FSEG VALIDATION ASSESSOR
Manual

Fire Safety Engineering Group
University of Greenwich
London

Software version: 1.1.0.2 (31/01/13)
Developer: Simo Haasanen

Introduction:

It is desirable to have objective measures of the level of agreement between predicted and measured performance rather than subjective assessments based on visual inspection of how well the predicted and measured curves agree. This is particularly important if the validation analysis is to be used by regulatory authorities to determine the suitability of an evacuation modelling tool. Thus, it is necessary to quantify the level of agreement between predicted and measured performance. This is achieved using a validation metric based on quantifiable differences between the predicted and measured curves.

The metric adopted and used in this software is based on the work of Peacock *et al*. [1] who defined a performance metric that could be used to assess how well fire model predictions agreed with a set of experimentally based validation temperature curves. However, it is noted that the equations defining the metric in [1] were incorrect and were corrected by FSEG researchers in [2] who adapted the methodology for use with evacuation models. In [2] the performance metric is used to assess how well evacuation model predictions agree with a set of experimentally based validation evacuation curves.

The metric consists of the Euclidean Relative Difference, the Euclidean Projection Coefficient and the Secant Cosine. These measures compare the shape of the model prediction to the experimental data as well as the distance apart.

- **The Euclidean Relative Difference (ERD)**

$$\frac{\|E-m\|}{\|E\|} = \frac{\sqrt{\sum_{i=1}^{n}(E_i - m_i)^2}}{\sqrt{\sum_{i=1}^{n} E_i^2}} \qquad (1)$$

The ERD is used to assess the average difference between the experimental data (E_i) and the model data (m_i). The smaller the value for the ERD, the better the overall agreement. Equation 1 should return a value of 0 if the two curves are identical in magnitude. An ERD of 0.2 suggests that the average difference between the model and experimental data points, taking into account all the data points, is 20%.

- **The Euclidean Projection Coefficient (EPC)**

$$\frac{\langle E, m \rangle}{\|m\|^2} = \frac{\sum_{i=1}^{n} E_i m_i}{\sum_{i=1}^{n} m_i^2} \tag{2}$$

The EPC calculates a factor which, when multiplied by each model data point (m_i), reduces the distance between the model (m) and experimental (E) vectors to its minimum. Thus the EPC provides a measure of the best possible level of agreement between the model and experimental curves. An EPC of 1.0 suggests that the difference between the model (m) and experimental (E) vectors are as small as possible.

- **The Secant Cosine (SC)**

$$\frac{\langle E, m \rangle}{\|E\|\|m\|} = \frac{\sum_{i=s+1}^{n} \frac{(E_i - E_{i-s})(m_i - m_{i-s})}{s^2(t_i - t_{i-1})}}{\sqrt{\sum_{i=s+1}^{n} \frac{(E_i - E_{i-s})^2}{s^2(t_i - t_{i-1})} \sum_{i=s+1}^{n} \frac{(m_i - m_{i-s})^2}{s^2(t_i - t_{i-1})}}} \tag{3}$$

The SC provides a measure of how well the shape of the model data curve matches that of the experimental data curve. It makes use of the first derivative of both curves. The SC measure includes a 'smoothing' term, s, which attempts to remove noise in both the experimental data and the model prediction. Selecting an appropriate value of s is dependent on the number of data points in the data-set, given by n. It is desirable to keep the ratio s/n as low as possible. An SC of 1.0 suggests that the shape of the model (m) curve is identical to that of the experimental (E) curve.

A computer programme has been provided that determines the metric values for any two data-sets. The computer programme can be used to compare the experimental exit curve with the predicted exit curve(s). This programme is called FSEG_VALIDATION_ASSESSOR and is freely available from the FSEG website at:

http://fseg.gre.ac.uk/validation/introduction/

Software requirements:

- Microsoft Windows XP or later
- Microsoft Office or Microsoft Access Database Engine 2010 Redistributable (see troubleshooting section)

How to use the software and the expected workflow:

The programme assumes that the experimental data represents the exiting time for each person that was measured exiting the geometry. Similarly, the software assumes that there is a model predicted exiting time corresponding to each person in the experimental data-set. In addition, there may be multiple predicted exiting data-sets derived from repeat simulations and so the

programme can read in more than one predicted data-set. However, it is important that there is a model predicted exiting data point corresponding to each measured experimental exiting data point. The data should be arranged in a spreadsheet as follows:

(i) The exiting data should be arranged into columns of increasing exit time order, one column for each data-set. Thus the first entry in a column represents the time for the first person from that data-set to exit, the second entry represents the time for the second person from that data-set to exit and so on.

