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Developing Quantitative Air Traffic Risk-Benefit Pathways for Class Delta Airports: Improving Small Tower Operations

Katherine A. Berry

Michael W. Sawyer

Jordan Hinson

DEVELOPING QUANTITATIVE AIR TRAFFIC RISK-BENEFIT PATHWAYS FOR CLASS DELTA AIRPORTS: IMPROVING SMALL TOWER OPERATIONS

Katherine A. Berry, Michael W. Sawyer, and Jordan Hinson
Fort Hill Group, LLC
Washington, DC

The primary responsibility of an Airport Traffic Control Tower (ATCT) controller is to prevent collisions between aircraft and other hazards on the surface and in the immediate vicinity. The safety service provided by controllers at towers with larger operations greatly exceeds the costs of establishing those towers. As the number of operations decreases, the costs of operating the tower may begin to outweigh the benefits of staffing the tower. Safety event reports describing instances where an ATCT controller provided a service that reduced the consequences of the event were collected. The reports were classified to identify latent factors, causal factors, and positive safety benefits. The adverse causal factors and positive safety benefits were then utilized to determined statistically significant risk-benefit pathways describing the safety benefits that controllers provide at airports in Class Delta (D) airspace. This paper presents the dynamic risk-benefit pathway, one of the three pathways for Class D ATCT.

ATCTs and the controllers that staff them provide both efficiency and safety services to the aviation industry. The primary responsibility of an ATCT controller is to prevent collisions between aircraft and other hazards (e.g., terrain, ground vehicles) on the airport surface and in the immediate vicinity of the airport (FAA, 2012). Set in 1990, the Office of Policy and Plans (APO) developed criteria for the establishment and discontinuance of ATCT (FAA-APO-90-7) (FAA, 1990). However, operations in the National Airspace System (NAS) have and are continuing to transition to support Next Generation Air Transportation System (NextGen) initiatives and other enhancements to the NAS. The Federal Aviation Administration's (FAA's) APO is reviewing and potentially updating the cost, safety benefit, and efficiency benefit criteria outlined in the 1990 policy for ATCT establishment; the focus of the review is on low volume tower operations, such as airports in Class D airspace. In examining the safety benefit of ATCT controllers, the safety service provided by tower controllers at towers with larger operations, such as the Core 30 airports, greatly exceeds the costs of establishing those towers. Controllers at larger operation towers are necessary to efficiently and safely manage air traffic. However, as the number of operations at a tower decreases, the costs of operating the tower may begin to outweigh the benefits.

Prior internal research of Class D airports identified hazards and classified those hazards for towered airports in Class D airspace. The impact those airport characteristics have on operations and controller performance has yet to be fully examined. With the focus on visual air traffic services (VATS), the purpose of this study is to assess the operational safety benefit provided by tower controllers in Class D airspace and to determine the potential safety benefit that a controller could have provided during safety events in non-towered operations. As part of the larger project (Berry, Sawyer, & Hinson, 2014), this paper presents the safety benefits and associated risks with the previously identified hazards representing dynamic hazards.

Methodology

For the safety benefits assessment of VATS operations, a sample of 35 FAA towered airports in Class D airspace was identified. Utilizing a previous FAA study, the airport characteristics were identified for each of the airports in the sample set. Narrative safety data for the airport sample set was gathered from the FAA's Air Traffic Safety Action Program (ATSAP). ATSAP is a voluntary, non-punitive reporting system for air traffic controllers. ATSAP reports submitted by controllers at the sample airports for the calendar years of 2011, 2012, and 2013 time period were queried, resulting in 792 reports and safety event narratives. The focus of the ATSAP program is to provide the air traffic community an outlet for reporting a safety event that might otherwise have gone unknown. The purpose of this analysis is to examine the safety benefits that controllers provide in the control tower environment. The 792 ATSAP reports were filtered to identify those reports describing a safety event where the controller provided a safety benefit. The question examined in the filtering exercise was, "Did the controller provide a service that reduced the severity or consequences of the safety event described in the report?" Each of the 792 ATSAP reports were examined with the question by at least two human factors subject matter experts (SMEs), resulting in 175 ATSAP reports identified as describing a safety event where a controller provided a safety benefit.

