MANAGING SECTOR CONGESTION USING AIRSPACE RESTRICTION PLANNER

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Abstract

This paper describes a capability, called the Airspace Restriction Planner (ARP), which is designed to predict and manage sector congestion problems. The capability allows the Traffic Management Coordinators (TMCs) to identify the sectors that are going to be over-congested, identify the detailed characteristics of incoming traffic, and plan traffic flow management restrictions such as altitude capping, rerouting, departure delays, and time-based metering or miles-in-trail restrictions. The capability also provides immediate feedback on the effectiveness of the planned restrictions prior to their execution. This capability was prototyped using the NASA's Future Air Traffic Management Concept Evaluation Tool. Using Cleveland Air Route Traffic Control Center's (ARTCC's) Ravenna sector airspace, human-in-the-loop simulations were conducted to examine the effectiveness and usability of the ARP. The results indicated that the TMCs were able to plan more accurate traffic flow management restrictions with the ARP. All eight participants indicated that this capability is valuable and needed for more precise ARTCC-level sector congestion management operations.

Introduction

One of the roles of the TMCs is to detect and prevent potential airspace overload. Within the United States domestic airspace, each sector has an established limit for sector count, called the Monitor Alert Parameter (MAP) [1]. Typically, when a sector is predicted to be over the MAP value, then a sector considered to be overloaded. The TMCs of the ARTCC Traffic Management Unit (TMU) monitor the sectors and incoming traffic flows to predict and prevent potential situations involving excessive traffic clustering (congestion). Such situations may be the natural result of en route traffic levels, or intensified by flow restrictions (such as the re-routing of traffic around weather or the spacing of traffic) intended to resolve other congestion problems in downstream airspace or airport. Depending on the number of flights (i.e., sector count) and the complexity of the traffic, clustering situations can be workload intensive for the sector controllers [2]. Observations and discussions with TMCs indicate that the current decision support capabilities are not very efficient, effective, and accurate in generating and evaluating the traffic flow restrictions for managing a sector congestion situation particularly in the presence of metering. Based on discussions with other researchers and operational experts within the US and Europe, it is apparent that the sector congestion problems are common. Therefore, the researchers were motivated to develop a capability for the TMCs, called the ARP, which will allow the TMCs to plan, and evaluate traffic flow restrictions for the sector congestion management. The paper describes the current practice, the proposed prototype capability, and summary results of a human-in-the-loop simulation.

Background

The TMC in the US typically monitors the en route congestion situation on their Traffic Situation Display using flight data from the Enhanced Traffic Management System (ETMS). When sector counts are predicted to exceed their respective MAP values, a red alert is issued for those sectors. The TMC then investigates the situation further to assess whether or not the incoming traffic will present too much complexity for the sector controllers. If so then, under current operations, the TMC plans and executes a flow restriction strategy that may combine several degrees of freedom including reroutes, capping the altitudes of internal departures, and MIT spacing.

To formulate a MIT restriction that is needed to protect a sector, the TMCs assess the makeup of the traffic flow that will traverse the sector (e.g., the composition of overflights, internal departures, and arrivals). The TMC must then choose both the stream(s) to restrict and the size of the spacing requirement to produce the most effective results. For example, if the Cleveland ARTCC sector 48 is expected to exceed its sector monitor alert parameter of 14, then the Cleveland TMC may issue a restriction on an eastbound flow from Chicago ARTCC to reduce the sector complexity. In many cases, the flow that has the most aircraft gets the restriction since this is the easiest approach for preventing sector overload with minimal coordination in today's system.

A particularly effective option at the disposal of the TMC is to control the departures of flights from internal airports within the ARTCC. Generally, internal options are considered first before restrictions are passed back on adjacent upstream facilities. For example, internal departures for Cleveland ARTCC include aircraft departing from Cleveland, Detroit, Rochester, Pittsburgh, and Buffalo. The TMC monitors the designated traffic streams (e.g., Philadelphia arrival flow, Washington Metro Flow) and examines potential situations that could cause aircraft clustering.

