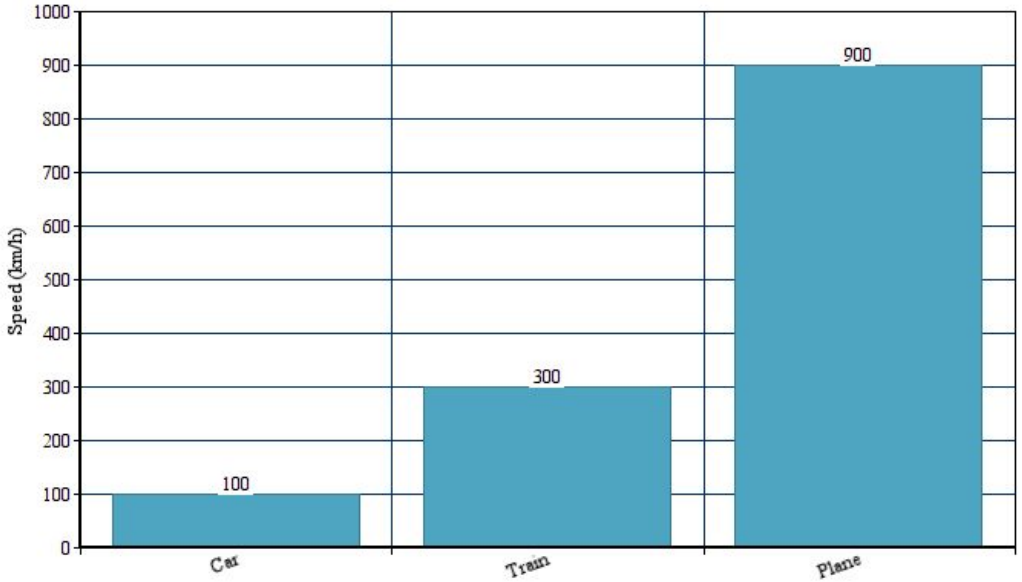

The outer limits
A new way of transport

Outline

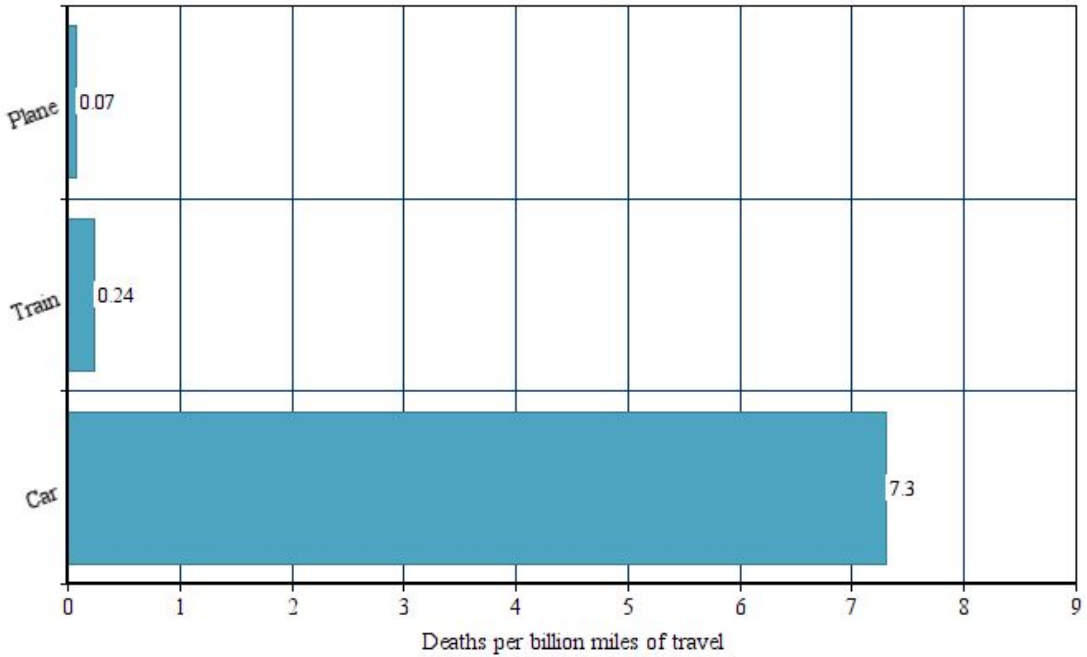
I. Motivations: The problem of the conventional transportation ways
   A. Conventional means of transport
   B. Pros and cons
II. Designing a better solution
   A. The friction issue: solid and fluid contact
   B. Quantifying the energy consumption: the combustion engine model
III. The hyperloop project
IV. Conclusion

