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Engineered Material Arresting System Sign Simulation

August 2022

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7. Author(s)

W. Russ Gorman[2] and James White[2]

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9. Performing Organization Name and Address

[1]GDIT
600 Aviation Research Blvd.
Egg Harbor Township, NJ 08234

[2]Applied Research Associates
2628 Fire Road, Ste300
Egg Harbor Township, NJ 08234

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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 possess sufficient surrounding space to support the desired 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 115 EMAS beds installed at 67 airports in the United States, there have been 18 incidents where EMAS has safely stopped overrunning aircraft, carrying 419 crew and passengers. Despite its proven effectiveness, there is evidence that test subjects occasionally avoid EMAS beds. The Federal Aviation Administration (FAA) Airport Technology Research and Development Branch's Safety Section (ATR) conducted two research projects in 2013 and 2016 to identify conceptual EMAS signage that would inform a test subject about the presence of EMAS during normal operations and an overrun excursion. Subsequent ATR research had two objectives: gain test subject input about the location of EMAS signs that best inform a test subject about the presence of EMAS on a runway and evaluate the effectiveness of these signs during an overrun excursion. Project plans to conduct this research during a year-long study at operational airports was considered too costly. The Office of Airport Safety and Standards recommended the use of flight simulators due in part to their ability to simulate a runway overrun excursion within a controlled laboratory setting.

FedEx and FlightSafety International (FSI) agreed to host these simulations, provide test subjects, develop high-fidelity simulation scenarios, conduct the simulations, and collect data. Actual flight simulation exercises at FSI began in February 2022. A total of 11 test subjects completed the simulations and submitted data by March 7, 2022. Simulations at FedEx are not expected to begin until April 2022. Although the 11 data sets indicated some trends among the test subjects, more data is needed to make any significant conclusions regarding the effectiveness of EMAS. It is recommended that simulations continue until there are at least 100 data sets each from FSI and FedEx.

17. Key Words

EMAS, Engineered Material Arresting System, RSA, Overruns, Veer-offs, Signage

18. Distribution Statement

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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
ALSF-2	Approach lighting system with sequenced flashing lights
ATR	Airport Technology Research and Development (R&D) Branch, Safety Section
CANSO	Civil Air Navigation Services Organization
C.F.R.	Code of Federal Regulations
EMAS	Engineered Material Arresting System
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FSI	FlightSafety International
IRB	Institutional Review Board
JFK	John F. Kennedy International Airport
LGA	LaGuardia Airport
MDW	Chicago Midway International Airport
MEM	Memphis International Airport
ORD	Chicago O'Hare International Airport
R&D	Research and development
RDR	Runway distance remaining
RSA	Runway safety area
SFO	San Francisco International Airport
SOP	Standard operating procedure
TEB	Teterboro Airport

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 115 EMAS beds installed at 67 airports in the United States, there have been 18 incidents in which EMAS systems have safely stopped overrunning aircraft, which carried 419 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 Oct. 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 pilots, develop high-fidelity simulation scenarios, conduct the simulations, and collect 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. Actual flight simulation exercises at FSI began in February 2022.

A total of 11 test subjects completed the simulations and submitted data by March 7, 2022. Simulations at FedEx are not expected to begin until April 2022.

To date, there is not enough data to formulate any meaningful conclusions regarding the effectiveness of EMAS signage during a simulated overrun, or the optimal location to inform test subject regarding its availability at an airport. The 11 data sets indicated the following trends:

- Most test subjects knew the purpose of EMAS
- Most did not know that EMAS was available during the simulation.
- EMAS signs are more useful during normal operations than during an actual overrun.
- Test subjects prefer the EMAS signs 500 feet before the end of the runway as opposed to the end.
- If given the option, most test subjects prefer the signs at the beginning of the takeoff run.

It is recommended that simulations continue until there are at least 100 data sets each from FSI and FedEx.

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 feet wide by 1,000 feet 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 January 5, 2022, there are 115 EMAS beds installed at 67 airports in the United States. Since the completion of the EMAS installations, there have been 18 incidents where EMAS has safely stopped overrunning aircraft, which carried 419 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. Once again, the pilot stated that he had forgotten about the presence of EMAS (FlightSafety Foundation, 2017).

In response to these types of incidents, AAS tasked the FAA Airport Safety Research and Development (R&D) Branch Safety Section (ATR) with developing and testing 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 feet 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. In particular, 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 participants, develop high-fidelity simulation scenarios, and collect 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.

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.

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.

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 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 airport with EMAS
- 93% (313 of 336 test subjects) were aware of EMAS at airport where they operated (Klass & Vitagliano, 2013)

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 effectively 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 also encourage them to further 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.

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 should 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 feet 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's Airway Facilities Tower Integration Laboratory (AFTIL).

Figure 1. Conceptual EMAS Information Sign

Figure 2. Location of Conceptual EMAS Information Signs in AFTIL

<u>THE 2016 RESEARCH EFFORT—DEVELOPMENT AND EVALUATION OF EMAS SIGNAGE</u>

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). 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.

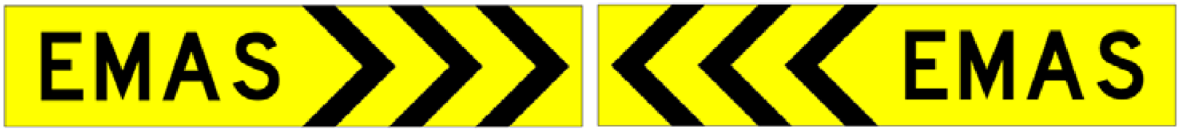

Figure 3. Conceptual EMAS Sign—One Section on Each Side of Runway

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).

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, and
- ability to simulate a runway overrun excursion.

<u>GENERAL SIMULATOR SCENARIOS</u>

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 left-hand side of the runway facing the test subject, as shown in Figure 3. Both signs shown in Figure 3 have these same dimensions and will be positioned approximately 35 feet from the left and right edges of the runway and illuminated at night.

Figure 5. Conceptual EMAS Sign Dimensions

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 subject 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 feet 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 feet 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 feet to over 500 feet from the end of the physical runway. In those cases where the leading edge of the EMAS is only 35 feet 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.

SIMULATION SCENARIO FOR OBJECTIVE 2—SIGN EFFECTIVENESS

The secondary research objective is to assess 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 either include the placement of EMAS signs at one of the three locations discussed for Objective 1 or will not include any EMAS signage.

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 (if they were present) 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), and it must be performed prior to the sign effectiveness testing. After the emergency overrun scenario testing has 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. For example, a test subject that experiences an overrun excursion on Runway 11 at Newark International Airport (EWR) will see that veering off to the left yields more real estate than veering off to the right before encountering the perimeter fencing. 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.

