Capella Days 2020:
High Speed Transportation Case Study

Virgin Hyperloop

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Itinerary

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“Hyperloop” – Revolutionary Mass Transportation Technology

What is the system?

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Speed

We're building for fast, effortless journeys that expand possibilities. Our system can propel passenger or cargo pods at speeds of over 1000 km/h. That is 3x faster than high-speed rail and more than 10x faster than traditional rail.

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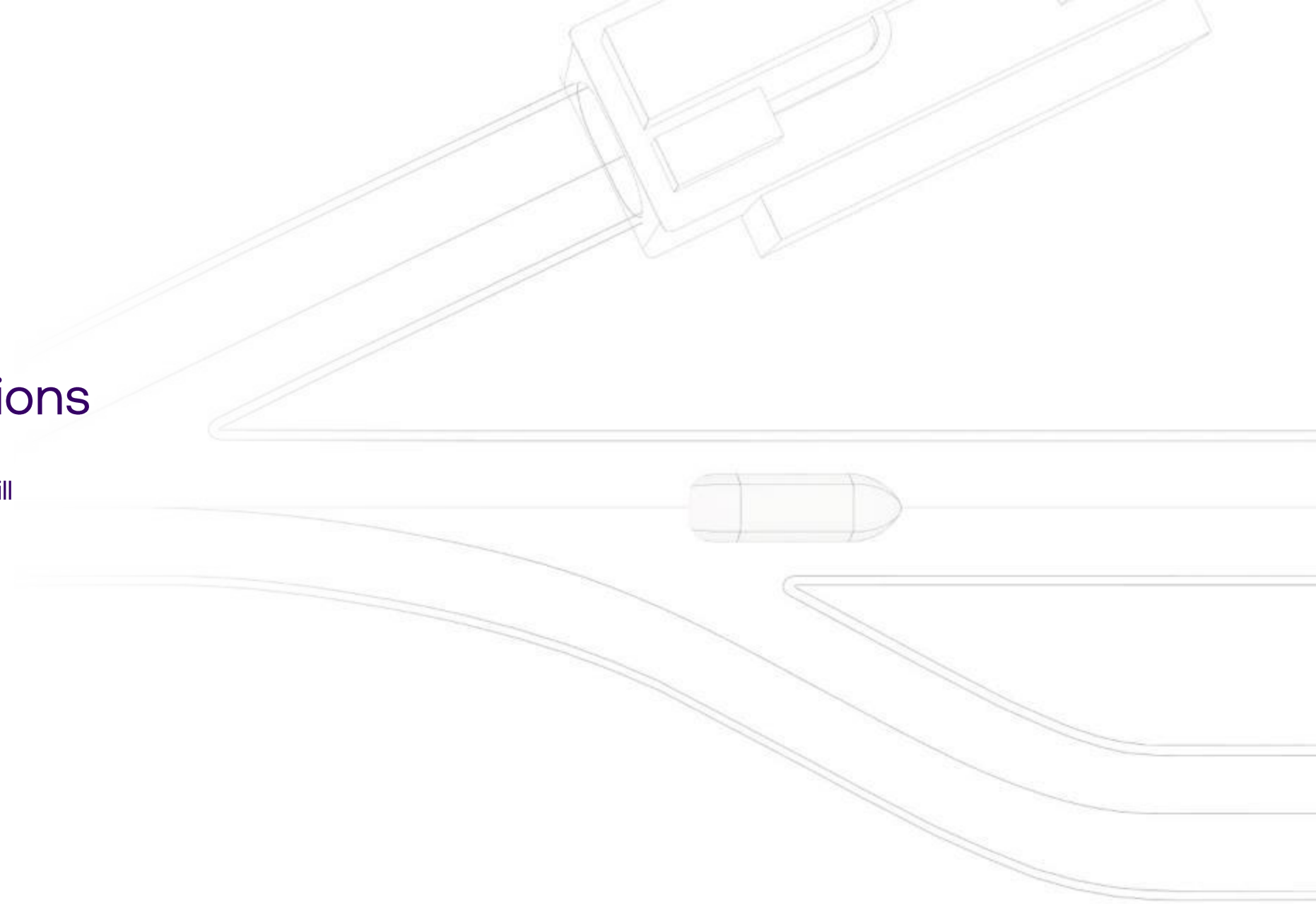

System Operations

The passenger of the future will expect direct and on-demand transportation. With Virgin Hyperloop, there are no timetables. Several pods can depart per minute, and the system does not require stops at every station.