I. Motivation

Speed that we can think of

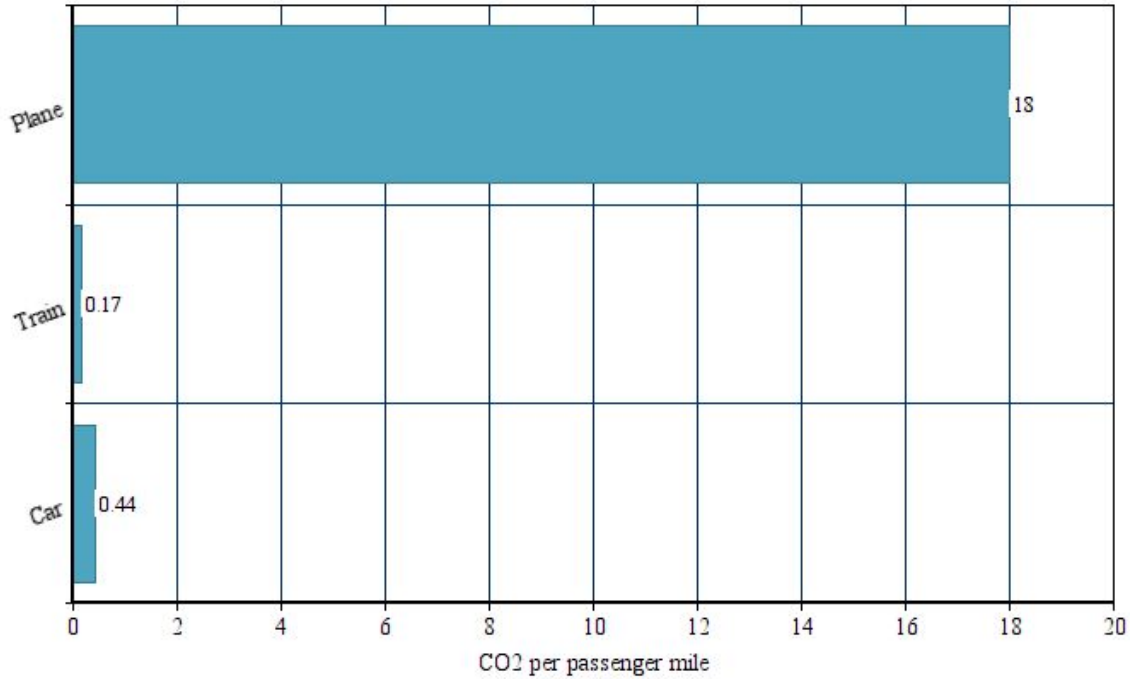


Safety issue



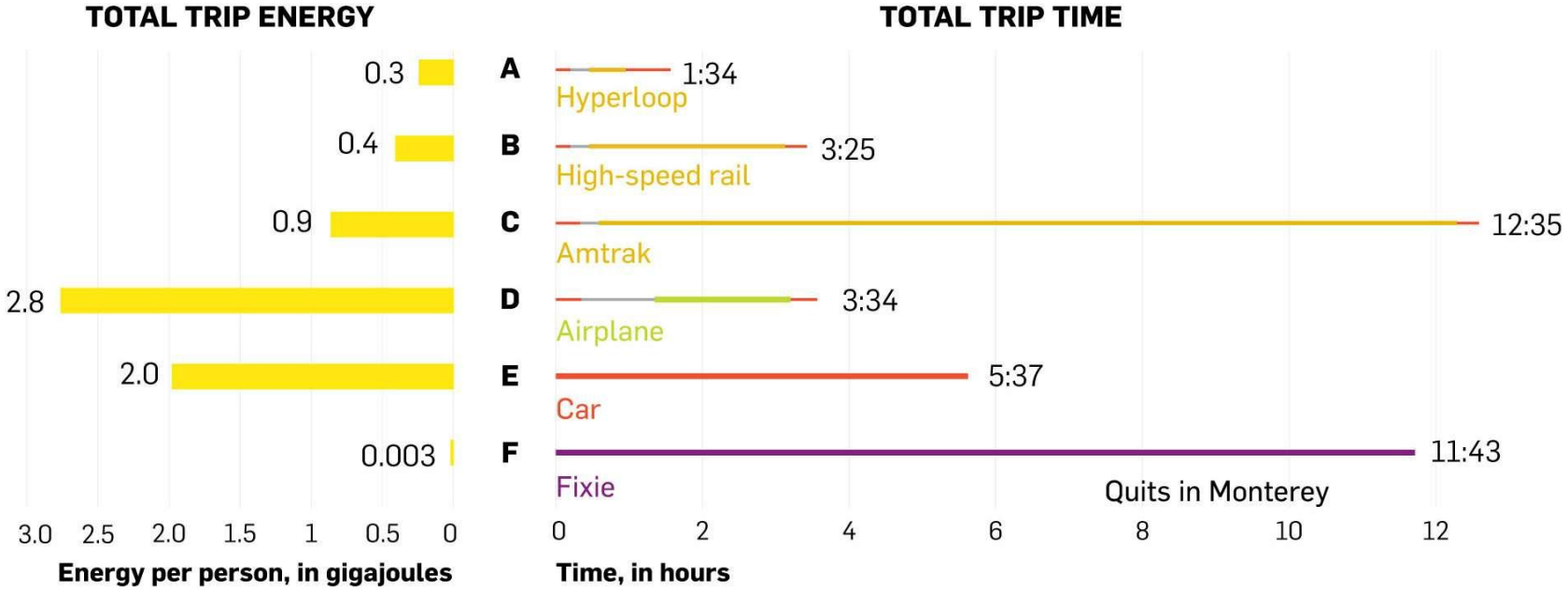
Data: Ian Savage, http://faculty.wcas.northwestern.edu/~ipsavage/436.pdf

Pollution rate



Data: wikipedia.org

SF to LA



Data: Department of Transportation; Oak Ridge Transportation Energy Data Book; Google Maps; Mikhail Chester, Arizona State University; Elon Musk, Hyperloop White Paper; Megan Ryerson, University of Pennsylvania; California High Speed Rail Authority

In a nutshell

Transport	Advantages	Disadvantages
Car	Cheap You choose time for departure	Not safe Slow
Plane	Fast Cheap	Long time to check-in and board Airports are far away Flights are rare Big CO2 remission
Train	Easy and fast to board Train stations are in a downtown normally Comfortable Low CO2 emission	Slow when distance is big Expensive

II. Designing a better solution

- What are the main physical issues faced by a body in motion?
- How to quantify this dynamical constraint?
- How to build a motion engine by limiting the effect of this dynamical constraint?

