



**A new approach to the Urban Transportation by cable,
a sort of Copernican revolution**

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"Cities should respect nature, consider the urban ecological environment as an asset, integrate environmental issues into urban planning and administration, and accelerate the transition to sustainable development. They should promote the use of renewable energy sources and build low-carbon eco-cities. They should strongly advocate for conservation of resources and promote environment-friendly manufacturing. Cities and their citizens should join together to create sustainable lifestyles and an ecological civilization in which people and environment co-exist in harmony.

Shanghai Declaration on Better Cities, Better Life "

Pollution is the great problem of our cities: let's see what the old newspapers used to tell us (from an Eric Morris' s research¹):

"In 1894, the *Times of London* estimated that by 1950 every street in the city would be buried nine feet deep in horse manure. One New York prognosticator of the 1890s concluded that by 1930 the horse droppings would rise to Manhattan's third-story windows....even when it had been removed from the streets, the manure piled up faster than it could be disposed of...early in the century farmers were happy to pay good money for the manure, by the end of the 1800s stable owners had to pay to have it carted off.



As a result of this glut...**vacant lots in cities across America became piled high with manure; in New York these sometimes rose to forty and even sixty feet.** [bold added]"

Eric Morris goes on: "**...the private automobile was widely hailed as an environmental savior.** In the span of two decades, technology eradicated a major urban planning nightmare that had strained governments to the breaking point, vexed the media, tormented the citizenry, and brought society to the brink of despair. [bold added]"

"When the solution to a given problem doesn't lay right before our eyes, it is easy to assume that no solution exists. But history has shown again and again that such an assumptions are wrong.

This is not to say the world is perfect. Nor that all progress is always good...But humankind has a great capacity for finding technological solutions to seemingly intractable problems, and this will likely be the case for global warming. It isn't that the problem isn't potentially large. It's just that human ingenuity – when given proper incentives – is bound to be larger. Even more encouraging, **technological fixes are often far simpler, and therefore cheaper, than the doomsayers could have imagined.** [bold added, p. 11]"²

Now we have the endothermic motor pollution in place of the manure, but the problem is substantially the same and, once again, our technology has to find a solution.

Urban transportation is a big business and in the future it will become even bigger.

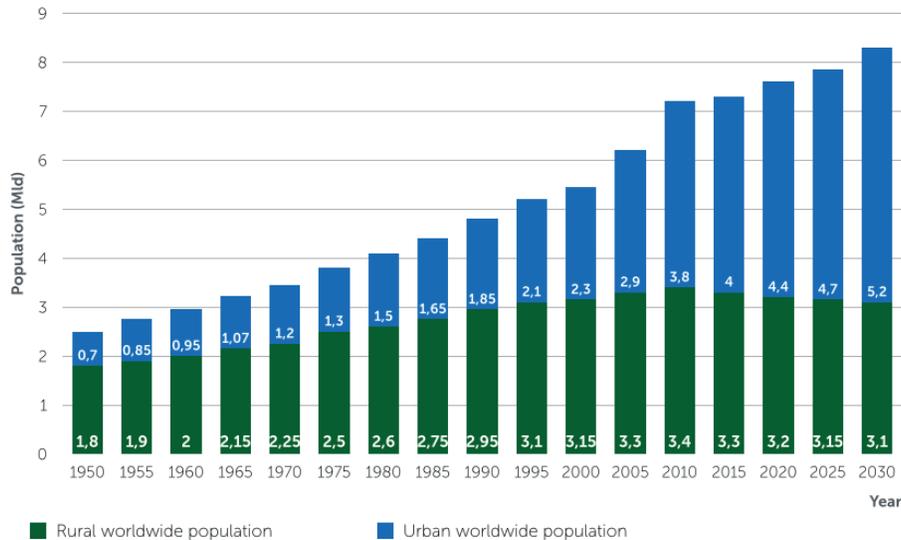
¹ Quoted from the internet site "nofrackingconsensus.com", quoting Eric Morris, an Assistant Professor of City and Regional Planning at Clemson University.

