Software Metrics & Software Metrology

Alain Abran

Chapter 13
Convertibility Across Measurement Methods

Part 4 of this book

- Part 4 of this book looks into 2 key issues from metrology that are often neglected in most ‘software metrics:

- Convertibility across distinct ‘metrics’ which claim to measure the same attribute
- A standard-étalon for a measure:
  - It does not exist yet for the measurement of software because nobody has really look into it!

- Chapter 13 presents the status on the convertibility studies for the COSMIC measurement method & classical Function Points
- Chapter 14 presents the initial draft for a methodology to establish a standard-étalon for the COSMIC measurement method

Agenda

This chapter covers:

- The convertibility in measurement
- Overview of previous convertibility studies for COSMIC.
- A convertibility study of an industrial dataset.
- Function Points to COSMIC convertibility: related issues and discussion.

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The convertibility in measurement

- Sometimes in the field of software measurement, a large number of ‘metrics’ are proposed for the same attribute, such as software complexity, cohesion, and coupling, as well as the various characteristics of software quality, such as maintainability, reliability, etc.

- This leaves practitioners with a number of alternatives, but without much information about how to compare the results obtained from such alternatives.
  - Even in the 3 technical reports of ISO 9126, often different ‘metrics’ are proposed to measure the same quality characteristics or sub characteristics, without any documentation as to convertibility across those measures.
    - This is a bit like measuring temperature using different units of measurement, but without knowing how to convert from one system of measurement to another.

The convertibility in measurement

- There is one software measurement domain where convertibility across methods has long been a concern, that is, functional size measurement.
- This chapter presents, for illustrative purposes, work done on convertibility in the functional size measurement community.
  - Several organizations are interested in using ratios of convertibility ratios between the COSMIC measurement method and 1st-generation functional size measurement (in particular, the traditional Function Points method), in order to leverage data from their historical databases of software measures.
  - Previous convertibility studies have indicated that the convertibility of Function Points (FP) to COSMIC can be simple, with a very good correlation for most MIS projects, but that there are some outliers for which convertibility is less straightforward.

The convertibility in measurement

- This chapter provides further insights into this issue of convertibility between traditional FP and COSMIC.
  - It analyzes a dataset of 14 projects measured with both sizing methods, and for which measurement results are available at the detailed level.
  - The analysis reported in this chapter identifies reasons why, for some MIS projects, convertibility is not so straightforward.
  - It also provides lead indicators to identify outliers for convertibility purposes.

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- The convertibility in measurement
- **Overview of previous convertibility studies for COSMIC**.
- A convertibility study of an industrial dataset.
- Function Points to COSMIC convertibility: related issues and discussion.

Overview of previous convertibility studies

The following preconditions exist in all studies reported in this chapter:

- 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.
- All convertibility studies reported here were carried out with duplicate measurements using both COSMIC and FP (or the NESMA equivalent) on the same set of functional user requirements.
- The specific versions of methods used in each convertibility study are documented for each study.
- The FP result is considered not to include the value adjustment factor (VAF):
  - which means that the result, in conformity with ISO 14143-1 and ISO 20926, is unadjusted function points (UFP).

Overview of previous convertibility studies

Fetcke [1999]

- In the Fetcke study, 4 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 CFP represents COSMIC functional size units and UFP represents unadjusted function points, with a very high coefficient of determination (R^2) of 0.97:

Y(CFP) = 1.1 * (UFP) – 7.6 (1)

- Of course, because the number of data points is small (only 4 in this dataset), care must be exercised in extrapolating the results:
  - to larger datasets, and to
  - datasets from different contexts.
- To summarize: in this study, the duplicate measurement of software containing few data files & from the human end-user's viewpoint gave fairly similar results, and a convertibility formula with a slope fairly close to 1.

Overview of previous convertibility studies

Vogelezang [2003,2004]

- In the Vogelezang study, the COSMIC measurements were carried out on 11 projects already measured with the NESMA FP method [ISO 24570].
- The linear regression model of this dataset provides the following convertibility formula, with a coefficient of determination (R^2) of 0.99:

Y(CFP) = 1.2 * (UFP) – 87 (2)

- Vogelezang postulates that the figure 87, the constant in equation (2), probably owes its existence to the counting of the logical files of data (ILFs and EIFs) in FP [Vogelezand 2004] that are not directly included in COSMIC.
  - This interpretation suggests that the high value of 87 might not be due entirely to the error term in this model.

