

# Rollover Crashworthiness Assessment for Cutaway Buses Acquired by the State of Florida

## 1. Scope

The Rollover Crashworthiness Assessment for Cutaway Buses Acquired by the State of Florida (FL-STANDARD) applies to all cutaway-type buses procured through FDOT TRIPS (Transit-Research-Inspection-Procurement Services) contracts. It establishes the procedures and performance criteria for assessment of rollover crashworthiness.

## 2. Purpose

The purpose of this Standard is to reduce death and injuries resulting from the collapse of the cutaway bus passenger compartment during rollover accidents.

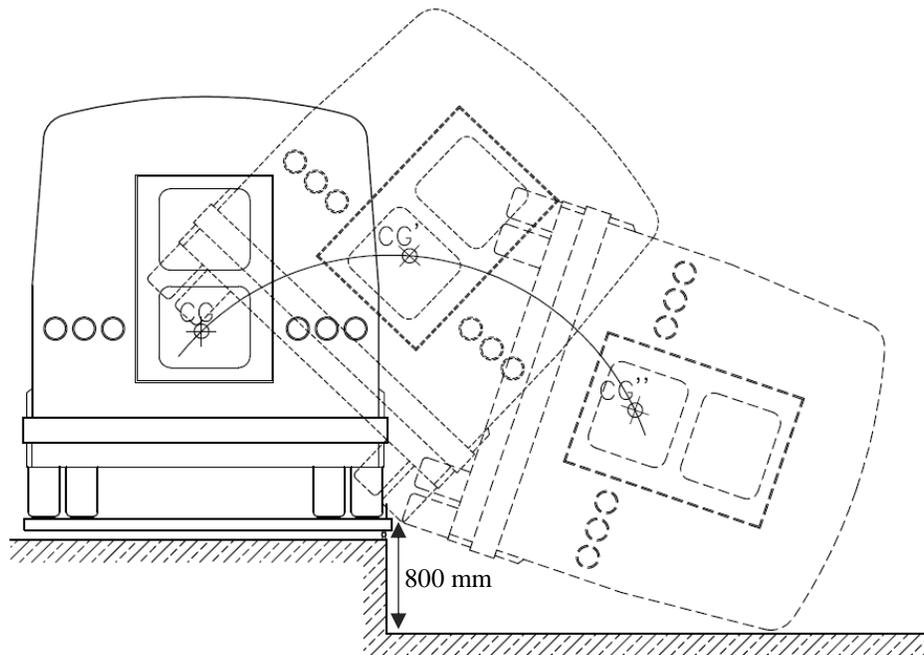


Figure 1: FL-STANDARD Rollover Test

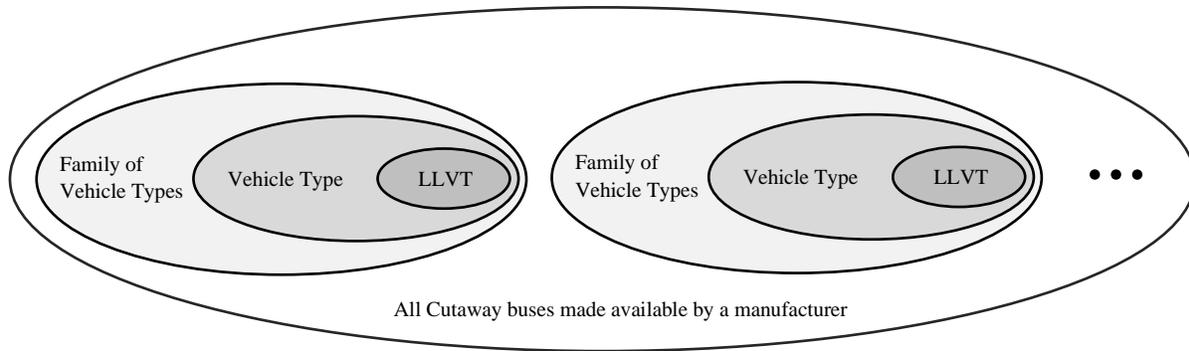
## 3. Approval

Approval under the FL-STANDARD consists of pre-test, test, and post-test requirements. The approval process is initiated by the manufacturer through Request for Approval. The request is followed by a Rollover Test of a cutaway bus (Figure 1). Successful completion of the Rollover Test grants approval. Approval is then maintained through meeting the Modification of Approval and Conformity of Production requirements.

## 4. Requirements

More detailed descriptions of the required approval procedures may be found in the FL-STANDARD Test Procedure.