Designing a better solution

I. The friction issue: solid and fluid contact
II. Quantifying the energy consumption: the combustion engine model
III. Rethink the movement: the static movement model

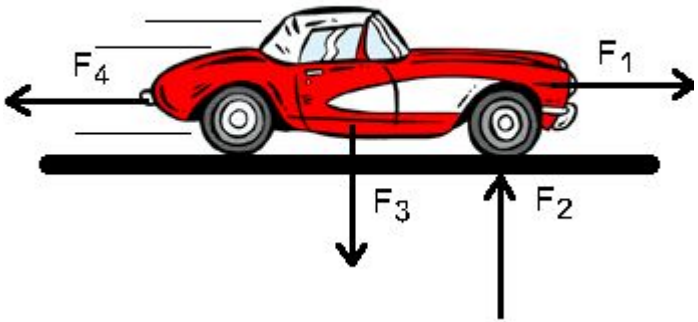
The friction issue: solid and fluid contact

Formal definition (over one point):

- Opposition force created by the motion

$$\overrightarrow{F_{friction}} = -\alpha * \overrightarrow{F_{mouvement}}$$

  - α is the motion force



Designing a better solution

I. The friction issue: solid and fluid contact
   1. **Definition of the friction energy**
   2. How to fight friction.
   3. Get rid of friction

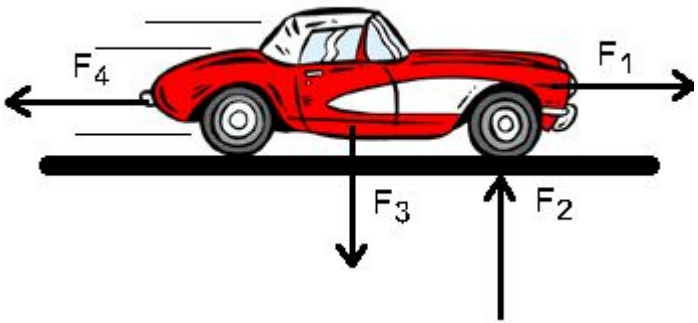
II. Quantifying the energy consumption: the combustion engine model

III. Rethink the movement: the static movement model

The friction issue: solid and fluid contact

Formal definition (over all the solid):

$$\overrightarrow{F_{friction}} = \alpha_{tire/road} * \int_{tire} \overrightarrow{F_{mouvement}} + \alpha_{sheetMetal/air} * \int_{\text{sheet metal}} \overrightarrow{F_{mouvement}}$$



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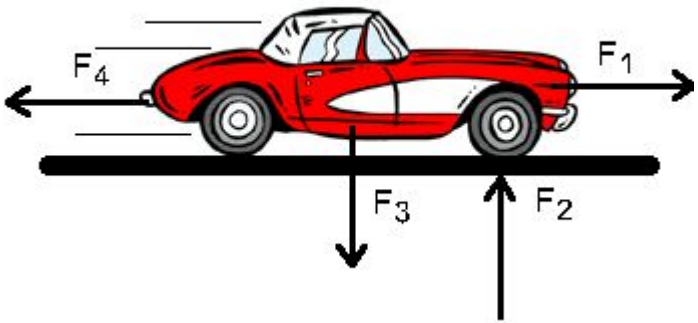

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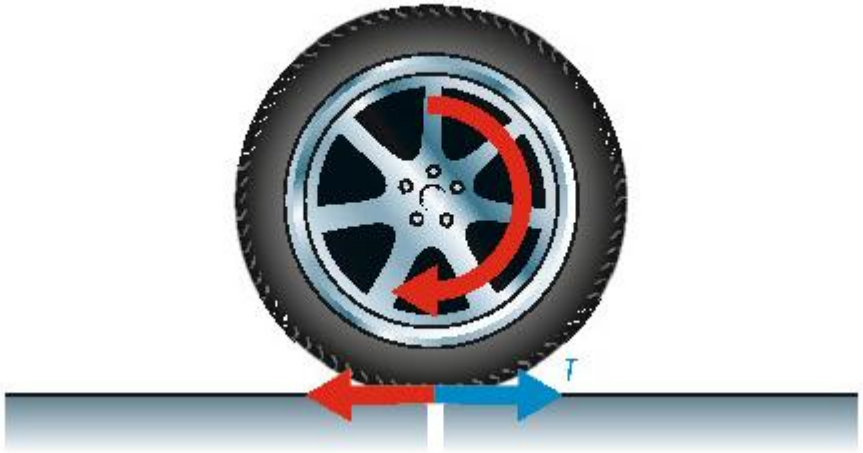
The friction issue: solid and fluid contact



