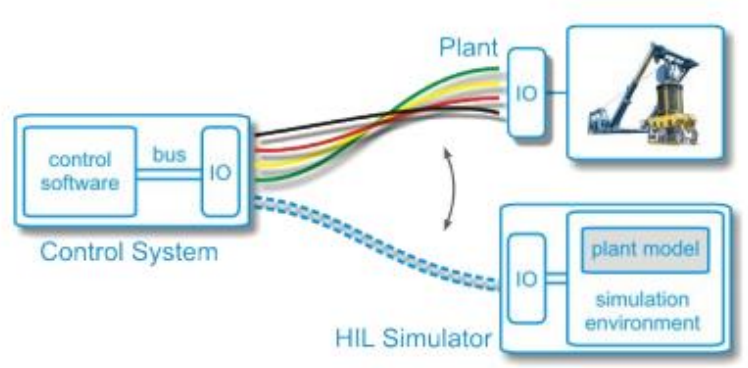
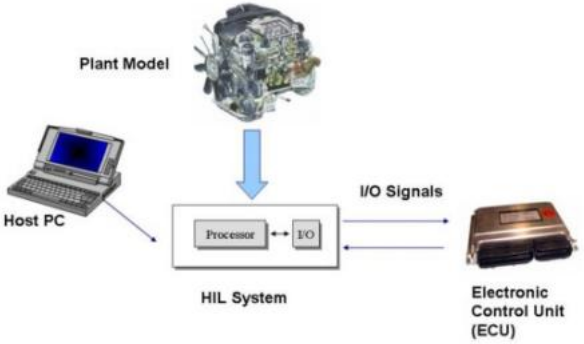
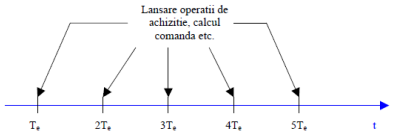
C11: Hardware in the Loop - HIL

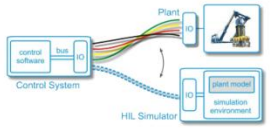
Cuprins:







C11: HIL

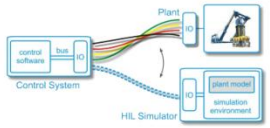


1. Introducere

- **C10 – Tendinte - 6. Alte directii**
  - IoT
  - Industry 4.0
  - **HIL – HWIL – hardware in the loop**
  - **SIL – software in the loop**
  - HITL – human in the loop

…

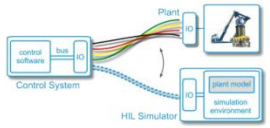
C11: HIL



1. Introducere

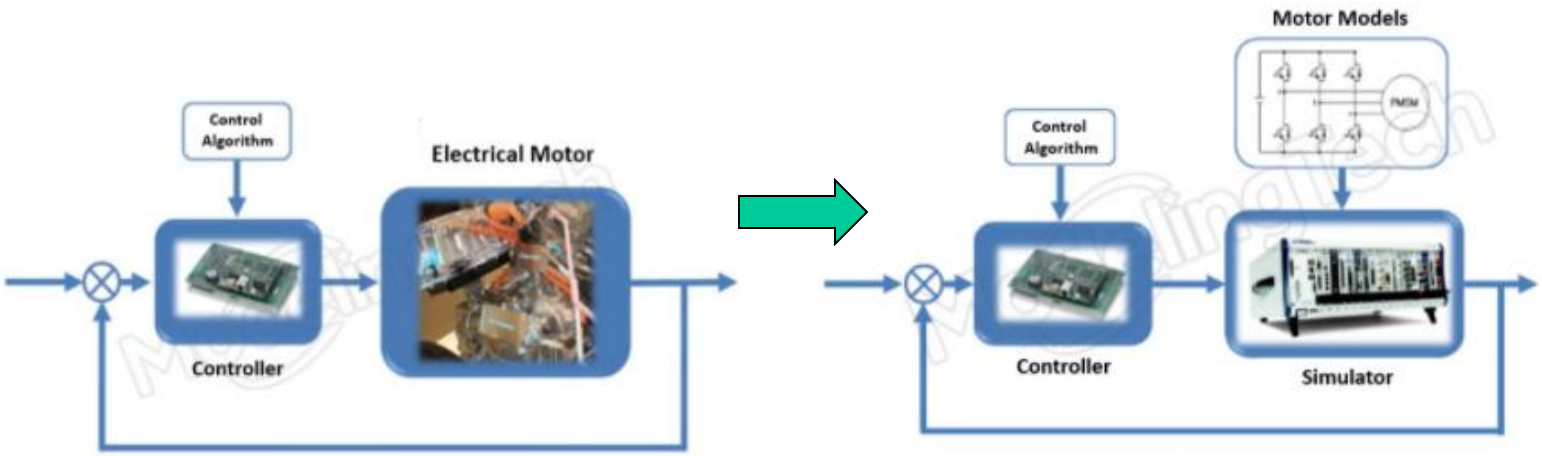
- Sistemele Hardware-in-the-Loop există de cel mult 15-20 de ani.
- “Rădăcinile” sale se găsesc în industria aeronautica.
- HIL devine prezent în toate industriile, in special, datorita scurtarii timpul până la introducerea pe piață și a complexitatii foarte mari.