² This opinion is by Dona Laframboise, a Canadian journalist specialized in environmental issues

1) The size of the market

There are many forecast about the size of this market and here I quote from a **Dimensione Ingegnerie** (D.I. - Turin, Italy)³ study:

"With the economic evolution and the shift from the agricultural to the industrial society, the cities have



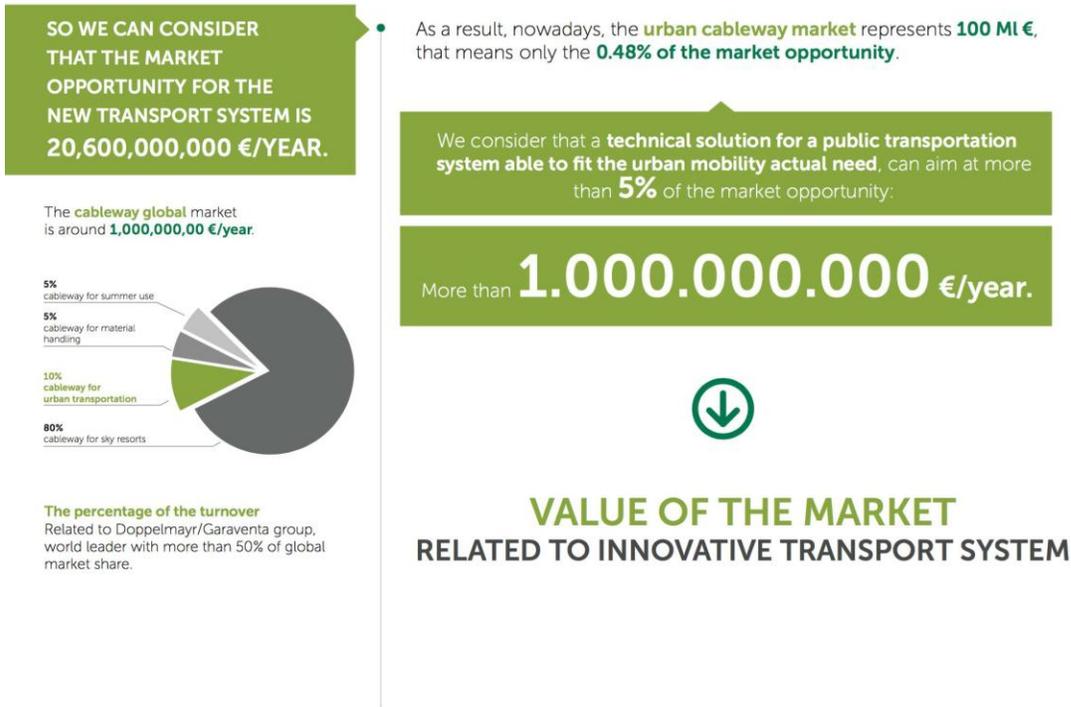
experienced a steadily growth.

On the 01/01/2015 the worldwide population that is living in large urban areas (with more than 500,00 inhabitants) is 2,059,386,000."

The figure above quotes D.I. report, that assumes that in the next 20 years the communities with more than 500,000 inhabitants will be 4,199 and, if each of them will built a new urban transportation system, the market size is 206 systems per year. That figure is, in my opinion, a bit conservative, since also many smaller urban areas will need urban transportation systems, and it is logic to forecast than the most of them will be light systems, for instance tram, trolley bus, self drive electric bus, people movers, inclined lifts and gondola lifts. D.I.'s report assumes as average cost of a light urban transportation system 100,000,000 Euros, and evaluates the yearly market in 20,6000,000,000 Euros per year; this second assumption could be a bit optimistic, since many systems will have smaller dimensions and cost.

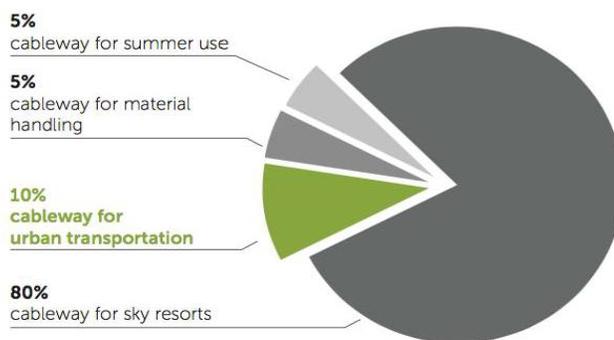
The today modal split is really unfavorable to the cableways, since their share of the market is the 0.48%, only, but, in D.I. opinion, it could rise up to the 5%; the following figure is quoted from the cited report:

³ <http://www.dimensioneing.it/en/>



Note that the source of the split of the cableway market is related to the Doppelmayr-Garaventa group, it is not from a research extended to the whole market, but it is anyway an useful indication.

