Final Year Project

Master´s Degree

University of La Coruña and Technical University of Sofia

Computer-Aided Design of Platform and Cab for a Car Driving Simulator.

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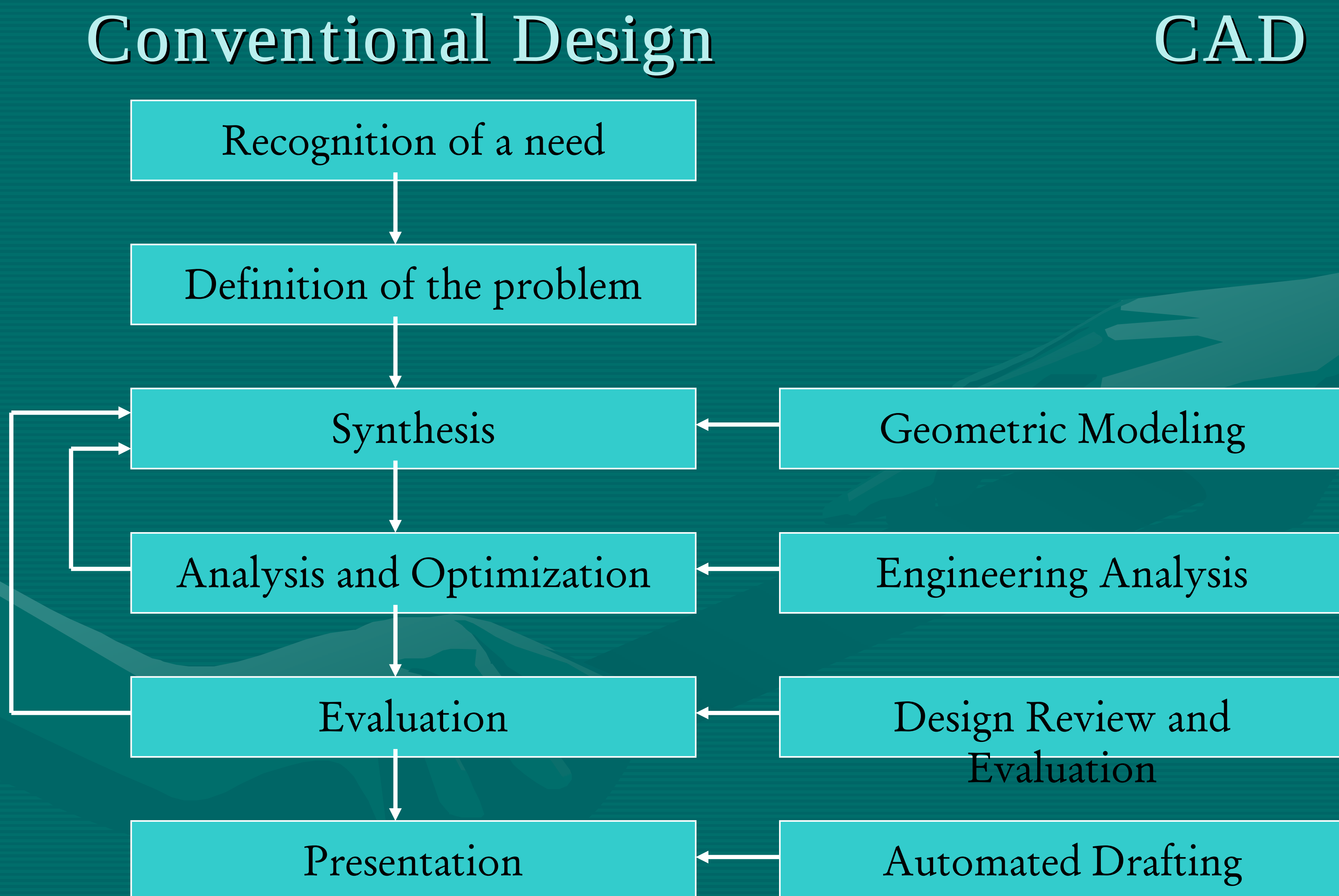
Objective of the Project

- The design of several of the sub-systems of a mid-level driving simulator. This would include:

  - Problem identification and definition
  - Choice of hardware for the main sub-systems of the simulator;
  - Preparation of 3D models for these items;
  - Design of a supporting structure;
  - Analysis and optimization of the frame;

The Design Process



Introduction to simulation

- *Definition of Simulation*
- *Areas of Application of Simulation*

-study of and experimentation with complex systems;

-verification of analytical solutions;

