Research on Frangible Connections and Structures

Presented to: IESALC Fall Technology Meeting

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FAA Research on Frangible Connections and Structures

- FAA Airport Technology R&D
- Select Engineering Services (SES)
- Applied Research Associates (ARA)

Joint Airfield Frangibility Study Group

Research Objective

- **The overall objective of this research is to develop a better methodology for measuring and evaluating the frangibility characteristics of connections/structures intended for use on Airport Runway Safety Areas (RSAs) and Taxiway Safety Areas (TSAs).**
- **The FAA Frangibility Guidebook was Developed to Prescribe these Methodologies for Measuring and Evaluating Frangible Characteristics in Connections/Structures Located in RSAs and TSAs.**

Research Elements

- **FAA Frangibility Requirements Review**
- **Full Scale Testing**
- **Finite Element Simulation**
- **Development of FAA Frangibility Guidebook**

FAA Advisory Circulars Containing Frangibility Criteria

AC 70/7460-1	Obstruction Marking and Lighting	L	12/04/2015
AC 150/5300-13	Airport Design	A	09/28/2012
AC 150/5220-23	Frangible Connections	NR	04/27/2009
AC 150/5340-30	Design and Installation Details for Airport Visual Aids	H	7/21/2014
AC 150/5345-26	Specification For L-823 Plug and Receptacle, Cable Connectors	D	9/30/2008
AC 150/5345-27	Specification for Wind Cone Assemblies	E	09/26/2013
AC 150/5345-28	Precision Approach Path Indicator (PAPI) Systems	G	09/29/2011
AC 150/5345-44	Specifications for Runway and Taxiway Signs	K	10/08/2015
AC 150/5345-45	Low-Impact Resistant (LIR) Structures	C	04/06/2007
AC 150/5345-46	Specification for Runway and Taxiway Light Fixtures	E	03/02/2016
AC 150/5345-53	Airport Lighting Equipment Certification Program	D	09/26/2012
EB-79A	Determining RSA NAVAID Frangibility and Object and Fixed-By-Function Requirements		01/21/2016

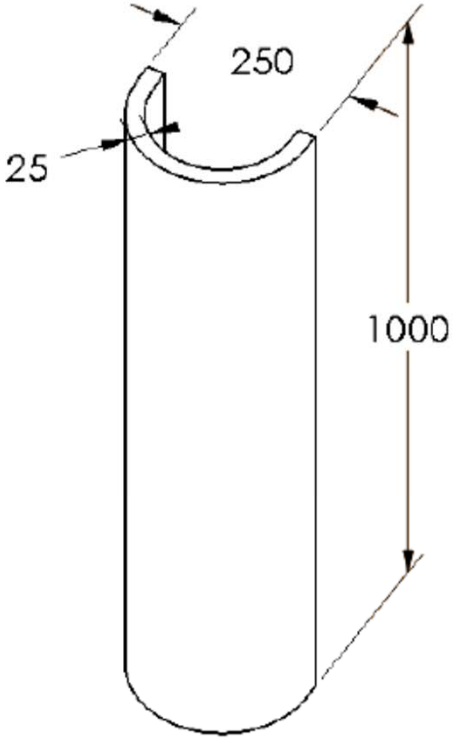
Frangible Structures Included in Testing

- **FAA Approved Approach Lighting Systems**
- **Frangible Configuration of the End Fire Glide Slopes (EFGS)**
- **Mounting Configuration of Approach Lighting System located in the EMAS.**

Frangibility Testing

Current FAA Criteria

- **Test System and Setup**
  - Aircraft mass of 6613.8 pounds (3000 kg)
  - Traveling at 75.6 knots (140 kph)
  - Impactor must be Semi-circular steel tube (rigid body) with dimensions of 3.28 ft (1.0 m) long or 5 times the cross section of tower, 9.8 in (250 mm) diameter, and 1.0 in (25 mm) wall thickness
  - Load cells mounted as closely as possible to impactor. Minimum recording rate of 10 kHz
  - High speed video to verify aircraft direction would not be adversely affected by structure
  - Impact Location: 13.1 ft (4 m) above grade or 3.28 ft (1 m) from top, whichever is higher.



Frangibility Testing (Continued)