The **cableway global** market is around **1,000,000,00 €/year.**



In many cases the use of the cableway technology is conditioned by the morphology of the area, that makes the cableways the best solution.

The development of China and India, where the urban transportation by cable is not developed, will be a very important factor of the future market. Future trends in the use of cable cars also were indicated

by Wu et al. (2013), who noted that cable cars in China play an important role in diverse urban transport networks⁴.

Currently , rail transit systems have a limited share of 10.7% of China's urban transportation passenger volumes. However, many rail transit systems are under construction or in the planning stages in cities throughout China, and this share is set to grow.

This industry revenue is expected to amount to \$8.6 billion in 2016, up 10.7% from 2015, with average annual growth of 15.6% over the past five years.

The Subway, Light Rail and Cable Car Transport industry is still restricted to a few large cities in China, mainly the four metropolitan cities of Shanghai, Beijing, Guangzhou and Shenzhen. Due to the state-owned and public-interest nature of the industry, rail transit systems are generally monopolized by one or two operational firms formed by the government in each city.⁵

Anyway, different analysis can give different results, but, in any case, the market size is huge: if the urban transportation cableways could actually conquer the 5% of the global urban transportation market, its share could even surpass the sky resort related one; in any case, the market could soar, if the D.I. forecast will show true, up to 20 systems and to 2,000,000,000 Euros per year.

Looking at the data from another point of view, today there are about 1000 towns with more than 500,000 inhabitants in the world; looking at the Countries with cities with more than 100,000 inhabitants, we see at the top of the list 5 Countries:

1. **India** – 328
2. **Brazil** – 300
3. **USA** – 295
4. **Japan** – 263
5. **China** – 209



Chongqing cableway in China, retired after 20 yrs of operation, should be now running again

In total these cities house around 2.1 billion people or around 28% of the world's population; the cities with more than 100,000 inhabitants are NOW about 4037 in the world.

These and even smaller cities need and usually have some kind of public transportation system, mainly based on busses and street cars.

USA and Japan have an high *pro-capite* income and a large private cars diffusion; because of that, both of them will support environmental friendly transportation systems; China, Brazil and India are heavily investing in transportation system, widely based on electric busses and, where there is space enough, studying self driven busses running on reserved lane, but they could become a good market for cableway solutions, if offered a system fitting their needs.

⁴ Increasing the capacity of cable cars for use in public transportation, Tezak, Sever, Lep- University of Maribor, 2016

⁵ Subway, Light Rail & Cable Car Transport in China: Market Research Report - Copyright © 1999-2017 IBISWorld

A **Jaspal Singh's**⁶ study about India reveals that :

"The cities of this diverse country and its urban population play an important role in the growth of the country. As per the 2011 census, 31.2% of India's population (377 million) is living in urban areas. As the UN estimates, this numbers will grow to 40% (590 million) by 2030 and 58% (875 million) by 2050. While only 30% of the total population live in urban areas, approximately 63% of India's Gross Domestic Product (GDP) is contributed by those urban areas....In a move to recognize and act upon urban mobility issues, in 2006 the federal government of India introduced the National Urban Transport Policy (NUTP), setting the policy framework for providing sustainable mobility for the future .

In 2015 the government unveiled its new plan to upgrade 100 cities into 'smart cities' and to 'renew' 500 cities. According to estimates from ICRA Limited (2016), 100 of the largest Indian cities require approximately \$15.4 billion to procure 150,000 new buses and upgrade ancillary transport infrastructure. It will be difficult for state governments or local bodies to invest such a large sum without further federal government support."

Below we will check the soaring number of electric buses in China,

Anyway, you agree or not with the D.I. analysis, the market is big and it is growing and the cableways share could become larger.

