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Design for Reliability of Mechatronic Systems Supported by Knowledge-Based Systems in Design Process Early Phases

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Mech. Engineering Dept. UFSC

3rd International Conference on Mechanical & Aerospace Engineering
October 05-07, 2015 San Francisco, USA

Where are we located?

UFSC-BRAZIL

State Santa Catarina

- One of the highest standards of living in Latin America
- 293 cities

State Capital Florianopolis

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Source: CNN August 2013

Structure

Why tackle mechatronic systems design?

Why the early stages?

What is a Knowledge-Based System?

Examples of KBS projects developed

Some decisions related to the current prototype

Conclusion and some works ahead

Why mechatronic system design?

Faults in mechatronic systems > many causes.

Classification of sources performance variability:

(1) manufacturing processes;

(2) the operating environment;

(3) product deterioration.

Electromagnetic may cause simple malfunction or even the physical destruction.

Typical design process

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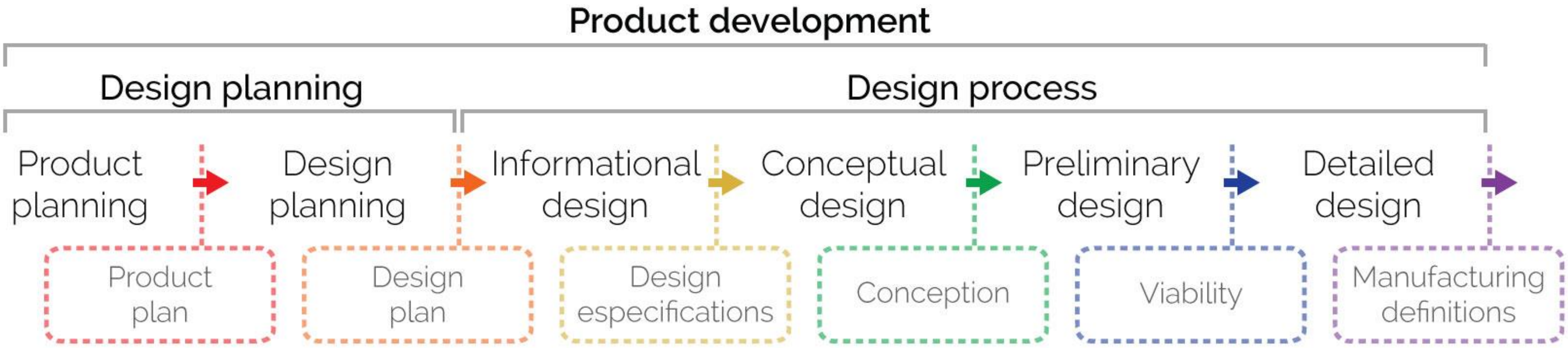

KBS definition / development process

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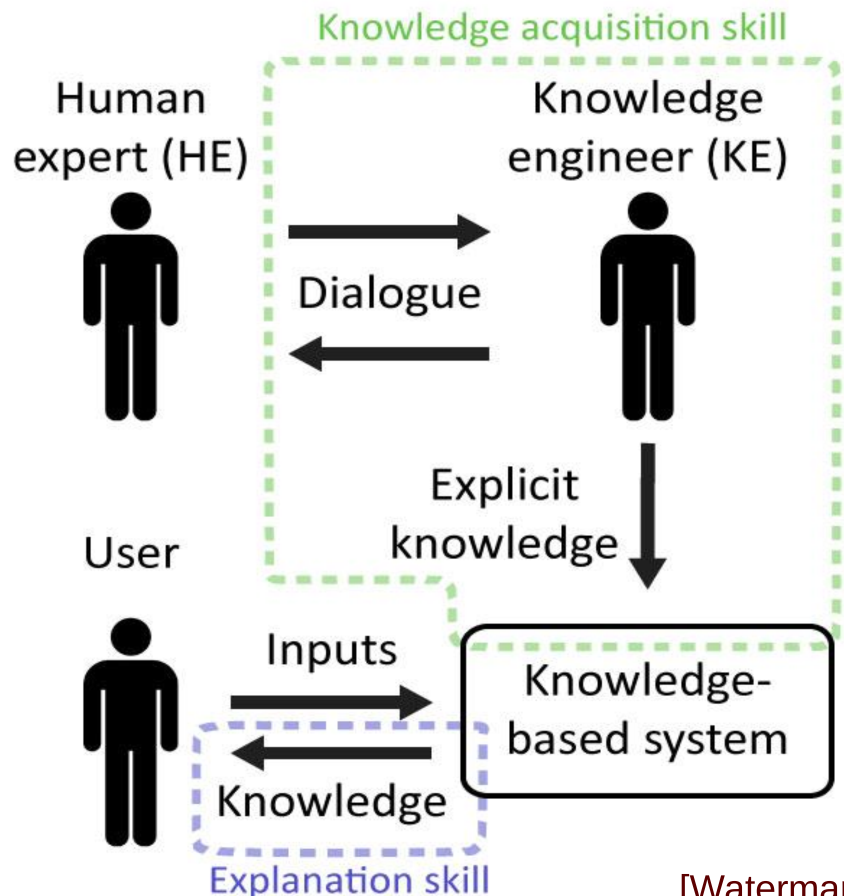
feasibility study

knowledge acquisition

knowledge representation

implementation

verification and validation



[Waterman, 1986]

"… an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution" Prof. Edward Feigenbaum

