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Differences in structural design and safety requirements of urban buses in Europe and North America

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This article conducts a comparative analysis of the design and safety requirements for urban buses in Europe and North America. European and American regulations are assessed for their impact on vehicle body design, structural strength, evacuation solutions, flammability of materials, accessibility, and vehicle equipment configuration. The analysis demonstrates that differing regulatory approaches across both regions result in significant differences in the structural architecture, safety systems, and functional organization of city buses. These differences are found to limit the ability to configure fully universal designs for both markets.

Key words: *city buses, technical norms, safety*

1. Introduction

Bus transport remains a key element of urban mobility systems in both Europe and North America, accounting for a significant portion of public transport journeys and acting as a link between rail transport and local commuting [46]. In the last decade, growing environmental and vehicle quality requirements (electrification, improved accessibility, raised passenger information standards) have imposed new constraints and innovative incentives on transport manufacturers and organizers [11, 58]. At the same time, the regulatory frameworks on both sides of the Atlantic shape these processes differently, leading to design and operational differences that are noticeable even in the most typical market segments – city buses with a length of approximately 12 m (≈ 40 ft) and 18 m (≈ 60 ft). In Europe, bus design and approval are based primarily on the regulations of the United Nations Economic Commission for Europe (UNECE) and the General Safety Regulation (GSR) (including those concerning body structure, doors and emergency exits, and flammability of materials) as well as on Euro VI and subsequent emission standards [12, 49]. In the United States and Canada, a similar role is played by sets of federal standards and guidelines, including the Federal Motor Vehicle Safety Standards (FMVSS) (including emergency exits, flammability of materials), Americans with Disabilities Act (ADA) regulations regarding accessibility, and U.S. Environmental Protection Agency (EPA) regulations for heavy vehicles [30, 57, 58]. The clash of these two orders results in a number of design differences, from body dimensions and geometry (e.g., permissible width), through door layout and width, and passenger transfer logic, to accessibility solutions (ramp type, wheelchair space orientation), lighting, signage, and integration of Heating, Ventilation, and Air Conditioning (HVAC) systems and electronics [49, 57].

Despite the abundance of normative sources and industry reports, the literature lacks a single, synthetic approach that systematically compares the design and operation of city buses in the EU and North America. Existing literature on urban buses primarily focuses on selected, narrowly defined problem areas. Operational studies analyze passenger exchange strategies and the impact of solutions such as all-door boarding on dwell time and perceived service quality [9, 22]. Research in ergonomics and accessibility investigates the interior layout of low-floor buses and the accommodation conditions for wheelchair users and other passengers requiring mobility assistance [8]. Meanwhile, studies addressing structural safety usually compare individual homologation procedures, such as ECE R66 and FMVSS 220, limiting their scope to structural resistance in rollover scenarios [18].

At the same time, a rapidly developing body of research is devoted to the electrification of bus transport, concentrating mainly on vehicle scheduling, charging strategies, and operational cost optimization [6]. More recent comparative studies between Europe and North America primarily address the functional and legal requirements for automated bus systems rather than the comprehensive architecture of urban buses [21]. As a result, there is still no integrated study that simultaneously compares European and North American regulatory frameworks and their implications for structural design, interior layout, accessibility solutions, operational assumptions, and the overall safety of urban buses.

This gap hinders the drawing of design and purchasing conclusions in tender procedures, as well as comparisons of operational efficiency across different urban contexts. The novelty of this study lies in combining these perspectives into a single, coherent comparative analysis of the European Union and North American approaches to urban bus design and regulation. The present work was conducted using a comparative analysis of international regulations, type-approval standards, tender specifications, and technical documentation for city buses in operation in Europe and North America.

