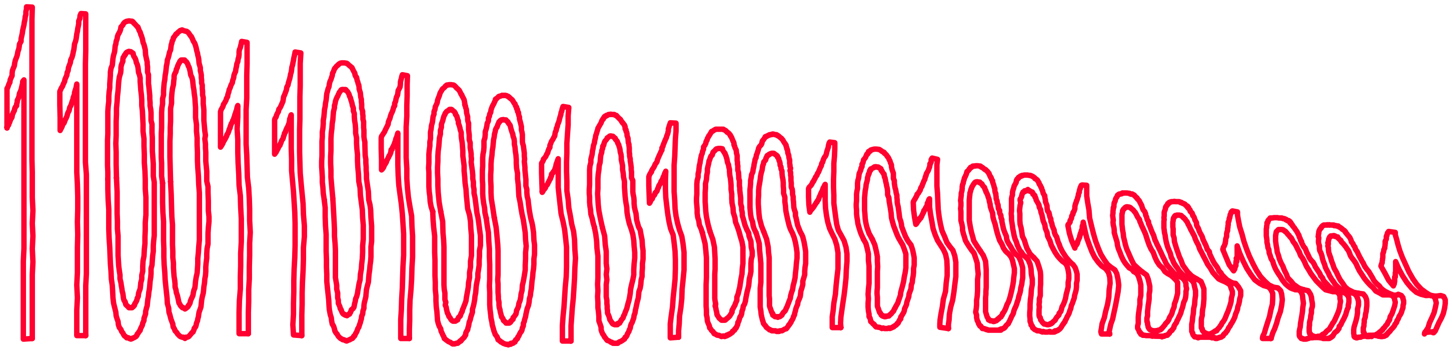
GALORATH

Software Total Ownership Cost, Software Maintenance & SEER-SEM

ISPA/SCEA 2007

Maintenance Defined

- **Dictionary: "The work of keeping something in proper order"**
- **Software maintenance is different from hardware maintenance because:**
  - Software doesn't physically wear out, but...
  - Software often gets less useful with age and...
  - It may be delivered with undiscovered flaws
- **Software maintenance is: "The process of modifying existing operational software while leaving its primary functions intact."**



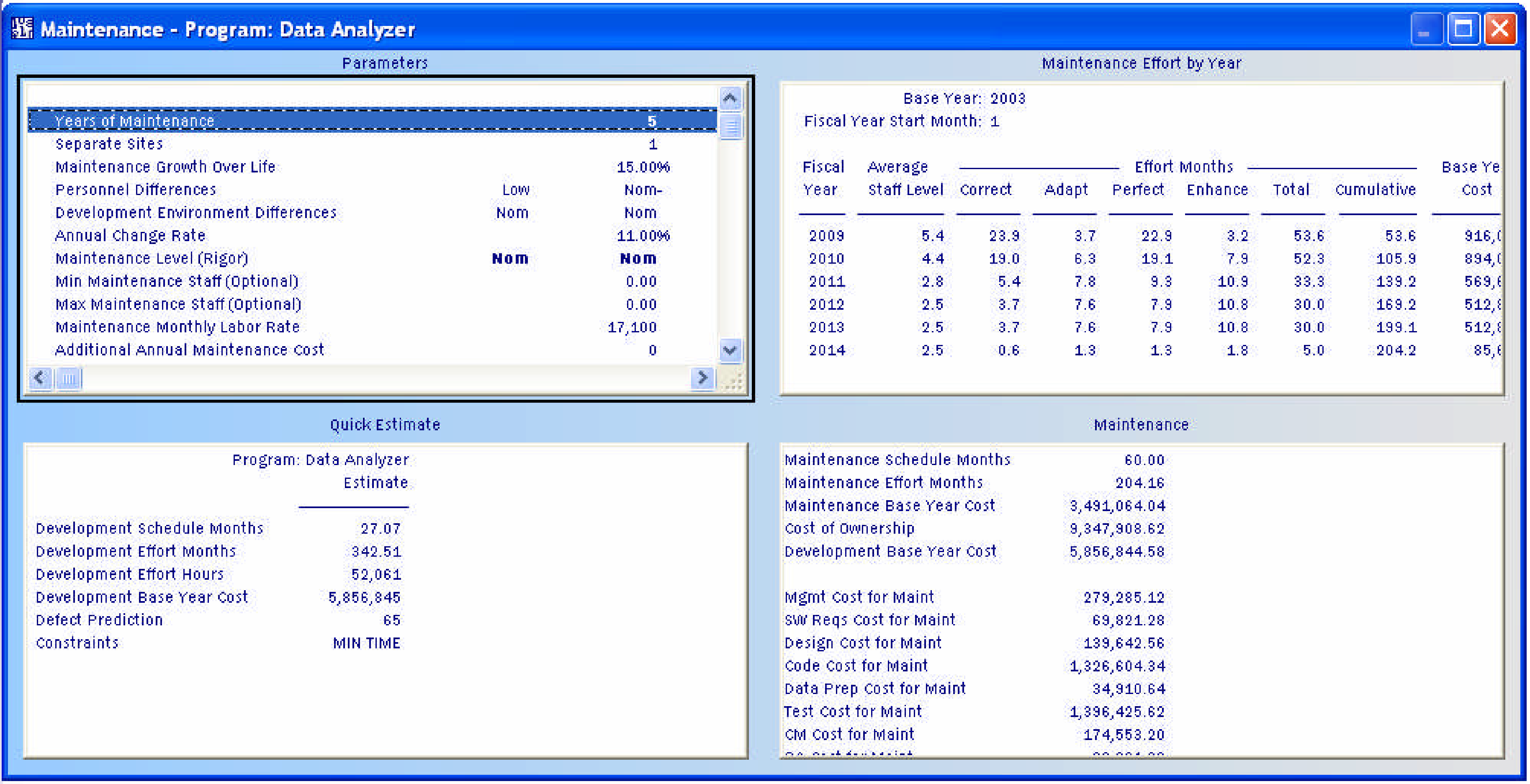
SEER® by GALORATH

Maintenance Dissected

- **Maintenance typically 50% + of the total software workload:**
  - Highly dependent on maintenance rigor & operational “life expectancy”
  - Reducing maintenance costs can reduce life cycle costs <u>significantly</u>
- **Generally includes sustaining engineering & new function development:**
  - Corrective changes (fixing bugs)
  - Adapting to new requirements (OS upgrade, new processor)
  - Perfecting or improving existing functions (improve speed, performance)
  - Enhancing application with (minor) new functions (new feature)
- **For every new software product we develop, we get one more to maintain -- for ?? years**

SEER® by GALORATH

SEER-SEM Maintenance Provides Insight to Total Ownership Cost



Maintenance - Program: Data Analyzer

Parameters

Years of Maintenance		5
Separate Sites		1
Maintenance Growth Over Life		15.00%
Personnel Differences	Low	Nom-
Development Environment Differences	Nom	Nom
Annual Change Rate		11.00%
Maintenance Level (Rigor)	**Nom**	**Nom**
Min Maintenance Staff (Optional)		0.00
Max Maintenance Staff (Optional)		0.00
Maintenance Monthly Labor Rate		17,100
Additional Annual Maintenance Cost		0

Maintenance Effort by Year

Base Year: 2003
Fiscal Year Start Month: 1

Fiscal	Average	Effort Months						Base Ye
Year	Staff Level	Correct	Adapt	Perfect	Enhance	Total	Cumulative	Cost
2009	5.4	23.9	3.7	22.9	3.2	53.6	53.6	916,
2010	4.4	19.0	6.3	19.1	7.9	52.3	105.9	894,
2011	2.8	5.4	7.8	9.3	10.9	33.3	139.2	569,
2012	2.5	3.7	7.6	7.9	10.8	30.0	169.2	512,
2013	2.5	3.7	7.6	7.9	10.8	30.0	199.1	512,
2014	2.5	0.6	1.3	1.3	1.8	5.0	204.2	85,

Quick Estimate

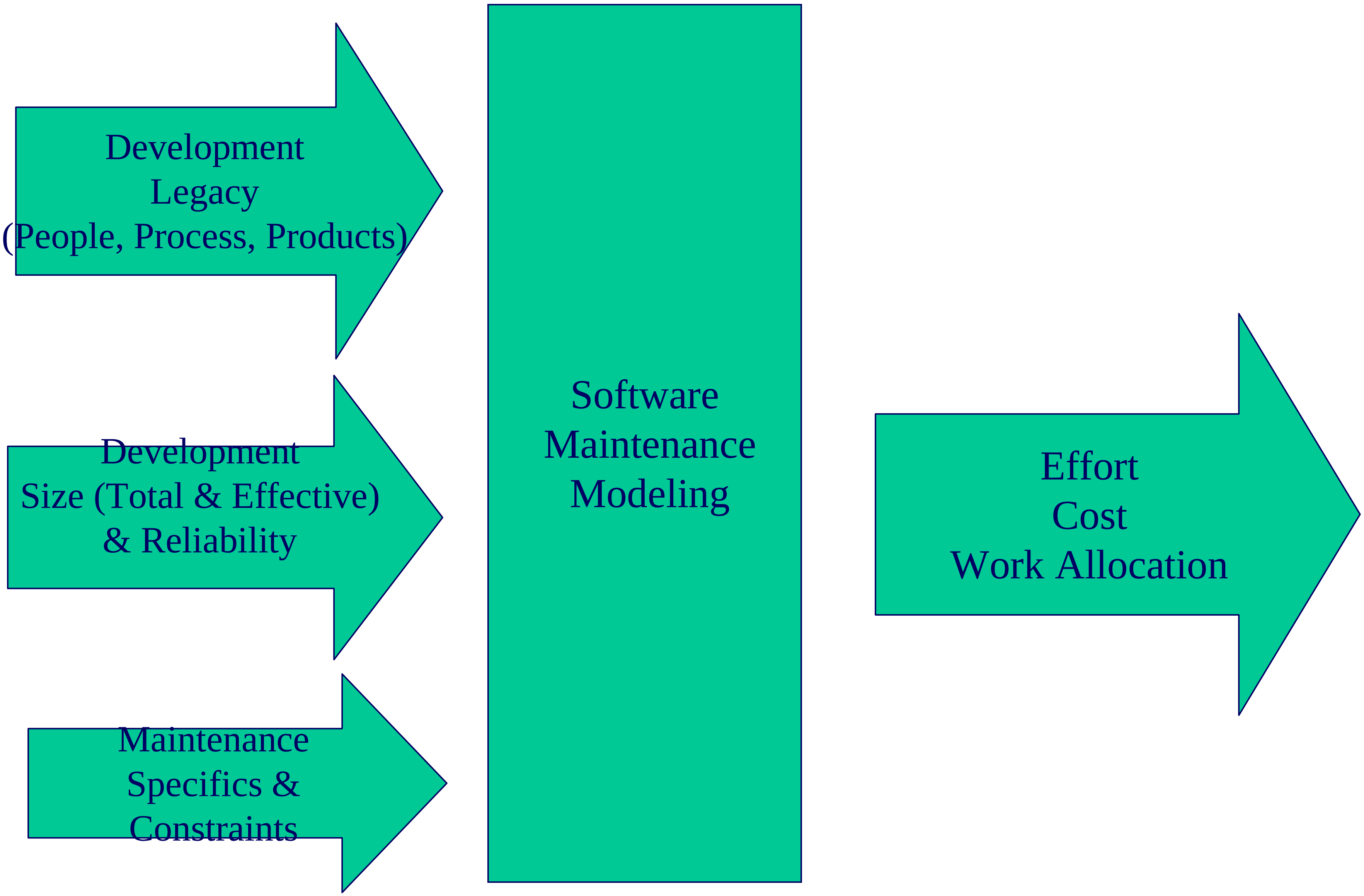
Program: Data Analyzer	Estimate
Development Schedule Months	27.07
Development Effort Months	342.51
Development Effort Hours	52,061
Development Base Year Cost	5,856,845
Defect Prediction	65
Constraints	MIN TIME

