# Convertibility of Function Points to COSMIC-FFP: Identification and Analysis of Functional Outliers

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**Abstract.** COSMIC-FFP (ISO 19761) represents the second generation of functional size of the software, based on its ease of understanding and use and it is applicable to various kinds of software applications; this new method has achieved rapidly an ISO recognition as an international standard as well as market acceptance in various countries. Several organizations are therefore interested in using convertibility ratios between COSMIC- FFP and first generation of functional size measurement (in particular Function Point Analysis – FPA - ISO 20926), in order to leverage data from their historical databases of software measures. Previous convertibility studies have indicated that convertibility of FPA to COSMIC-FFP can be simple, with a very good correlation for most MIS projects, but that there are some outliers for which convertibility is less straightforward. This study analyzes a new data set of 14 projects measured with both sizing methods, and for which measurement results are available at the detailed level. The analysis reported here identifies reasons why, for some MIS projects, convertibility is not so straightforward. This analysis also provides lead indicators to identify outliers for convertibility purposes.

**Keywords:** ISO 19761, COSMIC-FFP, IFPUG, Convertibility, Functional Size Measurements (FSM), Software Measures.

## 1 Introduction

Since the late ’70s, function points have been used as a measure of software size to calculate project productivity and project estimates. Even though a large number of variants of the Function Point Analysis (FPA) method have been proposed over the years to tackle various weaknesses in the design of the original FPA method, only four have achieved recognition as ISO measurement standards:

- ISO 19761: COSMIC-FFP [ISO 03a].
- ISO 20926: Function Point Analysis (e.g. IFPUG 4.1, unadjusted function points only) [ISO 03b];
- ISO 20968: Mk II [ISO 02]
- ISO 24570: NESMA [ISO 05] (A Dutch interpretation of FPA v. 4.1 which produces similar results [NESM04]).

The FPA, MarkII and NESMA methods were primarily designed to measure business application software. COSMIC-FFP, the newest method, was designed to handle other types of software as well, such as real-time, telecommunications and infrastructure software.

Organizations interested in converting to the newest COSMIC-FFP measurement method have expressed interest in a convertibility ratio that would allow them to leverage their investments in historical data measured with FPA. The goal of this paper is to provide industry with insights into this issue of convertibility between FPA and COSMIC-FFP. All convertibility studies reported here were carried out with duplicate measurements using both COSMIC-FFP and FPA (or the NESMA equivalent) on the same set of functional user requirements (FURs). The specific versions of methods used in each convertibility study are documented for each study.

This paper is organized as follows: an overview of related work is presented in section 2, and the new data set in section 3. The convertibility formulae based on the total FPA size and FPA transactions size are presented in section 4. Outliers are identified and discussed in section 5 and a summary in section 6.

## 2 Related work

The following preconditions exist in all studies reported here:

- All functionalities inside the boundary of the software being measured are included in the measurement.
- Measurements have been taken from the human end-user's viewpoint.
- FPA is considered not to include the value adjustment factor (VAF), in conformity with ISO 14143-1 [ISO98] and ISO 20926, that is, unadjusted function points (UFP).

Data from both the Fetcke 1999 study and the Vogelezang and Letherthuis 2004 study were included in the discussion on convertibility in the COSMIC Implementation Guide to ISO 19761 [ABRA03, chapter 8]. They are discussed here as individual data sets.

**Fetcke 1999**

In the Fetcke 1999 study [FETC99], four software applications of a data storage system were measured. These are business applications with few data entities.

The linear regression model of Fetcke's data provides the following convertibility formula, where 'Cfsu' represents COSMIC-FFP functional size units and 'UFP' represents unadjusted function points, with a very high coefficient of determination ($R^2$) of 0.97:

$$\mathbf{Y(Cfsu) = 1.1 * (UFP) - 7.6} \qquad \mathbf{(1)}$$

Of course, because the number of data points is small (that is, only four in the data set), care must be exercised in the extrapolation of these results to larger data sets, and to data sets from different contexts. In summary, the duplicate measurement of software containing few data files and from the human end-user's viewpoint gave very similar results, and a convertibility formula with a slope fairly close to 1.

**Vogelezang & Lesterhuis 2003**

In the Vogelezang & Lesterhuis 2003 study [VOGE03, VOGE04], the COSMIC-FFP measurements were carried out on 11 projects already measured with the NESMA FPA (ISO 24570).