C11: HIL



1. Introducere

- Hardware-in-the-loop (HIL) este o tehnică utilizată pentru dezvoltarea și testarea sistemelor de control / elemente conexe ale unor componente, mașini și sisteme complexe.
- Prin HIL partea fizică a unei mașini sau a unui sistem este înlocuită cu un simulator hardware-software.



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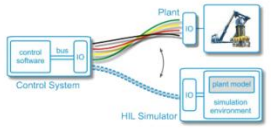


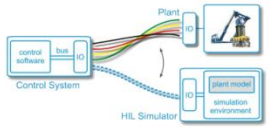
1. Introducere

Complexitatea instalației /componentei simulate este asigurata prin adăugarea unei reprezentări matematice / logice a tuturor elementelor structurale:

- mecanice;
- Electrice si electronice;
- Software;
- Comunicatie / transfer de date / protocoale.
- Compatibilitate electrica si mecanica (conectori!)

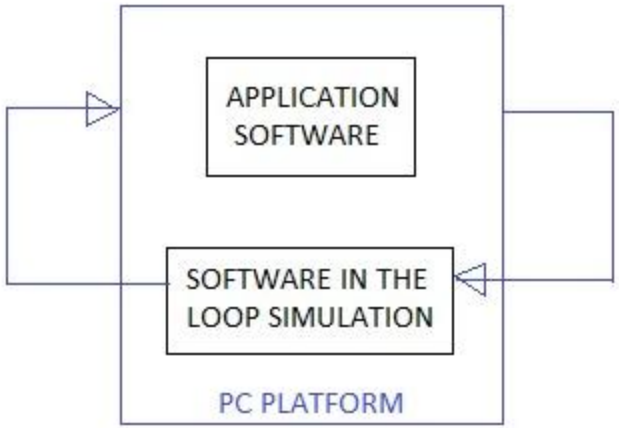
- (sunt reprezentate toate elementele!)

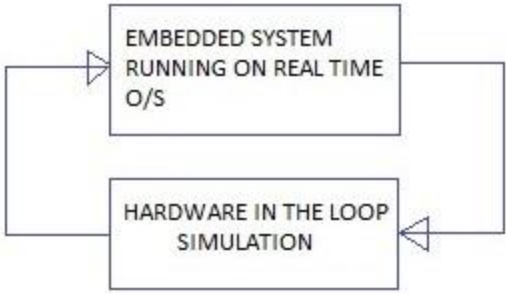
C11: HIL



1. Introducere

- SIL ≠ HIL
- HIL este o formă de simulare în timp real. HIL diferă de simularea în timp real (SIL) prin adăugarea unei componente (hardware) reale în buclă. Această componentă poate fi o „unitate de control electronic” (ECU).





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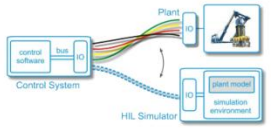
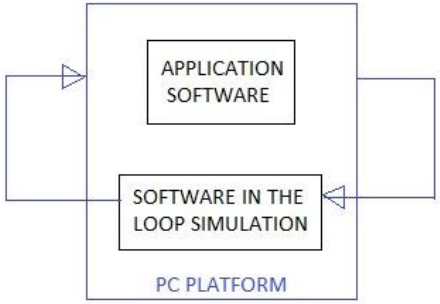


1. Introducere

SIL

- Aplicatiile “proces” si “controller” sunt co-simulate pe (aceeasi) mașina gazdă, in mod uzual.
- Vectorii de intrare sunt generati din cerințele (produsului) sau din alt model executabil.
- Utilizabil cu limbaje cu implementarea grafică (de exemplu, LabView, Simulink) dar si a codurilor generale (MATLAB / C / C ++).



