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Engineered Material Arresting System Sign Simulation—Expanded Data Analysis

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Final Report

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16. Abstract

Engineered Material Arresting System (EMAS) is a specially designed surface that is installed at the end of certain runways that do not have sufficient surrounding space to support the standard runway safety area (RSA). EMAS is designed to reduce the extent and associated risks of a runway excursion by arresting an aircraft that experiences an overrun excursion during a landing or an aborted takeoff. Of the 121 EMAS beds installed at 69 airports in the United States, there have been 20 incidents where EMAS has safely stopped overrunning aircraft, carrying 428 crew and passengers. Despite its proven effectiveness, there is evidence that pilots occasionally avoid EMAS beds during an overrun excursion. Previous research by the Federal Aviation Administration (FAA) Airport Technology Research and Development Branch's Safety Section (ATR) identified conceptual EMAS signage that would inform a test subject about the presence of EMAS during normal operations and an overrun excursion. Current ATR research has two objectives: gain test subject input about the location of EMAS signs that best inform a pilot about the presence of EMAS on a runway and evaluate the effectiveness of these signs during an overrun excursion. The use of flight simulators at FedEx and FlightSafety International (FSI) were chosen as the most effective way to meet these objectives. Flight simulation exercises with 132 test subjects were completed by September 2022.

Data analysis concluded the following:

- There is no evidence that the EMAS signs influenced the pilot to steer straight at the end of the runway during a simulated overrun excursion.
- Most test subjects reported that EMAS signage would be beneficial as a reminder during normal operations and during an actual overrun.
- Test subjects preferred that the EMAS signs be located near the end of the runway in lieu of 500 ft before the end of the runway.
- Test subjects also indicated that EMAS signage would also be useful at the departure end of the runway and 1,000 ft or more before the end of the runway.

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LIST OF ACRONYMS

AAS	Airport Safety & Standards, Airport Engineering Division
ACY	Atlantic City International Airport
AFTIL	Airway Facilities Tower Integration Laboratory
AIM	Aeronautical Information Manual
ALPA	Airline Pilots Association
ALSF-2	Approach lighting system with sequenced flashing lights
ATR	Airport Technology Research and Development Branch, Safety Section
BI	Basic indoctrination
CANSO	Civil Air Navigation Services Organization
C.F.R.	Code of Federal Regulations
CG	Center of gravity
CLT	Charlotte Douglas International Airport
COR	Contracting Officer's Representative
DHHS	Department of Health and Human Services
DOF	Degrees of freedom
EMAS	Engineered Material Arresting System
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FSI	FlightSafety International
GA	General aviation
ID	Identification
inHG	Inches of mercury
IRB	Institutional Review Board
JFK	John F. Kennedy International Airport
kts	knots
LAX	Los Angeles International Airport
LGA	LaGuardia Airport
MDW	Chicago Midway International Airport
MEM	Memphis International Airport
NOTAM	Notice to Air Missions
ORD	Chicago O'Hare International Airport
OTA	Other Transaction Agreement
PI	Principal Investigator
PIC	Pilot-in-command
R&D	Research and development
RDR	Runway distance remaining
RSA	Runway safety area
RTO	Rejected takeoff
SFO	San Francisco International Airport
SOP	Standard operating procedure
TEB	Teterboro Airport
VMC	Visual Meteorological Conditions
ZFW	Zero-fuel weight

EXECUTIVE SUMMARY

In October 1999, the Office of Airport Safety and Standards (AAS) initiated a program to improve runway safety areas (RSAs) at commercial service airports by the end of 2015. However, many airports were built before the current 1,000-foot RSA standard was adopted and do not have adequate space available at the end of certain runways to support this safe distance requirement. In response to this distance-related issue, AAS sponsored research to develop an engineered material arresting system (EMAS) to help stop an aircraft during an overrun excursion at runways where the standard 1,000-foot length requirement cannot be achieved (Federal Aviation Administration, 2022). EMAS beds are comprised of low-density crushable materials that will deform under the weight of an aircraft tire and decelerate an aircraft in a manner that protects that aircraft, passengers, and crew.

Of the 121 EMAS beds installed at 69 airports in the United States, there have been 20 incidents in which EMAS systems have safely stopped overrunning aircraft, which carried 428 crew and passengers. Despite the proven effectiveness of EMAS, the Federal Aviation Administration (FAA) continues to receive anecdotal reports that pilots occasionally avoid EMAS beds, either intentionally or unintentionally.

In 2013, the FAA Airport Technology Research and Development (R&D) Branch, Safety Section (ATR) began to study why pilots sometimes showed a tendency to veer away from EMAS during a runway excursion. As part of this research, ATR recommended the placement of new information signage to inform pilots and improve their awareness of the presence of an EMAS serving a specific runway. This initial effort was supplemented by a second ATR study in 2016 that recommended multiple concept signage designs intended to improve pilot situation awareness of an EMAS serving a specific runway.

After receiving recommendations from AAS, ATR prepared a project plan to install prototype EMAS information signs at selected airports and evaluate pilot feedback regarding the usefulness of these signs. Coincidentally during this time, two aircraft incidents occurred illustrating that the issue persists where pilots occasionally veer away from EMAS during an overrun excursion. One incident involved a Boeing 737-700 charter flight, which was carrying then Vice-Presidential candidate Mike Pence. In that incident, the Boeing 737-700 overran Runway 22 while landing at LaGuardia Airport (LGA) in New York City on October 27, 2016. In a second incident on July 12, 2017, a HondaJet overran Runway 31C at Chicago Midway Airport (MDW) and veered to the left as it approached the EMAS bed. In both incidents, the pilots stated that they had forgotten that there was an EMAS bed at the end of the runway.

AAS determined that conducting the ATR project plan at operational airports would be too costly and time consuming. AAS recommended that ATR consider the use of flight simulators in lieu of operational airports. The use of flight simulations has numerous benefits by providing the ability to repeat a runway overrun excursion simulation within the confines of a controlled laboratory setting. FedEx and FlightSafety International (FSI) agreed to host these simulations, provide the pilots, develop high-fidelity simulation scenarios, conduct the simulations, and collect the data. The COVID-19 outbreak in March 2020 interrupted the research plan and resulted in a delay of the start of the flight simulation experiments.

Flight simulation exercises at FSI began on February 21, 2022. A total of 11 test subjects completed the simulations and submitted data on March 7, 2022. FSI submitted a second set of data that included an additional 19 test subjects on September 16, 2022. FedEx flight simulation exercises began on June 30, 2021. FedEx submitted 102 data sets on June 1, 2022.

- Analysis of all 132 data sets revealed that there is no evidence that the EMAS signs influenced the pilot to steer straight at the end of the runway during a simulated overrun excursion.
- Most test subjects reported that the EMAS signs would be useful during normal operations as a reminder and during an actual overrun excursion.
- Test subjects preferred that the EMAS signs be located near the end of the runway as opposed to 500 ft before the end of the runway.
- Test subjects also indicated that EMAS signage would be useful at the departure end of the runway and 1,000 ft or more before the end of the runway.

1. INTRODUCTION

A runway excursion occurs when an aircraft veers off the side or overruns the end of a runway. Excursions are the cause of more runway accidents than any other factor (Civil Air Navigation Services Organization [CANSO], n.d.). The Federal Aviation Administration (FAA) requires a runway safety area (RSA) at the end of each runway to provide a margin of safety for aircraft that experience an excursion overrun (FAA, 2012). The RSA is typically 500 ft wide by 1,000 ft long, graded, and clear of any obstacles that are not fixed by their function, such as approach lights.

In October 1999, the Office of Airport Safety and Standards (AAS) initiated a program to improve RSAs at commercial service airports by the end of 2015. Many airports built before the current 1,000-foot RSA standard was adopted have runway ends that do not have adequate space to support that requirement. In response to this distance-related issue, AAS sponsored research to develop an engineered material arresting system (EMAS) to stop aircraft during an overrun excursion at runways where the standard 1,000-foot length requirement cannot be achieved (FAA, 2022). EMAS beds are comprised of low-density crushable materials that deform under the weight of an aircraft tire and decelerate an aircraft in a manner that protects the aircraft, passengers, and crew.

According to the FAA, as of September 11, 2023, there are 121 EMAS beds installed at 69 airports in the United States. Since the completion of the EMAS installations, there have been 20 incidents where EMAS has safely stopped overrunning aircraft, which carried 428 crew and passengers (FAA, 2022). Despite the proven effectiveness of EMAS, the FAA continues to receive anecdotal reports that pilots occasionally avoid EMAS beds, either intentionally or unintentionally.

Recently, two high-profile incidents occurred in which pilots veered away from the EMAS bed during an overrun excursion. On Oct. 27, 2016, a Boeing 737-700 charter flight, carrying then Vice-Presidential candidate Mike Pence, overran Runway 22 while landing at LaGuardia Airport (LGA) in New York City. The crew veered to the right as it exited the end of the runway and cut across the EMAS at an angle. The captain stated that he had he had forgotten that there was an EMAS at the end of the runway. In a second incident on July 12, 2017, a HondaJet overran Runway 31C at Chicago Midway Airport (MDW) and veered to the left as it approached the EMAS bed. Again, the pilot stated that he had forgotten about the presence of EMAS. (FlightSafety Foundation, 2017)

In response to these types of incidents, AAS asked the FAA Airport Safety Research and Development (R&D) Branch Safety Section (ATR) to develop and test information sign prototype concepts that are intended to alert or remind a pilot that an EMAS is present at the end of the runway. After the initial research effort in 2013, ATR recommended that the installation of EMAS information signs should be on both sides of a respective runway, positioned 500 ft from the end of the runway.

In 2016, ATR evaluated six different proposed signage concepts positioned at multiple potential locations along the runway. The findings from the ATR 2016 research led to the final decision of a single form factor. In addition, most pilots expressed that the end of the runway would be the best location to place this signage, but no final decision was made regarding the sign location. Follow-on research was recommended to allow pilots the opportunity to evaluate this sign concept at multiple runway locations at multiple operational airports.

By 2018, ATR prepared a Project Plan to install the prototype EMAS information sign at three airports and evaluate pilot feedback regarding the usefulness of these signs. The plan also identified EMAS sign specifications, material costs, airport layout configurations, survey participants, survey tools, methods of analysis, and a sample airport installation plan. AAS review of this project plan included a recommendation to consider the use of flight simulation in lieu of installing actual signage at operational airports. The use of flight simulation has numerous advantages versus an operational airport setting. Simulation provides the ability to consistently and safely test a pilot's reaction to a runway overrun excursion safely in a laboratory setting in a repeatable manner within budget. ATR successfully negotiated agreements with FedEx and FlightSafety International (FSI) to host these simulations, provide the participants, develop high-fidelity simulation scenarios, and collect the data.

The primary research objective of this current effort is to determine the optimal runway position for EMAS signage for pilot education and awareness during normal operating conditions. The secondary research objective is to assess the effectiveness of EMAS signs during an emergency overrun excursion. Because of the inherent danger involved in an overrun excursion scenario, this secondary objective can only be achieved using a flight simulator.

2. PREVIOUS RESEARCH EFFORTS (2013 AND 2016)

The results gathered during the two previous FAA research efforts provided a baseline for the current assessment of the effectiveness of the EMAS information signs with either reminding or alerting test subjects about the presence of EMAS at the end of a runway. The relevant conclusions of the preceding efforts are summarized and discussed in the following sections.

2.1 THE 2013 RESEARCH EFFORT—IMPROVED SIGNAGE, MARKING, AND LIGHTING OF EMAS

The 2013 research effort included two objectives:

- Determine if additional EMAS markings are required to prevent vehicle operators from inadvertently entering the EMAS bed. This objective did not apply to the 2018 research effort in which the focus was to encourage operational aircraft to use EMAS during emergency overrun excursions.

- Determine if additional EMAS markings are required to improve test subject awareness during overruns of runways with EMAS beds (Klass & Vitagliano, 2013). This objective was relevant to the 2018 research effort.

2.1.1 Test Subject Survey Results

The 2013 research effort also used a test subject survey questionnaire to gauge test subject knowledge about EMAS. The survey received responses from 399 test subjects. Note that not all survey questions were answered by each test subject. The number of responses and corresponding percentages for each question (Klass & Vitagliano, 2013) are listed below:

- 95% (356 of 375 test subjects) know the purpose of an EMAS

- 66% (246 of 372 test subjects) believe yellow chevrons are adequate for marking
- 91% (336 of 369 test subjects) operated at airports with EMAS
- 93% (313 of 336 test subjects) were aware of EMAS at airports where they operated

2.1.2 Discussion of Test Subject Survey Results

Based on survey results, most pilots (95%) know the purpose of an EMAS, and most (93%) know that an EMAS is present at airports where they operate. These results suggest that the prototype EMAS information sign may best serve as a reminder to pilots. An EMAS information sign may reinforce a pilot's memory of the presence of an EMAS during normal operations and conceivably make that information more accessible for decision-making under an emergency overrun condition (Klass & Vitagliano, 2013).

It is also believed that for pilots who are not aware of the purpose of EMAS, an information sign may encourage them to inquire about EMAS to better understand its function. However, during the actual emergency overrun event, an EMAS information sign will most likely provide no benefit in real time to the pilot. It is unlikely that it will influence a pilot's action to use EMAS during such a stressful event.

2.1.3 The 2013 Research Report Recommendations

The 2013 research report recommended three areas for improving awareness of EMAS: publications, education, and visual aids. Pilot feedback indicated that most pilots (86%) became aware of EMAS from the official FAA Airport Diagram. The 2013 report recommended that EMAS information be presented in other publications, in addition to the Airport Facility Diagram and the FAA Form 5010. The information should be presented in a manner similar to how it is presented in the Airport Diagram to ensure consistency of information and to aid in the information being recognizable. Pilots also suggested that recurrent training/ground school should emphasize the safety features of EMAS, and that the potential safety features of EMAS should be included in takeoff/approach briefings (Klass & Vitagliano, 2013).

The 2013 report also recommended stand-alone EMAS information signs with an information arrow on both sides of the runway set 500 ft from the end of the runway, as shown in Figures 1 and 2. This concept shown in these figures received the most positive feedback during the simulations that were conducted in the FAA Airway Facilities Tower Integration Laboratory (AFTIL).

Figure 1. Conceptual EMAS Information Sign

Figure 2. Location of Conceptual EMAS Information Signs in AFTIL

2.2 THE 2016 RESEARCH EFFORT—DEVELOPMENT AND EVALUATION OF EMAS SIGNAGE

The 2016 research effort evaluated six EMAS information sign concepts that varied in shape, size, color, and location. The objective was to identify the optimal sign and location to remind or alert test subjects that an EMAS is available at the end of a runway. Each concept met the following criteria:

- Conspicuity: Sign should be sufficiently distinct from the surrounding environment and visible while moving at a high rate of speed.
- Comprehensibility: Sign should be concise and unambiguous enough for the intended message to be understood by test subjects of all types and experience levels consistently.
- Uniqueness: Sign should be unmistakable with limited or no similarity to other signage.
- Consistency: Sign should be consistent with existing FAA guidance to the maximum extent possible to facilitate adoption by airports and sign manufacturers. (Subbotin, 2016)

2.2.1 The 2016 Research Report Recommendations

The 2016 research report stated that test subjects preferred the EMAS information signs shown in Figure 3 to be located just beyond the end of the runway, as shown in Figure 4. This recommendation was based on feedback from test subjects viewing the concept signs in a runway environment on Runway 4/22 at Atlantic City International Airport (ACY). This concept garnered an overwhelming preference from the test subjects.

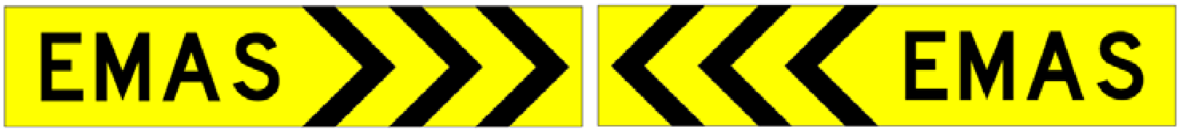

Figure 3. Conceptual EMAS Sign—One Signage Section on Each Side of Runway

Figure 4. Location of EMAS Information Signs at the End of Runway 4 at ACY Airport

The 2016 report also addressed several human factors considerations during both normal operations and emergency overrun conditions. Researchers selected the chevron shape because it was indicative of the marking pattern used for denoting an overrun area at the end of a runway containing a blast pad or an EMAS bed. The EMAS acronym was considered the most efficient way to convey the intended meaning of the sign. However, the report recognized that new shapes and symbols, like EMAS, on airport signs require pilot education and outreach. (Subbotin, 2016)

The 2016 report also explored the importance of sign location, particularly the downsides of collocating an EMAS information sign with a runway distance remaining (RDR) sign. Each sign (RDR or EMAS) provides specific information to the pilot. Colocation of these signs has the potential to create visual clutter and reduce the effectiveness of either sign. It was determined that positioning the EMAS sign closer to the end of the runway during an overrun may be better suited for alerting the pilot that EMAS is available. (Subbotin, 2016)

3. RESEARCH USING FLIGHT SIMULATORS

Based on a review of the results of the 2013 and 2016 research efforts, ATR sponsored a project plan to install prototype EMAS information signs at three operational airports and evaluate test subject feedback regarding the usefulness of these signs. Based on the 2013 study results, the project plan premised that most test subjects (95%) know the purpose of an EMAS, and most (93%) know that that an EMAS is present at airports where they operate. Consequently, the project plan targeted those two distinct populations.

The project plan included a year-long survey that would measure the effectiveness of EMAS information signs at reinforcing existing test subject knowledge of EMAS and the residual effect the signs might have on those test subjects during a hypothetical overrun. The survey was also intended to measure the effectiveness of the EMAS information signs in alerting test subjects who do not know the function of an EMAS. The residual effect on this population would be measured by the number of test subjects who stated they intend to seek education and training regarding the purpose of EMAS.

AAS reviewed the project plan and concluded that the cost and logistics of using operational airports were too high and time consuming. AAS then recommended ATR consider the use of flight simulators in lieu of operational airports. Flight simulators had several advantages over operational airports, including:

- a safer, more carefully controlled, repeatable experiment
- ability to conduct repetitive experiments
- lower cost
- less time to build necessary infrastructure
- ability to simulate a runway overrun excursion

3.1 GENERAL SIMULATOR SCENARIOS

There are two simulator scenarios that align with the two research objectives. Each scenario requires a high-fidelity visual representation of the runway environment, including the RSA, during both day and night conditions. The simulator must be able to accurately represent the EMAS signs, EMAS bed, runway lights, paint markings, and any obstructions within and just beyond the RSA. This includes approach lights, localizers, buildings, and perimeter/blast fences.

Figure 5 shows the exact dimensions of a prototype EMAS sign. This is the proposed sign design that will be placed on the sides of the runway facing the test subject, as shown in Figures 3 and 4. Both signs shown in Figure 3 have these same dimensions and will be positioned approximately 35 ft from the left and right edges of the runway and illuminated at night.

Figure 5. Conceptual EMAS Sign Dimensions

3.1.1 Simulation Scenario for Objective 1—Optimal Sign Location

The primary objective of this simulation effort is to determine optimal locations of EMAS signs for test subjects' education and awareness during normal operating conditions. The simulation scenario for the first objective includes the simultaneous placement of the conceptual EMAS signage pair (shown in Figure 3) at all proposed signage locations for each respective runway. This scenario enables a flight crew to consider all options and identify the optimal sign location during a single simulation.

Two EMAS signs (one on each side of the runway) will be placed approximately 35 ft from the left and right edges of the runway, as shown in Figure 4, at up to three possible locations along the length of the runway:

- 500 ft before the end of the physical runway
- At the physical end of the runway
- At the leading edge of the EMAS bed

It is noted that the leading edge of the EMAS can range from 35 ft to over 500 ft from the end of the physical runway. In those cases where the leading edge of the EMAS is only 35 ft from the end of the physical runway, one set of signs will suffice for both the end of runway and beginning of EMAS locations.

The simulator must have the ability to show the EMAS signs in all three locations simultaneously or just one location at a time. Test subjects should be primed about the objective of the simulation. A post-simulation survey questionnaire will be given to explore test subject knowledge about EMAS and ask test subjects to rank the locations as a function of their usefulness in reminding test subjects about the presence of EMAS.

3.1.2 Simulation Scenario for Objective 2—Sign Effectiveness

The secondary research objective is to assess the effectiveness of EMAS signs during an emergency overrun excursion. In this scenario, the simulator will be configured to cause the test subject to experience an overrun excursion. As the aircraft nears the end of the runway the test subject must decide to steer straight or veer to the left or right at the end of the runway. This simulation will include either the placement of EMAS signs at one of the three locations discussed for Objective 1 or will not include any EMAS signage. During many of the experiments there were multiple pilots making observations (i.e., one pilot in control of the aircraft and the other[s] in the role of supporting flight crew).

The overrun scenario requires an element of surprise, so the test subject should not be primed about the objective of the simulation. A post-simulation survey questionnaire will be given to ask if the test subject noticed the EMAS signs during the overrun, and if the signs were a factor in their decision-making process regarding whether to steer straight or to veer to the left or right at the end of the runway. Because of the required element of surprise, the sign effectiveness experiment can only be performed once per pilot (test subject group), and it must be performed prior to the optimal sign location simulation. After the emergency overrun scenario simulations are completed, the test subject will then be invited to conduct the simulation exercise for optimal sign locations.

The simulator must be configured in a manner to cause the aircraft to overrun but still provide directional control to the test subjects. Airport runways selected for this simulation must have EMAS present and ideally have an RSA with obstacles that favor veering in one direction over another. The RSA for Runway 11 at Newark International Airport (EWR) presents an ideal scenario[1]. A test subject that experiences an overrun excursion on EWR's Runway 11 will see that veering off to the left yields more real estate before encountering the perimeter fencing than going straight or veering off to the right. Figure 6 shows the RSA at EWR Airport for test subjects operating on Runway 11. The New Jersey (NJ) Turnpike is present along the right edge of the figure.