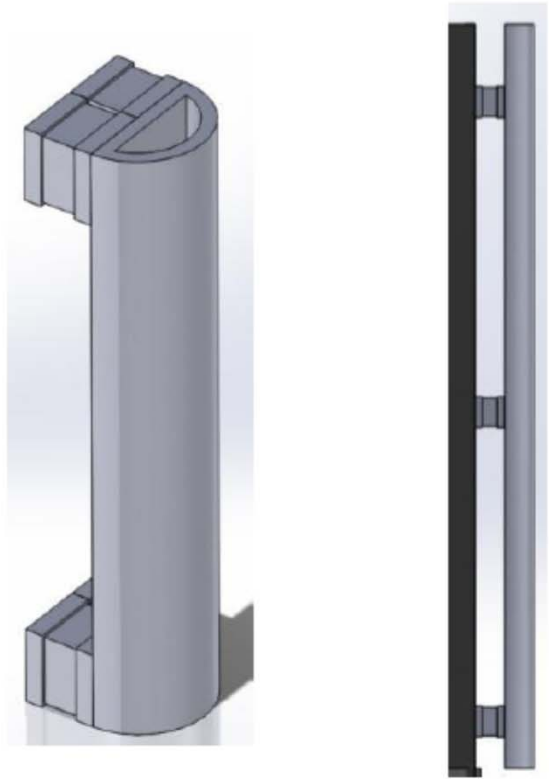
Current FAA Criteria

- Approval Criteria
  - LIR structure must not exert a force greater than 10,116 lbf (45 kN)
  - Maximum energy imparted to aircraft should not exceed 40,566 ft-lb (55 kJ)
  - Failure mode must be fracturing , windowing, or bending
  - Electrical cabling must separate, not impede failure
  - No large fragments that could damage other parts of aircraft

Frangibility Testing (Continued)

Test System and Setup

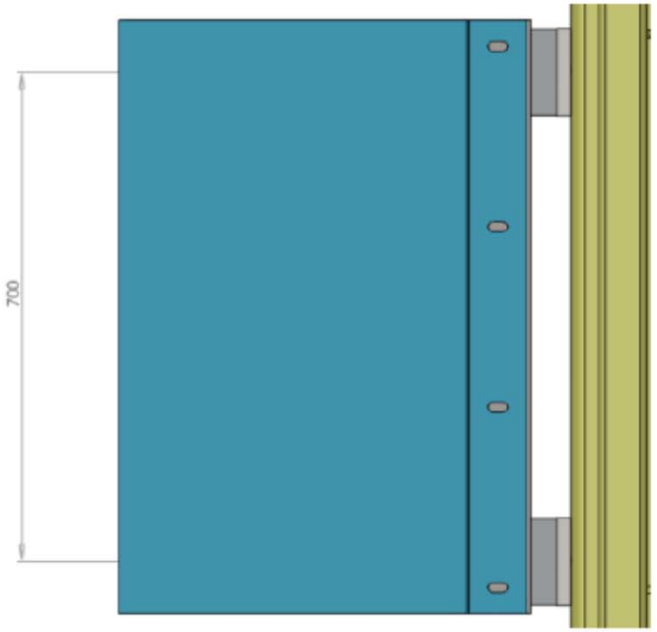
- Instrumentation
  - Past tests have included a variety of load cell configurations
  - Typically single axis load cells were used
  - Some attempts to capture side forces were done by putting load cells next side by side.
  - Using multiple load cells for longer impactors.



Frangibility Testing (Continued)

