



HIDDEN FAILURE SCENARIOS OF AN AIRCRAFT COLLECTOR FUEL TANK

Heitor Azuma Kagueiama
Federal University of Santa Catarina

Acires Dias
Federal University of Santa Catarina

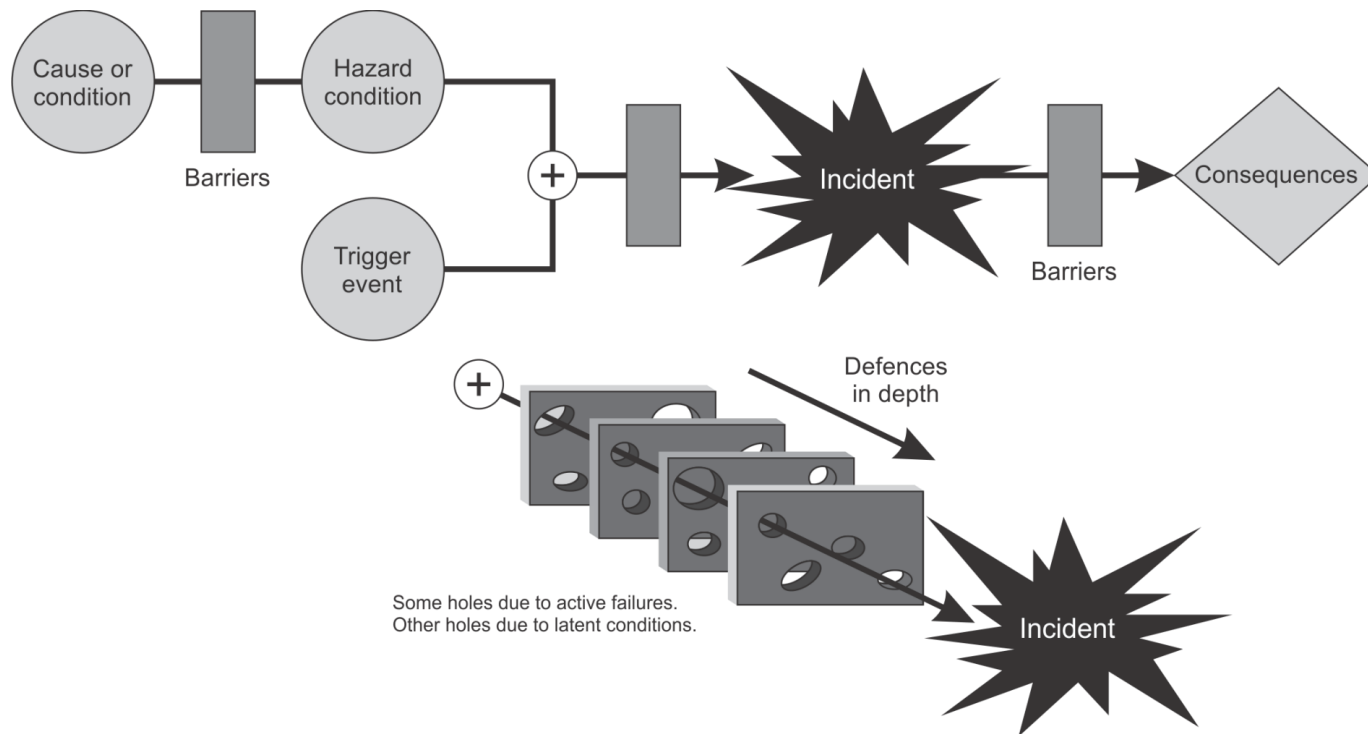
Johan Ölvander
Linköping University

Research goal: characterize and evaluate the occurrence probability of hidden failures to help improve the design of aircraft systems

Paper goal: characterize hidden failures

- Monte Carlo simulation for event time sampling
- Simultaneous occurrence of specific events
- Demonstrate how often the system is exposed to hidden failures

Risk: outcome, likelihood, significance, causal scenario, and population affected



Favarò & Saleh: Observability-in-depth

- Drawback: non-observable events
- Events that are not observable can escalate and compromise the lines of defense

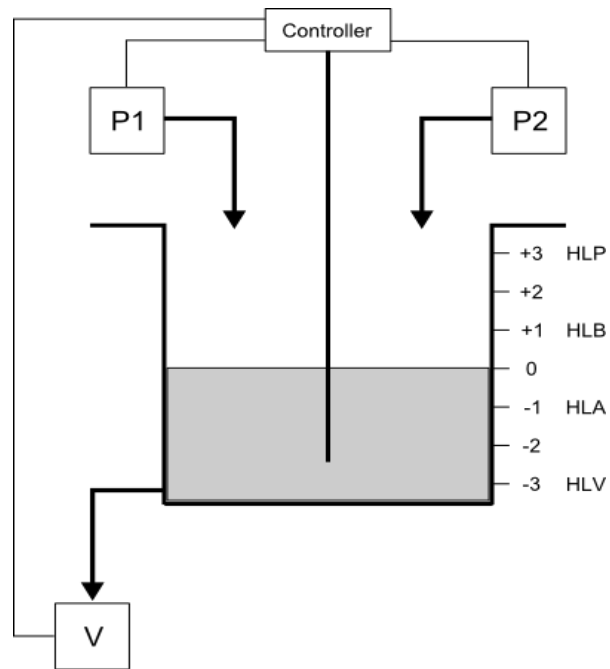
Research contribution: detailed definition of hidden failure