The current sector management operations consist of the following tedious steps:

1. Identification of congested sector using ETMS MAP and predicted sector count.
2. Examining the incoming traffic composition by creating lists of aircraft. The traffic composition is provided in the table format but can only be sorted by arrival, departure, route, sector entry, and sector exit time. It does not offer quick grouping of aircraft (number of aircraft by arrival airport, departure airport, jetway, etc.). The process of identifying a group of aircraft involves cognitive processing.
3. Once the traffic composition is understood, the TMCs need to decide which group of aircraft needs to be placed under restriction. Such a process again involves cognitive processing and depends on the skill and experience of the TMCs. Usually, the TMCs end up selecting a large group of aircraft (e.g., Chicago departures or Detroit arrivals) rather than multiple smaller groups of aircraft (e.g., combined departures from Syracuse, Buffalo, and Rochester), if the restriction could achieve the same result.
4. Once a group of aircraft is chosen for restriction, the next step is to identify what restriction to put in place. Usually, these restrictions include MIT or departure delays. However, at some times, the TMCs also use altitude capping and rerouting. The identification and placement of restrictions is a highly subjective process and could vary from one TMC to another TMC.

Limitations of Current Practices

Field observations and discussions with the TMCs indicated that the current practice for sector congestion management is based on intuition, mental calculations, history, experience, and TMC skill. Today's operational process is manually intensive, provides no feedback on the impact of Traffic Flow Management (TFM) actions or the restrictions that TMCs have chosen to use, and provides no system feedback to reflect the impact of active traffic flow restrictions. The system does not provide any feedback on the effectiveness of the restriction. The TMCs often end up over-restricting or under-restricting the sector due to a lack of feedback. This process usually takes considerable cognitive analysis and may not result in optimal results as any over-restrictions may cause unnecessary delays and under-restrictions may not protect the sector congestion and cause higher controller workload.

A challenge in planning and executing the most effective restrictions stems from a lack of decision support automation. Few if any operational tools help TMCs to plan traffic flow management restrictions, let alone optimize them for minimal and equitable traffic impact. Basic capabilities are needed to predict a restriction's affect on airspace and traffic flow. There is no accurate way to identify what restrictions should be used, particularly if they must be combined with other flow restrictions. In current practice, restrictions may be over-protective or under-protective, and often are implemented without knowing either way.

It is difficult if not impossible for TMCs to objectively assess the combined effect of multiple restrictions on a resource (e.g., sector or airport) that is being protected. These multiple restrictions may involve MIT restrictions and/or other restrictions such as rerouting, capping, and departure delays. TMCs are typically forced (by the lack of automation) to use operationally expedient solutions that often impact busy flows to/from a major airport. To be operationally effective, restrictions tend to be conservative, which results in unnecessary delays.

Additionally, the effect of restrictions on adjacent or surrounding sectors is not easily identifiable. The other sector counts may increase beyond their MAP values as a result of restrictions (i.e., collateral damage) imposed to protect a sector. The impact collateral damage cannot be easily identified under current operations.

Airspace Restriction Planner

The ARP is a functional capability that aids ARTCC TMCs in planning local traffic flow initiatives to mitigate en route sector congestion problems. Alternatively, with ARP capabilities, the TMC may elect to take action to mitigate the congested situations using the ARP. The ARP will enable the TMC to visualize the projected traffic situation by decomposing it into user-defined streams. In addition, the TMC will be able to evaluate the effect of various stream-specific, user-defined traffic flow restrictions or set of restrictions. After the TMCs have decomposed the traffic into streams, they create restrictions using the available options or Degrees of Freedom (DoF) in order to alleviate the over-congestion. The initial version of ARP will support provisional planning (i.e., manual "trial" like planning) of restriction solutions for proof of concept research; automated advisories will be developed at a higher maturity level of the tool. The ARP provides feedback to the user regarding the effectiveness of the proposed solution, and the TMC may accept, reject, or modify the solution. Once active, the ARP models the impact of the restriction and feeds that information forward to other TFM capabilities (e.g., Multi-Center Traffic Management Advisor, ETMS) to enable those systems to more accurately model the incoming traffic demand (and better diagnose congestion problems if/when they occur).

The ARP is being developed and evaluated within the framework of existing Future Air Traffic Management Concept Evaluation Tool (FACET).

