



# HOW TO REVIEW A SPREADSHEET

Reduce the risk that your spreadsheet  
gives you the wrong answer



ICAEW THOUGHT LEADERSHIP

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## FOREWORD



Spreadsheets remain fundamental to modern business operations. Professionals across various sectors dedicate considerable time to using spreadsheets to input data and formulas to share and present information. However, without adequate review, the outputs can be notoriously prone to error.

Consider how often you rely upon the calculation of a spreadsheet as the basis for making a decision. How confident are you that those vital numbers are correct?

While there is no completely foolproof method by which to validate a spreadsheet, we can all benefit from learning and following best practice.

I would like to thank our Excel Community's advisory group who have developed this guidance. Drawing on expertise from both practice and business, this guide will help you reduce spreadsheet risk and increase confidence in your decision-making.

A handwritten signature in black ink that reads "Alan Vallance". The signature is written in a cursive style with a long, sweeping underline that extends to the right.

Alan Vallance,  
Chief Executive of ICAEW

## WHY DO SPREADSHEETS NEED REVIEWING?

Spreadsheet risk affects all businesses. A common statistic quoted about spreadsheets is that as many as 90% contain a mistake. This figure is based on research by Ray Panko, of the University of Hawaii, and others. The rate of error in any one cell can be quite low, but extrapolated to the size of a typical spreadsheet, the chance that a mistake will be made is compounded.

Although any individual mistake may only make a marginal difference to the outcome, in aggregate they can become costly. Serious mistakes reach the press with reasonable frequency, such as the debacle around the West Coast Mainline franchise in 2012 and more recently the [mislaying of coronavirus contact tracing details](#) by Public Health England in 2020.

Spreadsheets are used for many purposes, from small single-use calculations to sprawling financial models that are used for many years. This guide lays out a general approach that could be adapted for all types of spreadsheets and users but is particularly aimed at small and medium-sized business users reviewing typical finance workbooks.

We have aimed to provide a guide for all spreadsheet packages, although Excel is the dominant program in the field at present.

This guide follows our previously published work:

- the [Twenty principles for good spreadsheet practice](#), which sets out guidelines for efficient and safe spreadsheet use;
- the [Spreadsheet competency framework](#), to assist in getting the right person with the right skills in the right role; and
- the [Financial modelling code](#), which provides a set of principles for robust modelling.


The *Twenty principles* are the foundation of ICAEW's guidance on spreadsheets, and in this guide you will see cross-references to specific principles where appropriate. Having all business-critical spreadsheets constructed correctly, by a team of people with the necessary skills, is the basis for a good quality output and reduces the likelihood of error.

It is vital that, wherever possible, a review is carried out by a third party, in addition to a self-review by the spreadsheet's author. This independence will better challenge the logic used and values derived. Research from Ray Panko found that self-review catches only 34% to 69% of errors.

There is no way to fully automate a review to ensure the validity of a spreadsheet. Most tools and techniques only alert reviewers to areas that might require further investigation and can't identify what might be missing. Human judgement plays a key role in constructing and reviewing a spreadsheet. By their nature, spreadsheets can change or fail in unexpected ways. Their fallibility makes their creation and review an imperfect science but, as we show in this guide, with the right approach that can always be improved.

### TWENTY PRINCIPLES FOR GOOD SPREADSHEET PRACTICE

The guidance in this document is based on ICAEW's *Twenty principles for good spreadsheet practice*. The principles are a high-level set of guidance for achieving good practice in any spreadsheet environment.

Please refer to [icaew.com/excel20principles](https://www.icaew.com/excel20principles) for more details. 

## WHAT A REVIEW CONSISTS OF

When a spreadsheet is being used to provide the numbers that form the basis of a significant decision, it is reasonable to expect that the data, logic and results are reviewed for accuracy. A review can take several forms – a management review, peer review, external check, or just a self-check – and care should be taken to communicate exactly what the person commissioning the review wants done, and what the reviewer has done. It might be the case that a colleague does a quick check for you and, before long, that description has morphed into “it’s been audited”, implying unfounded validity.

