"SKYTRAK"

VERTICAL TRANSPORTATION FOR THE 21st CENTURY

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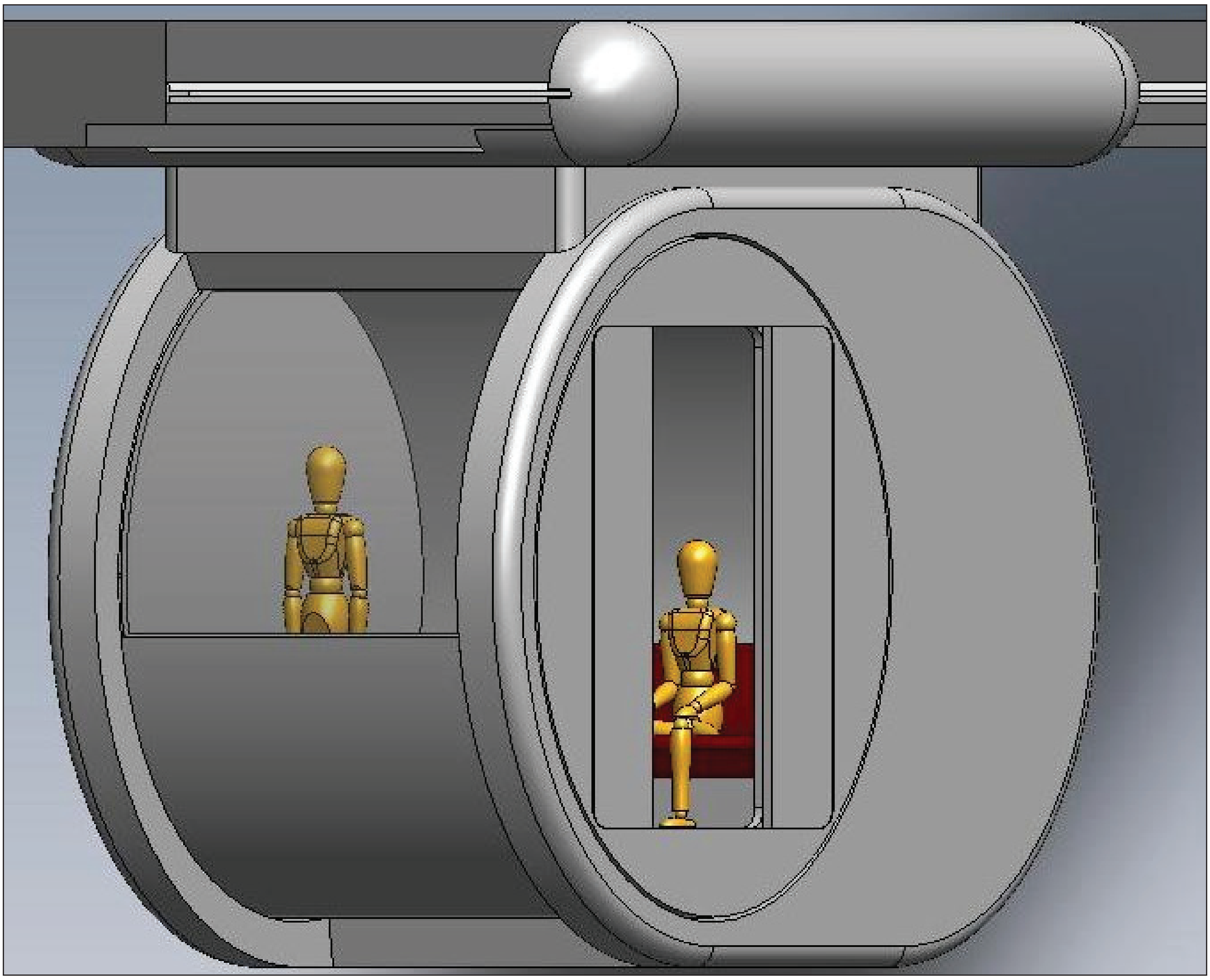
This article is a summary of highlights from a paper presented in late 2009 at the New Civil Engineer's Conference held in London called "Engineering Design for Tall Buildings" entitled "Vertical Transportation, Maximising Core Efficiency - New Concepts".

