DOCKET NO. SA-516

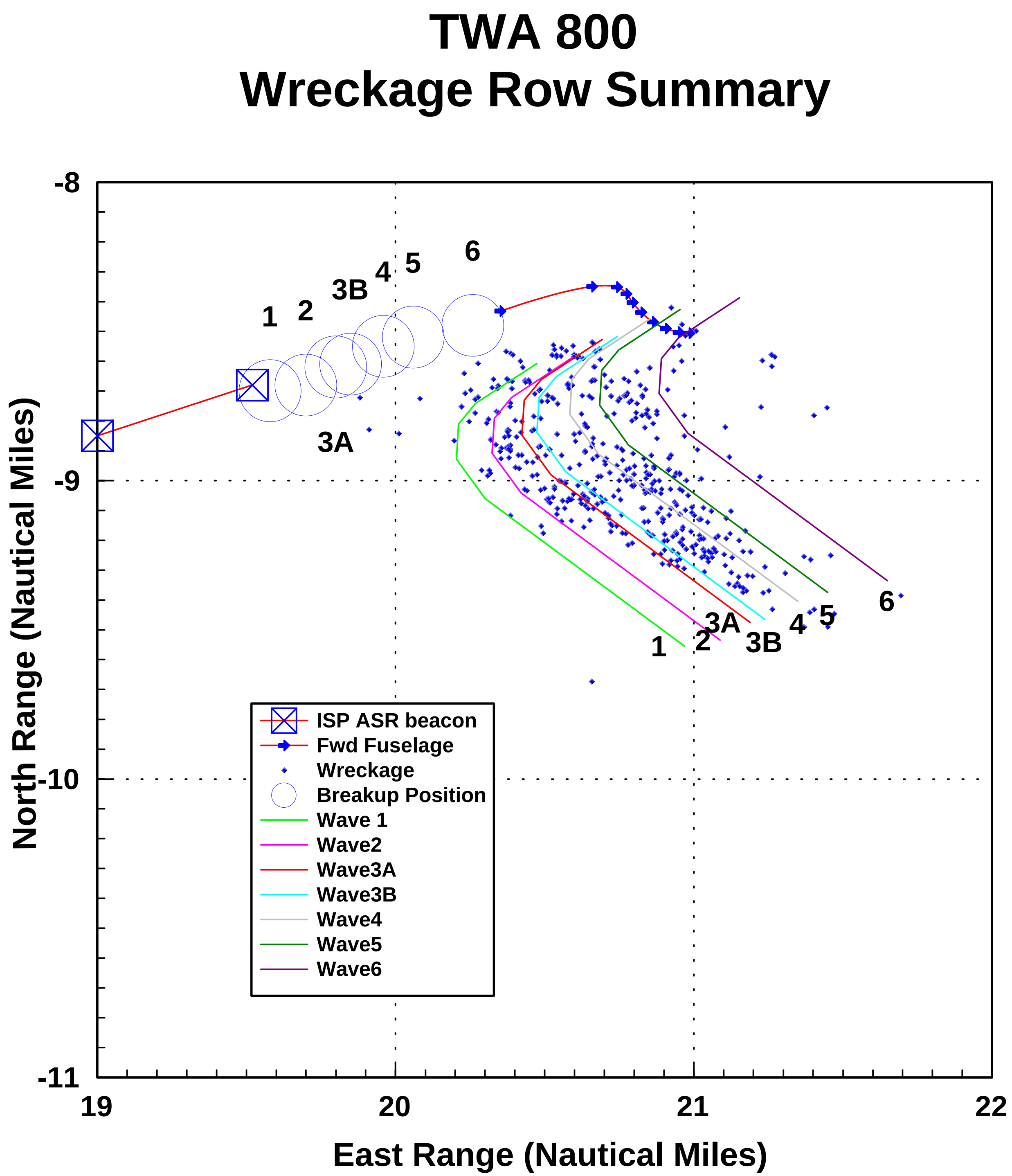
EXHIBIT NO. 22B

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

TRAJECTORY STUDY
Supporting Material
(97 Pages)

ATTACHMENT 1

Scatter Curve Summary

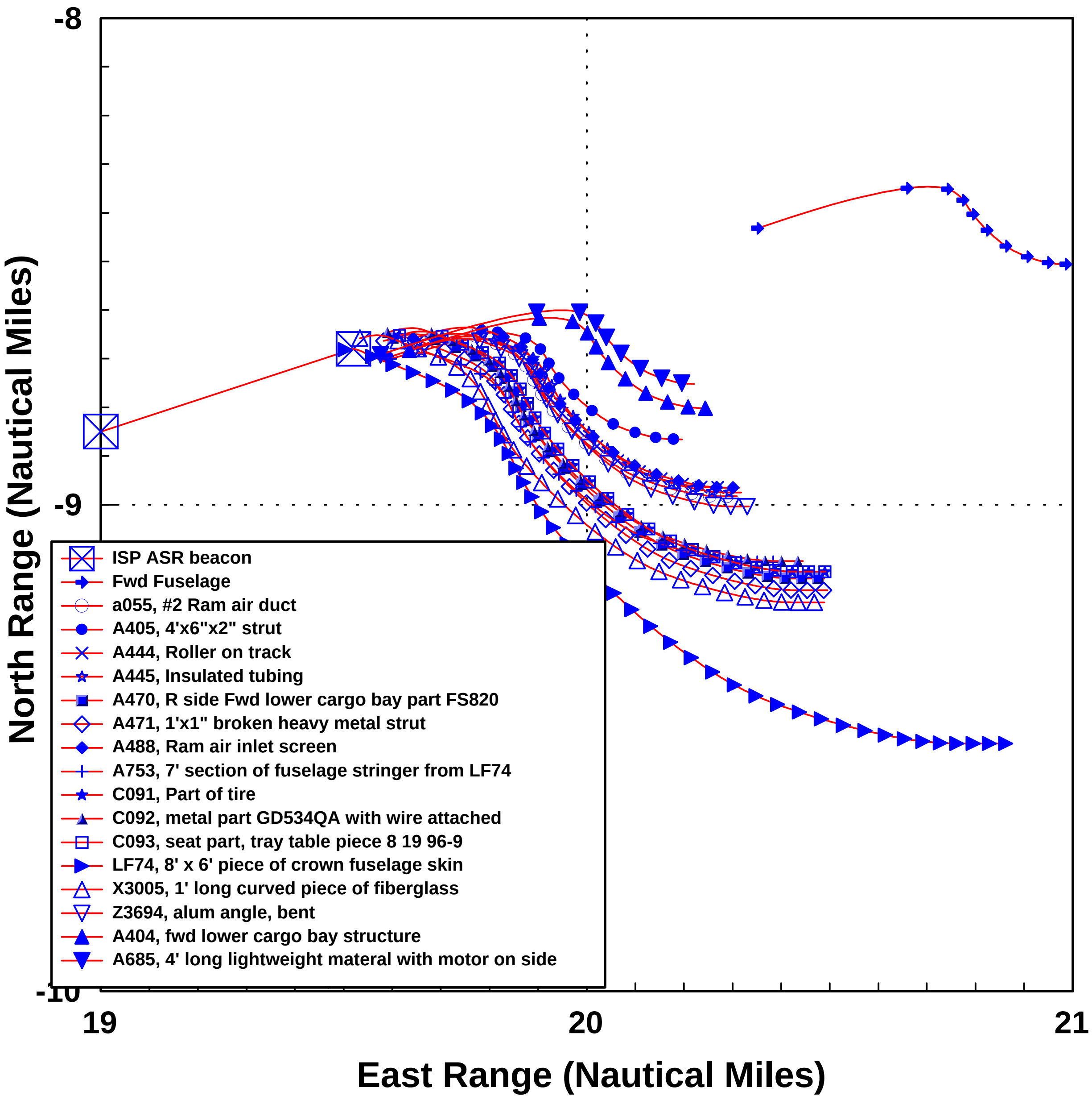


TWA 800
Wreckage Row Summary
North Range (Nautical Miles)
East Range (Nautical Miles)
-8
-9
-10
-11
19
20
21
22
1
2
3B
4
5
6
3A
1
2
3A
3B
4
5
6
ISP ASR beacon
Fwd Fuselage
Wreckage
Breakup Position
Wave 1
Wave2
Wave3A
Wave3B
Wave4
Wave5
Wave6

