Syncing Senses

Optimizing Visual and Motion Integration in Advanced Dynamic Driving Simulators

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- 25 years of experience
- Independent company
- Standard and bespoke simulators
- OEM – High-end motorsport and universities
- Focus on system integration

Simulators built to experience reality in the virtual world

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Share insights from recent simulator development

Bandwidth

Latency

Self Motion Perception

Self Motion Perception (SMP)

- SMP is what enables us humans to register how we move through space over time, allowing us to adjust our own movement and behaviour accordingly.

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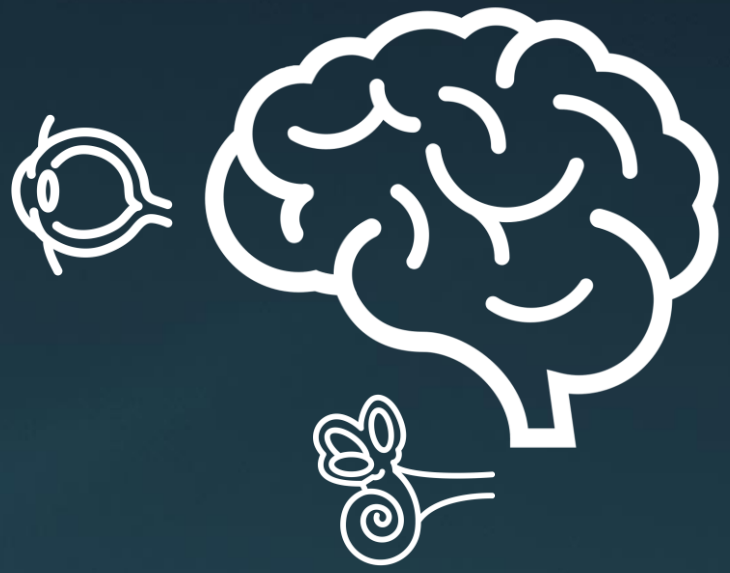
Self Motion Perception



Visual vestibular interaction

Visual inputs typically outweigh motion cues

Inputs should match what the brain is expecting

Visual references to fixed world disrupt SMP

Yaw inertial amplitude = yaw visual amplitude

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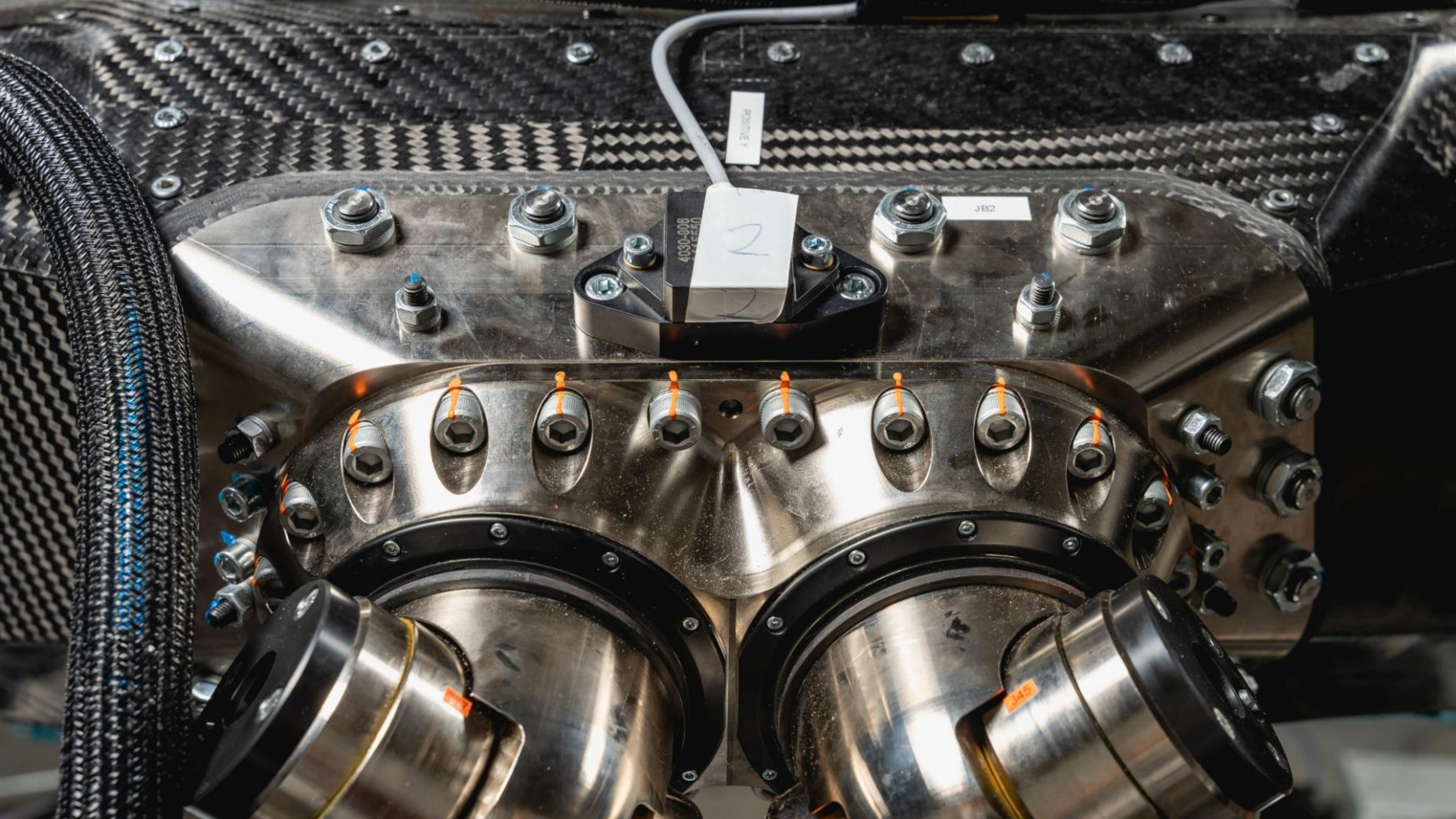
JB2
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Bandwidth