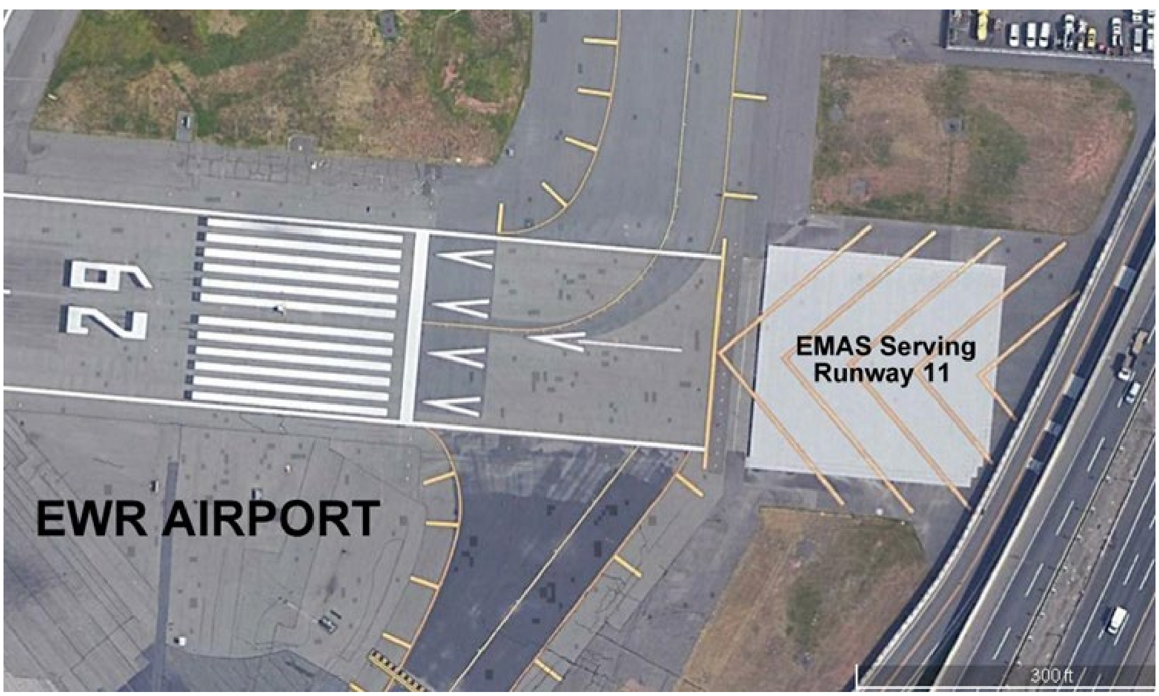

Figure 6. The RSA at EWR Airport

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 Tennessee. 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 would not provide enough additional value to undertake that task. Also, during this visit, it was determined that aborted takeoffs would be simulated instead of landings. The aborted takeoff presented a more realistic scenario and 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.

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 feet from the end of the runway. The standard setback for EMAS is 200 feet 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 feet from the end of Runway 18R. The yellow arrows show the locations for the EMAS signage at all three locations: 500 feet before the end of the runway; at the end of the runway; and at the leading edge of the EMAS.

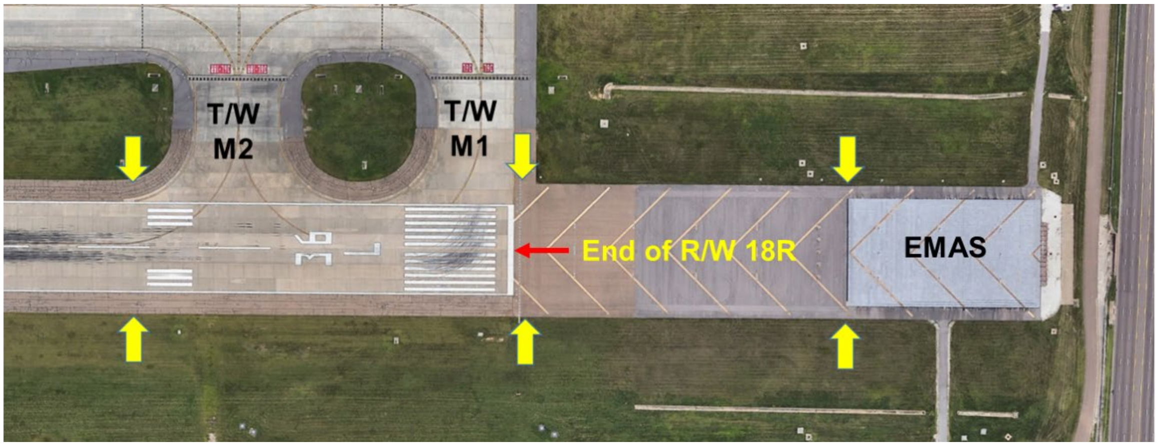

Figure 7. The RSA for Runway 18R at MEM with EMAS and EMAS Signage Locations

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.

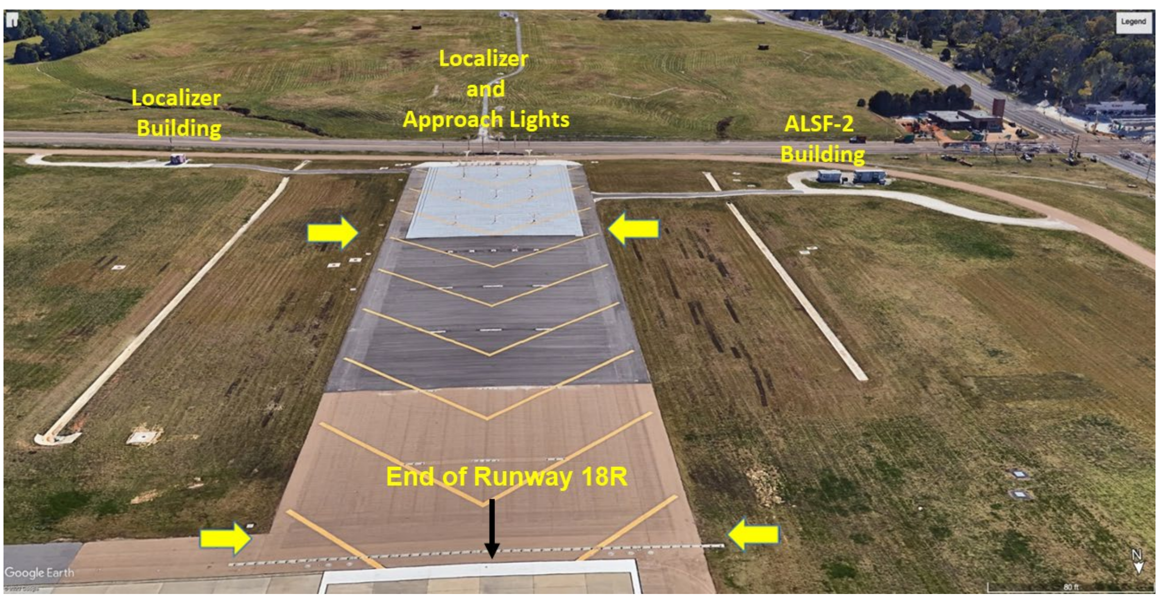

Figure 8. Obstructions in the RSA for Runway 18R at MEM Airport

<u>NEWARK LIBERTY INTERNATIONAL AIRPORT</u>

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 (35 feet) from the end of Runway 11. The placement of the yellow arrows shows only two locations for the EMAS signs: 500 feet 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.

