

appendix F

A Simple System Dynamics Model of the SDF

This System Dynamics model was developed using Vensim® Professional32 Version 3.0C. It is provided as a reference for anyone interested in pursuing this more fully. There are many excellent texts on the subject and the interested reader is referred to those works.

(01) Cum SS Tasks = INTEG (SS Tasks Gen'd, 0)

Units: Task

Uses: (20)SS Finished

(25)SS Task Gen

(02) Cum Sys Syn Tasks = INTEG (Sys Syn Tasks Gen'd, 0)

Units: Task

Uses: (46)Sys Syn Finished

(52)Sys Syn Task Gen

(53)Sys Syn Tasks Gen'd

(03) Cum UD RW= INTEG (Cum UD RW Rate, 0)

Units: Task

(04) Cum UD RW Rate = Sys Rqmt RW Gen + Sys Syn RW Gen + SS RW Gen

Units: Task/Month

Uses: (03)Cum UD RW

(05) FINAL TIME = 100

Units: Month

(06) Handoff Constraint = 0

Units: Dimensionless

Uses: (26)SS Task Released

(55)Sys Syn Tasks Released

- (07) INITIAL TIME = 0
Units: Month
- (08) Nominal Quality = 0.5
Units: Dimensionless
Uses: (22)SS Quality
(39)Sys Rqmt Quality
(49)Sys Syn Quality
- (09) Number of SS = 1
Units: Dimensionless
Uses: (25)SS Task Gen
(35)Syn Tasks for SS
- (10) Productivity = 0.5
Units: Task/(Man * Month)
Uses: (13)RW Pot Work Rate
(21)SS Potential Work Rate
(38)Sys Rqmt Potential Work Rate
(47)Sys Syn Potential Work Rate
- (11) Release Delay = 1
Units: Month
Uses: (26)SS Task Released
(55)Sys Syn Tasks Released
- (12) RW Percent = 0.125
Units: Dimensionless
Uses: (14)RW Staff Level
- (13) RW Pot Work Rate = Productivity * RW Staff Level
Units: Task/Month
Uses: (23)SS RW Disc
(40)Sys Rqmt RW Disc
(50)Sys Syn RW Disc
- (14) RW Staff Level = Staff Level * RW Percent
Units: Man
Uses: (13)RW Pot Work Rate
- (15) SAVEPER = TIME STEP
Units: Month
- (16) SR Prvc'd Fraction Complete = (SR Work Prvc'd Complete)/Tasks To Do
Units: Dimensionless
Uses: (52)Sys Syn Task Gen
(55)Sys Syn Tasks Released

- (17) $SR\ Tasks\ for\ Sys\ Syn = Tasks\ To\ Do * 1$
 Units: Task
 Uses: (52)Sys Syn Task Gen
 (53)Sys Syn Tasks Gen'd
- (18) $SR\ Work\ Prcv'd\ Complete = Sys\ Rqmt\ Undisc\ RW + Sys\ Rqmt\ Work\ Done$
 Units: Task
 Uses: (16)SR Prcv'd Fraction Complete
- (19) $SRD\ Avg\ Qlty = Sys\ Rqmt\ Work\ Done / \max(0.001, Sys\ Rqmt\ Work\ Done + Sys\ Rqmt\ Undisc\ RW)$
 Units: Dimensionless
 Uses: (49)Sys Syn Quality
- (20) $SS\ Finished = IF\ THEN\ ELSE\ (SS\ Work\ Done / \max(0.001, Cum\ SS\ Tasks) > 0.9999, 0, 1)$
 Units: Dimensionless
 Uses: (23)SS RW Disc
 (24)SS RW Gen
 (30)SS Work Acc
- (21) $SS\ Potential\ Work\ Rate = Productivity * Staff\ Level$
 Units: Task/Month
 Uses: (24)SS RW Gen
 (30)SS Work Acc
- (22) $SS\ Quality = Nominal\ Quality * Syn\ Avg\ Qlty$
 Units: Dimensionless
 Uses: (24)SS RW Gen
 (30)SS Work Acc
- (23) $SS\ RW\ Disc = IF\ THEN\ ELSE\ (SS\ Undisc\ RW \leq 0, 0, \min(RW\ Pot\ Work\ Rate, RW\ Pot\ Work\ Rate * SS\ Undisc\ RW)) * SS\ Finished$
 Units: Task/Month
 Uses: (29)SS Undisc RW
 (32)SS Work To Do
- (24) $SS\ RW\ Gen = IF\ THEN\ ELSE\ (SS\ Work\ To\ Do \leq 0, 0, 1) * \min(SS\ Work\ To\ Do, SS\ Potential\ Work\ Rate) * (1 - SS\ Quality) * SS\ Finished$
 Units: Task/Month
 Uses: (29)SS Undisc RW
 (32)SS Work To Do
 (04)Cum UD RW Rate
- (25) $SS\ Task\ Gen = IF\ THEN\ ELSE\ (Cum\ SS\ Tasks > Syn\ Tasks\ for\ SS * Table\ for\ SS\ Tasks\ wrt\ Syn\ FC\ (Sys\ Syn\ Prcv'd\ Fraction\ Complete), 0, Number\ of\ SS * (Sys\ Syn\ Work\ Acc + Sys\ Syn\ RW\ Gen))$

