Error Modeling in COMPASS

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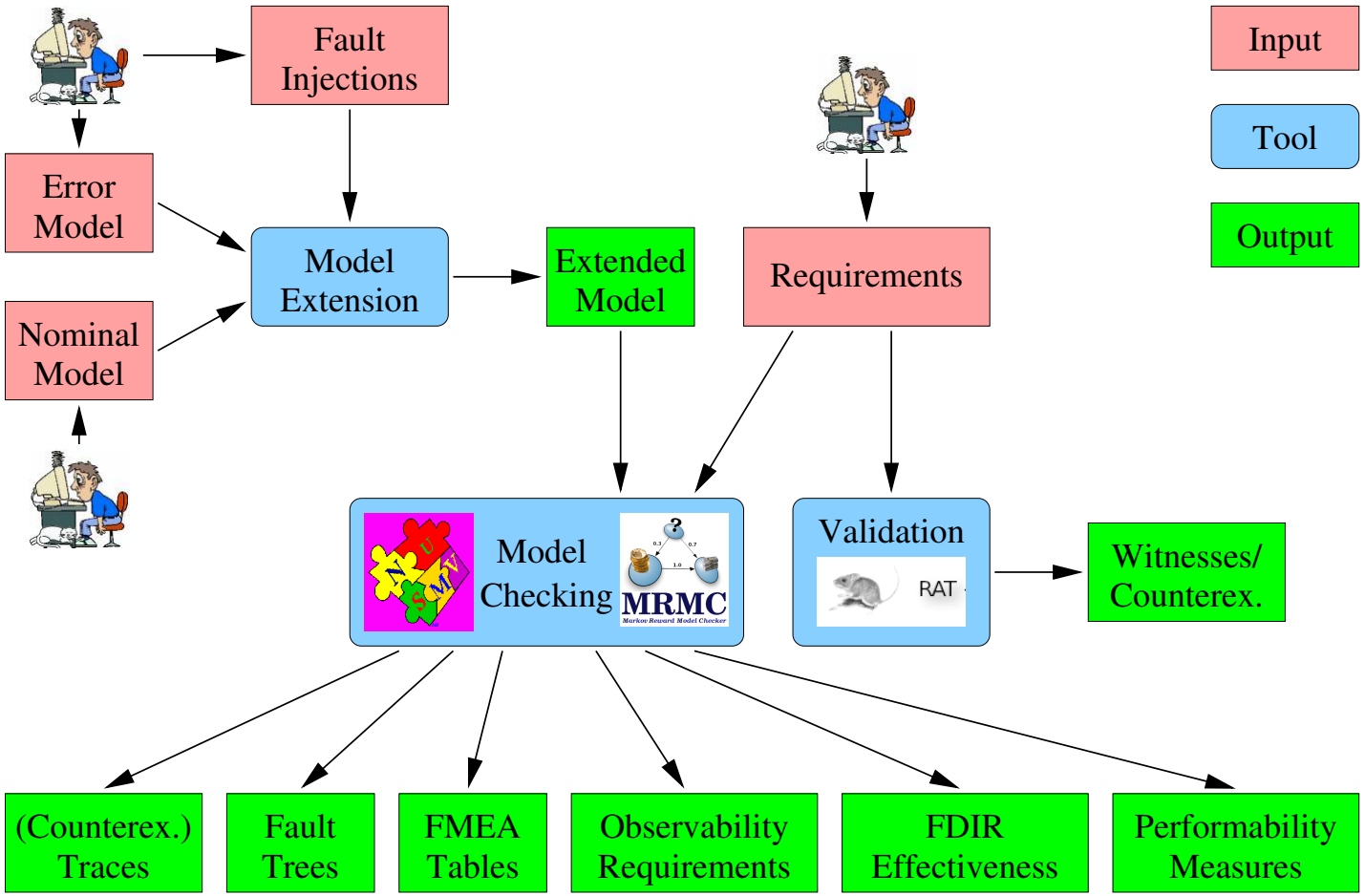
Software Modeling and Verification Chair
RWTH AACHEN UNIVERSITY