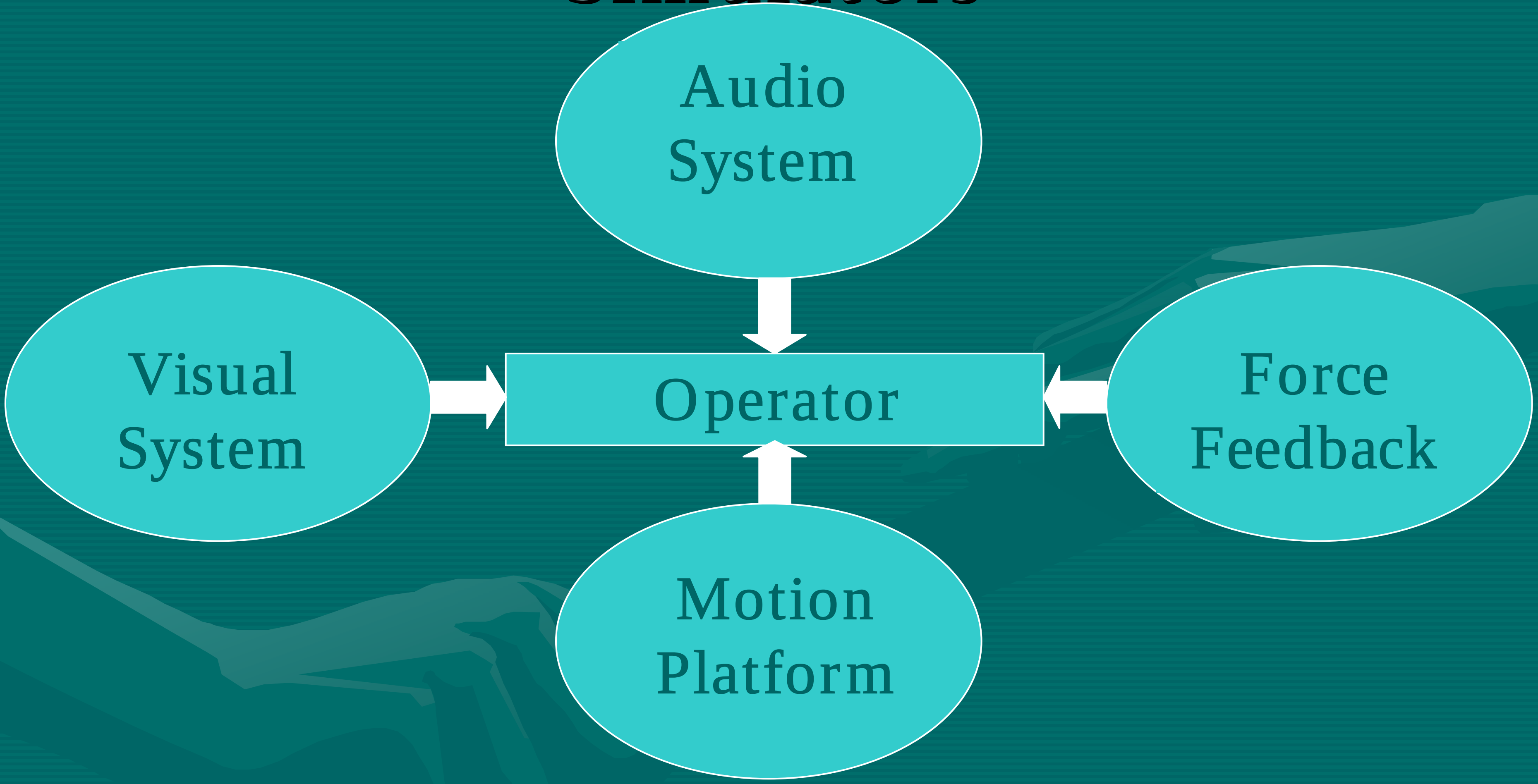
-training and evaluation of personnel;

-experimentation with new designs prior to implementation;

The Driving Simulator

- Complete control of environmental factors.
- Cost-effective for set-up and data collection.
- Safe environment for testing.
- Dynamic driving environment with workload and tasks similar to actual driving.

Basic Structure of Driving Simulators



Classification of Driving Simulators

- High-level;
- Mid-level;
- Low-level;

Problem Identification and Definiftion

- Recognition of a need for a driving simulator

  - Explore the possibilities and the robustness of the developed by the Mechanical Engineering Laboratory multibody dynamics formulations.

  - Offer a competitive, efficient and low-cost tool to driving schools.

Problem Identification and Definiftion

- Definition of the problem.

  - Minimized overall dimensions and weight;

  - A six degree-of-freedom motion base, capable of accelerations between 0.5 and 2g;

