

**Software Verification & Validation - Exercise Solution**

v1.41 KJS

November 6, 2003

Quality goal - defects <	<b>1</b>	defect density <	0.1 defects/KLOC
Product size (LOC):	<b>10000</b>	KLOC:	10
Defect injection rates	<b>design</b>	<b>50</b> defects/KLOC	==> 500 defects injected in design
	<b>code</b>	<b>75</b> defects/KLOC	==> 750 defects injected in code
	<b>total:</b>	<b>125</b> defects/KLOC	==> 1250 defects

Productivity (LOC/hr) **10.0**  
 Total implementation time (design->UT) 1000 hrs

	Percent of total implementation time spent in phase	Hours spent in phase (if performed)
Design	<b>22.1%</b>	221.00
Design Review	<b>11.1%</b>	111.00
Design Inspection	<b>8.8%</b>	88.00
Code	<b>20.0%</b>	200.00
Personal Code Review	<b>10.0%</b>	100.00
Compilation	<b>3.4%</b>	34.00
Code Inspection	<b>8.8%</b>	88.00
Unit Test	<b>15.8%</b>	158.00

Yields	Defect density threshold	Yield if under threshold	Yield if over threshold
Unit Test	<b>5.00</b>	<b>90.0%</b>	<b>60.0%</b>
Integration Test	<b>1.00</b>	<b>80.0%</b>	<b>50.0%</b>
System Test	<b>1.00</b>	<b>80.0%</b>	<b>50.0%</b>

Assume that **defect-free test time** in IT and ST is the same as the time spent in UT.  
 Add **5 hours per defect** [found] in IT to the IT time (total IT time = defect-free time + 5 hrs/defect found in IT)  
 Add **10 hours per defect** [found] in ST to the ST time (totalSIT time = defect-free time + 5 hrs/defect found in ST)

**Values in shaded areas are based on data from the Software Engineering Institute which is used in their Personal Software Process<sup>SM</sup> and Team Software Process<sup>SM</sup>. See <http://www.sei.cmu.edu>.  
<sup>SM</sup> Personal Software Process and Team Software Process are service marks of Carnegie Mellon University.**

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Product size: 10 KLOC  
 Total defect injection rate: 125 defects/KLOC  
 Total productivity rate: 10 LOC/hr  
 Total defects injected: 1250  
 Implementation time (hrs): 1000.00

Development Approach	Number of ST cycles	Number of defects remaining	Defect density (defects/KLOC)	Total development time (hrs)	ST time as % of total time	Test time as % of total time	Increase in total time vs. #1	Defect Ratio vs. #1
<b>1. All phases performed</b>	1	0.14	0.01	1333.17	12.1%	25.0%		
<b>2. No design R&amp;I</b>	3	0.23	0.02	1544.38	34.3%	48.1%	15.84%	1.57
	2	1.13	0.11	1381.88			3.65%	7.86
<b>3. No code or design inspection</b>	4	0.27	0.03	1882.65	40.7%	56.2%	41.22%	1.89
	2	6.75	0.68	1534.25			15.08%	47.17
<b>4. No reviews or inspections</b>	6	0.31	0.03	2803.19	56.1%	79.3%	110.26%	2.18
	2	31.25	3.13	2180.75			63.58%	218.38

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**All Phases Performed**

Quality goal - defects < 1.00 defect density < 0.1 defects/KLOC  
 Product size (LOC): 10000.00 KLOC: 10  
 Defect injection rates design 50.00 defects/KLOC  
 code 75.00 defects/KLOC  
 Productivity (LOC/hr) 10.00  
 Total implementation time (design->UT) 1000.00 Actual Impl: 1000.00 Total Test Time (IT->ST): 333.17

