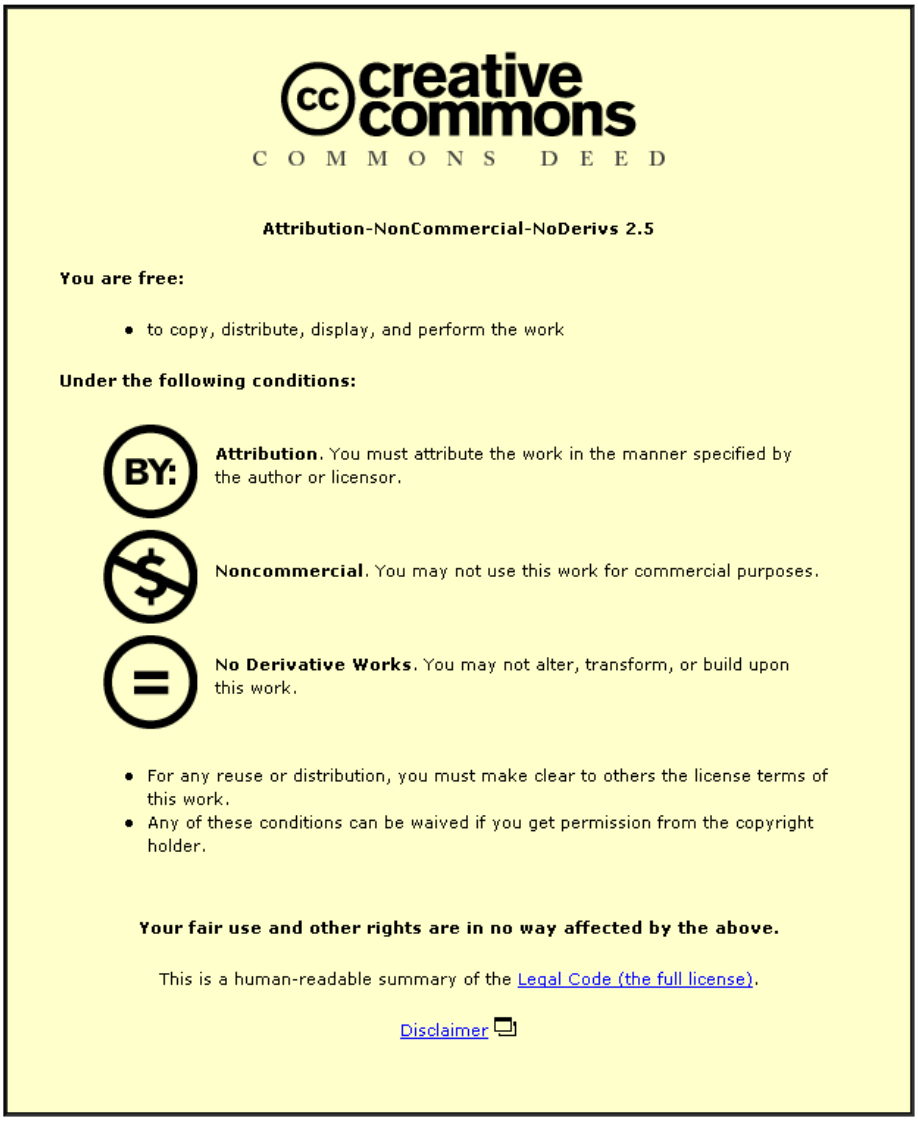

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Aircraft Fuel System Diagnostics Using Digraphs

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Overview

- Aim of Research.
- Diagnostic method - Digraphs.
- Application - Aircraft Fuel System.
- Results.
- Conclusions.

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Aim of Research

- Method to deal with key characteristics: DIGRAPHS.
- Qualitative causal model which illustrates the cause and effect behaviour in a system.
- Digraphs comprise:
  i. Set of nodes, representing system process variables.
  ii. Edges (lines) illustrating the inter-relationships which exist between process variables.
  iii. Deviations: 0, +/-1, +/-5, +/-10.