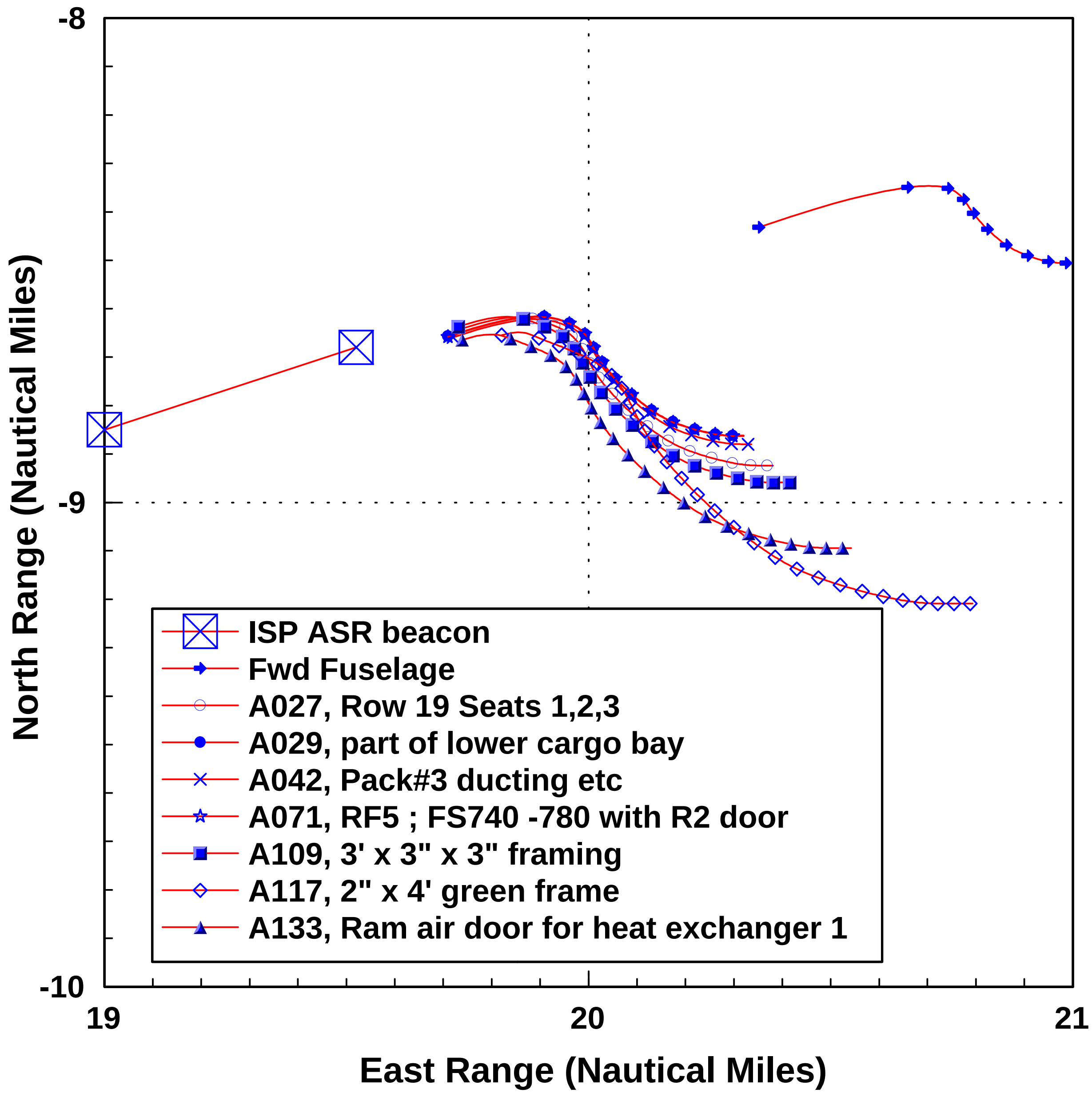
ATTACHMENT 2

Wreckage Trajectory by Wreckage Band

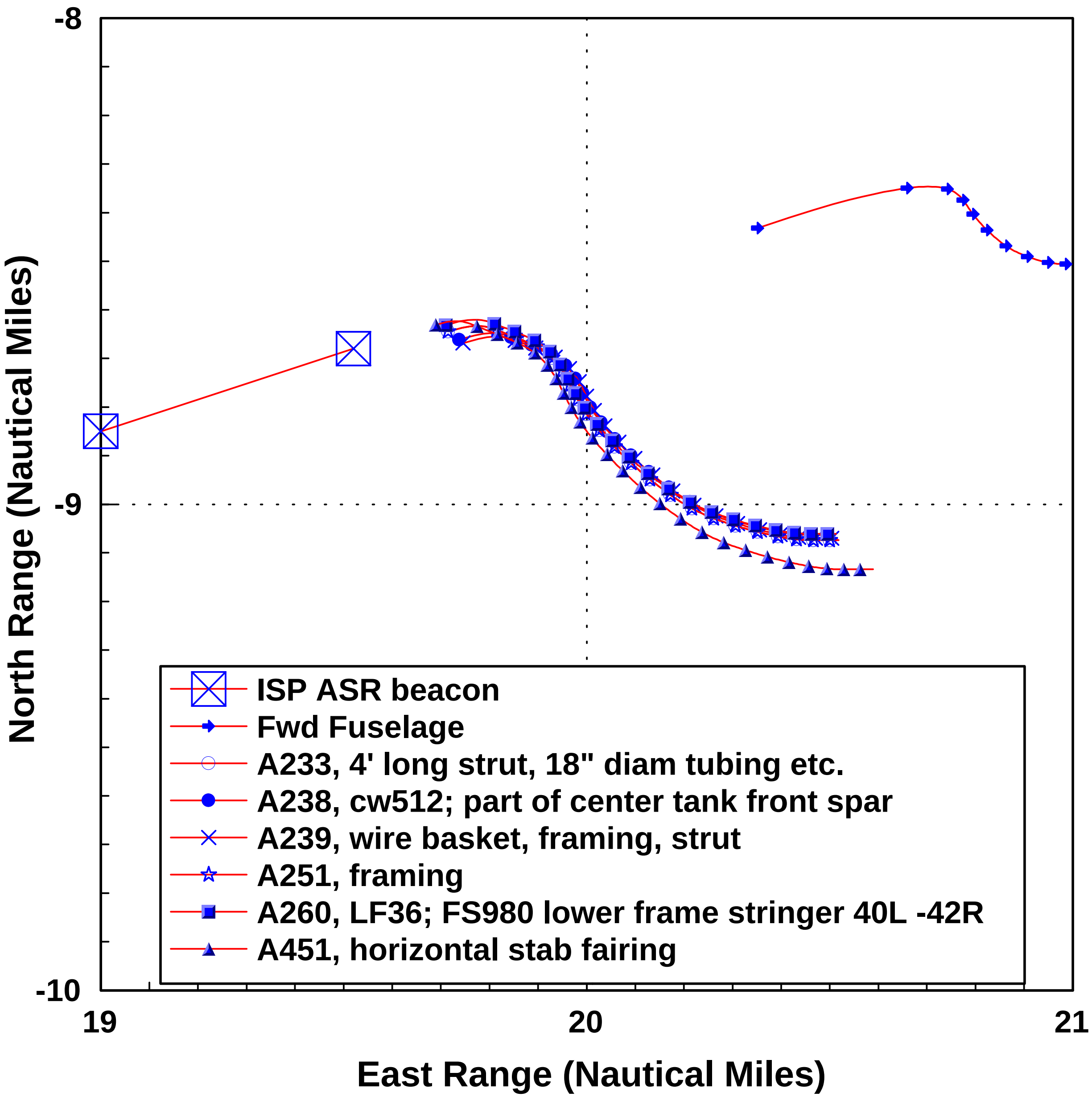
TWA 800
Wreckage Row 1



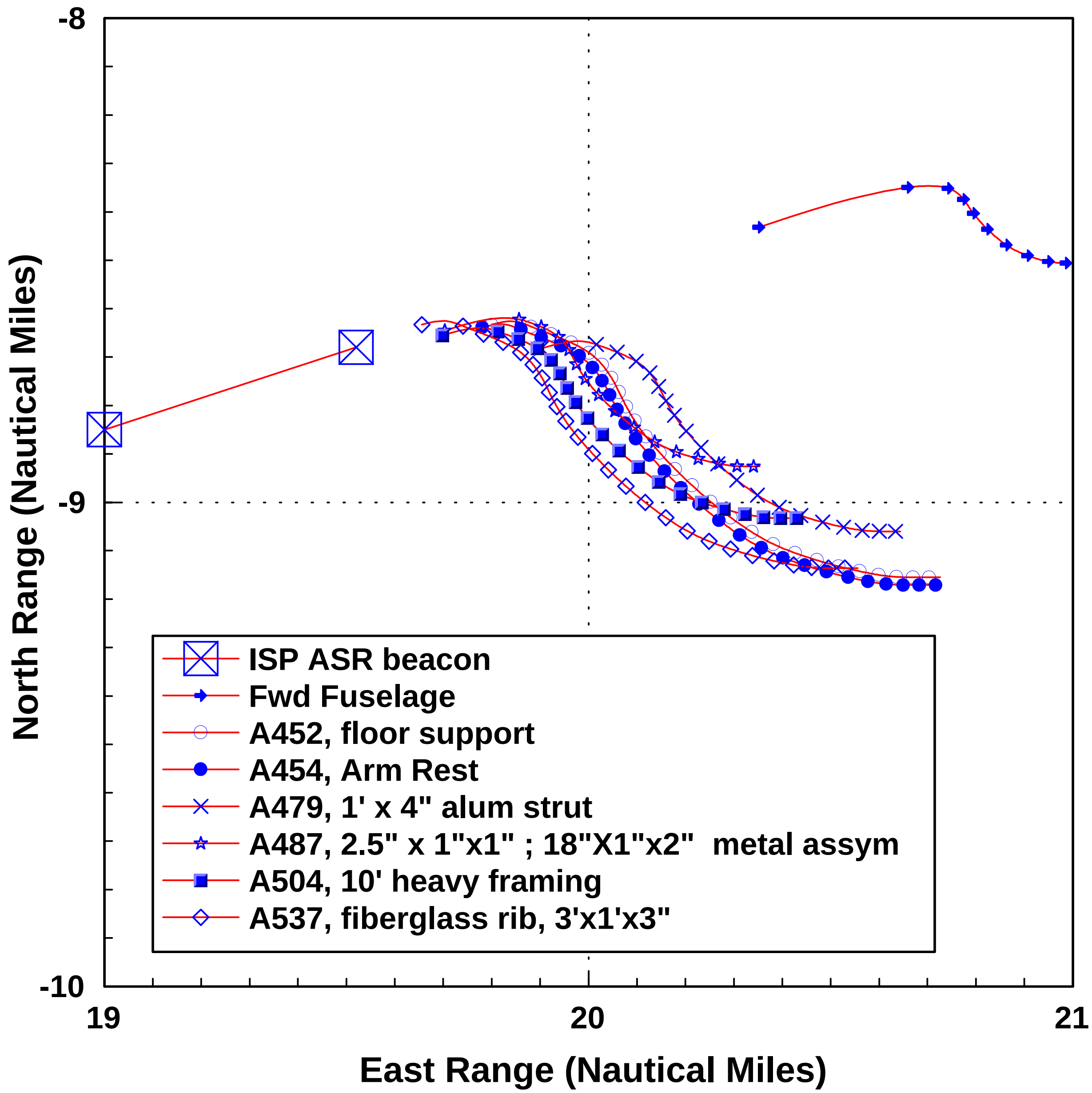
TWA 800
Wreckage Row 2



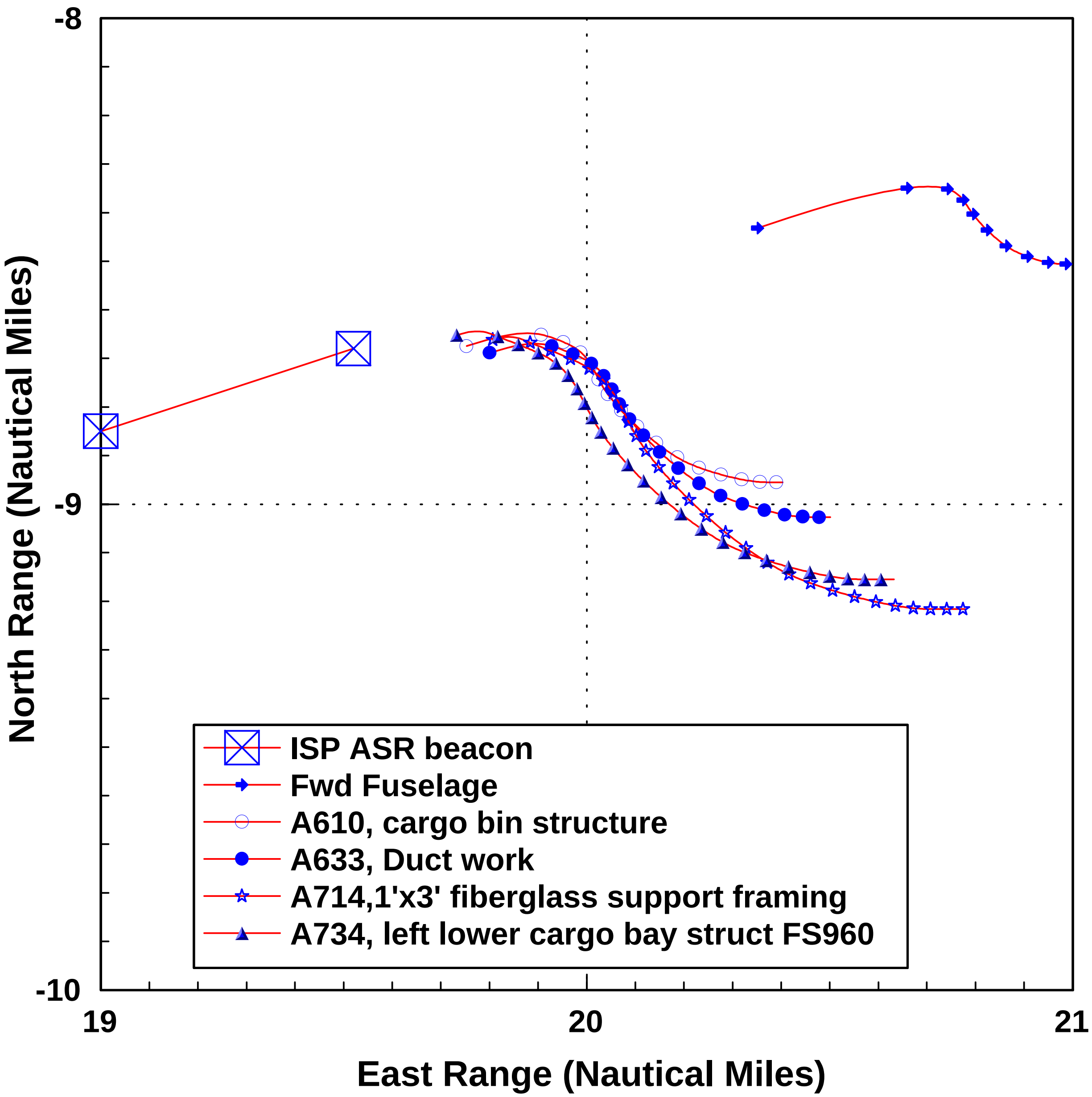
TWA 800
Wreckage Row 2



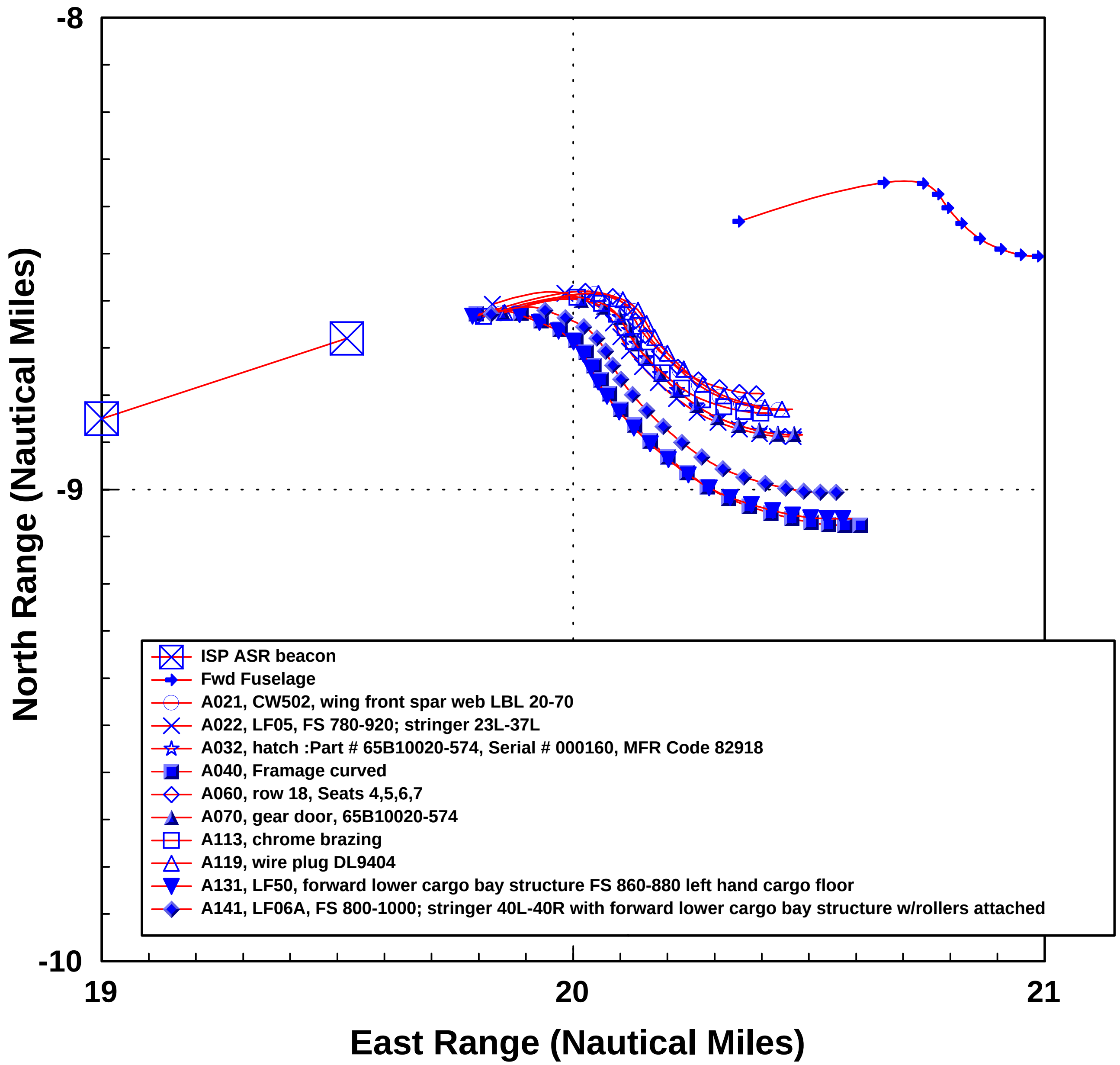
TWA 800
Wreckage Row 2



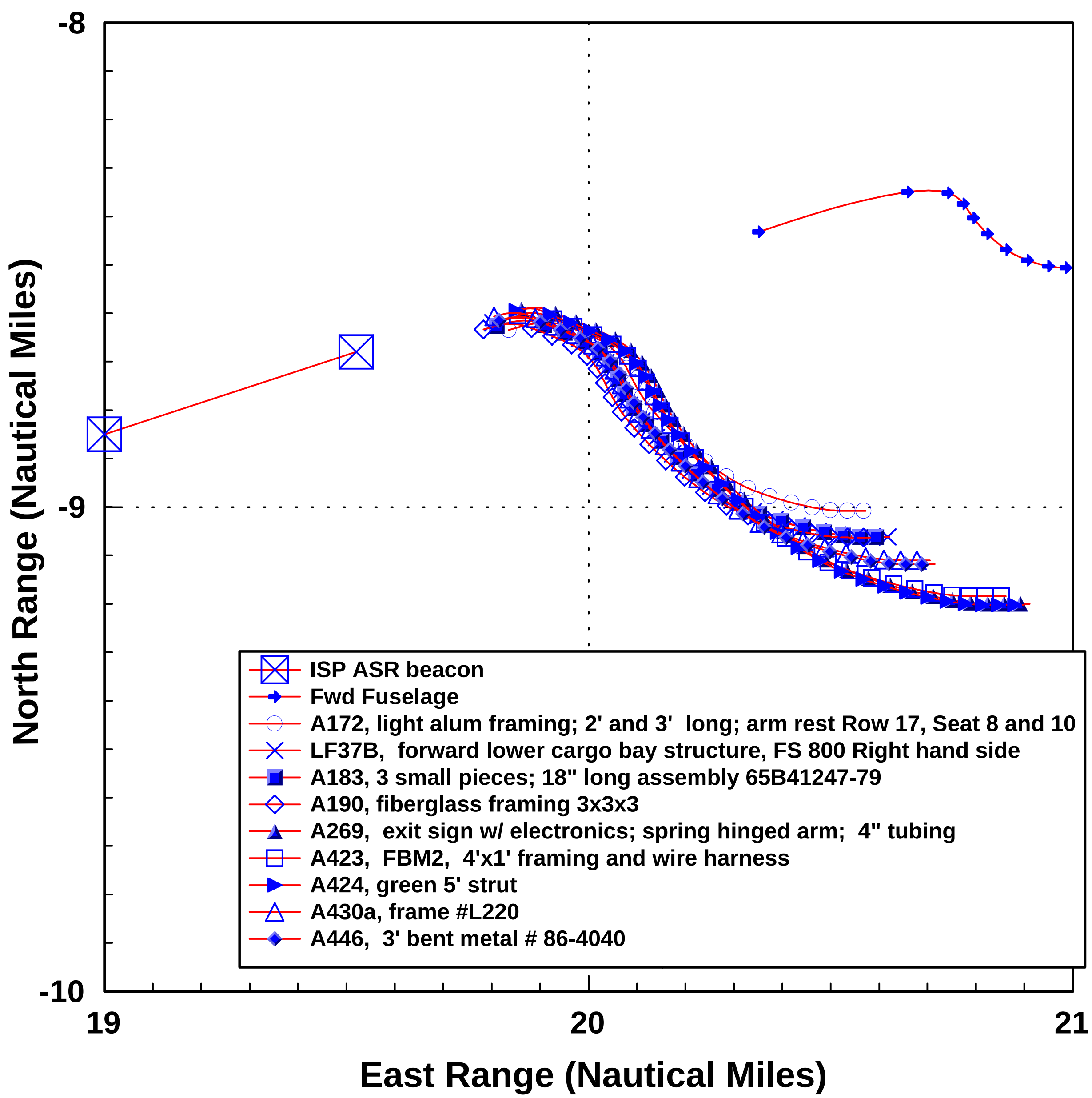
TWA 800
Wreckage Row 2



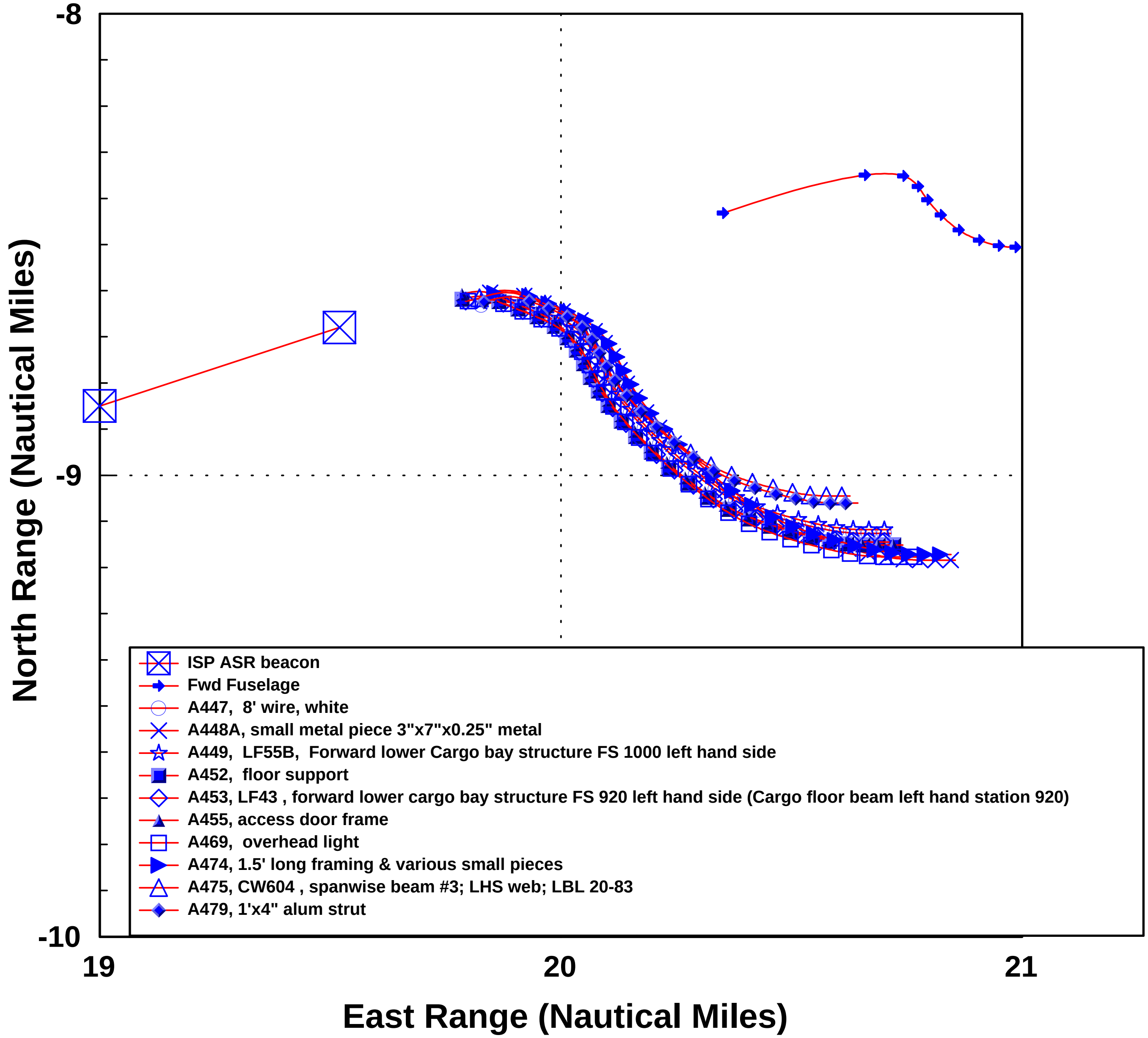
TWA 800
