

Disrupting Innovation in railways:

contribution of design theory

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ikos



Collegio Ingegneri Ferroviari Italiani

Long term collaborations on risk analysis, technology forecasting, new product development



Giacomo Bersano

Technical and Innovation Director

- Politecnico di Torino, 30 years work experience
- PMP® for 15 years
- Expert of Design Theory, author of 30 articles and 1 book
- Lecturer at ENSAM Paristech, ICAM, EMA



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1. A FEW WORDS ON IKOS GROUP



SPECIALIZED IN RAILWAYS

We can intervene in all domains of this industry. Our vision: to accelerate performances and innovation of our clients and carrier for our consultants !

1000 ENGINEERS

Are involved on state-of-the-art projects around the world

10 COUNTRIES

We have 14 subsidiaries around the world : France, Spain, Belgium, Germany, Switzerland, UK, USA, Italy, Sweden and Canada.

15 YEARS OF EXPERIENCE

Founded in 2005 to bring technical expertise to major players in railways, IKOS management has more than 25 years of experience in this field.

The logo for IKOS, featuring a stylized human figure icon to the left of the word 'ikos' in a bold, lowercase sans-serif font. The background of the entire slide is a blue-tinted photograph of a modern railway station platform with tracks receding into the distance.

ikos

IKOS LAB

INNOVATION CENTRE

innovation is at the heart of our growth and IKOS LAB leads our activities on R&D, Business intelligence, Knowledge Management and more...

AN OFFER ON ENERGY

Based on its expertise on railways, IKOS developed a complementary offer on energy

They trust us...



BECAUSE INNOVATION AND PERFORMANCE OF M THE RAILWAY PROJECTS ARE OUR PRIORITY WE CREATED ...



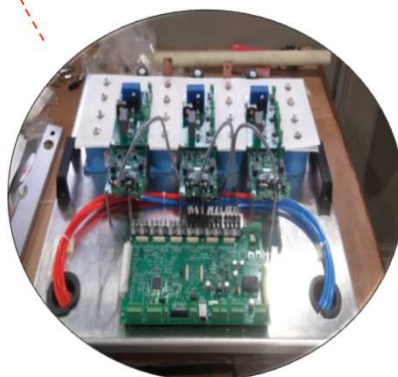
WORK PACKAGES

- Expertise, audit
- Complex projects
- Task forces



INNOVATION

- Technological watch
- Innovation and R&D projects
- Thesis and internships



TRAINING

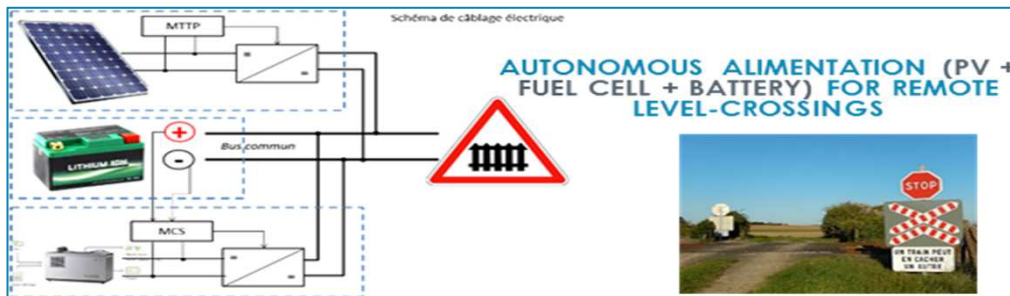
- IKOS Academy
- Partnerships with Universities
- Skills development



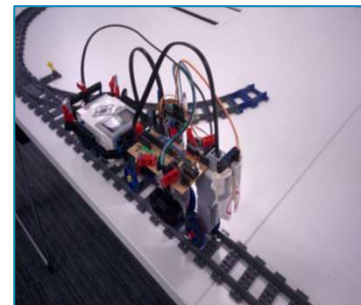
KNOWLEDGE MANAGEMENT

- Knowledge sharing
- Capitalization on experiences





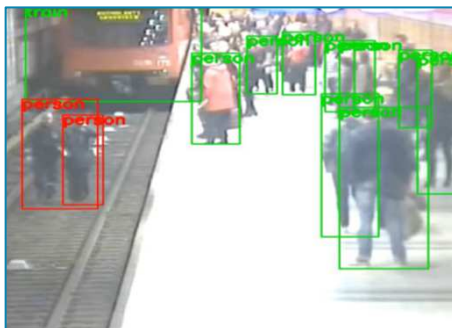
Innovation for level crossing



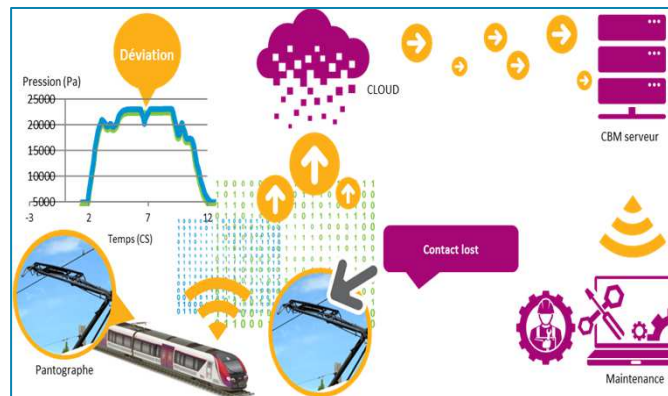
Comfort Measuring station



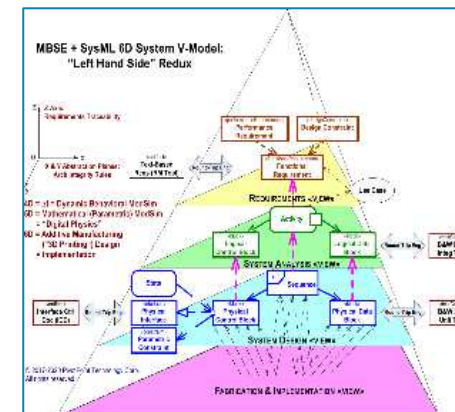
Positioning by camera vision



AI for platform safety



IKIM: IKOS predictive maintenance platform



Model based System Engineering

2. DEFINITIONS FOR INNOVATION



Defining common grounds

Creativity is a mental process involving the generation of new ideas or concepts, or new associations between existing ideas or concepts. *Source: Wikipedia*



An invention is an object, process, or technique which displays an element of novelty
Source: Wikipedia