This is nothing new, I remember that many years ago, during the last Munich Trade Show , speaking with the late Kurt Leitner, the urban transportations and material transportation were seen as possible future developments, but that involved investments in engineering and technology.

Because of that, it is important to find out why the cableways actually have a so small share of the market and how they could reach the 5% share of the light urban transportation market.

I examined many reports and articles written by transportation specialists, by economist and institutions , for instance the World Bank, Global Environment Facility, The Future of Transportation World Conference and I found out that the word "cableways" is practically missing!

That means that cableways, as designed today, can solve just marginal transportation problems and that our technology is not well known, but by a small number of specialists; many independent studies agree.

Quoting "Aerial cableways as urban transport systems" by **Certu- STRMTG-CETE** (English version):

"Aerial cable transport systems are particularly well suited to overcoming obstacles and other divisive features in the urban landscape, such as railway lines, water courses, large depressions, changes in level, etc. They help avoid the need to build highly expensive infrastructure.

Unlike other forms of transport, they are not limited by maximum acceptable inclines and can run in a straight line even if there is a change in level.

Cable transport systems can achieve the same levels of capacity and commercial speed as tramways or BHLS (Bus with a high level of service). But cable transport systems are not sufficient to form the backbone of an urban transport network in a large conurbation because of the length of the lines (which is limited to few kilometers), the small number of stations on the same line and the significant difficulties associated with construction in a dense urban fabric.

Cable transport systems do, however, offer a solution to demands which traditional transports systems (buses, tramways, and metro systems) are unable to address satisfactorily because of technical or financial

⁶ Singh is an Urban Transport Expert and is currently working as Head of the UITP India Office

constraints. They can open up areas which were previously poorly served because of obstacles or changes in level.

They can thus complement, rather than compete with, other transport systems.

Nowadays, the development of cable transport systems is still slow. This is particularly because of public acceptability considerations, regulation, property impact and safety aspects. Land regulation is a central subject, to improve implementation timescales of cable transport systems.

Lessons must still be drawn from the experience and assessments of larger international urban implementation, to inform future discussion in France. Certu – STRMTG - CETE - December 2011 - 13/14"

The cableways used in Urban Transportation field are not just gondola lifts, but also detachable of jig-back systems running on rails⁷; in 2010 I wrote, for the 2011 Rio Oitaf meeting: "The cable APM already solves some urban transportation problems by means of the classic (or slightly modified) ski area technologies.

If the cableway gets out of its special niche, that is where there are obstacles or high vertical drops, its current success could be jeopardized by electric self propelled systems, based on automotive components and therefore reliable and cost effective.

Further cable powered APMs developments, with carriers able to run on track and on rope as well and to ride lines with corners, convexities and concavities, could generate really competitive systems, that could be able to solve transportation problems until now unresolved without passengers trans-shipment; a system able, like the San Francisco one, to connect itself to the haul rope in any point of the line without complicated stations and able to grant acceptable ropes life and speed, could open really new possibilities. The development of the cable powered APMs asks for a strong research commitment, but the interesting results could pay well for that."

I could quote many reports, but I would find the same concepts and similar answer to the previous question: why there are so few urban transportation system based on the cableway technology?

Again, the answer is the same:

Cableways are fit to solve some special problems, for instance natural or manmade obstacles along the line, for instance a river to cross, lines with a high gradient, but no existing system fits all of the urban transportation requirements.

The detachable system station machinery is expensive and complicated, and this makes not cost effective a long line with many stations, it is not easy to change line without trans-shipping the passengers, as a PRT system can do, because of the complexity of the switches and of the translation system inside a classic detachable cableway station; furthermore, the line can make corners only if there is a station and this limits the system layout⁸.

Another problem is the maintenance cost and time, the CEN standards notwithstanding, since the urban transportation has average loads and hours of operation by far different from the ski facilities: the detachable grips have to work for by far more cycles (think of a 1500 ft distance between the stations) and there are often too many rollers along the line (the bicable and the 3S are a bit better from this point of view) and the friction of the system is another relevant issue, especially for the monocable and double monocable (DMC) systems.

⁷ See, for instance the Venice shuttle or the Perugia detachable minimetrò.

