The events of September 11 highlighted how unpredictable and devastating terrorist attacks can be. The insurance industry is now trying to find if such attacks can be predicted and priced for. In a race against both time and each other, the risk modelling agencies say they are almost there. Bianca Markram reports.

An insoluble problem?

Grant Robertson

"Ant colonies have an incredible intelligence capability because of their ability to communicate across space," says Gordon Woo, a mathematician and specialist in earthquake risk modelling. "Individual ants can come to a single solution for a problem across hundreds of miles." Woo has been hired by Risk Management Solutions (RMS) to explore whether terrorism can be modelled.

It had never before occurred to anyone in the insurance industry to study ants. But insect behaviour is not just a hobby to Woo. It is one of many theories insurance executives, mathematicians and risk modelling agencies the world over are exploring in an effort to find a way to model terrorism risk. "I use this as an analogy to explain how difficult it is to pin down a terrorist group such as Al-Qaeda," he says. "It functions on the same principles of swarm intelligence as an ant colony would."

Swarm intelligence. The behaviour of ants. Game theory. Phrases such as these are becoming increasingly familiar to the insurance industry. The three largest risk modellers – Applied Insurance Research (AIR), Eqecat and RMS – are in a race against both time and each other to find a formula that can assess the risk of terrorism. Without such a model most insurance companies will not touch many terrorism risks.

September 11 redefined what terrorism meant to the insurance industry. And since that date the industry has, understandably, backed away from offering terrorism cover. Just a handful of companies will now write this business and even they will not touch certain risks. Most will not touch it at all.

But if the probability of attack could be measured – in the same way that insurers can determine the probability of an earthquake of a hurricane occurring – such a risk could be accurately priced. At least that is the theory.

Some say this is impossible. Natural catastrophes are modelled by studying historical frequency. Many other criteria are taken into account but critics argue that historical data is crucial. They say a probabilistic model cannot be created without it.

"Human behaviour is unpredictable. Storm clouds cannot change their behaviour when forecasts are broadcast. But people can."

Jon Gascoigne, risk analyst at Benfield Group

The human element

But with incidents such as terrorism, the historical data is not sufficiently accurate to allow reliable predictions. Critics also argue that, even if the data were available, the actions of humans cannot be quantified.

"Human behaviour is unpredictable," says Jon Gascoigne, risk analyst at reinsurance broker Benfield. "Storm clouds cannot change their behaviour when forecasts are broadcast. But people can." He says that the stock markets are proven examples of how human response can be unpredictable and will change according to forecasts and new information. Sceptics say that this is the biggest reason why terrorism risk cannot be modelled.

Before September 11, terrorism was covered in most property insurance policies. In many cases this was because it was not specifically excluded. Most insurance companies did not worry about assessing it as a specific risk. Some may have monitored concentrations of risks. But modelling was never considered.

Hiscox Syndicate 33, a Lloyd's syndicate, still offers limited terrorism cover. But it believes terrorism cannot be modelled because of its unpredictable nature. It instead manages its exposure by avoiding concentrations. It will also not cover buildings in central city locations. "We would rather underwrite in smaller population areas and make sure that we do not concentrate too much risk in one location," says a spokeswoman for Hiscox. ▶

Interview: Gordon Woo

In the mind of a terrorist

Gordon Woo is the man Risk Management Solutions hopes will find a way of modelling the risk of terrorism. He explains to Bianca Markram his work so far and why the behaviour of ants may help insurers.


Gordon Woo

Gordon Woo is about as smart as they come. He graduated at top of his class from Cambridge University, where he studied mathematics. He also has a PhD in theoretical physics from Massachusetts Institute of Technology and has written the book *The Mathematics of Natural Catastrophes*.

For 10 years he modelled earthquake risk for Eqecat before he moved to Risk Management Solutions two years ago. Now he is trying to find a way to model terrorism using game theory.

