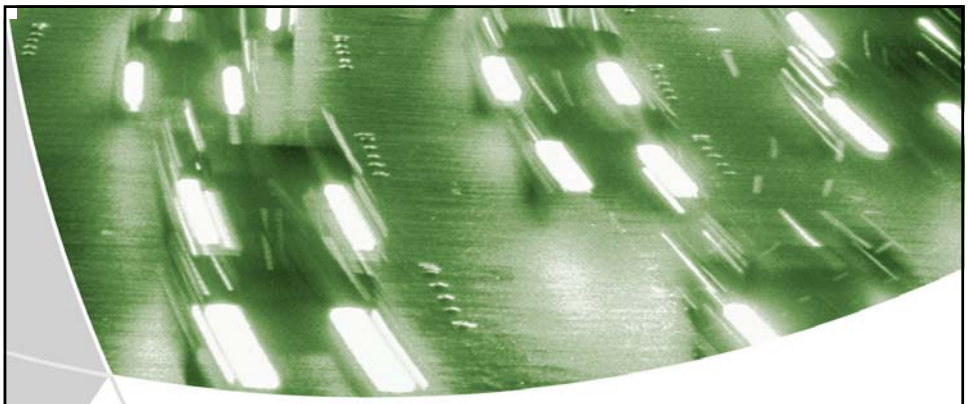


A Survey of State-of-the-art Motion Platform Technology and Motion Cueing Algorithms

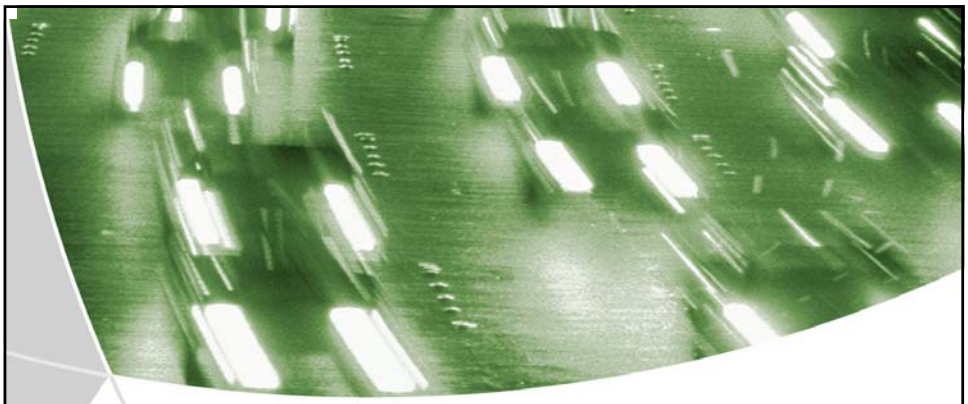
Dipl.-Ing. Martin Fischer

2nd Motion Simulator Conference, 20.09.07

Introduction

Motion Cueing Algorithm (MCA)
=
Motion Drive Algorithm (MDA)
=
Washout Algorithm (WA)

- „**Motion cueing**“ describes the presentation of visual, acoustic, vestibular and **haptic** information (cues) with the aim to resemble real movements in virtual environments



Motion Platform Technology

Motion Platform History
Early Flight Simulators

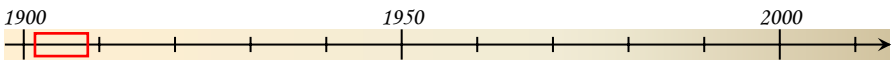
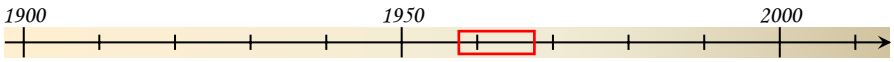
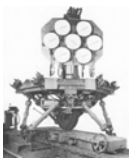



