Examples of Reverse Engineering

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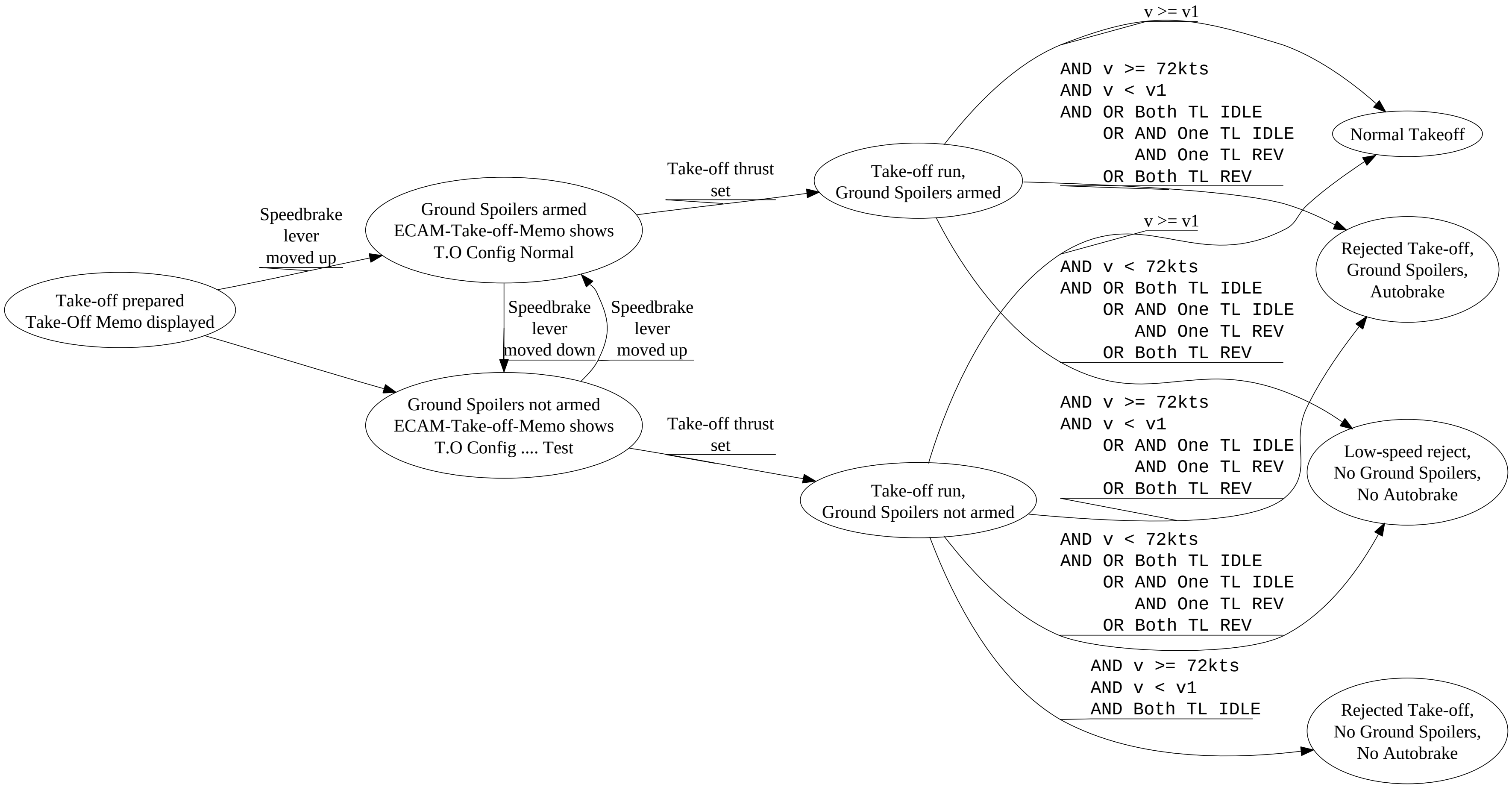
<u>Airbus A320: Rejected Takeoff with one or two Unserviceable Thrust Reversers</u>

Taking into account procedures from the FCOM (Flight Crew Operating Manual) and MEL (Minimum Equipments List) for the Airbus A320 series of airliners, the following Predicate-Action Diagrams have been created.