Wreckage Row 3a



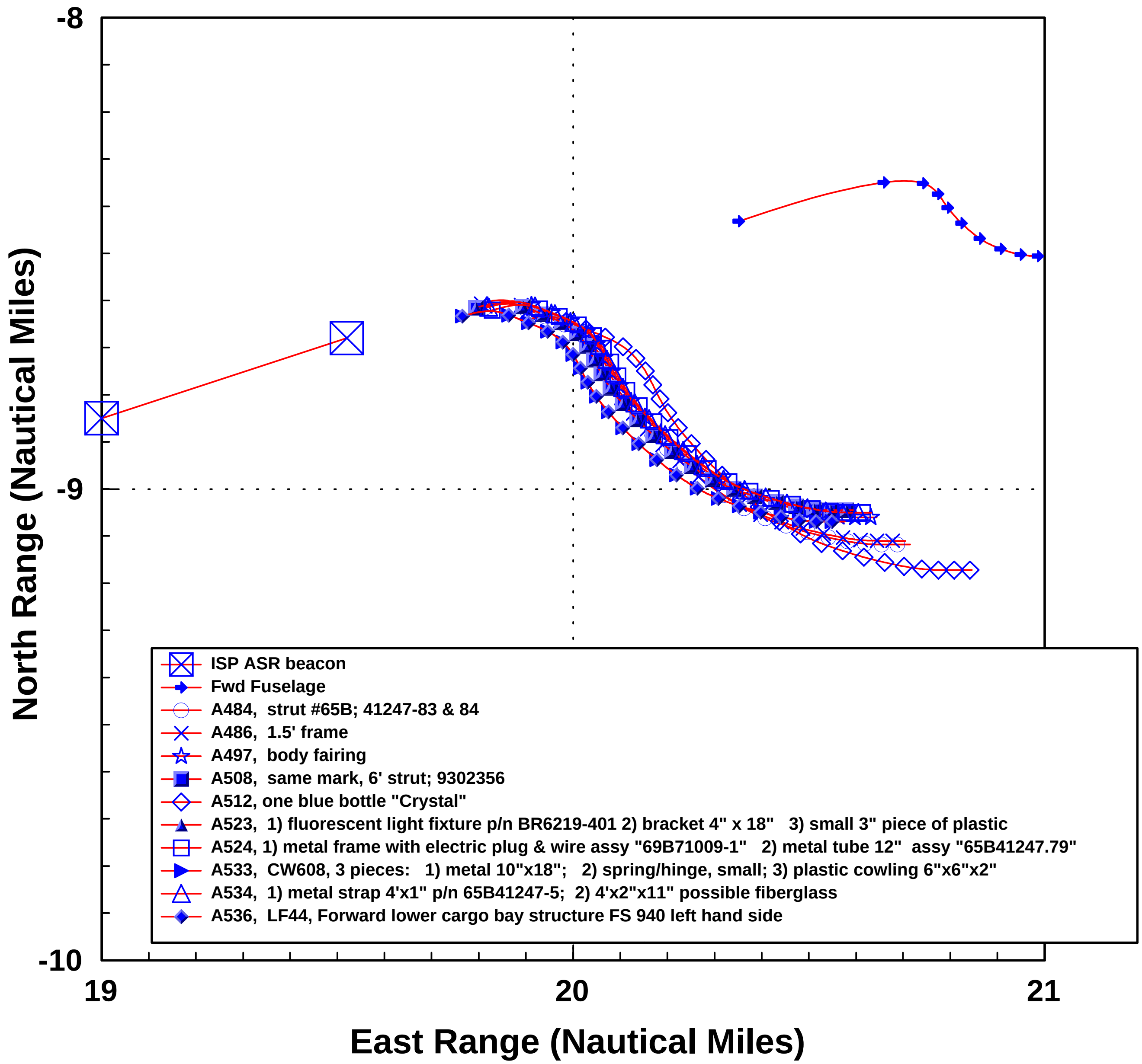
TWA 800
Wreckage Row 3a



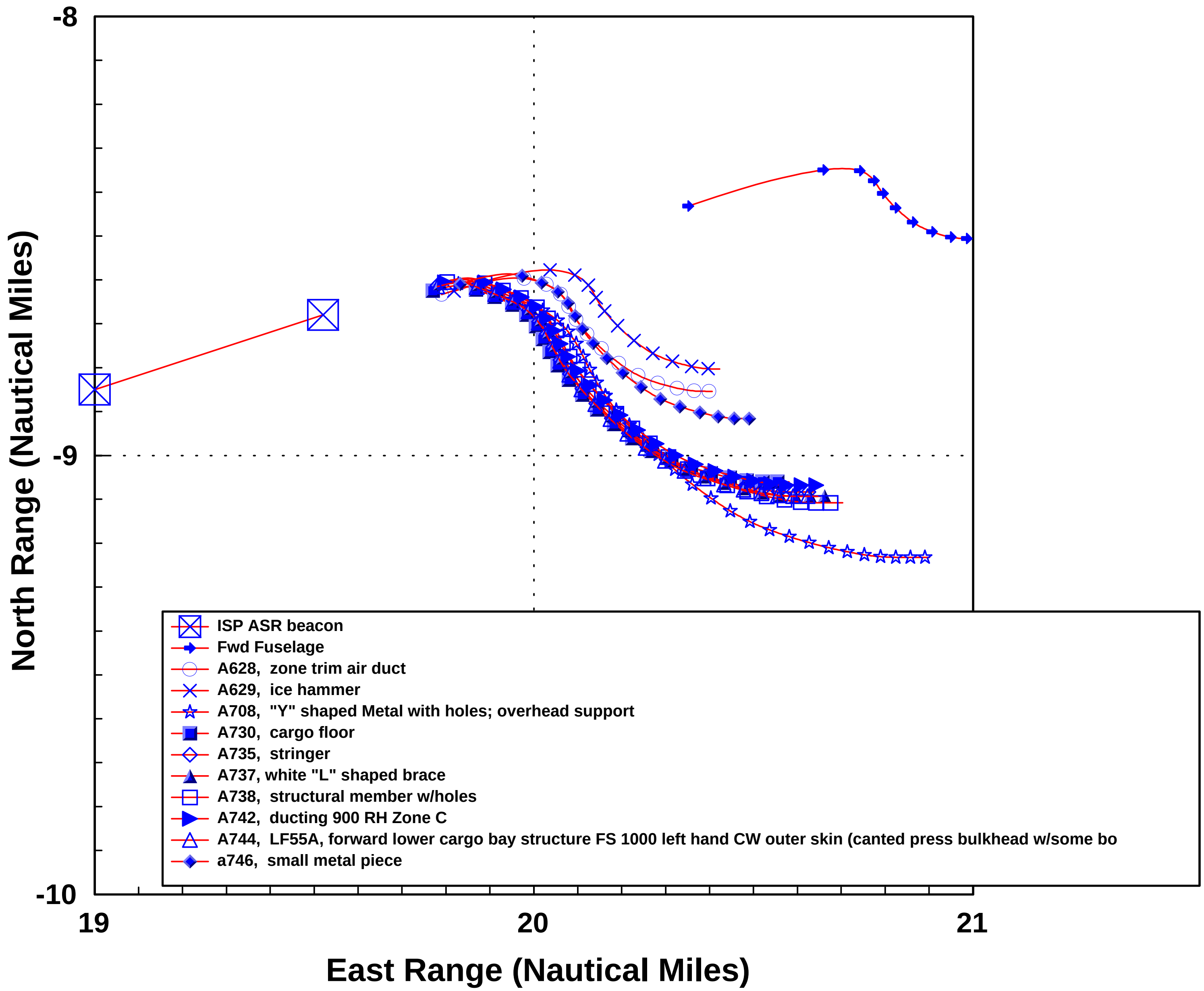
TWA 800
Wreckage Row 3a



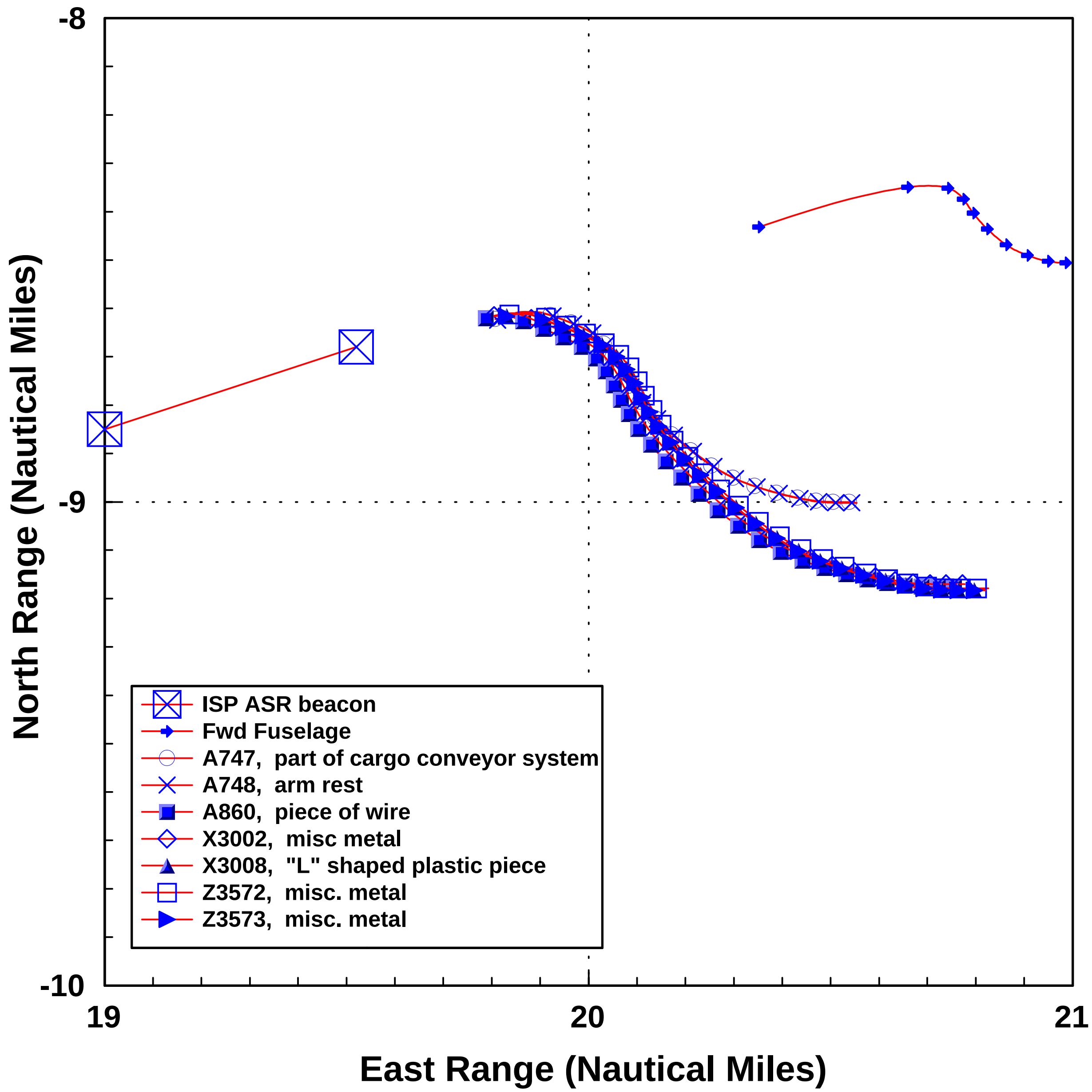
TWA 800
Wreckage Row 3a



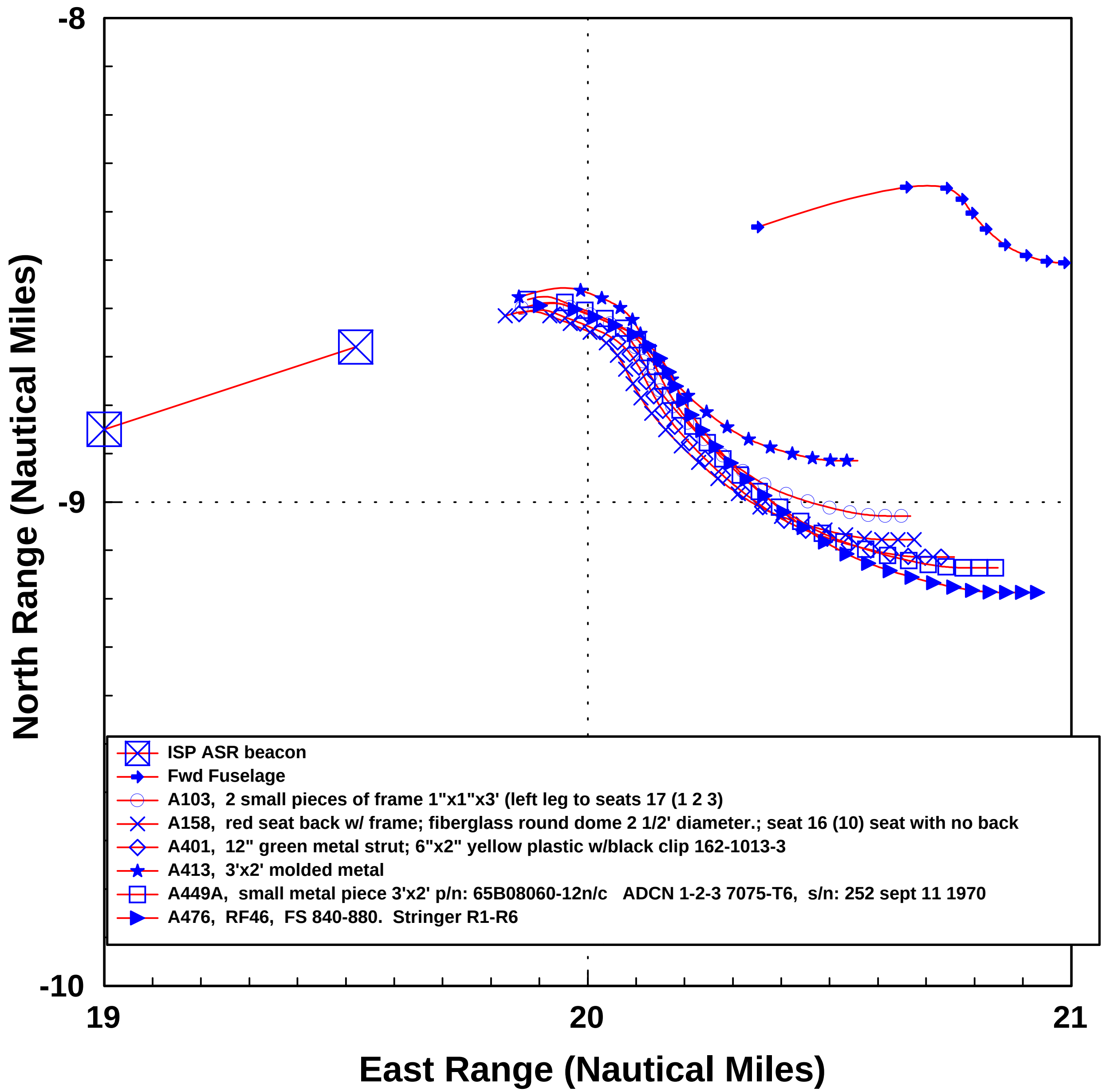
TWA 800
Wreckage Row 3a



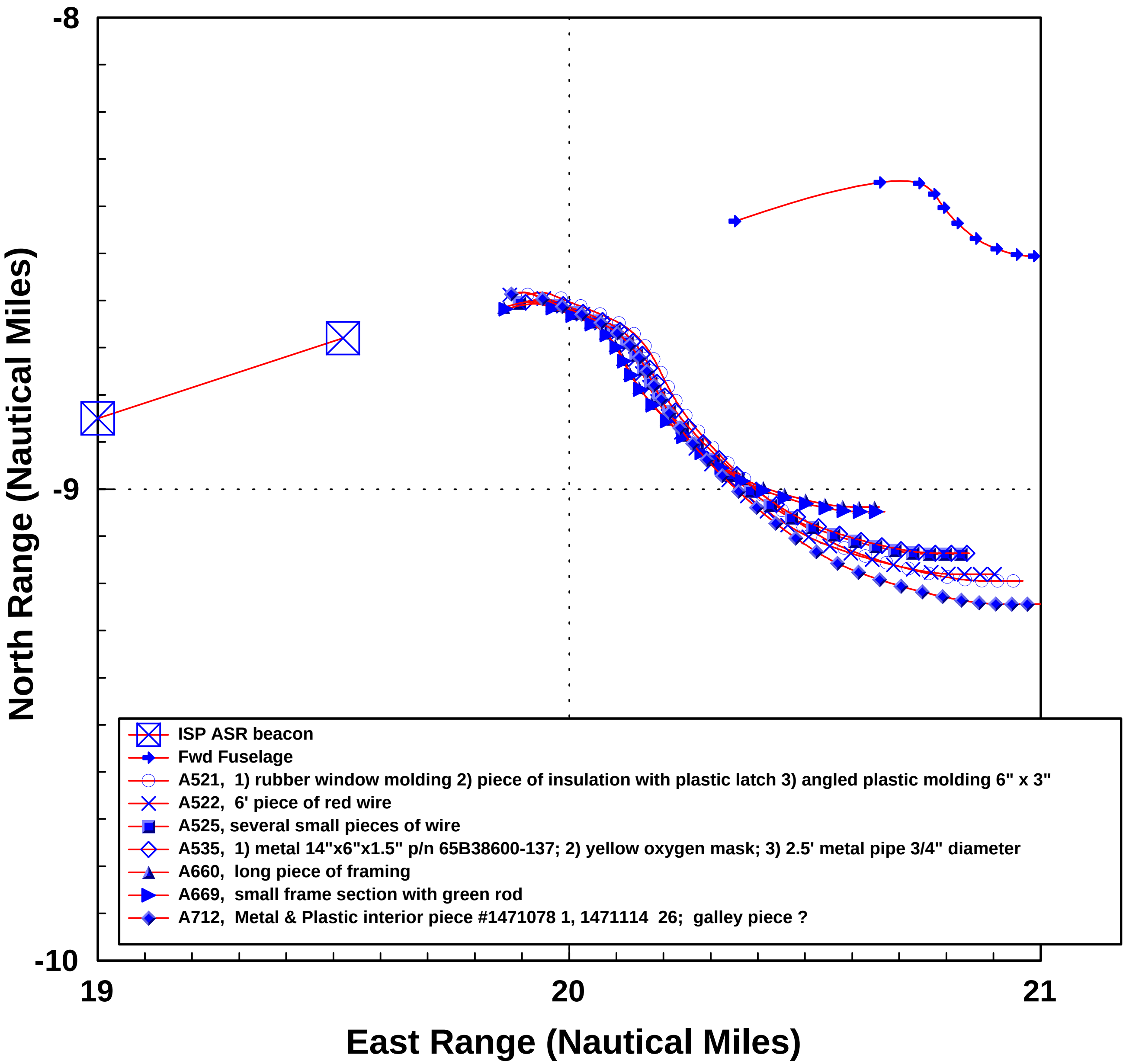
TWA 800
Wreckage Row 3a



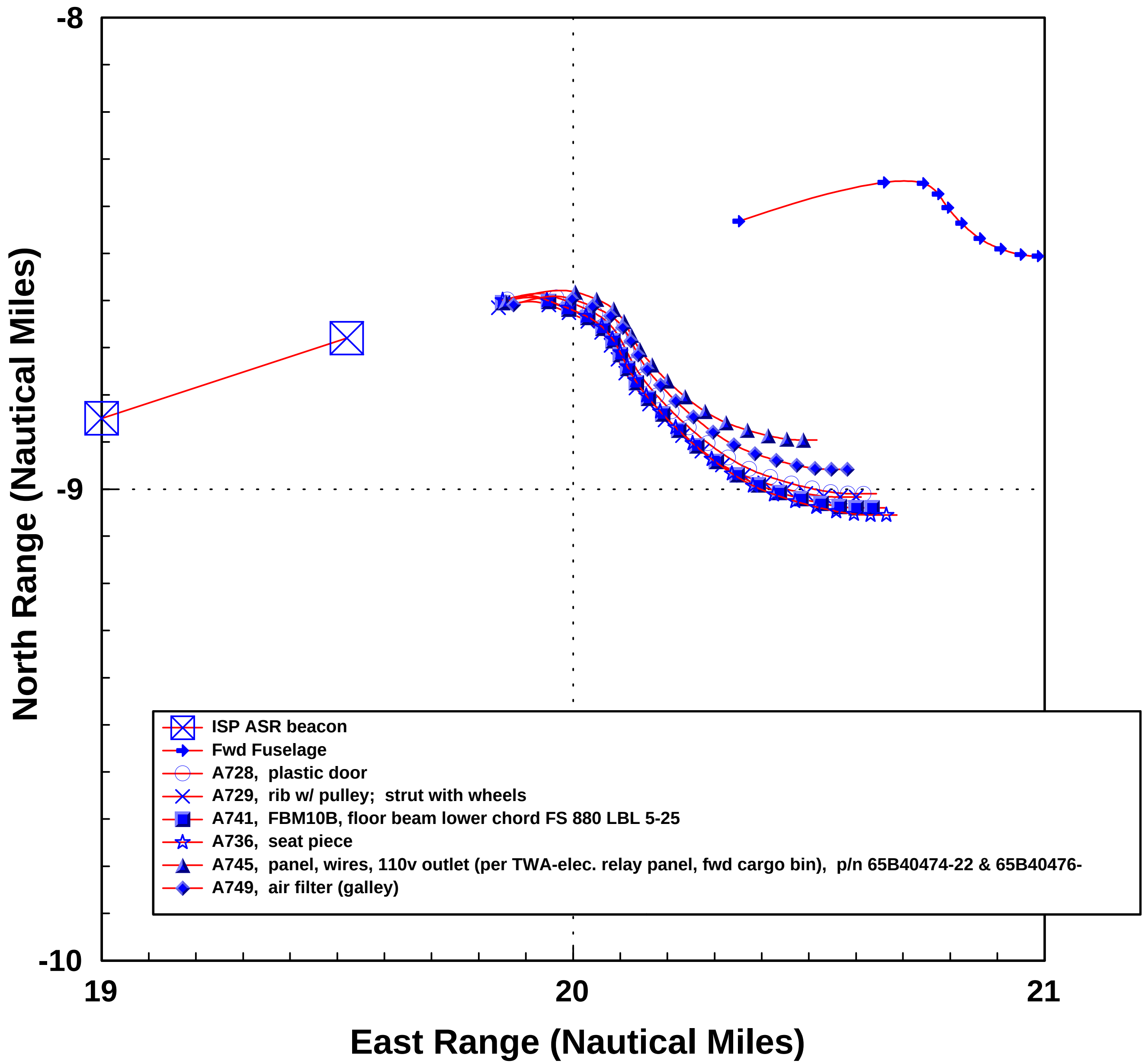
TWA 800
Wreckage Row 3b



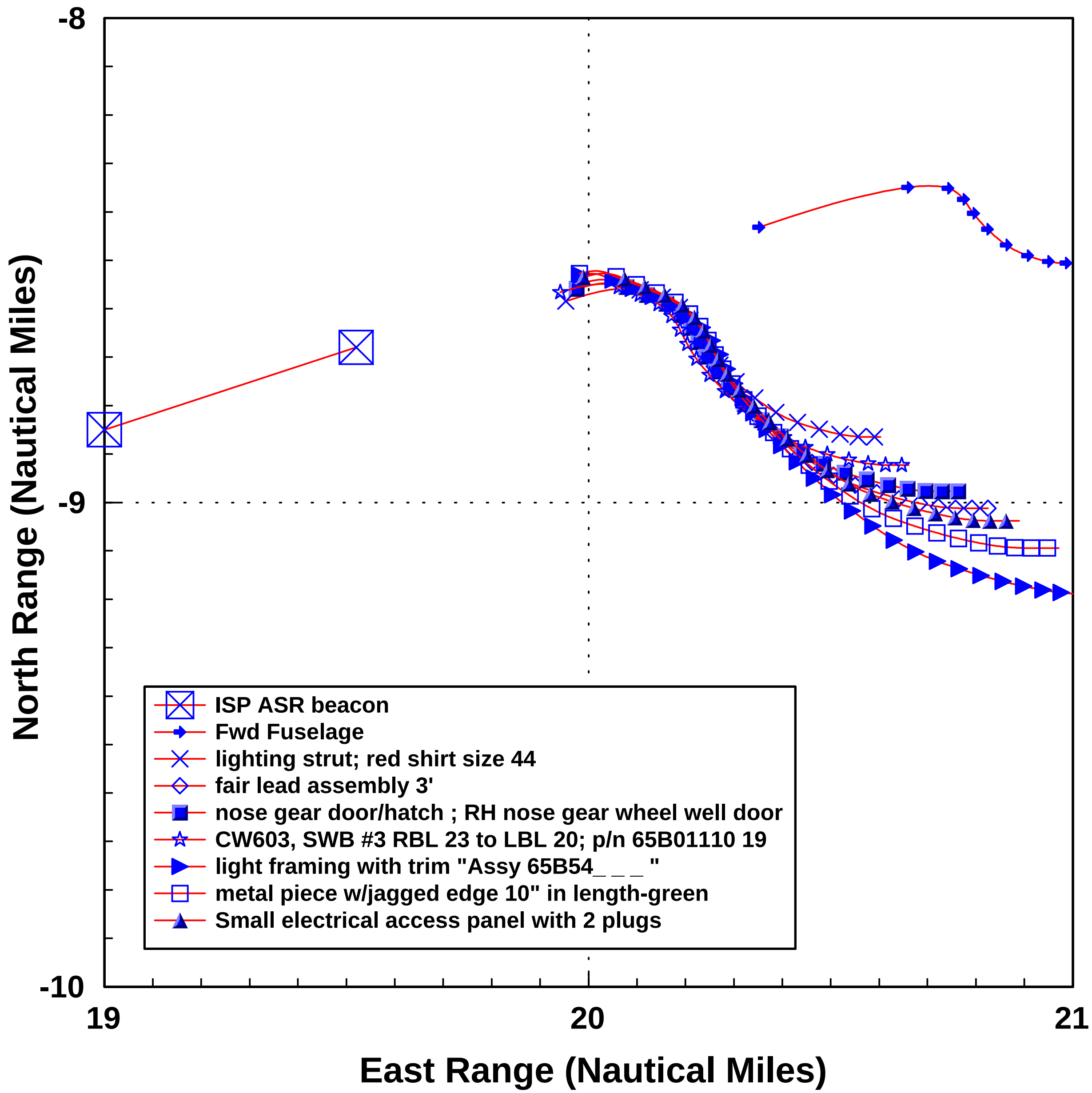
TWA 800
