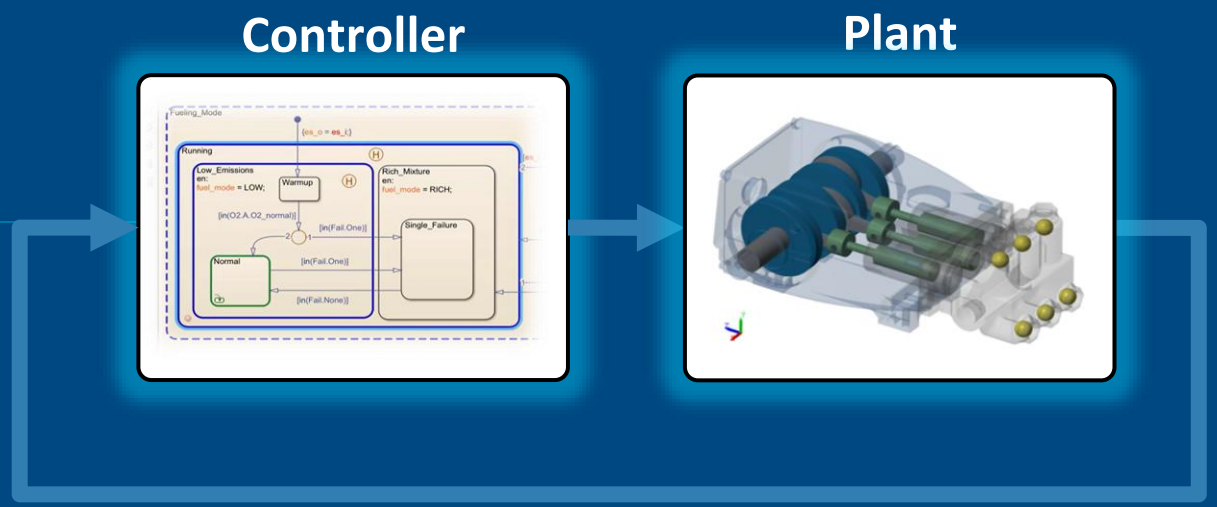
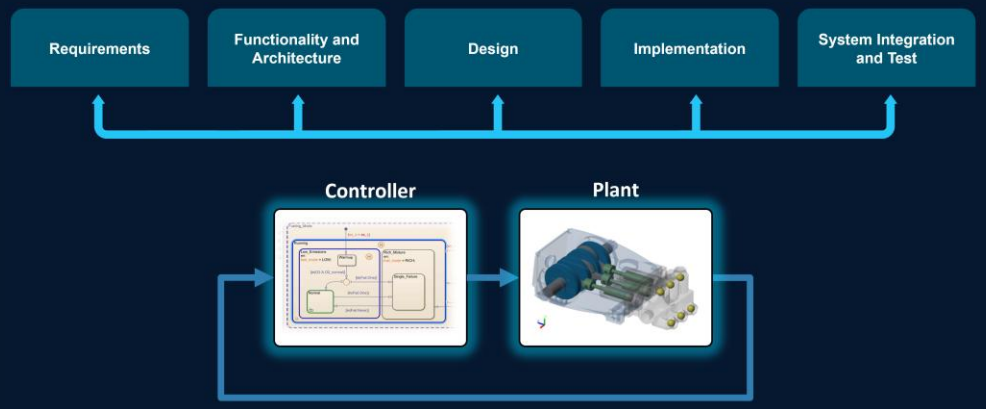
Model-Based Design



Mathieu Cuenant – *Application Engineer*
mcuenant@mathworks.com

Model-Based Design in *theory*



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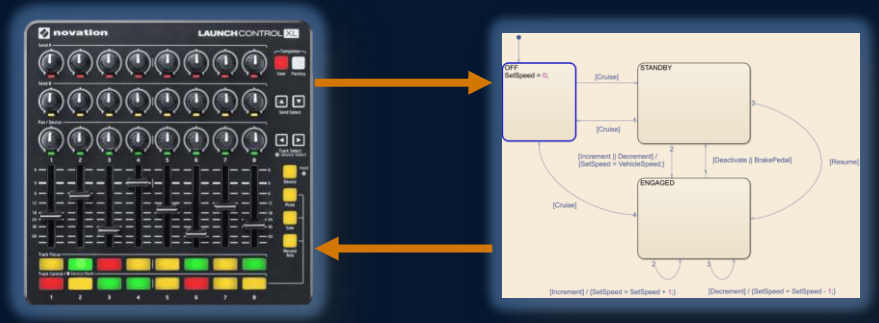
Model-Based Design in *practice*



MODEL-BASED DESIGN

Requirements

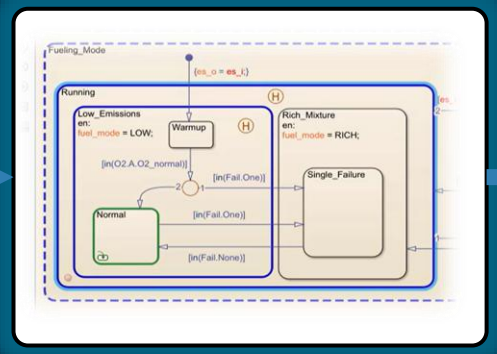
Functionality and Architecture

Design

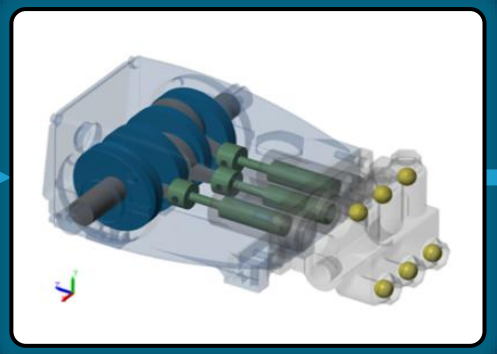
Implementation

System Integration and Test

Controller



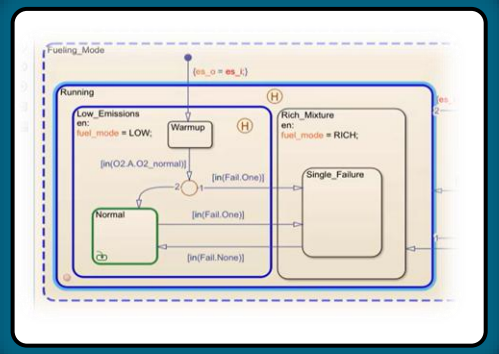
Plant



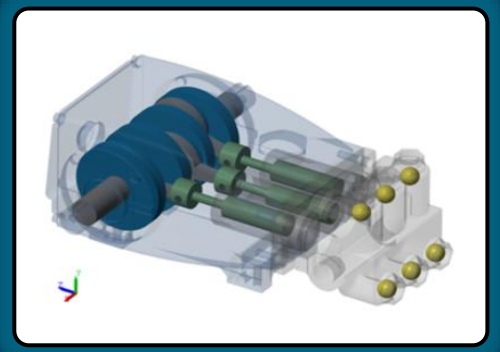
MODEL-BASED DESIGN

- Requirements Capture
- Software Design
- Verification and Validation
- Rapid Prototyping
- Automatic Code Generation

Controller



Plant



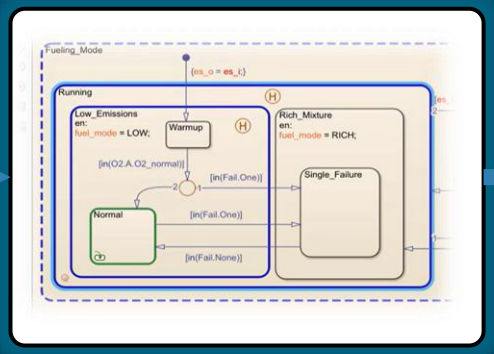
- Physical System Architecture
- Tradeoff Studies
- Component Sizing
- Component Integration
- Fault Injection

MODEL-BASED DESIGN

System-Level Simulation

- Early Integration
- Functional V&V
- Performance Characterization
- Sensitivity Analysis
- Optimization

Controller



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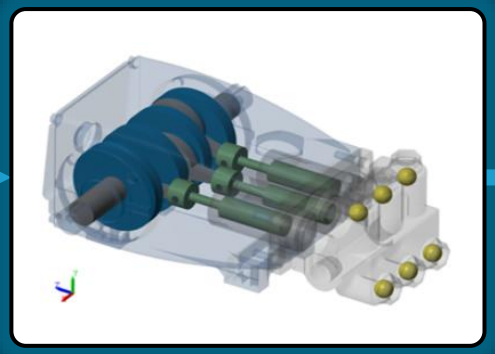