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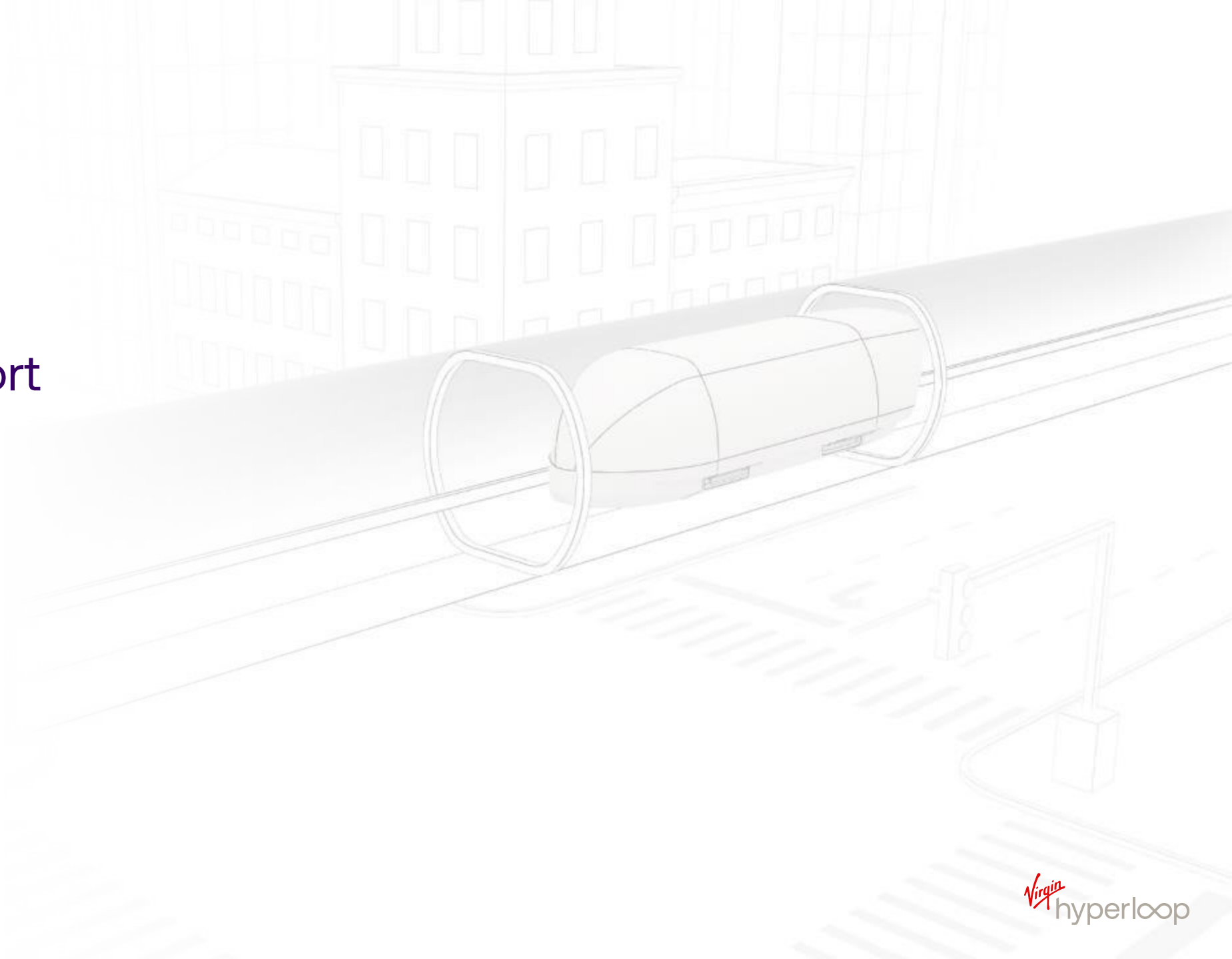
Safety & Comfort

