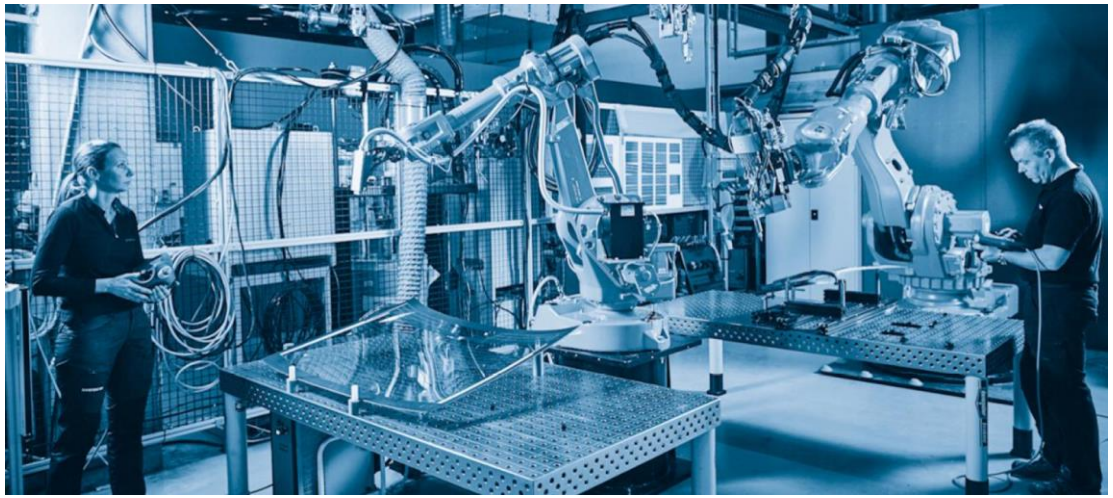
Development of actuators, sensors and intelligent control systems for sustainable forming processes

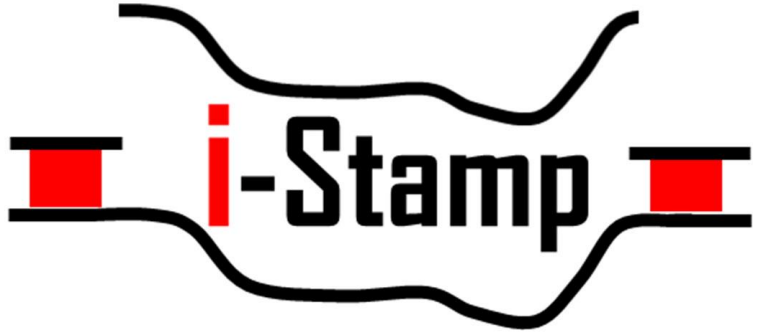
RISE - Component Manufacturing

Forming Technology (Olofström)



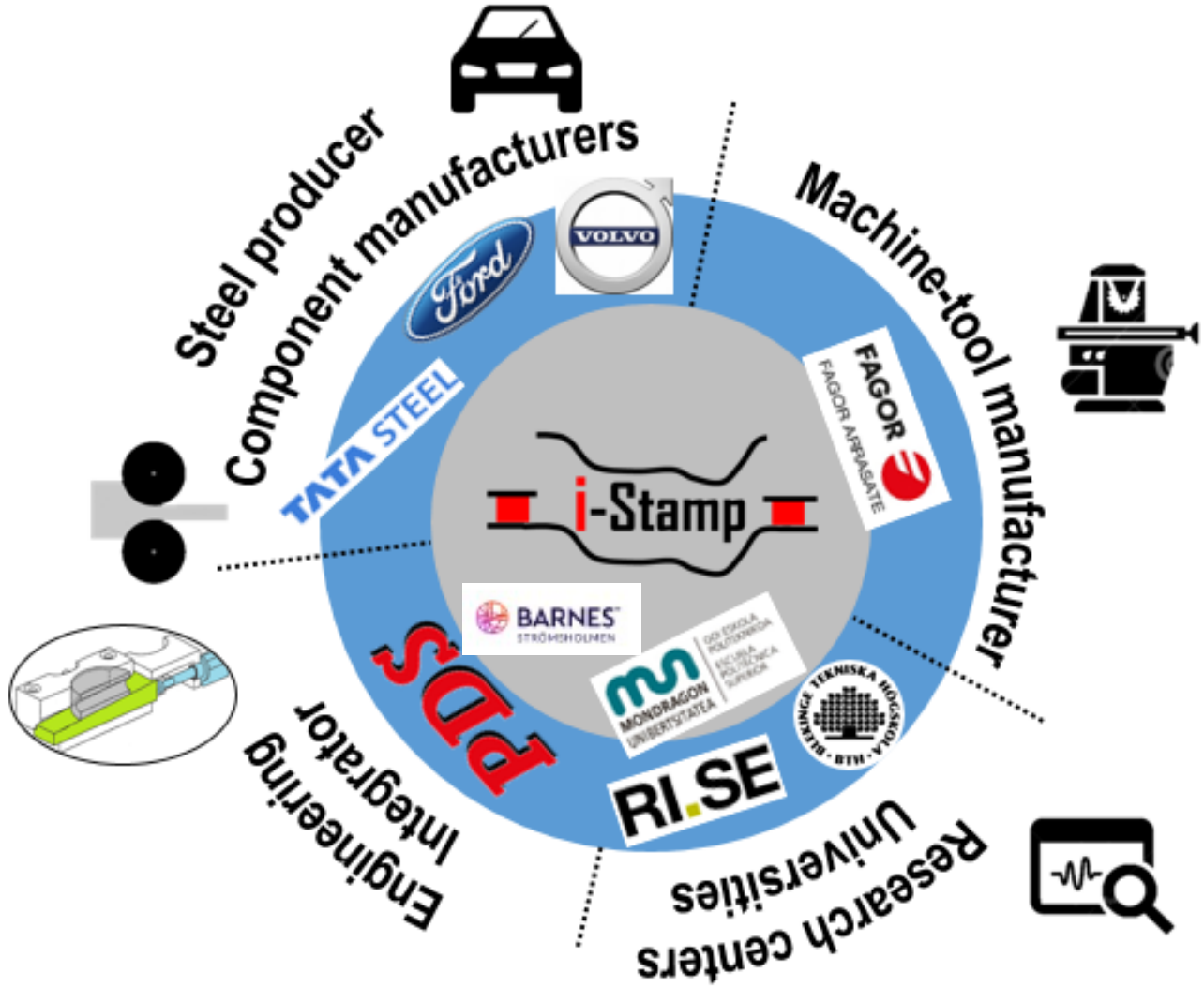
Mechanical Joining Technology (Mölndal)

