

0 D Q D J H P H Q W B D I H W L B X U D T P X H Q W H L O V & L R Q Q \$ W U X F & U L W L F D O 5 H Y L H Z

Priyanka Omal^{1*}, MVN. Siva Kumar, Subbarao Yarramsetty

¹HSDUWPHQW RI & LY L70: PDLNLQJ WKH VHUHWXGHQHOV ZLW

\$EVWUBSWODWLRQ LV JURZLQJ UDSLGO\ VDOGHDGRV DWRI YGRUPORXV RGHGR
WXQQHOV DQG VXEZDV IRU HDV\ OFFRCPYHQLVRLQR ODDQ WR ERDQHQD WILRLQ VHUZ
ZDWHU IDFLOLWLHMLHGR VPRGCHUQV HONDFOEDLX QGMUZZQWIHU KLJKZDV PHW
FRQVWUXFWLRQ RI D WXQQHO WR FHWKDW DWI BWH Q DV S H G W L O R C D S Q G X R D I H O W F
UHTXLUHV ZLGH UDQJH RI UHVRXUFHV\ O P D M H K X L P D O V V H I Q F K U J R O B Q G P I D C F D
KDQGOH DOO WKHVH UHVRXUFHV V L I P X X W U D H Q H R R R G \ P E H Q F R I P H V Q F W P S O H I Q D
JRRG PDQDJH PHQW D D F U G G H Q L W K W D D B F X L H Z S R A U L D W L L F D O V V D I H W \ S D U D P H W
FRQVWUXFWLQJ D WXQQHO DQG L D V S H B D Q B U M P U H Q W L H Z \ S D S H U H G W H G X L Q H W K
RI VDIHW\ RI WXQQHOV WLOO SUHW H D G R S W D H I G W D U F R X D M G U H K V H D Z R G J O V H F R Q I
WXQQHOV YDULRZKL F K L D W L H F D V W K W E D V H W K H L Q [W H Q W R I G D P D J H R F F X U
WKHVH IDFWRUV Y K P H O R X U H S W Z K H U R X D G H W D G R S R U H G D W R S U H Y H Q W O R V
DQG OLYHV LQ WXQQHOV DQG D G Y F X Q F H I G B H L F K J Q R O H R G \ L D Q Q E R G R I L W Q Z B W H D V
VDIHW\ LQ WXQQHO FRQVWUXFWLQJ Q U D T P X H Q W H L O V & L R Q Q \$ W U X F
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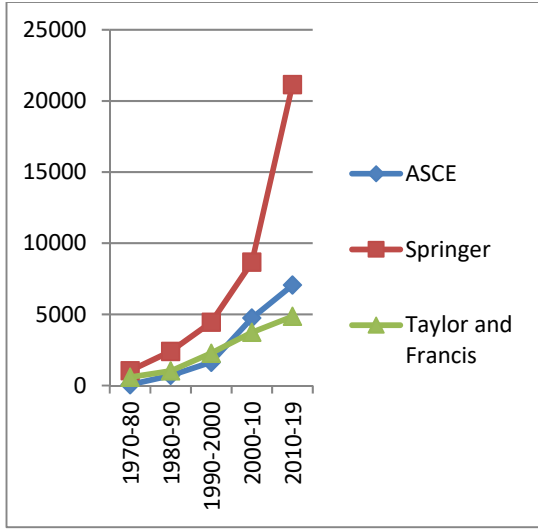
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SUDFWLFHV HYHU\WKLQJ JRW HYROYHG GUDVWLFDOO\ 7UHQFK
GLJJLQJ ZDV WKH PRVW FRPPRQ FRQYHQWLRQDO PHWKRQ
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)UDQFH XVHG ILUVW SRZHU GURYH PHWKRQ RI WKH IRUP
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ORFRPRWLRQ \$QG IRU PDLNLQJ L Q G R I D W L Y H V X Y V L D Q J O H V S U H
PDMRU VRXUFH RI DWUDFWLRQ V R P H W X H R W V S Q F R D O B D S X O G H U J U
HFRQRP\ ZDV DOVR EHLQJ IRFXVHG F R Q V W U X F W L R Q Q W O F H W L R Q H V V H Q W
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HQYLURQPHQW ODQ\ VKRUW WLPH S D U D P H Q W F R L N H U X Y H K L F O H @
VSHHG ZLQG VSHHG ZLQG GLUHFWRQ PLI DQG DJH SOD\ D
FUXFLDO UROH WKDQ ORQJ WLPH S D U D P H W H U H D O E N H V P R Q G W R E D F D W L
DQG FRQWUROOLQJ DV ODWWHU W K H V S D W R I W H I V K L O G P H H G W R W X Q Q H
VKRZV WKH QXPEHU RI SXEOLFDFWLRQ
SXEOLFDFWLRQ JUDSK)URP WKH SDVW

