Exercise B: Model Based Estimate Solutions

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Project Description

1. Your company is developing mission critical embedded software for a flight project. It is a reusable telecom system.
2. The flight software's three primary functions are monitoring data , data transfer, and command and control.
3. The telecom system has some design heritage with an existing telecom system that has been developed. There is a small amount of code inheritance. All new code developed will be in C.
4. A software development environment including a test-bed exists.
5. The software is nearing its preliminary design review (PDR). The software must be delivered in 17 months (68 weeks), with a small, though experienced (3 years C experience, but very little experience in the development tools), development staff.
6. Requirements are immature, therefore 10-20% requirement volatility is expected.
7. There is concurrent HW development. The HW is being developed by a contractor in another state.
8. The project is currently budgeted at 75 Work-Months.
9. The cost of maintenance does not need to be included.

This is an example of a software development project. It is meant to illustrate the basic steps of developing a software estimate. It is not intended to serve as a source for answers to all questions that may arise regarding software estimation.

Cost Driver Ratings

- Estimate cost driver ratings for each module
- Assume all cost drivers except Product Complexity (CPLX) are the same for each function
- Fill in the missing cost driver ratings on the next slide based on the given comments and assumptions:

		Monitor Data			Data Transfer			Command and Control			Comments/Assumptions
Size		**Low**	**Most Likely**	**High**	**Low**	**Most Likely**	**High**	**Low**	**Most Likely**	**High**	Derived size by analogy from Project X but most likely in physical lines of code rather than logical lines. Reduced physical lines by 25% to get logical lines.
New Code		3750	5250	7500	3000	5000	6500	5000	8000	13000	
Adapted Code					1000	1000	1000	2500	2500	2500	
Assessment and Assimilation	AA				4	4	4				Assume some module test and evaluation
Software Understanding	SU				Nom	Nom	Nom				Assume nominal software understanding
Programmer Unfamiliarity	UNFM				0.4	0.4	0.4				Somewhat familiar
% Design Modified					0	0	0	0	0	0	
% Code Modified					15	20	25	0	0	0	
% Retest					100	100	100	100	100	100	
% Code breakage		10	15	20	10	15	20	10	15	20	10-20% of code rewritten due to requirements volatility.
Scale Factor Name		**Low**	**Most Likely**	**High**	**Low**	**Most Likely**	**High**	**Low**	**Most Likely**	**High**	**Comments/Assumptions**
Precedentedness	PREC	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Somewhat unprecedented. Considerable organizational understanding of product objectives and experience in working with related SW systems. Extensive concurrent development of associated new HW and operational procedures. Minimal need for innovative dat
Development Flexibility	FLEX	Low	Low	Low	Low	Low	Low	Low	Low	Low	Development will be more rigorous for mission critical software.
Architecture/Risk Resolution	RESL	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Little risk management plan. However, % of top SW architect available. As this scale factor was widely variable and somewhat unknown, assume nominal so that it would have little affect on the effort estimate.
Team Cohesion	TEAM	High	High	High	High	High	High	High	High	High	Cooperative team.
Process Maturity	PMAT	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Upper CMM Level 1

Cost Driver Ratings (cont'd)

