Chip simulation of automotive ECUs

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9. Symposium
Steuerungssysteme !r automobile Antriebe
"erlin#Tempelho , $%.#$&.%9.$%&$

Outline of the talk

Chip simulation of automotive ECUS

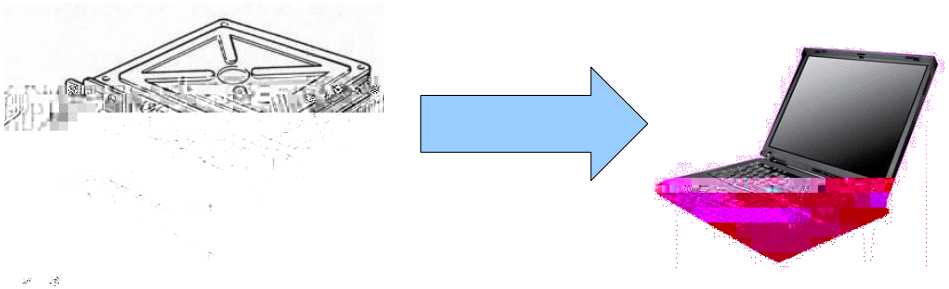
&. Moti(ation

$. Setting up a simulation

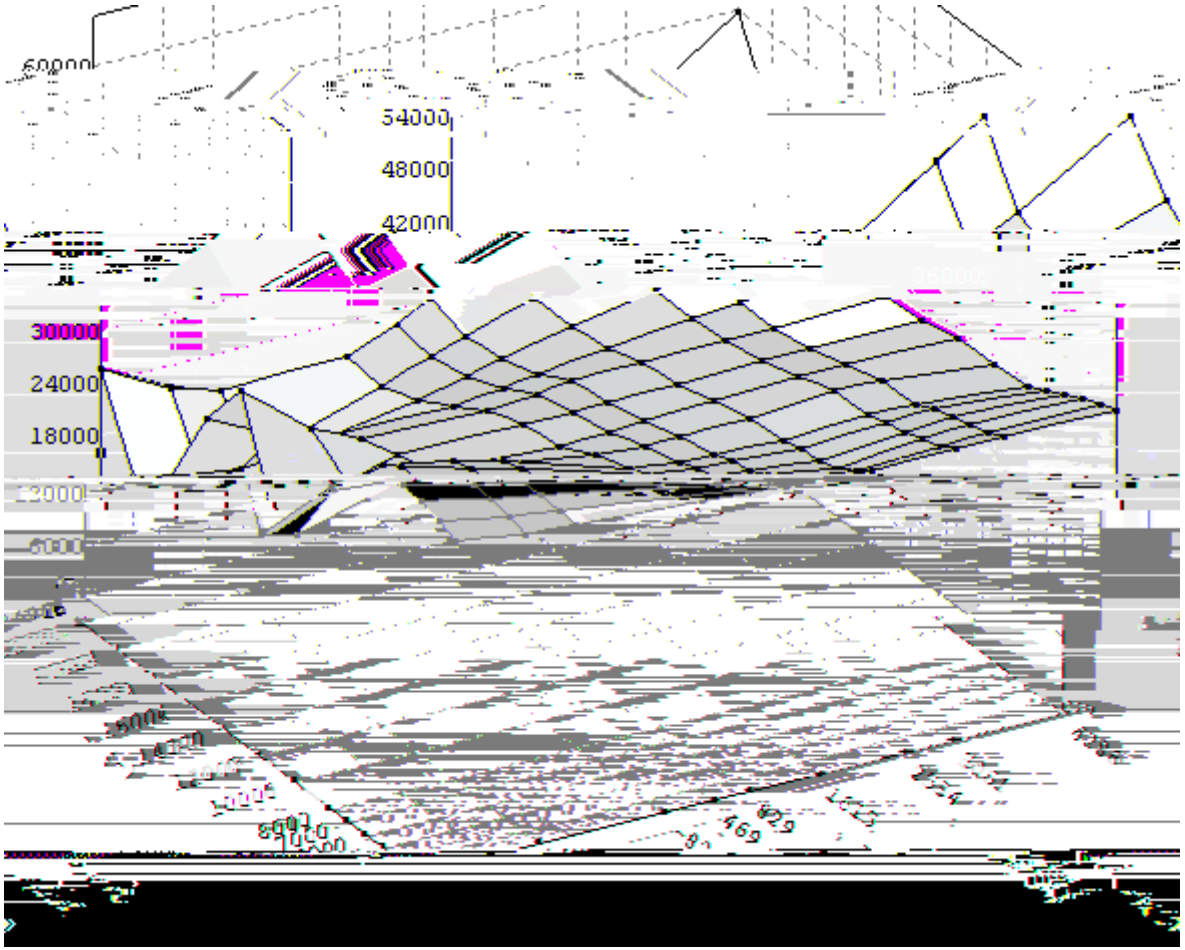
+. ,er ormance

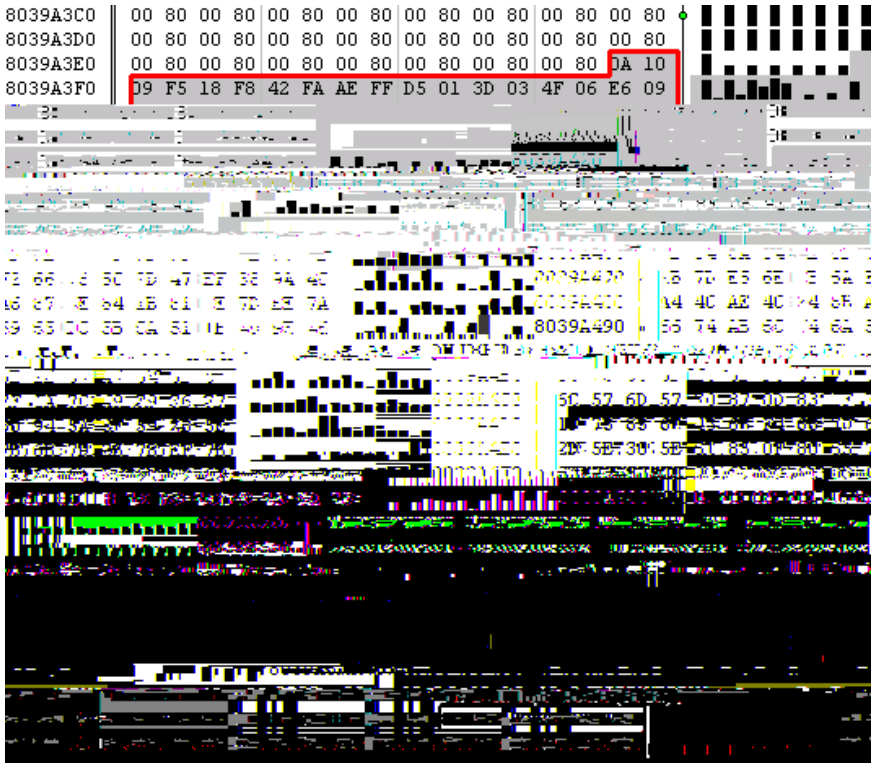
-. .imitations

/. 'onclusion



ECU: more than 30.000 software parameter





En"ine #ali$ration

tune more than +%.%%%) ' * parameter
0one by the 1) M, not by the supplier o the) ' *