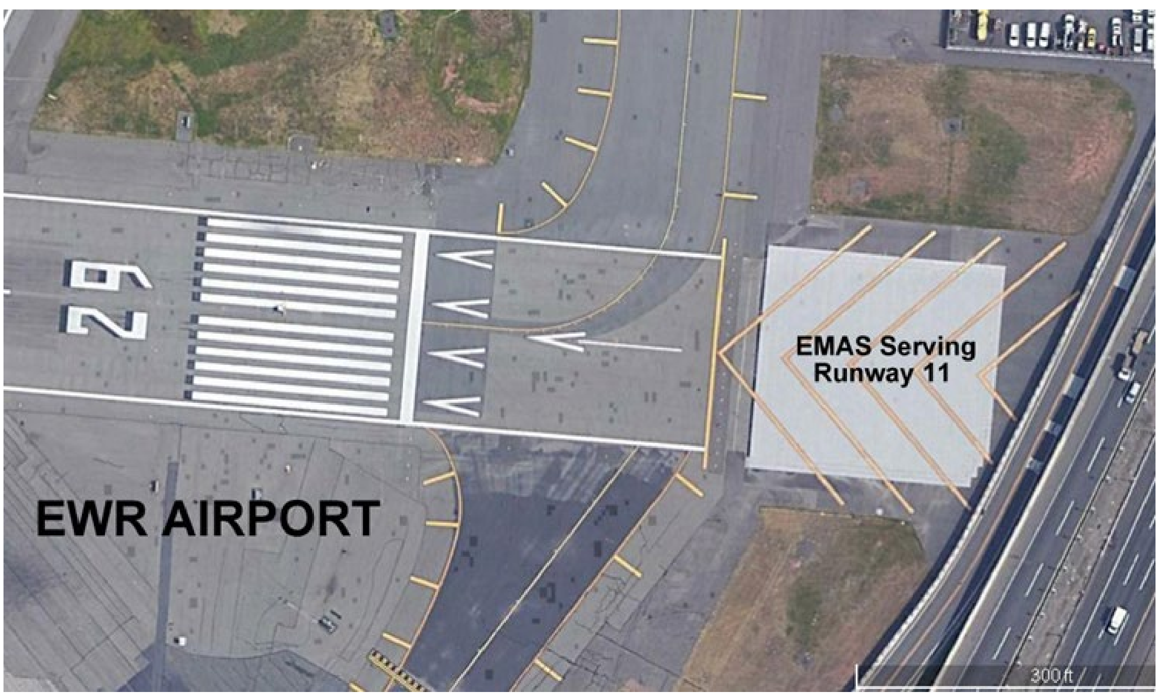

Figure 6. The RSA at EWR Airport

[1] Due to aircraft performance constraints this scenario was not utilized, but it does represent the ideal conceptual configuration to test and record pilot decision-making.

3.2 FEDEX FLIGHT SIMULATOR

In February 2019, ATR initiated discussions with FedEx regarding the use of their flight simulator facilities in Memphis, TN, to support the EMAS signage project. By early March 2020, ATR and FedEx agreed on a list of three candidate airports that could support the EMAS signage simulations. The criteria for selection included the following:

- Presence of an EMAS
- High-fidelity runway representation in the FedEx simulator
- RSA with obstacles
- RSA that would favor veering one direction over another
- A realistic scenario that would accurately portray a real-world potential emergency scenario

These airports met the criteria:

- Memphis International Airport (MEM) Runway 18R
- Newark International Airport (EWR) Runway 11
- San Francisco International Airport (SFO) Runway 1R
- Chicago International Airport (ORD) Runway 4R
- John F. Kennedy International Airport (JFK) Runway 4R

ATR and FedEx scheduled a kickoff meeting in late March 2020 at the FedEx simulation facility in Memphis, TN. The COVID-19 outbreak delayed this initial meeting until June 30, 2021. During that time frame, ATR and FedEx concurred that ORD and JFK airports would not be required to collect the necessary data. It was determined that the workload to incorporate these airports into the FedEx simulation environment would be too cumbersome and that their inclusion would not provide enough additional value to undertake that task. During this visit, it was also determined that aborted takeoffs would be simulated instead of landings. In landing scenario dry runs, it was frequently observed that the pilots were consistently able to stop short of EMAS during attempts to force an overrun excursion during landing. The aborted takeoff scenario provided the ability to cause an overrun excursion more consistently.

ATR and FedEx determined that since no funds were being provided to FedEx, an Other Transaction Agreement (OTA) was not required as part of the research partnership.

3.2.1 Memphis International Airport

MEM is the home base for the FedEx fleet. Consequently, there is some intrinsic flight training value to FedEx, and additional value because the EMAS is set back 550 ft from the end of the runway. The standard setback for EMAS is 200 ft from the end of the physical runway (FAA, 2012). This long setback provides the test subject with a different perspective of the EMAS bed and associated signage versus an EMAS bed that is closer to the end of the runway.

Figure 7 shows the RSA for Runway 18R at MEM Airport. The leading edge of the EMAS is set back 550 ft from the end of Runway 18R. The yellow arrows show the locations for the EMAS signage at all three locations: 500 ft before the end of the runway; at the end of the runway; and at the leading edge of the EMAS.

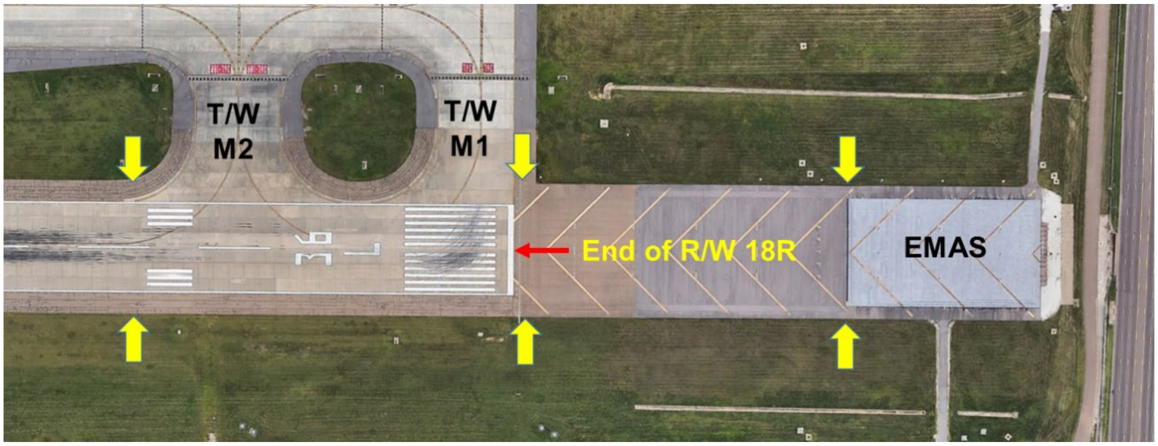

Figure 7. The RSA for Runway 18R at MEM with EMAS and EMAS Signage Locations

Figure 8 shows the RSA and EMAS for Runway 18R at MEM Airport and several obstructions. The localizer building for Runway 18R and the approach lighting system with sequenced flashing lights (ALSF-2) building for Runway 36L are located along the extended centerline of the runway. The ALSF-2 building to the right appears larger and closer than the localizer building to the left. If a test subject can notice this difference during an excursion, they would likely veer to the left to gain more distance before encountering the obstruction.

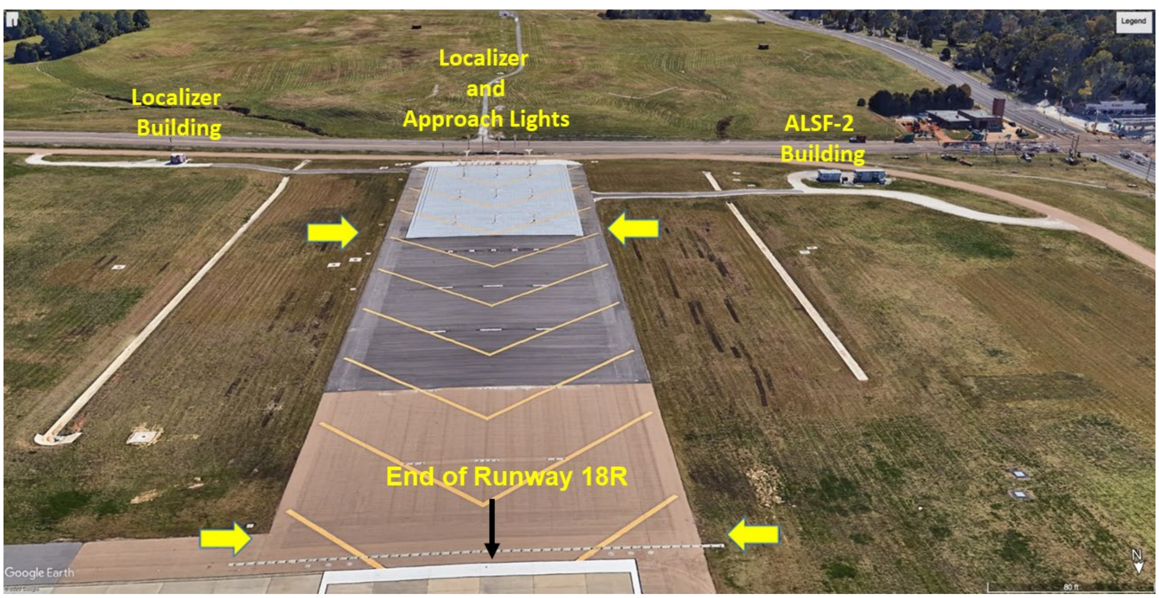

Figure 8. Obstructions in the RSA for Runway 18R at MEM Airport

3.2.2 Newark Liberty International Airport

Runway 11 at EWR was selected as a candidate because of the very constrained RSA. Figure 9 shows that the leading edge of the EMAS is very close to the end of Runway 11, only 35 ft away. The placement of the yellow arrows shows only two locations for the EMAS signs: 500 ft before the end of the runway and at the end of the runway. The leading edge of the EMAS is so close to the end of the runway that only one set of signs is necessary.

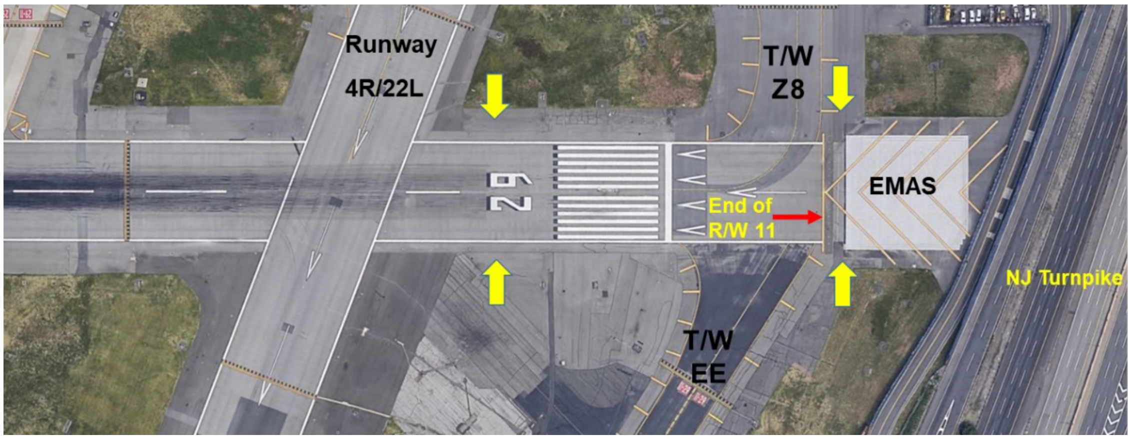

Figure 9. The RSA for Runway 11 at EWR Showing EMAS and EMAS Signage Locations

Figure 10 shows the proximity and angle of the NJ Turnpike, just past the perimeter fencing. The angle of the fencing sets up a geometry that shows more real estate to the left of the runway than the right during a simulated overrun excursion. It is expected that if a test subject elects to veer during an excursion, they will choose the left side because there is more distance prior to encountering the perimeter fencing.

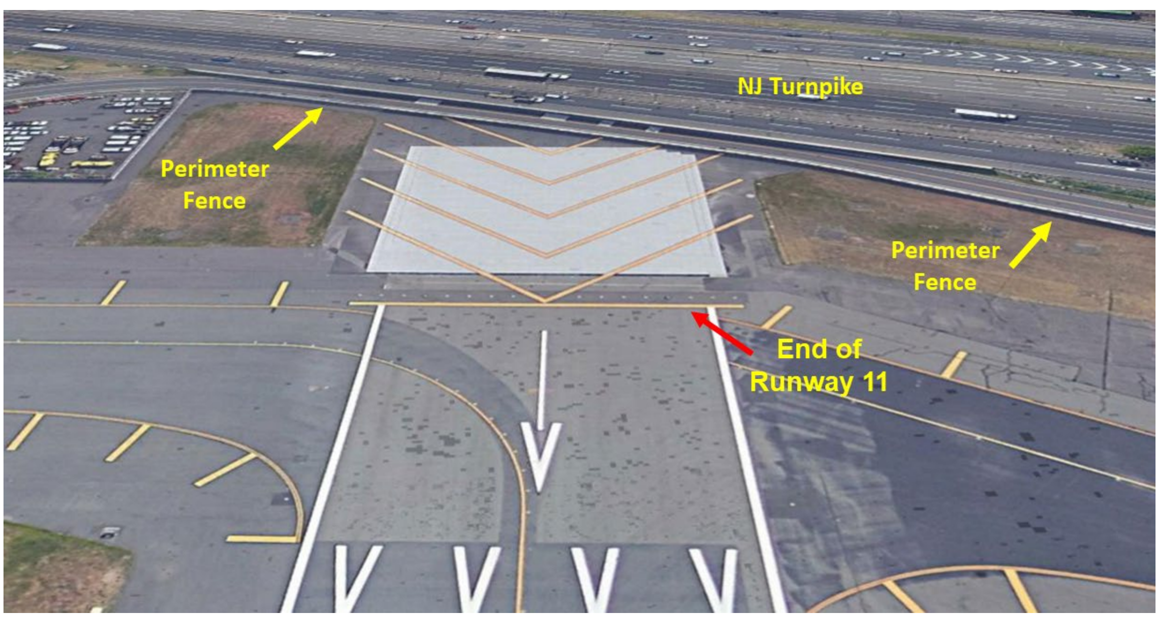

Figure 10. Obstructions in the RSA for Runway 11 at EWR

During the dry run testing phase, FedEx decided that the overrun scenario at EWR Runway 11 was not realistic, since this runway was not of sufficient length to serve the B777 aircraft type modeled by their simulator. Therefore, this runway was ultimately removed from consideration for the sign effectiveness testing. However, one experiment was performed by the test conductor slewing along this runway during the optimal sign location testing. This single outlier is included in the analysis.

3.2.3 San Francisco International Airport

Runway 1R at SFO was selected because of the RSA that is constrained by the presence of a seawall on three sides. The placement of the yellow arrows in Figure 11 shows only two locations, like EWR, for the location of the EMAS signs.

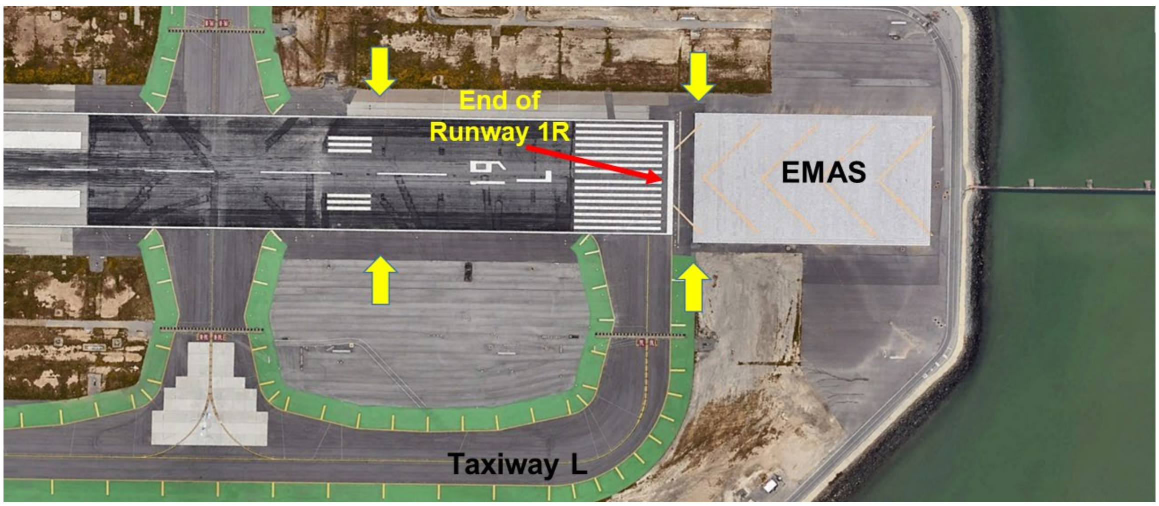

Figure 11. The RSA for Runway 1R at SFO Showing EMAS and EMAS Signage Locations

Figure 12 is an aerial view of the RSA and EMAS serving Runway 1R at SFO Airport. This view shows that the proximity and position of the seawall sets up a geometry that yields more real estate to the right of the runway than the left during a simulated overrun excursion. It is expected that if a test subject elects to veer during an excursion, they will choose the right side because there is more distance prior to encountering the seawall.

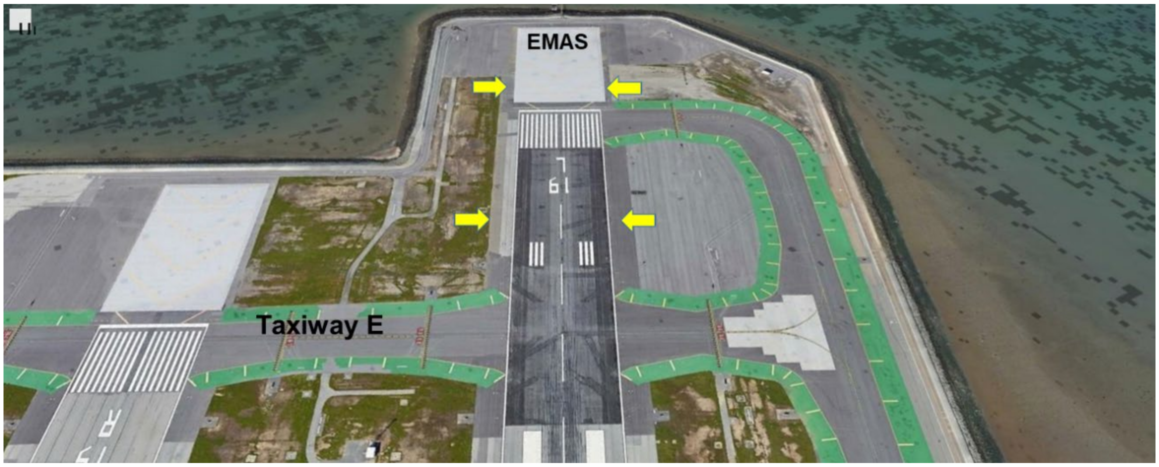

Figure 12. Aerial View of the RSA for Runway 1R at SFO Airport

3.2.4 FedEx Simulator Capabilities

The flight simulator at FedEx is manufactured by Thales Training and Simulation Ltd. The specifications for the simulator are listed below:

- Aircraft model—Boeing 777-306ER
- Simulator host computer—Kontron Industrial PC featuring RACE IV+ Processor boards
- Motion system—Thales—Hydraulic, Synergistic 6 degrees of freedom (DOF), digital, Hybrid eM2K
- Control loading—Digital, hydraulic
- Visual manufacturer—Rockwell Collins
- Image generator—EP8000
- Image type of display—Mirror FOV 200x40, Projectors LCOS JVC VS2200
- Scenery types—Day/Dusk/Dawn/Night

The FedEx simulator was able to render a visual representation of the EMAS signs that would be visible to test subjects. Figure 13 shows a view through the windshield of the FedEx simulator. The EMAS sign is visible just left of center.

Figure 13. View Through the Windshield of the FedEx Flight Simulator

3.2.5 FedEx Test Subject Population

Simulations originally began on June 30, 2021, and, after a COVID-related delay, resumed on April 6, 2022. Test subjects from the Basic Indoctrination (BI) class were asked if they wanted to volunteer. The BI class consists primarily of experienced pilots who are new to FedEx. This process continued until June 1, 2022. The original expectation was that FedEx would provide over 100 test subjects. The procedure for capturing feedback during the testing effort from the FedEx test subjects is detailed in Appendix A.

3.3 FLIGHTSAFETY INTERNATIONAL FLIGHT SIMULATOR

In March 2020, ATR initiated discussions with FlightSafety International (FSI) regarding the use of their flight simulator facilities at Teterboro Airport (TEB) in Teterboro, NJ, to support the EMAS signage project. ATR and FSI concluded that TEB was sufficient to collect the necessary data.

3.3.1 Teterboro Airport

TEB is a general aviation (GA) airport with a high level of business jet activity. The FSI pilot training center is at TEB, and the FSI flight simulator has a high-fidelity visual representation of the airport. Runway 6 at TEB was selected as a candidate for the simulations because of the RSA that is constrained by a major highway just past the end of the EMAS. Figure 14 shows the RSA for Runway 6 at TEB, the EMAS, and the proximity of a major highway (NJ Route 46) just past the end of the EMAS. Like EWR and SFO, there are only two locations for the EMAS signs (indicated by yellow arrows) because the EMAS is set back only 35 ft from the end of the runway.

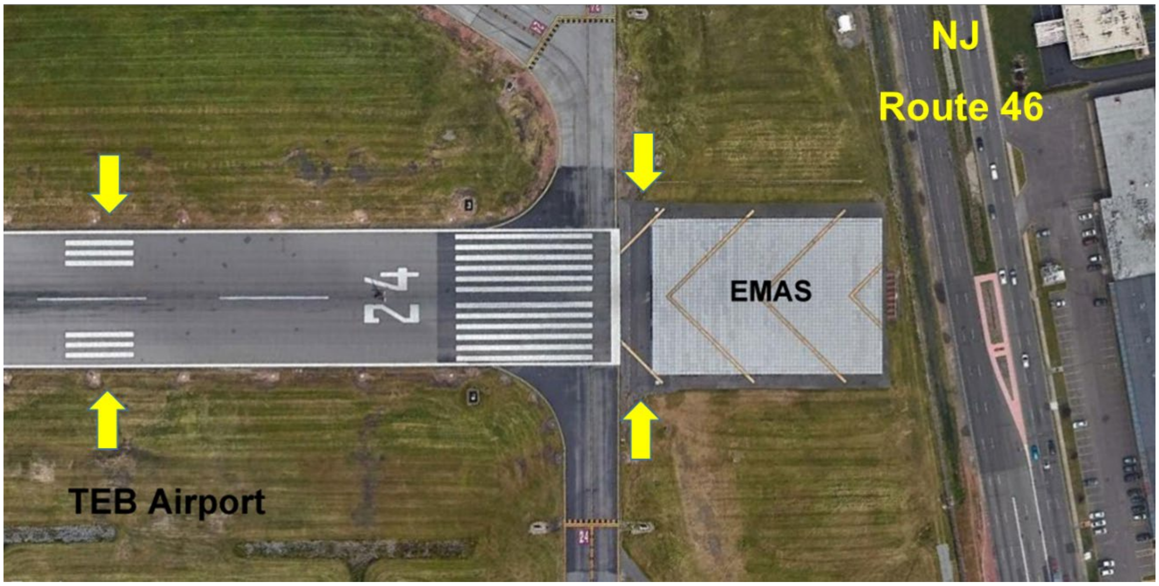

Figure 14. The RSA for Runway 6 at TEB Showing EMAS and Signage Locations

Figure 15 is an aerial view of the RSA and EMAS serving Runway 6 at TEB. This view shows the proximity and position of a highway (NJ Route 46) and perimeter fencing. The angle of the highway/fencing relative to the extended centerline sets up a geometry that appears to yield more real estate to the right of the runway than the left during a simulated overrun excursion. It is expected that if a test subject elects to veer during an excursion, they will choose the right side because there is more distance prior to encountering the perimeter fencing.

