CHANGING FROM FPA TO COSMIC
A TRANSITION FRAMEWORK

H.S. van Heeringen
Sogeti Nederland
harold.van.heeringen@sogeti.nl

Abstract   Many organizations are considering to change their functional size measurement method from FPA to COSMIC, mainly because of the fact that more and more projects become 'less sizeable' with FPA. A lot of them refrain from doing so, because they fear to loose their experience base based on function points. This paper presents a framework to successfully transform a functional size measurement method from FPA to COSMIC. The purpose of this paper is to offer some guidance to make it easier for organizations to transfer to COSMIC, while keeping the experience data that has been gathered with FPA. It continues on earlier work of Vogelezang and Lesterhuis (2003) and Desharnais, Abran & Cuadrado (2006).

For this paper, 26 projects have been sized with both methods. An analysis will be presented to see if there are differences between measurements carried out in COSMIC and FPA. Furthermore, an analysis will be presented about the outliers (the data points that do not correlate with the regression formula).

1. INTRODUCTION

Many organizations worldwide rely in their project estimation on the functional size measurement method Function Point Analysis (FPA). FPA is the worldwide standard functional sizing technique and has been used since the early eighties of the previous century as a method to estimate software development projects. Many organizations worldwide have been using the method for many years now and these organizations often have build up a history database with metrics based on FPA.

FPA has been developed in the era where software development environments were rather stable. In those days most of the applications were programmed in a 3GL programming language like Cobol, while the waterfall development method was used on a mainframe hardware platform. The counting guidelines of FPA are well applicable on systems with these characteristics. However, more and more organizations encounter problems in applying the FPA counting guidelines to more modern types of docu-

mentation, like for instance UML. This leads to more projects that are rated 'uncountable', which leads to less reliable estimations and less confidence in functional size measurement methods (FSM).

In the late nineties, an international consortium of scientists and practitioners decided to develop a new FSM and called it COSMIC Full Function Points. COSMIC is a so-called 2nd generation FSM [1] and is, like IFPUG FPA [2] and NESMA FPA [3][4] also an ISO certified functional sizing method [5]. COSMIC is now gaining more and more attention from the metrics community worldwide and is recognized as the successor for FPA in many organizations.

2. REASONS TO APPLY COSMIC INSTEAD OF FPA

One of the complaints from FSM practitioners these days is that the FPA functional sizing method is becoming hard to apply on a number of new forms of functional requirement documentation. In this era of web ap-

plications and service oriented architectures, the guidelines to identify logical files for instance are sometimes hard to apply. Many applications don't even work with permanent data any more, so there will be no EIF's and ILF's present. This notion leads to less confidence in the method and of course in less confidence in the estimations based on this method. COSMIC can often be applied in circumstances where FPA can not be applied. One of the reasons is the possibility to identify separate layers and/or peer components in an information system. Where FPA only considers a logical transaction from the start (for instance user input) until the end (for instance write to database), the concept of peer components makes it possible to size the different subsystems that carry out the functionality. COSMIC is therefore better suitable to size applications with different technical components.

Furthermore, with COSMIC there is the possibility to measure size of software in other domains than the traditional business application domain. While FPA can only be used to size business applications, COSMIC claims to be applicable in the real-time software and the infrastructure software domain, next to being applicable in the business application domain as well. Organizations that develop software in these two domains do not have a real choice when it comes to choosing the appropriate functional sizing method.

Another reason to consider a transfer to COSMIC is because with this method the size differences between separate functions can be expressed more accurately. In FPA, an EI function for instance gets 3, 4 or 6 function points. A complex one gets 6 points, but a very complex EI also gets 6 points. In COSMIC, the size for a function can be any number between two and (theoretically) infinity. It is therefore possible to state that function A is for instance twice as big as

function B. Measurement becomes more accurate and this has also an effect on the whole Estimating and Performance Measurement process within organizations. This characteristic also makes it easier to carry out some form of scope management, like for instance SouthernSCOPE [6], making it easier to accurately define the scope that fits within the budget available.

Next to these arguments, COSMIC claims to be a more intuitive method, with fewer guidelines than FPA. This makes it easier to learn the method and to apply it correctly. Theoretically, this may be true. However, in our experience this argument is not entirely valid. We experience as much discussion in COSMIC analysis as in FPA and our research shows us that there are no significant differences between the 'analysis speeds' of the methods. The launch of version 3.0 of the COSMIC Measurement manual [7] and the existence of the Business Application Guideline [8] may prove that COSMIC is a faster method, but this needs further investigation.

