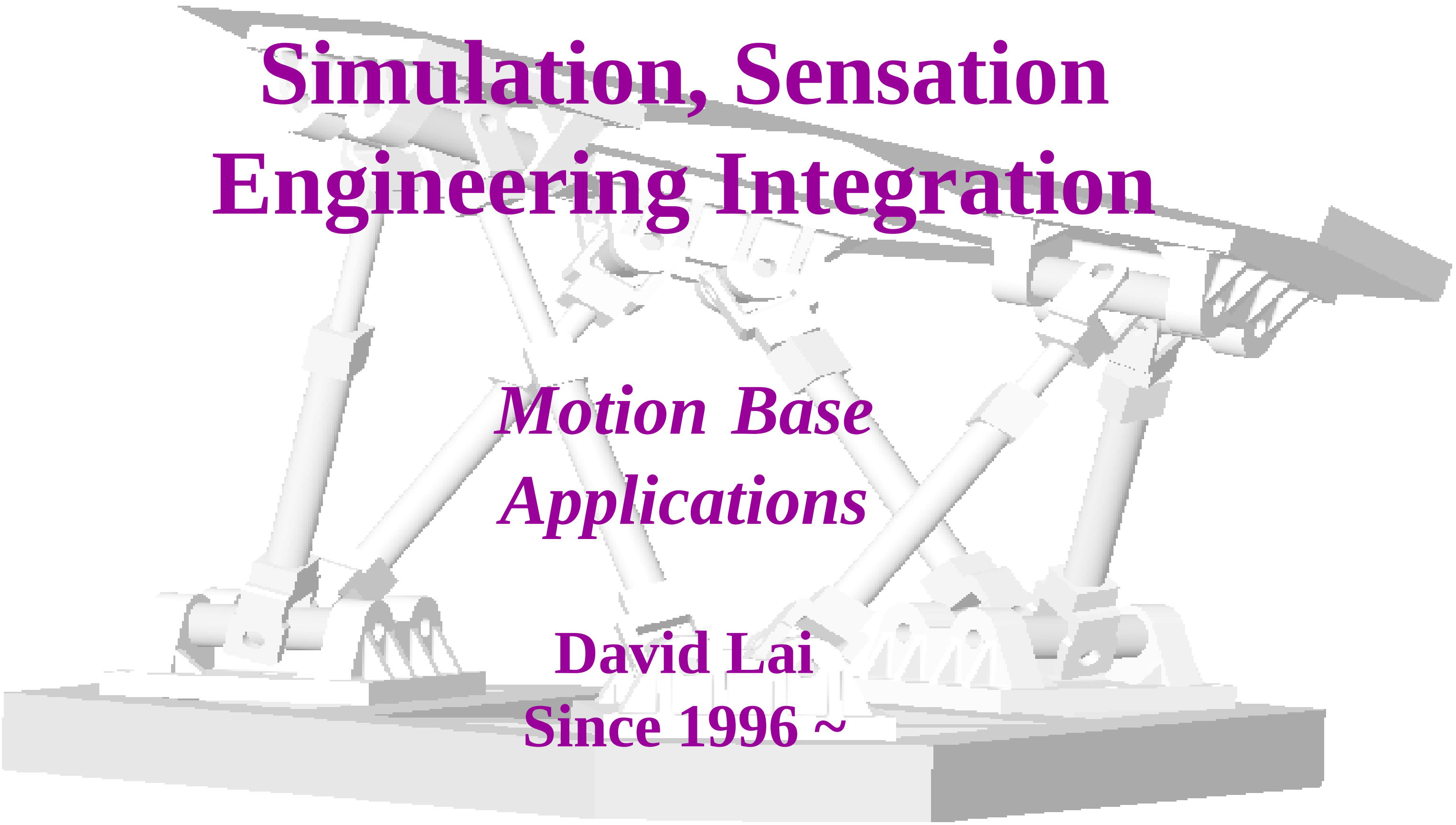
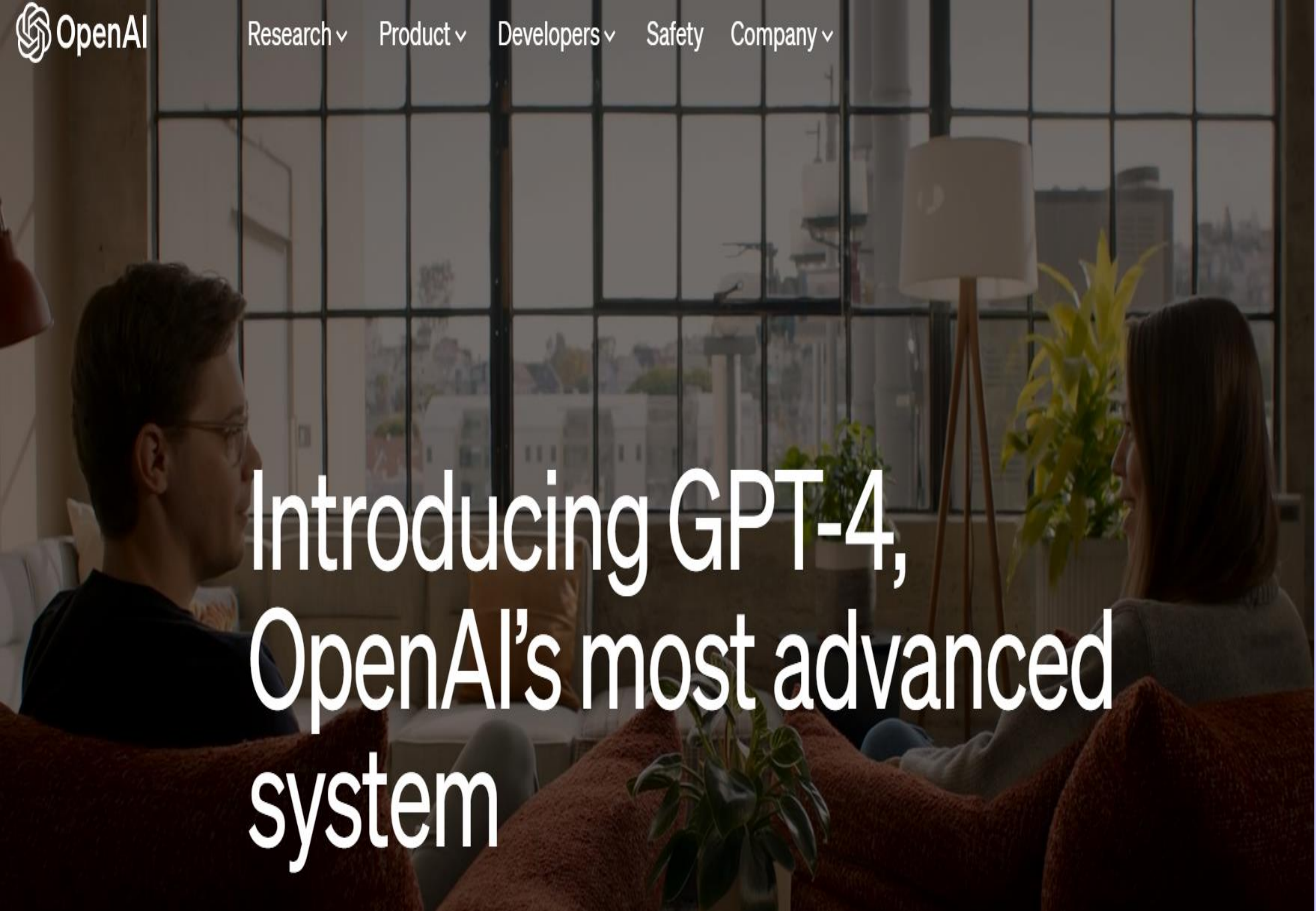
Simulation, Sensation Engineering Integration



Motion Base Applications

David Lai

Since 1996 ~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TH

What are the applications of motion base?

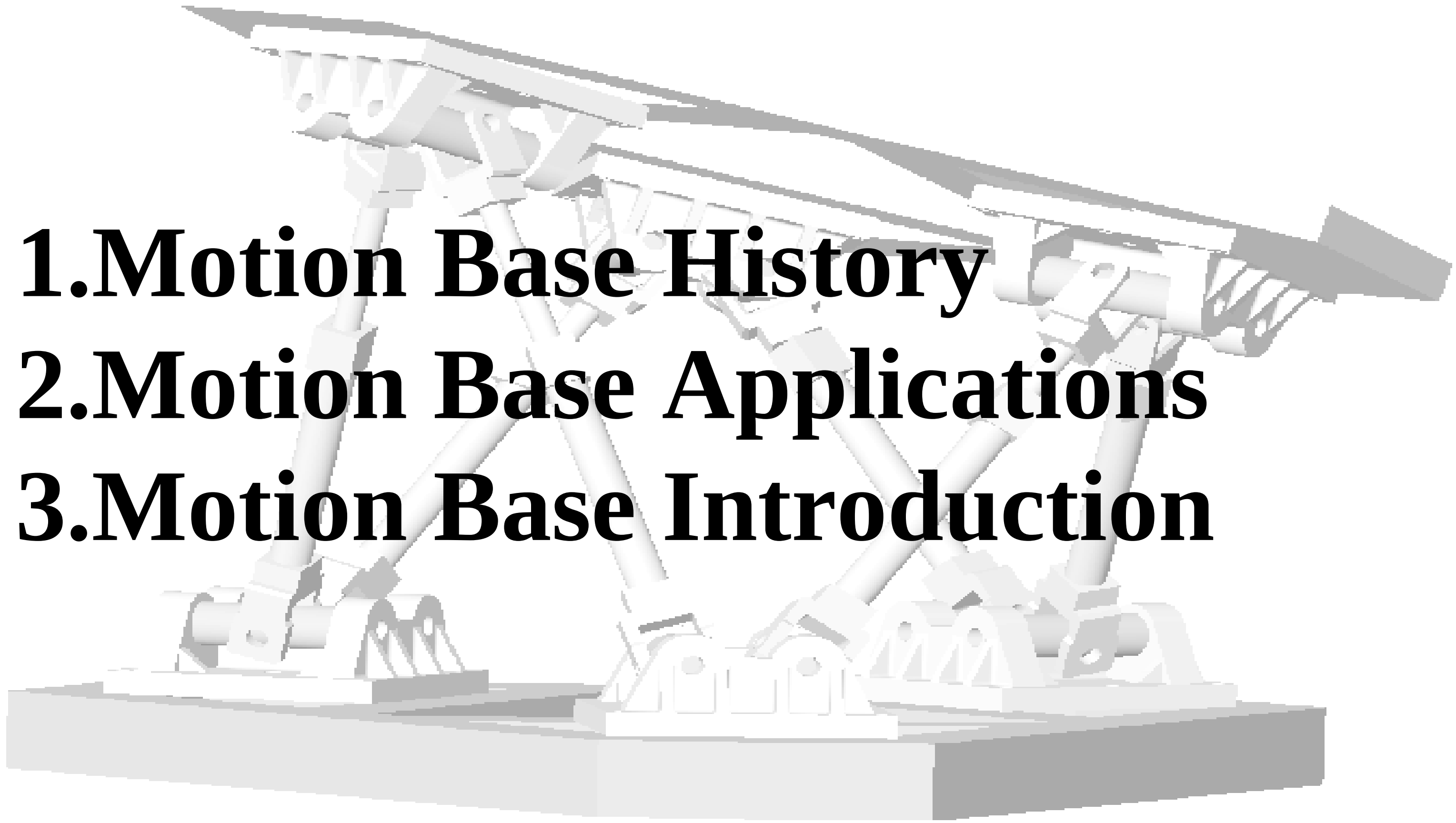
Motion bases are used in a variety of applications where precise and realistic motion simulation is required. Some of the common applications of motion bases include:

1. Flight and driving simulators: Motion bases are used extensively in flight simulators and driving simulators to provide a realistic experience of flying or driving. The motion base simulates the movements of the aircraft or vehicle, creating a realistic sensation of acceleration, deceleration, turns, and turbulence.
2. Amusement park rides: Motion bases are also used in amusement park rides, such as roller coasters and simulators. The motion base provides a thrilling and immersive experience for riders, simulating the sensation of flying, falling, or spinning.
3. Military training: Motion bases are used in military training simulators to simulate the movement of tanks, aircraft, and other military vehicles. The simulators provide a realistic training experience for soldiers, helping them prepare for real-world situations.
4. Medical training: Motion bases are also used in medical training simulators, such as surgical simulators and patient simulators. The motion base can simulate the movement of the patient or the surgical instrument, allowing medical professionals to practice and improve their skills in a realistic and safe environment.
5. Industrial testing: Motion bases are used in industrial testing to simulate the movement of products or equipment, such as testing the durability of a vehicle or the performance of a piece of machinery.