KBS Structure

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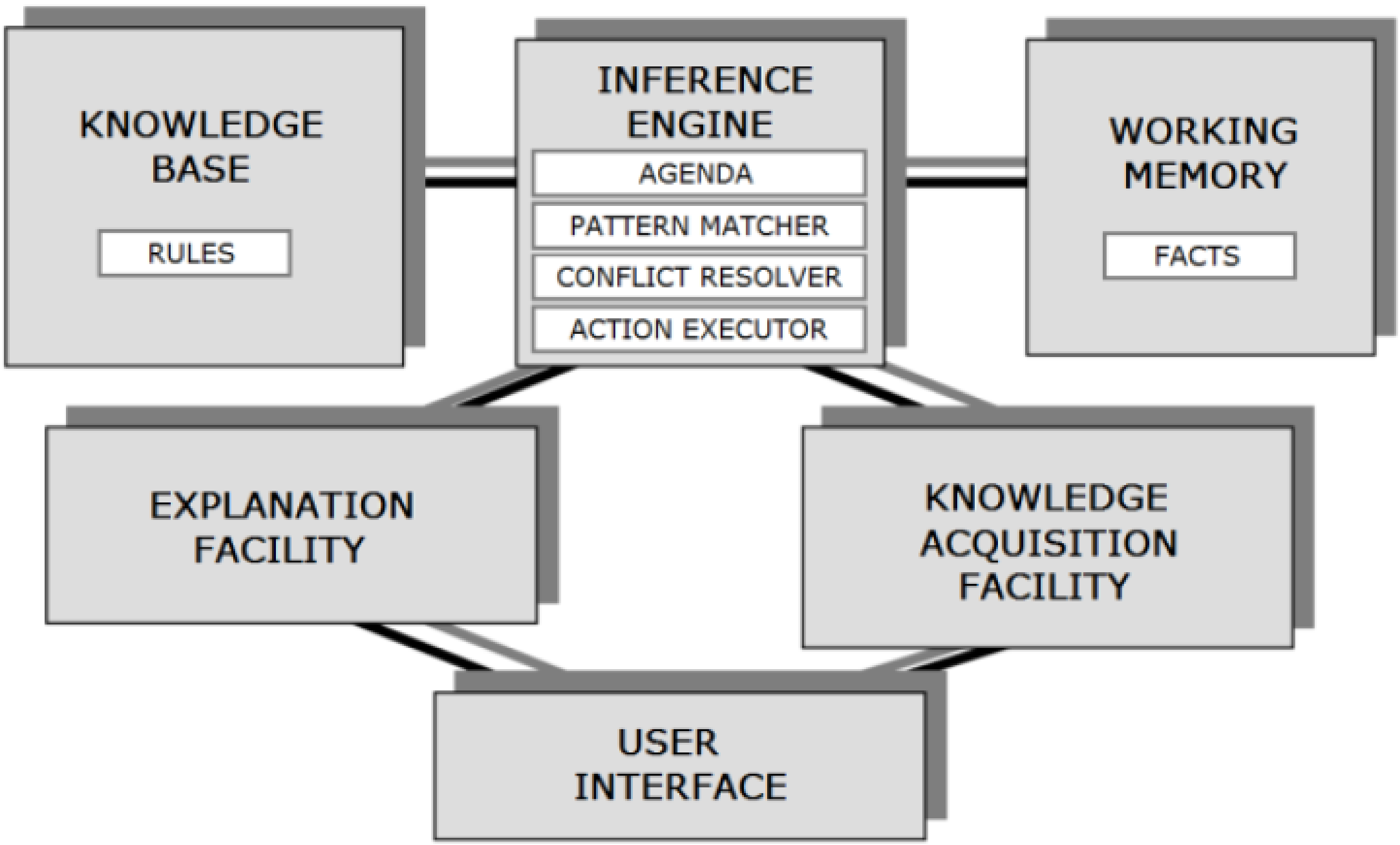

Figure 2. Knowledge-based system basic structure
(Adapted from Giarratano & Riley, 2005)

Some KBS projects developed

fluid power system design (Silva and Back, 2000),

cogeneration power plants design (Matelli, *et al., 2009),*

hermetic compressors diagnosis (Pedroso and Silva, 2014)

detection, disambiguation and mitigation of faults in sensors (Silva et al 2012)

Initial Project

Expert System for design of hydraulic systems focusing on concurrent engineering perspective