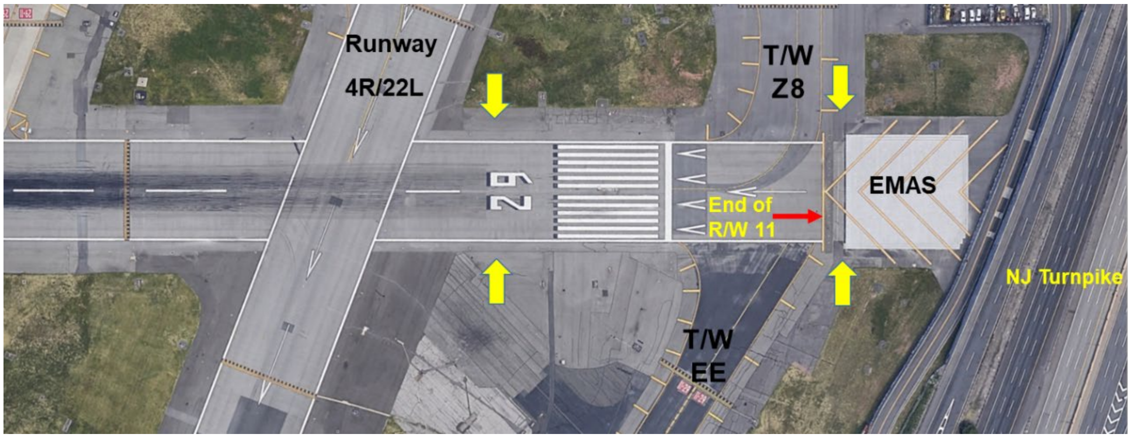

Figure 9. The RSA for Runway 11 at EWR Showing EMAS and EMAS Signage Locations

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 likely choose the left side because there is more distance prior to encountering the perimeter fencing.

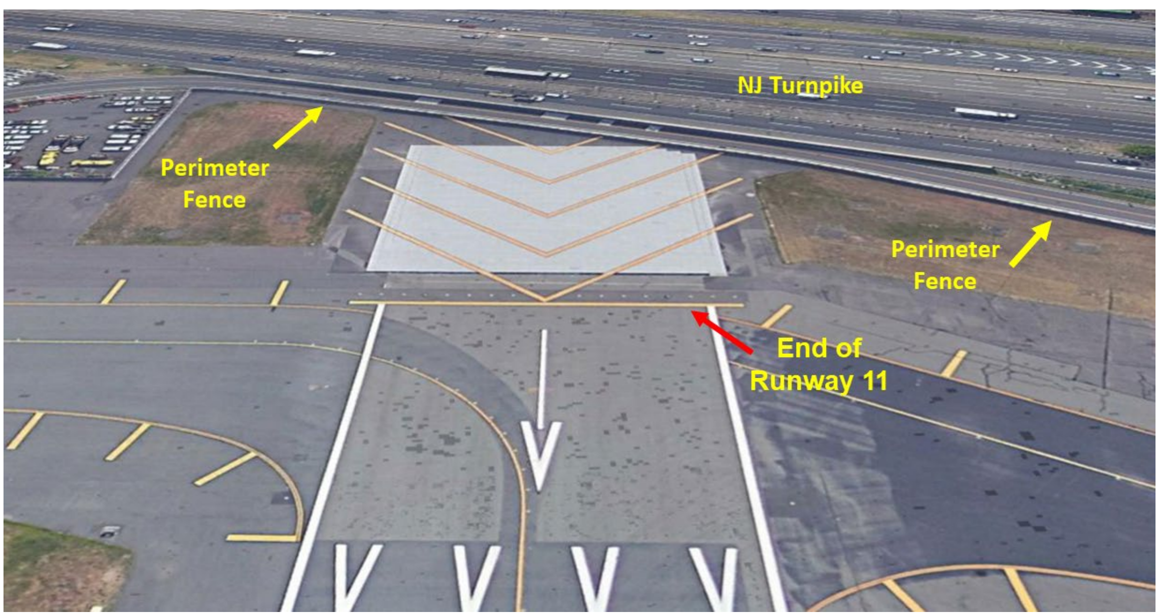

Figure 10. Obstructions in the RSA for Runway 11 at EWR

SAN FRANCISCO INTERNATIONAL AIRPORT

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

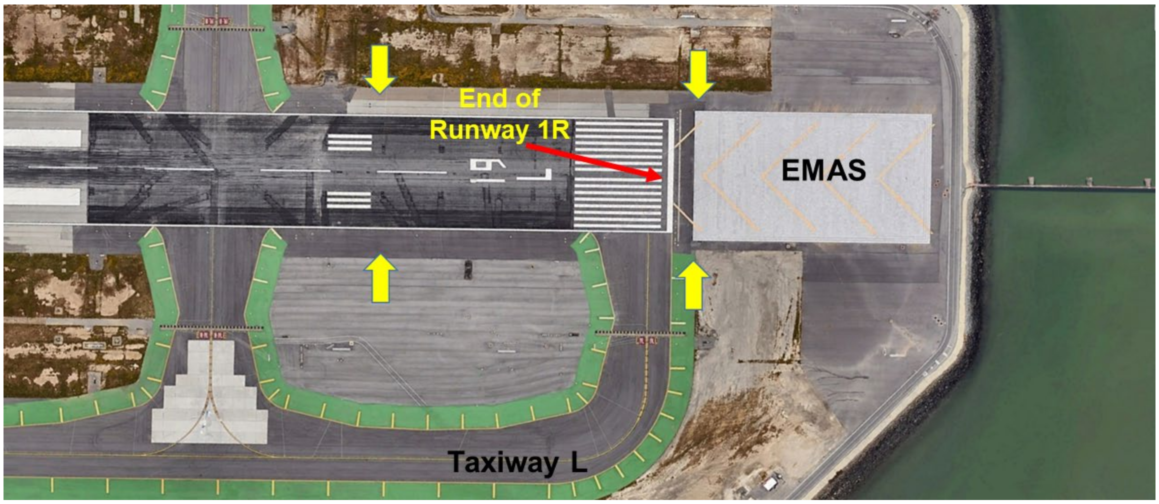

Figure 11. The RSA for Runway 1R at SFO Showing EMAS and EMAS Signage Locations

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 likely choose the right side because there is the appearance of more distance prior to encountering the seawall.

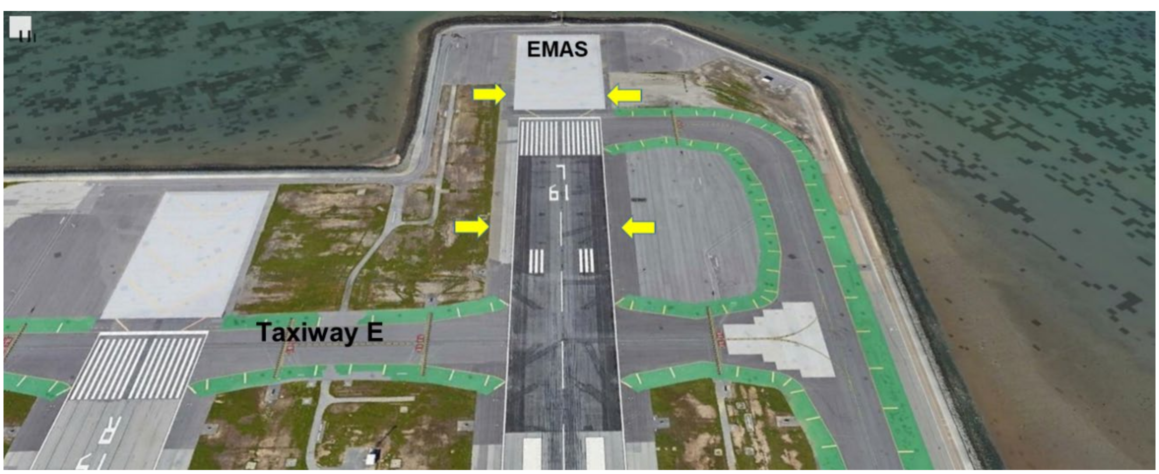

Figure 12. Aerial View of the RSA for Runway 1R at SFO Airport

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

FEDEX TEST SUBJECT POPULATION

Simulations began on April 6, 2022. Test subjects from the Basic Indoctrination (BI) class will be asked if they want to volunteer. The BI class consists of experienced test subjects who are new to FedEx. The expectation is that 20 to 25 test subjects will volunteer from each class. There are two classes a month. This process will continue until the first week of June 2022. It is expected that FedEx will provide over 100 test subjects. The procedure for capturing feedback during the testing effort from the FedEx test subjects is detailed in Appendix A.

