Suspension

Collaboration Meeting
2024-08-19

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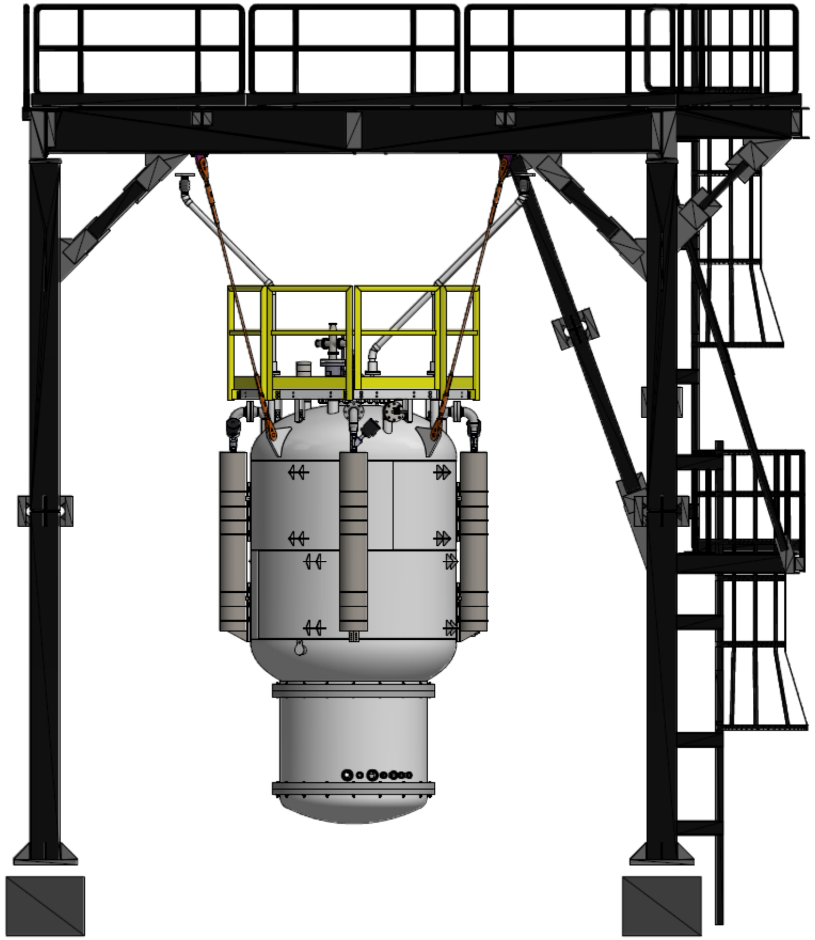
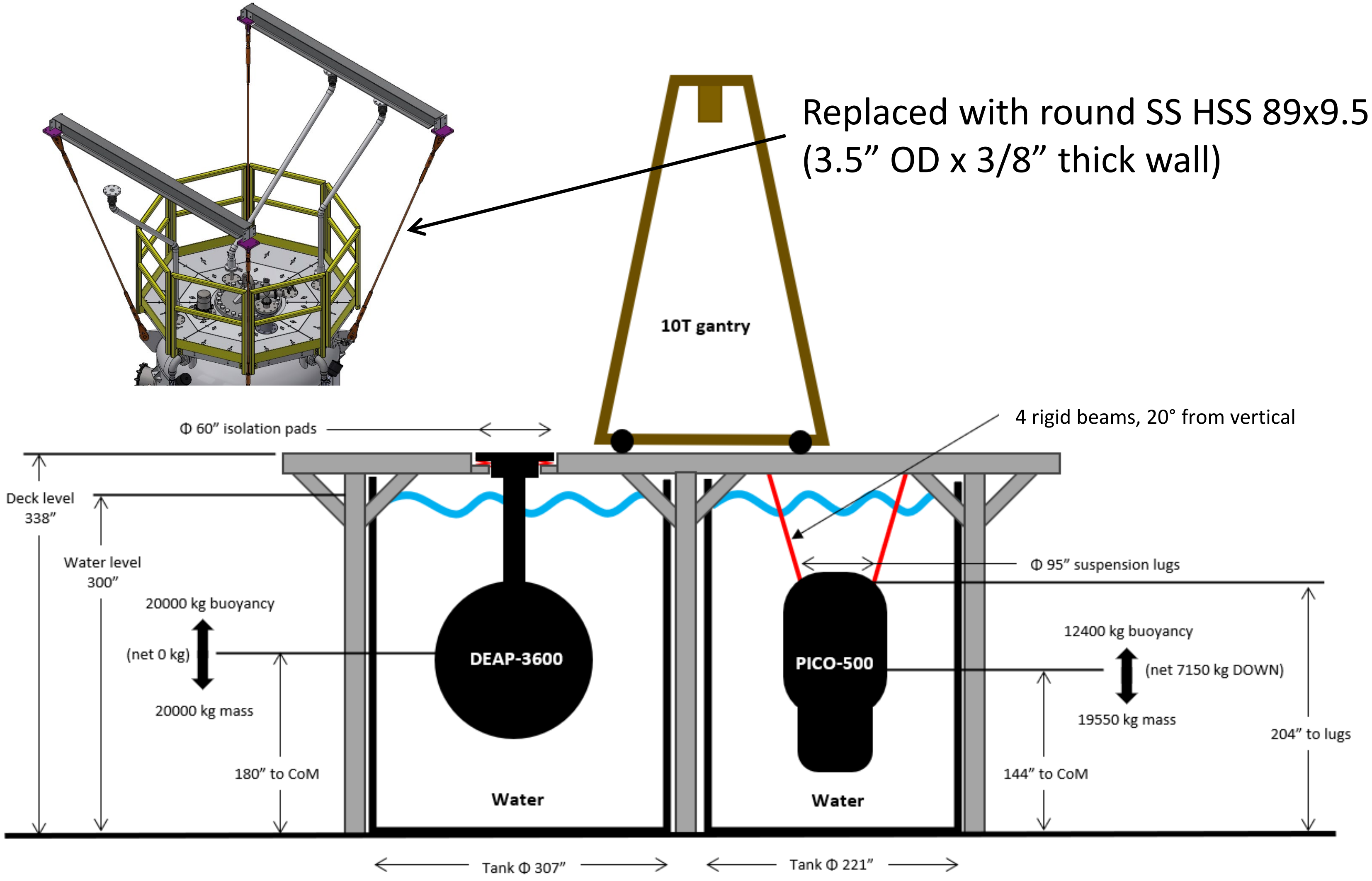
Overview





