

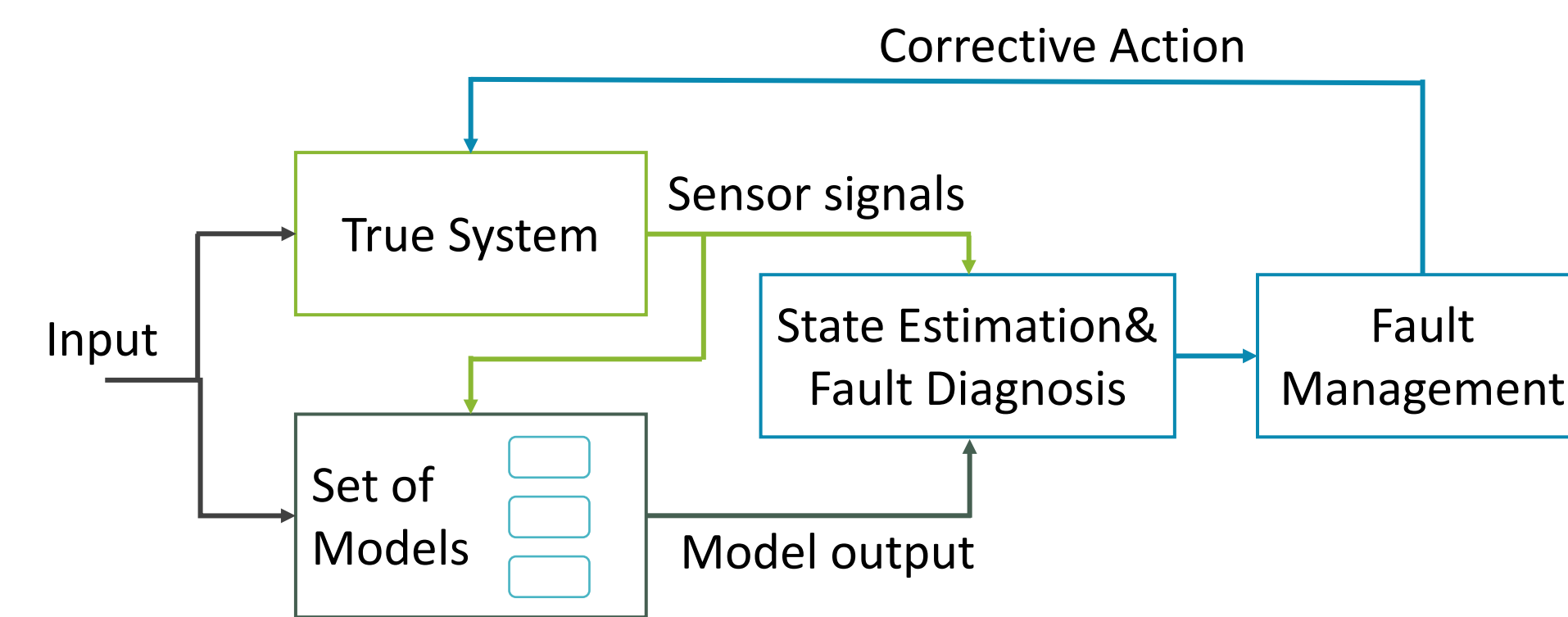
New Model-Based Fault Management Strategy

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Basic Idea Behind The Strategy

- Based on prior knowledge of the faults, a set of model should be derived representing healthy and all possible faulty conditions.
- Applying an adaptive estimation strategy derived from the model set makes it possible to estimate the states and identify the true model, which in this scenario means fault identification.
- Feeding the information from the estimation strategy, namely the estimated state and the identification, to a Fault Tolerant Controller (FTC) for corrective action to manage the faults.