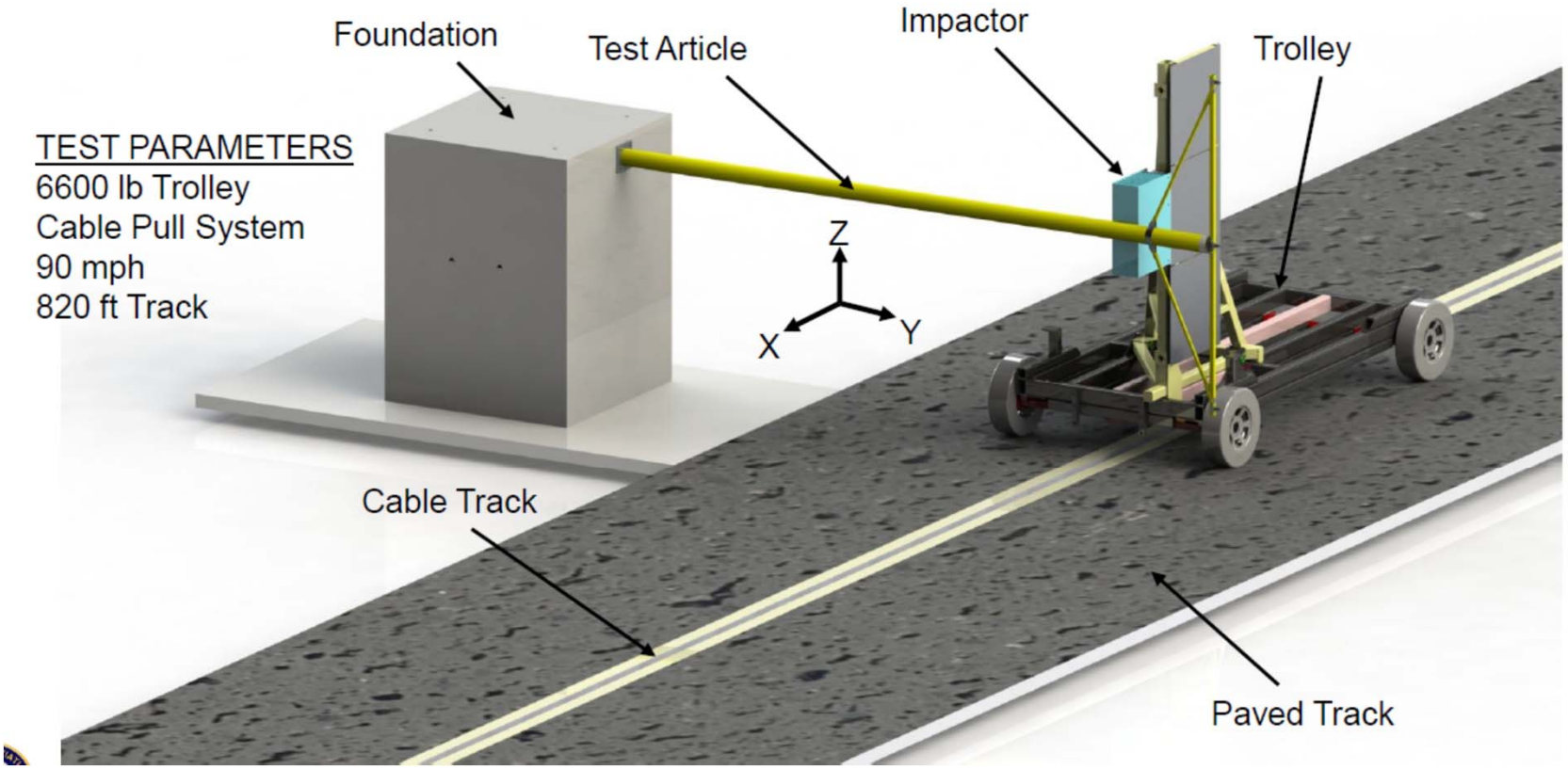
Test System and Setup

- Final Instrumentation
  - Tri-axial load cells
  - Max two load cells per impactor
  - Spacing should be no larger than 1 meter
  - Minimize weight in front of load cells (no greater than 55 pounds (25 kg)
  - Record data at 20 kHz
  - Use High Speed video at a minimum of 1000 fps
  - Video must capture failure mode and time of impact



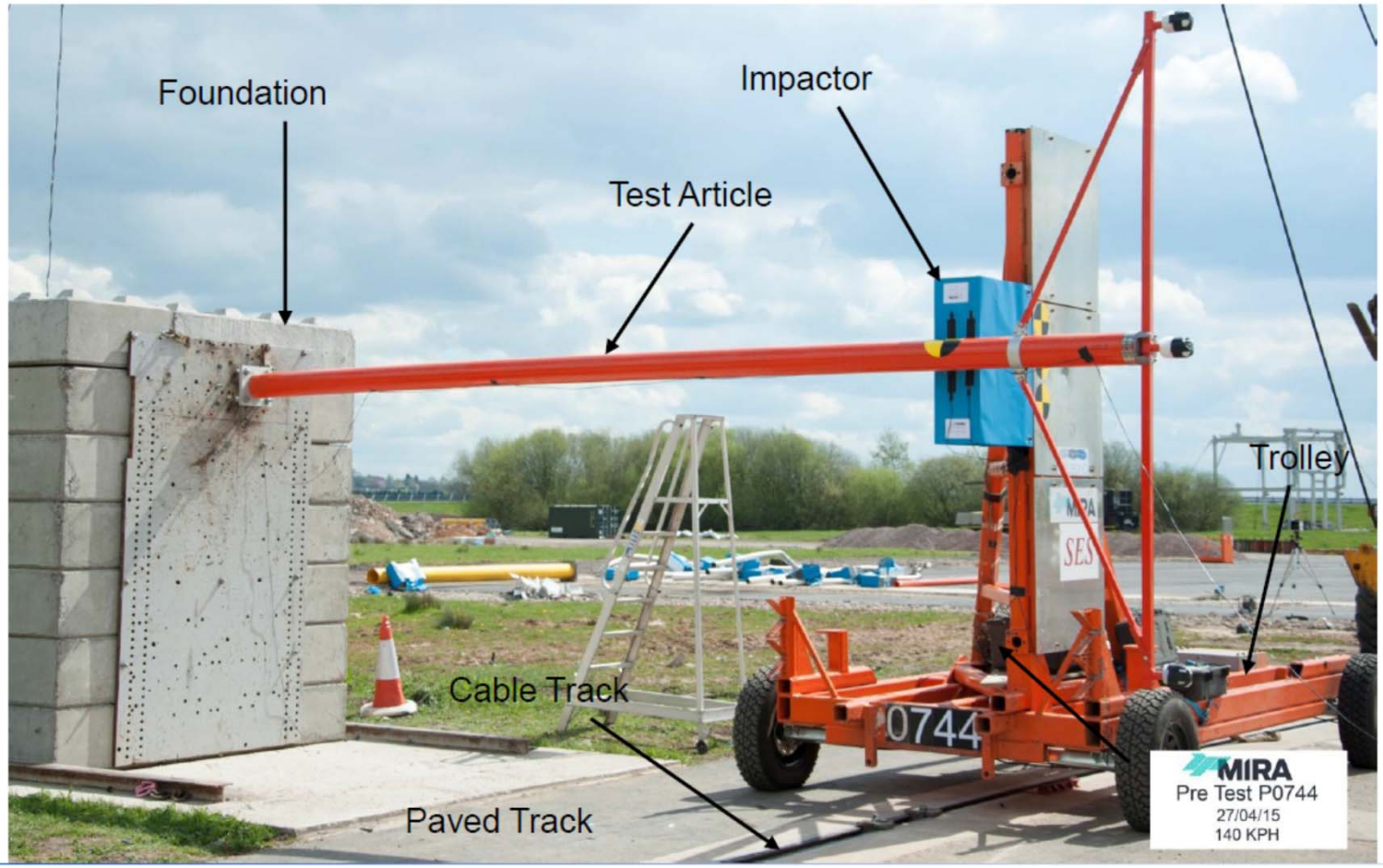
Frangibility Testing (Continued)