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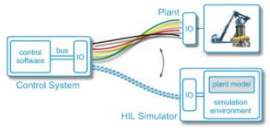
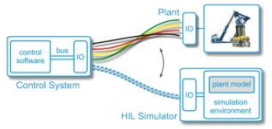


2. Prezentare generala

- **Motivatie HIL**
  - Creșterea siguranței;
  - Îmbunătățire calitate;
  - Economisire timp;
  - Reducere cost (financiar);
  - Factorul uman.

C11: HIL



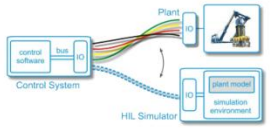
2. Prezentare generala

- **Motivatie HIL**
  - **Factorul uman** – in mod uzual NU este inclus in model!

Simulatoarele de formare au o mulțime de avantaje față de instruirea la locul de muncă:

• Oferă o conștientizare avansată vizualizând aspecte care ar fi invizibile pe o mașină reală. Acest lucru îi ajută pe cursanți să înțeleagă rapid funcționarea mașinii.
• Nu se defectează atunci când un stagiar face o greșeală. Acest lucru permite cursanților să facă si o instruire fără supraveghere.

C11: HIL

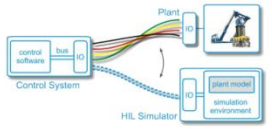


2. Prezentare generala

- **Motivatie HIL**
  - **Factorul uman** – in mod uzual NU este inclus in model!

• Permit schimbarea condițiilor meteorologice și a altor variabile. Un stagiar poate fi învățat să manipuleze o mașină în orice condiții.
• Susțin scenariile: cursanții pot fi învățați cum să rezolve probleme și cum să reacționeze în situații tipice.

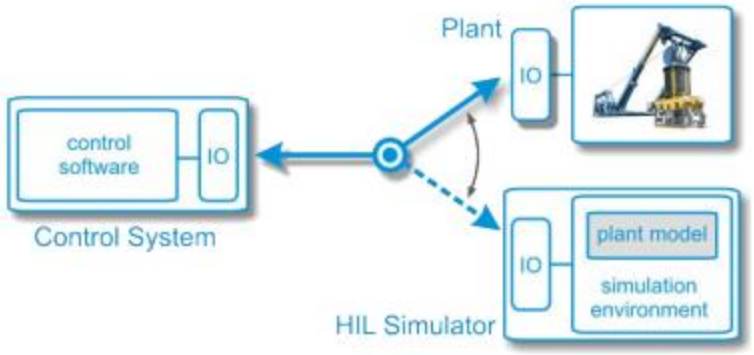
C11: HIL



2. Prezentare generala

- **Componente**

- **Software – aplicatie TR**
- **Hardware – arhitectura de TR**



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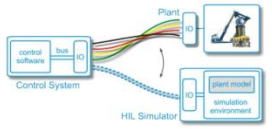
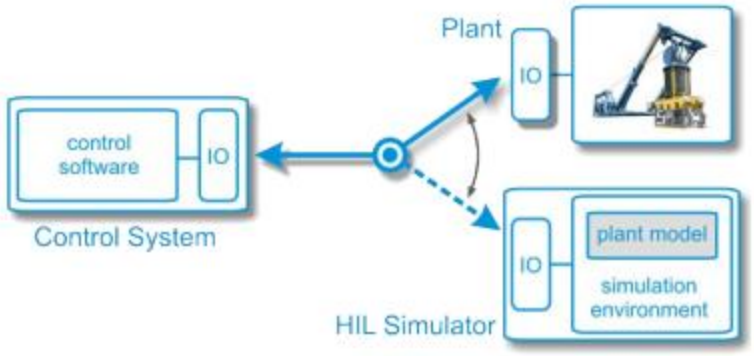


