SYSTEM DYNAMICS AND SYSTEM CONTROLS USING ALTAIR ACTIVATE

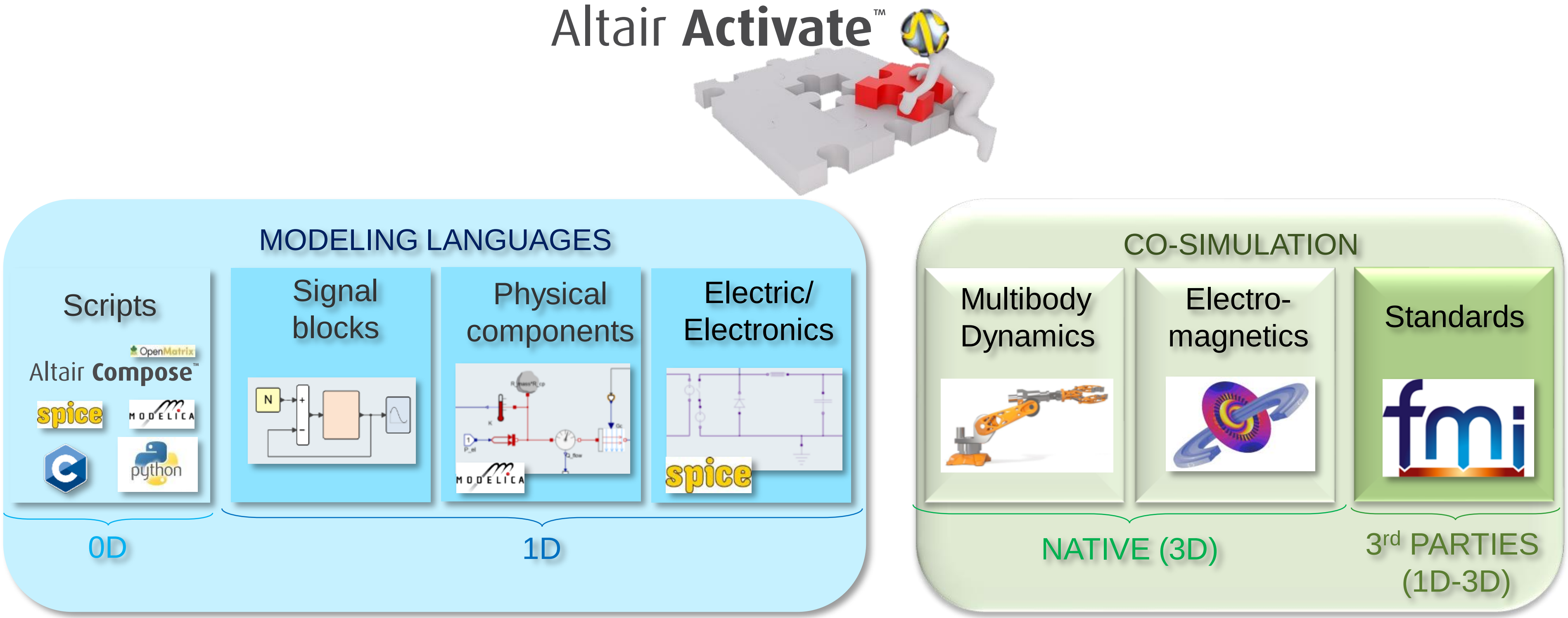
Patrick Goulding, Application Engineer

Agenda

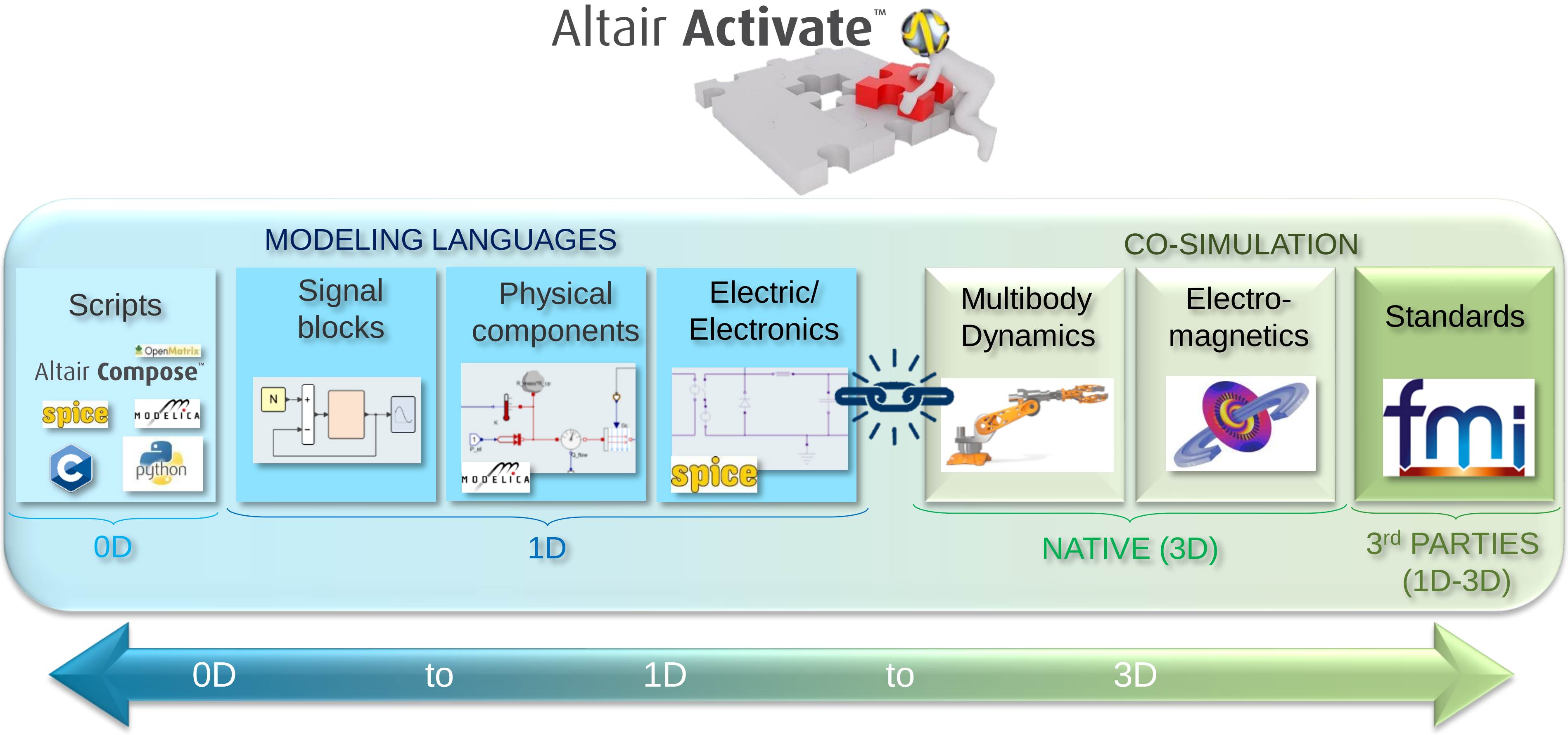
System Dynamics and System Controls using Altair Activate

WHAT IS ALTAIR ACTIVATE?