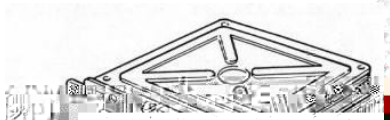
%ro#ess to ay

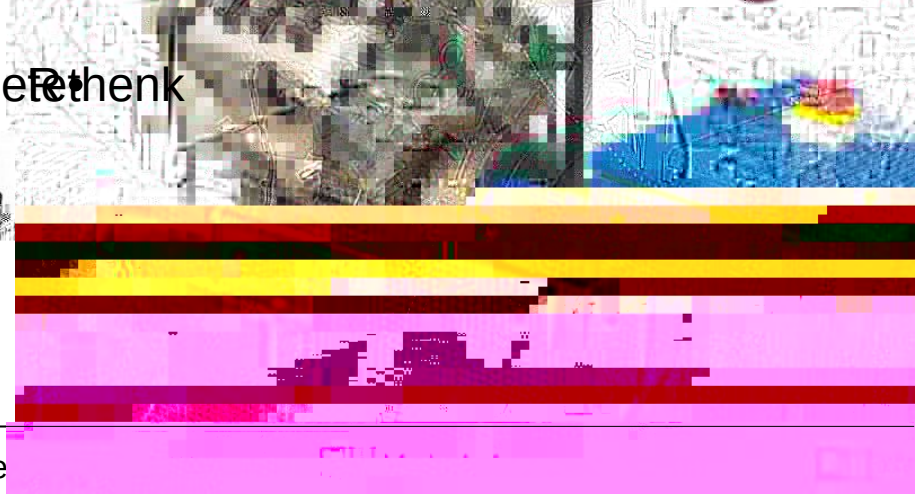
automate0 optimi2ation o stationary states
real#time test rig or (ehicle3 base0 on the real) ' *
, ' base03 engine an0) ' * both simulate0, e.g. in Simulink

%ro$lems

real#time test rig3
limite0 repro0ucibility
e4pensi(e 5in(est, operation6
slo7 5real time6

