

# 7KH XVH RI R[LGHV DV D FDWDO\VW IRU WKH UH HPLVVLRQ

ODULD 5DM%NDWRV] :yMWRZLVF]DXMDDV] DGG 5DIDá =\EDáD

\$\*+ 8QLYHUVLW\ RI 6FLHQFH DQG 7HFKQRORJ\ )DFXOW\ RI 0DWHULDOV 6FLHQFH DQG &H  
)DFXOW\ RI 0DWHULDOV 6FLHQFH DQG (QLQHULQJ :DUVDZ 8QLYHUVLW\ RI 7HFKQRORJ\

SEVWUDFKW PRUSKRORJLFDO FKDUDFWHUL]DWLRQ RI D VHULHV RI FRED  
E\ WKH GHSRVLWLRQ ERZHU ZLWK D PRODU UDZLW RWKHHUDXQJHR [LGHWWR  
ZDV SHUIRUPHG 7KH SRZGHUV ZHUH DOVR WPSURHEJODLQHG KZLWKKHURUHRW&FV  
RI SRWDVVLXP DWRPVQYHWÁQBDWH WKH HIIHFW RRQD&KHFJ DWS&GLWLLF DFFRVL  
WKH ; UD\ GLIUDFWLRQ 6(0 ('; ODVHU SDUWLFOH VL]H GLVWULEXWLRQ D  
7KH FDWDO\VWV ZHUH WHVWHG WKURXJK WKH ORZ WHPSHUDWXUH GHFRPS  
RI f& WR f& 7KH DGGWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
ORZHU WHPSHUDWXUHVf& f& f&7KHWHHVW FDWDO\WLF SURSHUWLHV ZHUH  
LQ ZKLFK WKH UDWLR RI FHULXP R[LGHWWR FREDOW R[LGHWUDQJHG IURP

## ,QWURGXFWRQ

/RZHULQJ RI WKH WHZSHHG&FXWLRQ

12 HPLVVLRQ WR WKH DWPRVSKHUHDFWLRQ LV HERORRPLFDOO\ DGYDQ  
LQWHQVH WKDQ LQ WKH FDVH RIRWWRWUJRWKHHUDXQJHR [LGHWWR  
EXW WKH \*:3 \*OREDO :DUPLQJ RIRWWRWUJRWKHHUDXQJHR [LGHWWR  
R[LGHV LV WLPHV KLJKHU WKDORIRWWRWUJRWKHHUDXQJHR [LGHWWR  
,W LV HVWLPDWHG WKDW WKH LGXUWHFQHUHQWUJRWKHHUDXQJHR [LGHWWR  
WR WKH WRWDO JUHHQKR XVH HIIHFWLW\ DWLWUJRWKHHUDXQJHR [LGHWWR  
> @ 1LWURXV R[LGHV KDV WKH DFWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
UDGLDWLRQ DQG LQGLUHFWRU GHVWURSUW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
WKH FKHPDFDO UHDFWLRQV RI VDFWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
,Q WKH XSSHU VWUDWRVSKHUH WHPERQDWHXVLRQIRVDRZ&DSOV  
QLWURXV R[LGHV UHDFWLRQ UHDFWLRQV RI W&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
WKXV GHVWUR\LQJ WKH QDWXUDO DQG WKH W&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
> @

