



Ageing Simulation Tutorial

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life.augmented

TRD / STD / TPS / *Electrical Characterization & Reliability*

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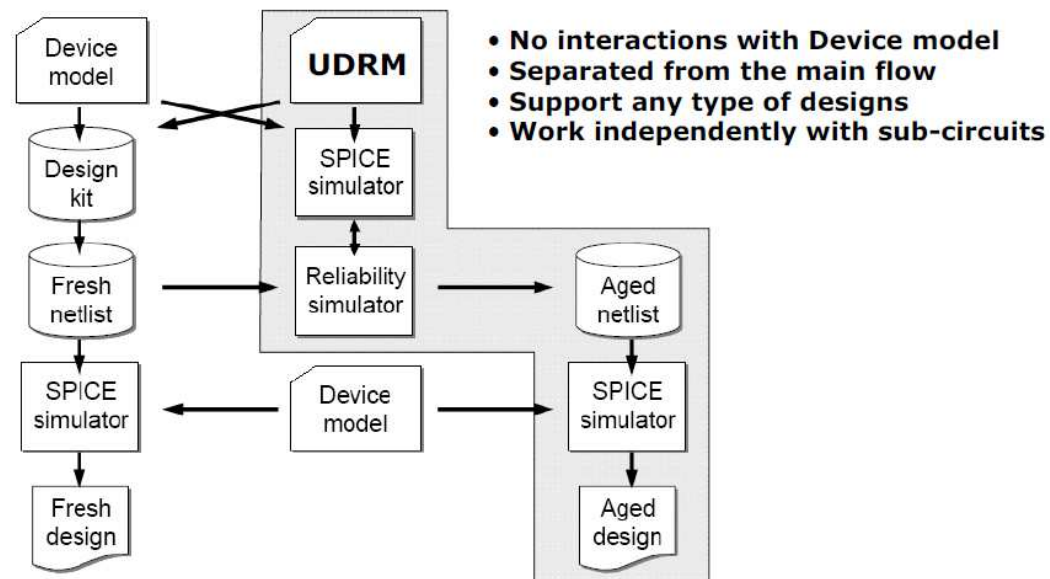
Device to Product Reliability