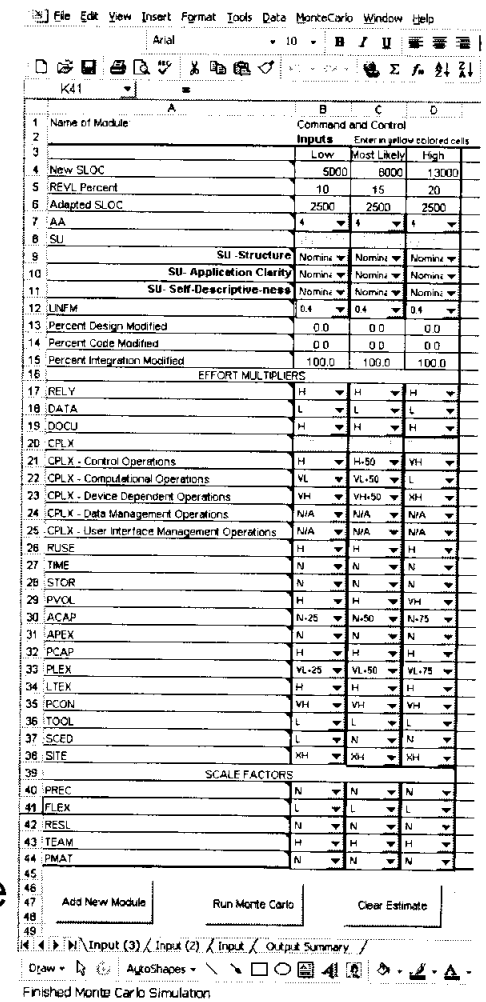
Cost Driver Name		Monitor Data Low	Monitor Data Most Likely	Monitor Data High	Data Transfer Low	Data Transfer Most Likely	Data Transfer High	C&C Low	C&C Most Likely	C&C High	Comments/Assumptions
Required Software Reliability	RELY	High	High	High	High	High	High	High	High	High	Mission critical software effect of SW failure would lead to high financial loss
Database Size	DATA	Low	Low	Low	Low	Low	Low	Low	Low	Low	No Database
Documentation Match to Lifecycle Needs	DOCU	High	High	High	High	High	High	High	High	High	Increased documentation required for mision critical software.
Product Complexity	CPLX										Function 1 = Monitor Data, Function 2 = Data Transfer, Function 3 = Command and Control
CPLX - Control Operations		Nom	Nom	Nom	Nom	Nom	Nom	High	Hi+50	VH	Functions 1 and 2 have Nominal control operations. Commands are interrupt-driven and therfore Hi-Vhi control ops. Function 3 has high to very high control ops
CPLX - Computational Operations		VL	VL	VL	VL	VL	VL	VL	VL+50	Low	Functions 1, 2 have Very low computational operations. Function 3 has Vlo-Low computational ops.
CPLX - Device Dependent Operations		VL	VL	VL	VL	VL	VL	VH	VH+50	XH	Device Drivers are in command & control. Therefore Vhi-Ehi. Monitor Data and Data Transfer have Very Low Device dependent ops.
CPLX - Data Management Operations		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A. This embedded software has no Data Mgmt Operations
CPLX - User Interface Management Operations		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A. This FSW has no User Interface Mgmt Ops.
Required Reusability	RUSE	High	High	High	High	High	High	High	High	High	Across program. Pieces of SW will NOT be used, however, entire subsystem intended for use on several different missions with little or no modification. So expecting ~a 7% impact on effort.
Execution Time Constraint	TIME	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	no time constraints
Main Storage Constraint	STOR	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	no memory constraints
Platform Volatility	PVOL	High	High	VH	High	High	VH	High	High	VH	Development platform is stable, however using new target platform (using concurrent HW engineering, which is a major risk of this system). Major change every 2-6 mo.; Minor change every 1-2 wk for optimistic and intermediate cases. However, using new HW
Analyst Capability	ACAP	Nom+25	Nom+50	Nom+75	Nom+25	Nom+50	Nom+75	Nom+25	Nom+50	Nom+75	between 55th to 75th percentile. More than nominally capable analysts.
Applications Experience	APEX	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	Telecom system experience. ~1 year
Programmer Capability	PCAP	High	High	High	High	High	High	High	High	High	75th percentile. Highly capable programmers with 10+ yrs experience
Platform Experience	PLEX	VL +25	VL+50	VL +75	VL +25	VL+50	VL +75	VL +25	VL+50	VL +75	Not much experience with the Operating System. Using a COTS real time OS. Between 2-6 months experience
Language and Tool Experience	LTEX	High	High	High	High	High	High	High	High	High	10+ years of language experience. Low experience with tools, however tools are simple. So ~3 years average
Personnel Continuity	PCON	VH	VH	VH	VH	VH	VH	VH	VH	VH	less than 3% per year turnover. Team is new, but expect not to change further.
Use of Software Tools	TOOL	Low	Low	Low	Low	Low	Low	Low	Low	Low	edit, code debug and simple, frontend, backend, CASE , little integration
Required Development Schedule	SCED	Low	Nom	Nom	Low	Nom	Nom	Low	Nom	Nom	Just right, not too tight for first delivery, so assume nominal for Optimistic and Intermediate cases. For pessimistic case, assume schedule is too tight.
Multisite Development	SITE	XH	XH	XH	XH	XH	XH	XH	XH	XH	Fully collocated

About SCAT

- Uses Cocomo II.2000 Model equations
- Currently supported for PCs only
- Incorporates uncertainty by allowing input of low, most likely, and high inputs – outputs a model-based engineering cost risk estimate based on Monte Carlo techniques
- For point estimates, use same values or ratings for low, most likely, and high
- If entering a range, enter ratings and values in increasing scale from left to right.
  - Example 1: 10,000, 20,000, 38,000
  - Example 2: Very Low, Very Low+50, Low
- For uniform distributions (a low and a high input), use a midpoint value for the most likely.