7KH UHGXFWRQREH1FDUULHG PHWDOV 7KH DONDOL PHWDOV PD\ DI  
GLIIHUHQW WHPSHUDWXUH UDQJHV DQG ZKLFK UHVXOGEH LPSURYHG WKJ  
FDWDO\VWV VXLWDEOH IRU WKH SUHDGOLWUJRWKHHUDXQJHR [LGHWWR  
,Q WHUPV RI KLJKHU WHPSHUDWXUH UHDFWLRQV UHDFWLRQV UHDFWLRQV  
f& WR f& IRU WKH UHGXFWRQREH1FDUULHG PHWDOV 7KH DONDOL PHWDOV PD\ DI  
FKDUDFWHUL]HG E\ JRRG WKHUPDO RIRWWRWUJRWKHHUDXQJHR [LGHWWR  
SHURYVNLWHV DQG PD\HQLWH > WKH UHGXFWRQREH1FDUULHG PHWDOV 7KH DONDOL PHWDOV PD\ DI  
WHPSHUDWXUH UDQJHV EHWZHHQ DFWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
NQRZQ DV R[LGHV FDWDO\VWV ZLWK DFWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
DQG D VPDOO DPRXQW RI SUHFLRQV DWLWUJRWKHHUDXQJHR [LGHWWR  
R[LGHV DUH DSSOLHG > @ ,W ZDV W&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
FRXOG EH D YHU\ JRRG FDWDO\VW UHDFWLRQV UHDFWLRQV UHDFWLRQV  
FDWDO\WLFDOO\ DFWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
7KLV NLQG RI FDWDO\VWV EDVHG RQ VSLQH G&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
DUH VFFHVVIXOO\ FKHFNHG LQGHVWURSUW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
ZLWK PDLQWDLQLQJ WKHUPDO VWDFWLRQDRIW&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
DQG KLJK FDWDO\WLF DFWLRQV RI W&F2YHG WKH WHPERQDWHXVLRQIRVDRZ&DSOV  
> @ R[LGHV DQG FHULXP R[LGHWUDQJHG IURP

D&RUHVSRQGLQJ DXWKRU UDMVND#DJK HGX SO

> @ +RZHYHU UHVHDFK LQWDRQQLKH FQREDOVWREDPHGURVFRS\ Z  
 FDWDO\VWV DQG SURPRWHG VDSNFVWLRVFRVSDO6\WKN;RIGXSLQ\$12 6(0  
 DQG SRWDVVLXP VKRZV WKDW LW VFDQRVQLQJLHOOHFWRU DG KLIHFYHRVFRS  
 FRPSOHWH FRQYHUVLRQ DW D WIKIPSHUDDWDOELHOVLZJH R1&WKH SRZC  
 > @ 6XFK FDWDO\VWV DUH YHQRDFW DYHGLQWDFLWL BQDFMDL RXUBIQBQ  
 GR QRW FRQWDLQ SUHFLRXV PHWDDQV WZKILBKLORQVH\$DQDQWDFDO ;13  
 IXUWKHU UHGXFHV WKHLU FRVW ZLWK7DQ SDGHSQHFU RRSRDVDRZXPQJ  
 LRQV VLJQLILFDQWO\ LPSURYHV7WKKMSHEDMDQ\WLFIDFURSHUHWIRH WKH  
 RI FREDOW FRQWDLQLQJ FDWDOEVWKH\WPHVWRKR GP DQILQQLHWURJHC  
 VSLQHGV > @ 3RWDVVLXP SURPRWHGPFREDOXW\$6\$S LQHOLFURPHV  
 FDWDO\VWV REWDLQSHUHFHEDPRWKKIDLYJH BRLWVULEXWLRQ '/6 ZDV FKDU  
 KLJK VWDELOLW\ DQG ORZ ZRUN IXUWWRBQWPSOR\IQLQJ WKH ODOYHUQ OD  
 ,Q WKH SUHVHQW ZRUN ZH UHSRUW RQ WKH FDWDO\WLF DFWLYLW\  
 RI D VHULHV RI . SURPRWHG &R &H RILGHFRPSRVLWHV ZLWK  
 WKH PRODUKSHUFRH\H2DQJLQJ \$URF[HQREHG TXDUW] IORZ UHDF  
 UHVSHFWLYHO\ :H WU\ WR ILQG WKHRXWLGUXSRDQJHFDVVPKSHUWURP  
 SDUWLFLSDWLRQ RI WZR R[LGHV FRUPLQJ %\$FR5SRVZDWHYDNGHULQOWKH  
 FDWDO\WLF WHVWV %HIRUH SURSHU  
 ([SHULPHQWDO HDFK VDPSOH J D VWDQGDUG  
 \$ VHULHV RI &R &H FRPSRVLWH FROVLVWLFQJRI\NHHSLOJWKH VDPSO  
 SUHSDUHGE\ WKH GHVWELSLZGHY &H2ZDV IORZLRIRU FPPLQ XQWLO U  
 OHUF DV VKRZQ LQ 7DEOH f& 6DPSSOHV ZHUH \$IWHU WKLW WU  
 REWDLQHG WKURXJK WKH SUHFLSLWDLRZQJWKURRPWHPSHUDWX  
 RI &H2&H1A 2 RQ WKHFRZGHU DW FSDQJHG WR WKH WDUJHW PLIWXUH  
 " XVLQJ D O DPPRQLD VROXWLRQ > WKH FDWDO\WLF WHVWV ZHUH FDU  
 SUHFLSLWDWH ZDV DJHG IRU WZR RIXU\ DWLQWRPWHPSHUDWXUH U  
 DQG WKHQ VHYUDO WLPHV HOKXWHG & JURFVWKH DWPFILWUXUH FRQW  
 RI KIGUR[LGH LRQV WR REWDLQWKH)ROHBUOHXWFRPSOHWHFKDUD  
 7KH VOXUU\ SUHSDUHGE LQ WKLW PDQGHUHQWV ZHUH SHURURHG W  
 DW f& DQG FDOFLQHG IRU KRPSOH ZR FKDUDFWHULJH WKH FDU  
 7KH UHVXOWDQW SRZGHUV KDYH RI 2GLI\H PDQGHU WKH WHPSHUDWXU  
 RI &H2URP WR PRO DQG D FROVWDLQWZDV UHVSHFWLYHO\ ZDV GHWHUPLQHG  
 RI &2R PRO UHVSHFWLYHO\ ZDV GHWHUPLQHG  
 7KH LPSUHJQDWLRQ RI WKH FDWDO\WLVZDV PDGH XVLQJ  
 WKH GU\ LPSUHJQDWLRQ2R H2WKRG ZLWK  
 WR REWDLQ DQRPQDQFRQW VXIILF5'HQW WR ILOO  
 WKH SRUHV RI WKH VXSSRUW >LJ@UH%HSRUHVSHUWRWKHQ3' VSHFWU  
 WKH LPSUHJQDWLRQ RI HDFK VDPSOHWZDWRQSWLKHQ EGBQMLW\HG  
 ZDV PHDVXUHG WZLFH E\ WLWUDWKQJFRFEDOFDUULHU, LQ[GMWLSKOVHG  
 ZDWHU DQG WKH FHULXP GLR[LGH SKDVH ,&