Wreckage Row 3b



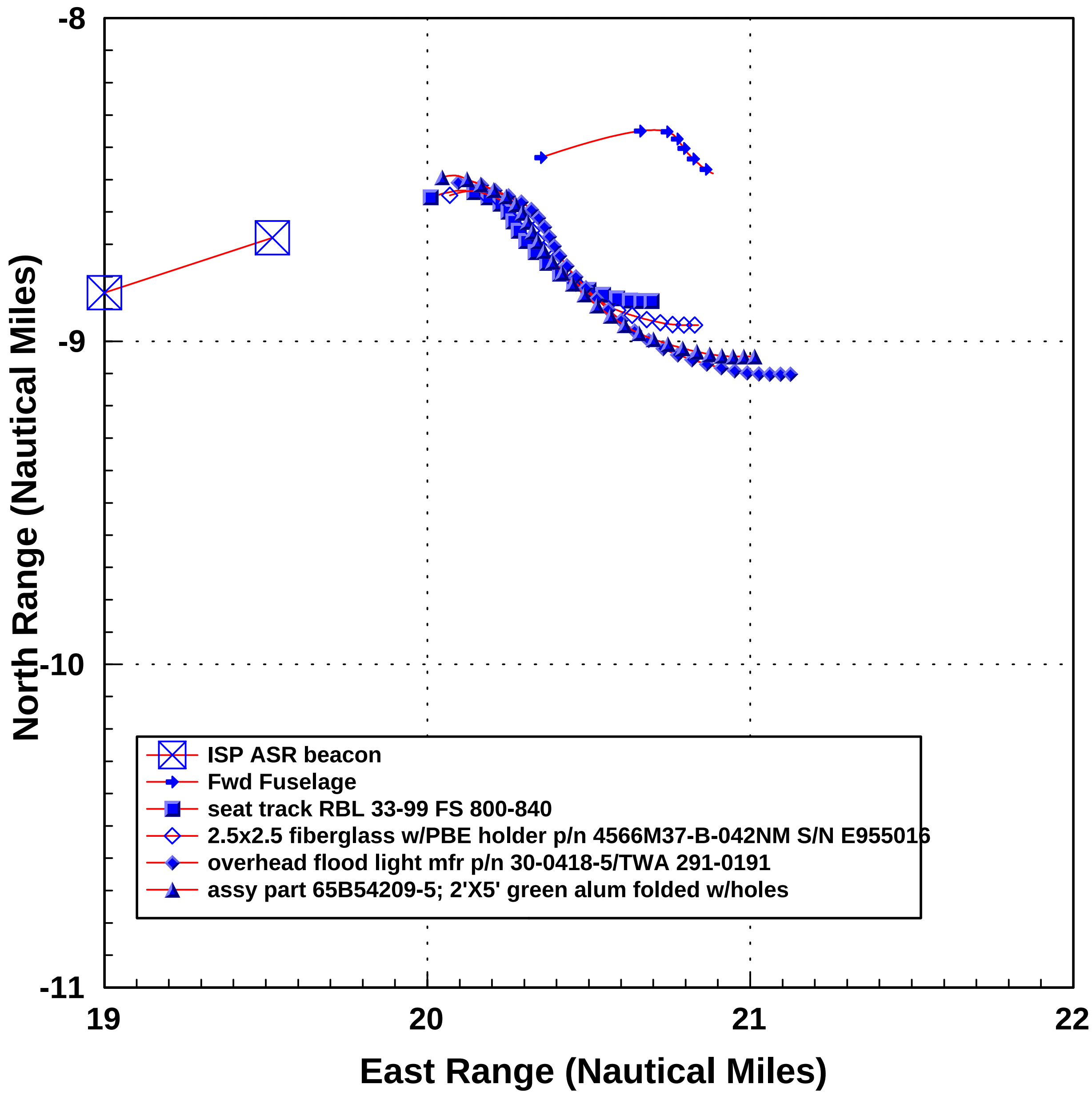
TWA 800
Wreckage Row 3b



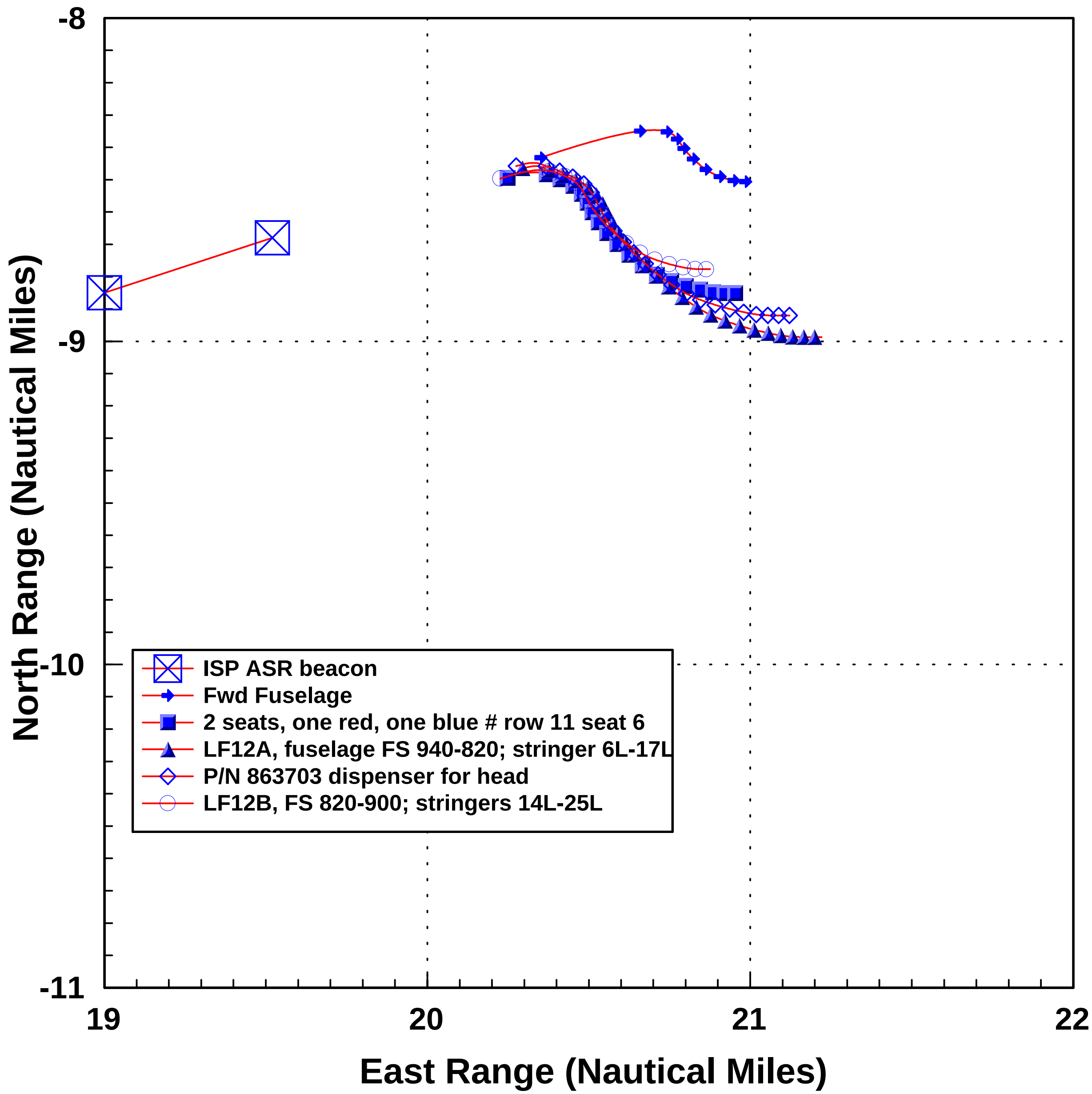
TWA 800
Wreckage Row 4



TWA 800
Wreckage Row 5



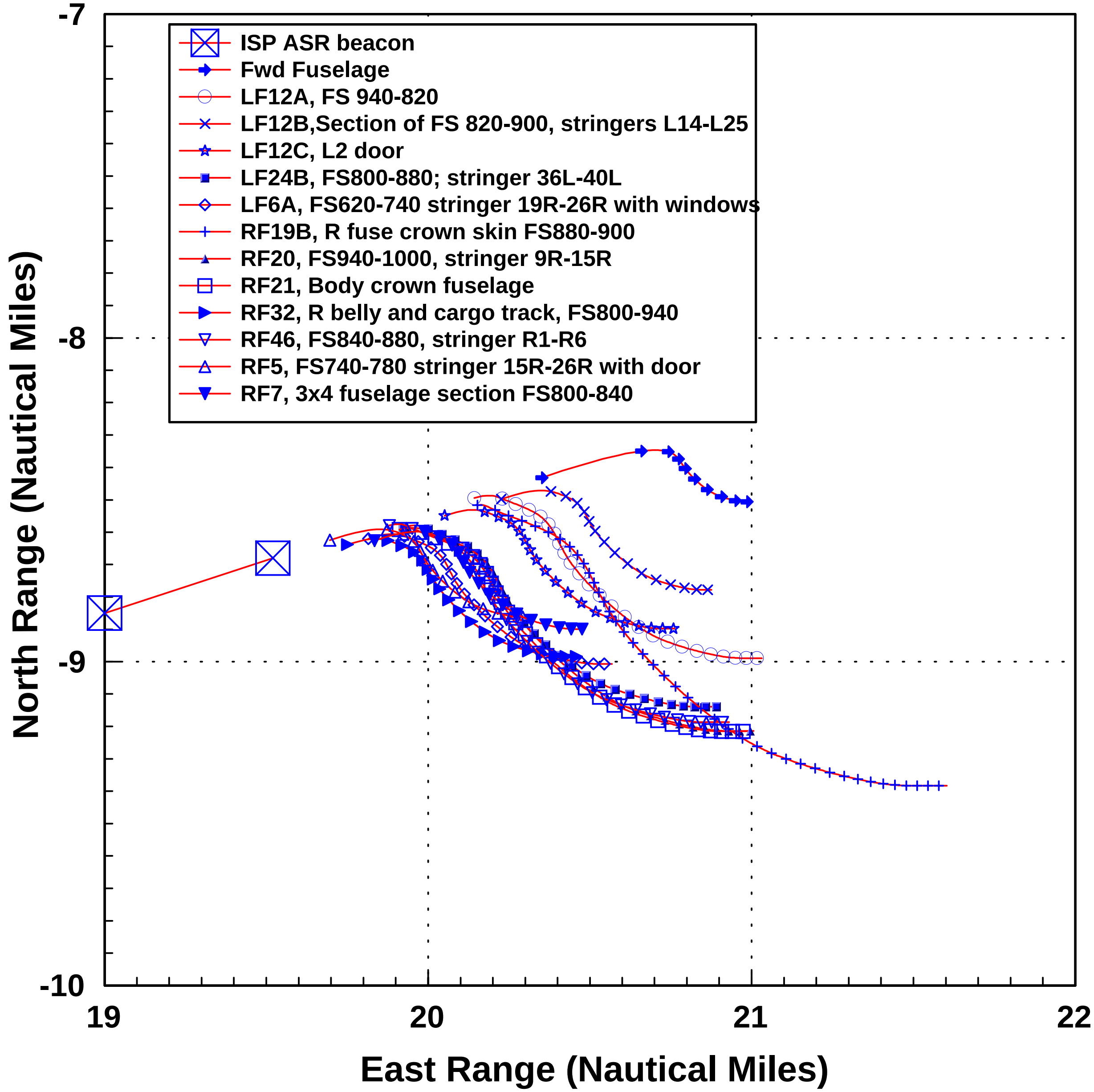
TWA 800
Wreckage Row 6



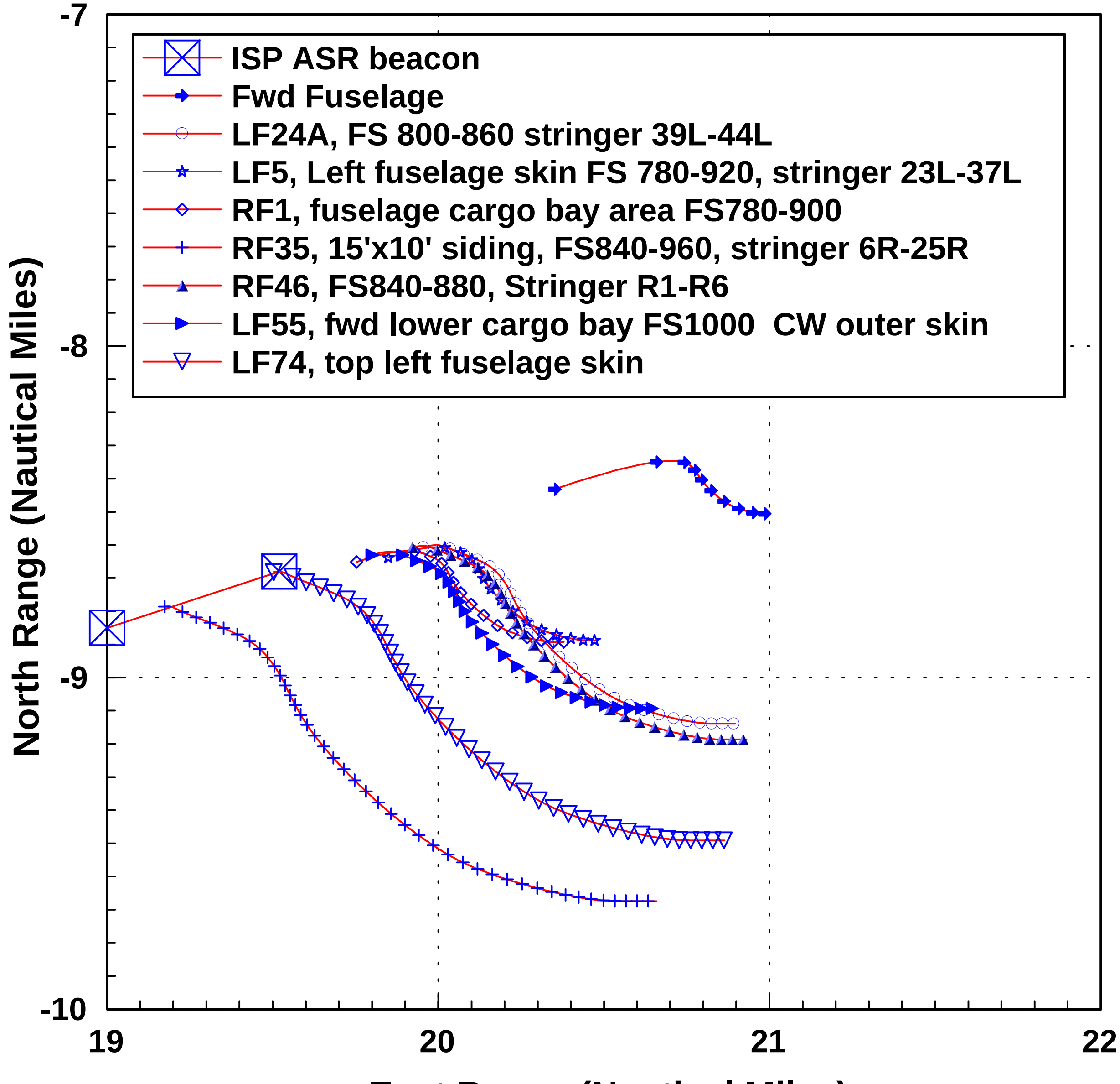
ATTACHMENT 3

Red Zone Fuselage Skin Trajectories

TWA 800
Red Area Fuselage Skin
Trajectories



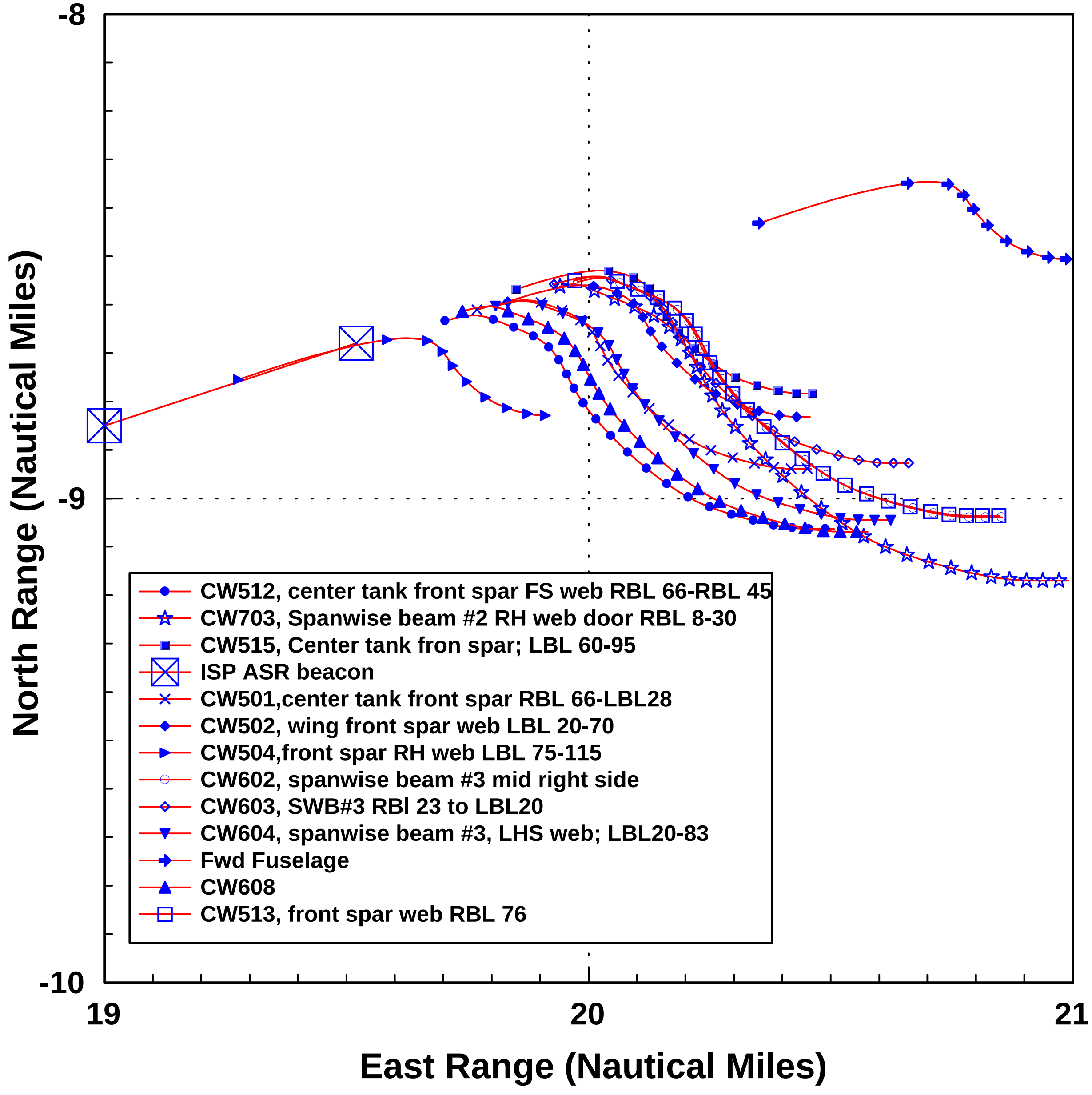
TWA 800
Red Area Fuselage Skin
Trajectories