Airspace Restriction Planner Objectives

In order to manage sector congestion problems, TMCs use mental calculations, educated "guess work," and historically validated solutions to solve sector congestion problems when they arise. The methods that TMCs currently use are safe and historically accepted; however, they are workload intensive (limiting the amount of traffic that a single TMC can manage with minimal impacts), often have collateral impacts, and their actual operational effectiveness is often unmeasured or unknown. The purpose of the ARP is to provide the TMC with a method to plan ahead, to improve the TMC's ability to create restrictions with less workload, and to improve the effectiveness and efficiency of the restrictions created. The ARP provides the TMCs with access to a wider range of restriction possibilities and enables them to combine and compare viable restrictions to obtain the best possible solution that is "just in time, and just enough."

In operational terms, the objectives of the ARP are to:

- Improve the coordination of airspace restrictions used to solve sector congestion, particularly in the presence of restrictions including metering/spacing;
- Reduce overall traffic impacts (e.g., delay) due to restrictions needed to resolve/prevent sector congestion;
- Improve the TMC productivity in managing sector congestion; and
- Implement restrictions that are "just in time, and just enough" with minimal collateral impact.

Airspace Restriction Planner Functionality

The ARP was developed with four key functions:

- The Traffic Analyzer,
- The Restriction Planner,
- The Restriction Analyzer, and
- The Multiple Restriction Evaluator (this functionality was not planned for the simulation described here but will be used during the follow-on work).

Traffic Analyzer

The purpose of the Traffic Analyzer is to help the TMC visualize the traffic composition in order to identify those flights/streams that contribute the greatest impact to reducing the sector congestion problem. The Traffic Analyzer contains of a load graph to display the predicted traffic demand for a specified sector during a specified time frame. The load graph can be set to view the entire traffic demand for that sector, or it can be configured to display the composition of the traffic demand based on various attributes and user defined streams. For example, the load graph can display airborne vs. pre-departure (still on the ground) traffic, external vs. internal pre-departure traffic, all traffic with a common upstream attribute (e.g., departure point, sector, or facility) or downstream attribute (e.g., destination, sector, or facility), or traffic designated by full or partial routes of flight. Using the load graph, the TMC can pick and choose those flights or groups of flights (traffic streams) to impact with restrictions in their planning for reducing the sector congestion. The Traffic Analyzer also gives the TMC the ability to create a hierarchy of attributes and sort the traffic according to this hierarchy. Figures 1 and 2 show basic and details traffic in sector 48. The red color indicates that sector count of ZOB48 is expected to be over the MAP value and all predicted aircraft are airborne. The yellow color (i.e., ZOB66) indicates that the sector count is expected to be above its MAP value but not all aircraft are airborne.

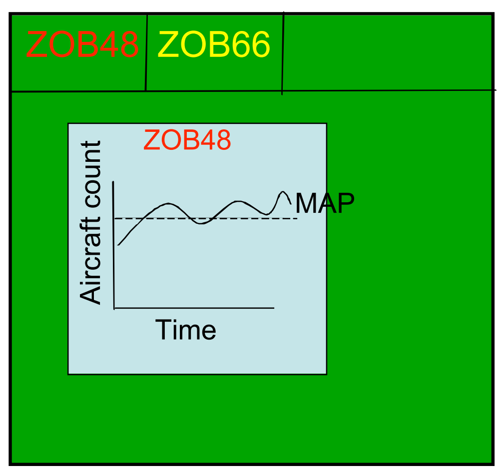

Figure 1. Basic Load Graph

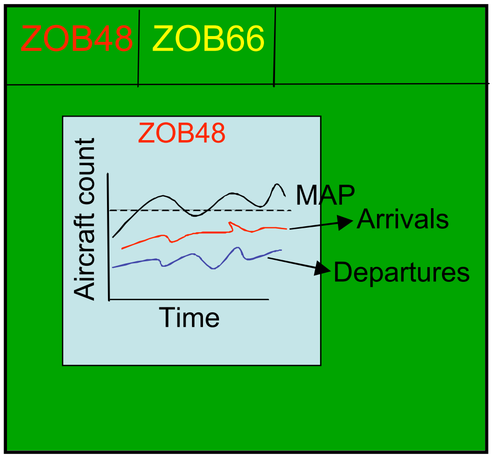

Figure 2. Detailed Traffic Analysis

The Restriction Planner

Based on the traffic composition identified with the Traffic Analyzer, the TMC uses the Restriction Planner to develop various provisional restrictions that may alleviate the sector congestion. A single provisional restriction consists of applying a DoF, such as capping, to a specific stream to prevent it from entering a congested sector. If that sector still needs more help in reducing congestion, applying another DoF, such as metering, to a different stream entering that sector would be a second provisional restriction. Putting one or more provisional restrictions together to solve a particular airspace congestion problem is a TFM solution plan. Figure 3 shows an example restriction planner window where the restrictions can be planned on pre-selected streams.