Photo in Airbus Training, Toulouse, of Antoinette Simulator - dated 1909

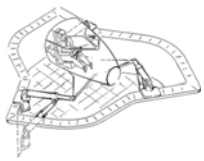
Motion Platform History



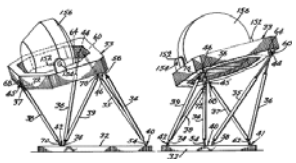


Gough Platform ’54

C. Kappel ’60s

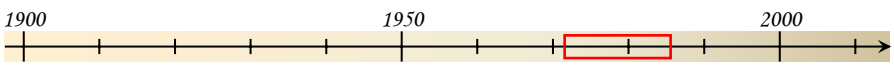


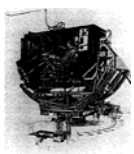
Stewart Platform ’66



First Patent ’67

Motion Platform History

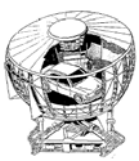




VW 70’s

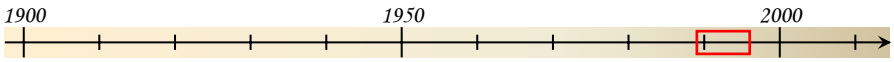
VTI I ’84

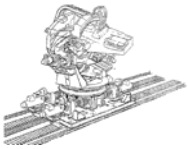
IFAS (IKK) ’84



Daimler Benz ’85

Motion Platform History





Mazda ’90

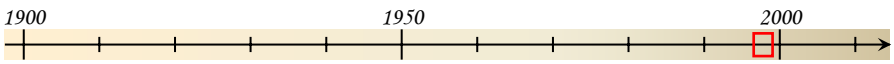
Trygg Hansa ’91
VTI II ‘02

Daimler Benz ’93

Ford VIRTTEX ’94

JARI ’96

Motion Platform History



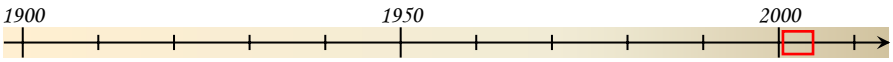
BMW ~’98/99

Renault ’99

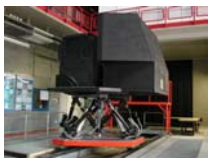
Nissan ’99

IZVW ’99

Motion Platform History



Ford VIRRTEX new ’01

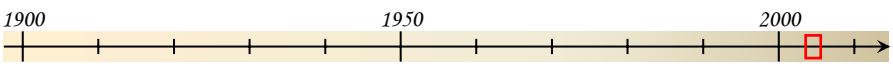


IFAS MARS ’01

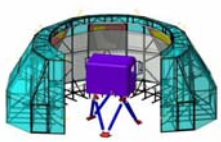
NADS-1 ’02

BMW ’03

Motion Platform History



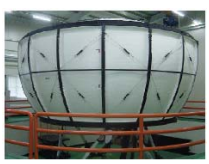
VTI III ’04



TU München ’04

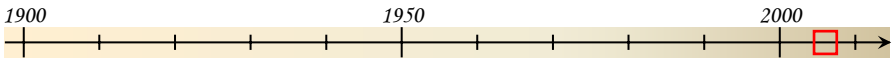
IFAS MARS ’04

ULTIMATE ’04



Katech KAAS ’05

Motion Platform History



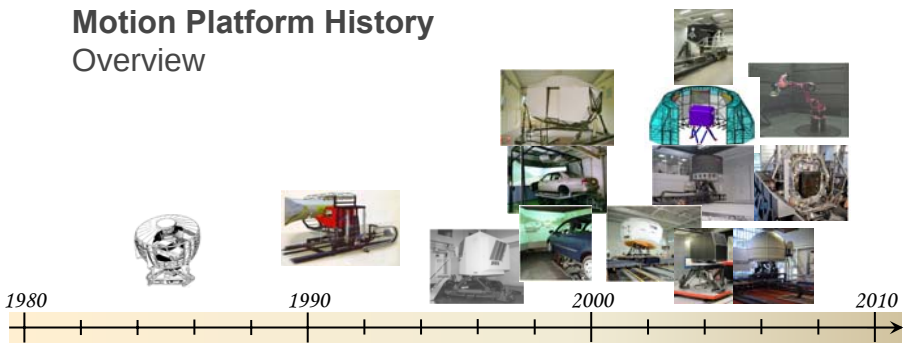
DLR SimCar ’05

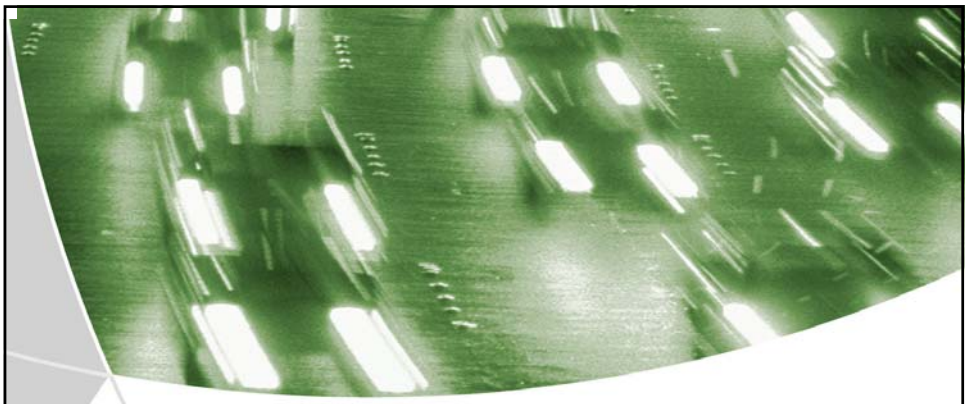
LADS ’06

MPI RoboCoaster ’07

TNO DESDEMONA ’07

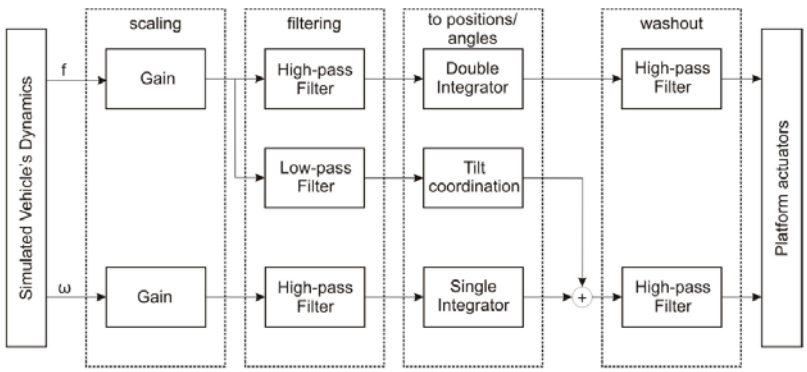
Motion Platform History
Overview





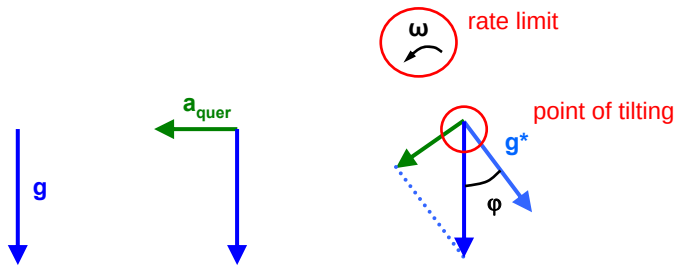
