Control and Mechatronics

Basis Courses

- System Identification
- Model Predictive Control
- Advanced Control Systems
- Nonlinear Control
- Mechatronic Systems
- Basics of Robotics

Optional Courses

- Robotics & Microrobotics
- Modelling of Dynamic Systems
- Microsystems and Sensors I, II
- Bio-inspired Adaptive Machines
- Applied Machine Learning
- Etc.

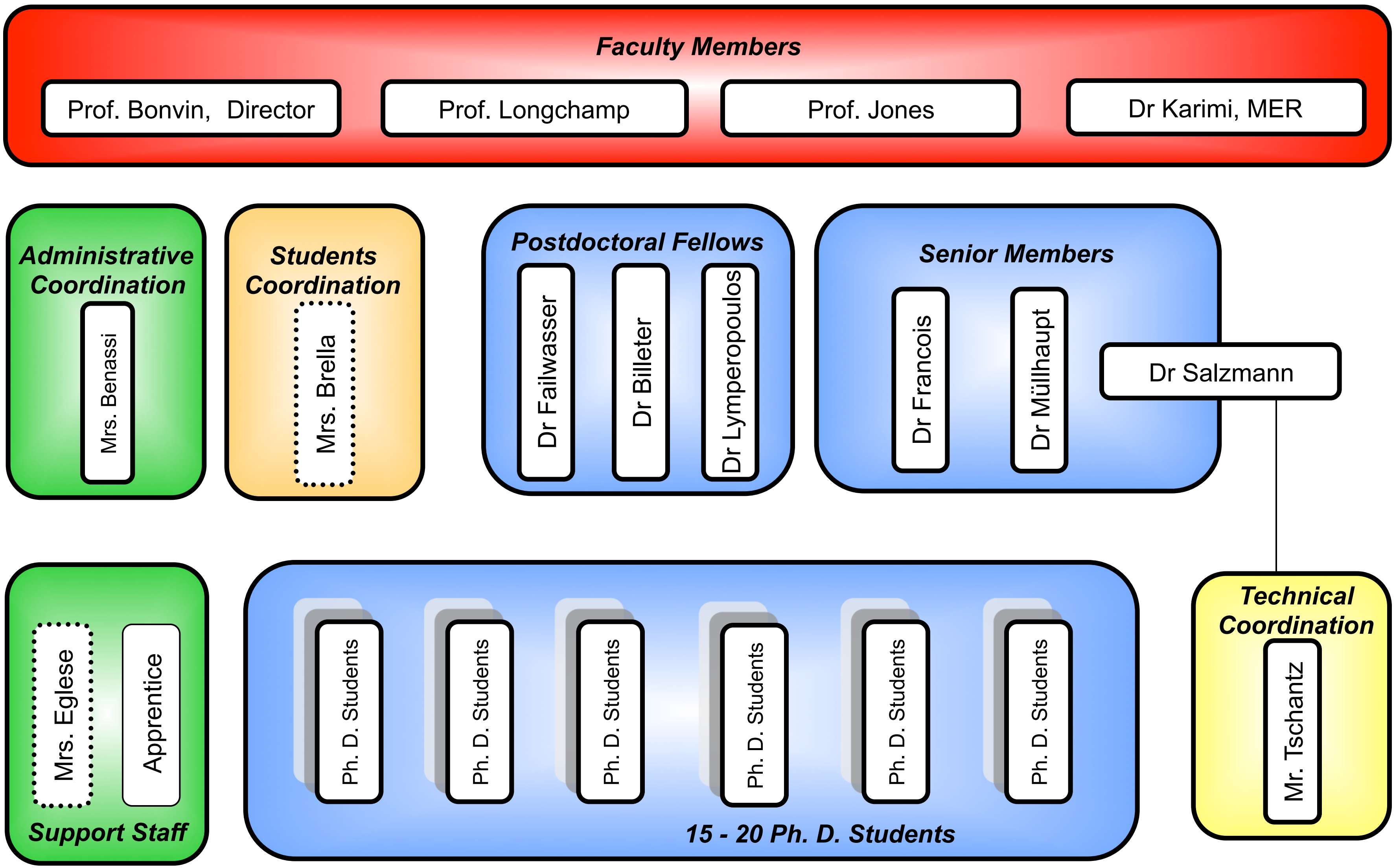
Projects:

- Semester 7 (MS1) : 10 cred.
- Semester 8 (MS2) : 10 cred.
- Semester 9 (MS3) : 10 cred.
- Master (MS4): 30 cred.
- SHS : 6 cred.