The Restriction Analyzer

As each provisional restriction is formulated, the TMC can use the Restriction Analyzer to predict the impact of that restriction on the sector congestion (and neighboring regions of airspace). The Restriction Analyzer shows the new traffic characteristics with the affect of the restriction. The effect of restrictions is shown in the similar format that is provided in Figures 1 and 2. The TMCs are provided with feedback that enables them to assess the impact of their actions on the traffic flow and the sector demand. Through the use of the Restriction Analyzer, the TMC can build a TFM plan analyzing the impact of each planned restriction on sector congestion as it is added to the National Airspace System.

The Multiple Restriction Evaluator

Using the Multiple Restriction Evaluator, the TMC can evaluate two or more provisional TFM plans in order to compare their effectiveness in reducing sector congestion and traffic impacts and choose the plan that has just the right impact on the airspace.

Working with the Restriction Planner, the Restriction Analyzer, and the Multiple Restriction Evaluator, the TMC has the flexibility to choose and optimize the combination of DoFs and to optimize the restriction to fit the specific traffic composition.

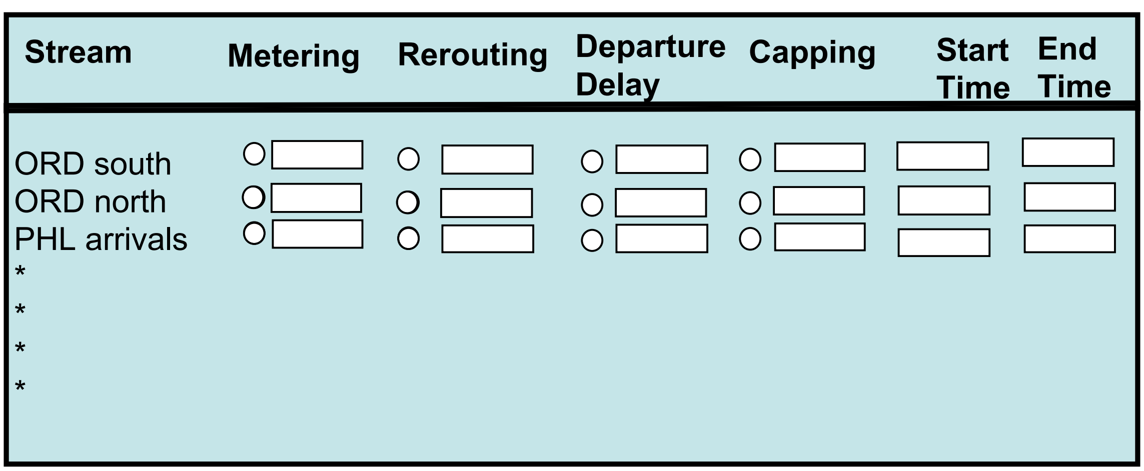

Figure 3. Restriction Planner Window

Airspace Restriction Planner Degrees of Freedom

TMCs use a variety of methods to control the flow of traffic into congested airspace. These methods of impacting traffic flow are referred to as the ARP DoF. Having multiple DoF at their disposal enables the TMC to tailor the TFM to each unique situation. The ARP will initially provide the TMC with four DoF (Metering, Altitude capping, Departure planning, and Rerouting).

Metering

Metering is a method of spacing traffic using either time or distance to ensure that they arrive at a fix or destination with a pre-determined interval [3]. The metering of traffic may be accomplished with either MIT or TBM in a manner similar to current practices. When applying a metering restriction to a specific flow of traffic, the TMC must take into consideration any metering restriction that may already be in place on that flow.