2. Regulatory framework

2.1. Europe (EU/UNECE) – construction, fire safety

The basis for European type approval of M2/M3 buses is UN Regulation No. 107, which specifies, among other things, vehicle classes, requirements for doors and emergency exits, passenger compartment, markings, and equipment [49]. For dimensions, the 2.55 m width limit is important. For flammability of materials and resistance to fuels/lubricants, UN Regulation No. 118 applies, including test methods and assessment criteria [50]. For exhaust emissions from heavy-duty vehicles (including city buses), the framework is Regulation (EC) No. 595/2009 (Euro VI) and its implementing acts [12]. Together, this creates a set of requirements that, on the EU side, directly affects the geometry, interior layout, material selection, and system integration in buses.

2.2. United States and Canada – safety, availability, dimensions

In the USA, key safety requirements are defined by the federal FMVSS standards: FMVSS 217 (emergency exits, window retention and release, operating forces, dimensions, markings) [30] and FMVSS 302 (ignition resistance and flame spread rate of interior materials) [31]. Bus accessibility is defined by 49 CFR Part 38 (ADA) – including parameters for ramps, wheelchair spaces and attachments, voice/light information systems, and the location of control devices [57]. For gauge dimensions, the federal width limit of 102 inches (≈2.59 m) on the National Network, resulting from 23 CFR §658.15 [13], is important. For exhaust emissions, the final EPA Heavy-Duty Phase 3 requirements apply, covering, among others, transit and school buses [58]. This regulatory package sets different design priorities in North America than in the EU (e.g., emergency exit architecture, flammability criteria, consequences of a wider gauge, and specific ADA requirements).

Differences and their design implications:

- Emergency exits and windows: R107/EU vs. FMVSS 217/USA – differences in the location and dimensions of evacuation portals and window release requirements [30, 49]
- Flammability of materials: UNECE R118 vs. FMVSS 302 – impact on the selection of upholstery, linings, and insulation [31, 50]
- Accessibility: UNECE vs. precise ADA Part 38 requirements (ramps, wheelchair space and orientation, information interfaces) – implications for door location and interior layout [57]
- Clearance dimensions: The EU uses a practical 2.55 m, while the US uses 102″ (≈2.59 m) – differences translate into seating arrangements, aisle widths, and turning circles [13, 49]
- Emissions: Euro VI (EU) vs. EPA HD Phase 3 (USA) – different compliance and propulsion planning paths (e.g., limit compliance strategies, electrification) [11, 12, 58].

3. Dimensions, geometry and running gear

3.1. Normative assumptions and constraints

Bus dimensions result from a compromise between capacity and accessibility requirements and the spatial constraints of the street network. On the EU side, UN R107 design regulations (vehicle classes M2/M3, minimum circulation spaces, doors, emergency exits) are key, indirectly determining overhang length, floor height, and aisle width [49]. In North America, vehicle width limits on the national network are set by the federal limit of 102″ (≈2.59 m), which translates into a slightly wider gauge than is typical in the EU (practically 2.55 m) [13, 14]. Street design guidelines for bus traffic emphasize that the choice of vehicle design has direct consequences for curves, platform edges, and lane widths [25, 27, 46].

- The length (≈ 12 m / 40 ft) allows for a full low floor in the door area and a rear service section. R107 does not mandate a specific length, but requirements regarding the number and location of doors and aisles determine the minimum usable space [49]
- Width: The difference of 2.55 m (EU) vs. 2.59 m = 102″ (US) changes the potential seating arrangement (number of seats side-by-side and aisle width) and turning kinematics; a wider body typically requires larger curves while maintaining the same tires/wheelbase [27, 28, 46]
- Height depends on the drive/HVAC architecture R107 requirements for exits and roof equipment, which indirectly affect the available space under the roof [49].

4. Design and operational consequences

4.1. Door layout, passenger flow and passenger space

In European buses, the standard is a full low floor in the door zone and a system of at least 2–3 pairs of doors (Fig. 1), designed for parallel flows of boarding and alighting and a short dwell time during rush hours [38, 49].

