Next Generation Air Transportation System (NGATS) Air Traffic Management (ATM) - Airportal Project

Reference Material

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1.1 NGATS ATM-Airportal Project Vision, Strategic Goal, and Performance Objectives

1.1.1 Vision Statement

The NGATS ATM-Airportal Project ("Airportal Project") vision is an airportal environment that is managed to the highest possible level of throughput and operational efficiency. Operators will achieve maximum productivity in the use of gates, taxiways, runways, approach airspace, and other airportal resources while minimizing the impact of weather and balancing safety and environmental requirements. Such productivity is essential to meet future growth in demand for air transportation services, which NASA, the Joint Planning and Development Office (JPDO) and other experts anticipate will double or triple by 2025.

The Airportal Project will investigate innovative new technologies, approaches, and procedures with the goal of enabling capacity enhancements within the airport and terminal domains to meet the JPDO NGATS capacity goals. This will be achieved by addressing the constraints that exist in these domains and investigating technologies and procedures to enhance flexibility. Through collaboration with university and industry partners, foundational research will be conducted to identify and evaluate these constraints and the innovative solutions to address them. Further assessment will be undertaken in conjunction with industry partners in research areas that require systems analyses and evaluation.

1.1.2 Strategic Goal and Performance Objectives

The major goal of the Airportal Project is to enable capacity improvements to achieve the JPDO NGATS capacity goals in the terminal and airport domains of the National Airspace System (NAS). Since every airport is a unique environment and demand is not expected to increase equally at each airport as the system grows, the Airportal Project will develop and evaluate a suite of capacity increasing concepts and the system analysis capability to aid tailoring solutions to specific needs. The performance objectives in support of this goal are the following:

- Optimize surface traffic operations to enable capacity and efficiency enhancements
- Explore transformational approaches, enabled by NGATS capabilities, for increasing airportal throughput
- Maximize the capacity of individual runways
- Maximize the capacity of multiple runways with airspace and taxi interactions (closely-spaced parallel and converging runways)
- Minimize runway incursion threats in all weather conditions
- Model and predict wake vortex behavior to enable super density operations
- Balance arrival and departure traffic management to enable capacity achievements
- Balance safety, efficiency, and environmental requirements

1.1.3 Project Scope

The Airportal Project will conduct foundational research and discipline-based technology development focused on issues related to the ground and terminal area domains of the NAS. The Airportal Project was formulated in response to the need to achieve the maximum possible productivity in the combined use of gates, taxiways, runways, terminal airspace, and other airportal resources necessary to enable key capabilities of the Next Generation Air Transportation System (NGATS). Foundational research activities will focus on development and validation of algorithms, technologies, and operational procedures to enable integrated solutions that will safely expand capacity and increase throughput in the airportal domain.

The Airportal Project will work in close collaboration with the NGATS ATM-Airspace Project, which will focus predominantly on the en route airspace.[i]

1.2 ARMD Investment Justification (Why NASA?)

ARMD investment in the Airportal Project is appropriate and justified by the Project's alignment of its research portfolio with NASA's charter to address the national need, its goal to "advance knowledge in the fundamental disciplines of aeronautics and develop technologies for safer aircraft and higher capacity airspace systems," [ii] and the ARMD principles to "dedicate ourselves to the mastery and intellectual stewardship of the core competencies of Aeronautics for the Nation in all flight regimes" and "focus our research in areas appropriate to NASA's unique capabilities." [iii]

In its 2006 Decadal Survey of Civil Aeronautics: Foundation for the Future,[iv] the National Research Council Steering Committee for the Decadal Survey of Civil Aeronautics identified four high-priority strategic objectives[1] and fifty-one highest-priority research and technology challenges for NASA aeronautics. The Airportal Project research will directly contribute to achieving all four of the high-priority strategic objectives and to ten of the fifty-one highest priority research and technology challenges.

1.2.1 Alignment with NASA Charter

The Airportal Project's focus on directly expanding NAS capacity and throughput in the airportal environment directly aligns with NASA's charter to address the national need and provide benefit to the public. Without significant expansion, demand for air transportation services will soon outpace NAS capacity, which will impose significant, tangible economic and social costs to the nation.

Level 2 and Level 3 research activities across the Project contribute to technologies, operational procedures, and systems needed to expand NAS capacity to meet future demand and enable the NGATS.

- Level 3 research in Surface Operations will focus on developing trajectory-based automation technologies to increase the safety and efficiency of surface operations — thus minimizing significant delays during departure operations and increasing runway

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[1] Increase Capacity, Improve Safety and Reliability, Increase Efficiency and Performance, and Reduce Energy Consumption and Environmental Impact

throughput — and minimize runway incursions in all weather conditions, thus increasing safety.

- Level 3 research in Runway Operations will focus on identification and prioritization of constraints to achieving airportal capacity at the individual airport level, identifying alternative concepts for improving the capacity of individual runways and multiple-runways that interact, and integrating runway management concepts with surface management concepts.
- Level 3 research in Metroplex and Regional Airport Operations will enable the use of dynamic NGATS resources by addressing the operation of multiple airport systems (metroplex and use of additional regional airports) and enabling seamless “ramp to TRACON” (Terminal Radar Approach Control) traffic flow across the NGATS through integration of dynamic operator roles, decision aids, airportal and terminal area constraints, and weather information. The work is guided through the identification and understanding of new roles, responsibilities and authority required between humans and automation, and development of operational concepts to guide research priorities.
- Level 2 research in Surface Capabilities will lay some of the groundwork for future operational enhancement to surface traffic flow by providing domain-specific 4D Trajectory clearance methods, taxi conformance algorithms, and taxi route optimization methods.
- Level 2 research in Runway Capabilities will contribute to NAS capacity expansion in future airportal operations with algorithms to enable alternative concepts for management of the physical space in the airportal environment to maximum efficiency. These algorithms include runway balancing, runway scheduling, and initial cataloging and assessment of alternative concepts, at the subsystem level, for particular capacity enhancing operations.
- Level 2 research in Enabling Capabilities contributes to NAS capacity expansion by providing crosscutting research functions that apply to surface, airport, and multiple-airport systems. This work includes Equivalent Visual Operations (EVO) capabilities (in collaboration with the Integrated Intelligent Flight Deck Technologies (IIFDT) Project) applicable to virtual towers or to the flight deck as well as capabilities for network analysis that can be applied to metroplex opportunities.

1.2.2 Alignment with Agency Goal

The Airportal Project’s research also aligns with the Agency’s goal to “*advance knowledge in the fundamental disciplines of aeronautics and develop technologies for safer aircraft and higher capacity airspace systems.*”

- Level 1 research in Applied Physics includes development of trajectory-based models that will leverage 4D trajectories and Required Navigation Performance (RNP) to enable transformational concepts. Research to identify and correct the most critical (to aircraft operations) deficiencies in today’s state-of-the-art real-time wake vortex prediction models will be performed.
- Level 1 research in Applied Human/System Integration also supports the Agency goal. The key challenge is to understand the information requirements and necessary functions that will characterize the future NGATS operational environment. In addition, the

development and validation of human performance models are critical elements to this research area for providing the assessment of operator roles, responsibilities, and decision-making parameters.

- Level 1 research in Applied Mathematics seeks to extend state-of-the-art optimization techniques for application to future airportal environments. Other research will explore the behavior and characteristics of individual airportal environments and networks of airports in a metroplex and explore concepts such as large-deviation theory for application to system safety methodologies.

1.2.3 Alignment with ARMD Principles

The Airportal Project's focus on developing algorithms and developing and modeling advanced operational concepts for the airportal environment is especially appropriate to NASA's capabilities and core competencies in air traffic management. This focus demonstrates the Project's alignment with ARMD principles to "dedicate ourselves to the mastery and intellectual stewardship of the core competencies of aeronautics for the Nation in all flight regimes" and "focus our research in areas appropriate to NASA's unique capabilities".[v] The Airportal Project will leverage NASA's unique capabilities in air traffic management research as demonstrated in previous successful research projects. These include the Terminal Area Productivity (TAP), Advanced Air Transportation Technologies (AATT), and Virtual Airspace Modeling and Simulation (VAMS) Projects. Each enabled innovations that improved the capacity of operations at and between major airports in the NAS.

1.3 Research Relevance

1.3.1 Problem Statement

Four of the nation's 35 busiest airports are already at capacity and 27 will reach capacity limits by 2025 in the absence of improvements[vi]. Next to environmental issues, airportal capacity is the constraining factor to achieving the NGATS vision for NAS capacity in 2025[vii]. Building new airports and runways is extraordinarily expensive and can take decades to complete, particularly if procedural constraints and separation standards between converging runways or parallel runways do not allow new runways to fit on existing airport property. Land for new airports is simply not available where critical airport capacity is required. Environmental issues also limit the ability of airports to expand — e.g., during the 1990s, environmental issues forced 12 of the nation's busiest commercial airports to cancel or indefinitely postpone expansion projects.[viii]

Despite these constraints, air traffic is expected to continue to increase in the coming years and could double, or even triple, by 2025.[ix] All other factors remaining constant, such an increase will mean longer delays at airports already experiencing delays. At airports that do not currently experience frequent delays, a dramatic increase in air traffic will almost certainly create them. The associated environmental impact and economic inefficiencies could cost the nation $30 billion annually.[x] The risk of runway incursions and taxiway incidents at airports could increase as the volume of air traffic exceeds the capacity of the airports to safely and efficiently accommodate the increased traffic.

One of the biggest limiting factors in expanding air traffic capacity lies in airport operations, where a multitude of factors can cause flight delays and other incidents, the effects of which can cascade throughout the NAS. One significant factor is weather, particularly low cloud ceilings and poor visibility. This can impact arrival and departure paths and runway configuration, which do not easily adapt to changing weather conditions and dynamic schedule changes. In addition, traffic flow management on the airport surface is not well integrated with traffic flow management in other NAS domains, as each domain tends to focus on its own needs with inadequate consideration to system-wide efficiency. There are also complex merging and spacing requirements that must be negotiated as aircraft transition to and from the surface, terminal, and en route domains of the airspace. Sequencing and conflict mitigation must also be addressed to ensure that each aircraft maintains a safe distance from other aircraft, vehicles, terrain, and obstacles. The number of available runways, runway occupancy time requirements, wake separation requirements, surface congestion, and gate availability can each create a bottleneck at a given airport, at any given time. Safety and environmental needs must also be balanced. All of these conditions are further impacted by human performance, which often contributes to constraints in overall operational effectiveness.

Thus, it is not one factor that must be managed. Many factors must be managed in sequence or simultaneously. Meeting future NAS capacity needs presents an even greater challenge. As the Airspace Systems Program's research project for increasing capacity and throughput in the airport environment, the Airportal Project understands the dynamics of this complex problem. The research proposed in this document is focused on enabling the solution.

1.3.2 Airportal State-of-the-Art Technologies and Procedures

Airportal surface and terminal area management today is characterized by human operators making complex decisions with highly complex outcomes, using outdated, static operational procedures and, in many cases, limited software-based decision-support capabilities. In addition, information is poorly distributed, and most airports make minimal use of advanced decision-support capabilities and automation. Today's state-of-the-art technologies and research approaches do not adequately address the issues necessary to facilitate airportal capacity solutions.

There are a number of functions and procedures that may enable capacity benefits within the airport and terminal domains. Research has been conducted to try to determine the capacity improvements that may be attributed to some of these technologies, but these studies have not addressed the breadth of various procedures and technologies being developed for future operations. In addition, the interdependencies of new functions have not been adequately addressed. The Airportal Project will emphasize system studies (concepts, constraints, benefits) early in the project. These assessments will be updated as research findings mature and will help guide and prioritize the efforts within the Project.

Although there are many existing technologies that provide accurate surface surveillance (i.e., Airport Surface Detection Equipment [ASDE], Automatic Dependent Surveillance-Broadcast [ADS-B]), the ability to accurately predict the location and state of aircraft and vehicles has not been sufficiently addressed. These predictive capabilities are essential for NGATS strategic planning and coordinated surface management optimization. Research in this area is ongoing in the U.S. and in Europe; however, one of the existing significant challenges to improving predictability on the surface is the ability to identify and characterize uncertainties. Uncertainties are represented by weather effects, passenger and baggage handling, physical airport constraints, and several other factors related to the multiple users in the airport environment. Optimization strategies for surface operations must include the ability to account for these uncertainties. Thus, identification and investigation of these uncertainties are critical to achieving the capacity goals in this Project.

Another area where the state of the art is insufficient for dealing with significant NAS capacity increases is in arrival and departure management. In current operations, arrival and departure balancing is accomplished without automation assistance, and with little information sharing among the various operators. A strong connection between the management of surface operations and arrivals and departures does not exist today. This results in inefficiencies that lead to reductions in capacity in the terminal and airport area. In addition, coordination among nearby airports in a metroplex area is conducted without predictive information and with little or no flexibility to make adjustments to changing conditions. Research technologies and procedures have begun to address arrival and departure balancing, but they have not yet achieved the ability to represent the coordination of operations necessary when considering the interdependencies of the surface operations, as well as the coordination with airports in close proximity. The Airportal Project will be investigating these critical interactions to insure that requirements for the technologies that constitute potential solutions address the necessary interactions among the many operators within a metroplex environment.

In order to move traffic safely within the terminal area, wake disturbances must be accurately identified and accounted for in future technologies and procedures. Although wake modeling research and development has been ongoing for a number of years, there are several research challenges that exist in this area. Wake vortex decay in the presence of vertical shears and in ground effect, for example, is operationally significant to both in-trail and parallel runway super-density concepts. The modeling is not yet sufficiently developed to enable benefits. In addition, the development of probabilistic models is critical to account for some of the uncertainties that must be addressed to ensure system safety when predicting wake behavior.

Human performance is another research area where the Airportal Project can offer enhancements over the current state of the art. Several efforts have defined operator roles and responsibilities within the context of the NAS, but very little work has been done to define this work within the airport domain. Those tasks that have explored human factors in the airport and terminal area have done so relative to the current operations and procedures. The Airportal Project will define and evaluate the operator roles and responsibilities, and those of the automation tools, within the context of proposed new technologies and procedures. In addition, this Project will advance the state of the art in human performance modeling by adding airport and terminal operations and their implications to the data within the model, thereby allowing for evaluation of the future system-wide NAS operations in the modeling tools.

1.3.3 Rationale for Research Not Pursued

Resource constraints and competing priorities means that the Project must prioritize what research is conducted in support of the 2025 NGATS Operational Concept, vision, and goals. The key opportunities for improving capacity in the airportal environment include use of more runways or airports, increasing the base capacity of existing hubs, and reducing the capacity impact of adverse weather conditions. These opportunities suggest research topics in Super-Density Operations, Equivalent Visual Operations, and Aircraft Trajectory-Based Operations that contribute to increased metroplex and regional airport utilization, virtual towers, decoupling runway pairs that interfere with each other (closely-spaced parallel and converging runways), reduced wake vortex separation constraints, runway balancing, taxiway and gate use optimization including low-visibility taxi operations, and “ramp to en route” traffic management integration. The Project will emphasize system studies in the first years to assess those factors that most constrain achieving NGATS capacity goals in order to prioritize the research portfolio in the mid and later years of the Project. Research will also strive to identify transformational concepts enabled by the JPDO NGATS capabilities.

Due to finite resources, the Airportal Project will limit its research in a few technical areas. In particular, the Project will not initially pursue research in reduced runway occupancy time, wake vortex hazard characterization, or wake vortex sensors. Runway occupancy time was the subject of considerable research in prior NASA projects. A “Brake-to-Vacate” system is being introduced by a major transport aircraft manufacturer to reduce Runway Occupancy Time (ROT). The full spectrum of research relevant to reducing wake vortex constraints to Super Density Operations are beyond the scope of the project resources and activity there will focus within NASA’s unique skills in modeling and predicting wake behavior. Although hazard characterization is critical to the implementation of wake solutions and is required to firmly establish validation criteria for wake modeling and sensors, defining a hazard standard is an activity that regulatory agencies must lead. Until a joint approach to characterize the hazard is defined, NASA will employ plausible ranges of hazard definitions in its modeling, and collaborate with other agencies to help define the appropriate NASA contribution. Wake vortex sensor development is not pursued because commercial systems are available today to acquire these measurements in clear weather conditions, and efforts to develop all-weather sensors are beyond the scope of the Airportal resources. Virtual tower research is not an emphasis and will be limited in scope to consist of identifying opportunities for enabling research in automated surface planning, runway balancing and scheduling, equivalent visual operations, and human information requirements to contribute to NGATS virtual tower concepts.

