QSM

MEASURES FOR EXCELLENCE

Telecom Software Benchmarks

10 Years Apart

1992-2002

Telecom Background:
What happened in 1992 and 2002?

We benchmarked in 1992; 10 years later we repeat the benchmark. Basically it's the same organisation building the same type of software for Telecom products. High software content determines the time to market and reliability.

10 years is a long time so why the gap? Well objective benchmarking is risky. The original benchmark revealed local management misconceptions about productivity. They were betting that software re-use provides significant process productivity benefits. The 1992 results showed otherwise. Certainly re-use gave major benefits by reducing the size of the developed software but this was independent of the local team process productivity. Moreover the results highlighted that development process productivity and time pressure in addition to size are major independent factors determining time, effort and reliability. Management closed its eyes to the evidence. So as the messengers we got shown the door.

Time rolls by. Commercial pressures are enormous- its Telecom. The company is committed to move up the CMMI maturity levels. The goal is Level 2 where Measurement and Analysis is a Key Process Area. Management changes take place.

Now it's 2002 and here we go again. Still collecting the same core data as in 1992 and as recommended by the SEI: time, effort, size and defects (Ref. 1). Our measurement techniques are unchanged- measure development process productivity separate from size and time pressure. Measure time pressure. Compare projects against industry reference measures determined from current Telecom projects worldwide. Now, however, the reference measures are based on 2002 values since these are updated about every two years from our industry database.
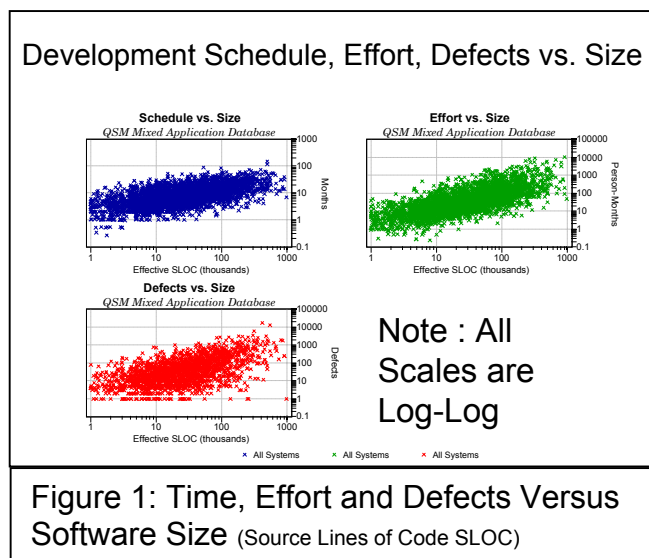
What do we find? Well the process productivity has indeed improved over the 10 years but the time to market pressure has also increased. The time pressure means that today relatively more people are used to develop software more quickly with a significant increase in effort and defects. The commercial results are very interesting as we compare the 10-year differences in process productivity and the consequence of time pressure.

Lets look in detail at the benchmarking measures used, the 1992 and 2002 findings and then use the results to show how the bottom line works out. Our final conclusions highlight the practicality and benefits of continuous benchmarking. Keep in mind that benchmarking their suppliers is of real interest to purchasers of external software developments (Ref. 5).

The Benchmark Measures: Industry Trend-Lines, Process Productivity and Time Pressure

Evidence from thousands of completed developments covering all software application types is shown below in Figure 1. Here we plot the time, effort and defects for each project against the size making the scales logarithmic. Mathematical "least squares best fit" analysis of the data provides "trend lines" that show the time, effort and defects are related to size in a power (exponential) form. (Mathematically we find the correlation coefficient (r^2) is significant in each case..

Specific "trend-lines" are derived for each type of software application for instance Telecom, process control or business systems.