(ii) In the first column provide the exiting time for each person derived from the experimental data-set (called *Base Case in the programme and* E_i *in equations 1-3).*

(iii) In the next columns provide the exiting data for each person derived from the model predictions (called *Trial Case in the programme and* m_i *in equations 1-3*). Note multiple predicted model data-sets can be loaded at one time.

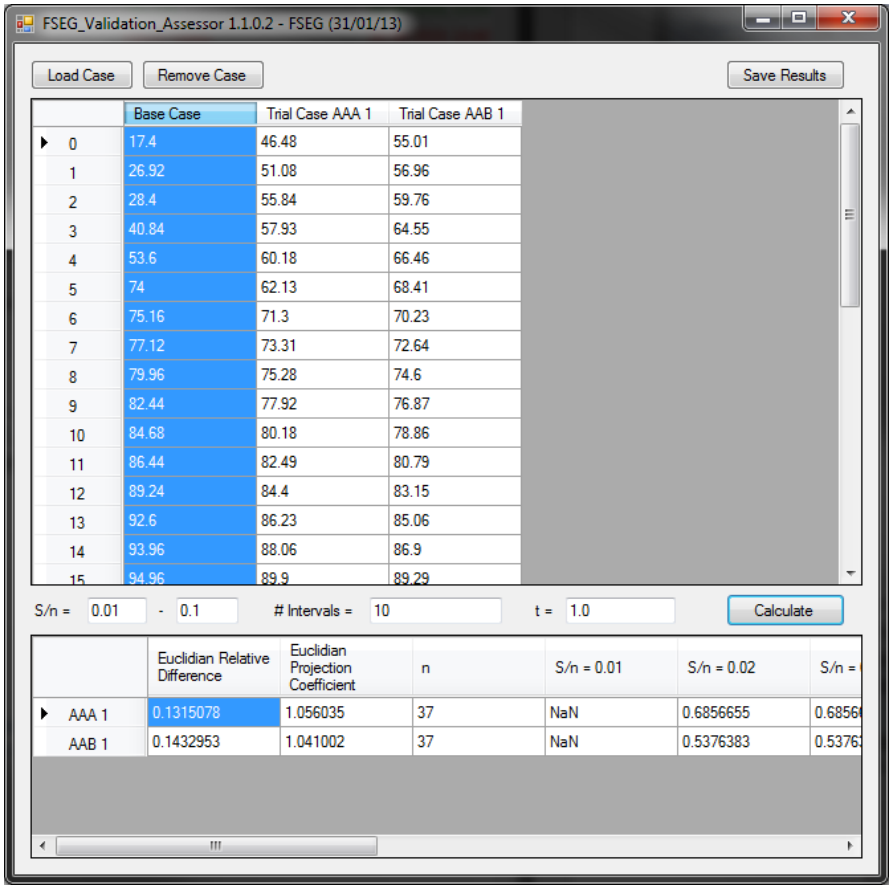
Note: as the software assumes that each data point represents the exiting time for one person (agent), the software automatically associates the exiting order to each exit time data point and so there is no need to read in the person number associated with each time point.

The experimental data-set and the model data-sets are then loaded into the software as follows:

1. Load the data sets from files using the button *Load Case*.
2. Select the desired cells for the case and then press *Set Base Case* to set the selected data as the *Base Case* or press *Add Trial Case* to set the selected data as a new *Trial Case*. Note: multiple *Trial Cases* are set if multiple columns of data are selected when pressing the *Add Trial Case* button. Repeat this step until all desired data sets are loaded.
3. Set the desired values for the calculations in the *s/n*, *Intervals* and *t* fields. Press calculate once done.
4. Save the results into a new file by pressing the *Save Results* button. The saved file will match the data in the second table.

More details on the functionality available on each window can be seen in the appropriate section below.

Main window of the software:



Button functionality:

Load Case – Open an .xls or .xlsx Microsoft Excel file to load data into the software.

Remove Case – Remove the selected column/data set from the first table.