Design-In-Reliability

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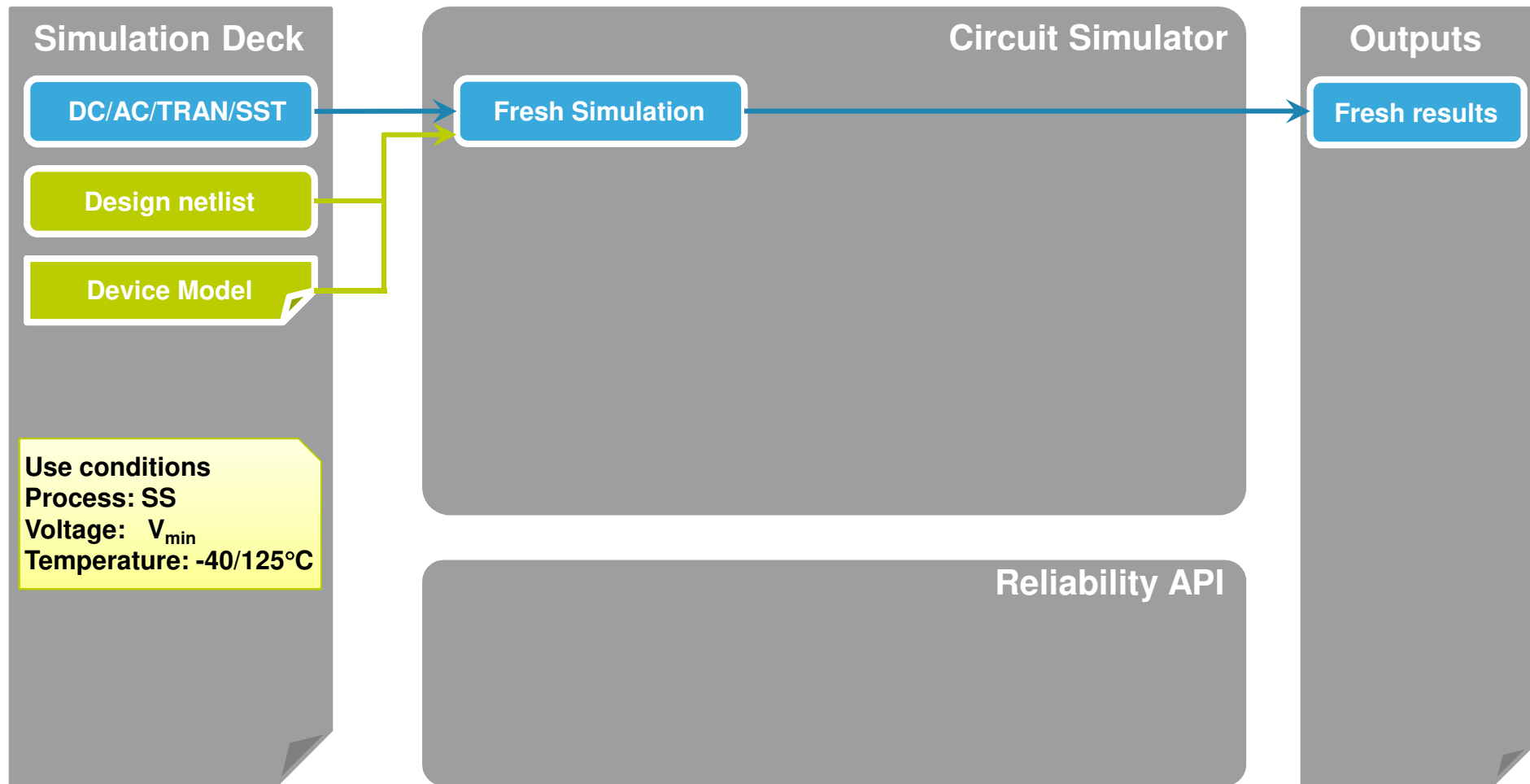
- **Ageing simulation**

- Simulator is eldo, hspice, spectre
- Supported platforms: RH60
- Supported technologies: from C065LP (limited to eldo) to C028FDSOI
- Supported reliability models: Hot Carrier Injection, Bias Temperature Instability and Time Dielectric Dependent Breakdown