, ' 3 re(erse enc





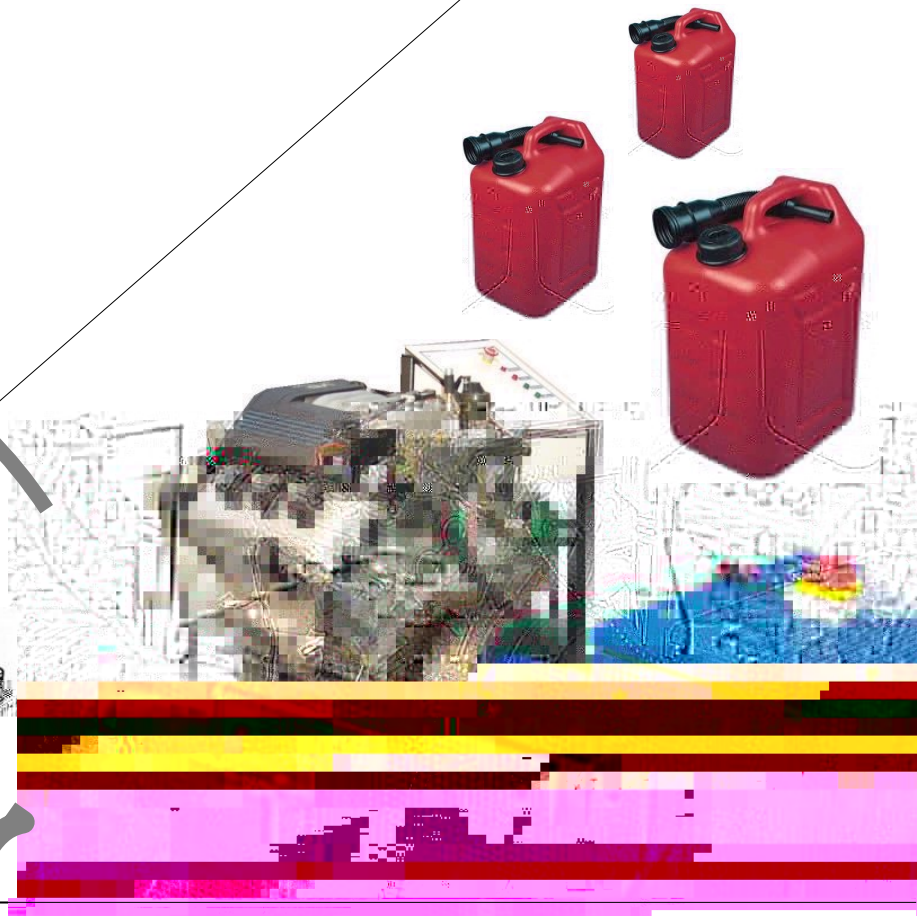
! otivation

& ea