Full Scale Testing



Frangibility Testing (Continued)

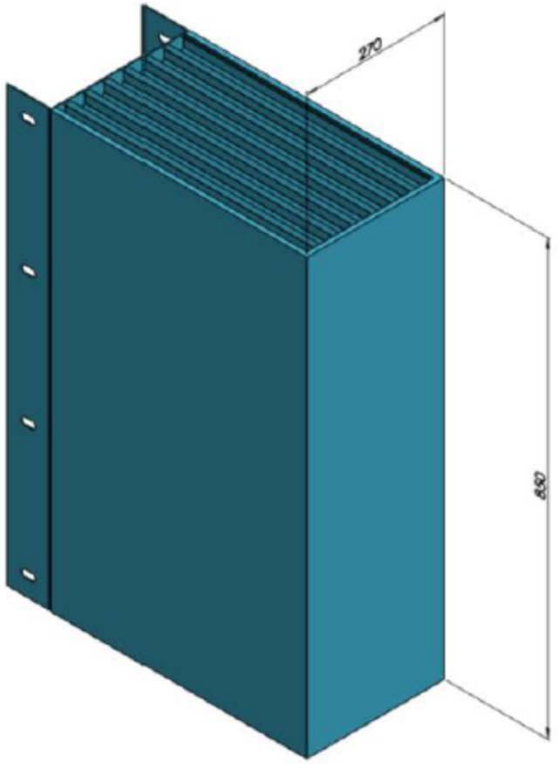
Full Scale Testing



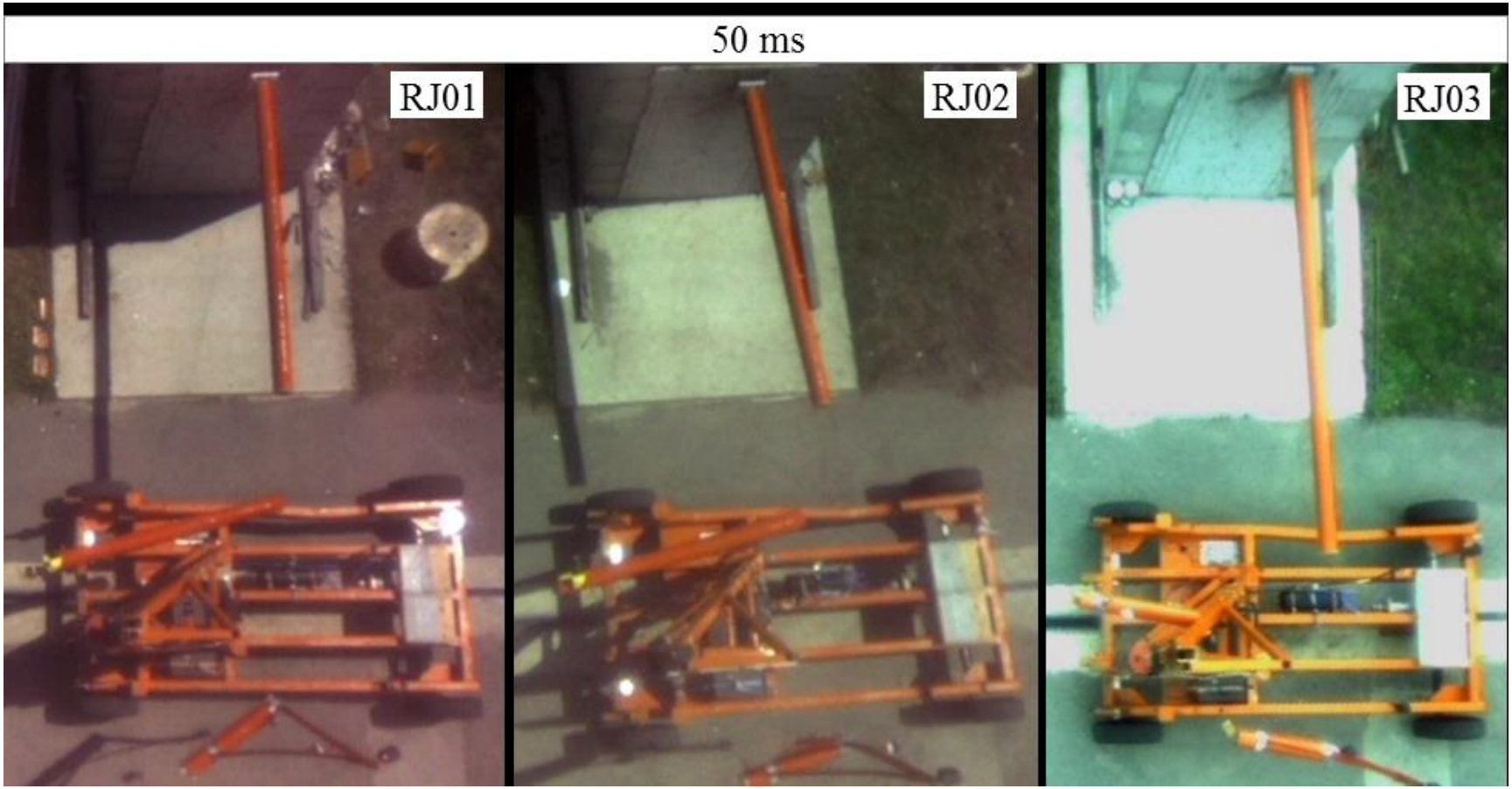
Frangibility Testing (Continued)

