Swiftube

(A Different Approach to "Hyperloop")

This will be the single greatest feat in human achievement that will have the biggest impact on personal travel, climate change, and the transport of goods undertaken since the freeway system.

Swiftube will provide a lasting, safe, efficient, and fast global network for transport, FOREVER.

Key differences: No Vacuum tubes or levitation.

Instead, ***Swiftube*** utilizes a smooth, low-drag tube and large-diameter rail-like wheels to simply, swiftly, and smoothly transport passengers and goods from point "A" to "E", skipping B, C, and D (unless a break is desired - at any time).

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Any company/government using this PROPRIETARY and PATENT-PENDING information agree to a Swiftube/Spice of Life Ventures, LLC a royalty of US$0.01 for every 100 miles (162 km) of pod/capsule travel.

What is Our Ideal Transportation System?

- "Beam me up, Scotty"... Maybe in 1000 years… Must be Realistic

- The five (prioritized) principles: Safe, Cheap (reasonably priced), Fast (incl. easy on/off), Comfortable, and Efficient/Clean. After "reasonably safe", most people value fast and cheap and do not prioritize comfort or how energy-efficient it is.

- Can transport our EV / Car with us, or have unlimited configurations (private pods).

- Enjoyable: bar, internet/cell service, watch zipping by the countryside and cars.

- Walk out of our home, get into a pod that quickly takes us anywhere in the world (i.e. Tom Cruise's Minority Report movie)

- Must include standard shipping containers if we want to make a dent in climate change.

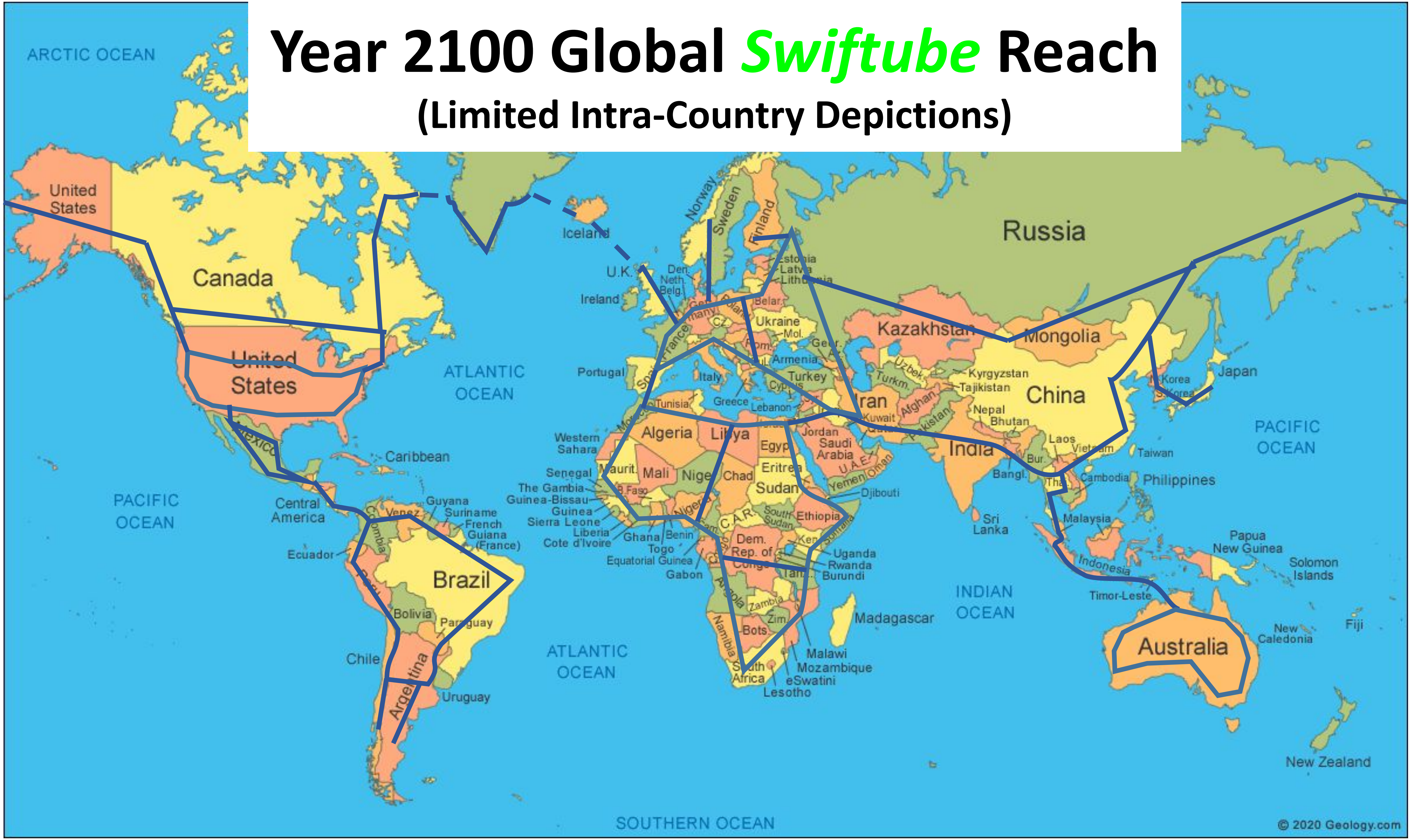
So What’s Wrong with Hyperloop?

- Most Hyperloop concepts rely on a vacuum. Vacuum = outer space = costly inspections, cleanliness standards, rigorous testing, and likely some deaths.
- Most Hyperloops employ magnetic levitation, which requires superconductors that are both hard to mine (rare earth elements) and expensive to operate/cool. Japan’s newest maglev train is costing over €260M per km and struggling with issues.
- Large-diameter vacuum tubes require strong materials (steel), so windows in the pods and tubes is challenging. Nearly half of the customer base will not ride.
- Multiple system exits and entries multiply the cost. High volumes of pods/traffic are unattainable due to lock-in/lock-outs.

***We have been so consumed with “can/how”, we forgot to ask “Should we build it?”**

Year 2100 Global *Swiftube* Reach

(Limited Intra-Country Depictions)

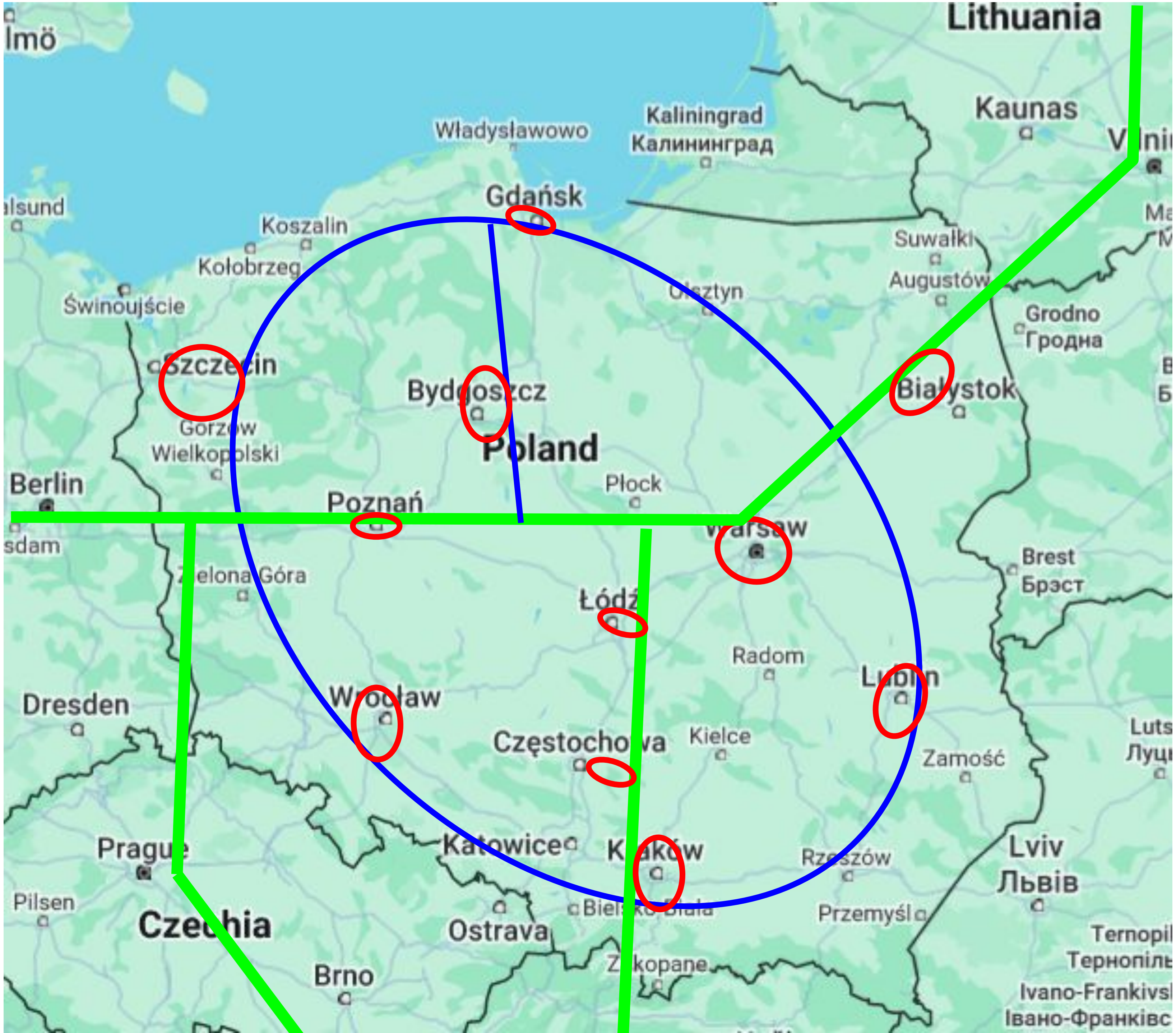


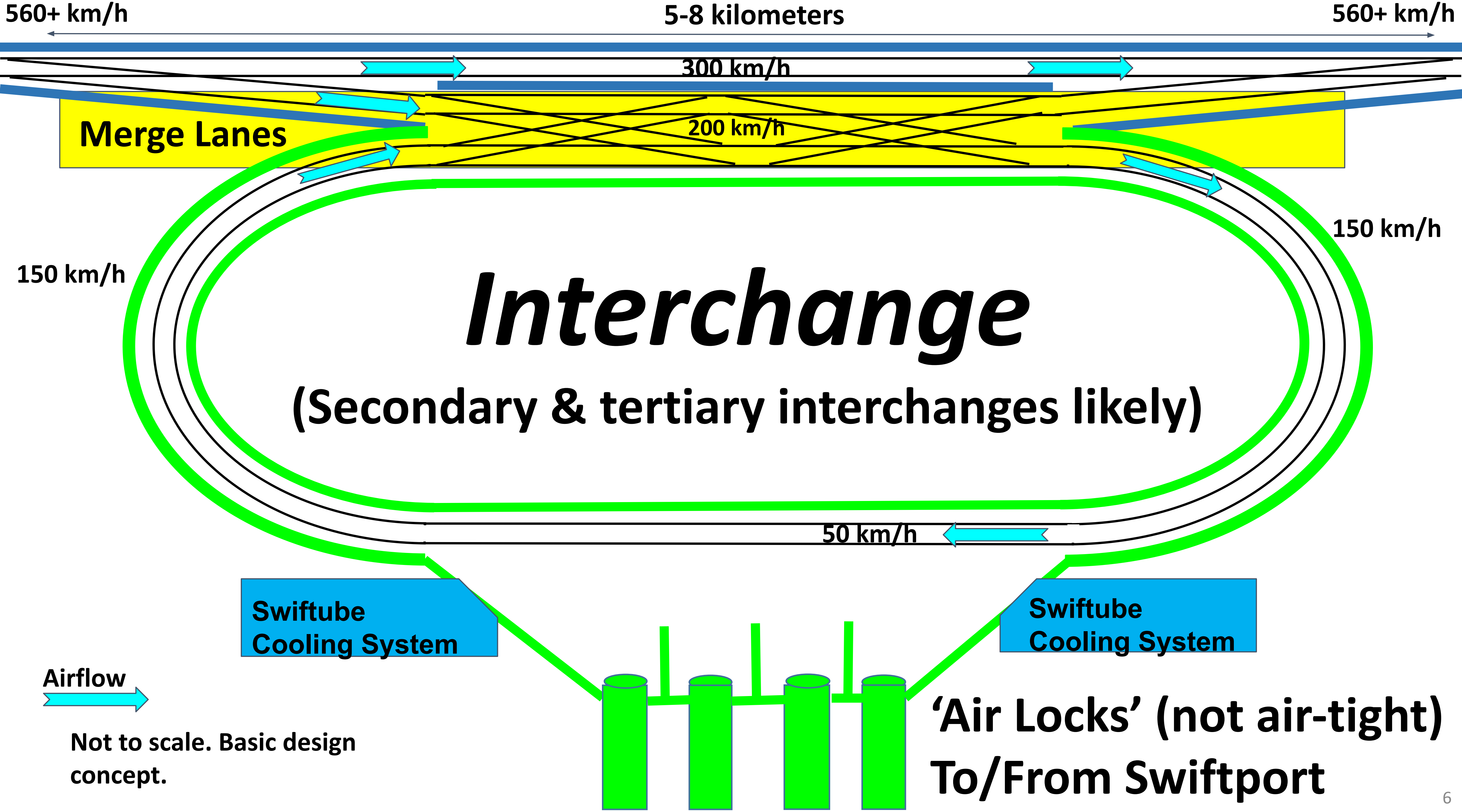
Poland's *Swiftube* Development

◯ **Primary** ***Swiftube*** Loops
(one each direction)

⬯ **Secondary** ***Swiftube***
Loops for entry/exit

╲ **International**
Swiftube
Loop





560+ km/h

5-8 kilometers

560+ km/h

300 km/h

Merge Lanes

200 km/h

150 km/h

150 km/h

Interchange

(Secondary & tertiary interchanges likely)

50 km/h

Swiftube Cooling System

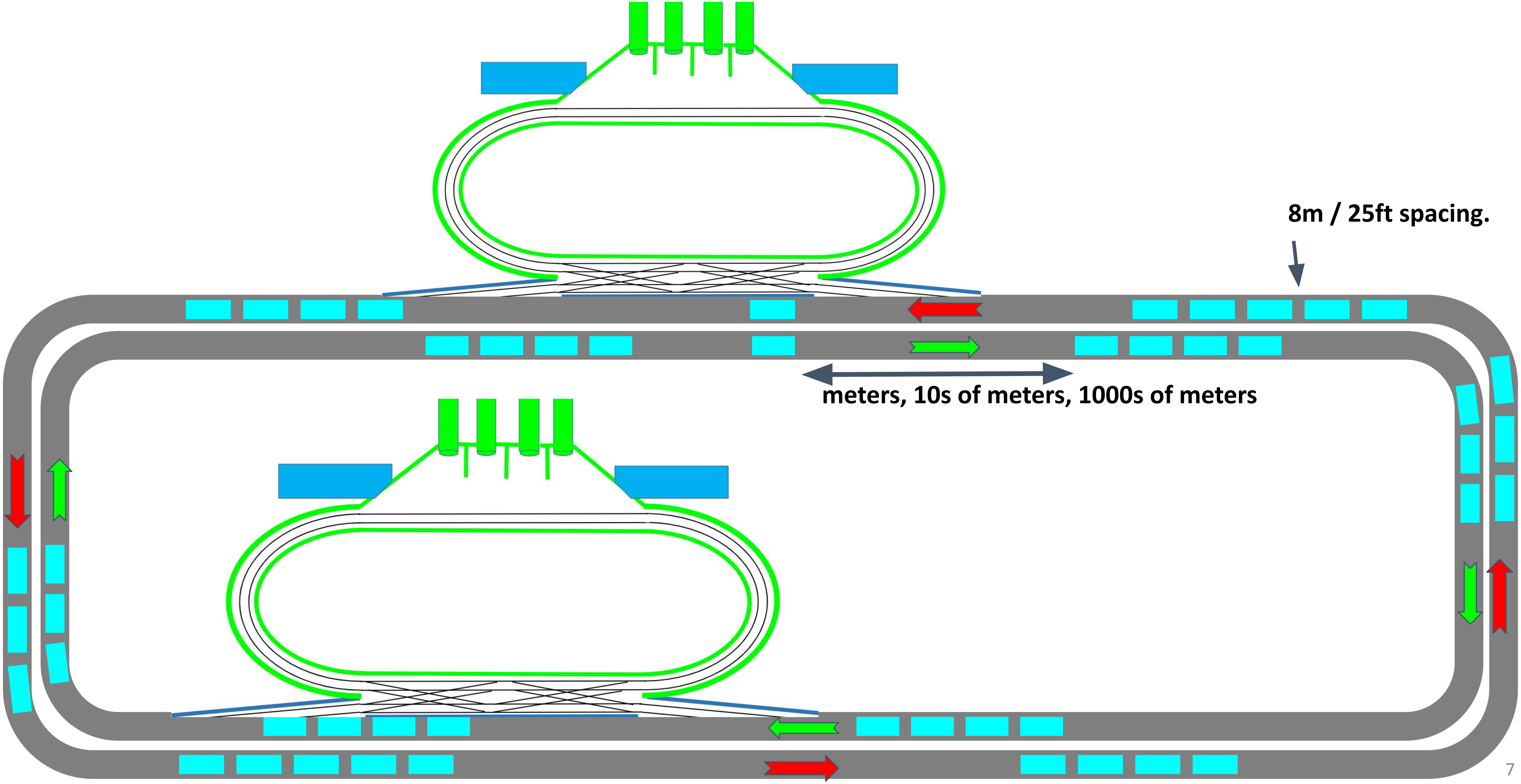
Swiftube Cooling System

Airflow

Not to scale. Basic design concept.