COMPASS Methodology

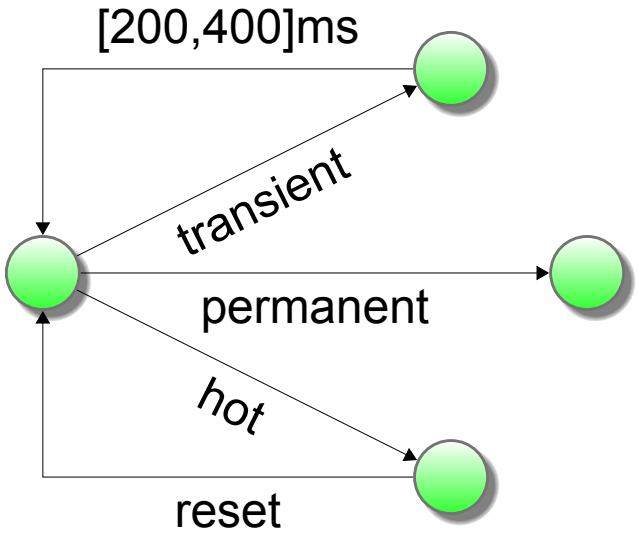


Error Models

Example

Error model with transient, hot and permanent faults/failures

- Transient: Recovery after some delay;
- Hot: Recovery after restart/reset of device;
- Permanent: Recovery not possible, device lost.



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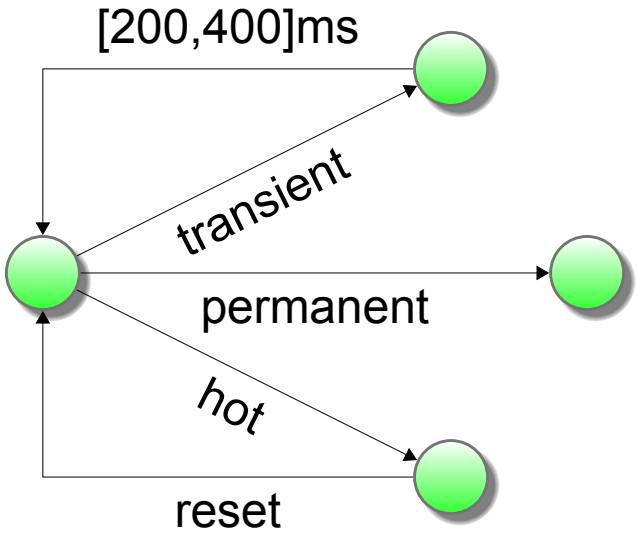

Probabilistic error occurrences : Faults happen after some random delay.