Phase	Number of defects at start of phase	Defect density at start of phase	Defects Injected	Defect Removal Yield	Defects Removed	Defects Remaining	Defect density at end of phase	Time spent in phase	Total phase time	% of total time
Design	0.00	0.00	500	0.0%	0.00	500.00	50.00	221.00	221.00	16.58%
Design Review	500.00	50.00	0	70.0%	350.00	150.00	15.00	111.00	111.00	8.33%
Design Inspection	150.00	15.00	0	70.0%	105.00	45.00	4.50	88.00	88.00	6.60%
Code	45.00	4.50	750	0.0%	0.00	795.00	79.50	200.00	200.00	15.00%
Personal Code Review	795.00	79.50	0	70.0%	556.50	238.50	23.85	100.00	100.00	7.50%
Compilation	238.50	23.85	0	50.0%	119.25	119.25	11.93	34.00	34.00	2.55%
Code Inspection	119.25	11.93	0	70.0%	83.48	35.78	3.58	88.00	88.00	6.60%
Unit Test	35.78	<b>3.58</b>	0	90.0%	32.20	3.58	0.36	158.00	158.00	11.85%
Integration Test	3.58	<b>0.36</b>	0	80.0%	2.86	0.72	0.07	172.31	172.31	12.92%
<b>System Test, cycle 1</b>	0.72	<b>0.07</b>	0	80.0%	0.57	<b>0.14</b>	<b>0.01</b>	160.86	160.86	12.07%
System Test, cycle 2	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 3	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 4	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 5	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 6	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 7	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
<b>Total ST cycles:</b>	<b>1.00</b>					<b>0.14</b>	<b>0.01</b>	<b>1333.17</b>		

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**No Design Reviews or Inspections**

Quality goal - defects < 1.00 defect density < 0.1 defects/KLOC  
 Product size (LOC): 10000.00 KLOC: 10  
 Defect injection rates design 50.00 defects/KLOC  
 code 75.00 defects/KLOC

Productivity (LOC/hr) 10.00

Total implementation time (design->UT) 1000.00 Actual Impl: 801.00 Total Test Time (IT->ST): 743.38

Phase	Number of defects at start of phase	Defect density at start of phase	Defects Injected	Defect Removal Yield	Defects Removed	Defects Remaining	Defect density at end of phase	Time spent in phase	Total phase time	% of total time
Design	0.00	0.00	500	0.0%	0.00	500.00	50.00	221.00	221.00	14.31%
Design Review	500.00	50.00	0	0.0%	0.00	500.00	50.00	0.00	0.00	0.00%
Design Inspection	500.00	50.00	0	0.0%	0.00	500.00	50.00	0.00	0.00	0.00%
Code	500.00	50.00	750	0.0%	0.00	1250.00	125.00	200.00	200.00	12.95%
Personal Code Review	1250.00	125.00	0	70.0%	875.00	375.00	37.50	100.00	100.00	6.48%
Compilation	375.00	37.50	0	50.0%	187.50	187.50	18.75	34.00	34.00	2.20%
Code Inspection	187.50	18.75	0	70.0%	131.25	56.25	5.63	88.00	88.00	5.70%
Unit Test	56.25	5.63	0	60.0%	33.75	22.50	2.25	158.00	158.00	10.23%
Integration Test	22.50	2.25	0	50.0%	11.25	11.25	1.13	214.25	214.25	13.87%
System Test, cycle 1	11.25	1.13	0	50.0%	5.63	5.63	0.56	186.13	529.13	34.26%
System Test, cycle 2	5.63	0.56	0	80.0%	4.50	1.13	0.11	180.50		
<b>System Test, cycle 3</b>	1.13	0.11	0	80.0%	0.90	<b>0.23</b>	<b>0.02</b>	162.50		
System Test, cycle 4	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 5	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 6	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 7	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
<b>Total ST cycles:</b>	<b>3.00</b>					<b>0.23</b>	<b>0.02</b>	<b>1544.38</b>		
<b>After 2 ST cycles:</b>						<b>1.13</b>	<b>0.11</b>	<b>1381.88</b>		

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**No Design or Code Inspections**

Quality goal - defects < 1.00 defect density < 0.1 defects/KLOC  
 Product size (LOC): 10000.00 KLOC: 10  
 Defect injection rates design 50.00 defects/KLOC  
 code 75.00 defects/KLOC

Productivity (LOC/hr) 10.00  
 Total implementation time (design->UT) 1000.00 Actual Impl: 824.00 Total Test Time (IT->ST): 1058.65

