General Guidance for Geoscientists on the Communication of Geohazard Information to Different User Groups

Alan Thompson[1], Brian Marker[1] & Jane Poole[2]

[1] Cuesta Consulting Limited, United Kingdom
[2] Idris Consulting Limited

Introduction

Communication is essential in preparing for, avoiding or responding to, the occurrence of natural geohazards – i.e. physical (geological) processes which have the potential to cause harm to people and/or to the things which people rely on.

While the starting point for dealing with any kind of geohazard is for geoscientists to develop a robust understanding of the physical processes involved, the responsibility for minimising the associated risks to people, buildings, infrastructure and livelihoods rests with a range of other professionals. These include engineers, planners, developers, architects, consultants, national and local Governments, emergency services, insurance and reinsurance providers and teachers. Some responsibility – for themselves and others – also rests with the general public. However, for positive actions to be taken to reduce risk, and thereby build resilience to natural hazards, appropriate information needs to be passed from the geoscientists to each of these groups in ways which each of them can understand and act upon (McKirdy *et al,* 1998; Marker, 2008; Liverman, 2008).

A key point to recognise is that risk-communication is not simply a one-way process; not just telling people things and expecting them to respond. Effective communication requires frequent interaction, dialogue and collaboration, so that information can properly address the requirements of those who need to use it, and so that the geoscientists themselves can get involved in helping to design appropriate solutions, policies or action plans.

This document provides generalised guidance on the ways in which this can be done and introduces a generic flow-chart model of geoscience communication that is capable of being applied to a wide range of different geohazards and circumstances. It should be read in conjunction with the paper by Thompson *et al* (in prep[1]), which provides a more detailed explanation of the key principles involved and a more comprehensive review of the associated literature.

Together, the guidance and the paper form complementary outputs from one section of a three-year collaborative research project on "*Disaster Resilient Cities: Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur*"[2].

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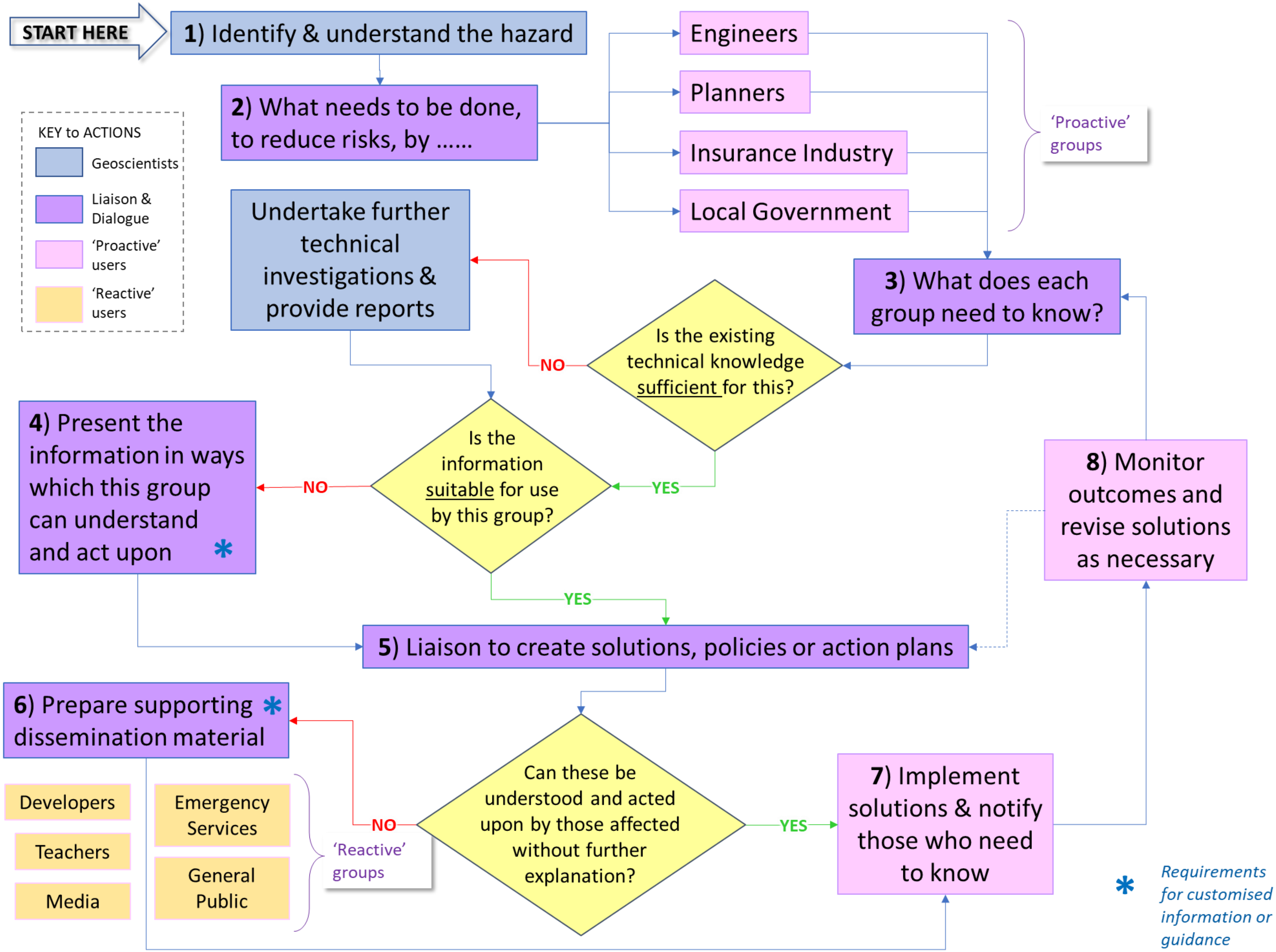