Error Models

```
-- Error model with transient, hot and permanent failures
error model gpsError
    features
        nok : out error propagation;
end gpsError;

error model implementation gpsError.i
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        transient_fault        : error event occurrence poisson 0.001 per hour;
        hot_fault              : error event occurrence poisson 0.001 per day;
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    states
        ok                     : initial state;
        transient_failure_prop : error state;
        transient_failure      : error state urgent in 400 msec;
        hot_failure_prop       : error state;
        hot_failure            : error state;
        permanent_failure_prop : error state;
        permanent_failure      : error state;









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        hot_failure_prop       : error state;
        hot_failure            : error state;
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        permanent_failure      : error state;
    transitions
        ok                     -[ transient_fault               ]-> transient_failure_prop;
        transient_failure_prop -[ nok                           ]-> transient_failure;
        transient_failure      -[ nok within 200 msec to 400 msec ]-> ok;
        ok                     -[ hot_fault                     ]-> hot_failure_prop;
        hot_failure_prop       -[ nok                           ]-> hot_failure;
        hot_failure            -[ @activation                   ]-> ok;
        transient_failure      -[ @activation                   ]-> ok;
        ok                     -[ permanent_fault               ]-> permanent_failure_prop;
        permanent_failure_prop -[ nok                           ]-> permanent_failure;
end gpsError.i;
```
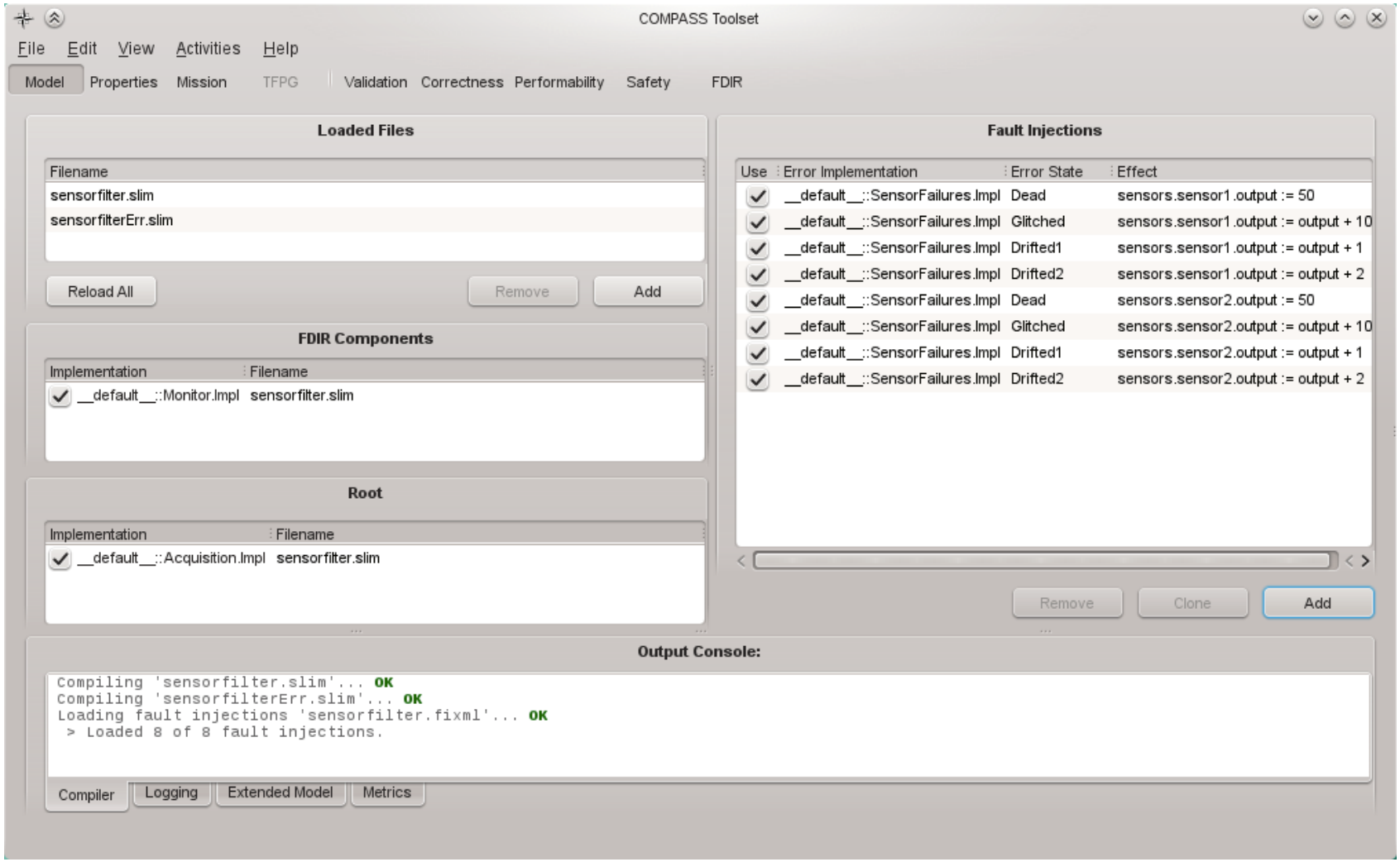