I-Stamp

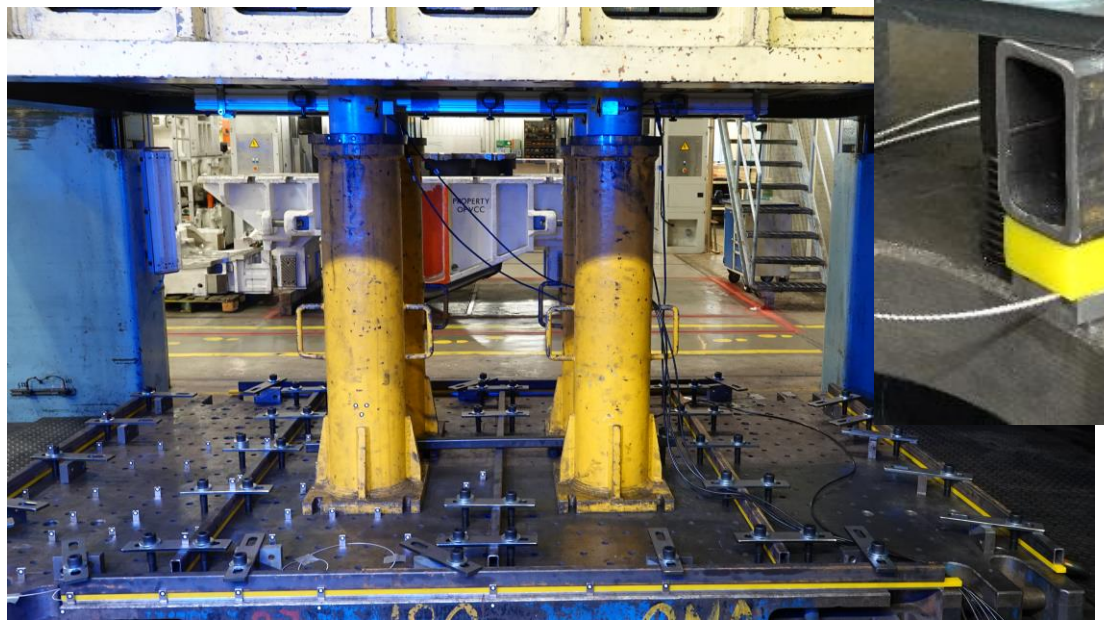


- Scope and objective: Intelligent and sustainable stamping processes using hybrid control strategies. I-Stamp will develop new hybrid control systems, i.e. initially they are run using meta-models, reduced form FEM simulations, and later calibrated with real industrial data.
- Funding: Smart Eureka Advanced Manufacturing / Vinnova
- Total budget 1136 k€ (Sweden 5,9 MSEK)
- Project duration 2022-01-01 - 2024-06-30