Figure 1: Generic Flow-Chart Model of Geoscience Communication in relation to Geohazards

Stage 1) Identifying and Understanding the Hazard and Associated Risks

This fundamental requirement is the starting point for the model. As well as incorporating the normal responsibilities for technical investigation and analysis that will be familiar to all geoscientists, it also includes being able to explain the hazard – and any uncertainties relating to it – in plain language.

As explained more fully in the paper by Thompson *et al* (in prep), which divides this stage into these separate components, being able to explain things in plain language can be seen as an integral part of developing a true understanding of the subject. The idea is often referred to as the "Feynman Technique", named after Richard Feynman (1918–1988), a philosopher and Nobel Prize-winning physicist who formalised it as a refinement of the more general notion of 'learning by teaching'. His concept[3] involved:

- Identifying everything that you know about a particular subject;
- explaining this knowledge to a (real or imaginary) non-expert audience, such as an intelligent, enthusiastic child;
- using this process to identify gaps in your knowledge;
- filling those gaps by learning more;
- then reassembling the information into a logical narrative, or story.

Feynman's technique recognises that you need to thoroughly understand something in order to be able to tell a convincing story about it. The ability to turn a topic into a narrative is therefore a good test of one's depth of understanding. It is also of particular importance in being able to cascade information down to those who need to use it – the various 'target audiences'.

By following this technique, geoscientists can be sure that they understand the hazard well enough, and can explain it clearly enough, to be able to engage effectively with other professionals or the wider community, in order to pass relevant details on.

Stage 2) Identifying the Target Audiences: What needs to be done, and by whom?

The second stage of the flowchart requires identification of the particular target audiences to which geoscience information needs to be provided, in order for them to play their part in risk reduction. Geoscientists will sometimes know, intuitively, what needs to be done – e.g. whether the hazard itself can be reduced in some way; whether it can be avoided, by discouraging development in hazard-prone areas; or whether it is likely to require emergency evacuations from existing development in response to warnings. However, they will need to liaise with other professionals (those with the responsibility for carrying out these actions) in order to discuss the feasibility, or otherwise, of different approaches, and so that they can tailor their inputs and advice accordingly.

Depending on circumstances, actions may be needed by **engineers** (e.g. to design structures which will provide protection from the hazard or to repair existing structures); by **local authority planners** (e.g. to devise policies which guide new development to safe locations or which help to control the nature of development within areas that may be affected by hazards); by other **local Government officers** (such as those responsible for issuing public warnings and coordinating emergency responses); and/or the **insurance industry** (in order to provide the cover needed to protect livelihoods at reasonable (affordable) premiums and to facilitate recovery following actual hazard

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[3] see for example https://tpofto.com/the-feynman-technique/ and https://medium.com/taking-note/learning-from-the-feynman-technique-5373014ad230

events). Together, these are shown in Figure 1 as '*Proactive*' user-groups, because of the various roles which they need to play in reducing risk and/or supporting recovery.

