ILLUSTRATION STOCK

Probable maximum loss estimation in loss events

Usefulness for industrial insureds

Any company's strategic risk-management decisions between technical safety measures insurance coverage, risk retention, self insurance and alternative risk transfer (ART) are taken in light of a risk assessment and other business considerations. Probable maximum loss estimation provides essential upper-threshold information for proper decision-making in the overall risk management policy.

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Every so often a slew of adverse circumstances might come together to produce events of maximum destruction. These events might spill beyond any company's internal and external protection resources and cause huge losses in both human and money terms.

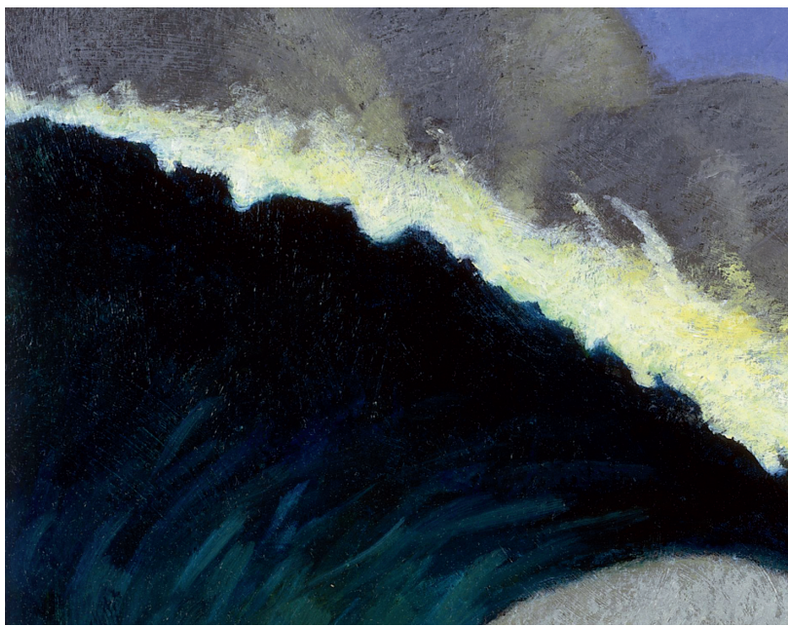
Although the likelihood of suffering a maximum loss is very low, even remote, it is no less true that no one who is exposed to risks of a natural, technological or social nature can rule them out completely.

Throughout history extreme events have certainly occurred: meteorite strike, glaciation, extinction of species, human pandemics, among others, not to mention apocryphal events in the Old Testament: plagues, universal flood, destruction of the Tower of Babel, sinking of Atlantis...

Extreme events still occur in today's post-industrialised ICT world, whether bound up with technological risks, natural catastrophes or antisocial movements, any of which might trigger

consequences known as «black swan events» or «maximum possible losses».

Any company, within its own particular scale of risks and size, is liable to suffer maximum loss events that might jeopardise its ongoing viability. It is therefore crucial to identify all risks and circumstances that might lead to these extreme situations and ascertain their potential economic and financial scale. In view of these magnitudes and other salient factors the firm will be able to take reasonable decisions and allocate suitable resources to ensure proper technical protection, in terms of safety measures, and financial protection, in terms of risk retention, insurance coverage and alternative risk transfer (ART).



Historical background and trends

The first documented use of maximum loss calculations dates right back to preparations for warfare in ancient times, for estimating potential losses on both sides. Down the ages and right up to today it has been habitual practice to establish the level of victims in ranges of optimistic, normal and pessimistic outcomes. In the great civil engineering works considerations of this type were also habitual in terms of likely bodily harm (serious and light injuries and deaths) to be suffered by workers during these huge construction works.

After the Industrial Revolution, in the nineteenth and first half of the twentieth centuries, maximum loss analyses in terms of human and money losses were also the norm in high-risk sectors such as maritime navigation, railways, aviation, mining or the chemical industry, then taking in the nuclear and aerospace industries in later years.

By the mid nineteenth century the insurance sector had begun to use maximum loss calculations on an ad hoc basis for the insurance policies of large industrial firms, especially reinsurance assignment. Since the final decade of last century, with rather a patchy distribution among countries and markets, their use has spread to risk management and risk transfer in medium-sized and large firms.