The linear regression model of this data set provides the following convertibility formula, with a coefficient of determination ($R^2$) of 0.99:

**Y(Cfsu) = 1.2 * (UFP) - 87 (2)**

Vogelezang and Lesterhuis postulate that the constant 87 probably owes its existence to the counting of the logical files of data (ILFs and EIFs) in FPA [VOGE04], which are not directly included in COSMIC-FFP; this interpretation suggests that the high value of 87 might not be due entirely to the error term alone in this model.

With this specific data set, the two largest projects have significant influence on the regression model: it can therefore be observed that the conversion formula does not work well for small projects, those with fewer than 200 NESMA points, even providing negative numbers, which is not possible in practice. This means that, for small projects in this environment, distinct regression models should be built using only data within a relatively similar range. For instance, this data set was split into two ranges: fewer that 200 UFP and over 200 UFP. The linear regression model of the subset of data with fewer than 200 NESMA points provides the following convertibility formula, with a coefficient of determination ($R^2$) of 0.85 [ABRA05]:

**Y(Cfsu) = 0.75 * (UFP) - 2.6 (3)**

The convertibility formula from equation (3) with a slope of 0.75 and a much smaller error term of -2.6 is more relevant for representing small projects in this data set, and leads to a much smaller convertibility delta, both in absolute and in relative terms.

Next, the linear regression model of the data subset for projects larger than 200 NESMA points provides the following convertibility formula, with a coefficient of determination ($R^2$) of 0.99 [ABRA05]:

**Y(Cfsu) = 1.2 * (UFP) - 108 (4)**

The models for the full data set and for the data set of projects over 200 NESMA points are fairly similar in terms of both their slope and their error terms. There is still, however, a large difference in convertibility results for project 8, at 260 NESMA points, both in absolute and in relative terms. This means that there must be some peculiarities in the way functionality is measured that leads to non straightforward convertibility in some instances.

**Desharnais 2005 data set**

The duplicate measurement results reported in [ABRA05] were collected in 2005 using FPA 4.1 and COSMIC-FP 2.2. This data set comes from a single governmental organization and was measured using the documentation of completed projects.

The linear regression model of the Desharnais 2005 data provides the following convertibility formula, with a coefficient of determination ($R^2$) of 0.91:

$$Y(Cfsu) = 0.84 * (UFP) + 18 \qquad (5)$$

Again, a large difference in convertibility results for one project was noted, both in absolute and in relative terms. This means, again, that there must be some peculiarities in the way functionality is measured that leads to non straightforward convertibility for this project.

In the FPA measurement method, the data are taken into account from multiple perspectives, once as logical data files (ILF – Internal Logical Files, and EIF – External Interface Files) and once again whenever there are references in FPA transactions (Input, Output, Enquiries transaction types). This has already been noted in [VOGE03a], where it is reported that, in FPA-like methods, 30 to 40% of functional size comes from the data files. By taking into account only the FPA data file points from the FPA transaction-type points, it was investigated next whether or not a better convertibility ratio could be derived by excluding the FPA data files, that is, by taking into account only the size from the transactions (UFP-TX).

With the FPA points for the transactions only and the linear regression model of the data in Figure 7, which provides the following convertibility formula with a coefficient of determination ($R^2$) of 0.98, we have:

$$Y(Cfsu) = 1.35 * (UFP\text{-}TX) + 5.5 \qquad (6)$$

Thus, there is a slight improvement in the ($R^2$) for the convertibility formula when using only the results of the transactions for FPA, instead of the total size derived from both data and transactions; again, with such a small data set, this should be taken as indicative only, and should be investigated with larger data sets.

## 3 Desharnais 2006 data sets

### 3.1 Context

In 2006, another set of 14 MIS projects was measured using Function Point Analysis (IFPUG version 4.1) and COSMIC-FFP 2.2. The FPA and COSMIC-FFP measurements were taken concurrently using of the same documentation by a single expert in both measurement methods. All 14 projects come from a single governmental organization (different from the one reported in the Desharnais 2005 study). As for the data sets reported in the literature review, the measurements were taken from the user's viewpoint, that is, taking into account that most of the functionalities of the software involve interaction with a human, which is typical of business software applications.