In addition, there are a number of more '*Reactive*' user groups, as shown later in the flow chart sequence. These comprise the various groups of people who will (primarily) need to respond to the actions of others in helping to minimise risks – both to themselves and others. They include **developers**, **emergency services**, **teachers**, the **general public** and the **media**. In practice, some of the groups may behave either proactively and/or reactively as circumstances change.

As a starting point, within Stage 2 of the model, geoscientists need to find out the best means of establishing contact with influential people in each of the proactive groups and open dialogue with them. In many cases, those people will be able to facilitate later contacts within the reactive groups or (in the case of Local Government officers, for example) may suggest that they themselves act as conduits for passing on the information. That may sometimes be the best route for the dissemination of information to the media or the general public – particularly in the case of early warnings where authority and control are important – but for other groups it will usually be beneficial for the geoscientists to communicate directly with those who need to respond.

Stage 3) Understanding the Requirements for Information: What does each group need to know?

Stage 3 of the model is for the geoscientists to liaise and engage in dialogue with each of the identified groups to understand their requirements for information. The paper (Thompson *et al* in prep.) provides detailed suggestions as to the *types* of information likely to be required by each group (briefly summarised in Table 1, below), together with observations on the *characteristics* or *qualities* of the information likely to be required in each case. These, however, are only broad suggestions. The details will always need to be established or confirmed through close liaison and dialogue on a case-by-case basis.

Examples of such liaison include the original work in the UK from which this generic model was developed (Thompson *et al*, 1996, 1998) and similar collaboration between geoscientists, engineers, planners, insurers and others in dealing with the aftershocks of the Canterbury Earthquakes in New Zealand (Becker *et al*, 2015). In both cases, the geoscientists assessed what was needed, through dialogue with the users, before developing the advice or guidance that was needed.

Within Stage 3, the flowchart incorporates additional steps for:

- making sure that the available existing knowledge is <u>sufficient</u> to address these requirements;
- undertaking additional investigations, where necessary; and
- checking that the information (whether existing or new) is <u>suitable</u> for use by the intended audience.

Each of these steps is of fundamental importance in making sure that any solutions, policies or action plans which are subsequently developed are based on the best available information.

Types of Information / Guidance	“Proactive” User Groups				“Reactive” user groups			
	Engineers	Planners	Local Government	Insurers	Emergency Services	Developers	General Public	Media
Detailed technical information (including historical + monitoring data) on the nature, timing, causes, behaviour and spatial distribution of specific hazards *	✓			✓				
Simplified but clear and comprehensive advice on the nature, significance, magnitude, probability and spatial extent of the hazards **		✓	✓	✓				
Simplified summaries of key information on hazards, solutions and actions required**					✓	✓	✓	✓
Detailed technical input / comments on appropriate engineering solutions**	✓							
Clear, reasoned advice on appropriate planning approaches, including both forward planning policies and development control procedures**		✓	✓			✓		
Clear understanding of the need for rapid communication and the types of action required by emergency workers in response to warnings**			✓		✓			
Customised advice to provide an understanding of their full range of responsibilities**			✓		✓	✓		✓
Straightforward explanations on what to do in response to warnings**			✓				✓	
General guidance on responsible communication of hazard and risk information**	✓	✓	✓	✓	✓	✓	✓	✓

NOTES: * information or guidance produced by geoscientists. ** Information or guidance produced by geoscientists in collaboration with the relevant ‘target audience’

Table 1: Outline of the main types of information or guidance likely to be needed by various user groups in dealing with or responding to geohazards. (Taken from Thompson *et al,* 2019).

Existing information is often insufficient for the purpose of dealing adequately with the hazard. It may be inadequate to support modelling predictions or technical assessments on which engineering or geotechnical designs will be based; or it may be unreliable as a basis for forecasting specific hazard events for which early warnings and emergency actions are likely to be required. Thus, geoscientists have a vital role in advising whether or not the information is ‘*fit for purpose*’. Equally, other professionals, particularly local Government officials and private sector developers, have a responsibility to take account of that advice and to promote the funding for any additional work that may be needed. Again, good communication, sensible liaison and collaboration are all key factors.

In some – perhaps many – cases, there will be a need to undertake further technical studies in order to gain a more reliable understanding of the hazards themselves and/or the most appropriate ways of dealing with them. Additional boreholes or geophysical surveys, for example, may help to define the extent of subsidence potential within a particular area; geomorphological interpretation of satellite images, aerial photographs and/or LiDAR data may help to identify the location, timing and extent of landslides and other forms of ground instability; and further geotechnical and/or hydrometric monitoring data will invariably enhance the reliability of modelling predictions of such things as flooding and mass movement events.

