Project Report
TIP-63
Revision 1

NASPlay: Advanced Air Traffic Management: FY17 Homeland Protection & Air Traffic Control & HADR Technical Investment Program

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5 March 2018

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ABSTRACT

In FY17, Lincoln Laboratory (LL) continued applying internal allocated funding toward its Air Traffic Control mission area. These investments have enabled new capability development to occur that will enable development and evaluation of new decision support technologies and will facilitate program growth with sponsors within the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), Department of Defense (DoD), and Department of Homeland Security (DHS). The allocated program executed in FY17 was Program **TI90-1501** to support an operational planning capability for Air Traffic Management (ATM), called *National Airspace System Play (NASPlay)*.

NASPlay development effort focused on six areas:

1. **Operational evaluation of real-time NASPlay capabilities.** Over a period of three days, several NASPlay scenarios were run in conjunction with real-time forecasts in order to aid traffic managers in making real-time air traffic management decisions. The NASPlay simulations were evaluated with traffic managers post-hoc to improve what NASPlay could provide.
2. **Development of capabilities to enable faster simulation processing.** Data ingest feeds were modified to better support the real-time evaluation capability of NASPlay.
3. **Scenario and simulation creator development.** A Hyper Text Markup Language (HTML) interface was created to enable user-friendly scenario creation and simulation execution for NASPlay, which provided the capability of quick new NASPlay scenarios to be created without development or interaction with code.
4. **Weather training capability exposure.** Based upon traffic manager feedback, a past weather training capability was developed and exposed to traffic managers to aid in convective weather traffic management training.
5. **Expansion of NASPlay analytics.** Additional means of viewing NASPlay data, including time-series data, were developed and explored.
6. **NASPlay simulation validation efforts.** Because of the complex nature of simulating the National Airspace System combined with weather, ongoing validation efforts with each new scenario created were required to monitor emergent behaviors.

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1. INTRODUCTION

National Airspace System Play (NASPlay) is an integrated planning, simulation, playback, and training system to support the Federal Aviation Administration's (FAA's) air traffic management capability. NASPlay is a web-based capability that can be accessed through any browser. The system utilizes actual air traffic management data, including Aircraft Situation Display to Industry (ASDI) flight schedules, Corridor Integrated Weather System (CIWS) convective weather information, U.S. jet routes, and aircraft simulation to enable realistic representation of the National Airspace System (NAS). Actual traffic management actions have been emulated in NASPlay to enable simulation of alternative traffic management decisions for the same set of initial data. The entire NAS can be simulated in fast-time, simulating 24 hours in only a couple of hours, to generate the resulting flight data from different traffic management decisions. Once these simulations have been run, NASPlay can playback, in real-time or fast-time, the flight data resulting from traffic management decisions on a graphical user interface similar to those used by the FAA. In addition, analytics were developed to enable statistical comparisons of data from different traffic management decisions to enable the evaluation of the quality of the decisions.

1.1 NASPLAY CONOPS EVOLUTION

NASPlay was originally conceived as means to train air traffic managers on decision-making utilizing realistic weather and traffic data. An air traffic management game was created in the first two years of allocated funding as a proof of concept to garner feedback from air traffic managers and to encourage a more immersive training experience. The high-fidelity simulation of the NAS-wide air traffic was received positively, but it was discovered that the NAS-wide system was of sufficient complexity such that few training objectives existed in air traffic management.

Thus, with the created simulation as a starting point, the NASPlay concept of operations evolved to aid the FAA in identifying measurable ways of predicting and improving air traffic management decision-making. The conops transitioned from a training focus to an operational focus.

In FY17, the focus of the allocated funding for NASPlay including exploring NASPlay as a means to support the operational air traffic management decision process and modifying the NASPlay system to enable this use.

1.2 REPORT OUTLINE

This remainder of this report will focus on describing the following:

- NASPlay Core Capabilities
- Plan, Execute, Review, Train, Improve (PERTI)
- Weather Training Capability
- Summary of FY17 Contributions

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2. NASPLAY CORE CAPABILITIES

NASPlay architecture is illustrated in Figure 1. The core technologies include the simulation capabilities (implementation of control strategies, representation of constraints, and simulated system behavior in response to both), the *NASPlay* game server architecture, and automation for scenario generation. The simulation engine is based on a commercially available air traffic simulator (AirTOp), with extensions developed at Lincoln to define convective weather constraints and simulation behaviors in response to those constraints. The *NASPlay* game server is an Apache server; the game progresses through ordinary service of scenario pages, images, etc. Scenario generation requires the preparation of input schedules, calculation of resource constraints due to weather, design of the decision tree that will be played out in the scenario, modeling of Traffic Management Initiative decisions in the decision tree, simulation of each branch in the decision tree (accounting for constraints), collation of images and comments to be presented to the player during the course of game play, and specification of the scenario-specific user interface configuration. In the next sections, the data feeds, NASPlay gaming interface, AirTOp simulation, weather impact models, analytics and scoring, and scenario/decision tree creator will be further described.

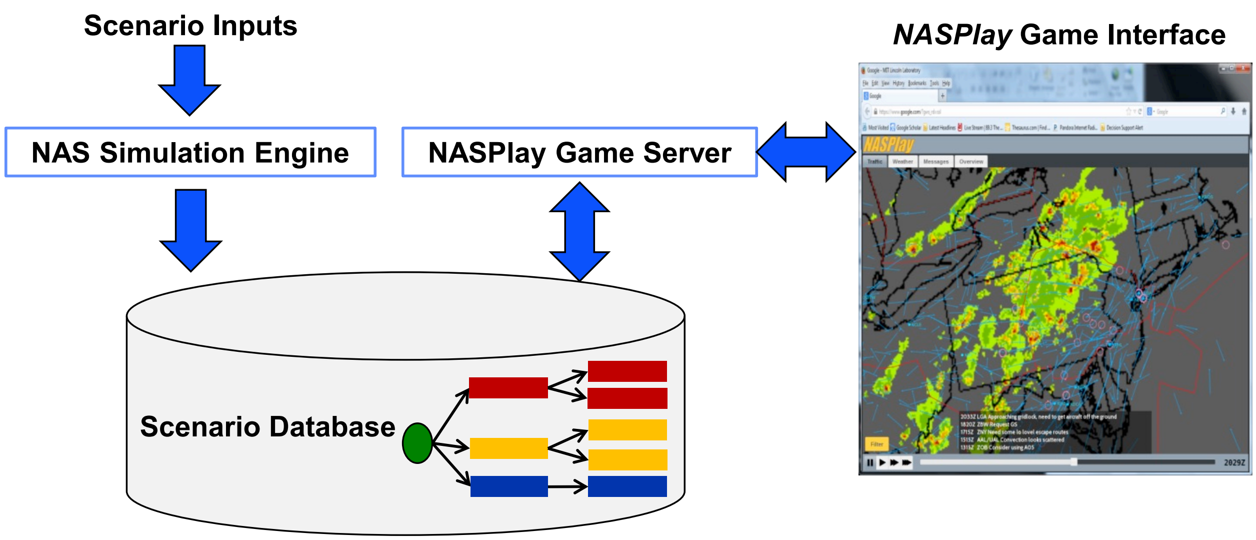

Figure 1. NASPlay overview.

2.1 DATA FEEDS

Operational data required by NASPlay include the following:

- Flight planning messages, obtained from the Traffic Flow Management System (TFMS) System Wide Information Management (SWIM) feed, required for generation of flight plans and demand,
- CIWS observed Vertically Integrated Liquid (VIL) and echo top grid product time series, obtained from the MIT LL CIWS archives, required for the generation of convective weather-related capacity constraints,
- Observed Traffic Flow Impact output time series, calculated offline from the observed CIWS weather products, required as the estimation of capacity constraints,
- CIWS forecast VIL and/or echo top images, obtained from the MIT LL CIWS archives, required only for game play user feedback/situational awareness, and
- Traffic Flow Impact (TFI) forecast images (optional), for user feedback during game play.

This year, one of the primary thrusts for development was to explore ways to speed up simulation preprocessing and AirTOp performance to support the operational timeframes. One means of executing this thrust was through the re-architecting of the demand generation process. Flight planning ingest was transitioned from the FAA ASDI system to an internal Lincoln flight planning database populated by the TFMS SWIM data feed. Flight plans for "typical" scheduling days were generated in advance and stored in the database. As a result, flight plans do not have to be processed at scenario generation time, reducing the scenario generation time by as much as a factor of two.

2.2 NASPLAY GAMING INTERFACE

The NASPlay human-machine interface shown in Figure 2 was built to be highly interactive, and this interactivity remains whether using NASPlay for game mode or simulation playback mode. Initially users can choose which day they want to focus on, and then an initial traffic/weather scenario begins to play out on the combined traffic and weather screen. Users have the ability to fast-forward, pause, or rewind the time loop of traffic and weather. In addition to the temporal controls, several other tabs at the top of the screen offer different views of the situation, including temporally changing traffic delays at key NAS airports, messages from the airlines as they are received, and weather forecasts for that viewed time period.

