Failure-Modes-and-Effects Analysis (FMEA)

- Assessment of potential effects of component failure
- Performed during design
- Variant problem
  - versions of subsystems
- Safety critical application
  - completeness of results

- component centred model-based reasoning
- engineering tasks on electrical systems
  - Simulation
  - Failure modes and effects analysis (FMEA)
  - Sneak circuit analysis
- Commercially available product
  - Adopted by Ford world wide as part of product development process

Example: Airbag System
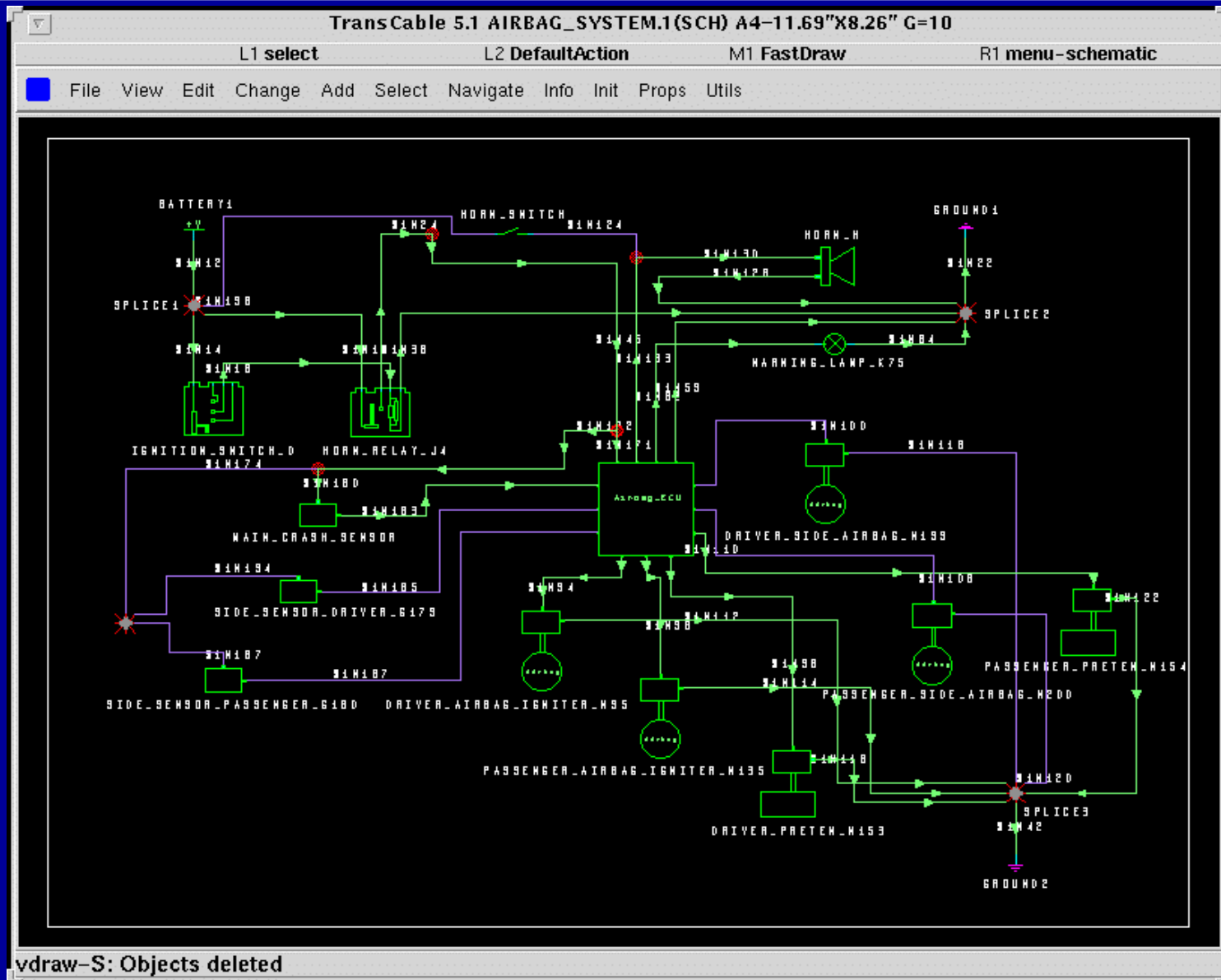
Performing FMEA with AutoSteve

1. Airbag circuit drawn in engineer's normal ECAD tool
2. Check all components have AutoSteve definitions (behavior failures)
3. Set up functions of circuit
4. Link functions to schematic
5. Set up scenario for testing the circuit
6. Run scenario for all failures, to generate FMEA report
7. Check FMEA report

- Simulation: state of each component at any point in time - too much detail.
- Important: function - characteristic overall behavior
- E.g. for airbag system:
  - Horn activated
  - Front airbags activated
  - Side airbags activated ...
- Recognised by circuit activity
  - current flow