The Virgin Hyperloop delivers airline speeds, the same G-forces as rail, and the ease of riding a metro. A central command & control ensures safe and reliable passage throughout the network.



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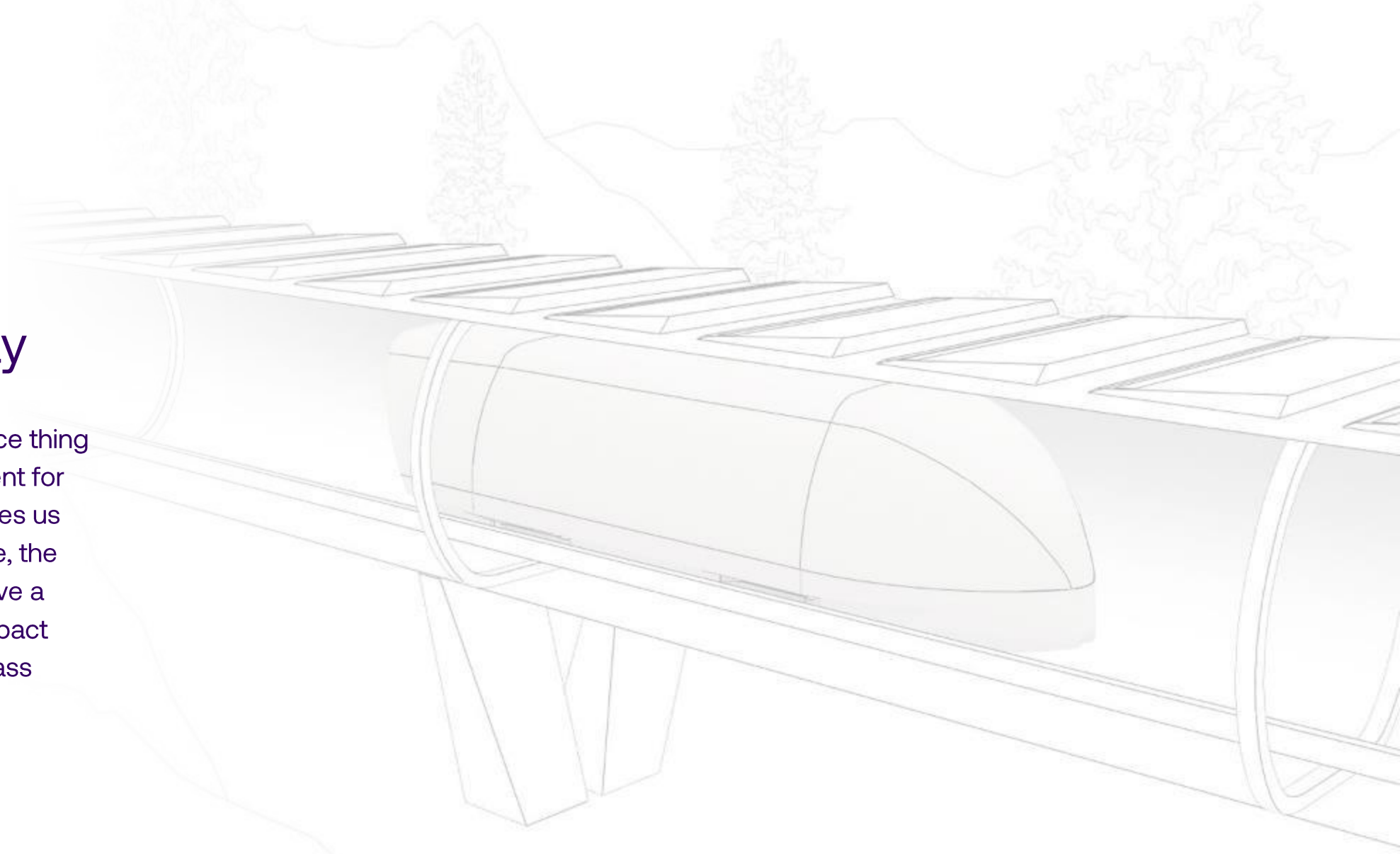

