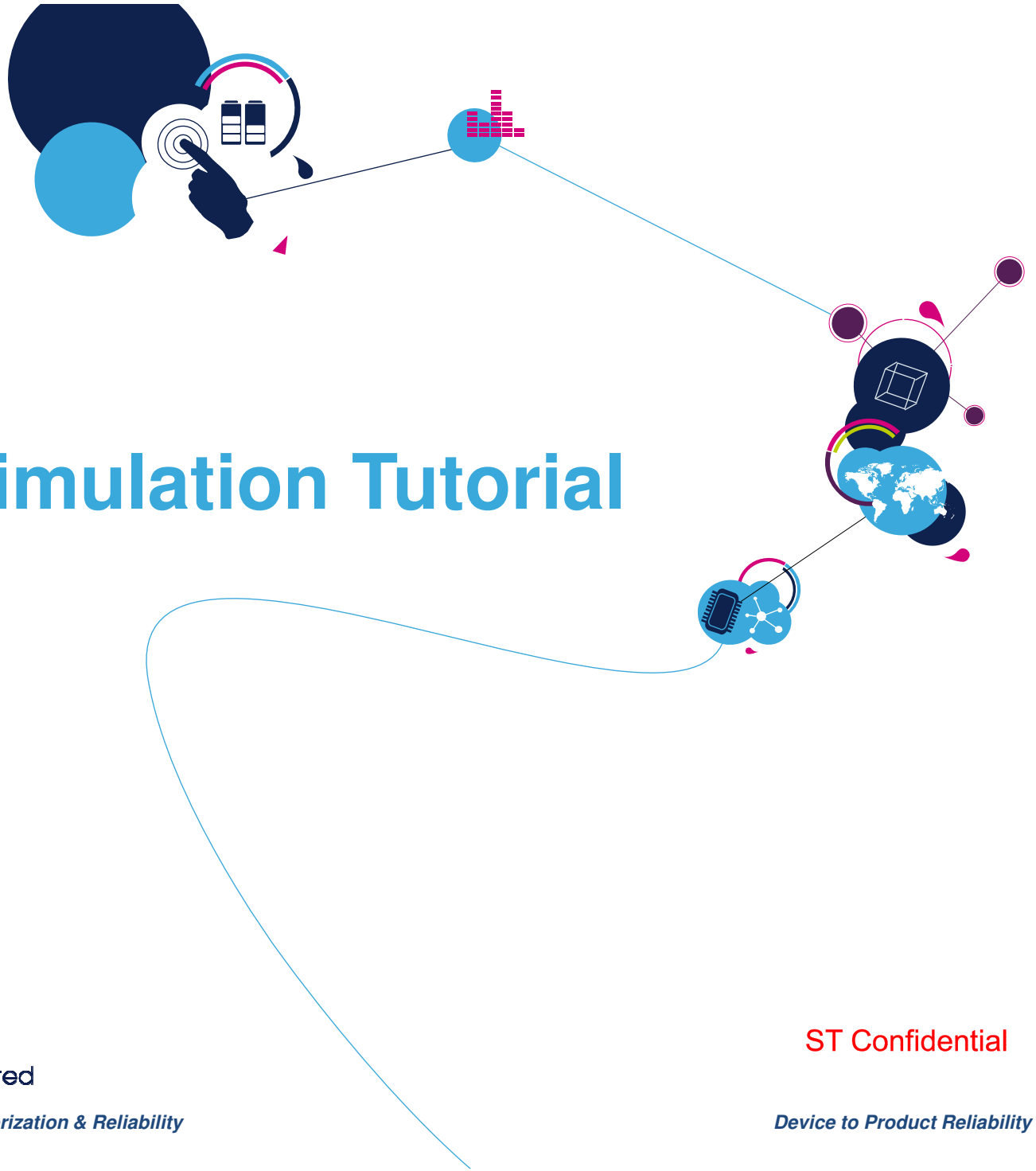

Ageing Simulation Tutorial

11/10/2017

life.augmented

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

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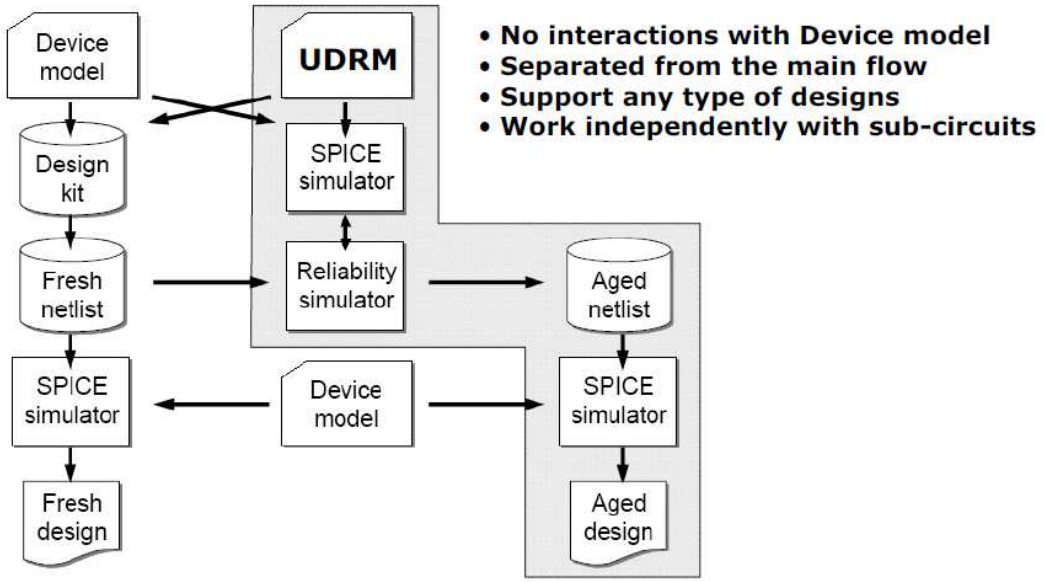
