

## **Annex A**      Buoyancy Analysis Results

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<b>CONTRACT NUMBER:</b>	EASA.2020.C02
<b>CONTRACTOR / AUTHOR:</b>	DART Aerospace
<b>IPR OWNER:</b>	European Union Aviation Safety Agency
<b>DISTRIBUTION:</b>	Public

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**DATE:** 08 December 2023

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## 1. Buoyancy Analysis General Set Up and Assumptions

The general buoyancy analysis model set up ensures the accuracy of the waterline relative to the helicopter by checking two conditions. The model needed to be neutrally buoyant, and the centers of gravity needed to be balanced. Neutral buoyancy was achieved when the summation of volumes of the submerged portions of buoyant objects (float bags, fuel tank, and inherent buoyant volume) equaled the volume necessary to keep the system weight afloat. To balance the model, the helicopter's stable buoyancy position was established by finding the orientation in which the helicopter's center of gravity and the center of buoyancy of all the contributing buoyancy object were vertically in line. The pitch, roll, and waterline depth parameters in the model were adjusted until the buoyant objects' volume equaled the adjust MTOW and the center of gravity of the system was in-line with the center of buoyancy.

Once the model's neutral buoyancy position was achieved the following assumptions outlined the verification of the cabin airspace.

1. The individual air pockets were placed on the static water line and had to fit into the cabin without being obstructed by seat backs, seat cushions, or the walls of the cabin.
2. In line with the recommendations of NPA 2016-01, it was assumed that the buoyancy model would need to provide passengers with access to their air pockets without needing to cross seat backs. If the cabin is divided by seat backs, there must be sufficient volume for the passengers within their individual rows, meaning the air pockets for those passengers must fit within their row.
3. In line with the recommendations of NPA 2016-01, another goal of the high float design was to create an air pocket within the cabin that would position the emergency exits with a significant portion remaining above the water line, or with opening handles at an accessible depth, to assist in egress.
4. The seat cushions would not block the passengers' bodies from accessing their air pockets placed at the waterline and that a human body must fit under the seat cushion if that is where the air pocket must be placed.
5. Both the NPA 2016-01 head air pocket and revised tapered head air pocket were evaluated in each buoyancy scenario.
6. Body models would be used in the buoyancy model that had the worst-case waterline to further verify cabin airspace.

It should be noted that initially the buoyancy analysis was performed with the elliptical airpocket volume as recommended in the NPA 2016-01 (EASA, 2016). In a second iteration, a new airpocket volume and shape was defined: 'tapered airpocket'. In the first iteration of the tapered airpocket the nose of the head model remained outside of the volume. In a second iteration of the tapered airpocket (final recommended airpocket volume) the volume was adjusted to fit the nose within the airpocket. Feasibility of the revised tapered air pocket was verified in the worst-case airpocket scenario only.

## 2. CS29 Results

Both with and without the float critical compartment damaged:

1. The center of buoyancy (CG of the submerged portion of the floats, fuel tank, and inherent buoyant volume) was able to be aligned with the center of CG of the helicopter and the buoyancy of the submerged portion of the float was equal to the weight of the helicopter at the adjusted MTOW.
2. The individual air pockets were able to be placed on the static water line within the cabin without being obstructed by seat backs, seat cushions, or the walls of the cabin. The air pockets were able to be placed so that the passengers within each row would be able to access them without needing to cross seat backs. The air pockets were also able to be placed so that the passengers' bodies would be able to fit in the area under the air pockets, referring specifically to the air pockets beneath the seat cushions.
3. The emergency exits were positioned with a significant portion remaining above the water line. The emergency exits for the forward most row of passengers was positioned below the waterline due to the attitude of the aircraft, but was still considered accessible, being a negligible distance below the waterline.

Damaged Compartment	Air Pocket Type	Result	Comment
No Damage	NPA 2016-1	FAIL [2.1.1]	NPA air pockets collide with seats and other air pockets
No Damage	Tapered	PASS [2.1.2]	No Collisions
Primary EFS, LH FWD Chamber	NPA 2016-1	FAIL [2.2.1]	NPA air pockets collide with floor, seats, and other air pockets
Primary EFS, LH FWD Chamber	Tapered	PASS [2.2.2]	No Collisions
HEFS, LH FWD Chamber	NPA 2016-1	FAIL [2.3.1]	NPA air pockets collide with floor, seats, and other air pockets
HEFS, LH FWD Chamber	Tapered	Pass [2.3.2]	No Collisions

*Table 1 Results of CS29 Air Pocket Analysis*

## 2.1 CS29 Air pocket Analysis: No Critical Compartment Damaged

2.1.1 CS29 HEFS, Heavy FWD CG, No Compartment Damaged, NPA 2016-01 Air pocket: Fail.

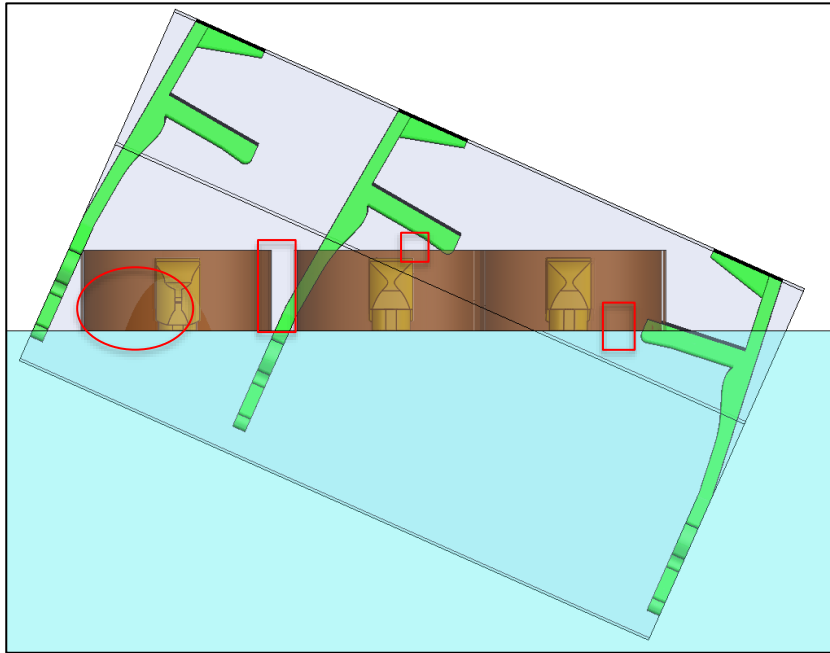


Figure 1: NPA Air Pocket Side View: collision with walls, seats, back rest and other air pockets

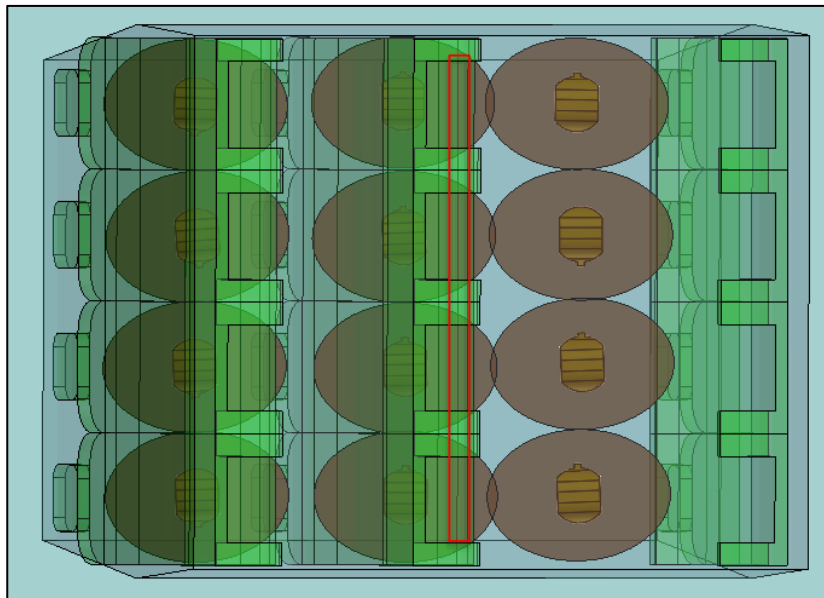
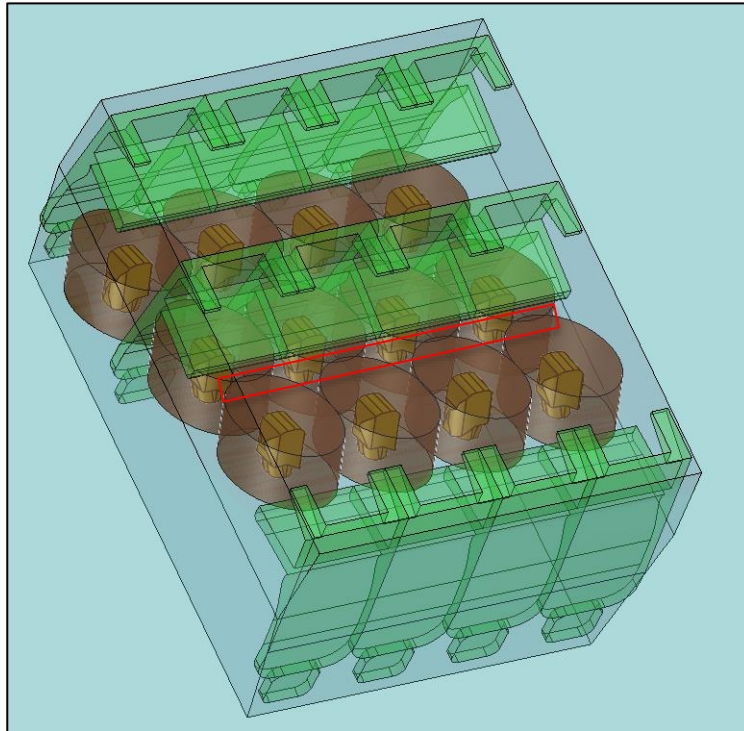
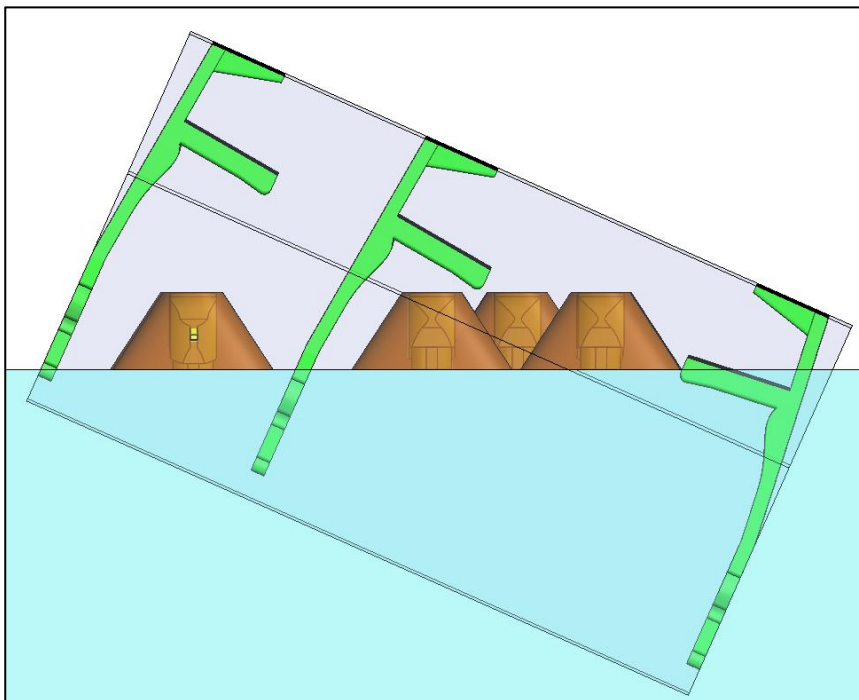