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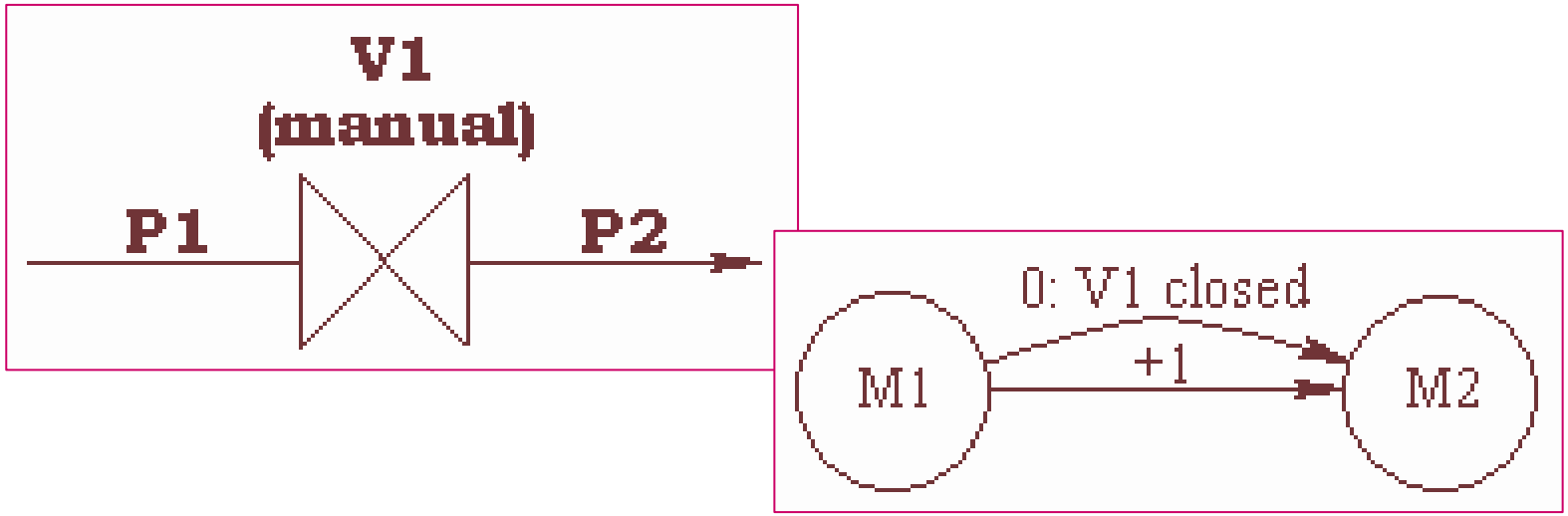
An Example of a Simple Digraph



- M1: mass flow at location 1 - independent variable.
- M2: mass flow at location 2 - dependant variable.
- Two arcs:
  - '+1' signed - normal.
  - '0: V1 closed' signed - conditional.

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Digraph Diagnostic Model Development

1) Define system to be analysed.

2) Compile list of system component failures.

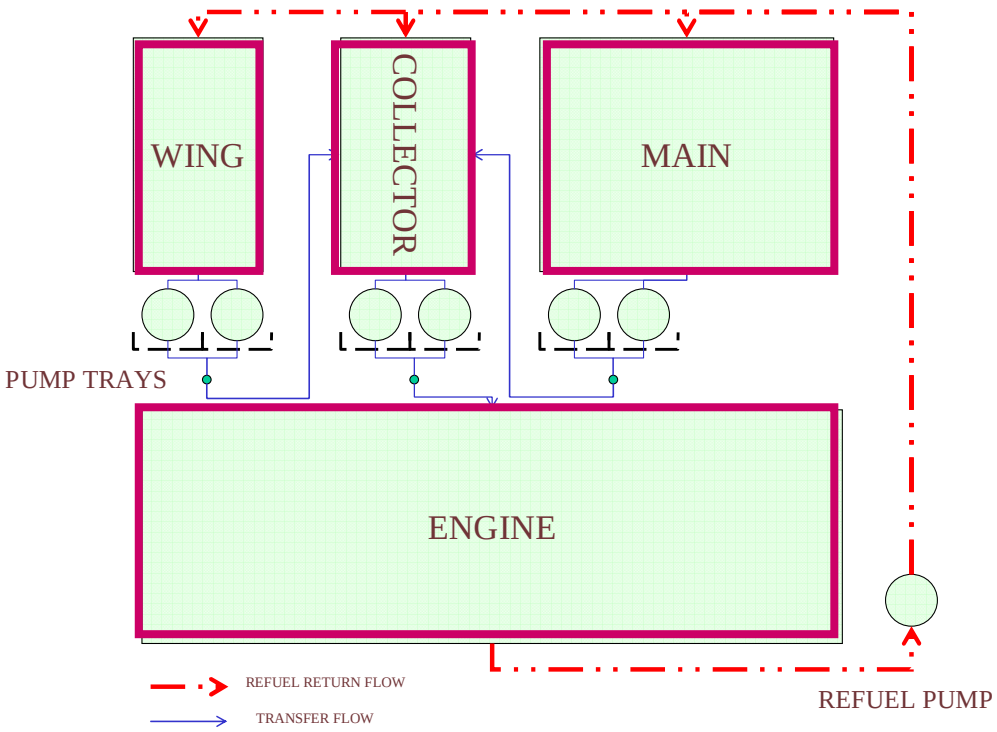
3) Separate system into sub-units.