This data set is presented in Table 1. While the data are available at the function-type level for FPA and at the data movement level for COSMIC-FFP, only the totals at the function-type levels are presented in Table 1.

| ID. | FPA size (in Function Points – FP) | | | | | | COSMIC-FFP size (in Cfsu) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Input** | **Output** | **Inquiries** | **ILF and EIF** | **Total FP** | | **Entry** | **Exit** | **Read** | **Write** | **Total Cfsu** |
| 1 | 31 | 145 | 95 | 112 | 383 | | 63 | 155 | 120 | 26 | 364 |
| 2 | 98 | 162 | 168 | 217 | 647 | | 96 | 233 | 91 | 45 | 565 |
| 3 | 104 | 127 | 71 | 98 | 400 | | 59 | 125 | 146 | 68 | 398 |
| 4 | 64 | 55 | 25 | 61 | 205 | | 39 | 66 | 55 | 28 | 188 |
| 5 | 94 | 135 | 66 | 77 | 372 | | 52 | 158 | 173 | 65 | 448 |
| 6 | 22 | 29 | 22 | 53 | 126 | | 20 | 37 | 24 | 7 | 88 |
| 7 | 24 | 21 | 10 | 56 | 111 | | 11 | 41 | 47 | 16 | 115 |
| 8 | 94 | 51 | 72 | 70 | 287 | | 45 | 103 | 104 | 46 | 298 |
| 9 | 202 | 54 | 148 | 96 | 500 | | 78 | 110 | 198 | 193 | 579 |
| 10 | 83 | 128 | 28 | 105 | 344 | | 54 | 114 | 92 | 31 | 291 |
| 11 | 55 | 88 | 69 | 105 | 317 | | 49 | 119 | 98 | 28 | 294 |
| 12 | 103 | 49 | 57 | 49 | 258 | | 50 | 86 | 78 | 38 | 252 |
| 13 | 42 | 35 | 10 | 26 | 113 | | 19 | 23 | 39 | 33 | 114 |
| 14 | 157 | 115 | 70 | 105 | 447 | | 67 | 149 | 167 | 84 | 467 |

**Table 1: Total functional size at the function-type level**

### 3.2 Distribution of functional size at the transactional and data movement levels

Analysis of the distribution of the transactions in FPA and the distribution of data movements in COSMIC-FFP is one way to identify discrepancies in the measurement results. Figure 1 presents the distribution of function-type sizes for the FPA measurement results: the total sizes of FPA Input and Output function types have the same percentage of 36%, while the Inquiry function type is lower at 28% (Figure 1). The distribution of function-type size for this set of 14 projects is reasonably comparable to the distribution of function types of the 3,161 IFPUG projects in the February 2006 edition of the International Software Benchmarking Standards Group – ISBSG – repository (Figure 2). Figure 3 presents the distribution of data movement types in COSMIC-FFP units for this data set of 14 projects: the eXits have the greatest ratio at 43%, and the Writes the lowest at 7%.

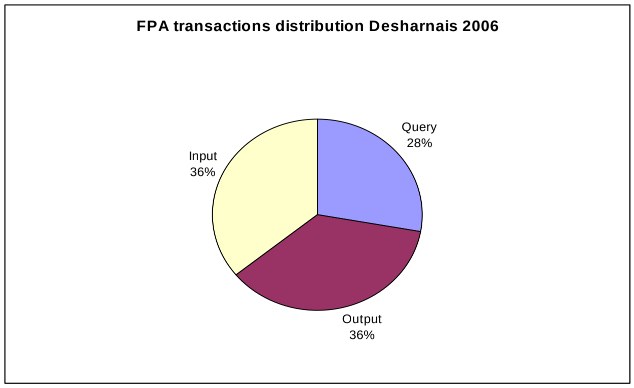

Figure 1: FPA transaction size distribution (N= 14)

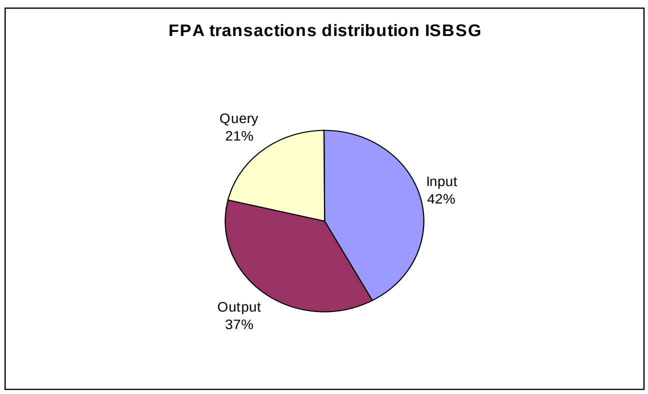

Figure 2: ISBSG transaction size distribution (N=3,161)