Tool Support



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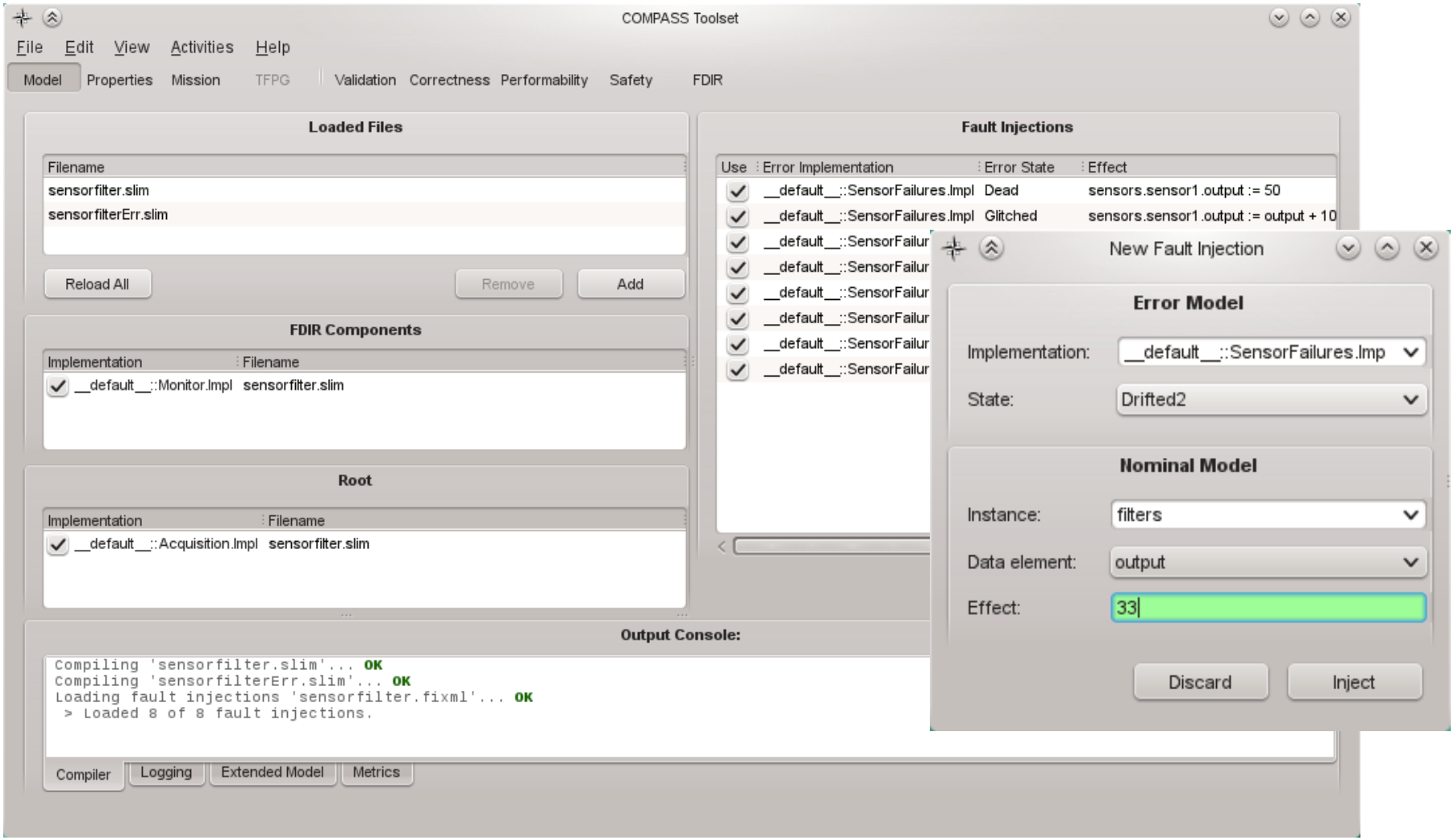