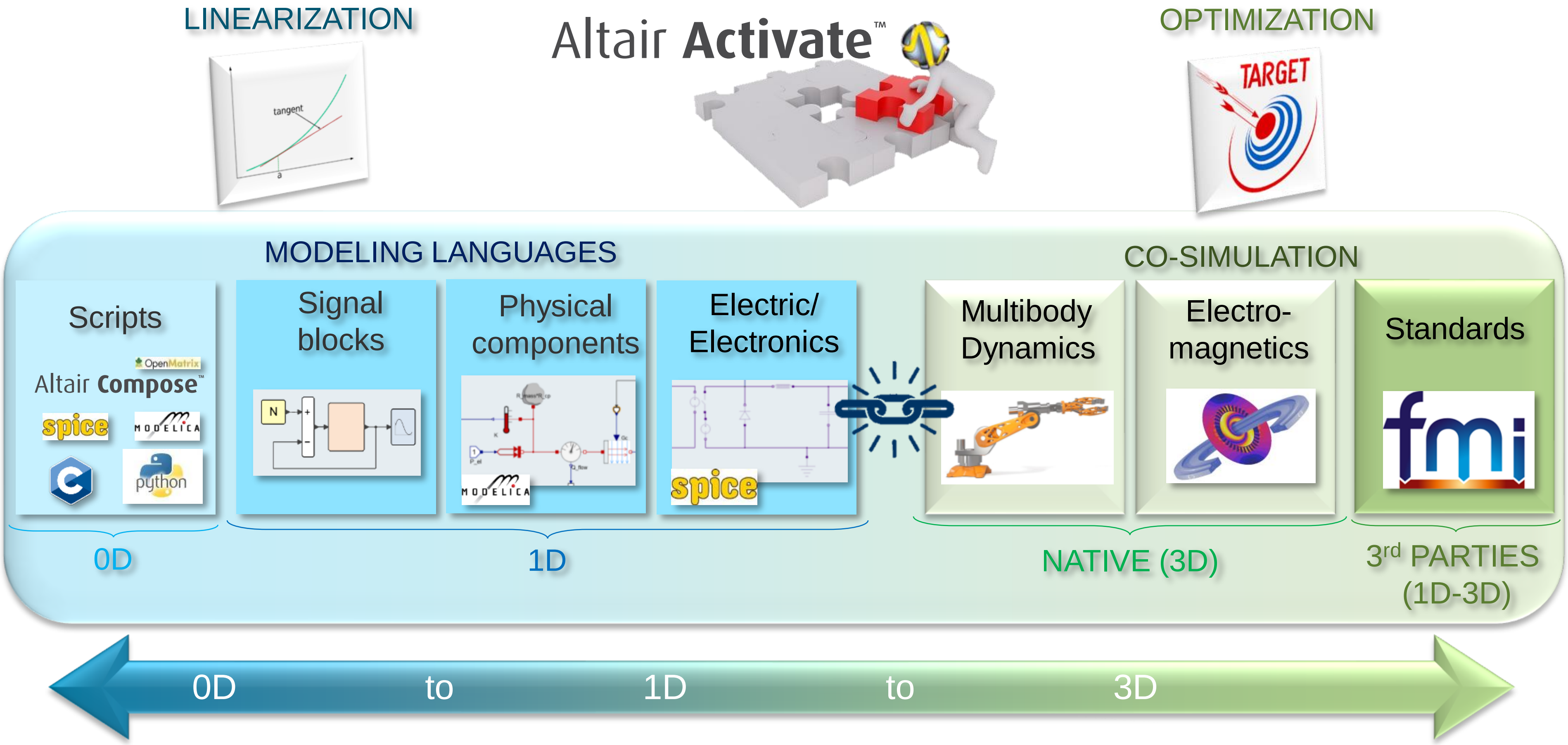
Open and flexible integration platform



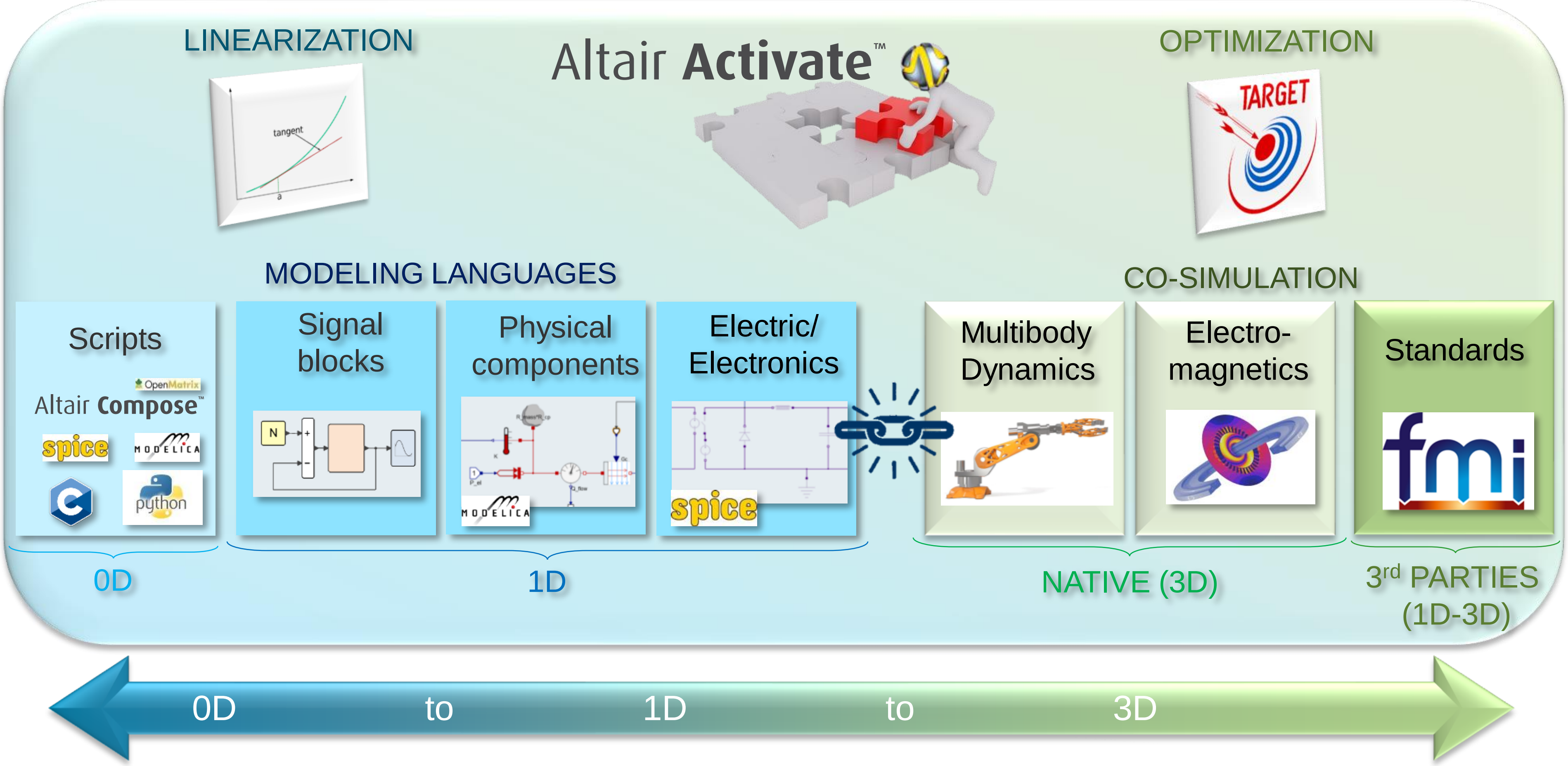
Open and flexible integration platform

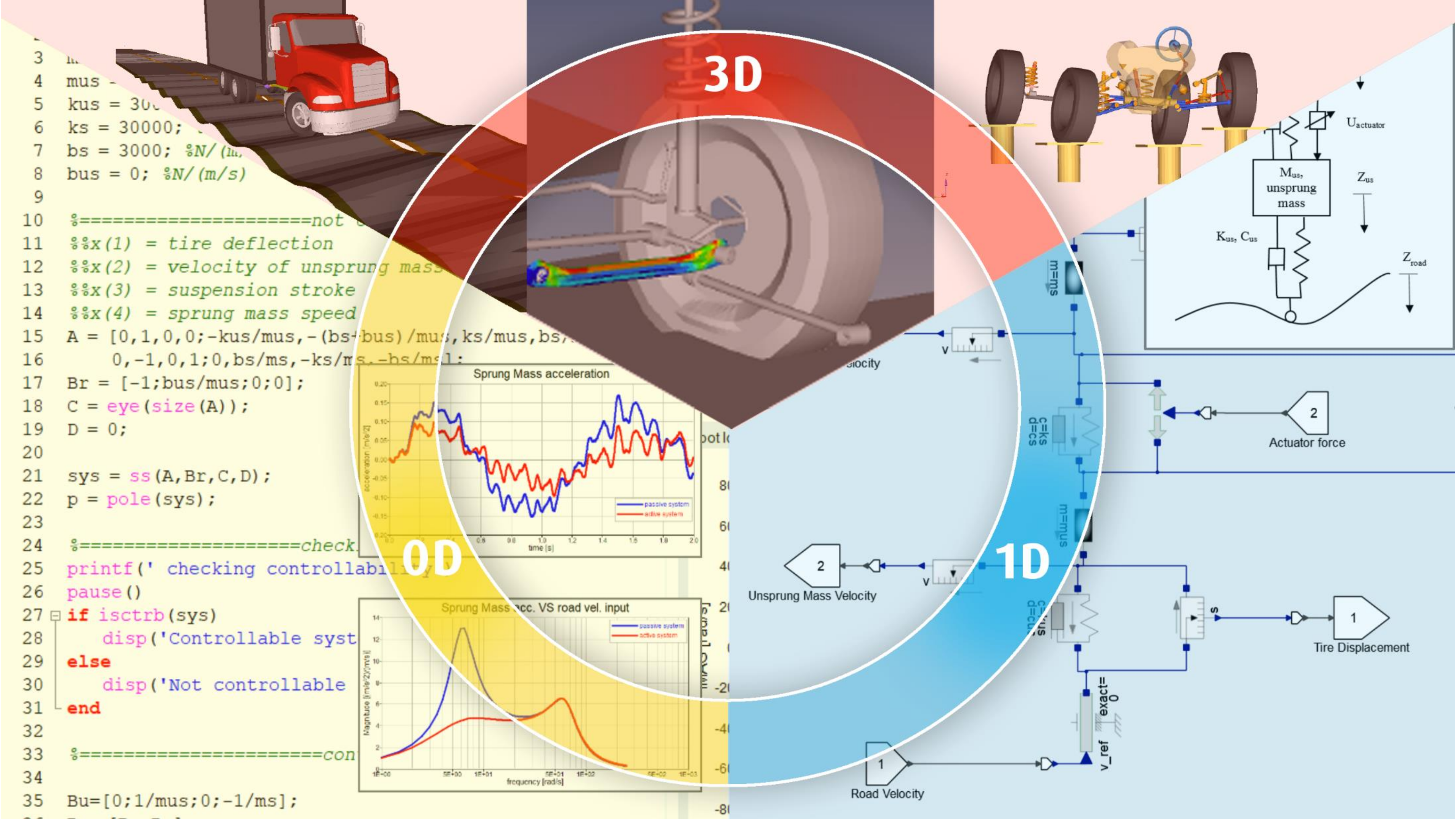


Open and flexible integration platform



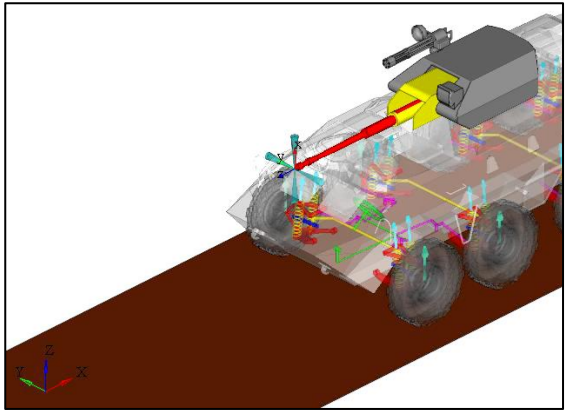
Open and flexible integration platform



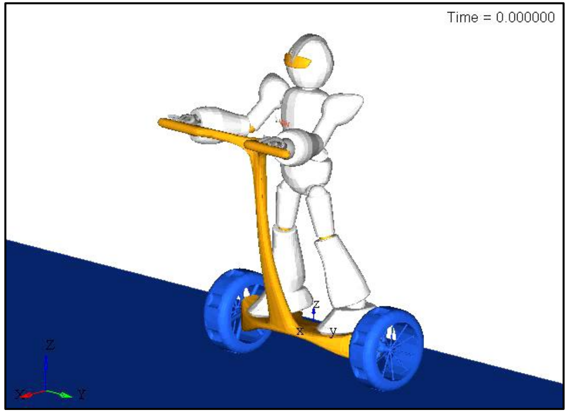


3D
0D
1D
ks = 30000;
bs = 3000; %N/(m
bus = 0; %N/(m/s)
%%x(1) = tire deflection
%%x(2) = velocity of unsprung mass
%%x(3) = suspension stroke
%%x(4) = sprung mass speed
Br = [-1;bus/mus;0;0];
C = eye(size(A));
D = 0;
sys = ss(A,Br,C,D);
p = pole(sys);
printf(' checking controllability