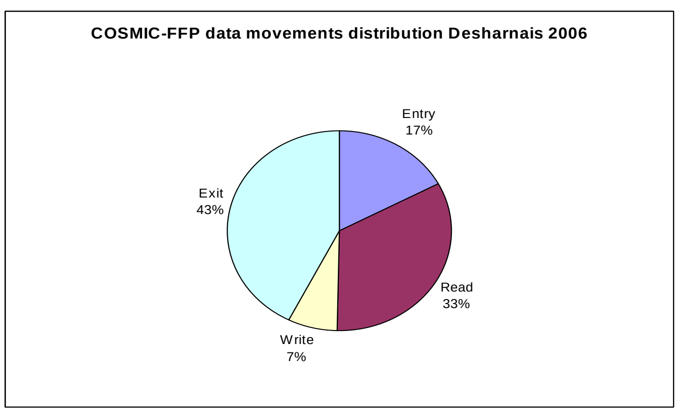

Figure 3: COSMIC-FFP data movement distribution (14 projects)

### 3.3 Quality of the documentation

It is important to stress that the quality of the measurement results depends on the competence of the measurer, but this is not the only major factor impacting their quality. Also important is the quality of the documentation, which is the key input to the measurement process, since it has a significant impact on the measurement results, in terms of the proper number of functions identified and the assignment of the correct size to each of these functions.

For the measurement results reported here, the measurement process was performed on software projects which had been completed and were currently in use in the organization. While on the one hand there was no uncertainty in terms of whether or not there were unspecified requirements – a situation typical when measuring early in the development life cycle, on the other hand, the documentation of projects implemented cannot be assumed to be perfect, documentation often being neglected in projects, which in turn leaves software maintainers with poor documentation to work with.

While the functional size of the 14 software applications implemented was measured from the maintenance documentation, the quality of the documentation was classified using the following criteria:

A: Full documentation – that is, all the required detailed information was available for the measurement process;

B: Documentation, but with an incomplete data model;

C: All functions identified;

D: Only the number of functions identified, but without enough detail for accurate measurement;

E: Implicit documentation of a function.

Using the above criteria, the following observations were made:

- For 12 projects, the documentation was of good quality (= A or B) for over 95% of their functional processes.
- For projects 3 and 9, the documentation was of good quality for only 62% and 71% of their functional processes respectively.

On a weighted average, the project documentation was considered to be of good quality for more than 90% of the functions measured.

For the projects with documentation of less than good quality, assumptions had to be made for the measurement of the functions not documented well enough for precise measurement; however, since the same assumptions were made for the concurrent duplicate measurement with both methods, this could not be a source of significant distortions for convertibility purposes in this specific case study reported here r.

# 4 Identification and analysis of outliers

**4.1 Convertibility analysis using total FPA size**

The first convertibility analysis investigates the FPA to COSMIC-FFP relationship based only on total FPA size, that is, on the summation of all FPA size units, without looking into the details of the measurement. The measurement results of the duplicate measurement of the 14 applications are reported in Table 2 and are presented graphically in Figure 4, with the FPA data on the x-axis and the COSMIC data on the y-axis.

The linear regression model of the data in Figure 4 provides the following convertibility formula, with a coefficient of determination ($R^2$) of 0.93:

$$Y(Cfsu) = 1.0^* (UFP) - 3 \quad (7)$$

This convertibility formula represents an almost 1 to 1 convertibility ratio. This does not mean, however, that this produces entirely accurate results, as can be seen in column (4) of Table 2 (e.g. the difference between the convertibility results and the direct measurements in COSMIC-FFP). Column (5) presents the same difference as a percentage: it can be observed that for 9 projects out of 14 the relative difference is less than 10%, for 4 projects it is between 10 and 20% and for one project it is 39%. The weighted average of the absolute difference (from column (4)) for all projects is (absolute (difference) / total COSMIC size) = 428 Cfsu / 4,461 Cfsu = 9.5%.