Classification of Benefits and Risks

The filtered 175 ATSAP reports were classified with the Air Traffic Analysis and Classification System (AirTracs) utilizing the consensus method, which required a consensus or agreement on the causal factors contributing to the report by a panel. The panel members included human factors experts, retired air traffic controllers, and flight deck experts. AirTracs provides a framework for systematically and thoroughly examining the impact of human performance on air traffic accidents and incidents. The framework of the AirTracs causal category model is based on the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) model (DoD, 2005), while the detailed causal factors incorporate factors from Human Error in ATM (HERA) and JANUS (Isaac et al., 2003). The AirTracs framework promotes the identification of causal trends by allowing factors ranging from the immediate operator context to agency-wide influences to be traced to individual events. The causal category model is displayed in Figure 1. For more information on the AirTracs causal factor categories see Berry, Sawyer, & Austrian, 2012.

To determine the risks or latent factors present, each report was evaluated across all levels of the AirTracs framework, and the presence or absence of each AirTracs causal category was recorded. It is important to note that the AirTracs categories are not mutually exclusive. For example, an individual report can include both an execution act and a decision act. To determine the safety benefits present, each safety benefit was classified with the FAA's strategic job analysis for the tower domain (AIR, 2011). In order to identify risk-benefit pathways, associations among AirTracs factors and safety benefit tasks were measured. Starting at the highest AirTracs tier and continuing to the lowest AirTracs tier, the relationship among the factors within the tier, the various factors at lower tiers, the strategic job tasks, and airport characteristics were examined using a Pearson's chi-square test to measure the statistical strength of the association. In the instances where the assumptions of the Pearson's chi-square test were not met, a Fisher's Exact Test was conducted (Sheskin, 2011). If the relationship resulted in a significant association identified through the Pearson's chi-square test or Fisher's Exact Test ($p<0.05$), the odds ratio value was calculated for that particular association (Sheskin, 2011).