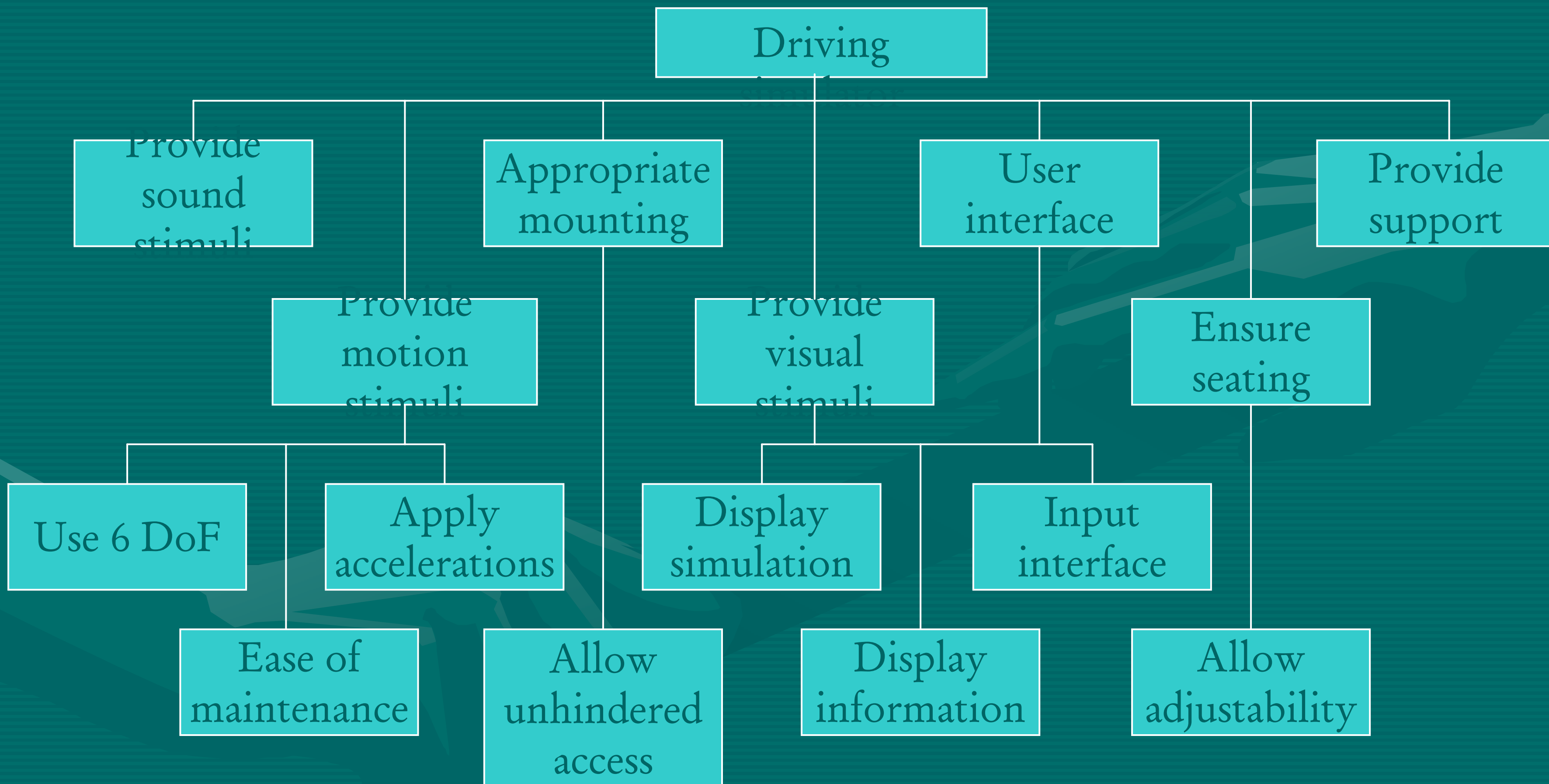
  - A high quality visual system for full immersion in the simulation;

  - Sound system, control units and seat;

  - Supporting structure;

Problem Identification and Definiftion

Functional Analysis System Technique

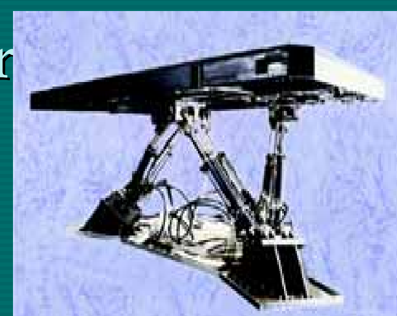


Choice of a Motion Base

- Six Degree-of-Freedom Motion Bases
  - Serial Mechanisms;
  - Parallel Mechanisms – the Stewart Platform;

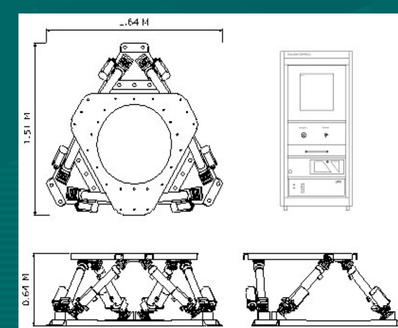
    Hydraulic Actuator

  Series 6DOF9000H



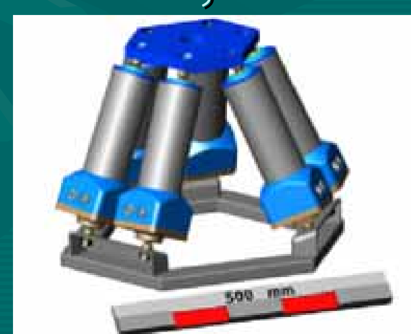
    Electric Actuators;

  DSMP608 electric



    Electromagnetic Actuators;