Device to Product Reliability

Design-In-Reliability

- **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



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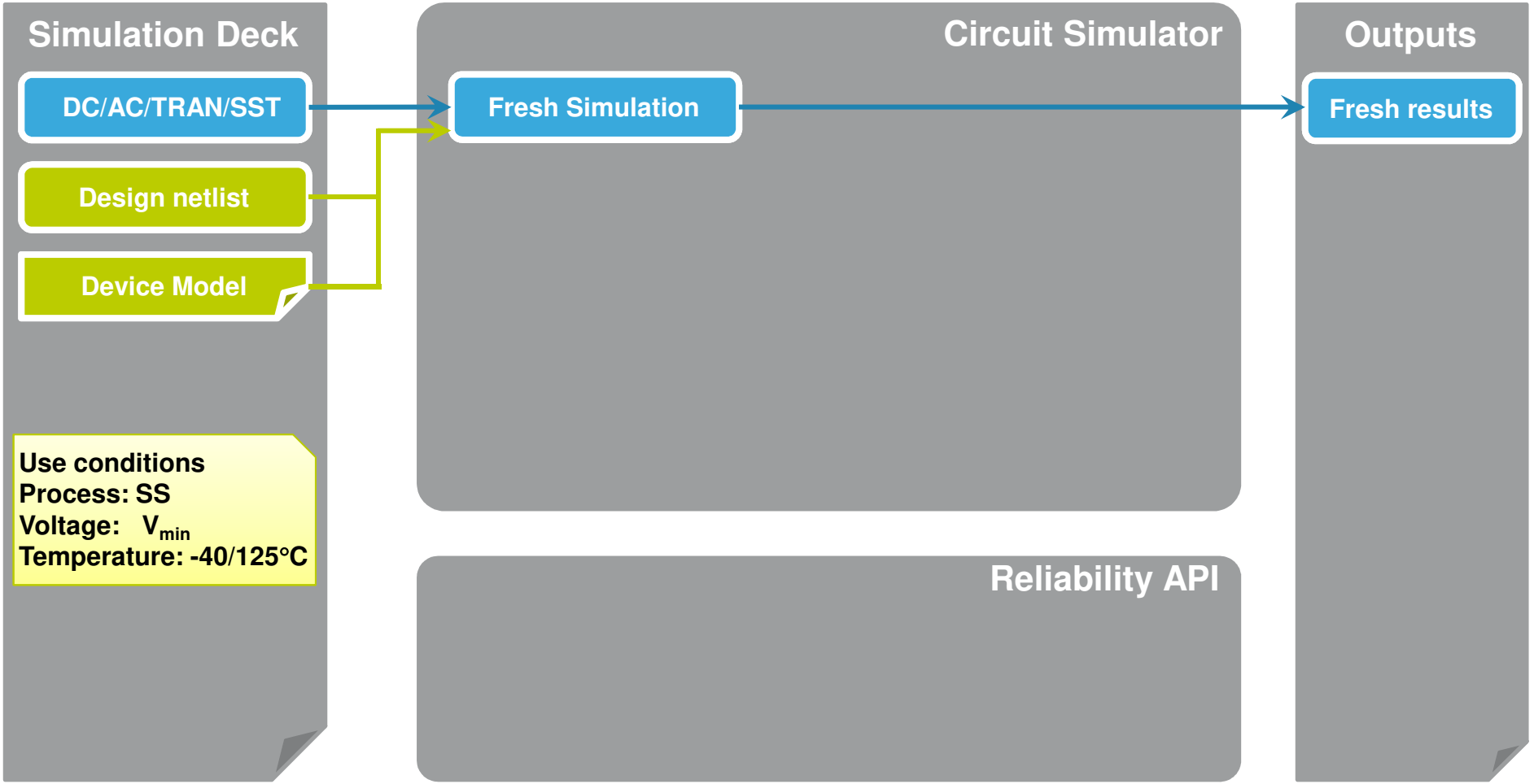
Reliability Simulation Flow – Step 1