There has been much talk over the past thirty years or more about the dream of having more than two passenger cabins travelling in one shaft. Why? Because of the innate efficiency gains, especially for very tall buildings, that would follow such a quantum leap in passenger handling capacity for any given lift shaft. Such a solution would be especially applicable for high rise groups of shuttle lifts.

As most consultants and lift companies will attest to, it is the goal of building designers to continually improve building efficiency i.e. the net to gross built floor areas such as to increase the proportion of that more valuable part of the building which is the "rentable" or "saleable" element.

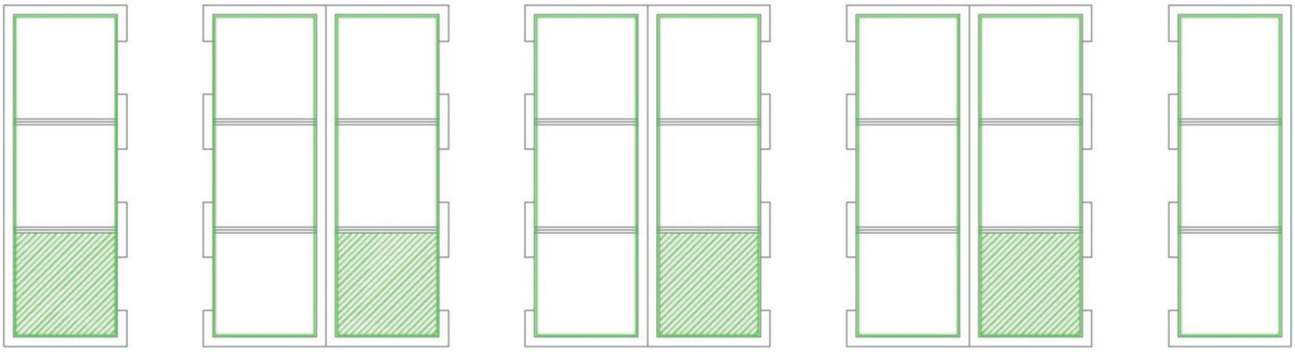


In recent years' consultants and designers' attention has been focussed upon such techniques as:

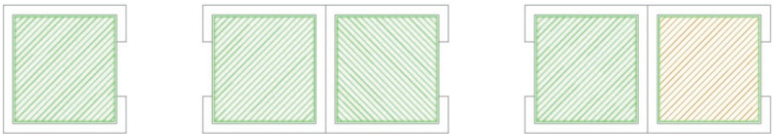
- Use of double deck lifts and 3-D "Double Deck Destination" Control
- Use of Shuttle & Local Goods Lift Services similar to Passenger Lifts
- Time Sharing of Lifts to achieve 24 hour utilisation (multi-use towers)
- 'Twin Lift' solutions for passenger and goods lift service
- Combining Different Uses of Decks/ Entrances at Different Times

All of these are being pursued for one simple expedient and that is minimisation of the space taken out of the building by the lifts.

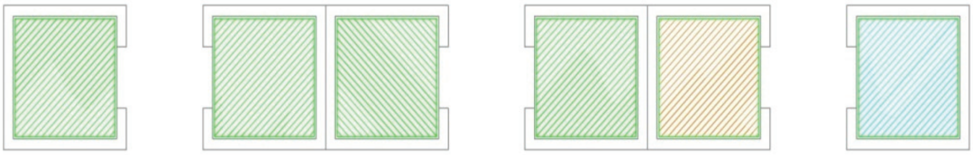
But let's look briefly at the approximate scale of the core space savings that might be achieved by such new technology. Supposing a conventional 40 floor high rise office building needed four groups of six single deck passenger lifts @ 1600kg at speeds between 2.5 and 6.0m/s in order to obtain 15% 5-minute handling capacity with an average interval of 30s. At the main lobby we would have lift shafts and lobbies occupying approximately 400 sq m perhaps looking something like this in plan:



Supposing one passenger lift @ 1600kg at 6.0m/s appeared in one shaft travelling "up" every 30s. At the main lobby we would have a revised footprint of lift shafts and lobbies that looked like this:



The fifth shaft, shown in orange colour, is for "down" travelling passengers in "up peak". Finally, because of the very high handling capacity of each shaft we might add in an extra shaft, shown in blue, for redundancy to ensure overall system performance at all times, producing a footprint something like this.