ATTACHMENT 4

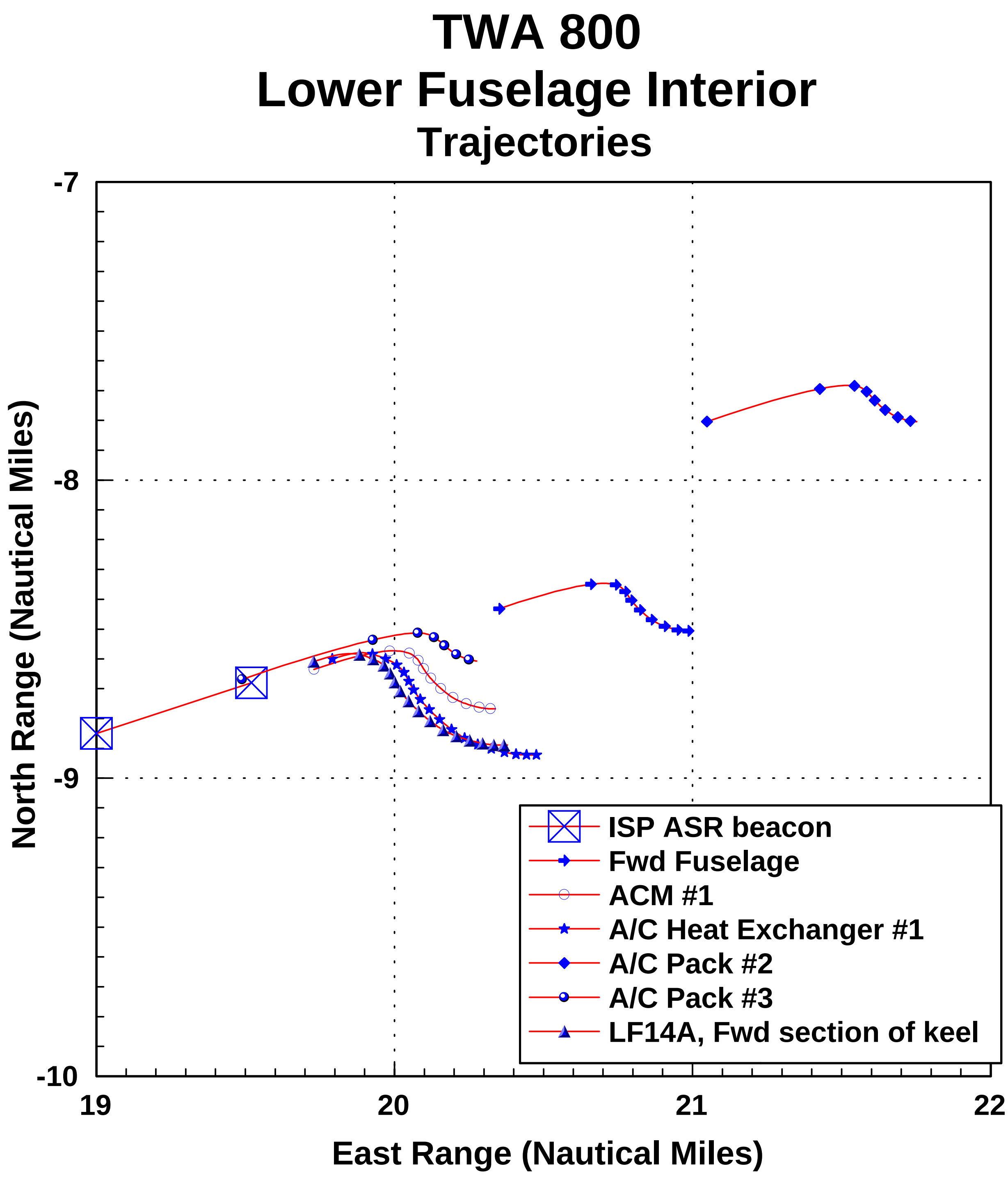
Center Tank Trajectories

TWA 800
Center Tank Parts
Trajectories



ATTACHMENT 5

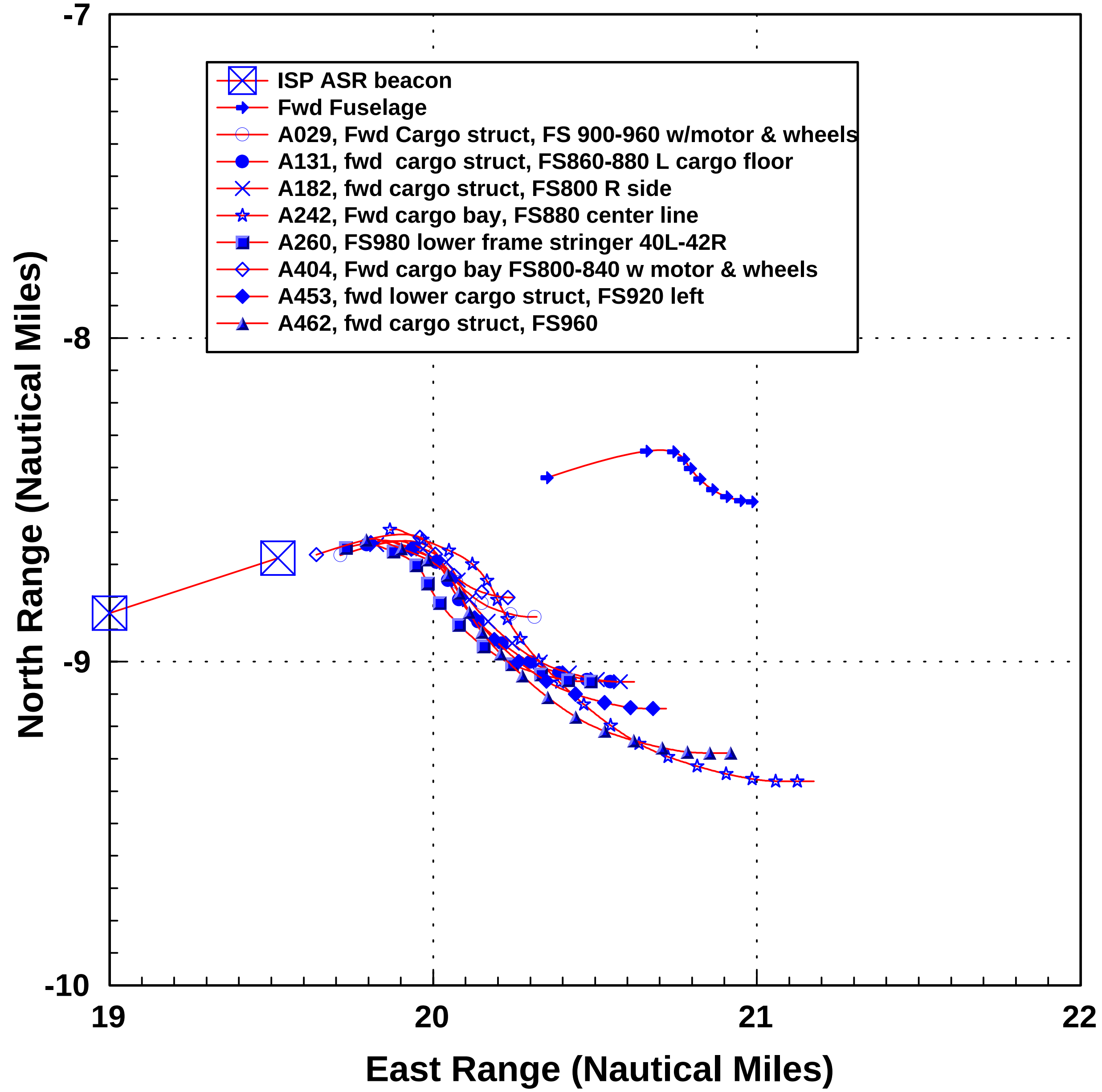
Lower Fuselage Interior
(Beneath Center Tank)
Trajectories


TWA 800
Lower Fuselage Interior
Trajectories
-7
-8
-9
-10
19
20
21
22
North Range (Nautical Miles)
East Range (Nautical Miles)
ISP ASR beacon
Fwd Fuselage
ACM #1
A/C Heat Exchanger #1
A/C Pack #2
A/C Pack #3
LF14A, Fwd section of keel

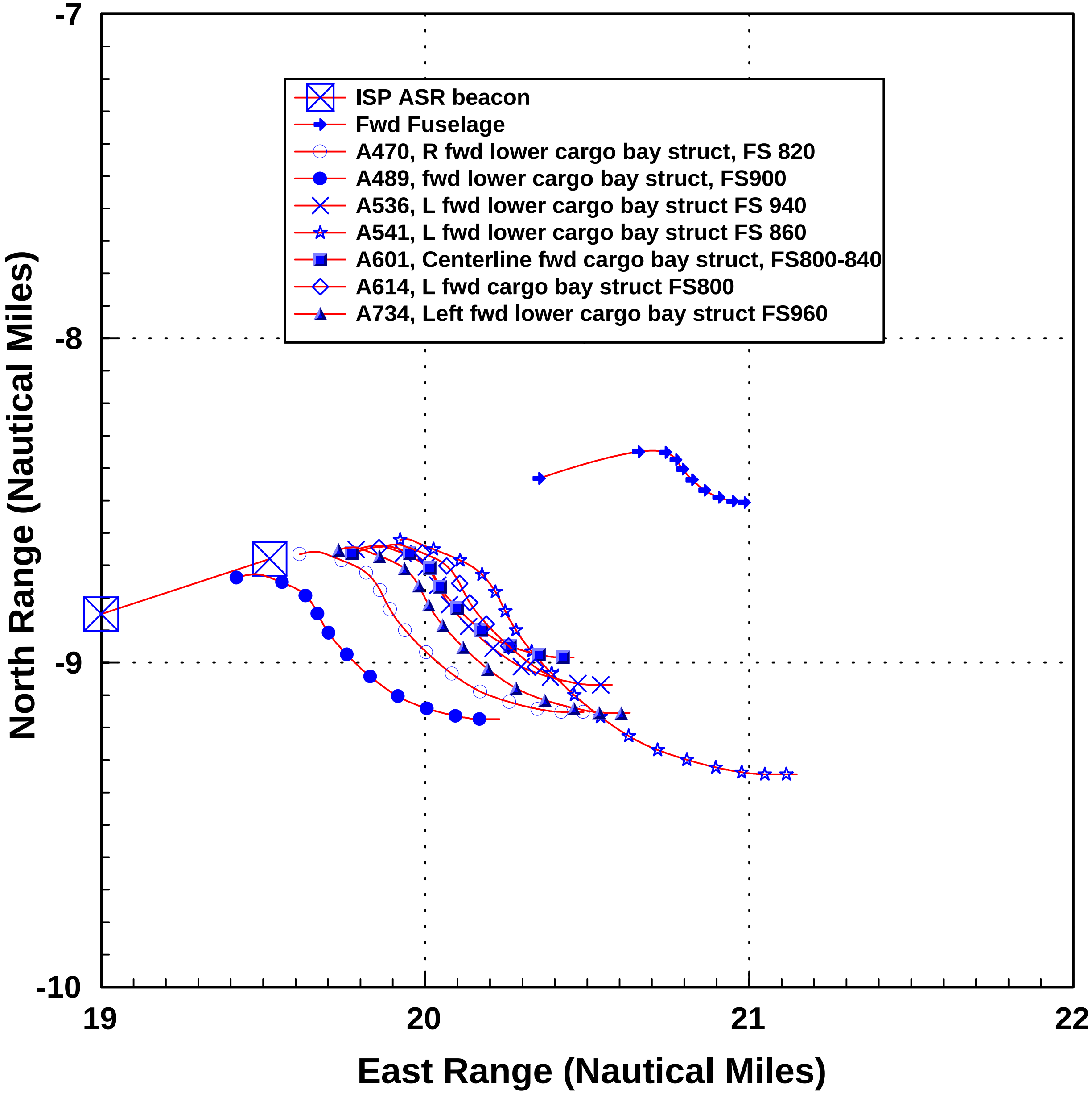
ATTACHMENT 6

Forward Cargo Structure Trajectories

TWA 800
Forward Cargo Structure
Trajectories



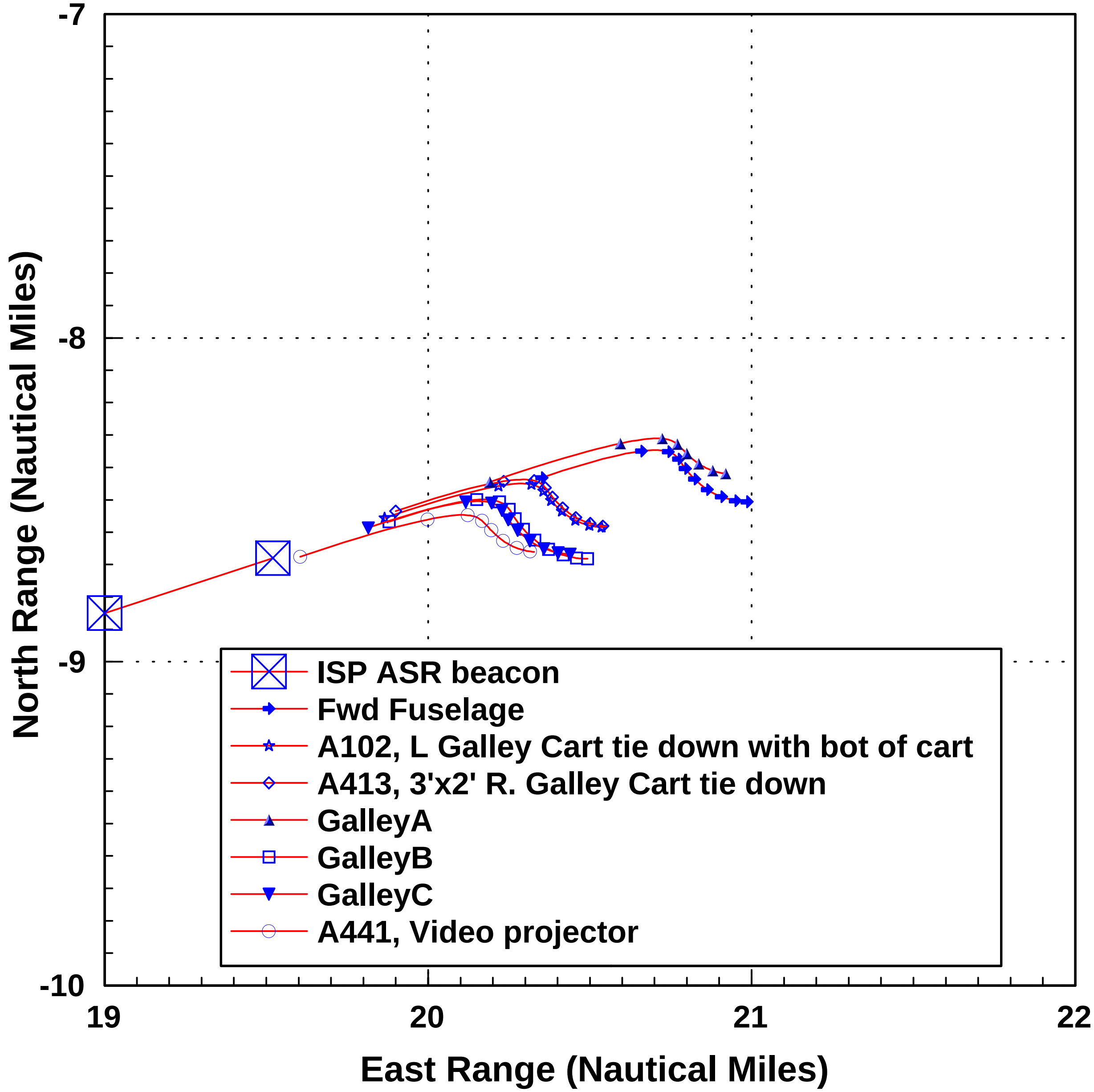
TWA 800
Forward Cargo Structure
Trajectories



