Emerging Extensions

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Goals of Presentation

You should get a working overview of the COCOMO II Emerging Extension

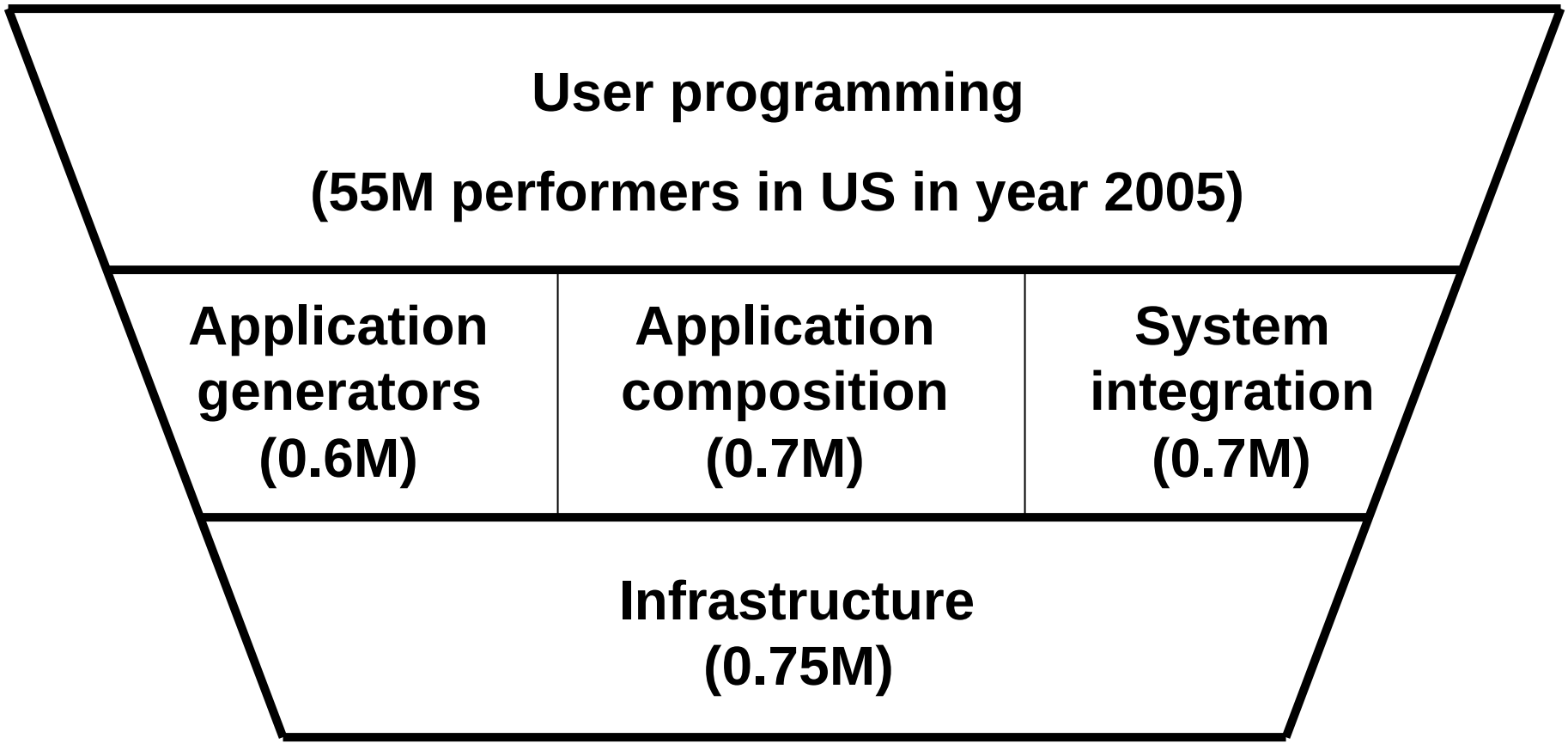
- What they are & how they work
- Principles behind them
- How they are distinct from COCOMO II

You will learn about

- Application Composition
- Dynamic COCOMO
- COPSEMO
- CORADMO
- COQUALMO
- COPROMO
- Expert COCOMO

Application Composition

The future of the software practices marketplace



Applications Composition methods rely on an Integrated Computer-Aided Software Engineering (ICASE) environment

ICASE environments generally include:

1. An applications framework (e.g. client-server or peer-to-peer message-passing) with middleware (integrate & manage execution of applications components)

2. A set of common utilities, such as

· **a graphic user interface (GUI) builder**	· **a networking support package**
· **a database management system**	·

3. Frequently

- a domain architecture and set of reusable domain components
- a repository for managing & accessing components & reusable assets

4. Development tools for

- design
- construction
- integration
- test

For applications which fit ICASE capabilities, systems traditionally requiring 10-20 people for 1-2 years can be developed by 2-6 people in 2-6 months.

The Application Point Model

SLOC sizing doesn't work: GUI Builders & visual programming make SLOCS irrelevant

Function points are too low-level: multiple GUI-iterations before number inputs or queries can be estimated

Based on "Object Points" [of Banker, Kauffman, and Kumar]:

- a metric/technique for ICASE-based financial applications
- sizing primitives based on number of
  - Screens
  - Reports
  - Third-generation language (3GL) modules

The Application Point Model (cont.)

Added project's productivity rate in NOP/PM based on

- ICASE system's maturity and capability
- developers' experience & capability in using ICASE

Used their data [see Table 5.1] for determing productivity rating scale's Low and High levels

- Low:
  - average productivity of 7 NOP/PM
  - an average maturity and experience of 6 months
- High:
  - average productivity of 25 NOP/PM
  - average maturity and experience of 18 months

Changed the name to Application Points: avoids confusion with conventional object-oriented applications sizing metrics

Application Point Estimation Procedure

Step 1: Assess Application Counts: estimate the number of screens, reports, and 3GL components that will comprise this application. Assume the standard definitions of these elements in your ICASE environment.

Step 2: Classify each element instance into simple, medium and difficult complexity levels depending on values of characteristic dimensions. Use the following scheme:

For Screens				For Reports			
Number of Views contained	# and source of data			Number of Sections contained	#and source of data		
	Total<4 (<2srvr< 3clnt)	Total<8 (2/3 srvr 3-5 clnt)	Total 8+ (>3 srvr >5 clnt)		Total<4 (<2srvr< 3clnt)	Total<8 (2/3 srvr 3-5 clnt)	Total 8+ (>3 srvr >5 clnt)
<3	simple	simple	medium	0-1	simple	simple	medium
3-7	simple	medium	difficult	2 or 3	simple	medium	difficult
>8	medium	difficult	difficult	4+	medium	difficult	difficult

step 3: Weigh the number in each cell using the following scheme. The weights reflect the relative effort required to implement an instance of that complexity level:

Element Type	Complexity-Weight		
	Simple	Medium	Difficult
Screen	1	2	3
Report	2	5	8
3GL Component			10

Step 4: Determine application Points: add all the weighted element instances to get one number, the Application Point count.

Step 5: Estimate percentage of reuse you expect to be achieved in this project. Compute the New Application Points to be developed, NAP=(Application Points) (100-%reuse)/100.

Step 6: Determine a productivity rate, PROD=NAP/person-month, from the following scheme.

Developers' experience and capability	Very Low	Low	Nominal	High	Very High
ICASE maturity and capability	**Very Low**	**Low**	**Nominal**	**High**	**Very High**
PROD	4	7	13	25	50

Step 7: Compute the estimated person-months: PM=NAP/PROD.

NOP: New Object Points (Object Point count adjusted for reuse).

clnt: number of client (personal workstation) data tables used in conjunction with the SCREEN or REPORT.

srvr: number of server (mainframe or equivalent) data tables used in conjunction with the SCREEN or REPORT.

%reuse: the percentage of screens, reports, and 3GL modules reused from previous applications, prorated by degree of reuse.

Application Composition – Application Points

Little data collected so far – thus an emerging extension

Relatively easy to apply by hand:
use experimentally on applications composition projects

More work to be done on detailed counting rules and cost drivers

Application Composition – Other Approaches

Being experimentally applied such as

- Enhanced Object Points [Stensrud, 1998]
- Unified Modeling Language use cases
  - still have a very wide range of interpretation
  - difficult to be used confidently as a sizing metric outside a relatively uniform group of applications and practitioners

Outline

Application Composition

Dynamic COCOMO

COPSEMO

CORADMO

COQUALMO

COPROMO

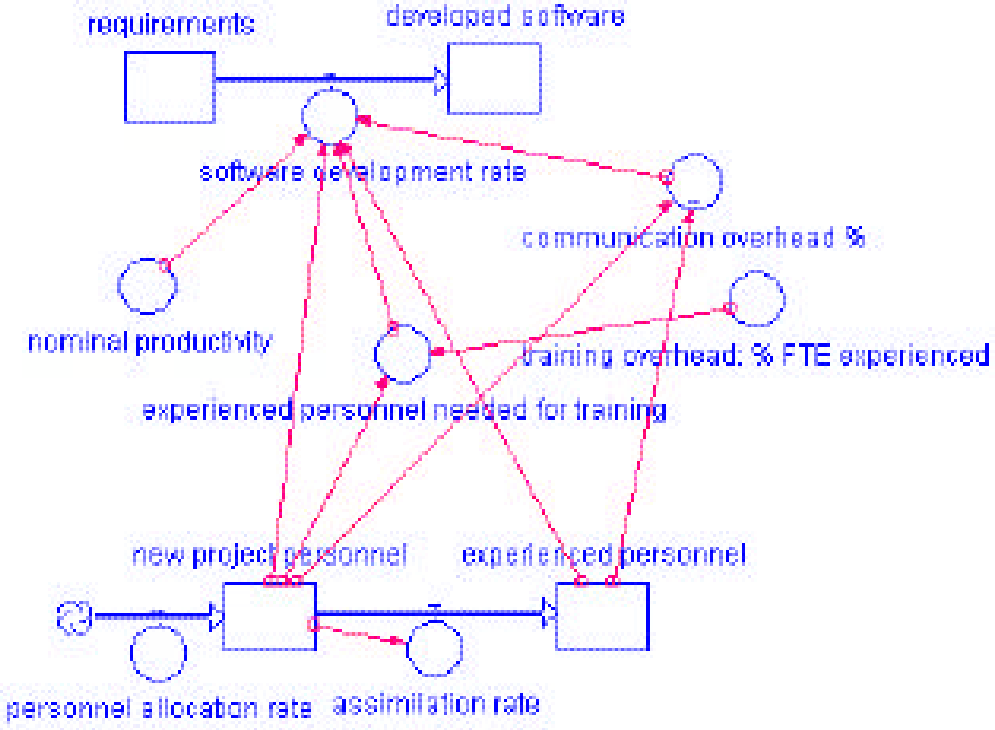
Expert COCOMO

Dynamic COCOMO

Section 5.2.5: an alternative approach for exploring effort and schedule phase distributions – a system dynamic's model of the software development process.