DEVELOPMENT

Requirements

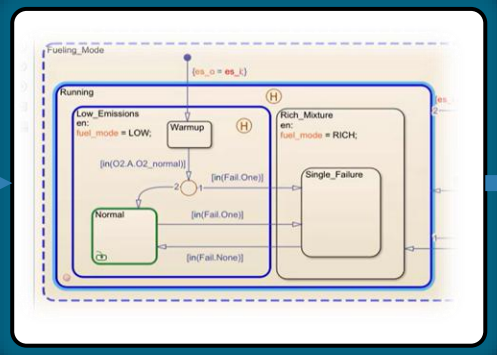
Functionality and Architecture

Design

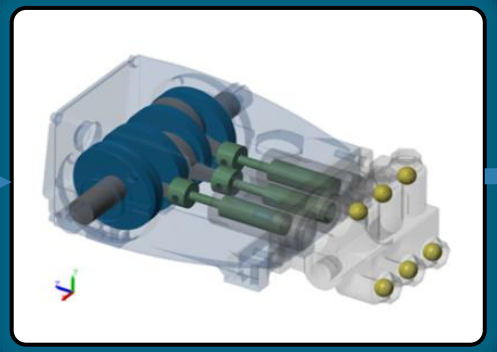
Implementation

System Integration and Test

Controller



Plant



Commissioning

DEVELOPMENT

Requirements

Functionality and Architecture

Design

Implementation

System Integration and Test

OPERATION

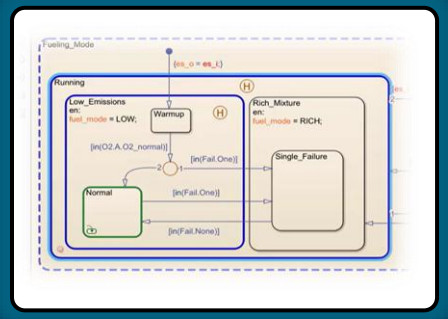
Deployment

Operation

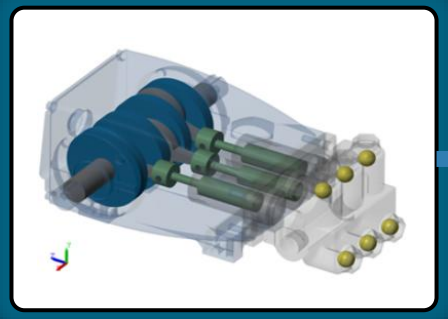
Maintenance

Evolution

Controller

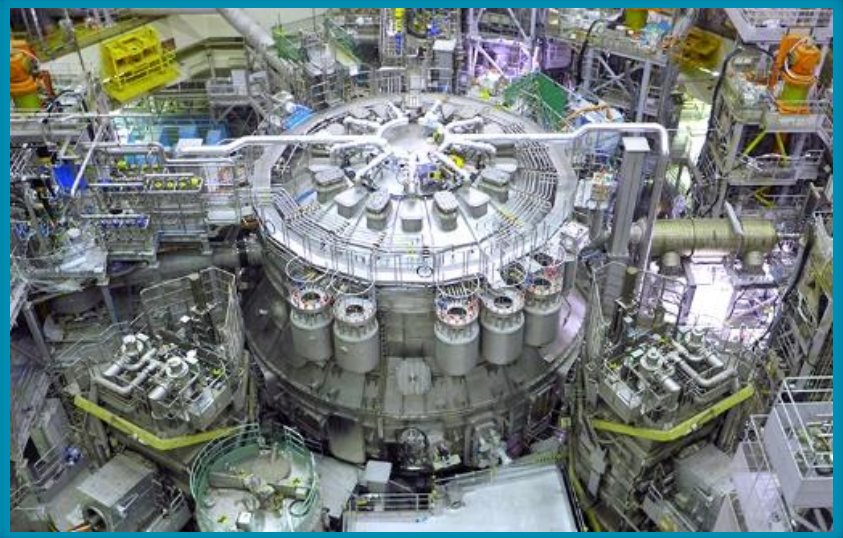


Plant



DEVELOPMENT

Requirements | Functionality and Architecture | Design | Implementation | System Integration and Test