pause()
if isctrb(sys)
disp('Controllable syst
else
disp('Not controllable
end
Bu=[0;1/mus;0;-1/ms];
Sprung Mass acceleration
passive system
active system
time [s]
Sprung Mass acc. VS road vel. input
frequency [rad/s]
Uactuator
Mus, unsprung mass
Zus
Kus, Cus
Zroad
Actuator force
Unsprung Mass Velocity
Tire Displacement
Road Velocity

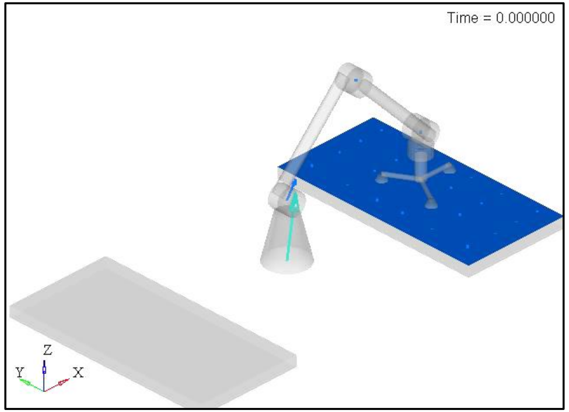
Examples of Multi-Disciplinary System Simulations (3D+1D+0D)



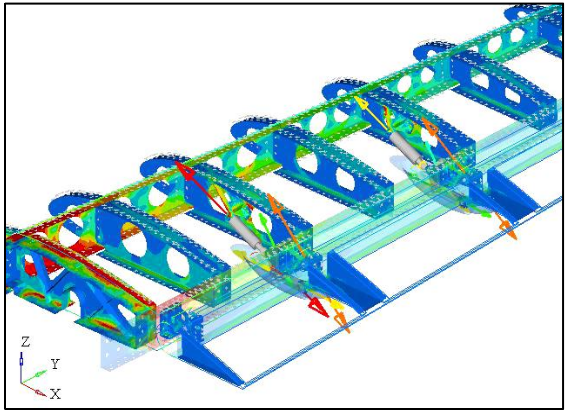
Multi-body, Controls



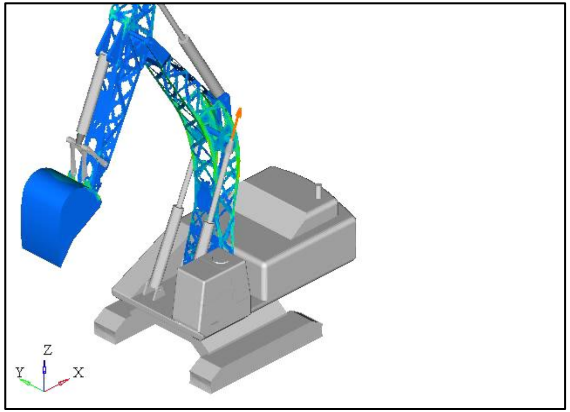
Motors, Multi-body, Controls



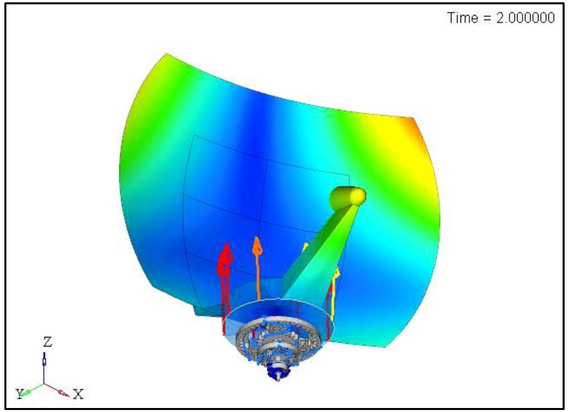
Structural, Motors, Multi-body, Controls