Hydraulic Systems Design- Concurrent Engineering

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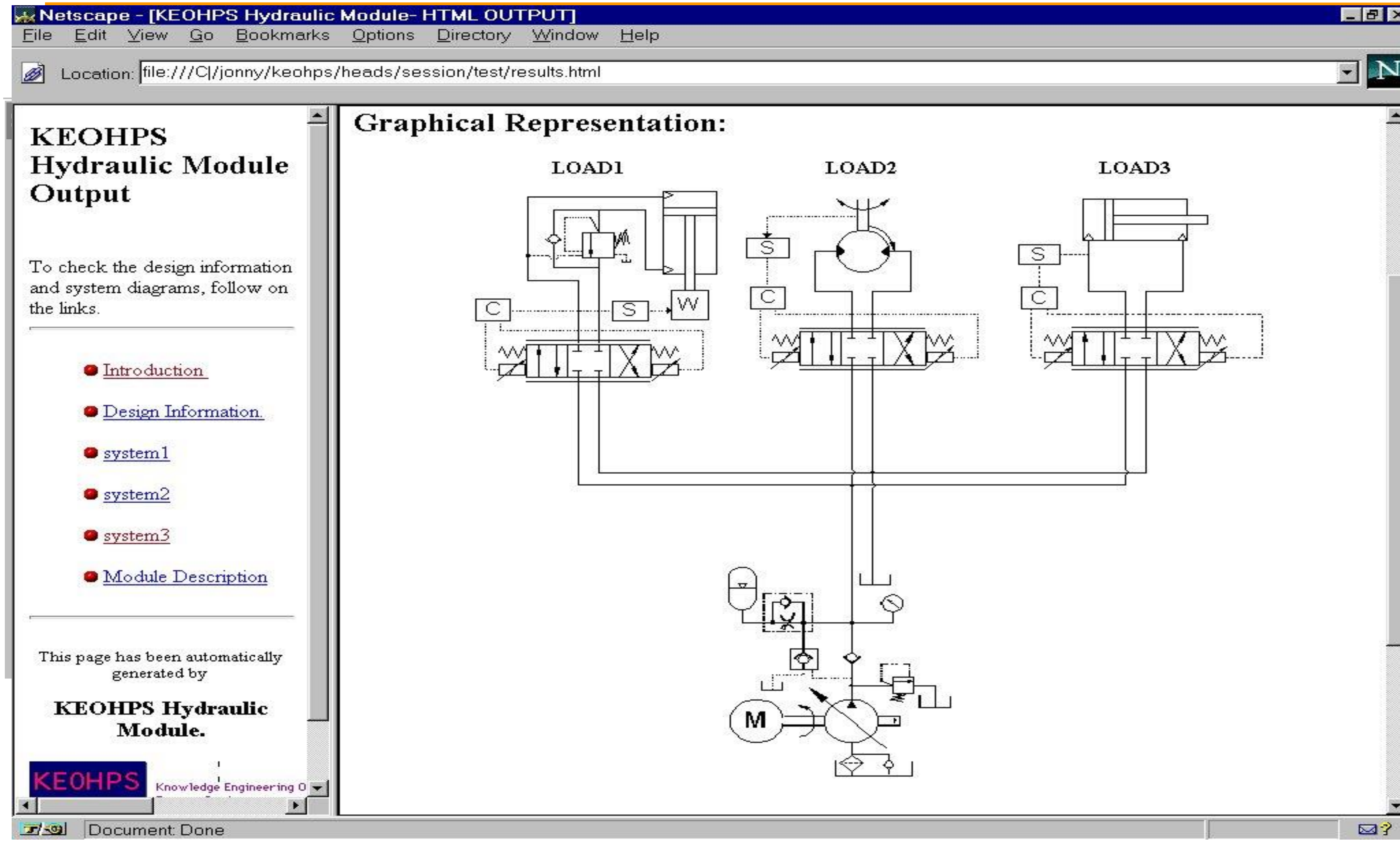

Automatic alternative generation

Circuit representation

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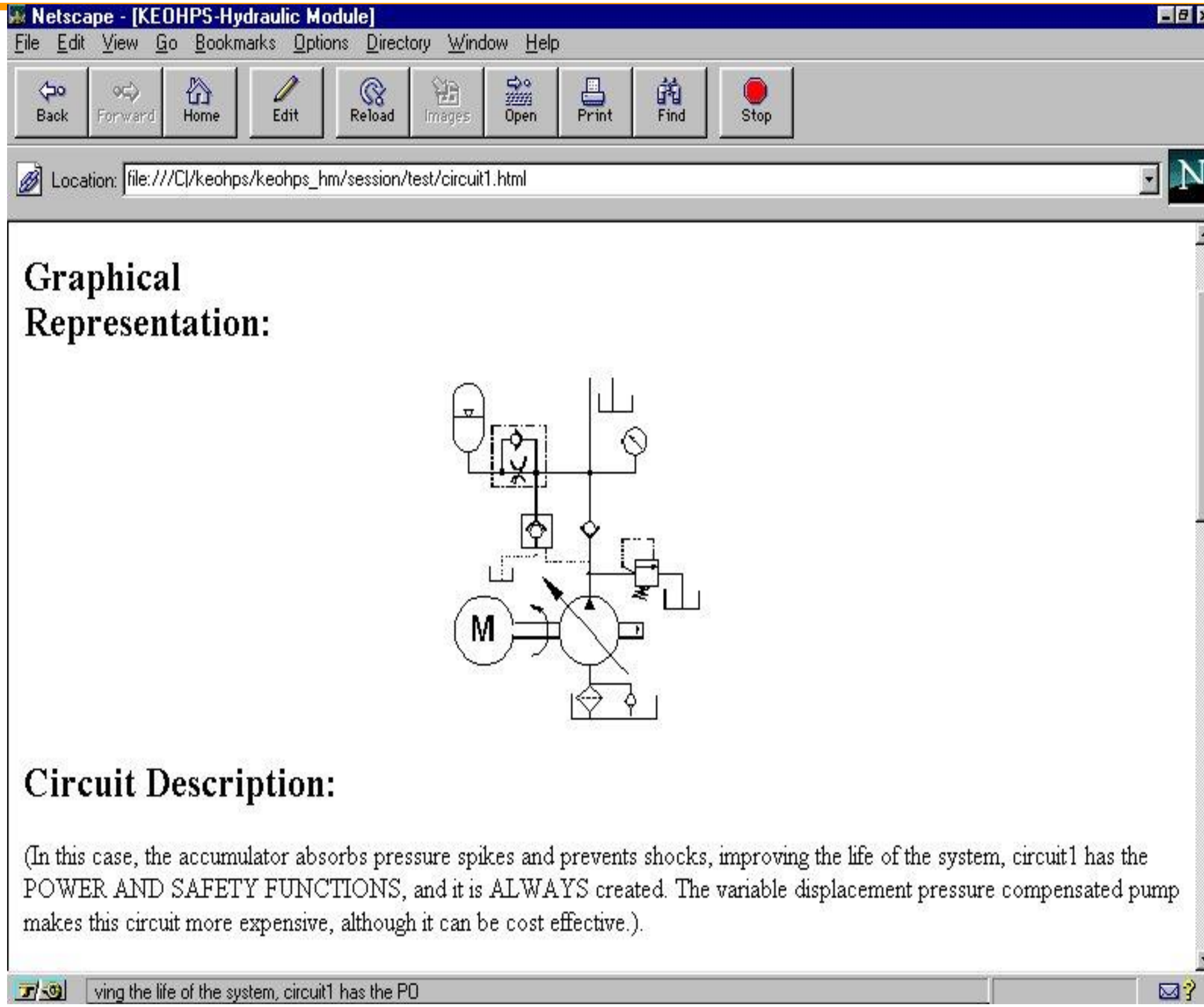