Maintenance

Maintenance Schedule Months	60.00
Maintenance Effort Months	204.16
Maintenance Base Year Cost	3,491,064.04
Cost of Ownership	9,347,908.62
Development Base Year Cost	5,856,844.58
Mgmt Cost for Maint	279,285.12
SW Reqs Cost for Maint	69,821.28
Design Cost for Maint	139,642.56
Code Cost for Maint	1,326,604.34
Data Prep Cost for Maint	34,910.64
Test Cost for Maint	1,396,425.62
CM Cost for Maint	174,553.20

SEER® by GALORATH

Simplified Maintenance Block Diagram



Development
Legacy
(People, Process, Products)

Development
Size (Total & Effective)
& Reliability

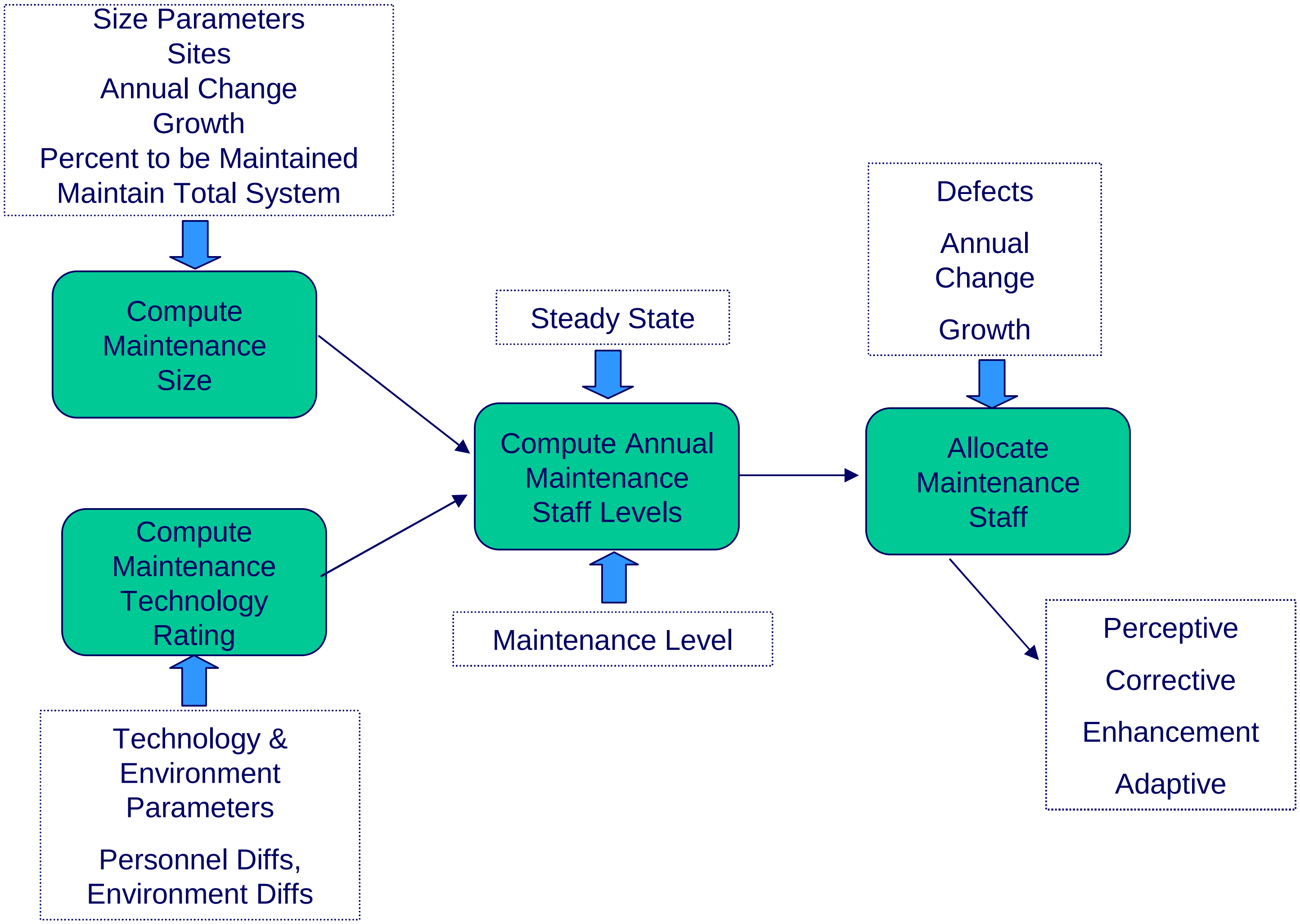
Maintenance
Specifics &
Constraints

Software
Maintenance
Modeling

Effort
Cost
Work Allocation

SEER® by GALORATH

Maintenance Calculation Flow



Size Parameters
Sites
Annual Change
Growth
Percent to be Maintained
Maintain Total System

Compute Maintenance Size

Compute Maintenance Technology Rating

Technology & Environment Parameters

Personnel Diffs, Environment Diffs

Steady State

Compute Annual Maintenance Staff Levels

Maintenance Level

Defects

Annual Change

Growth

Allocate Maintenance Staff

Perceptive

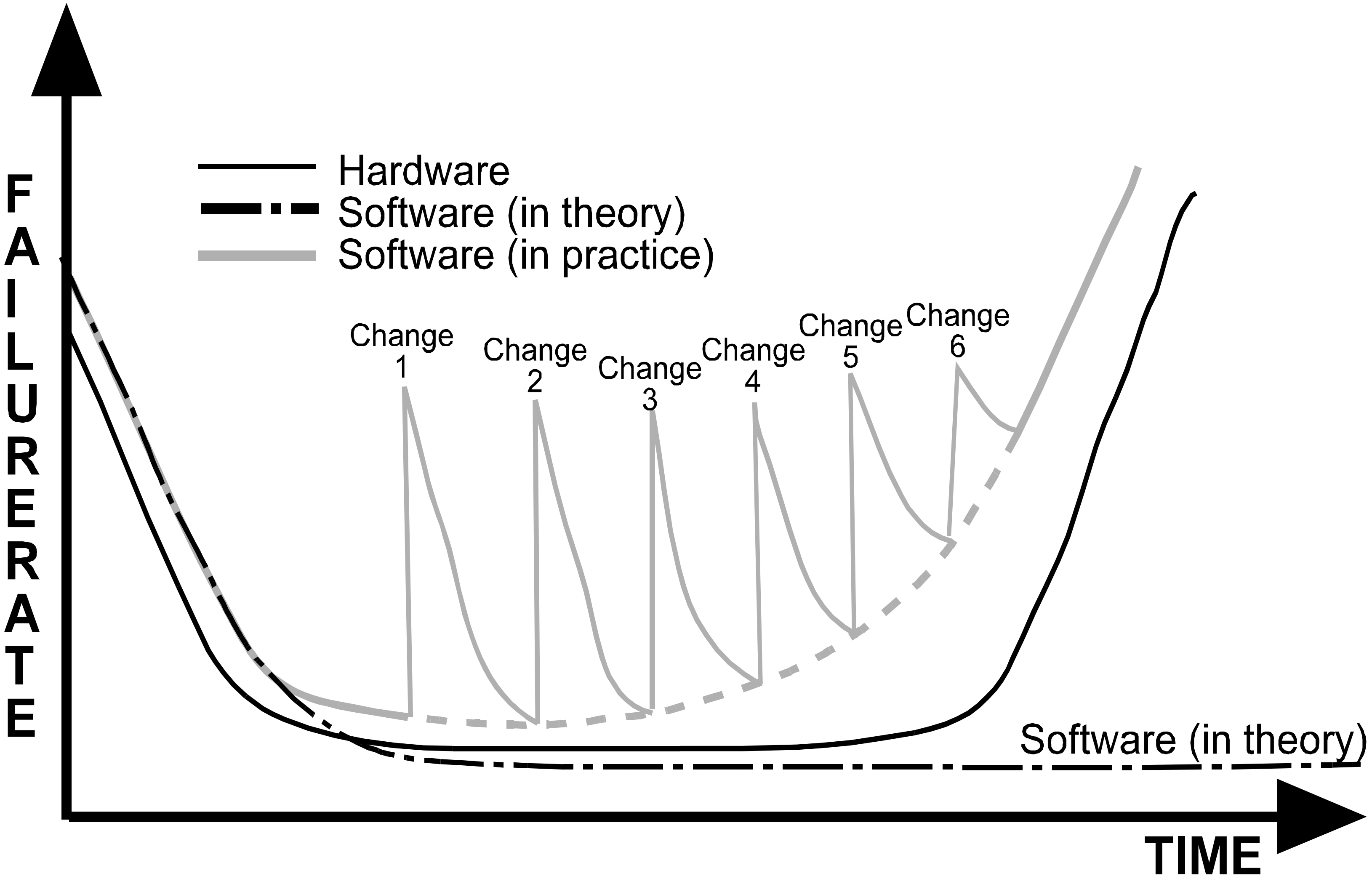
Corrective

Enhancement

Adaptive

SEER® by GALORATH

Software Maintenance Is Often A Series of Block Changes



SEER® by GALORATH

Software Maintenance Goals, Questions, Metrics Adapted from Mitre 1997

Goal	Question	Metric(s)
Maximize Customer Satisfaction	How many problems affect the customer?	1. Current Change Backlog 2. Software Reliability
Minimize cost	How much does a software maintenance delivery cost?	
	How are costs allocated	Cost per activity
	What kinds of changes are being made?	Number of changes by type
	How much effort is expended per change	Staff hours expended by change /type
Minimize Schedule	How difficult is the delivery?	Complexity Assessment Software Maintainability Computer resource Utilization
	Are we meeting delivery schedules?	Percentage of On-Time Deliveries

SEER® by GALORATH

Development Quality Impacts Maintenance

http://www.bcs.org/server.php?show=ConWebDoc.3063

- IEEE Std 1919-1993: Software maintenance defines maintenance as:

Modification of a software product after delivery to correct faults, to improve performance or other attributes, or to adapt the product to a modified environment

  - States that maintenance starts after delivery

- **Largest costs of software production occur after the 'development phase' is complete**
  - Maintenance up to 75 per cent of the total ownership cost.

