

# **An approach for the automated risk assessment of structural differences between spreadsheets (DiffXL)**

John Hunt  
Excel for Managers  
John.Hunt@ExcelForManagers.com

## **ABSTRACT**

This paper outlines an approach to quantify the risks associated with changes made to spreadsheets. The methodology focuses on structural differences between spreadsheets and suggests a technique by which a risk analysis can be achieved in an automated environment. The paper offers an example that demonstrates how contiguous ranges of data can be mapped into a generic list of formulae, data and metadata. The example then shows that comparison of these generic lists can establish the structural differences between spreadsheets and be used to quantify the level of risk that each change has introduced. Lastly the benefits, drawbacks and limitations of the technique are discussed in a commercial context.

## **1 INTRODUCTION**

In business, a primary reason for choosing to use a spreadsheet over a fully managed computer application is the spreadsheet's flexibility: - Its ability to be updated or adapted quickly. Actual figures, for example monthly sales data, are often expected to change, but the calculation or formulae in a spreadsheet may also need regular review or up-dating to meet new requirements, legislation or even the ability to correctly adapt to a new financial year.

In many organisations, changes to the workings and calculations of a spreadsheet are left relatively unmanaged. A requirement to create new documentation or test the changes is often left to the conscience of the spreadsheet owner. Consequently managers, operational risk managers or auditors are frequently left unaware that a modification has even been made.

It follows that in many instances a change in a spreadsheet cell value cannot be accurately attributed to an expected numerical change (say sales data) or a change caused by a difference in functionality, or both. Therefore this ability to make unregulated changes to a spreadsheet may by its own nature give rise to a business and audit risk that is unknown, un-quantified and quite possibly simply ignored.

Left unmanaged, a spreadsheet that was once well designed, documented, tested and implemented, may well become prone to significant unknown errors over time.

## 2 BACKGROUND

### 2.1 Definition: Structural Change

In the context of this paper, a structural change is defined as the addition, removal, or modification of any formula or data in a worksheet cell. A structural change does NOT include a change to the format of a cell or a change in the displayed/calculated value of a previously defined formula cell.

### 2.2 Why test for structural changes?

Many spreadsheets used for reporting or valuation purposes are re-run on a cyclical basis. Good business practice dictates that any change to a spreadsheet's process or calculation method is documented and, where appropriate, suitable re-testing and/or approval carried out. However it is not unusual for undocumented and untested changes to creep into spreadsheets, often accidentally. A typical example of an accidental change is the replacement of a formula with an absolute value to mitigate a known error in source data. If the spreadsheet is subsequently saved, a structural change has been made, and future values have a high risk of being incorrect.

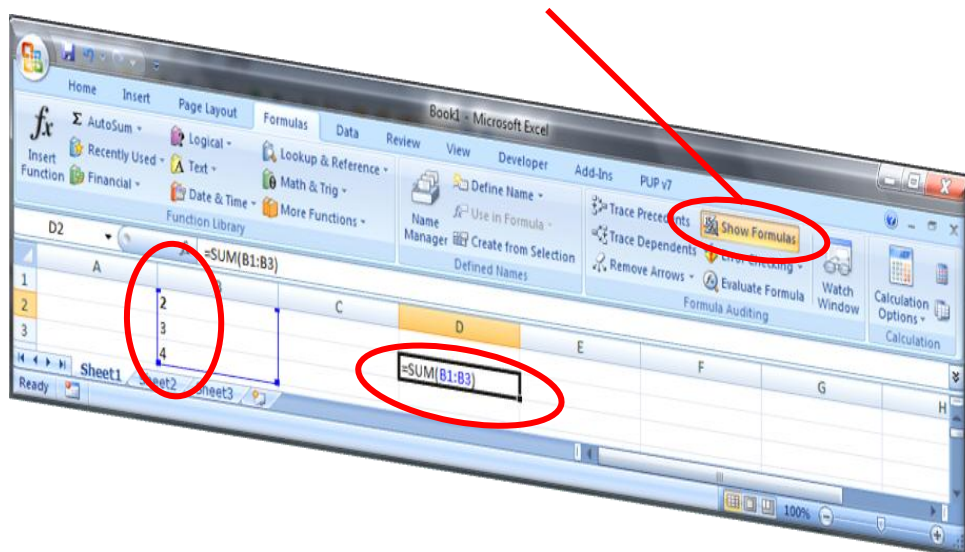
### 2.3 Minimising risk & semi-automated testing