7DEOH7KH VDPSOH V\PEROV

6DPSOH	%HIRUH	\$IWHU	LPSUHJQDWLRQ
&R2	&R	&RB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	
&R2 &H2	&R &H	&R &HB.	

)LJXU7KH ;5' SDWWZHQ&Q2FRWDRQ\VWV EHIRU  
 LPSUHJQDWLRQ

,Q WKH ;5' VSHFWUD QR RWKHU S  
 DQG RU &H ZDV REVHUYHG 6LPLODU  
 VHH UHIOHFWLRQV IURP DOO SKDVH

0HWKRGV  
 7KH PRUSKRORJ\ RI WKH SDUWLFLSDWRUWLPJSHUHG DWLQJ UH

IURP DQ\ RI WKH FRPSRXQGV FRQWUOLH LQSJHSRHWV LKXPH VSHFLILF  
 7KH &HF2\ VWDOOLWH VLJH UHJDUGLGHV LNDW ERDQWHQW LQ2 WKH FR  
 VDPSOH ZDV DSSUR[LPDWHO\ WKH RFRPH DQ WKLGH FDVH\ RWBDDWLF G  
 VDPSOHV UHDFKLQJ DERXW QPXU7DFHGDUIHDFVLRQGLFOMWHG E\ WK  
 RI &R ZHUH FKDQJHG DIWHU WKH ZLGH WLGQRID &HQJ WKH FRQWHQW  
 ZHUH EURDGHQHG \$IWHU LPSUHJQDWLRQ WKH VSHFLILF  
 IRU HDFK VDPSOH EHFDXVH RI ILO  
 SRWDVV LXP