Innovation is the renewal and enlargement of products range, services and associated markets; creation of new production methods, supply and distribution; introduction of management changes, work organization, training and environment of work force"
Source: EIS

Design science supports the practice of design engineering, including understanding the complexity of the products, the people who design them and those who use them, the process of designing and its organization." *Saeema Ahmed-Kristensen*

Philosophical foundation

The 21st century will be characterized by numerous challenges:

✓ In the technical field:

- Change of technologies & increasing of complexity

✓ At environmental level:

- Limit of natural resources and global warming
- Transition from an industrial society to a knowledge based one
- Instability of markets, new pressure groups

✓ At competition level:

- Increase of competition & globalization

✓ At organization level:

- Acceleration of change and diversity of human resources

Source: J.M. Higgins

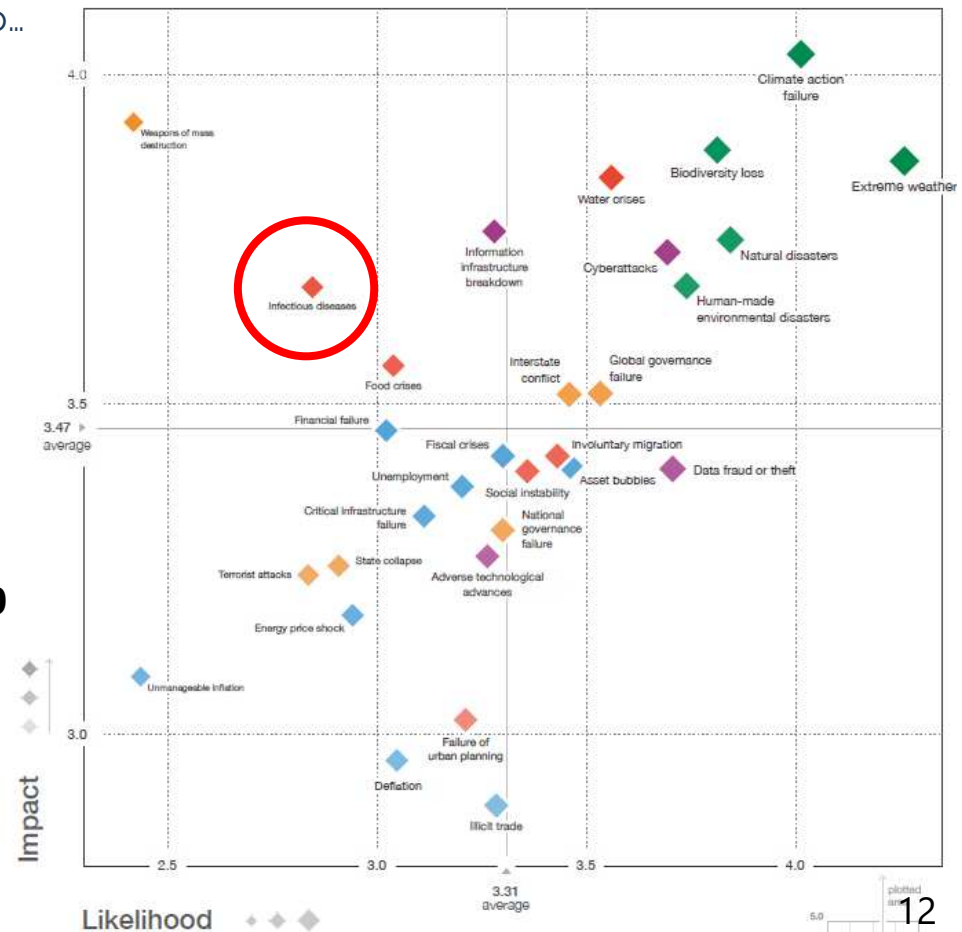
NB: infectious diseases identified long ago...

Greatest concern for the world

| | |
|--|-------|
| Prolonged recession of the global economy | 58.5% |
| High levels of structural unemployment (especially youth) | 43.8% |
| Another global outbreak of COVID-19 or different infectious disease | 40.1% |
| Weakening of fiscal positions in major economies | 39.2% |
| Failure of industries or sectors in certain countries to properly recover | 35.4% |
| Surge in bankruptcies (big firms and SMEs) and a wave of industry consolidation | 35.2% |
| Tighter restrictions on the cross-border movement of people and goods | 34.0% |
| Economic collapse of an emerging market or developing economy | 33.7% |
| Protracted disruption of global supply chains | 33.7% |
| Exploitation of COVID-19 crisis for geopolitical advantage | 29.5% |
| Weakened capacity or collapse of national social security systems | 27.7% |
| Humanitarian crises exacerbated by a reduction in foreign aid | 27.4% |
| Cyberattacks and data fraud due to a sustained shift in working patterns | 25.4% |
| Fresh surge in inequality and societal divisions | 25.1% |
| Sharp increase in inflation globally | 25.1% |
| Governmental retention of emergency powers and/or erosion of civil liberties | 24.9% |
| Healthcare becomes prohibitively expensive or ineffective | 23.9% |
| Additional unemployment from accelerated workforce automation | 18.7% |
| Nationalization of strategic industries in certain countries | 17.6% |
| Exacerbation of mental health issues | 17.0% |
| Anger with political leaders and distrust of government | 17.0% |
| Massive capital outflows and slowdown in Foreign Direct Investment | 16.4% |
| Higher risk of failing to invest enough in climate resilience and adaptation | 16.1% |
| Failure to support and invest in multilateral organisations for global crisis response | 15.0% |
| Sharp underfunding of retirement due to pension fund devaluation | 13.0% |
| Sharp erosion of global decarbonisation efforts | 11.2% |
| Failure of education and training systems to adapt to a protracted crisis | 9.2% |
| Breakdown of IT infrastructure and networks | 8.4% |
| Exacerbation of long-standing military conflicts | 7.2% |
| Abrupt adoption and regulation of technologies (e.g. e-voting, telemedicine, surveillance) | 6.3% |
| Spikes in anti-business sentiment | 3.2% |