Test System and Setup

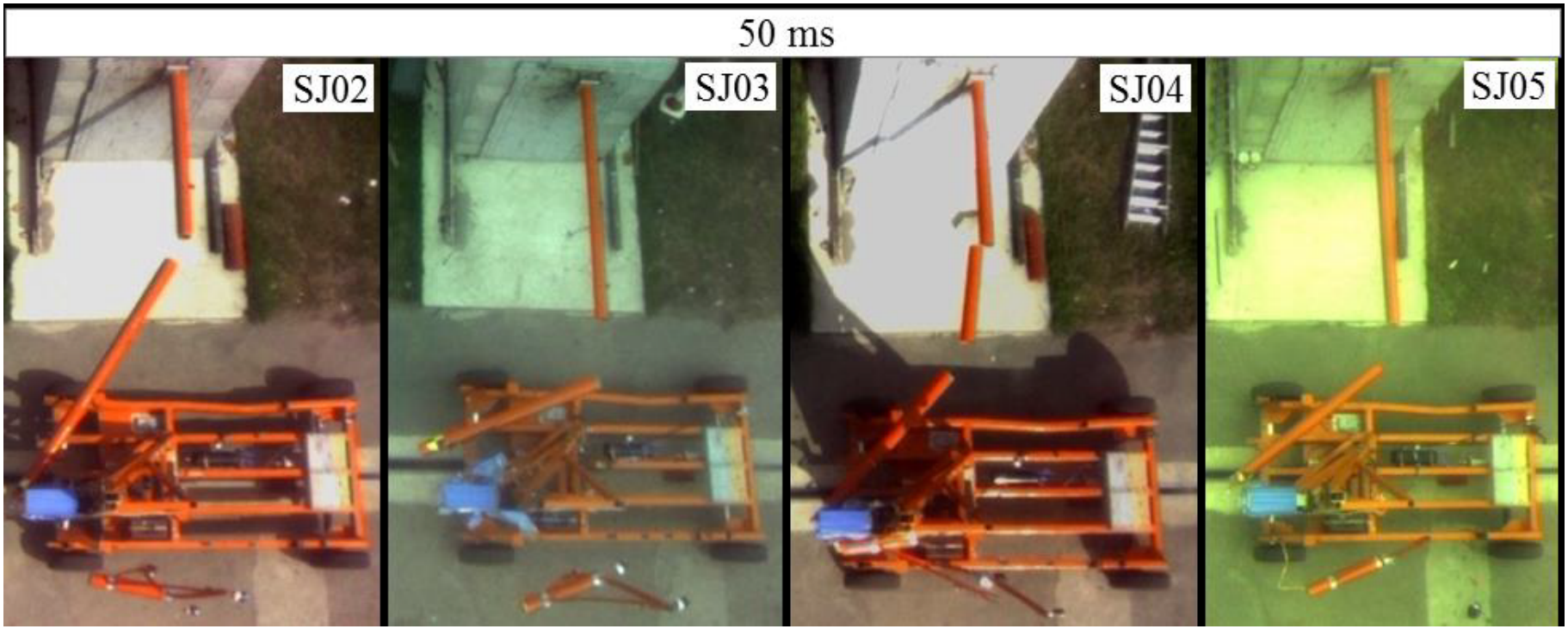
- Impactor Design
  - Using a rigid impactor does not produce the same results as a deformable impactor such as an airplane wing.
  - To use a deformable impactor, it must be repeatable in order to establish a standard.
  - Honeycomb impactor are repeatable, customizable, and inexpensive to produce.
  - Crush Strength was designed to match the Piper Navajo at wing station 147.5