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   1. Definition of the friction energy
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   3. **Get rid of friction**

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The friction issue: solid and fluid contact

More formally:

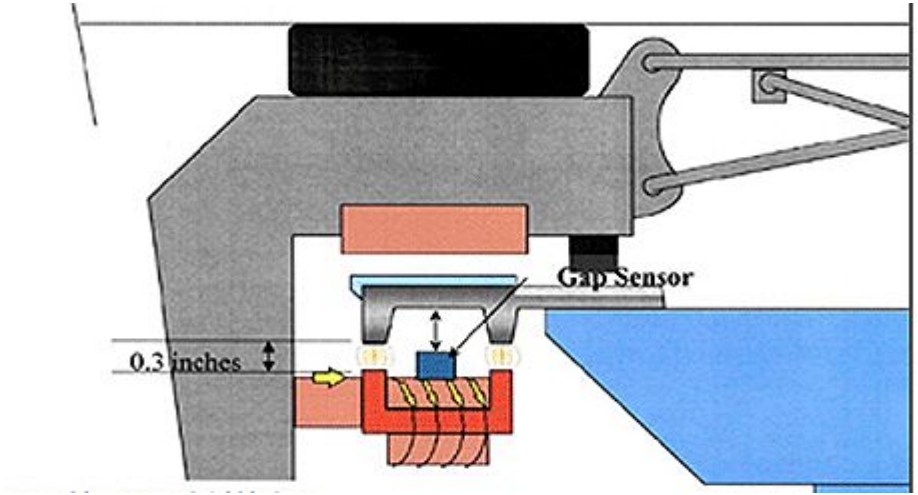
- Newton's 1st principle: **"The rate change of linear momentum of an object is directly proportional to the external force on the object"**.
- Newton's 2nd **"Every action has an equal and opposite reaction"**.
- Friction $\Longleftrightarrow$ Movement.

Outline

The friction issue: solid and fluid contact

Conclusion:

- Do not remove the friction
- Remove the biggest part of the friction: solid friction



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Quantifying the energy consumption

Kinetic energy:

$$E_{\mathrm{k}} = \frac{1}{2}mv^2$$

- Only depends on the weight and the speed
- Represents the energy needed to create the motion and to fight friction

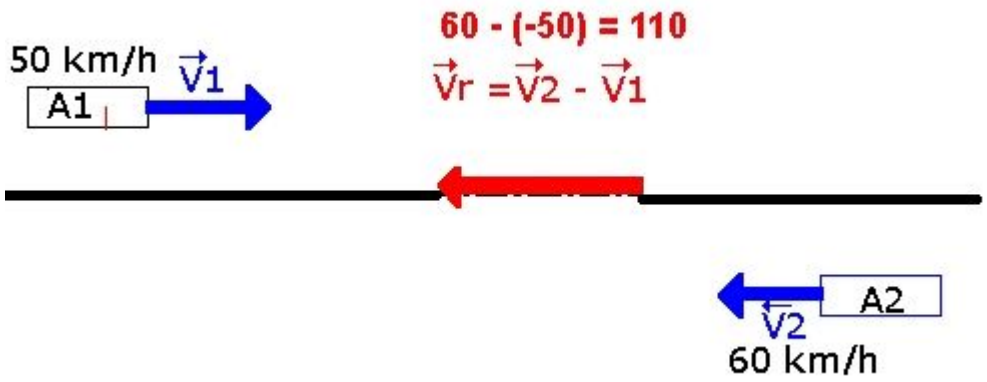
Outline

I. The friction issue: solid and fluid contact
II. Quantifying the energy consumption: the combustion engine model
    1. **Formal quantification of the movement energy**
III. Rethink the movement: the static motion model