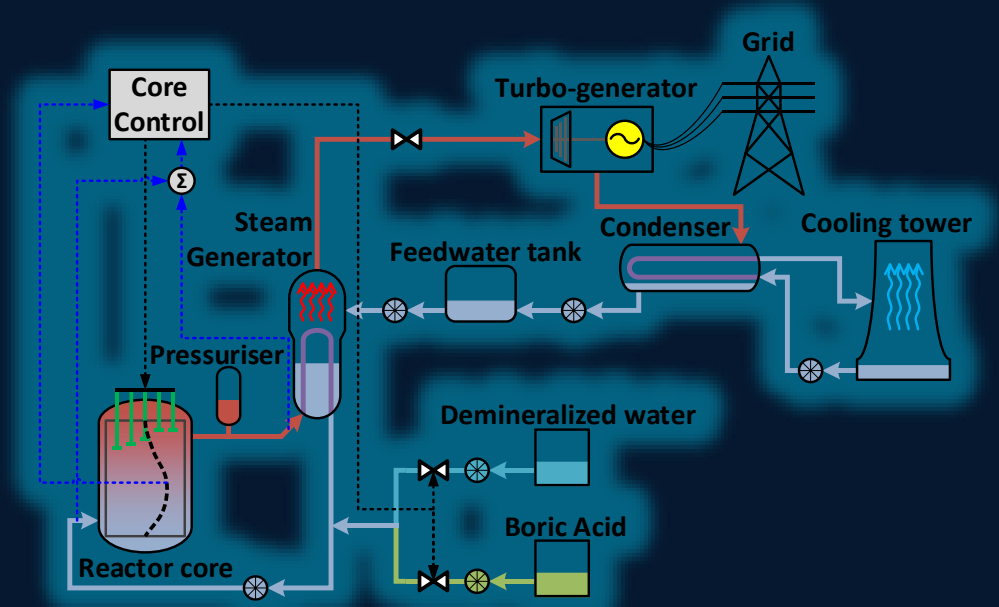


cea

TOKAMAK Cryogenic System

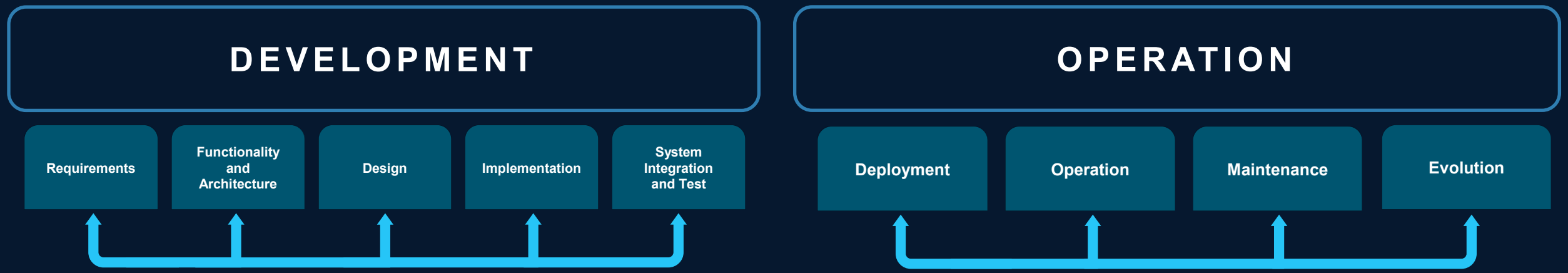
OPERATION

Deployment | Operation | Maintenance | Evolution



framatome

Operator Assistance Predictive System

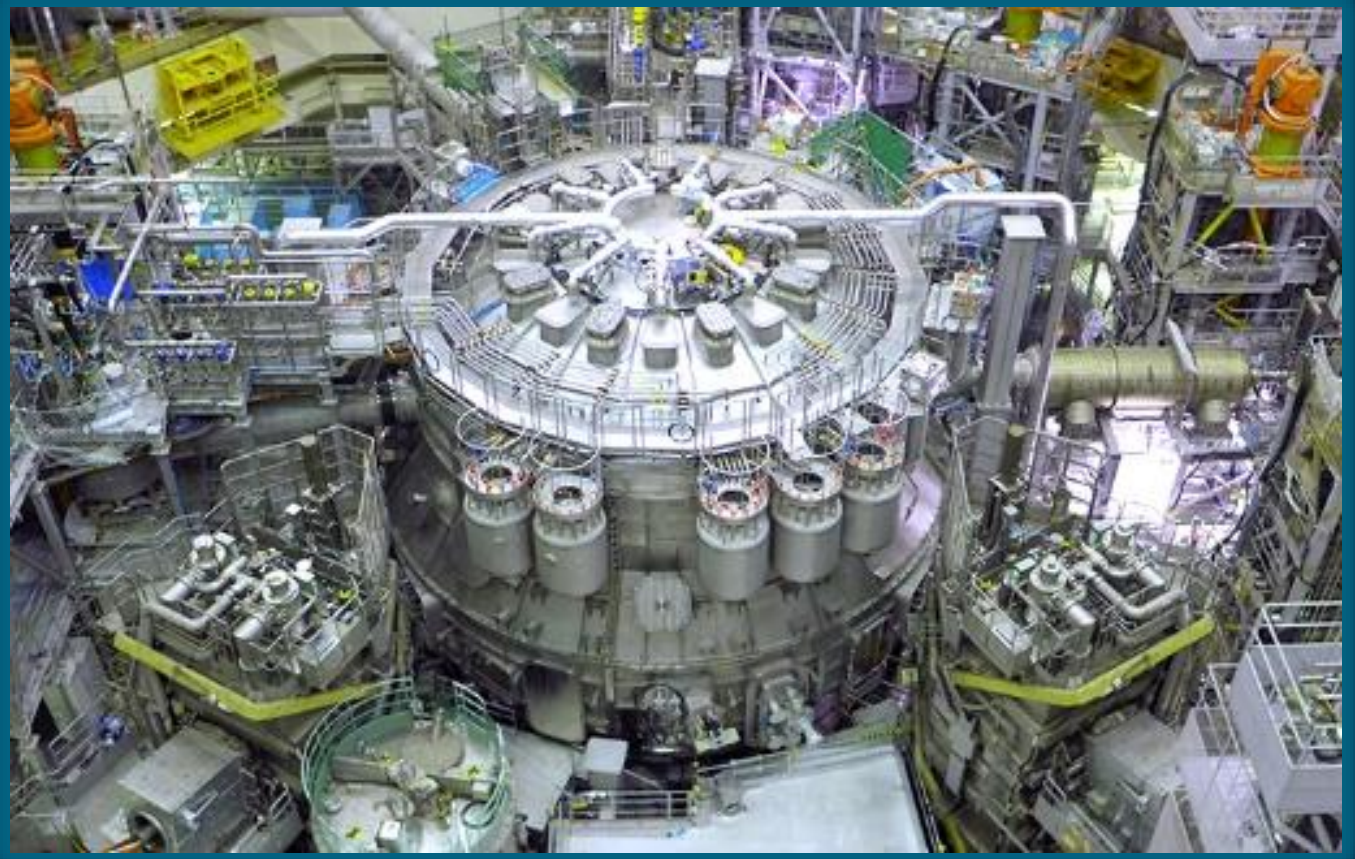


MATLAB EXPO

FRANCE

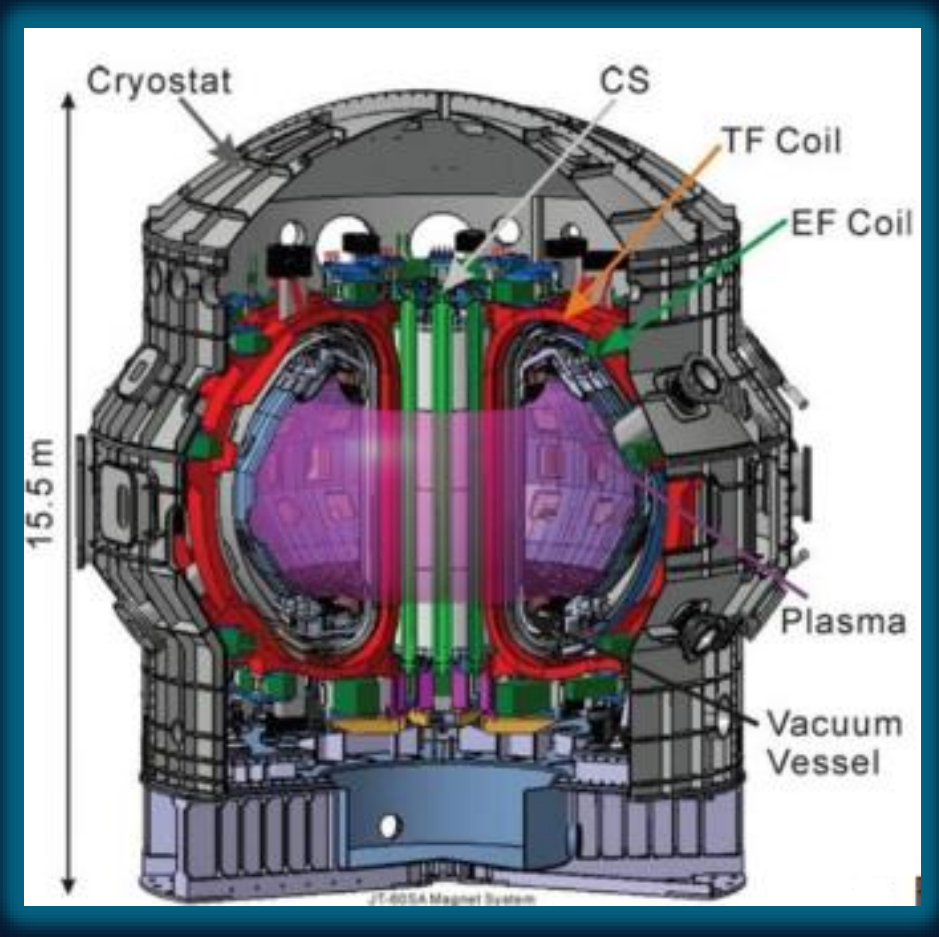
6 octobre 2026 | Paris

Simcryogenics : un outil de modélisation pour la cryogénie



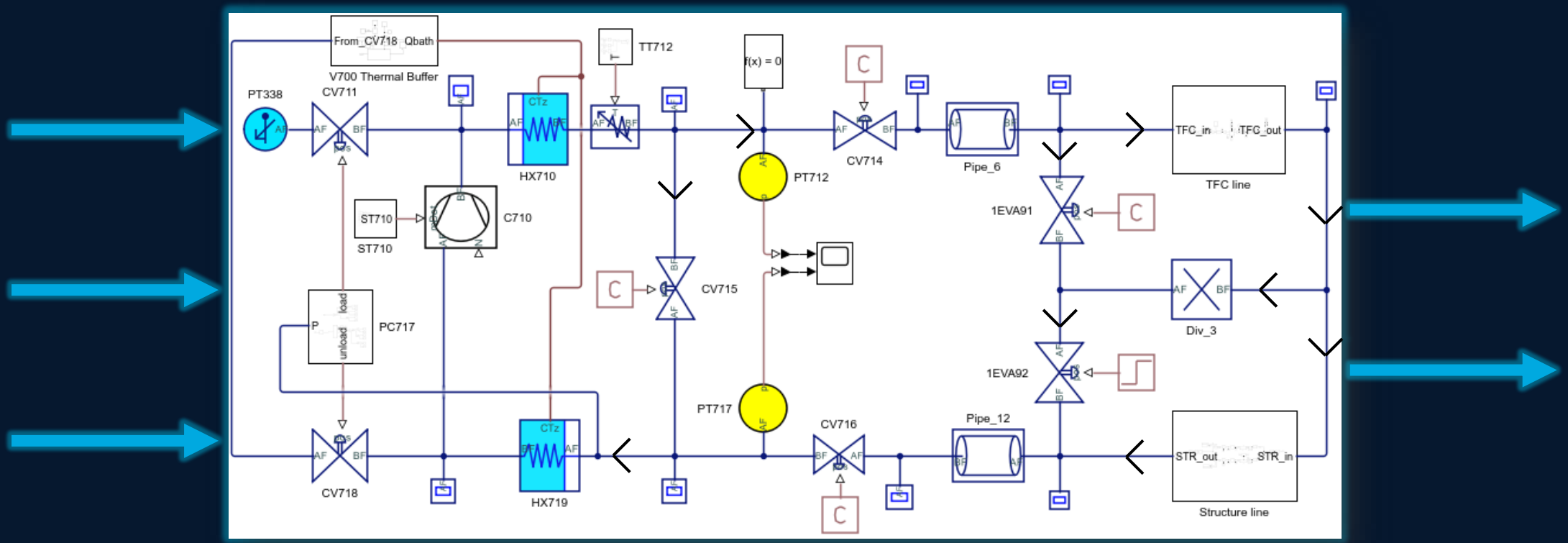
TOKAMAK JT-60SA

Simcryogenics : un outil de modélisation pour la cryogénie

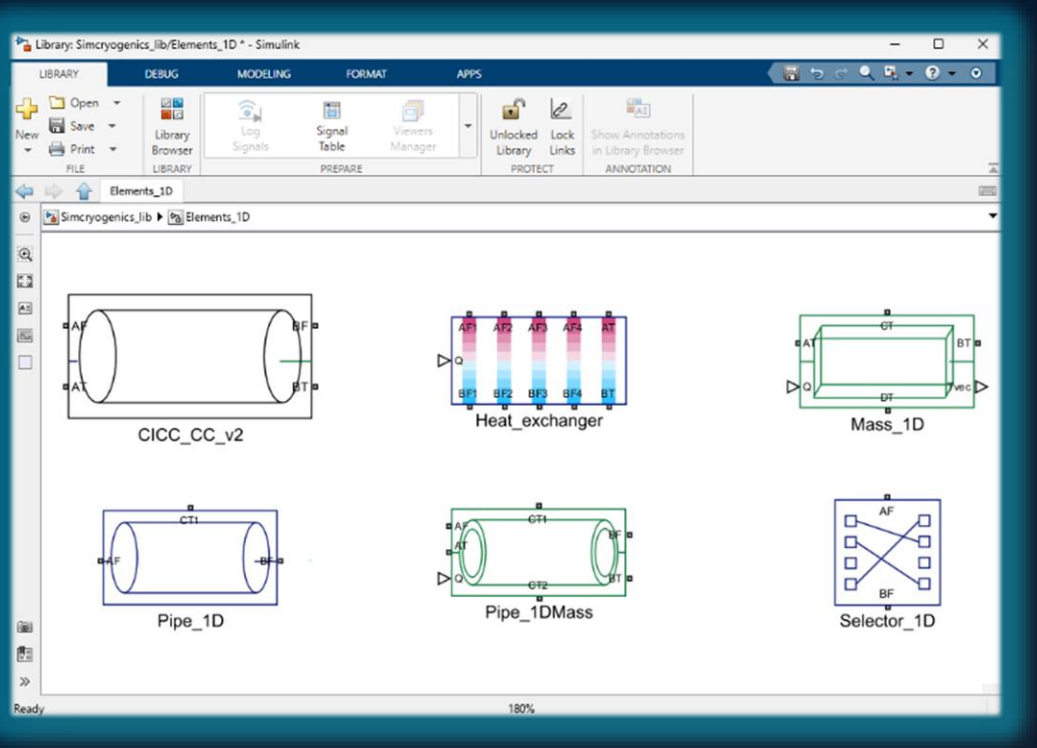


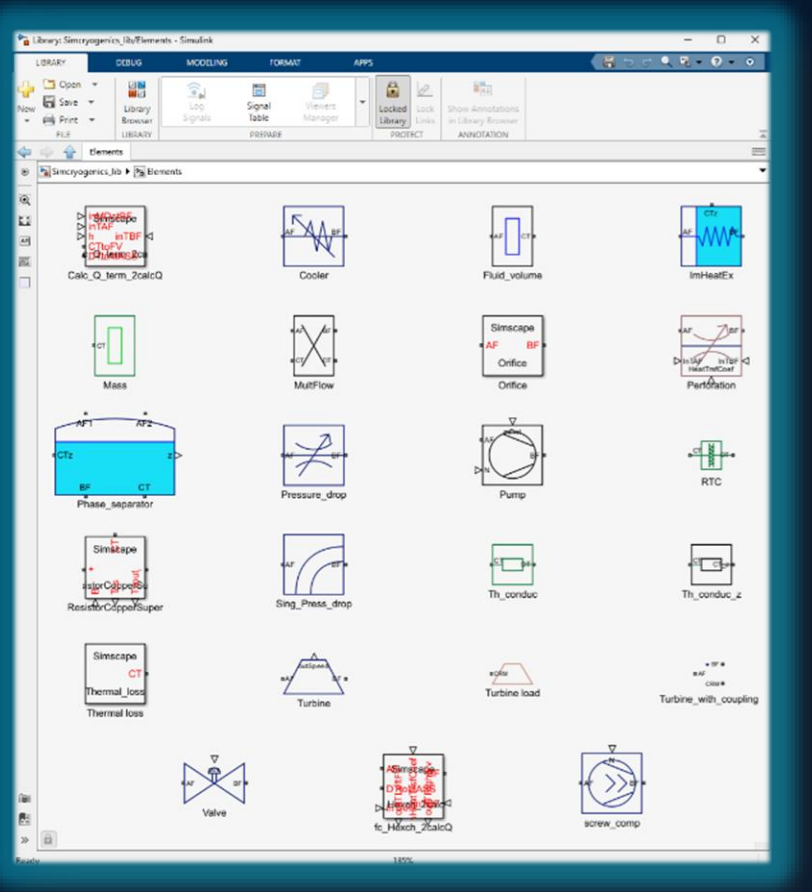
TOKAMAK JT-60SA

Specification Model

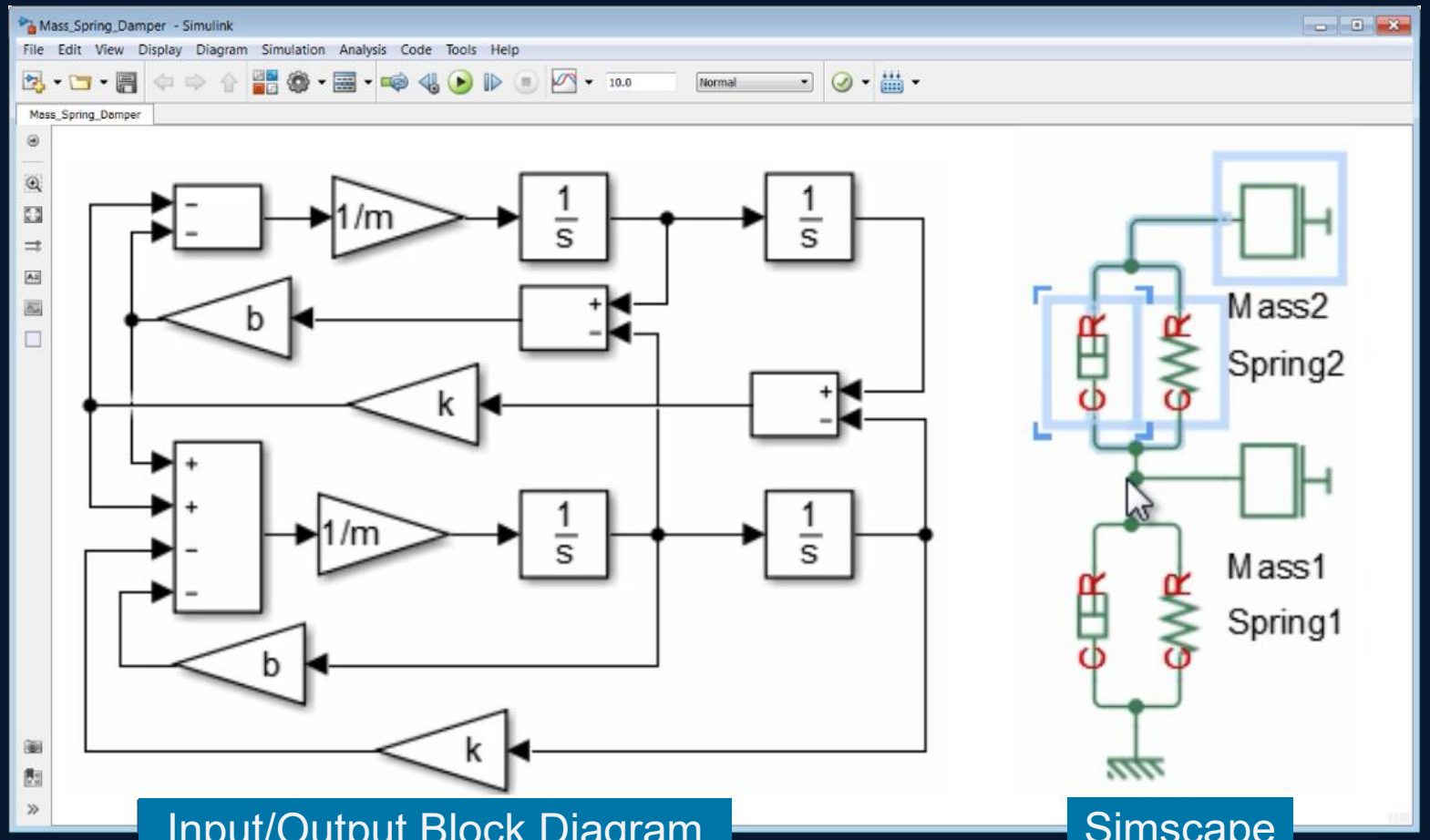


Library of Components

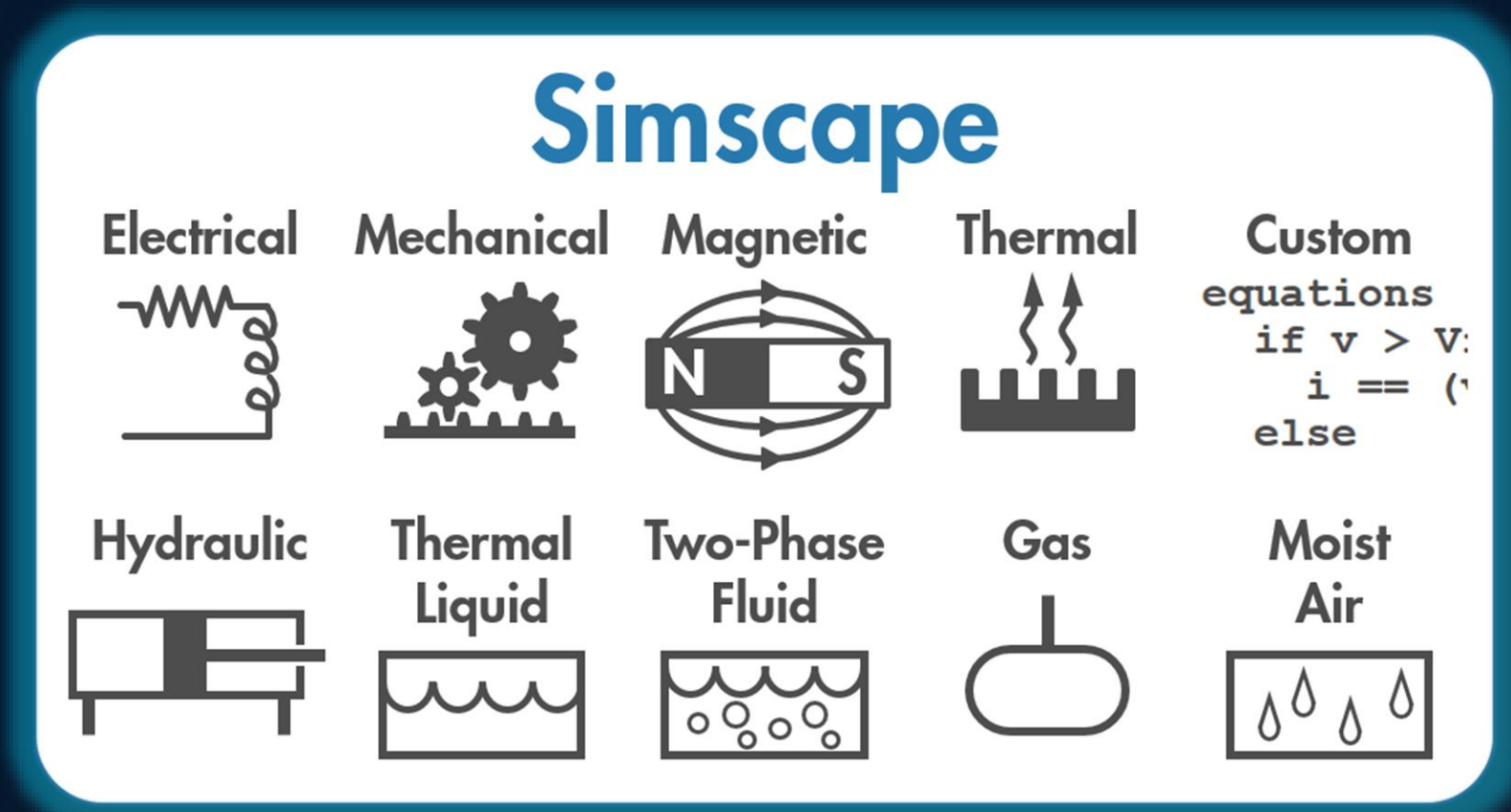




Modeling Approach



Modeling Approach



Documentation | Examples | Functions | Blocks | Apps | Language Syntax | Videos | Answers

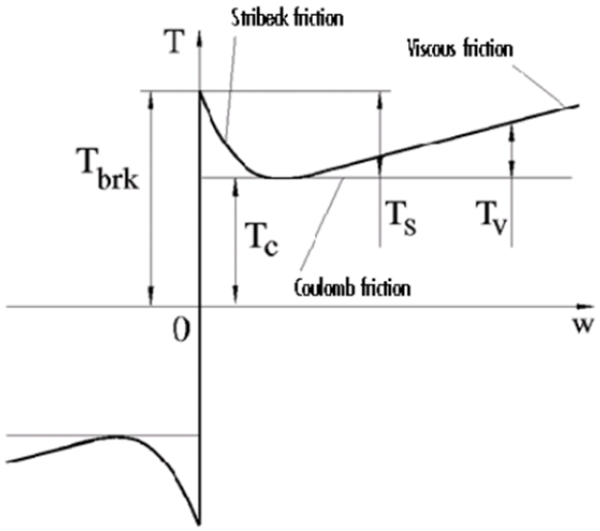
