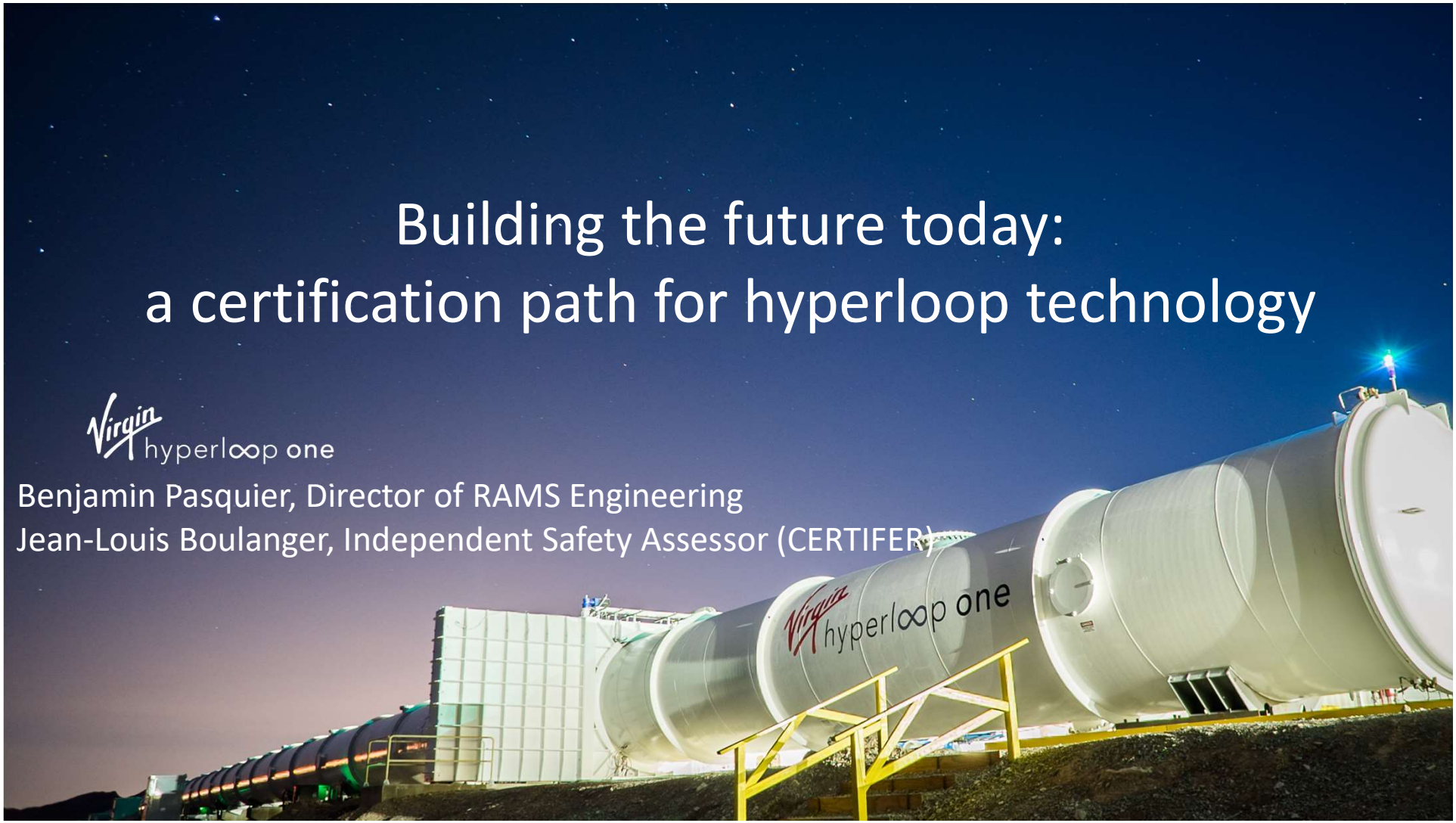
Building the future today: a certification path for hyperloop technology

Virgin hyperloop one

Benjamin Pasquier, Director of RAMS Engineering
Jean-Louis Boulanger, Independent Safety Assessor (CERTIFER)



Agenda

1. Introduction
2. Key Features
3. Certification
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5. Path to the Future
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INTRODUCTION

Introduction: Market Demand

People want to travel…

- Fast and in a predictable fashion: time is money.
- Affordable ticket price.
- Comfortably, no violation of personal space.
- Safely, in a way environmentally friendly.
- Door to door is the dream, on-demand becoming a must (shortest waiting time).
- And be able to live where they want…

Cities are looking for…

- Solutions to congested urban areas.
- Cost-efficient and non-disruptive upgrades or expansions of existing transportation networks.
- Mass commuting within wide urban areas, allowing local business and residential developments.
- Safest transportation system with lowest possible environmental impact.

