Task 7: Strategic Job Analysis - Selecting the Air Traffic Controller of the Future (Broach)

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Project Start Date: FY08 Q1 **Anticipated End Date:** FY12 Q4

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Requirements Statement
Operational Shortfall or Knowledge Gap Air traffic operations are expected to increase over the next decade (FAA, 2010). To accommodate that anticipated growth, new technologies and procedures are being developed and implemented under the umbrella of the Next Generation Air Transportation System (NextGen). While the *Concept of Operations for the Next Generation Air Transportation System Version 2.0* ("NextGen ConOps;" Joint Planning & Development Office [JPDO], 2007) provides a broad description of a distributed, complementary and highly-automated system of air-ground system, it lacks sufficient detail to deduce and justify the physical, perceptual, psychomotor, and cognitive abilities and other personal characteristics (e.g., "aptitudes") that will be required of Air Navigation Service Providers (ANSPs, e.g., air traffic control specialists) in the future. In other words, the impact of NextGen on the *ab initio* aptitude requirements is not known.
Benefit in Closing the Shortfall or Gap Understanding the impact of NextGen-related changes on the *ab initio* profile of required aptitudes will provide a basis for modifying the agency's personnel selection criteria for ANSPs.
Description of the Desired Product The desired products are (a) a maintainable and extensible job/task analysis information database providing the capability to access, manage, update, compare, and report work statement by aptitude requirements in parallel with NextGen development, and (b) analyses of the impact of mid-term NextGen concepts of operation and use, solution sets, operational improvements, and enablers on the profile of aptitudes required of ANSPs at entry into the occupation. That profile will serve as selection test specifications in compliance with the *Uniform Guidelines on Employee Selection Procedures* ("*Uniform Guidelines*;" 27 C.F.R. § 1607) and relevant federal laws, regulations, and policies and professional standards, principles, and practices.

Schedule
FY10 – Analyze concepts of operations and use, technologies, and procedures for surface operations (e.g., legacy Air Traffic Control Tower [ATCT]) in the mid-term & start JAIdB development
FY11 – Analyze concepts of operations and use, technologies, and procedures for terminal operations (e.g., terminal radar approach control [TRACON])in the mid-term; complete JAIdB development
FY12 – Analyze concepts of operations and use, technologies, and procedures for en route operations (e.g., legacy air route air traffic control center [ARTCC]) in the mid-term; update JAIdB.

Research Objective(s)
Conduct analyses of the work to be performed by ANSPs in parallel with evolving NextGen concepts of operation, solution sets, and operational improvements. Identify new or changed ability requirements linked to mid-term (now through about 2018, also known as "NextGen Segment Alpha" as of April 2010) NextGen concepts of operation, solution sets, and operational improvements. Develop specifications for assessment of those new or changed physical, perceptual, psychomotor and cognitive abilities and other personal characteristics (e.g., "aptitudes") to ensure that future ANSPs will be able to fulfill new or changed roles and responsibilities in the NAS (FAA *2010 National Aviation Research Plan* [NARP], p. 35).

Background
The idea of identifying the profile of physical, perceptual, psychomotor and cognitive abilities and other personal characteristics (e.g., "aptitudes") to be required at some future time for a job has been discussed in the personnel selection research literature for over two decades. Often described as "strategic job analysis," the underlying concept is relatively straightforward: describe how a job might be performed at some future point, and from that description, deduce the aptitudes, knowledge, and skills that are likely to be required. Dunnette (1982), for example, framed the problem in terms of constructing a "Job/Person Characteristics Matrix." Other perspectives on the problem have been articulated by Peterson and Bownas (1982), Schneider and Konz (1989), Knapp, Russell and Campbell (1993), Campion (1994), and, more recently, by Schippman (1999). In the mid-1990s, the Aerospace Human Factors Research Division (AAM-500) sponsored research to review the state-of-the-art in job analysis, integrate previous technical approaches to strategic job analysis, and develop a practical, applied framework for conducting a strategic job analysis (see Knapp, Morath, Quartetti & Ramos, 1996) in anticipation of a future requirement to assess the impact of concepts of operation and use, technologies, and procedures on the work performed by ANSPs and the aptitudes required to enter the ANSP occupation. This research task applies that methodology in the context of NextGen to identify aptitudes that should be assessed as part of the ANSP selection process.