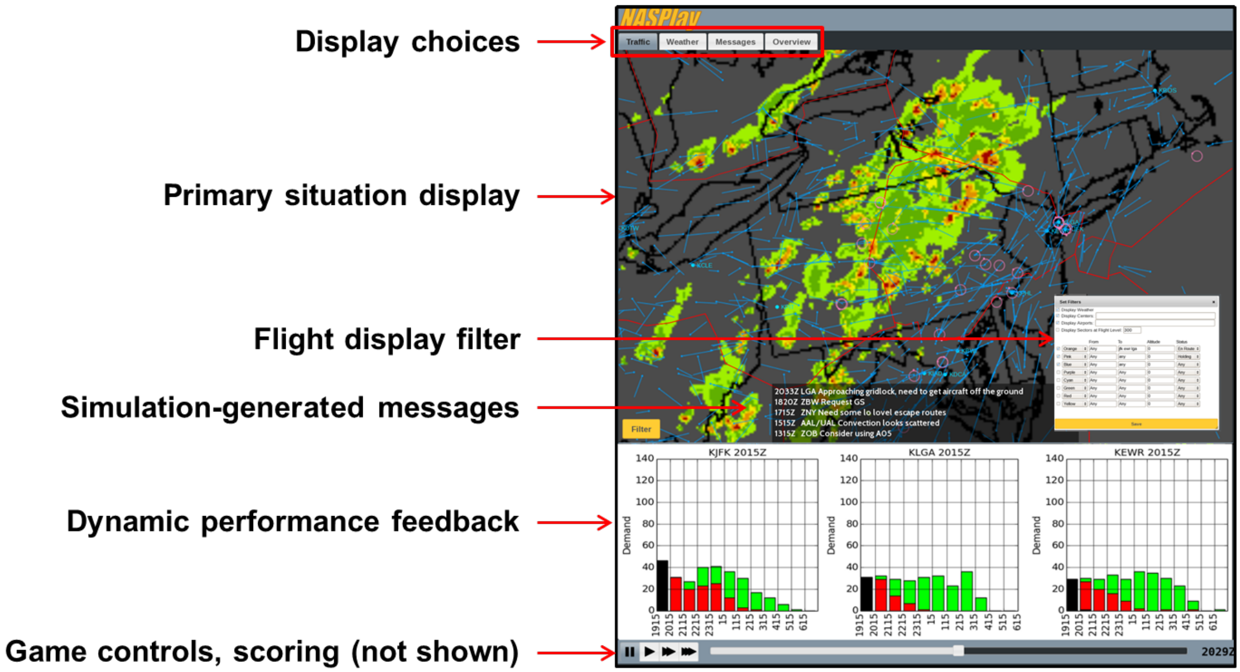

Figure 2. NASPlay Gaming Interface.

For the game and simulation playback in NASPlay, there comes a time at which alternative traffic management decisions are possible. The gaming interface allows the user to choose which of these decisions that he or she would like to see executed. Depending on the scenario, there may be multiple decisions of this sort to input. At the end of the scenario day, a scoring and analytics screen is shown to provide the user the statistics of that particular traffic management decision choice as compared with other choices that could have been made. Few changes were made in FY17 to the gaming interface.

2.3 AIRTOP SIMULATION

NASPlay was developed to enable researchers to swap out simulation capabilities if a better simulation capability was discovered/developed. The simulation engine used in the current prototype of NASPlay is a Belgian-developed simulation capability called AirTOp.

After a technical evaluation of an array of existing simulation capabilities, the AirTOp simulation capability was chosen due to its agent-based foundation and flexible development environment. In addition, AirTOp had already been used with success for surveillance requirements assessment for another Laboratory program.

AirTOp's agent-based implementation enables fine-grained control over several key elements of NAS operation and simulation:

1. **Dynamic capacity constraints.** Simulations may be initialized with time-varying capacity constraints on any airspace resource that is defined in the NAS adaptation.
2. **Rule-based resolution of demand/capacity imbalance.** The default resolution implemented in AirTOp is to delay individual flights on the ground until they can realize their flight plans without overloading the capacity of any airspace resource. AirTOp provides hooks to modify the default behavior and create contingencies for exceptions to the default.
3. **Options for tactical weather avoidance.** AirTOp provides mechanisms to implement tactical weather avoidance options such as no-notice holding and trajectory vectoring to avoid weather. In addition, hooks are available to integrate models that trigger diversions, Ground Stops, and other tactical responses to airspace constraints.
4. **Hooks for calculation of default and custom performance and scoring metrics.** AirTOp supports the specification of watch points that can trigger data analysis and the output of user-specified simulation state data for incorporating the generation of performance and scoring metrics into the simulation.
5. **Comma Separated Values (CSV) text file format for all Input/Output (I/O).**

Several weeks of training were required for development staff to familiarize themselves with the environment. After training was completed, the baseline structure for the NAS was input into the simulation capability (e.g., Air Route Traffic Control Center (ARTCC) boundaries, air traffic control sector boundaries, navigation fixes, jet routes, playbook reroutes, aircraft types, airports). A full day's flight plan schedule data was obtained from our archived TFMS data feed and ingested into AirTOp. As is common with aviation data, a significant amount of preprocessing of the data was required to return reasonable output:

1. Correction (where possible) or removal of flight plans with ambiguously or incorrectly specified navigation fixes,
2. Assignment of aircraft type where flight plans do not specify an aircraft type, or where the type is unknown to AirTOp's trajectory model,
3. Proper sequencing of departure times to ensure temporal continuity of flight plans that have multiple stops and continuation legs,
4. Filtering of flight plans that are unnecessary for the game scenario to reduce simulation run time,
5. Specification of missing or realistic cruise altitudes and air speeds for flight plans, and
6. Conversion of scheduled flight plans into AirTOp's input format.
7. Determining which ASDI/TFMS flight plan or update to use in cases of multiple entries.
8. Removing any "loops" from routings.

Converting units of measurement, especially for speed (e.g., Mach, indicated airspeed, true airspeed).

2.4 WEATHER IMPACT MODELS

In FY15, constraints due to convective weather impacts were modeled as a combination of time-variant fix and traffic flow capacities through strategically placed Flow Constrained Area (FCA) boundaries (Figure 3). This resulted in fairly stable and tractable system behavior that enabled the detailed examination of NAS system dynamics. However, the assignment of flights to a small number of strategic constrained traffic flows is challenging, and many flights that were not assigned to flows were able to fly through weather-impacted regions unconstrained. As a result, the NAS capacity impacts of convective weather constraints were underestimated, biasing the performance assessment of different traffic management strategies.

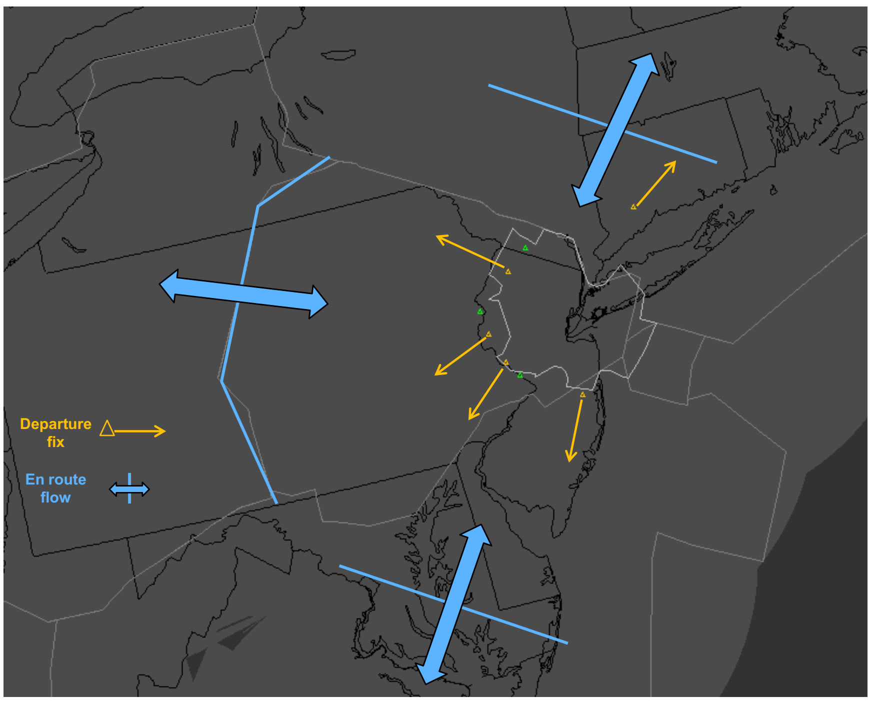

Figure 3. Capacity constraints modeled in NASPlay prior to FY16 development.

In FY16, a revised Air Traffic Control (ATC) sector capacity model was developed, implemented and tested in the NASPlay simulation. Convective weather constraints may now be represented through a combination of fix, traffic flow, and sector occupancy capacities. Constraint types may be independently activated, allowing the simulation of different combinations of constraint types. Validation of the new sector capacity model and simulation response to ATC sector constraints is ongoing.

Three commonly observed tactical NAS responses to unanticipated weather constraints and congestion were added to the simulation:

1. **Triggered diversions.** A global upper limit on airborne delay can be applied to flights. Flights whose airborne delay will exceed the limit if they are allowed to continue to their destination now divert to the nearest major Aviation System Performance Metrics (ASPM 77) airport.
2. **Triggered Approval Request (APREQ).** When significant, unanticipated airspace constraints arise, the APREQ process may be initiated. Under APREQ, departures from first- or second-tier airports upstream of the constraints are required to hold on the ground until given approval to depart.
3. **Triggered tactical reroutes.** Airborne flights headed toward constrained and congested airspace may be rerouted through unconstrained airspace.

All three behaviors are automatically triggered by constraint/congestion thresholds and may be separately enabled or disabled in the simulation. The playback user interface also allows the user to identify flights that have been diverted or tactically rerouted and to display the dynamic evolution of APREQ-related ground delay at NAS airports. In FY17, few modifications were made to the weather impact and system response models, but validation efforts with each new scenario identified bugs and inefficiencies in existing models that were corrected.