Different approaches are needed to review the business logic and assumptions in a spreadsheet versus the formulas and construction of it – neither alone is sufficient. There are formal standards, such as the standard on non-audit reviews, ISAE 3000, that could form the basis for an assurance engagement over a spreadsheet, but in this guide we set out principles for completing a more generic, informal review. For more complex or business-critical spreadsheets, a more formal review, perhaps by an external expert, could be more appropriate.

Several types of errors can occur within a spreadsheet. These might include:

- **Data integrity errors** – the source information is incorrect, leading to the infamous problem of “garbage in, garbage out”.
- **Formula errors** – the data is incorrectly used in calculations, providing flawed results. Some of these errors can be detected during development and application by employing quality control techniques that consist of built-in tests (such as a check or flag that indicates whether the balance sheet balances).
- **Process errors** – the spreadsheet’s management is compromised through errors, such as using an incorrect version of the spreadsheet.
- **Communication errors** – the spreadsheet is misleading, or its results are not presented or explained well.
- **Meta errors** – these exist outside the scope of the spreadsheet’s cells. For example, where a spreadsheet is not the best tool to answer the question at hand, or the question is not the right one to be asking. These issues should be considered early on to avoid wasting effort on a detailed review of a fundamentally flawed approach.

In a large spreadsheet, where there may be tens of thousands of cells containing formulas and thousands of distinct formulas, it would take a long time for a reviewer to manually test and validate every cell. The impracticalities of cost and time would make it inevitable that corners will be cut. Therefore, instead it is helpful to target the most critical areas and outputs.

In this guide we will focus on five main review stages:

- **Initial review:** checking the big-picture elements to get an initial impression of the state of the workbook and prepare for later stages of review.
- **Structural review:** checking that the spreadsheet is well laid out and includes appropriate checks.
- **Data review:** checking the validity of the input data used in the spreadsheet.
- **Analytical review:** checking if the spreadsheet’s output looks reasonable at a holistic level.
- **Detailed review:** checking the spreadsheet at a more detailed level, including at the individual formula level.

We conclude with a synopsis of post-review activities.

# INITIAL REVIEW

Often little consideration is given to project management when a new spreadsheet is started. Instead, the user opens their spreadsheet package, types a title in cell A1, and construction has begun. The word “construction” is deliberately used here, because in any building project detailed planning and logistics are carefully thought through before any work commences on site. An essential consideration at the outset of a spreadsheet project is whether the appropriate package is being used by someone with sufficient competence – and, indeed, whether a spreadsheet is the appropriate tool in the first place.

The table highlights some of the core areas that should be considered before construction starts. They should be checked at the start of any review to help build a picture of the workbook and build the basis for the main bulk of the review.

Question	Context	Action
<b>What is the purpose of the spreadsheet?</b>	Understand the key spreadsheet outputs that are being sought, what decisions will be made using these outputs and who will be relying on the validity of these outputs (both internal and external).	Identify the purpose clearly and consider how an incorrect output would affect that purpose.
<b>What level of risk is associated with the spreadsheet?</b>	Assess the key risk areas associated with the spreadsheet (both modelling risk and business risk) and ensure any review and testing can focus on the calculations that underpin the critical values.	Keep an eye on materiality and ensure time is spent on the significant areas that drive the outputs, taking care not to dismiss multiple immaterial items that when aggregated could become material. Assess the level of assurance/validation that will need to be obtained based on this risk assessment.
<b>How competent is the author?</b>	<p>ICAEW research shows that most spreadsheet users are primarily self-taught, having learned from the work of others and internet searches. This can lead to overconfidence.</p> <p>A spreadsheet constructed by those with appropriate expertise is likely to include fewer errors than one crafted by people working beyond their level of experience.</p> <p>Research by Ray Panko also shows that most people believe they make fewer mistakes than other people. Therefore, even with experience, an author is inclined not to believe their own fallibility.</p>	In practice, competence can be achieved through a blend of staff training, collaborative building, peer review and the development of good structural design. Ensure that the author(s) understand their capability as defined by the <i>Spreadsheet competency framework</i> and they are familiar with the <i>Twenty principles for good spreadsheet practice</i> and, if appropriate, the <i>Financial modelling code</i> for more complex budgeting and forecasting applications.