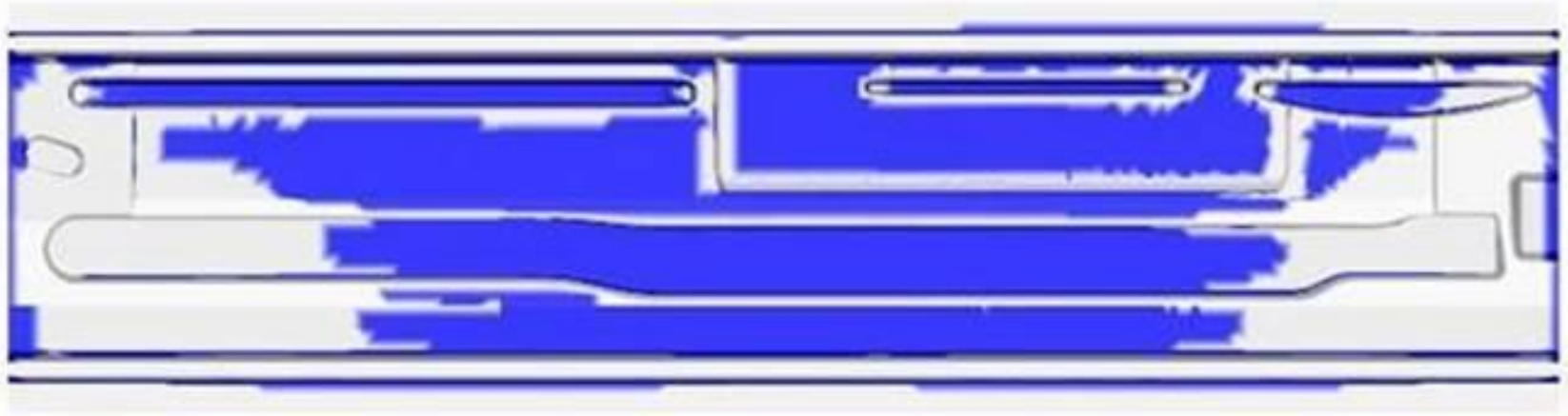
Partners

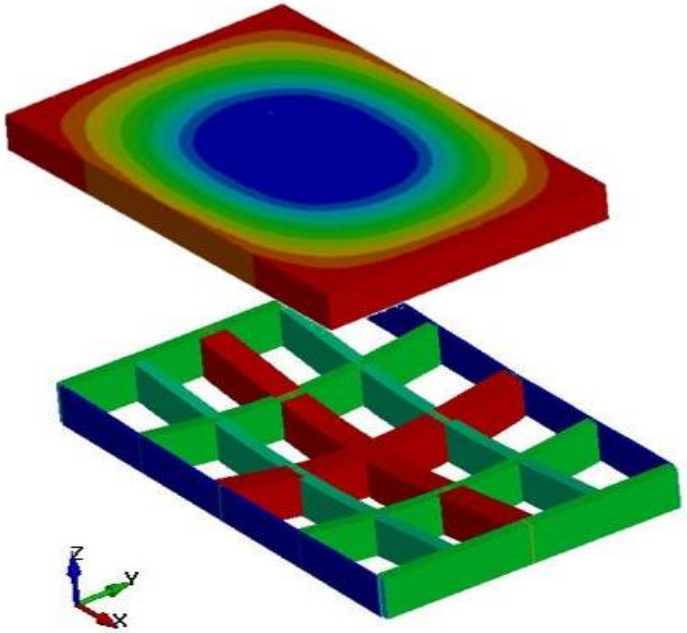

Steel producer
Component manufacturers
Machine-tool manufacturer
Engineering integrator
Research centers Universities
TATA STEEL
Ford
VOLVO
FAGOR
FAGOR ARRASATE
i-Stamp
BARNES
STRÖMSHOLMEN
MONDRAGON UNIBERTSITATEA
BTH
RI.SE
PDS

Measuring press deflections

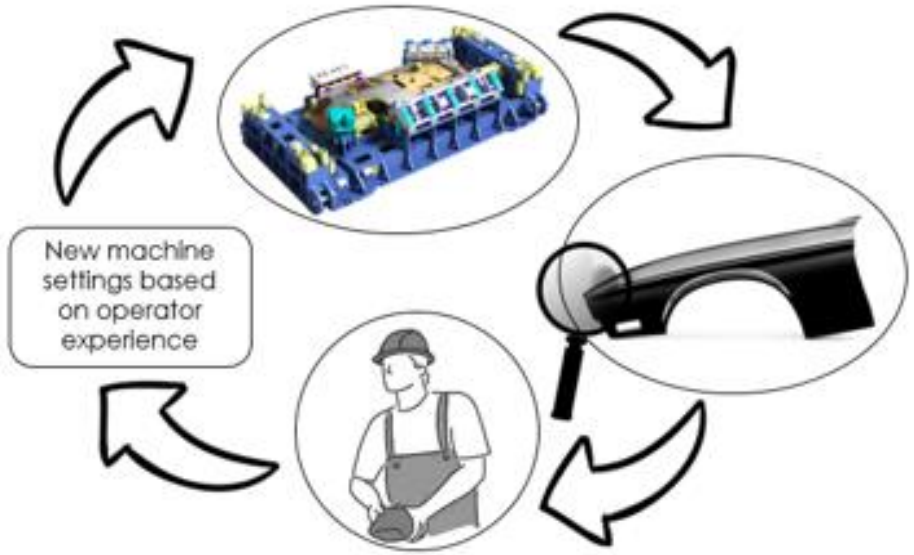


Comparison of spotting between physical part and corresponding numerical evaluation