Units: Task/Month
Uses: (28)SS Tasks Ready
(27)SS Tasks Gen'd

(26) SS Task Released = IF THEN ELSE (Sys Syn Prcv'd Fraction Complete
< Handoff Constraint, 0, 1) * SS Tasks Ready/Release Delay

Units: Task/Month
Uses: (28)SS Tasks Ready
(32)SS Work To Do

(27) SS Tasks Gen'd = SS Task Gen

Units: Task/Month
Uses: (01)Cum SS Tasks

(28) SS Tasks Ready = INTEG (SS Task Gen – SS Task Released, 0)

Units: Task
Uses: (26)SS Task Released

(29) SS Undisc RW = INTEG (SS RW Gen – SS RW Disc, 0)

Units: Task
Uses: (23)SS RW Disc

(30) SS Work Acc = IF THEN ELSE (SS Work To Do <= 0, 0, 1) * min
(SS Work To Do, SS Potential Work Rate) * SS Quality * SS Finished

Units: Task/Month
Uses: (31)SS Work Done
(32)SS Work To Do

(31) SS Work Done= INTEG (SS Work Acc, 0)

Units: Task
Uses: (20)SS Finished

(32) SS Work To Do= INTEG (SS Task Released + SS RW Disc – SS Work
Acc – SS RW Gen, 0)

Units: Task
Uses: (24)SS RW Gen
(30)SS Work Acc

(33) Staff Level = 5

Units: Man
Uses: (14)RW Staff Level
(21)SS Potential Work Rate
(38)Sys Rqmt Potential Work Rate
(47)Sys Syn Potential Work Rate

- (34) $\text{Syn Avg Qlty} = \text{IF THEN ELSE} (\text{Sys Syn Work Done} > 0, \text{Sys Syn Work Done} / \max(0.0001, \text{Sys Syn Work Done} + \text{Sys Syn Undisc RW}), 1)$
 Units: Dimensionless
 Uses: (22)SS Quality
- (35) $\text{Syn Tasks for SS} = \text{Tasks To Do} * \text{Number of SS}$
 Units: Task
 Uses: (25)SS Task Gen
- (36) $\text{Syn Work Prcv'd Complete} = \text{Sys Syn Undisc RW} + \text{Sys Syn Work Done}$
 Units: Task
 Uses: (48)Sys Syn Prcv'd Fraction Complete
- (37) $\text{Sys Rqmt Finished} = \text{IF THEN ELSE} ((\text{Sys Rqmt Work Done} / \text{Tasks To Do}) \geq 0.9999, 0, 1)$
 Units: Dimensionless
 Uses: (40)Sys Rqmt RW Disc
 (41)Sys Rqmt RW Gen
 (43)Sys Rqmt Work Acc
- (38) $\text{Sys Rqmt Potential Work Rate} = \text{Productivity} * \text{Staff Level}$
 Units: Task/Month
 Uses: (41)Sys Rqmt RW Gen
 (43)Sys Rqmt Work Acc
- (39) $\text{Sys Rqmt Quality} = \text{Nominal Quality}$
 Units: Dimensionless
 Uses: (41)Sys Rqmt RW Gen
 (43)Sys Rqmt Work Acc
- (40) $\text{Sys Rqmt RW Disc} = \text{IF THEN ELSE} (\text{Sys Rqmt Undisc RW} \leq 0, 0, \min(\text{RW Pot Work Rate}, \text{Sys Rqmt Undisc RW} * \text{RW Pot Work Rate})) * \text{Sys Rqmt Finished}$
 Units: Task/Month
 Uses: (42)Sys Rqmt Undisc RW
 (45)Sys Rqmt Work To Do
- (41) $\text{Sys Rqmt RW Gen} = \text{IF THEN ELSE} (\text{Sys Rqmt Work To Do} \leq 0, 0, 1) * \min(\text{Sys Rqmt Work To Do}, \text{Sys Rqmt Potential Work Rate}) * (1 - \text{Sys Rqmt Quality}) * \text{Sys Rqmt Finished}$
 Units: Task/Month
 Uses: (42)Sys Rqmt Undisc RW
 (45)Sys Rqmt Work To Do
 (04)Cum UD RW Rate
 (52)Sys Syn Task Gen