- Property of a input-output transfer function
- Desired acceleration (from virtual vehicle) → actual acceleration
- Usable bandwidth?
- Control engineering uses ±3dB
- Would we realy allow -3 or +3 dB variation of the transfer magnitude in the range of interest? Is a gain of 0.71 or 1.4 tollerable?

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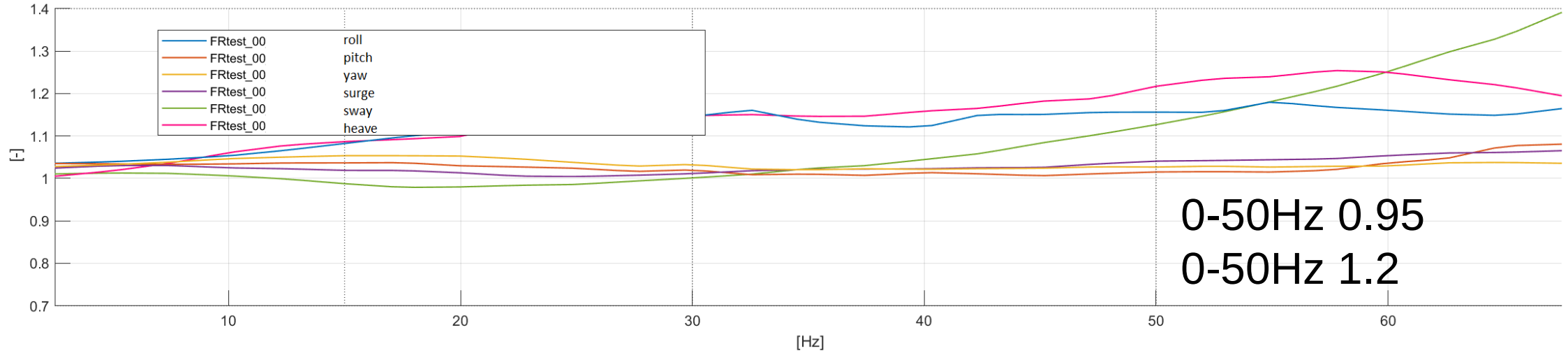
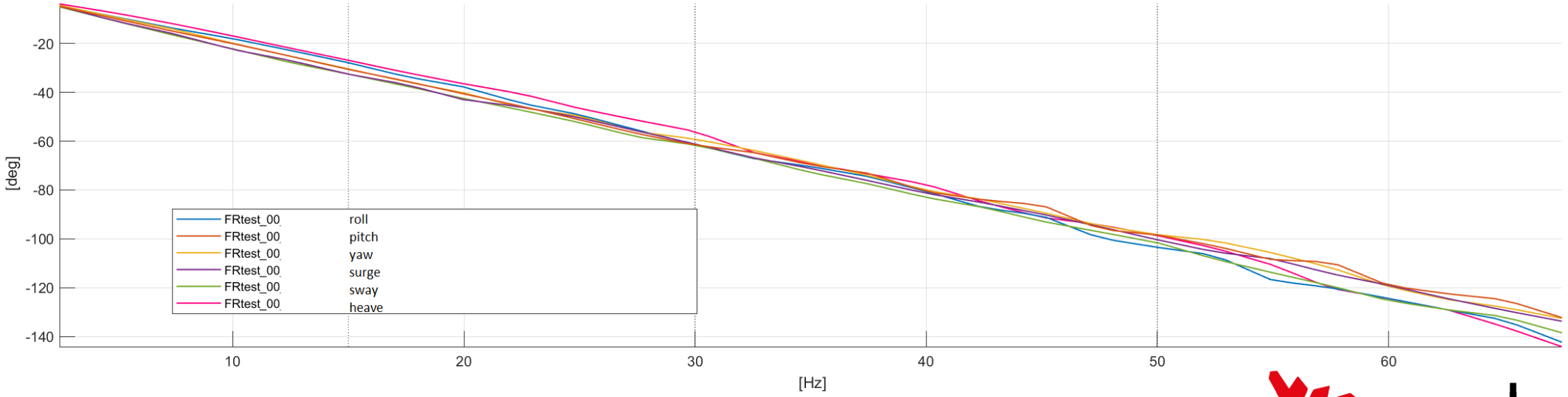
FRtest_00_Freq_C - Joint Blocks