NextGen is the FAA's "system of systems" that, through continuous improvements and upgrades, will make the air transportation system safer and more reliable, increase its capacity, and reduce environmental impact. The FAA *2010 NextGen Implementation Plan* (NGIP) describes the operational environment "now and into the mid-term, which is defined here as 2012-2018" (p. 5). To be consistent with the NGIP, "mid-term" in this research task refers to the expected operational environment of 2018.

NextGen concepts of operation and capabilities are likely to change the technologies and procedures used by ANSPs, perhaps substantially. For example, ANSPs might shift from (very) tactical of single aircraft to (more) strategic control of a flow of traffic. ANSPs might also delegate separation assurance responsibilities with pilots (under certain conditions) in a performance-based air traffic management system. The impact of these changes in concepts, technologies, procedures and, possibly, the work itself, on the aptitudes required to *enter* the ANSP occupation is unknown.

There is considerable speculation and comment on the likely profile of abilities that will be required of the Next Generation of ANSPs. For example, the 2010 NARP sets out a requirement by 2015 to "Develop selection procedures to transform the (ANSP) workforce into a new generation of service providers that can manage traffic flows in a highly automated system" (p. 35). The embedded supposition is that the aptitude profile required "in a highly automated system" is at least qualitatively different than the profile required for today's NAS. However, previous research on the impact of ATC modernization has suggested that the aptitudes required to enter the ANSP occupation were not likely to change substantially with increased automation. For example, an evaluation of the impact of AERA 2 services by Manning and Broach (1992) suggested little substantive change to the profile of cognitive abilities required at entry into the ANSP occupation. Similar research a decade later in Germany reached much the same conclusion (Eiβfeldt, 2002). More recent research in Europe under the auspices of the Aviator 2030 program suggests that, within the limits of the simulations and methods used, the abilities profile required of *pilots* might change more than the profile required of *controllers* (Deutsches Zentrum für Luft- und Raumfahrt (DLR) e.V, 2009, p. 88; emphasis added). Future ability requirements ratings by controllers participating in the DLR study were *lower* for 3, higher for just one, and *unchanged* on 36 of 40 dimensions from Fleishman's Functional Job Analysis Scales (F-JAS)(p. 49-50). However, it might be the case that some of the abilities on which ANSPs have been selected in the past might not be justifiable in the future (Hopkins, 2007), or that new constructs such as "Trust in Automation" might become important. Therefore, systematic research is needed to map changes in ANSP work under different operational concepts and technology configurations and then infer the aptitudes that are likely to be required in the future to perform that work as the NAS evolves under NextGen.

The purpose of this research task is to evaluate mid-term NextGen concepts for their impact on the profile of aptitudes required to *enter* the occupation circa 2018. For purposes of this research and consistent with the *Uniform Guidelines*, "aptitude" refers to innate traits and learned capabilities that a new hire must have at the time of entry on duty (EOD), that is, on Day 1 of employment with the FAA as an ANSP. Physical, perceptual psychomotor, innate and some learned cognitive abilities, personality traits, preferences, and attitudes are "aptitudes" in the context of this research task. In contrast, "knowledge" and "skills" are learned through training provided by the FAA after hire and are addressed in a parallel research task (AJP-61 "Strategic Training Needs Analysis"). It is important to note that this research task (Task 7) assumes that selection into the ANSP occupation in the FAA will continue to be made on the basis of *aptitude*, not demonstrated ATC knowledge and skill.

Previous Activity on this Task
There are two sets of parallel research activities in this task: procurement or development of a job analysis tool to capture, represent, and compare the current and future work of ANSPs; and analyses of the impact of mid-term NextGen initiatives on the work performed by ANSPs in surface, terminal, and en route operations (e.g., the legacy operating environments of ATCT, TRACON, and ARTCC).

FY09 activity for this task included (a) conducting a market survey to determine if there were any commercially-available job/task analysis software applications to capture and represent the current and future work of ANSPs, (b) building a first prototype of the JAIdB to refine the functional capabilities and data requirements for the tool, (c) identifying mid-term NextGen surface operations concepts of operation and use, OIs, and technology enablers that are likely to impact ANSPs in the mid-term, (d) gathering information through discussions with program representatives and researchers in meetings and conferences, and (e) reviewing relevant documents.