- **Maintenance costs generally not result of poor requirements or design**

- **Even if "right the first time" change is inevitable:**
  - Political decisions (e.g. introduction of a new tax).
  - Hardware related changes.
  - Operating system upgrades over time.
  - Competition - new features to be added.
  - System almost instantly complying to outdated requirements

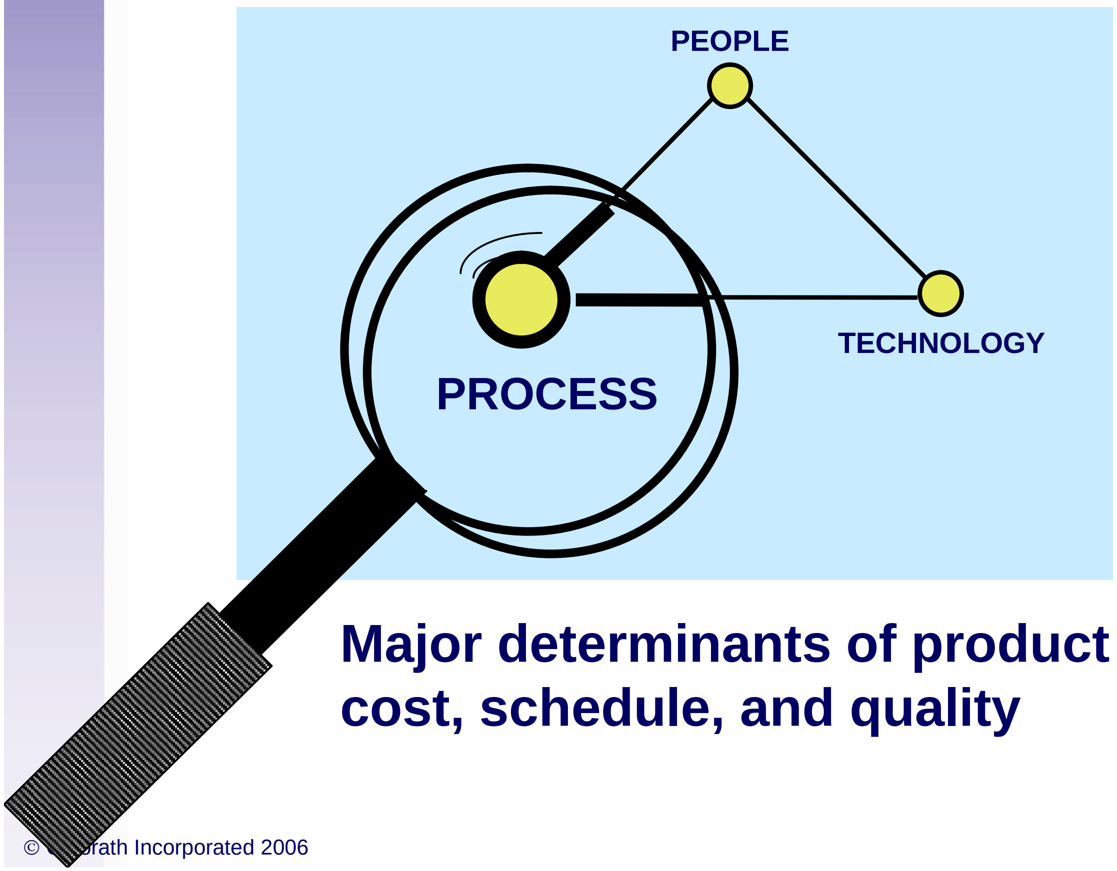
- **Construction may not affect function, but greatly affects future maintainability**

- **Maintainability goals during development can significantly reduce total ownership costs**

SEER® by GALORATH

Major Process Improvement Goal Lowering Defects. Source CMMI Tutorial

- Everyone realizes the importance of having a motivated, quality work force but...
- ...even our finest people can’t perform at their best when the process is not understood or operating
  “at its best.”



Major determinants of product cost, schedule, and quality

SEER® by GALORATH

Software Maintenance Critical Success Factors

- Functionality: Preserve or enhance functionality
- Quality: Preserve or increase quality of system
- Complexity: Should not increase product complexity relative to the size
- Volatility: should not lead to increase in product volatility
- Costs: Relative costs per maintenance task should not increase for similarly scoped tasks
- Deadlines: Agreed upon release deadlines should be kept and delays should not increase
- User Satisfaction: Increase or at least not decrease
- Profitability: Be profitable or at least cover its costs

SEER® by GALORATH

Why Maintenance Is Hard

- May not have had maintenance as a goal
- System may not have been fully tested
- Documentation may be inadequate
- Maintenance staff may be inexperienced
- The tendency to produce quick & dirty fixes
- Process or language experience may have left a mess
- The "but I only changed 1 line syndrome"

Why Software Maintenance Costing Is Harder

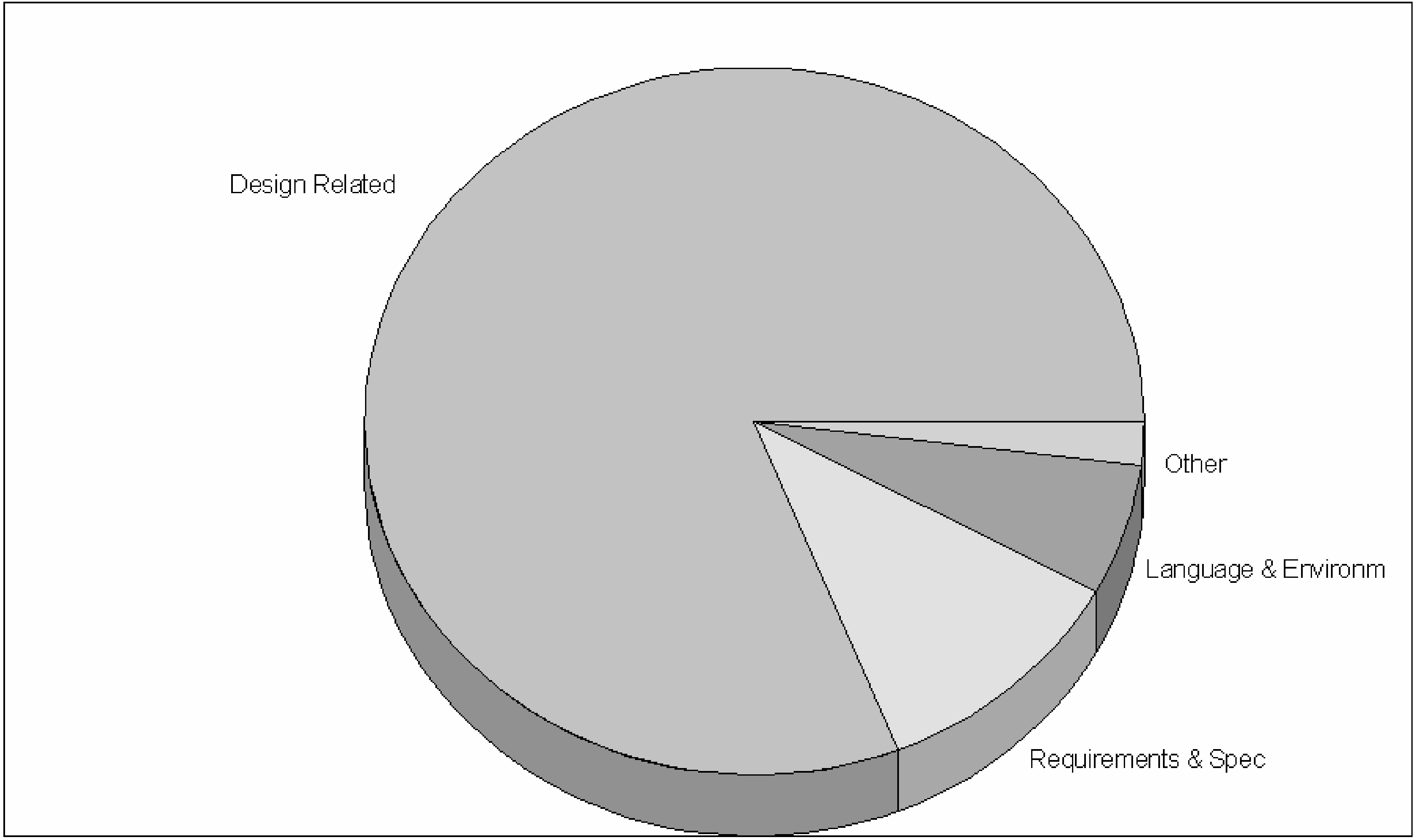
- **Software Maintenance treated as A Level Of Effort Activity**
- **This Means You Can Maintain Software With A Larger Or Smaller Staff Depending On Your Desires / Budget**

Maintaining A Car	**Maintaining Software**
High Maintenance: Go By The Book (Regular Oil Changes, Etc.)	● Fix emergencies ● Provide new functionality as needed ● Adapt as necessary ● Software may not degenerate over time
Nominal Maintenance: Go Partially By The Book (Less Frequent Oil Changes, Etc.	● Fix emergencies ● Provide some required new functionality ● Adapt when there is time
Low Maintenance: Go Slightly By The Book (Add Oil When The Low Oil Light Goes On	● Fix only emergencies and small adaptations ● Software will degenerate over time

SEER® by GALORATH

Sources of Software Errors

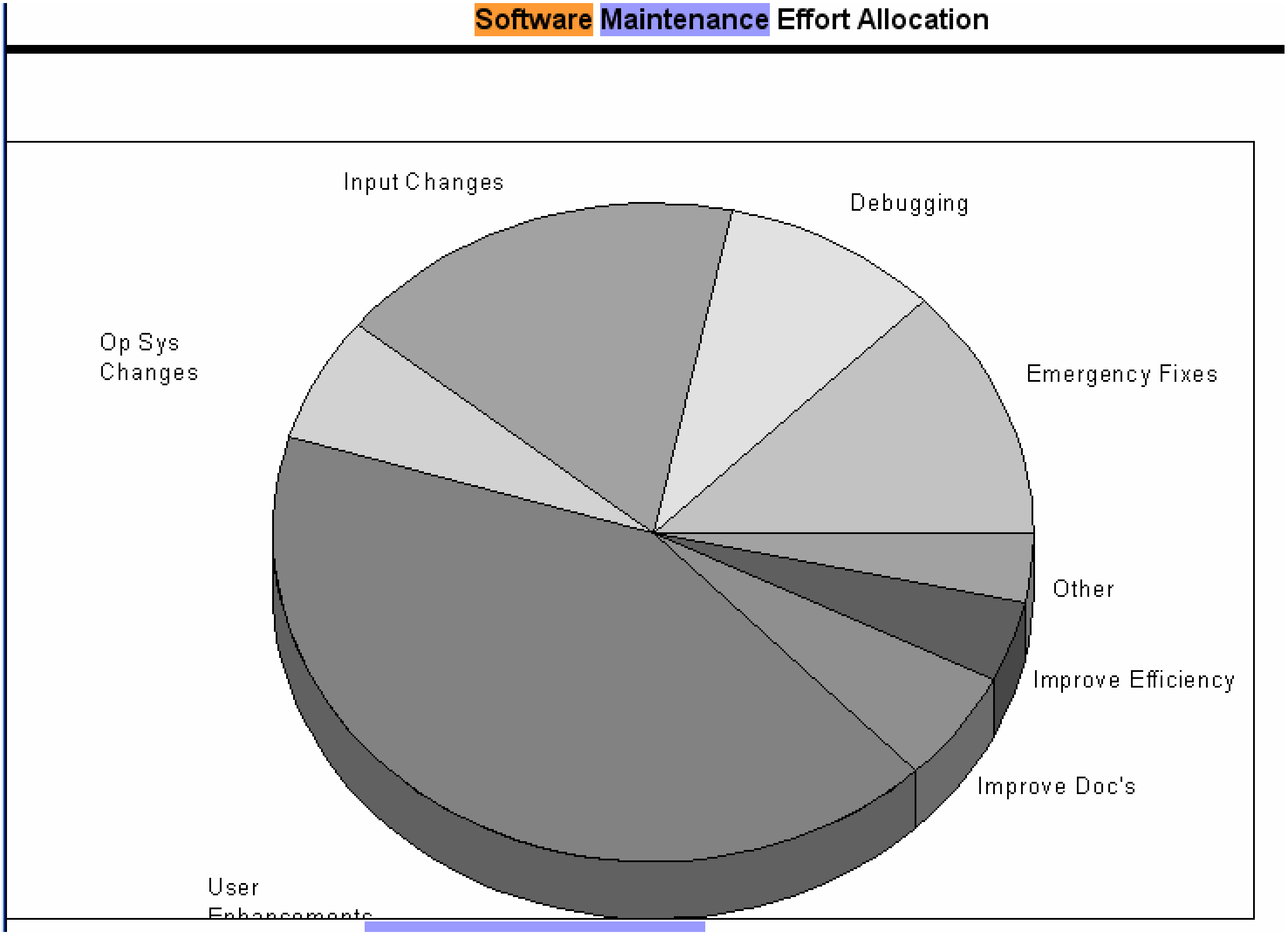
sources of software errors (source IEEE transactions)