Updates to this plan will refine several themes introduced in this plan but not yet fully developed. The first theme is system safety methodology to assess and manage the risk of transformational systems for which little or no historical data exists to assess component risks or failure modes. This theme includes data mining, risk assessment methodologies, large-deviation theory to quantify rare events, and system failure modes and recovery methods. The second theme is addressing the metroplex airport configuration from an opportunity space perspective. Most metroplex research to date addresses management of complex airspace traffic flow interactions between multiple airports to mitigate associated operational constraints. An additional opportunity space may exist to manage schedules, route networks, and airport balancing to achieve greater capacity in a metropolitan area. The third theme is prioritization of specific runway complex operational concepts for detailed research, to take place as initial system constraint and benefit studies mature and initial assessments are made of a wide variety of concepts. The Project approach is to open the concept space so as to facilitate identification of innovative, transformational concepts, then refine activities to address the most promising. The fourth theme is increased integration of environmental modeling (performed by the Subsonic Fixed Wing Project and the JPDO Systems and Engineering Analysis Division) with surface and runway operational concept evaluations. The fifth theme is increased integration across the Airportal and Airspace Projects of common capabilities and studies in areas of modeling and simulation, 4D trajectory attributes and uncertainty, human/system integration, human performance modeling, concepts of operation, safety methodologies, and common demand scenarios for benefits analysis.

Airportal resources will be leveraged to the maximum extent with contributions from relevant NASA projects. In particular flight deck technologies and concepts being developed by the IIFDT Project will be investigated as enabling Airportal Super-Density and Equivalent Visual Operations. Collaboration with the Subsonic Fixed-Wing Project will provide environmental modeling and estimated benefits of advanced aircraft technologies. The NGATS ATM-Airspace project is also investing in several key capabilities enabling to Airportal concepts, including 4D Trajectory capabilities, trajectory uncertainty estimation, foundational human performance modeling, metroplex operations, and gate-to-gate concepts of operation.

1.3.4 Innovative Nature of Research

The 2025 NGATS Operational Concept represents a transformation of today's air transportation system from an outdated system that is unable to respond to the forces of change to a future system that is dynamic, flexible, responsive and able to meet future needs. The most significant challenges in Airportal research will be identified and addressed to enable the capacity growth predicted by the JPDO. The Airportal Project's work in advanced operational concepts will contribute to that future system with innovative technologies and processes and new applications of existing Airportal technologies and processes. The concepts and technologies lay the foundation for increased capacity by allowing for significant advancements in the identification, prediction, and analyses of airport and terminal capacity constraints. This also permits additional work in deriving solution sets that include optimization functions and methods.

The Airportal Project will address research issues in the airport and terminal domains by conducting discipline-based technology development in support of the 2025 NGATS Operational Concept as defined by the JPDO. The foundational research and development areas for this project include surface traffic movement optimization, automation and human factors, predictive algorithms, system safety, technologies supporting reduced separation standards, and data-mining methodologies. In addition, the interaction with the aeronautics and aviation community at the systems level (Levels 3 and 4) is also unique because the Airportal Project will work jointly with partners to research surface management, coordinated arrivals and departures, and metroplex operations. Collaborations associated with system-level design and operation ensures the Project's ability to provide integrated solutions for safe, efficient, high capacity Airportal systems.

1.3.5 NGATS ATM-Airportal Project Level Chart

Figure 1 shows the Airportal Project research and development activities in support of the JPDO vision, 2025 NGATS Operational Concept, and Airspace Systems Program guidance. In an attempt to address the relevant concepts, technologies, and analyses, three primary research areas are proposed: Safe and Efficient Surface Operations (SESO), Coordinated Approach/Departure Operations Management (CADOM), and Airportal Transition and Integration Management (ATIM). Each area conducts research at Levels 1-4. The focus represented at Level 4 is to develop integrated solution sets for safe, efficient, high capacity airportals by optimizing operations in the terminal and airportal domains of the NAS. No two airportals are identical, and constraints to capacity as well as capacity demands vary greatly from one airport to another. The emphasis at Levels 1-2 is to develop elemental capabilities, or building blocks, with which to formulate, at Level 3, operational benefits for the surface domain (gates, ramps, and taxiways) and runway domain (runway surface, multiple-runway coupling, and associated terminal airspace). Alternate combinations and permutations of these capacity options are formulated and assessed at Level 4 to provide the concepts and knowledge required to adapt the elemental building blocks to various airportal challenges and needs. The chart shows proposed research at all levels with NASA-sponsored academic and industrial research partners working with the Project at Levels 1-2. NASA, JPDO-contributing agencies, and large systems integrators are working with the Project at Levels 3-4. This approach ensures that ARMD will provide intellectual stewardship of the engineering and science needed to develop research results and products for the terminal and airportal technical domains in order to meet national needs as established by NASA and the JPDO.

Research will draw on NASA's core strengths. The chart below, Figure 1, shows a decomposition of the research with foundational research at Level 1, disciplinary research at Level 2 to develop elemental capabilities, and multi-disciplinary domain-specific research at Level 3 employing super density operations, equivalent visual operations, and trajectory-based operations. Research culminates in NAS-wide integrated solution sets to enable NGATS capacity goals at Level 4. There is significant linkage and integration between the three research areas, with surface capabilities and operations focused within SESO, runway capabilities and operations focused within CADOM, and metroplex/regional operations, analysis of Conops, and human/automation principles focused within ATIM.

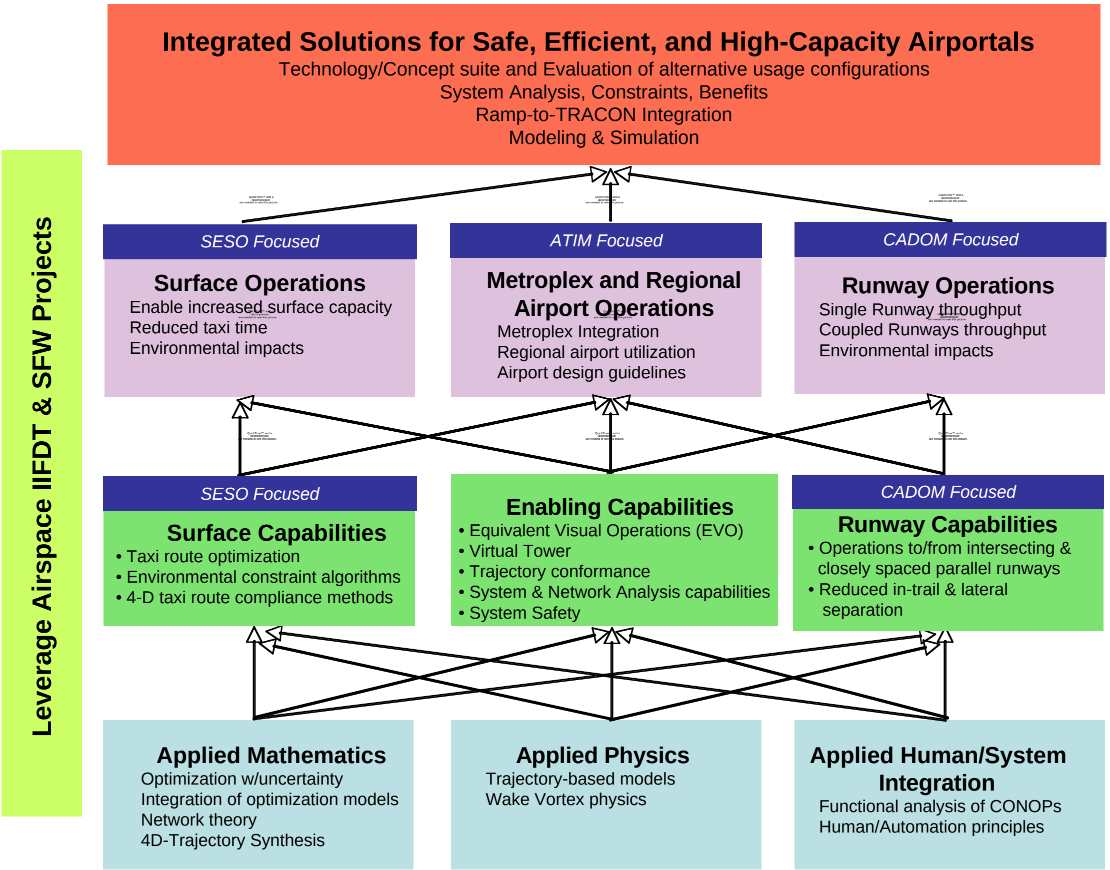

Figure 1. NGATS ATM-Airportal Project Level Chart

1.3.6 Coordination with the NGATS ATM-Airspace Project

Although surface operations and terminal areas have unique constraints, airspace and airportal solutions are necessarily dependent upon one another. Many improvements in one area rely on close coordination with improvements in the other in order to ensure capacity improvements throughout the NAS. Therefore, the Airportal Project will tightly couple research activities with work in the NGATS ATM-Airspace Project. The Projects will exchange and eventually integrate requirements, technologies, and procedures in common capabilities such as 4D trajectory-based operations, separation assurance, demand scenarios, and coordinated concepts of operation.

The functional division between airportal and airspace research areas resides within the terminal airspace. The integration between the NGATS ATM-Airportal and Airspace Projects will be a result of the functions that cross the domains of the two projects, or functional building blocks, such as 4D trajectory capabilities, used by both projects. Proposed research in the Airportal Project will focus on concepts, technologies, constraints, and procedures related to surface operations, separation assurance, operations at single runways and multiple runways with airspace or taxiing interactions, wake vortex prediction, departure management, and final approach. The NGATS ATM-Airspace Project will deliver aircraft within the terminal area in accordance with airport surface operations and runway/final approach requirements. Similarly, the Airportal Project will deliver aircraft to the terminal area relative to airspace constraints.

Unlike high altitude airspace where aircraft have abundant room to maneuver, airportal surface movement with its complex network of taxiways, runways, and ramps can be highly restrictive during peak traffic hours. Also, aircraft flight paths become tightly restricted during peak traffic times as aircraft move closer to the surface and line up to land with speed adjustment and altitude degrees of freedom no longer available to Air Traffic Control (ATC) after aircraft join the final approach segment. The airportal constraints dominate the aircraft trajectory within this airspace.

1.4 ATM-Airportal Project Milestones and Metrics

Table 1 identifies and describes the milestones, metrics, and dependencies that the Airportal Project will use to measure progress toward specific deliverables.

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Table 1. *NGATS ATM-Airportal Project Milestones and Metrics*

Airportal Milestones Numbering Scheme

Project	Level	Area	Description
AP	.4 .3 .2 .1	S C A	Safe and Efficient Surface Operations Coordinated Arrival and Departure Operations Management Airportal Transition and Integration Management

Level 4 Milestones

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.4.S.01	4Q11	Initial validation of 4 Dimensional trajectory (4DT)-based safe and efficient surface operation functions and procedures	Perform validation of automated, safe, and efficient surface operations for normal and off-normal conditions through fast- and real-time simulations. Fast-time simulations are used to evaluate performance of integrated functions. Real-time simulations with human-in-the-loop (flight deck and service providers) will be used for assessing effectiveness of computer generated clearances and advisories.	Metrics include runway throughput, average taxi delays at 2x and 3x operations, exceedance of environmental constraints at 2x and 3x, maximum throughput available within environmental constraints, fuel savings, runway crossing time compliance, efficacy of runway incursion techniques, and system operator acceptance/compliance of taxi clearances. Metrics compare simulation findings with 2005 published operational performance at 3 major airports. Metric targets to be established by ATIM system analysis studies (AP.3.A.03).	AP.1.A.02 AP.2.A.02 AP.2.A.05 AP.2.A.11 AP.2.S.04 AP.2.S.05 AP.2.S.08 AP.2.S.09 AP.3.A.03 AP.3.A.07 AP.3.S.01 AP.3.S.02 AP.3.S.03	AP.4.A.01
AP.4.C.01	4Q11	Assessment of an integrated suite of Airportal concepts and technologies needed to mitigate operational constraints to achieving the single-airport contribution to NGATS capacity goals.	For individual airports of various configurations, assess the benefits of the various combinations and configurations of the multiple concepts developed for surface, single-runway, and multiple-runway capacity enhancements.	Airport capacity goal metrics set via system studies that define metro-region demand and the relative contributions of individual airports and multi-airport integration. Metrics include maximum potential capacity achievable, demand vs. delay characteristics, cost/benefit/safety trends and relative performance of alternate technology configurations. The outcome is a set of guidelines for JPDO use in choosing and combining Airportal results to achieve specific, site-dependent, goals.	AP.3.C.02 AP.3.C.07 AP.3.C.10	AP.4.A.01

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.4.A.01	4Q11	Initial simulation(s) of integrated sets of Airportal super-density concept elements and capabilities	Perform a set of culminating experiments to quantify system-level dynamics of, and measure contributions of key Airportal contributions to, super-density operations. The scope of the experiments will include multiple airports (and associated terminal airspace) within a metropolitan region. Key aspects include optimization for taxi scheduling and route planning, balanced allocation of Airportal resources to maximize Airportal productivity in response to arrival, departure, and surface traffic demands, SESO CD&R, and CADOM and SESO contributions to equivalent visual operations. Fast-time simulations will be used to evaluate the performance of Airportal concepts and algorithms. Selected non-normal and off-nominal situations, including system failures, emergency events, and weather impacts will be studied. This work assesses the foundation for airport and terminal planning and scheduling for enhanced throughput, and establishes the scope for out-year real-time simulation experiments.	Results quantify the benefits of a suite of surface, runway, and metroplex operational concepts applicable to at least three reference airport/metroplex configurations that illustrate relevant multiple runway and multiple airport constraints, as determined by airport studies (AP.3.C.07). Results define combinations of concepts and technologies required to achieve JPDO capacity and efficiency goals or identify roadblocks to achieving those goals where they may exist. Completion of peer review by, and disposition of comments from, the JPDO Systems and Engineering Analysis Division (SEAD) (or equivalent). Metrics include impacts on: throughput (per hour) and productivity of the individual and set of airports, aggregate measures of taxi delays during peak operations, fuel consumption, emissions, noise, and rates of runway/taxiway conflicts/incidents. The outcome is a set of guidelines and modeling tools for JPDO use in choosing and combining Airportal results to achieve specific, metroplex-dependent, NAS-wide goals.	AP.1.A.02 AP.2.A.01 AP.2.A.02 AP.2.A.06 AP.2.A.11 AP.2.S.04 AP.3.A.03 AP.3.A.04 AP.3.A.05 AP.3.A.06 AP.3.C.05 AP.3.C.07 AP.3.C.09 AP.3.S.02 AP.3.S.03 AP.4.S.01 AP.4.C.01	Out year Milestones

Level 3 Milestones

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.A.01	4Q07	Develop initial Airportal operational concepts, including Airportal functions, requirements, and procedures	Development of operational concept options and considerations for the Airportal environment. Concept will include Associate Principal Investigator/Principal Investigator/Project Scientist (API/PI/PS) concurrence, integration of API concept additions, and coordination/integration with Airspace project ConOps.	Concepts include alternatives for operations in each of the Airportal domains of gate, ramp, taxiway, runway, and terminal airspace which are consistent with and add detail to the high-level NGATS CONOPS, and show consideration of opportunities enabled by NGATS capabilities such as RNP, 4D-trajectory based operations, and shared situational awareness. Appropriate references are provided to point to relevant research results (by NASA, FAA, industry, and academia) in constraints and operational concepts to help determine the degree to which individual concepts have been studied and aid detailed future project planning.	Existing work AP.1.C.01	AP.1.S.02 AP.1.S.03 AP.1.S.04 AP.2.A.10 AP.2.A.04 AP.2.A.06 AP.2.S.03 AP.2.S.06 AP.2.S.07 AP.2.S.08 AP.2.S.09 AP.3.A.03 AP.3.A.04 AP.3.S.02 AP.3.C.01 AP.4.A.01
AP.3.A.02	4Q07	Conduct initial operational concept analyses for research portfolio management decision making	Primary research to indicate "risk-adjusted potential benefits" of the areas of opportunity for NASA Airportal research.	Results describe risk-adjusted potential benefits of each concept identified by AP.3.A.01 to include the potential benefit mechanisms and conditions under which the benefits might be realized.	Existing work	AP.3.A.03 AP.3.A.04 AP.3.A.06 AP.3.C.10
AP.3.C.01	4Q08	Catalog and assess alternatives for runway balancing and the potential benefits	Literature searches, and interviews with key researchers and authorities to develop a list of concept options for improving the throughput of runways and associated ground operations by managing the sequencing, scheduling, and assignments of arriving and departing aircraft to runways. Both runway to taxiway and runway to airside coordination should be considered. Provide an initial quantitative assessment of the potential benefits, required operational capabilities and/or equipage, and safety issues to guide further study or detailed assessments.	Results identify alternate mechanisms (at least six) for capacity or efficiency increases by managing the assignment, scheduling, or sequencing of aircraft to or from single-runways or multiple-runways on a single airport. Results provide initial estimates of quantitative benefits, or more detailed benefits if available from prior research. Appropriate references are provided to point to relevant research results (by NASA, FAA, industry, and academia) to help determine the degree to which individual concepts have been studied and aid detailed future project planning. Implications for management of aircraft on the surface and in the terminal/en route domains are specified. The results also show consideration for opportunities enabled by NGATS capabilities	AP.1.C.01 AP.3.A.01 AP.2.S.03	AP.2.C.04 AP.3.A.04