Motion Cueing Algorithms

MCA structure



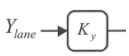
Tilt Coordination

- Initial accelerations via translational movements
- Sustained accelerations via body tilt (tilt coordination)



MCA hexapod

- Classical washout
- Optimal control
- Coordinated adaptive
- Lane based

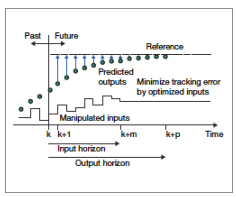


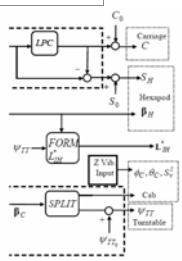
MCA Add-on‘s

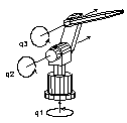
- Extensions to the classical MCA
  - Adaptive highpass filter (UTTIAS)
  - Nonlinear filter (Renault)
  - Adaptive gain & filter (Nihon University)
- Scenario dependent switching
  - Intelligent Adaptive MDA (NADS)
  - Time Variant MCA (DLR)

Simulator specific approaches

- ULTIMATE – Model predictive control
- NADS – MDA for redundant DoF
- DESDEMONA – Spherical washout filter
- RoboCoaster – Robot arm MCA

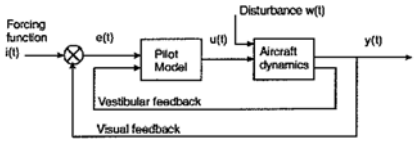


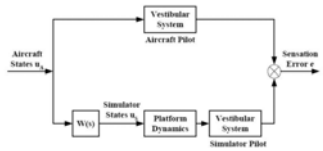


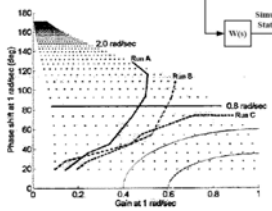


Tuning

- Offline Tuning
  - Human control models
  - Human perception models
  - Empirical methods (Sinacori/Schroeder)
- Online Tuning
  - Human-in-the-loop

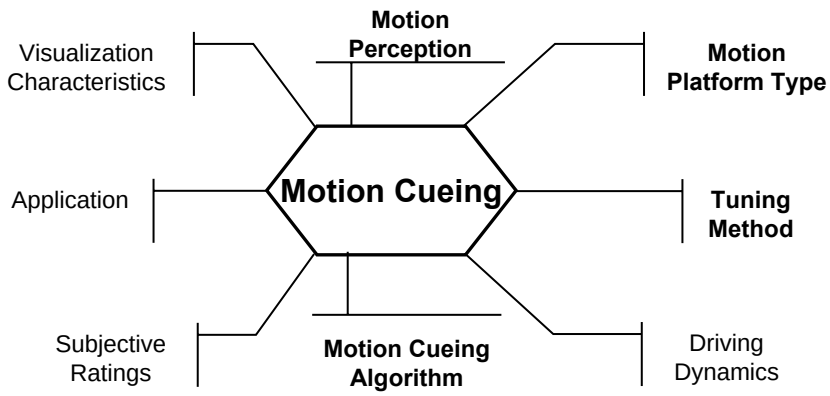






Motion Cueing Issues

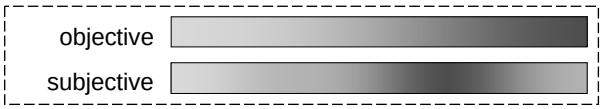
Important Motion Cueing Factors



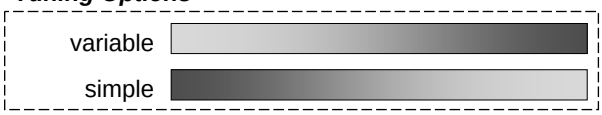
Opposing Aspects I

Motion Response

Realism



Tuning Options



Opposing Aspects II

Tuning Criteria

manoeuvre

subject

Sustained Accelerations False Cues

tilt rate

delay