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LiMo 2040 Sustainable urban Living and Mobility Concept - Elevator System

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Abstract: How can individual mobility in urban areas be maintained alongside scooters and cargo bikes if conventional vehicles are foreseeably no longer allowed to enter city centers? And how can urban living be combined with individual mobility in a sustainable and socially acceptable way? LiMo-2040 attempts to provide answers to these questions. It follows a holistic approach according to the criteria: As light, as compact and as simple (cost-effective) as possible. Modular e-vehicle concepts (consisting of vehicle cabin and chassis) are known, but have not yet been thought through to their logical conclusion. The LiMo cabin is not only a vehicle cabin, but also a component of a modern high-rise apartment. It therefore requires no parking space and combines urban living and individual mobility sustainably and cost-effectively. If a vehicle is needed, an app can be used to book a chassis that comes along autonomously and waits until the cabin, including its occupants, travels down a sophisticated rail system, docks and autonomously heads for the desired destination.

Key words: Modular, urban mobility, sustainability, elevator, autonomous.

1. Introduction

The modular vehicle concept, which (virtually) no longer needs a parking space and combines individual mobility with urban living, was already presented as a concept idea at the Stuttgart Symposium 2023 [1]. The trick of the matter is the multifunctional cabin: it is not only a vehicle cabin, but also an elevator cabin and, above all, a component of a modern apartment; most of the time the cabin hangs on the building like a kind of glazed balcony (miniature conservatory). If a vehicle is needed, an app can be used to book a chassis that comes along autonomously and waits until the cabin, including occupants, travels down a sophisticated rail system, docks and autonomously heads for the desired destination (Fig. 1).

LiMo 2040 has the potential to revolutionize urban mobility! The special features can be summarized as follows:

- Comfortable passenger transport (especially for people with limited mobility).
- Cabin extends and enriches living space (miniature conservatory).
- Elevator in the building is omitted.
- Parking at the place of residence is no longer necessitated.
- Parking space requirement for chassis minimal (nesting like shopping carts).
- Use of the car sharing principle: On average, only 2 chassis are needed for 10 cabs.
- Compact cabin dimensions allow efficient transport by rail.

The technical realization of the cabin and chassis has already been demonstrated [1]. The focus of the following remarks will be on the connection of the cabin to the building.

2. Structural Design of the Elevator System

How does the cabin get from the chassis to the home? This question is being investigated in detail based on a concept study. Quite incidentally, research has shown

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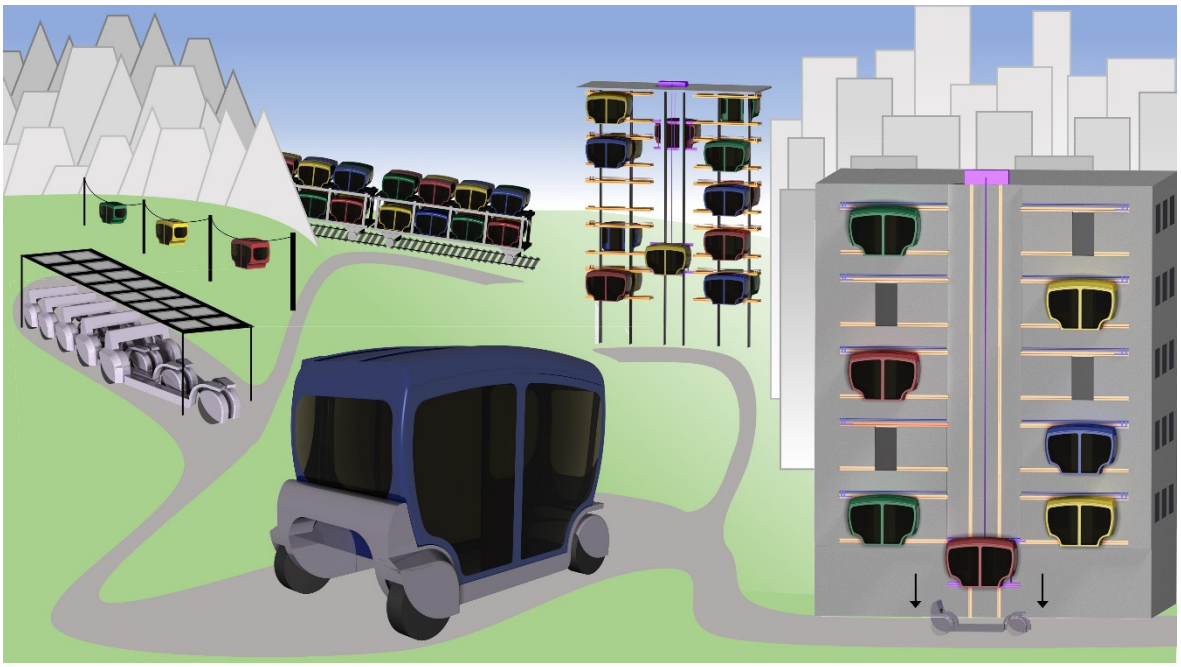

Fig. 1 Concept idea LiMo 2040.
Source: F. Schmid.

that the idea for LiMo 2040 is new, and that Esslingen University of Applied Sciences has a unique selling point here, which is why special attention is being paid to the elevator system.