There will almost always be more that can be achieved, in terms of sound analysis and prediction, with more and better data. However, budgets for such work will usually be limited so it is wise to remember that being ‘*fit for purpose’* does not necessarily mean striving for perfection. Compromises may need to be reached where the imperfections are considered to be acceptable.

This will often be the case, for example, where additional periodic monitoring data that are needed to develop or validate a model will take additional time – often many years – to compile. In such cases, a precautionary approach will often be needed to develop interim solutions, plans or policies to aid risk reduction, despite the lack of scientific certainty regarding the scale of risk involved. Where this is needed, the limitations and uncertainties of any modelling that is carried out – and of any public warning systems based on the modelling outputs – will need to be understood, and properly communicated, to those who are likely to be affected. Further observations relating to the communication of uncertainties are given in Doyle *et al* (2019) and Thompson *et al* (in prep).

In other situations, however – such as the engineering design of buildings or structures on unstable ground, or the promotion of development in areas which are likely to be susceptible to serious flooding or subsidence – it is <u>not</u> acceptable to rely on inadequate data. In such cases, a more restrictive precautionary approach may be needed, with a presumption against development in areas which might be at risk unless and until adequate data becomes available to demonstrate that the level of risk is acceptable as it stands or can be adequately mitigated. It may be appropriate, in such cases, for developers to invest in the additional data collection needed to provide greater clarity, provided that there is external oversight of such work and a system of approval by appropriate regulators.

In terms of being *suitable*, the key requirement is for the information obtained to be capable of being understood – and acted upon – by the target audience(s) involved. In almost all cases, this will require customised information or guidance to be prepared, through collaboration between the geoscientists and the end-users. In the model, this is covered by the optional Stage 4.

Stage 4) Presenting the Information in Ways which each Group can Understand and Act Upon

Stages 4 to 7 of the model all relate to the final key principle of geohazard communication: delivering the required information and guidance in the right form. The breakdown reflects important differences between each of the steps involved:

- **Stage 4** relates to the provision of basic information relating to the geohazard(s) that is suitable for use by the proactive user groups, where this is not already available;
- **Stage 5** relates to the development of formal solutions (e.g. engineering designs and plans), policies (e.g. for planning control) or action plans (e.g. for emergency responses);
- **Stage 6** concerns information that is suitable for use by reactive groups, as explanations of what they need to do; and
- **Stage 7** deals with the implementation of the adopted solutions, including early warnings, where appropriate.

Where Stage 4 is required, geoscientists need to put considerable effort into transforming the information contained in technical reports into accurate but non-technical language. Most scientists (whether consciously or otherwise) rely on technical terminology to enable them to exchange information in a very precise (and usually very concise) manner. Whilst this may be appropriate in a purely scientific or technical setting (for example in detailed geotechnical reports or scientific journal publications), it is wholly inappropriate for passing information on to planners, politicians and other decision-makers who do not possess the skills or training required to follow complex technical explanations and are mystified by "technical jargon". It is at this stage, therefore, where the benefits of applying the Feynman Technique at the outset will pay dividends, enabling a clear, easily understood logical narrative to be produced with no reliance upon widely incomprehensible language.

In each case, the outputs need to be prepared through close liaison with the relevant target audience, or user-group, so that the geoscientists can be certain that the key issues are properly understood by those who need to take action. This will often be an iterative process with draft documents and other outputs being discussed and revised, as necessary, until a clear understanding has been achieved.

The target audiences themselves do not need to become experts in geoscience, they simply need to understand the specific issues involved so that they can see how their particular actions will help to reduce the associated risk. Here again, there may be merit in applying the Feynman Technique, with the user seeking to produce a clear, logical narrative about their role in the process.

Stage 5) Liaising to Create Solutions, Policies or Action Plans

Once the appropriate information and guidance are in place, geoscientists can liaise with the various proactive users to develop one or more effective solutions. As noted above, these may comprise engineering designs and plans (produced in collaboration with engineers) to guard against the effects of known hazards; policies for the spatial location and control of new development (produced in liaison with local planning authorities); or action plans (e.g. for emergency warnings and other responses), produced in collaboration with local authorities and the emergency services.

In each case, the primary responsibility for the solutions rests with the relevant user group, but the geoscientists still need to be fully involved, to check that their advice is being properly implemented and that appropriate account is being taken of any uncertainties within that advice.