Reliability Simulation Flow – Step 1

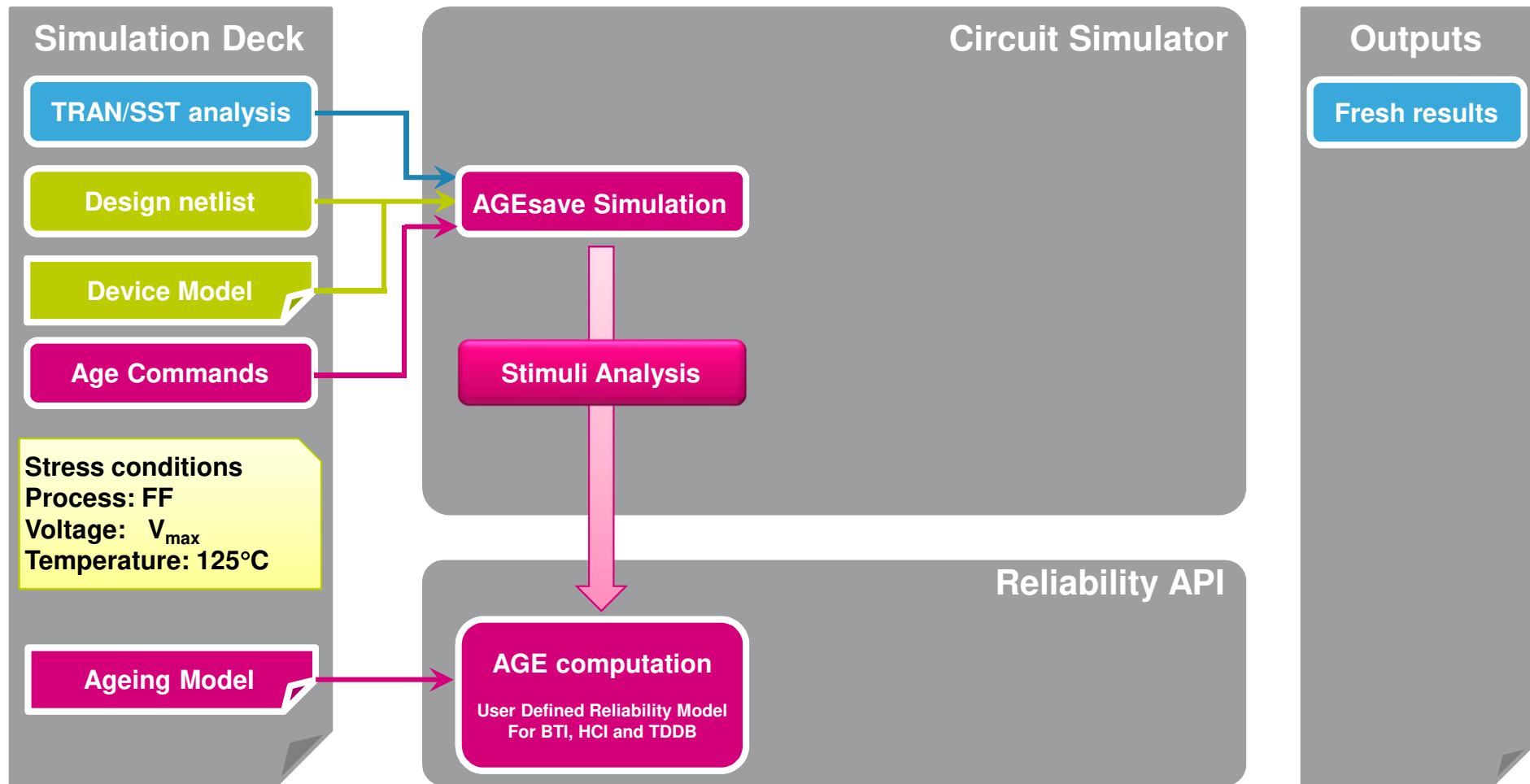
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Reliability Simulation Flow – Step 2