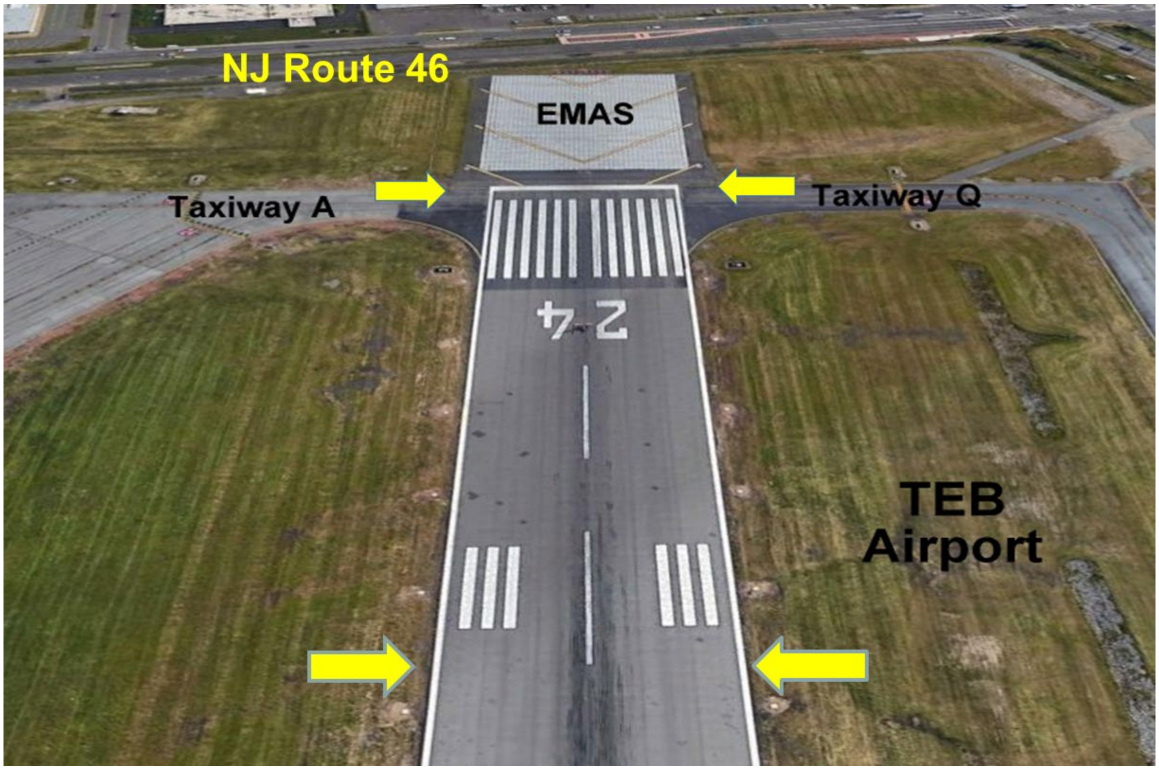

Figure 15. Aerial View of the RSA for Runway 6 at TEB Airport

3.3.2 FSI Simulator Capabilities

The FSI simulator is for a Dassault-Falcon-2000LXS aircraft with the following specifications:

- Garrett TFE731-60
- Pratt & Whitney PW 308C+ engines
- A Vital 1100 visual system with 9.25 glass
- 200° by 40° Field of View

Figure 16 shows a view through the cockpit windshield that includes the EMAS signage and the RSA at the end of Runway 6 at TEB.

Figure 16. View from Inside FSI Simulator Near the End of Runway 6 at TEB

3.3.3 FSI Test Subject Population

FSI agreed to solicit participation from test subjects who use their simulator for flight training and certification. Approximately 70% (corporate and private) operate under Part 91[2] (corporate and private) and approximately 30% operate under Part 135[3] (on demand charter operations). The procedure for capturing feedback during the testing effort from the FSI test subjects is detailed in Appendix B. This process began on February 21, 2022, and continued until September 16, 2022.

4. RESEARCH DESIGN

Two experiments are under consideration at the FedEx and FSI simulator facilities:

- Optimal Sign Location
- Sign Effectiveness

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[2] General Operating and Flight Rules,14 C.F.R. § 91 https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-91?toc=1

[3] Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board Such Aircraft, 14 C.F.R. § 135 (1978) https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-135

The order in which the experiments are conducted impacts the workload associated with reconfiguring the simulator and down-time for test subjects between simulations. There are also impacts to the usefulness of the data from a human factors' perspective. For example, the Sign Effectiveness experiment requires an element of surprise. If the test subject is aware that the exercise is related to EMAS ahead of time, they are then cued to the importance of EMAS and would likely steer straight into the EMAS and not veer to the left or right. For this reason alone, test subjects must experience the overrun scenario before beginning the optimal sign location experiment. As an added benefit, if a test subject experiences an unexpected overrun excursion simulation, they are more likely to be primed about the importance of EMAS signage during subsequent optimal sign location experiments.

4.1 NUMBER OF TEST PARTICIPANTS

FedEx and FSI originally estimated that they could provide at least 100 test subjects each and planned to conduct the EMAS signage simulations at the end of regularly scheduled test subject training sessions. Test subjects selected by FedEx and FSI would participate in the overrun simulation immediately after their regularly scheduled flight training.

FedEx requested that the simulations include the option to use the entire flight crew as the test subjects. This means that the post-simulation survey questionnaire would be presented to the entire crew and that responses would be recorded for each individual member. FSI did not request this option.

Ultimately, FSI was able to provide 30 test subjects, each one acting as the pilot-in-command (PIC) of the aircraft. FedEx was able to provide 102 test subjects, but only 32 were pilots flying the aircraft, with 70 test subjects who were additional crew.

4.2 SIGN EFFECTIVENESS EXPERIMENT

Although the Sign Effectiveness experiment supports the secondary objective, it is discussed here first because this experiment must precede the Optimal Sign Location experiment. Once the test subject is aware that EMAS is the focal point of the experiments, the element of surprise is absent, and the simulation results have little value. There is a significant probability that once the experiments begin, test subjects will share this information with other test subjects (no malice intended), and the element of surprise will be diminished. This conjecture will be supported or refuted during post-simulation surveys early in the experiment.

During the Sign Effectiveness simulation, the unprimed test subject (either a single test subject or a crew) will experience an aircraft overrun excursion and be forced to steer straight at the end of the runway or veer left or right. The hypothesis is that the presence of EMAS signs will reduce the number of veer-offs. The simulators will be configured with only one set of EMAS signs at a time, or with no EMAS signs at all. Test subjects will experience only one overrun scenario. Test subject action (steering straight or veering) will be recorded, and a follow-up survey questionnaire will explore the test subjects' decision-making process to steer straight or veer and the role of EMAS signage.

In the event test subjects gain insight regarding the nature of the experiment, the test instructor will still administer the overrun excursion simulation so long as there is adequate time to complete the Optimal Sign Location experiments at all available airports. The rationale is that even with the loss of surprise, the experience of an overrun excursion will heighten the sensitivity of the test subject to the importance of EMAS and EMAS signage.

4.2.1 FedEx Simulation Configurations

FedEx and ATR agreed to configure their simulator to include all three airports—MEM, EWR, and SFO—for each EMAS sign location under both day and night conditions. This yields the following number of configurations:

- MEM—Eight configurations
  - Three different sign locations
  - No sign
  - Day and night
- EWR—Six configurations
  - Two different sign locations
  - No sign
  - Day and night
- SFO—Six configurations
  - Two different sign locations
  - No sign
  - Day and night

FedEx decided that the overrun scenario at EWR was not realistic, since the length of Runway 11 using EMAS was not of sufficient length to serve the B777 aircraft type modeled by their simulator. Therefore, it was removed from the test scenario configuration list below. Table 1 shows the configurations for the remaining two airports.

Table 1. Possible EMAS Sign Configurations for FedEx

Configuration Number	Airport	Sign Location	Day/Night
1	MEM 18R	500 ft from end	Day
2	MEM 18R	500 ft from end	Night
3	MEM 18R	End of runway	Day
4	MEM 18R	End of runway	Night
5	MEM 18R	At EMAS	Day
6	MEM 18R	At EMAS	Night
7	MEM 18R	No signage	Day
8	MEM 18R	No signage	Night
9	SFO 1R	500 ft from end	Day
10	SFO 1R	500 ft from end	Night
11	SFO 1R	End of runway	Day
12	SFO 1R	End of runway	Night

Configuration Number	Airport	Sign Location	Day/Night
13	SFO 1R	No signage	Day
14	SFO 1R	No signage	Night

To eliminate any bias related to the order in which test subjects experience a simulated overrun, the research team prepared a randomized list of simulation configurations, as shown in Table 2. Each test subject PIC is assigned a unique number with a corresponding configuration. Test subjects who were not flying the aircraft used the PIC identification with a suffix designation (i.e., 001a, 001b, 001c).

Table 2. Randomized Configurations for Sign Effectiveness Experiment at FedEx

Test Subject PIC Identification	Configuration Number for Overrun
001	1
002	12
003	10
004	14
005	9
006	11
007	7
008	3
009	5
010	8
011	13
012	4
013	6
014	2
015	4
016	2

Test Subject PIC Identification	Configuration Number for Overrun
017	5
018	8
019	13
020	7
021	3
022	11
023	9
024	14
025	10
026	1
027	6
028	12
029	6
030	1
031	13
032	5

Because there are 14 different configurations and only 32 test subject PICs , there will only be two simulations for most configurations, and three simulations for configurations 1, 5, 6 , and 13. This small sample size lessens the ability to conduct any rigorous statistical analysis to reject the null hypothesis with any degree of confidence. Consequently, data analysis will record quantitative test subject actions and aggregate test subject responses to the questionnaire.

4.2.2 Simulation Sequencing at FedEx

The first test subject PIC (001) at FedEx was assigned the configuration number 1 from Table 2. This means that the simulator will be configured as shown in Table 2 as follows:

- MEM 18R—EMAS Signs 500 before end of runway–Daytime

The second test subject PIC (002) will be assigned configuration number 12 from Table 2, meaning the simulator will be configured as follows:

- SFO 1R—EMAS signs at end of runway–Nighttime

Once all 14 possible configurations are used once (after test subject PIC 014), they begin to repeat. For example, configuration 4 will be used for the second time on test subject PIC 015. This process is repeated each time all 14 configurations are used, meaning that 12 configurations are each used twice, and four configurations are each used three times.

4.2.3 FSI Simulation Configurations

FSI agreed to configure their simulator for Runway 6 at TEB. This runway has an EMAS and a constrained RSA. As shown in Figure 14, the EMAS is set back only 35 ft from the end of the runway, meaning there are only two EMAS sign locations: 500 ft before the end of the runway and the end of the runway. This yields six different configurations:

- Two different sign locations
- No sign
- Day and night

There are six possible simulator configurations, as shown in Table 3.

Table 3. Randomized Configurations for Sign Effectiveness Experiment at FSI

Configurations for Overrun Scenario			
Configuration Number	Airport	Sign Location	Day/Night
1	TEB 6	500 ft from end	Day
2	TEB 6	500 ft from end	Night
3	TEB 6	End of runway	Day
4	TEB 6	End of runway	Night
5	TEB 6	No signage	Day
6	TEB 6	No signage	Night

To eliminate any bias related to the order in which test subjects experience a simulated overrun, the research team prepared a randomized list of simulation configurations, as shown in Table 4. Each test subject is assigned a unique number with a corresponding configuration.

Table 4. Randomized List of Simulation Configurations for Sign Effectiveness Experiment at FSI

Test Subject Identification	Configuration Number for Overrun		Test Subject Identification	Configuration Number for Overrun
001	1		016	4
002	4		017	5
003	2		018	6
004	6		019	2
005	5		020	1
006	3		021	4
007	4		022	6
008	3		023	5
009	2		024	3
010	6		025	2
011	1		026	3
012	5		027	5
013	2		028	4
014	1		029	1
015	3		030	6

4.2.4 Simulation Sequencing at FSI

As shown in Table 4, the first test subject (001) at FSI is assigned the configuration number 1. This means that the simulator will be configured as shown in Table 3 as follows:

- TEB Runway 6—EMAS signs 500 ft before end of the runway–Daytime

The second test subject (002) is assigned configuration number 4 from Table 3, meaning the simulator will be configured as follows:

- TEB Runway 6—EMAS signs at end of runway–Nighttime

Once all six possible configurations are used once (after test subject 006), they begin to repeat. For example, configuration 4 will be used for the second time on test subject 007. This process is repeated each time all six configurations are used, meaning that each configuration is used five times for the population of 30 test subjects.

4.2.5 Scenario to Force an Overrun Excursion

FSI developed a simulation scenario in which the test conductor causes the test subject to abort the takeoff and force an overrun excursion by jamming the elevator just before V1 at 127 knots. The test subject will have to decide to steer straight or veer left or right at the end of the runway.

FedEx simulation programmers suggested that an engine failure on takeoff just short of V1, along with programmed brake and hydraulic system failures, would create an overrun scenario with no errors on the part of the pilot (i.e., only aircraft failures). A series of test runs were performed at MEM Runway 18R and SFO Runway 1R. It was found that with each pilot flying the simulator, the aircraft consistently reached V1 speed at the same point on each runway. During these test runs the FedEx programmer experimented with a series of aircraft failures to create a situation where the aircraft would reach the EMAS at a speed of 70 knots or less. A partial brake failure and hydraulic failure along with a major engine failure as the aircraft approaches V1 speed was found to produce the desired result. Each runway had a specific set of failures programmed in the scenario to create this event. The EMAS surface was programmed to create 1G[4] deceleration when entered.

4.3 OPTIMAL SIGN LOCATION EXPERIMENT

FedEx and FSI agreed that the Optimal Sign Location experiment would follow the survey questionnaire segment of the Sign Effectiveness experiment. Each test subject (single test subject or crew) was asked to participate in additional simulations immediately following the overrun excursion simulation. They were then briefed on the objective of both experiments and asked to evaluate sign locations that would improve test subject education and awareness about the presence of EMAS during normal operations.

The simulators were configured to show all EMAS sign locations at the same time, and the test subjects could view the EMAS signage as many times as time allows. At the FedEx simulator, test subjects would view the EMAS signage at all three airports when there was adequate time. At a minimum, the test subjects would evaluate sign locations at the airport where the overrun excursion occurred. At the FSI simulator, only TEB Runway 6 signage was available. A post-simulation survey would evaluate test subject knowledge about EMAS and solicit input regarding optimal sign locations.

FSI and FedEx developed a procedure to allow the test conductor to slew the aircraft along the centerline of the runway and provide the test subjects with multiple vantage points of the EMAS signs. This is an important feature because it allows the test subjects adequate time to view the signs in context and to immediately compare the different sign locations. The objective for the test subject is to choose the location that best informs or reminds them about the presence of the EMAS at the end of the runway during normal operations.

5. PLAYBOOKS/CHECKLISTS

FedEx and FSI requested the use of playbooks while conducting the simulations. The playbooks are a simplified version of the simulation procedure. Based on recommendations from FedEx and FSI, the playbooks were streamlined further into a checklist format. The checklist is a step-by-step procedure for use by the test conductor to perform the simulations.

[4] 1G equals 32.2 ft per second per second deceleration.

The checklists include:

- Instructions for each test subject prior to simulation
- Informed consent for each test subject
- Specific instructions to configure the simulator for each test subject in the proper order (per the configuration tables)
- Instructions about initiating the simulations, including specific actions to force an overrun excursion
- Instructions for administering post-simulation survey questionnaires
- Instructions to collect, disseminate, and archive test subject responses
- Four survey questionnaires:

    1. Overrun excursion simulation
    2. Optimal sign location simulation—daytime
    3. Optimal sign location—nighttime
    4. Demographics

5.1 QUESTIONNAIRE 1

Survey Questionnaire 1—Two Pages

Test conductor should record answers.

You (test subject) are now requested to participate in a brief survey about your experience during the overrun excursion simulation. Your performance will not be critiqued or judged in any manner. Your participation is strictly voluntary. No personal information will be collected during this survey, and all answers are strictly confidential and completely anonymous. The results of this survey will be combined with other survey results and analyzed in a summary format to support the safety-focused goal of this research.

Test Subject Number ______ **Configuration Number _______**

1. Did pilot steer straight or veer off at the end of the runway? **Circle one.**

   Steer straight Veer-off left Veer-off right

2. Were you aware that this was an emergency overrun scenario before participating in this experiment? **Circle one.**

   YES NO

   Please note that there is no penalty for having foreknowledge of the experiment. This information merely helps with assessing the responses.

3. Did you know that there was an EMAS bed serving this runway? **Circle one.**

   YES NO

4. Did you know the function of EMAS? **Circle one**.

   YES NO

5. Did you notice the EMAS signage (shown below) during the excursion overrun? **Circle one.**

   YES NO

Page 1

6. If yes, did they influence your decision-making to steer straight or veer off at the end of the runway? **Circle one.**

YES NO

7. If yes, how would you rate how strongly it influenced your decision? **Circle one.**

Little to None Moderate Strong

8. Do you think EMAS signage would be useful during an actual overrun? **Circle one.**

YES NO

9. Do you think EMAS signage would be useful under normal operating conditions? **Circle one.**

YES NO

10. Do you want to share any thoughts about this simulated overrun excursion or your decision-making process to steer straight or veer off at the end of the runway?

END OF QUESTIONNAIRE 1

5.2 QUESTIONNAIRE 2

Survey Questionnaire 2

Daytime Slewing on Runway

Test Subject Number(s) ____ Airport Name ______

1. Please circle the sign location that you believe would be more likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion:

500 ft before the end of runway   At the end of runway   At beginning of EMAS bed

2. Can you suggest a different location for EMAS signage? If so, why is this location better?

3. How effective do you think these signs would be in future normal operations as a reminder that EMAS was present? **Circle one**.

Little to None   Moderate   Strong

Please provide your rationale:

4. How effective do you think these signs would be during an emergency overrun? **Circle one.**

Little to None   Moderate   Strong

Please provide your rationale:

5. Additional comments:

END OF QUESTIONNAIRE 2

5.3 QUESTIONNAIRE 3

Survey Questionnaire 3

Nighttime Slewing on Runway

Test Subject Number(s) ______Airport Name ______

1. Please circle the sign location that you believe would be more likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion:

500-ft before the end of runway   At the end of runway   At beginning of EMAS bed

2. Can you suggest a different location for EMAS signage? If so, why is this location better?

3. How effective do you think these signs would be in future normal operations as a reminder that EMAS was present? **Circle one**.

Little to None   Moderate   Strong

Please provide your rationale:

4. How effective do you think these signs would be during an emergency overrun? **Circle one.**

Little to None   Moderate   Strong

Please provide your rationale:

5. Additional comments:

END OF QUESTIONNAIRE 3

5.4 QUESTIONNAIRE 4

Demographic Survey

Test Subject Number ______

1. What is the usual aircraft type that you fly? ____

2. How many hours do you have on that aircraft type? __________________________________

3. How did you learn about EMAS?

   ____
   ____
   ____
   ____

4. Do you plan differently for airports with EMAS versus airports without EMAS?

   ____
   ____
   ____
   ____

5. What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?

   ____
   ____
   ____
   ____

END OF DEMOGRAPHIC SURVEY

Copies of the entire checklists for FedEx and FSI are included in Appendices A and B, respectively.

6. PROTECTION OF HUMAN RESEARCH SUBJECTS

FAA Order 9500.25A, *Protection of Human Research Subjects*, "establishes standardized policies and procedures for conducting research involving human test subjects" (FAA, 2019). This Order also established an Institutional Review Board (IRB) and an associated set of standard operating procedures (SOPs) to implement the Order. The local IRB at the William J. Hughes Technical Center established a Local IRB SOP to comply with the revised Department of Health and Human Services (DHHS) Common Rule (Federal Policy for the Protection of Human Subjects, 2017), Title 45 Code of Federal Regulations (C.F.R) Part 46 (Protection of Human Subjects [Public Welfare], 2017), Title 49 C.F.R. Part 11 (Protection of Human Subjects [Transportation], 1991), and the FAA Protection of Human Research Subjects, Order 9500.25B (FAA, 2019). These SOPs are based on the procedures developed by the FAA IRB, Civil Aerospace Medical Institute at the Mike Monroney Aeronautical Center in Oklahoma City, OK, to address revisions to the Common Rule (FAA, 2019).

The Local IRB SOP has provisions for the approval process including an Application Form to request either exempt status or expedited review. ATR received an exempt status from the Local IRB for the Optimal Sign Location experiment based on meeting the requirements 49 C.F.R. 11.104 (Exempt Research, 2009), which implements 45 C.F.R. 46 for Department of Transportation agencies. A copy of the Local IRB Research Proposal Notice of Approval to Conduct Research is provided in Appendix C.

6.1 INFORMED CONSENT

The Local IRB SOP provided guidelines for the preparation of Informed Consent documentation. Each test subject is provided an opportunity to review this documentation prior to participation in the simulation experiments. The informed consent documentation is included in the checklists for both FedEx and FSI.

7. DATA ANALYSIS FROM FLIGHT SIMULATION EXERCISES AT FSI

Because of COVID-19 restrictions, flight simulations did not start until February 21, 2022. By March 7, 2022, FSI submitted 11 data sets to the FAA for their use. By September 16, 2022, FSI submitted additional data that included 19 more test subjects.

Tables 5 through 28 provide a summary of test subject responses to the questions in each of the four post survey Questionnaires. The identities of the test subjects cannot be derived from these tables. The data source document for these tables was made available to the FAA for further analysis in a separate document.

7.1.1 Sign Effectiveness Data

Table 5 provides a summary of test subject responses from the Sign Effectiveness overrun excursion simulation.

Table 5. Summary of FSI Data from Sign Effectiveness—Overrun Excursion Simulation

	Question	Count	%
1	*Pilot action at end of runway*		
	Steer straight	30*	100%
	Veer off	0	0%
2	*Aware of experiment?*		
	No	30	100%
	Yes	0	0%
3	*Knowledge of EMAS at end of runway?*		
	No	19	63%
	Yes	11	37%
4	*Know the function of EMAS?*		
	Yes	28	93%
	No	2	7%
5	*Notice the EMAS signs during overrun simulation?*		
	No	30	100%
	Yes	0	0%
6	*Did signage influence decision-making?*		
	Not applicable**	30	100%
7	*Rate the influence of signage on decision-making*		
	Not applicable**	30	100%
8	*Do you think EMAS signage would be useful during an actual overrun?*		
	No	20	67%
	Yes	10	33%
9	*Do you think EMAS signage would be useful under normal operating conditions?*		
	Yes	15	50%
	No	14	47%
	Blank/No response	1	3%
*	Four test subjects did not respond to this question, but eyewitnesses confirmed that all test subject PICs steered straight at the end of the runway.		
**	N/A—If test subject answered "No" to Question 5 (did not see the EMAS signage during the overrun), then the signage could not have an influence on their decision-making. —		

7.1.2 Findings from Sign Effectiveness Simulation

- Thirty test subjects conducted the overrun excursion simulation at TEB Runway 6 and completed Survey Questionnaire 1.