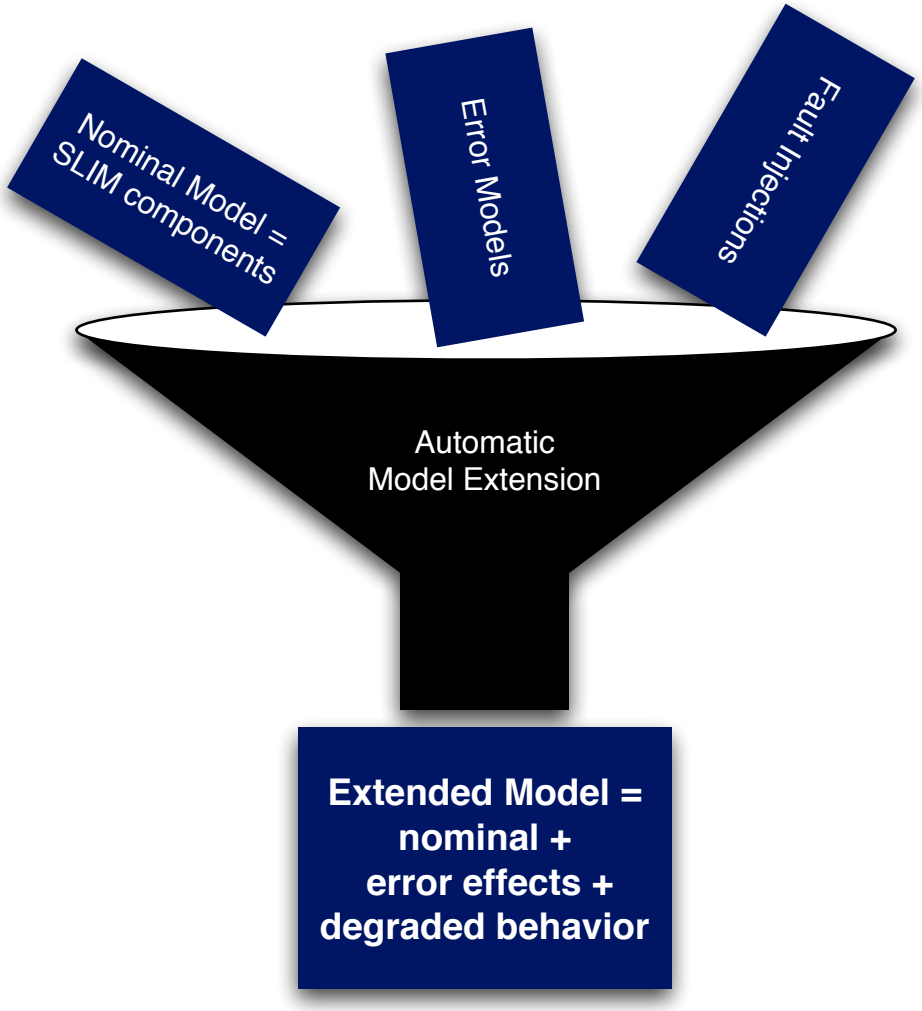
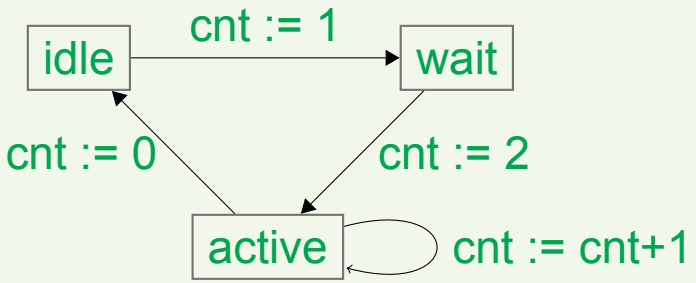