In the months following September 11, he spent his time studying terrorism websites, reading Al-Qaeda training manuals and talking to many specialists in fighting terrorism in the hope of uncovering patterns in terrorist behaviour.

Here, he explains how and why game theory could be the answer.

How did you get involved in risk modelling?
Purely by coincidence. After finishing my PhD in the US, I worked at an insurance company for six months. But I soon realised that there might be something else for me out there. I then started working for an engineering company that specialised in earthquakes. And that is how I got into earthquakes.

Why the interest in terrorism modelling?
The market is driven by supply and demand. A hotel chain, for instance, needs insurance to remain in business. But after the losses of September 11, terrorism cover became limited. If a quantitative model is not developed in a situation like this, the market mechanisms will remain unbalanced. The insurance industry cannot deal with the problem by sticking its head in the sand. Terrorism risk issues are going to be around for some time. That is why RMS is investing resources in developing a terrorism model.

The insurance industry should be an important part of the solution. The models the industry has developed in reaction to natural disasters not only put a price tag on the insurance risk. They also save lives.

Why can you not apply catastrophe modelling principles and extend it to terrorism?
With catastrophe modelling we have historical data to rely on. Nature is cyclical and we can depend on that. [For terrorism] a different approach is ▶

"Game theory is drawing a lot of attention at the moment because of *A Beautiful Mind*. And, although it has some applicability, I think it is more hype than reality. But Eqecat has developed a model on the basis of pure probability."

Rick Clinton, president of Eqecat

◀ She says Hiscox uses a computer modelling system that shows where its risks are. "We ensure that we do not have too much exposure in one place," she adds.

And other insurers and reinsurers that still offer terrorism coverage use similar methods. As a spokeswoman at Munich Re puts it: "Reinsurers have to limit their liability."

The insurance industry is cautious. September 11 burnt too many fingers for insurers to dive back in without knowing precisely what they are dealing with. But terrorism cover is essential for many industries and demand has increased since September 11. Some governments have stepped in to help the private insurance market. But most are also keen to act merely as a backstop to the insurance industry, not replace it completely. Either way, an accurate way of pricing the risk is desperately needed.

Peter Buetikofer, deputy head of property product management at Swiss Re, says his company started talking about modelling terrorism risk almost immediately after September 11. "You have to bear in mind that, before September 11, terrorism was just one aspect of a property insurance policy," he says. "Generally it led only to very minor losses. In special markets [where there was a higher risk of terrorism] such as the UK or Spain there were governmental solutions for terrorism cover. But September 11 has taught us the expensive lesson that the loss potential is by far higher. Before that, no-one could imagine that such loss was possible."

Swiss Re is now studying different loss possibilities, return periods and the severity of such events. "Depending on these results we will adjust insurance conditions by excluding certain probabilities and limiting our exposure to a bearable size," says Buetikofer.

These investigations should eventually allow the reinsurer to price the risk. "We use our best evaluation available at this current moment. We price the risk on this basis and run the model for several years. Through the monitoring of claims in the years to come, we'll then see whether we need to adjust the price," he explains.

Swiss Re is in favour of state involvement as part of the solution to terrorism risk. Aside from being in a better position to be the insurer of the last resort, a government can also declare terrorism insurance as mandatory. This would expand the risk community and thus spread the risk.

Munich Re shares this view. "Should developments assume apocalyptic proportions, which we do not think likely, even reinsurers with the best standing will be able to absorb only the first substantial wave of claims," says the spokeswoman. "That is the contribution they can and should be expected to make. Over and

Interview: Gordon Woo
(continued)

◀ necessary. One that puts you into the mind of the terrorist.