Fig. 1. Door layout of a European bus

In North America (40 ft), the 2-door model (Fig. 2) and front-door boarding (entrance at the front, exit at the rear) are predominant, which is related to the location of fare boxes at the front doors [2, 17]. More and more agencies are testing or implementing boarding with all doors open on high-demand lines, which, in research and evaluations, results in a significant reduction in dwell time and lower stop-to-stop variability [26]. In North American vehicles, despite a slightly wider gauge (102″ ≈ 2.59 m) favoring a wider aisle, the geometry itself, without changing the boarding policy, is worse than in Europe [13, 26].

Differences in floor architecture translate into space management and passenger flows. In the EU, a full low floor across all doors promotes rearward vehicle movement and more standing space in the door areas. In the USA/Canada, 40-foot low-floors are common, with a raised platform above the drive axle (a step in the rear) that limits the natural rearward movement of passengers in a 2-door configuration [44]. In European practice, thanks to 2–3 pairs of doors and a wide corridor between them, capacity (number of passenger exchanges per stop) is higher [26, 35, 38]. In the EU, a greater variety of seat orientations is permitted, including space above the wheel arches and seats longitudinally or rearward positioned locally (Fig. 3).

Fig. 2. Door layout of an American bus

Fig. 3. Seat arrangement in an EU bus

In practice, NA seats are usually positioned forward-facing or longitudinally to the aisle (Fig. 4), and rear-facing seating arrangements in the passenger area are rare; regulations and guidelines focus, among other things, on providing forward-facing seats in the priority area [17, 26].

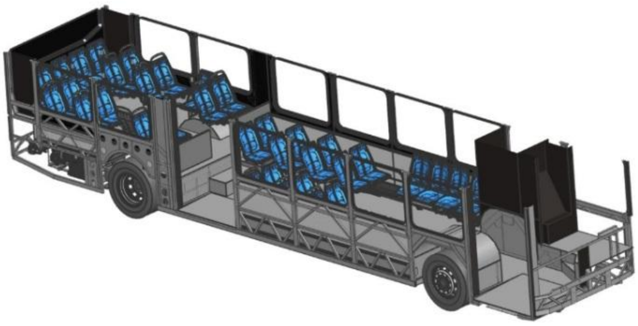

Fig. 4. Seat arrangement in an NA bus

Accessibility and wheelchair access are managed differently. In the EU (e.g., in city specifications), the ramp is usually located at the middle door (Fig. 5), and the wheelchair position is usually rearward-facing (Fig. 6) with an appropriate backrest. This facilitates the dispersion of flows at entrances and minimizes collisions with traffic near the driver's cabin [11, 40, 45].

Fig. 5. EU wheelchair ramp

Fig. 6. EU wheelchair space

In NA, in accordance with ADA Part 38 and Access Board guidelines [55], at least one position must allow forward-facing immobilization, and many operators combine ramp operation at the front door with driver assistance. A typical solution is a folding (flip-out) ramp in the first door (Fig. 7) [35, 56, 57].

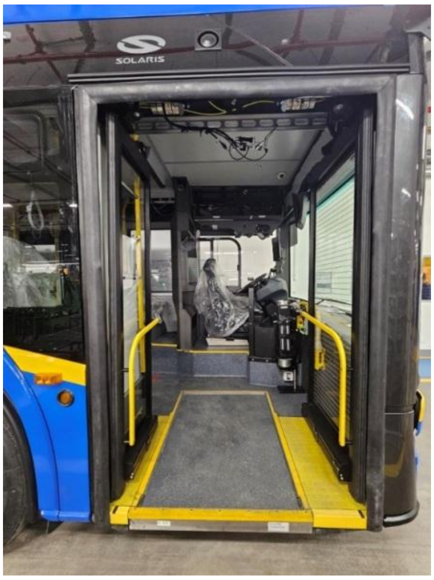

Fig. 7. NA wheelchair ramp

Interior ergonomics also differ in many respects. In the EU, multi-door systems strive for wide standing areas and as many free aisles as possible at the doors (fewer fare barriers in the entry area), which facilitates fast turnover. In NA, many systems, especially outside Bus Rapid Transit (BRT), still concentrate validation at door 1. They use more longitudinal seats in the front to increase standing area during peak hours [2, 17, 26].

