-eri,ica.ion o, .he de*i)n i* ;rac.icall9 i ' ;o**i5le+ In*.ead, .he *9*.e' 'u*. 5e *u5/ec.ed .o -eri, ica.ion .e*.in) $\langle i.h a \rangle$ *u,,icien. co-era)e .o 9ield con,idence in *a,e.9 and a-aila5ili.9+ Like<i*e, .he anal9*i* o, *9*.e ' ;er,or ' ance under ; o**i5le ,aul. *cenario* 'u*. 5e anal9=ed 59 .e*.in) ra.her .han :roo.+

3radi.ional con.rol-de*i)n 'e.hod* ,ocu* on ro5u*.

'e.hod* can onl9 5e a;; lica5le on *u5*e.couchle%i.9 .ha. ,or 'al ; roo,-5a*ed

; er, or ' ance and *.a5ili.9 in .er ' * o, ' odel uncer.ain.9 and

di*.ur5ance* in clo*ed-loo; *9*.e '*+ \$or .he co '; le%

a))re)a.e o, -ehicle con.rol ,unc.ion*, .he .radi.ional

and relia5le ;er,or ' ance a. a rea*ona5le co*.+

3he -eri,ica.ion .e*.in) in-ol-e* .he anal9*i* o, a -a*. nu ' 5er o, *cenario* *elec.ed in a *9*.e ' a.ic <a9+ 3hi* <ork i* co' 'onl9 done 'anuall9 .o a lar)e e%.en. in de*i)n re-i*ion*, hard<are-in-.he-loo; A6ILB ri)*, and

;ro.o.9;e .e*.in)+ 3he 'anual in-ol-e'en. i* .i'econ*u ' in) and li ' i.* .he nu ' 5er o, ca*e* .ha. can 5e in-e*.i)a.ed and .e*.ed, and .he -eri,ica.ion ;roce** i* al*o -er9 co*.l9+ 3here are)rea. i '; ro-e 'en.* in e,, icienc9 and co-era)e .o 5e)ained ,ro' ,ur.her au.o'a.in) .he*e ;rocedure*+ 3he hu ' an in.er-en.ion i* al*o a *ource o, error .ha. 'a9 5e reduced 59 au.o 'a.ion+ Ano.her i**ue i* .ha. -eri,ica.ion .e*.in) u*uall9 i* a;; lied a. la.er ; ha*e* in .he de*i)n ;roce**, and ;ro5le ' * .ha. are iden.i,ied in .he*e .e*.* 'a9 re:uire lar)e and e%;en*i-e *.e;* 5ack+i ?eri,ica.ion .e*.in) 5a*ed on 'odel* or *o,.<are 'a9 5e a;;lied a. earlier ;ha*e* and ;ro5le '* 'a9 .hu* 5e iden.i.ied earlier+

3he co ' 5ina.ion o, a .ool .ha. au.o ' a.icall9 ;roduce*

co '; u.er-)a 'e; rinci; le* and re)ard .he *9*.e ' under .e*. a* an o; ; onen. .ha. i* de,ea.ed <hen .he *;eci,ica.ion i* -iola.ed+ 3he 'e.hodolo)9 i* de 'on*.ra.ed on an au.o-codin) i '; le 'en.a.ion o, a 5rake-5lendin) ,unc.ion ,or a hea-9 -ehicle, in co'5ina.ion <i.h a *i'ula.ion 'odel i'; le 'en.ed in Modelica+ I. i* *ho<n .ha. a -a*. nu ' 5er o, *cenario* can 5e anal9=ed <i.h 'odera.e 'anual e,,or., and .ha. re*ul.* corre*;ondin) .o hi)h-co-era)e \$MEA > \$3 Aanuaee *a,e

.e*.in) ,or -eri,ica.ion o, co'; le% cha**i*-con.rol *9*.e'*+ 3he 'e.hod* are deri-ed ,ro'

.he .ool and 'e.hod ,or au3

-≬\$H.

\$est Scenario

3he .e*. con*i*.* o, a dri-er .ha. 5rake* and *.eer* .he -ehicle+ 4ear *hi,.in) i* ' ade au.o ' a.icall9+ 3he Dri-er can)i-e in;u.* accordin) .o .he .a5le 5elo<+

Drivers

"a#e	\$nit	%alues
/ ra, e Pedal Position (0 to (>0! 0&(9! 0&-! 0&*9?
Steerin. A heel An . le	rad	>0! 089?

6& V.H'C0. M*+.0

30 .e*. and -eri,9 .he 5rake-5lendin) ,unc.ion i. i* nece**ar9 .o *i ' ula.e i.* o;era.in) en-iron ' en. includin) .he .rac.or .o<in)--ehicle, a dri-er, and .he road+ 3hi* en-iron ' en. ' u*. ; roduce reali*.ic re*; on*e* .o .he con.rol ac.ion* co ' ; u.ed 59 .he , unc.ion+ \$or .hi* ; ur; o*e a ' odel i* 5uil. u*in) .he Modelica-5a*ed .ool* D9 ' ola and ?ehicle D9na ' ic* Li5rar9, and + Modelica i* an o;en-*;eci,ica.ion hi)h-le-el o5/ec.-orien.ed and co';onen.-5a*ed lan)ua)e de*i)ned ,or 'ul.i-do'ain 'odelin) ,or *i 'ula.ion o, co '; le% *9*.e '*+ Modelica i* de*i)ned ,or acau*al and e:ua.ion 5a*ed 'odelin), <hich 'ake* .he 'odel* hi)hl9 reada5le and reu*a5le+ An ou.*.andin) ,ea.ure o, Modelica-5a*ed *olu.ion* in .he con.e%. o, -eri,ica.ion .e*.in) i* .he e%;o*ed and 'odi,ia5le 'odel *ource code in co ' 5ina.ion <i.h .he hi)h-le-el ' odel de*cri:.ion*+ I. i* : o**i5le .o - ie < and ' odi.9 or e%.end .he i'; le 'en.a.ion o, co '; onen. and *9*.e ' 'odel*+ In .hi* <a9 in*.ru ' en.* can 5e added .o .he - ehicle ' odel, *uch a* *en*or in*.ru ' en.* ,or cri.eria e-alua.ion, and in*.ru ' en.* ,or in; u. e%ci.a.ion and ; ara 'e.er -aria.ion* .o de*cri5e o;era.in) condi.ion*, .olerance -aria.ion*, and ,aul.