Instead of the whole core taking up the equivalent of 36 shafts at the ground floor the new solution takes up the equivalent of 9 shafts or 100 sq m i.e. 25% of the conventional solution. Building wide the conventional solution might take out the equivalent of 10,000 sq m whereas the new solution might take out 4,000 sq m. That's nominally 60% more efficient than a conventional lift solution. A significant part of the additional capital value released by the new solution, due to the additional rentable area gained, can be applied to the new more sophisticated passenger transportation system.

Whereas the conventional solution needed 24 lifts the new solution needs only six therefore immediately the "lift" within each shaft can cost four times what the conventional lifts did without adding any capital cost. Perhaps the new vertical transportation system could potentially cost ten times more per shaft than each conventional lift as one applies some of the capital value gained from the efficiency savings to the new vertical transportation system but the overall solution would still represent additional value to the final development.

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The taller and larger the building the more pronounced the efficiency savings and the more scope there is to expend monies on a more advanced vertical transportation system. Well, in simplistic terms, that's the driver for wanting to be able to deliver more than two cabins travelling in one shaft.

Pretty well everyone realises however, that once one moves beyond having two cabins in one shaft you are almost certainly talking about the application of linear motors along the entire length of travel of the cabs that would, in theory, be moving up or down each shaft.

Of course, once one dispenses with basic components such as ropes and counterweights it becomes, as they say, "a whole new ball game". Just stop for a moment to imagine some of the implications of that decision alone:

1. Increase in local shaft structural loads of approximately 6-7 times
2. Increase in drive motor power by approximately 6-7 times
3. Increase in energy losses of approximately 6-7 times
4. Transmission of power and data to/from the lift car without trailing cables
5. Increase in the braking force required from the fail-safe brake
6. Manual release of the fail-safe brake for passenger release not feasible
7. Impact of emergency stopping in either direction
8. Control of headway between cabins and ability to take cabins offline

To counter that list most of the key components necessary have been identified and are available at commercially viable costs. Examples are:

1. Linear Motors – Retarders - Generators
2. Rare Earth Permanent Magnets, Super Capacitors
3. Power Inverters and Fast Response High Efficiency Sensor-less Drives
4. Control Software and Data-logging
5. Security and Monitoring Systems
6. Transportation Control Software (SIL4)
7. Wireless Signalling and Communications
8. Lightweight materials for Cabin Structure

Research has continued apace over recent years and readers interested in some of the more technical aspects such as the progress of the application of "long stator linear motors to a multi mobile system" may like to look at papers that have been presented in recent years from the EPFL (Ecole Polytechnique Federale de Lausanne) in Switzerland, which indicates direct links with Schindler and their R&D work in this area. Some of the key challenges where solutions appear unclear however at the moment include:

- Free fall under gravity when the brake is released
- Trapping of passengers in cabins on the track during emergency stopping
- Power failure in the "up" direction at high speed etc.

In reviewing these papers it appears that the speed of some of the systems being considered might be low enough such that an emergency stop in the up direction may not cause too much passenger distress however at higher speed, and for more practical applications, the technical challenge still exists. A recent invention by Mike Godwin (patent pending) described here may represent the solution to that last item.