States/Governments are looking for…

- Cost-efficient solutions allowing mass intercity commuting, business development and job creation.
- Integration between transportation modes allowing rapid transfer between key nodes.
- Innovation, being at the cutting edge of technology.
- Safest transportation system with lowest possible environmental impact.
- The most efficient way to “regulate” any emerging transportation solution…

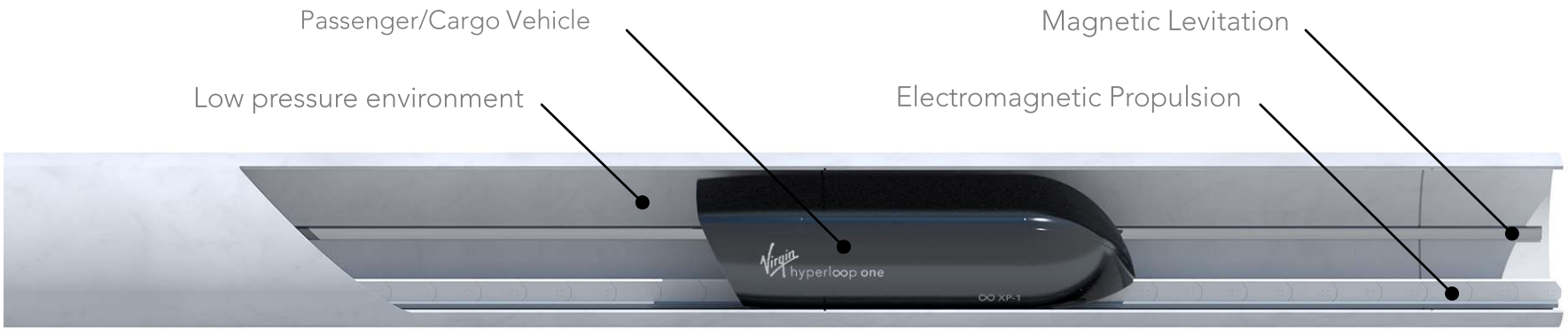
Introduction: Hyperloop

In response to the market demand, hyperloop offers a new mode of transportation in which vehicles carrying passengers or cargo can travel at ultra-high-speeds (up to 1,000 kph) in a low-pressure environment (100 Pa) within an enclosed structure:

- Based on ground-breaking technology.
- Comfortable travel at airlines speeds.
- On-demand, reliable transport for passengers and cargo.
- High capacity, enabling mass transportation: more than 16,000 passengers per hour per direction.
- Economically competitive alternative to existing transportation means.
- Connecting cities like metro stops.
- No limitation in terms of integration with existing transportation modes.
  - Hyperloop is a complement.
- Modular deployment with significantly less footprint than highspeed railway.
- At least as safe as existing transportation means.
- Zero direct emissions, energy efficient… a response to the climate change crisis!

Introduction: Hyperloop

New technology bringing transformative change in transportation



Virgin hyperloop one

Introduction: Hyperloop

A hybrid transportation system…

- Pods travel on a guideway like a train, become autonomous like autonomous cars.
- Fast moving in low pressure environment like a plane.
- Docking/undocking at portals.
- With levitation/guidance/propulsion/braking using magnetic technology.

As such, several parts of the system have pedigree in terms of safety and regulatory framework. Key innovative aspects reside in:

- The usage of existing technologies in different application and environment.
- Flight control system, control and command system.
- Safety and performance targets.

Introduction: Virgin Hyperloop One

On a mission to create fast, effortless journeys that expand possibilities and eliminate the barriers of distance and time

$370+ million
In funding raised from venture and strategic investors

400+ tests
Run at the world's first full-scale hyperloop test site

200+ employees
Specializing in aerospace, transportation, infrastructure, construction, etc.

9+ Projects
Around the world

Introduction: Virgin Hyperloop One

Los Angeles

Innovation Campus

KEY FEATURES

Key Features

Solution includes

- Wayside and on-board safety-critical real-time systems
  - Control & command (like a train) involving both wayside and on-board.
  - Flight control (like an aircraft).
  - Pressure management and tube environmental control system.
- High-dependability system to ensure mission-criticality of the flight
  - Multiple redundancies.
  - Graceful degradation of operations.
- Pods travelling in convoys.
- Wayside <> Pod and Pod <> Pod communication.
- Line-of-sight via sensors.
- On-demand operations and traffic supervision.

Key Features

Some related safety challenges

- Driving timing performance for sensing, computing, communicating, reacting, and headway constraints.
- High throughput via convoying: high safety target on individual pod system.
- Flight control system algorithms.
- Adaptiveness to maximize responsiveness and safely manage degraded modes.

