Design and Testing of an Energy-Absorbing Crewseat for the F/FB-111 Aircraft

Volume III—Data From Seat Testing

S. Joseph Shane

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Design and Testing of an Energy-Absorbing Crewseat for the F/FB-111 Aircraft

Volume III—Data From Seat Testing

S. Joseph Shane
Simula Inc.
Phoenix, Arizona

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1.0 INTRODUCTION

This volume presents data from the testing of an energy-absorbing crew seat in an F/FB-111 crew module. A complete description of the program is contained in Volume I: Final Report. Data from the dynamic test series on the seat is contained in Volume II.

Dynamic testing of the energy-absorbing seat and the operational F/FB-111 seat in an F/FB-111 crew module was conducted at NASA Langley Research Center. The testing is described in Section 4.0 of Volume I, and the resulting data are presented in Sections 2.0 through 14.0 of this volume.

Table 1 lists the data recorded. The four axes recorded on the seat pan include a measurement along the seat back tangent line as well as the three major axes. The seat deflection was measured along the seat back tangent line, but the dynamic response of the linear string potentiometers could not accurately show the seat stroke. Final seat stroke was measured and is recorded in Volume I.

DRI is presented using the same three acceleration measurements used in the seat testing: seat pan z-axis, seat pan along the back tangent line, and dummy pelvis z-axis.

The test conditions are listed at the beginning of each chapter. To be positive, the sign convention for the crew module orientation is for the following earth reference conditions:

- Pitch - nose up
- Roll - right wing down
- Yaw - nose right.
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* Class 60 and Class 180 filters per SAE Recommended Practice J211b.
2.0 NASA TEST NO. 1

HORIZONTAL VELOCITY: 34 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: -13°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 45°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
TIME (SEC)

RIGHT BULKHEAD
NASA TEST NO. 1
SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 1
LEFT DUMMY PELVIS
NASA TEST NO. 1
ACCELERATION (g)

TIME (SEC)

RIGHT DUMMY PELVIS
NASA TEST NO. 1
LEFT DUMMY CHEST
NASA TEST NO. 1
TIME (SEC)

RIGHT DUMMY CHEST
NASA TEST NO. 1
13
LEFT SEAT

RIGHT SEAT

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 1
LEFT SEAT

DRI = 20.24

RIGHT SEAT

DRI = 22.68

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 1

17
DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 1

LEF

T SE

AT

30--

'-' 10--

10--

TIME

50

30

10

-10

-30

-50

0

.05

.10

.15

.20

.25

.30

.35

DRI = 23.37

RIGHT SEAT

50

30

10

-10

-30

-50

0

.05

.10

.15

.20

.25

.30

.35

DRI = 23.92

TIME

DRAWN: 23.37

D2: 23.92

NASA TEST NO. 1

18
3.0 NASA TEST NO. 2

HORIZONTAL VELOCITY: 34 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 0°
CREW MODULE ROLL: 15°
CREW MODULE YAW: 90°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 2

TIME (SEC)
TIME (SEC)

LEFT SEAT PAN
NASA TEST NO. 2
ACCELERATION (G)

TIME (SEC)

RIGHT SEAT PAN
NASA TEST NO. 2
23
CAPSULE C.G.
NASA TEST NO. 2
LEFT SEAT

RIGHT SEAT

SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 2
LEFT DUMMY PELVIS
NASA TEST NO. 2
LEFT DUMMY CHEST
NASA TEST NO. 2
RIGHT DUMMY CHEST
NASA TEST NO. 2
30
ACCELERATION (G)

RIGHT DUMMY HEAD
NASA TEST NO. 2
RIGHT DUMMY HEAD
NASA TEST NO. 2
LEFT SEAT

DRI = 23.34

RIGHT SEAT

DRI = 24.89

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 2
LEFT SEAT

DRI = 22.04

RIGHT SEAT

DRI = 24.64

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 2
LEFT SEAT

DRI = 24.16

RIGHT SEAT

DRI = 24.52

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 2
4.0 NASA TEST NO. 3

HORIZONTAL VELOCITY: 34 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 17°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 90°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 3
LEFT SEAT PAN
NASA TEST NO. 3
41
CAPSULE C.G.
NASA TEST NO. 3
43
SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 3
LEFT DUMMY PELVIS
NASA TEST NO. 3
45
RIGHT DUMMY PELVIS

NASA TEST NO. 3

46
LEFT DUMMY HEAD
NASA TEST NO. 3
49
RIGHT SEAT

LEFT SEAT

TIME (SEC)