Altitude Capping

Altitude capping restricts the altitude profile of one or more flights. For example, flights may be restricted to remain at or below a specified altitude, at or above a specified altitude, or between two specified altitudes. This effectively prevents these flights from entering a congested sector by keeping them above the sector ceiling or below the sector floor. Once an aircraft or stream of aircraft has been capped, it is possible for these flights to be subjected to another DoF imposed by the TMC responsible for the new airspace.

Departure planning

Departure planning enables the TMC to plan and manage the departure release time of flights. These flights are departing terminal areas geographically located within congested airspace and departing terminal areas en route to congested airspace prior to their departure. This allows a portion (or all) of any necessary delay (due to the congested airspace) to be absorbed on the ground.

Internal Departure Planning

TMCs have the authority to control flights departing terminal areas within their airspace. They can use departure times as a means to mitigate sector congestion essentially controlling the volume of traffic into the overhead streams.

External Departure Planning

TMCs have no formal or direct authority over flights departing terminal areas that are external to their own airspace. Many times, TMCs would like to have the authority to release flights departing terminal areas external to and within close proximity to their airspace and en route to or through their ARTCC. In order to use external departure planning as a means to mitigate congestion, TMCs must coordinate their actions with the ARTCC under whose control the traffic falls. This coordination is either formal or on a case-by-case basis.

Formal coordination takes place under a letter of agreement between two ARTCCs giving one ARTCC an authority to release certain flights departing from certain terminal areas within the geographical boundaries of another ARTCC. Such flights typically depart in one ARTCC's airspace, within close proximity of the second ARTCC. For example, Columbus International Airport (CMH) is located in Indianapolis Center (ZID) just outside the boundary of Cleveland ARTCC (ZOB). Traffic departing CMH bound for Philadelphia International Airport (PHL) enters ZOB within a few minutes after departure. Because these flights spend very little time in ZID before entering ZOB, there is little time for ZID controllers to comply with the necessary restrictions that ZOB TMCs may want to impose on these flights (and less time/distance remains for ZOB controllers to merge and space the CMH departures with the other ZOB traffic). Therefore, through a letter of agreement, ZID gives ZOB permission to determine departure times for those flights departing CMH bound for PHL and flying through ZOB, which gives the ZOB TMCs the latitude to impose timely and necessary restrictions on the affected flights.

Single case coordination is done on a case-by-case basis. Placing a restriction on one or more departing flights not covered under a formal letter of agreement must be explicitly coordinated with the neighboring ARTCC at the time it is needed.

Departure Restrictions

Departure planning may be used to restrict the times of departing aircraft causing them to absorb delay while still on the ground. There are two methods by which TMCs can restrict departures. They may use individual flight releases at airports for low volume departures and/or use departure rates at airports with a higher volume of departures.

Individual flight releases are managed via the current Approval Request (APREQ) process. Under an APREQ, terminals/towers request releases from the ARTCC TMU and then receive release times for flights leaving terminal areas identified in the APREQ. Departure rates can be managed by applying a departure rate to either an entire airport or a select stream of traffic departing a particular airport (e.g., all flights bound to the same destination or traveling along the same route segment).

Rerouting

Rerouting enables the TMC to protect congested airspace or offload a congested airway by moving selected flights to an alternative route. Some terminal areas, such as Chicago O'Hare, have more than one parallel route terminating in their airspace, thus providing TMCs with an easily accessible alternate route. The primary concern with these restrictions is to select an appropriate alternative flight plan. One alternative would remove the flight from the sector of interest or off the airway of interest and another would substitute a reasonable route that involves neither too much nor too little delay. The preliminary plan is to apply rerouting to specific flights prior to departure.

Airspace Restriction Planner Development and Validation

The ARP development and validation used FACET to demonstrate the ARP concept, refine the operations and procedures, and assess the feasibility of ARP. FACET was used to simulate the necessary traffic scenarios (recorded from ETMS data) and as the platform for developing and executing initial ARP algorithms. TMC subject matter experts used the ARP capabilities to solve a set of representative problems and provide feedback. The experiment team also collected and analyzed FACET-recorded metrics that reflect the impact of restrictions on traffic flows and airspace resources (sectors and airports). The ARP development and validation activities were conducted over a span of two years. The researchers first conducted site visits to ZOB to understand the current operational practices and gain initial feedback on the concept. Then researchers conducted two cognitive walkthroughs and storey-boarding exercises at NASA Ames with ZOB TMCs. The purpose of these exercises was to gain user feedback on the concept, information needs, capabilities, and human-computer interfaces (HCI). Then human factors researchers developed a prototype using FACET. The researchers conducted a prototype evaluation at NASA Ames using four subject matter experts from ZOB. Based on the initial prototype evaluation, the software algorithms and HCIs were modified. Finally, the researchers conducted the human-in-the-loop (HITL) simulation at the ZOB.