A recent year long feasibility study working with specialist companies from China to Belgium and from Spain to Switzerland has arrived at the design of a prototype cabin able to move not only horizontally and vertically but through a curved trajectory as well. The reason for targeting the curved trajectory solution was the realisation that such a vertical transportation system would offer architects and building designers not only greater efficiency but a new "degree of freedom" for the shapes and designs of buildings of the future. For more information and a short video see http://www.lerchbates.eu/index.php/uncategorized/skytrak/.

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The following diagrams illustrate the concept of how one or more cabins travel on a track and how some of the safety solutions would operate.

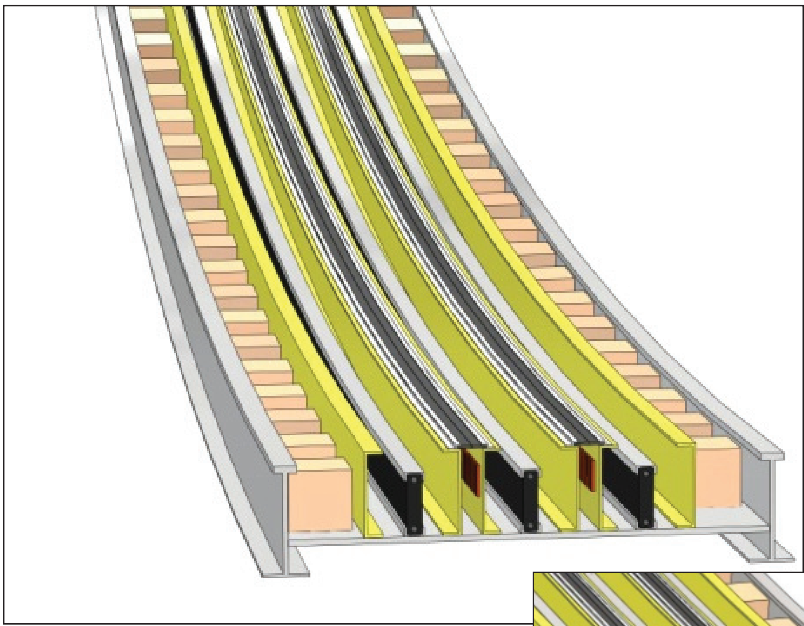

Figure 2 shows the main drive and track structure comprising three double sided main motor sections (black), twin magnet tracks for safety retarding under gravity, on-board power generation and deceleration control during emergency "up" stopping. Track side power switching devices are also shown.

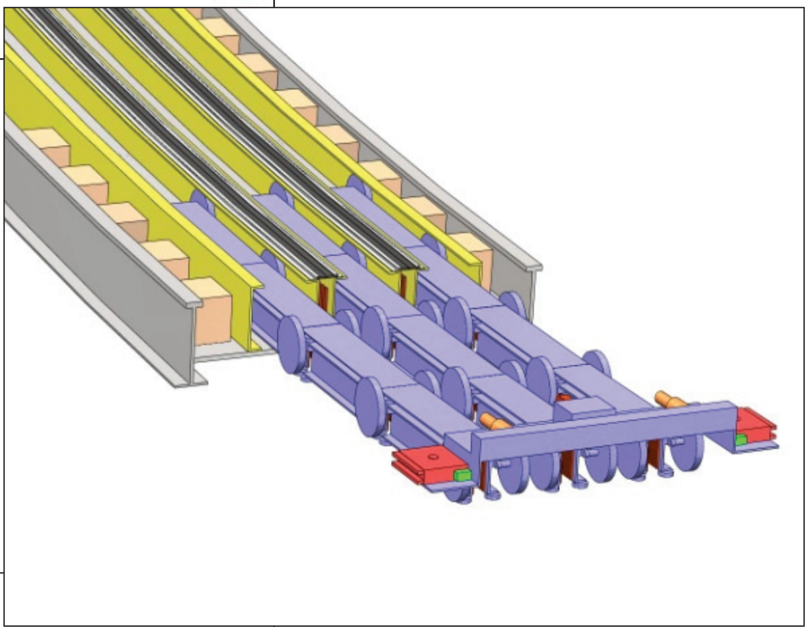

Figure 3 shows the main drive moving magnet assembly (blue) with articulated sections, guide wheels and brakes (red).