- (42) $\text{Sys Rqmt Undisc RW} = \text{INTEG}(\text{Sys Rqmt RW Gen} - \text{Sys Rqmt RW Disc}, 0)$
 Units: Task
 Uses: (18)SR Work Prcv'd Complete
 (19)SRD Avg Qlty
 (40)Sys Rqmt RW Disc
- (43) $\text{Sys Rqmt Work Acc} = \text{IF THEN ELSE}(\text{Sys Rqmt Work To Do} \leq 0, 0, 1) * \min(\text{Sys Rqmt Work To Do}, \text{Sys Rqmt Potential Work Rate}) * \text{Sys Rqmt Quality} * \text{Sys Rqmt Finished}$
 Units: Task/Month
 Uses: (44)Sys Rqmt Work Done
 (45)Sys Rqmt Work To Do
 (52)Sys Syn Task Gen
- (44) $\text{Sys Rqmt Work Done} = \text{INTEG}(\text{Sys Rqmt Work Acc}, 0)$
 Units: Task
 Uses: (18)SR Work Prcv'd Complete
 (19)SRD Avg Qlty
 (37)Sys Rqmt Finished
- (45) $\text{Sys Rqmt Work To Do} = \text{INTEG}(\text{Sys Rqmt RW Disc} - \text{Sys Rqmt RW Gen} - \text{Sys Rqmt Work Acc}, \text{Tasks To Do})$
 Units: Task
 Uses: (41)Sys Rqmt RW Gen
 (43)Sys Rqmt Work Acc
- (46) $\text{Sys Syn Finished} = \text{IF THEN ELSE}(\text{Sys Syn Work Done} / \max(0.001, \text{Cum Sys Syn Tasks}) > 0.9999, 0, 1)$
 Units: Dimensionless
 Uses: (50)Sys Syn RW Disc
 (51)Sys Syn RW Gen
 (57)Sys Syn Work Acc
- (47) $\text{Sys Syn Potential Work Rate} = \text{Productivity} * \text{Staff Level}$
 Units: Task/Month
 Uses: (51)Sys Syn RW Gen
 (57)Sys Syn Work Acc
- (48) $\text{Sys Syn Prcv'd Fraction Complete} = (\text{Syn Work Prcv'd Complete}) / (\text{Tasks To Do})$
 Units: Dimensionless
 Uses: (25)SS Task Gen
 (26)SS Task Released