Light-weighting, Structural, Multi-body



Hydraulics, Light-weighting, Structural, Multi-body



CFD, EMag, Structural, Motors, Multi-body, Controls

Multi-Body: Different levels of fidelity

Altair **Activate**

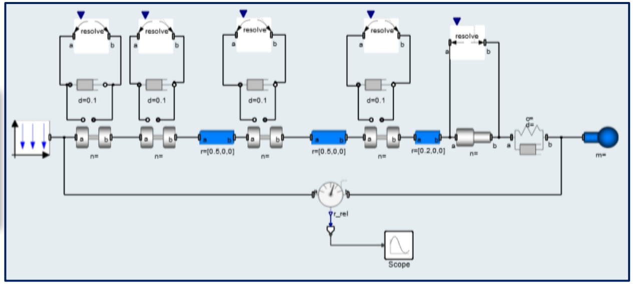
Altair **Compose**™

```
clc,clear,close all;
%=====================system parameters
ms = 750; %kg
mus = 75; %kg
kus = 300000; %N/m
ks = 30000; %N/m
bs = 3000; %N/(m/s)
bus = 0; %N/(m/s)
A = [0,1,0,0;-kus/mus,-(bs+bus)/mus,ks/mus,bs/mus;...
    0,-1,0,1;0,bs/ms,-ks/ms,-bs/ms];
Br = [-1;bus/mus;0;0];
C = eye(size(A));
D = 0;

sys = ss(A,Br,C,D);
p = pole(sys);
```