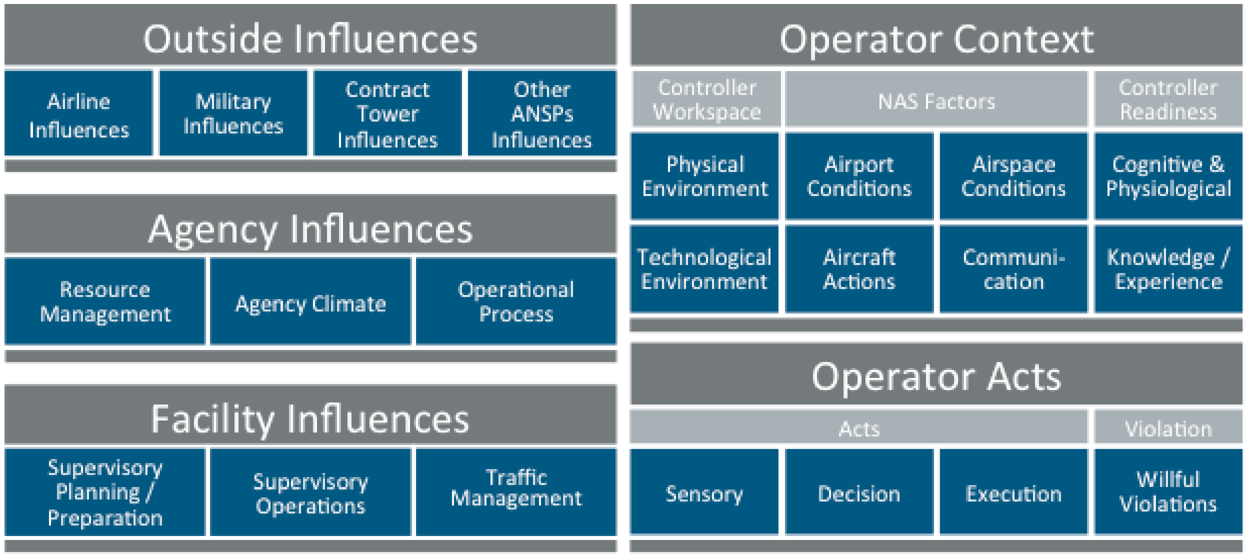

Figure 1. AirTracs Framework

Results and Discussion

When examining the safety benefits that tower controllers provide at the sample set of FAA staffed towered airports in Class D airspace, the three following human factors safety-benefit pathways emerged: Dynamic Risk-Benefit Pathway, Static Risk-Benefit Pathway, and Communication Risk-Benefit Pathway. The human factors safety-benefit pathways represent key associations among AirTracs factors, safety-critical tasks, and airport characteristics. This paper will present the findings for the Dynamic Risk-Benefit Pathway. The first human factors-safety risk-benefit pathway incorporates how a controller at a Class D towered airport provided a safety-benefit service to mitigate a dynamic risk and can be found in Figure 2.

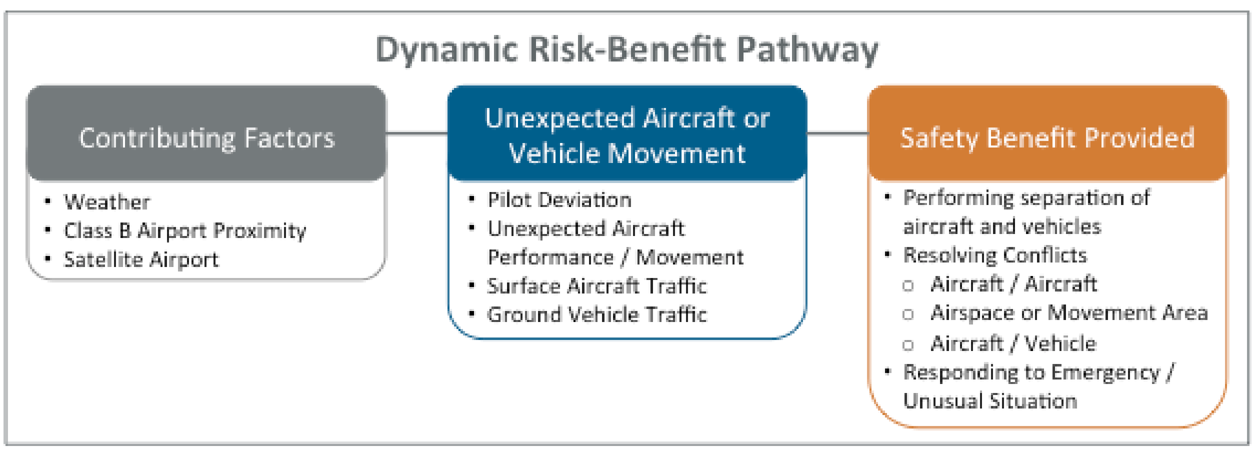

Figure 2. Dynamic Risk-Benefit Pathway

The central blue box in the risk-benefit pathway graphic depicts the AirTracs factors that presented a key risk to operations in the ATSAP reports. For this pathway, the factors were dynamic in nature as they were a result of human actions and were not consistently present at all airports in every situation. Those dynamic risk factors were found to be pilot deviations, unexpected aircraft performance/movement, airport surface aircraft traffic, and ground vehicle traffic. Table 1 shows the level of classification for each risk factor. The values in Table 1 can be interpreted in the following way: in 62.26% of the ATSAP reports classified, there was a pilot deviation. In most cases, risk factors represent active pilot or driver errors or failures, and it is necessary to examine the latent factors associated with those risk factors to better understand why those risk factors may occur.

Table 1. *Risk Factor Classification Level – Dynamic Risk-Benefit Pathway*

Risk Factor	Percentage of Classified Reports
Pilot Deviation	62.26% of ATSAP Reports
Unexpected Aircraft Performance/Movement	25.47% of ATSAP Reports
Airport Surface Aircraft Traffic	10.38% of ATSAP Reports
Ground Vehicle Traffic	6.60% of ATSAP Reports

The left gray box in the risk-benefit pathway graphic depicts the contributing factors associated with the risk factors. The contributing factors represent a combination of the airport characteristics previously identified (e.g., Class B Airport Proximity) and contributing factors from the application of AirTracs (e.g., weather). Those contributing factors found to be associated with the dynamic risk factors were weather, Class B airport proximity, and satellite airports. Table 2 shows the level of classification for each contributing factor. The values in Table 2 are represented in one of two manners: 1) For airport characteristics, 34.29% of the sampled towered airports are in proximity to a Class B airport; 2) For AirTracs factors, in 7.55% of the ATSAP reports classified, weather was a contributing factor.