⁸ It is possible to imagine a corner device opening and closing the grip keeping the full speed, but this involves high centrifugal acceleration on the passengers and some difficult control; the system could be simpler for the DMC layout and if the line inclination is low.

On the user point of view, there is the passenger's comfort to take in account and there are not many examples of really reliable and well working air conditioning systems or at least of ventilation devices able to grant acceptable conditions even in case of long stop because of a system failure.

Anyway none of them is an actual problem, because there are many solutions to each of the issues above, based on well known and experimented technologies.

2) Competition in the light systems field

As shown before, there is a very big market waiting for light urban transportation, but there are many competitors willing to seize a good share of it.

Each system feature will assure him a certain number of contracts, because it fits clearly better to the local transportation requests, but the technical evolution could modify the balance among the different systems.

In any case, electric cars and busses, trains, cableways and other environmental friendly system need electricity.

A new Elon Musk's proposal is based on a future where private but electric cars are still the prevailing urban transportation system.

2.1) from where electricity will come?

The electric driven vehicles are silent and non pollutant, at least on the spot, since the power shall be produced somewhere.

Human ingenuity is solving this problem in different ways, for instance by means of combined solar power



This project of an island on Dogger Bank could make the wind power of the future a lot cheaper and more effective.

It is thought the island – or possibly islands – could act as a hub for thousands of new wind turbines, which would eventually generate green electricity for more than 80 million people.

Under the proposal, the island would be connected by electricity cables to the UK, Norway, the Netherlands, Germany, Denmark and Belgium.

There are many projects of big power facilities in sunny desert areas, the superconductivity at ordinary temperature will make their energy transfer efficient ... perhaps the increased electricity request will be satisfied without nuclear power plants.

Four sure the diffusion of small power spots will help too; in the USA there are households that can produce their own power and load their plug in car too and in Germany there are examples of energetic self-sufficient communities.

2.2) Personal Rapid Transportation and Automated People Movers

For instance, a metro-shuttle running on a bridge does not need a driver per carrier, has an intrinsic distance control between two carriers and has no endothermic air polluting and noisy motor: today such a system offers many advantages on a small fleet of diesel minibus.

When, and it could be tomorrow, the minibuses will run without a driver and by means of an electric motor, with no need of a dedicated bridge, the balance could change.

If the demand will be interesting, special tires could dramatically decrease the friction⁹, since the kind of use does not request relevant transversal effects.

Because of the previous paragraphs considerations, the main competitors are: the APM, the self driven and non pollutant vehicles and the PRT (personal rapid transit).

There are **PRT** system with autonomous electric vehicles operating in different parts of the world, and, in November at Las Vegas, the **ATRA** conference **PODCAR CITY & ADVANCED TRANSIT CONFERENCE 2017** will make the point on the status of the art; the subtitle of the conference is: "*Smart Cities, Smart transportation, smart energy*".

The driverless **Masdar Personal Rapid Transit (PRT)** system at the carbon neutral Masdar City in Abu Dhabi, UAE, has functioned at over 99% efficiency since it began services.

The transport system hit 500,000 passengers and 1,000,000 million passengers in November 2012 and May 2014 at a daily average of 692 and 787 people respectively. Since May 2014, the system saw an increase of 175% in passenger traffic to reach 2,000,000 transported passengers in November 2016.

At **Heathrow Airport** there is an example of PRT connecting the Terminal 5; it cost 30 million pounds for a 3.8 km long line and has a maximum capacity of 656 p/h at 11 m/s maximum speed.

At **Suncheon**, Korea, a 4.6 km long system reaches an higher capacity, 1313 passengers per hour, and it realized by means of the Vectus technology, that uses linear motors in pace of lithium batteries.