**PRINCIPLE #5**

Focus on the purposes of the spreadsheet.

**PRINCIPLE #3**

Ensure designers and users of spreadsheets have appropriate knowledge, competence, experience, and awareness of functionality.

Question	Context	Action
<b>Has the spreadsheet been subject to any earlier review?</b>	Any earlier reviews can help you to identify which risk areas may have been considered already, and which have not yet been addressed. If a change log is present in the file, then changes from previous reviews can be reviewed there.	Consider the experience of the previous reviewer and what their review consisted of. Don't take their conclusions for granted; instead perform a lighter review to confirm their findings. Consider what important aspects might have been outside of the previous reviewer's scope, or what they might have missed, and focus your attention there.
<b>What is the life cycle of the spreadsheet?</b>	A spreadsheet to support a single event (for example, the purchase of an asset or investment) will have a different structure to one that will have ongoing use, where all the data will need to be updated regularly.	Check that metadata is present, such as the last update time for inputs that are regularly refreshed.
<b>What construction controls have been used?</b>	As spreadsheets evolve, there needs to be a clear naming convention and version control, especially if they are built by more than one author. This should ideally be communicated through a user guide or control sheet. If there are linked files, these need to be kept clearly annotated to ensure contributors are all working on the latest version.	Establish clear processes for naming, storage and back-ups. Including a change log can help to clarify the changes made in each version.
<b>Should passwords be required?</b>	<p>There are two main scenarios to consider:</p> <ul style="list-style-type: none"> <li>• With confidential models and strategic plans, there needs to be a limited pool of people able to access sensitive information.</li> <li>• For models or templates that may be available to a wide audience (such as a business case template), it will be necessary to protect key calculation cells from being corrupted through user error.</li> </ul>	Establish a clear password protocol for access to the files, sheets and cells. This is explained further on page 17.

**PRINCIPLE #20**

Manage access levels and protection to reduce the risk of accidental or malicious changes.

## STRUCTURAL REVIEW

Once the initial review has been completed, it's time to begin assessing the spreadsheet itself. The structural review aims to provide an overview of the entire spreadsheet without getting into details, get a sense of the overall soundness of the workbook and the risks it holds.

Here are some initial considerations to gauge confidence in the spreadsheet's structure and logic:

- **Fitness for purpose** - can the spreadsheet deliver the result that it was developed for? Have obvious compromises and simplifications been made in generating the results?
- **Documentation** - is direction and instruction provided to all users within the spreadsheet? Is that documentation all safely contained within the spreadsheet itself, or is some in accompanying emails or files that might become separated and lost over time?
- **Key sheets** - is there a clear overview of the structure (perhaps including a map) showing how the sheets are linked together? Are the inputs, workings and outputs clearly separated and identified? Is there a summary sheet that draws in the key values?
- **Clear structure and logical flow** - is the spreadsheet laid out with logic that builds down each sheet and from sheet to sheet? Is the layout and look of the workbook consistent throughout?
- **Legibility** - are the formulas created to aid validation (short formulas with only a few operands that have been copied over several rows), or have they become overly complex (multi-line formulas), making them challenging to unpick and verify?
- **Separation of cells** - are inputs, calculations and outputs separated and clearly labelled, with units?
- **Formatting convention** - have the monetary units been clearly identified and are they used consistently (both currency and scale - thousands/millions)? Does the workbook have a clear and consistent sign (+/-) convention?
- **Time series convention** - do all the time series start in the same column on every sheet? What time period are the calculations based on (ie, weekly/monthly/quarterly), and is that periodicity consistent across the workbook?
- **Checks and flags** - have checks and flags been built in to validate the results being generated? Are they all indicating correct operation?
- **External sources** - where the spreadsheet relies on links to other spreadsheets or external data sources, are these clearly identified and have they been reviewed and refreshed to ensure they are up to date?
- **Complex functionality** - do the spreadsheet author, reviewer and user have suitable experience in any complex functionality that has been used? Consider ICAEW's *Spreadsheet competency framework* to assess competence. For example, complex functionality includes:
  - application of arrays and dynamic arrays;
  - the scenario manager and iterative techniques used to derive values;
  - macros and Visual Basic for Applications (VBA);
  - volatile functions such as OFFSET or INDIRECT;
  - PivotTables and the need to refresh them;
  - answers derived from Power Query and Power Pivot;
  - inherently complex functions such as the programming function LAMBDA; or
  - other add-ins or tools.