- Table 5 shows that 30 test subjects (100%) "steered straight" at the end of the runway during the overrun excursion simulation. Each test subject was the PIC of the aircraft at the time of the overrun simulation. Four test subjects (13%) did not respond to the question. Primary sources at the simulations have indicated that no test subjects veered off at the end of the runway. Therefore, the PIC decided to steer straight at the end of the runway during all 30 runway overrun excursion simulations.

- All 30 test subjects (100%) indicated that they were not aware of the nature of the experiment before simulations commenced.

- Nineteen test subjects (63%) did not know that there was an EMAS serving Runway 6 at TEB. Conversely, 11 test subjects (37%) did know there was an EMAS at the end of the runway.

- Twenty-eight test subjects (93%) knew the function of EMAS. Conversely, only two test subjects (7%) did not know the function of EMAS. All 11 test subjects who knew about the presence of EMAS also knew its function.

- All 30 test subjects (100%) indicated that they did not see the EMAS signage during the simulated overrun. Note that nine test subjects (30%) experienced a simulation that did not include EMAS signage (i.e., configurations 5 and 6).

- Questions regarding the influence of the EMAS signage (or its strength) are moot if the test subjects did not see the signs during the simulated overrun excursion.

- Twenty test subjects (67%) indicated that EMAS signage would not be useful during an actual overrun excursion. Conversely, 10 test subjects (33%) indicated the signage would be useful during such an event.

- Fifteen test subjects (50%) indicated that EMAS signage would be useful during normal operating conditions; 14 test subjects (47%) indicated the signage would not be useful during normal operations; and one test subject (3%) did not respond.

7.1.3 Optimal Sign Location Data

Immediately after the overrun simulation and completion of Survey Questionnaire 1, test subjects were briefed on the nature of the Sign Effectiveness experiment they just completed. Test subjects were then asked if they would like to participate in a follow-up experiment to help determine the optimal location of EMAS signage.

The flight simulator was then reconfigured to conduct the Optimal Sign Location experiments by displaying all four EMAS signs (two at each location) at the same time, as shown in Figures 14 and 15. In this second experiment, the test subjects were allowed to move the aircraft along Runway 6 at TEB and view the EMAS signage from different perspectives (slewing), during both day and night operations. The intent was to simulate normal taxiing operations and not an emergency overrun situation. The objective of the experiment was to gain pilot and crew input regarding the sign locations that provided optimal pilot education and awareness during normal operating conditions. Test subjects responded to Survey Questionnaires 2 (Daytime Slewing) and

3 (Nighttime Slewing) to document this information. Test subjects also completed Survey Questionnaire 4 to document demographic information.

Table 6 offers a summary of test subject responses to Survey Questionnaire 2 (Daytime) at TEB Runway 6.

Table 6. Summary of FSI Data from Daytime Slewing at TEB Runway 6

Question		Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	500 ft before end of runway	17	57%
	End of runway	11	37%
	Blank/no response or None	2	7%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/no response	10	33%
	Departure end	10	33%
	1,000 ft or more before end of runway	4	13%
	On runway or at EMAS bed	3	10%
	Both locations	1	3%
	End of EMAS	1	3%
	Not applicable*	1	3%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	20	65%
	Strong	6	19%
	Little to none	5	16%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to none	19	63%
	Moderate	8	27%
	Strong	3	10%
*	Responses were not useful for this question, e.g., "EMAS signs ahead."		

7.1.4 Findings from FSI Daytime Slewing at TEB Runway 6

- Thirty test subjects completed Survey Questionnaire 2—Daytime Slewing at TEB 6.
- Twenty-eight test subjects (98%) responded to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*, in the following order:
  - 500 ft before the end of the runway (17 or 57%)
  - End of the runway (11 or 37%)
  - No response (2 or 7%)
- Thirty test subjects responded to Question 2: *How effective do you think these signs would be during an emergency overrun?* as follows:
  - Blank/no response (10, or 33%). This implies that their answer to Question 1 was adequate.
  - Departure end[5] of the runway (10, or 33%)
  - 1,000 ft or more from the end of the runway (4, or 13%)
  - On runway or at EMAS bed (3, or 10%)
  - Both locations (1, or 3%)
  - End of EMAS (1, or 3%)
  - Not applicable (1, or 3%)
- Thirty-one[6] test subjects responded to Question 3: *How effective are EMAS signs during normal operations*? as follows:
  - Moderate (20, or 65%)
  - Strong (6, or 19%)
  - Little to none (5, or 16%
- Thirty test subjects responded to Question 4: *How effective are EMAS signs an emergency overrun*? as follows:
  - Little to none (19, or 63%)
  - Moderate (8, or 27%)
  - Strong (3, or 10%)

Table 7 provides a summary of test subject responses to Survey Questionnaire 3 (Nighttime) at TEB Runway 6.

[5] The FAA defines the departure end of runway as the end of the runway available for the ground run of an aircraft departure.

[6] Two responses to Question 3 were recorded for test subject 007.

Table 7. Summary of FSI Data from Nighttime Slewing at TEB 6

Question		Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	End of runway	14	47%
	500 ft before end of runway	13	43%
	Both	2	7%
	Blank/no response or None	1	3%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/no response	18	60%
	Departure end	8	27%
	Not applicable*	2	7%
	Point of entry on EMAS	1	3%
	1,000 ft or more before end of runway	1	3%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	18	60%
	Little to none	8	27%
	Strong	4	13%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to none	14	47%
	Moderate	10	33%
	Strong	5	17%
	Blank/no response	1	3%
*	Responses were not useful for this question (e.g., "500 ft is confusing")		

7.1.5 Findings from FSI Nighttime Slewing at TEB Runway 6

- Thirty test subjects completed Survey Questionnaire 3—Nighttime Slewing at TEB 6.

- Twenty-nine test subjects (99%) responded to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*, in the following order:

  - End of the runway (14, or 47%)
  - 500 feet before the end of the runway (13, or 43%)
  - Both (2, or 7%)
  - No response (1, or 3%)

- Thirty test subjects responded to Question 2: *Can you suggest a different location for EMAS signage*? as follows:

  - Blank/no response (18, or 60%). This implies that their answer to Question 1 was adequate.

- Departure end of the runway (8, or 27%)
- Not applicable (2, or 7%)
- 1,000 feet or more from the end of the runway (1, or 3%)
- On EMAS entry point (1, or 3%)

- Thirty test subjects responded to Question 3: *How effective are EMAS signs during normal operations*? as follows:

  - Moderate (18, or 60%)
  - Little to none (8, or 27%)
  - Strong (4, or 13%)

- Thirty test subjects responded to Question 4: *How effective are EMAS signs an emergency overrun*? as follows:

  - Little to none (14, or 47%)
  - Moderate (10, or 33%)
  - Strong (5, or 17%)
  - Blank/no response (1, or 3%)

7.1.6 Aggregate Data from FSI Slewing at TEB Runway 6

The previous tables provided a summary of test subject data separately by time of day. Table 8 aggregates subject test data for both daytime and nighttime slewing simulations at TEB Runway 6.

Table 8. Aggregate of FSI Data from Slewing at TEB 6

Question		Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	500 ft before end of runway	30	50%
	End of runway	25	42%
	Blank/no response or None	3	5%
	Both	2	3%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/no response	28	47%
	Departure end	18	30%
	1,000 or more before end of runway	5	8%
	On runway or at EMAS bed	4	7%
	Not applicable*	3	5%
	Both locations	1	2%
	End of EMAS	1	2%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	38	62%
	Little to none	13	21%

	Question	Count	%
	Strong	10	16%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to none	33	55%
	Moderate	18	30%
	Strong	8	13%
	Blank	1	2%
*	Responses were not useful for this question (e.g., "500 ft is confusing")		

7.1.7 Findings from Aggregate Data—FSI Slewing at TEB Runway 6

- Thirty test subjects completed Survey Questionnaire 2—Slewing at TEB 6.
- The combination of day and night data yielded 60 responses to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion,* in the following order:
  - 500 ft before the end of the runway (30, or 50%)
  - End of the runway (25, or 42%)
  - Blank (3, or 5%)
  - Both locations (2, or 3%)
- The combination of day and night data yielded 60 responses to Question 2: *How effective do you think these signs would be during an emergency overrun?* in the following order:
  - Blank/no response (28, or 47%). This implies that their answer to Question 1 was adequate.
  - Departure end of the runway (18, or 30%)
  - 1,000 ft or more from the end of the runway (5, or 8%)
  - On runway or EMAS bed (4, or 7%)
  - Not applicable (3, or 5%)
  - Both locations (1, or 2%)
  - End of EMAS (1, or 2%)
- The combination of day and night data yielded 61 responses to Question 3: *How effective are EMAS signs during normal operations*?
  - Moderate (38, or 62%)
  - Little to none (13, or 21%
  - Strong (10, or 16%)
- The combination of day and night data yielded 60 responses to Question 4, *How effective are EMAS signs an emergency overrun*?
  - Little to none (33, or 55%)
  - Moderate (18, or 30%)
  - Strong (8, or 13%)

- Blank/no response (1, or 2%)

7.1.8 Demographic Data from FSI Test Subjects

All test subjects were asked to complete Questionnaire 4—Demographics, which included the following five questions:

1. What is the usual aircraft type that you fly?

2. How many hours do you have on that aircraft type?

3. How did you learn about EMAS?

4. Do you plan differently for airports with EMAS versus airports without EMAS?

5. What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?

While informative to some degree, Questions 1 and 2 do not add substantial insight regarding pilot decision-making. Responses to Questions 3, 4, and 5 provide researchers with some insight regarding prior pilot knowledge about EMAS and a means to improve that knowledge base.

Table 9. How Did FSI Test Subjects Learn About EMAS

How did you learn about EMAS?	**Count**	**%**
Training/School/Safety Officer	7	23%
FlightSafety International/Experience/Peers	6	20%
Previous overrun accident	5	17%
Don't remember	5	17%
FAA documents/reading	4	13%
This exercise	1	3%
Blank	1	3%
Unreadable	1	3%

Table 10. How Do FSI Pilots Plan for EMAS

Do you plan differently for airports with EMAS versus airports without EMAS?	**Count**	**%**
No	28	93%
Yes	1	3%
Blank or Not Applicable	1	3%

Table 11. Preflight Planning for FSI Pilots

What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?	**Count**	**%**
Jeppesen 10-9 chart/Airfield or airport chart	21	70%
None	4	13%
Blank/No response	2	7%
Taxi charts	1	3%
Notices to Air Missions (NOTAMs)	1	3%
Foreflight	1	3%

7.1.9 Findings from FSI Demographic Data

- FSI pilots learned about EMAS from a wide variety of sources:
  - Training, school, or safety officer (7, or 23%)
  - Flight Safety International/experience/peers (6, or 20%)
  - Previous overrun accidents[7] (5, or 17%)
  - Don't remember (5, or 17%)
  - FAA documents/reading (4, or 13%)
  - This exercise (1, or 3%)
  - Blank (1, or 3%)
  - Unreadable (1, or 3%)
- Most FSI test subjects (28, or 93%) indicated that they do not plan differently for airports with EMAS versus airports without EMAS; only one test subject (1%) plans differently; and one other (1%) did not respond.
- Most FSI test subjects (21, or 70%) indicated that they use the Jeppesen 10-9 Airport Page or an airfield/airport chart for preflight planning regarding surface information like EMAS at airport destination.
  - Six test subjects (7%) either did not respond or do not use preflight documentation.
  - The three remaining test subjects (10%) use either taxi charts, NOTAMs, or Foreflight (a commercial aviation application) for preflight planning.

8. DATA ANALYSIS FROM FLIGHT SIMULATION EXERCISES AT FEDEX

Flight simulation exercises at FedEx began on June 30, 2021. FedEx delivered the complete set of test subject data to the FAA on June 1, 2022.

The tables that follow provide a summary of test subject responses to the questions in each of the four survey questionnaires. The identity of the test subjects cannot be derived from these tables.

[7] Test subjects did not mention if they were involved in these accidents.

The data source document for these tables was made available to the FAA for further analysis in a separate document.

8.1 SIGN EFFECTIVENESS DATA

Table 12 provides a summary of test subject responses from the Sign Effectiveness overrun excursion simulation.

Table 12. Summary of FedEx Data from Sign Effectiveness—Overrun Excursion Simulation

	Questionnaire 1	**Count**	**%**
1	*Pilot action at end of runway*		
	Steer straight	32	100%
	Veer off	0	0%
2	*Aware of experiment?*		
	No	95	93%
	Yes	7	7%
3	*Knowledge of EMAS at end of runway?*		
	No	89	87%
	Yes	13	13%
4	*Know the function of EMAS?*		
	Yes	90	88%
	No	12	12%
5	*Notice the EMAS signs during overrun simulation?*		
	No	79	77%
	Yes	23	23%
6	*Did signage influence decision-making?*		
	Not applicable*	83	81%
	No	14	14%
	Yes	5	5%
7	*Rate the influence of signage on decision-making*		
	Not applicable*	94	92%
	Blank/No response	3	3%
	Strong	2	2%
	Moderate	2	2%
	Little to none	1	1%
8	*Do you think EMAS signage would be useful during an actual overrun?*		
	Yes	81	79%
	No	21	21%
9	*Do you think EMAS signage would be useful under normal operating conditions?*		
	Yes	74	73%

Questionnaire 1		Count	%
	No	27	26%
	Blank/No response	1	1%
*	N/A—If test subject answered "No" to Question 5 (did not see the EMAS signage during the overrun), then the signage could not have an influence on their decision-making; or test subject was not flying the aircraft and was not part of decision-making process.		

8.1.1 Findings from Sign Effectiveness Simulation

- One hundred and two test subjects conducted the overrun excursion simulation and completed Survey Questionnaire 1. Sixty-three test subjects (62%) conducted the simulation at MEM Runway 18R, and 39 test subjects (38%) conducted the simulation at SFO Runway 1R.

- Table 12 shows that the PIC decided to steer straight at the end of the runway during all 32 runway overrun excursion simulations. This figure must be considered alongside the fact that only the PIC of the aircraft at the time of the overrun decided to steer straight. The balance of the crew (70 test subjects) was not in control of the aircraft and their responses were not factored into this result.

- Ninety-five test subjects (93%) were not aware of the nature of the experiment. Of the seven test subjects (7%) that indicated they knew about the experiment, only three were the PIC of the aircraft during the overrun simulation.

- Only 13 of the 62 test subjects (13%) knew that there was an EMAS serving either Runway 18R at MEM (eight test subjects) or Runway1R at SFO (five test subjects). Conversely, 89 test subjects (87%) did not know there was an EMAS serving either runway (i.e., 54 test subjects at MEM and 35 test subjects at SFO).

- Ninety test subjects (88%) knew the function of EMAS. Conversely, 12 test subjects (12%) did not know the function of EMAS.

- Seventy-nine test subjects (77%) responded that they did not see the EMAS signs during the simulated overrun excursion. The 23 subjects (23%) who did see the EMAS signage were almost evenly split between MEM (10) and SFO (13), and only seven (7%) of these were the PIC. One subject at MEM indicated they saw the signs under *Configuration 7—No signage/Daytime*. Three subjects at SFO indicated they saw the signs under *Configuration 13—No signage/Daytime*. These additional four test subjects bring the total number of test subjects that did not see the sign to 83.

- For 83 (79 at MEM and 4 at SFO) test subjects (81%), the question regarding the influence of EMAS signage on decision-making was not applicable. If the test subjects did not see the EMAS signage, the signs could not influence their decision-making.

- All 14 test subjects (14%) who stated that the EMAS signs did not have an influence on their decision-making also recorded that they did see the EMAS signage during the overrun simulation.

- All five test subjects (5%) who stated that the EMAS signs did have an influence on their decision-making also recorded that they saw the EMAS signage during the overrun simulation. However, two of these subjects at SFO indicated they saw EMAS signage under *Configuration 13—No signage/Daytime*.

    - None of the five test subjects was the PIC of the aircraft.

- Most test subjects (94, or 92%) did not see the sign or answered no. Only five test subjects (5%) qualified how strongly the EMAS signage influenced their decision-making. None of these were the PIC during the simulated overrun.

  - Two test subjects (2%) indicated a "Strong" influence.
  - Two test subjects (2%) indicated that the signs had a "Moderate" influence.
  - One test subject (1%) indicated that EMAS signage had "Little-to-none" influence.
  - Three test subjects (3%) did not respond.

- Eighty-one test subjects (79%) indicated that EMAS signage would be useful during an actual overrun excursion; 21 test subjects (21%) indicated the signage would not be useful during such an event.

- Seventy-four test subjects (73%) indicated that EMAS signage would be useful during normal operating conditions; 27 test subjects (26%) indicated the signage would not be useful during normal operations; and one test subject (1%) did not respond.

8.2 OPTIMAL SIGN LOCATION DATA

Immediately after the overrun simulation and completion of the Survey Questionnaire 1, test subjects were thanked for their participation and then briefed on the nature of the Sign Effectiveness experiment they just completed. Test subjects were then asked if they would like to participate in a follow-up experiment to help determine the optimal location of EMAS signage.

The flight simulator was then reconfigured to conduct the Optimal Sign Location experiments at either MEM or SFO, depending on where the overrun simulation occurred. At MEM, the simulator was configured to display all six EMAS signs (two at each of the three locations along Runway 18R) at the same time, as was shown in Figure 7. At SFO, the simulator was configured to show all four EMAS signs (two each at both locations along Runway 1R) at the same time as shown in Figure 11.

The test subjects were allowed to move the aircraft along Runway 18R or Runway 1R and view the EMAS signage from different perspectives (slewing), during both day and night operations. The intent was to simulate normal taxiing operations and not an emergency overrun situation. The objective of the experiment was to gain pilot and crew input regarding the sign locations that provided optimal pilot education and awareness during normal operating conditions. Test subject responses to Survey Questionnaires 2 (daytime slewing) and 3 (nighttime slewing) document this information. Test subjects also completed Survey Questionnaire 4 to document demographic information.

The original intent, if time allowed, was to let the test subjects conduct the Optimal Sign Location experiment at all three airports (MEM, SFO, and EWR). Time constraints during the simulations dictated that test subjects conducted the Optimal Sign Location experiment primarily at the airport where they conducted the Sign Effectiveness experiment.

8.2.1 Daytime Slewing at MEM

Table 13 provides a summary of test subject responses to Survey Questionnaire 2 from simulations at MEM Runway 18R during daytime.

Table 13. Summary of FedEx Data from Daytime Slewing at MEM Runway 18R

Questionnaire 2		Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	500 ft before end of runway	19	31%
	End of runway	19	31%
	Beginning of EMAS	14	23%
	500 ft before end of runway; beginning of EMAS	3	5%
	End of runway; beginning of EMAS	2	3%
	500 ft before end of runway; end of runway	2	3%
	Blank/No response or none	2	3%
	All three locations	1	2%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/No response	26	39%
	1,000 ft or more before end of runway	8	12%
	Centered on end of runway or beginning of EMAS bed	8	11%
	Departure end	6	9%
	Different color	6	9%
	Painted on runway or EMAS bed	4	6%
	Not applicable*	3	5%
	Multiple locations	2	3%
	End of EMAS	1	2%
	With distance-to-go markers	1	2%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	29	47%
	Little to none	21	34%
	Strong	12	19%
4	*How effective do you think these signs would be during an emergency overrun?*		

Questionnaire 2		Count	%
	Little to None	26	42%
	Strong	19	31%
	Moderate	17	27%
*	Responses were not useful for this question (e.g., "Use Jeppesen charts")		

8.2.2 Findings from Daytime Slewing at MEM

- Sixty-two test subjects completed Survey Questionnaire 2—Daytime Slewing at MEM 18R.

- Fifty-two test subjects (84%) responded to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*, with a single selection:

  - 500 ft before the end of the runway (19, or 31%)
  - End of the runway (19, or 31%)
  - Beginning of EMAS bed (14, or 23%)
  - Eight test subjects (13%) responded with multiple locations
  - Two test subjects (3%) did not respond

- Some of the 62 test subjects provided multiple responses to Question 2: *Can you suggest a different location for EMAS signage?* yielding 65 responses.

  - Blank/No response (26, or 39%). This implies that their answer to Question 1 was adequate.
  - 1,000 ft or more from the end of the runway (8, or 12%)
  - Centered on the end of the runway or beginning of EMAS bed (8, or 12%)
  - Departure end of the runway (6, or 9%)
  - Different color EMAS signage (6, or 9%)
  - Painted on runway or EMAS bed (4, or 6%)
  - Miscellaneous (8, or 12%)

- Sixty-two test subjects responded as follows to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*

  - Moderate (29, or 47%)
  - Little to none (21, or 34%)
  - Strong (12, or 19%)

- Sixty-two test subjects responded as follows to Question 4: *How effective are EMAS signs an emergency overrun*?

  - Little to none (26, or 42%)
  - Strong (19, or 31%)
  - Moderate (17, or 27%)

8.2.3 Outlier Data Point from EWR

- One test subject switched to the EWR Runway 11 simulation scenario and completed Survey Questionnaire 2—Daytime Slewing at EWR. Note that the EMAS bed is set back only 35 ft from the end of the runway, so one set of signs will suffice for both locations.
  - Question 1—*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*.
    - Beginning of EMAS bed/end of runway
  - Question 2—*Can you suggest a different location for EMAS signage*?
    - No response
  - Question 3—*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?
    - Little to none
  - Question 4—*How effective do you think these signs would be during an emergency overrun*?
    - Little to none

8.2.4 Nighttime Slewing at MEM

Table 14 provides a summary of test subject responses to Survey Questionnaire 3 from simulations at MEM Runway 18R during nighttime.

Table 14. Summary of FedEx Data from Nighttime Slewing at MEM Runway 18R

	Questionnaire 3	**Count**	**%**
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	500-ft before end of runway	21	34%
	End of runway	17	28%
	Beginning of EMAS	12	20%
	End of runway; beginning of EMAS	3	5%
	500-ft before end of runway; End of runway	2	3%
	Blank/No response or None	3	5%
	500-ft before end of runway; beginning of EMAS	2	3%
	All three locations	1	2%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/No response	26	41%
	1,000 ft or more before end of eunway	11	17%
	Centered on end of runway or beginning of EMAS bed	6	9%

Questionnaire 3		Count	%
	Departure end	5	8%
	Not applicable*	4	6%
	Different color	3	5%
	Multiple locations	3	5%
	Painted on EMAS or runway	2	3%
	End of EMAS	2	3%
	500 ft before end of runway	1	2%
	With distance-to-go markers	1	2%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	26	43%
	Little to none	22	36%
	Strong	12	20%
	Blank	1	2%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to none	24	40%
	Strong	18	30%
	Moderate	18	30%
	Blank	1	2%
*	Responses were not useful for this question (e.g., "Use Jeppesen charts")		

8.2.5 Findings from Nighttime Slewing at MEM

- Sixty-one test subjects completed Survey Questionnaire 3—Nighttime Slewing at MEM 18R. One test subject switched to SFO for the nighttime slewing.