2.5 ANALYTICS AND SCORING

End of scenario score screens are provided within NASPlay. Figures 4 and 5 show these screens currently provided. Figure 4 shows the “Rating” screen, which compares the choice that the user selected with the other choices available. The user is then graded on a curve compared to the other alternative traffic management decisions. Figure 5 shows the FAA AERO screen emulation, which replicates data that the air traffic managers already view after a day. This was developed after a suggestion by one of the air traffic managers who viewed an early NASPlay prototype.

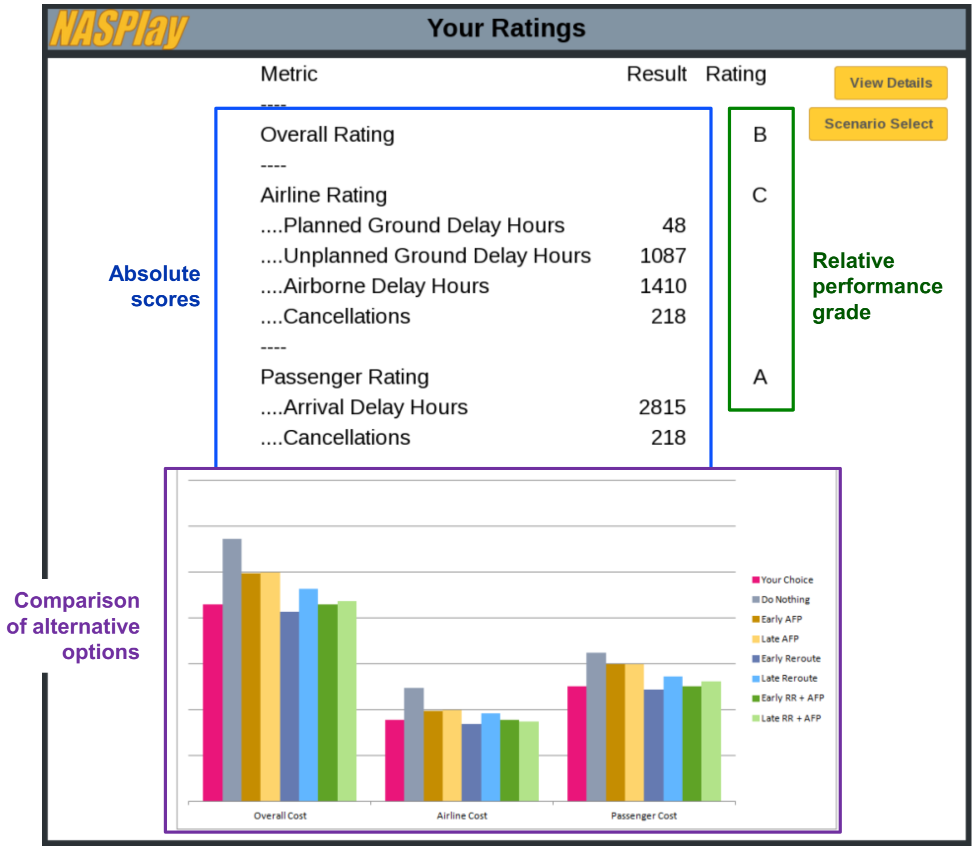

Figure 4. Post-game scoring screen.

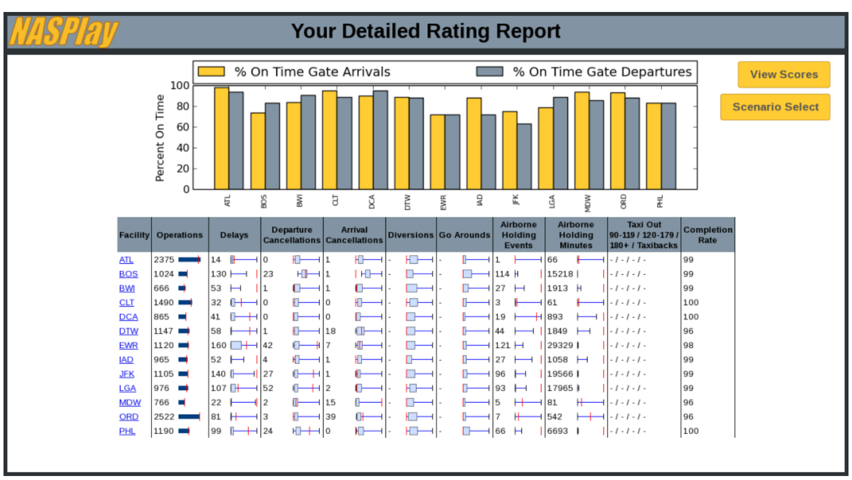

Figure 5. Emulation of FAA AERO analysis tool.

In FY17, an additional time-series view that is currently unavailable to air traffic managers was developed to aid operational decision review. An example of this analytic is provided in Figure 6. In these graphics, the temporal viewpoint, which is not easily viewable in NASPlay, is shown. To ease visual interpretation, mild smoothing algorithms were applied. The two decision options are “do nothing” and implement an Airspace Flow Program (AFP)/reroute option. In these time series graphics, the traffic manager can directly compare the two decision options for different metrics (e.g., holding, diversions, ground delay, and reroute mileage). This type of analytic could be valuable in determining the practical significance of a Traffic Management Initiative (TMI). For example, when considering the holding metric, the “do nothing” and AFP/reroute option look similar, except there is extra holding for the “do nothing” case around 1900Z and less holding in this option around 0000Z. The statistics may say the holding is the same for each option (total), but viewing it in a time series manner lets the traffic manager see that there may be more holding earlier, but less holding later, which may impact their ultimate decision.

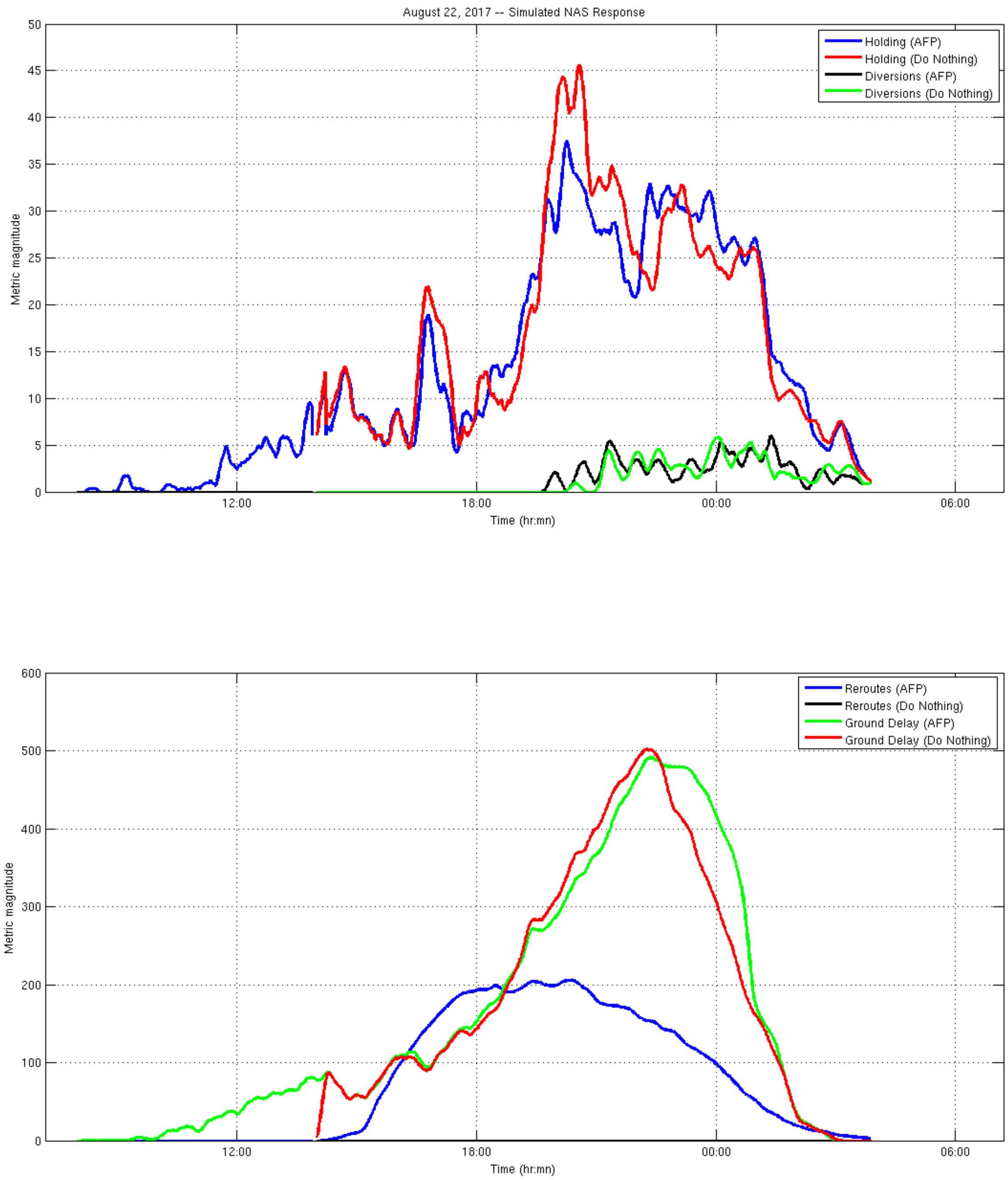

Figure 6. Temporal perspective of NASPlay simulation metrics for different decision options.