Software Maintenance Effort Allocation

SEER® by GALORATH

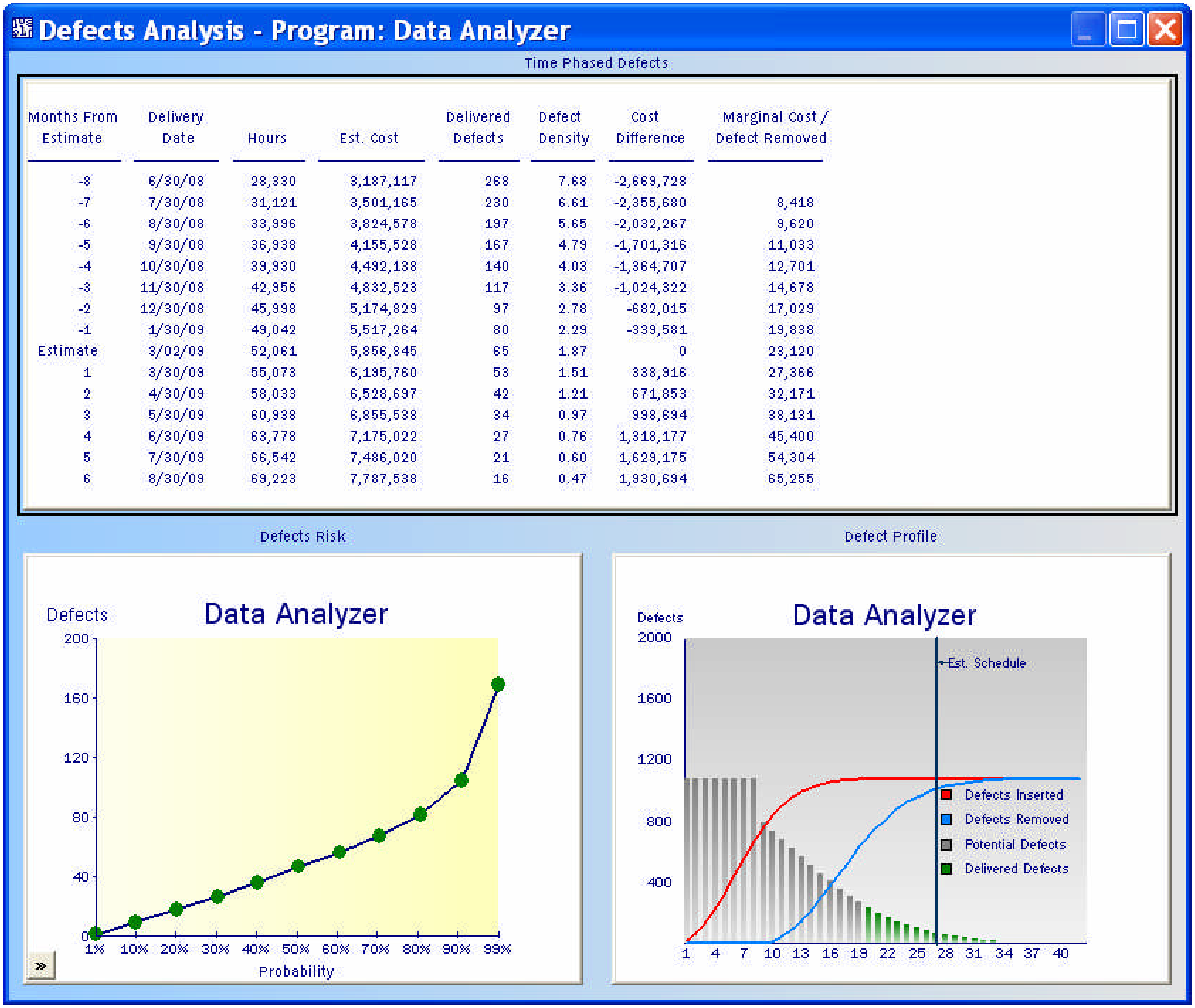
Allocation of Softwaree Effort Source IEEE



Software Maintenance Effort Allocation

SEER® by GALORATH

Development Defects Analysis Is a Clue to Maintenance Issues



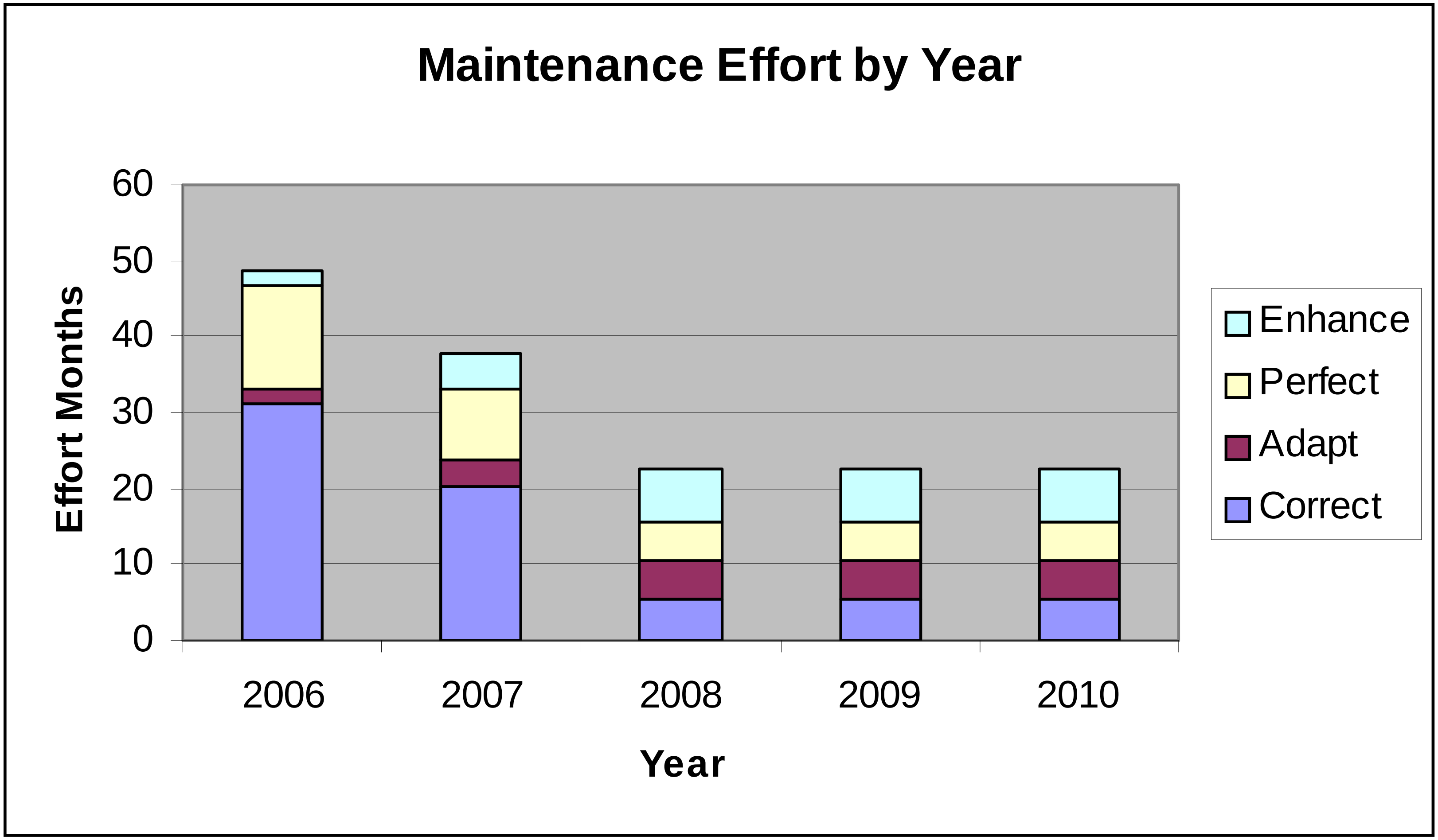
Defects Analysis - Program: Data Analyzer

Time Phased Defects

Months From Estimate	Delivery Date	Hours	Est. Cost	Delivered Defects	Defect Density	Cost Difference	Marginal Cost / Defect Removed
-8	6/30/08	28,330	3,187,117	268	7.68	-2,669,728	
-7	7/30/08	31,121	3,501,165	230	6.61	-2,355,680	8,418
-6	8/30/08	33,996	3,824,578	197	5.65	-2,032,267	9,620
-5	9/30/08	36,938	4,155,528	167	4.79	-1,701,316	11,033
-4	10/30/08	39,930	4,492,138	140	4.03	-1,364,707	12,701
-3	11/30/08	42,956	4,832,523	117	3.36	-1,024,322	14,678
-2	12/30/08	45,998	5,174,829	97	2.78	-682,015	17,029
-1	1/30/09	49,042	5,517,264	80	2.29	-339,581	19,838
Estimate	3/02/09	52,061	5,856,845	65	1.87	0	23,120
1	3/30/09	55,073	6,195,760	53	1.51	338,916	27,366
2	4/30/09	58,033	6,528,697	42	1.21	671,853	32,171
3	5/30/09	60,938	6,855,538	34	0.97	998,694	38,131
4	6/30/09	63,778	7,175,022	27	0.76	1,318,177	45,400
5	7/30/09	66,542	7,486,020	21	0.60	1,629,175	54,304
6	8/30/09	69,223	7,787,538	16	0.47	1,930,694	65,255

SEER® by GALORATH

Typical Maintenance Staffing



SEER® by GALORATH

SEER-SEM Recommends Estimating Specific Block Changes As Additional Development

When To Use Maintenance Model

- **To estimate sustaining engineering independent of block changes**
- **When block changes are completely unknown**

When To Use Development Model

- **When specific planned changes or change cycles are known**
- **When refresh cycles are known or can be approximated**
- **Block changes are known or anticipated batches of enhancements**
  - Estimate block changes or major upgrades as additional incremental development rather than maintenance
- **Support of fielded software while additional incremental development is underway:**
  - Can be estimated as general or non-dedicated maintenance, but…
  - May be more realistic to assume this effort is included in subsequent incremental development, not separate maintenance contract
  - Previous build maintenance almost always ends when subsequent build is fielded

