NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 7, 2015

Attachment 4 – Simulator Testing

OPERATIONAL FACTORS

ENG11IA047

Contents

A. ERJ-145 SIMULATOR TESTS

Simulator testing was conducted in an ExpressJet E145 simulator on September 30, 2011.

1.0 Simulator Cockpit

Photo 1: EMB Simulator Cockpit

Photo 2: EMB145 Tiller Wheel

2.0 Instructor Panel

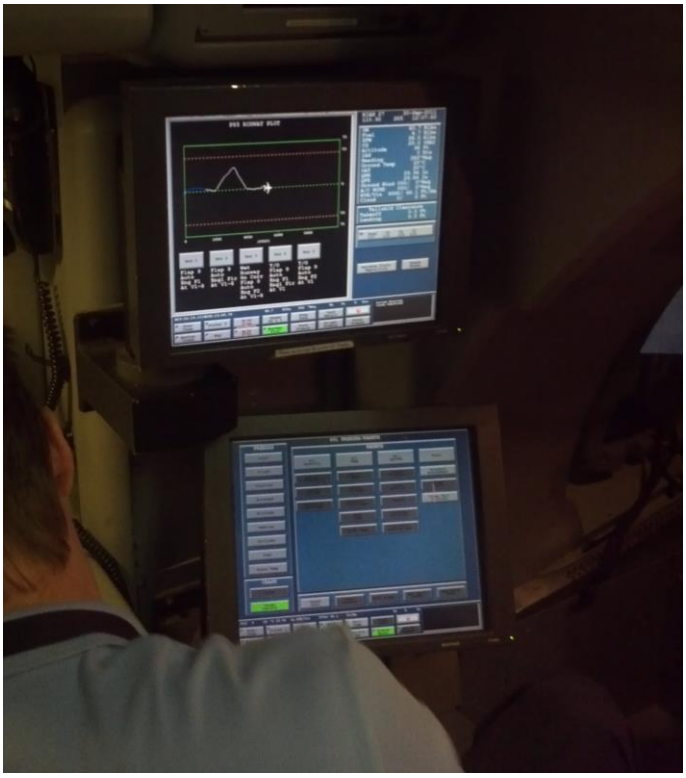
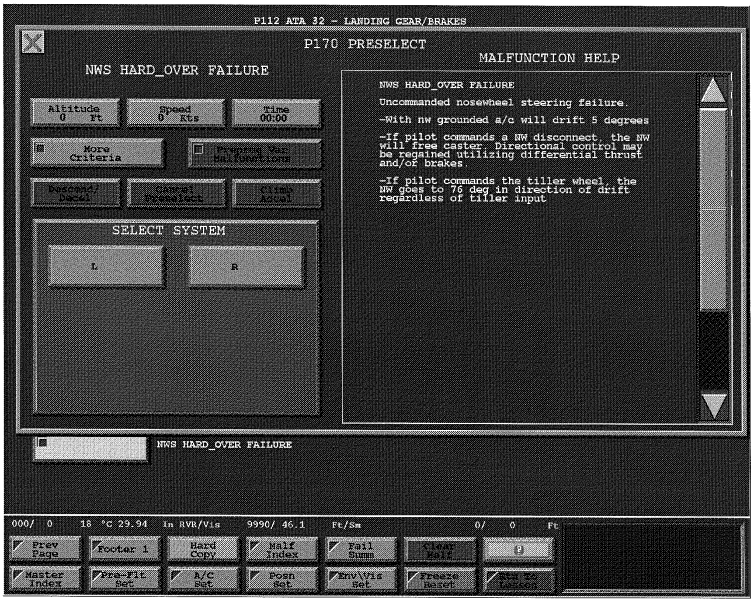


Photo 2: EMB145 Simulator Instructor Panel

2.1 Malfunction Page



3.0 Scenario One (Left swerve at touchdown, calm winds, normal recovery)

3.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

3.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

3.3 Event:

- Initiate uncommanded swerving upon touchdown to the left.
- Crew initiates recover based upon normal Quick Reference Checklist procedures.

3.4 Notes

- Recovery efforts began 2-3 seconds after nose wheel touchdown. When at full right rudder input, aircraft was still moving to the left before Captain pressed the disconnect switch. No differential braking or reverse was used.
- No aural or visual alerts were noticed until after the Captain hit the disconnect switch, then an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated.
- Pilot used full rudder input to assist in directional control of aircraft.
- Directional control was achieved after the Captain in hit the disconnect switch.
- The FO did not press the disconnect switch.
- Captain called out "we're swerving, uncommanded swerving" at beginning of event.

3.5 Ground Track

Note: Ground track did not print out for Scenario One.

4.0 Scenario Two (Right swerve at 100 knots, calm winds, normal recovery)

4.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

4.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,700 lbs (ZFW – 36,000)