The market survey did not identify any commercially available off-the-shelf software applications that provided, or could be adapted to provide, the required capabilities to represent ANSP work and associated aptitudes currently and in the future. The summary report on the market survey was delivered at the end of FY09. A prototype of the JAIdB, based on the functional capabilities and data requirements, was developed in Microsoft Access® 2003 and delivered in FY09. The prototype was used to assess the viability of the relational database model that underlies the SJA methodology as described by Knapp, et al. (1996). Given the lack of commercially-available job/task analysis applications, the decision was made to develop the JAIdB capability required to support this research task. The market survey, JAIdB Notional Design document, and JAIdB prototype were used to develop a Performance Work Statement and Concept of Operations and Use (ConOps) for the JAIdB as the basis for a procurement action to build the JAIdB application. A review of research of surface trajectory-based operations (STBO) was initiated and an annotated bibliography of STBO research documents developed.

Proposed or Planned Research
The SJA research task is intended to provide the scientific foundation for the continued evolution of the ANSP selection procedures in accordance with relevant guidelines, standards, principles, policies, and practices. The starting point for the analysis is the job as it is performed today, with existing technologies and procedures. The JAIdB is an enabling technology – a tool – for this research task. The JAIdB will be used to capture, represent, and compare current and future descriptions of the work and required aptitudes. The quality of future-oriented analyses of ANSP work and aptitudes in the mid-term will depend on both the quality of information available and timely access to NextGen design teams, technology demonstrations, proofs-of-concept, human-in-the-loop simulations, pilot tests, and other documents. It is also important to understand that as the ANSP occupation evolves, assessment of the impact of concepts of operation and use, technologies, and procedures must be on-going and continuous, rather than episodic or a "one of" effort. An over-arching goal for this research task is to develop and implement a process of continual job analysis in parallel with emerging concepts of operations, technologies, and procedures to support the evolution of the ANSP occupational selection procedures. Ideally, the JAIdB will be incorporated into the human-systems integration (HSI) suite of tools to assess the

impact of proposed concepts of operation and use, technologies, and procedures on the human operators (e.g., ANSPs).

A multi-step methodology is used to assess the impact of NextGen concepts of operation and use, technologies, and procedures on the aptitudes required at hire into the ANSP occupation. First, existing work description and aptitude requirements are used to develop a baseline description of ANSP work, including graphical depictions of the flow and sequence of work elements (e.g., "Work Flow Diagrams," similar to the CTA, Inc. "Composition Graphs"). This baseline is captured in the JAIdB. Second, relevant documents and prototypes for a working environment and timeframe are reviewed. Multiple sources for information on NextGen concepts of operation and use, technologies, and procedures are used to build a description of how the ANSP provides services at a particular time. NextGen information sources include JPDO documents, Enterprise Architecture artifacts (such as the OV-6c event sequence diagrams), and interviews of system designers, engineers, architects, and participants in demonstrations, proofs-of-concept and HITL participants. Third, from the review, Work Flow Diagrams and work statements (activities, sub-activities, tasks, etc.; "SJA artifacts") are developed. The SJA artifacts are essentially a description of how ANSP work might be performed in the mid-term. Fourth, the SJA artifacts are presented to SMEs, such as HITL participants for a NextGen capability, system designers and other subject matter experts (SMEs) as appropriate. The SMEs review the SJA artifacts using defined NextGen operational scenarios. Revisions are made to the SJA artifacts based on SME input. The SJA artifacts are used to construct a representation of ANSP future work. The description of work is not constrained to current positions and types of facilities; new positions, with new or different responsibilities, and new types of facilities are identified and described where appropriate. Fifth, the description of the work developed in step 4 is used to construct a work statement-by-aptitude matrix. Sixth, an exercise is conducted with SMEs (including psychologists) to link work statements to aptitudes. This exercise is similar to the exercises conducted in CoVATCH, the 1992 analysis of AERA 2 by Manning and Broach, and the recent work in Germany. The goal is to establish an empirical linkage between work statements and ANSP aptitudes. Seventh, the mid-term work statements, aptitudes, and "NextGen linkages" are compared to the baseline (developed in the first step) to identify changes in the work and aptitude profile. Finally, the changes identified in the comparison of the baseline to future work statements-by-aptitude are translated into specifications of the aptitudes to be assessed as part of the controller selection process.