SEER® by GALORATH

Maintenance Parameters: Scope

- **Years of Maintenance**
  - Number of years for which software maintenance costs will be estimated
    - Maintenance typically begins when operational test & evaluation is completed
- **Separate Sites**
  - Number of separate operational sites where the software will be installed and users will have an input into system enhancements
    - Count only sites that have some *formal* input
    - Do not necessarily count all user sites
  - Alters both amount and allocation of maintenance effort
    - More sites = more enhancing, corrective, and perfective effort

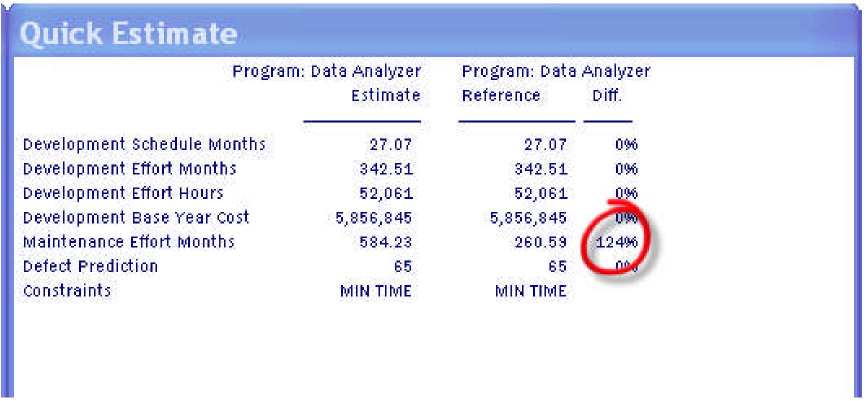
SEER® by GALORATH

Maintenance Growth Over Life

- **Anticipated size growth from the point immediately after the software is turned over to maintenance to the end of the maintenance cycle**
- **May include additions of new functionality**

Rating	Description
100%	Major updates adding many new functions
35%	Moderate updates adding some new functions
20%	Minor updates & enhancements to existing function
5%	No updates expected, some minor enhancements
0%	Sustaining engineering only

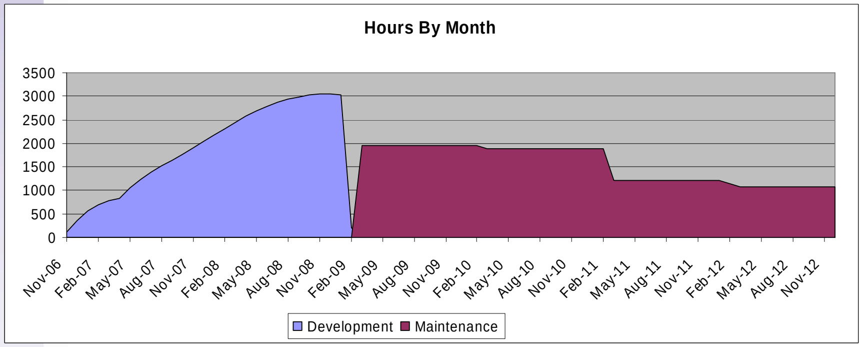
0 vs 100% growth over 5 years



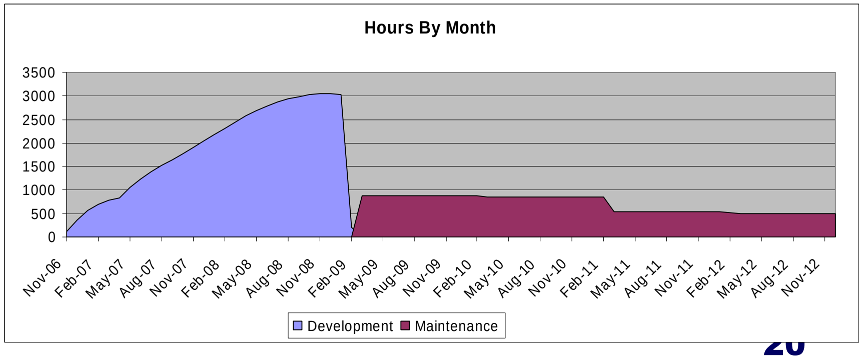
Quick Estimate

	Program: Data Analyzer Estimate	Program: Data Analyzer Reference	Diff.
Development Schedule Months	27.07	27.07	0%
Development Effort Months	342.51	342.51	0%
Development Effort Hours	52,061	52,061	0%
Development Base Year Cost	5,856,845	5,856,845	0%
Maintenance Effort Months	584.23	260.59	124%
Defect Prediction	65	65	0%
Constraints	MIN TIME	MIN TIME	

100% growth over 5 years
Initial 27 mo development



0% growth over 5 years
Initial 27 mo development



SEER® by GALORATH

Technology & Environment Differences

- **Personnel Differences**
  - Rates maintenance personnel's capabilities and experience in comparison to development personnel
- **Development Environment Differences**
  - Rates the quality of the maintenance environment in comparison to the tools and practices used in the development environment

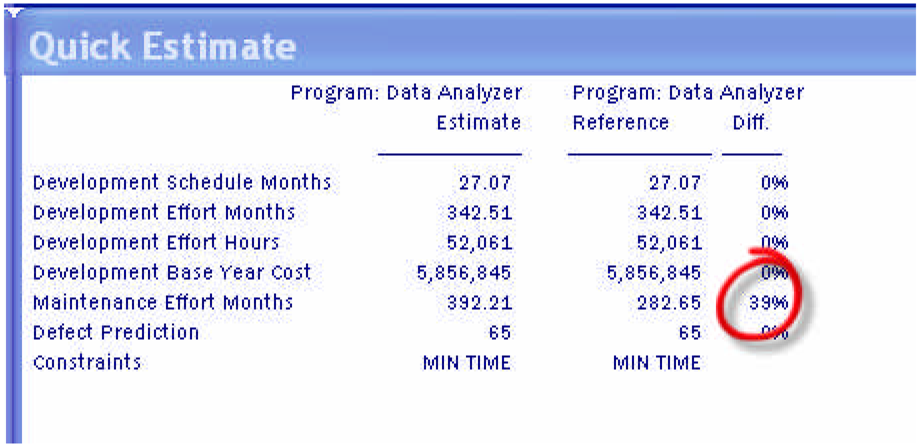
Rating	Description
Very High	Significantly better than development
High	Slightly better than development
Nominal	Same as development
Low	Somewhat less than development
Very Low	Significantly lower than development

Annual Change Rate

- **Average percent of the software impacted by software maintenance and sustaining engineering per year**
- **May include changes, revalidation, reverse engineering, redocumentation, minor changes for new hardware, or recertification**

Rating	Description
35%	Very High
15%	High
11%	Nominal
5%	Low
0%	Very Low

50% vs 0 annual change over 5 years



Quick Estimate

	Program: Data Analyzer Estimate	Program: Data Analyzer Reference	Diff.
Development Schedule Months	27.07	27.07	0%
Development Effort Months	342.51	342.51	0%
Development Effort Hours	52,061	52,061	0%
Development Base Year Cost	5,856,845	5,856,845	0%
Maintenance Effort Months	392.21	282.65	39%
Defect Prediction	65	65	0%
Constraints	MIN TIME	MIN TIME	

Maintenance Level (Rigor)

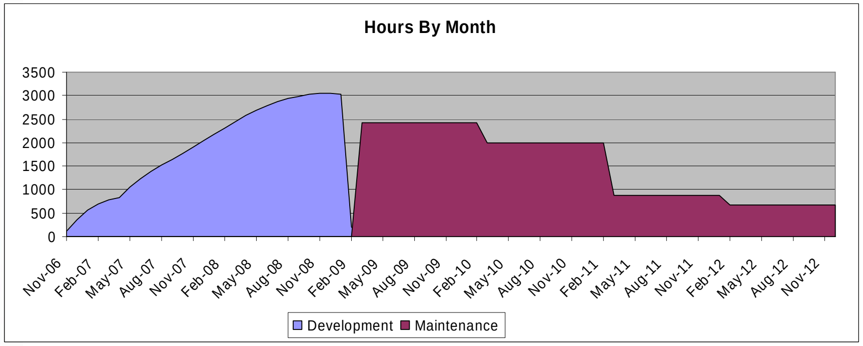
- **Rates the thoroughness with which maintenance activities will be performed**

Rating	Description
Very High +	Full complete maintenance estimate (From Raleigh Curve)
Very High	**Thorough maintenance** for all types of software maintenance activities, including regular documentation updates. Well planned in both the long and short term with frequent reviews of priorities. Dedicated maintenance staff
High	**Complete maintenance** including maintenance planning and priority review. Software documentation is updated on a semi-regular basis. Software will not degenerate over time
Nominal	**Average maintenance activity**. Short term planning and prioritization of maintenance activity. Documentation is updated less than once a year (change pages and addenda). Software will become less useful over time
Low	**Basic maintenance, reactive to emergencies and problems** as they arise. No planning of maintenance activity. Documentation is updated only with change pages and addenda. Software will degenerate over time
Very Low Little	**Bare bones maintenance. Non-dedicated team** doing emergency fixes. to no documentation update. Software will degenerate rapidly. May also represent sustaining engineering effort of a delivered incremental build during development of subsequent builds

SEER® by GALORATH

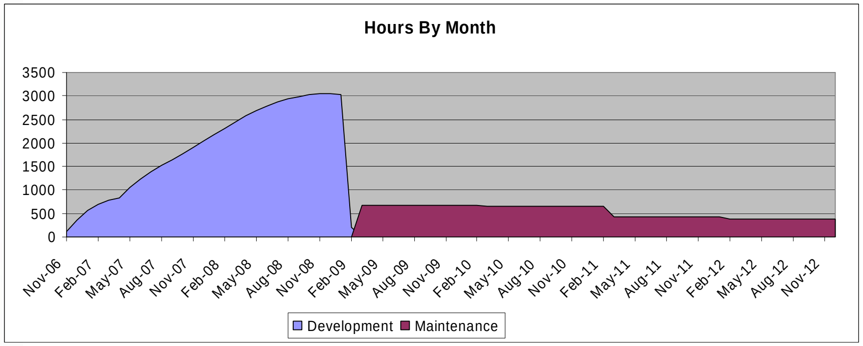
Software Maintenance: Pure Raleigh Assumption Overestimates

Maintenance Rigor: vhi+ (pre-1995)

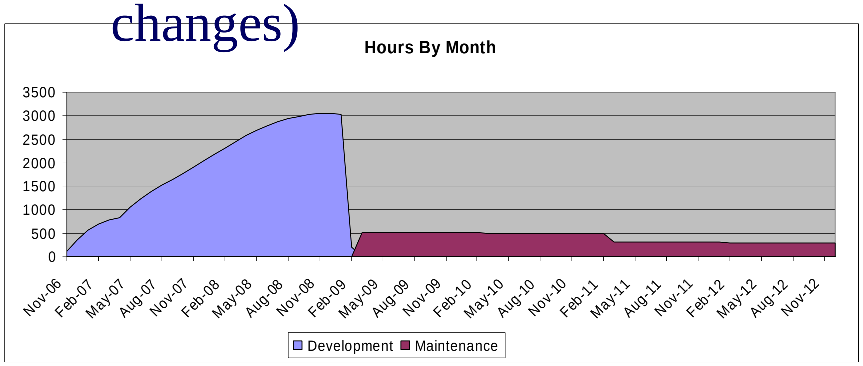


- Maintenance Rigor set to vhi+ (pre 1995 SEER-SEM maintenance model)
- Used Raleigh Application found this level staffing was never allowed during maintenance