Sustainability

Sustainability is not a nice thing to have; it's a requirement for transportation that moves us forward. Over its lifetime, the Virgin Hyperloop will have a lower environmental impact than other modes of mass transportation.

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Where We Are

Our Engineering Progress & Upcoming Goal

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Delivering Results in Years, Not Decades

- Test track located in North Las Vegas, NV
- Tube length of 500 m
- World's 3rd largest vacuum structure
- Top speed reached: **387 km/h (240 mph)**
- 400+ test runs

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DevLoop Test Site

- Located in North Las Vegas, NV
- Tube length of 500m
- World's 3rd largest vacuum structure
- Top speed reached: 387 km/h
- 400+ test run

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Working Towards U.S. Certification

- Building on our continued testing at DevLoop we are continuing to refine & mature our proven technology we are:
  - Integrating systems into systems-of-systems
  - Optimizing data flow between nodes, control architectures, & performance

- The *newly announce* HCC (Hyperloop Certification Center) in West Virginia will help hyperloop achieve:
  - Key technological milestones, like faster speeds and turning
  - Key political milestones, like creating a national framework for safety certification

Full-Scale

The Hyperloop Certification Center would house a track that is at least

6 miles long

Coming Soon

Our goal is to achieve certification by the year

2025

The System

Central Command & Control

Central to ensuring our system safety & efficiency - directing infrastructure and portal (station) operations & optimizes the flow of traffic.

Infrastructure & Portals

Networks of tubes connecting destinations, pumps reduce air resistance, communication systems provide fast trip information & entertainment.

Passengers

Our passengers—their needs and *experience* are central to our system design. Optimizing their transportation is our goal.

Pods

Small pods (up to 28 passengers) provide direct to destination journeys at high frequency. The system will dynamically size available fleet in the system to match demand.

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Capella First Target: Passenger Pod

- Passenger/cargo compartment
  - ECLSS (environmental control & life support systems)
  - Vacuum compatible
  - Passenger Entertainment & Information systems
- C&C Systems
  - Autonomous operations
    - Nominal & off-nominal situation handling
  - On-board systems monitoring
  - Direct to destination
  - Route handling (joining/existing alignment), convoying (enables each pod in a convoy to function as a train-car)
- Sensing
  - Line of site sensor package (like in autonomous cars)
- Communication System
  - Pod-Pod communication (Similar autonomous cars in completely dedicated lanes)
  - Far-Field Communication
    - For route information & guidance
    - Passenger Entertainment