- Fifty test subjects (82%) responded to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*, with a single selection:

  - 500 ft before the end of the runway (21, or 34%)
  - End of the Runway (17, or 28%)
  - Beginning of EMAS bed (12, or 20%)
  - Eight test subjects (13%) responded with multiple locations.
  - Three test subjects (5%) did not respond.

- Some of the 61 test subjects provided multiple responses to Question 2: *Can you suggest a different location for EMAS signage?* yielding 64 responses.

  - No response (26, or 41%). This implies that their answer to Question 1 was adequate.
  - 1,000 ft or more from the end of the runway (11, or 17%)
  - Centered on the end of the runway or beginning of EMAS bed (6, or 9%)
  - Departure end of the runway (5, or 8%)
  - Miscellaneous or not applicable (4, or 7%%)

- Multiple locations (3, or 5%)
- Different color EMAS signage (3, or 5%)
- Painted on Runway or EMAS bed (2, or 3%)

- Sixty-one test subjects responded as follows to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*

    - Moderate (26, or 43%)
    - Little to none (22, or 36%
    - Strong (12, or 20%)
    - Blank/No response (1, or 2%)

- Sixty-one test subjects responded as follows to Question 4: *How effective are EMAS signs an emergency overrun*?

    - Little to none (24, or 40%)
    - Strong (18, or 30%)
    - Moderate (18, or 30%)
    - Blank/No response (1, or 2%)

8.2.6 Daytime Slewing at SFO

Table 15 provides a summary of test subject responses to Survey Questionnaire 2 from daytime simulations at SFO 1R.

Table 15. Summary of FedEx Data from Daytime Slewing at SFO Runway 1R

Question		Count	%
1	*Most Informative Sign Location*		
	End of runway/Beginning of EMAS*	21	54%
	500-ft before end of runway	13	33%
	Both locations	4	10%
	Blank/No response or None	1	3%
2	*Alternative (Subject Preferred) Sign Location*		
	Departure end	9	23%
	No or Blank/No response	8	21%
	Painted on runway or EMAS bed	7	18%
	1,000 ft or more before end of runway	5	13%
	Centered on end of runway of beginning of EMAS bed	4	10%
	Not applicable**	3	8%
	Different color	2	5%
	Arrow point forward	1	3%
3	*How Effective Are Signs During Normal Operations?*		
	Moderate	19	49%
	Little to None	10	26%
	Strong	9	23%
	Blank	1	3%

Question		Count	%
4	*How Effective Are Signs During an Emergency Overrun?*		
	Moderate	17	44%
	Strong	12	31%
	Little to None	8	21%
	Blank	2	5%
*	For SFO—Beginning of EMAS is only 35 ft from end of runway, so one set of signs sufficed for both locations.		
**	Responses were not useful for this question (e.g., "Use Aeronautical Information Manual")		

8.2.7 Findings from Daytime Slewing at SFO

- Thirty-nine test subjects completed Survey Questionnaire 2—Daytime Slewing at SFO 1R. Note that the EMAS bed is set back only 35 ft from the end of the runway, so one set of signs will suffice for both locations.

- Thirty-four test subjects (87%) responded to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*, with a single selection:

  - End of runway/Beginning of EMAS (21, or 54%)
  - 500 ft before the end of the runway (13, or 33%)
  - Four test subjects (10%) selected both locations
  - One test subject (3%) did not respond

- Thirty-nine test subjects responded to Question 2: *Can you suggest a different location for EMAS signage*?

  - Departure end of the runway (9, or 23%)
  - Blank/No response (8, or 21%). This implies that their answer to Question 1 was adequate.
  - Painted on Runway or EMAS bed (7, or 18%)
  - 1,000 ft or more from the end of the runway (5, or 13%)
  - Centered on the end of the runway or beginning of EMAS bed (4% or 10%)
  - Not applicable (3, or 8%)
  - Different color EMAS signage (2, or 5%)
  - Arrow pointing forward (1, or 2%)

- Thirty-nine test subjects responded to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?

  - Moderate (19, or 49%)
  - Little to none (10, or 26%
  - Strong (9, or 23%)
  - Blank/No response (1, or 3%)

- Thirty-nine test subjects responded to Question 4: *How effective are EMAS signs an emergency overrun*?

  - Moderate (17, or 44%)
  - Strong (12, or 31%)
  - Little to none (8, or 21%)
  - Blank/No response (2, or 5%)

8.2.8 Nighttime Slewing at SFO

Table 16 provides a summary of test subject responses to Survey Questionnaire 2 from nighttime simulations at SFO 1R.

Table 16. Summary of FedEx Data from Nighttime Slewing at SFO Runway 1R

Question		Count	%
1	*Most Informative Sign Location*		
	End of runway/Beginning of EMAS*	22	54%
	500-ft before end of runway	14	34%
	Blank/No response or None	3	7%
	Both locations	2	5%
2	*Alternative (Subject Preferred) Sign Location*		
	No or Blank/No response	14	34%
	Departure end	7	17%
	1,000 ft or more before end of runway	5	12%
	Centered on end of runway or beginning of EMAS bed	5	12%
	Not applicable**	4	10%
	Painted on runway or EMAS bed	3	7%
	Different color	2	5%
	Arrow point forward	1	2%
3	*How Effective Are Signs During Normal Operations?*		
	Moderate	21	51%
	Strong	10	24%
	Little to None	8	20%
	Blank	2	5%
4	*How Effective Are Signs During an Emergency Overrun?*		
	Moderate	15	37%
	Strong	14	34%
	Little to None	10	24%
	Blank	2	5%
*	For SFO—Beginning of EMAS is only 35 ft from end of runway, so one set of signs sufficed for both locations.		
**	Responses were not useful for this question (e.g., "Use Aeronautical Information Manual")		

8.2.9 Findings from Nighttime Slewing at SFO

- Forty-one test subjects completed Survey Questionnaire 3—Nighttime Slewing at SFO 1R. Note that the EMAS bed is set back only 35 ft from the end of the runway, so one set of signs will suffice for both locations.

- Thirty-six test subjects (88%) responded to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*, with a single selection:

  - End of runway/Beginning of EMAS (22, or 54%)
  - 500 ft before the end of the runway (14, or 34%)
  - 3 test subjects (7%) did not respond
  - 2 test subjects (7%) selected both locations

- Forty-one test subjects responded to Question 2: *Can you suggest a different location for EMAS signage*?

  - Blank or No response (14, or 34%). This implies that their answer to Question 1 was adequate.
  - Departure end of the runway (7, or 17%)
  - 1,000 ft or more from the end of the runway (5, or 12%)
  - Centered on the end of the runway or beginning of EMAS bed (5, or 12%)
  - Miscellaneous or not applicable (4, or 10%)
  - Painted on Runway or EMAS bed (3, or 7%)
  - Different color EMAS signage (2, or 5%)
  - Arrow pointing forward (1, or 3%)

- Forty-one test subjects responded to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?

  - Moderate (21, or 51%)
  - Little to none (10, or 24%
  - Strong (8, or 20%)
  - No response (2, or 5%)

- Forty-one test subjects responded to Question 4: *How effective are EMAS signs an emergency overrun*? as follows:

  - Moderate (15, or 37%)
  - Strong (14, or 34%)
  - Little to none (10, or 24%)
  - No response (2, or 5%)

8.2.10 Aggregate Data from Slewing at MEM

Table 17 provides an aggregate of subject test data for MEM 18R by combining responses from both daytime and nighttime slewing simulations.

Table 17. Aggregate of FedEx Data from Slewing at MEM 18R

	Question	Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	500-ft before end of runway	40	33%
	End of runway	36	29%
	Beginning of EMAS	26	21%
	End of runway; Beginning of EMAS	5	4%
	500-ft before end of runway; Beginning of EMAS	5	4%
	500-ft before end of runway; End of runway	4	3%
	Blank/No response or None	5	4%
	All three locations	2	2%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/No response	52	40%
	1,000 ft or more before end of runway	19	15%
	Centered on end of runway or beginning of EMAS bed	14	11%
	Departure end	11	9%
	Different color	9	7%
	Painted on runway or EMAS bed	6	5%
	Not applicable*	7	5%
	Multiple locations	5	4%
	End of EMAS	3	2%
	With distance-to-go markers	2	2%
	500 ft before end of runway	1	1%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	55	45%
	Little to None	43	35%
	Strong	24	20%
	Blank	1	1%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to None	50	41%
	Strong	37	30%
	Moderate	35	28%
	Blank/No response	1	1%
*	Responses were not useful for this question (e.g., “Use Jeppesen charts”)		

8.2.11 Findings from Aggregate Slewing Data at MEM

- Sixty-two test subjects completed Survey Questionnaire 2 (Daytime) and 61 test subjects completed Questionnaire 3 (Nighttime)—Slewing at MEM 18R.

- The combination of day and night data yielded 123 responses to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*. Most (102, or 83%) provided a single selection:

  - 500 ft before the end of the runway (40, or 33%)
  - End of the Runway (36, or 29%)
  - Beginning of EMAS bed (26, or 21%)
  - 16 responses (11%) included multiple locations
  - Five responses (4%) were blank

- Some of the 123 test subjects provided multiple responses to Question 2: *How effective do you think these signs would be during an emergency overrun*? yielding 129 responses.

  - Blank/No response (52, or 40%). This implies that their answer to Question 1 was adequate.
  - 1,000 ft or more from the end of the runway (19, or 15%)
  - Centered on the end of the runway or beginning of EMAS bed (14, or 11%)
  - Departure end of the runway (11, or 9%)
  - Different color EMAS signage (9, or 7%)
  - Painted on Runway or EMAS bed (6, or 5%)
  - Not Applicable (7, or 5%)
  - Multiple locations (5, or 4%)
  - End of EMAS (3, or 2%)
  - Miscellaneous (3, or 2%)

- The combination of day and night data yielded 123 responses to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?

  - Moderate (55, or 45%)
  - Little to none (43, or 35%
  - Strong (24, or 20%)
  - Blank/No response (1, or 1%)

- The combination of day and night data yielded 123 responses to Question 4: *How effective are EMAS signs an emergency overrun*?

  - Little to none (50, or 41%)
  - Strong (37, or 30%)
  - Moderate (35, or 28%)
  - Blank/No response (1, or 1%)

8.2.12 Aggregate Data from Slewing at SFO

Table 18 provides an aggregate of subject test data for SFO 1R by combining responses from both daytime and nighttime slewing simulations.

Table 18. Aggregate of FedEx Data from Slewing at SFO 1R

Question		Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	End of runway; beginning of EMAS	43	54%
	500-ft before end of runway	27	34%
	Both locations	6	8%
	Blank/No response or None	4	5%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/No response	22	28%
	Departure end	16	20%
	Painted on runway or EMAS bed	10	13%
	1,000 ft or more before end of runway	10	13%
	Centered on end of runway of beginning of EMAS bed	9	11%
	Not applicable*	7	9%
	Different color	4	5%
	Arrow point forward	2	3%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	40	50%
	Strong	19	24%
	Little to None	18	23%
	Blank/No response	3	4%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Moderate	32	40%
	Strong	26	33%
	Little to None	18	23%
	Blank	4	5%
*	Responses were not useful for this question (e.g., "Use Jeppesen charts")		

8.2.13 Findings from Aggregate Slewing at SFO

- Thirty-nine test subjects completed Survey Questionnaire 2 (Daytime) and 41 test subjects completed Questionnaire 3 (Nighttime)—Slewing at SFO 1R. Note that the EMAS bed is set back only 35 ft from the end of the runway, so one set of signs will suffice for both locations.

- The combination of day and night data yielded 80 responses to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*. Most (70, or 88%) provided a single selection:

  - End of runway/Beginning of EMAS (43, or 54%)
  - 500 ft before the end of the runway (27, or 34%)
  - Six test subjects (8%) selected both locations

- Four test subject (5%) did not respond

- The combination of day and night data yielded 80 responses to Question 2: *How effective do you think these signs would be during an emergency overrun*?

  - Blank/No response (22, or 28%). This implies that their answer to Question 1 was adequate.
  - Departure end of the runway (16, or 20%)
  - Painted on runway or EMAS bed (10, or 13%)
  - 1,000 ft or more from the end of the runway (10, or 13%)
  - Centered on the end of the runway or beginning of EMAS bed (9, or 11%)
  - Not applicable (7, or 9%)
  - Different color EMAS signage (4, or 5%)
  - Arrow point forward (2, or 3%)

- The combination of day and night data yielded 80 responses to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?

  - Moderate (40, or 50%)
  - Strong (19, or 24%)
  - Little to none (18, or 23%)
  - Blank (3, or 4%)

- The combination of day and night data yielded 80 responses to Question 4: *How effective are EMAS signs an emergency overrun*?

  - Moderate (32, or 40%)
  - Strong (26, or 33%)
  - Little to none (18, or 23%)
  - Blank/No response (4, or 5%)

8.2.14 Aggregate Data for All FedEx Simulations

Table 19 provides an aggregate of subject test data responses from both MEM and SFO under both daytime and nighttime simulations.

Table 19. Aggregate of Data from All FedEx Slewing

	Question	**Count**	**%**
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	End of runway/Beginning of EMAS	105	52%
	500-ft before end of runway	67	33%
	Both locations	22	11%
	Blank/No response or None	9	4%
2	*Can you suggest a different location for EMAS signage?*		

	Question	Count	%
	No or Blank/No response	74	35%
	1,000 ft or more before end of runway	29	14%
	Departure end	27	13%
	Centered on end of runway or beginning of EMAS bed	23	11%
	Painted on runway or EMAS bed	16	8%
	Not applicable*	14	7%
	Different color	13	6%
	Multiple locations	5	2%
	End of EMAS	3	1%
	With distance-to-go markers	2	1%
	Arrow point forward	2	1%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	95	47%
	Little to None	61	30%
	Strong	43	21%
	Blank	4	2%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to None	68	33%
	Moderate	67	33%
	Strong	63	31%
	Blank	5	2%
*	Responses were not useful for this question (e.g., "Use Jeppesen charts")		

8.2.15 Findings for All Slewing Simulations at FedEx

- One hundred and two test subjects completed Survey Questionnaires 2 and 3. The combination of day and night data from both airports yielded 203 responses.

- The combination of day and night data from both airports yielded 203 responses to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*. Most (172, or 85%) identified a single location.

  - End of the runway/Beginning of EMAS (105, or 52%)
  - 500 ft before the end of the runway (67, or 33%)
  - 22 test subjects (11%) responded with both locations
  - Nine test subjects (4%) did not respond

- The combination of day and night data from both airports yielded 208 responses to Question 2: *Can you suggest a different location for EMAS signage*?

  - Blank/No response (74, or 35%). This implies that their answer to Question 1 was adequate.
  - 1,000 ft or more from the end of the runway (29, or 14%)

- Departure end of the runway (27, or 13%)
- Centered on the end of the runway or beginning of EMAS bed (22, or 11%)
- Painted on runway or EMAS bed (16, or 8%)
- Not applicable (14, or 7%)
- Different color EMAS signage (13, or 6%)
- Multiple locations (5, or 2%)
- End of EMAS (3, or 1%)
- With distance-to-go Markers (2, or 1%)
- Arrow point forward (2, or 1%)

- The combination of day and night data from both airports yielded 203 responses to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?

  - Moderate (95, or 47%)
  - Little to none (61, or 30%)
  - Strong (43, or 21%)
  - Blank/No response (4, or 2%)

- The combination of day and night data from both airports yielded 203 responses to Question 4: *How effective are EMAS signs an emergency overrun*?

  - Little to none (68, or 33%)
  - Moderate (67, or 33%)
  - Strong (63, or 31%)
  - Blank/No response (5, or 2%)

8.2.16 Demographic Data from FedEx Test Subjects

All test subjects were asked to complete Questionnaire 4—Demographics, which included the following five questions:

1. What is the usual aircraft type that you fly?

2. How many hours do you have on that aircraft type?

3. How did you learn about EMAS?

4. Do you plan differently for airports with EMAS versus airports without EMAS?

5. What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?

While informative to some degree, Questions 1 and 2 do not add substantial insight regarding pilot decision-making. Responses to Questions 3, 4, and 5 provide researchers with some insight regarding pilot prior knowledge about EMAS and a means to improve that knowledge base. Tables 20, 21, and 22 provide test subject response to these three questions.

Table 20. How Did FedEx Test Subjects Learn About EMAS

How did you learn about EMAS?	**Count**	**%**
Training, school, FSI, or study	44	43%
Experience/Seeing during normal operations/Peers	16	16%
FAA documents/Reading	14	14%
Previous overrun accident/News	10	10%
This exercise	7	7%
Don't remember/None	4	4%
Internet	3	3%
Jeppesen charts	1	1%
Military	1	1%
Airline Pilots Association (ALPA)	1	1%
Aeronautical Information Manual (AIM)	1	1%

Table 21. How Do FedEx Pilots Plan for EMAS

Do you plan differently for airports with EMAS versus airports without EMAS?	**Count**	**%**
No	82	80%
Yes	14	14%
Blank or not applicable	5	6%

Table 22. Preflight Planning for FedEx Pilots

What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?	**Count**	**%**
Jeppesen 10-9 chart or Airfield/Airport diagram	65	64%
Not applicable or Blank	16	16%
None	13	13%
Taxi Charts	3	3%
Charts	3	3%
Flight Deck Pro	1	1%
Preflight brief	1	1%

8.2.17 Findings from FedEx Demographic Data

- FedEx pilots learned about EMAS from a wide variety of sources:
  - Forty-four FedEx pilots (43%) learned about EMAS through training, school, study, or FSI
    - Training—27 (26%)
    - School—12 (12%)
    - FSI—4 (4%)
    - Study—1 (1%)

- Fourteen FedEx pilots (14%) learned about EMAS through experience, seeing during normal operations, or their peers.
  - Experience—9 (9%)
  - Seeing during normal operations—5 (5%)
  - Peers—2 (2%)
- Fourteen FedEx pilots (14%) learned about EMAS through reading and FAA documents.
  - Reading 7 (7%)
  - FAA documents 7 (7%)
- Ten FedEx pilots[8] (10%) learned about EMAS from previous overrun accidents or the news.
  - Overrun accidents 5 (5%)
  - News 5 (5%)
- Seven FedEx pilots (7%) learned about EMAS from these simulation exercises.
- Four FedEx pilots (4%) don't remember how they learned about EMAS.
- Seven FedEx pilots (7%) learned about EMAS from assorted sources.
  - Internet—3 (3%)
  - Jeppesen charts—1 (1%)
  - Military—1 (1%)
  - ALPA—1 (1%)
  - AIM—1 (1%)

• Most FedEx test subjects (82, or 80%) indicated that they do not plan differently for airports with EMAS versus airports without EMAS; 14 test subjects (14%) indicted that they do plan differently; and five test subjects (6%) did not respond or the responses were not applicable.

• Most FedEx test subjects (65, or 64%) indicated that they use the Jeppesen 10-9 Airport Page or an airfield/airport chart for preflight planning regarding surface information like EMAS at airport destination.

  - The responses of 16 test subjects (16%) were either not applicable or blank.
  - Thirteen test subjects (13%) indicted that they don't use preflight documentation.
  - The eight remaining test subjects (8%) use either Taxi Charts, unidentified charts, Flight Deck Pro, or a preflight brief.

[8] Test subjects did not mention if they were involved in these accidents.

8.3 COMBINED FSI AND FEDEX DATA ANALYSIS

The following section provides a combined summary of all data recorded at both the FSI and FedEx simulation facilities for both the Sign Effectiveness and Optimal Sign Location simulations. There is also a section that compares test subject data for the Optimal Sign Location simulation between daytime and nighttime.

8.3.1 Sign Effectiveness Data

The combined number of test subjects for the Sign Effectiveness simulation equaled 132, with 30 for FSI and 102 for FedEx. Table 23 provides a summary view of test subject responses.

Table 23. Combined FedEx and FSI Sign Effectiveness Data

	Questionnaire 1	Count	%
1	*Pilot action at end of runway*		
	Steer straight	62	100%
	Veer off	0	0%
2	*Aware of experiment?*		
	No	125	95%
	Yes	7	5%
3	*Knowledge of EMAS at end of runway?*		
	No	108	82%
	Yes	24	18%
4	*Know the function of EMAS?*		
	Yes	118	89%
	No	14	11%
5	*Notice the EMAS signs during overrun simulation?*		
	No	109	83%
	Yes	23	17%
6	*Did signage influence decision-making?*		
	Not applicable*	113	86%
	No	14	11%
	Yes	5	4%
7	*Rate the influence of signage on decision-making*		
	N/A*	124	94%
	Blank	3	2%
	Moderate	2	2%
	Strong	2	2%
	Little to none	1	1%
8	*Do you think EMAS signage would be useful during an actual overrun?*		
	Yes	91	69%
	No	41	31%
9	*Do you think EMAS signage would be useful under normal operating conditions?*		

Questionnaire 1		Count	%
	Yes	89	67%
	No	41	31%
	Blank/No response	2	2%
*	N/A—If test subject answered "No" to Question 5 (did not see the EMAS signage during the overrun), then the signage could not have an influence on their decision-making; or test subject was not flying the aircraft and was not part of decision-making process.		

8.3.2 Findings from Combined FedEx and FSI Sign Effectiveness Simulation

- One hundred and thirty-two test subjects conducted the overrun excursion simulation and completed Survey Questionnaire 1.
  - 102 FedEx (77%)
  - 30 FSI (23%)
- There were 30 simulated overrun excursions at FSI. In each case, the PIC of the aircraft elected to steer straight. There were 32 simulated overrun excursions at FedEx. In each case, the PIC of the aircraft elected to steer straight. Table 23 shows that all 62 test subjects (PICs) "steered straight" at the end of the runway during the overrun excursion simulation. This figure is lower than the total of 132 test subjects because only the PIC of the aircraft at the time of the overrun decided to steer straight. The balance of the crew for FedEx (70 of 102 test subjects) did not control the aircraft.
- One hundred and twenty-five test subjects (95%) indicated that they were not aware of the nature of the experiment.
  - All seven test subjects (5%) that indicated that they knew about the experiment were from FedEx and only three (2%) were the PIC of the aircraft during the overrun simulation.
- One hundred and eight test subjects (82%) did not know that there was an EMAS serving the runway during the overrun excursion simulation, 24 (18%) did know.
- One hundred and eighteen test subjects (89%) knew the function of EMAS, 14 (11%) did not.
- One hundred and nine test subjects (83%) responded that they did not see the EMAS signs during the simulated overrun excursion.
  - None of the 30 FSI test subjects saw the EMAS signs.
  - The 23 FedEx test subjects (17%) who did see the EMAS signage were almost evenly split between day (12) and night (11). Four of these test subjects indicated that they saw the EMAS signs under configurations where EMAS signs were not present.
  - Only seven of the 32 FedEx PIC test subjects saw the EMAS signs.