FLIGHTSAFETY INTERNATIONAL 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.

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 Airport, and the FSI flight simulator has a high-fidelity visual representation of the airport. Runway 6 at TEB Airport was selected as a candidate for the simulations because of the RSA 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 (yellow arrows) since the EMAS is set back only 35 feet from the end of the runway.

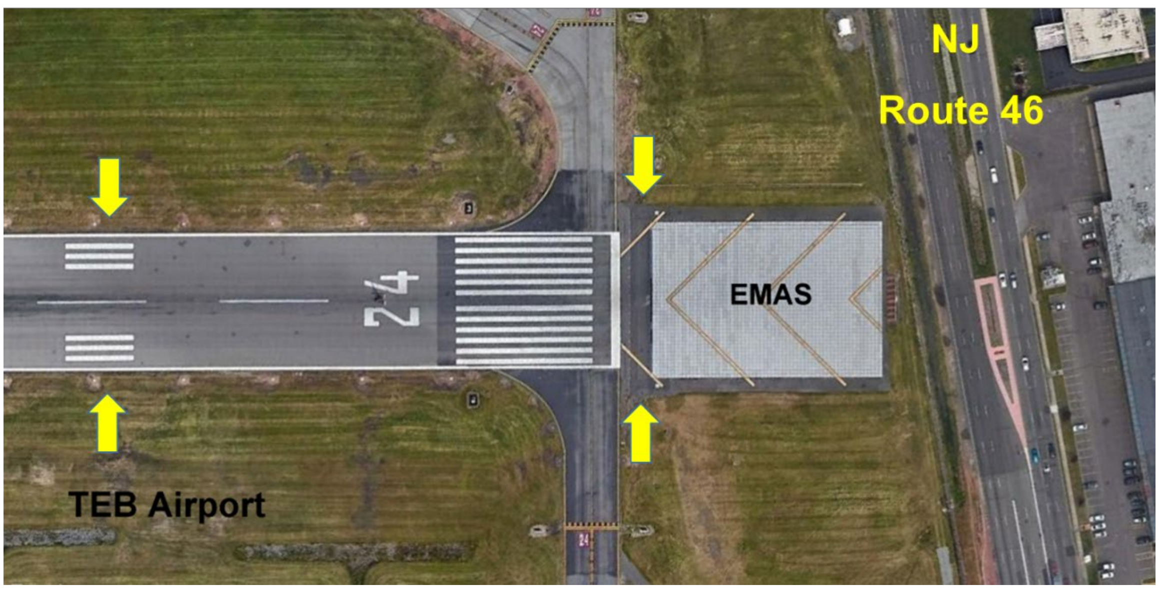

Figure 14. The RSA for Runway 6 at TEB Showing EMAS and Signage Locations

Figure 15 is an aerial view of the RSA and EMAS serving Runway 6 at TEB Airport. 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 likely choose the right side because there is the appearance of more distance prior to encountering the perimeter fencing.

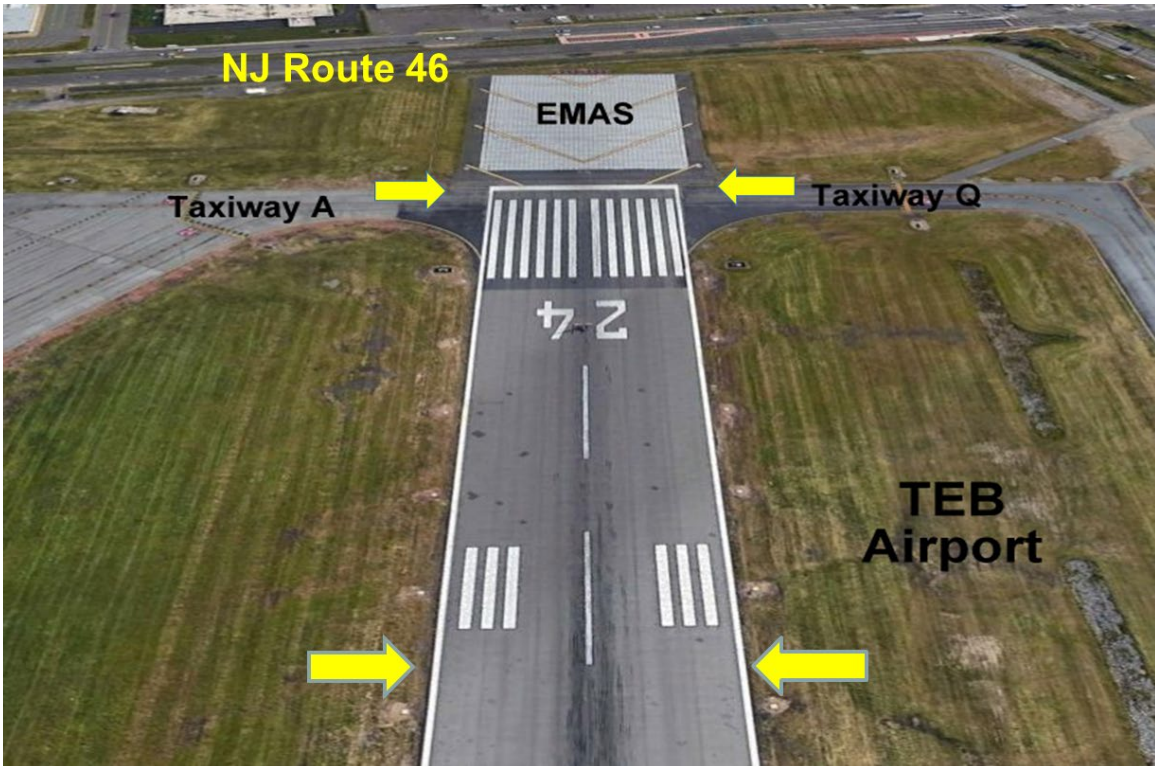

Figure 15. Aerial View of the RSA for Runway 6 at TEB Airport

SIMULATOR CAPABILITIES AT FSI

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 Airport.

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

TEST SUBJECT POPULATION FOR FSI

FSI agreed to solicit participation from test subjects that use their simulator for flight training and certification Approximately 70% (corporate and private) operate under Part 91[1] (corporate and private) and approximately 30% operate under Part 135[2] (on demand charter operations). The procedure for capturing feedback during the testing effort from the FSI test subjects is detailed in Appendix B.

RESEARCH DESIGN

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

- Optimal Sign Location
- Sign Effectiveness

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[1] 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

[2] 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, it is argued that 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.

NUMBER OF TEST PARTICIPANTS

FedEx and FSI originally estimated that they could provide at least 100 test subjects each as test subjects 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.