Rotational Friction

Friction in contact between rotating bodies

Libraries:
Simscape / Foundation Library / Mechanical / Rotational Elements

Description

The Rotational Friction block represents friction in contact between rotating bodies. The friction torque is simulated as a functio



The Stribeck friction, T_S, is the negatively sloped characteristics taking place at low velocities [1]. The Coulomb friction, T_C, result
often referred to as the breakaway friction, T_{brk}. The friction is approximated with the following equations:

$$T = \sqrt{2e}\,(T_{brk} - T_C)\cdot \exp\left(-\left(\frac{\omega}{\omega_{St}}\right)^2\right)\cdot\frac{\omega}{\omega_{St}} + T_C\cdot\tanh\left(\frac{\omega}{\omega_{Coul}}\right) + f\omega$$

$$\omega_{St} = \omega_{brk}\sqrt{2}$$

$$\omega_{Coul} = \omega_{brk}/10$$

$$\omega = \omega_R - \omega_C$$

Data Inspector | Logic Analyzer | Bird's-Eye Scope

REVIEW RESULTS

Block Parameters: Rotational Friction

Rotational Friction

The block represents friction in the contact between rotating bodies. The friction force is simulated as a function of relative velocity and assumed to be the sum of Stribeck, Coulomb, and viscous components. The sum of the Coulomb and Stribeck frictions at zero velocity is often referred to as the breakaway friction.

Connections R and C are mechanical rotational conserving ports. The block positive direction is from port R to port C. This means that if port R velocity is greater than that of port C, the block transmits torque from port R to port C.

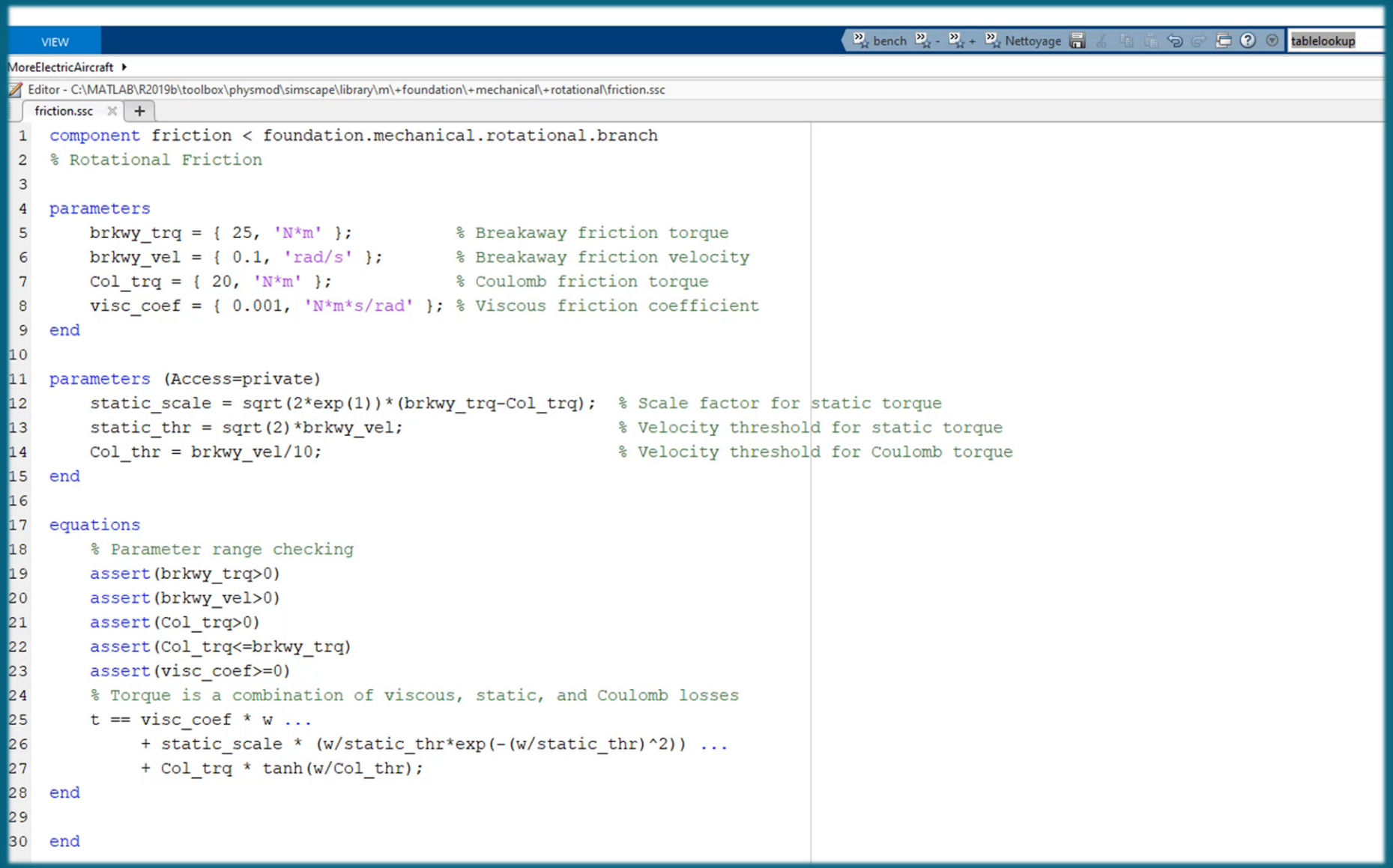
Source code

Settings

Parameters | Variables

Breakaway friction torque:	25	N*m	Compile-time
Breakaway friction velocity:	0.1	rad/s	Compile-time
Coulomb friction torque:	20	N*m	Compile-time
Viscous friction coefficient:	0.001	N*m/(rad/s)	Compile-time