Replaced with round SS HSS 89x9.5 (3.5” OD x 3/8” thick wall)
10T gantry
Φ 60” isolation pads
4 rigid beams, 20° from vertical
Deck level 338”
Water level 300”
20000 kg buoyancy
(net 0 kg)
20000 kg mass
180” to CoM
DEAP-3600
Water
Φ 95” suspension lugs
12400 kg buoyancy
PICO-500
(net 7150 kg DOWN)
19550 kg mass
204” to lugs
144” to CoM
Water
Tank Φ 307”
Tank Φ 221”

Timeline

- January – April
  - Model PV and platform response to earthquake with new SNOLAB seismic data
  - Look at wire rope cables and response with empty water tanks (no buoyancy / drag effects)
- May
  - Look at response to filled water tank on suspension – uplift and impact loads are a concern
  - Change to rigid bar
- June
  - Effect of full water tank: drag negligible – tank is weakly attached to ground horizontally so doesn't move much in earthquake, and vertical water velocity is very small
  - Effect of full water tank: dynamic pressure is significant – earthquake can accelerate the water vertically: find water tank f_n → peak water acceleration → peak buoyant load on PV
- July
  - Install suspension reinforcing beams
- August
  - Finalize design report for PV and platform response
  - Recheck PV stresses with PVEng with new max PV up and down acceleration and buoyancy
  - Issue PO to Makami for 3rd party review (check that assumptions, calculation approaches, and results appear reasonable and consistent with engineering best practice)
  - Measure alignment of platform and water tank and install suspension lugs
- September / October
  - Complete 3rd party review with Makami
  - Complete component design of suspension elements
  - Install outer lid and fit up suspension feedthroughs
  - Complete suspension TDR
  - Begin mobilizing for PV UG construction
  - Procure suspension hardware

Load Cases

Case	Experiment	Water Tank	Detector	Mass, kg	Buoyancy, kg
1 – Normal operating	PICO	Full	Filled, suspended from platform	19550	12400
	DEAP	Full	Filled, suspended from platform on seismic isolators	20000	20000
2 – PICO commissioning, DEAP operating	PICO	Empty	Filled, suspended from platform	19550	0
	DEAP	Full	Filled, suspended from platform on seismic isolators	20000	20000
3 – PICO commissioning, DEAP offline	PICO	Empty	Filled, suspended from platform	19550	0
	DEAP	Empty	Empty, rigidly suspended from platform (no seismic isolation)	16400	0
4 – PICO operating, DEAP offline	PICO	Full	Filled, suspended from platform	19550	12400
	DEAP	Empty	Empty, rigidly suspended from platform (no seismic isolation)	16400	0

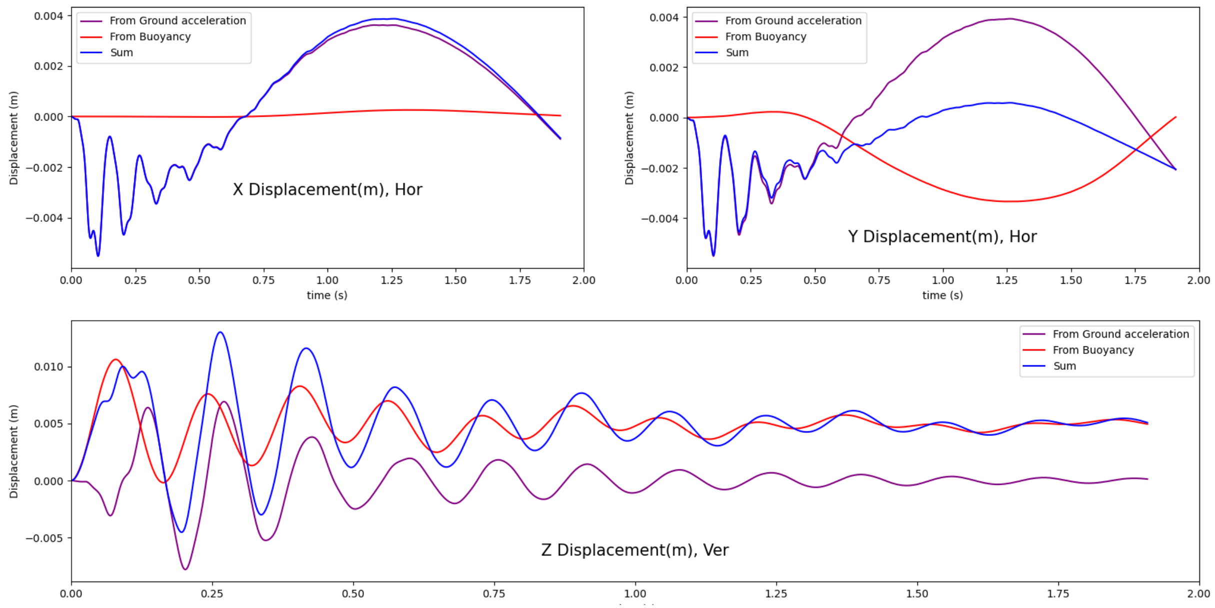
- Modeling of all 4 cases is complete
  - PV accelerations and lug loading are similar to prior cable work, except compression load is new and must be checked
  - Overall impact of DEAP is small
- Largest PICO response when DEAP tank is full (DEAP is decoupled from platform → platform has higher fn → higher acceleration)
  - Case 1 – max compression on suspension: 127 kN
  - Case 2 – max tension on suspension: 113 kN
  - Case 1 and 2 – max horizontal load