Overview of previous convertibility studies

Desharnais 2005 dataset

- The duplicate measurement results reported in [Abran 2005c] were collected in 2005 using FPA version 4.1 and COSMIC version 2.2.
  - Dataset = 6 projects 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:

$$\mathbf{Y(CFP) = 0.84 * (UFP) + 18} \qquad \mathbf{(3)}$$

  - A large difference in convertibility results for 1 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 lead to non straightforward convertibility for this project

Overview of previous convertibility studies

- In FP, the data are taken into account from multiple perspectives:
  - once as logical data files (ILF – Internal Logical Files, and EIF – External Interface Files) and
  - again whenever there are references in FP transactions (the transaction types Input, Output, and Enquiries).
    - This has already been noted in [Vogelezand 2003], where it is reported that, in FP-like methods, 30 to 40% of functional size comes from the data files.

- By taking into account only the FP data file points from the FP transaction-type points, it was investigated next whether or not a better convertibility ratio could be derived by excluding the FP data files, that is, by taking into account only the size from the transactions (UFP-TX).

Overview of previous convertibility studies

- With the FP for the transactions only (TX), the linear regression model provides the following convertibility formula with a coefficient of determination (R^2) of 0.98:

$$\mathbf{Y(CFP) = 1.35 * (UFP\text{-}TX) + 5.5} \qquad \mathbf{(4)}$$

  - Thus, there is a slight improvement in the (R2) for the convertibility formula when using only the results of the transactions for UFP, instead of the total size derived from both data and transactions.

  - Again, with such a small dataset, this result should be taken as indicative only, and be investigated with larger datasets.

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- **A convertibility study of an industrial dataset**.
- Function Points to COSMIC convertibility: related issues and discussion.

A convertibility study of an industry dataset

Context

In 2006, another set of 14 MIS projects was measured using UFP version 4.1 and COSMIC version 2.2 [Desharnais 2006].

- The UFP and COSMIC measurements were taken concurrently, using 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).

A convertibility study of an industry dataset

- **Distribution of functional size at the transactional and data movement levels**
  - Analysis of the distribution of the transactions in FP and the distribution of data movements in COSMIC is one way to identify discrepancies in the measurement results.
  - The Figure presents the distribution of function-type sizes for the UFP measurement results:
    - the total size (expressed as a percent) of the Input and Output function types is the same, at 36%,
    - while the total size of the Inquiry function type is lower, at 28% (See Figure).

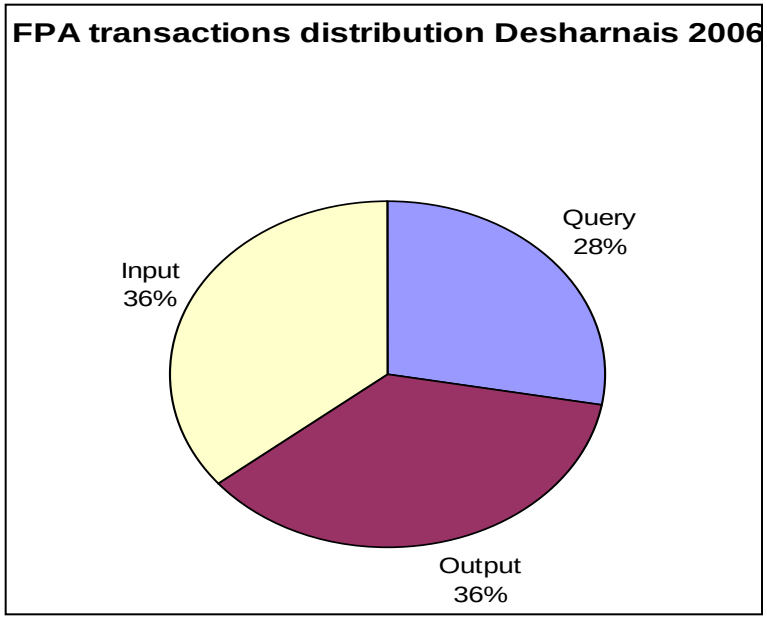


Figure : FP transaction size distribution (N= 14) [Desharnais 2006]

A convertibility study of an industry dataset

- The distribution of the function-type size for this set of 14 projects is reasonably comparable to the distribution of function types of the 3,161 UFP (IFPUG version) projects in the February 2006 edition of the International Software Benchmarking Standards Group – ISBSG – repository (Figure below).