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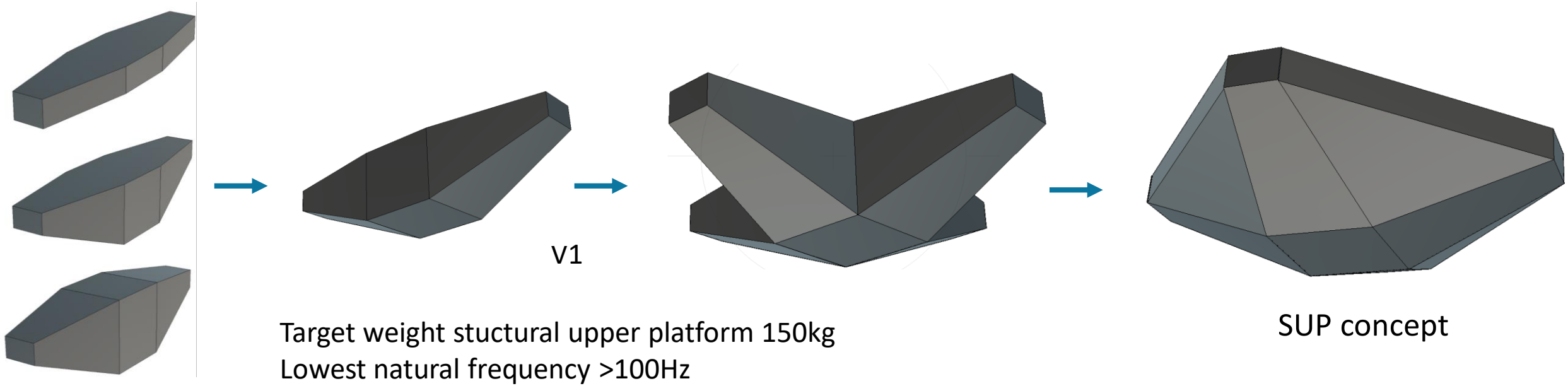
Challenging weight and stiffness targets:



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Target weight stuctural upper platform 150kg
Lowest natural frequency >100Hz

