Calibration, validation and verification: “Fools rush in where angels fear to tread”.

Edmund Penning-Rowsell with some help from Paul Samuels (and Ben Gouldby)

Yalding, Kent, 2000
Calibration, validation and verification: “Fools rush in where angels fear to tread”.

Calibration is a comparison between measurements – one of known magnitude or correctness made or set with one device and another measurement made in as similar a way as possible with a second device. The calibration process begins with the design of the measuring instrument that needs to be calibrated.

Verification and validation are independent procedures that are used together for checking that a product, service, or system meets requirements and specifications, and that it fulfills its intended purpose.

"Validation. The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers.

"Verification. The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition. It is often an internal process.

Calibration, validation and verification: “Fools rush in where angels fear to tread”.

But what about floods and flood risk assessment in particular?

**Calibration** is a comparison between **flood risk measurements** of known magnitude or correctness with comparable modelled results (or *vice versa*).

**Verification and validation** are independent procedures that are used for checking that **a risk assessment** meets our requirements and is fit for its intended purpose.

- **“Validation”**. The assurance that a **flood risk assessment** meets the needs of relevant stakeholders.
- **“Verification”**. An evaluation of whether or not a **flood risk assessment** complies with a requirement, specification, or imposed condition.
Our assessment of risk*: Why is a national economic** assessment of flood risk important?

- It informs the whole UK discourse and debate about floods, risk management and climate change
- It therefore affects policy to a significant extent
- It also affects capital and revenue budgets for flood risk management

* Fluvial and coastal ONLY here
** Not financial losses
Who said annual average flood damage was approximately **£1bn** in England and Wales??

<table>
<thead>
<tr>
<th>Document</th>
<th>Quotation</th>
</tr>
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<tbody>
<tr>
<td>Foresight Future Flooding (Ex. Sum.)</td>
<td>“...even with the present flood defences, we experience an (annual) average of £1,400 million of damage (£1,040 in England and Wales).” (2004)</td>
</tr>
<tr>
<td>Foresight Future Flooding (Volume 1)</td>
<td>“Within the NAFRA 2002 study it was estimated that the annual average economic damage due to flooding is, on average, in the order of £1 billion pa”. (Evans 2004)</td>
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<tr>
<td>Flooding in England (the EA)</td>
<td>“The expected annual damages to residential and non-residential properties in England at risk of flooding from rivers is £1 billion.” (EA 2004)</td>
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<tr>
<td>Flood risk management in England (NAO)</td>
<td>“The annual costs of flood damage in England are estimated to be at least £1.1 billion” (NAO 2009)</td>
</tr>
<tr>
<td>CCRA, main document (flooding)</td>
<td>“Present day Expected Annual Damage (EAD) to residential and non-residential properties from tidal or river flooding is of the order of £1.2 billion in England and Wales. The EAD is an estimate of the average annual damage to property and contents. The total damage could be much higher if other assets and indirect and intangible losses are included.” (Defra 2011)</td>
</tr>
<tr>
<td>The EA’s Long Term Investment Strategy</td>
<td>“The average annual cost of damage from flooding in England is estimated at more than £1 billion. These costs are borne by householders, businesses, central and local government and others including insurance companies”. (EA 2011)</td>
</tr>
<tr>
<td>CCRA Executive Summary</td>
<td>“Annual damage to UK properties due to flooding from rivers and the sea currently totals around £1.3 billion (and) is projected to rise to between £2.1 billion and £12 billion by the 2080s.” (Defra 2012b)</td>
</tr>
<tr>
<td>CCRA: Floods and Coastal Erosion, Sector Perspective</td>
<td>“On average, annual damage to properties and their contents due to river and tidal flooding in the UK currently totals around £1.3 billion” (Defra 2012b)</td>
</tr>
</tbody>
</table>

All based on the same assessment of risk; these are not independent verifications.
Figure 1: An illustration of the high consequence risks facing the United Kingdom

- Major Industrial Accidents
- Coastal Flooding
- Inland Flooding
- Non-conventional Attacks*
- Pandemic Influenza
- Animal Disease
- Major Transport Accidents
- Severe Weather
- Attacks on Critical Infrastructure
- Attack on Cross-Phased