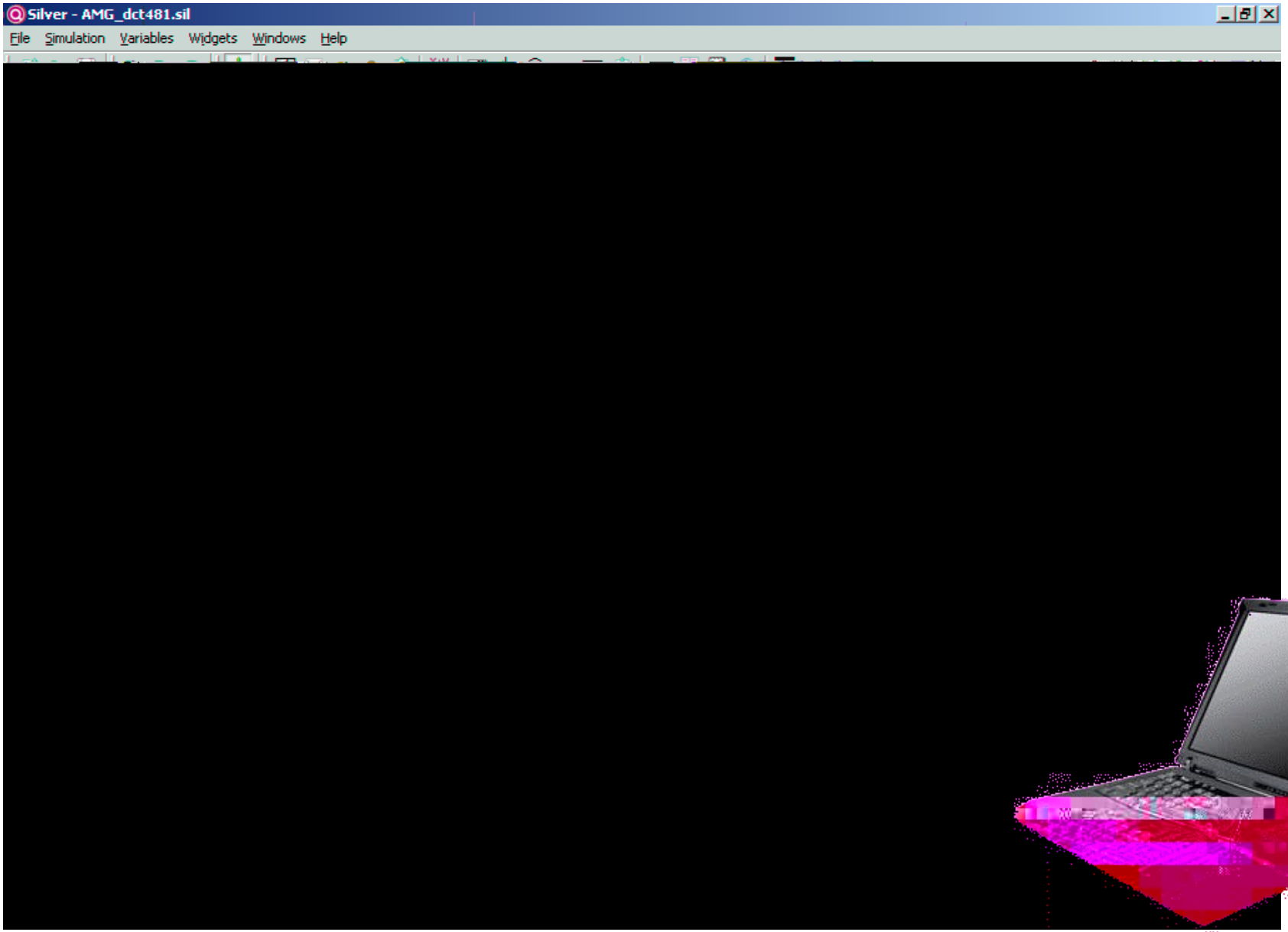
mo(e engine calibration 5an0 other 0e(elopment tasks6 rom test rig to , '