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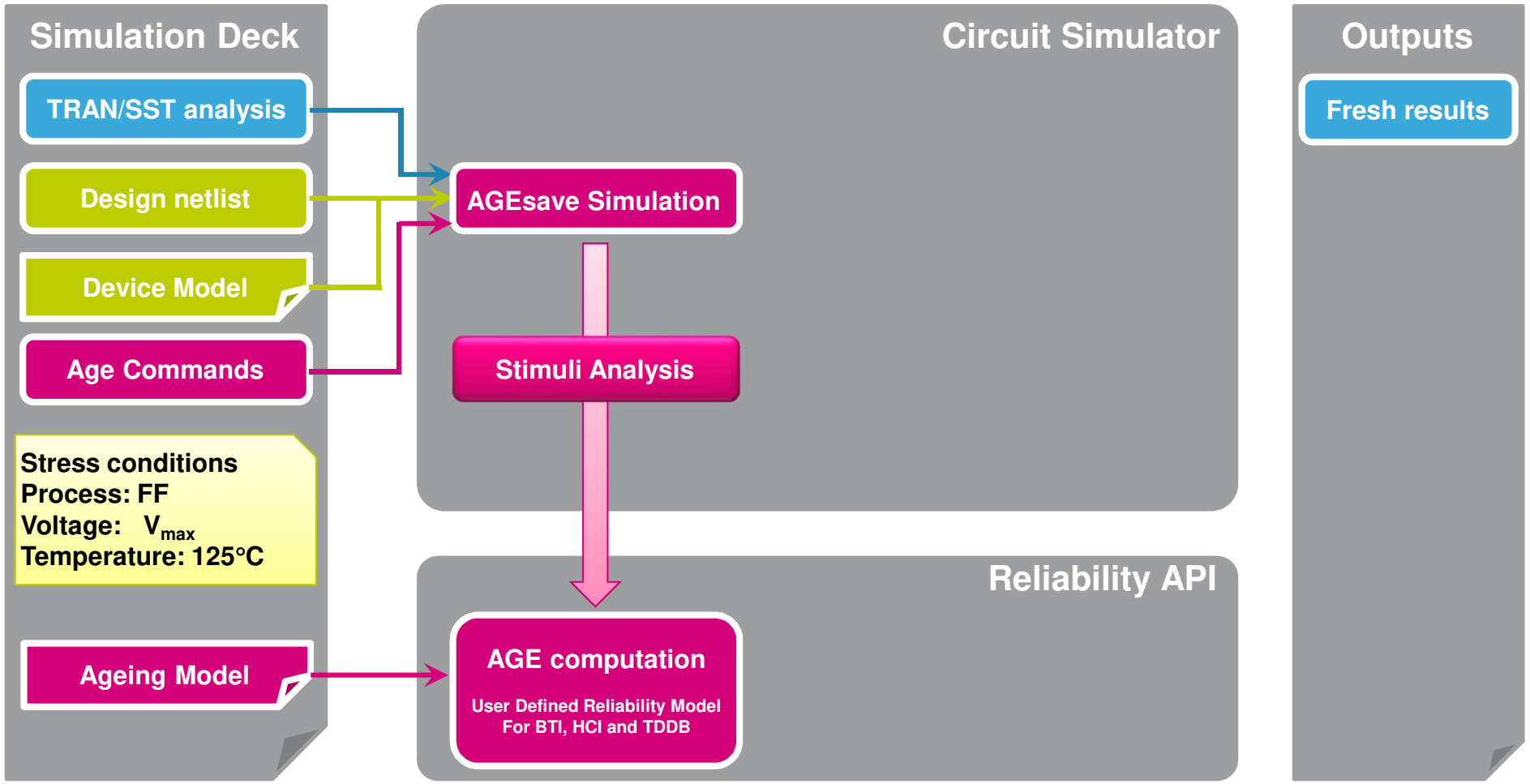
Reliability Simulation Flow – Step 2