4) Identify control loops, if present.

5) Generate digraph models for the sub-units.

6) Form system digraph by connecting any common variables from the sub-unit models.

Fuel System



- Represents aircraft fuel system.
- Active supply tanks: main, wing and collector.
- Engine tank treated as ‘tanker’.
- System behaviour:
  - 7 flow transmitters.
  - 6 pressure transmitters.
  - 4 level transmitters.

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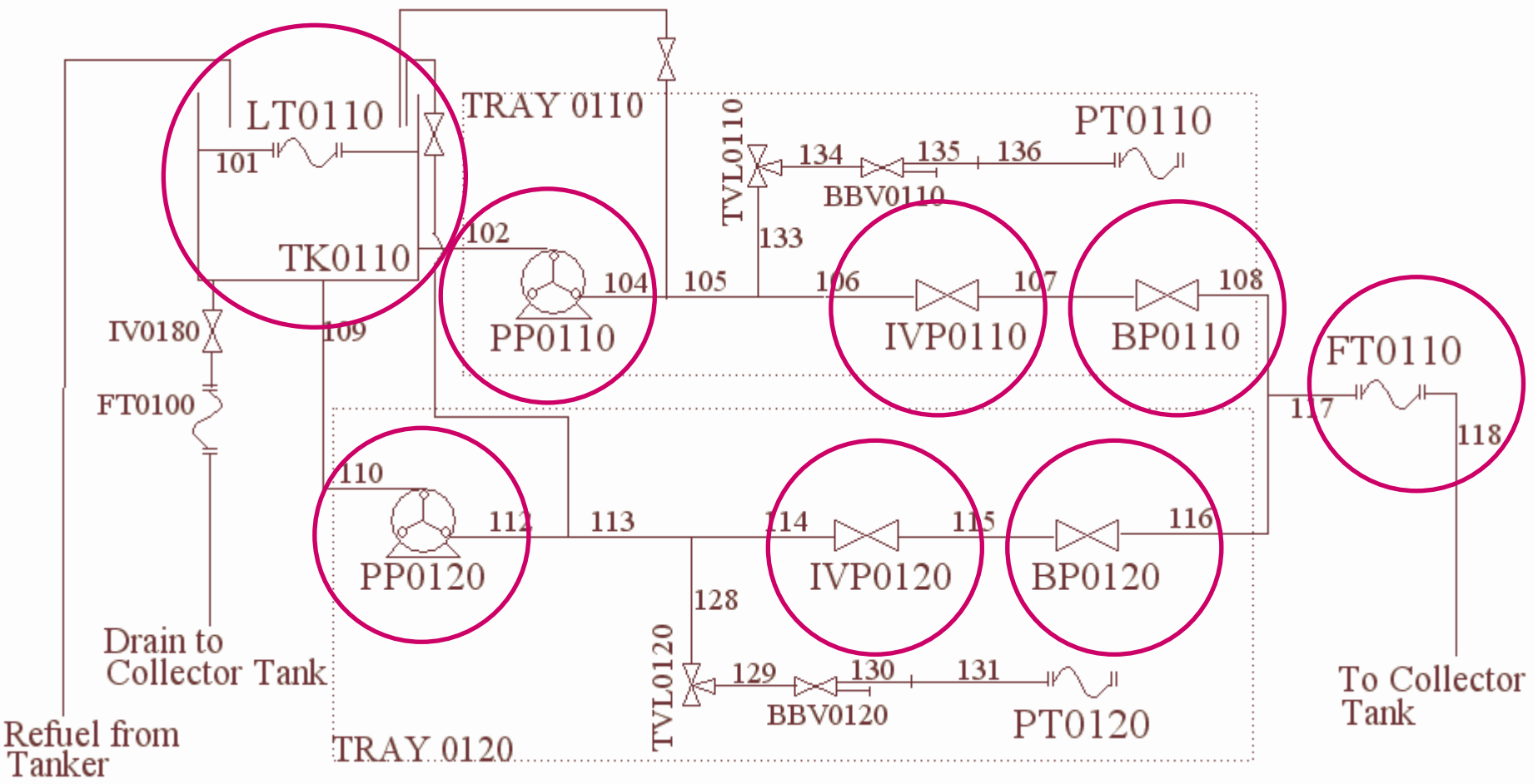
Main Tank Schematic