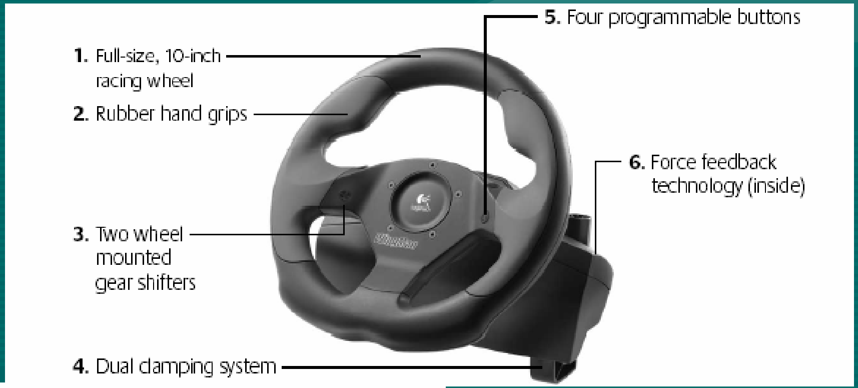
  Emag-400 series

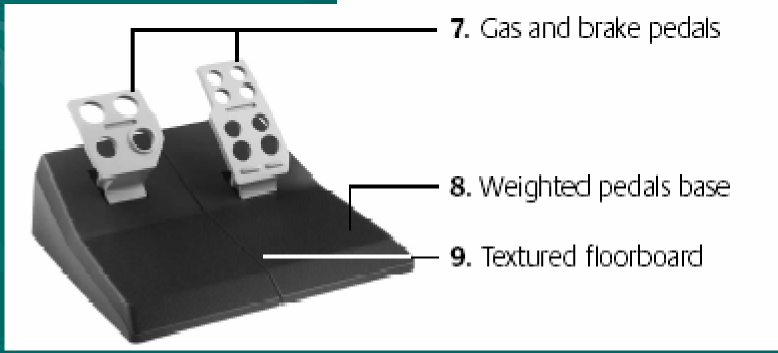


Choice of Control Units

- Force Feedback Wheel and Pedals

PC with Pentium® 166+ MHz (or compatible processor)
Windows® 98, Me, 2000, XP
Mac® OS X 10.2.3 or later
32 MB RAM
20 MB available hard drive space
CD-ROM drive
Available USB Port





Choice of a Visual System

- Primary Visual System
  - Projection Screens;
  - Display Systems;
  - The Head Mounted Display;

- Secondary Display

Choice of a Seat

- The Recaro Mobility LXF Seat

  - Ergonomics;

  - Dimensions;

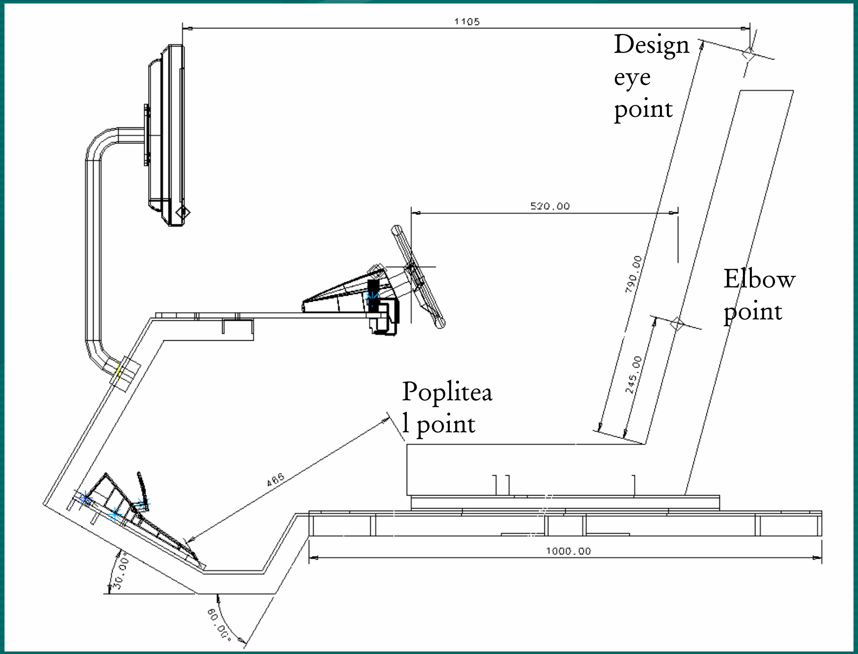
  - Price;

Design of the supporting structure

- Determination of basic dimensions;
- Simulator model;
- Analyses – procedures followed and results;
- Optimization of the designed structure;

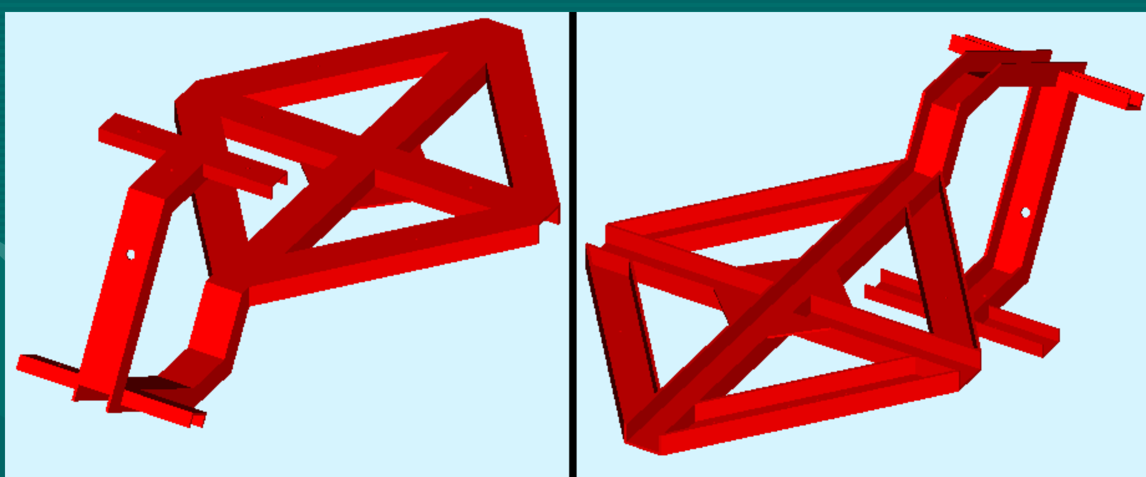
Design and Modeling of the Supporting Structure