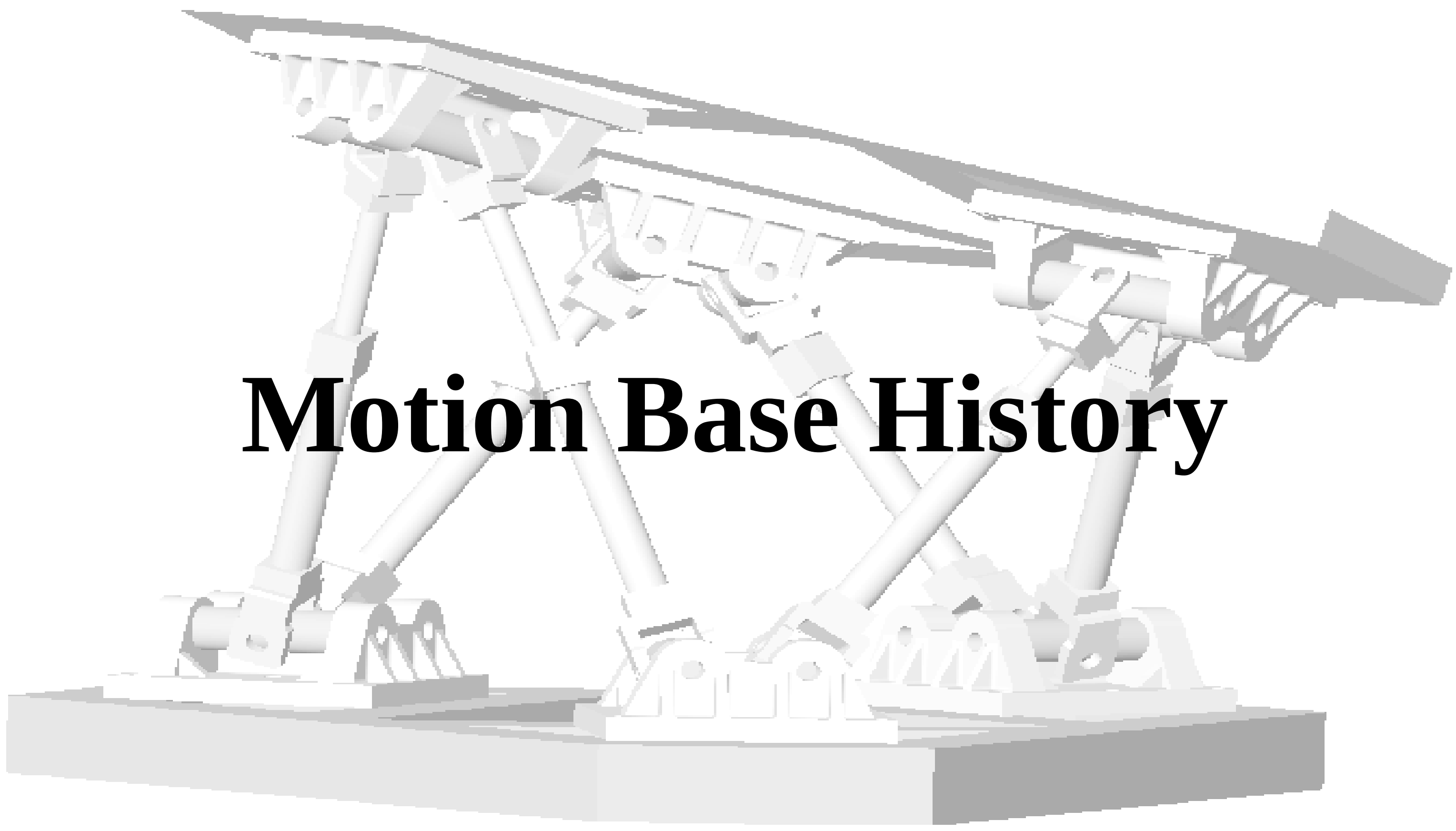
Overall, motion bases are used in a wide range of applications where realistic and precise motion simulation is required.

Regenerate response

Outlines

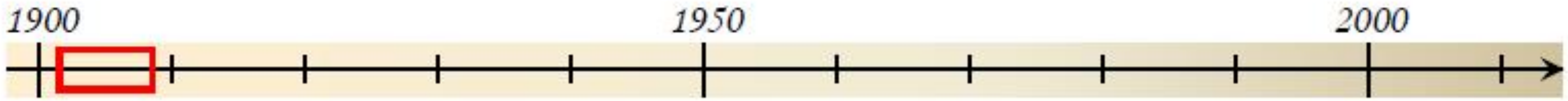


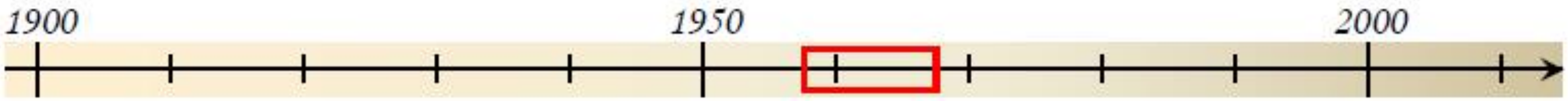
1. **Motion Base History**
2. **Motion Base Applications**
3. **Motion Base Introduction**