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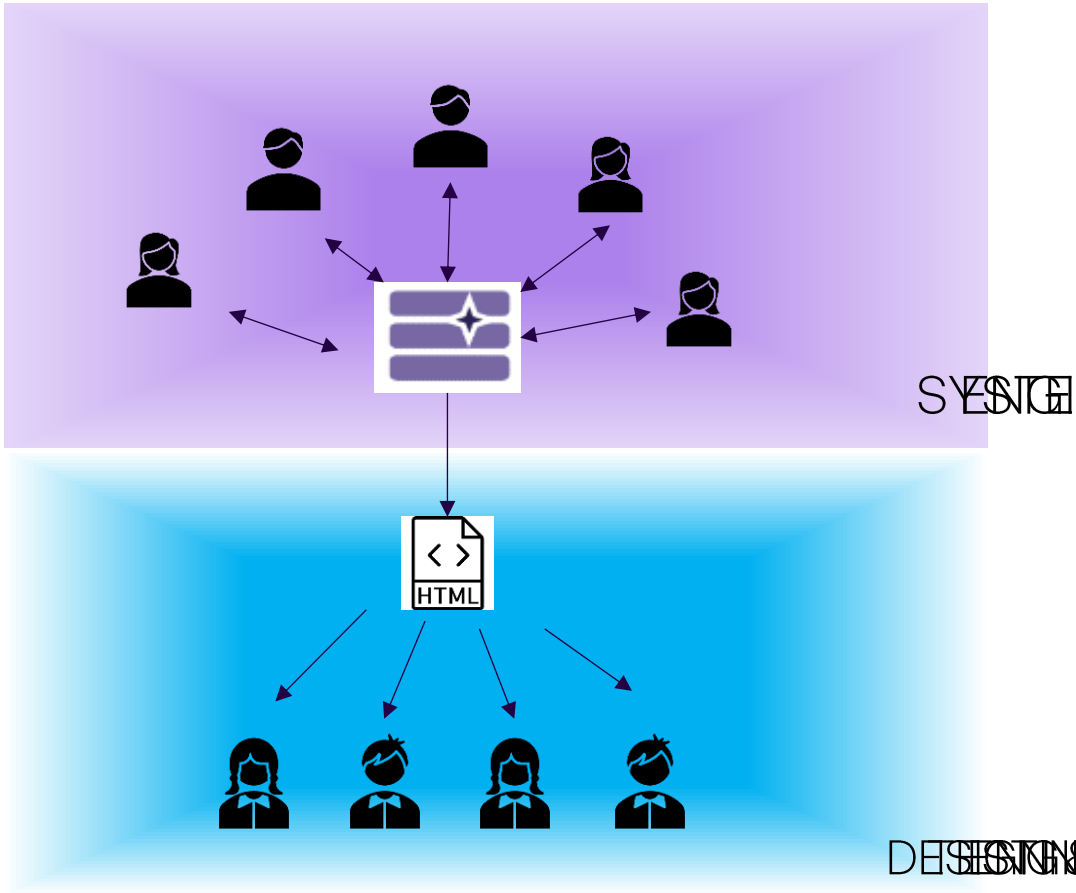
Our MBSE Configuration (Currently)

- Model-Augmented Engineering Process Currently
- Utilize Capella v1.4.0
  - Differentiate between human & non-human (decomposable) Actors – extremely helpful with analyzing internal & human driven scenarios
- Primarily utilize Logical Architecture & Physical Architecture perspectives
  - Maturity of our technology gives the most benefit from efforts in these perspectives
- Custom Properties & Diagram Styling
  - Consistent diagram styles & key enables clarity
- Requirements Add-on (via DOORS NG)
  - Augmenting model functions, exchanges, sequences with text requirements to eliminate ambiguity & aid in full MBSE adoption
- Single Passenger Pod Model
  - Team for Capella to enable co-modeling



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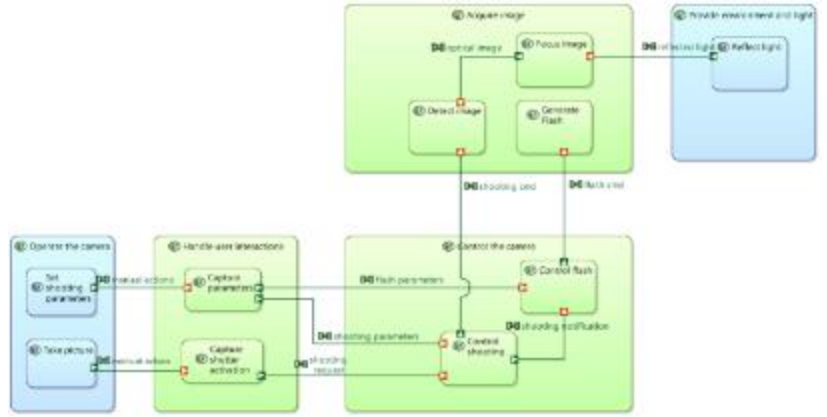
Leveraging Logical Architecture Perspective