&RUUHVSRRQGLUJDDXWKRUXGHQWQLWZDFLQ

IRUW\ WKRXVDQG SXEOLFDWLRQ ZKLFK HDEH B B F B B OD VFKHG CRHQ JH IRU W
YDULRXV LQWHUQHWR VXRUFHV ZDWRK XPD IDFXWR QX R LQHW KR I SURFHVV RI
SXEOLFDWLRQV GRQH LQ 6SULQJRXU G DVLQRZHG H \$EW K\$ 6R I(WXQQHO VHF
\$PHULFDQ 6RFLHW\ RI &LYLO (QJLQKH D LQJ D DQ GW 7 D\ Q R U L D Q Q \ L F V
UDQFLV

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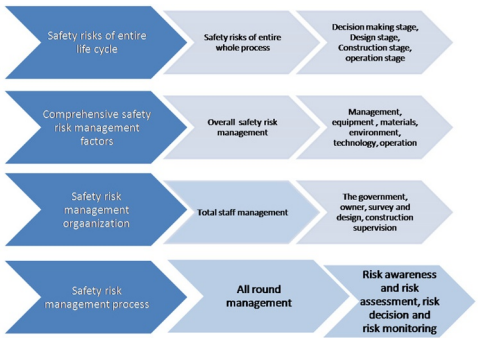


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VDIHW\ VLWH FRQGLWLRQV EXLQJ DGGVYHKLFOHV DQG DGGVYHKLFOHV
RI PDQSRZHU TXDQWLW\ RI PDWHULDOV DQG GHWDLOV DQG DGGVYHKLFOHV
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IXWXUH GLVXWHV +XPDQ KHDWK DQG DFFLGHQWDO IDFWRUV



)LJ 0HWKRGRORJ\ DGRSWHG E\ &KLQJ IRU XQGHUFRQWURO
HQJLQHULQJ

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ULVN 0DQ\ FRPSDQLHV QRZ NHHS D WUDFN RI DQG DFFLGHQWDO IDFWRUV
OLNH DSSURYH SD\PHQWV XSGDWH URRU\ JHHU\ UHFDGVWLRQV RI WKH WR
DGMXVWPHQW TXDOLW\ FRWURO DGGVYHKLFOHV DQG DGGVYHKLFOHV RI ZDW
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HQHUJ\ DQDO\VLV KDV EHHQ GRFXPHQW\ &KHDG GULYHV
VKLHOG RSHUDWLRQV DQG YDULRXV QRQOLQHDU SDUDPHWHUV

7KH FDXVDW\ IDFWRU DV JLYHQ & D V X D W L H V S R U L W D W L R Q V R I I R F X
7DEOH IRU WKH SUH FDOFXODWLRQ RI ULVN DQG WKH H\WHQW RI
GDPDJH FDXVHG E\ VHYHUDO FDXVHG VSHULSKHUDO V
PRGHV

7DEOH DW DOLW\ IDFWRU DGRSWHG IRU LPSDFW\ QDQV V K H U N V K R X O G E H U L J R U P

ORGH RI WUDQVSRU L W D W L R Q V R I I R F X	& D V X D W L H V S R U L W D W L R Q V R I I R F X
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5DLOZD\	
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7KHUH LV D KLJK GHJUH RI XQFRUFRQVSHXVHG MRU VWH
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XQFHUWDLQW\ LQ FRQVWUXFWLRQV QDQV V K H U N V K R X O G E H U L J R U P
> @ \$ QXPEHU RI KD]DUGV DUH SHUHQWV V K H U N V K R X O G E H U L J R U P