- (49) Sys Syn Quality = Nominal Quality * SRD Avg Qlty
 Units: Dimensionless
 Uses: (51)Sys Syn RW Gen
 (57)Sys Syn Work Acc
- (50) Sys Syn RW Disc = IF THEN ELSE (Sys Syn Undisc RW <= 0, 0, min
 (RW Pot Work Rate, RW Pot Work Rate * Sys Syn Undisc RW)) *
 Sys Syn Finished
 Units: Task/Month
 Uses: (56)Sys Syn Undisc RW
 (59)Sys Syn Work To Do
- (51) Sys Syn RW Gen = IF THEN ELSE (Sys Syn Work To Do <= 0, 0, 1)
 * min (Sys Syn Work To Do, Sys Syn Potential Work Rate) * (1 – Sys
 Syn Quality) * Sys Syn Finished
 Units: Task/Month
 Uses: (56)Sys Syn Undisc RW
 (59)Sys Syn Work To Do
 (04)Cum UD RW Rate
 (25)SS Task Gen
- (52) Sys Syn Task Gen = IF THEN ELSE (Cum Sys Syn Tasks > Table Sys
 Syn Tasks wrt SR FC (SR Prcv'd Fraction Complete) * SR Tasks for
 Sys Syn, 0, Sys Rqmt Work Acc + Sys Rqmt RW Gen)
 Units: Task/Month
 Uses: (54)Sys Syn Tasks Ready
 (53)Sys Syn Tasks Gen'd
- (53) Sys Syn Tasks Gen'd = Sys Syn Task Gen *
 IF THEN ELSE (Cum Sys Syn Tasks >= SR Tasks for Sys Syn, 0, 1)
 Units: Task/Month
 Uses: (02)Cum Sys Syn Tasks
- (54) Sys Syn Tasks Ready = INTEG (Sys Syn Task Gen – Sys Syn Tasks
 Released, 0)
 Units: Task
 Uses: (55)Sys Syn Tasks Released
- (55) Sys Syn Tasks Released = IF THEN ELSE (SR Prcv'd Fraction Complete
 < Handoff Constraint, 0, 1) * Sys Syn Tasks Ready/Release Delay
 Units: Task/Month
 Uses: (54)Sys Syn Tasks Ready
 (59)Sys Syn Work To Do

- (56) Sys Syn Undisc RW = INTEG (Sys Syn RW Gen – Sys Syn RW Disc, 0)
 Units: Task
 Uses: (34)Syn Avg Qlty
 (36)Syn Work Prcv'd Complete
 (50)Sys Syn RW Disc
- (57) Sys Syn Work Acc = IF THEN ELSE (Sys Syn Work To Do <= 0, 0, 1)
 * min (Sys Syn Work To Do, Sys Syn Potential Work Rate) * Sys
 Syn Quality * Sys Syn Finished
 Units: Task/Month
 Uses: (58)Sys Syn Work Done
 (59)Sys Syn Work To Do
 (25)SS Task Gen
- (58) Sys Syn Work Done = INTEG (Sys Syn Work Acc, 0)
 Units: Task
 Uses: (34)Syn Avg Qlty
 (36)Syn Work Prcv'd Complete
 (46)Sys Syn Finished
- (59) Sys Syn Work To Do = INTEG (Sys Syn Tasks Released + Sys Syn RW
 Disc – Sys Syn RW Gen – Sys Syn Work Acc, 0)
 Units: Task
 Uses: (51)Sys Syn RW Gen
 (57)Sys Syn Work Acc
- (60) Table for SS Tasks wrt Syn FC([(0,0),(1,1)],(0,0),(0.5,1))
 Units: Dimensionless
 Uses: (25)SS Task Gen
- (61) Table Sys Syn Tasks wrt SR FC([(0,0),(1,1)],(0,0),(0.5,1))
 Units: Dimensionless
 Uses: (52)Sys Syn Task Gen
- (62) Tasks To Do = 50
 Units: Task
 Uses: (45)Sys Rqmt Work To Do
 (16)SR Prcv'd Fraction Complete
 (17)SR Tasks for Sys Syn
 (35)Syn Tasks for SS
 (37)Sys Rqmt Finished
 (48)Sys Syn Prcv'd Fraction Complete
- (63) TIME STEP = 0.0625
 Units: Month