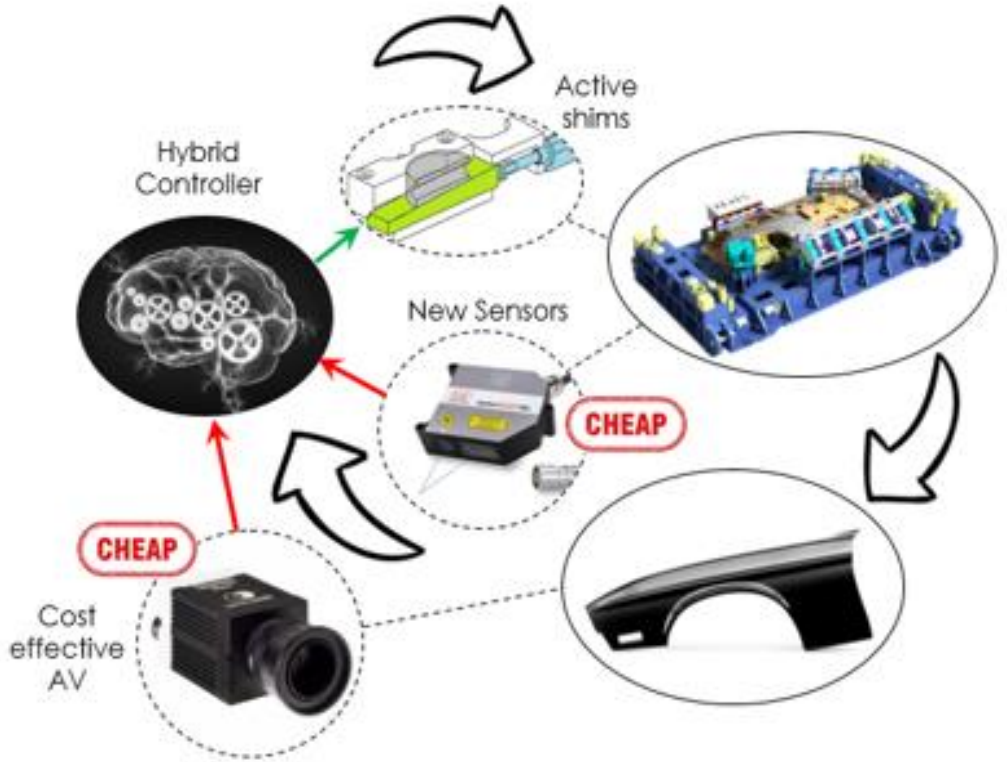




I-Stamp project approach

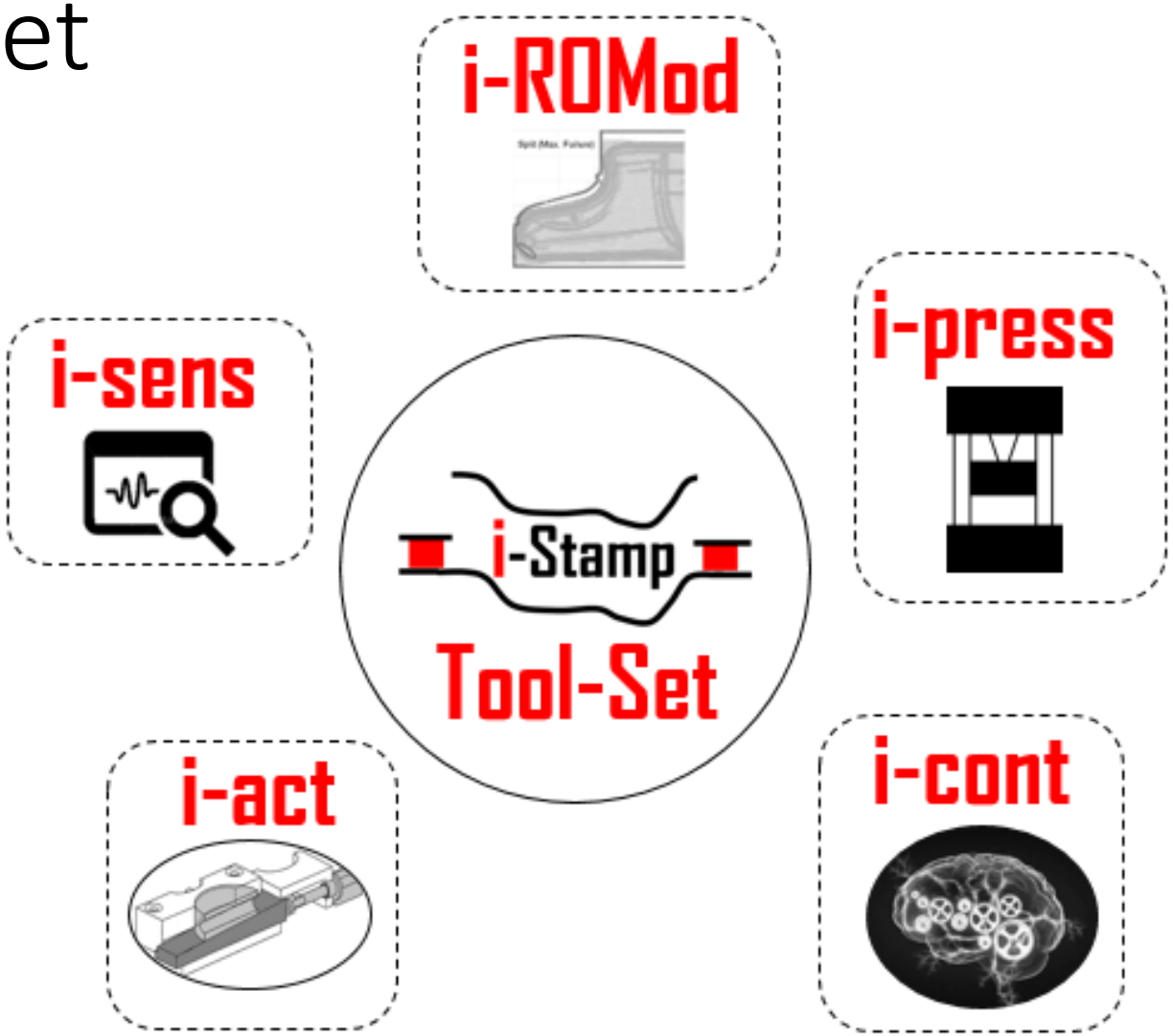


a)



b)