Case 1

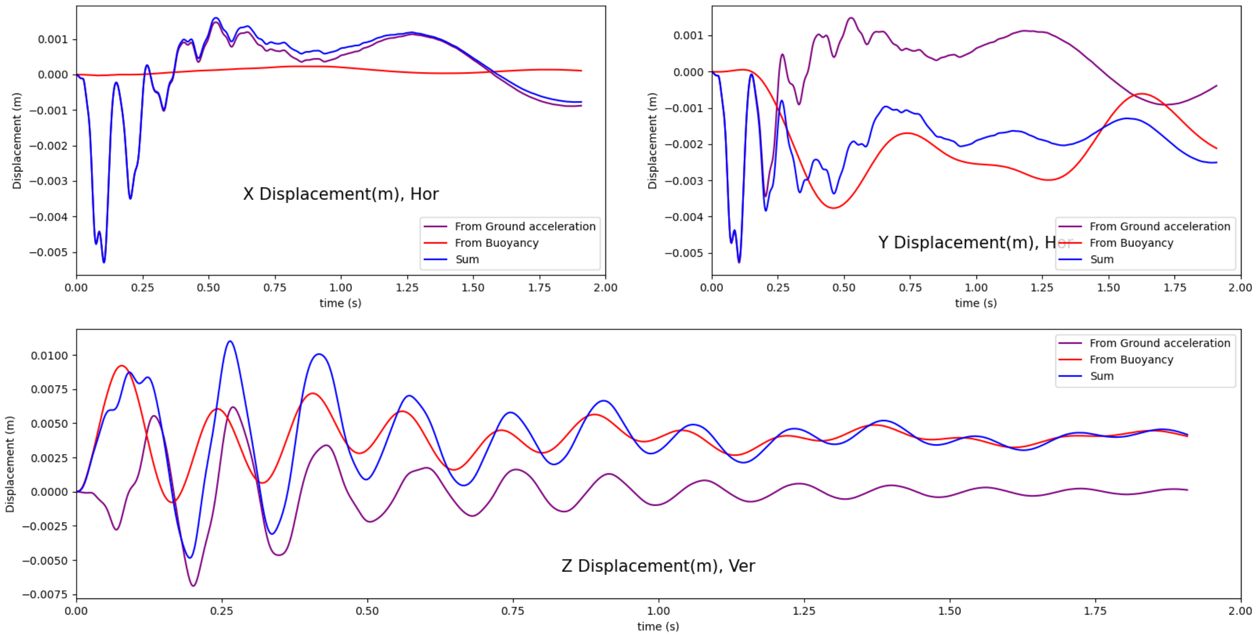
Displacement

- Limited to about +/- 1 cm
- Designing for +/-3”