2.6 SCENARIO AND DECISION TREE CREATOR

To create new training games or decision making simulations, user-friendly interfaces were developed to enable non-developers to generate new content. Figure 7 below shows a Hyper Text Markup Language (HTML) map that guides the content creator through the steps required to produce a new training game or decision making simulation. The content creator would begin at the star and then proceed where the arrows direct. Once the paths through "Export data" are complete, then the new content can be viewed.

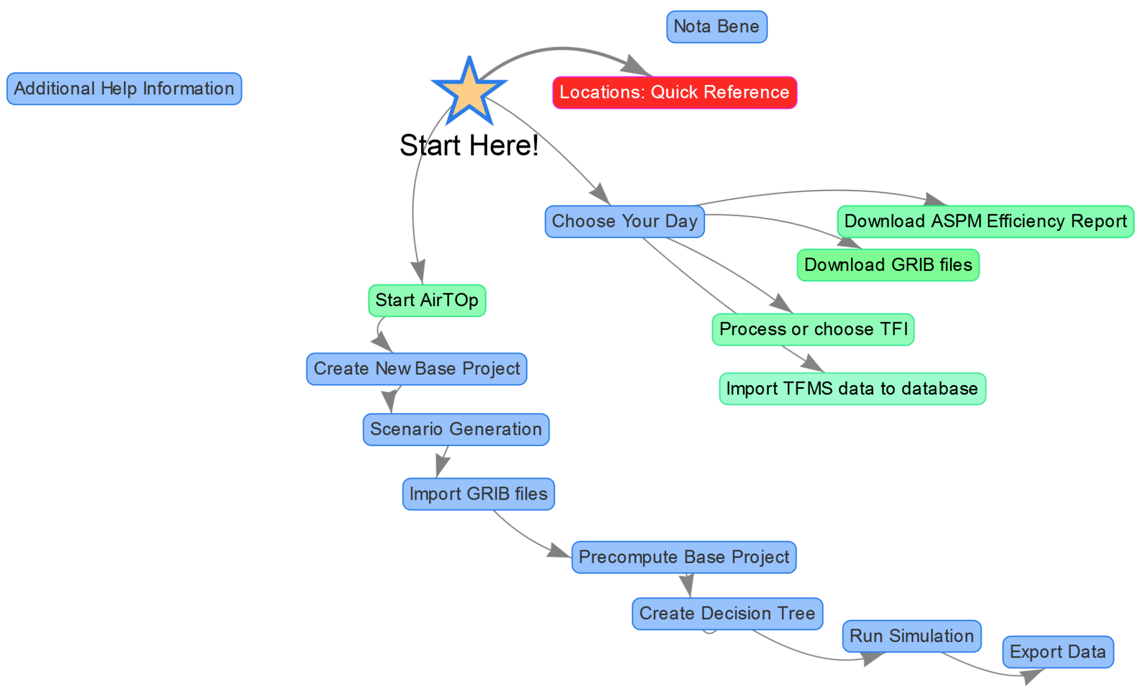

Figure 7. HTML guide to create new NASPlay content.

The three other capabilities generated to aid the automatic content creation include a scenario generator, which runs individual AirTOp simulations, a decision tree creator, which generates the options in a training game or decision making simulation, and an exporter, which prepares AirTOp simulation data for viewing. The scenario generator interface is shown in Figure 8 and the decision tree creator interface is shown in Figure 9.

The scenario generator enables the content creator to select the date and time of the simulation to create and how long the simulation would run. It also enables the content creator to choose the data feeds

(ASDI or TFMS) from which to retrieve flight schedule information, which Air Route Traffic Control Centers (ARTCCs) that flights fly through, and whether Route Availability Planning Tool (RAPT) data should be acquired as well. The scenario generator performs the scheduling and weather impact data ingest, and conditions this data for use in AirTOp.

The decision tree creator enables the content creator to determine which traffic management initiatives to include in the training game/decision making simulation, and what parameters these TMIs should have. It also enables the content creator to specify what data to display on the situation display (e.g., FCA lines, flight filtering capabilities). The decision tree creator organizes the simulated data, as well as provides the non-programmatically generated data to the NASPlay gaming interface.

The process is finalized by a third tool, a facility to export AirTOp simulation data into a format interpretable by the NASPlay gaming interface. The exporter computes game statistics and scoring metrics, generates the delay graphs used to provide the dynamic performance feedback during the game, and acquires the graphical representations of the weather for display during the game. This tool is not interactive.

For FY17, the scenario generator was improved, the decision tree creator was developed, scenario generation automation was improved, and overall NASPlay documentation was created.

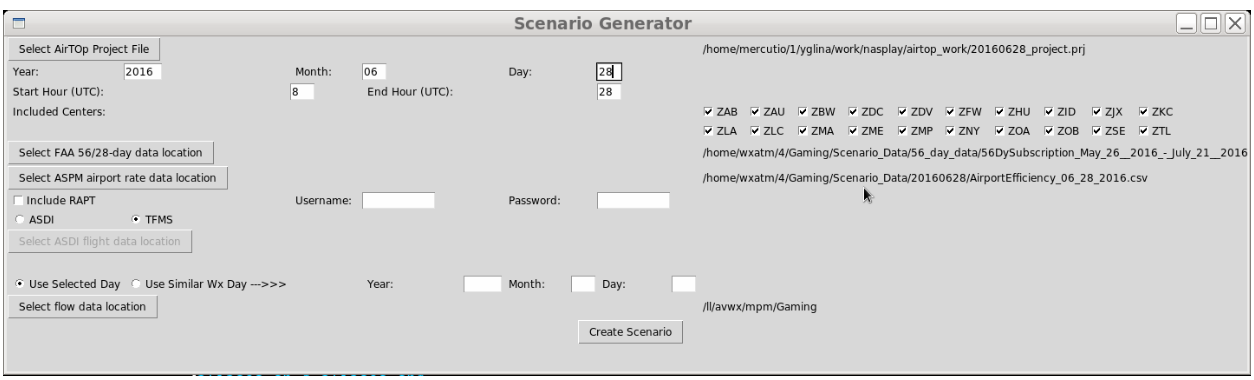

Figure 8. Scenario generator interface.

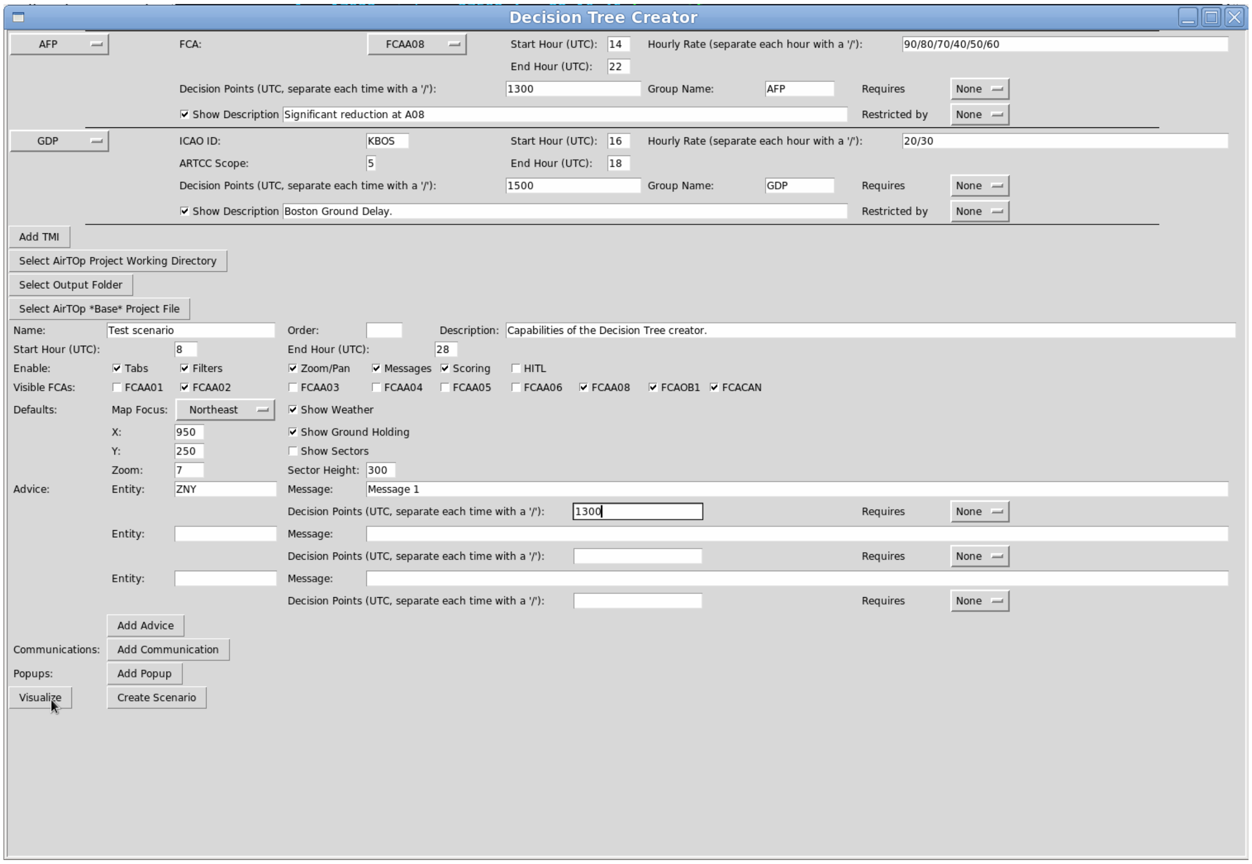

Figure 9. Decision tree creator interface.

