

UNIVERSIT

T a 3:<O3?GF .: ?USbIRMS3C + CGKLIMMSEC + CS
QKSMS

[,300\$

P 3?LZGRK;LMLN\$

T a 3:<GO3?F .: ?USbIRMS3C + CGKLIMMSEC + CS
QKSMS

J13.9\$

P 3?LZGRK;LMLN\$

T a 3:<GO3?F .: ?USbIRMS3C + CGKLIMMSEC + CS
QKSMS

'/,1.60\$

P 3?LZGRK;LMLN\$

T a 3:<GO3?F .: ?USKIMMSEC + CGSNIRMSEC + CS
QKSMS

@ "9,3:V] 915#\$\$

P 3?LZGRK;LMLN\$

T a 3:<GO3?F .: ?USKIMMSEC + CGSNIRMSEC + CS
QKSMS

c#F*3.+*3-7'8*+56+) 3-L*\$.(70*/M

* .#SRGW;LMLN

O3?F .: ?G\$QRLS\$ \$\$

F2#, .16"/G\$QYZS\$TQRLS`QRWMUS

T [#61.0\$9.\$* .#L\$G\$ ' * . =3?S3</#, .99.US

@ "990#9.#\$<,9+\$/ "#<9::971.6I\$

%5/1.6\$

P *0153:\$! "#3/,#\$

O#016.\$3.=\$! #5"\$

! 770.06-34', -56+) 3.06-M'

c%:.\$F2#, .16"/\$1./# .012#0/*=#./0\$71::3\$,12#9.\$' * . =3?SG\$:3/#3</#, .99.\$<9,\$ɢ/,3/19. ;\$F,1#./3/19. ;\$&99+
30016. +#./0V* .E3581.6;\$3.=\$d2#.1.6\$#2#./C

'/*=#./0\$<9,\$=3?G9.:?S1./# .012#0\$0"9*:=3\$,12#3, :?S9.\$/"#<1,0/\$=3?S<9,\$6#.#,3:\$1.0/, *5/19.0CS%::'\$5"99:\$9<\$%./3.=\$
O#016.\$-./# .012#0/*=#./0\$0"9*:=,\$#E9,/\$9\$/"#P 3,1#//3\$@3+E*0\$9.\$P 9.=3?S+9, .1.6\$.9\$/"#\$(#.#037\$@3+E*0CS\$

%:9.6\$71/"E3?+#./;?9*,\$#610/,3/19.\$1.<9,+3/19.\$+*0/\$1.5:*=#/"#<9*,\$<9,+0\$>#:97CS%::QE&'"'+1.9,\$
E9:15?S<9,+0\$+*0/\$>#<1:=#=9*/\$3.=\$016.#=#>#<9,#0/*=#./0e\$,#610/,3/19.\$10\$59.01=#,#=#L6) >4*.*C\$S

J3, #./0\$0"9*:=<1:.\$9*//"#&#^*1, #=#P 1.9,0\$%*/"9,1f3/19.0\$A9,+0C\$d35"\$@9: #6#9<\$/"#S%,/0\$* .1/\$71::0#.=<9,+0\$
/"9*6"\$O95*'16.C\$

KC (') \$P 1.9,0\$TJ3,/15IE3./U\$@9=#9<\$@9. =*5/

LC (') \$P 1.9,0\$d+#,6#.5?P #=#153:\$- .<9,+3/19.\$A9,+

RC (') \$P 1.9,0\$D 312#,\$3.=\$&#:#30#G\$J3,/15IE3/19.\$%6,##+ #./\$3.=\$g13>1:1/?\$D 312#,

NC J158\$)E\$%*/"9,1f3/19.\$A9,+

J:#30#<1::9*/\$3.=#:#5/,9.153::?016.\$/"#<9,+0\$30\$099.\$30\$E9001>:#\$/9\$"9:=?9*,\$,#610/,3/19.C\$

)E9.\$9*,\$,#5#1E/\$9<\$?9*,\$59+E:#/#=\$3EE:153/19.\$3.=E3?+#./;?9*\$71::,\$,#5#12#3\$59.<1,+3/19.\$#+31:\$/"3/\$
1.5:*=#0\$9*,\$,#59,=\$9<\$?9*,\$E3?+#./0/3/*0C\$J:#30#\$5"#58\$/"10\$1.<9,+3/19.\$<9,\$355*,35?\$3.=#:#/\$*0\$8.97\$9<\$3.?\$
.#5#003,?\$3=H*0/+#./0\$,16"/\$373?C\$