Model-Based Estimate

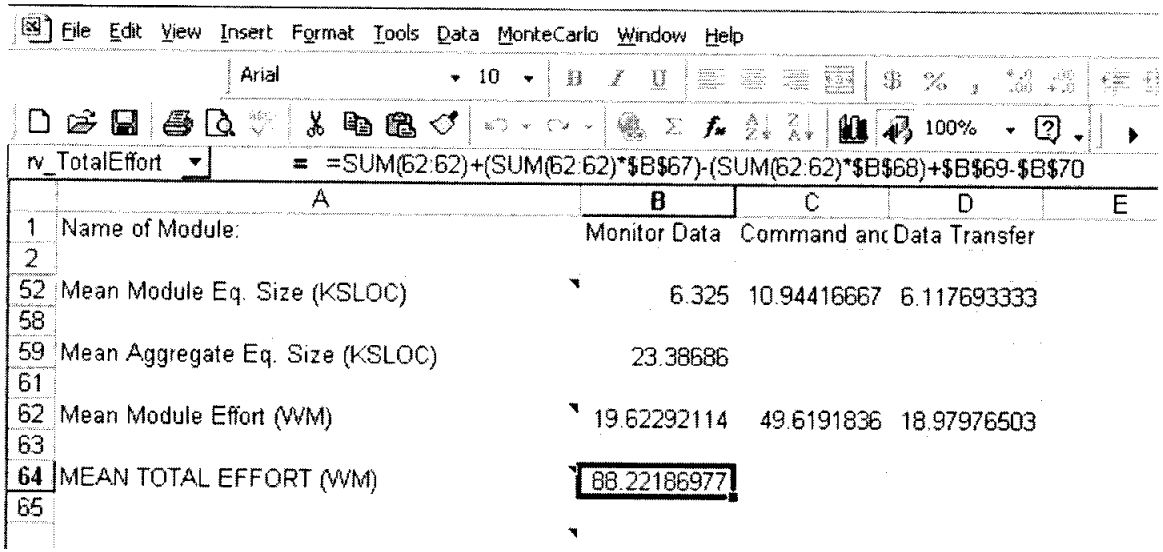
- Take size estimates from Exercise A and Input into SW cost modeling Tool
- Input Cost Driver Ratings into Tool
  - Step 1: Use drop down boxes to select ratings
  - Step 2: Enter numbers in yellow cells only
  - Step 3: Document your basis of estimate
  - Step 4: For additional modules, click "Add Module" button and repeat steps 1-4 as necessary
- Run Monte Carlo to generate cumulative probability distribution of total effort
  - Step 1: Click "Run Monte Carlo" button
- Compare engineering estimate or budget with model-based estimate
  - Step 1: Analyze the CDF curve on the "CDF output" sheet. Find where your engineering estimate or budget falls on the curve.