3. PERTI OPERATIONAL EVALUATION

The Federal Aviation Administration is re-evaluating their current method of planning traffic management before an event and reviewing traffic management decisions once the event has occurred. The trial system that they are attempting to implement is called PERTI. The PERTI operational concept is shown in Figure 10.

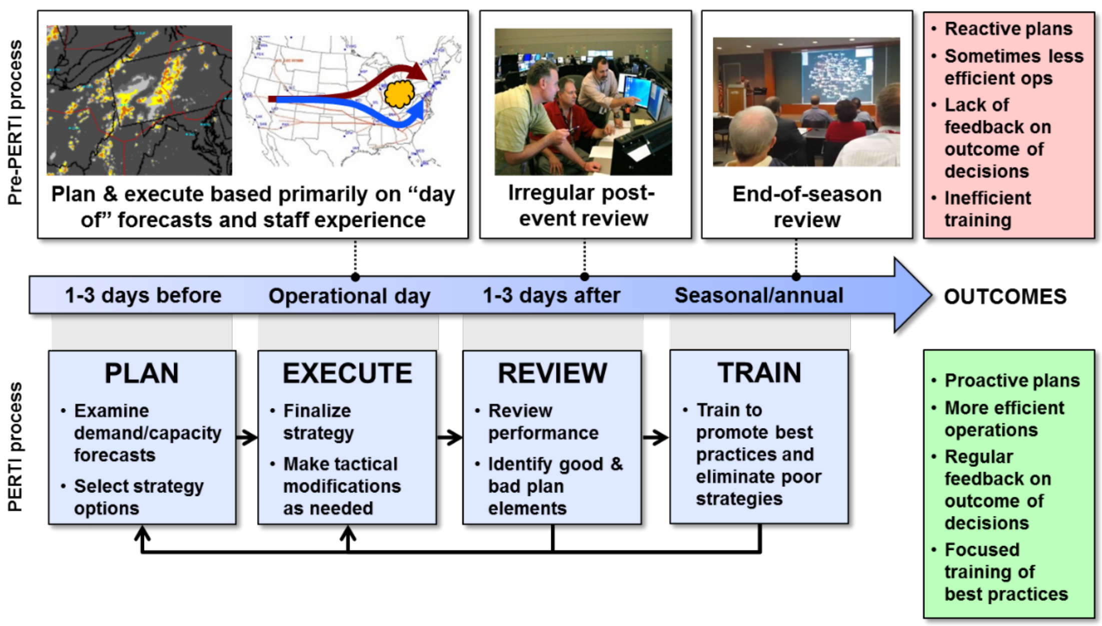

Figure 10. Plan, Execute, Review, Train, Improve (PERTI) operational concept.

Key elements of the PERTI ConOps include earlier initiation of operational planning when significant weather impacts are anticipated (to better inform airline customers about potential traffic management initiatives), test alternative TMIs before an event, continue to simulate potential adjustments to the operational plan as an event unfolds, review alternative strategies post-event to inform future decision making, and better utilize data analytics throughout these processes.

3.1 ROLE OF NASPLAY IN PERTI

Because NASPlay combines a simulation capability, an array of data analytics, and advanced models for weather impacts and operational system responses, it is well suited to the PERTI ConOps. As a result of the socialization of NASPlay at the ATCSCC over the last couple of years, ATCSCC management agreed to a NASPlay trial within the PERTI context.

The NASPlay trial process, illustrated in Figures 11 and 12, describes how NASPlay can be used to inform operational decision-making both at the strategic and tactical levels. In the days before an event, NASPlay simulations can be run on "similar weather forecast" days to try out different TMI combinations. As forecasts are updated, TMI plans can also be modified to account for this new information. On the day of an event, 8-hour Consolidated Storm Prediction for Aviation (COSPA) and CIWS forecasts can then be used to provide simulations on which the TMI execution decisions can be made. After the event, visualized analyses and statistics that NASPlay collects can be used to review the decisions made using the actual weather and forecasts available.

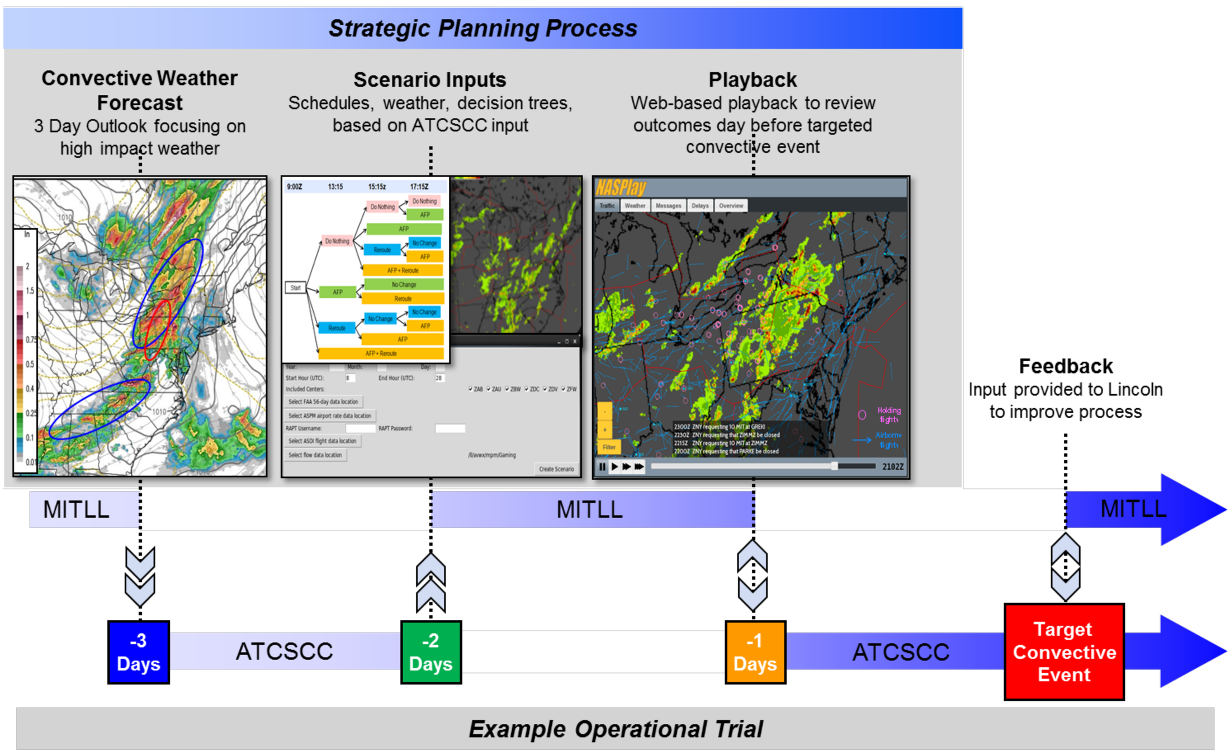

Figure 11. NASPlay's role in strategic planning process in PERTI.

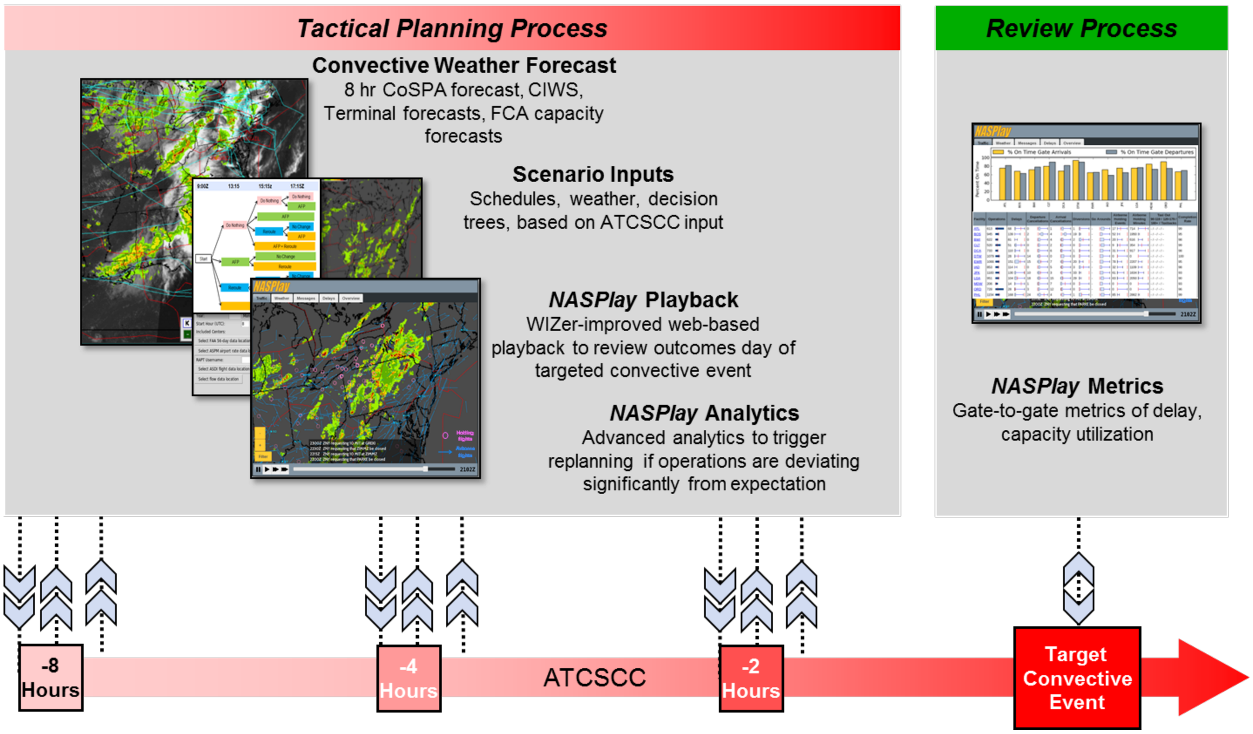

Figure 12. NASPlay's role in tactical planning process in PERTI.