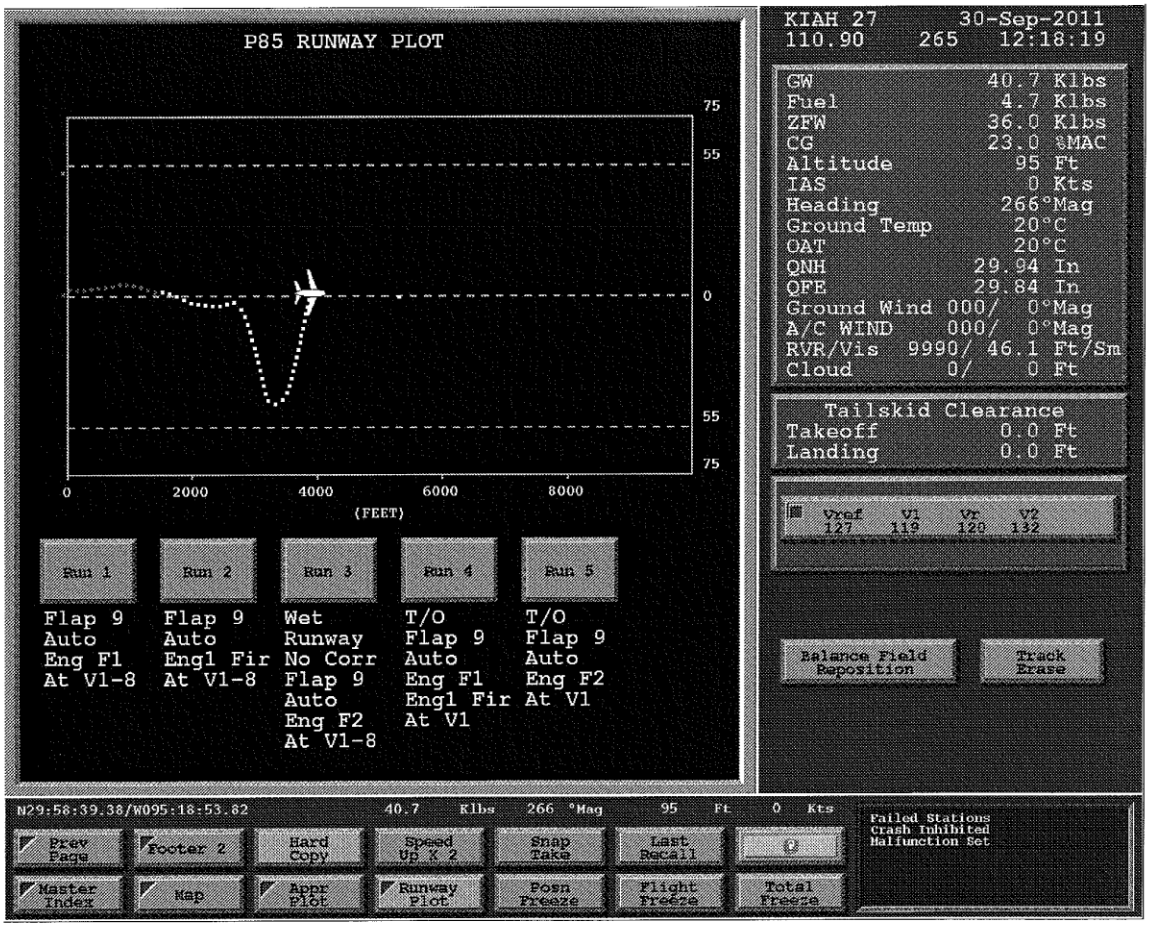
4.3 Event:

- Instructor to select uncommanded swerving to the right at 100 knots.
- Crew initiates recover based upon normal Quick Reference Checklist procedures.

4.4 Notes

- Captain called out "uncommanded steering" at initiation of event.
- Captain stated his recovery efforts included using left rudder, followed by using the brakes after touchdown and the aircraft swerving. He estimated he applied about 70% of left brake and 30% right brake. He considered this event "more aggressive than the previous one."
- No aural or visual alerts were noticed until after the Captain hit the disconnect switch, then an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated.
- Directional control was achieved after the Captain in hit the disconnect switch.
- FO pressed the disconnect switch because "it felt more aggressive to the right."
- Captain used max reverse thrust on both engines, with no differential thrust used for directional control. He said "the only time we ever consider asymmetrical thrust is when we have a reverse bucket inop."
- Captain said that full reverse thrust decelerated the aircraft more, and it became more controllable quicker.

4.5 Ground Track



5.0 Scenario Three (Right swerve, disconnect switch held, calm winds, normal recovery)

5.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

5.2 Setup:

- Position: 500’ on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
  - Clear skies, daylight visuals
  - Winds calm

    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,400 lbs (ZFW – 36,000)

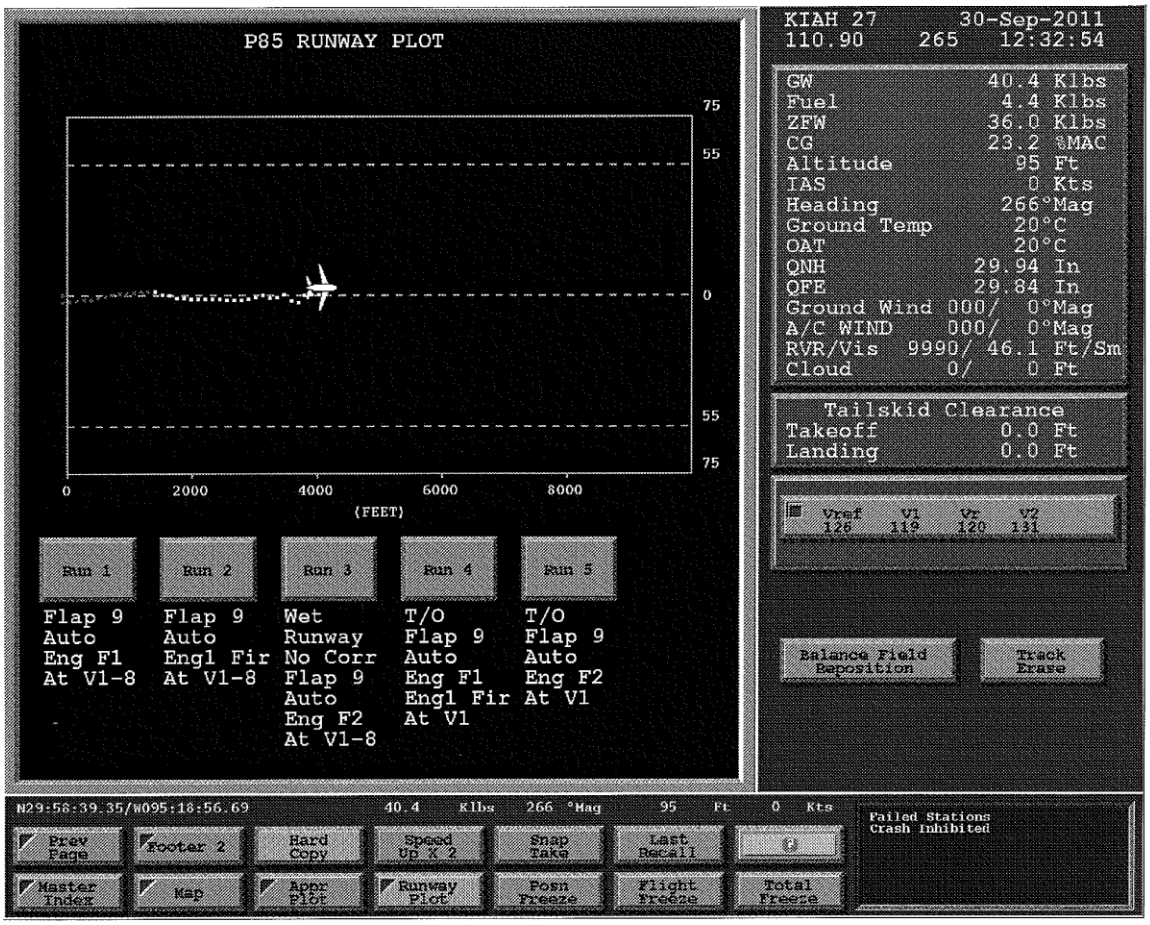
5.3 Event:

- Captain will press and hold disconnect switch for approach and landing.
- Instructor selects uncommanded swerving to the right upon touchdown.
- Crew initiates recover based upon normal Quick Reference Checklist procedures.

5.4 Notes

- Two seconds after nose wheel touchdown, an aural "ding" was heard and the "steer inop" EICAS message and master caution illuminated.
- Captain made no callout at the initiation of the swerving.
- Captain said he did not any pull either direction, and the landing and direction of travel "felt normal".
- Aural alerts (sounds)
- There was no differential braking or no reverse thrust used.
- There was no swerving noticed by crewmembers and observers.
- Pilot rudder inputs were normal.

5.5 Ground Track



6.0 Scenario Four (Left swerve, calm winds, tiller wheel recovery)

6.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

6.2 Setup:

- Position: 500’ on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
  - Clear skies, daylight visuals
  - Winds calm

    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,200 lbs (ZFW – 36,000)

6.3 Event:

- Instructor selects uncommanded swerving to the left at 100 knots.
- Crew initiates recovery based on tiller wheel, rudder and braking alone (no disconnect switch).

6.4 Notes

- At main wheel touchdown, crew heard a "thumping" noise (possible blown tire from previous scenario) and the aircraft began to swerve to the left.
- Captain called out "uncommanding nosewheel" at initiation of event.
- Captain reached for the tiller about 3 seconds into the event and applied full right tiller for directional control.
- Captain also used full right rudder, right braking and max reverse thrust (no differential reverse was used).
- There were no aural or visual alerts during the event.

6.5 Ground Track

Did not print ground track; there was a question whether or not the aircraft landed with a burst tire from the previous scenario that had not been cleared. Scenario was repeated in Scenario Four (a)

7.0 Scenario Four (a) (Left swerve, calm winds, tiller wheel recovery)

7.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

7.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,200 lbs (ZFW – 36,000)

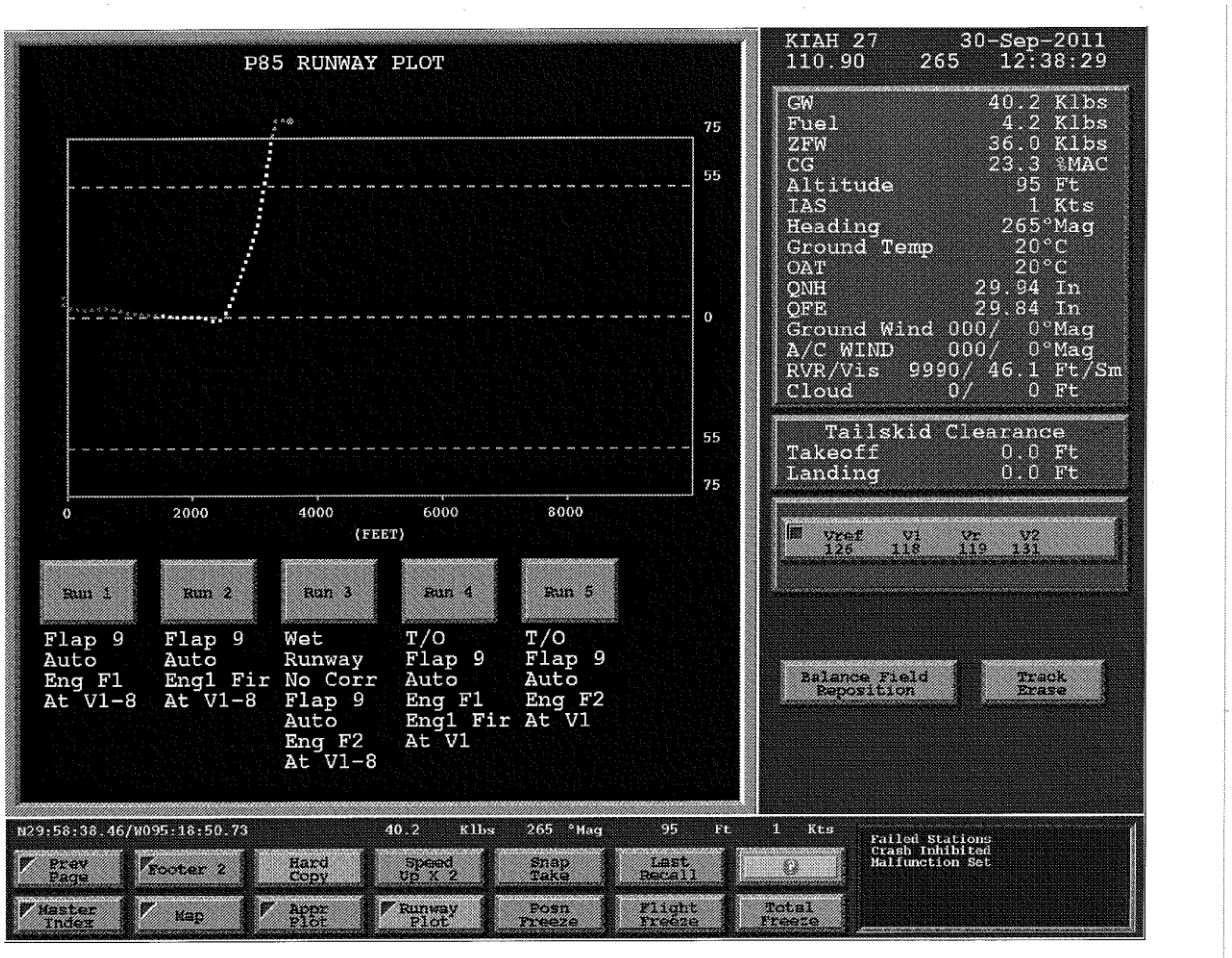
7.3 Event:

- Instructor selects uncommanded swerving to the left at 100 knots.
- Crew initiates recovery based on tiller wheel, rudder and braking alone (no disconnect switch).

7.4 Notes

- This was a repeat of the previous scenario due to a blown tire fault that was not cleared prior to landing.
- Captain called out "uncommanded steering" at initiation of event.
- Captain said he had some control with the tiller, but not full control.
- Full right rudder and full right brake were used.
- Initially, max reverse was used, and then the Captain used differential reverse thrust only after the aircraft departed the runway.

7.5 Ground Track



8.0 Scenario Four (b) (Right swerve, calm winds, tiller wheel recovery)

8.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

8.2 Setup:

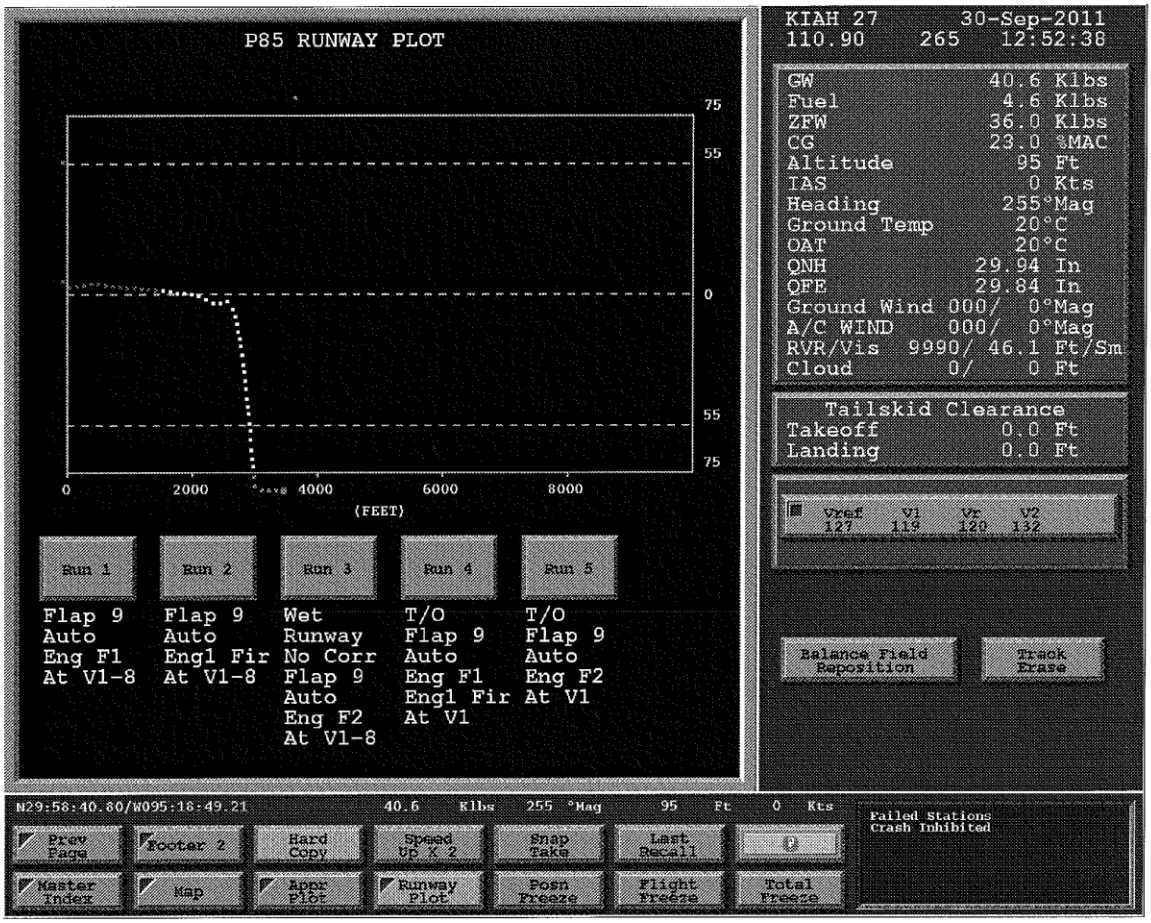
- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,600 lbs (ZFW – 36,000)
-

8.3 Event:

- Instructor selects uncommanded swerving to the right at 100 knots.
- Crew initiates recovery based on tiller wheel, rudder and braking alone (no disconnect switch).
- FO will use yolk disconnect switch at approximately 80 knots, after the swerving event begins.