The first attempts to harmonise use of maximum loss estimates within the insurance world came in think tanks convened by CEA (*Comité Européen des Assurances*, now renamed Insurance Europe) in 1963 and 1970 and the IMIA (International Machinery Insurers Association) in 1971. Notable inputs from Spain were made by the

THESE ESTIMATES EVALUATE ONLY THE LOSS IMPACT IN ADVERSE CIRCUMSTANCES REGARDLESS OF THE PROBABILITY OF OCCURRENCE

working group set up by the Cooperative Insurance Company Institute (*Institución Cooperativa de Entidades Aseguradoras*: ICEA), which published a technical guide on this matter in 1996.

Listing all macro-accidents or «black swan events» occurring in recent years would go well beyond our remit here. But for the purposes of anticipating possible future events in specific firms, some of the most notable references are:

- Asbestosis. USA., 1978
- Rapeseed oil intoxication. Spain, 1980
- Bophal gas leak (India), 1986
- Chernobyl nuclear accident. Ukraine, 1986
- Tailings pond sludge outflow. Aznalcóllar (Spain), 1998
- Trade Center terrorist attack. New York, 2001
- Bird flu. South Asia, 2004
- BP Deepwater Horizon rig oilspill. Gulf of Mexico, 2010
- Wildfires. Australia, 2010
- Earthquake, tsunami and nuclear disaster. Fukushima (Japan), 2011
- Hurricane Sandy. USA, 2012

Most of them reached a level of maximum possible loss; others remained at a lower level of «forseeable»; they would be very unlikely to recur in the same circumstances and damage levels. The important point is for them to serve as pause for thought when considering comparative cases, albeit on different scales and in different circumstances. We should never lose sight here of the old saw: «Whatever has happened once can happen again».

Today's technique of risk assessment by maximum loss estimation is now becoming more widespread in the risk management procedures of major firms, especially in the design of insurance policies. It is hardly used, however, in defining overall risk management programmes and very rarely in control and reduction plans (safety); neither is there any reciprocal influence with risk retention and insurance plans.

Fundamental calculation/estimation principles

By a widely recognised principle the statistical measurement of risk (R) is based on two essential factors: the probability (P) and the impact (I) from a given risk or hazard on a given asset or property. As well as the statistical risk evaluation (R = P x I), it is also advisable to use other stochastic, random or forward-looking evaluation methods. These include evaluation of maximum losses per event, dealt with herein.

These estimates evaluate only the loss impact in adverse circumstances regardless of their probability of occurring.

Evaluation of maximum losses per event depends on the first risk analysis measure, i.e., identification of damage or hazard sources and of assets exposed thereto, grouping both as shown in

the risk analysis matrix of figure 1. This scheme ushers in the next risk assessment measure, represented by the interaction of each hazard source with the various assets exposed, in due accordance with the methods to be used.

Application of maximum loss methods depends on a selection of hazard sources and an identification of the assets supposedly involved, as well as an identification of the contexts or circumstances that are liable to trigger extreme loss events.

The information needed for these evaluations is very wide and varied, taking in corporate, financial, research, capital, productive, labour and commercial aspects. Detailed and painstaking field research is essential to cross check document-based information with the real situation on the ground. It is likewise crucial to establish the special circumstances and contexts that have occurred in the past or might occur in the future and might determine the scope of maximum losses.

The next step is then to estimate the potential maximum loss for each selected asset and hazard source under the adverse circumstances considered. It should be made clear here that the term «estimate» means an approximate valuation of no great precision in money terms. The crucial factor here is the size of the maximum losses in relation to the firm's total value. As we will see later, these maximum losses are expressed in money terms and also as a percentage of the total value. For decision-making purposes it suffices to know the range this falls in.

The maximum loss may be estimated in relation to the firm as a whole or against singular or critical elements, such as certain bottleneck processes, centralised stores, data processing centres, R&D units or key executive posts.