System dynamic's model example: Brooks' Law

- "Adding manpower to a late software project makes it later"



Dynamic COCOMO (cont.)

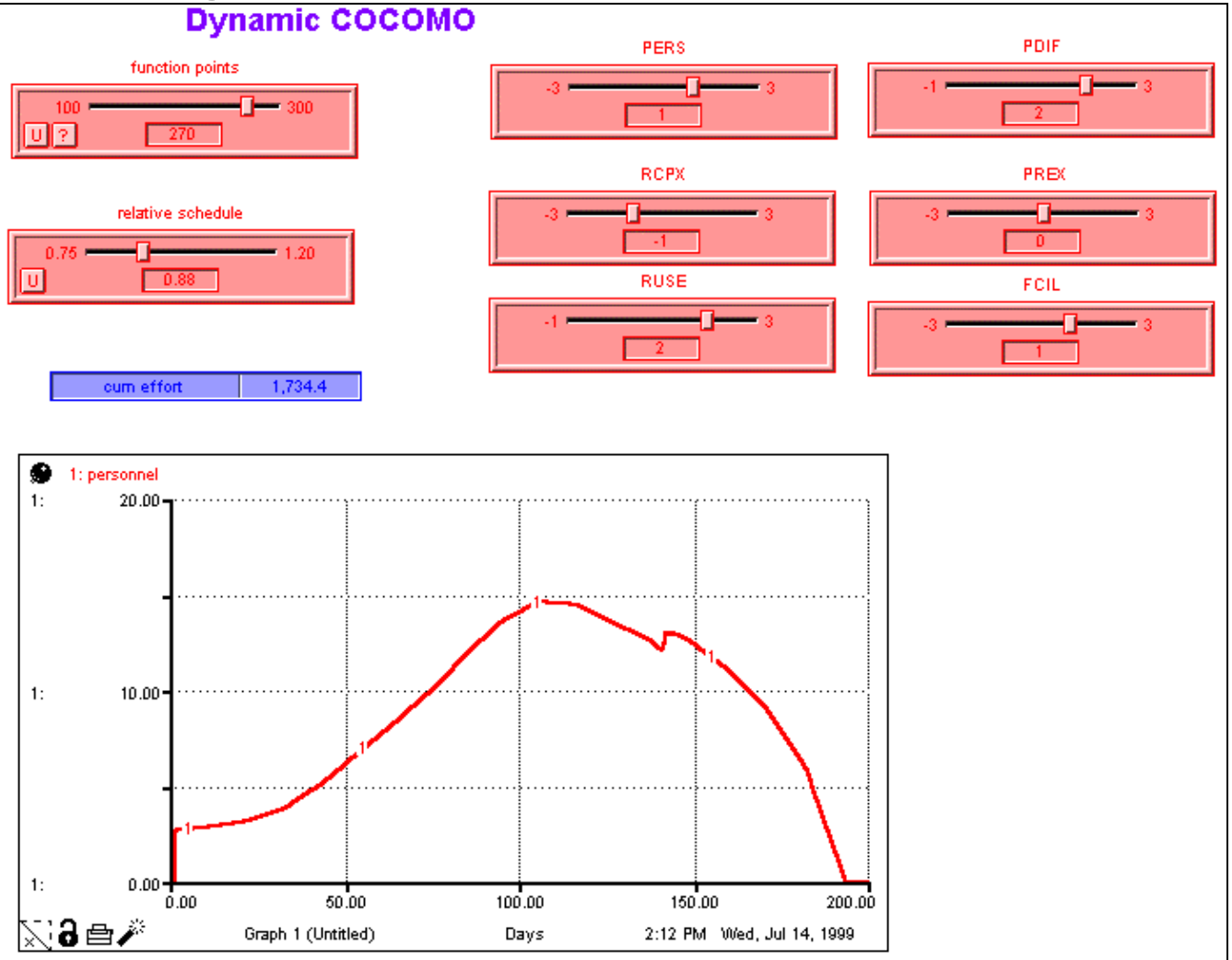
Sample Interface to Dynamic COCOMO

Sliders for Parameters based on 1996 COCOMO model

Size (Fct. Pts)
Sched

PERS
RCPX
RUSE

PDIF
PREX
FCIL



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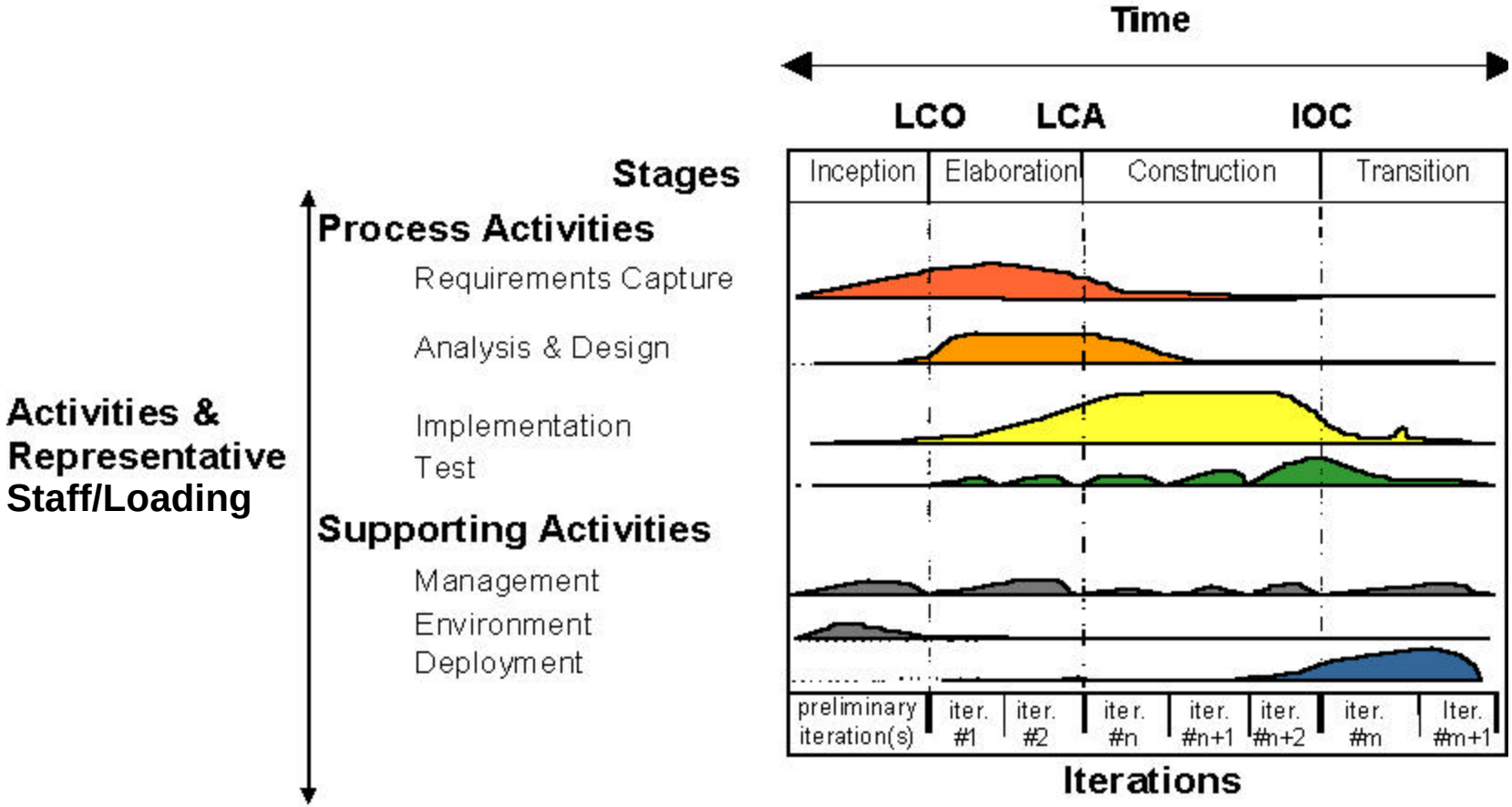
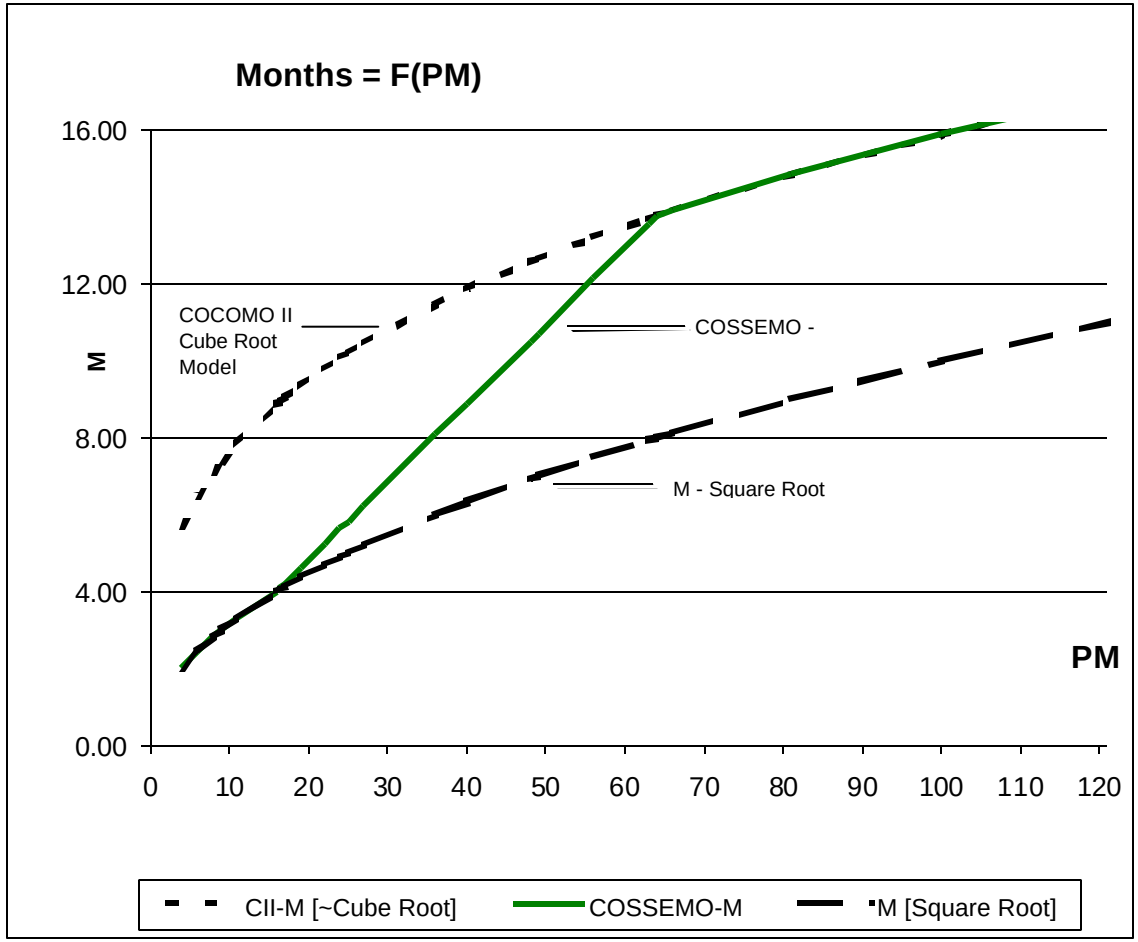
Process Model
Life Cycle Anchor Points