In any case, the carriers are very comfortable, and, from the **ATRA** site, the main features are:

- The system is rail based and all vehicles are captive on the running rails
- Operational speeds in the range of 10-12m/sec.
- The system is controlled on an asynchronous basis
- Typical headway (time between vehicles) is 4-5 seconds
- All vehicles are controlled via a distributed control system
- Vehicles are powered by a current collection system installed along the guideway
- Each vehicle has CCTV and 2 way communications
- Heating/cooling/air conditioning (HVAC) of vehicles is automatically controlled
- Each vehicle incorporates real-time, passenger information displays

⁹ "Electric and Hybrid Buses for Urban Transport: Energy Efficiency Strategies" - Springer . - " NHTSA TIRE ROLLING RESISTANCE TEST DEVELOPMENT PROJECT – PHASE 2" , U.S. Department of Transportation - National Highway Traffic Safety Administration

- The guideway is a concrete pillar and beam construction with typical spans of 30m (50m over the main river)
- A CCTV system oversees the track for safety and security reasons
- Comprehensive maintenance facilities are located adjacent to Station 1

The capacity and the costs are not impressive and the only system that has features comparable to a updated transportation by cable system is the old (in operation from 1975, phase 2 in 1979) **Morgantown** one by **Boeing**, but it cost 21,7 million dollars per kilometer plus the land used by the system.

The capacity is 4800 p/h and the max. speed 13.3 m/s at a 15 s minimum carriers interval and has transported 75 million passengers with no serious accident.

These systems seems not competitive with an improved urban transportation aerial cableway, because of the high carrier cost and of the use of a dedicated track , often running on a bridge.

But the cost of an electric carrier is fast decreasing, since the automotive industry is producing electric cars and busses in a soaring quantity.

A recent report¹⁰ forecast a new oil crisis because by 2022 the manufacturing cost of a traditional and of an electric car will become the same.

That means a large amount of automotive components available at a reasonable price; furthermore many control system, as anti collision, lane control, obstacle recognition and so on are now normally mounted even on not expensive cars.

In future a PRT vehicle derived by a van, will become by far less expensive and its cost will be close to a classic DMC cableway detachable one.

But no panic, the bigger problem is always the track cost and, because of that, a potential development of the PRT could affect the Mini Metro sales, that anyway are not exciting, and of the cable liner, that is more a shuttle system than a true urban transportation one, with many stations and lines crossing.

The following figures show the rise of the electric cars and the continuous increase of electric busses in China; please, note that they are not autonomous vehicles, but classic man driven vehicles using an electric motor.

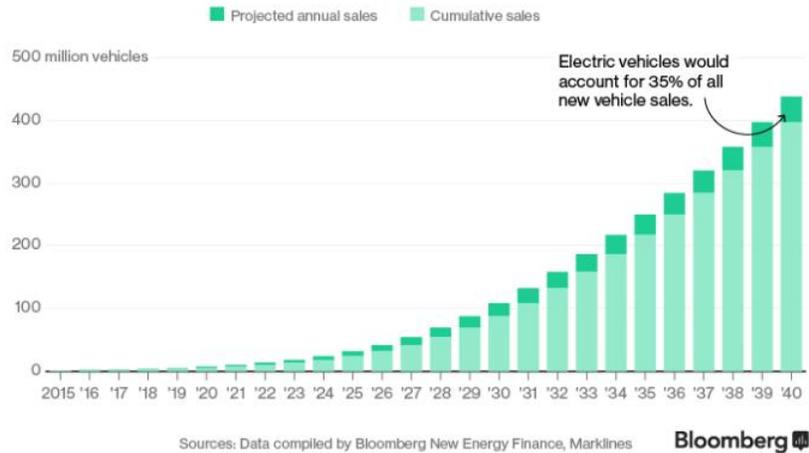
At the moment the most of the electric cars and busses use classic electricity plugs and store the energy onboard in lithium batteries, leaving the energy storage problem to the power supplier; there is the hydrogen fuel cells technology too, that is strongly supported by some automotive companies.