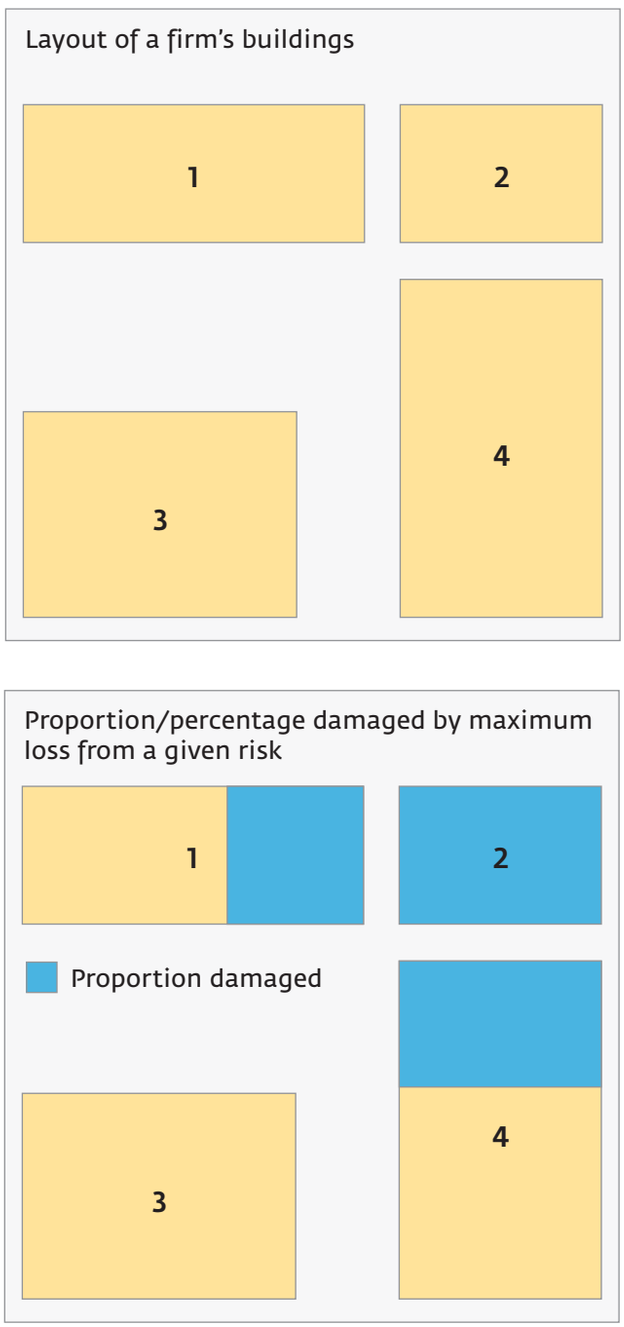
Once the abovementioned basic elements of maximum loss estimation have been defined, a valuation is then made of the damage in the established level cases: possible, foreseeable, probable or other selected values.

This involves a representation of the situations that would ensue in each chosen case and the maximum loss by groups of personal, tangible, intangible and third party assets and other singular items impinging heavily on the company's operations. As for capital assets the best procedure is to assess them as a whole and also broken down into damage of buildings, facilities, machinery and goods.

Figure 1. Risk Analysis Matrix

RISKS HAZARDS (IDENTIFICATION)	ASSETS (IDENTIFICATION) Personal Party	Tangible	Intangible	Third
Nature	DAMAGED ASSETS (EVALUATION)			
Human-antisocial				
Technological	Time	Context		Scenario

Figure 2.



Usual nomenclature

As already pointed out these risk assessment techniques have been used for some time in the insurance world. In that process a series of terms have been coined for use in the major groups of reinsurers, insurers and brokers of major industrial risks. These habitual terms and the corresponding abbreviations are listed in the table below:

Terms	Abbreviation
Maximum Possible Loss or Maximum Foreseeable Loss	MPL or MFL
Probable Maximum Loss	PML
Estimated Maximum Loss	EML
Normal Loss Expectancy	NLE
Large Loss Probability	LLP
Absolute Maximum Loss	AML
Total Probable Loss	TPL

As this table shows the words loss and maximum recur in most of the terms with alternation of possible, probable, expected and absolute as the third word, several with the letter P standing for them. The abbreviations, therefore, both in English and Spanish often raise doubts about what the «P» stands for; two of the most commonly used terms are PML standing for Probable Maximum Loss and MPL, the first two letters switching position, standing for Maximum Possible Loss.