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.C.02	4Q08	Identify key airport capacity constraint factors and rank according to airport demand forecasts	Identify key airport capacity constraints, and quantify and rank their impact on Airportal operations. Consider factors such as meteorological conditions, runway configuration, gates, surface operations, noise and environment. Conduct a combination of literature searches, interview with leading analysts, and system studies or simulations to identify the major constraints to achieving Airportal capacity and identify the relative criticality of each constraint based on the number of airports affected, frequency of impact at those airports, and relative NGATS demand forecasts at those airports. Airportal capacity goals can only be achieved by considering the airport infrastructure as a system. The NGATS capacity gains do not imply equal gains at every airport. Some may only be capable of increasing capacity 10% to 50% of current rates while other (underutilized) airports may need to increase by factors of 3 to 5. Understanding the options available and the most beneficial concepts and technologies to study will require an estimate of the NGATS demand growth at individual metropolitan areas, and the estimated airport infrastructure and attributes at and near that area. This study will leverage FAA forecasts and prior NASA demand modeling to assess potential future growth scenarios and identify the greatest future capacity gaps. Results will be used to guide the CADOM research portfolio and to enable targets to be set for specific contributions to overall capacity.	Results shall tabulate the airports of significance to NGATS capacity goals (56 FACT 2 study airports at the minimum). For each airport the results shall describe the airport geometry (taxiway and runways, spacing between parallel runways), runway configurations used as a function of weather condition (winds, ceiling, visibility), current VMC and IMC capacity, primary capacity constraints (may be more than one depending on airport configuration or weather conditions) and the next two constraints expected to dominate as primary constraints are mitigated. The results should also provide the forecast demand at each airport through 2025, uncertainty factors in this forecast, and the current and expected fleet mix (small, large, heavy). The difference between demand and capacity at each of these airports will be defined. Key constraint results will include at a minimum description of criticality of gate availability, taxi constraints, single runway capacity for arrival and departure, constraints due to runways that interfere with each other (converging or parallel), coupling between arrivals and departures or runway crossings during taxi, constraints due to loss of capacity or runway utilization as the weather condition varies, terminal airspace design constraints, and operational factors that introduce non-physics based inefficiencies (for example separating aircraft from airspace rather than from aircraft to simplify traffic complexity). The relative importance of the following factors (at a minimum) will be provided: loss of visual conditions, runway coupling factors, wake vortex constraints, gate availability, taxi route/schedule optimization, and environment	New work AP.3.A.03	AP.2.C.07 AP.3.C.04 AP.3.C.07
AP.3.A.03	4Q08	Define baseline performance expectations and metrics for Airportal operations, including regional airports	Primary research to focus on literature review to gain understanding of baseline performance and relevant metrics with consideration for range of equipage, and use of regional airports. The baseline is envisioned as being a representation of the current system, but could include aspects of early NGATS concepts as appropriate.	The results will identify at least two quantitative metrics for capacity, safety, and throughput. The performance expectations will be expressed in terms of the 2005 OEP metrics, as well as any additional metrics identified based on results from AP.3.A.01 and AP.3.A.02, and expert technical input from the Airportal APIs.. References are provided as well as a gap assessment of the literature.	Existing work AP.3.A.01 AP.3.A.02	AP.2.S.03 AP.3.A.06 AP.3.C.02 AP.3.S.02 AP.3.S.03 AP.4.A.01 AP.4.S.01

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.S.01	1Q09	Develop baseline tools for surface operations data analysis and real-time system performance monitoring	Database application software will be developed to analyze the large amount of operational data originating from different sources including surveillance systems, simulations, and decision support systems. The tool extracts information regarding individual aircraft such as Out-Off-On-In (OOOI) times and runway crossing time. The tool also provides aggregate surface traffic information such as the number of operations on each runway within specified time intervals. Algorithms will be developed to monitor surface system performance, in real-time, such as runway load distributions, and taxi conformance on both an individual and aggregate basis. Data mining techniques will be applied and/or developed for this purpose. The algorithms will also *predict* system-performance parameters and surface events.	Validation of derived data against independent data sources (e.g., Aviation System Performance Metrics); validation of predicted vs. actual surface performance data (taxi delays, number of aircraft in the queue...) during post-run analysis results; subjective evaluation of usability of developed tools by subject matter experts. Validation methods/targets to be defined by 3Q08 to potentially include review by Subject Matter Experts (SME) that the prediction of surface events is as good or better than an experienced SME. This baseline performance level will be assessed for overall system performance by the studies of AP.3.S.02.	AP.2.S.04 AP.2.S.05	AP.3.S.02 AP.4.S.01

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.C.04	1Q09	Identify the mechanisms that lead to differences between IMC and VMC rates of operations, potential technologies and procedures that could eliminate the differences, and the ranking/weight of such procedures	Literature searches, and interviews with key researchers to identify the specific mechanisms (e.g., loss of visual approaches, changing runway availability due to missed approach path conflicts, other) that lead to the differences between Airportal capacity in instrument and visual meteorological conditions. Identify potential concepts or technologies for mitigating these differences and, using demand forecasts and location specific airport attributes, ranks the relative contribution of each mitigation concept to achieving the NGATS capacity goals.	Results shall tabulate the airports of significance to NGATS capacity goals (56 FACT 2 study airports at the minimum). For each airport the results shall describe the airport geometry (taxiway and runways, spacing between parallel runways), runway configurations used as a function of weather condition (winds, ceiling, visibility), current VMC and IMC capacity, primary capacity constraints (may be more than one depending on airport configuration or weather conditions) and the next two constraints expected to dominate as primary constraints are mitigated. The results should also provide the forecast demand at each airport through 2025, uncertainty factors in this forecast, and the current and expected fleet mix (small, large, heavy). The difference between demand and capacity at each of these airports will be defined. Key constraint results will include at a minimum description of criticality of gate availability, taxi constraints, single runway capacity for arrival and departure, constraints due to runways that interfere with each other (converging or parallel), coupling between arrivals and departures or runway crossings during taxi, constraints due to loss of capacity or runway utilization as the weather condition varies, terminal airspace design constraints, and operational factors that introduce non-physics based inefficiencies (for example separating aircraft from airspace rather than from aircraft to simplify traffic complexity). The relative importance of the following factors (at a minimum) will be provided: loss of visual conditions, runway coupling factors, wake vortex constraints, gate availability, taxi route/schedule optimization, and environment.	AP.3.C.02	AP.3.C.06
AP.3.C.06	4Q09	Develop initial concepts for leveraging IIFDT EVO capabilities to enable CSPR and converging runway arrivals	Research to develop and document candidate concepts of operation for arrival operations to closely-spaced and converging runways under restricted visibility conditions. Develop recommendations for research to enable equivalent visual operations based on equipage developed by ARMD Safety Program. This milestone will be performed in coordination with the IIFDT project.	At least three concepts per operation type (CSPR, converging, intersecting runways) should be proposed, at least one of which should be compatible with or enabling to airports with no-towers or virtual towers. Concepts define potential benefit mechanisms, conditions under which the concept may be used, and limitations of the concepts.	AP.3.C.04 IIFDT	AP.2.C.03 AP.3.A.04 AP.3.C.07 AP.3.C.09

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.S.02	3Q10	Integrate and evaluate surface traffic planning algorithms/tools in fast-time simulation environment	Integration of taxi route planning, runway schedule, environmental model, and surface operations data analysis into a fast-time simulation environment. Test optimized taxi routes meeting departure schedule constraints. The departure scheduler provides optimal schedule as input to taxi route solution. Taxi optimization solution generates time-based taxi routes that minimize overall taxi delays and maximize runway throughputs. Conduct fast-time simulations to evaluate the benefits in both normal and off-normal conditions.	Via fast time simulation to show the ability to manage 2x traffic demand scenarios with taxi delays similar to the baseline (1x throughput without optimization). Results of this milestone will be used to determine the utility of this optimization approach. Metrics include average taxi delay reduction, throughput increase, environmental impacts, and fuel efficiency under increased Airportal traffic density. The performance improvement is based on comparison to taxi routes developed by subject matter experts presented with the same 1X and 2X traffic-demand scenarios. Results are used to feed benefits analysis and trade studies to assess potential utility of taxi route optimization	AP.1.A.02 AP.1.S.04 AP.2.A.01 AP.2.A.02 AP.2.C.04 AP.2.S.03 AP.2.S.04 AP.3.A.01 AP.3.S.01	AP.3.C.05 AP.3.C.09 AP.4.S.01 AP.4.A.01
AP.3.C.05	3Q10	Initial evaluation of integrated systems for optimizing automated surface operations and arrival/departure operations	Evaluation includes initial integrated Airportal traffic flow management through fast-time simulations. Initial system integrates Airportal capacity-enhancing capabilities (e.g. optimized surface operations & improved runway operations) with decision support capabilities (e.g. arrival/departure balancing).	Metrics include average taxi delay reduction and airport throughput increase under a range of traffic density with first generation integrated operations. Results to be used to determine issues associated with surface/runway integration and to feed system studies to define future research.	AP.2.C.02 AP.2.C.03 AP.2.C.04 AP.3.S.02	AP.3.C.07 AP.3.C.09 AP.4.A.01
AP.3.C.07	4Q10	Determine the distribution of eligible airports for specific improvements - CSPR, converging runways, high approach landing concepts, new regional airports, new gates	Use operational forecasts, airport layouts, and locations of underutilized regional airports, as well as cataloging of capacity enhancing concepts, to determine the number of locations (metropolitan areas and airports) that may achieve benefit from the various concepts or where the concepts may enable new runway construction, and the fraction of future demand gaps that are closed by these locations. The result is a demand-weighted summary of concepts~~.~~	At a minimum the 56 airports tabulated in the FAA FACT 2 study will be studied. For these airports the results will define which may be eligible for new parallel or converging/intersecting runways under at least the scenarios of current-day constraints and two reduced-constraint scenarios enabled by NGATS capabilities. At least the alternative concepts identified in AP.2.C.02, AP.2.C.03, AP.3.C.06 are considered as potential capacity-enhancing concepts for each airport.	AP.2.C.02 AP.2.C.03 AP.3.C.02 AP.3.C.05 AP.3.C.06 AP.3.C.08	AP.3.A.06 AP.3.C.08 AP.3.C.10
AP.3.C.08	4Q10	Evaluate potential Airportal capacity impacts of a change in aircraft mix, such as incorporation of short haul, tilt rotor, Extreme Short Take-Off and Landing (ESTOL) and Supersonic Business Jet (SSBJ)	Future changes in fleet mix, to include aircraft tailored to the demands of the NGATS, may open new opportunities to meet demand or may create new constraints. Collaborate with the Subsonic Fixed Wing (SFW) and Subsonic Rotary Wing (SRW) projects and possibly the proposed JPDO Aircraft Working Group to define opportunities and incorporate into the Airportal research.	Metrics include nature of the impact (benefit or constraint) relative to capacity, efficiency, and the environment, whether the interaction should affect Airportal research task or SFW/SRW tasks or both, and the timeframe for potential realization. Results disseminated to Program Director (PD) and PI of each affected ARMD project.	AP.3.C.07 SFW SRW	AP.3.A.06 AP.3.C.07

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.A.07	4Q10	Guidelines for shared decision-making in the Airportal environment	Define protocols and sharing of key information to enhance collaborative decisions (e.g., pilot-controller, tower-ramp/dispatch, controller-TFM, surface-tower-terminal, etc.)	Protocols include potential future scenarios of candidate NGATS changes as well as communications between pilots and controllers. Report includes descriptions of decision-making roles and communication processes among multiple operators in a dynamic environment, and protocols to enhance collaborative decision-making process.	AP.2.A.10 AP.2.A.11	AP.3.A.04 AP.3.S.03 AP.4.S.01
AP.3.A.04	4Q10	Develop intermediate Airportal operational concepts, including Airportal functions, requirements, and procedures	Development of operational concepts of use for the Airportal environment including consideration of the interaction with the airspace and regional operations. The concepts will feature the project's technical area contributions in the context of a concept of operations that addresses the overall set of Airportal problems with consideration for alternative concept (solution) approaches.	Concepts include alternatives for operation in each of the Airportal domains of gate, ramp, taxiway, runway, and terminal airspace which are consistent with, and add detail to, the high-level NGATS CONOPS, and show consideration of opportunities enabled by NGATS. Peer review of concepts with the JPDO is completed and comments addressed.	AP.2.A.01 AP.2.A.03 AP.2.A.06 AP.2.A.11 AP.2.C.02 AP.2.C.03 AP.2.S.03 AP.2.S.06 AP.2.S.07 AP.2.S.08 AP.2.S.09 AP.3.A.01 AP.3.A.02 AP.3.A.07 AP.3.C.06 AP.3.C.09 AP.3.S.02	AP.2.A.07 AP.3.A.06 AP.4.A.01
AP.3.C.09	2Q11	Develop coordinated air/surface Airportal concept of operations for single-airport capacity enhancement	Develop terminal and airport configuration techniques for nominal operations based on surface optimization, runway balancing, coupled runway constraint mitigation, and wake vortex separation. Research integrates results from SESO and CADOM for single-airport optimization and feeds ATIM metroplex optimization.	Results provide requirements for interfacing concepts, information exchange, and operational procedures developed within the Project for culminating experiments to be conducted by CADOM and ATIM. Successful completion of Requirements Review.	AP.2.C.07 AP.3.C.05 AP.3.C.06 AP.3.S.02	AP.3.A.04 AP.3.C.10 AP.4.C.01 AP.4.A.01
AP.3.C.10	3Q11	Assess potential shortcomings of proposed Airportal concepts using safety methodologies for rare events and blunders	Enable Airportal system level concept assessments by developing the methodologies and algorithms to assess safety for concepts that may be inhibited by provision for very rare events, for example the 30 degree blunder constraints to CSPR approaches. Provide a risk based (Safety Management System compatible) methodology for assessing safety risk of proposed Airportal concepts. Identify potential means or strategies for collecting and analyzing field data to assess the frequency of rare events.	Results provide a tabulation of rare events that may govern or inhibit specific Airportal concepts and the estimated probability of each rare event taking place. Specific metrics to be identified during concept development activities AP.2.C.02 and AP.2.C.03.	AP.1.C.06 AP.2.C.02 AP.2.C.03 AP.2.C.06 AP.3.A.02 AP.3.C.07 AP.3.C.09	AP.4.C.01

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.3.A.06	3Q11	Conduct intermediate benefits analysis of Airportal solutions for capacity and safety enhancements	Final update of concept/benefits analyses to capture the project's "risk-adjusted" potential benefit contribution to the NGATS capacity, flexibility, efficiency, and safety goals. Additional considerations will include how Airportal Project's capabilities may impact Airspace Project capabilities and benefits. Collaboration with JPDO and related FAA activities to maximize leveraging of relevant tools, analyses, and results.	Results include analysis of solution concepts identified by Qtr4, FY10 within SESO, CADOM, and ATIM and consider, at a minimum, the factors of capacity, efficiency, and environmental. Analysis considers the frequency of occurrence of the conditions that enable the benefit to accrue. A peer review by, and disposition of comments from, the JPDO SEAD (or equivalent) is completed.	AP.3.A.02 AP.3.A.03 AP.3.A.04 AP.3.C.07 AP.3.C.08	AP.4.A.01 Out-year Milestones
AP.3.A.05	3Q11	Integration of Airportal human performance model with Airportal modeling and simulation capabilities	Integration of the human performance capabilities with the Airportal capabilities	Airportal human performance model software is interfaced with other airport simulation capabilities, and software interfaces are tested. Validation of the HPM itself to be described by AP.2.A.05.	AP.2.A.04 AP.2.A.05	AP.4.A.01
AP.3.S.03	4Q11	Integrate and evaluate initial runway/ surface conflict detection and resolution	Primary focus is to integrate aircraft-based solution of low altitude/runway/taxiway conflict detection & resolution (CD&R) and ground-based taxi conformance monitoring and longer term CD&R solution. Probability of Detection (POD) and Probability of False Detection (PFD) will be determined as function of key parameters such as equipage and time horizon. Human-in-the-loop simulations are necessary in order to evaluate the effectiveness of CD&R advisories.	Metrics include Probability of Detection (POD) and Probability of False Detection (PFD) of conflict detection (for runway/low altitude/taxiway incursion) and taxi clearance conformance via simulations. Assess time-to-conflict at detection of the conflict. Human factors analysis results in pilot/controller evaluation on alerting and resolution advisories. POD and PFD targets to be established by 1Q11 based on collaborations with JPDO/FAA and FAA standards for intended function, and approved by Project PI/Program PD.	AP.2.A.03 AP.2.S.03 AP.2.S.07 AP.2.S.10 AP.2.S.11 AP.3.A.07	AP.4.S.01 AP.4.A.01