SUP concept

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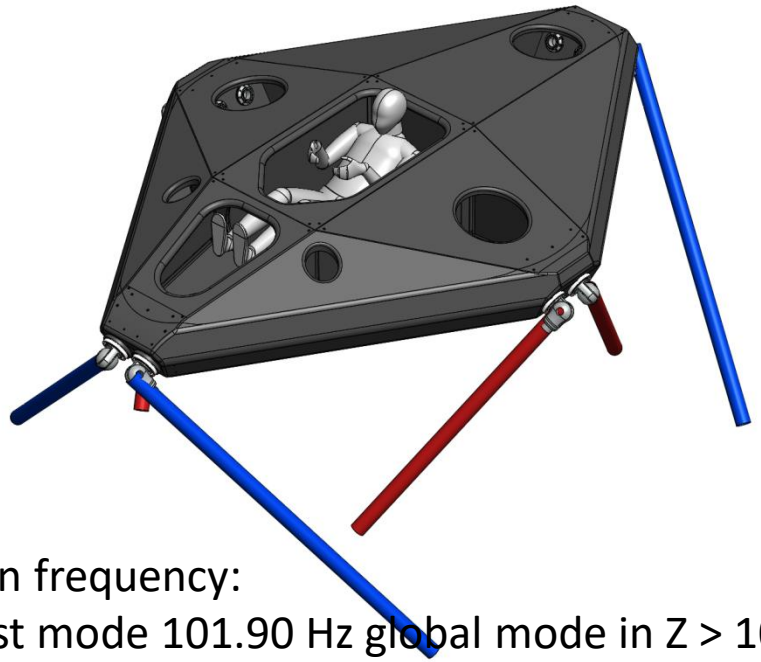
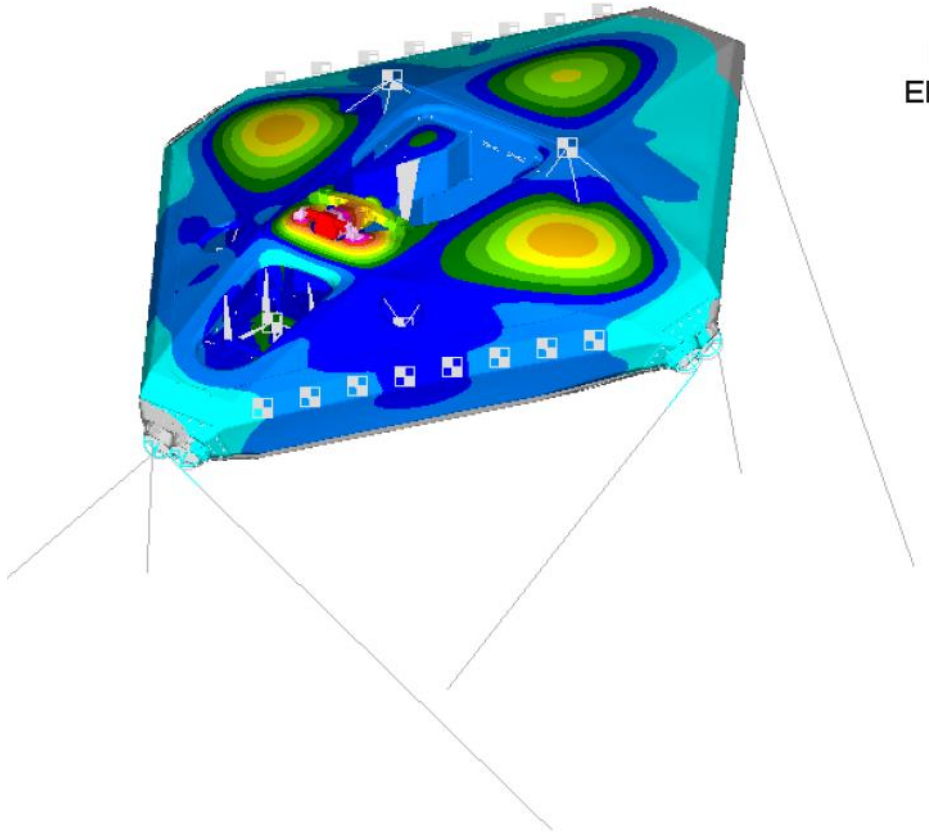
SUP (**S**tructural **U**pper **P**latform)





Eigen frequency:
- First mode 101.90 Hz global mode in Z > 100 Hz
- Second mode 102.38 Hz global mode in Y
- Third mode 122.16 Hz local mode in Z

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What is factors are important when assessing simulator latency

Human cognitive response time whilst controlling a vehicle:

- 100 [ms] Professional race car driver
- 200 [ms] to > 1 [s] for an average driver

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Is latency a number?

- Check all directions; Expert drivers sense if one direction is out of sync
- Identify transport delay and phase lag of dynamic response
  - Linear phase lag (constant delay in time domain) is desirable but hard to achieve for higher frequencies
- Synchronize visual latency with motion latency

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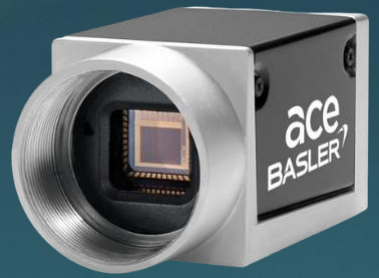
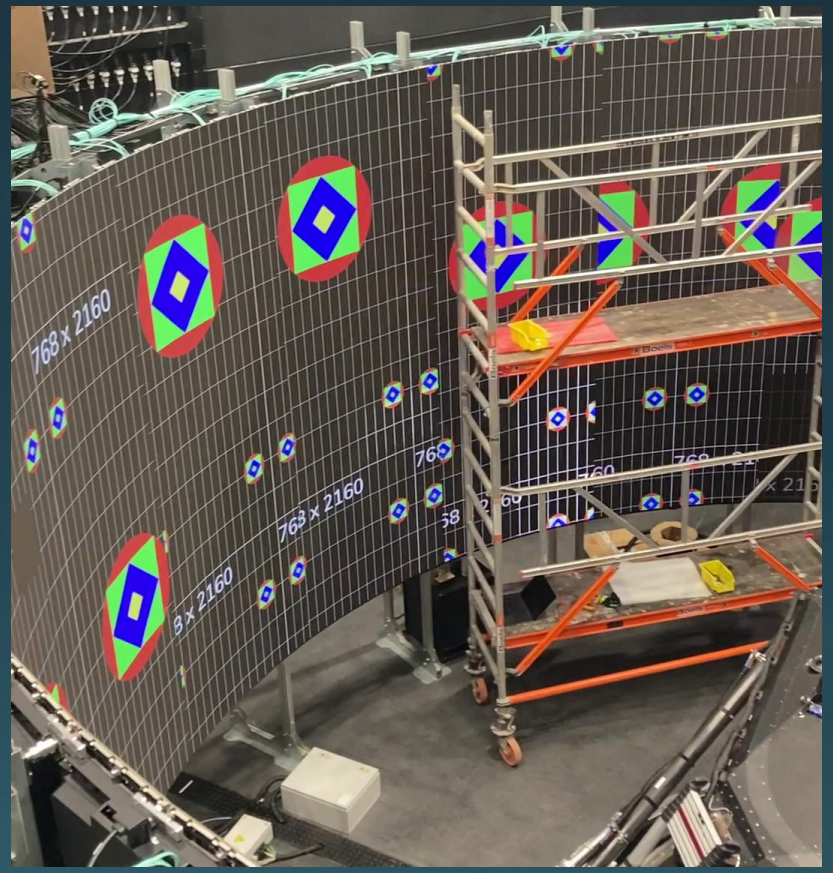
Visual system latency measurements