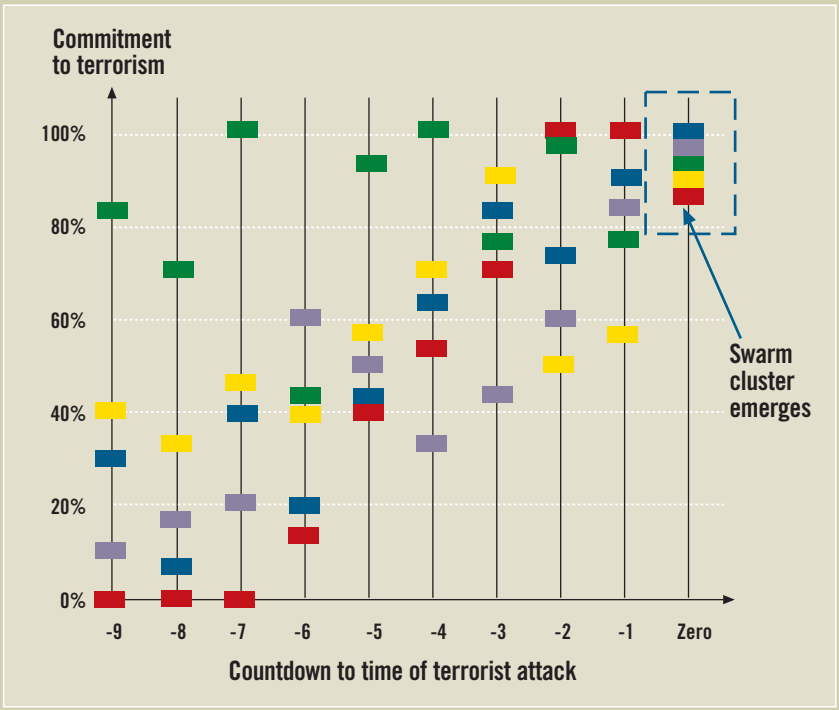
How did you think of applying game theory to terrorism?

This is what makes my situation unique. Almost all the modellers in the industry are from an engineering background. But I am a mathematician. My approach to the problem is different. Ideas like game theory come more naturally to me.

It is a mathematical tool, first used in the 1950s by Rand Corporation, the theoretical think-tank for the military. John Nash, the mathematician depicted in the movie *A Beautiful Mind*, consulted for Rand during that time, applying game theory to the network behaviour of terrorists.

The US Secretary of Defense has invited me to give a talk at a conference this coming August. The government is trying to come up with response strategies, especially in the event of a bio- or chemical attack. The reason I am invited is because of my knowledge on network behaviour or swarm intelligence as applied in game theory. The best way to combat netwars [wars against networks of terrorists] is by also having a smart way to communicate across a network. The defender needs the