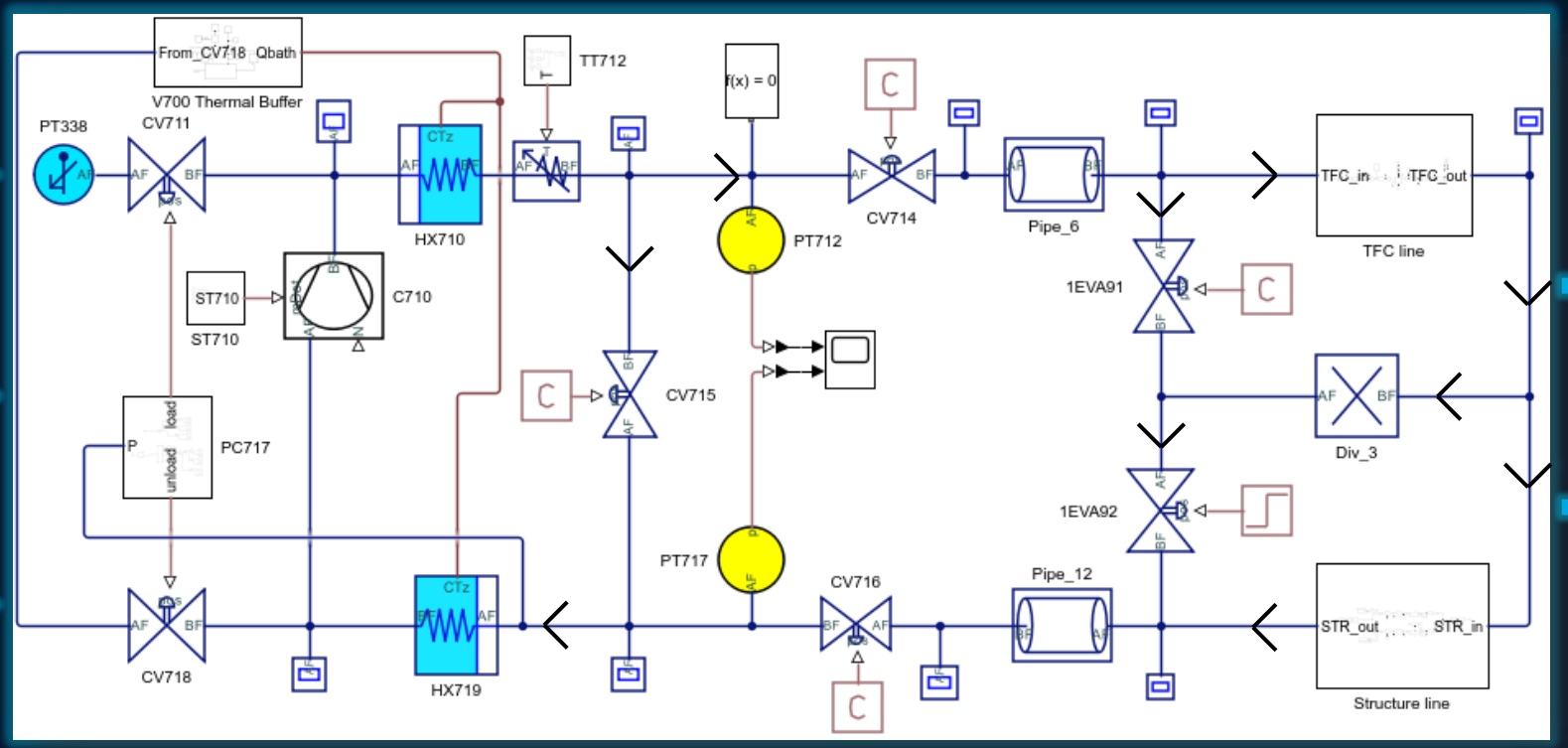
OK | Cancel | Help | Apply


VIEW
bench
Nettoyage
tablelookup
MoreElectricAircraft
Editor - C:\MATLAB\R2019b\toolbox\physmod\simscape\library\m\+foundation\+mechanical\+rotational\friction.ssc
friction.ssc
component friction < foundation.mechanical.rotational.branch
% Rotational Friction
parameters
brkwy_trq = { 25, 'N*m' }; % Breakaway friction torque
brkwy_vel = { 0.1, 'rad/s' }; % Breakaway friction velocity
Col_trq = { 20, 'N*m' }; % Coulomb friction torque
visc_coef = { 0.001, 'N*m*s/rad' }; % Viscous friction coefficient
end
parameters (Access=private)
static_scale = sqrt(2*exp(1))*(brkwy_trq-Col_trq); % Scale factor for static torque
static_thr = sqrt(2)*brkwy_vel; % Velocity threshold for static torque
Col_thr = brkwy_vel/10; % Velocity threshold for Coulomb torque
end
equations
% Parameter range checking
assert(brkwy_trq>0)
assert(brkwy_vel>0)
assert(Col_trq>0)
assert(Col_trq<=brkwy_trq)
assert(visc_coef>=0)
% Torque is a combination of viscous, static, and Coulomb losses
t == visc_coef * w ...
+ static_scale * (w/static_thr*exp(-(w/static_thr)^2)) ...
+ Col_trq * tanh(w/Col_thr);
end
end

CEA Cryogenic Model

Internal Variables

Inputs

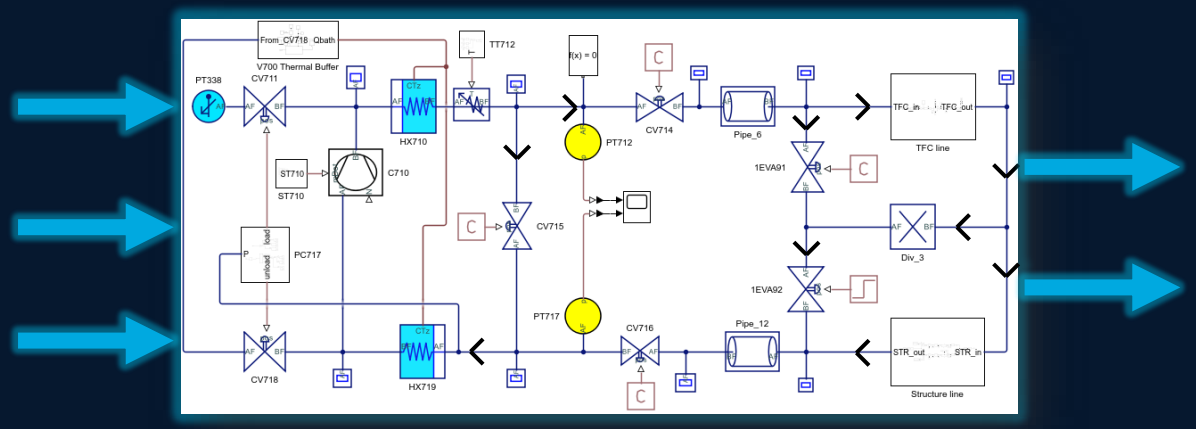


Outputs

Initial Conditions

Parameters

CEA Cryogenic Model



Architecture Studies

Conceptual Design

Parametric Studies

Optimization

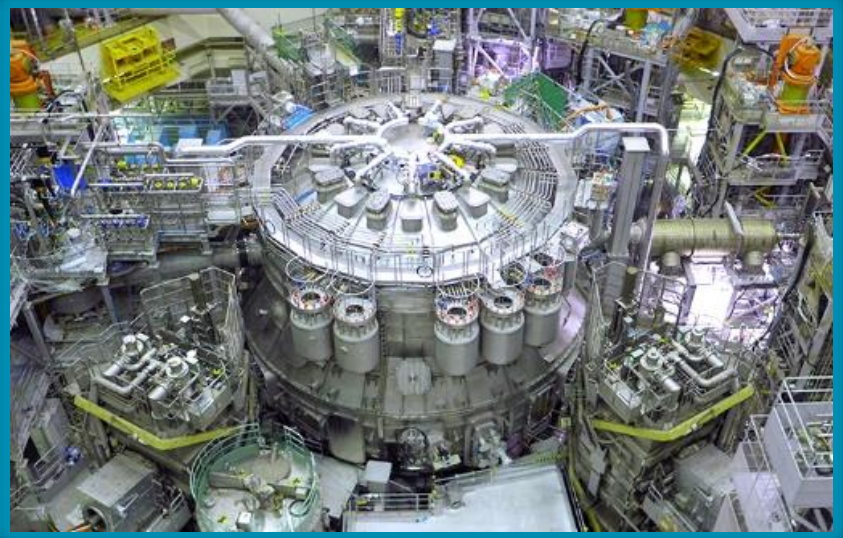
Linearization

Control Design

Functional Verification and Validation

DEVELOPMENT

Requirements | Functionality and Architecture | Design | Implementation | System Integration and Test