Development Schedule, Effort, Defects vs. Size

Schedule vs. Size
QSM Mixed Application Database

Effort vs. Size
QSM Mixed Application Database

Defects vs. Size
QSM Mixed Application Database

Note : All Scales are Log-Log

Figure 1: Time, Effort and Defects Versus Software Size (Source Lines of Code SLOC)

Further mathematical analysis links effort, time, size and process productivity in a software equation. Complete details of the evidence from many thousands of projects and the formulation of the equation are set out in Ref. 2.

Fortunately the math is capable of being understood and used at all levels by

expressing the three key "drivers" in straightforward management terms.

Driver 1: Size: Software size quantifies the amount of software function developed. Any concrete measure of software size applies, such as logical input statements, objects and function points. The evidence is that re-use does indeed give benefits. It results in smaller size. However specifying more features may increase size and costs significantly more in terms of time, effort and defects.

Driver 2: Process Productivity: Team process productivity is derived mathematically (Ref. 3) and quantified in terms of a process productivity parameter (P). The discrete values of this parameter are expressed using a linear management scale going from 1 to 40 termed the Process Productivity Index or PI. This management scale represents quantified step values. The higher the PI then the higher is the project team process productivity. Here the values apply inversely (namely divide) and improving team process productivity significantly reduces development time and effort.

Reference PI values are determined from the industry database for each application type based on recent developments. The values provide a benchmark reference for comparison. Currently for Telecom developments, 2002, a mean PI value of 13 is found. The PI value is a high-level measure that benchmarks the entire development environment. It is separate from the size and time pressure. Measuring the PI continuously reveals process improvement as we show for this development group over the 10 years between 1992 and 2002.

Driver 3: Time: Development time is the third driver. What is not self evident is how powerful is the time driver. Development effort, cost and defects are highly sensitive to how long you allow for development. Cutting time to market demands means enormous increase in effort, cost and defects. Conversely planning a little more time, say 4 to 6 weeks, yields large reductions in all three.

Time pressure is expressed mathematically as a gradient value in the software equation. A simplified scale from 1 to 10 is used termed the Manpower Build-up Index (MBI) where higher numbers mean more time pressure. Full details are set out in Ref 2.

The 1992 and 2002 Developments Versus The 2002 Industry Trend Lines

The diagram below, Figure 2, shows the trend lines determined from recent Telecom projects. Each benchmarked project is shown plotted in terms of the time and effort versus the size.
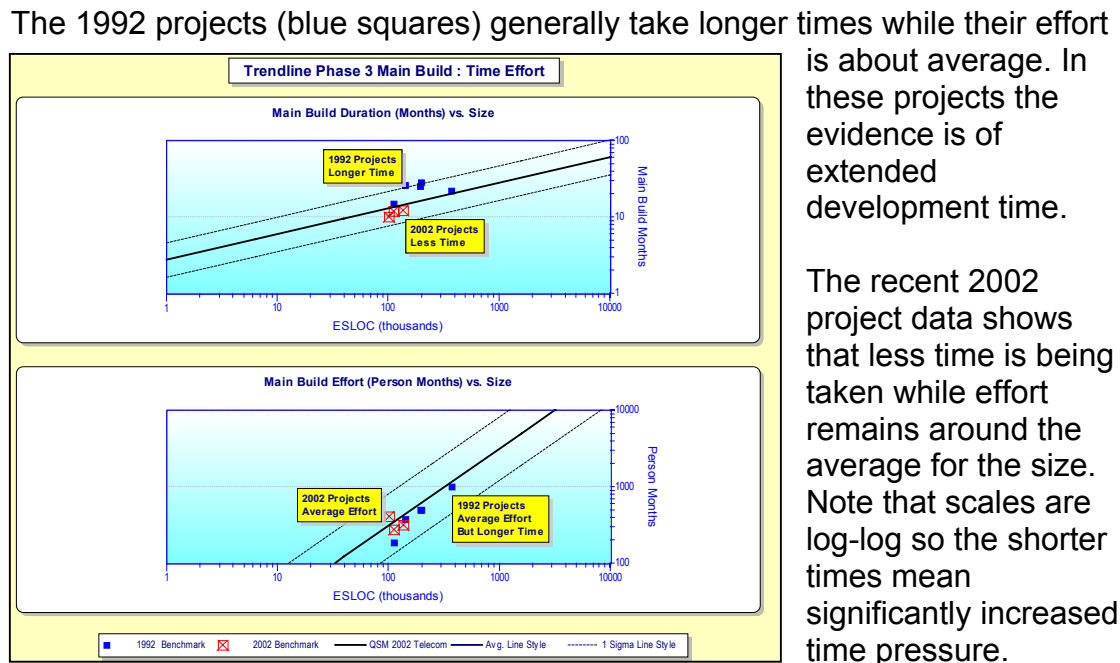
The 1992 projects (blue squares) generally take longer times while their effort is about average. In these projects the evidence is of extended development time.