I-Stamp tool-set

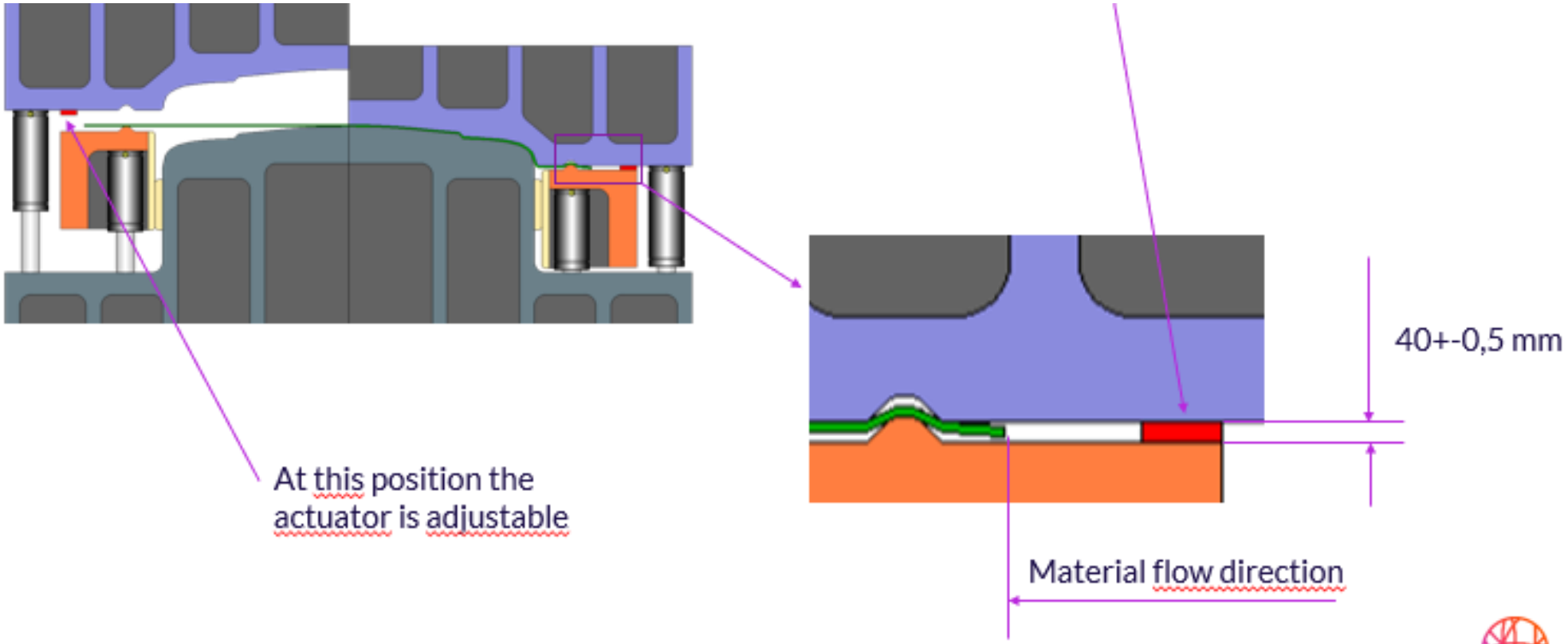


I-Sens

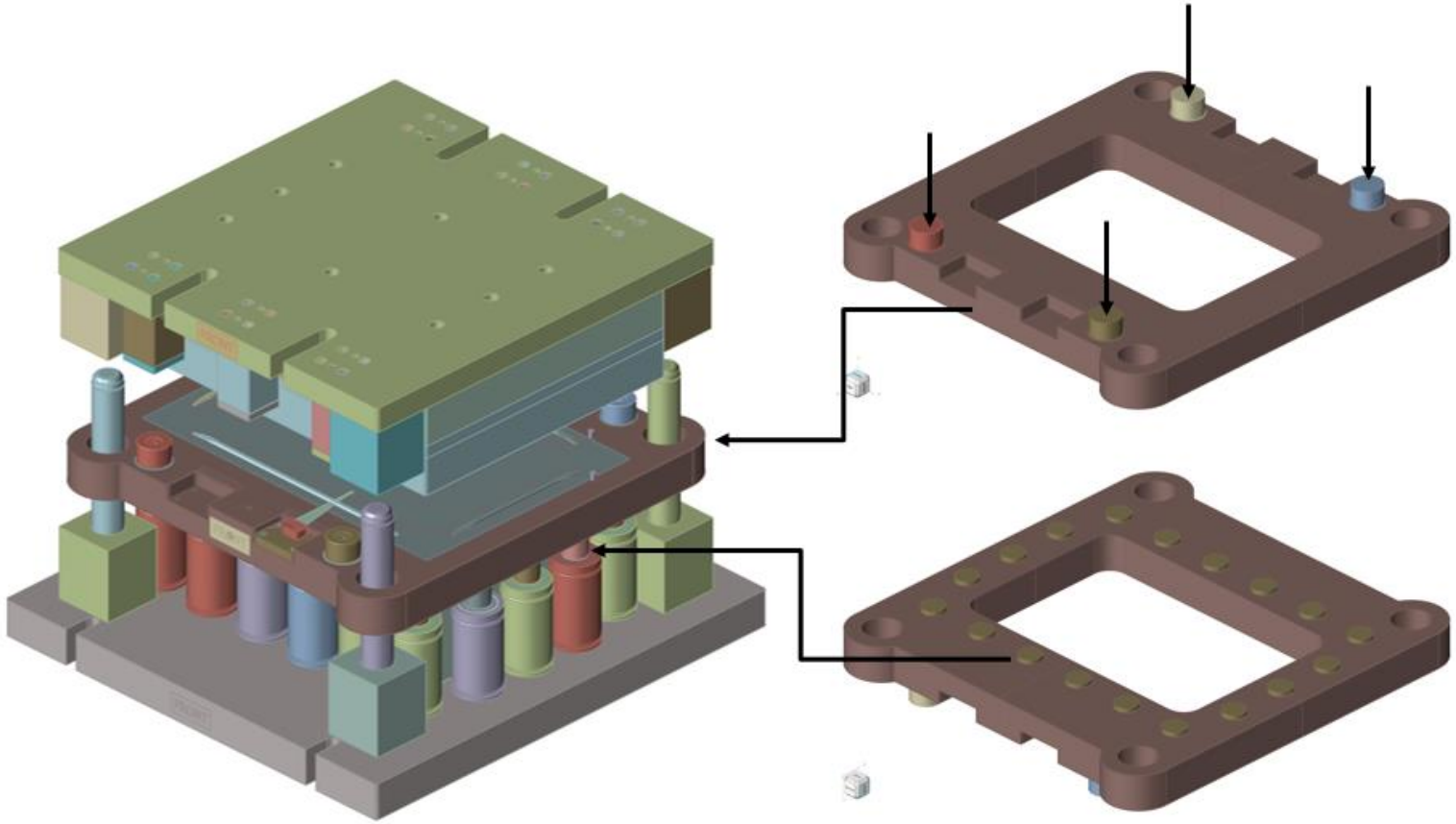
	A	B	C	D	E
Bild					
Tillverkare	Micro-Epsilon	Micro-Epsilon	Banner Engineering	Banner Engineering	Omron
Modell	optoNCDT 1320-100	optoNCDT 1420-200	LM250	LE150	ZX1-LD300
Mätområde	100	200	300	100	300
Start	50	60	100	50	150
Focus	100	160	250	100	300
End	150	260	400	150	450
Output 1	4-20 mA	4-20 mA	4-20 mA	4-20 mA	4-20 mA
Output 2	-	0-5 V	-	-	-
Upplösning	-	-	100-250 mm: 0,02 mm 250-400 mm: 0,2 mm	0,004 mm	0,03 mm
Repeterbarhet	0,01 mm	0,008 mm	100-250 mm: 0,05 mm 250-400 mm: 0,3 mm	0,002 mm	-
Linjäritet (+/-)	0,1 mm (0,1% FS)	0,16 mm (0,08% FS)	100-250 mm: 0,4 mm 250-400 mm: 0,9 mm	0,07 mm	0,6 mm (0,2% FS)
Mäthastighet	1 ms	1 ms	1 ms	0,25 - 4 ms	1 - 100 ms
Ljuspunkt (start)	1,1 x 0,75 mm	1,1 x 0,75 mm	3,2 x 2,2 mm	2,12 x 0,68 mm	-
Ljuspunkt (center)	1,1 x 0,75 mm	1,1 x 0,75 mm	2,1 x 1,5 mm	1,44 x 0,49 mm	Ø0,52 mm
Ljuspunkt (end)	1,1 x 0,75 mm	1,1 x 0,75 mm	1,2 x 0,9 mm	0,77 x 0,31 mm	-
Matningsspänning	11 - 30 VDC	11 - 30 VDC	12 - 30 VDC	10 - 30 VDC	10 - 30 VDC

