logical relationships between them did not exist. Nor did the existing materials support the identification of concept-driven capability needs, evaluate functional gaps and opportunities for collaboration, or analyze alternatives to inform stakeholder decision making and solution implementation. The JPF, Fig. 2, provides the framework to hierarchically relate and organize the content contained throughout the NextGen-related documentation.

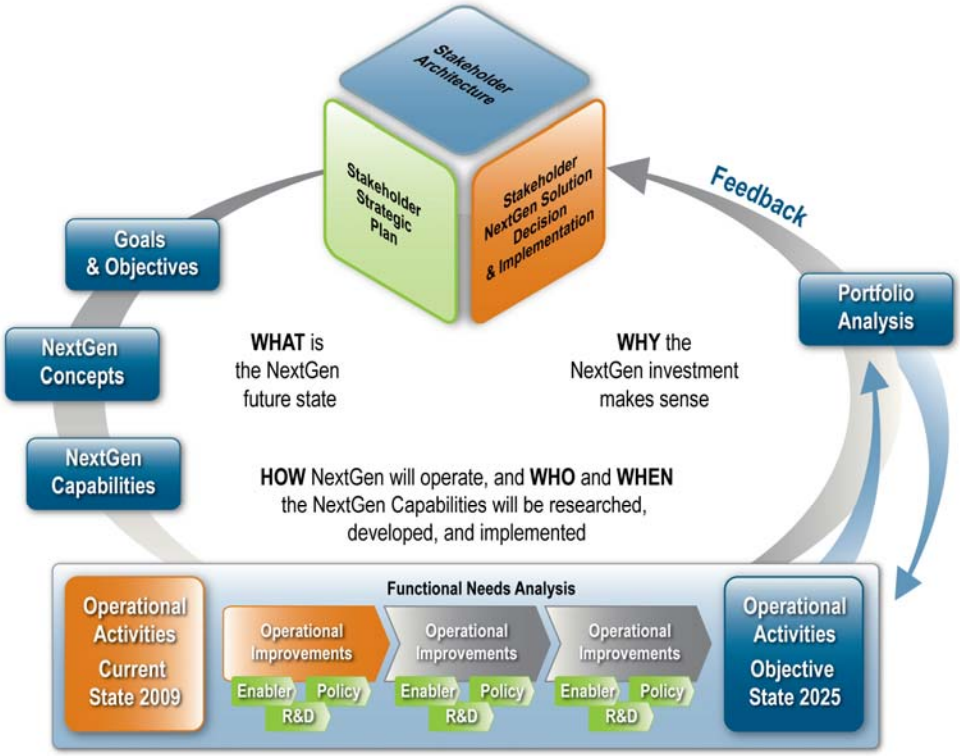

Figure 2. The Joint Planning Framework.

With the JPF, the JPDO has an effective framework to organize the significant collection of information and can begin to provide a coherent and compelling value proposition for the 2025 air transportation system. The JPF enables transparency and enforces the uniqueness needed to logically traverse the line of sight from the NextGen goals and objectives described in the NGATS Integrated Plan[8] to the concepts and capabilities, their supporting operations (i.e. activities), and the material and non-material investments (i.e. enablers, research, development, policy) needed to achieve the operational improvement and the full efficacy associated with the capability. The framework also supports traditional portfolio activities including the analysis of cost, benefits, schedule, and risk factors. It also adds an additional level of fidelity to enable the JPDO to analyze capability performance and align investments against strategic performance objectives.

B. The Joint Planning Environment

The overarching objective of the Joint Planning Environment (JPE) is to provide accessibility, as well as improved clarity and consistency of NextGen enterprise data and information to a broad NextGen stakeholder community through a centralized, integrated, web-accessible user interface. To meet this objective, the JPDO initiated the JPE design by defining solution requirements that would address the previously described challenges, support the JPF, and meet the needs of the NextGen stakeholder community including the JPDO directorate and contractor staff, partner agencies and industry subject matter experts, and oversight bodies such as the OMB and GAO. The analysis of JPE requirements yielded both functional requirements (e.g., usability, architecture integration and management, information visualization and reporting, security, etc.) and non-functional requirements (e.g., cost, time to market, extensibility, etc.), and, in addition, formed the basis of the scoring system used by the JPDO to evaluate alternative software solutions. The JPDO evaluated four alternatives, an in-house, custom-built solution, and three Commercial Off-the-Shelf (COTS) solutions using the scoring system found in Appendix A. The JPDO also asked the COTS vendors to prepare a proof of concept utilizing actual NextGen data to demonstrate the solutions' ability to satisfy both functional and non-functional requirements.