Laboratoire d'Automatique

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

LA Structure



LA Teaching

Semester	Bachelor			Master		
	4	5	6	7	8	9
	Dynamical Systems	Control Systems	Multivariable Control	System Identification	Advanced Control Systems	
		Laboratory		Nonlinear Systems	Model Predictive Control	
				Semester Project 1	Semester Project 2	MS project
Doctoral School		Estimation Theory	Linear System Theory	Optimal Control		

LA Research Activities

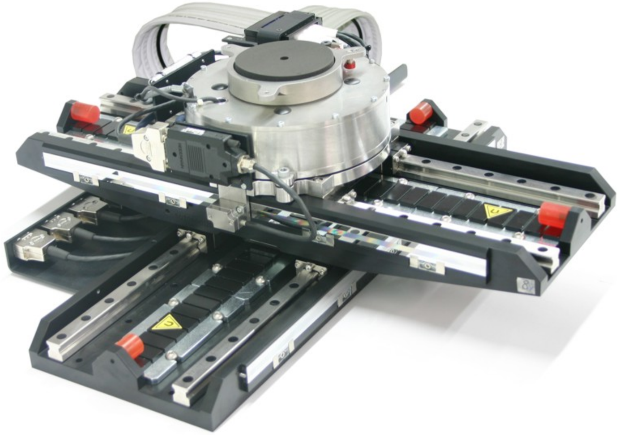
- **Identification and Control of Linear Systems**
  - Data-driven correlation-based controller tuning
  - Robust controller synthesis by convex optimization
  - Robust controller design using frequency-domain data
- **Measurement-based Optimization**
  - Run-to-run optimization of dynamic Processes
  - Transformation of optimization problem to control problem
  - Calibration models to infer unmeasured variables
- **Nonlinear Control**
  - Feedback linearization, exact and approximate
  - Lyapunuv stability
  - Quotient methods
- **Model Predictive Control**
  - High-speed model-predictive control, Computational geometry
  - Control of buildings, scheduling, renewable energy

Selected Industial Projects

Electrod vibration control

Geometry evolution in a grinding machine

Nano positioning control



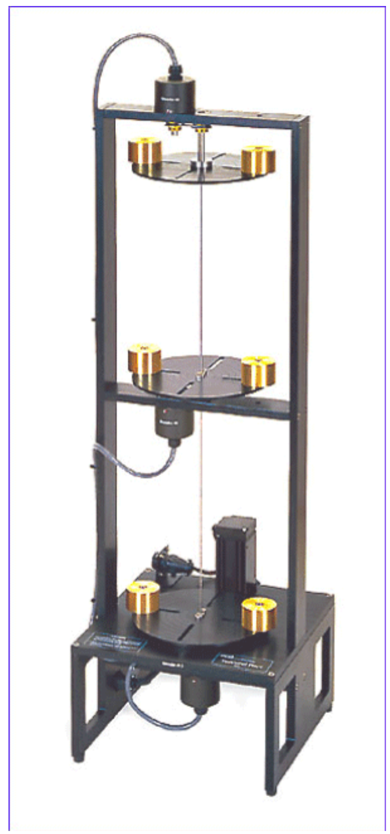
Performance monitoring in hydro power plants

Selected Projects

Control of an experimental Kite

Control of a unicycle

Robust control of a torsional system



Control of an active suspension system

Selected Projects

Modeling vehicle dynamics

Fly Phone

Building Temperature Control

Agile quad-copters

Modeling Sports Vehicle Dynamics

Projet de Semestre 2014

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École Polytechnique Fédérale de Lausanne

Laboratoire d'Automatique

Project Goals

Modeling and simulation of a sports vehicle.

THE NISSAN

Why The NISSAN GTR?

Nissan GT-R	0 – 100 [km/h]
2008 Mk 1	3.5 [s]
2011 Mk 2	3.0 [s]
2012 Mk 3	2.8 [s]

- Performance by electronic control loops.
- Advanced launch control.
- High performance torque management.