Simulation Objectives

HITL simulation was used to make a preliminary assessment of the usefulness of the ARP capabilities and to refine HCI concepts and procedures.

The objectives of this real-time HITL simulation were to:

1. Demonstrate proof of concept,
2. Evaluate the ARP capability, and
3. Conduct a human factors assessment.

Demonstrate Proof of Concept

The purpose of this objective was to demonstrate the capabilities of the ARP and show that the ARP can be used to develop a provisional plan to solve or mitigate congested airspace problems. Using the Traffic Analyzer, a TMC determined the composition of a traffic sample for a set of ZOB sector congestion problems. Sector 48 (Ravenna) was used for the simulation. This sector was known to have sector congestion problems leading to redesign. Based on the traffic composition, the TMC determined a course of action to alleviate the congestion and developed a provisional restriction plan using the Restriction Planner and any combination of the DoF. After analyzing the provisional restriction plan using the Restriction Analyzer, the TMC then analyzed ARP feedback indicating the effectiveness of the plan.

Evaluate ARP Capability

The objective here was to evaluate the effectiveness of algorithms and capabilities of the ARP in a simulated operational setting to determine whether the ARP functions perform as expected. TMC subject matter experts were presented with a series of simulated traffic problems and had the opportunity to solve them with and without the use of the ARP. The performance and functionality of the ARP capabilities to help solve congestion problem were evaluated through subjective feedback. TMCs provided feedback with respect to criteria such as: effectiveness of the ARP capabilities in restriction planning, functionality of the ARP algorithms, and effectiveness of the provisional restriction plan.

Human Factors Assessment

The purpose of the human factors assessment was to determine, through TMC feedback and other metrics, whether there were aspects associated with the ARP that need refinement based on human factors issues. Areas of interest were the HCI, acceptability, usefulness, usability, operational procedures, and concept in general.

Simulation Design

This study involved both a baseline condition (within which TMCs worked the simulation problem without use of the ARP features) and experimental conditions (whereby TMCs used the ARP capabilities to solve the same problem). Under the baseline condition, the TMCs analyzed the simulated traffic and decided upon a restriction (as they currently operate) using only the monitor alert information and a list of aircraft predicted to enter sector 48. The list included call sign, sector entry time, departure airport, arrival airport, and a route, as applicable. The list also included the status of flight (i.e., proposed or active). The proposed flights were those, which are not yet airborne, and active flights are those that are airborne. The actual MAP for Sector 48 is 14. In order to create demand-capacity imbalance, the MAP was reduced to 12, and the 10 (such a reduction in the MAP can occur in real operations as well, particularly under thunderstorm-induced altitude compression situations). In today's system, ETMS shows the predicted sector congestion by showing the peak one-minute sector count at every 15-minute interval. Red color is used when a sector is expected to have aircraft count above the monitor alert parameter and all expected aircraft are airborne and yellow color is used when a sector is expected to have aircraft count above the monitor alert parameter and some or all expected aircraft are still on the ground (i.e., proposed flights). In order to be consistent with the operational system, we used the same color-coding.

Simulation Participants

Eight current TMCs from ZOB participated in this HITL simulation.

Airspace

The simulation study used ZOB airspace because of its complexity and researcher familiarity.

Traffic Scenario

The researchers visited ZOB and observed the traffic and TMC operations. From discussions with TMCs and observations, researchers identified several cases (e.g., traffic situations) of interest that could potentially benefit from the ARP. A study case involving Sector 48 congestion was selected because it represented one of the most complex sector congestion situations.