4.1 Request for Approval - The request for approval will be submitted by the vehicle manufacturer to FDOT.



**Figure 2: Relationship between the required bus categories.**

4.1.1. The manufacturer must categorize their available cutaway vehicles into Vehicle Types. A Vehicle Type is a cutaway bus produced with the same design technical specification, main dimensions, and structural arrangement. For example, a 22 ft. 138” WB bus, a 24 ft. 158” WB bus, and a 26 ft. 176” WB bus would be three different vehicle types, while two 22 ft. 158” WB buses with different interior configurations would be considered a single vehicle type.

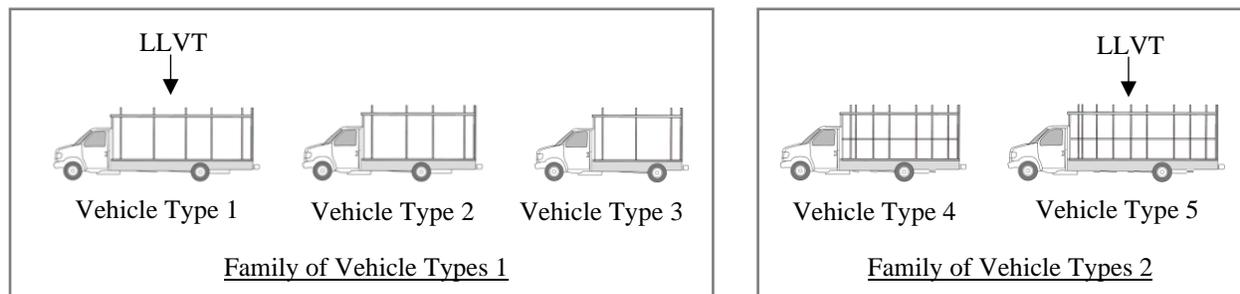
4.1.2. For all declared Vehicle Types, the manufacturer will provide the following information to FDOT:

- a) Descriptions and dimensioned drawings of the passenger compartment and chassis.
- b) The unloaded mass of the vehicle and the associated axle loads.
- c) The exact position of the unloaded vehicle's center of gravity (including height).

4.1.3. At the request of FDOT, a complete vehicle will be presented to check its unloaded mass, axle loads, position of the center of gravity, and all other data and information related to the Vehicle Type definition.

4.1.4. The manufacturer must categorize the submitted vehicle types into Family of Vehicle Types. A Family of Vehicle Types is a collection of Vehicle Types in which the design of the passenger compartment frame is similar enough for them to be considered together as a group for the purposes of this Standard.

4.1.5. For each Family of Vehicle Types, FDOT will determine the Vehicle Type least likely to meet the requirements of this Standard using the method described in the Test Procedure. This determination is made primarily by using the loaded vehicle mass and the COG location to find



**Figure 3: Example of required bus categorization showing five vehicle types split into two families due to structural differences, and the LLVT chosen from each family.**

the Vehicle Type that will have the greatest amount of test energy. The Least Likely Vehicle Type (LLVT) will then be considered representative of the Family of Vehicle Types for the purposes of this Standard.

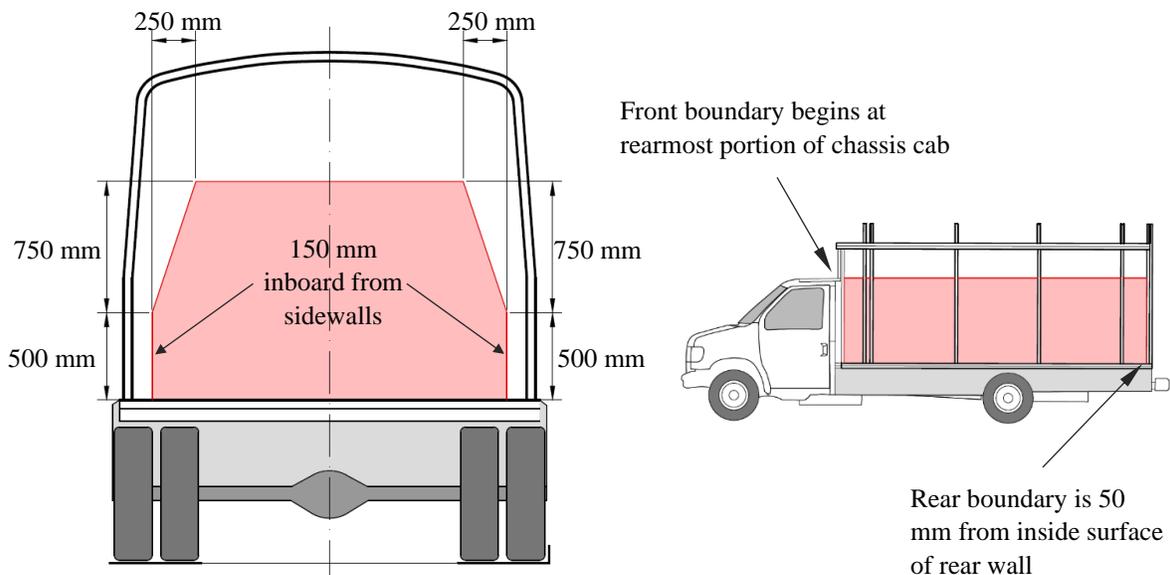
4.2. Rollover Test – The Rollover Test will be conducted by FDOT.