I-Sens

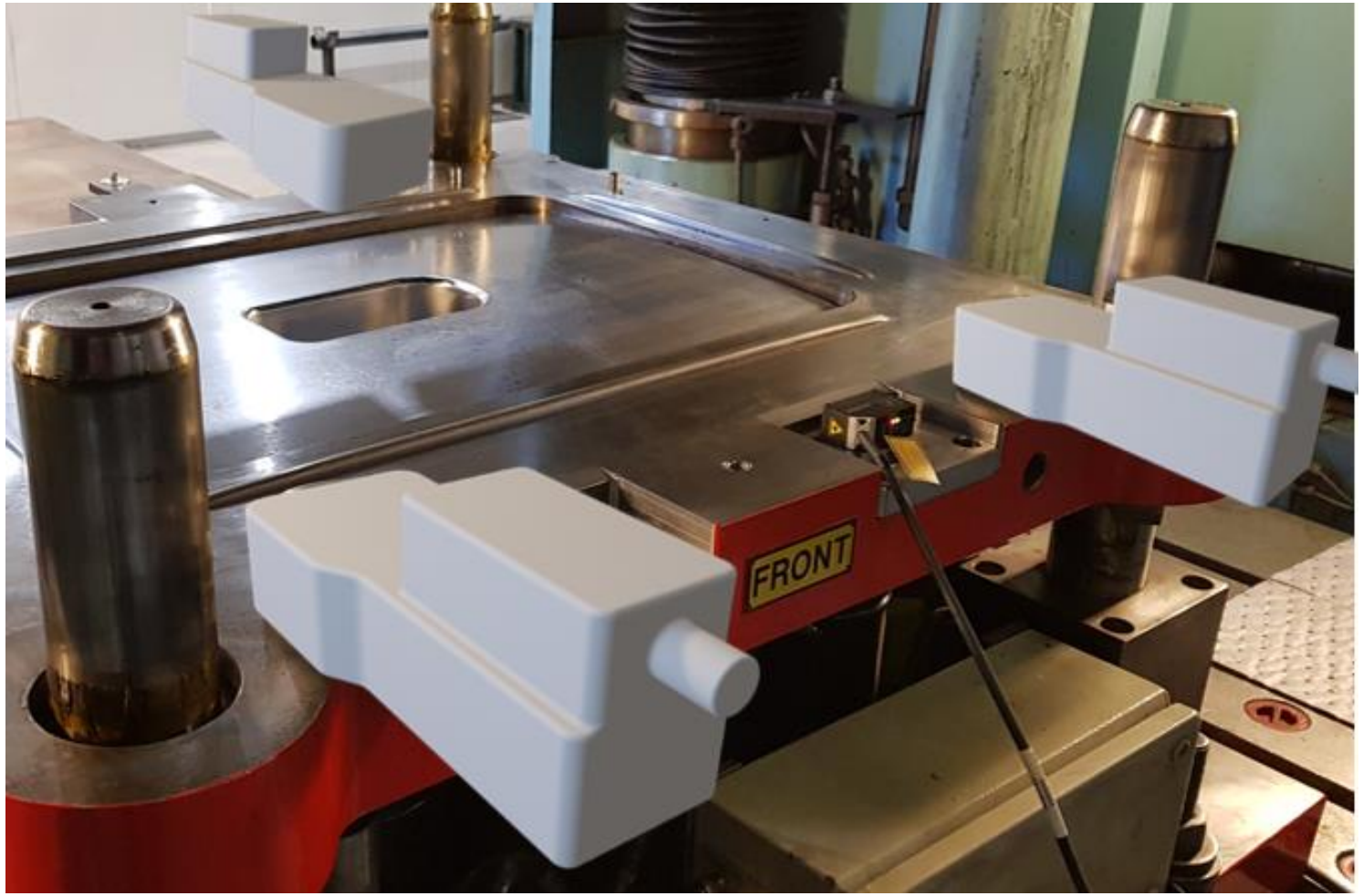
Actuator – active shims



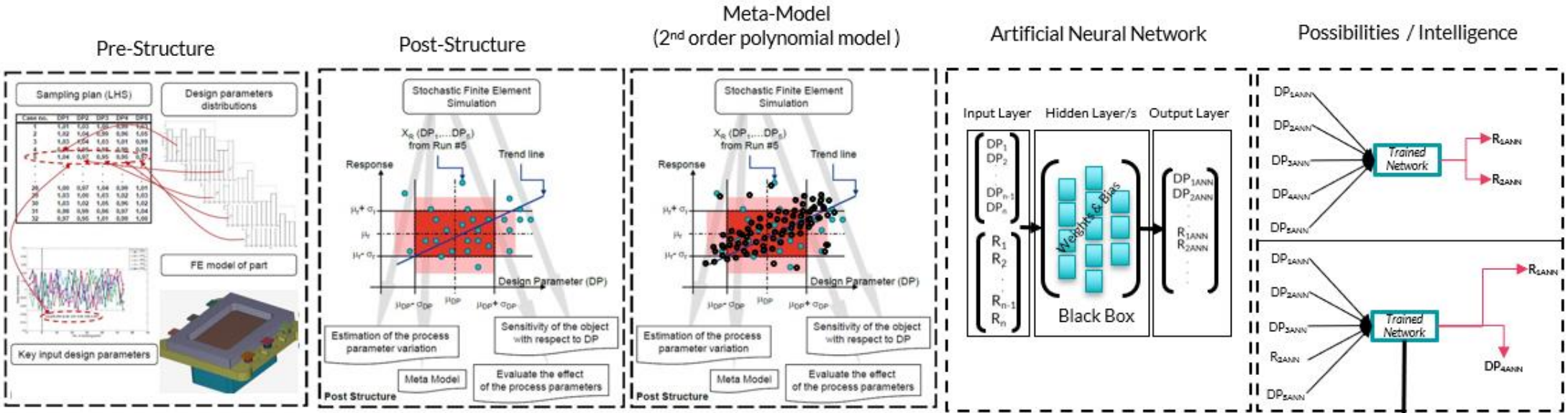
Tool set-up in the laboratory



Tool set-up in the laboratory



The process of developing an intelligent control system



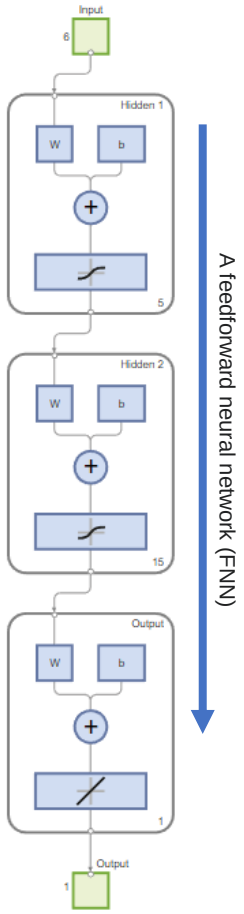
The total number of trials (N_c) needed for exhaustively searching the parameter combination space is

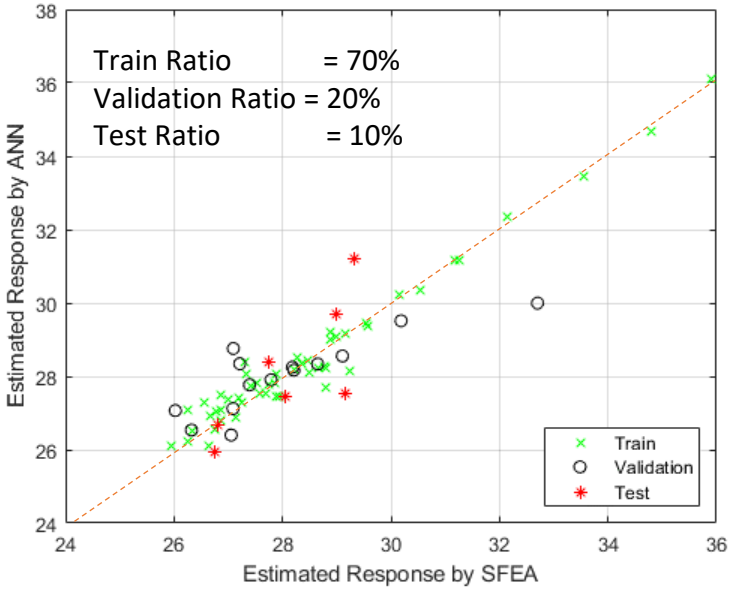
$$N_c = \frac{N!}{K!\,(N-K)!}$$