As an example, consider the mid-term tower cab Decision Support Tools (DSTs) described by MITRE in the "*Near-Term Concept of Use (ConUse) for Surface Decision Support Tools*" dated September 2009 and in "*A Mid-Term Concept of Operations for a Tower Flight Data Manager (TFDM)*." Both documents were produced for the ATO Terminal Services Tower Flight Data Manager (TFDM) program and describe DSTs for the tower cab to be fielded between now and 2018. The "Taxi Routing Tool" is described as providing information about the airport surface needed by the ANSP working the Ground Control position in the (undefined) "near-term." In the mid-term, the Taxi Routing Tool capabilities will expand to include pre-defined 2D taxi routes, with the automation recommending "optimized 2D taxi routes" with conformance monitoring and alerting. Currently, there is no automation in the tower cab for generating taxi routes, monitoring conformance, and alerting when an aircraft is out of conformance. The ANSP responsible for operations in the movement area relies upon the out-the-window view, standard

procedures (including “standard” taxi routes), and radio communications to control and monitor taxi routing. Conformance monitoring and alerting might introduce a new sub-activity (monitoring the conformance display) or change how “Checking and evaluating traffic movement” is performed at the task level.

To begin, this analytic exercise will be conducted for concepts, technologies, and procedures required to conduct mid-term surface operations as described in the 2010 NGIP. In FY2011, concepts, technologies, and procedures required to conduct mid-term terminal operations will be evaluated. In FY2012, the exercise will be conducted for mid-term en route concepts.

Research Question(s)

There are four basic research questions addressed in this research, each applied to an operational environment (surface, terminal, and en route):

1. How will mid-term (~2018) NextGen concepts of operation and use, technologies, and procedures change the work performed and tools used by ANSPs?

2. Given a description of the work performed and tools used by ANSPs in the mid-term (~2018), what aptitudes will be required?

3. How does that profile of aptitudes required in the mid-term (~2018) compare to the baseline profile?

4. What changes in ANSP selection criteria are needed to address those differences?

Technical Approach

Current Year

Review mid-term concepts, technologies, and procedures in surface operations to develop Work Flow Diagrams and work statement lists (“SJA artifacts”).

Conduct SME review of the SJA artifacts for mid-term surface operations.

Conduct SME panel exercise to link work statement to ANSP aptitudes for mid-term surface operations.

Analyze linkages data for surface operations in the mid-term and compare to current ANSP aptitude requirements. Describe changes in an aptitude specifications document.

Complete development of the Screening Information Request (SIR) or Other Transaction Agreement (OTA) Appendix for the development of the JAIdB using a commercially available database application.

Award a contract or OTA Appendix for the development of the JAIdB using a commercially

available database application. (Dependent on AMQ-300 action if contract, AJP-61 & AJA if OTA Appendix).

Begin development of the JAIdB (after award).

Out-Years

Review mid-term concepts, technologies, and procedures in terminal operations to develop Work Flow Diagrams and work statements lists ("SJA artifacts").

Conduct SME review of the SJA artifacts for mid-term terminal operations.

Conduct SME panel exercise to link work statements to ANSP aptitudes for in mid-term terminal operations.

Analyze linkages data for terminal operations in the mid-term and compare to current ANSP aptitude requirements. Describe changes in an aptitude specifications document.

Update surface operations JAIdB baseline with mid-term NextGen changes (work statements, aptitudes, and their linkages).

Review mid-term concepts, technologies, and procedures in en route operations to develop Work Flow Diagrams and work statements lists ("SJA artifacts").

Conduct SME review of the SJA artifacts for mid-term en route operations.

Conduct SME panel exercise to link work statements to ANSP aptitudes for in mid-term en route operations.

Analyze linkages data for en route operations in the mid-term and compare to current ANSP aptitude requirements. Describe changes in an aptitude specifications document.

Update terminal operations JAIdB baseline with mid-term NextGen changes (work statements, aptitudes, and their linkages).

Complete development of the JAIdB and populate with baseline data.