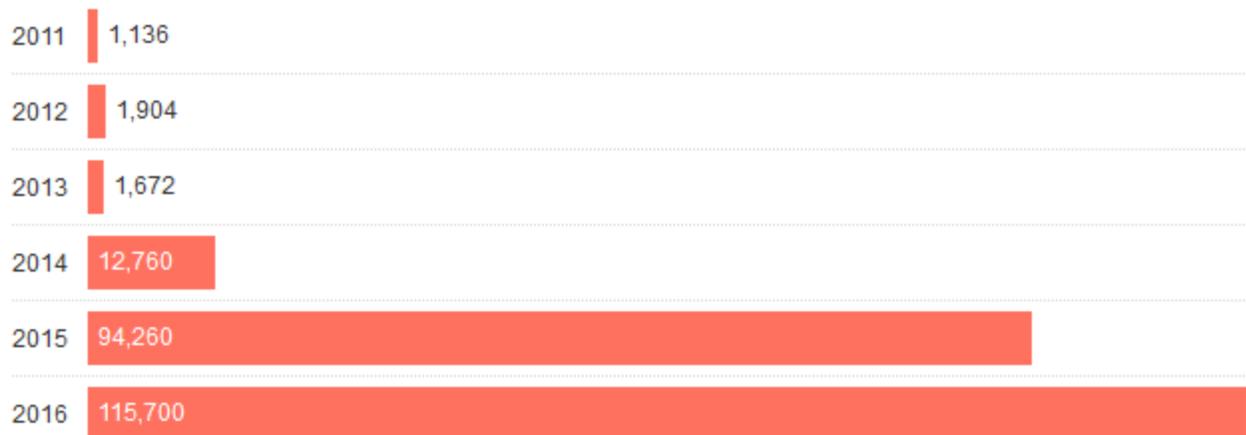
¹⁰ "Here's How Electric Cars Will Cause the Next Oil Crisis", Bloomberg Company, by Tom Randall Feb. 25, 2016

The Rise of Electric Cars

By 2022 electric vehicles will cost the same as their internal-combustion counterparts. That's the point of liftoff for sales.



Fully electric bus sales in China from 2011–2016. #Winning



The electric bus diffusion is now large, for instance in China there are 170,000 electric bus at work. An electric bus is a no pollution vehicle and should not spread grease or oil on the road, but in case of some components failure; the transmission devices evolution will allow a really high efficiency. The bus bad side is that each bus running needs a driver and, to cover the full timetable, it is necessary to hire more than a driver per bus: this is a heavy cost.

But, how long a bus will need a driver? The automatic drive for car and busses is arriving, some experimental shuttles are in operation and, the number and quality of the companies working at that, assures that reliable and cost effective system will be soon on the market.



For instance there is the “navette autonome” of Paris, supported by important industrial groups, or the new Volkswagen Cedric proposal.



Bozen/Bolzano 6 - 9 June 2017

An autonomous vehicle with electric motor, batteries or fuel cells as well, could overcome the track cost problem, since a dedicated lane on an existing road and some causeways or bridges, where indispensable, are all the requested infrastructure.

The only true problem is the interval between the carriers in low adherence conditions, that could limit the system capacity, if not running on a dedicated track.

On the energetic point of view, the transportation by cable could have some advantage, but also could not; for instance, even if a single full vehicle is running because of poor number of customers, the rope, all the rollers and all the acc.dec. rails are moving, in the PRT case just the single full vehicle will be running.

In any case, as told before, if the system runs on rails, the small friction increase because of the heavier self propelled carrier would be quite negligible if compared with the machinery above.

If we compare a reserved lane and a cableway operating speed, we find that a monocable or double cable detachable runs at $6 \div 7$ m/s, a 2S or 3S a little faster, but an autonomous electric van or bus could easily run at 22 m/s and more.

An automated minibus is flexible, can have PRT features and can reach different points of the city or switch from a line to another without problems; a classic gondola lift carrier has none of these features.

3) decision time

It is time to take a decision:

- a) *To go on using the classic ski area technology where it fits the local transportation problem and be content with the about 0,5% market share, hoping in a small increase in future*
- b) *Try to seize the 5% of the market, that could mean to double the today cableway production*

In any case, both solutions imply some design improvement .

3.1) first path

If the manufacturers will decide to follow the **first path**, the mission is not really hard, even if some work is needed.

For instance:

- *carriers have to completely stop at the stations*
- *passengers comfort should improve*
- *maintenance cost*
- *system friction*
- *components life*
- *rescue system*

Some of the previous target are, at least partially, met by the recent gondola lifts; others will be achieved for sure.

There is also a cultural factor, since a cableway is not always accepted as an element of the urban landscape.

