PREDICTING AIR TRAFFIC CONTROL STUDENT SUCCESS AND IMPROVING PLACEMENT THROUGH SKILL APTITUDE TESTING

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In order to improve Air Traffic Control (ATC) training efficiency and reduce the risk of student failure, the FAA needs tools that can predict student success and inform student placement in training. By considering student aptitude, the FAA could reduce training costs by reducing student failure rates and transfers between facilities. In order to explore the benefits of early aptitude assessment, The MITRE Corporation (MITRE) created a prototype Radar Vectoring Aptitude Test designed to be administered to students before they begin their training to assess their aptitude for the skill of radar vectoring. The FAA office of Safety and Technical Training (AJI-2) in Air Traffic Operations (ATO), the FAA Civil Aerospace Medical Institute (CAMI), and MITRE are working in collaboration to evaluate the prototype with trainees at the FAA Academy.

Introduction

The Federal Aviation Administration (FAA) plans to hire more than 6,300 air traffic controllers over the next 5 years (FAA, 2015) and the need to improve training to increase efficiency and effectiveness have been well documented (Barr, Brady, Koleszar, New, and Pounds, 2011; Hutson, et al., 2014). A number of factors contribute to inefficiency in Air Traffic Control (ATC) training including imperfect assessment of student aptitude early in the training process. After a candidate is hired by the FAA, they attend the FAA Academy at the Mike Monroney Aeronautical Center in Oklahoma City, OK. At that time, they are assigned a training option (en route or terminal). The FAA bases assignments primarily on facility staffing needs but students may indicate an interest in a particular facility or geographical preference. At the completion of their training, top performers at the FAA Academy may be offered a choice among openings at various facilities. Towers, TRACONS and en route facilities differ in operations, complexity, and required skills (Pierce, et al., 2016). Because student assignment to facilities is not based on an assessment of student strengths and aptitude for the unique skills required by different facility types, there can be a mismatch between student aptitude and facility placement. This mismatch can contribute to students failing to complete training at their first assigned facility. The FAA has a need for enhanced tools that can predict student success in training and help place students in either an en route or terminal environment based on an assessment of their aptitude for specific fundamental ATC skills. By using aptitude assessment to inform student placement in training, the FAA could possibly decrease training cost and risk;

more appropriate student placement in training could reduce the overall amount of time students spend in training and the student failure rate.

In order to explore the validity and benefits of early aptitude assessment, The MITRE Corporation (MITRE) created a prototype Radar Vectoring Aptitude Test capability. Radar vectoring is one of the critical tasks performed by terminal and en route controllers to ensure safe separation, to space aircraft, to sequence traffic, and to facilitate the efficient flow of traffic. The aptitude test is designed to be administered to students before they begin their training at the FAA Academy to assess their aptitude for the skills required for efficient and effective radar vectoring. The prototype is currently being evaluated with developmental trainees at the FAA Academy (referred to as students throughout this report) at the beginning of their training. Those students will be followed over the course of their training so that the relationship between aptitude test performance, training performance, and, ultimately, their success in achieving certification as an Air Traffic Controller can be assessed. If the evaluation indicates a relationship between aptitude test performance and student success in training, then additional skill aptitude tests, beyond vectoring, could aid the FAA in predicting student success and further support student placement in training.

Radar Vector Aptitude Test Prototype Description

The following is an overview description of the Radar Vector Aptitude Test Prototype. Radar vectoring is one of the critical tasks performed by terminal and en route controllers. The knowledge, skills, abilities, and other characteristics (KSAOs) necessary to perform an air traffic controller's job have been determined and documented by the American Institute of Research (AIR) (Krokos, et al., 2011; Krokos, et al., 2011; Krokos, et al., 2011). Throughout this document, the term aptitude is used to encompass the set of KSAOs that are needed to successfully perform the task of radar vectoring. The Radar Vector Aptitude Test prototype is designed to objectively assess those KSAOs. Specifically, the Radar Vector Aptitude Test will assess student aptitude for the following:

- Basic and advanced compass use
- Phraseology for issuing a vector clearance and oral communication
- Interpreting a data block
- Vectoring Skill
- Scanning, Prioritization, and Planning
- Situation Awareness
- Tolerance for increased/high workload

The aptitude test is composed of 4 sections. Each section has multiple subtests, allowing for varying levels of difficulty and an opportunity to adequately test for basic knowledge and skill. Each subsequent section is more difficult than the last and later sections are designed to assess more operationally comprehensive aptitudes and skills. The test takes approximately 3 hours to complete. Additionally, there is a participant survey at the end of the test. The survey captures feedback on the completeness of instructions and practice allowed, as well as data about previous student knowledge.