The recent 2002 project data shows that less time is being taken while effort remains around the average for the size. Note that scales are log-log so the shorter times mean significantly increased time pressure.

Figure 2: 1992 and 2002 Projects versus the 2002 Telecom Trend Lines: Time: Effort Versus Size

1992 and 2002 Process Productivity (PI) and Time Pressure (MBI) Benchmark Findings

The core measures are input to the software equation to calculate the team process productivity and the time pressure for each project. The average values determined for the 1992 and 2002 benchmark projects are shown in Figure 3.
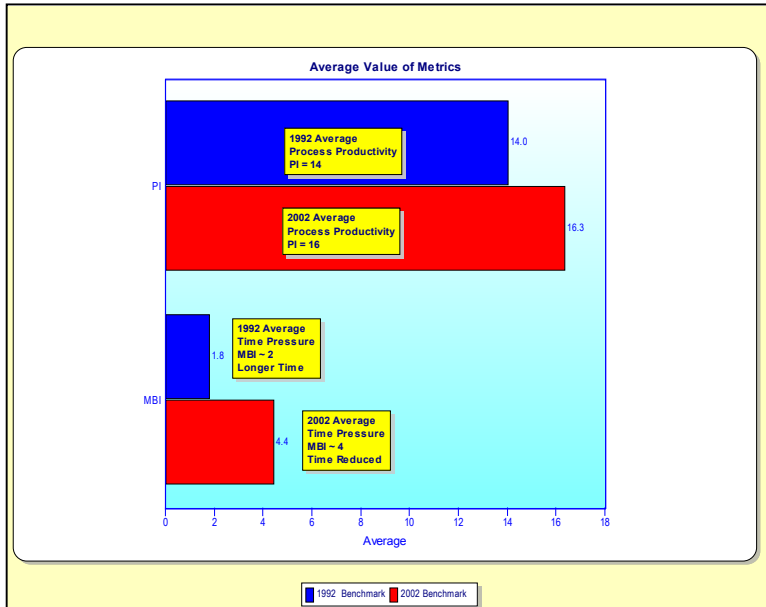

Figure 3: 1992 and 2002 Projects: Average Process Productivity (PI) and Time Pressure (MBI)

For the process productivity the benchmark shows that the 1992 projects achieved an average PI of 14. Ten years later the average PI has improved to just over 16. In addition the 2002 PI value is above the expected Telecom PI value, currently 13.

Meanwhile the time pressure measure (MBI) has increased from an average of around 2 in 1992 to 4 in the 2002 projects. This reflects the reduced time to market to deliver the Telecom products.

The Benchmark Differences between 1992 and 2002

How do we interpret the differences in the benchmark findings over the 10 years and what is their significance?

First there is clear evidence of improved process productivity. The average PI value has improved from 14 to 16 over the 10 years. In part this is due to the company following a vigorous implementation of the CMMI Key Process Areas (KPA's). We find that management factors lead to improved process productivity. The KPA's focus on essential software management techniques and the quantified results below show action on these bring substantial commercial benefits.

Second the benchmark of the current process productivity PI of 16 is above the 2002 Telecom mean value of 13. Hence the development group is performing well above current industry norms. Again the commercial consequences are significant and enable senior managers to demonstrate the value for money their organisation provides.