2. Prezentare generala

- **Componenta Software**

- **Modelare**
- **Simulare**
- **Validare**
- **Implementare software**



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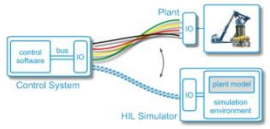
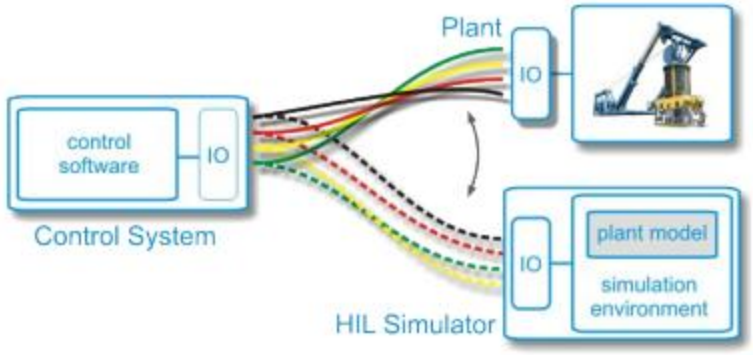
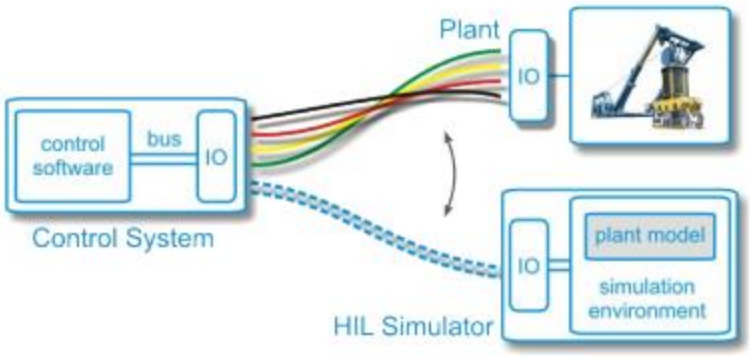


2. Prezentare generala

- **Componenta Hardware**



- **Sistem HW de TR**
- **Comunicatie**
- **Conexiune (wired – bus - radio)**



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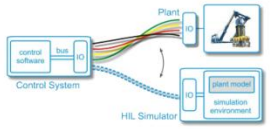


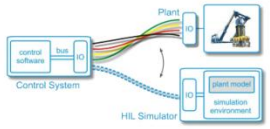
3. Dezvoltare - Implementare

Pașii principali:

- 1. Elaborare model matematic.
- 2. Validare si simulare sofware model.
- 3. Implementare aplicatie sofware cu functionare in TR pe hardware-ul ales.
- 4. Validare structura SIL in TR.

$$H_m(q^{-1}) = \frac{b_0 + b_1 q^{-1} + b_2 q^{-2}}{a_0 + a_1 q^{-1} + a_2 q^{-2}} = \frac{y(k)}{u(k)}$$

C11: HIL

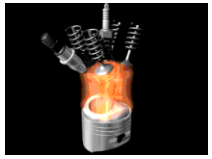


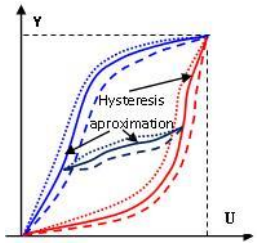
3. Dezvoltare - Implementare

Model matematic:

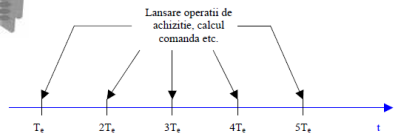
- model continuu - discretizat;
- sistem cu fct. continua;
- sistem cu ev. discrete;
- sistem hibrid;
- comportamente liniare;
- neliniaritati;
- fuzzy;

$$H_m(q^{-1}) = \frac{b_0 + b_1 q^{-1} + b_2 q^{-2}}{a_0 + a_1 q^{-1} + a_2 q^{-2}} = \frac{y(k)}{u(k)}$$





!!! Perioada de esantionare **Te** !!!