Nissan 2012 : Base price 126’800 [CHF]

Base price : 267’100 [CHF]
0-100[km/h] : 3.1 [s]
RWD

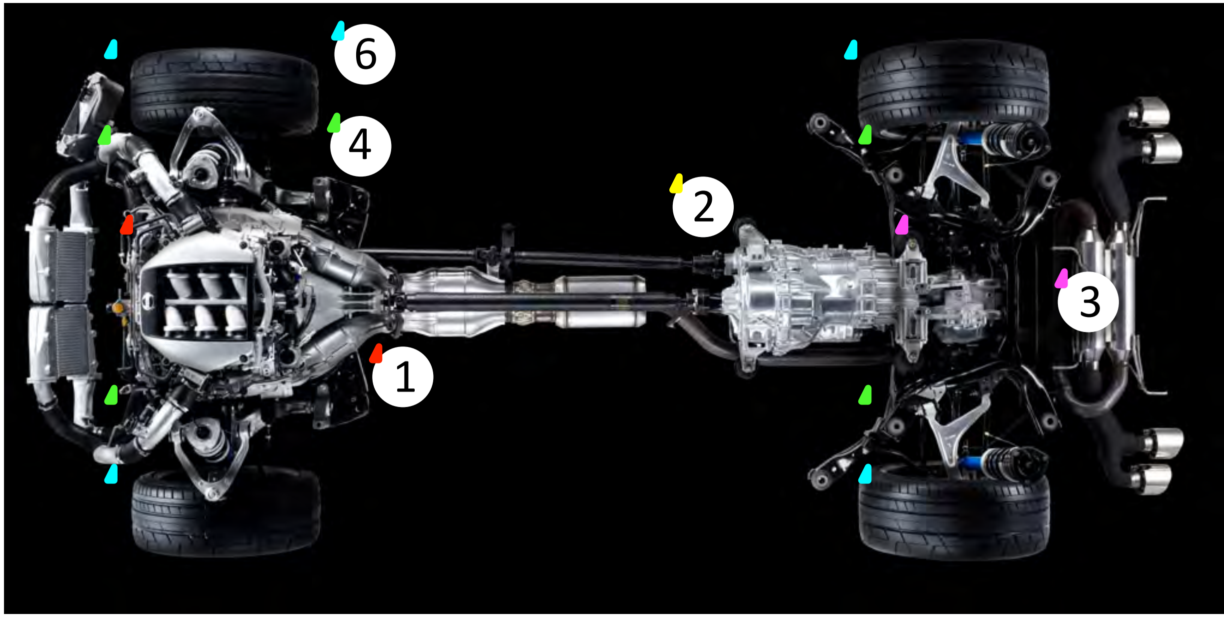
Base price : 433’000 [CHF]
0-100[km/h] : 2.9 [s]
AWD

Base price : 338’100 [CHF]
0-100[km/h] : 3.1[s]
RWD

What Is A Sports Vehicle?

A Vehicle Is :