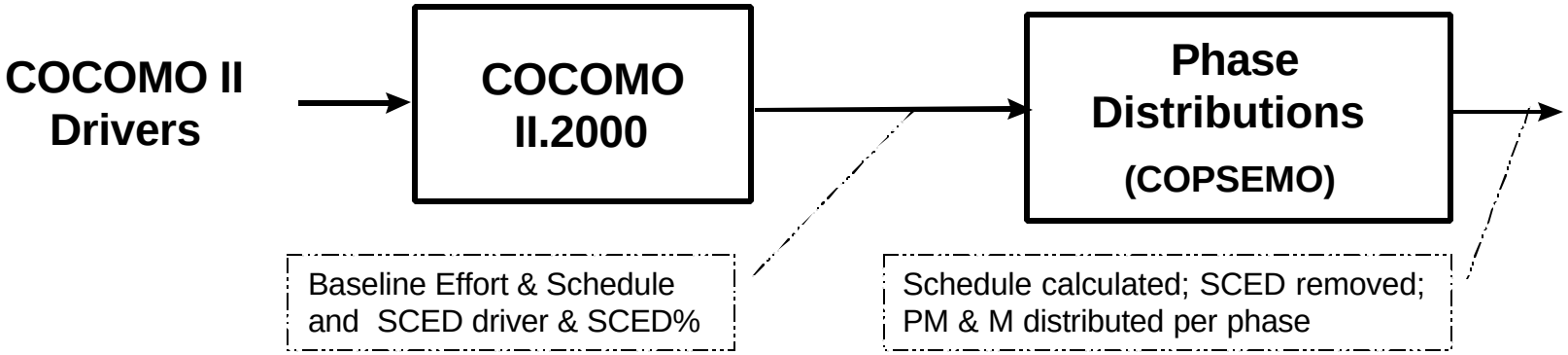


(Source: Rational Software Corporation)

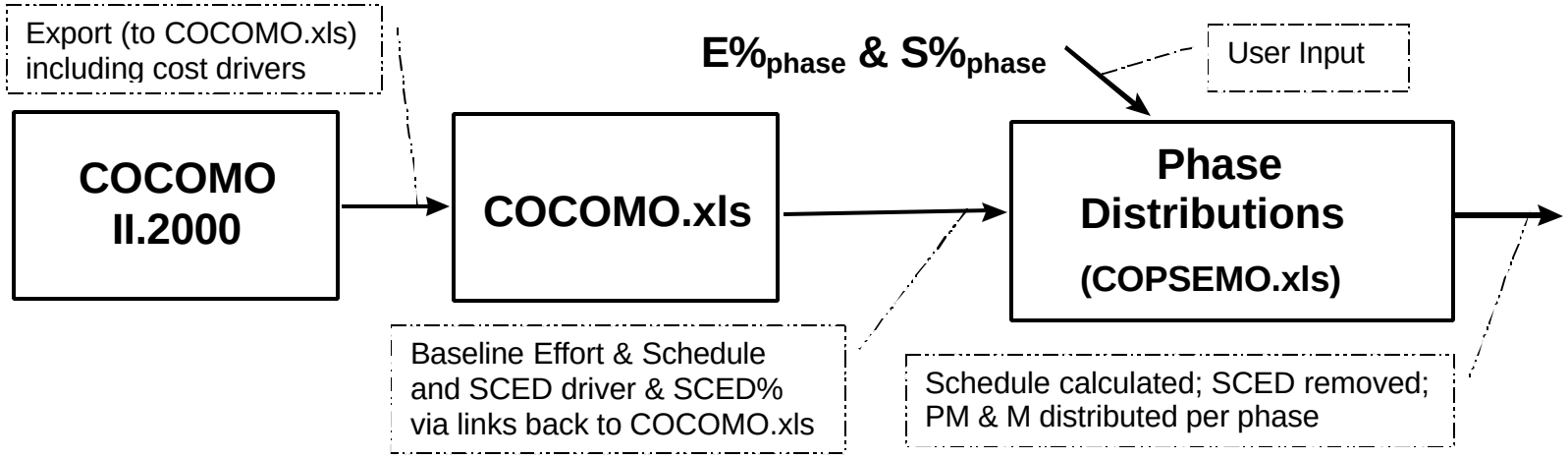
COSSEMO Duration Calculation



COPSEMO Logical &Physical Models



COPSEMO Logical Model

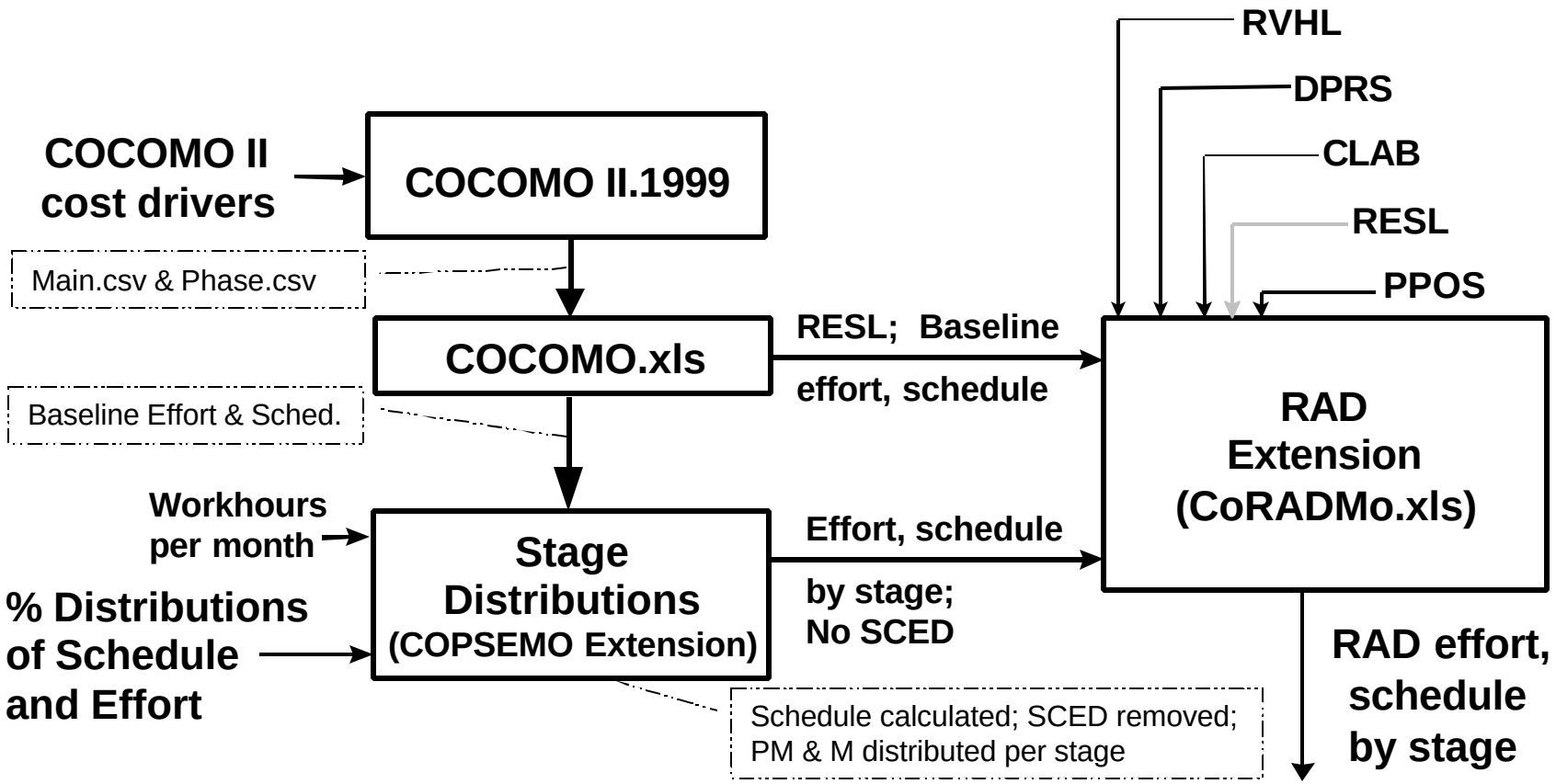


COPSEMO Physical Model

COCOMO II MBASE/RUP Phase & Activity Distribution Values

		Development			Total IECT		Total
	Inception	Elaboration	Construction	Transition	Royce	COCOMO II	Maint.
Rational schedule	10	30	50	10	100		
COCOMO II Schedule	12.5	37.5	62.5	12.5		125	
Rational Effort	5	20	65	10	100		
COCOMO II Effort	6	24	76	12		118	
Activity % of phase of IECT	100	100	100	100	100	118	
Management	14	12	10	14	12	13	11
Environment/CM	10	8	5	5	12	7	6
Requirements	38	18	8	4	12	13	12
Design	19	36	16	4	18	22	17
Implementation	8	13	34	19	29	32	24
Assessment	8	10	24	24	29	24	22
Deployment	3	3	3	30	6	7	8