ProSisc- Exp. Sist. Cogeration Power Plant Design

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1. Definition of different plant diagrams based on utilities:
   1. electricity,
   2. saturated steam,
   3. hot water
   4. chilled water
2. specification and sizing of the plant components;
3. economic feasibility and sensitivity analysis;

Interface examples
input data- power demand

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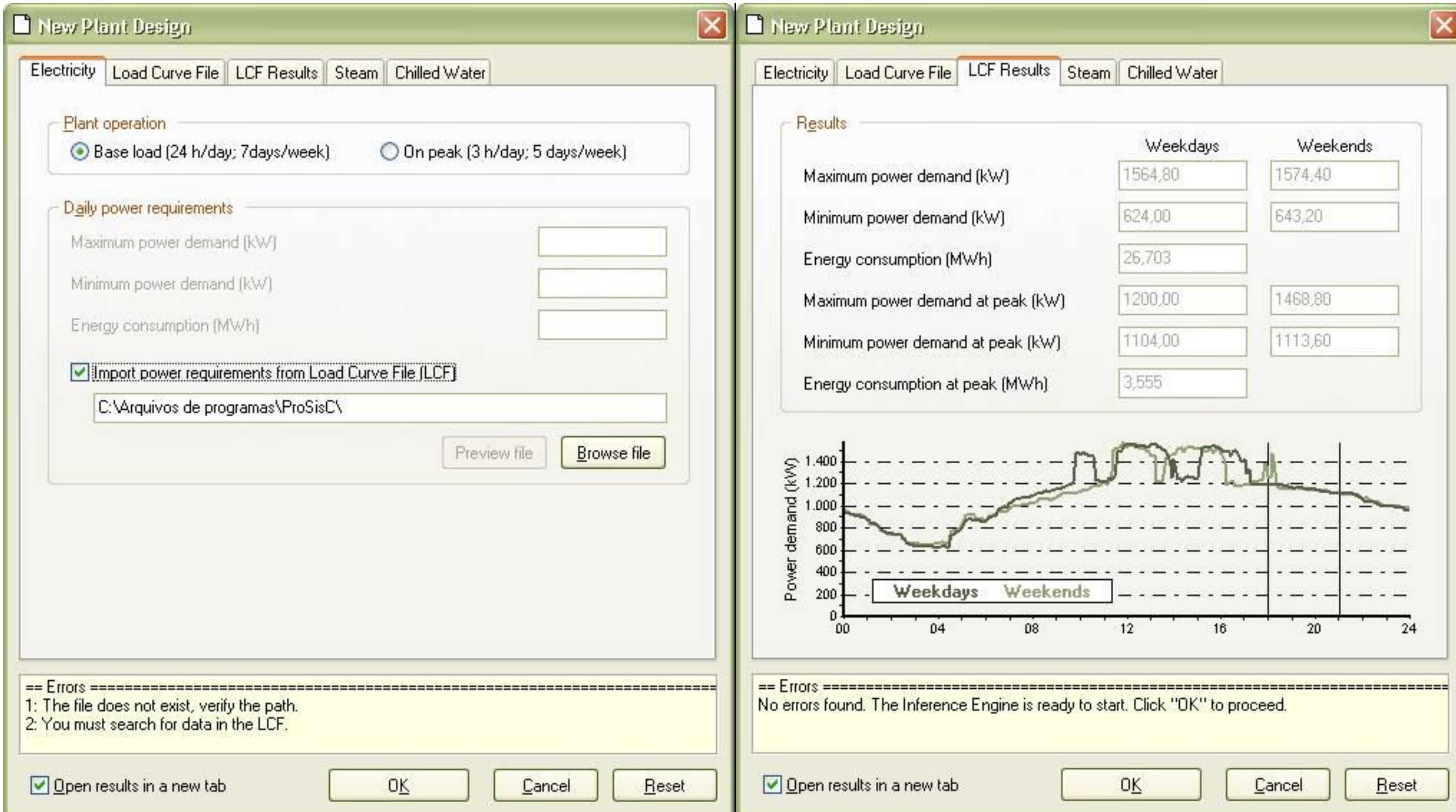