1. Engine
2. Gear box
3. Differential
4. Suspension
5. Chassis
6. Tire Dynamics
7. Aerodynamics



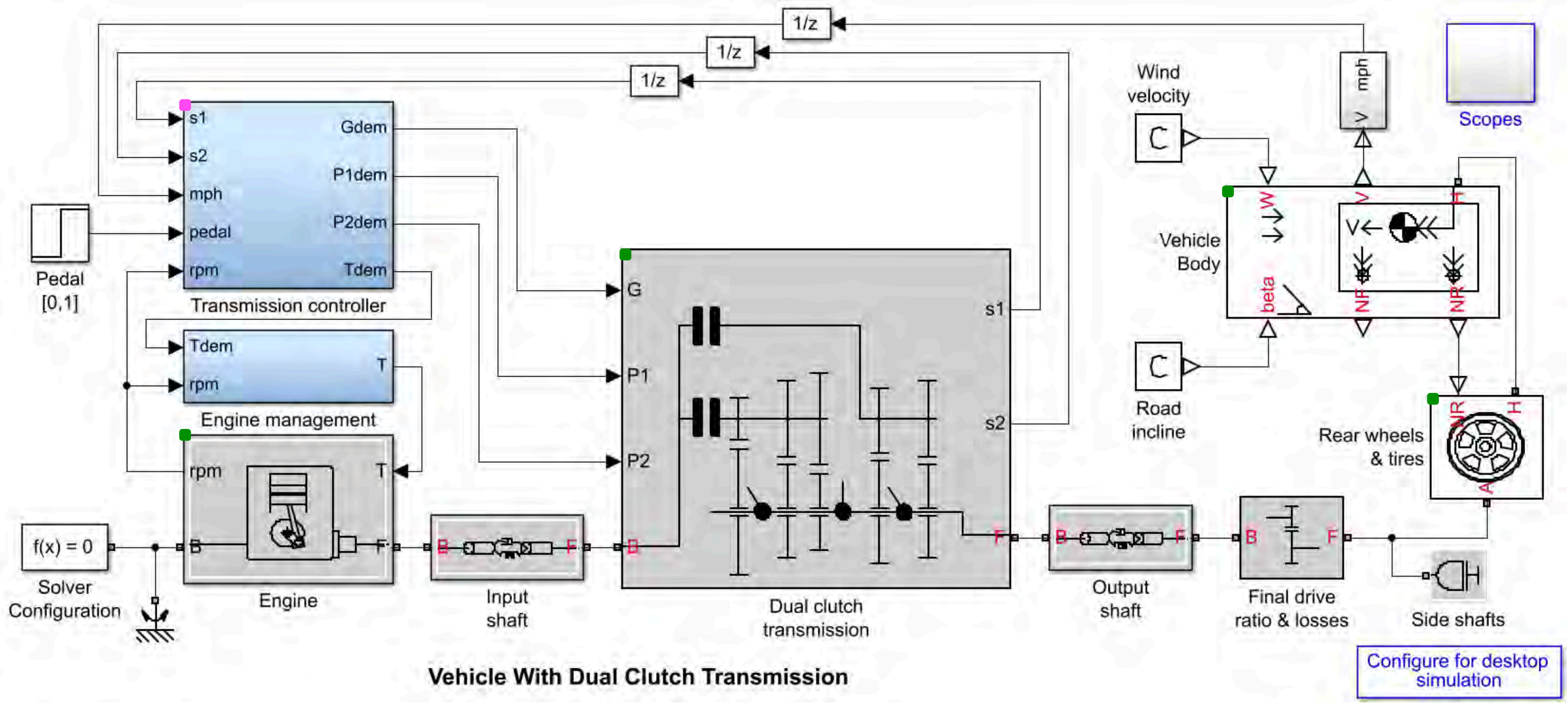
A sports vehicle is :