5. Safety

5.1. Glazing and evacuation through windows.

In terms of passenger safety, both Europe and North America have clearly defined regulatory requirements for body design and evacuation systems. These include emergency exit doors, side and rear emergency windows, and requirements for their signage and accessibility. Despite the common goal of ensuring rapid and safe evacuation, the detailed technical solutions and regulatory philosophies differ on both sides of the Atlantic.

In Europe, UN ECE R107 requires an appropriate number of emergency exits and, at the same time, equips these areas with glass-breaking devices (hammers) at specified locations and with specified markings. In practice, this favors the use of bonded glass with safety hammers (Fig. 8) [49].

Fig. 8. EU emergency exit windows

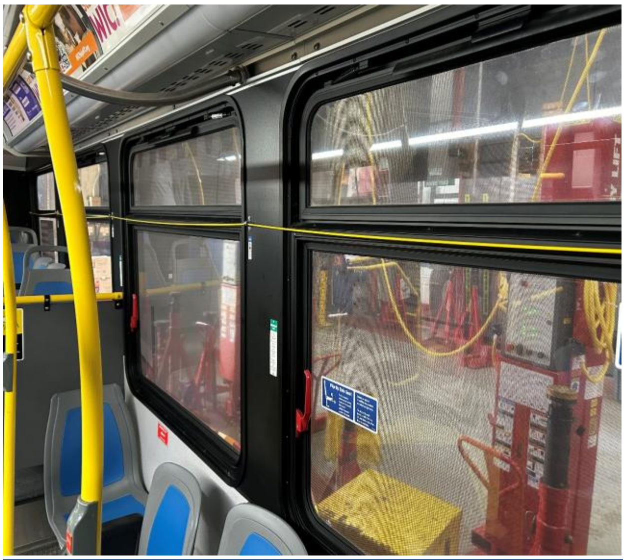

Fig. 9. Emergency windows NA

In North America, the FMVSS 217 standard precisely defines the number and types of emergency exits (doors, emergency windows, roof exits) as well as requirements for operating forces, opening dimensions, and signage. As a result, NA transit buses commonly feature tilt-and-slide windows with levers and instructions at the window. These are not glued but bolted to the bus frame (Fig. 9).

5.2. Bumpers

For city buses in the US, the federal bumper standard 49 CFR Part 581 does not apply to buses (it applies to passenger cars), which is confirmed by both the text of the regulation and interpretations by the National Highway Traffic Safety Administration (NHTSA) [5]. In practice, however, public transportation agencies (transit agencies) require the use of energy-absorbing bumpers at the front and rear (Fig. 10) and low-speed tests (e.g., 5 mph). These requirements stem not from federal regulations, but from purchasing standards developed by the American Public Transportation Association (APTA). The APTA Bus Procurement Guidelines document is a set of technical recommendations used in preparing tender specifications. An RFP (Request for Proposals), in turn, is a formal request for proposals published by the contracting authority (transportation agency) specifying detailed technical requirements for the vehicle. Numerous RFPs (e.g., SRTA, Tuscaloosa) explicitly require front and rear bumpers with specific resistance parameters and the ability to return to their original shape after impact [5, 39, 47]. Reinforced rear bumpers in North America also have practical operational significance. In depot conditions, they enable buses to be maneuvered using special pushers mounted on service vehicles. In emergency situations, they also allow a disabled bus to be safely pushed out of the lane using a properly prepared service vehicle. This solution requires appropriate reinforcement of the bumper zone structure and its integration with the vehicle frame.