Economic Societal Tech Geopolitical Environmental

Source:
WEF 2020



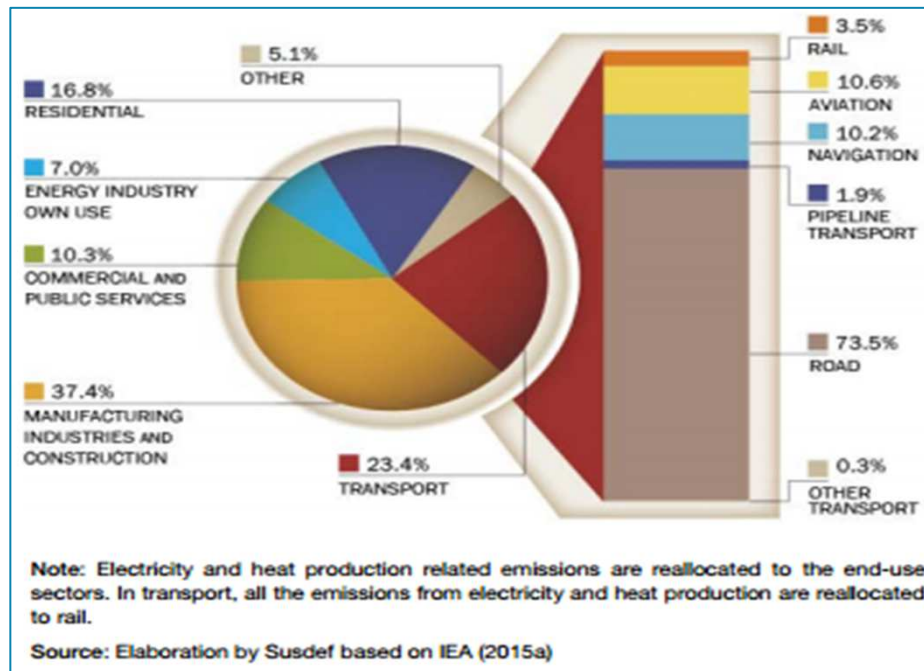
The role of railways innovation for the society

Correlation with Smart cities, decarbonation, consumption and production....



Source: IIASA, The World in 2050 initiative 13

Ex: Impact on WW CO2 emissions

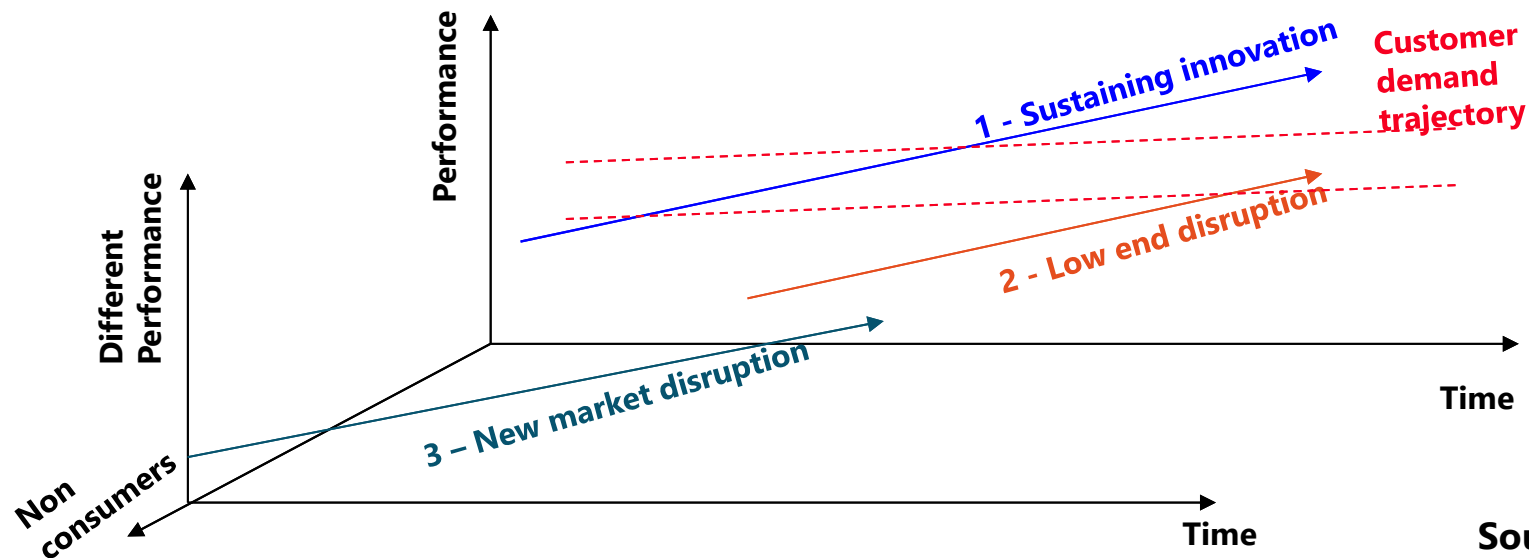


| | Passenger PKM | Freight TKM | Total TU |
|------------|---------------|-------------|----------|
| ROAD | 81.9% | 8.3% | 30.5% |
| AVIATION | 11.4% | 0.8% | 4.0% |
| NAVIGATION | 0.3% | 82.2% | 57.5% |
| RAIL | 6.4% | 8.7% | 8.0% |

Source: Elaboration by IEA based on IEA (2016b), UIC (2015a) and UNCTAD (2014)

A link between market position and type of innovation

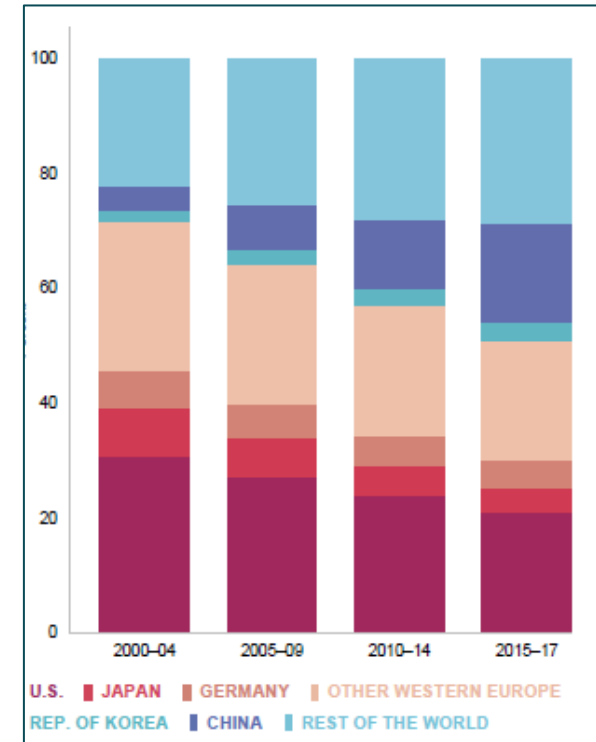
New organizations can use relatively simple, convenient, low cost innovations to create growth and triumph over powerful incumbents. Existing companies have a high probability of beating entrant attacking with sustaining innovations, but almost always loose to attackers armed of disruptive Innovation



Source: C. Christensen

Most efficient countries for innovation

South Korea since 2008 files more patents than EU



This is no accident

Sources: World Patent Report 2017 & 2019



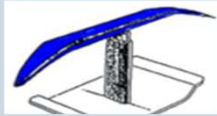






A Perpetual Crisis Machine (extracted from www.fortune.com)



TRIZ implementation in 2002 has generated 90 Million \$ saving, from 2003 more than \$180 million a year.