Figure 2: NPA Air Pocket Top View: collision with other air pockets

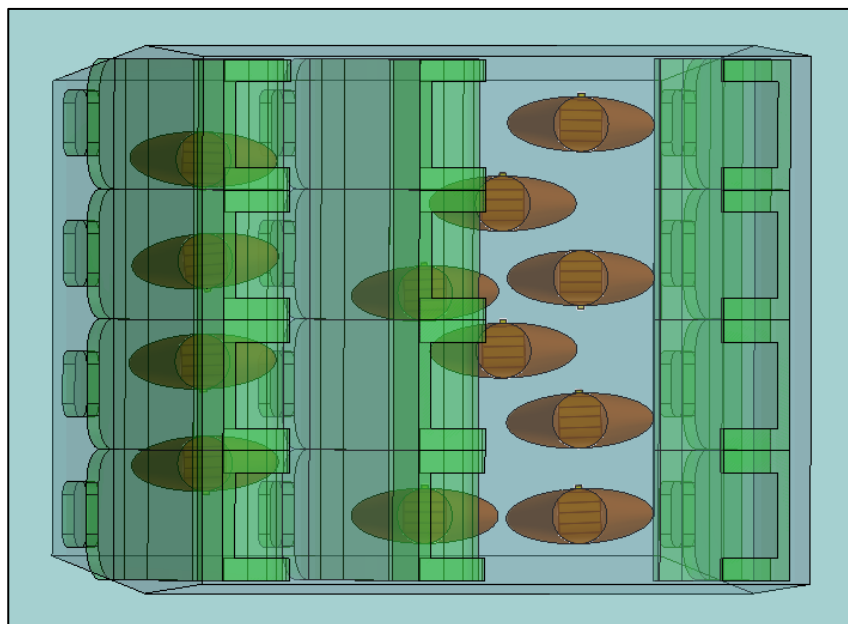


*Figure 3: NPA Air Pocket Iso. View: collision with other air pockets*

### 2.1.2 CS29 HEFS, Heavy FWD CG, No Compartment Damaged, Tapered Air Pocket: Pass.

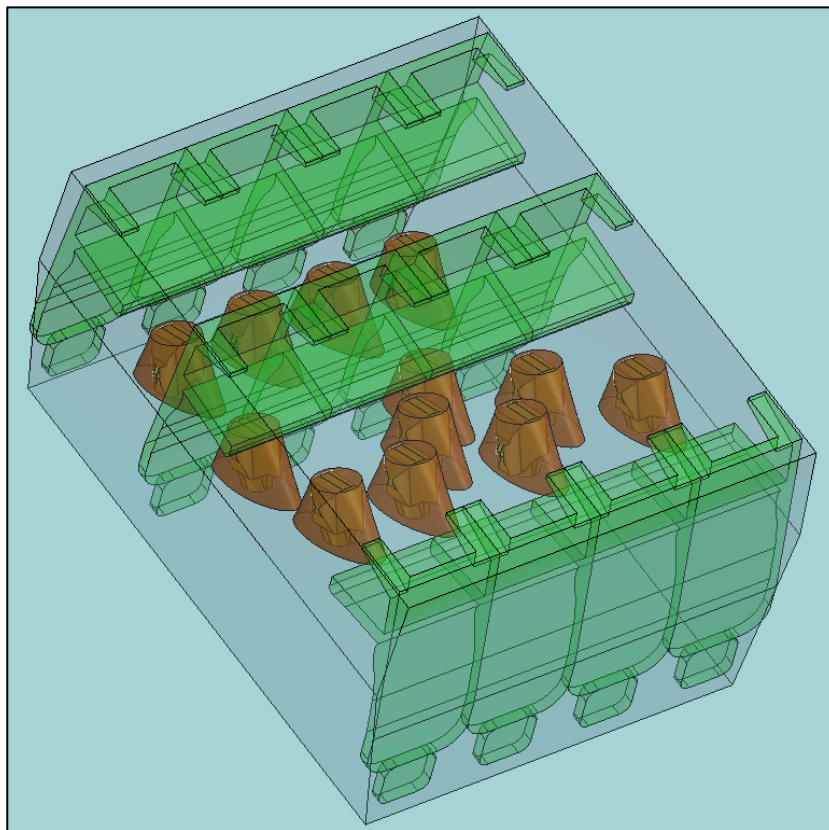


*Figure 4: Tapered Air Pocket Side View: No Collisions*



*Figure 5: Tapered Air Pocket Top View: No Collisions*

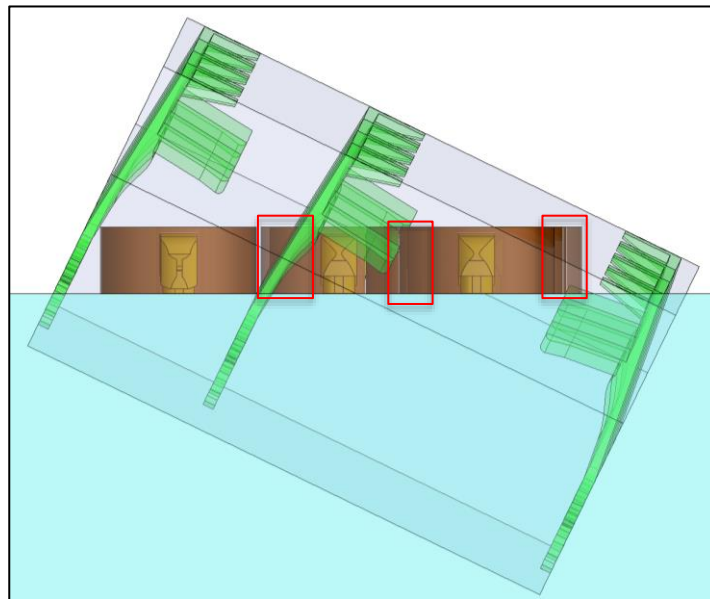




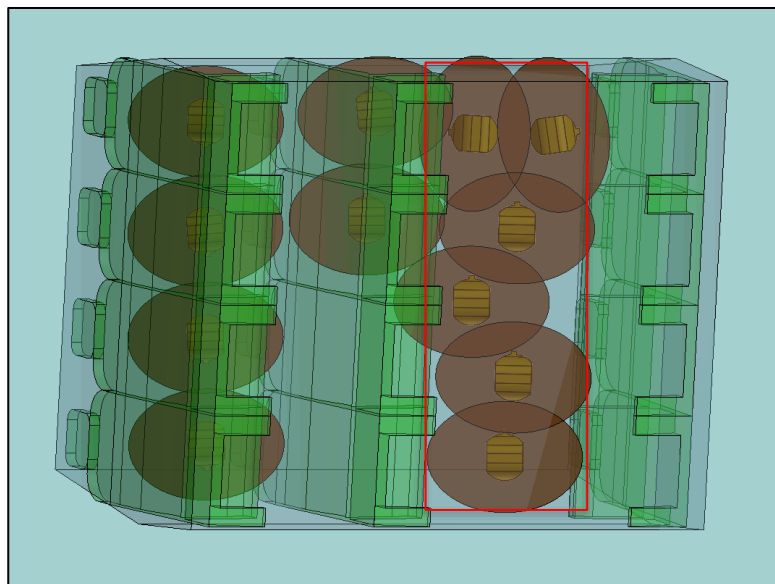
*Figure 6: Tapered Air Pocket Iso. View: No Collisions*