Motion Base History

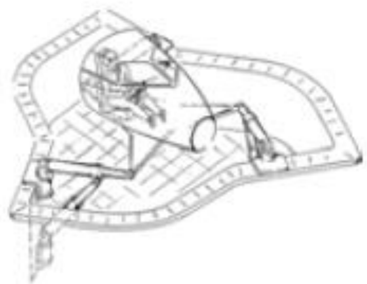
Motion Base History



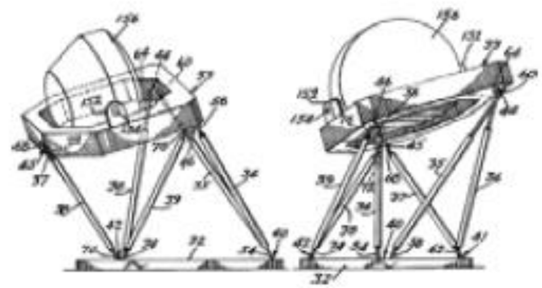


Gough Platform ’54

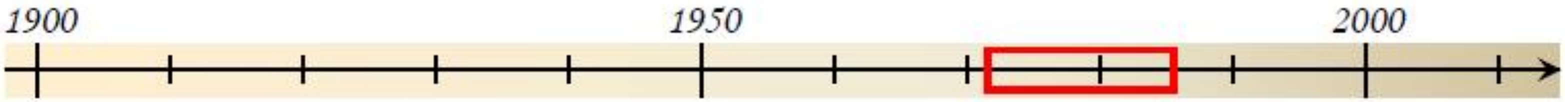
C. Kappel ’60s



Stewart Platform ’66



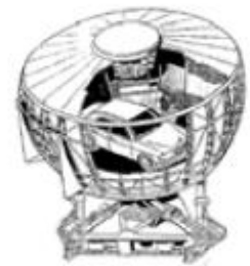
First Patent ’67



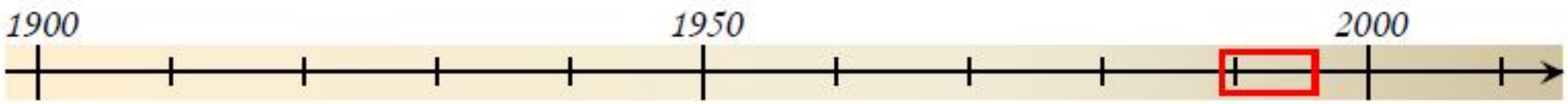
VW 70's

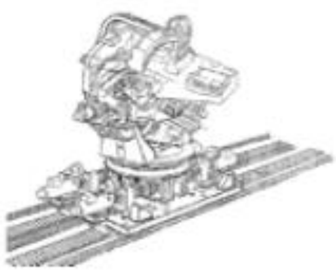
VTI I '84

IFAS (IKK) '84



Daimler Benz '85



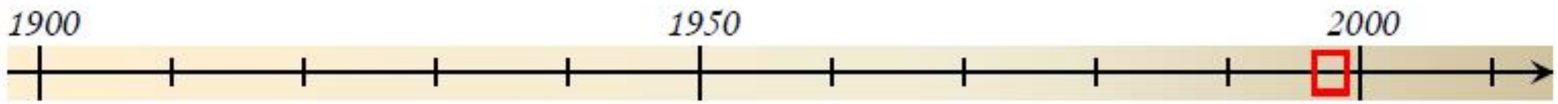


Mazda '90

Trygg Hansa '91
VTI II '02

Daimler Benz '93

JARI '96

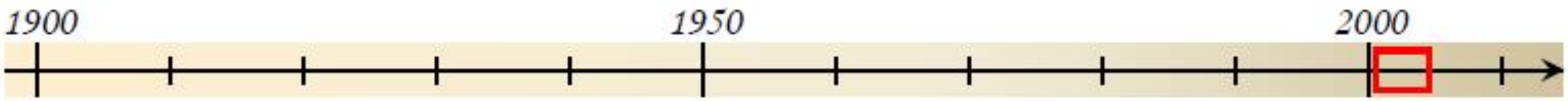


BMW ~'98/99

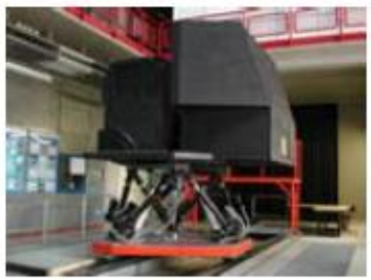
Renault '99

Nissan '99

IZVW '99



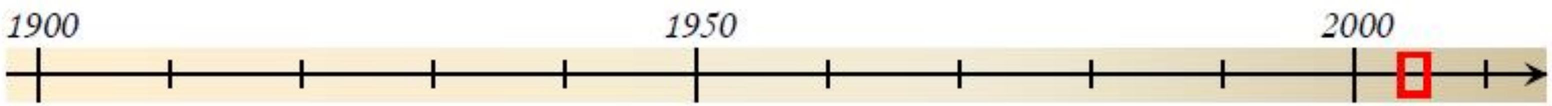
Ford VIRRTEX
new '01



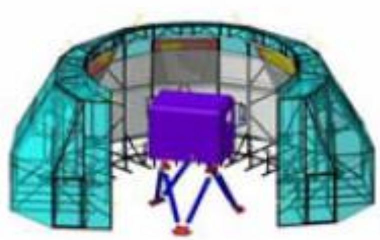
IFAS MARS '01

NADS-1 '02

BMW '03



VTI III '04

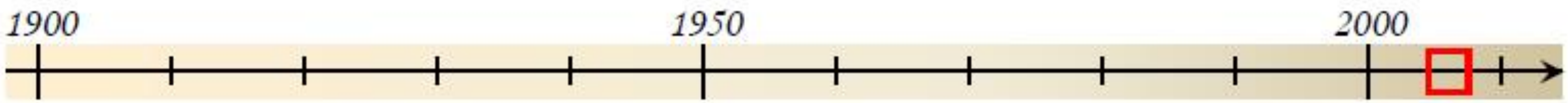


TU München '04

IFAS MARS '04

ULTIMATE '04

Katech KAAS '05

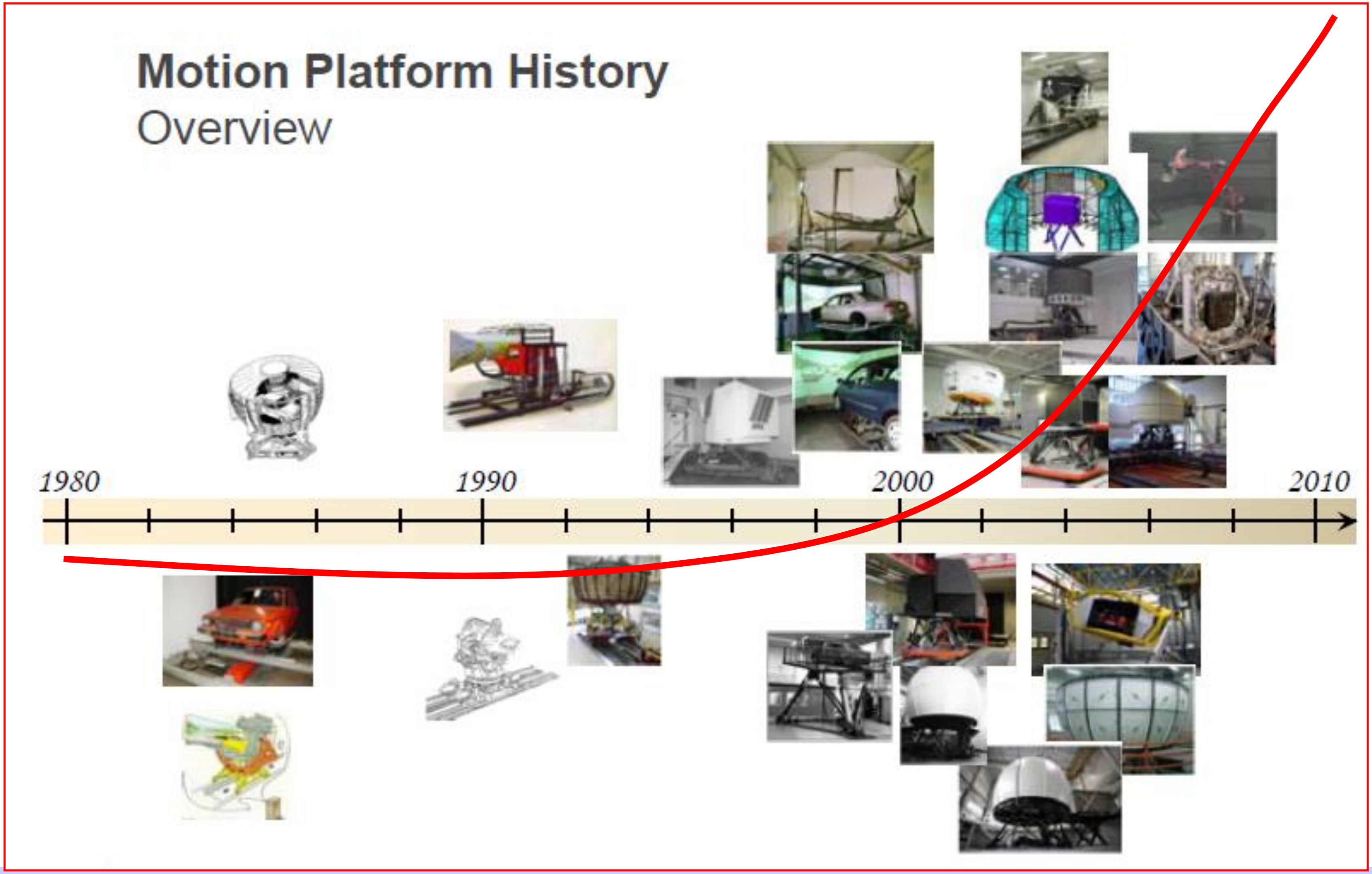


DLR SimCar '05

LADS '06

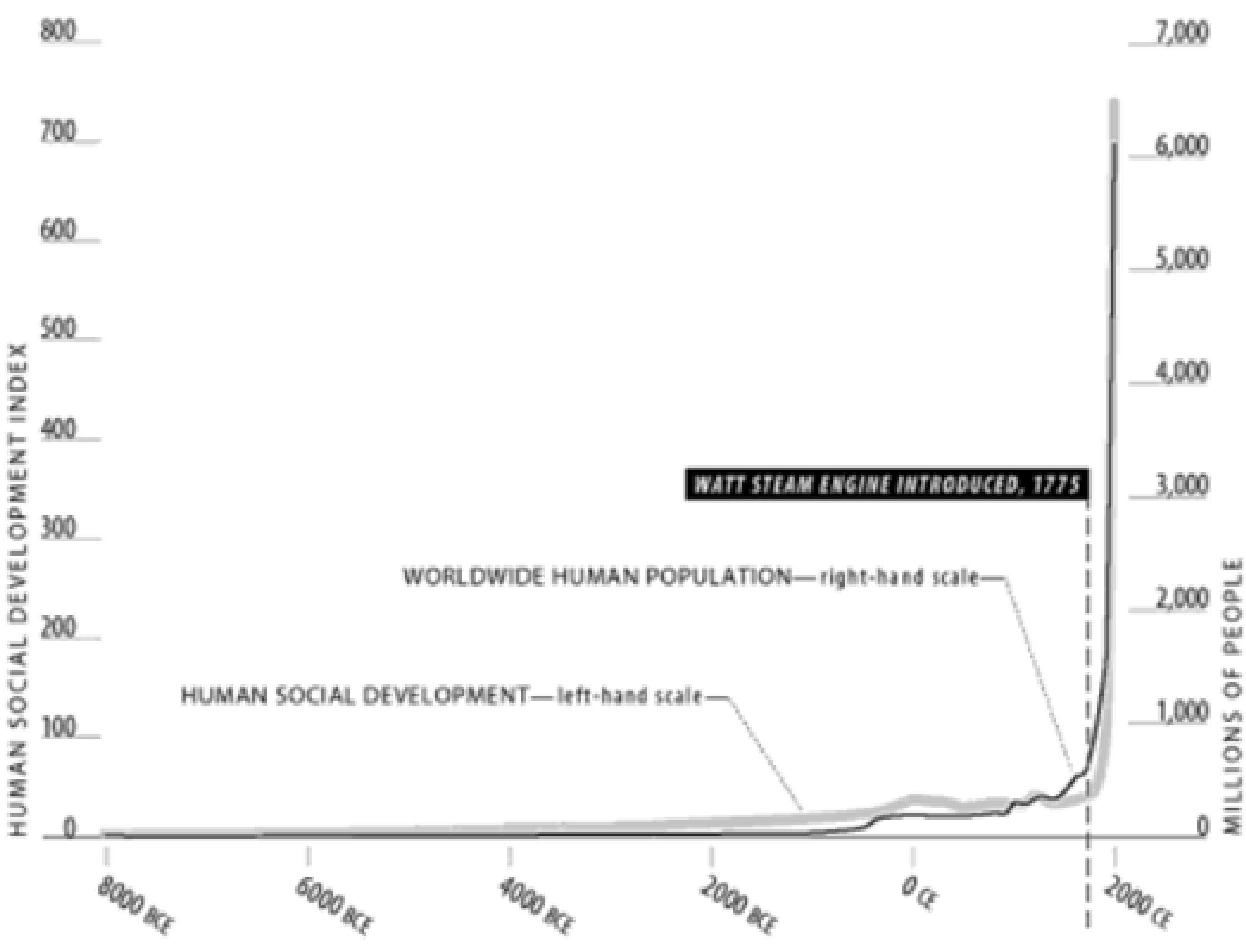
MPI RoboCoaster '07

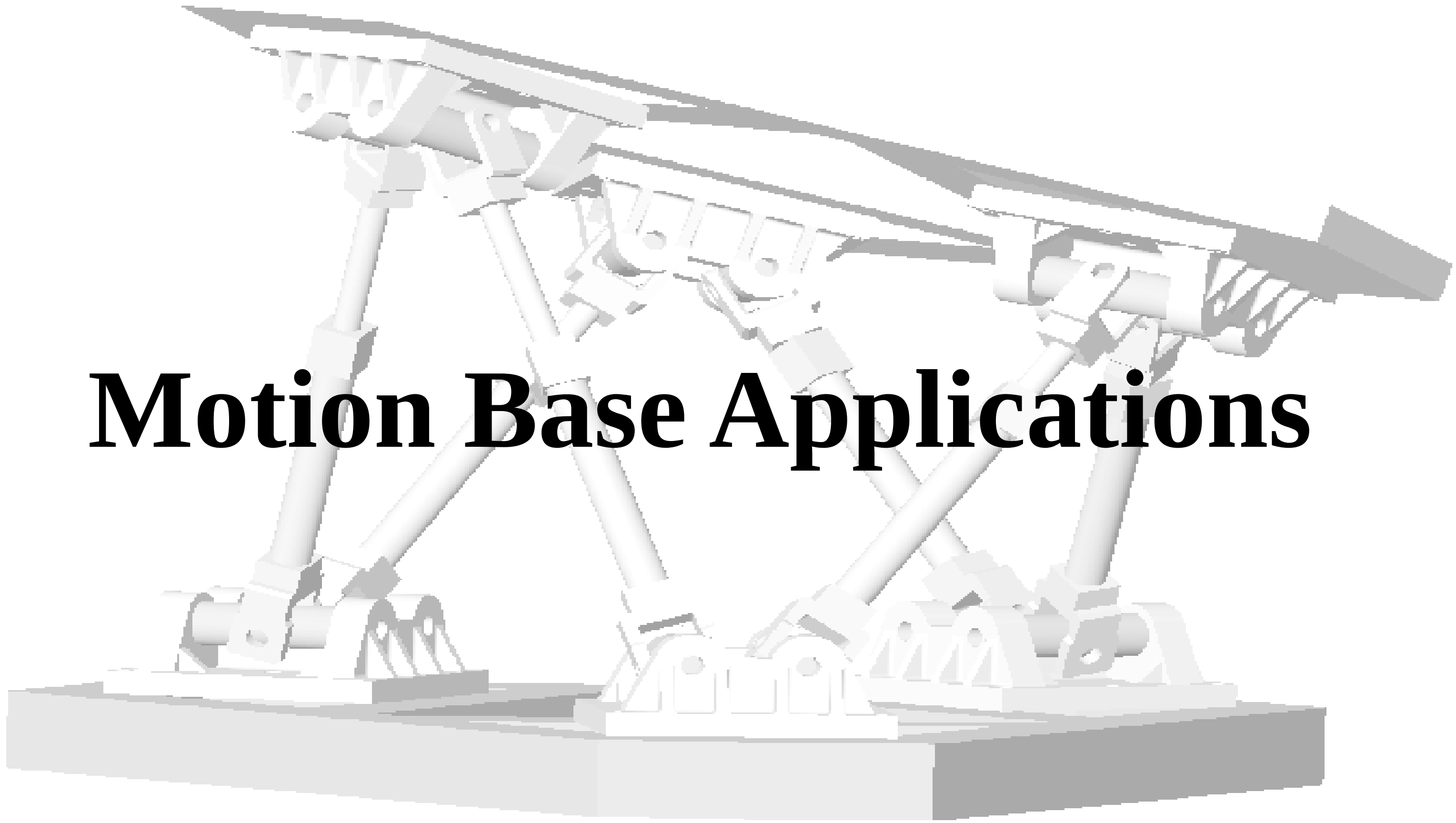
TNO DESDEMONA '07


Motion Platform History
Overview
1980
1990
2000
2010

Growth Curve

FIGURE 1.2 What Bent the Curve of Human History? The Industrial Revolution.