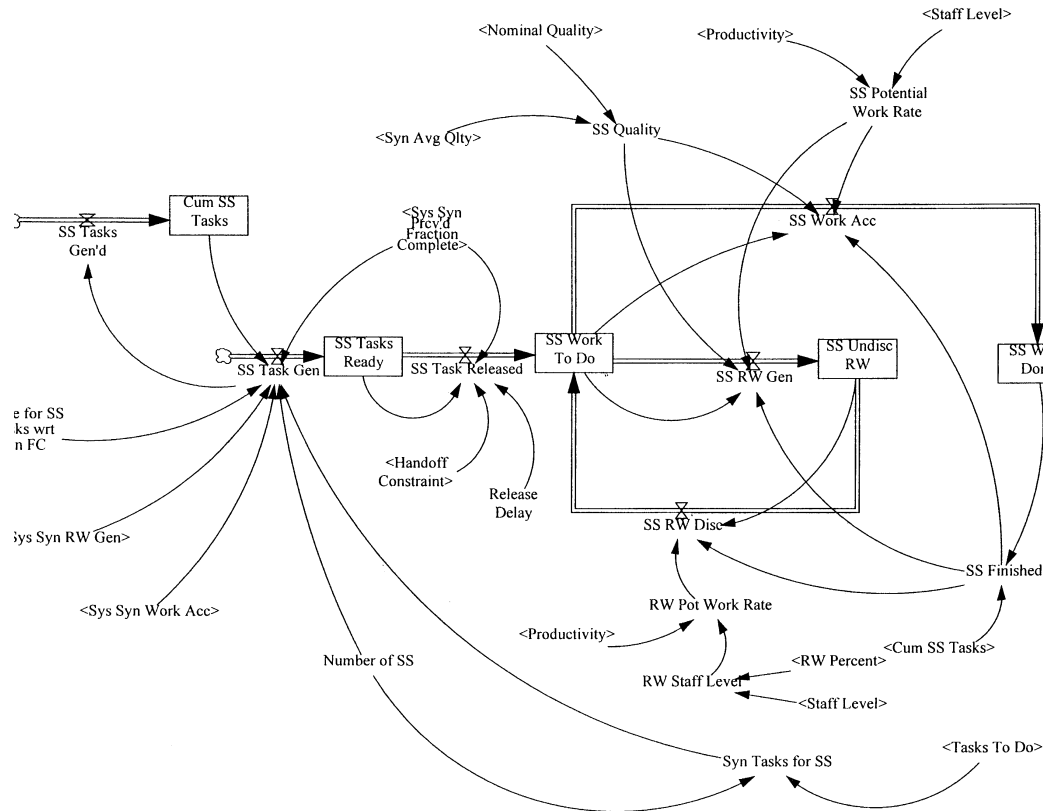


Figure F1 Requirements Development Phase.