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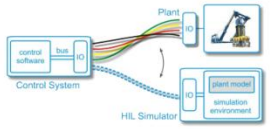
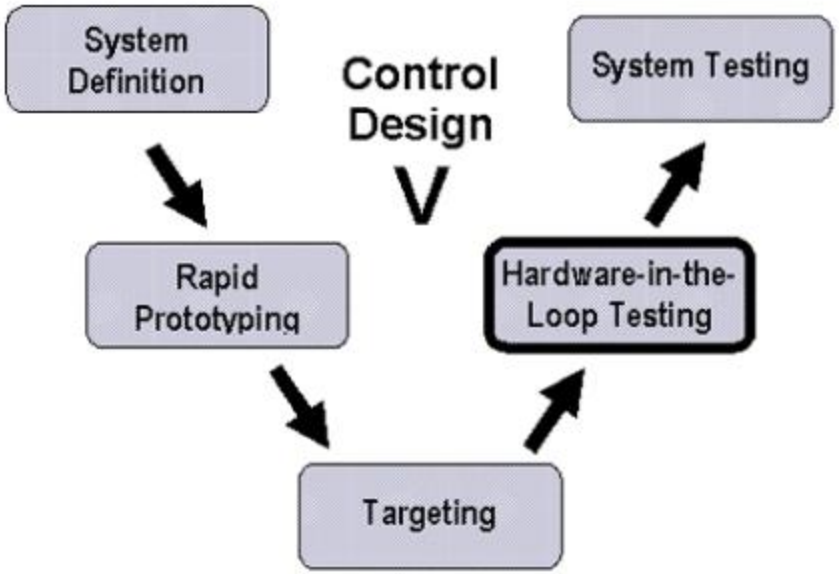


3. Dezvoltare - implementare

Strategie de dezvoltare – in “V”:



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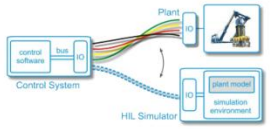
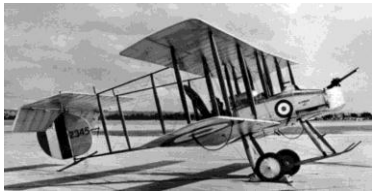
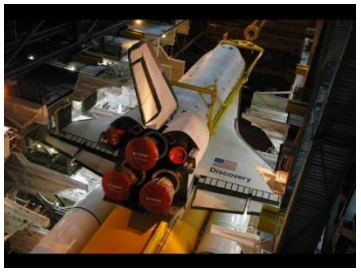


3. Dezvoltare - implementare

- **Suport foarte bun pt.:**
  - Optimizarea algoritmilor de reglare
  - Optimizarea punctelor de functionare
  - Optimizare operationala – Asset management
  - Diagnoza a defectelor, reconfigurare





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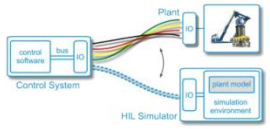
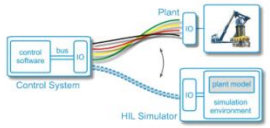


4. Exemple

- Echipamente medicale
- Instalatii / echipamente industriale
- Sisteme de producere si generare a energiei
- Bunuri de larg consum
- Aerospace
- Automotive
- Control Proces

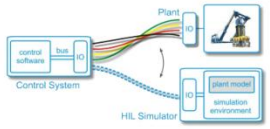
C11: HIL



4. Exemple ...in ordine alfabetica:

- **Aeronautica - (zona militara si spatiala)**:

C11: HIL



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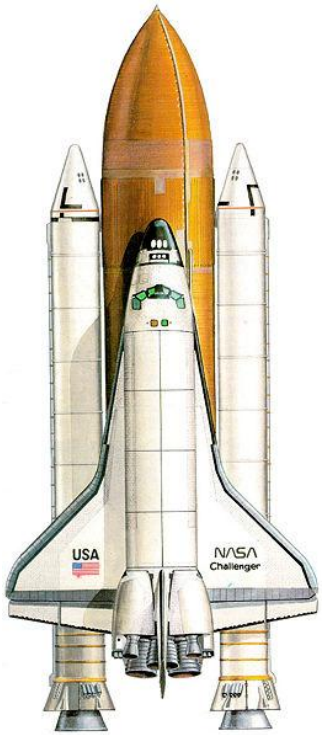

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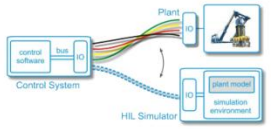

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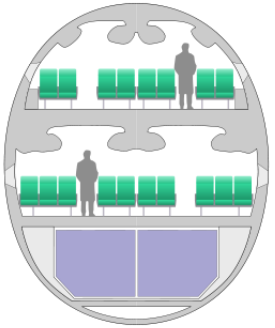