- Evaluation of measurement data from test with high speed camera
  - Barco Truepix 1.5 LED wall @ 180 [FPS].
  - NVIDIA Quaddro A6000 768 X 2160 per channel
  - GPU-out to panel validated latency 4.6 ms
  - Basler acA640-750um





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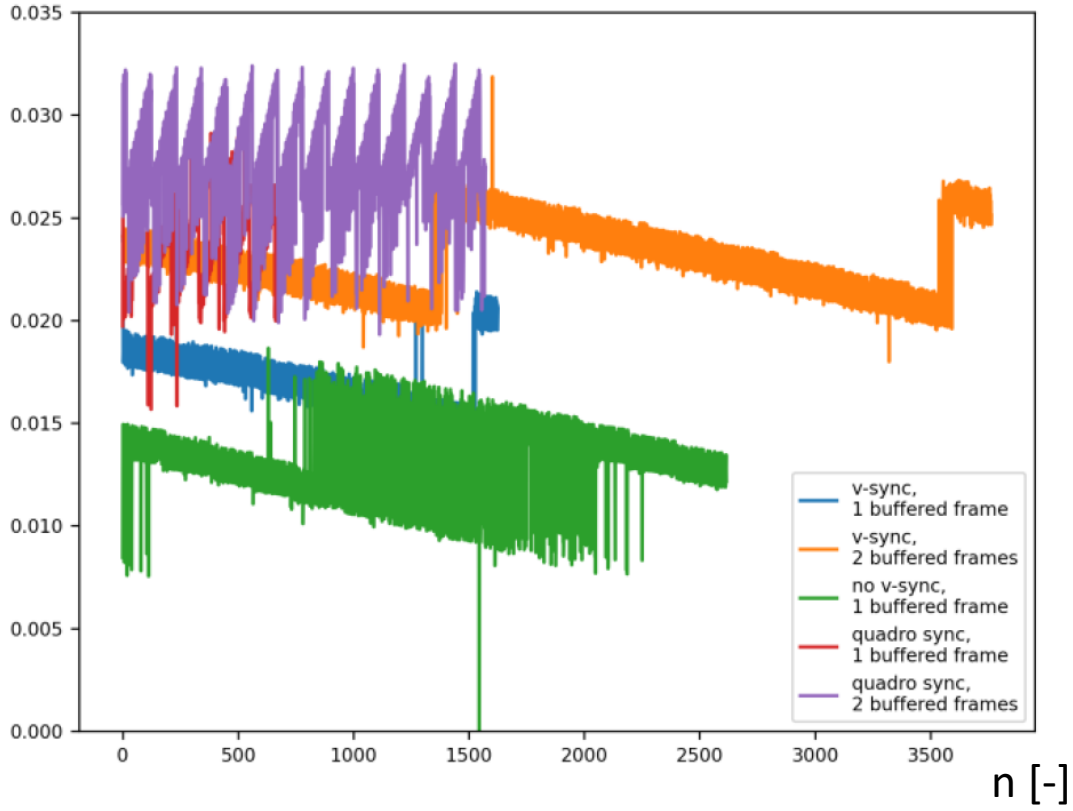
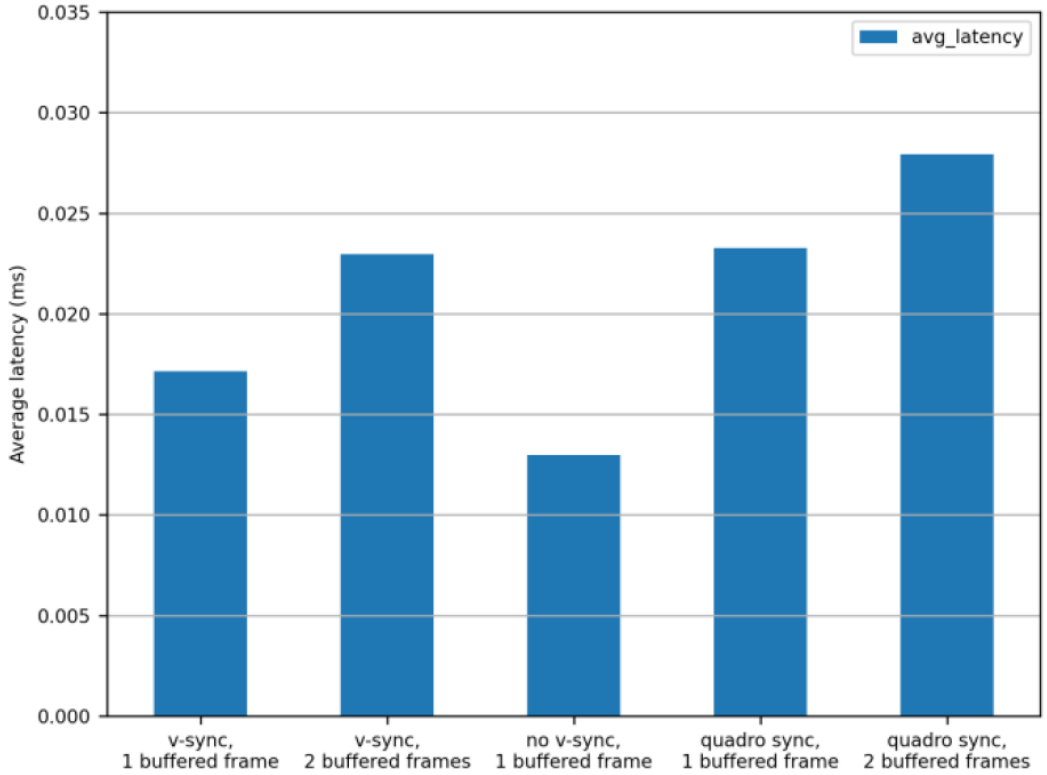
Visual system latency measurement results