## 2.2 CS29 Air pocket Analysis: Primary EFS Critical Compartment Damaged

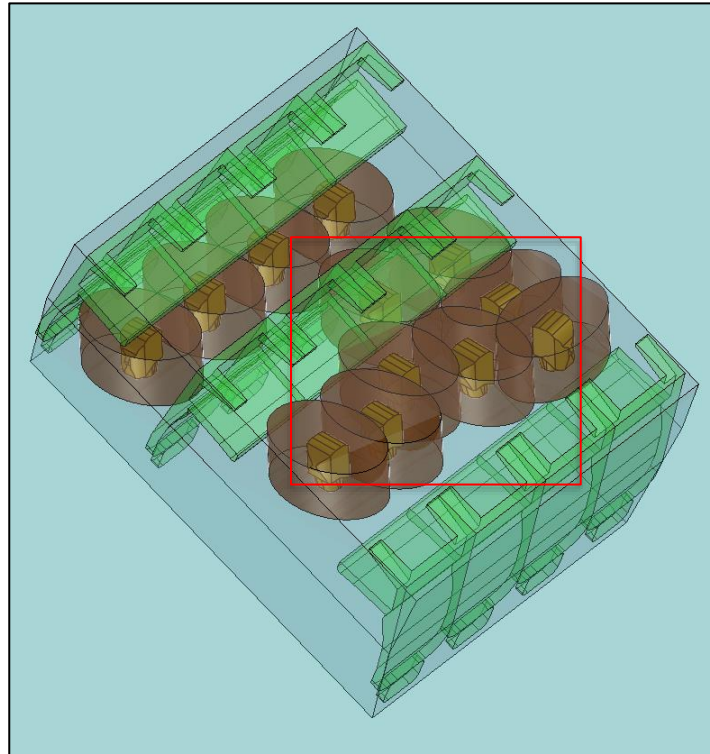
### 2.2.1 CS29 HEFS, Heavy FWD CG, Primary EFS LH FWD-Most Compartment Damaged, NPA 2016-01: Fail.



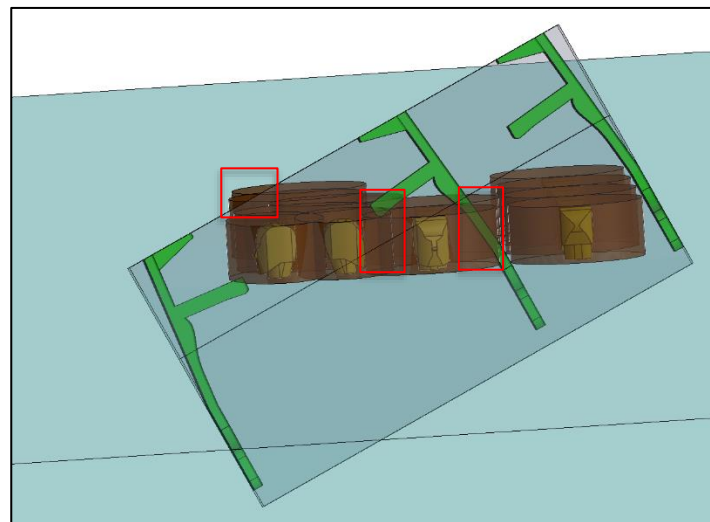
*Figure 7: NPA Air Pocket Side View: Collision with floor, back rest, seats, and other air pockets*



*Figure 8: NPA Air Pocket Top View: Collision with floor, back rest, seats, and other air pockets*

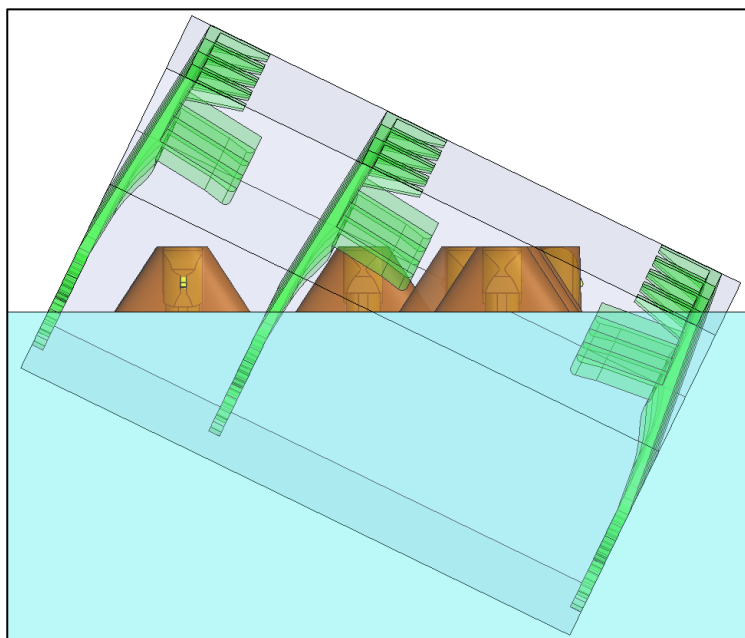


*Figure 9: NPA Air Pocket Iso. View: Collision with floor, back rest, seats, and other air pockets*

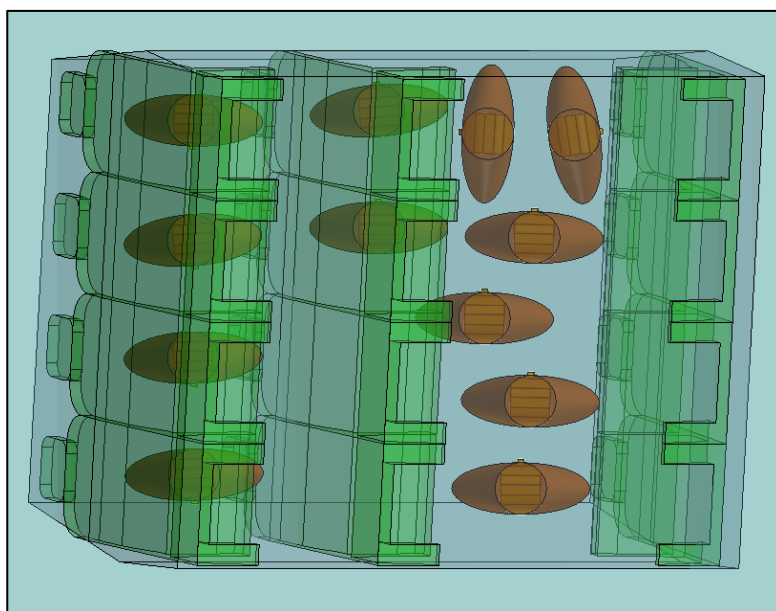


*Figure 10: NPA Air Pocket Normal to Cabin/Seats View: Collision with floor, back rest, seats, and other air pockets*

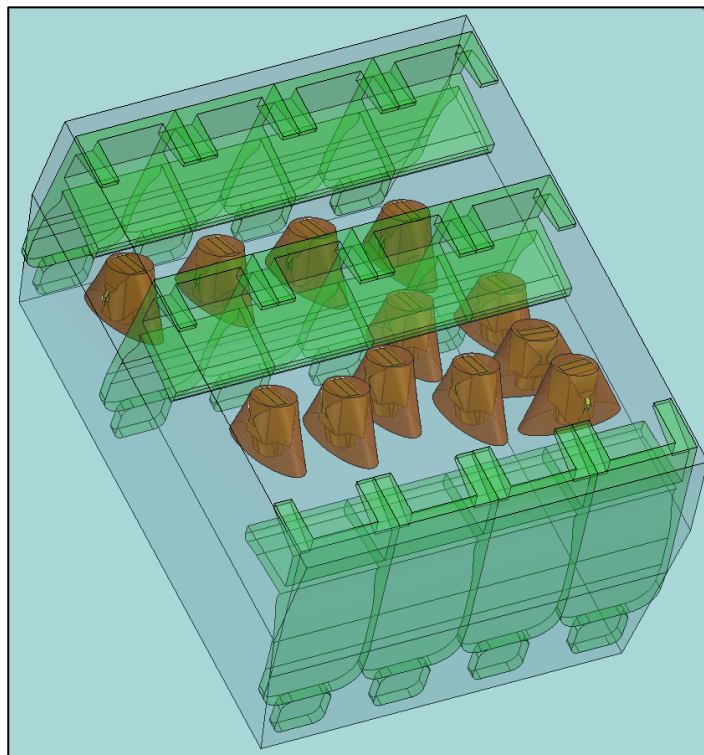
2.2.2 CS29 HEFS, Heavy FWD CG, Primary EFS LH FWD-Most Compartment Damaged, Tapered: Pass.