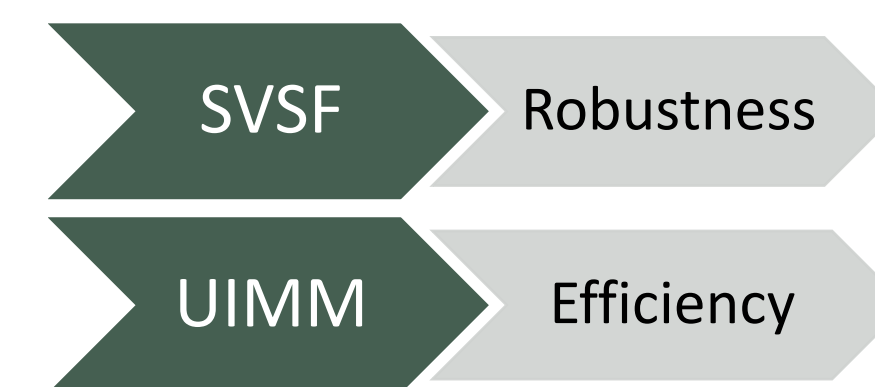


Background

- Residual-based fault detection:** This approach, which is also known as the observer-based method, compares the predicted value of the output from an observer to the measured output in order to obtain a residual error. If the residual error components exceed the predefined thresholds, faults are detected, and then, isolated through further analyses. The core element of this diagnostic system is an observer or a filter. It does not provide a proper state estimation needed for a closed-loop application.
- Joint state and parameter estimation:** This approach augmented the model parameters to the state vector to be estimated online during the process. It is a nonlinear filtering problem and the optimal solution needs solving a set of nonlinear PDEs. Suboptimal solution can be achieved using well-known strategies like augmented EKF, but for large parameter uncertainty the covariance linearization of EKF becomes invalid.
- Adaptive multiple model:** The main idea behind such a method is to use a finite number of models to represent different fault conditions. A finite number of filters are run in parallel based on these models. This strategy has three steps: the generation of individual state estimates matching to a given parameter vector; the evolution of the hypothesis probability; and the combination of the individual estimates.

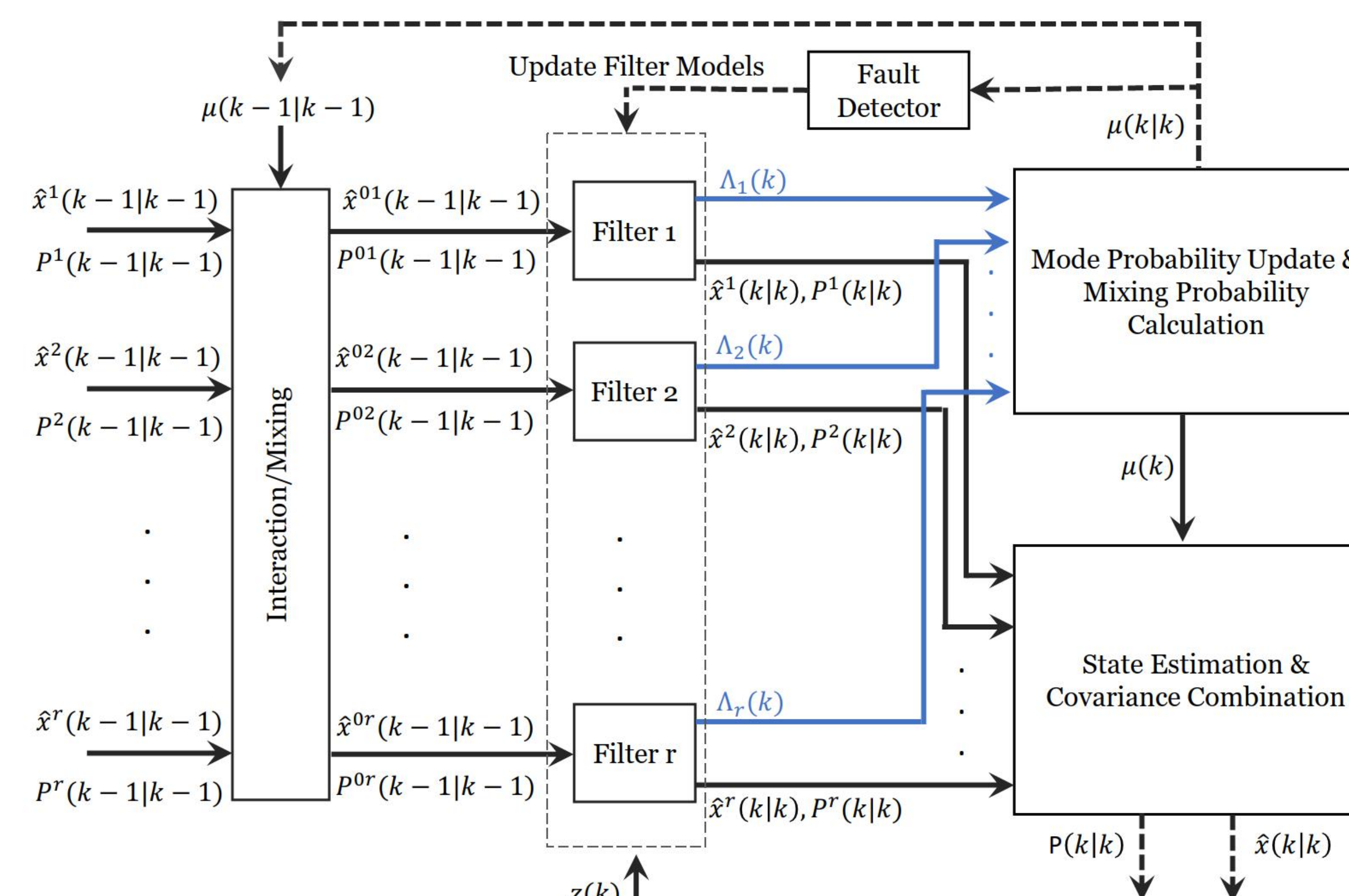
Why UIMM-SVSF-VBL?