Fig. 10. Front and rear bumpers NA

In North America, front-mounted bicycle racks are a common solution on buses; recommendations and implementation examples appear in APTA materials and city/agency operational guides. As a standard, 2–3-position racks are used, mounted at the front (Fig. 11), which allows the driver to observe loading/unloading [3, 33]. At the same time, the American regulator clarifies the legal framework: the NHTSA interpretation of FMVSS 108 indicates that bicycles in a rack are "temporary cargo," and the rack itself cannot obscure required lights/reflectors. If the installation does not render the mandatory devices inoperable, it is permissible; this also applies to installation by transit agencies themselves [33]. In several jurisdictions (e.g., California), length- and front-reach regulations have been clarified to explicitly allow extensions of up to ~40″ forward of the front of the bus. At the operational level, National Association of City Transportation Officials (NACTO)/city guidelines remind that the stand changes the turning geometry/front overhang and requires additional clearance at platforms and in the bay (e.g., typical clearance of 4 ft in front of the front at the stop) [3, 41].

Fig. 11. NA bicycle racks

In Europe, front racks are not permitted and do not pass approval procedures due to requirements regarding pedestrian safety/external protruding elements, field of vision, and light markings. In the UK, technical authorities have assessed front racks as unacceptable on city buses [29, 37]. Furthermore, Transport for London (TfL) explicitly states that installing front racks does not meet the Bus Safety Standard requirements and negatively affects parking times/capacity; bicycle parking and interchange integration are preferred [24]. These generalizations also appear in EU projects, which indicate that front racks are not permitted in the EU due to the risk of pedestrian injury from protruding elements [23, 38].

5.3. Signage and pictograms

In the EU, R107 regulates the marking of safety devices, but in practice, ISO-compliant pictograms and legible photoluminescent markings predominate, with a smaller proportion of long texts (Fig. 12) [49].

Fig. 12. EU safety markings and pictograms

In North America, ADA regulations (49 CFR Part 38), in conjunction with FMVSS 217, result in a large number of labels and text stickers concerning, among others, priority seats, wheelchair positions and instructions, emergency exits and audio-visual information (Fig. 13–15) [30, 57].

Fig. 13. Safety markings and pictograms NA

Fig. 14. Signage and pictograms – informational NA

Fig. 15. Signage and pictograms – prohibiting certain behaviors NA

5.4. Stop-request: buttons and pull-cords

In Europe, STOP buttons predominate (Fig. 16), arranged according to operator specifications, while meeting the R107 requirements regarding accessibility and legibility of control elements [49].

Fig. 16. STOP buttons in the EU

In the US and Canada, the stop-request system must be accessible from the wheelchair attachment points and provide both an audible and visual signal. Regulations §38.37 allow operators to choose the activation mechanism – either a pull cord (Fig. 17) or a button. In practice, this translates into the widespread use of pull cords that operate in parallel with buttons. Their presence is acknowledged in many operators' operating procedures – for example, in standard operating instructions. Pull cords are particularly valued for their ease of use, reliability, and ease of integration with existing signaling systems, as well as passenger and operator habits. Additionally, their physical form can be more intuitive for passengers with limited dexterity, supporting ADA-compliant accessibility. In older vehicles, pull cords may be the primary mechanism for requesting a stop, while in newer models, they are used as a supplement to buttons, increasing the flexibility of the system [1, 20, 57].

Fig. 17. Pull cord

5.5. Standards for the installation and color of lights and rear windows

On the EU side, the basis is UN/ECE R48 (installation) together with specific regulations (e.g. R6 – turn signals), which rigidly define the colors: at the front, turn signals must be yellow (amber), at the rear also amber, and position and brake lights are signaled in red [52, 53]. In the EU, a horizontal arrangement of lights is predominant (Fig. 18).