‘Air Locks’ (not air-tight) To/From Swiftport

Pod Grouping to Improve Speed & Efficiency



Energy Use / Cost Comparisons

Car: Average 20km/l, €1.80/l = $0.09 per km. Avg 2 passengers = €0.045 per passenger-km (€.045 / p-km)

Conventional train: Average 0.21 km/l = €4.8 per km. Avg 500 passengers, €0.01 / p-km

Plane: Average 0.21 km/l = €4.8 per km. Avg 125 passengers, €0.04 / p-km

Freight Train: Average 209 tonne-km per liter. Avg 20-ton container gets 10.5 km/l, €0.17 per container-km(c-km)

Swiftube: Average spacing of 100m. 240kw of power at 300 km/h = 0.8kwh per km = €0.23 / c-km, and €0.005 / p-km. Could even be ¼ this spacing (4x more efficient, or 2x faster). With wind and solar power utilized over the majority of the network, ***Swiftube*** energy costs are driven even lower.

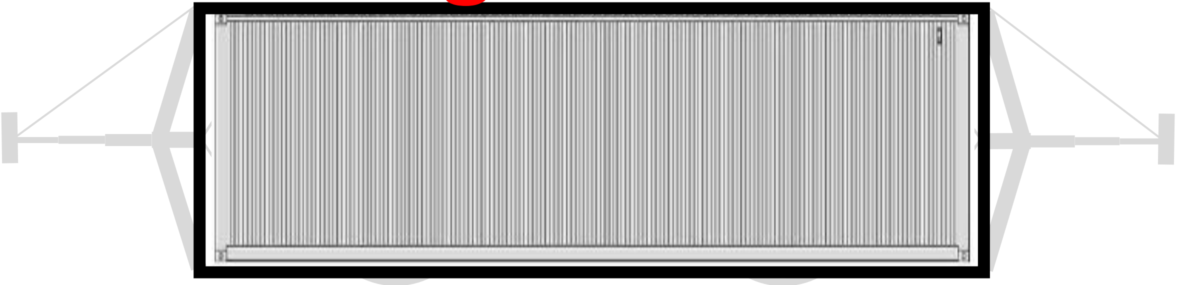
Transrapid Maglev: 41 kWh/km(1) at 450km/h = €1.40 / c-km, and €0.03 / p-km. However, at slower speeds, and without (or at least fewer) point-to-point transit options.

TVG High Speed Rail: 29.4 kWh/km(2) at 320km/h = €1.02 / c-km, and €0.02 / p-km.

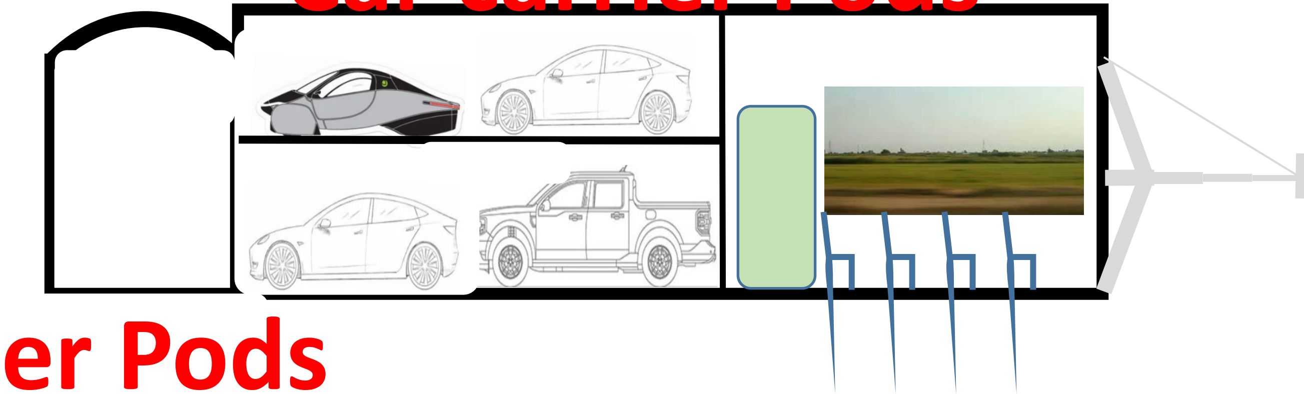
[1] ENERGY CONSUMPTION OF TRACK-BASED HIGH-SPEED TRAINS: MAGLEV SYSTEMS IN COMPARISON WITH WHEEL-RAIL SYSTEMS by E. Fritz(Institut für Bahntechnik (Dresden, Germany)), J. Klühspies,R. Kircher, and M. Witt (The International Maglev Board), L. Blow (Maglev Transport consulting group (Arlington, USA))

[2] TVG Wikipedia

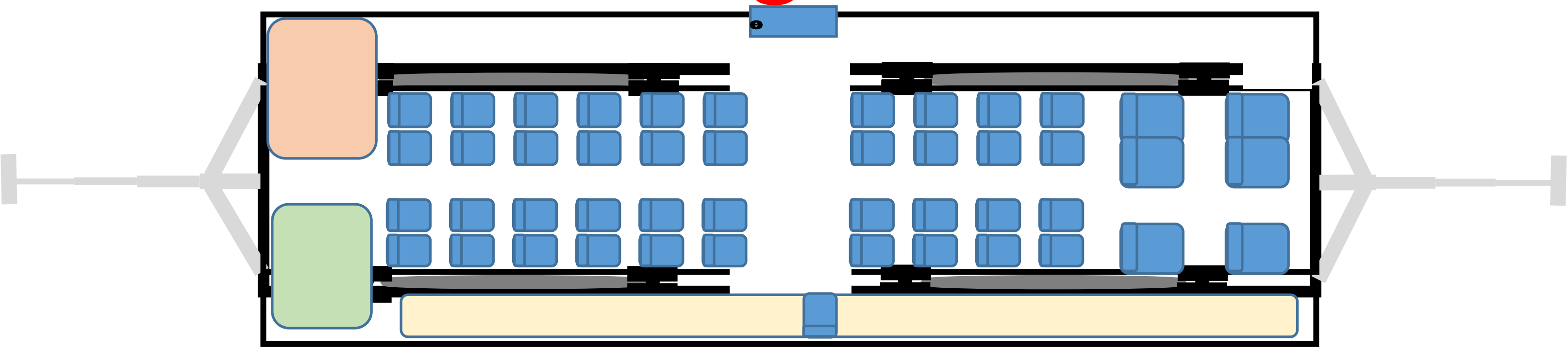
Freight Pods



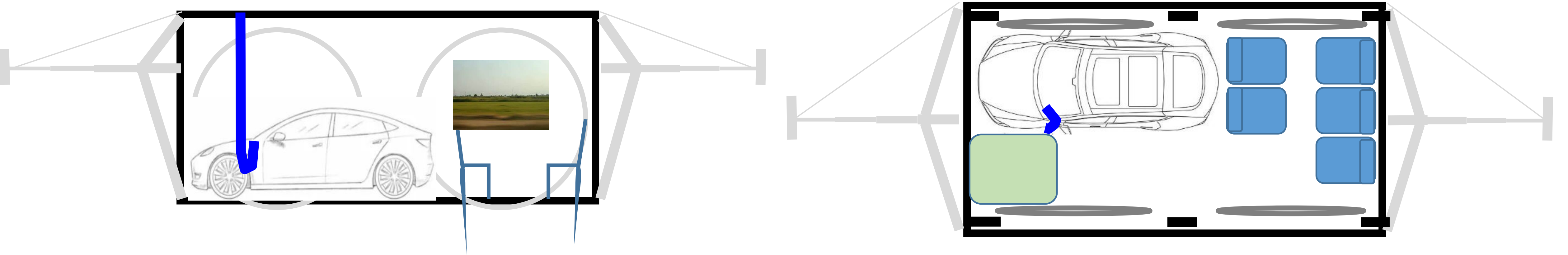
Car carrier Pods



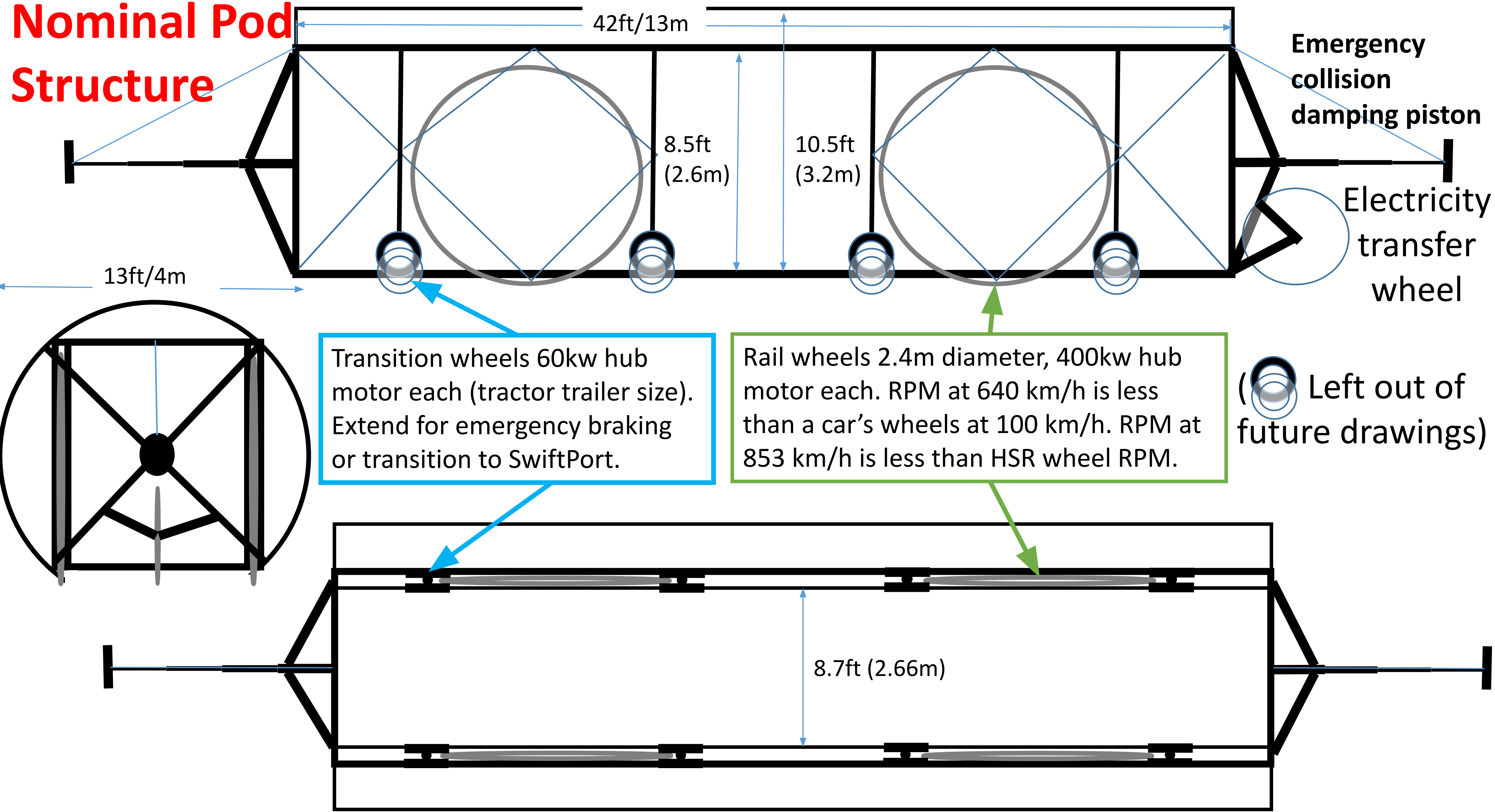
Passenger Pods



Individual Pods



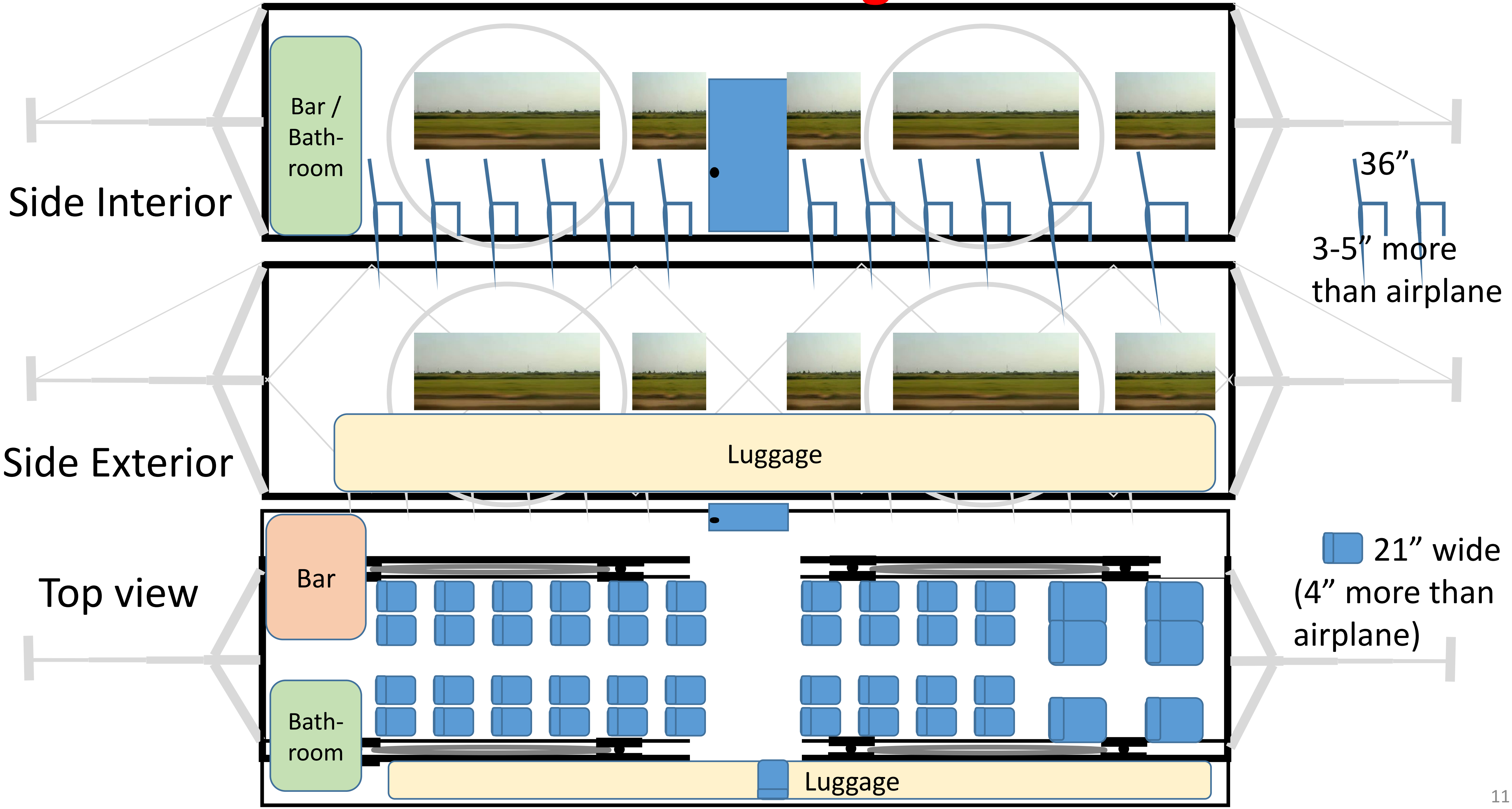
Nominal Pod Structure



Transition wheels 60kw hub motor each (tractor trailer size). Extend for emergency braking or transition to SwiftPort.