CERTIFICATION

Certification: Definition

Aviation

- The legal recognition that a product, service, organization or person **complies with the applicable requirements**.
- Authority: organization or person responsible within the country concerned with the **certification of compliance** with applicable requirements.
- Certification is **generic**: once a type is certified, any aircraft of that type is allowed to fly providing certification conditions are fulfilled.

Railway

- The process of analysis to determine whether the design authority and the validator have achieved a product that **meets the specified requirements** and to form a judgement as to whether the **product is fit for its intended purpose**.
- Accredited organization: body responsible for delivering an assessment or a certificate.
- Authority: body responsible for delivering the **authorization for revenue service** of the safety-related system.
- Certification is **generic**: a generic product or generic system.
  - Once a type is certified, any railway application of that type is allowed to enter revenue providing certification conditions are fulfilled in the context of authorization for entering service revenue (CROSS-ACCEPTANCE).
- Service revenue authorization is **specific**: a particular system – made of a particular guideway and specific vehicles – is allowed to enter revenue providing certification conditions are fulfilled.
  - Technical interoperability creates the opportunity for generic authorization e.g. specific vehicles allowed to operate on any compliant guideway.

Certification: Definition

Hyperloop

- Approach may be **similar to Railway**.
- The Authority (state/country) grants – under fulfillment of certain criteria – authorizes a particular hyperloop system (infrastructure and pods) to enter into revenue service providing certification conditions are fulfilled.
- Service revenue authorization is **specific.**

Certification: Regulations

No existing regulations or standards addressing hyperloop system, no existing process for certification of a hyperloop system.

- Regulatory framework usually results from extensive accumulated knowledge and experience on systems.
- Establishing such framework can be lengthy depending on region, context, approach (e.g. prescriptive vs. performance-based).

However, dialogue is progressing well in several regions…

- In the U.S.: USDOT/Non-Traditional and Emerging Transportation Technology (NETT) Council.
- In Europe: Directorate-General for Mobility and Transport (DG Move).
- In India: Principal Scientific Advisor (PSA)/Consultative Group on Future Transportation (CGFT).

Certification: Standard Framework

5th Mode of Transportation System

Hyperloop is considered as the 5th mode of transportation

- It is a kind of guided transportation…
- It is like a plane…
- It uses autonomous vehicles like an autonomous car…

Railway standards such CENELEC 50126 (IEC 62278) being studied as a general framework

- CENELEC 50126 is derived from IEC 61508 but specialized for railway transportation.
- CENELEC 50126 covers from concept until decommissioning.
- CENELEC 50126 is used for classic railway, subway and tramway.
- CENELEC 50126 introduces the notion of code of practice.
  - It allows usage of other standards (such as DO-178) for some parts.
  - It allows usage of certified product from another domain based on CROSS-ACCEPTANCE process.

VISION FOR HYPERLOOP

Vision for Hyperloop System

Goal for any hyperloop company

- A hyperloop system authorized by the relevant authority to enter into revenue service based on fulfilment of established criteria within this decade.
  - Criteria should include independent positive review by an accredited (or approved) Independent Safety Assessor (ISA).
  - The first hyperloop success will trace a successful path forward for the entire hyperloop industry.

Standardization of hyperloop systems

- A standard framework for any hyperloop system, mostly performance-based.
- Common criteria worldwide and mutual recognition of certification authorities.
  - Report from an accredited ISA covering generic product layer on one application should be a valid piece of the certification argument anywhere: CROSS-ACCEPTANCE principle.

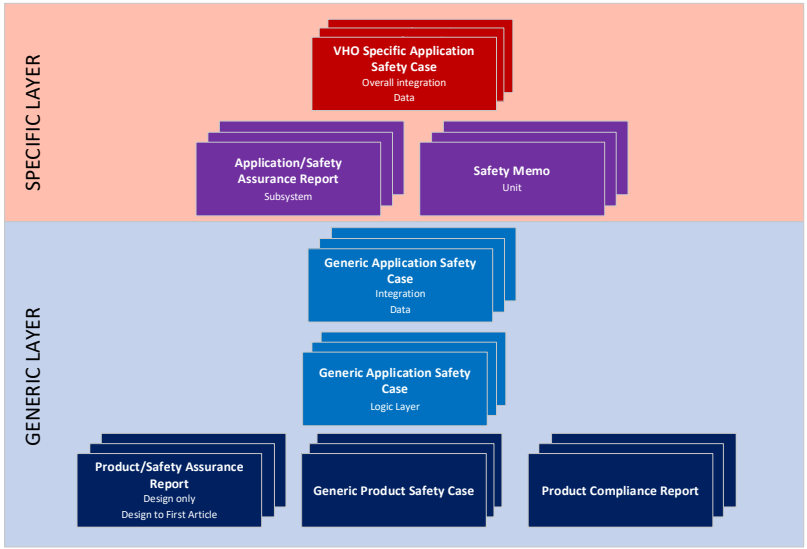
Interoperability of hyperloop systems

- A technical objective with network/line interconnection benefits, but currently we see variability of potential design concepts and stages of development.