Maintenance Rigor: nom

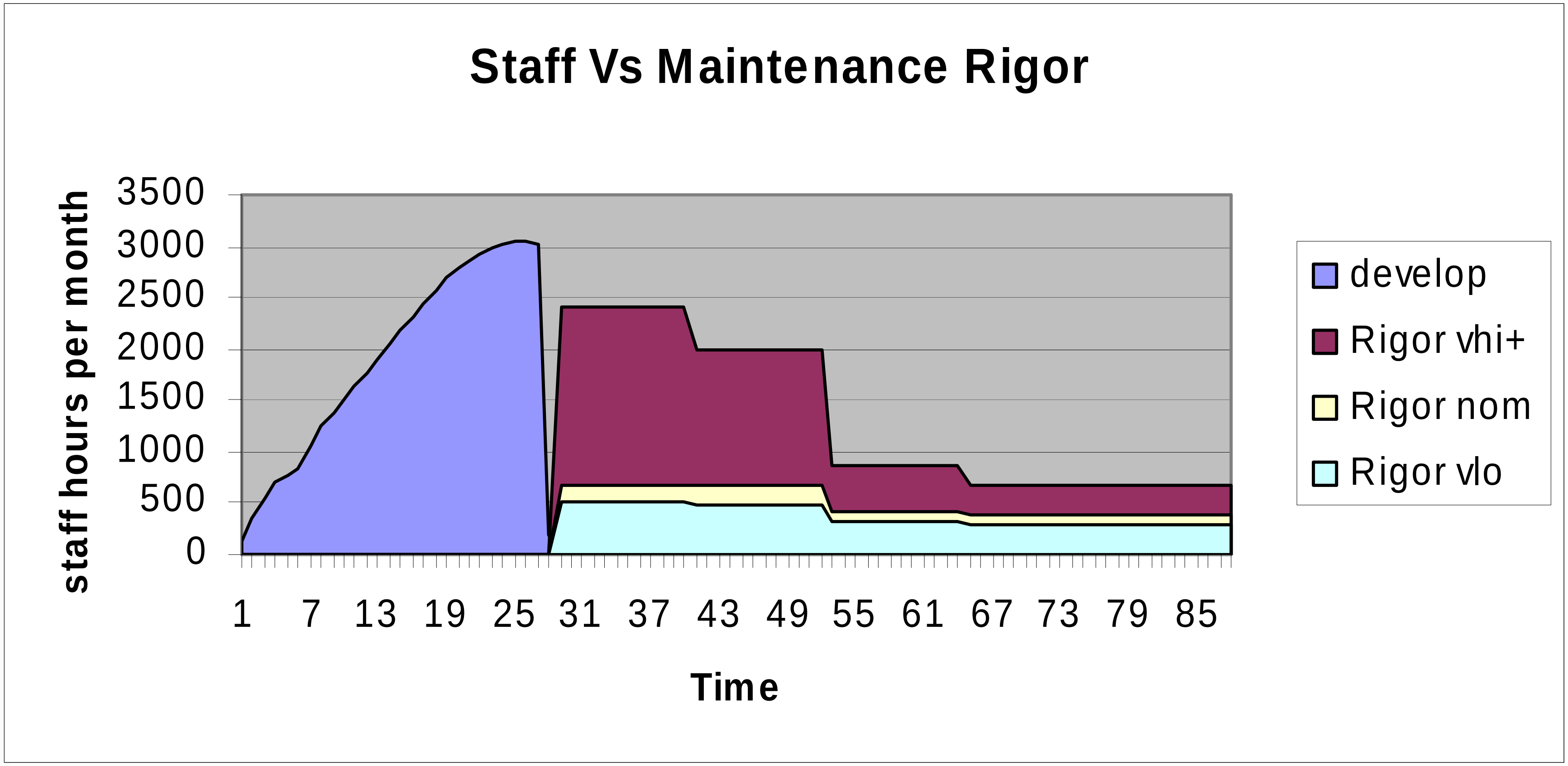


Maintenance Rigor vlo (emergency changes)



SEER® by GALORATH

Key Driver: Maintenance Level (Rigor)
Most Projects Spend Low During Maintenance



SEER® by GALORATH

Percent to be Maintained

- **Enter the percent of the total code that will be maintained**
- **If maintenance will be shared with another organization, enter only the portion to be included in this estimate**
- **If software cannot be changed, do not include it in the percent to be maintained (e.g. non updateable embedded processors)**

Rating	Description
100%	Maintenance for entire WBS element will be included in the estimate
15%	Maintenance effort is outside the estimate, but some maintenance integration effort is required
0%	No maintenance effort is included in the estimate

Maintain Total System

- **Parameter determines whether *total* size or *effective* size should be used to estimate maintenance**
  - If the software is entirely new lines of code, this parameter has no effect
- **Default setting is YES so that maintenance is estimated based on the entire completed Program, not just the changes**
  - Set to **NO** if preexisting code maintenance is someone else's responsibility
- **For COTS, this should be set to NO since you generally don't maintain the COTS package (the vendor does this)**

Rating	Description
YES	**Normal**: Estimate maintenance of the total WBS element, including preexisting code
NO	**Special**: Estimate maintenance of the effective size (current changes) only. Maintenance of the entire preexisting code is <u>not</u> included in the estimate

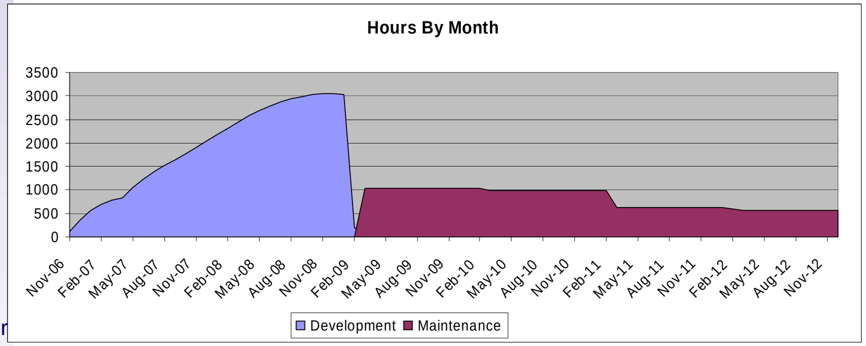
SEER®
by GALORATH

Steady State Maintenance Only

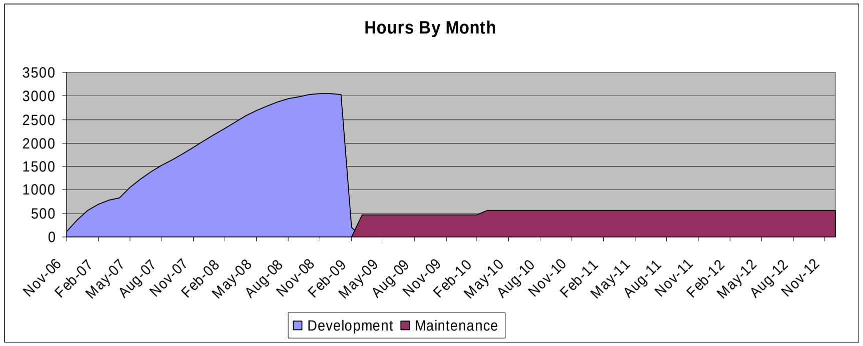
- **Indicates whether maintenance profile should be effort-based, or fixed staff.**

Rating	Description
YES	Estimate maintenance with a fixed annual staff level. (For Contracts where level of effort will not allow rampdown or planned initial block change will be added to effort)
NO	Estimate maintenance with additional effort in the first years.

no

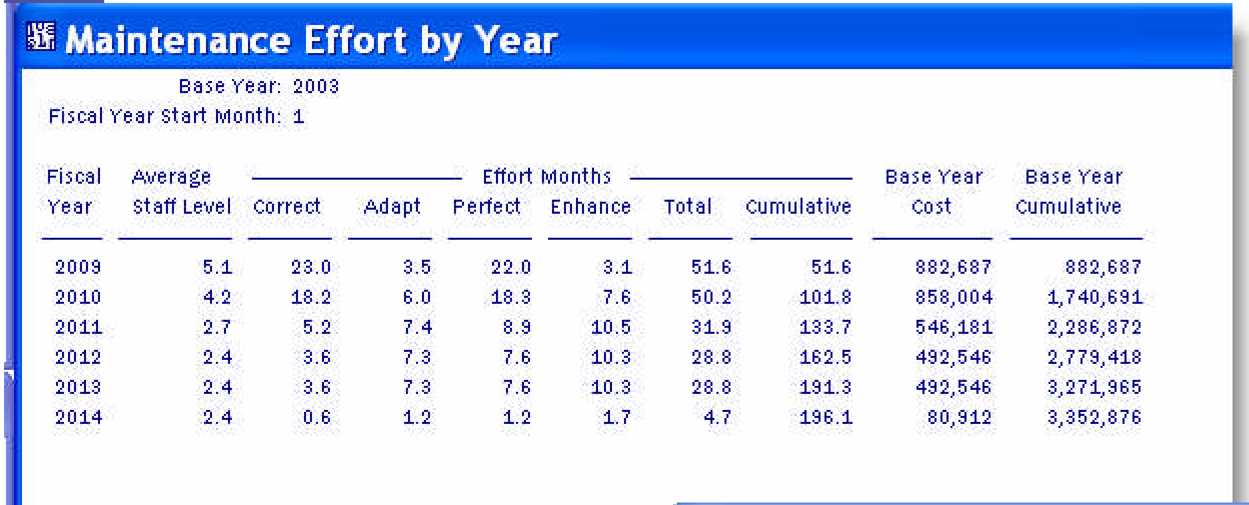


yes



SEER® by GALORATH

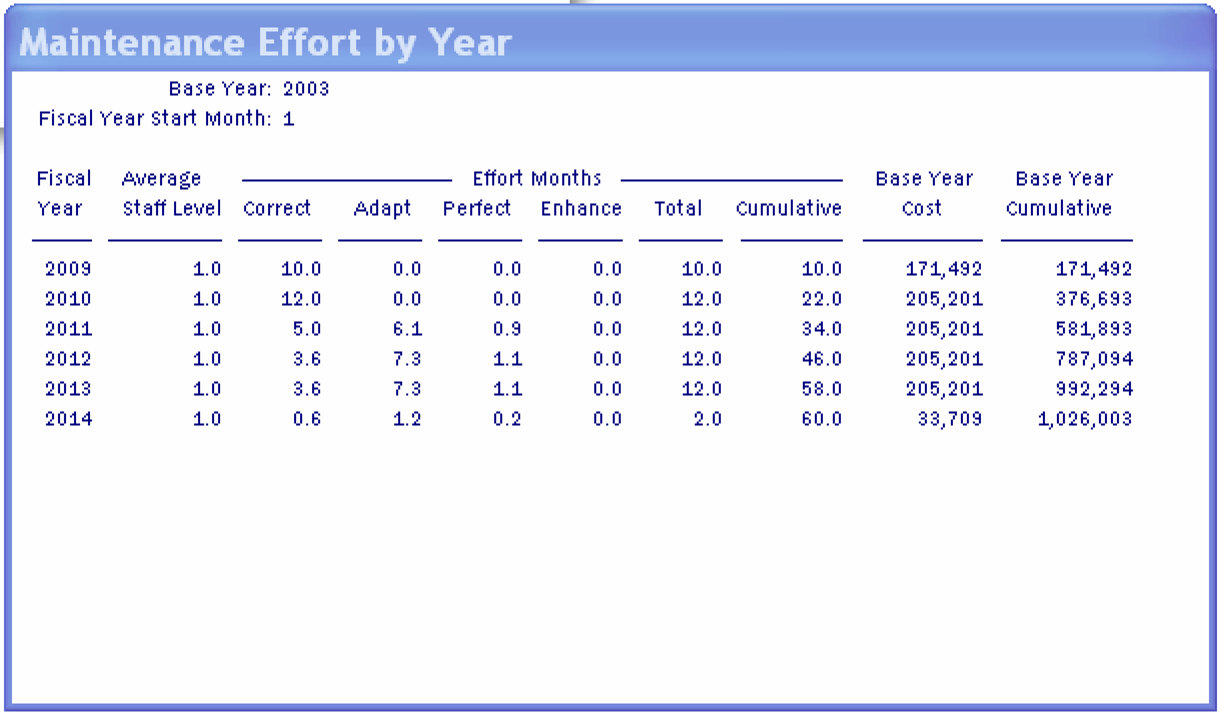
SEER-SEM Maintenance Model Approximates Effort Spread Based On Staff