Air Traffic Resources Required

Access to ANSPs serving as participants and/or Subject Matter Experts (SMEs) in proof-of-concept studies, demonstrations, reviews, human-in-the-loop simulations (HITL), and design/engineering groups will be required to identify changes in the tasks, activities and/or job duties performed by ANSPs under the different NextGen ConOps, OIs, solution sets, capabilities and/or enablers.

Access to ATO system designers, architects, engineering teams, and test and evaluation (e.g.,

IOT&E) groups will be required as well to identify relevant changes in tasks, activities and/or job duties associated with NextGen ConOps, OIs, solution sets, capabilities and/or enablers.

On-going and timely access to documents associated with functional requirements, development and evaluation of NextGen ConOps, OIs, solution sets, capabilities and/or enablers is also required.

Analysis of the impact of NextGen initiatives is entirely dependent on timely access to NextGen staff, developers, documents, studies, study participants, and reports. Delays in timely access to relevant SMEs, working groups, documents, etc. will severely impact both the schedule for and quality of this research task.

Calibration

N/A

FY10 Milestone Schedule		
Description	Proposed Start Date	Proposed Completion Date
Complete Screening Information Request (SIR) or OTA Appendix for development of JAIdB	FY10 Q1	FY10 Q2
Award contract or OTA Appendix for JAIdB development (Dependent on AMQ-300 and AMC-7 [AGC])	FY10 Q2	FY10 Q4
Develop JAIdB with baseline data (completion @ +11 months depends on award date)	FY10 Q4	FY11 Q3
Review mid-term NextGen concepts, technologies, and procedures for surface operations	FY09 Q3	FY10 Q3
Conduct SME exercise to link work statements to ANSP aptitudes for mid-term surface operations	FY10 Q4	FY10 Q4
Review mid-term NextGen concepts, technologies, and procedures for terminal operations	FY10 Q4	FY11 Q2
FY2011 Milestone Schedule		
Identify changes in aptitude requirements for surface operations in the mid-term	FY11 Q1	FY11 Q1
Review mid-term NextGen concepts, technologies, and procedures for en route operations	FY11 Q2	FY12 Q2
Update surface operations JAIdB baseline with mid-term NextGen changes	FY11 Q3	FY11 Q3
Conduct SME exercise to link work statements to ANSP aptitudes for mid-term terminal operations	FY11 Q3	FY11 Q3
Describe changes in aptitude requirements for mid-term terminal operations	FY11 Q3	FY11 Q4
Update terminal operations JAIdB baseline with mid-term NextGen changes	FY11 Q3	FY11 Q4
FY2012 Milestone Schedule		
Conduct SME exercise to link work statements to ANSP aptitudes for mid-term en route operations	FY12 Q2	FY12 Q3
Describe changes in aptitude requirements for en route operations in the mid-term	FY12 Q3	FY12 Q4
Update en route operations JAIdB baseline with mid-term NextGen changes	FY12 Q3	FY12 Q4

FY10 Deliverables		
Description	Proposed Completion Date	Actual Completion Date
JAIdB Screening Information Request (SIR)	FY10 Q2	FY10 Q2
JAIdB Award	FY10 Q4	
Mid-term NextGen surface operations SJA artifacts	FY10 Q3	
Mid-term NextGen surface operations work statement-to-aptitude linkages data	FY10 Q4	
FY2011 Deliverables		
Mid-term NextGen surface operations aptitude specifications report	FY11 Q1	
Mid-term NextGen surface operations update to JAIdB	FY11 Q3	
Mid-term Next terminal operations SJA artifacts	FY11 Q2	
Mid-term NextGen terminal operations work statement-to-aptitude linkages data	FY11 Q3	
Functional JAIdB	FY11 Q3	
Mid-term NextGen terminal operations aptitude specifications report	FY11 Q4	
Mid-term NextGen terminal operations update to JAIdB	FY11 Q4	
FY2012 Deliverables		
Mid-term NextGen en route operations SJA artifacts	FY12 Q2	
Mid-Term Next Gen en route operations work statement-to-aptitude linkages data	FY12 Q3	
Mid-term NextGen en route operations aptitude specifications report	FY12 Q4	
Mid-term NextGen en route operations update to JAIdB	FY12 Q4	