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 subject test is aware that EMAS is the focal point of the experiments, the element of surprise is absent, and the simulation results have little value. It is noted that 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 when conducting 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 subject's 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 here 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.

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 feasible based on the length of the runway, and it was removed from the configuration list.

Table 1 shows these configurations in tabular form.

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
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 is assigned a unique number with a corresponding configuration.

Table 2. Randomized Configurations for Sign Effectiveness Experiment at FedEx

Test Subject Identification	Configuration Number for Overrun		Test Subject Identification	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

Test Subject Identification	Configuration Number for Overrun		Test Subject Identification	Configuration Number for Overrun
045	14		095	14
046	12		096	13
047	8		097	2
048	5		098	12
049	4		099	7
050	3		100	1

Because there are 14 different configurations and only 100 expected test subjects, there will only be 7 test subjects for each configuration. 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.

SIMULATION SEQUENCING AT FEDEX

The first test subject (001) at FedEx will be assigned the configuration number 001 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 (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 014), they begin to repeat. For example, configuration 4 will be used for the second time on test subject 015. This process is repeated each time all 14 configurations are used, meaning that each configuration is used seven times for the population of 100 test subjects.

SIMULATION CONFIGURATIONS AT FSI

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 feet from the end of the runway, meaning there are only two EMAS sign locations: 500 feet 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		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

Test Subject Identification	Configuration Number for Overrun		Test Subject Identification	Configuration Number for Overrun
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

SIMULATION SEQUENCING AT FSI

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

TEB Runway 6—EMAS signs 500 feet 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 16 times for the population of 96 test subjects.

SCENARIO TO FORCE AN OVERRUN EXCURSION

FSI developed a simulation scenario wherein 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 (and enter the EMAS) or veer left or right at the end of the runway.

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) is asked to participate in additional simulations immediately following the overrun excursion simulation. They are briefed on the objective of both experiments and asked to rank optimal sign locations as a function of test subject education and awareness during normal operations.

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

FSI 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 two different sign locations. The objective for the test subject is to choose the location that best informs or reminds the test subject about the presence of the EMAS at the end of the runway.

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.

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

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

---

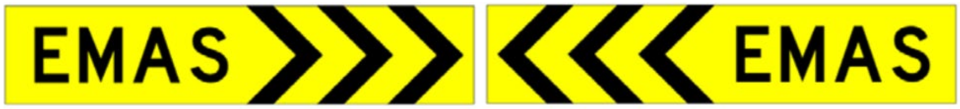
4. Did you know the function of EMAS? **Circle one**.

   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 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

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

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

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.

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" (Federal Aviation Administration, 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.

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.

DATA FROM FLIGHT SIMULATION EXERCISES AT FSI

Because of COVID-19 restrictions, actual flight simulations did not start until February 21, 2022. By March 7, 2022, FSI submitted 11 data sets to the FAA for their use. Tables 5 through 9 present a compilation of all data provided by the 11 test subjects.

The tables provide a high-level view of all responses to all the post-simulation survey questions. Certain patterns are discernable in these data sets. The identity of the test subjects cannot be derived from these tables. Table 5 is the key that explains the abbreviated table headings used in Table 6.

Table 5. Heading Key for Sign Effectiveness—Overrun Excursion Simulation

Column Label	Explanation
Test Subject	Test subject number and corresponding configuration number is from Table 4.
Config	Configuration number as defined in Table 3 and referenced in Table 4.
Location of signs	Either 500 feet before the end of the runway or at the end of the runway; either day or night
Straight or veer	Did the test subject steer straight at the end of the runway or veer left or right?
Aware of Sim Scenario	Was the test subject aware of the nature of the simulation beforehand (was subject not surprised)?
Knowledge of EMAS on Runway	Was test subject aware of the presence of EMAS at the end of the Runway?
Function of EMAS	Did the test subject understand the function of EMAS?
Notice EMAS signs	Did the test subject see the EMAS signage during the overrun?
Influence decision	If test subject saw the EMAS signs, did it influence decision-making to go straight or veer-off?
How much	If the signs did influence decision-making, by how much?
Useful during overrun	Would these signs be useful during a real life overrun?
Useful under normal ops	Would these signs be useful during normal operations, as a reminder that EMAS was present?

Table 6. Compilation of FSI Data from Sign Effectiveness—Overrun Excursion Simulation

Test Subject	Config	Location of Signs	Straight or Veer	Aware of Sim Scenario	Knowledge of EMAS on Runway	Function of EMAS	Notice EMAS Signs	Influence Decision	How much	Useful During Overrun	Useful Under Normal Operations
001	1	500–Day	Straight	No	Yes	Yes	No	NA[4]	NA	No	No
002	4	End–Night	Straight	No	No	Yes	No	NA	NA	No	Yes
003	2	500–Night	Straight	No	Yes	Yes	No	NA	NA	Yes	Yes
004	6	None–Night	Straight	No	No	No	No	NA	NA	No [1]	No
005	5	None–Day	– [3]	No	No	Yes	NA	NA	NA	No	No
006	3	End–Day	–	No	No	No	No	NA	NA	No	No
007	4	End–Night	NA [5]	No	No	Yes	No	NA	NA	No	No
008	3	End–Day	Straight	No	Yes	Yes	No	NA	NA	Yes	Yes
009	2	End–Night	Straight	No	No	Yes	No	NA	NA	No	Yes
010	6	None–Night	Straight	No	Yes	Yes	No	NA	NA	No [2]	Yes
011	1	500–Day	Straight	No	Yes	Yes	No	NA	NA	Yes	Yes

Notes:
[1] Sign was seen too late during the overrun excursion to be of any assistance.
[2] There was not time to process the sign during the overrun excursion.
[3] Two dashed (–) indicates no input from test subject.
[4] NA means not applicable (If pilots did not see the sign, it could not have an influence on decision-making).
[5] It is not clear why test subject answered this way. Indications from FSI is that all test subjects went straight at the end of the runway.

Table 7. General Comments from Test Subjects on Simulation and Decision-making Process

Test Subject	Do you want to share any thoughts about this simulation or your decision-making process to steer straight or veer-off at the end of the runway?
001	No comments
002	–
003	–
004	Too late
005	No comments
006	Enough signs looking down runway; Not noticeable
007	Nice to know EMAS was present
008	No would have gone straight
009	No
010	By the time realized it was over
011	No

Table 8. Compilation of FSI Data from Optimal Sign Location Simulation—Daytime and Nighttime

Test Subject	Day or Night	500 ft or End	Alternative Suggestion	Effective as Reminder Under Normal Operations	Effective During Overrun	General and Specific* Comments
001	Day	500 ft	Beginning	Little to none	Little to none	–
001	Night	500 ft	Beginning	Little to none	Little to none	–
002	Day	500 ft	Departure end after the fact	Moderate	Little to none	–
002	Night	500 ft	Departure end	Little to none	Little to none	Effective at what will not change planning or procedure
003	Day	End	–	Moderate	Moderate	* Bigger
003	Night	End	–	Moderate	Moderate	–
004	Day	500 ft	No	Little to none	Little to none	* Too late
004	Night	500 ft	NA	Little to none	Little to none	–
005	Day	500 ft	–	Moderate	Little to none	Tunnel vision
005	Night	Both	No	Moderate	Moderate	* If put into scan
006	Day	500 ft	Better at hold-short	Moderate	Little to none	* Better at beginning * No effect
006	Night	500 ft	Beginning of runway, not end	Little to none	Little to none	–
†007a	Day	Neither	Beginning of runway	Little to none	Little to none	* Two-person crew for daytime sim; Focused inside; focused on problem; bad location info before T.O.
†007b				Moderate		
†007	Night	500 ft	Approach end	Little to none	Moderate	Reduce level of stress sooner I saw
008	Day	500 ft	Both 500 ft and EMAS	Moderate	Moderate	* Strong if signs were bigger Even with bigger signs might not differentiate. Different color or shape
008	Night	Both	No	Little to none	Strong	* Multiple signs will not distinguish * Lighted signs less visual distractions
009	Day	500 ft	No	Strong	Moderate	* Alerting you to fact they are there * Tunnel vision
009	Night	End	No	Strong	Strong	* Points out EMAS is there *RBA