- For 113 test subjects (86%) the question regarding the influence of EMAS signage on decision-making was not applicable. If the test subjects did not see the EMAS signage, the signs could not influence their decision-making.
    - All 14 test subjects (10%) who stated that the EMAS signs did not have an influence on their decision-making also recorded that they saw the EMAS signage during the overrun simulation.
    - All five test subjects (4%) who stated that the EMAS signs did have an influence on their decision-making also recorded that they saw the EMAS signage during the overrun simulation. None of the test subjects was the PIC during the simulation.
- Most test subjects (124, or 94%) did not see the sign or answered no. Only five test subjects (5%) qualified how the EMAS signage influenced their decision. None of the test subjects were the PIC during the simulated overrun.
    - Two test subjects (2%) indicated that the signs had a “Moderate” influence.
    - Two test subjects (2%) indicated a “Strong” influence.
    - One test subject (1%) indicated that EMAS signage had “Little-to-none” influence.
    - Three other subjects (3%) did not respond.
- Ninety-one test subjects (69%) indicated that EMAS signage would be useful during an actual overrun excursion; 41 test subjects (31%) indicated the signage would not be useful during such an event.
- Eighty-nine test subjects (67%) indicated that EMAS signage would be useful during normal operating conditions; 41 test subjects (31%) indicated the signage would not be useful during normal operations; and two test subjects (2%) did not respond.

8.3.3 Discussion on Sign Effectiveness Simulation

All 62 test subjects who were flying the aircraft during the simulation elected to steer straight at the end of the runway. This is not a surprising result. Pilots are trained to remain on centerline while trying to bring an aircraft to a stop. The overrun simulation scenarios were designed to force an overrun and ideally present a situation where a veer-off decision had potential benefit that exceeded the benefit to going straight. For example, during a high-speed overrun on Runway 11 at EWR, a pilot could decide to veer left at the end of the runway and “buy” more real estate if the exit speed was high enough to reach the perimeter fencing along the runway centerline extended. Figure 6 shows that a veer-off to the left has more distance before encountering the fencing. Unfortunately, the forced overruns at EWR were not possible, and the overrun scenarios at MEM and SFO did not have RSAs that presented a benefit for veering off.

The fact that most test subjects (83%) did not see the EMAS signs is also not surprising. During an overrun the pilot is fixated on what is directly ahead and not signage located on the edges of the runway, and out of foveal view. It is also worth noting that the EMAS signage used in the simulations are a novelty to pilots because they are not in use at any airports. Only 7 of the 32

FedEx PICs indicated that they saw the EMAS signage, and none indicated that the signage had an influence on decision-making.

The premise of the overrun simulation was that if the PIC intentionally veered left or right during the overrun excursion, the EMAS signage—especially signage at the end of the runway—would move into the pilot's foveal vision and alert the pilot that EMAS was available and cause the pilot to revert to runway centerline.

8.3.4 Conclusions for Sign Effectiveness Simulation

1. In all 62 overrun simulations the pilot flying the aircraft decided to go straight during the simulated emergency overrun excursion. The EMAS signage had no impact on pilot decision-making. In most cases the EMAS signs were not even noticed, and there is no evidence that the signage (when noticed) influenced the pilot to steer straight at the end of the runway.

2. Most (69%) pilots and crew that experienced this simulated overrun excursion stated that EMAS signs would be useful during an actual overrun excursion.

3. Most (67%) pilots and crew that experienced this simulated overrun excursion stated that EMAS signs would be useful during normal operations.

8.4 OPTIMAL SIGN LOCATION DATA

The combined number of test subjects for the Optimal Sign Location Simulations equaled 132, with 30 for FSI and 102 for FedEx.

Table 24 provides an aggregate of all test subject responses to Questionnaires 2 (Daytime) and 3 (Nighttime).

Table 24. Combined FSI and FedEx Optimal Sign Location Data

	Question	Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*		
	End of runway/Beginning of EMAS	130	49%
	500 ft before end of runway	97	37%
	Both	24	9%
	Blank/No response or None	12	5%
2	*Can you suggest a different location for EMAS signage?*		
	No or Blank/No response	102	38%
	Departure end	45	17%
	1,000 ft or more before end of runway	34	13%
	On middle of runway or at middle of EMAS bed	27	10%
	Not applicable*	17	6%
	Painted on runway or EMAS bed	16	6%
	Different color	13	5%
	Both or multiple locations	6	2%
	End of runway	3	1%
	With distance-to-go markers	2	1%
	Arrow point forward	2	1%
	End of EMAS	1	0%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*		
	Moderate	133	50%
	Little to none	74	28%
	Strong	53	20%
	Blank/No response	4	2%
4	*How effective do you think these signs would be during an emergency overrun?*		
	Little to none	101	38%
	Moderate	85	32%
	Strong	71	27%
	Blank	6	2%
*	Responses were not useful for this question (e.g., "Use Jeppesen charts")		

8.4.1 Findings from Combined FSI and FedEx Optimal Sign Location Simulation

- One hundred and thirty-two test subjects completed Survey Questionnaires 2 and 3.
- The combination of day and night data from both airports yielded 263 responses to Question 1: *Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion.*

- Most (227, or 86%) of these responses identified a single location. (Note the reason that some of the response counts in this section exceed the number of test participants is because some of the questions were found in multiple surveys answered by each participant.)

  - End of the runway/Beginning of EMAS (130, or 49%)
  - 500 ft before the end of the runway (97, or 37%)
  - 24 test subjects (9%) responded with both locations.
  - 12 test subjects (5%) did not respond.

- The combination of day and night data from both airports yielded 268 responses Question 2: *Can you suggest a different location for EMAS signage*?

  - Blank/No response (102, or 38%). This implies that their answer to Question 1 was adequate.
  - Departure end of the runway (45, or 17%)
  - 1,000 ft or more from the end of the runway (34, or 13%)
  - Centered on the end of the runway or beginning of EMAS bed (26, or 10%)
  - Not applicable (17, or 6%)
  - Painted on runway or EMAS bed (16, or 6%)
  - Different color EMAS signage (13, or 5%)
  - Multiple locations (6, or 2%)
  - End of runway (3, or 1%)
  - With distance-to-go markers (2, or 1%)
  - Arrow point forward (2, or 1%)
  - End of EMAS (1, or 0%)
  - Beginning of EMAS (1, or 0%)

- The combination of day and night data from both airports yielded 264 responses to Question 3: *How effective do you think these signs would be in future normal operations as a reminder that EMAS was present*?

  - Moderate (133, or 50%)
  - Little to none (74, or 28%)
  - Strong (53, or 20%)
  - Blank/No response (4, or 2%)

- The combination of day and night data from both airports yielded 263 responses to Question 4: *How effective are EMAS signs an emergency overrun*?

  - Little to none (101, or 38%)
  - Moderate (85, or 32%)
  - Strong (71, or 27%)
  - Blank/No response (6, or 2%)

8.4.2 Comparison of Daytime and Nighttime Data

Table 25 provides a comparison of all FSI and FedEx data between daytime and nighttime simulations for the Optimal Sign Locations simulations only. The time of day was not a differentiating factor for test subject responses to the questions for the Sign Effectiveness simulation, because all 62 PICs of the aircraft elected to steer straight.

Table 25. Comparison of Daytime and Nighttime Data

Question		Day Count	%	Night Count	%
1	*Sign location that you believe would be most likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion*				
	End of runway/Beginning of EMAS	65	49%	65	49%
	500 ft before end of runway	49	37%	48	36%
	Combinations or Both	12	9%	12	19%
	Blank/No response or None	6	5%	7	5%
2	*Can you suggest a different location for EMAS signage?*				
	No or Blank/No response	44	33%	58	43%
	Departure end	25	19%	20	15%
	1,000 ft or more before end of runway	17	13%	17	13%
	On runway or at EMAS bed	15	11%	12	9%
	Painted on runway or EMAS bed	11	8%	5	4%
	Different color	8	6%	5	4%
	Not applicable*	7	5%	10	7%
	Both or multiple locations	3	2%	3	2%
	End of runway	1	1%	2	1%
	With distance-to-go markers	1	1%	1	1%
	Arrow point forward	1	1%	1	1%
	End of EMAS	1	1%	0	0%
3	*How effective do you think these signs would be in future normal operations as a reminder that EMAS was present?*				
	Moderate	68	52%	65	49%
	Little to none	36	27%	38	29%
	Strong	27	20%	26	20%
	Blank/No response	1	1%	3	2%
4	*How effective do you think these signs would be during an emergency overrun?*				
	Little to none	53	40%	48	36%
	Moderate	42	32%	43	33%
	Strong	34	26%	37	28%
	Blank	2	2%	4	3%
*	Responses were not useful for this question (e.g., "Use Jeppesen charts")				

8.4.3 Findings from Comparison of Daytime and Nighttime Data

Table 25 shows that there was little deviation between test subject responses between daytime and nighttime simulations for the Optimal Sign Location simulations.

8.4.4 Discussion on Optimal Sign Location Simulation

The combined data for the Optimal Sign Location simulation indicated that 49% of the test subjects preferred EMAS signs at the end of the runway/beginning of EMAS, and 37% preferred the signs 500 ft from before the end of the runway. The former figure includes those test subjects at MEM who preferred the EMAS signs at the beginning of the EMAS bed, which was located about 500 ft past the end of the runway. The logic of adding those results to the end of runway/beginning of the EMAS bed is that only 14 of the 132 test subjects (11%) preferred EMAS signs at the beginning of the EMAS bed at MEM during daytime. This figure was slightly lower (12, or 9%) at nighttime.

8.4.5 Conclusions from Optimal Sign Location Simulations

1. Test subjects reported that EMAS signs are more informative at the end of the runway/beginning of EMAS (49%) than 500 ft before the end of the runway (37%).

2. Thirty-eight percent of test subjects declined to provide an alternative location for EMAS signage when asked. This implies that they were satisfied with the locations presented in the simulation.

3. When test subjects did provide an alternative location, 17% preferred signage that was present at the departure end of the runway and 13% preferred a location 1,000 ft or more from the end of the runway.

4. Test subjects reported that EMAS signage would be beneficial as a reminder during normal operations and during an actual overrun.

9. DEMOGRAPHIC DATA

All test subjects were asked to complete Questionnaire 4—Demographics, which included the following five questions:

1. What is the usual aircraft type that you fly?

2. How many hours do you have on that aircraft type?

3. How did you learn about EMAS?

4. Do you plan differently for airports with EMAS versus airports without EMAS?

5. What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?

While informative to some degree, questions 1 and 2 do not add substantial insight regarding pilot decision-making. All pilots steered straight during the emergency and their feedback was not related to their aircraft type or years of experience.

Responses to questions 3, 4, and 5 provide researchers with some insight regarding pilot prior knowledge about EMAS and a means to improve that knowledge base. Tables 26, 27, and 28 provide test subject responses to these three questions.

Table 26. How Did Test Subject Learn About EMAS

How did you learn about EMAS?	**Count**	**%**
Training, school, FSI, or study	51	39%
Experience/Seeing during normal operations/Peers	22	17%
FAA documents/Reading	18	14%
Previous overrun accident/News	15	11%
This exercise	8	6%
Don't remember/None	9	7%
Internet	3	2%
Jeppesen charts	1	1%
Military	1	1%
ALPA	1	1%
AIM	1	1%
Blank (no response)	1	1%
Unreadable	1	1%

Table 27. How Do Pilots Plan for EMAS

Do you plan differently for airports with EMAS versus airports without EMAS?	**Count**	**%**
No	110	83%
Yes	15	11%
Blank or Not applicable	7	5%

Table 28. Preflight Planning for Pilots

What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?	**Count**	**%**
Jeppesen 10-9 chart or Airfield/Airport diagram	86	65%
Not applicable or Blank	18	14%
None	17	13%
Taxi charts	4	3%
Charts	3	2%
Flight Deck Pro	1	1%
Preflight brief	1	1%
Foreflight	1	1%
NOTAMs	1	1%

9.1 FINDINGS FROM COMBINED DEMOGRAPHIC DATA

- Pilots learned about EMAS from a wide variety of sources:

  - Fifty-one FedEx and FSI pilots (39%) learned about EMAS through training, school, study, or from their employer.
  - Twenty-two FedEx pilots (17%) learned about EMAS through experience, seeing during normal operations, or their peers.
  - Fourteen FedEx pilots (14%) learned about EMAS through reading and FAA documents.
  - Ten FedEx pilots (10%) learned about EMAS from previous overrun accidents or the news.
  - Seven FedEx pilots (7%) learned about EMAS from these simulation exercises.
  - Four FedEx pilots (4%) don't remember how they learned about EMAS.
  - Seven FedEx pilots (7%) learned about EMAS from assorted sources:

    - Internet—3 (3%)
    - Jeppesen charts—1 (1%)
    - Military—1 (1%)
    - ALPA—1 (1%)
    - AIM—1 (1%)

- Most FedEx test subjects (110, or 83%) indicated that they do not plan differently airports with EMAS versus airports without EMAS

  - Fifteen test subjects (11%) indicated that they do plan differently.
  - Seven test subjects (5%) did not respond, or the responses were not applicable.

- Most FedEx test subjects (86, or 65%) indicated that they use the Jeppesen 10-9 Airport Page or an airfield/airport chart for preflight planning regarding surface information like EMAS at airport destination.

  - The responses of 18 test subjects (14%) were either not applicable or blank.
  - Seventeen test subjects (13%) indicated that they don't use preflight documentation.
  - Seven test subjects (5%) use some unspecified type of chart.

- The four remaining test subjects (4%) use either Flight Deck Pro, Foreflight, NOTAMs, or a preflight brief.

9.2 CONCLUSIONS FROM COMBINED DEMOGRAPHIC DATA

1. Pilots learned about EMAS from a wide variety of sources. Over half of pilots (56%) learned about EMAS from training or experience.

2. Most pilots (83%) do not plan differently for airports with EMAS versus airports without EMAS.

3. Most pilots (65%) use Jeppesen charts or airfield/airport diagrams for preflight planning regarding surface information like EMAS.

10. RECOMMENDATIONS

1. Consider surveying active pilots regarding the value and recommended placement of EMAS signage.

2. Consider the use of EMAS signage at both the departure end for takeoffs and the end of the runway for landings as a reminder of its presence.

3. Consider accentuating EMAS presence in airport diagrams and Jeppesen charts and potentially including in other flight preparation charts.

4. Resolve issue where the EMAS image is hidden on the tablet-version of the Jeppesen 10-9 chart while the user is scrolling within the diagram.

5. Continue outreach to expand efforts to educate pilots about the function of EMAS and how to identify its presence for a particular runway.

6. Consider including EMAS during pre-departure and pre-arrival briefings. Specifically, in addition to general education on EMAS and its functionality, also highlight the safety success and rationale for including it in pilot pre-departure and pre-arrival briefings to reinforce its presence on the assigned runway.

7. Include the EMAS overrun experience in pilot training simulations.

11. REFERENCES

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APPENDIX A—FEDEX CHECKLIST

This appendix shows the FedEx Checklist, which details the step-by-step process to conduct the Engineered Material Arresting System (EMAS) Sign Simulation experiment. It also lists all materials and forms that are required to conduct the experiment and collect the results. This checklist includes separate appendices (marked in bold) not to be misconstrued with the three appendices in this report (Appendix A—FedEx Checklist, Appendix B—FlightSafety International [FSI] Checklist, and Appendix C—Institutional Review Board Approval).

CHECKLIST FOR FEDEX TEST CONDUCTOR

Flight Simulation Exercise Supporting Federal Aviation Administration (FAA) EMAS Signage

Test conductor fills out all questionnaires and survey.

Step	Action	Check
1	Review background material as necessary to understand why we are doing this experiment and your role and responsibility as test conductor. You can find this information in **Appendix A**. *Consider Appendix A to be a high-level overview.*	
2	Greet new test subject(s) and ask them if they are willing to participate in an FAA-sponsored experiment designed to improve airport safety. Provide Informed Consent form to test subjects and acquire willingness to participate. Informed Consent form is attached in **Appendix B**. You should always have multiple consent forms available.	
3	Each subject must sign the consent form. Test conductor will sign forms, store securely in a locked cabinet, and then send originals to the FAA Principal Investigator. No copies will be retained.	
4	Assign a unique identification (ID) number to each test subject. Numbers begin at 001 and increase by one for each subsequent test subject. In the event there is more than one participant at a time (e.g., a crew of two or three), assign suffix letters a, b, and c to the ID. Example 002a, 002b, 002c for a three-person crew. Anonymity is a requirement so please **do not align subject ID # with Informed Consent forms**.	
5	Go to **Appendix C** and find the appropriate simulator configuration for each unique ID. For example, ID 001 will use Configuration 1 in the simulator. ID 002 will use Configuration 12.	
6	Go to **Appendix D** to see the details regarding the 14 different simulator configurations sign locations and day/night scenarios. Configure simulator accordingly.	
7	Provide take-off instructions to the test subject as spelled out in **Appendix E** and then begin the simulation.	
8	The test conductor will cause the pilot to abort the takeoff and force a rejected takeoff and subsequent overrun excursion. *The pilot will have to decide to steer straight (and enter the EMAS) or veer left or right at the end of the runway.*	

Step	Action	Check
9	Conduct the post-simulation survey questionnaire with test subjects. Use Questionnaire 1 in **Appendix F**. Record the responses of the test subject(s) directly on the questionnaire**. Be sure the test subject ID number(s) and configuration number are included on each questionnaire.**	
10	Congratulate the test subjects on completing the overrun scenario and thank them for their input on the survey.	
11	Inform test subjects about the follow-on experiment that will help identify the optimal location for EMAS signage. Refer to **Appendix G** for more specific information to share with test subjects. You are encouraged to show them the images in **Appendix G** if there is adequate time. *Reminder: the FAA needs input from experienced pilots to know where to position EMAS signs that best inform or remind pilots about the presence of EMAS at the end of the runway.*	
12	Reconfigure the simulator to show all EMAS signs during daylight at the same airport **where the overrun simulation was conducted**, either Memphis International Airport (MEM) or San Francisco International Airport (SFO). Refer to images in **Appendix G** as a reminder if necessary.	
13	Slew the aircraft along the centerline of the runway and encourage the test subjects to view the signs from multiple vantage points. *Remember that the objective is to choose the location that best informs or reminds the pilot about the presence of the EMAS at the end of the runway.*	
14	Conduct the post-slewing survey questionnaire with the test subjects. Use Questionnaire 2 in **Appendix H**. Be sure to add the test subject ID number(s) and airport name.	
15	Reconfigure the simulator to show all EMAS signs during nighttime.	
16	Slew the aircraft along the centerline of the runway and encourage the test subjects to view the signs from multiple vantage points.	
17	Conduct the post-slewing survey questionnaire with the test subjects. Use Questionnaire 3 in **Appendix I**. Be sure to add the test subject ID number(s) and the airport name. *If the pilot feedback is the same as for daytime, just add a note to the top of questionnaire that states this fact.*	
18	If there is adequate time, reconfigure the simulator for either SFO or MEM and conduct the daytime and nighttime slewing on the runway.	
19	Conduct the post-slewing survey questionnaires with the test subjects by using **Appendices H** and **I** accordingly. Be sure to include test subject ID number(s) and airport name.	
20	If there is time remaining, reconfigure the simulator for EWR and conduct the daytime and nighttime slewing on the runway.	
21	Conduct the post-slewing survey questionnaires with the test subjects by using **Appendices H** and **I** accordingly. Be sure to include test subject ID number(s) and airport name.	
22	Conduct demographic survey shown in **Appendix J.**	
23	Thank the test subjects for their participation on behalf of the FAA Airport Safety Research Team.	

Step	Action	Check
24	Assemble all questionnaire response forms together and either scan and email to the FAA Principal Investigator (PI); or mail to the FAA PI at the end of each week of simulations.	
25	Test conductor should make multiple copies of **Appendices B**, **F**, **H**, **I**, and **J**. *These must be filled out by the conductor for each test subject.*	

APPENDIX A (Step 1)

Synopsis of EMAS Signage Flight Simulation Experiments

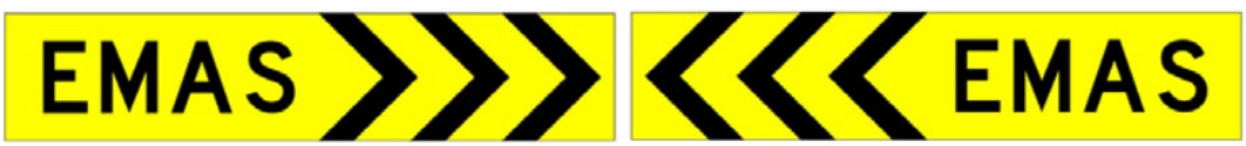
Background

The Federal Aviation Administration (FAA) Airport Technology Research and Development (ATR) Branch requests your participation in a research effort to help improve airport safety. More specifically, the FAA needs your help to acquire pilot feedback on the effectiveness and optimal location of signage that informs or reminds pilots about the presence of Engineered Material Arresting Systems (EMAS) at the end of a runway.

Your role as a test conductor is to guide test subjects through two separate but related flight simulation experiments and collect their feedback. The Checklist at the beginning of this document provides a step-by-step procedure. Your participation is greatly appreciated and crucial to the development of FAA standards for the eventual deployment of EMAS signage at airports across the nation.

EMAS Signage Concept

The FAA developed conceptual EMAS signage (shown below) that will be placed on either side of the runway. The current research effort is to get pilot input regarding the effectiveness of this signage during an overrun excursion to select the location that best informs a pilot about the presence of EMAS for a runway during normal operations.



The FedEx simulator has already been configured to show the EMAS signage at three airports:

- Memphis International Airport (MEM) Runway 18R
- San Francisco International Airport (SFO) Runway 1R
- Newark Liberty International Airport (EWR) Runway 11

Sign Effectiveness Experiment

The FedEx flight simulator will be configured to show EMAS signage at different airports and at different locations during day or night, or no signage at all (see Steps 5 and 6 for more information about the different configurations). The test conductor will cause the pilot to abort the takeoff and force an overrun excursion (see Steps 7 and 8 for more information). The pilot will have to decide to steer straight (and enter the EMAS) or veer left or right at the end of the runway. The test conductor will then conduct a post-simulation survey with the test subjects (see Steps 9 and 10 for more information).

Sign Location Experiment

The test conductor will then reconfigure the simulator to show all the EMAS signage at the same time, at the same airport (MEM or SFO) where the overrun simulation was conducted, during both day and night conditions (see Steps 11, 12, and 15 for more information). The test conductor will slew the aircraft along the runway to solicit pilot input regarding the most effective sign location (see Steps 13 and 16). The test conductor will then conduct a second post-simulation interview (see Steps 14 and 17).

If there is adequate time, the test conductor will then reconfigure the simulator to show the EMAS signage at the two other airports not involved with the overrun simulation (Steps 18 and 20). The test conductor will then slew the aircraft along these two runways during both daytime and nighttime conditions and conduct post-simulation surveys (Steps 19 and 21).