3.2 OPERATIONAL EVALUATION

In 2017, a trial of NASPlay as a support technology to PERTI was conducted. Several days before, Lincoln forecasters identified 22 August 2017 as a potential convective weather day that could impact NAS flights significantly. Two days prior to the event, convective forecasts from multiple medium and short range models were consulted, and the consensus indicated that there would be a disruption to NAS operations, reducing throughput into and out of New York Terminal Radar Approach Control (TRACON), as seen in Figure 13.

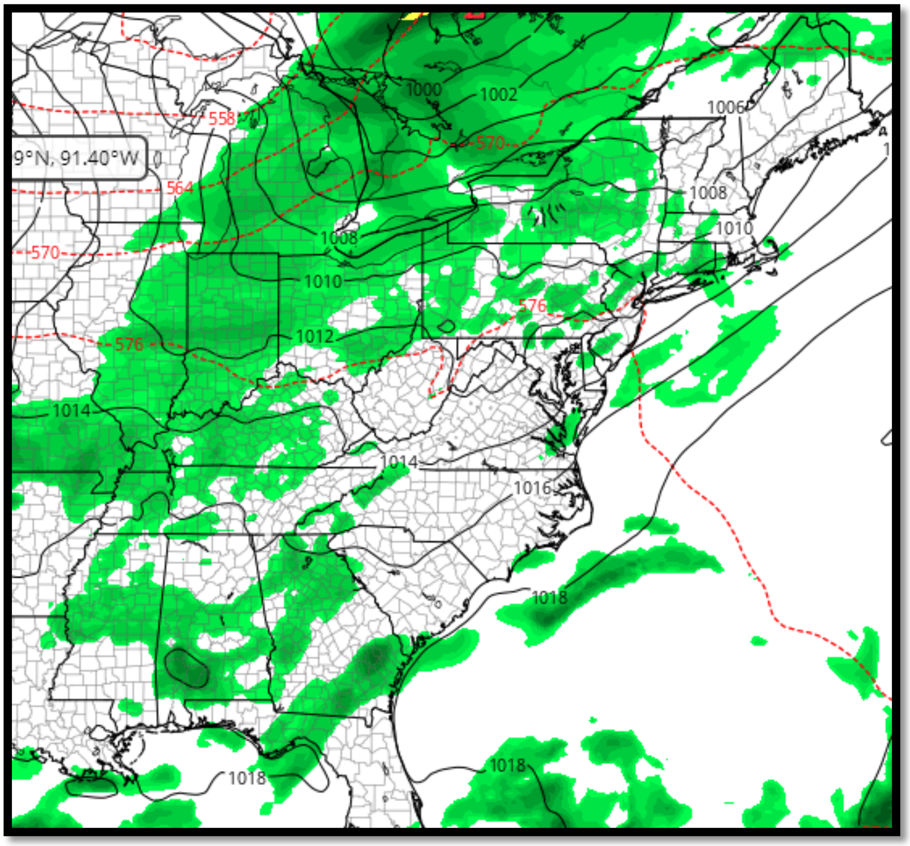

Figure 13. 24-hour forecast for 22 August 2017, valid 1800 UTC.

One day before the event, a "similar weather day" was chosen for NASPlay simulation based upon weather and traffic impact similarities. The convective weather for this similar weather day of 13 August 2016 is shown below in Figure 14.

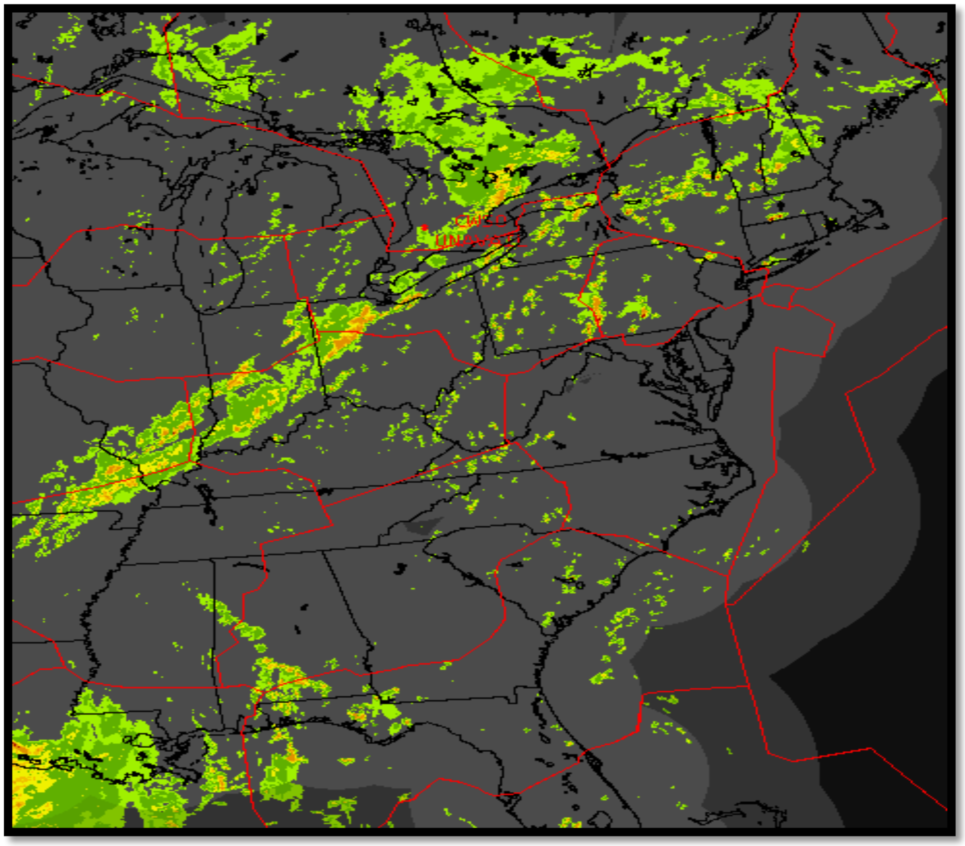

Figure 14. Convective weather pattern of 13 August 2016, a "similar weather day" in weather and traffic impacts to 22 August 2017.

Once the similar weather day was chosen, the remainder of the NASPlay data was aggregated, including flight schedule (a previous schedule from an August Tuesday) and weather and volume FCA capacity constraints. Coordination with the ATCSCC enabled understanding which strategic TMIs were being considered, including doing nothing (no TMI) and implementing AFPs/Playbook reroutes. The specific TMIs considered for the AFP/reroute option were:

- AFP implemented at 1400Z, control in effect from 1800Z to 0200Z for:
  - FCA0B1 rates: 70:70:60:60:60:60:70:90:100
  - FCAA08 rates: 90:90:90:90:90:90:90:90:100
- Reroutes: AZEZU playbook and CAN-ULUTO-EAST-4

Using this information, NASPlay simulations were run and decision-making simulation replay was provided with the following statistical information:

- Total NAS ground delay (Expected Departure Clearance Time (EDCT), tactical—held on the ground due to airspace congestion)
- Total NAS airborne delay (holding, reroute)
- Cancellations (flights cancelling after 3 hours total ground delay)
- Diversions (flights diverting when airborne holding = 45 min)

Figure 15 shows the emulation of the flight schedule monitor output for the "do nothing" option as compared to the AFP option. Because the weather forecasts are only forecasts, there is a strong possibility that the timing of the arrival of the weather will be early or late. If the demand controls misestimate the arrival of the weather, delaying the demand until later would only make the situation worse by increasing the number of flights affected by the weather.