Output interface- Scheme with specifications

Solutions → ProSisC 0.3.0

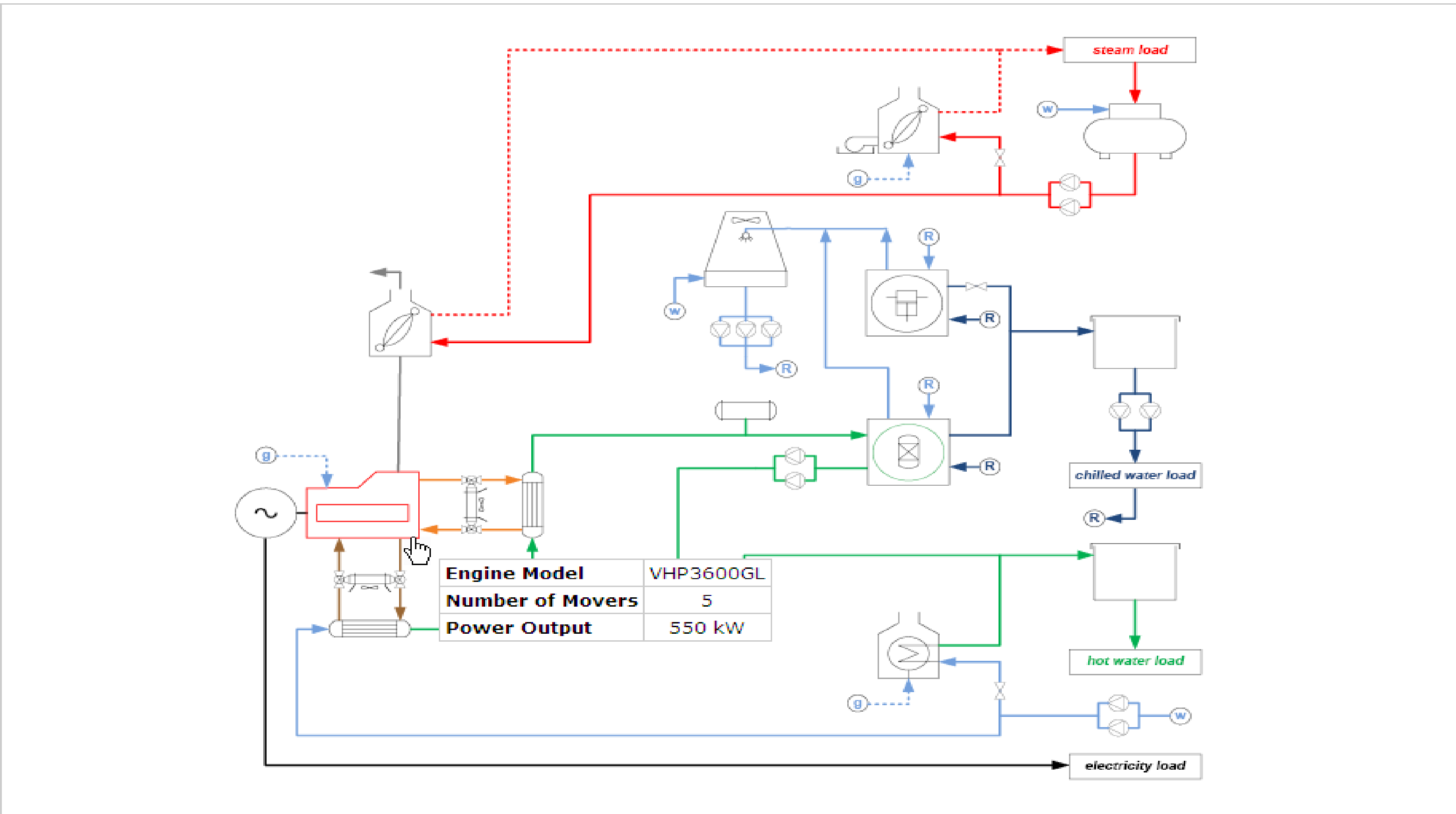
AZIL

− Design Requirements

Electrical Power Demand	
Plant Daily Operation	Base-load (24 h/day)
Power Supply Connection	Tied to Utility Bus

Steam Demand	
Steam demand [kW]	1500
Condensate temperature [ºC]	4

− Plant Diagram



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journal homepage: www.elsevier.com/locate/eswa

A knowledge-based system approach for sensor fault modeling, detection and mitigation

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ABSTRACT

Sensors are vital components for control and advanced health management techniques. However, sensors continue to be considered the weak link in many engineering applications since often they are less reliable than the system they are observing. This is in part due to the sensors' operating principles and their susceptibility to interference from the environment. Detecting and mitigating sensor failure modes are becoming increasingly important in more complex and safety-critical applications. This paper reports on different techniques for sensor fault detection, disambiguation, and mitigation. It presents an expert system that uses a combination of object-oriented modeling, rules, and semantic networks to deal with the most common sensor faults, such as bias, drift, scaling, and dropout, as well as system faults. The paper also describes a sensor correction module that is based on fault parameters extraction (for bias, drift, and scaling fault modes) as well as utilizing partial redundancy for dropout sensor fault modes). The knowledge-based system was derived from the results obtained in a previously deployed Neural Network (NN) application for fault detection and disambiguation. Results are illustrated on an electro-mechanical actuator application where the system faults are jam and spalling. In addition to the functions implemented in the previous work, system fault detection under sensor failure was also modeled. The paper includes a sensitivity analysis that compares the results previously obtained with the NN. It concludes with a discussion of similarities and differences between the two approaches and how the knowledge based system provides additional functionality compared to the NN implementation.

