



Equilibrium control

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G. De Tommasi^{1,2}

on behalf of the CREATE team and
IC commissioning group on Equilibrium Control

¹Consorzio CREATE

²Department of Electrical Engineering and Information Technology, University of Naples
Federico II, Italy



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Contents

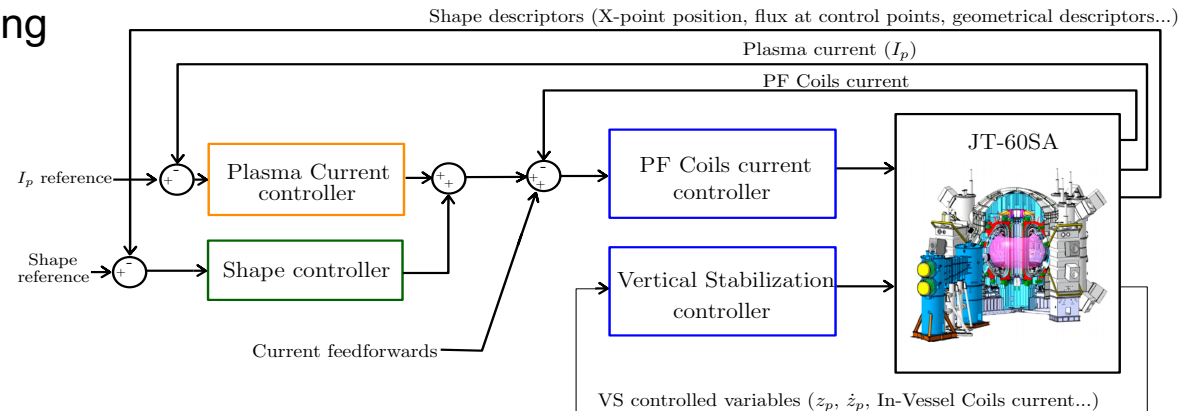


- Quick overview of the available tools
- Activities in support to IC
- 2022 activities

Tools for Plasma Magnetic Control Design & Validation

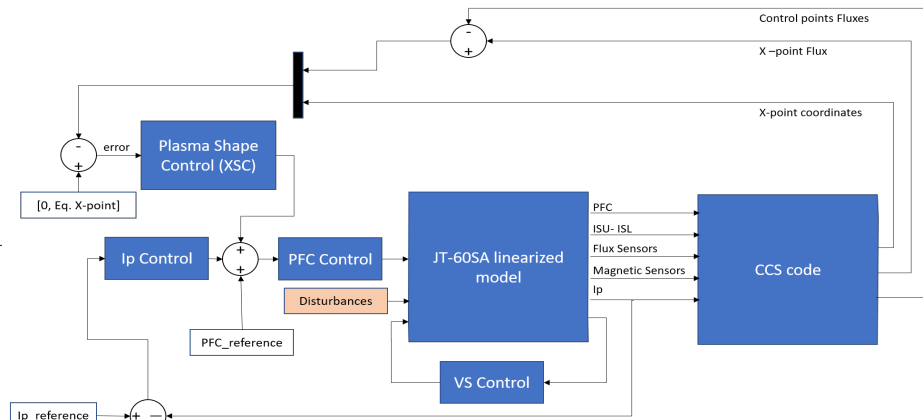
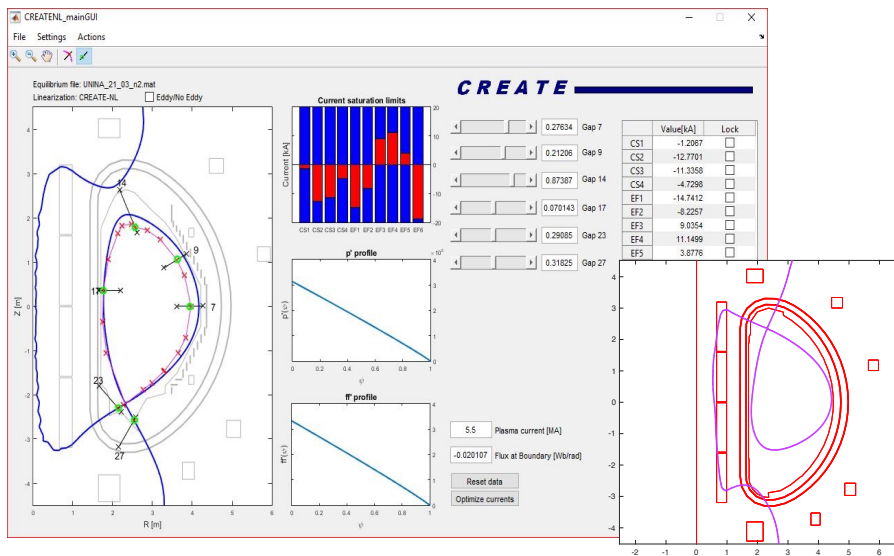