For the purposes of this study, to facilitate understanding in the business world and favour its liaison with the insurance market, the following

APPLICATION OF MAXIMUM LOSS METHODS DEPENDS ON A SELECTION OF THE HAZARD SOURCES AND AN IDENTIFICATION OF THE ASSETS SUPPOSEDLY INVOLVED, AS WELL AS AN IDENTIFICATION OF THE CONTEXTS OR CIRCUMSTANCES THAT ARE LIABLE TO TRIGGER EXTREME LOSS EVENTS

terms have been used in the original Spanish text, expressed here in English with the Spanish translation and Spanish abbreviation:

- Maximum Possible Loss (*Pérdida Máxima Posible*: PMPos)
- Maximum Foreseeable Loss (*Pérdida Máxima Previsible*: PMPre)
- Probable Maximum Loss (*Pérdida Máxima Probable*: PMPro)

Models of Maximum Loss Evaluation per Events

In everyday insurance practice this nomenclature is usually reduced to the abbreviations. Often only one term is used, namely Probable Maximum Loss (PML), or at most two with the addition of Maximum Possible Loss (MPL). This study suggests a three-scale system giving more precise information on the gravity of maximum losses and thereby facilitating decision taking in terms of technical safety measures and financial protection measures adopted by the firm.

The three selected maximum loss terms for this article are the following, with a conceptual explanation in each case.

- **Maximum Possible Loss**. Maximum value liable to destruction by a given hazard, under the most adverse conditions, especially worst-case conditions of inhouse and external safety, pertaining to a good or set of goods.
  It is expressed as the percentage damage in relation to the total value of the good or set of goods. It is also best to express it in money terms under the denomination Maximum Exposed Value (*Valor Máximo Expuesto*) to give due account of the economic scale being dealt with.
  The expression «under the most adverse conditions», playing such a decisive role in the definition, refers to the concurrence of negative factors in the surrounding environment (natural catastrophes, supply cuts, social demonstrations, etc…) and the consequent inoperativeness of inhouse and external security and safety measures (public and private).
  The events of terrorism, sabotage, aircraft crashes and major accidents in neighbouring plant and equipment are not taken into account as initiators of loss events of another type (fires, explosions, mechanical collapses, toxic leaks or

pollutants, etc.…). They do have to be taken into account as independent direct causes where concurrence is possible.

- **Maximum Foreseeable Loss**. Maximum value liable to destruction by a given hazard or risk under conditions of productive shutdown (working shifts) with inoperativeness of inhouse protection measures, except for automatic measures and the intervention of external resources, albeit with some delay, in relation to a good or set of goods.
It is expressed as the percentage damage in relation to the total value of the good or set of goods. The expression «under conditions of productive shutdown (working shifts)» used in the definition refers to the moments in which there is no labour activity: annual holidays, public holidays, nighttime, evenings, when the intervention of any emergency team depends on the efficacy of the surveillance service. There is therefore likely to be some timelag in discovering the emergency and in giving out the distress call and the arrival of the external rescue services. Due account is given here to the functioning of automatic protection systems, if any.

- **Probable Maximum Loss**. Maximum value liable to destruction by a given hazard under normal conditions of operation, especially conditions of inhouse and external safety and security, in relation to a good or set of goods.
It is expressed as the percentage damage in relation to the total value of the good or set of goods. The expression «under normal conditions of operation» used in the above definition, refers to working-day operation with inefficient intervention of inhouse protection resources – unless a very high efficacy is guaranteed – calling for the intervention of external rescue resources, whose participation manages to check the advance of the event. The very optimistic, best-case scenario of an always successful intervention by inhouse resources – unless this is fully guaranteed – would lead to low-profile cases of «minimum losses», which would involve no significant setback for the firm. This valuation seeks the level of maximum losses that could reasonably be regarded as exceptional and which provide a reference range of probable economic impact.

The risk of fire with knock-on material damage is the most widespread in firms of all types and usually has the greatest destruction potential. For this very reason the technical criteria for maximum loss estimation due to fire with material damage are given in an annex as a guideline for the procedure to follow with this particular risk. These guidelines are then translatable to other risks, with the logical particular considerations in each case.

Usefulness for industrial insureds

The information furnished by maximum loss evaluation of the main risks of any firm, together with other evaluation methods, is essential for analysing this risk, taking the corresponding decisions and defining the risk management programme.

The first step along the way is to establish the comparative hierarchy of maximum loss values, pooled into three ranges of possible, foreseeable and probable, as reflected in a risk profile graph of the type shown in Figure 3.

The normal state of affairs is for the order of importance of the maximum losses of the various risks (see Figure 4) to fall within the three classification ranges, but straying beyond them cannot be ruled out; this would call for special one-off explanations and considerations. The main conclusion to be drawn from this joint analysis would be to work from a general principle of proportionality, whereby the greater the risk the more measures of technical and financial protection measures are assigned thereto.