Motion Base Applications

Train

Taiwan Railway EMU 600 Simulator

Boat

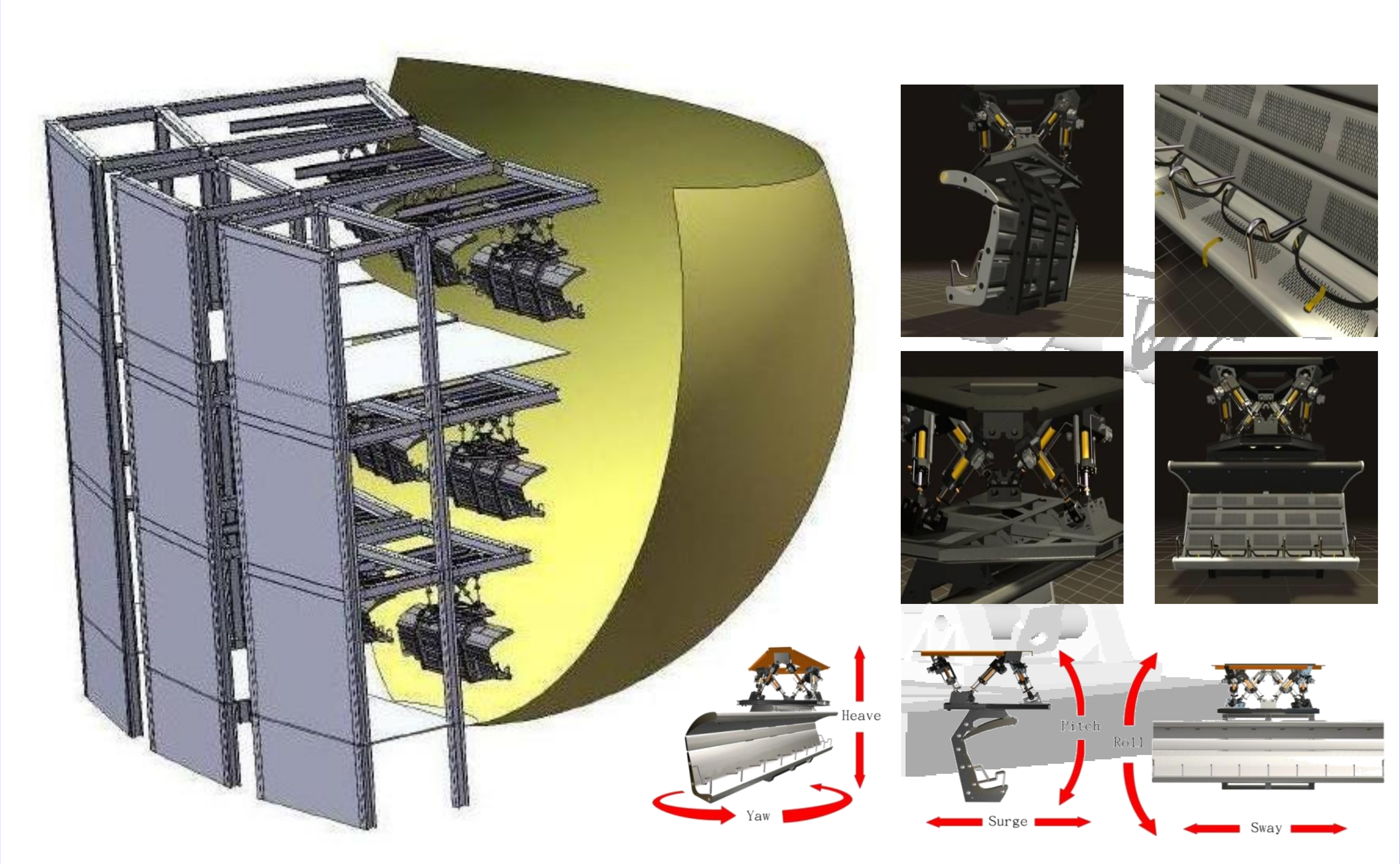
Taiwan Navy Boat Handling Simulator

Flight Simulator

Earthquake

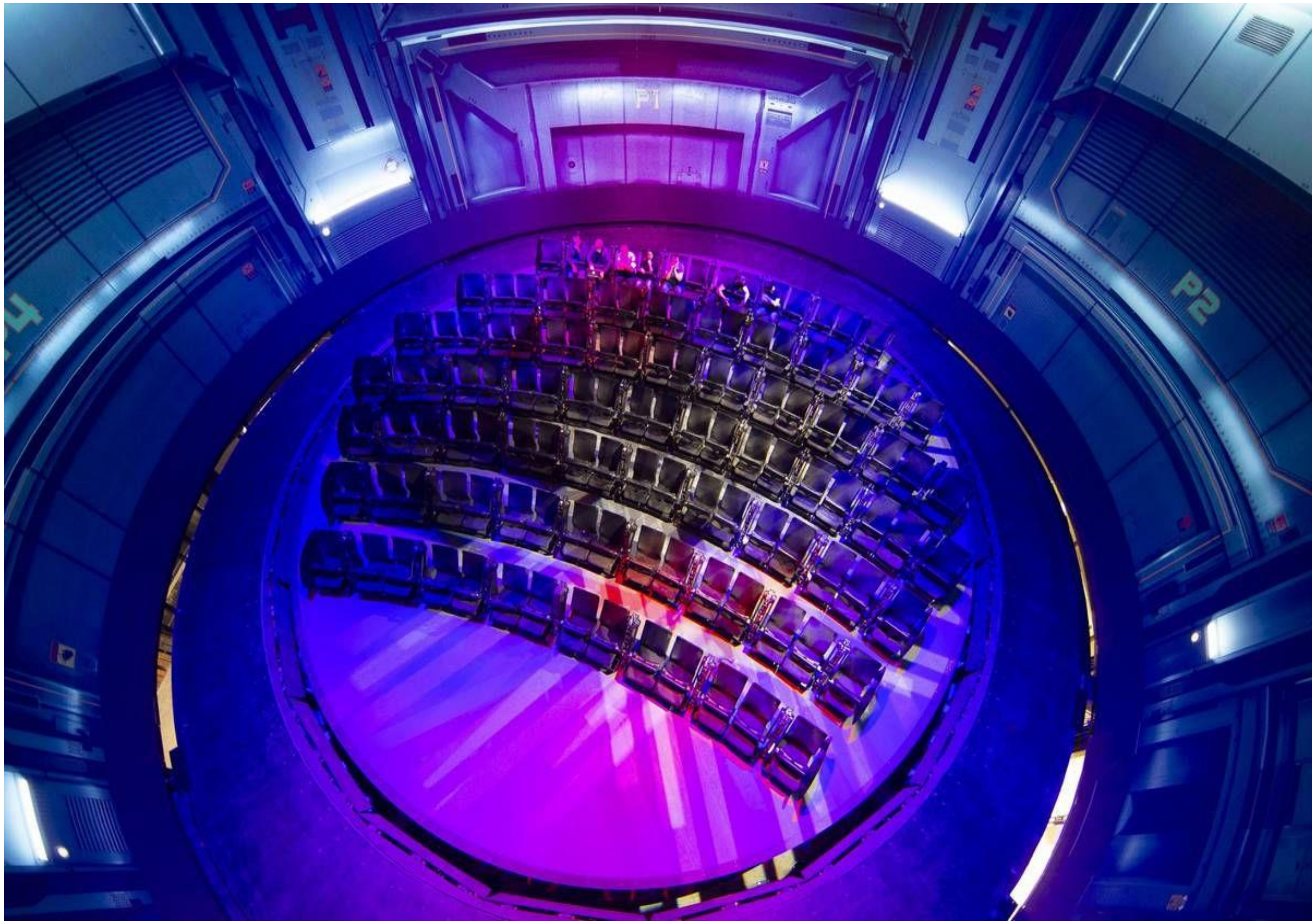
Earthquake Survival Simulator

Flying Theater



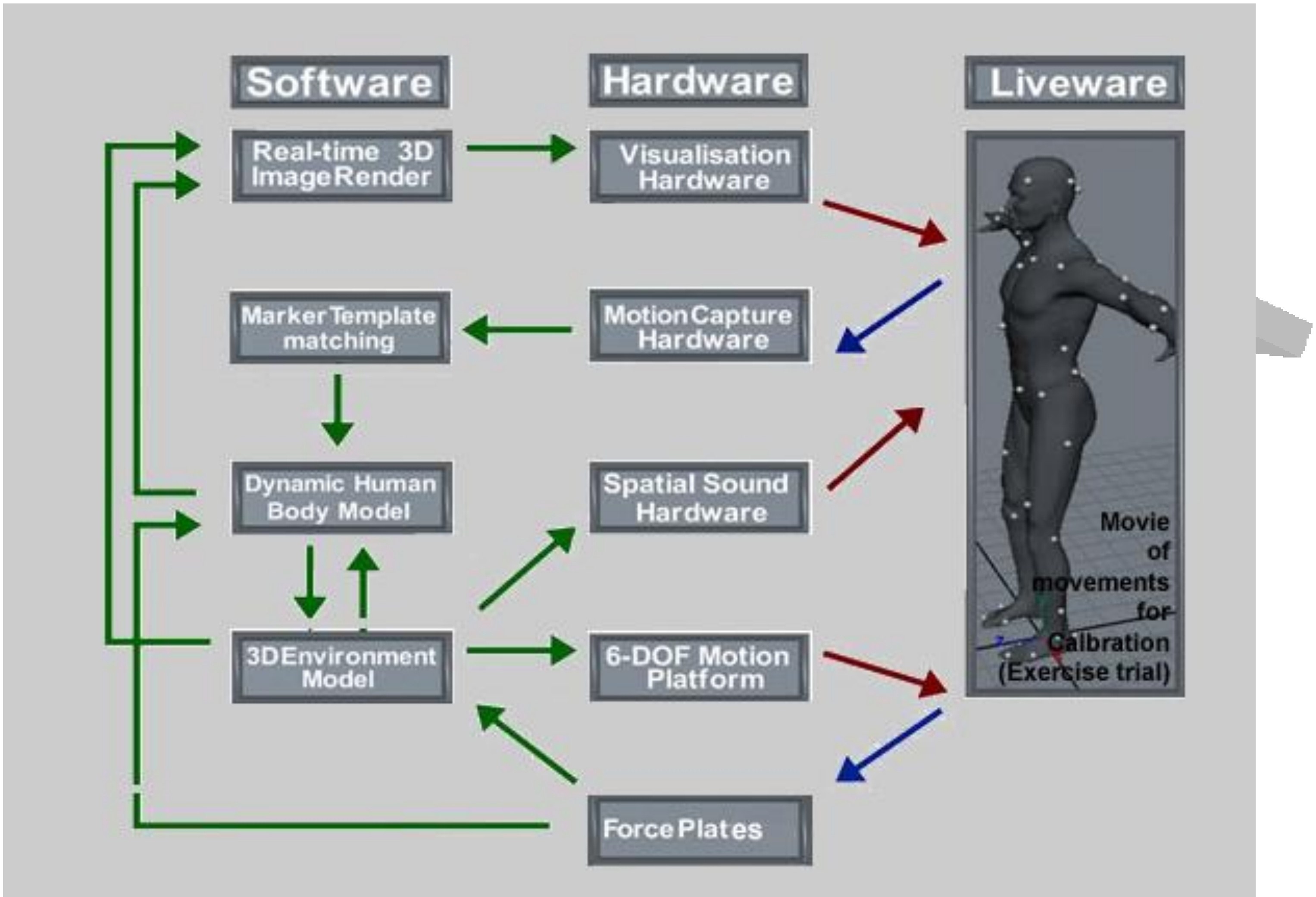
4D Theater

“Chasseurs de Tornades” at France Futuroscope



120 seats, platform can rotate at 28km/h, 3 DOF

Medical



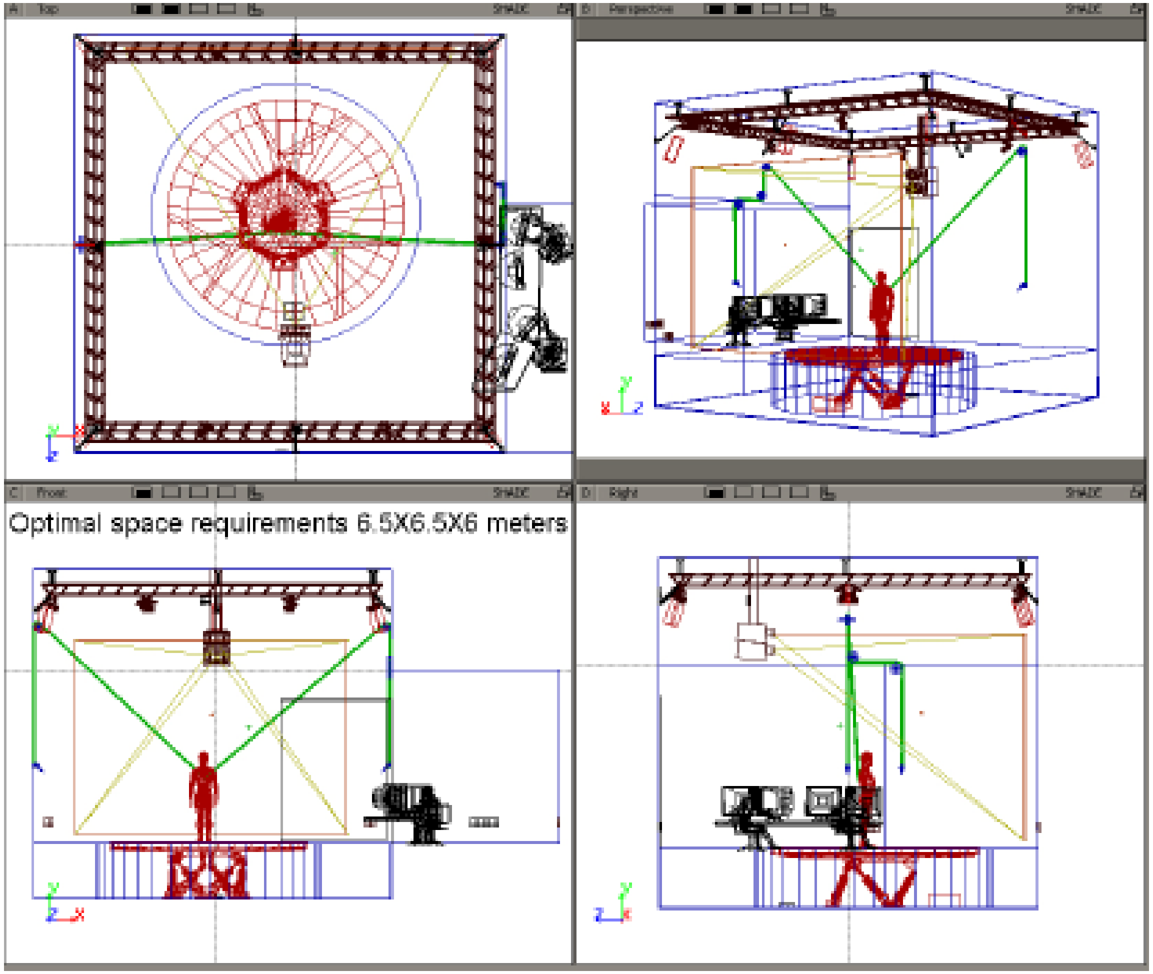
Software
Hardware
Liveware
Real-time 3D ImageRender
Visualisation Hardware
Marker Template matching
Motion Capture Hardware
Dynamic Human Body Model
Spatial Sound Hardware
3DEnvironment Model
6-DOF Motion Platform
Force Plates
Movie of movements for Calibration (Exercise trial)

Assistant Tools

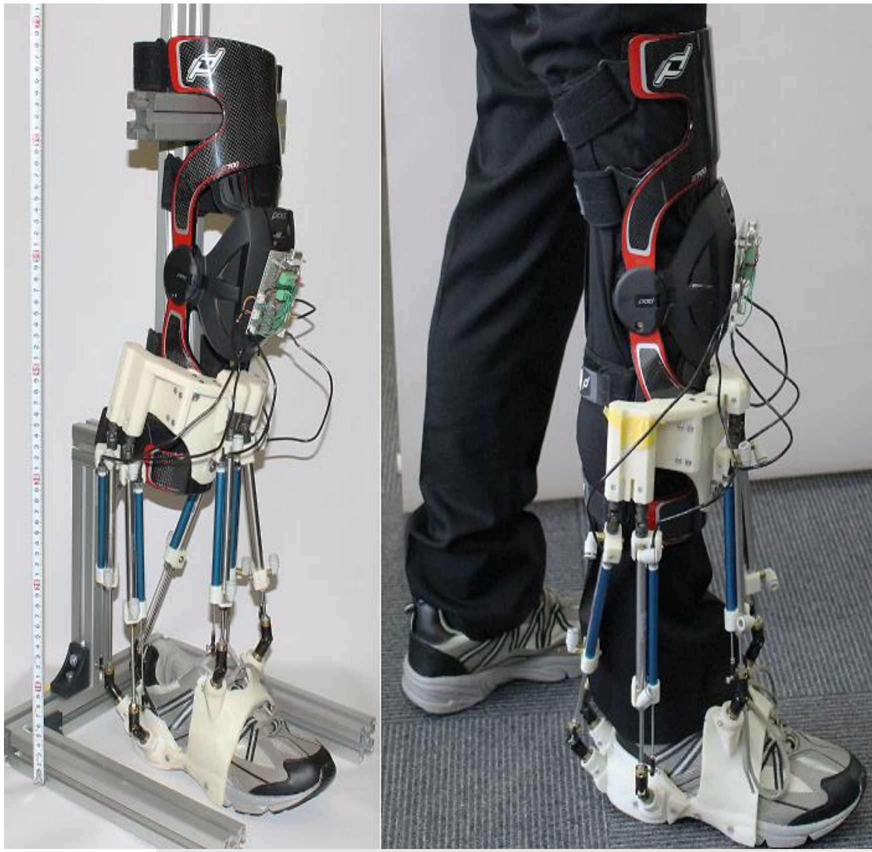
Figure 1. The Rutgers Mobility Simulator. © Rutgers University and UMDNJ. Reprinted by permission.