Operating Modes: Dormant & Active Component Failure Modes: 43

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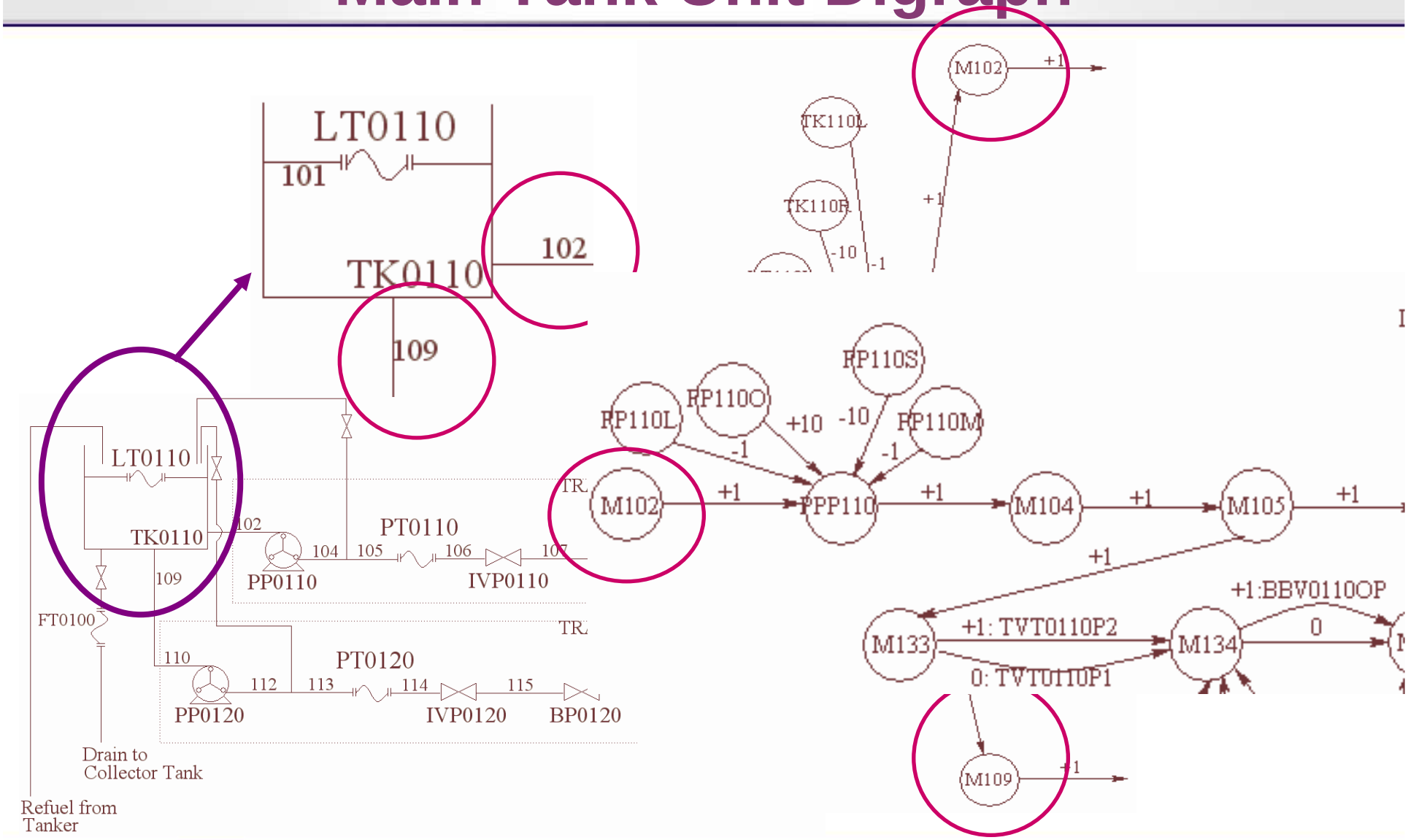
Main Tank Unit Digraph