SEAT STROKE
NASA TEST NO. 3
LEFT SEAT

DRI = 20.71

RIGHT SEAT

DRI = 22.48

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 3
53
DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 3

LEFT SEAT

DRI = 21.77

RIGHT SEAT

DRI = 22.44
5.0 NASA TEST NO. 4

HORIZONTAL VELOCITY: 34 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: -13°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 75°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
RIGHT SEAT PAN
NASA TEST NO. 4
60
CAPSULE C.G.
NASA TEST NO. 4
61
LEFT SEAT

RIGHT SEAT

ACCELERATION (G)

SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 4
62
LEFT DUMMY CHEST
NASA TEST NO. 4
65
RIGHT DUMMY CHEST
NASA TEST NO. 4
RIGHT SEAT

DISPLACEMENT (IN.)

TIME (SEC)

SEAT STROKE
NASA TEST NO. 4
LEFT SEAT

TIME (SEC)

DISPLACEMENT (IN.)

SEAT STROKE
NASA TEST NO. 4

70
LEFT SEAT

DRI = 20.52

RIGHT SEAT

DRI = 21.70

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 4

71
LEFT SEAT

DRI = 20.74

RIGHT SEAT

DRI = 21.92

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 4
72
DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 4

LEFT SEAT
DRI = 23.24

RIGHT SEAT
DRI = 23.75
6.0 NASA TEST NO. 5

HORIZONTAL VELOCITY: 34 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 17°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 45°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 5

ACCELERATION (G)

TIME (SEC)
RIGHT BULKHEAD
NASA TEST NO. 5

TIME (SEC)
RIGHT SEAT PAN
NASA TEST NO. 5
78
CAPSULE C.G.
NASA TEST NO. 5
79
LEFT SEAT

RIGHT SEAT

ACCELERATION (G)

TIME (SEC)

SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 5
LEFT DUMMY PELVIS
NASA TEST NO. 5

TIME (SEC)
RIGHT DUMMY CHEST
NASA TEST NO. 5
LEFT DUMMY HEAD
NASA TEST NO. 5

TIME (SEC)

ACCELERATION (G)

X

Y

Z
RIGHT DUMMY HEAD
NASA TEST NO. 5
88
DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 5

DRI = 22.50

DRI = 22.89
LEFT SEAT

DRI = 21.51

TIME

RIGHT SEAT

DRI = 24.54

TIME

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 5
91
LEFT SEAT

DRI = 26.86

RIGHT SEAT

DRI = 23.45

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 5

92
7.0 NASA TEST NO. 6

HORIZONTAL VELOCITY: 43 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 6
ACCELERATION (G)

TIME (SEC)

LEFT SEAT PAN
NASA TEST NO. 6

96
CAPSULE C.G.
NASA TEST NO. 6

ACCELERATION (G)

TIME (SEC)

CAPSULE C.G.
NASA TEST NO. 6
98
SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 6
100
LEFT DUMMY PELVIS
NASA TEST NO. 6
LEFT DUMMY CHEST
NASA TEST NO. 6
104
RIGHT DUMMY HEAD
NASA TEST NO. 6
107
LEFT SEAT

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 6
108

RIGHT SEAT
LEFT SEAT

![Graph showing dynamic response index for the left seat with DRI = 20.25.]

RIGHT SEAT

![Graph showing dynamic response index for the right seat with DRI = 21.83.]

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 6
109
LEFT SEAT

DRI = 21.84

RIGHT SEAT

DRI = 22.39

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 6
110
8.0 NASA TEST NO. 7

HORIZONTAL VELOCITY: 43 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 7°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 180°
LEFT SEAT: Energy Absorbing
RIGHT SEAT: Energy Absorbing
RIGHT BULKHEAD
NASA TEST NO. 7
LEFT SEAT PAN
NASA TEST NO. 7

114
RIGHT SEAT PAN
NASA TEST NO. 7

TIME (SEC)
LEFT SEAT

RIGHT SEAT

SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 7
LEFT DUMMY PELVIS
NASA TEST NO. 7
119
LEFT DUMMY CHEST
NASA TEST NO. 7
RIGHT DUMMY CHEST
NASA TEST NO. 7
123
LEFT DUMMY HEAD
NASA TEST NO. 7
LEFT DUMMY HEAD
NASA TEST NO. 7
SEAT STROKE
NASA TEST NO. 7

RIGHT SEAT

LEFT SEAT

DISPLACEMENT (IN.)