' enefit

simulation runs much aster than real time
enables use o mathematical optimi2ation



Example) *CU Control Software in Silver



Settin" up a *riCore simulation

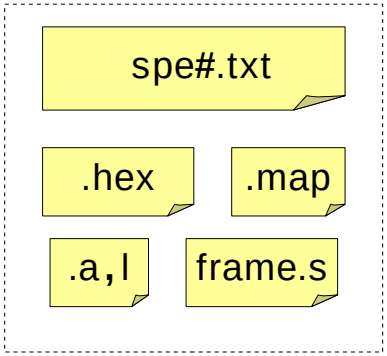
&. 7rite spec.t4t to speci y 7hat unctions to run
$. step an0 0ebug the simulation in Sil(er 0ebug mo0e
+. generate ast running S:unction or Sil(er mo0ule3 runs 7ithout a$l an0 he4

Settin" up a *riCore simulation

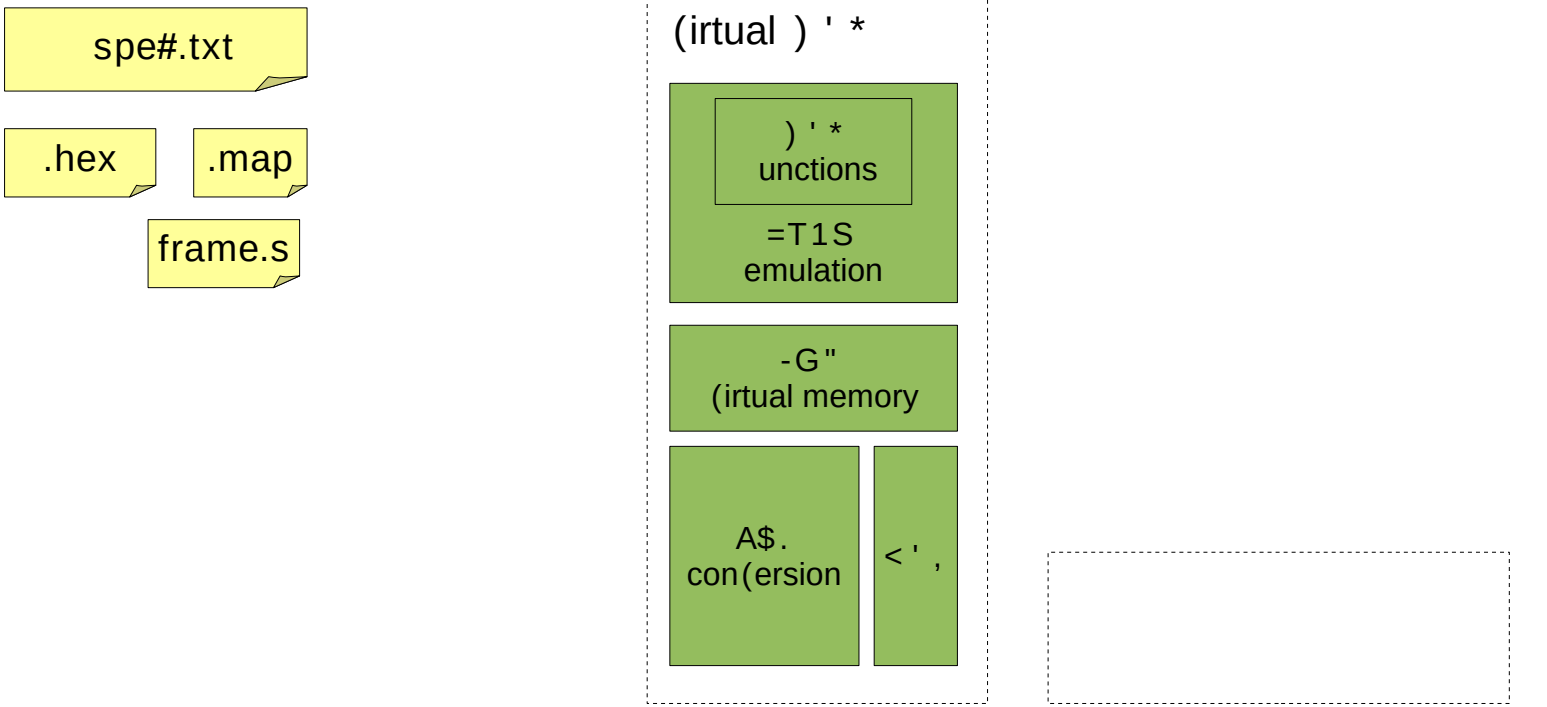
&. 7rite spec.t4t to speci y 7hat unctions to run
$. step an0 0ebug the simulation in Sil(er 0ebug mo0e
+. generate ast running S:unction or Sil(er mo0ule3 runs 7ithout a$l an0 he4

```
01 # specification of sfunction or Silver module
02 hex_file(m12345.hex, Tri ore!1.3.1"
03 a2l_file(m12345.a2l"
04 map_file(m12345.map"      # a T#S$%&' or '&( map file
05 frame_file(frame.s"       # assem)ler code to emulate *T+S
0, frame_set(ST-.!S%/-, 10" # Silver step si0e in ms
01 frame_set(T-2T!ST#*T, 0xa0000000" # location of frame code
03
04 # functions to )e simulated, in order of execution
10 task_initial(#5 6-!ini"
11 task_initial(#5 6-!inis7n"
12 task_triggered(#5 6-!s7n, tri88er!#5 6-!s7n"
13 task_periodic(#5 6-!20ms, 20, 0"
14 task_periodic(#5 6-!200ms, 200, 0"
15
1, # interface of the 8enerated sfunction or Silver module
11 a2l_function_inputs(#5 6-"
13 a2l_function_outputs(#5 6-"
14 a2l_function_parameters_defined(#5 6-"
```