Evident failures: loss of active functions

Hidden failures:

- Not observable until another event occurs
- Characterized by one or more events that compose a fault scenario
- Managed by periodic inspections
- Accumulation of events

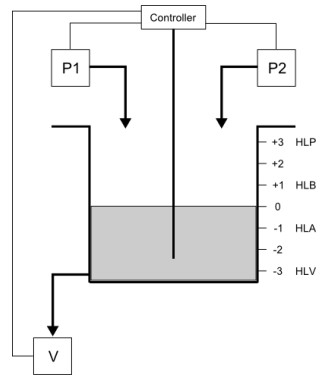
CASE STUDY: BENCHMARK PROBLEM



Configuration	P1	P2	V	Flow (m/h)
1	On	Off	Off	0,6 m/h
2	On	On	Off	1,2 m/h
3	On	Off	On	0,0 m/h
4	On	On	On	0,6 m/h
5	Off	Off	Off	0,0 m/h
6	Off	On	Off	0,6 m/h
7	Off	Off	On	-0,6 m/h
8	Off	On	On	0,0 m/h

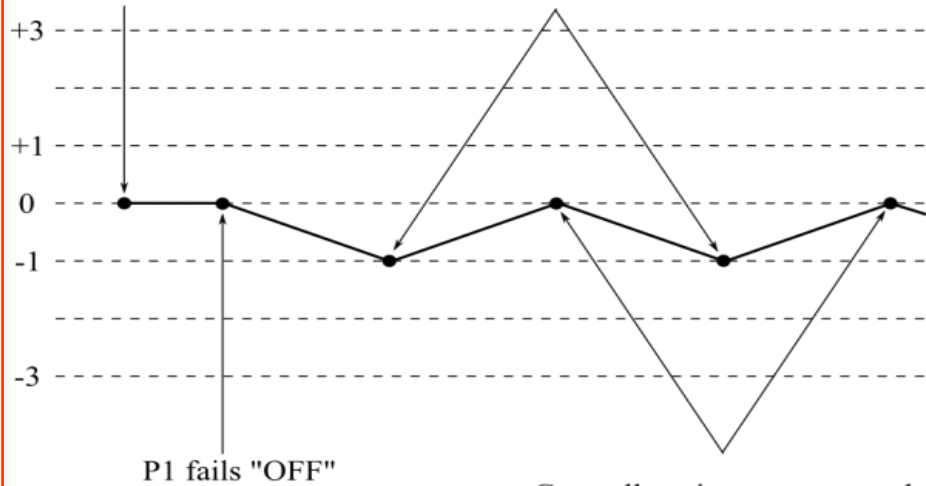
Component	Failure rate (failure/h)	Flow rate (m/h)
P1	0,004566	0,6
P2	0,005714	0,6
V	0,003125	-0,6

CASE STUDY: BENCHMARK PROBLEM



Normal condition:
P1 "ON", P2 "OFF" and
V "ON"

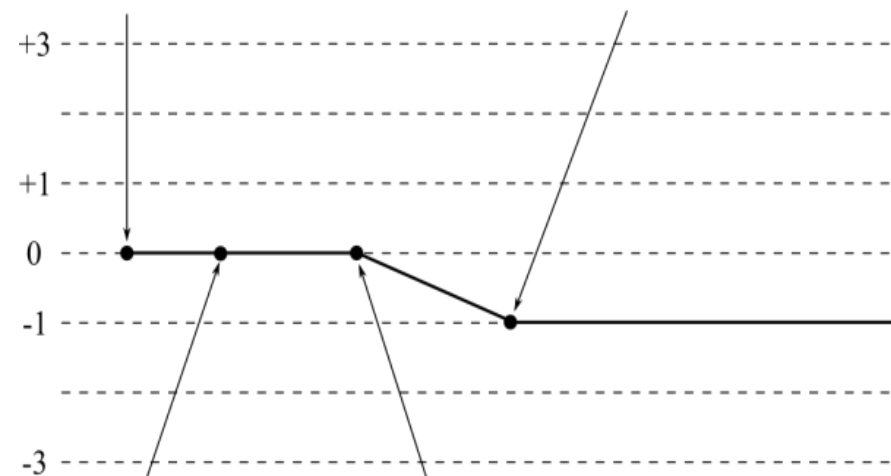
Controller triggers command:
Turn on P1 (failed), Turn on P2
and turn off V