Drift fault: parameters calculation and mitigation via a KBS

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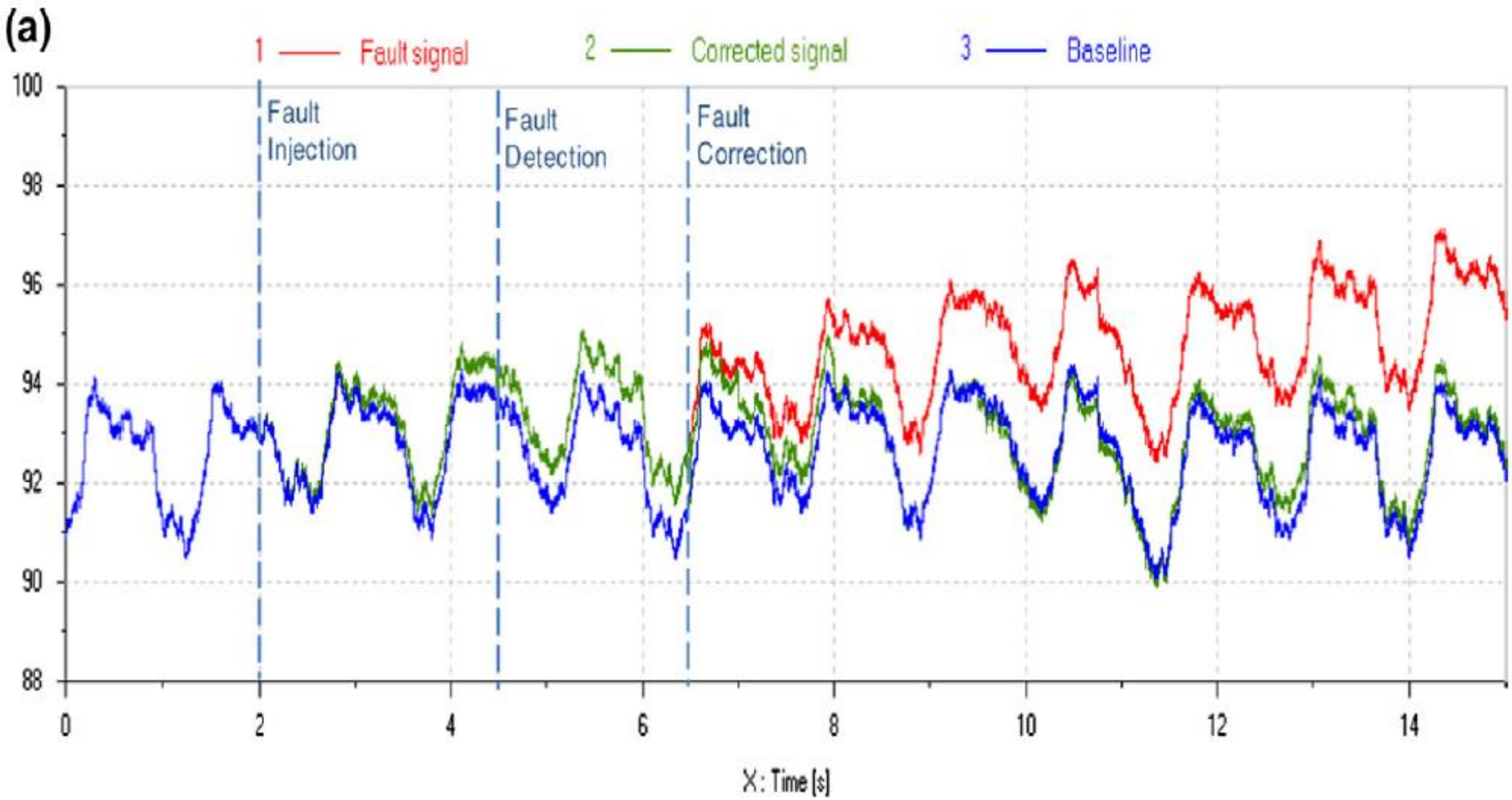

National Aeronautics and Space Administration

Knowledge-Based System to Support Plug Load Management

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Scott Poll
NASA Ames Research Center, USA

Introduction

Lighting and HVAC loads have been the top contributors to building energy consumption.

With the decreasing trend in lighting and HVAC energy consumption, plug and process loads are taking up an increasingly larger slice of the building energy use pie.

We describe the development of a knowledge-based system to analyze data collected from a plug load monitoring system. The KB system generates summary usage reports and alerts building personnel of malfunctioning equipment and unexpected plug load consumption. In terms of plug load energy consumption, it has been found that motivated users are **key to saving energy.**

The system is planned to be applied to Sustainability Base, a recently constructed LEED Platinum office building at NASA Ames Research Center, to identify malfunctioning loads and reduce building energy consumption. In the current phase, a testbed was designed.

Sustainability Base

List of equipment Monitored in the testbed

Equipment	No.	Equipment	No.
Desktop	6	Calculator	1
Laptop	3	Storage drive	1
Printer	7	Battery charger	1
Phone	2	Vend. machines	2
Speaker	3	Space heater	1
Scanner	3	External drive	1
Monitor	7	Coffee maker	1
Hub	2	Refrigerator	1
Copier	1	Bridge	1
Shredder	3	Microwave	1
Lamp	2	**TOTAL**	50

Hooey, B. L., Silva, J. C., & Foyle, D. C. (2012). A design rationale capture tool to support design verification and re-use. In Proceedings of the 4th International Conference on Applied Human Factors and Ergonomics. San Francisco, July 21-25, 2012.

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A Design Rationale Capture Tool to Support Design Verification and Re-use

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[3]NASA Ames Research Center, Moffett Field, CA, USA