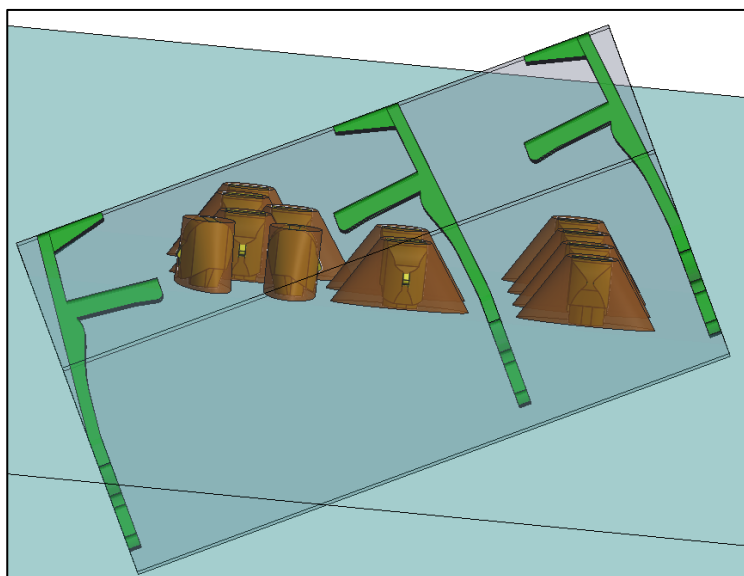
*Figure 11: Tapered Air Pocket Side View: No Collisions*



*Figure 12: Tapered Air Pocket Top View: No Collisions*



*Figure 13: Tapered Air Pocket Iso. View: No Collisions*



*Figure 14: Tapered Air Pocket Normal to Cabin/Seats View: No Collisions*

## 2.3 CS29 Air pocket Analysis: High Mounted EFS Critical Compartment Damaged

### 2.3.1 CS29 HEFS, Heavy FWD CG, HEFS LH FWD-Most Compartment Damaged, NPA 2016-01: Fail.

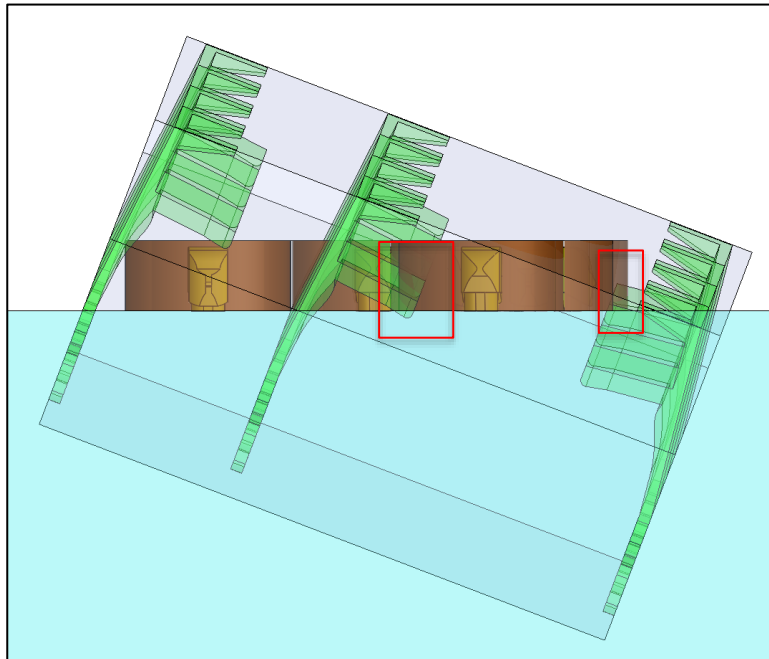


Figure 15: NPA Air Pocket Side View: Collision with floor, back rest, seats, and other air pockets

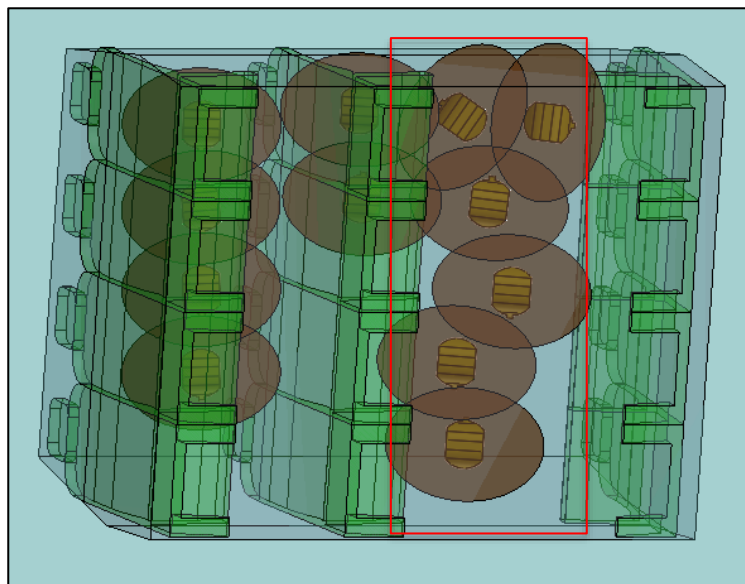


Figure 16: NPA Air Pocket Top View: Collision with floor, back rest, seats, and other air pockets

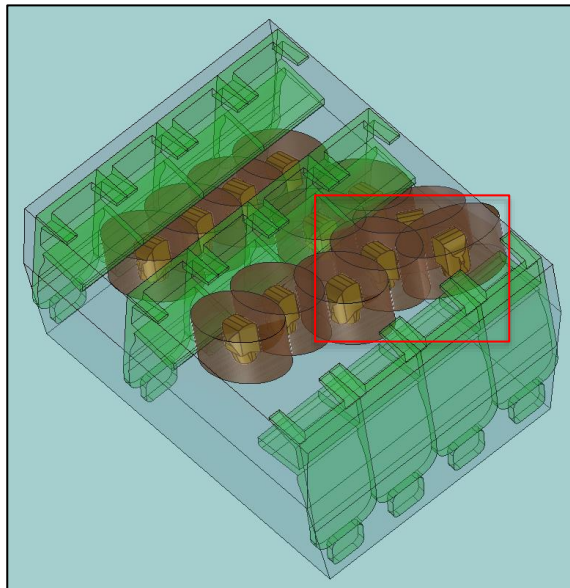


Figure 17: NPA Air Pocket Iso. View: Collision with floor, back rest, seats, and other air pockets

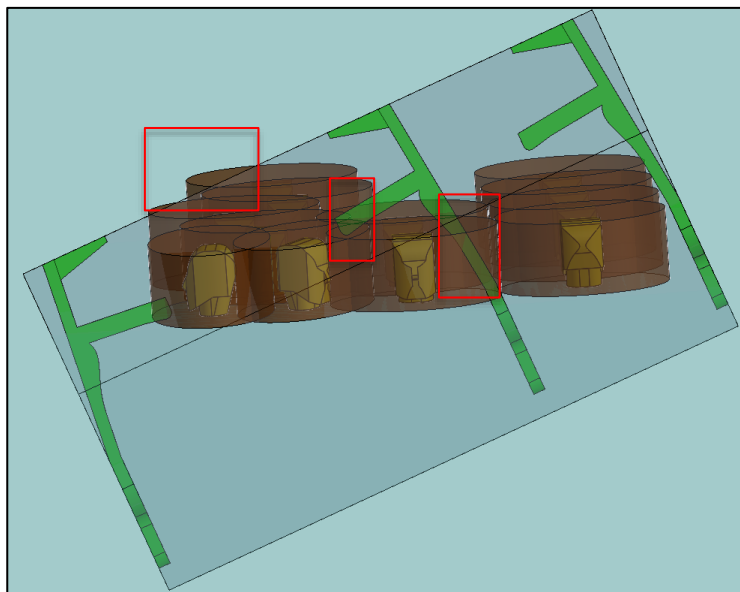
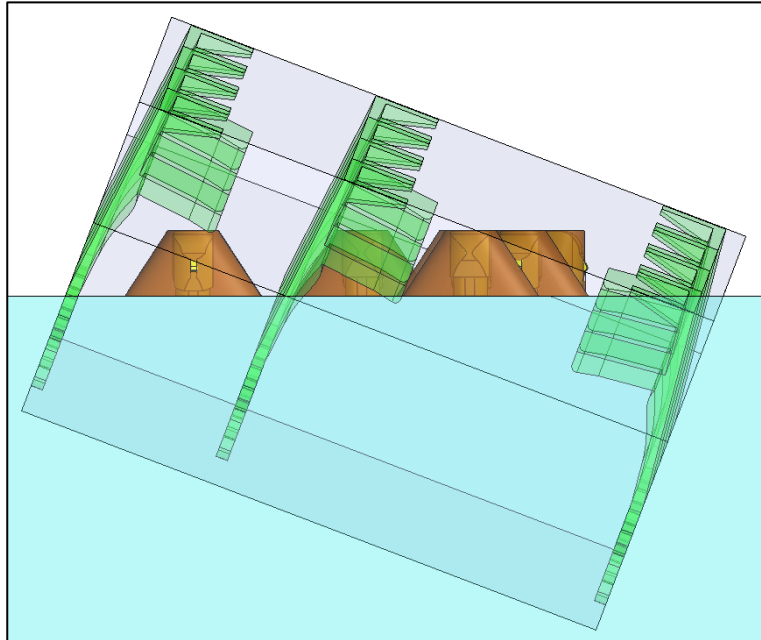