APPENDIX B (Step 2)

Informed Consent Form

Informed Consent to Participate in Research Study

Office of Airports Research Effort

Principal Investigator (PI): Ryan King (FAA)
Co-investigators: N/A
Sponsors: AAS-100 Office of Airports Safety and Standards
Contractor: GDIT and ARA Support Team

Invitation to Participate in Research Study

Ryan King (ANG-E261 Airport Safety R&D Section) invites you to participate in a research effort to support the Office of Airports at your organization's flight simulation training center. This study is sponsored by AAS-100 Office of Airports Safety and Standards and funded by ANG-E261 Airport Safety R&D Section.

Your participation is greatly appreciated and invaluable in helping to create recommendations intended to improve airport safety. Potential participants of varying experience levels who participate in your respective organization's standard flight simulation training program are invited to participate. During this study, test pilots will participate in flight simulation scenarios that are designed to help evaluate pilot's behavior for the purpose of identifying potential areas for safety improvement.

Note that this is not a student or university project designed to fulfill an academic requirement. This experiment is designed solely by the FAA to help improve airport safety. It is estimated that 50 to 100 individuals will participate in this research study.

Potential Conflicts of Interest

The investigator has no financial interest in this research or its outcome. The FAA is fully funding this research with no assistance from any outside source. The study is not being sponsored or funded by a funder, grantor or institution that has developed an agent/compound, or diagnostic test being used in the study that may have a potential financial interest in the outcome of the study.

Investigators are not personally receiving consulting fees or other payments for the purpose of this research. There are no agents, compounds, devices, or diagnostic tests being tested in this study for which a patent may be filed, or any royalties or compensation received.

Description of Participant Involvement

You will be asked to participate in a flight simulation designed to aid in the improvement of airport safety. The simulation is designed to be similar to a normal training scenario, and no new experimental procedures are being introduced as part of this experiment. The length of the simulation is not expected to exceed 5 to 10 minutes. After the simulation has completed, you will be asked to complete a short interview questionnaire that is not expected to exceed 5 minutes to complete. The total time commitment for the entire experiment is anticipated to be 15 minutes in duration.

No simulator data will be collected; and no audio, video, still photographs, or other media that would identify the individual as a participant will be collected. The only data that will be collected will be in the form of a short questionnaire in paper format.

No personal identifying information will be collected during the interview. Each set of collected questionnaire results will be identified by a unique identification number that is only intended to identify each respective set of results. This unique identification number will not be traceable back to an individual, and an individual's name or any other identifying information will not be located on the survey. This is further discussed in the "Confidentiality" section of this informed consent document.

Potential Benefits

You will not directly benefit from your participation in this study. The only benefit to you is that your data and feedback will help inform FAA decisions regarding airport safety and benefit the overall aviation community.

Risks and discomforts

The discomfort and risks associated with this study are similar to the discomfort and risks associated with regular flight simulation participation during the standard training process.

Compensation

No compensation will be received by the participants of this research study.

Participant's Rights

The local FAA Institutional Review Board has reviewed this research project under expedited review and found it to be acceptable, according to applicable state and federal regulations designed to protect the rights and welfare of subjects in research.

Cost to Participant

You will not incur any costs for participating in this research study.

Confidentiality

The execution of the simulation scenario and the post-simulation interview data collection process are anonymous, and we will treat all data as strictly confidential. You may refuse to answer any interview question or refuse to take part in the survey in its entirety at your discretion without penalty.

No physiological monitoring or recording equipment will be used during this experiment. We will request general information relevant to the experiment, but we will not gather any personal information that may identify an individual's identity or that individual's responses or test results. No simulator data will be collected, and no audio, video, still photographs, or other media that would identify the individual as a participant will be collected. The only data that will be collected will be in the form of a short questionnaire in paper format. Since the original collected data will be in paper hardcopy format (and not electronically), storage on password protected computers and FAA servers is not relevant. Interview forms will be collected by your organization's training staff and delivered to the FAA with no personal identifying information contained on them. No copies of the originals will be made during this process. All collected documents will be maintained by the FAA using established security procedures by keeping the hardcopy files in locked filing cabinets.

All individual results and feedback are anonymous, and we will treat all data as strictly confidential. No personal identifying information will be collected during the interview. Each set of collected questionnaire results will be identified by a unique identification number that is only intended to uniquely identify each respective set of results. This unique identification number will not be traceable back to an individual, and an individual's name or any other identifying information will not be recorded on the survey. Once the survey is complete, it will not be traceable back to the test participant.

No names or identities will be released in any research reports, publications, or presentations resulting from this work. Results will primarily be presented in summary or aggregate form. Individual comments or suggestions will be tailored when necessary to ensure that no identifying information is present. The original hard copy surveys will be shredded once the formal report is delivered by the FAA to the sponsor.

All collected data is strictly for the use of this research project. This data will not be made available to other researchers for related studies following completion of this study without additional informed consent. To help ensure the highest accuracy possible, you are requested not to share your experience during the flight simulation, including any test configuration details, with other test participants.

Injury

This experiment involves conducting a flight simulation scenario that should be similar to a typical training scenario. No extreme situation is anticipated that would result in injury to any participants. However, in the event of any injury incurred while participating in this study, medical treatment will be provided by emergency responders, local hospitals, or clinics. Notify one of the researchers immediately if medical attention is needed. It is the policy of this institution to provide neither financial compensation nor free medical treatment in the event of such injury.

Voluntary Nature of Participation and Withdrawal

Your participation in this study is completely voluntary and it is your choice whether to participate or not. Your performance during the study will not be critiqued or judged in any manner. You may decline or withdraw your participation in the study at any time, and no reason must be disclosed. The choice to decline or withdraw from the study will not cause any penalty or loss of any benefit to which you are entitled. During the study, the principal investigator or research team member will share any new information that develops that may affect your decision to continue to participate. The PI or research team may also terminate your participation in the study at any time if they determine this to be in your best interest. Any information or data provided will be destroyed if the participant decides to withdraw early.

Contact Information

If you have questions about the study, please ask them before signing this form. You can ask any questions that you have about this study at any time, or after your participation concludes

For questions, concerns, or complaints about this study, please contact the principal investigator, Ryan King, at ryan.king@faa.gov.

If you feel that you have been treated unfairly, or you have questions regarding your rights as a research participant, you may contact the Local Institutional Review Board at (609) 485-8629 or the FAA IRB at (405) 954-2700.

Signature and Consent to Be in the Research Study

I have been informed about the purpose, procedures, possible benefits, and risks of this research study. I have read (or someone has read to me) this form, and I have received a copy of it. I have had the opportunity to ask questions and to discuss the study with an investigator. My questions have been answered to my satisfaction. I have been told that I can ask other questions any time. I voluntarily agree to participate in this study. I am free to withdraw from this study at any time without penalty and without the need to justify my decision. The withdrawal will not in any way affect any benefits to which I am otherwise entitled. I agree to cooperate with the principal investigator and the research staff and to inform them immediately if I experience any unexpected or unusual symptoms.

Below, I have indicated my decision about being re-contacted for related studies in the future by placing an "X" next to my choice:

___ Yes, please contact me about related studies
___ No, please do NOT contact me about related studies

Participant: By signing this consent form, you indicate that you are voluntarily choosing to take part in this research.

____
Printed Name of Participant

____________________________________ ________________
Signature of Participant Date

Investigator

I have fully explained this study to the subject to the best of my ability. As a representative of this study, I have explained the purpose, the procedures, the possible benefits and risks that are involved in this research study. I have answered the subject's questions to his/her satisfaction before requesting the signature(s) above. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily. There are no blanks in this document. A copy of this form has been given to the subject.

____

Printed Name of Test Conductor

______________________________ ______________ __________
Signature of Test Conductor Date Time

APPENDIX C (Step 5)

Aligning Test Subject with Randomized Simulation Configuration

Test Subject ID	Configuration Number for Overrun		Test Subject ID	Configuration Number for Overrun
001	1		051	10
002	12		052	11
003	10		053	7
004	14		054	9
005	9		055	6
006	11		056	9
007	7		057	6
008	3		058	5
009	5		059	8
010	8		060	2
011	13		061	13
012	4		062	7
013	6		063	12
014	2		064	11
015	4		065	10
016	2		066	1
017	5		067	14
018	8		068	3
019	13		069	5
020	7		070	8
021	3		071	14
022	11		072	12
023	9		073	9
024	14		074	10
025	10		075	2
026	1		076	1
027	6		077	4
028	12		078	13
029	6		079	7
030	1		080	6
031	13		081	3
032	5		082	11
033	11		083	11
034	2		084	12
035	14		085	2
036	7		086	10
037	12		087	3
038	4		088	5
039	10		089	13
040	9		090	7
041	3		091	9
042	8		092	4
043	13		093	6
044	2		094	1
045	14		095	14
046	12		096	13
047	8		097	2
048	5		098	12
049	4		099	7
050	3		100	1

APPENDIX D (Step 6)
Six Different Simulator Configurations

Configuration Number	Airport	Sign Location	Day/Night
1	MEM 18R	500 ft from End	Day
2	MEM 18R	500 ft from End	Night
3	MEM 18R	End of R/W	Day
4	MEM 18R	End of R/W	Night
5	MEM 18R	At EMAS	Day
6	MEM 18R	At EMAS	Night
7	MEM 18R	No Signage	Day
8	MEM 18R	No Signage	Night
9	SFO 1R	500 ft from End	Day
10	SFO 1R	500 ft from End	Night
11	SFO 1R	End of R/W	Day
12	SFO 1R	End of R/W	Night
13	SFO 1R	No Signage	Day
14	SFO 1R	No Signage	Night

APPENDIX E (Step 7)

Aircraft Overrun Simulation

1. The simulator will be configured in one of the 14 different airport configurations shown in Appendix D.
2. Test subject(s), pilot, or crew will be requested to depart from either MEM or SFO with Visual Meteorological Conditions (VMC) in effect. After departure, the pilot is requested to perform a short flight. Below are the specific settings that will be used during the MEM or SFO departure.
   a. MEM 18R Departure with planned landing at Charlotte Douglas International Airport (CLT) Runway 18C
   b. SFO 1R departure with planned landing at Los Angeles International Airport (LAX) Runway 25R
   c. Standard Atmosphere (calm winds, 29.92 inches of mercury [inHg], 15C, dry runway)
   d. Zero-fuel weight (ZFW) = 500,000
   e. Center of gravity (CG) = 28
   f. Fuel = 200,000
   g. Flaps = 15
   h. V1 = 158
3. The test conductor will try to cause a rejected takeoff (RTO) and subsequent overrun excursion by entering the following malfunctions:
   a. Brakes fail 1-8 & 10
   b. Engine fail @ 150 knots (kts) L or R
   c. Control Column Breakout—Pitch L or R @ 150 kts
4. The timing of these malfunctions is at the discretion of the test conductor.
5. It is important that the test subjects are not aware of the impending RTO and overrun excursion.

APPENDIX F (Step 9**)**

Survey Questionnaire 1—Two Pages

Test conductor should record answers.

You (test subject) are now requested to participate in a brief survey about your experience during the overrun excursion simulation. Your performance will not be critiqued or judged in any manner. Your participation is strictly voluntary. No personal information will be collected during this survey, and all answers are strictly confidential and completely anonymous. The results of this survey will be combined with other survey results and analyzed in a summary format to support the safety-focused goal of this research.

Test Subject Number(s) ______ **Configuration Number _______**

1. Did pilot steer straight or veer off at the end of the runway? **Circle one.**

   Steer straight Veer-off left Veer-off right

---

2. Were you aware that this was an emergency overrun scenario before participating in this experiment? **Circle one.**

   YES NO

   Please note that there is no penalty for having foreknowledge of the experiment. This information merely helps with assessing the responses.

---

3. Did you know that there was an EMAS bed serving this runway? **Circle one.**

   YES NO

---

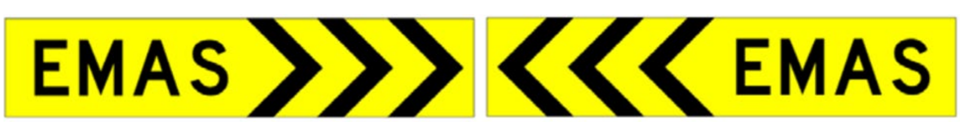
4. Did you know the function of EMAS? **Circle one**.

   YES NO

---

5. Did you notice the EMAS signage (shown below) during the excursion overrun? **Circle one.**

   YES NO



Page 1

6. If yes, did they influence your decision-making to steer straight at the end of the runway? **Circle one.**

YES NO

7. If yes, how would you rate how strongly it influenced your decision? **Circle one.**

Little to None Moderate Strong

8. Do you think EMAS signage would be useful during an actual overrun? **Circle one.**

YES NO

9. Do you think EMAS signage would be useful under normal operating conditions? **Circle one.**

YES NO

10. Do you want to share any thoughts about this simulated overrun excursion or your decision-making process to steer straight or veer off at the end of the runway?

END OF QUESTIONAIRE 1

Page 2

APPENDIX G (Step 11)

Instructions for the Optimal Sign Location Experiment

The test conductor may read or show the following information to the test subject(s):

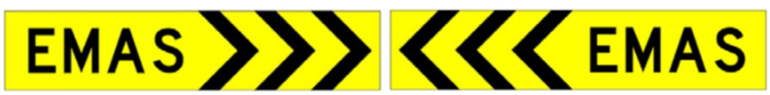
Congratulations on completing the emergency overrun scenario and thank you for your feedback. This completes the first experiment, where the goal was to assess the effect of EMAS signage on your decision-making process during an emergency overrun excursion.

Next, we are requesting your voluntary participation in additional tests that are designed to solicit pilot input regarding the location of the EMAS signage that best informs a pilot about the presence of EMAS at the end of a runway.

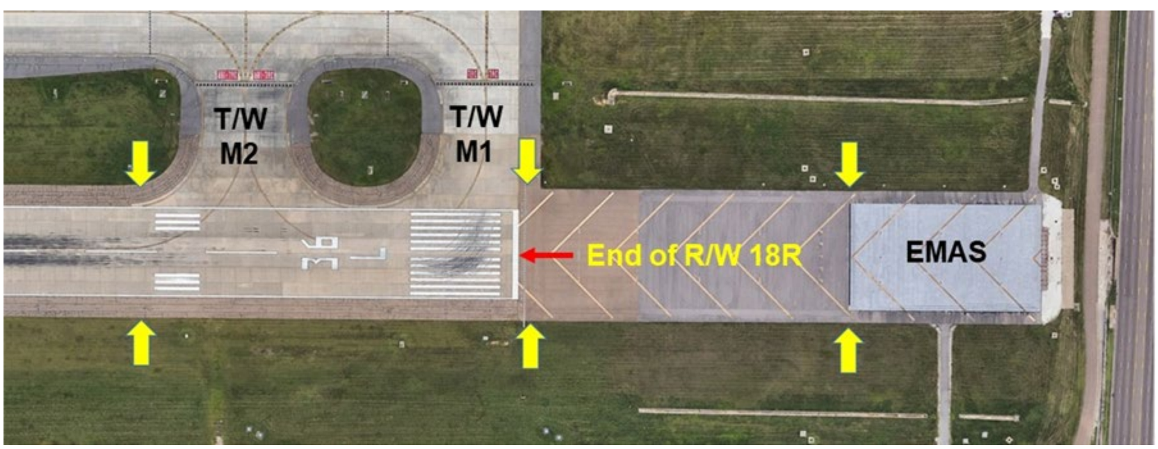
The simulator will be configured to show the EMAS signage at two or three locations:

- At the beginning of the EMAS bed (MEM only)
- At the end of the runway
- 500 ft inboard from the end of the runway

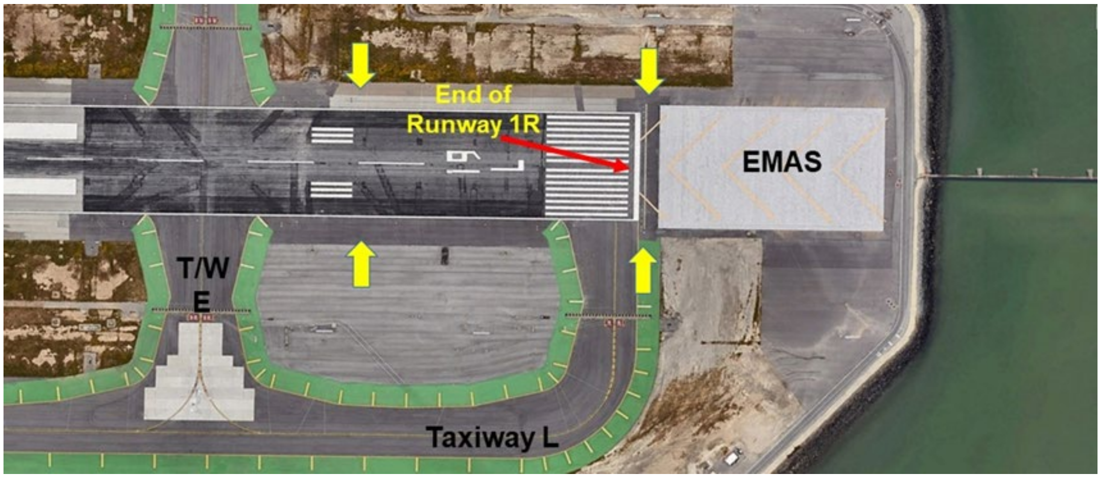
This is what the EMAS signage looks like, with one sign on each side of the runway.



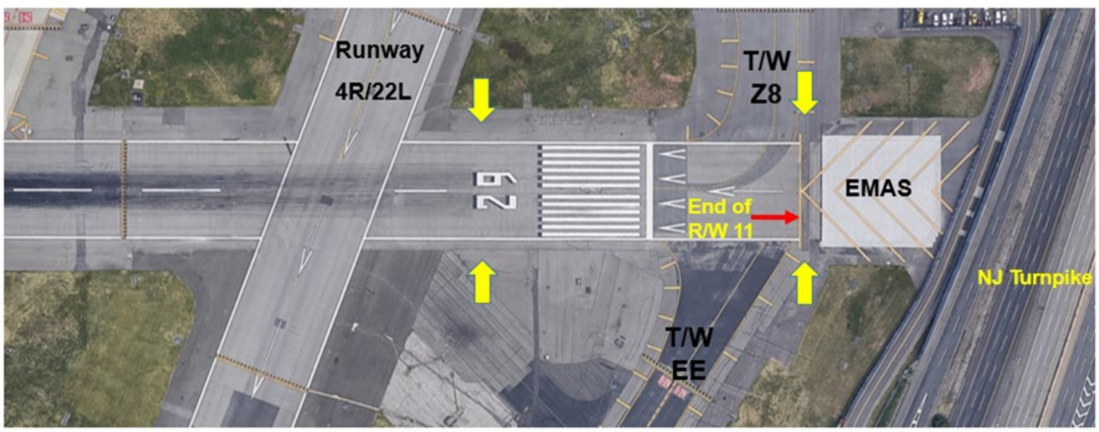
This is an aerial view of the EMAS signage locations on Runway 18R at MEM.



This is an aerial view of the EMAS signage locations at SFO Runway 1R.



This is an aerial view of the EMAS signage locations at EWR Runway 11.



Reconfigure the simulator to show all EMAS signs during daylight at the same airport where the overrun simulation was conducted, either MEM or SFO.

The test conductor will slew the aircraft along the runway under daytime conditions with EMAS signage at all locations and ask the test subjects to view the signs from multiple vantage points along the runway. The test conductor will then conduct a post-slewing survey with Questionnaire 2 (in Appendix H).

The test conductor will then repeat the simulation but with nighttime settings and conduct a post-slewing survey with Questionnaire 3 (Appendix I).

If there is adequate time, the test conductor will reconfigure the simulator to a different airport (MEM or SFO) than the one where the overrun simulation occurred and proceed with both daytime and nighttime slewing simulations and surveys.

If additional time remains, the test conductor will reconfigure the simulator to the third airport (EWR) and proceed with both daytime and nighttime slewing simulations and surveys.

APPENDIX H (Steps 14, 19, 21)

Survey Questionnaire 2

Daytime Slewing

Test Subject Number(s)____ Airport Name ______

1. Please circle the sign location that you believe would be more likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion:

500-ft before the end of runway   At the end of runway   At beginning of EMAS bed

---

2. Can you suggest a different location for EMAS signage? If so, why is this location better?

____

____

____

____

3. How effective do you think these signs would be in future normal operations as a reminder that EMAS was present? **Circle one**.

Little to None   Moderate   Strong

Please provide your rationale:

____

____

____

____

4. How effective do you think these signs would be during an emergency overrun? **Circle one.**

Little to None   Moderate   Strong

Please provide your rationale:

____

____

____

____

5. Additional comments:

____

____

____

____

END OF QUESTIONAIRE 2

APPENDIX I (Step 17)
Survey Questionnaire 3
Nighttime Slewing on Runway
Test Subject Number(s) ______Airport Name ______

Please circle the sign location that you believe would be more likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion:

500-ft before the end of runway   At the end of runway   At beginning of EMAS bed

---

1. Can you suggest a different location for EMAS signage? If so, why is this location better?

____
____
____
____

2. How effective do you think these signs would be in future normal operations as a reminder that EMAS was present? **Circle one**.

Little to None   Moderate   Strong

Please provide your rationale:

____
____
____
____

3. How effective do you think these signs would be during an emergency overrun? **Circle one.**

Little to None   Moderate   Strong

Please provide your rationale:

____
____
____
____

4. Additional comments:

____
____
____
____

END OF QUESTIONAIRE 3

APPENDIX J (Step 22)
Demographic Survey
Test Subject Number ______

1. What is the usual aircraft type that you fly? ____

2. How many hours do you have on that aircraft type? __________________________________

3. How did you learn about EMAS?
____
____
____
____

4. Do you plan differently for airports with EMAS versus airports without EMAS?
____
____
____
____

5. What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?
____
____
____
____

END OF DEMOGRAPHIC SURVEY

APPENDIX B—FLIGHTSAFETY INTERNATIONAL CHECKLIST

This Appendix shows the FlightSafety International (FSI) Checklist, which details the step-by-step process to conduct the experiment. It also lists all materials and forms that will be required to conduct the experiment and collect the results. The FSI Checklist has its own separate appendices, not to be confused with the three primary appendices in this report (Appendix A—FedEx Checklist, Appendix B—FSI Checklist, and Appendix C—Institutional Review Board Approval).

CHECKLIST FOR FSI TEST CONDUCTOR

Flight Simulation Exercise Supporting FAA EMAS Signage

Test conductor fills out all questionnaires and survey.