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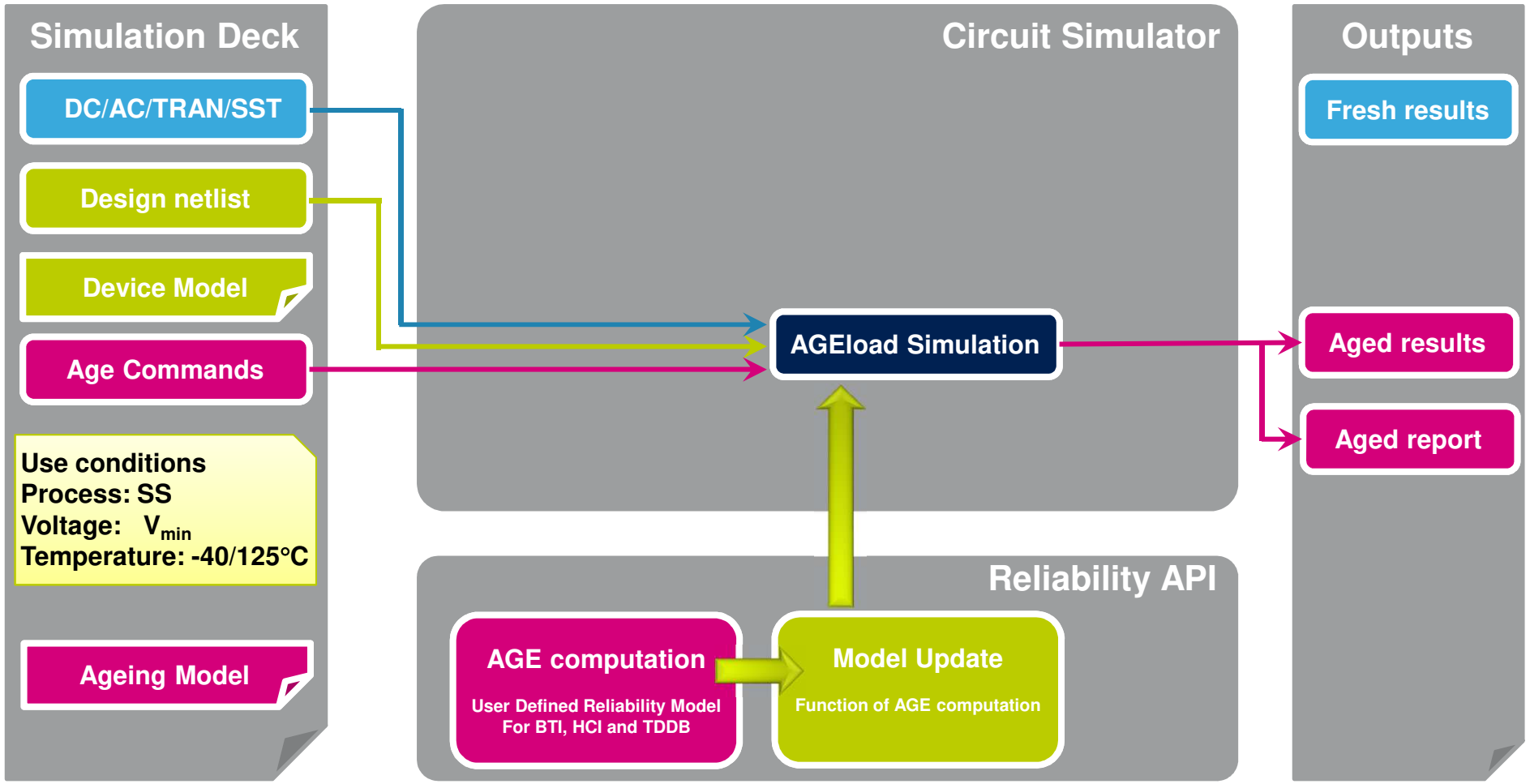
Reliability Simulation Flow – Step 3