The JPDO selected Enterprise Elements to serve as the core software solution for the JPE. Enterprise Elements outscored all other solutions relative to both functional and non-functional evaluation criteria. The staff at Enterprise Elements quickly demonstrated the ability to load the NextGen EA and a partial representation of the IWP into the

software, establish relationships between the two information sources, and allow the JPDO staff to use the software within a 24 hour period. This proved to be an extremely convincing proof of concept. Compared to the other alternative solutions considered, Enterprise Elements also required a limited number of technical staff to adapt and maintain the software, enabling the JPDO to retain a small footprint of JPE contractor support. Lastly, Enterprise Elements provided a flexible security architecture with user-, role-, and data attribute-based access control policies.

1. Design Philosophy and Constraints

A key component of the JPE's design philosophy is to leverage existing technical infrastructure and minimize customization in order to promote reusability, portability, and cost reduction. As seen in Fig. 3, the JPE's technical architecture is a combination of the Enterprise Elements solution and other pre-existing JPDO COTS solutions including IBM System Architect, the Adobe Product Suite, Troux Architect, Microsoft Office, Oracle, AnyGantt, Camtasia, and FusionCharts. Additionally, the JPE's utilization of Oracle and Java Server technology conformed to the FAA's existing infrastructure standards and IT policies, further reducing acquisition costs and satisfying technical constraints. This demonstrates how the JPE's technical architecture can be plugged into existing technical architectures yielding a reusable architecture.

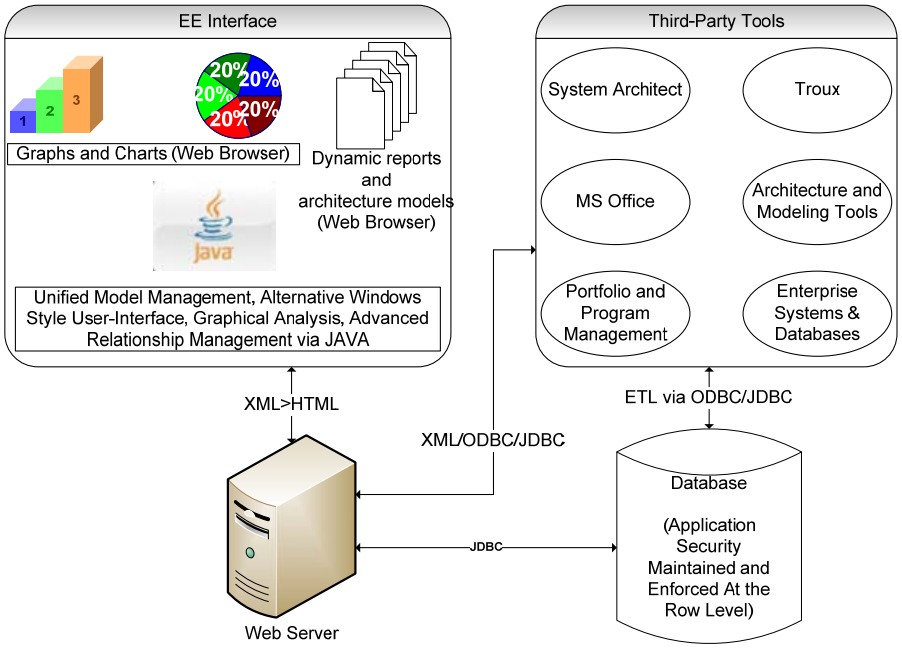

Figure 3. The JPE Technical Architecture.