Ex: Shinkansen

| Problem | Model | Biological characteristics | Application | |
|---|---|--|---|--|
| The pantograph vibrated and made loud noise | <p>Howl</p>  | Tiny serrations on its primary feathers minimize the vortex generated by movement | <p>Before</p>  | <p>After</p>  |
| The supporting frame for the pantograph had a high degree of wind resistance resulting in aerodynamic noise | <p>Adelie Penguin</p>  | Shaped like a spindle which allows it to move effortlessly through water to catch fish. | <p>Before</p>  | <p>After</p>  |
| Loud bang when entering a tunnel (increase in pressure from the entering train) | <p>King Fisher</p>  | Glide through the air and precisely dive into water to snag fish. It is the most efficient animal on earth to transition from low pressure (air) to high pressure (water). | <p>Before</p>  | <p>After</p>  |

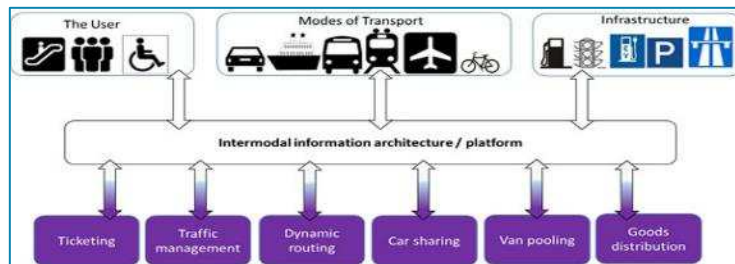
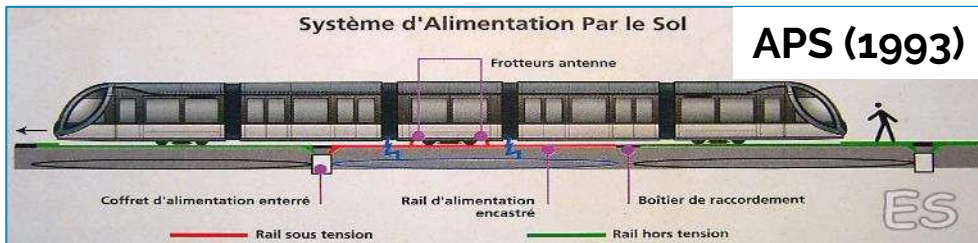
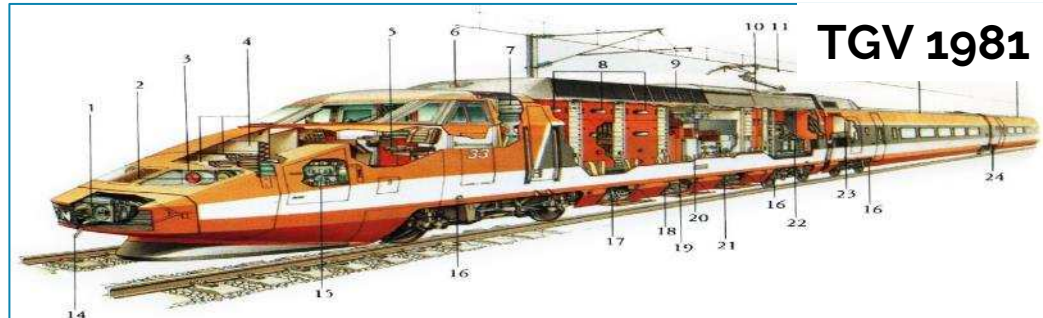
Consumption -15%; speed +10%; acoustic standards compliant

3. Application in railways



System level

Some case study



Apps for intermodality 2014

Some case study

↑ System level



Aerotraine (Bertin, 1973)

<https://www.youtube.com/watch?v=5VvsxaaFNAs>



PRT ARAMIS (Matra, 1970-87)

<https://fresques.ina.fr/mitterrand/fiche-media/Mitter00305/l-exposition-universelle-a-paris-pour-1989-annulee.html>



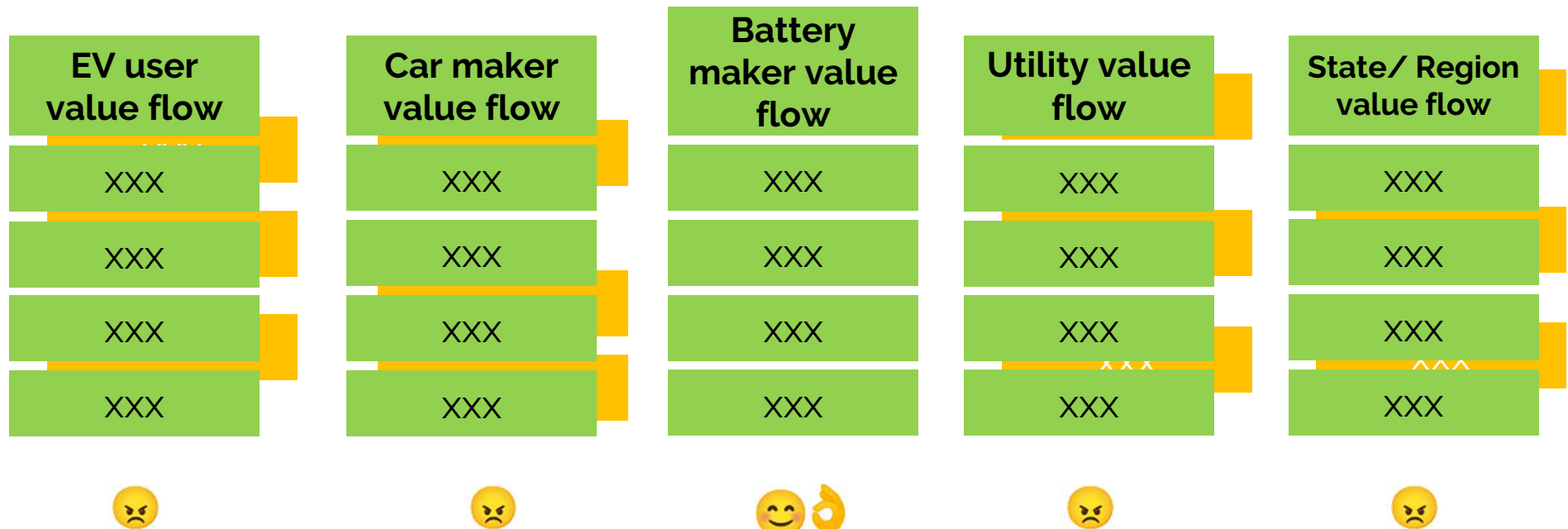
Swissmetro (1992-2010)