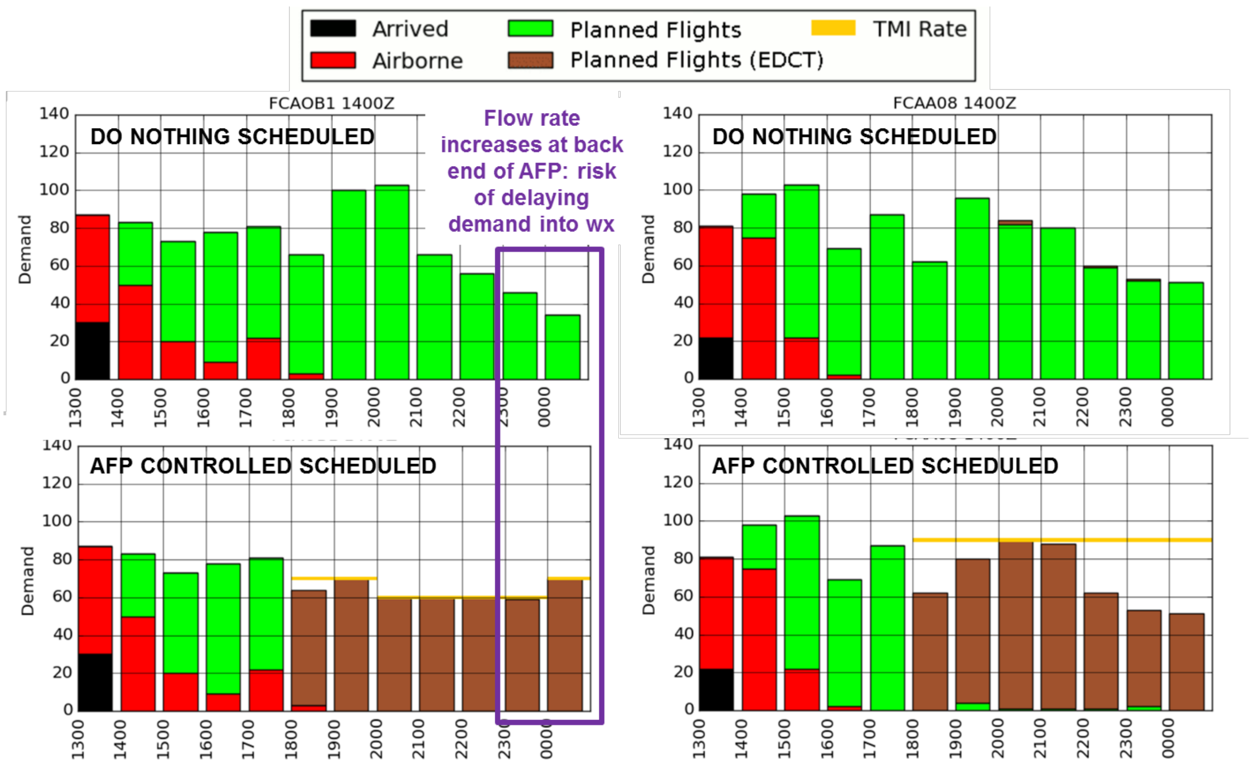

Figure 15. Flight Schedule Monitor emulated output from NASPlay comparing two options: "Do nothing" and implementing AFPs and reroutes.

Statistics were also generated by NASPlay for this event simulation, which are shown in Figure 16 and previously shown in Figure 6. As expected, ground delays due to the TMI were present, where they were not in the "do nothing" case. Early tactical ground delays were present in the "do nothing" case, but later tactical ground delays were evident in the TMI case. Few differences were evident in airborne holding, cancellations, and diversions between the two options, statistically. Additional insight can be gained about the characterization of the temporal aspect of the holding, cancellations, diversions, and ground delay from Figure 6 with the new visualization. Some slight impact of additional airborne holding at the peak period for the "do nothing" case is apparent from this visualization. However, it appears that implementing a TMI for this weather day does not appear to be a desirable option because the benefits it affords do not outweigh the control costs.

Statistic	**Do-nothing**	**TMI (AFPs + Re-route)**	**Comments**
TMI delay (EDCT + reroute time-of-flight) (total minutes / per-flight minutes / # flights)	0	21,082 / 29 / 718	Lots of controlled flights, but…
Tactical ground delay (minutes)	29,173 (front-loaded)	28,604 (back-loaded)	Do-nothing delays early in the day; TMI delays later
Airborne holding (total minutes / per-flight minutes / # flights)	11,385 / 4.4 / 2580	12,561 / 5.1 / 2469	Differences are negligible
Airborne holding > 15 minutes (total minutes / per-flight minutes / # flights)	6680 / 30 / 221	6249 / 31 / 202	
Cancellations (commercial passenger / all)	417 / 537	402 / 537	
Diversions (commercial passenger / all)	60 / 74	69 / 82	

Figure 16. Statistics generated by NASPlay for two decision options: "Do nothing" and implement AFPs and reroute.

Tactically, the outcomes of the "do nothing" and TMI options were compared through the NASPlay playback. Hour 2 of the AFP (2000Z) is shown for each option below in Figure 17. Minimal differences in traffic density, airborne holding, and diversions were present, and ground delays in New York (NY) metro, Detroit Metropolitan Airport (DTW), and Buffalo Niagara International Airport (BUF) were slightly lower with the TMI option.

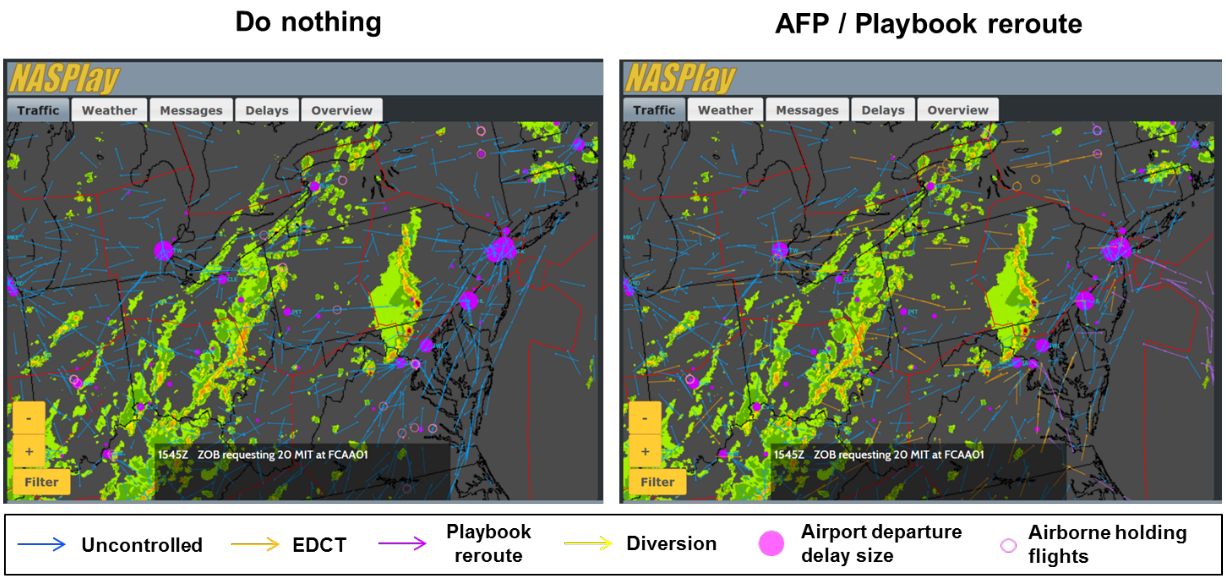

Figure 17. Tactical outcome comparison at hour 2 of AFP (2000Z) for the "do nothing" option and TMI option.

Hour 6 of the AFP (0000Z) showed a slightly different tactical situation. Figure 18 shows this playback data. Minimal differences in traffic density, airborne holding, and diversions were present. However, ground delays in NY metro, Philadelphia International Airport (PHL), DTW, and BUF were slightly higher with the TMI option.

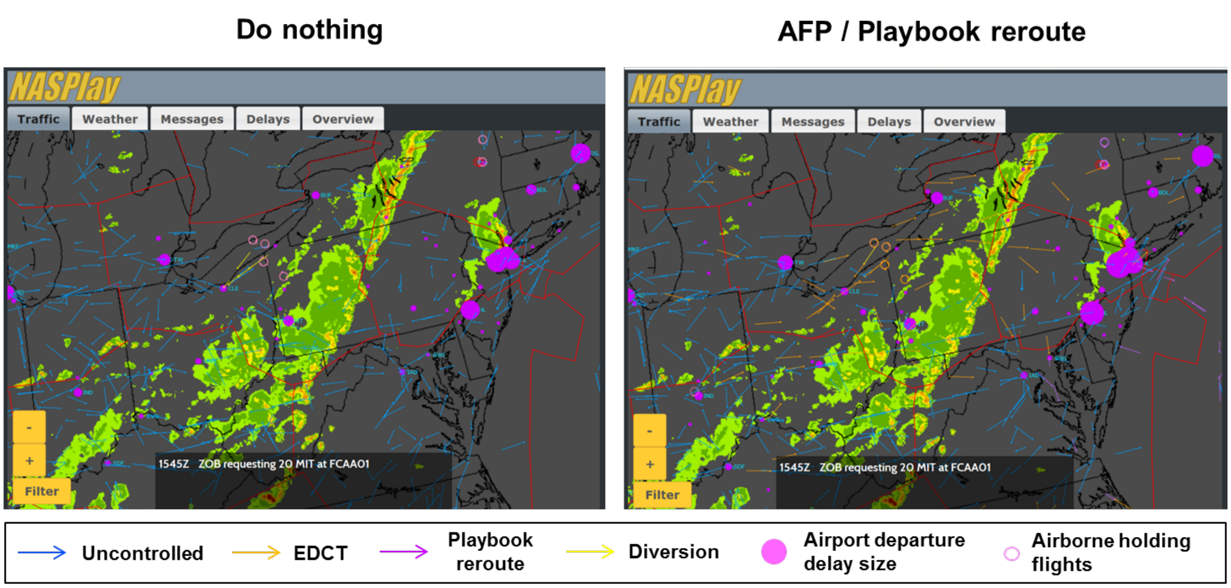

Figure 18. Tactical outcome comparison at hour 6 of AFP (0000Z) for the "do nothing" option and TMI option.

Thus, a day before the August 22 event, the NASPlay simulation could aid the traffic managers in tentatively determining that an AFP/reroute TMI would overconstrain the NAS for this particular event. Both statistical and tactical outcomes pointed to negligible advantages, with possible negative outcomes with uncertainty.

On the morning of the event, another NASPlay simulation was run with the same-day forecast information, shown in Figure 19. The morning of event forecasts indicated that the storms may not be as impactful as even the "similar day" run earlier. This provided confirmation that no TMI action was necessary for the event day. The earlier and later NASPlay simulations could provide traffic managers with data-supported information with which to coordinate with the airlines to enable better planning and execution of NAS flights and contingency plans.