TIME (SEC)
LEFT SEAT

DRI = 22.29

RIGHT SEAT

DRI = 21.57

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 7
LEFT SEAT

RIGHT SEAT

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 7

DRI = 18.47

DRI = 18.36
LEFT SEAT

DRI = 18.96

RIGHT SEAT

DRI = 21.06

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 7

131
9.0 NASA TEST NO. 8

HORIZONTAL VELOCITY: 0 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: F-111 Operational
RIGHT SEAT: Energy Absorbing
LEFT SEAT PAN
NASA TEST NO. 8
135
LEFT DUMMY PELVIS
NASA TEST NO. 8
139
LEFT DUMMY CHEST
NASA TEST NO. 8
141
RIGHT DUMMY HEAD
NASA TEST NO. 8
LEFT THIGH

LEFT SEAT PAN LOADS
NASA TEST NO. 8
LEFT SEAT PAN LOADS
NASA TEST NO. 8
146
RIGHT SEAT PAN LOADS
NASA TEST NO. 8
RIGHT SEAT STROKE
NASA TEST NO. 8
DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 8
150
LEFT SEAT

DRI = 24.58

RIGHT SEAT

DRI = 22.35

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 8
151
10.0 NASA TEST NO. 9

HORIZONTAL VELOCITY: 0 ft/sec
VERTICAL VELOCITY: 25 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: F-111 Operational
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 9

153
LEFT SEAT PAN
NASA TEST NO. 9
155
RIGHT SEAT PAN
NASA TEST NO. 9
156
CAPSULE C.G.
NASA TEST NO. 9
157
LEFT SEAT

RIGHT SEAT

SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 9
TIME (SEC)

LEFT DUMMY PELVIS
NASA TEST NO. 9

159
ACCELERATION (G)

TIME (SEC)

LEFT DUMMY HEAD
NASA TEST NO. 9
LEFT THIGH

RIGHT THIGH

FORCE (LB)

TIME (SEC)

RIGHT SEAT PAN LOADS
NASA TEST NO. 9
LEFT REAR EXIT PORT PRESSURE
NASA TEST NO. 9
EXIT PORT PRESSURES
NASA TEST NO. 9
168
LEFT SEAT

RIGHT SEAT

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 9
170
LEFT SEAT

DRI = 18.30

RIGHT SEAT

DRI = 16.33

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 9
171
11.0  NASA TEST NO. 10

HORIZONTAL VELOCITY: 0 ft/sec
VERTICAL VELOCITY: 25 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: F-111 Operational
RIGHT SEAT: Energy Absorbing
RIGHT BULKHEAD
NASA TEST NO. 10

TIME (SEC)
Accleration (G)

TIME (SEC)

RIGHT SEAT PAN
NASA TEST NO. 10
SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 10
ACCELERATION (G)

TIME (SEC)

RIGHT DUMMY PELVIS
NASA TEST NO. 10
180
LEFT DUMMY HEAD
NASA TEST NO. 10

TIME (SEC)
RIGHT SEAT PAN LOADS
NASA TEST NO. 10
186
TIME (SEC)

RIGHT SEAT STROKE

NASA TEST NO. 10
LEFT FRONT

LEFT CENTER

LEFT REAR

EXIT PORT PRESSURES
NASA TEST NO. 10
EXIT PORT PRESSURES
NASA TEST NO. 10
LEFT SEAT

D.R.I. = 15.29

RIGHT SEAT

D.R.I. = 15.62

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 10
190
LEFT SEAT

DRI = 14.73

RIGHT SEAT

DRI = 15.36

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 10
191
LEFT SEAT

Dynamic Response Index
Dummy Pelvis Z-Axis
NASA Test No. 10

DRI = 18.93

RIGHT SEAT

Dynamic Response Index
Dummy Pelvis Z-Axis
NASA Test No. 10

DRI = 17.49
NASA TEST NO. 11

HORIZONTAL VELOCITY: 0 ft/sec
VERTICAL VELOCITY: 25 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: F-111 Operational
RIGHT SEAT: Energy Absorbing
LEFT SEAT PAN
NASA TEST NO. 11

196
RIGHT SEAT PAN
NASA TEST NO. 11

197
TIME (SEC)

CAPSULE C.G.
NASA TEST NO. 11
LEFT SEAT

ACCELERATION (G)

RIGHT SEAT

TIME (SEC)

SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 11
LEFT DUMMY PELVIS
NASA TEST NO. 11
200
TIME (SEC)

RIGHT DUMMY PELVIS
NASA TEST NO. 11
LEFT DUMMY CHEST
NASA TEST NO. 11
RIGHT DUMMY CHEST
NASA TEST NO. 11

ACCELERATION (G)