| Project number | FPA Total points | COSMIC 2.2 (2) | With convertibility formula '(3) | % diff (4) = (3) – (2) | (5) = (4)/(2) |
|---|---|---|---|---|---|
| 1 | 383 | 364 | 379 | 15 | 4% |
| 2 | 647 | 565 | 643 | 78 | 14% |
| 3 | 400 | 398 | 396 | -2 | 0% |
| 4 | 205 | 188 | 202 | 14 | 7% |
| 5 | 372 | 448 | 368 | -80 | -18% |
| 6 | 126 | 88 | 123 | 35 | 39% |
| 7 | 111 | 115 | 108 | -7 | -6% |
| 8 | 287 | 298 | 284 | -14 | -5% |
| 9 | 500 | 579 | 496 | -83 | -14% |
| 10 | 344 | 291 | 340 | 49 | 17% |
| 11 | 317 | 294 | 314 | 20 | 7% |
| 12 | 258 | 252 | 255 | 3 | 1% |
| 13 | 113 | 114 | 110 | -4 | -4% |
| 14 | 447 | 467 | 443 | -24 | -5% |

Table 2 Convertibility comparison on Total FPA Size (N= 14)

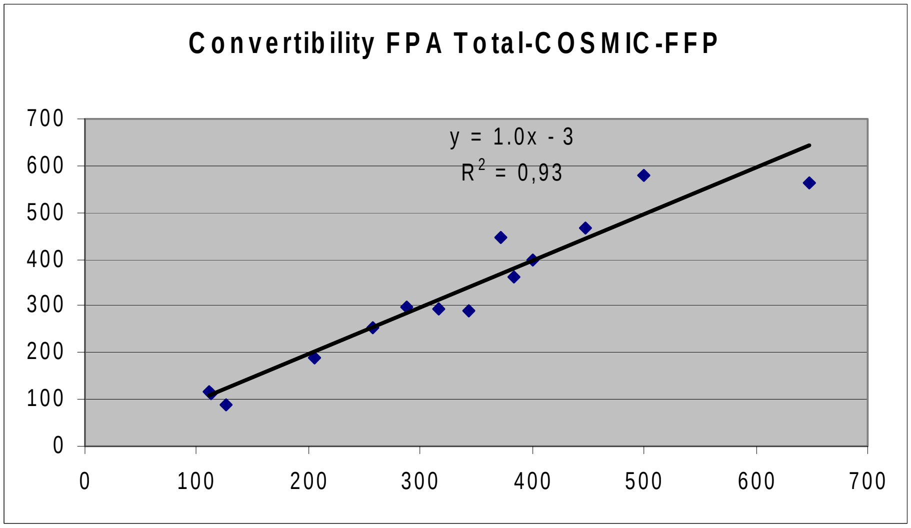

Figure 4: Convertibility model on Total FPA Size (N=14)

### 4.2 Convertibility analysis based on the FPA transactions sizes

The next convertibility analysis is based on the sizes of the three FPA transaction types (Input, Output, Inquiries) – that is, excluding the sizes from the Internal and External logical files of the IFPUG method.

The measurement results of the duplicate measurement of the 14 applications are reported in Table 3 and presented graphically in Figure 5, with the FPA transaction sizes on the x-axis and the COSMIC data on the y-axis.

The linear regression model of the data in Figure 5 provides the following convertibility formula, with a coefficient of determination ($R^2$) of 0.98:

$$Y(Cfsu) = 1.36^* (UFP\text{-}TX) + 0 \qquad (8)$$

This convertibility formula is, of course, different from (7), since it is derived from a distinct basis (FPA transaction size rather than total FPA size) and its $R^2$ (0.98) is slightly better than the previous one (0.93). Again, this does not mean that entirely accurate results are produced for all projects converted, as can be seen in column (4) of Table 3, which represents the difference between the results of the convertibility and direct measurements in COSMIC-FFP. In column (5), the same difference is presented as a percentage. Some significant improvements can be observed:

- 9 projects out of 14 have a very small relative difference of less than 5%;
- 4 projects have a relative difference of between 10% and 15%; and
- 1 project has a relative difference of 35%.