So, why is not every organisation transferring their FSM to COSMIC at the moment? One of the reasons is certainly because the method is relatively unknown. Another reason can be that there are relatively few analysts available who know the method and who are able to do a good COSMIC analysis. Furthermore the number of training facilities is small. In addition, many organizations that do consider a transfer, fear to loose their experience base in FPA. If that is the case, they feel that they throw away a lot of experience data which had cost a lot of work to collect. In section 7 of this paper a framework is presented that helps organizations to transform their functional sizing method from FPA to COSMIC without losing their experience base. First, the differences and similarities between the two methods are discussed.

3. DIFFERENCES AND SIMILARITIES

Both FPA and COSMIC are ISO certified Functional Sizing Methods [1][5][3]. This means that both methods can be used to measure the functional size of software, independent of the technical implementation or the (skilled) individual conducting the analysis. However, measurements carried out with the two methods do not yield the same results. Unlike other areas where there are multiple measurement methods to measure the same metric (like for instance the length metric in meter or yard), it is not possible to apply a mathematical sound conversion formula. The reason for this is the fact that at this moment it is not possible to do an exact conceptual mapping of the base functional components [9] that both methods measure. Gencel and colleagues [10] are currently conducting research on an FSM unification model, which may lead to an exact conceptual mapping between the methods in the future. The most important differences in the two methods are presented in table 3.1.

Characteristic	NESMA/IFPUG FPA	COSMIC
Applicable on domain	Business software	Business / Real-time / Infrastructure software
Data model required?	Required	Not required (but very handy)
Measurement of separate components	Not possible	Possible
Size limit per function	Yes	Size is not limited
Benchmarking data	Lots [11] (ISBSG R10 n= 3108)	Few [11] (ISBSG R10 n=110)
Measurement of processing functionality	No	No, but local extension is possible

Characteristic	NESMA/IFPUG FPA	COSMIC
Early sizing	Based on datamodel	Based on process model

Table 3.1. Main differences between FPA and COSMIC

However, there are also a lot of similarities between the two methods. Both methods only size the functional user requirements out of the total set of requirements. Furthermore the functional user requirements identified are broken down in functions by both methods. In FPA there are two types of functions: data functions and transactional functions. In COSMIC, there is only one type of function: the functional process. The COSMIC Functional process coincides strongly with the transactional function in FPA. Schematically, both methods look like this:
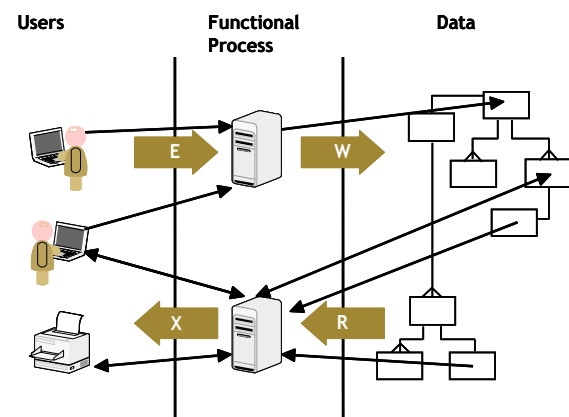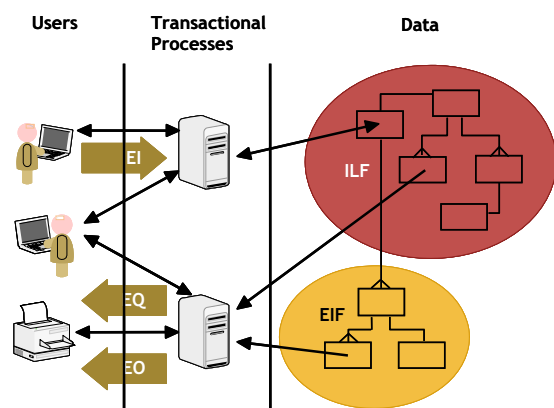

Figure 3.1. COSMIC schematically

Figure 3.2. FPA schematically

In detail, the methods can be compared in the following way [10]:

FSM Method	Data types	Data size	Transaction types	Transaction	Transaction size
FPA	ILF	# RET's # DET's	External input (EI)		# DET's # files referenced
	EIF		External output (EO)		
			External Inquiry (EQ)		
COSMIC	Transient	Part of Functional process	Functional Proces	Entry	# data movements
				Exit	# data movements
	Persistent			Read	# data movements
				Write	# data movements

Table 3.2. Comparison of the two FSM methods

In short: FPA sizes the logical entities (ILF's and EIF's) in the data model with a number of function points (limited to 15 points per entity). Furthermore, FPA identifies logical transactions (EI, EO, EQ) and sizes these with function points (limited to 7 points per transaction). COSMIC does not size the entities in the data model, but it does size the logical transactions and there is no size limit of the logical transactions. However, as the number of entities in the data model increase, the average number of data movements within the functional processes is likely to increase as well. This means that the data model that is explicitly sized within FPA is only implicitly sized in COSMIC.

This leads to the assumption that there is no definite conceptual mapping possible between the BFC-types of the two methods, but a strong relationship between the outcomes measured with both methods is very likely [9]. There have already been reported a number of conversion formula's in the past few years.

4. PREVIOUS STUDIES

Convertibility between functional sizing methods is a highly relevant topic, which is proven by the fact that there have been a number of studies that report a conversion formula. These studies have been carried out by measuring a number (N) of projects with both methods, while using the end user measurement viewpoint from COSMIC. The findings of these studies are presented in table 4.1.

The findings of these studies make it clear that there is a high correlation between functional size measured in COSMIC and functional size measured in IFPUG or NESMA FPA and that the conversion formula is in most cases close to 1 on 1. However, in most of these studies a number of serious outliers have been reported.

5. NEW ANALYSIS

In 2006, Sogeti has sized 26 projects in both FPA and COSMIC. In the COSMIC measurements, only the end user measurement viewpoint has been used, to make the outcomes of the analysis comparable.

The measurements have been carried out by NESMA certified analysts and have also been reviewed by NESMA certified analysts. The analysts have a considerable amount of COSMIC experience as well. Most of the COSMIC analyses are reviewed by COSMIC entry level certified analysts, so the quality of the measurements should be high. Still, there is always the impact of the documentation quality. These measurements have

been carried out as part of the Sogeti bidding process. This means that the documentation is delivered by client organizations, requesting a price quotation based on the requirements described. In many cases, the quality of the documentation was not very good and the analysts had to make a lot of assumptions during the analysis. The projects involved are all situated in the business application domain. The major part of the organizations involved is banking, insurance and government organizations. The dataset is presented in table 5.1.

Based on the dataset above from table 5.1, the correlation between FP and CFP is the showed in figure 5.1.

Author / year	Formula	Correlation	N
Fetcke (1999) [12]	Y(CFP) = 1.1 (IFPUG) – 7.6	R2 = 0.97	4
Vogelezang & Lesterhuis (2003) [13][14][15]	Y(CFP) = 1.2 (NESMA) – 87 Y(CFP) = 0.75 (NESMA) – 2.6 (<200 FP) Y(CFP) = 1.2 (NESMA) – 108 (>200 FP)	R2 = 0.99	11
Desharnais & Abran (2006) [16]	Y(CFP) = 1.0 (IFPUG) –3 Y(CFP) = 1.36 (IFPUG-TX) +0 (Transactions only)	R2 = 0.93 R2 = 0.98	14

Table 4.1. Previous conversion studies

| Project ID		#FP Nesma	# ILF	#EIF	# EI	# EO	# EQ		#CFP	# Func. Proc.
1		302	11	6	16	19	9		313	54
2		653	13	1	53	53	20		603	110
3		606	17	0	45	55	8		778	152
4		245	6	6	31	23	3		257	43
5		112	2	9	6	4	0		75	8
6		499	16	3	45	34	1		445	66
7		565	34	0	38	25	1		488	64
8		249	14	3	23	14	1		270	36
9		129	1	12	4	6	4		73	14
10		381	0	30	0	42	0		281	42
11		924	45	2	136	7	5		1144	143
12		1076	45	2	136	7	43		1448	181
13		412	14	1	19	21	11		509	51
14		279	11	4	20	20	1		286	44
15		279	11	4	20	20	1		352	44
16		136	3	0	13	11	2		137	25
17		135	3	2	0	0	0		120	15
18		874	32	0	95	39	13		925	159
19		61	1	4	1	6	0		66	7
20		1622	27	4	124	169	1		1864	223
21		627	23	1	58	25	22		714	113
22		586	31	0	75	30	2		620	118
23		741	34	0	49	51	13		893	113
24		498	21	0	63	39	6		530	104
25		286	12	1	20	23	4		252	35
26		334	6	8	26	27	3		301	34