Figure 3. Scheme showing maximum loss levels per event of a given risk

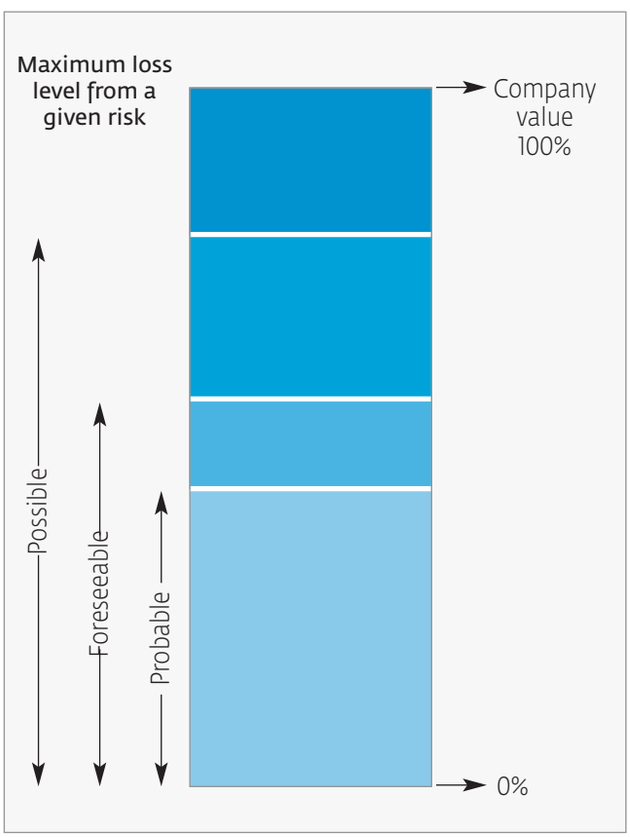
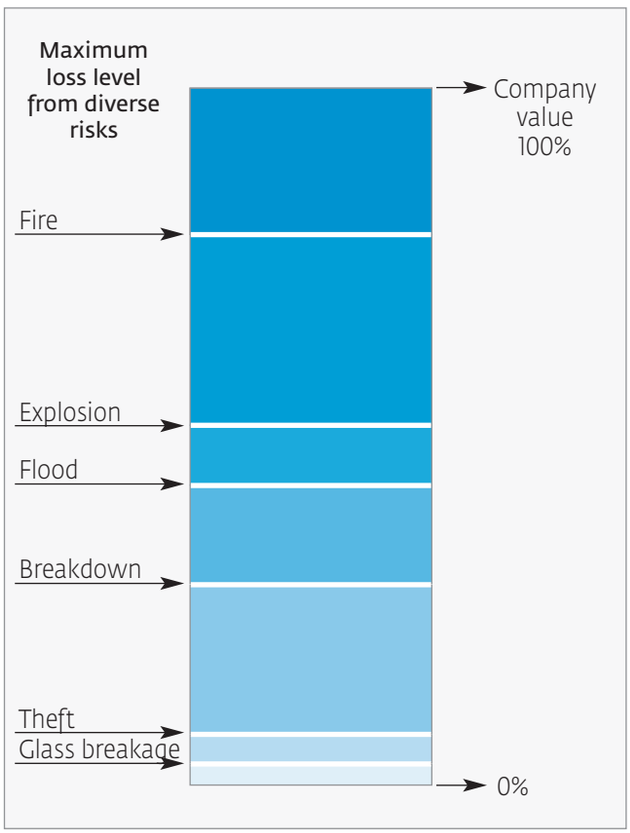


Figure 4. Scheme showing the breakdown of possible maximum loss per event of diverse risks



The interpretation and use of this information for decision taking in companies' various risk management stages should be steered in the following directions:

■ Reduction and control. Safety and security

Legal safety and security regulations lay down the minimum requisites to be met by companies.