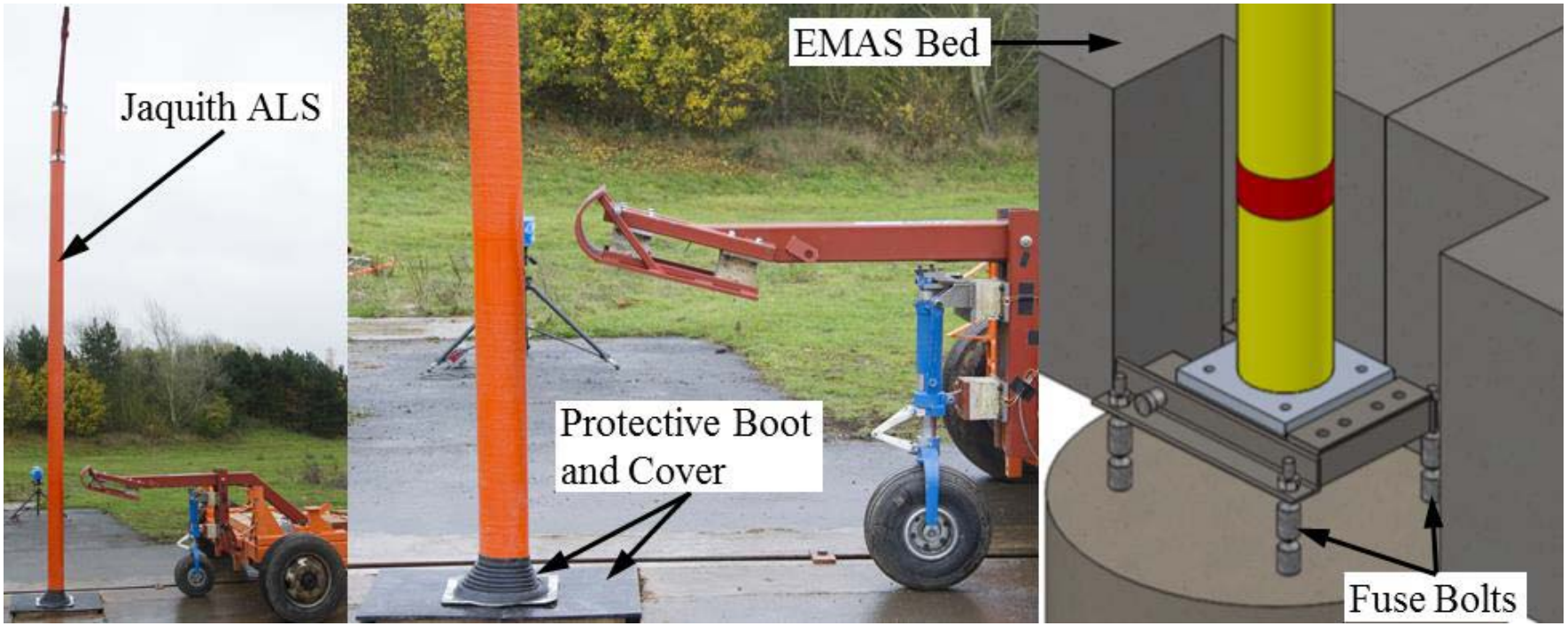
Impact with Rigid Impactor



Impact with Soft Impactor

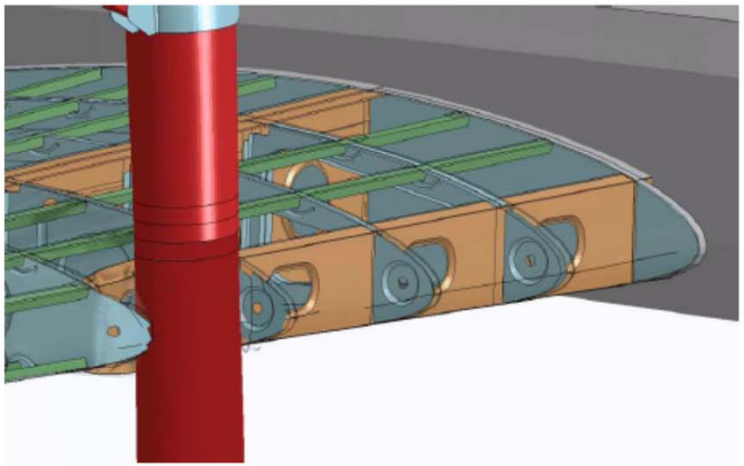


Testing of ALS in EMAS



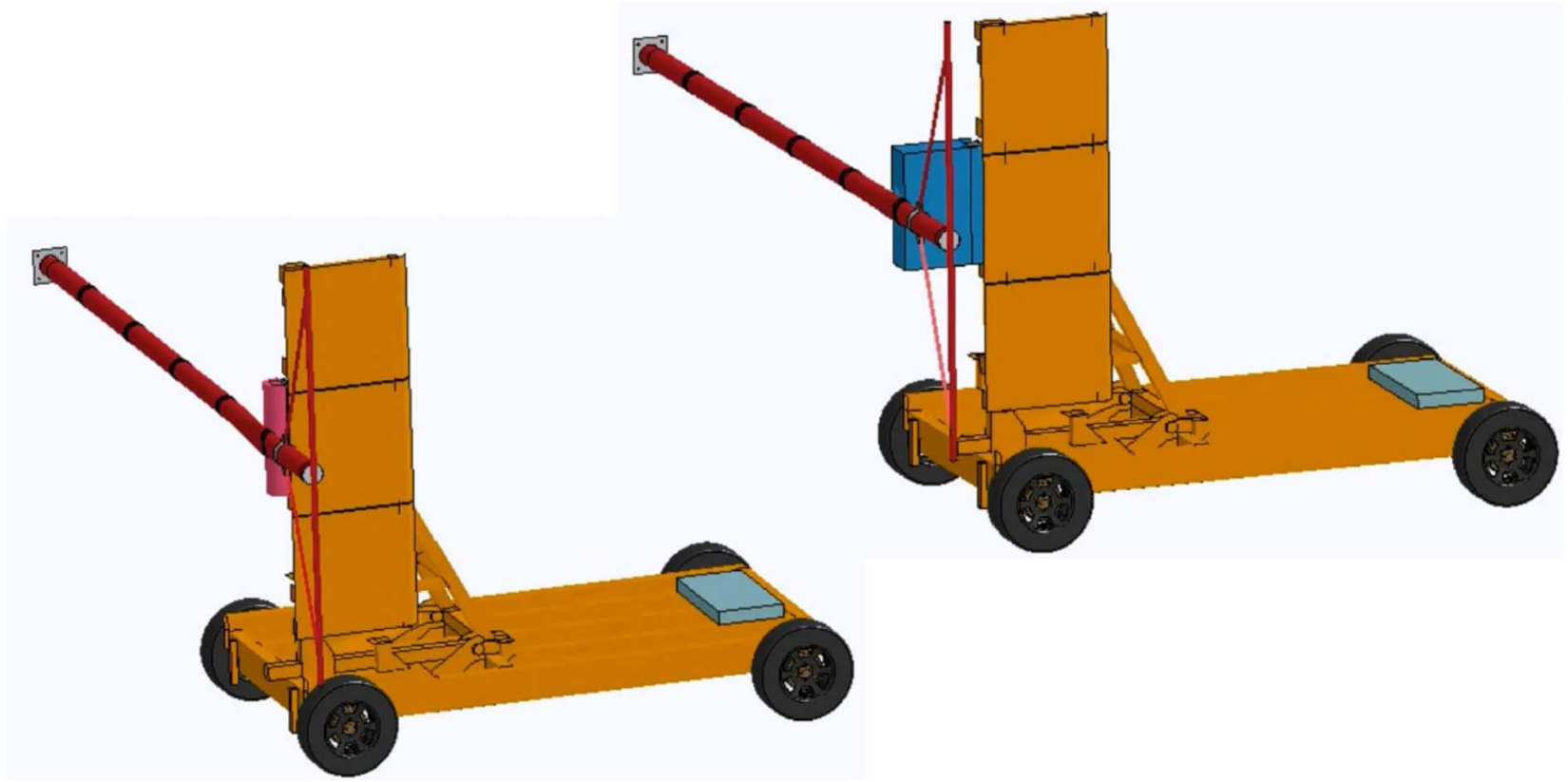
FAA Frangibility Study

Aircraft simulation with LIR structure



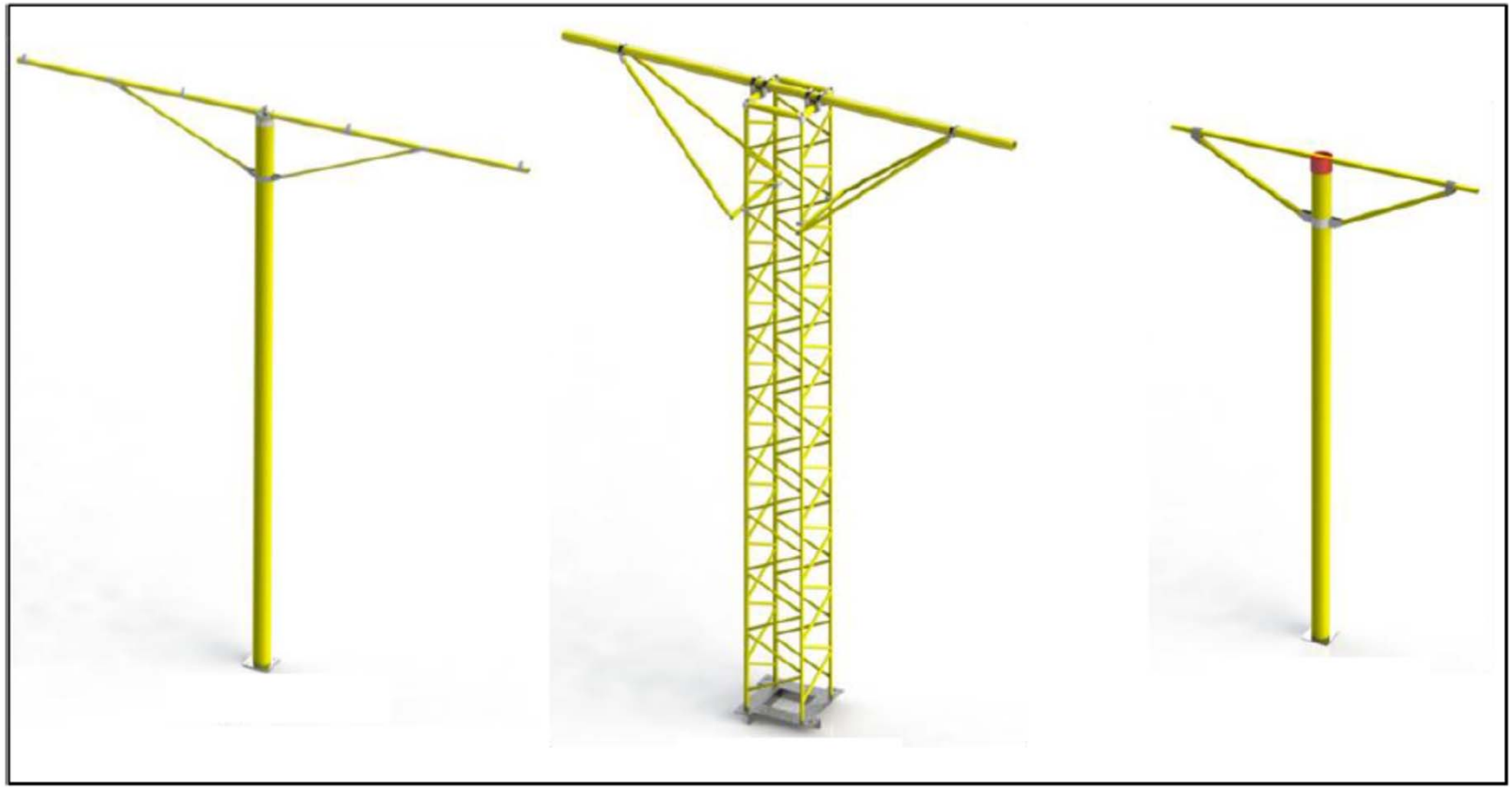
FAA Frangibility Study

Simulation using LS-Dyna



FAA Frangibility Study

Products Chosen for Simulation and Testing



6.0 Meters | 6.0 Meters | 6.0 Meters

FAA Frangibility Guidebook Content

- **Guidebook Contains Instruction for Airfield Product Manufacturers in Design, Testing and Qualification of Products.**