### PRINCIPLE #7

Make the spreadsheet easy to use, providing supporting guidance where helpful.

### PRINCIPLE #13

Use the simplest features, functions, or formulas for the task.

### PRINCIPLE #17

Build in checks, controls, and alerts from the outset.

If a high proportion of these areas are covered effectively, it's a good indicator that the spreadsheet may provide a good framework and is ready for a more in-depth review. Of course, no review can prove definitively that a spreadsheet is error-free, but we can reduce the potential for error.

Finding weaknesses in many of these areas should raise alerts about the spreadsheet's robustness. Substantial corrective work may be required before time is invested in further review.



## DATA REVIEW

The purpose of the data review is to check that the input data in the spreadsheet makes sense and agrees with the external sources from which it comes. This is a relatively short but critical step in ensuring that the spreadsheet is up to date and capable of producing the outputs it was made for.

This is also a good moment to do some basic testing on varying inputs to check for any substantial flaws that might indicate an error elsewhere.

A data review might consist of one or more of the following items.

Item	Description
<b>Validity of standing data</b>	Check, for example, that opening balances and tax rates are correct by agreeing to appropriate data sources.
<b>Test data</b>	Create a set of test data with a known result to ensure that the spreadsheet gives the same response.
<b>Zero inputs</b>	If the spreadsheet is fed with input data of all zeroes, it might be expected to produce a zero output. The validity of any non-zero values will require investigation. The cause is often the result of an IF formula not being set up to handle values outside expected amounts.
<b>Stress testing</b>	This is the process of feeding the spreadsheet with data outside of its normal operating values. This will test its robustness and ability to handle errors.
<b>Delta testing</b>	By storing the results for one scenario and comparing it against another, delta testing can be used to assess whether alternative scenarios give appropriate variances. For example, a small change in any one assumption might be expected to give a small change in the overall result. Checking that a series of small assumption changes gives the appropriate deltas to key outputs can confirm the way the logic is being applied.

## ANALYTICAL REVIEW

An analytical review is completed to independently assess whether the spreadsheet result looks right. Using charts, ratios and recalculation will provide signals that either confirm or challenge the validity of values. There are four broad categories of analytical review:

**Reasonableness** – do the assumptions and results look reasonable? For example, an assumption about revenue growth at 10% per annum may be reasonable for the next year or even two, but if compounded over 10 years will have provided over 250% growth. What proportion of the whole market does this become and, if it is significant, then is it likely that competitors will watch passively and let it happen?

**Trend analysis** – charts can make results clear, although they are not good for communicating precise numerical detail. Charts help us to identify patterns or trends that either support or contradict our expectation and, therefore, direct us to areas in the spreadsheet that may need further investigation. Reviewing charts at the line-item level can be more revealing than at the total level. For example, looking at revenue and costs separately can show more subtleties than looking at profit. The use of Sparklines (see the Useful functionality section on page 13) for each of the time series rows can provide a visual audit of the values being generated.

**Ratio analysis** – developing a set of ratios can add insight into the way a time series of values is evolving. Judgements about reasonableness can interpret the appropriateness of these metrics. If appropriate, checks can be included that flag when a ratio exceeds its expected range. Some examples might be EBITDA margin, net margin, EBITDA to cash flow, depreciation to gross asset value, leverage, receivable or payable days, or revenue per employee. Charts of these also reveal the trends that are emerging. Each of the trends should be challenged to justify their validity. For example, what is causing the margin to narrow or widen? Why is cash increasing or decreasing? Are there sufficient staff for the changing scale of the business?

**Reperformance/parallel computation** – reperforming the key calculations either exactly or by using indicative values will affirm the results being generated. For spreadsheets where the wrong result would have serious consequences, it may be appropriate to have a full parallel computation. This is the process whereby two people independently develop a solution so that the two answers can be compared and reconciled.