The weighted average of the absolute difference for all projects is (absolute (difference) / total COSMIC size) = 259 Cfsu / 4,461 Cfsu = 5.8%; this is a major improvement when compared to the 9.5% difference with convertibility based on total FPA size..

| Project number | FPA TX points | COSMIC 2.2 (2) | With convertibility formula '(3) | % diff (4) = (3) – (2) | (5) = (4)/(2) |
|---|---|---|---|---|---|
| 1 | 271 | 364 | 369 | 5 | 1% |
| 2 | 430 | 565 | 585 | 20 | 4% |
| 3 | 302 | 398 | 411 | 13 | 3% |
| 4 | 144 | 188 | 196 | 8 | 4% |
| 5 | 295 | 448 | 401 | -47 | -10% |
| 6 | 73 | 88 | 99 | 11 | 13% |
| 7 | 55 | 115 | 75 | -40 | -35% |
| 8 | 217 | 298 | 295 | -3 | -1% |
| 9 | 404 | 579 | 549 | -30 | -5% |
| 10 | 239 | 291 | 325 | 34 | 12% |
| 11 | 212 | 294 | 288 | -6 | -2% |
| 12 | 209 | 248 | 284 | 36 | 15% |
| 13 | 87 | 114 | 118 | 4 | 4% |
| 14 | 342 | 467 | 465 | -2 | 0% |

**Table 3 : Convertibility comparison on FPA transaction size only (N=14)**

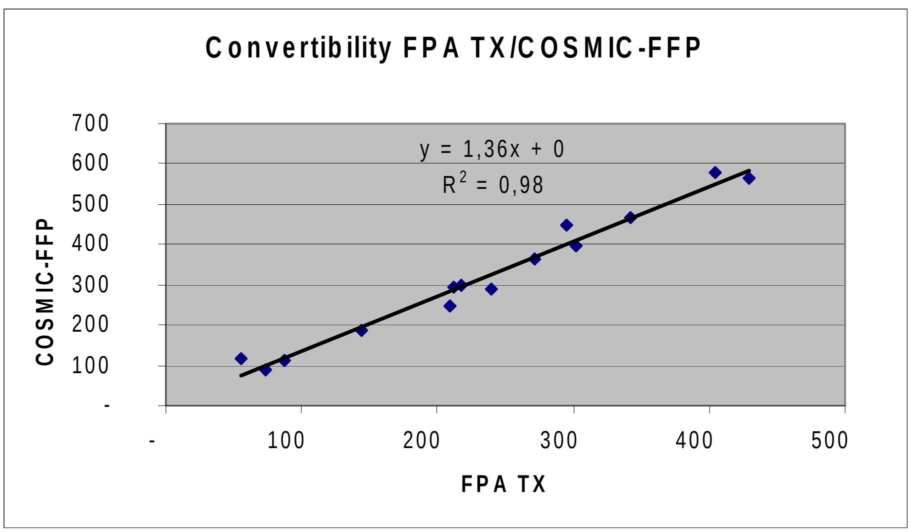


**Figure 5: Convertibility model on FPA transaction size only (N=14)**

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# 5 Discussion

### 5.1 Analysis at the FPA transaction level

While measuring the 14 MIS projects in 2006, it was observed, in the context of the documentation available for measuring these projects, that the concept of functional process in COSMIC-FFP is, in practice, equivalent to the concept of functional transaction type in FPA. When identifying a COSMIC-FFP functional process in the documentation of a project, it was observed that there is an equivalent FPA elementary process.

While the mapping of the total size at the total level is reasonably direct from FPA to COSMIC-FFP for this sample, there are differences at the lower levels (sub-totals at the function-type level and individual measurement results at the functional process level).

As noted in previous studies [VOGE03a] and [ABRA05], there is a difference in measuring the size of the COSMIC-FFP functional processes when compared to FPA transactions: the COSMIC-FFP functional process is based on the number of data movements in a functional process, while the FPA transactions (Input, Output and Inquiries) are based on the number of Data Element Types (DET), File Type References (FTR) and on sets of weights (from 3 to 7) provided in different FPA weight tables. In FPA, the sizes of the files (ILF and EIF) are added to the sizes of the transactions (input, output, query) to obtain the FPA total size in UFP; in FPA, this is equivalent to adding together distinct entity types (eg. adding the sizes of Tables to the sizes of TV sets) leading to totals without a clear interpretation of the summation results and, thereby, leaving end results difficult to interpret from a size viewpoint. In COSMIC-FFP, there is no such equivalent of adding something of a different nature: only data movement types – Entry, Exit, Read and Write – are added together; it is therefore expected that convertibility at the transaction level be more meaningful.