D#"\$9E#/"3/\$?9*\$71:.\$>#H91.1.6\$*0\$<9,\$/"10\$?#3,h0\$1.5,#=1>:#\$%,/0(')\$'*+++#,\$-./#.012#B\$-<\$?9*\$"32#3.?\$
^*#0/19.0;\$E:#30#\$59./35/\$*0\$3/\$NWMGSWbGYWNL\$9,\$3,0 i 8#.#037C#=#*C\$D#3,#\$:9981.6\$<9,73,=\$/9\$0##1.6\$?9*\$
/"10\$ '*+++#,\$j\$k9\$F7:0B\$

'##\$?9*\$1.\$*.#,\$

a3,,109.\$g9.6\$\$
-./#,1+\$O#3.;@\$9::#6#\$9<\$/"#\$\$,/\$

O,C\$g#0:1#\$\$C\$[:3587#::
-./#,1+\$%009513/#\$O#3.;@\$9::#6#\$9<\$/"#\$\$,/\$EE L□□

1. N6) >4*.''''*D0/.+3.06-'Q6+) 'G'@9+E:#/#\$/'#&#^*1,#=#A9,+0\$:953/#=#'#,#C
!"10\$,#610/,3/19. \$<9,+ \$10\$,#^*1,#=#/9\$3//#.=\$/''#\$\$%&! (')\$ '* + + #,\$-./#.012#C

2. 83J'''*D0/.+3.06-'Q**'G\$%\$5,#=1/\$53,=#10\$,#^*1,#=#<9,\$E3?+ #. /#

3. '*) 0-7*+'G'N6) >4*.*!'44';' I 0-6+/'8640LJ'Q6+) /
%::<9,+0\$+*0/\$>#<1::=#9*/\$3.=016.#=#>#<9,#\$/'"#0/*=#./0e\$,#610/,3/19.\$10\$59.01=#,#=#59+E:#/#C
O95*'16. \$<9,+0\$71::=\$#0#./\$>?\$#35"\$=#E3,/+#./\$*E9. \$,#610/,3/19.C

- @#::E"9.#0\$3,#\$3::97#=#3/\$/'#1./#.012#>*/\$3,#\$#4E#5/#=#/9\$>#9<<=#*,1.6\$3::0#0019.0;\$5:300#0;\$3.=
,#"#3,03:0C
- '/*=#./0\$<9,\$92#, .16"/\$71::\$.9/\$>#3::97#=#/9\$>,1.6\$3\$53,\$9./9\$53+E*0C
- '/*=#./0\$,#610/#,#=#<9,\$/'"#F2#, .16"/\$-./#.012#3,#,#^*1,#=#/9\$H91.\$/'"#9,1#./3/19.\$0#0019.\$9.
'*.=3?\$3</#,.99.\$30\$7#:::\$30\$/'"#2#.#1.6\$#2#./\$J:#30#"\$32#3/\$:#30/\$9.#\$E3,#./9,\$6*3,=13.\$E,#0#./
<9,\$/'"#9,1#./3/19.\$0#0019.C

P304*J'\$LF664'65' I (/0L'K3J'6-4JM' I 3J'9R'G'S?'9:9;'
a 3:<GO3?P *015\$bIRMS3 + \$GKLIMMSE + \$9,\$KIMMSE + \$G\$NIRMSE + '

\$LF664'65' !+. '3-7'K*/0D- 'K3J'6-4JM'T (-*'S'G'T (-*'U@'9:9;'
bIRMS3 + \$G\$KLIMMSE + \$@:300#0'
KLIMMSE + \$G\$KIMMSE + \$g*.5''
KIMMSE + \$G\$NIRMSE + \$@:300#0\$

K3-L*'K3J'6-4JM T (-*'S'G'T (-*'U@'9:9;