Level 2 Milestones

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.C.02	3Q08	Catalog and assess alternatives for reduced in-trail separation	Literature searches, and interviews with key researchers and authorities to develop a list of concept options for improving the acceptance rate of individual runways to arriving and departing aircraft. Examples of concepts include displaced thresholds to operate smaller aircraft above the glide slope of larger aircraft (High Approach Landing System), dynamic wake vortex constraints, aircraft sequencing to avoid unfavorable arrival pairs, and other concepts. Provide an initial qualitative assessment of the potential benefits, required operational capabilities and/or equipage, and safety issues to guide further study or detailed assessments.	Results identify alternate concepts (at least six) for increased single-runway capacity increases due to reduced in-trail aircraft spacing on arrival and departure. At least three of the concepts must not require active wake vortex prediction. Results specify initial estimates of potential throughput increases, benefit mechanisms, estimated availability of the concepts (e.g.; VMC or IMC only, low visibility only, for heavy aircraft only...), and safety issues. Appropriate references are provided to point to relevant research results. Implications for management of aircraft on the surface and in the terminal/en route domains are specified. The results also show consideration for opportunities enabled by NGATS capabilities.	New work	AP.2.C.04 AP.3.C.05 AP.3.A.04
AP.2.S.04	4Q08	Develop a fast-time simulation environment to evaluate performance of surface traffic optimization algorithms	This milestone is to develop requirements and software for a high-fidelity fast-time surface traffic simulation capability. The surface will be modeled using a node-link representation depicting gates, aprons, taxiways, and runways. The simulation software will provide an aircraft simulation model that will interface with the surface traffic-planning module. The simulation software architecture will be flexible enough to accommodate various degrees of fidelity in both aircraft simulation model and surface traffic planning technique.	Validate simulation against actual traffic data (e.g., taxi delay, aircraft in the queue) from several operational scenarios (e.g., heavy demand, challenging weather, runway or taxiway closure) and document the variance in simulation outputs. Validation targets to be developed by1Q08, potentially including review by SMEs that the simulation provides a suitable representation of surface traffic behavior, and will be approved by the Project PI.	AP.1.S.03 AP.2.S.03	AP.2.C.07 AP.2.S.08 AP.3.S.01 AP.3.S.02 AP.4.A.01 AP.4.S.01
AP.2.S.05	4Q08	Develop a real-time simulation environment to evaluate performance of surface traffic algorithms	This milestone is to develop requirements and software to provide a high-fidelity real-time surface traffic simulation capability to evaluate surface algorithms in real-time. The software development requires integration of existing surface model and aircraft target generation capability. The simulation software architecture will be flexible enough to accommodate various degrees of fidelity in both aircraft simulation model and surface traffic planning technique.	Quantitative and qualitative assessment of simulation data against actual traffic data (e.g., taxi delay, aircraft in the queue) from several operational scenarios. Document reports the variance in simulation outputs. Validation targets to be developed by1Q08, potentially including review by SMEs that the simulation provides a suitable representation of surface traffic behavior, and will be approved by the Project PI.	AP.1.S.03 AP.2.S.03	AP.2.C.04 AP.2.S.08 AP.3.S.01 AP.4.S.01

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.A.01	4Q08	Identify and describe constraints that need to be communicated between the Airportal Project (SESO & CADOM) and the ASDO/Airspace Project to enable seamless transition	Research to identify surface-related constraints that must be considered by the terminal area technologies and procedures. These constraints would need to be addressed to insure seamless transition between the NGATS Airportal and Airspace domains to enable transformational concepts while providing flexibility to support future concept research paths.	Results describe the information types and objects that are common to the domains of surface operations, runway operations (including approach and departure paths), terminal metering and spacing, and en route trajectory management, and the decision processes performed in these domains that require information from any of the other domains. Review by Airspace Project researchers and JPDO is conducted to determine that the reported set of constraints appears essentially complete. This is a risk reduction milestone and any missed information types or constraints should be identified later as research tasks across research areas are integrated.	Existing work	AP.3.S.02 AP.3.A.04 AP.4.A.01
AP.2.A.02	4Q08	Determine the model requirements for integration of the surface model with the NAS system model	Determine (in collaboration with the Airspace Project) the requirements for creating the necessary "hooks" for linking the surface and NAS system model to insure successful model integration.	The milestone is met upon successful completion of a Requirements Review, to be completed prior to software design and coding, indicating concurrence by the surface model and NAS model software engineers and the SESO API that the integration requirements are complete.	Existing work	AP.3.S.02 AP.4.S.01 AP.4.A.01
AP.2.C.04	2Q09	Develop initial airport arrival/departure balancing algorithm	Research provides initial algorithms to define balance for airport arrival/departure operations. Algorithm identifies high-capacity solutions within the solution space of possible airport operations.	Metrics include airport throughput and/or total aircraft delays with a fixed demand during steady state weather conditions and during wind shifts requiring runway configuration changes. Benefit is validated by comparing throughput to that produced by subject matter experts (SME) in the same scenarios and by comparison to the estimated theoretical maximum throughput values (considering no uncertainties or unused slots). The target for the initial algorithm is performance at least equal to an experienced SME.	AP.2.C.02 AP.2.S.05 AP.3.C.01	AP.2.S.03 AP.3.C.05
AP.2.A.03	2Q09	Develop preliminary functional allocation (roles/ responsibilities) among system users and automation technologies	Develop candidate roles and responsibilities for system users and automation technologies in interim Airportal environment.	Identified roles and responsibilities address the Airportal surface domain, related ANSP functions, and a plausible range of allocation between humans and automation and between ANSP and aircraft. This is a risk reduction milestone and results will be refined or added to by ongoing assessments of alternatives within SESO and CADOM.	AP.1.A.01 AP.2.A.10	AP.2.A.11 AP.2.S.06 AP.2.S.07 AP.2.S.09 AP.3.A.04 AP.3.S.03

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.S.03	3Q09	Develop algorithms to generate robust optimized solutions for surface traffic planning and control	The research focus is to develop system architecture and algorithms to generate optimized solution(s) for surface traffic planning and control including taxi routes and runway schedule, to allow surface throughput gains with little or no increase in delays. The solution will cover the entire domain of surface operations including ramps, taxiways, and runways. The objective is to increase runway throughput and taxi efficiency while satisfying system constraints. The algorithms must be robust so that they will work efficiently in the presence of various uncertainties. Both deterministic and stochastic optimization approaches will be explored. Computational performance requirements for real-time applications will be investigated.	For each optimization solution method developed, solve for surface traffic planning problems for at least two major airports for both current-day traffic demand and future demands (e.g., 2x). Compare efficiency metrics (e.g., taxi delays, runway queue lengths) and runway throughput for each solution method. Compare robustness of the solutions against uncertainties. Goal is to demonstrate increased runway throughput and improved surface movement efficiency while satisfying identified system constraints.	AP.1.A.02 AP.1.C.01 AP.1.S.02 AP.1.S.04 AP.2.C.04 AP.2.C.07 AP.3.A.01	AP.1.S.02 AP.1.S.04 AP.2.S.04 AP.2.S.05 AP.2.S.07 AP.2.S.08 AP.2.S.10 AP.3.S.03 AP.3.C.01 AP.3.S.02 AP.3.A.04
AP.2.S.06	3Q09	Develop and evaluate initial aircraft-based low altitude, runway, and taxiway conflict detection and resolution (CD&R) algorithms	Expand aircraft-based algorithm to detect conflicts at low altitude (currently TCAS and runway incursion prevention system does not generate alerts in this area). Develop aircraft-based algorithm for taxiway conflict detection. Develop conflict resolution advisory system for low altitude, runway, and taxiway conflicts. POD and PFD will be determined as function of key parameters such as equipage and time horizon. Algorithms developed for multiple vehicles types while considering current traffic levels.	Metrics include POD and PFD of conflict detection for runway/low altitude/taxiway incursion via simulations. Assess time-to-conflict at detection of the conflict. The targets for Probability of Detection (POD) and Probability of False Detection (PFD) will be established via collaboration with JPDO/FAA. FAA standards will be investigated to define requirements as a function of intended use (advisory vs. sole means of preventing collisions) by 1Q09 with PI concurrence. Initial target anticipated to be on the order of POD = 0.99 for scenarios that would result in hull-loss collisions if not detected.	AP.1.S.02 AP.1.S.03 AP.2.A.03 AP.2.A.10 AP.3.A.01	AP.2.S.10
AP.2.S.07	4Q09	Develop and evaluate initial ground-based taxi clearance conformance monitoring and conflict detection/resolution algorithm	Primary focus is to develop ground-based algorithm for pilot conformance of clearances and conflict detection and resolution (CD&R). Effectiveness of the algorithm will be evaluated through Monte Carlo simulations. Uncertainties in pilot/aircraft performance and errors in surveillance data need to be considered. POD and PFD will be determined as function of key parameters such as time horizon. Delivery mechanism of CD&R measures to flight deck will also be investigated.	Metrics include POD and PFD of conflict detection (for runway/low altitude/taxiway incursion) and taxi clearance conformance via simulations. Assess time-to-conflict at detection of the conflict. The targets for Probability of Detection (POD) and Probability of False Detection (PFD) will be established via collaboration with JPDO/FAA. FAA standards will be investigated to define requirements as a function of intended use (advisory vs. sole means of preventing collisions) by 1Q09 with PI concurrence. Initial target anticipated to be on the order of POD = 0.99 for scenarios that would result in hull-loss collisions if not detected.	AP.1.S.02 AP.1.S.03 AP.2.S.03 AP.2.A.03 AP.2.A.10 AP.3.A.01	AP.2.S.11 AP.3.S.03

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.S.08	4Q09	Develop and evaluate algorithm for airport runway configuration planning for single airport operations (Joint MS with CADOM)	Airport runway configuration specifies runways to be used for departures and arrivals. Weather (i.e., direction of wind), traffic demands, airline preference, and controller workloads are among the factors to be considered in determining runway configuration. The algorithm will provide advisories to plan runway configuration changes to make the most efficient use of airport runways while satisfying constraints on single airport operations.	Metrics of interest in judging value of a runway configuration is total cost of operations (taxi delay, arrival delays, fuel burn) and throughput of the airport. Algorithm output is compared to the judgment of subject matter experts (controllers), given the same scenarios, to determine the degree to which the algorithm improves cost and throughput metrics. The sensitivity of the metrics to the timing of runway configuration changes relative to algorithm-recommended times is also assessed.	AP.2.S.03 AP.2.S.04 AP.2.S.05 AP.2.A.10 AP.3.A.01	AP.4.S.01
AP.2.S.09	4Q09	Develop basis for requirements for presenting 4D taxi clearances to flight deck and perform analysis on pilot performance on taxi clearance compliance	Conduct medium-fidelity piloted simulations to explore pilot performance with varying levels and options for 4D taxi information presentations. Analyze taxi-conformance data to establish a basis for surface automation system requirements. This milestone will be performed in coordination with the IIFDT project.	Metrics of interest in pilot conformance include time error at significant waypoints (runway or taxiway intersections), pilot workload or errors in secondary tasks, and incidents of incorrect turns or taxiway selection. Results to be used to assess benefits of 4D taxi concepts and information presentation options. Target benefits include improved system performance (decreased departure queue size), decreases in taxi time from efficiencies in 4D taxi operations, and decreases in fuel burn and emissions from these improvements.	AP.2.A.03 AP.2.A.10 AP.3.A.01	AP.2.S.11 AP.4.S.01 AP.3.A.04

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.C.03	4Q09	Catalog and assess alternatives, benefits, and safety issues for enabling various closely-spaced parallel runway and converging/inter-secting runway arrival/departure concepts	Literature searches, and interviews with key researchers and authorities to develop a list of concept options for improving the acceptance rate of converging, intersecting, and closely-spaced parallel runways (CSPR) with less than 2500 foot centerline spacing to arriving and departing aircraft. Include consideration of JPDO NGATS capabilities in RNP and 4D Trajectory Based Operations, wake vortex, and blunder detection. Examples of concepts include 4D trajectories to prevent conflicts during possible crossing missed approaches, land and hold short operations in low visibility conditions, and other concepts. Provide an initial qualitative assessment of the potential benefits, required operational capabilities, and safety issues to guide further study or detailed assessments. Conduct Monte Carlo analysis to identify trades between safety and benefits in a parametric study of converging and CSPR concepts that include NGATS capabilities for precise aircraft delivery. The trades will consider various runway configurations, aircraft delivery precision, assumptions about blunder protection, wake constraints, and aircraft pairing/speed schedule uncertainties.	Results identify at least 10 alternate concepts for increased capacity on closely-spaced parallel, converging, and intersecting runways. At least five of the concepts must require little or no active wake vortex prediction. The results show consideration for opportunities enabled by NGATS capabilities. Results specify initial estimates of potential throughput increases, benefit mechanisms, estimated availability of the concepts (e.g.; VMC or IMC only, low-visibility only, for heavy aircraft only...), aircraft equipage or RTSP capabilities, and safety issues. Appropriate references are provided to point to relevant research results.	AP.3.C.06	AP.3.C.05 AP.3.C.07 AP.3.A.04
AP.2.A.04	4Q09	Human performance model (HPM) development for Airportal operator roles, workload, situational awareness	Identification of potentially relevant HPM capabilities that may be leveraged for Airportal/surface experimental applications. Existing HPM capabilities will be enhanced/extended to support project studies.	Concurrence of APIs that models will meet their simulation needs and are ready to begin validation phase. Report to document enhancements to existing HPMs in creation of models for appropriate Airportal decision makers (e.g., controllers, pilots, airline operators).	AP.2.A.10 AP.3.A.01	AP.2.A.05 AP.3.A.05
AP.2.A.07	4Q09	Determine research issues that are a critical path to Airportal metroplex capabilities	Determination of the capabilities and key research issues to addressing metroplex Airportal issues. Where appropriate, determine what data requirements and methods exist from Airportal operations for enabling safe and efficient regional airport usage (e.g. runway configuration or parallel runway operations).	Key research areas address at least the research issues identified by the JPDO R&D Plan, issues associated with weather disruptions, airport configuration changes, and traffic density implications of increasing the utilization of regional airports, and results of Airspace Project metroplex research tasks. Results demonstrate consideration of advanced NGATS operational capabilities.	AP.3.A.01	AP.3.A.04 AP.2.A.06

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.A.10	4Q09	Develop human/automation information requirements and decision-making guidelines for human-human and human-machine delegation of Airportal decision-making	Primary research to include definition of minimum information and performance levels for humans and machines for safe and productive Airportal operations. Research includes consideration of the transition issues between the Airportal Project and ASDO/Airspace Project.	Report to include information requirements for human operators and automation technologies, decision-making guidelines based on information requirements, and issues impacting transition between Airportal and Airspace. Identified guidelines address the Airportal surface domain, and related ANSP functions. This is a risk reduction milestone and results will be refined or added to by ongoing assessments of alternatives within SESO and CADOM.	AP.1.A.01 AP.3.A.01	
AP.2.A.06	2Q10	Develop algorithm for airport runway configuration for multiple airport (metroplex) operations	Airport runway configuration specifies runways to be used for departures and arrivals. Weather (i.e., direction of wind), traffic demands, airline preference, and controller workloads are among the factors to be considered in determining runway configuration. The algorithm will provide advisories to Air Traffic Control Tower coordinators to change runway configuration in order to make the most efficient use of airport runways while satisfying constraints in both single and multiple airport operations.	Algorithm is used to address operational issues for at least one large airport and two secondary airports in the same geographic region. Algorithm output is compared to the judgment of subject matter experts, given the same scenarios, to determine the degree to which the algorithm improves metroplex operations. Metrics of interest include arrival/departure delays and combined throughput of the multi-airport system. The target improvement levels will be informed by results from AP.2.A.07.	AP.2.A.07 AP.3.A.01	AP.3.A.04 AP.4.A.01 Out-year Metroplex research
AP.2.C.06	3Q10	Develop wake vortex predictor that provides probabilistic estimates of wake location	Develop probabilistic estimates of wake location. Develop probability density functions (PDFs) of wake behavior and use field data to train models. Conduct this training initially using only wake position due to suspect quality of the circulation values in existing field data. Incorporate circulation values once accuracy has been estimated by AP.1.C.03 and as improved quality data becomes available from ongoing international field studies. Evaluate relative contributions of various error sources (initial wake conditions, atmospheric data, and wake sensor accuracy) using combinations of LES case studies and assessments of accuracy of deterministic models (AP.1.C.02) and accuracy of wake sensors (AP.1.C.03) to generalize results to applications using different sensors than were employed in prior field studies	Defined confidence intervals (confidence levels for spatial accuracy of prediction as a function of wake age, wind values, generating-aircraft weight range, and ground proximity). Confidence bounds validated via separate data sets, new data sets that may become available from FAA field tests. Validation extent is contingent upon availability of new data sets.	AP.1.C.02 AP.1.C.03	AP.1.C.06 AP.3.C.10