Table 2. *Contributing Factor Classification Level – Dynamic Risk-Benefit Pathway*

Contributing Factor	Percentage of Classified Reports or Airports
Satellite Airports	42.86% of the Sampled Towered Airports
Class B Airport Proximity	34.29% of the Sampled Towered Airports
Weather	7.55% of ATSAP Reports

In order for the contributing factor to be included in the pathway, at least one of the contributing factors had to have a statistical association with at least one of the risk factors. Table 3 depicts the associations and their odds ratios. For those pairings with odds ratios, the pairing was first found to be statistically significant via the Pearson's Chi Square test or Fisher's Exact Test ($p < 0.05$). Upon being found significant, the odds ratio for the pairing was determined. The odds ratio can be interpreted in the following way: when a report was found to include weather as a contributing factor, the odds of the report also including unexpected aircraft performance/ movement were 5.758 times greater than those reports that did not indicate weather as a factor.

Table 3. *Contributing Factors – Risk Factors Associations Odds Ratios – Dynamic Risk-Benefit Pathway*

	Risk Factors	
Contributing Factors	Pilot Deviation	Unexpected Aircraft Performance/Movement
Satellite Airports	2.285	2.526
Class B Airport Proximity		2.526
Weather		5.758

The right orange box in the risk-benefit pathway graphic depicts the safety benefits provided by a controller through safety-critical tasks. These safety-critical tasks depict how a controller identified, responded to, and recovered from the dynamic risks. For the dynamic risk-benefit pathway, the safety benefits provided by tower controllers include performing separation of aircraft and vehicles, resolving conflicts, and responding to emergencies/unusual situations. Table 4 showing the level of classification for each benefit. The values in Table 4 can be interpreted in the following way: in 37.74% of the ATSAP reports classified, a controller performed safety-critical tasks related to resolving aircraft to aircraft conflicts.

Table 4. *Contributing Factor Classification Level – Dynamic Risk-Benefit Pathway*

Benefit Factor	Percentage of Reports
Resolving Conflicts – Airspace or Movement Area	40.57% of ATSAP Reports
Resolving Conflicts – Aircraft/Aircraft	37.74% of ATSAP Reports
Responding to Emergencies/Unusual Situations	17.92% of ATSAP Reports
Resolving Conflicts – Aircraft/Vehicle	12.26% of ATSAP Reports
Performing Separation of Aircraft and Vehicles	8.49 % of ATSAP Reports

In order for the safety benefit to be included in the pathway, at least one of the risk factors had to have a statically significant association with at least one of the safety benefits. Table 5 depicts the associations and their odds ratios. For those pairings with odds ratios, the pairing was first found to be statistically significant via the Pearson’s Chi Square test or Fisher’s Exact Test ($p < 0.05$). Upon being found significant, the odds ratio for the pairing was determined. The odds ratio can be interpreted in the following way: when a report was found to include a pilot deviation as a risk factor, the odds of the report including the safety-benefit tasks associated with resolving aircraft to aircraft conflicts were 2.50 times greater than those reports not including a pilot deviation.

Table 5. *Risk Factors Safety Benefit Associations Odds Ratios – Dynamic Risk-Benefit Pathway*

	Risk Factor			
Safety Benefit	Pilot Deviation	Unexpected Aircraft Performance/ Movement	Airport Surface Aircraft Traffic	Ground Vehicle Traffic
Performing Separation of Aircraft and Vehicles			5.56	
Resolving Conflicts	9.05	3.19		
Resolving Conflicts – Aircraft/Aircraft	2.50		21.67	
Resolving Conflicts – Airspace or Movement Area	5.66	3.08		
Resolving Conflicts – Aircraft/Vehicle				78.86
Responding to Emergencies/Unusual Situations	14.00	6.10		

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