Power Assistant Wheel

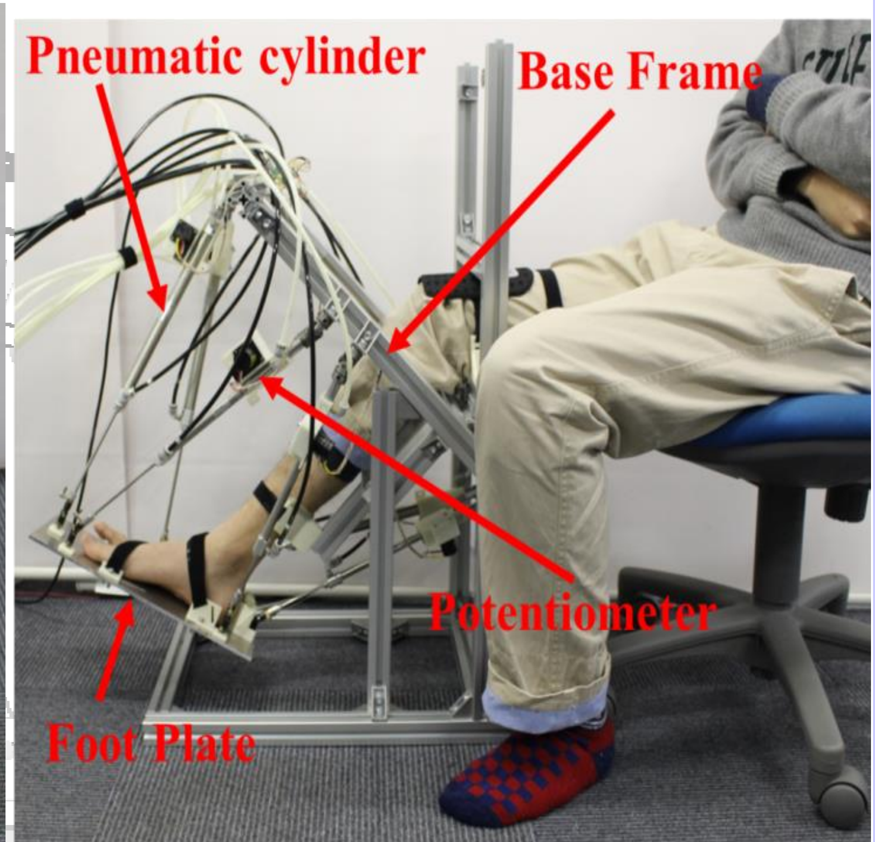
CAREN System



Rehabilitation

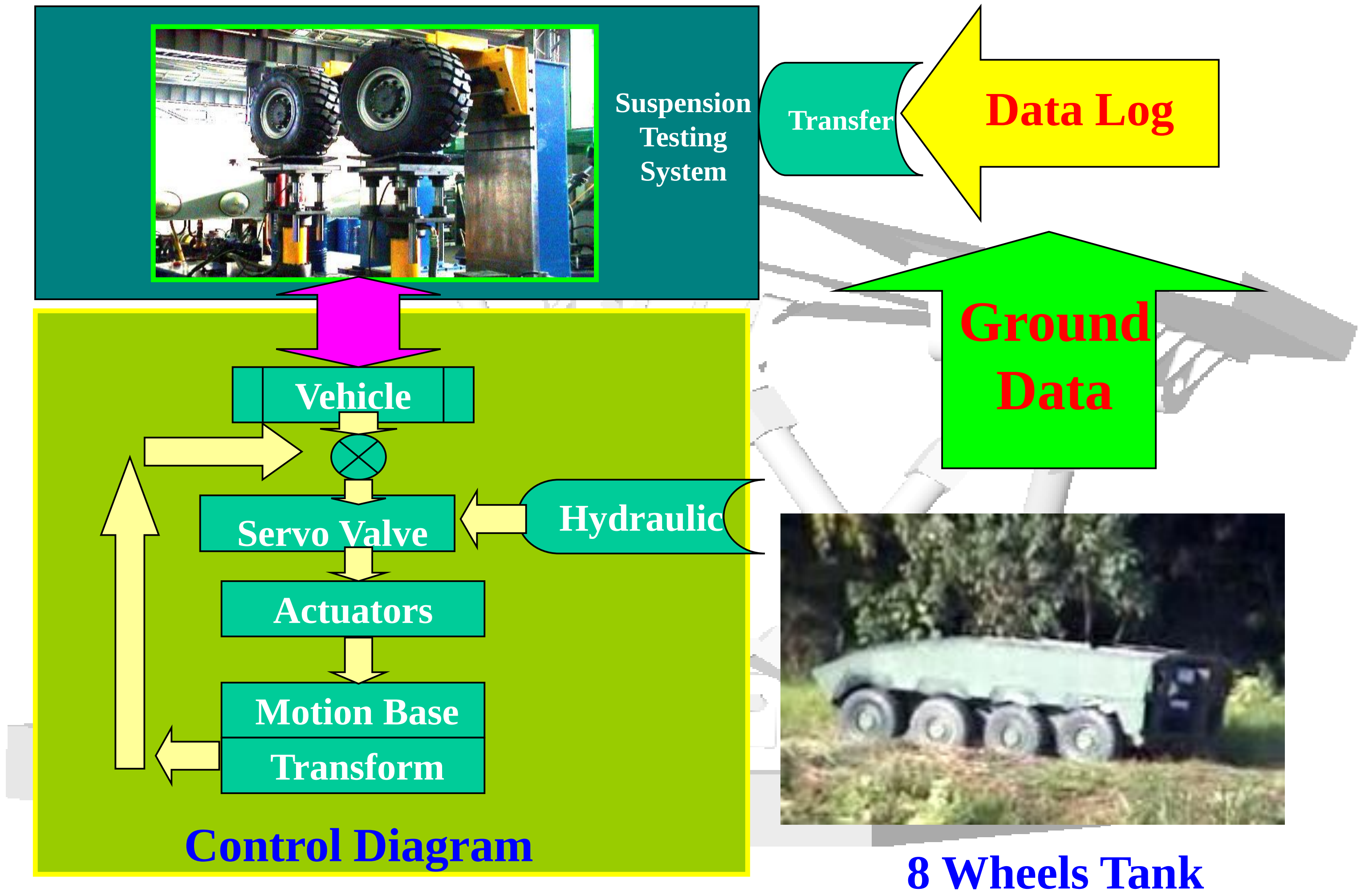


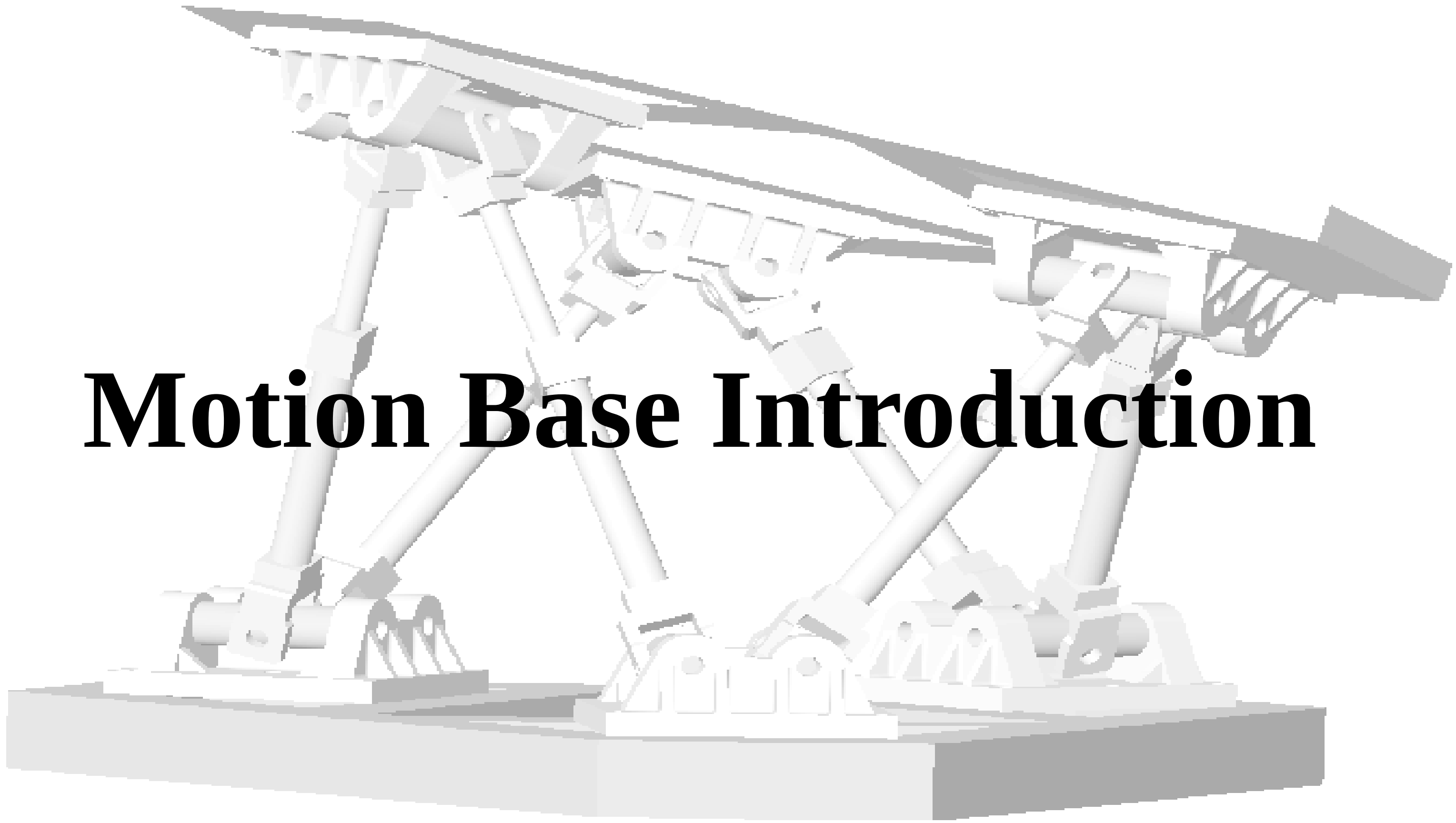
外骨骼輔具



復健輔具

Engineering

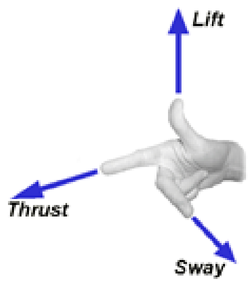




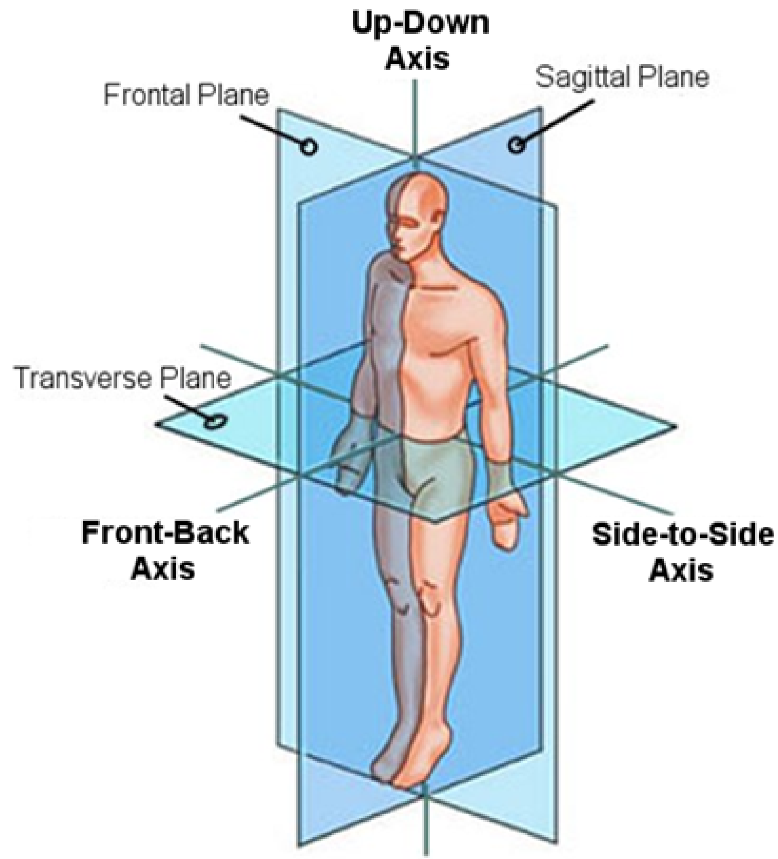
Motion Base Introduction

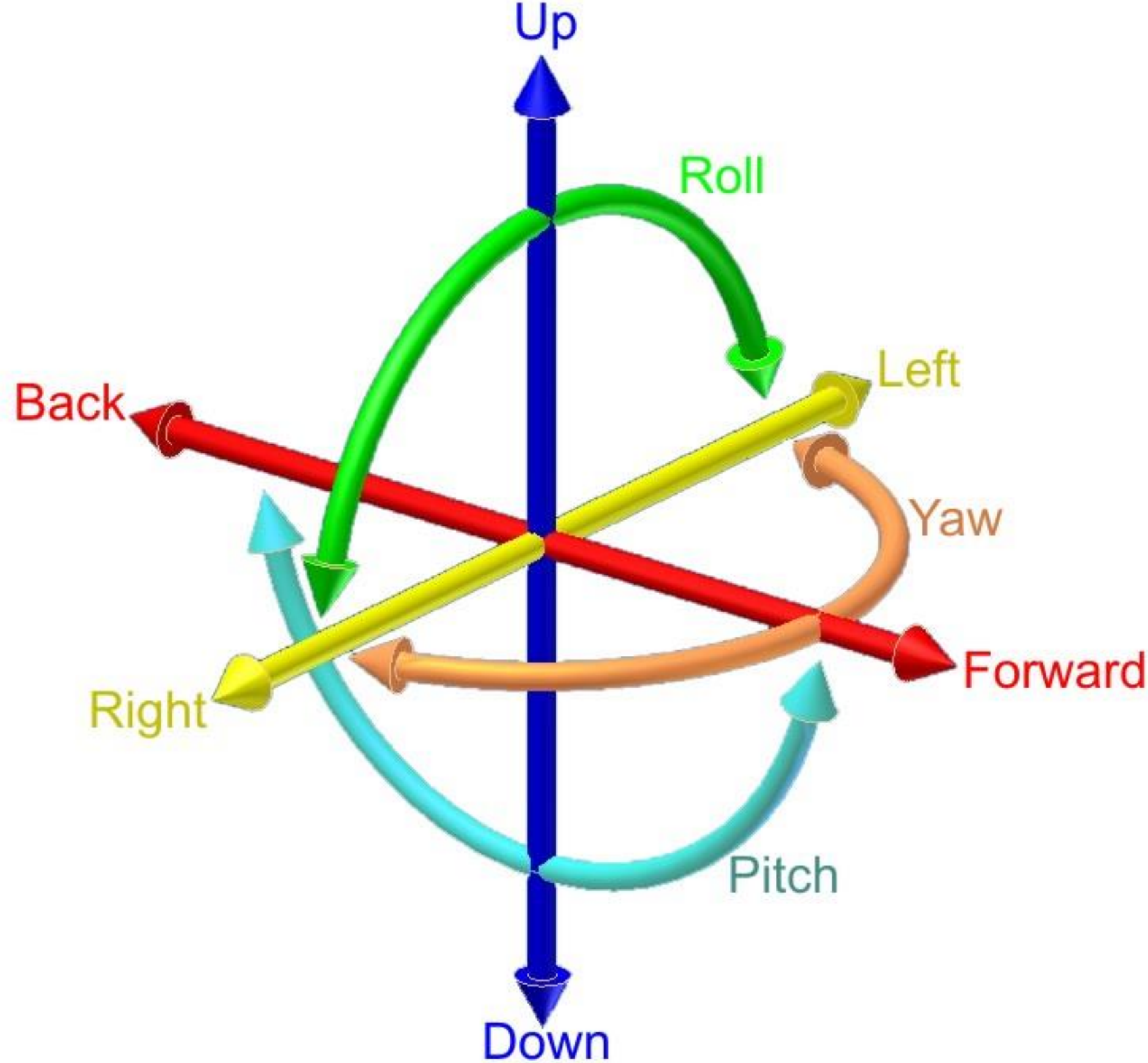
6 Degrees of Freedom

- Movement Along an Axis (3DOF)
  - Along the Side-to-Side Axis
    - Sway/Slide: Toward-Away
  - Along the Front-Back Axis
    - Thrust: Forward-Backward
  - Along the Up-Down Axis
    - Lift: Up-Down
  - DISTANCE: Inches, Feet, Meters

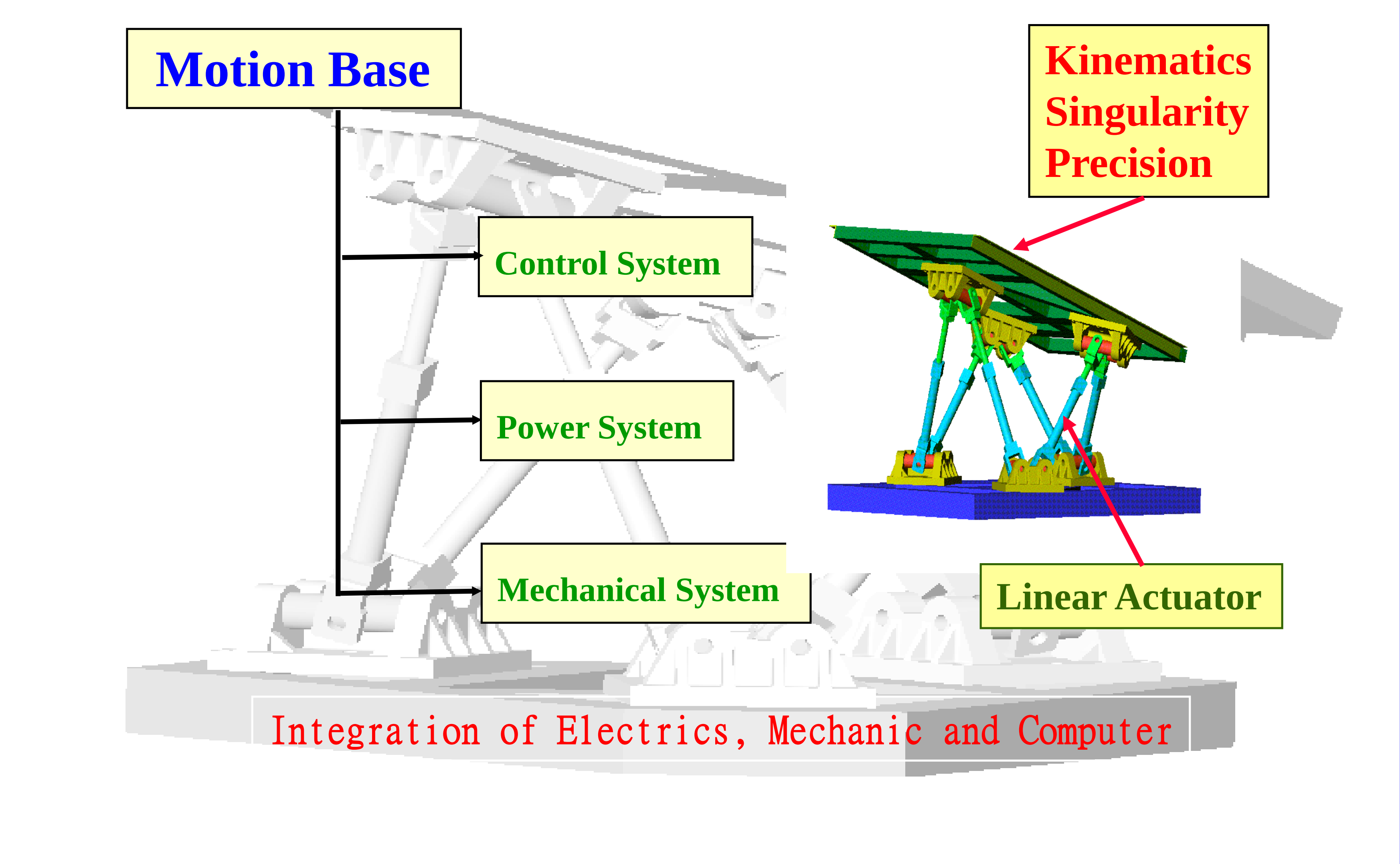


- Rotation Around an Axis (3DOF)
  - Around the Side-to-Side Axis