Post-design, there are several simple ways in which businesses can help minimise the risks from spreadsheet changes. Some of these are physical methods, such as locking formula cells and protecting worksheet structure. Others are process driven such as a peer review of changes, the requirement to run pre-defined test scripts after each change, or using a spreadsheet comparison program to highlight value differences from identical input data.

### 2.4 Comparing spreadsheets: Formula view

One useful test/auditing method is to examine the formula view of a spreadsheet. The visibility of text or values entered directly (such as in B2:B4 below) is maintained, whilst the formulae themselves are shown (such as in D2) instead of their resultant value.

Reviewing formulae and values in Excel™ 2007



A key reason for viewing spreadsheets using this method is that direct structural spreadsheet comparisons can be made.

Given that there are no other differences between the spreadsheets (such as the use of different macros or named range changes etc.), it is safe to conclude that for any given set of inputs two spreadsheets with identical cell-for-cell formula views will give the same results: - Many spreadsheet comparison programs use a coded version of 'Formula View' as their primary basis of comparison.

## 2.5 Auditing, testing & reviewing with a formula map

Formula mapping programs are auditing tools that give a visual representation of the formula and data-structure of a worksheet, which can be useful after the initial spreadsheet design or after any known changes have been made. They make it relatively simple to spot unexpected formulae variations and some inconsistencies such as the accidental overwriting of a formula cell with a value.

Formula maps generally split a spreadsheet range into elements. In the example below, cells of the same colour represent cells with the same R1C1 formula, and static, directly entered values are shown in grey, making it relatively easy to spot the accidental overwriting of a formula with a number, as highlighted.

Base	X	Y	Gamma	Delta	Idx	Stock	Avg.
CORONA	7.031065	4.502179	1.561703	1.640327	52	7	0.170597
CORONA	61.91627	17.85029	3.568602	1.280222	19	1	0.513578
CORONA	126.6281	96.10542	1.317596	1.758958	53	276	0.398513
CORONA	0.856899	0.316199	2.71	1.369004	2	1	0.264752
CORONA	14.93735	7.117257	2.098751	1.476474	31	260	0.569398
CORONA	7.563898	5.377154	1.406673	1.710897	53	71	0.055886
CORONA	18.37504	5.052502	3.63682	1.274966	52	269	0.123271
CORONA	41.28708	19.63448	2.102784	1.47556	53	156	0.17075
CORONA	21.30119	11.1082	1.917637	1.521475	53	85	0.586524
CORONA	11.10962	5.226876	2.128004	1.469924	53	1	0.816692
CORONA	11.2525	7.155265	1.572618	1.635882	53		

### 3 A SUGGESTED APPROACH FOR THE AUTOMATED RISK ASSESMENT OF SPREADSHEET CHANGES

#### 3.1 Definition: DiffXL

DiffXL is the creation and subsequent comparison of contiguous range data and metadata, with a view to providing a risk based analysis of structural spreadsheet differences.

#### 3.2 Creating Generic DiffXL Data Lists

This section proposes a method that can be used to ascertain if there are certain differences between spreadsheets or spreadsheet versions, and attempts to categorize the relative level of risk that the change has created.

*Please note that the terminology, samples and references within this paper relate to a Microsoft Excel™ implementation of the methodology. Although the terminology may differ, the principles should be identical in other spreadsheet applications.*

The proposed method first involves the storage of generic data from contiguous-range elements within each worksheet. Each element is deemed to consist of a rectangular range of cells with the same formulae (in R1C1 reference style) or a rectangular range of cells with *no* formula. The elements' details are stored for future comparative analysis. The actual data stored about these elements may take many forms, each with subtly differing analysis requirements and conclusions available. One such structure is described below by way of an example.