Relative Impact vs. Relative Likelihood

National Risk Register

2010
2013
From ‘NAAR’ in 2000/2001 to ‘NAFRA’ 2008 (£ billions)

..... modelling flood risk to gauge AAD

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<td>Damages p.a. (England)</td>
<td>0.626</td>
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<td>0.801</td>
<td>1.060</td>
<td>Results not available</td>
<td>2.332*</td>
<td>1.411</td>
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<td>Damages p.a. (Wales)</td>
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<td>Damages p.a. (total England and Wales (£bn))</td>
<td>1.797</td>
<td>1,909</td>
<td>1,741</td>
<td>Results not available</td>
<td>2,218++</td>
<td>2,306</td>
<td>2,625</td>
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<td>Properties affected (England)</td>
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But without any significant calibration

Each one traceable back to one source: These, again, are NOT really independent assessments

.... all accompanied by myriad changes in method and data, but with the same aim

NAAR = National Assessment of Risk. NAFRA = National Flood Risk Assessment
From ‘NAAR’ in 2000/2001 to ‘NAFRA’ 2008 (£ billions)

….. modelling flood risk to gauge AAD

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<td>Damages p.a. (total England and Wales (£bn))</td>
<td>0.801</td>
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<td>Properties affected (total England and Wales)</td>
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Annual average flood damage (£ billions)

- c. £1bn
- New flood spreading model
- Based on the WAAD method

…. all accompanied by myriad changes in method and data, but with the same aim
Doubts about coastal flood risk:

Foresight 2004 (The only mapped RASP result): what does geography tell us?
Doubts about coastal flood risk:

Most of Blackpool is well above current extreme sea levels if defences are breached.

The Environment Agency’s flood maps showing defences.

£10 millions annual average damage??

24m

23m

9m

14m
Doubts about coastal flood risk:

Where else is current AAD also deemed to be ‘high’ or ‘medium’?

Is this a pattern of actual flood damage at the coast that we recognise?
The flood damage record:
What have been the historical damage values?

<table>
<thead>
<tr>
<th>Date</th>
<th>Economic losses at 2010 values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>£0.45bn*</td>
</tr>
<tr>
<td>1953</td>
<td>£5bn</td>
</tr>
<tr>
<td>2000</td>
<td>£0.79bn+</td>
</tr>
<tr>
<td>2007</td>
<td>£3.2bn</td>
</tr>
<tr>
<td>2013/14</td>
<td>£1.3bn?</td>
</tr>
</tbody>
</table>

How can the annual average be c. £1bn if there have only been two/three (maybe three/four) floods since 1894 with losses greater than that value?

* £12m at 1947/8 prices (the £0.45bn may well be too low); + 2000 prices
The flood damage record:
ABI data on flood insurance claims (£ billions)

From the ABI Press Release of Nov. 2010 we get an inflation adjusted average for the period 1990-2009 of just

£0.226bn

The simple average (£0.226bn) has been up-rated by 20% to reflect less than compete insurance penetration (c. 90%) and an element for underinsurance.
The flood damage record:
Environment Agency data on the number of houses flooded

At an average of £30,000 per event, this gives a grossed-up (economic) AAD of £0.261 bn

The houses > total AAD is factored by the proportion of 2007 losses attributable to the residential sector, adjusted to economic values.
The flood damage potential: London’s flood risk (£ billions)

**EA Thames region**

**TE2100 non-Thames areas:**
- Southern (50%)
- Anglian (50%)

**Total Thames Region plus all the TE2100 area**

**TE2100 area AAD**

**Thames area outside TE2100 area**

**NAFRA value** for the TE2100 area + all the Thames region: £0.66bn

**TE2100 value:** £0.07bn

Implied AAD in the rest of the Thames region of £0.59bn: This is simply not credible
‘Reversing’ the WAAD analysis: What **event losses** are ‘needed’ to get to the ‘target’ AAD of £1bn?