Current Project- scope definition
Possible EMI Problems

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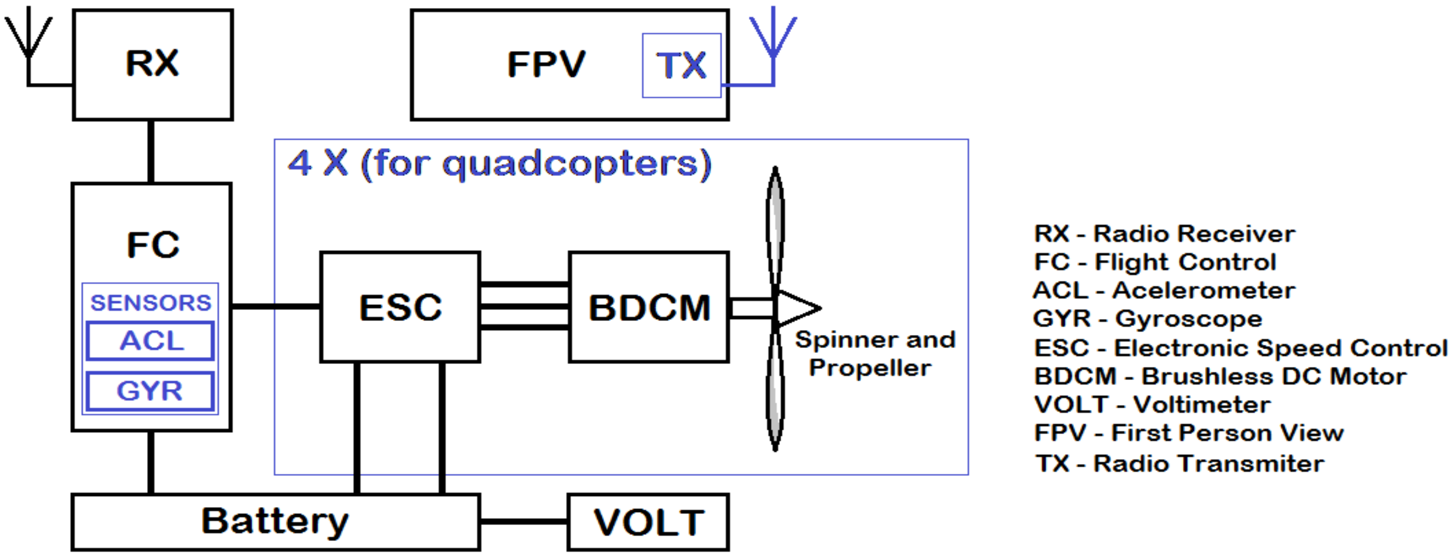

drone block diagram

- If EMI coupling ACL/GYR sensors
    - Reliability may be compromised
        - malfunction in sensors
        - noise signal to controller
    - Danger to circuitry integrity
        - EMI currents can produce excessive heat

Rule example: stray inductance

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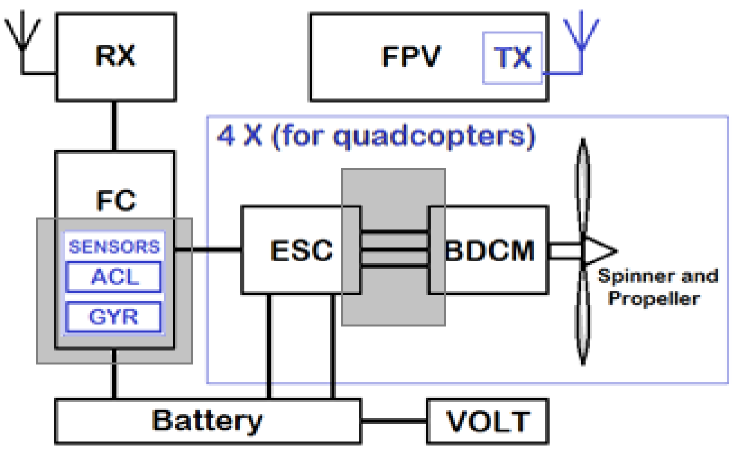

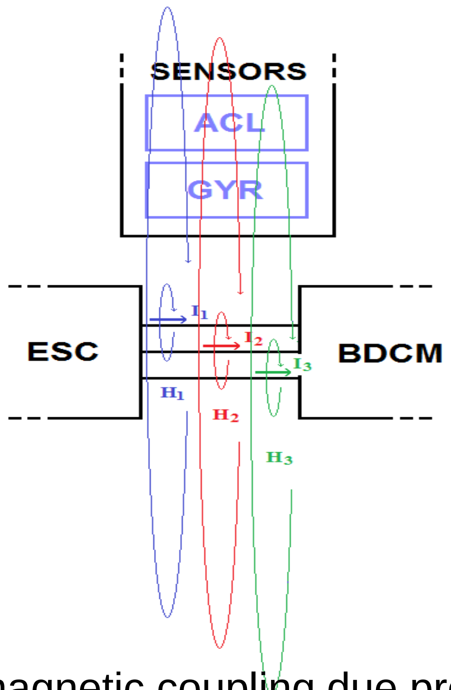

a) functional diagram

b) magnetic coupling due proximity

If ESC circuit drives strong switching currents to BDCM

f ≅ 10 kHz and I > 20A

Then EMI is radiated and may cause malfunction or degradation

(stray inductance)

Rule example: stray capacitance

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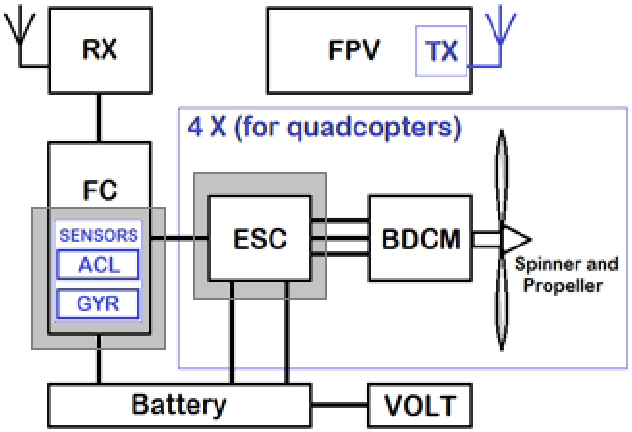