Consider the following mini-spreadsheet, shown below in normal, formula map and R1C1 formula view. The steps to create the rectangular element list are as follows ...

	A	B	C	D	E
1	Base	X	Y	Gamma	Delta
2	CORONA	7.031065	4.502179	0.01311	0.059024
3	CORONA	61.91627	17.35029	0.308808	5.357904
4	CORONA	126.6281	96.10542	4.662414	448.0832
5	CORONA	0.856899	0.316199	0.032906	0.010405
6	CORONA	14.93735	7.117257	0.428304	3.048348

	1	2	3	4	5
1	Base	X	Y	Gamma	Delta
2	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
3	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
4	CORONA	=Data!RC	96.10542	=Data!RC*Freq	=RC[-2]*RC[-1]
5	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
6	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]

The first 'rectangular' element is established. In this example it consists of six cells of non-formula data, highlighted. Note that although the first row is evidently a title, and rows 2 to 6 are other entries, they are both considered as a single rectangular element. The start row and column are recorded, along with rectangle's size, recorded as the number of rows and number of columns. There are no formulae for this rectangle, so the letter 'V' (for Value) is entered and the formula column is left blank.

(R1C1 reference view of the spreadsheet)

(Generic list of metadata)

	1	2	3	4	5
1	Base	X	Y	Gamma	Delta
2	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
3	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
4	CORONA	=Data!RC	96.105	=Data!RC*Freq	=RC[-2]*RC[-1]
5	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
6	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]

Row	Col	Rows	Cols	F/V	Formula
1	1	6	1	V	
1	2	1	4	V	
2	2	5	1	F	=Data!RC
2	3	2	1	F	=Data!RC
2	4	5	1	F	=Data!RC*Freq
2	5	5	1	F	=RC[-2]*RC[-1]
4	3	1	1	V	
5	3	2	1	F	=Data!RC

The first rectangle element is now excluded, and the next rectangle is established. In this case it is the remainder of the title row. Its position and size is noted as before.

Note that in this particular example the rectangles are being established using an algorithm that broadly creates segments top to bottom and *then* left to right. The order in which the segments of any contiguous range are established is unimportant, but the method must be consistent for future comparisons to be accurate.

	1	2	3	4	5
1	Base	X	Y	Gamma	Delta
2	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
3	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
4	CORONA	=Data!RC	96.105	=Data!RC*Freq	=RC[-2]*RC[-1]
5	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
6	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]

Row	Col	Rows	Cols	F/V	Formula
1	1	6	1	V	
1	2	1	4	V	
2	2	5	1	F	=Data!RC
2	3	2	1	F	=Data!RC
2	4	5	1	F	=Data!RC*Freq
2	5	5	1	F	=RC[-2]*RC[-1]
4	3	1	1	V	
5	3	2	1	F	=Data!RC

The third rectangle element is a series of 5 formulae, whose R1C1 formulae are identical. The position and size is recorded. An 'F' (for formula) is noted, along with the R1C1 formula.

	1	2	3	4	5
1	Base	X	Y	Gamma	Delta
2	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
3	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
4	CORONA	=Data!RC	96.105	=Data!RC*Freq	=RC[-2]*RC[-1]
5	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
6	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]

Row	Col	Rows	Cols	F/V	Formula
1	1	6	1	V	
1	2	1	4	V	
2	2	5	1	F	=Data!RC
2	3	2	1	F	=Data!RC
2	4	5	1	F	=Data!RC*Freq
2	5	5	1	F	=RC[-2]*RC[-1]
4	3	1	1	V	
5	3	2	1	F	=Data!RC

The 5 remaining elements are calculated and recorded. Note the inconsistent value in row 4, column 3 which prevented a single large area (R2C2 to R6C3) being created.