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Tutorial: typical eldo netlist

- Include models
- Power definition and signals
- Circuit

```
.lib $MODELS_PATH/LPmos_psp_lvt.lib LVTLP_TT
…
.lib $MODELS_PATH/age.lib all
```

Include library of ageing models

```
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
- Analysis and probe/extract options

```
.age
+TAGE=10
…
```

Add dedicated options for ageing (see next slide)

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

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Tutorial: eldo options

- 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            } Activation degradation mechanisms
+ TDDB=1
+ LOG
+ MODE=SAVE
+ AGELIB=stress_5yrs.lib ASCII
+ TSTART=2n        } Time windows of integration
+ TSTOP=3n
+ AGEALL
+ COMPUTE_LAST=NO
+ AGEDSIM=0
+ PLOT=ALL
+ TRELAX=0
+ CIRCUIT_REPORT = 1   Generation of AGED_REPORT.log
+ AREA_SCALING= 100    Scaling factor for TDDB analysis (IP multiplicity at SoC level)
```

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

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Tutorial: hspice format

- 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
+trelax= 0
+area_scaling=100
+circuit_report = 1
```

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Tutorial: spectre format

- 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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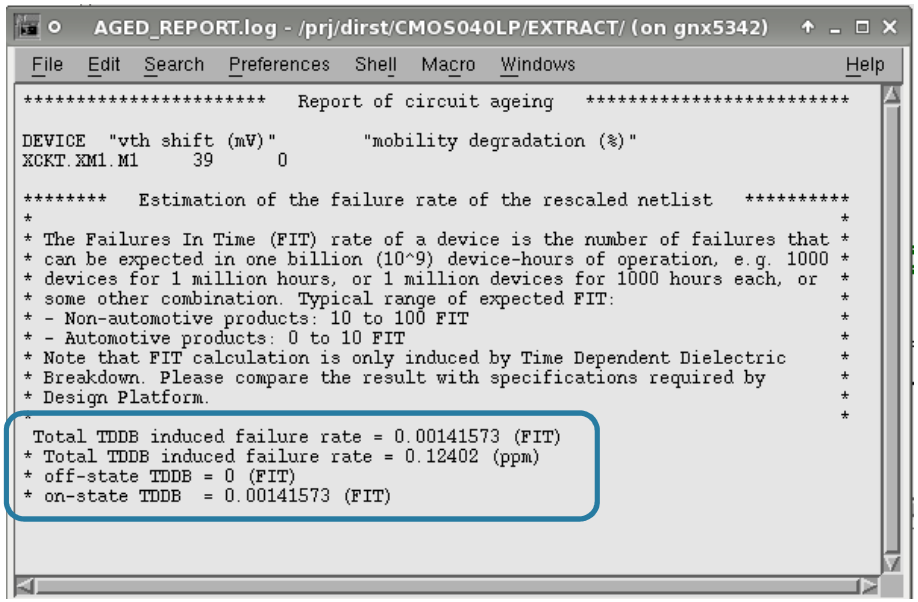
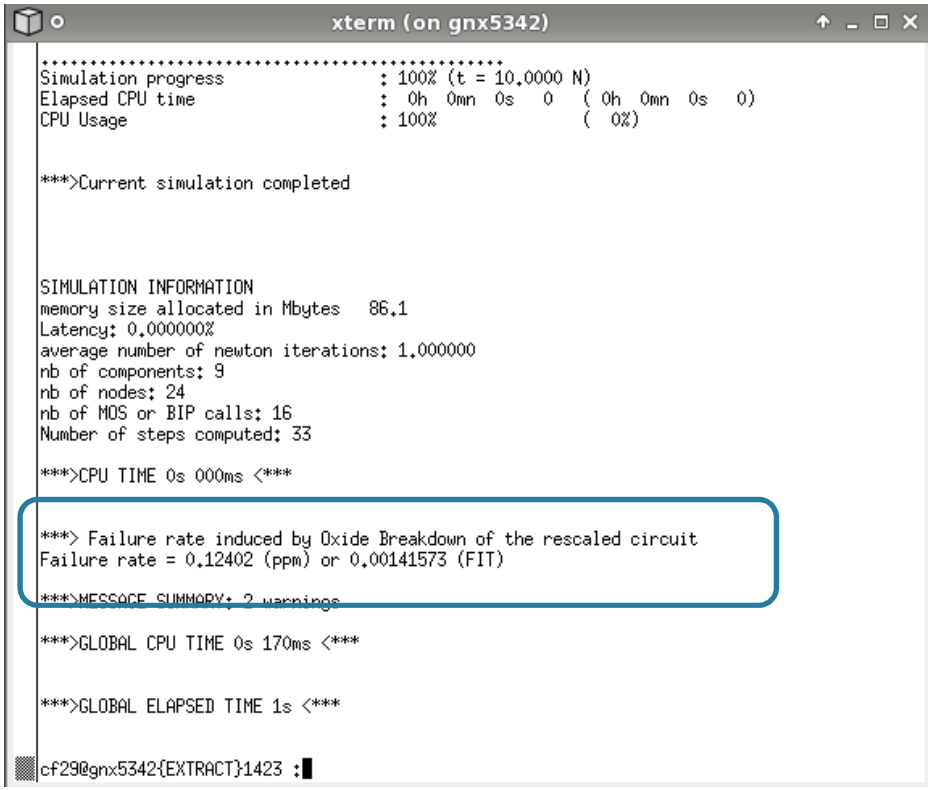
TDDB results

- All informations stored in AGED_REPORT.log file:
  - TDDB failure rate informations (also available in the terminal in prompt)
- TDDB 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





Notes

- Ageing simulation general note
  - Area_scaling option is a custom option: multiplicity of IP to estimate the failure rate at SOC level induced by TDDB
  - 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

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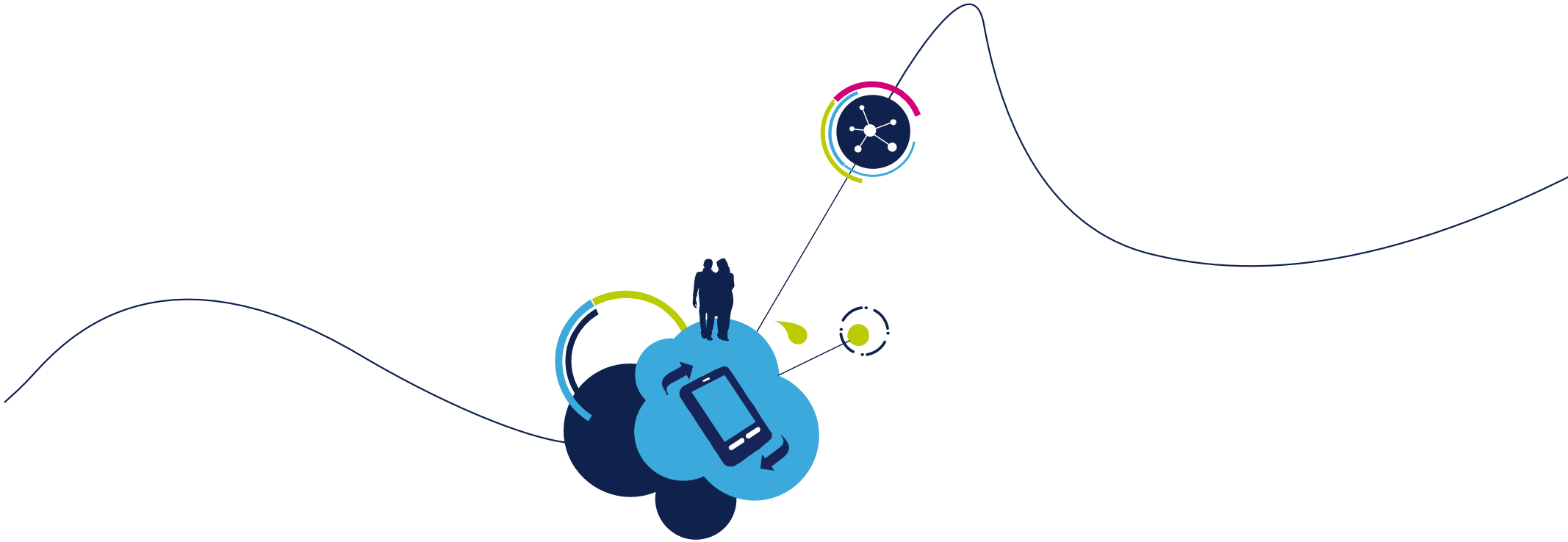

End of report

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