Sector 48 (Ravenna) - Limited sector capacity problem

The focus of this case is on the sector capacity problem often experienced at ZOB. Sector 48 (Ravenna) is a high altitude sector (flight level FL240 to FL290) within the middle of ZOB (See Figure 4). A number of factors result in very complex traffic flows. The sector has a large number of heavy-traffic jet airways that intersect over the Dreyer (DJB) VOR. The sector also serves as transition airspace for a number of airports below (Cleveland, Akron-Fulton, Akron-Canton, Mansfield, Wayne County, Burke Lakefront, and Lorain County Regional airports). As a result, the sector has a lot of climbing and descending aircraft mixing with the overflights. The sector, when busy, is seldom able to absorb delay for metering/spacing even though MIT restrictions are often passed back upstream on the traffic flows that transit the sector.

The simulation test scenario was comprised of all flights from ETMS data on September 10, 2001 that departed between 1800 and 2300 Zulu time and transited through the ZOB48 sector. This includes all aircraft types, classes, and airlines. Typically, in current operations, MIT restrictions are set at several points due to predicted sector counts exceeding the sector capacity, corresponding to typical afternoon and evening rush congestion. Traffic entered ZOB48 from all directions with the major flows of traffic between New York, Washington, and Chicago ARTCCs.

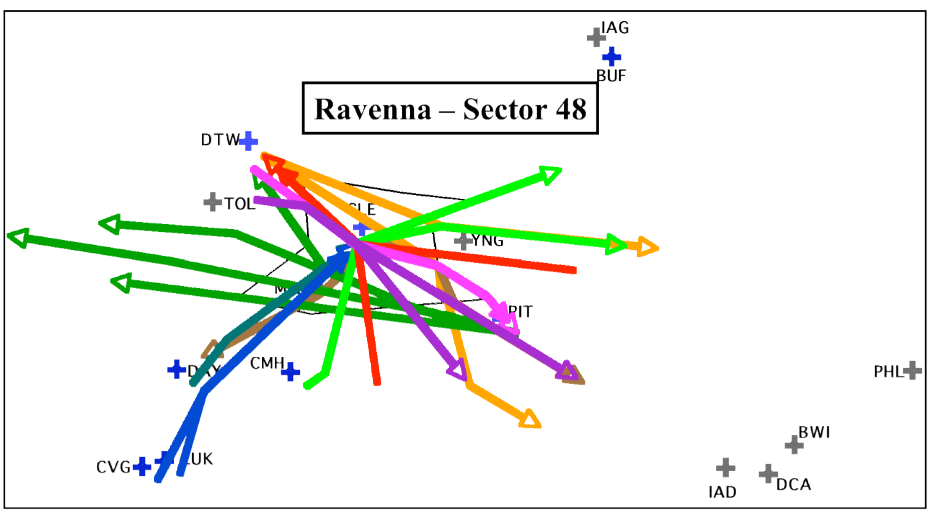

Figure 4. Sector 48 Layout and Traffic Flows

Data Collection

The researchers conducted discussions with the TMCs during and after the ARP simulation. A verbal protocol technique was used to gather insight into the TMC's thoughts and rational behind their decisions. The researchers took written notes of the TMC comments and discussions.

ARP Comparison

One of the objectives of this study was to compare the restrictions that TMCs would formulate without ARP capability (baseline) and with ARP capability. Due to small sample size and purpose of the simulation study, it was not possible to conduct a statistical comparison of various metrics such as total delay, airborne delay, ground delay, number of flights impacts, etc. Therefore the primary means of comparison was to show that ARP allows the TMCs to create restrictions more precisely than not using ARP.

Results and Discussions

Objective 1: Demonstrate Proof of Concept

Overall, all participants indicated that ARP provides a useful capability that allows TMCs to create restrictions much more effectively as compared with their current operations. They all indicated that they would use the ARP capability if it were made available to them for operational use.

The TMCs indicated that the Traffic Analyzer, Restriction Planner, and Restriction Analyzer were all useful for generating restrictions and examining impact of those restrictions. All the functions of Traffic Analyser (e.g., aircraft count, flight lists) were useful. All the fuctions of Restriction Planner (e.g., stream identifier, tabular display of aircraft in different streams) were useful. Moreover, the functions of Restriction Analyzer (e.g., provide feedback of restriction) were also very useful. These functionalities do not exist in current operations and the TMCs may over-protect or under-protect a congested sector without such ARP capabilities.