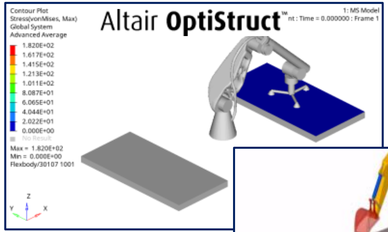
EQUATIONS

MODELICA



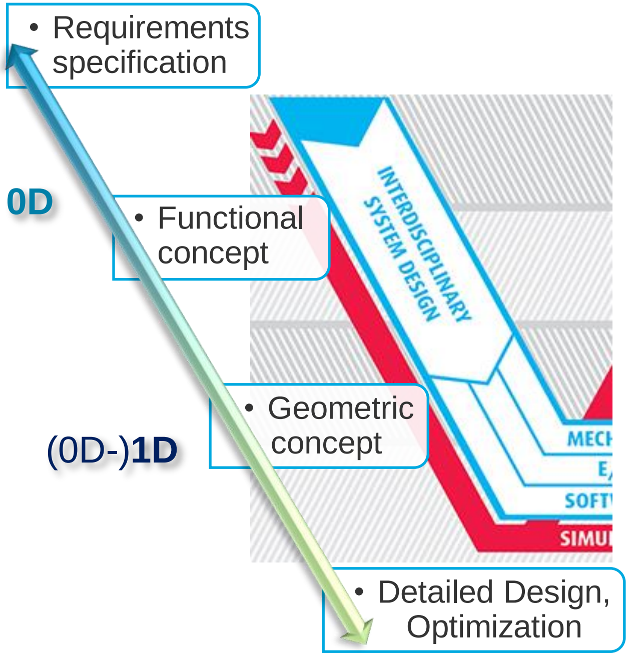
DIAGRAMS

Altair **MotionSolve**™
Altair **MotionView**™



EDEM®

CAD



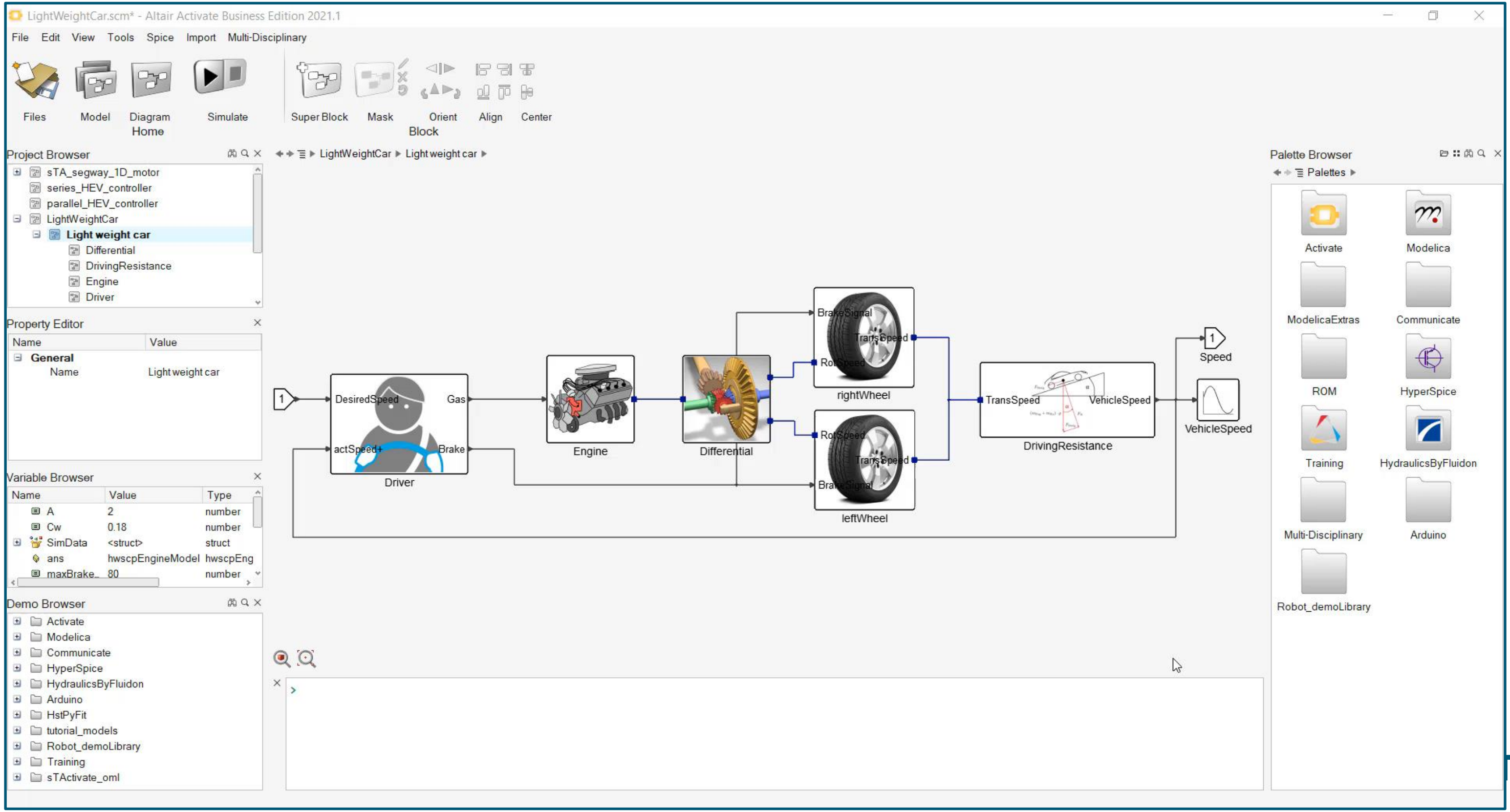
0D

(0D-)**1D**

(0D-1D-)**3D**
co-simulation

Altair Activate

Tour of the User Interface



TAIR

MECHANICAL MODELING EXAMPLE