Test Subject	Day or Night	500 ft or End	Alternative Suggestion	Effective as Reminder Under Normal Operations	Effective During Overrun	General and Specific* Comments
010	Day	500 ft	1000-ft marks more time to react	Strong	Little to none	* Actual sign provides reminder * No time to react
10	Night	End	No	Strong	Little to none	* Provide situation awareness
011	Day	End	NA	Strong	Little to none	* EMAS at end * See it taking active at other end * Going off end no matter what so signs don't matter
011	Night	End	End of runway	Moderate	Little to none	* Reminder * Not helpful * Signs not going to help if going off

Notes:
†Test subject 007 appears to have two inputs during the daytime simulation.
* Specific comments provided by test subjects.

Table 9. Demographics of Test Subjects

Test Subject	Usual Type Aircraft	Number of Hours	How Did You Learn About EMAS	Plan Different if No EMAS	Preflight Planning Docs
001	–	–	–	–	–
002	2000S	8000	Industry journal	No	Do not use EMAS as a consideration
003	Falcon 2000	2000	Flight school	No	Airport Diagram
004	Falcon 2000	300	From experiment	No	NOTAMs
005	Falcon 2000	600	School	No	Nothing
006	2000 LX	300	Didn't	No	Don't know
007a	LXS 2000	800	Bus ex stuck incident	No	Jepps
007b	LXS 2000	1200			
008	F 2000 LXS	800	Safety officer	No	10-9s; Third-party Foreflight
009	F 2000S	450	Don't remember	No	Foreflight
010	2000 Easy	2000	TEB overrun	No	Jepps/AFD
011	F 2000 LXS	150	Don't remember	No	Don't use; don't brief

NOTAM = Notice to Airmen
AFD = Airport Facility Directory

DATA ANALYSIS

The 11 data sets from FSI provided information about the effectiveness of EMAS signage during a simulated overrun excursion from the test subject's perspective, and the test subjects' preferences regarding the location of these signs along the runway. Below is a summary of the some of the key findings from these data sets.

SUMMARY OF DATA FROM SIGN EFFECTIVENESS SIMULATION

- All six configurations were used twice except for configuration 5, which was used only once.
- Eight of eleven test subjects indicated they went straight at the end of the runway; two did not respond; and one responded not applicable (NA). Informal information from FSI is that all 11 test subjects went straight at the end of the runway during the emergency overrun scenario.
- All 11 test subjects indicated they were not aware of the nature of the simulation beforehand.
- Six test subjects did not know that an EMAS was present at the end of Runway 6 at TEB; five test subjects were aware of the EMAS on Runway 6.
- Nine test subjects knew the function of EMAS; two did not.
- Ten test subjects indicated that they did not see the EMAS signage during the overrun excursion; one gave an NA response. It is assumed that this NA response meant that the test subject (007) did not see the sign. The simulations for test subjects 004, 005, and 010 did not include EMAS signage.
- Since all 11 test subjects did not see the sign, the signs did not influence their decision-making.
- Eight test subjects indicated that the signs would not be useful during an actual overrun excursion; three indicated that the signs would be useful. One test subject commented that any sign would be "too late." One other test subject commented that there would not be (enough) time to process.
- Six test subjects indicated that the EMAS signage would be useful during normal operations; five indicated that the signs would not be useful during normal operations.
- Five test subjects provided comments on the simulation exercise and their decision-making process. They indicated that the signs would either be unnoticeable or that they would provide information too late to influence the test subject's decision-making.

FINDINGS FROM SIGN EFFECTIVENESS SIMULATION

- Test subjects did not see the EMAS signs during a simulated overrun excursion, so it was not a factor in their decision-making to steer straight at the end of the runway. This was not an unexpected result. As indicated by test subject commentary, the signs would not be noticeable under high-stress conditions where the test subject is focused on what is directly ahead and not to the sides of the runway. It is likely that the only way a test subject would see this sign would be during a veer-off maneuver when the sign would come into the foveal view, or direct line of sight.

- Most (6 of 11) did not know that there was an EMAS serving Runway 6 at TEB. This indicates that more effort should be placed on test subject awareness regarding the presence of EMAS on a runway.
- Most (9 of 11) knew the function of EMAS. This indicates widespread knowledge of EMAS.
- Most (8 of 11) think the signs would not be useful during an actual overrun. This is not surprising since that they did not see the sign during the overrun excursion. Additionally, these signs are still in the conceptual form, not present at any airport, and therefore unfamiliar to test subjects.
- Most (6 of 11) think the signs would be useful during normal operations. This is in line with theory that the signs will build awareness over time as they are viewed repeatedly as pilots' taxi past them.
- EMAS signage, if noticed at all, is unlikely to provide information in time to the test subject for proper action during an emergency overrun excursion.

SUMMARY OF DATA FROM OPTIMAL SIGN LOCATION SIMULATION—DAYTIME

1. When asked to choose between two EMAS sign locations (500 feet from end of runway or at the end of the runway) most (8 of 12[3]) test subjects preferred the 500-ft location; two selected the end of the runway; and one selected neither. One test subject also mentioned bigger signs.
2. When asked if they had an alternative location, four preferred a location near the beginning of the runway (i.e., hold short or departure end of runway), one preferred both the 500-ft and EMAS locations, and one preferred a location 1,000 feet from the end of the runway. Five test subjects did not comment.
3. When asked if EMAS signs would be effective as a reminder that an EMAS was present on the runway during normal operations, most (9 of 12) indicated that the signs would have a moderate (6 of 9) to strong effect (3 of 9), three indicated the effect to be little to none.
4. When asked if EMAS signs would be effective during an actual overrun, most (9 of 12) indicated that the signs would have little to no effect and three indicated a moderate effect.

SUMMARY OF DATA FROM OPTIMAL SIGN LOCATION SIMULATION—NIGHTTIME

1. When asked to choose between two EMAS sign locations (500 feet from end of runway or at the end of the runway), five of eleven test subjects preferred the 500-ft location; four

[3] There were two test subjects for test subject 007.

selected the end of the runway; and two selected both locations. One test subject also mentioned bigger signs.

2. When asked if they had an alternative location, four preferred a location near the beginning of the runway; one suggested the end of the runway, which is not valid since it is one of the standard choices. Most (7 of 11) did not comment or provide a valid alternative location.

3. When asked if EMAS signs would be effective as a reminder that an EMAS was present on the runway during normal operations, most (6 of 11) indicated the signs would have little to no effect, three indicated a moderate effect, and two indicated a strong effect.

4. When asked if EMAS signs would be effective during an actual overrun, most (6 of 11) indicated that the signs would have little to no effect, three indicated a moderate effect, and two indicated a strong effect.