If **residential** AAD is £0.38bn (to get a total AAD of £1bn), these are the event losses that are needed **for the 100- and 50-year events**, assuming a ‘national’ mean SOP of 1:10 and 1:25 years.
Summary results: Not £1bn+ but less than a third of that (averages = £0.26bn to £0.30bn)

<table>
<thead>
<tr>
<th>Sources of data</th>
<th>Annual average loss [£bn]: financial values</th>
<th>Annual average loss [£bn]: economic values</th>
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<tbody>
<tr>
<td>Environment Agency NAFRA 2008 (adjusted by Area teams)</td>
<td>N/A</td>
<td>1.281</td>
</tr>
<tr>
<td>National Audit Office (2011)</td>
<td>N/A</td>
<td>1.1</td>
</tr>
<tr>
<td>EA residential property numbers</td>
<td></td>
<td>0.261</td>
</tr>
<tr>
<td>ABI press release (ABI, 2010) covering 1990-2009</td>
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<td>0.360</td>
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<tr>
<td>ABI claims average 1998-2009</td>
<td></td>
<td>0.606</td>
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<tr>
<td>IBM risk profile (adjusted NAFRA model to historic data)</td>
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<td>0.500</td>
</tr>
<tr>
<td>'Reversing' WAAD calculations</td>
<td></td>
<td>0.263</td>
</tr>
</tbody>
</table>

Simple averages of items in bold (2 significant figures only)

Summary results: Not £1bn+ but less than a third of that (averages = £0.26bn to £0.30bn)

* Corrected in the Circulation Note to 0.322 and 0.26 to allow for insurance penetration
The Circulation* Note’s extension of economic damages (residential only)

£bn at 2010 prices (except 2011 to 2013/14 which are at prices then ruling)

- £0.146
- £0.147

Caveat: the ABI does not represent the whole market (c. 82%)


Paul Samuel’s analysis of the Circulation Note’s economic damages (residential only)

PS (12.6.2014): “I have played with the data and supposed 2007 would be the highest damage if we had 50 years of record. Assuming my use of the Gamma function is correct (need to check this), this changes EAD to £144 M from £178 M to give you an idea of the importance of this particular event in the bigger picture. I have ideas for other ways of exploring sensitivities, we should also explore some of the temporal and spatial differences of the 2007 flooding to understand the impact of the event.”

Up-dated residential fraction of damages: 2000 (45.2%); 2007 (37.9%) & 2013/14 (64.9%). Weighted mean = 41.8%.

Calculated Residential AAD = £0.144bn

Total ADD = £0.34bn

£0.25 [0.26*] £0.30 billion
The analysis was undertaken by my statistician colleague David Wyncoll. David fitted a GEV using a Bayesian technique to represent parameter uncertainty. Integration of the fitted GEV provides an estimate of EAD. The x (y?) axis scale is £billion. The solid red line represents the best estimate of EAD, this relates to the estimate that Paul has produced and that you have presented. The upper dashed red line is the upper 95% estimate of EAD, taking account of the uncertainties in the fitted distribution. Ben Gouldby 8.1.2015
So, again, what event damages are needed? To get a (residential only) EAD of £1.6bn?

Assuming a national average SOP of 1:25 years, it looks like [c.£15bn * 1.6] = £22.5bn??

2007: residential losses were £1.84bn (55,000 houses flooded).

Can we believe, say, 670,000 houses might be flooded in one event* ??

* £33,000 each
A ‘realist’ approach to the extent of flood risk in England and Wales: Conclusions from IBG paper

Conclusion No. 1: the model(s) appears unstable and unreliable

Conclusion No. 2: some RASP/NAFRA predictions look badly exaggerated

Conclusion No. 3: The likely AAD is £0.26-£0.30bn, not £1.0-£1.3bn

Conclusion No. 4: Counter-arguments are at best weak and at worst misinformed

Conclusion No. 4b: Up-dating does not change the results to any marked extent (maybe to £0.34bn)

Conclusion No. 5: This exaggeration must not continue; we must be realistic and honest about the risks that we face
Calibration, validation and verification: “Fools rush in where angels fear to tread”.

CONCLUSIONS:

1. We want our flood risk assessment results to be believed, and produce the impacts that are wise and sensible.

2. To achieve this we need (much) more attention to every aspect of verification, validation and calibration.

3. This is not a ‘bolt on’ option, but is quite simply essential.
Calibration, validation and verification: “Fools rush in where angels fear to tread”.

The end!
The end, except ….

Red dots are NRPs (classified)
Blue dots are 999s (unclassified NRPs)
Red dots are NRPs (classified)
Blue dots are 999s (unclassified NRPs)