In addition, when analyzing the results for each functional process and each transaction, it was observed that the COSMIC-FFP sizes of all the functional processes are, in this data set, systematically equal to or higher than the FPA size of corresponding transactions. There are at least two explanations for this:

- The weights in the FPA table for the transactions are limited to 7 points, while there is no such upper limit in the number of data movements in a COSMIC functional process.
- The measurement of the error messages: on the one hand, Function Point Analysis version 4.1 rules includes error messages as a part of the transaction without assigning it additional points, while, on the other hand, COSMIC-FFP recognizes an error message as one additional data movement in a functional process. The result is that a simple functional process has one more COSMIC-FFP size unit (e.g. the data movement that takes into account the error message in the measurement process).

**5.2 Analysis of variations at the FPA data level and identification of functional outliers**

In the previous section, it was seen that, for this data set, the COSMIC-FFP size of an FPA transaction was systematically larger, while the FPA data size was not taken into account.

The ratio of FPA Data size to FPA Transaction size was analyzed next. In actual measurements with FPA, the ratio of files to transactions is not constant and can vary across projects. The potential impact of this is analyzed next: Table 4 presents the ratio of FPA size allocated to the data files, referred to as Data points in Table 4. In this data set, the average ratio of FPA data file size over the PFA total size is 27% (bottom line – Table 4); this ratio varies from a low of 19% to a maximum of 50%.

For this analysis, the four projects further away from the average on functional distribution (identified in bold in table 4) are investigated, that is, the 2 projects with the lowest ratio (of 19%) of data file points (projects 9 and 12) and the 2 with the highest ratios of 42% and 50% (projects 6 and 7). For these 4 projects, we look at the relative error of convertibility based on FPA transaction size in Table 3:

- Projects within the lower ratios: project 9 has a relative convertibility error of -5% (Table 3), while project 12 has a convertibility error of 15%.;
- Projects within the highest ratios: project 6 has a relative convertibility error of 13%, while project 7 has by far the highest convertibility error, at 35%.

| **Project number** | Total FPA size | Data size | Data / Total FPA |
|---|---|---|---|
| 1 | 383 | 112 | 29% |
| 2 | 646 | 217 | 34% |
| 3 | 400 | 98 | 25% |
| 4 | 205 | 61 | 30% |
| 5 | 372 | 77 | 21% |
| **6** | **126** | **53** | **42%** |
| **7** | **111** | **56** | **50%** |
| 8 | 287 | 70 | 24% |
| **9** | **500** | **96** | **19%** |
| 10 | 344 | 105 | 31% |
| 11 | 317 | 105 | 33% |
| **12** | **258** | **49** | **19%** |
| 13 | 113 | 26 | 23% |
| 14 | 447 | 105 | 23% |
| All | 4 509 | 1 230 | 27% |

**Table 4 : Ratio of FPA data file size over FPA total size (N=14 projects)**

While outliers on one characteristic can help identify candidates for explaining variances on another characteristic, this does not necessarily constitute a cause-and-effect relationship. Outliers are, however, good candidates for identifying hypotheses for further research. In particular, project 7, with both the largest variation of data sizes from the average and the largest relative convertibility delta (e.g. 35% – Table 3) needs to be investigated at a detailed level. Similarly, projects 6, 7 and 9 should be looked into at the detailed level.

From Table 2, one project (6) shows a 39% convertibility error when comparing the total FPA points (126) and converted COSMIC-FFP points (88), while two others projects of similar size (project 7 with 111 FPA and project 13 with 113 FPA) have only a 6% and -4% difference with the convertibility formula (7). In terms of the ratio of FPA data file size to transaction size, this project (6), has its FPA data file size representing 42% of the total (Table 4), a long way from the average of 27%. This, then, contrasts with project 7, with a 50% data file ratio (table 4) and only a -6% convertibility error (table 2) on total FPA size; by contrast, this variation for project 7 is -35% (table 3) when convertibility is derived from FPA transaction size. Such variation from average functional profiles and from basis of convertibility (total FPA size or FPA transaction size) can provide clues for identification of convertibility outliers, but does no provide a full rationale (that is, it does not lead necessarily to a cause-effect relationship for convertibility purposes).