- **Guidebook Provides Direction Relating to Testing of Frangible Connections Currently Referenced to the National Cooperative Highway Research Program (NCHRP) in FAA AC 150/5220-23 “Frangible Connections”.**

Frangibility Guidebook Content

- **Frangible Connections (AC 150/5220-23)**
- **Small Low-Impact Resistant Structures**
  - **End-Fire Glideslopes (FAA-E-2970)**
  - **Signs, Runway and Taxiway (AC 150/5345-44)**
  - **Light Fixtures, Runway and Taxiway (AC 150/5345-46)**
  - **Precision Approach Path Indicators (PAPIs) and Runway End Identifier Lights (REILs) (AC 150/5345-28 and 150/5340-30)**
  - **Wind Cones (AC 150/5345-27)**
  - **Jet Blast Deflectors**

Frangibility Guidebook Content (Continued)

- **Approach Lighting Systems (150/5345-45)**
- **ILS Glideslope Towers**

Frangibility Guidebook Content (Continued)

- **Design Requirements**
  - **Frangibility**
  - **Fabrication and Assembly**
  - **Environmental (Wind/Deflection, Jet Blast, Temperature, Relative Humidity, Solar Radiation, Salt Spray, and Vibration).**

- **Test Requirements**
  - **Frangibility Qualification Procedure and Test Setup**
  - **Environmental Qualification Procedure and Test Setup**

FAA Frangibility Guidebook Status

- **Frangibility Guidebook Currently Under Review at FAA Headquarters**
- **Anticipate Publication of Frangibility Guidebook in Early 2017.**

QUESTIONS?