Table 5.1. Dataset Sogeti analysis 2006
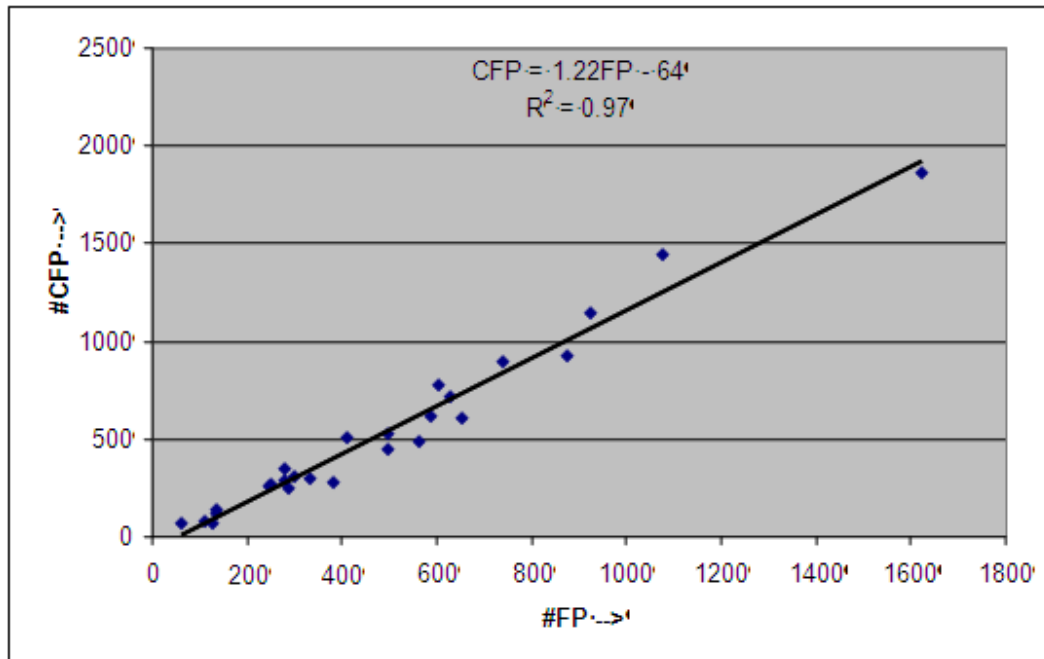
Figure 5.1. Conversion formula FPA – COSMIC

The conversion formula that can be calculated form this dataset is the following:

CFP = 1.22 (NESMA FP) - 64
R^2 = 0.97

This diagram shows almost the same results as the results presented of previous studies. There is quite a high correlation, but the correlation formula deviates from those reported earlier. So, this means that one of the conclusions of Abran [16] that correlation is often very high, but that there are some variations in the conversion formula across organizations, looks valid. However, based on the fact that the dataset consists of projects of numerous different organizations, it can be concluded that a conversion formula with a high correlation coefficient can be found in any dataset with projects measured with both methods, at least as long as the software resides in the business application domain.

Based on the similarities and differences between the two methods, one would expect that there is a relationship between the percentage of the data functions of the total function points and the average number of CFP per functional process. If the percentage of the data functions is low, this implies that there are not many files to be referenced in the system and this would result in a low amount of Reads and Writes in COSMIC. One might suspect that a low ratio data functions/total FP would correspond to a low number of CFP per functional process. Figure 5.2 shows us however that this is not the case.