4.2.1. The manufacturer will build the LLVT passenger compartment onto a suitable chassis. A used chassis with a model year  $\leq 12$  years from the date of test is allowed in place of a new cutaway chassis.

4.2.2. The LLVT test bus must be built using normal production methods to the submitted Vehicle Type design specification. All structural and high mass items must be included; however, all parts do not need to be new, cosmetically perfect, or (in some cases) operational. Non-structural or low mass items can be omitted. The FL-STANDARD Test Procedure contains more detailed test bus build requirements and guidelines.

4.2.3. The LLVT test bus will be transported to the FDOT Springhill Bus Testing Facility in Tallahassee, FL.

4.2.4. The Rollover Test is conducted by placing the prepared LLVT on a tilt table that is 800 mm above a smooth and level concrete surface, as illustrated in Figure 1. One side of the tilt table is raised until the vehicle becomes unstable, rolls off the platform, and impacts the concrete surface below. The rollover test will be carried out on that side of the vehicle that is determined to be most vulnerable.



**Figure 4: FL-STANDARD Survival Space.**

4.2.5. Performance on the FL-STANDARD is evaluated using the concept of Survival Space. The Survival Space is a three-dimensional volume defined within the passenger compartment, as shown in Figure 4. The Survival Space begins at the rearmost portion of the chassis cab and ends 50 mm from the inside surface of the passenger compartment rear wall. The outer boundary of

the survival space at any transverse cross section between or at the front and rear boundaries is defined by the following symmetric polygon:

- a) Segment 1 extends vertically from the floor to an end point that is 500 mm above the floor and 150 mm inboard of the side wall;
- b) Segment 2 starts at the end point of Segment 1. The end point of Segment 2 is 750 mm vertically above and 250 mm horizontally inboard of the end point of Segment 1.
- c) Segment 3 is a horizontal line that starts at the end point of Segment 2 and ends at the vertical longitudinal center plane of the vehicle.

4.2.6. In order for approval to be granted, the passenger compartment frame of the vehicle must have sufficient strength to ensure that no part of the vehicle outside the survival space at the start of the test will intrude into the survival space at any time during the test. Any structural parts originally within the survival space will be ignored when evaluating the intrusion into the survival space.

4.2.7. Each anchorage of all vehicle seats and other permanently fastened interior items (if present) will not completely separate from its mounting structure during at any time during the rollover test.

4.2.8. After the vehicle comes to rest on the impact surface and while still resting on its side, each roof and rear emergency exit of the vehicle will be capable of releasing and opening with a force of not more than 60 pounds applied perpendicular to the door surface.

#### 4.3. Modification of Approval

4.3.1 Every proposed modification of an approved Vehicle Type by the manufacturer will be submitted to FDOT, which will proceed with one of the three following courses of action:

- a) Agree that the modifications made are unlikely to have any negative effect on rollover crashworthiness and that the modified vehicle type still complies with the requirements of this Standard.
- b) Require a further test report to prove that the modified vehicle type complies with the requirements of this Standard.
- c) Refuse the extension of approval and require a new approval procedure to be carried out.

4.3.2. The decision of FDOT, in cooperation with the manufacturer, will be based on an evaluation of how the proposed changes will affect the Vehicle Type's rollover crashworthiness.

#### 4.4. Conformity of Production

4.4.1. Every vehicle manufactured under this Standard will conform to an approved Vehicle Type.

4.4.2. The normal frequency of inspections authorized by FDOT to check conformity will be once every year. If non-conformity is discovered in the course of one of these visits, FDOT may increase the visit frequency to re-establish the conformity of production as rapidly as possible.

4.4.3. The approval granted in respect of a Vehicle Type pursuant to this standard may be withdrawn if the requirements specified in this section are not complied with.

## **5. Disclaimer**

This specification is extracted from, and is consistent with, bus safety standards as required by the referenced U.S., U.N., and E.U. regulations as of the date of release of this Revision.

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