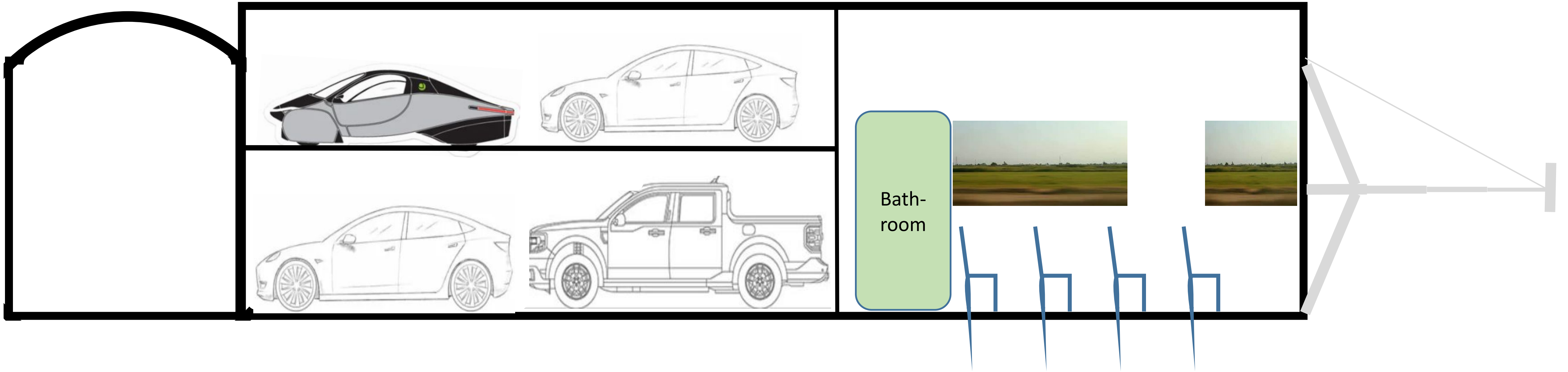
Rail wheels 2.4m diameter, 400kw hub motor each. RPM at 640 km/h is less than a car's wheels at 100 km/h. RPM at 853 km/h is less than HSR wheel RPM.

Nominal Passenger Pod

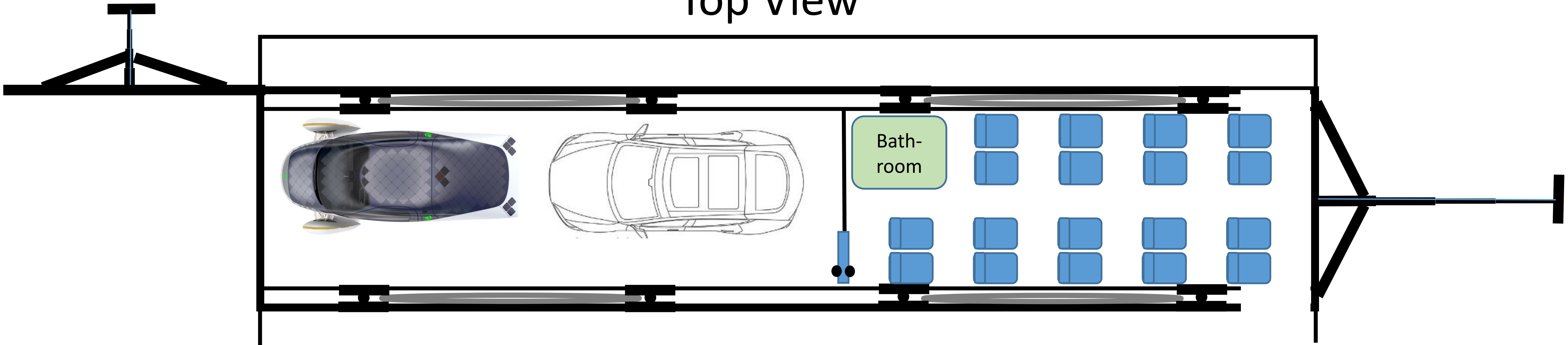


Multi-Car Carrier Pod

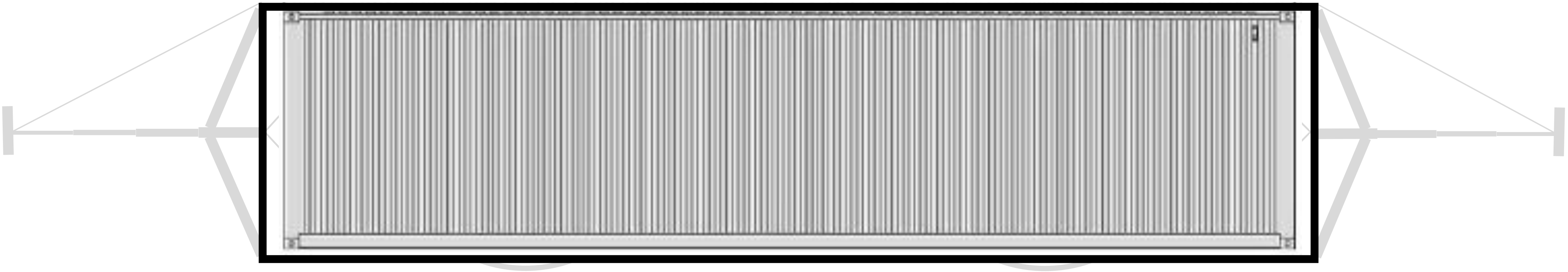
Side View



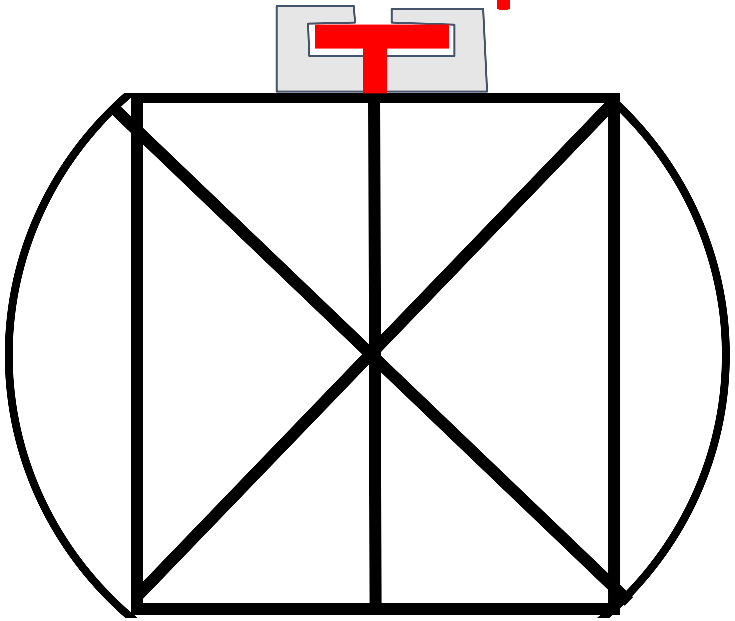
Top View



CONEX Box Pod



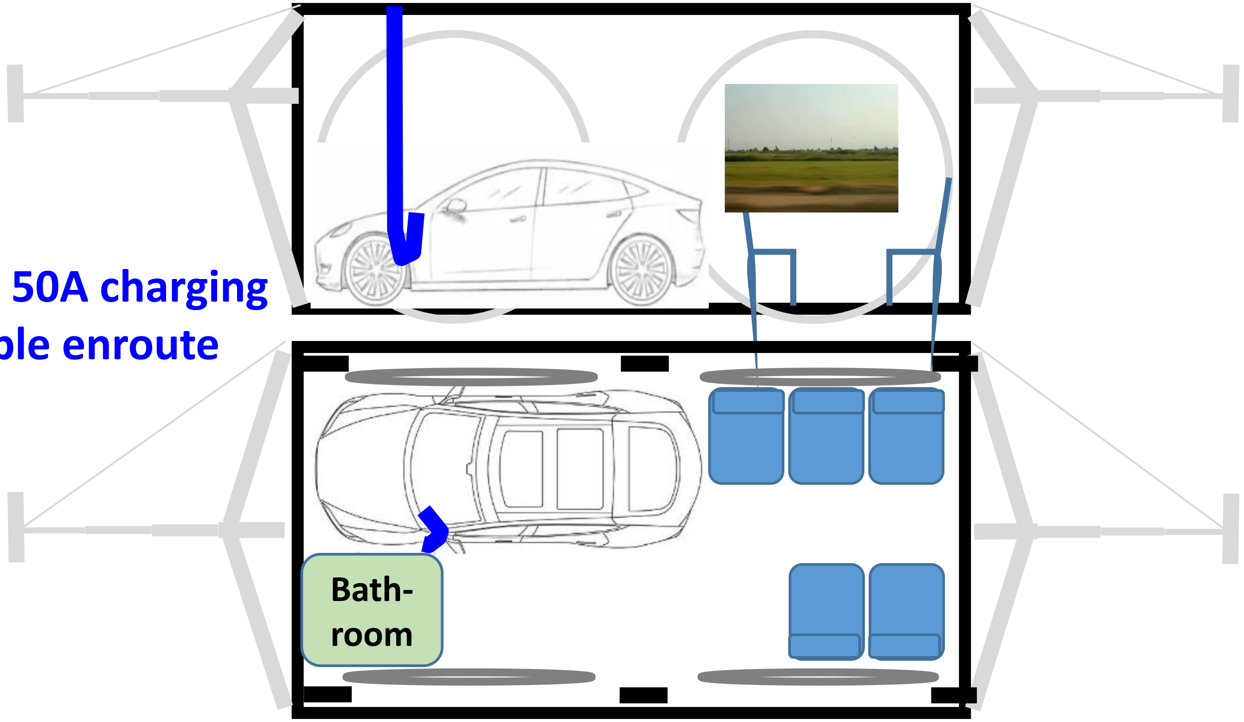
MAGLEV Option



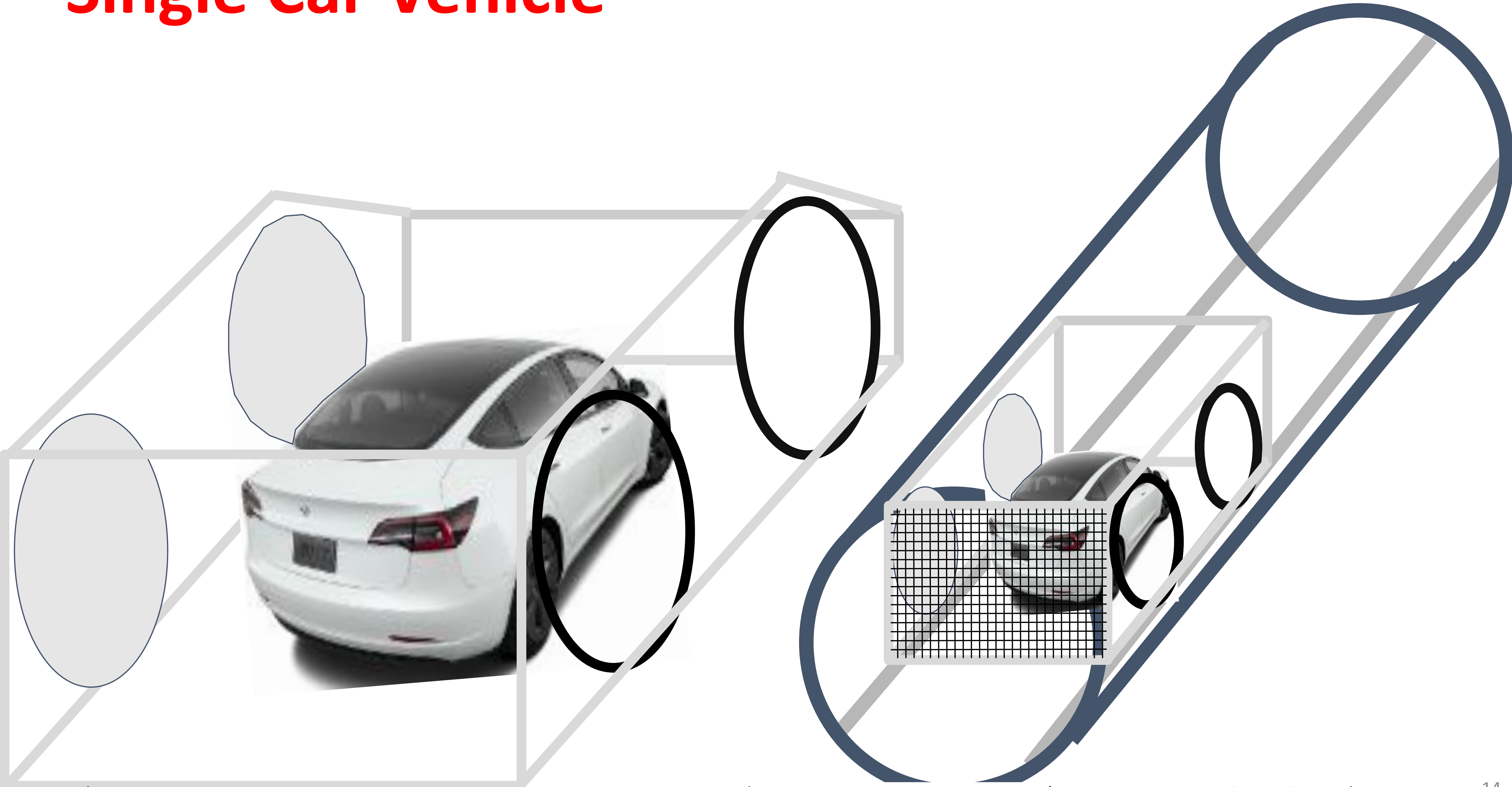
Swiftube **Design will incorporate the ability to eventually transition to magnetic levitation, once the technology matures with better high-temperature superconductors.**

Smaller Single Car Pod

240V - 50A charging available enroute



Single Car Vehicle



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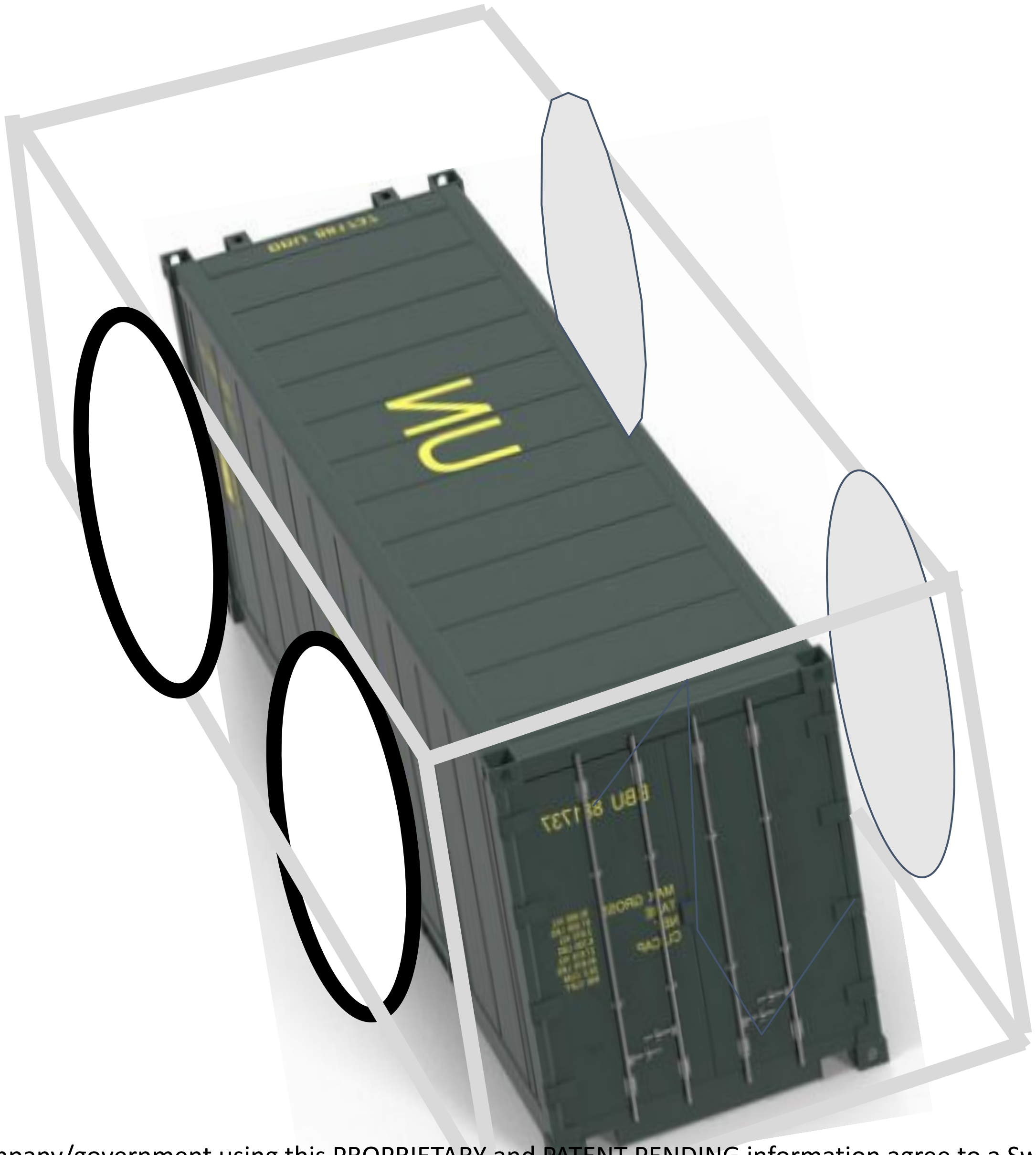
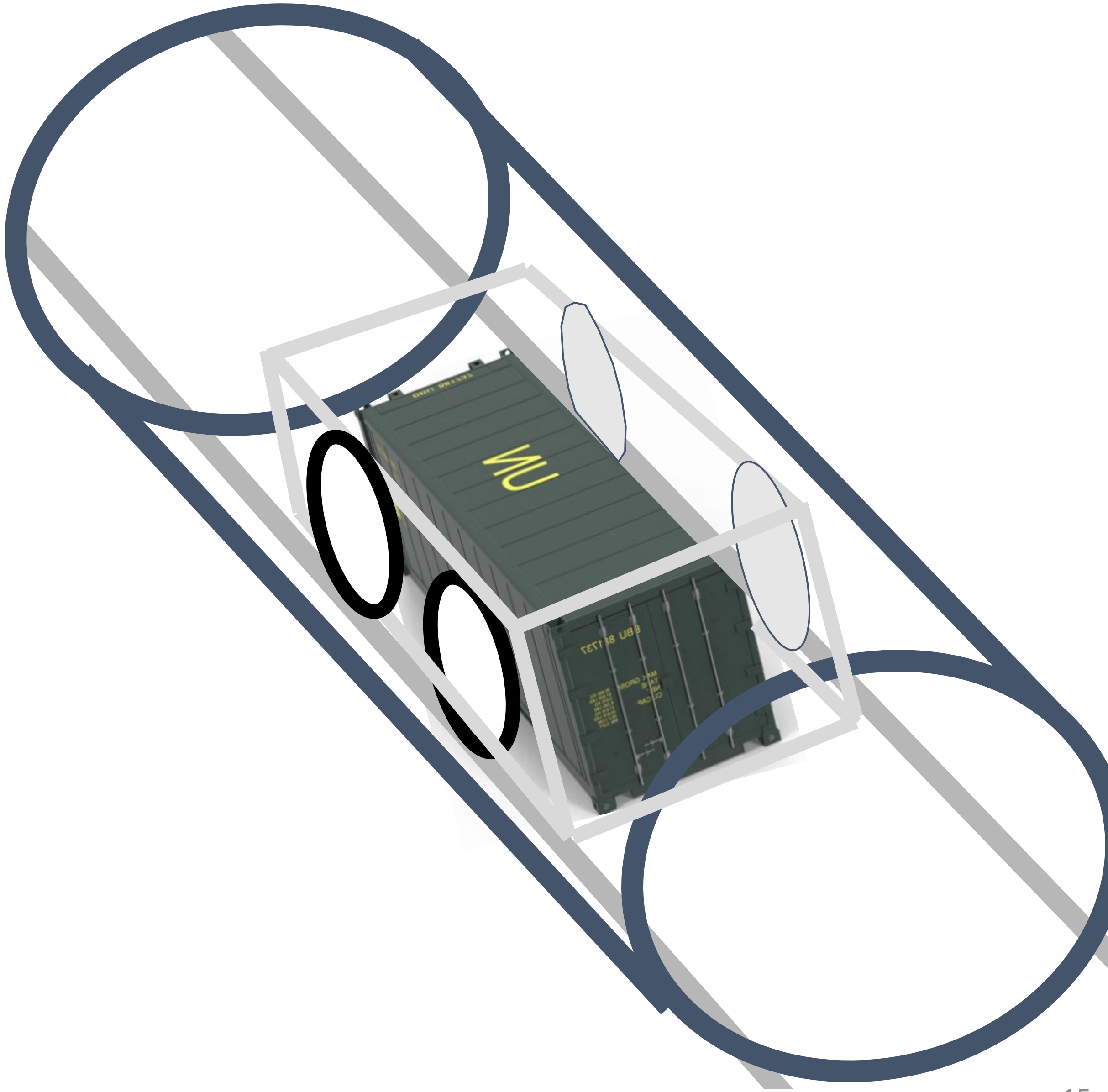
Shipping Container Vehicle