So, there does not appear to be a relationship between the number of function points derived from the data model and the average number of CFP per function. If this is true, why is the correlation between FP and CFP then this high?
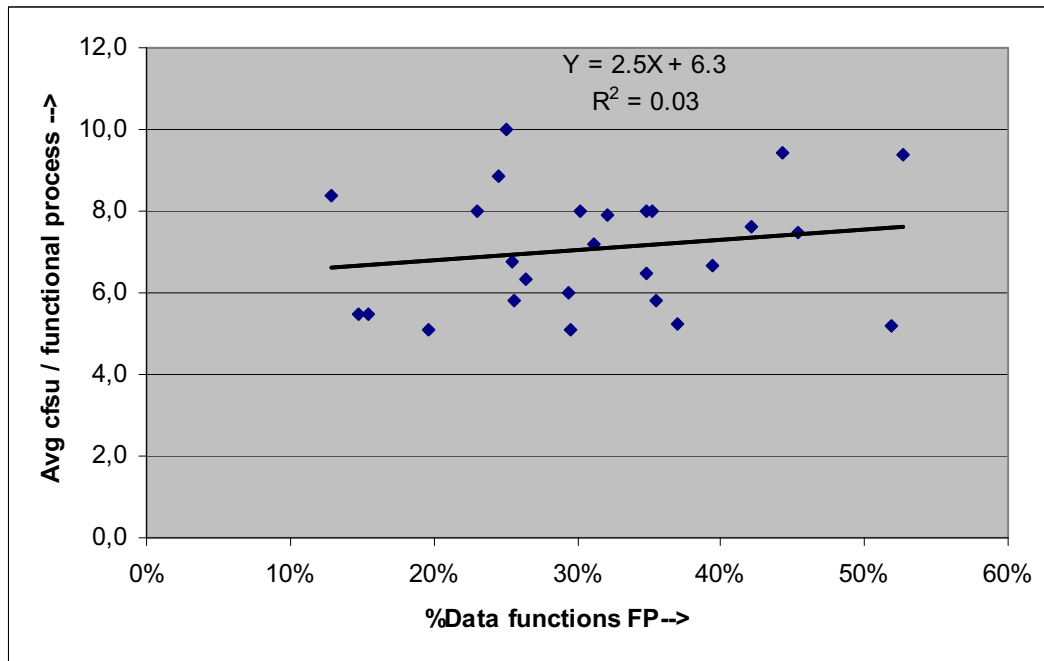
Figure 5.2. Relationship between the number of CFP per functional process and the percentage of function points that the data model delivers

From theory and previous work, we expect the amount of COSMIC functional processes to be equal to the number of FPA elementary user transactions. However, this study shows different results. In a lot of projects we see that the number of COSMIC functional processes is higher than the number of FPA elementary user transactions. The main reason for this is that in IFPUG and NESMA FPA there are particular guidelines for the so-called code tables. Code tables consist most of the times of only two attributes: a code + a description. In IFPUG these tables are not counted at all, and also the associated functionality is discarded. In NESMA, there is only one data function in total for code tables ILF and one data function for code tables EIF and standard one EI, one EO and one EQ for the associated functionality. However in COSMIC there are some other rules to count code tables. Counting a code table is directly dependable on the fact whether it can be marked as an object of

interest to the user. If there is any functionality for the user to maintain the code table, COSMIC regards the table as 'of interest' to the user and the functionality to maintain the code table is counted as regular functionality. Furthermore, data movements containing data elements from these code table objects of interest are counted just like other data movements. For instance, the checking Reads of the code table are counted in other functional processes as well.

This notion means that systems with a relative high number of code tables, and where these code tables are considered an object of interest, are likely to have a higher number of CFP per functional process and a higher amount of functional processes in total. This can be an explanation for outliers where the number of CFP exceeds the expected amount of function points significantly.

6. OUTLIER ANALYSIS

In this paragraph the outliers of the study are analyzed in order to make it possible to learn from them. In this study, outliers are identified that deviate more than 20% of the trend line shown in figure 5.1. Of course, these data points are also responsible for the fact that the trend line is as it is, but this is the only way possible to study this. From the dataset in table 5.1, only projects 7, 9, 10, 16 and 19 are considered to be an outlier.

From this sample, it becomes clear that 2 out of 5 projects are relatively small. When looking at these projects into detail, we see that in general, projects with a fairly small size in function points, are even smaller in COSMIC. This is true for project 9. This is quite logical, because of the fixed points FPA gives for the data functions derived from the logical data model. In project 19, the high number of CFP per functional process makes up for the lack of points from the data model. Within the metrics community it is often said that it makes no sense to apply functional size metrics to small projects (below 150 FP). This is supported by recent research from Vogelezang and Prins [17].