	1	2	3	4	5
1	Base	X	Y	Gamma	Delta
2	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
3	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
4	CORONA	=Data!RC	96.105	=Data!RC*Freq	=RC[-2]*RC[-1]
5	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
6	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]

Row	Col	Rows	Cols	F/V	Formula
1	1	6	1	V	
1	2	1	4	V	
2	2	5	1	F	=Data!RC
2	3	2	1	F	=Data!RC
2	4	5	1	F	=Data!RC*Freq
2	5	5	1	F	=RC[-2]*RC[-1]
4	3	1	1	V	
5	3	2	1	F	=Data!RC

### 3.3 Recording static information

In order to ascertain if any change between spreadsheets has been made, there is also a requirement to assess any change in static information. To give a guaranteed 100% accuracy then both spreadsheets must be opened and a cell by cell comparison made, or every static cell's location and value must be stored. Assuming the preferred option is to store the values in the generic list, this can be achieved as follows...

By definition, each rectangular segment (line in the list) must consist of either formulae or static data. For each segment that contains static data, concatenate the cells' string values and separate every cell with a delimiting character (for example '|') irrespective of the cell's status. In the previous example, the first segment could therefore be made to include the data string...

*Base|CORONA|CORONA|CORONA|CORONA|CORONA* and this string could be stored in the Formula column, I.e.

	1	2	3	4	5
1	Base	X	Y	Gamma	Delta
2	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
3	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
4	CORONA	=Data!RC	96.105	=Data!RC*Freq	=RC[-2]*RC[-1]
5	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]
6	CORONA	=Data!RC	=Data!RC	=Data!RC*Freq	=RC[-2]*RC[-1]

Row	Col	Rows	Cols	F/V	Formula
1	1	6	1	V	Base CORONA CORONA CORONA CORONA CORONA
1	2	1	4	V	
2	2	5	1	F	=Data!RC
2	3	2	1	F	=Data!RC
2	4	5	1	F	=Data!RC*Freq
2	5	5	1	F	=RC[-2]*RC[-1]
4	3	1	1	V	

This exacting method may be appropriate or essential in some circumstances. However it can become cumbersome for large segments, and result in generic list file sizes approaching or even exceeding that of the original spreadsheet.

One alternative is to concatenate the cell values as above, but hold a checksum based on the entire string. Although it would not be possible to ascertain which cell(s) had changed directly from the checksum, it would still be possible to ascertain with a high degree of probability that a change had been made within any data segment, and if necessary the two files opened to retrieve the difference by cell.

A small but important limitation for storing static values in this way is that any cells containing a value consisting solely of the separating character or characters (e.g. ||| in the above example) could fool a change-test algorithm. In the commercial implementation of this method, a non-printing character is used as the separating character to help minimise this risk.

A final example of a segment list for a worksheet with two contiguous ranges is shown below.

Sheet	Contig ID	Row	Col	Rows	Cols	F/V	Formula
Sheet1	1	1	1	6	1	V	CAA8E7F2
Sheet1	1	1	2	1	4	V	1CE2BE24
Sheet1	1	2	2	5	1	F	=Data!RC
Sheet1	1	2	3	2	1	F	=Data!RC
Sheet1	1	2	4	5	1	F	=Data!RC*Freq
Sheet1	1	2	5	5	1	F	=RC[-2]*RC[-1]
Sheet1	1	4	3	1	1	V	DF578763
Sheet1	1	5	3	2	1	F	=Data!RC
Sheet1	2	8	2	1	4	F	=AVERAGE(R[-6]C:R[-2]C)

### 3.5 Drawing risk based conclusions from the comparison of two DiffXL lists

In order to draw appropriate conclusions, a comparison of two lists is required. The expectation is that this process would be accomplished automatically through a series of difference algorithms. Both qualitative and quantitative conclusions can be made.

At this stage, it is also possible to include a subjective risk assessment of any changes. The actual and genuine level of risk is dependent on numerous factors, including the type of data, type of change, and number of simultaneous changes.