)LJXUH7KH H[HPSODU\ LVRWKHUP DGVRUSW  
 FXUYHV

)LJXUH7KH ;5' SDWWH2UQW2RDW&RO\ VWV  
 LPSUHJQDWLRQ

)LJXUH LV D FROOHFWLRQ RI JUD  
 DQG DGVRUSWLRQ IRU VDPSOHV &R  
 ,W FDQ EH VHHQ WKDW DV D UHVXO  
 RI VXUIDFH SRUHV ZDV VLPLODU DQ  
 XQQRWLFHDEOH FKDQJH LQ WKH VSH  
 UHPDLQLQJ VDPSOHV WKH K\VWHUH  
 GHVRUSWLRQ UHVHPEOHG WKH UHVX  
 7KH DYHUDJH DGVRUSWLRQ SRUH  
 LPSUHJQDWLRQ ZDV FDOFXODWHG D  
 LPSUHJQDWLRQ DW QP 7KH K\VWH  
 WR WKH GH %RHU FODVVLILFDWLRQ  
 ZKLFK KDYH DQ HORQJDWHG WXEX  
 WLPH WKH K\VWHUHVLV ORRS RI D  
 LVRWKHUPV UHSUHVHQWV WKH FDV  
 LQYROYHV WKH IRUPDWLRQ RI D PX  
 DFFRUGLQJ WR WKH SULQFLSOHV RI

3DUWLFOH VLJH GLVWULEXWLRQ

)LJXUH7KH FU\ VWDOOLWH VLJH IRU &R 7KH SDUWLFOH VLJH GLVWULEXWLRQ  
 ,W ZDV FDOFXODWHG WKDW WKH DQG YROXPH LKXPH VSHFLILF GUMD  
 FREDOW ,, ,, R[LGH SKDVH ZDV LPSUHJQDWLRQ RWBY &UHVH QWHG LQ )  
 DGGHG &W2ZDV UHGXFHG WR DERXW GHYHURLPHG DU WKH EDVLV RI  
 WUHQG IRU D \VWHPDWLF GHFUHDVH RI VDPSOHV &R LKXPH VLQ E  
 RI WKH FU\ VWDOOLWH RI FREDOW LPSUHJQDWLRQ ZLWK &RQZLW LXP L  
 LQFUHDVLQJ WKH FRQWHQW RI &R  
 EDVLV RI YROXPH GLVWULEXWLRQ D  
 ZKHQ LW FRPHV WR WKH PD[LXP SDU  
 RJ WR J EHIRUH LPSUHJQDWLRQ DQG DUREGLFDWH WKH IRUPDWL  
 RJ WR J DIWHU LPSUHJQDWLRQ LKXPH ZSMFRLQH OPHG E\ WKH 6(0 H[D  
 GHSHQGHQFH ZDV IRXQG LQ WKH FD  
 DIWHU LPSUHJQDWLRQ &R &HB. Z  
 SHDNV ZHUH REVHUYHG IRU WKH SDU  
 DQG PLFURQV ZKLFK LV DOVR  
 WKH IRUPDWLRQ RI ODUJH DJJORPHU  
 )LJXUH VKRZV WKH YROXPH RI JU  
 UHODWLYH WR WKH SDUWLFOH VLJH I  
 7KH ODUJHVW DPRXQW RI SDUWLFOH  
 LV REVHUYHG IRU WKH SDUWLFOH VL  
 WR DSSUR[ PLFURQV IRU WKH VD  
 LPSUHJQDWLRQ +RZHYHU WKH JUDL  
 DUH DFWXDOO\ DJJORPHUDWHV ZK  
 E\ TXDQWLWDWLYH DQDO\VLV DQG

%(7

7KH VSHFLILF VXUIDFH DUHD RI FDW DQGV ZDV LKXPH VSHFLILF GUMD  
 RJ WR J EHIRUH LPSUHJQDWLRQ DQG DUREGLFDWH WKH IRUPDWL  
 RJ WR J DIWHU LPSUHJQDWLRQ LKXPH ZSMFRLQH OPHG E\ WKH 6(0 H[D  
 GHSHQGHQFH ZDV IRXQG LQ WKH FD  
 DIWHU LPSUHJQDWLRQ &R &HB. Z  
 SHDNV ZHUH REVHUYHG IRU WKH SDU  
 DQG PLFURQV ZKLFK LV DOVR  
 WKH IRUPDWLRQ RI ODUJH DJJORPHU  
 )LJXUH VKRZV WKH YROXPH RI JU  
 UHODWLYH WR WKH SDUWLFOH VLJH I  
 7KH ODUJHVW DPRXQW RI SDUWLFOH  
 LV REVHUYHG IRU WKH SDUWLFOH VL  
 WR DSSUR[ PLFURQV IRU WKH VD  
 LPSUHJQDWLRQ +RZHYHU WKH JUDL  
 DUH DFWXDOO\ DJJORPHUDWHV ZK  
 E\ TXDQWLWDWLYH DQDO\VLV DQG  
 )LJXUH7KH VSHFLILF VXUIDFH DUHD RI FDW DQGV ZDV LKXPH VSHFLILF GUMD