By using virtualization technology and dynamic resource allocation, the development application server, development database server, test application server, test database server, and file server have all been configured as five virtual machines residing on one physical server, resulting in a cutting edge technology, a private cloud. The JPE takes advantage of cutting edge cloud computing concepts to increase sustainability and reduce the costs associated with server cooling, power requirements, and physical space requirements.

Another aspect of the JPE's design philosophy is the ability to adapt and keep pace with rapidly changing requirements of the NextGen stakeholder communities. The JPDO utilizes an iterative, incremental, and agile software development approach called SCRUM to manage the JPE requirements and ensure quality results are delivered. Inherent to this approach is a focus on working software over comprehensive documentation, customer collaboration, and responsiveness to change based upon short, frequent development cycles. The JPE is also designed to support a single, inter-related metamodel that is consistent with the JPF to describe the elements, relationships, and dependencies across the various NextGen data sets.

2. Functionality of the JPE

The JPE provides numerous immediate benefits to the JPDO and NextGen stakeholder community. It offers a centralized and web-based user interface for accessing the vast amounts of NextGen planning information. Previously disparate and disconnected NextGen planning information is now integrated and accessible via multiple entry points tailored to the needs of the individual user. The JPE Homepage, Fig. 4, lays out six different portals for accessing NextGen planning information.

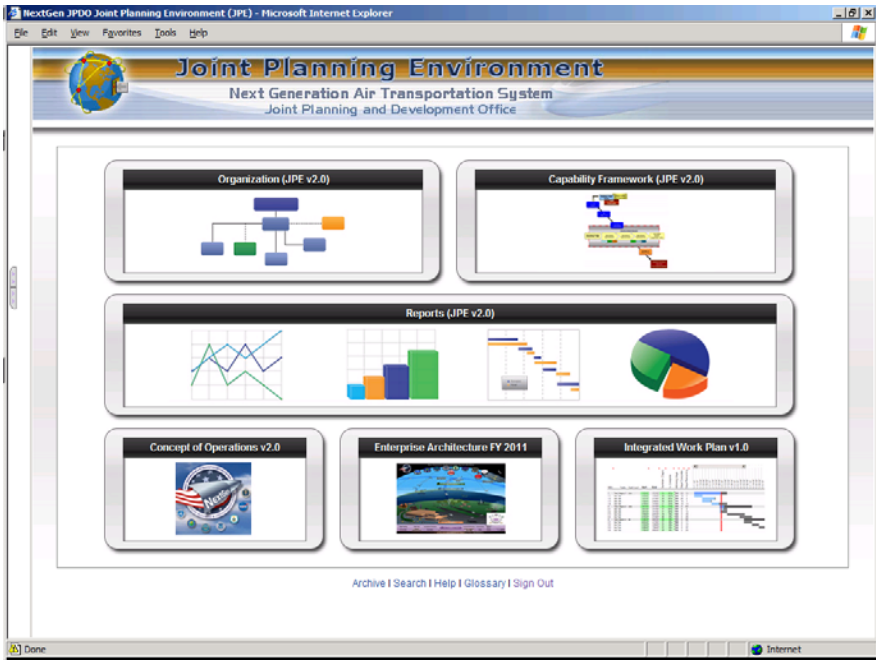

Figure 4. The JPE Homepage.

From each of the entry points on the JPE Homepage, users have direct access to the content contained in the original three NextGen foundational planning documents, a series of structured reports, organizationally-focused data, and data organized around the JPF. Once beyond the homepage, the JPE provides users the following additional functionality:

- **Information Visualization:** the JPE provides users the ability to visualize and traverse the NextGen planning data and their relationships through interactive graphics, enterprise architecture models, roadmaps, and drill-down capabilities.
- **Search, Query, and Export:** the JPE provides users the ability to search across the entire repository of NextGen information, including filtering and sorting features that help narrow results and make disparate data discoverable and accessible from a single location. The JPE also provides the ability to construct basic queries across multiple data sources to support first-order analyses, as well as the ability to export data in multiple formats to generate JPDO deliverables.

- **Decision Support and Reporting:** the JPE provides users the ability to create traditional tabular reports, as well as enhanced charts, graphs and executive dashboards to support decision making. Furthermore, the JPE provides a graphical analysis capability that allows the user to model and visualize the relationships between any combination of planning elements creating semantic network diagrams and predecessor maps. The graphs can be saved, shared with other users, and converted into tabular formats for additional analysis and reporting. A sample predecessor map is depicted in Fig. 5, showing the predecessor and successor relationships between particular IWP planning elements.