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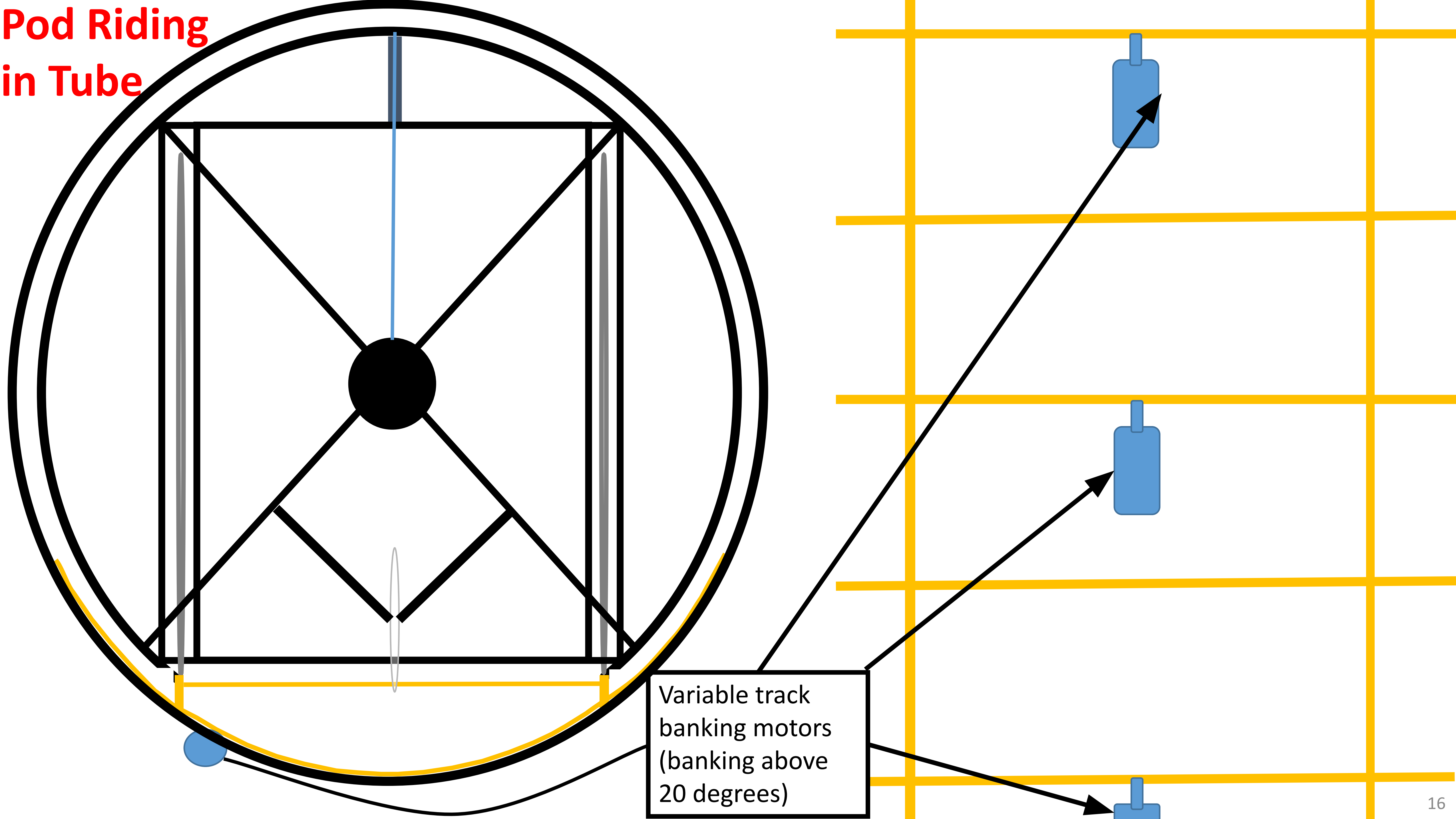
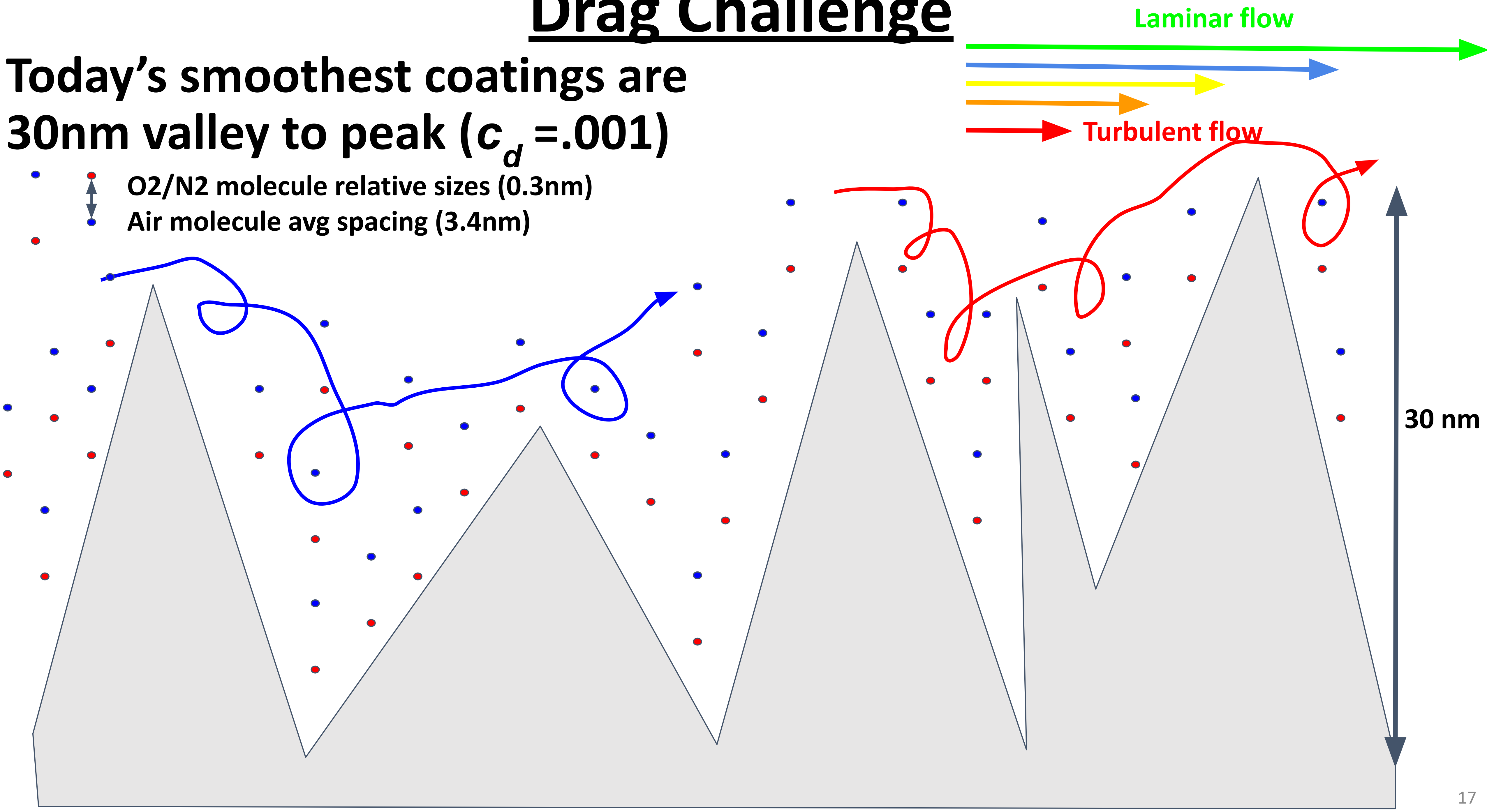
Pod Riding in Tube



Variable track banking motors (banking above 20 degrees)

Drag Challenge

Today's smoothest coatings are 30nm valley to peak (c_d =.001)



O2/N2 molecule relative sizes (0.3nm)

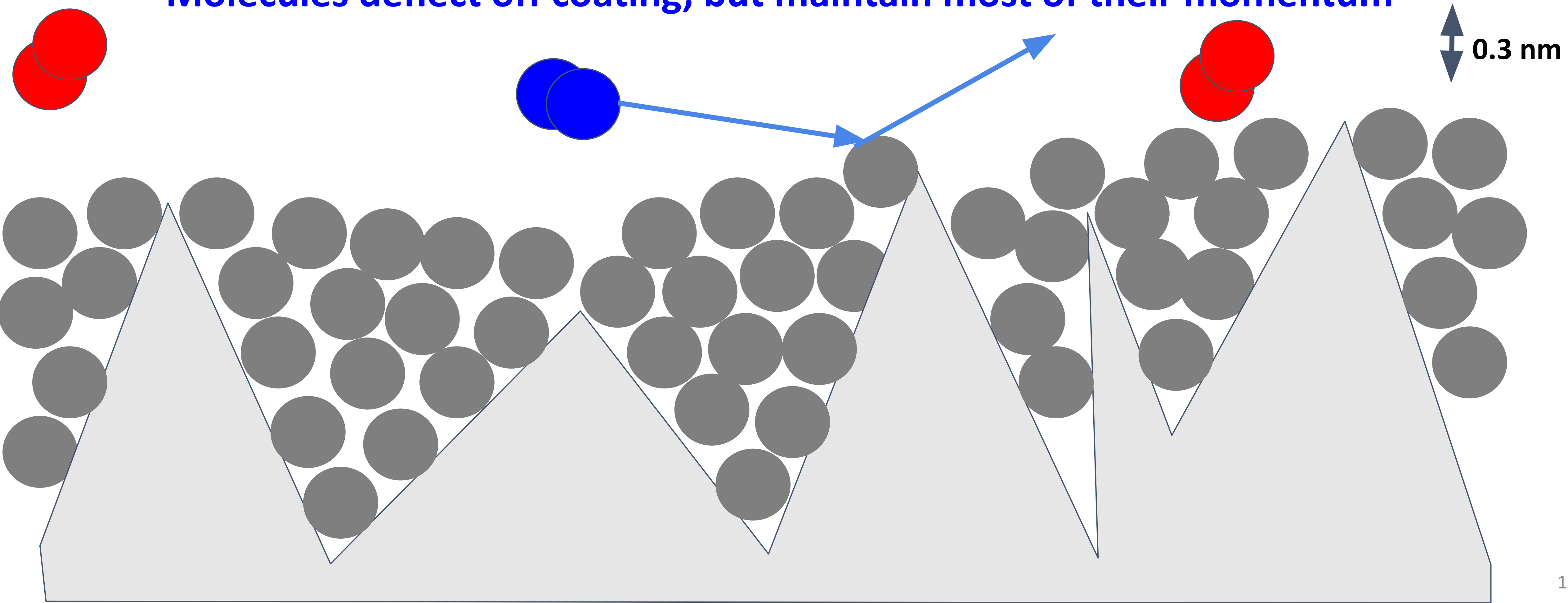
Air molecule avg spacing (3.4nm)

Reaching for a Smoothness <.00001 c_d

Carbon, Lithium, Water all equal or smaller molecules than O2/N2

O2/N2 molecule relative sizes

Molecules deflect off coating, but maintain most of their momentum



Drag and Power Calculations

(200 km / 125 mile full-scale track)

Assumptions: 200 km (125 miles) tube, 4m (13.1ft) diameter (smaller surface area for flat bottom offset by 3-track surface area), electric motor/pod is 100% efficient, drag coefficient (c_d) of .001 based on 1/64” boundary layer after smoothing & low-drag aircraft paint (or film) applied, pod acting as a perfectly sealed piston in tube, treat turns as straight pipe, and no port area.

$F_d = c_d \, 1/2 \, \rho \, v^2 A$

ρ(air) = 1.2kg/m^3 , A = lxdxπ (200000m)x(4m)x π = 2,513,274m^2

So F_d (v)= (.001)x(0.5)x(1.2kg/m^3)x(v)^2 x (2,513,274m^2)

F_d (v)=1508 kg/m x v^2

F_d (44.7m/s or 100mph)=~3,000kN = 663,000 lbf, or 34psi on front of pod. That would require 120,100kW of energy to push around at 100mph.

600kW per pod if spaced 1km apart, or ~60kW if 100m apart. ~240kW at 200mph, ~980kW at 400mph.

Compare to ~7,200kW(1) for a 737 airplane - 7x more efficient, or 2x more efficient per passenger.

Double-checking calculations… for 100m spacing, F_d (44.7m/s or 100mph)=1506N = 67.3kW

P_{pod} (300km/h or 200mph) = ~240kW for 100m spacing.

1 Energy and Power of Flying, Andrea Eller

Safety Considerations

- Tube emergency exits will be every 2km (always 20 seconds away at 200km/h).
- Pylon and tube support systems will be “soft” for earthquake support. Earthquake sensors will exist every 10 km and trigger a system slowdown/ shutdown. Finally, redundant tube/track alignment sensors will indicate any problems that require attention.
- ***Swiftube*** systems are inherently safe any high-volume, containing any crash/ derailment to inside the tube. Interconnecting pod/system sensors immediately slow following pods in the event of a stoppage.
- Transition wheels act as emergency brakes in the event of an emergency. They are also capable of moving a pod under battery power to the next interchange.
- Fire safety features include fire extinguishers in each pod, non-flamable construction, batteries mounted externally, and fire suppression systems for the wheels.
- Continuous video monitoring and calls within a pod to direct passengers how to proceed in an emergency.

Safety Considerations, continued

- Air is frequently changed out in the tube via ports and leakage.
- Pods would be designed to limit noise for a smooth, quiet ride. It would be quiet outside of the tube as well.
- Areas tunnelled under waterways and oceans would have an interconnecting tube that would include hatches rated to the sea pressure above, and alerts/communications via each tube to ensure a quick escape.
- “Instant backing” feature in each tubeway between interchanges to allow immediate removal from the danger area of any pods stuck behind a crash, fire, or flooding casualty (terrorist action).