## DETAILED REVIEW

Finally, we come to the stage of validating details within the spreadsheet. The actual steps performed at this stage will need to be proportionate to the context, scale and risk of the spreadsheet being reviewed, based on the understanding developed in the earlier stages.

A detailed review might include one or more of the following items.

Item	Description
<b>Detailed testing of formulas</b>	The detailed interrogation of formulas can be a long and unrewarding task. The vast majority of the code will be correct and this can lull a reviewer into agreeing with a plausible formula rather than challenging it.
<b>Software diagnostic tools</b>	Consider the use of specialist diagnostic tools and Excel add-ins to interrogate the workbook. These tools are programmed to look for many of the typical problems listed in this document and usually generate a list of findings for the user to investigate.
<b>Inspecting the workbook</b>	Excel has a function to inspect a workbook and look for potential issues. There are three options: <ul style="list-style-type: none"> <li>• <b>Inspect workbook</b> – a list of 22 attributes can be individually selected and it returns a report of findings.</li> <li>• <b>Check accessibility</b> – this option checks for content that people with disabilities may find difficult to read.</li> <li>• <b>Check compatibility</b> – this checks for features that are not supported by earlier versions of Excel.</li> </ul>
<b>Independent expert review</b>	For some spreadsheets that are business critical, it may be appropriate to ask an independent expert to complete a review. Some accounting and other firms offer this service.

At this stage, it is useful to be aware of some of the most common errors and high-risk areas that cause a spreadsheet to fail. This guide divides the key areas a reviewer should check into design principles and formulas. In the next section, we present some useful Excel functionality that can support a detailed review.

### DESIGN PRINCIPLES

These issues affect the wider design and operation of the spreadsheet:

- **Balancing figures** – for example, a number being used to make a balance sheet balance. While it might be tempting to use this technique to correct rounding, this is usually a sign of an issue elsewhere and should be resolved instead.
- **Unused inputs** – data that is entered but is neither referenced in calculations nor contributes to the outputs. These might be omissions or superfluous information.
- **Signage** – is data using the correct sign? For example, should creditors be entered as a positive or negative number? Have they appeared on the outputs correctly?
- **Daisy chaining** – this is the term for where formulas pull values from other formulas that themselves link to a source without alteration, rather than linking directly to the original input cell. This is generally discouraged.
















- **External links** - how stable is the link and how susceptible is the source data/spreadsheet to changes the user may not be aware of? For example, is the source file stored separately to the spreadsheet from where it might be removed? Can the data be captured in a way that allows the links to be removed and, if not, are all external links stored together and easily identified?
- **Display errors** - for example, a percentage under 50% is shown with integer number formatting and therefore displays as zero.
- **Hidden calculations** - to present outputs succinctly, it can be tempting to hide rows or columns of information, hide entire worksheets, or use white font on a white background. If there are calculations that are not required for the outputs, they should be placed on a workings sheet so that all content can remain visible, or disguised with the easily reversible group feature instead of hiding.
- **Spell check** - while not related to the output values, a spell check can assist in making the spreadsheet appear more professional, increase user confidence and avoid misunderstandings.
- **Macros and VBA** - program code should not refer directly to cell addresses using A1/R1C1 notation as this easily leads to misalignment when cells, rows or columns are inserted, deleted or moved.

## FORMULAS

These issues can affect individual or groups of formulas:

- **Circular references** - this is where a cell formula references back to itself. Excel will note this in the bottom left footer of the screen and show the cell address of the most recently created one. By default, recalculations involving a circular reference will be suspended and results will not be refreshed when the data changes. Iterative calculations can be enabled to allow these to operate, but this can mask unintentional cases of circularity.
- **Range names** - where cells or ranges have been given names, ensure they refer to the correct blocks of cells. Late additions to spreadsheets can easily be omitted accidentally from ranges.
- **Indirect address ranges** - functions such as OFFSET and INDIRECT create cell address references by using cell values. Consequently, the results can be difficult to verify.
- **Incorrect data formatting** - this can include a numeric value that contains text characters or spaces, or text similar to a date. Excel will assume their data type, which can lead to numbers being ignored or changed.
- **Nested IF and IFS** - an IF statement performs a logical test (true or false) and returns one of two outcomes. Nesting is where another IF test is used within an outcome field of a previous IF test. This nesting can become overly complex and difficult to check. Avoid nesting by splitting the formula into separate cells.
- **Incorrect use of functions** - misunderstanding the detail of the arguments of some functions can lead to error. For example, the NPV function requires the value series to be period 1 to period N, with any period 0 values being added outside the function.
- **IFERROR** - the use of this function can mask errors beyond what is intended. For example, this function might be used to hide divide by zero errors in a year-on-year comparison, but could also hide an unrelated calculation error, whereas an explicit check for a 0 divisor will not.
- **Recalculation** - it is possible to toggle between automatic calculation when any cell changes, or manual when calculation is forced by pressing F9. Large spreadsheets can become slow to recalculate and therefore be switched to manual. The danger is that the user will forget to recalculate when deriving values.
- **Non-traditional Excel** - If expanded Excel functionality such as Power Query data transformations or Power Pivot Measures have been used, these should be reviewed by an appropriately competent person.

## USEFUL FUNCTIONALITY

Function or Formula	Application																																																						
<b>Search for external references</b>	The Find tool can be used to search for square brackets or the .xls string to detect external references, as can the Edit Links option. Be aware that external references can also be hidden in chart titles, the definitions of named ranges, or in data validation rules, and these will not be found by such a search.																																																						
<b>Sparklines</b>	<p>Sparklines are single cell charts. Using them for each time series can provide a visual audit that the numbers are developing as expected. An extract from a model is shown below:</p> <table border="1"> <tbody> <tr> <td></td> <td>500,014</td> <td>515,014</td> <td>530,464</td> <td>546,377</td> <td>562,768</td> <td>579,651</td> <td>597,040</td> <td>614,951</td> </tr> <tr> <td></td> <td>-216,300</td> <td>-222,789</td> <td>-229,473</td> <td>-236,357</td> <td>-243,448</td> <td>-250,751</td> <td>-258,274</td> <td>-266,022</td> </tr> <tr> <td></td> <td>-55,000</td> <td>-55,000</td> <td>-52,000</td> <td>-52,000</td> <td>-52,000</td> <td>-52,000</td> <td>-52,000</td> <td>-52,000</td> </tr> <tr> <td></td> <td>-18,450</td> <td>-19,096</td> <td>-19,764</td> <td>-20,456</td> <td>-21,172</td> <td>-21,913</td> <td>-22,680</td> <td>-23,474</td> </tr> <tr> <td></td> <td>-25,750</td> <td>-26,523</td> <td>-27,319</td> <td>-28,139</td> <td>-28,984</td> <td>-29,854</td> <td>-30,750</td> <td>-31,673</td> </tr> <tr> <td></td> <td><b>184,514</b></td> <td><b>191,606</b></td> <td><b>201,908</b></td> <td><b>209,425</b></td> <td><b>217,164</b></td> <td><b>225,133</b></td> <td><b>233,336</b></td> <td><b>241,782</b></td> </tr> </tbody> </table> <p>As can be seen above, even with most of the data cut off, the lines show a consistent trend, except the middle line which takes a step up and looks unusual, prompting further investigation.</p>		500,014	515,014	530,464	546,377	562,768	579,651	597,040	614,951		-216,300	-222,789	-229,473	-236,357	-243,448	-250,751	-258,274	-266,022		-55,000	-55,000	-52,000	-52,000	-52,000	-52,000	-52,000	-52,000		-18,450	-19,096	-19,764	-20,456	-21,172	-21,913	-22,680	-23,474		-25,750	-26,523	-27,319	-28,139	-28,984	-29,854	-30,750	-31,673		<b>184,514</b>	<b>191,606</b>	<b>201,908</b>	<b>209,425</b>	<b>217,164</b>	<b>225,133</b>	<b>233,336</b>	<b>241,782</b>
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<b>Formula Auditing Group</b>	<p>There is a group of tools on the Formulas ribbon in the Formula Auditing Group.</p> <ul style="list-style-type: none"> <li>• Trace Precedents - find the cells that are the source of the values in the current cell (or Ctrl + [ within the same sheet).</li> <li>• Trace Dependents - find the cells that are based upon the result of the current cell (or Ctrl + ] within the same sheet).</li> <li>• Remove Arrows - both of the tools above show arrows to the connected cells or a Go To dialog box when the connection is on another sheet. This button removes those arrows.</li> <li>• Show Formulas - this will change your view so you see formulas rather than their results. This makes it easy to scan along rows and columns and observe inconsistencies and challenge unexpected calculations. The formulas view can be toggled on and off with Ctrl+` or from the ribbon.</li> <li>• Error Checking - this will find incidents of error (#DIV/0!, #NUM! and #VALUE!) and provide options including: <ul style="list-style-type: none"> <li>- Help on this Error, which takes you to Microsoft online help.</li> <li>- Show Calculation Steps, which shows the parts of the formula that work and the parts that Excel cannot interpret.</li> <li>- Ignore Error, which allows you to abandon correction, at which point a new option emerges: Copy formula from left. This may be a quicker way to resolve the issue.</li> </ul> </li> <li>• Trace Error - similar to Trace Precedents, this tool can show where the errors in a cell spring from.</li> <li>• Circular References - a list of the circular references that need resolving.</li> <li>• Evaluate Formula - this is helpful to debug a complex formula by evaluating each part individually. This helps locate the part that may be incorrect (also ALT m v).</li> </ul>																																																						