Integrating Erroneous and Nominal Behaviour

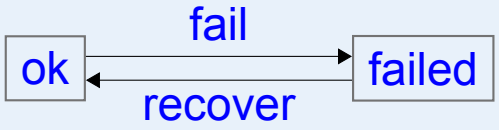


Model Extension by Example

Nominal behaviour

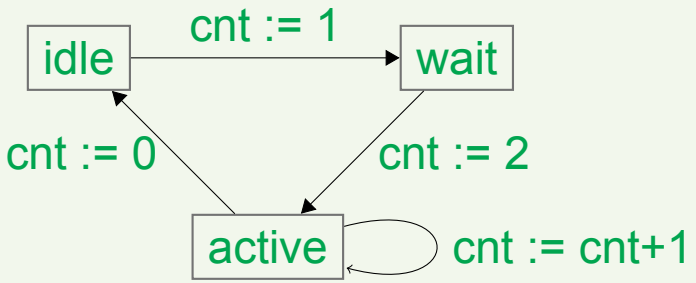


Error behaviour



Model Extension by Example

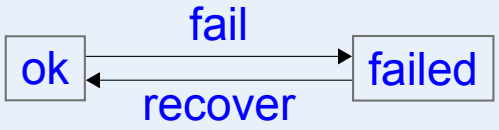
Nominal behaviour



Fault injection

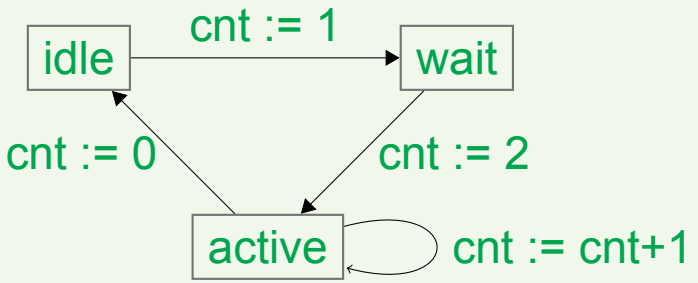
failed: cnt := -1

Error behaviour



Model Extension by Example

Nominal behaviour



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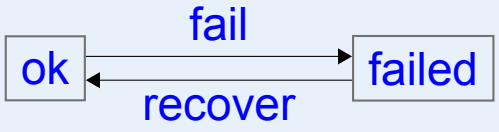
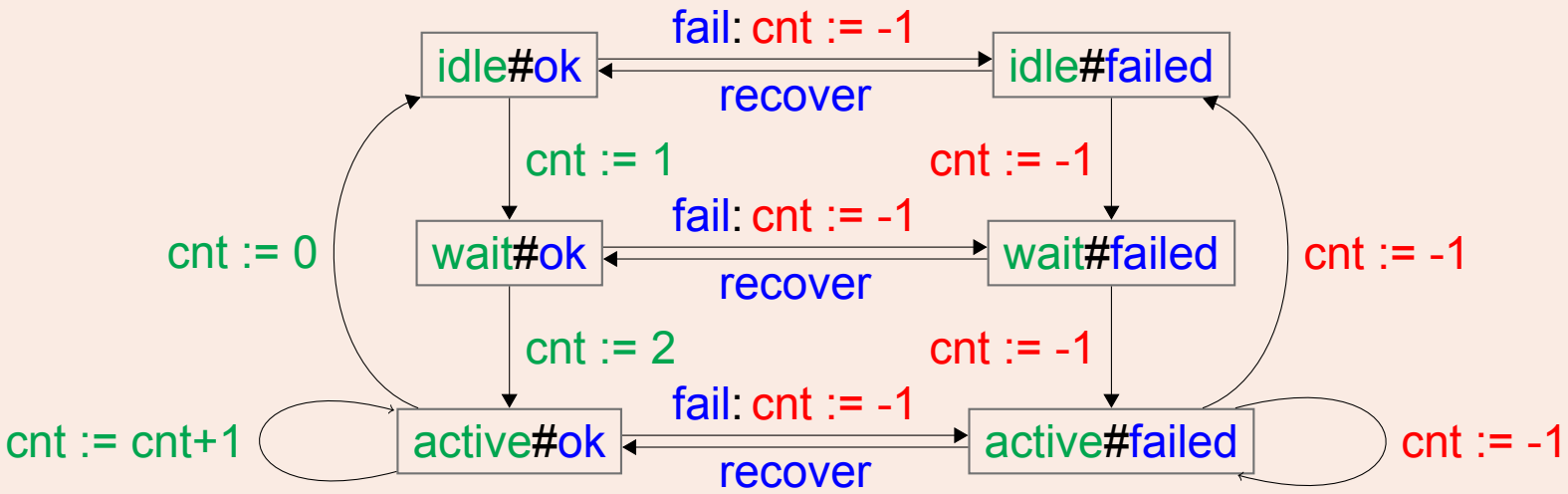
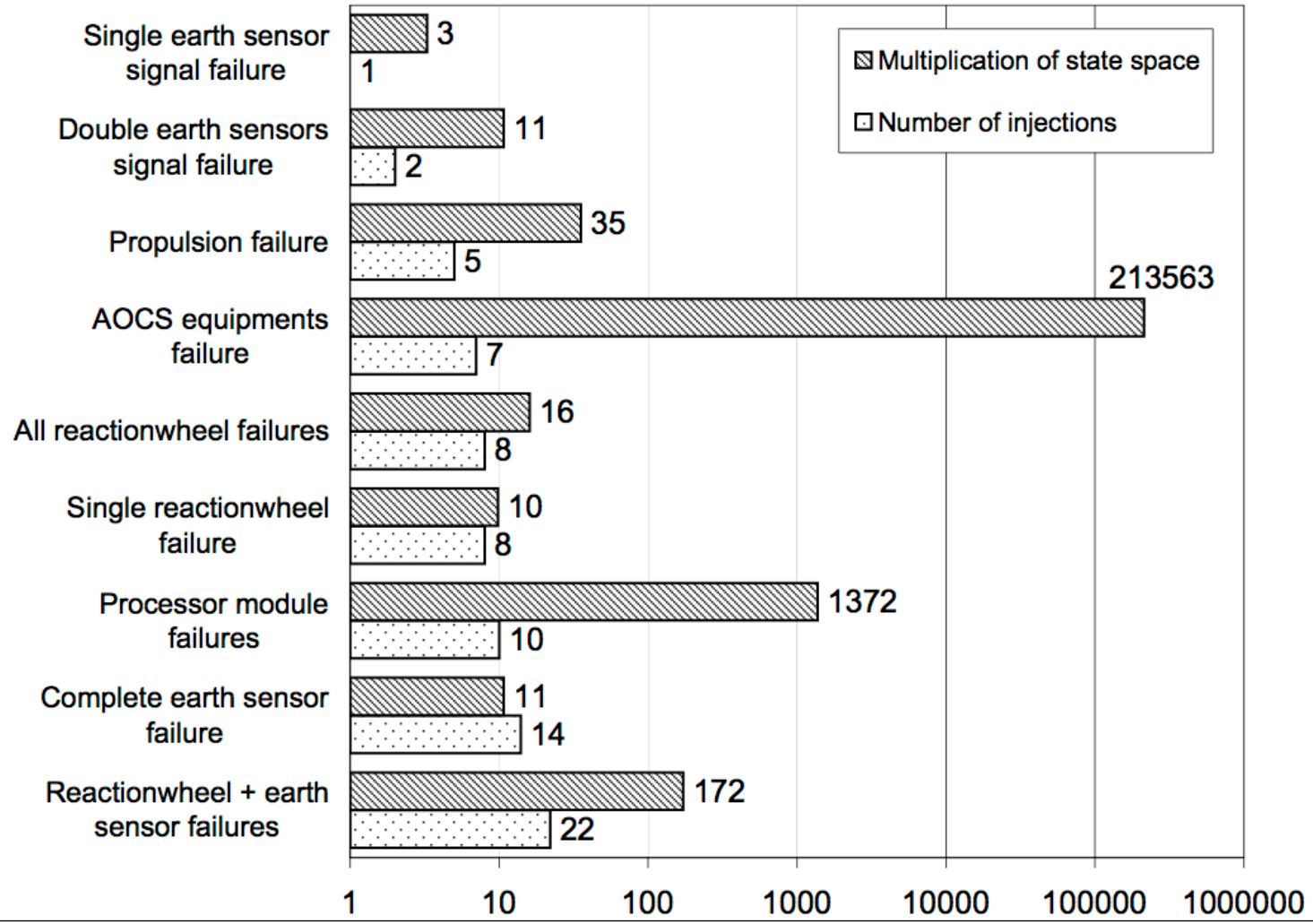


Extended model



Effect of Fault Injections (from Satellite Case Study [ICSE 2012])



Contribution to AADL Error Model Annex (V2): Error State History

- EMA:

```
initial error state | error state
```

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- EMA:

  `initial error state` | `error state`

- COMPASS:

  `initial state` | `activation state` | `error state`

  - `initial state`: like `initial error state`, but supporting error state history
    - after reactivation of component, error model resumes error state from last deactivation
    - appropriate for hardware components
  - `activation state`: like `initial error state`, but without error state history
    - after reactivation of component, error model reset to activation state
    - appropriate for software components
  - `error state`: like EMA `error state`

Possible Future Extensions

Current fault injection mechanism

s: $d := f$ means that while being in error state s, the assignment $d := f$ is active, where d is a data element and f the fault effect.

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s: $d := f$ means that while being in error state s, the assignment $d := f$ is active, where d is a data element and f the fault effect.

Possible extensions to increase expressiveness and usability

- Transient fault effects
  - only when entering state s, the assignment $d := f$ is performed
- Error-triggered nominal transitions
  - error transition $s \rightarrow s'$ causes mode transition $m \rightarrow m'$
- Disabling of nominal transitions
  - while being in error state s, nominal event e is disabled

The End