ZRUNIRUFH GXULQJ JURXWLQJ RSHUDWLQJ *URXWLQJ ZRUN
FRQVLVWV RI WKUHH PDMRU VDFHV WDELOLVWV YLDFHQW RI ULWLFDO SR
SRZHU\XO K\GUDXOLF DQG SQHXPDWLQJ IRU VDFHV RI XOGHUZDW
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FDSDFLWLHV IRU PL[LQJ SURFHVV DQG 8VDJH RI LPSRUWDQW SDUDP
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)ORRGV DUH DQRWKHU IDFWRU ZKLFK HXVH\ JKLHQD\ DWHRQ WKH OD
WXQQHO FRQVWUXFWLRQ 'HWDLGHV V R X Q G K L Q E H H Q I R Q G Q W H U X S W L
HOLFLWHG RQ UHJLRQ ZLVH IORRGHFLK R Q D V F R Q P H Q W W H P K O W L X H Q I
DUFKLYHV ZKLFK LQFOXGHV D HQWLQ\ R Q W L Q W D O F R Q G W L R Q E : K L O H C
DQDO\VLV XVLQJ UHPRWH VHQLVW X Q G H Q V Z L O J H H Q G B R Q F D O H G X F H W K
LQIRUPDWLRQ V\ VWHP * , 6 F P X W L L H U Q W H U D O S P L W L R Q Q J I U R P W K H

G VFHQDULR EDVHG DQDO\VLV ZKLFK G L Y H Q Y H E S S O R B H K L Q G H U L Q
EDVHG RQ HYDOXDWLRQ RI RYHURZHQ E D V N H R R V D S K B O W V K D O O
V\ VWHPV KDV EHHQ SURSRVHG IRU L R S S U R V H G K D W K W X Q Q H O V > @
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VDWHOOLWH EDVHG UDGLR QDYLDWLRQ V\ VWHPV OLNH JOREDO
SRVLWLRQ V\ VWHP *36 RU RXU L Q Q D W H R X V O \ G H Y H O R S H G S P H W H U
, QGLDQ 5HJLRQDO 1DYLDWLRQ 6 D W H O O L W H 6 \ V W H P , 5 1 6 6
1DY, & DQG EXLOG LQIRUPDWLRQ PRGHQDQJ W % L E X W A V D O V R D G L H Q W * H R
EHHQ SURSRVHG > @ 7XQQHO L V P D Q W O L Q J O D F K L Q H L V D V
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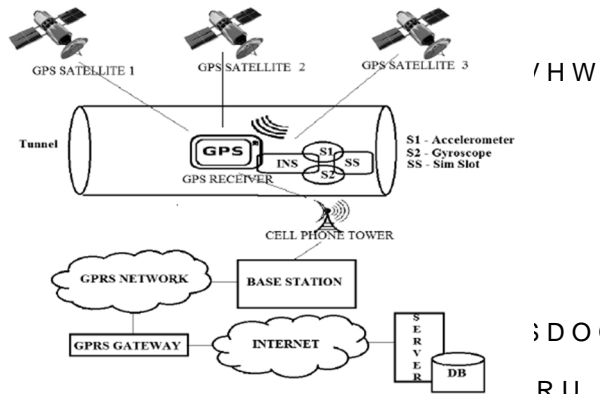
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ODFN RI RFFXSDWLRQDO PHGLF Q H W B R E L Q G R S H O W L V G W K P S H U D W X U H , Q V
V\ VWHP ZLWK D ORZ DZDUHQHV RI K H D O W K D Q G V D I H W L L W X H V
DW DOO OHYHOV RI PDQDJHPHQW DW PDQ\ WXQQHO FRQVWUXFWLRQ
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ERG\ SURSHU FOLHQW VXSHU\LVW R I R N H O G F W R S K L A K W O F D W R E W U X E W
XQLRQV ZKLFK VKRXOG KDYH D K S D S U L W H U V K R G R K P W X F W E R Q L Y D O R
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3UHYPHWLYH PHDVXUHV