FINDINGS FROM OPTIMAL SIGN LOCATION SIMULATIONS

1. Daytime results favored the 500-ft location (8) with the rest being divided between runway end (2) and neither location (1). Nighttime results were more evenly split between the 500-ft location (5), runway end (4), and both locations (2). The data do not identify why the ratios are different between day and night.

2. While soliciting alternative sign locations, four test subjects during the daytime simulation and four test subjects during the nighttime simulation suggested a location near the beginning of the takeoff location. This result may be driven in part because the simulated runway excursion included a takeoff/rejected takeoff procedure as opposed to a landing sequence.

3. More daytime test subjects (9) indicated that the signs would be useful during normal operations than nighttime test subjects (5). The data does not help identify why there is a significant difference between daytime and nighttime.

4. More nighttime test subjects (5) indicated that the signs would be useful during an actual overrun than daytime test subjects (3). The data do not identify why there is a difference between daytime and nighttime results.

5. It is noteworthy that only three test subjects in the Sign Effectiveness emergency overrun simulations indicated that the signs would be helpful during an actual overrun. Even after seeing the signs during the Optimal Sign Location simulation, there was no improvement during the daytime and only a slight improvement at nighttime.

FINDINGS FROM DEMOGRAPHIC SURVEY

1. All test subjects that responded (10 of 11) reported their usual aircraft type as a Dassault Falcon 2000.

2. The average number of hours of experience on that type aircraft was approximately 1,500 hours, with a range from 300 hours to 8,000 hours and a median of 800 hours.

3. Given that most participants (9 of 11) knew the function of EMAS, the source of that knowledge varied: flight school, journals, EMAS incidents, or a safety officer.

4. None of the test subjects plan differently if EMAS is not present at airports where they operate. The implication here is that if they remember that an EMAS is present, they will use it if necessary.

5. The test subjects reported a wide variety of preflight planning documents: Jeppesen charts, Airport Diagrams, and an integrated third-party application called ForeFlight.

CONCLUSIONS

1. There are not enough data to formulate any meaningful conclusions regarding the effectiveness of EMAS signage during a simulated overrun or the optimal location to inform test subjects regarding its availability at an airport.

2. Although most test subjects knew the purpose of EMAS, most did not know that EMAS was available during the simulation.

3. Early indications from test subject feedback is that EMAS signs are more useful during normal operations than during an actual overrun.

4. Test subjects prefer the EMAS signage be placed at 500 feet before the end of the runway as opposed to the end.

5. If given the option, a number of the test subjects prefer the signs at the beginning of the takeoff run.

RECOMMENDATIONS

It is recommended that researchers continue data collection from FSI and FedEx until there are at least 100 data sets from each research partner. Continuing data collection will add more validity to the conclusions drawn in this report. More data sets may also uncover other possible placements for the signs, which were not a part of the original experiment (Conclusion point #5).

Given early data trends, researchers should also consider locating the EMAS signs at the beginning of the runway in addition to the other proposed locations. The signage near the end of the runway will inform test subjects about the presence of EMAS each time they complete a landing. The signage near the beginning of the runway will inform test subjects about the presence of EMAS each time they depart from that runway. These repeated exposures to EMAS signage can help improve pilot familiarity with EMAS and inform pilots about the availability of EMAS during an overrun excursion.

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APPENDIX A—FEDERAL EXPRESS CHECKLIST

Appendix A shows the FedEx 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 FedEx Checklist (Appendix A of this report) has its own separate appendices not to be misconstrued with the three appendices in this report (Appendix A—FedEx Checklist, Appendix B—FSI Checklist, and Appendix C—Institutional Review Board Approval).

CHECKLIST FOR FEDEX 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**. *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 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 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.*	
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.**	

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 - 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 <u>**where the overrun simulation was conducted**</u>, either MEM or 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 airport 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 airport 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.	
24	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.	
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 day and night 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, diagnostic test being used in the study, disclose that they 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 'Confidentially' 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		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 CLT Runway 18C
    b. SFO 1R departure with planned landing at LAX Runway 25R
    c. Standard Atmosphere (Calm winds, 29.92inHg, 15C, Dry runway)
    d. ZFW = 500,000
    e. 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 @150kts L or R
    c. Control Column Breakout – Pitch L or R @150kts
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 _______**

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

Steer straight Veer-off left Veer-off right

---

12. 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.

---

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

YES NO

---

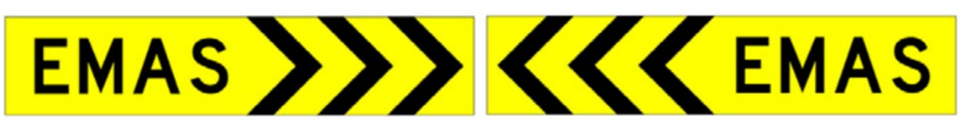
14. Did you know the function of EMAS? **Circle one**.

YES NO

---

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

YES NO



Page 1

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

YES NO

---

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

Little to None Moderate Strong

---

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

YES NO

---

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

YES NO

---

20. 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.

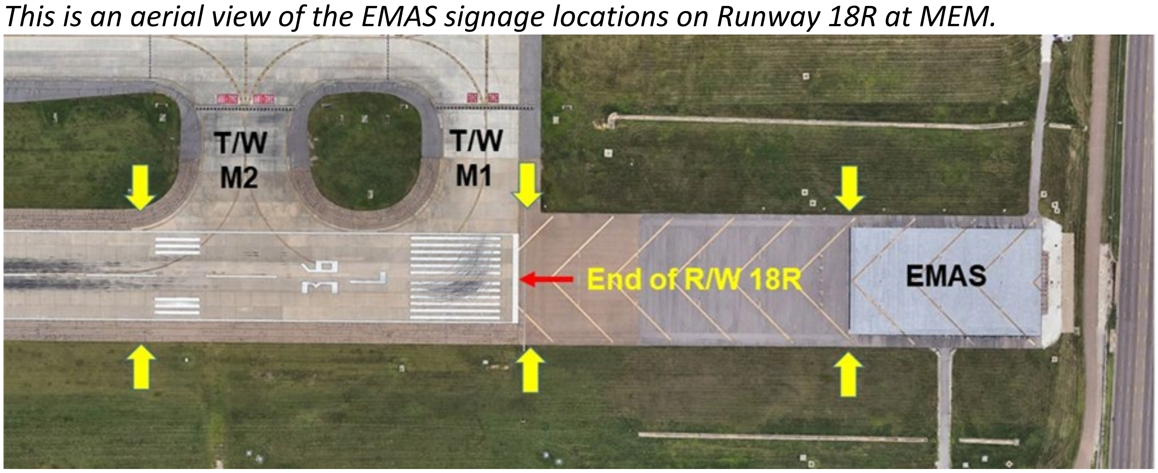
Next, we are requesting your voluntary participation in additional tests that are designed to solicit pilot input regarding the location of the EMAS signage that best informs a pilot about the presence of EMAS at the end of a runway.