Hypothesis and Conclusions

- Hyperloop systems offer superior speed and possibly lowest energy costs (until near-zero drag coatings are developed).

- Hyperloop construction costs are estimated at $55M/mile (€30M/km)
  - Complex energy delivery (superconductors), tube, and control systems dominate cost.

- ***Swiftube*** construction costs are less than ⅓ that of “traditional” Hyperloop systems. - PVC/HDPE compared to steel. Simpler energy delivery. Complex controls needed.

- ***Swiftube*** systems rely on minimizing drag, compared to Maglev and vacuum tube challenges.

- Hyperloop vacuum tube systems can’t realistically incorporate freight (half of transportation-related greenhouse emissions).

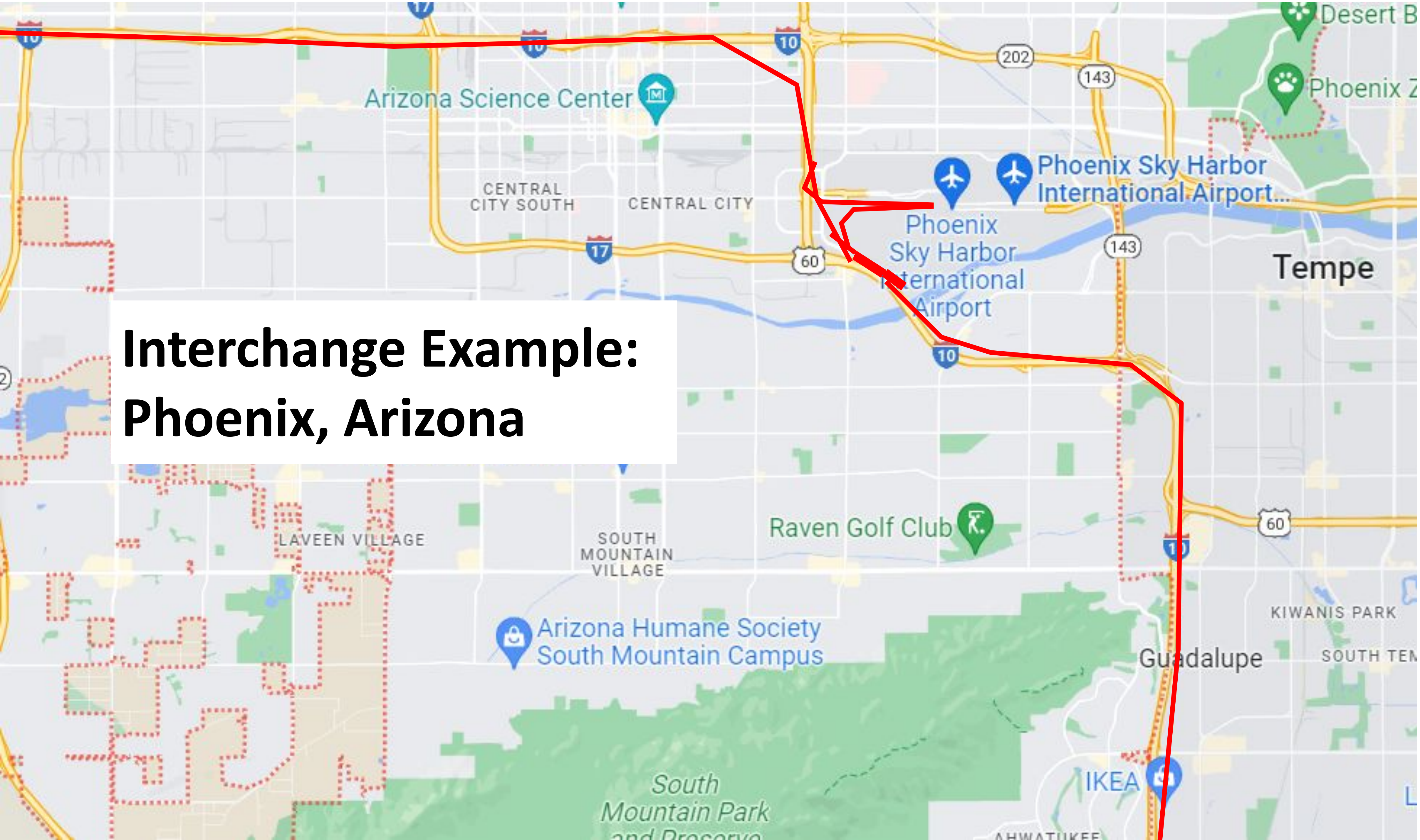
- ***Swiftube*** systems are inherently safe with high-volume and offer quick escape in an emergency.

Backup Slides - Calculations and test considerations

US, Canada, and Mexico Primary Loop Development

Phase 1 2035
Phase 2 2040
Phase 3 2045
Phase 4 2050
Phase 5 2055+
Rx ~Two 2GW Nuclear / Fusion Reactors

Interchange Example: Phoenix, Arizona



Interchange Example Phoenix, Arizona (continued).

Merge Lanes

(North/West)

(South/East)

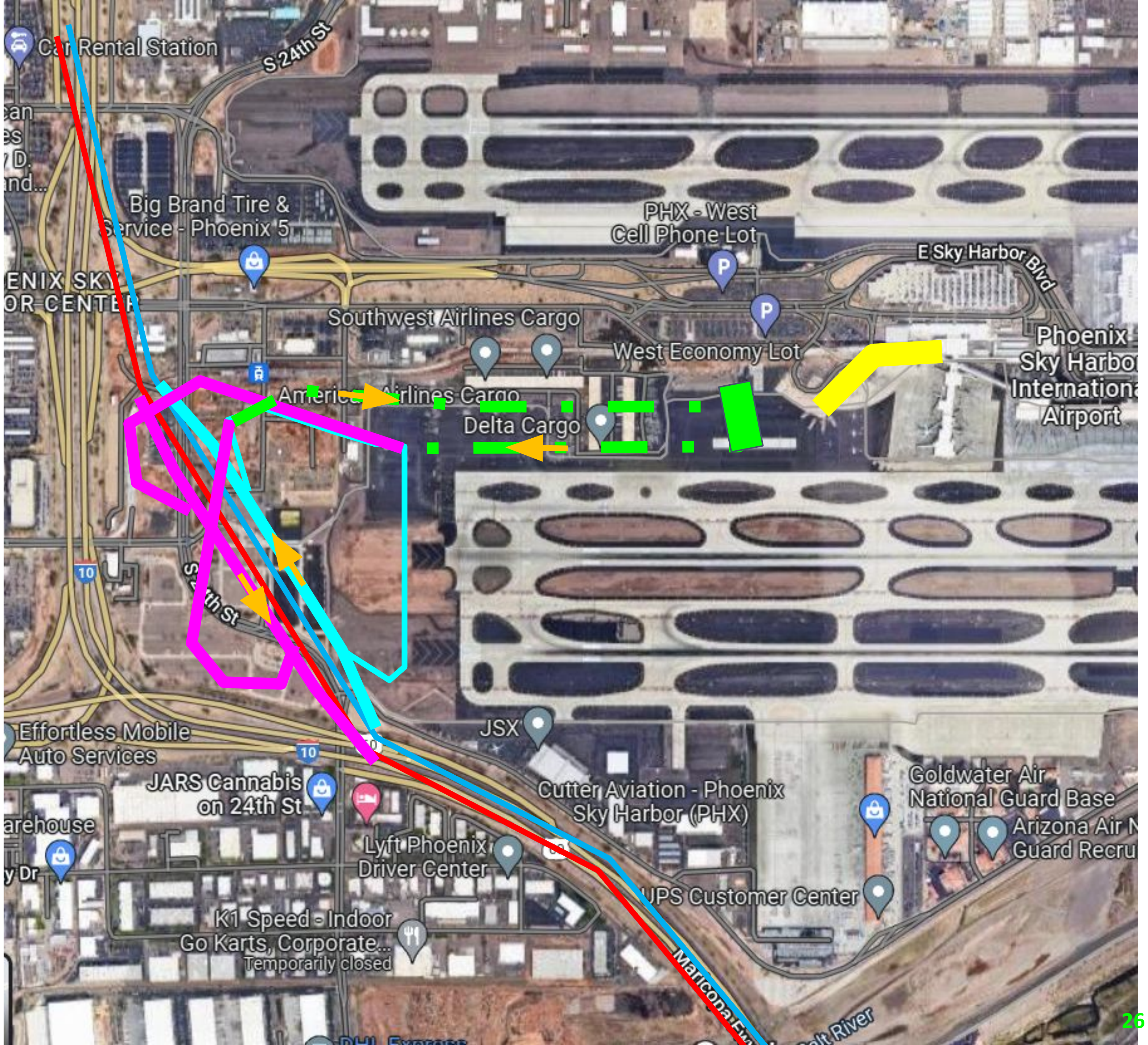
Through-tubes

West-bound

East-bound

Combined On/Off Tube

New Swiftube Terminal

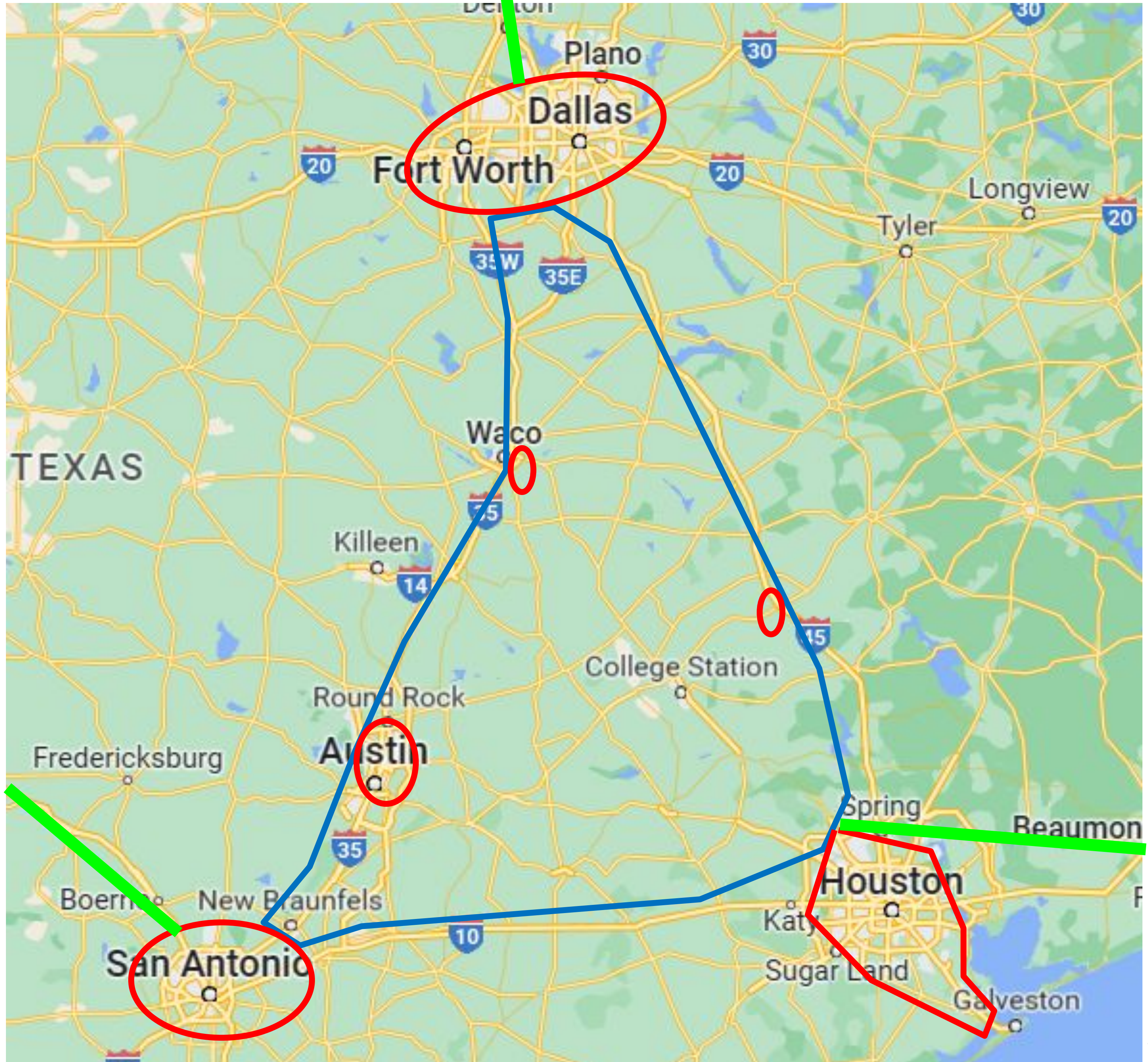


Texas *Swiftube* Development

Primary ***Swiftube*** Loops (one each direction)

Secondary ***Swiftube*** Loops for entry/exit

National ***Swiftube*** Loops

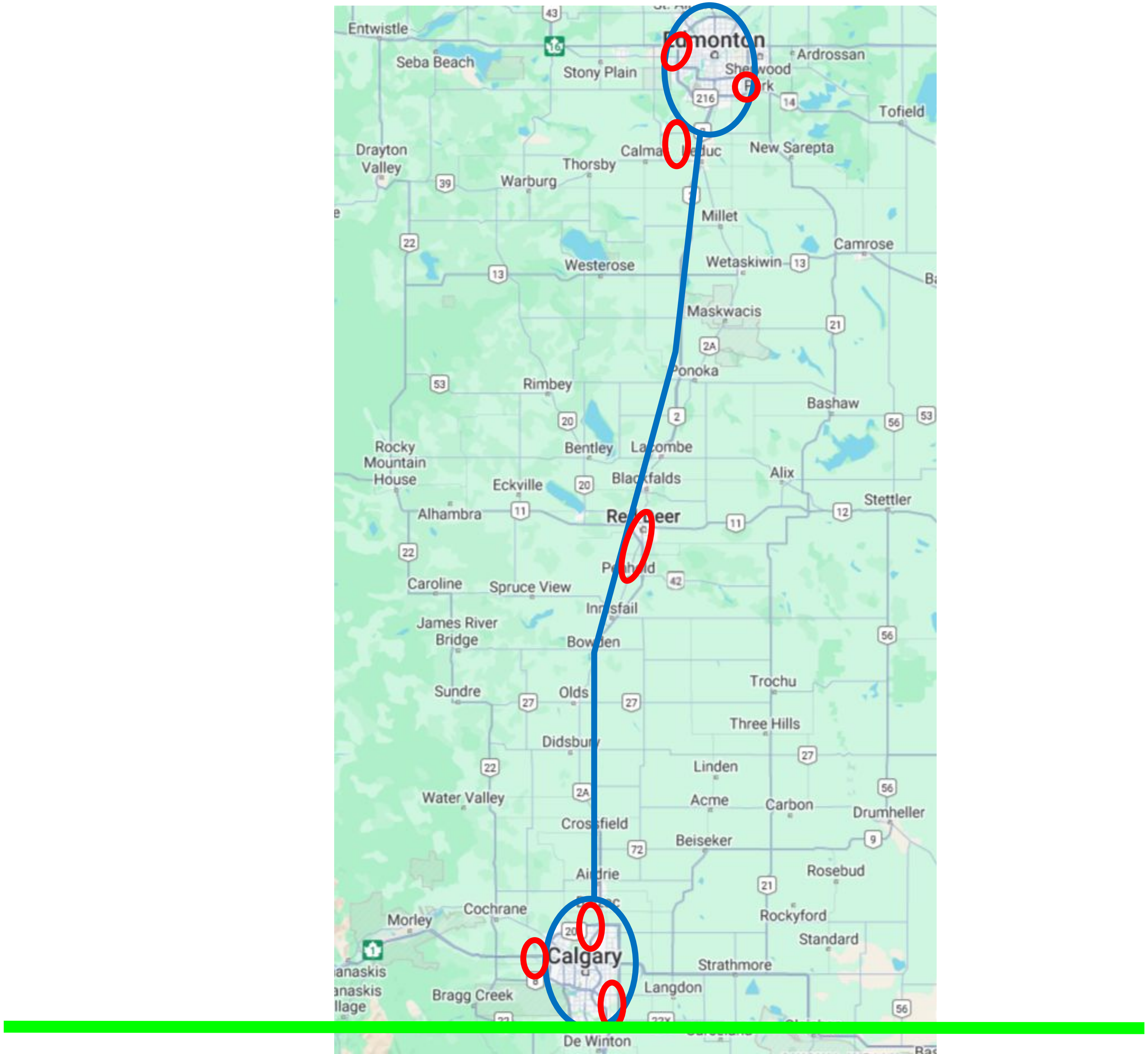


Alberta *Swiftube* Development

Primary *Swiftube* Loops
(one each direction)