OLJKW DW QLJKW DQG VKLIW ZRUNL
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\$VVXPSWLRQ RI VHTXHQWLD O DFFLGHV LQVWURGDZHU D ZKHQ H[SRVHO
DQG PDMRU GHYHORSPHQW WRRN SOHWHUURXQGH DQG RPHEDG OLQNHG WR
:RUOG :DU IRU D QXPEHU RI VDIHW\ FODVVLFDWLRQ LQVWURGDZHU H[SRVXUH
> @ ,QFRUSRUDWLRQ RI ULVN EDVHG RYHU D WRRHFWLYH JXDUG
DQG FRQWURO KDG EHHQ SURSRVHG ZKLFK FDQ EH FODVVILHG
LQWR TXDOLWDWLYH DQG TXDQWLWDWLYH ULVN DQDO\VHV WR SUHYHQW
KHDY\ FDVXDOW\ H[ORVVSURSKO\ VDIHW\ YLRODWLRQV > @ \$WWH
IRUPXODWH WKH EDVLF HYHQW G DQG XVLQJ WKHP LQ VXEVHTXHQV
IHDVLEOH PHWKRQ RI DGRSWLRQ DQDO\VLV KDG EHHQ WDNHQ LQW
WXQQHOV PHWKRQV ZKLFK FDQ E HQJLQHULQJ PHWKRQ UHYHUVH
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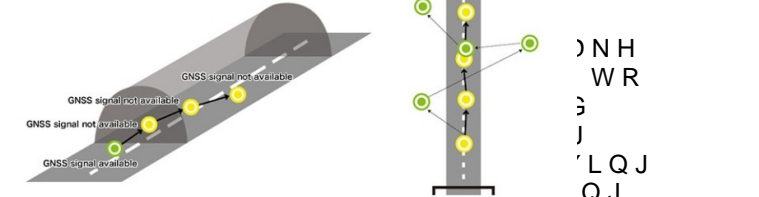
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ZLWK D ORQJ SHULRG RYHU URF
WKHUH LV ORZHU ODWHUDO SU
SUHOLPLQDU\ FKHFN XS RI XQGHUJURXQG FRQGLWLRQV LQ WKH
+LPDOD\ DQ UHJLRQ D QRYHO PXWLSO HJUDSK WHFKQLTXH KDG
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Utilizing Dead Reckoning capability
Not utilizing Dead Reckoning capability



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VHLVPLF ULVN > @ ,QFOXVLRQ
UHDFWLRQV VKDOO EH GRQH I
SURFHGXUH RI ORQJ WXQQHOV D
VDIHW\ HGXFDWLRQ VKRXOG DOV
WXQQHO VDIHW\ 7KH GHVLJQHU
HQYLURQPHQWDO LQIOXHQH ZKLOH
GHVLJQLQJ WXQQHOV > @
)LJ VKRZV IXQFWLRQLQJ LQVLGH
D WXQQHO EIRU SURSHU
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QRW NQRZ WKH FHQWUH OLQH
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Utilizing Dead Reckoning capability
Not utilizing Dead Reckoning capability

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PDQDJHPHQW SODQ LQ > @
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SURMHFW > @

Utilizing Dead Reckoning capability
Not utilizing Dead Reckoning capability

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H[SRVHO RI D VHYHUH SDVW
ILUH LQ +RQGRQDYLQVWURGDZHU
IURP D WUXFN FDUULQJ
GLHVHO RXWVLGH D WXQQHO > @
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D QHRSOLQJ RI QHWZRUNHG
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RUDGFDWLRQV WH 5DQJLQJ
LPSURPHQW VDIHW\ WH
5DGRQ FRQWHQW LQ WXQQHO
HQYLURQPHQW VDIHW\ WH
WR YHQWLQDWLRQ SURYLVRQ
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PDQDJHPHQW SODQ LQ > @
YHULXV QHJLQHUV DUH LQYROYHG
SURMHFW > @

Utilizing Dead Reckoning capability
Not utilizing Dead Reckoning capability

SLFWXUH RI G\QDPLF ERQG EHWZHQ
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EHLQJ ZLGH\ XVHG IRU UDSLQ DQG
' PRGHV \$ VWUXFWXUDO DQDO\VLV
FRQVWUXFWLRQ VFKHGXOH DQG PDW
EH GRQH

7KHUH LV D GHUWK RI H\SHULHQ
FRQVWUXFWLRQ PDQDJHPHQW LQ X
LPSURYH WKH IXQFWLRQLQJ RI PD
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WHFKQRORJ\ UDGLR IUHTXHQF\
*,6 *36 56 WHFKQRORJ\ DQG YLU
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PRGHUOLQJ VRIWZDUH 63(&)(0'
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PRGHUOLQJ DQDO\VLV > @

([WUD VDIHW\ PHDVXUHV VKRXOG
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DUHD SURQH WR ILUH IRU IXOO Y
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HTXLSSHG DW WKH WXQQHO VLWH
FRXOG KHOS UHOLHYH GULYHUV
H\WHQW DQG PRUHYHU GHYHORS
WKDW FDQ LQWHQVLI\ GULYHUV
LQIRUPDWLRQ PRGHV %,0V KDV
LQIRUPDWLRQ DFFRXWULQJ RYHU
LQIUDVWUXFWXUH DVVHWV > @