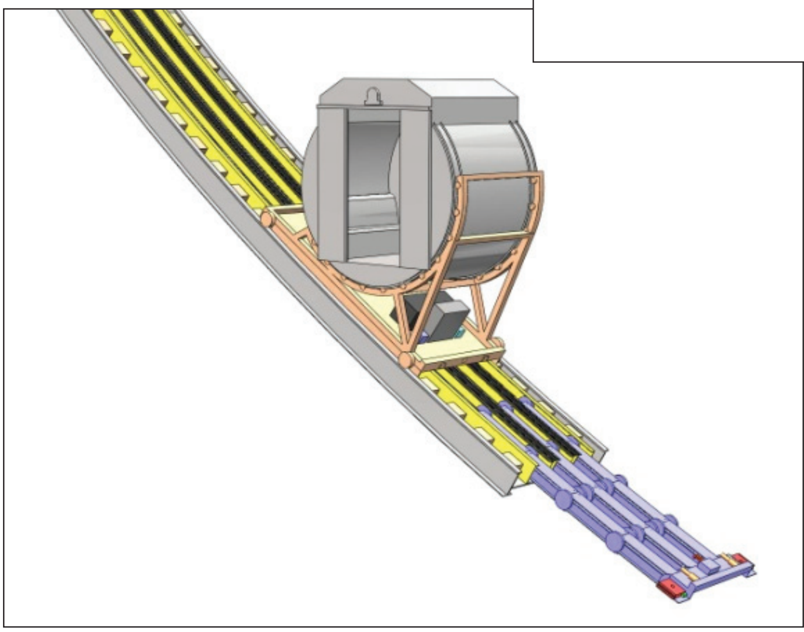

Figure 4 shows the passenger carrying assembly as a lightweight structure of approximately 3m diameter which can detach from the main drive assembly and can rotate in the form of a drum (grey). The whole cabin has a low centre of gravity. The retarders, which engage the twin magnet tracks under the main cabin assembly, negate passenger entrapment by returning the car at low speed to the nearest floor under gravity. An over-speed governor is mounted on board together with wireless data, batteries and a super capacitor pack.

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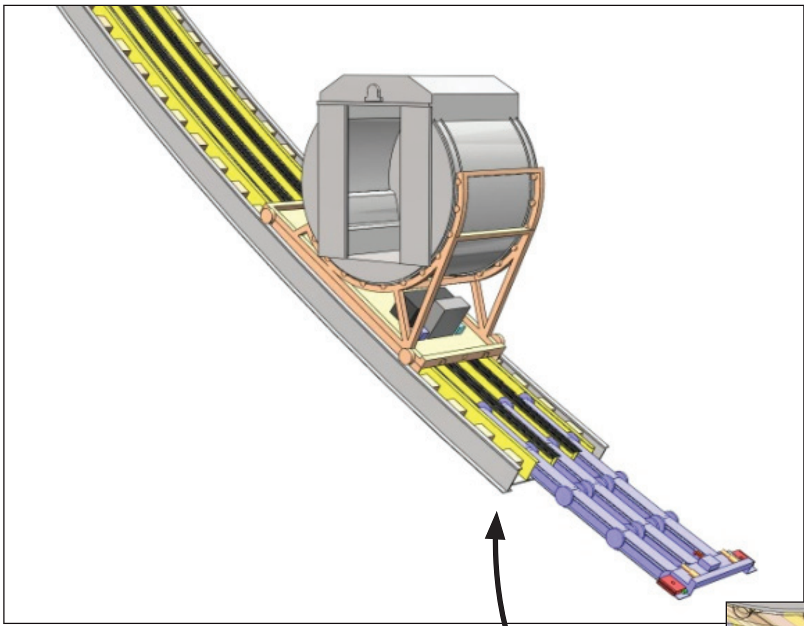

