


# PlayMaker:

## An Application of Case-Based Reasoning to Air Traffic Control Plays



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### Abstract

When events such as severe weather or congestion interfere with the normal flow of air traffic, air traffic controllers may implement plays that reroute one or more traffic flows. Currently, plays are assessed and selected based on controllers' experience using the National Playbook, a collection of plays that have worked in the past. This paper introduces PlayMaker, a CBR prototype that replicates the Playbook and models how controllers select plays. This paper describes the PlayMaker design, a model validation, and discusses developments necessary for a full-scale CBR tool for this application.

### 1 Introduction

The Air Traffic Control System Command Center (ATCSCC) is responsible for establishing nationwide responses to situations that affect air traffic control (ATC) operations.

Bad weather and congestion are the most common situations requiring controller intervention. When a situation interferes with normal routes, controllers reroute traffic to avoid it. They select new routes based on where the event is located, the route's original path, and conditions in areas where the aircraft may be sent.

Over time, controllers have identified numerous recurring situations and have collected their solutions into *plays* contained in the National Playbook [1]. A play contains the reroutes that are necessary to handle the situation. The reroutes in a play have been selected and negotiated with stakeholders to minimize their impact on airlines, airports, and ATC facilities. An example is shown in Figure 1.

When a situation arises that requires reroutes, controllers select and initiate the play that they believe is best for the situation and the overall ATC system. Controllers then contact system stakeholders such as the airlines, local ATC facilities, and the military to inform them which play has been selected.

#### Motivating Problem

- Playbook is currently maintained manually
- Many controllers will be eligible to retire after 2006
- Increased need to justify reroutes
- Novel situations arise for which no play exists

### 2 PlayMaker Design

PlayMaker is a feature-vector CBR system [2] that we prototyped using the Esteem® CBR shell [3]. The features and an example of a case are provided in Table 1.

We selected 20 plays from 135 available in the National Playbook. Our ATC domain expert examined each play and described the situations where it is normally used. This process resulted in 32 cases because several plays could be applied to multiple situations.

### 3 Prototype Validation

We performed a validation of the PlayMaker prototype by comparing its responses to novel situations to those of an ATC domain expert. We constructed six test situations and presented these to our ATC expert and to PlayMaker.

For 4 of the 6 test situations, the play recommended by our expert was one of the top three plays retrieved by PlayMaker, as shown in Table 2. However, the similarity scores on PlayMaker were low (58-80% match). This indicates that though our case base and metrics are on the right track, more work is needed.

#### Two Mismatched Test Situations

1. We unintentionally created a situation for which controllers in the field do not use a Playbook play. In the test situation, controllers at the ATCSCC would develop an ad hoc play to precisely address the situation rather than institute a stored play. We developed a new test situation by moving the location. The ATC expert and PlayMaker matched on the revised test situation
2. Situation was more complex than our of features and similarity metric could handle. We could specify either the location of a storm or the location of congestion but not both.

### 4 Future Work

1. Improve *Location* to allow users to specify locations as polygons, using latitude-longitude geometry, and containing altitude and movement parameters.
2. Add precision to the *Direction of the Majority* feature
3. System must be able to represent situations with multiple event locations. Multiple simultaneous problems occur often in the ATC system.
4. Compute *Severity* based on operational data rather than having expert estimate it.
5. Improve case base with broader set, more event locations and severities. Compare cases based on actual occurrences to cases based on generalized plays.
6. Develop adaptation methods to create new plays. In particular, determine offline method for deriving plays and presenting them to controllers for negotiation and validation before a situation actually occurs.
7. Develop methods to change plays as traffic flows change over time.

Feature	Type of Feature Matching	Weight	Example Value	Example Comments
Location East-West	Absolute Fuzzy Range: 3	0.190	16	These Location values yield the southeast of Virginia and the northeast of North Carolina.
Location North-South	Absolute Fuzzy Range: 3	0.190	-2	
Severity	Absolute Fuzzy Range: 2	0.095	5	No traffic may come through the area
Time of Day	Exact	0.048	0700 to 1859	Storm forecast to arrive at 10:00 am
Direction of Majority	Partial (case indifferent)	0.381	N	Northbound traffic primarily
Effect on Major Facilities	Absolute Fuzzy Range: 1	0.095	2	New York and Washington are both affected

**Table 1.** Features, matching functions, and weights of the PlayMaker similarity metric. The table also includes an example of one of the cases based on an actual play from the Playbook.

Test Situation	Matched in Top 3 Retrieved items?	Similarity Score
1. Hurricane out in the Atlantic Ocean. Effects (heavy rain, high winds) will start being felt in the Outer Banks of North Carolina around 1000 today.	No	N/A
1 (revised). Move location of Test Situation 1 to near Wilmington, NC. All other features identical.	Match	65
2. Strong thunderstorms north and northeast of Dallas starting around 1500 today.	Match	80
3. Moderate storms over southern North Carolina and all of South Carolina, affecting north and southbound routes, starting around 2000 tonight and continuing until 0300 tomorrow.	Match	63
4. Two navairs out of service along J75 from 0000 tonight until 0600 tomorrow.	Match	73
5. Very heavy congestion expected all day today along northbound routes in ZDC.	Match	58
6. Moderate weather affecting all Appalachian Mountain areas all day today, coupled with heavy congestion in ZDC during the day.	No	N/A

**Table 2.** Test situations used in the validation, whether PlayMaker agreed with our ATC expert regarding the correct play to apply to that situation, and, if there was a match, the similarity score for the retrieved case.



**Figure 1.** A map showing the play known as Snowbird 5. Red lines show routes of southbound traffic heading for western Florida. Note that traffic is avoiding the Carolina coast where an event, typically weather, is occurring.

### References

- [1] Federal Aviation Administration: Air Traffic Control System Command Center National Severe Weather Playbook. Retrieved February 29, 2004 from the World Wide Web: <http://www.fly.faa.gov/PLAYBOOK/pbindex.html>. (2004)
- [2] Aamodt, A., Plaza, E.: Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches. *Artificial Intelligence Communications* 7 (1994) 39-59
- [3] Esteem Software Incorporated: Esteem Version 1.4. Stottler Henke Associates, San Mateo, CA. (1994)