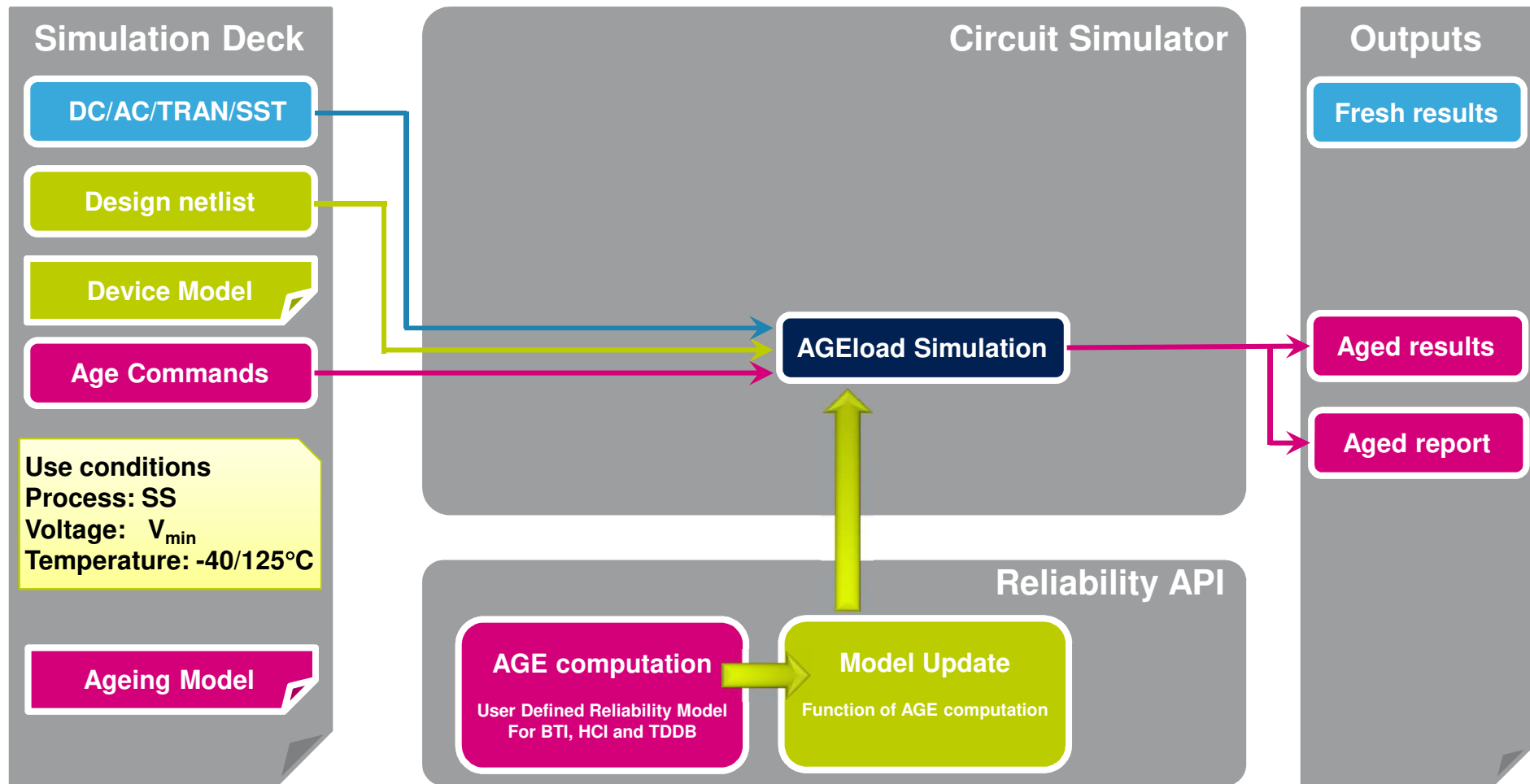
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Reliability Simulation Flow – Step 3

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Tutorial: typical eldo netlist

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- Include models

```
.lib $MODELS_PATH/LPmos_psp_lvt.lib LVTLP_TT
```

```
...
```

```
.lib $MODELS_PATH/age.lib all      Include library of ageing models
```

- Power definition and signals

- Circuit

```
XM1_LVT INT_LVT A_LVT VMINUS VMINUSP nlvtlp w=0.225 l=0.04  
XM2_LVT INT_LVT A_LVT VDD_LVT VDD_LVT plvtlp w=0.225 l=0.04  
XM3_LVT Z_LVT INT_LVT VMINUS VMINUSP nlvtlp w=0.225 l=0.04  
XM4_LVT Z_LVT INT_LVT VDD_LVT VDD_LVT plvtlp w=0.225 l=0.04  
CC_LVT Z_LVT 0 1f
```

- Ageing options

```
.age  
+TAGE=10
```

Add dedicated options for ageing (see next slide)

```
...
```

- Analysis and probe/extract options

```
.tran 1p 10n  
.probe tran i v
```

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Tutorial: eldo options

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- 2 Simulations are needed (separated by .alter)
 - First one with **mode=save**. Waveform are analyzed and degradation is computed
 - Second one with **mode=load**. Simulation of degraded performance

```
.age TAGE=5 Time of projection
+ TUNIT=Y Unit of time of projection
+ NBRUN=1
+ HCI=1
+ BTI=1
+ TDDDB=1 } Activation degradation mechanisms
+ LOG
+ MODE=SAVE
+ AGELIB=stress_5yrs.lib ASCII
+ TSTART=2n
+ TSTOP=3n } Time windows of integration
+ AGEALL
+ COMPUTE_LAST=NO
+ AGEDSIM=0
+ PLOT=ALL
+ TRELAX=0
+ CIRCUIT_REPORT = 1
+ AREA_SCALING= 100
```