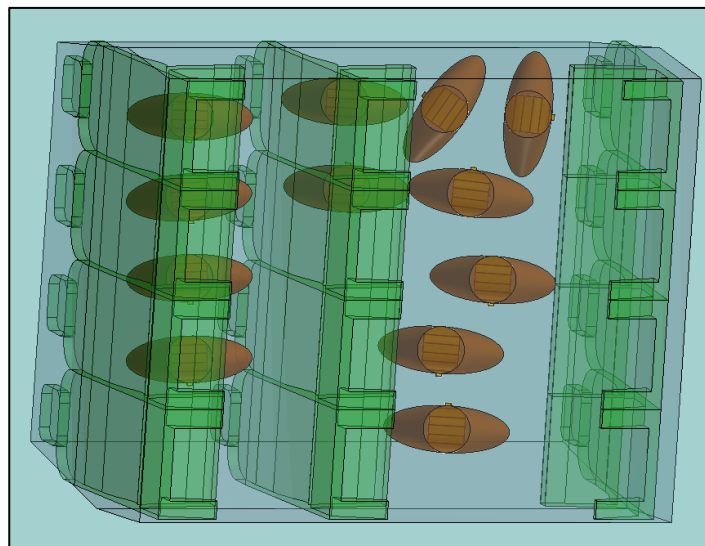
Figure 18: NPA Air Pocket Normal to Cabin/Seats View: Collision with floor, back rest, seats, and other air pockets



### 2.3.2 CS29 HEFS, Heavy FWD CG, HEFS LH FWD-Most Compartment Damaged, Tapered: Pass.



*Figure 19: Tapered Air Pocket Side View: No Collisions*



*Figure 20: Tapered Air Pocket Top View: No Collisions*



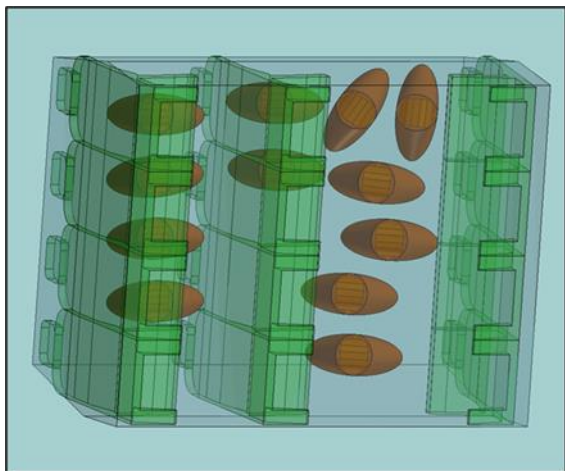


Figure 21 Revised Tapered Air Pocket Top View: No overlap

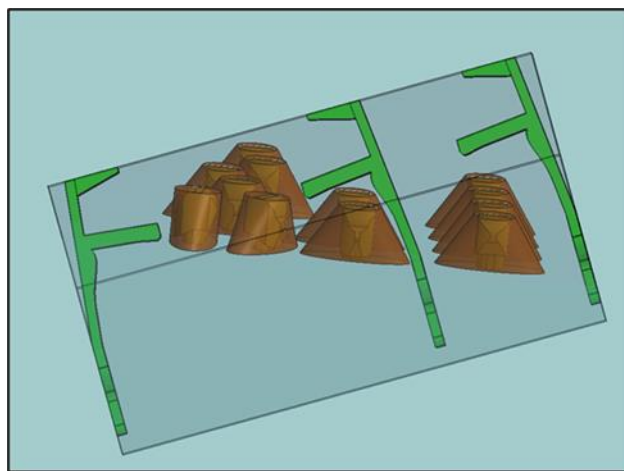


Figure 22 Revised Tapered Air Pocket Side View: No overlap

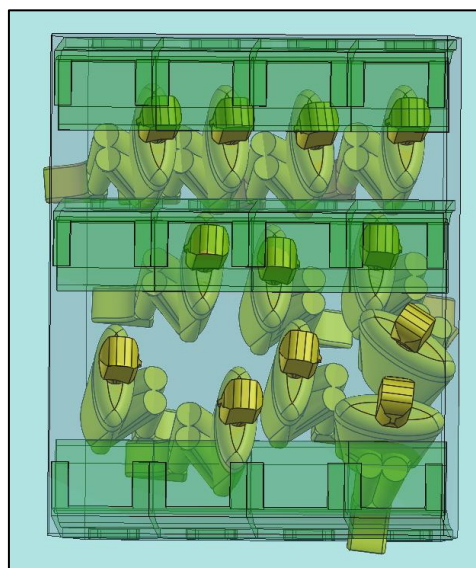
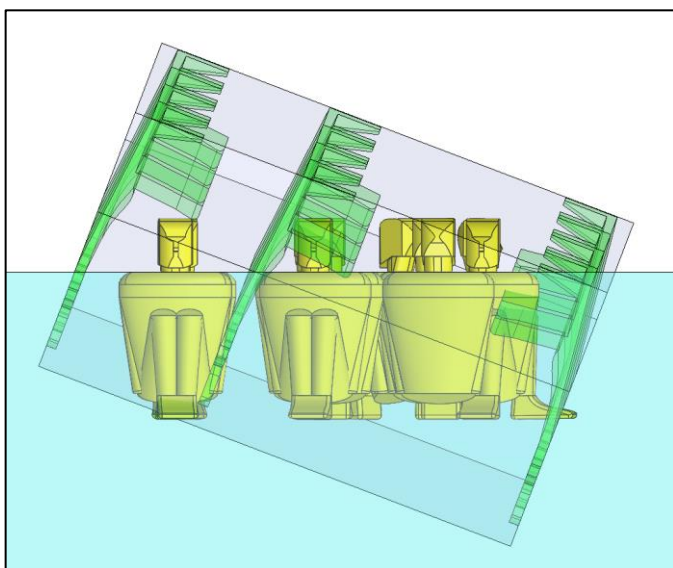


Figure 23: CS29 Full Scale Test HEFS Critical Compartment Damaged, body models

### 3. CS27 Results

Both with and without the float critical compartment damaged:

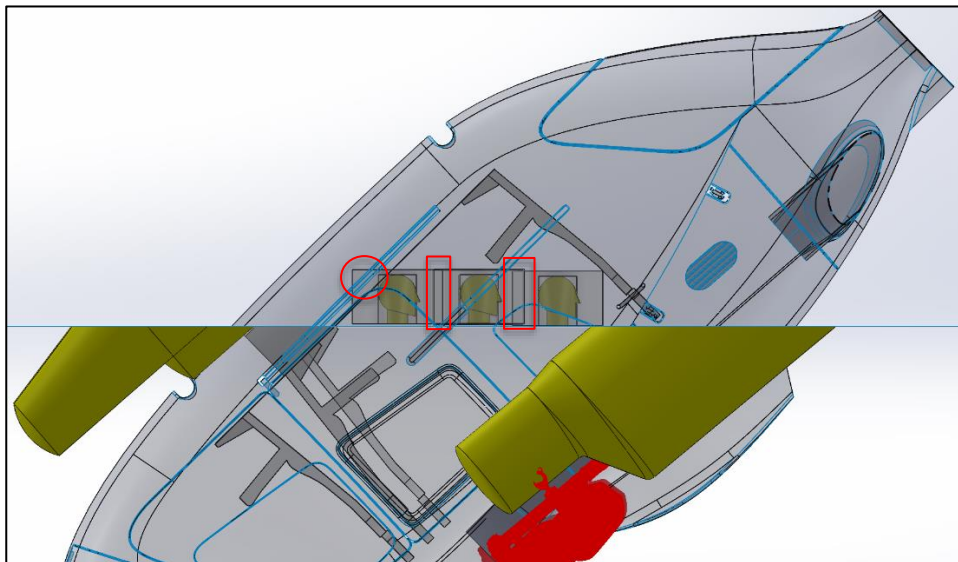
1. The center of buoyancy (CG of the submerged portion of the floats, fuel tank, and inherent buoyant volume) was able to be aligned with the center of CG of the helicopter and the buoyancy of the submerged portions of the floats was equal to the weight of the helicopter at the adjusted MTOW.
2. The individual air pockets were able to be placed on the static water line within the cabin without being obstructed by seat backs, seat cushions, or the walls of the cabin. The air pockets were able to be placed so that the passengers within each row would be able to access them without needing to cross seat backs. The air pockets were also able to be placed so that the passengers' bodies would be able to fit in the area under the air pockets, referring specifically to the air pockets beneath the seat cushions.
3. The emergency exits were positioned below the waterline due to the attitude of the aircraft, but was still considered accessible, being a negligible distance below the waterline.