2QH RI WKH PDLQ LQIHUHQFHV WKDW
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WXQQHOLQJ ZLWK VHJPHQWDO FRQF
WRZDUGV K\GURHOHFWULF SRZHU GH
WUDQVSRUDDWLRLQ HVSHFLDOO\ LQ
> @

'LVFXVVLRQV DQG &RQFOXVLRQ

7DEOH VXPPDULJHV DOO WKH SDVW
DGRSWHG UHPHGLHV

7DEOHXQQHOV FRQVWUXFWHG LQ SDVW
ZLWK DGRSWHG UHPHGLHV

HQ WKH VWUXFWXUDO V\WHP
DQG WKH FRQVWUXFWLRQ DQG WKH
EHLQJ ZLGH\ XVHG IRU UDSLQ DQG
' PRGHV \$ VWUXFWXUDO DQDO\VLV
FRQVWUXFWLRQ VFKHGXOH DQG PDW
EH GRQH

7KHUH LV D GHUWK RI H\SHULHQ
FRQVWUXFWLRQ PDQDJHPHQW LQ X
LPSURYH WKH IXQFWLRQLQJ RI PD
KXPDQ UHVRXUFH PDQDJHPHQW SUR
FRQVWUXFWLRQ SURMHFW ZKLFK
XWLOLWLHV DQG WRROV DQG WHFK
*XLGH WR WKH 3URMHFW ODQDJHP
30%2. > @ 1XPURXV WHFKQ
DGRSWHG IRU WKH FRQVWUXFWLRQ
EDVHG WHFKQRORJ\ LQIRUPDW
WHFKQRORJ\ UDGLR IUHTXHQF\
*,6 *36 56 WHFKQRORJ\ DQG YLU
SURSHU XVDJH RI DGYDQFHG VHL
PRGHUOLQJ VRIWZDUH 63(&)(0'
VWXGLHV KDG EHQ FRQGXFWHG RQ
DURXQG H\FDYDWLRQV YLD DQDO\VLV
339 FRQRXUV DQG DPSOLILFDWL
N' UDWLRV %RWK WKH ORDGLQJ
DQG µµG\QDPLF LQWHUDFWLRQV
PRGHUOLQJ DQDO\VLV > @

([WUD VDIHW\ PHDVXUHV VKRXOG
UHPHGLDO ZRUN ,QVWDOODWLRLQV
DUHD SURQH WR ILUH IRU IXOO Y
HPHUHQF\ QLFKHV D FRPSUHVVHG
HTXLSSHG DW WKH WXQQHO VLWH
FRXOG KHOS UHOLHYH GULYHUV
H\WHQW DQG PRUHYHU GHYHORS
WKDW FDQ LQWHQVLI\ GULYHUV
LQIRUPDWLRQ PRGHV %,0V KDV
LQIRUPDWLRQ DFFRXWULQJ RYHU
LQIUDVWUXFWXUH DVVHWV > @

2QH RI WKH PDLQ LQIHUHQFHV WKDW
WKDW QLQH XVXDO ULVN IDFWRUV IRU
EHHQ LGHQWLILHG L H H\FDYDWLRQ
7%0 VHJPHQW DVVHPEO\ VSHFLDO
FRQGLWLRQV DUULYDO RI 7%0 JURX
PXFNLQJ DQG VKDIW FRQVWUXFWLRQ
H\FDYDWLRQ UDWH FDQ EH DQDO\JHG
WHVWLQJ ZKLFK XVHV QXPHULFDO
YLFR SODVWLQ FRQVWLWXWLYH ODZ
WXQQHOLQJ ZLWK VHJPHQWDO FRQF
WRZDUGV K\GURHOHFWULF SRZHU GH
WUDQVSRUDDWLRLQ HVSHFLDOO\ LQ
> @