Maintenance Effort by Year

Base Year: 2003
Fiscal Year Start Month: 1

Fiscal	Average	Effort Months						Base Year	Base Year
Year	Staff Level	Correct	Adapt	Perfect	Enhance	Total	Cumulative	Cost	Cumulative
2009	5.1	23.0	3.5	22.0	3.1	51.6	51.6	882,687	882,687
2010	4.2	18.2	6.0	18.3	7.6	50.2	101.8	858,004	1,740,691
2011	2.7	5.2	7.4	8.9	10.5	31.9	133.7	546,181	2,286,872
2012	2.4	3.6	7.3	7.6	10.3	28.8	162.5	492,546	2,779,418
2013	2.4	3.6	7.3	7.6	10.3	28.8	191.3	492,546	3,271,965
2014	2.4	0.6	1.2	1.2	1.7	4.7	196.1	80,912	3,352,876



Maintenance Effort by Year

Base Year: 2003
Fiscal Year Start Month: 1

Fiscal	Average	Effort Months						Base Year	Base Year
Year	Staff Level	Correct	Adapt	Perfect	Enhance	Total	Cumulative	Cost	Cumulative
2009	1.0	10.0	0.0	0.0	0.0	10.0	10.0	171,492	171,492
2010	1.0	12.0	0.0	0.0	0.0	12.0	22.0	205,201	376,693
2011	1.0	5.0	6.1	0.9	0.0	12.0	34.0	205,201	581,893
2012	1.0	3.6	7.3	1.1	0.0	12.0	46.0	205,201	787,094
2013	1.0	3.6	7.3	1.1	0.0	12.0	58.0	205,201	992,294
2014	1.0	0.6	1.2	0.2	0.0	2.0	60.0	33,709	1,026,003

1 staff (Right) vs estimated staff (top):

- •Enhancements don’t occur
- •Emergency adoptions & perfecting

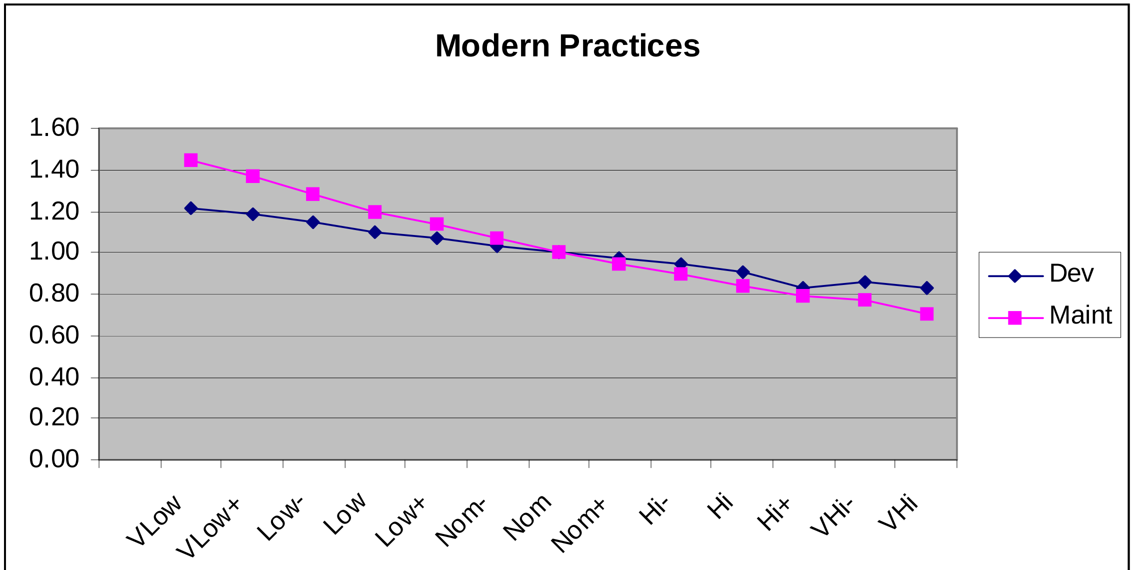
SEER® by GALORATH

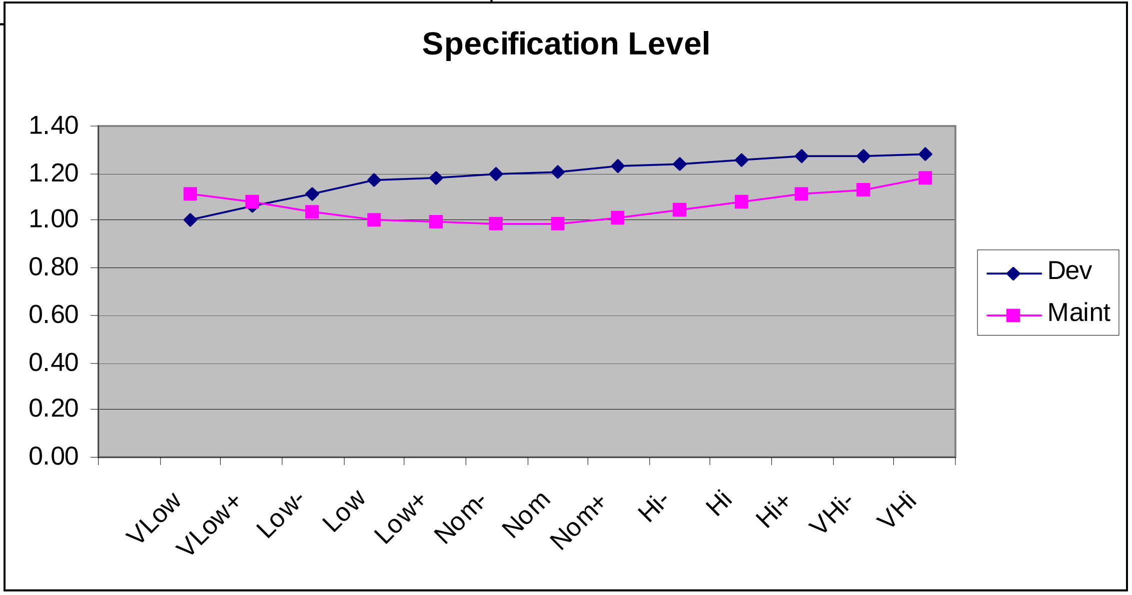
Maintenance Schedule & Staffing

- **Minimum and Maximum Maintenance Staff (Optional)**
  - Enter maintenance staffing constraints, if desired
- **Maintenance Monthly Labor Rate**
  - Enter average monthly labor rate <u>for maintenance personnel</u>
- **Additional Annual Maintenance Cost**
  - Enter any additional throughput costs
    - Dissemination
    - License fees
    - Equipment lease
    - Training
- **Maintenance start date**
  - Date when maintenance activities will begin
    - Model defaults to delivery date (day after SI&T ends)

SEER® by GALORATH

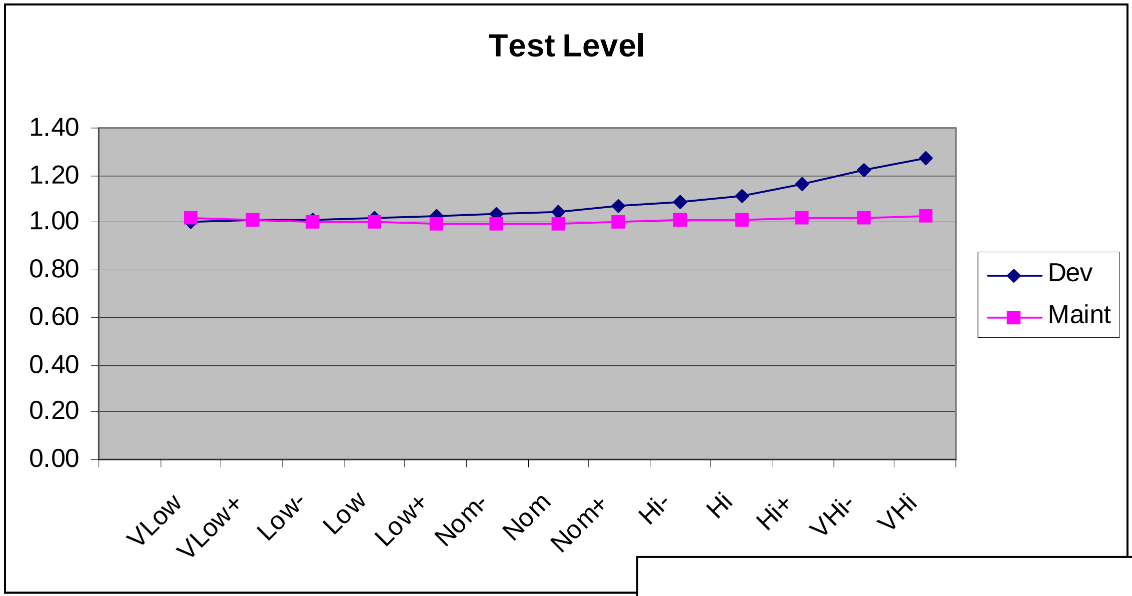
Parameter Sensitivity Development Vs Maintenance - 1