The *category* of risk also needs to be taken into account. For example risk may be considered in different terms if the user is looking at the risk of an incorrect result, the risk of a catastrophic malfunction of the spreadsheet or the risk of failing an audit, and so on. A variety of change-test algorithms, or settings within the algorithms would therefore be deemed to be appropriate within different industries or departments.

Below are some of the types of change to spreadsheet structure that can be ascertained using DiffXL, together with a suggested (user-configurable) associated level of risk.

<b>Comparison</b>	<b>Risk</b>
Entire range moved	Low
New static text, placed away from other ranges	Low
One or more ranges sorted	Low
Text or headers changed	Medium
Contiguous range split into two or more segments	Medium
New items added within a range	Medium
Formulae change throughout an entire range	Medium
Items removed from within a range	Medium
Items removed or changed, breaking up a range	Medium
Numeric cell changed to a number which is formatted as text	High
Overwrite a formula with a number or text	High
New data and formulae introduced	High
New or deleted worksheets	High

## **4 BENEFITS, DRAWBACKS & LIMITATIONS OF USING THE DiffXL METHODOLOGY**

### **4.1 Benefits of using the DiffXL methodology**

The ability to demonstrate that no structural differences have been made to a spreadsheet over time, or to be able to identify where changes have been made, may be of benefit to some spreadsheet owners, managers and auditors.

DiffXL's ability to assign a relatively low risk indicator to simple changes such as the movement of a block of cells from the top to the bottom of a spreadsheet, or the sorting of a data range, means testing and approval effort can be best allocated where changes have been identified as more likely to result in material differences to calculated values.

DiffXL can be used in commercially sensitive or secure environment: Once a DiffXL list has been created for a spreadsheet, that list is generally the only requirement to perform difference tests or analysis. If the checksum method for storing static values is used, there are therefore few security issues with releasing the lists for external analysis or reporting.

A Diff XL based control framework can be run as a background process, either directly when a spreadsheet change is made or at any pre-defined frequency. A system could easily alert owners or managers only if a change of a certain magnitude of risk has been detected. This offers the potential for a discreet and un-obtrusive corporate testing regime.

### **4.2 Drawbacks & limitations of using the DiffXL methodology**

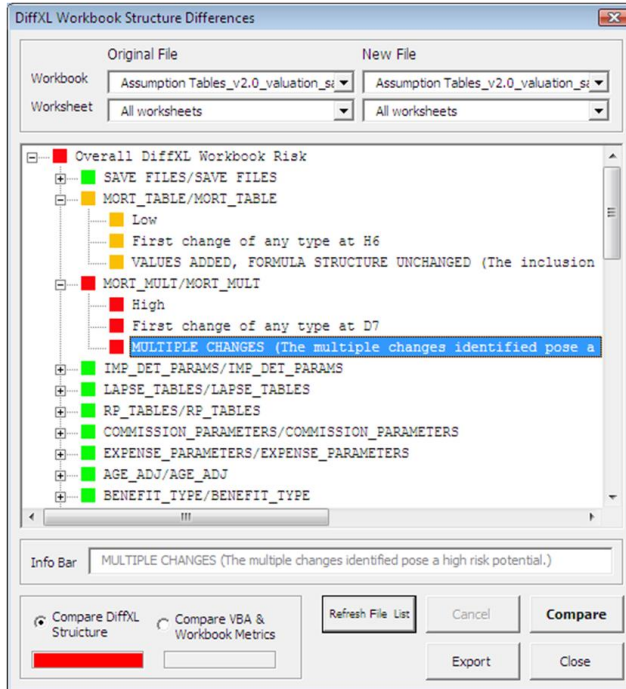
Changing spreadsheet data or formulae is only one way to change the operation of a spreadsheet. In a commercial application, other aspects of the spreadsheet also need to be considered and analysed, for example changes to macros, named ranges or data connections.