- Determination of the dimensions for the frame and platforms.
  - Overall dimensions of the parts to be mounted;
  - Ergonomic requirements and anthropometric data for a standard population;



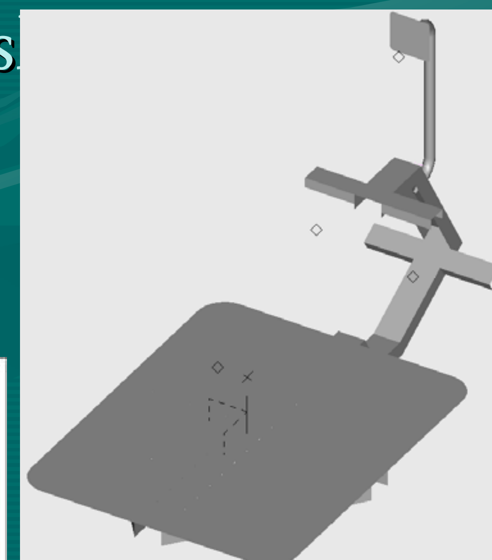
The Simulator Model

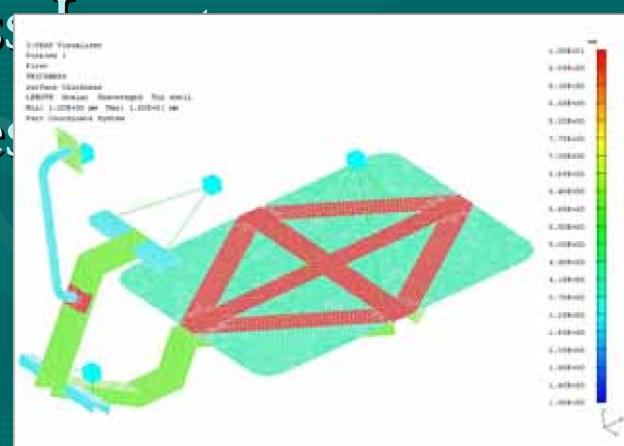
- The model of the frame
- The simulator assembly



Analysis: Model Meshing

- Type of Elements Used for the Finite Elements Model.
  - Thin Shell Elements – surface for mes
  - Lumped Mass Elements;
  - Rigid Bar Elements;
  - Surface Thickness
- Material Propertie
- Model Meshing.



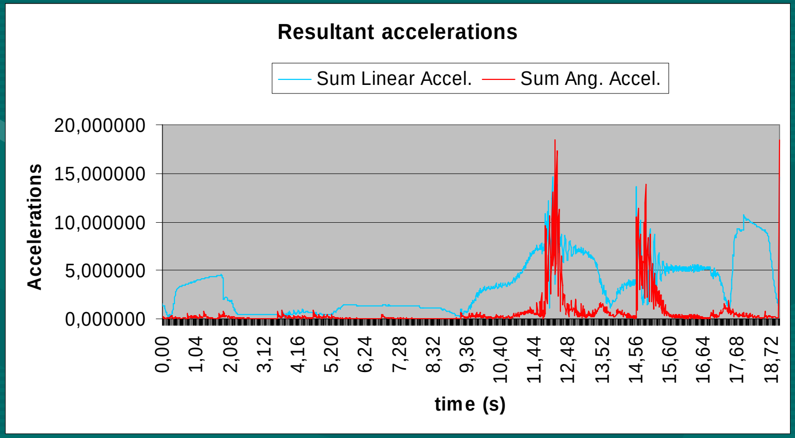


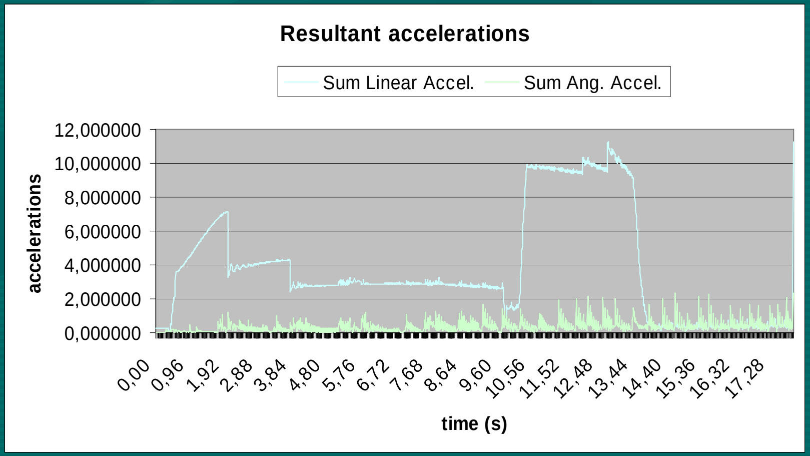
Analysis: Boundary Conditions

- Application of restraints.
- Loading conditions – maneuvers performed.