- Interacting Multiple Model (IMM) strategy is a well-known suboptimal technique to solve the dynamic multiple model estimation problem.
- The proposed strategy named Updated IMM (UIMM) combined with SVSF-VBL filter (UIMM-SVSF-VBL).
- UIMM is a more efficient version of IMM with better performance in identifiability. It has the following property:
 - Fewer filters running in parallel
 - Higher Computational Efficiency
 - Avoiding combinatorial explosion
 - Robustness



Number of Faults	1	2	3	4	n
Number of Filters in IMM	2	4	8	16	2^n
Number of Filters in UIMM	2	3	4	5	n+1

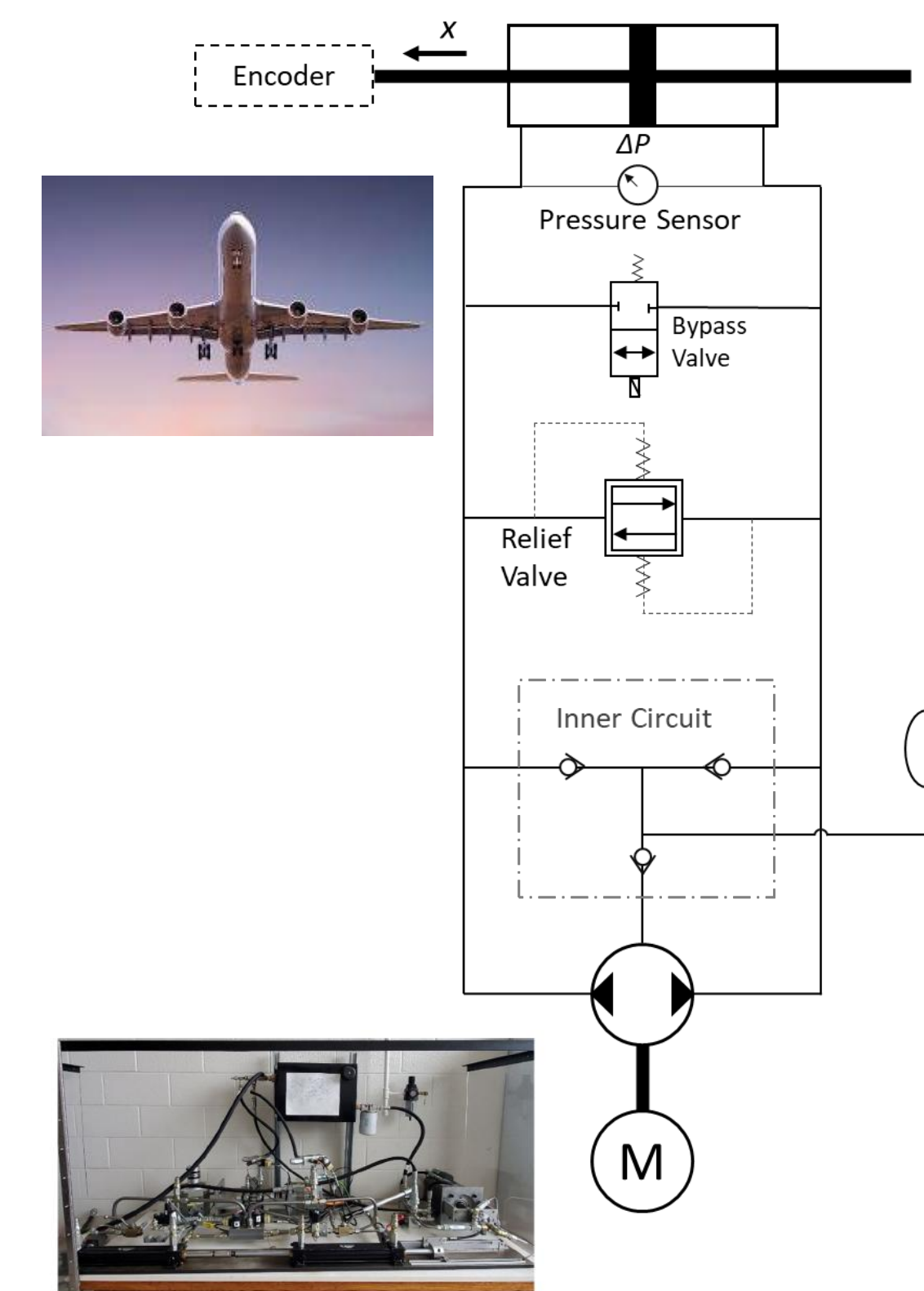
What Is Happening In Each Loop?



Case Study: Electro-Hydraulic Actuator

Ubiquitous applications, especially in harsh environments and with strict safety requirements, make the fault management in hydraulic actuators an imperative concern for the industry. The most common faults in the EHA systems are:

- Internal and external leakage.
 - Increasing friction due to faults in the sealing and packing of hydraulic cylinder.
- To detect and isolate these faults, the sensors signals are monitored and compared to the outputs from the system models. The faults are detected and isolated using the Proposed FDD strategy, then evaluated for corrective action in an adaptive FTC controller.



Results

The sequence used to simulate fault conditions:
1. The system is healthy at the start of the simulation;
2. A leakage fault is introduced at 1sec;
3. At 2sec the friction fault is also applied.