'LVFXVVLRQV DQG &RQFOXVLRQ

7DEOH VXPPDULJHV DOO WKH SDVW
DGRSWHG UHPHGLHV

7DEOHXQQHOV FRQVWUXFWHG LQ SDVW
ZLWK DGRSWHG UHPHGLHV

\$ QXPEHU RI VWXGLHV KDYH SURYH & KHQDQVWKH VXXQRQ FDQ , QW & R
 E H X V H G D V D V K R U (W W L P H V K H O W H U L I
 VHFRQGDU\ GLVDVWHU VXFK DV ODQDQDNLGH DRUG BYDO) DRZHCHO 7XQQ
 RFFXUV , W FDQ DOVR DFW DV DQFKSRUWDQW URXWH IRU SRVW
 GLVDVWHU UHVFXH RSHUDWLRQV % DUUVRQV , \$7665HJLILHG
 LQQRYDWLYH DQG FRQLQXR XV WHFKQRORJDQV KDYH DQFRPH: DQJ DQG
 WR HQVXUH WXQQHO VDIHW\ G&RQQWUW% XE DQV DQVWFLRQ 7KH
 H[WHQW RI GDPDJH GXH WR FDUUL DQZXRWRHR & GYDQD DQOLEHN : =ZDDU
 WDNHQ LQWR DFFRXQW DQG VFRXOHC GRUBDGBI VDFHU WR
 SUHYHQW ILUH KDJDUGV 'HVLJQ ADIHWQ DQGLWRUQQJ DQFRN OHFK *H
 VDIHW\ LQIRUPDWLRQ VKDOO EH NHSW XSGDWHG E\
 UHVHDUFKHUV DQG WXQQHO HQJLQH H SVHU \$WU LFW WDFKWHBNDQJHLFKW
 WXQQHO FRQVWUXFWLRQ VDIHW\ PQQDJHPHQW LV D FUXFLDO
 SURFHVV RI VDIHW\ LQIRUPDWLRQ FRDQFHFWLRQ VFRVFKHGXQLDQJ. 'X DQ
 WUDQVPLVLRQ VWRUDJH DQFRMEK (QYDOXDWLRQ DQG
 UHVSQRVH ZKLFK VKRXOG EH GRQH ADIMEKGRWODU DQGLDQGLQJK , QW
 5RFN OHFK 0LQ 6FL
 5HIHUHQFHV * \$QGUHRWWL DQG & * /DL 7XQQ 8
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 , 2FDN (QYLURQ (DUWK 6FL 7 , \$LUSRW & RXQRVQW\ 'LVWULFW
 ; /L DQG + =KX 1 7 & LW\
 - &KHQ - <DQJ + :DQJ % /LX DQG & Review on Fire Safety Management
 *HRWHFK 6SHF 3XEO and Application to Hong Kong
 0 : *XL DQG 0 & &KLHQ *HRWHFK 3HRO (QJTD 7XQQ 8QGHUJU 6S
) OHQJ 5 &KHQ DQG ; .DQJ 7XQQ < 8QGHUJU \$ DQSKDQVVFH Q G
 7HFKQRO 1 (L (.KDLQJ * \$EXGX[LNH 3 3RV
 = +X + 'LQJ - /DL + :DQJ ; 'LYDNDQJ 8LYH DOLQJDP 1 1D]HKD *
 &RQVWU %XLOG ODWHU &KULVWRSRXORWLDQ N6RK 6RO DQD DQG -
 & *XR 0 :DQJ / <DQJ = 6XQ & DU =KDQJ DQG -
 ;X 5HQHZ 6XVWDLQ (QHUJ\ 5HY : (O GDVK
 - . /HPOH\ 7XQQ 8QGHUJU 6S 7HFKQRO & /L DQG ; /L ,QW - 5RFN OHFK 0L
 0 6 7RPDU DQG 6 .KXUDQD 7XQQ 8QGHUJU 6S 7XQQ 8QGHUJU 6S 7HF
 7HFKQRO
 , 7 &RPPLWWHH *URXS < <DQ ; :DQJ / 6KL DQG + /LX
 2VDPD %HGDLU 3UDFW 3HULRG 6WUXFWH HOG DQG 7U+DUWPDQQ
 : /LX 7 =KDR : =KRX DQG - 7DQJ
 ' 0 =KDQJ = 5. /+X DQJ - < <DQ
 DQG - =KDQJ 7XQQ 8QGHUJU 6S 7HFKQRO 6ZDQHO 0 3DOPHU * %DUOD
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 + 6DOHKLJ DQGR5 (QXU6WUXFW 5HV
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 - 3HUIRUP &RQVWU)DFLO
 + 0 /X 6 / 6KHQ \$ =KRX DQG - <DQJ 7XQQ
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) &KHQ + 3HQJ ; 0D - /LDQJ : +DR DQG ;
 3DQ 7XQQ 8QGHUJU 6S 7HFKQRO
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 & *UHHG &RQVWU 0DQDJ (FRQ
 \$ %DODVXEUDPDQLDQ
 & /ySH])HUQiQGH] ' \$ 3ULHWR *)HUQiQGH]
 9LHMR / 3DQGR DQG (&)HUQiQGH] - *HRWHFK
 *HRHQYLURQPHQWDO (QJ