How a five-man cluster emerges

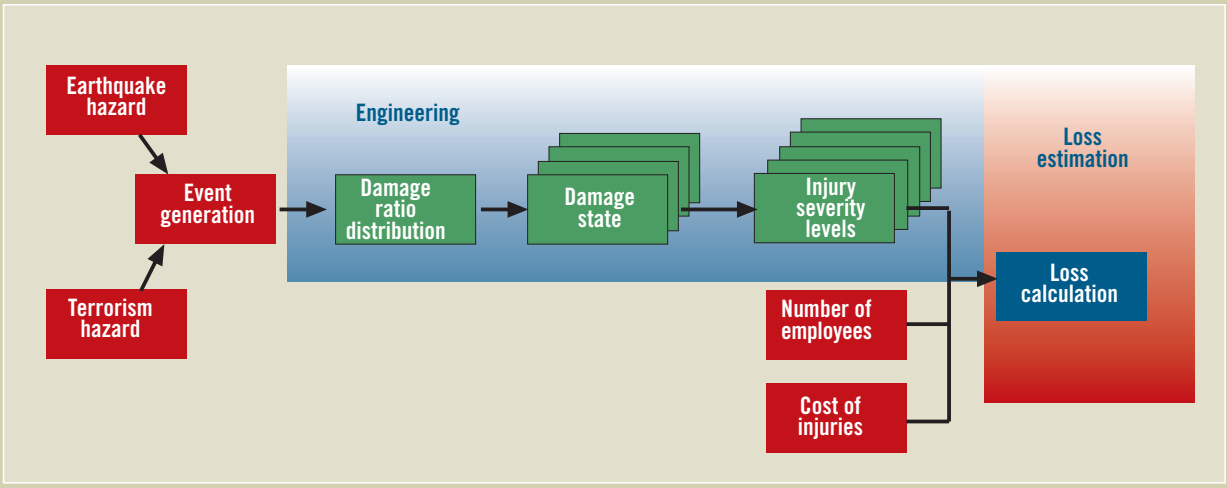


The chart shows how a five-man cluster can suddenly emerge, without central control, even if the conspirators are geographically widely separated. The commitment of an individual to participating in terrorism is gauged in percentage terms and graphed as the ordinate on the plot. Clustering is in this dimension, rather than in actual space dimensions, so the detection of a cluster by security services in advance of the zero hour for attack would be extremely difficult.

Source: *Quantifying Insurance Terrorism Risk*, by Gordon Woo

Predicting an attack

AIR's approach to modelling terrorism



Source: Applied Insurance Research

beyond this, other tools should be made available that allow the burden to be shared among society as a whole."

But none of these methods quantify the actual risk of an attack. And this is what the industry needs. Different theories are emerging speculating how this could be done. Insurers also recognise that, if it can be quantified, terrorism could be profitable.

Playing the game

RMS believes it will eventually have a formula for modelling terrorism and is set on finding a solution for its customers. Woo is the mind behind the company's attempts. He believes it is too early to begin pricing the risk using models. But he thinks that game theory can help understand the patterns of terrorism behaviour.

"The insurance industry can assess risks better if they understand what the risks are."

Gordon Woo, mathematician and risk modelling consultant at Risk Management Solutions.

Game theory is a mathematical approach made famous by the recent film *A Beautiful Mind*, which depicts the life of mathematician and Nobel Prize winner John Nash. Woo ▶

Interview: Gordon Woo

(continued)

independence and the spatial intelligence that its enemy has. The US seems to realise this.

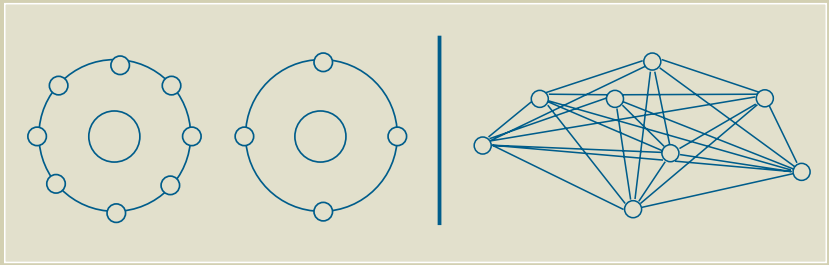
I thought: 'This is great!' I could not imagine that these men of the muscle industry would ever be interested in a mathematical solution. I am delighted that they are addressing some of these very interesting ideas.

How does game theory work?

Game theory is a theory of conflicts. It helps to explain how adversaries would interact during a conflict. I look at the interaction between the aggressor, Al-Qaeda, and the defender, the United States of America. I imagine different attack possibilities, the use of different strategies, weapons, targets, how these targets could be defended or not, and what the likely outcome of these situations could be.

To develop a quantitative model, you need principles as cornerstones. One of these is swarm intelligence. Insect behaviour reveals a lot about swarm intelligence. Ant colonies have incredible intelligence capability because of their ability to communicate across space.

Terrorist networks explained



On the left:
A two-hub terrorist network with centralised leadership. The cells attached to a hub would, for security reasons, be isolated from one another. Cells may be linked up to one another for operations with instructions on a need-to-know basis. The hub architecture could be hierarchical with certain functions centralised. If one of the hubs is discovered and destroyed, the other hub is unable to proceed with the attack, lacking the discovered hub's information. It may also now lack an important link in the network chain.