8.4 Notes

- Same scenario as previous, however FO was instructed to hit the disconnect switch at 80 during the serving event, and while the captain was using the tiller wheel.
- Swerve appeared "aggressive" to the crew, and felt uncontrollable.
- Captain used up to full tiller wheel input for directional control.
- When FO pressed the disconnect switch at 80 knots, there were no aural or visual alerts observed during the swerving event.
- The aural "ding" was heard and the "steer inop" EICAS and master caution illuminated only after the aircraft came to a stop, and while the FO continued to hold the disconnect switch.



9.0 Scenario Five (Left swerve, crosswind, normal recovery)

9.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

9.2 Setup:

- Position: 500’ on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
  - Clear skies, daylight visuals
  - Winds 180 degrees at 30 knots (90 degrees left crosswind)
  - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,700 lbs (ZFW – 36,000)

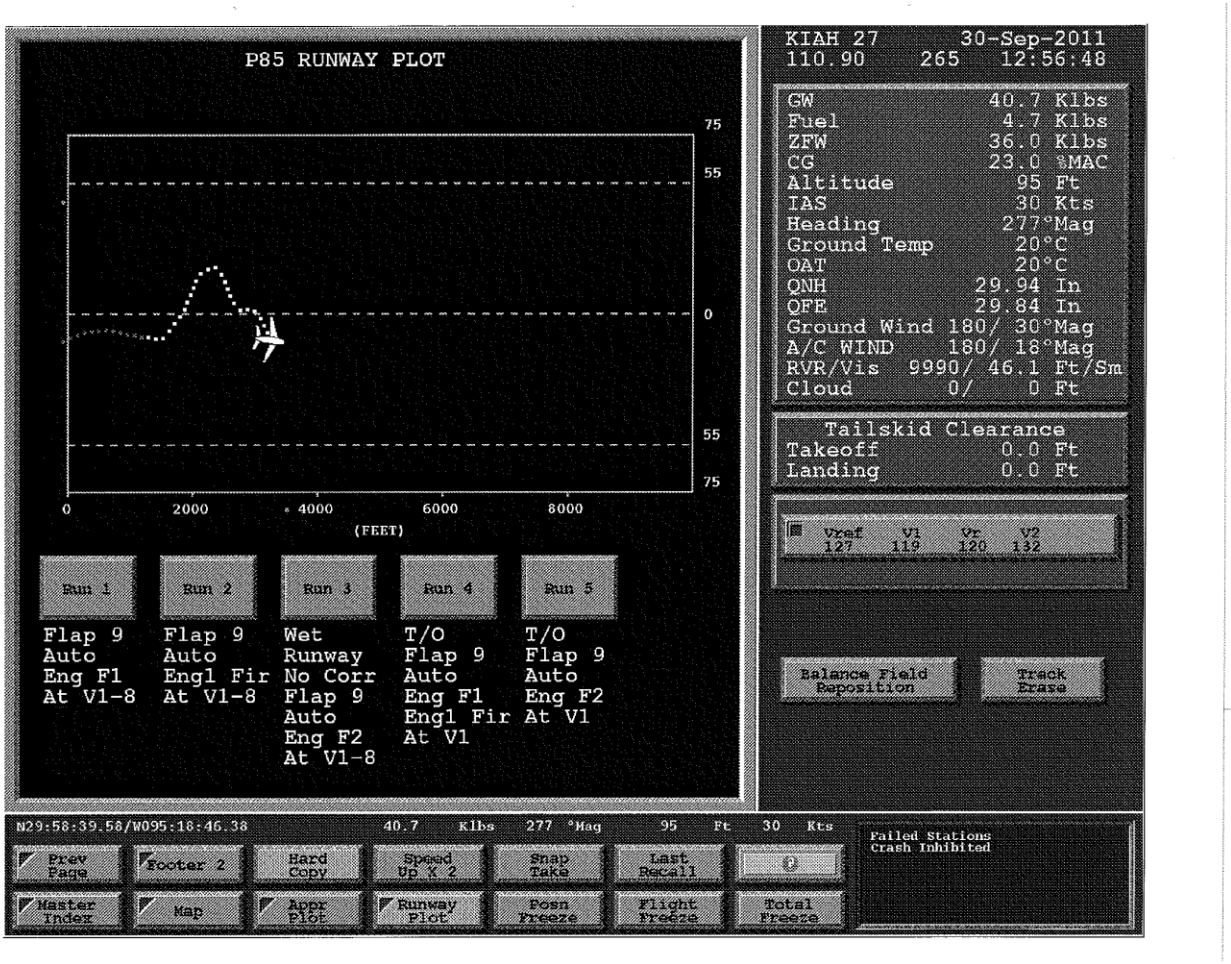
9.3 Event

- Instructor selects uncommanded swerving to the left upon touchdown.
- Crew initiates recover based upon normal Quick Reference Checklist procedures.

9.4 Notes

- Crew felt some swerving to the left during the rollout, but was controllable.
- No aural or visual alerts were noticed until after the Captain hit the disconnect switch, then an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated.