    - Bend: Forward-Backward
  - Around the Front-Back Axis
    - Side Bend: Trail-Lead
  - Around the Up-Down Axis
    - Turn: Open-Closed
  - ANGLE: Degrees, Radians, Revs



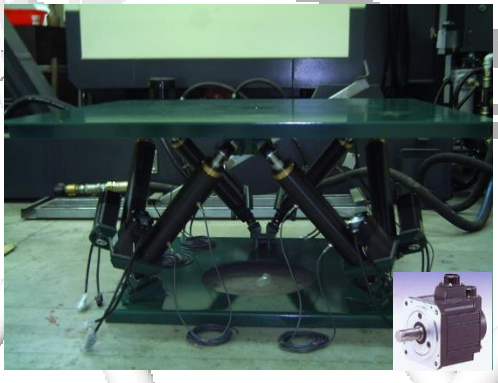

Up
Roll
Left
Back
Yaw
Forward
Right
Pitch
Down

Motion Base


Motion Base
Control System
Power System
Mechanical System
Kinematics
Singularity
Precision
Linear Actuator
Integration of Electrics, Mechanic and Computer

Power

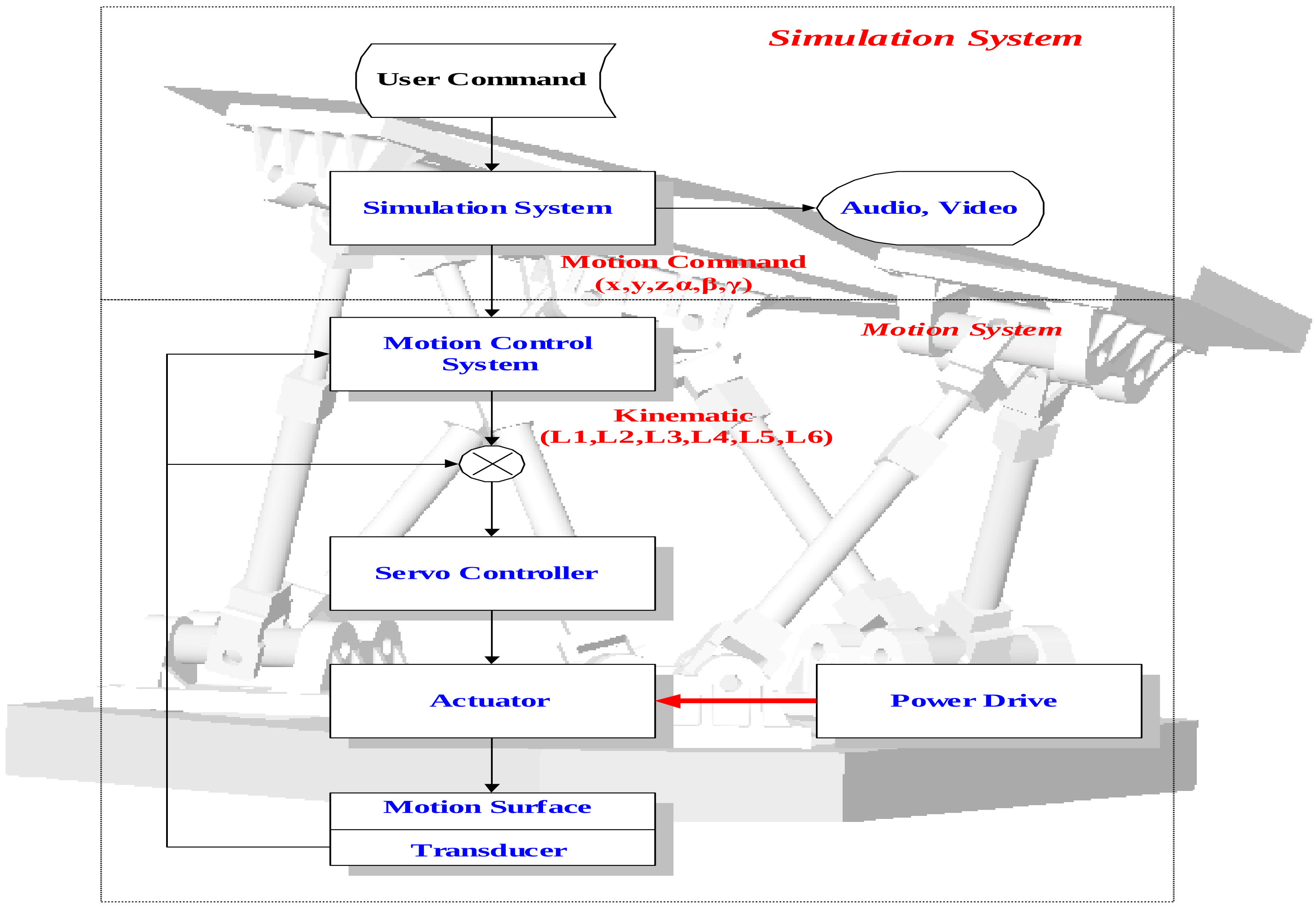
Hydraulic



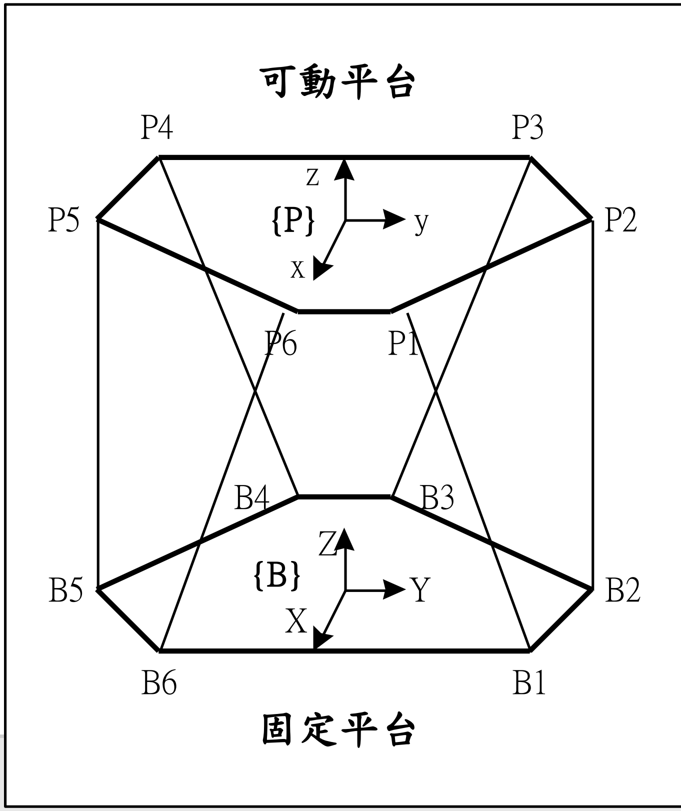
Electric

Pneumatic

Control Unit



Coordinate



- Define two coordinate

  { P } Moving Platform、

  { B } Fixed Platform

- { B } →{ P }

  Movement (Surge, Sway, Heave)