  - Severe braking;

  - 180º-degree turn;



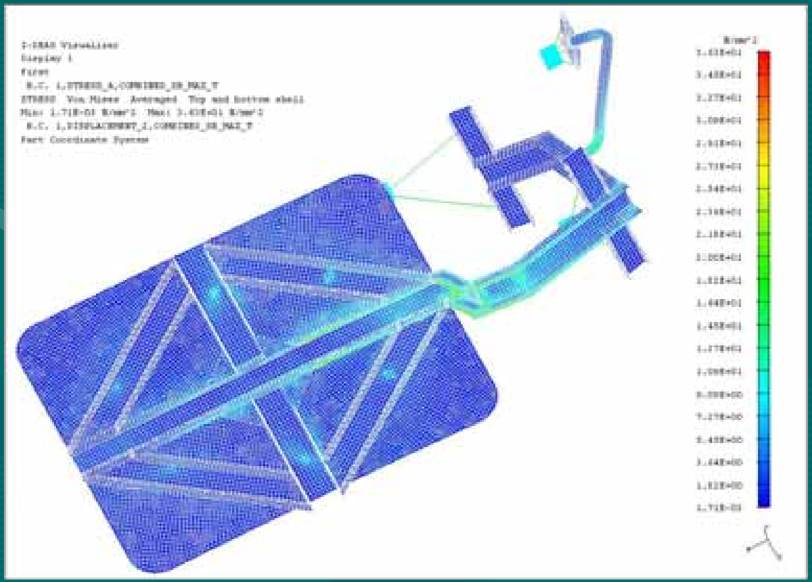


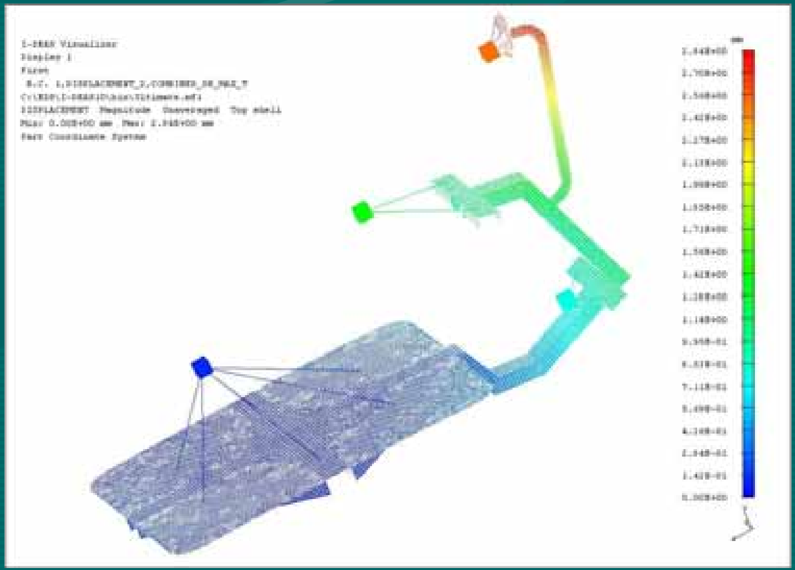
Analysis: Results

- The severe braking maneuver.

  - Stress values–criterion is $\sigma \leq \sigma_{yield}/2(\sigma \leq 137.5 N/mm^2)$

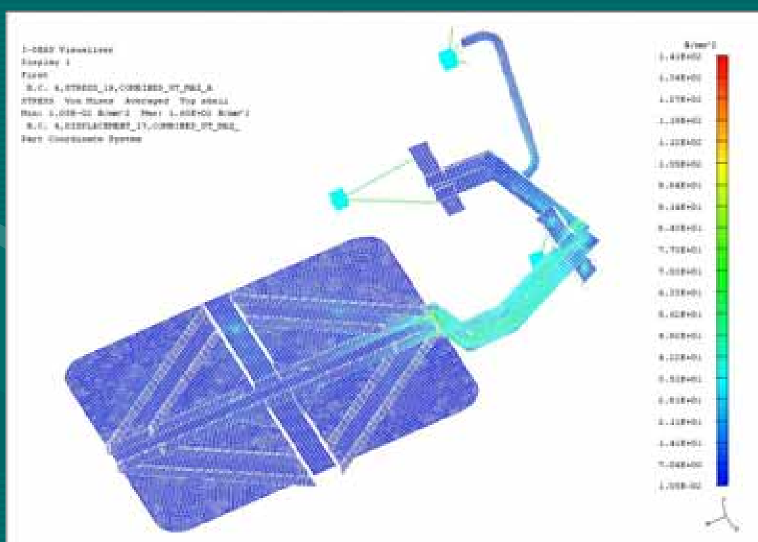
  - Displacement values

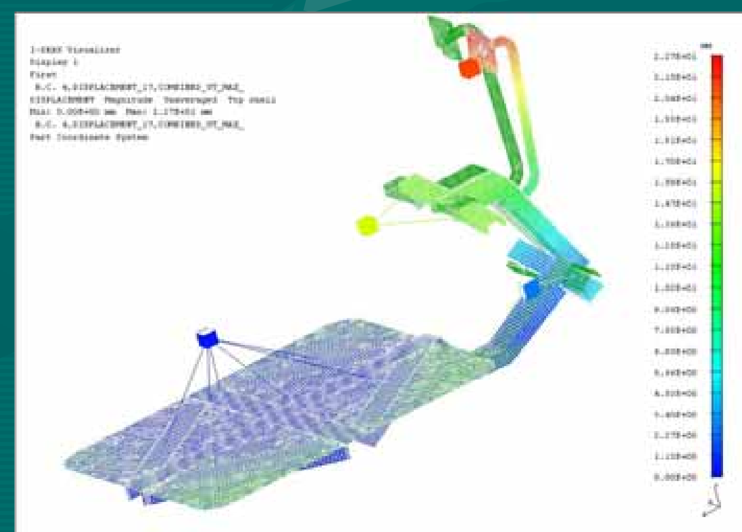




Analysis: Results

- The 180°-degree turn maneuver
  - Stress values–criterion is $\sigma \leq \sigma_{yield}/2 (\sigma \leq 137.5 N/mm^2)$
  - Displacement Values