The same but improved

1. **Optimization**
2. **Control**

Aspects of the Project

- Specific Modeling
- General Modeling
- Control



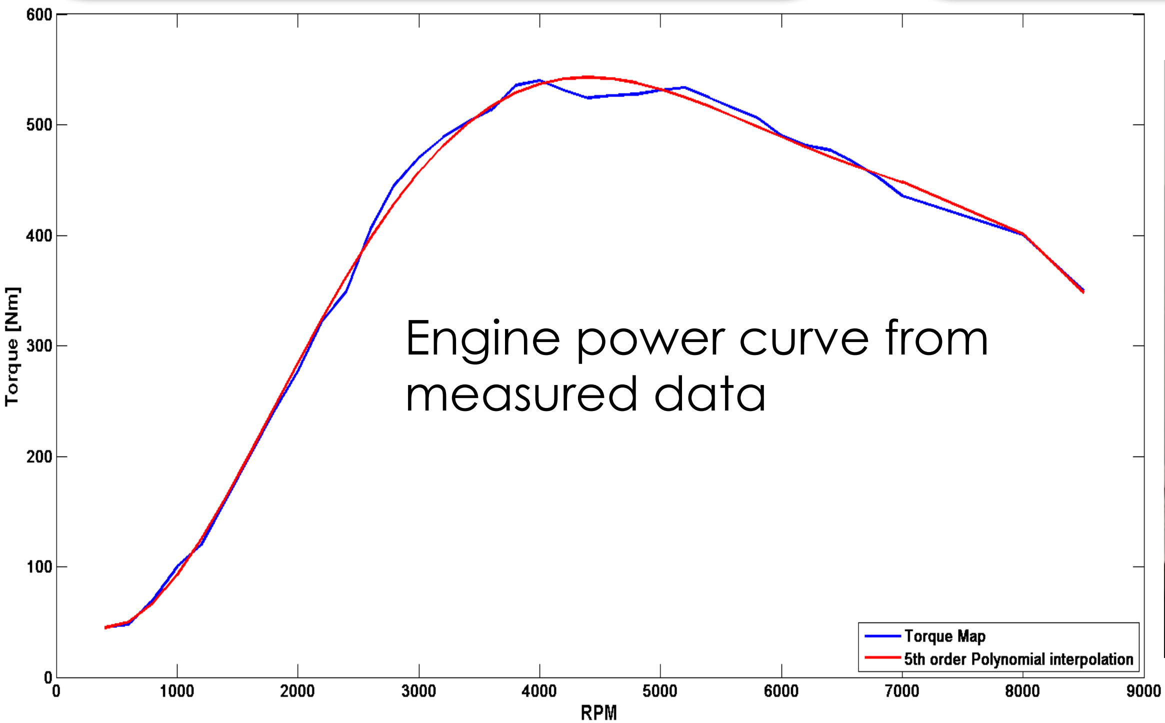
Example I: Motor Dynamics

$$\dot{a} = \frac{1}{\tau}(T - a)$$

$$\dot{\omega} = \frac{1}{J_m} \cdot Torque = \frac{1}{J_m} \cdot \frac{a \cdot P_{\max} \cdot P_n(\omega)}{\omega}$$

$$P_n(\omega) = (\frac{\omega}{\omega_o}) + (\frac{\omega}{\omega_o})^2 - (\frac{\omega}{\omega_o})^3$$

- Engine Response Dynamics
- Engine output shaft dynamics
- Engine Power Curve



Example II: Gearbox

Double Clutch, 6 speed gearbox

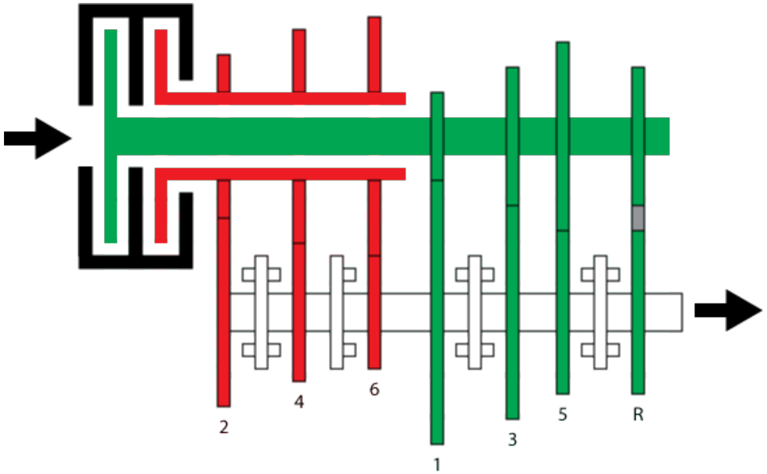
$$\dot{p}_1 = \frac{1}{\tau_1}(q_1 - p_1)$$

$$\dot{\omega}_1 = \frac{1}{J_1}(T_c - T_r) \qquad \dot{\omega}_o = \frac{1}{J_o}(T_r - T)$$