https://www.youtube.com/watch?v=E7M3EOD_GzE

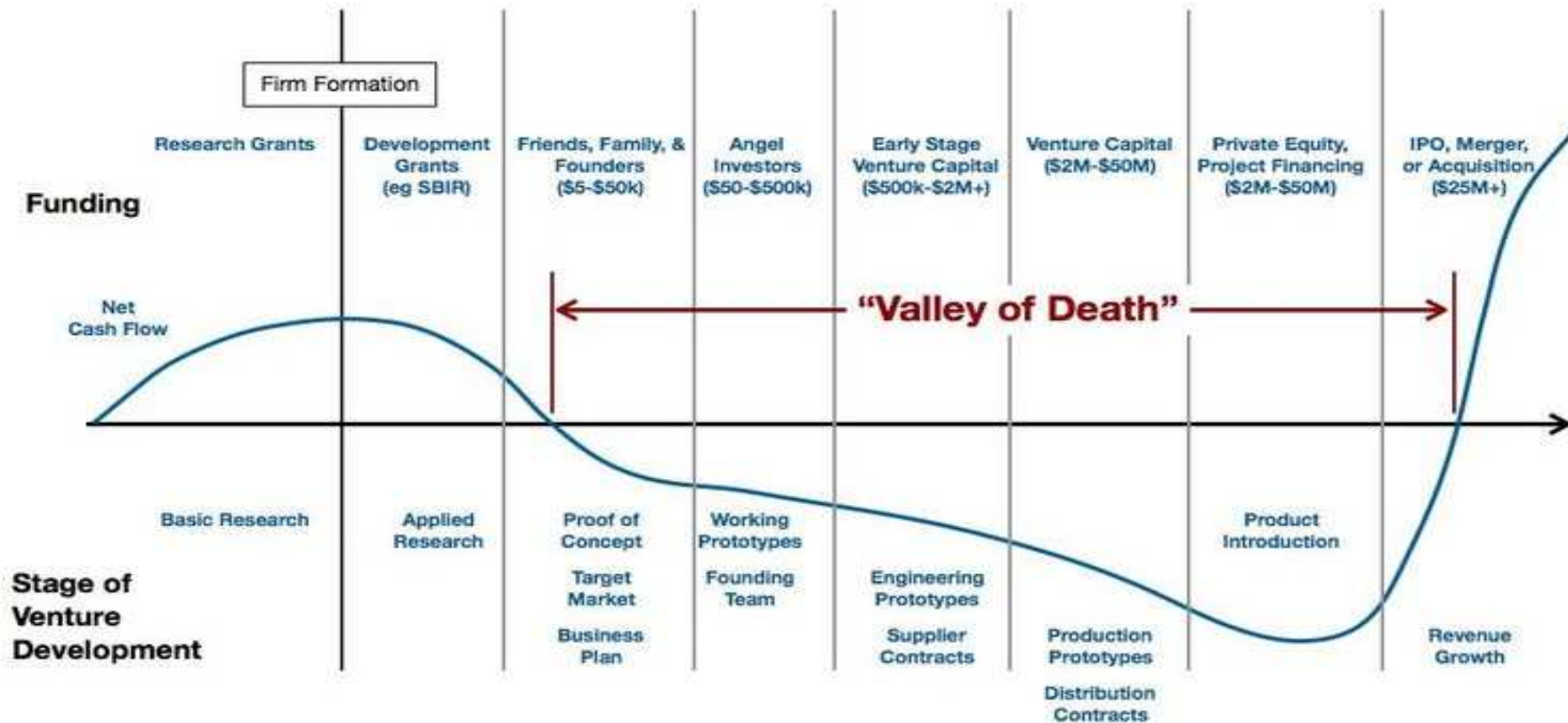
Analysis of network of problems for the whole value chain for electric cars fast charging

Successful products solve user problems and do not create new ones. For this method, future clients' normal flow of activities are depicted in green boxes, and the related problems in orange.

example



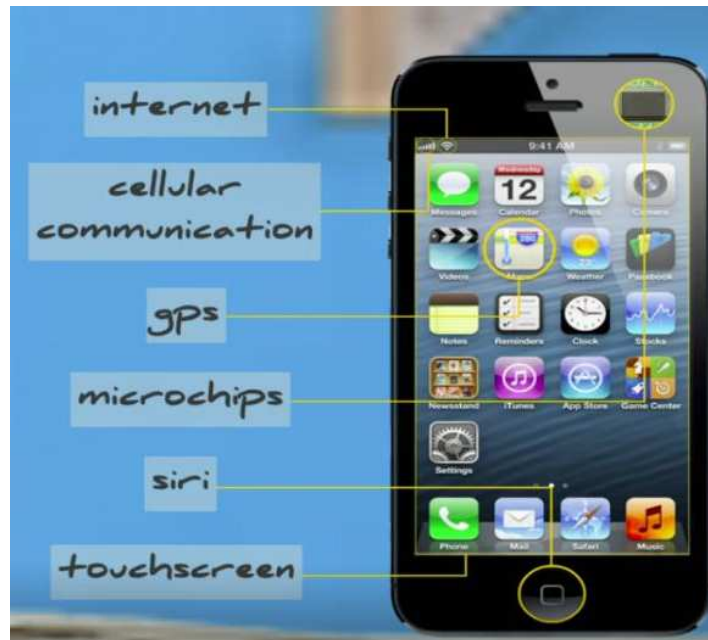
Lifecycle of a venture



Source: UC Davies

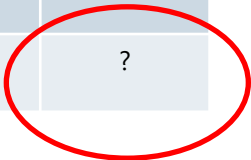
Analysis 3/3: The role of governments is essential

Apple (Iphone), Tesla, Space X....all funded by the US government



Source: M. Mazzucato

| Innovation | SYSTEM LEVEL | COST | COMPANY | STATE SUPPORT |
|---------------|--------------|------|-----------|---------------|
| TGV | SYS | HIGH | INCUMBENT | Y |
| VAL | SYS | HIGH | OUTSIDER | Y |
| GROUND FEED | Comp | MID | OUTSIDER | Y |
| INTERMODALITY | Comp | LOW | OUTSIDER | ? |
| AREOTRAIN | SYS | HIGH | OUTSIDER | N |
| ARAMIS PRT | SYS | HIGH | OUTSIDER | N |
| SWISSMETRO | SYS | HIGH | OUTSIDER | N |
| HYPERLOOP | SYS | HIGH | OUTSIDER | ? |



4. ...AND THE FUTURE?