Reconsider the movement

Formal definition a movement:

- Function of the referential
- Einstein: “Everything is relative”



Outline

I. The friction issue: solid and fluid contact

II. Quantifying the energy consumption: the combustion engine model
   1. Formal quantification of the movement energy
   2. The reciprocating engine

III. Reconsider the movement: the static motion model
   1. **What is a movement**
   2. Motion without impulse

Reconsider the movement: the static motion model

Creating a movement on a solid:

- External impulse on the solid

- Referential motion: idea of the referential

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III. Rethink the movement: the static motion model
   1. What is a movement
   2. **Motion without impulse**

Reconsider the movement: the static motion model

Creating a movement on a solid:

- The movement by depression:

  1st principle of thermodynamic: **“A system where different parts have different level of energies will tend toward stabilisation”**

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    1. What is a movement
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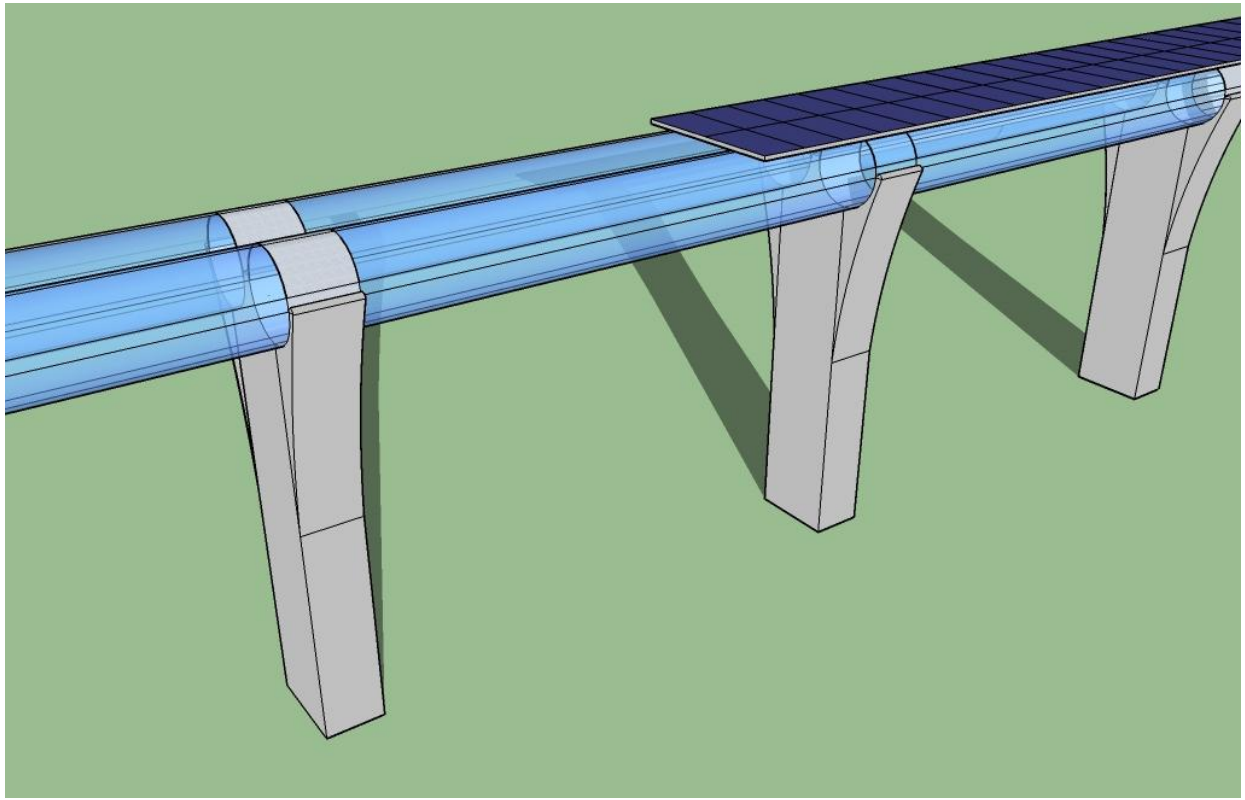
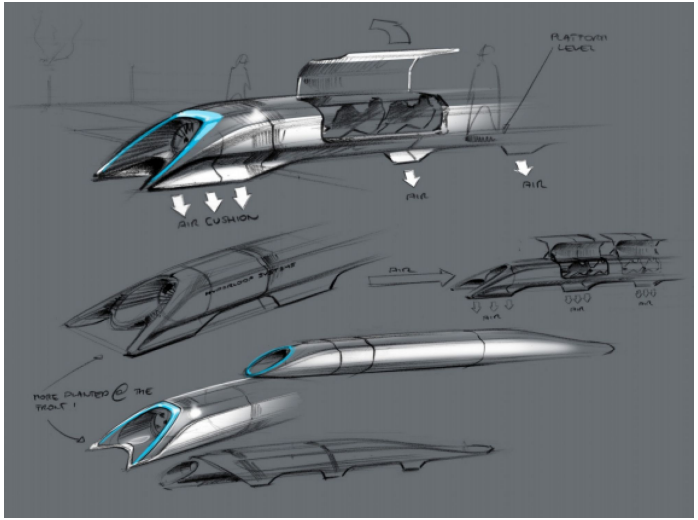
III. The hyperloop project