Physical COCOMO II RAD Extension



COPSEMO Implementation

Default values: Ratio

	Inception			Elaboration			Construction			Transition		
Effort %	6.0	6.0		24.0	24.0		76.0	76.0		12	12.0	
Schedule %	12.5	12.5		37.5	37.5		62.5	62.5		12.5	12.5	

COPSEMO Calculations

COPSEMO

Step

1.0 ..... Currently implemented only for projects (not modules)

Get COCOMO-II.98 data and adjustments

2.0 **BOLD: required** *Italic: optional* *Project:* *32K Nom+SCED=1.07* **TotalSize=** **32,000** **PM_C=** **142.2** **M_C=** **16.07**

(automatically from COCOMO.xls) **SCED_R=** **L** **SCEDinc:** **50%** **SCED%=** **1.07** P_C= 8.851

Work hours per months (non-overhead or "billable"; COCOMO-II.1998 default=152)= **152**

3.0 Calculate Baseline values: PM_BS by adjusting work hours per months; M_BS by applying COPSEMO's M=f(PM) to PM_BS; and P_BS from PM_BS/M_BS.

Calculate Months_Base-Schedule (M_BS) as function of COCOMOII-98.2 calculated effort (PM_CnoSCED)

If PM_C<16 then M_BS = Sqrt(PM_CnoSCED); and therefore P=M

If 16<=PM_C<64 then M_BS=(Mof64-4)/48*PMnoSCED)+(4-16*(Mof64-4)/48)

If PM=>64 then M_BS =3.67*(PM_C^(0.28+0.2*(B_C-0.91)))*SCEDph/100

M_BS= =IF(PMnoSCED<16.001,SQRT(PMnoSCED),IF(PMnoSCED<64,((Mof64-4)/48*PMnoSCED)+(4-16*(Mof64-4)/48),3.67*POWER(PMnoSCED,(0.28+0.2*(B-0.91)))*SCEDph/100))

PM_BS= 142.2 M_BS= 16.07 P_BS= 8.851

4.0 Get Effort % & Schedule % per stage

x		Default	CV		Default	CV		Default	CV		Default	CV		Default	2xDflt		2xDflt	2xT %Eff	2xT %S
x	Inc % Effort	**6.0**	12.0	Inc %Sch	**12.5**	25.0	Elab % Ef	**24.0**	48.0	Elab %Sc	**37.5**	75.0	C % Eff	**76.0**		62.5	125.0	24	25
x	I %Eff Rang	2	15.0	I %S Ran	2	30.0	E %Eff R	20	28.0	E %Sch F	33.0	42.0	C % E F	72.0	80.0	58	67	0-20	0-20

Default values: *Italic*

		Inception			Elaboration			Construction			Transition			Total E&C			Total		
	Effort %	*6.0*	**6.0**		*24.0*	**24.0**		*76.0*	**76.0**		*12*	**12.0**		100.0			118.0		
	Schedule %	*12.5*	**12.5**		*37.5*	**37.5**		*62.5*	**62.5**		*12.5*	**12.5**		100.0			125.0		
	P/Ave(P)		0.48			0.64			1.22			0.96			1.00			Does not apply		
	PM/M=P	PM	/ M	= P	PM	/ M	= P	PM	/ M	= P	PM	/ M	= P	PM	/ M	= P	PM	/ M	= P-ave
BS	**32,000**	8.53	/ 2.01	= 4.25	34.13	/ 6.03	= 5.66	108.08	/ 10.04	= 10.76	17.07	/ 2.01	= 8.50	**142.2**	/ **16.07**	= 8.85	167.8	/ 20.09	= 8.35

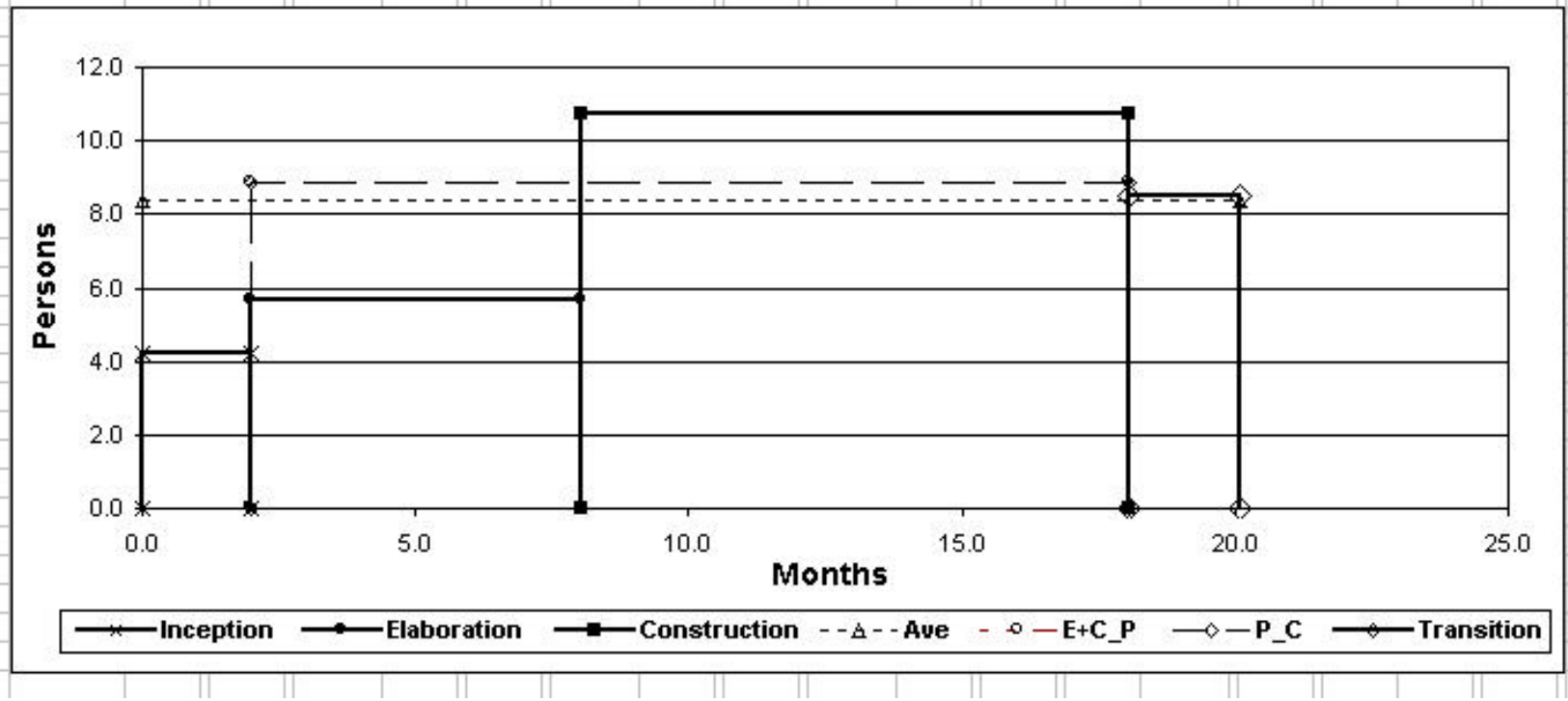
Ave(P) refers to the average number of persons on the project; it is the same as PM_BS/M_BS for the entire project,

and each stage's P/Ave(P) is the same as stage's Effort%/Schedule%.