Project 7 deviates from the trend line because of the fact that there are fewer COSMIC functional processes than FPA logical transactions identified, instead of the other way around. The high average number of CFP per functional process does not make up for the lack of data model function points and the difference in the number of functions. When analyzing the detailed FPA and COSMIC analysis, the following reasons come to mind:

- There are a lot of different elementary FPA functions identified for the different processing towards a printer or a file. In COSMIC there is only an extra exit (X) counted for the different lay-out of the output towards the printer or a file.
- There are a lot of combo- or list boxes present that list attribute values of ILF's or EIF's. In NESMA FPA, each of these different combo- or list box is counted as an individual EO (4 function points). In COSMIC the combo- and list boxes are not separately counted, but are part of a bigger function. The fact that a number of values must be read and presented lead to one Read and one Exit data movement. So, each of these combo- and list boxes result in a difference in the total number of functions, and there is only a small correction in the increase of the average CFP per functional process.

Project 16 deviates 34.4% from the trend line, but it does not look very strange. On first sight, the amount of data functions is quite low (only 3 ILF's). There seems to be a fully filled CRUD matrix, resulting in 13 EI's, 11 EO's and 2 EQ's. The number of transactions is almost equal to the number of COSMIC functional processes. The deviation lies in the fact that the average number of CFP per functional process (5.5) is significantly lower than the average (7.1) and only slightly above the average number of FP per function (4.5).

Project 10 is an application in which only EIF's and EO's are present. The average number of FP is 5.5 whereas the average number of CFP is 6.7. Again, the lack of the points for the data model in COSMIC is an important factor, as the difference between the average number of CFP per functional process and the average number of function points per transactional process is not high enough to cover up for this.

In short, the results of this analysis are the following:

- The conversion of small projects (<150 FP) tend to contain a lot of uncertainty. Most of the times the number of function points is significantly higher than the number of CFP due to the influence of the data functions.
- The assumption that the number of FPA transactions is the same to the number of COSMIC functional processes is false. There are a number of detailed counting guidelines in both functional sizing methods that can lead to a difference in the number of functions (in both directions). The trend line indicates that for projects with a reasonable size the functional size measured in COSMIC should be higher than the functional size in FPA. If the number of FPA logical transactions is higher, the average number of CFP must be very high to make up for the lack of data function points plus the difference in transactional processes.
- When an application has a lot of maintainable code tables, the size in CFP is more likely to be higher than the size in FP. Code tables are not counted in IFPUG, while in NESMA FPA only a limited number of function points can be counted for these tables and the associated functionality. In COSMIC, the existence of code tables can lead to a lot of CFP.

7. A TRANSITION FRAMEWORK

The Sogeti conversion formula confirms the previous studies. The correlation between the outcomes of the two methods is strongly related. Where previous studies concentrated on a data set of rather homogeneous projects (carried out in one organization), the Sogeti study shows that this homogeneity to organization is not really an important factor. With a dataset with business applications out of quite different organizations, it is also possible to derive a conversion formula with a high correlation coefficient.

This brings us back to the main question of this paper. How can an organization switch from FPA to COSMIC without loosing their experience data? This transition must be divided into two parts: the conversion of the history metrics database and the conversion of the organization's processes and procedures.

7.1. Converting the metrics database

When converting a metrics database from FPA to COSMIC, a number of activities should be carried out:

1. Identify a data set that you will count in COSMIC

Make sure that there is enough variation in the projects as it comes to size. At least two very large projects (above 1000 FP) should be counted with COSMIC, as these are the projects that have a big impact on the shape of the slope of the conversion formula. It is advisable to exclude the small projects (below 150 FP) from the dataset, as it is proven that small projects will most of the time become an outlier. Also exclude other projects which can be expected to become an outlier, like projects with many code tables or projects with a lot of separate functions to route output to a specific device. Preferably, include a number of recent projects in the data set, because this enlarges the chance that the functional documentation is complete and of sufficient quality. The data set should contain at least 15 projects to be able to derive accurate statistics out of it.

2. Measure the projects in the data set identified with COSMIC.

Make sure that the analysis is done by an experienced COSMIC analyst and that every analysis is reviewed by a peer. It is important that the detailed variant of COSMIC is used and that the end user measurement viewpoint is being applied. If the documentation is not good enough to do so, it would be better to exclude the project from the data set.