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.2.A.05	4Q10	Conduct initial validation of Airportal human performance models.	Determination of human-in-the-loop and fast-time model data necessary to insure successful comparison for the initial model validation, and available for Airportal project to utilize. Validation of the model to include comparison to other fast-time models and to human-in-the loop data where available to the project.	Initial validation determines the extent to which the HPM has a predictive ability that is sensitive to airportal-relevant behaviors, with clearly characterized assumptions. Metrics against which to assess performance will be defined in collaboration with the end-user APIs by 1Q10 with concurrence by the Project PI, potentially including review by SMEs that the simulation provides a suitable representation of human performance.	Existing work AP.2.A.04 AP.3.A.01 AP.3.A.03 AP.3.S.01	AP.4.A.01 AP.4.S.01
AP.2.A.11	4Q10	Develop interim roles and responsibilities between machines and humans for advanced concepts	Primary research to focus on surface, wake, and separation tool enhancements and non-normal situations, including recommended roles for humans and machines to provide maximum safety/ prod. Definition to include any modifications to human/machine roles and responsibilities due to refined functions and procedures after prior milestone related to roles and responsibilities.	Identified roles and responsibilities address all Airportal operational domains (surface, runway, terminal/metroplex airspace) and all advanced concepts proposed within SESO and CADOM. At least two plausible alternate distributions of roles are defined along with associate benefits and disadvantages of those distributions.	AP.1.A.01 AP.2.A.03 AP.2.A.10	AP.3.A.04 AP.4.A.01 AP.4.S.01
AP.2.C.07	1Q11	Develop airborne spacing algorithms for multi-runway airports	Develop and evaluate, using fast-time simulations, aircraft departure/arrival separation algorithms that satisfy constraints arising from wake vortex, surface capacities, and safety of air and surface operations at airports operating multiple runways (including closely-spaced parallel runways).	Algorithms demonstrate satisfaction of identified constraints in fast-time simulation. Metrics include capacity, delays with various traffic demands, number of constraints violated, stability of spacing values. Target capacity values dependent on analysis (AP.3.C.02) to estimate required airport contribution to NGATS capacity goals.	AP.1.C.06 AP.2.S.04 AP.3.C.02	AP.2.S.03 AP.3.C.09
AP.2.S.10	4Q11	Develop interim aircraft-based final approach, runway, and taxiway conflict detection and resolution algorithms	Enhance aircraft-based final approach, runway, and taxiway conflict detection and resolution algorithms based on initial evaluations. POD and PFD will be determined as function of key parameters such as equipage and time horizon. Expand algorithms to enable accurate conflict detection and resolution for expected NGATS capacity demands (up to 3 times current levels).	Metrics include POD and PFD of conflict detection for runway/low altitude/taxiway incursion via simulations. Assess time-to-conflict at detection of the conflict. POD and PFD targets to be established by 1Q11 based on collaborations with JPDO/FAA and FAA standards for intended function, and approved by Project PI/Program PD.	AP.2.S.03 AP.2.S 06	AP.3.S.03
AP.2.S.11	4Q11	Assess system performance of varying options for 4D taxi clearance information to provide a scientific basis for future systems requirements for mature surface automation	Conduct medium-fidelity piloted simulations to evaluate surface automation concepts for 4D taxi.	Metrics of interest in pilot conformance include time error at significant waypoints (runway or taxiway intersections), pilot workload or errors in secondary tasks, and incidents of incorrect turns or taxiway selection for varying level or options of automation interface.	AP.1.S.05 AP.2.S.07 AP.2.S.09	Out year milestones

Level 1 Milestones

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.1.C.01	4Q07	Assess and characterize current airport decision processes and information requirements involved in balancing arrival/departure operations	Research operational issues and decision processes currently involved in determining the balance between arrival and departure operations, which may change as NGATS capabilities are introduced. Determine current state-of-the-art and identify research opportunities for supporting the NGATS vision.	Define options for use of runway balancing for improving airspace operations and for improving surface operations. Metrics include information types, sources, users, and confidence.	New Work	AP.2.S.03 AP.3.A.01 AP.3.C.01
AP.1.A.01	2Q08	Identification and initial assessment of Airportal human/ automation roles and responsibilities critical to advanced concepts	Primary research into human-automation problems. Leverages advances in applications outside of Airportal, and builds on lessons where roles and responsibilities were reallocated among decision-makers and automation to maximize productivity and safety. A cognitive task analysis of current Airportal operations will leverage prior work to define an appropriate baseline for exploring new allocations of roles/responsibilities for advanced concepts. Research will also examine varying levels of automation, including the possibility of a mixed human/machine role, and requirements for future decision-making roles	Identified roles and responsibilities address Airportal surface domain and proposed NGATS operational capabilities. Results will be updated (AP.2.A.11) as research matures in advanced surface and runway/terminal operations.	Existing work	AP.2.A.03 AP.2.A.10 AP.2.A.11
AP.1.A.02	4Q08	Identify initial set of operational events (including weather) to which the integrated Airportal must react in real-time without impacting overall optimization strategy	Research to identify events in terminal airspace and surface operations (e.g. weather, maintenance, canceled operations) to which the integrated system must react in real-time.	Report documenting the initial set of weather and operational events to which the integrated Airportal must react in real time. Results include at least 20 non-normal events that will stress advanced surface operations, runway management, and terminal/metroplex management, including both short-term and long-lasting events.	Existing work	AP.1.A.05 AP.2.S.03 AP.3.S.02 AP.4.A.01 AP.4.S.01

AP.1.C.03	1Q09	Assess accuracy of wake vortex sensor data used in wake model validation	Circulation estimation of wakes with current generation pulsed lidar is challenging and field data contains poorly quantified error sources complicating model validation. This activity will assess the accuracy of these lidars to measure the circulation (and position) of wake vortices of various strengths, separations, and aspect angles. Characterization will be based on a combination of statistical database of wake vortex field measurements and modeling and analysis of sensor performance given numerical wake vortex flow fields. The error magnitudes in the sensor data are required for (1) assessment of the accuracy of current wake predictor models, (2) assessing feasibility of alternate concepts for runway capacity gains, some of which might require wake vortex sensing, (3) determination of the suitability of field data circulation values for training probabilistic predictor models	Statistical assessment of accuracy of measuring wake position and strength for weak wakes (about 60 m^2/s) to strong wakes (about 600 m^2/s) at different aspect angles to the lidar and in different background wind levels. Metrics include mean and variance of measurement errors in these conditions.	New work	AP.1.C.02 AP.2.C.02 AP.2.C.03 AP.2.C.06
AP.1.S.03	2Q09	Develop and validate surface 4D trajectory model	Develop a high-fidelity 4D trajectory model and software that will be used for predicting aircraft surface trajectories based on 4D taxi clearances and factors including aircraft performance characteristics. 4D taxi clearances are provided by the surface traffic scheduler. Uncertainties that will affect the trajectory prediction will be identified and requirements for model accuracy will be defined. Perform validation of predicted trajectories against actual flight data and/or data from simulations.	Resulting trajectory model predicts aircraft deviation between 4D taxi clearance time-at-fixes and actual time-at-fixes within targets to be established by 4Q08 and approved by the Project PI. The initial, largely subjective, validation will be updated in AP.2.S.06 and AP.2.S.07 as the performance of conflict detection algorithms using these trajectory models is assessed.	AP.3.A.01	AP.1.S.05 AP.2.S.04 AP.2.S.05 AP.2.S.06 AP.2.S.07
AP.1.A.05	2Q09	Develop Airportal requirements for weather information	Develop requirements for weather observation and forecast information, and other weather-related research needed from organizations external to ARMD to enable Airportal success. This includes the specific needs in terms of meteorological information, geographic coverage, grid density, forecast time horizon and update frequency. The array of information needs will be the output of this milestone, but examples include surface winds, icing, snow accumulation, windshear, and other phenomena that have a primary impact on Airportal productivity.	Requirements must include consideration for weather information needed for runway configuration decisions, traffic flow management decisions, and runway capacity decisions including wake vortex prediction. Successful completion of a Requirements Review by all project APIs and a JPDO representative indicate milestone completion. It is expected that additional requirements will be identified by SESO and CADOM research in later years.	AP.1.A.02	AP.3.A.04

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.1.S.02	3Q09	Model and quantify the uncertainties in predicting surface movement and traffic optimization	Research to identify and prioritize sources of uncertainties that may reduce effectiveness of surface optimization solutions (e.g., push back times, pilot conformance to 4D taxi clearances, aircraft performance, surveillance, estimated arrival times, and runway exits). Identify dependency for each identified uncertainty on various operational conditions such as weather, demand, and technologies. Model and quantify identified uncertainties from observed data.	Results to include sources of uncertainties, priorities and dependencies needed to be considered in surface traffic optimization process; methods for data collection/analysis; and probability distributions of identified uncertainties. At a minimum, the domains of gate activities (aircraft loading, pushback times), ramp and taxiway movements, runway movements, airport and terminal weather, and en route constraints must be considered.	AP.2.S.03 (co-dep) AP.3.A.01	AP.1.S.05 AP.2.S.03 AP.2.S.06 AP.2.S.07
AP.1.S.04	3Q09	Investigate environmental constraints for Airportal operations and develop tools to provide the surface traffic scheduler with mitigation solutions in real-time	Research focus is to characterize environmental constraints (i.e., aircraft noise and emissions) for super-density Airportal operations; identify/develop techniques to analyze noise/emissions output in real-time and provide advisories to reduce the environmental impact; and develop software interface with the surface traffic scheduler.	Identifies relevant FAA and JPDO emissions metrics, defines which are global constraints vs. local constraints, and identifies current environmental constraints, and plausible future constraint scenarios. Performance of the environmental tool will be evaluated via fast-time simulations that compare noise footprints and emissions loading using the real-time environmental tool vs. current post-processing methods.	AP.2.S.03 (co-dep) AP.3.A.01	AP.2.S.03 AP.3.S.02
AP.1.C.02	4Q09	Assess sensitivity and accuracy of current real-time wake vortex models and improve performance as needed	Assess accuracy of real-time wake predictor models and sensitivity of wake behavior to uncertainty in atmospheric parameters. The resulting information will be used within the project to estimate feasibility and benefits of various concepts of operation, and outside of NASA to define weather system requirements. This work will be performed in collaboration with tasks to identify and assess alternate operational concepts to (1) define the metrics of interest in assessing wake model performance and (2) provide operational concept researchers with expected performance of the predictors. Assess accuracy, strengths, and weaknesses of deterministic wake vortex real-time prediction models. Based on parametric studies with Large Eddy Simulations (LES), improve real-time model performance as needed.	The results define the key parameters needed for assessment of wake prediction and provides quantification of wake motion and decay uncertainty from deterministic wake models in terms of these parameters. Compare model results against LES results and available field data to estimate accuracy of predictions for various aircraft types and realistic ambient conditions. Estimate the range of ambient conditions where vertical shear effects may be operationally significant. Target values are not appropriate for this milestone; the intent is to quantify the state of the art in terms relevant to application of wake knowledge to alternate operational procedures.	AP.1.C.03 AP.2.C.02 AP.2.C.03	AP.2.C.02 AP.2.C.03 AP.2.C.06 (concurrent with 2.C.02 and 2.C.03)

Milestone Number	Program Year	Title	Description	Metrics	Dependency	Feeds
AP.1.S.05	2Q10	Explore advanced aircraft guidance and control methods for surface traffic management and develop requirements for super-density surface operations	Primary focus is to investigate both current and future technologies in automated taxi control capability of aircraft on the surface. This milestone will also address data communication between Air Traffic Control (ATC) and flight deck, levels of automation, pilot monitoring requirements and aircraft performance requirements to achieve super-density surface operations. A sensitivity study will be performed to define the trade space between taxi delay reduction and the degree to which aircraft control conforms to 4D trajectory clearances to provide a basis for future requirements definition.	Successful acceptance review by the PI and PS. Findings include at least three alternate concepts (e.g., flight deck based and ground tug options), airport taxi capacity/delay as a function of aircraft 4D taxi clearance conformance, and expected conformance from alternate technologies.	AP.1.S.02 AP.1.S.03	AP.2.S.11
AP.1.C.06	2Q10	Develop stochastic tools to evaluate the safety of proposed flight procedures	Research focus on developing methodologies and tools to estimate probability density functions for aircraft trajectory conformance and wake vortex encounters for various single-runway and multiple-runway concepts.	Models estimate potential for collisions or wake encounters when various capacity enhancing procedures are being utilized. Models accommodate aircraft trajectory conformance attributes, wake behavior, procedures for single-runway and multiple-runway options. Validation methods to be established as an element of the research milestone.	AP.2.C.06	AP.2.C.07 AP.3.C.10

1.4.1 NGATS ATM-Airportal Project Roadmap

Integrated Solutions for Safe, Efficient & High Capacity Airportals

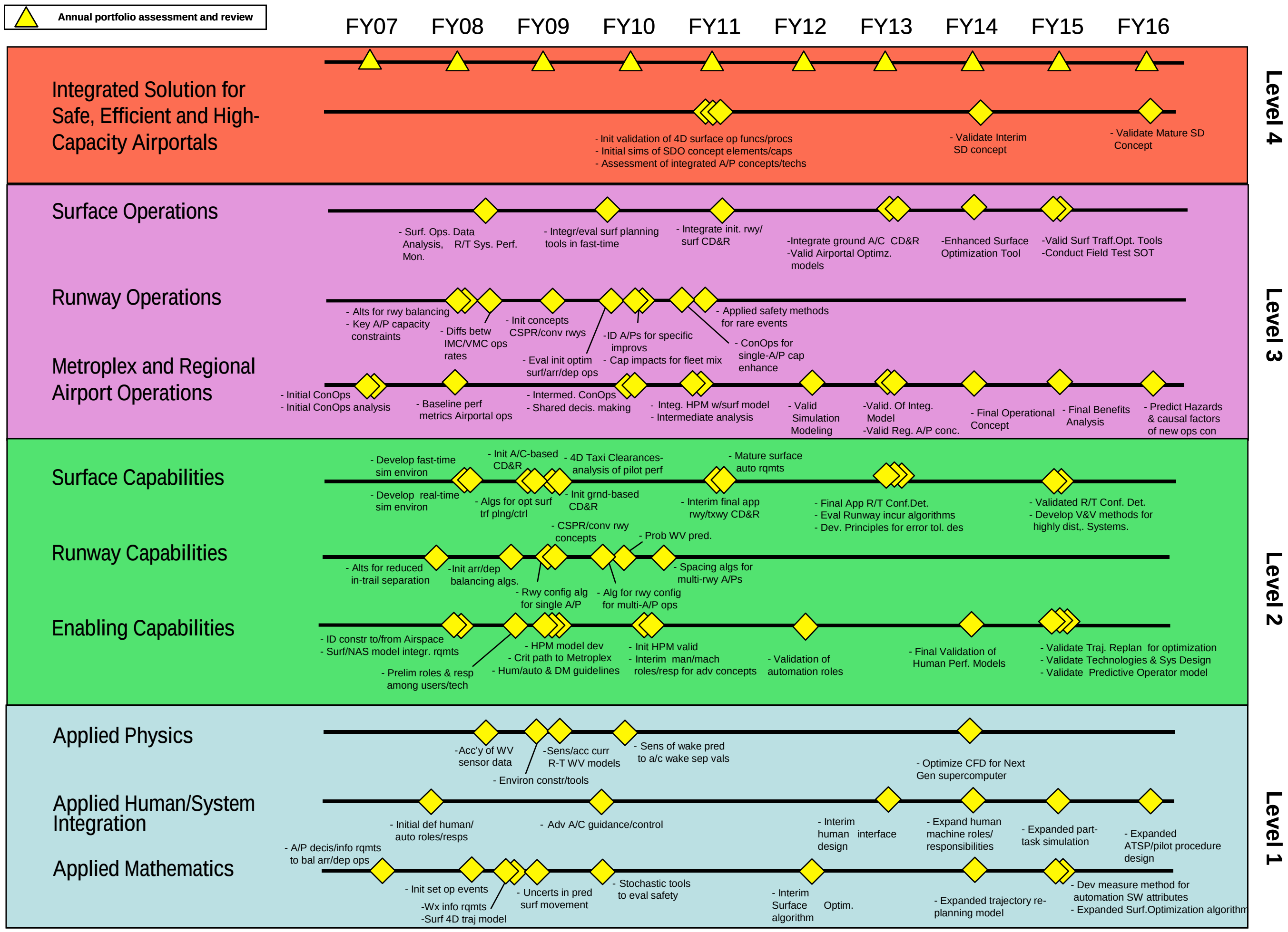

Figure 2. NGATS ATM-Airportal Project Roadmap

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1.5 Technical Approach

The Airportal Project will conduct foundational research and discipline-based technology development to enable the NGATS as defined by the JPDO. The Airportal Project will develop an initial Concept of Operations (ConOps) representing the airportal environment. This ConOps will be continually refined by research results, system studies, and active collaboration with the JPDO.