RIRMSE + \$G\$SIMMSE + \$! "#3/,# \$ J#,<9, + 3 . 5# \$ ' /* = 1#0\$E:35# + # . /\$3* = 1/19 . 0\$
SIMMSE + \$F2#, . 16" /\$ɢ/,3/19 . V@"#58G1 . \$\$
SIKSSE + \$G\$SINSSE + \$F,1# . /3/19 . \$ ' #0019 . \$
F2#, . 16" /\$J3, /151E3 . /0\$3, # \$, #^*1, # = \$/9\$3//# . = \$/"#9, 1# . /3/19 . \$0#0019 . \$71/"\$3/\$:#30/\$9 . # \$E3, # . /#6*3, = 13 . \$
E, #0# . /C\$
YIMMSE + \$G\$YINSSE + \$@"#58G1 . \$3/\$] 1::36# \$ ' *1/#0\$
WIMM\$O1 . . #, \$3 . = \$#2# . 1 . 6\$35/121/1#0\$<9, \$/"#F2#, . 16" /\$J3, /151E3 . /0B\$

I 6-73J@T(- *'S'G'U@'9:9;M'

! "#\$05" # = * : # \$23, 1#0\$#35" \$ = 3 ? \$<9, \$/"#53 + E\$> * /\$6# . #, 3:: ? IS
WIRM\$3 + \$G\$bIRM\$3 + \$ [, #38<30/\$
bIRM\$3 + \$G\$KLIMMSE + \$&#"#3, 03:0V@:300#0\$
KLIMMSE + \$G\$KIMMSE + \$g* . 5"\$
KIMMSE + \$G\$NIRMSE + \$, #"#3, 03:0\$3 . = \$5:300#0\$
SIRMSE + \$G\$WIMMSE + \$O1 . . #, \$
WIMMSE + \$d2# . 1 . 6\$%5/121/1#0\$

! '#\$%&'(%)#*+%, '-. / 01213%145 56-%(7\$6789:68;

- %:: \$E#, 09 . 3:\$1/# + 0;\$/91:#/, 1#0;\$3 . = \$E#, 09 . 3:\$ + # = 153/19 . 0C
- [3/"\$97#:#0C
- [# = \$0"##/0;\$>:3 . 8#;/;\$3 . = \$E1::97\$<9,\$3\$01 . 6:#\$># = \$9,\$0:##E1 . 6\$>36\$T' "##/\$01f#<9,\$\$=9, + \$># = 0\$10\$! 71 .
d4/, 3Gg9 . 6UC
- %:3, + \$5:958\$30\$. ## = # = B
- @:9/"#0\$<9,\$/"#7##8C\$O, #00\$<9,\$% , /0 (') \$ ' * + + #, \$- . /# . 012#10\$530*3:C\$ %/"#: #/15\$0"9#0\$3, # \$3\$>#//#,
5"915#\$/ "3 . \$<:IEG<:9E0\$9,\$03 . = 3:0\$<9,\$/"#7##8\$30\$09 + # \$73:81 . 6\$71:: \$># \$1 . 29:2# = C
- 'E# . = 1 . 6\$ + 9 . # ? \$<9,\$0 . 3580\$3 . = \$2# . = 1 . 6\$ + 35"1 . #0C

! '67% ! '6-6%&'(% = '%, '- / 6=98\$-#9'7;%

\$(-73JT(-*'9@'9:9;'

O,C\$ [9>>1# \$ [31:#? \$J#,<9, + 3 . 5# \$ 1 \$A3 + 1: ? \$@# . /#,\$
Nbb\$J, 1::3 + 3 . \$D3 . :3J

J3, #. /TOU\$3. =J3, /151E3. /0\$<9, \$92#, . 16"/\$3, #\$, #^*1, #=#/9\$3//#. =\$/"#7#:59 + #0#0019. V9, 1# . /3/19. C\$!9*, 0\$9<\$/"# \$ @9: :#6#9<\$/"# \$%, /0\$71::>#3231:3>: #<9, \$E3, #. /0\$3. =0/*=#. /0\$=#, 1. 6\$/"#3</#, . 99. C\$%</#, \$/"#9, 1# . /3/19. \$0#0019. \$ 0/*=#. /0\$71::>+92# \$1. /9\$/"# \$] 1::36# \$ ' *1/#\$ "9*01. 6C\$ ' / *=#. /0\$71::>, #5#12#\$/ "#1, \$=99, \$8#? \$355#00\$9\$, 99 + 0\$1. \$/"# \$] 1::36# \$ ' *1/#0C\$ ' / *=#. /0\$, #610/#, #=#30\$O3? \$@3 + E#, 0\$ "32#\$/ "#9E/19. \$/9\$ + ##/9\$. \$ ' * . =3? \$#2# . 1. 6\$#2# . /\$3. =\$/"# \$ 3</#, . 99. \$9, 1# . /3/19. \$0#0019. C\$d35"\$@F ! %\$* . 1/\$71::>#0# . =0E#51<15\$=#/31:0\$1. #3, :? \$0E, 1. 6\$<9, \$/"#1, #2# . 1. 60\$T:3/# \$ 3</#, . 99. U\$#2# . /0B\$