1. Logical Functional decomposition, definition & refinement of the Passenger Pod
   - **Logical Data Flow** diagrams enabling allocation-agnostic functional breakdown & information network design
   - **Logical Function Breakdown** diagrams provide organized traceability to find breakdown inconsistencies
2. Logical Component decomposition, definition & refinement
   - **Logical Architecture** diagrams enable complete view of component functional scope
3. Behavioral Analysis of the system in given circumstances
   - **Functional Chain** – on top of Data Flow or Architecture diagrams allows broad definition of behavioral flow through the network

     ~~transition~~
   - **Exchange Scenario** – provided accurate Functional Chain, enables detailed sequencing, mode change, & timing definition expected from the system **(+function allocation)**

1.



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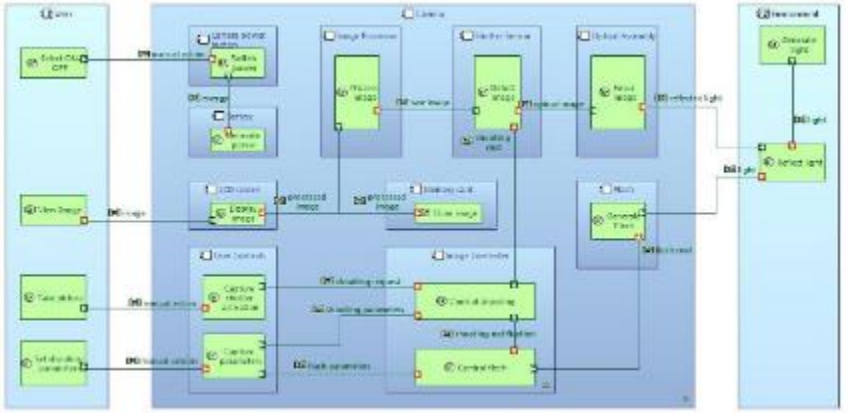

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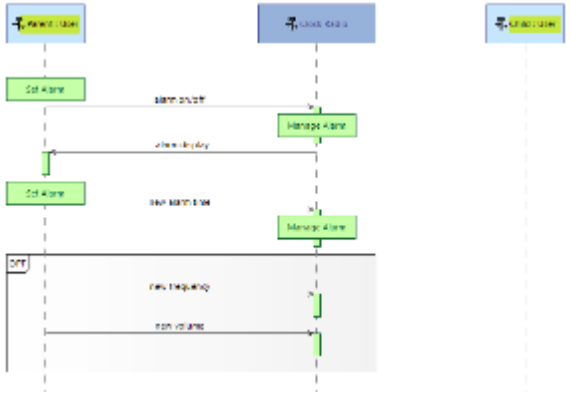