Damaged Compartment	Air Pocket Type	Result	Comment
No Damage	NPA 2016-1	FAIL [3.1.1]	NPA air pockets collide with floor and other air pockets
No Damage	Tapered	PASS [3.1.2]	No Collisions
Primary EFS, LH FWD Chamber	NPA 2016-1	FAIL [3.2.1]	NPA air pockets collide with floor, seat, back rest, and other air pockets
Primary EFS, LH FWD Chamber	Tapered	PASS [3.2.2]	No Collisions
HEFS, LH FWD Chamber	NPA 2016-1	FAIL [3.3.1]	NPA air pockets collide with floor, seat, back rest, and other air pockets
HEFS, LH FWD Chamber	Tapered	PASS [3.3.2]	No Collisions

*Table 2 Results of CS27 Air Pocket Analysis*

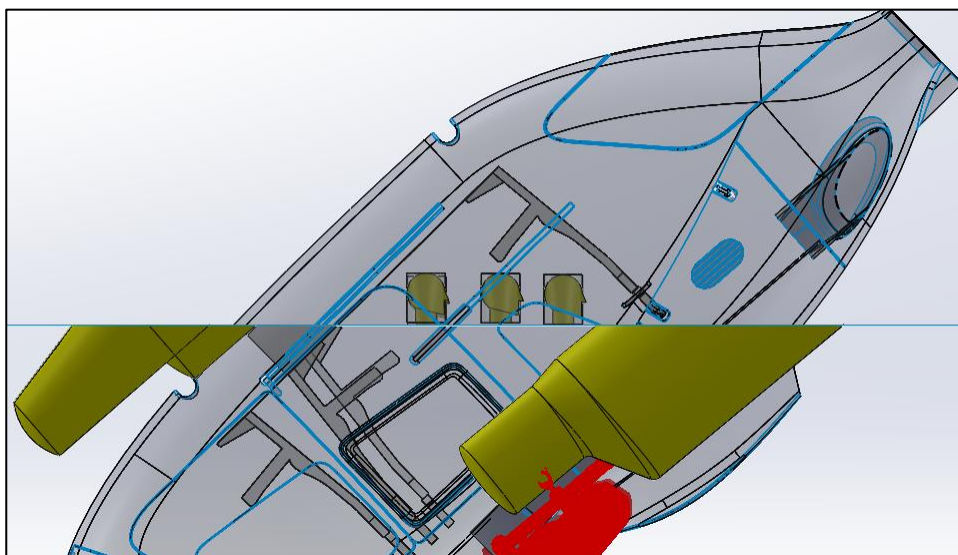
### 3.1 CS27 Air pocket Analysis: No Critical Compartment Damaged

#### 3.1.1 CS27 HEFS, Heavy FWD CG, No Compartment Damaged, NPA 2016-01 Air pocket: Fail.

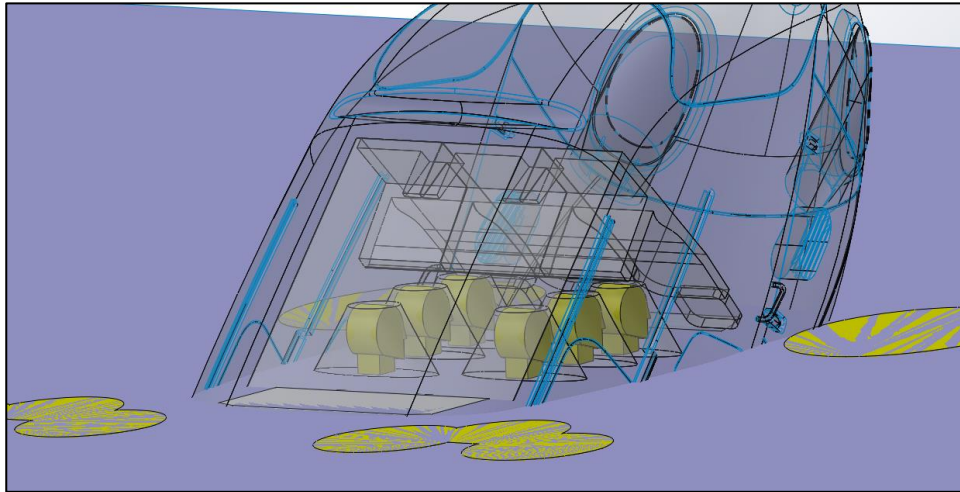


*Figure 24: NPA air pocket: collision with floor, and other air pockets*

#### 3.1.2 CS27 HEFS, Heavy FWD CG, No Compartment Damaged, Tapered Air pocket: Pass.



*Figure 25: Tapered Air Pocket: no collisions*

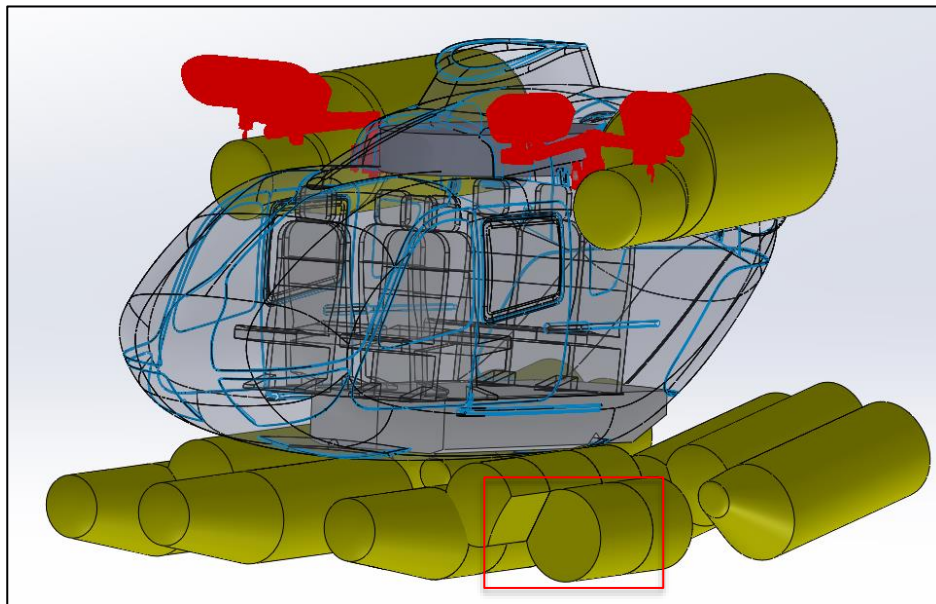


*Figure 26: Tapered Air Pocket: no collisions*

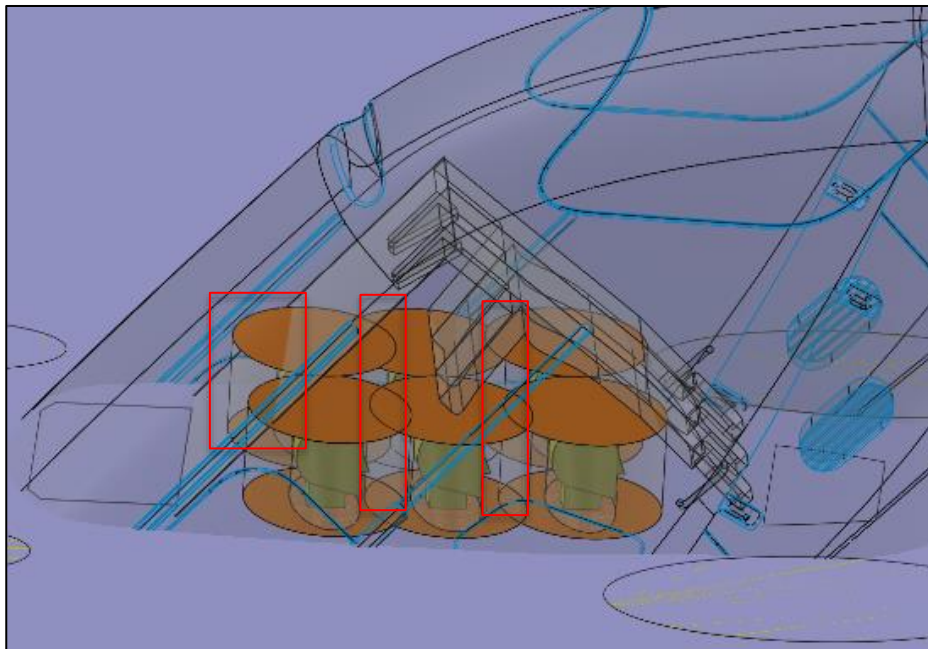


## 3.2 CS27 Air pocket Analysis: Primary EFS Critical Compartment Damaged

### 3.2.1 CS27 HEFS, Heavy FWD CG, Primary EFS LH FWD-Most Compartment Damaged, NPA 2016-01: Fail.



*Figure 27: LH FWD Primary EFS Damaged*



*Figure 28: NPA air pocket: collisions with floor, and other air pockets*

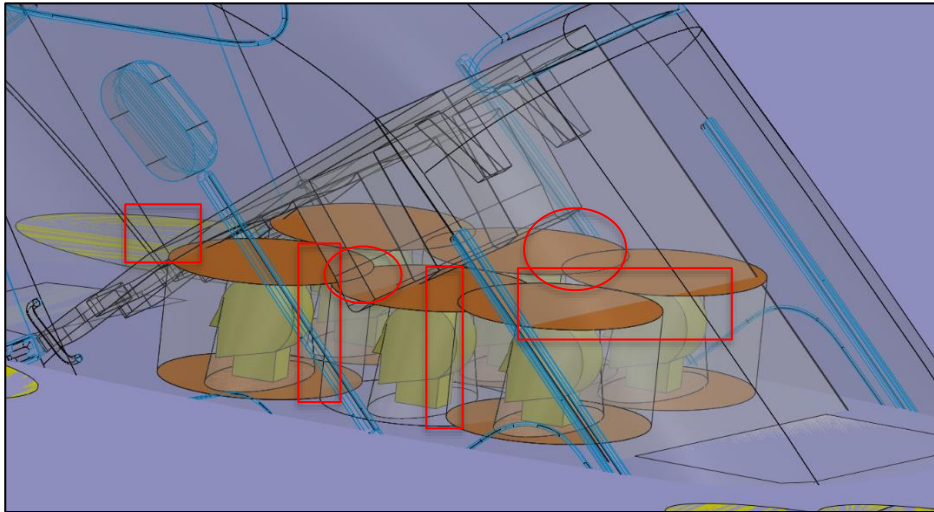


Figure 29: NPA air pocket: collisions with floor, seat, back rest, and other air pockets