., \$6-% / 6=98\$-# \$9 ' 7#7&%>-967\$# \$9 ' 7#7 ' ?%? ' '#\$; %

' / *=#. /0\$71::>E:35#\$/ "#1, \$>#:9. 61. 60\$1. \$/"#1, \$, 99 + 0\$T + 16"/\$73. /\$9\$3/\$:#30/\$ + 38# \$?9*, \$>#=#BU\$3. =E, 95##=#/9\$/"# \$ 3EE, 9E, 13/#\$* . 1/0\$<9, \$35/121/1#0C\$d35"\$* . 1/\$71::>#0# . =0E#51<150\$<9, \$/"10\$:3/#, \$/"10\$ ' E, 1. 6\$30\$#43 + E:#0\$ P *0153:\$! "#3/, # \$ 71::>\$"90/\$3. \$3*=1/19. C\$

! "#\$%&'@#5)48%A '4897=%B9+6; %

% D d ' F P d B\$ (') \$=9#0\$. 9/\$"32# \$=9, + 0\$7# \$"32# \$') - ! d ' B\$
' * + + #, \$- . /# . 012# \$0/*=#. /0\$71::>\$#"9*0#=#1. \$/"# \$] 1::36# \$ ' *1/#0; \$9. 2# . 1# . /: ?\$; 953/#=#. #3, \$/"# \$ [31: #? \$@# . /# , \$3. = \$ D1:09. \$ [*1:=1. 6C\$O3. 5# \$0/*=#. /0\$71::>#0" *//:#=#/9\$@"30/31. \$J91. /# \$213\$ P 1. 1G] 3. 0\$3</#, \$>, #38<30/\$#2#, ?\$=3? \$3. = \$, #/ * , . #=#>? \$SIMM\$E C + C\$g* . 5"\$71::>#0# , 2#=#3/\$@"30/31. \$J91. /#<9, \$O3. 5# \$0/*=#. /0C\$

! "#\$%&' () "&+'

% :: \$0*1/#\$, 99 + 0\$3, # \$31, 659. =1/19. #=#71/"\$E, 123/#\$>#=#, 99 + 0\$TK9, \$L\$>#=#, 99 + 0U\$3. =E, 123/#\$, #0/, 99 + 0\$E#, \$0*1/#C\$% O%G 59 + E:13. /\$, 99 + 0\$3. =E, 123/#\$, 99 + 0\$3, # \$ 3231:3>: # \$ * . =#, 0E#513:\$ 51, 5* + 0/3. 5#0C\$ J :#30# \$:#/\$ *0\$ 8. 97 \$ 1< 0E#513:\$ 3559 + + 9=3/19. 0\$3, #\$. ##=#=#B!

! "#\$%?9CC\$'6%	CD%8*'6&4C6%E6%9+6; %

% :: \$0/*=#. /0\$71::>\$# \$1. \$5:300#0; \$, # " #3, 03:0; \$9, \$9/"# , \$35/121/1#0\$<, 9 + \$bIRMS3 + \$jZIKS\$E + \$#35"\$=3?C\$g* . 5"\$10\$ 0#, 2#=#3/\$. 99. \$71/"\$=1. . #, \$3, 9* . =SIRM\$E + C\$! "#, # \$71::>#09 + # \$<, ##\$/1 + #<9, \$ + 90/\$53 + E#, 0\$1. \$/"# \$3</#, . 99. 0C\$ m9*\$ + 3? \$*0#\$/ "10\$/1 + #/\$9\$09513:1f# \$71/"\$9/"# , \$53 + E#, 0\$1. \$3EE, 92#=#3, #30\$9, \$, #0/C\$d35"\$#2# . 1. 6\$0/*=#. /0\$71::> \$ E3, /151E3/# \$1. \$30E#513:\$35/121/?\$E:3. . #=#J3, /151E3. /0\$71::>, #5#12# \$3\$ + 9, #=#/31: #=#05" #=#: #3/#, \$1. \$/"# \$0E, 1. 6\$ <, 9 + \$#35"\$@9: :#6#9<\$/"# \$%, /0\$) . 1/\$TO3. 5#V ! "#3/, #V P *015V%, /UC\$