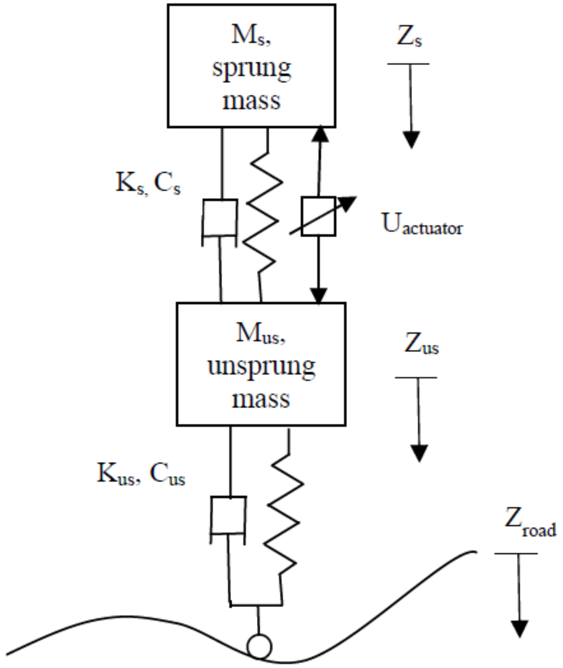
ALTAIR

Example: Active Suspension

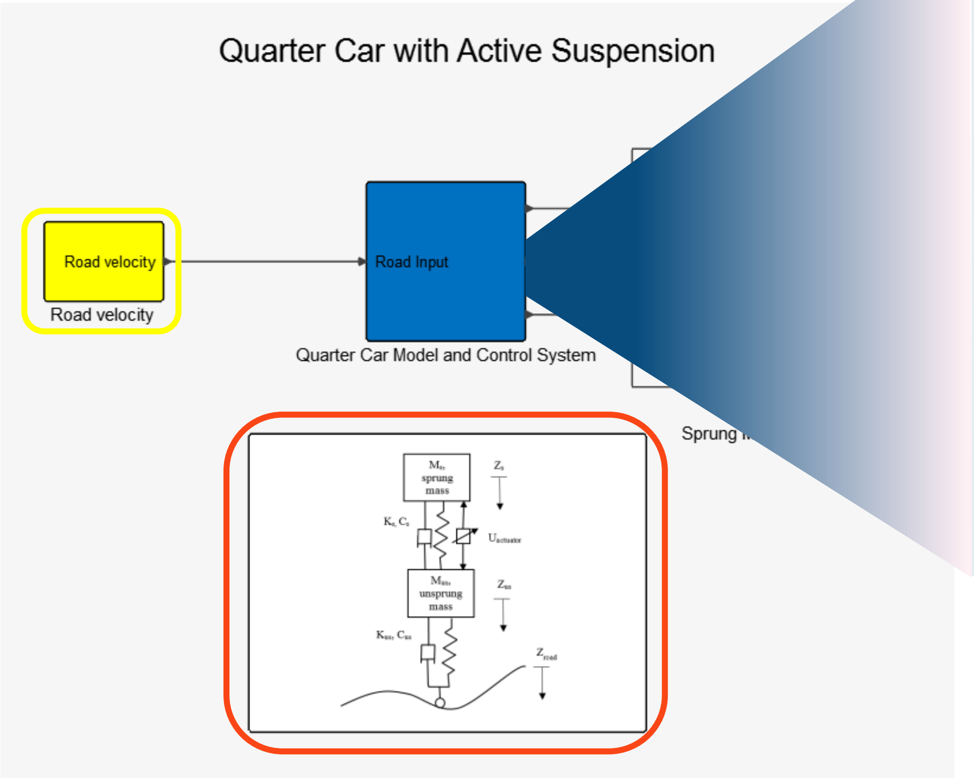
Quarter-car: passive system only

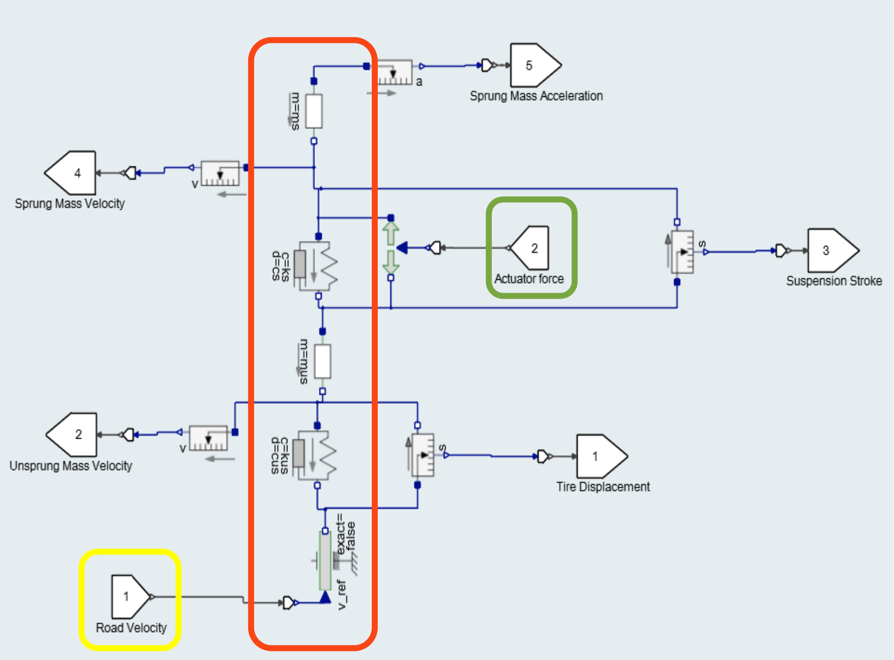
Description of system states:

- Tire deflection: Z_us – Z_road
- Unsprung mass velocity: d(Z_us)/dt
- Suspension stroke: Z_s – Z_us
- Sprung mass velocity: d(Z_s)/dt