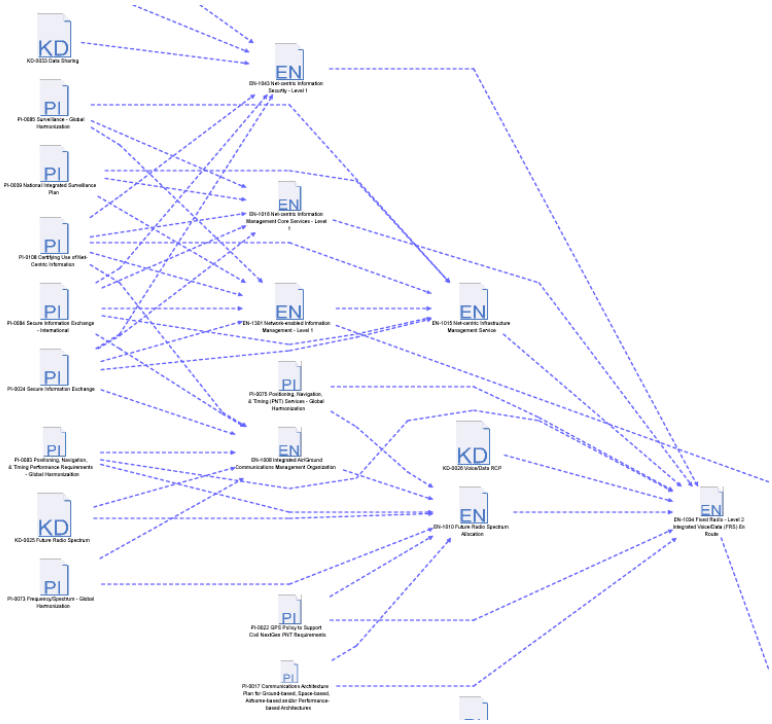

Figure 5. Sample Predecessor Map.

Administrative features along with data development, integration and management functionality are also resident within the JPE. Extract, transform, and load capabilities also exist for the quick integration and normalization of data from various tools, technologies and architecture models to create immediate access to consistent, accurate, and reliable information. Administrative tasks, such as security administration, data model management, and element relationship management, are enabled through a graphical user interface that resembles an "Explorer"-like browser. The JPE is also configured to preserve baseline copies of data and record historical records of changes to support the JPDO's Configuration Management Plan[9] processes.

3. Who is Using the JPE and How

As the collaborative environment for NextGen planning elements, the JPE has transformed the way the JPDO develops and maintains NextGen planning data. Users now have the ability to update planning element data attributes directly in a centralized online repository rather than developing and tracking multiple versions in an offline environment. The JPE is also used by the JPDO to store, in an access controlled area of the site, the results of cost, benefit, and risk modeling of various NextGen alternatives. This allows the JPDO to relate the portfolio analytics with the concepts and capabilities and to better understand and communicate, through budget guidance and recommendations, the path to NextGen that provides the highest return on investment.

The JPDO also uses the JPE as the mechanism for vetting and validating the NextGen planning information and maintaining configuration control. Prior to the JPE, a formalized method for providing comments or suggesting changes did not exist, nor was there a formal mechanism for the JPDO to track and adjudicate the comments and communicate the results. Now with the JPE, anyone may request an account to provide general comments or suggest specific changes to any of the NextGen planning elements. By formalizing the commenting and change management

processes, and utilizing the JPE's workflow engine alerting and forms, the JPDO is able to respond to comments and incorporate the resulting changes in a more efficient and timely manner.

While the JPDO continues to be the JPE's primary user, its utility and popularity is ever increasing with external users, including NextGen partner agencies and industry representatives, OMB, Congressional staff, the GAO and all other persons interested in NextGen planning information. The JPE's search, reporting, and visualization capabilities have been extensively used to support Congressional committee hearings and to highlight priority areas and collaboration opportunities for Federal agencies and industry. Furthermore, the EA models and IWP elements have been the starting point for further decomposition and detailed implementation planning in the avionics and weather domains. Most recently, the JPE provided the foundation for the development of operational scenarios and mission threads for interagency focus areas such as integrated communications, navigation, and surveillance to validate concepts and alternative architectures, and develop critical functional, performance, and interoperability requirements.