3.2) The second path

If the manufacturers will follow the second path, since they judge the market interesting, there is by far more work to do.

We have to remember that our system layout is more than one hundred years old and many Codes are based on concepts that are not younger.

For instance, we go on debating the track brake and for sure the huge spring pack and complicated levers to get a tiny stroke and a variable braking force are a strong support to its abolition, but millions of passengers ride every hour vehicles, by far faster than any cableway, relying on pressure activated brakes and we could do the same, saving money, enhancing the safety and checking the system at each station stop, but this has never been made nor allowed.

Furthermore, we have automatic autonomous car running on our roads, but a robotic grip, just a "robotic" S.Francisco system, has never been made nor allowed.

We still use complex acceleration and deceleration beams, where a few dollar worth belt can put out of order a many million dollars gondola lift and stop an urban transportation system during the rush hours (problems ever happen when they are inopportune).

In cableways business, the state of the art is obviously strongly influenced by economic factors and no Manufacturer develops something new if, in his opinion, the market will not reward his effort; they hold that it is better, on the industrial point of view, to make small and safe steps improving the existing concepts; there are many examples in the cableways history.

Sometimes a manufacturer made a mistake and went out of business refusing a bit of innovation, but , in other cases, reasonable evolution without revolution meant money and too aggressive innovation meant to run out of business.

An example: had Kurt Leitner not joined the "*detachable manufacturer club*", probably the company had returned back to her previous agricultural machinery and piano frames manufacturing; the glorious F.lli Marchisio refused the detachable (in 1973 I spoke about that with Felice Marchisio, proposing a grip based on their fixed one concept) and their name is now in the cableways history only; think about the inexorable decline of another historical manufacturer, who refused to change its well established technology: the American Riblet.

Obviously there are cases where too much innovation put out of business a company, think of Yan or the cableways branch of Neyrpic after the Jandri accident.

To follow the second path means a bit of revolution and this is the reason why no cableway company followed it until now.

A competitive urban transportation cableway requests at least these additional features:

- *on board or very simplified acc-dec devices*

- to run on left and right corners, support and hold down towers
- to run on rails and cables as well
- to change line without too many complications

The result appears to be something very different from a classic ski-area gondola lift, perhaps a new transportation system, for instance a crossover between the cableways and the pod cars.

Just think of a detachable gondola lift with autonomous acceleration and deceleration devices controlled by means of a simplified carriers management system derived by the ULTRA PRT ... technologies available years ago.

Since our technology and concepts are very old, a suggestion to solve this first point comes from the past; quoting my report at 2011 OITAF meeting again : *...New York Brooklyn Bridge Railway, hauled by a rope along the line, but fitted with a small on board motor for the short station displacements (today we could resume this concept to cut out the acceleration-deceleration beams and the always complicated links between different rope loops),"* .

A very interesting system by D.I. was shown at a Politecnico di Torino meeting, "TRAM, PEOPLE MOVER E VEICOLI A GUIDA AUTONOMA" on the 23rd of September 2016; the system is substantially a DMC with motors onboard for acceleration, deceleration and taxing purposes.

There are obviously other systems able to give similar performances, some of them more fit for large carriers running on rails, other fit to classic bicable as monocable small carriers.

As always , speaking of innovative systems, nobody is willing to buy the first one, but everybody would better to buy the second one; anyway, the D.I.'s solution seems to be the closest to an actual realization.

4) Conclusions

The purpose of these notes is not to make a catalog of the innovative proposals and of their advantages and downsides, but it is clear that the "second path" is the way to take advantage of the rope undeniable positive features without the rigidity and the limits of the classic gondola lifts.

There is the Standards and Codes problem too, because it should be carefully studied how such a transportation system matches with the European, American and Chinese Standards, since many guidelines, still used by the Standards, are modern elaborations of very old basic concepts and heavily influenced by those old concepts.

Made clear who are the competitors and made some hypothesis on the possible market, we will see if a cableways manufacturer or a transportation company, since a cableway know how is not mandatory in this case, will proceed on this second path, that imply time and new investments, to seize a possibly rich share of the urban transportation market, or if the use of the existing cableway technology, adapted as well as possible to the urban transportation requests, will continue to be the more conservative but safer choice.