It turns out that if the standard procedure of arming Ground Spoilers before Take-Off is violated (as may happen, see notes for the diagrams), subsequent correct following of the standard procedure for a rejected Take-Off with two unserviceable thrust reversers (namely not to select reverse thrust on either engine) leads to a a Hazard by not deploying Ground Spoilers.

The second diagram shows the case in which only a single thrust reverser is unserviceable, and in addition to the case for two unserviceable reversers, it takes into account the possibility of asymmetric thrust lever handling. In normal operations, unlike for aircraft with hydromechanical thrust levers, a thrust lever staggering is never used on the A320. In a previous MEL the standard procedure for selecting reverse thrust in case of one unserviceable thrust reverser was to retard both levers to idle, but then select reverse thrust only for the working reverser. As in the case for two u/s thrust reversers, not selecting reverse thrust with unarmed Ground Spoilers presents a hazard, additionally there is the hazard of selecting reverse thrust on one engine while leaving the other engine at (maximum or flexible) takeoff thrust. Retarding only one thrust lever to idle while leaving the other at takeoff thrust, if handled properly, is not a hazard, since the aircraft is certified for one-engine-out takeoff operations, although usually takeoff is rejected if an engine fails before v1.



Notes:

1/ This state machine assumes both reversers inop, which is allowed according to MEL

2/ Not arming ground spoilers for Take-off will be displayed blue in Take-off memo
Bottom line will show TEST in blue.

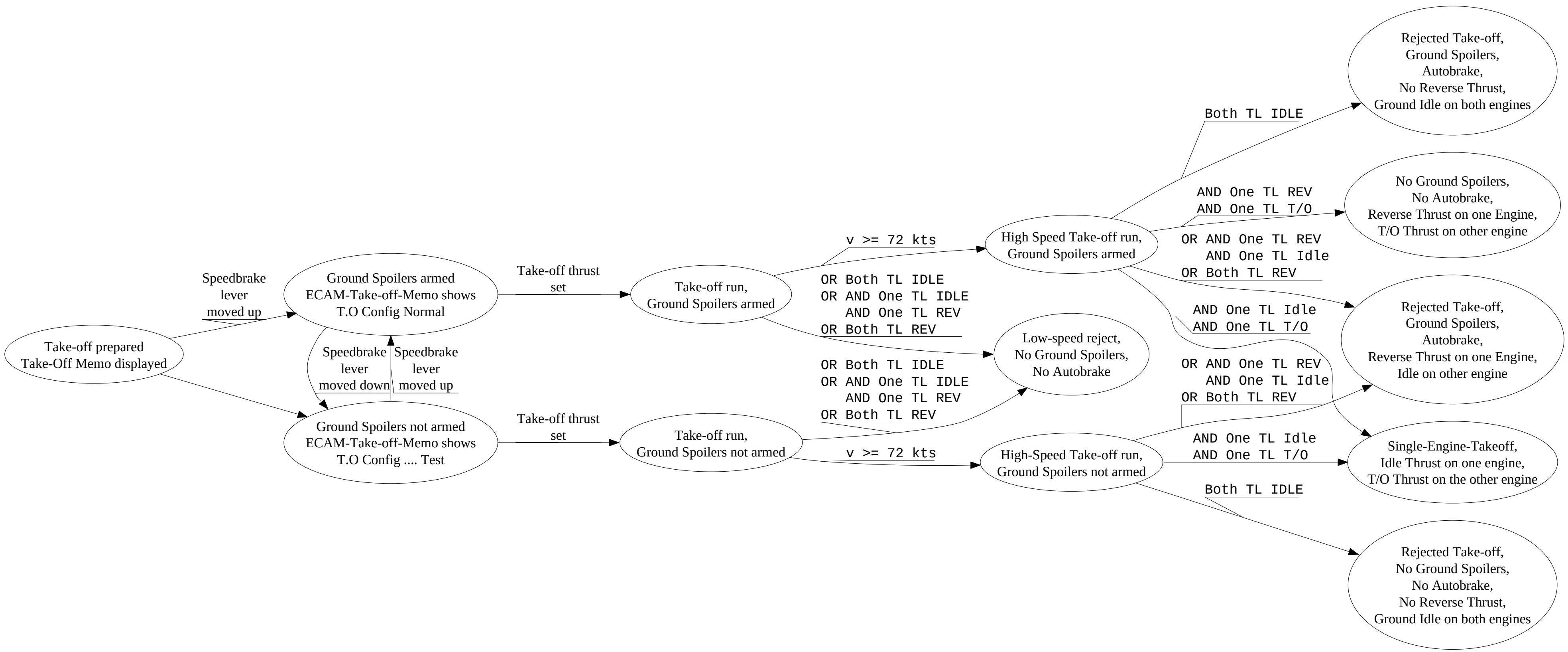
3/ Disarming Ground Spoilers by pushing down the speedbrake lever after T.O
Memo bottom line shows NORMAL will revert SPLRS line to blue.
However, bottom line will continue to show NORMAL in green!
This has been tested in a Fixed-Base Simulator.
Behaviour of actual aircraft may differ.