Phase	Number of defects at start of phase	Defect density at start of phase	Defects Injected	Defect Removal Yield	Defects Removed	Defects Remaining	Defect density at end of phase	Time spent in phase	Total phase time	% of total time
Design	0.00	0.00	500	0.0%	0.00	500.00	50.00	221.00	221.00	11.74%
Design Review	500.00	50.00	0	70.0%	350.00	150.00	15.00	111.00	111.00	5.90%
Design Inspection	150.00	15.00	0	0.0%	0.00	150.00	15.00	0.00	0.00	0.00%
Code	150.00	15.00	750	0.0%	0.00	900.00	90.00	200.00	200.00	10.62%
Personal Code Review	900.00	90.00	0	70.0%	630.00	270.00	27.00	100.00	100.00	5.31%
Compilation	270.00	27.00	0	50.0%	135.00	135.00	13.50	34.00	34.00	1.81%
Code Inspection	135.00	13.50	0	0.0%	0.00	135.00	13.50	0.00	0.00	0.00%
Unit Test	135.00	13.50	0	60.0%	81.00	54.00	5.40	158.00	158.00	8.39%
Integration Test	54.00	5.40	0	50.0%	27.00	27.00	2.70	293.00	293.00	15.56%
System Test, cycle 1	27.00	2.70	0	50.0%	13.50	13.50	1.35	225.50	765.65	40.67%
System Test, cycle 2	13.50	1.35	0	50.0%	6.75	6.75	0.68	191.75		
System Test, cycle 3	6.75	0.68	0	80.0%	5.40	1.35	0.14	185.00		
<b>System Test, cycle 4</b>	1.35	0.14	0	80.0%	1.08	<b>0.27</b>	<b>0.03</b>	163.40		
System Test, cycle 5	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 6	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
System Test, cycle 7	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
<b>Total ST cycles:</b>	<b>4.00</b>					<b>0.27</b>	<b>0.03</b>	<b>1882.65</b>		
<b>After 2 ST cycles:</b>						<b>6.75</b>	<b>0.68</b>	<b>1534.25</b>		

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**No Design or Code Reviews or Inspections**

Quality goal - defects < 1.00 defect density < 0.1 defects/KLOC  
 Product size (LOC): 10000.00 KLOC: 10  
 Defect injection rates design 50.00 defects/KLOC  
 code 75.00 defects/KLOC

Productivity (LOC/hr) 10.00

Total implementation time (design->UT) 1000.00 Actual Impl: 613.00 Total Test Time (IT->ST): 2354.44

Phase	Number of defects at start of phase	Defect density at start of phase	Defects Injected	Defect Removal Yield	Defects Removed	Defects Remaining	Defect density at end of phase	Time spent in phase	Total phase time	% of total time
Design	0.00	0.00	500	0.0%	0.00	500.00	50.00	221.00	221.00	7.88%
Design Review	500.00	50.00	0	0.0%	0.00	500.00	50.00	0.00	0.00	0.00%
Design Inspection	500.00	50.00	0	0.0%	0.00	500.00	50.00	0.00	0.00	0.00%
Code	500.00	50.00	750	0.0%	0.00	1250.00	125.00	200.00	200.00	7.13%
Personal Code Review	1250.00	125.00	0	0.0%	0.00	1250.00	125.00	0.00	0.00	0.00%
Compilation	1250.00	125.00	0	50.0%	625.00	625.00	62.50	34.00	34.00	1.21%
Code Inspection	625.00	62.50	0	0.0%	0.00	625.00	62.50	0.00	0.00	0.00%
Unit Test	625.00	62.50	0	60.0%	375.00	250.00	25.00	158.00	158.00	5.64%
Integration Test	250.00	25.00	0	50.0%	125.00	125.00	12.50	783.00	783.00	27.93%
System Test, cycle 1	125.00	12.50	0	50.0%	62.50	62.50	6.25	470.50	1571.44	56.06%
System Test, cycle 2	62.50	6.25	0	50.0%	31.25	31.25	3.13	314.25		
System Test, cycle 3	31.25	3.13	0	50.0%	15.63	15.63	1.56	236.13		
System Test, cycle 4	15.63	1.56	0	50.0%	7.81	7.81	0.78	197.06		
System Test, cycle 5	7.81	0.78	0	80.0%	6.25	1.56	0.16	189.25		
<b>System Test, cycle 6</b>	1.56	0.16	0	80.0%	1.25	<b>0.31</b>	<b>0.03</b>	164.25		
System Test, cycle 7	0.00	0.00	0	80.0%	0.00	0.00	0.00	0.00		
<b>Total ST cycles:</b>	<b>6.00</b>					<b>0.31</b>	<b>0.03</b>	<b>2803.19</b>		
<b>After 2 ST cycles:</b>						<b>31.25</b>	<b>3.13</b>	<b>2180.75</b>		

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