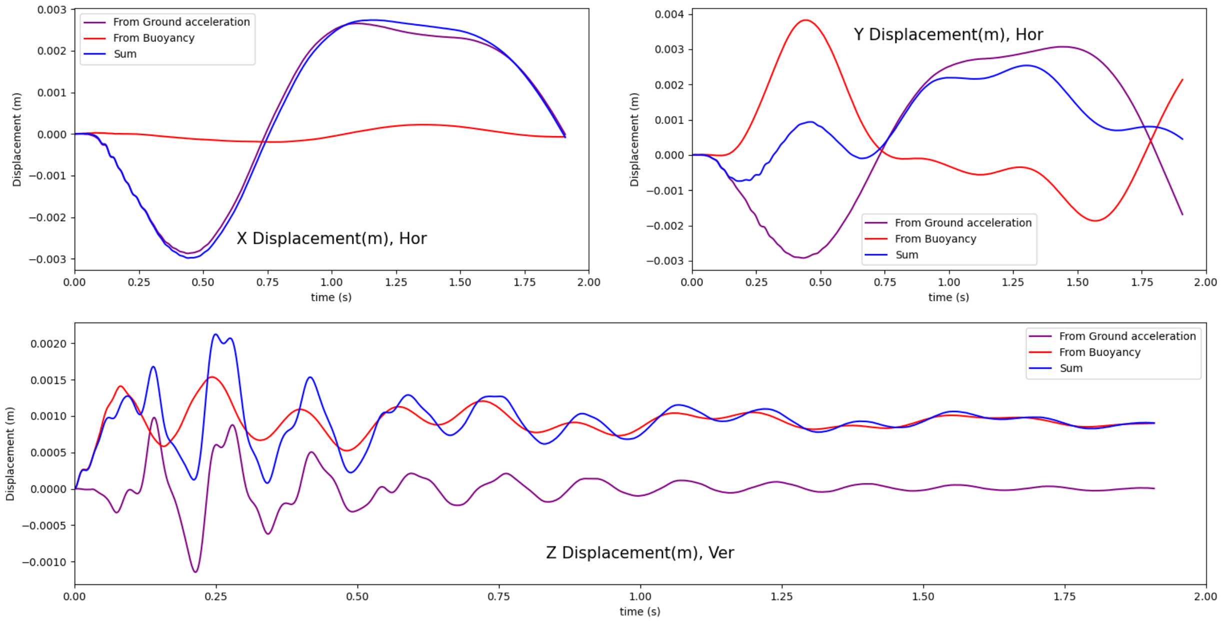
PV relative to floor



Platform relative to floor



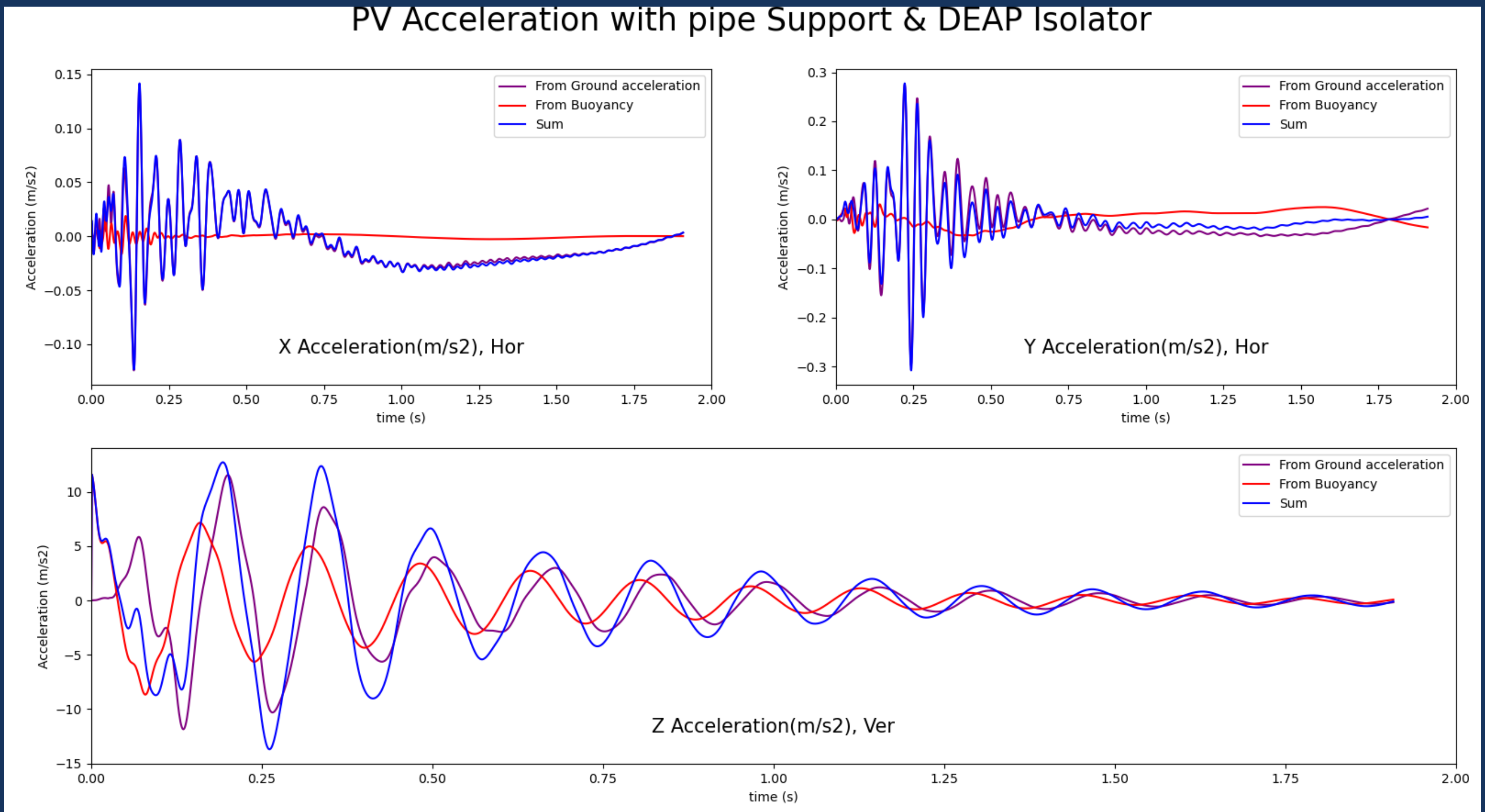
PV relative to platform



Case 1

Acceleration: max x/y 0.03g   max z 1.4g

PICO tank full, DEAP tank full
Upwards load on platform



1 – Normal operating

2 – PICO commissioning, DEAP operating

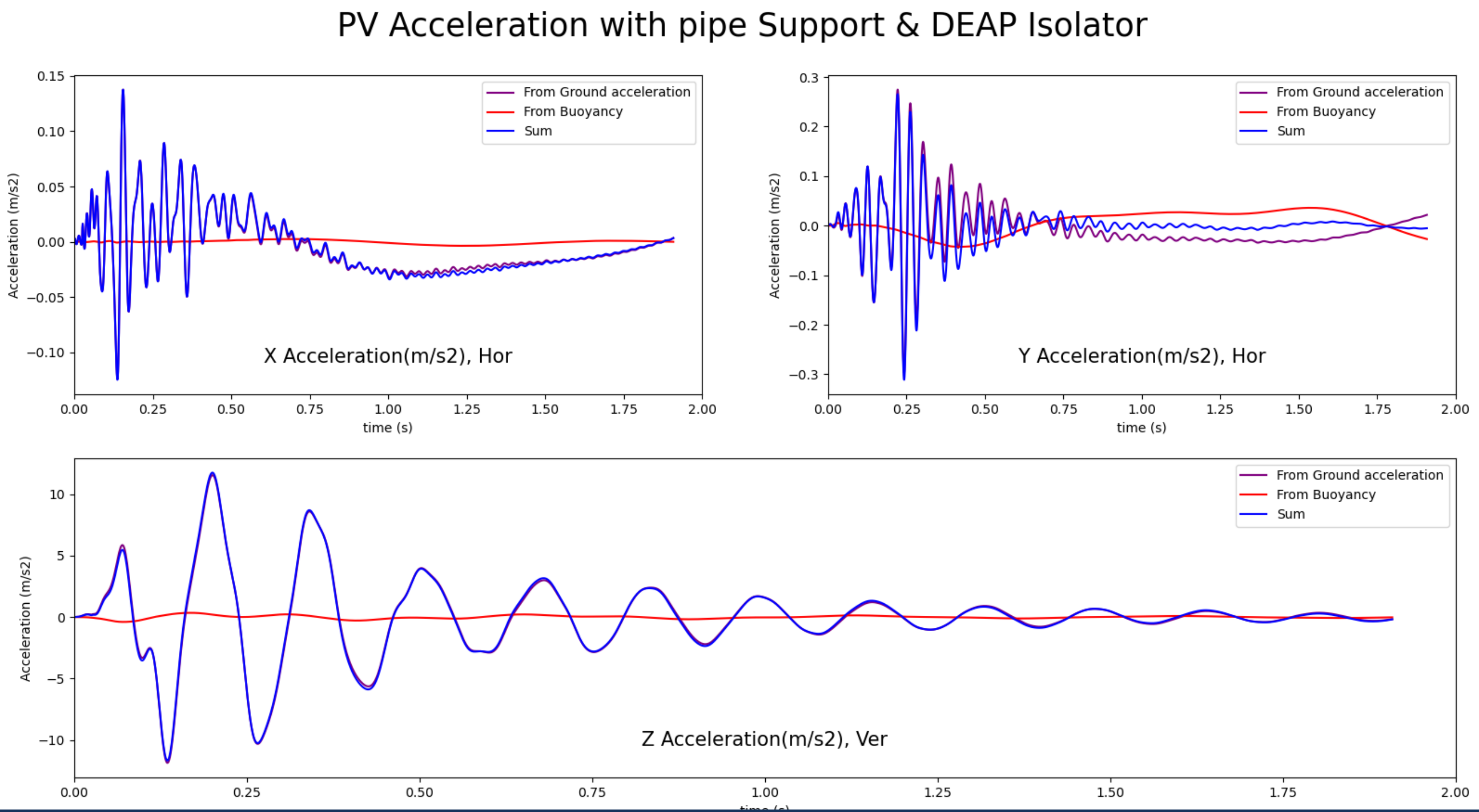