COPSEMO "Courtesy" Plot

5.0 Plot of P vs. M. "Input" values: **BOLD**

		Inception				Elaboration				Construction				Transition				Total E&C				Total			
	Effort %	**6.0**				**24.0**				**76.0**				12.0				100.0				106.0			
	Schedule %	**12.5**				**37.5**				**62.5**				12.5				100.0				112.5			
	P/Ave(P)	0.48				0.64				1.22				1.00				1.00							
	PM/M=P	PM	/	M	= P	PM	/	M	= P	PM	/	M	= P	PM	/	M	= P	PM	/	M	= P	PM	/	M	= P-ave
BS	**32000.00**	8.53	/	2.01	= 4.25	34.13	/	6.03	= 5.66	108.08	/	10.04	= 10.76	17.07	/	2.01	= 8.50	**142.2**	/	**16.1**	= 8.9	167.8	/	20.09	= 8.35



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Background

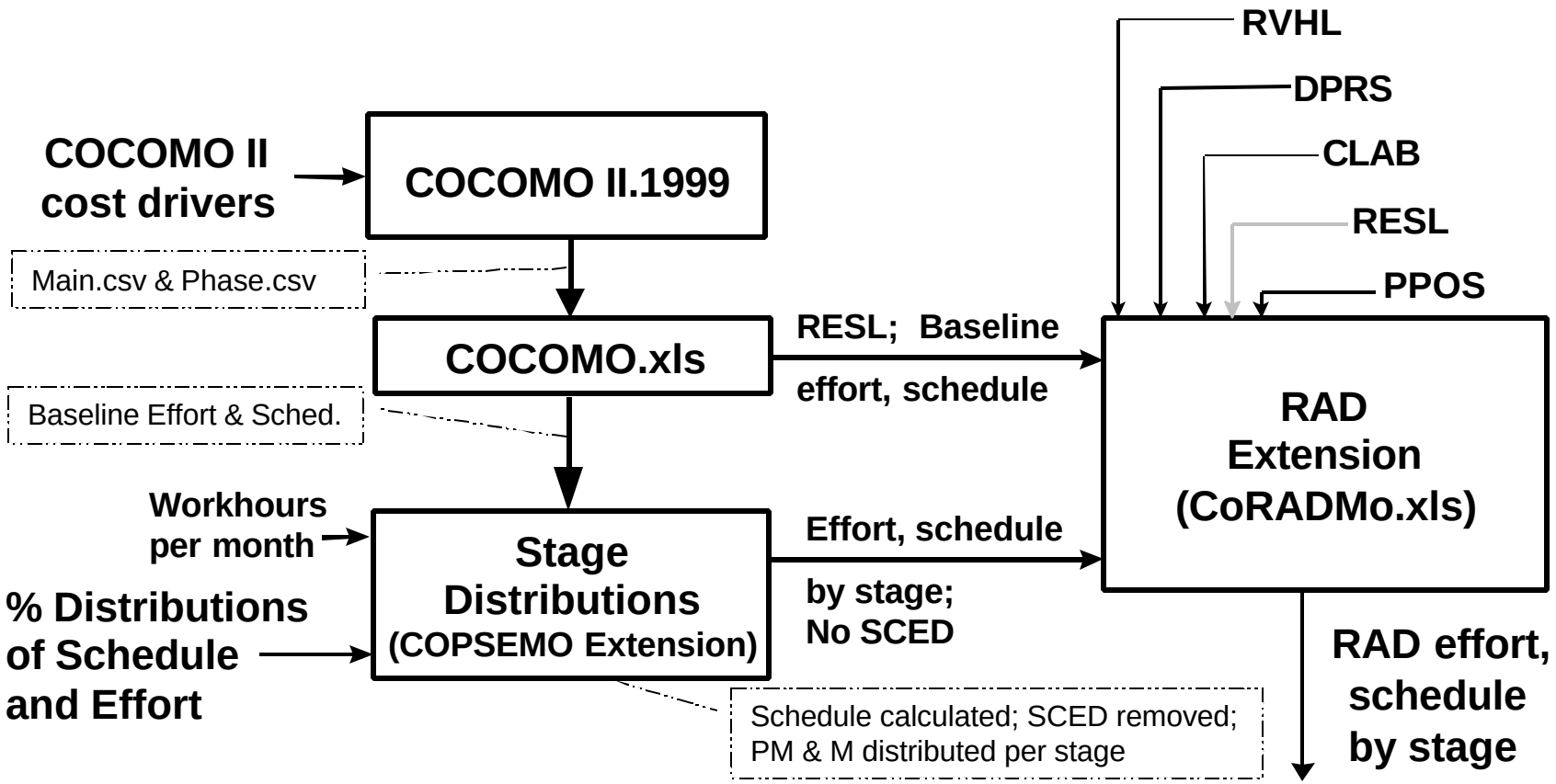
RAD (Rapid Application Development)

an application of any of a number of techniques or strategies to reduce software development cycle time

COCOMO II Schedule

- Reflects a waterfall process model: Needs COPSEMO
- Duration calculation unreasonable for small projects
- COCOMO II Model does not address RAD strategies; Needs stronger capability to reason about RAD Opportunity Tree strategies/tradeoffs:
  - Reuse, Very High Level Languages (VHLL) (RVHL)
  - Development Process Reengineering (DPRS)
  - Collaboration Technology (CLAB)
  - Architecture, Risk Resolution (RESL)
  - Prepositioning Assets (PPOS)

Physical COCOMO II RAD Extension



An Example of Implementation

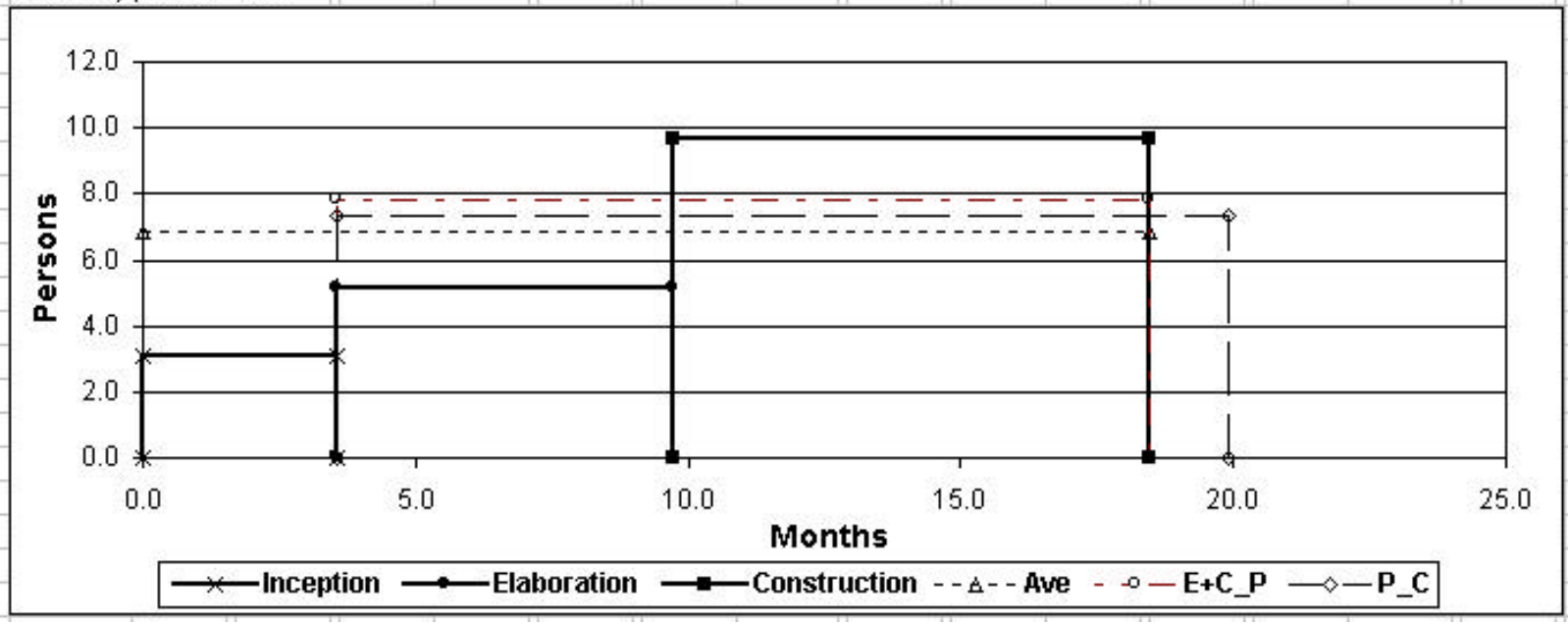
	A	B	C	E	G	H	J	L	M	O	Q	R	T	V	W	Y	AA
1		CORADMO	Original (before split into DoD/Commercial): Inception's Effort and Schedule are above and beyond Elaboration's and Construction's contribution														
5	Step																
6	1.0	. . . . .	Currently implemented only for projects (not modules)														
7		Get COCOMO-II.98 data and adjustments															
8	2.0	**BOLD: required**	***Italic: optional***	***Project:***	***32KNom + H RESL&PMAT***							**TotalSize=**	**32,000**	**PM_C=**	**119.9**	**M_C=**	**16.34**
9		(automatically from COCOMO.xls)				**SCED_R=**	**N**	**SCEDinc:**	**0%**	**SCEDV=**	**1.00**					P_C=	7.338
10		Including Scale Factor Ratings				**PREC_R:**	**N**	**FLEX_R:**	**N**	**RESL_R:**	**H**	**TEAM_R:**	**N**	**PMAT_R:**	**H**		
16		**Work hours per months** (non-overhead or "billable"; COCOMO-II.1998 default=152)										**152**					
17																	
18	3.0	Calculate Baseline values: PM_BS by adjusting work hours per months; M_BS by applying COSSEMO's M=f(PM) to PM_BS; and P_BS from PM_BS/M_BS.															
24		PM_BS=	119.9	M_BS=	16.34	P_BS=	7.338										
25																	
26	4.0	Get Eff% & Sched % per stage															
30	5.0	Distribute PM (PM_BS) and M (M_BS) according to the Effort% & Schedule% per stage; and calculate P for the stage from its PM/M.															

			Inception	Elaboration	Construction	Total E&C	Total
40							
41		Effort %	**10.0**	**28.0**	**72.0**	100.0	110.0
42		Schedule %	**24.0**	**40.0**	**60.0**	100.0	124.0
43		P/Ave(P)	0.42	0.70	1.20	1.00	Does not apply
44		PM/M=P	PM / M = P	PM / M = P	PM / M = P	PM / M = P	PM / M = P-ave
45	BS	**32,000**	11.99 / 3.92 = 3.06	33.57 / 6.54 = 5.14	86.34 / 9.80 = 8.81	**119.9** / **16.34** = 7.34	131.9 / 20.26 = 6.51
46							
47	6.0	Get the Schedule Multipliers values.					
48			RVHL N	DPRS N	CLAB H	RESL H	PPOS N
49							

			Inception			Elaboration			Construction		
50											
51			PM	M	P	PM	M	P	PM	M	P
52	N	RVHL	0.980	0.980	1.000	0.99	0.99	1.00	1.00	1.00	1.00
53	N	DPRS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
54	H	CLAB	0.930	0.930	1.000	0.950	0.950	1.000	0.980	0.980	1.000
55	H	RESL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.910	1.099
56	N	PPOS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
57		Π	0.911	0.911	1.000	0.941	0.941	1.000	0.980	0.892	1.099

An Example of Implementation (cont.)