VKRZHG WKDW IRU WKH PDMRUL WU DR LQ S DUWK HFOH V HWXK WVL JHF RZDQ/FLGH  
 LQ WKH QP UDQJH 6XFK EPDDUNCHGG GWRIPWKF % (7 DQDO\VLV  
 EHWZHHQ WKH DQDO\VLV RI WKH SDUWLFOH VLJH GLVWULEXWLRQ  
 VKRZHG DV D YROXPH SHUFHQWDJH DQG WKH TXDQWLWDWLYH  
 SHUFHQWDJH ZDV QRWLFHG GXH WR WKH SHUFHQWDJH DQDO\VLV DUH VK  
 EXW ODUJH DJJORPHUDWHV LQ SRZOHFWHG RYHU LJXUH FURQ JUDLQ  
 7KH SDUWLFOH VLJH GLVWULEXWLRQ RYHU DJJORPHUDWHV PHDVXU  
 WKH KLJKHVW FROHFW RIRW2 QKW YKIDH RI WKHVH DJJORPHUDWH  
 IURP WKH SUHYLRXVO\ GHVFULEHG RQH VDP SOHV \$LXUHVSHFWLYH XRIY 7KHWK  
 EDVHG RQ D QXPEHU RI SDUWLFOHV RZ VDP SOHV &R JK &H PRO &H  
 DQG &R &HB. VKRZV WKDW WKH DYHUDJH JUDQ DQDO\VLV ERQW HUPV  
 FDVHV ZDV DERXW QP )RU VKRZV HQR &KLJQH LFDQW GHYLDWL  
 DQG &R &HB. LW HTXDOOHG KHDO EDQPSO LMRQ DV VKRZQ  
 VDP SOHV &R &H DQG &R &HB. LKHUHFKH VLOH RI JUDLQV GHW  
 DQG QP UHVSHFWLYHO\ LPDJHV ZDV DERXW -P \$IWHU LP  
 DQG VLJH RI DJJORPHUDWHV GLG QP  
 7KHVH REVHUYDWLRQV DUH FRQVLVW  
 IURP WKH DQDO\VLV RI WKH SDUWLFO

)LJXUH D LQ GLVWULEXWLRQ IRU VHOHFWHG VDP SOHV  
 7KH ZHLJKWHG DYHUDJH SDUWLFOH VLJH ZDV FDOFXODWHG  
 DQG FROHFWHG LQ )LJXUH EDVHG RQ WKH GDWD REWDLQHG ZKHQ  
 DQDO\VLQJ WKH SDUWLFOH VLJH GLVWULEXWLRQ IRU D QXPEHU  
 RI SDUWLFOHV

)LJXUH (0 LPDJHV RI FDWDO\VVV  
 5 &DOWF MWV  
 7KH &R &H FDWDO\VVV VG ZHFUR SDFW LMLH  
 ZKLFK LV VKRZQ LQ )LJXUH 2 DQG )  
 FRQYHUVLRQ ZDV QHJOLJLEOH XS W  
 VDP SOHV ,W ZDV REVHUYHG WKDW  
 R[LGH UHJDUGOHVV RI LWV TXDQV  
 WKH FDWDO\WLF SURSODGLWLRQ X  
 R[LGH FDQ VWDELOLJH PHWDO R[LG  
 )LJXUH KH ZHLJKWHG DYHUDJH SDUWLFOH VLJH DQDO\VLV LW\ E\ FKDQJ  
 ,W ZDV REVHUYHG WKDW WKH RIJHWDO RIFGHV RQ RI &H2  
 WKH ODUJHU WKH ZHLJKWHG DYHUDJH JUDQ DWLXUHV WKDW ZKLFK WKH  
 FDOFXODWHG LQ UHODWLRQ WR WKH PHDVXUHQWV RI WKH QXPEHU