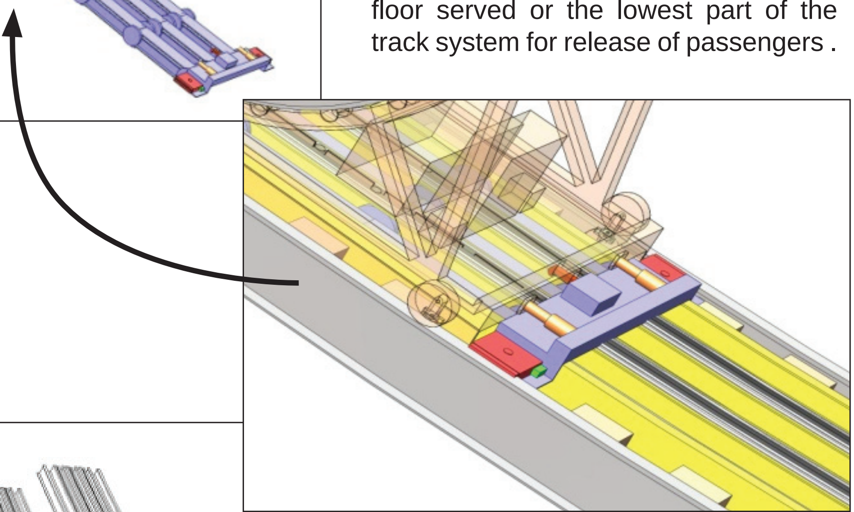

Figure 5 when stopping at high speed in the "up" direction the main drive assembly instantly stops on its brakes and an inertia latch permits the cabin assembly to become detached from the main drive assembly and able to continue its journey in the "up" direction providing controlled deceleration with the aid of the on board stored energy for at least 3s using power from the super capacitors. The cabin then rolls back, at controlled speed, using the retarders to rejoin the main drive assembly and thence to continue its safe descent downwards at low speed to the nearest floor served or the lowest part of the track system for release of passengers .

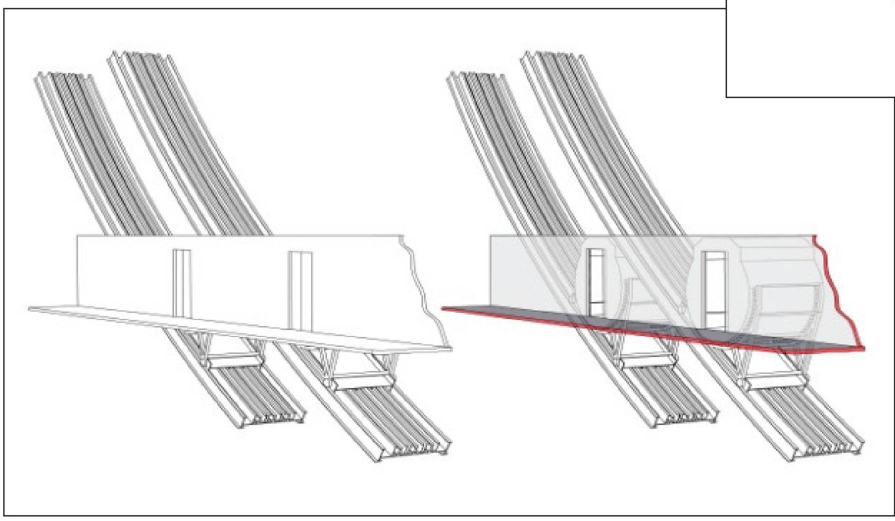

Figure 6 shows how existing standard fire-rated lift landing arrangements can be used for passengers entering and alighting from the cabins.

As a result of this recent feasibility study and accompanying inventions there is now a body of work available, which was begun by Mike Godwin in 1976, to realise this important development in vertical transportation. Historically the name "Skytrak" was coined in 1986 at the inauguration of the IAEE, within a paper presented by Mike Godwin, describing the opportunities and challenges of applying linear motors to vertical transportation. So, to the question most regularly asked by the child in the back seat, "Are we there yet!?" the authors believe, in a nutshell, yes we are!