Results:





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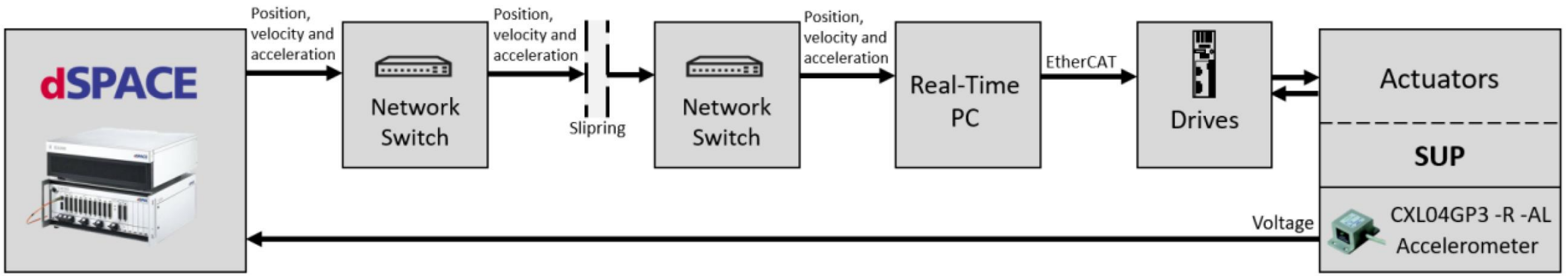
Motion system round-trip delay measurements

- dSPACE Scalexio host, Ethernet host communication, EtherCAT servo communication