4/ Not arming ground spoilers for Take-off is a violation of SOP.

5/ Selecting Reverse with both thrust reversers inop is a violation of SOP

6/ Not selecting Reverse thrust on either engine is SOP (MEL) for
A320 with both reversers inop.
Here following a SOP will lead to a rejected Take-off with no ground spoilers
and no automatic brake
This is a Hazard.

7/ Not Arming the autobrake will leave a blue line in ECAM Memo and not change
T.O Config from Test to NORMAL.



Notes:

1/ This state machine assumes one thrust reverser inop, which is allowed according to MEL

2/ ECAM T.O Memo will display T.O CONFIG NORMAL when Ground Spoilers are armed (and all other tasks are done.) Unarming them again will display SPLRS ... ARM (blue), but T.O CONFIG NORMAL remains, and does not revert to TEST (blue).

3/ Not arming ground spoilers for Take-off is a violation of SOP.

4/ Not retarding both thrust levers to idle is a violation of SOP

5/ Not selecting reverse thrust on any engine with operable reverser is a violation of SOP.

Boeing B777: Fuel System

The first diagram is the Causal Control Flow Diagram (CCFD) for the Electronic Engine Control (EEC) of the Boeing B777.

A CCFD is like a functional block diagram, except for three points:

• Signal magnitudes are omitted (we have used signs +/- indicating monotone-increasing and monotone-decreasing influence where necessary, but it is not necessary on this);

•Equipment duplication (usually there to provide redundant pathways) may be omitted, and in this case is (only one instance of each device is shown);

• It will include the human operator as a control-system component if heshe is one

It shows the signal paths between all the various devices.

The following diagrams show fuel flow. The fuel flow diagrams includes the normal fuel flow to engines, as well as the cross-feed system, the scavenge system, the water scavenge system and the jettison system.

The diagram has been split; the first partial graph contains the tanks and the tanks pumps, scavenge and jettison system, the second partial graph details fuel flow inside the engine nacelles.