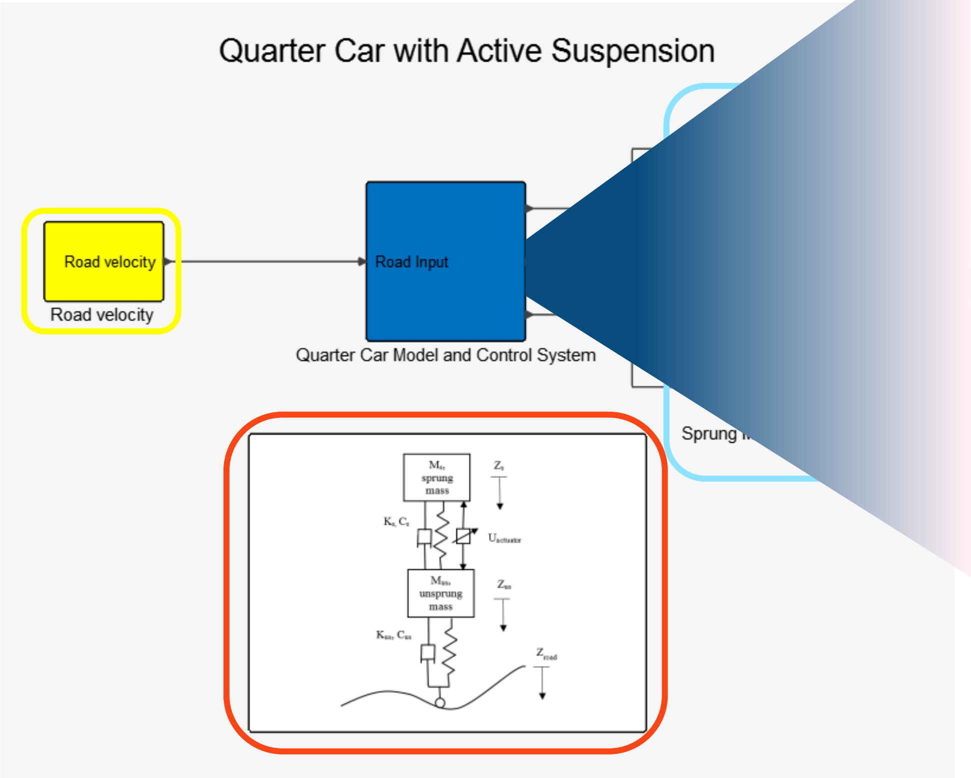


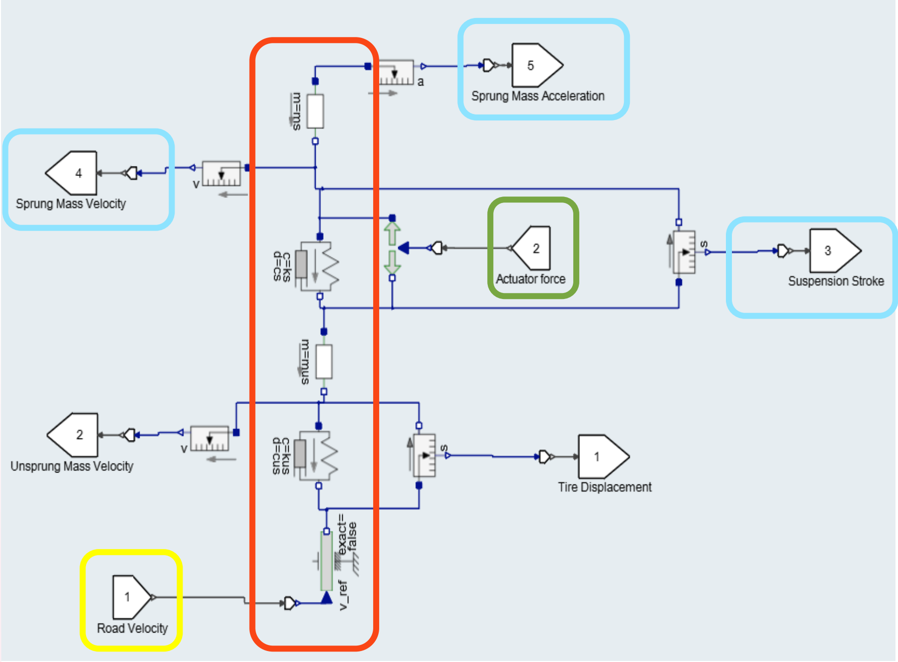
Example: Active Suspension (modeling with Modelica)