3. Create a local statistically based conversion formula

Administrate the results in Excel or in other spreadsheet software and insert a scatter chart type. In excel, it is possible to display the regression formula and the correlation coefficient (R2) in the chart. If the correlation coefficient is high enough (like higher than 0.90), there is a strong correlation between the size measurement in FPA and the size measurement in COSMIC. If the correlation is below 0.90, than the situation deviates from the situations we have seen in the Sogeti study and in the previous studies. Try to explain the fact that the correlation is low. If there are a number of outlier projects that skew the regression line heavily, then exclude these outliers from the data set in order to get a higher correlation.

4. Apply the formula to convert the FPA sizes into COSMIC sizes

When the formula is there, this is the easy part.

5. Analyze the outliers

Analyze the differences between the actual COSMIC analysis and the COSMIC size based on the regression formula. If the difference is greater than 20%, the data point could be considered an outlier. Analyze the reasons for the differences and try to explain these reasons. If there are good reasons for these outliers, than there is no problem. However, when there are no good reasons

for the deviation, it might be that either the FPA or the COSMIC analysis is not good. For instance, a different scope has been analyzed, resulting in a very different size.

6. Recalculate the metrics database

Size is often used as input for derived metrics, such as Project Delivery Rate (PDR: total effort / size) or Quality (total defects / size). These metrics should be recalculated with the new size.

7.2. Conversion of the organization's processes and procedures

Transferring the functional size measurement method from FPA to COSMIC is a project of its own. The required activities depend heavily on the organization. When the metrics database is converted, the organization should be ready to do their functional size measurements from that moment on in COSMIC. This means that a number of activities should have been carried out before. Activities that come to mind (non-limitative) are:

- Revision of all processes and procedures involved, like estimation, project control and internal benchmarking.
- Training of the FPA analysts in COSMIC or outsourcing FSM to a supplier of COSMIC analysis.
- Communicate the transfer to all stakeholders.
- Revise calculation and estimating instruments so that they are fit to use CFP instead of FP.
- Change the tool that is used to administrate the counts (if that tool only suits FPA).

7.3. Investment

The effort that is needed to transfer is very dependable on the number of projects and their size in the data set that has been desig-

nated to be counted in COSMIC. In our experience, the analysis speed of a COSMIC analysis is about 200 CFP per day for a detailed count (for an experienced analyst), which is comparable to productivity rates for detailed FPA counts. This includes documentation intake, administration of the analysis and reporting the analysis. The costs of the COSMIC analysis for the projects in the dataset can be calculated roughly using this metric.

The costs of the incorporation of the COSMIC method in the organization depends a.o. on the organization structure of the organization, the level of maturity, the level of formality, the activities required and the absolute size of the organization.

When converting a metrics database from FPA to COSMIC, a number of activities should be carried out:

8. CONCLUSSIONS & DISCUSSION

The conversion studies mentioned in this paper all report high correlation between measurements in FPA and COSMIC. Although there are some detailed counting guidelines that can lead to deviating results, the larger part of the measurements can be converted quite well using a local based conversion formula.

This study was carried out on a heterogeneous data set with projects from different organizations, while previous studies analyzed a data set with projects coming from one organization. The results are comparable. It is possible to derive a conversion formula with a high correlation coefficient no matter what data set is analyzed, as long as we are comparing FPA measurements with COSMIC measurements in the end user measurement viewpoint. Most studies report a

higher functional size in CFP than in FP and this study acknowledges this.

This means that organizations that are willing to transfer to COSMIC can do so without loosing too much of their history data.

However, one aspect that needs attention in the future is how to deal with 'FPA in enhancement situations'. There are a number of different approaches being used nowadays and most of these approaches use the concept of a baseline analysis. This means that the functionality that is involved in an enhancement project is being sized to form a baseline. After that, the changes in functionality are being measured to see which BFC's are added, which are modified and which are deleted from the baseline. Organizations that use baselines and store these for future use lose the use of these baselines after converting to COSMIC. This is because it is not possible to transfer the details of an FPA baseline analysis to the details of a COSMIC baseline analysis.

Gracias a la vida y al amor que nos han dado tanto en lo que pensar…

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