9.5 Ground Track



10.0 Scenario Five (a) (Right swerve, crosswind, normal recovery at 100 knots)

10.1 Participants

Captain Chris Petri - XJT E145 Line Captain

First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

10.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds 360 degrees at 30 knots (90 degrees right crosswind)
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,700 lbs (ZFW – 36,000)

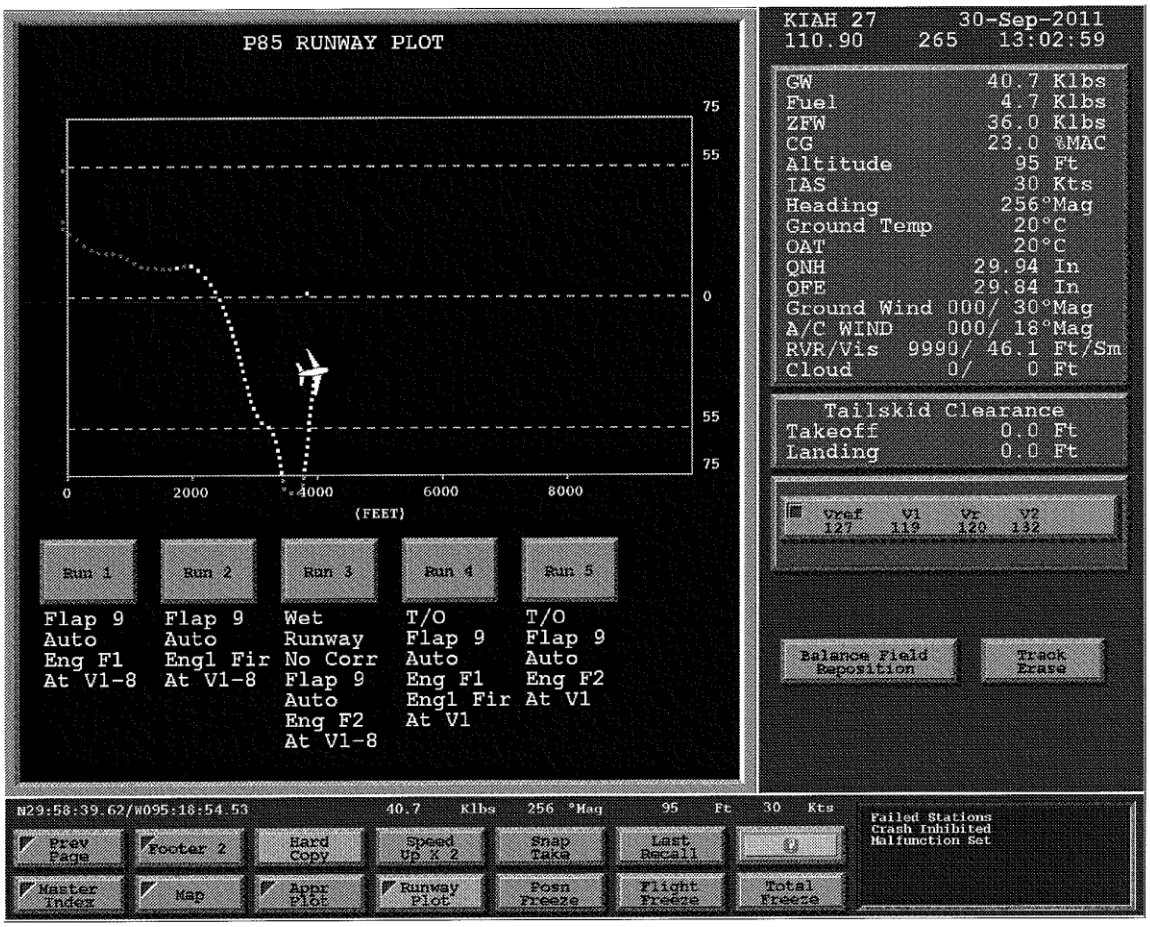
10.3 Event

- Instructor selects uncommanded swerving to the right at 100 knots.
- Crew initiates recovery based upon normal QRC procedures.

10.4 Notes

- Crew noticed that aircraft nose moved "aggressive" to the right.
- Captain actually moved his left hand to the tiller wheel and "bumped" it when the aircraft began to swerve right.
- FO pressed the disconnect switch, and the aural "ding" and visual "steer inop" EICAS and master caution illuminated.
- FO said he held the switch down.
- While the FO held the disconnect switch, Captain was asked to momentarily steer with the tiller wheel. As the tiller was depressed, the nose wheel steering connected momentarily, but disconnected when the tiller was released (FO remained pressing the disconnect switch). Aural and visual alerts were then observed.

10.5 Ground Track



11.0 Scenario Six (Left swerve, crosswind, tiller wheel recovery)

11.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

11.2 Setup:

- Position: 500’ on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals

    - Wind 180 degrees at 20 knots (90 degree left crosswind)
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,500 lbs (ZFW – 36,000)