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Fuel System Digraph

- The unit model for main tank:
  - 242 nodes
    - 43 process variables
    - 199 component failure modes
    - 140 of 199 being pipe failures
- Full system digraph:
  - 3 tanks combined.
  - 842 nodes;
    - 151 are process variable nodes
    - 691 are component failure mode nodes

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Diagnostic Procedure

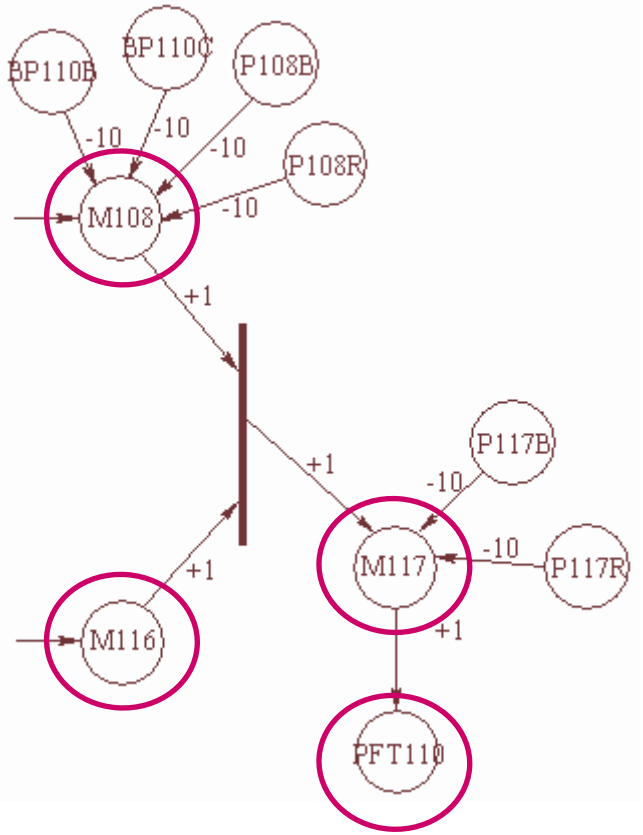
1) Diagnostics is based on comparing retrieved sensor readings with those expected.

2) Given the presence of a deviation, diagnosis involves:
   - Noting the location of the given deviation.
   - Noting the location of non-deviations.
   - Back-trace to find deviation causes.

	LT0110	FT0100	FT0110	PT0110/ PT0120
ACTIVE	>PSO	No flow	**Flow**	Pressure
Retrieved	>PSO	No flow	**No flow**	Pressure

Fault Diagnostics (2)

- PFT110(-10) → M117(-10)
  → P117B, P117R.
- M117(-10)
  → M108(-10) AND M116(-10).
- M108(-10)
  → P108B/R, BP110B/C.
- 83 failure mode options:
  - 2 single order.
  - 81 second order.



Conclusions

- Component failure mode results are consistent with recorded sensor readings.
- Flagging of non-deviating sections removes conflicting results, also reduces number of determined fault combinations.
- Digraph suitable method for steady state diagnostic analysis for fuel tank system.
- Future work: Specific fault identification, dynamics.