1.5.1 Safe and Efficient Surface Operations

1.5.1.1 Problem Statement

The purpose of the SESO research area is to manage traffic on the surface among the gates, taxiways, and runways safely and efficiently to enable maximum throughput and capacity in the airport environment.:

- Current surface operations involve numerous independent entities, such as ATC, airport authority, airline ramp operators, and pilots, acting with diverse, and often mutually exclusive, objectives over limited resources of the airport.
- Lack of common situational awareness makes it difficult for coordination among the air traffic control tower and other ATC facilities and NAS operators.
- Static ATC procedures limit the flexibility and efficiency of surface operations and often cause an imbalance in runway loads, thus limiting capacity. One example of such procedures is the static mapping between runways and departure fixes.
- Each airport is a unique environment to a far greater extent than the analogous airspace structure. Different airport layouts (e.g., runways and taxiways) and procedures pose unique challenges to achieving and maintaining efficient operations at peak capacity without sacrificing safety.
- The complexity of systems that can be manually controlled in an efficient manner is limited by the inherent cognitive capabilities of humans. Workload issues will affect their ability to effectively manage the future capacity growth called for by the JPDO.

The SESO research will investigate new technologies and concepts to increase airport capacity by enhancing the flexibility and efficiency of surface operations. Research in this area will also consider the implications of the performance characteristics of many types of aircraft including new large aircraft and Very Light Jets (VLJs). The products of the research in this area are evaluations of integrated automation technologies and procedures that will provide the following capabilities:

- Improved surface traffic planning through: 1) balanced runway usage; 2) optimized taxi route planning of departures and arrivals; 3) departure scheduling satisfying environmental constraints, dynamic wake vortex separation criteria, and constraints driven by other NAS domains; and 4) efficient runway configuration management.
- Ensured safety in ground operations through the examination of taxi clearance conformance-monitoring methods and surface conflict detection and resolution. This research will be done in coordination with the IIFDT Project. The IIFDT and Airportal

Projects will be working on flight deck technologies for surface conflict detection and resolution, and will also be collaborating in the development of requirements for the display characteristics of these technologies for the flight crews.

1.5.1.2 State of the Art

Recent advances in surface surveillance technology have allowed both industry and government agencies to investigate new surface-operation technologies, from enhancement of situational awareness, to safety technology, to runway incursion prevention. The Airport Surface Detection Equipment – Model X (ASDE-X) system, scheduled to be installed at 35 U.S. airports by the year 2010, provides the accurate position and identification of aircraft and vehicles on the surface through a fusion process of surveillance data from multiple sources, including ADS-B and multi-lateration transponders.[xi] The Surface Management System (SMS) is the most recent surface decision support prototype that uses ASDE-X to aid tower controllers in managing surface traffic to increase efficiency and capacity.[xii] Although SMS provides situational awareness and strategic planning tools for managers, improvement in aircraft trajectory prediction is needed for better estimation of surface event times. The capability to provide active advisories for taxi planning and departure scheduling does not yet exist.

Although surface automation technologies are being investigated, there are still challenges in quantifying uncertainties and developing predictive capabilities to enable optimized surface management solutions. Runway incursions are one of the most serious safety concerns in surface operations, and research efforts have been made by NASA and the Federal Aviation Administration (FAA) to improve the technology to detect potential collision risks and generate alerts to pilots and controllers. The Runway Incursion Prevention System (RIPS) is an initial aircraft-based incursion alert system developed and tested by NASA, where the on-board software detects potential incursion risks against other traffic on the runway.[xiii] The Runway Status Light system (RWSL) is an automated runway lighting system, developed by the FAA and field-tested at Dallas/Fort Worth (DFW) airport, that provides visual indication of runway status directly to pilots and ground vehicle operators.[xiv] These technologies have shown great promise with current traffic levels for airport operations, but the efficacy of these approaches has not been examined when considering the dramatic capacity increases that are suggested as part of the NGATS concept.

Departure scheduling and taxi planning have been the focus of research in academia and research organizations in both the U.S. and Europe in recent years. However, most of the research is still in conceptual stages.[xv],[xvi],[xvii] Research in the Airportal Project will examine optimization methodologies as part of departure and taxi management.

1.5.1.3 Alignment with the JPDO

The validated surface technologies developed under the Airportal Project will be aligned with the super-density surface operations concept set forth by the JPDO, and they will provide sufficient flexibility to meet the requirements for super-density terminal operations, as well. The research in SESO maps to a number of research concepts and functions discussed in the JPDO NGATS Concept of Operations (CONOPS).

The NGATS CONOPS describes a highly automated surface conflict detection capability. In addition, the concept emphasizes the importance of the improved estimation of departure times for flow management and trajectory management. The identification of environmental constraints, particularly noise, is also discussed in the NGATS CONOPS. Finally, the integration of taxi operations and 4D trajectories is stated as a requirement for managing departure scheduling. The SESO technical approach will be conducting research and development in all of these areas.

1.5.1.4 Approach

There is one Level 4 milestone, and there are three Level 3 milestones in the SESO research area. This research incorporates foundational research and multi-disciplinary techniques to investigate surface management solutions.

The Level 4 milestone in the SESO technical area (*AP.4.S.01*) involves the initial evaluation of 4D trajectory-based safe and efficient surface operations concepts. Algorithms developed through Level 2 and 3 milestones will be integrated and evaluated within the fast-time and real-time simulation environments with a validated human performance model (*AP.2.S.04*, *AP.2.S.05, AP.1.A.02*, *AP.2.A.02*, *AP.2.A.05*) to evaluate the concepts of operation for safe and efficient surface operations. The results will be evaluated according to the performance metrics for airportal operations. For this purpose, the simulation environment will be combined with the system performance measurement tools (*AP.3.S.01*). Metrics such as aggregate taxi delays and runway crossing times will be compared between actual operational data and the results from simulations with surface traffic planning algorithms (*AP.3.S.02*). Human-in-the-loop (HITL) real-time simulations will be conducted to evaluate human factors metrics such as pilot evaluation of 4D taxi clearances (*AP.2.S.09*). Test scenarios will be generated to conduct experiments under various traffic conditions including high traffic density and increased levels of uncertainty in model parameters under off-nominal circumstances. The performance of taxi conformance monitoring and initial surface Conflict Detection and Resolution (CD&R) algorithms will also be evaluated using real-time simulations (*AP.3.S.03, AP.2.A.11*, *AP.3.A.07*). The runway-configuration planning algorithm will be integrated and evaluated within the real-time simulation environment (*AP.2.S.08*).

The objective of the first Level 3 milestone in the SESO area (*AP.3.S.01*) is to develop tools to monitor the states of the system, measure the performance of surface algorithms, and verify the modeling and simulation of the system. A simulation produces a large amount of operational data in real-time. These data may include traffic data such as tracks of aircraft and vehicles, and derived data such as OOOI (Out, Off, On, and In) times of the individual aircraft, and actual taxi routes. The analyzed data provide the operators with information regarding the current state of the system such as arrival/departure rate, weather information, runway configuration, and average taxi delay in real-time. In addition, data mining technology will be applied to monitor the state of the system and report any abnormal conditions that may require actions to be taken to correct the situation. The North Texas Research Facility (NTX), along with other facilities with access to surface and terminal data, will be used to assist in the data mining efforts for the surface domain.

The post-simulation data generated from both fast- and real-time simulations will be analyzed using these tools (*AP.2.S.04*, *AP.2.S.05).* The data stored in the database system can be used for post-event data analysis to assess the system performance and validate surface algorithms in many ways. For example, metrics such as runway crossing time and taxi time will serve as good indicators to evaluate performance of the algorithms developed for optimized ground operations. Software for database management and post data analysis will be developed.

Metrics to evaluate the states of the system as well as to measure the system performance will be identified.

The objective of the second SESO Level 3 milestone (*AP.3.S.02***)** is to develop and evaluate the integrated solution of departure scheduling and taxi route planning, which will serve as an enabling technology to increase runway throughput and improve overall taxi efficiency. Work in this milestone relies upon foundational research in the Level 1 and Level 2 areas.

Optimized taxi route planning enables the efficient movement of aircraft from ramp area to runway departure queue, and from arrival runway to ramp area, under physical constraints such as taxiway layout, location of gates, spots holding areas, runway queues, and runway exits (*AP.2.S.03*). A spot is a location on the airport surface where control is transferred between ATC and the airline operators. The taxi route planning algorithm needs to coordinate with a departure-scheduling algorithm in a closed loop to manage active runway crossings. This will be done by providing arrival information (e.g., runway exit and required-time arrival at the runway crossing queue) to the departure-scheduling algorithm and evaluating multiple algorithmic approaches.

The optimization problem is defined in terms of what to optimize (i.e., objective function) and how to incorporate uncertainties in the model parameters. Taxi route optimization can be formulated by either a deterministic or stochastic optimization problem, depending on whether or not uncertainties are considered in the formulation. The objective function for either formulation is likely to minimize the cost associated with delays, e.g., a weighted sum of gate delay (i.e., engine-off) and taxiway delay (i.e., engine-on) of all flights within a specified planning horizon. In the case of a stochastic optimization problem, one possible solution can be obtained by minimizing the expected cost of delay. For any stochastic optimization method, accurate probabilistic information of model parameters is required, such as pushback times for departure flights at the gates. Both deterministic and stochastic optimization methods may require frequent updates of the solution, as new information of the system is available.

The departure-scheduling algorithms will provide an optimum runway schedule for each departure flight and runway from which the aircraft will depart (*AP.2.S.03*). The optimized scheduling (i.e., sequencing and spacing) algorithms must consider constraints from many sources, including Traffic Flow Management (TFM) initiatives (e.g., ground delay program), demands for arrivals and departures, and initial departure routes (*AP.2.A.01, AP.2.A.02, AP.3.A.01*). Environmental impacts from aircraft noise and emissions will be assessed dynamically, and constraints must be incorporated in the departure scheduling process so that the solution would not violate the constraints (*AP.1.S.04)*. Collaboration with the Subsonic Fixed Wing Project will enable estimates of capacity benefits from improved aircraft environmental characteristics. The departure-scheduling algorithms will be tightly coupled with the arrival/departure balancing capability (*AP.2.C.04*) so that the departure rate is managed within the boundary of the airport operating point. The integrated ground operations decision support systems must be robust against weather and other operational events (e.g., stuck on a taxiway due to a mechanical problem) in its overall optimization strategy (*AP.1.A.02*).

Validation of the integrated optimized ground operations will be performed through a series of fast-time simulations with scenarios developed for various operational conditions including normal/off-normal weather conditions, low/high traffic demands, and TFM initiatives (*AP.2.S.04*). The performance of the surface algorithms will be evaluated using the surface performance analysis tool (*AP.3.S.01*).

The objective of the third SESO Level 3 milestone (*AP.3.S.03***)** is to develop and evaluate the integrated surface conflict detection and resolution algorithms to ensure the safety of surface operations. The purpose of aircraft-based CD&R algorithms is to detect potential collision risks between the ownship aircraft and other traffic either on the surface or in the air (i.e., within the airport arrival/departure zones). The initial conflict detection algorithm was developed and tested by NASA for relatively simple runway incursion scenarios. In the Airportal Project, the aircraft-based algorithms will be expanded in two stages. First, the algorithm will be expanded to detect conflicts at low altitudes (currently Traffic Alert and Collision Avoidance System (TCAS) and the runway incursion prevention system do not generate alerts in this area) and taxiways. A conflict resolution advisory system for low altitude, runway, and taxiway conflicts will also be generated. Algorithms will be developed for multiple vehicle types while considering current traffic levels. Second, the algorithms will be further developed to enable accurate conflict detection and resolution for expected NGATS capacity demands (up to three times current levels) (*AP.2.S.10*). The algorithms will be evaluated using fast-time and real-time simulations, and human-in-the-loop evaluations.

Research examining ground-based conflict detection and resolution algorithms will explore the capability of taxi conformance monitoring and the detection of surface/low altitude conflicts similar to the airborne algorithms (*AP.2.S.07*). The 4D surface trajectory model will be used to predict the future position and speed of aircraft and vehicles on the ground. While the airborne algorithms allow properly equipped aircraft (i.e., with ADS-B and visual aids in the flight deck) to detect collision risks with other traffic, the ground-based algorithm scans the state of every aircraft and vehicle within a specified area, detects potential collision risks, and generates an alert/advisory to avoid the dangerous situation. These algorithms will be integrated with the taxi route planning capability that will provide the system with planned 4D trajectory-based taxi clearances of aircraft and ground vehicles (*AP.2.S.03*). The importance of 4D trajectories for surface operations is the link to the airside operations in order to achieve integration and efficiency. Research will investigate the monitoring and performance parameters necessary for taxi automation technology development. In addition, roles and responsibilities of the human operators and automation systems need to be defined for issuing alerts/advisories to the flight deck (*AP.2.A.03, AP.3.A.07*). Requirements definition for data presentation and simulations are necessary in order to assess the acceptance of CD&R advisories.

1.5.1.5 Foundational Research

There are a number of foundational research areas in SESO. They will depend upon Level 1 research in applied physics and applied mathematics for system optimization and design. NASA Research Announcement (NRA) partnerships will also be used to leverage collaborations with academia and industry.

One foundational research area is to investigate the surface optimization problems in the presence of uncertainties (*AP.2.S.03*). Research in optimizing ground operations such as taxi route planning and departure scheduling will require the examination of current operations and modeling of surface traffic. Optimization problems will be formulated with proper control strategies, and algorithms will be evaluated for simple scenarios to assess acceptability of each method.

The modeling and quantification of the uncertainties in predicting surface movement and traffic optimization (*AP.1.S.02*) is another foundational research area within SESO. Surface operations inherently have uncertainties, and the incorporation of these uncertainties in optimization problems is very important. This foundational research will determine the types of uncertainties and their probabilistic information to be considered in optimization framework. An example of this is the uncertainty in the pushback times of departure flights. The probability distributions of actual pushback time around the scheduled pushback time as a function of prediction horizon (i.e., X-minutes prior to scheduled pushback time) can be determined from analyzing airline data. The purpose of this research is to develop the methodologies to employ this information in the optimization problem, realizing that the actual probability distributions may change as NGATS capabilities are introduced in the system.

Foundational research in SESO will also involve applied physics and the development and validation of 4D surface trajectory models (*AP.1.S.03*). Trajectory model development to provide high-fidelity 4D surface trajectories based on aircraft dynamics will be conducted. These research efforts will serve as a basis for the prediction of surface events of aircraft, runway/taxiway conflict detection and resolution, and multi-airport operations. The 4D surface trajectory development will be coordinated with similar 4D trajectory development that is being conducted in the NGATS ATM-Airspace Project.

Another foundational research area involves the investigation of environmental constraints within the airport environment (*AP.1.S.04*). These efforts will leverage the areas of applied physics and applied mathematics. In this research area, the focus is to: 1) investigate methodologies to estimate aggregated environmental impacts due to aircraft noise and emissions on the surface and terminal airspace for future airportal traffic scenarios (e.g., increased traffic, fleet mix, and regional airports); 2) explore mitigation strategies; and 3) develop concepts/requirements for integrating estimation/mitigation solutions in the surface traffic optimization framework.