"Everything that can be invented has been invented."

Charles H. Duell, Commissioner of US patent office in 1899



Science based vision from Cesare Marchetti (2000)

- Nuclear power stations extracting Uranium from the sea, generating hydrogen for the planet by 2100
- Maglev “like” transport development;
- The construction of cities in space from 2050 (using maglev tech);
- Producing massive food by fermentation, capable of feeding 1000 billion humans, and the end of intensive agriculture
- The lengthening of human life after 2050, + TRANS-humanism.
- Quantum computers between 2100 and 2200;
- ...

Using logistic substitution model, a new transport system is supposed to arrive very soon...

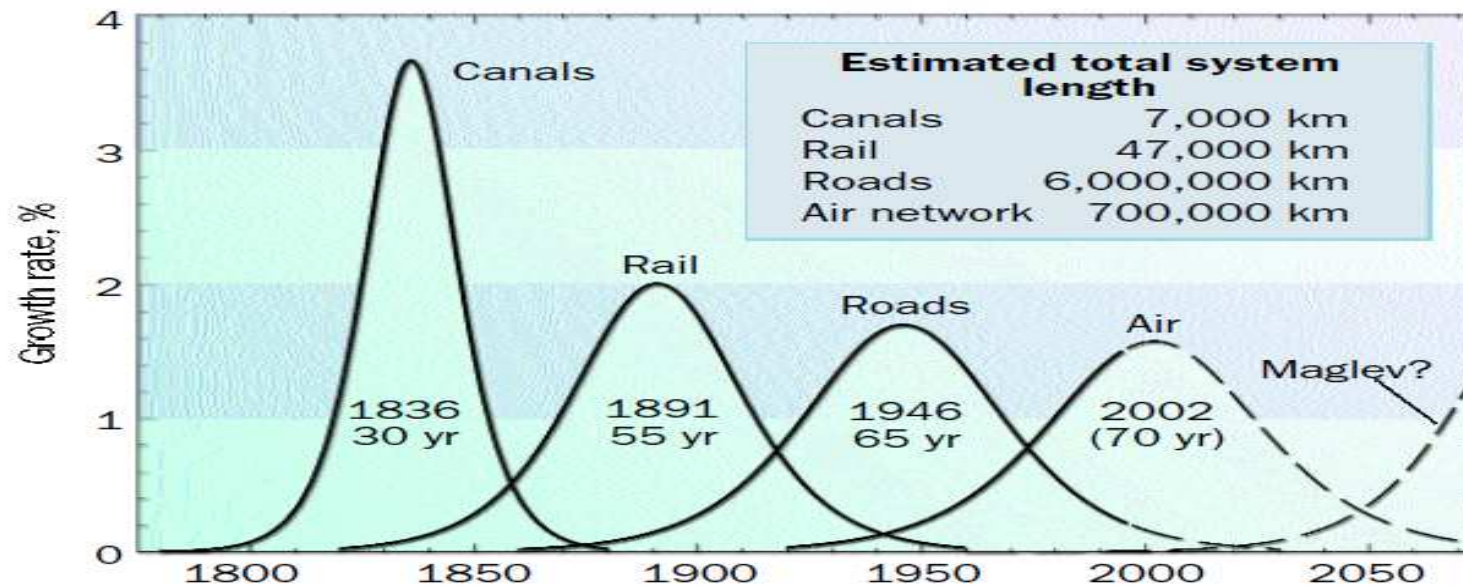
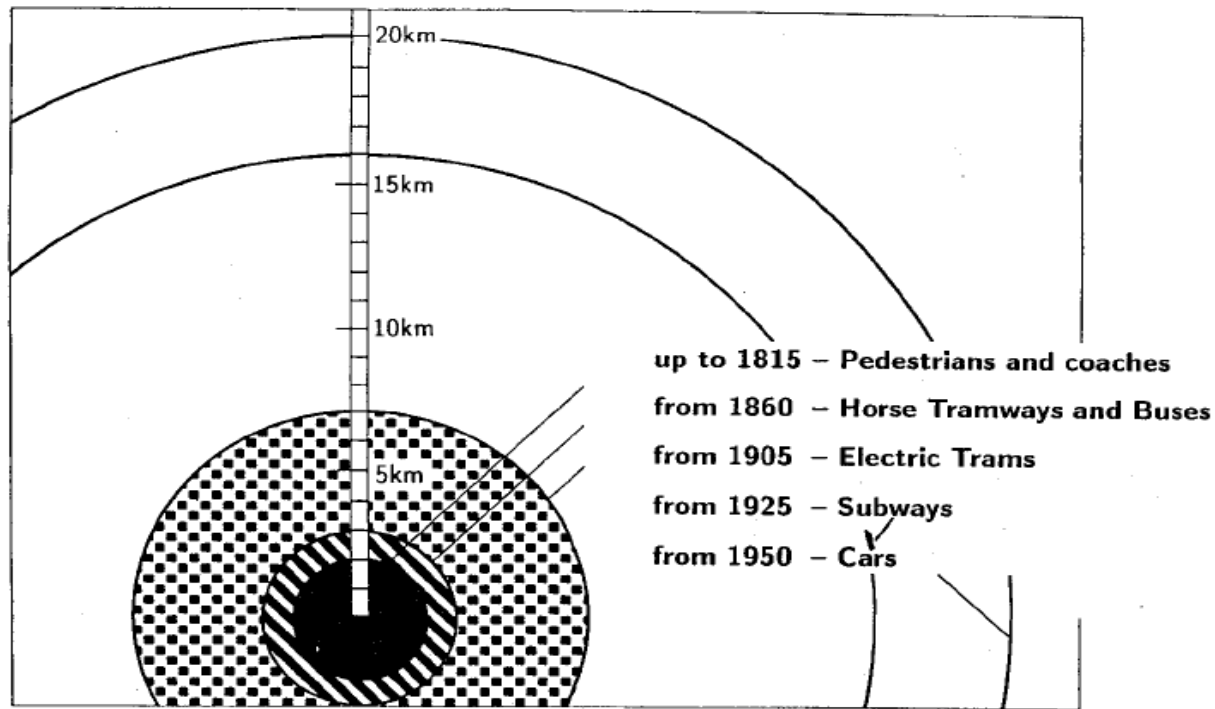


Figure 3. Smoothed historical rates of growth of the major components of the U.S. transport infrastructure, showing the peak year and the time for the system to grow from 10% to 90% of its extent (conjecture shown by dashed curves).