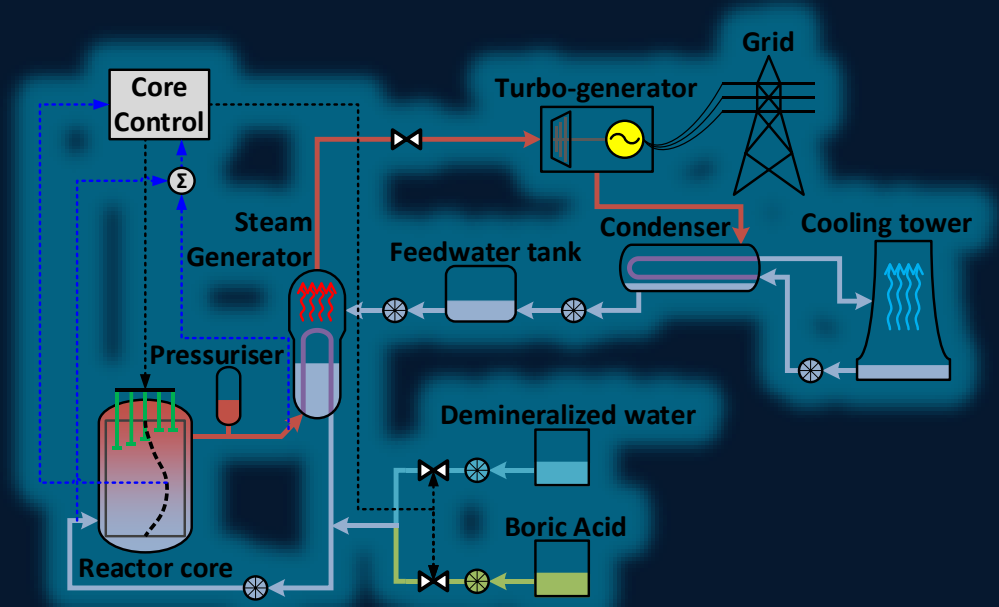


cea

TOKAMAK Cryogenic System

OPERATION

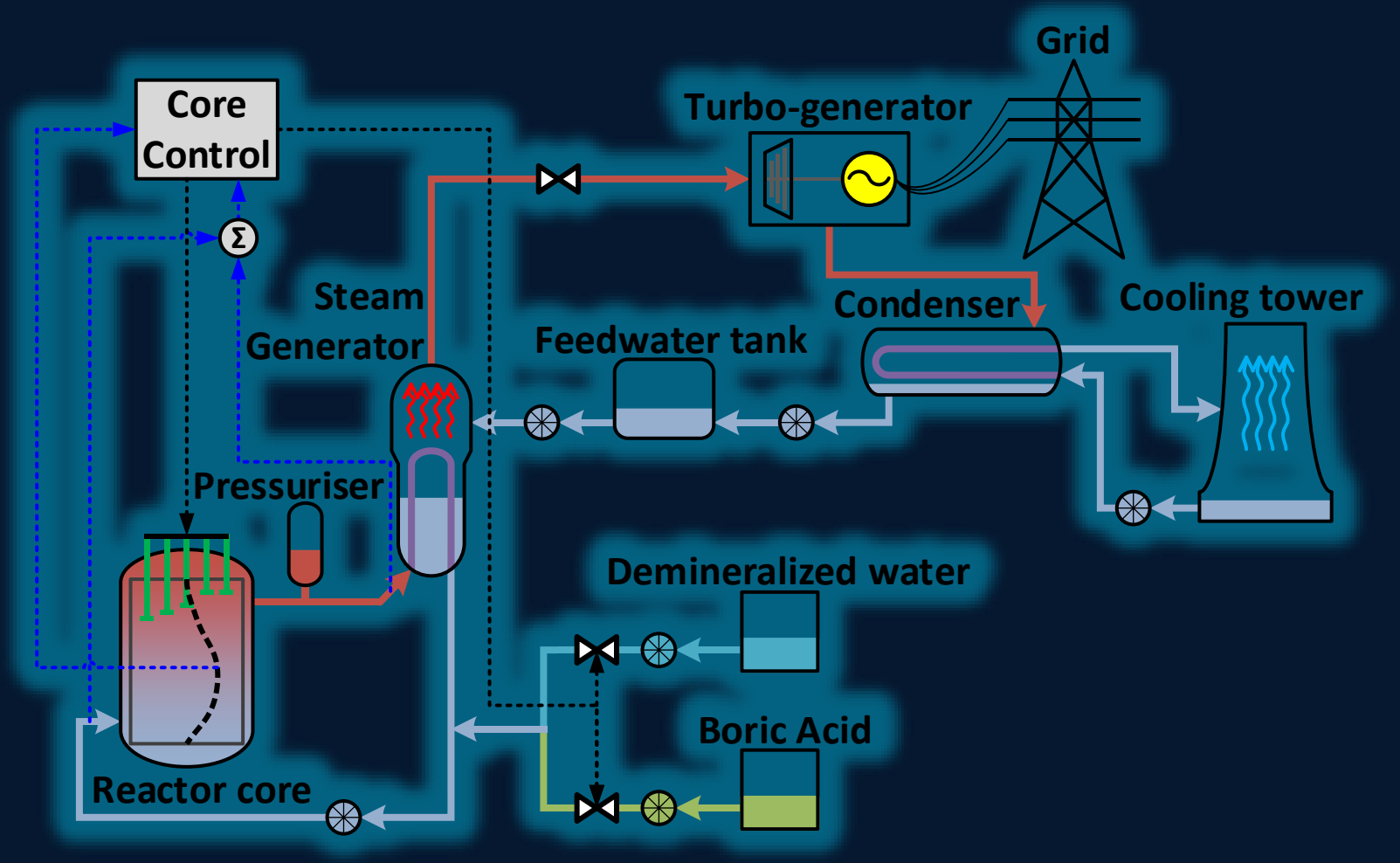
Deployment | Operation | Maintenance | Evolution