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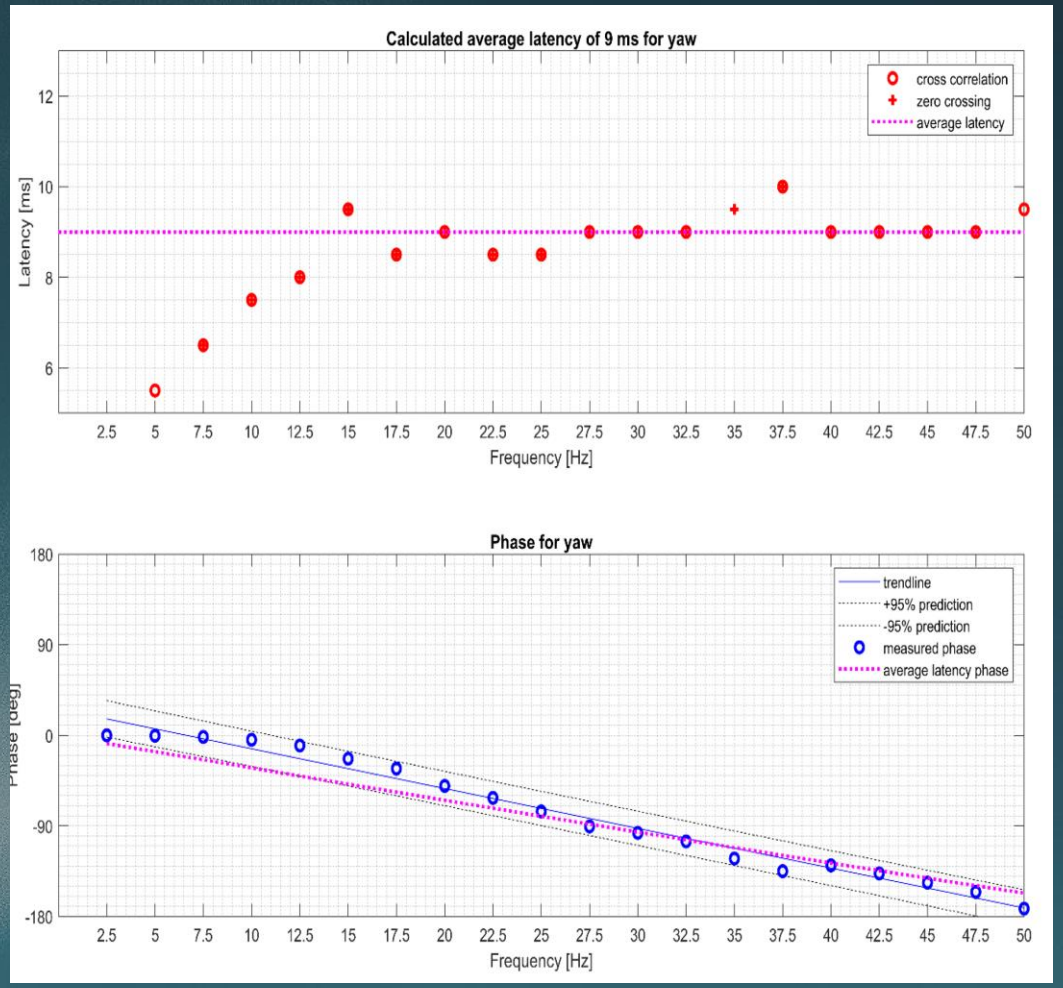
Motion system round trip delay results



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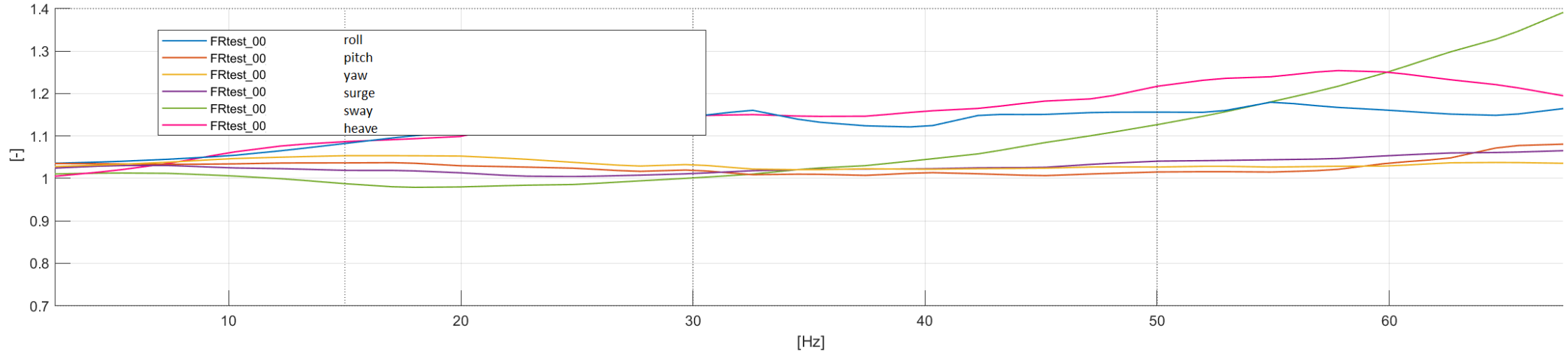
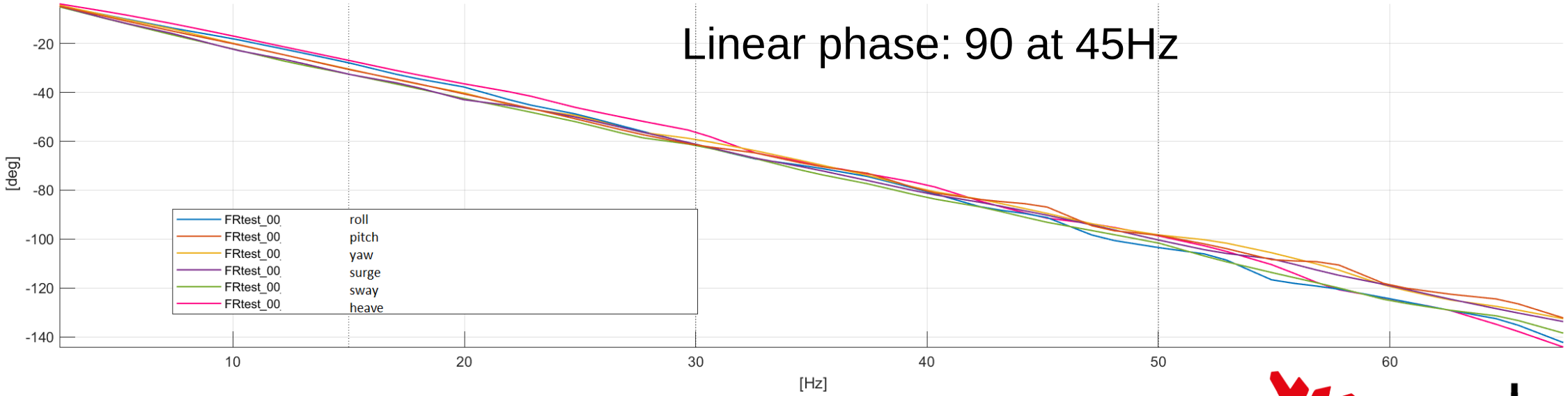
FRtest_00_Freq_C - Joint Blocks