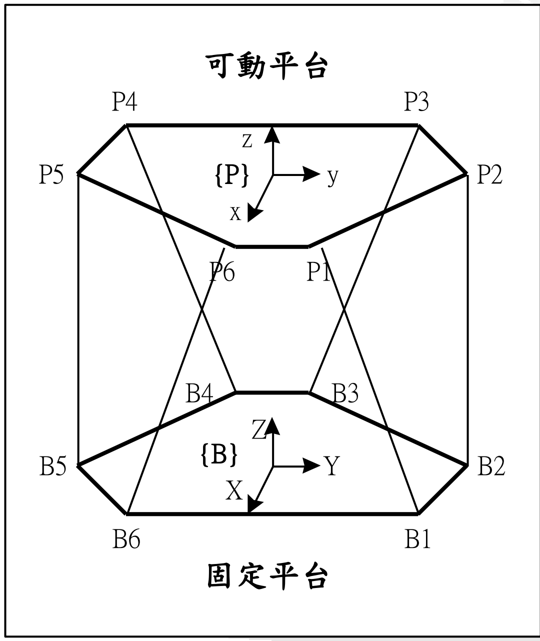
  Rotation (Roll, Pitch, Yaw)

Inverse Kinematic

- Moveable Platform Position (x, y, z, α , β , γ)
- Actuator Length Li

$$S_i = R \bullet P_i + P - B_i$$

$$L_i = \| S_i \|$$



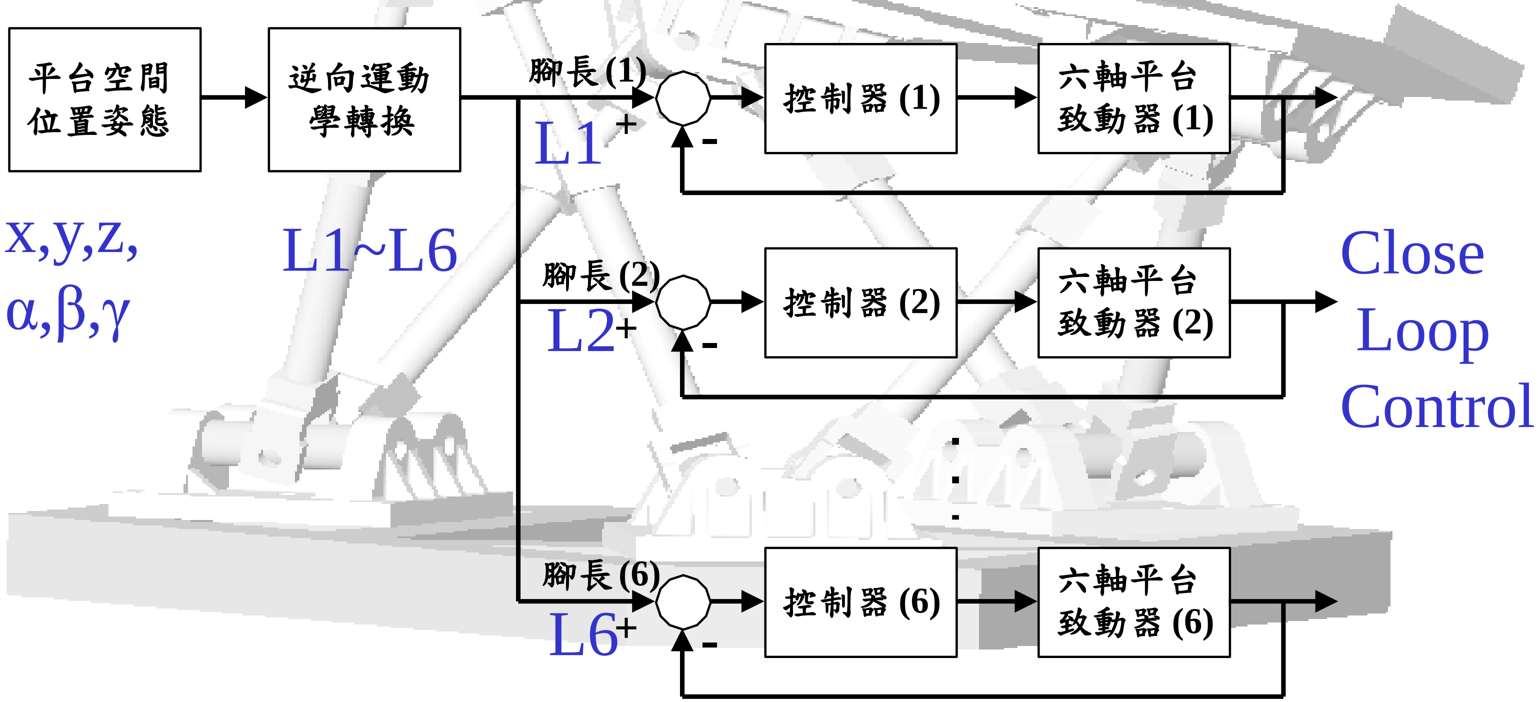
$$R = \begin{bmatrix} c\alpha & -s\alpha & 0 \\ s\alpha & c\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c\beta & 0 & s\beta \\ 0 & 1 & 0 \\ -s\beta & 0 & c\beta \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & c\gamma & -s\gamma \\ 0 & s\gamma & c\gamma \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}$$

- Inverse Kinematic：

$$\begin{aligned} L_i^2 = {} & x^2 + y^2 + z^2 + r_p^2 + r_B^2 + 2(r_{11}p_{ix} + r_{12}p_{iy})(x - b_{ix}) \\ & + 2(r_{21}p_{ix} + r_{22}p_{iy})(y - b_{iy}) + 2(r_{31}p_{ix} + r_{32}p_{iy})z \\ & - 2(xb_{ix} + yb_{iy}) \end{aligned}$$

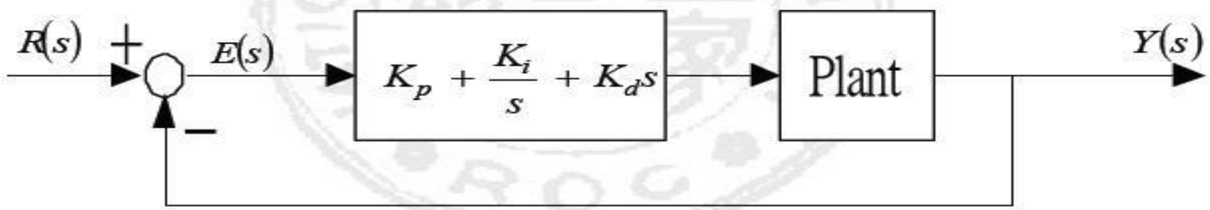
Control Flow

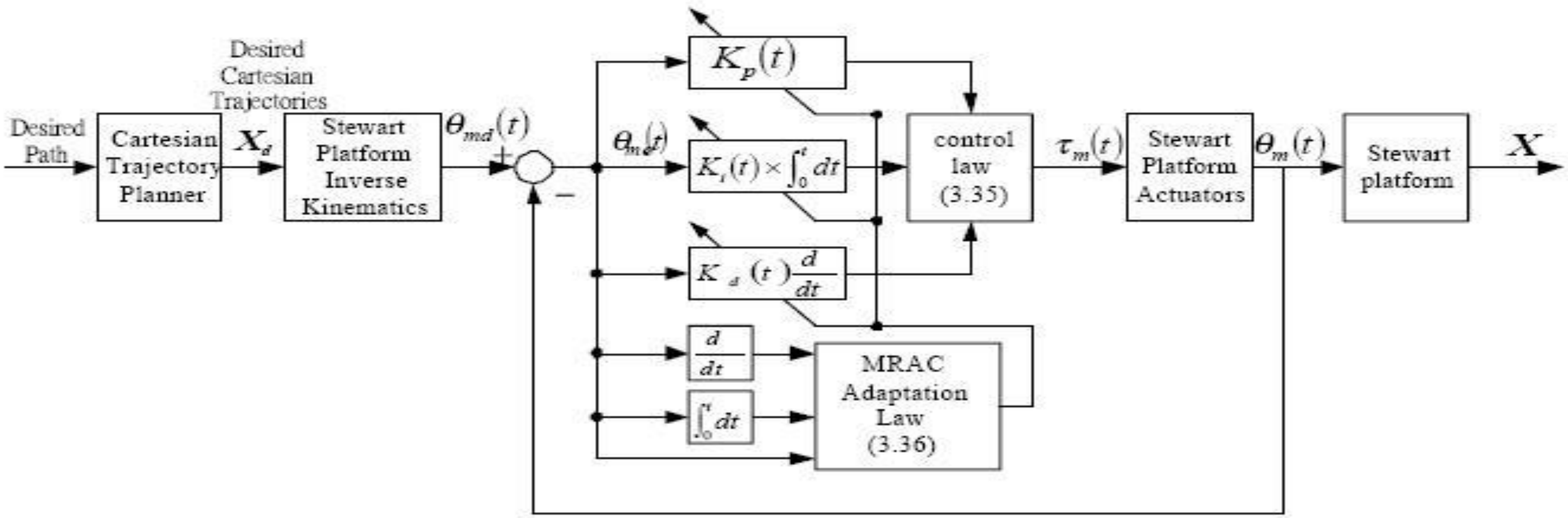
- 對六軸平台運動軌跡的描述是採用 Cartesian Space 表示， 即可動平台的位置姿態(x, y, z, α , β , γ)，經由逆向運動學的轉換得各個致動器所對應的長度，再透過控制器來控制各個致動器的長度，即我們實際是在 Joint Space 下做電動致動器的控制。



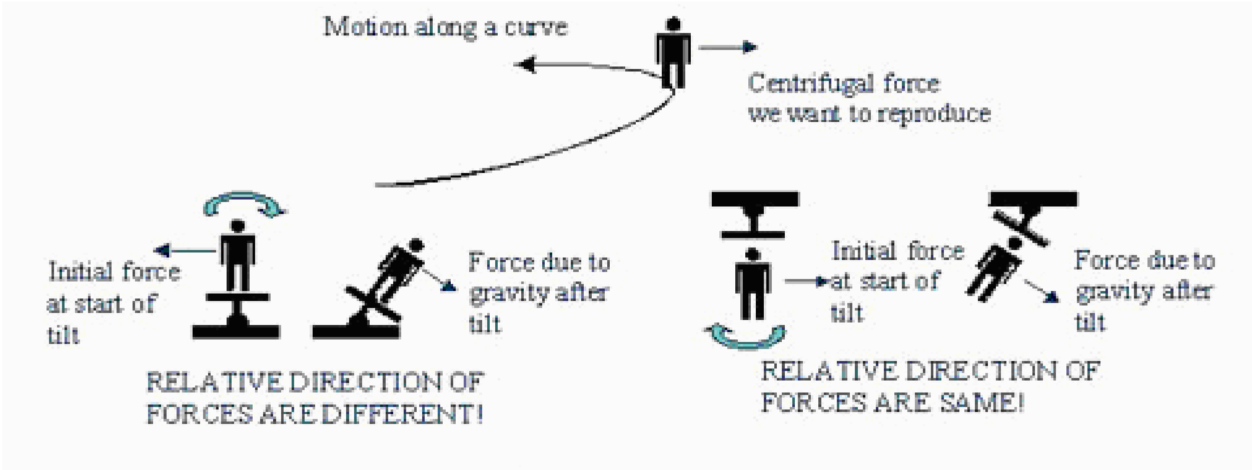
PID

利用PID (比例控制、積分控制及微分控制)控制器的原理，經Inverse Kinematics所求得的腳長轉換為電壓值驅動致動器上之驅動元件，讓致動器能來回運動。