1.5.2 Coordinated Arrival and Departure Operations Management

1.5.2.1 Problem Statement

Airport capacity is constrained by numerous factors. Capacity at individual runways can be limited by runway occupancy time, final approach spacing constraints, and noise restrictions. Trajectory uncertainty on final approach as aircraft slow and reconfigure for landing creates the need for controllers to add buffers to arrival spacing to prevent violating the minimums prescribed by wake and radar separation values. The capacity of multiple runway systems at an airport is often constrained by interference between operations on those runways. For example, converging runways (intersecting flight paths) and closely-spaced parallel runways (CSPRs) often can be used simultaneously in visual meteorological conditions (VMC) but not in instrument meteorological conditions (IMC) due to the need to detect blunders, provide safe missed-approach paths, or avoid wake vortices. Air traffic control techniques for arrival/departure management rely on static “rules of thumb” aided by airport decision-support systems that are poorly coordinated with each other and with strategic NAS management objectives. These systems cannot provide the capacity increases required to attain NGATS airportal capacity goals. Much of the past research in these areas has been over-constrained by the policies and technologies of the current ATC system rather than considering the opportunities (4D trajectories, RNP and performance-based services, and shared situation awareness, among others) introduced by the JPDO NGATS vision. New concepts and technologies, and new ways of “seamlessly” integrating these technologies are required.

1.5.2.2 State of the Art

Runway capacity is governed by static rules and procedures based on preventing more than one aircraft on a runway at one time, prevention of conflicting missed approach paths, assumptions of major blunders on closely-spaced approach paths, and static wake vortex criteria based on worst-case scenarios from decades of observation. In general, any operational procedure is (and must be) limited by safety analysis for rare but plausible events such as an aircraft engine failure on takeoff or a missed approach. Many of these constraints today have little or no basis in formal system safety or risk analysis. For example, CSPR operations are constrained by a decades-old assumption of a sudden blunder creating a 30-degree course change by one aircraft. The worst-case wake observations take place in specific atmospheric conditions that are detectable. Airport capacity is dramatically decreased during IMC conditions, when separation responsibilities transfer to the Air Navigation Service Provider (ANSP) from the flight crews and these constraints become more restrictive. For example, missed approaches become more likely, and the inability to visually de-conflict missed approach paths prohibits converging runways from being used during IMC. The inability to see and to visually separate from nearby traffic restricts CSPR operations in IMC. Numerous concepts have been evaluated in research for mitigating these constraints, but have not yet been evaluated in the JPDO NGATS context (using new NGATS capabilities), nor systematically evaluated as a suite of interacting capabilities in a common trade space. Prior research such as Airborne Information for Lateral Spacing (AILS), Terminal Area Capacity-Enhancing Concept (TACEC), and the Aircraft Vortex Spacing System (AVOSS) have been individually studied but the outcomes have not yet been systematically combined to find concept spaces that promise to maximize or near-maximize capacity without sub-optimizing a solution to the particular aspect of capacity being studied.

Capacity is also limited by the need to configure the airport intelligently and to balance arrivals and departures on the runways to minimize lost runway and surface productivity. This balancing is based on complex interactions between many competing factors. A partial list of these factors includes: weather (wind, ceiling, visibility), runway length and condition, demand, traffic flow direction, noise, airport optimization strategies, flight schedules, and airline preferences. Individual decision support tools for many of these factors are currently available to aid operators in making airport configuration decisions. However, the current decision support capabilities are poorly coordinated with each other, if at all, and human skill and experience is normally required to make decisions. The science of prioritizing a large set of competing and conflicting factors to arrive at optimized arrival/departure runway balancing decisions is in its infancy. There is, for example, some prior research to develop tools to mitigate the impacts of weather on airport operations. However, the technical complexity of the envisioned NGATS environment far exceeds the scope and capabilities of these prior efforts. CADOM research will leverage NASA’s unique breadth of technical expertise in surface and airspace operations to develop integrated concepts and technologies that are capable of meeting the NGATS needs.

1.5.2.3 Alignment with the JPDO

The principal technical elements of the CADOM research area are exceptionally well aligned with the NGATS vision and with the future airspace visions expressed by the FAA. The JPDO CONOPS[xviii] lists the critical capabilities that must be enabled to achieve the NGATS vision. The principal technical elements of CADOM seek to address some of these capabilities, including reductions in CSPR separation standards, and improved runway capacity. Both parallel runway and single runway capacity issues require a system approach to blending improved trajectory performance, EVO, air traffic and flight deck procedures, surface optimization concepts, and wake behavior modeling to increase the capacity of existing runways, and to enable new runway construction on existing airport property. The CADOM area will add converging runway operations to the concept articulated by the JPDO. The JPDO Concept of Operations, studies conducted for the JPDO Systems and Engineering Analysis Division by the FAA William J. Hughes Technical Center[xix], and the FAA Research, Engineering and Development Advisory Committee[xx], all stress wake vortex as a critical constraint to Airportal capacity and NGATS operational concepts. CADOM will provide the foundational capability to model and predict wake behavior in the atmosphere and provide the knowledge base and models required for other agencies to formulate requirements for associated weather prediction systems and wake modeling and prediction systems.

CADOM will also collaborate with the IIFDT Project and the Airspace Project to conduct fundamental research in the area of system safety, so as to enable risk assessments of transformational systems for which little or no historical data exists for traditional probabilistic risk assessments, and for which very rare events drive system performance.

The CADOM research plan includes initial evaluation of optimized integrated surface and arrival/departure operations *(AP.3.C.05).* The initial tests will integrate airportal capacity-enhancing capabilities (e.g. optimized surface operations, enhanced runway capacity, and arrival/departure balancing).

1.5.2.4 Approach

This research area combines intermediate research products from lower levels into multi-disciplinary solutions to increase airportal capacities. The Level 4 CADOM milestone (*AP.4.C.01*) involves an assessment of operational concepts and technologies for improving single-airport capacity. CADOM will focus on a suite of concepts and technologies rather than a point-design integrated system because no two airports are identical in their constraints and operational opportunities. One airport may be primarily constrained by single runway throughput, another by the inability to simultaneously operate CSPR, and a third by gate or taxiway utilization. The CADOM element will integrate surface improvements pioneered by SESO for single-airport capacity, including the interface between airborne and surface operations. The scope of CADOM is single-airport, including the final approach and initial climb airspace, where trajectories are highly constrained by the runway configuration. Multi-airport systems (metroplex and additional regional airports serving a metropolitan area) are addressed by the ATIM element. Although CADOM is single-airport in scope, the ensemble of single-airport issues nationally will be used to assess CADOM priorities and benefits. For example, if loss of converging runway operations during IMC constrains far more aircraft movements annually across all major hubs than CSPR, more resources would be applied to converging runway EVO concepts. This assessment must be periodically updated as NGATS concepts and architecture are refined and future demand forecasts are updated. At Level 3 a suite of operational outcomes is being investigated. These include the ability to integrate multiple disciplinary capabilities to improve the capacity of individual runways, and multiple runway systems on a given airport whose operations interfere with each other (CSPR and converging). Environmental impacts must be considered as each concept is investigated to assess the point at which further capacity-gain research is dependent on enabling environmental capabilities. At Level 2, individual capabilities are being developed that can be combined into operational outcomes at Level 3. These include information requirements for balancing runways, disciplinary aspects of single- and multiple-runway super-density operations, trajectory uncertainty, and safety methods. Level 1 will provide the foundational research into optimization, wake vortex physics, and human/automation principles.

The key near-term research challenges are to:

- Identify the key constraints to the national airportal capacity goals, quantify their relative contributions to forecast demand gaps, and provide for a clean-sheet identification of alternatives to mitigating the most critical constraints in the context of advanced NGATS operational capabilities.
- Simultaneously initiate the foundational research necessary to address known crosscutting issues that enable capacity improvement. These foundational elements form the basis for development of alternative operational concepts and technologies that can be prioritized as system constraint studies mature.
- Identify and coordinate with common research topics being carried out in related projects (IIFDT, Airspace, and Subsonic Fixed Wing Projects) to maximize the applicability and integration of research ongoing and yet to be carried out.
- Develop appropriate strategies for balancing the use of airportal arrival, departure, and surface capacity resources to meet traffic demand while satisfying tactical and strategic resource constraints.
- Enable all-weather operations through the mitigation of weather impacts.

Key longer-term challenges involve merging research products from the SESO focus area, the NGATS ATM-Airspace Project, and other NASA projects, into comprehensive solution sets that capture maximum airportal capacity benefits (e.g., use of airborne self-spacing and precision navigation capabilities and the use of equivalent visual operations technologies) (*AP.3.C.01, AP.3.C.04, AP.3.C.06, AP.3.C.08*).

There are nine Level 3 CADOM milestones. The emphasis in the first year of execution is on activities to identify key Airportal constraints to system capacity (*AP.3.C.02)*, weighted by the potential impact of the constraints to closing the gap between demand and capacity, and cataloging and assessing alternative concepts for runway balancing (AP.3.C.01) which blends SESO (*AP.2.S.03*) and CADOM (*AP.1.C.01*) research. These activities are key to opening the concept space early and preventing pre-mature focus on specific concepts that may or may not be the most beneficial. These activities are supported by Level 2 milestones to catalog and assess alternatives for increasing single-runway and multi-runway capacity (*AP.2.C.02, AP.2.C.03*). These alternatives consider capabilities available from JPDO NGATS (RNP, performance based services, 4D Trajectories) as well as EVO and wake vortex prediction, and prevent focusing on one of these capabilities alone as *the* answer to capacity.

The evaluation of integrated concepts for optimizing automated surface operations and arrival/departure operations is the focus of milestone AP.3.C.05. The objective of this milestone is to develop and assess initial concepts to coordinate surface, wake avoidance, and runway balancing operations while satisfying airportal constraints. The milestone includes specific dependencies on SESO research to provide optimized taxi-route planning and departure scheduling capabilities (*AP.3.S.02*). At Level 1, current airport decision processes involved in balancing arrival/departure operations are characterized and initial requirements for decision support systems and displays for airside and groundside human operators are assessed. These decision processes may change as NGATS concepts are clarified and pilot/ANSP roles and responsibilities are refined. At Level 2, safety issues for CSPR concepts (*AP.2.C.03*) and for single runway concepts (*AP.2.C.02*) are assessed and initial airport arrival/departure balancing algorithms are developed (*AP.2.C.04*).

Milestone AP.3.C.06 develops initial concepts and initial system requirements for use of EVO technologies to conduct CSPR approaches in IMC. This milestone is dependent on technologies developed by the IIFDT and Airspace Projects. It supplies EVO elements to be included in subsequent integrated concepts represented by (*AP.3.C.09*). The EVO concept development is supported by Level 1 research to identify relevant airportal atmospheric phenomena and human-operator decisions that must be addressed to use EVO technologies operationally. At Level 2, safety issues related to the use of alternative technologies for approaches, including wake vortex avoidance, are investigated (*AP.2.C.02*, *AP.2.C.03*).

A critical component for analyzing the safety of potential operational concepts and procedures is the probabilistic wake model developed at Level 2 (*AP.2.C.06*). This wake model will be used in quantitative statistical analyses to assess wake-encounter probabilities. These encounter probabilities will be used to conduct safety analyses on operational concepts that are constrained by potential wake vortex encounters.

The objective of milestone AP.3.C.09 is to develop detailed concepts for single-airport capacity enhancements, based on the results from SESO (*AP.3.S.02*) and CADOM (*AP.2.C.07, AP.3.C.05*).

1.5.2.5 Foundational Research

Foundational research in support of CADOM will be accomplished through two distinct channels. The primary channel will be Level 1 research supported directly by the Airportal Project. The secondary channel will involve partnerships with industry and academia established through the NRA process.

CADOM foundational research will be accomplished through the Level 1 Applied Physics, Applied Mathematics, and Applied Human/System Integration areas. Under the Applied Human/System Integration area, foundational research conducted within the ATIM focus area will be applied to decision processes and automation concepts for the airport surface (SESO) and runway operations (CADOM). This work will investigate and characterize the decision processes involved in airport configuration management and runway balancing (*AP.1.C.01*) and support concepts for runway SDO and EVO operations.

Under the Applied Physics technical area, CADOM will enhance the state of the art of trajectory modeling, focusing on final approach, and initial climb, as well as wake vortex modeling. Opportunities to leverage Airspace project research related to 4D Trajectory specification and uncertainty will be explored to address trajectory uncertainty in the Airportal domain. An assessment of the state of the art of wake vortex prediction will be made early in the project (*AP.1.C.02*) to summarize and integrate recent advances in wake modeling, and to provide quantitative inputs to Level 2 and Level 3 activities to investigate alternative (to full wake prediction) concepts for improving runway capacity. Also required for quantitative analysis of airportal concept benefits is knowledge of the sensitivity of wake behavior to ambient conditions and the accuracy to which those conditions are known (*AP.1.C.02*). Enhancements to the wake modeling will be initially guided by known knowledge gaps (e.g., wake vertical motion and decay rates in the presence of vertical wind shears) and later by the results of alternative concept analysis and the sensitivity of system benefits to wake prediction accuracy. The accuracy of existing lidar-based ground-based wake vortex sensors will be assessed (*AP.1.C.03*) since much of the data used in wake model validation depends on existing data sets taken with these sensors.

Under the Applied Mathematics area, mathematics applicable to system safety assessment, such as application of large deviation theory, data mining, and other methods to detect and analyze extremely rare events in the NAS, will be developed (*AP.1.C.06*). This body of research is required due to the difficulty in assessing the safety of transformational operational concepts for which little or no historical safety data exists and for which the potential for extremely rare events will constrain concept application. This research topic will leverage work already underway by the IIFDT and Airspace Projects.

1.5.3 Airportal Transition and Integration Management

ATIM leads three areas of research: Integration (intra-project) Management, Transition (inter-project) Management, and Metroplex Operations. Integration Management is comprised of crosscutting technical challenges in four areas: the development of ConOps alternatives; Portfolio Management analysis of ConOps possibilities; Human/System Integration support of the concept and capability thrusts of each of the three Airportal Project research areas, and Model Integration.

1.5.3.1 Problem Statement

The JPDO envisions a highly flexible airportal environment characterized by highly integrated, optimized surface, arrival, and departure operations. A seamless transition between operations in the airportal environment and surrounding airspace is necessary for traffic to move efficiently in and out of dense metropolitan airspace. This is key to achieving the maximum use of airportal resources at major, secondary, and metroplex regions of airports. Considering the additional challenges for realizing the NGATS 2025 two to three times capacity growth goal, it is clear that foundational research is required to enable transformational changes in areas such as the distribution of roles and responsibilities from human-to-human and human-to-automation and novel approaches to the utilization of airportal resources within a metropolitan region.

There is a need to develop a set of smaller operational concepts that add enough additional operational and technical detail, beyond the JPDO NGATS CONOPS**,** to focus the direction of NASA's exploration of transformational approaches to key airportal challenges, including the seamless transition between surface and terminal airspace. These mini-concepts are needed to pose the operational context and define the analytical and experimental hypotheses to guide Airportal Project research. This approach divides key challenges into smaller, more tractable pieces, while ensuring a reasonable level of interoperability within the airportal domain, as well as the operational transition between the Airportal and Airspace Project domains. In many cases, the formulation of alternative mini-concepts, to explore alternative approaches to answering a key research question, is needed to focus trade studies that will provide useful information for guiding revisions to the JPDO NGATS CONOPS.

The potential value and relative contribution to NGATS of addressing different airportal challenges is not well understood. For example, what is the relative system value of removing bottlenecks to surface throughput, reductions in arrival/departure separation standards, balancing of arrival, departure, and surface resources for maximum airport productivity, or novel metroplex operations? This information is critical for Program decisions to maximize the value of NASA research to JPDO NGATS efforts.

Modeling and simulation is an essential experimental method necessary to understand the complex dynamics of the airspace system, and to assess the relative merits of alternative approaches to solving NGATS challenges. Modeling and simulation of airportal operations is a critically weak link at the component, airportal system, and gate-to-gate “airspace” system levels.

Current-day human roles, responsibilities, and authority are already highly complex and distributed across ATM system operators even before considering any significant NGATS redistributions from human to human, and human to automation. The challenge is the application of best practices to leverage radically increased levels of human-centered automation for specific surface, arrival, and departure concepts for an operational domain that is relatively new to the application of trajectory-based decision support.