In North America, FMVSS 108 permits red or yellow turn signals at the rear, with yellow at the front; this has led to different lighting semantics and design practices for rear lamp assemblies for years [29, 32]. Additionally, three red identification lamps are required at the upper edge of the rear, which influences the arrangement of lighting elements and the composition of the rear wall [15]. In NA design practice, vertical "towers" of lamps at the corners (stop/tail, turn signal, reversing) in a column arrangement are often used (Fig. 18), which facilitates meeting visibility requirements and integration with bumpers and service panels. In NA, purchasing specifications often do not require a rear window [4]. Similarly, a number of RFPs state that if a bus has a rear window, the manufacturer must meet additional specification requirements [41]. In Europe, the dominant practice for 12-meter city buses is to retain the rear window. Exceptions occur when the HVAC/drive installation occupies the window area and the customer accepts a closed rear end [41, 52].

Fig. 18. EU and NA lights layout

5.6. Flammability of internal materials

In the EU, UN/ECE R118 is used, which covers the behavior of materials when exposed to fire (flammability, burning rate, melting/dripping) and, in newer editions, the ability to repel fuel or oil (Annex 9 test). R118 defines three basic reactions to fire tests: horizontal flame spread (Annex 6), melting and dripping (Annex 7), and vertical flame spread (Annex 8); the limiting criteria are, for example, ≤ 100 mm/min for horizontal and vertical tests, and in the melting test, no ignition of cotton wool by drops. The scope of the regulation applies (depending on the version) to materials in the passenger compartment and additional components (e.g., insulation in the engine/heating compartment – Annex 9 oil immersion test; electrical cables – Annex 10 resistance to flame propagation). A material that passes Annex 8 (vertical) generally also meets Annex 6 (horizontal) [10, 50].

In the US/Canada, FMVSS 302 is the basis for a single horizontal test that measures the flame spread rate of materials inside the passenger compartment (including panels, carpets, linings, headliners, seat belts, and curtains; each layer within 13 mm of the cabin airspace is considered). The passing criterion is ≤ 102 mm/min or extinguishment before 60 s and < 51 mm of burnt length. The procedure describes sample preparation (102 × 356 mm), conditioning, and Bunsen burner flame conditions [31, 43].

Key practical differences include:

- Test philosophy and completeness. R118 is a set of tests (horizontal/vertical/melting + special tests for fuels and cables) that more broadly reflects real-world fire scenarios in buses; FMVSS 302 is limited to horizontal combustion of cabin materials. Consequently, the same material may meet FMVSS 302 requirements but not R118 Annex 7/8 requirements (e.g., due to vertical spread or dripping) [19, 50].
- Thresholds and criteria. FMVSS 302: ≤ 102 mm/min (horizontal); R118: ≤ 100 mm/min (horizontal and vertical). Minor numerical differences are less significant than the test orientation (vertical vs. horizontal) and the melting/dripping condition in R118.
- Scope of components. FMVSS 302 explicitly lists a long list of interior components and states that any layer within 13 mm of the cabin is subject to the requirements. R118 separates responsibilities between interior components, hot cell insulation (Annex 9), and ductwork (Annex 10) [31, 50].
- Design implications: for buses, this means that it's easier to avoid meeting EU requirements for vertical elements (walls, curtains, and covers) and overhead materials (Annex 7), and for insulation in hot zones, fuel/oil resistance must be confirmed. Therefore, materials that are acceptable overseas may require a different selection in EU tenders.

5.7. Electronic cabinet and equipment layout

In Europe, city bus manufacturers prefer service bays in the rear corners, hidden behind large flaps and logically separating the HV/LV and drivetrain. Manufacturers' materials emphasize modular component packaging in the rear and roof areas, which minimizes the need for cassettes above the wheel arches in the interior and allows for ground-level servicing of entire corner sections after opening the flaps.

In North American buses, key HV/LV points (battery disconnects, HV system access, fuse and control panels) are most often located in the rear curbside so that service and emergency procedures can be performed from sidewalk level. Driver/crew instructions explicitly instruct drivers/crews to approach the rear curbside and open the Battery Disconnect access door in an emergency, clearly locating the main power disconnect point at the rear of the vehicle [42]. In parallel, product materials describe an easily accessible compartment housing the traction power electronics and on-board systems—a typical modular service cabinet. In North American practice, there is also a variant of the electrical cabinet, accessible from the inside on the left wheel well (Fig. 19), for mounting on-board electronics, which perpetuates the practice of using the front left wheel well as a location for selected modules.