### 3.2.2 CS27 HEFS, Heavy FWD CG, Primary EFS LH FWD-Most Compartment Damaged, Tapered: Pass.

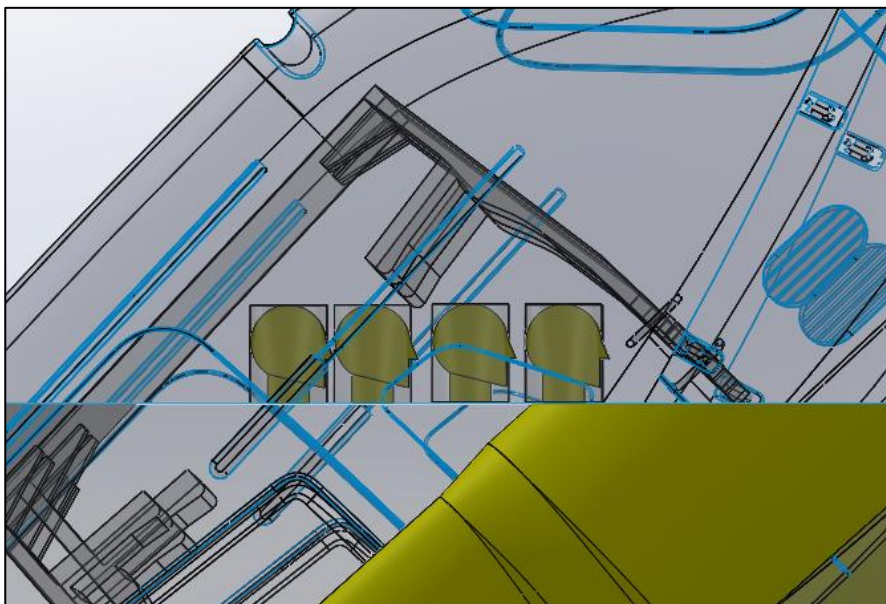
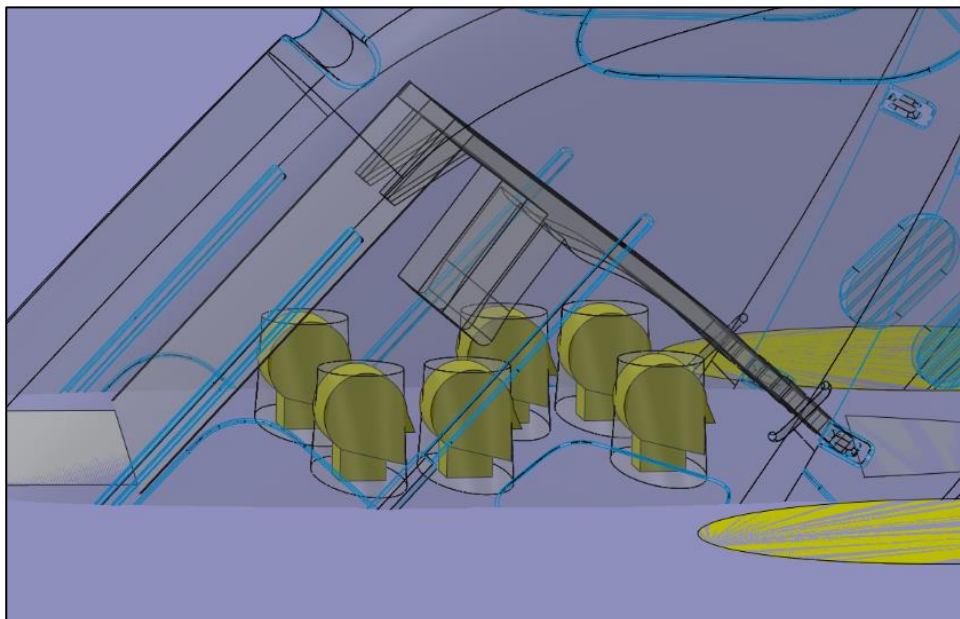
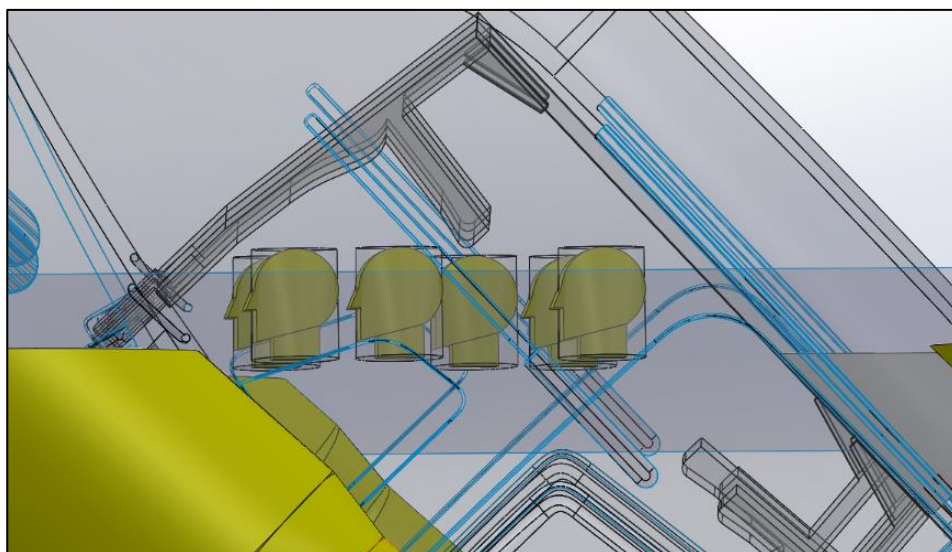


Figure 30: Tapered air pocket: no collisions with other air pockets or floor



*Figure 31: Tapered air pocket: no collisions with back rest*

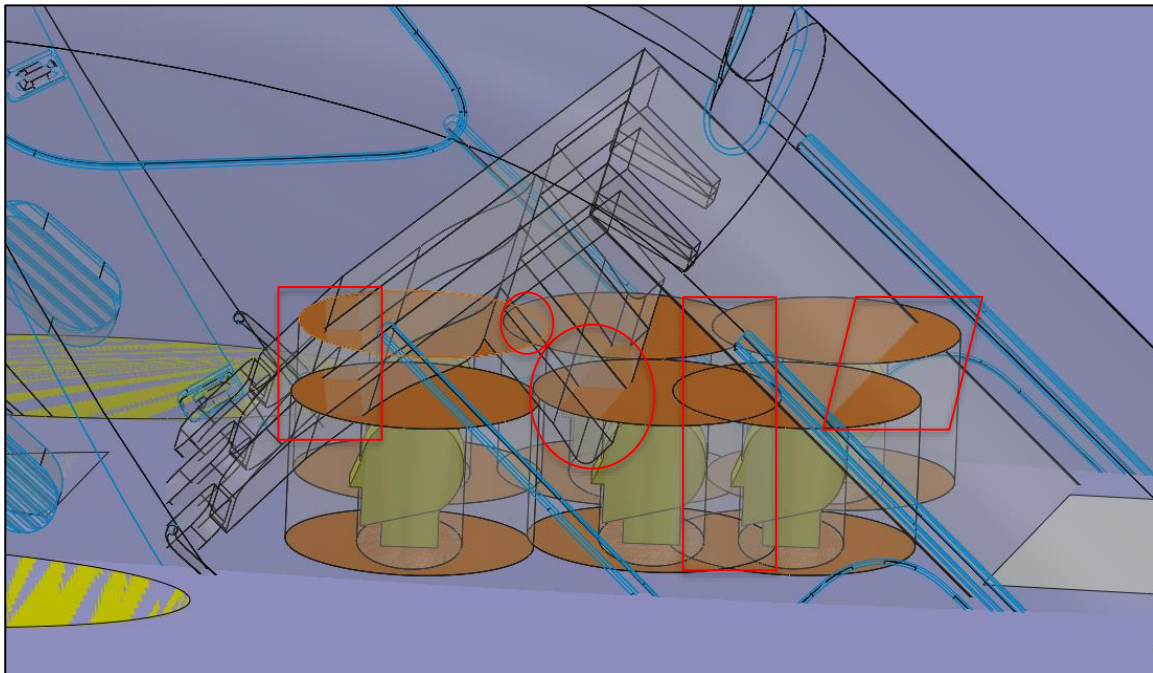


*Figure 32: Tapered air pocket: no collisions with seats, back rests, and floor*



### 3.3 CS27 Air pocket Analysis: High Mounted EFS Critical Compartment Damaged

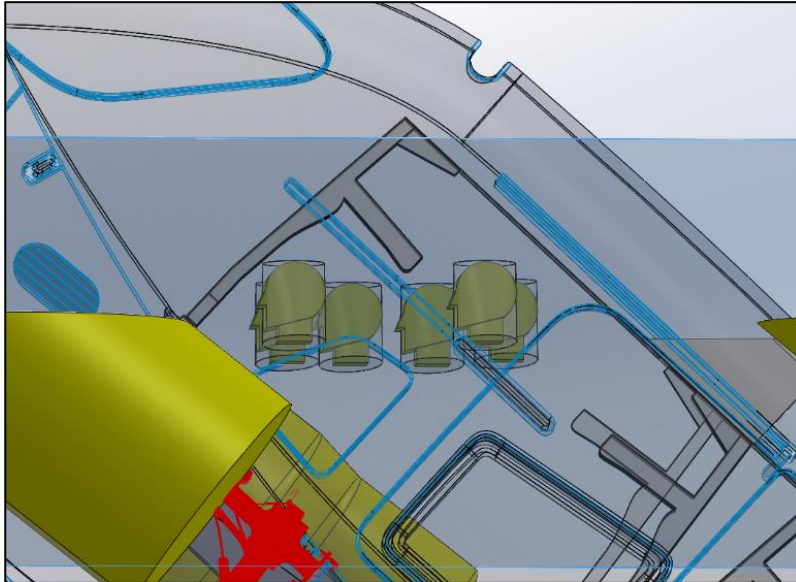
#### 3.3.1 CS27 HEFS, Heavy FWD CG, HEFS LH FWD-Most Compartment Damaged, NPA 2016-01: Fail.