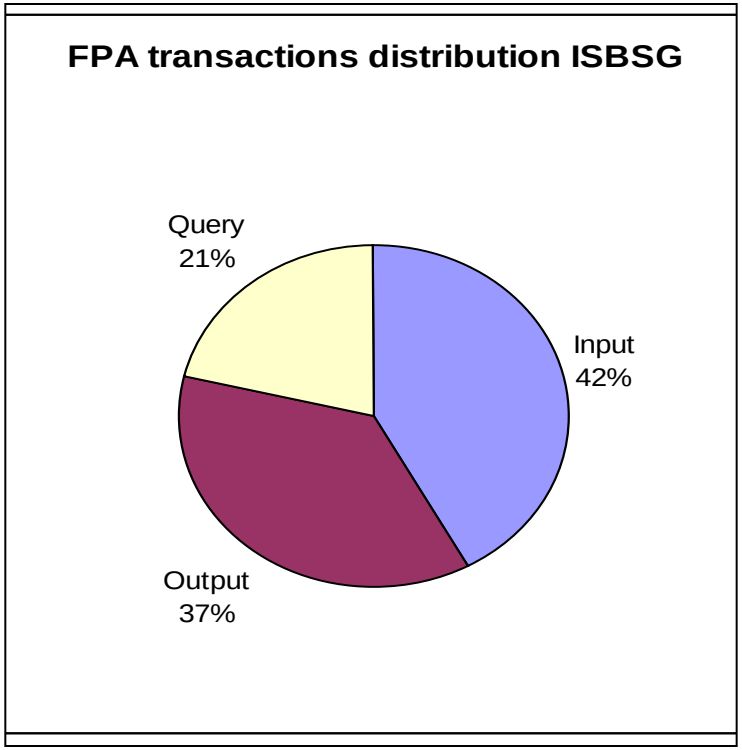


Figure : **ISBSG 2006** FP transaction size distribution (N=3,161)

A convertibility study of an industry dataset

Convertibility using total UFP size

- The first convertibility analysis investigates the relationship of UFP to COSMIC based only on total UFP, that is:
  - only on the summation of all the UFP, without looking into the details of the measurement results.

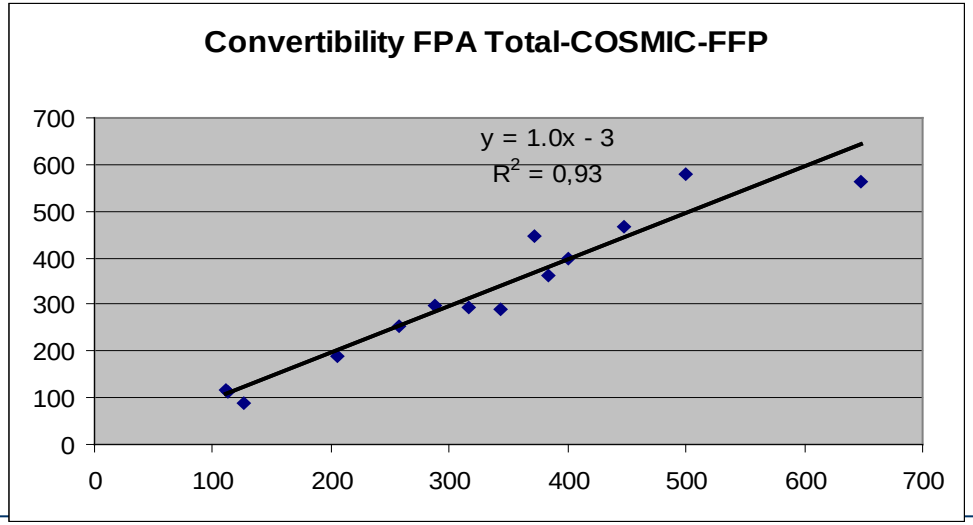
- The measurement results of the duplicate measurement of the 14 applications are reported in Table 1 and presented graphically in Figure 3, with the UFP data on the x-axis and the COSMIC data on the y-axis.

A convertibility study of an industry dataset

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

Y(CFP) = 1.0* (UFP) - 3 (5)

- This convertibility formula represents a convertibility ratio of almost 1 to 1.
- This does not mean, however, that the results produced will be entirely accurate, as can be seen in columns 4 and 5 of Table (next Slide):
  - For 9 projects out of 14, the relative difference is less than 7%;
  - For 4 projects, the relative difference is between 14% and 17%; and
  - For 1 project, the relative difference is 39%.



Convertibility model on Total UFP Size (N=14)

A convertibility study of an industry dataset

Table: Convertibility comparison on Total UFP Size (N= 14)

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%

A convertibility study of an industry dataset

Convertibility using FP transaction size – TX

- The next convertibility analysis is based on the sizes of the 3 FP transaction types (Inputs, Outputs, and 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 below and presented graphically in next slide: with the UFP transaction sizes (TX) on the x-axis and the COSMIC data on the y-axis.