A ' ?%&' ?6%=6\$%#- '47&; %

-/\$71::># \$. #5#003, ?\$9\$73:8\$/9\$?9*, \$5:300#0\$3. = \$ + #3:0\$#35"\$=3?C\$! "#\$73:8\$/38#0\$9. :? \$3\$<#7 \$ + 1. * /#0C\$ J3, /151E3. /0\$3, # \$3=210#=#/9\$7#3, \$3/"# :#15\$0"9#0\$9\$=31: ?\$35/121/1#0\$3. =>, 1. 6\$3. \$* + >, #:3\$1. \$530#9<, 31. C\$O3. 5# \$ 0/*=#. /0\$7 "9\$3, # \$92#, . 16"/\$71::>#0" *//:#=#213\$ + 1. 123. \$/9\$@"30/31. \$J91. /# \$3</#, \$>, #38<30/\$#35"\$ + 9, . 1. 6\$3. = \$ >358\$/9\$/"# \$ + 31. \$53 + E*0\$3/\$=1. . #, C\$

! "#\$9, (%E6* '56%9CC; %

-<\$30/*=#. /\$>#59 + #0\$1::>\$7 "1: # \$3/\$/"# \$ ' * + + #, \$- . /# . 012# \$71/"\$3. \$1. <#5/19*0\$21, *0; \$^*3, 3. /1. # \$ "9*01. 6\$10\$3231:3>: # \$9\$ /"# \$0/*=#. /\$* . /1:\$3E3, #. /\$53. \$3, , 12#C\$d2# . /\$3. = \$] # . *# \$ P 3. 36# + #. /E#, 09. . #: \$10\$9. 601/#\$LNW; \$3. = \$3231:3>: # \$10\$ 3: 73?0\$ (') J O \$3. = \$ZKK\$30\$. ##=#=#C\$J :#30# \$59 + E: #/#/"# \$ "3:/"\$<9, + \$/"9, 9*6":?; \$E3?1. 6\$0E#513:\$3//# . /19. /\$9\$3. ?\$ 0E#51<15\$3::# , 61#0\$9, \$59. =1/19. 0\$/"3/\$ + 3? \$3EE: ?\$9\$?9* C\$<\$/ "#, # \$10\$3\$ + #=#153:\$59. =1/19. \$/"# \$ ' * + + #, \$- . /# . 012# \$0/3<<\$ 0"9*:= \$8. 97 \$9<; \$E: #30# \$/#: \$*0\$3>9*\$/ "10\$>#<9, #/\$" #0/3, /\$9<\$/ "10\$7 ##8C\$F<\$59*, 0#; \$1<\$?9*\$6#/\$0158\$9, \$"*, /; \$7##4E#5/\$?9*\$9\$:#/\$*0\$8. 97 \$09\$53. \$"#: E\$?9*\$1 + + #=#13/#: ?C\$

! '#\$%#E' 4\$%'6%#8\$%&#D;%

J#,<9,+3.5#0\$71:.\$>#"\$#=#9.\$A,1=3?§3</#,.99.\$3/\$/"#\$ [31:#?§'5"99:§9<\$P*015\$ [*1:=1.6;\$'/1::7#::§
J#,<9,+1.6\$%/,0\$@#./#;§3.=\$/"#P3,1#//3\$O3.5#§!"#3/,#§9.\$/"#\$P3,1#//3\$@3+E*0\$%==1/19.3:§
1.<9,+3/19.\$71:.\$>#0#./\$<,9+\$#35"\$* .1/\$/"10\$0E,1.6\$

/4068%

&*:#0\$3.=§J9:151#0\$<9,\$%&! '(') '\$ '* + + #, \$- ./# .012#0\$53.\$>#<9* .=\$9.\$/"#\$nk#. #,3:\$&*:#0\$3 .=\$
J9:151#0n\$- .<9,+3/19.\$' "##/\$>#:97\$D#4E#5/\$9*,\$E3,/151E3./0\$/9\$3:73?0\$>#"32#3EE,9E,13/#:?\$71/"\$
,#0E#5/\$<9,\$9/"#,\$0/*=#./0\$3 .=\$<9,\$/"#\$<351:1/1#0\$9<\$ (#. .#037\$' /3/#\$) .12#,01/?\$o3/*,3::?;\$7#=\$9\$.9/\$

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