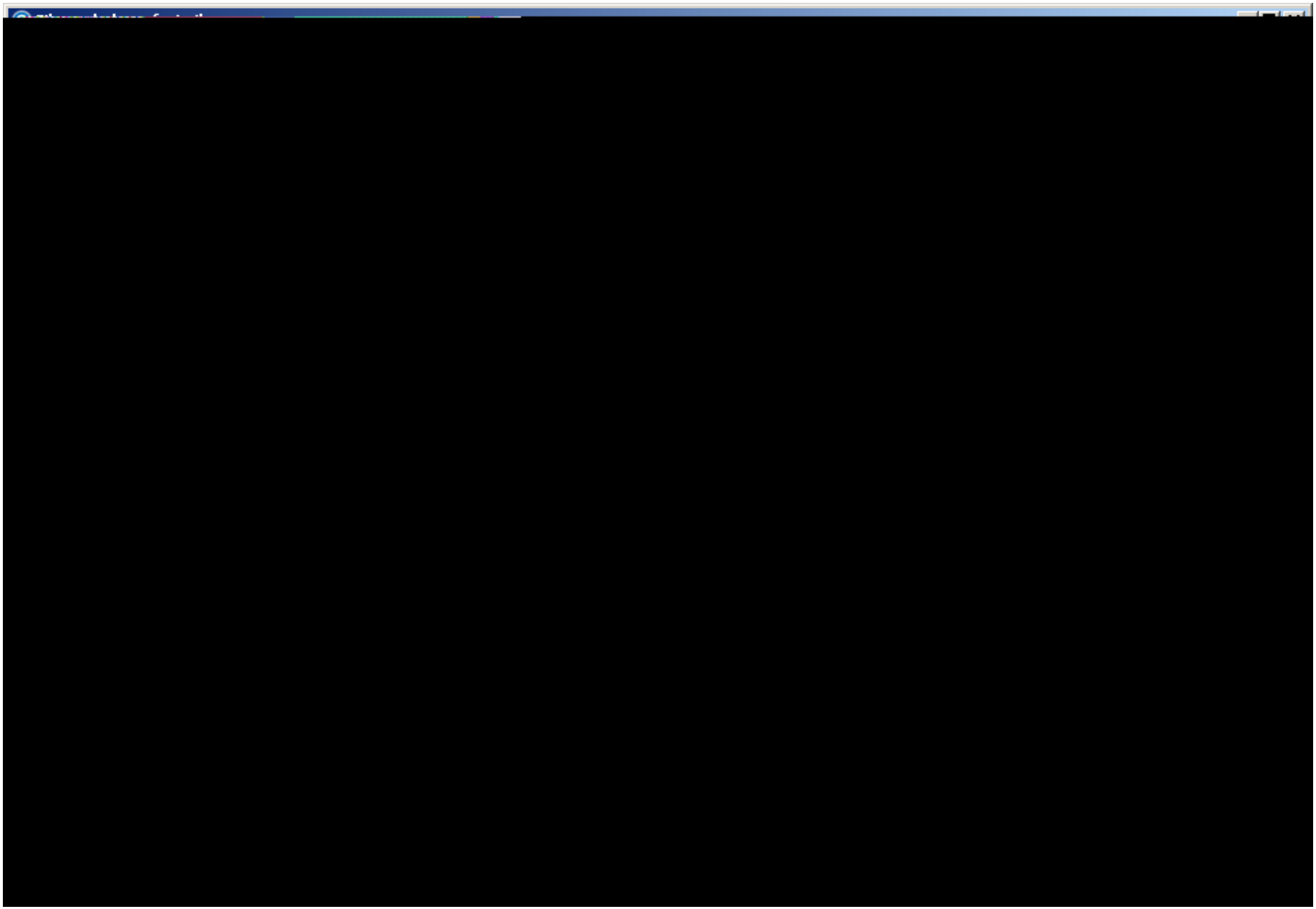
"enerate S-un#tion in !.*/.'0Simulink



characteristics turne0 into
MAT.A" 7orkspace (ariables
rea0 by S# unction
may be mo0i ie0 by script


spe#.txt
.hex
.map
frame.s
(irtual) ' *
) ' *
unctions
=T1S
emulation
-G"
(irtual memory
A$.
con(ersion
< ' ,

1irtual ECU runnin" in Silver: !E213



%erforman#e an /imitations

4un #omplex fun#tion for a measure s#enario5 3.**6** minutes

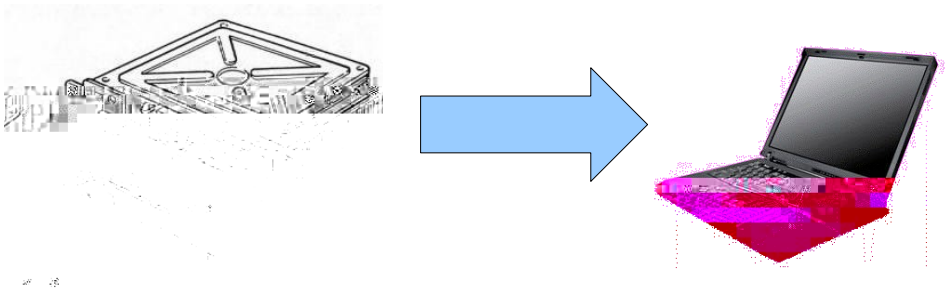
tar"et	exe#ution time	!&%S
Sil(er in 0ebug mo0e	9&9.&/ sec	%.-&
generate0 Sil(er mo0ule or MAT.A";Simulink S:unction	9.+% sec	-%.?%
M)D&@ 7ith T'&@9@, &?% Mh2	$&%.%% sec	$@%

/imitations3
instruction accurate, but not cycle accurate
base0 on Tri'ore speci ication3 Asilicon bugsA are not simulate0
,' ,, 'A> controllers an0 other on chip 0e(ices not mo0ele0

Summary

ECU simulation on **7** in ows %C

7ithout e4pensi(e re(erse engineering
7ithout access to) ' * source iles
base0 on H)<, MA , an0 A$. ile
lo7 7ork e ort or mo0eling
high accuracy o mo0el
application e4ample3 automate0 calibration



7orks or Tri ' ore processors3 T ' &@9B, T ' &@9@, T ' &@9?, ...
per ormance3 -% M9 , S