3 – PICO commissioning, DEAP offline

4 – PICO operating, DEAP offline

Case 2

Acceleration: max x/y 0.03g max z 1.3g

PICO tank empty, DEAP tank full
Downwards load on platform

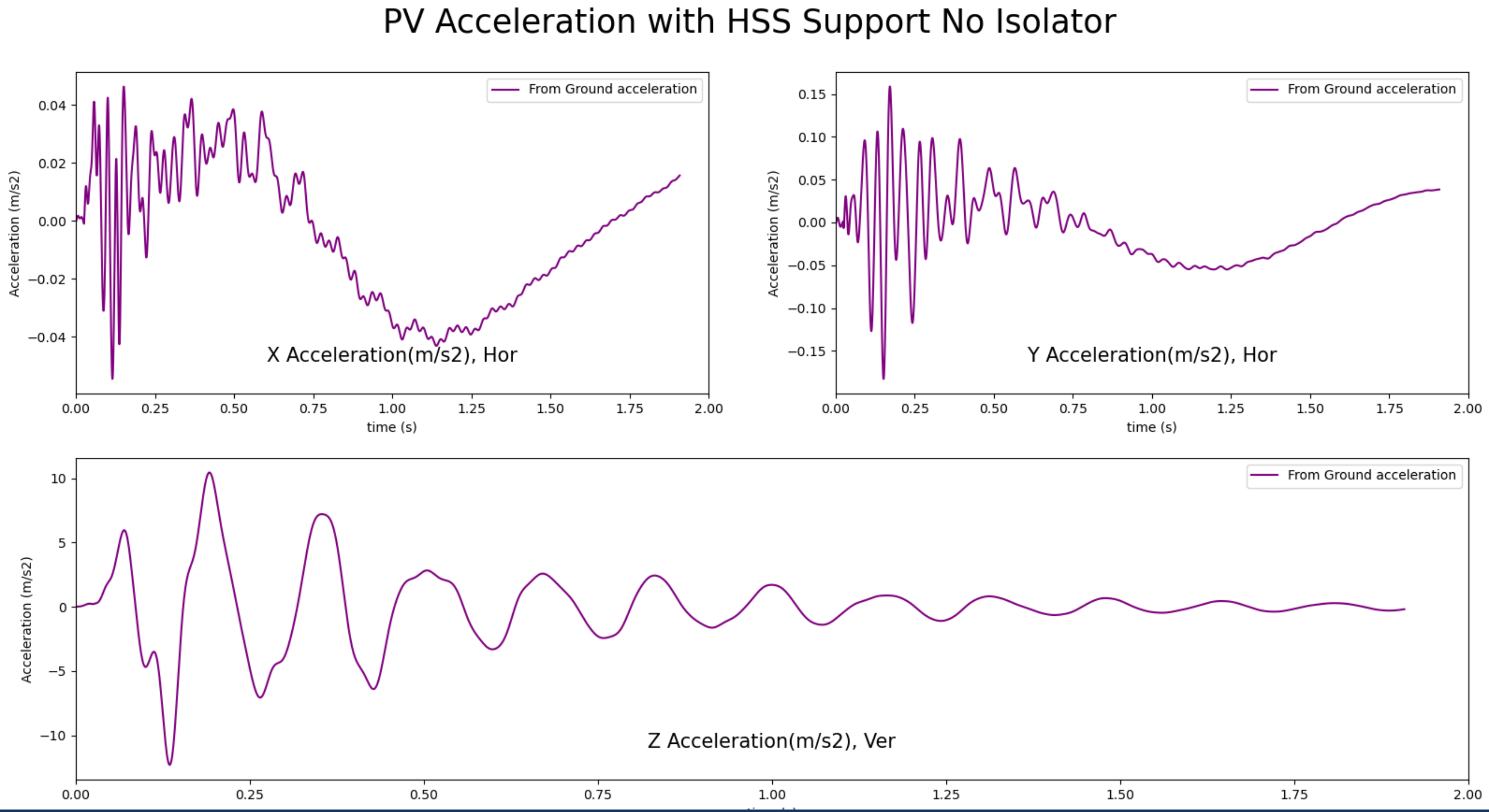


- 1 – Normal operating
- 2 – PICO commissioning, DEAP operating
- 3 – PICO commissioning, DEAP offline
- 4 – PICO operating, DEAP offline