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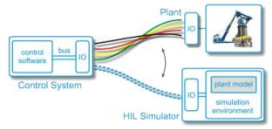
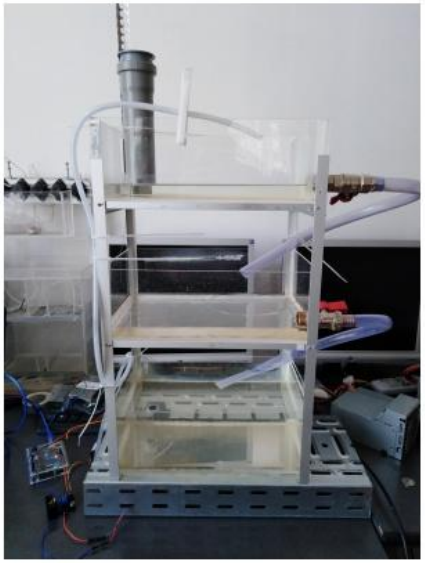
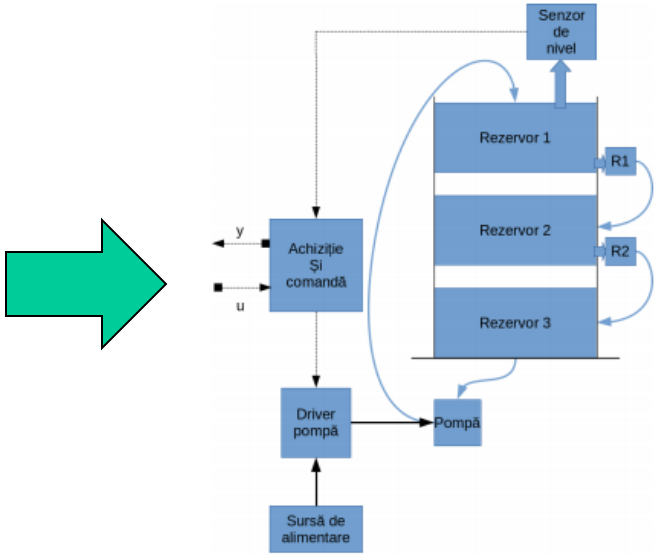
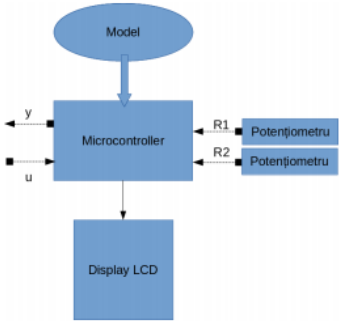


4. Exemple

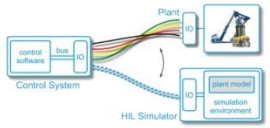
- **Control (proces)**: - ex. Instalatie didactica:





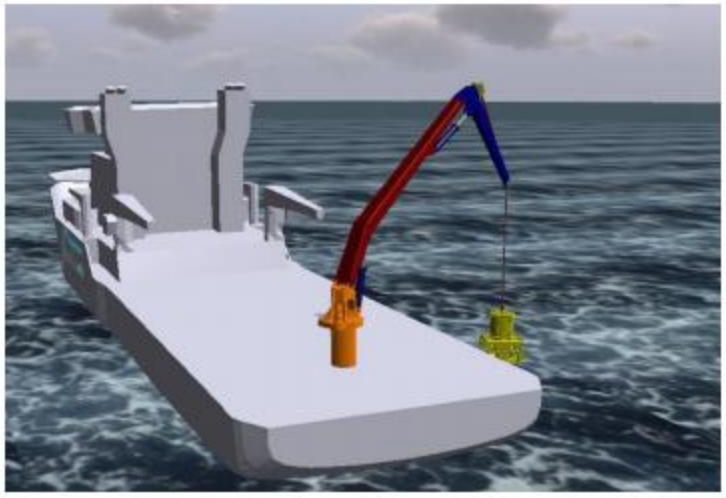


C11: HIL

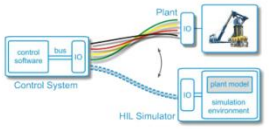


4. Exemple

- **Control (proces)**: - ex. Macara pe o nava:

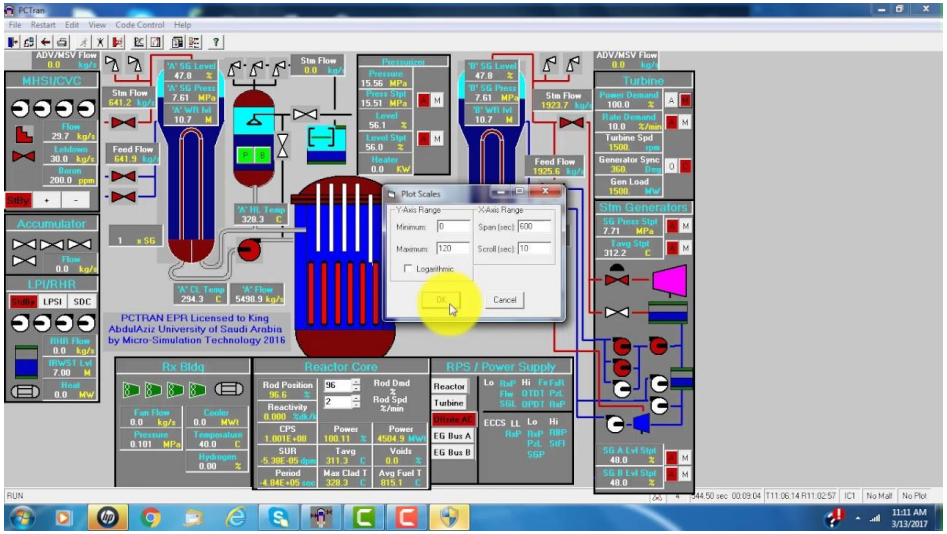


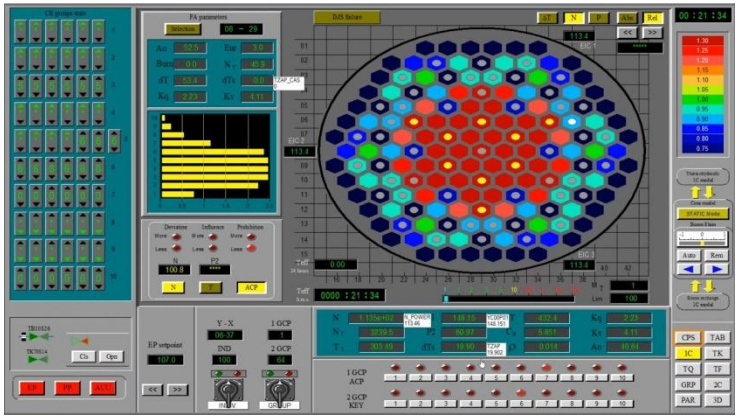
C11: HIL



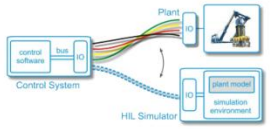
4. Exemple

- **Control (proces)**: - ex. Instalatie nucleara:



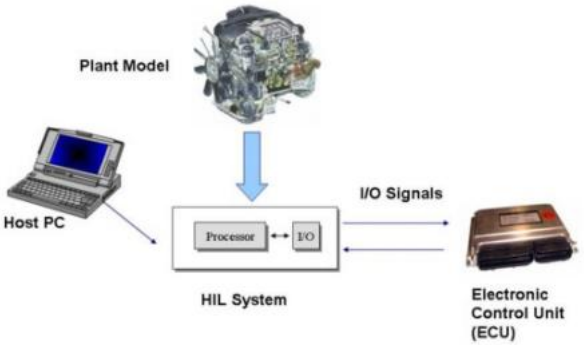


C11: HIL

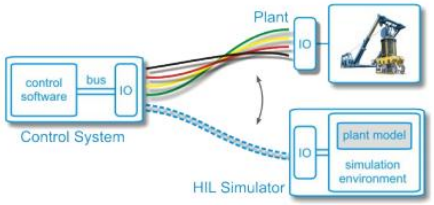

Plant
control software
bus
IO
Control System
plant model
simulation environment
HIL Simulator

• • •


A320


Plant Model
Host PC
I/O Signals
Processor
I/O
HIL System
Electronic Control Unit (ECU)


AIRBUS A380
Lufthansa
A380


Plant
IO
control software
bus
IO
Control System
plant model
IO
simulation environment
HIL Simulator

- end -

What is HIL Testing? (hil-simulation.com)

Introduction to Hardware-in-the-Loop Simulation (yumpu.com)

Hardware-In-the-Loop testing | Controller test | Dynamic modeling | Test and verification (modeling-tech.com)

Software in the loop testing vs Hardware in the loop testing (test-and-measurement-world.com)