To provide an explanation for this, we need to look at project 6 in Table 1 to see that the number of eXits and Reads are relatively high, and this increases the number of points. When looking more closely (eg. at the detailed duplicate measurements results of each functional process)  of project 6, we observed that out of its 11 functional processes, 4 have a high number of Reads (8 data movements) while 1 functional process has a high number of Writes (8 data movements). This means that in COSMIC-FFP the number of data movements is higher, since a higher number of files (e.g. data groups) are handled by both Reads and Writes. This is not so in the case for project 7 which does not have a higher number of FPA functional processes over the FPA limits set by its weights tables, but still has the lowest ratio of FPA transaction size (50%) with respect to total FPA size.

For these 14 projects, 688 functional processes are identified, and we did a survey of the number of data movements for each functional process: 17 (2%) functional processes have more than 4 data movements for a Read, 30 (4%) data movements for a Write, 525 (76%) have 1 or 2 data movements for a Read and 439 (64%) functional processes have 1 or 2 data movements for a Write. Project 6 is atypical because 4 of its 11 functional processes have more than 4 data movements (36%). FPA, with its table upper limit of 6 or 7 points, cannot correspondingly provide larger size for those larger functional processes.

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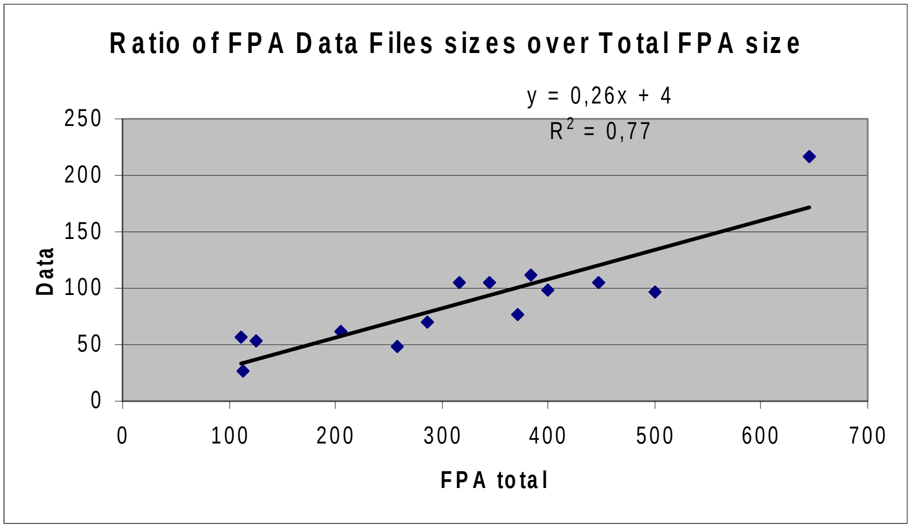


## 6 Summary

This 2006 study is a replication, but with a larger data set (14 projects from a single organization), of the 2005 study (6 projects from a single, but different organization), and the findings were similar at the total FPA size and FPA transaction size. They were also comparable to the findings of previous studies: the convertibility formula is within the same range and work for most of the software measured with both methods: however, there are a few projects for which the convertibility formula provides poor results.

In summary, this analysis together with the findings highlighted in the literature review, indicates that a relatively reasonable convertibility formula can be obtained for each MIS data set, but that there are some variations in the convertibility formulae across organizations. These variations could be caused by extraneous factors, such as non homogeneity in the distribution of FPA function types (ratio of data files to transactions sizes) and the documentation types (varying across development methodologies) or variation in the quality of such documentation, across the organizations where the measurements were derived.

These analyses also provided an indication that convertibility can be straightforward either based on total FPA size or FPA transaction size for the majority of the projects in a data set, even though there are larger variations for a few projects. These analyses also indicated that for this data set the convertibility error is smaller (e.g. weighted average difference of 5.8%) when the basis for convertibility is based on FPA transaction size only. This means that convertibility of a full portfolio of software applications could be reasonably accurate overall, but that a few individual projects would show some larger variation from the values predicted by the convertibility formulae. This study has also identified some candidate lead indicators to explain these greater variations, such as a large dispersion of FPA file ratio from the sample average, as well as the ratio of FPA processes the size of which is constrained by the upper limits in the FPA tables of points.

This study did not investigate more complex contexts, such as those having projects with more algorithmic-rich processes and/or when there are software users other than software or engineered devices, such as in the case of real-time software. Under these latter conditions, of course, backward convertibility (from COSMIC-FFP to FPA) is not of much interest, nor is it an issue, since functionality related to non-human users (such as interactions with sensors or controllers in embedded software, or in multi-layered software) is not usually taken into account and not measured in first generation measurement methods.

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