Linear phase: 90 at 45Hz

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How did we apply the lessons learned?

- Designed a completely new simulator concept
- Infinite yaw
- Unique combination of bandwidth and workspace
- Parallel motion for 3-dof primary Surge-Sway-Yaw.
- Carries any secondary 3 or 6 DoF system

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- Surge, sway, and yaw primary motion base
- Supports a variety of secondary high-bandwidth motion systems
- Cost-efficient modular motion concept
- Easy installation and low maintenance
- Minimal installation height
- Up to 360 and infinite yaw

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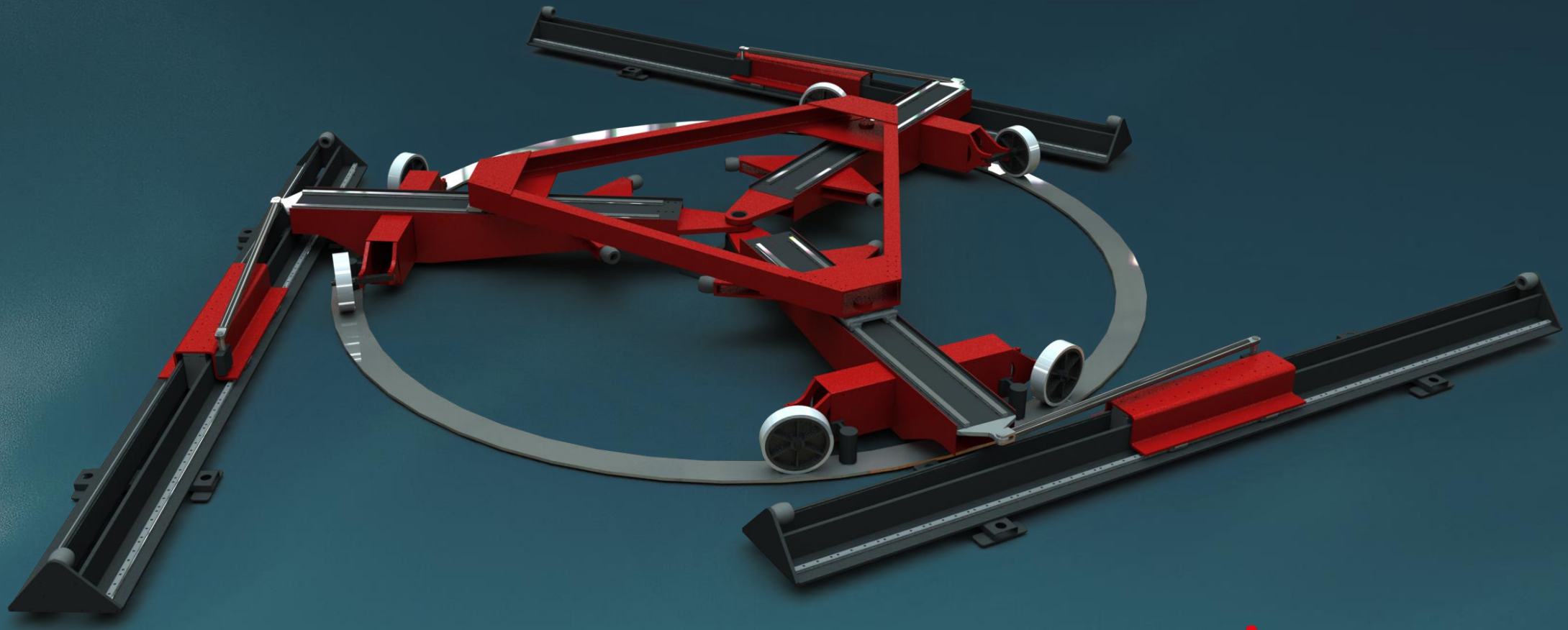
Ready for Real

Meet the RoRa 3-DOF Primary motion



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RoRa configurations

Infinite yaw
On-board visuals

80-degree yaw
Off-board visuals

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