$$\dot{p}_2 = \frac{1}{\tau_2}(q_2 - p_2)$$

$$\dot{\omega}_2 = \frac{1}{J_2}(T_c - T_r)$$

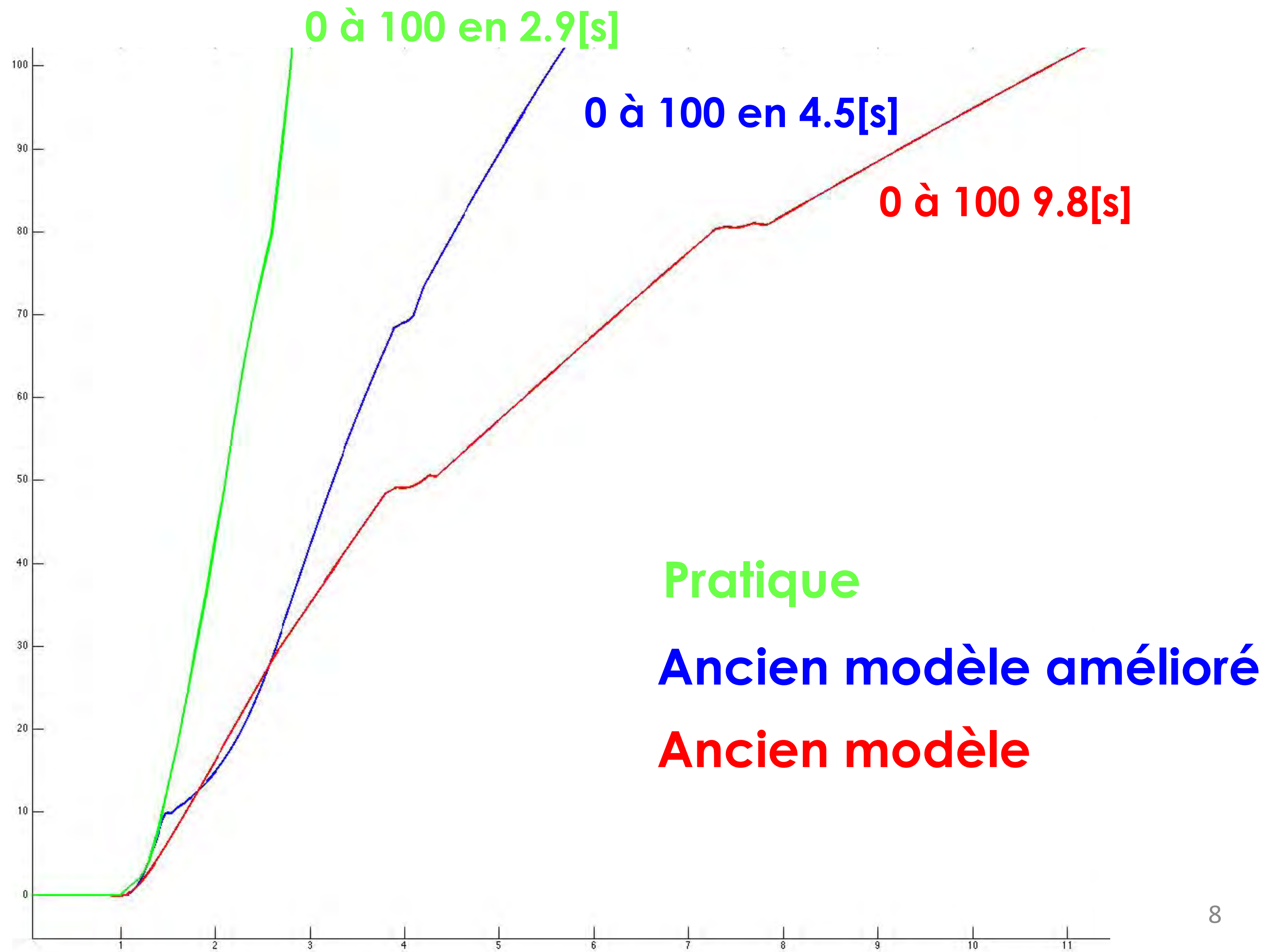
- Clutch 1 pressure dynamics
- Clutch 1 shaft dynamics
- Clutch 2 pressure dynamics
- Clutch 2 shaft dynamics
- Output shaft dynamics



Torque passing through clutch

$$T_c = \begin{cases} 0 & \text{(Open)} \\ c_d \omega_i + \mu_d p_i A_i & \text{(Slipping)} \\ -\mu_s p_i A_i \le T_c \le \mu_s p_i A_i & \text{(Closed)} \end{cases}$$

Results : 0 -> 100km/h



What Will You Gain?

Proficiency in :

- Physical Phenomenon Modeling.
- Dynamic Systems Simulation.
- Simulation with event based model switching.
- Control.

There Is Still Far to Go

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