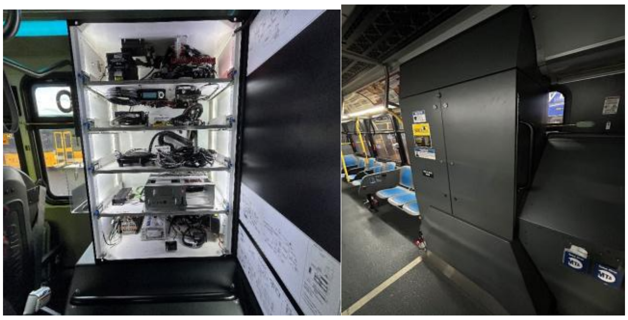

Fig. 19. Electrical cabinet on the wheel arch NA

5.8. Frame strength and structural safety

Design differences between buses in Europe and North America stem not only from regulations regarding doors, lighting, and accessibility, but also from differing approaches to frame strength, passive safety, and methods for assessing the superstructure. In Europe, the core regulations include UNECE regulations, particularly R66.02, R29, and R100, while in the US, this role is primarily fulfilled by the Altoona test program, supplemented by guidelines on static roof loads. It's worth noting that, unlike passenger cars, neither the EU nor the North American states has a separate, mandatory side impact test for city buses.

5.9. Rollover test

In the EU, the primary regulation for the structural resistance of M2/M3 buses is UN/ECE R66.02 [54]. The regulation defines criteria for maintaining a survival space, which must remain intact after a vehicle rolls over. During the physical test, the bus body is placed on a platform tilted around a predetermined pivot point. Once the critical angle is exceeded, the structure freely falls onto the impact surface (Fig. 20).

The regulations specify:

- the pivot point and rollover axis
- vehicle preparation method (weight, configuration, fluid status)
- the precise boundaries of the survival space
- criteria for permissible structural deformation.

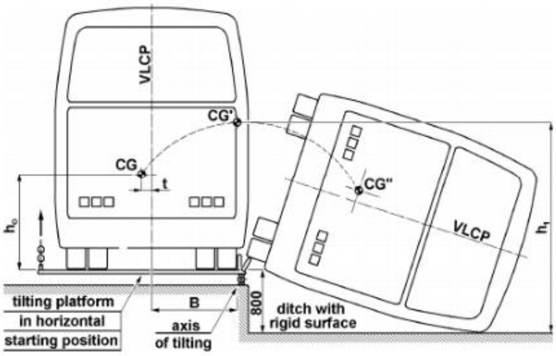

Fig. 20. Rollover test in the EU [59]

The test is considered as passed if, after the rollover, no structural, skin, or equipment element enters the survival space, which defines the geometric shape within which passengers must fit after the structure deforms. Deformations of the pillars, body, and roof do not violate the protective zone. Doors and emergency exits remain operable in accordance with R107 requirements (after deformation corrections specified in the procedure).

Other methods for confirming compliance with R66.02 are also available:

- Physical rollover of the complete vehicle. This is the most reliable method, but also the most expensive. It is primarily performed at manufacturer research centers
- Section rollover (module test). A section of the structure is tested (usually the side section and roof). This method is less expensive and widely used in homologation
- FEM simulation (Finite Element Method). The regulations allow for full confirmation of compliance through numerical analysis—provided that the model has been previously calibrated using the results of a physical section test [36, 54].

5.10. Lateral roll test

EU countries also use a static stability test in which the bus is tilted until a critical angle is reached, typically around 28–35° (Fig. 21). This test assesses the center of gravity and vehicle stability, supplementing the requirements of R66.02 [54].