ATTACHMENT 7

Selected Cabin Interior Trajectories

TWA 800
Cabin Interior
Trajectories

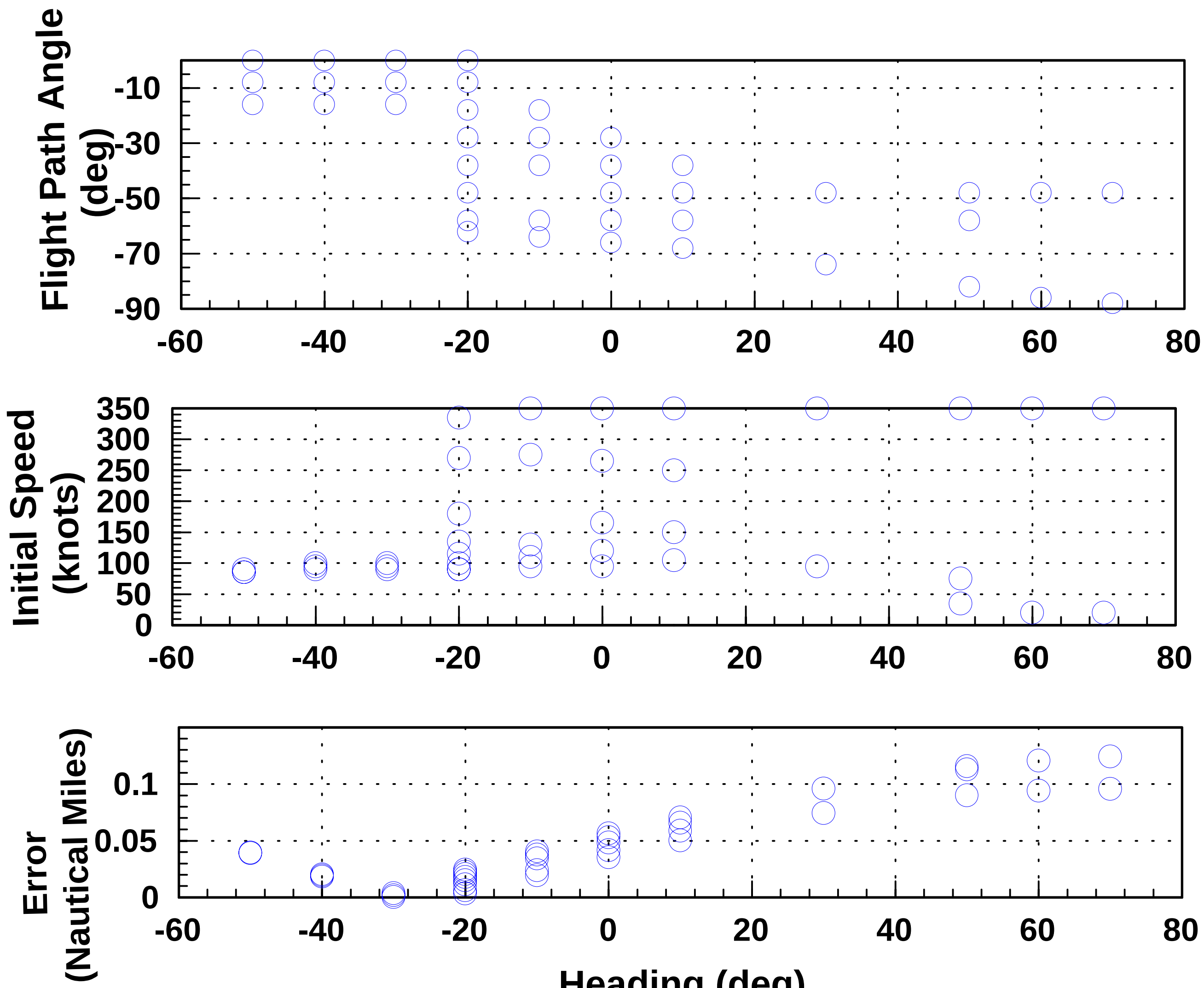


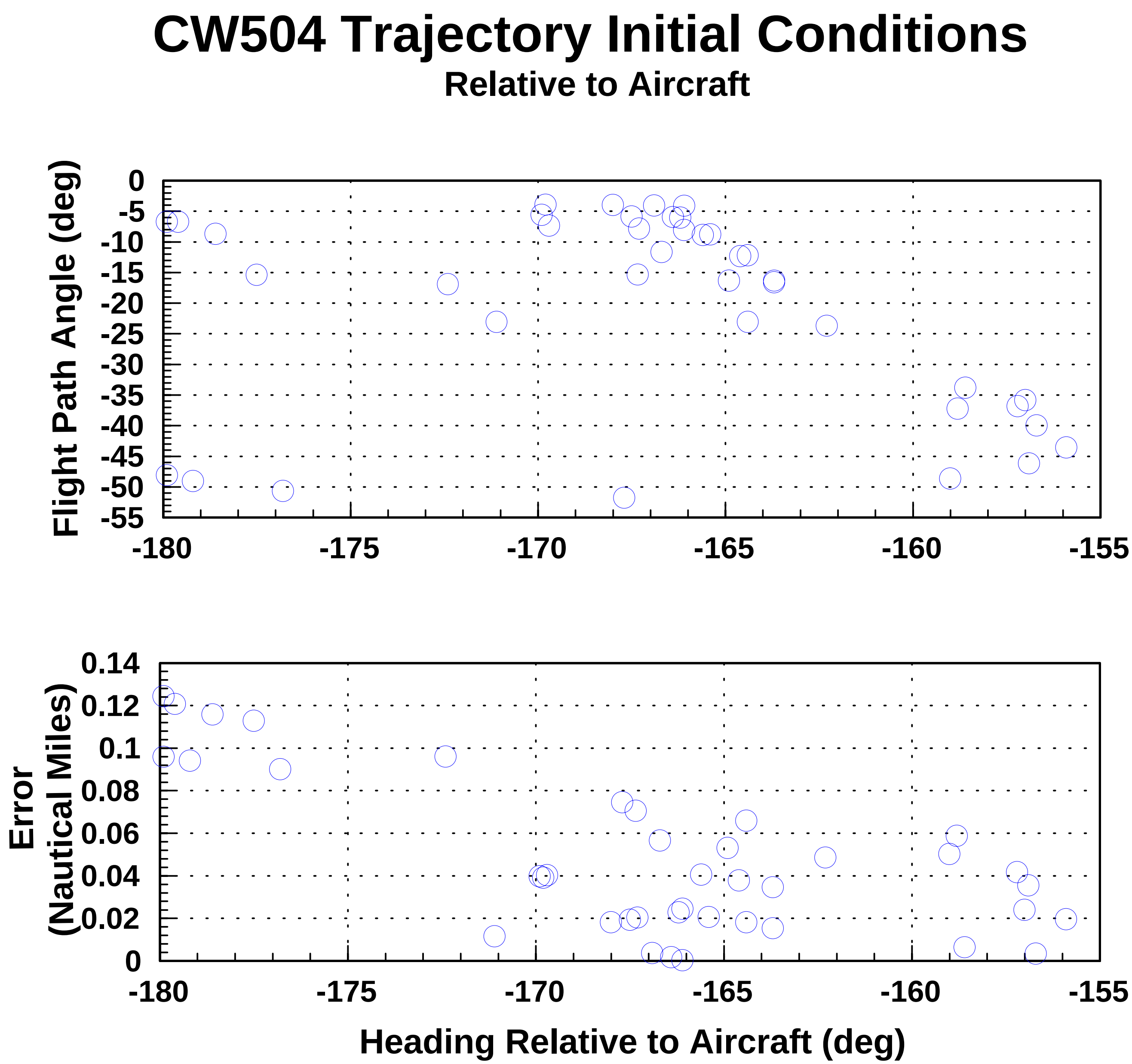
ATTACHMENT 8

Item CW504 required initial conditions from wave 1

CW504 Trajectory Initial Conditions

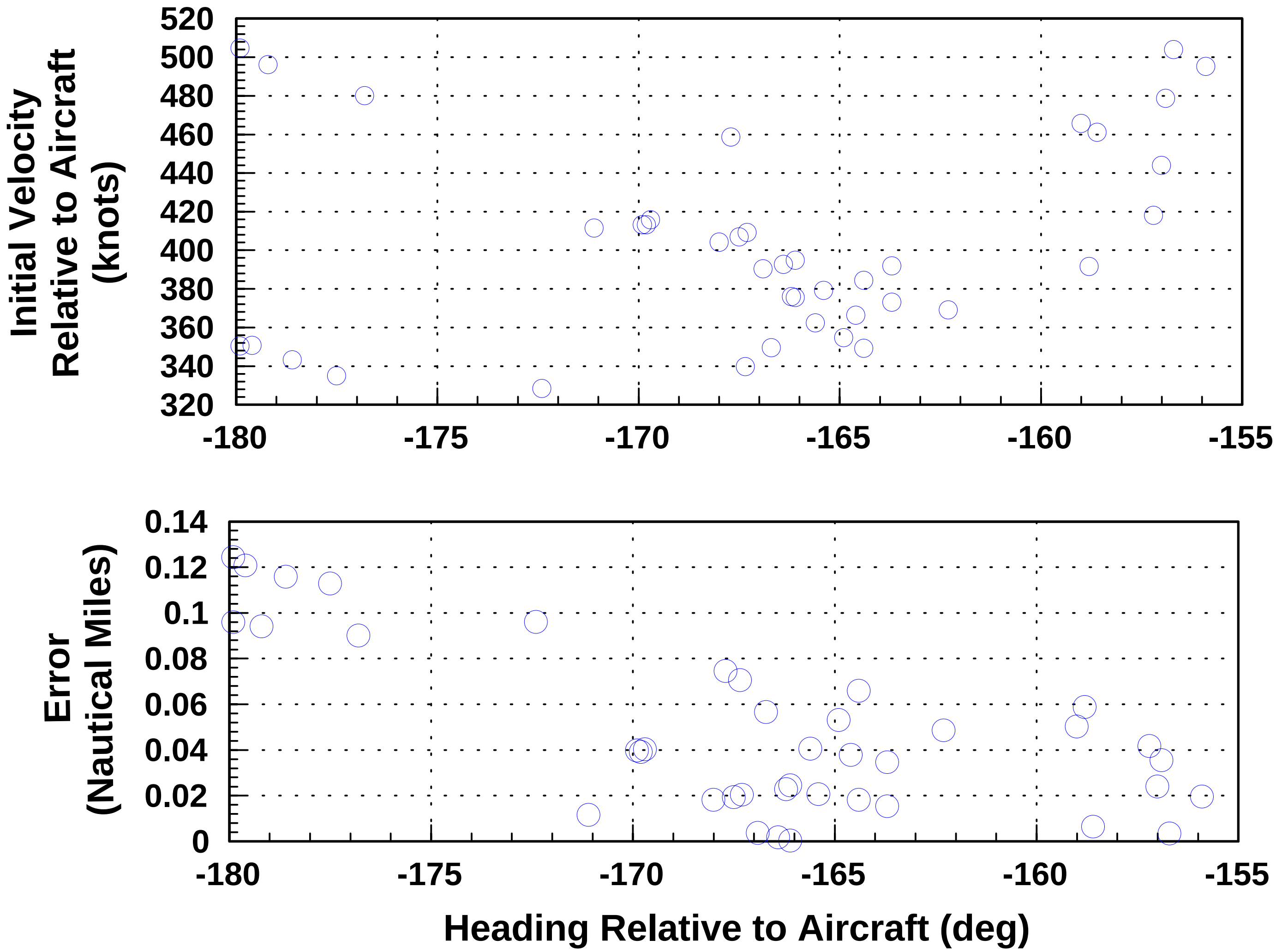
Relative to Ground




CW504 Trajectory Initial Conditions
Relative to Aircraft
Flight Path Angle (deg)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-180
-175
-170
-165
-160
-155
Error
(Nautical Miles)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-180
-175
-170
-165
-160
-155
Heading Relative to Aircraft (deg)

CW504 Trajectory Initial Conditions

Relative to Aircraft



ATTACHMENT 9

Ballistic Coefficient Estimates

Ballistic Coefficient Calculations

Fuselage Skin (Red Zone)

Part LF5 (tag A022)

Location: 40:38:41.57 N 72 39 07.30W

Description: Section of left fuselage, FS 780-920; stringer 23L-37L

Weight: 215lb. (Boeing Estimate)
Area: 5.0 * 8.3 = 41.7 ft^2

Falling Mode: Part LF5 will probably fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The drag coefficient for an object falling in this mode should be between 0.4 and 0.65 depending on angle

Wt/C_DS = 215.0/0.4(41.7) = 12.9 lbs/ft^2

Wt/C_DS = 215.0/0.65(41.7) = 7.9 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 7.9 to 12.9 lbs/ft^2

Part LF6A (tag A141)

Location: 40 38 34.40N 72:39:0.30W

Description: forward lower cargo bay structure FS 900-980

Weight: 375.0 (Boeing Estimate)
Area: 8.0 * 16.7 = 134 ft^2

Falling Mode: Item LF6A will probably fall with one end down perhaps with rotation about the diagonal axis.

Ballistic Coefficient: The ballistic coefficient will be calculated with a high and low drag coefficient assuming rotation for the low drag coefficient.

Low Drag Mode
The drag coefficient for the lowest drag mode anticipated is 0.5
Wt/C_DS = 375/0.5(134) = 5.6 lbs/ft^2

High Drag Mode
The drag coefficient for the highest drag mode anticipated is 0.9
Wt/C_DS = 375/0.9(134) = 3.1 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.1 to 5.6 lbs/ft^2

Part LF6B (tag B2016)

Location: 40 39 04.30 N 72 38 27.20 W

Description: FS 740-800; stringer 44L-43R

Weight: 81lb. (Boeing Estimate)
Area: $5.0 * 8.0 = 40.0\ ft^2$

Falling Mode: Item LF6B will most likely will fall with a rotation about a tilted long axis describing a circular path about a center point off the heavy end.

Ballistic Coefficient: The ballistic coefficient will be calculated with a maximum and minimum anticipated axis tilt angle.

Low Axis Tilt Mode
The drag coefficient with the lowest anticipated axis tilt is 0.9
$Wt/C_DS = 811/0.9(40.0) = 22.5\ lbs/ft^2$

High Axis Tilt Mode
The drag coefficient with the highest anticipated axis tilt is 0.5
$Wt/C_DS = 811/0.5(40.0) = 40.5\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 22.5$ to $40.5\ lbs/ft^2$

Part LF12A (tag A126)

Location: 40:38:35.38 N 72 38 08.94 W

Description: fuselage FS 940-820; stringer 6L-17L

Weight: 217lb. (Boeing Estimate)
Area: 5.0 * 10.0 = 50ft^2

Falling Mode: Part LF12A will most likely will fall with a rotation about a tilted long axis describing a circular path about a center point off the heavy end. A flat plate falling mode is also possible.

Ballistic Coefficient: On the high end the ballistic coefficient will be calculated with the minimum anticipated axis tilt angle (lowest drag). On the low end the ballistic coefficient will be calculated for the flat plate mode (highest drag).

Flat plate mode
The drag coefficient for the flat plate mode is approximately 1.18.
Wt/C_DS = 217/1.18(50.0) = 3.7 lbs/ft^2

High axis tilt mode
The drag coefficient with the highest anticipated axis tilt is 0.5
Wt/C_DS = 217/0.5(50.0) = 8.7 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.7 to 8.7 lbs/ft^2

Part LF12B (tag A181)

Location: 40:38:48.07 N 72:38:35.95 W

Description: FS 820-900; stringers 14L-25L

Weight: 108 lb. (Boeing Estimate)
Area: 5.5 * 3.8 + 3 * 1 = 23.9 ft^2

Falling Mode: Part LF12B could fall with a rotation about a tilted long axis describing a circular path about a center point off the heavy end or with one edge towards the airflow.

Ballistic Coefficient: On the high end the ballistic coefficient will be calculated assuming one edge towards the airflow mode(lowest drag). On the low end the ballistic coefficient will be calculated using the lowest anticipated angle for the axis of rotation in the rotation about the long axis mode (highest drag).

Small end towards airflow mode
The drag coefficient in this mode is approximately 0.25
$Wt/C_DS = 108/0.25(23.9) = 18.1 \ lbs/ft^2$

Low axis tilt mode
The drag coefficient with the lowest anticipated axis tilt is approximately 0.7
$Wt/C_DS = 108/0.7(23.9) = 6.5 \ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 6.5 \text{ to } 18.1 \ lbs/ft^2$

Part LF12C (tag A136)

Location: 40:38:40.86 N 72:38:45.07 W

Description: L2 door 65B04425-411

Weight: 220 lb. (Boeing Estimate)
Area: 6.5 * 3.8 = 24.7 ft^2

Falling Mode: The door could fall with one edge forward(small area into the wind), or in a flat plate mode (large area into the wind) or with a rotation about a tilted long axis describing a circular path about a center point off the heavy end or with one end down.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculating the ballistic coefficient for the flat plate and edge forward falling modes.

<u>Flat plate mode:</u>
The drag coefficient for part LF12C in a flat plate mode should be approximately 1.18.
$Wt/C_DS = 220.0/1.18(24.7) = 7.5$ lbs/ft^2

<u>Edge forward mode:</u>
The drag coefficient for part LF12C in edge forward mode should be approximately 0.2.

$Wt/C_DS = 220.0/0.2(24.7) = 44.5$ lbs/ft^2

Ballistic Coefficient Summary: $Wt/C_DS =$ 7.5 to 44.5 lbs/ft^2

Part LF24A (tag A2017)

Location: 40 38 26.39 N 72 38 34.66 W

Description: FS 800-860; stringer 39L-44L

Weight: 33 lb. (Boeing Estimate)
Area: 3.0 * 5.0 = 15 ft^2

Falling Mode: Item LF24A could fall as a flat plate or with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient:

Flat Plate Mode
The drag coefficient of this object falling as a flat plate should be approximately 1.18
$Wt/C_DS = 33.0/ 1.18 (15.0) = 1.9 lbs/ft^2$

Rotation about long axis with on side down
The drag coefficient of this object rotating with one side down could be as low as 0.4.
$Wt/C_DS = 33.0/ 0.4 (15.0) = 5.5 lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.9$ to $5.9 lbs/ft^2$

Part LF24B (tag A252)

Location: 40:38:26.39 N 72:38:34.66 W

Description: FS 800-880; stringer 36L-40L

Weight: 18.0lb. (Boeing Estimate)
Area: $7.0 * 2.0 = 14.0\ ft^2$

Falling Mode: Part LF24B could fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end, could fall as a flat plate, or may even fly non ballistic.

Ballistic Coefficient: The ballistic coefficient will be calculated for both the rotation about it's long axis mode and the flat plate falling mode.

Rotation about long axis mode:
The drag coefficient of an object falling in this mode could be as low as 0.4.
$Wt/C_DS = 18.0/0.4(14.0) = 3.2\ lbs/ft^2$

Flat plate mode:
The drag coefficient for part LF24B in this mode should be approximately 1.18.
$Wt/C_DS = 18.0/1.18(14.0) = 1.1\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.1$ to $3.2\ lbs/ft^2$

Part LF55B (tag A449)

Location: 40 38 27.71 N 72 38 48.87 W

Description: Forward lower Cargo bay structure FS 1000 left hand

Weight: 20 lb. (estimate)
Area: $2.5 * 2.0 = 5.0\ ft^2$

Falling Mode: Part A449 could fall anywhere between one edge to the airflow and a flat plate mode.

Ballistic Coefficient:

Edge to the airflow mode:
The drag coefficient of this object falling with one edge to the airflow should be approximately 0.3.
$Wt/C_DS = 20.0/(0.3)(5.0) = 13.3\ lbs/ft^2$

Flat plate mode:
The drag coefficient of this object falling as a flat plat should be approximately 1.2.
$Wt/C_DS = 20.0/(1.2)(5.0) = 3.3\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.3$ to $13.3\ lbs/ft^2$

Part RF1 (tag A004)

Location: 40 38 41.29 N 72 39 15.25W

Description: FS 760-960; stringer 22R-37R; pn 6580173

Weight: 543 lb. (Boeing Estimate)
Area: 10.0 * 13.0 = 130 ft^2

Falling Mode: Item RF1 could fall as a flat plate but will more likely fall with a rotation about it's long axis with the long axis tilted down

Ballistic Coefficient:

Flat Plate Mode
The drag coefficient for this item in flat plate mode should be 1.18
Wt/C_DS = 543/1.18(130.0) = 3.5 lbs/ft^2

Rotation about Tilted Long Axis Mode
The drag coefficient for this item rotating about a tilted long axis could be as low as 0.4
Wt/C_DS = 543/0.4(130.0) = 10.4 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.5 to 10.4 lbs/ft^2

Part RF5 (tag A071)

Location: 40:38:43.1 N 72:39:19.8 W

Description: FS 740-780 stringers 15R-26R with R2 door attached (#5804951 7 on bottom inner door frame)

Weight: 316 lb. (Boeing Estimate)
Area: 9.0 * 6.0 = 54 ft^2

Falling Mode: With the heavy mass of the door on one side and the aspect ratio it has, item RF5 will most likely rotate about it’s long axis with the long axis pointed down as it describes a circular flight path with the center off the heavy end.

Ballistic Coefficient: The ballistic coefficient will be calculated for each end of the probable tilt angles for this item

Low Axis Tilt
The drag coefficient for the low end of possible axis tilt should be about 0.9
Wt/C_DS = 316/0.9(54.0) = 6.5 lbs/ft^2

High Axis Tilt
The drag coefficient for the low end of possible axis tilt should be about 0.4
Wt/C_DS = 316/0.4(54.0) = 14.6 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 6.5 to 14.6 lbs/ft^2

Part RF7 (tag A033)

Location: 40:38:40.9 N 72:39:07.4 W

Description: Right fuselage skin FS 800-850 with top of door frame

Weight: 93 lb. (measured), c.g offset from center in both x and y

Area: $3.33 * 4.42 - 1.0 = 13.7\ ft^2$

Falling Mode: Item RF7 could fall as a flat plate but will more likely fall with a rotation about it's long axis with the long axis tilted down

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculating the coefficient for the flat plate mode (highest drag) and for a rotation about the long axis at maximum anticipated tilt (lowest drag).

Flat Plate Mode

The drag coefficient for this item in flat plate mode should be 1.18

$Wt/C_DS = 93/1.18(13.7) = 5.7\ lbs/ft^2$

Rotation about Tilted Long Axis Mode

The drag coefficient for this item rotating about a tilted long axis could be as low as 0.4

$Wt/C_DS = 93/0.4(13.7) = 17\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 5.7$ to $17\ lbs/ft^2$

Part RF19b (tag A268)

Location: 40: 38: 11.33 N 72: 37: 39.0 W

Description: Piece of right fuselage

Weight: 0.7 lb. (measured 1.0 eliminated attached small stringer piece)
Area: 1.2 * 1.1 - 0.2 = 1.12 ft^2

Falling Mode: Item RF19B could fall as a flat plate or with a rotation about it's long axis with the long axis tilted down

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculating the coefficient for the flat plate mode (highest drag) and for a rotation about the long axis at maximum anticipated tilt (lowest drag).

Flat Plate Mode
The drag coefficient for this item in flat plate mode should be 1.18
Wt/C_DS = 0.7/1.18(1.12) = 0.53 lbs/ft^2

Rotation about Tilted Long Axis Mode
The drag coefficient for this item rotating about a tilted long axis could be as low as 0.4
Wt/C_DS = 0.7/0.4(1.12) = 1.6 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 0.53 to 1.6 lbs/ft^2

Part RF20 (tag A212)

Location: 40: 38: 21.82 N 72: 38: 25.96 W

Description: Piece of right fuselage

Weight: 26.0 lb. (measured)

Area: $4.17 * 3.67 - 3.0 - 4.0 = 8.3\ ft^2$

Falling Mode: Part RF20 should fall with the convex side facing to the wind.