Main features

- Speed from 480 up to 1220 km/h depending on landscape
- Capsules every 30 seconds
- Air cushion
- Solar energy usage
- Energy production from braking of capsulas

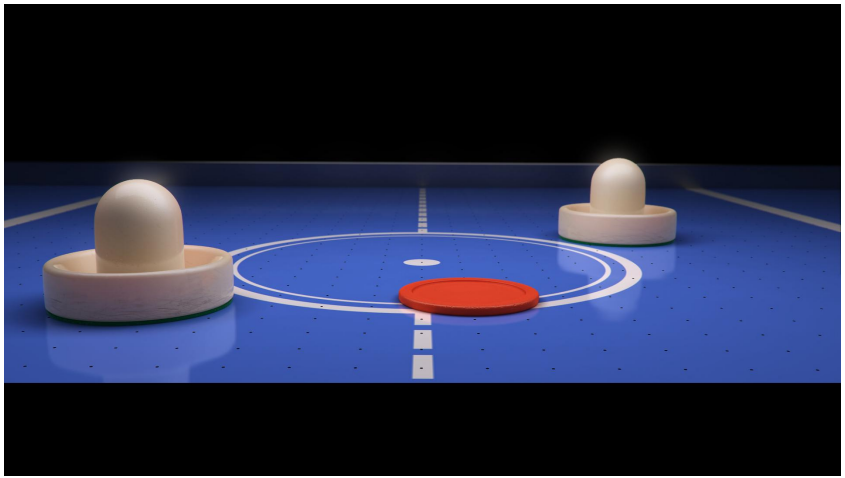


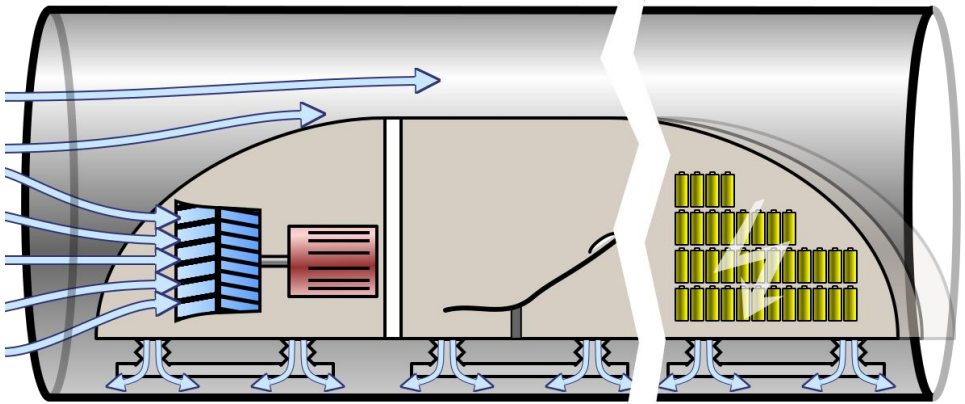
Vacuum idea

- No need to maintain ideal vacuum (0 Pa)
- Fore-vacuum of 100 Pa (1/1000 of air pressure) is enough
- Lower price of pumps and construction

Air cushion

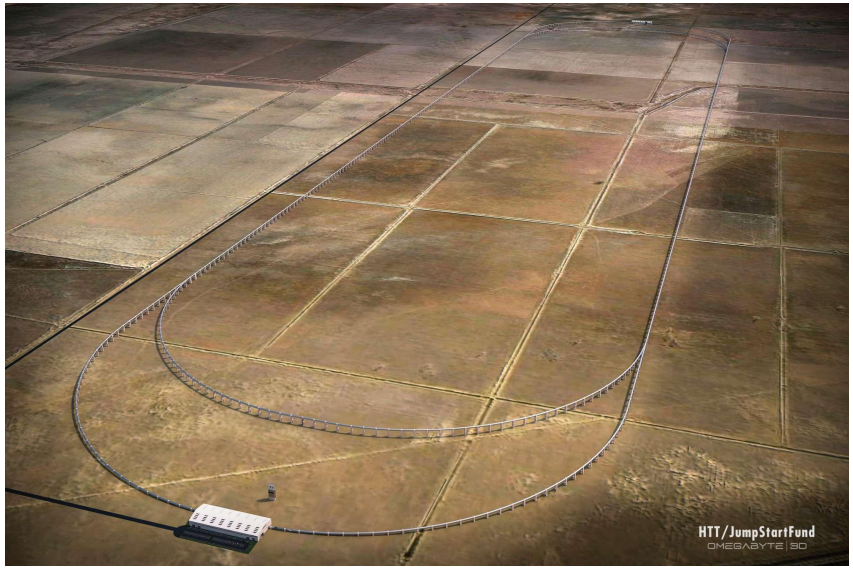
- Capsulas float on a 0.5-1.3 mm layer of air
- Active transfer of high air pressure air from front to the rear of the vessel





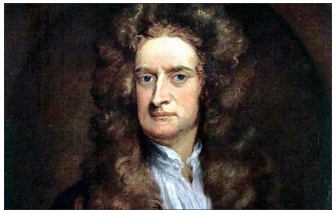
Modeling problems

- Heating of the the capsule surface (Ansys)
- Rotation around the longitudinal axis (Ansys)
- Speed of 1220 is unreachable (The MathWorks)
- Diameter of the tube is too small (NASA Glenn Research Center)

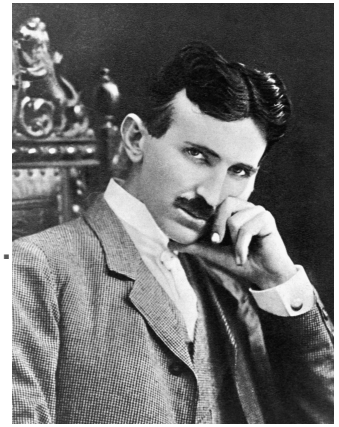


Conclusion

- Very simple physical principles described by Isaac NEWTON in the 17th century



- Improvement and implementation realised by Nikolas TESLA in the early 19th century (the **floating infinite engine**)



- However, the industry still does not use it in the 21st century.

  Why?

Conclusion

Albert EINSTEIN:

“The industry will never renew a process before having drawn all its profits”