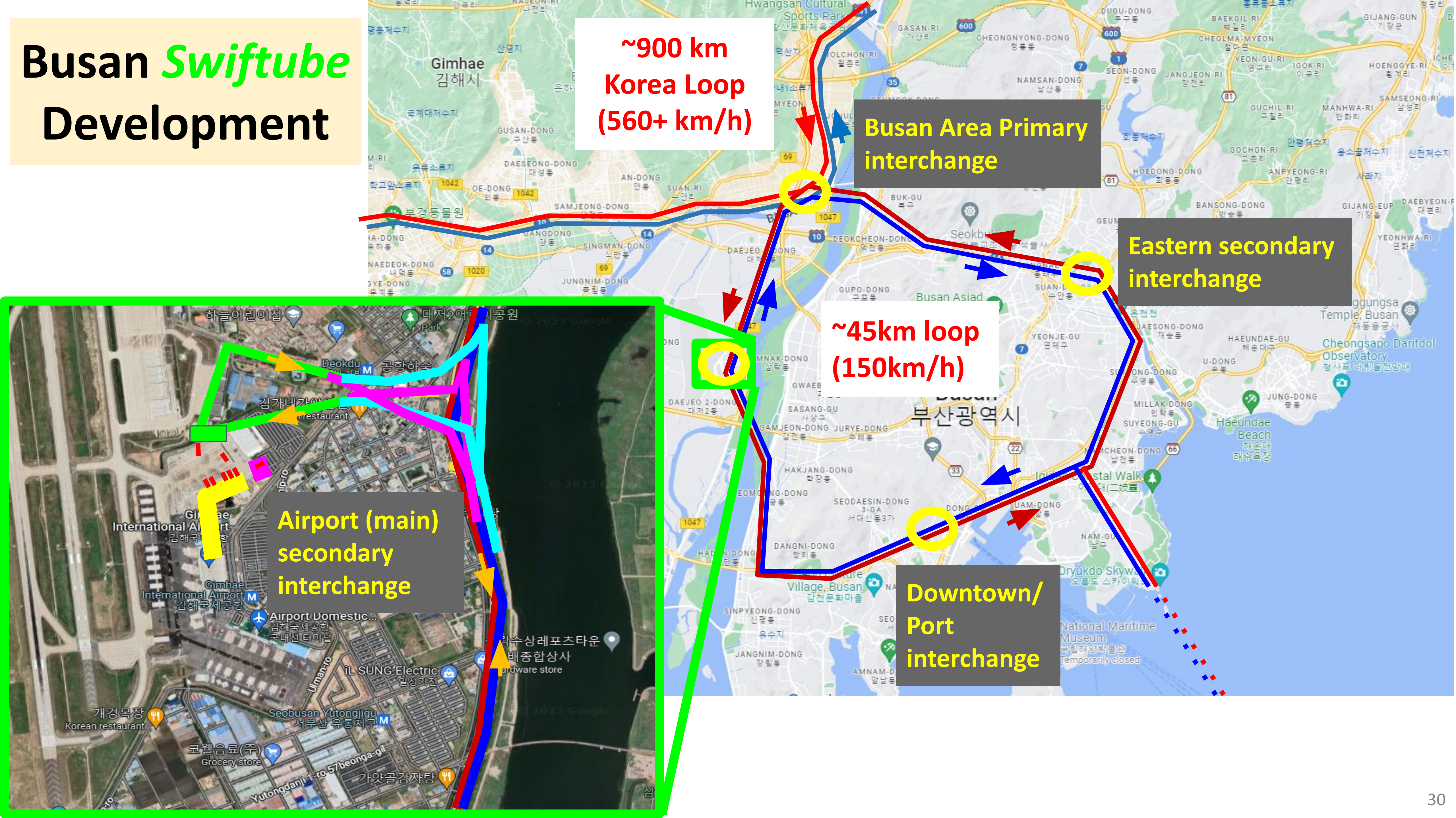
Secondary *Swiftube*
Loops for entry/exit

National *Swiftube*
Loop



Japan, Korea, China Development

Busan *Swiftube* Development



~900 km
Korea Loop
(560+ km/h)

Busan Area Primary interchange

Eastern secondary interchange

~45km loop
(150km/h)

Downtown/ Port interchange

Airport (main) secondary interchange

Energy Cost Comparisons

***Swiftube*:**

Average spacing of 100m. 700kW of power at 560km/h (350mph) = 1.25 kWh per km (2kWh per mile) = $0.30 per container-mile (CM), and $0.006 per passenger-mile (PM). ¼ of this spacing possible (4x more efficient, or 2x faster). With solar & wind power utilized over the majority of the network, ***Swiftube*** energy costs are driven even lower.

Transrapid Maglev:

41 kWh/km(1) (66 kWh/mi) at 450km/h (280mph) = $1.25 per CM, and $0.021 per PM. However, at slower speeds, and without (or at least fewer) point-to-point transit options.

TVG HSR:

29.4 kWh/km(2) (47 kWh/mi) at 320km/h (200mph) = $0.88 per CM, and $0.015 per PM.

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[1] ENERGY CONSUMPTION OF TRACK-BASED HIGH-SPEED TRAINS: MAGLEV SYSTEMS IN COMPARISON WITH WHEEL-RAIL SYSTEMS by E. Fritz(Institut für Bahntechnik (Dresden, Germany)), J. Klühspies,R. Kircher, and M. Witt (The International Maglev Board), L. Blow (Maglev Transport consulting group (Arlington, USA))

[2] TVG Wikipedia

Drag and Power Calculations (5 mile proving track)

1/13th-scale track, 5 miles.

Assumptions: 5 mile (8 km) tube, 12" (0.305 m) diameter (smaller surface area for flat bottom offset by 3-track surface area), electric motor/pod is 100% efficient, drag coefficient (c_d) of .001 based on 1/64" boundary layer after smoothing & low-drag aircraft paint applied, pod acting as a perfectly sealed piston in tube, treat turns as straight pipe, and no port area.

$F_d = c_d \, 1/2 \, \rho \, v^2 \, A$

ρ(air) = 1.2kg/m^3 , A = lxdxπ (8046m)x(0.305m)x π = 7710m^2

So F_d (v)= (.001)x(0.5)x(1.2kg/m^3)x(v)^2 x (7710m^2)

F_d (v)=4.626kg/m x v^2

F_d (44.7m/s or 100mph)=~9.2kN= 2050 lbf, or ~18psi on front of pod, or 421kW of energy to push around at 100mph.

52kW per pod if spaced 1km apart, or 5.2kW if 100m apart. ~21kW at 200mph, ~84kW at 400mph.

Drag and Power Calculations (30 mile track)

Quarter-scale track, 30 miles (needed to reduce banking to expected rates at 200-400 mph) and minimize bend drag.

Assumptions: 30 mile (50 km) tube, 48” (1.2192 m) diameter (smaller surface area for flat bottom offset by 3-track surface area), electric motor/pod is 100% efficient, drag coefficient (c_d) of .001 based on 1/64” boundary layer after smoothing & low-drag aircraft paint applied, pod acting as a perfectly sealed piston in tube, treat turns as straight pipe, and no port area.

$F_d = c_d\ 1/2\ \rho\ v^2\ A$

ρ(air) = 1.2kg/m^3 , A = lxdxπ (50000m)x(1.2192m)x π = 191511m^2

So F_d (v)= (.001)x(0.5)x(1.2kg/m^3)x(v)^2 x (191511m^2)

F_d (v)=114.9kg/m x v^2

F_d (44.7m/s or 100mph)=~230kN = 51,000 lbf, or 28psi on front of pod, or 6,400kW of energy to push around at 100mph.

128kW per pod if spaced 1km apart, or ~13kW if 100m apart. ~50kW at 200mph, ~200kW at 400mph.

Power Comparisons -***Swiftube*** to High-Speed Rail (HSR) and ***Swiftube*** usage projections

134,100kW (134 MW) of energy to push a ***Swiftube*** pod, by itself in 200km of tube at 160 km/h. At HSR speeds of ~320 km/hr, the energy is 536MW.

HSR operates on ~10MW of energy. So the equivalent is 54 pods, or 3.7km between pods.

There are over 1.4 million containers moving ~1000km per day by road and rail around the US. Even just 10% moving by ***Swiftube***, or 140k (50k at any time) over ~10,000km of tube is 1 pod per 200m.

About one in 40 people take a trip >1000km every day, or about 10M/day. Again, just 10% moving by ***Swiftube*** ~30k pods (10k at any time) is 1 pod per 1km.

With the above usage, conservative estimates are 1 pod per 200m.

1 Energy and Power of Flying, Andrea Eller

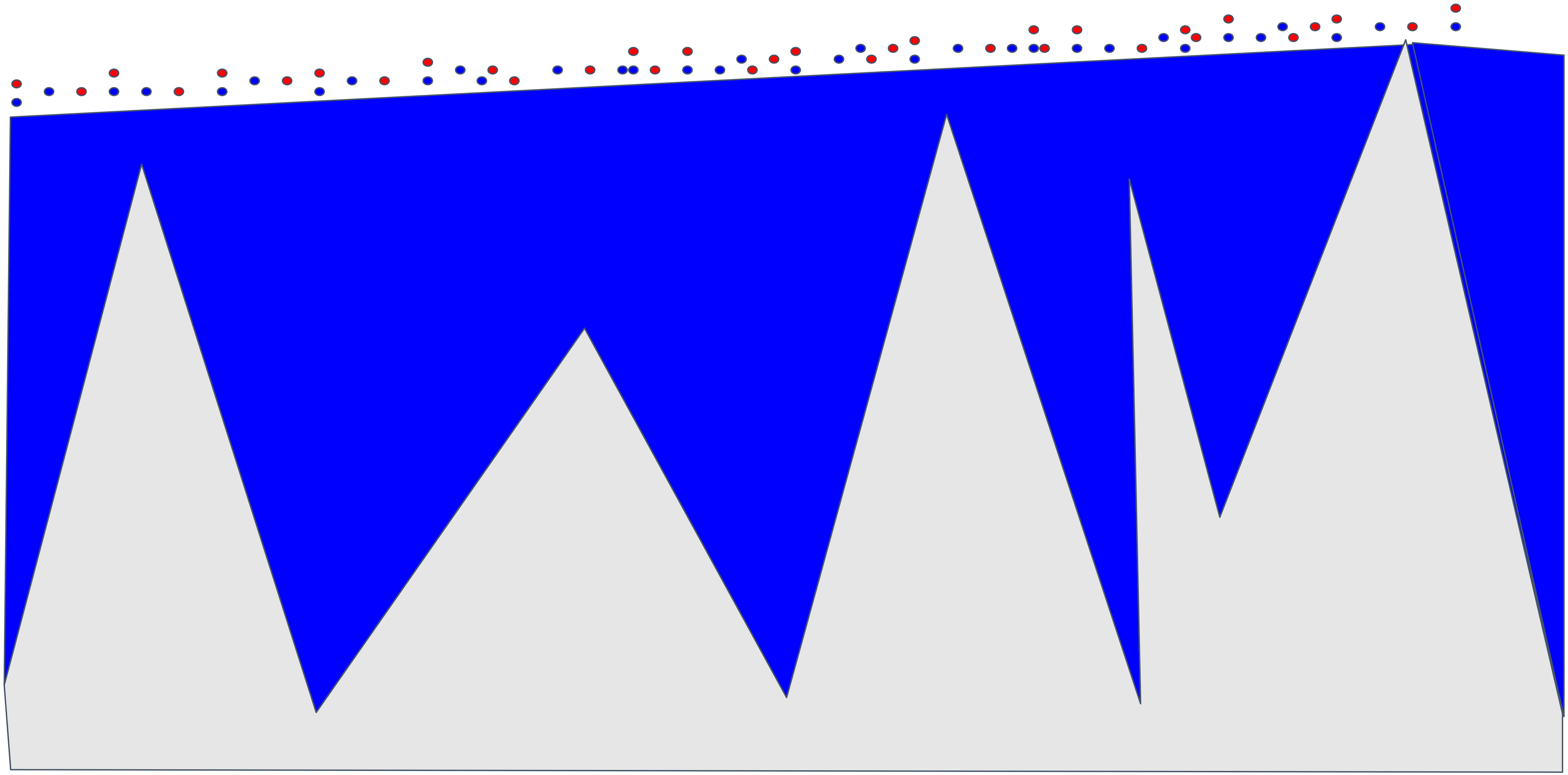
Drag Calculation Conclusions/Questions

One pod every 10 km (6.5 miles) requires 6,700 kW of energy to push the mass of air in the pipe at 161 km/h (100 mph). This is untenable, but more pods equidistant from each other would equally split the load. For speeds of over 161 mph, less than 2 km spacing (1300 kW per vehicle) would be needed.

Pods even more closely spaced would result in less drag per pod and allow for either less energy consumption per pod, or a faster speed.

Swiftube being closed loops could add efficiencies that would improve the energy requirements above. One hypothesis is that the closed loop would significantly improve the efficiency of moving air (conservation of momentum). However, another hypothesis is this will not change the energy requirements, as drag exists regardless of it being in an open loop or closed loop.

Surface defects filled with water (ice)



Turn Banking Calculations (30-mile track)

Banking Formula:

$\theta = \tan\text{-}1\ [v^2 / Rg]$

$\theta_{(89.4\text{m/s - 200mph - 5mi dia curve})} = \tan\text{-}1\ [(89.4\text{m/s})^2 / (4023\text{m} \times 9.8\text{m/s}^2)]$

$\theta_{(89.4\text{m/s - }\mathbf{200mph}\text{ - 5mi dia curve})} = 11.5$ degrees

$\theta_{(134.1\text{m/s - }\mathbf{300mph}\text{ - 5mi dia curve})} = 24.5$ degrees

$\theta_{(134.1\text{m/s - }\mathbf{400mph}\text{ - 5mi dia curve})} = 39$ degrees

Turn Banking Calculations (proving track)

Banking Formula:

$\theta = \tan\text{-}1\ [v^2 / Rg]$

$\theta_{(89.4\text{m/s - 200mph - 5mi dia curve})} = \tan\text{-}1\ [(89.4\text{m/s})^2 / (1159\text{m} \times 9.8\text{m/s}^2)]$

$\theta_{(89.4\text{m/s - }\mathbf{200mph}\text{ - 5mi dia curve})} = 35 \text{ degrees}$

Swiftube Test Track Considerations

Open-air testing:

- Both In-tube version pod and an aerodynamic model to be tested on 20 miles of track laid out (same to later be located inside of the tube)
- Pods outfitted with drag racing parachutes to ensure quick deceleration in case of emergency.

In-tube testing:

- Light one every 40 feet (3 lengths of pipe). Offset to the left (leaving) to direct pod escape to closest exit (along with painting/signage on tube).
- Exit every 500 yds, 30”x 48”. Sealed.
- VHF Communications with pods throughout travel (primary), and internet connectivity for calls/texting (secondary).
- Tube sectioned for thermal expansion / contraction.
- Instrument cluster including accelerometers, anemometer (aircraft air speed sensor), pressure sensors, and temperature sensors. 10 clusters total, two located on the ends of the interchange, one in the middle of the interchange (sensing the pass-thru and merge tubes), one at each of the “off-ramp” and “onramp” tubes, one in the exchange area, one near the end of each straight-away, one in the middle of each turn.
- Pod tracking throughout.
- Solar Power to demonstrate how much solar can impact the power challenges.
- One Camera every 200 yards.
- Contracts for pipe, track, solar, and as much equipment as possible to include returns for reimbursement of 30-40%

Swiftube Testing Objectives

Primary

- Test/verify the physics models for the efficiency differences between Pods in open-air and in-tube.
- Understand efficiency with different numbers of pods in the closed-loop system. Vary distances between pods from 2 feet to 1 mile. Determine kW per pod average at 100mph - max (33mph increments).
- Test and validate the physics models for drag in an untreated tube and a smoothed tube, painted with aircraft low-drag paint. Test varying diameters and aerodynamics of vehicles to obtain efficiencies in varying configurations.
- Understand the temperature expansion and contraction effects on the system with both PVC and HDPE plastic tubes.
- Test and validate the physics models for deceleration time, emergency braking, and collisions between pods.
- Extensive Solar power atop tube to validate how much solar power can offset power needs.
- Test various types of pipe materials, shading conditions, weather protections, and treatments to maximize tube longevity.
- Develop and test pod connectivity for uniform and safe operations, including emergency stops and rail-switching system timing.
- Determine heat removal needs.
- Final test of the system, explosion testing. Set off an explosive in 1 pod in the middle of a 10-pod group (classify this test, release uncharacterized details to the public).

Secondary

- Establish continuous WiFi throughout the tube.
- Remotely control pods and develop software algorithms to drive point to point.
- Test electric transfer wheel (or other technology) to power pods and recharge onboard batteries and other vehicles.

Test Site Ideals

- Desolate (300-400 Square miles)
- Flat.
- Minimal road crossings.
- Close to civilization (in cell range)
- Wide temperature ranges.
- Mostly sunny.
- Electricity available nearby.

Area outside of Salt Lake City near the Bonneville Salt Flats appears best suited.

Minimal Test track

- ~29.7 miles of tube/track
- Two ~7 mile straight-aways would provide useful test areas for steady-state acceleration and braking tests.
- Limits speed and time for straight-away emergency braking tests.

Design to minimize waste. Easy to disassemble, recycle PVC/HDPE pipe, and solar panels.