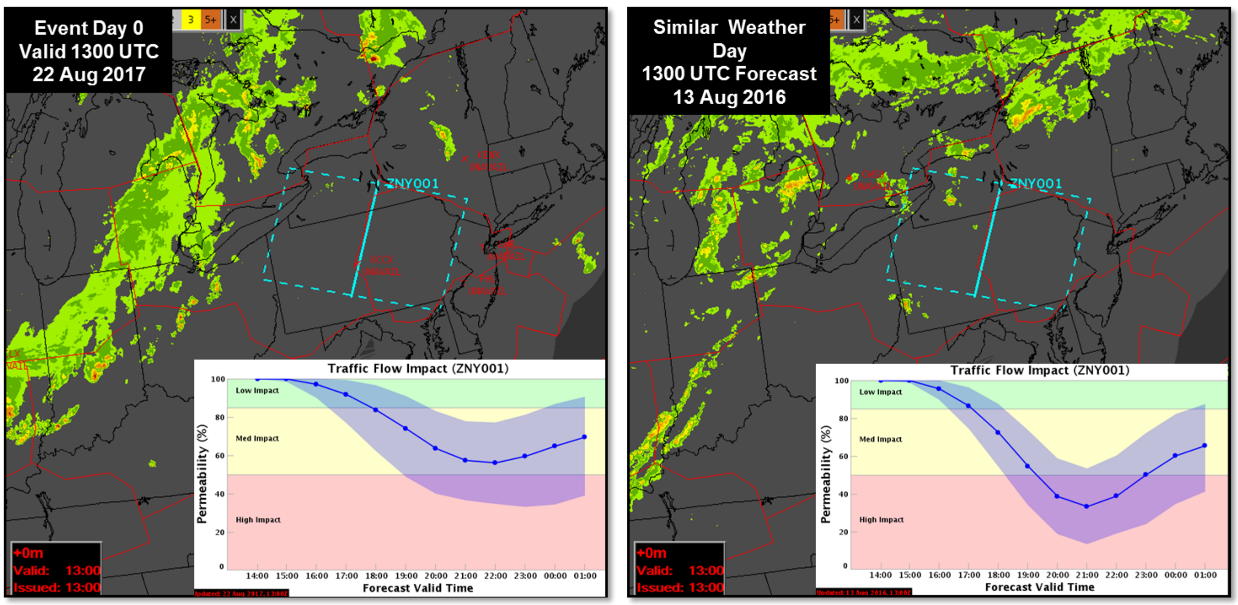

Figure 19. Day of event forecast and traffic flow impact analysis as compared to the "similar weather day" run 24 hours earlier.

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4. WEATHER TRAINING CAPABILITY

While demonstrating NASPlay capabilities to the Boston Center Training traffic management coordinators (TMCs), they suggested a simplification that would fill a training capability gap: it would be useful to them to have a web-based compilation of all of the convective weather days from the past years for which trainees could view the weather and then select the TMI that they would apply to that situation. The TMCs said that it would be helpful for the trainees to simply see and make decisions for such a large variety of scenarios, and that the ability to collect and view what others had chosen for TMIs would add additional benefit.

In response to this request, it was determined that the solution was a simple webpage with a minimal data collection capability. Within two weeks, the prototype was developed. The Weather Categorization capability was then demonstrated to the TMCs who requested it, and it was received with much fanfare.

Figure 20 illustrates the weather training capability.

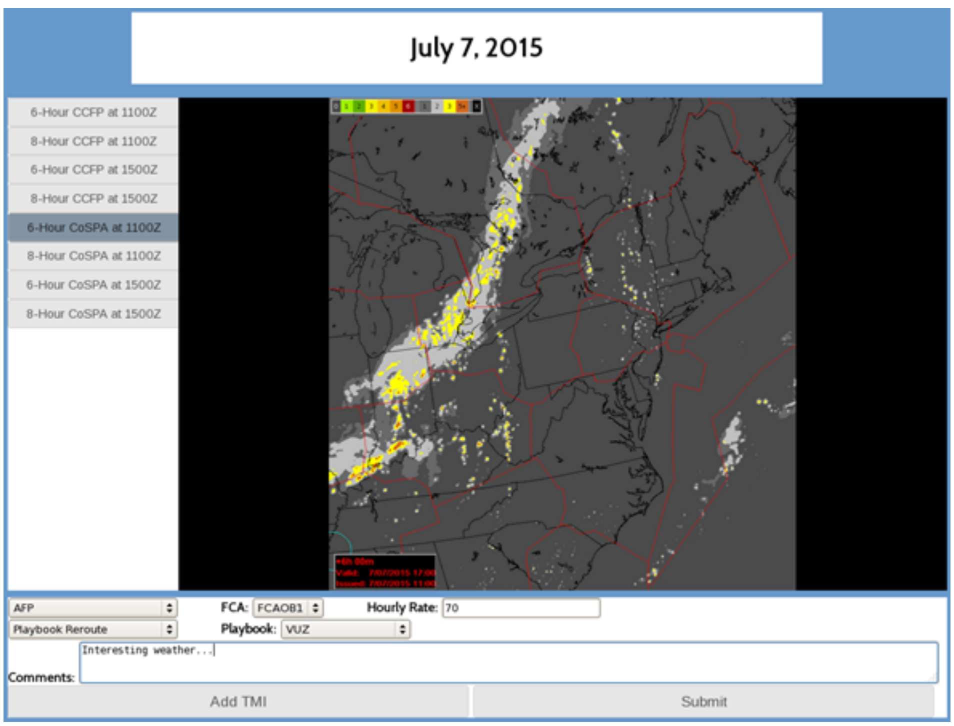

Figure 20. Weather training capability.

Access to the weather training capability is through a website, which was configured and validated by Lincoln ISD during FY17. When the website is accessed, the trainee is required to login with a username and password. Once logged in, the trainee is surveyed about their current job and years of experience. The trainee then views a screen similar to figure 20 in which a past convective weather day is presented. The trainee is able to view archived forecasts for different times of the day for both the CoSPA, an MIT LL product, and the Collaborative Convective Forecast Product (CCFP), an FAA product. The actual date on which this weather occurred is provided at the top of screen. Once the trainee views the weather information, the trainee selects which traffic management initiatives he or she would apply through the menus at the bottom of the screen. The menus provide options of the TMI type, the rate, and the location. Trainees can also add any unstructured comments, such as timing of the TMI, in the input area. Once the TMIs are specified, the trainee submits the decision. The next screen provides feedback about how many other TMCs chose the same TMIs and the rates that were chosen. The data collected from this website include which forecasts were viewed by the trainee and how long, which TMI was selected and any unstructured comments, and background experience information from the trainees.

The response from the operational users was enthusiastic. They suggested that the Weather training capability would be a valuable training tool for new and experienced users in preparation for the onset of convective weather season. It was also noted that data gathered from operational users also provides a starting point for NASPlay training scenario generation.

5. SUMMARY

The NASPlay program has generated an all-in-one planning, simulation, playback, analysis, and training system for the purposes of air traffic management operational decision making, training, and human-in-the-loop concept evaluation. Each of the conops has been explored and trialed with the system over the last several years. This data-driven approach to traffic management is precisely what is required by the FAA to improve efficiency of operations at a national level.

In 2017, the major contributions to NASPlay included:

1. **Operational evaluation of real-time NASPlay capabilities.** Over a period of three days, several NASPlay scenarios were run in conjunction with real-time forecasts in order to aid traffic managers in making real-time air traffic management decisions. The NASPlay simulations were evaluated with traffic managers post-hoc to improve what NASPlay could provide.
2. **Development of capabilities to enable faster simulation processing.** Data ingest feeds were modified and scenario generation was partially re-architected to better support the real-time evaluation capability of NASPlay.
3. **Scenario and simulation creator development.** An HTML interface was created to enable user-friendly scenario creation and simulation execution for NASPlay, which provided the capability of quick new NASPlay scenarios to be created without development or interaction with code.
4. **Weather training capability exposure.** Based upon traffic manager feedback, a past weather training capability was developed and exposed to traffic managers to aid in convective weather traffic management training.
5. **Expansion of NASPlay analytics.** Additional means of interpreting NASPlay output, including time-series data, were developed and explored.
6. **NASPlay simulation validation efforts.** Because of the complex nature of simulating the National Airspace System combined with weather, ongoing validation efforts with each new scenario were required to monitor emergent behaviors.

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GLOSSARY

AFP	Airspace Flow Program
APREQ	Approval Request
ARTCC	Air Route Traffic Control Center
ASDI	Aircraft Situation Display to Industry
ASPM	Aviation System Performance Metrics
ATC	Air Traffic Control
ATM	Air Traffic Management
BUF	Buffalo Niagara International Airport
CCFP	Collaborative Convective Forecast Product
CIWS	Corridor Integrated Weather System
COSPA	Consolidated Storm Prediction for Aviation
CSV	Comma Separated Values
DTW	Detroit Metropolitan Airport
DHS	Department of Homeland Security
DoD	Department of Defense
EDCT	Expected Departure Clearance Time
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
HTML	Hyper Text Markup Language
I/O	Input/Output
MIT LL	MIT Lincoln Laboratory
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASPlay	National Airspace System Play
NY	New York
PERTI	Plan, Execute, Review, Train, Improve
PHL	Philadelphia International Airport
RAPT	Route Availability Planning Tool
SWIM	System Wide Information Mangement
TFI	Traffic Flow Impact
TFMS	Traffic Flow Management System
TMCs	Traffic Management Coordinators
TMI	Traffic Management Initiative
TRACON	Terminal Radar Approach Control
VIL	Vertically Integrated Liquid