To keep the size to a minimum and in the interest of clarity the graph contains the following simplifications:

• The APU is not shown in detail

• Multiple fuel spray nozzles are represented by a single node

• Multiple spill valves and fuel bleed lines are represented by a single node

• All 4 crossfeed valves (two on each side) are represented by a single node

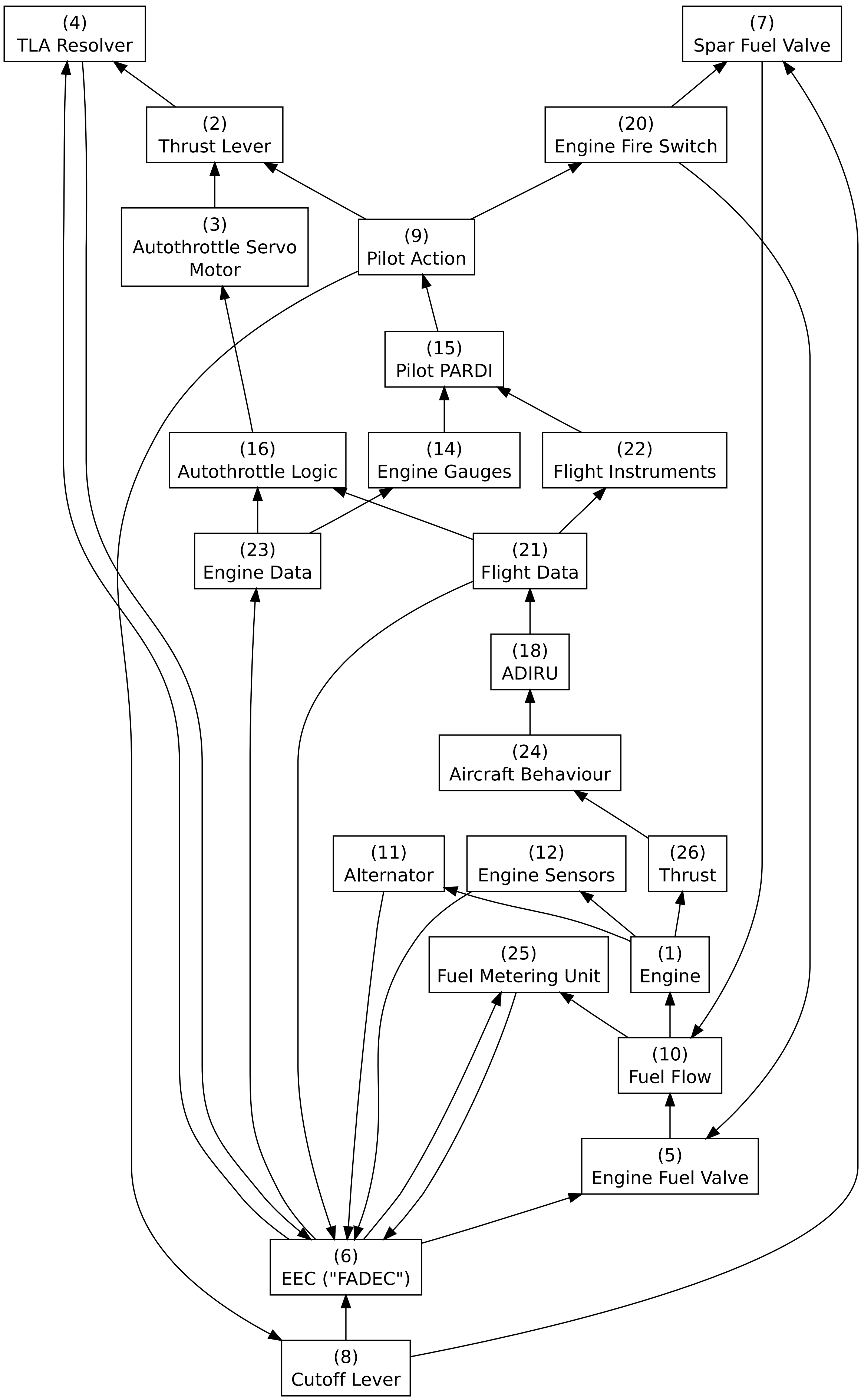
Some details in the fuel flow graph are unverified and may be inaccurate. These include:

• Position of the spill valves

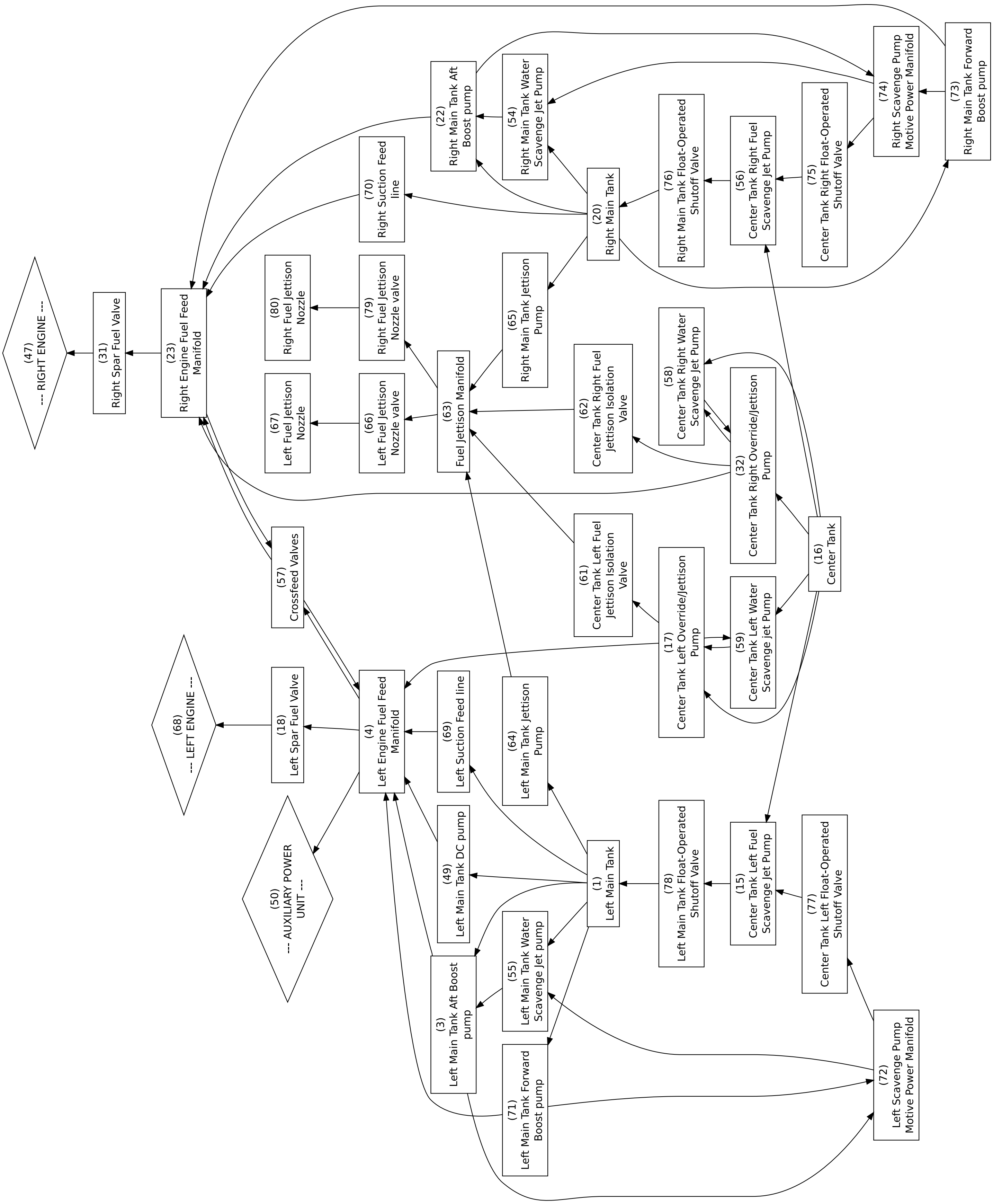
• Fuel bleed return flow

• Position of the (low pressure) Fuel filter

The Causal Control-Flow Diagram



Fuel Flow: Tanks, Crossfeed System, Scavenge Systems, Jettison System



Fuel Flow: Engine