On the right:
A network with no central control, operating on the principle of swarm intelligence. Each node signifies an individual or group of individuals in the network, spread across space. It can coordinate without central command, similar to the swarming of insects. The cells can meet in an internet chat room and spontaneously coordinate an attack. If one of the cells is discovered, the others are unaffected, still able to execute the attack.

Source: *Quantifying Insurance Terrorism Risk*, by Gordon Woo

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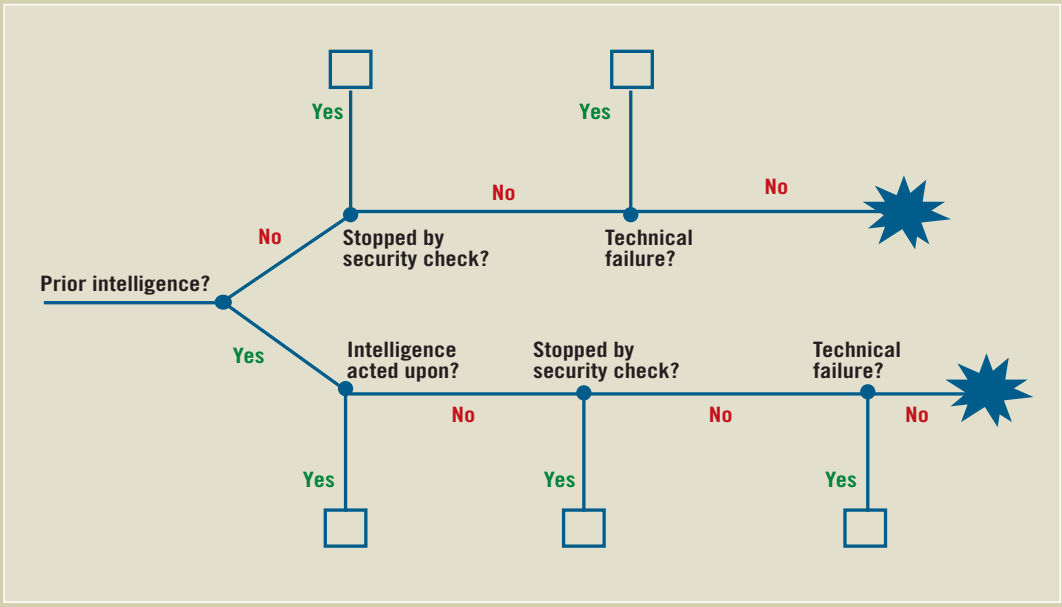
Preventing an attack

Event-tree depicting the alternative outcomes for a planned attack

Each branch is assigned a probability weight. The five square termination points signify that the attack is thwarted; the two starred termination points signify that some notable loss results.



Source: *Quantifying Insurance Terrorism Risk*, by Gordon Woo

◀ believes its theories can help assess which buildings might be targeted and how likely the success of such an attack would be, given the strength of defence. "The insurance industry can assess risks better if they understand what the risks are," says Woo.

In February this year, Woo presented his first paper on the subject in Cambridge, Massachusetts, at a meeting of the National Bureau of Economic Research. He said that the models used for natural catastrophes are inadequate for evaluating terrorism risk and that a new model is required. (See p25 for full interview with Woo.)

But sceptics say that even game theory cannot quantify human behaviour and, as such, will fall short in any attempts to quantify the risk reasonably. But some in the industry are listening to Woo and believe his theories may have a role in helping insurers assess terrorism risk.

Interview: Gordon Woo

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◀ Individual ants can come to a single solution for a problem across hundreds of miles. Argentinean ants have a special connectivity that spans practically the whole Mediterranean. They are defined as a colony in terms of thousands of square miles.

I use this as an analogy to explain how difficult it is to pin down a terrorist group such as Al-Qaeda. It functions on the same principles of swarm intelligence as an ant colony would. The organisation consists of a vast network of units that are able to operate completely independently of each other and without centralised leadership.