THE FIRST STEP ALONG THIS PATH IS TO ESTABLISH THE COMPARATIVE HIERARCHY OF MAXIMUM LOSS VALUES, POOLED INTO THREE RANGES OF POSSIBLE, FORESEEABLE AND PROBABLE

THE FUNDAMENTAL RISK-REDUCTION OBJECTIVE IS TO REDUCE THE PROBABILITY OF LOSS EVENTS; ANOTHER IMPORTANT AIM IS TO REDUCE THE IMPACT OF CALCULATED MAXIMUM LOSSES BY MEANS OF SAFETY MEASURES FOR THIS PURPOSE

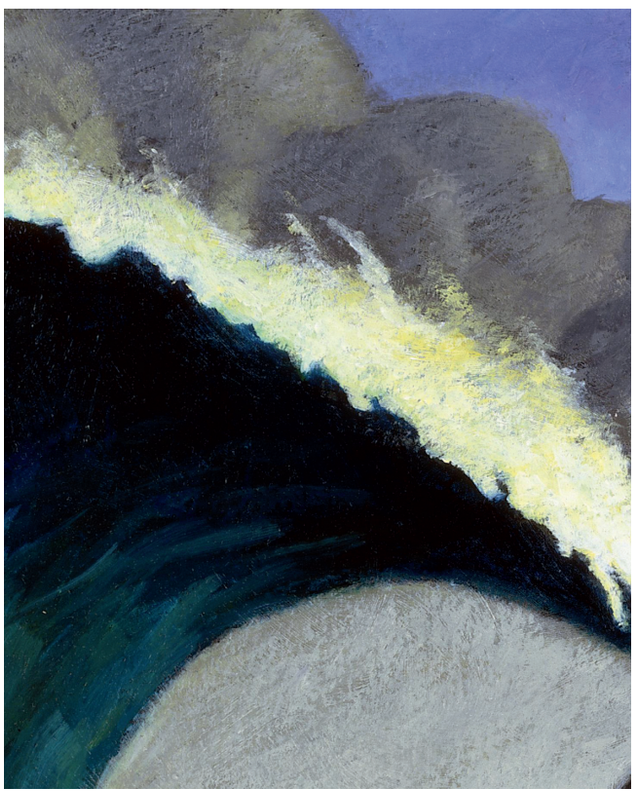
But the overriding factor here is the firm's will to overcome any safety problems, thereby achieving a higher level of protection. This decision and the grading thereof are adopted in due accordance with the obtained maximum loss values and other business factors.

The fundamental risk-reduction objective is to reduce the probability of loss events by means of appropriate safety measures; another important aim is to reduce the impact of calculated maximum losses by means of specific safety measures for this purpose.

Thus, in the case of a risk representing very low maximum loss levels in the three ranges (possible, foreseeable and probable), for example, below 5% of total asset values, then the recommendation would be not to increase safety measures unless it be a question of risks to people or critical intangible assets for the company.

In the case of low maximum loss levels in the three ranges (from 5 to 20%), the recommendation would be to bring in basic, low-cost safety measures. At middling levels (20 to 40%) in any of the three ranges, the recommendation would then be to bring in medium-cost safety measures also of a medium technical level.

In the case of high levels (over 40%) in any of the three ranges, high technical level safety measures should be brought in. If two or all three ranges (possible, foreseeable and probable) top 40%, the level of safety measures should then be doubled.



Risk retention / Self insurance

Very low maximum loss risks with no likelihood of frequent loss events of any appreciable size can be taken into account when deciding between total risk retention, i.e., self-insurance, or risk transfer to insurance, in view of the company's financial capacity and the comparative costs of both options.

On other occasions the maximum loss levels, especially within the range of probable, serve to establish the limits of excess waivers / deductibles in certain insurance policies.

Insurance-based risk transfer at first risk or partial value

Thoroughgoing maximum possible loss estimations establish the ceiling or limit that would never be exceeded in any loss event of a given risk. It is therefore a logical company stance to apply for insurance coverage up to this limit as first risk, first loss or partial value.

The application, backed up by the broker and if technically justified, will be accepted by the insurers with a premium reduction in comparison to total value coverage.

When drawing up company insurance policies under this arrangement, corresponding sublimits and limits are usually established for the various risks covered: fire, theft, explosions, physical and chemical risks, natural catastrophes, etc…

On some occasions coverage limits might be fixed in relation to probable maximum losses on a multi-layered basis, in which higher ranges (foreseeable risks) are covered by alternative risk transfer (ART) arrangements, as we will see later.

Multi-layered risk transfer

In the case of major, multinational corporations trading in several productive sectors the best option is often layered risk transfer arrangements on the basis of a master policy, providing the central coverage structure, around which the particular requirements of the various firms are integrated in due accordance with the legislation in the countries they trade in.