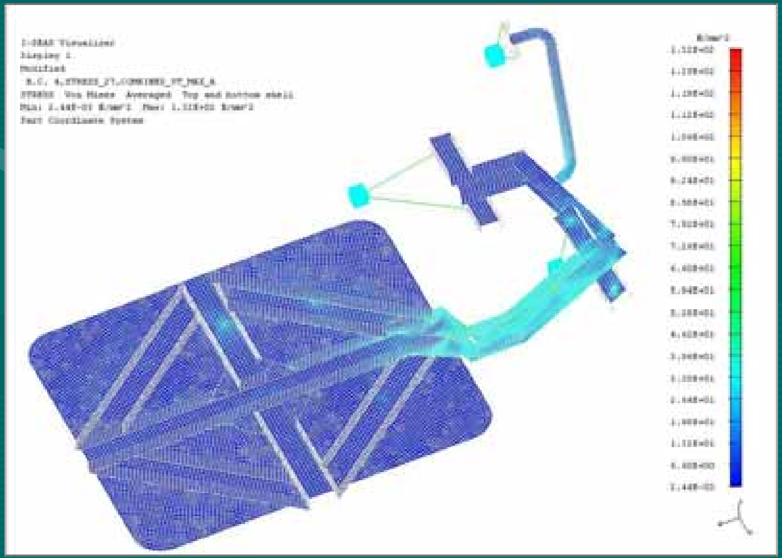


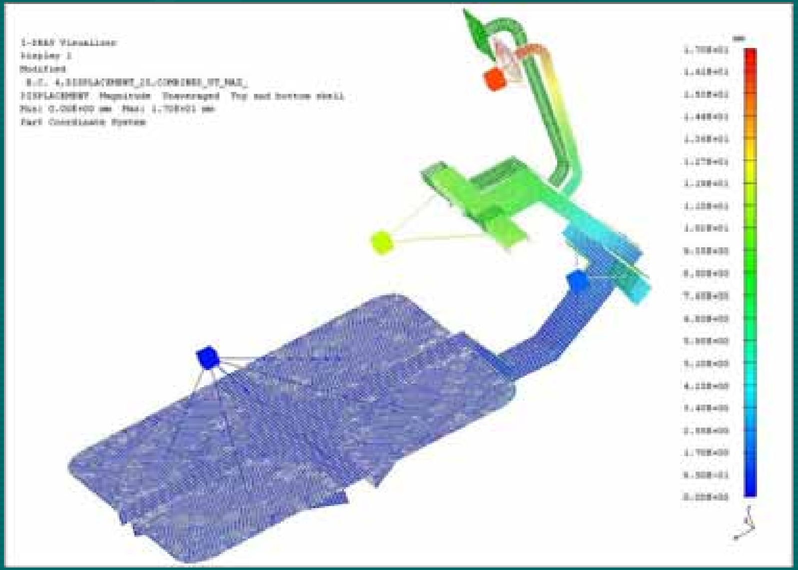
Analysis: Modified Design

- Modifications applied.
- The 180°-degree turn maneuver.

  - stresses;

  - displacements;