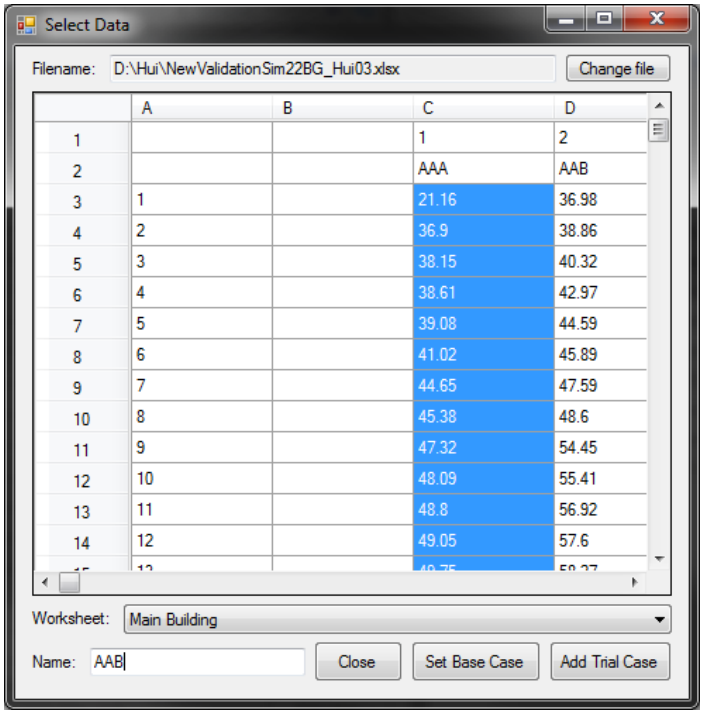
Save Results – Save results from the second table into a comma separated values (.csv) file.

Calculate – Calculate the results from the loaded cases.

Notes:

If a field has a value of *NaN* (Not a Number) instead of a number, it indicates a division by zero in the calculation.

Load Case window:



	A	B	C	D
1			1	2
2			AAA	AAB
3	1		21.16	36.98
4	2		36.9	38.86
5	3		38.15	40.32
6	4		38.61	42.97
7	5		39.08	44.59
8	6		41.02	45.89
9	7		44.65	47.59
10	8		45.38	48.6
11	9		47.32	54.45
12	10		48.09	55.41
13	11		48.8	56.92
14	12		49.05	57.6

Button functionality:

Change file – Load a different file than the one currently loaded (indicate in the *Filename* field).

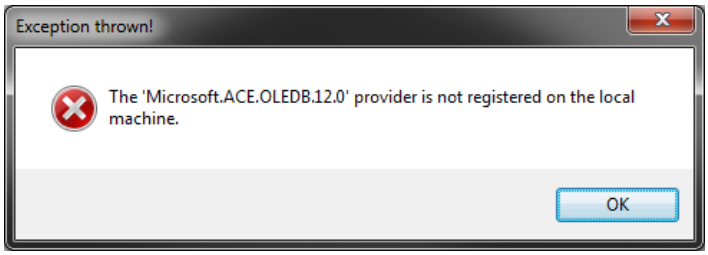
Worksheet – Change the worksheet in the Microsoft Excel file.

Name – Set a custom name for the data set if used as a Trial Case.

Close – Closes the window. Same as the X button in the top right corner.

Troubleshooting:

The following error occurs:



Explanation:

The software relies on Microsoft Office to load proprietary Microsoft Excel spreadsheet files. Microsoft provides a free to download software to enable this functionality if a full version of Microsoft Office is not installed on the computer.

To resolve:

The following software package need to be downloaded and installed: Microsoft Access Database Engine 2010 Redistributable. Select the 32-bit version and not the 64-bit (i.e. x64) from the following link:

http://www.microsoft.com/en-in/download/details.aspx?id=13255

References:

1. Peacock, R.D., Reneke, P.A., Davis, W.D., Jones, W.W.: Quantifying Fire Model Evaluation Using Functional Analysis, Fire Safety Journal, 22, 167-184, (1999).

2. Galea, E.R., Deere, S., Brown, R.,Filippidis, L., Two Evacuation Model Validation Data-sets for Large Passenger Ships, SNAME (The Society of Naval Architects and Marine Engineers) Journal of Ship Research, Vol 57, number 3, pp155-170, Sept 2013, http://dx.doi.org/10.5957/JOSR.57.3.120037