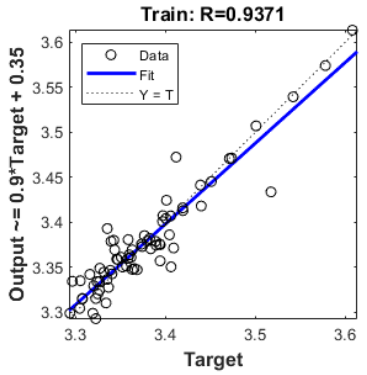
where N is the number of design parameters taken K at a time. For instance, the case of N=5 and K=3, N_c is equal to 10

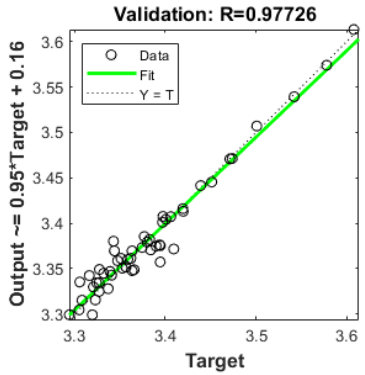
RISE – Research Institutes of Sweden

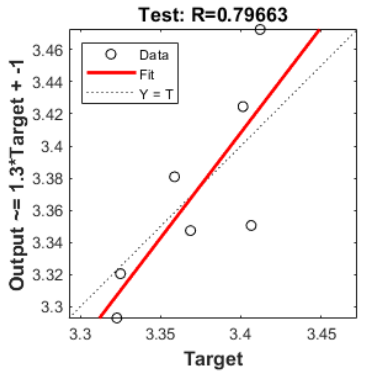
ISTAMP ANN-based application











Performance of the ANN Network

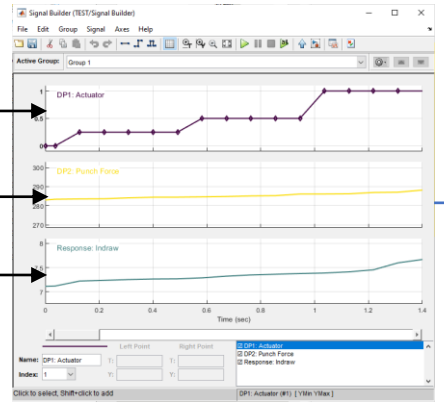
The target model predicts approximately
+/- MSE [%] of Response value