It would now be appropriate to construct a prototype to ensure passenger ride quality can be achieved and for the necessary safety type testing and certification to be obtained.

Therefore let us ask architects and building designers to dream about a new generation of 21st century buildings wherein these new possibilities for vertical transportation will dominate their inherent design and use.......

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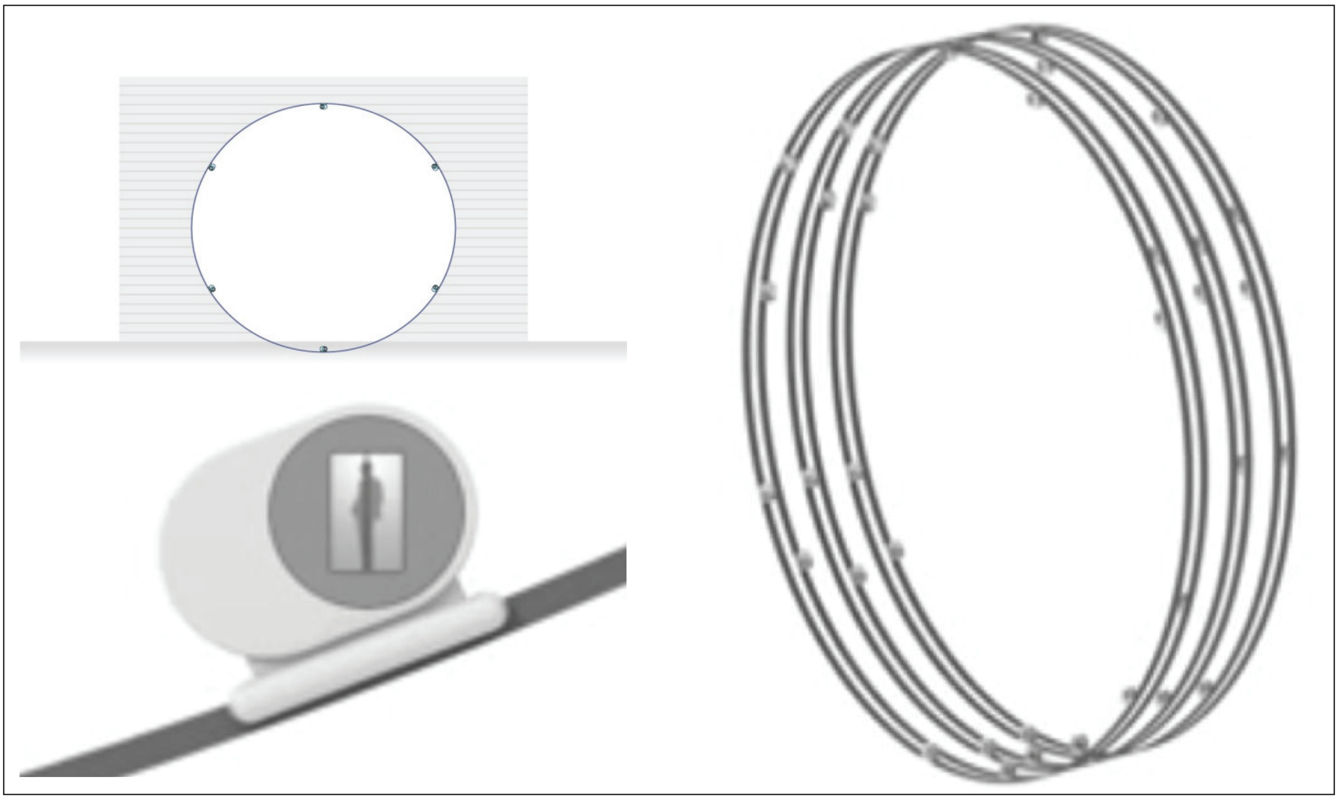

Figure 7 New shapes of buildings are now possible using the "Skytrak" vertical transportation solution operating on 360 degree tracks with multiple cabins as shown here.❑