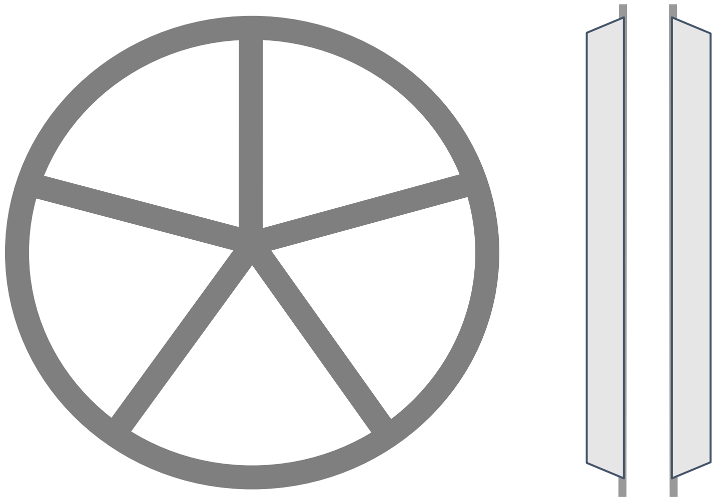
But First… Proving track/tube

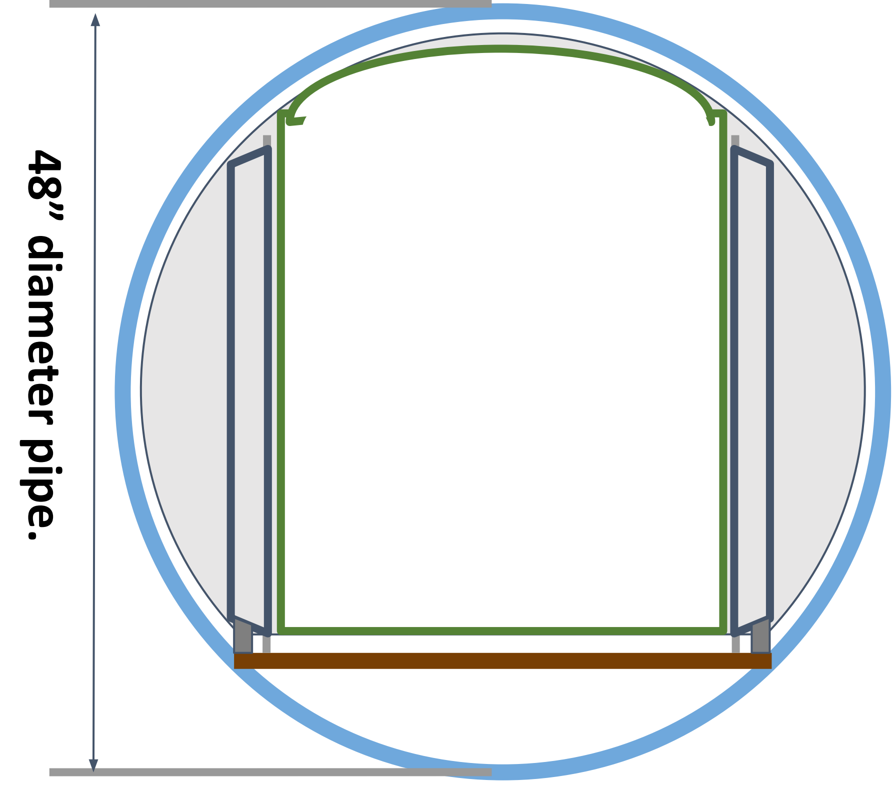
1/13 scale tube/track

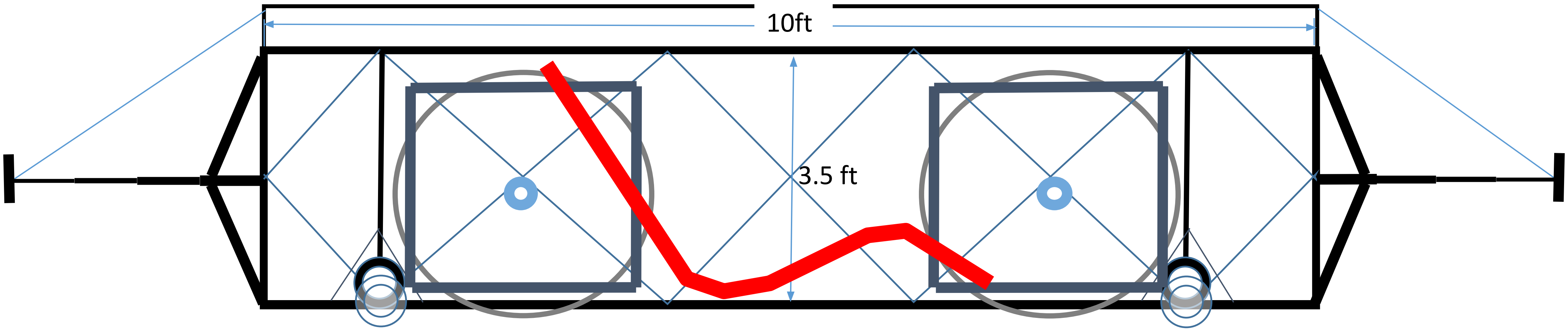
- ~5 miles of tube/track

Design to minimize waste. Easy to disassemble, recycle PVC/HDPE pipe, and solar panels.

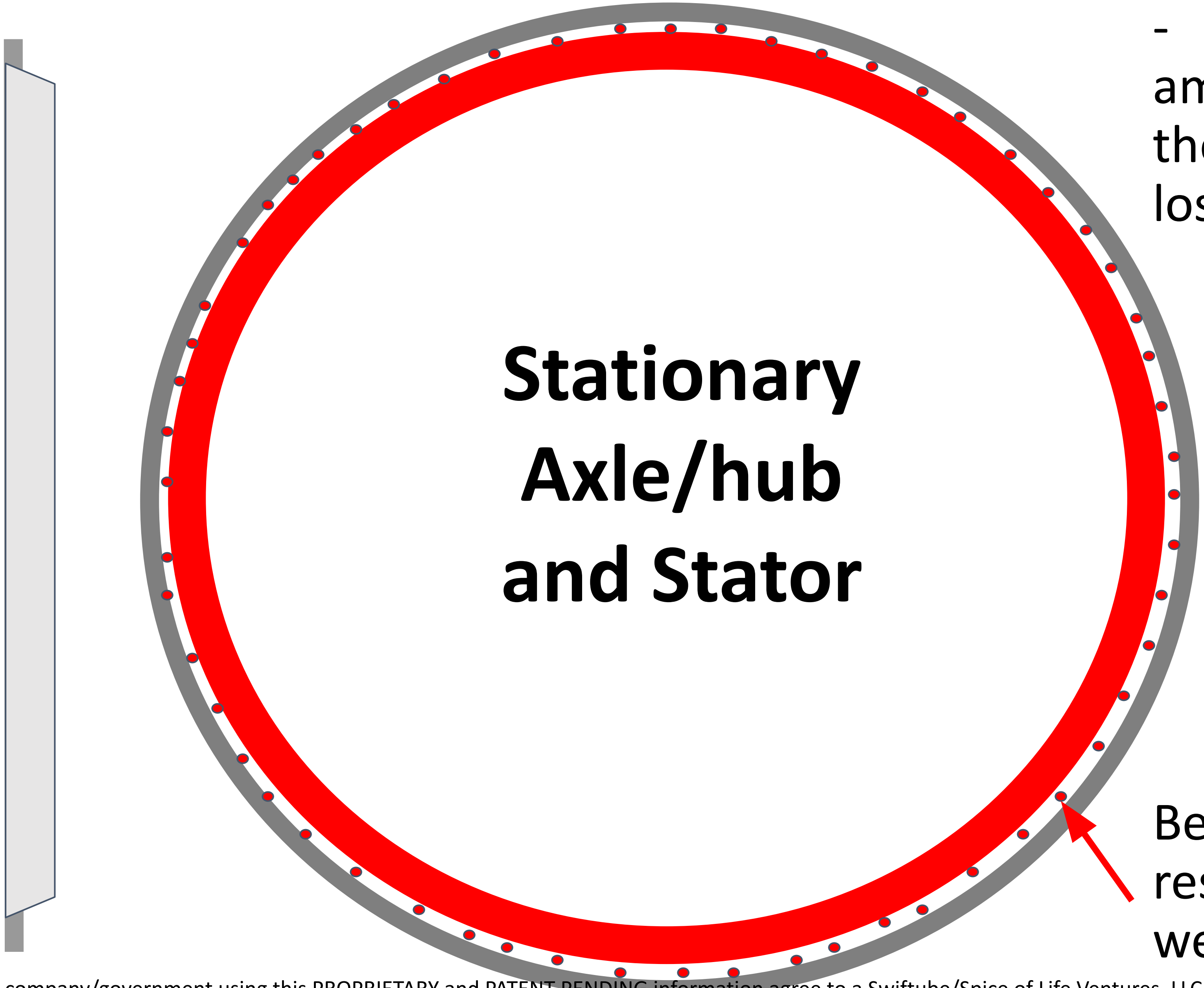
Test Vehicle







Wheels

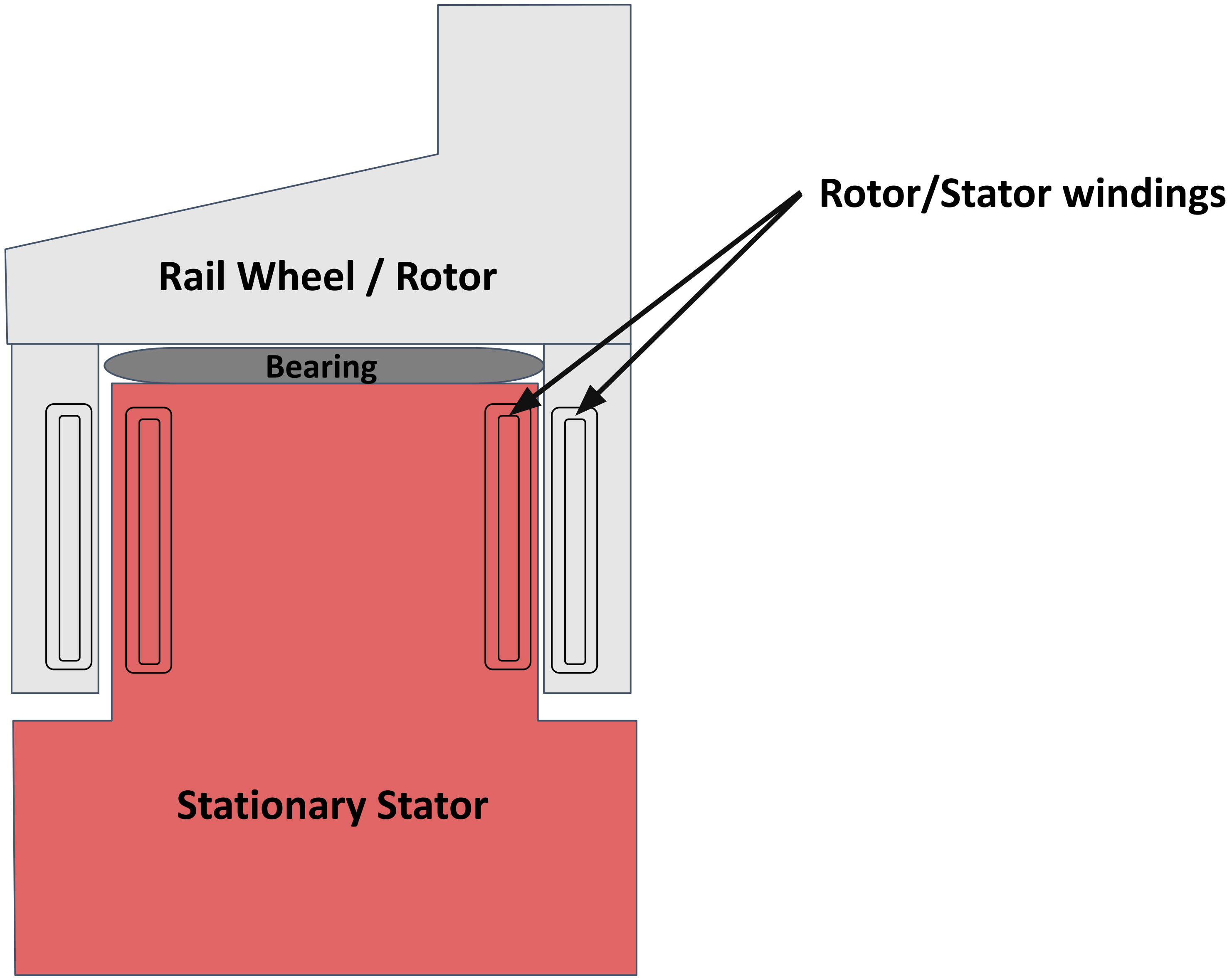


Wheel/Rotor

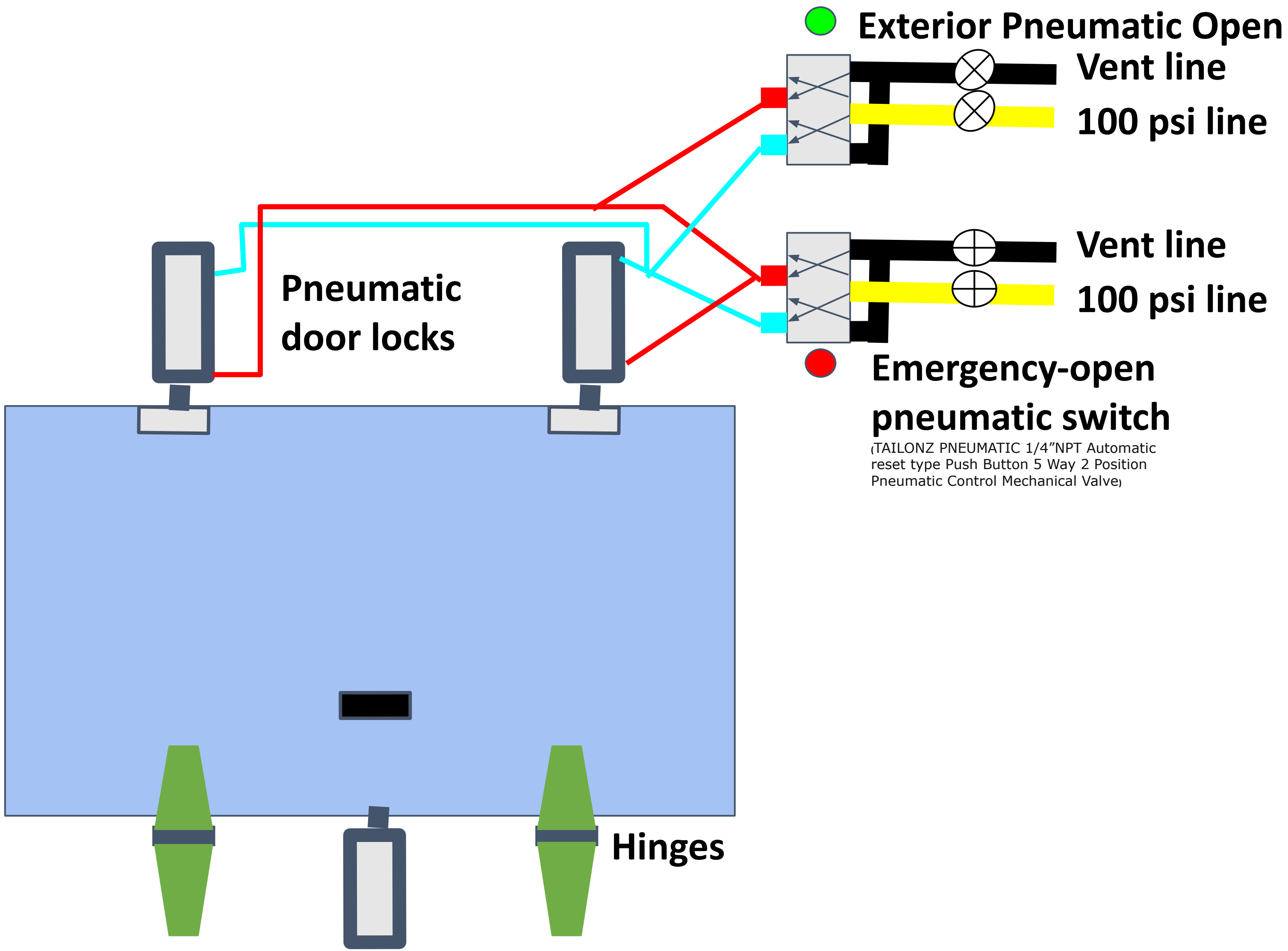
- Designed to minimize the amount of turning "wheel", thereby reducing air-induced losses within the wheel housing.

Bearings over an increased area result in significantly less bearing wear/maintenance.