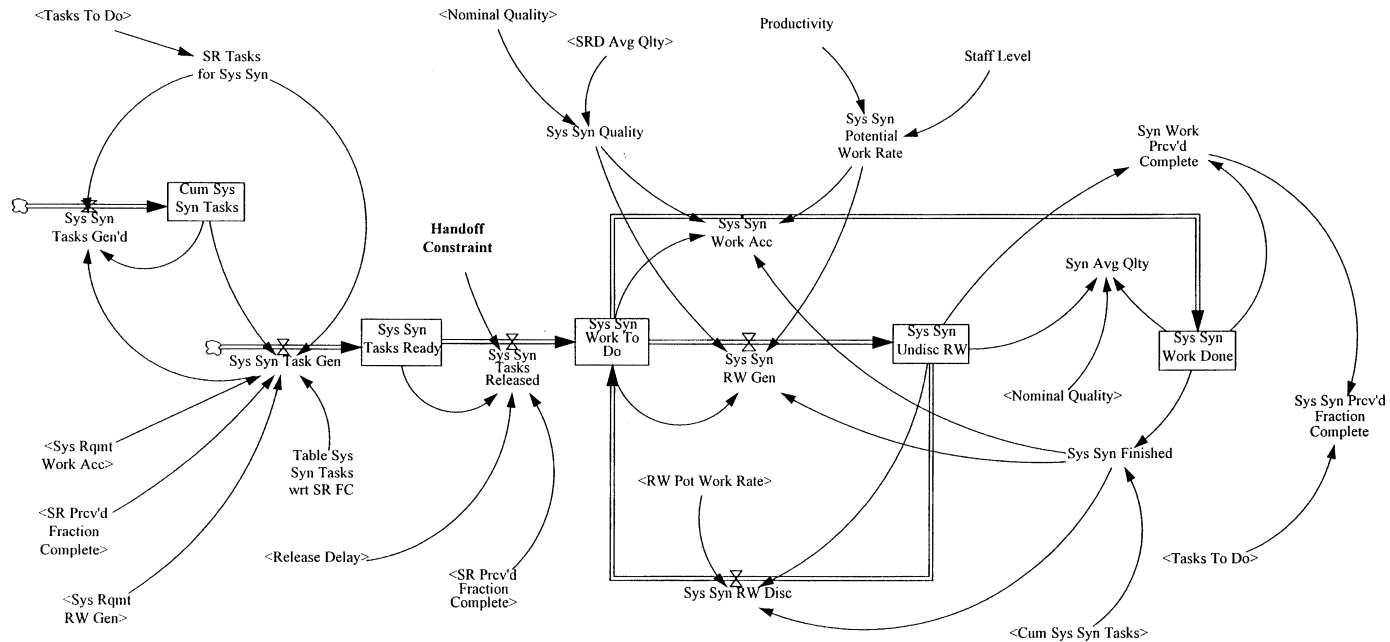


Figure F2 Synthesis Phase.

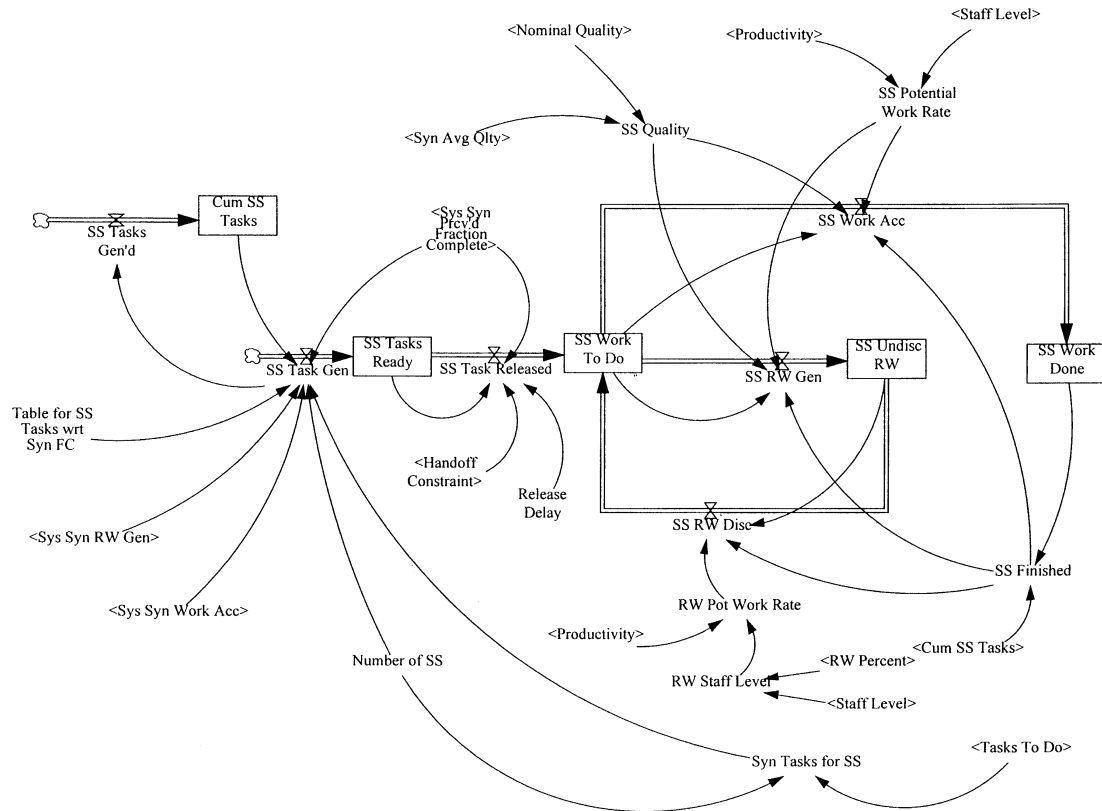


Figure F3 Subsystem Phase.