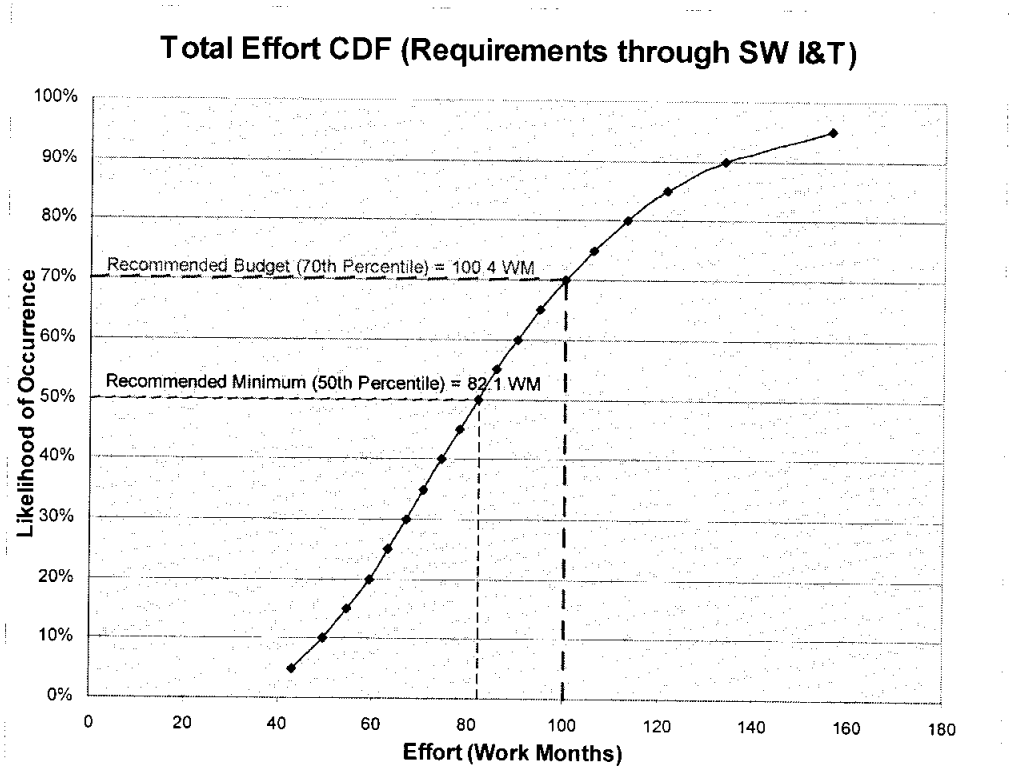
	A	B	C	D
1	Name of Module	Command and Control		
2		Inputs	Enter in yellow colored cells	
3		Low	Most Likely	High
4	New SLOC	5000	8000	13000
5	REVL Percent	10	15	20
6	Adapted SLOC	2500	2500	2500
7	AA	4	4	4
8	SU			
9	SU -Structure	Nominal	Nominal	Nominal
10	SU- Application Clarity	Nominal	Nominal	Nominal
11	SU- Self-Descriptive-ness	Nominal	Nominal	Nominal
12	UNFM	0.4	0.4	0.4
13	Percent Design Modified	0.0	0.0	0.0
14	Percent Code Modified	0.0	0.0	0.0
15	Percent Integration Modified	100.0	100.0	100.0
16	EFFORT MULTIPLIERS			
17	RELY	H	H	H
18	DATA	L	L	L
19	DOCU	H	H	H
20	CPLX			
21	CPLX - Control Operations	H	H-50	VH
22	CPLX - Computational Operations	VL	VL-50	L
23	CPLX - Device Dependent Operations	VH	VH-50	XH
24	CPLX - Data Management Operations	N/A	N/A	N/A
25	CPLX - User Interface Management Operations	N/A	N/A	N/A
26	RUSE	H	H	H
27	TIME	N	N	N
28	STOR	N	N	N
29	PVOL	H	H	VH
30	ACAP	N-25	N-50	N-75
31	APEX	N	N	N
32	PCAP	H	H	H
33	PLEX	VL-25	VL-50	VL-75
34	LTEX	H	H	H
35	PCON	VH	VH	VH
36	TOOL	L	L	L
37	SCED	L	N	N
38	SITE	XH	XH	XH
39	SCALE FACTORS			
40	PREC	N	N	N
41	FLEX	L	L	L
42	RESL	N	N	N
43	TEAM	H	H	H
44	PMAT	N	N	N

Summary Output Sheet

- "Output Summary" Sheet provides summary information (mean values):
  - Module Equivalent Size (KSLOC)
  - Module Effort (WM)
  - Total Equivalent Size of Project (KSLOC)
  - Total Effort (WM) for requirements through SW I&T Phases



	A	B	C	D	E
1	Name of Module:	Monitor Data	Command anc	Data Transfer	
2					
52	Mean Module Eq. Size (KSLOC)	6.325	10.94416667	6.117693333	
58					
59	Mean Aggregate Eq. Size (KSLOC)	23.38686			
61					
62	Mean Module Effort (WM)	19.62292114	49.6191836	18.97976503	
63					
64	MEAN TOTAL EFFORT (WM)	88.22186977			
65					

Model-Based Estimate: CDF Output

- Click "Run Monte Carlo" to generate Cumulative Distribution Function Chart
- "CDF Output" Sheet:
  - 50th percentile is the recommended minimum
  - 70th percentile is the recommended budget
- Don't forget to save your estimate using a new file name
- To start a new estimate, click "Clear Estimate"