Collectively, the proactive users and the geoscientists need to ensure that the solutions, policies or action plans that are created can be understood and acted upon by those who need to respond (i.e. the various 'reactive' user-groups). This is likely to be primarily an issue for policies and action plans where, in many cases, there will be a need to produce suitably targeted, informative, dissemination material [Stage 6] before moving on to implementation [Stage 7]. For engineering solutions, this may be less of an issue, since contractors will be familiar with the implementation of engineering designs, though there will still be an important requirement for supervision and compliance checking.

Stage 6) Preparing Supporting Dissemination Material

Where Stage 6 is required, as it often will be, geoscientists will again have an important role to play in helping to produce suitably targeted dissemination material. Here again – perhaps more than ever – the Feynman Technique will be extremely beneficial in helping to ensure that the explanations provided can be clearly understood.

The type of supporting material required will clearly vary from one situation to another but will need to be written with selected clear objectives in mind rather than just being an opportunity to explain everything about a particular hazard. The latter might be appropriate for suitably targeted and well-presented educational broadcasts, aimed at stimulating general interest in the subject, but not for more serious or urgent messages. The objectives of general dissemination material might include raising awareness of specific potential dangers and/or of actions that will need to be taken if and when emergency warnings are given, but carefully phrased to not give rise to undue fear or panic. Messages to developers will need to be aimed at raising awareness of planning policies and development control procedures, including the reasons why these are being used and the need for compliance with them. They will also need to explain the legal position regarding responsibility for safe development and secure occupancy.

In many situations, it is prudent to prepare draft versions of messages that will need to be issued as public warnings in connection with specific hazard events. Advance preparation of such drafts – which will usually need to be refined with up to date information regarding timing and location of the specific event etc., before being issued – will help to ensure that the wording is accurate and measured and that these can be released quickly. Further advice regarding warnings and other public information, including methods of dissemination, is given by Mileti (1995), Ahmad *et al* (2014), Noorhashirin *et al* (2016), Niles *et al,* (2019) and in the review by Thompson *et al* (in prep).

Once again, although the proactive user groups will generally be responsible for issuing such information, geoscientists have a very important role to play in making sure that the content and recommendations remain grounded in an accurate understanding of the known facts and available predictions, including levels of confidence.

Stage 7) Implementing Solutions

The final stage of 'delivering the information' is to implement the solutions: building the engineering structures, publishing and adopting planning policies, and publishing action plans – complete with training sessions where these are needed (as they often will be). By this stage of the process, geoscientists will probably have limited direct involvement, though they may periodically be asked by the media to comment on the background to particular procedures or in response to future hazard events.

Stage 8) Monitoring of Outcomes and Revising Solutions as Necessary

In order to ensure that the approaches, policies and procedures for dealing with geohazards are working correctly, and in order for them to remain relevant and appropriate in a rapidly changing world, there is a need for ongoing monitoring, feedback, continuous improvement and updating Awareness campaigns will need to be run at appropriate intervals to keep essential facts in mind and because of changing populations in risk areas.

This will be of particular importance in relation to hazards for which predictive modelling and forecasting is required, where the models can be continually refined and outcomes continually improved as new data is collected on both hazard events and causative factors. An important aspect of this will be to monitor changing thresholds or frequencies of hazard events in response to ongoing climate change, which may necessitate completely revised models being used to predict future events. Adaptation to climate change may also necessitate completely new approaches to spatial planning and even emergency responses.

New approaches are also likely to come from technological developments, particularly in the fields of data collection, analysis, artificial intelligence and computerised connectivity (the "Internet of Things" – IoT) provided the Feynman principles are kept in mind.

For all of these reasons, Stage 8 is shown in the model as a feedback loop, taking things back to a reassessment of the requirements for information, in Stage 3. In some cases, it may be possible to 'short-circuit' that loop by linking back to Stage 5, and simply modifying the existing solutions. In either case. Geoscientists are then brought back into the process, through collaboration with the user-groups concerned.

Conclusions

The generic model of communication presented here been developed to illustrate the various ways in which suitable information can be provided by geoscientists to different target audiences or user-groups in order to develop effective and appropriate responses to natural geohazards. It is designed to be used in conjunction with the more detailed review of key principles and previous literature provided in the paper by Thompson *et al* (in prep). Together, these provide a framework of guidance which can be adapted, as necessary, and applied to many different geohazard types and geographical areas. Reference should also be made to the series of more specific case studies which are published on the 'downloadables' section of the project website (http://ancst.org/nuof/)

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