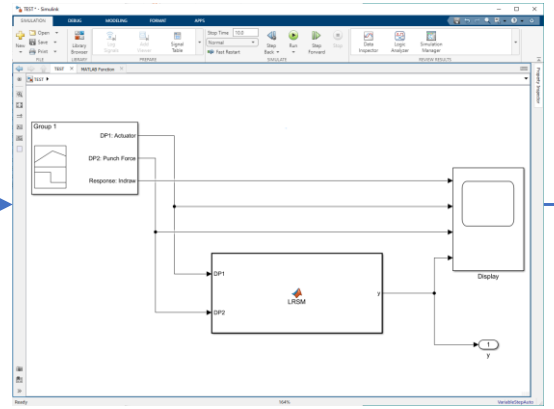
RMSE Train (true) < 1.08%
RMSE Validation (true) < 0.99%
RMSE Test(true) < 0.04%

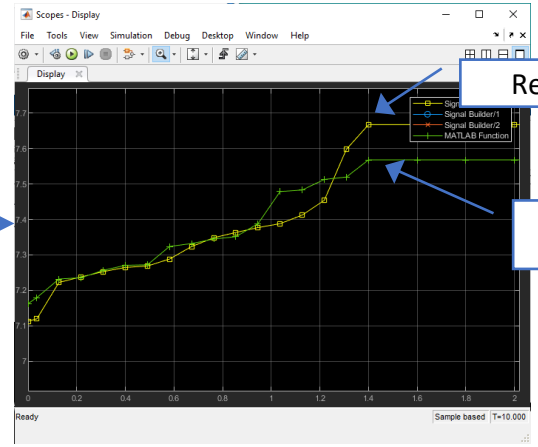
MSE: Mean Squared Error

Data transition between MATLAB & PLC

Design Parameters & Responsens







Response

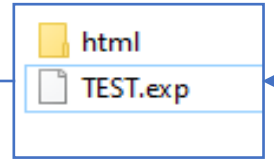
RSM function

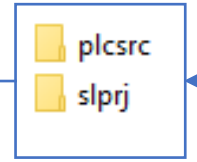
```
function y = LRSM01(DP1,DP2)

%% '1 = linear' – Constant and linear terms (the default)
 A =[-5.1182 0.1803 0.0434 0 0 0];
%% '2 = interaction' – Constant, linear, and interaction terms
%  A =[-6.1151 -11.5619 0.0470 0.0408 0 0];
%% '3 = quadratic' – Constant, linear, interaction, and squared terms
% A =[-247.3913 -38.7169 1.7800 0.1382 -0.5706 -0.0031];
%% '4 = purequadratic' – Constant, linear, and squared terms
%  A =[391.8743 0.1245 -2.7804 0 -0.0852 0.0050];
%% RSM equation
y = A(1) + A(2)*DP1 + A(3)*DP2 + A(4)*DP1*DP2 + A(5)*DP1^2 + A(6)*DP2^2;
end
```

```
(*
 *
 * File: TEST.exp
 *
 * IEC 61131-3 Structured Text (ST) code generated for subsystem "TEST/MATLAB Function"
 *
 * Model name                    : TEST
 * Model version                 : 1.29
 * Model creator                 : raminmo
 * Model last modified by        : raminmo
 * Model last modified on        : Wed May 10 11:16:17 2023
 * Model sample time             : 0s
 * Subsystem name                : TEST/MATLAB Function
 * Subsystem sample time         : 0.2s
 * Simulink PLC Coder version    : 3.4 (R2021a) 14-Nov-2020
 * ST code generated on          : Thu May 11 09:01:53 2023
 *
 * Target IDE selection          : 3S CoDeSys 2.3
 * Test Bench included           : No
 *
 *)
FUNCTION_BLOCK MATLAB0
VAR_INPUT
    DP1: LREAL;
    DP2: LREAL;
END_VAR
VAR_OUTPUT
    y: LREAL;
END_VAR
(* Outport: '<Root>/y' incorporates:
 *  MATLAB Function: '<Root>/MATLAB Function' *)
(* '1 = linear' – Constant and linear terms (the default) *)
(* MATLAB Function 'MATLAB Function': '<S1>:1' *)
(* '<S1>:1:4' A =[-5.1182 0.1803 0.0434 0 0 0]; *)
(* '2 = interaction' – Constant, linear, and interaction terms *)
(* A =[-6.1151 -11.5619 0.0470 0.0408 0 0]; *)
(* '3 = quadratic' – Constant, linear, interaction, and squared terms  *)
(* A =[-247.3913 -38.7169 1.7800 0.1382 -0.5706 -0.0031]; *)
(* '4 = purequadratic' – Constant, linear, and squared terms *)
(* A =[391.8743 0.1245 -2.7804 0 -0.0852 0.0050]; *)
(* RSM equation *)
(* '<S1>:1:12' y = A(1) + A(2)*DP1 + A(3)*DP2 + A(4)*DP1*DP2 + A(5)*DP1^2 + A(6)*DP2^2; *)
y := ((0.1803 * DP1) + -5.1182) + (0.0434 * DP2);
END_FUNCTION_BLOCK
```

Simulink PLC Coder™

Generates hardware-independent IEC 61131-3 Structured Text and Ladder Diagrams from Simulink® models, Stateflow® charts, and MATLAB® functions.





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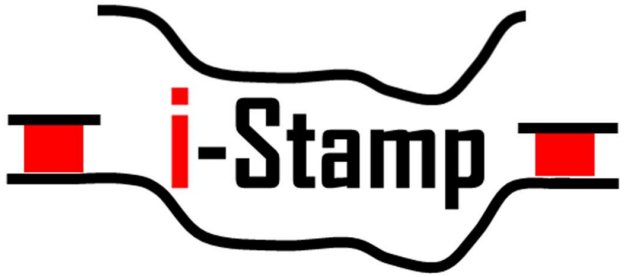
Manufacturing R&D Clusters

Further implementations



- Establish seamless interaction between ISTAMP Application with the existing Control System
  - Control av Input & Output
  - PLC Source code
  - Implementation of Correction
- Increase the quantity of data points based on SFEA to improve Predictor and Corrector replies.
- Validation, validation and validation
- Publication
- Develop hybrid control systems, i.e. calibrate control systems with real industrial data