Vision for Hyperloop System

Goal to optimize hyperloop solution deployment.

- Internal certification based on safety cases and Independent Safety Assessments (ISA)
- Deployment phases within a project addressed by an approach by “unit”
- Subsequent deployments are optimized in terms of certification
  - A stable generic layer of the hyperloop system certified by an Authority for a certain use and in a certain environment should be acceptable by another Authority for a similar use and in a similar environment.
  - Promotion of cross-acceptance concept.
- “Nested Safety Case”



PATH TO CERTIFICATION

Path to Certification

From technology company to mature transportation company

- Starting point: an organization – technology company - focusing on prototyping using latest technologies for innovative solutions
  - Building test rigs, in laboratory and at scale.
  - Fast moving: iterative, evolving rapidly.
- Challenge: transitioning from a technology company to a transportation company, while maintaining creativity and agility.

- How do we get there?
  - Create a competent organization from a transportation viewpoint: organization (new constraints and functions), people (new roles), processes/tools.
  - Increase safety maturity:
    - By recruitment: expertise from transportation industry.
    - By training of personnel to enhance their understanding…
  - Certify a Quality Management System (ISO).
  - Coaching of engineers by experienced services.

Path to Certification

From prototyping to safety-graded solution

- Starting point: an advanced design solution - down to the detailed level - building on a full scale functioning prototype.
- Challenge: certify a new transportation technology within timescale compatible with the market.

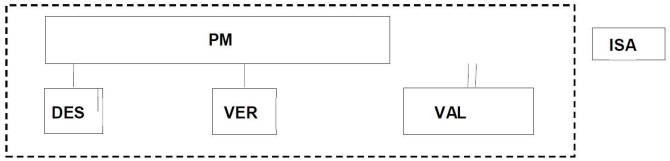
- How do we get there?
  - Breakdown the overall system into technological blocks which have engineering pedigree or legacy.
  - Create customized safety rationale for the identified technological blocks and identify pertinent risk assessment criteria:
    - Supporting safety-critical and mission-critical behaviors.
    - If proven technological block (with legacy from another industry), ensure that the impact of specifics created by hyperloop's environment/application is controlled.
  - Iterate on requirements at all levels:
    - Use robust engineering, safety and verification processes to allow justification by analysis and in-house testing.

Path to Certification

From prototyping to safety-graded solution

- Starting point: a delivery program subject to aggressive funding priorities to secure investor will.
- Challenge: support compressed program timelines while bringing in the reality of discipline, rigor and effort required for safety-critical developments.

- How do we get there?
  - In the absence of regulatory and standard framework:
    - Review, adopt and rollout (parts of) existing industry standards through a controlled internal process.
    - Adopt a proven umbrella framework allowing safety-critical developments and allowing flexibility in terms of approach to risk analysis: IEC 62278.
    - Design a risk matrix allowing achievement of overall safety and service availability targets.
  - Align organization with respect to the selected framework.
  - Independent evaluation by external services of the organization's readiness for production of a commercial safety-critical system.



Path to Certification

From safety-graded solution to first application

- Starting point: a solution designed from scratch with no performance records, with no “acceptance” legacy (or free from any “acceptance” legacy).
- Challenges
  - Progressing the design and implementation of a full transportation system at a fast pace while the regulatory framework is being defined.
  - Building a strong safety argument acceptable to any future Authority.

- How do we get there?
  - Secure the attention from transportation departments and authorities that this technology is moving forward…
    - Engage with and support proactively transportation bodies working on new technologies for regulatory purposes.
  - Define requirements and adopt processes based on best practices in other industries (and hence most likely to be acceptable) using diversity of in-house expertise and collaboration with technical advisors.
  - Capitalize on the history of transportation safety and carry over proven features and principles: systematic Lessons Learnt implementation to maximize the chances to get it right up-front.
  - Engage Independent Safety Assessors (ISA) with worldwide reputation and access to expertise from various transportation industries.
  - Build full scale test track e.g. Hyperloop Certification Center (HCC).

CONCLUSION

Conclusion

Introducing an innovative transportation system such as hyperloop raises a range of real challenges

- A hybrid system designed to be at least as safe as other existing transportation systems.
- Many technical safety challenges incl. in embedded real-time systems, but common problematic with other transport systems.
- Starting points and goals are clear, success depends on chosen path.

Challenges are overcome by

- Executive commitment to safety.
- Engineering excellence and diversity of people.
- No complacency, appetite for continuous learning and doing things right.
- Learning from the transportation industry: ERTS 2020 onwards.

Virgin Hyperloop One, functional testing starting 2021!

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