	A	B	C	E	G	H	J	L	M	O	Q	R	T	V	W	Y	AA
57		Π	0.911	0.911	1.000	0.941	0.941	1.000	0.980	0.892	1.099						
58																	
59	7.0	Apply the product of user selected Schedule Multipliers to each PM, M and P in each stage.															
60																	
61	8.0	Calculate PM and M "Total E&C" and "Total" (I+E+C) by adding the stages PM and M. Calculate P "Total E&C" and "Total" (I+E+C) by dividing total PM by total M															
64			Inception			Elaboration			Construction			Total E&C			Total		
65		Effort %	**10.0**			**28.0**			**72.0**			100.0			110.0		
66		Schedule %	**24.0**			**40.0**			**60.0**			100.0			124.0		
67		P/Ave(P)	0.42			0.70			1.20			1.00					
68		PM/M=P	PM /	M =	P	PM /	M =	P	PM /	M =	P	PM /	M =	P	PM /	M =	P-ave
69	BS	**32000.00**	11.99 /	3.92 =	3.06	33.57 /	6.54 =	5.14	86.34 /	9.80 =	8.81	**119.9** /	**16.3** =	7.3	131.9 /	20.3 =	6.5
70		Π	0.91	0.91	1.00	0.94	0.94	1.00	0.98	0.89	1.10						
71	RAD	Eff&Schd	10.93 /	3.57 =	3.06	31.58 /	6.15 =	5.14	84.61 /	8.74 =	9.68	116.2 /	14.9 =	7.8	127.1 /	18.5 =	6.9
74																	
75	9.0	Courtesy plot of P vs M															



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Application Composition

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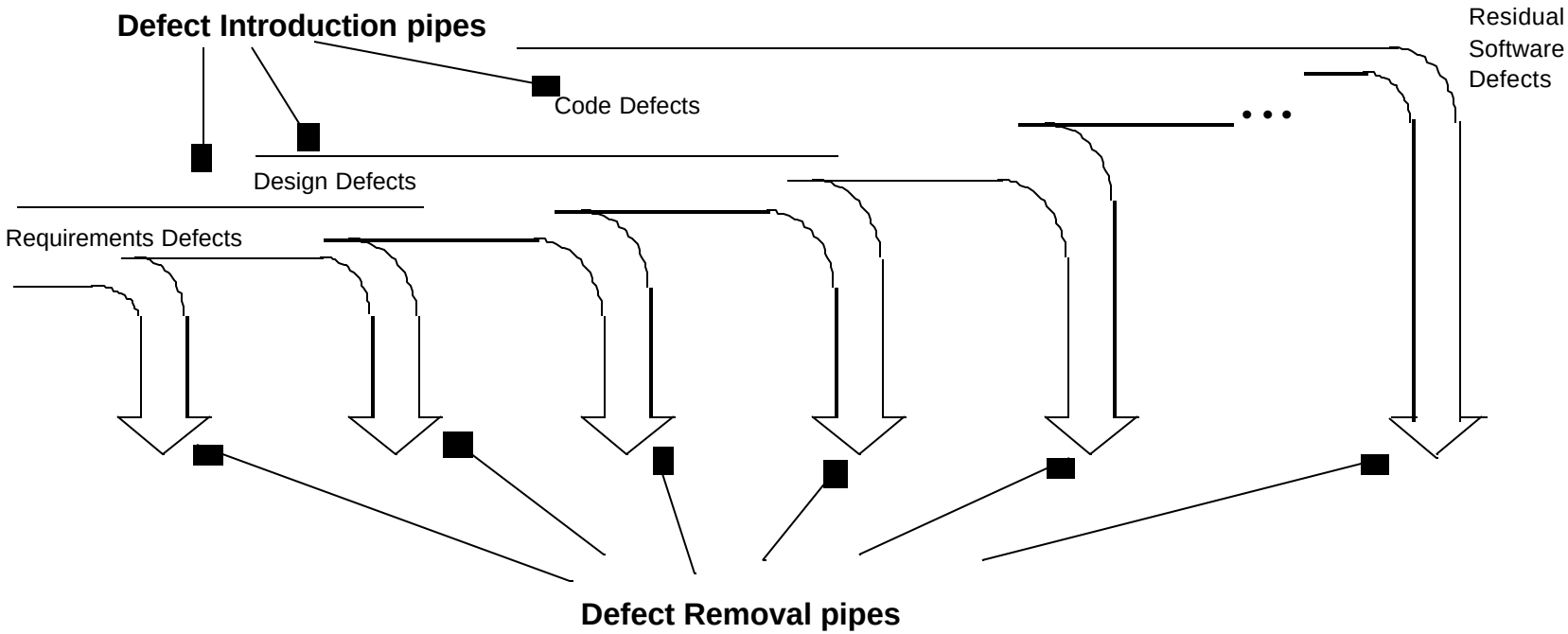
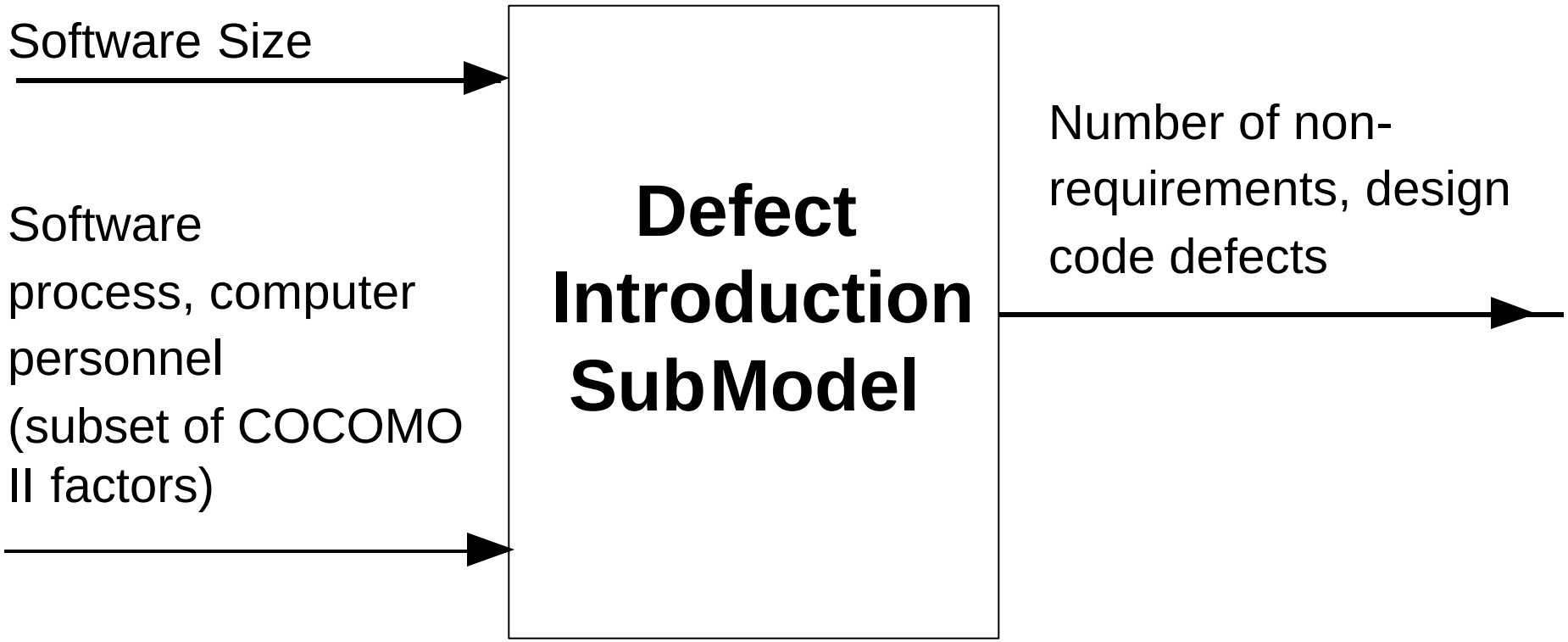
Expert COCOMO