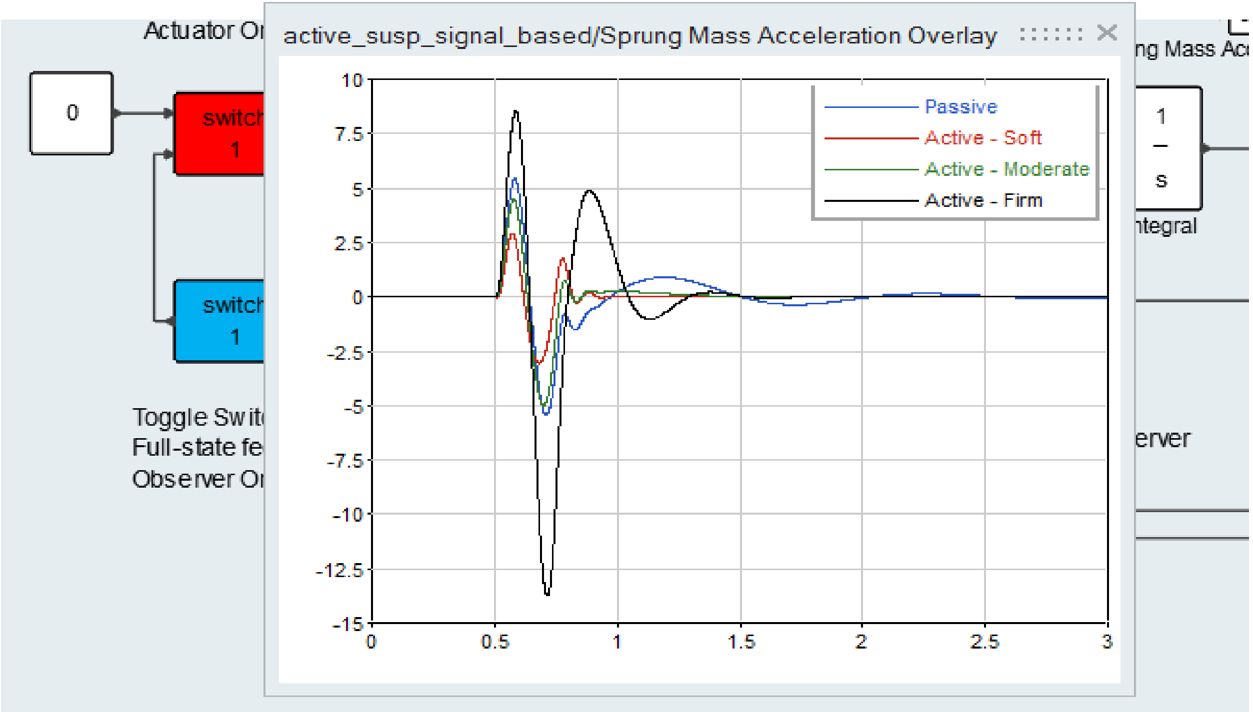


Example: Active Suspension (modeling with Modelica)





Example: Active Suspension (Controls)



Linear Quadratic Regulator (LQR) control using *LQR()* function in Control library

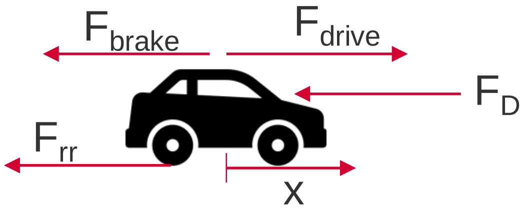
```
//suspension tuning choice
choice = 'soft'
choice = 'moderate'
choice = 'firm'
```

```
if choice == 'soft' then
print("soft ride")
Q = C`*C // need square matrix
Q(1,1) = 1E3; // weight for tire deflection
Q(2,2)= 10; //velocity of unsprung mass
Q(3,3) = 10; // suspension stroke
Q(4,4) = 1E2; //sprung mass speed
R = 1; // weight for input force
```

VEHICLE DYNAMICS

Vehicle Dynamics

Simple car dynamics:

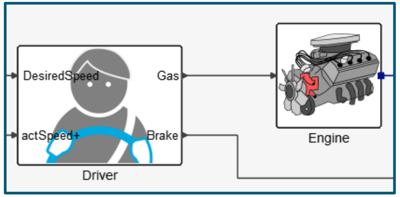


$$m\ddot{x} = F_{drive} - F_{brake} - F_{rr} - F_D$$

Driving force:

$$F_{drive} = \frac{1}{r} * M_{drive}$$

Drive torque : M_{drive} = 0 to 200 Nm
Wheel radius: r = 0.275 m



Brake force:

$$F_{brake} = \beta \frac{1}{r} * M_{brake}$$

Braking torque : M_{brake} = 3500 Nm
Brake pedal position : β = 0 to 1

Rolling friction:

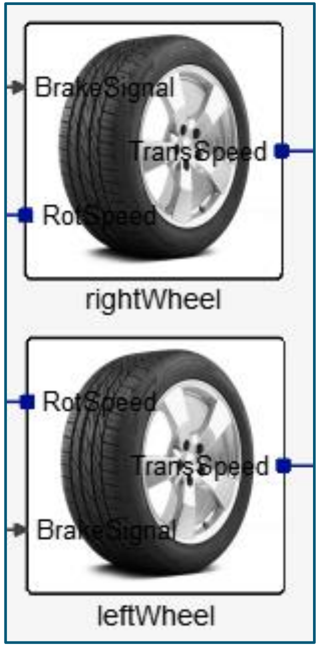
$$F_{rr} = \mu_{rr} * m * g$$

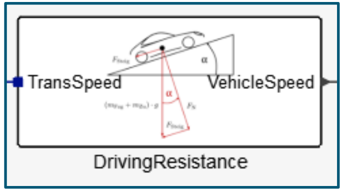
Car mass : m = 1350 kg
Rolling friction coefficient : μ_{rr} = 0.015

Drag:

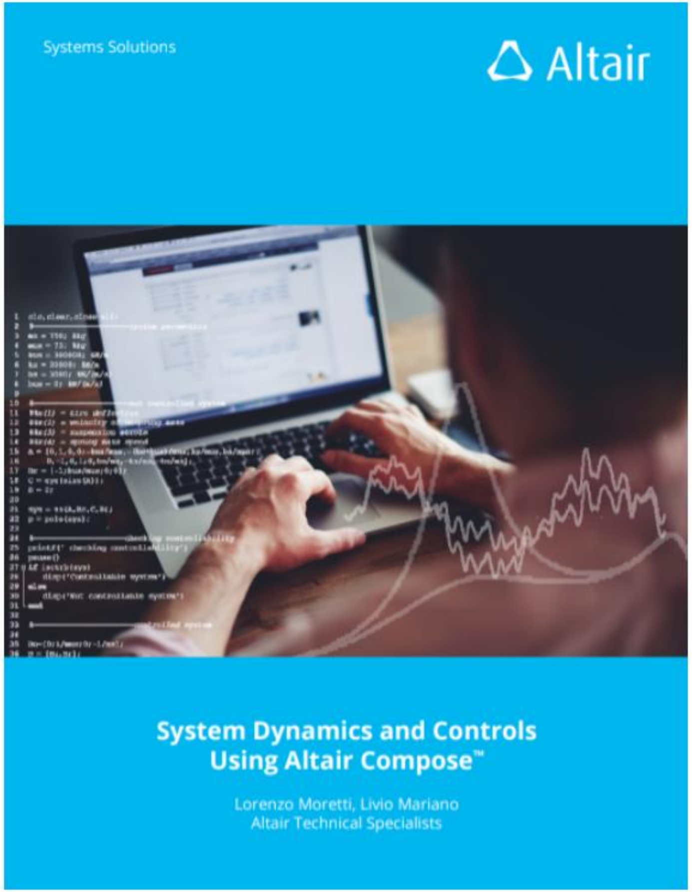
$$F_D = \frac{1}{2} A * \rho * c_w * \dot{x}^2$$

Cross sectional area : A = 2,14 m^2
Drag coefficient : c_w = 0.33
Density of air : ρ =1,204 kg /m3





E-book for System Dynamics and Controls Using Altair Compose



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