TIME (SEC)

0 0.04 0.08 0.12 0.16 0.20 0.24

Z
-10
-15
-20

Y
0
-5

X
0
-5
LEFT DUMMY HEAD
NASA TEST NO. 11
RIGHT DUMMY HEAD
NASA TEST NO. 11

ACCELERATION (G)

TIME (SEC)
LEFT THIGH

CENTER

RIGHT THIGH

RIGHT SEAT PAN LOADS
NASA TEST NO. 11
RIGHT SEAT STROKE
NASA TEST NO. 11
LEFT FRONT

LEFT CENTER

LEFT REAR

TIME (SEC)

EXIT PORT PRESSURE
NASA TEST NO.11
EXIT PORT PRESSURES
NASA TEST NO. 11
LEFT SEAT

DRI = 14.22

RIGHT SEAT

DRI = 14.66

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 11
LEFT SEAT

DRI = 13.99

RIGHT SEAT

DRI = 14.40

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 11
212
DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 11
213
13.0 NASA TEST NO. 12

HORIZONTAL VELOCITY: 0 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: F-111 Operational
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 12

ACCELERATION (G)

TIME (SEC)
RIGHT BULKHEAD
NASA TEST NO. 12
RIGHT SEAT PAN
NASA TEST NO. 12
SEAT PAN ALONG BACK TANGENT LINE
NASA TEST NO. 12

LEFT SEAT

RIGHT SEAT

ACCELERATION (G)

TIME (SEC)
LEFT DUMMY PELVIS
NASA TEST NO. 12
221
LEFT DUMMY CHEST
NASA TEST NO. 12
223
LEFT DUMMY HEAD  
NASA TEST NO. 12  
225
RIGHT SEAT STROKE
NASA TEST NO. 12
LEFT SEAT

DRI = 24.92

RIGHT SEAT

DRI = 20.93

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 12
231
LEFT SEAT

DRI = 23.91

RIGHT SEAT

DRI = 20.39

DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 12
232
LEFT SEAT

DRI = 23.55

RIGHT SEAT

DRI = 15.81

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 12

233
HORIZONTAL VELOCITY: 34 ft/sec
VERTICAL VELOCITY: 32 ft/sec
CREW MODULE PITCH: 2°
CREW MODULE ROLL: 0°
CREW MODULE YAW: 0°
LEFT SEAT: F-111 Operational
RIGHT SEAT: Energy Absorbing
LEFT BULKHEAD
NASA TEST NO. 17
RIGHT BULKHEAD
NASA TEST NO. 17
RIGHT SEAT PAN
NASA TEST NO. 17
238
CAPSULE C.G.
NASA TEST NO. 17
LEFT DUMMY PELVIS
NASA TEST NO. 17
RIGHT DUMMY PELVIS
NASA TEST NO. 17
243
LEFT DUMMY CHEST
NASA TEST NO. 17

ACCELERATION (G)

TIME (SEC)
RIGHT DUMMY CHEST
NASA TEST NO. 17
RIGHT DUMMY HEAD
NASA TEST NO. 17

ACCELERATION (G)

TIME (SEC)
LEFT SEAT

DRI = 23.88

RIGHT SEAT

DRI = 22.32

DYNAMIC RESPONSE INDEX
SEAT PAN Z-AXIS
NASA TEST NO. 17

251
DYNAMIC RESPONSE INDEX
BACK TANGENT LINE
NASA TEST NO. 17
252
LEFT SEAT

DRI = 30.64

RIGHT SEAT

DRI = 21.97

DYNAMIC RESPONSE INDEX
DUMMY PELVIS Z-AXIS
NASA TEST NO. 17
253
Over the past years, several papers and reports have documented the unacceptably high injury rate during the escape sequence (including the ejection and ground impact) of the crew module for F/FB-111 aircraft. This report documents a program to determine if the injury potential could be reduced by replacing the existing crewseats with energy-absorbing crewseats. An energy-absorbing test seat was designed using much of the existing seat hardware. An extensive dynamic seat test series, designed to duplicate various crew module ground impact conditions, was conducted at a sled test facility. Comparative tests with operational F-111 crewseats were also conducted. After successful dynamic testing of the seat, more testing was conducted with the seats mounted in an F-111 crew module. Both swing tests and vertical drop tests were conducted. The vertical drop tests were used to obtain comparative data between the energy-absorbing and operational seats. Volume I describes the energy-absorbing test seat and testing conducted, and evaluates the data from both test series. Volume II presents the data obtained during the seat test series, while Volume III presents the data from the crew module test series.