Step	Action	Check
1	Review background material as necessary to understand why we are doing this experiment and your role and responsibility as test conductor. You can find this information in **Appendix A**.	
2	Greet new test subject(s) and ask them if they are willing to participate in an FAA-sponsored experiment designed to improve airport safety. Provide Informed Consent form to test subjects and acquire willingness to participate. Informed Consent form is attached in **Appendix B**. You should always have multiple consent forms available.	
3	Each subject must sign the consent form. Test conductor will sign forms, store securely in a locked cabinet, and then send originals to the FAA Principal Investigator. No copies will be retained.	
4	Assign a unique identification (ID) number to each test subject. Numbers begin at 001 and increase by one for each subsequent test subject. In the event there are more than one participant at a time (example a crew of two or three), assign suffix letters a, b, and c to the ID. Example 002a, 002b, 002c for a three-person crew. Anonymity is a requirement so please d**o not align subject ID # with informed consent forms**.	
5	Go to **Appendix C** and find the appropriate simulator configuration for each unique ID. For example, ID 001 will use Configuration 1 in the simulator. ID 002 will use Configuration 4.	
6	Go to **Appendix D** to see the details regarding the six different simulator configurations sign locations and day/night scenarios. Configure simulator accordingly.	
7	Provide take-off instructions to the test subject as spelled out in **Appendix E** and then begin the simulation.	
8	The test conductor will cause the pilot to abort the takeoff and force an overrun excursion by jamming the elevator just before V1 at 127 knots. *The pilot will have to decide to steer straight (and enter the Engineered Material Arresting System [EMAS]) or veer left or right at the end of the runway.*	
9	Conduct the post-simulation survey questionnaire with test subjects. Use the questionnaire in **Appendix F**. Record the responses of the test subject(s) directly on the questionnaire**. Be sure the test subject ID number(s) and configuration number are included on each questionnaire.**	

Step	Action	Check
10	Congratulate the test subjects on completing the overrun scenario and thank them for their input on the survey.	
11	Inform test subjects about the follow-on experiment that will help identify the optimal location for EMAS signage. Refer to **Appendix G** for more specific information to share with test subjects. You are encouraged to show them the images in **Appendix G** if there is adequate time. *Reminder: TheFAA needs input from experienced pilots to know where to position EMAS signs that best inform or remind pilots about the presence of EMAS at the end of the runway.*	
12	Reconfigure the simulator to show all EMAS signs during daylight. Refer to images in **Appendix G** as a reminder if necessary.	
13	Slew the aircraft along the centerline of the runway and encourage the test subjects to view the signs from multiple vantage points. *Remember that the objective is to choose the location that best informs or reminds the pilot about the presence of the EMAS at the end of the runway.*	
14	Conduct the post-slewing survey questionnaire with the test subjects. Use the questionnaire in **Appendix H**. Be sure to add the test subject ID number(s).	
15	Reconfigure the simulator to show all EMAS signs during nighttime.	
16	Slew the aircraft along the centerline of the runway and encourage the test subjects to view the signs from multiple vantage points.	
17	Conduct the post-slewing survey questionnaire with the test subjects. Use the questionnaire in **Appendix I**. Be sure to add the test subject ID number(s). *If the pilot feedback is the same as for daytime, just add a note to the top of questionnaire that states this fact.*	
18	Conduct demographic survey shown in **Appendix J.**	
19	Thank the test subjects for their participation on behalf of the FAA Airport safety research team.	
20	Assemble all questionnaire response forms together and either scan and email to FAA PI; or mail to FAA PI at the end of each week of simulations.	
21	Test instructor should make multiple copies of **Appendices B**, **F**, **H**, **I**, and **J**. *These must be filled out by the conductor for each test subject.*	

APPENDIX A (Step 1)
Synopsis of EMAS Signage Flight Simulation Experiments

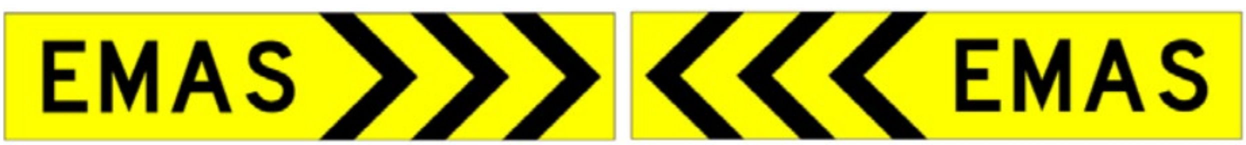
Background

The Federal Aviation Administration (FAA) Airport Technology Research and Development (ATR) Branch requests your participation in a research effort to help improve airport safety. More specifically, the FAA needs your help to acquire pilot feedback on the optimal location of signage that informs or reminds pilots about the presence of Engineered Material Arresting Systems (EMAS) at the end of a runway.

Your role as a test conductor is to guide test subjects through two separate but related flight simulation experiments and collect their feedback. The Checklist at the beginning of this document provides a step-by-step procedure. Your participation is greatly appreciated and crucial to the development of FAA standards for the eventual deployment of EMAS signage at airports across the nation.

EMAS Signage Concept

The FAA developed conceptual EMAS signage (shown below) that will be placed on either side of the runway. The current research effort is to get pilot input regarding the location that best informs a pilot about the presence of EMAS for a runway.



The FSI simulator has already been configured to show the EMAS signage at Teterboro Airport (TEB) at the end of Runway 6 and/or 500 ft inboard from the end of Runway 6, during both day and night conditions.

Sign Effectiveness Experiment

The FSI flight simulator for the Falcon 2000 LXS will be configured to show EMAS signage at different locations during day or night, or no signage at all (see Steps 5 and 6 for more information). The test conductor will cause the pilot to abort the takeoff and force an overrun excursion (see Step 8 for more information). The pilot will have to decide to steer straight (and enter the EMAS) or veer left or right at the end of the runway. The test conductor will then conduct a post-simulation interview for the test subjects (see Steps 9 and 10 for more information).

Sign Placement Experiment

Reconfigure the simulator to show all the EMAS signage at the same time during both day and night conditions (see Steps 11, 12, and 15 for more information). The test conductor will slew the aircraft along the runway to solicit pilot input regarding the most effective sign location (see Steps 13 and 16). The test conductor will then conduct a second post-simulation interview (see Steps 14 and 17).

APPENDIX B (Step 2)

<u>Informed Consent Form</u>

Informed Consent to Participate in Research Study
Office of Airports Research Effort

Principal Investigator (PI): Ryan King (FAA)
Co-investigators: N/A
Sponsors: AAS-100 Office of Airports Safety and Standards
Contractor: GDIT and ARA Support Team

Invitation to Participate in Research Study

Ryan King (ANG-E261 Airport Safety R&D Section) invites you to participate in a research effort to support the Office of Airports at your organization's flight simulation training center. This study is sponsored by AAS-100 Office of Airports Safety and Standards and funded by ANG-E261 Airport Safety R&D Section.

Your participation is greatly appreciated and invaluable in helping to create recommendations intended to improve airport safety. Potential participants of varying experience levels who participate in your respective organization's standard flight simulation training program are invited to participate. During this study, test pilots will participate in flight simulation scenarios that are designed to help evaluate pilot's behavior for the purpose of identifying potential areas for safety improvement.

Note that this is not a student or university project designed to fulfill an academic requirement. This experiment is designed solely by the FAA to help improve airport safety. It is estimated that 50 to 100 individuals will participate in this research study.

Potential Conflicts of Interest

The investigator has no financial interest in this research or its outcome. The FAA is fully funding this research with no assistance from any outside source. The study is not being sponsored or funded by a funder, grantor, or institution that has developed an agent/compound or diagnostic test being used in the study that may have a potential financial interest in the outcome of the study.

Investigators are not personally receiving consulting fees or other payments for the purpose of this research. There are no agents, compounds, devices, or diagnostic tests being tested in this study for which a patent may be filed, or any royalties or compensation received.

Description of Participant Involvement

You will be asked to participate in a flight simulation designed to aid in the improvement of airport safety. The simulation is designed to be similar to a normal training scenario, and no new experimental procedures are being introduced as part of this experiment. The length of the simulation is not expected to exceed 5 to 10 minutes. After the simulation has completed, you will be asked to complete a short interview questionnaire that is not expected to exceed 5 minutes to complete. The total time commitment for the entire experiment is anticipated to be 15 minutes in duration.

No simulator data will be collected; and no audio, video, still photographs, or other media that would identify the individual as a participant will be collected. The only data that will be collected will be in the form of a short questionnaire in paper format.

No personal identifying information will be collected during the interview. Each set of collected questionnaire results will be identified by a unique identification number that is only intended to identify each respective set of results. This unique identification number will not be traceable back to an individual, and an individual's name or any other identifying information will not be located on the survey. This is further discussed in the "Confidentiality" section of this informed consent document.

Potential Benefits

You will not directly benefit from your participation in this study. The only benefit to you is that your data and feedback will help inform FAA decisions regarding airport safety and benefit the overall aviation community.

Risks and Discomforts

The discomfort and risks associated with this study are similar to the discomfort and risks associated with regular flight simulation participation during the standard training process.

Compensation

No compensation will be received by the participants of this research study.

Participant's Rights

The local FAA Institutional Review Board has reviewed this research project under expedited review and found it to be acceptable, according to applicable state and federal regulations designed to protect the rights and welfare of subjects in research.

Cost to Participant

You will not incur any costs for participating in this research study.

Confidentiality

The execution of the simulation scenario and the post-simulation interview data collection process are anonymous, and we will treat all data as strictly confidential. You may refuse to answer any interview question or refuse to take part in the survey in its entirety at your discretion without penalty.

No physiological monitoring or recording equipment will be used during this experiment. We will request general information relevant to the experiment, but we will not gather any personal information that may identify an individual's identity or that individual's responses or test results. No simulator data will be collected and no audio, video, still photographs, or other media that would identify the individual as a participant will be collected. The only data that will be collected will be in the form of a short questionnaire in paper format. Since the original collected data will be in paper hardcopy format (and not electronically), storage on password protected computers and FAA servers is not relevant. Interview forms will be collected by your organization's training staff and delivered to the FAA with no personal identifying information contained on them. No copies of the originals will be made during this process. All collected documents will be maintained by the FAA using established security procedures by keeping the hardcopy files in locked filing cabinets.

All individual results and feedback are anonymous, and we will treat all data as strictly confidential. No personal identifying information will be collected during the interview. Each set of collected questionnaire results will be identified by a unique identification number that is only intended to uniquely identify each respective set of results. This unique identification number will not be traceable back to an individual, and an individual's name or any other identifying information will not be recorded on the survey. Once the survey is complete, it will not be traceable back to the test participant.

No names or identities will be released in any research reports, publications, or presentations resulting from this work. Results will primarily be presented in summary or aggregate form. Individual comments or suggestions will be tailored when necessary to ensure that no identifying information is present. The original hard copy surveys will be shredded once the formal report is delivered by the FAA to the sponsor.

All collected data is strictly for the use of this research project. This data will not be made available to other researchers for related studies following completion of this study without additional informed consent. To help ensure the highest accuracy possible, you are requested to not share your experience during the flight simulation, including any test configuration details, with other test participants.

Injury

This experiment involves conducting a flight simulation scenario that should be similar to a typical training scenario. No extreme situation is anticipated that would result in injury to any participants. However, in the event of any injury incurred while participating in this study, medical treatment will be provided by emergency responders, local hospitals, or clinics. Notify one of the researchers immediately if medical attention is needed. It is the policy of this institution to provide neither financial compensation nor free medical treatment in the event of such injury.

Voluntary Nature of Participation and Withdrawal

Your participation in this study is completely voluntary and it is your choice whether to participate or not. Your performance during the study will not be critiqued or judged in any manner. You may decline or withdraw your participation in the study at any time, and no reason must be disclosed. The choice to decline or withdraw from the study will not cause any penalty or loss of any benefit to which you are entitled. During the study, the principal investigator or research team member will share any new information that develops that may affect your decision to continue to participate. The PI or research team may also terminate your participation in the study at any time if they determine this to be in your best interest. Any information or data provided will be destroyed if the participant decides to withdraw early.

Contact Information

If you have questions about the study, please ask them before signing this form. You can ask any questions that you have about this study at any time, or after your participation concludes

For questions, concerns, or complaints about this study, please contact the principal investigator, Ryan King, at ryan.king@faa.gov.

If you feel that you have been treated unfairly, or you have questions regarding your rights as a research participant you may contact the Local Institutional Review Board at (609) 485-8629 or the FAA IRB at (405) 954-2700.

Signature and Consent to be in the research study

I have been informed about the purpose, procedures, possible benefits and risks of this research study. I have read (or someone has read to me) this form, and I have received a copy of it. I have had the opportunity to ask questions and to discuss the study with an investigator. My questions have been answered to my satisfaction. I have been told that I can ask other questions any time. I voluntarily agree to participate in this study. I am free to withdraw from this study at any time without penalty and without the need to justify my decision. The withdrawal will not in any way affect any benefits to which I am otherwise entitled. I agree to cooperate with the principal investigator and the research staff and to inform them immediately if I experience any unexpected or unusual symptoms.

Below, I have indicated my decision about being re-contacted for related studies in the future by placing an "X" next to my choice:

___ Yes, please contact me about related studies
___ No, please do NOT contact me about related studies

Participant: By signing this consent form, you indicate that you are voluntarily choosing to take part in this research.

____
Printed Name of Participant

___________________________________ _______________
Signature of Participant Date

Investigator

I have fully explained this study to the subject to the best of my ability. As a representative of this study, I have explained the purpose, the procedures, the possible benefits and risks that are involved in this research study. I have answered the subject's questions to his/her satisfaction before requesting the signature(s) above. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily. There are no blanks in this document. A copy of this form has been given to the subject.

____
Printed Name of Test Conductor

_____________________________ _____________ __________
Signature of Test Conductor Date Time

APPENDIX C (Step 5)

Aligning Test Subject with Randomized Simulation Configuration

Test Subject ID	Configuration Number for Overrun		Test Subject ID	Configuration Number for Overrun
001	1		049	6
002	4		050	3
003	2		051	5
004	6		052	1
005	5		053	4
006	3		054	2
007	4		055	2
008	3		056	1
009	2		057	5
010	6		058	4
011	1		059	3
012	5		060	6
013	2		061	3
014	1		062	1
015	3		063	6
016	4		064	2
017	5		065	5
018	6		066	4
019	2		067	4
020	1		068	1
021	4		069	6
022	6		070	3
023	5		071	5
024	3		072	2
025	2		073	4
026	3		074	6
027	5		075	2
028	4		076	1
029	1		077	3
030	6		078	5
031	6		079	3
032	3		080	6
033	1		081	1
034	5		082	5
035	2		083	4
036	4		084	2
037	4		085	5
038	2		086	3
039	3		087	1
040	5		088	6
041	1		089	4
042	6		090	2
043	1		091	3
044	5		092	1
045	6		093	6
046	4		094	2
047	2		095	5
048	3		096	4

APPENDIX D (Step 6)

Six Different Simulator Configurations

POSSIBLE CONFIGURATIONS FOR OVERRUN SCENARIO			
Configuration Number	**Airport**	**Sign Location**	**Day/Night**
1	TEB R/W 6	500 ft from end	Day
2	TEB R/W 6	500 ft from end	Night
3	TEB R/W 6	End of runway	Day
4	TEB R/W 6	End of runway	Night
5	TEB R/W 6	No Signage	Day
6	TEB R/W 6	No Signage	Night

APPENDIX E (Step 7)

Aircraft Overrun Simulation

1. The simulator will be configured in one of the six different configurations shown in Appendix D.
2. The pilot will be requested to depart from Runway 6 at TEB under Visual Meteorological Conditions (VMC) in effect. After departure, the pilot is requested to perform a short flight and land at LaGuardia Airport (LGA) Runway 13.
3. Due to construction at the beginning of Teterboro Airport (TEB) Runway 6, the departure will commence approximately 450 ft from the departure end of Runway 6.
4. At the beginning of this simulation, the Falcon 2000 LXS aircraft, cargo, and fuel will weigh 42,800 lbs.
5. The departure flap configuration will be SF1.
6. The required distance for a successful departure under these conditions is approximately 5,350 ft and the available distance for takeoff will be 5,550 ft.

APPENDIX F (Step 9**)**

Survey Questionnaire 1—Two Pages

You (test subject) are now requested to participate in a brief survey about your experience during the overrun excursion simulation. Your performance will not be critiqued or judged in any manner. Your participation is strictly voluntary. No personal information will be collected during this survey, and all answers are strictly confidential and completely anonymous. The results of this survey will be combined with other survey results and analyzed in a summary format to support the safety-focused goal of this research.

Test Subject Number(s) ______ **Configuration Number _______**

1. Did pilot steer straight or veer off at the end of the runway? **Circle one.**

   Steer straight Veer-off left Veer-off right

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2. Were you aware that this was an emergency overrun scenario before participating in this experiment? **Circle one.**

   YES NO

   Please note that there is no penalty for having foreknowledge of the experiment. This information merely helps with assessing the responses.

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3. Did you know that there was an EMAS bed serving this runway? **Circle one.**

   YES NO

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4. Did you know the function of EMAS? **Circle one**.

   YES NO

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5. Did you notice the EMAS signage (shown below) during the excursion overrun? **Circle one.**

   YES NO

Page 1

6. If yes, did they influence your decision-making to steer straight at the end of the runway? **Circle one.**

YES NO

7. If yes, how would you rate how strongly it influenced your decision? **Circle one.**

Little to None Moderate Strong

8. Do you think EMAS signage would be useful during an actual overrun? **Circle one.**

YES NO

9. Do you think EMAS signage would be useful under normal operating conditions? **Circle one.**

YES NO

10. Do you want to share any thoughts about this simulated overrun excursion or your decision-making process to steer straight or veer off at the end of the runway?

END OF QUESTIONAIRE 1

Page 2

APPENDIX G (Step 11)

Instructions for the Optimal Sign Location Experiment

The test instructor may read or show the following information to the test subject(s):

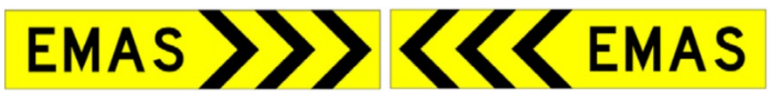
Congratulations on completing the emergency overrun scenario and thank you for your feedback. This completes the first experiment, where the goal was to assess the effect of EMAS signage on your decision-making process during an emergency overrun excursion.

Next, we are requesting your voluntary participation in two additional tests that are designed to solicit pilot input regarding the location of the EMAS signage that best informs a pilot about the presence of EMAS at the end of a runway.

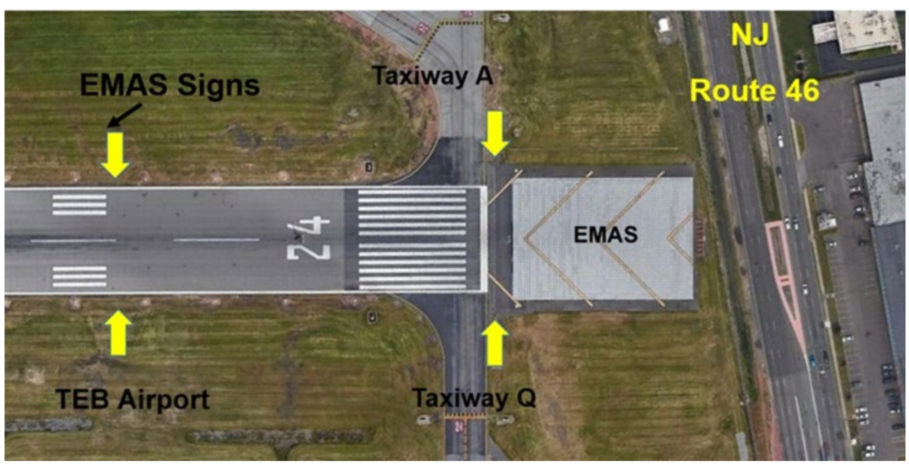
The simulator will be configured to show the EMAS signage at two locations:

- At the end of Runway 6
- 500 ft inboard from the end of Runway 6

This is what the EMAS signage looks like, with one sign on each side of the runway.



This is an aerial view of the EMAS signage locations on Runway 6 at TEB.



The test instructor will slew the aircraft along Runway 6 under daytime conditions with EMAS signage at both locations and encourage the test subjects to view the signs from multiple vantage points. The test instructor will conduct a post-slewing survey with Questionnaire 2.

The test instructor will then repeat the simulation but with nighttime settings and conduct a post-slewing survey with Questionnaire 3.

APPENDIX H (Step 14)
Survey Questionnaire 2
Daytime Slewing on Runway 6
Test Subject Number(s)____

1. Please circle the sign location that you believe would be more likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion:

500-ft before the end of Runway 6 | At the end of Runway 6

____

2. Can you suggest a different location for EMAS signage? If so, why is this location better?

____
____
____
____

3. How effective do you think these signs would be in future normal operations as a reminder that EMAS was present? **Circle one**.

Little to None | Moderate | Strong

Please provide your rationale:

____
____
____
____

4. How effective do you think these signs would be during an emergency overrun? **Circle one.**

Little to None | Moderate | Strong

Please provide your rationale:

____
____
____
____

5. Additional comments:

____
____
____
____

END OF QUESTIONAIRE 2

APPENDIX I (Step 17)
Survey Questionnaire 3
Nighttime Slewing on Runway 6
Test Subject Number(s) ______

Please circle the sign location that you believe would be more likely to inform a pilot about the presence of EMAS during normal operations or during an overrun excursion:

500-ft before the end of Runway 6 At the end of Runway 6

1. Can you suggest a different location for EMAS signage? If so, why is this location better?

2. How effective do you think these signs would be in future normal operations as a reminder that EMAS was present? **Circle one**.

Little to None Moderate Strong

Please provide your rationale:

3. How effective do you think these signs would be during an emergency overrun? **Circle one.**

Little to None Moderate Strong

Please provide your rationale:

4. Additional comments:

END OF QUESTIONAIRE 3

APPENDIX J (Step 18)
Demographic Survey
Test Subject Number ______

1. What is the usual aircraft type that you fly? ____

2. How many hours do you have on that aircraft type? __________________________________

3. How did you learn about EMAS?
____
____
____
____

4. Do you plan differently for airports with EMAS versus airports without EMAS?
____
____
____
____

5. What documentation do you use in your preflight planning regarding surface information like EMAS at airport destinations?
____
____
____
____

END OF DEMOGRAPHIC SURVEY

APPENDIX C—INSTITUTIONAL REVIEW BOARD APPROVAL

LOCAL INSTITUTIONAL REVIEW BOARD RESEARCH PROPOSAL NOTICE OF APPROVAL TO CONDUCT RESEARCH

The purpose of this notice is to inform the principal investigator or Contracting Officer's Representative (COR) that this board has reviewed your research proposal and hereby approves it under the authority of Federal Aviation Administration (FAA) Order 9500.25B and the delegated authority from the FAA Institutional Review Board (IRB) to operate a local IRB. This approval is for the proposal as written. Any changes to the research design which impact how data is collected from human participants must be submitted for additional review. This approval refers only to the issues related to protection of human subjects participating in your study. Approval means that the board members believe that human participants will be placed under minimal risk or no risk as defined in FAA Order 9500.25B.

Research Proposal Title: Pilot Feedback on Engineered Material Arresting System (EMAS)

Date on Proposal: October 21, 2021

Principal Investigator: Ryan King, BSCE

Organization Doing Research: ANG-E261 Airport Safety R&D Section

Carolina M. Zingale

Signature of Local IRB Chairperson

11/10/2021

Date

Certificates of review are on file with the chairperson.