Third time pressure is evident due to getting products to market quicker. This costs substantially more money and results in more defects. Modelling an average project shows the impact of increased time pressure (MBI 4) in 2002 compared to the more protracted schedules back in 1992 (MBI 2).

Quantifying the Bottom Line Impact Over the 10 Years

For the purpose of calculating the commercial benefits we use the average size of the 2002 developments which is 120,000 statements consisting mainly of C and C++. There are clear benefits due to the improved process productivity. These are shown next. However the cost of reduced development time needs to be understood as we show below.

Process Improvement Benefits

In Figure 4 we illustrate the benefits of the process improvement based on the average size with the time pressure found in 2002 (MBI 4).
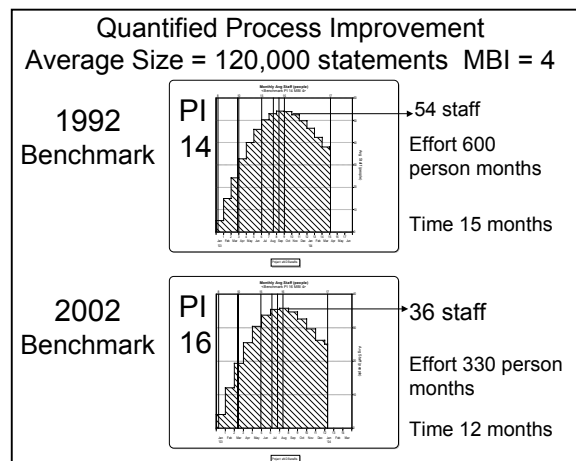

Figure 4: Quantifying the Process Productivity Improvement 1992 versus 2002.

The benchmark measurement results over the 10 years show that:

1. Development time is reduced by 3 months
2. Total development effort has fallen from 600 person months to 330, a saving of 270 person months
3. Maximum staffing has dropped from 54 to 36 staff.

Assuming a labour rate of $100,000 per person year this represents a saving of over $2,000,000 per project.
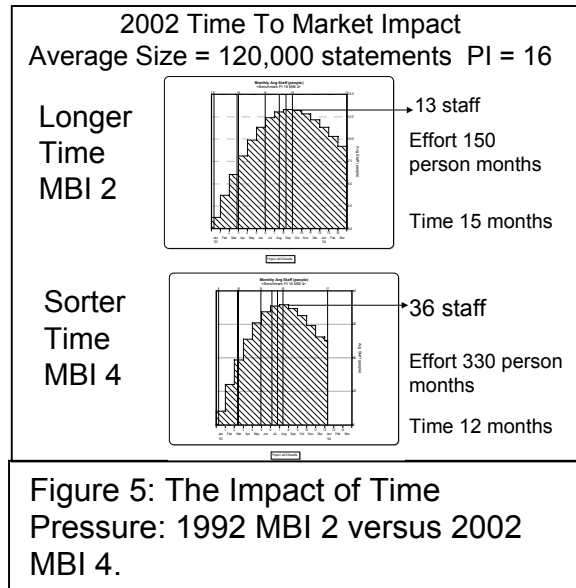
Equally interesting is to compare the group's average development against the 2002 Telecom industry PI value of 13. (Incidentally the Telecom average MBI in 2002 is also 4). Here we find that at a PI of 13 and MBI of 4 to develop 120,000 statements the industry 2002 average gives:

- Development Time =17 months
- Development Effort =830 person months
- Peak staff = 66 people

So compared to the 2002 Telecom industry average the benchmark group takes 5 months less and uses 500 person months less effort. This represents a saving of over $4,000,000 and demonstrates the value for money provided by this development organisation.

Time Pressure Consequences

Figure 5 shows the impact of time pressure. Today's shorter time for developments is measured by an MBI of 4. This is compared with the 1992-benchmark findings an MBI of 2.