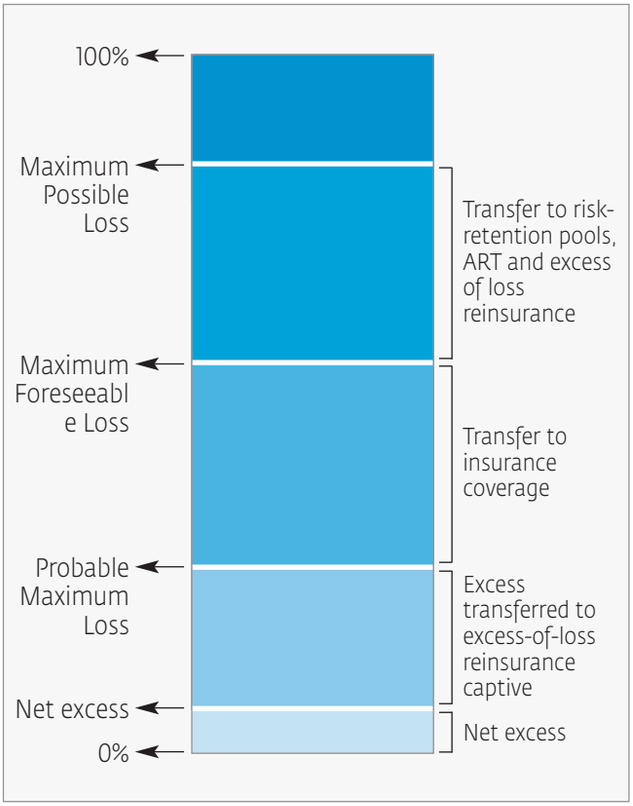
A multi-layered programme is also designed to include various financial protection arrangements: excess waivers or deductibles, copayments, risk retention groups, first risks, alternative risk transfer (ART), reinsurance captives and others layered in or included in segments of economic impact determined from maximum losses in previously evaluated loss events.

The arrangements and segments in each case are established in view of the particular business group's financial capacity, its risk management policies, its general policies and its economic-financial tolerance.

Figure 5 shows an example of multi-layered coverage arrangements in which maximum loss references serve to fix the following coverage limits:

WHEN DRAWING UP COMPANY INSURANCE POLICIES UNDER FIRST RISK ARRANGEMENT, CORRESPONDING SUBLIMITS AND LIMITS ARE USUALLY ESTABLISHED FOR THE VARIOUS RISKS COVERED: FIRE, THEFT, EXPLOSIONS, PHYSICAL AND CHEMICAL RISKS, NATURAL CATASTROPHES, ETC…

Figure 5. Multi-layered coverage model and mechanisms used



- 0 to net excess (net excess retained by the business group).
- Net excess to Probable Maximum Loss : excess transferred to the excess-of-loss reinsurance captive.
- First risk insurance coverage: Probable Maximum Loss to Maximum Foreseeable Loss. This can be taken out in a single segment or several segments with different conditions for certain companies of the group and countries and according to the risks covered, including possible partial assignment (excess of loss) to the reinsurance captive.
- Maximum Foreseeable Loss to Maximum Possible Loss . Under this arrangement the design of the various segments has to be adapted to the different firms, countries and risks covered and the shareout of segments within the arrangement of alternative risk transfer (ART) protection, risk-retention pools or groups and commercial reinsurance.

■ Other measures within the firm´s general management procedures

Maximum loss levels in events are explicit indicators of a company's strength in the face of fortuitous adverse circumstances. If most estimations of losses from main risks fall within very high values – as a general rule, over 40% of its equity value – then the company concerned would be very vulnerable and there would be a need for costly risk management improvement programmes. Conversely, if most of the main risks fall below this threshold figure, the company concerned would be well protected and there would be hardly any need for improvements; risk management costs would be correspondingly low.

Within a company's general operations there are some particular operations where, in addition to the specific information pertaining to that field of business, maximum loss information may be useful and revealing as supporting criteria. Examples might be the following:

- Company mergers and takeovers.
- Stress tests in financial, commercial or adverse social situations.
- Guarantee of the supply of products or services in the face of fortuitous events.
- Ability to service loans and pay shareholder remuneration.
- Degree of business continuity and resilience.
- Negotiations with public authorities, trade unions and other liaison groups.

Conclusions

Maximum loss evaluation provides crucial information for defining any company's risk management programme. The main objectives are to reduce said maximum levels by means of financial protection and safety measures, with periodic monitoring of the trend in these indicators.

These evaluations might help to ascertain a firm's vulnerability to extreme fortuitous risks; this qualification, together with business opportunity risks, would then reveal the company's strengths and weaknesses.