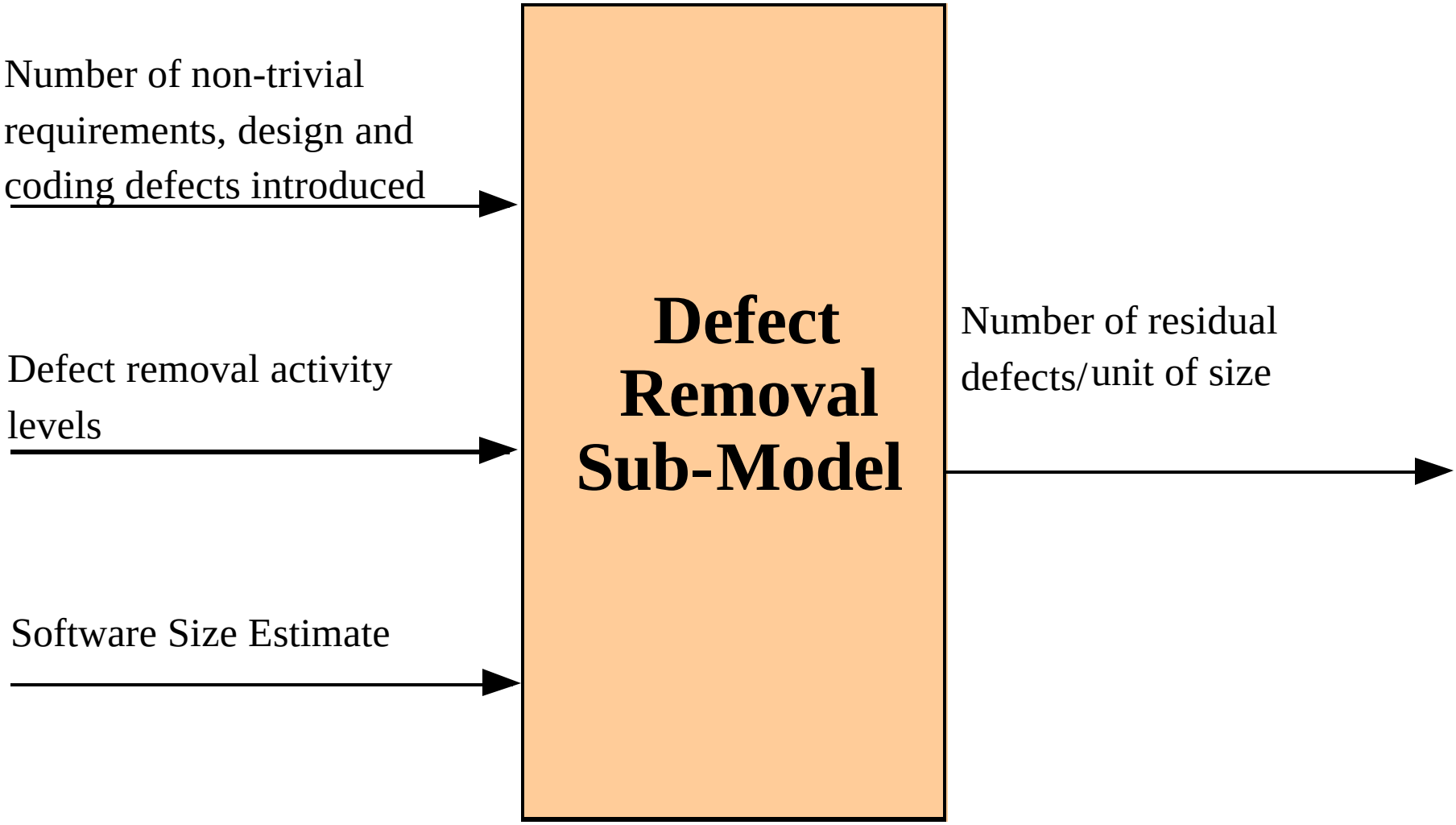
COQUALMO Model Framework



COQUALMO Defect Introduction (DI) Sub-Model



COQUALMO Defect Removal (DR) Sub-Model



COQUALMO Defect Removal Profiles

3 relatively orthogonal profiles
- **Automated Analysis**
- **People Reviews**
- **Execution Testing and Tools**

Each profile has 6 levels
- **Very Low, Low, Nominal, High, Very High, Extra High**
  - **Very Low--removes the least number of defects**
  - **Extra High--removes the most defects**

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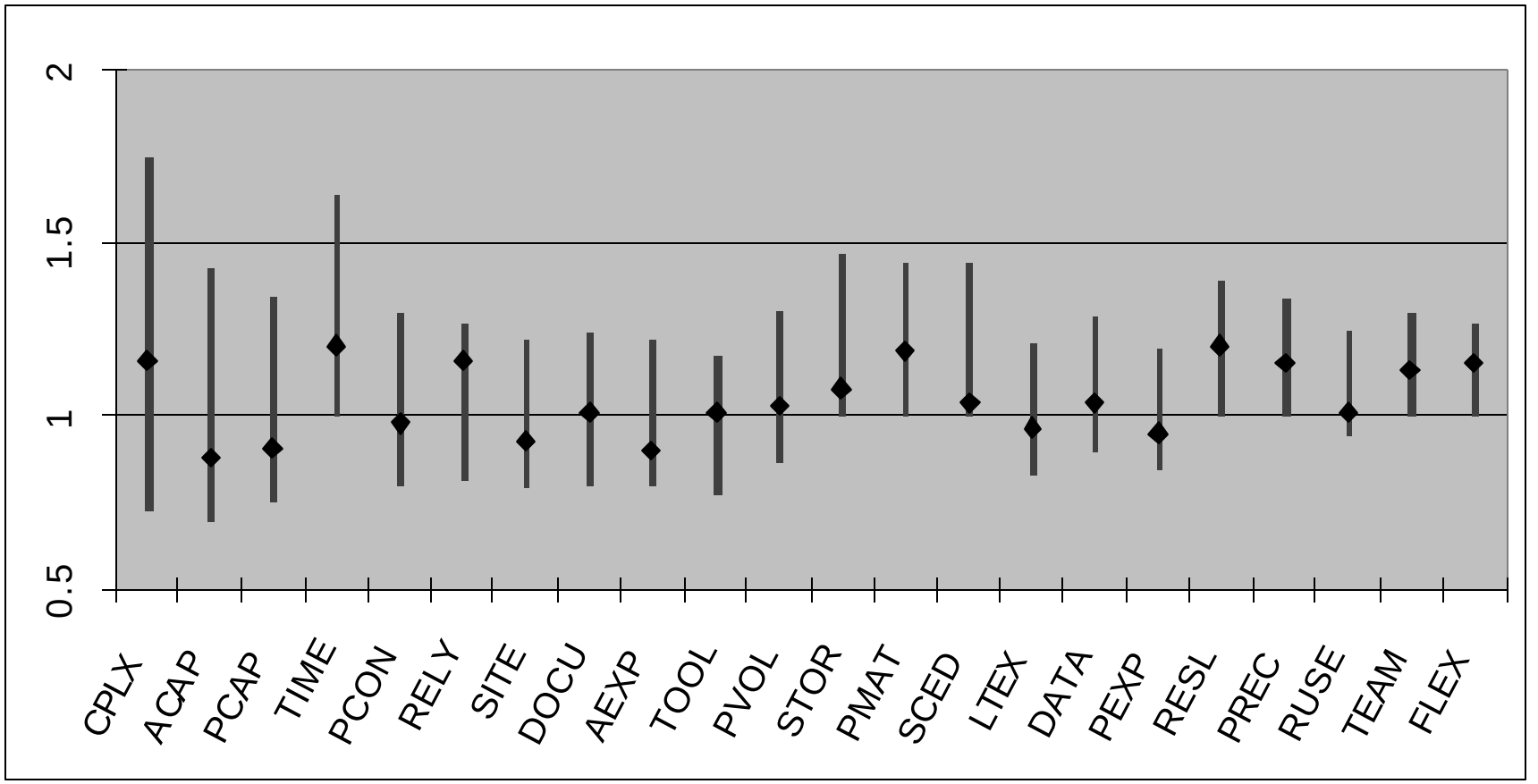
COPROMO

Expert COCOMO

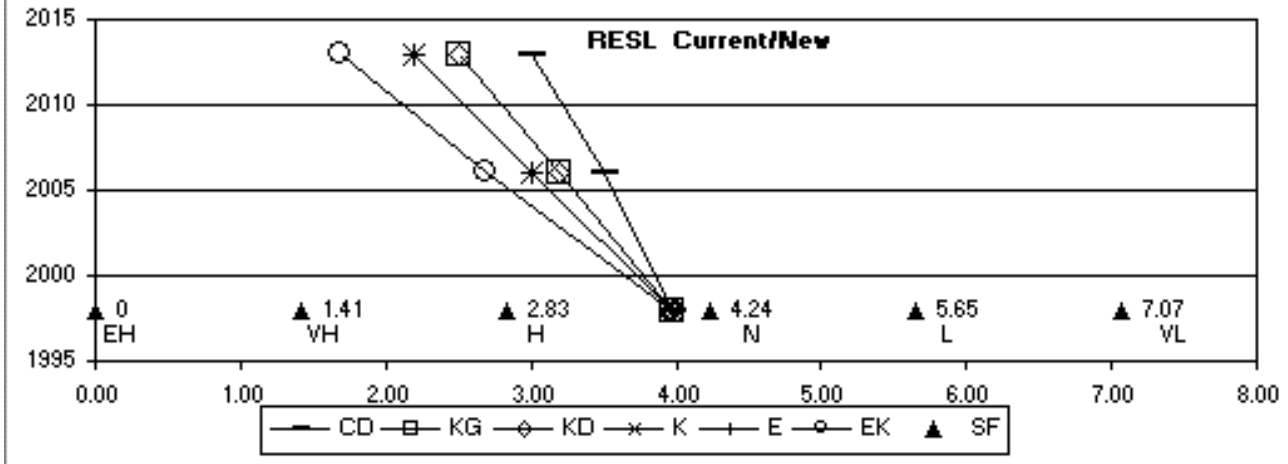
COPROMO Average Productivity Multipliers