Case 3

PICO tank empty, DEAP tank empty
Downwards load on platform

Acceleration: max x/y 0.02g max z 1.3g



1 – Normal operating

2 – PICO commissioning, DEAP operating

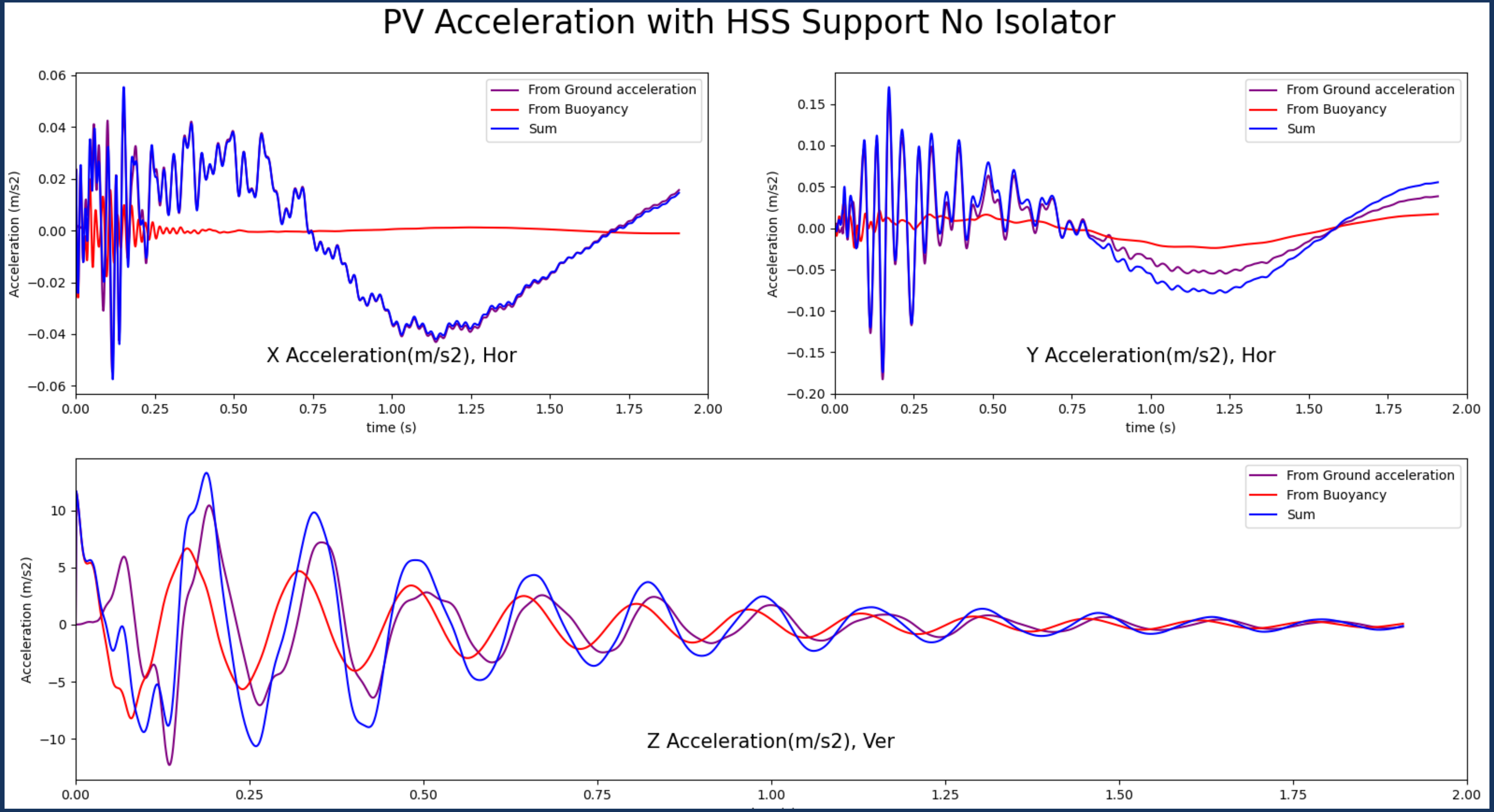
3 – PICO commissioning, DEAP offline

4 – PICO operating, DEAP offline

Case 4

PICO tank full and DEAP tank empty
Upwards load on platform

Acceleration: max x/y 0.02g   max z 1.3g



1 – Normal operating

2 – PICO commissioning, DEAP operating

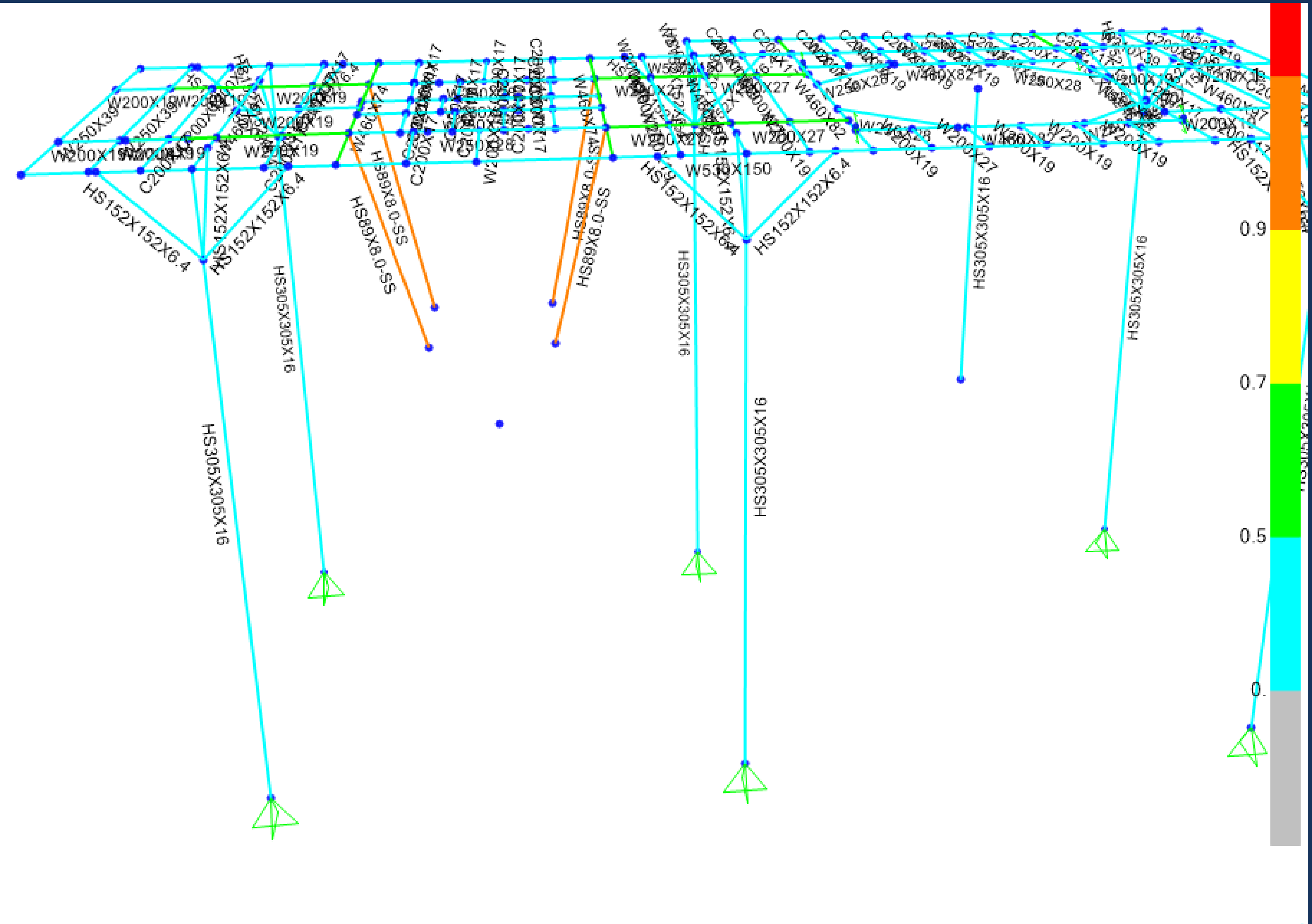
3 – PICO commissioning, DEAP offline

4 – PICO operating, DEAP offline

Case 1

Utilization (should be <1)