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

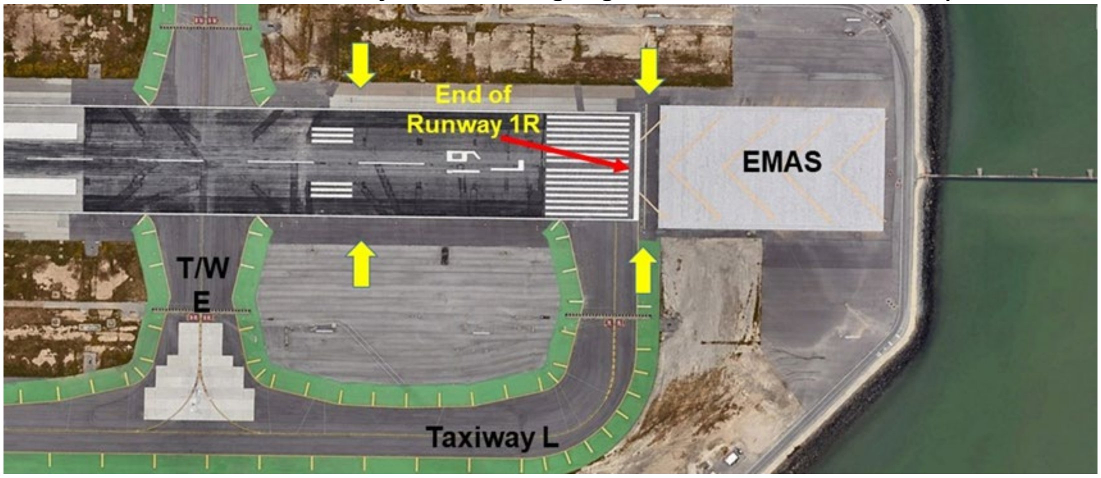
- *At the beginning of the EMAS bed (MEM only)*
- *At the end of the runway*
- *500 feet inboard from the end of the runway*

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

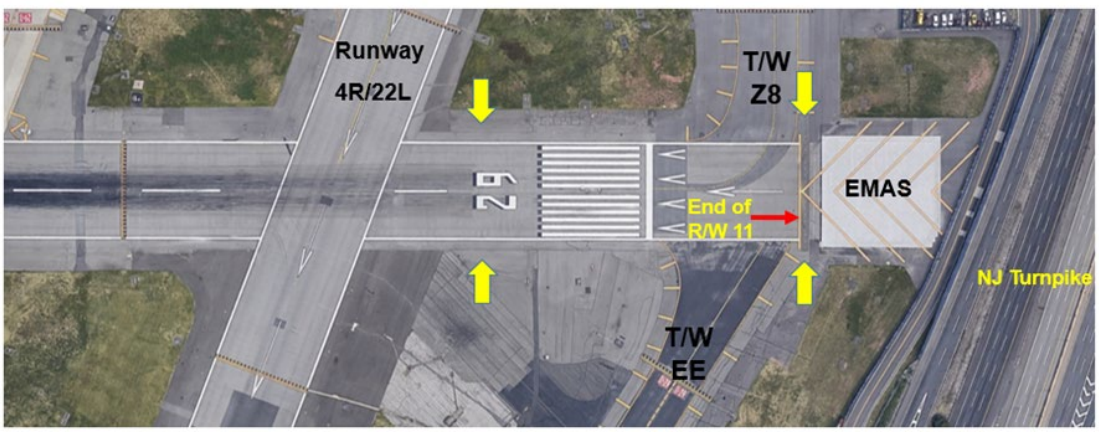
This is an aerial view of the EMAS signage locations on Runway 18R at MEM.



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 ______

6. 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

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

8. 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:

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

Little to None Moderate Strong

Please provide your rationale:

10. 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 ______

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

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

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

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

10. 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

Appendix B shows the 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 (Appendix B of this report) has its own separate appendices not to be misconstrued with the three 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 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 - 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. 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 feet 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 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)

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, diagnostic test being used in the study, disclose that they 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 'Confidentially' 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

6. The simulator will be configured in one of the six different configurations shown in Appendix D.
7. 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 LGA Runway 13.
8. Due to construction at the beginning of TEB Runway 6, the departure will commence approximately 450 feet from the departure end of Runway 6.
9. At the beginning of this simulation, the Falcon 2000 LXS aircraft, cargo, and fuel will weigh 42,800 pounds.
10. The departure flap configuration will be SF1.
11. The required distance for a successful departure under these conditions is approximately 5,350 feet and the available distance for takeoff will be 5,550 feet.

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 _______**

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

Steer straight Veer-off left Veer-off right

---

22. 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.

---

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

YES NO

---

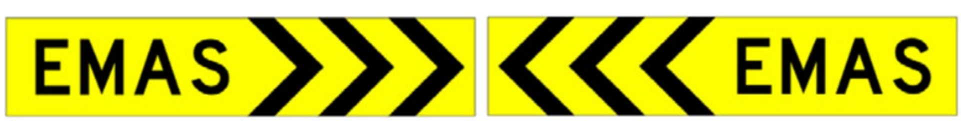
24. Did you know the function of EMAS? **Circle one**.

YES NO

---

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

YES NO



Page 1

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

YES NO

---

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

Little to None Moderate Strong

---

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

YES NO

---

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

YES NO

---

30. 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):

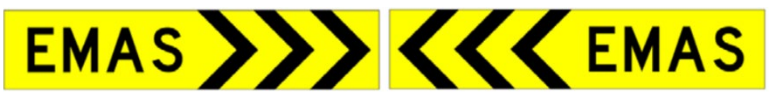
Congratulations on completing the emergency overrun scenario and thank you for your feedback. This completes the first experiment, where the goal was to assess the effect of EMAS signage on your decision-making process during an emergency overrun excursion.

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.

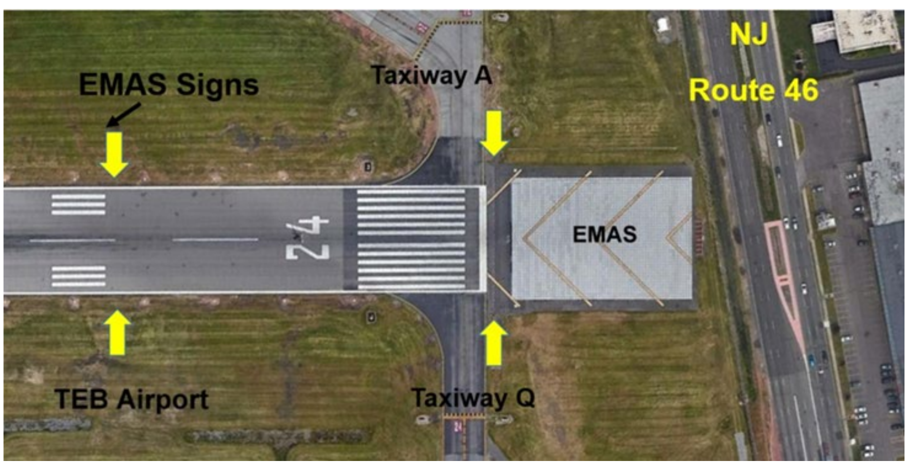
The simulator will be configured to show the EMAS signage at two locations:

- At the end of Runway 6
- 500 feet 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)____

11. 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

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

13. 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:

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

Little to None Moderate Strong

Please provide your rationale:

15. 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

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

6. 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:

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

Little to None Moderate Strong

Please provide your rationale:

8. Additional comments:

END OF QUESTIONAIRE 3

APPENDIX J (Step 18)

Demographic Survey

Test Subject Number ______

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

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

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

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

15. 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 COR that this board has reviewed your research proposal and hereby approves it under the authority of FAA order 9500.25B and the delegated authority from the FAA IRB to operate a local Institutional Review Board. 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.