"From these possibilities, game theory predicts that the statistical likelihood of an attack on less significant or valuable targets becomes the same as attacks on prominent targets."

Different cells can communicate across space through internet chat rooms, for example. Without pertinent leadership they can come to a collective solution. They could coordinate an attack without having to meet beforehand. This is an important aspect of understanding terrorism behaviour.

Another principle applied to game theory is the timing of an attack. The problem here is that you have two competing forces. The terrorist has to climb a weapon-effectiveness curve. He has to invest time in preparing the weapon and in training to use it. During that time, the risk of discovery becomes bigger.

We use specialist advice on weapons and their uses. From there we can draw a weapons effectiveness curve in a variety of situations and determine how long it would take a person to train for an attack to maximise damage. It is this tension between improving effectiveness and

Fact file: Gordon Woo

- Attended the same London high school as Field Marshal Montgomery of Alamein – a celebrated general in the British army in the Second World War – and learned applied mathematics from a brigadier in the British army.
- Was the top of his class in mathematics when he graduated from Cambridge University.
- Gained a PhD in theoretical physics at Massachusetts Institute of Technology as a Kennedy Scholar.
- His acquaintance with the mathematical game theory of conflict stems from his tenure in the Society of Fellows at Harvard University.
- Author of the book *The Mathematics of Natural Catastrophes*.
- Experienced in quantitative risk assessment at nuclear, chemical, petroleum and military installations.
- Catastrophe risk consultant for Eqecat for almost 10 years.
- Catastrophe risk consultant for RMS for the last two years.

John Major, actuary and vice-president at reinsurance broker Guy Carpenter, thinks that game theory could be important in measuring the human element of terrorist attacks.

In a paper he wrote in response to Woo's theory, he describes game theory as an "important analysis tool" for the insurance industry. "Terrorism risk differs in kind from natural and man-made [accidental] catastrophes because of the elements of intelligence and intent," he wrote. "As a consequence of that, in modelling the terrorism risk, probability is not enough." He continues: "A model very much in the spirit of the one presented here has the potential to offer useful insights to the insurance profession."

An important aspect of game theory, as Woo suggests it would be applied to terrorism, would be input from specialists such as government security agencies. Many argue that this could present a problem because of the secret nature and sensitivity of information like this. But Woo thinks it would be problematic for a different reason.

"I agree, but only because nobody really knows the specific details of any operation," he says. "When Al-Qaeda captives are questioned you have to ask yourself whether they have access to the information that you want and whether you can believe them. I don't think that intelligence actually knows a lot more than anyone else."

He also points out that there is a lot of information in the public domain, although much of it is written in Arabic. "It is important to grasp principles. You don't know what the terrorists are doing, but you can figure out what they might be up to through game theory," he concludes.

Rival methods

AIR, which was recently bought by the Insurance Services Office (ISO) is also working on a number of projects concerning terrorism modelling. And it says some techniques are already up and running. "AIR has the capability to analyse the risk of terrorism now," says Jack Sequist, product manager of AIR's terrorism model.

"AIR has the capability to analyse the risk of terrorism now."

Jack Sequist, product manager of AIR's terrorism model

AIR's approach involves extending its existing natural catastrophe models to deal with terrorism. Sequist says that the model selects "hundreds of thousands different targets and attack possibilities". Specialists in terrorism help chose these targets. From this database, probabilistic losses are determined for worker's compensation, property losses and business interruption if different events happen. AIR uses a modelling technique known as the Delphi Method to calculate probabilities and model risks they have limited information about.

"This method most accurately represents the best opinions of what can happen in the future," says Sequist. The Delphi Method calculates the probabilities of attacks in all the different locations. AIR gets information from its location database, applies the specialists' knowledge, and from this generates probabilities. ▶

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being discovered that helps identifying the timing of an attack.

Al-Qaeda will start with a wish list. I imagine [Osama] Bin Laden asking himself: "How can I give old Uncle Sam a real punch on the jaw? What is a good target?" They will themselves look at what the likelihood is of discovery, especially if the US increases defence of its more prominent, valuable targets.