f & IRU VDPSOHV FRQW VLDPLHQJW BRQZWHGF WHP SHUDWXUH DW ZKLFK WK  
LV REVHUYHG IRU WKH WHP SRQDMXUJHRQQHWHUZHVLQRGQVHUYHG IU  
WKH FRQYHUVLRQV RORZHU7IRU WKRI VDP SOHV WKH VDP SOH VKRZLQJ W  
FRQWDLQLDQG&HDW WKH VDPH WLSUHR SHUW&H0VZDXW&R &HB.  
GHJUHHV KLJKOHUWKRZQ ZQ )LJXUH

6XPPDU\

\$ VHULHV RI &R &H R[LGHV FRPSRVL  
E\ WKH ;5' 6(0 ('; '/6 DQG %(7 WH  
\$OO DQDO\VHG FDWDO\VWV ZHUH  
WHP SHUDWXUFR PSRVLWLRQ

7KH UHVXOWV VXJJHVWHG WKDW  
R[LGH FDXVHV DQ LQFUHDVH LQ WK  
DQ LPSURYHPHQW LQ WKH FDWDO\W  
VXUIDFH DUHD RI WKH FDWDO\WV R  
ZDV UHGXFHG E\ ILOOLQJ WKH SRUH  
H[DPLQDWLRQ FDUULHG RXW IRU DV  
E\ WKH SUHFLSLW DQDQV KRZHG  
WKH SUHVHQFH RI SGGZHRVLIHRP RQO\

)LJXUH7KH21FRQYHUVLRQ EHIRUH LPSUHJQDWLRQ

7KH FUI\WVDOOLWH VLJH FDOFXODWH  
VKRZHG WKDW IRU DQ LPSUHJQDWL  
RFFXUUHG LQ WKH FDVH RI DOO VDP  
DUHD ZDV HQODUJHG ZKHQ R[LGHV  
IRU DOO VDPSOHV ,W ZDV DOVR IR  
LQ SRZGHUV KDYH DQ HORQJDWHG  
7KH DGGLWLRQ FRIQV&BDEUDO\ OF  
WKH WHP SHUDWXUH DW ZKLFK WK  
WKH FRQYHUVLRQ RI 7R VXP XS  
WKH PRVW VLJQLILFDQW LPSDFW  
RI WKH FDWDO\WLF SURSHUWLHV

\$FNQRZOHGJPHQW

0 5DMVND DFNQRZOHGJHV WKH  
IRU 6FLHQFH \*UDQW IRU <RX  
QR DW WKH 'HSDUWPH  
&KHPLVWU\ )DFXOW\ RI ODWHULDOV

)LJXUH7KH21FRQYHUVLRQ EHIRUH LPSUHJQDWLRQ

\$\* to 867  
7KLV ZRUN KDV EHHQ SDUWLDOO\  
SURMHFW QR '( & 6 67  
WKH UHVXUFXHV DVVLJQHG IRU VFL  
&HQWUH 1&1 3RODQG DQG SD  
E\ WKH 1DWLRQDO &HQWUH IRU 5HV  
1&%5 3RODQG XQGHU WKH SURMHF

5HIHUUHQFHV

/ ;XH + +H &K /LX &K =KDQJ  
(QYLURQ 6FL 7HFKQRO  
( \$ 'DYLGVRR (QYLURQ 5HV /HWW  
( \$ 'DYLGVRR ' .DQWHU (QYLUR

8 &KHOODP = 3 ;X + & =HQJ &K

)LJXUH7HPSHUDWXUFRQYHUVLRQ RI

DQG 3pUH] 5DPLUp] ) .DSWHLMQ \$\$\$

\$IWHU LPSUHJQDWLRQ D VLJQ  
FDWDO\WLF SURSHUWLHV RI D  
GHPRQVWUDWHG 7KH WHP SHUD  
FRQYHUVLRQ ZDV DFKLHYHG ZH  
YDOXHV ZKLFK LV SUHVHQWHG  
DFWLYLW\ ZDV LPSURYHG WR  
WKH VDPSOHV LQ WKH RDPH  
UDWLR ZDV LQ WKH UDQJH RI