Ballistic Coefficient: The drag coefficient of this object falling with convex side forward should be approximately 2.1.

$Wt/C_DS = 26.0/2.1(8.3) = 1.49\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.49\ lbs/ft^2$

Part RF21 (tag A2031 (was B561))

Location: 40:38:21.75 N 72:38:27.64 W

Description: Piece of right fuselage in red zone

Weight: 20.5 lb. (measured)
Area: $3.4 * 4.3 - .5 * (4.3 - 1.67) * 2.4 = 11.5\ ft^2$

Falling Mode: Part RF21 could fall in with the large area to the airflow or could fly in a non ballistic manner.

Ballistic Coefficient: The drag coefficient of this object falling with the large area to the airflow should be approximately 1.18

$Wt/C_DS = 20.5/1.18(11.5) = 1.51\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.51\ lbs/ft^2$

Part RF32 (tag A605)

Location: 40 38 35.80N 72 39 09.00W

Description: Right belly and cargo track between FS 800-940

Weight: 120lb. (Boeing Estimate)
Area: 7.0 * 4.5 = 31.5 ft^2

Falling Mode: Item RF32 will probably fall between a flat plate mode and a mode with a rotation about a tilted long axis describing a circular flight path about a line off the low end.

Ballistic Coefficient: The ballistic coefficient will be calculated for both modes.

Flat Plate Mode
The drag coefficient for this object falling as a flat plate is 1.18.
Wt/C_DS = 120.0/1.18(31.5) = 3.2 lbs/ft^2

Rotation About Tilted Long Axis Mode
The drag coefficient for this object falling with the highest probable tilt is approximately 0.4.
Wt/C_DS = 120.0/0.4(31.5) = 9.5 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.2 to 9.5 lbs/ft^2

Part RF35 (tag A421)

Location: 40:37:54.37 N 72:38:53.54 W

Description: Piece of right fuselage with 4 window frames

Weight: 389 lb. (Boeing Estimate)
Area: 7.5 * 12.25 = 92 ft^2

Falling Mode: Part RF35 has a weight offset to the window frames with a camber (fuselage curvature) for most of the part and an inverse camber (pealed metal) on the opposite end. This piece will probably fly.

Ballistic Coefficient: The ballistic coefficient will be calculated as a flat plate to get the minimum possible ballistic coefficient.

Flat plate mode:
The drag coefficient for this mode should be approximately 1.18.

Wt/C_DS = 389/1.18(92.0) = 3.8 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.8 lbs/ft^2

Part RF46 (tag A476)

Location: 40 38 23.46 N   72 38 31.94 W

Description: FS 840-880. Stringer R1-R6

Weight: 21.0lb. (Measured)
Area: 3.3 * 4.1 = 13.5ft^2

Falling Mode: Item RF46 will probably fall at an angle with the curved side down

Ballistic Coefficient: The ballistic coefficient will be estimated with a drag coefficient for a low pitch angle and a 90 deg pitch angle (flat plate).

Flat Plate Mode
The drag coefficient for a flat plat is 1.18
Wt/C_DS = 21.0/1.18(13.5) = 1.31 lbs/ft^2

Lower Pitch Angle Mode
The drag coefficient for the object at low pitch is approximately 0.7
Wt/C_DS = 21.0/0.7(13.5) = 2.2 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 1.31 to 2.2 lbs/ft^2

Center Fuel Tank (Red Zone)

Part CW501 (tag A018)

Location: 40:38:38.5 N 72:39:08.8 W

Description: Section of forward wall of center fuel tank

Weight: 223 lb. (measured)
Area: 6.5 * 5.4 = 35.1ft^2

Falling Mode: Part CW501 could fall with one edge down or a mode with a rotation about a tilted long axis describing a circular flight path about a line off the low end or as a flat plate.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculations for the one edge down mode (low drag) and for a flat plate mode (high drag).

One edge down mode:
The drag coefficient of this object falling with one edge down will be approximately 0.25.
$Wt/C_DS = 223/(0.25)(35) = 25.5$ lbs/ft^2

Flat plate mode:
The drag coefficient of an object falling in this mode will be approximately 1.4 (drag is added for several holes).

$Wt/C_DS = 223/(1.4)(35) = 4.6$ lbs/ft^2

Ballistic Coefficient Summary: $Wt/C_DS = 4.6$ to 25.5 lbs/ft^2

Part CW502 (tag A021)

Location: 40:38:44.94 N 72:39:08.97 W

Description: wing front spar web LBL 20-70

Weight: 115 lb. (measured)
Area: 3 * 6.25 = 18.8 ft^2

Falling Mode: Part CW502 could fall with one edge to the air flow. A mode with a rotation about a tilted long axis describing a circular flight path about a line off the low end.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculations for the edge to the airflow mode (low drag) and for the rotation about the principle axis at the minimum anticipated angle of tilt.

One edge down mode:
The drag coefficient of this object falling with one edge down will be approximately 0.2.
$Wt/C_DS = 115/(0.2)(18.8) = 30.6$ lbs/ft^2

Rotation about the long axis mode:
The drag coefficient of in this mode with the minimum anticipated tilt will be approximately 0.8.

$Wt/C_DS = 115/(0.8)(18.8) = 7.6$ lbs/ft^2

Ballistic Coefficient Summary: $Wt/C_DS = 7.6$ to 30.6 lbs/ft^2

Part CW504 (tag A236)

Location: 40:38:45.26 N 72:39:51.96 W

Description: front spar RH web LBL 75-115

Weight: The weight is estimated by scaling the measured weight of part CW502 by the area ratio.
Wt = (11.9/18.8) * 115.0 = 73 lb. (estimate) .

Area: 3.0 * 4.5 + 1.25 * 2.75 - 5.0 = 11.9 ft^2

Falling Mode: Part CW504 could fall with a rotation about a tilted long axis describing a circular flight path about a line off the low end, or with one edge to the airflow.

Ballistic Coefficient: The ballistic coefficient will be estimated for both probable modes

Rotation about long axis mode:
The drag coefficient of an object falling in this mode will be approximately 0.4.
$Wt/C_DS = 73/(0.4)(11.9) = 15.3\ lbs/ft^2$

One edge to the airflow mode:
The drag coefficient of this object falling with one edge to the airflow will be approximately 0.1.
$Wt/C_DS = 73/(0.1)(11.9) = 61.3\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 15.3$ to $61.3\ lbs/ft^2$

Part CW512 (tag A238)

Location: 40:38:31.08 N 72:39:05.10 W

Description: front spar; FS web RBL 66-RBL 45; cw tank

Weight: 17 lb. (measured)
Area: $1.3 * 1.7 + 5.8 * 0.3 = 4.0\ ft^2$ (front)
$5.8 * 0.6 = 3.48\ ft^2$ (side)

Falling Mode: This object will probably fall like an arrow, but could fall with a rotation about a tilted long axis describing a circular flight path about a line off the low end), or with either the top or side into the airflow.

Ballistic Coefficient: The ballistic coefficient will be bracketed with calculations for the arrow mode (low drag) and for the front to the airflow mode (high drag).

Arrow mode
The drag coefficient of this object falling as an arrow should be approximately 0.1
$Wt/C_DS = 17/(0.1)(4.0) = 42.5\ lbs/ft^2$

Front to the airflow mode
The drag coefficient of this object falling with the front to the airflow should be approximately 1.2
$Wt/C_DS = 17/(1.2)(4.0) = 3.5\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.5$ to $42.5\ lbs/ft^2$

Part CW513 (tag A500)

Location: 40 38 32.60 N 72 38 38.37 W

Description: front spar web RBL 76

Weight: 2.5 lb. (Measured)
Area: $0.9 * 2.0 = 1.8\ ft^2$

Falling Mode: Item CW513 will probably tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item.

Ballistic Coefficient: The ballistic coefficient will be calculated on both the high and low pitch end of the anticipated axis tilt angle range.

Low Axis Angle Mode
The drag coefficient of this item with a low principle axis angle should be approximately 0.9
$Wt/C_DS = 2.5/0.9(1.8) = 1.5\ lbs/ft^2$

High Axis Angle Mode
The drag coefficient of this item with a high principle axis angle should be approximately 0.4
$Wt/C_DS = 2.5/0.4(1.8) = 3.5\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.5$ to $3.5\ lbs/ft^2$

Part CW514 (tag A459)

Location: 40 38 28.11 N 72 39 02.61 W

Description: front spar web and stiffner++

Weight: 5.5 lb. (Measured)
Area: 0.6 * 3.1 = 1.9 ft^2

Falling Mode: Item CW514 will probably tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item.

Ballistic Coefficient: The ballistic coefficient will be calculated on both the high and low pitch end of the anticipated axis tilt angle range.

Low Axis Angle Mode
The drag coefficient of this item with a low principle axis angle should be approximately 0.9
Wt/C_DS = 5.5/0.9(1.9) = 3.2 lbs/ft^2

High Axis Angle Mode
The drag coefficient of this item with a high principle axis angle should be approximately 0.4
Wt/C_DS = 5.5/0.4(1.9) = 7.2 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.2 to 7.2 lbs/ft^2

Part CW515 (tag A618)

Location: 40:38:47.8 N 72:39:08.4 W

Description: front spar; LBL 60-95 (above CW504**)**

Weight: The weight is estimated by scaling the measured weight of part CW502 by the area ratio.
Wt = (2.34/18.8) * 115.0 = 15 lb. (estimate) .

Area: 2.3 * 1.45 - 1.0 = 2.34 ft^2

Falling Mode: Part tag CW515 has it's center of mass offset to one side and could fall with this side down or could tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item.

Ballistic Coefficient: To bracket the ballistic coefficient, the ballistic coefficient will be calculated for the heavy side down mode (low drag) and for the rotation about the long axis mode at the lowest anticipated axis angle (high drag).

Heavy side down mode
In this mode, the drag coefficient should be approximately 0.15.
Wt/C_DS = 15/(0.15)*(2.34) = 42.7 lbs/ft^2

Low Axis Angle Mode
The drag coefficient of this item with a low principle axis angle should be approximately 0.9
Wt/C_DS = 15/0.9(2.34) = 7.1 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 7.1 to 42.7 lbs/ft^2

Part CW602 (tag A210)

Location: 40:38:32.43 N 72:38:37.87 W

Description: spanwise beam #3 -mid right side; p/n 65B10683 2
(perfectly flat, good condition).

Weight: 47.5 lb. (measured)
Area: 2.5 * 4.5 = 11.3 ft^2

Falling Mode: Part tag CW602 could fall with one edge down or could tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item. A mode with the front/back to the airflow is also possible.

Ballistic Coefficient: To bracket the ballistic coefficient, the ballistic coefficient will be calculated for the one edge into the airflow mode (low drag) and for the front/back the airflow (high drag).

One edge into the airflow mode
In this mode, the drag coefficient should be approximately 0.15.
$Wt/C_DS = 47.5/(0.15)*(11.3) = 28.0\ lbs/ft^2$

Front/back to the airflow mode
The drag coefficient of this item with the front/back to the airflow should be approximately 1.2.
$Wt/C_DS = 47.5/1.2(11.3) = 3.5\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 4.7$ to $28\ lbs/ft^2$

Part CW603 (tag A227)

Location: 40:38:39.15 N 72:38:52.96 W

Description: SWB #3 RBL 23 to LBL 20; p/n 65B01110 19 (perfectly flat, good condition).

Weight: Since the structure is similar, the weight of Part CW603 will be estimated by scaling the weight of part CW604 by the area ratio.
Wt = (12.8/28.6) * 108

Wt = 48.3lb. (estimated)

Area: 4.25 * 3 = 12.8 ft^2

Falling Mode: Part tag CW603 could fall with one edge down or could tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item.

Ballistic Coefficient: To bracket the ballistic coefficient, the ballistic coefficient will be calculated for the one edge into the airflow mode (low drag) and for the rotation about the long axis mode at the lowest anticipated axis angle (high drag).

One edge into the airflow mode
In this mode, the drag coefficient should be approximately 0.15.
Wt/C_DS = 48.3/(0.15)*(12.8) = 25 lbs/ft^2

Low Axis Angle Mode
The drag coefficient of this item with a low principle axis angle should be approximately 0.9
Wt/C_DS = 48.3/0.9(12.8) = 4.2 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 4.2 to 25 lbs/ft^2

Part CW604 (tag A475)

Location: 40:38:32.09 N 72:38:55.64 W

Description: spanwise beam #3; LHS web; LBL 20-83 (perfectly flat, good condition).

Weight: 108 lb. (measured)
Area: $5.2 * 5.5 = 28.6\ ft^2$

Falling Mode: Part CW604 will most likely tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item but could also fall with the front forward.

Ballistic Coefficient: To bracket the ballistic coefficient, the ballistic coefficient will be calculated for the rotation about the long axis mode at the highest anticipated axis angle (low drag) and for the front forward mode (high drag).

High axis angle mode
The drag coefficient of this item with a low principle axis angle should be approximately 0.6
$Wt/C_DS = 108/0.6(28.6) = 6.3\ lbs/ft^2$

Front forward mode
The drag coefficient of this item in this mode should be approximately 1.2.
$Wt/C_DS = 108/1.2(28.6) = 3.1\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.1$ to $6.3\ lbs/ft^2$

Part CW608 (tag A533)

Location: 40:38:30.66 N 72:38:59.76 W

Description: 3 pieces: 1) metal 10"x18"; 2) spring/hinge, small; 3) plastic cowling 6"x6"x2"

Weight: 5.0 lb. (estimate)
Area: 1.4 * 8/12 + 1.5/12 * 4/12 = 1 ft^2

Falling Mode: With the c.g. offset with a heavy doubler, part CW608 could with the heavy side into the wind. However, with this shape, tumbling about both axis is possible as is falling as a flat plate at an angle.

Ballistic Coefficient: The ballistic coefficient for this object will be bracketed by calculations for an edge to the airflow (low drag) and front to the airflow (high drag).

Edge to the airflow:
The drag coefficient with the edge to the airflow will be approximately 0.1
Wt/C_DS = 5.0/(0.1)(1.0) = 50.0 lbs/ft^2

Front to the airflow:
The drag coefficient with the front to the airflow will be approximately 1.2
Wt/C_DS = 5.0/(1.2)(1.0) = 4.2 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 4.2 to 50.0 lbs/ft^2

Part CW703 (tag A490)

Location: 40:38:24.48 N 72:38:27.12 W

Description: spanwise beam #2 RH web door RBL 8-30

Weight: 7.0 lbs (measured)
Area: 2.75 * 2 = 5.5 ft^2

Falling Mode: Part CW703 will probably fall with the front forward but could also tumble about a tilted long axis describing a circular path about a line of rotation off the heavy end of the item. There is a possibility the object could fly.

Ballistic Coefficient: To bracket the ballistic coefficient, the ballistic coefficient will be calculated for the rotation about the long axis mode at the highest anticipated axis angle (low drag) and for the front forward mode (high drag).

Highest axis angle tumble mode:
The drag coefficient of this object at the highest anticipated axis angle will be approximately 0.4.
$Wt/C_DS = 7.0/(0.4)(5.5) = 3.2\ lbs/ft^2$

Front forward mode:
The drag coefficient of this object falling with the front forward should be approximately 1.2.
$Wt/C_DS = 7.0/(1.2)(5.5) = 1.1\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.1$ to $3.2\ lbs/ft^2$

Part CW911 (tag A2054)

Location: 40 38 27.14 N 72 38 34.54 W

Description: cw spanwise beam #1 section

Weight: 2.0 lb. (measured)
Area: 21.5/12 * 9/12 = 1.3 ft^2

Falling Mode: Part CW911 could fall with one edge forward, with the large area forward or with rotation about a tilted axis describing a circular path about a point off the low side.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculations for the edge toward the airflow mode (low drag) and large area toward the airflow mode.

Edge toward the airflow mode:
The drag coefficient of this object falling with one edge toward the airflow should be approximately 0.2.
$Wt/C_DS = 2.0/(0.2)(1.3) = 7.7 \text{ lbs/ft}^2$

Large area towards airflow mode:
The drag coefficient of this object falling with the large area towards the airflow should be approximately 1.2.
$Wt/C_DS = 2.0/(1.2)(1.3) = 1.3 \text{ lbs/ft}^2$

Ballistic Coefficient Summary: $Wt/C_DS = 1.3 \text{ to } 7.7 \text{ lbs/ft}^2$

Forward Cargo Area

Part N/A (tag A029)

Location: 40 38 43.19 N 72 39 19.80 W

Description: forward lower cargo bay structure FS 900-960 L/H CW w/ motor and wheels, pn 747-5100-5-0

Weight: 77.0 lb. (measured)
Area: 5.5 * 2.0 = 11.0 ft^2 (top)
0.7 * 2.0 = 1.4 ft^2 (front)

Falling Mode: Item A029 could fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end. It could also fall with the front side forward.

Ballistic Coefficient: The highest ballistic coefficient will be obtained with the front into the airflow mode. The lowest ballistic coefficient will be obtained with the item rotating about a pitched long axis.

Rotation about long axis at min anticipated pitch angle mode
The drag coefficient for this object rotating about the min anticipated pitched long axis should be approximately 0.7
Wt/C_DS = 77/0.7(11) = 10.0 lbs/ft^2

Front side forward mode
The drag coefficient for a flat plate is approximately 1.18
Wt/C_DS = 77/1.18(1.4) = 46.6 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 10 to 46.6 lbs/ft^2

Part LF50 (tag A131)

Location: 40 38 31.09 N 72 38 58.69 W

Description: forward lower cargo bay structure FS 860-880 left hand cargo floor

Weight: 56.0 lb. (measured)
Area: 7.9 * 1.9 = 15.0 ft^2 (top)

Falling Mode: Item LF50 should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end. It could also fall as a flat plate at a pitch angle

Ballistic Coefficient: The lowest ballistic coefficient will be obtained for the flat plate mode pitched fully into the airflow. The highest ballistic coefficient will be obtained with the item rotating about a pitched long axis.

Rotation about long axis at max anticipated pitch angle mode
The drag coefficient for this object rotating about the max anticipated pitched long axis should be approximately 0.6
Wt/C_DS = 56/0.6(15) = 6.2 lbs/ft^2

Flat Plate mode
The drag coefficient for a flat plate is approximately 1.18
Wt/C_DS = 56/1.18(15) = 3.2 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.2 to 6.2 lbs/ft^2

Part LF37B (tag A182)

Location: 40 38 31.07 N 72 38 56.26 W

Description: forward lower cargo bay structure, FS 800 Right hand side

Weight: 17.7 lb. (measured)
Area: $0.9 * 6.0 + 0.5 * 3.0 * 1.4 = 7.5\ ft^2$ (side)

Falling Mode: Item LF37B should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum anticipated axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
$Wt/C_DS = 17.7/0.4(7.5) = 5.9\ lbs/ft^2$

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
$Wt/C_DS = 17.7/0.7(7.5) = 3.4\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.4$ to $5.9\ lbs/ft^2$

Part N/A (tag A242)

Location: 40 38 12.43 N 72 38 12.68 W

Description: forward lower cargo bay structure FS 880 center line (7'x 2 1/2" light interior framing; wire harness W552-M621)

Weight: 16.0 lb. (measured)
Area: 6.9 * 0.5 * (1.8 + 1.4) = 11.0ft^2

Falling Mode: Item A242 could fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end or could fall as a flat plate.

Ballistic Coefficient: The ballistic Coefficient will be calculated for rotation about the maximum anticipated axis pitch angles (low drag) mode and for the flat plate (high drag) mode to bracket the ballistic coefficient.