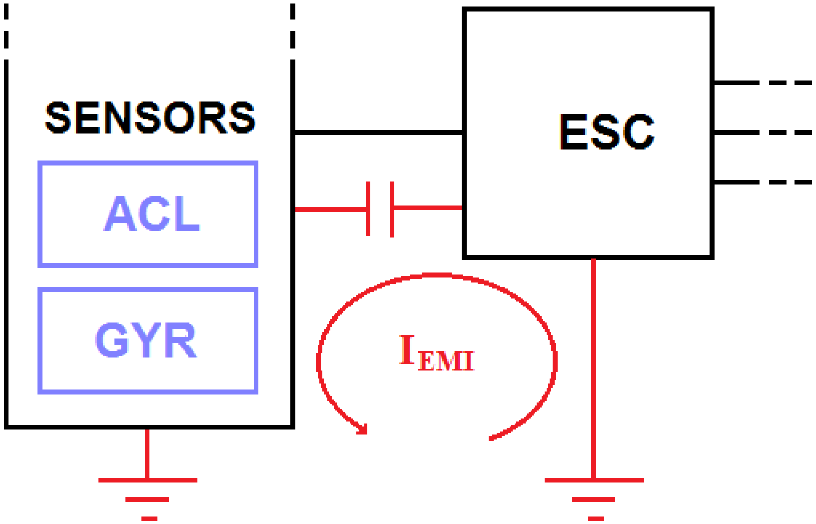

a) functional diagram b) electric coupling due proximity

If AC voltages are present at solder pads in a PCB

Then EMI is conducted and may cause malfunction or degradation

(stray capacitance)

Classes in a drone design

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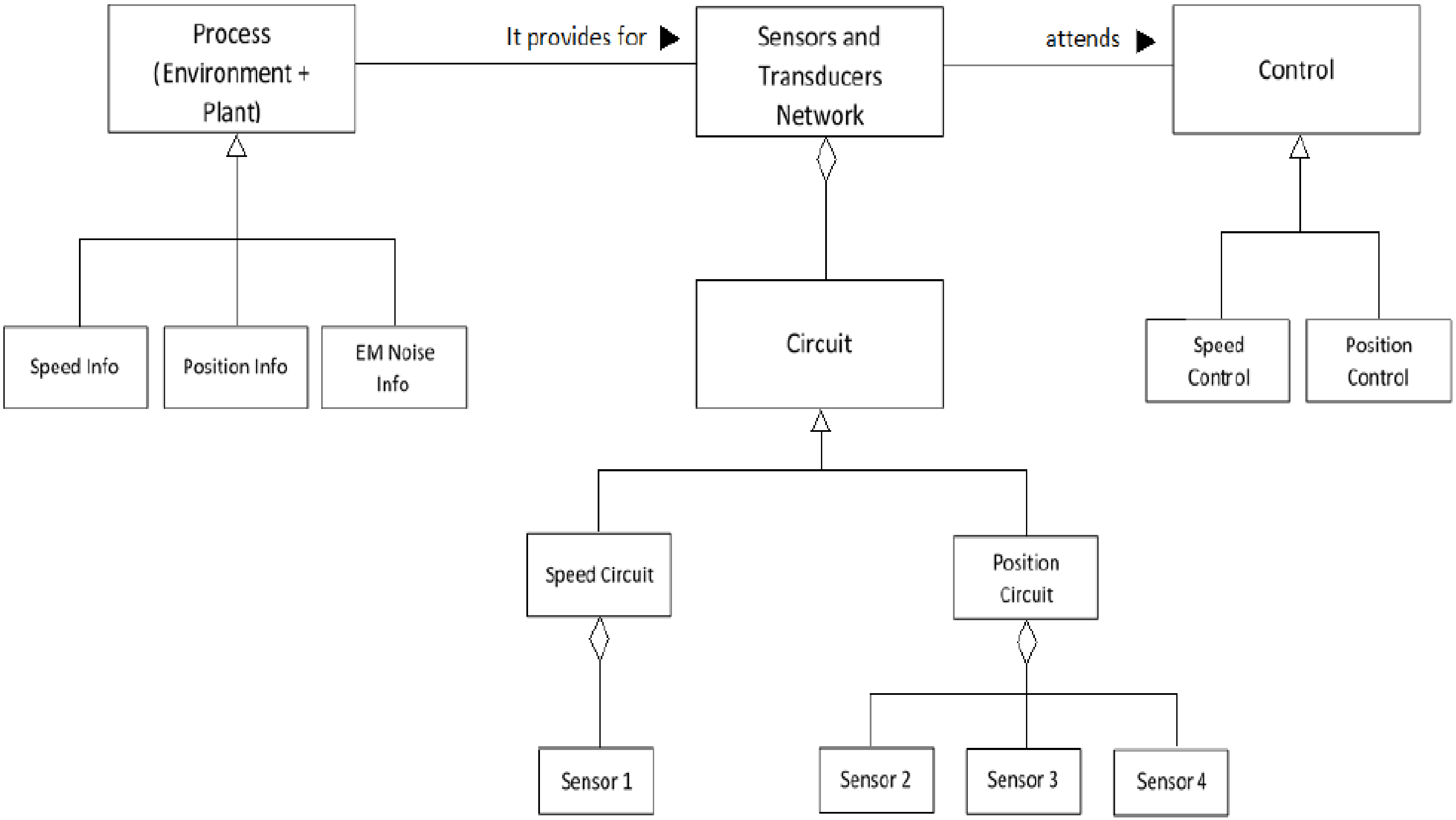

Common Points

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- Incremental approach
- Combination of
  - Rules
  - Oriented Modeling objects and
  - Semantic networks as techniques of knowledge representation
- Effective participation of experts in the systems validation
- Implementation in CLIPS (KBS shell)

Conclusion

A rapid prototype has been implemented.

Current functionality comprises:

- evaluation of topologies and technologies applied to the drive circuits (ESC), PCB layout,
- separation between circuitry potentially interfering and victim circuits,
- modes of operation in switched circuits (described by frequency, switching times, and duty cycle)
- and the need for filters and shields to interfering circuits.

Potential to assist designers in EMC criteria for the development of mechatronic products

If knowledge is power to create KBS is a valuable strategy!

Thank you!

coach.jonny

coachjonny

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