Radar Vector Aptitude Test Sections

The goal of Section 1 is to familiarize the student with the prototype and to test the student's understanding or knowledge of the compass, data block, and phraseology, as well as their aptitude to use this knowledge to effectively vector aircraft. Section 1 consists of three tests: ***Practice Test, Basic Compass Test,*** and ***Advanced Compass Test***. Figure 1 is a screen shot from the ***Practice Test:***

Figure 1. Section 1 Practice Test

The goal of Section 2 is to test the student's aptitude for compass use and proper phraseology in order to vector more than one aircraft at a time. Additionally, since multiple aircraft are moving, situation awareness, prioritization, planning, scanning, and oral communication are also assessed in Section 2. There are two tests in Section 2, the ***Basic Shapes Test*** and the ***Advanced Shape Test.*** Figure 2 is screen shot of the ***Advanced Shape Test***:

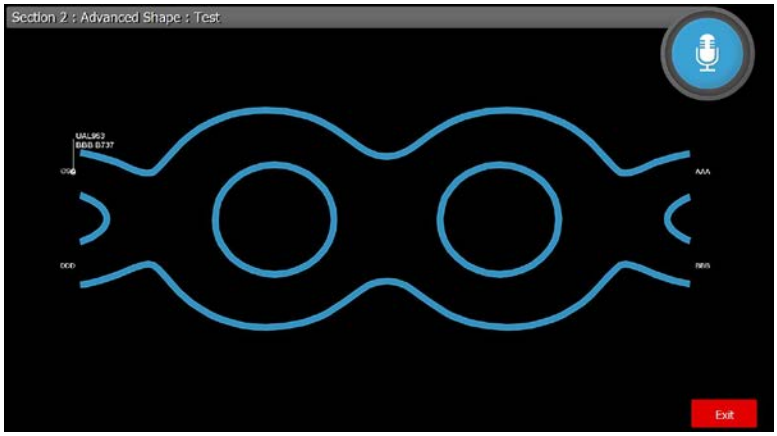

Figure 2. Section 2 Advanced Shape Test

The goal of Section 3 is to continue assessing a student's vectoring skills, as well as situation awareness, prioritization, and scanning. The following tests are administered in Section 3: ***Simple Shape Test, Scenario 1 Test,*** and ***Scenario 2 Test.*** Figure 3 is screen shot of the ***Scenario 1 Test***:

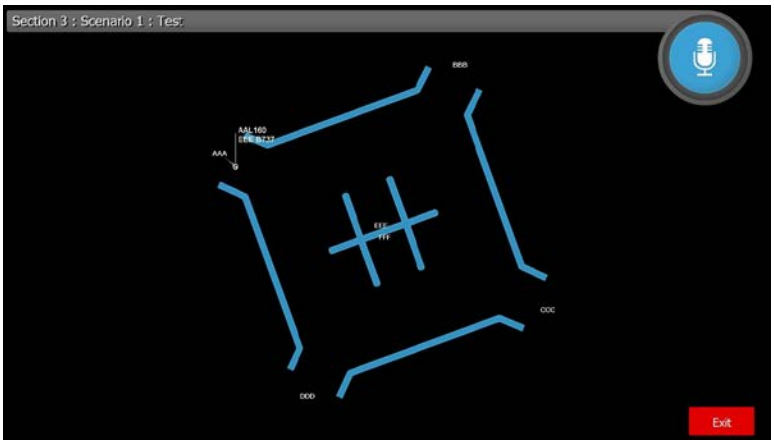

Figure 3. Section 3 Scenario 1 Test

The goal of Section 4, which is the most complex section, is to continue assessing a student's vectoring skills, as well as situation awareness, prioritization, and scanning in more complicated situations, all with an increased workload. Section 4 consists of 2 tests, ***Scenario 3 Test*** and ***Scenario 4 Test***, which aid in determining a student's ability to vector in a terminal and en route environment. Figure 4 is a screen shot from the ***Scenario 3 Test.***