Fig. 21. View of the bus during the lateral tilt test [7]

5.11. Frontal impact – driver's compartment protection (UN/ECE R29)

Protection of the driver's cab against deformation in a collision is defined by UN/ECE R29 [51]. Although the regulation originally applies to trucks, many urban bus manufacturers use its requirements as a design reference:

- cab resistance to frontal impact
- maintaining the driver's protective space
- reinforcing the upper and lower elements of the front structure.

In low-floor vehicles, these requirements are met by additional reinforcements on the floor and A-pillars.

5.12. R100 – Electric Bus Safety (HV)

UN/ECE R100 regulation specifies the safety of high-voltage systems in electric vehicles [48], including:

- impact resistance of the battery housing
- protection against puncture and short circuit after a collision
- insulation requirements
- protection against water ingress.

5.13. Altoona Program (FTA Bus Testing Program)

In the US, there is no regulation directly equivalent to the European R66. The structural strength and durability of buses are assessed primarily by the Altoona program – an accelerated durability test on a special test track (49 CFR Part 665) [16]. Altoona focuses on operational durability.

These tests include:

- structural fatigue testing (12-year simulation cycle)
- frame strength and deformation assessment
- structural torsion and deflection tests
- dynamic loading of roof components (HVAC, batteries)
- suspension system and body stiffness tests.

5.14. Roof Load Test – static roof load

In accordance with NHTSA guidelines and the bidding standards of many transportation agencies, transit buses in North America are subjected to a static roof load test [34]. The load is quasi-static and is applied to the roof structure in a controlled manner, typically through a beam that distributes the force over a defined area. Depending on the customer's specifications, the load value is typically several thousand pounds or a specified percentage of the gross vehicle weight. The test verifies that:

- the roof structure can support the specified load without loss of load-bearing capacity
- there is no permanent deformation of the supporting structure
- the roof equipment mountings (HVAC, traction batteries, converters) remain intact.

Unlike the European R66, this test does not simulate a vehicle rollover but rather tests the strength of the local roof structure.

5. Conclusions

The conducted comparative review demonstrated that the differences between urban buses operating in Europe and North America are systemic and stem primarily from differing regulatory frameworks and vehicle design philosophies. In Europe, bus design is directly subordinated to detailed UNECE regulations, which precisely define requirements for body strength, rollover protection of the passenger compartment, high-voltage system safety, evacuation, and fire behavior of materials. This approach leads to a high degree of superstructure standardization and a clear emphasis on passive safety and structural integrity. In North America, the regulatory system is based on a combination of FMVSS regulations, ADA accessibility requirements, and procurement and operational practices shaped by transportation agencies. The emphasis is shifted to service life, operational functionality, and vehicle configuration flexibility. The Altoona program and static roof load tests verify the durability of the structure under operational conditions. These differences directly impact the frame architecture, passenger compartment organization, evacuation solutions, interior material selection, exterior lighting configuration, service component layout, and vehicle accessories. As a result, designs intended for the European and North American markets can rarely be considered fully universal. The same bus model typically requires distinct approval and design variants, tailored to the specifics of a given legal and operational system. Differences in regulatory approaches mean that urban bus design is not only a technical issue but also the result of integrating the legal, infrastructural, and operational requirements specific to a given market. Understanding these conditions is crucial for manufacturers planning transatlantic operations, for transport organizers formulating tender requirements, and for further research on design optimization in the context of the globalization of the urban bus market.

Nomenclature

ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
BRT	bus rapid transit
CFR	Code of Federal Regulations
DOT	Department of Transportation
EPA	Environmental Protection Agency
EU/UE	European Union
eCFR	Electronic Code of Federal Regulations
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
FTA	Federal Transit Administration
HVAC	heating, ventilation and air conditioning
LCC/TCO	life cycle cost/total cost of ownership
NA	North America
NACTO	National Association of City Transportation Officials
NHTSA	National Highway Traffic Safety Administration
RFP	request for proposal
SFMTA	San Francisco Municipal Transportation Agency
TfL	Transport for London
TRB	Transportation Research Board
TRL	Transport Research Laboratory

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