Unless direct cell-to-cell comparison between spreadsheets for static values is used, there is a small risk that a value change will not be detected by this methodology. In most implementations the risk is negligible, but nevertheless possible and dependent on the method in which the static data is stored (directly or through a checksum), the quality of any checksum, and the use of the separating character.

Although based on objective algorithms, overall risk assessments may still be subjective. As an example, should three low risk changes constitute a low, medium or high risk change?

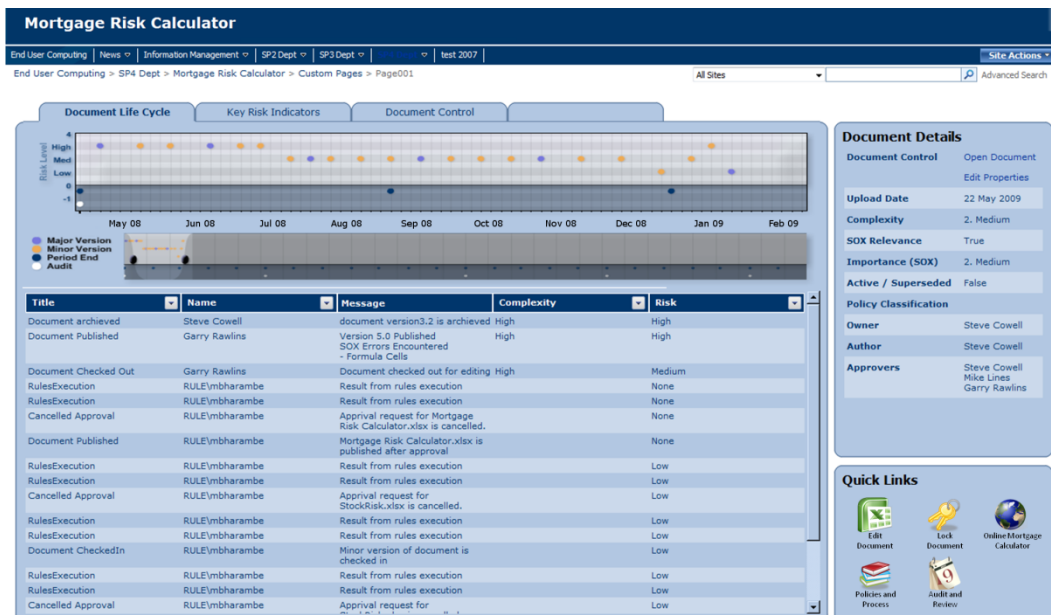
## 5 DiffXL IN COMMERCIAL APPLICATIONS

Listed below are screenshots from two products where the DiffXL methodology has been applied in conjunction with more established analysis techniques..



a) An auditor's tool that directly compares spreadsheets from one year to the next to ascertain the level of risk associated with any changes. The tool can be run directly from a memory stick so no software installation is required and gives a quick indication on whether (or where) further detailed analysis is required.

b) A SharePoint™ Control Framework that monitors spreadsheets and alerts the owner if cumulative changes have exceeded a pre-defined level of risk. Here, the spreadsheet's complexity and change-risk at each 'publish' is charted for the owner or auditor. A non-SharePoint™ version of this product is also available.



Further details of the DiffXL Audit Assistant and the IDAS SharePoint Control Framework can be obtained from the author.

## **6 ACKNOWLEDGEMENTS**

The author wishes to express sincere thanks to Mike Lines of Rule Financial Ltd for his assistance with the commercial implementation of DiffXL.

## **7 SUMMARY**

This paper has discussed an alternative spreadsheet comparison methodology.

DiffXL does not compare spreadsheets directly and is not a substitute or replacement for any of the established auditing and comparison methods and tools.

For some owners, risk managers or auditors, it may be speedier or relatively more important for them to understand the risk profile of the difference rather than the difference per se. For these people a comparison based upon DiffXL can offer insightful information.

A DiffXL toolkit or control framework may be of particular interest to auditors who wish to quickly highlight areas of most concern and to companies that desire discreet ongoing spreadsheet control management.