Function or Formula	Application
<p><b>Watch Window</b></p>	<p>The Watch Window - also under the Formula Auditing Group - enables you to monitor what happens to a set of selected cells as the spreadsheet changes. This is especially useful if the key outputs are in a different part of the workbook from the inputs being changed.</p> <p>Use the Add Watch button to select which cells to monitor. They include the book, sheet, range name, cell reference, value and formula.</p> <p>The values will update as changes are made to the spreadsheet.</p> <p>The Delete Watch button removes items from the Watch Window.</p> 
<p><b>Formula consistency</b></p>	<p>Several options can be used to check that a formula is consistent along a time series.</p> <p>Go To Special will highlight the cell contents that meet selectable criteria. This allows you to highlight all instances of an attribute of interest, for example, formulas in an inputs area.</p> <p>Highlight a row and press Ctrl + \ which will highlight any cells that are inconsistent with the rest, or use Ctrl Shift \ for columns.</p> <p>Switch to R1C1 so that all the formulas will look the same. R1C1 mode shows formulas in a relative format rather than an absolute format. For example, if cell D9 referred to the cell to its left and added 1 it would be =C9+1. E9 would be =D9+1 and so on. In R1C1 mode, the references are relative and each cell would show the same formula =RC[-1]+1 - this means take the cell one column to the left and add 1. In this format, when looking along a row in Show Formulas mode, all the formulas will be identical and it will be easier to check their consistency. Turn on R1C1 mode from File &gt; Options &gt; Formulas.</p>

Function or Formula	Application
<b>Hidden sheets, cells and cell contents</b>	<p>To ensure all the information is visible, it is helpful to unhide any worksheets, rows and columns.</p> <ul style="list-style-type: none"><li>• For rows and columns, click on the top left corner cell to select all (or use Ctrl A), then right click on a column header and select Unhide. Similarly, right click on a row header and Unhide.</li><li>• For sheets, right click any tab and select Unhide and a dialog box will list the available hidden sheets. However, in Visual Basic, there is also another status called 'very hidden' that can only be selected in the VB Editor. To identify whether this is the case, type =INFO("NUMFILE") into any cell and the result is the number of worksheets in the workbook. If the total does not equal the number of visible worksheet tabs, you will know there are also one or more very hidden sheets.</li><li>• To reveal text hidden via formatting, use select all and temporarily clear all formatting.</li><li>• To reveal numbers that have been hidden using the custom number format of ;;; first check if that format has been used by going to the Format Cells dialog box for Numbers and selecting Custom at the bottom of the menu on the left. If the format is discovered, use select all to apply an alternative format to the sheet to reveal any incident where it has been applied.</li></ul>

## POST-REVIEW ACTIVITIES

The review does not end when the last formula has been checked, but rather when the findings of the review have been documented, communicated to the appropriate people, and changes have been implemented. It could also lead to another review. It is important to record what checks have been performed and the rigour of any testing that was conducted.