2.1 Concept Finding

Decisive criteria in the development of a suitable elevator system are:

- Security
- Costs
- Design

From the different solution variants, the following 3 concepts are shortlisted:

1. Elevator placed in front of the facade; suspension via trolleys

2. "Roller coaster" suspension

3. Integrated elevator with flat carriage and lateral cabin support

2.1.1 Concept 1

Here, the elevator system is deliberately "placed in front" of the building and emphasized as an architectural feature. The tinted glass facade gives the front a futuristic appearance (Fig. 2). The cabin is suspended via trolleys in so-called C-rails. The disadvantage is the great effort and associated high costs. The question of how the booth can be connected to the housing in a stable and slip-proof manner is also still unresolved.

Concepts 2 and 3 dispense with an elevator housing for cost reasons. The cabin is transported along the building wall via a rail system. The cabin bearings must absorb the forces shown in Fig. 3.

A problem in the suspension of the cabin is the upper fixed bearing, which must absorb not only the horizontal force but also the particularly large vertical force.

The lower floating bearing is not critical, since only horizontal compressive forces are transmitted here.

2.1.2 Concept 2

The suspension of a roller coaster seems spectacular at first. Here we are talking about dynamic tracks in three-dimensional space. It fulfills requirements that are not actually imposed on a flat building wall (Fig. 4).

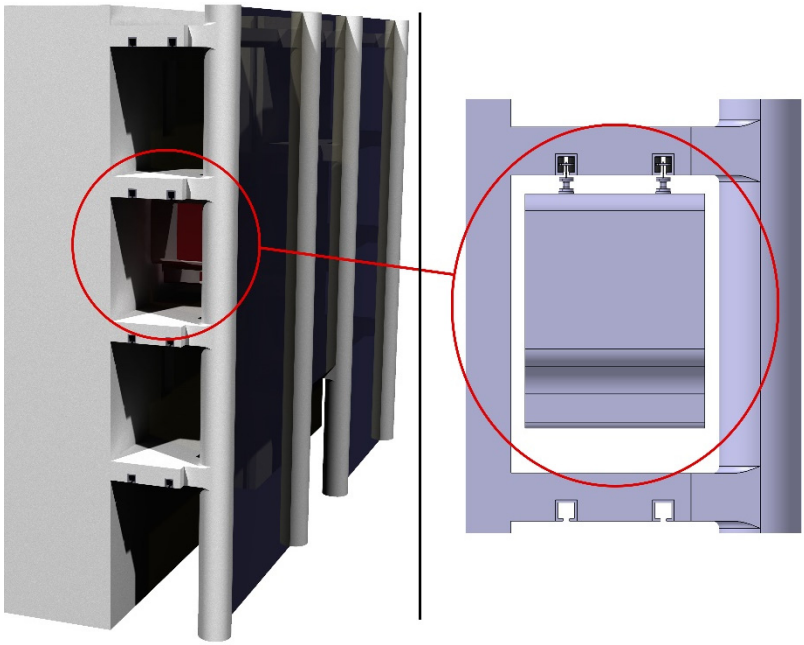

Fig. 2 Building concept with elevator facade – suspension via trolleys (concept 1).

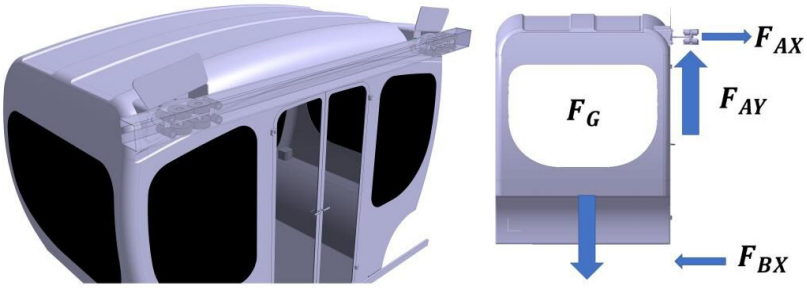

Fig. 3 Cabin with bearing and bearing forces (right).

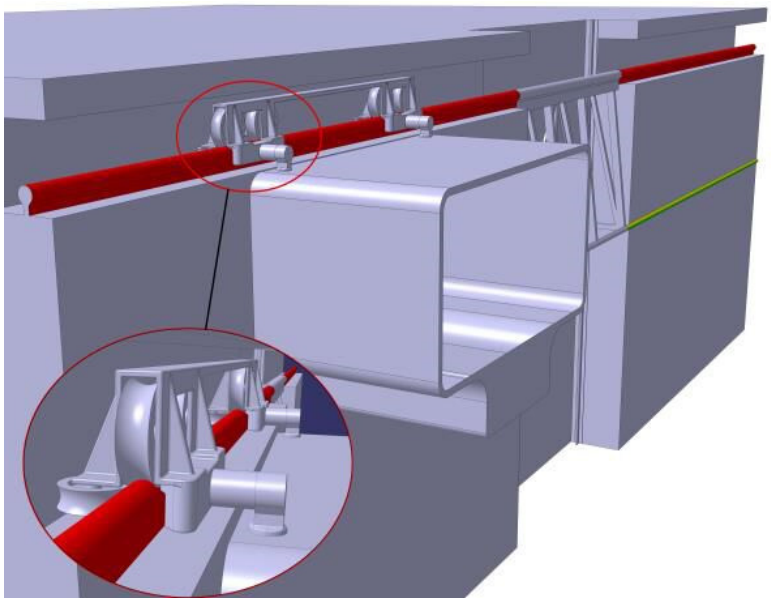

Fig. 4 Roller coaster support - adaptation to the building (concept 2).