*Generation of AGED_REPORT.log
Scaling factor for TDDDB analysis (IP
multiplicity at SoC level)*

```
.age
+ MODE=LOAD
+ AGELIB=stress_5yrs.lib ASCII
+ AGEALL
+ COMPUTE_LAST=NO
+ AGEDSIM=YES
+ PLOT=ALL
+ TRELAX=0
```

Tutorial: hspice format

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- 2 Simulations are needed

- First one with **simmode=0**. Waveform are analyzed and degradation is computed
- Second one with **simmode=1**. Simulation of degraded performance

```
.option mraapi = 1
.option appendall
.option nomod= 1
.option macmod=1
.option radegfile = stress_5yrs.radeg
.mosra
+ reltotaltime = 5 yr
+ relstep = 1 yr
+ simmode = 0           0 (save)/ 1 (ageing)/ 2 (all)
+hci= 1
+bti= 1
+tddb=1
+agingstart= 2e-9
+agingstop= 18e-9
+trelex= 0
+area_scaling=100
+circuit_report = 1
```


Tutorial: spectre format

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- 2 Simulations are needed
 - First one with **simmode type=stress**. Waveform are analyzed and degradation is computed
 - Second one with **simmode type =aging**. Simulation of degraded performance

```
simulator lang = spectre
parameters hci= 1
parameters bti= 1
parameters tddb= 1
parameters trelax= 0
parameters area_scaling = 100
parameters circuit_report= 1
//parameters path_report="./../psf/"
```

```
simulator lang = spectre
rel reliability {
age time=[5y]
simmode type = all stress / aging / all
uri_lib "../FRESH_DEVICE/age/%B/libURI.so
report_model_param value=yes
tran_stress tran start =0n stop=20n write="spectre.ic" writefinal="spectre.fc" annotate=status maxiters=5
tran_aged tran start =0n stop=20n write="spectre.ic" writefinal="spectre.fc" annotate=status maxiters=5
}
```