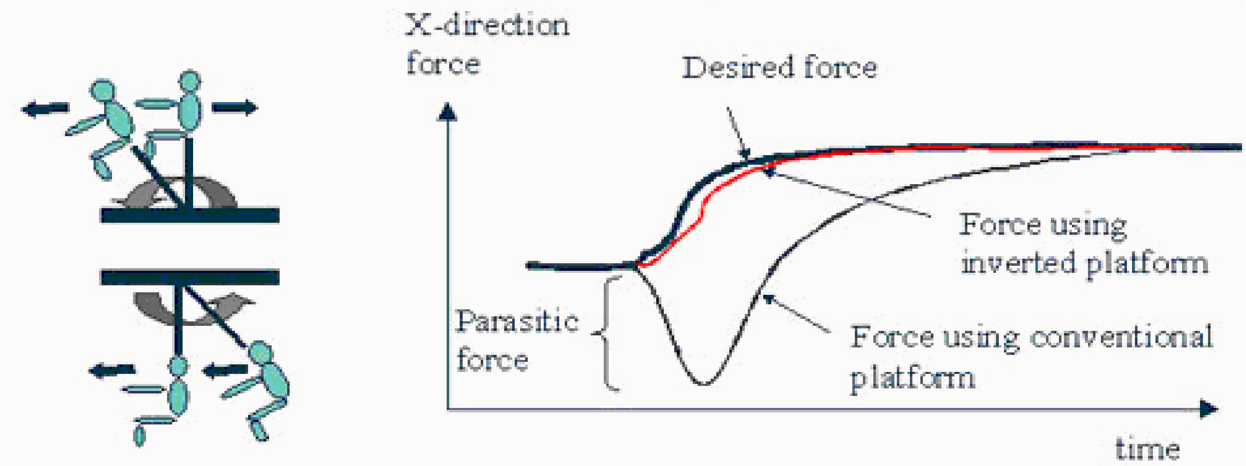




Motion Cues

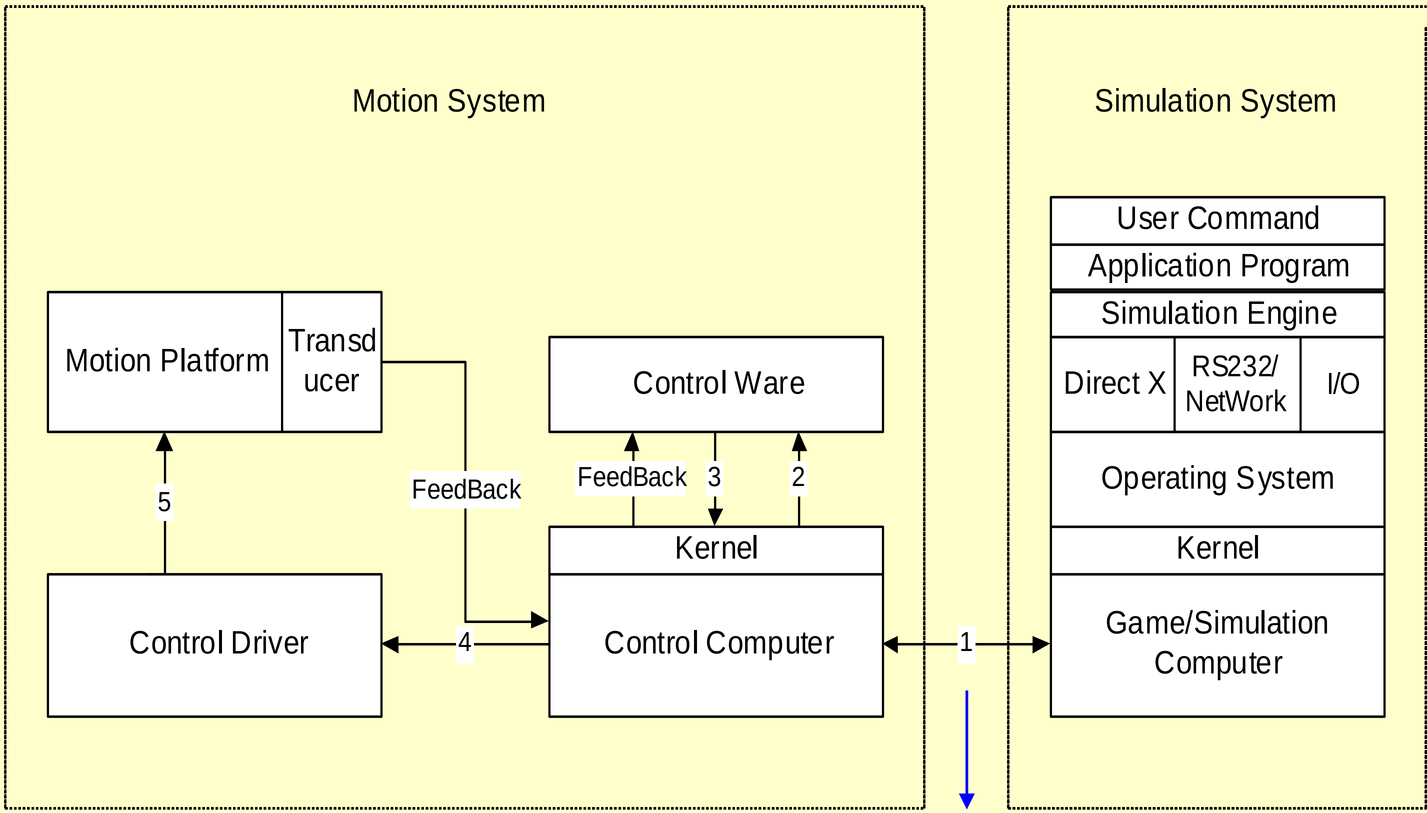


<Fig 1: Forces during a turn>



< Fig 2: Conventional and Inverted Platform Force Reproduction >

Simulation System



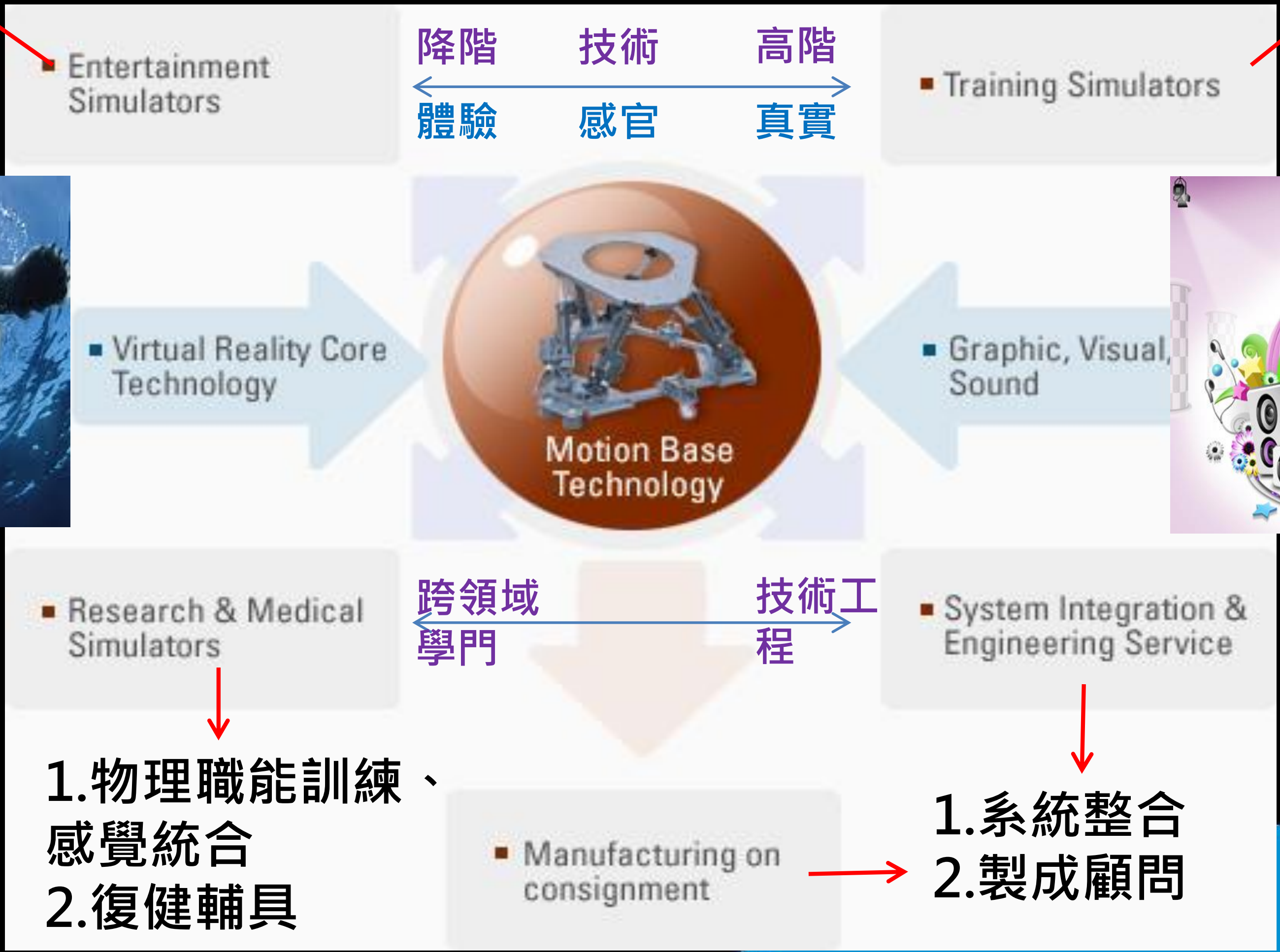
Protocol (UDP)

影 像 模 擬 系 統 與 動 作 平 台 系 統 關 連 圖

Applications

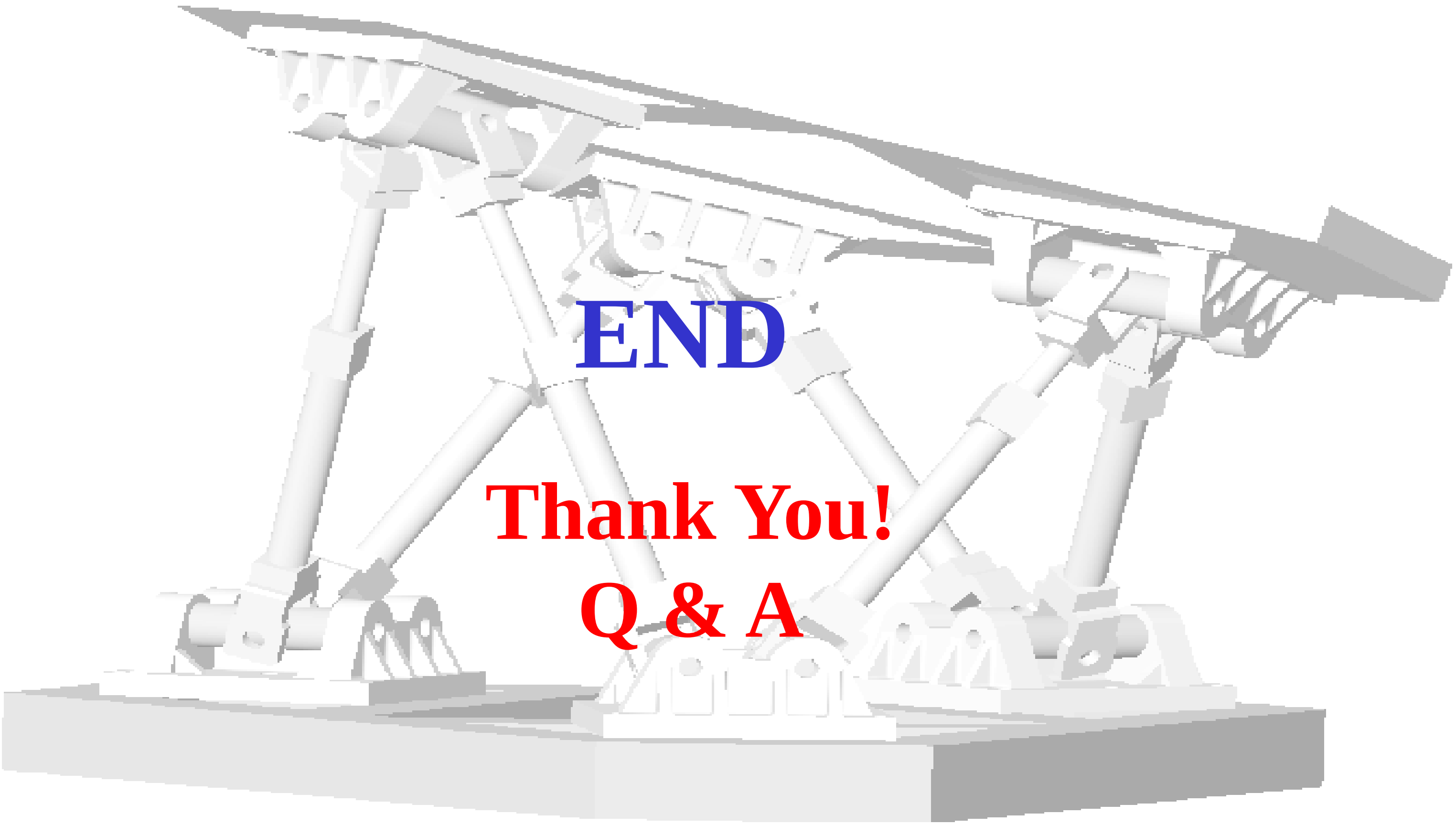
4D動感影院
Dark Rides
賽車遊戲機

訓練級
模擬機



VR/AR/MR
五感沉浸體驗

聲光影音
整場特效



END

Thank You!

Q & A