< ;X & ;XMDUGLQ & 7DQFHORW  
3DUYXOHVFX 0 &DElp & 5 +HQU  
\*UDQJHU - &DWDO  
3 \*UDQJHU 3 (VWHYHV 6 .LHJH  
/HFOHUFT \$\$\$O &DWDO %  
- 3HWU\N ( .RadNRZVND \$\$\$O  
WR /RZHUHQJ

```
( ,ZDQHN . .UDZF]\N - 3HWU\N - : 6REF]DN =
.DV]NXU $SSO &DWDO %
( 3DFKDWRXULGRX ( 3DSLWVD $ 'HOLPLWLV 0 $
9DVLOLDGHV $ 0 (IVWDWKLRLX 0 ' $PLULGLV 2 6
$OH[HHY ' %ORRP * ( 0DUQHOORV 0 .RQVRODNLV
( ,OLRSRXORX $SSO &DWDO %
, 9 <HQWHNDNLV * *RXOD 3 3DQDJLRWRSRXORX 6
.DPSRXUL 0 - 7D\ORU * .\ULDNRX 5 0 /DPEHUW
$SSO &DWDO %
/ 2EDORYi 0 5HOL - /DQJ 9 0DW MND -
.XNXWVFKRYi . .Rpt &DWDO 7RGD\
' 3LHWURJLDFRPL 0 & &DPSD / 5 &DUERQH 6
7XWL 0 2FFKLX]]L $SSO &DWDO %
* *U]\EHN 3 6WHOPDFKRZVNL 3 ,QG\ND 0 ,QJHU
0 :LON $ .RWDUED = 6RMND &DWDO 7RGD\

0 ,QJHU 0 :LON 0 6DUDPRN * *U]\EHN $
*URG]ND 3 6WHOPDFKRZVNL : 0DNRZVNL $
.RWDUED = 6RMND ,QG (QJ &KHP 5HV

* *U]\EHN 3 6WHOPDFKRZVNL 6 *XG\ND 3
,QG\ND = 6RMND 1 *XLOOPQ +XUWDGR 9 5LFR 3pUH]
$ %XHQR /ySH] $ .RWDUED $SSO &DWDO %

$ %XHQR /ySH] , 6XFK %DVDQH] & 6DOLQDV
0DUWLQH] GH /HFHD - &DWDO
6 6XDUH] 0 <DWHV ) - *LO /LDPELDV - $ 0DUWLQ
3 $YLOD - %OXUFRMNDKG

6 ,PDPXUD - 7DGDQL < 6DLWR < 2NDPRWR +
-LQGDL & .DLWR $SSO &DWDO $
: 3LVNRU] ) =DVDGD 3 6WHOPDFKRZVNL $
.RWDUED = 6RMND &DWDO 7RGD\
/ ;XH &K =KDQJ + +H < 7HUDRND &DWDO 7RGD\

/ ;XH &K =KDQJ + +H < 7HUDRND $SSO &DWDO
%
* 0DQLDN 3 6WHOPDFKRZVNL = 6RMND
9 5LFR 3pUH] $ %XHQR /ySH] $SSO &DWDO %

3 /HJXWNR : .DVSHUD 7 -DNXEHN 3
6WHOPDFKRZVNL .RWDUED 7RSLF &DWDO

* =KDQJ < *XR / /X = =KDQJ / :DQJ /
=KRX - 6KDR 0DW /HWW
/ /L / 6RQJ + :DQJ &K &KHQ < 6KH < =KDQ
; /LQ 4 =KHQJ ,QW - +\GURJHP (QHUI\

0 0D]DKHUL 6 $ +DVVDQ]DGHK 7DEUL]L 0
$PLQ]DUH 6 . 6DGUQH]KDDG &HUDPLF 0DWHULDOV

) =DVDGD 3 6WHOPDFKRZVNL * 0DQLDN - ) 3DXO
$ .RWDUED = 6RMND &DWDO /HWW
```