COPROMO Sample Drivers in Model

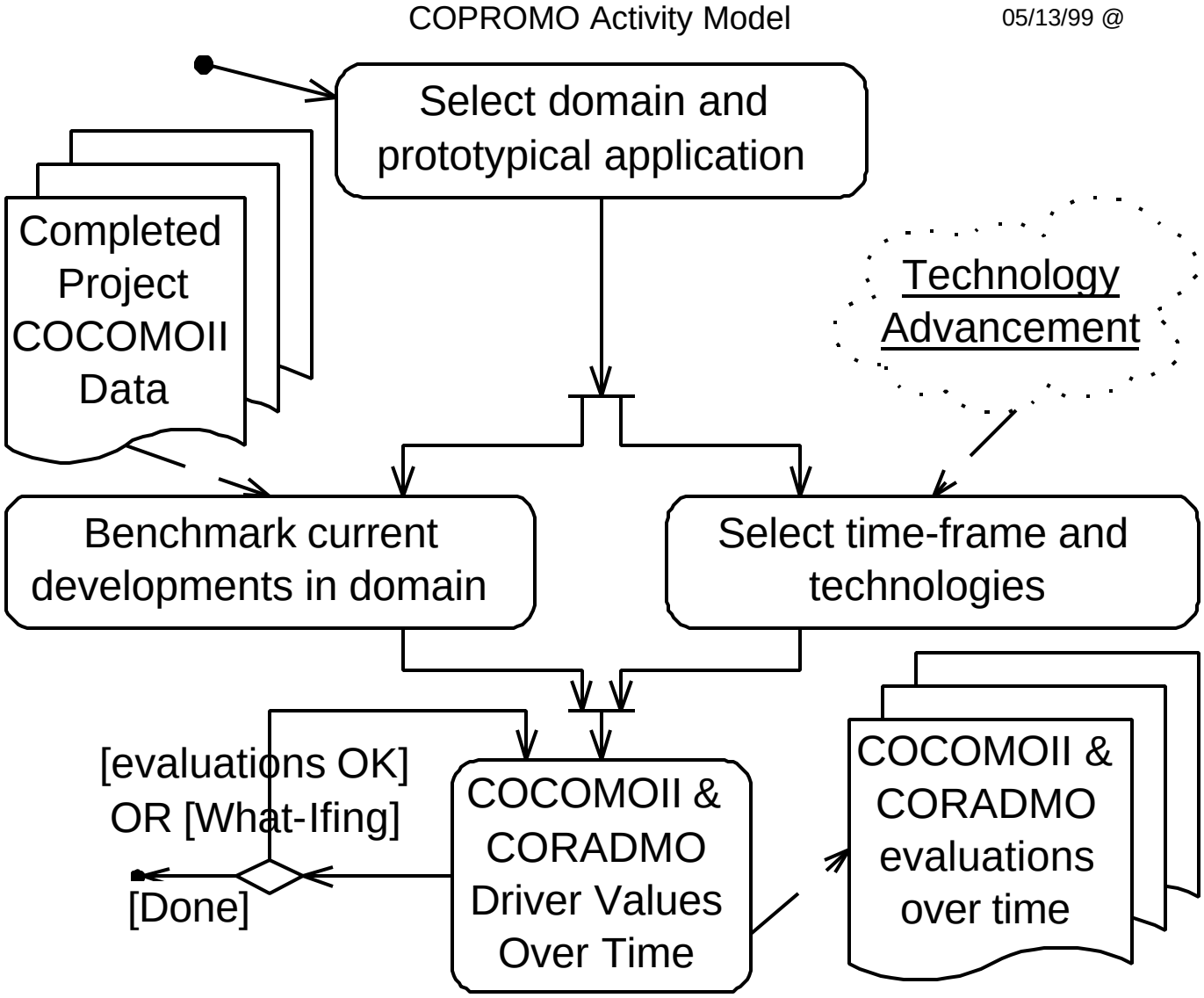
RESL: Architecture/Risk Resolution

Driver		Baseline	CD@+8	CD@+15	KG@+8	KG@+15	KD@+8	KD@+15	K@+8	K@+15	E@+8	E@+15	EK@+8	EK@+15
RESL	default	3.97	3.50	3.00	3.20	2.50	3.20	2.50	3.00	2.20	3.00	2.20	2.70	1.70
RESL	new													

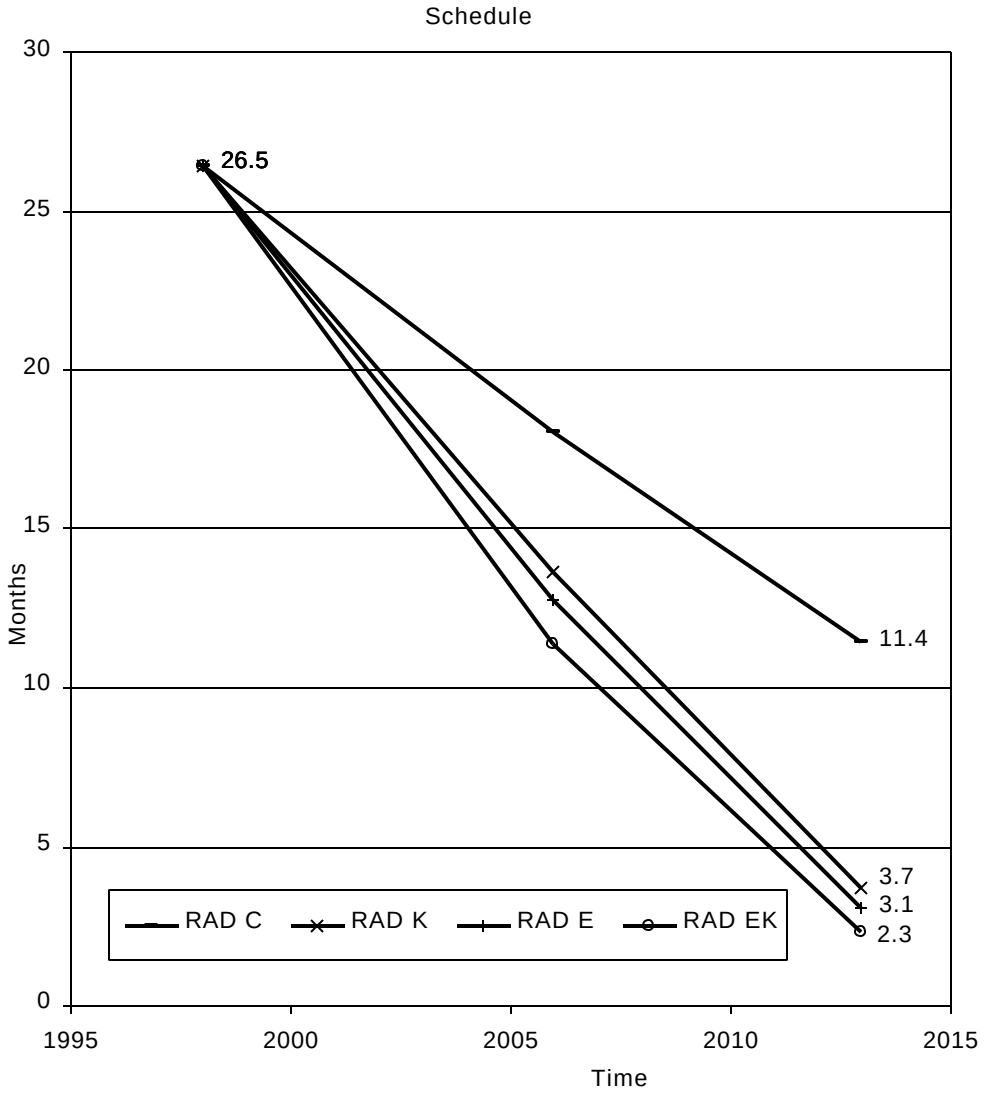


CD:	Significant gains due to open systems technology, commercial OO architecture technology and DoD emphasis on risk management
KG:	Significant additional gains over CD via domain architectures
KD:	Significant additional gains over CD via architecture and risk advisor technology
K:	Complementary gains from KG and KD
E:	Major additional gains over CD via domain architecture, general architecture technology, high assurance technology, and rationale capture
EK:	Complementary gains from E and K

COPROMO Activity Model



COPROMO Results



Outline

Application Composition

Dynamic COCOMO

COPSEMO

CORADMO

COQUALMO

COPROMO

Expert COCOMO

Expert COCOMO Partial Rule Taxonomy

Overall Project Risk

Schedule risk	Product risk	Platform risk	Personnel risk	Process risk	Reuse risk
SCED	**RELY**	**TIME**	**ACAP**	**TOOL**	**RUSE**
sced_cplx	rely_acap	sced_time	acap_risk	sced_tool	ruse_rely
sced_rely	rely_pcap	time_pcap	cplx_acap	tool_acap	ruse_aexp
sced_time	rely_pmat	time_acap	*cplx_acap_pcap*	tool_pcap	ruse_ltex
sced_pvol	sced_rely	cplx_time_sced	pmat_acap	cplx_tool	ruse_acap
sced_tool	*rely_data_sced*	*time_stor_sced*	rely_acap	time_tool	ruse_time
sced_acap	rely_stor_sced	*time_pvol_sced*	*rely_acap_pcap*	*tool_pmat*	ruse_stor
sced_aexp	rely_acap_pcap	ruse_time	ruse_acap	pcon_tool	ruse_docu
sced_pcap	prec_rely	time_tool	sced_acap	*site_tool*	prec_ruse
sced_vexp	resl_rely	prec_time	stor_acap	*resl_tool*	resl_ruse
sced_ltex	ruse_rely	flex_time	time_acap	**SITE**	
sced_pmat	**DATA**	resl_time	tool_acap	site_docu	
sced_docu	*rely_data_sced*	**STOR**	*pcon_acap*	*site_tool*	
sced_pcon	**SIZE**	stor_acap	prec_acap	pcon_site	
sced_site	size_pcap	stor_pcap	resl_acap	sced_site	
sced_prec	**CPLX**	ruse_stor	**AEXP**	*prec_site*	
sced_flex	cplx_acap	cplx_stor_sced	*ltex_aexp_sced*	*team_site*	
sced_resl	cplx_acap_pcap	*time_stor_sced*	ruse_aexp	**PREC**	
sced_team	cplx_pcap	prec_stor	sced_aexp	*prec_flex*	

Expert COCOMO (cont.)

Web-based input

Enter the product size in SLOC : 150000

Rate each driver below from Very Low (VL) to Extra High (EH). For **HELP** on each cost driver, select the driver name.

	Very Low (VL)	Low (L)	Nominal (N)	High (H)	Very High (VH)	Extra High (EH)
Scale Drivers						
Precedentedness	○ VL	○ L	○ N	◉ H	○ VH	○ XH
Development Flexibilty	○ VL	○ L	◉ N	○ H	○ VH	○ XH
Architecture/Risk Resolution	○ VL	○ L	○ N	◉ H	○ VH	○ XH
Team Cohesion	○ VL	◉ L	○ N	○ H	○ VH	○ XH
Process Maturity	○ VL	◉ L	○ N	○ H	○ VH	○ XH
Product Attributes						
Required Reliability	○ VL	○ L	○ N	○ H	◉ VH	
Database Size		○ L	◉ N	○ H	○ VH	
Product Complexity	○ VL	○ L	○ N	○ H	◉ VH	○ EH
Required Reuse		○ L	◉ N	○ H	○ VH	○ EH
Documentation	○ VL	○ L	○ N	◉ H	○ VH	

Expert COCOMO (cont.)