4. Next Steps

The JPE will continue to evolve along with NextGen. The JPDO regularly communicates with NextGen stakeholders and JPE users to solicit feedback and identify additional features and enhancements that will provide a more effective and efficient NextGen planning environment. For example, the JPE is currently going through a cosmetic redesign to reflect feedback received regarding the user interface and general navigation of the site. Once the redesign is complete, all NextGen planning information will be available in a single browser window instead of using multiple frames to display the content. Additionally, NextGen planning information will be accessible via an expandable navigation menu at the top of every page and a breadcrumb trail will be displayed so the user is able to jump back and forth to targeted pages with relative ease. Users will also have access to the JPE's global search functionality from any screen, making it easier to locate content. Lastly, the aesthetic quality of the site will be updated to be more consistent with the JPDO's established style guide.

As the NextGen portfolio continues to mature, more rigorous portfolio analysis and management functionalities can be added to the JPE. The JPE's architecture will be able to integrate COTS portfolio packages in addition to adding the functionality directly to existing JPE software. Program points of contact from industry and partner agencies could possibly use the JPE to report status information for individual NextGen programs, and in turn the JPDO could use that information to make modifications to the global NextGen program. All of this information could be integrated with the current Data.gov website -- a priority, open government initiative of the current administration to increase the ability to easily find, download, and use information.

The JPDO also is currently examining business intelligence solutions and reporting engines that can be integrated onto the overall JPE architecture. This will allow users to create, save, and execute their own self-defined reports on demand. Additionally, complex visualization options are being explored, for example, reports that render 3-D graphics, animated reports that show how NextGen will evolve over time, and cutting edge reports that use Flash technology that move beyond standard tabular reporting.

V. Summary

In creating an integrated plan to address NextGen, the JPDO has developed and published a suite of foundational planning documents. The ConOps describes the NextGen environment in prose form, written around nine key capabilities. The NextGen EA provides a very structured view of NextGen, developed and refined using the DoDAF and FEA frameworks. The EA is intended to provide consistency in defining the future operational and system environment and a common reference for NextGen stakeholders to leverage as they coordinate their respective architectures, investments, and implementation plans. The IWP provides a pathway for the transformation to NextGen. The IWP is intended to be a master planning document that depicts the collaborative stakeholder efforts that are needed to implement the NextGen vision. In addition, efforts to analyze the NextGen portfolio from the perspectives of benefits, costs and risks utilize critical information from all of these documents.

As the work products produced by the JPDO evolved and matured over the past two years, it has become increasingly apparent that a framework is needed to link these sets of fundamental data and information together. NextGen stakeholders, engineers and decision makers alike, required the ability to directly access and analyze the latest NextGen planning information to support their respective budget development and capital planning efforts.

Furthermore, oversight functions by various government entities require the ability to survey NextGen planning information to understand the dependencies and implications of alternative solutions, ensure proper alignment of stakeholder investments, and identify and track transformational progress and risks. With this as the impetus, the JPDO created the JPF and JPE. The JPF is used to organize the comprehensive suite of NextGen planning information, while the JPE provides a process to evaluate, select, and deploy a dynamic and integrated decision support system.

After employing a rational process to evaluate several options, the JPDO developed a comprehensive JPE that provides the capability to graphically visualize information, perform global searches and queries and export the results, and support for decision making and reporting. This capability is being used by both government and industry stakeholders for a variety of different tasks and has transformed the way that NextGen stakeholders access NextGen planning data. Thus, offering an increase in the efficacy of JPDO-developed data and information. This, ultimately, will lead to improved benefits to both public and private stakeholders in the NextGen initiative.

Appendix

A. JPE Evaluation Process

This appendix provides additional details on the JPE tool evaluation process. It may be possible for an organization to reuse this evaluation architecture with appropriate modifications to evaluate technical alternatives for a similar set of requirements.