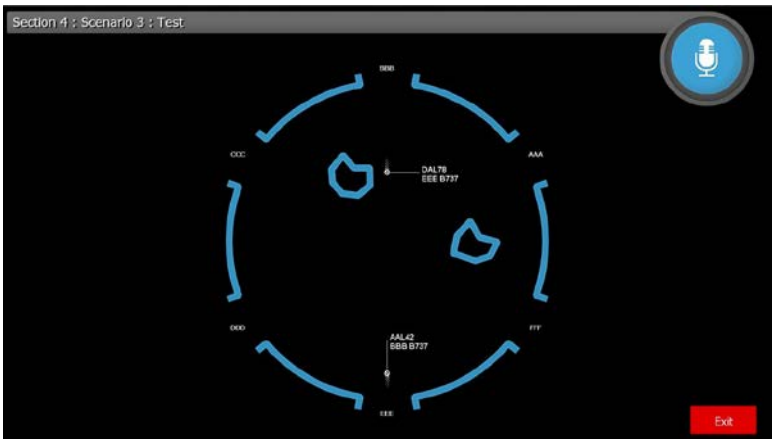

Figure 1. Section 4 Scenario 3 Test

Evalution Conduct

These next two sections present an overview of the evaluation conduct and data analysis. The evaluation is being conducted in partnership with CAMI in their lab facilities in Oklahoma City, OK. Before each test, A CAMI Principal Investigator (PI) gives students a 30-minute overview of the purpose and specifics of the evaluation. A CAMI appointed proctor is present to monitor system performance and student usage. Additionally, the students complete a demographics questionnaire. The students are asked to sign a voluntary consent form that describes the purpose, goals, risks, benefits, voluntary nature, and data collection/storage procedures of the study.

Data Collection and Assessment

MITRE and CAMI have analyzed the data to ensure that there is enough variation between students' scores, verifying that the test is neither too hard nor too easy and validating that the test is capturing differences in student aptitude. Using the first six months of data collection (N = 594), analyses are being conducted to determine which metrics generated by the aptitude test software will be used to create an overall scoring algorithm. These will be completed using correlation and regression methods with FAA Academy performance as the predicted outcome variable. In other words, each metric available will be examined separately and in combination with the other metrics to create a usable and predictive score.

Data from the ***Basic*** and ***Advanced Compass Tests*** will be studied to determine student success based on the number of correct vector clearances the student issued. Data from the ***Shapes*** and ***Scenario Tests*** will be used to calculate how many aircraft students successfully guided to the destination gate. For those aircraft that exited successfully, the number of vectors issued will be tallied. Additionally, data such as how many aircraft exited incorrect gates, how many times did the countdown clock reach zero, and how many times did the system respond to a student issued clearance with "say again" will be reviewed. Further analysis may include a determination of how far off incorrect vectors were and calculations of how close students came to the boundary. For shapes that included multiple aircraft, data may be studied to see in cases where the first aircraft failed to successfully reach the exit gate (i.e. the aircraft hit the boundary), were adjustments made to successfully vector subsequent aircraft? Data collected from later scenario tests, such as students' ability to control multiple aircraft and reaction to gate changes and moving objects may be indicators of a tolerance for higher workload and situation awareness. Data will also be examined to determine if students' performance improved over the course of the test, possibly indicative of aptitude.

The data collected from January 2017 – June 2017 (approximate sample size of 732) will be used to cross-validate the scoring algorithm determined using the data from first six months of the evaluation and make modifications, if needed. Then combining all data collected (N = 1,326), the overall predictive validity, utility, and fairness of the aptitude test for placement purposes will be evaluated. Utility will be assessed by comparing the cross-tabulations of actual placements versus indicated test placements. If those who would have been placed, based on the placement indicated by the Radar Vectoring Aptitude Test prototype score, into the option to which they were actually placed succeed at a higher rate than those who were placed in a different option than the one indicated by the aptitude test placement, then it is possible that the aptitude test will help increase the pass rate at the FAA Academy and be operationally useful. Fairness, as defined by the U.S. Equal Employment Opportunity Commission's Uniform Guidelines on Employee Selection Procedures, will be assessed to determine likelihood of adverse impact against protected groups ("Adoption of Questions and Answers to Clarify and Provide a Common Interpretation of the Uniform Guidelines on Employee Selection Procedures", 1979.)

Next Steps

MITRE, CAMI, and AJI-2 will continue to collaborate on the prototype evaluation and validation. MITRE and CAMI will continue the data analysis with data collected from students through FY2017 to first determine an overall Radar Vectoring Aptitude score that will be used to predict performance. A report on the results of the first year of the evaluation will be delivered to

the FAA at the end of FY17. Also in FY17 detailed plans for the longitudinal study of students' performance will be developed in order to assess the test's ability to predict field training performance. The students will be followed over the course of their training to assess the relationships between score, training performance at the FAA Academy and at their first facility and, ultimately, their achievement of CPC status.

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NOTICE