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TDDDB results

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- All informations stored in AGED_REPORT.log file:
 - TDDDB failure rate informations (also available in the terminal in prompt)
- TDDDB model is implemented in addition with BTI/HCI, it enables to address:
 - Transient and static violation of V_{gs}/V_{ds} , time to breakdown determination
 - Failure rate of the circuit (FIT and ppm calculation) assuming a scaling factor

```
AGED_REPORT.log - /prj/dirst/CMOS040LP/EXTRACT/ (on gn5342)
File Edit Search Preferences Shell Macro Windows Help

***** Report of circuit ageing *****

DEVICE "vth shift (mV)" "mobility degradation (%)"
XCKT.XM1.M1 39 0

***** Estimation of the failure rate of the rescaled netlist *****
*
* The Failures In Time (FIT) rate of a device is the number of failures that
* can be expected in one billion (10^9) device-hours of operation, e.g. 1000
* devices for 1 million hours, or 1 million devices for 1000 hours each, or
* some other combination. Typical range of expected FIT:
* - Non-automotive products: 10 to 100 FIT
* - Automotive products: 0 to 10 FIT
* Note that FIT calculation is only induced by Time Dependent Dielectric
* Breakdown. Please compare the result with specifications required by
* Design Platform.
*
Total TDDDB induced failure rate = 0.00141573 (FIT)
* Total TDDDB induced failure rate = 0.12402 (ppm)
* off-state TDDDB = 0 (FIT)
* on-state TDDDB = 0.00141573 (FIT)
```

```
xterm (on gn5342)
*****
Simulation progress : 100% (t = 10,000 N)
Elapsed CPU time : 0h 0mn 0s 0 ( 0h 0mn 0s 0)
CPU Usage : 100% ( 0%)

***>Current simulation completed

SIMULATION INFORMATION
memory size allocated in Mbytes 86.1
Latency: 0.000000%
average number of newton iterations: 1.000000
nb of components: 9
nb of nodes: 24
nb of MOS or BIP calls: 16
Number of steps computed: 33

***>CPU TIME 0s 000ms <***

***> Failure rate induced by Oxide Breakdown of the rescaled circuit
Failure rate = 0.12402 (ppm) or 0.00141573 (FIT)

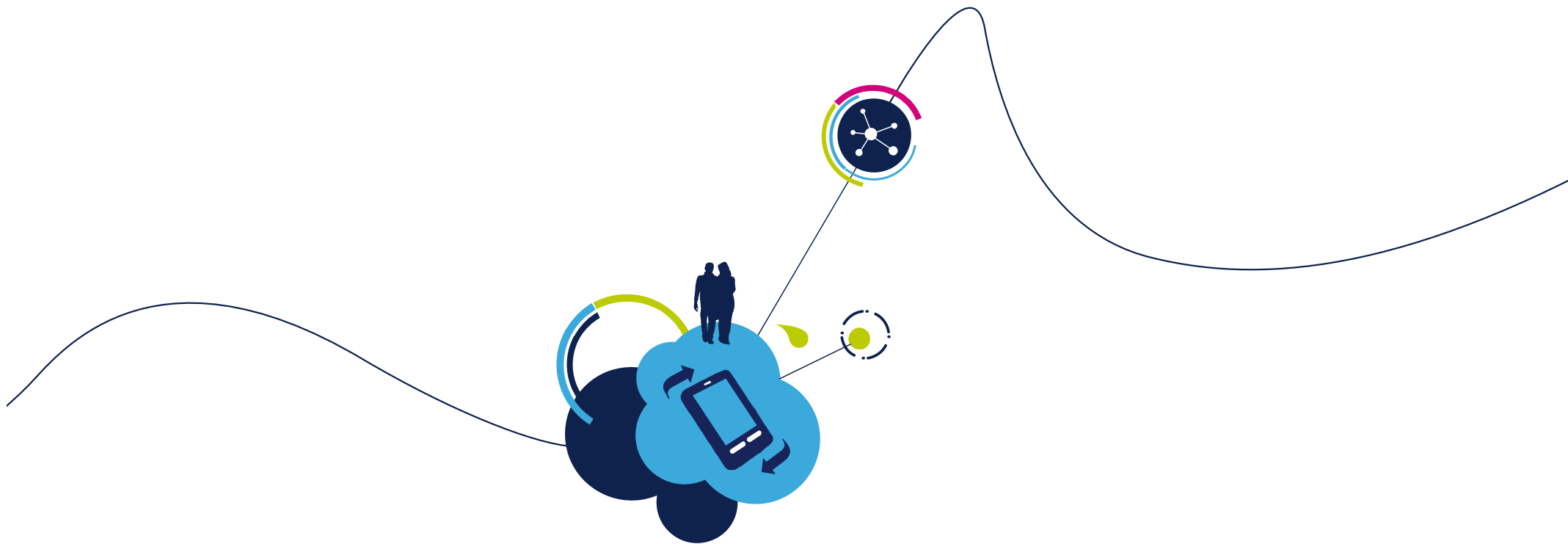
***>MESSAGE SUMMARY: 2 warnings

***>GLOBAL CPU TIME 0s 170ms <***

***>GLOBAL ELAPSED TIME 1s <***

cf29@gn5342{EXTRACT}1423 :
```

- Ageing simulation general note
 - Area_scaling option is a custom option: multiplicity of IP to estimate the failure rate at SOC level induced by TDDDB
 - Note that MODE=agesim enables to save & load in a single run (without .alter)
 - Tstart & Tstop are time window for a representative waveform which is reproduced during a period of Tage
 - Transient simulation is needed for mode=save
- Misc.
 - More details about options are available (UDRM, MOSRA and URI)
 - Eldo premier support .age options
 - A dedicated flow is available for sizing under ageing constraint in wicked
 - Ageing include dispersion with Monte Carlo simulation is not supported for hspice/xa/spectre



End of report