Source: C. Marchetti

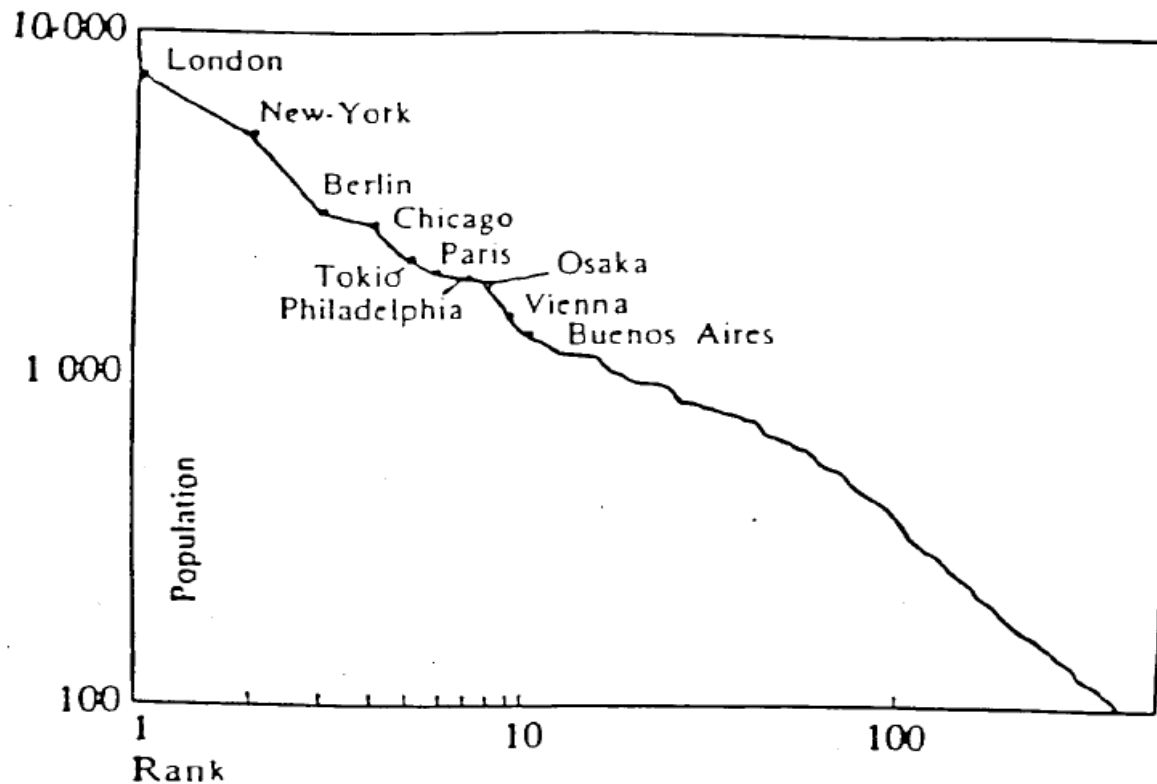
Evolution of Berlin city diameter with distance traveled on 1 hour/day



Source: C. Marchetti

Future of transport for scholars: focus on biggest cities

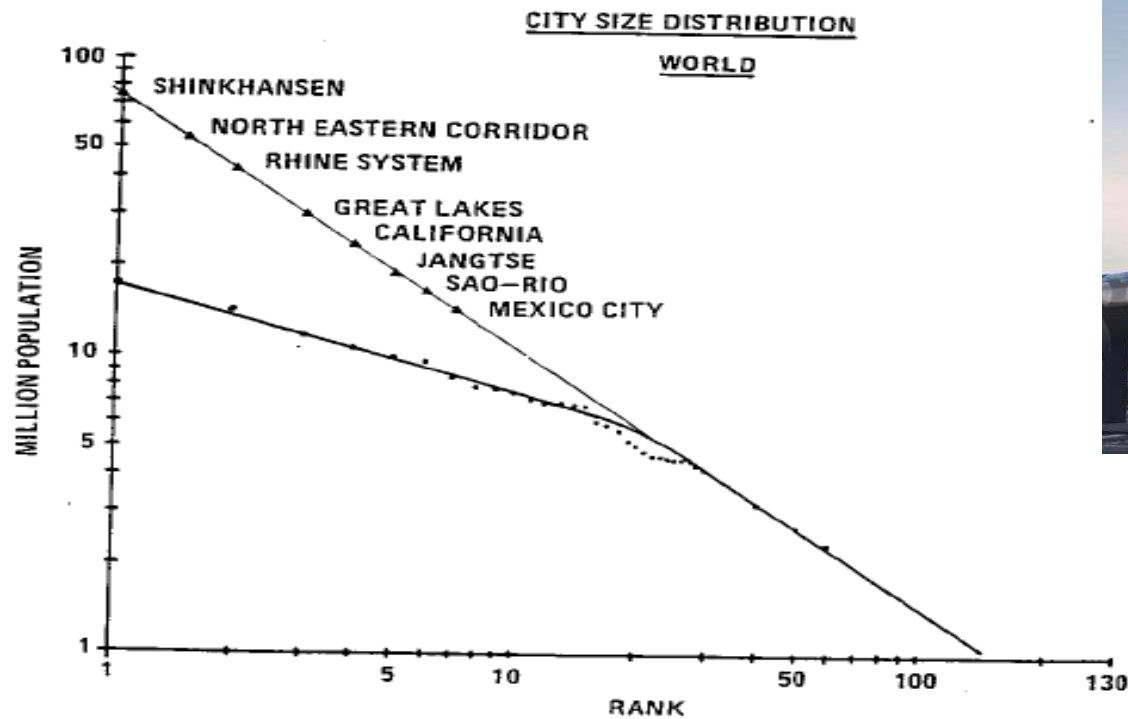
According to Zipf cities are naturally distributed around a log relationship