As mentioned in the body of the paper, the JPDO evaluated four technical alternatives for the JPE; a custom solution and three COTS solutions. To perform an objective evaluation, consistent evaluation methods and criteria were applied to each alternative considered. As such, a grading system was constructed to quantify the evaluation criteria results and a scorecard was created to capture and communicate the evaluation results. The grading system considered both functional and non-functional criteria. Most critical to the construction of the grading system is a solid foundation of application user and sponsor defined requirements. These requirements were the basis for each of the individual score card line items as described below.

The remainder of this appendix will list the elements contained within the grading system and the summarized scorecard.

Criteria	Weight	Criteria	Weight
Corporate Profile	**100%**	**Ease of Adoption**	**100%**
Install Base	15.00%	Usability	50.00%
Corporate References	15.00%	Training	10.00%
R&D Strategy	35.00%	Customization	40.00%
Release Strategy	35.00%	**Time To Market**	**100%**
Extensibility	**100%**	Functional Gap	10.00%
Standards Based	10.00%	Data Gap	10.00%
XML Driven	40.00%	Number of Resources	20.00%
Interface with Other Products	25.00%	Deployment	60.00%
Web Services	25.00%		

Figure 6. Detailed Breakdown of Non-Functional Criteria.

Function	Weight	Function	Weight
Version Control	**8.00%**	**OMB Interface**	**5.00%**
Object Level	2.75%	**Schedule Management**	**2.50%**
Workproduct Level	5.75%	**Document Generation**	**4.00%**
Audit	**3.00%**	IWP (Word)	2.00%
Diff of Exact Change	2.00%	ConOps (Word)	1.00%
Date/Time Stamp/User Only	1.00%	EA Work Products (Word, Excel, Visio)	1.00%
Workflow/Configuration Control	**7.00%**	**Relationship Management (Including Investment to Capability)**	**8.50%**
If/Then Capability	1.00%	Intra-Work stream	4.25%
Simple Routing	2.00%	Inter-Work stream	4.25%
View Status at Point in Time	1.00%	**Data Presentation**	**9.00%**
Email Integration	2.00%	Any Entry Point	2.00%
CMMI compliant	1.00%	Multi-Directional Drill Through	2.00%
Security Control	**3.00%**	Web Enabled	5.00%
Reporting	**8.50%**	**Edit ConOps In Word and save to repository**	**2.00%**
Canned	4.25%	**What-if Scenario Generation**	**4.00%**
Ad-Hoc	4.25%	**Gap Analysis**	**4.00%**
Modeling	**4.00%**	**Data Export Capability**	**6.00%**
Document Decomposition	**3.00%**	**Data Import Capability**	**8.00%**
Commenting at Object Level	**2.00%**	**Edit IWP Narratives In Word and save to repository**	**3.00%**
Search/Filter Interface	**5.00%**		

Figure 7. Detailed Breakdown of Functional Criteria.

The scoring was based on a four-point scale. A score of zero indicated the alternative did not satisfy any of the criteria. A score of one indicated that the alternative satisfied 1% - 50% of the criteria. A score of two indicated the alternative satisfied 51% - 75% of the criteria, while scoring a three indicated that the alternative satisfied 76% - 89% of the criteria. Finally, a score of four indicated that the alternative satisfied 90% or more of the criteria.

SOLUTION	FUNCTIONALITY (50%)	NON-FUNCTIONAL EVALUATION CRITERIA (50%)					
	Versioning Auditing Workflow Reporting Presentation....	Price (20%)	Time to Market (15%)	Ease of Adoption (7.5%)	Extensibility (5%)	Corporate Profile (2.5%)	Total Score
Enterprise Elements (COTS Solution 1)	2.79	3.00	3.90	3.60	3.25	3.10	**3.09**
Custom Solution	4.00	1.00	2.10	2.70	1.20	2.25	**2.84**
COTS Solution 2	2.92	2.00	2.10	2.40	3.00	2.60	**2.57**
COTS Solution 3	3.35	1.00	1.50	2.00	3.10	4.00	**2.51**

Figure 8. Evaluation Scorecard.

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