Table : Convertibility comparison on FP transaction size only –TX (N=14)

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%

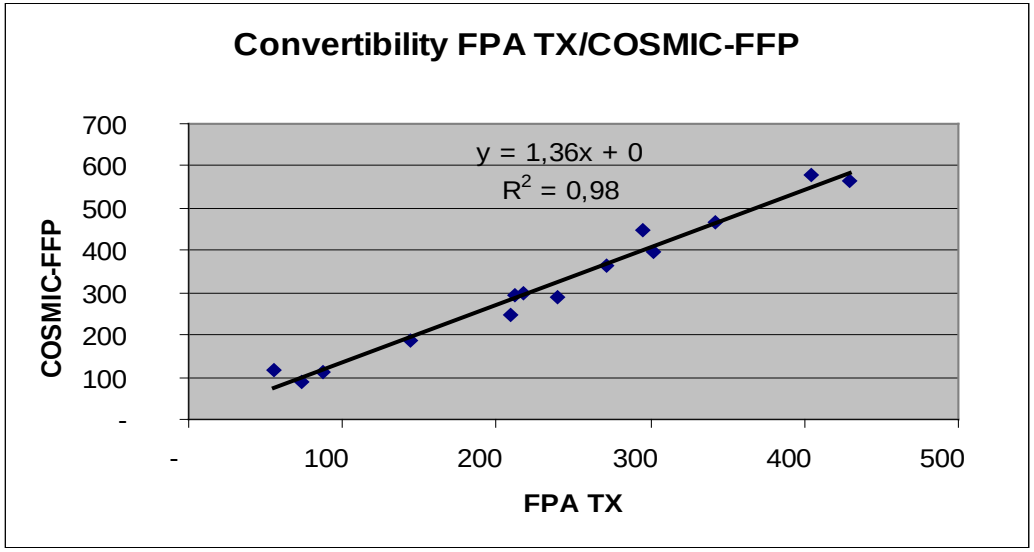
A convertibility study of an industry dataset

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

$$\mathbf{Y(CFP) = 1.36^* (TX) + 0 \qquad (6)}$$

- This convertibility formula is, of course, different from (5), since it is derived from a distinct basis (FP transaction size rather than total FP size) and its R^2 (0.98) is slightly better than the previous one (0.93).

Figure 4: Convertibility model on FP transactions size only - TX (N=14)



A convertibility study of an industry dataset

- Again, this does not mean that entirely accurate results are produced for all projects converted, as can be seen in column (4) of previous Table, which represents the difference between the results of the convertibility and direct measurements in COSMIC.
- 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%.

A convertibility study of an industry dataset

Context

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- The UFP and COSMIC measurements were taken concurrently, using the same documentation, by a single expert in both measurement methods.
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  - (different from the one reported in the Desharnais 2005 study).

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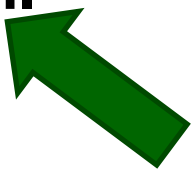
- A convertibility study of an industrial dataset.
- **Function Points to COSMIC convertibility: related issues and discussion.**



FP to COSMIC Convertibility: Issues and Discussion

Convertibility at the data level

- The measurement of data is particular to the traditional FP method (see Chapter 9):
  - In FP, the sizes of the files (ILF and EIF) are added to the sizes of the transactions (Input, Output, and Enquiry) to obtain the FP total size in UFP:
    - This is equivalent to adding together distinct entity types (analogous to 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 which are difficult to interpret from a size viewpoint.
- In COSMIC, there is no equivalent to adding 2 different entity types:
  - Only data movement types – Entry, Exit, Read, and Write – are added together.
- Therefore, it is expected that convertibility at the transaction level be more meaningful.

FP to COSMIC Convertibility: Issues and Discussion

- **Convertibility at the Transactions (TX) level**
  - The concept of the functional process in COSMIC is, in practice, equivalent to the concept of the functional transaction type in Function Points:
    - When identifying a COSMIC functional process in the documentation of a project, it was observed that there is an equivalent FP elementary process.
    - While the mapping of the total size at the total level is reasonably direct from FP to COSMIC CFP 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).

FP to COSMIC Convertibility: Issues and Discussion

- Notwithstanding this, there is still a difference between measuring the size of COSMIC functional processes and measuring FP transactions:
  - the COSMIC functional process is based on the number of data movements in a functional process, while
  - the FP transactions (Input, Output, and Inquiries) are based:
    - on the number of Data Element Types (DET) and File Type References, (FTR), and
    - on sets of weights (from 3 to 7) provided in different FP weight tables.
- In addition, when analyzing the results for each functional process and each transaction, it was observed that the COSMIC sizes of all the functional processes are, in this dataset, systematically equal to or higher than the FP size of corresponding transactions.

FP to COSMIC Convertibility: Issues and Discussion

There are at least 2 explanations for this:

- The weights in the FP tables for the transactions are limited to 7 points, while there is no such upper limit to the number of data movements in a COSMIC functional process.
- The measurement of the error messages:
  - On the one hand, FP version 4.1 rules includes error messages as a part of a transaction without assigning it additional points;
  - On the other hand, COSMIC 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 size units (e.g. the data movement that takes into account the error message in the measurement process).

A convertibility study of an industry dataset

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Agenda

This chapter has discussed:

- The lack of convertibility concerns in software ‘metrics
- Overview of previous convertibility studies for COSMIC.
- A detailed COSMIC convertibility study of an industrial dataset.
- Function Points to COSMIC convertibility: related issues and discussion.