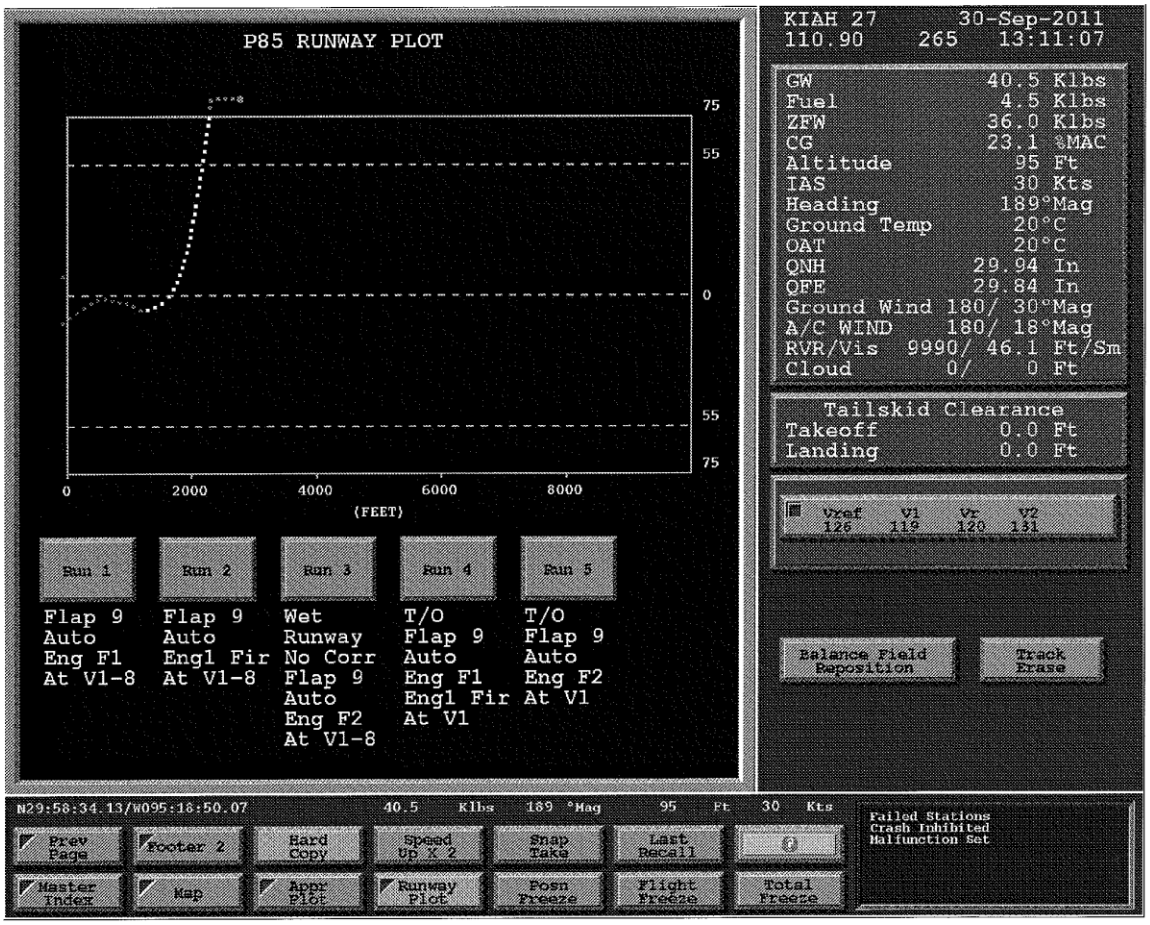
11.3 Event:

- Instructor selects uncommanded swerving at touchdown to the left, with a left 90 degree crosswind at 30 knots.
- Crew initiates recovery based on tiller wheel, rudder and braking alone (no disconnect switch).

11.4 Notes

- Captain used full tiller wheel input for directional control, and stated "there was no control, whatsoever."
- Captain used full rudder input and full right reverse.
- No aural or visual alerts were noticed until after the FO hit the disconnect switch, then an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated.

11.5 Ground Track



12.0 Scenario Seven (Left swerve, crosswind, FO normal recovery)

12.1 Participants

Captain	Chris Petri - XJT E145 Line Captain
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Luciano Saraiva – Embraer

12.2 Setup:

- Position: 500’ on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Wind 180 degrees at 20 knots (90 degree left crosswind)

- OAT - 20 degrees C; Altimeter - 29.94
- Weight: 40,300 lbs (ZFW – 36,000)

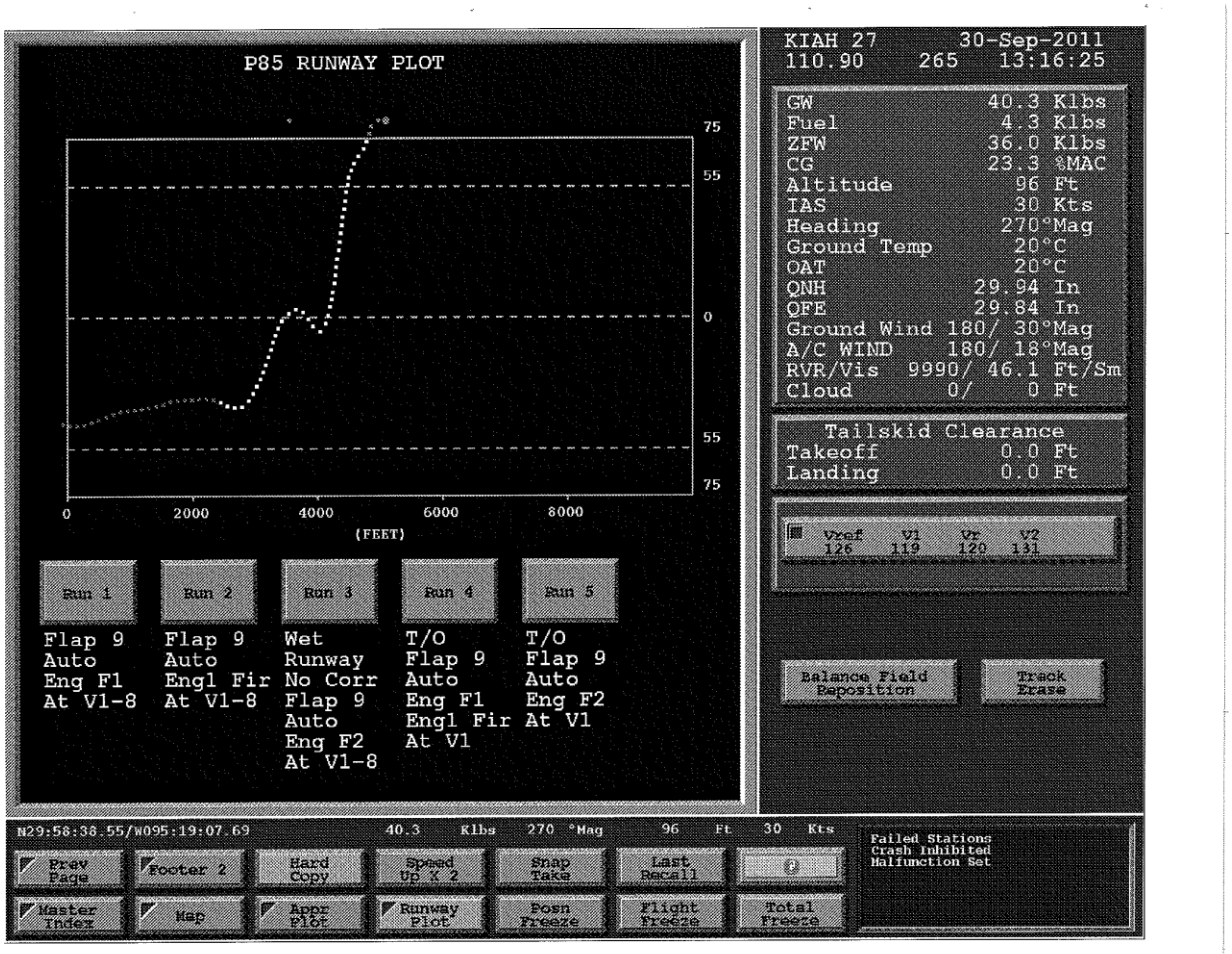
12.3 Event:

- Instructor selects uncommanded swerving at touchdown to the left, with a left 90 degree crosswind at 30 knots.
- FO initiates recovery based upon normal QRC procedures.

12.4 Notes

- FO landing from the right seat with a direct left crosswind (no Captain input).
- FO used right braking and rudder pedal deflection for directional control.
- FO used both hands on the control yolk with crosswind input and did not use reverse thrust.

12.5 Ground Track



13.0 Scenario Eight (Right swerve, calm winds, FO normal recovery)

13.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Chris Petri - XJT E145 Line Captain

13.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

13.3 Event:

- FO is pilot flying.
- Instructor selects uncommanded swerving at touchdown to the right with calm winds.
- FO initiates recovery based upon normal QRC procedures.

13.4 Notes

- FO landing from the right seat with calm winds (no Captain input).
- FO used right braking and rudder pedal deflection for directional control.
- FO used max reverse to slow aircraft.
- FO pressed the disconnect switch to maintain control and an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated.

14.0 Scenario Nine (Normal takeoff/landing)

14.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Chris Petri - XJT E145 Line Captain

14.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

14.3 Notes:

- This was a normal takeoff, flight and landing for the Embraer representative.

15.0 Scenario Ten (Right swerve, calm winds, FO normal recovery at 100 knots)

15.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Chris Petri - XJT E145 Line Captain

15.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

15.3 Event:

- FO is the pilot flying.
- Instructor selects uncommanded swerving at touchdown to the right with calm winds.
- FO initiates recovery based upon normal QRC procedures.

15.4 Notes

- FO landing from the right seat with calm winds (no Captain input).
- FO used right braking and rudder pedal deflection for directional control.

- FO pressed the disconnect switch at 100 knots to maintain control. No aural "ding" was heard and the master caution and EICAS "steer inop" did not illuminate.

16.0 Scenario Eleven (Right swerve, calm winds, FO normal recovery at 80 knots)

16.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Chris Petri - XJT E145 Line Captain

16.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
  - Clear skies, daylight visuals
  - Winds calm
  - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

16.3 Event:

- FO is the pilot flying.
- Instructor selects uncommanded swerving at touchdown to the right with calm winds.
- FO initiates recovery based upon normal QRC procedures.

16.4 Notes

- FO landing from the right seat with calm winds (no Captain input).
- FO used right braking and rudder pedal deflection for directional control.
- FO pressed the disconnect switch at 80 knots to maintain control and an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated.

17.0 Scenario Twelve (Right swerve, calm winds, FO normal recovery at 80 knots)

17.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety

Chris Petri - XJT E145 Line Captain

17.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

17.3 Event:

- FO is the pilot flying.
- Instructor selects uncommanded swerving at touchdown to the right with calm winds.
- FO initiates recovery based upon normal QRC procedures.

17.4 Notes

- Repeat of previous scenario.
- FO landing from the right seat with calm winds (no Captain input).
- FO used right braking and rudder pedal deflection for directional control.
- FO pressed the disconnect switch at 80 knots to maintain control and an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated after a 2 second delay.

18.0 Scenario Thirteen (Right swerve, calm winds, FO normal recovery at 80 knots)

18.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Chris Petri - XJT E145 Line Captain

18.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
    - Clear skies, daylight visuals
    - Winds calm
    - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

18.3 Event:

- FO is the pilot flying.
- Instructor selects uncommanded swerving at touchdown to the right with calm winds.
- FO initiates recovery based upon normal QRC procedures.

18.4 Notes

- Repeat of previous scenario.
- FO landing from the right seat with calm winds (no Captain input).
- FO used right braking and rudder pedal deflection for directional control.
- FO pressed the disconnect switch at 80 knots to maintain control and an aural "ding" was heard and the master caution and EICAS "steer inop" illuminated after a 2-3 second delay.
- Speed was noted as slowing between 45 and 50 knots when the aural and visual alerts were observed.

19.0 Scenario Fourteen (Right swerve, calm winds, disconnect switch pressed)

19.1 Participants

Captain	Luciano Saraiva – Embraer
First Officer (FO)	John Randolph - XJT E145 Line First Officer
Instructor	Brian Alexander - XJT E145 Check Airman
Test Director	David Lawrence - NTSB
Observers	Trey Ables - XJT Safety
	Chris Petri - XJT E145 Line Captain

19.2 Setup:

- Position: 500' on approach, IAH runway 27 (elevation – 96 feet)
- Configuration: Flaps 45; gear down; Autopilot – off; Flight directors – on.
- Environmental:
  - Clear skies, daylight visuals
  - Winds calm
  - OAT - 20 degrees C; Altimeter - 29.94
- Weight: 41,000 lbs (ZFW – 36,000)

19.3 Event:

- FO is the pilot flying.
- FO initiates normal landing with the steering disconnect switch pressed

19.4 Notes

- Upon main wheel touchdown, and an aural “ding” was heard and the master caution and EICAS “steer inop” illuminated with speed at approximately 104 knots.