- A set of *control-oriented* tools has been developed in 2017-2018 (Matlab/Simulink environment)
- The tools have been used during FP8 to
 - Propose a possible architecture for plasma magnetic control at JT-60SA
 - Assess the performance of the magnetic control system
 - benchmark QST preliminary results
 - propose possible alternative approaches to plasma shape control
 - assess feasibility of ELM pacing with vertical kicks
- Perform code benchmarking





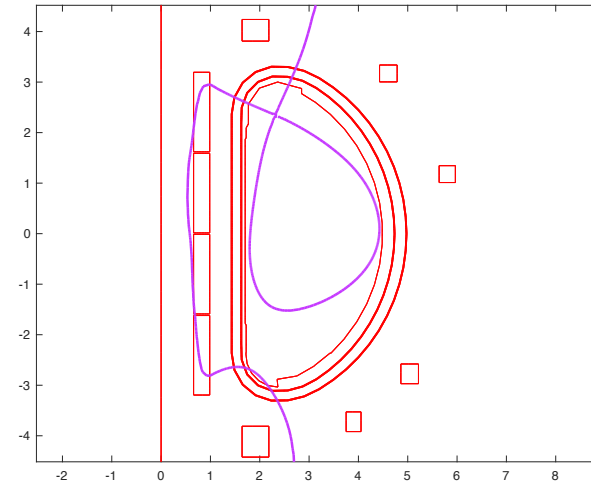
- 2D control-oriented modelling tools (CREATE-L and CREATE-NL) → capability to generate linear models for a generic equilibrium
- Customized Simulink library to easily build-up control-oriented simulation schemes that make use of the linear model
- The same tools have been also coupled with the QST CCS (plasma boundary reconstruction) and FBC (Flux-boundary control) codes





The main support action to IC **would have been (still is)** the onsite participation to the commissioning of the plasma (magnetic) equilibrium control system (D. Abate (RFX) + M. Bonotto (RFX) + support from CREATE team)

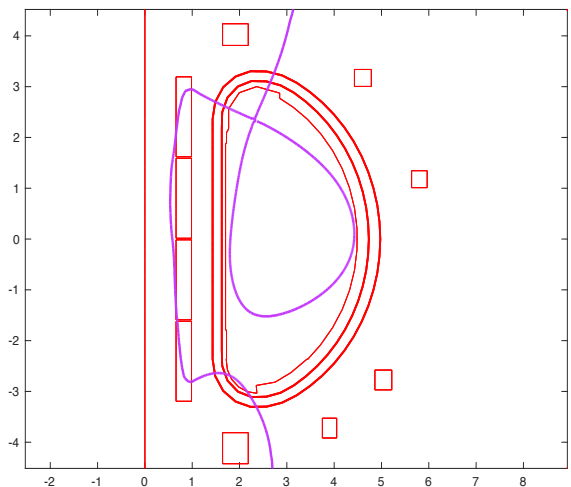
- **Open-loop plasmaless model validation → DONE (presentation by L. Pigatto)**
- **Preliminary assessment of overall stabilization capabilities in absence of internal coils for the IC upper-single-null configuration**





Different plasma equilibria have been generated to account for different possible β_p and I_i values

I_i	β_p	Elongation	Growth Rate [1/s]
0.84	0.82	1.45	Stable
1.25	0.70	1.45	Stable
0.78	0.15	1.46	0.36



- The first assessment aimed at verifying the controllability **without the FPCC coils**
- A MIMO controller for the current in CS/EF coils has been designed and tested on all the equilibria (by including a model of the CS/EF power supply)
- The controller guarantees a stable closed-loop behaviour for all the considered cases
- Since the plasma shape control approaches envisaged for JT-60SA rely on an inner PFC control loop this preliminary result suggested that plasma position and shape control should be feasible also in absence of in-vessel coils



1. **Add the capability to generate equilibria starting from experimental data in CREATE EGENE**
2. **Once experimental data will be available → open and closed-loop plasma linear model validation**
3. **Training with QST tools → mainly MECS to be possibly used in to validate control strategies**



1. **Model agnostic approach for vertical stabilization based on Extremum Seeking**
2. **Data-driven control techniques for plasma magnetic control**