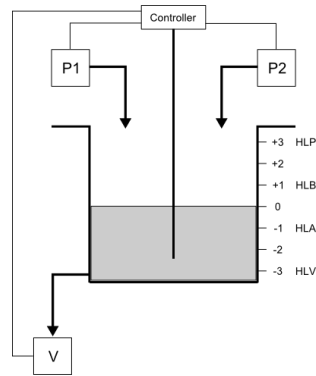
Controller triggers command:
Turn on P1 (fails), turn off P2
and turn on V

Normal condition:
P1 on, P2 off and
V on

Controller triggers command:
P1 on (fails), P2 on (fails) and
V off

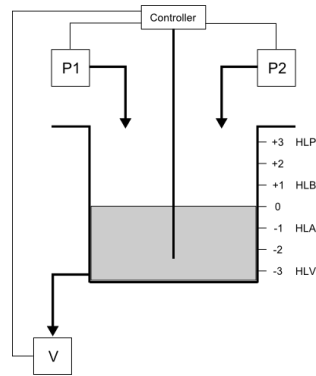


CASE STUDY: BENCHMARK PROBLEM



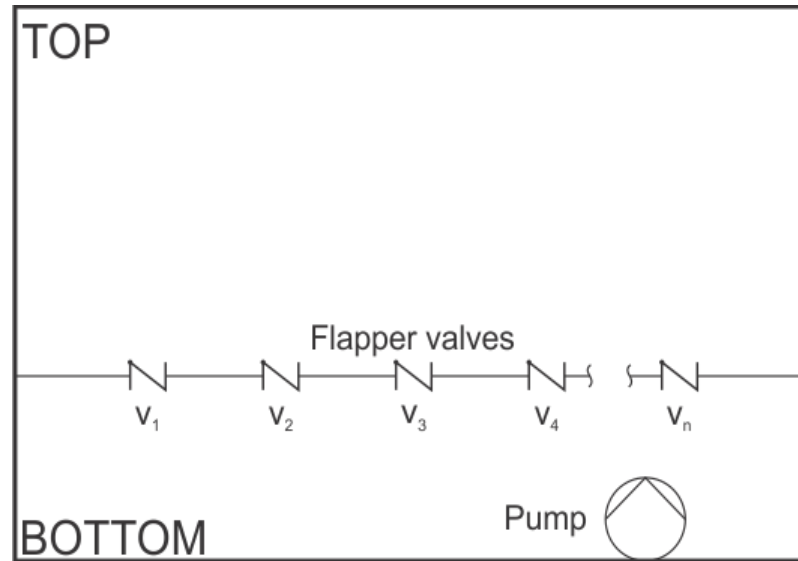
Sample	P1		P2		V	
	Failure time (h)	Failure mode	Failure time (h)	Failure mode	Failure time (h)	Failure mode
1	421,30	Off	182,94	On	116,57	On
2	278,54	On	179,89	On	19,82	Off
3	7,77	On	376,07	Off	398,91	Off
4	230,89	Off	332,71	Off	333,62	On
5	240,72	Off	257,82	On	51,87	Off

CASE STUDY: BENCHMARK PROBLEM



Time (h)	Fluid level (m)	Event description
0,00	0	Original condition, P1 on, P2 off, V on
116,57	0	Hidden failure of V, on
182,94	0	Evident failure of P2, on
184,61	+1	Controller actuates, P1 off, P2 on, V on; level stable
421,30	+1	Evident failure of P1 off

CASE STUDY: COLLECTOR TANK

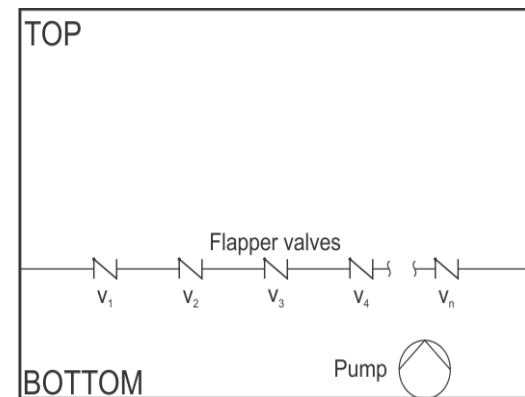


Collector tank: pump always submerged

- Allow inverted flight
- Avoid fuel gas suction
- Pump cooled by the fuel

Collector tank:

- Two sections connected by flapper valves
- Pump with two intake sections
- Sustain a 10s inverted flight with after burner
- No maintenance
- 2000 flight hours life
- Valve failure rate 0,00041 failures/flight hour



Collector tank:

Valve 1	Valve 2	Valve 3	Valve 4	Valve 5
1337	4693	4758	2149	5824
510	32	330	34	2325
1295	218	620	5050	645
1583	2173	2316	1028	163
2912	642	2353	1214	5490

CONCLUSIONS

- Useful during design and use phases
- Dynamic aspects are important for the definition of hidden failures
- Useful to evaluate maintenance performance
- Flight profile is determinant
- Different hidden failure scenarios besides the redundant and protection systems

THANK YOU

heitor.kagueiama@liu.se