framatome

Operator Assistance Predictive System

L'OAPS : un système temps réel d'aide au pilotage de réacteur nucléaire



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Operator Assistance Tool

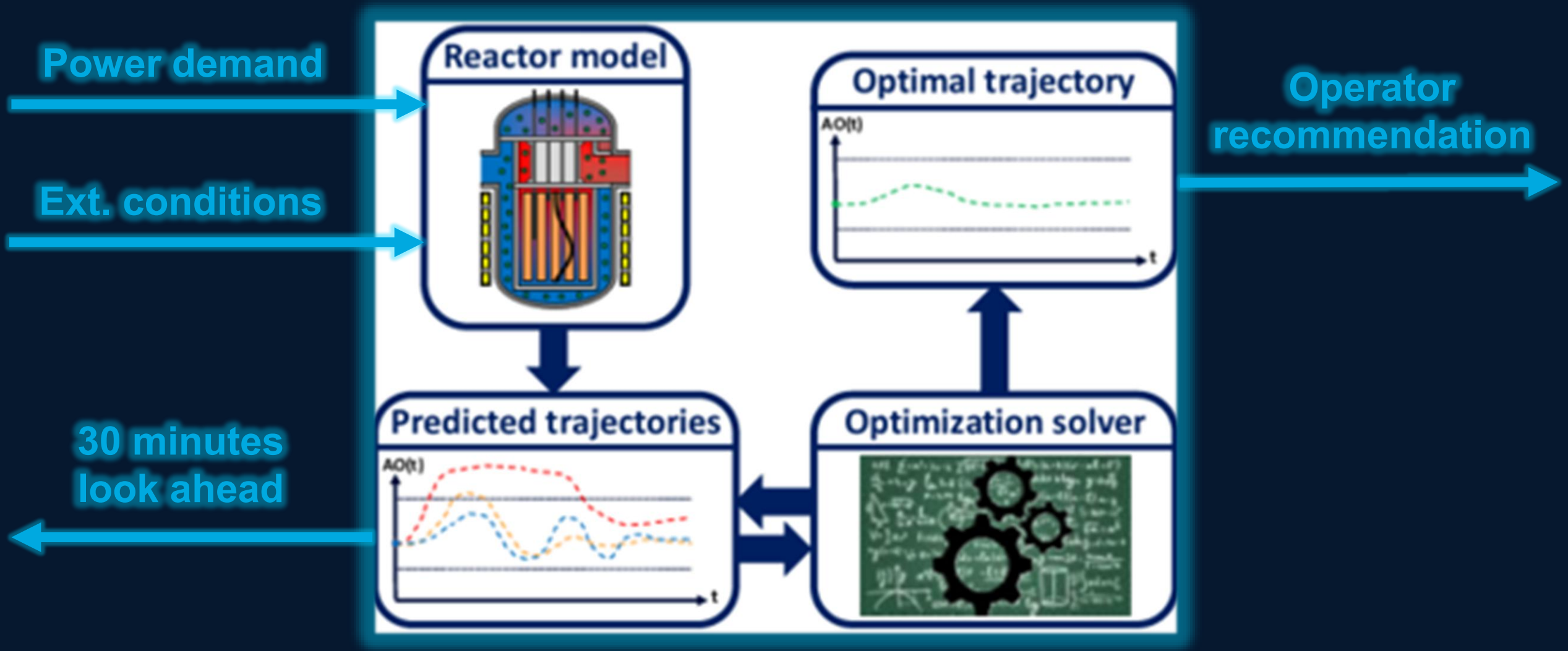
Turbine power

Xe and B concentrations

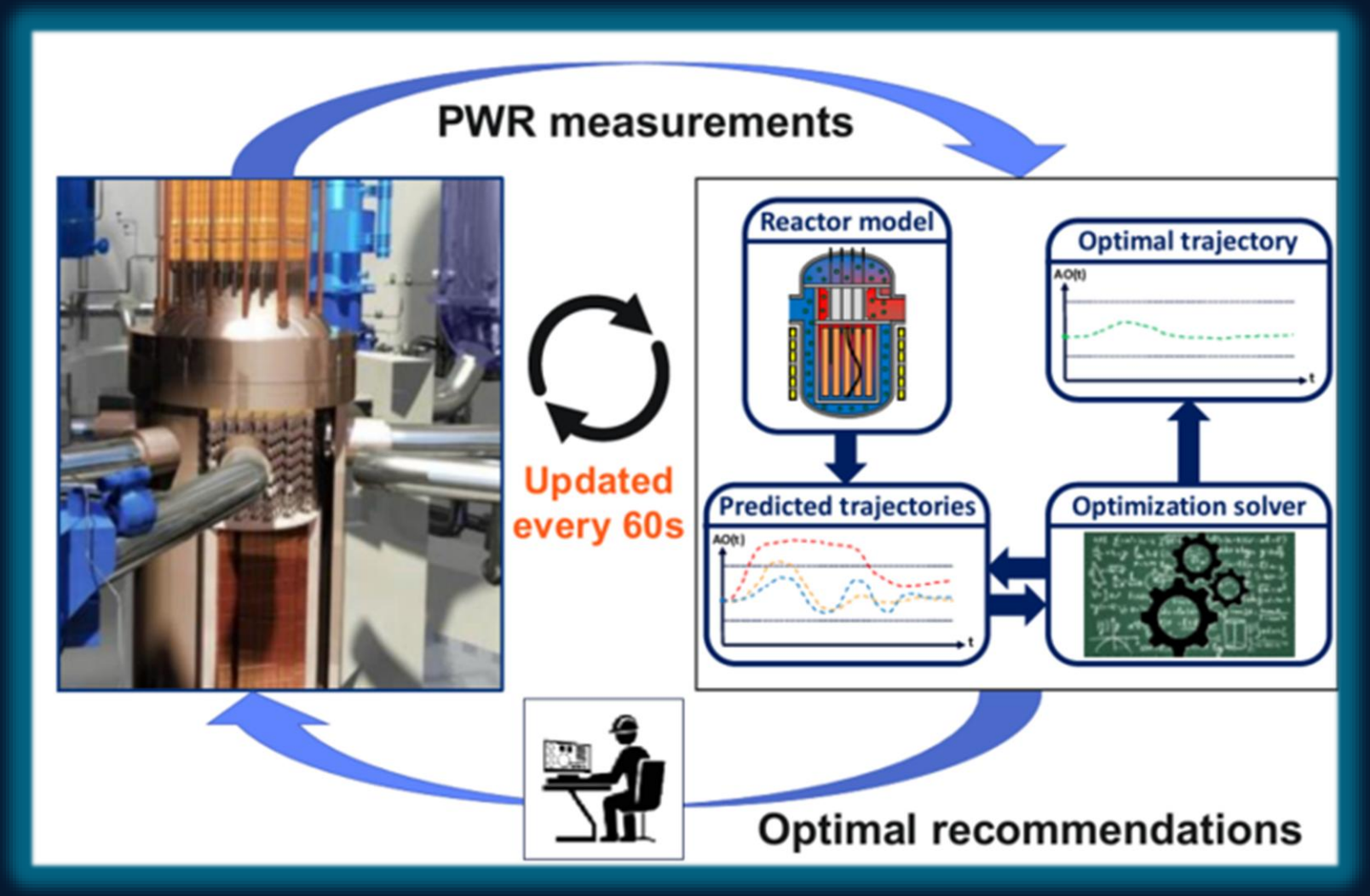
Axial-offset control

Temperature control

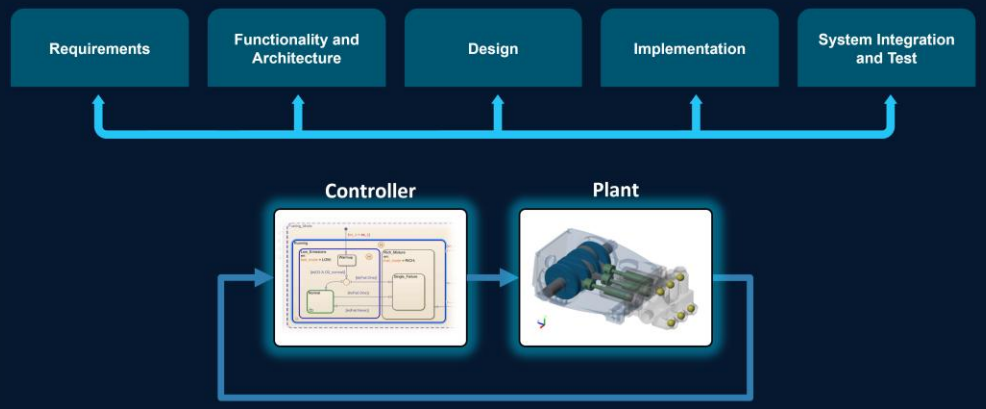
Predictive Nuclear Reactor Model



Predictive Nuclear Reactor Model



Model-Based Design in *theory*



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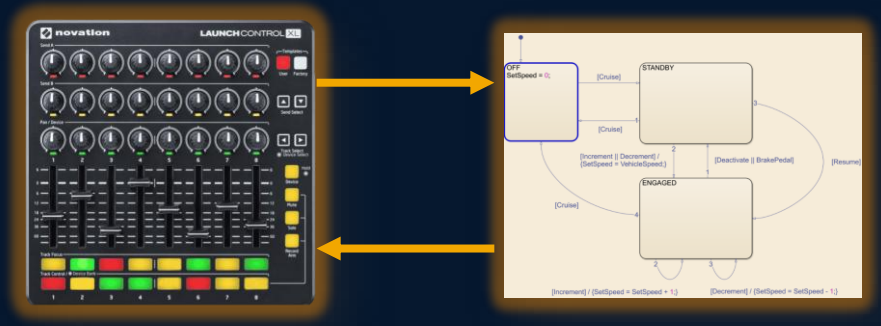
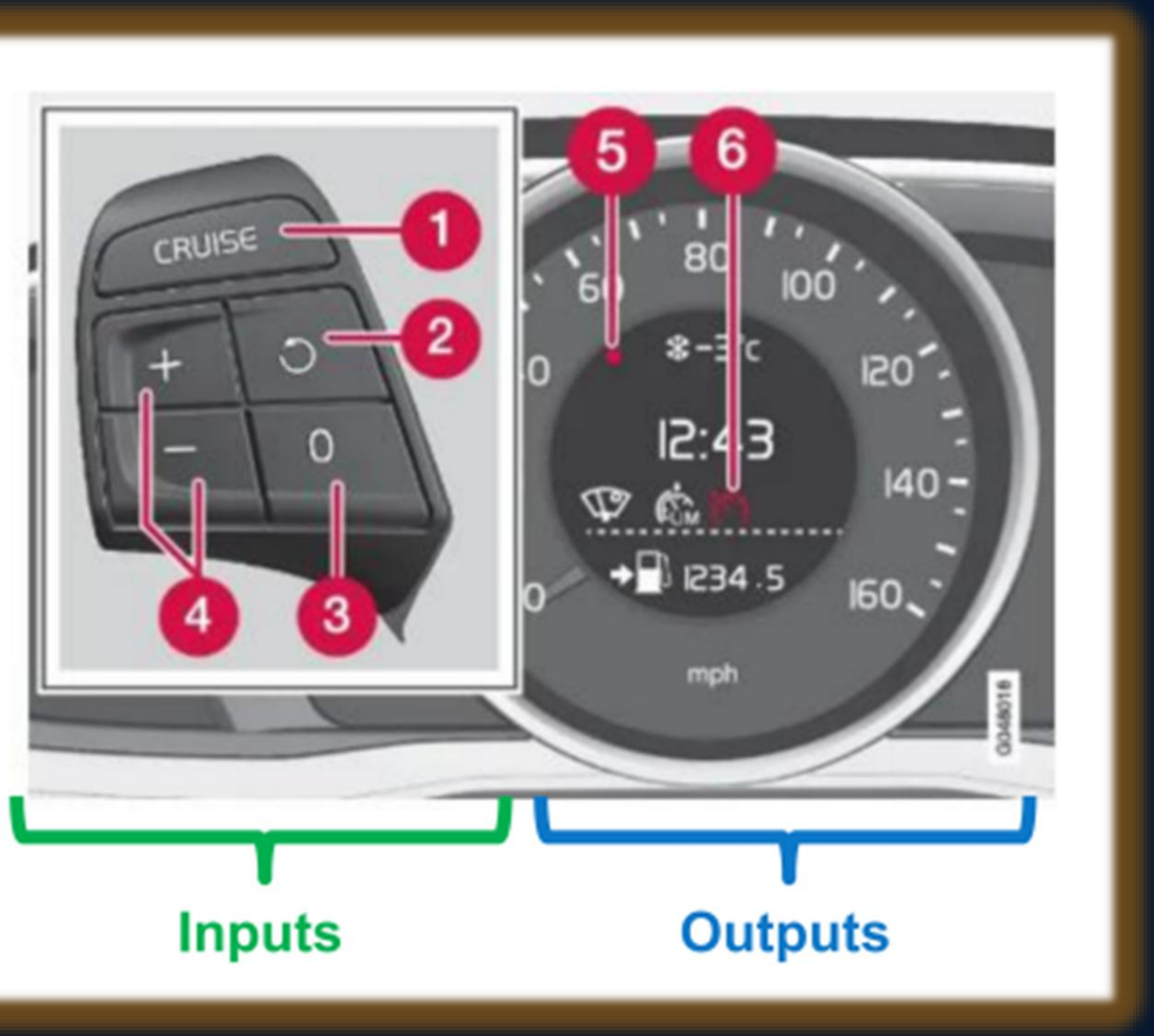
Model-Based Design in *practice*





Model-Based Design in ***practice***