From these possibilities, game theory predicts that the statistical likelihood of an attack on less significant or valuable targets becomes the same as attacks on prominent targets.

The reason is that, because the defenders would concentrate on protecting the more valuable targets, softer, less significant targets will be left unprotected. What is to keep someone from stocking an apartment in a residential area full of explosives over time and then setting it off? That would be really easy to do and the damage could be devastating. Imagine the loss in human lives, the damage to residential properties. Can you imagine the insurance claims rising from that?

But how can you quantify human behaviour?

People are sceptical because they do not know how game theory works. I don't think human behaviour is that contentious. I spoke about principles earlier. Here is another principle of game theory. Humans (terrorists) have two properties: they are intelligent, and they are rational.

Al-Qaeda terrorists are smart. The terrorists that were involved in the September 11 attacks all had a high level of education. And they are not irrational religious fanatics. You have to place people in a historical-cultural context. You have to respect your enemy before you can understand him. And only by understanding him, you'll be able to predict his actions.

Imagine the UK has a general election. Say the Conservative Party is elected, but Tony Blair, being a friend of George Bush, phones him up and says: "George, I want to stay in Downing Street a little longer." Bush pulls it off by, for argument's sake, assassinating the opposition and Blair manages to stay in his position. Do you suppose the many angry people in the UK would be irrational in their anger?

This is how Bin Laden sees it. He has a grievance as a Saudi citizen. According to him the Saudi people don't want their king in power. But he believes he is in power because the Americans keep him there – to their own advantage. Bin Laden sees America as the bad guy. It is a rational conclusion in this context.

What is the future for terrorism modelling?

This is a booming time for the insurance profession and it will offer a lot of growth for at least the next 10 years. We are only in the beginning stages of modelling. The insurance industry needs to make an effort to try and catch up with governments' understanding of terrorism. As quantitative models become more available in the next few months, more industry players will get involved.

And this is why I contribute. I want to find a solution. The insurance world will benefit, but in the process many lives might also be saved. ●

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"We have developed a true probabilistic model by which we include chemical and biological terrorism risk, something that none of the other modellers are considering. They are only looking at blast-like explosions."

Rick Clinton, president, Eqecat

But Eqecat says it is ahead of both RMS and AIR in its development of a terrorism model. "We have developed a true probabilistic model by which we include chemical and biological terrorism risk, something that none of the other modellers are considering," says Rick Clinton the company's president. "They are only looking at blast-like explosions."

According to Clinton, the other modelling agencies have developed their models from a deterministic framework, which he believes limits them. He explains: "They use certain events and then put it on a probabilistic level. With something like game theory, for instance, you still have to make underlying assumptions of probability."

He adds: "Game theory is drawing a lot of attention at the moment because of *A Beautiful Mind*. But, although it has some applicability, I think it is more hype than reality. Eqecat has developed a model on the basis of pure probability." He says he does not want to elaborate further because of client confidentiality.

All talk?

The question now is whether the modelling agencies can deliver on their promises. And, more than that, whether they can create a solution that insurers can use to price the risk and which is recognised by regulators and rating agencies.

"I am somewhat sceptical as to whether this kind of risk can be accurately quantified," says Ted Collins, managing director at Moody's in New York. "I would say that if an insurer bases its terrorism risk wholly on a probabilistic model, it would constitute a big risk, whereas the insurer that limits its exposure is a lesser risk."

But Sequist believes that AIR is very close to creating a model that will please the raters, as does Clinton at Eqecat. "[Eqecat's model] will stand up to the scrutiny of rating agencies," he says. Woo at RMS is more cautious and says that it is too soon to put an exact price on terrorism. But he believes game theory could greatly aid insurance companies in understanding the risk.

Sequist says that AIR's model will be ready in July. Eqecat's could probably appear around September, says Clinton. The race is now on to see which gets there first. ●