PICO tank full, DEAP tank full
Upwards load on platform



1 – Normal operating

2 – PICO commissioning, DEAP operating

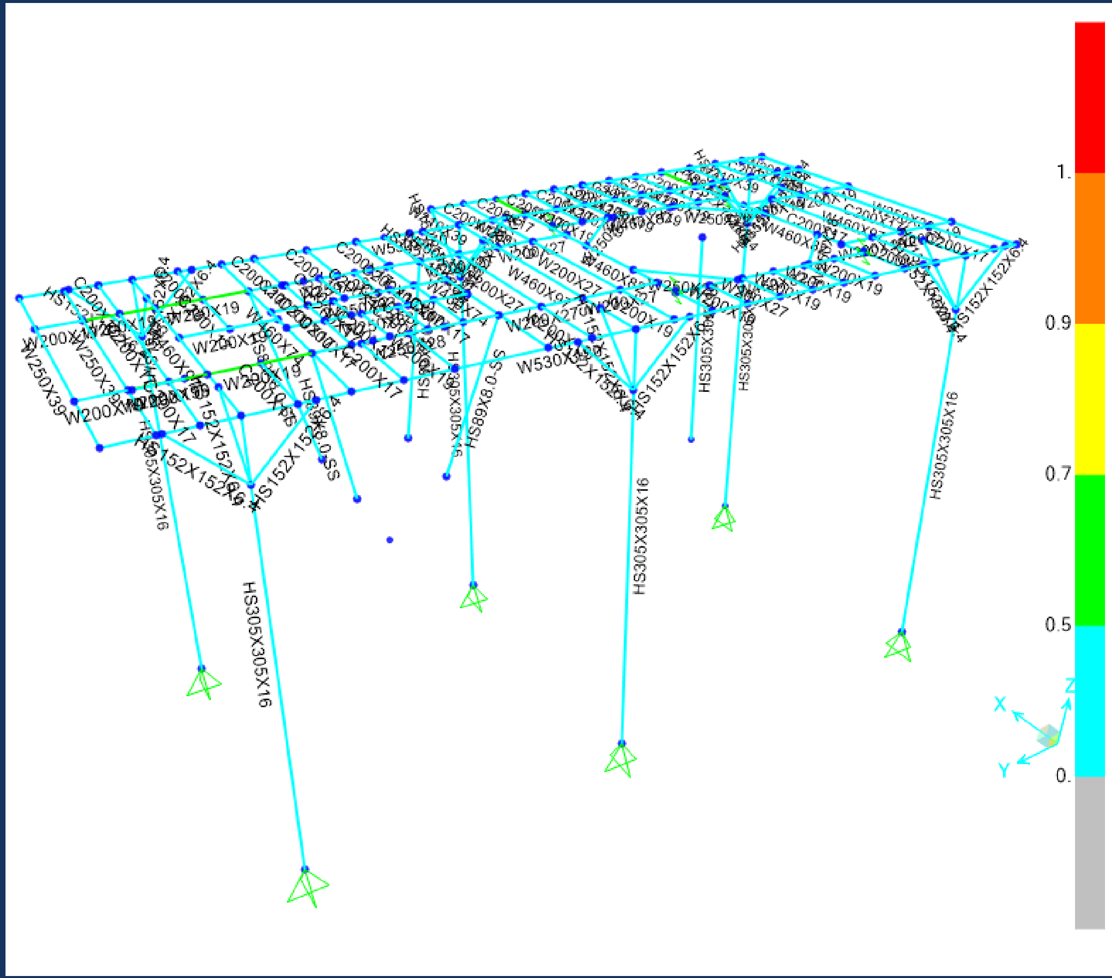
3 – PICO commissioning, DEAP offline

4 – PICO operating, DEAP offline

Case 2

Utilization (should be <1)

PICO tank empty, DEAP tank full
Downwards load on platform



1 – Normal operating

2 – PICO commissioning, DEAP operating

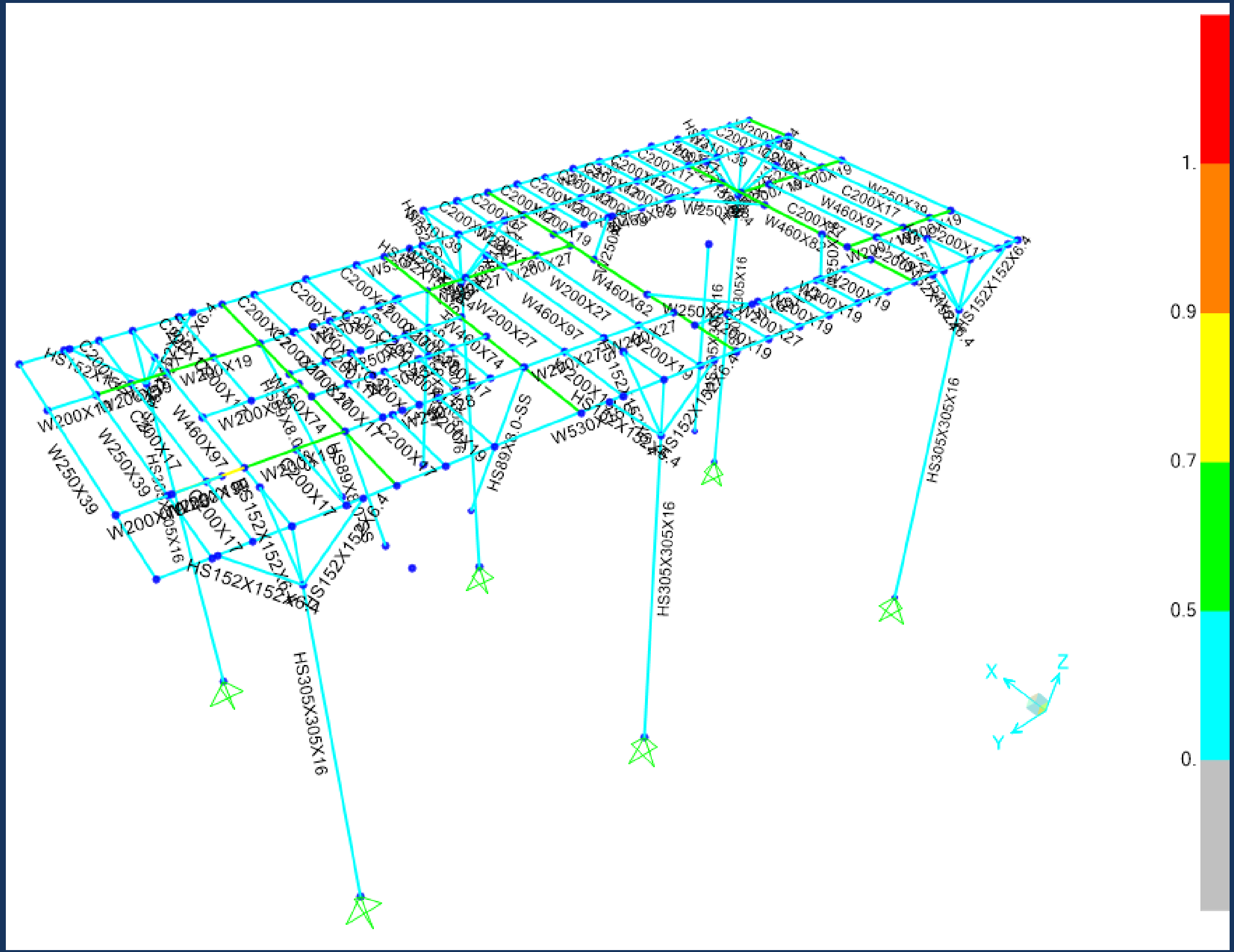
3 – PICO commissioning, DEAP offline

4 – PICO operating, DEAP offline

Case 3

Utilization (should be <1)