High axis pitch angle mode
The drag coefficient for this object rotating about a the highest anticipated pitched long axis should be approximately 0.4
Wt/C_DS = 16.0/0.4(11.0) = 3.6 lbs/ft^2

Flat plate mode
The drag coefficient for this object will be flat plat drag plus additional drag for the openings. The drag coefficient should be approximately 1.3
Wt/C_DS = 16.0/1.3(11.0) = 1.1 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 1.1 to 3.6 lbs/ft^2

Part (tag A260)

Location: 40 38 31.20 N 72 39 04.68 W

Description: FS 980 lower frame Stringer 40L-42R

Weight: 19 lb. (measured 18 added 1 for touching ground)
Area: $9.5 * 0.7 = 6.6 \text{ ft}^2$

Falling Mode: Item A260 should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum anticipated axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
$Wt/C_DS = 19.0/0.4(6.6) = 7.2 \text{ lbs/ft}^2$

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
$Wt/C_DS = 19.0/0.7(6.6) = 4.1 \text{ lbs/ft}^2$

Ballistic Coefficient Summary: $Wt/C_DS = 4.1 \text{ to } 7.2 \text{ lbs/ft}^2$

Part N/A (tag A404)

Location: 40 38 46.79 N 72 39 25.61 W

Description: forward lower cargo bay structure FS 800-840 L/H CW w/motor and wheels (cargo floor 4'x3'x2'; ac motor w/brake p/n747-5826-1-0; s/n 5475)

Weight: 118 lb. (measured)
Area: 0.5 * 5.0 + 0.5 * 0.9 = 3.0 ft^2

Falling Mode: Item A404 should fall with the motor side down

Ballistic Coefficient: The drag coefficient should be flat plat drag plus some additional drag for interference, skin friction, wheels etc. We will assume 1.5

Wt/C_DS = 118/ 1.5(3.0) = 26 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 26 lbs/ft^2

Part LF43 (tag A453)

Location: 40 38 26.08 N 72 38 48.49 W

Description: forward lower cargo bay structure FS 920 left hand side (Cargo floor beam left hand station 920)

Weight: 9.5 lb. (measured)
Area: 0.75 * 5.0 + 0.5 * 3.0 * 1.0 = 5.25 ft^2

Falling Mode: Item LF43 should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum anticipated axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
Wt/C_DS = 9.5/0.4(5.25) = 4.5 lbs/ft^2

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
Wt/C_DS = 9.5/0.7(5.25) = 2.6 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 2.6 to 4.5 lbs/ft^2

Part   (tag A489)

Location: 40 38 24.48 N   72 38 27.12 W

Description: Forward lower cargo bay structures, FS 900

Weight: 1.5 lb. (measured)
Area: 1.0 * 1.3 = 1.3 ft^2

Falling Mode: Item A489 should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
Wt/C_DS = 1.5/0.4(1.3) = 2.9 lbs/ft^2

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
Wt/C_DS = 1.5/0.7(1.3) = 1.6 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 1.6 to 2.9 lbs/ft^2

Part LF44 (tag A536)

Location: 40 38 30.66 N 72 38 59.76 W

Description: Forward lower cargo bay structure FS 940 left hand side

Weight: 7.5 lb. (measured)
Area: 2.8 * 0.9 + 0.5 * 0.6 * 1.0 = 2.8 ft^2

Falling Mode: Item LF44 should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
$Wt/C_DS = 7.5/0.4(2.8) = 6.7\ lbs/ft^2$

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
$Wt/C_DS = 7.5/0.7(2.8) = 3.8\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.8$ to $6.7\ lbs/ft^2$

Part N/A (tag A541)

Location: 40 38 13.98 N 72 38 14.91 W

Description: forward lower cargo bay structure FS 860 left hand side (5'x2.5'x1" metal piece p/n 65B107; also a 1.5'x2" metal piece)

Weight: 11.5 lb. (measured)
Area: 5.0 * 2.0 = 10.0 ft^2

Falling Mode: Item A541 should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
Wt/C_DS = 11.5/0.4(10.0) = 2.9 lbs/ft^2

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.9
Wt/C_DS = 11.5/0.9(10.0) = 1.3 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 1.3 to 2.9 lbs/ft^2

Part LF31 (tag A601)

Location: 40 38 35.80 N 72 39 09.00 W

Description: forward lower cargo bay structure FS 800-840 centerline (FS 980 floor beam - LBL 20 to RBL 11. Cargo track (fwd cargo bay area)

Weight: 30.0 lb. (measured)
Area: 0.7 * 4.0 = 2.8 ft^2 (front)
2 * 0.3 * 5.0 + 2 * 0.3 * 4.0 + 1.5 = 6.9 ft^2 (bottom)

Falling Mode: Item LF31 could fall with the front to the airflow or with the bottom to the airflow or anywhere in between.

Ballistic Coefficient: The lowest and highest ballistic coefficient will be calculated using the bottom to the airflow and front to the airflow modes.

Front Forward Mode
The drag coefficient of this object falling as a flat plate should be approximately 1.18
Wt/C_DS = 30.0/ 1.18 (2.8) = 9.1 lbs/ft^2

Bottom Forward Mode
The drag coefficient of this object falling as a flat plate should be approximately 1.18
Wt/C_DS = 30.0/ 1.18 (6.9) = 3.7 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 3.7 to 9.1 lbs/ft^2

Part LF37A (tag A614)

Location: 40 38 28.29 N 72 38 49.71 W

Description: forward lower cargo bay structure FS 800 left hand side

Weight: 10.4 lb. (measured)
Area: 5.5 * 0.9 = 5.0 ft^2

Falling Mode: Item LF37A should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
$Wt/C_DS = 10.4/0.4(5.0) = 5.2\ lbs/ft^2$

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
$Wt/C_DS = 10.4/0.7(5.0) = 3.0\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.0$ to $5.2\ lbs/ft^2$

Part LF58A (tag A734)

Location: 40 38 25.50 N 72 38 55.40 W

Description: Forward lower cargo bay structure FS 960 left hand side

Weight: 6.0 lb. (measured)
Area: 3.0 * 1.0 = 3.0 ft^2

Falling Mode: Item LF58A should fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the maximum and minimum axis pitch angles to bracket the ballistic coefficient.

High Axis Pitch Angle Mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
$Wt/C_DS = 6.0/0.4(3.0) = 5.0 \text{ lbs/ft}^2$

Low Axis Pitch Angle Mode
The drag coefficient for this object rotating about the lowest anticipated pitched long axis should be approximately 0.7
$Wt/C_DS = 6.0/0.7(3.0) = 2.9 \text{ lbs/ft}^2$

Ballistic Coefficient Summary: $Wt/C_DS = 2.9 \text{ to } 5.0 \text{ lbs/ft}^2$

Part LF58B (tag A2047)

Location: 40 38 17.80 N 72 38 32.84 W

Description: FS 960 lower body frame stringer 43L-47L

Weight: 5.5 lb. (measured)
Area: 2.5 * 2.2 = 5.5 ft^2

Falling Mode: Item LF58B could fall with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end or as a flat plate at a angle of pitch.

Ballistic Coefficient: The ballistic Coefficient will be calculated for the rotation about the maximum anticipated axis pitch angles (low drag) and for the flat plate (high drag) mode to bracket the ballistic coefficient.

High axis pitch angle mode
The drag coefficient for this object rotating about a highly pitched long axis should be approximately 0.4
Wt/C_DS = 5.5/0.4(5.5) = 2.5 lbs/ft^2

Flat plate mode
The drag coefficient for this object falling as a flat plate should be approximately 1.18
Wt/C_DS = 5.5/1.18(5.5) = 0.85 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 0.85 to 2.5 lbs/ft^2

Selected Cabin Interior

Tag A413

Location: 40 38 59.9 N 72 39 01.2 W

Description: Right Galley Cart tie down

Weight: 21.5 lb. (measured)
Area: 2 * 3.3 = 6.6 ft^2

Falling Mode: Part A413 could fall with the convex side facing into the airflow or with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic coefficient will be calculated for both probable modes. The highest anticipated axis angle will be considered for the rotating mode to bracket the high end of possible ballistic coefficients.

Convex Side Forward Mode
The drag coefficient of this object falling as a flat plate should be approximately 1.18
Wt/C_DS = 21,5/ 1.18 (6.6) = 2.8 lbs/ft^2

Rotation about long axis with one side down
The drag coefficient of this object rotating with one side down could be as low as 0.4.
Wt/C_DS = 21.5/ 0.4 (6.6) = 8.1 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 2.8 to 8.1 lbs/ft^2

Tag A102

Location: 40 38 59.74 N 72 39 02.41 W

Description: Left Galley Cart hold down with bottom of cart

Weight: 51 lb. (measured)
Area: 6 ft^2

Falling Mode: Part A102 could fall with the convex side facing into the airflow or with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic coefficient will be calculated for both probable modes. The highest anticipated axis angle will be considered for the rotating mode to bracket the high end of possible ballistic coefficients.

Convex Side Forward Mode
The drag coefficient of this object falling as a flat plate should be approximately 1.18
$Wt/C_DS = 51.0/ 1.18 (6.0) = 7.2 lbs/ft^2$

Rotation about long axis with one side down
The drag coefficient of this object rotating with one side down could be as low as 0.4.
$Wt/C_DS = 51.0/ 0.4 (6.0) = 21 lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 7.2 \text{ to } 21 lbs/ft^2$

Galley A (tag A249 & A250)

Location: 40 39 09.49 N 72 38 31.92 W

Description: A Galley (behind first class)

Weight: 459 lb. (TWA Estimate)
Area: 5.8 * 5.7 = 33.0 ft^2 (front) 5.8 * 1.9 = 11.0 ft^2 (top)

Falling Mode: The galley will most likely fall with the top down (heavy ovens) but could also tumble or fall as a flat plate

Ballistic Coefficient: The ballistic coefficient will be calculated for both the smallest and largest area to the airflow to determine the range.

Top forward flat plate
The drag coefficient of the galley (based on frontal area) should be approximately 1.18.
$Wt/C_DS = 459.0/(1.18)(11.0) = 35 lbs/ft^2$

Back/front forward flat plate
The drag coefficient of the galley (based on frontal area) should be approximately 1.18.
$Wt/C_DS = 459.0/(1.18)(33.0) = 12 lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS =$ 12 to 35.0 lbs/ft^2

Galley B (tag A426)

Location: 40 38 53.91 N 72 39 06.15 W

Description: B Galley

Weight: 459 lb. (TWA estimate)
Area: 6.0 * 6.7 = 40.2 ft^2 (front) 6.0 * 2.0 = 12.0 ft^2 (top)

Falling Mode: It is not known if this galley had ovens when it fell so the weight is unknown. The object could fall with the oven side forward, with the front or back forward or could tumble

Ballistic Coefficient: The ballistic coefficient range will be obtained by calculating the ballistic coefficient based on both the front/back area forward and the bottom forward.

Top forward flat plate
The drag coefficient of the galley (based on frontal area) should be approximately 1.18.
Wt/C_DS = 459.0/(1.18)(12.0) = 32 lbs/ft^2

Back/front forward flat plate
The drag coefficient of the galley (based on frontal area) should be approximately 1.18.
Wt/C_DS = 459.0/(1.18)(40.2) = 9.7 lbs/ft^2

Ballistic Coefficient Summary: Wt/C_DS = 9.7 to 32 lbs/ft^2

Galley C (A062)

Location: 40 38 54.8 N 72 39 09.9 W

Description: C Galley

Weight: 535 lb. (TWA estimated)
Area: 7.75 * 6.4 = 49.6 ft^2 (side) 7.75 * 2.4 = 18.6 ft^2 (top)

Falling Mode: It is not known if this galley had ovens when it fell so the weight is unknown. The object could fall with the oven side forward, with the front or back forward or could tumble

Ballistic Coefficient: The ballistic coefficient range will be obtained by calculating the ballistic coefficient based on both the front/back area forward and the bottom forward.

Top forward flat plate
The drag coefficient of the galley (based on frontal area) should be approximately 1.18.
$Wt/C_DS = 535/(1.18)(18.6) = 24.4 \text{ lbs/ft}^2$

Back/front forward flat plate
The drag coefficient of the galley (based on frontal area) should be approximately 1.18.
$Wt/C_DS = 535/(1.18)(49.6) = 9.1 \text{ lbs/ft}^2$

Ballistic Coefficient Summary: $Wt/C_DS = 9.1 \text{ to } 24.4 \text{ lbs/ft}^2$

Part N/A (tag A441)

Location: 40 38 55.26 N -72 39 19.08 W

Description: Video Projector

Weight: 36.5 lb. (measured)
Area: 1.4 * 1.6 = 2.2 ft^2 (top)
1.4 * 0.3 = 0.4 ft^2 (side)
1.4 * 0.5 = 0.7 ft^2 (front)

Falling Mode: The video projector should either fall with one side forward or with a rotation about it's long axis with one side down describing a circular path about a point off the heavy end.

Ballistic Coefficient: The ballistic coefficient will be calculated for both probable modes. The lowest anticipated axis angle will be considered for the rotating mode to bracket the low end of possible ballistic coefficients.

Small Side Down Mode
The drag coefficient of this object falling as a flat plate should be approximately 1.18
$Wt/C_DS = 36.5/ 1.18 (0.7) = 44 lbs/ft^2$

Rotation about long axis with one side down
The drag coefficient of this object rotating with one side down could be as high as 0.8.
$Wt/C_DS = 36.5/ 0.8 (2.2) = 21 lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 21$ to 44 lbs/ft^2

Lower Fuselage Interior

Part ACM#1 (tag A147)

Location: 40:38:48.8 N 72:39:18.3 W

Description: blower assembly w/ piping part # 1923; Air Cycle Machine #1. casting P/N 18488, ACM valve turbo bypass; P/N 719223-3 P9 747, 6CB00026-27 B A14694
(Air Cycle Machine from pack #1)

Weight: 75.5 lb. (measured)
Area: $3.14 * 1.5^2 + 1.5 * 0.5 = 7.8\ ft^2$

Falling Mode: The ACM will probably fall with the aircraft forward (pump side) down trailing the duct facing aft towards the heat exchanger.

Ballistic Coefficient: The drag coefficient for this ACM should be between 0.3 and 0.7.

Low Drag W/C_DS
$Wt/C_DS = 75.5/(0.3)(7.8) = 32\ lbs/ft^2$

High Drag W/C_DS
$Wt/C_DS = 75.5/(0.7)(7.8) = 13.8\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 13.8$ to $32\ lbs/ft^2$

Heat Exchanger #1 (tag A024)

Location: 40:38:39.55 N 72:39:07.45 W

Description: Heat exchanger for pack #1

Weight: 101 + 15 + 8 = 124 lb. (Boeing estimate)
Area: 3.5 * 2 = 7 ft^2 (frontal)
3.5 * 8 = 28 ft^2 (bottom)

Falling Mode: The heat exchanger could fall with the aircraft aft side facing the airflow trailing the area change duct , could tumble, or could fall with the aircraft bottom/top side to the airflow.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculations for the aft side forward mode with minimum estimated drag and for the bottom side forward mode with maximum estimated drag.

Aft to the airflow with minimum estimated drag
The minimum drag in this mode should be approximately 0.5 (based on frontal area)
$Wt/C_DS = 124/(0.5)(7) = 35.4\ lbs/ft^2$

Bottom to the airflow with maximum estimated drag
The minimum drag in this mode should be approximately 1.5 (based on top area and with drag added for ducting)
$Wt/C_DS = 124/(1.5)(28) = 3.0\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 3.0$ to $35.4\ lbs/ft^2$

A/C Pack #2 (tag C883)

Location: 40:39:46.15 N 72:37:26.49 W

Description: Air conditioner Pack #2

Weight: 360 lb. (Boeing data)
Area: **7** ft^2 (frontal)
28 + 5 = 33 ft^2 (top)

Falling Mode: The A/C pack could fall with the small area side facing the airflow, could tumble, or could fall with the large area side to the airflow.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculations for the small area to the airflow mode with minimum estimated drag and for the large area to the airflow with maximum estimated drag.

Small area to the airflow with minimum estimated drag
The minimum drag in this mode should be approximately 0.7 (based on frontal area)
$Wt/C_DS = 360/(0.7)(7) = 73\ lbs/ft^2$

Bottom to the airflow with maximum estimated drag
The minimum drag in this mode should be approximately 1.5 (based on top area and with drag added for ducting)
$Wt/C_DS = 360/(1.5)(33) = 7.3\ lbs/ft^2$

Ballistic Coefficient Summary: $Wt/C_DS = 7.3 \text{ to } 73\ lbs/ft^2$

A/C Pack #3 (tag A111 & A408)

Location: 40:38:58.5 N 72:39:23.16 W

Description: Air conditioning pack #3 (these two items were found close together indicating an intact unit in the air with a water impact breakup).

Weight: 360 lb. (Boeing data)
Area: **7** ft^2 (frontal)
28 + 5 = 33 ft^2 (top)

Falling Mode: The A/C pack could fall with the small area side facing the airflow, could tumble, or could fall with the large area side to the airflow.

Ballistic Coefficient: The ballistic coefficient will be bracketed by calculations for the small area to the airflow mode with minimum estimated drag and for the large area to the airflow with maximum estimated drag.

Small area to the airflow with minimum estimated drag
The minimum drag in this mode should be approximately 0.7 (based on frontal area)
$Wt/C_DS = 360/(0.7)(7) = 73 \text{ lbs/ft}^2$

Bottom to the airflow with maximum estimated drag
The minimum drag in this mode should be approximately 1.5 (based on top area and with drag added for ducting)
$Wt/C_DS = 360/(1.5)(33) = 7.3 \text{ lbs/ft}^2$

Ballistic Coefficient Summary: $Wt/C_DS = 7.3 \text{ to } 73 \text{ lbs/ft}^2$

ATTACHMENT 10

Ballistic Coefficient Summary

Red Zone Fuselage Skin

Wreckage Item	Calculated W/C_DS	Actual W/C_DS (based on position on the curve)
LF5	7.9 to 12.9	9.4
LF6A	3.1 to 5.6	4.8
LF6B	22.5 to 40.5	29.0
LF12A	3.7 to 8.7	3.1
LF12B	6.5 to 18.1	8.0
LF12C	7.5 to 44.5	5.7
LF24A	1.9 to 5.5	2.7
LF24B	1.1 to 3.2	2.5
LF55	3.3 to 13.3	3.5
RF1	3.5 to 10.4	9.8
RF5	6.5 to 14.6	10.0
RF7	5.7 to 17.0	8.3
RF19B	0.53 to 1.6	1.05
RF20	1.49	2.0
RF21	1.51	2.0
RF32	3.23 to 9.5	5.8
RF35	3.8	1.0 [1]
RF46	1.31 to 2.2	2.1

Note: This ballistic coefficient assumes that RF35 fell in a ballistic manner. It did not. See the section on RF35 for details.

Center Tank

Wreckage Item	Calculated W/C_DS	Actual W/C_DS (based on position on the curve)
CW501	4.6 to 25.5	6.3
CW502	7.6 to 30.6	10.0
CW504	15.3 to 61.3	25.
CW512	3.5 to 42.5	4.0
CW513	1.5 to 3.5	3.2
CW514	3.2 to 7.2	3.6
CW515	7.1 to 42.7	11.3
CW602	3.5 to 28.0	3.2
CW603	4.2 to 25	5.2
CW604	3.1 to 6.3	3.8
CW608	4.2 to 50.0	3.6
CW703	1.1 to 3.2	2.1
CW911	1.3 to 7.7	2.4

Lower Fuselage Interior

Wreckage Item	Calculated W/C_DS	Actual W/C_DS (based on position on the curve)
ACM1	13.8 to 32	18.0
HEXC1	3.0 to 35.4	6.5
PACK2	7.3 to 73	37.0
PACK3	7.3 to 73	50.0
KEEL1	Insufficient Data	8.0

Forward Cargo

Wreckage Item	Calculated W/C_DS	Actual W/C_DS (based on position on the curve)
A029	10.0 to 46.6	13.0
A131	3.2 to 6.2	4.1
A182	3.4 to 5.9	4.1
A242	1.1 to 3.6	1.3
A260	4.1 to 7.2	4.3
A404	26	18.0
A453	2.6 to 4.5	2.9
A462	0.85 to 2.5	1.8
A489	1.6 to 2.9	3.9
A536	3.8 to 6.7	4.2
A541	1.3 to 2.9	1.5
A601	3.7 to 9.1	6.5
A614	3.0 to 5.2	3.5
A734	2.9 to 5.0	3.0

Selected Cabin Interior

Wreckage Item	Calculated W/C_DS	Actual W/C_DS (based on position on the curve)
A102	7.2 to 21	32.0
A313	2.8 to 8.1	29.0
A441	21 to 44	40.0
GALLEYA	12 to 35	42
GALLEYB	9.7 to 32	20
GALLEYC	9.1 to 24.4	24