Airspace and Airportal Project operations are naturally coupled. The division of the two domains is a necessary and convenient way to break gate-to-gate system problems down into more manageable components. However, because of the highly-coupled nature of traffic operations that transition between the two domains, geographic divisions force arbitrary boundaries that do not discriminate between key decision makers. Operators such as pilots, dispatchers, air traffic controllers, and traffic managers continuously make, or are substantially affected by, decisions in both domains.

Even with airportal throughput improvements optimistically expected from the research presented above, limitations in airportal throughput are still anticipated to be a critical bottleneck to reaching the NGATS vision for system capacity in 2025. To unlock additional airportal productivity improvements requires an allocation of resources that is balanced with the overall traffic-system demands. However, limitations in the current JPDO projections for airport/runway expansion beg for the investigation of novel approaches for dramatically increasing airportal throughput during peak congestion. One potentially valuable, yet unexplored, approach is the optimization of metroplex (regional inter-airport) operations.

1.5.3.2 State of the Art

Because the ATIM technical area is comprised of crosscutting challenges, there are a number of topics related to the state of the art that will be discussed. These include roles and responsibilities for the operators and automation, human performance modeling, and metroplex operations.

Roles and Responsibilities:

The foundation for this involves the understanding of the tasks necessary for the various operator roles in the airport and terminal domain. Traditional task analyses, although quite mature as a discipline, do not lend themselves to NGATS because the traditional approach focuses on the physical tasks without consideration for the cognitive aspects. The time-constrained “multi-tasking” nature of air traffic management requires a cognitive approach to extract the critical cognitive-task components. Assessments such as a cognitive task analysis (CTA) provide for a solid baseline case from which appropriate distributions of roles and responsibilities can be determined for advanced concepts without missing a critical cognitive-task component. These methods have not yet been applied to the terminal and surface domains.

Although some foundational work is needed to support the application to the surface and terminal domains, the vast majority of this work will be the application of already established best practices to the specific concept-driven algorithmic studies within the project's technical areas.

Human Performance Modeling:

Human Performance Modeling (HPM) represents the human element for modeling and simulation studies, particularly fast-time simulations. The human element refers to the aspects of modeling human behavior to predict the system's performance with humans in the loop (e.g., decision-making and execution delays), and modeling of the state and behavior of humans within a system to predict the conditions that will challenge the human in actual operations (e.g., excessive workload). HITL simulations provide the highest fidelity representation of human factors outside of the field. Although HITL is critical for the calibration of lower-fidelity models (e.g., HPM), and system development, the costs can be prohibitive. Comparatively speaking, a properly validated HPM lends itself to exploratory studies over a significantly broader range of test conditions and experimental variables for a fraction of the time and cost.

HPM has been developed and successfully applied to challenging decision-making domains outside of ATM (e.g., military/civilian flight deck operations, astronautics, and space operations control). ATM applications are particularly challenging because models of the system, even its components, must not only be developed for ANSP roles, but also for the other operators (pilots, flight planners/dispatchers, ramp control, and support services) that interact with, or affect, the ANSP.

There are two distinct gaps that Airportal research will address. Although initial attempts have been made to develop and apply HPM to en route operations (sponsored under the VAMS Project), the development of ANSP HPM models has yet to begin for terminal area and surface domains. Another very significant limitation in the state of the art of HPM is the modeling of human workload, particularly under unanticipated conditions. The HPM efforts in this project will be directly focused and driven by the unique modeling and simulation needs of the Project's technical areas.

Metroplex Decision Making

The complex combinations of conditions and interdependencies within the airspace system far exceed the ability of current mathematics and models to accurately predict behavior. Understanding of the dynamics of most of the airspace system is still rather limited - hence the importance placed on the development and experimental application of modeling and simulation methods for analyzing the airspace system and its components. In particular, the topic of metroplex operations is just emerging as a new and critical component of the airspace system, and is expected to be a key enabler for achieving NGATS capacity goals.

One critical NGATS research need is to develop models to adequately represent the dynamics of metroplex operations within the airspace system. The most significant metroplex dynamic for NGATS is the interdependency between closely-coupled traffic flows among two or more neighboring airports within close proximity of each other. Except for past studies of a few specific airports operating within a metroplex environment, the typical range of metroplex dynamics across our airspace system is not well understood or documented. State-of-the-art modeling and simulation approaches have yet to be developed for metroplex operations.

A second key metroplex research area involves the exploration of novel approaches to optimally utilize airportal resources across a metroplex to achieve transformational gains in airportal capacity. The current state-of-the-art in metroplex-decision making is limited to the current state of practice. Current practice is based on long-evolved sets of pre-defined plans and manual decisions uniquely developed within the terminal and tower facilities that control the resources within each metroplex. Moreover, these plans and decisions vary greatly from one metroplex area to another due to the unique character of each metroplex area, e.g., airport proximity, orientation, terrain, traffic flows, and traffic demand. Little if any research has been conducted to explore automation-assisted metroplex decision making to enable large increases in airportal capacities, let alone the exploration of algorithms and the potential operational envelope for the dynamic optimization of metroplex decisions.

1.5.3.3 Alignment with the JPDO

The need to functionally re-allocate roles and responsibilities among humans and automation, key to transformational reductions in workload and increases in ANSP productivity is specifically called out in the JPDO NGATS CONOPS. The requirement to develop human/automation information requirements is also called out in the CONOPS with respect to concerns over increased human reliance on automation. The JPDO identifies the need to determine research issues that are critical path to metroplex capabilities, implicitly including the need to define the operational concept aspects of metroplex operations and assess the potential benefits.

1.5.3.4 Approach

Research in the ATIM technical area integrates much of the work across the Project's technical areas, as well as performing crosscutting research (e.g., human system integration and concept analyses for portfolio management) and research in metroplex operations. The Level 3 research combines foundational work in these areas, as well as multi-disciplinary efforts.

There is one Level 4 milestone and six Level 3 milestones within ATIM. Each of these contributes to the integration components and research elements that comprise the solution set of this technical area.

The Level 4 milestone is a culminating set of simulation experiments of key combinations of Airportal capabilities for super-density operations. (*AP.4.A.01*). The primary goal of this research is to quantify system-level dynamics, and measure contributions, of integrated sets of key airportal concept elements and capabilities. The focus of the quantitative analysis will be to assess the dynamics of the integrated set of capabilities, and to quantify the relative and combined contribution of the capabilities that increase surface and terminal capacity while maintaining, or improving upon, current safety and environmental levels. Fast-time simulation will be used for the Level 4 validation to insure a full initial evaluation.

The study of these key combinations of Airportal super-density concepts builds upon several major areas of contribution from across the Project. The SESO technical area contributes the development and evaluation of algorithmic capabilities for integrated optimized ground operations (*AP.3.S.02*) integrated with initial runway/surface conflict detection and resolution (*AP.3.S.03*). SESO also contributes the development of a fast-time simulation environment to evaluate the performance of surface traffic optimization algorithms at both local and NAS-wide levels (*AP.2.S.04*). The CADOM area contributes the development and component evaluation of algorithmic capabilities for capacity enhancements and single-airport arrival/departure balancing (*AP.3.C.05*). CADOM also contributes the development of concepts and techniques for coordinated air/surface airportal operations that utilize dynamic separations, including EVO concepts for CSPRs (*AP.3.C.06, AP.3.C.09*). The ATIM technical area will provide the development of the airportal operational concepts (*AP.3.A.04*), baseline performance (*AP.3.A.03*) and benefits assessments (*AP.3.A.06*). In addition, ATIM research in runway configuration for multiple airports will be considered in this research (*AP.2.A.06*). These will help establish the foundation for this research by defining the functions and operational procedures used in the validation efforts. ATIM will also develop and validate human performance models (*AP.3.A.05*) to represent critical airportal operators in fast-time simulation studies. ATIM will collaborate with the NGATS ATM-Airspace Project on the design and integration of the airportal surface model within the Airspace NAS-wide model (*AP.2.A.02*), which in turn will be used to conduct these ATIM experiments.

The first two Level 3 milestones (*AP.3.A.01, AP.3.A.02*) involve the development of initial airportal operational concepts and an initial concept analysis (risk-adjusted benefits assessment) to organize and guide the research from an integrated project point of view, and determine the relative contributions to NGATS goals expected from the Airportal Project. The work in this area will reflect elements and efforts in the SESO, CADOM and ATIM technical areas. The concept alternatives will include consideration of functions, requirements, and procedures for the surface and terminal area. The development of concepts is a necessary foundation to ensure that the Project's set of mini-concepts and capabilities support an integrated system, and that they enable the assessment of the total (and relative) benefit contributions of the Project's mini-concepts and capabilities. Both of these initial milestones will help to formulate the research portfolio and to drive prioritization for the later years of the Airportal Project.

Because these milestones occur early in the Project, and are intended to provide guidance for the research tasks in the later years, they do not have any specific dependencies related to other project activities. Research in previous aeronautics projects and programs will be leveraged. In addition, it is expected that some of the early project activities will coordinate with the work in the development of concepts and capacity assessments. These include the initial definition of the operator roles and responsibilities (*AP.1.A.01*) which will help provide the background for the procedure definition, and the identification of weather and operational events to which the airportal environment must be able to respond to without compromising airportal contributions to NGATS goals (*AP.1.C.01*).

In FY08, there is a Level 3 milestone in the ATIM technical area that will define the baseline performance expectations and metrics for airportal operations (*AP.3.A.03*). This work will include performance expectations and metrics for regional airports. This milestone will rely upon research associated with the development of operational concepts (*AP.3.A.01*) and concept analyses (*AP.3.A.02*) to determine the critical metrics for the evaluation of the technical capabilities developed for this project. In addition, this work will leverage the baseline and metrics work within previous aeronautics projects, and will also incorporate relevant data available from other agencies.

The ATIM technical area will be responsible for creating intermediate airportal operational concept alternatives in FY10, including functions, requirements, and procedures (*AP.3.A.04*). This research effort will leverage the development of the initial operational concepts (*AP.3.A.01*) and the initial benefits assessment (*AP.3.A.02*) in FY07. Findings within the first few years of the

Project regarding the surface and terminal technologies, including findings from the Airspace Project, will be considered in the development of this intermediate set of operational concepts. The technologies and procedures that will be considered in this intermediate concept include taxi route optimizations (*AP.2.S.03*), conflict detection requirements and technologies (*AP.2.S.06, AP.2.S.07*), and runway configuration algorithms (*AP.2.S.09*). In addition, more specific operational concept alternatives associated with EVO and dynamic separation technologies will be incorporated into this work (*AP.3.C.09*). Of critical importance to the concept for NGATS is the seamless transition of traffic operations from ramp through terminal airspace. The details of an approach to a seamless transition will be defined in collaboration with the NGATS Airspace Project (*AP.2.A.01*). Insight into the range of metroplex research and operations that can be pursued within the Project will be incorporated (*AP.2.A.06*, *AP.2.A.07*). Some of the dependencies for the procedural portions of the operational concepts are the development of preliminary functional allocation (*AP.2.A.03*), interim roles and responsibilities for human operators and automation technologies (*AP.2.A.11*), and decision-making guidelines (*AP.3.A.07*). This foundational work will provide guidance for the human-machine roles and tasks for these intermediate operational concept alternatives developed within this Level 3 milestone. Moreover, the thrust of this set of human-system integration research is directly focused on the specific concepts and capabilities being investigated within the Project's technical areas.

The next Level 3 milestone in the ATIM technical area is the integration of airportal human performance models with other airportal modeling capabilities (*AP.3.A.05*). This work involves the incorporation of the airportal modeling environment designed for testing tools and technologies with the human performance models for the assessment of the operators. This effort is critical to the future system evaluation of the capacity and safety of the airport and terminal domains. Work in this milestone relies upon the initial validation of these models (*AP.2.A.05*) with existing data to insure the soundness of the stand-alone human performance models prior to integration. Work in the later years (beyond FY11) of the Project will refine and further validate the integrated model based on modified NGATS procedures and additional data.

The final ATIM Level 3 milestone is an intermediate set of concept (benefits) analyses of airportal concepts and capabilities (*AP.3.A.06*). This FY11 milestone will revise and enhance the initial benefits assessment, scheduled for FY07, based on results from airportal research and a significantly greater level of fidelity within the analyses. It will incorporate the knowledge gained from the initial concept analyses (*AP.3.A.02*), and provide a more detailed benefits assessment based upon the information gained from the Project in the preceding years. This work will help to further prioritize the work for the latter five years of the Airportal Project.

In addition to the previous concept analyses (*AP3.A.02*), other research will provide important data for this intermediate benefits assessment. The milestone that will develop the intermediate Airportal ConOps (*AP.3.A.04*) will be used to help determine the appropriate functions and procedures to model for the benefits assessments. The milestone that defines the baseline performance expectations and metrics for airportal operations (*AP.3.A.03*) will also be used to help provide the comparison methods and metrics for this intermediate benefits assessment.

1.5.3.5 Foundational Research

There are a number of foundational research areas in the ATIM technical area. Since ATIM represents the crosscutting elements of this project, human/system integration and automation design is one of the areas that is researched. The identification and assessment of human-operator roles in the airportal environment is examined (*AP.1.A.01, AP.2.A.11*), as well as the information requirements and decision-making tasks for both humans and automation (*AP.2.A.10*). The other crosscutting foundational area within ATIM is the identification of weather requirements and operational events that are critical for the maintenance of the flexibility and robustness of the surface and terminal areas (*AP.1.A.02, AP.1.A.05*). These foundational research topics must be adequately addressed to insure the success of the work within the Airportal Project.

Appendix A. Acronyms

4D	Four-Dimensional
4DT	Four-Dimensional Trajectory
AATT	Advanced Air Transportation Technologies Project
ADS-B	Automatic Dependent Surveillance Broadcast
AILS	Airborne Information for Lateral Spacing
AOC	Airline Operations Center
ANSP	Air Navigation Service Provider
API	Associate Principal Investigator
ARMD	Aeronautics Research Mission Directorate
ADS-B	Automatic Dependent Surveillance - Broadcast
ASDE	Airport Surface Detection Equipment
ASDE-X	Airport Surface Detection Equipment, Model X
ASP	Airspace Systems Program
ATC	Air Traffic Control
ATIM	Airportal Transition and Integration Management
ATM	Air Traffic Management
AVOSS	Aircraft Vortex Spacing System
CADOM	Coordinated Arrival and Departure Operations Management
CD&R	Conflict Detection and Resolution
CONOPS	Concept of Operations (JPDO)
ConOps	Concept of Operations (NASA)
CSPR	Closely-Spaced Parallel Runway
CTA	Cognitive Task Analysis
DFW	Dallas-Fort Worth International Airport
ESTOL	Extreme Short Take-Off and Landing
EVO	Equivalent Visual Operations
FAA	Federal Aviation Administration
FY	Fiscal Year
HITL	Human-in-the-Loop
HPM	Human Performance Modeling
IIFDT	Integrated Intelligent Flight Deck Technologies
IMC	Instrumented Meteorological Conditions
IPT	Integrated Product Team
JPDO	Joint Planning and Development Office
L1	Level 1
L2	Level 2
L3	Level 3
L4	Level 4
LES	Large Eddy Simulation (models)
NAS	National Airspace System
NGATS	Next Generation Air Transportation System
NRA	NASA Research Announcement
NTSB	National Transportation Safety Board
NTX	North Texas Research Station
OEP	Operational Evolution Plan
OOOI	Out, Off, On, In
PDF	Probability Density Functions
PFD	Probability of False Detection
PI	Principal Investigator
PM	Project Manager
POD	Probability Of Detection
PS	Project Scientist
R&D	Research and Development
REDAC	FAA Research, Engineering, and Development Advisory Committee
RIPS	Runway Incursion Prevention System
RNP	Required Navigation Performance
ROT	Runway Occupancy Time
RWSL	Runway Status Light system
SDO	Super-Density Operations
SEAD	Systems and Engineering Analysis Division
SESO	Safe and Efficient Surface Operations
SFW	Subsonic Fixed Wing
SLDAST	System-Level Design, Analysis & Simulation
SME	Subject Matter Expert
SMS	Surface Management System
SRW	Subsonic Rotary Wing
SSBJ	Supersonic Business Jet
TACEC	Terminal Area Capacity-Enhancing Concept
TAP	Terminal Area Productivity Project
TASS	Terminal Area Simulation System
TCAS	Traffic Alert and Collision Avoidance System
TFM	Traffic Flow Management
TRACON	Terminal Radar Approach Control
VAMS	Virtual Airspace Modeling and Simulation Project
VLJ	Very Light Jets
VMC	Visual Meteorological Conditions

Appendix B. References

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