Wheels (cont)


Rotor/Stator windings
Rail Wheel / Rotor
Bearing
Stationary Stator

Exit Door Design



Exterior Pneumatic Open

Vent line

100 psi line

Vent line

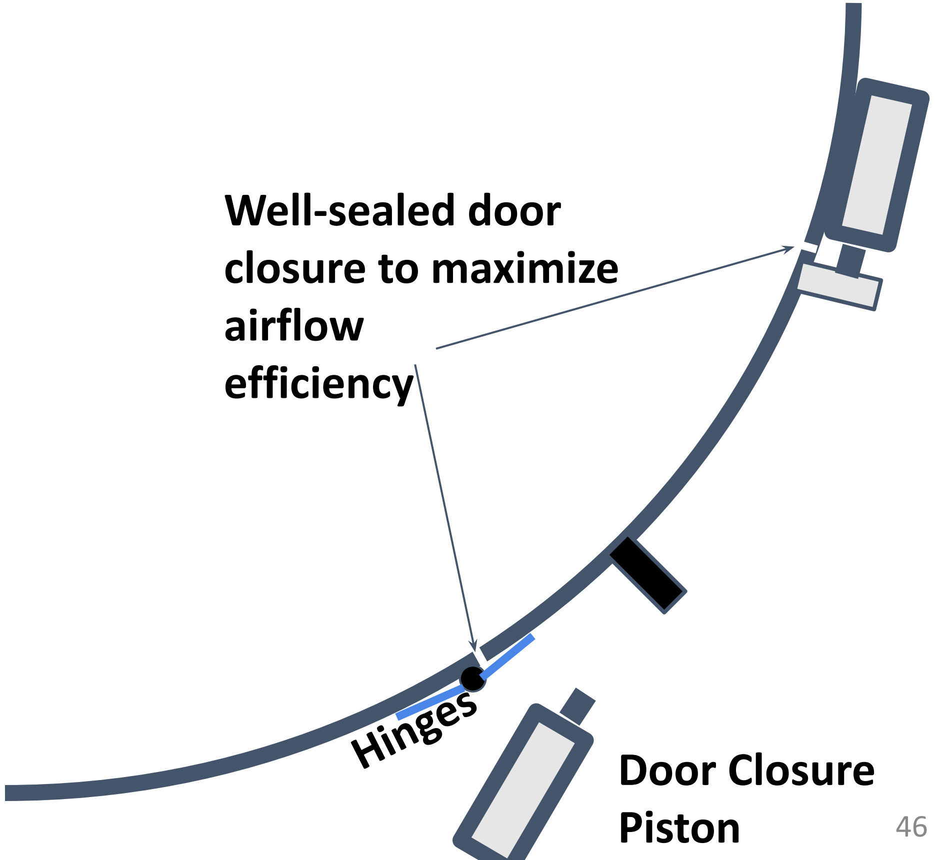
100 psi line

Pneumatic door locks

Emergency-open pneumatic switch

(TAILONZ PNEUMATIC 1/4”NPT Automatic reset type Push Button 5 Way 2 Position Pneumatic Control Mechanical Valve)

Hinges



Well-sealed door closure to maximize airflow efficiency

Hinges

Door Closure Piston

1/13th Scale Proving Track Expense Details

- Pipe for 6 miles (5 miles plus 1 mile for port) 31,680 linear feet. $20/foot = $633,000 .
- 10 engineers & technicians, $130k each/year x 2 years = $2.6 million
- Land lease $200,000
- Plywood sheets, $35 ea, 12ft/sheet = $100,000
- Rails 7920 of 12ft, $20 ea = $160,000
- 20 pods, $20k ea = $400,000
- Ground preparation, culverts = $1 million
- Solar panels for power offset = $1 million
- Wiring, pneumatic actuators, communications, etc. = $2 million
- Deconstruction, sell back of scrap and pipes. = Even

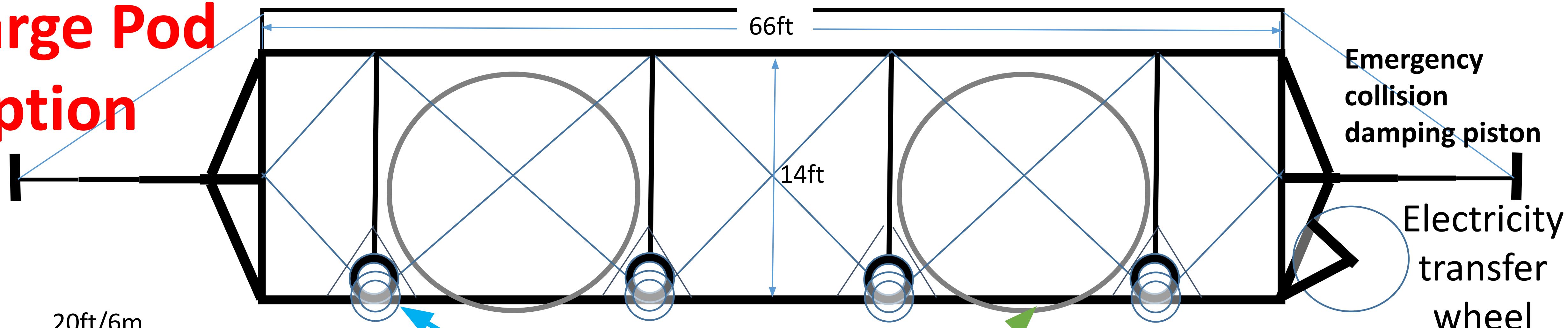
~$ 8 million. Unaccounted expenses - ~$6 million, Total $14 million (~$0.04 for every American)

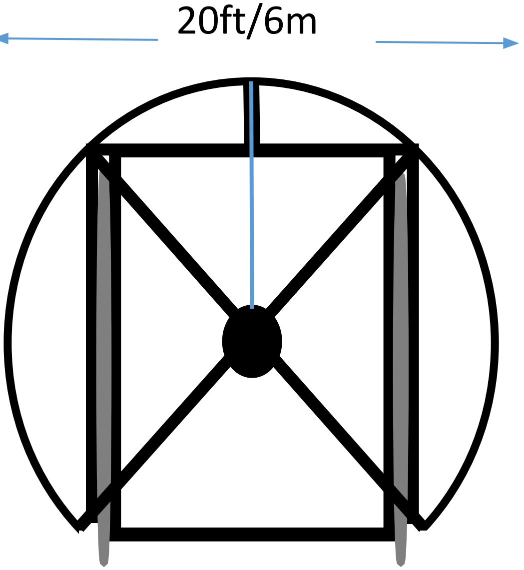
¼ Scale 30-Mile Test Track Expense Details

- Pipe for 33 miles (30 miles plus 3 miles for port) 174,300 linear feet. $100/foot = $18 million.
- 100 engineers & technicians, $130k each/year x 3 years = $40 million
- Land lease $1 million
- Plywood sheets, $35 ea, 12ft/sheet = $1 million
- Rails 29,000 at 12ft, $100 ea = $3 million
- 100 pods, $200k ea = $20 million
- Ground preparation, culverts = $3 million
- Solar panels for power offset = $10 million
- Wiring, pneumatic actuators, communications, etc. = $15 million
- Deconstruction, sell back of scrap and pipes. = -$5 million

~$106 million. Unaccounted expenses - ~$43 million, Total $149 million ($0.44 for every American)

Large Pod Option

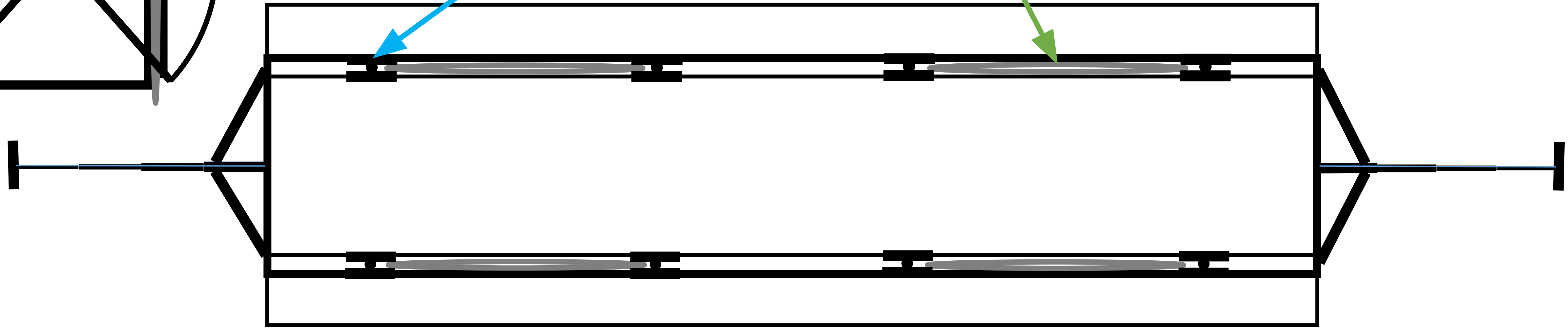




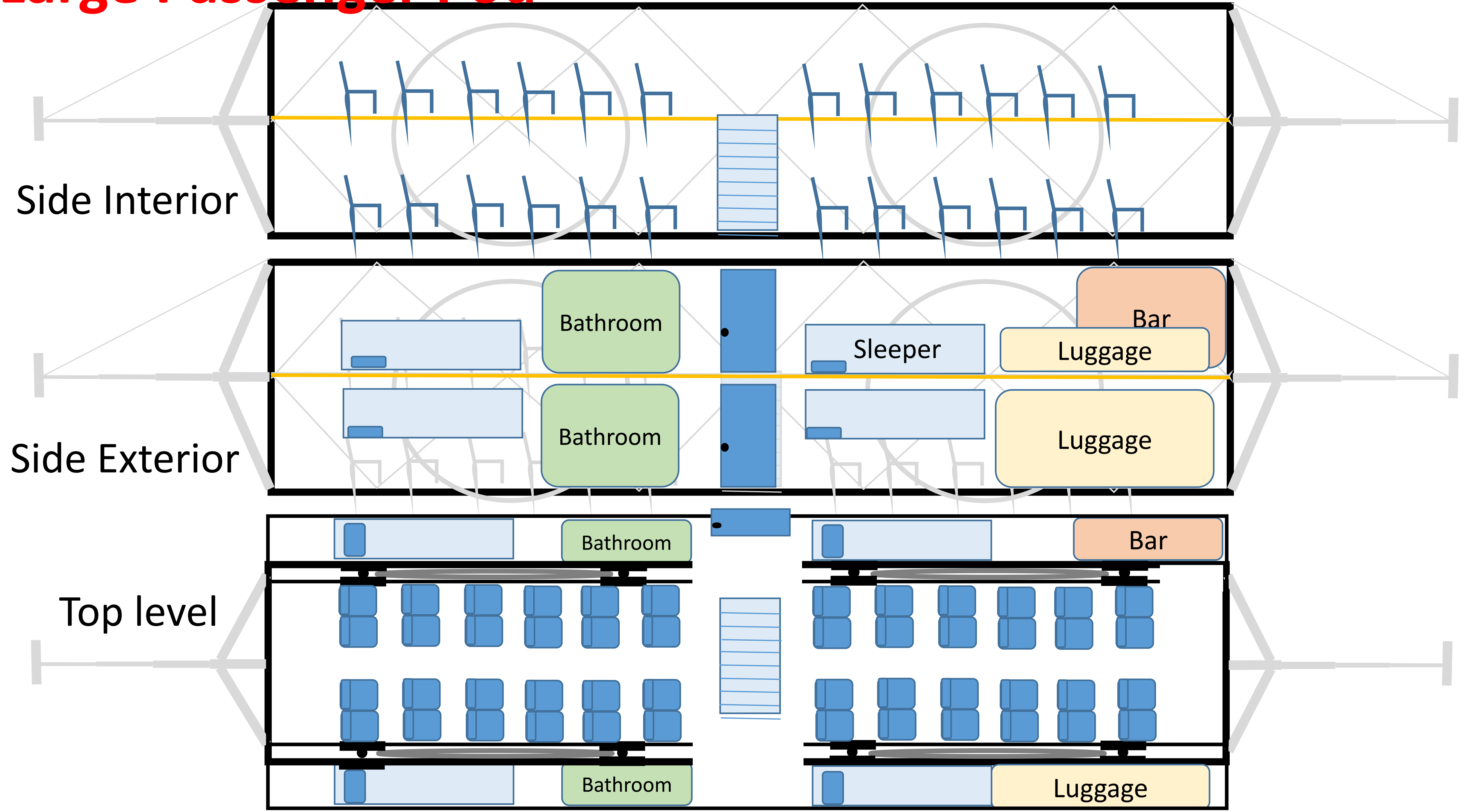
Transition wheels 100kw hub motor each (car size). Extend for emergency braking and transition to a SwiftPort.

Rail wheels 12ft diameter, 800kw hub motor each. RPM at 700 MPH is less than a car's wheels at 70 MPH.

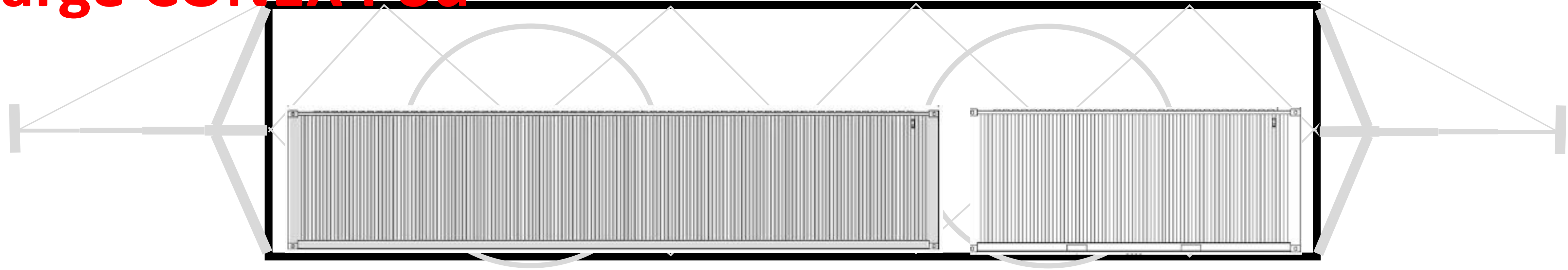
(Left out of future drawings)



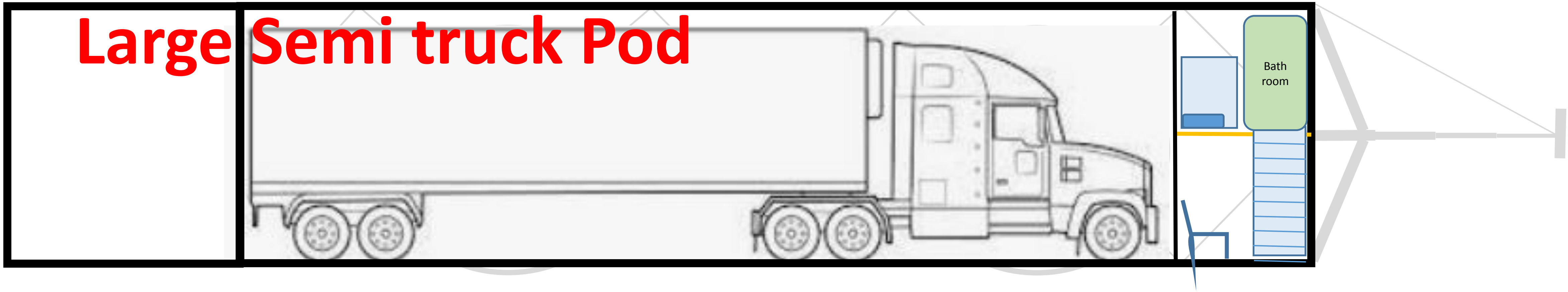
Large Passenger Pod



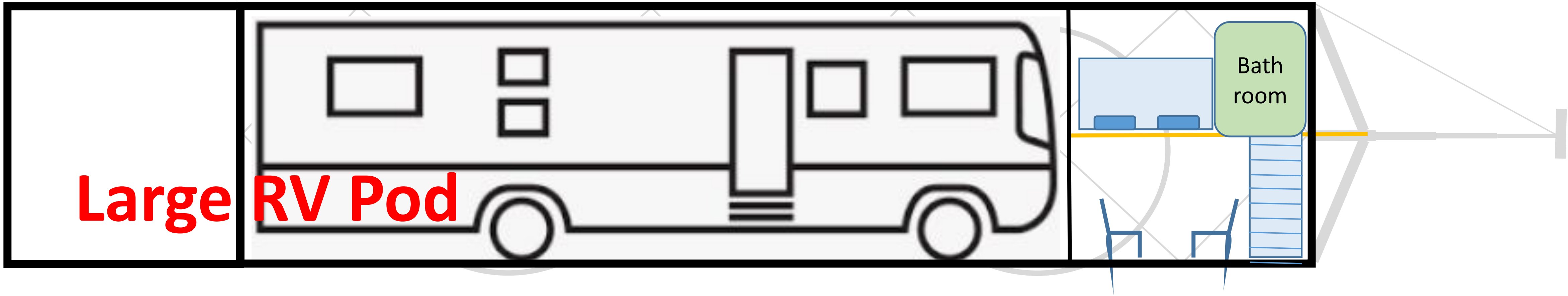
Large CONEX Pod



Large Semi truck Pod



Large RV Pod



Any company/government using this PROPRIETARY and PATENT-PENDING information agree to a Swiftube/Spice of Life Ventures, LLC a royalty of US$0.01 for every 100 miles (162 km) of pod/capsule travel.