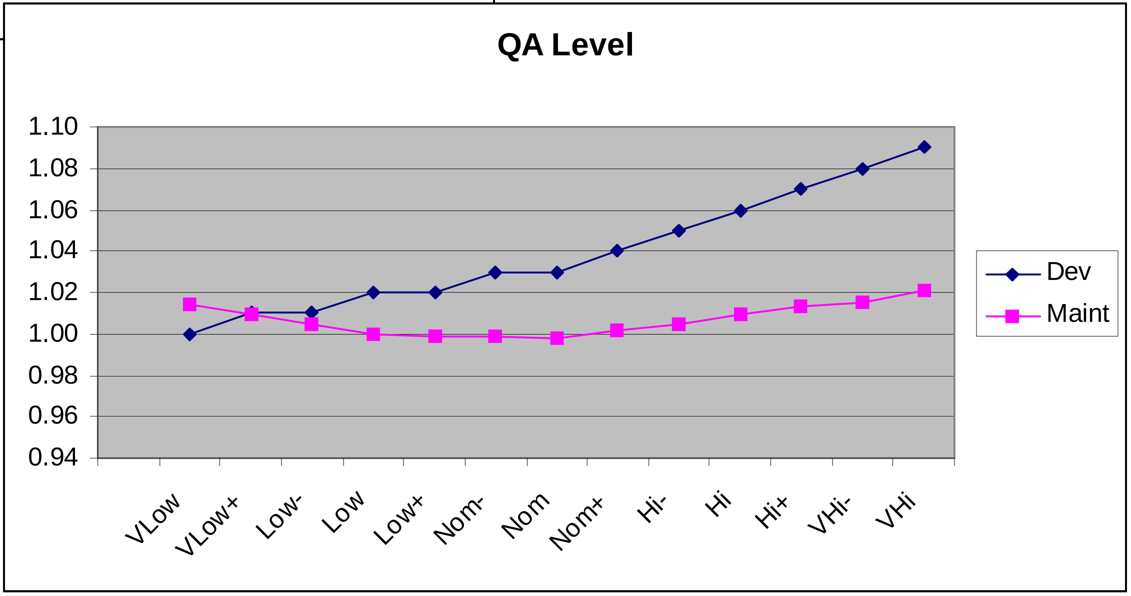

Modern Practices


Specification Level

SEER® by GALORATH

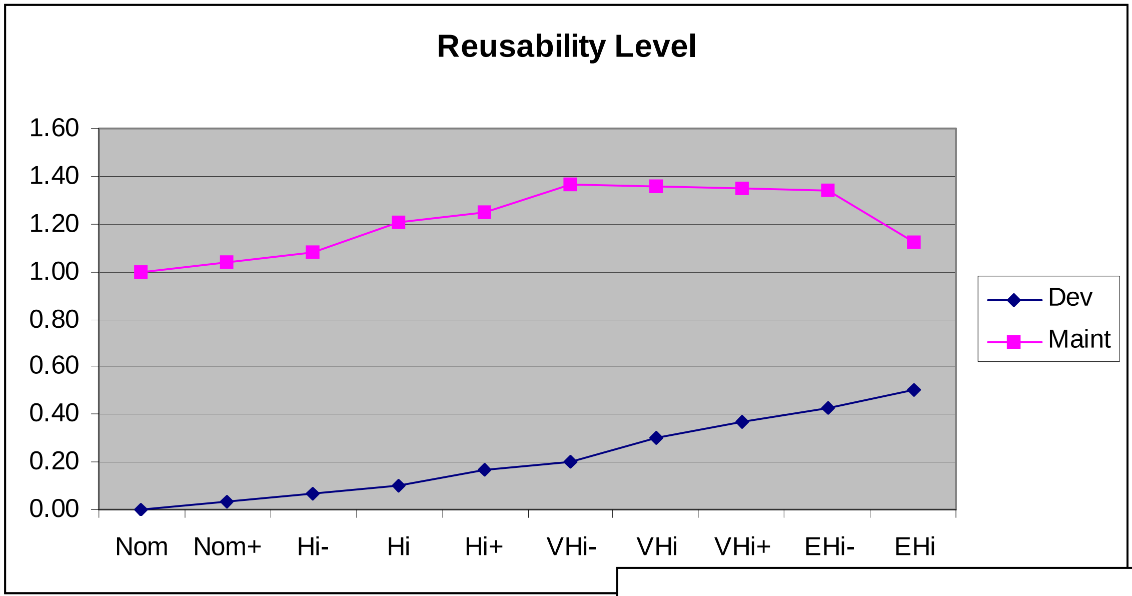
Parameter Sensitivity Development Vs Maintenance - 2

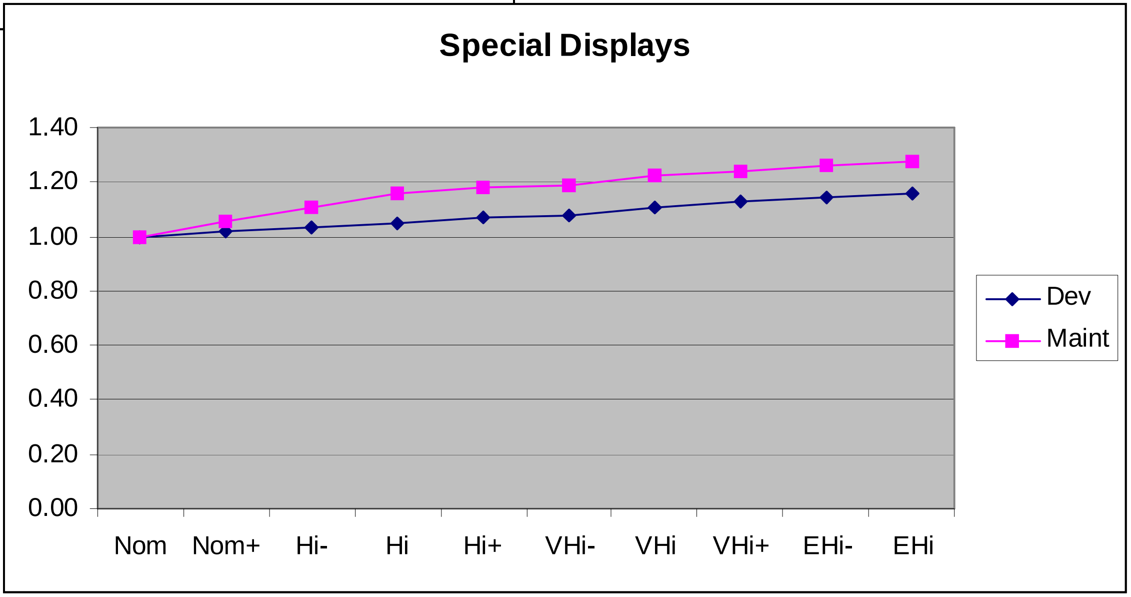




SEER® by GALORATH

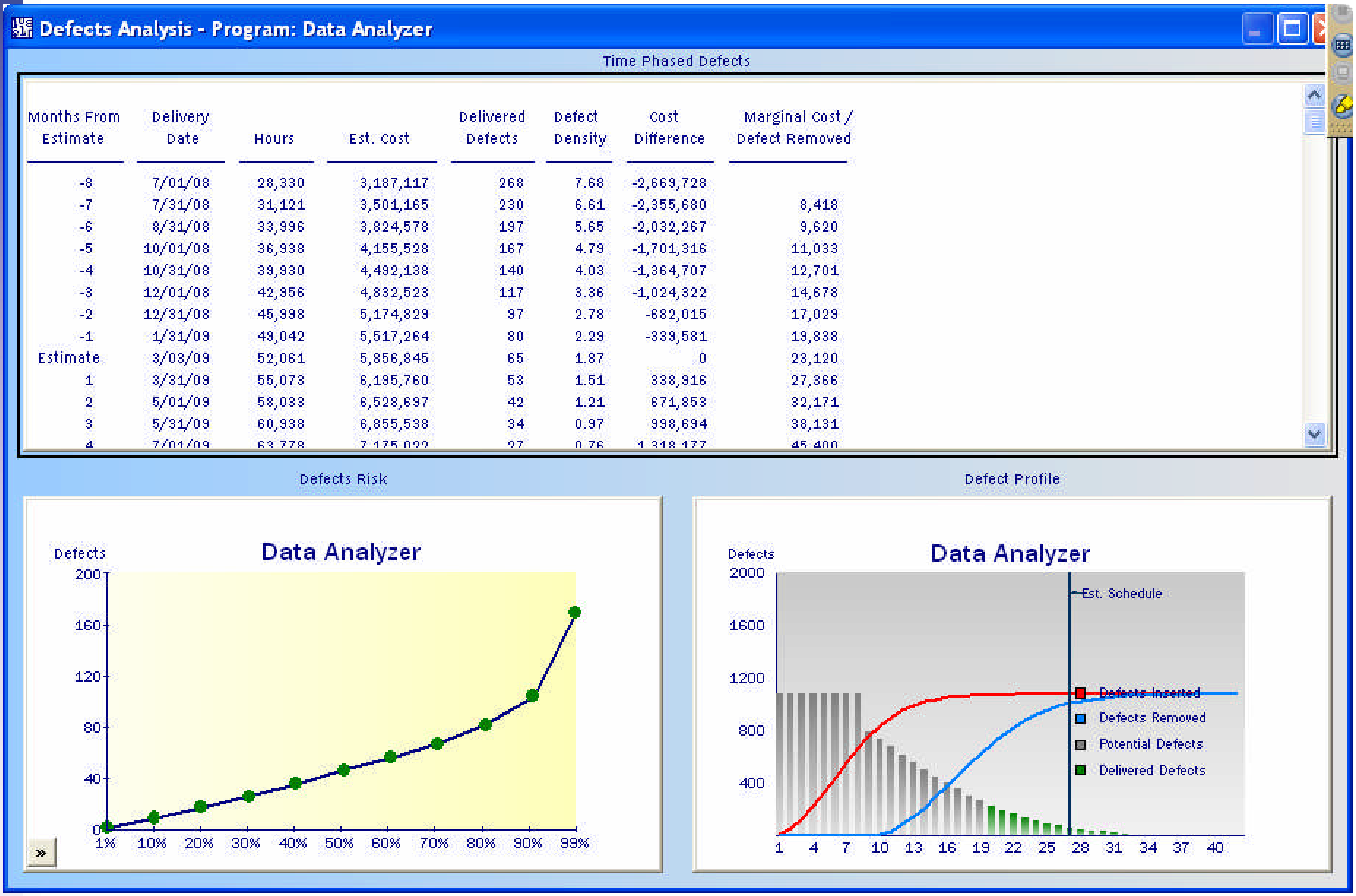
Parameter Sensitivity Development Vs Maintenance - 3





SEER® by GALORATH

Defects Can Be Reduced By Further Development Testing but Not Eliminated



Defects Analysis - Program: Data Analyzer

Time Phased Defects

Months From Estimate	Delivery Date	Hours	Est. Cost	Delivered Defects	Defect Density	Cost Difference	Marginal Cost / Defect Removed
-8	7/01/08	28,330	3,187,117	268	7.68	-2,669,728	
-7	7/31/08	31,121	3,501,165	230	6.61	-2,355,680	8,418
-6	8/31/08	33,996	3,824,578	197	5.65	-2,032,267	9,620
-5	10/01/08	36,938	4,155,528	167	4.79	-1,701,316	11,033
-4	10/31/08	39,930	4,492,138	140	4.03	-1,364,707	12,701
-3	12/01/08	42,956	4,832,523	117	3.36	-1,024,322	14,678
-2	12/31/08	45,998	5,174,829	97	2.78	-682,015	17,029
-1	1/31/09	49,042	5,517,264	80	2.29	-339,581	19,838
Estimate	3/03/09	52,061	5,856,845	65	1.87	0	23,120
1	3/31/09	55,073	6,195,760	53	1.51	338,916	27,366
2	5/01/09	58,033	6,528,697	42	1.21	671,853	32,171
3	5/31/09	60,938	6,855,538	34	0.97	998,694	38,131
4	7/01/09	63,778	7,175,022	27	0.76	1,318,177	45,400

Defects Risk

Defect Profile

SEER® by GALORATH

Conclusions

- **Software Maintenance can be 75% of total ownership costs**
- **Development decisions, processes and tools can impact maintenance costs**
- **Generally even a perfect delivered system quickly needs upgrade**
- **While software maintenance is often treated as a level of effort activity there are consequences:**
  - Quality, functionality and reliability
- **Software total ownership costs and risks can be estimated using SEER for Software**