This methodology should ideally be applied during the predesign phase of any project. This would then make it possible to apply measures involving layout, industrial processes, construction, safety systems and others, as compatible with the planned operational processes, in the interests of reducing maximum loss values beforehand and facilitating risk management once the firm is up and running.

As already pointed out, maximum loss calculations cannot claim any great accuracy. Their remit is rather to establish, on reasonable grounds, the ballpark figure to be taken into account by the company in its daily activities and in due accordance with its particular financial capacities.

Even if there is no previous maximum loss experience to go on it is still recommendable to grasp the nettle and take the first steps on the basis of reasonable hypotheses. This system can then be honed in light of ongoing experience and expert advice to build up a reliable skill-set for the company's risk management procedures.

Technical criteria for estimating

The fundamental factors for establishing maximum losses in the three aforementioned ranges – possible, foreseeable and probable – from fire, considering only material damage, are the following:

- Separation by open space, free of any type of fuel, in buildings to prevent fire spread. If there is a predominance of liquid fuel with appreciable ground slope, specific distance calculations would have to be carried out.
- Separation by highly reliable constructed firewalls between buildings or parts of buildings to balk fire spread.
- Type of building structure (reinforced concrete, fire-protected steel frame, non-fire-protected steel frame) and material finish.
- Architectural development in horizontal and/or vertical, at great height, in basements or with difficult access for firefighters.
- Contents and layout of machinery, equipment, furnishings and merchandise that facilitate fire spread horizontally and /or vertically.
- Material means of fire protection: manual and automatic and human: first intervention teams, second intervention teams or brigades, emergency and contingency plans.
- Capacity of attacking the fire by public firefighting forces.

These general factors and other specific factors are dealt with below for each range of maximum loss:

Maximum Possible Loss

Special factors within this range are windspeeds of over 80 kph or other natural catastrophes that might occur in the zone and inoperativeness of the means of protection against fire (including inhouse automatic resources and external rescue services).

maximum losses from fire with material damage

- Minimum safety gaps with open space between buildings according to the fire risk rating: slight, normal and extra, as indicated at the end of this annex:
  - Between buildings of slight risk: minimum distance of 30 metres.
  - Between buildings of normal risk and between buildings of normal and slight risk: minimum distance of 40 metres.
  - Between buildings of extra risk and between buildings of extra risk opposite normal or slight: minimum distance of 50 metres.

- Firewall separation between buildings or parts of buildings with over 4 hours fire resistance or more if fires of longer duration are likely, such as warehouses of paper mill cores, bundles of scrap paper, cotton bales or the like.

Maximum Foreseeable Loss

Hypothesis of fire outbreak outside working hours with deficient or non-existent human surveillance; only automatic detection and extinguishing resources, if any, would act and firefighting service on call, and hence with delayed intervention.

- Minimum open-space safety gaps:
  - Between buildings of slight risk: minimum distance of 10 metres.
  - Between buildings of normal risk and between buildings of normal and slight risk: minimum distance of 15 metres.
  - Between buildings of extra risk and between buildings of extra risk opposite normal or slight: minimum distance of 25 metres.

- Firewall separation between buildings or parts of buildings with over 2 hours fire resistance or more if fires of longer duration are likely.

Probable Maximum Loss

Hypothesis of fire outbreak in working hours with failed intervention of inhouse fire protection resources, calling for intervention by the public firefighting service and a likely result of joint intervention by both.

- Minimum open-space safety gaps:
  - Between buildings of slight risk: minimum distance of 5 metres.
  - Between buildings of normal risk and between buildings of normal and slight risk: minimum distance of 10 metres.
  - Between buildings of extra risk and between buildings of extra risk opposite normal or slight: minimum distance of 20 metres.

- Firewall separation between buildings or parts of buildings with over 1 hour's fire resistance or more if fires of longer duration are likely.

Fire Risk Rating

Taken from the automatic sprinkler installation standards:

- Slight: offices, hospitals, schools, museums, residences and dwellings.
- Normal: foodstuff, beverages, cement, glass, vehicles, electrical and electronic appliances, paper, textiles, footwear, shopping and leisure centres, tobacco, wood, chemicals and non-foam plastic.
- Extra:
  - Processing plant, paint, varnish, resins, rubber, distilleries, refineries, fireworks and foam-based plastic.
  - Storage facilities: warehouses of all types with stacking heights of over 4 metres.