Source: C. Marchetti

ikos Future of transport for scholars: megacities & ultra high speed

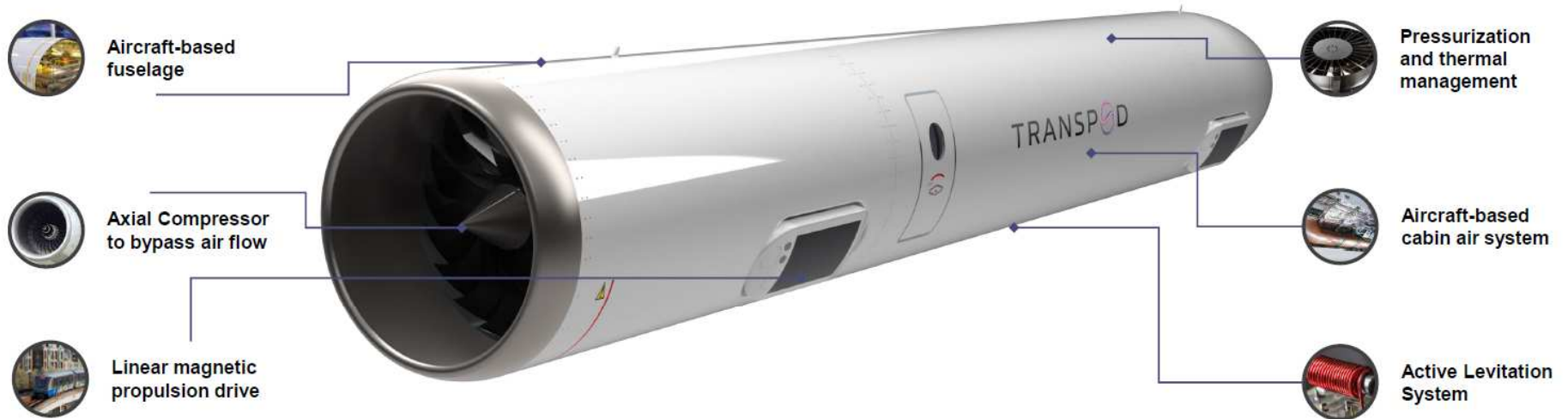
Possible megacity development as an interconnected network (Based on Zipf)



Source: C. Marchetti

A player of ultra high speed: TRANSPOD

A self-driving pod vehicle is composed of many subsystems



TransPod innovates in four key areas



Reduced tube infrastructure cost from innovative tube design



Advanced power-transmission system for high-speed



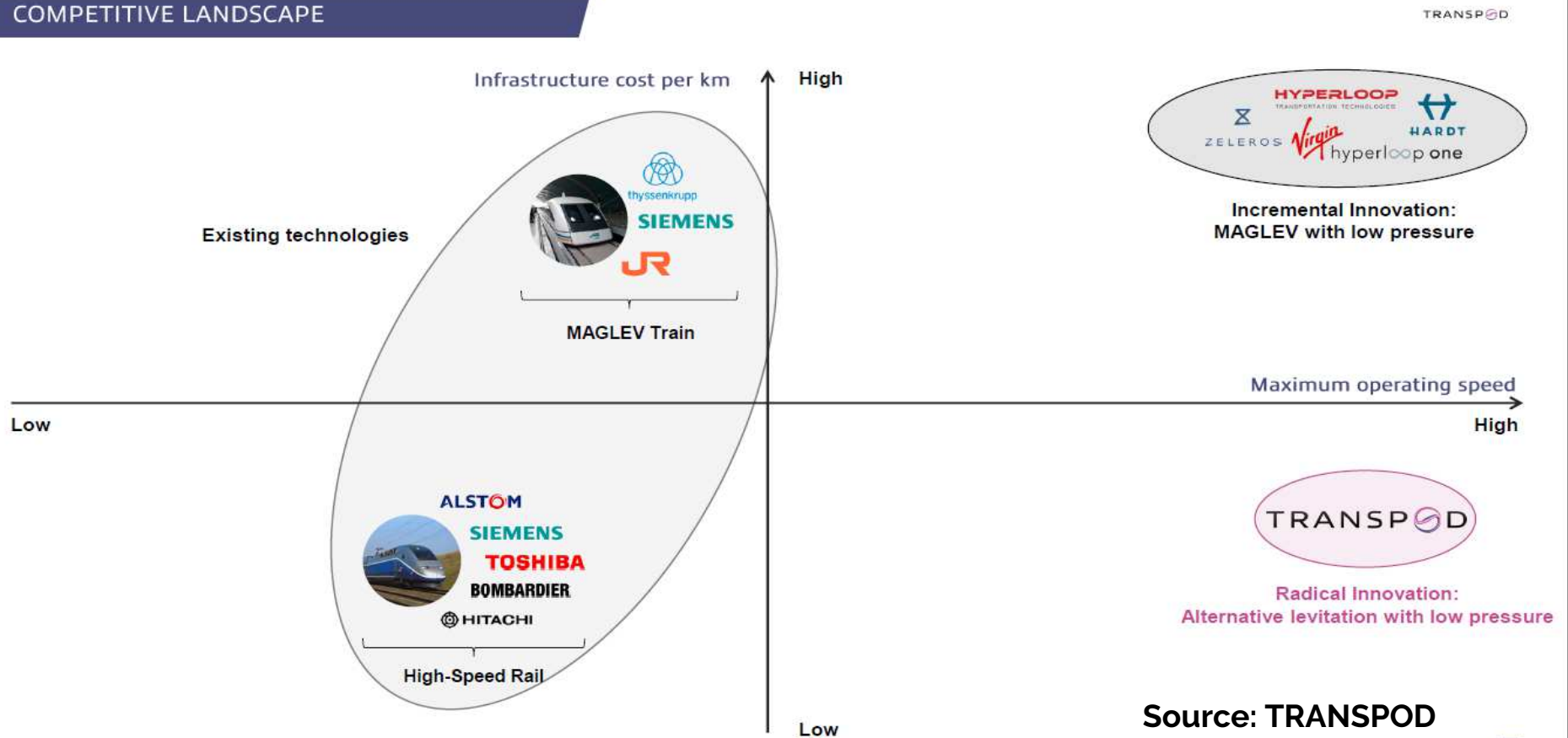
Aircraft-based control system



Artificial intelligence-based stability mechanism

Source: TRANSPOD

COMPETITIVE LANDSCAPE



Source: TRANSPOD

If you are worried about the future, create it!



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