PICO tank empty, DEAP tank empty
Downwards load on platform

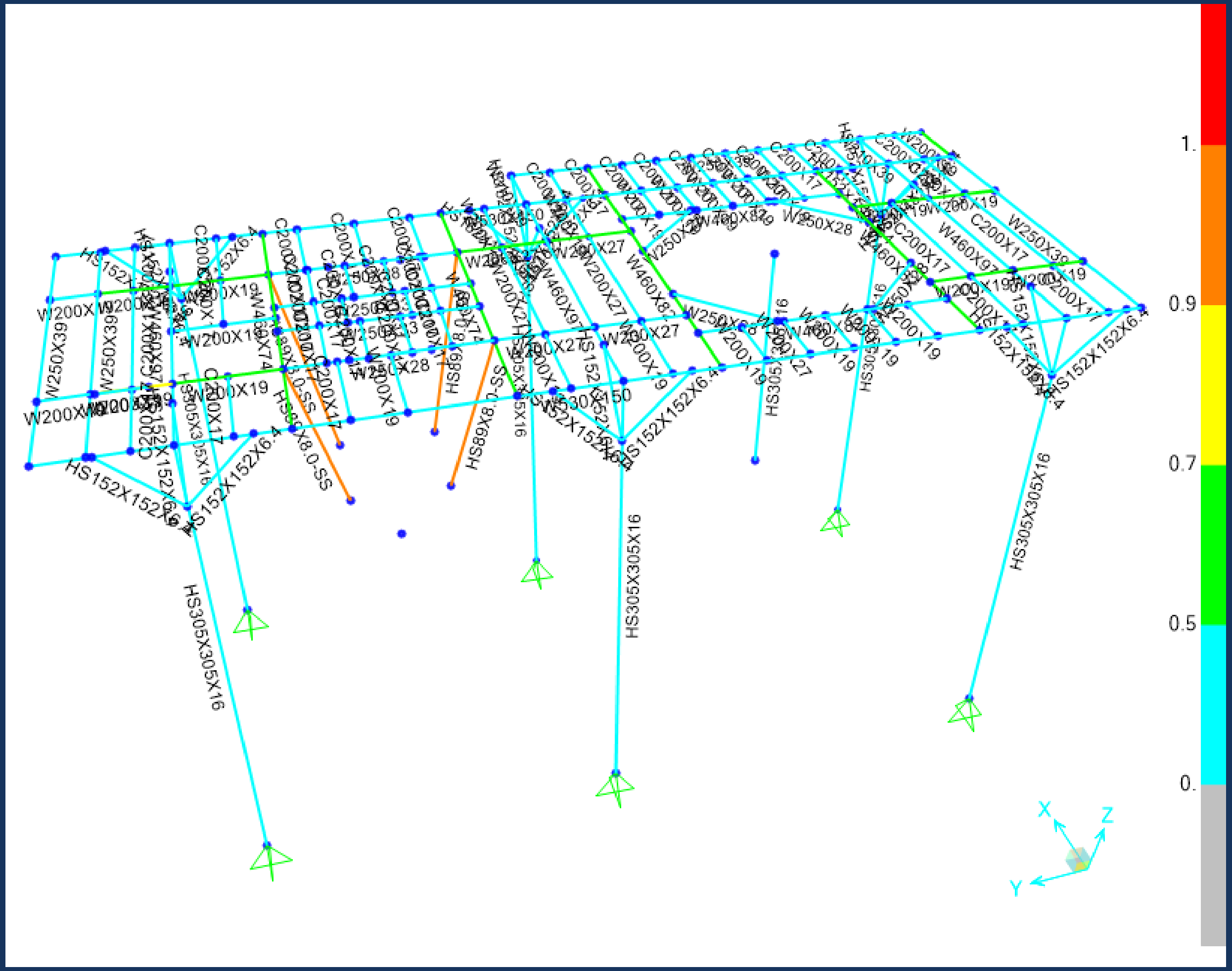


- 1 – Normal operating
- 2 – PICO commissioning, DEAP operating
- 3 – PICO commissioning, DEAP offline
- 4 – PICO operating, DEAP offline

Case 4

Utilization (should be <1)

PICO tank full and DEAP tank empty
Upwards load on platform



- 1 – Normal operating
- 2 – PICO commissioning, DEAP operating
- 3 – PICO commissioning, DEAP offline
- 4 – PICO operating, DEAP offline

PV PVEng Scope

Done

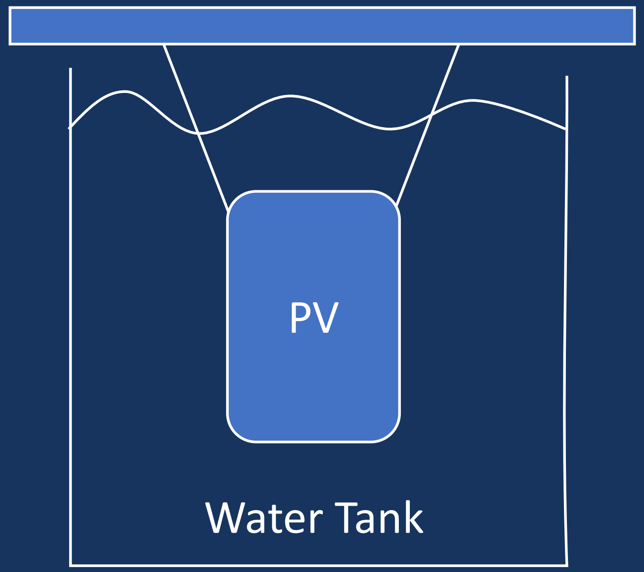
- **Case 1 - check stresses with max downward loading (water tank empty)**
  - Pressure + Weight + Earthquake
  - Pressure = 220 psi
  - 1a – Earthquake = 1.5g vertical (downward gravity load), 0.03g N/S and E/W
  - 1b – Earthquake = 1.5g vertical (downward gravity load), 0.3g N/S and E/W

In Progress

- **Case 2 – check stresses with max upward loading (water tank full)**
  - Weight + Earthquake + Buoyancy
  - (Pressure = 0 psi)
  - Earthquake = 1.75g vertical (upward gravity load), 0.03g N/S and E/W
  - Buoyancy = 3g vertical (upward buoyancy load = 3g * 12400 kg)

In Progress

- **Case 3 – check stresses at lugs (20 deg from vertical)**
  - 3a – Tension – Increase until code stress limit (need at least 127 kN)
  - 3b – Compression – Increase until code stress limit (need at least 135 kN)



Mechanical Design

- Mechanical design starting soon
- Primary element is round SS HSS 89x9.5 (3.5” OD x 3/8” thick wall)
- Other requirements:
  - Provision for adjustment of the length of each suspension element by +/- 3”.
  - All suspension elements located inside the water tank must be stainless steel.
  - Suspension elements must fit through the openings in the outer lid.
  - Provision for adapting a light-tight seal between each suspension element and its opening in the outer lid. The suspension element will ideally be smooth and round near the lid opening to facilitate making a light-tight seal.
  - It must be possible to move the suspension elements out of the way of the PV during the final PV lift. This involves lifting the PV up by roughly 6 ft from its normal operating elevation to allow for the IV to be positioned underneath the PV.
  - The PV-side of the suspension element must adapt to the existing four suspension lugs on the top of the PV, as detailed on reference document N – 2023-03-01 - PICO-500 PV drawings.
  - Suspension element clevis pins must be appropriately captured to prevent loosening/shifting from small side loads or vibrations.
  - Consider installation methodology to install the suspension elements and balance loading between the four supporting elements, as reasonably possible.
  - The suspension connections at the platform-side must be aligned with the as-built location of the connections on the PV. This is necessary to ensure that loads on the suspension elements are axial only and not acting out-of-plane.

Wrapping up

- Urgent need to close out engineering and design + reviews
  - PVEng stress analysis of PV
  - Makami 3rd party review for PV and platform response
  - Mechanical design of suspension elements
  - Suspension TDR at SNOLAB
- Completion of these will allow for welding of the PV to begin

End