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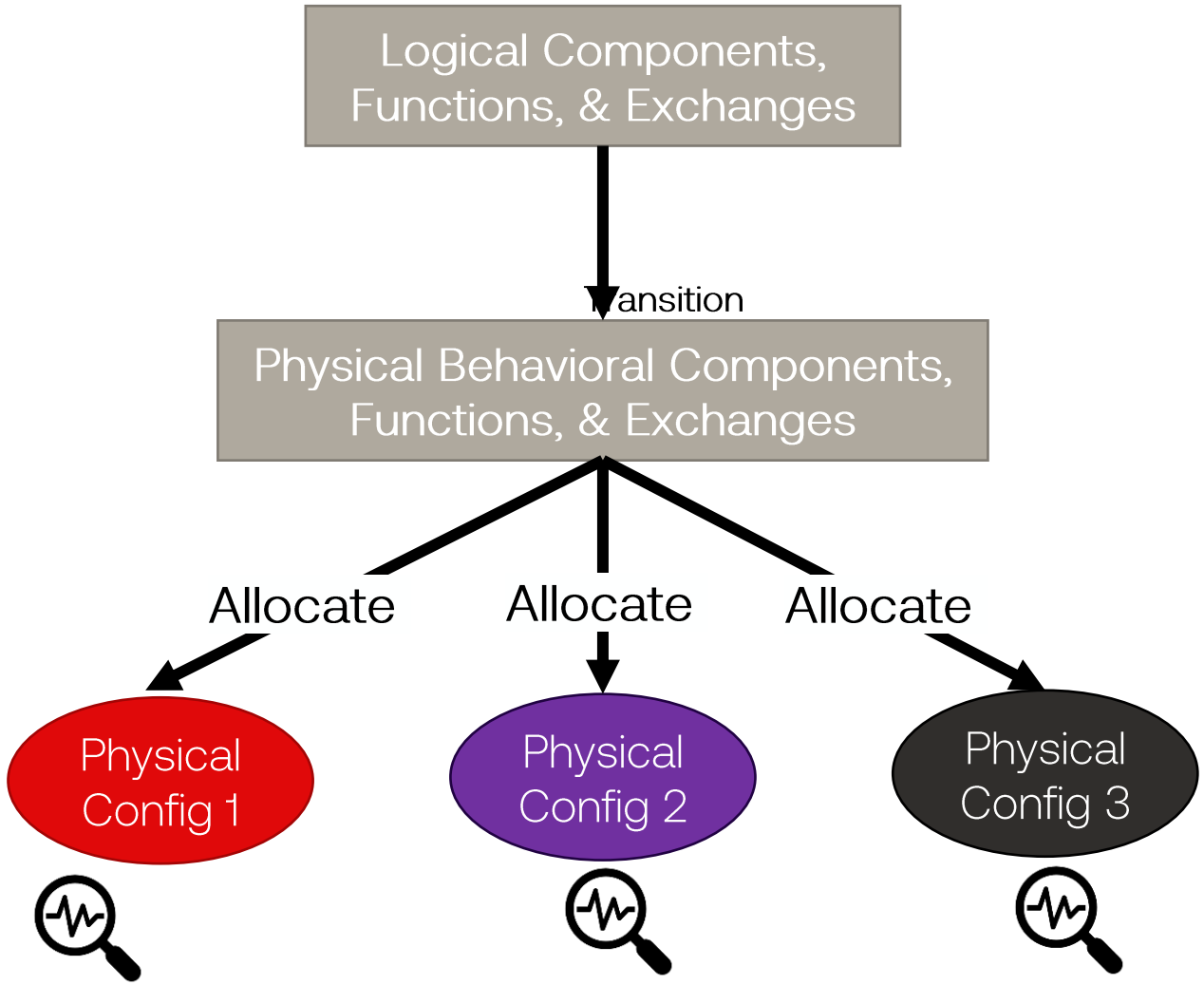
Leveraging Physical Architecture

For multiple physical configurations:

- Detail physical implementation of the Passenger Pod to the lowest detail – *Focus on Physical Nodes*
  - Combining data flow, power distribution, & select physical interfaces
- Transition and allocate Logical Components (and allocated functions) as Behavioral Components to Physical Nodes
- Analyze *select* behavioral system responses
  - Goal: Understand & define system response where implementation specific