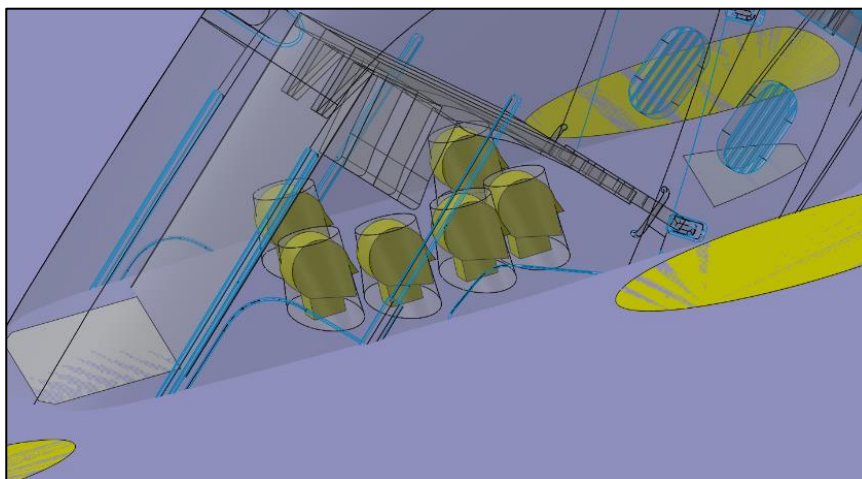
*Figure 33: NPA Air Pocket: collisions with back rest, seats, floor, and other air pockets*



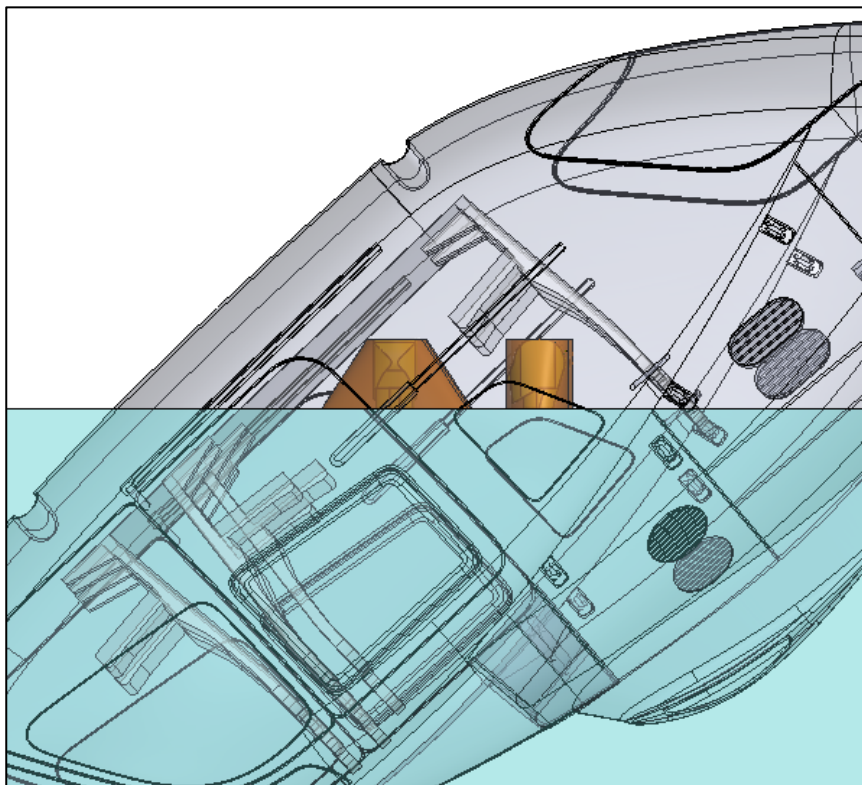
### 3.3.2 CS27 HEFS, Heavy FWD CG, HEFS LH FWD-Most Compartment Damaged, Tapered: Pass.



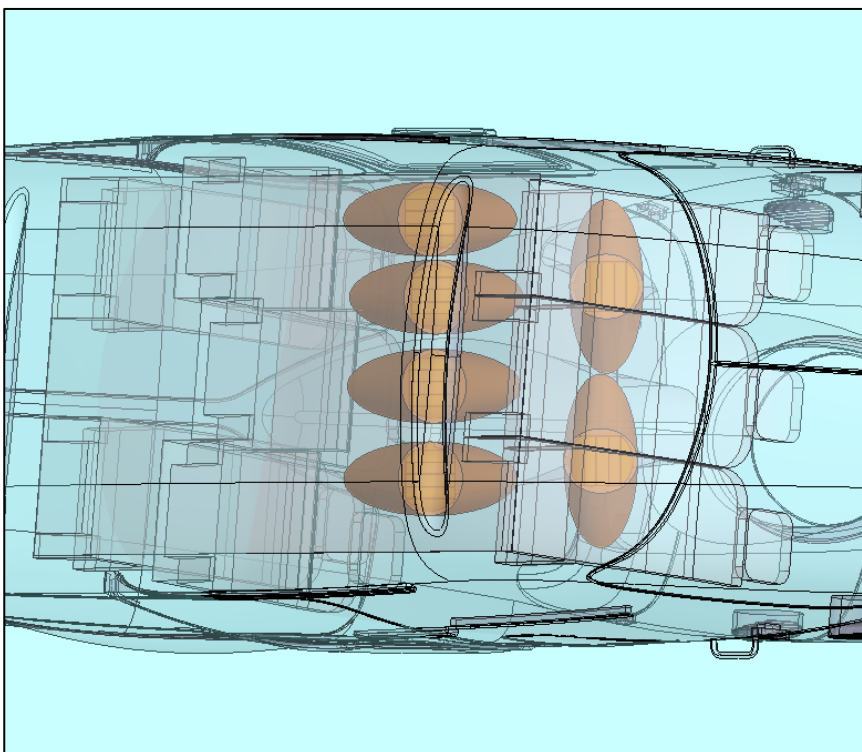
*Figure 34: Tapered air pocket: no collisions with back rest, seats, and floor*



*Figure 35: Tapered air pocket: no collisions with other air pockets*



*Figure 36: Revised Tapered air pocket: no collisions with back rest, seats, and floor*



*Figure 37: Revised Tapered air pocket: no collisions with other air pockets*

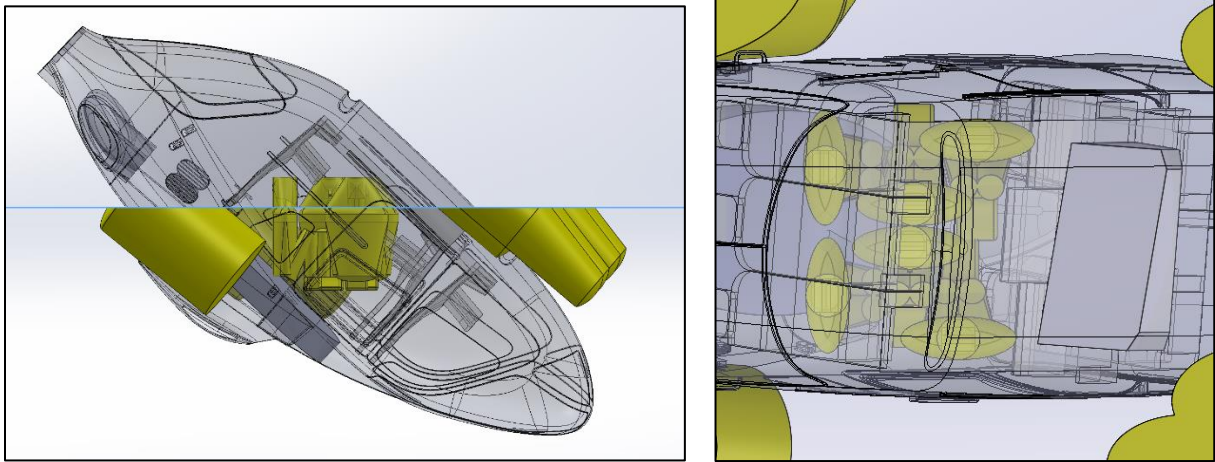


Figure 38: CS27 HEFS Damaged Full Capsize with Body Models



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