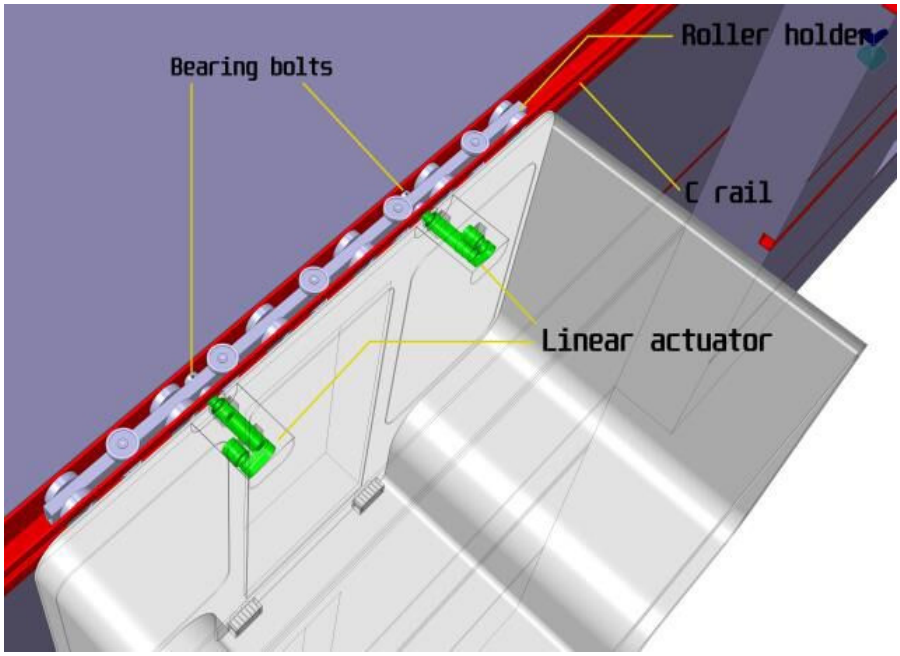

Fig. 5 Compact storage system (concept 3).

A decisive disadvantage of concept 2 is the relatively large distance of the guide tube (red) from the building, since the horizontal bearing rollers must fit in between. In terms of design, this variant is rather eye-catching.

2.1.3 Concept 3

Concept 3 appears comparatively inconspicuous. From the outside, only the slots of the C-rails are visible, like vehicles with sliding doors. The flat elevator cabin sits flush with the building wall on the outside in a flat building slot. To support the cabin, simple roller bearings extendable from the cabin roof were initially planned (as shown in Fig. 2, left). However, because of the high surface pressure, wide rollers with large diameters are required. To keep the rollers small, the large force at the fixed bearing is distributed over many rollers mounted in an approx. 1.5 m long roller holder (Fig. 5). The connection to the booth is made via a bearing bolt mounted in the booth, which is extended via an electrically driven spindle (linear actuator) and connected to the roller holder in the C-rail.

The elevator cabin essentially consists of 2 short cross rails (C-profiles) which connect the cabin to the roller holder via the locating pins. Via two long vertical rails in the building slot, the cabin is conveyed to the desired floor by means of a conventional traction sheave elevator. As soon as the transverse rail of the elevator carriage is aligned with the transverse rail on the building, the whole installment can be moved horizontally by a longitudinally installed geared motor, which drives a vertical pair of rollers. The roller holder and gear motor (not shown) are located inside the C-rail, which is shown cut away for a better overview (Fig. 5).

When the cabin is positioned exactly in front of the apartment, it is pulled to the building with the help of the linear actuators for a firm and sure-footed connection.

FEM calculations have shown that a C-rail of size 120x80mm (WxH) and wall thickness 6 mm withstands the load with a large safety margin, as does a bearing bolt with outer diameter 30 mm and inner diameter 14 mm. The roller holder designed as a rectangular hollow section with a cross-section of 45x30mm (WxH) and a wall thickness of 8 mm is also uncritical according to the FEM analysis.

6. Conclusions

The concept idea is to be further elaborated in the

coming semesters with the aim of testing a prototype constellation at Esslingen University of Applied Sciences. The initiative for a market launch could ideally come from an urban planning or a housing company, since the building side plays a decisive role.

References

[1] Gabele, H., Ossendorf, T., and Schmid, F. 2023. “Martin Ziegler: HElmar-LiMo 2040, Sustainable Urban Living and Mobility Concept.” Stuttgart Symposium 2023, Springer Verlag: ISBN978-3-658-42235-6.