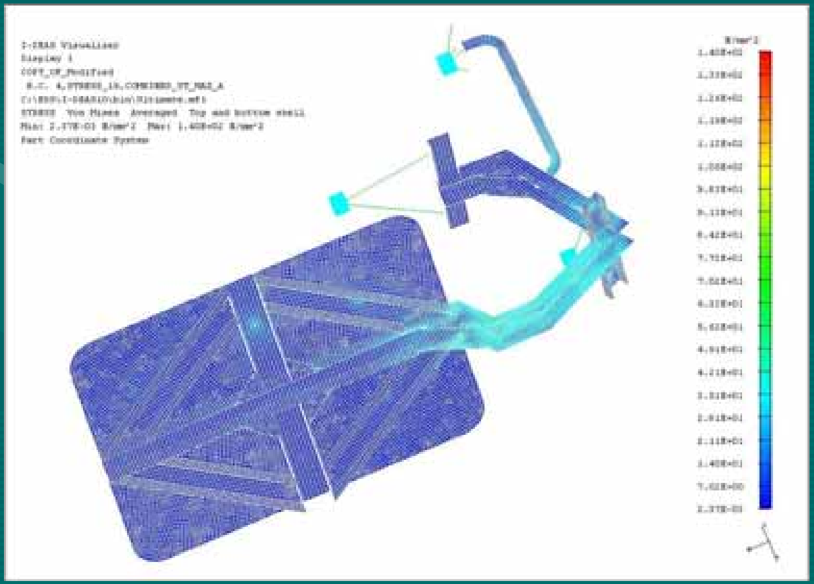


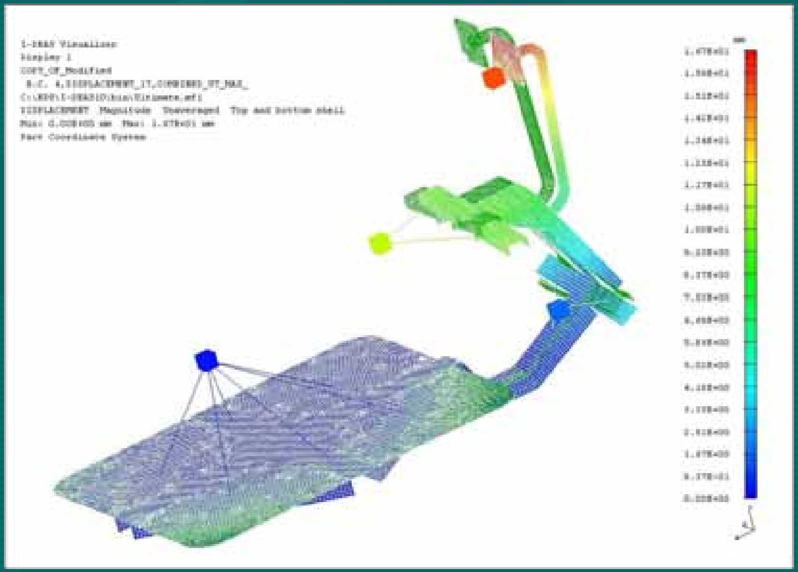
Analysis: Further Modifications

- Modifications applied.
- The 180°-degree turn maneuver.

  - stresses;

  - displacements;





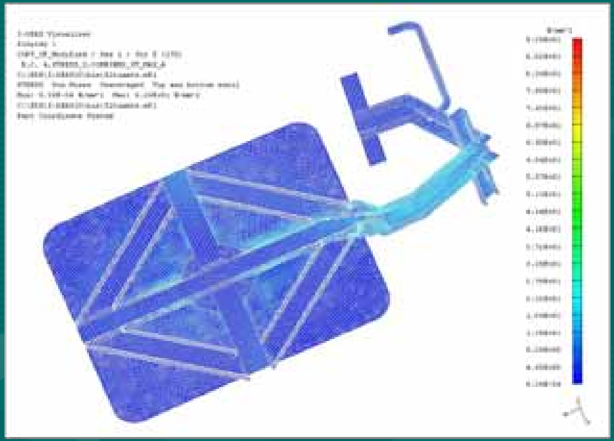
Optimization

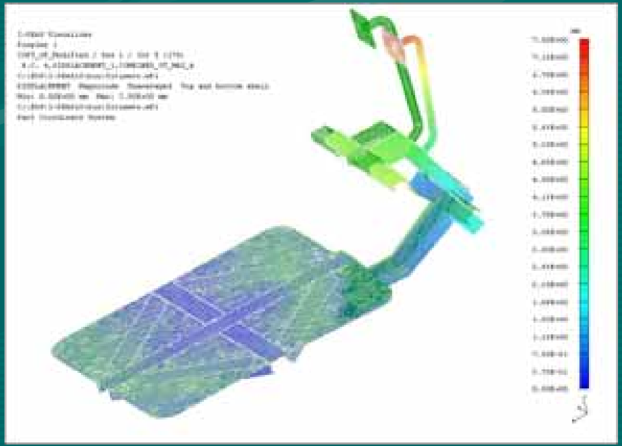
- Geometry-based math programing redesign.
- Redesign parameters.
- Stress limit – 137.5 N/mm^2.
- Displacement limit
- Design goal – minimization of mass.

Parameter	Initial value	Maximal value	Minimal value
Bar width	80mm	88mm	72mm
Rib width	100mm	110mm	90mm
Platform thickness	4mm	5mm	3mm

Optimization - Simplified

- New boundary conditions.
  - Removing the lumped mass elements;
  - Applying distributed forces in place of the weights of the parts;
- Results.
  - First iteration;
  - Last iteration;





Preliminary Price Estimate

Item	Quantity	Price in Euro	Mass in kg
Motion base	1	55500	58
Wheel and pedals	1	80	0.4
Head Mounted Display	1	1795	0.155
Head Tracker	1	2195	N/A
Display	1	410	4.4
Seat	1	450	6
Steel channels (80mmx45mmx6mm)	5.277m	307	34
Steel channels (60mmx30mmx3mm)	0.6m	27	1.2
Steel plate (4mm)	0.8m^2	96.6	24.8
Steel plate (6mm)	0.05m^2	12	2.2
Composite plate (ayrlite)	0.36m^2	130	1.2155
Steel tube	0.62m	11	2.28
Total	N/A	61013.6	134.6505

Conclusions

- The design of a driving simulator would offer a multitude of opportunities for investigation and research;
- A preliminary solution for an economical, yet effective driving simulator has been reached;
- The I-Deas 10 NX Series CAD software has been found to offer a wide range of modeling and simulation capabilities;
- The performed analysis showed that the loading conditions are much more demanding when angular accelerations are dominating.
- A feasible solution for the platform was obtained;
- The variation of the parameters during optimization was found to have negligible effect on performance;