Result: FMEA Report

FmeaEditor V2.0

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Name	Failure	Potential Failure Mode	Potential Failure Effect	Potential Failure Cause	Sev	Det	Occ	RPN
		activity.		continuously .				
HORN_H	Horn fails to sound	Regardless of any event change, the "Horn sounds" function was never achieved.	Horn fails to sound.	The component HORN_H has failure horn fails to sound .	2	10	4	80
HORN_RELAY_J4	switch stuck closed	When IGNITION_SWITCH_D was set to Off (5) the "Horn sounds", "Warning Lamp illuminates" and "Frontal Bag & Belts fired" functions were achieved unexpectedly.	Horn sounds unexpectedly. Lamp illuminates unexpectedly. Possible death of occupants if seated incorrectly.	The component HORN_RELAY_J4 has failure switch stuck closed .	10	10	1	100
HORN_RELAY_J4	switch stuck open	When MAIN_CRASH_SENSOR was set to detected (4) the "Horn sounds" function was not achieved. Finally, regardless of any event change, the "Warning Lamp illuminates" and "Frontal Bag & Belts fired" functions were never achieved.	Lamp fails to illuminate. Possible death of occupants.	The component HORN_RELAY_J4 has failure switch stuck open .	10	10	2	200
HORN_RELAY_J4	coil burned out	When MAIN_CRASH_SENSOR was set to detected (4) the	Lamp fails to illuminate. Possible death of occupants,	The component HORN_RELAY_J4 has failure coil burned out .	10	10	3	300

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Example: Sneak Circuit
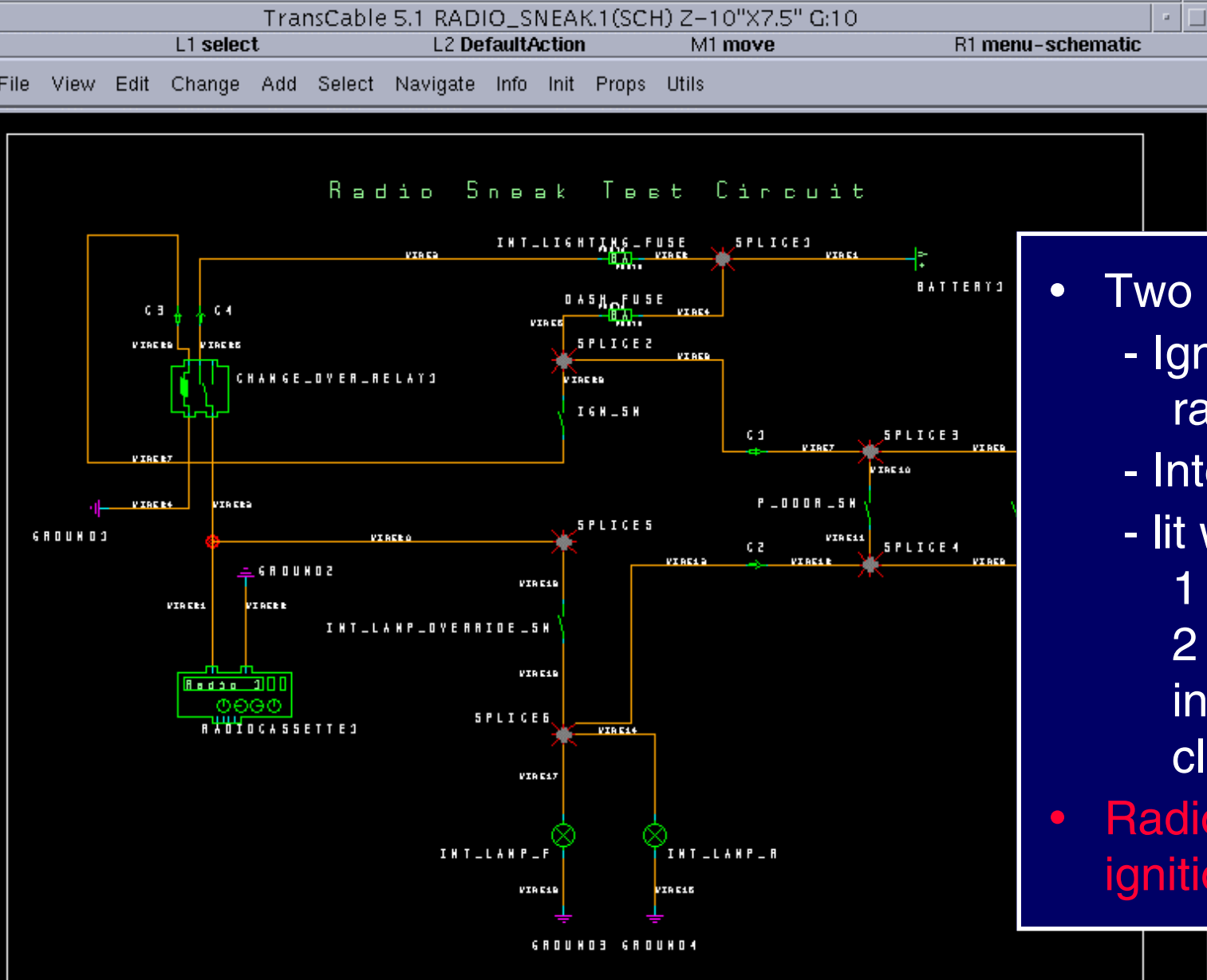
- Two systems
  - Ignition-switched radio cassette
  - Interior lamps:
  - lit when
    1 door open
    2 ignition on and interior switch closed
- Radio on when ignition not on!

Performing Senak Circuit Analysis with AutoSteve

- Detects unintended interaction
- Needed: intended input conditions for functions
- Simulation for all switch settings
  - no failures
- Sneak condition: functions
  - occurring when they should not
  - not occurring when they should

1. Airbag circuit drawn in engineer's normal ECAD tool
2. Check all components have AutoSteve definitions (behavior, failures)
3. Set up functions of circuit
4. Link functions to schematic
5. Declare correct activation of functions
6. Run sneak circuit tool
7. Look at sneak results

Benefits of AutoSteve

- **Rapid** production of FMEA reports
- **Timely** production of FMEA reports
    - Much earlier than is possible without qualitative reasoning
- **Consistent, complete** production of FMEA reports
- Use of results for incremental FMEA, diagnosis