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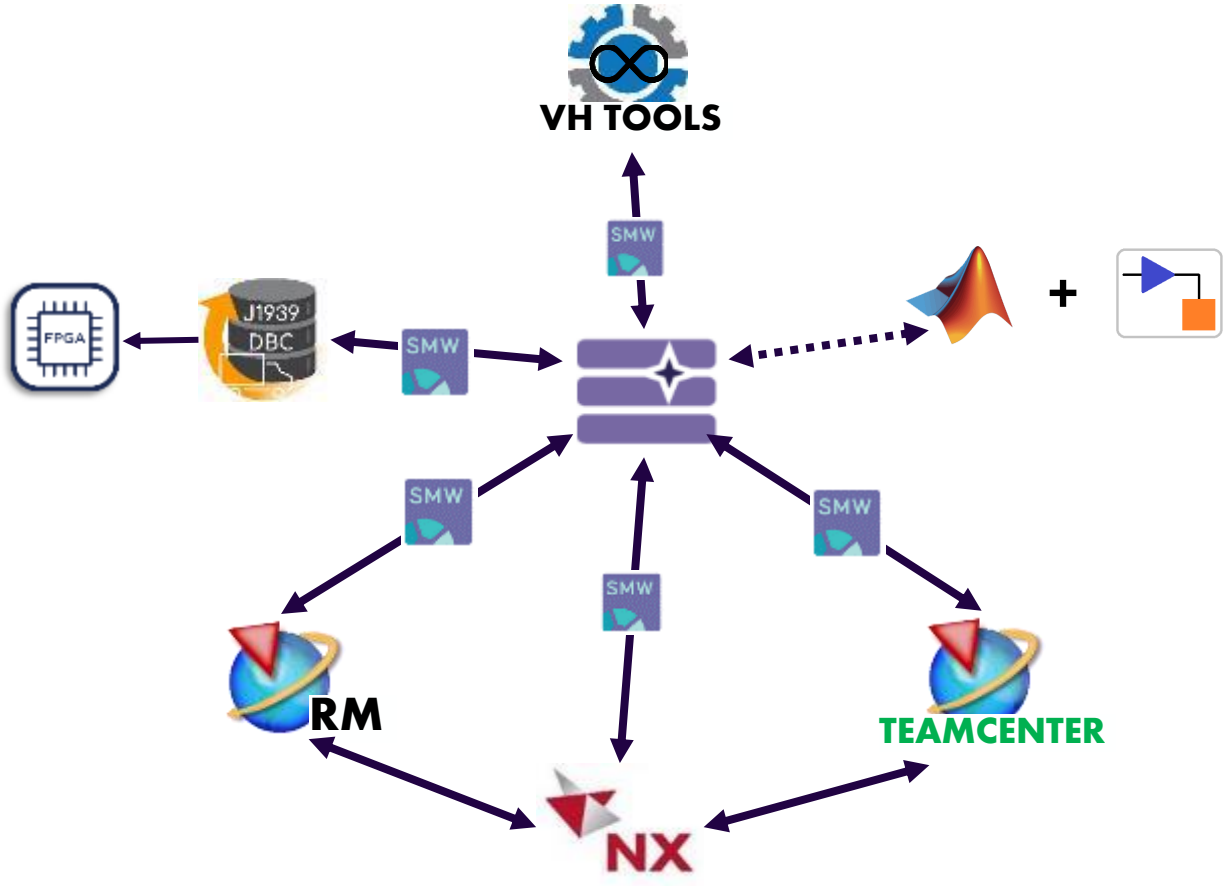
Next Steps: Model Augmented ➧ Model Centric Engineering



- Capella is central to enabling fast-paced execution of the technically complex, safety critical system of systems - Hyperloop:
  - Efficiencies in Model-Centric & Model Based engineering critical to schedule
  - Cross-tool integration minimizes human error (e.g. document ICDs)
- System Modeling Workbench integrates Capella into TeamCenter Product Lifecycle Management & TeamCenter Requirement Management
  - Enhanced model/requirement augmentation
  - Provides Model Lifecycle Management processes to ensure quality & change control
  - SMW library/dependency management & System-to-Subsystem transition enable granular models
- SMW/TC & Capella API allow for custom integrations with analysis & development tools

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Questions?

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