Objective 2: Evaluate ARP Capability

Depending on the availability of participants, a participant conducted one to eight runs of different traffic samples. All participants were first provided familiarization with the simulation and ARP features. A member of the research team operated the FACET-based simulation while each participant analyzed the traffic problems, made decisions, and interacted with the ARP capabilities.

Each participant first worked the traffic problems without using ARP features. They simply used the FACET-based "look-a-like" model of the monitor alert display and flight lists (that they use in operations today), and decided upon the flow restriction(s) they would choose to mitigate the sector congestion. After the participant decided upon a restriction, the research team evaluated that restriction using the ARP to examine its effectiveness. In all cases, the TMCs had under protected the sector (i.e., the actual traffic count exceeded the target value).

As a next step, the participants used the ARP features to define traffic streams (subsets of traffic to analyze) and analyze the composition of the congestion. Based on that information, the participants then used ARP to formulate a provisional "what if" restriction plan. This involved the selection of a restriction DoF (e.g., capping, rerouting, departure delays, or metering) for each stream the TMC wanted to restrict. The TMC then used the ARP capabilities to analyze the impact of the restriction and modify it until they created a restriction plan that indeed achieved the target traffic count. The TMCs indicated that such a capability to plan and evaluate restrictions was very unique and valuable to their operations.

The various TMCs approached the same problem slightly differently in terms of their choice of flows and DoFs they wanted to evaluate to solve the problem. The TMCs created a variety of restrictions on Chicago flows, Cincinnati departures, Detroit arrivals, Pittsburgh departures, and overflights on jet route 64 (a major west-bound corridor through Sector 48). The TMCs naturally chose restriction DoFs including departure delays, arrival metering, rerouting, and capping of flights that had not yet departed. As a natural consequence, this resulted in all the restriction planner features being exercised. The TMCs indicated that creating restrictions using ARP was much easier compared to current operations.

An additional planned feature of ARP called multi-center ARP was discussed. In today's operations, if a downstream (or upstream) TMC position (within the same or an adjacent ARTCC) creates a restriction, the impact of that restriction is not reflected in the ETMS data. ETMS traffic flow predictions are based on the "undelayed/unrestricted" trajectory predictions. This can create significant inaccuracies in predicting sector loads in the presence of restrictions and perhaps result in some unnecessary additional restrictions. However, a multi-center ARP capability (i.e., where ARP functions are interconnected between TMC positions within and between ARTCCs) will provide information about planned restrictions and increase the accuracy of traffic flow predictions. This will help TMCs minimize unnecessary restrictions within/across center boundaries.

Although it was not provided in this simulation, the TMCs liked the idea of displaying collateral impact of any ARP generated restrictions on other adjacent sectors to make sure that the adjacent sectors do not get congested.

Objective 3: Human Factors Operations

The researchers and the participants conducted cognitive walkthroughs of system and identified display and HCI related issues. These issues included use of color, font size, and organization of data (e.g., tabular versus graphs). Participants also indicated some areas for improvement such as improving the ease with which restrictions are created within the tool.

Conclusions

The researchers identified a need for a capability to better manage sector congestion particularly within the presence of TBM. The field observations and subject matter expert discussions led researchers to develop and iteratively enhance the prototype capability. The human-in-the-loop simulations results show merits of ARP and its operational use.

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Key Words

Airspace Restriction Planer, Sector Congestion, Traffic Flow Management, Traffic Management Coordinator, Rerouting, Altitude Capping, Departure Rate, Metering, and Miles-in-Trail.

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Biographical Sketches

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Steven Green manages NASA's en route ATM research. An instrument-rated pilot, he received a M.S. degree (Aeronautics & Astronautics) from Stanford University, and joined NASA Ames in 1985 to pursue ATM research. One of the four CTAS "founders," he led the development and field testing of the CTAS Descent Advisor and pioneered NASA's concepts for integrating FMS and ATM automation through data link. Mr. Green co-chaired RTCA's FMS-ATM-AOC Integration Work Group and co-led NASA's Distributed Air-Ground Traffic Management (DAG) effort. His current research is focused on the enhancement of the CTAS Traffic Management Advisor for regional en route metering. Mr. Green is the U.S. co-lead for the US/Europe ATM R&D Action Plan 16 for the development of "common" trajectory-prediction capabilities, and he is the NASA technical lead for the integration of weather/forecast products and ATM automation.