in/ec.ion+ \$i)ure 8 *ho<* .he .rac.or 'odel and .he 'ain ;o<er.rain, 5rake*, and cha**i* *u5*9*.e'*, and .he in*.ru 'en.* u*ed 59 3e*.Wea-er+ 3he ;o<er.rain 'odel include* a)ear50%, en)ine re.arder, dri-eline re.arder, and dri-eline <i.h ,inal)ear and di,,eren.ial+ 3he 5rake *u5*9*.e' include* co';onen.* ,or *er-ice di*k-5rake* <i.h ABS+ 3he cha**i* con.ain* ,ron. and rear a%le*, <i.h *.eerin), ca5in, ,ra 'e, and <heel*+ 3he -ehicle run* on an in,ini.e ;lane <i.h con,i)ura5le inclina.ion and *ur,ace ,ric.ion+ 3he 'odel con.ain* a5ou. *e-en .hou*and e:ua.ion* and "3 con.inuou* *.a.e*+ 1. i* .ran*la.ed in.o @code u*in) .he D9 'ola inline .ra;e=oid in.e)ra.ion ,ea.ure ,or)enera.ion o, e,,icien. real-.i 'e_e*i 'ula.ion code+ 1. i* .hen co ';iled and linked in.o a DLircan

Ö"a`a#

R 1%

'oni.ored *a,e.9 ha=ard* and .he ;o**i5le ,aul.* .ha. could 5e rela.ed .o .he '+ 3he .ool chain hel;ed .o anal9=e, in de.ail, .he cau*e-e,,ec. rela.ion*hi;, an o.her<i*e e%.re 'el9 di,,icul. en.er;ri*e, i, ;o**i5le a. all, con*iderin) .he co'; le%i.9 and .he a 'oun. o, *o,.<are ,unc.ion* in-ol-ed+ G, cour*e, .he *i 'ula.ion re*ul.* need .o 5e e-alua.ed and co'; le 'en.ed 59 .he anal9*i* o, e%; erienced en)ineer*+ A* a *econd *.e;, .he .ool chain ;re*en.ed here can 5e u*ed .o -eri,9 .ha. .he coun.er 'ea*ure* de*i)ned .o i'; ro-e *9*.e' *a,e.9 are *ucce**,ul+

i) ure # *ho<* a ;iece o, a co-era)e re;or.) enera.ed 59 3e*.Wea-er, ,or anal9*i* o, .he *in) le ,aul. e-en. *+

inserted faults	Brk'dl'osC#d(S&	speed
· · · ·	no)#ra,e	((0220
	little)#ra,e	(0&(0
	some)#ra,e	(0&(0
	much)#ra,e	(0&(0
		((0220
En.2etrdAct)+0).ainEomission	no)#ra,e	(0&(0
		((0220
	little)#ra,e	(0&(0
		((0820
	some)#ra,e	(0&(0
		((0820
	much)#ra,e	(0&(0
		((0820
D	D	D
driveBine2etarderA5le+orOueShareCodeE no)#ra,e omission little)#ra,e some)#ra,e much)#ra,e	(0&(0	
		((0820
	little)#ra,e	(0&(0
		((0820
	some)#ra,e	(0&(0
		((0220
	much)#ra,e	(0&(0
		((0220

\$i)ure #+ Su5*eeD,#p*er.ed ,aul.* A3 ou. o, 33B+

Mo*. o, .he en.ire cro** ;roduc. o, in*er.ed ,aul.*, 5rake ;edal ;o*i.ion* and *;eed* are e-alua.ed - onl9 a ,e< *;eed co ' 5ina.ion* are ' i**in)+ 3he *;eed i* no. direc.l9 con.rolled, 5u. a con*e:uence o, .he 5rake ;edal ;o*i.ion+

) o#ustness Study

6@i.he

\$or .he ro5u*.ne** *.ud9, .he e,,ec. o, co ' 5ined -aria.ion* o, -ehicle ;ara 'e.er*, road condi.ion*, and dri-er in; u. *e: uence are in-e*.i)a.ed+ 3he *earch *;ace i* .hen o, cour*e enor 'ou* and i. i* i ';lau*i5le .ha. co ';le.ene** can 5e achie-ed+ Ne-er.hele**, .he 'a/or re*ul. i* .ha. o,.en cri.ical *i)nal* and ;ara 'e.er* can 5e e,,ec.i-el9 iden.i,ied+ 3hu*, al*o .hi* kind o, *.ud9 can re-eal e%i*.in) ri*k* or ro5u*.ne** <eakne**e*, .ha. need .comeide: for the comeide comeid ΥΊ;

а