This record should be completed on a separate worksheet within the workbook that was tested, so that the review results do not become separated from the source as the file is moved around. A copy of the reviewed sheet should be archived, and any subsequent spreadsheet amendments should be subjected to further reviews.

A typical review sheet might include:

Topic	Description
<b>The spreadsheet being reviewed</b>	Details of the spreadsheet, the version and date accessed, and a brief description of the outputs that it produces.
<b>Review completed</b>	The reviewers' details, the date and time the review was performed, and a description of the work that was completed.
<b>Methodology</b>	A note of the methodology that was followed - whether a modelling standard such as Operis, SMART, FAST, or another standard - and an assessment of the compliance to that methodology.
<b>Risk assessment</b>	An assessment of the risk level to the organisation in both the creation and outputs of the spreadsheet.
<b>Structure and features</b>	An overview of the spreadsheet layout, features (such as macros), and calculation bases (such as net present value on mid-year or year-end values).
<b>Findings</b>	A summary of the review findings, together with the work needed to correct any deficiencies. Comments here might cover: <ul style="list-style-type: none"> <li>• Inputs: clarity of identification and location.</li> <li>• Formulas: left to right consistency, empty cells and any errors.</li> <li>• Flags: inbuilt checks to validate results.</li> <li>• Ratios: areas to check consistency of values along the time series.</li> </ul>
<b>Corrections</b>	Include a narrative on the changes that were implemented as a result of the initial review. Any subsequent review should check that the initial findings have been corrected. It may be worthwhile to include a note of any quantitative change to the spreadsheet's outputs due to corrections.



Finally, upon completing a spreadsheet review, there are several steps that should be considered to ensure it is reliably maintained.

**Long life cycle spreadsheet** – Spreadsheets used for budgets, management reporting or strategy, for example, are likely to have a long life cycle compared to a spreadsheet built to evaluate a single transaction. It is likely these long life cycle spreadsheets will need to be rolled forward frequently to the next period on which they report. Care is needed to ensure that the data to be updated is clearly identified to avoid any legacy values remaining. A process is required to verify that the new data is aligned and opening balances are agreed. User guidance should be included as the author of the spreadsheet may no longer be at the organisation when it is time to roll it forward. Such spreadsheets can also suffer from scope creep, with the core aim changing or becoming lost over time, introducing further risks.

**Protection** – When a spreadsheet moves from development to application it may be necessary to protect the logic from both deliberate and inadvertent change. Examples are templates for budgets and business cases, which may be used by a large audience who may not all have the relevant expertise.

A password protocol should be established over access to the files, sheets and formula cells. In many cases only the data entry cells should be accessible. These cells should be formatted clearly to make their location obvious and, if appropriate, data validation should be used to prevent inappropriate inputs.

Ensuring that at least a small group has access will prevent spreadsheets from becoming inaccessible. However, making the password too widely known removes the benefit of the protection that it is there to provide.

For confidential spreadsheets, the file location may provide the best protection, which is unlikely to be the central server.

**Spreadsheet updates** – As a spreadsheet evolves it is important to keep track of what has changed and who made the changes. This serves two purposes:

- to signal to other users that the spreadsheet has changed. This enables them to check that it has not corrupted other areas that may have become inadvertently damaged.
- to keep track of who holds the spreadsheet knowledge and has the master version of the sheet and is, therefore, best able to make future enhancements.

A clear and agreed protocol is required to record version numbers and to inform co-authors and users when it has changed. Detailed change logs are also very helpful, and more than merit the labour they take to maintain.

User guides, covering the routine update process and normal checks, as well as troubleshooting guides, should be revised to reflect any changes.

## ACKNOWLEDGEMENTS

This guide is the result of debate among members of the Tech Faculty's Excel Community Advisory Committee, as well as comments from the community's members and beyond. The project was led and authored by **John Tennent** of Corporate Edge. Contributing members include:

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February 2024, Interbrand, Best Global Brands 2023