2002 Time To Market Impact
Average Size = 120,000 statements PI = 16

Longer Time MBI 2
→ 13 staff
Effort 150 person months
Time 15 months

Sorter Time MBI 4
→ 36 staff
Effort 330 person months
Time 12 months

Figure 5: The Impact of Time Pressure: 1992 MBI 2 versus 2002 MBI 4.

Due to the reduced time we see that the impact in 2002 compared to 1992 is that an average development:
- Takes 3 months less time
- Costs 180 person months more effort

If the commercial pressures did allow the longer time of 3 months (MBI 2) then a further potential saving of $1,500,000 is practical.

Here we see that marketing decisions play a significant role in determining development costs.

Conclusions

The benchmark results shown here use core data from completed projects: development time, effort and size as well as defects. This basic data is quick to collect and allows benchmarking to be done within 4 to 6 weeks. The results reveal how a development group compares with up to date industry reference measures (Trend Lines, Process Productivity and Time Pressure (MBI)).

Compared with the expected 2002 Telecom average values this group is performing exceptionally well and enjoys substantial benefits as a result. In addition it is unique in that the original benchmark performed in 1992 allows an evaluation and quantification of process productivity improvement over the 10 years. Again the results demonstrate the large commercial benefits gained over the last decade.

The customers for the products of these development groups are also motivated to benchmark their suppliers in the same way (Ref. 3/5). The increasing costs and risks in the purchasing and the outsourcing of external developments mean that benchmarking leads to informed negotiations with suppliers. Purchasers are able to evaluate supplier value for money as well as checking new proposals are consistent with the supplier capability.

The benchmark case study demonstrates that it is practical to continuously collect data and quantify process improvement. Note this is independent of size and time pressure in each development. Companies are able to calculate the return on investment through process improvement initiatives such as CMMI. In the case study we lack the details of the investments over the period and the continuous data collection and measurement on all projects.

We find that with initiatives such as CMMI there is increasing pressure to cost justify the investments being made to move up the maturity levels (Ref. 4). There is an equal need to judge if the process improvement changes are really bringing benefits. The results shown here enable the return on investments to be calculated as well as confirm real improvements are made. In addition the data and its use provides the means to satisfy in part the Measurement and Analysis KPA at Level 2 of CMMI.

Finally is this benchmarking and ROI calculation capability new? Well no. One of the first instances where we benchmarked over a number of years is set out in detail under Ref. 2. Here the developments are from a large business system group. This work involved evaluating the application development environment and recommending actions for process improvement. Chapter 12 "Managing a Productivity Program" sets out our findings, recommendations and results including full details of the ROI calculation. Over three years the data shows that the ROI is around 77% based on investments of approximately $23,000,000. Our improvement recommendations at that time (1985) are set out that focussed on software management practices. It will be seen that these recommendations are in line with CMMI Key Process Areas.

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Ref.1: The SEI Core Measures Anita D. Carleton, Robert E. Park and Wolfart B. Goethert The Journal of the Quality Assurance Institute July 1994

Ref. 2: L.H. Putnam and Ware Myers "Measures For Excellence: Reliable Software, On Time, Within Budget:" Prentice Hall New York 1992

Ref. 3: Geerhard W. Kempff "Managing Software Acquisition" Managing System Development July 1998 Applied Computer Research Inc. P.O. Box 82266, Phoenix, AZ, USA.

Ref. 4: Lawrence H. Putnam "The Economic Value of Moving up the SEI Scale *Managing System Development* July 1994 Applied Computer Research Inc. P.O. Box 82266, Phoenix, AZ, USA

Ref. 5: Lawrence H. Putnam and Ware Myers "Control the Software Beast With Metrics Based Management" CROSSTALK August 2002 The Journal of Defense Software Engineering USAF Hill Air Force Base.

For further information on QSM's practices, refer to Lawrence H. Putnam and Ware Myers, Industrial Strength Software: Effective Management Using Measurement, IEEE Computer Society Press, Los Alamitos, CA, 1997, 309 pp.